SERVICE MANUAL

3326A
TWO-CHANNEL SYNTHESIZER

HEWLETT PACKARD

HEWLETT PACKARD

SERVICE MANUAL

MODEL 3326A TWO CHANNEL SYNTHESIZER

Serial Number: All

IMPORTANT NOTICE

This manual applies to instruments with the above serial number and greater. As changes are made in the instrument to improve performance and reliability, the appropriate pages will be revised to include this information.

WARNING

To prevent potential fire or shock hazard, do not expose equipment to rain or moisture.

Manual Part No. 03326-90010
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P.O. Box 69, Marysville, Washington 98270 U.S.A.

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CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

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This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

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Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements. This is a Safety Class 1 instrument.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING

Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

SAFETY SYMBOLS

General Definitions of Safety Symbols Used On Equipment or In Manuals.

⚠	Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.
ϟ	Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).
⏚ OR (⏚)	Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.
(⏚)	Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.
⊥ OR ⊥	Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.
∼	Alternating current (power line).
⎓	Direct current (power line).
≂	Alternating or direct current (power line).
WARNING	The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.
CAUTION	The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.
N O T E:	The NOTE sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

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APPENDIX A
GLOSSARY OF SIGNAL NAMES

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GENERAL INFORMATION

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GENERAL INFORMATION

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SECTION I
GENERAL INFORMATION

1-1 INTRODUCTION

This service manual contains all the information required by service technicians to test, adjust, and service the HP 3326A Two-Channel Synthesizer (shown in Figure 1-1). Information required to service the two options which alter the HP 3326A's electrical specifications — namely, the high stability frequency reference (Option 001) and the high voltage output (Option 002) — is included in this manual. The rear panel outputs (Option 003) has no effect on the instrument performance or specifications. An instrument with Option 003 is tested in the same manner as a standard instrument.

The manual is divided by topics into six sections, as listed in Table 1-1. For repairs, the problem board will be found by consulting the fault isolation to the board level part of the "Service" section. The board level repair part of the "Service" section will help to isolate a printed circuit board's defective functional sub-block. For certification, the "Performance Tests" section should be used first. If a test fails, the "Adjustments" section and/or board level repair part of the "Service" section should be consulted. Figure 1-2 shows the flow of this manual.

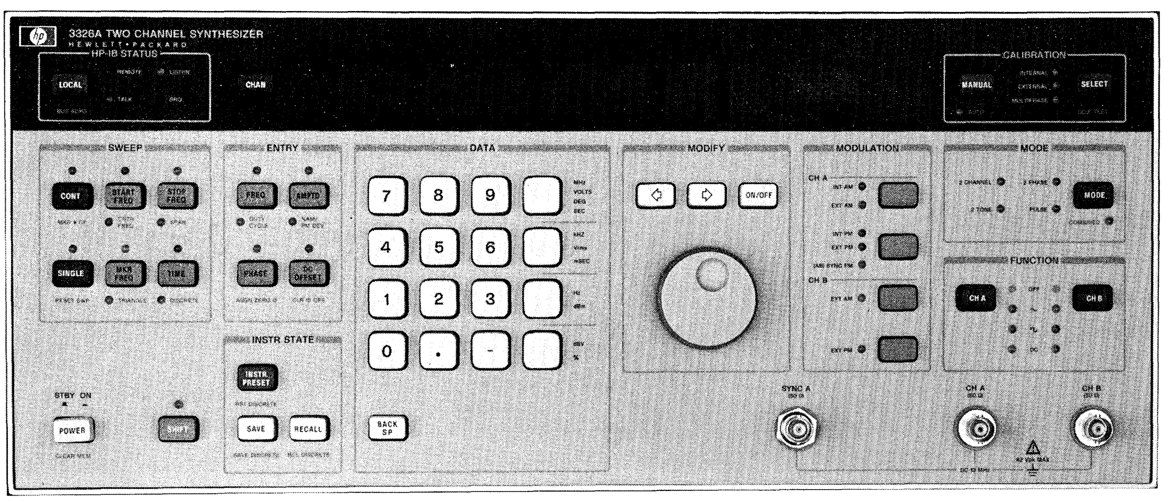


Figure 1-1. HP 3326A Two-Channel Synthesizer

Be careful to read sub-section 1-18, "Safety Considerations," before initiating any troubleshooting procedures.

Additional copies of this service manual and the latest manual change supplements can be obtained by ordering the manual part number listed on the title page. The microfiche part number listed on the title page can be used to order 4 by 6 inch microfiche transparencies of the manual. The microfiche package also includes the latest manual change supplements.

Table 1-1. Manual Section Descriptions

Section	Topic	Contents
I	General Information	— Specifications — Test equipment — Options — Option installation — Front and rear panel features — Maintenance — Safety considerations
II	Performance Tests	— Procedures to verify specifications in Table 1-5
III	Adjustments	— Procedures to adjust to specifications in Table 1-5 — Safety considerations
IV	Replaceable Parts	— Ordering information for all parts in HP 3326A (including options)
V	Backdating	— Changes which adapt the manual to older units
VI	Service	
	Fault Isolation to the Board Level	— Self test descriptions — Procedures to isolate a fault to the board level — Overall instrument theory of operation — Safety considerations
	Board Level Repair	— Individual circuit board troubleshooting data — Board level theory of operation — Safety considerations

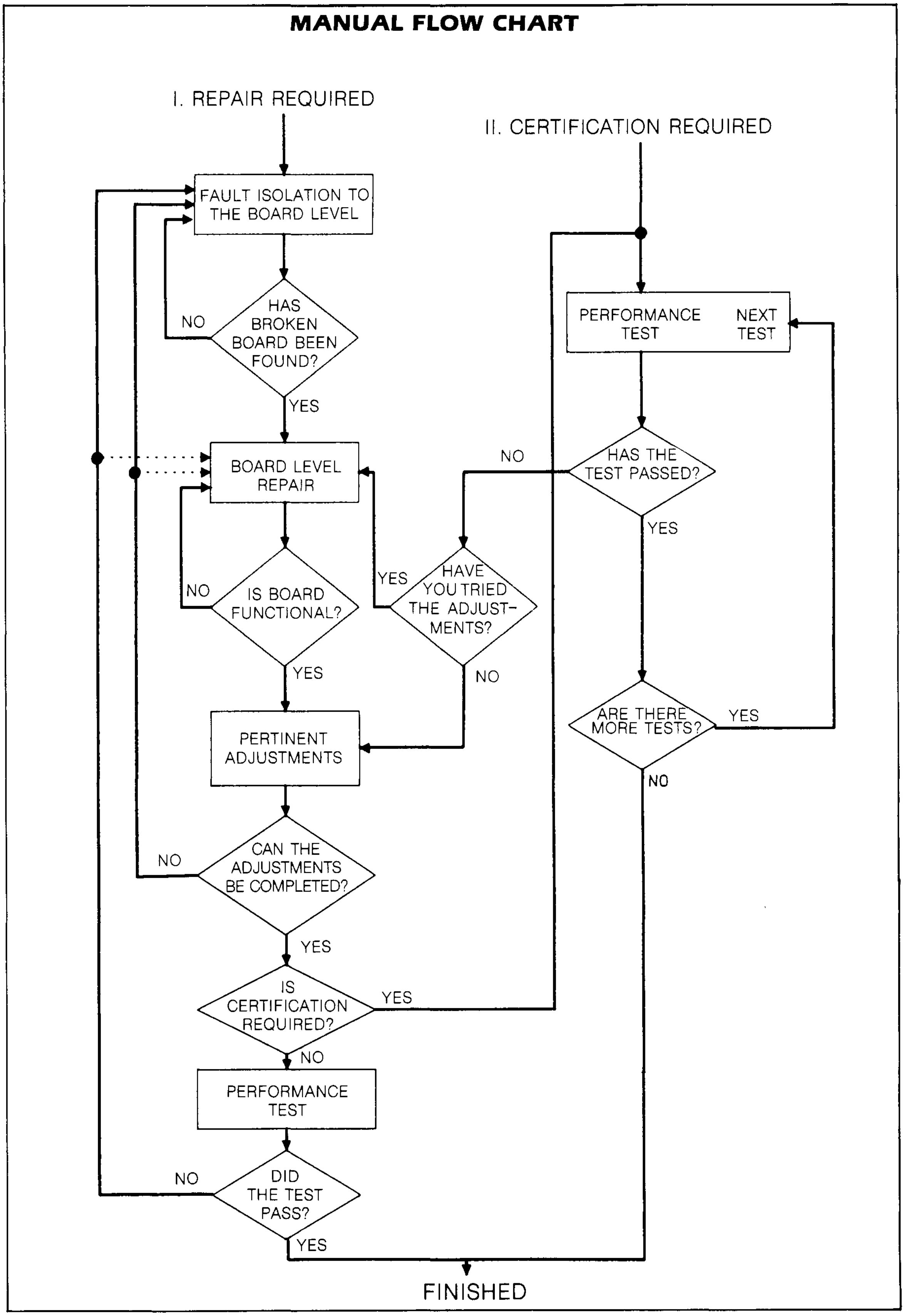


Figure 1-2. HP 3326A Manual Flow Chart

1-2 INSTRUMENTS COVERED BY THIS MANUAL

The HP 3326A identification serial number is located on the rear panel (Figure 1-3). The first four digits and the letter constitute the serial number prefix. The letter designates the country in which the instrument was manufactured (A = USA; G = West Germany; J = Japan; U = United Kingdom). The prefix is the same for all identical instruments and changes only when a major instrument change is made. The last five digits of the serial number form a sequential suffix that is unique to each instrument.

Figure 1-3. Serial Number Plate

The contents of this manual apply to all instruments. When changes have been made to the instrument, including serial number prefix changes, a yellow Manual Changes supplement that defines the changes and explains how to adapt the manual to the newer instruments will be available. In addition, backdating information contained in Section V will adapt the service manual for instruments with serial numbers other than those listed on the title page.

In addition to change information, the Manual Changes supplement may contain information for correcting errors in the manual. To keep this manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. The supplement for this manual is keyed to this manual's part number, which appears on the title page. Complimentary copies of the supplement are available from Hewlett-Packard.

For information concerning a serial number prefix not listed on the title page or in the Manual Changes supplement, contact your nearest Hewlett-Packard sales and service office. Addresses are listed at the back of this manual.

1-3 GENERAL DESCRIPTION

The HP 3326A is an HP-IB (Hewlett-Packard Interface Bus) programmable, precision two channel synthesizer covering the frequency range dc to 13 MHz. The variety of features found in the HP 3326A is made possible by having two independently controlled sources in one instrument. Capabilities are grouped into four operating modes: two-channel, two-phase, two-tone and pulse. A variety of modulations and waveforms are provided in each of these modes.

For a complete instrument description, refer to the *HP 3326A Two-Channel Synthesizer Operating Manual.*

1-4 POWER REQUIREMENTS

CAUTION

Before applying ac line power to the HP 3326A, ensure the voltage selector on the HP 3326A rear panel is set for the proper line voltage and the correct line fuse is installed in the fuse holder. Procedures for changing the line voltage selector and fuse are contained in sub-section 1-6, "Line Voltage and Fuse Selection."

The HP 3326A can operate from any single phase ac power source supplying 100 V, 120 V, 220 V or 240 V (−10% to +5%) in the frequency range from 48 to 66 Hz (see Figure 1-4). Power consumption is less than 290 VA when on (with all options), and less than 15 VA in standby.

Selector Voltage	Voltage Range
100	90-105V
120	108-126V
220	198-231V
240	216-252V

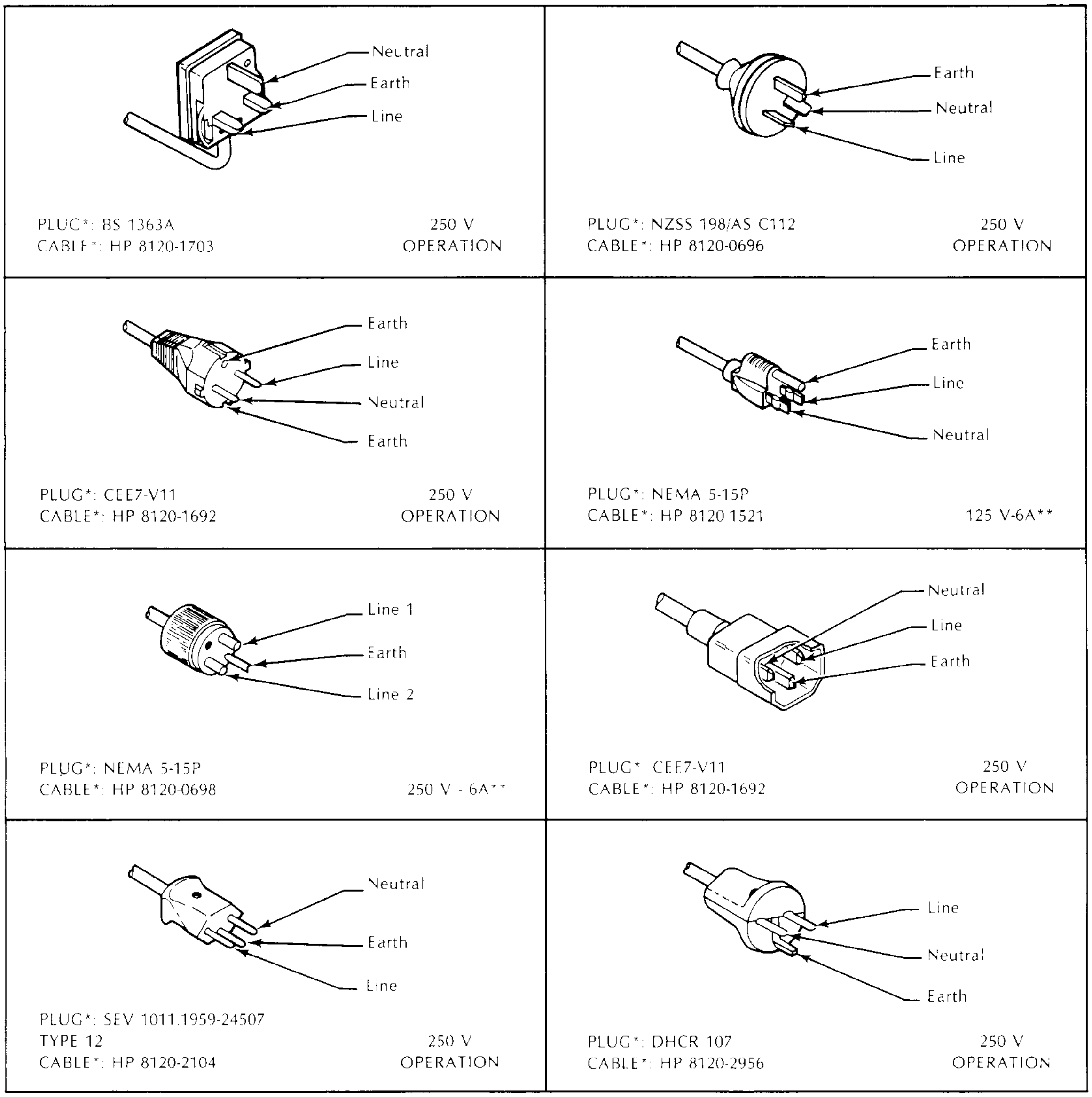
Figure 1-4. Line Voltage Ranges

1-5 POWER CABLES

In accordance with international safety standards, this instrument is equipped with a three-wire power cable. When connected to an appropriate power line outlet, this cable grounds the instrument cabinet. The type of power cable shipped with each instrument depends on the country of destination. Refer to Figure 1-5 for the connector configurations and HP part numbers of the available power cables.

WARNING

The power cable plug must be inserted into a socket outlet provided with a protective earth terminal. Defeating the protection of the grounded instrument cabinet can subject the operator to lethal voltages.



*The number shown for the plug is the industry identifier for the plug only.
The number shown for the cable is an HP part number for a complete cable including the plug.
**UL listed for use in the United States of America.

Figure 1-5. Power Cables Available

1-6 LINE VOLTAGE AND FUSE SELECTION

CAUTION

The line voltage should be set to the line voltage of the power source. Also ensure that the common connection of the power outlet is connected to a protective earth contact.

WARNING

Line voltage is present with the instrument even when the POWER switch is in STANDBY position. To prevent electrical shock, use care when working in the vicinity of the input power circuits.

WARNING

To protect operating personnel, the HP 3326A chassis and cabinet must be grounded. The HP 3326A is equipped with a three-wire power cord which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power plug is the ground connection.

An interruption of this protective conductor inside or outside the instrument or disconnection of the protective earth terminal is likely to make the apparatus dangerous. Intentional interruption is prohibited.

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

The line voltage selector is set at the factory to correspond to the most commonly used line voltage of the country of destination. The line voltage selected for the HP 3326A is indicated on the line voltage selector. Refer to Figure 1-4 for the line voltage ranges and Figure 1-6 for setting the line voltage and selecting the appropriate fuse.

To change the line voltage:

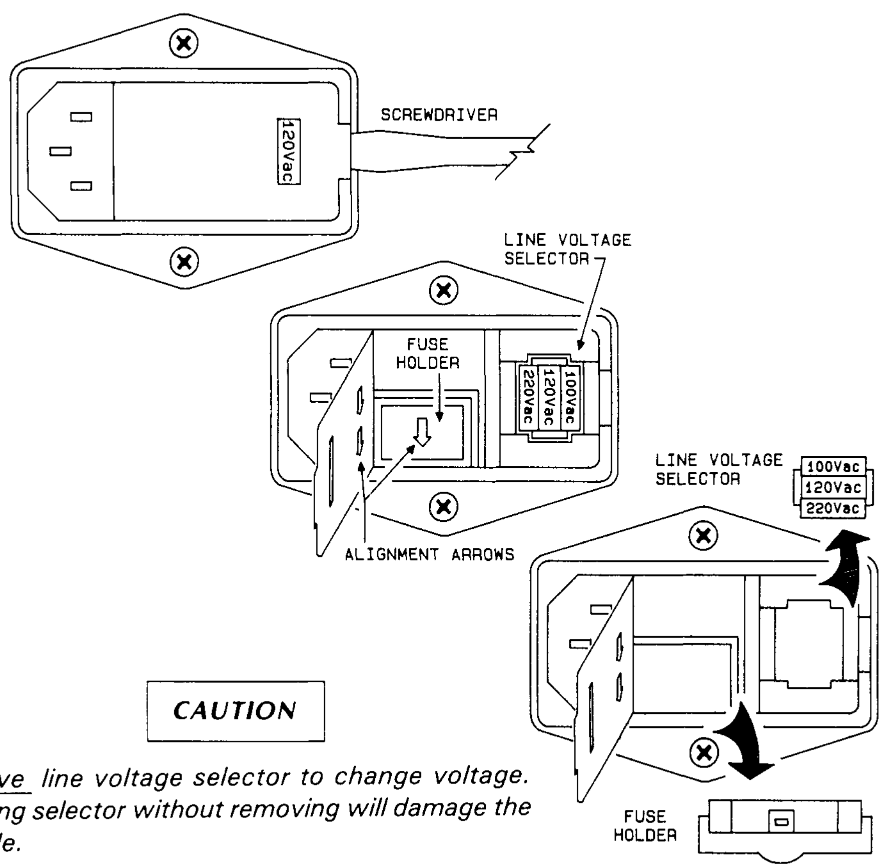
- Remove the power cord.
- Pry open the power selector cover with a small, flat bladed screwdriver.
- Remove the cylindrical line voltage selector.
- Reinstall the cylindrical line voltage selector and ensure the required voltage label is facing out of the power selector.
- Close the power selector by pushing firmly on the black cover.
- Check that the correct line voltage appears through the window in the power selector cover.

To check or replace the fuse:

- Remove the power cord.
- Pry open the power selector cover with a small, flat bladed screwdriver.
- Pull the white fuse holder out of the power selector and remove the fuse from the fuse holder.
- To reinstall the fuse, insert a fuse with the proper rating into the fuse holder. Align the white arrow on the top of the fuse holder with the two white arrows on the power selector cover. All three white arrows should point in the same direction. Push the fuse holder into the power selector.

- Close the power selector by pushing firmly on the black cover.
- As a safety precaution, check that the correct line voltage appears through the window in the power selector cover.

Fuse Selection		
Line Voltage	**Fuse**	**HP Part Number**
100V/120V	3.0 A 250 V Normal BLOW	2110-0003
220V/240V	2 A 250 V Normal BLOW	2110-0002



CAUTION

Remove line voltage selector to change voltage. Rotating selector without removing will damage the module.

Figure 1-6. Power Selector

1-7 OPERATION

Front panel controls, indicators and connectors are shown and described in Figure 1-7. Rear panel controls and connectors are shown and described in Figure 1-8. Error codes displayed on the front panel as a result of internal calibrations and tests are explained in fault isolation to the board level part of Section VI.

For complete operating instructions, refer to the *HP 3326A Two-Channel Synthesizer Operating Manual.*

1 STATUS

Display panel displays frequency (up to 11 digits), amplitude, phase offset, dc offset, sweep frequencies and time, marker frequency, and HP-IB address values, as well as error messages.

CHAN key selects channel for display and modification.

CH A and **CH B** indicators indicate channel selected for display and modification.

HV-A and **HV-B** indicators illuminate when the high voltage option is enabled.

ϕ OFFSET indicator illuminates when a phase offset exists for channel B relative to channel A.

EXT REF indicator illuminates when the HP 3326A is operating with an external frequency reference or high stability frequency option (Option 001).

2 DATA

Frequency, amplitude, offset, time, phase, duty cycle, modulation level, memory location, and HP-IB address values are entered with the numeric keypad followed by a units suffix.

BACK SP key removes the least significant digit from the display during data entry.

3 HP-IB STATUS

REMOTE, **LISTEN**, **TALK**, and **SRQ** status indicators provide an indication of HP-IB operation.

LOCAL key switches HP 3326A control from remote operation to front panel operation unless local lockout is in effect.

BUS ADRS key enables display or modification of the HP-IB address stored in nonvolatile memory.

4 SWEEP

CONT and **SINGLE** keys select either continuous or single frequency sweeps. During discrete frequency sweeps, the SINGLE key steps through the sweep elements.

START FREQ and **STOP FREQ** keys allow entry or modification of the frequency sweep start and stop frequencies.

MKR→CF key centers the sweep span around the marker frequency.

CNTR FREQ and **SPAN** keys allow entry or modification of the frequency sweep start and stop frequencies in terms of sweep center frequency and sweep span.

MKR FREQ key allows entry or modification of a marker frequency.

TIME key allows entry or modification of the frequency sweep sweep time. For discrete frequency sweeps, time is the dwell time for each discrete frequency sweep element.

RESET SWEEP key resets the frequency sweep circuits.

TRIANGLE key selects triangle (indicator illuminated) or ramp (indicator extinguished) linear frequency sweeps. The ramp sweep function sweeps from start to stop frequency, while the triangle sweep function sweeps from start to stop to start frequencies.

DISCRETE key enables discrete frequency sweeps (frequency hopping). Discrete frequency sweeps sequence through the discrete frequency sweep elements stored with the SAVE DISCRETE key.

5 ENTRY

FREQ key allows entry or modification of frequency values.

AMPTD key allows entry or modification of amplitude values.

DUTY CYCLE key allows entry or modification of the square wave duty cycle.

% AM/PM DEV key allows entry or modification of percent of AM modulation or PM deviation.

PHASE key allows entry or modification of phase values.

DC OFFSET key allows entry or modification of dc offset values.

ASGN ZERO ϕ key assigns a zero value to phase offset without changing the phase of the output.

CLR ϕ OFS key restores the channel B phase offset value without changing the phase of the output.

6 INSTR STATE

INSTR PRESET key sets the following setup:

Mode	2 CHANNEL
Combined operation	Off
Frequency A and B	1000 Hz
Amplitude A and B	100 mVpp
Phase	0°
Duty cycle	50 %
DC offset A and B	0 V
Modulation	Off
Modulation level	30%
Sweep	Off Ramp 13 MHz span 1 s. sweep 6.5 MHz marker
Function A and B	Sine wave
High voltage	Off
Calibration	Internal
Autocalibration	Off

SAVE and **RECALL** keys save and recall setups from nonvolatile memory registers 0 – 9. Register 0 contains the last setup prior to removing power.

CLR DISCRETE key erases all discrete frequency sweep elements stored in memory.

7 POWER/SHIFT

POWER KEY applies power to the entire HP 3326A when ON (depressed). In STBY, power is applied only to the high stability frequency reference option (Option 001) when the HP 3326A is connected to a suitable power source.

CLEAR MEM key clears the contents of internal memory if the key is held down when power is applied.

SHIFT key enables the front panel keys to select the alternate functions printed in blue.

8 MODIFY

Rotary knob modifies frequency, amplitude, phase, offset, duty cycle, modulation level and time values when enabled by arrow keys or ON key.

← and → keys enable the rotary knob and select display (flashing) digit modified.

ON/OFF key enables and disables the modify function and flashing digit.

9 MODULATION

Modulation keys select internal and external AM and PM sources. Internal modulation uses channel B to modulate channel A. External modulation inputs are on the rear panel.

INT AM, **INT PM**, **EXT AM**, **EXT PM**, and **(AB) SYNC PM** indicators illuminate to indicate the type of modulation selected with the modulation keys.

10 CALIBRATION

MANUAL key initiates an HP 3326A calibration.

AUTO key enables automatic calibration.

INTERNAL, **EXTERNAL**, and **MULTIPHASE** indicators illuminate to indicate the phase calibration source selected with the SELECT key.

SELECT key selects the HP 3326A phase calibration source. Multiphase and external phase calibration inputs are on the rear panel.

SELF TEST key initiates a self test.

11 MODE

MODE key selects the 2 CHANNEL, 2 PHASE, 2 TONE, or PULSE operating modes. The 2 CHANNEL mode provides two independent sources, the 2 PHASE mode provides two tracking sources with a phase offset, the 2 TONE mode provides two tracking sources with a frequency offset, and the PULSE mode provides a pulse signal and its complement.

2 CHANNEL, **2 PHASE**, **2 TONE**, or **PULSE** indicators illuminate to indicate the the mode selected.

COMBINED key combines channel A and B to produce a composite output at channel A.

12 FUNCTION

CH A and **CH B** keys select the function outputs for each channel.

~, ⊓⊔, and **DC** indicators indicate function selected with CH A and CH B keys.

HV keys enable the high voltage option for low impedance outputs with levels up to 40 Vpp.

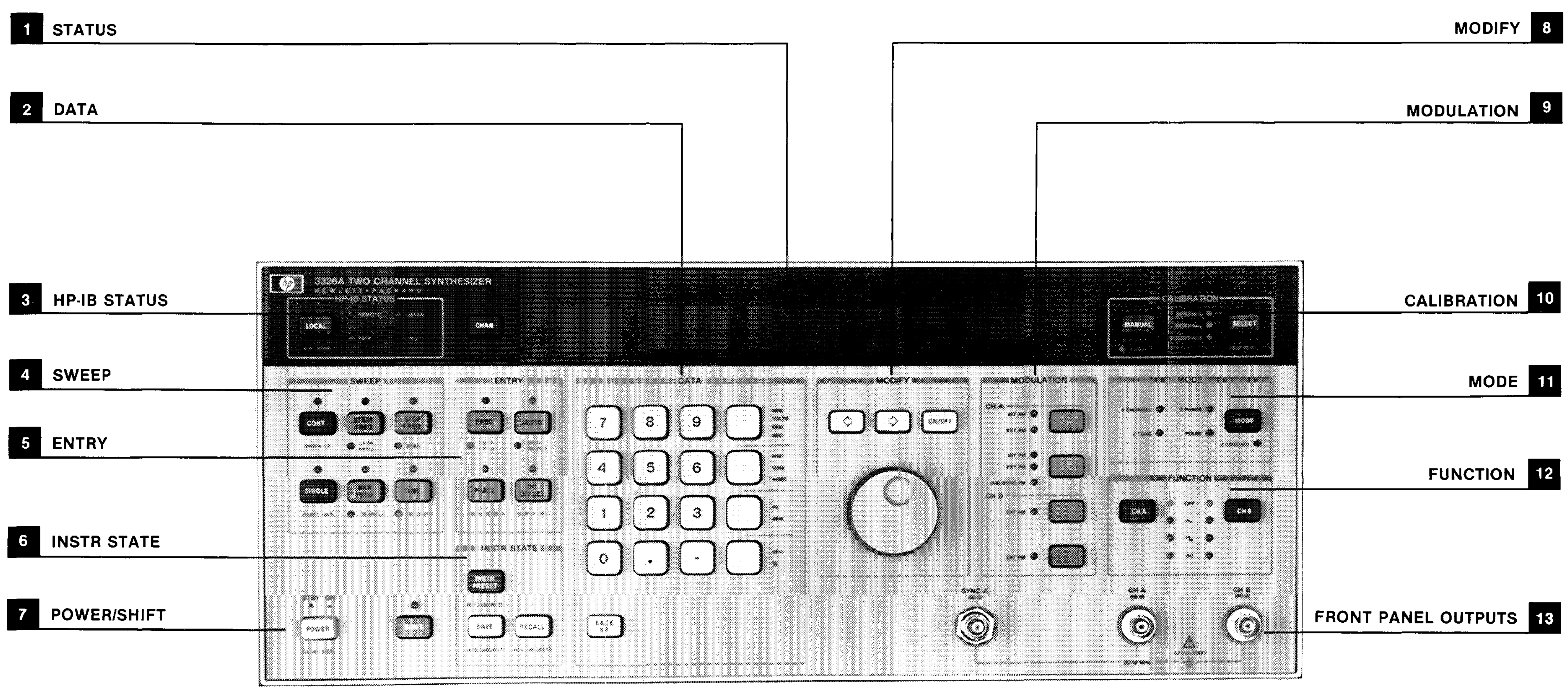
13 FRONT PANEL OUTPUTS

SYNC A output provides a TTL square wave with same frequency as channel A. SYNC A output impedance is 50 Ω.

CH A and **CH B** outputs provide standard impedance of 50 Ω. High voltage output impedance is less than 2 Ω to 50 kHz and less than 10 Ω to 1 MHz.

⚠ **WARNING**

The maximum peak voltage (ac + dc) that can be safely applied between the chassis and the outer conductor of the HP 3326A input and output connectors is ± 42 Vpk.



1 MODULATION INPUTS

A-AMPTD MOD IN and **B-AMPTD MOD IN** connectors provide the input to externally modulate the amplitude of the channel A and B outputs (100 kHz maximum modulation frequency). 1 Vdc (-1 Vdc for channel B) corresponds to 100% modulation.

A-PHASE MOD IN/SYNC PM IN and **B-PHASE MOD IN** connectors provide the input to externally phase modulate the channel A and B outputs (5 kHz maximum modulation frequency). ±1 Vdc corresponds to ±360° modulation.

2 CALIBRATION INPUTS

A-EXT PHASE CAL IN and **B-EXT PHASE CAL IN/ MULTI φ REF IN** connectors allow the HP 3326A to sense phase externally for an external or multiphase calibration. These inputs require a 1 kHz to 13.1 MHz signal with an amplitude of 3 to 10 Vpp.

3 CHANNEL OUTPUTS

CH A OUT OPT 003 and **CH B OUT OPT 003** are optional rear panel outputs for channel A and B.

4 FREQUENCY REF INPUT/OUTPUT

1, 2, 5, 10 MHz REF IN connector allows the HP 3326A to phase-lock to a stable frequency reference. This input is referenced to chassis ground.

10 MHz OUT connector provides 10 MHz square wave (>3 dBm 50 Ω) as a frequency reference for other instruments. This output is referenced to chassis ground.

10 MHz OVEN OUTPUT Option 001 provides a high stability frequency reference when connected to 1, 2, 5, 10 MHz REF IN. The 10 MHz OVEN OUTPUT is a square wave (>3 dBm 50 Ω). This output is referenced to chassis ground.

5 20-33 MHz B-L.O. OUTPUT

20-33 MHz B-L.O. OUTPUT provides an output offset from the channel B frequency by 20 MHz. This output is referenced to chassis ground.

6 MARKER OUT

MARKER OUT TTL level signal provides a negative going transition at the frequency entered with the MKR FREQ key.

7 EXT TRIG INPUT

EXT TRIG IN allows external triggering of sweeps on negative edge transition of a TTL signal.

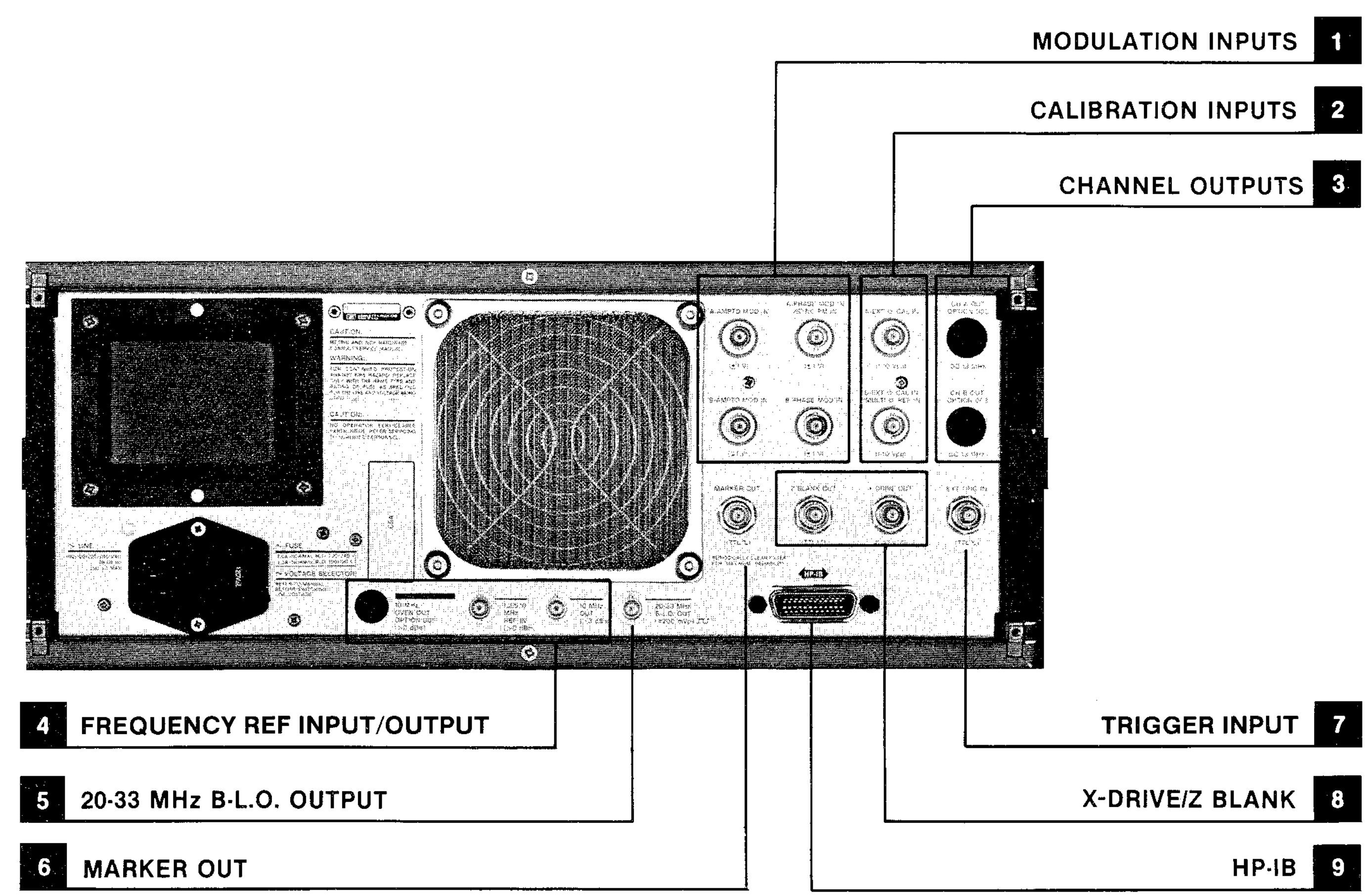
8 X-DRIVE/Z-BLANK OUTPUTS

X-DRIVE provides linear 0 to 10 V ramp proportional to sweep time.

Z-BLANK TTL output drops low at start of sweep during frequency sweeps, capable of sinking current (100 mA maximum) from a positive source.

9 HP-IB

HP-IB connector allows remote operation of the HP 3326A with an external controller. This connector is referenced to chassis ground.



1-8 OPTIONS

Listed below are the three options which electrically alter the HP 3326A. Option 001 and Option 002 also alter the HP 3326A's electrical specifications. Option 003 has no effect on the specifications. Instructions on how to install these options are included in an installation note provided in the field installable options kits.

Option 001, High Stability Frequency Reference

Option 001 provides improved frequency stability and integrated phase noise characteristics. Details on the repair of the option are given in the board level repair part of the "Service" section, under "Oven Reference, A80." The HP part number of the field installable kit is 03326-88801.

Option 002, High Voltage Output

Option 002 increases the output level by a factor of four and expands the allowable dc offset range. Details on the repair of this option are given in board level repair part of the "Service" section, under "HV Amplifier, A1 and A11." The HP part number of the field installable kit is 03326-88802.

Option 003, Rear Panel Outputs

Channel A (CH A) and channel B (CH B) output connectors are provided on the rear panel. The channel A synchronous output connector (SYNC A) remains positioned on the front panel. Instrument specifications do not change. The HP part number of the field installable kit is 03326-88803.

Table 1-2 lists the available standard exterior hardware options.

Table 1-2. Hardware Options

Option	Description	HP Part Number
Option 907	Front Handle Kit	5061-0090
Option 908	Rack Flange Kit	5061-0078
Option 909	Rack Flange/Front Handle Kit	5061-0084
Option 910	Extra Operating Manual	03326-90000
Option 914	Delete Service Manual	

1-9 INSTALLATION OF FIELD INSTALLABLE OPTIONS

WARNING

Only trained service technicians should install these options since it necessitates removal of the instrument covers. To avoid electrical shock, make sure the power cable is disconnected before removing the instrument cover.

Save Switch

The HP 3326A will be in the PRESET condition when power is applied to the instrument if the save switch on the controller board (the third switch on A61S1) is in the OPEN position. If the save switch is in the NOT OPEN position, the instrument will be in the same state when power is applied as it was when power was turned off (i.e. the last instrument state will be "saved").

Options 001, 002, and 003

Instructions for installing the high stability frequency reference, high voltage outputs, and rear panel outputs options are located in an installation note. This note is included in the field installable option kits. For quick reference, put the installation note at the end of "General Information."

1-10 SPECIFICATIONS

The HP 3326A specifications are listed in Table 1-5. The specifications describe the instrument's warranted performance. Unless otherwise stated, the specifications apply to the channel A and channel B outputs in all modes, with combined operation off. A warm-up period of 30 minutes is required, unless otherwise noted.

Supplemental characteristics are intended to provide additional information by giving typical, non-warranted, performance specifications. These supplemental characteristics are denoted as "typical," "nominal," or "approximate."

1-11 ACCESSORIES SUPPLIED

The HP 3326A is supplied with the accessories listed in Table 1-3.

NOTE

The service manual is not included with the HP 3326A if Option 914 is requested. Option 914 deletes the service manual from the product.

Table 1-3. Accessories Supplied

Accessory	Quantity	HP Part Number
Operating Manual	1	03326-90000
Service Manual	1	03326-90010
Line Power Cord	1	See Figure 1-5

1-12 ACCESSORIES AVAILABLE

The Hewlett-Packard accessories listed in Table 1-4 are available for use with the HP 3326A:

Table 1-4. Accessories Available

Accessory	Model/HP Part Number	Description
Ground Isolator	15507A	Breaks signal grounds between input and output connectors.
50 Ohm Feed Through Termination	11048C	Terminates outputs in 50Ω.
Transit Case	9211-2656	Provides rugged protection, transportation, and storage.
Service Accessory Kit	03326-84401	Required for servicing. Kit includes two printed circuit board extenders and adapter cables.

1-13 WARRANTY

The HP 3326A Two-Channel Synthesizer is warranted and certified as indicated in the "Preface" of this manual. For further information, contact the nearest Hewlett-Packard sales and service office; addresses are provided at the back of this manual.

1-14 SERVICE AND USER AIDS

Hewlett-Packard provides several documents helpful to the user and to the repair technician.

Product Notes

These notes provide product-specific application information, as well as discussions of the HP 3326A Two-Channel Synthesizer's specifications and characteristics. Contact the nearest Hewlett-Packard sales and service office for ordering information.

Programming Notes

Detailed information on using the HP 3326A over the Hewlett-Packard Instrument Bus (HP-IB) is contained in these documents. An HP-IB introductory operating guide and a quick reference guide are contained in the operating manual. The introductory operating guide may be purchased separately.

Service Notes

Hewlett-Packard makes design improvements to its current line of instruments on a continuing basis. Many of these improvements can be incorporated in instruments produced earlier. Modification and general service information is passed on in the form of Service Notes. To obtain the Service Notes, contact the nearest Hewlett-Packard sales and service office.

Service Accessory Kit

A kit containing the unique accessories needed to service the HP 3326A is available for purchase from your local Hewlett-Packard sales and service office. Order HP part number 03326-84401.

1-15 GROUNDING

There are two distinct grounds in the HP 3326A: CGND and GND. CGND, or chassis ground, is connected to the protective earth ground of the power plug. The following parts of the instrument are connected to chassis ground:

- HP-IB connector, pins 12 (shield), 18-24
- Instrument chassis, frame, covers, all exposed metal surfaces
- Four rear panel output connectors (the shields of these connectors are connected to CGND at the rear panel)

    20-33MHz B-L.O. OUT
    10MHz OUT
    1,2,5,10MHz REF IN
    10MHz OVEN OUT, OPTION 001

The rest of the instrument uses GND, an isolated ground. GND is connected to CGND through varistors and capacitors on several boards in the instrument. See the power supply (A70) schematic for the details.

The maximum safe float voltage for the connectors on the HP 3326A is 42 Vpk.

WARNING

DO NOT interrupt the protective earth ground or float the HP 3326A above the specified 42 Vpk maximum. This action could expose the operator to potentially hazardous voltages!

Make sure that only fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuse holders must be avoided.

1-16 RECOMMENDED TEST EQUIPMENT

Table 1-6 lists the test equipment and accessories needed to test, adjust, and repair the HP 3326A Two-Channel Synthesizer, including Option 001 and Option 002.

NOTE

The performance tests, adjustments, fault isolation procedures, and repair procedures are written for the recommended test equipment. Substituting alternate test equipment may require that some procedures be modified.

1-17 OPERATOR MAINTENANCE

Operator maintenance is limited to replacing the line fuse and cleaning the fan filter. There are no operator controls inside the HP 3326A.

Only trained service personnel should perform any instrument repair. Refer to the safety symbol chart in the "Preface" for all applicable instrument and manual safety symbols.

WARNING

Under no circumstances should an operator remove any covers, screws, shields, or in any other way enter the HP 3326A. There are no operator controls inside the HP 3326A Two-Channel Synthesizer.

Fuse

The main ac line fuse is located on the rear panel power module. See Figure 1-6 for fuse location and the fuse part numbers corresponding to various line voltages. Replacement instructions are given in sub-section 1-6, "Line Voltage and Fuse Selection."

WARNING

Make sure that only fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuse holders must be avoided.

Fan

The cooling fan's air filter is located on the rear panel. To service the filter, remove the power cable and remove the four knurled nuts that hold the filter to the rear panel. Clean the filter using a solution of warm water and a mild soap or replace the filter. The air filter should be cleaned every 30 days.

Cleaning Solvents

Unplug the instrument power cord before cleaning any portion of the instrument. Use only non-abrasive, non-corrosive cleansers. A solution of warm water and mild soap is recommended.

1-18 SAFETY CONSIDERATIONS

The HP 3326A is a Safety Class I instrument (provided with a protective earth contact). Before applying power to the instrument or removing any of the covers, review the warnings and cautions found on the instrument and in this manual.

Refer to the safety symbol chart in the "Preface" for all applicable instrument and manual safety symbols.

WARNING

The operator should not remove the instrument covers for any reason. Any adjustment, maintenance, or repair of the opened instrument must be carried out only by a skilled technician who is aware of the hazard involved. The opening of covers or removal of parts may expose parts with harmful voltages.

Unless otherwise stated, the following specifications apply to the Channel A and Channel B outputs in all modes, with the internal combiner and all modulation off, and outputs terminated in 50 ohms. For tabular data, specifications apply at and above the stated frequency or amplitude range.

SPECIFICATIONS describe the instrument's warranted performance after a warm-up period of 30 minutes (except where noted). SUPPLEMENTAL CHARACTERISTICS are intended to provide information useful in applying the instrument by giving typical, but non-warranted, performance parameters. Supplemental characteristics are denoted as *typical*, *nominal*, or *approximate.*

MODES

TWO-CHANNEL: Channels A and B are independent.

TWO-PHASE: Channels A and B are the same frequency, with a calibrated phase difference between them.

TWO-TONE: Channel B frequency must be within 100 kHz of the Channel A frequency.

PULSE: Channel B is the complement of the Channel A output.

WAVEFORMS

Sine, Square, Pulse and DC.

FREQUENCY

RANGE: DC to 13 MHz.

RESOLUTION: 1 μHz below 100 kHz. 1 mHz at or above 100 kHz.

ACCURACY: $\pm 5 \times 10^{-6}$ of selected value, 20°C to 30°C, at time of frequency reference calibration with standard instrument.

STABILITY: $\pm 5 \times 10^{-6}$/year, 20°C to 30°C, with standard instrument.

MAIN SIGNAL OUTPUTS (Channels A and B, all waveforms unless noted)

IMPEDANCE: 50Ω ± 1Ω, DC to 100 kHz.

RETURN LOSS: >20 dB, 100 kHz to 13 MHz.

CHANNEL ISOLATION: >80 dB below the larger signal, or < −90 dBm, whichever is greater, 10 Hz to 13 MHz, sine wave only, Two-Channel and Two-Tone modes. For square wave and DC, *typically* >80 dB to 5 MHz, *typically* >65 dB to 13 MHz.

CONNECTOR: Front panel BNC (rear panel if Option 003).

FLOATING: Both outputs share the same ground and may be floated up to ±42 V peak (AC + DC).

AC AMPLITUDE (All Waveforms)

RANGE (WITHOUT DC OFFSET):

Units Displayed	Function: Sine min	Sine max	Square min	Square max
peak-to-peak	1.000 mV	10.00 V	1.000mV *	10.00V *
rms	0.354 mV	3.54 V	0.500 mV	5.00 V
dBm(50Ω)	−56.02	+23.98	−53.01	+26.99
dBV	−69.03	+10.97	−66.02	+13.98

* also applies to pulse mode

RESOLUTION: 4 digits, or approximately 0.1% of value for peak-to-peak entry, 0.3% of value for rms entry, and 0.01 dB for dBm or dBV entry.

ACCURACY: Relative to selected value after performing self-calibration.

Sine Wave:

Amplitude	0.001 Hz – 100 kHz	100 kHz – 1 MHz	1 MHz – 13 MHz
+23.98 dBm – +3.98 dBm	±0.1 dB	±0.3 dB	±0.6 dB
+3.98 dBm – −36.02 dBm	±0.2 dB	±0.5 dB	±0.8 dB
−36.02 dBm – −56.02 dBm			±1.0 dB

Square Wave and Pulse (50% duty cycle):

Amplitude	0.001 Hz – 100 kHz	100 kHz – 1 MHz	1 MHz – 13 MHz
10.00 Vpp – 1.00 Vpp	±1.0% *	±3.0%	±6.0%
1.00 Vpp – 100 mVpp	±2.0% *	±5.0%	±8.0%

* Also for 5% to 95% duty cycle in pulse mode

WAVEFORM CHARACTERISTICS

SINE WAVE SPECTRAL PURITY:

Harmonic Distortion: Harmonically related signals will be less than the following levels relative to the fundamental, or < −90 dBm, whichever is greater

Amplitude	10 Hz – 50 kHz	50 kHz – 100 kHz	100 kHz – 1 MHz	1 MHz – 13 MHz
+23.98 dBm – +13.98 dBm	−80 dBc	−70 dBc	−55 dBc	−30 dBc
+13.98 dBm – −56.02 dBm	−80 dBc	−80 dBc	−65 dBc	−50 dBc

Spurious: In Two-Channel mode, all non-harmonically related output signals (10 Hz* to 40 MHz) will be less than the following levels relative to the fundamental, or < −90 dBm, whichever is greater.

Channel Frequency	Spurious Level
10 Hz to 1 MHz	−80 dBc
1 MHz to 13 MHz	−70 dBc

*Ground isolation must be maintained.

Integrated Phase Noise: For a 30 kHz band centered on a 10 MHz carrier (excluding ±1 Hz about the carrier).

With option 001: < −63 dBc.

With standard instrument: *typically* < −60 dBc.

SQUARE WAVE AND PULSE CHARACTERISTICS:

Rise/fall time: ≤15 ns 10% to 90% at full output at 1 MHz.

Overshoot: ≤5% of peak-to-peak amplitude at full output at 1 MHz.

Square Wave symmetry: ≤ ±1% of period + 6ns.

Pulse Width range: 1% to 99% of period or 20 ns, whichever is greater.

Pulse Width resolution: 0.1% of period.

Pulse Width accuracy: ≤ ±1% of period ±20 ns.

DC ONLY

RANGE: 0 to ±5.0 V.

RESOLUTION: 3 digits or 10 mV.

ACCURACY (AFTER PERFORMING SELF-CALIBRATION): ±75 mV.

SPECIFICATIONS

DC OFFSET

RANGE: *Maximum DC Offset is a function of the selected AC amplitude.*

AC Amplitude	Max AC + DC	Max DC Offset
1.0 to 10.0 Vpp	±5.0 V	±4.5 V
0.1 to 1.0 Vpp	±0.5 V	±0.45 V
10 mV to 100 mVpp	±50 mV	±45 mV
1 mV to 10 mVpp	±5 mV	±4.5 mV

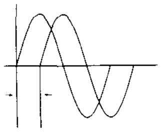
RESOLUTION: 4 digits.

DC ACCURACY (AFTER PERFORMING SELF-CALIBRATION):

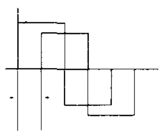
	Function	
	Sine Wave	Square Wave*/Pulse*
10 Hz to 50 kHz	±2.0% of max DC	±2.0% of max DC
50 kHz to 1 MHz	±2.0% of max DC	±6.0% of max DC
1 MHz to 13 MHz	±5.0% of max DC	±6.0% of max DC

* midpoint between peaks at 50% duty cycle

PHASE OFFSET



The following specifications apply to the Phase Offset between Channels A and B in the Two-Phase mode only. Phase is defined as the difference in rising edge to rising edge (using the midpoint as the reference point) for sine and square waves.



RANGE: ±720°.

RESOLUTION: 0.01°.

ABSOLUTE ACCURACY: *in degrees* with the following output waveforms on Channels A and B, equal amplitude levels, and either internal phase calibration or external phase calibration (using a power splitter and equal length cables).

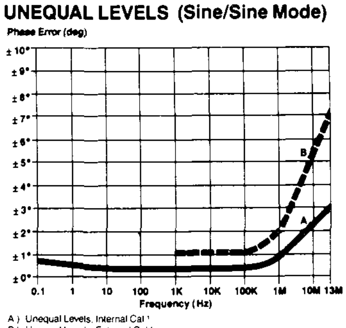
Sine/Sine Outputs:

Cal Mode	0.1 Hz	10 Hz	1 kHz	100 kHz	1 MHz	13 MHz
Internal[1]	±0.5°	±0.2°	±0.2°	±0.3°	±2.0°	
Internal[2]	±0.8°	±0.4°	±0.4°	±0.5°	±3.0°	
External[1]	N/A		±0.2°	±0.3°	±2.0°	

1 = Both amplitude levels between 1 V to 10 Vpp (+3.98 to +23.98 dBm).
2 = Both amplitude levels between 0.1 V to 10 Vpp (−16.02 to +23.98 dBm).

Typical performance

UNEQUAL LEVELS (Sine/Sine Mode)



A) Unequal Levels, Internal Cal[1]
B) Unequal Levels, External Cal[1]

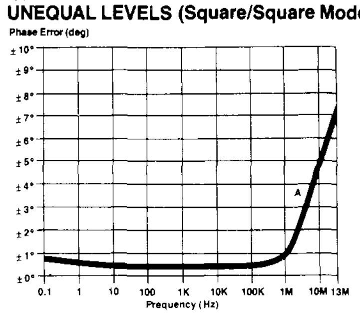
Square/Square Outputs:

Cal Mode	0.1 Hz	10 Hz	1 kHz	100 kHz	1 MHz	13 MHz
Internal[1]	±0.5°	±0.2°	±0.2°	±0.7°	±5.0°	
Internal[2]	±0.8°	±0.4°	±0.4°	±1.0°	±7.0°	
External[1]	N/A		±0.2°	±0.7°	±5.0°	

1 = Both amplitude levels between 1 V to 10 Vpp (+6.99 to +26.99 dBm).
2 = Both amplitude levels between 0.1 V to 10 Vpp (−13.01 to +26.99 dBm).

Typical Performance

UNEQUAL LEVELS (Square/Square Mode)



A) Unequal Levels, Internal Cal[1]

STABILITY WITH TEMPERATURE: *typically* ±0.3°phase/°C, 20°C to 30°C.

STABILITY WITH TIME: *typically* ±0.1°/10 min after a 30 min warm-up, ±0.02°/10 min after a 1 hr warm-up.

AMPLITUDE MODULATION

The following specifications apply to the Channel A and Channel B outputs with external modulation or to the Channel A output with internal modulation (Channel B is the modulation source). External amplitude modulation is allowed in any mode while internal amplitude modulation is allowed only in the Two-Channel mode.

WAVEFORMS: Sine, square, or pulse (pulse allowed in external only).

CARRIER FREQUENCY RANGE: DC to 13 MHz.

MODULATION FREQUENCY RANGE: DC to 100 kHz.

MODULATION DEPTH: 0 to 100%.

The following specifications apply at 10 MHz carrier frequency, 1 kHz modulation rate.

Envelope Distortion: < −46 dB at 80% AM depth

Incidental PM: < 5° peak at 50% AM depth

Modulation Depth Accuracy (internal only): ±5% of setting at 80% AM depth

Modulation Depth Resolution (internal only): 0.1%

EXTERNAL MODULATION:

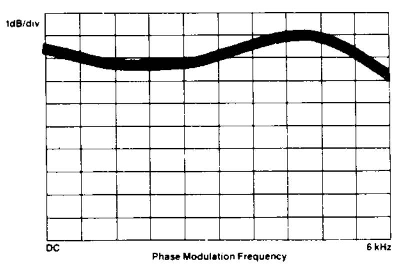
Channel A sensitivity: *approximately* −1.0 V for 0%, +1.0 V for 100%.

Channel B sensitivity: *approximately* +1.0 V for 0%, −1.0 V for 100%.

Input impedance: 10 kΩ nominal.

SPECIFICATIONS

Typical PM Deviation Frequency Response



PHASE MODULATION

The following specifications apply to the Channel A and Channel B outputs with external and synchronous phase modulation, and to the Channel A output with internal phase modulation (Channel B is the modulation source). External and synchronous PM are allowed in any mode while internal PM is allowed only in the Two-Channel mode.

WAVEFORMS: Sine, square, or pulse (pulse allowed in external only).

CARRIER FREQUENCY RANGE: DC to 13 MHz.

MODULATION FREQUENCY RESPONSE: DC to 200 Hz: ±0.5dB
DC to 5 kHz: See typical plot

PHASE DEVIATION: ±360°

DISTORTION (10 MHz CARRIER FREQUENCY, 1 kHz MODULATION RATE):
≤ −50 dB for less than ±45° peak deviation,
≤ −37 dB at ±90° peak deviation

Incidental AM: <0.5% at 360° peak deviation

INTERNAL MODULATION:
Phase deviation resolution: 1°.
Phase deviation accuracy: ±5% of setting, 200 Hz rate, ≥45° phase deviation.

EXTERNAL AND SYNCHRONOUS MODULATION:
Sensitivity: *approximately* 360°/V.
Input impedance: >4 kΩ nominal.

FREQUENCY SWEEP

SWEEP TYPES:
Linear sweep: User selectable Start/Stop Frequencies and Sweep Time.
Discrete sweep: 1 to 63 user selectable sequential elements. Each element consists of Channel A and B frequencies and the dwell time before switching to the next element.

LINEAR SWEEP:
Sweep forms: Triangle, ramp.
Sweep time: 5 ms to 1000 s, limited to 5 mHz/s to 500 MHz/s sweep rates.
Sweep Width: 25 µHz to 13 MHz.

DISCRETE SWEEP DWELL TIME: 5 ms to 1000 s between switching elements, limited to 5 mHz/s to 500 MHz/s sweep rates.

PHASE CONTINUITY: Sweep is phase continuous over the full frequency range.

OUTPUT COMBINER

The following specifications apply when Channel A and B are combined on the Channel A output with the Channel B output automatically turned off and terminated in 50Ω. The combiner may be used in the Two-Channel, Two-Phase and Two-Tone modes only. DC offset is automatically set to 0 V when the combiner is on.

FREQUENCY RANGE: DC to 13 MHz.

RETURN LOSS: >20 dB.

AMPLITUDE: The maximum settable levels of Channels A and B are each reduced by 6.02 dB.

AMPLITUDE ACCURACY: Add the following to the amplitude accuracy of Channel A or B, given on page 10.

DC to 100 kHz	±0.1 dB
100 kHz to 13 MHz	±0.3 dB

INTERMODULATION DISTORTION: In the Two-Tone mode, third-order intermodulation difference products will be less than the following levels relative to the higher of the fundamentals, or < −90 dBm, whichever is greater. Both channels must be in the indicated frequency band with a minimum frequency separation of 10 Hz.

	10 Hz – 1 MHz	1 MHz – 13 MHz
+17.96 dBm – +7.96 dBm	−70 dB	−45 dB
+7.96 dBm – −62.04 dBm	−80 dB	−65 dB

AUXILIARY OUTPUTS

SYNC A: Square Wave with the same frequency as Channel A.
Level: V_{High} ≥1.2 V, V_{Low} ≤ 0.1 V into 50Ω.
Output impedance: 50Ω nominal.
Connector: Front panel BNC.

X-AXIS DRIVE: Linear ramp proportional to sweep time in linear sweep mode and discrete sweep (if dwell time is < 1000 s).
Level: 0 to +10 V DC.
Linearity: ±0.2% between 10% and 90% of ramp.
Accuracy: ±4% of full scale value, >10 KΩ load.
Connector: Rear panel BNC.

Z-AXIS BLANK: TTL compatible level that is low during sweep.
Connector: Rear panel BNC.

SWEEP MARKER: TTL compatible level that makes a high-to-low transition at the selected marker frequency during linear sweep or is low during discrete frequencies, pulsing high for a minimum of 10 µs between frequency changes.
Connector: Rear panel BNC.

10 MHz REFERENCE: > +3 dBm output for frequency-locking additional instruments to the 3326A.
Impedance: 50Ω nominal.
Connector: Rear panel BNC.

10 MHz OVEN OUTPUT (OPTION 001 ONLY): > +3 dBm internal high stability frequency reference output for phase-locking other instruments.
Connector: Rear panel BNC.

20 – 33 MHz LO OUTPUT: ≥200 mVpk square wave output that is offset 20 MHz from the channel B output frequency in the two-channel mode.
Impedance: 50Ω nominal, AC coupled.
Connector: Rear panel BNC.

SPECIFICATIONS

AUXILIARY INPUTS

EXTERNAL REFERENCE INPUT: For phase-locking the 3326A to an external frequency reference. Signal from 0 dBm to +20 dBm into 50Ω. Reference must be 1, 2, 5 or 10 MHz ± 10 ppm. Channel A phase stability with respect to external reference input is ±1°/°C.

Connector: Rear panel BNC. With option 001 this input must be connected to the 10 MHz Oven Output.

EXTERNAL TRIGGER: TTL compatible level that initiates linear or discrete sweep on high to low transition.

Connector: Rear panel BNC.

CHANNEL A EXTERNAL PHASE CALIBRATION: For external or multiphase calibration.

Frequency range: 1 kHz to 13 MHz.

Amplitude range: 1 to 10 V peak-to-peak.

Impedance: 50Ω nominal.

Waveform: Sine wave or square wave with 50% duty cycle.

Connector: Rear panel BNC.

CHANNEL B EXTERNAL PHASE CALIBRATION: For external or multiphase calibration. Specifications identical to Channel A external phase calibration input.

Connector: Rear panel BNC.

CHANNEL A EXTERNAL AMPLITUDE MODULATION: *See modulation specifications.*

Connector: Rear panel BNC.

CHANNEL B EXTERNAL AMPLITUDE MODULATION: *See modulation specifications.*

Connector: Rear panel BNC.

CHANNEL A EXTERNAL PHASE MODULATION/SYNCHRONOUS PHASE MODULATION: *See modulation specifications.*

Connector: Rear panel BNC.

CHANNEL B EXTERNAL PHASE MODULATION: *See modulation specifications.*

Connector: Rear panel BNC.

SAVE/RECALL MEMORY

Ten non-volatile memory locations.

Front panel setups can be stored in memory locations 1 through 9. Last front panel setup is saved in memory location 0 when power is removed. Use of discrete sweep overwrites memory locations 1 through 9 with the 63 discrete elements, where an element consists of Channel A and B frequencies and the dwell time between elements.

HP-IB CONTROL

CAPABILITY: Compatible with IEEE Standard 488 – 1978. All front panel functions, except line switch and HP-IB address, are programmable. Special HP-IB only functions include Service Requests, diagnostics, device trigger for external trigger, and front panel display secure mode. The 3326A is compatible with most HP 3325A HP-IB mnemonics.

INTERFACE FUNCTIONS: SH1,AH1,T6, L4,SR1,RL1,PP0,DC1,DT1,C0,E1.

TYPICAL SWITCHING TIMES (EXCLUSIVE OF PROGRAMMING TIME):

Frequency (to within ±10ppm):
≤10 ms for a 100 kHz step,
≤25 ms for a 1 MHz step,
≤70 ms for a 10 MHz step.

Phase (to within ±1°): ≤15 ms.

Amplitude (to within amplitude specifications): ≤ 30 ms.

OPTIONS

OPTION 001 HIGH STABILITY FREQUENCY REFERENCE

Improves frequency stability and integrated phase noise characteristics.

STABILITY: $\pm 5 \times 10^{-8}$/week, after 72 hours continuous operation, $\pm 1 \times 10^{-7}$/mo. after 15 days continuous operation.

WARM-UP TIME: Reference will be within $\pm 1 \times 10^{-7}$ of final value 15 minutes after turn-on at 25°C for an off time of 24 hours.

PHASE NOISE: see Sine Wave Spectral Purity section.

OPTION 002 HIGH VOLTAGE OUTPUT

Increases output level by a factor of 4 and expands the allowable DC offset range. The following specifications apply to the Channel A and Channel B outputs in all modes with the internal combiner off.

FREQUENCY RANGE: DC to 1 MHz.

OUTPUT IMPEDANCE:
DC to 50 kHz: <2Ω.
50 kHz to 1 MHz: <10Ω.

MAXIMUM OUTPUT CURRENT: ±20 mA peak.

AMPLITUDE:

Range: 4 mV to 40 Vpp without DC offset. Levels are 4 times the standard instrument ranges. Amplitude is entered in peak-to-peak units only.

Accuracy: ≤ ±12% of peak-to-peak value for sine, square, and pulse for 400 mV to 40 Vpp values.

SINE WAVE HARMONIC DISTORTION: Harmonically related signals will be less than the following levels relative to the fundamental, into 1 kΩ, 200 pF, no DC offset.

	10 Hz – 50 kHz	50 kHz – 100 kHz	100 kHz – 1 MHz
40.00 Vpp – 12.64 Vpp	−75 dB	−65 dB	−40 dB
12.64 Vpp – 400 mVpp	−80 dB	−75 dB	−55 dB

SPECIFICATIONS

SQUARE WAVE AND PULSE CHARACTERISTICS:
Rise/fall time: ≤150 ns, 10% to 90% at full output with 1 k Ω, 200 pF load.
Overshoot: ≤10% of peak-to-peak amplitude at full output with 1 kΩ, 200 pF load.

DC ONLY AND DC OFFSET CHARACTERISTICS:
DC Only Range: 0 to ±20 V.
DC Offset Range: ±20 V independent of the AC amplitude range. DC + AC peak must be less than 20 V.
DC Offset Accuracy: ±(140 mV +1% of setting) for sine waves DC to 1 MHz, square waves DC to 50 kHz.

OUTPUT COMBINER: The following specifications apply when Channel A and B are combined on the Channel A output (Channel B output is off). The combiner may be used in the Two-Channel, Two-Phase and Two-Tone modes. DC offset is automatically set to 0 V when the combiner is on.

INTERMODULATION DISTORTION: Third-order intermodulation difference products will be less than the following levels relative to the higher of the fundamentals (sine wave only). Both channels must be in the indicated frequency band with a minimum frequency separation of 10 Hz.

	10 Hz – 100 kHz	100 kHz – 1 MHz
20.00 Vpp – 6.32 Vpp	−60 dB	−40 dB
6.32 Vpp – 200 mVpp	−75 dB	−55 dB

OPTION 003 REAR PANEL MAIN SIGNAL OUTPUTS

Replaces front panel Channel A and B outputs with rear panel outputs.

GENERAL

OPERATING ENVIRONMENT:
Temperature: 0°C to 55°C.
Relative Humidity: 95%, 0°C to 40°C.
Altitude: ≤4,572 m (15,000 ft).

STORAGE ENVIRONMENT:
Temperature: −40°C to +75°C.
Altitude: ≤15,240 m (50,000 ft).

POWER: 100/120/220/240V, +5%, −10%; 48 to 66 Hz; 120 VA, 290 VA with all options, 100 VA standby.
WEIGHT: 27 kg (60 lbs.) net, 37 kg (81 lbs.) shipping.
DIMENSIONS: 177 mm H × 425.5 mm W × 497.8 mm D (7″ × 16−3/4″ × 19−5/8″).

ACCESSORIES INCLUDED:

1 ea. Operating Manual (HP Part Number 03326−90000). 1 ea. Service Manual (HP Part Number 03326−90010).

ACCESSORIES AVAILABLE:

15507A Ground Isolator for breaking signal grounds between input and output connectors, thereby isolating a connector from the chassis ground.

11048C 50 Ohm Feed Thru Termination for terminating outputs in 50Ω.

11652−60009 50 Ohm BNC Power Splitter. 11667A 50 Ohm Type N Power Splitter for use in external and multiphase calibration.

03326−84401 Service Accessory Kit for trouble-shooting and repair of the 3326A. Includes extender boards and cables.

9211−2656 Transit Case for rugged protection, transportation, and storage.

RELATED EQUIPMENT

1980B Oscilloscope Measurement System (DC to 100 MHz)
3561A Dynamic Signal Analyzer (125 μHz to 100 kHz)
3585A Spectrum Analyzer (20 Hz to 40 MHz)
3586C Selective Level Meter (50 Hz to 32.5 MHz)

ORDERING INFORMATION:

3326A Two-Channel Synthesizer

Option 001 High Stability Frequency Reference
(to retrofit order HP Part Number 03326-88801)

Option 002
High Voltage Output
(to retrofit order HP Part Number 03326-88802)

Option 003 Rear Panel Main Signal Outputs
(to retrofit order HP Part Number 03326-88803)

Option 907
Front Handle Kit
(to retrofit order HP Part Number 5061-0090)

Option 908 Rack Flange Kit
(to retrofit order HP Part Number 5061-0078)

Option 909 Rack Flange and Front Handle Kit
(to retrofit order HP Part Number 5061-0084)

Option 910
Extra Operating Manual

Option 914
Delete Service Manual

15507A Ground Isolator

11048C 50 Ohm Feed Thru Termination

9211-2656 Transit Case

03326-84401 Service Accessory Kit

Table 1-6. Recommended Test Equipment

Instrument Type	Critical Specifications	Recommended Model	Use†
AC Voltmeter	Ranges: 0.1 to 1 V Frequency range: 20 Hz to 1 MHz Input impedance: ≥ 1 MΩ Meter: Log scale Accuracy (100 Hz to 10 kHz): ±1%	HP 400FL	P
Digital Voltmeter	DC function Ranges: 0.1, 1, 10, 100 V Accuracy: ±0.05% Resolution: 6 digits AC function True RMS Ranges: 1, 10, 100 V Accuracy: ±0.2% Resolution: 6 digits Crest factor: 4:1	HP 3455A HP 3456A	P,A,T
High Speed DC Digital Voltmeter	DC voltage: 0 to ±10 V Sample/hold measurement External trigger: Low true TTL edge triggered Trigger delay: Selectable 10 µs to 140 µs	HP 3437A	P
Oscilloscope	Vertical Bandwidth: dc to 100 MHz Deflection: 0.01 V to 10 V/div Horizontal: Sweep: 0.05 µs to 1 s/div x10 magnification Delayed sweep	HP 1740A	P,A,T
Oscilloscope	Vertical Bandwidth: dc to 200 MHz	HP 1715A	A
Sampling Oscilloscope	Dual channel Vertical deflection: 2 mV/div Horizontal sweep: 10 ps to 50 µ/div	Tektronix 7603 with 7T11/7S11 and S-1	P
Spectrum Analyzer	Frequency range: 20 Hz to 40 MHz Amplitude accuracy: ±0.4 dB Spurious responses: 80 dB below reference	HP 3585A	P,A,T
Electronic Counter	Frequency measurement Frequency range: to 13 MHz Resolution: 8 digits Accuracy: ± 2 counts Time interval average A to B Resolution: 0.1 ns	HP 5334A	P
Frequency Synthesizer	Frequency: 1 kHz to 20 MHz Amplitude: to +13.0 dBm Output impedance: 50 Ω Spurious: > 75 dB below fundamental	HP 3325A HP 3326A HP 3335A	P,A,T
Modulation Analyzer	Detector: Peak PM rate: 20 Hz to 100 kHz AM depth resolution: 0.1%	HP 8901A	P

† P = Performance tests A = Adjustments T = Troubleshooting
‡ These components are included in the Service Accessory Kit, HP part number 03326-84401.

Table 1-6. Recommended Test Equipment (Cont'd)

Instrument Type	Critical Specifications	Recommended Model	Use†
Signature Analyzer	Maximum clock: > 8 MHz Clock setup time: < 20 ns	HP 5006A HP 5005A	T
Logic Probe	Logic one threshold: 2.0 V +0.4 V, −0.2 V Logic zero threshold: 0.8 V +0.2 V, −0.4 V	HP 545A	T
Double Balanced Mixer	Impedance: 50 Ω Frequency: 1 MHz to 20 MHz	HP 10534A	P
Directional Bridge	Frequency range: 100 kHz to 13 MHz Input impedance: 50 Ω	HP 8721A	P
Thermal Converter	Input impedance: 50 Ω Voltage input: 0.5 Vrms Frequency range: 5 Hz to 13 MHz	HP 11051A	P
50 Ω Step Attenuator	Impedance: 50 Ω Attenuation range: 0 to 40 dB	HP 355D	P
50 Ω Feed Thru Termination	Accuracy: ±0.2% Power rating: 1 W	HP 11048C	P
1 MHz Low Pass Filter	Cut-off frequency: 1 MHz Stopband attenuation: 50 dB by 4 MHz Stopband frequency: 4 MHz to 80 MHz TTE Inc. 2214 S. Barry Ave. Los Angeles, Ca 90064	 J903	P
1 kΩ Load Voltage Divider ‡	Input resistance: 1 kΩ Output voltage: 0.053 input voltage Resistor 52.68 Ω 0.1% 0.5 W Resistor 2 kΩ 0.1% 0.5 W (2 each) Resistor 18 kΩ 0.1% 0.125 W	 HP part no. 0698-6060 HP part no. 0698-8226 HP part no. 0698-8167	P
15 kHz Equivalent Noise Filter ‡	Corner frequency: 10 kHz Capacitor 1600 pF 5% Resistor 10 kΩ 1%	 HP part no. 0160-2223 HP part no. 0757-0340	P
1 kΩ/50 Ω Matching Pad and Load ‡	Load: 1 kΩ, 200 pF Output impedance: 50 Ω Capacitor 200 pF ±1% Resistor 1.91 kΩ 1% 0.5 W (2 each) Resistor 52.68 Ω 0.1% 0.5 W	 HP part no. 0140-0220 HP part no. 0698-3341 HP part no. 0698-6060	P,A

† P = Performance tests A = Adjustments T = Troubleshooting
‡ These components are included in the Service Accessory Kit, HP part number 03326-84401.

Table 1.6. Recommended Test Equipment (Cont'd)

Instrument Type	Critical Specifications	Recommended Model	Use†
1.5 Hz Low Pass Filter ‡	Cut-off frequency: ≤ 1.5 Hz		A
	Resistor 1 MΩ	HP part no. 0698-8827	
	Capacitor 0.1 μF	HP part no. 0160-4571	
BNC-to-Triax Adapter		HP part no. 1250-0595	P
Power Splitter	50 Ω input BNC connectors	HP part no. 11652-60009	P
Service Accessory Kit		HP part no. 03326-84401	P,A,T
	Kit contains:		
	PC board extender (2 each)	HP part no. 03326-66591	
	Phono plug to BNC adapter cable	HP part no. 03326-61618	
	SMB to BNC adapter cable	HP part no. 03585-61616	
	SMB to SMB cable (4 each)	HP part no. 03585-61601	
	Phono cable, 12 inch, precision (4 each)	HP part no. 8120-4492	
	Phono jack to jack adapter (4 each)	HP part no. 1250-1961	
	SMB to SMB adapter (2 each)	HP part no. 1250-0669	
	1.5 Hz low pass filter components	See description above	
	1 kΩ/50 Ω matching pad and load components	See description above	
	1 kΩ load voltage divider components	See description above	
	15 kHz equivalent noise filter components	See description above	

† P = Performance tests
A = Adjustments
T = Troubleshooting

‡ These components are included in the service accessory kit, HP part number 03326-84401.

SECTION II
PERFORMANCE TESTS

SECTION II
PERFORMANCE TESTS

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SECTION II

HP 3326A PERFORMANCE TESTS

2-1 INTRODUCTION

This section contains test procedures to verify that the HP 3326A meets the specifications listed in Table 1-5. The test procedures may be used for verifying HP 3326A operation during periodic maintenance, troubleshooting, or after repairs and adjustments.

2-2 SPECIFICATIONS

Specifications for the HP 3326A are listed in Table 1-5. These specifications are the performance standards or limits against which the HP 3326A is tested. Any changes in specifications due to manufacturing, design, or traceability to the U. S. National Bureau of Standards are included in Table 1-5 of this manual and/or the Manual Changes Supplement. Specifications listed in this manual supersede all previous specifications for the HP 3326A.

2-3 EQUIPMENT REQUIRED

Each performance test lists the recommended equipment to complete that test. A complete list of the equipment used to perform all the tests is provided in Table 1-6. Any equipment that meets or exceeds the critical specifications listed in Table 1-6 may be substituted for the recommended model.

2-4 TEST RECORD

Test results can be entered on the Performance Test Record located at the end of this section. The test record lists all of the tested specifications and their acceptable limits. The test record may be copied without written permission from the Hewlett-Packard Company.

2-5 CALIBRATION CYCLE

The HP 3326A requires periodic verification of performance. Depending on the use and environment the HP 3326A is subject to, the performance tests should be performed at least every 12 months.

2-6 OPERATIONAL VERIFICATION TESTS

The Operational Verification Tests for the HP 3326A listed in Table 2-1 are a subset of the HP 3326A Performance Tests. The Operation Verification Tests use a minimum amount of equipment and give the user a high level of confidence that the HP 3326A meets specifications as listed in Table 1-5. However, the Operational Verification Tests do not guarantee that all specifications are met.

Table 2-1. Operation Verification Tests

Test Name	Paragraph	Comments
Frequency Accuracy	2-11	
Spurious Signals	2-13	Check for harmonic distortion as well as spurious signals.
Combiner IM Distortion	2-14	Perform if IM distortion products are critical to measurement.
Sine Wave Amplitude Accuracy	2-17	
Square Wave/Pulse Amplitude Accuracy	2-18	
High Voltage Amplitude Accuracy	2-19	
Combiner Amplitude Accuracy	2-20	
Square Wave Symmetry and Pulse Width Accuracy	2-23	
DC Only Accuracy	2-24	
DC Offset Accuracy	2-25	
Phase Offset Accuracy	2-26	
Amplitude Modulation	2-27	Perform if amplitude modulation is required.
Phase Modulation	2-28	Perform if phase modulation is required.
SYNC A Output	2-29	Perform if SYNC A output is required.
X-Drive Linearity	2-30	Perform if X-Drive is required.

2-7 MINIMIZING SPECTRUM ANALYZER INTRODUCED DISTORTION

When making distortion measurements with a spectrum analyzer, make sure that the analyzer's internal distortion does not mask the distortion of the device under test. One technique to ensure this is to increase the analyzer's input attenuation which results in lower signal levels at the analyzer's input. This yields better intermodulation and harmonic distortion performance. Adjust the analyzer's reference level controls to obtain the proper display.

2-8 PRESET STATE

Table 2-2 lists the PRESET state of the HP 3326A. The PRESET state is used as the initial setup for the HP 3326A for each performance test and is modified for the test by subsequent steps in the procedure.

Table 2-2. HP 3326A Preset State

KEY GROUP	KEY	PRESET STATE/VALUE
MODE	MODE COMBINED	2 CHANNEL Off
FUNCTION	CH A CH B CH A HV CH B HV	Sine wave Sine wave Off Off
STATUS	CHAN	Channel A
ENTRY	FREQ DUTY CYCLE AMPTD % AM/PM DEV PHASE ASSIGN ZERO ϕ DC OFFSET CLR ϕ OFS	1 kHz 50 % 0.1 V Peak-to-peak 30 % (AM)/108° (PM) 0° — 0 V —
SWEEP	CONT START FREQ CNTR FREQ STOP FREQ SPAN SINGLE RESET SWP MKR FREQ TRIANGLE TIME DISCRETE	Disabled 0 Hz 6.5 MHz 13 MHz 13 MHz Disabled — 6.5 MHz (Channel A) Ramp selected 1 second Disabled (Linear sweep)
CALIBRATION	MANUAL AUTO SELECT SELF TEST	— Disabled INTERNAL —
MODULATION	—	Off
MODIFY	ON/OFF	Off
UNGROUPED KEYS	SHIFT	Off
TRIGGER SIGNAL	—	Single sweep pending
HP-IB STATUS	LOCAL BUS ADRS	No effect No effect

2-9 HIGH VOLTAGE TESTS

The high voltage tests apply only to instruments equipped with Option 002, High Voltage Output. Option 002 increases the output level by a factor 4 and expands the allowable DC offset range. The specifications for Option 002 apply whenever the high voltage output is enabled. If Option 002 is installed, the HP 3326A briefly displays "3326A OP. 1 2", or "3326A OP. 2", for the option list after power is applied.

2-10 REPAIRS FOR FAILED PERFORMANCE TESTS

When any of the test measurements are out of the listed tolerances, see Table 2-3 for a list of pertinent adjustments. This table also lists the boards that, if defective, could cause a test failure. The most likely board to cause a failure is listed first, the next most likely is listed second, and so on. The table assumes there are no service self test or calibration errors; only a performance specification is out of range.

The adjustments listed do NOT include the +15 V, VCO FREQ, or A and B OFFSET adjustments. The +15 V adjustment (#1) effects the power supply. The VCO FREQ adjustment (#4) effects the frequency range available in the HP 3326A. The A and B OFFSET adjustment (#9) is correct if the instrument can calibrate itself properly.

If Table 2-3 leads you to suspect a board that has a duplicate in the other channel, the best way to verify that the board is defective is to interchange the two identical boards. If the suspect board fails again while it is in the other channel, it is probably defective. This is the best method to solve subtle, non-catastrophic, failures.

Table 2-3. Repairs for Failed Performance Tests

Para. No.	Performance Test	Related Adjustments		Boards Affecting Specification			
		No.	Name	Reference Designator			Range
				Ch A	Ch B	Common	
2-11	Frequency Accuracy	3 2	FREQ CENTER OVEN FREQ			A50 A80	All All
2-12	Harmonic Distortion	16 11 6	BIAS 2nd HARMONIC APIs	A3 A5 A4 A31-A35	A13 A15 A14 A41-A45		All All All < 50 kHz
2-12	HV Harmonic Distortion	16 11 6	BIAS 2nd HARMONIC APIs	A1 A3 A5 A4 A31-A35	A11 A13 A15 A14 A41-A45		All All All All < 50 kHz
2-13	Spurious Signals	6 5 10	APIs 100 kHz 2:1 SPUR	A31-A35	A41-A45		APIs, 100 kHz, 10 MHz, 20 MHz, etc.
						A50	100 kHz, 10 MHz, 20 MHz, etc.
				A5	A15		2:1 spur, > 13 MHz (filter)
				A6	A16		> 1.5 MHz (filter)
				A4	A14		> 13 MHz (filter)
						A62	Sync spurs (cable)
2-14	Combiner IM Distortion	—	—	A3	A13		All
2-14	Combiner HV IM Distortion	—	—	A1 A3	A11 A13		All All

Table 2-3. Repairs for Failed Performance Tests (Cont.)

Para. No.	Performance Test	Related Adjustments		Boards Affecting Specification			
		No.	Name	Reference Designator			Range
				Ch A	Ch B	Common	
2-15	Return Loss	—	—	A3	A13		> 3.98 dBm
				A2	A12		< 3.98 dBm
2-15	Combiner Return Loss	—	—	A2			All (combiner)
				A3			All (50 Ω termination)
2-16	Channel Isolation †	—	—	A1-A6	A11-A16		All (supply bypassing)
						A21-A24	All (supply bypassing)
						A70	All (supply noise)
2-17	Sine Wave Amplitude Accuracy	7	V REF			A36	< 100 kHz (cal accuracy)
		8	PEAK DETECT GAIN				
		13	FLATNESS	A2	A12		All (return loss, flatness, attenuator accuracy)
				A5	A15		> 100 kHz (flatness)
				A4	A14		> 100 kHz (flatness)
				A3	A13		All (flatness, return loss)
2-17	Sine Wave Amplitude Flatness	13	FLATNESS	A5	A15		> 100 kHz
				A3	A13		> 100 kHz
				A2	A12		> 100 kHz
				A4	A14		> 100 kHz
2-17	Attenuator Accuracy	—	—	A2	A12		All
				A3	A13		All (return loss)
2-18	Square Wave/ Pulse Amplitude Accuracy	7	V REF			A23	All
		8	PEAK DETECT GAIN			A36	< 100 kHz, 1 to 10 Vpp
				A2	A12		All (attenuator accuracy)
				A3	A13		All (return loss), < 3.17 Vpp (pre-10 dB pad)
2-18	Square Wave Flatness	14	OVERSHOOT			A23	All
				A3	A13		All
				A2	A12		All (flatness)
				A3	A13		< 3.17 Vpp (pre-10 dB pad)
2-19	HV Amplitude Accuracy	7	V REF	A1	A11		All
		8	PEAK DETECT GAIN			A36	< 100 kHz (cal accuracy)
		13	FLATNESS	A2	A12		All (return loss, flatness, attenuator accuracy)
				A5	A15		> 100 kHz (flatness)
				A4	A14		> 100 kHz (flatness)
				A3	A13		All (flatness, return loss)

† Suspect bad grounding in the cables and loose screws.

Table 2-3. Repairs for Failed Performance Tests (Cont.)

Para. No.	Performance Test	Related Adjustments		Boards Affecting Specification			
		No.	Name	Reference Designator: Ch A	Ch B	Common	Range
2-19	HV Amplitude Flatness	15	HV OVERSHOOT	A1	A11		All
		13	FLATNESS	A5	A15		> 100 kHz
				A3	A13		> 100 kHz
				A2	A12		> 100 kHz
				A4	A14		> 100 kHz
2-20	Combiner Amplitude Accuracy	7	V REF	A2			All (combiner)
		8	PEAK DETECT GAIN			A36	< 100 kHz (cal accuracy)
		13	FLATNESS				
				A2	A12		All (return loss, flatness, attenuator accuracy)
				A5	A15		> 100 kHz (flatness)
				A4	A14		> 100 kHz (flatness)
				A3	A13		All (flatness, return loss)
2-21	Integrated Phase Noise	—	—	A31-A35	A41-A45		All
						A50	All
						A80	< 100 Hz
2-22	Square Wave Rise/Fall Time	14	OVERSHOOT			A23	All
				A3	A13		All
2-22	Square Wave/ Pulse Overshoot	14	OVERSHOOT	A3	A13		All
						A23	All
2-23	Square Wave Symmetry	12	DC OFFSET	A5	A15		All (dc offset vs. frequency)
						A23	All
				A4	A14		All (dc offset)
2-23	Pulse Width Accuracy	6	APIs			A36	All (phase cal path)
		12	DC OFFSET				
				A31-A35	A41-A45		All (phase performance)
				A5	A15		All (dc offset vs. frequency)
						A23	All
				A4	A14		All (dc offset)
2-24	DC Only Accuracy	7	V REF			A36	All
		8	PEAK DETECT GAIN	A2	A12		All (return loss)
				A3	A13		All (return loss)
2-25	DC Offset Accuracy	7	V REF			A36	> 1 Vpp, ac
		8	PEAK DETECT GAIN	A2	A12		< 1 Vpp, ac (attenuator accuracy)
				A3	A13		All (return loss)
2-26	Phase Offset Accuracy †	6	APIs			A36	All (phase cal accuracy)
				A31-A35	A41-A45		All (phase accuracy)

† Suspect bad grounding in the cables and loose screws.

Table 2-3. Repairs for Failed Performance Tests (Cont.)

Para. No.	Performance Test	Related Adjustments		Boards Affecting Specification			
		No.	Name	Reference Designator			Range
				Ch A	Ch B	Common	
2-27	AM Envelope Distortion	—	—	 A6	 A16	A22	All All
2-27	Incidental PM	—	—	A6	A16		All
2-27	Modulation Index Accuracy	—	—	 A6	 A16	A22	All All
2-28	PM Distortion	—	—	A31-A35	A41-A45		All
2-28	Incidental AM	—	—	A31-A35 A6 A5	A41-A45 A16 A15		All All All
2-28	PM Phase Deviation Accuracy	—	—	A31-A35	A41-A45	 A50 A36	All All All
2-29	Sync A Output	—	—			A62	All (sync)
2-30	X-Drive Linearity	—	—			A61	All

† Suspect bad grounding in the cables and loose screws.

PERFORMANCE TESTS

2-11 FREQUENCY ACCURACY

EQUIPMENT REQUIRED:

Universal Counter HP 5334A
(calibrated within three months or with an accurate 10 MHz external reference input)

SPECIFICATIONS:

Accuracy:

$\pm 5 \times 10^{-6}$ of selected value, 20° C to 30° C, at time of frequency reference calibration with standard instrument.

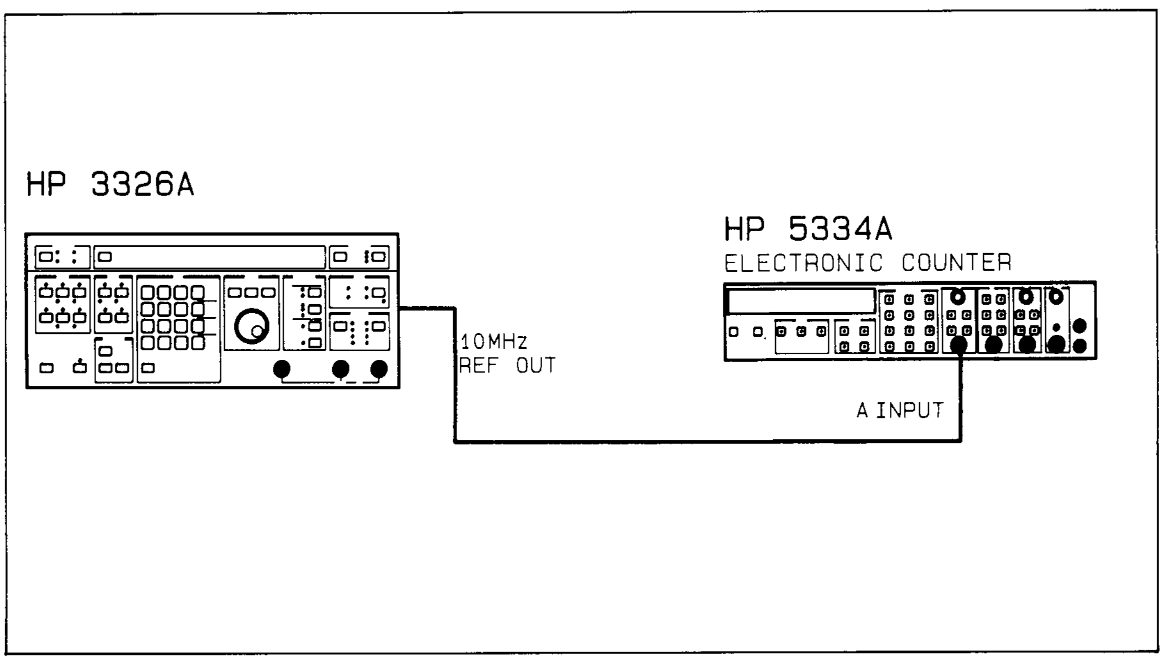

Figure 2-1. Frequency Accuracy Test

FREQUENCY ACCURACY TEST:

1. Preset the HP 3326A and reset the universal counter.

2. Allow the HP 3326A and universal counter to warm up for 30 minutes.

3. Connect the equipment as follows (illustrated in Figure 2-1):

   - HP 3326A 10 MHz REF OUTput to universal counter channel A 50 Ω input

4. Set the universal counter to count the frequency of the HP 3326A input with 1 Hz resolution, and adjust for stable triggering. For the HP 5334A counter:

FUNCTION	FREQ A
CHANNEL A SLOPE	Positive (LED Off)
AC COUPLING	OFF
50 Ω Z	ON
COMMON INPUT (COM A)	OFF
AUTO TRIGGER	ON

5. Record the universal counter frequency on the test record. Universal counter should indicate 10,000,000 Hz ±50 Hz.

2-12 HARMONIC DISTORTION

EQUIPMENT REQUIRED:

Spectrum Analyzer HP 3585A

COMPONENTS:

* C1 Capacitor 200 pF ±1% 1 ea HP Part No. 0140-0220

* R1 955 Ω Resistor (parallel combination of two 1.91 kΩ resistors)
Resistor 1.91 kΩ 1% ½ W 2 ea HP Part No. 0698-3341

* R2 Resistor 52.68 Ω .1% ½ W 1 ea HP Part No. 0698-6060

* Used to test high voltage output (Option 002)

SPECIFICATIONS:

Harmonic Distortion with Standard Output
Harmonic Distortion: Harmonically related signals will be less than the following levels relative to the fundamental, or < −90 dBm, whichever is greater.

	10 Hz – 50 kHz	50 kHz – 100 kHz	100 kHz – 1 MHz	1 MHz – 13 MHz
+ 23.98 dBm – + 13.98 dBm	− 80 dBc	− 70 dBc	− 55 dBc	− 30 dBc
+ 13.98 dBm – − 56.02 dBm	− 80 dBc	− 80 dBc	− 65 dBc	− 50 dBc

Harmonic Distortion with High Voltage Output
Sine Wave Harmonic Distortion: Harmonically related signals will be less than the following levels relative to the fundamental, into 1 kΩ, no dc offset.

	10 Hz – 50 kHz	50 kHz – 100 kHz	100 kHz – 1 MHz
40.00 Vpp – 12.64 Vpp	− 75 dB	− 65 dB	− 40 dB
12.64 Vpp – 400 mVpp	− 80 dB	− 75 dB	− 55 dB

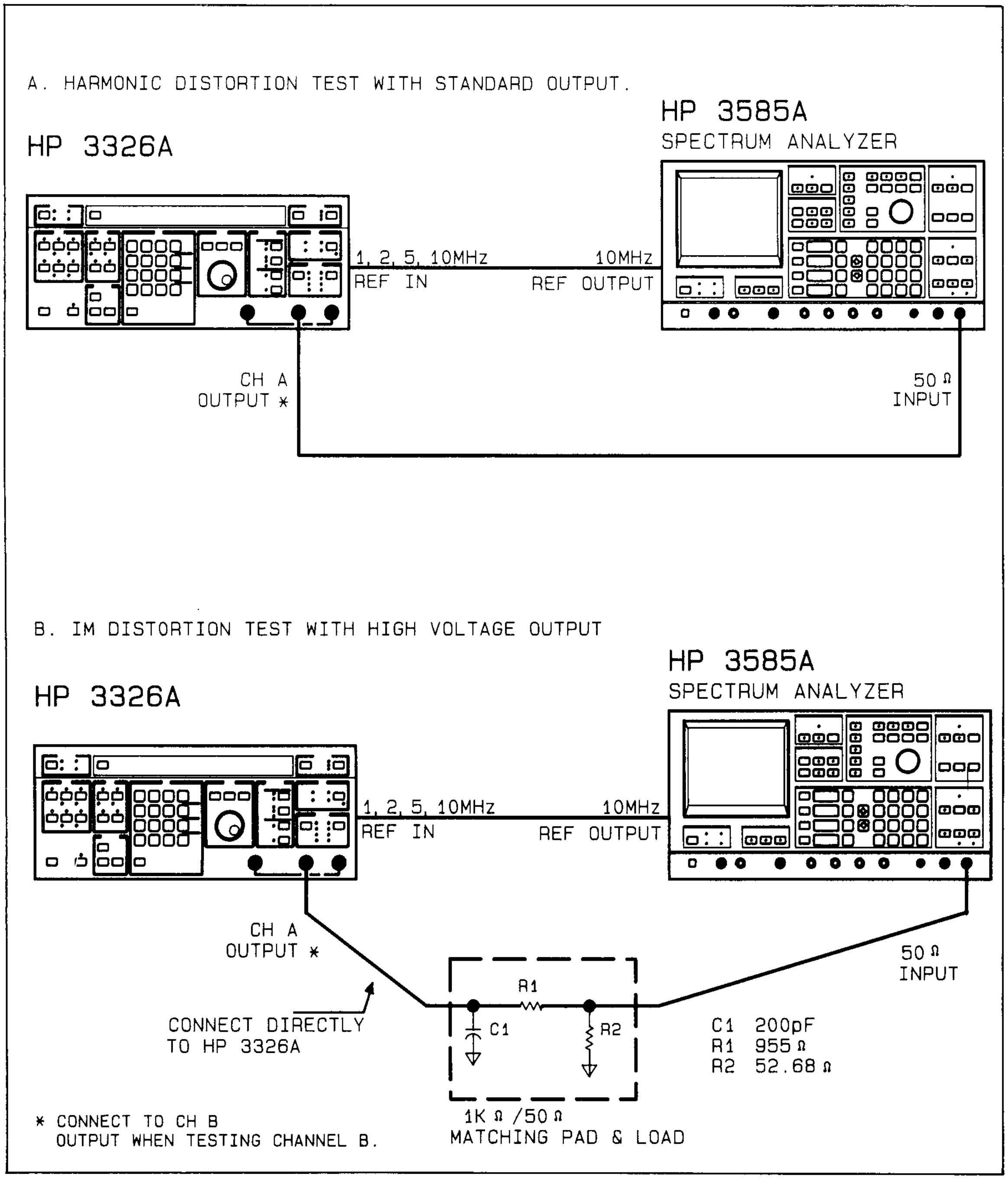

Figure 2-2. Harmonic Distortion Test

HARMONIC DISTORTION TEST WITH STANDARD OUTPUT:

NOTE

When making harmonic distortion measurements with a spectrum analyzer, increase the analyzer's input attenuation to decrease the signal levels at the analyzer's input. This yields better intermodulation and harmonic distortion performance. Adjust the analyzer's reference level controls to obtain the proper display.

1. Preset the HP 3326A and the spectrum analyzer.

2. Connect the test equipment as follows (illustrated in Figure 2-2(A)):

   - HP 3326A CH A output to spectrum analyzer 50 Ω input
   - HP 3326A 1,2,5,10 MHz REF INput to spectrum analyzer 10 MHz reference output (phase lock HP 3326A to spectrum analyzer)

3. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	160 Hz
AMPLITUDE	13.98 dBm

4. Tune the spectrum analyzer to display at least three harmonics. For the HP 3585A spectrum analyzer:

NOTE

The speed of the measurement may be increased by manually tuning the spectrum analyzer to the fundamental and harmonic frequencies. The spectrum analyzer must be phase locked to the HP 3326A for accurate results with manual tuning. Manual tuning is used in the HP 3585A procedures.

   - Press RANGE and the up arrow to set the input range to 20 dBm.
   - Set the resolution bandwidth (RBW) to 3 Hz and video bandwidth (VBW) to 1 Hz.
   - Set the CENTER FREQUENCY to the fundamental frequency (160 Hz).
   - Set the FREQUENCY SPAN to 0 Hz.
   - Enable the OFFSET and press the ENTER OFFSET key.
   - Set the CF STEP SIZE to the fundamental frequency.

5. Measure the value of the largest harmonic, relative to the fundamental, and record this value in the Performance Test Record. The value should be at least 80 dB below the fundamental frequency value. For the HP 3585A:

   - Press the CENTER FREQUENCY key and press the up arrow to measure the first and second harmonics of the fundamental frequency.

6. Repeat steps 4 and 5 for the following frequencies and specifications:

FREQUENCY	SPECIFICATION
910 Hz	< -80 dBc
47 kHz	< -80 dBc
91 kHz	< -80 dBc
300 kHz	< -65 dBc
910 kHz	< -65 dBc
13 MHz	< -50 dBc

7. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	160 Hz
AMPLITUDE	23.98 dBm

8. Tune the spectrum analyzer to display at least three harmonics. For the HP 3585A, set the input attenuation for 30 dBm. (Refer to Step 4 and 5 for manual tuning procedures for the HP 3585A).

9. Measure the value of the largest harmonic, relative to the fundamental, and record this value in the Performance Test Record. The value should be at least 80 dB below the fundamental frequency value.

10. Repeat steps 8 and 9 for the following frequencies and specifications:

FREQUENCY	SPECIFICATION
910 Hz	< −80 dBc
47 kHz	< −80 dBc
91 kHz	< −70 dBc
300 kHz	< −55 dBc
910 kHz	< −55 dBc
13 MHz	< −30 dBc

11. Preset the HP 3326A and connect the HP 3326A channel B output to the spectrum analyzer 50 Ω input.

12. Repeat steps 3 through 10 substituting channel B for channel A.

HARMONIC DISTORTION TEST WITH HIGH VOLTAGE OUTPUT:

1. Preset the HP 3326A and the spectrum analyzer.

2. Connect the test equipment as follows (illustrated in Figure 2-2(B)):

- HP 3326A CH A output to 1 kΩ/50 Ω matching pad and load input
- 1 kΩ/50 Ω matching pad and load output to spectrum analyzer 50 Ω input
- HP 3326A 1,2,5,10 MHz REF INput to spectrum analyzer 10 MHz reference output (phase lock HP 3326A to spectrum analyzer)

NOTE

The 1 kΩ/50 Ω matching pad and load is constructed in a small metal box with two BNC connectors. The components for the 1 kΩ/50 Ω matching pad and load are listed under Equipment Required.

3. Set the HP 3326A as follows:

CHANNEL	CH A
HIGH VOLTAGE	On
AMPLITUDE	12.63 Vpp
FREQUENCY	160 Hz

4. Tune the spectrum analyzer to display at least four harmonics. For the HP 3585A spectrum analyzer:

NOTE

The speed of the measurement may be increased by manually tuning the spectrum analyzer to the fundamental and harmonic frequencies. The spectrum analyzer must be phase locked to the HP 3326A for accurate results with manual tuning. Manual tuning is used in the HP 3585A procedures.

- Press RANGE and the up arrow to set the input range to 20 dBm.
- Set the resolution bandwidth (RBW) to 3 Hz and video bandwidth (VBW) to 1 Hz.
- Set the CENTER FREQUENCY to the fundamental frequency (160 Hz).
- Set the FREQUENCY SPAN to 0 Hz.
- Enable the OFFSET and press the ENTER OFFSET key.
- Set the CF STEP SIZE to the fundamental frequency.

5. Measure the value of the largest harmonic, relative to the fundamental, and record this value in the Performance Test Record. The value should be at least 80 dB below the fundamental frequency value. For the HP 3585A:

- Press the CENTER FREQUENCY key and press the up arrow to measure the first and second harmonics of the fundamental frequency.

6. Repeat steps 4 and 5 for the following frequencies and specifications:

FREQUENCY	SPECIFICATION
910 Hz	< -80 dBc
6.2 kHz	< -80 dBc
47 kHz	< -80 dBc
91 kHz	< -75 dBc
300 kHz	< -55 dBc
910 kHz	< -55 dBc

7. Change the HP 3326A setup as follows:

CHANNEL	CH A
FREQUENCY	160 Hz
AMPLITUDE	40 Vpp

8. Repeat steps 4 and 5 for the following frequencies and specifications:

FREQUENCY	SPECIFICATION
160 Hz	< −75 dBc
910 Hz	< −75 dBc
6.2 kHz	< −75 dBc
47 kHz	< −75 dBc
91 kHz	< −65 dBc
300 kHz	< −40 dBc
910 kHz	< −40 dBc

9. Preset the HP 3326A and connect the HP 3326A channel B output to the 1 kΩ/50 Ω matching pad and load (Refer to Figure 2-2(B)).

10. Repeat steps 3 through 8 substituting channel B for channel A.

2-13 SPURIOUS SIGNALS

EQUIPMENT REQUIRED:

Spectrum Analyzer HP 3585A

SPECIFICATIONS:

All non-harmonically related output signals (10 Hz to 40 MHz) will be less than the following levels relative to the fundamental, or < −90 dBm, whichever is greater at 20° C ± 20° C:

Channel Frequency	Spurious Level
10 Hz to 1 MHz	- 80 dBc
1 MHz to 13 MHz	- 70 dBc

NOTE

Ground isolation must be maintained.

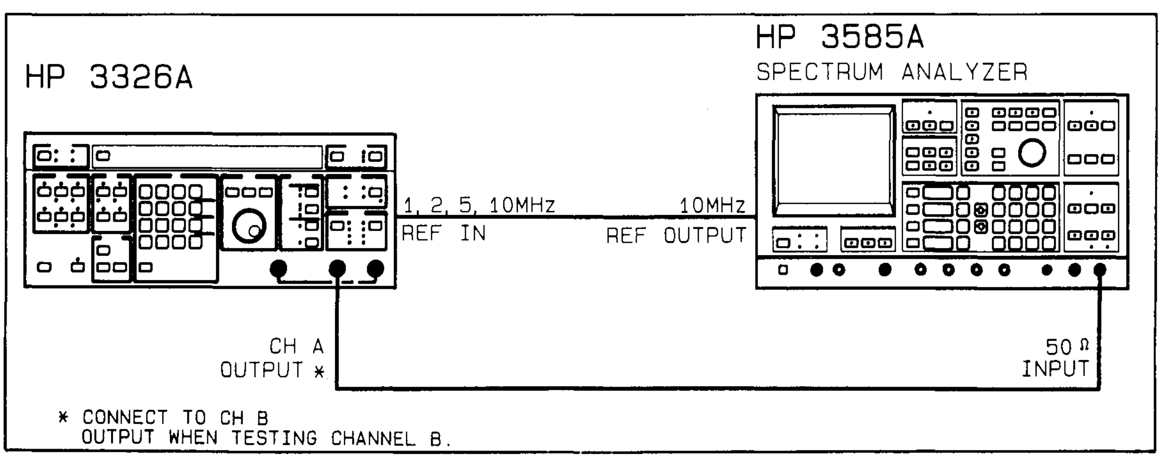

Figure 2-3. Spurious Signals Test

SPURIOUS SIGNALS TEST:

1. Preset the HP 3326A and spectrum analyzer.

2. Connect the test equipment as follows (illustrated in Figure 2-3):

   - HP 3326A CH A output to spectrum analyzer 50 Ω input
   - HP 3326A 1,2,5,10 MHz REF INput to spectrum analyzer 10 MHz reference output (phase lock HP 3326A to spectrum analyzer)

3. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	3 MHz
AMPLITUDE	3.98 dBm

4. Adjust the spectrum analyzer to display the fundamental frequency and any spurious responses due to the mixer. For the 3 MHz fundamental frequency, the mixer introduces a spurious response at 14 MHz. For 3 MHz, set the HP 3585A as follows:

   - Press RANGE and the up arrow to set the input range to 10 dBm.
   - Press DSPL LINE and adjust the rotary knob for a −80 dB level.
   - Press STOP FREQ and set to 20 MHz.
   - Press MARKER and adjust the rotary knob to place the marker on the fundamental frequency.

NOTE

Adjust the resolution bandwidth (RBW) and video bandwidth (VBW) to resolve the measurement and lower the noise floor required.

   - Press MKR→REF LVL and wait for the sweep to update the display.

5. Verify that all spurs are at least 80 dB below the fundamental frequency.

6. Set the HP 3326A to the following frequencies and verify that all spurs are below spurious level:

FREQUENCY	SPECIFICATION	EXPECTED SPURIOUS SIGNALS
1 MHz	< −80 dBc	1 kHz, 2 kHz, 5 kHz, 10 kHz, 20 kHz, 50 kHz
5.1 MHz	< −70 dBc	9.8 MHz, 14.9 MHz
7 MHz	< −70 dBc	6 MHz, 13 MHz
9 MHz	< −70 dBc	2 MHz, 11 MHz
11 MHz	< −70 dBc	3 kHz, 9 MHz
13 MHz	< −70 dBc	3 kHz, 6 MHz, 7 MHz

7. Preset the HP 3326A and connect the HP 3326A channel B output to the spectrum analyzer 50 Ω input.

8. Repeat steps 3 through 6 substituting channel B for channel A.

2-14 COMBINER IM DISTORTION

EQUIPMENT REQUIRED:

Spectrum Analyzer HP 3585A

Components:

* C1 Capacitor 200 pF 1% 1 ea HP Part No. 0140-0220

* R1 955 Ω Resistor (parallel combination of two 1.91 kΩ resistors)
Resistor 1.91 kΩ 1% ½ W 2 ea HP Part No. 0698-3341

* R2 Resistor 52.68 Ω 0.1% ½ W 1 ea HP Part No. 0698-6060

* Used to test High Voltage (Option 002)

SPECIFICATIONS:

Combiner Intermodulation Distortion: In the two-tone mode, third-order intermodulation difference products will be less than the following levels relative to the higher of the fundamentals. Both channels must be in the indicated frequency band with a minimum frequency separation of 10 Hz.

	10 Hz – 1 MHz	1 MHz – 13 MHz
+ 17.96 dBm – + 7.98 dBm	− 70 dB	− 45 dB
+ 7.98 dBm – − 56.02 dBm	− 80 dB	− 65 dB

Combiner High Voltage Intermodulation Distortion: Third-order intermodulation difference products will be less than the following levels relative to the higher of the fundamentals (sine wave only). Both channels must be in the indicated frequency band with a minimum frequency separation of 10 Hz.

	10 Hz – 100 kHz	100 kHz – 1 MHz
20.00 Vpp – 6.32 Vpp	− 60 dB	− 40 dB
6.32 Vpp – 200 mVpp	− 75 dB	− 55 dB

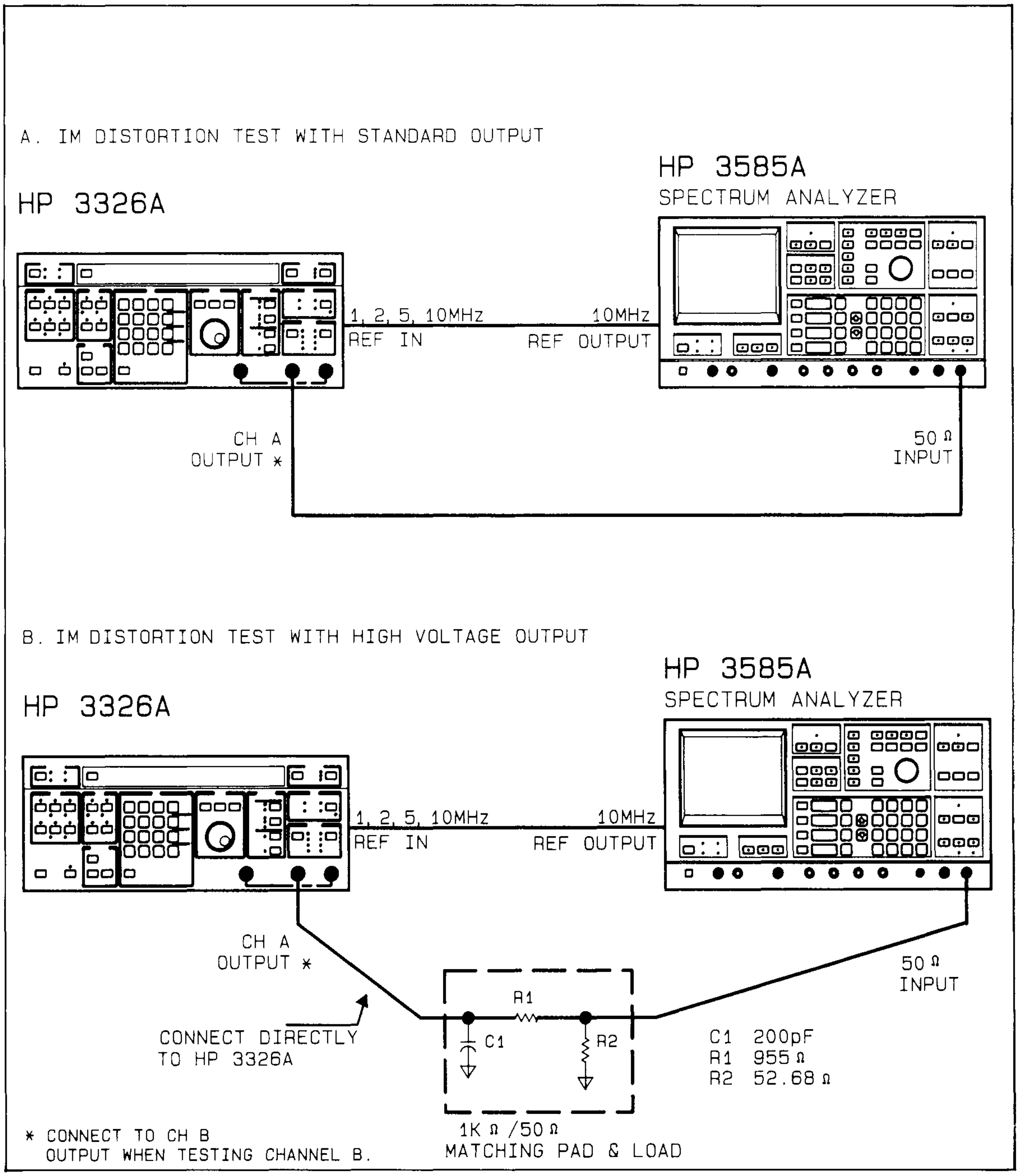

Figure 2-4. Combiner IM Distortion Test

COMBINER IM DISTORTION TEST FOR STANDARD OUTPUT:

1. Preset the HP 3326A and spectrum analyzer.

2. Connect the test equipment as follows (illustrated in Figure 2-4(A)):

   - HP 3326A CH A output to spectrum analyzer 50 Ω input
   - HP 3326A 1,2,5,10 MHz REF INput to spectrum analyzer 10 MHz reference output (phase lock HP 3326A to spectrum analyzer)

3. Set the HP 3326A as follows:

CHANNEL	CH A
AMPLITUDE	17.96 dBm
FREQUENCY	900 kHz
COMBINED	ON
CHANNEL	CH B
AMPLITUDE	17.96 dBm
FREQUENCY	1 MHz

4. Tune the spectrum analyzer to cover the frequency range containing the third-order IM distortion difference products. For the frequencies of 900 kHz and 1 MHz, the third-order IM distortion products appear in the frequency range of 0.5 MHz to 5 MHz. For the HP 3585A spectrum analyzer:

NOTE

The speed of the measurement may be increased by manually tuning the spectrum analyzer to the fundamental and harmonic frequencies. The spectrum analyzer must be phase locked to the HP 3326A for accurate results with manual tuning. Manual tuning is used in the HP 3585A procedures.

- Press RANGE and the up arrow to set the input range to 30 dBm.
- Set the resolution bandwidth (RBW) to 3 Hz and video bandwidth (VBW) to 1 Hz.
- Set the CENTER FREQUENCY to the channel A frequency.
- Set the FREQUENCY SPAN to 0 Hz.
- Enable the OFFSET and press the ENTER OFFSET key.

5. Measure the third-order intermodulation distortion difference products relative to the largest fundamental frequency. For fundamental frequencies of 900 kHz and 1 MHz, the third- order intermodulation products appear at: 0.8 MHz, and 1.1 MHz
For the HP 3585A:

- Press the CENTER FREQUENCY key, then enter the value of each third-order intermodulation distortion product with the numeric entry keys.

6. Record the largest third-order intermodulation value on the Performance Test Record. Verify that the largest third-order intermodulation product is more than 70 dB below the largest fundamental frequency.

7. Repeat steps 4 through 6 for the following HP 3326A CH A and CH B frequencies and third-order IM specifications:

CH A FREQUENCY	CH B FREQUENCY	THIRD-ORDER IM SPECIFICATION	THIRD-ORDER DIFFERENCE IM PRODUCTS
20 Hz	120 Hz	< −70 dBc	80 Hz, 220 Hz
999.9 kHz	1 MHz	< −70 dBc	.9998 MHz, 1.0001 MHz,
13 MHz	13.1 MHz	< −45 dBc	12.9 MHz, 13.2 MHz
13 MHz	13.0001 MHz	< −45 dBc	12.9999 MHz, 13.0002 MHz

8. Set the HP 3326A as follows:

CHANNEL	CH A
AMPLITUDE	7.95 dBm
FREQUENCY	20 Hz
COMBINED	ON
CHANNEL	CH B
AMPLITUDE	7.95 dBm
FREQUENCY	120 Hz

9. Repeat steps 4 through 6 for the following HP 3326A CH A and CH B frequencies and third-order IM specifications:

CH A FREQUENCY	CH B FREQUENCY	THIRD-ORDER IM SPECIFICATION	THIRD-ORDER DIFFERENCE IM PRODUCTS
20 Hz	120 Hz	< −75 dBc	80 Hz, 220 Hz
900 kHz	1 MHz	< −55 dBc	0.8 MHz, 1.1 MHz, 2.8 MHz, 2.9 MHz
999.9 kHz	1 MHz	< −55 dBc	0.9998 MHz, 1.0001 MHz,
13 MHz	13.1 MHz	< −65 dBc	12.9 MHz, 13.2 MHz
13 MHz	13.0001 MHz	< −65 dBc	12.9999 MHz, 13.0002 MHz

COMBINER HIGH VOLTAGE IM DISTORTION TEST:

1. Preset the HP 3326A and spectrum analyzer.

2. Connect the test equipment as follows (illustrated in Figure 2-4(B)):

   - HP 3326A CH A output to 1 kΩ/50 Ω matching pad and load input
   - 1 kΩ/50 Ω matching pad and load output to spectrum analyzer 50 Ω input
   - HP 3326A 1,2,5,10 MHz REF INput to spectrum analyzer 10 MHz reference input (phase lock HP 3326A to spectrum analyzer)

NOTE

The 1 kΩ/50 Ω matching pad and load is constructed in a small metal box with two BNC connectors. The components for the 1 kΩ/50 Ω matching pad and load are listed in the Equipment Required section.

3. Set the HP 3326A as follows:

CHANNEL	CH A
HIGH VOLTAGE	ON
AMPLITUDE	20 Vpp
FREQUENCY	900 kHz
COMBINED	ON
CHANNEL	CH B
HIGH VOLTAGE	ON
AMPLITUDE	20 Vpp
FREQUENCY	1 MHz

4. Tune the spectrum analyzer to cover the frequency range containing the third-order IM distortion difference products. For the frequencies of 900 kHz and 1 MHz, the third-order IM distortion difference products appear in the frequency range of 0.5 MHz to 5 MHz. For the HP 3585A spectrum analyzer:

NOTE

The speed of the measurement may be increased by manually tuning the spectrum analyzer to the fundamental and harmonic frequencies. The spectrum analyzer must be phase locked to the HP 3326A for accurate results with manual tuning. Manual tuning is used in the HP 3585A procedures.

   - Press RANGE and the up arrow to set the input range to 30 dBm.
   - Set the resolution bandwidth (RBW) to 3 Hz and video bandwidth (VBW) to 1 Hz.
   - Set the CENTER FREQUENCY to the channel A frequency.
   - Set the FREQUENCY SPAN to 0 Hz.
   - Enable the OFFSET and press the ENTER OFFSET key.

5. Measure the third-order intermodulation distortion difference products relative to the largest fundamental frequency. For fundamental frequencies of 900 kHz and 1 MHz, the third-order intermodulation products appear at: 0.8 MHz, and 1.1 MHz
For the HP 3585A:

- Press the CENTER FREQUENCY key, then enter the value of each third-order intermodulation distortion product with the numeric entry keys.

6. Record the largest measured value on the Performance Test Record. Verify that the largest third-order intermodulation difference product is more than 40 dB below the largest fundamental frequency.

7. Repeat steps 4 through 6 for the following HP 3326A CH A and CH B frequencies and third-order IM specifications:

CH A FREQUENCY	CH B FREQUENCY	THIRD-ORDER IM SPECIFICATION	THIRD-ORDER DIFFERENCE IM PRODUCTS
999.9 kHz	1 MHz	< −40 dBc	0.9998 MHz, 1.0001 MHz
99.9 kHz	100 kHz	< −55 dBc	99.8 kHz, 100.1 kHz,

8. Change the HP 3326A output levels to 6.31 Vpp and repeat steps 4 through 6 for the following HP 3326A CH A and CH B frequencies and third-order IM specifications:

CH A FREQUENCY	CH B FREQUENCY	THIRD-ORDER IM SPECIFICATION	THIRD-ORDER DIFFERENCE IM PRODUCTS
99.9 kHz	100.1 kHz	−75 dBc	99.8 kHz, 100.1 kHz
900 kHz	1 MHz	−55 dBc	0.8 MHz, 1.1 MHz,
999.9 kHz	1 MHz	−55 dBc	0.9998 MHz, 1.0001 MHz

2-15 RETURN LOSS

EQUIPMENT REQUIRED:

Spectrum Analyzer	HP 3585A
50 Ω Directional Bridge	HP 8721A

NOTE

Directional bridges are also part of a 50 Ω Transmission/Reflection Kit (HP 11652A).

SPECIFICATIONS:

Return Loss Standard Output: >20 dB, 100 kHz to 13 MHz

Return Loss Combined Output: >20 dB

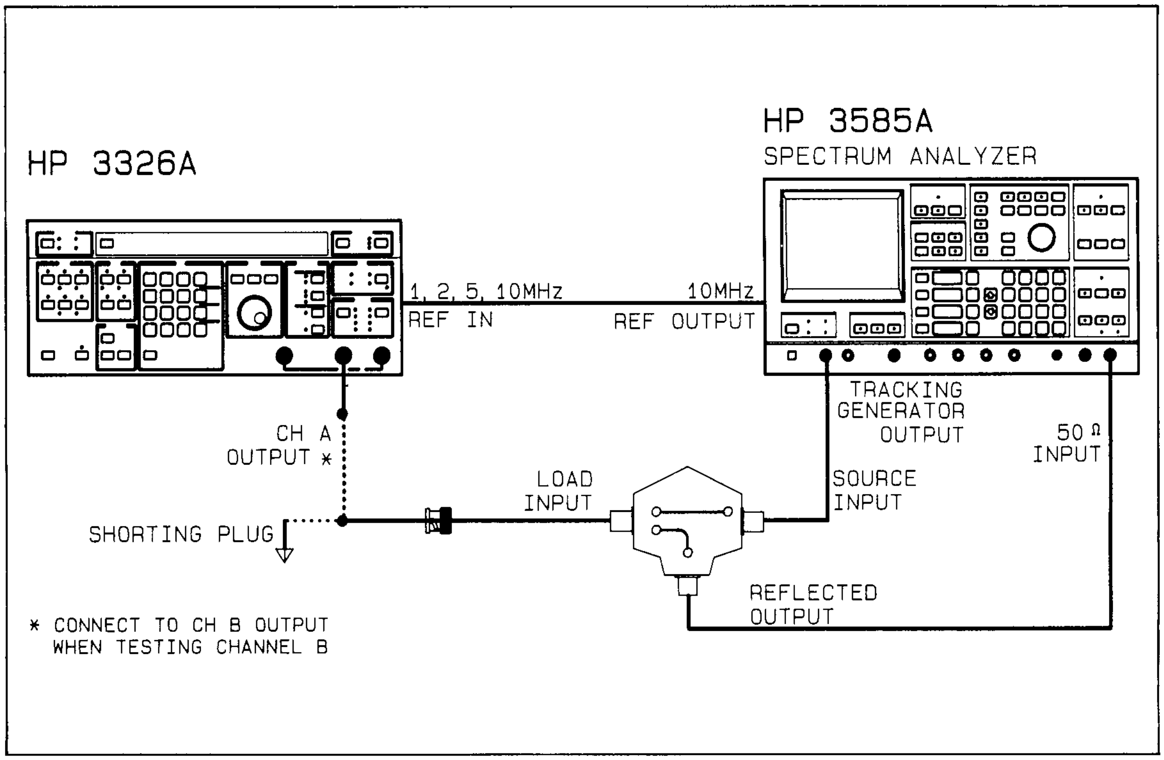

Figure 2-5. Return Loss Test

RETURN LOSS TEST:

1. Preset the HP 3326A and spectrum analyzer.
2. Adjust the spectrum analyzer tracking generator output to 10 dBm.
3. Connect the test equipment as follows (illustrated in Figure 2-5):
   - Directional bridge source input to spectrum analyzer tracking generator output

NOTE

The HP 8721A directional bridge has two inputs labeled source. Use the input labeled source from the source, reflected, and load label on the directional bridge.

- Directional bridge reflected output to spectrum analyzer 50 Ω input
- HP 3326A 1,2,5,10 MHz REF INput to spectrum analyzer 10 MHz reference output (phase lock HP 3326A to spectrum analyzer)

4. Set the spectrum analyzer to cover the frequency range from 100 kHz to 13 MHz. For the HP 3585A:

- Press the START FREQ key and enter 100 kHz with the numeric keypad.
- Press the STOP FREQ key and enter 13 MHz.

5. Short the directional bridge load port and store the resulting trace in the spectrum analyzer memory. For the HP 3585A:

- Press the MKR → REF LVL key.
- Turn off REF LVL TRACK.
- Press the STORE A → B key.

6. Set the HP 3326A as follows:

CHANNEL	CH A
FUNCTION	DC

7. Remove the short from the directional bridge load port and connect the HP 3326A CH A output to the directional bridge load port.

8. Verify that the return loss is greater than 20 dB between 1 MHz and 13 MHz. Record the minimum difference for return loss on the performance test record.

9. Verify that the return loss is greater than 23 dB at 100 kHz.

NOTE

3 dB is added to the return loss specification at 100 kHz to compensate for the directional bridge.

10. Repeat steps 6 through 9 substituting channel B for channel A.

11. Set the HP 3326A as follows:

CHANNEL	CH A
COMBINED	ON
FUNCTION	DC

CHANNEL	CH B
FUNCTION	DC

NOTE

With the combiner enabled, only the HP 3326A CH A output is active.

12. Connect the HP 3326A CH A output to the directional bridge load port and repeat steps 8 and 9.

2-16 CHANNEL ISOLATION

EQUIPMENT REQUIRED:

Spectrum Analyzer	HP3585A
50 Ω Feed Thru Termination	HP 11048C

SPECIFICATIONS:

Channel Isolation:

> 80 dB below the larger signal, or < −90 dBm, whichever is greater, 10 Hz to 13 MHz, sine wave only, two-channel, and two-tone modes. For square wave and dc, typically > 80 dB to 5 MHz, typically > 65 dB to 13 MHz.

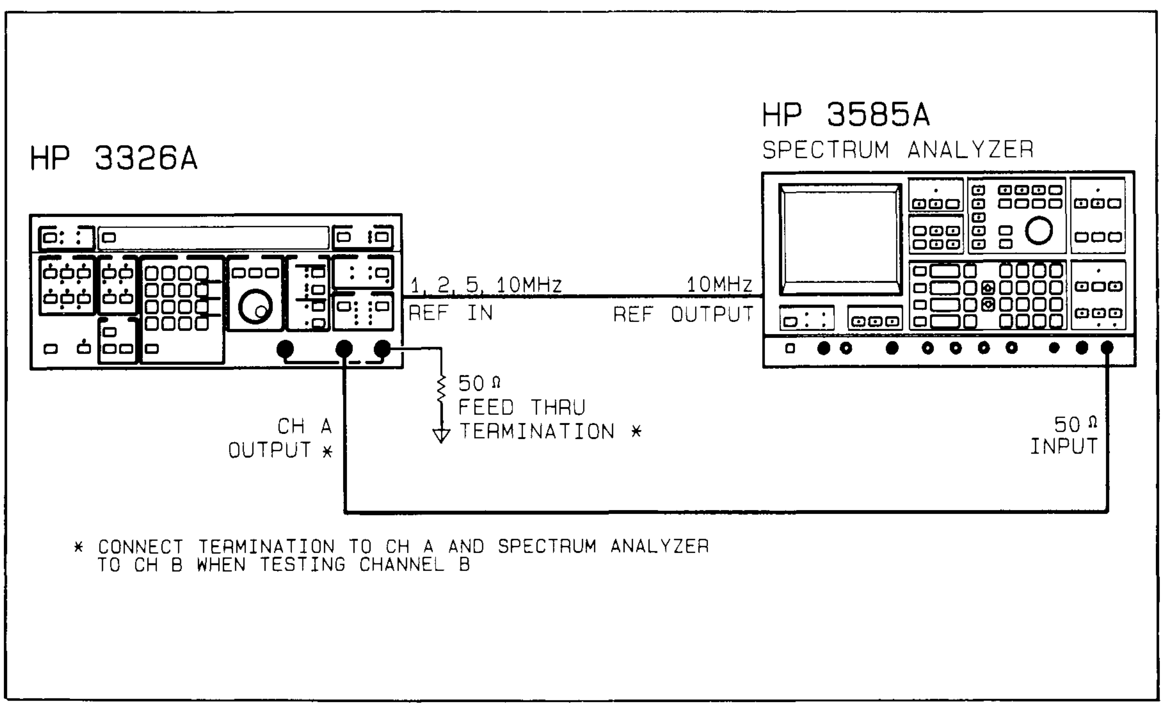

Figure 2-6. Channel Isolation Test

CHANNEL ISOLATION TEST:

1. Preset the HP 3326A and the spectrum analyzer.

2. Connect the test equipment as follows (illustrated in Figure 2-6):

   - HP 3326A CH A output to spectrum analyzer 50 Ω input
   - Connect 50 Ω load to HP 3326A CH B output
   - HP 3326A 1,2,5,10 MHz REF INput to spectrum analyzer 10 MHz reference output (phase lock HP 3326A to spectrum analyzer)

3. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	20 Hz
AMPLITUDE	23.97 dBm
CHANNEL	CH B
FREQUENCY	100 Hz
AMPLITUDE	23.97 dBm

4. Set the spectrum analyzer frequency range to include both the HP 3326A channel A and channel B frequencies. For the HP 3585A:

   - Press RANGE and the up arrow to set the input range to 30 dBm.
   - Set the resolution bandwidth (RBW) to 3 Hz and video bandwidth (VBW) to 1 Hz.
   - Set the CENTER FREQUENCY to the channel A frequency.
   - Set the FREQUENCY SPAN to 0 Hz.
   - Enable the OFFSET and press the ENTER OFFSET key.
   - Set the CF STEP SIZE to the fundamental frequency.

NOTE

The speed of the measurement may be increased by manually tuning the spectrum analyzer to the fundamental and harmonic frequencies. The spectrum analyzer must be phase locked to the HP 3326A for accurate results with manual tuning. Manual tuning is used in the HP 3585A procedures.

5. Verify that the signal corresponding to the channel B frequency is 80 dB below the signal corresponding to the channel A frequency. Record the amplitude difference between the two signals on the Performance Test Record. For the HP 3585A:

   - Press the CENTER FREQUENCY key, then enter the channel B frequency value.

6. Repeat steps 4 and 5 using the following HP 3326A channel B frequencies:

   1000 Hz
   10 kHz
   95 kHz
   950 kHz
   9.5 MHz
   12.9 MHz

7. Change the HP 3326A CH A frequency to 1.05 MHz and repeat steps 4 and 5 using the following HP 3326A channel B frequencies:

   100 Hz
   1000 Hz
   10 kHz
   95 kHz
   950 kHz
   9.5 MHz
   12.9 MHz

8. Change the HP 3326A CH A frequency to 13 MHz and repeat steps 4 and 5 using the following HP 3326A channel B frequencies:

   100 Hz
   1000 Hz
   10 kHz
   95 kHz
   950 kHz
   9.5 MHz
   12.9 MHz

9. Preset the HP 3326A and set as follows:

CHANNEL	CH A
FREQUENCY	20 Hz
AMPLITUDE	23.97 dBm
MODE	2 TONE
CHANNEL	CH B
FREQUENCY	95.02 kHz
AMPLITUDE	23.97 dBm

10. Set the spectrum analyzer frequency range to include both the HP 3326A channel A and channel B frequencies. (Refer to steps 4 and 5 for HP 3585A manual tuning procedures.)

11. Verify that the signal corresponding to the channel B frequency is 80 dB below the signal corresponding to the channel A frequency. Record the amplitude difference between the two signals on the Performance Test Record.

12. Change the HP 3326A CH B frequency to 130 Hz and repeat steps 10 and 11.

13. Change the HP 3326A CH A frequency to 1.05 MHz and repeat steps 10 and 11 using the following HP 3326A channel B frequencies:

    1.145 MHz
    1.0501 MHz

14. Change the HP 3326A CH A frequency to 12.9 MHz and repeat steps 10 and 11 using the following HP 3326A channel B frequencies:

    12.995 MHz
    12.9001 MHz

15. Preset the HP 3326A and spectrum analyzer.

16. Connect the 50 Ω feed thru termination to the HP 3326A channel A output. Connect the HP 3326A channel B output to the 50 Ω input on the spectrum analyzer.

17. Repeat steps 3 through 14 substituting channel B for channel A, and channel A for channel B.

2-17 SINE WAVE AMPLITUDE ACCURACY

EQUIPMENT REQUIRED:

AC/DC Digital Voltmeter average converter OPT 001	HP 3455A
50 Ω Step Attenuator	HP 355D
Thermal converter	HP 11051A
50 Ω Feed Thru Termination	HP 11048C

SPECIFICATIONS:

Relative to selected value after performing self calibration.

Sine wave

Amplitude	0.001 Hz – 100 kHz	100 kHz – 1 MHz	1 MHz – 13 MHz
+23.98 dBm – +3.98 dBm	±0.1 dB	±0.3 dB	±0.6 dB
+3.98 dBm – −36.02 dBm	±0.2 dB	±0.5 dB	±0.8 dB
−36.02 dBm – −56.02 dBm	±0.2 dB	±0.5 dB	±1.0 dB

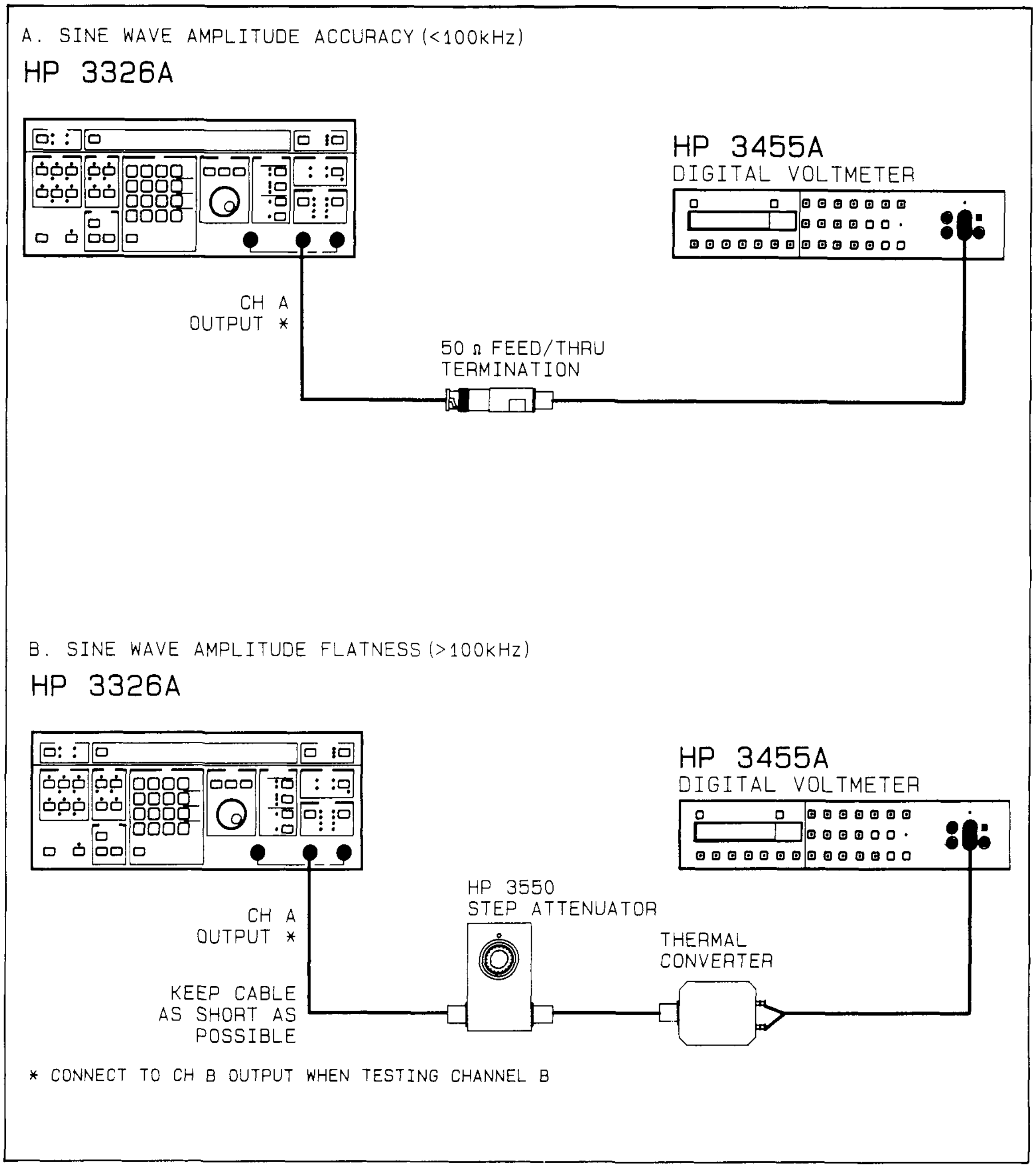

Figure 2-7. Amplitude Accuracy Test

SINE WAVE AMPLITUDE ACCURACY TEST (<100 kHz):

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-7(A)):

   - HP 3326A CH A output through 50 Ω feed thru termination to ac digital voltmeter input

3. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	100 Hz
AMPLITUDE	23.98 dBm

4. Press the MANUAL calibration key to calibrate the HP 3326A.

5. Verify that the voltmeter reads between 3.495 Vrms and 3.577 Vrms (23.98 dBm ±0.1 dB).

6. Verify that the ac voltmeter reads between 3.495 Vrms and 3.577 Vrms at the following frequencies:

   1 kHz
   100 kHz

7. Set the HP 3326A amplitude to 3.98 dBm (0.3536 Vrms).

8. Verify that the voltmeter reads between 0.3455 Vrms and 0.3616 Vrms (3.98 dBm ±0.2 dB) at the following frequencies:

   100 Hz
   1 kHz
   100 kHz

9. Set the HP 3326A amplitude to −36.02 dBm (3.536 mVrms).

10. Verify that the voltmeter reads between 3.455 mVrms and 3.616 mVrms (3.98 dBm ±0.2 dB) at the following frequencies:

   100 Hz
   1 kHz
   100 kHz

11. Repeat steps 1 through 10 substituting channel B for channel A.

SINE WAVE AMPLITUDE FLATNESS TEST (> 100 kHz):

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-7(B)):

   - HP 3326A CH A output to 50 Ω step attenuator input
   - 50 Ω step attenuator output to 0.5 Vrms thermal converter input
   - Thermal converter output to dc digital voltmeter input

NOTE

For accurate test results, allow the HP 3326A and thermal converter to settle and adjust to surrounding temperatures. Avoid sudden temperature changes around the thermal converter.

3. Set the 50 Ω step attenuator to 0 dB.

4. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	1 kHz
AMPLITUDE	3.98 dBm

5. Press the HP 3326A MANUAL calibration key.

6. Read the dc voltmeter and record the 3.98 dBm sine wave reference reading on the Performance Test Record.

7. Change the HP 3326A amplitude to 3.88 dBm and record the dc voltmeter reading on the Performance Test Record.

8. Subtract the 3.88 dBm dc voltmeter reading from the 3.98 dBm dc voltmeter reading to determine the voltmeter change corresponding to a 0.1 dB amplitude change.

9. Change the HP 3326A amplitude to 3.68 dBm and determine the voltmeter change corresponding to a 0.3 dB amplitude change.

10. Set the HP 3326A amplitude to 3.38 dBm and determine the voltmeter change corresponding to a 0.6 dB amplitude change.

11. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	100 kHz
AMPLITUDE	3.98 dBm

12. Record the dc voltmeter reading.

13. Verify that the dc voltmeter is within the reading of step 6 plus or minus the 0.1 dB tolerance determined in step 8.

14. Set the HP 3326A to 1 MHz and record the dc voltmeter reading.

15. Verify that the dc voltmeter is within the reading of step 6 plus or minus the 0.3 dB tolerance determined in step 9.

16. Select the 1 MHz digit with the MODIFY arrow keys and increase the output to 13 MHz in 2 MHz steps with the rotary knob. Press the MANUAL calibration key and record the voltmeter reading at each 2 MHz frequency step.

17. Verify that the dc voltmeter readings are within the readings of step 6 plus or minus the 0.6 dB tolerance determined in step 10.

18. Change the attenuator to 20 dB.

19. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	1 kHz
AMPLITUDE	23.98 dBm

20. Press the HP 3326A MANUAL calibration key.

21. Read the dc voltmeter and record the 23.98 dBm sine wave reference reading on the Performance Test Record.

22. Change the HP 3326A amplitude to 23.88, 23.68, and 23.38 dBm and record the dc voltmeter reading for each amplitude setting. Subtract the 23.88, 23.68, and 23.38 dBm dc voltmeter readings from the 23.98 reference reading to establish the dc voltmeter change for a 0.1, 0.3, and 0.6 dB change in the HP 3326A.

23. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	100 kHz
AMPLITUDE	23.98 dBm

24. Record the dc voltmeter reading and verify that the reading is within the reading of step 21 plus or minus the 0.1 dB tolerance determined in step 22.

25. Set the HP 3326A to 1 MHz.

26. Record the dc voltmeter reading and verify that the reading is within the reading of step 21 plus or minus the 0.3 dB tolerance determined in step 22.

27. Select the 1 MHz digit with the MODIFY arrow keys and increase the output to 13 MHz in 2 MHz steps with the rotary knob. Press the MANUAL calibration key and record the voltmeter reading at each 2 MHz frequency step. Verify that the dc voltmeter readings are within the readings of step 21 plus or minus the 0.6 dB tolerance determined in step 22.

28. Repeat steps 1 through 27 substituting channel B for channel A.

29. Disconnect thermal converter from HP 3326A.

2-18 SQUARE WAVE/PULSE AMPLITUDE ACCURACY

EQUIPMENT REQUIRED:

High Speed DC Voltmeter	HP 3437A
BNC-to-Triax Adapter HP Part No.	1250-0595
Oscilloscope	HP 1740A
50 Ω Step Attenuator	HP 335D

SPECIFICATIONS:
Relative to selected value after performing self calibration. Square wave (50% duty cycle)

	0.001 Hz – 100 kHz	100 kHz – 1 MHz	1 MHz – 13 MHz
10.00 Vpp – 1.00 Vpp	±1.0% *	±3.0%	±6.0%
1.00 Vpp – 100 mVpp	±2.0% *	±5.0%	±8.0%

* Also for 5% to 95% duty cycle in pulse mode.

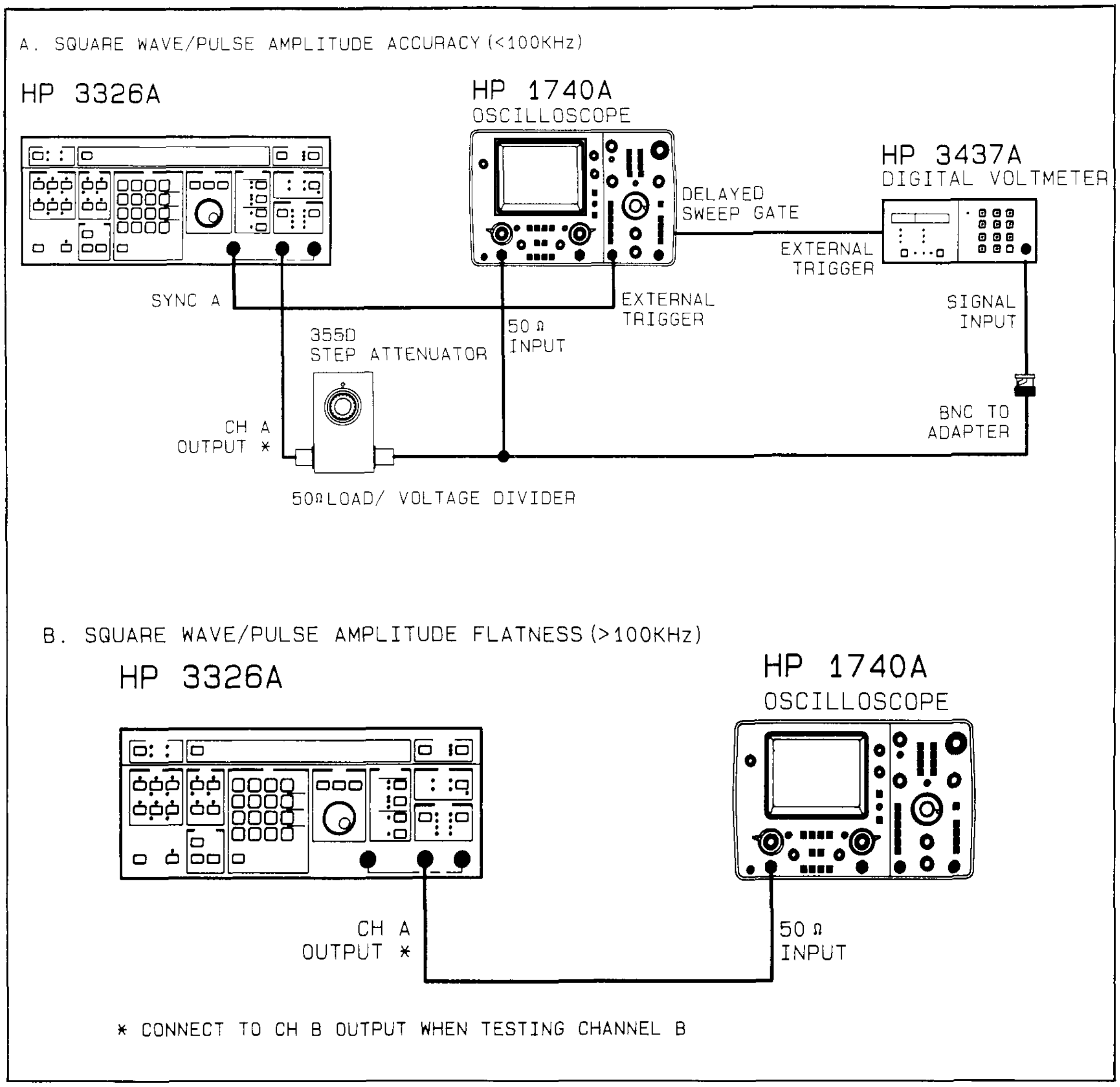

Figure 2-8. Square Wave/Pulse Amplitude Accuracy Test

SQUARE WAVE/PULSE AMPLITUDE ACCURACY TEST (< 100 kHz):

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-8(A)):

   - HP 3326A SYNC A output to oscilloscope external trigger input
   - HP 3326A CH A output to 50 Ω step attenuator input
   - 50 Ω step attenuator output to oscilloscope 50 Ω input
   - 50 Ω step attenuator output to high speed voltmeter input

3. Set the 50 Ω step attenuator to 10 dB.

4. Set the HP 3326A as follows:

CHANNEL	CH A
FUNCTION	Square
FREQUENCY	99.9 Hz
AMPLITUDE	10 Vpp

5. Set the oscilloscope as follows:

DISPLAY	A or B
VERTICAL SENSITIVITY	0.5 V/div
TRIGGER	External
MAIN SWEEP	1 ms/div
DELAYED SWEEP	5 μs/div
DELAY	250 s

6. Set the high speed voltmeter as follows:

RANGE	0.1 V
TRIGGER	External
DELAY	0 s

7. One cycle of the square wave should fill the screen of the oscilloscope. The sample time for the voltmeter should be seen as the intensified spot of the delayed sweep.

8. Press the MANUAL calibration key to calibrate the HP 3326A.

9. Read the positive peak voltage of the attenuated waveform on the voltmeter. If the reading is not stable, press HOLD, then EXT alternatively to repeat readings.

10. Change oscilloscope delay to 750 s and read negative peak on the voltmeter.

11. Add the two readings to obtain volts peak-to-peak. Verify that the sum is between 3.02 volts and 3.08 volts.

12. Set the HP 3326A frequency to 1 kHz.

13. Set the oscilloscope as follows:

MAIN SWEEP	50 μs/div
DELAYED SWEEP	0.05 μs/div

14. Read the positive peak voltage on the voltmeter; then push negative trigger on the oscilloscope and read negative peak voltage.

15. Verify that the sum is between 3.02 and 3.08 volts.

16. Set the HP 3326A frequency to 100 kHz.

17. Set the oscilloscope as follows:

Main Sweep	0.5 μs/div

18. Read positive and negative peak voltages in the center of the oscilloscope screen (select between positive and negative trigger to view the trace maximum and minimum values). Verify that the peak-to-peak voltage is between 3.02 and 3.08 volts.

19. Reduce the HP 3326A amplitude to 3 Vpp, and set the 50 Ω step attenuator to zero.

20. Repeat steps 4 through 18 for 3 Vpp with a minimum voltage reading of 2.97 V and a maximum voltage of 3.03 V.

21. Reduce the HP 3326A amplitude to 1 Vpp.

22. Repeat steps 4 through 18 for 1 Vpp with a minimum voltage reading of 0.99 V and a maximum voltage of 1.01 V.

23. Preset the HP 3326A.

24. Press the HP 3326A MODE key to enable the 2 PHASE mode.

25. Repeat steps 2 through 22 substituting channel B for channel A.

SQUARE WAVE FLATNESS TEST:

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-8(B)):

   - HP 3326A CH A output to oscilloscope 50 Ω vertical input

NOTE

If the oscilloscope does not have a 50 Ω input, a 50 Ω feed thru termination (HP 11048C) may be used.

3. Set the HP 3326A as follows:

CHANNEL	CH A
FUNCTION	Square wave
FREQUENCY	1 kHz
AMPLITUDE	10 Vpp

4. Set the oscilloscope as follows:

VERTICAL SENSITIVITY	2 V/div
TIME/DIVISION	0.1 ms

5. Select the 1 MHz digit with the MODIFY arrow keys and increase the frequency to 13 MHz in 2 MHz steps with the rotary knob. Verify that the two lines that appear on the oscilloscope remain within ½ major division of the 5 division separation.

6. Repeat steps 1 through 5 substituting channel B for channel A.

2-19 HIGH VOLTAGE AMPLITUDE ACCURACY

EQUIPMENT REQUIRED:

AC/DC Digital Voltmeter	HP 3455A
average converter	OPT 001
High Speed DC Voltmeter	HP 3437A
BNC-to-Triax Adapter HP Part No.	1250-0595
Oscilloscope	HP 1740A

COMPONENTS:

R1 947 kΩ Resistor (parallel combination of two 2 kΩ and one 18 kΩ resistors)
Resistor 2 kΩ 0.1% 0.5 W 2 ea HP Part No. 0698-8226
Resistor 18 kΩ 0.1 % 0.125 W HP Part No. 0698-8167

R2 Resistor 52.68 Ω 1% ½ W 1 ea HP Part No. 0698-6060

SPECIFICATIONS:

High Voltage Amplitude Accuracy

≤ ±12% of peak-to-peak value for sine, square, and pulse for 400 mVpp to 40 Vpp values.

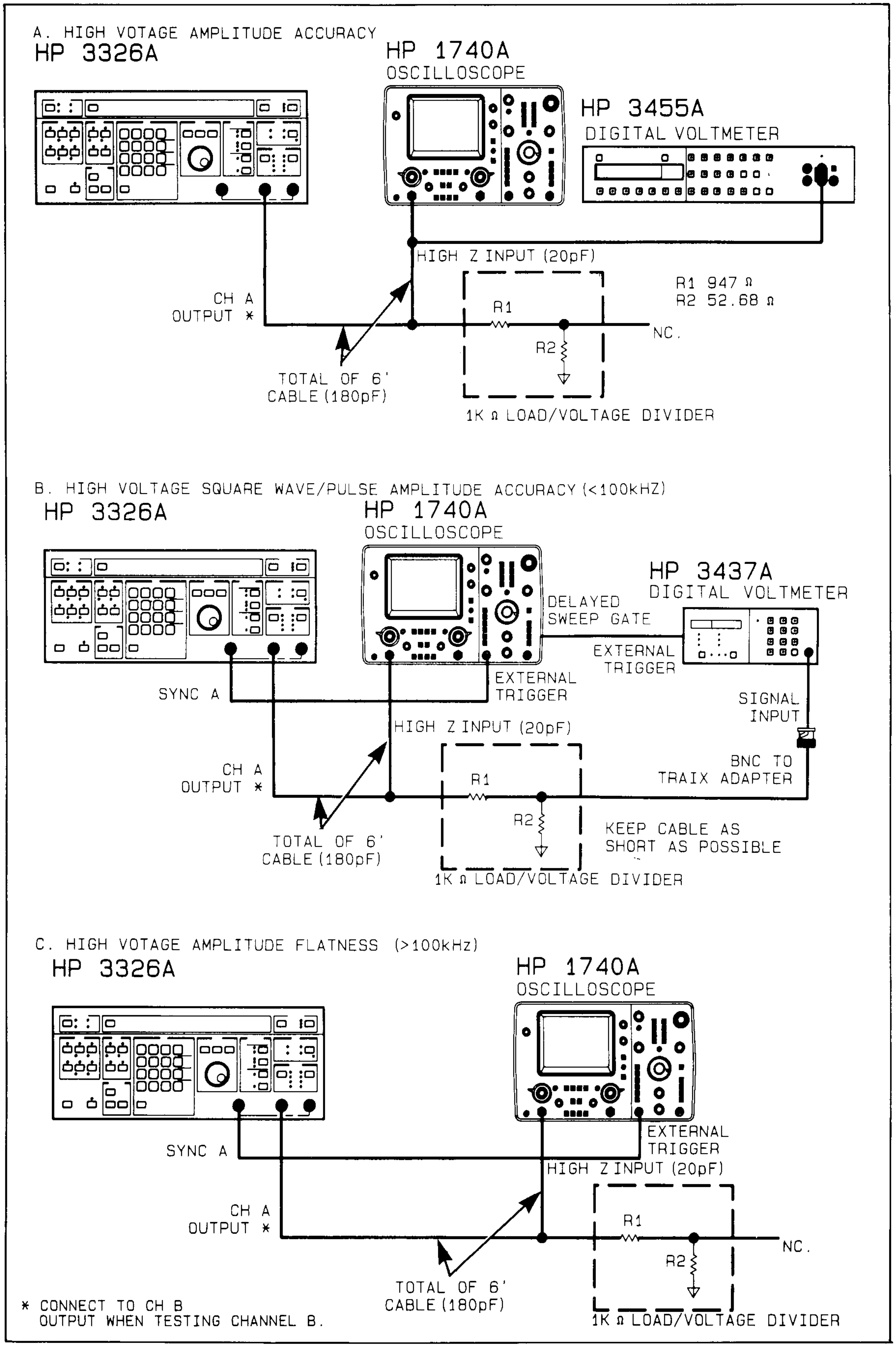

Figure 2-9. High Voltage Amplitude Accuracy Test

HIGH VOLTAGE AMPLITUDE ACCURACY TEST (< 100 kHz):

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-9(A)):

   - HP 3326A CH A output to ac/dc voltmeter high impedance input
   - HP 3326A CH A output to oscilloscope high impedance input

NOTE

The oscilloscope 20 pF input capacitance is combined with the cable capacitance to provide a 200 pF capacitive load to the test circuit.

   - HP 3326A CH A output to 1 kΩ load/voltage divider input (do not connect 1 kΩ load/voltage divider output)

NOTE

The 1 kΩ load/voltage divider is constructed in a small metal box with two BNC connectors. The components for the 1 kΩ load/voltage divider are listed under Equipment Required.

3. Set the HP 3326A as follows:

CHANNEL	CH A
HIGH VOLTAGE	ON
FUNCTION	Sine
FREQUENCY	2 kHz
AMPLITUDE	14.14 Vrms (40 Vpp)

4. Press the MANUAL calibration key.

5. Verify that the ac voltmeter reads between 13.86 and 14.42 Vrms.

6. Change the HP 3326A FUNCTION to OFF.

7. Connect the test equipment as follows (illustrated in Figure 2-9(B)):

   - HP 3326A SYNC A output to oscilloscope external trigger input
   - HP 3326A CH A output to oscilloscope high impedance input
   - HP 3326A CH A output to 1 kΩ load/voltage divider input
   - 1 kΩ load/voltage divider output to high speed voltmeter input
   - Oscilloscope delayed sweep gate to high speed voltmeter external trigger input

8. Set the HP 3326A as follows:

CHANNEL	CH A
HIGH VOLTAGE	ON
FUNCTION	Square Wave
FREQUENCY	2 kHz
AMPLITUDE	14.14 Vrms (40 Vpp)

9. Trigger the high speed dc voltmeter on delayed sweep gate from the oscilloscope. For the HP 3437A voltmeter:

RANGE	1 V
TRIGGER	External

10. Set the oscilloscope as follows:

DISPLAY	A or B
VERTICAL SENSITIVITY	2 V/div
VERTICAL POSITION	8 o'clock
TRIGGER	External
MAIN SWEEP	20 μs/div
DELAYED SWEEP	0.05 μs/div
DELAY	650 s
MAGNIFY	×10

11. Read the positive peak voltage on the dc voltmeter.

12. Switch the oscilloscope to negative trigger, set vertical position to 4 o'clock.

13. Read the negative peak voltage on the dc voltmeter.

14. Verify that the peak-to-peak voltage is between 1.854 and 2.360 volts.

15. Repeat step 1 through 14 substituting channel B for channel A.

HIGH VOLTAGE AMPLITUDE FLATNESS TEST (> 100 kHz):

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-9(C)):

   - HP 3326A CH A output to oscilloscope high impedance input
   - HP 3326A CH A output to 1 kΩ load/voltage divider input (do not connect the 1 kΩ load/voltage divider output)

NOTE

a. The oscilloscope 20 pF input capacitance is combined with the cable capacitance to provide a 200 pF capacitive load to the test circuit.

b. The 1 kΩ load/voltage divider is constructed in a small metal box with two BNC connectors. The components for the 1 kΩ load/voltage divider are listed under Equipment Required.

3. Set the oscilloscope as follows:

VERTICAL SENSITIVITY	10 V/div
TIME/DIVISION	1 ms/div

4. Set the HP 3326A as follows:

CHANNEL	CH A
HIGH VOLTAGE	ON
FREQUENCY	1 kHz
AMPLITUDE	20 Vpk

5. Adjust oscilloscope intensity and focus for a sharp trace.

6. Select the 100 kHz digit with the MODIFY arrow keys and increase the frequency to 1.001 MHz in 200 kHz steps with the rotary knob. Verify that the width of the bright region on the oscilloscope screen is 4 plus or minus 0.48 divisions for all frequency steps.

7. Repeat steps 1 through 6 substituting channel B for channel A.

2-20 COMBINER AMPLITUDE ACCURACY

EQUIPMENT REQUIRED:

Spectrum Analyzer HP 3585A

SPECIFICATIONS:

Combiner Amplitude Accuracy: Add the following to the amplitude accuracy of channel A or B.

DC to 100 kHz	±0.1 dB
100 kHz to 13 MHz	±0.3 dB

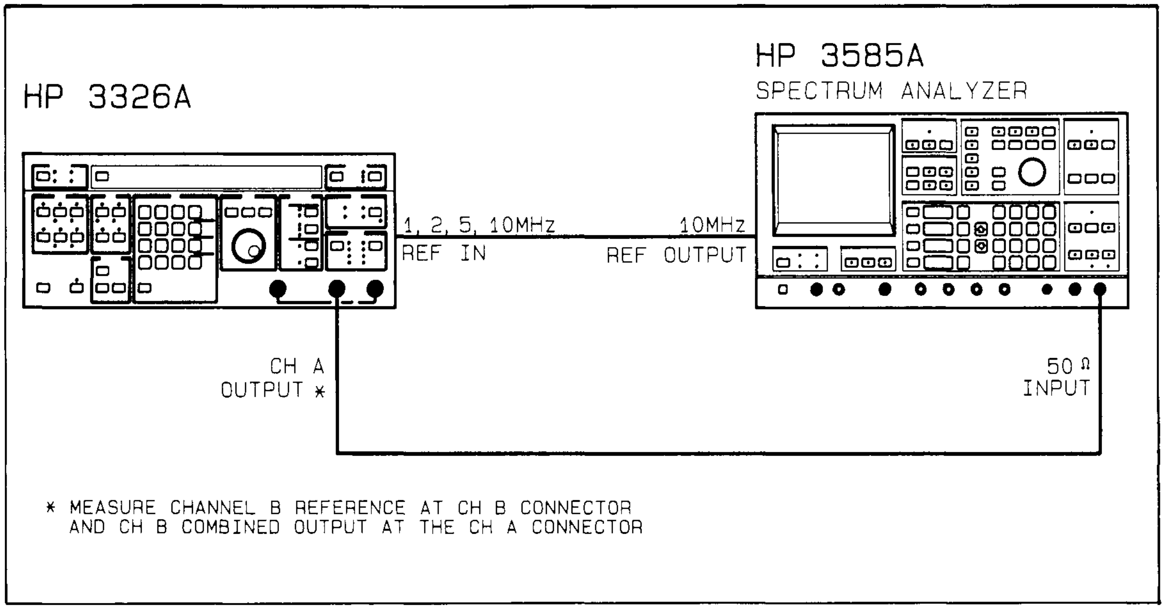

Figure 2-10. Combiner Amplitude Accuracy Test

COMBINER AMPLITUDE ACCURACY TEST

1. Preset the HP 3326A and spectrum analyzer.

2. Connect the test equipment as follows (illustrated in Figure 2-10):

   - HP 3326A CH A output to spectrum analyzer 50 Ω input
   - HP 3326A 1,2,5,10 MHz REF INput to spectrum analyzer 10 MHz reference output (phase lock HP 3326A to spectrum analyzer)

3. Set the HP 3326A as follows:

CHANNEL	CH A
AMPLITUDE	17.9 dBm
FREQUENCY	100 Hz
CHANNEL	CH B
AMPLITUDE	17.9 dBm
FREQUENCY	1.3 MHz

4. Measure the 100 Hz signal amplitude with the spectrum analyzer to establish a reference value.

5. Enable a combined output by pressing the blue SHIFT key followed by the MODE key. Combined operation is enabled when the COMBINED indicator is illuminated.

6. Measure the 100 Hz component of the combined output with the spectrum analyzer.

7. Verify that the 100 Hz signal amplitude does not vary from the reference amplitude by more than ±0.2 dB.

8. Disable the combined output by pressing the blue SHIFT key followed by the MODE key. Combined operation is disabled when the COMBINED indicator is extinguished.

9. Repeat steps 4 through 8 for the following channel A frequencies and tolerances:

FREQUENCY	TOLERANCE
130 kHz	±0.3 dB
13 MHz	±0.3 dB

10. Repeat steps 4 through 9 for channel B amplitudes of:

 7.9 dBm
 −2.1 dBm
 −12.1 dBm
 −22.1 dBm
 −32.1 dBm
 −42.1 dBm
 −52.1 dBm.

11. Preset the HP 3326A and repeat steps 3 through 10 substituting channel B for channel A, and channel A for channel B.

NOTE

When the combined output is enabled, the channel B output is disabled. Thus it is necessary to measure the channel B reference level at the channel B connector and the channel B combined output at the channel A connector.

2-21 INTEGRATED PHASE NOISE

EQUIPMENT REQUIRED:

DC Digital Voltmeter	HP 3455A
AC Voltmeter	HP 400FL
Sine Wave Signal Source	Oven Output of HP 3585A, HP 3325A, or HP 3326A
Mixer	HP 10534A
1 MHz Low Pass Filter	TTE Inc. J903 (Refer to Table 1-5 for address)
50 Ω Feed Thru Termination	HP 11048C

Components:

R1	Resistor 10 kΩ ±1% 1 ea HP Part No. 0757-0442
C1	Capacitor 1600 pF ±5% 1 ea HP Part No. 0160-2223

SPECIFICATIONS:

Integrated Phase Noise: For a 30 kHz band centered on a 10 MHz carrier (excluding ±1 Hz about the carrier).
With option 001: < −63 dBc
With standard instrument: typically < −60 dBc

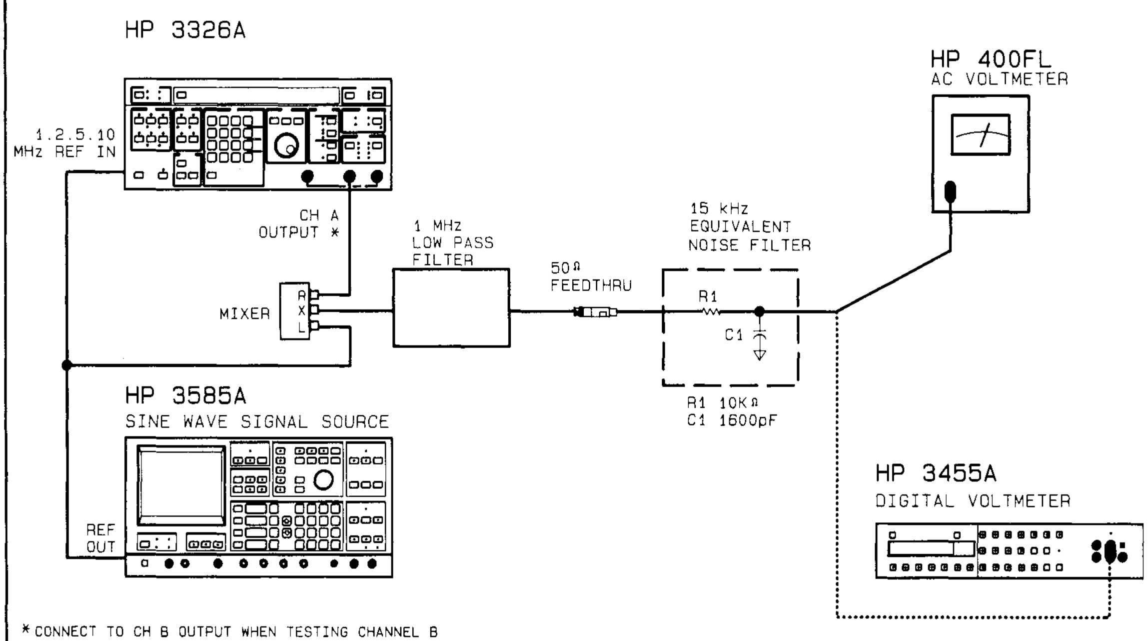

Figure 2-11. Integrated Phase Noise Test

INTEGRATED PHASE NOISE TEST:

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-11):

- HP 3326A CH A output to mixer R input
- Mixer X output to 1 MHz low pass filter input
- 1 MHz low pass filter output to 50 Ω feed thru termination
- 50 Ω feed thru termination to 15 kHz equivalent noise filter input
- 15 kHz equivalent noise filter output to ac voltmeter input
- Sine wave signal source 10 MHz temperature stabilized frequency reference (oven) output to HP 3326A 1,2,5,10 MHz REF INput
- Sine wave signal source 10 MHz temperature stabilized frequency reference (oven) output to mixer L input

NOTE

The 15 kHz equivalent noise filter is constructed in a small metal box with two BNC connectors. The components for the 15 kHz equivalent noise filter are listed under Equipment Required.

3. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	10.001 MHz
AMPLITUDE	0 dBm

4. Record the ac voltmeter reading (dB scale).

5. Change the HP 3326A frequency to 10 MHz.

6. Connect the 15 kHz filter output to the dc digital voltmeter.

7. Press the HP 3326A PHASE key. Using the MODIFY controls, adjust the HP 3326A phase for a minimum reading on the dc digital voltmeter.

8. Disconnect the 15 kHz filter output from the dc digital voltmeter and connect it to the ac voltmeter.

9. Record the ac voltmeter reading (dB scale) and subtract it from the previous reading and record on the Performance Test Record. The difference should be −63 dB or less.

10. Repeat steps 1 through 9 substituting channel B for channel A.

2-22 SQUARE WAVE OVERSHOOT AND RISE/FALL TIME

EQUIPMENT REQUIRED:

Sampling Oscilloscope with 7T11/7S11	TEK7603 and S-1
Attenuator	HP 355D

SPECIFICATIONS:

HP 3326A with Standard Output

Rise/fall time: ≤ 15 ns 10% to 90% at full output at 1 MHz.

Overshoot: ≤5% of peak-to-peak amplitude at full output at 1 MHz.

HP 3326A with High Voltage Output

Rise/fall time: ≤ 125 ns 10% to 90% at full output with 1 kΩ, 200 pF load.

Overshoot: ≤10% of peak-to-peak amplitude at full output with 1 kΩ, 200 pF load.

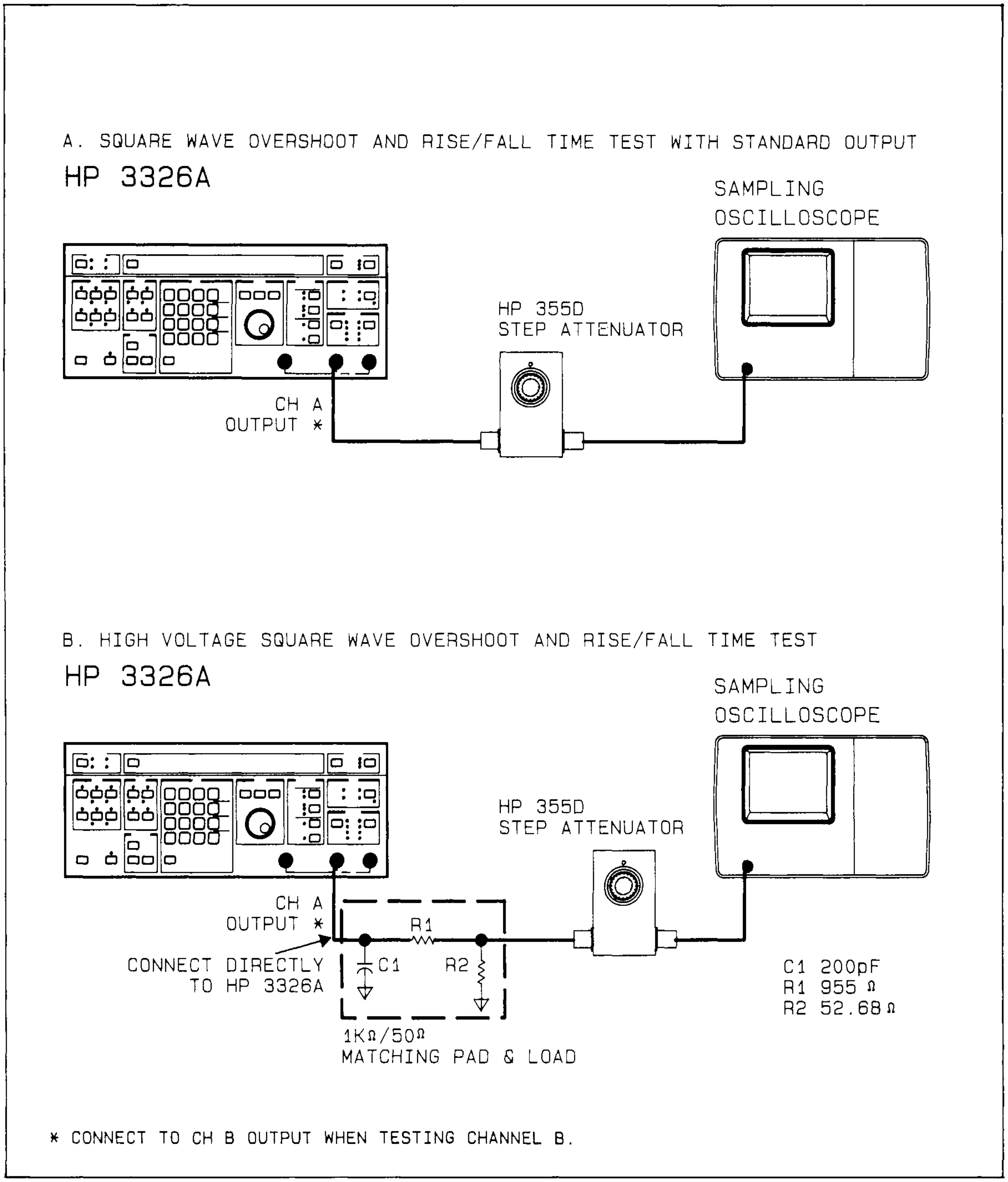

Figure 2-12. Square Wave Overshoot and Rise/Fall Time Test

SQUARE WAVE OVERSHOOT AND RISE/FALL TIME TEST

1. Preset the HP 3326A.
2. Connect the test equipment as follows (illustrated in Figure 2-12(A)):

   - HP 3326A CH A output to attenuator input
   - Attenuator output to sampling oscilloscope input

3. Set the attenuator for 40 dB attenuation.

4. Set the HP 3326A as follows:

CHANNEL	CH A
FUNCTION	Square Wave
FREQUENCY	1 MHz
AMPLITUDE	10 Vpp

5. Adjust the oscilloscope vertical and horizontal controls so that the square wave rise time between the 10% and 90% points can be measured. Rise time should be less than 15 ns.

6. Adjust the oscilloscope vertical and horizontal controls so that the square wave fall time between the 10% and 90% points can be measured. Fall time should be less than 15 ns.

7. Adjust the oscilloscope vertical and horizontal controls so that the square wave overshoot can be measured. Overshoot should be less than ±5% of peak-to-peak amplitude displayed on the oscilloscope.

8. Repeat steps 1 through 7 substituting channel B for channel A.

HIGH VOLTAGE SQUARE WAVE OVERSHOOT AND RISE/FALL TIME TEST

1. Preset the HP 3326A

2. Connect the test equipment as follows (illustrated in Figure 2-12 (B)):
   - HP 3326A CH A output to 1 kΩ/50 Ω matching pad and load input
   - 1 kΩ/50 Ω matching pad and load input to attenuator input
   - Attenuator output to sampling oscilloscope input

3. Set the attenuator for 10 dB attenuation.

4. Set the HP 3326A as follows:

CHANNEL	CH A
FUNCTION	Square Wave
FREQUENCY	1 MHz
AMPLITUDE	40 Vpp

5. Adjust the oscilloscope vertical and horizontal controls so that the square wave rise time between the 10% and 90% points can be measured. Rise time should be less than 125 ns.

6. Adjust the oscilloscope vertical and horizontal controls so that the square wave fall time between the 10% and 90% points can be measured. Fall time should be less than 125 ns.

7. Adjust the oscilloscope vertical and horizontal controls so that the square wave overshoot can be measured. Overshoot should be less than ±10% of peak-to-peak amplitude displayed on the oscilloscope.

8. Repeat steps 1 through 7 substituting channel B for channel A.

2-23 SQUARE WAVE SYMMETRY AND PULSE WIDTH ACCURACY

EQUIPMENT REQUIRED:

Universal Counter HP 5334A

SPECIFICATIONS:

Square Wave symmetry: ≤±1% of period + 6 ns.

Pulse Width accuracy: ≤±1% of period ±20 ns.

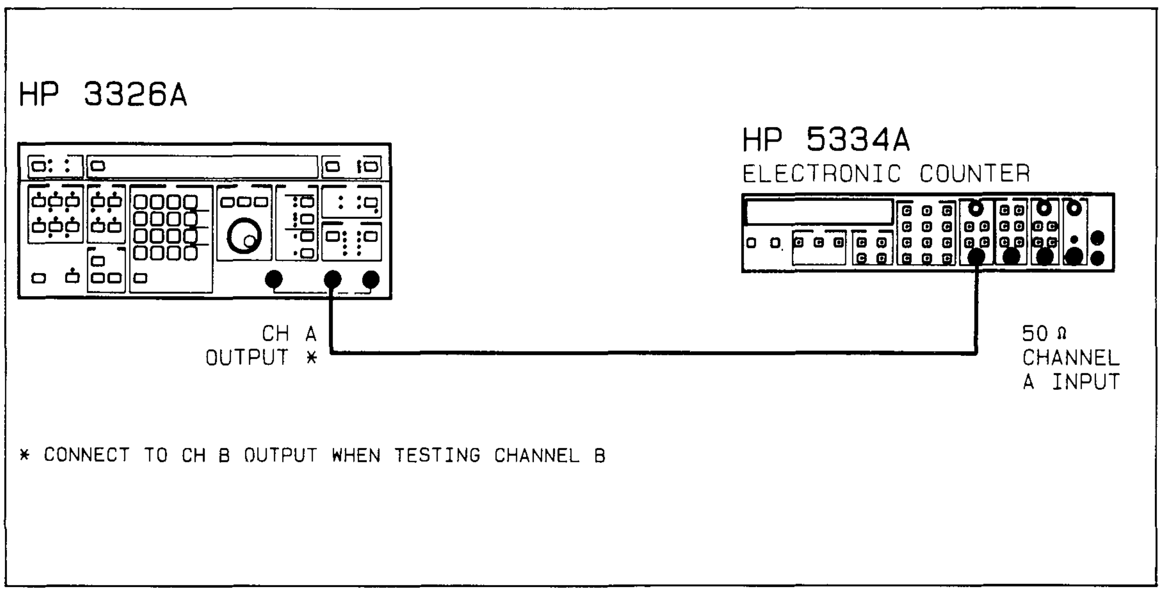

Figure 2-13. Square Wave Symmetry and Pulse Width Accuracy Test

SQUARE WAVE SYMMETRY TEST:

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-13):

   - HP 3326A CH A output to universal counter channel A 50 Ω input

3. Set the HP 3326A as follows:

FUNCTION	Square Wave
FREQUENCY	10 kHz
AMPLITUDE	1 Vrms

4. Set the universal counter to measure the positive pulse width and note the reading. For the HP 5334A:

COMMON INPUT (COM A)	OFF
PULSE WIDTH A	ON
AC COUPLING	OFF
50 Ω Z	ON
CHANNEL A SLOPE	Positive (LED Off)
GATE TIME ADJUSTED FOR STABLE READING	

5. Set the universal counter to measure the negative pulse width and note the reading. For the HP 5334A:

COMMON INPUT (COM A)	OFF
PULSE WIDTH A	ON
AC COUPLING	OFF
50 Ω Z	ON
CHANNEL A SLOPE	Negative (LED On)
GATE TIME ADJUSTED FOR STABLE READING	

6. The reading in step 4 should be equal to the reading in step 5 plus or minus 1 μs.

7. Change the HP 3326A frequency to 10 MHz and repeat steps 4 and 5. The reading in step 4 should be equal to the reading in step 5 plus or minus 7 ns.

8. Repeat steps 1 through 7 substituting channel B for channel A.

PULSE WIDTH ACCURACY:

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-13):

   - HP 3326A CH A output to universal counter channel A 50 Ω input

3. Set the HP 3326A as follows:

CHANNEL	CH A
MODE	PULSE
FREQUENCY	10 kHz
AMPLITUDE	2.8 Vpp
DUTY CYCLE	50 %

4. Set the universal counter to measure the positive pulse width and note the reading. For the HP 5334A:

COMMON INPUT (COM A)	OFF
PULSE WIDTH A	ON
AC COUPLING	OFF
50 Ω Z	ON
CHANNEL A SLOPE	Positive (LED Off)
GATE TIME ADJUSTED FOR STABLE READING	

5. The reading in step 4 should be equal to 1 μs plus or minus 1.02 μs.

6. Change the HP 3326A frequency to 10 MHz and measure the positive pulse width. The reading should be equal to 1 ns plus or minus 21 ns.

7. Repeat steps 1 through 5 substituting channel B for channel A.

2-24 DC ONLY ACCURACY

EQUIPMENT REQUIRED:

DC Digital Voltmeter	HP 3455A
50 Ω Feed Thru Termination	HP 11048C

Components:

* R1 947 Ω Resistor (parallel combination of two 2kΩ and one 18 kΩ resistors)
Resistor 2 kΩ 0.1% 0.5 W 2 ea HP Part No. 0698-8226
Resistor 18 kΩ 0.1% 0.125 W 1 ea HP Part No. 0698-8167

* R2 Resistor 52.68 Ω 0.1% 0.5 W 1 ea HP Part No. 0698-6060

* Used to test High Voltage (Option 002)

SPECIFICATIONS:

Standard HP 3326A

Range: 0 to ±5 V into 50 Ω
Accuracy (after performing self-calibration): ±75 mV

HP 3326A with High Voltage Option

DC Only Range: 0 to ±20 V
DC Only and DC Offset Accuracy: ±140 mV ±1% of setting for sine waves DC to 1 MHz, square waves DC to 50 kHz

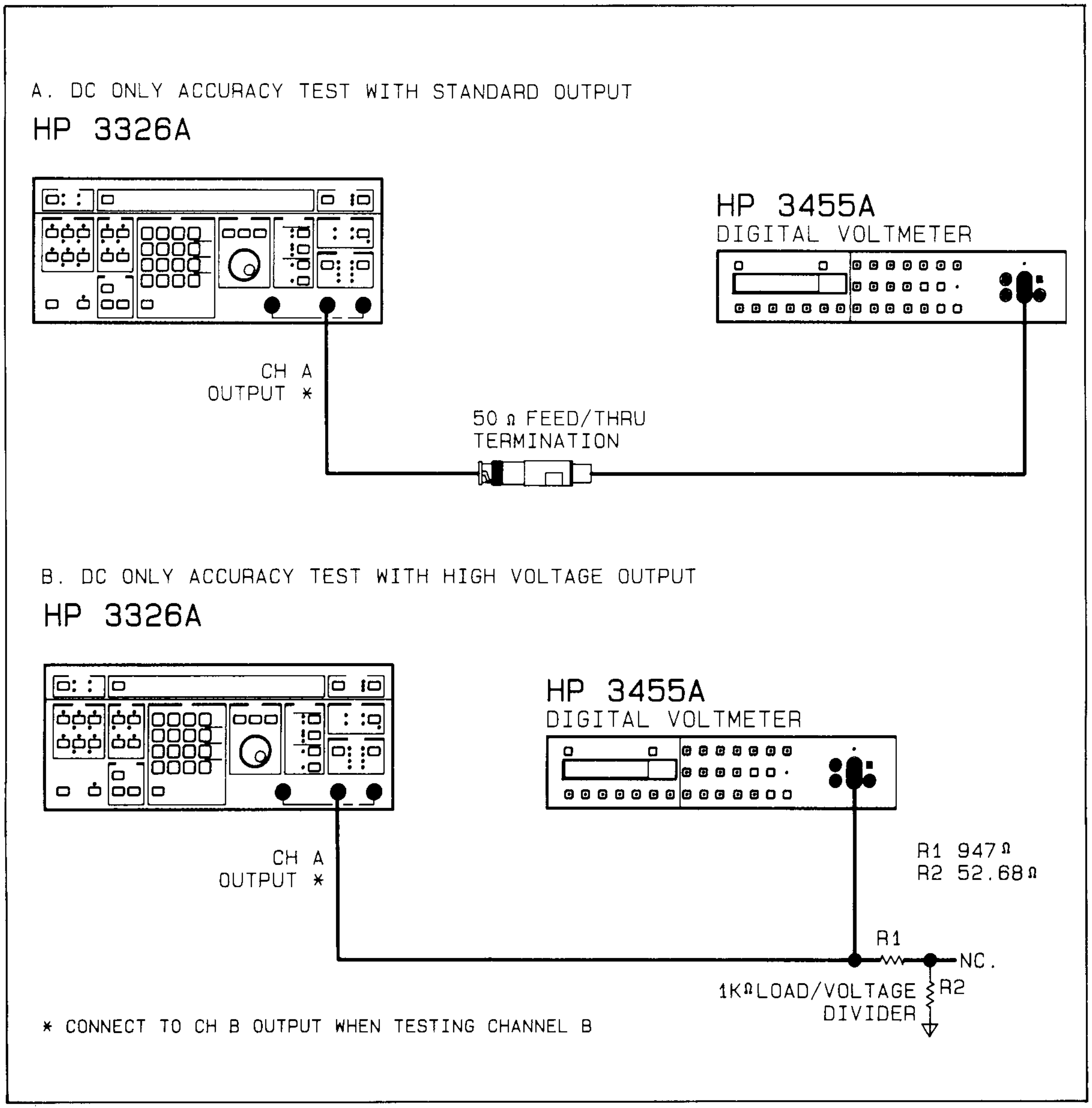

Figure 2-14. DC Only Accuracy Test

DC ONLY ACCURACY TEST WITH STANDARD OUTPUT:

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-14(A)):

   - HP 3326A CH A output through 50 Ω feed thru termination to dc digital voltmeter input

3. Set the HP 3326A as follows:

CHANNEL	CH A
FUNCTION	DC
DC OFFSET	5 V

4. Press the HP 3326A MANUAL calibration key.

5. Record the dc digital voltmeter reading. The voltmeter should read between +4.925 V and +5.075 V.

6. Change the HP 3326A dc offset to −5 V and press the HP 3326A MANUAL calibration key. Verify that the dc digital voltmeter reads between −4.925 V and −5.075 V.

7. Change the HP 3326A dc offset to 0 V and press the HP 3326A MANUAL calibration key. Verify that the dc digital voltmeter reads between −0.075 V and 0.075 V.

8. Repeat steps 1 through 7 substituting channel B for channel A.

DC ONLY ACCURACY TEST WITH HIGH VOLTAGE OUTPUT:

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-14(B)):

   - HP 3326A CH A output to dc digital voltmeter input
   - HP 3326A CH A output to 1 kΩ load/voltage divider input (do not connect 1 kΩ load/voltage divider output)

NOTE

The 1 kΩ load/voltage divider is constructed in a small metal box with two BNC connectors. The components for the 1 kΩ load/voltage divider are listed under Equipment Required.

3. Set the HP 3326A as follows:

CHANNEL	CH A
FUNCTION	DC
HIGH VOLTAGE	ON
DC OFFSET	20 V

4. Press the HP 3326A MANUAL calibration key.

5. Record the dc digital voltmeter reading. The voltmeter should read between +19.66 V and +20.34 V.

6. Change the HP 3326A dc offset to −20 V and press the HP 3326A MANUAL calibration key. Verify that the dc digital voltmeter reads between −19.66 V and −20.34 V.

7. Change the HP 3326A dc offset to 0 V and press the HP 3326A MANUAL calibration key. Verify that the dc digital voltmeter reads between −140 mV and 140 mV.

8. Repeat steps 1 through 7 substituting channel B for channel A.

2-25 DC OFFSET ACCURACY

EQUIPMENT REQUIRED:

DC Digital Voltmeter	HP 3455A
50 Ω Feed Thru Termination	HP 11048C

SPECIFICATIONS:

Standard Output

Range: Maximum DC Offset is a function of the selected AC amplitude.

	Function	
	Sine Wave	Square Wave*/Pulse*
10 Hz to 50 kHz	±2.0% of max DC	±2.0% of max DC
50 kHz to 1 MHz	±2.0% of max DC	±6.0% of max DC

* midpoint between peaks at 50% duty cycle

High Voltage

DC Offset Range: ±20 V independent of ac amplitude range. DC + AC peak must be less than 20 V.

DC Offset Accuracy: ±140 mV ±1% mV ±1% of setting for sine waves DC to 1 MHz, square waves DC to 50 kHz (Refer to DC Only Accuracy for test).

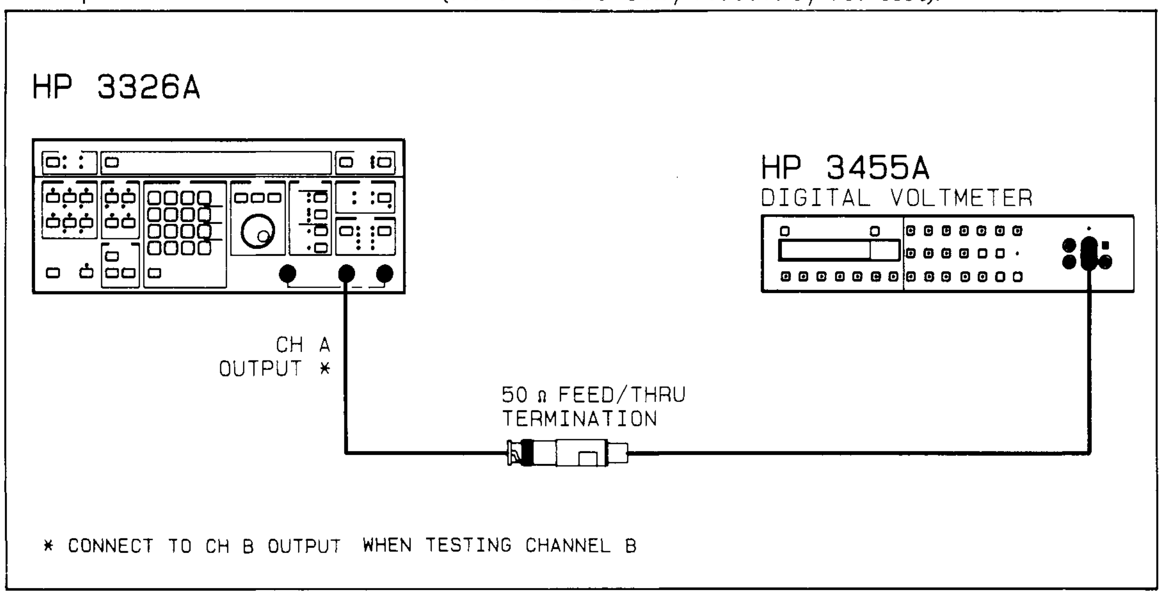

Figure 2-15. DC Offset Accuracy Test

DC OFFSET ACCURACY TEST:

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-15):

   - HP 3326A CH A output through 50 Ω feed thru termination to dc digital voltmeter input

3. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	13.0 MHz
AMPLITUDE	1 Vpp
DC OFFSET	4.5 V

4. Press the HP 3326A MANUAL calibration key.

5. After amplitude calibration the dc digital voltmeter reading should be between 4.27 Volts and 4.73 Volts.

6. Repeat steps 4 and 5 for the following dc offsets, frequencies, and tolerances:

FREQUENCY	DC OFFSET	TOLERANCE
13 MHz	−4.5 V	−4.73 V ≤ V ≤ −4.27 V
1 MHz	−4.5 V	−4.59 V ≤ V ≤ −4.41 V
1 MHz	+4.5 V	4.41 V ≤ V ≤ 4.59 V

7. Set the HP 3326A function to square wave.

8. Repeat steps 4 and 5 for the following dc offsets, frequencies, and tolerances:

FREQUENCY	DC OFFSET	TOLERANCE
50 kHz	−4.5 V	−4.73 V ≤ V ≤ −4.27 V
50 kHz	+4.5 V	4.27 V ≤ V ≤ 4.73 V
1 MHz	+4.5 V	4.23 V ≤ V ≤ 4.77 V
1 MHz	−4.5 V	−4.77 V ≤ V ≤ −4.23 V
13 MHz	−4.5 V	−4.77 V ≤ V ≤ −4.23 V
13 MHz	+4.5	4.23 V ≤ V ≤ 4.77 V

9. Repeat steps 1 through 8 substituting channel B for channel A.

2-26 PHASE OFFSET ACCURACY

EQUIPMENT REQUIRED:

Spectrum Analyzer	HP 3585A
Power Splitter	HP Part No. 11652-60009
Universal Counter	HP 5334A

SPECIFICATIONS:

Absolute accuracy: in degrees with the following output wave forms on Channels A and B, equal amplitude levels, and either internal phase calibration or external phase calibration (using a power splitter and equal length cables).

Sine/Sine Outputs:

Cal Mode	0.1 Hz – 10 Hz	10 Hz – 1 kHz	1 kHz – 100 kHz	100 kHz – 1 MHz	1 MHz – 13 MHz
Internal[1]	±0.5°	±0.2°	±0.2°	±0.3°	±2.0°
Internal[2]	±0.8°	±0.4°	±0.4°	±0.5°	±3.0°
External[1]	N/A	N/A	±0.2°	±0.3°	±2.0°

1 = Both amplitude levels between 1 V to 10 Vpp (+3.98 to +23.98 dBm)
2 = Both amplitude levels between 0.1 V to 10 Vpp (−16.02 to +23.98 dBm).

Square/Square Outputs:

Cal Mode	0.1 Hz – 10 Hz	10 Hz – 1 kHz	1 kHz – 100 kHz	100 kHz – 1 MHz	1 MHz – 13 MHz
Internal[1]	±0.5°	±0.2°	±0.2°	±0.7°	±5.0°
Internal[2]	±0.8°	±0.4°	±0.4°	±1.0°	±7.0°
External[1]	N/A	N/A	±0.2°	±0.7°	±5.0°

1 = Both amplitude levels between 1 V to 10 Vpp (+6.99 to +26.99 dBm).
2 = Both amplitude levels between 0.1 V to 10 Vpp (−13.01 to +26.99 dBm).

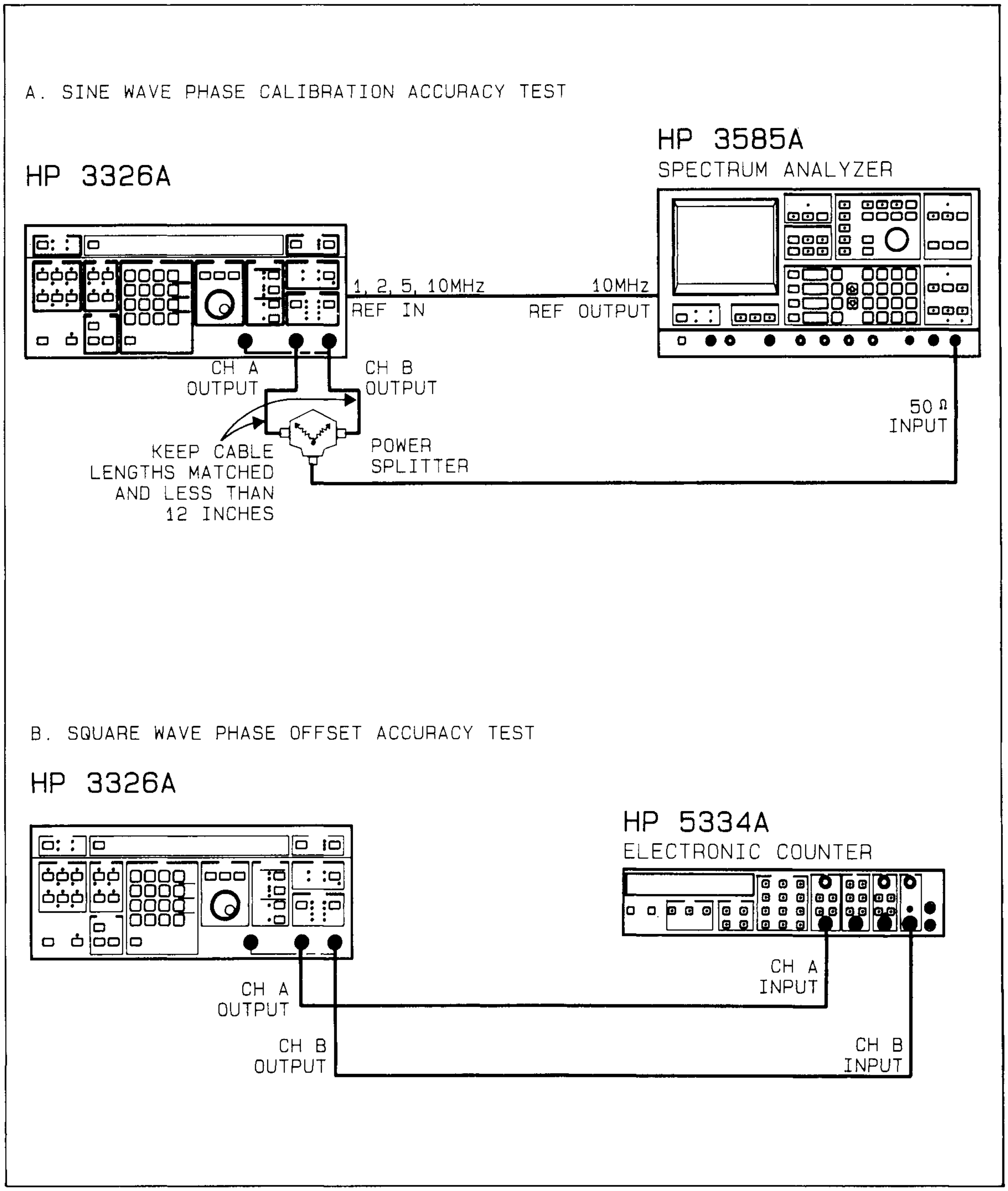

Figure 2-16. Phase Offset Accuracy Test

SINE WAVE PHASE ACCURACY TEST:

1. Preset the HP 3326A and spectrum analyzer.

2. Connect the equipment as follows (illustrated in Figure 2-16(A)):

   - HP 3326A CH A and CH B outputs to power splitter outputs

- Power splitter input to spectrum analyzer 50 Ω input
- HP 3326A 1,2,5,10 MHz REF INput to spectrum analyzer 10 MHz reference output (phase lock HP 3326A to spectrum analyzer)

NOTE

Keep the length of each cable connecting the HP 3326A to the power splitter less than 12 inches and equal in length.

3. Set the HP 3326A as follows:

CHANNEL	CH A
MODE	2 PHASE
AMPLITUDE	1.1 Vpp
FREQUENCY	13 MHz
CHANNEL	CH B
AMPLITUDE	1.1 Vpp
PHASE	180°

4. Tune the spectrum analyzer center frequency to the HP 3326A frequency and disable reference level tracking. For the HP 3585A spectrum analyzer:
   - Set the resolution bandwidth (RBW) to 3 Hz and video bandwidth (VBW) to 1 Hz.
   - Set the CENTER FREQUENCY to 13 MHz.
   - Set the FREQUENCY SPAN to 0 Hz.

NOTE

The speed of the measurement may be increased by manually tuning the spectrum analyzer to the fundamental and harmonic frequencies. The spectrum analyzer must be phase locked to the HP 3326A for accurate results with manual tuning. Manual tuning is used in the HP 3585A procedures.

5. Enable the CH B amplitude display on the HP 3326A.
6. Press the HP 3326A MANUAL calibration key to calibrate the HP 3326A.
7. Increase or decrease the CH B amplitude in 1 mV steps to obtain a minimum indication on the spectrum analyzer.
8. Press the HP 3326A MANUAL calibration key to calibrate the HP 3326A.
9. Enable the CH B phase display on the HP 3326A.
10. Increase or decrease the CH B phase to obtain a minimum indication on the spectrum analyzer.

11. Subtract the HP 3326A CH B phase reading from 180 to determine the HP 3326A phase accuracy. For 13 MHz, the phase accuracy is ±2.0°.

12. Repeat steps 3 through 11 using the following frequencies:

FREQUENCY	TEST LIMITS
1 kHz	±0.2°
100 kHz	±0.2°
1 MHz	±0.3°

SQUARE WAVE PHASE OFFSET ACCURACY TEST:

1. Preset the HP 3326A and reset the universal counter.

2. Connect the equipment as follows (illustrated in Figure 2-16(B)):

   - HP 3326A CH A output to universal counter channel A 50 Ω input
   - HP 3326A CH B output to universal counter channel B 50 Ω input

NOTE

Use 50 Ω loads if the universal counter does not have 50 Ω inputs.

3. Set the HP 3326A as follows:

CHANNEL	CH A
MODE	2 PHASE
FREQUENCY	100 kHz
AMPLITUDE	10 Vpp
FUNCTION	Square Wave
CHANNEL	CH B
AMPLITUDE	10 Vpp
FUNCTION	Square Wave

4. Set the universal counter to measure the time interval between the rising edge of the channel A signal and the rising edge of the channel B signal. For the HP 5334A counter:

ATTENUATOR	X 10
TIME INTERVAL A→B	ON
AUTO TRIGGER	OFF
TRIGGER LEVEL	(SENS ON) 0 V
COMMON INPUT (COM A)	OFF
AC COUPLING	OFF
50 Ω Z	ON
SLOPE	Positive (LED OFF)
GATE TIME ADJUSTED FOR STABLE READING	
100 GATE AVERAGE	ON

5. Press the HP 3326A MANUAL key to calibrate the HP 3326A, then the HP 3326A PHASE key to display phase.
6. Using the HP 3326A MODIFY controls, adjust the phase until the counter reads approximately 200 ns.
7. Record the universal counter reading (to 2 decimal places) on the Performance Test Record in the space for "Counter Reference."
8. Press the HP 3326A blue SHIFT key followed by the ASGN ZERO ϕ key.
9. Set the HP 3326A CH B PHASE to −10°.
10. Record the counter reading (to 2 decimal places) on the Performance Test Record in the space for "Time Interval."
12. Subtract the time "Counter Reference" value from the "Time Interval" and record the difference in the space for "Phase Difference." This is the phase difference (in microseconds or nanoseconds) between the HP 3326A channels.
13. Verify that the phase difference is between 272.22 ns and 283.34 ns.
14. Set the HP 3326A phase to −100°.
15. Record the counter reading (to 2 decimal places) IN THE SPACE FOR 100° Increment Time Interval."
16. Enter the time difference between the "Zero Phase Time Interval" and the reading in the previous step in the "Time Difference" column. 't should be from 2722.22 ns to 2783.33 ns.

2-27 AMPLITUDE MODULATION

EQUIPMENT REQUIRED:

FREQUENCY SYNTHESIZER	HP 3325A
MODULATION ANALYZER	HP 8901A
SPECTRUM ANALYZER	HP 3585A

SPECIFICATIONS:

The following specifications apply at 10 MHz carrier frequency, 1 kHz modulation source:

Envelope distortion: < −46 dB (at 80% modulation depth)

Incidental PM: ≤ 5° peak (at 50% modulation depth)

Modulation depth accuracy (internal only): ±5% of setting (at 80% modulation depth)

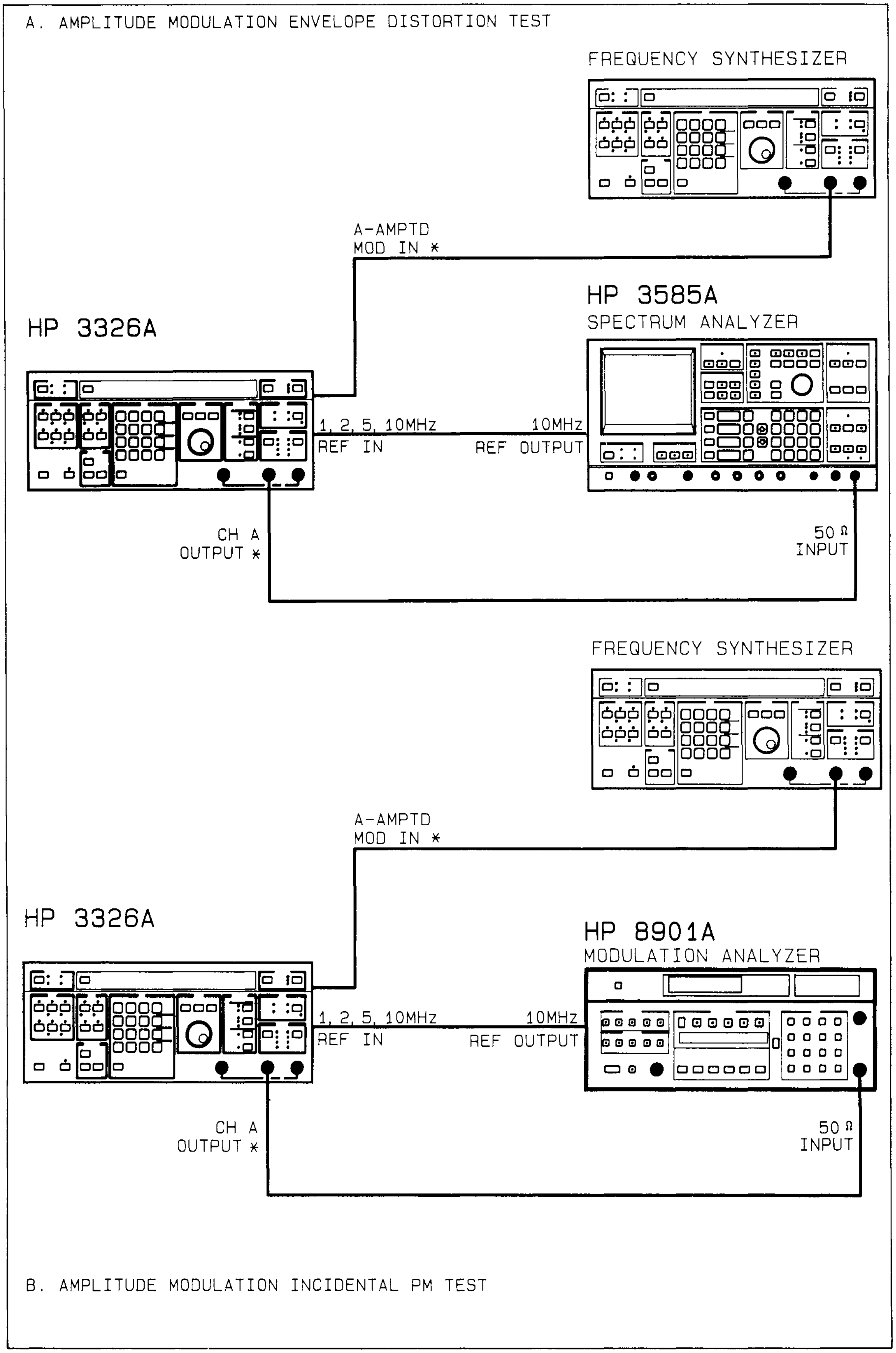

Figure 2-17. Amplitude Modulation Test

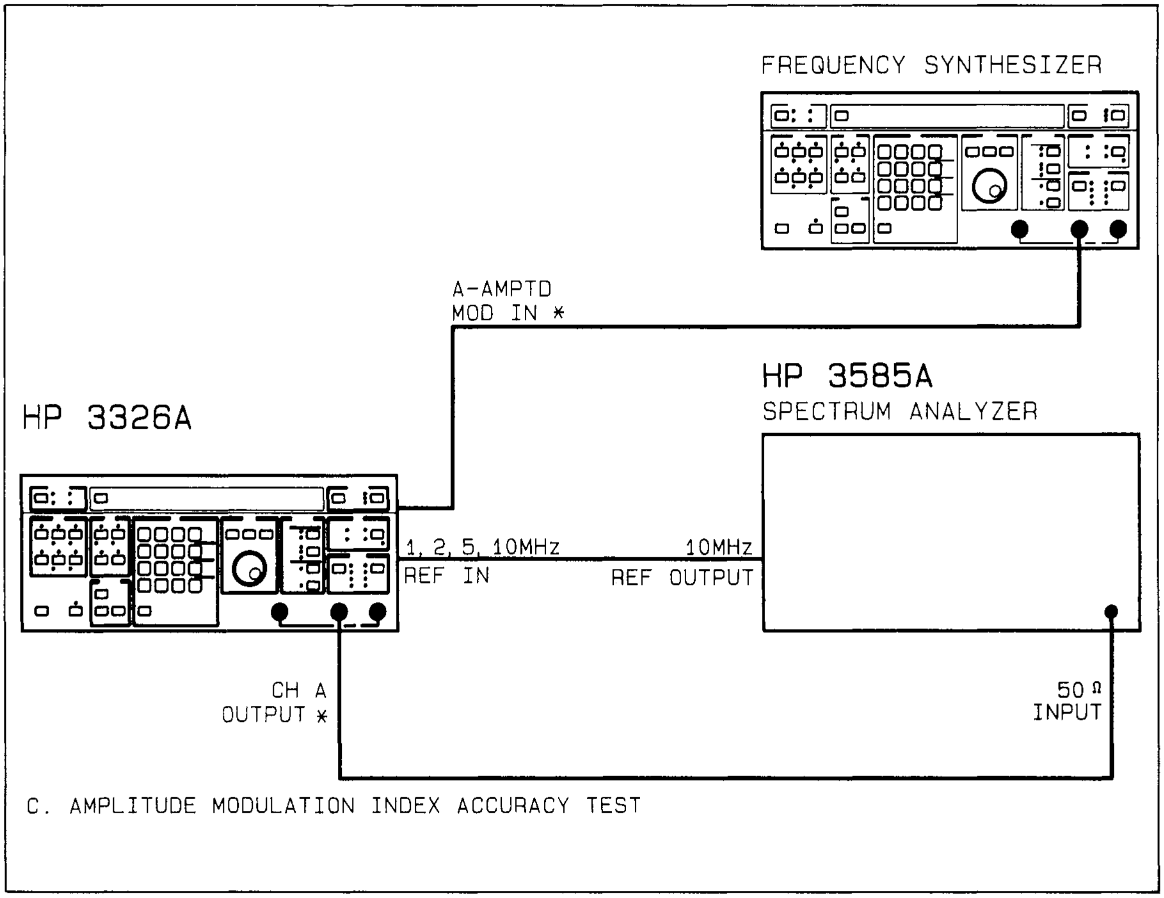

Figure 2-17. Amplitude Modulation Test (continued)

AMPLITUDE MODULATION ENVELOPE DISTORTION TEST:

1. Preset the HP 3326A and spectrum analyzer.

2. Connect the test equipment as follows (illustrated in Figure 2-17(A)):

   - Frequency synthesizer output to HP 3326A rear panel A-AMPTD MOD INput
   - HP 3326A CH A output to spectrum analyzer 50 Ω input
   - HP 3326A 1,2,5,10 MHz REF INput to spectrum analyzer 10 MHz reference output (phase lock HP 3326A to spectrum analyzer)

3. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	10 MHz
AMPLITUDE	3 Vpp
EXTERNAL AM	ON

4. Set the frequency synthesizer to 1 kHz and adjust the level to produce 80% modulation of the HP 3326A output. 80% modulation is indicated by modulation sidebands being 8.0 dB down from the carrier as viewed on the 2 dB/div display of the spectrum analyzer.

5. Adjust the spectrum analyzer to display the fundamental frequency, the 10 kHz sideband frequency, and at least 4 harmonics of the sidebands. All harmonics should be at least 46 dB lower than the modulation sidebands.

6. Repeat steps 1 through 5 substituting channel B for channel A, and B-AMPTD MOD IN for A-AMPTD MOD IN.

AMPLITUDE MODULATION INCIDENTAL PM TEST:

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-17(B)):

   - Frequency synthesizer output to HP 3326A rear panel A-AMPTD MOD INput
   - HP 3326A CH A output to modulation analyzer 50 Ω input
   - HP 3326A 1,2,5,10 MHz REF INput to modulation analyzer time base 10 MHz output (phase lock HP 3326A to modulation analyzer)

3. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	10 MHz
AMPLITUDE	13.98 dBm
EXTERNAL AM	ON

4. Set the modulation analyzer to measure amplitude modulation. For the HP 8901A:

MEASUREMENT	AM
DETECTOR	PEAK +
AUTOMATIC OPERATION	Enabled

5. Set the frequency synthesizer for 1 kHz and adjust the amplitude for an 50% modulation depth on the HP 3326A as measured by the modulation analyzer.

6. Set the modulation analyzer for phase modulation. For the HP 8901A:

MEASUREMENT	ϕM
DETECTOR	PEAK +
FM DE-EMPHASIS	OFF
AUTOMATIC OPERATION	Enabled

7. Verify that the incidental PM is ≤ 0.087 radians (5°).

8. Change the modulation analyzer detector to PEAK − and verify that the incidental PM is ≤ 0.087 radians (5°).

9. Repeat steps 1 through 8 substituting channel B for channel A, and B-AMPTD MOD IN for A-AMPTD MOD IN.

AMPLITUDE MODULATION DEPTH ACCURACY TEST:

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-17(C)):

   - Frequency synthesizer output to HP 3326A rear panel A-AMPTD MOD INput
   - HP 3326A CH A output to modulation analyzer 50 Ω input
   - HP 3326A 1,2,5,10 MHz REF INput to modulation analyzer time base 10 MHz reference output (phase lock HP 3326A to modulation analyzer)

3. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	10 MHz
AMPLITUDE	17.96 dBm
INTERNAL AM	ON
CHANNEL	CH B
FREQUENCY	1 kHz
% AM/PM DEVIATION	80%

4. Set the modulation analyzer for amplitude modulation. For the HP 8901A:

MEASUREMENT	AM
DETECTOR	PEAK +
AUTOMATIC OPERATION	Enabled

5. Verify that the modulation analyzer reads 80% ± 5%.

2-28 PHASE MODULATION

EQUIPMENT REQUIRED:

FREQUENCY SYNTHESIZER	HP 3325A
MODULATION ANALYZER	HP 8901A
SPECTRUM ANALYZER	HP 3585A

SPECIFICATIONS:

Linearity: ±0.5%, best fit straight line

Distortion (10 MHz Carrier Frequency, 1 kHz Modulation Rate): ≤ −50 dB for less than ±45° peak deviation, ≤ −37 dB at ±90° peak deviation at 200Hz rate.

Internal Modulation Phase Deviation Accuracy: 5% of setting, 200 Hz rate, > deviation

Incidental AM: < 0.5% at 360°

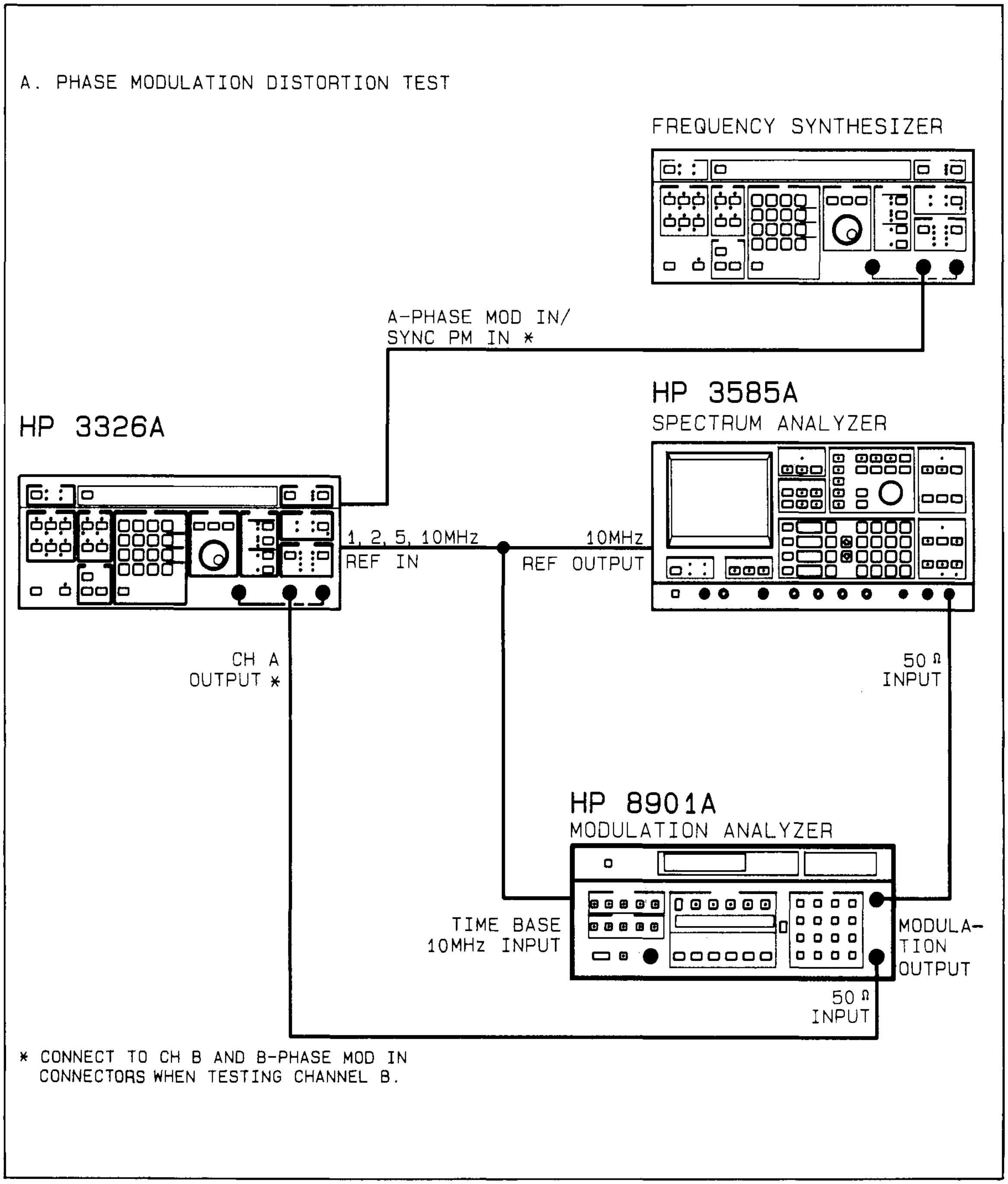

Figure 2-18. Phase Modulation Test

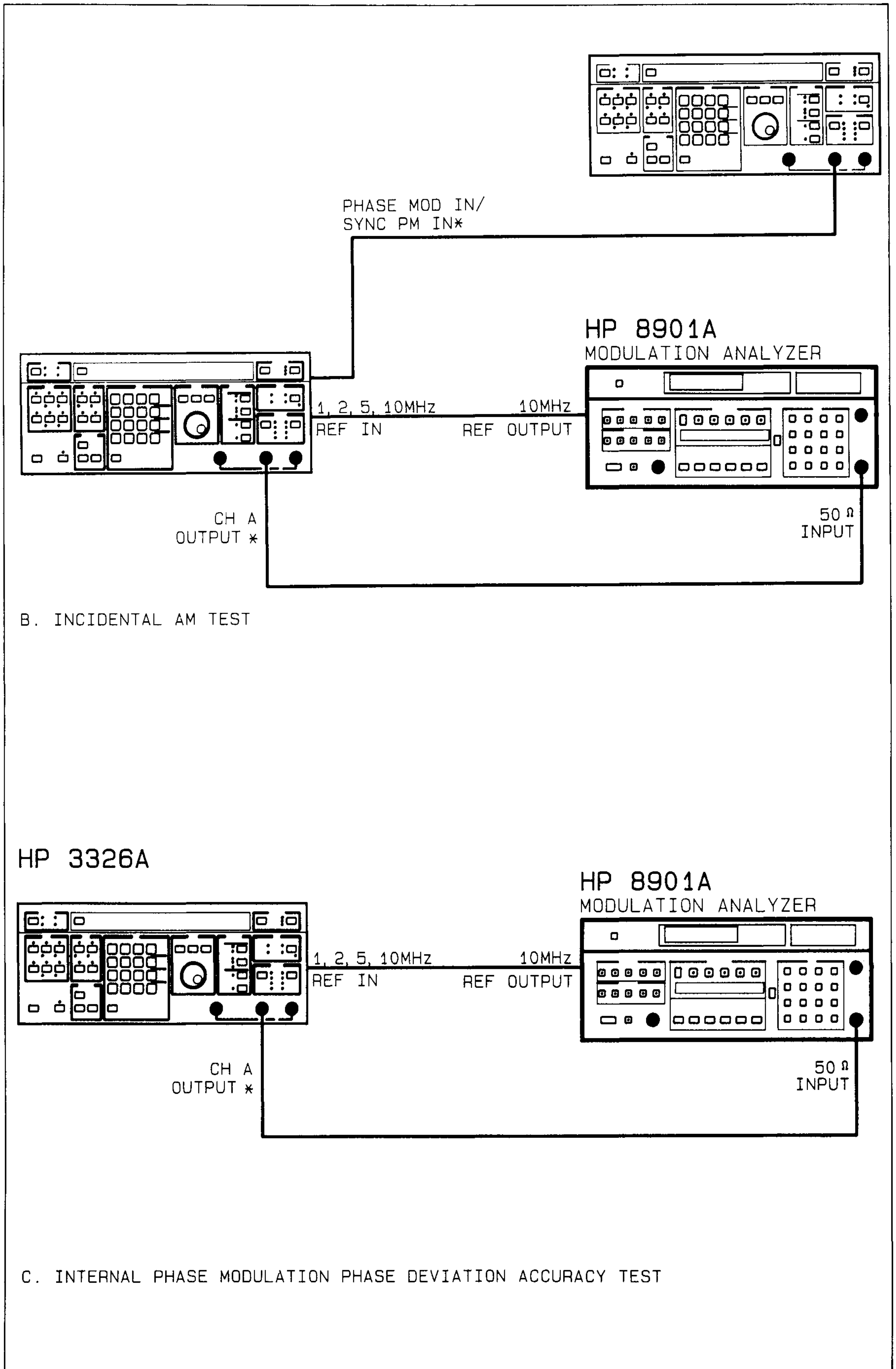

Figure 2-18. Phase Modulation Test (continued)

PHASE MODULATION DISTORTION TEST:

1. Preset the HP 3326A and spectrum analyzer.

2. Connect the test equipment as follows (illustrated in Figure 2-18(A)):

   - Frequency synthesizer output to HP 3326A rear panel A-PHASE MOD IN/SYNC PM INput
   - HP 3326A CH A output to modulation analyzer 50 Ω input
   - Modulation analyzer demodulated output to spectrum analyzer 50 Ω input
   - HP 3326A 1,2,5,10 MHz REF INput to spectrum analyzer 10 MHz reference output (phase lock HP 3326A to spectrum analyzer)
   - Frequency synthesizer 10 MHz reference input to spectrum analyzer 10 MHz reference output (phase lock frequency synthesizer to spectrum analyzer)

3. Set the HP 3326A as follows:

CHANNEL	CH A
FREQUENCY	10 MHz
AMPLITUDE	23.98 dBm
EXTERNAL PM	ON

4. Set the frequency synthesizer for an amplitude of 0.125 Vpp and frequency of 1 kHz output to modulate the HP 3326A. (The 0.125 Vpp should produce approximately 45° (0.78 radians) of modulation.)

5. Set the modulation analyzer for phase modulation. For the HP 8901A:

MEASUREMENT	ϕM
DETECTOR	PEAK +
AUTOMATIC OPERATION	Enabled

6. Measure the sidebands with respect to the 1 kHz modulating frequency with the spectrum analyzer. Verify that the sidebands are at least 50 dB below the 1 kHz carrier.

7. Set the frequency synthesizer for an amplitude of 0.25 Vpp and frequency of 1 kHz output to modulate the HP 3326A. (The 0.25 Vpp should produce approximately 90° (1.57 radians) of modulation.)

8. Measure the sidebands with respect to the 1 kHz modulating frequency with the spectrum analyzer. Verify that the sidebands are at least 37 dB below the 1 kHz carrier.

9. Repeat steps 1 through 8 substituting channel B for channel A and B-PHASE MOD IN for A-PHASE MOD IN/SYNC PM IN.

INCIDENTAL AM TEST:

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-18(B)):

   - Frequency synthesizer output to HP 3326A rear panel A-PHASE MOD IN/SYNC PM INput
   - HP 3326A CH A output to modulation analyzer 50 Ω input
   - HP 3326A 1,2,5,10 MHz REF INput to modulation analyzer time base 10 MHz reference output (phase lock HP 3326A to modulation analyzer)

3. Set the HP 3326A follows:

CHANNEL	CH A
FREQUENCY	10 MHz
AMPLITUDE	23.98 dBm
EXTERNAL PM	ON

4. Set the modulation analyzer to measure phase modulation. For the HP 8901A:

MEASUREMENT	PM
DETECTOR	PEAK +
AUTOMATIC OPERATION	Enabled

5. Set the frequency synthesizer for a 1 kHz output. Adjust the frequency synthesizer level to obtain 6.28 radians (360°) modulation on the modulation analyzer.

6. Set the modulation analyzer for amplitude modulation. For the HP 8901A:

MEASUREMENT	AM
DETECTOR	PEAK +
AUTOMATIC OPERATION	Enabled

7. Verify that the incidental AM is $\leq$0.5%.

8. Repeat the steps 1 through 7 substituting channel B for channel A, and B-PHASE MOD IN for A-PHASE MOD IN.

2-29 SYNC A OUTPUT

EQUIPMENT REQUIRED:

OSCILLOSCOPE HP 1740A

SPECIFICATIONS:

Square wave with the same frequency as channel A.

Level: $V_{high} \geq 1.2$ V; $V_{low} \leq 0.2$ V into 50 Ω

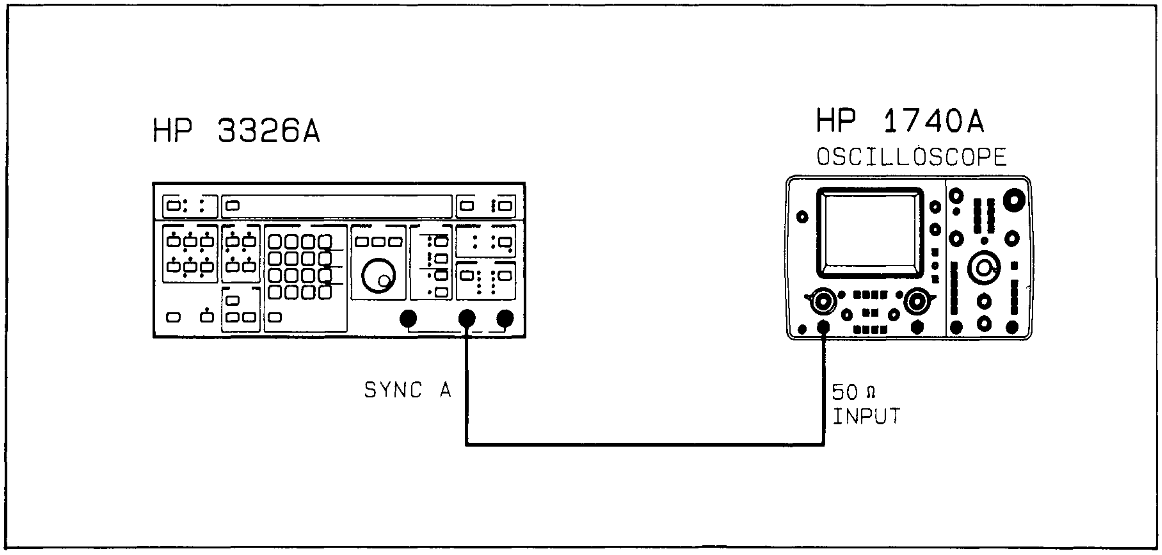

Figure 2-19. SYNC A Output Test

SYNC A OUTPUT TEST:

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-19):

   • HP 3326A SYNC A output to oscilloscope vertical 50 Ω input

NOTE

If the oscilloscope does not have a 50 Ω input, a 50 Ω feed thru termination (HP 11048C) may be used.

3. Set the HP 3326A channel A frequency to 13 MHz.

4. Set the oscilloscope to measure the high and low levels of the sync square wave.

5. Record the measurement on the Performance Test Record and verify that the high level is greater than +1.2 V and the low level is less than +0.2 V.

2-30 X-DRIVE LINEARITY

EQUIPMENT REQUIRED:

HIGH SPEED DIGITAL VOLTMETER	HP 3437A
BNC-TO-TRIAX ADAPTER HP PART NO.	1250-0595

SPECIFICATIONS:

Linearity: ±0.2% between 10% and 90% of ramp

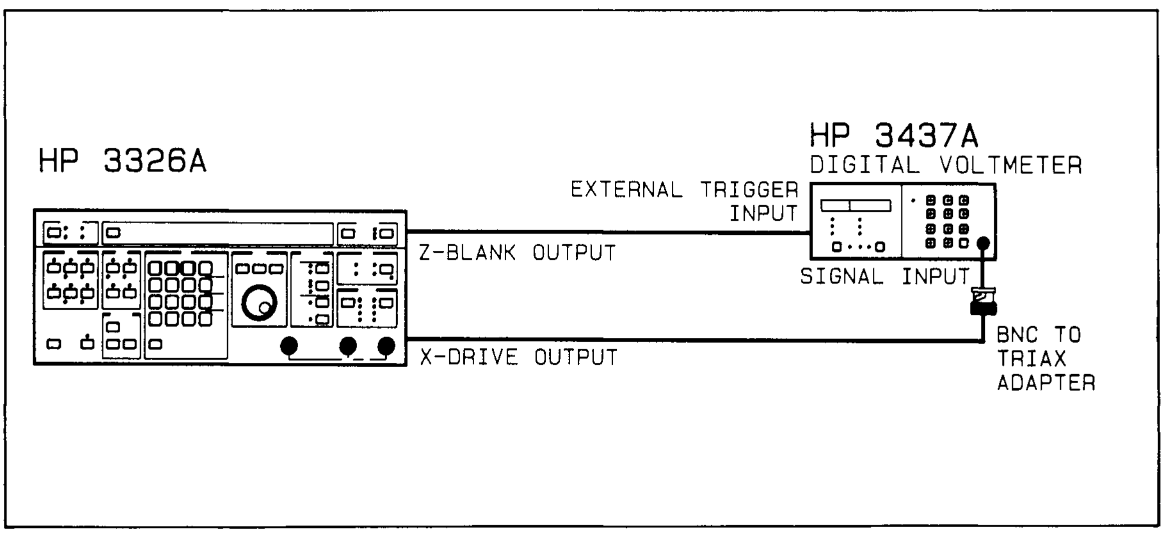

Figure 2-20. X-DRIVE Linearity Test

X-DRIVE LINEARITY TEST:

1. Preset the HP 3326A.

2. Connect the test equipment as follows (illustrated in Figure 2-20):

   - HP 3326A Z-BLANK output to voltmeter external trigger input
   - HP 3326A X-DRIVE output to voltmeter input

3. Set the voltmeter as follows:

RANGE	10 V
NUMBER OF READINGS	1
TRIGGER	External

NOTE

The HP 3437A voltmeter triggers on the negative going edge of the HP 3326A's Z BLANK signal. This occurs at the start of each sweep up.

4. Set the HP 3326A as follows:

TIME	0.01 s
SWEEP TYPE	CONT

5. Set the voltmeter delay to each of the following times for X_n. For each delay time, record the voltage reading (Y_n) in column C of the X-Drive Linearity Work Sheet at the end of this procedure, and on the Performance Test Record in the "Measured Results" column. In both places, record this voltage to 3 decimal places.

   X_1 = 0.001 s
   X_2 = 0.002 s
   X_3 = 0.003 s
   X_4 = 0.004 s
   X_5 = 0.005 s
   X_6 = 0.006 s
   X_7 = 0.007 s
   X_8 = 0.008 s
   X_9 = 0.009 s

6. Total all the entries in column C on the X-Drive Linearity Work Sheet.

7. Multiply the corresponding entries in X-Drive Linearity Work Sheet column A and column C together. Enter the results to 5 decimal places in column D.

8. Total all the entries in column D.

9. Using the total values for C and D on the work sheet, compute the slope m and the Y-intercept b of the straight line from the following equations:

   $m = 16{,}667D - 83.333C$

   $b = 0.527778C - 83.333D$

10. Using the equation $Y = mX + b$, and the values determined for m and b, calculate a value Y for each X recorded in column A. Enter the results in the Specification column on the Performance Test Record.

11. Multiply each Calculated Value on the Performance Test Record by 0.002 and enter in the Tolerance column.

12. For the HP 3326A to pass this performance test, the Measured Results must equal the corresponding Calculated Value plus or minus the Tolerance.

X-Drive Linearity Work Sheet

A	B	C	D
$X_1 = 0.001$	$(X_1)^2 = 0.000001$	$Y_1 =$ ______	$0.001Y_1 =$ ______
$X_2 = 0.002$	$(X_2)^2 = 0.000004$	$Y_2 =$ ______	$0.002Y_2 =$ ______
$X_3 = 0.003$	$(X_3)^2 = 0.000009$	$Y_3 =$ ______	$0.003Y_3 =$ ______
$X_4 = 0.004$	$(X_4)^2 = 0.000012$	$Y_4 =$ ______	$0.004Y_4 =$ ______
$X_5 = 0.005$	$(X_5)^2 = 0.000025$	$Y_5 =$ ______	$0.005Y_5 =$ ______
$X_6 = 0.006$	$(X_6)^2 = 0.000036$	$Y_6 =$ ______	$0.006Y_6 =$ ______
$X_7 = 0.007$	$(X_7)^2 = 0.000049$	$Y_7 =$ ______	$0.007Y_7 =$ ______
$X_8 = 0.008$	$(X_8)^2 = 0.000064$	$Y_8 =$ ______	$0.008Y_8 =$ ______
$X_9 = 0.009$	$(X_9)^2 = 0.000081$	$Y_9 =$ ______	$0.009Y_9 =$ ______

$\Sigma A = 0.045$ $\Sigma B = 0.000285$ $\Sigma C =$ ______ $\Sigma D =$ ______

PERFORMANCE TEST RECORD
3326A TWO-CHANNEL SYNTHESIZER

Serial Number: ______________________

Test Performed by: ______________________

Date: ______________________

2-11 FREQUENCY ACCURACY

FREQUENCY	COUNTER READING	TEST LIMITS
10 MHz	__________	±50 Hz

2-12 HARMONIC DISTORTION

Standard Output

@ 13.98 dBm

FREQUENCY	HARMONIC LEVEL Channel A	Channel B	TEST LIMITS
160 Hz	__________	__________	< −80 dBc
910 Hz	__________	__________	< −80 dBc
47 kHz	__________	__________	< −80 dBc
91 kHz	__________	__________	< −80 dBc
300 kHz	__________	__________	< −65 dBc
910 kHz	__________	__________	< −65 dBc
13 MHz	__________	__________	< −50 dBc

@ 23.98 dBm

FREQUENCY	HARMONIC LEVEL Channel A	Channel B	TEST LIMITS
160 Hz	__________	__________	< −80 dBc
910 kHz	__________	__________	< −80 dBc
47 kHz	__________	__________	< −80 dBc
91 kHz	__________	__________	< −70 dBc
300 kHz	__________	__________	< −55 dBc
910 kHz	__________	__________	< −55 dBc
13 MHz	__________	__________	< −30 dBc

High Voltage Output

@ 12.64 Vpp

FREQUENCY	HARMONIC LEVEL Channel A	Channel B	TEST LIMITS
160 Hz	________	________	< −80 dBc
910 Hz	________	________	< −80 dBc
6.2 kHz	________	________	< −80 dBc
47 kHz	________	________	< −80 dBc
91 kHz	________	________	< −75 dBc
300 kHz	________	________	< −55 dBc
910 kHz	________	________	< −55 dBc

@ 40 Vpp

FREQUENCY	HARMONIC LEVEL Channel A	Channel B	TEST LIMITS
160 Hz	________	________	< −75 dBc
910 Hz	________	________	< −75 dBc
6.2 kHz	________	________	< −75 dBc
47 kHz	________	________	< −75 dBc
91 kHz	________	________	< −65 dBc
300 kHz	________	________	< −40 dBc
910 kHz	________	________	< −40 dBc

2-13 SPURIOUS SIGNALS

FREQUENCY	LARGEST SPURIOUS LEVEL Channel A	Channel B	TEST LIMITS
1 MHz	________	________	< −80 dBc
5.1 MHz	________	________	< −70 dBc
7 MHz	________	________	< −70 dBc
9 MHz	________	________	< −70 dBc
11 MHz	________	________	< −70 dBc
13 MHz	________	________	< −70 dBc

2-14 COMBINER IM DISTORTION

Standard Output

@ 17.96 dBm

CHANNEL A FREQUENCY	CHANNEL B FREQUENCY	Largest Third-Order Product Level	TEST LIMITS
20 Hz	120 Hz	______	< −70 dBc
900 kHz	1 MHz	______	< −70 dBc
999.9 kHz	1 MHz	______	< −70 dBc
13 MHz	13.1 MHz	______	< −45 dBc
13 MHz	13.0001 MHz	______	< −45 dBc

@ 17.95 dBm

CHANNEL A FREQUENCY	CHANNEL B FREQUENCY	Largest Third-Order Product Level	TEST LIMITS
20 Hz	120 Hz	______	< −80 dBc
900 kHz	1 MHz	______	< −80 dBc
999.9 kHz	1 MHz	______	< −80 dBc
13 MHz	13.1 MHz	______	< −65 dBc
13 MHz	13.0001 MHz	______	< −65 dBc

High Voltage Output

@ 20 Vpp

CHANNEL A FREQUENCY	CHANNEL B FREQUENCY	Largest Third-Order Product Level	TEST LIMITS
99.9 kHz	100.1 kHz	______	< −55 dBc
900 kHz	1 MHz	______	< −40 dBc
999.9 kHz	1 MHz	______	< −40 dBc

@ 6.31 Vpp

CHANNEL A FREQUENCY	CHANNEL B FREQUENCY	Largest Third-Order Product Level	TEST LIMITS
99.9 kHz	100.1 kHz	________	< −55 dBc
900 kHz	1 MHz	________	< −40 dBc
999.9 kHz	1 MHz	________	< −40 dBc

2-15 RETURN LOSS

INDEPENDENT OUTPUTS

FREQUENCY	RETURN LOSS		TEST LIMITS
	Channel A	Channel B	
1 MHz − 13 MHz	________	________	> 20 dB
100 kHz	________	________	> 23 dB

COMBINED OUTPUTS

FREQUENCY	RETURN LOSS	TEST LIMITS
1 MHz − 13 MHz	________	> 20 dB
100 kHz	________	> 23 dB

2-16 CHANNEL ISOLATION

2 CHANNEL MODE

CHANNEL A FREQUENCY	CHANNEL B FREQUENCY	Difference Between Measured Levels	TEST LIMITS
20 Hz	100 Hz	________	> 80 dB
20 Hz	1000 Hz	________	> 80 dB
20 Hz	10 kHz	________	> 80 dB
20 Hz	95 kHz	________	> 80 dB
20 Hz	950 kHz	________	> 80 dB
20 Hz	9.5 MHz	________	> 80 dB
20 Hz	12.9 MHz	________	> 80 dB
1.05 MHz	100 Hz	________	> 80 dB
1.05 MHz	1000 Hz	________	> 80 dB
1.05 MHz	10 kHz	________	> 80 dB
1.05 MHz	95 kHz	________	> 80 dB
1.05 MHz	950 kHz	________	> 80 dB
1.05 MHz	9.5 MHz	________	> 80 dB
1.05 MHz	12.9 MHz	________	> 80 dB
13 MHz	100 Hz	________	> 80 dB
13 MHz	1000 Hz	________	> 80 dB
13 MHz	10 kHz	________	> 80 dB
13 MHz	95 kHz	________	> 80 dB
13 MHz	950 kHz	________	> 80 dB
13 MHz	9.5 MHz	________	> 80 dB
13 MHz	12.9 MHz	________	> 80 dB

2 TONE MODE

CHANNEL A FREQUENCY	CHANNEL B FREQUENCY	Difference Between Measured Levels	TEST LIMITS
20 Hz	95.02 kHz	________	> 80 dB
20 Hz	130 Hz	________	> 80 dB
1.05 MHz	1.145 MHz	________	> 80 dB
1.05 MHz	1.0501 kHz	________	> 80 dB
12.9 MHz	12.995 MHz	________	> 80 dB
12.9 MHz	12.9001 MHz	________	> 80 dB

2 CHANNEL MODE

CHANNEL A FREQUENCY	CHANNEL B FREQUENCY	Difference Between Measured Levels	TEST LIMITS
100 Hz	20 Hz	________	> 80 dB
1000 Hz	20 Hz	________	> 80 dB
10 kHz	20 Hz	________	> 80 dB
95 kHz	20 Hz	________	> 80 dB
950 kHz	20 Hz	________	> 80 dB
9.5 MHz	20 Hz	________	> 80 dB
12.9 MHz	20 Hz	________	> 80 dB
100 Hz	1.05 Mhz	________	> 80 dB
1000 Hz	1.05 MHz	________	> 80 dB
10 kHz	1.05 MHz	________	> 80 dB
95 kHz	1.05 MHz	________	> 80 dB
950 kHz	1.05 MHz	________	> 80 dB
9.5 MHz	1.05 MHz	________	> 80 dB
12.9 MHz	1.05 MHz	________	> 80 dB
100 Hz	13 MHz	________	> 80 dB
1000 Hz	13 MHz	________	> 80 dB
10 kHz	13 MHz	________	> 80 dB
95 kHz	13 MHz	________	> 80 dB
950 kHz	13 MHz	________	> 80 dB
9.5 MHz	13 MHz	________	> 80 dB
12.9 MHz	13 MHz	________	> 80 dB

2 TONE MODE

CHANNEL A FREQUENCY	CHANNEL B FREQUENCY	Difference Between Measured Levels	TEST LIMITS
95.02 kHz	20 Hz	________	> 80 dB
130 Hz	20 Hz	________	> 80 dB
1.145 MHz	1.05 MHz	________	> 80 dB
1.0501 kHz	1.05 MHz	________	> 80 dB
12.995 MHz	12.9 MHz	________	> 80 dB
12.9001 MHz	12.9 MHz	________	> 80 dB

2-17 SINE WAVE AMPLITUDE ACCURACY

SINE WAVE ACCURACY (<100 kHz)

@ 23.98 dBm

TEST FREQUENCY	AC VOLTMETER Channel A	Channel B	TEST LIMITS
100 Hz	______	______	3.536 ± 0.041 Vrms
1 kHz	______	______	3.536 ± 0.041 Vrms
100 kHz	______	______	3.536 ± 0.041 Vrms

@ 3.98 dBm

TEST FREQUENCY	AC VOLTMETER Channel A	Channel B	TEST LIMITS
100 Hz	______	______	353.6 ± 8.1 mVrms
1 kHz	______	______	353.6 ± 8.1 mVrms
100 kHz	______	______	353.6 ± 8.1 mVrms

@ −36.02 dBm

TEST FREQUENCY	AC VOLTMETER Channel A	Channel B	TEST LIMITS
100 Hz	______	______	3.536 ± 0.081 mVrms
1 kHz	______	______	3.536 ± 0.081 mVrms
100 kHz	______	______	3.536 ± 0.081 mVrms

SINE WAVE AMPLITUDE FLATNESS (> 100 kHz)

@ 3.98 dBm

3.98 dBm sine wave 1 kHz reference reading ______ (A)

3.88 dBm reading ______ (B) 0.1 dB Difference (A − B) ______

3.68 dBm reading ______ (C) 0.3 dB Difference (A − C) ______

3.38 dBm reading ______ (D) 0.6 dB Difference (A − D) ______

TEST FREQUENCY	DC VOLTMETER Channel A	Channel B	TEST LIMITS
100 kHz	________	________	A ± (A − B)
1 MHz	________	________	A ± (A − C)
3 MHz	________	________	A ± (A − D)
5 MHz	________	________	A ± (A − D)
7 MHz	________	________	A ± (A − D)
11 MHz	________	________	A ± (A − D)
13 MHz	________	________	A ± (A − D)

@ 23.98 dBm

23.98 dBm sine wave 1 kHz reference reading ________ (E)
23.88 dBm reading ________ (F) 0.1 dB Difference (E − F) ________
23.68 dBm reading ________ (G) 0.3 dB Difference (E − G) ________
23.38 dBm reading ________ (H) 0.6 dB Difference (E − H) ________

TEST FREQUENCY	DC VOLTMETER Channel A	Channel B	TEST LIMITS
100 kHz	________	________	E ± (E − F)
1 MHz	________	________	E ± (E − G)
3 MHz	________	________	E ± (E − H)
5 MHz	________	________	E ± (E − H)
7 MHz	________	________	E ± (E − H)
9 MHz	________	________	E ± (E − H)
11 MHz	________	________	E ± (E − H)
13 MHz	________	________	E ± (E − H)

2-18 SQUARE WAVE/PULSE AMPLITUDE ACCURACY

SQUARE WAVE/PULSE AMPLITUDE ACCURACY <100 kHz)

@ 10 Vpp

TEST FREQUENCY	DC VOLTMETER Channel A	Channel B	TEST LIMITS
99.9 Hz	________	________	3.05 ± 0.03 Vpp
1 kHz	________	________	3.05 ± 0.03 Vpp
100 kHz	________	________	3.05 ± 0.03 Vpp

@ 3 Vpp

TEST FREQUENCY	DC VOLTMETER Channel A	Channel B	TEST LIMITS
99.9 Hz	________	________	3.000 ± 0.030 Vpp
1 kHz	________	________	3.000 ± 0.030 Vpp
100 kHz	________	________	3.000 ± 0.030 Vpp

@ 1 Vpp

TEST FREQUENCY	DC VOLTMETER Channel A	Channel B	TEST LIMITS
99.9 Hz	________	________	1.000 ±0.010 Vpp
1 kHz	________	________	1.000 ±0.010 Vpp
100 kHz	________	________	1.000 ±0.010 Vpp

SQUARE WAVE FLATNESS

CHECK ONE:

	CHANNEL A	CHANNEL B
PASS	________	________
FAIL	________	________

2-19 HIGH VOLTAGE AMPLITUDE ACCURACY

HIGH VOLTAGE AMPLITUDE ACCURACY (< 100 kHz)

Sine Wave

TEST FREQUENCY	VOLTMETER Channel A	Channel B	TEST LIMITS
2 kHz	________	________	14.14 ± 0.28 Vrms

Square Wave

TEST FREQUENCY	VOLTMETER Channel A	Channel B	TEST LIMITS
2 kHz	________	________	2.11 ± 0.25 Vpp

HIGH VOLTAGE AMPLITUDE FLATNESS (> 100 kHz)

CHECK ONE:

	Channel A	Channel B
PASS	______	______
FAIL	______	______

2-20 COMBINER AMPLITUDE ACCURACY

@ 17.9 dBm

TEST FREQUENCY	AMPLITUDE DIFFERENCE Channel A	Channel B	TEST LIMITS
100 Hz	______	______	±0.2 dB
130 kHz	______	______	±0.3 dB
130 kHz	______	______	±0.3 dB

@ 7.9 dBm

TEST FREQUENCY	AMPLITUDE DIFFERENCE Channel A	Channel B	TEST LIMITS
100 Hz	______	______	±0.2 dB
130 kHz	______	______	±0.3 dB
130 kHz	______	______	±0.3 dB

@ −2.1 dBm

TEST Frequency	AMPLITUDE DIFFERENCE Channel A	Channel B	TEST LIMITS
100 Hz	______	______	±0.2 dB
130 kHz	______	______	±0.3 dB
130 kHz	______	______	±0.3 dB

@ −12.1 dBm

TEST FREQUENCY	AMPLITUDE DIFFERENCE Channel A	Channel B	TEST LIMITS
100 Hz	______	______	±0.2 dB
130 kHz	______	______	±0.3 dB
130 kHz	______	______	±0.3 dB

@ −22.1 dB

TEST FREQUENCY	AMPLITUDE DIFFERENCE Channel A	Channel B	TEST LIMITS
100 Hz	________	________	±0.2 dB
130 kHz	________	________	±0.3 dB
130 kHz	________	________	±0.3 dB

@ −32.1 dBm

TEST FREQUENCY	AMPLITUDE DIFFERENCE Channel A	Channel B	TEST LIMITS
100 Hz	________	________	±0.2 dB
130 kHz	________	________	±0.3 dB
130 kHz	________	________	±0.3 dB

@ −42.1 dBm

TEST FREQUENCY	AMPLITUDE DIFFERENCE Channel A	Channel B	TEST LIMITS
100 Hz	________	________	±0.2 dB
130 kHz	________	________	±0.3 dB
130 kHz	________	________	±0.3 dB

±52.1 dBm

TEST FREQUENCY	AMPLITUDE DIFFERENCE Channel A	Channel B	TEST LIMITS
100 Hz	________	________	±0.2 dB
130 kHz	________	________	±0.3 dB
130 kHz	________	________	±0.3 dB

2-21 INTEGRATED PHASE NOISE

PHASE NOISE Channel A	Channel B	TEST LIMITS
________	________	< ± 63 dB

2-22 SQUARE WAVE OVERSHOOT AND RISE/FALL TIME

STANDARD OUTPUT

	CHANNEL A	CHANNEL B	TEST LIMITS
Rise Time	________	________	< 15 ns
Fall Time	________	________	< 15 ns
Overshoot	________	________	< ±5% of Vpp

HIGH VOLTAGE OUTPUT

	CHANNEL A	CHANNEL B	TEST LIMITS
Rise Time	________	________	< 125 ns
Fall Time	________	________	< 125 ns
Overshoot	________	________	< ±10% of Vpp

2-23 SQUARE WAVE SYMMETRY AND PULSE WIDTH ACCURACY

SQUARE WAVE SYMMETRY

@ 10 kHz

	CHANNEL A	CHANNEL B	TEST LIMITS
Negative Pulse Width	________	________	
Positive Pulse Width	________	________	Negative Pulse Width = Positive Pulse Width ± 1 μs

@ 10 MHz

	CHANNEL A	CHANNEL B	TEST LIMITS
Negative Pulse Width	________	________	Negative Pulse Width = Positive Pulse Width ± 7 ns
Positive Pulse Width	________	________	

PULSE WIDTH ACCURACY

@10 kHz

	CHANNEL A	CHANNEL B	TEST LIMITS
Pulse Width	________	________	1 μs ± 1.02 μs

@ 100 kHz

	CHANNEL A	CHANNEL B	TEST LIMITS
Pulse Width	________	________	1 ns ± 21 ns

2-24 DC ONLY ACCURACY

STANDARD OUTPUT

DC VOLTAGE	DC VOLTMETER READING Channel A	Channel B	TEST LIMITS
5 V	________	________	5.0 ± 0.075 V
−5 V	________	________	−5.0 ± 0.075 V
0 V	________	________	0.0 ± 0.075 V

HIGH VOLTAGE OUTPUT

DC VOLTAGE	DC VOLTMETER READING Channel A	Channel B	TEST LIMITS
20 V	________	________	20.0 ± 0.34 V
−20 V	________	________	−20.0 ± 0.34 V
0 V	________	________	0.0 ± 0.14 V

2-25 DC OFFSET ACCURACY

SINE WAVE

Frequency	DC Offset	DC Voltmeter Reading Channel A	Channel B	Test Limits
13 MHz	4.5 V	________	________	4.5 ± 0.23 V
13 MHz	−4.5 V	________	________	−4.5 ± 0.23 V
1 MHz	4.5 V	________	________	4.5 ± 0.09 V
1 MHz	−4.5 V	________	________	−4.5 ± 0.09 V

SQUARE WAVE

Frequency	DC Offset	DC Voltmeter Reading Channel A	Channel B	Test Limits
50 kHz	−4.5 V	________	________	−4.5 ± 0.23 V
50 kHz	+4.5 V	________	________	4.5 ± 0.23 V
1 MHz	4.5 V	________	________	4.5 ± 0.27 V
1 MHz	−4.5 V	________	________	−4.5 ± 0.27 V
13 MHz	4.5 V	________	________	−4.5 ± 0.27 V
13 MHz	+4.5 V	________	________	4.5 ± 0.27 V

2-26 PHASE OFFSET ACCURACY

FREQUENCY	PHASE DIFFERENCE	TEST LIMITS
13 MHz		±2.0°
1 kHz		±0.2°
100 kHz		±0.2°
1 MHz		±0.3°

SQUARE WAVE PHASE OFFSET ACCURACY TEST

Counter Reference ____________

PHASE	TIME INTERVAL	PHASE DIFFERENCE	TEST LIMITS
−10°		277.78 ± 5.56 ns	
−100°		2752.78 ± 30.56 ns	

2-27 AMPLITUDE MODULATION

AMPLITUDE MODULATION ENVELOPE DISTORTION

LARGEST HARMONIC		TEST LIMITS
Channel A	Channel B	
________	________	> 46 dB below sidebands

AMPLITUDE MODULATION INCIDENTAL PM

INCIDENTAL PM LEVEL		TEST LIMITS
Channel A	Channel B	
________	________	≤ 0.087 radians

AMPLITUDE MODULATION DEPTH ACCURACY

% AM	AM MEASUREMENT Channel A	Channel B	TEST LIMITS
80 %	______________	______________	± 5%

2-28 PHASE MODULATION

PHASE MODULATION DISTORTION

Aproximate Modulation DEVIATION	Largest Sideband Channel A	Channel B	Test Limits
45°	______________	______________	> 50 dB
90°	______________	______________	> 37 dB

INCIDENTAL AM

INCIDENTAL AM LEVEL Channel A	Channel B	TEST LIMITS
______________	______________	≤ 0.5%

2-29 SYNC-A OUTPUT

	AMPLITUDE	TEST LIMITS
High Level	______	> +1.2 V
Low Level	______	< +0.2 V.

2-30 X-DRIVE LINEARITY

	MEASURED RESULTS	CALCULATED VALUE	TEST LIMITS ±0.2% of Calculated Value
X_1 = 0.001	______	______	______
X_2 = 0.002	______	______	______
X_3 = 0.003	______	______	______
X_4 = 0.004	______	______	______
X_5 = 0.005	______	______	______
X_6 = 0.006	______	______	______
X_7 = 0.007	______	______	______
X_8 = 0.008	______	______	______
X_9 = 0.009	______	______	______

SECTION III
ADJUSTMENTS

SECTION III
ADJUSTMENTS

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SECTION III
ADJUSTMENTS

3-1 INTRODUCTION

This section describes adjustments required to set the HP 3326A Two-Channel Synthesizer to its peak operating condition. These procedures should NOT be performed as routine maintenance. It is only necessary to perform them if a performance test fails (Table 2-3) or if a board level repair has been made (Table 3-3).

Table 3-1 lists the adjustments and related information. Table 3-3 describes the adjustments that should be performed after repair of a board. Figure 3-1 shows the order in which the adjustments should be performed.

When an adjustment cannot be completed, see Table 3-2 for the list of boards that, if defective, could cause the adjustment to fail.

Table 3-1. Adjustment List

Adjustment		Reference Designator			Schematic Number
Number	Name	Ch A	Ch B	Common	
1	+15 V			A70R114	16
2	OVEN FREQ (FINE) OVEN FREQ (COARSE)			A80R101 A80U101	19
3	FREQ CENTER			A50R115	13
4	VCO FREQ	A31L1	A41L1		11a
5	100 kHz	A33R39	A43R39		11c
6	API #1 API #2 API #3 API #4	A33R84 A33R86 A33R132 A33R90	A43R84 A43R86 A43R132 A43R90		11c
7	V REF			A36R217	12
8	PEAK DETECT GAIN − PEAK DETECT GAIN +			A36R201 A36R205	12
9	A OFFSET B OFFSET			A21R2 A21R22	7
10	2:1 SPUR	A5R316	A15R316		5
11	2nd HARMONIC	A5R424	A15R424		5
12	DC OFFSET	A5R400	A15R400		5
13	FLATNESS	A5C400	A15C400		5
14	OVERSHOOT	A3C103	A13C103		3
15	HV OVERSHOOT	A1C149	A11C149		1
16	BIAS	A3R130	A13R130		3
17	BATTERY CHECK			A61BT1	14a

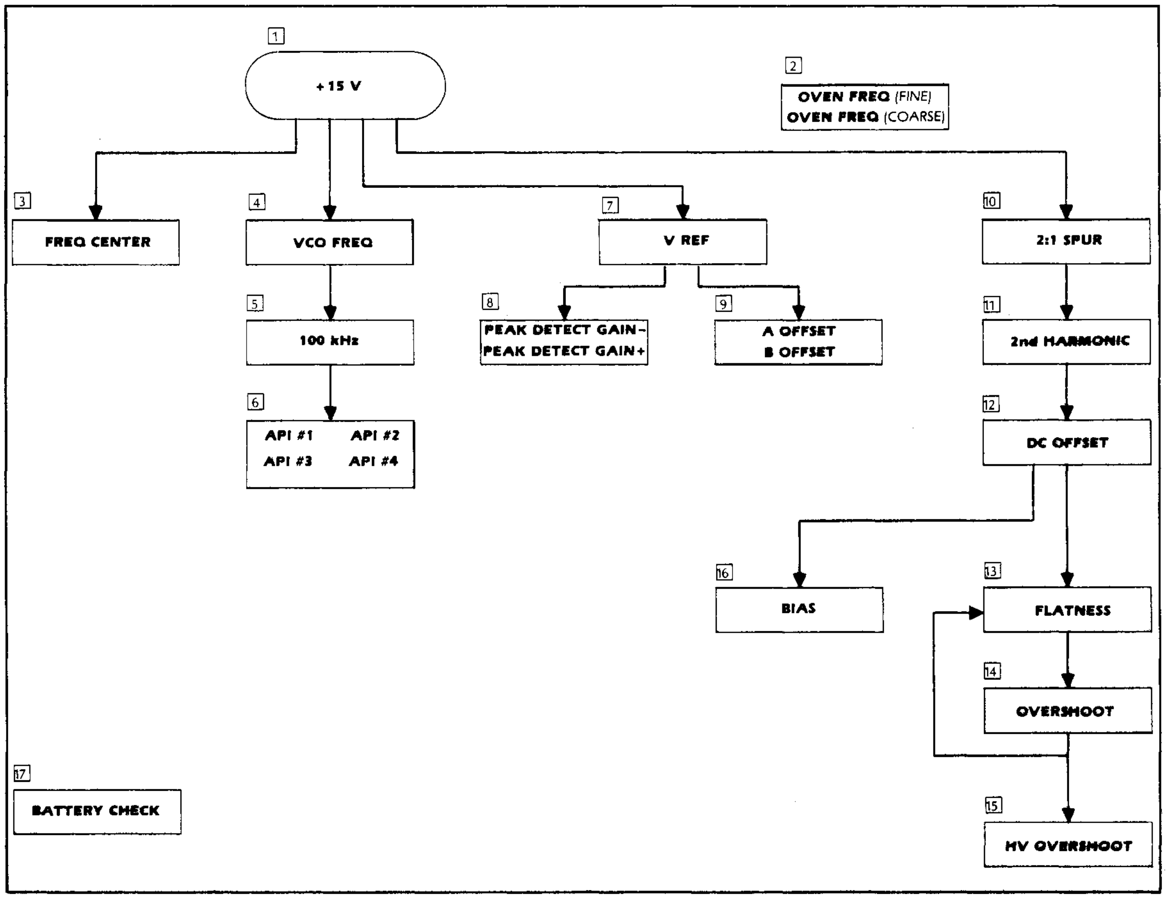


Figure 3-1. Adjustment Order

3-2 SAFETY CONSIDERATIONS

This manual contains information and warnings which must be followed to ensure safe operation and to retain the instrument in a safe condition (see safety summary page in the front of the manual). Service and adjustments should be performed only by qualified service personnel.

WARNING

Adjustments described in this section are performed with the protective covers removed and power applied. Energy available at many points can, if contacted, result in personal injury.

Maintenance described herein is performed with power supplied to the instrument and protective covers removed. Such maintenance should be performed by trained service personnel who are aware of the hazards involved (for example, fire and electrical shock). Primary power is supplied to the instrument whenever the line cord is attached, independent of the power switch position. Where maintenance can be performed without power applied, remove the power cord.

CAUTION

Do not insert or remove any circuit board in the HP 3326A with the line power turned on. Power transients caused by insertion or removal may damage the circuit boards.

3-3 FACTORY SELECTED COMPONENTS

There are no factory selected components in the HP 3326A.

3-4 REPAIRS FOR FAILED ADJUSTMENTS

When an adjustment cannot be completed, see Table 3-2 for the list of boards that, if defective, could cause the adjustment failure. The most likely board to cause the failure is listed first, the next most likely is listed second, and so on.

If Table 3-2 leads you to suspect a board that has a duplicate in the other channel, the best way to verify that the board is defective is to interchange the two identical boards. If the suspect board fails again while it is in the other channel, it is probably defective. This is the best method to solve subtle, non-catastrophic, failures.

3-5 POST-REPAIR ADJUSTMENTS

Table 3-3 lists the adjustments that need to be checked after a board is repaired. All adjustments on which a defective board could have an effect are listed with that board.

NOTE

Do not perform the full set of adjustments in the HP 3326A after a standard repair. Perform only the adjustments related to the repaired board (Table 3-3).

Table 3-2. Repairs for Failed Adjustments

Failed Adjustment		Suspect Boards				Schematic Number
Number	Name	Reference Designator			Name	
		Ch A	Ch B	Common		
1	+15 V			A70	Power Supply	16
2	Oven Freq			A80	Oven Reference	19
3	Freq Center			A50	Reference	13
				A70	Power Supply	16
4	VCO Freq	A31	A41		VCO	11a
		A32	A42		VCO Control	11b
		A33	A43		Phase Detector	11c
		A34	A44		FracN Digital	11d
5	100 kHz	A33	A43		Phase Detector	11c
		A32	A42		VCO Control	11b
		A31	A41		VCO	11a
		A34	A44		FracN Digital	11d
6	APIs †	A33	A43		Phase Detector	11c
		A34	A44		FracN Digital	11d
		A32	A42		VCO Control	11b
		A31	A41		VCO	11a
7	V Ref			A36	Calibrator	12
8	Peak Detect Gain			A36	Calibrator	12
9	A and B Offset			A21	Offset	7
				A36	Calibrator	12
				A70	Power Supply	16
10	2:1 Spur	A5	A15		Mixer	5
		A6	A16		Modulator	6
				A24	RF Switch	10
11	2nd Harmonic	A5	A15		Mixer	5
		A6	A16		Modulator	6
		A3	A13		Output Amp	3
		A4	A14		Preamp	4
				A24	RF Switch	10
12	DC Offset	A5	A15		Mixer	5
		A4	A14		Preamp	4
		A3	A13		Output Amp	3
				A23	Square	9
				A21	Offset	7
13	Flatness	A5	A15		Mixer	5
		A4	A14		Preamp	4
		A3	A13		Output Amp	3
		A2	A12		Attenuator	2a, 2b
14	Overshoot	A3	A13		Output Amp	3
				A23	Square	9
15	HV Overshoot	A1	A11		HV Amp	1
		A3	A13		Output Amp	3
				A23	Square	9
16	Bias	A3	A13		Output Amp	3
		A4	A14		Preamp	4
		A5	A15		Mixer	5
17	Battery Check			A61	Controller	14a

† For frequencies below 50 kHz, the API spurs coincide with the third and fifth harmonics of the main signal. If you cannot perform the adjustment at low frequencies, suspect A5, A4, A3, A2, and A1 (A15, A14, A13, A13, and A11).

Table 3-3. Post-Repair Adjustments

Repaired Boards		Related Adjustments	
Reference Designator	Name	Number	Name
A1, A11	HV Amp	15	HV Overshoot
A2, A12	Attenuator	13	Flatness
A3, A13	Output Amp	13 14 16	Flatness Overshoot Bias
A4, A14	Preamp	11 12 13	2nd Harmonic DC Offset Flatness
A5, A15	Mixer	10 11 12 13 14 16	2:1 Spur 2nd Harmonic DC Offset Flatness Overshoot Bias
A6, A16	Modulator	10 11	2:1 Spur 2nd Harmonic
A21	Offset	9	A and B Offset
A22	Level/AM	—	—
A23	Square	12 14	DC Offset Overshoot
A24	RF Switch	10 11	2:1 Spur 2nd Harmonic
A31, A41	VCO	4 5 6	VCO Freq 100 kHz APIs
A32, A42	VCO Control	5 6	100 kHz APIs
A33, A43	Phase Detector	5 6	100 kHz APIs
A34, A44	FracN Digital	5 6	100 kHz APIs
A35, A45	VCO ÷ 2	—	—
P/O A36	FracN Decoder	—	—
P/O A36	Calibrator	7 8 9	V Ref Peak Detect Gain A and B Offset
A50	Reference	3	Freq Center
A61	Controller	17	Battery Check
A62	Keyboard	—	—
A63	HP-IB Support	—	—
A70	Power Supply	1 3	+15 V Freq Center
A72	Front ESD	—	—
A75	Rear ESD	—	—
A80	Oven Reference	2	Oven Freq
A99	Motherboard	—	—

3-6 ADJUSTMENT #1, +15 V

DESCRIPTION: This procedure adjusts the +15V regulated supply and verifies the accuracy of the −15V and +5V supplies, which depend on the +15V supply for their references.

REFERENCE DESIGNATOR: A70R114
SCHEMATIC: 16

EQUIPMENT:

Digital voltmeter	HP 3455A

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. Preset the HP 3326A.

3. Connect the test equipment as follows:

   - Positive voltmeter terminal to TP105 (+15VDC) on power supply (A70)
   - Negative voltmeter terminal to GND (card nests)

NOTE

The +15 V adjustment must be performed while A70 is plugged into motherboard, in a fully loaded instrument.

4. Configure the voltmeter to measure Vdc.

5. Adjust R114 for a voltmeter reading of +15.000 ± 0.002 V.

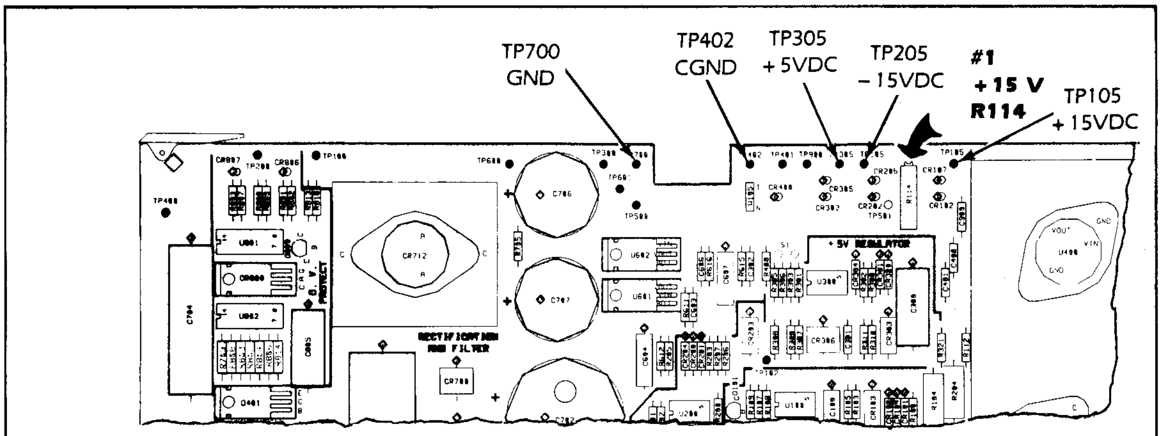
NOTE

The −15 V and +5 V supplies derive their reference from the +15 V supply. If the +15 V supply is not within specification, the other supplies cannot be measured accurately.

6. After the +15 V supply is adjusted properly, verify that the −15 V and +5 V supplies are working by checking TP205 and TP305, respectively. They should be −15.000 ± 0.020 V and +5.100 ± 0.060 V. If they are not the correct voltages, go to the power supply board level repair (sub-section 6-35).

7. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.



POWER SUPPLY BOARD (A70)

Figure 3-2. Adjustment #1 Location

3-7 ADJUSTMENT #2, OVEN FREQ

DESCRIPTION: This procedure is for instruments with the high stability frequency reference (Option 001). It adjusts the absolute frequency of the 10 MHz oven.

REFERENCE DESIGNATOR: Oven Freq (Coarse) A80U101
Oven Freq (Fine) A80R101

SCHEMATIC: 19

EQUIPMENT:

Oscilloscope	HP 1740A
USA National Bureau of Standards frequency standard	Radio Station WWV
Non-conductive adjustment tool	

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top and side covers. Reconnect main power cord and turn the instrument on.

NOTE

Instrument must be connected to ac power (either in STBY or ON) for at least 30 minutes before attempting this adjustment.

2. Preset the HP 3326A.

3. Connect the test equipment as follows:
   - HP 3326A rear panel 10MHz OVEN OUT, OPTION 001 output to 1,2,5,10MHz REF IN input
   - Frequency standard to oscilloscope external trigger connector (terminate frequency standard as required)
   - HP 3326A CH A output to oscilloscope 50 Ω input

4. Set the HP 3326A as follows:

Channel	CH A
Frequency	10 MHz
Amplitude	10 Vpp

5. Adjust the frequency of the oven reference using the coarse and fine adjustments.

   - Remove the screw from the coarse frequency adjustment in the end of the temperature controlled oven (U101) on the oven reference board (A80). This is accessible from the side of the instrument.
   - Using a non-conductive tool, adjust U101 for a stable CH A display as seen on the oscilloscope (as near stationary as possible).
   - Replace the screw in U101.
   - Adjust the fine frequency adjustment (R101) from the top of the instrument for a stable CH A display as seen on the oscilloscope (as near stationary as possible).

6. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the covers.

Refer to Table 3-2 if the adjustment cannot be completed.

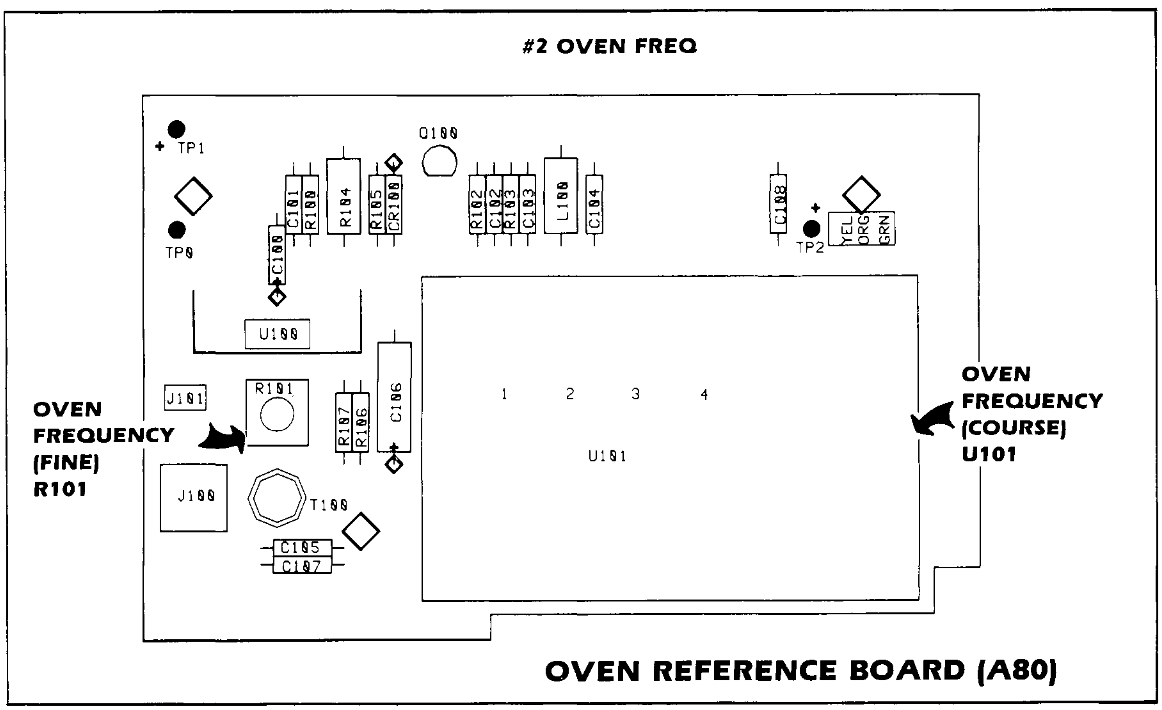


Figure 3-3. Adjustment #2 Location

3-8 ADJUSTMENT #3, FREQ CENTER

DESCRIPTION: This procedure adjusts the 20 MHz oscillator on the reference board (A50) to ensure the frequency accuracy of the HP 3326A. The adjustment is made with no external reference connected. The oscillator is normally phase locked to the 10 MHz reference oven (Option 001) or an external reference (1,2,5,10MHz REF IN).

REFERENCE DESIGNATOR: A50R115

SCHEMATIC: 13

EQUIPMENT:

Spectrum analyzer	HP 3585A

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. Preset the HP 3326A and spectrum analyzer.

3. Connect the test equipment as follows:
   - HP 3326A 10MHz OUT rear panel output to 50 Ω input of spectrum analyzer

NOTE

If the HP 3326A has Option 001 (high stability frequency reference) installed, disconnect the rear panel connection between 10MHz OVEN OUT, OPTION 001 and 1,2,5,10MHz REF IN.

4. Set the spectrum analyzer to measure the HP 3326A frequency, as follows:

Center frequency	10 MHz
Range	−15 dBm
Counter	On

5. Adjust FREQ CENTER (R115) on the reference board (A50) until the frequency of the square wave is 10 MHz ± 20 Hz.

6. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

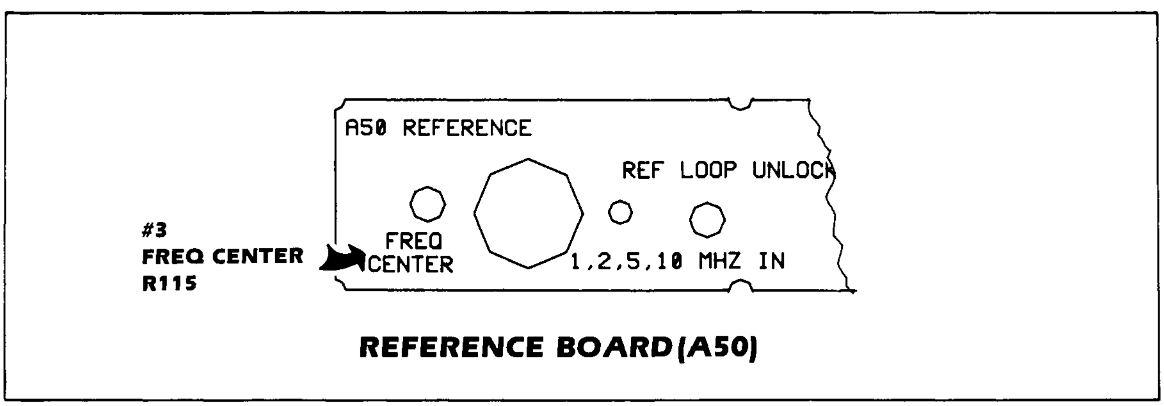


Figure 3-4. Adjustment #3 Location

3-9 ADJUSTMENT #4, VCO FREQ

DESCRIPTION: This procedure sets the voltage controlled oscillator (VCO) center frequency to ensure that the full tuning range of the VCO is available. This is required for the oscillator to remain in phase lock under all environmental conditions.

This adjustment must be done for both channels.

REFERENCE DESIGNATOR: A31L1, A41L1
SCHEMATIC: 11a

EQUIPMENT:

Digital voltmeter	HP 3455A
Service accessory kit	03326-84401
PC board extender	03326-66591
SMB (f) to SMB (f) cable (Qty 1)	03585-61601
Non-conductive adjustment tool	

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. While the HP 3326A is in STBY, place VCO board under test (A31 or A41) on an extender.

3. Preset the HP 3326A.

4. Connect the test equipment as follows:

   - Positive voltmeter terminal to VCO CONTROL VOLTAGE test point (TP5) on VCO control board (A32 or A42)
   - Negative voltmeter terminal to GND (card nests)

5. Set the HP 3326A as follows:

Channel	CH A or CH B
Frequency	0 MHz

6. Configure the voltmeter to measure Vdc.

7. Perform the adjustment with the board on the extender and check the adjustment with the board in the card nest. Repeat until the adjustment is accurate with the board in the card nest.

   - Adjust L1 on the VCO board (A31 or A41) with a non-conductive tool until the voltmeter reads 10 Vdc ± 10 mVdc.
   - Check adjustment at HP 3326A frequency of 13 MHz. The voltmeter reading should be > −2 Vdc (typically −1.7 Vdc). If not, readjust L1.

- Turn HP 3326A off. Place board back into card nest. Replace one top cover screw to make a good ground contact. Turn instrument on. Sequentially press **RECALL, 0** to restore HP 3326A test setup. Check the voltmeter readings again.
- If the readings are correct, go to step 8. If not, turn instrument off and put board on extender. Readjust L1 until the readings are correct while the board is in the card nest.

8. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

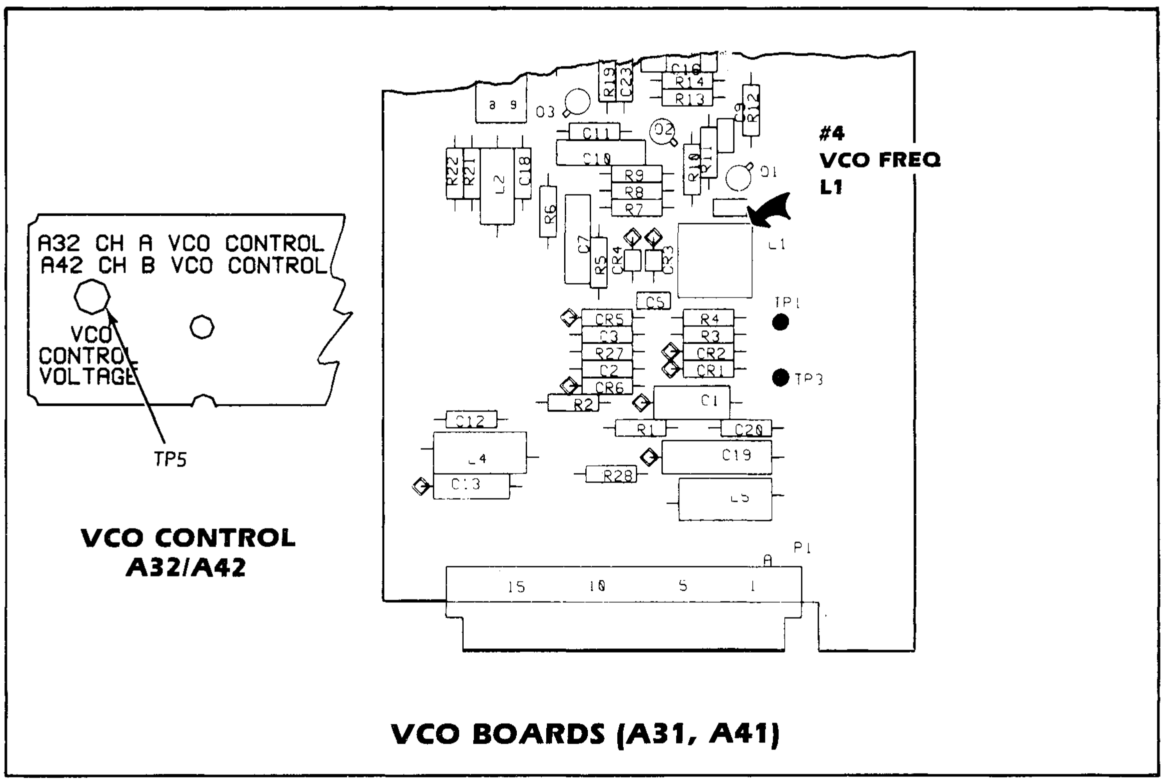


Figure 3-5. Adjustment #4 Location

3-10 ADJUSTMENT #5, 100 kHz

DESCRIPTION: This adjustment minimizes the 100 kHz synthesizer reference frequency sidebands on the synthesized signal. This is required for proper signal purity.

This adjustment must be done for both channels.

REFERENCE DESIGNATOR: A33R39, A43R39

SCHEMATIC: 11c

EQUIPMENT:

Spectrum analyzer	HP 3585A
Service accessory kit	03326-84401
PC board extender	03326-66591
SMB (f) to SMB (f) cable (Qty 2)	03585-61601

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. While the HP 3326A is in STBY, place phase detector board under test (A33 or A43) on an extender.

3. Preset the HP 3326A and the spectrum analyzer.

4. Connect the test equipment as follows:
   - External reference output of spectrum analyzer to 1,2,5,10MHz REF IN rear panel input of HP 3326A
   - Output of HP 3326A channel under test (CH A or CH B) to 50 Ω input of spectrum analyzer

5. Set the HP 3326A as follows:

Channel	CH A or CH B
Frequency	1 MHz
Amplitude	13.98 dBm

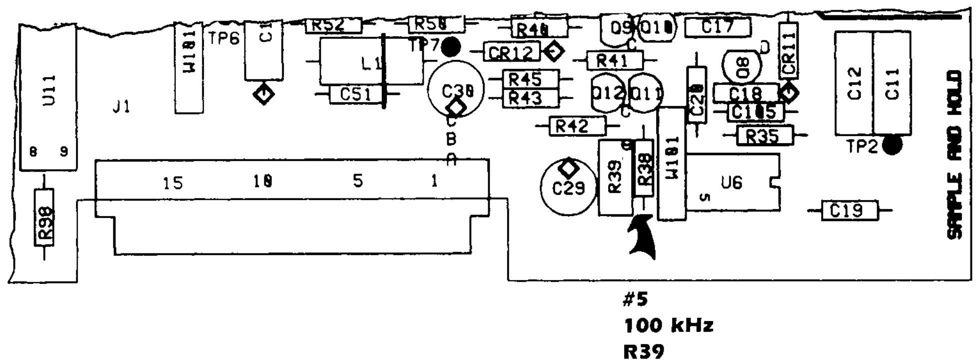
6. Set the spectrum analyzer to measure the level of the 200 kHz sideband relative to the 1 MHz sine wave carrier, as follows:

Center Frequency	1 MHz
Frequency Span	1 MHz
Marker → Reference Level	On
Manual Sweep	On
Offset	On
Enter Offset	On
Center Frequency	1.2 MHz
Res. BW	3 Hz
Video BW	1 Hz

7. Perform the adjustment with the board on the extender and check the adjustment with the board in the card nest. Repeat until the adjustment is accurate with the board in the card nest.
   - Adjust R39 for minimum level residual 200 kHz spur (< −85 dBc).
   - Check 100 kHz spur at spectrum analyzer center frequency of 1.1 MHz. If the spur is NOT below −85 dBc, readjust R39.
   - Turn HP 3326A off. Place board back into card nest. Replace one top cover screw to make a good ground contact. Turn instrument on. Sequentially press **RECALL, 0** to restore HP 3326A test setup. Check the spectrum analyzer reading again.
   - If the reading is correct, go to step 8. If not, turn instrument off and put board on extender. Readjust R39 until the reading is correct while the board is in the card nest.

8. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.



PHASE DETECTOR BOARDS (A33, A43)

Figure 3-6. Adjustment #5 Location

3-11 ADJUSTMENT #6, APIs

DESCRIPTION: This adjustment minimizes the analog phase interpolation (API) related spurs in the fractional-N LO.

This adjustment must be done for both channels.

REFERENCE DESIGNATORS: API #1 A33R84, A43R84
API #2 A33R86, A43R86
API #3 A33R132, A43R132
API #4 A33R90, A43R90

SCHEMATIC: 11c

EQUIPMENT: Spectrum analyzer HP 3585A

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. Preset the HP 3326A and the spectrum analyzer.

3. Connect the test equipment as follows:
   - External reference output of spectrum analyzer to 1,2,5,10MHz REF IN rear panel input of HP 3326A
   - Output of HP 3326A channel under test (CH A or CH B) to 50 Ω input of spectrum analyzer

4. Set the HP 3326A as follows:

Channel	CH A or CH B
Frequency	50.5 kHz
Amplitude	3.15 Vpp

5. Set the spectrum analyzer to measure the level of the API #1 spurious signal relative to the 50.5 kHz sine wave carrier, as follows:

Center Frequency	50.5 kHz
Frequency Span	1 kHz
Range	20 dBm
Marker → Reference Level	On
Manual Sweep	On
Offset	On
Enter Offset	On
Video BW	1 Hz
Center Frequency Step Size	1 kHz, step up once

6. Adjust R84 on the phase detector board (A33 or A43) for minimum level API #1 spur (< −88 dBc).

7. Change HP 3326A frequency to 50.05 kHz. Change spectrum analyzer center frequency to 50.05 kHz. Step up the center frequency once.

8. Adjust R86 for minimum level API #2 spur (< −88 dBc).

9. Change HP 3326A frequency to 50.005 kHz. Change spectrum analyzer center frequency to 50.005 kHz. Step up the center frequency once.

10. Adjust R132 for minimum level API #3 spur (< −88 dBc).

11. Change HP 3326A frequency to 50.0005 kHz. Change spectrum analyzer center frequency to 50.0005 kHz. Step up the center frequency once.

12. Adjust R90 for minimum level API #4 spur (< −88 dBc).

13. Change HP 3326A frequency to 50.00005 kHz. Change spectrum analyzer center frequency to 50.00005 kHz. Step up the center frequency once.

14. Check the amplitude of API #5 spur. If it is NOT < −88 dBc, go to the fractional-N local oscillator board level repair (sub-section 30).

15. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

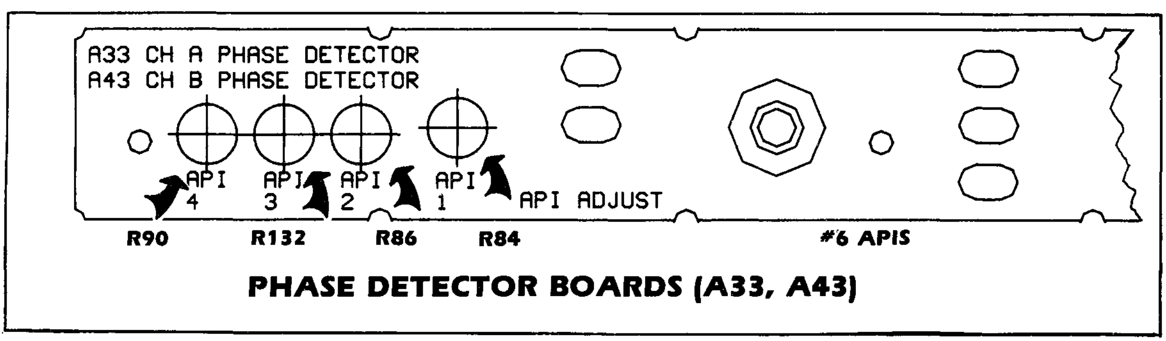


Figure 3-7. Adjustment #6 Location

3-12 ADJUSTMENT #7, V REF

DESCRIPTION: This procedure adjusts the 10.240 Vdc reference signal (V REF) used for square wave, level, and offset accuracy in the HP 3326A.

REFERENCE DESIGNATOR: A36R217

SCHEMATIC: 12

EQUIPMENT:

Digital voltmeter	HP 3455A

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. Preset the HP 3326A.

3. Connect the test equipment as follows:

   - Positive voltmeter terminal to TP206 (V REF TEST) on calibrator board (A36)
   - Negative voltmeter terminal to GND (card nests)

4. Configure the voltmeter to measure Vdc.

5. Adjust R217 (V REF ADJ) until voltmeter reads 10.240 ± 0.010 Vdc.

6. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

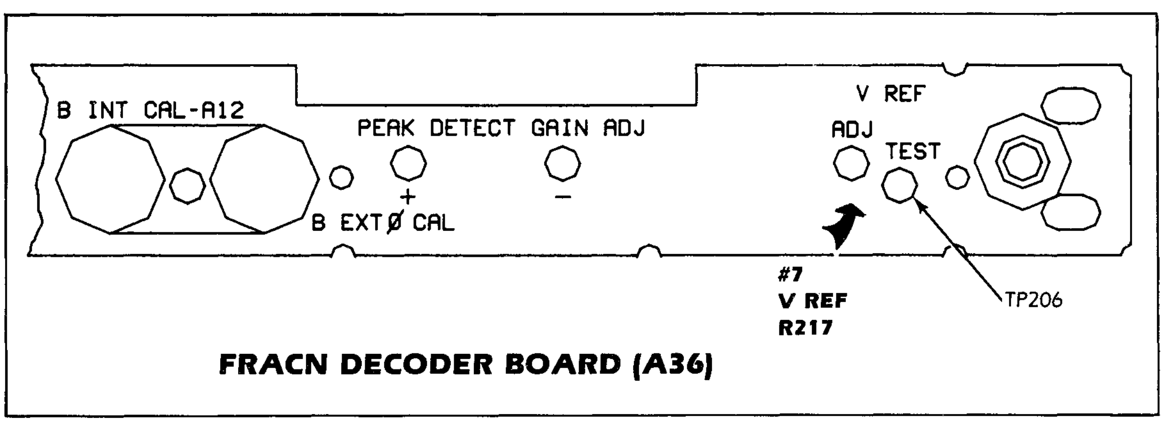


Figure 3-8. Adjustment #7 Location

3-13 ADJUSTMENT #8, PEAK DETECT GAIN

DESCRIPTION: This adjustment sets the gain of the amplitude/offset calibration path on the calibrator board (A36) by detecting negative and positive signal peaks with the peak detect voltmeter on A36.

REFERENCE DESIGNATOR: Peak Detect Gain − A36R201
Peak Detect Gain + A36R205

SCHEMATIC: 12

EQUIPMENT:

Digital voltmeter	HP 3455A
Sine wave signal source	HP 3325A
Service accessory kit	03326-84401
Phono plug to BNC (m) adapter cable	03326-61618
1.5 Hz low pass filter	
Resistor 1MΩ	0698-8827
Capacitor 0.1 μF	0160-4571
Calculator	

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. Preset the HP 3326A and the sine wave signal source.

3. Connect the test equipment as follows:

   - Disconnect A INT CAL-A2 cable (J2) from HP 3326A calibrator board (A36)
   - Connect sine wave source to J2 using phono plug to BNC adapter cable

4. To make a **Vdc reading**, connect the test equipment as follows (illustrated in Figure 3-9):

   - A INT CAL test point (TP200) on calibrator board (A36) to filter input
   - Voltmeter to filter output

   NOTE

   The filter is constructed in a small metal box with two BNC connectors. The components for the filter are listed under Equipment.

   To make a **Vrms reading**, connect the test equipment as follows:
   - Positive voltmeter terminal to A INT CAL test point (TP200)
   - Negative voltmeter terminal to GND (card nests)

5. Set the 50 Ω sine wave source as follows:

Frequency	1 kHz
Amplitude	9.5 Vpp

6. Adjust the negative peak voltage.
   - Display negative peak voltage on the HP 3326A by using a hidden front panel command (see sub-section 6-6). Press:

     [SHIFT] [ ] dBV % [4]

   - Take a Vdc reading and a Vrms reading (see step 4).
   - Compute x:

$$x = Vdc - Vrms\sqrt{2}$$

   - Adjust PEAK DETECT GAIN ADJ − (R201) until the front panel displays x.

7. Adjust the positive peak voltage.
   - Display positive peak voltage on the HP 3326A by using a hidden front panel command. Press:

     [SHIFT] [ ] dBV % [5]

   - Take a Vdc reading and a Vrms reading (see step 4).
   - Compute y:

$$y = Vdc + Vrms\sqrt{2}$$

   - Adjust PEAK DETECT GAIN ADJ + (R205) until the front panel displays y.

8. Repeat steps 6 and 7.

9. Reconnect the cable to A INT CAL-A2 (J2) to calibrator board (A36).

10. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

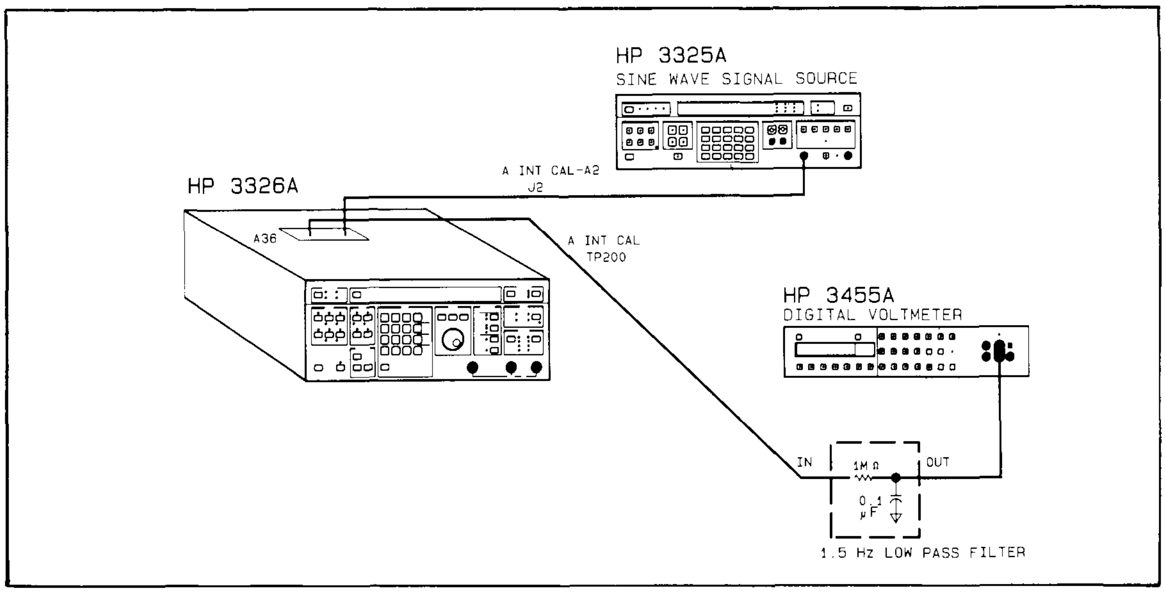


Figure 3-9. Equipment Setup for Measuring Vdc

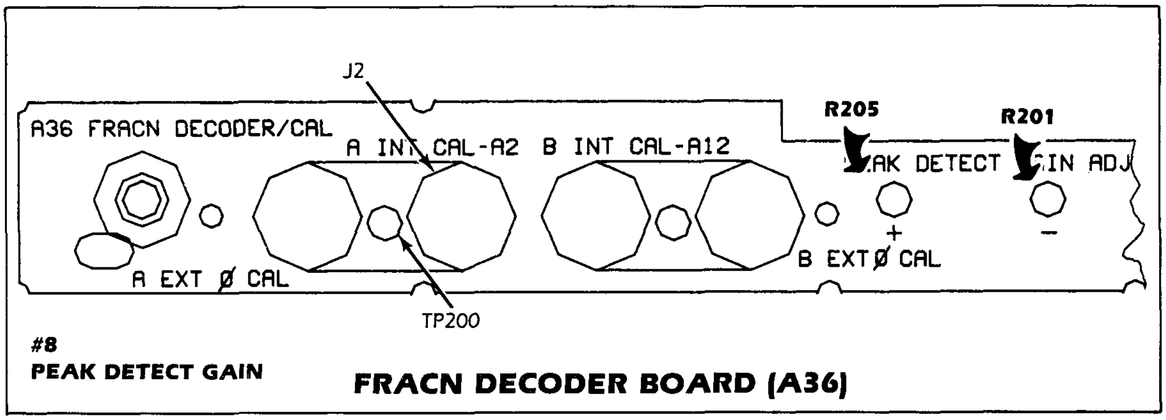


Figure 3-10. Adjustment #8 Location

3-14 ADJUSTMENT #9, A AND B OFFSET

DESCRIPTION: This procedure adjusts the residual offset to 0 V. This corrects for any error in the dc offset voltage on the offset board (A21).

REFERENCE DESIGNATOR: A Offset A21R2
B Offset A21R22

SCHEMATIC: 7

EQUIPMENT:

Digital voltmeter	HP 3455A

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. Preset the HP 3326A.

3. Connect the test equipment as follows:
   - Positive voltmeter terminal to A OFFSET TEST test point (TP1) on HP 3326A offset board (A21)
   - Negative voltmeter terminal to GND (card nests)

4. Set the HP 3326A as follows:

Channel	CH A or CH B
Function	DC

   Clear calibration constants (see sub-section 6-6):

   SHIFT [ ] dBV % [0]

5. Configure the voltmeter to measure Vdc.

6. Adjust A OFFSET ADJ (R2) to 0 Vdc ± 3 mVdc.

7. Repeat steps 2 through 6 for channel B, using B OFFSET TEST (TP2) and ADJ (R22).

8. Restore the calibration constants by pressing MANUAL calibration or by cycling POWER.

9. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

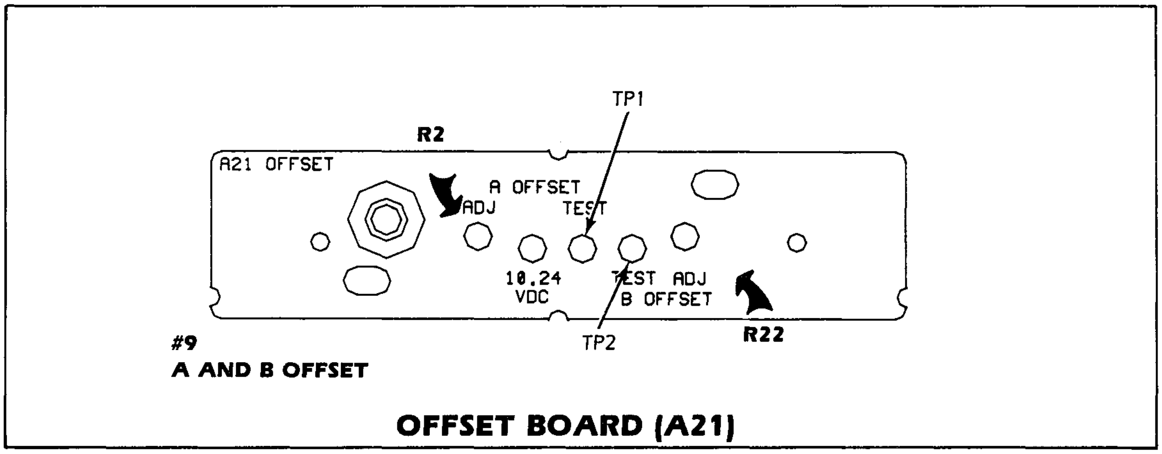


Figure 3-11. Adjustment #9 Location

3-15 ADJUSTMENT #10, 2:1 SPUR

DESCRIPTION: This adjustment minimizes the spurious signals that fall at two times the reference frequency minus the local oscillator (LO) frequency. The local oscillator frequency is the programmed frequency plus 20 MHz. These spurs fall in the dc to 13 MHz frequency band of the HP 3326A for output frequencies above 7 MHz. (The spurs would be in the 13 to 7 MHz range.)

This adjustment must be done for both channels.

REFERENCE DESIGNATOR: A5R316, A15R316
SCHEMATIC: 5

EQUIPMENT:

Spectrum analyzer	HP 3585A

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. Preset the HP 3326A and the spectrum analyzer.

3. Connect the test equipment as follows:
   - External reference output of spectrum analyzer to 1,2,5,10MHz REF IN rear panel input of HP 3326A
   - Output of HP 3326A channel under test (CH A or CH B) to 50 Ω input of spectrum analyzer

4. Set the HP 3326A as follows:

Channel	CH A or CH B
Frequency	7.1 MHz
Amplitude	3.15 Vpp

5. Set the spectrum analyzer to measure the level of the 12.9 MHz spurious signal relative to the 7.1 MHz sine wave carrier, as follows:

Center Frequency	7.1 MHz
Frequency Span	1 kHz
Range	20 dBm
Marker → Reference Level	On
Manual Sweep	On
Marker → Center Frequency	On
Offset	On
Enter Offset	On
Center Frequency	12.9 MHz
Video BW	1 Hz

6. Adjust 2:1 SPUR (R316) on the mixer board (A5 or A15) for minimum level (< −76 dBc).

7. Check the level of the spurs at two other frequencies.
   - Set the HP 3326A to 10.1 MHz. Set the center frequency of the spectrum analyzer to 9.9 MHz. Check that the 2:1 spur is below −76 dBc.
   - Set the HP 3326A to 12.9 MHz. Set the center frequency of the spectrum analyzer to 7.1 MHz. Check that the 2:1 spur is below −76 dBc.
   - If the spurs are not below −76 dBc, repeat step 6 and check again.

8. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

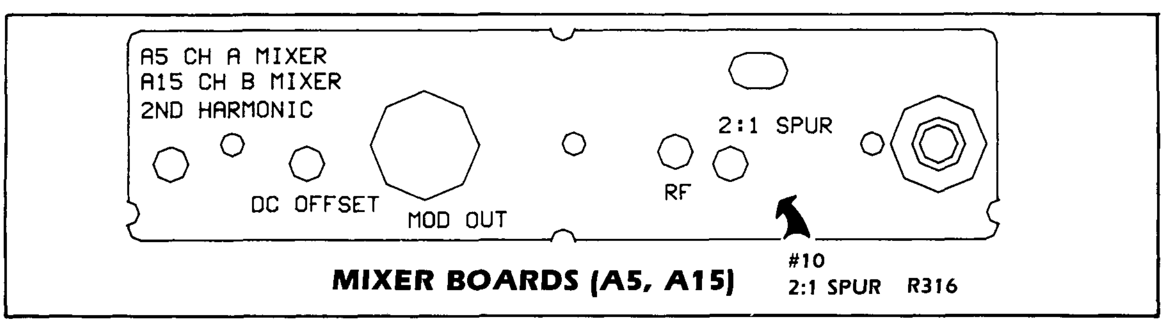


Figure 3-12. Adjustment #10 Location

3-16 ADJUSTMENT #11, 2nd HARMONIC

DESCRIPTION: This procedure adjusts the second harmonic of the sine wave output to minimize distortion.

This adjustment must be done for both channels. It must be performed AFTER the 2:1 spur adjustment (#10).

REFERENCE DESIGNATOR: A5R424, A15R424

SCHEMATIC: 5

EQUIPMENT:

Spectrum analyzer	HP 3585A

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. Preset the HP 3326A and the spectrum analyzer.

3. Connect the test equipment as follows:
   - External reference output of spectrum analyzer to 1,2,5,10MHz REF IN rear panel input of HP 3326A
   - Output of HP 3326A channel under test (CH A or CH B) to 50 Ω input of spectrum analyzer

4. Set the HP 3326A as follows:

Channel	CH A or CH B
Frequency	49 kHz
Amplitude	3.15 V

5. Set the spectrum analyzer to measure the level of the 98 kHz second harmonic relative to the 49 kHz sine wave carrier, as follows:

Center Frequency	49 kHz
Frequency Span	1 kHz
Range	25 dBm
Marker → Reference Level	On
Manual Sweep	On
Marker → Center Frequency	On
Offset	On
Enter Offset	On
Center Frequency	98 kHz
Video BW	1 Hz

6. Adjust 2ND HARMONIC (R316) on mixer board (A5 or A15) for minimum level (< −88 dBc).

7. Check harmonic at low frequency to verify the adjustment.
   - Set the HP 3326A to 4.9 kHz.
   - Repeat step 5 using center frequencies of 4.9 kHz and 9.8 kHz.
   - If the harmonic is NOT below −88 dBc, readjust R316 for minimum level (< −88 dBc) and repeat steps 5 and 6.

8. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

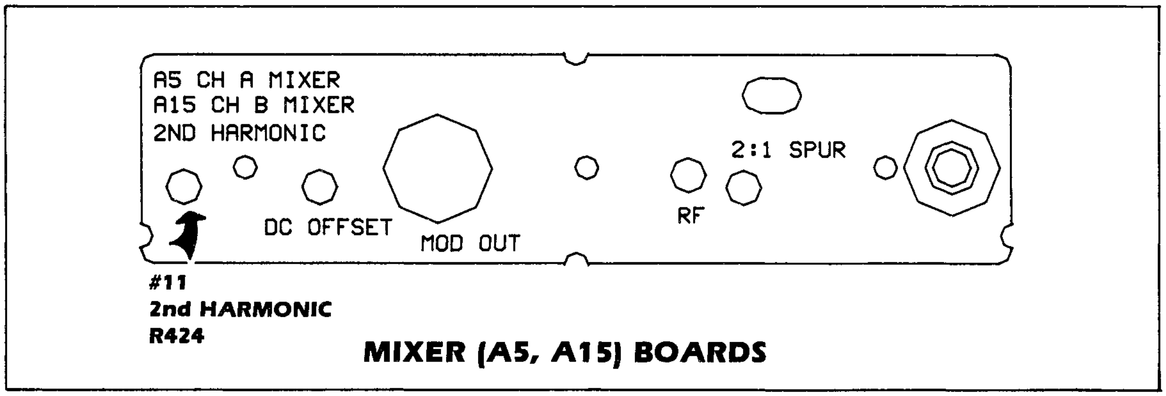


Figure 3-13. Adjustment #11 Location

3-17 ADJUSTMENT #12, DC OFFSET

DESCRIPTION: This procedure adjusts the square wave symmetry of the HP 3326A, thus minimizing the second harmonic of the square wave output. The second harmonic of the square wave is a function of the mixer board's dc offset.

This adjustment must be done for both channels.

REFERENCE DESIGNATOR: A5R400, A15R400

SCHEMATIC: 5

EQUIPMENT:

Spectrum analyzer	HP 3585A

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. Preset the HP 3326A and the spectrum analyzer.

3. Connect the test equipment as follows:
   - External reference output of spectrum analyzer to 1,2,5,10MHz REF IN rear panel input of HP 3326A

- Output of HP 3326A channel under test (CH A or CH B) to 50 Ω input of spectrum analyzer

4. Set the HP 3326A as follows:

Channel	CH A or CH B
Function	Square Wave
Frequency	49 kHz
Amplitude	3.15 Vpp

5. Set the spectrum analyzer to measure the level of the 98 kHz second harmonic relative to the 49 kHz sine wave carrier, as follows:

Center Frequency	49 kHz
Frequency Span	1 kHz
Range	20 dBm
Marker → Reference Level	On
Manual Sweep	On
Marker → Center Frequency	On
Offset	On
Enter Offset	On
Center Frequency	98 kHz
Video BW	1 Hz

6. Adjust DC OFFSET (R400) on mixer board (A5 or A15) for minimum second harmonic level of square wave (< −40 dBc).

7. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

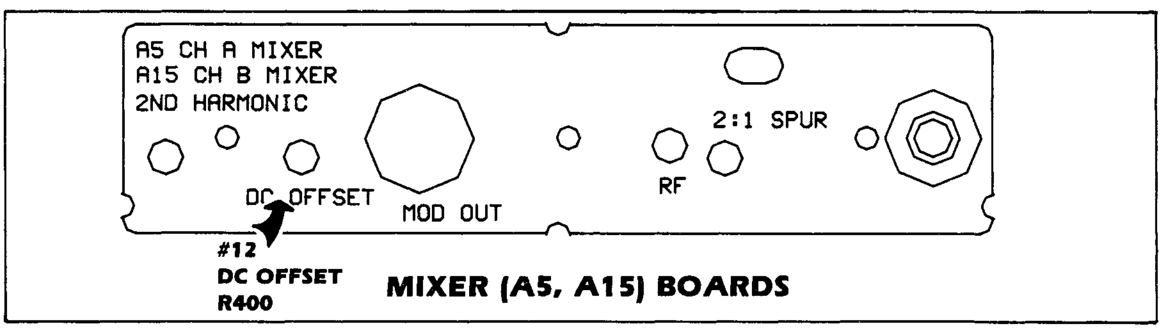


Figure 3-14. Adjustment #12 Location

3-18 ADJUSTMENT #13, FLATNESS

DESCRIPTION: This procedure adjusts the output signal level flatness at high frequencies. This is required for the HP 3326A to meet specifications (Table 1-5).

This adjustment must be done for both channels.

Always check the overshoot adjustment (#14) after performing this adjustment.

REFERENCE DESIGNATOR: A5C400, A15C400
SCHEMATIC: 5

EQUIPMENT:

Spectrum analyzer	HP 3585A
Service accessory kit	03326-84401
PC board extender	03326-66591

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. While the HP 3326A is in STBY, place mixer board under test (A5 or A15) on an extender.

3. Preset the HP 3326A and the spectrum analyzer.

4. Connect the test equipment as follows:

   - External reference output of spectrum analyzer to 1,2,5,10MHz REF IN rear panel input of HP 3326A
   - Output of HP 3326A channel under test (CH A or CH B) to 50 Ω input of spectrum analyzer
   - Z-BLANK OUT rear panel output of HP 3326A to spectrum analyzer external trigger input

5. Set the HP 3326A as follows:

Channel	CH A or CH B
Sweep Type	Continuous
Sweep Time	5 s
Amplitude	10 Vpp

6. Set the spectrum analyzer to display the swept sine wave from 0 to 13 MHz, as follows:

Range	25 dBm
Stop Frequency	13 MHz
Sweep Time	5 s
Trigger	External
dB/division	2 dB

   - Remove the top cover of the HP 3585A and put test jumper A15W1 into the test postion (accessible from the top of the board). This configures the instrument to display 0.2 dB/div when set for 2 dB/div on the front panel. Normally, only 1, 2, 5 and 10 dB/div increments are available.

7. Perform the adjustment with the board on the extender and check the adjustment with the board in the card nest. Repeat until the adjustment is accurate with the board in the card nest.

- Adjust C400 for best flatness (± 0.5 dB).

NOTE

The dc offset on the spectrum analyzer display may shift about 0.1 dB. This is due to uncertainty in the triggering on the HP 3585A. Increasing the sweep time stops the shifting offset.

- Turn HP 3326A off. Place board back into card nest. Replace one top cover screw to make a good ground contact. Turn instrument on. Sequentially press **RECALL, 0** to restore HP 3326A test setup. Check flatness again.
- If the reading is correct, go to step 8. If not, turn instrument off and put board on extender. Readjust C400 until the reading is correct while the board is in the card nest.

8. Check overshoot adjustment (#14).

9. Return test jumper A15W1 on the HP 3585A to normal position.

10. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

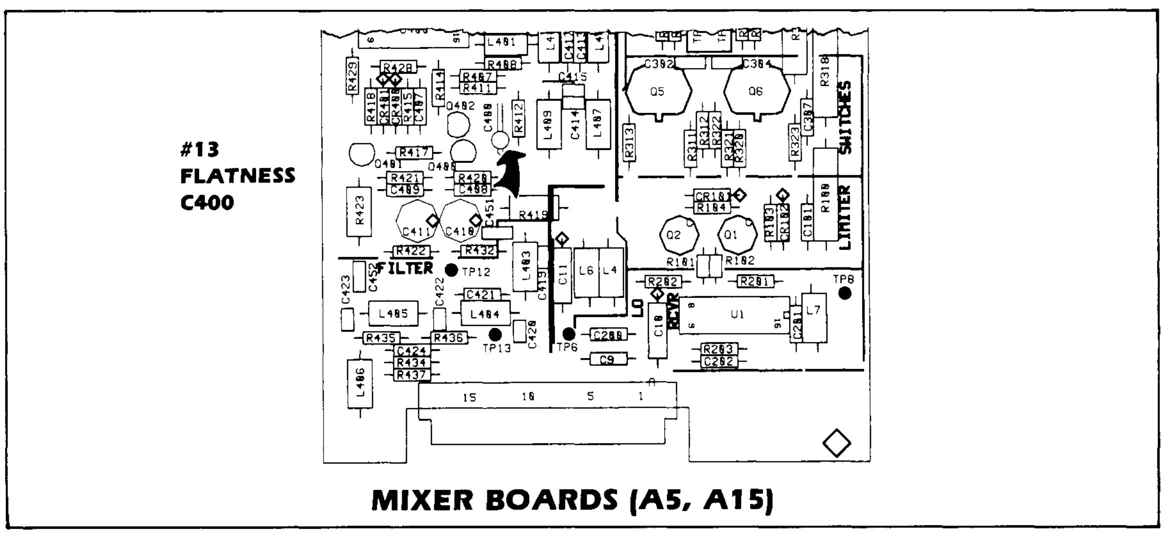


Figure 3-15. Adjustment #13 Location

3-19 ADJUSTMENT #14, OVERSHOOT

DESCRIPTION: This procedure adjusts the overshoot of the output signal to compensate for square wave level flatness.

This adjustment must be done for both channels.

Always check the flatness adjustment (#13) after performing this adjustment.

REFERENCE DESIGNATOR: A3C103, A13C103
SCHEMATIC: 3

EQUIPMENT:

Oscilloscope	HP 1715A

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. Preset the HP 3326A.

3. Connect the test equipment as follows:

   - Output of HP 3326A channel under test (CH A or CH B) to 50 Ω input of oscilloscope.

4. Set the HP 3326A as follows:

Channel	CH A or CH B
Function	Square
Frequency	13 MHz
Amplitude	10 Vpp

5. Perform the adjustment with the board outside the instrument and check the results with the board in the card nest.

   - Turn HP 3326A off. Remove the output amplifier board under test (A3 or A13) from the instrument.
   - Adjust C103. Begin the adjustment with C103 at minimum capacitance (plates not lined up).
   - Place board back into card nest. Turn instrument on. Sequentially press RECALL, 0 to restore HP 3326A test setup. Using the oscilloscope, check to see if the peak of the waveform caused by the positive overshoot has a slightly greater magnitude than the rest of the top portion of the waveform (Figure 3-17).
   - If the waveform matches Figure 3-17, go to step 6. If not, turn instrument off and remove board. Readjust C103 until the waveform is correct while the board is in the card nest.

6. Check sine wave flatness adjustment (#13).

7. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

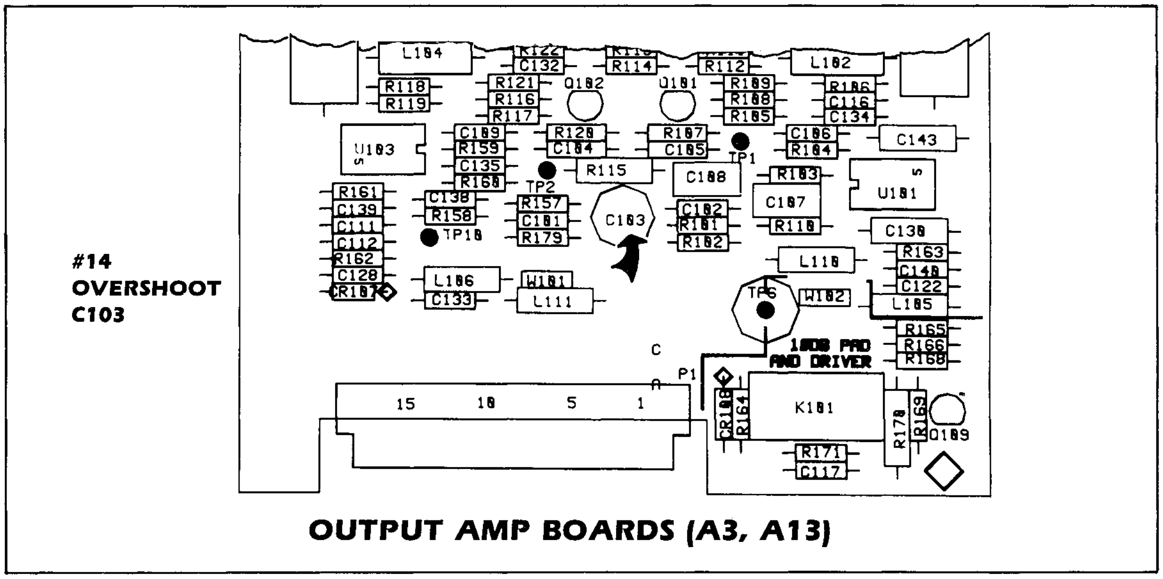


Figure 3-16. Adjustment #14 Location

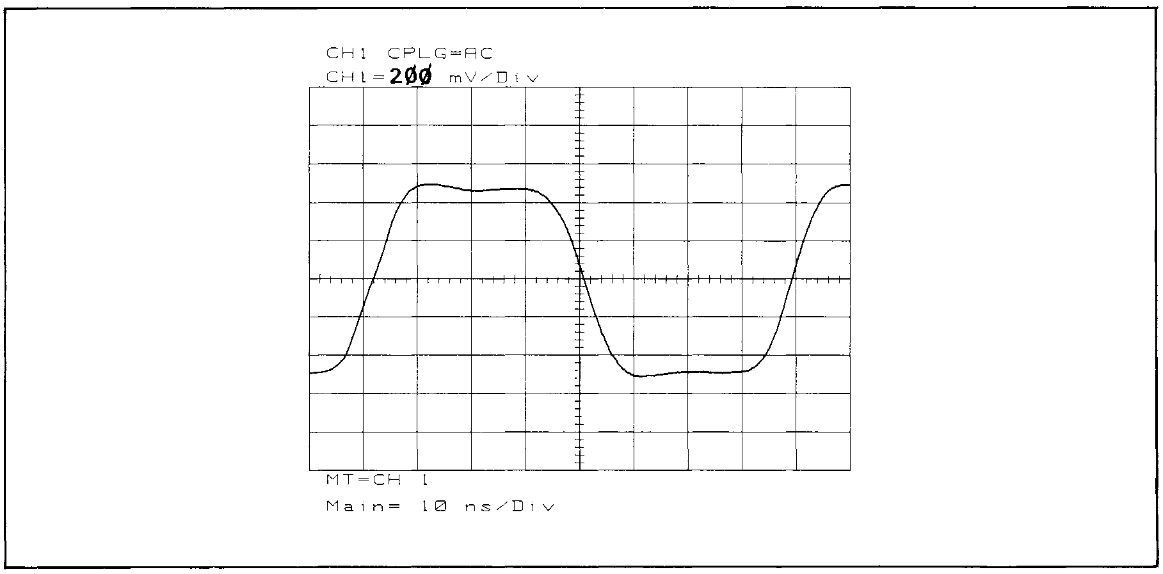


Figure 3-17. Square Wave Shape

3-20 ADJUSTMENT #15, HV OVERSHOOT

DESCRIPTION: This procedure increases the overshoot to modify the high voltage square wave shape. A 40 Vpp square wave signal is used. It also affects square wave rise time and sine wave flatness.

This adjustment must be done for both channels when the high voltage outputs option (Option 002) is in place.

REFERENCE DESIGNATOR: A1C149, A11C149

SCHEMATIC: 1

EQUIPMENT:

Oscilloscope	HP 1740A
Service accessory kit	03326-84401

PC board extender	03326-66591
1 kΩ/50Ω matching pad and load:	
Resistor 1.91 kΩ 1% 0.5 W (2)	0698-3341
Resistor 52.68 Ω 1% 0.5 W	0698-6060
Capacitor 200 pF ±1%	0140-0220
Non-conductive adjustment tool	

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover.

2. Place high voltage amplifier board under test (A1 or A11) on an extender. Reconnect main power cord.

CAUTION

Remove main power cord whenever you are placing the high voltage amplifier board (A1 or A11) on an extender. Otherwise, the +28VDC and −28VDC supplies can short to the card nests (GND) and blow the line fuse.

3. Preset the HP 3326A.

4. Connect the test equipment as follows (illustrated in Figure 3-18):

- Output of the HP 3326A channel under test (CH A or CH B) to 1 kΩ/50 Ω matching pad and load input.
- 1 kΩ/50 Ω matching pad and load output to the oscilloscope 50 Ω input.

NOTE

The 1 kΩ/50 Ω matching pad and load is constructed in a small metal box with two BNC connectors. The components required are listed under Equipment.

5. Set the HP 3326A as follows:

Channel	CH A or CH B
High Voltage	On
Function	Square Wave
Amplitude	40 Vpp
Frequency	1 MHz

6. Set the oscilloscope to display two periods of the square wave.

7. Perform the adjustment with the board on the extender and check the adjustment with the board in the card nest. Repeat until the adjustment is accurate with the board in the card nest.

- Adjust **C149** until the square wave shape has good edges and minimal overshoot (Figure 3-20).
- Check the level flatness of the high voltage square wave. If there is too much overshoot, there will be bad flatness. Perform the following:
    - Set the HP 3326A to 100 kHz. Set the oscilloscope time scale to show many peaks of the square wave. Adjust the wave for full scale (100%) on the oscilloscope display by removing the oscilloscope calibration and using the vernier adjustment.
    - Set the HP 3326A to 1 MHz. Leave the oscilloscope setup as is. Check the square wave flatness. There should be ≤ 10% difference (1 minor division ≅ 4%). If not, readjust C118.
- Turn HP 3326A off. Place board back into card nest. Replace one top cover screw to make a good ground contact. Turn instrument on. Sequentially press **RECALL, 0** to restore HP 3326A test setup. Check the square wave appearance and sine wave flatness again.
- If the readings are correct, go to step 8. If not, turn instrument off and put board on extender. Readjust C149 until the readings are correct while the board is in the card nest.

8. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

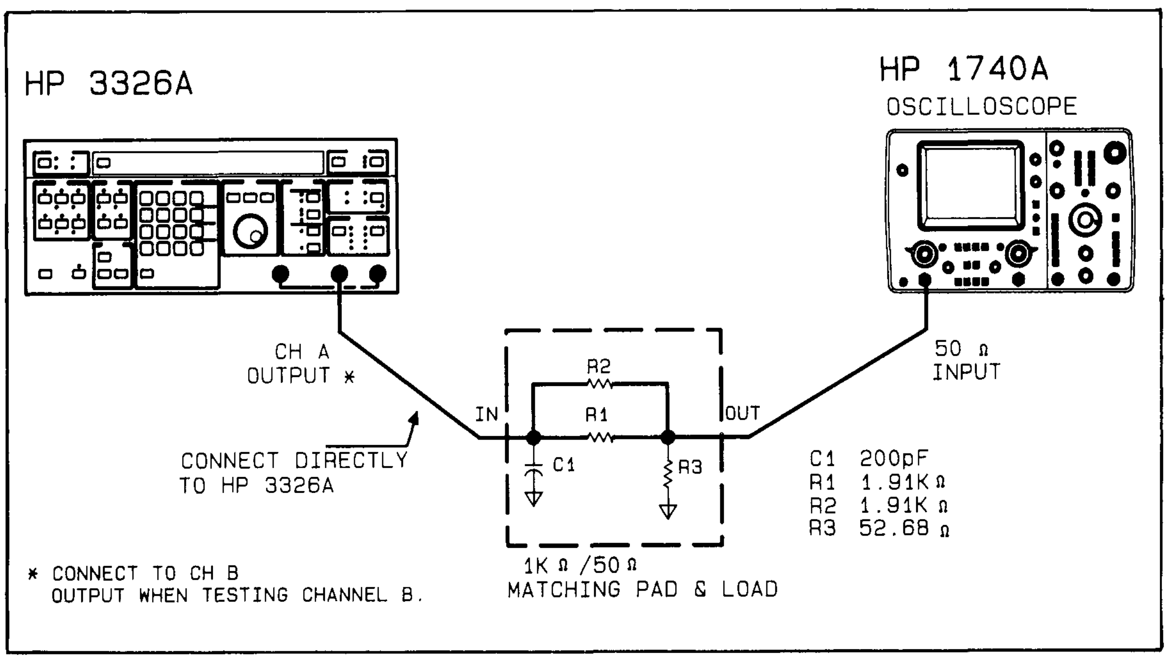


Figure 3-18. Adjustment #15 Setup

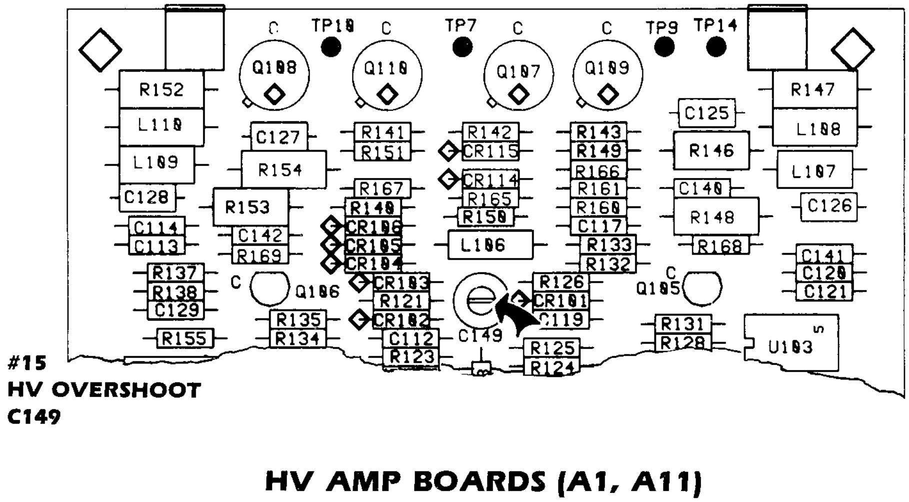


Figure 3-19. Adjustment #15 Location

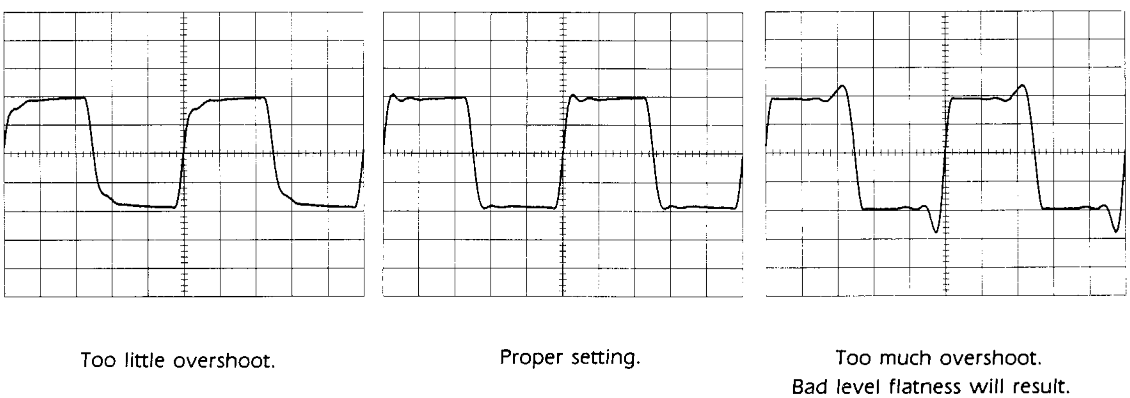


Figure 3-20. High Voltage Square Wave Shape

3-21 ADJUSTMENT #16, BIAS

DESCRIPTION: This adjustment minimizes high frequency distortion at all frequencies by adjusting the output amplifier's bias voltage level. This is required for the HP 3326A to meet specifications (Table 1-5).

This adjustment must be done for both channels.

REFERENCE DESIGNATOR: A3R130, A13R130

SCHEMATIC: 3

EQUIPMENT:

Digital voltmeter	HP 3455A

Spectrum analyzer	HP 3585A
Service accessory kit	03326-84401
PC board extender	03326-66591

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. While the HP 3326A is in STBY, place output amplifier board under test (A3 or A13) on an extender. (If channel A is under test, remove the SYNC cable from the top of A3. Leave it disconnected during the adjustment procedure.)

3. Preset the HP 3326A and the spectrum analyzer.

4. Connect the test equipment as follows:

   - External reference output of spectrum analyzer to 1,2,5,10MHz REF IN rear panel input of HP 3326A
   - Output of HP 3326A channel under test (CH A or CH B) to 50 Ω input of spectrum analyzer
   - Positive and negative voltmeter terminals to TP11 (BIAS) and TP7 (+15V2)

5. Set the HP 3326A as follows:

Channel	CH A or CH B
Frequency	13 MHz
Amplitude	10 Vpp

6. Set the spectrum analyzer to measure the level of the 39 MHz third harmonic relative to the 13 MHz sine wave carrier, as follows:

Center Frequency	13 MHz
Frequency Span	1 kHz
Range	25 dBm
Manual Sweep	13 MHz
Marker → Reference Level	On
Offset	On
Enter Offset	On
Center Frequency	39 MHz

7. Configure the voltmeter to measure Vdc.

8. There are two bias settings that will minimize the third harmonic distortion to an acceptable level (Figure 3-22). Adjust to the smaller of the two levels to avoid straining the amplifier.

   - Place R130 at the mechanical center.
   - Adjust R130 until the third harmonic distortion is at a minimum value.
   - Decrease R130 to assure the setting is at the lower bias voltage side of the minimum (null) setting to allow cooler operation. Distortion should be ≤ −35 dBc. The

absolute value of the bias voltage should be ≤ 0.7 Vdc. See Figure 3-22.

NOTE

This adjustment should be accurate when the board is returned to the card nest.

9. This completes the adjustment. Disconnect main power cord from the HP 3326A rear panel. Return the board to the card nest and replace the top cover.

Refer to Table 3-2 if the adjustment cannot be completed.

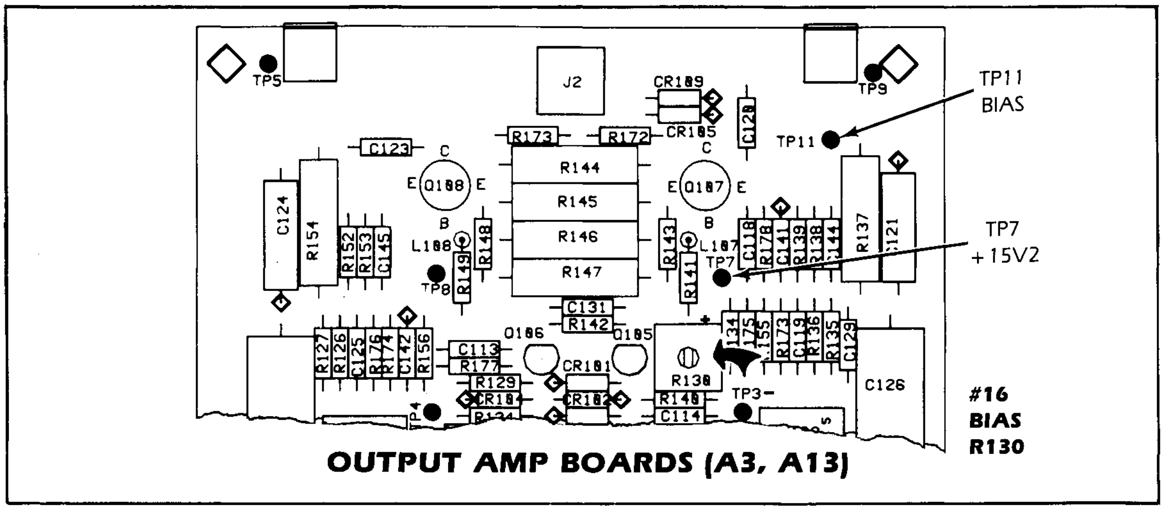


Figure 3-21. Adjustment #16 Location

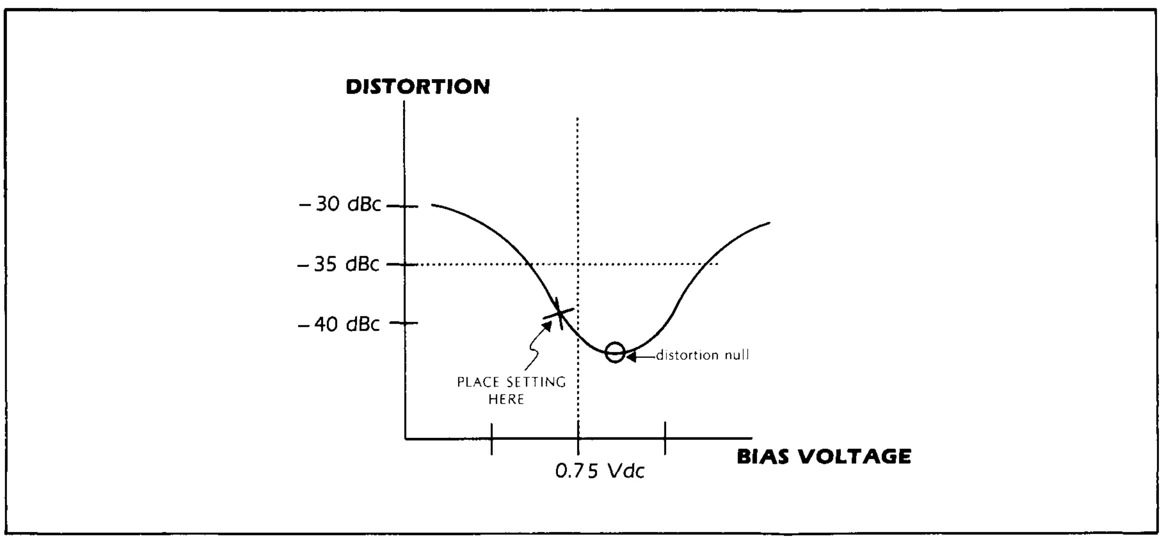


Figure 3-22. Third Harmonic Distortion at 13 MHz

3-22 ADJUSTMENT #17, BATTERY CHECK

DESCRIPTION: This procedure checks for excessive current drawn by RAM and measures the voltage of the battery on the controller board (A61).

REFERENCE DESIGNATOR: A61BT1

SCHEMATIC: 14a

EQUIPMENT:

Digital voltmeter	HP 3455A	
Service accessory kit		03326-84401
PC board extender		03326-66591

PROCEDURE:

1. Disconnect main power cord from the HP 3326A rear panel and remove the top cover. Reconnect main power cord.

2. Turn the HP 3326A off (STBY). Take mechanical support off of controller board (A61). Place A61 on an extender. LEAVE THE HP 3326A IN STANDBY.

3. Connect the test equipment as follows:

   - Connect voltmeter positive and negative terminals across R302

4. Configure the voltmeter to measure Vdc.

5. Measure the voltage across R302. This voltage should be $\leq$ 0.1 mVdc. A voltage greater than 0.1 mVdc indicates excessive current drain which may result in the discharge of BT1.

NOTE

If the voltage measured across R302 indicates a large current drain, suspect bad RAMs.

6. Measure the voltage at TP17 (CMOS PWR) with respect to GND (card nests). The voltage should be $\geq$ 2.2 Vdc, but $<$ 3.5 Vdc. If it is not, replace BT1.

7. This completes the check. Put board back into card nest. Disconnect main power cord from the HP 3326A rear panel and replace the top cover.

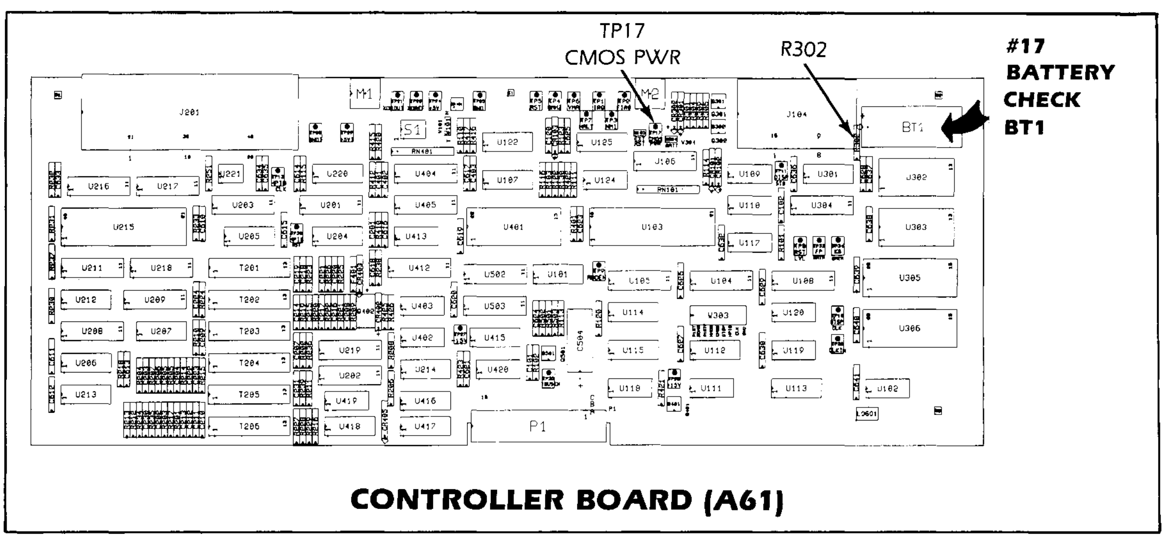


Figure 3-23. Adjustment #17 Location

SECTION IV
REPLACEABLE PARTS

SECTION IV
REPLACEABLE PARTS

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4-2	Replaceable Parts List	4-1
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SECTION IV
REPLACEABLE PARTS

4-1 INTRODUCTION

This section contains information for ordering replacement parts. Table 4-1 lists the abbreviations used in Table 4-3, Replaceable Parts List, and throughout this manual. Table 4-2 lists the names and addresses that correspond to the manufacturers' code numbers.

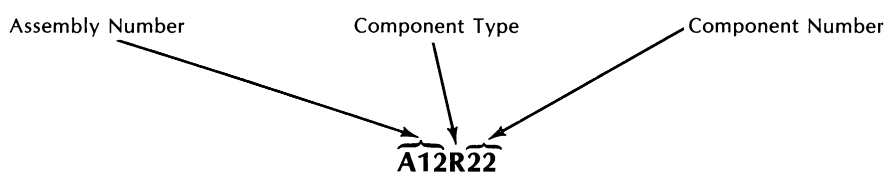
4-2 REPLACEABLE PARTS LIST

Table 4-3 is organized as follows:

1. PC boards and their components in alphanumeric order by reference designators.
2. Chassis-mounted components and hardware grouped by top, bottom, front, back and side assemblies. Groups of mechanical parts for Options 001 and 003 and the instrument frame are included. Cables are included in a separate group.

The information for each part consists of the following:

1. REFERENCE DESIGNATOR



2. HP PART NUMBER
3. CD - The Check Digit used by HP to verify that an order has been transmitted correctly.
4. QTY - The total quantity in the PC board.
5. DESCRIPTION - The HP description of the part.
6. MFR CODE - The manufacturer's code.
7. MFR PART NUMBER - The manufacturer's part number.

NOTE

The total quantity of each part is given once for each board — at the first appearance of the part number on the board component listing. The same system is used for total quantities for optional boards.

Table 4-1. Reference Designations and Abbreviations

Abbreviations

Ag	silver	NPO	negative positive zero (zero temperature coefficient)
Al	aluminum	ns	nanosecond(s) = 10^{-9} seconds
A	ampere(s)	nsr	not separately replaceable
Au	gold	Ω	ohm(s)
C	capacitor	obd	order by description
cer	ceramic	OD	outside diameter
coef	coefficient	p	peak
com	common	pA	picoampere(s)
comp	composition	pc	printed circuit
conn	connection	pF	picofarad(s) 10^{-12} farads
dep	deposited	piv	peak inverse voltage
DPDT	double-pole double-throw	p/o	part of
DPST	double-pole single-throw	pos	position(s)
elect	electrolytic	poly	polystyrene
encap	encapsulated	pot	potentiometer
F	farad(s)	p-p	peak-to-peak
FET	field effect transistor	ppm	parts per million
fxd	fixed	prec	precision (temperature coefficient, long term stability and/or tolerance)
GaAs	gallium arsenide	R	resistor
GHz	gigahertz = 10^{+9} hertz	Rh	rhodium
gd	guard(ed)	rms	root-mean-square
Ge	germanium	rot	rotary
gnd	ground(ed)	Se	selenium
H	henry(ies)	sect	section(s)
Hg	mercury	Si	silicon
Hz	hertz (cycle(s) per second)	sl	slide
ID	inside diameter	SPDT	single-pole double-throw
impg	impregnated	SPST	single-pole single-throw
incd	incandescent	Ta	tantalum
ins	insulation(ed)	TC	temperature coefficient
kΩ	kilohm(s) = 10^{+3} ohms	TiO_2	titanium dioxide
kHz	kilohertz = 10^{+3} hertz	tog	toggle
L	inductor	tol	tolerance
lin	linear taper	trim	trimmer
log	logarithmic taper	TSTR	transistor
mA	milliampere(s) = 10^{-3} amperes	V	volt(s)
MHz	megahertz = 10^{+6} hertz	vacw	alternating current working voltage
MΩ	megohm(s) = 10^{+6} ohms	var	variable
met flm	metal film	vdcw	direct current working voltage
mfr	manufacturer	W	watt(s)
ms	millisecond	w/	with
mtg	mounting	wiv	working inverse voltage
mV	millivolt(s) = 10^{-3} volts	w/o	without
μF	microfarad(s)	ww	wirewound
μs	microsecond(s)	*	optimum value selected at factory average value shown (part may be omitted)
μV	microvolt(s) = 10^{-6} volts	**	no standard type number assigned selected or special type
my	Mylar®	®	Dupont de Nemours
nA	nanoampere(s) = 10^{-9} amperes		
NC	normally closed		
Ne	neon		
NO	normally open		

Designators

A	assembly	Q	transistor
B	motor	QCR	transistor-diode
BT	battery	R(p)	resistor(pack)
C	capacitor	RT	thermistor
CR	diode or thyristor	S	switch
DL	delay line	T	transformer
DS	lamp	TB	terminal board
E	misc electronic part	TC	thermocouple
F	fuse	TP	test point
FL	filter	TS	terminal strip
HR	heater	U	microcircuit
IC	integrated circuit	V	vacuum tube, neon bulb, photocell, etc.
J	jack	W	cable, jumper
K	relay	X	socket
L	inductor	XDS	lampholder
M	meter	XF	fuseholder
MP	mechanical part	Y	crystal
P	plug	Z	network

Table 4-2. Manufacturers' Code List

MFR NO.	MANUFACTURER NAME	ADDRESS		ZIP CODE
H9027	Schurter A G H	Luzern	SW	
01121	Allen-Bradley Co	Milwaukee	WI	53204
01295	Texas Instr Inc Semicond Cmpnt Div	Dallas	TX	75222
02111	Spectrol Electronics Corp	City of Ind	CA	91745
03508	GE Co Semiconductor Prod Dept	Auburn	NY	13201
03888	K D I Pyrofilm Corp	Whippany	NJ	07981
04713	Motorola Semiconductor Products	Phoenix	AZ	85008
06665	Precision Monolithics Inc	Santa Clara	CA	95050
07263	Fairchile Semiconductor Div	Mountain View	CA	94042
11236	CTS of Berne Inc	Berne	IN	46711
13103	Thermalloy Co	Dallas	TX	75234
13606	Sprague Elect Co Semiconductor Div	Concord	NH	03301
14099	Semtech Corp	Newbury Park	CA	91320
15454	Ametek/Rodan Div	Anaheim	CA	92806
17856	Siliconix Inc	Santa Clara	CA	95054
18324	Signetics Corp	Sunnyvale	CA	94086
19701	Mepco/Electra Corp	Mineral Wells	TX	76067
20932	Emcon Div ITW	San Diego	CA	92129
24546	Corning Glass Works (Bradford)	Bradford	PA	16701
25403	N.V. Philips-Elcoma Department	Eindhoven	HL	02876
27014	National Semiconductor Corp	Santa Clara	CA	95051
27167	Corning Glass Works (Wilmington)	Wilmington	NC	28401
28480	Hewlett-Packard Co Corporate HQ	Palo Alto	CA	94304
3L585	RCA Corp Solid State Div	Somerville	NJ	
32997	Bourns Inc Trimpot Prod Div	Riverside	CA	92507
34335	Advanced Micro Devices Inc	Sunnyvale	CA	94086
34371	Harris Semicon Div Harris-Intertype	Melbourne	FL	32901
52063	Exar Integrated Systems Inc.	Sunnyvale	CA	94086
56289	Sprague Electric Co	North Adams	MA	01247
72136	Electro Motive Corp	Florence	SC	06226
72982	Erie Technological Products Inc	Erie	PA	16512
73138	Beckman Instruments Inc Helipot Div	Fullerton	CA	92634
75915	Littelfuse Inc	Des Plaines	IL	60016
84411	TRW Capacitor Div	Ogallala	NE	69153
91637	Dale Electronics Inc	Columbus	NE	68601

Replaceable Parts

Table 4-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1	03326-66501			SEE OPTION 002 PARTS LIST.		
A2	03326-66502	0	1	CHANNEL A ATTENUATOR BOARD	28480	03326-66502
A2C103-C115	0160-4571	8	26	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A2C116-C119	0160-3847	9	5	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A2C124-C129	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A2C130	0160-3875	3	3	CAPACITOR-FXD 22PF +-5% 200VDC CER 0+-30	51642	200-200-NPO-220J(.250LL)
A2C131	0160-3875	3		CAPACITOR-FXD 22PF +-5% 200VDC CER 0+-30	51642	200-200-NPO-220J(.250LL)
A2C132	0160-3875	3		CAPACITOR-FXD 22PF +-5% 200VDC CER 0+-30	51642	200-200-NPO-220J(.250LL)
A2C134-C139	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A2C140	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A2C141	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A2C142	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A2C143	0160-4805	1	1	CAPACITOR-FXD 47PF +-5% 100VDC CER 0+-30	27167	CAC02COG470J100A
A2CR101-CR105	1901-0040	1	4	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A2CR106	1902-0958	2	2	DIODE-ZNR 10V 5% DO-35 PD=.4W TC=+.075%	04713	SZ30035-016
A2CR107	1902-0958	2		DIODE-ZNR 10V 5% DO-35 PD=.4W TC=+.075%	04713	SZ30035-016
A2J1	1250-0544	9	1	CONNECTOR-RF SM-SNP M SGL-HOLE-FR 50-OHM	98291	051-049-0000-220
A2J2	1251-6254	2	2	CONNECTOR-SGL CONT RTANG-F	91833	901
A2J3	1251-6254	2		CONNECTOR-SGL CONT RTANG-F	91833	901
A2K101-K108	0490-1405	0	8	RELAY 2C 12VDC-COIL 2A 250VAC	28480	DS2E-S-DC12V-H69
A2L100	9140-0395	3	1	INDUCTOR RF-CH-MLD 560NH 5% .166DX.385LG	06560	4425-3J
A2L101	9100-0539	3	1	INDUCTOR RF-CH-MLD 10UH 5% .156DX.375LG	06560	4445-2J
A2L102	9100-0539	3	2	INDUCTOR RF-CH-MLD 10UH 5% .156DX.375LG	06560	4445-2J
A2L103	9140-0308	8	1	INDUCTOR RF-CH-MLD 120NH 5% .166DX.385LG	24226	15M120J-1
A2MP1	03326-04102	6	1	CVR, ATTENUATOR	28480	03326-04102
A2MP2	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A2MP3	0624-0333	6		SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A2MP4	2360-0113	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A2MP5	2360-0113	2		SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A2P1	1251-8410	6	1	CONN-POST TYPE 48-CONT RTANG-DPSLDR	28480	1251-8410
A2R103	0698-8390	6	2	RESISTOR 96.25 .1% .5W F TC=0+-50	19701	5053R
A2R104	0698-7982	0	1	RESISTOR 71.16 .1% .25W F TC=0+-50	19701	5043R
A2R105	0698-8390	6		RESISTOR 96.25 .1% .5W F TC=0+-50	19701	5053R
A2R106	0698-7984	2	6	RESISTOR 61.1 .1% .5W F TC=0+-50	19701	5053R
A2R107	0698-8258	5	3	RESISTOR 247.5 .1% .25W F TC=0+-25	19701	5043R
A2R108	0698-7984	2		RESISTOR 61.1 .1% .5W F TC=0+-50	19701	5053R
A2R109	0698-7984	2		RESISTOR 61.1 .1% .5W F TC=0+-50	19701	5053R
A2R110	0698-8258	5	2	RESISTOR 247.5 .1% .25W F TC=0+-25	19701	5043R
A2R111	0698-7984	2		RESISTOR 61.1 .1% .5W F TC=0+-50	19701	5053R
A2R112	0698-7984	2		RESISTOR 61.1 .1% .5W F TC=0+-50	19701	5053R
A2R113	0698-8258	5		RESISTOR 247.5 .1% .25W F TC=0+-25	19701	5043R
A2R114	0698-7984	2		RESISTOR 61.1 .1% .5W F TC=0+-50	19701	5053R
A2R115	0699-0760	0	3	RESISTOR 50 1% 2W MO TC=0+-200	24546	FP2
A2R116	0699-0760	0		RESISTOR 50 1% 2W MO TC=0+-200	24546	FP2
A2R117	0699-0760	0		RESISTOR 50 1% 2W MO TC=0+-200	24546	FP2
A2R119-R124	0683-1815	5	8	RESISTOR 180 5% .25W CF TC=0-400	77902	R-25J
A2R126	0757-0465	6	2	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A2R127	0698-4509	1	2	RESISTOR 80.6K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A2R128	0698-4499	8	2	RESISTOR 54.9K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A2R129	0757-0452	1	2	RESISTOR 27.4K 1% .125W F TC=0+-100	19701	5033R
A2R130	0757-0452	1		RESISTOR 27.4K 1% .125W F TC=0+-100	19701	5033R
A2R131	0698-4499	8		RESISTOR 54.9K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A2R132	0698-4509	1		RESISTOR 80.6K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A2R133-R136	0757-0442	9	4	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A2R137	0757-0449	6	2	RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A2R138	0757-0449	6		RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A2R143	0683-1815	5		RESISTOR 180 5% .25W CF TC=0-400	77902	R-25J
A2R144	0683-1815	5		RESISTOR 180 5% .25W CF TC=0-400	77902	R-25J
A2R145	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A2TP0-TP10	1251-0600	0	11	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A2U100	1858-0047	5	1	TRANSISTOR ARRAY 16-PIN PLSTC DIP	13606	ULN-2003A
A2U101	1826-0138	8	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	27014	SL24958
A2U102	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN53504
A2U103	1820-1206	1	1	IC GATE TTL LS NOR TPL 3-INP	01295	SN53513
A2U104	1820-1144	6	1	IC GATE TTL LS NOR QUAD 2-INP	01295	SN53243

PART NUMBER 9320-3991

See introduction to this section for ordering information
*Indicates factory selected value

Table 4-4. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3	03326-66503	1	2	OUTPUT AMPLIFIER BOARDS	28480	03326-66503
A3C101	0160-3847	9	13	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C103	0121-0451	3	1	CAPACITOR-V TRMR-AIR 1.7-11PF 175V	74970	187-0106-028
A3C104	0160-4571	8	15	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C105	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C106	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C107	0160-2237	9	1	CAPACITOR-FXD 1.2PF +-.25PF 500VDC CER	52763	0160-2237
A3C108	0160-2236	8	1	CAPACITOR-FXD 1PF +-.25PF 500VDC CER	52763	0160-2236
A3C109	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C111	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C112	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C113	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C114	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C116	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C117	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C118	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C119	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C120	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C121	0180-1746	5	2	CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS
A3C122	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C123	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C124	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS
A3C125	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C126	0180-2506	7	2	CAPACITOR-FXD 470UF+50-10% 25VDC AL	19701	3074GH471T025JPB
A3C127	0180-2506	7		CAPACITOR-FXD 470UF+50-10% 25VDC AL	19701	3074GH471T025JPB
A3C128	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C129	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C130	0180-0197	8	2	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	13606	150D225X9020A2-DYS
A3C131	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C132	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C133	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C134	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C135	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C138	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C139	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A3C140	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C141	0160-4571	8	3	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C142	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C143	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	13606	150D225X9020A2-DYS
A3C144	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3C145	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A3CR101-CR108	1901-0040	1	8	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A3CR109	1902-0961	7		DIODE-ZNR 13V 5% DO-35 PD=.4W TC=+.082%	04713	SZ30035-019
A3CR110	1902-0961	7	2	DIODE-ZNR 13V 5% DO-35 PD=.4W TC=+.082%	04713	SZ30035-019
A3J2	1251-6254	2	1	CONNECTOR-SGL CONT RTANG-F	91833	901
A3K101	0490-1405	0	1	RELAY 2C 12VDC-COIL 2A 250VAC	28480	DS2E-S-DC12V-H69
A3L102	9100-0539	3	4	INDUCTOR RF-CH-MLD 10UH 5% .156DX.375LG	06560	4445-2J
A3L104-L106	9100-0539	3		INDUCTOR RF-CH-MLD 10UH 5% .156DX.375LG	06560	4445-2J
A3L107-L108	9170-0894	0	2	CORE-SHIELDING BEAD	02114	56-590-65/4A6
A3L110-L111	9140-0395	3	2	INDUCTOR RF-CH-MLD 560NH 5% .166DX.385LG	06560	4425-3J
A3MP1	03326-04103	7	1	CVR, OUTPUT AMP	28480	03326-04103
A3MP2	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A3MP3	0624-0333	6		SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A3MP4	2360-0113	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A3MP5	2360-0113	2		SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A3MP6	0380-1077	9	1	STANDOFF-RVT-ON 6.35-MM-LG M3.0 X	00866	0380-1077
A3MP7	0515-0104	8	3	SCREW-MACH M3 X 0.5 8MM-LG PAN-HD	28480	0515-0104
A3MP8	2580-0003	5	2	NUT-HEX-W/LKWR 8-32-THD .125-IN-THK	28480	2580-0003
A3MP9	2580-0003	5		NUT-HEX-W/LKWR 8-32-THD .125-IN-THK	28480	2580-0003
A3MP10	2580-0004	6	2	NUT-HEX-DBL-CHAM 8-32-THD .125-IN-THK	73734	2580-0004
A3MP11	2580-0004	6		NUT-HEX-DBL-CHAM 8-32-THD .125-IN-THK	73734	2580-0004
A3MP101-MP106	1205-0235	0	6	HEAT SINK SGL TO-18-CS	13103	2224-B
A3MP107-MP110	4330-0952	6	4	INSULATOR-BEAD CERAMIC	25706	10-215A
A3MP111-MP112	0515-0104	8		SCREW-MACH M3 X 0.5 8MM-LG PAN-HD	28480	0515-0104
A3MP113	03326-01101	9	1	HTSK,OUTPUT AMP	28480	03326-01101
A3P1	T-54687	9	1	DIN CONN.-32 PIN MALE	28480	T-54687
A3Q101	1854-0795	2	2	TRANSISTOR NPN SI TO-92 PD=625MW	04713	SPS8028
A3Q102	1853-0448	0	2	TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320-3991

Table 4-5. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3Q103	1854-0795	2		TRANSISTOR NPN SI TO-92 PD=625MW	04713	SPS8028
A3Q104	1853-0448	0		TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A3Q105	1854-0215	1	2	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A3Q106	1853-0036	2	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	04713	SPS-3612
A3Q107	1854-0876	0	1	TRANSISTOR NPN PD=1W FT=1GHZ	04713	SRF2955
A3Q108	1853-0495	7	1	TRANSISTOR PNP PD=1W FT=1GHZ	04713	SRF2954
A3Q109	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A3R101	0698-6323	1	2	RESISTOR 100 .1% .125W F TC=0+-25	91637	CMF-55-1, T-9
A3R102	0698-6697	2	1	RESISTOR 402 .25% .125W F TC=0+-50	19701	5033R
A3R103	0698-4520	6	2	RESISTOR 143K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A3R104	0698-3279	0	2	RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A3R105	0683-2035	3	3	RESISTOR 20K 5% .25W CF TC=0-400	77902	R-25J
A3R106	0698-8827	4	2	RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A3R107	0683-1015	7	4	RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A3R108	0757-0442	9	4	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A3R109	0757-0387	1	2	RESISTOR 27.4 1% .125W F TC=0+-100	19701	5033R
A3R110	0698-3154	0	2	RESISTOR 4.22K 1% .125W F TC=0+-100	19701	5033R
A3R111-R114	0757-0277	8	4	RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A3R115	0698-7449	4	1	RESISTOR 1K .1% .25W F TC=0+-25	19701	5043R
A3R116	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A3R117	0683-2035	3		RESISTOR 20K 5% .25W CF TC=0-400	77902	R-25J
A3R118	0698-3279	0		RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A3R119	0698-4520	6		RESISTOR 143K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A3R120	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A3R121	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A3R122	0757-0387	1		RESISTOR 27.4 1% .125W F TC=0+-100	19701	5033R
A3R123	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A3R124	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A3R125	0683-1825	7	3	RESISTOR 1.8K 5% .25W CF TC=0-400	77902	R-25J
A3R126	0698-3228	9	2	RESISTOR 49.9K 1% .125W F TC=0+-100	19701	5033R
A3R127	0698-3271	2	2	RESISTOR 115K 1% .125W F TC=0+-100	19701	5033R
A3R128	0683-1825	7		RESISTOR 1.8K 5% .25W CF TC=0-400	77902	R-25J
A3R129	0683-4705	8	4	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A3R130	2100-0568	1	1	RESISTOR-TRMR 100 10% C TOP-ADJ 1-TRN	73138	72PR100-102B
A3R131	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A3R132	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A3R133	0683-1825	7		RESISTOR 1.8K 5% .25W CF TC=0-400	77902	R-25J
A3R134	0683-1825	7	1	RESISTOR 1.8K 5% .25W CF TC=0-400	77902	R-25J
A3R135	0698-3228	9		RESISTOR 49.9K 1% .125W F TC=0+-100	19701	5033R
A3R136	0698-3271	2		RESISTOR 115K 1% .125W F TC=0+-100	19701	5033R
A3R137	0757-0984	4	2	RESISTOR 10 1% .5W F TC=0+-100	19701	5053R
A3R138	0757-0465	6	2	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A3R139	0698-4532	0	2	RESISTOR 280K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A3R140	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A3R141	0683-1015	7	2	RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A3R142	0698-6324	2	1	RESISTOR 187 1% .125W F TC=0+-100	19701	5033R
A3R143	0683-0335	2	2	RESISTOR 3.3 5% .25W CF TC=0-400	77902	R-25J
A3R144-R147	0698-7990	0	4	RESISTOR 200 .1% .5W F TC=0+-25	19701	5053R
A3R148	0683-0335	2		RESISTOR 3.3 5% .25W CF TC=0-400	77902	R-25J
A3R149	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A3R152	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A3R153	0698-4532	0		RESISTOR 280K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A3R154	0757-0984	4		RESISTOR 10 1% .5W F TC=0+-100	19701	5053R
A3R155	0698-4489	6	1	RESISTOR 28K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A3R156	0698-4489	6		RESISTOR 28K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A3R157	0757-0438	3	2	RESISTOR 5.11K 1% .125W F TC=0+-100	19701	5033R
A3R158	0757-0441	8	2	RESISTOR 8.25K 1% .125W F TC=0+-100	19701	5033R
A3R159	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	19701	5033R
A3R160	0757-0441	8		RESISTOR 8.25K 1% .125W F TC=0+-100	19701	5033R
A3R161	0683-2035	3		RESISTOR 20K 5% .25W CF TC=0-400	77902	R-25J
A3R162	0757-0449	6	1	RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A3R163	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	19701	5033R
A3R164	0683-2015	9	1	RESISTOR 200 5% .25W CF TC=0-400	77902	R-25J
A3R165	0683-3035	5	1	RESISTOR 30K 5% .25W CF TC=0-400	77902	R-25J
A3R166	0683-1035	1	1	RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A3R168	0698-7608	7	1	RESISTOR 192.5 .5% .125W F TC=0+-50	19701	5033R
A3R169	0698-6377	5	1	RESISTOR 200 .1% .125W F TC=0+-25	91637	CMF-55-1, T-9
A3R170	0699-0412	9	1	RESISTOR 493 .1% .25W F TC=0+-25	19701	5043R

See introduction to this section for ordering information
*Indicates factory selected value

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Table 4-6. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3R171	0698-7608	7	1	RESISTOR 192.5 .5% .125W F TC=0+-50	19701	5033R
A3R172	0757-0422	5	1	RESISTOR 909 1% .125W F TC=0+-100	19701	5033R
A3R173	0698-4489	6	3	RESISTOR 28K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A3R174	0698-4489	6		RESISTOR 28K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A3R175	0683-4725	2	1	RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A3R177	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A3R178	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A3R179	0698-6323	1		RESISTOR 100 .1% .125W F TC=0+-25	91637	CMF-55-1, T-9
A3R180	0757-0401	0	1	RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A3TP1-TP11	1251-0600	0	11	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A3U101	1826-0413	2	1	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	34371	HA2-2605-B1392-001
A3U102	1826-0326	6	2	IC OP AMP GP DUAL 8-DIP-P PKG	07933	RC4558NB
A3U103	1826-0412	1	1	IC COMPARATOR PRCN DUAL 8-DIP-P PKG	27014	SL33675
A3U104	1826-0326	6		IC OP AMP GP DUAL 8-DIP-P PKG	07933	RC4558NB
A3W101	1251-4822	6	2	CONN-POST TYPE .100-PIN-SPCG 3-CONT	27264	22-03-2031
A3W101A	1258-0141	8	2	JMPR-REM .025P	22526	65474-004
A3W102	1251-4822	6		CONN-POST TYPE .100-PIN-SPCG 3-CONT	27264	22-03-2031
A3W102A	1258-0141	8		JMPR-REM .025P	22526	65474-004
A4	**03326-66504**	2	2	**PREAMPLIFIER BOARDS**	**28480**	**03326-66504**
A4C102-C103	0160-4571	8	12	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A4C109-C112	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A4C113	0160-4805	1	1	CAPACITOR-FXD 47PF +-5% 100VDC CER 0+-30	27167	CAC02COG470J100A
A4C114	0180-1746	5	6	CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS
A4C115	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS
A4C117	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A4C118	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS
A4C120	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A4C121	0160-3847	9	7	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A4C122	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A4C124	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A4C125	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS
A4C127	0180-0161	6	2	CAPACITOR-FXD 3.3UF+-10% 35VDC TA	13606	150D335X9035B2-DYS
A4C128	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A4C129	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS
A4C130	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A4C131	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS
A4C132	0180-0161	6		CAPACITOR-FXD 3.3UF+-10% 35VDC TA	13606	150D335X9035B2-DYS
A4C133	0160-4820	0	1	CAPACITOR-FXD 1800PF +-5% 100VDC CER	27167	CAC04COG182J100A
A4C134	0160-4389	6	1	CAPACITOR-FXD 100PF +-5PF 200VDC CER	51642	200-200-NPO-101J
A4C135	0160-4547	8	2	CAPACITOR-FXD 150PF +-5% 200VDC CER	51642	200-200-NPO-151J
A4C136	0160-4547	8		CAPACITOR-FXD 150PF +-5% 200VDC CER	51642	200-200-NPO-151J
A4C137	0160-4389	6		CAPACITOR-FXD 100PF +-5PF 200VDC CER	51642	200-200-NPO-101J
A4C138	0160-4804	0	1	CAPACITOR-FXD 56PF +-5% 100VDC CER 0+-30	27167	CAC02COG560J100A
A4C144	0160-2235	7	1	CAPACITOR-FXD .75PF +-.25PF 500VDC CER	52763	0160-2235
A4C145	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A4C146	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A4C147-C150	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A4CR101-CR105	1901-0040	1	5	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A4K101	0490-1405	0	1	RELAY 2C 12VDC-COIL 2A 250VAC	28480	DS2E-S-DC12V-H69
A4L102	9100-3551	5	1	INDUCTOR RF-CH-MLD 1UH 5% .166DX.385LG	24226	15M101J
A4L103	9100-0539	3	4	INDUCTOR RF-CH-MLD 10UH 5% .156DX.375LG	06560	4445-2J
A4L104	9100-0539	3		INDUCTOR RF-CH-MLD 10UH 5% .156DX.375LG	06560	4445-2J
A4L105	9140-0454	5	1	INDUCTOR RF-CH-MLD 18UH 5% .166DX.385LG	06560	4445-5J
A4L107	9140-0349	7	1	INDUCTOR RF-CH-MLD 1.1UH 5% .166DX.385LG	24226	15M111J
A4L109	9100-0539	3		INDUCTOR RF-CH-MLD 10UH 5% .156DX.375LG	06560	4445-2J
A4L110	9100-0539	3		INDUCTOR RF-CH-MLD 10UH 5% .156DX.375LG	06560	4445-2J
A4MP1	03326-04104	8	1	CVR, PREAMP	28480	03326-04104
A4MP2	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A4MP3	0624-0333	6		SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A4MP4	2360-0113	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A4MP5	2360-0113	2		SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A4MP101-MP108	1205-0235	0	8	HEAT SINK SGL TO-18-CS	13103	2224-B
A4P1	1252-0266	6	1	DIN CONN.-16 PIN MALE	06383	100-316-033
A4Q101	1854-0795	2	1	TRANSISTOR NPN SI TO-92 PD=625MW	04713	SPS8028
A4Q102	1853-0448	0	1	TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A4Q103	1854-0795	2		TRANSISTOR NPN SI TO-92 PD=625MW	04713	SPS8028

See introduction to this section for ordering information
*Indicates factory selected value

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Table 4-7. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A4Q104	1853-0448	0		TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A4Q105	1854-0795	2		TRANSISTOR NPN SI TO-92 PD=625MW	04713	SPS8028
A4Q106	1853-0448	0		TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A4Q107	1854-0215	1	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A4Q108	1853-0036	2	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	04713	SPS-3612
A4Q109	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A4R101	0757-0401	0	3	RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A4R104	0698-4520	6	2	RESISTOR 143K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A4R105	0757-0428	1	1	RESISTOR 1.62K 1% .125W F TC=0+-100	19701	5033R
A4R106	0683-2035	3	2	RESISTOR 20K 5% .25W CF TC=0-400	77902	R-25J
A4R107	0698-8827	4	2	RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A4R108	0683-1015	7	6	RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A4R109	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A4R110	0698-0085	0	2	RESISTOR 2.61K 1% .125W F TC=0+-100	19701	5033R
A4R111	0698-0085	0		RESISTOR 2.61K 1% .125W F TC=0+-100	19701	5033R
A4R112	0757-0283	6	1	RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A4R113	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A4R114	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A4R115	0683-2035	3		RESISTOR 20K 5% .25W CF TC=0-400	77902	R-25J
A4R116	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A4R117	0757-0428	1	1	RESISTOR 1.62K 1% .125W F TC=0+-100	19701	5033R
A4R118	0698-4520	6		RESISTOR 143K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A4R119	0757-0802	5	2	RESISTOR 162 1% .5W F TC=0+-100	19701	5053R
A4R120-R123	0698-3427	0	4	RESISTOR 13.3 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A4R124	0757-0802	5		RESISTOR 162 1% .5W F TC=0+-100	19701	5053R
A4R127	0683-4705	8	4	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A4R128	0683-1035	1	5	RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A4R129	0683-1035	1		RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A4R130	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A4R131	0698-3432	7	1	RESISTOR 26.1 1% .125W F TC=0+-100	19701	5033R
A4R132	0698-6324	2	1	RESISTOR 187 1% .125W F TC=0+-100	19701	5033R
A4R133	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A4R136	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A4R137	0683-1035	1		RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A4R138	0683-1035	1		RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A4R139	0698-3228	9	2	RESISTOR 49.9K 1% .125W F TC=0+-100	19701	5033R
A4R140	0757-0465	6	2	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A4R141	0683-2015	9	2	RESISTOR 200 5% .25W CF TC=0-400	77902	R-25J
A4R142	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A4R143-R144	0683-1005	5	2	RESISTOR 10 5% .25W CF TC=0-400	77902	R-25J
A4R145	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A4R146	0683-2015	9		RESISTOR 200 5% .25W CF TC=0-400	77902	R-25J
A4R147	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A4R148	0698-3228	9		RESISTOR 49.9K 1% .125W F TC=0+-100	19701	5033R
A4R150	0757-0277	8	1	RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A4R151	0683-1815	5	1	RESISTOR 180 5% .25W CF TC=0-400	77902	R-25J
A4R152	0683-3035	5	1	RESISTOR 30K 5% .25W CF TC=0-400	77902	R-25J
A4R153	0683-1035	1		RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A4R154	0698-6323	1	1	RESISTOR 100 .1% .125W F TC=0+-25	91637	CMF-55-1, T-9
A4R156-R157	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A4R158	0757-0422	5	1	RESISTOR 909 1% .125W F TC=0+-100	19701	5033R
A4R159	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A4R160	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A4R161	0757-0378	0	1	RESISTOR 11 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A4R163	0757-0277	8	1	RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A4TP0-TP10	1251-0600	0	11	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A4U101	1826-0715	7	1	IC OP AMP LOW-NOISE 8-DIP-P PKG	18324	CC3802
A4U102-U103	1826-0326	6	2	IC OP AMP GP DUAL 8-DIP-P PKG	07933	RC4558NB
A5	**03326-66505**	3	2	**MIXER BOARDS**	**28480**	**03326-66505**
A5C9	0160-4571	8	10	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A5C10-C11	0180-1746	5	2	CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS
A5C21	0160-5412	8	1	CAPACITOR-FXD 16PF +-5% 100VDC CER 0+-30	27167	CAC02C0G160J100A
A5C22	0160-4389	6	3	CAPACITOR-FXD 100PF +-5PF 200VDC CER	51642	200-200-NPO-101J
A5C101	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA

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See introduction to this section for ordering information
*Indicates factory selected value

Table 4-8. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5C200-C202	0160-3847	9	6	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A5C302	0160-3878	6	2	CAPACITOR-FXD 1000PF +-20% 100VDC CER	51642	200-100-X7R-102M(.250LL)
A5C304	0160-3878	6		CAPACITOR-FXD 1000PF +-20% 100VDC CER	51642	200-100-X7R-102M(.250LL)
A5C305	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A5C307	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A5C309	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A5C400	0121-0168	9	1	CAPACITOR-V TRMR-PSTN .2-1.5PF 600V	74970	273-0001-011
A5C401	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A5C402	0160-4805	1	1	CAPACITOR-FXD 47PF +-5% 100VDC CER 0+-30	27167	CAC02COG470J100A
A5C403	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A5C404	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A5C406	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A5C407	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A5C408	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A5C409	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A5C410-C411	0180-2765	0	2	CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A5C413	0160-4796	9	2	CAPACITOR-FXD 3.9PF +-.25PF 100VDC CER	27167	CAC02COG3R9C100A
A5C414-C415	0160-3875	3	2	CAPACITOR-FXD 22PF +-5% 200VDC CER 0+-30	51642	200-200-NPO-220J(.250LL)
A5C417	0160-4796	9		CAPACITOR-FXD 3.9PF +-.25PF 100VDC CER	27167	CAC02COG3R9C100A
A5C419	0160-4389	6		CAPACITOR-FXD 100PF +-5PF 200VDC CER	51642	200-200-NPO-101J
A5C420	0160-4547	8	2	CAPACITOR-FXD 150PF +-5% 200VDC CER	51642	200-200-NPO-151J
A5C421	0160-4804	0	1	CAPACITOR-FXD 56PF +-5% 100VDC CER 0+-30	27167	CAC02COG560J100A
A5C422	0160-4547	8		CAPACITOR-FXD 150PF +-5% 200VDC CER	51642	200-200-NPO-151J
A5C423	0160-4389	6		CAPACITOR-FXD 100PF +-5PF 200VDC CER	51642	200-200-NPO-101J
A5C424	0160-4820	0	1	CAPACITOR-FXD 1800PF +-5% 100VDC CER	27167	CAC04COG182J100A
A5C425	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A5C450	0160-3873	1	1	CAPACITOR-FXD 4.7PF +-.5PF 200VDC CER	51642	200-200-NPO-479D(.250LL)
A5C451-C452	0160-3558	9	2	CAPACITOR-FXD .1UF +-20% 50VDC CER	04222	SR205E104MAA
A5CR101-CR102	1901-0518	8	2	DIODE-SCHOTTKY SM SIG	28480	1901-0518
A5CR302	1901-0040	1	3	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A5CR400-CR401	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A5CR402-CR403	1902-0686	3	2	DIODE-ZNR 6.2V 2% DO-7 PD=.4W TC=+.002%	04713	SZ 12170
A5J1	1251-6254	2	1	CONNECTOR-SGL CONT RTANG-F	91833	901
A5L4	9100-1791	1	3	CORE-FERRITE CHOKE-WIDEBAND;IMP:>360	02114	VK200-19/4B
A5L6-L7	9100-1791	1		CORE-FERRITE CHOKE-WIDEBAND;IMP:>360	02114	VK200-19/4B
A5L20	9100-3547	9	1	INDUCTOR RF-CH-MLD 4.3UH 5% .166DX.385LG	24226	15M431J-1
A5L400-L401	9100-1626	1	2	INDUCTOR RF-CH-MLD 36UH 5% .166DX.385LG	06560	15-1315-1J
A5L404	9140-0349	7	1	INDUCTOR RF-CH-MLD 1.1UH 5% .166DX.385LG	24226	15M111J
A5L406	9140-0454	5	1	INDUCTOR RF-CH-MLD 18UH 5% .166DX.385LG	06560	4445-5J
A5L407	9100-3562	8	2	INDUCTOR RF-CH-MLD 4.7UH 5% .166DX.385LG	24226	15M471J
A5L408	9100-3553	7	2	INDUCTOR RF-CH-MLD 3.9UH 5% .166DX.385LG	24226	15M391J
A5L409	9100-3562	8		INDUCTOR RF-CH-MLD 4.7UH 5% .166DX.385LG	24226	15M471J
A5L410	9100-3553	7		INDUCTOR RF-CH-MLD 3.9UH 5% .166DX.385LG	24226	15M391J
A5MP1	03326-04105	9	1	CVR, MIXER	28480	03326-04105
A5MP2-MP3	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A5MP4-MP6	2360-0113	2	3	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A5MP7	03326-00601	2	1	SHIELD 1, MIXER	28480	03326-00601
A5MP8	03326-00602	3	1	SHIELD 2, MIXER	28480	03326-00602
A5P1	1252-0266	6	1	DIN CONN.-16 PIN MALE	06383	100-316-033
A5Q1-Q2	1853-0448	0	4	TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A5Q3	1854-0357	2	3	TRANSISTOR-DUAL NPN PD=360MW	04713	SD-2608
A5Q5-Q6	1854-0357	2		TRANSISTOR-DUAL NPN PD=360MW	04713	SD-2608
A5Q7	1854-0071	7	1	TRANSISTOR NPN SI PD=300MW FT=200MHZ	13606	CT-1200
A5Q400	1854-0795	2	1	TRANSISTOR NPN SI TO-92 PD=625MW	04713	SPS8028
A5Q401	1853-0448	0		TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A5Q402	1853-0448	0		TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A5R100	0757-0815	0	1	RESISTOR 562 1% .5W F TC=0+-100	19701	5053R
A5R101	0698-7212	9	2	RESISTOR 100 1% .05W F TC=0+-100	24546	C-3, T-0
A5R102	0698-7212	9		RESISTOR 100 1% .05W F TC=0+-100	24546	C-3, T-0
A5R103	0757-0401	0	14	RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R104	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R201	0757-0416	7	2	RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A5R202	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A5R203	0757-0394	0	3	RESISTOR 51.1 1% .125W F TC=0+-100	19701	5033R
A5R305	0699-0487	8	4	RESISTOR 500 .1% .1W F TC=0+-10	19701	5023Z
A5R306	0699-0487	8		RESISTOR 500 .1% .1W F TC=0+-10	19701	5023Z
A5R307	0757-0394	0		RESISTOR 51.1 1% .125W F TC=0+-100	19701	5033R
A5R308	0683-4705	8	7	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A5R309	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J

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See introduction to this section for ordering information
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Table 4-9. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5R310	0698-4420	5	1	RESISTOR 226 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A5R311	0699-0487	8		RESISTOR 500 .1% .1W F TC=0+-10	19701	5023Z
A5R312	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A5R313	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A5R314	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R315	0757-0394	0		RESISTOR 51.1 1% .125W F TC=0+-100	19701	5033R
A5R316	2100-3751	0	1	RESISTOR-TRMR 10 10% C SIDE-ADJ 17-TRN	73138	67XR10
A5R317	0757-0814	9	1	RESISTOR 511 1% .5W F TC=0+-100	19701	5053R
A5R318	0698-4862	9	1	RESISTOR 453 1% .5W F TC=0+-100	91637	CMF-65-2
A5R319	0683-2715	6	1	RESISTOR 270 5% .25W CF TC=0-400	77902	R-25J
A5R320	0683-2415	3	1	RESISTOR 240 5% .25W CF TC=0-400	77902	R-25J
A5R321	0699-0487	8		RESISTOR 500 .1% .1W F TC=0+-10	19701	5023Z
A5R322	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A5R323	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A5R324	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R325	0757-1094	9	2	RESISTOR 1.47K 1% .125W F TC=0+-100	19701	5033R
A5R326	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R327	0757-0439	4	1	RESISTOR 6.81K 1% .125W F TC=0+-100	19701	5033R
A5R328	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A5R400	2100-0545	4	2	RESISTOR-TRMR 1K 10% C SIDE-ADJ 17-TRN	73138	67XR1K
A5R401	0698-7850	1	2	RESISTOR 9.455K .1% .125W F TC=0+-25	19701	5033R
A5R402	0698-7850	1		RESISTOR 9.455K .1% .125W F TC=0+-25	19701	5033R
A5R403	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R404	0757-0283	6	1	RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A5R405	0757-0422	5	2	RESISTOR 909 1% .125W F TC=0+-100	19701	5033R
A5R406	0757-0384	8	2	RESISTOR 20 1% .125W F TC=0+-100	19701	5033R
A5R407	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R408	0757-0384	8		RESISTOR 20 1% .125W F TC=0+-100	19701	5033R
A5R409	0757-0422	5		RESISTOR 909 1% .125W F TC=0+-100	19701	5033R
A5R410-R412	0698-6320	8	3	RESISTOR 5K .1% .125W F TC=0+-25	91637	CMF-55-1, T-9
A5R414	0757-0401	0	1	RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R415	0757-0407	6	1	RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A5R416	0698-4427	2	1	RESISTOR 1.65K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A5R417	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R418	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R419	0686-4715	6	2	RESISTOR 470 5% .5W CC TC=0+529	01121	EB4715
A5R420	0757-0346	2	3	RESISTOR 10 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A5R421	0757-0346	2		RESISTOR 10 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A5R422	0698-4491	0	1	RESISTOR 30.9K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A5R423	0686-4715	6		RESISTOR 470 5% .5W CC TC=0+529	01121	EB4715
A5R424	2100-0545	4		RESISTOR-TRMR 1K 10% C SIDE-ADJ 17-TRN	73138	67XR1K
A5R425	0757-0450	9	1	RESISTOR 22.1K 1% .125W F TC=0+-100	19701	5033R
A5R426	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	19701	5033R
A5R427	0698-4445	4	1	RESISTOR 5.76K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A5R428	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R429	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R430	0698-3512	4	1	RESISTOR 1.18K 1% .125W F TC=0+-100	19701	5033R
A5R431	0698-3512	4	1	RESISTOR 1.18K 1% .125W F TC=0+-100	19701	5033R
A5R432	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R434	0757-0346	2		RESISTOR 10 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A5R435	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R436	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A5R437	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A5R450	0698-4440	9	1	RESISTOR 3.4K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A5R451	0757-0424	7	1	RESISTOR 1.1K 1% .125W F TC=0+-100	19701	5033R
A5T1	08552-6044	1	1	TRANS 6 TURNS	28480	08552-6044
A5T2	08552-6024	9	1	TRANS	28480	08552-6024
A5TP6-TP13	1251-0600	0	8	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A5U1	1820-0810	1	1	IC RCVR ECL LINE RCVR TPL 2-INP	04713	SC63470P116
A5U400	1858-0040	8	1	TRANSISTOR ARRAY 16-PIN PLSTC DIP	3L585	90978
A6	**03326-66506**	**4**	**2**	**MODULATOR BOARDS**	**28480**	**03326-66506**
A6C1	0160-4571	8	4	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A6C2	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A6C3	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A6C4	0180-1746	5	3	CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS
A6C5	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS

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Table 4-10. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A6C6	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS
A6C10	0160-3847	9	7	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A6C11	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A6C12	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	C320C103M1R5CA
A6C13	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A6C14	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A6C15	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A6C20	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A6C30	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A6C40	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A6C41	0160-3879	7	3	CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	C320C103M1R5CA
A6C42	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	C320C103M1R5CA
A6C50	0160-5412	8	1	CAPACITOR-FXD 16PF +-5% 100VDC CER 0+-30	27167	CAC02C0G160J100A
A6C51	0160-4350	1	1	CAPACITOR-FXD 68PF +-5% 200VDC CER 0+-30	51642	200-200-NPO-680J(.250LL)
A6C52	0160-4389	6	1	CAPACITOR-FXD 100PF +-5PF 200VDC CER	51642	200-200-NPO-101J
A6C53	0160-4788	9	1	CAPACITOR-FXD 18PF +-5% 100VDC CER 0+-30	04222	MA101A180JAA
A6C60	0160-4814	2	1	CAPACITOR-FXD 150PF +-5% 100VDC CER	27167	CAC02C0G151J100A
A6CR30	1901-0040	1	1	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A6J1	1251-6254	2	1	CONNECTOR-SGL CONT RTANG-F	91833	901
A6L1	9100-3560	6	3	INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A6L2	9100-3560	6		INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A6L3	9100-3560	6		INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A6L51	9100-3547	9	2	INDUCTOR RF-CH-MLD 4.3UH 5% .166DX.385LG	24226	15M431J-1
A6L52	9100-3547	9		INDUCTOR RF-CH-MLD 4.3UH 5% .166DX.385LG	24226	15M431J-1
A6MP1	03326-04106	0	1	CVR, MODULATOR	28480	03326-04106
A6MP2	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A6MP3	0624-0333	6		SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A6MP4	2360-0113	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A6MP5	2360-0113	2		SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A6P1	1252-0266	6	1	DIN CONN.-16 PIN MALE	06383	100-316-033
A6Q1	1854-0215	1	2	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A6Q2	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A6R12	0757-0277	8	3	RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A6R13	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A6R14	0757-0416	7	2	RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A6R15	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A6R16	0757-0280	3	4	RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A6R17	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A6R20	0757-0401	0	2	RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A6R21	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A6R22	0757-0446	3	1	RESISTOR 15K 1% .125W F TC=0+-100	19701	5033R
A6R23	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A6R30	0757-0428	1	1	RESISTOR 1.62K 1% .125W F TC=0+-100	19701	5033R
A6R31	0698-3152	8	1	RESISTOR 3.48K 1% .125W F TC=0+-100	19701	5033R
A6R32	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A6R33	0683-4705	8	8	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A6R34	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A6R35	0698-0085	0	2	RESISTOR 2.61K 1% .125W F TC=0+-100	19701	5033R
A6R36	0757-0443	0	1	RESISTOR 11K 1% .125W F TC=0+-100	19701	5033R
A6R37	0698-0085	0		RESISTOR 2.61K 1% .125W F TC=0+-100	19701	5033R
A6R40-R45	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A6R46	0757-0384	8	1	RESISTOR 20 1% .125W F TC=0+-100	19701	5033R
A6R47	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A6R50	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A6R60	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A6R61	0757-0420	3	1	RESISTOR 750 1% .125W F TC=0+-100	19701	5033R
A6TP1A-TP7	1251-0600	0	8	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A6U1	1820-0810	1	1	IC RCVR ECL LINE RCVR TPL 2-INP	04713	SC63470P116
A6U2	1858-0063	5	1	TRANSISTOR ARRAY 14-PIN PLSTC DIP	3L585	90977
A12	**03326-66512**	**2**	**1**	**CHANNEL B ATTENUATOR BOARD**	**28480**	**03326-66512**
A12C103-C110	0160-4571	8	24	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A12C111	0160-5271	7	1	CAPACITOR-FXD 30PF +-5% 100VDC CER 0+-30	27167	CAC02C0G300J100A
A12C113-C115	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A12C116-C119	0160-3847	9	5	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A12C124-C129	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA

See introduction to this section for ordering information
*Indicates factory selected value

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Table 4-11. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A12C130-C132	0160-3875	3	3	CAPACITOR-FXD 22PF +-5% 200VDC CER 0+-30	51642	200-200-NPO-220J(.250LL)
A12C134-C136	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A12C138-C139	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A12C140	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A12C141	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A12C142	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A12C143	0160-4805	1	1	CAPACITOR-FXD 47PF +-5% 100VDC CER 0+-30	27167	CAC02COG470J100A
A12CR101-CR102	1901-0040	1	4	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A12CR104-CR105	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A12CR106-CR107	1902-0958	2	2	DIODE-ZNR 10V 5% DO-35 PD=.4W TC=+.075%	04713	SZ30035-016
A12J1	1250-0544	9	1	CONNECTOR-RF SM-SNP M SGL-HOLE-FR 50-OHM	98291	051-049-0000-220
A12J2	1251-6254	2	2	CONNECTOR-SGL CONT RTANG-F	91833	901
A12J3	1251-6254	2		CONNECTOR-SGL CONT RTANG-F	91833	901
A12K101-K104	0490-1405	0	7	RELAY 2C 12VDC-COIL 2A 250VAC	28480	DS2E-S-DC12V-H69
A12K106-K108	0490-1405	0		RELAY 2C 12VDC-COIL 2A 250VAC	28480	DS2E-S-DC12V-H69
A12L100	9140-0395	3	1	INDUCTOR RF-CH-MLD 560NH 5% .166DX.385LG	06560	4425-3J
A12L101	9100-0539	3	1	INDUCTOR RF-CH-MLD 10UH 5% .156DX.375LG	06560	4445-2J
A12L102	9100-0539	3	1	INDUCTOR RF-CH-MLD 10UH 5% .156DX.375LG	06560	4445-2J
A12L103	9140-0308	8	1	INDUCTOR RF-CH-MLD 120NH 5% .166DX.385LG	24226	15M120J-1
A12MP1	03326-04112	8	1	CVR, ATTENUATOR-2	28480	03326-04112
A12MP2-MP3	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A12MP4-MP5	2360-0113	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A12P1	1251-8410	6	1	CONN-POST TYPE 48-CONT RTANG-DPSLDR	28480	1251-8410
A12R103	0698-8390	6	2	RESISTOR 96.25 .1% .5W F TC=0+-50	19701	5053R
A12R104	0698-7982	0	1	RESISTOR 71.16 .1% .25W F TC=0+-50	19701	5043R
A12R105	0698-8390	6		RESISTOR 96.25 .1% .5W F TC=0+-50	19701	5053R
A12R106	0698-7984	2	6	RESISTOR 61.1 .1% .5W F TC=0+-50	19701	5053R
A12R107	0698-8258	5	3	RESISTOR 247.5 .1% .25W F TC=0+-25	19701	5043R
A12R108-R109	0698-7984	2		RESISTOR 61.1 .1% .5W F TC=0+-50	19701	5053R
A12R110	0698-8258	5		RESISTOR 247.5 .1% .25W F TC=0+-25	19701	5043R
A12R111-R112	0698-7984	2		RESISTOR 61.1 .1% .5W F TC=0+-50	19701	5053R
A12R113	0698-8258	5		RESISTOR 247.5 .1% .25W F TC=0+-25	19701	5043R
A12R114	0698-7984	2		RESISTOR 61.1 .1% .5W F TC=0+-50	19701	5053R
A12R118	0699-0760	0	1	RESISTOR 50 1% 2W MO TC=0+-200	24546	FP2
A12R119-R122	0683-1815	5	7	RESISTOR 180 5% .25W CF TC=0-400	77902	R-25J
A12R124	0683-1815	5		RESISTOR 180 5% .25W CF TC=0-400	77902	R-25J
A12R126	0757-0465	6	2	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A12R127	0698-4509	1	2	RESISTOR 80.6K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A12R128	0698-4499	8	2	RESISTOR 54.9K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A12R129-R130	0757-0452	1	2	RESISTOR 27.4K 1% .125W F TC=0+-100	19701	5033R
A12R131	0698-4499	8		RESISTOR 54.9K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A12R132	0698-4509	1		RESISTOR 80.6K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A12R133-R136	0757-0442	9	4	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A12R137-R138	0757-0449	6	2	RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A12R139-R140	0757-0433	8	2	RESISTOR 3.32K 1% .125W F TC=0+-100	19701	5033R
A12R143-R144	0683-1815	5		RESISTOR 180 5% .25W CF TC=0-400	77902	R-25J
A12R145	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A12TP0-TP10	1251-0600	0	11	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A12U100	1858-0047	5	1	TRANSISTOR ARRAY 16-PIN PLSTC DIP	13606	ULN-2003A
A12U101	1826-0138	8	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	27014	SL24958
A12U102	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN53504
A12U103	1820-1206	1	1	IC GATE TTL LS NOR TPL 3-INP	01295	SN53513
A12U104	1820-1144	6	1	IC GATE TTL LS NOR QUAD 2-INP	01295	SN53243
A21	**03326-66521**	**3**	**1**	**OFFSET BOARD**	**28480**	**03326-66521**
A21C1	0160-3847	9	18	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C2	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C3	0160-4803	9	2	CAPACITOR-FXD 68PF +-5% 100VDC CER 0+-30	27167	CAC02COG680J100A
A21C4	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C6	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C7	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C8	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C21	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C22	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C23	0160-4803	9		CAPACITOR-FXD 68PF +-5% 100VDC CER 0+-30	27167	CAC02COG680J100A
A21C24	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C41	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA

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See introduction to this section for ordering information
*Indicates factory selected value

Table 4-12. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A21C42	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C43	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C46	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C51	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C52	0180-0116	1	3	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A21C53	0160-4571	8	1	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A21C54	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C60	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A21C61	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C62	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A21C63	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21C64	0180-0229	7	1	CAPACITOR-FXD 33UF+-10% 10VDC TA	13606	150D336X9010B2-DYS
A21C65	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A21K1	0490-1405	0	2	RELAY 2C 12VDC-COIL 2A 250VAC	28480	DS2E-S-DC12V-H69
A21K21	0490-1405	0		RELAY 2C 12VDC-COIL 2A 250VAC	28480	DS2E-S-DC12V-H69
A21L60-L62	9100-3560	6	3	INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A21MP1	03326-04121	9	1	CVR, OFFSET	28480	03326-04121
A21MP2-MP3	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A21MP4-MP5	2360-0113	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A21P1	1251-8410	6	1	CONN-POST TYPE 48-CONT RTANG-DPSLDR	28480	1251-8410
A21Q50	1854-0071	7	1	TRANSISTOR NPN SI PD=300MW FT=200MHZ	13606	CT-1200
A21R1	0698-7957	9	2	RESISTOR 9.8K 1% .125W F TC=0+-25	19701	5033R
A21R2	2100-3351	6	2	RESISTOR-TRMR 500 10% C SIDE-ADJ 1-TRN	73138	72XR500-142B
A21R3	0757-0442	9	4	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A21R4	0698-6320	8	2	RESISTOR 5K .1% .125W F TC=0+-25	91637	CMF-55-1, T-9
A21R5	0698-6348	0	2	RESISTOR 3K .1% .125W F TC=0+-25	19701	5033R
A21R6	0683-1825	7	2	RESISTOR 1.8K 5% .25W CF TC=0-400	77902	R-25J
A21R7	0683-1045	3	2	RESISTOR 100K 5% .25W CF TC=0-400	77902	R-25J
A21R9	0683-1815	5	2	RESISTOR 180 5% .25W CF TC=0-400	77902	R-25J
A21R21	0698-7957	9		RESISTOR 9.8K 1% .125W F TC=0+-25	19701	5033R
A21R22	2100-3351	6		RESISTOR-TRMR 500 10% C SIDE-ADJ 1-TRN	73138	72XR500-142B
A21R23	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A21R24	0698-6320	8		RESISTOR 5K .1% .125W F TC=0+-25	91637	CMF-55-1, T-9
A21R25	0698-6348	0		RESISTOR 3K .1% .125W F TC=0+-25	19701	5033R
A21R26	0683-1825	7		RESISTOR 1.8K 5% .25W CF TC=0-400	77902	R-25J
A21R27	0683-1045	3		RESISTOR 100K 5% .25W CF TC=0-400	77902	R-25J
A21R29	0683-1815	5		RESISTOR 180 5% .25W CF TC=0-400	77902	R-25J
A21R52	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A21R53	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A21R71	0683-2035	3	1	RESISTOR 20K 5% .25W CF TC=0-400	77902	R-25J
A21R72	0683-1035	1	2	RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A21R73	0683-1035	1		RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A21R100	0683-1025	9	1	RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A21TP0-TP6	1251-0600	0	7	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A21U1	1820-1730	6	4	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN58039
A21U2	1820-3465	8	3	IC FF TTL ALS D-TYPE POS-EDGE-TRIG COM	01295	SN74ALS174N
A21U3	1826-0705	5	2	D/A 12-BIT 20-CERDIP BPLR	34335	AM6012DC
A21U4	1826-0521	3	1	IC OP AMP LOW-BIAS-H-IMPD DUAL 8-DIP-P	01295	SN99855P
A21U5	1858-0047	5	1	TRANSISTOR ARRAY 16-PIN PLSTC DIP	13606	ULN-2003A
A21U21	1820-1730	6		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN58039
A21U22	1820-3465	8		IC FF TTL ALS D-TYPE POS-EDGE-TRIG COM	01295	SN74ALS174N
A21U23	1826-0705	5		D/A 12-BIT 20-CERDIP BPLR	34335	AM6012DC
A21U41	1820-1641	8	1	IC DRVR TTL LS BUS HEX 1-INP	01295	SN57698N
A21U42	1820-3465	8		IC FF TTL ALS D-TYPE POS-EDGE-TRIG COM	01295	SN74ALS174N
A21U43	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN53522
A21U45	1820-1730	6		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN58039
A21U46	1820-1730	6		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN58039
A21U51	1826-0493	8	1	IC OP AMP LOW-BIAS-H-IMPD 8-DIP-P PKG	27014	SL35068
A21U70	1820-0668	7	1	IC BFR TTL NON-INV HEX 1-INP	01295	SN24107
A22	**03326-66522**	**4**	**1**	**LEVEL/AM BOARD**	**28480**	**03326-66522**
A22C1	0160-4571	8	20	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C2	0180-0116	1	1	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A22C3	0160-4822	2	2	CAPACITOR-FXD 1000PF +-5% 100VDC CER	27167	CAC03COG102J100A
A22C100	0160-4803	9		CAPACITOR-FXD 68PF +-5% 100VDC CER 0+-30	27167	CAC02COG680J100A
A22C101	0160-4814	2	1	CAPACITOR-FXD 150PF +-5% 100VDC CER	27167	CAC02COG151J100A

See introduction to this section for ordering information
*Indicates factory selected value

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Table 4-13. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A22C102	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C103	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C104	0160-4808	4	1	CAPACITOR-FXD 470PF +-5% 100VDC CER	27167	CAC02C0G471J100A
A22C105	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C106	0160-4571	8	1	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C107	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C108	0160-4791	4	1	CAPACITOR-FXD 10PF +-5% 100VDC CER 0+-30	27167	CAC02C0G100J100A
A22C109	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C110	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C111	0160-3847	9	3	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A22C112	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C113	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C116	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A22C200	0160-4803	9	1	CAPACITOR-FXD 68PF +-5% 100VDC CER 0+-30	27167	CAC02C0G680J100A
A22C201	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C202	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C203	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	27167	CAC03C0G102J100A
A22C204	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C205	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C206	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C207	0160-4791	4	1	CAPACITOR-FXD 10PF +-5% 100VDC CER 0+-30	27167	CAC02C0G100J100A
A22C208	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C209	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C210	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A22C211	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C212	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C300	0180-0116	1	2	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A22C301	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A22C302	0180-0309	4	1	CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A22C303	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C304	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22C305	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A22CR100	1902-0948	0	2	DIODE-ZNR 3.9V 5% DO-35 PD=.4W TC=-.012%	04713	SZ30035-006
A22CR101	1902-0948	0		DIODE-ZNR 3.9V 5% DO-35 PD=.4W TC=-.012%	04713	SZ30035-006
A22CR102	1901-0050	3	4	DIODE-SWITCHING 80V 200MA 2NS DO-35	07263	FDH 6308
A22CR200	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	07263	FDH 6308
A22CR201	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	07263	FDH 6308
A22CR202	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	07263	FDH 6308
A22L1	9140-0129	1	2	INDUCTOR RF-CH-MLD 220UH 5% .166DX.385LG	04072	9210-92
A22L2	9140-0129	1		INDUCTOR RF-CH-MLD 220UH 5% .166DX.385LG	04072	9210-92
A22L3	9100-3560	6	1	INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A22MP1	03326-04122	0	1	CVR, LEVEL/AM	28480	03326-04122
A22MP2	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A22MP3	0624-0333	6		SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A22MP4	2360-0113	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A22MP5	2360-0113	2		SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A22P1	1251-8410	6	1	CONN-POST TYPE 48-CONT RTANG-DPSLDR	28480	1251-8410
A22Q1	1854-0071	7	1	TRANSISTOR NPN SI PD=300MW FT=200MHZ	13606	CT-1200
A22R1	0757-0465	6	1	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A22R2	0757-0465	6	1	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A22R10	0683-1025	9	1	RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A22R100	0698-3484	9	2	RESISTOR 6.65K 1% .125W F TC=0+-100	19701	5033R
A22R101	0698-4440	9	2	RESISTOR 3.4K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A22R102	0698-3484	9		RESISTOR 6.65K 1% .125W F TC=0+-100	19701	5033R
A22R103	0698-4440	9		RESISTOR 3.4K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A22R104	0757-0428	1	1	RESISTOR 1.62K 1% .125W F TC=0+-100	19701	5033R
A22R105	0698-3582	8	1	RESISTOR 41.2K 1% .125W F TC=0+-100	19701	5033R
A22R106	0757-0442	9	1	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A22R107	0698-4519	3	1	RESISTOR 140K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A22R108	0698-4424	9	2	RESISTOR 1.4K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A22R109	0698-3152	8	2	RESISTOR 3.48K 1% .125W F TC=0+-100	19701	5033R
A22R110	0699-0131	9	4	RESISTOR 5.12K .25% .125W F TC=0+-50	19701	5033R
A22R111	0699-0131	9		RESISTOR 5.12K .25% .125W F TC=0+-50	19701	5033R
A22R112	0698-4476	1	2	RESISTOR 10.2K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A22R113	0698-7848	7	2	RESISTOR 1.25K .1% .125W F TC=0+-25	19701	5033R
A22R114	0698-0063	4	2	RESISTOR 5.23K 1% .125W F TC=0+-100	19701	5033R
A22R115	0698-3279	0	4	RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A22R116	0683-1515	2	4	RESISTOR 150 5% .25W CF TC=0-400	77902	R-25J

See introduction to this section for ordering information
*Indicates factory selected value

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Table 4-14. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A22R117	0683-1515	2		RESISTOR 150 5% .25W CF TC=0-400	77902	R-25J
A22R119	0683-1045	3	2	RESISTOR 100K 5% .25W CF TC=0-400	77902	R-25J
A22R200	0698-3279	0		RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A22R201	0698-3279	0		RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A22R202	0698-3148	2	1	RESISTOR 102K 1% .125W F TC=0+-100	19701	5033R
A22R203	0698-4486	3	1	RESISTOR 24.9K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A22R204	0698-4424	9		RESISTOR 1.4K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A22R205	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	19701	5033R
A22R206	0699-0131	9		RESISTOR 5.12K .25% .125W F TC=0+-50	19701	5033R
A22R207	0699-0131	9		RESISTOR 5.12K .25% .125W F TC=0+-50	19701	5033R
A22R208	0698-4476	1		RESISTOR 10.2K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A22R209	0698-7848	7		RESISTOR 1.25K .1% .125W F TC=0+-25	19701	5033R
A22R210	0698-0063	4		RESISTOR 5.23K 1% .125W F TC=0+-100	19701	5033R
A22R211	0698-3279	0		RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A22R212	0683-1515	2		RESISTOR 150 5% .25W CF TC=0-400	77902	R-25J
A22R213	0683-1515	2		RESISTOR 150 5% .25W CF TC=0-400	77902	R-25J
A22R215	0683-1045	3		RESISTOR 100K 5% .25W CF TC=0-400	77902	R-25J
A22TP0-TP16	1251-0600	0	17	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A22U1	1826-0519	9	1	IC OP AMP LOW-BIAS-H-IMPD 8-DIP-P PKG	01295	SN99853P
A22U2	1820-1971	7	4	ANALOG SWITCH 4 SPST 16 -DIP-P	17856	DG201CJ
A22U3	1826-0521	3	2	IC OP AMP LOW-BIAS-H-IMPD DUAL 8-DIP-P	01295	SN99855P
A22U4	1826-0705	5	2	D/A 12-BIT 20-CERDIP BPLR	34335	AM6012DC
A22U5	1820-1971	7		ANALOG SWITCH 4 SPST 16 -DIP-P	17856	DG201CJ
A22U6	1820-1971	7		ANALOG SWITCH 4 SPST 16 -DIP-P	17856	DG201CJ
A22U7	1826-0521	3		IC OP AMP LOW-BIAS-H-IMPD DUAL 8-DIP-P	01295	SN99855P
A22U8	1826-0705	5		D/A 12-BIT 20-CERDIP BPLR	34335	AM6012DC
A22U9	1820-1971	7		ANALOG SWITCH 4 SPST 16 -DIP-P	17856	DG201CJ
A22U10-U13	1820-1730	6	4	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN58039
A22U14	1820-3465	8	1	IC FF TTL ALS D-TYPE POS-EDGE-TRIG COM	01295	SN74ALS174N
A22U15	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN53522
A22U16	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN53504
A23	**03326-66523**	**5**	**1**	**SQUARE BOARD**	**28480**	**03326-66523**
A23C1	0180-0116	1	1	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A23C2	0180-0309	4	3	CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A23C3	0180-0116	1	1	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A23C100	0160-4794	7	4	CAPACITOR-FXD 5.6PF +-.5PF 100VDC CER	27167	CAC02COG5R6D100A
A23C101	0160-4794	7		CAPACITOR-FXD 5.6PF +-.5PF 100VDC CER	27167	CAC02COG5R6D100A
A23C102-C105	0160-4571	8	31	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A23C200	0160-4794	7		CAPACITOR-FXD 5.6PF +-.5PF 100VDC CER	27167	CAC02COG5R6D100A
A23C201	0160-4794	7		CAPACITOR-FXD 5.6PF +-.5PF 100VDC CER	27167	CAC02COG5R6D100A
A23C202-C205	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A23C300	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A23C301	0180-0309	4		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A23C302	0160-4787	8	4	CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30	27167	CAC02COG220J100A
A23C303	0160-4787	8		CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30	27167	CAC02COG220J100A
A23C304	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A23C305	0180-0309	4		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A23C306	0160-4787	8		CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30	27167	CAC02COG220J100A
A23C307	0160-4787	8		CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30	27167	CAC02COG220J100A
A23C308	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A23C400-C409	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A23C500-C509	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A23CR100	1902-0952	6	6	DIODE-ZNR 5.6V 5% DO-35 PD=.4W TC=+.046%	04713	SZ30035-010
A23CR101	1902-0952	6		DIODE-ZNR 5.6V 5% DO-35 PD=.4W TC=+.046%	04713	SZ30035-010
A23CR300	1901-0050	3	2	DIODE-SWITCHING 80V 200MA 2NS DO-35	07263	FDH 6308
A23CR301	1902-0953	7	2	DIODE-ZNR 6.2V 5% DO-35 PD=.4W TC=+.053%	04713	SZ30035-011
A23CR302	1902-0953	7		DIODE-ZNR 6.2V 5% DO-35 PD=.4W TC=+.053%	04713	SZ30035-011
A23CR303	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	07263	FDH 6308
A23CR400	1902-0957	1	4	DIODE-ZNR 9.1V 5% DO-35 PD=.4W TC=+.069%	04713	SZ30035-015
A23CR401	1902-0952	6		DIODE-ZNR 5.6V 5% DO-35 PD=.4W TC=+.046%	04713	SZ30035-010
A23CR402	1902-0957	1		DIODE-ZNR 9.1V 5% DO-35 PD=.4W TC=+.069%	04713	SZ30035-015
A23CR403	1902-0952	6		DIODE-ZNR 5.6V 5% DO-35 PD=.4W TC=+.046%	04713	SZ30035-010
A23CR500	1902-0957	1		DIODE-ZNR 9.1V 5% DO-35 PD=.4W TC=+.069%	04713	SZ30035-015
A23CR501	1902-0952	6		DIODE-ZNR 5.6V 5% DO-35 PD=.4W TC=+.046%	04713	SZ30035-010
A23CR502	1902-0957	1		DIODE-ZNR 9.1V 5% DO-35 PD=.4W TC=+.069%	04713	SZ30035-015

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See introduction to this section for ordering information
*Indicates factory selected value

Table 4-15. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A23CR503	1902-0952	6		DIODE-ZNR 5.6V 5% DO-35 PD=.4W TC=+.046%	04713	SZ30035-010
A23L1	9100-3560	6	2	INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A23L2	9100-3560	6		INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A23L300	9100-3559	3	2	INDUCTOR RF-CH-MLD 5.1UH 5% .166DX.385LG	24226	15M511J-1
A23L301	9100-3559	3		INDUCTOR RF-CH-MLD 5.1UH 5% .166DX.385LG	24226	15M511J-1
A23MP1	03326-04123	1	1	CVR, SQUARE	28480	03326-04123
A23MP2	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A23MP3	0624-0333	6		SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A23MP4	2360-0113	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A23MP5	2360-0113	2		SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A23P1	T-54687	9	1	DIN CONN.-32 PIN MALE	28480	T-54687
A23Q400-Q404	1854-0215	1	10	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A23Q500-Q504	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A23R100	0757-0401	0	4	RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A23R101	0757-0407	6	2	RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A23R102	0757-0465	6	1	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A23R103	0698-4421	6	6	RESISTOR 249 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R104	0757-0465	6	3	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A23R105	0757-0280	3	16	RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A23R106	0698-3446	3	2	RESISTOR 383 1% .125W F TC=0+-100	19701	5033R
A23R107	0757-0161	9	2	RESISTOR 604 1% .125W F TC=0+-100	19701	5033R
A23R108	0683-0825	5	2	RESISTOR 8.2 5% .25W CF TC=0-400	77902	R-25J
A23R109	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A23R200	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A23R201	0757-0407	6		RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A23R202	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A23R203	0698-4421	6		RESISTOR 249 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R204	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A23R205	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A23R206	0698-3446	3		RESISTOR 383 1% .125W F TC=0+-100	19701	5033R
A23R207	0757-0161	9		RESISTOR 604 1% .125W F TC=0+-100	19701	5033R
A23R208	0683-0825	5		RESISTOR 8.2 5% .25W CF TC=0-400	77902	R-25J
A23R209	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A23R300	0683-0275	9	3	RESISTOR 2.7 5% .25W CF TC=0-400	77902	R-25J
A23R301-R303	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A23R304	0683-0275	9		RESISTOR 2.7 5% .25W CF TC=0-400	77902	R-25J
A23R305	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A23R306	0757-0283	6	4	RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A23R307	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A23R308	0757-0283	6		RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A23R309	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A23R310	0683-0275	9		RESISTOR 2.7 5% .25W CF TC=0-400	77902	R-25J
A23R311	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A23R312	0757-0283	6		RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A23R313	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A23R314	0757-0283	6		RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A23R315-R318	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A23R400	0757-0442	9	4	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A23R401	0683-5615	1	2	RESISTOR 560 5% .25W CF TC=0-400	77902	R-25J
A23R402	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A23R403	0698-6943	1	4	RESISTOR 20K .1% .125W F TC=0+-50	19701	5033R
A23R404	0698-6943	1		RESISTOR 20K .1% .125W F TC=0+-50	19701	5033R
A23R406	0699-0189	7	4	RESISTOR 259.6 .1% .125W F TC=0+-25	19701	5033R
A23R407	0699-0189	7		RESISTOR 259.6 .1% .125W F TC=0+-25	19701	5033R
A23R408	0757-0284	7	2	RESISTOR 150 1% .125W F TC=0+-100	19701	5033R
A23R409	0698-4381	7	2	RESISTOR 48.7 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R410	0698-4451	2	2	RESISTOR 340 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R411	0698-4424	9	2	RESISTOR 1.4K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R412	0698-4421	6		RESISTOR 249 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R413	0698-4421	6		RESISTOR 249 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R414	0698-8343	9	2	RESISTOR 590K 1% .125W F TC=0+-100	19701	5033R
A23R415	0757-0482	7	2	RESISTOR 511K 1% .125W F TC=0+-100	19701	5033R
A23R416	0698-3226	7	2	RESISTOR 6.49K 1% .125W F TC=0+-100	19701	5033R
A23R417	0757-0449	6	2	RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A23R418	0698-3516	8	2	RESISTOR 6.34K 1% .125W F TC=0+-100	19701	5033R
A23R419	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A23R420	0698-4442	1	2	RESISTOR 4.42K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1

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*Indicates factory selected value

Table 4-16. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A23R421-R424	0683-4705	8	8	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A23R500	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A23R501	0683-5615	1		RESISTOR 560 5% .25W CF TC=0-400	77902	R-25J
A23R502	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A23R503	0698-6943	1		RESISTOR 20K .1% .125W F TC=0+-50	19701	5033R
A23R504	0698-6943	1		RESISTOR 20K .1% .125W F TC=0+-50	19701	5033R
A23R506	0699-0189	7		RESISTOR 259.6 .1% .125W F TC=0+-25	19701	5033R
A23R507	0699-0189	7		RESISTOR 259.6 .1% .125W F TC=0+-25	19701	5033R
A23R508	0757-0284	7		RESISTOR 150 1% .125W F TC=0+-100	19701	5033R
A23R509	0698-4381	7		RESISTOR 48.7 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R510	0698-4451	2		RESISTOR 340 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R511	0698-4424	9		RESISTOR 1.4K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R512	0698-4421	6		RESISTOR 249 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R513	0698-4421	6		RESISTOR 249 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R514	0698-8343	9		RESISTOR 590K 1% .125W F TC=0+-100	19701	5033R
A23R515	0757-0482	7		RESISTOR 511K 1% .125W F TC=0+-100	19701	5033R
A23R516	0698-3226	7		RESISTOR 6.49K 1% .125W F TC=0+-100	19701	5033R
A23R517	0757-0449	6		RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A23R518	0698-3516	8		RESISTOR 6.34K 1% .125W F TC=0+-100	19701	5033R
A23R519	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A23R520	0698-4442	1		RESISTOR 4.42K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A23R521-R524	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A23TP1-TP4	1251-0600	0	15	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A23TP100	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A23TP200	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A23TP300-TP301	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A23TP400-TP402	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A23TP500-TP503	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A23U100	1826-0244	7	2	IC COMPARATOR HS 14-DIP-P PKG	18324	CR546
A23U200	1826-0244	7		IC COMPARATOR HS 14-DIP-P PKG	18324	CR546
A23U300	1820-0817	8	1	IC FF ECL D-M/S DUAL	04713	SC63470P131
A23U301	1820-1400	7	2	IC GATE ECL AND QUAD 2-INP	04713	SC63470P104
A23U302	1820-1400	7		IC GATE ECL AND QUAD 2-INP	04713	SC63470P104
A23U400	1826-0023	0	2	IC MODULATOR 14-DIP-C PKG	04713	SC14912LK
A23U401	1826-0522	4	2	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	SN99856N
A23U500	1826-0023	0		IC MODULATOR 14-DIP-C PKG	04713	SC14912LK
A23U501	1826-0522	4		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	SN99856N
A24	**03326-66524**	**6**	**1**	**RF SWITCH BOARD**	**28480**	**03326-66524**
A24C1	0160-3847	9	13	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C2	0160-4571	8	10	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A24C3	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C10	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A24C11	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C12	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C20	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C21	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A24C22	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C30	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C31	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A24C32	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C40	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A24C41	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C42	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C43	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C50	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C51	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A24C52	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A24C70-C73	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A24C81	0180-0116	1	2	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A24C82	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A24CR1-CR3	1901-0040	1	12	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A24CR20-CR22	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A24CR30-CR32	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A24CR50-CR52	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A24J2-J3	1251-6254	2	2	CONNECTOR-SGL CONT RTANG-F	91833	901
A24L10	9100-0539	3	1	INDUCTOR RF-CH-MLD 10UH 5% .156DX.375LG	06560	4445-2J

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320 3991

Table 4-17. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A24L81-L82	9100-1791	1	2	CORE-FERRITE CHOKE-WIDEBAND;IMP:>360	02114	VK200-19/4B
A24MP1	03326-04124	2	1	CVR, RF SWITCH	28480	03326-04124
A24MP2-MP3	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A24MP4-MP5	2360-0113	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A24P1	T-54687	9	1	DIN CONN.-32 PIN MALE	28480	T-54687
A24Q1-Q8	1854-0795	2	8	TRANSISTOR NPN SI TO-92 PD=625MW	04713	SPS8028
A24R1	0683-4705	8	16	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R2	0757-0424	7	10	RESISTOR 1.1K 1% .125W F TC=0+-100	19701	5033R
A24R3	0757-1094	9	4	RESISTOR 1.47K 1% .125W F TC=0+-100	19701	5033R
A24R4	0757-0424	7		RESISTOR 1.1K 1% .125W F TC=0+-100	19701	5033R
A24R5	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R6	0757-0410	1	4	RESISTOR 301 1% .125W F TC=0+-100	19701	5033R
A24R7	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R8	0683-2225	3	4	RESISTOR 2.2K 5% .25W CF TC=0-400	77902	R-25J
A24R9	0698-3438	3	4	RESISTOR 147 1% .125W F TC=0+-100	19701	5033R
A24R10	0757-0416	7	9	RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A24R11	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A24R12	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A24R13	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R14	0757-0280	3	4	RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A24R15	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A24R16	0698-3160	8	4	RESISTOR 31.6K 1% .125W F TC=0+-100	19701	5033R
A24R17	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	19701	5033R
A24R20	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R21	0757-0424	7		RESISTOR 1.1K 1% .125W F TC=0+-100	19701	5033R
A24R22	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	19701	5033R
A24R23	0757-0424	7		RESISTOR 1.1K 1% .125W F TC=0+-100	19701	5033R
A24R24	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R25	0757-0410	1		RESISTOR 301 1% .125W F TC=0+-100	19701	5033R
A24R26	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R27	0683-2225	3		RESISTOR 2.2K 5% .25W CF TC=0-400	77902	R-25J
A24R28	0698-3438	3		RESISTOR 147 1% .125W F TC=0+-100	19701	5033R
A24R29	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A24R30	0757-0424	7		RESISTOR 1.1K 1% .125W F TC=0+-100	19701	5033R
A24R31	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	19701	5033R
A24R32	0757-0424	7		RESISTOR 1.1K 1% .125W F TC=0+-100	19701	5033R
A24R33	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R34	0757-0410	1		RESISTOR 301 1% .125W F TC=0+-100	19701	5033R
A24R35	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R36	0683-2225	3		RESISTOR 2.2K 5% .25W CF TC=0-400	77902	R-25J
A24R37	0698-3438	3		RESISTOR 147 1% .125W F TC=0+-100	19701	5033R
A24R38	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A24R41	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A24R42	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A24R43	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A24R44	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A24R45	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A24R46	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	19701	5033R
A24R47	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	19701	5033R
A24R50	0757-0424	7		RESISTOR 1.1K 1% .125W F TC=0+-100	19701	5033R
A24R51	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	19701	5033R
A24R52	0757-0424	7		RESISTOR 1.1K 1% .125W F TC=0+-100	19701	5033R
A24R53	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R54	0757-0410	1		RESISTOR 301 1% .125W F TC=0+-100	19701	5033R
A24R55	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R56	0683-2225	3		RESISTOR 2.2K 5% .25W CF TC=0-400	77902	R-25J
A24R57	0698-3438	3		RESISTOR 147 1% .125W F TC=0+-100	19701	5033R
A24R58	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A24R60	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R69	0757-0424	7		RESISTOR 1.1K 1% .125W F TC=0+-100	19701	5033R
A24R70	0757-0424	7		RESISTOR 1.1K 1% .125W F TC=0+-100	19701	5033R
A24R71	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A24R72	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A24R73	0698-3156	2	1	RESISTOR 14.7K 1% .125W F TC=0+-100	19701	5033R
A24R74	0698-3161	9	1	RESISTOR 38.3K 1% .125W F TC=0+-100	19701	5033R
A24R80	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R81	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J

See introduction to this section for ordering information
*Indicates factory selected value

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Table 4-18. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A24R82	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24R83	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A24TP1-TP8	1251-0600	0	8	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A24U1	1820-0810	1	2	IC RCVR ECL LINE RCVR TPL 2-INP	04713	SC63470P116
A24U2	1820-0810	1		IC RCVR ECL LINE RCVR TPL 2-INP	04713	SC63470P116
A24U4	1826-0138	8	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	27014	SL24958
A24U5	1820-2488	3	1	IC FF TTL ALS D-TYPE POS-EDGE-TRIG	01295	SN71171N
A31	**03326-66531**	**5**	**2**	**VCO BOARDS**	**28480**	**03326-66531**
A31C1	0180-0228	6	1	CAPACITOR-FXD 22UF+-10% 15VDC TA	13606	150D226X9015B2-DYS
A31C2	0160-4571	8	1	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A31C3	0160-3847	9	6	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A31C5	0160-4040	6	1	CAPACITOR-FXD 1000PF +-5% 100VDC CER	04222	SR201A102JAA
A31C7	0160-0127	2	3	CAPACITOR-FXD 1UF +-20% 25VDC CER	13606	2C37Z5U105M025A
A31C8	0160-3876	4	1	CAPACITOR-FXD 47PF +-20% 200VDC CER	51642	200-200-X7R-470M(.250LL)
A31C9	0160-0571	0	1	CAPACITOR-FXD 470PF +-20% 100VDC CER	51642	200-100-X7R-471M(.250LL)
A31C10	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	13606	2C37Z5U105M025A
A31C11	0160-4801	7	1	CAPACITOR-FXD 100PF +-5% 100VDC CER	27167	CAC02C0G101J100A
A31C12	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A31C13	0180-0309	4	1	CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A31C14	0180-0374	3	1	CAPACITOR-FXD 10UF+-10% 20VDC TA	13606	150D106X9020B2-DYS
A31C15	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	13606	2C37Z5U105M025A
A31C16	0160-3879	7	2	CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	C320C103M1R5CA
A31C17	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	C320C103M1R5CA
A31C18	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A31C19	0180-0100	3	1	CAPACITOR-FXD 4.7UF+-10% 35VDC TA	13606	150D475X9035B2-DYS
A31C20	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A31C22	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A31C23	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A31CR1	1901-0040	1	2	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A31CR2	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A31CR3	0122-0162	5	2	DIODE-VVC 29PF 10% BVR=30V	25403	BB809
A31CR4	0122-0162	5		DIODE-VVC 29PF 10% BVR=30V	25403	BB809
A31CR5	1901-0518	8	1	DIODE-SCHOTTKY SM SIG	28480	1901-0518
A31CR6	1902-0959	3	1	DIODE-ZNR 11V 5% DO-35 PD=.4W TC=+.076%	04713	SZ30035-017
A31J1	1250-0544	9	2	CONNECTOR-RF SM-SNP M SGL-HOLE-FR 50-OHM	98291	051-049-0000-220
A31J2	1250-0544	9		CONNECTOR-RF SM-SNP M SGL-HOLE-FR 50-OHM	98291	051-049-0000-220
A31L1	9140-0257	6	1	COIL-VAR 297NH-363NH Q=140 PC-MTG	28480	Q2.33TAPPED
A31L2	9100-0539	3	1	INDUCTOR RF-CH-MLD 10UH 5% .156DX.375LG	06560	4445-2J
A31L3	9140-0349	7	1	INDUCTOR RF-CH-MLD 1.1UH 5% .166DX.385LG	24226	15M111J
A31L4	9100-1791	1	2	CORE-FERRITE CHOKE-WIDEBAND; IMP:>360	02114	VK200-19/4B
A31L5	9100-1791	1		CORE-FERRITE CHOKE-WIDEBAND; IMP:>360	02114	VK200-19/4B
A31MP1	03326-04131	1	1	CVR, VCO	28480	03326-04131
A31MP2	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A31MP3	0624-0333	6		SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A31MP4-MP6	2360-0113	2	3	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A31P1	1252-0266	6	1	DIN CONN.-16 PIN MALE	06383	100-316-033
A31Q1-Q3	1854-0345	8	3	TRANSISTOR NPN 2N5179 SI TO-72 PD=200MW	04713	SRF5064
A31R1	0757-0280	3	6	RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A31R2	0683-2205	9	1	RESISTOR 22 5% .25W CF TC=0-400	77902	R-25J
A31R3	0757-0439	4	1	RESISTOR 6.81K 1% .125W F TC=0+-100	19701	5033R
A31R4	0698-4443	2	1	RESISTOR 4.53K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A31R5	0698-4405	6	1	RESISTOR 107 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A31R6	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A31R7	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A31R8	0698-4490	9	1	RESISTOR 29.4K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A31R9	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A31R10	0683-1015	7	3	RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A31R11	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J.
A31R12	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A31R13	0757-0394	0	1	RESISTOR 51.1 1% .125W F TC=0+-100	19701	5033R
A31R14	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A31R15	0698-3279	0	2	RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A31R16	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A31R17	0698-3279	0		RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A31R18	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A31R19	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320 3991

Table 4-19. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A31R20	0757-0283	6	1	RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A31R21	0757-0427	0	1	RESISTOR 1.5K 1% .125W F TC=0+-100	19701	5033R
A31R22	0683-1025	9	1	RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A31R23	0757-0316	6	2	RESISTOR 42.2 1% .125W F TC=0+-100	19701	5033R
A31R24	0683-3915	0	2	RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A31R25	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A31R26	0757-0316	6		RESISTOR 42.2 1% .125W F TC=0+-100	19701	5033R
A31R27	0683-4725	2	1	RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A31R28	8150-3375	5	1	RESISTOR-ZERO OHMS 22 AWG LEAD DIA	75042	ZEROHM
A31TP1-TP4	1251-0600	0	4	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A31U1	1820-0802	1	1	IC GATE ECL NOR QUAD 2-INP	04713	SC63470P102
A32	03326-66532	6	2	VCO CONTROL BOARDS	28480	03326-66532
A32C1	0160-0362	7	1	CAPACITOR-FXD 510PF +-5% 300VDC MICA	00853	0160-0362
A32C2	0160-0299	9	1	CAPACITOR-FXD 1800PF +-10% 200VDC POLYE	13606	192P18292
A32C3	0160-0154	5	1	CAPACITOR-FXD 2200PF +-10% 200VDC POLYE	13606	192P22292
A32C4	0160-6146	7	1	C-F 910PF +-5%	27167	CAC03C0G911J100A
A32C5	0160-0300	3	1	CAPACITOR-FXD 2700PF +-10% 200VDC POLYE	13606	192P27292
A32C6	0160-3847	9	9	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A32C7	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A32C8	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A32C9	0160-5349	0	2	CAPACITOR-FXD 200PF +-5% 100VDC CER	13606	292CC0G201J100B
A32C10	0160-5349	0		CAPACITOR-FXD 200PF +-5% 100VDC CER	13606	292CC0G201J100B
A32C11	0180-0309	4	1	CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A32C12	0180-0100	3	2	CAPACITOR-FXD 4.7UF+-10% 35VDC TA	13606	150D475X9035B2-DYS
A32C13	0180-0100	3		CAPACITOR-FXD 4.7UF+-10% 35VDC TA	13606	150D475X9035B2-DYS
A32C14	0160-4787	8	1	CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30	27167	CAC02C0G220J100A
A32C16	0160-0128	3	1	CAPACITOR-FXD 2.2UF +-20% 50VDC CER	13606	3C37Z5U225M050A
A32C21	0160-4801	7	1	CAPACITOR-FXD 100PF +-5% 100VDC CER	27167	CAC02C0G101J100A
A32C22	0160-4532	1	1	CAPACITOR-FXD 1000PF +-20% 50VDC CER	27167	CAC02X7R102M100A
A32C23	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A32C24	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A32C50	0180-0374	3	1	CAPACITOR-FXD 10UF+-10% 20VDC TA	13606	150D106X9020B2-DYS
A32C51	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A32C55	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A32C56	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A32C57	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A32CR5	1990-0486	6	1	LED-LAMP LUM-INT=2MCD IF=25MA-MAX BVR=5V	28480	1990-0486
A32CR21	1901-0040	1	1	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A32CR22	1902-0943	5	2	DIODE-ZNR 2.4V 5% DO-35 PD=.4W TC=-.037%	04713	SZ30035-001
A32CR23	1902-0943	5		DIODE-ZNR 2.4V 5% DO-35 PD=.4W TC=-.037%	04713	SZ30035-001
A32J1	1251-4670	2	1	CONN-POST TYPE .100-PIN-SPCG 3-CONT	22526	65500-103
A32J1A	1258-0141	8	1	JMPR-REM .025P	22526	65474-004
A32L1	9100-2575	1	1	INDUCTOR RF-CH-MLD 1.5MH 10%	06560	15S-152K
A32L2	9100-2578	4	1	INDUCTOR RF-CH-MLD 2.7MH 10%	06560	15S-272K
A32L3	9100-3345	5	3	INDUCTOR RF-CH-MLD 2UH 5% .166DX.385LG	06560	15A2R0J
A32L4	9100-3345	5		INDUCTOR RF-CH-MLD 2UH 5% .166DX.385LG	06560	15A2R0J
A32L5	9100-3345	5		INDUCTOR RF-CH-MLD 2UH 5% .166DX.385LG	06560	15A2R0J
A32MP1	03326-04132	2	1	CVR, VCO CONTROL	28480	03326-04132
A32MP2	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A32MP3	0624-0333	6		SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A32MP4	2360-0113	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A32MP5	2360-0113	2		SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A32P1	T-54687	9	1	DIN CONN.-32 PIN MALE	28480	T-54687
A32Q1	1854-0215	1	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A32Q21	1855-0081	1	1	TRANSISTOR J-FET N-CHAN D-MODE SI	34677	F1843
A32R1	0757-0280	3	5	RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A32R2	0683-1015	7	2	RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A32R4	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A32R5	0757-0426	9	1	RESISTOR 1.3K 1% .125W F TC=0+-100	19701	5033R
A32R6	0698-4470	5	1	RESISTOR 6.98K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A32R7	0698-4453	4	2	RESISTOR 402 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A32R8	0698-4461	4	1	RESISTOR 698 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A32R9	0698-4453	4		RESISTOR 402 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A32R10	0683-1035	1	2	RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A32R11	0683-1035	1		RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320-3991

Table 4-20. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A32R12	0683-1555	0	2	RESISTOR 1.5M 5% .25W CF TC=0-900	77902	R-25J
A32R13	0683-1555	0		RESISTOR 1.5M 5% .25W CF TC=0-900	77902	R-25J
A32R14	0757-0411	2	1	RESISTOR 332 1% .125W F TC=0+-100	19701	5033R
A32R15-R17	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A32R18	0683-3025	3	2	RESISTOR 3K 5% .25W CF TC=0-400	77902	R-25J
A32R19	0757-0442	9	1	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A32R21	0683-1025	9	4	RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A32R22	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A32R23	0683-3025	3		RESISTOR 3K 5% .25W CF TC=0-400	77902	R-25J
A32R24	0698-4125	7	1	RESISTOR 953 1% .125W F TC=0+-100	19701	5033R
A32R25	0683-1045	3	2	RESISTOR 100K 5% .25W CF TC=0-400	77902	R-25J
A32R26	0683-1045	3		RESISTOR 100K 5% .25W CF TC=0-400	77902	R-25J
A32R27	0757-0444	1	1	RESISTOR 12.1K 1% .125W F TC=0+-100	19701	5033R
A32R28	0698-3152	8	1	RESISTOR 3.48K 1% .125W F TC=0+-100	19701	5033R
A32R29	0757-0427	0	1	RESISTOR 1.5K 1% .125W F TC=0+-100	19701	5033R
A32R30	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A32R31	0698-3279	0	2	RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A32R32	0698-3279	0		RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A32R50	0837-0275	6	1	THERMISTOR DISC 50-OHM TC=+2.35%/C-DEG	28480	RL3006-50-110-25-PTO
A32R60	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A32R61	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A32TP1-TP8	1251-0600	0	8	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A32U1	1826-0715	7	1	IC OP AMP LOW-NOISE 8-DIP-P PKG	18324	CC3802
A32U2	1826-0138	8	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	27014	SL24958
A32U4	1820-2488	3	1	IC FF TTL ALS D-TYPE POS-EDGE-TRIG	01295	SN71171N
A32U21	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN53504
A32U22	1820-1971	7	1	ANALOG SWITCH 4 SPST 16 -DIP-P	17856	DG201CJ
A32U23	1826-0139	9	1	IC OP AMP GP DUAL 8-DIP-P PKG	04713	SC25137P1
A33	**03326-66533**	**7**	**2**	**PHASE DETECTOR BOARDS**	**28480**	**03326-66533**
A33C1-C4	0160-3847	9	26	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C5	0180-0553	0	6	CAPACITOR-FXD 22UF+-20% 25VDC TA	28480	T362C226M025ASC8245
A33C6	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C7	0180-0553	0		CAPACITOR-FXD 22UF+-20% 25VDC TA	28480	T362C226M025ASC8245
A33C8	0180-2765	0	18	CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A33C10	0160-4787	8	3	CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30	27167	CAC02COG220J100A
A33C11	0160-5306	9	2	CAPACITOR-FXD .1UF +-10% 100VDC	19701	719A1CA104PK101SA
A33C12	0160-5306	9		CAPACITOR-FXD .1UF +-10% 100VDC	19701	719A1CA104PK101SA
A33C13	0160-4461	5	2	CAPACITOR-FXD 150PF +-2.5% 630VDC POLYP	25088	B33062/150PF/2.5%/630V
A33C14	0160-4461	5		CAPACITOR-FXD 150PF +-2.5% 630VDC POLYP	25088	B33062/150PF/2.5%/630V
A33C15	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C16	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C17	0160-2207	3	2	CAPACITOR-FXD 300PF +-5% 300VDC MICA	00853	0160-2207
A33C18	0160-2207	3		CAPACITOR-FXD 300PF +-5% 300VDC MICA	00853	0160-2207
A33C19	0160-3847	9	1	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C20	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C21	0160-4793	6	1	CAPACITOR-FXD 6.8PF +-.5PF 100VDC CER	27167	CAC02COG6R8D100A
A33C22-C26	0160-0576	5	7	CAPACITOR-FXD .1UF +-20% 50VDC CER	04222	SR205C104MAA
A33C29	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A33C30	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A33C32	0180-0309	4	1	CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A33C34	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C35	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C37	0180-0553	0		CAPACITOR-FXD 22UF+-20% 25VDC TA	28480	T362C226M025ASC8245
A33C38	0180-0553	0		CAPACITOR-FXD 22UF+-20% 25VDC TA	28480	T362C226M025ASC8245
A33C39	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C44	0160-4787	8		CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30	27167	CAC02COG220J100A
A33C45	0180-0553	0		CAPACITOR-FXD 22UF+-20% 25VDC TA	28480	T362C226M025ASC8245
A33C46	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C47	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A33C48	0160-4787	8		CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30	27167	CAC02COG220J100A
A33C49	0160-4789	0	2	CAPACITOR-FXD 15PF +-5% 100VDC CER 0+-30	27167	CAC02COG150J100A
A33C50	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A33C51	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C52	0160-4789	0		CAPACITOR-FXD 15PF +-5% 100VDC CER 0+-30	27167	CAC02COG150J100A

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320-3991

Table 4-21. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A33C55-C59	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A33C63	0180-0553	0		CAPACITOR-FXD 22UF+-20% 25VDC TA	28480	T362C226M025ASC8245
A33C64	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C66	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C67	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C72	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C76	0160-4571	8	3	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A33C77	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A33C78	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A33C80-C82	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C83	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	04222	SR205C104MAA
A33C84	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C85	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C86	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	04222	SR205C104MAA
A33C87	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C90	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C91	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C92	0180-2794	5	1	CAPACITOR-FXD 3.3UF+-20% 35VDC TA	28480	MD6-035-335-20/9038
A33C93	0180-2794	5		CAPACITOR-FXD 3.3UF+-20% 35VDC TA	28480	MD6-035-335-20/9038
A33C94	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A33C95	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A33C96	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A33C97	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A33C98	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A33C100-C103	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A33C104	0180-0229	7	1	CAPACITOR-FXD 33UF+-10% 10VDC TA	13606	150D336X9010B2-DYS
A33C105	0160-2243	7	1	CAPACITOR-FXD 2.7PF +-.25PF 500VDC CER	52763	0160-2243
A33CR1	1901-0040	1	13	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A33CR5	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A33CR6	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A33CR11	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A33CR12	1902-3054	5	1	DIODE-ZNR 3.65V 5% DO-35 PD=.4W	04713	SZ30016-056
A33CR13-CR15	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A33CR17	1902-0777	3	2	DIODE-ZNR 1N825 6.2V 5% DO-7 PD=.4W	04713	SZ14376RL
A33CR18-CR20	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A33CR21	1902-0777	3		DIODE-ZNR 1N825 6.2V 5% DO-7 PD=.4W	04713	SZ14376RL
A33CR30	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A33CR31	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A33CR36	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A33J1	1250-0544	9	1	CONNECTOR-RF SM-SNP M SGL-HOLE-FR 50-OHM	98291	051-049-0000-220
A33L1	9140-0748	0	1	INDUCTOR 250UH 25% .25DX.5LG Q=3	04213	1670-1
A33L2-L12	9100-3560	6	16	INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A33L100-L103	9100-3560	6		INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A33MP1	03326-04133	3	1	CVR, PHASE DETECTOR	28480	03326-04133
A33MP2	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A33MP3	0624-0333	6		SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A33MP4	2360-0113	2	3	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A33MP5	2360-0113	2		SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A33MP6	2360-0113	2		SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A33MP7	0515-0886	3	1	SCREW-MACH M3 X 0.5 6MM-LG PAN-HD	28480	0515-0886
A33MP8	0535-0004	9	1	NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	28480	0535-0004
A33P1	1251-8410	6	1	CONN-POST TYPE 48-CONT RTANG-DPSLDR	28480	1251-8410
A33Q1	1853-0448	0	3	TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A33Q2	1853-0448	0		TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A33Q3	1854-0345	8	1	TRANSISTOR NPN 2N5179 SI TO-72 PD=200MW	04713	SRF5064
A33Q4	1853-0448	0		TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A33Q6	1855-0308	5	1	TRANSISTOR-JFET DUAL N-CHAN D-MODE SI	17856	DN 324
A33Q7	1855-0081	1	7	TRANSISTOR J-FET N-CHAN D-MODE SI	34677	F1843
A33Q8	1855-0081	1		TRANSISTOR J-FET N-CHAN D-MODE SI	34677	F1843
A33Q9-Q12	1854-0215	1	8	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A33Q13-Q17	1853-0089	5	6	TRANSISTOR PNP 2N4917 SI PD=200MW	07263	S33022
A33Q18	1855-0081	1		TRANSISTOR J-FET N-CHAN D-MODE SI	34677	F1843
A33Q19	1854-0795	2	1	TRANSISTOR NPN SI TO-92 PD=625MW	04713	SPS8028
A33Q20	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A33Q21	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A33Q22-Q24	1855-0081	1		TRANSISTOR J-FET N-CHAN D-MODE SI	34677	F1843
A33Q25	1855-0082	2	2	TRANSISTOR J-FET P-CHAN D-MODE SI	04713	SS3723
A33Q26	1855-0082	2		TRANSISTOR J-FET P-CHAN D-MODE SI	04713	SS3723

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320 3991

Table 4-22. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A33Q27	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A33Q29	1855-0081	1		TRANSISTOR J-FET N-CHAN D-MODE SI	34677	F1843
A33Q30	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A33Q31	1854-0830	6	1	TRANSISTOR-DUAL NPN PD=500MW	27014	LM394H
A33Q32	1853-0089	5		TRANSISTOR PNP 2N4917 SI PD=200MW	07263	S33022
A33R1	0683-4705	8	20	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R2	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R3	0683-3915	0	7	RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A33R4	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R5	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A33R6	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R7	0683-3915	0	1	RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A33R8	0683-4705	8	1	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R9	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A33R10	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R11	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R12	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A33R13	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R14	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A33R15	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R16	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A33R17	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R18	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A33R19	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R20	0683-3325	6	1	RESISTOR 3.3K 5% .25W CF TC=0-400	77902	R-25J
A33R21	0757-0402	1	1	RESISTOR 110 1% .125W F TC=0+-100	19701	5033R
A33R22	0698-3700	2	1	RESISTOR 715 1% .125W F TC=0+-100	19701	5033R
A33R23	0683-2015	9	1	RESISTOR 200 5% .25W CF TC=0-400	77902	R-25J
A33R24	0683-2205	9	1	RESISTOR 22 5% .25W CF TC=0-400	77902	R-25J
A33R25	0683-5125	8	1	RESISTOR 5.1K 5% .25W CF TC=0-400	77902	R-25J
A33R26	0683-4715	0	2	RESISTOR 470 5% .25W CF TC=0-400	77902	R-25J
A33R27	0698-3441	8	1	RESISTOR 215 1% .125W F TC=0+-100	19701	5033R
A33R28	0683-1015	7	2	RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A33R31	0698-3156	2	2	RESISTOR 14.7K 1% .125W F TC=0+-100	19701	5033R
A33R32	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	19701	5033R
A33R33	0757-0450	9	1	RESISTOR 22.1K 1% .125W F TC=0+-100	19701	5033R
A33R35	0683-1035	1	1	RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A33R36	0757-0280	3	3	RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A33R37	0698-4422	7	2	RESISTOR 1.27K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A33R38	0698-4422	7		RESISTOR 1.27K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A33R39	2100-3875	9	1	RESISTOR-TRMR 2K 10% C TOP-ADJ 17-TRN	32997	3299W-DM3-202
A33R40-R43	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R44	0757-0421	4	2	RESISTOR 825 1% .125W F TC=0+-100	19701	5033R
A33R45	0757-0421	4		RESISTOR 825 1% .125W F TC=0+-100	19701	5033R
A33R46	0757-0416	7	2	RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A33R47	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A33R48	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R49	0757-0439	4	1	RESISTOR 6.81K 1% .125W F TC=0+-100	19701	5033R
A33R50	0683-1835	9	1	RESISTOR 18K 5% .25W CF TC=0-400	77902	R-25J
A33R51	0683-1025	9	8	RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A33R52	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A33R53	0757-0283	6		RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A33R54	8150-3375	5	2	RESISTOR-ZERO OHMS 22 AWG LEAD DIA	75042	ZEROHM
A33R55	8150-3375	5		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	75042	ZEROHM
A33R57	0683-6815	5	1	RESISTOR 680 5% .25W CF TC=0-400	77902	R-25J
A33R58	0683-1825	7	1	RESISTOR 1.8K 5% .25W CF TC=0-400	77902	R-25J
A33R59	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R60	0683-1525	4	1	RESISTOR 1.5K 5% .25W CF TC=0-400	77902	R-25J
A33R61	0757-0278	9	1	RESISTOR 1.78K 1% .125W F TC=0+-100	19701	5033R
A33R62	0757-0444	1	1	RESISTOR 12.1K 1% .125W F TC=0+-100	19701	5033R
A33R63	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A33R64	0757-0440	7	2	RESISTOR 7.5K 1% .125W F TC=0+-100	19701	5033R
A33R65	0757-0418	9	1	RESISTOR 619 1% .125W F TC=0+-100	19701	5033R
A33R66	0757-1094	9	2	RESISTOR 1.47K 1% .125W F TC=0+-100	19701	5033R
A33R67	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	19701	5033R
A33R68	0698-3440	7	1	RESISTOR 196 1% .125W F TC=0+-100	19701	5033R
A33R69	0757-0401	0	1	RESISTOR 100 1% .125W F TC=0+-100	19701	5033R

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320 3991

Table 4-23. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A33R70	0698-3443	0	1	RESISTOR 287 1% .125W F TC=0+-100	19701	5033R
A33R71	0698-0083	8	2	RESISTOR 1.96K 1% .125W F TC=0+-100	19701	5033R
A33R72	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A33R73	0698-3151	7	2	RESISTOR 2.87K 1% .125W F TC=0+-100	19701	5033R
A33R74	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	19701	5033R
A33R75	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A33R76	0698-3151	7		RESISTOR 2.87K 1% .125W F TC=0+-100	19701	5033R
A33R77	0698-3512	4	1	RESISTOR 1.18K 1% .125W F TC=0+-100	19701	5033R
A33R78-R82	0698-4469	2	8	RESISTOR 1.15K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A33R83	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	19701	5033R
A33R84	2100-3054	6	1	RESISTOR-TRMR 50K 10% C SIDE-ADJ 17-TRN	73138	89PR50K
A33R85	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A33R86	2100-3352	7	1	RESISTOR-TRMR 1K 10% C SIDE-ADJ 1-TRN	73138	72XR1K-143B
A33R87	0698-3279	0	1	RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A33R88	0757-0283	6	2	RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A33R89	0757-0488	3	1	RESISTOR 909K 1% .125W F TC=0+-100	19701	5033R
A33R90	2100-0552	3	1	RESISTOR-TRMR 50 10% C SIDE-ADJ 1-TRN	73138	72XR50-139B
A33R91	0757-0346	2	1	RESISTOR 10 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A33R92	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A33R93	0698-8827	4	3	RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A33R94	0698-3512	4	1	RESISTOR 1.18K 1% .125W F TC=0+-100	19701	5033R
A33R95	0683-2435	7	2	RESISTOR 24K 5% .25W CF TC=0-400	77902	R-25J
A33R96	0757-0465	6	1	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A33R97	0683-5615	1	1	RESISTOR 560 5% .25W CF TC=0-400	77902	R-25J
A33R98	0683-4715	0		RESISTOR 470 5% .25W CF TC=0-400	77902	R-25J
A33R99	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A33R101	0683-1015	7		RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A33R102	0698-4469	2		RESISTOR 1.15K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A33R103	0698-4434	1	2	RESISTOR 2.32K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A33R104	0698-4434	1		RESISTOR 2.32K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A33R105	0698-4469	2		RESISTOR 1.15K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A33R106	0698-4469	2		RESISTOR 1.15K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A33R108	0683-2435	7		RESISTOR 24K 5% .25W CF TC=0-400	77902	R-25J
A33R117	0757-0430	5	2	RESISTOR 2.21K 1% .125W F TC=0+-100	19701	5033R
A33R118	0757-0430	5		RESISTOR 2.21K 1% .125W F TC=0+-100	19701	5033R
A33R119	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A33R121	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R122	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R125	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A33R126	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A33R127	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A33R128	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A33R129	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A33R130	0683-7515	4	1	RESISTOR 750 5% .25W CF TC=0-400	77902	R-25J
A33R131	0683-0275	9	1	RESISTOR 2.7 5% .25W CF TC=0-400	77902	R-25J
A33R132	2100-3354	9	1	RESISTOR-TRMR 50K 10% C SIDE-ADJ 1-TRN	73138	72XR50K-149B
A33R135	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R136	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A33R139	0686-1015	3	1	RESISTOR 100 5% .5W CC TC=0+529	01121	EB1015
A33TP1-TP9	1251-0600	0	9	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A33U1	1820-0802	1	2	IC GATE ECL NOR QUAD 2-INP	04713	SC63470P102
A33U2	1820-0802	1		IC GATE ECL NOR QUAD 2-INP	04713	SC63470P102
A33U3	1820-0817	8	1	IC FF ECL D-M/S DUAL	04713	SC63470P131
A33U4	1826-0715	7	3	IC OP AMP LOW-NOISE 8-DIP-P PKG	18324	CC3802
A33U5	1826-0700	0	1	IC OP AMP WB 14-DIP-C PKG	34371	HA1-5195-B2544
A33U6	1826-0208	3	1	IC OP AMP GP 8-DIP-P PKG	27014	SL27613
A33U8	1826-0551	9	1	IC V RGLTR-FXD-POS 4.9/5.1V TO-220 PKG	27014	SL36385
A33U10	1820-0693	8	1	IC FF TTL S D-TYPE POS-EDGE-TRIG	01295	SN24661
A33U11	1820-1196	8	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN53525
A33U12	1826-0226	5	2	IC V RGLTR-FXD-POS 11.5/12.5V TO-39 PKG	07263	SL24564
A33U15	1810-0294	4	1	NETWORK-RESISTOR 16 PIN DIP; RES	28480	1810-0294
A33U17	1826-0715	7		IC OP AMP LOW-NOISE 8-DIP-P PKG	18324	CC3802
A33U18	1826-0139	9	1	IC OP AMP GP DUAL 8-DIP-P PKG	04713	SC25137P1
A33U19	1826-0716	8	1	IC OP AMP LOW-NOISE DUAL 8-DIP-C PKG	18324	CC3895
A33U20	1826-0715	7		IC OP AMP LOW-NOISE 8-DIP-P PKG	18324	CC3802
A33U21	1826-0476	7	1	ANALOG SWITCH SPDT 8 -DIP-P	01295	SN99487P
A33U24	1858-0040	8	1	TRANSISTOR ARRAY 16-PIN PLSTC DIP	3L585	90978
A33U25	1826-0226	5		IC V RGLTR-FXD-POS 11.5/12.5V TO-39 PKG	07263	SL24564
A33W101	03335-61617	9	1	CBL ASSY	28480	03335-61617

See introduction to this section for ordering information
*Indicates factory selected value

Table 4-24. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A34	03326-66534	8	2	FRACN DIGITAL BOARDS	28480	03326-66534
A34C1-C12	0160-3847	9	32	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C13-C14	0180-0229	7	2	CAPACITOR-FXD 33UF+-10% 10VDC TA	13606	150D336X9010B2-DYS
A34C17	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C19-C21	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C22	0160-4811	9	1	CAPACITOR-FXD 270PF +-5% 100VDC CER	27167	CAC02COG271J100A
A34C23	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C24	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C26-C28	0180-0553	0	4	CAPACITOR-FXD 22UF+-20% 25VDC TA	28480	T362C226M025ASC8245
A34C29	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C30	0180-2765	0	6	CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A34C31	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C32	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C33	0180-0553	0		CAPACITOR-FXD 22UF+-20% 25VDC TA	28480	T362C226M025ASC8245
A34C34	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C39	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C40	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C101-C104	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C105	0160-4789	0	1	CAPACITOR-FXD 15PF +-5% 100VDC CER 0+-30	27167	CAC02COG150J100A
A34C106	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C107	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A34C108	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A34C109	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C110	0160-4787	8	1	CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30	27167	CAC02COG220J100A
A34C111	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C112	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A34C115	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C116	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A34C117	0160-3847	9	2	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34C118	0180-2765	0		CAPACITOR-FXD 15UF+-20% 20VDC TA	28480	MD7-020-156-20/9038
A34C119	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A34CR1	1902-0945	7	1	DIODE-ZNR 3V 5% DO-35 PD=.4W TC=-.043%	04713	SZ30035-003
A34CR101	1901-0040	1	2	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A34CR102	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A34J1	1250-0544	9	1	CONNECTOR-RF SM-SNP M SGL-HOLE-FR 50-OHM	98291	051-049-0000-220
A34L1	9100-3560	6	2	INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A34L2	9100-3560	6		INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A34L3	9100-1791	1	3	CORE-FERRITE CHOKE-WIDEBAND;IMP:>360	02114	VK200-19/4B
A34L4	9100-1791	1		CORE-FERRITE CHOKE-WIDEBAND;IMP:>360	02114	VK200-19/4B
A34L5	9100-1791	1		CORE-FERRITE CHOKE-WIDEBAND;IMP:>360	02114	VK200-19/4B
A34L6	9140-0748	0	1	INDUCTOR 250UH 25% .25DX.5LG Q=3	04213	1670-1
A34L101-L103	9100-3345	5	3	INDUCTOR RF-CH-MLD 2UH 5% .166DX.385LG	06560	15A2ROJ
A34MP1	03326-04134	4	1	CVR, FRAC-N DIGITAL	28480	03326-04134
A34MP2	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A34MP3	0624-0333	6		SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A34MP4-MP6	2360-0113	2	3	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A34P1	1251-8410	6	1	CONN-POST TYPE 48-CONT RTANG-DPSLDR	28480	1251-8410
A34Q1	1854-0215	1	2	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A34Q2	1854-0795	2	1	TRANSISTOR NPN SI TO-92 PD=625MW	04713	SPS8028
A34Q101	1853-0448	0	2	TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A34Q102	1853-0448	0		TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A34Q103	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A34R1	0683-1025	9	8	RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A34R2	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A34R5	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A34R6	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A34R7	0683-4315	6	3	RESISTOR 430 5% .25W CF TC=0-400	77902	R-25J
A34R8	0683-2715	6	3	RESISTOR 270 5% .25W CF TC=0-400	77902	R-25J
A34R9	0683-1035	1	4	RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A34R11-R13	0683-1035	1		RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A34R14	0683-4715	0	2	RESISTOR 470 5% .25W CF TC=0-400	77902	R-25J
A34R15	0683-4715	0		RESISTOR 470 5% .25W CF TC=0-400	77902	R-25J
A34R16	0757-0401	0	1	RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A34R17	0698-3152	8	1	RESISTOR 3.48K 1% .125W F TC=0+-100	19701	5033R
A34R18	0757-0444	1	1	RESISTOR 12.1K 1% .125W F TC=0+-100	19701	5033R
A34R19	0683-2025	1	1	RESISTOR 2K 5% .25W CF TC=0-400	77902	R-25J
A34R20	0683-1015	7	1	RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A34R21	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J

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See introduction to this section for ordering information
*Indicates factory selected value

Table 4-25. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A34R22	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A34R27	1810-0275	1	2	NETWORK-RES 10-SIP 1.0K OHM X 9	91637	CSC10A01-102G/MSP10A01-102G
A34R28	1810-0275	1		NETWORK-RES 10-SIP 1.0K OHM X 9	91637	CSC10A01-102G/MSP10A01-102G
A34R29	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A34R101	0683-8205	1	1	RESISTOR 82 5% .25W CF TC=0-400	77902	R-25J
A34R102	0683-2015	9	1	RESISTOR 200 5% .25W CF TC=0-400	77902	R-25J
A34R103	0683-2715	6		RESISTOR 270 5% .25W CF TC=0-400	77902	R-25J
A34R104	0683-4315	6		RESISTOR 430 5% .25W CF TC=0-400	77902	R-25J
A34R105	0683-8215	3	6	RESISTOR 820 5% .25W CF TC=0-400	77902	R-25J
A34R106	0683-8215	3		RESISTOR 820 5% .25W CF TC=0-400	77902	R-25J
A34R107	0683-3915	0	9	RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A34R108	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A34R109	0683-4705	8	11	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A34R110	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A34R111	0683-8215	3		RESISTOR 820 5% .25W CF TC=0-400	77902	R-25J
A34R113	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A34R114	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A34R115	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A34R116	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A34R117	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A34R118	0698-7332	4	2	RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A34R119	0698-7332	4		RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A34R120	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A34R121	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A34R122	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A34R123	0683-7515	4	1	RESISTOR 750 5% .25W CF TC=0-400	77902	R-25J
A34R124	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A34R125	0757-0316	6	1	RESISTOR 42.2 1% .125W F TC=0+-100	19701	5033R
A34R126	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A34R128-R130	0683-8215	3		RESISTOR 820 5% .25W CF TC=0-400	77902	R-25J
A34R131	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A34R132	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A34R133-R136	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A34R137	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A34R140	0683-2715	6		RESISTOR 270 5% .25W CF TC=0-400	77902	R-25J
A34R141	0683-4315	6		RESISTOR 430 5% .25W CF TC=0-400	77902	R-25J
A34TP1-TP2	1251-0600	0	15	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A34TP4-TP16	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A34U1	1820-0629	0	4	IC FF TTL S J-K NEG-EDGE-TRIG	01295	SN23357
A34U2	1820-0629	0		IC FF TTL S J-K NEG-EDGE-TRIG	01295	SN23357
A34U3	1820-1196	8	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN53525
A34U4	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN53525
A34U5	1820-1279	8	2	IC CNTR TTL LS DECD UP/DOWN SYNCHRO	01295	SN53645
A34U6	1820-1279	8		IC CNTR TTL LS DECD UP/DOWN SYNCHRO	01295	SN53645
A34U7	1820-0681	4	3	IC GATE TTL S NAND QUAD 2-INP	01295	SN24649
A34U8	1820-0681	4		IC GATE TTL S NAND QUAD 2-INP	01295	SN24649
A34U9	1820-1322	2	1	IC GATE TTL S NOR QUAD 2-INP	01295	SN84050
A34U10	1820-0629	0		IC FF TTL S J-K NEG-EDGE-TRIG	01295	SN23357
A34U11	1820-0629	0		IC FF TTL S J-K NEG-EDGE-TRIG	01295	SN23357
A34U12	1820-0683	6	1	IC INV TTL S HEX 1-INP	01295	SN24651
A34U13	1820-0693	8	2	IC FF TTL S D-TYPE POS-EDGE-TRIG	01295	SN24661
A34U14	1820-1367	5	1	IC GATE TTL S AND QUAD 2-INP	01295	SN85092N
A34U15	1820-1641	8	1	IC DRVR TTL LS BUS HEX 1-INP	01295	SN57698N
A34U16	1820-1144	6	1	IC GATE TTL LS NOR QUAD 2-INP	01295	SN53243
A34U17	1820-0693	8		IC FF TTL S D-TYPE POS-EDGE-TRIG	01295	SN24661
A34U18	1820-2004	9	1	IC MISC NMOS	28480	1820-2004
A34U19	1820-1445	0	1	IC LCH TTL LS 4-BIT	01295	SN57206
A34U20	1820-0681	4		IC GATE TTL S NAND QUAD 2-INP	01295	SN24649
A34U21	1820-1112	8	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN53030
A34U22	1820-1201	6	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN53508
A34U101	1820-0817	8	4	IC FF ECL D-M/S DUAL	04713	SC63470P131
A34U102	1820-0820	3	1	IC FF ECL J-BAR K-BAR COM CLOCK DUAL	04713	SC63470L135
A34U103	1820-0817	8		IC FF ECL D-M/S DUAL	04713	SC63470P131
A34U104	1820-0817	8		IC FF ECL D-M/S DUAL	04713	SC63470P131
A34U105	1820-0803	2	1	IC GATE ECL OR-NOR TPL	04713	SC63470P105
A34U106	1826-0715	7	1	IC OP AMP LOW-NOISE 8-DIP-P PKG	18324	CC3802
A34U107	1820-0802	1	1	IC GATE ECL NOR QUAD 2-INP	04713	SC63470P102
A34U108	1820-0817	8		IC FF ECL D-M/S DUAL	04713	SC63470P131

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See introduction to this section for ordering information
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Table 4-26. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A35	**03326-66535**	**9**	**2**	**VCO/2 BOARDS**	**28480**	**03326-66535**
A35C1	0160-3847	9	9	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A35C2	0180-0228	6	3	CAPACITOR-FXD 22UF+-10% 15VDC TA	13606	150D226X9015B2-DYS
A35C3	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A35C4	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A35C5	0180-0228	6		CAPACITOR-FXD 22UF+-10% 15VDC TA	13606	150D226X9015B2-DYS
A35C6	0180-0228	6		CAPACITOR-FXD 22UF+-10% 15VDC TA	13606	150D226X9015B2-DYS
A35C7	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A35C8	0160-4819	7	1	CAPACITOR-FXD 2200PF +-5% 100VDC CER	27167	CAC04C0G222J100A
A35C9-C13	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A35CR1	1902-0950	4	1	DIODE-ZNR 4.7V 5% DO-35 PD=.4W TC=+.025%	04713	SZ30035-008
A35CR2	1901-0040	1	2	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A35CR3	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A35J1	1250-0544	9	1	CONNECTOR-RF SM-SNP M SGL-HOLE-FR 50-OHM	98291	051-049-0000-220
A35J2	1251-6254	2	1	CONNECTOR-SGL CONT RTANG-F	91833	901
A35L1-L3	9100-3345	5	3	INDUCTOR RF-CH-MLD 2UH 5% .166DX.385LG	06560	15A2R0J
A35MP1	03326-04135	5	1	CVR, VCO/2	28480	03326-04135
A35MP2-MP3	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A35MP4-MP6	2360-0113	2	3	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A35P1	1252-0266	6	1	DIN CONN.-16 PIN MALE	06383	100-316-033
A35R1	0683-3915	0	6	RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A35R2	0683-4705	8	5	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A35R3	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A35R4	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A35R5	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A35R6	0683-4315	6	1	RESISTOR 430 5% .25W CF TC=0-400	77902	R-25J
A35R7	0683-2715	6	1	RESISTOR 270 5% .25W CF TC=0-400	77902	R-25J
A35R8-R11	0683-3915	0		RESISTOR 390 5% .25W CF TC=0-400	77902	R-25J
A35R12	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A35R13	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A35R14	8150-3375	5	1	RESISTOR-ZERO OHMS 22 AWG LEAD DIA	75042	ZEROHM
A35TP1-TP3	1251-0600	0	3	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A35U1	1820-0802	1	1	IC GATE ECL NOR QUAD 2-INP	04713	SC63470P102
A35U2	1820-0820	3	2	IC FF ECL J-BAR K-BAR COM CLOCK DUAL	04713	SC63470L135
A35U3	1820-0820	3		IC FF ECL J-BAR K-BAR COM CLOCK DUAL	04713	SC63470L135
A36	**03326-66536**	**0**	**1**	**FRACN DECODER/CALIBRATOR BOARD**	**28480**	**03326-66536**
A36C1	0180-0116	1	2	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A36C2	0180-0309	4	1	CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A36C3	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A36C4-C12	0160-4571	8	30	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A36C100	0160-4835	7	4	CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A36C101	0160-0128	3	2	CAPACITOR-FXD 2.2UF +-20% 50VDC CER	13606	3C37Z5U225M050A
A36C102	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A36C103	0160-0128	3		CAPACITOR-FXD 2.2UF +-20% 50VDC CER	13606	3C37Z5U225M050A
A36C104-C107	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A36C108-C111	0160-5302	5	4	CAPACITOR-FXD 6.8PF +-10% 200VDC CER	04222	MA106A6R8K200V
A36C112-C113	0160-4441	1	2	CAPACITOR-FXD .47UF +-10% 50VDC CER	28480	C330C474K5R5CA
A36C114	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A36C115	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A36C116	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A36C117	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A36C200	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A36C201	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A36C202	0160-4799	2	1	CAPACITOR-FXD 2.2PF +-.25PF 100VDC CER	27167	CAC02C0G2R2C100A
A36C206-C210	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A36C211	0160-4401	3	1	CAPACITOR-FXD .01UF +-10% 100VDC POLYP	84411	HEW-446
A36C212-C219	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A36C220	0160-4834	6	1	CAPACITOR-FXD .047UF +-10% 100VDC CER	27167	CAC04X7R473K100A
A36CR100	1902-0951	5	4	DIODE-ZNR 5.1V 5% DO-35 PD=.4W TC=+.035%	04713	SZ30035-009
A36CR101	1901-0050	3	4	DIODE-SWITCHING 80V 200MA 2NS DO-35	07263	FDH 6308
A36CR102	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	07263	FDH 6308
A36CR103	1902-0951	5		DIODE-ZNR 5.1V 5% DO-35 PD=.4W TC=+.035%	04713	SZ30035-009
A36CR104-CR106	1901-0040	1	10	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A36CR107	1902-0951	5		DIODE-ZNR 5.1V 5% DO-35 PD=.4W TC=+.035%	04713	SZ30035-009
A36CR108	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	07263	FDH 6308
A36CR109	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	07263	FDH 6308

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See introduction to this section for ordering information
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Table 4-27. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A36CR110	1902-0951	5		DIODE-ZNR 5.1V 5% DO-35 PD=.4W TC=+.035%	04713	SZ30035-009
A36CR111-CR115	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A36CR200	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A36CR201	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A36CR202	1902-0680	7	1	DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	04713	SZ14377RL
A36F1	2110-0301	1	2	FUSE .125A 125V .281X.093	75915	275.125
A36F2	2110-0301	1		FUSE .125A 125V .281X.093	75915	275.125
A36J1	1251-6254	2	4	CONNECTOR-SGL CONT RTANG-F	91833	901
A36J2-J4	1251-6254	2		CONNECTOR-SGL CONT RTANG-F	91833	901
A36K1-K2	0490-1362	8	2	RELAY-REED 1C 500MA 25VDC 12VDC-COIL 2VA	95348	F811131-5 W/MR5290SW/1K OHM CL
A36K3-K5	0490-1405	0	3	RELAY 2C 12VDC-COIL 2A 250VAC	28480	DS2E-S-DC12V-H69
A36L1	9100-1618	1	2	INDUCTOR RF-CH-MLD 5.6UH 10%	06560	15-4435-1K
A36L2	9100-1791	1	1	CORE-FERRITE CHOKE-WIDEBAND; IMP:>360	02114	VK200-19/4B
A36L3	9100-1618	1		INDUCTOR RF-CH-MLD 5.6UH 10%	06560	15-4435-1K
A36MP1	03326-04136	6	1	CVR, FRAC-N DECOD/CAL	28480	03326-04136
A36MP2-MP3	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A36MP4-MP6	2360-0113	2	3	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A36P1	1251-8410	6	1	CONN-POST TYPE 48-CONT RTANG-DPSLDR	28480	1251-8410
A36Q200	1854-0071	7	1	TRANSISTOR NPN SI PD=300MW FT=200MHZ	13606	CT-1200
A36R1-R3	0683-1025	9	7	RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A36R100	0757-0401	0	4	RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A36R101	0698-4453	4	2	RESISTOR 402 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A36R102	0683-0275	9	2	RESISTOR 2.7 5% .25W CF TC=0-400	77902	R-25J
A36R103	0683-5115	6	2	RESISTOR 510 5% .25W CF TC=0-400	77902	R-25J
A36R104	0698-3258	5	2	RESISTOR 5.36K 1% .125W F TC=0+-100	19701	5033R
A36R105	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A36R106	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A36R107	0698-4453	4		RESISTOR 402 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A36R108	0683-0275	9		RESISTOR 2.7 5% .25W CF TC=0-400	77902	R-25J
A36R109	0683-5115	6		RESISTOR 510 5% .25W CF TC=0-400	77902	R-25J
A36R110	0698-3258	5		RESISTOR 5.36K 1% .125W F TC=0+-100	19701	5033R
A36R111	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A36R115	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A36R116	0757-0442	9	6	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A36R117	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A36R118	0757-0280	3	2	RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A36R119	0698-6396	8	2	RESISTOR 20M 5% .25W CC TC=-900/+1200	01121	CB2065
A36R120	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A36R121	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A36R122	0757-0443	0	2	RESISTOR 11K 1% .125W F TC=0+-100	19701	5033R
A36R123	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A36R124	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A36R125	0698-6396	8		RESISTOR 20M 5% .25W CC TC=-900/+1200	01121	CB2065
A36R126	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A36R127	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A36R128	0757-0443	0		RESISTOR 11K 1% .125W F TC=0+-100	19701	5033R
A36R129	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A36R130	0683-3055	9	2	RESISTOR 3M 5% .25W CF TC=0-900	77902	R-25J
A36R131	0683-3055	9		RESISTOR 3M 5% .25W CF TC=0-900	77902	R-25J
A36R200	0698-8319	9	4	RESISTOR 10K 1% .1W F TC=0+-10	19701	5023Z
A36R201	2100-3123	0	3	RESISTOR-TRMR 500 10% C SIDE-ADJ 17-TRN	73138	89PR500
A36R202	0698-8319	9		RESISTOR 10K 1% .1W F TC=0+-10	19701	5023Z
A36R203	0698-3245	0	1	RESISTOR 20.5K 1% .125W F TC=0+-100	19701	5033R
A36R204	0698-8319	9		RESISTOR 10K 1% .1W F TC=0+-10	19701	5023Z
A36R205	2100-3123	0		RESISTOR-TRMR 500 10% C SIDE-ADJ 17-TRN	73138	89PR500
A36R206	0683-2755	4	1	RESISTOR 2.7M 5% .25W CF TC=0-900	77902	R-25J
A36R207	0698-8319	9		RESISTOR 10K 1% .1W F TC=0+-10	19701	5023Z
A36R210	0757-0277	8	1	RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A36R211	0698-4430	7	1	RESISTOR 1.91K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A36R212	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A36R213	0698-4455	6	1	RESISTOR 536 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A36R214	0757-1094	9	1	RESISTOR 1.47K 1% .125W F TC=0+-100	19701	5033R
A36R215	0683-1015	7	1	RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A36R216	0698-8182	4	1	RESISTOR 2.21K 1% .125W F TC=0+-25	19701	5033R
A36R217	2100-3123	0		RESISTOR-TRMR 500 10% C SIDE-ADJ 17-TRN	73138	89PR500
A36R218	0698-6801	0	1	RESISTOR 3.48K 1% .125W F TC=0+-25	19701	5033R
A36R219-R222	0757-1012	1	4	RESISTOR 100 .25% .5W F TC=0+-100	19701	5053R
A36TP0-TP12	1251-0600	0	26	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034

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See introduction to this section for ordering information
*Indicates factory selected value

Table 4-28. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A36TP100-TP105	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A36TP200-TP207	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A36U1	1820-1196	8	4	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN53525
A36U2	1820-1216	3	2	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN53522
A36U3	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN53525
A36U4	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN53525
A36U5	1820-1212	9	1	IC FF TTL LS J-K NEG-EDGE-TRIG	01295	SN53519N
A36U6	1820-1199	1	1	IC INV TTL LS HEX 1-INP	01295	SN53506
A36U7	1820-1201	6	2	IC GATE TTL LS AND QUAD 2-INP	01295	SN53508
A36U8	1820-1208	3	1	IC GATE TTL LS OR QUAD 2-INP	01295	SN53515
A36U9	1820-1144	6	1	IC GATE TTL LS NOR QUAD 2-INP	01295	SN53243
A36U10	1820-1203	8	1	IC GATE TTL LS AND TPL 3-INP	01295	SN53510
A36U11	1820-1112	8	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN53030
A36U12	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN53522
A36U13	1858-0047	5	1	TRANSISTOR ARRAY 16-PIN PLSTC DIP	13606	ULN-2003A
A36U14	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN53525
A36U15	1820-1730	6	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN58039
A36U16	1820-2024	3	3	IC DRVR TTL LS LINE DRVR OCTL	01295	SN58948
A36U17	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN58948
A36U18	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN58948
A36U19	1820-1201	6		IC GATE TTL LS AND QUAD 2-INP	01295	SN53508
A36U100	1826-0638	3	2	IC COMPARATOR HS 8-DIP-P PKG	27014	SL38578
A36U101	1826-0638	3		IC COMPARATOR HS 8-DIP-P PKG	27014	SL38578
A36U102	1820-0693	8	1	IC FF TTL S D-TYPE POS-EDGE-TRIG	01295	SN24661
A36U103	1826-0412	1	1	IC COMPARATOR PRCN DUAL 8-DIP-P PKG	27014	SL33675
A36U200	1826-0413	2	1	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	34371	HA2-2605-B1392-001
A36U203	1826-0850	1	1	ANALOG SWITCH -PIN	17856	DG211CJ
A36U204	1826-1217	6	1	PEAK DETECTOR 14 -CERDIP	06665	PKD-01EY
A36U205	1826-0208	3	1	IC OP AMP GP 8-DIP-P PKG	27014	SL27613
A36U206	1826-1044	7	1	D/A 12-1/2-BIT 24-DIP-C BPLR	24355	AD41435
A36U207	1826-0319	7	1	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	27014	SL31560
A36U208	1826-0065	0	1	IC COMPARATOR PRCN 8-DIP-P PKG	27014	SL14334
A36U209	1820-1978	4	1	IC RGTR TTL L 12-BIT	34335	AM25L04PC
A50	**03326-66550**	**8**	**1**	**REFERENCE BOARD**	**28480**	**03326-66550**
A50C1	0180-0309	4	6	CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A50C2	0180-0309	4		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A50C3	0160-4571	8	39	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C4	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C5	0180-0116	1	2	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A50C6	0180-0309	4		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A50C7	0180-0116	1		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	13606	150D685X9035B2-DYS
A50C8	0180-0229	7	1	CAPACITOR-FXD 33UF+-10% 10VDC TA	13606	150D336X9010B2-DYS
A50C9	0180-0309	4		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A50C10	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C11	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C100	0180-1746	5	1	CAPACITOR-FXD 15UF+-10% 20VDC TA	13606	150D156X9020B2-DYS
A50C101	0160-3877	5	2	CAPACITOR-FXD 100PF +-20% 200VDC CER	51642	200-200-X7R-101M(.250LL)
A50C102	0160-3877	5		CAPACITOR-FXD 100PF +-20% 200VDC CER	51642	200-200-X7R-101M(.250LL)
A50C103	0160-3847	9	5	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A50C104	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C105	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A50C106	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C107	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C108	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A50C109	0160-4803	9	1	CAPACITOR-FXD 68PF +-5% 100VDC CER 0+-30	27167	CAC02COG680J100A
A50C110	0160-5413	9	1	CAPACITOR-FXD 160PF +-5% 100VDC CER	27167	CAC02COG161J100A
A50C111	0160-0127	2	4	CAPACITOR-FXD 1UF +-20% 25VDC CER	13606	2C37Z5U105M025A
A50C112-C118	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C120	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C122	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C200-C204	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C205	0160-4787	8	3	CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30	27167	CAC02COG220J100A
A50C206	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C207	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA

See introduction to this section for ordering information
*Indicates factory selected value

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Table 4-29. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A50C208	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C209	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C210	0180-0309	4		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A50C298	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A50C299	0160-4846	0	1	CAPACITOR-FXD 1500PF +-5% 100VDC CER	27167	CAC04COG152J100A
A50C300-C302	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C400	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C401	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C402	0160-4787	8		CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30	27167	CAC02COG220J100A
A50C403	0160-4787	8		CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30	27167	CAC02COG220J100A
A50C404	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A50C405	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	13606	2C37Z5U105M025A
A50C406	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	13606	2C37Z5U105M025A
A50C407	0160-4532	1	2	CAPACITOR-FXD 1000PF +-20% 50VDC CER	27167	CAC02X7R102M100A
A50C408	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	13606	2C37Z5U105M025A
A50C410	0160-5349	0	1	CAPACITOR-FXD 200PF +-5% 100VDC CER	13606	292CCOG201J100B
A50C411	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C412	0180-0309	4		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A50C413	0160-4532	1		CAPACITOR-FXD 1000PF +-20% 50VDC CER	27167	CAC02X7R102M100A
A50C414	0160-4814	2	1	CAPACITOR-FXD 150PF +-5% 100VDC CER	27167	CAC02COG151J100A
A50C415-C420	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C497	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C498	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A50C499	0160-4803	9	1	CAPACITOR-FXD 68PF +-5% 100VDC CER 0+-30	27167	CAC02COG680J100A
A50CR100	0122-0162	5	1	DIODE-VVC 29PF 10% BVR=30V	25403	BB809
A50CR102	1901-0040	1	12	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A50CR103	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A50CR200	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A50CR400	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A50CR403-CR406	1901-0535	9	4	DIODE-SCHOTTKY SM SIG	28480	1901-0535
A50CR407-CR414	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A50J1	1251-6254	2	2	CONNECTOR-SGL CONT RTANG-F	91833	901
A50J2	1250-0544	9	2	CONNECTOR-RF SM-SNP M SGL-HOLE-FR 50-OHM	98291	051-049-0000-220
A50J3	1250-0544	9		CONNECTOR-RF SM-SNP M SGL-HOLE-FR 50-OHM	98291	051-049-0000-220
A50J4	1251-6254	2		CONNECTOR-SGL CONT RTANG-F	91833	901
A50L1-L4	9100-3559	3	6	INDUCTOR RF-CH-MLD 5.1UH 5% .166DX.385LG	24226	15M511J-1
A50L5	9100-1791	1	2	CORE-FERRITE CHOKE-WIDEBAND;IMP:>360	02114	VK200-19/4B
A50L6	9100-3559	3		INDUCTOR RF-CH-MLD 5.1UH 5% .166DX.385LG	24226	15M511J-1
A50L100	9100-1617	0	1	INDUCTOR RF-CH-MLD 3.9UH 10%	06560	15-4425-13K
A50L101	9140-0253	2	2	INDUCTOR RF-CH-MLD 300NH 1% .166DX.385LG	24226	15M300F-1
A50L200	9140-0253	2		INDUCTOR RF-CH-MLD 300NH 1% .166DX.385LG	24226	15M300F-1
A50L201	9100-3559	3		INDUCTOR RF-CH-MLD 5.1UH 5% .166DX.385LG	24226	15M511J-1
A50L202	9100-1791	1		CORE-FERRITE CHOKE-WIDEBAND;IMP:>360	02114	VK200-19/4B
A50MP1	03326-04150	4	1	CVR, REFERENCE	28480	03326-04150
A50MP2-MP3	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A50MP4-MP9	2360-0113	2	6	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A50P1	T-54687	9	1	DIN CONN.-32 PIN MALE	28480	T-54687
A50Q100-Q103	1854-0215	1	5	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A50Q104	1855-0081	1	2	TRANSISTOR J-FET N-CHAN D-MODE SI	34677	F1843
A50Q200	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A50Q400	1855-0081	1		TRANSISTOR J-FET N-CHAN D-MODE SI	34677	F1843
A50Q401	1854-0457	3	1	TRANSISTOR-DUAL NPN PD=400MW	04713	SD485
A50R100	0757-0465	6	5	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A50R101	0757-0442	9	9	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A50R102	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A50R103	0698-3150	6	3	RESISTOR 2.37K 1% .125W F TC=0+-100	19701	5033R
A50R104	0757-0401	0	3	RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A50R105	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A50R106	0757-0422	5	1	RESISTOR 909 1% .125W F TC=0+-100	19701	5033R
A50R107	0757-0277	8	12	RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A50R108	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A50R109	0757-0449	6	2	RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A50R110	0698-3444	1	1	RESISTOR 316 1% .125W F TC=0+-100	19701	5033R
A50R111	0698-3152	8	2	RESISTOR 3.48K 1% .125W F TC=0+-100	19701	5033R
A50R112	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A50R113	0757-0416	7	17	RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R114	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A50R115	2100-3094	4	1	RESISTOR-TRMR 100K 10% C SIDE-ADJ 17-TRN	73138	89PR100K

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320 3991

Table 4-30. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A50R116	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A50R117	0698-3279	0	3	RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A50R118	0757-0401	0	1	RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A50R119	0698-0082	7	1	RESISTOR 464 1% .125W F TC=0+-100	19701	5033R
A50R120	0698-3150	6		RESISTOR 2.37K 1% .125W F TC=0+-100	19701	5033R
A50R121	0698-4491	0	1	RESISTOR 30.9K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A50R122	0698-4121	3	1	RESISTOR 11.3K 1% .125W F TC=0+-100	19701	5033R
A50R123	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A50R124	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A50R125	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R126	0683-1025	9	18	RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R127-R132	0757-0316	6	7	RESISTOR 42.2 1% .125W F TC=0+-100	19701	5033R
A50R134	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A50R135	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A50R137	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A50R138	0757-0316	6		RESISTOR 42.2 1% .125W F TC=0+-100	19701	5033R
A50R197	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R198	0757-0316	6		RESISTOR 42.2 1% .125W F TC=0+-100	19701	5033R
A50R199	0757-0316	6		RESISTOR 42.2 1% .125W F TC=0+-100	19701	5033R
A50R200	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R201	0757-0316	6		RESISTOR 42.2 1% .125W F TC=0+-100	19701	5033R
A50R202	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A50R203	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A50R204	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R207	0757-0316	6		RESISTOR 42.2 1% .125W F TC=0+-100	19701	5033R
A50R208	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R209	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A50R210	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A50R211	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R212	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R213	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R214	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R216	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R218	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R219	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R220	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R221	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A50R222	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R223	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R224	0757-0449	6		RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A50R300	0757-0409	8	2	RESISTOR 274 1% .125W F TC=0+-100	19701	5033R
A50R301	0757-0409	8		RESISTOR 274 1% .125W F TC=0+-100	19701	5033R
A50R302	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R303	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R400	0757-0280	3	2	RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A50R401	0698-4437	4	2	RESISTOR 2.94K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A50R402	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A50R403	0757-0446	3	1	RESISTOR 15K 1% .125W F TC=0+-100	19701	5033R
A50R404	0757-0470	3	1	RESISTOR 162K 1% .125W F TC=0+-100	19701	5033R
A50R405	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R406	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R407	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A50R408	0698-4437	4		RESISTOR 2.94K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A50R409	0698-8827	4	1	RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A50R410	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A50R411	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A50R412	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R413	0698-4498	7	1	RESISTOR 53.6K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A50R414	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A50R415	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	19701	5033R
A50R416	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R417	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R418	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R419	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R420	0757-0407	6	3	RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A50R421	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A50R422	0698-3279	0		RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320 3991

Table 4-31. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A50R423	0757-0407	6		RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A50R424	0757-0407	6		RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A50R425	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A50R426	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A50R427	0757-0419	0	1	RESISTOR 681 1% .125W F TC=0+-100	19701	5033R
A50R428	0698-3279	0		RESISTOR 4.99K 1% .125W F TC=0+-100	19701	5033R
A50R429	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A50R430	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R431	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R432	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R495	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	19701	5033R
A50R496	0698-3150	6		RESISTOR 2.37K 1% .125W F TC=0+-100	19701	5033R
A50R497	0757-0277	8		RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A50R498	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A50R499	0698-3228	9	1	RESISTOR 49.9K 1% .125W F TC=0+-100	19701	5033R
A50T100	08552-6044	1	2	TRANS 6 TURNS	28480	08552-6044
A50T300	08552-6044	1		TRANS 6 TURNS	28480	08552-6044
A50TP1-TP7	1251-0600	0	7	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A50U100	1820-0817	8	3	IC FF ECL D-M/S DUAL	04713	SC63470P131
A50U101	1820-0810	1	4	IC RCVR ECL LINE RCVR TPL 2-INP	04713	SC63470P116
A50U102	1820-0810	1		IC RCVR ECL LINE RCVR TPL 2-INP	04713	SC63470P116
A50U200	1820-0810	1		IC RCVR ECL LINE RCVR TPL 2-INP	04713	SC63470P116
A50U201	1820-0817	8		IC FF ECL D-M/S DUAL	04713	SC63470P131
A50U202	1820-1383	5	2	IC CNTR ECL BCD POS-EDGE-TRIG	04713	SC63470L138
A50U203	1820-1383	5		IC CNTR ECL BCD POS-EDGE-TRIG	04713	SC63470L138
A50U204	1826-0210	7	1	IC COMPARATOR HS 14-DIP-P PKG	27014	SL27610
A50U300	1820-0817	8		IC FF ECL D-M/S DUAL	04713	SC63470P131
A50U400	1826-0138	8	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	27014	SL24958
A50U401	1826-0340	4	1	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	27014	SL617760
A50U402	1820-0810	1		IC RCVR ECL LINE RCVR TPL 2-INP	04713	SC63470P116
A50Y100	0410-0680	3	1	CRYSTAL-QUARTZ 40.000 MHZ	33096	0410-0680
A61	**03326-66561**	**1**	**1**	**CONTROLLER BOARD**	**28480**	**03326-66561**
A61BT1	1420-0278	7	1	BATTERY 2.9V .72A-HR LI/S-DIOX W-FLEX	28480	B9511
A61C101	0160-4835	7	5	CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A61C102	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A61C120	0160-0127	2	2	CAPACITOR-FXD 1UF +-20% 25VDC CER	13606	2C37Z5U105M025A
A61C201	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A61C202-C223	0160-3847	9	23	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A61C224	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A61C230	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A61C231	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A61C401	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	13606	2C37Z5U105M025A
A61C402	0160-0300	3	1	CAPACITOR-FXD 2700PF +-10% 200VDC POLYE	13606	192P27292
A61C403	0160-4801	7	1	CAPACITOR-FXD 100PF +-5% 100VDC CER	27167	CAC02C0G101J100A
A61C504	0180-0062	6	1	CAPACITOR-FXD 300UF+75-10% 6VDC AL	13606	30D307G006DD2
A61C610-C621	0160-4571	8	30	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A61C623-C630	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A61C632-C641	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A61CR101	1901-0040	1	3	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A61CR102	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A61CR103	1902-3080	7	1	DIODE-ZNR 4.53V 2% DO-35 PD=.4W	04713	SZ30016-084
A61CR301	1901-0535	9	2	DIODE-SCHOTTKY SM SIG	28480	1901-0535
A61CR302	1902-0946	8	1	DIODE-ZNR 3.3V 5% DO-35 PD=.4W TC=-.039%	04713	SZ30035-004
A61CR401	1990-0485	5	1	LED-LAMP LUM-INT=2MCD IF=30MA-MAX BVR=5V	28480	1990-0485
A61CR402	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A61CR405	1901-0535	9		DIODE-SCHOTTKY SM SIG	28480	1901-0535
A61J104	1251-5648	6	1	CONN-POST TYPE .100-PIN-SPCG 16-CONT	76381	3408-1202
A61J201	1251-5652	2	1	CONN-POST TYPE .100-PIN-SPCG 40-CONT	76381	3432-1202
A61J303	1251-3835	9	1	CONN-POST TYPE .100-PIN-SPCG 9-CONT	27264	22-05-2091
A61MP2-MP7	0624-0333	6	6	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A61MP8	5000-9043	6	1	PIN EXTR	28480	5000-9043
A61MP9	5040-6843	2	1	EXTR-PC BD	28480	5040-6843
A61MP10-MP12	0403-0285	9	3	BUMPER FOOT-ADH MTG 12.7-MM-WD	76381	SJ-5018 GRAY
A61P1	1251-8410	6	1	CONN-POST TYPE 48-CONT RTANG-DPSLDR	28480	1251-8410
A61Q301	1853-0036	2	2	TRANSISTOR PNP SI PD=310MW FT=250MHZ	04713	SPS-3612

PART NUMBER 9320 3991

See introduction to this section for ordering information
*Indicates factory selected value

Table 4-32. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A61Q302	1854-0215	1	2	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A61Q401	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	04713	SPS-3612
A61Q402	1854-0692	8	1	TRANSISTOR NPN SI PD=15W FT=50MHZ	04713	SJE1634K
A61Q501	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A61R101	0683-1025	9	15	RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R102	0683-1055	5	2	RESISTOR 1M 5% .25W CF TC=0-800	77902	R-25J
A61R103	0683-1055	5		RESISTOR 1M 5% .25W CF TC=0-800	77902	R-25J
A61R110	0683-4725	2	12	RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A61R111	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A61R113	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R114	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A61R115	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R116	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R122	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R123	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A61R130	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R201	0757-0283	6	5	RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A61R202	0757-0283	6		RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A61R203-R210	0757-0407	6	23	RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A61R211	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R212	0757-0283	6		RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A61R213	0757-0283	6		RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A61R214	0757-0407	6		RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A61R215	0757-0407	6		RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A61R216	8150-3375	5	2	RESISTOR-ZERO OHMS 22 AWG LEAD DIA	75042	ZEROHM
A61R217	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A61R218	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R219-R229	0757-0407	6		RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A61R230	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R231-R233	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A61R234	0757-0415	6	2	RESISTOR 475 1% .125W F TC=0+-100	19701	5033R
A61R235	0757-0415	6		RESISTOR 475 1% .125W F TC=0+-100	19701	5033R
A61R236	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R237	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R238	0757-0407	6		RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A61R239	0757-0407	6		RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A61R251	0683-4715	0	1	RESISTOR 470 5% .25W CF TC=0-400	77902	R-25J
A61R301	0683-2235	5	1	RESISTOR 22K 5% .25W CF TC=0-400	77902	R-25J
A61R302	0683-1005	5	1	RESISTOR 10 5% .25W CF TC=0-400	77902	R-25J
A61R304	0683-8205	1	1	RESISTOR 82 5% .25W CF TC=0-400	77902	R-25J
A61R306	0683-1525	4	1	RESISTOR 1.5K 5% .25W CF TC=0-400	77902	R-25J
A61R309	0683-1035	1	1	RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A61R401	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R404	8150-3375	5		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	75042	ZEROHM
A61R410	0698-8059	4	1	RESISTOR 4.32K .1% .125W F TC=0+-25	19701	5033R
A61R412	0698-6360	6	1	RESISTOR 10K .1% .125W F TC=0+-25	19701	5033R
A61R415	0757-0453	2	1	RESISTOR 30.1K 1% .125W F TC=0+-100	19701	5033R
A61R416	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A61R417	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A61R420	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R421	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A61R422	0683-6215	9	1	RESISTOR 620 5% .25W CF TC=0-400	77902	R-25J
A61R423	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A61R425	0683-2225	3	1	RESISTOR 2.2K 5% .25W CF TC=0-400	77902	R-25J
A61R426	0683-9115	4	1	RESISTOR 910 5% .25W CF TC=0-400	77902	R-25J
A61R501	0757-0283	6		RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A61R502	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61R503	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A61RP101	1810-0269	3	2	NETWORK-RES 9-SIP 10.0K OHM X 8	13606	216CJ104
A61RP401	1810-0269	3		NETWORK-RES 9-SIP 10.0K OHM X 8	13606	216CJ104
A61S1	3101-2063	8	1	SWITCH-RKR DIP-RKR-ASSY 4-1A .05A 30VDC	81073	76YY2074S
A61T201-T206	1810-0751	8	6	NETWORK-TRANSFORMER	28480	1810-0751
A61TP1-TP11	1251-0600	0	26	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A61TP13	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A61TP17	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A61TP21	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A61TP22	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034

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See introduction to this section for ordering information
*Indicates factory selected value

Table 4-33. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A61TP24-TP30	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A61TP32-TP35	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A61U101	1820-1146	8	1	IC BFR CMOS NON-INV HEX	3L585	CD4050BE
A61U102	1820-1367	5	1	IC GATE TTL S AND QUAD 2-INP	01295	SN85092N
A61U103	1820-2624	9	1	IC-MPU; CLK FREQ=2 MHZ, ENHANCED 6800	04713	MC68809P
A61U104	1820-2024	3	10	IC DRVR TTL LS LINE DRVR OCTL	01295	SN58948
A61U105	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN58948
A61U106	1820-2075	4	3	IC TRANSCEIVER TTL LS BUS OCTL	01295	SN59111N
A61U107	1820-1975	1	1	IC SHF-RGTR TTL LS NEG-EDGE-TRIG PRL-IN	01295	SN58817N
A61U108	1820-1987	5	1	IC SHF-RGTR TTL LS COM CLEAR STOR 8-BIT	34335	AM74LS299N
A61U109	1820-1443	8	1	IC CNTR TTL LS BIN ASYNCHRO	01295	SN57204
A61U110	1820-1206	1	2	IC GATE TTL LS NOR TPL 3-INP	01295	SN53513
A61U111	1820-0683	6	1	IC INV TTL S HEX 1-INP	01295	SN24651
A61U112-U115	1820-1240	3	4	IC DCDR TTL S 3-TO-8-LINE 3-INP	01295	SN47883
A61U117	1826-0138	8	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	27014	SL24958
A61U118	1820-1144	6	1	IC GATE TTL LS NOR QUAD 2-INP	01295	SN53243
A61U119	1820-1203	8	1	IC GATE TTL LS AND TPL 3-INP	01295	SN53510
A61U120	1820-1197	9	2	IC GATE TTL LS NAND QUAD 2-INP	01295	SN53504
A61U122	1820-1212	9	1	IC FF TTL LS J-K NEG-EDGE-TRIG	01295	SN53519N
A61U124	1820-1322	2	1	IC GATE TTL S NOR QUAD 2-INP	01295	SN84050
A61U125	1820-1196	8	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN53525
A61U201-U203	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN58948
A61U204-U207	1820-1440	5	7	IC LCH TTL LS QUAD	01295	SN57201
A61U208	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN58948
A61U209	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN58948
A61U211	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN58948
A61U212-U214	1820-1440	5		IC LCH TTL LS QUAD	01295	SN57201
A61U215	1820-2548	6	1	IC-GENERAL PURPOSE INTERFACE BUS ADAPTER	01295	MP9203NL
A61U216	1820-3431	8	1	IC TRANSCEIVER TTL S INSTR-BUS IEEE-488	27014	DS74160AN
A61U217	1820-3513	7	1	IC TRANSCEIVER TTL S INSTR-BUS IEEE-488	27014	DS75160AN
A61U218	1820-1997	7	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	27014	GDEA105
A61U219	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	27014	GDEA105
A61U220	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN53525
A61U221	1990-0545	8	1	OPTO-ISOLATOR LED-PDIO/XSTR IF=40MA-MAX	28480	1990-0545
A61U301	1820-1145	7	1	IC BFR CMOS INV HEX 1-INP	3L585	CD4049UBE
A61U302	1818-1784	5	1	IC CMOS 16384 (16K) STAT RAM 250-NS 3-S	28480	1818-1784
A61U303	1818-1845	9	1	IC NMOS 16384 (16K) STAT RAM 100-NS 3-S	28480	1818-1845
A61U304	1820-2075	4		IC TRANSCEIVER TTL LS BUS OCTL	01295	SN59111N
A61U305	03326-60301	5	1	PROGRAMMED PROM	28480	03326-60301
A61U306	03326-60302	6	1	PROGRAMMED PROM	28480	03326-60302
A61U401	1820-3415	8	1	IC-PROGRAMMABLE TIMER MODULE,2MHZ,6800	04713	MC68B40P
A61U402	1820-1112	8	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN53030
A61U403	1820-1211	8	1	IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN53518
A61U404	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN58948
A61U405	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN58948
A61U412	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	27014	GDEA105
A61U413	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN53504
A61U415-U417	1820-1194	6	3	IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN53527
A61U418	1826-0838	5	1	D/A 10-BIT 16-PLASTIC CMOS	24355	AD11/435
A61U419	1826-0522	4	1	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	SN99856N
A61U420	1820-1206	1		IC GATE TTL LS NOR TPL 3-INP	01295	SN53513
A61U502	1820-2075	4		IC TRANSCEIVER TTL LS BUS OCTL	01295	SN59111N
A61U503	1820-1917	1	1	IC BFR TTL LS LINE DRVR OCTL	01295	SN58746N
A61W101	1251-5990	1	2	CONN-POST TYPE .100-PIN-SPCG 3-CONT	00779	87348-3
A61W101A	1258-0141	8	4	JMPR-REM .025P	22526	65474-004
A61W105	1251-5750	1	2	CONN-POST TYPE .100-PIN-SPCG 2-CONT	00779	640098-2
A61W105A	1258-0141	8		JMPR-REM .025P	22526	65474-004
A61W304	1251-5750	1		CONN-POST TYPE .100-PIN-SPCG 2-CONT	00779	640098-2
A61W304A	1258-0141	8		JMPR-REM .025P	22526	65474-004
A61W401	1251-5990	1		CONN-POST TYPE .100-PIN-SPCG 3-CONT	00779	87348-3
A61W401A	1258-0141	8		JMPR-REM .025P	22526	65474-004
A62	**03326-66562**	**2**	**1**	**KEYBOARD**	**28480**	**03326-66562**
A62C2	0160-3847	9	18	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A62C4-C9	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A62C11	0160-4571	8	4	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA

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See introduction to this section for ordering information
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Table 4-34. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A62C12	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A62C101-C107	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A62C108	0160-4801	7	1	CAPACITOR-FXD 100PF +-5% 100VDC CER	27167	CAC02COG101J100A
A62C109	0180-0374	3	1	CAPACITOR-FXD 10UF+-10% 20VDC TA	13606	150D106X9020B2-DYS
A62C111	0160-4835	7	1	CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A62C113-C115	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A62C116-C117	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A62C200-C202	0160-4300	1	3	CAPACITOR-FXD .047UF +80-20% 100VDC CER	28480	562CZC101AL473ZA26
A62C203	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A62CR1	1990-0486	6	1	LED-LAMP LUM-INT=2MCD IF=25MA-MAX BVR=5V	28480	1990-0486
A62CR2-CR28	1990-0831	5	40	LED-LAMP LUM-INT=800UCD IF=20MA-MAX	28480	1990-0831
A62CR29	1990-0485	5	1	LED-LAMP LUM-INT=2MCD IF=30MA-MAX BVR=5V	28480	1990-0485
A62CR30-CR48	1990-0831	5		LED-LAMP LUM-INT=800UCD IF=20MA-MAX	28480	1990-0831
A62CR49-CR56	1901-0040	1	9	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A62CR101	1901-0029	6	4	DIODE-PWR RECT 600V 750MA DO-29	04713	SR1358-10B
A62CR102	1901-0029	6		DIODE-PWR RECT 600V 750MA DO-29	04713	SR1358-10B
A62CR103	1901-0050	3	2	DIODE-SWITCHING 80V 200MA 2NS DO-35	07263	FDH 6308
A62CR104	1901-0029	6		DIODE-PWR RECT 600V 750MA DO-29	04713	SR1358-10B
A62CR105	1901-0029	6		DIODE-PWR RECT 600V 750MA DO-29	04713	SR1358-10B
A62CR107	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	07263	FDH 6308
A62CR108	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A62CR109	1902-0940	2	1	DIODE-ZNR 1N5339B 5.6V 5% PD=5W IR=1UA	04713	SZP40149
A62CR200	1990-0759	6	1	LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	1990-0759
A62DS201	1990-1039	7	1	HLMP-2670	28480	1990-1039
A62J1	1251-7666	2	1	CONN-POST TYPE .100-PIN-SPCG 16-CONT	76381	3408-1002
A62J2	1251-4813	5	1	CONN-POST TYPE .100-PIN-SPCG 5-CONT	27264	22-05-2051
A62J3-J13	1200-0474	9	11	SOCKET-IC 14-CONT DIP-SLDR	28480	C931410
A62J14	1200-0473	8	2	SOCKET-IC 16-CONT DIP DIP-SLDR	28480	C931602
A62J15	1200-0473	8		SOCKET-IC 16-CONT DIP DIP-SLDR	28480	C931602
A62J16	1200-0583	1	1	SOCKET-IC 24-CONT DIP DIP-SLDR	28480	C93-24-02
A62J101	1250-0643	9	1	CONNECTOR-RF BNC FEM PC 50-OHM	24931	28JR175-2
A62J102	1251-6254	2	1	CONNECTOR-SGL CONT RTANG-F	91833	901
A62K101	0490-1346	8	1	RELAY-REED 1A 500MA 200VDC 5VDC-COIL	12617	HE321A5131
A62L101-L103	9140-0395	3	3	INDUCTOR RF-CH-MLD 560NH 5% .166DX.385LG	06560	4425-3J
A62MP1-MP43	05328-40003	8	43	STAND-L.E.D	28480	05328-40003
A62Q1-Q17	1853-0016	8	17	TRANSISTOR PNP SI TO-92 PD=300MW	04713	SPS3320
A62Q101	1854-0215	1	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A62R1-R3	1810-0269	3	3	NETWORK-RES 9-SIP 10.0K OHM X 8	13606	216CJ104
A62R4-R19	0683-2205	9	16	RESISTOR 22 5% .25W CF TC=0-400	77902	R-25J
A62R20-R35	0684-1021	7	16	RESISTOR 1K 10% .25W CF TC=0-400	77902	R-25J
A62R36-R51	0683-1015	7	16	RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A62R52	0683-1025	9	3	RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A62R53	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A62R54	0683-1815	5	2	RESISTOR 180 5% .25W CF TC=0-400	77902	R-25J
A62R55	0683-1025	9		RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A62R56	0683-1045	3	1	RESISTOR 100K 5% .25W CF TC=0-400	77902	R-25J
A62R57	0683-1815	5		RESISTOR 180 5% .25W CF TC=0-400	77902	R-25J
A62R58	0683-0335	2	2	RESISTOR 3.3 5% .25W CF TC=0-400	77902	R-25J
A62R59	0683-0335	2		RESISTOR 3.3 5% .25W CF TC=0-400	77902	R-25J
A62R101	0757-0317	7	1	RESISTOR 1.33K 1% .125W F TC=0+-100	19701	5033R
A62R103	0698-4493	2	1	RESISTOR 34K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A62R104	0683-4705	8	1	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A62R105	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A62R106	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A62R107	0683-7545	0	1	RESISTOR 750K 5% .25W CF TC=0-800	77902	R-25J
A62R108	0698-8827	4	2	RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A62R109	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A62R110	0757-0465	6	3	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A62R111	0698-4436	3	1	RESISTOR 2.8K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A62R112	0698-4533	1	1	RESISTOR 294K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A62R113	0757-0422	5	1	RESISTOR 909 1% .125W F TC=0+-100	19701	5033R
A62R114	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A62R115	0757-0400	9	1	RESISTOR 90.9 1% .125W F TC=0+-100	19701	5033R
A62R116	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A62S1-S45	5060-9436	7	45	PB-SWITCH	28480	5060-9436
A62S46	3101-2748	6	1	SWITCH-PB DPDT ALTNG .1A	28480	3101-2748
A62TP1-TP10	1251-0600	0	10	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034

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See introduction to this section for ordering information
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Table 4-35. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A62U1-U5	1820-1662	3	5	IC SHF-RGTR CMOS SERIAL-IN PRL-OUT 8-BIT	3L585	CD4094BE
A62U6	1820-0938	4	1	IC FF CMOS J-K M/S POS-EDGE-TRIG DUAL	3L585	CD4027BE
A62U7	1820-2031	2	1	IC SHF-RGTR CMOS ASYNCHRO PRL-IN	04713	SC45122PK
A62U8-U10	1858-0047	5	3	TRANSISTOR ARRAY 16-PIN PLSTC DIP	13606	ULN-2003A
A62U11-U21	1990-0592	5	11	DISPLAY-NUM-SEG 1-CHAR .43-H	28480	1990-0592
A62U22	1990-0634	6	1	DISPLAY-AN-SEG 4-CHAR .15-H RED	28480	1990-0634
A62U101	1826-0210	7	1	IC COMPARATOR HS 14-DIP-P PKG	27014	SL27610
A62U102	1820-1199	1	1	IC INV TTL LS HEX 1-INP	01295	SN53506
A62U103	1826-0138	8	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	27014	SL24958
A62U104	1826-0715	7	1	IC OP AMP LOW-NOISE 8-DIP-P PKG	18324	CC3802
A62VR200	0837-0313	3	1	TNR 15G 560 KM	28480	0837-0313
A63	**03326-66563**	3	1	**HP-IB SUPPORT BOARD**	**28480**	**03326-66563**
A63C1	0160-4300	1	1	CAPACITOR-FXD .047UF +80-20% 100VDC CER	28480	562CZC101AL473ZA26
A63C2-C5	0160-4822	2	4	CAPACITOR-FXD 1000PF +-5% 100VDC CER	27167	CAC03C0G102J100A
A63C6	0160-3847	9	1	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A63C7	0160-3847	9	1	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A63CR1-CR4	1901-0029	6	6	DIODE-PWR RECT 600V 750MA DO-29	04713	SR1358-10B
A63CR6	1902-3345	7	1	DIODE-ZNR 51.1V 5% DO-35 PD=.4W	04713	SZ30016-1386
A63CR7-CR8	1901-0029	6		DIODE-PWR RECT 600V 750MA DO-29	04713	SR1358-10B
A63CR11	1902-0940	2	1	DIODE-ZNR 1N5339B 5.6V 5% PD=5W IR=1UA	04713	SZP40149
A63CR12	1902-0632	9	1	DIODE-ZNR 1N5354B 17V 5% PD=5W TC=+75%	04713	SZP40123
A63J1	03326-61603	2	1	40 PIN CABLE	28480	03326-61603
A63J3-J6	1250-1687	3	4	CONNECTOR-RF BNC FEM PC 50-OHM	24931	28JR175-7
A63MP639	0380-0678	4	2	STANDOFF-RVT-ON .25-IN-LG 6-32-THD	06540	9533B-B-0632-14
A63R1	8150-3375	5	1	RESISTOR-ZERO OHMS 22 AWG LEAD DIA	75042	ZEROHM
A63R2-R4	0837-0275	6	3	THERMISTOR DISC 50-OHM TC=+2.35%/C-DEG	28480	RL3006-50-110-25-PTO
A63R5	0837-0223	4	1	THERMISTOR DISC 10-OHM	28480	RL4008-10-110-40-PTI
A63U2	1252-0137	0	1	CONNECTOR 24P	9D949	57-20240-23(438)(398)
A63VR1	0837-0313	3	1	TNR 15G 560 KM	28480	0837-0313
A70	**03326-66570**	2	1	**POWER SUPPLY BOARD**	**28480**	**03326-66570**
A70C100	0180-0309	4	1	CAPACITOR-FXD 4.7UF+-20% 10VDC TA	13606	150D475X0010A2-DYS
A70C101	0180-0098	8	3	CAPACITOR-FXD 100UF+-20% 20VDC TA	13606	150D107X0020S2-DYS
A70C200	0180-0098	8		CAPACITOR-FXD 100UF+-20% 20VDC TA	13606	150D107X0020S2-DYS
A70C201	0160-3847	9	5	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A70C202	0160-4835	7	7	CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A70C300	0180-0159	2	1	CAPACITOR-FXD 220UF+-20% 10VDC TA	13606	150D227X0010S2-DYS
A70C301	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A70C302	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A70C303	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A70C400	0160-0170	5	4	CAPACITOR-FXD .22UF +80-20% 50VDC CER	13606	2C37Z5U224Z050A
A70C401	0160-0127	2	2	CAPACITOR-FXD 1UF +-20% 25VDC CER	13606	2C37Z5U105M025A
A70C603	0160-0170	5		CAPACITOR-FXD .22UF +80-20% 50VDC CER	13606	2C37Z5U224Z050A
A70C604	0180-0100	3	2	CAPACITOR-FXD 4.7UF+-10% 35VDC TA	13606	150D475X9035B2-DYS
A70C606	0160-0170	5		CAPACITOR-FXD .22UF +80-20% 50VDC CER	13606	2C37Z5U224Z050A
A70C607	0180-0100	3		CAPACITOR-FXD 4.7UF+-10% 35VDC TA	13606	150D475X9035B2-DYS
A70C700	0180-2908	3	2	CAPACITOR-FXD 6300UF+-20% 28VDC AL	13606	622D632M028AA2A
A70C701	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A70C702	0180-2908	3		CAPACITOR-FXD 6300UF+-20% 28VDC AL	13606	622D632M028AA2A
A70C703	0180-2154	1	1	CAPACITOR-FXD 1900UF+75-10% 15VDC AL	13606	39D198G015GL2-DSB
A70C704	0180-2779	6	2	CAPACITOR-FXD 470UF+75-10% 50VDC AL	13606	30D477G050FK2
A70C705	0180-2779	6		CAPACITOR-FXD 470UF+75-10% 50VDC AL	13606	30D477G050FK2
A70C706	0180-2655	7	2	CAPACITOR-FXD 9000UF+75-10% 16VDC AL	00853	300JT103U016B
A70C707	0180-2655	7		CAPACITOR-FXD 9000UF+75-10% 16VDC AL	00853	300JT103U016B
A70C708	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A70C709	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A70C710	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	27167	CAC04X7R104K050A
A70C805	0180-0098	8		CAPACITOR-FXD 100UF+-20% 20VDC TA	13606	150D107X0020S2-DYS
A70C810-C812	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A70C900	0160-0170	5		CAPACITOR-FXD .22UF +80-20% 50VDC CER	13606	2C37Z5U224Z050A
A70C901	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	13606	2C37Z5U105M025A
A70CR100	1901-0040	1	11	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A70CR101	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A70CR102	1990-0486	6	5	LED-LAMP LUM-INT=2MCD IF=25MA-MAX BVR=5V	28480	1990-0486

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320 3991

Table 4-36. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A70CR103	1902-0632	9	2	DIODE-ZNR 1N5354B 17V 5% PD=5W TC=+75%	04713	SZP40123
A70CR104	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A70CR105	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A70CR106	1902-0777	3	1	DIODE-ZNR 1N825 6.2V 5% DO-7 PD=.4W	04713	SZ14376RL
A70CR107	1990-0485	5	4	LED-LAMP LUM-INT=2MCD IF=30MA-MAX BVR=5V	28480	1990-0485
A70CR108	1901-0662	3	7	DIODE-PWR RECT 100V 6A	04713	SR2302K
A70CR109	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A70CR200	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A70CR201	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A70CR202	1990-0486	6		LED-LAMP LUM-INT=2MCD IF=25MA-MAX BVR=5V	28480	1990-0486
A70CR203	1902-0632	9		DIODE-ZNR 1N5354B 17V 5% PD=5W TC=+75%	04713	SZP40123
A70CR204	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A70CR205	1990-0485	5		LED-LAMP LUM-INT=2MCD IF=30MA-MAX BVR=5V	28480	1990-0485
A70CR206	1901-0662	3		DIODE-PWR RECT 100V 6A	04713	SR2302K
A70CR300	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A70CR301	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A70CR302	1990-0486	6		LED-LAMP LUM-INT=2MCD IF=25MA-MAX BVR=5V	28480	1990-0486
A70CR303	1902-0940	2	1	DIODE-ZNR 1N5339B 5.6V 5% PD=5W IR=1UA	04713	SZP40149
A70CR304	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A70CR305	1990-0485	5		LED-LAMP LUM-INT=2MCD IF=30MA-MAX BVR=5V	28480	1990-0485
A70CR306	1901-0662	3		DIODE-PWR RECT 100V 6A	04713	SR2302K
A70CR400	1990-0485	5		LED-LAMP LUM-INT=2MCD IF=30MA-MAX BVR=5V	28480	1990-0485
A70CR700-CR703	1901-0662	3		DIODE-PWR RECT 100V 6A	04713	SR2302K
A70CR704-CR711	1901-0029	6	8	DIODE-PWR RECT 600V 750MA DO-29	04713	SR1358-10B
A70CR712	1906-0231	2	1	DIODE-CT-RECT 200V 15A	18546	R772
A70CR800	1884-0231	4	1	THYRISTOR-SCR TO-220AB VRRM=100	3L585	72048
A70CR806	1990-0486	6		LED-LAMP LUM-INT=2MCD IF=25MA-MAX BVR=5V	28480	1990-0486
A70CR807	1990-0486	6		LED-LAMP LUM-INT=2MCD IF=25MA-MAX BVR=5V	28480	1990-0486
A70F501	2110-0297	4	2	FUSE .5A 125V NTD .281X.093	75915	275.500
A70F502	2110-0297	4		FUSE .5A 125V NTD .281X.093	75915	275.500
A70F700	2110-0423	8	1	FUSE 1.5A 125V NTD .281X.093	75915	27501.5
A70J101	1252-0270	2	1	CONNECTOR-POST TYPE, 17 PIN	27264	09-74-1171
A70J105	1251-4670	2	1	CONN-POST TYPE .100-PIN-SPCG 3-CONT	22526	65500-103
A70J105A	1258-0141	8	1	JMPR-REM .025P	22526	65474-004
A70MP1	03326-21101	1	1	HEAT SINK	28480	03326-21101
A70MP2-MP3	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A70MP4-MP7	0340-0580	3	4	INSULATOR-XSTR THRM-CNDCT	55285	7403-09FR-02
A70MP8-MP12	0380-0562	5	5	SPACER-RND .25-IN-LG .14-IN-ID .25-IN-OD	06540	9224-N140
A70MP13-MP15	0403-0285	9	3	BUMPER FOOT-ADH MTG 12.7-MM-WD	76381	SJ-5018 GRAY
A70MP16	0515-0158	2	5	SCREW-MACH M3 X 0.5 20MM-LG	83486	0515-0158
A70MP17	0515-0213	0	10	SCREW-MACH M3 X 0.5 14MM-LG PAN-HD	16941	0515-0213
A70MP18	0515-0407	4	2	SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	16941	0515-0407
A70MP19	0515-0104	8	4	SCREW-MACH M3 X 0.5 8MM-LG PAN-HD	28480	0515-0104
A70MP20	0535-0004	9	13	NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	28480	0535-0004
A70MP21	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116
A70MP22	1480-0116	8		PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116
A70MP23	2190-0644	3	21	WASHER-LK EXT T-B 3.0 MM 3.15-MM-ID	28480	2190-0644
A70MP24	2680-0128	7	4	SCREW-MACH 10-32 .25-IN-LG PAN-HD-POZI	01536	2680-0128
A70MP25	4040-0755	2	2	EXTR-PC BD VIO POLYC .062-IN-BD-THKNS	28480	4040-0755
A70MP26	4040-0755	2		EXTR-PC BD VIO POLYC .062-IN-BD-THKNS	28480	4040-0755
A70MP27	8150-4289	2	2	JMPR 22GA BLK 175MM 8x8	28480	8150-4289
A70MP28	8150-4289	2		JMPR 22GA BLK 175MM 8x8	28480	8150-4289
A70MP29	0890-0768	4	0	TUBING-HS .187-D/.093-RCVD .02-WALL	06090	RNF-100-3/16-BLU
A70MP100	1205-0477	2	1	HEAT SINK SGL TO-3-CS	13103	6060B-2-SM1
A70P1	1251-8410	6	1	CONN-POST TYPE 48-CONT RTANG-DPSLDR	28480	1251-8410
A70Q100	1854-0618	8	2	TRANSISTOR NPN SI DARL TO-3 PD=150W	04713	SJ3237
A70Q101	1854-0094	4	1	TRANSISTOR NPN SI PD=200MW FT=350MHZ	04713	SPS 234
A70Q200	1853-0387	6	1	TRANSISTOR PNP SI DARL TO-3 PD=150W	04713	SJ6891K
A70Q300	1854-0618	8		TRANSISTOR NPN SI DARL TO-3 PD=150W	04713	SJ3237
A70Q401	1853-0479	7	1	TRANSISTOR PNP DARL TO-220AB PD=50W	03508	X45E217
A70Q800	1853-0036	2	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	04713	SPS-3612
A70R10	0683-1005	5	6	RESISTOR 10 5% .25W CF TC=0-400	77902	R-25J
A70R100	0683-4325	8	2	RESISTOR 4.3K 5% .25W CF TC=0-400	77902	R-25J
A70R101	0683-4725	2	11	RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A70R102	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A70R103	0757-0401	0	3	RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A70R104	0811-3290	7	2	RESISTOR .1 5% 2W PW TC=0+-800	75042	BWH

See introduction to this section for ordering information
*Indicates factory selected value

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Table 4-37. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A70R105	0757-0459	8	2	RESISTOR 56.2K 1% .125W F TC=0+-100	19701	5033R
A70R106	0757-0439	4	2	RESISTOR 6.81K 1% .125W F TC=0+-100	19701	5033R
A70R107	0683-2205	9	1	RESISTOR 22 5% .25W CF TC=0-400	77902	R-25J
A70R108	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A70R109	0683-3325	6	1	RESISTOR 3.3K 5% .25W CF TC=0-400	77902	R-25J
A70R110	0683-9115	4	1	RESISTOR 910 5% .25W CF TC=0-400	77902	R-25J
A70R111	0683-5135	0	1	RESISTOR 51K 5% .25W CF TC=0-400	77902	R-25J
A70R112	0683-1525	4	2	RESISTOR 1.5K 5% .25W CF TC=0-400	77902	R-25J
A70R113	0699-0593	7	1	RESISTOR 13.665K .1% .125W F TC=0+-25	19701	5033R
A70R114	2100-3109	2	1	RESISTOR-TRMR 2K 10% C SIDE-ADJ 17-TRN	73138	89PR2K
A70R115	0698-6360	6	3	RESISTOR 10K .1% .125W F TC=0+-25	19701	5033R
A70R116	0683-1005	5		RESISTOR 10 5% .25W CF TC=0-400	77902	R-25J
A70R117	0683-5115	6	1	RESISTOR 510 5% .25W CF TC=0-400	77902	R-25J
A70R118	0683-4735	4	1	RESISTOR 47K 5% .25W CF TC=0-400	77902	R-25J
A70R200-R202	0683-4325	8		RESISTOR 4.3K 5% .25W CF TC=0-400	77902	R-25J
A70R203	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A70R204	0811-3290	7		RESISTOR .1 5% 2W PW TC=0+-800	75042	BWH
A70R205	0757-0459	8		RESISTOR 56.2K 1% .125W F TC=0+-100	19701	5033R
A70R206	0757-0439	4		RESISTOR 6.81K 1% .125W F TC=0+-100	19701	5033R
A70R207	0683-1525	4		RESISTOR 1.5K 5% .25W CF TC=0-400	77902	R-25J
A70R208	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A70R209	0683-1005	5		RESISTOR 10 5% .25W CF TC=0-400	77902	R-25J
A70R210	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	19701	5033R
A70R211	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	19701	5033R
A70R212	0683-1005	5		RESISTOR 10 5% .25W CF TC=0-400	77902	R-25J
A70R300	0683-2225	3	1	RESISTOR 2.2K 5% .25W CF TC=0-400	77902	R-25J
A70R301	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A70R302	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A70R303	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	19701	5033R
A70R304	63312-80001	4	1	R:F .005	28480	63312-80001
A70R305	0757-0465	6	1	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A70R306	0698-4308	8	1	RESISTOR 16.9K 1% .125W F TC=0+-100	19701	5033R
A70R307	0683-6215	9	3	RESISTOR 620 5% .25W CF TC=0-400	77902	R-25J
A70R308	0683-1005	5		RESISTOR 10 5% .25W CF TC=0-400	77902	R-25J
A70R309	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A70R310	0698-6378	6	1	RESISTOR 14.9K .1% .125W F TC=0+-50	91637	CMF-55-1, T-2
A70R311	0698-4472	7	1	RESISTOR 7.68K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A70R321	0683-1005	5		RESISTOR 10 5% .25W CF TC=0-400	77902	R-25J
A70R400	0683-6215	9		RESISTOR 620 5% .25W CF TC=0-400	77902	R-25J
A70R401	0683-6215	9		RESISTOR 620 5% .25W CF TC=0-400	77902	R-25J
A70R402	0683-1025	9	1	RESISTOR 1K 5% .25W CF TC=0-400	77902	R-25J
A70R403	0683-1035	1	2	RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A70R611	0757-0428	1	1	RESISTOR 1.62K 1% .125W F TC=0+-100	19701	5033R
A70R612	0757-0403	2	1	RESISTOR 121 1% .125W F TC=0+-100	19701	5033R
A70R615	0698-4439	6	1	RESISTOR 3.24K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A70R616	0698-3442	9	1	RESISTOR 237 1% .125W F TC=0+-100	19701	5033R
A70R700	0686-2025	7	2	RESISTOR 2K 5% .5W CC TC=0+647	01121	EB2025
A70R701	0686-2025	7		RESISTOR 2K 5% .5W CC TC=0+647	01121	EB2025
A70R702	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A70R703	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A70R704	0683-4725	2		RESISTOR 4.7K 5% .25W CF TC=0-400	77902	R-25J
A70R705	0683-4715	0	1	RESISTOR 470 5% .25W CF TC=0-400	77902	R-25J
A70R800	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A70R801	0757-0442	9	7	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A70R802	0698-4436	3	1	RESISTOR 2.8K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A70R803	0757-0427	0	1	RESISTOR 1.5K 1% .125W F TC=0+-100	19701	5033R
A70R804	0698-4485	2	1	RESISTOR 23.2K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A70R805-R807	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A70R808	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A70R809	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A70R810	0683-1045	3	1	RESISTOR 100K 5% .25W CF TC=0-400	77902	R-25J
A70R811	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A70R813	0683-4315	6	1	RESISTOR 430 5% .25W CF TC=0-400	77902	R-25J
A70R814	0683-1035	1		RESISTOR 10K 5% .25W CF TC=0-400	77902	R-25J
A70SK1-SK5	1200-1158	8	5	8118 PF 303 POWER SOCKET	13103	8118PF303
A70TC1	3103-0020	7	1	SWITCH-THRM FXD +100C 8A OPN-ON-RISE	14604	3450-21-315
A70TP100	1251-0600	0	16	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A70TP102	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320 3991

Table 4-38. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A70TP105	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A70TP200	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A70TP205	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A70TP300	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A70TP305	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A70TP400-TP401	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A70TP402	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A70TP500-TP501	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A70TP600-TP601	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A70TP700	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A70TP900	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A70U100	1826-0243	6	3	IC OP AMP GP DUAL TO-99 PKG	27014	SL29583
A70U200	1826-0243	6		IC OP AMP GP DUAL TO-99 PKG	27014	SL29583
A70U300	1826-0243	6		IC OP AMP GP DUAL TO-99 PKG	27014	SL29583
A70U400	1820-0430	1	2	IC V RGLTR-FXD-POS 4.8/5.2V TO-3 PKG	27014	SL10236
A70U401	1990-0545	8	1	OPTO-ISOLATOR LED-PDIO/XSTR IF=40MA-MAX	28480	1990-0545
A70U601	1826-0527	9	1	IC V RGLTR-ADJ-NEG 1.2/37V TO-220 PKG	27014	SL35761
A70U602	1826-0393	7	1	IC V RGLTR-ADJ-POS 1.2/37V TO-220 PKG	27014	SL33706
A70U801	1826-0138	8	2	IC COMPARATOR GP QUAD 14-DIP-P PKG	27014	SL24958
A70U802	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	27014	SL24958
A70U900	1820-0430	1		IC V RGLTR-FXD-POS 4.8/5.2V TO-3 PKG	27014	SL10236
A72	**03326-66572**	**4**	**1**	**FRONT ESD BOARD**	**28480**	**03326-66572**
A72C1-C2	0160-4300	1	2	CAPACITOR-FXD .047UF +80-20% 100VDC CER	28480	562CZC101AL473ZA26
A72VR1-VR2	0837-0313	3	2	TNR 15G 560 KM	28480	0837-0313
A75	**03326-66575**	**7**	**1**	**REAR ESD BOARD**	**28480**	**03326-66575**
A75C1-C5	0160-4300	1	5	CAPACITOR-FXD .047UF +80-20% 100VDC CER	28480	562CZC101AL473ZA26
A75VR1-VR3	0837-0313	3	3	TNR 15G 560 KM	28480	0837-0313
A80	**03326-66580**			**SEE OPTION 001 PARTS LIST.**		
A99	**03326-66599**	**5**	**1**	**MOTHERBOARD**	**28480**	**03326-66599**
A99C1-C11	0160-3847	9	26	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A99C30-C34	0160-3847	9	26	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A99C40-C45	0160-3847	9	26	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A99C103	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A99C105	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A99C113	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A99C115	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A99J1-J5	1251-6254	2	5	CONNECTOR-SGL CONT RTANG-F	91833	901
A99J80	1251-6429	3	2	CONN-POST TYPE .100-PIN-SPCG 3-CONT	00779	640456-3
A99J202	1251-6429	3		CONN-POST TYPE .100-PIN-SPCG 3-CONT	00779	640456-3
A99L30	9100-3345	5	6	INDUCTOR RF-CH-MLD 2UH 5% .166DX.385LG	06560	15A2ROJ
A99L31	9100-3345	5		INDUCTOR RF-CH-MLD 2UH 5% .166DX.385LG	06560	15A2ROJ
A99L32-L34	9100-1791	1	6	CORE-FERRITE CHOKE-WIDEBAND;IMP:>360	02114	VK200-19/4B
A99L40	9100-3345	5		INDUCTOR RF-CH-MLD 2UH 5% .166DX.385LG	06560	15A2ROJ
A99L41	9100-3345	5		INDUCTOR RF-CH-MLD 2UH 5% .166DX.385LG	06560	15A2ROJ
A99L42-L44	9100-1791	1		CORE-FERRITE CHOKE-WIDEBAND;IMP:>360	02114	VK200-19/4B
A99L105	9100-3345	5		INDUCTOR RF-CH-MLD 2UH 5% .166DX.385LG	06560	15A2ROJ
A99L115	9100-3345	5		INDUCTOR RF-CH-MLD 2UH 5% .166DX.385LG	06560	15A2ROJ
A99MP10-MP11	0403-0285	9	2	BUMPER FOOT-ADH MTG 12.7-MM-WD	76381	SJ-5018 GRAY
A99MP201	0400-0062	4	1	GROMMET-RND .5-IN-ID .625-IN-GRV-OD	51633	8069
A99T45	08552-6044	1	1	TRANS 6 TURNS	28480	08552-6044
A99XA1	1252-0247	3	12	DIN CONN.-16 PIN FEMALE	06383	100-316-433
A99XA2	1252-0238	2	11	DIN CONN.-48 PIN FEMALE	06383	100-348-433
A99XA3	1252-0248	4	7	DIN CONN.-32 PIN FEMALE	06383	100-332-433
A99XA4	1252-0247	3		DIN CONN.-16 PIN FEMALE	06383	100-316-433
A99XA5	1252-0247	3		DIN CONN.-16 PIN FEMALE	06383	100-316-433
A99XA6	1252-0247	3		DIN CONN.-16 PIN FEMALE	06383	100-316-433
A99XA11	1252-0247	3		DIN CONN.-16 PIN FEMALE	06383	100-316-433
A99XA12	1252-0238	2		DIN CONN.-48 PIN FEMALE	06383	100-348-433
A99XA13	1252-0248	4		DIN CONN.-32 PIN FEMALE	06383	100-332-433
A99XA14	1252-0247	3		DIN CONN.-16 PIN FEMALE	06383	100-316-433
A99XA15	1252-0247	3		DIN CONN.-16 PIN FEMALE	06383	100-316-433

See introduction to this section for ordering information
*Indicates factory selected value

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Table 4-39. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A99XA16	1252-0247	3		DIN CONN.-16 PIN FEMALE	06383	100-316-433
A99XA21	1252-0238	2		DIN CONN.-48 PIN FEMALE	06383	100-348-433
A99XA22	1252-0238	2		DIN CONN.-48 PIN FEMALE	06383	100-348-433
A99XA23	1252-0248	4		DIN CONN.-32 PIN FEMALE	06383	100-332-433
A99XA24	1252-0248	4		DIN CONN.-32 PIN FEMALE	06383	100-332-433
A99XA31	1252-0247	3		DIN CONN.-16 PIN FEMALE	06383	100-316-433
A99XA32	1252-0248	4		DIN CONN.-32 PIN FEMALE	06383	100-332-433
A99XA33	1252-0238	2		DIN CONN.-48 PIN FEMALE	06383	100-348-433
A99XA34	1252-0238	2		DIN CONN.-48 PIN FEMALE	06383	100-348-433
A99XA35	1252-0247	3		DIN CONN.-16 PIN FEMALE	06383	100-316-433
A99XA36	1252-0238	2		DIN CONN.-48 PIN FEMALE	06383	100-348-433
A99XA41	1252-0247	3		DIN CONN.-16 PIN FEMALE	06383	100-316-433
A99XA42	1252-0248	4		DIN CONN.-32 PIN FEMALE	06383	100-332-433
A99XA43	1252-0238	2		DIN CONN.-48 PIN FEMALE	06383	100-348-433
A99XA44	1252-0238	2		DIN CONN.-48 PIN FEMALE	06383	100-348-433
A99XA45	1252-0247	3		DIN CONN.-16 PIN FEMALE	06383	100-316-433
A99XA50	1252-0248	4		DIN CONN.-32 PIN FEMALE	06383	100-332-433
A99XA61	1252-0238	2		DIN CONN.-48 PIN FEMALE	06383	100-348-433
A99XA70	1252-0238	2		DIN CONN.-48 PIN FEMALE	06383	100-348-433
				TOP VIEW MECHANICAL PARTS		
MP124	03326-01208	7	1	CLAMP,CAP	28480	03326-01208
MP125	03326-21202	3	2	CAP BOOT	28480	03326-21202
MP126	2190-0879	6	2	WASHER-FL NM NO. 4 .128-IN-ID .245-IN-OD	28480	5610-55-16
MP127	0515-0853	4	2	SCREW-MACH M3 X 0.5 8MM-LG PAN-HD	13764	50M030050N008
MP128	0535-0004	9	2	NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	28480	0535-0004
MP130	03326-01215	6	1	CTLR TIE DOWN	28480	03326-01215
MP131	03326-01216	7	1	PWR SUP TIE DN	28480	03326-01216
MP132	7121-4780	6	1	VOLTAGE CAUTION LBL	28480	7121-4780
MP135	0515-0104	8	115	SCREW-MACH M3 X 0.5 8MM-LG PAN-HD	28480	0515-0104
MP136-MP138	0515-0212	9	7	SCREW-MACH M3.5 X 0.6 6MM-LG PAN-HD	16941	0515-0212
MP139	0515-0642	9	1	SCREW-MACH M3.5 X 0.6 8MM-LG PAN-HD	16941	0515-0642
MP140	0515-0218	5	6	SCREW-MACH M3.5 X 0.6 6MM-LG	16941	0515-0218
MP141	03326-62001	6	1	REAR NEST	28480	03326-62001
MP142	03326-62002	7	3	FORWARD NEST	28480	03326-62002
MP143	03326-01201	0	1	BRACE, FRONT	28480	03326-01201
MP144	03326-01202	1	1	BRACE, REAR	28480	03326-01202
MP145	03326-24103	9	4	PLATE, INSULATOR	28480	03326-24103
MP146	0515-0570	2	12	SCREW-MACH M3 X 0.5 8MM-LG 90-DEG-FLH-HD	28480	0515-0570
MP147	0340-0114	9	16	INSULATOR-FLG-BSHG NYLON	23050	0340-0114
MP148	0515-0224	3	23	SCREW-MACH M3.5 X 0.6 12MM-LG PAN-HD	16941	0515-0224
MP149	03326-01206	5	2	CTLR SUPPORT	28480	03326-01206
MP150	0515-0244	7	4	SCREW-MACH M3 X 0.5 4MM-LG PAN-HD	28480	0515-0244
MP151-MP153	1400-1195	7	4	CLAMP-CABLE .38-DIA 1-WD NYL	06383	ACC38-A
MP154-MP155	2190-0005	0	109	WASHER-LK EXT T NO. 4 .116-IN-ID	28480	2190-0005
MP160	03326-34302	1	1	LABLE, CBL ROUTING	28480	03326-34302
				BOTTOM VIEW MECHANICAL PARTS		
MP203	0515-0239	0	96	SCREW-METRIC SPECIALTY M3 X0.5; 11.0 MM	01536	0515-0239
MP205	0515-0212	9		SCREW-MACH M3.5 X 0.6 6MM-LG PAN-HD	16941	0515-0212
MP206	0515-0218	5		SCREW-MACH M3.5 X 0.6 6MM-LG	16941	0515-0218
MP207	1400-1195	7		CLAMP-CABLE .38-DIA 1-WD NYL	06383	ACC38-A
MP208	2190-0005	0		WASHER-LK EXT T NO. 4 .116-IN-ID	28480	2190-0005
MP209	1400-0908	8	1	CLAMP-CABLE .188-DIA .75-WD PVC	06915	KKC-3
	03326-01217	8	7	BRACKET, GROUND	28480	03326-01217
				SIDE VIEW MECHANICAL PARTS		
MP301	03326-21201	2	2	PWR SUP BD GUIDE	28480	03326-21201
MP302	0515-0414	3	4	SCREW-MACH M4 X 0.7 10MM-LG PAN-HD	16941	0515-0414
MP303-MP304	1400-0611	0	3	CLAMP-FL-CA 1-WD	76381	3484-1000

See introduction to this section for ordering information
*Indicates factory selected value

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Table 4-40. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
				FRAME MECHANICAL PARTS		
MP401	5021-4712	0	1	BEZEL,FRONT FRAME	28480	5021-4712
MP402	5020-8806	9	1	REAR FRAME	28480	5020-8806
MP403	5020-8837	6	4	CORNER STRUT	28480	5020-8837
MP404	5040-7201	8	4	FOOT	28480	5040-7201
MP405	5040-7202	9	1	TRIM TOP	28480	5040-7202
MP406	5040-7219	8	2	STRAP HDL CAP-FR	28480	5040-7219
MP407	5040-7220	1	2	STRAP HDL CAP-R	28480	5040-7220
MP408	5060-9804	3	2	STRAP HDL 18IN	28480	5060-9804
MP409	5060-9835	0	1	TOP COVER	28480	5060-9835
MP410	5060-9847	4	1	BOTTOM COVER	28480	5060-9847
MP411	5060-9942	0	2	SIDE CVR-STDPERF	28480	5060-9942
MP412	2510-0192	6	16	SCREW-MACH 8-32 .25-IN-LG 100 DEG	28480	2510-0192
MP413	2680-0172	1	4	SCREW-MACH 10-32 .375-IN-LG 100 DEG	28480	2680-0172
MP414	5001-0440	1	2	TRIM SIDE	28480	5001-0440
				FRONT PANEL MECHANICAL PARTS		
MP501	03326-00101	7	1	SUBPANEL FRONT	28480	03326-00101
MP502	03326-04301	7	1	FRT DRESS PNL	22670	03326-04301
MP503	03326-29301	9	1	DISPLAY WINDOW	28480	03326-29301
MP505	0535-0006	1	8	NUT-HEX DBL-CHAM M4 X 0.7 3.2MM-THK	28480	0535-0006
MP506	0515-0407	4	11	SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	16941	0515-0407
MP507	2190-0646	5	8	WASHER-LK EXT T-B 4.0 MM 4.15-MM-ID	28480	2190-0646
MP510	2190-0054	9	2	WASHER-LK INTL T 1/2 IN .505-IN-ID	28480	2190-0054
MP511	2950-0035	8	1	NUT-HEX-DBL-CHAM 15/32-32-THD	28480	2950-0035
MP512	2950-0154	2	2	NUT-HEX-DBL-CHAM 1/2-28-THD .078-IN-THK	28480	2950-0154
MP513	3050-0313	8	1	WASHER-FL NM 1/2 IN .5-IN-ID .75-IN-OD	28480	3050-0313
MP514-MP515	5040-7624	9	5	WASHER-SHOULDER	28480	5040-7624
MP520	5061-8008	9	1	CABLE ASSY,RPG	28480	5061-8008
MP521	2190-0016	3	1	WASHER-LK INTL T 3/8 IN .377-IN-ID	28480	2190-0016
MP522	3050-0067	9	5	WASHER-FL MTLC 5/16 IN .375-IN-ID	73734	31-550
MP523	2950-0043	8	1	NUT-HEX-DBL-CHAM 3/8-32-THD .094-IN-THK	28480	2950-0043
MP531	3050-0071	5	2	WASHER-FL MTLC NO. 8 .169-IN-ID	73734	3050-0071
MP532	03326-01220	3	2	TERM-SOLDR LUG-MOD	28480	03326-01220
MP540-MP543	5041-0212	9	4	K/CAP-"BLANK"	28480	5041-0212
MP544-MP547	5041-0310	8	4	KEY BLANK	28480	5041-0310
MP548	5041-0720	4	1	KEY INSTR PRESET	28480	5041-0720
MP549	5041-0944	4	1	KEY CAP PWR	28480	5041-0944
MP550	5041-1870	7	1	KEYCAP-RECALL	28480	5041-1870
MP551	5041-2745	7	1	K/CAP-SHIFT	28480	5041-2745
MP552	5041-2910	8	1	K-CAP -	28480	5041-2910
MP553	5041-2911	9	1	K-CAP .	28480	5041-2911
MP554	5041-2913	1	1	KEY-CAP 1	28480	5041-2913
MP555	5041-2914	2	1	KEY-CAP 2	28480	5041-2914
MP556	5041-2915	3	1	KEY-CAP 3	28480	5041-2915
MP557	5041-2916	4	1	KEY-CAP 4	28480	5041-2916
MP558	5041-2917	5	1	KEY-CAP 5	28480	5041-2917
MP559	5041-2918	6	1	KEY-CAP 6	28480	5041-2918
MP560	5041-2919	7	1	KEY-CAP 7	28480	5041-2919
MP561	5041-2920	0	1	KEY-CAP 8	28480	5041-2920
MP562	5041-2921	1	1	KEY-CAP 9	28480	5041-2921
MP563	5041-2922	2	1	KEY-CAP 0	28480	5041-2922
MP564	5041-4546	0	1	K/CAP - CHAN	28480	5041-4546
MP565	5041-2967	5		K/CAP-"ARROW"	28480	5041-2967
MP566	5041-2976	6	1	K/CAP - AMPTD	28480	5041-2976
MP567	5041-2977	7	1	K/CAP - FREQ	28480	5041-2977
MP568	5041-2978	8	1	K/CAP - PHASE	28480	5041-2978
MP569	5041-2979	9	1	K/CAP - TIME	28480	5041-2979
MP570	5041-2967	5	2	K/CAP-"ARROW"	28480	5041-2967
MP571	5041-2974	4	1	K-CAP SINGLE	28480	5041-2974
MP572	5041-2969	7	1	K/CAP-BACK SP	28480	5041-2969
MP573	5041-2970	0	1	K/CAP-CONT	28480	5041-2970
MP574	5041-2971	1	1	K/CAP-LOCAL	28480	5041-2971
MP575	5041-2972	2	1	K/CAP-MANUAL	28480	5041-2972
MP576	5041-2973	3	1	K/CAP-MODE	28480	5041-2973
MP577	5041-2980	2	1	K/CAP-START FREQ	28480	5041-2980
MP578	5041-2981	3	1	K/CAP-STOP FREQ	28480	5041-2981

See introduction to this section for ordering information
*Indicates factory selected value

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Table 4-41. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
MP579	5041-2982	4	1	K/CAP-ON/OFF	28480	5041-2982
MP580	5041-2983	5	1	K/CAP-SELECT	28480	5041-2983
MP581	5041-2984	6	1	K/CAP-CH A	28480	5041-2984
MP582	5041-2985	7	1	K/CAP-CH B	28480	5041-2985
MP583	5041-2986	8	1	K/CAP-DC OFFSET	28480	5041-2986
MP584	5041-2987	9	1	K/CAP-MKR FREQ	28480	5041-2987
MP585	5041-4536	8	1	K/CAP-SAVE	28480	5041-4536
MP587	0370-3033	0	1	KNOB-BASE 1-1/2 JGK .25-IN-ID	28480	0370-3033
MP588	03326-01203	2	1	WINDOW BRACE FOR DISPLAY	28480	03326-01203
MP589	3050-0032	5	2	FLAT WASHER	28480	3050-0032
				REAR PANEL MECHANICAL PARTS		
K612	0490-1222	9	1	RELAY 1C 6VDC-COIL 2A 115VAC	28480	0490-1222
MP202	03326-24106	2	1	HP-IB CBL SHLD	28480	03326-24106
MP601	03326-00102	8	1	REAR PANEL	28480	03326-00102
MP602	03326-01214	5	1	CAP BRACE	28480	03326-01214
MP603	0360-0005	9	1	TERMINAL-SLDR LUG PL-MTG FOR-#8-SCR	79963	9-.169
MP604	7120-4835	0	1	LABEL-INFORMATION .75-IN-WD 2-IN-LG PPR	35860	7120-4835
MP610	9135-0243	9	1	LINE POWER MODULE	28480	9135-0243
MP611	0515-0426	7	2	SCREW-MACH M3 X 0.5 10MM-LG	16941	0515-0426
MP613	0515-0897	6	2	SCREW-MACH M3 X 0.5 8MM-LG PAN-HD	28480	0515-0897
MP614-MP615	2190-0004	9	9	WASHER-LK INTL T NO. 4 .115-IN-ID	28480	2190-0004
MP616-MP617	0535-0004	9	9	NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	28480	0535-0004
MP626	03326-04151	5	1	LINE POWER MODULE SAFETY SHIELD	28480	03326-04151
MP627	7120-3534	4	1	LABEL-WARNING .6-IN-WD 1.4-IN-LG VINYL	22670	7120-3534
MP628	0515-0104	8	2	SCREW-MACH M3 X 0.5 8MM-LG PAN-HD	28480	0515-0104
MP631	7100-1115	1	1	TRANSFORMER COVER	9F971	C400
MP632	1251-5709	0	1	KEYING PLUG-AMP MTS CONN	00779	640629-1
MP633	1400-0493	6	4	CABLE TIE .062-1.25-DIA .14-WD NYL	59730	TYB-24M-8
MP634	2190-0073	2	6	WASHER-LK HLCL NO. 8 .168-IN-ID	28480	2190-0073
MP635	2510-0138	0	4	SCREW-MACH 8-32 3-IN-LG PAN-HD-POZI	01536	2510-0138
MP636	2580-0004	6	4	NUT-HEX-DBL-CHAM 8-32-THD .125-IN-THK	73734	2580-0004
MP637	3050-0027	1	4	WASHER-FL MTLC NO. 10 .203-IN-ID	78471	3050-0027
MP638	3050-0681	3	4	WASHER-FL NM NO. 8 .172-IN-ID .375-IN-OD	72653	6514
MP640	1250-1558	7	9	ADAPTER-COAX STR F-BNC F-RCA-PHONO	24931	29JJ126-3
MP642	3050-0313	8	4	WASHER-FL NM 1/2 IN .5-IN-ID .75-IN-OD	28480	3050-0313
MP643-MP644	5040-7624	9	16	WASHER-SHOULDER	28480	5040-7624
MP645	0380-0643	3	2	STANDOFF-HEX .255-IN-LG 6-32-THD	14480	0380-0643
MP646	0380-1556	9	1	SPACER-RND .286-IN-LG .17-IN-ID	28480	0380-1556
MP647	2190-0073	2		WASHER-LK HLCL NO. 8 .168-IN-ID	28480	2190-0073
MP648	2950-0035	8	4	NUT-HEX-DBL-CHAM 15/32-32-THD	28480	2950-0035
MP649	6960-0041	1	1	PLUG-HOLE FL-HD FOR .5-D-HOLE NYL	28480	6960-0041
MP650	6960-0095	5	2	PLUG-HOLE DOME-HD FOR .562-D-HOLE NYL	28480	6960-0095
MP652	0515-0407	4	2	SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	16941	0515-0407
MP653	0535-0004	9		NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	28480	0535-0004
MP654	3050-0066	8	13	WASHER-FL MTLC NO. 6 .147-IN-ID	73734	1451
MP660	3160-0394	8	1	FAN-TBAX 106-CFM 115V 50/60-HZ	28480	W2S-107-AA15-13
MP661	T-54962	3	4	M3.5X0.6 20mm MACH SCR	28480	T-54962
MP662	0535-0013	0	4	NUT-THUMB M3.5 X 0.6 5MM-THK 8.6MM-WD	14480	0535-0013
MP663	1400-1100	4	1	MOUNT-CA TIE .375-WD NYL	06383	TM2S6
MP664-MP666	3050-0635	7	7	WASHER-FL MTLC NO. 6 .143-IN-ID	73734	3050-0635
MP667	3150-0218	4	1	FILTER-AIR 32 STD MESH MET sCREEN	28480	3150-0218
MP668-MP669	3160-0092	3	2	FINGER GUARD	28875	055012
MP670-MP673	3050-0635	7		WASHER-FL MTLC NO. 6 .143-IN-ID	73734	3050-0635
MP674	0515-0260	7	4	SCREW-MACH M3.5 X 0.6 16MM-LG PAN-HD	16941	0515-0260
MP675	2190-0007	2	4	WASHER-LK INTL T NO. 6 .141-IN-ID	28480	2190-0007
MP676	0535-0007	2	4	NUT-HEX DBL-CHAM M3.5 X 0.6 2.8MM-THK	28480	0535-0007
T630	9100-4399	1	1	TRANSFORMER	28480	9100-4399
W619	03326-61605	4	1	RELAY JUMPER CABLE	28480	03326-61605
W619	1251-6556	7	1	CONN-POST TYPE .100-PIN-SPCG 3-CONT	00779	640440-3
W620	8150-4270	1	1	JMPR 22GA BLK 50MM 8x8	28480	8150-4270
W621	8150-4279	0	3	JMPR 22GA BLK 100MM 8x8	28480	8150-4279
W622	8150-4279	0		JMPR 22GA BLK 100MM 8x8	28480	8150-4279
W623	8150-4279	0		JMPR 22GA BLK 100MM 8x8	28480	8150-4279
W624	8150-4289	2	1	JMPR 22GA BLK 175MM 8x8	28480	8150-4289
W625	8150-4556	6	1	JMPR 18GA GRNYEL 100MM 8x8	28480	8150-4556
	03326-34304	3	1	LABEL, FUSE	28480	03326-34304

See introduction to this section for ordering information
*Indicates factory selected value

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Table 4-42. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
				CABLES		
W101	03326-61619	0	1	SMB/BNC CH A CBL ASSY VIOLET	28480	03326-61619
W102	03326-61620	3	1	SMB/BNC CH B CBL ASSY VIOLET	28480	03326-61620
W105	03326-61608	7	1	CBL, A INT CAL	28480	03326-61608
W106	03326-61609	8	1	CBL, B INT CAL	28480	03326-61609
W107	03326-61610	1	1	CBL, B COMBINE	28480	03326-61610
W108	03326-61611	2	1	CBL, A LO 2	28480	03326-61611
W109	03326-61612	3	1	CBL, B LO 2	28480	03326-61612
W110	03326-61613	4	1	CBL, A EXT 0 CAL	28480	03326-61613
W111	03326-61614	5	1	CBL, B EXT 0 CAL	28480	03326-61614
W112	03326-61615	6	1	CBL, SYNC	28480	03326-61615
W113	03326-61616	7	1	CBL, 1,2,5,10 MHZ IN	28480	03326-61616
W114	03326-61617	8	1	CBL, 10 MHZ OUT	28480	03326-61617
W115	03585-61603	5	2	CABLE ASSY ORNG	28480	03585-61603
W116	03585-61603	5		CABLE ASSY ORNG	28480	03585-61603
W117	8120-2587	6	4	CABLE ASSY-COAX 50-OHM 1.5KV 8.5-IN-LG	82389	4C5255A
W118	03585-61604	6	4	CABLE ASSY YEL	28480	03585-61604
W119	03585-61604	6		CABLE ASSY YEL	28480	03585-61604
W120	03585-61604	6		CABLE ASSY YEL	28480	03585-61604
W121	03585-61604	6		CABLE ASSY YEL	28480	03585-61604
W122	8120-2844	8	3	CABLE-COAXIAL RG174/U; L 4.0 IN	82389	EX-9203
W123	8120-2844	8		CABLE-COAXIAL RG174/U; L 4.0 IN	82389	EX-9203
W124	8120-2844	8		CABLE-COAXIAL RG174/U; L 4.0 IN	82389	EX-9203
W133	03326-61602	1	1	16 PIN CABLE	28480	03326-61602

PART NUMBER 9320 3991

See introduction to this section for ordering information
*Indicates factory selected value

Table 4-43. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
				OPTION 001 **HIGH STABILITY FREQUENCY REFERENCE** **FIELD INSTALLABLE KIT** **HP PART NUMBER 03326-88801**		
A80	03326-66580	4	1	**OVEN REFERENCE BOARD**	28480	03326-66580
A80C100	0180-2205	3	1	CAPACITOR-FXD .33UF+-10% 35VDC TA	13606	150D334X9035A2-DYS
A80C101	0160-4571	8	1	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A80C102	0160-4834	6	2	CAPACITOR-FXD .047UF +-10% 100VDC CER	27167	CAC04X7R473K100A
A80C103-C104	0160-4846	0	2	CAPACITOR-FXD 1500PF +-5% 100VDC CER	27167	CAC04COG152J100A
A80C105	0160-4834	6		CAPACITOR-FXD .047UF +-10% 100VDC CER	27167	CAC04X7R473K100A
A80C106	0180-0374	3	1	CAPACITOR-FXD 10UF+-10% 20VDC TA	13606	150D106X9020B2-DYS
A80C107-C108	0160-3847	9	2	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A80CR100	1902-0958	2	1	DIODE-ZNR 10V 5% DO-35 PD=.4W TC=+.075%	04713	SZ30035-016
A80J100	1251-6254	2	1	CONNECTOR-SGL CONT RTANG-F	91833	901
A80J101	1251-5750	1	1	CONN-POST TYPE .100-PIN-SPCG 2-CONT	00779	640098-2
A80L100	9100-2486	3	1	INDUCTOR RF-CH-MLD 330NH 5% .166DX.385LG	24226	15M330J
A80MP100	0340-0564	3	1	INSULATOR-XSTR THRM-CNDCT	55285	7403-09FR-51
A80MP101	1205-0298	5	1	HEAT SINK PLSTC-PWR-CS	13103	6030D
A80MP170	03326-01209	8	1	BRACE,OVEN	28480	03326-01209
A80MP872	0515-0886	3	2	SCREW-MACH M3 X 0.5 6MM-LG PAN-HD	28480	0515-0886
A80MP873	0515-0104	8	1	SCREW-MACH M3 X 0.5 8MM-LG PAN-HD	28480	0515-0104
A80MP874	0535-0004	9	1	NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	28480	0535-0004
A80MP875	0590-1445	0	2	THD INSR-NUT	46384	KF2-M3-ET
A80MP876	2200-0103	2	3	SCREW-MACH 4-40 .25-IN-LG PAN-HD-POZI	77250	2200-0103
A80MP877	3050-0440	2	1	WASHER-SHLDR NO. 4 .115-IN-ID .2-IN-OD	28480	5607-45
A80MP883	3050-0716	5	3	WASHER-FL MTLC NO. 5 .128-IN-ID	70318	NAS620-C5
A80Q100	1853-0020	4	1	TRANSISTOR PNP SI PD=300MW FT=150MHZ	04713	SPS 3609
A80R100	0757-0442	9	1	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A80R101	2100-3252	6	1	RESISTOR-TRMR 5K 10% C TOP-ADJ 1-TRN	73138	72PR5K-107B
A80R102	0683-2225	3	1	RESISTOR 2.2K 5% .25W CF TC=0-400	77902	R-25J
A80R103	0683-4705	8	2	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A80R104	0687-6811	9	1	RESISTOR 680 10% .5W CC TC=0+529	01121	EB6811
A80R105	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A80R106	0698-7221	0	1	RESISTOR 237 1% .05W F TC=0+-100	24546	C-3, T-0
A80R107	0698-0085	0	1	RESISTOR 2.61K 1% .125W F TC=0+-100	19701	5033R
A80T100	08552-6044	1	1	TRANS 6 TURNS	28480	08552-6044
A80TP0-TP2	1251-0600	0	3	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A80U100	1826-0393	7	1	IC V RGLTR-ADJ-POS 1.2/37V TO-220 PKG	27014	SL33706
A80U101	0960-0465	7	1	OSC HIGH STABY	12020	OSC 73-52
A80W871	03326-61604	3	1	OVEN JMPR CBL	28480	03326-61604
MP878	1250-1499	5	1	ADAPTER-COAX RTANG M-BNC F-BNC	98291	1250-1499
MP880	1400-0493	6	1	CABLE TIE .062-1.25-DIA .14-WD NYL	59730	TYB-24M-8
MP881	7120-8377	3	1	OPTION 001 DECAL	91345	7120-8377
MP882	8120-2587	6	1	CABLE ASSY-COAX 50-OHM 1.5KV 8.5-IN-LG	82389	4C5255A
W879	1250-1558	7	1	ADAPTER-COAX STR F-BNC F-RCA-PHONO	24931	29JJ126-3
	0515-0886	3	4	SCREW-MACH M3 X 0.5 6MM-LG PAN-HD	28480	0515-0886
	03326-90020	8	1	INSTALLATION NOTE	28480	03326-90020
				OPTION 002 **HIGH VOLTAGE OUTPUT** **FIELD INSTALLABLE KIT** **HP PART NUMBER 03326-88802**		
A1	03326-66501	9	2	**HV AMPLIFIER BOARDS**	28480	03326-66501
A1C101	0160-0128	3	1	CAPACITOR-FXD 2.2UF +-20% 50VDC CER	13606	3C37Z5U225M050A
A1C102-C103	0160-4571	8	10	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A1C104	0180-0291	3	6	CAPACITOR-FXD 1UF+-10% 35VDC TA	13606	150D105X9035A2-DYS
A1C105	0160-3847	9	11	CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A1C106	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	13606	150D105X9035A2-DYS
A1C107	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A1C108	0160-4834	6	1	CAPACITOR-FXD .047UF +-10% 100VDC CER	27167	CAC04X7R473K100A
A1C109	0160-4793	6	1	CAPACITOR-FXD 6.8PF +-.5PF 100VDC CER	27167	CAC02COG6R8D100A
A1C110	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A1C112	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A1C113	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A1C114	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA

See introduction to this section for ordering information
*Indicates factory selected value

Table 4-44. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1C116	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	13606	150D105X9035A2-DYS
A1C117	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A1C118	0160-4793	6	1	CAPACITOR-FXD 6.8PF +-.5PF 100VDC CER	27167	CAC02COG6R8D100A
A1C119	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A1C120	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A1C121	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A1C123	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	13606	150D105X9035A2-DYS
A1C124	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A1C125	0160-5267	1	2	CAPACITOR-FXD 4700PF +-5% 50VDC CER	27167	CAC04COG472J050A
A1C126	0160-5409	3		CAPACITOR-FXD 3000PF +-5% 50VDC CER	27167	CAC04COG302J050A
A1C127	0160-5267	1		CAPACITOR-FXD 4700PF +-5% 50VDC CER	27167	CAC04COG472J050A
A1C128	0160-5409	3	2	CAPACITOR-FXD 3000PF +-5% 50VDC CER	27167	CAC04COG302J050A
A1C129	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A1C130-C131	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A1C132-C133	0180-0100	3		CAPACITOR-FXD 4.7UF+-10% 35VDC TA	13606	150D475X9035B2-DYS
A1C134-C137	0160-3847	9		CAPACITOR-FXD .01UF +100-0% 50VDC CER	04222	MA105C103PAA
A1C138-C139	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	13606	150D105X9035A2-DYS
A1C140	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
A1C141-C142	0160-4808	4	2	CAPACITOR-FXD 470PF +-5% 100VDC CER	27167	CAC02COG471J100A
A1C143-C144	0180-0374	3	2	CAPACITOR-FXD 10UF+-10% 20VDC TA	13606	150D106X9020B2-DYS
A1C145	0160-4801	7	2	CAPACITOR-FXD 100PF +-5% 100VDC CER	27167	CAC02COG101J100A
A1C146-C147	0180-0100	3	4	CAPACITOR-FXD 4.7UF+-10% 35VDC TA	13606	150D475X9035B2-DYS
A1C148	0160-4801	7		CAPACITOR-FXD 100PF +-5% 100VDC CER	27167	CAC02COG101J100A
A1C149	0121-0451	3	1	CAPACITOR-V TRMR-AIR 1.7-11PF 175V	74970	187-0106-028
A1CR101-CR102	1902-0958	2	2	DIODE-ZNR 10V 5% DO-35 PD=.4W TC=+.075%	04713	SZ30035-016
A1CR103-CR106	1901-0040	1	5	DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A1CR111	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	07263	FDH1088
A1CR114-CR115	1902-0557	7	2	DIODE-ZNR 24V 5% PD=1W IR=5UA	04713	SZ40145-022
A1CR116-CR117	1902-0176	6	2	DIODE-ZNR 47V 5% PD=1W IR=5UA	04713	SZ40145-029
A1K101	0490-1405	0	1	RELAY 2C 12VDC-COIL 2A 250VAC	28480	DS2E-S-DC12V-H69
A1L101-L102	9100-3560	6	4	INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A1L103	9140-0639	8	1	INDUCTOR RF-CH-MLD 100UH 10% .172DX.5LG	91637	IMS-5-01
A1L104-L105	9100-3560	6		INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	24226	15M561J
A1L106	9100-3551	5	1	INDUCTOR RF-CH-MLD 1UH 5% .166DX.385LG	24226	15M101J
A1L107	9140-0398	6	2	INDUCTOR RF-CH-MLD 12UH 5% .166DX.385LG	06560	4445-3J
A1L108	9140-0118	8	1	INDUCTOR RF-CH-MLD 500UH 5% .2DX.45LG	04072	9220-14
A1L109	9140-0398	6		INDUCTOR RF-CH-MLD 12UH 5% .166DX.385LG	06560	4445-3J
A1L110	9140-0118	8	1	INDUCTOR RF-CH-MLD 500UH 5% .2DX.45LG	04072	9220-14
A1MP1	03326-04101	5	1	CVR, HV AMP	28480	03326-04101
A1MP2-MP3	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	01536	0624-0333
A1MP4-MP5	2360-0113	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	01536	2360-0113
A1MP6-MP9	2200-0770	9	4	SCREW-MACH 4-40 .188-IN-LG 100 DEG	77250	2200-0770
A1MP10	0515-0104	8	2	SCREW-MACH M3 X 0.5 8MM-LG PAN-HD	28480	0515-0104
A1MP11	0535-0004	9	2	NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	28480	0535-0004
A1MP101	1205-0235	0	4	HEAT SINK SGL TO-18-CS	13103	2224-B
A1MP102	1205-0235	0		HEAT SINK SGL TO-18-CS	13103	2224-B
A1MP103	1205-0095	0	2	HEAT SINK SGL TO-5/TO-39-CS	13103	2225B
A1MP103A	1200-0185	9	6	INSULATOR-XSTR NYLON	13103	7717-86N RED
A1MP104	1205-0095	0		HEAT SINK SGL TO-5/TO-39-CS	13103	2225B
A1MP104A	1200-0185	9		INSULATOR-XSTR NYLON	13103	7717-86N RED
A1MP105	1205-0235	0		HEAT SINK SGL TO-18-CS	13103	2224-B
A1MP106	1205-0235	0		HEAT SINK SGL TO-18-CS	13103	2224-B
A1MP107	1205-0250	9	4	THERMAL LINK SGL TO-5/TO-39-CS	05820	2604 TH 5E
A1MP107A	1200-0185	9		INSULATOR-XSTR NYLON	13103	7717-86N RED
A1MP108	1205-0250	9		THERMAL LINK SGL TO-5/TO-39-CS	05820	2604 TH 5E
A1MP108A	1200-0185	9		INSULATOR-XSTR NYLON	13103	7717-86N RED
A1MP109	1205-0250	9		THERMAL LINK SGL TO-5/TO-39-CS	05820	2604 TH 5E
A1MP109A	1200-0185	9		INSULATOR-XSTR NYLON	13103	7717-86N RED
A1MP110	1205-0250	9		THERMAL LINK SGL TO-5/TO-39-CS	05820	2604 TH 5E
A1MP110A	1200-0185	9		INSULATOR-XSTR NYLON	13103	7717-86N RED
A1MP146A-MP146B	4330-0952	6	4	INSULATOR-BEAD CERAMIC	25706	10-215A
A1MP153A-MP153B	4330-0952	6		INSULATOR-BEAD CERAMIC	25706	10-215A
A1P1	1252-0266	6	1	DIN CONN.-16 PIN MALE	06383	100-316-033
A1Q101	1854-0795	2	1	TRANSISTOR NPN SI TO-92 PD=625MW	04713	SPS8028
A1Q102	1853-0448	0	1	TRANSISTOR PNP SI TO-92 PD=625MW	04713	SPS7848
A1Q103	1854-0263	9	3	TRANSISTOR NPN 2N3019 SI TO-39 PD=800MW	04713	ST1481
A1Q104	1853-0037	3		TRANSISTOR PNP SI TO-39 PD=1W FT=100MHZ	04713	SS 2109
A1Q105	1854-0474	4	1	TRANSISTOR NPN SI PD=310MW FT=100MHZ	04713	SPS1172

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320 3991

Table 4-45. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1Q106	1853-0264	8	1	TRANSISTOR PNP SI PD=310MW FT=100MHZ	04713	SPS6793
A1Q107	1854-0263	9		TRANSISTOR NPN 2N3019 SI TO-39 PD=800MW	04713	ST1481
A1Q108	1853-0037	3	3	TRANSISTOR PNP SI TO-39 PD=1W FT=100MHZ	04713	SS 2109
A1Q109	1854-0263	9		TRANSISTOR NPN 2N3019 SI TO-39 PD=800MW	04713	ST1481
A1Q110	1853-0037	3		TRANSISTOR PNP SI TO-39 PD=1W FT=100MHZ	04713	SS 2109
A1R101	0698-4613	8	1	RESISTOR 953 1% .25W F TC=0+-100	91637	CMF-60-1, T-1
A1R102	0698-6598	2	1	RESISTOR 499 .1% .25W F TC=0+-50	19701	5043R
A1R103	0757-0465	6	4	RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A1R104	0757-0429	2	2	RESISTOR 1.82K 1% .125W F TC=0+-100	19701	5033R
A1R105	0757-0449	6	6	RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A1R106	0698-7332	4	2	RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A1R107	0683-4705	8	8	RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A1R108	0757-0449	6		RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A1R109	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	19701	5033R
A1R110	0757-0422	5	1	RESISTOR 909 1% .125W F TC=0+-100	19701	5033R
A1R111	0698-3442	9	1	RESISTOR 237 1% .125W F TC=0+-100	19701	5033R
A1R112	0698-4475	0	1	RESISTOR 9.76K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A1R113	0757-0277	8	1	RESISTOR 49.9 1% .125W F TC=0+-100	19701	5033R
A1R114	0698-3342	8	1	RESISTOR 2K .25% .5W F TC=0+-100	19701	5053R
A1R115	0757-0449	6		RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A1R116	0698-7332	4		RESISTOR 1M 1% .125W F TC=0+-100	19701	5033R
A1R117	0757-0449	6		RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A1R118	0757-0429	2		RESISTOR 1.82K 1% .125W F TC=0+-100	19701	5033R
A1R119	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A1R120	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A1R121	0757-0400	9		RESISTOR 90.9 1% .125W F TC=0+-100	19701	5033R
A1R122-R125	0757-0403	2	4	RESISTOR 121 1% .125W F TC=0+-100	19701	5033R
A1R126	0757-0400	9	2	RESISTOR 90.9 1% .125W F TC=0+-100	19701	5033R
A1R127	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A1R128	0757-0199	3	2	RESISTOR 21.5K 1% .125W F TC=0+-100	19701	5033R
A1R129	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A1R130	0757-0442	9	3	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A1R131	0757-0449	6		RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A1R132	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A1R133	0757-0294	9	1	RESISTOR 17.8 1% .125W F TC=0+-100	19701	5033R
A1R134	0757-0199	3		RESISTOR 21.5K 1% .125W F TC=0+-100	19701	5033R
A1R135	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A1R136	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A1R137	0698-3572	6	2	RESISTOR 60.4K 1% .125W F TC=0+-100	19701	5033R
A1R138	0757-0472	5	2	RESISTOR 200K 1% .125W F TC=0+-100	19701	5033R
A1R139	0757-0449	6		RESISTOR 20K 1% .125W F TC=0+-100	19701	5033R
A1R140	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A1R141	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A1R142	0757-0407	6	1	RESISTOR 200 1% .125W F TC=0+-100	19701	5033R
A1R143	0683-4705	8		RESISTOR 47 5% .25W CF TC=0-400	77902	R-25J
A1R144	0698-3572	6		RESISTOR 60.4K 1% .125W F TC=0+-100	19701	5033R
A1R145	0757-0472	5		RESISTOR 200K 1% .125W F TC=0+-100	19701	5033R
A1R146	0686-4705	4	2	RESISTOR 47 5% .5W CC TC=0+412	01121	EB4705
A1R147	0757-0735	3	1	RESISTOR 1.3K 1% .25W F TC=0+-100	19701	5043R
A1R148	0757-0338	2	2	RESISTOR 1K 1% .25W F TC=0+-100	19701	5043R
A1R149	0757-0384	8	4	RESISTOR 20 1% .125W F TC=0+-100	19701	5033R
A1R150	0757-0346	2	1	RESISTOR 10 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A1R151	0757-0384	8		RESISTOR 20 1% .125W F TC=0+-100	19701	5033R
A1R152	0757-0735	3	1	RESISTOR 1.3K 1% .25W F TC=0+-100	19701	5043R
A1R153	0686-4705	4		RESISTOR 47 5% .5W CC TC=0+412	01121	EB4705
A1R154	0757-0338	2		RESISTOR 1K 1% .25W F TC=0+-100	19701	5043R
A1R155	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	19701	5033R
A1R156	0698-4492	1	2	RESISTOR 32.4K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A1R157	0757-0283	6	1	RESISTOR 2K 1% .125W F TC=0+-100	19701	5033R
A1R158	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R
A1R159	0698-4492	1		RESISTOR 32.4K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A1R160	0698-3158	4	1	RESISTOR 23.7K 1% .125W F TC=0+-100	19701	5033R
A1R161	0698-4308	8	1	RESISTOR 16.9K 1% .125W F TC=0+-100	19701	5033R
A1R162	0698-4482	9	2	RESISTOR 17.4K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A1R163	0683-1815	5	1	RESISTOR 180 5% .25W CF TC=0-400	77902	R-25J
A1R164	0698-4482	9		RESISTOR 17.4K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
A1R165	0683-1015	7	1	RESISTOR 100 5% .25W CF TC=0-400	77902	R-25J
A1R166-R167	0757-0384	8		RESISTOR 20 1% .125W F TC=0+-100	19701	5033R

See introduction to this section for ordering information
*Indicates factory selected value

Table 4-46. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1R168-R169	0757-0405	4	2	RESISTOR 162 1% .125W F TC=0+-100	19701	5033R
A1TP1-TP14	1251-0600	0	14	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
A1U101	1826-0139	9	1	IC OP AMP GP DUAL 8-DIP-P PKG	04713	SC25137P1
A1U102	1826-0715	7	1	IC OP AMP LOW-NOISE 8-DIP-P PKG	18324	CC3802
A1U103-U104	1826-0493	8	2	IC OP AMP LOW-BIAS-H-IMPD 8-DIP-P PKG	27014	SL35068
A1U105	1826-0138	8	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	27014	SL24958
A1U106	1826-0147	9	1	IC V RGLTR-FXD-POS 11.5/12.5V TO-220 PKG	04713	SC25174P
A1U107	1826-0221	0	1	IC V RGLTR-FXD-NEG 11.5/12.5V TO-220 PKG	04713	SC25266PK
MP11	03326-34303	2	1	HV CH A & B LABLES FOR THE FRONT PANEL	22670	03326-34303
MP12	0515-0104	8	6	SCREW-MACH M3 X 0.5 8MM-LG PAN-HD	28480	0515-0104
	7120-8376	2	1	OPTION 002 DECAL	91345	9211-0046
	03326-90020	8	1	INSTALLATION NOTE	28480	03326-90020
				OPTION 003 REAR PANEL OUTPUTS FIELD INSTALLABLE KIT HP PART NUMBER 03326-88803		
MP960	03326-01220	3	2	TERM-SOLDR LUG-MOD	28480	03326-01220
MP961	6960-0095	5	2	PLUG-HOLE DOME-HD FOR .562-D-HOLE NYL	28480	6960-0095
MP962	7120-8375	1	1	OPTION 003 DECAL	91345	7120-8375
MP963-MP966	5040-7624	9	4	WASHER-SHOULDER	28480	5040-7624
	03326-90020	8	1	INSTALLATION NOTE	28480	03326-90020
				HP 3326A SERVICE ACCESSORY KIT HP PART NUMBER 03326-84401		
	03326-66591	7	2	PC BOARD EXTENDERS	28480	03326-66591
	03326-61618	9	1	PHONO PLUG TO BNC ADAPTER CABLE	28480	03326-61618
	03585-61616	0	1	SMB TO BNC ADAPTER CABLE	28480	03326-61616
	03585-61601	3	4	SMB TO SMB CABLE	28480	03585-61601
	8120-4492	6	4	12 IN. PRECISION LENGTH PHONO CABLE	82389	8120-4492
	1250-1961	6	4	PHONO JACK TO PHONO JACK ADAPTER	82389	349A
	1250-0669	9	2	SMB TO SMB ADAPTER	98291	51-072-0000
	03326-90001	5	1	SERVICE KIT OPERATING NOTE	28480	03326-90001
				LOW PASS FILTER COMPONENTS		
	0698-8827	4	1	R-F 1M .01 1/8W	19701	5033R
	0160-4571	8	1	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	MA205E104ZAA
				1 KOHM/50 OHM MATCHING PAD AND LOAD		
	0140-0220	4	1	CAPACITOR-FXD 200PF +-1% 300VDC MICA	09023	0140-0220
	0698-3341	7	2	RESISTOR 1.91K 1% .5W F TC=0+-100	28480	0698-3341
	0698-6060	3	1	RESISTOR 52.68 .1% .5W F TC=0+-50	28480	0698-6060
				1 KOHM LOAD VOLTAGE DIVIDER COMPONENTS		
	0698-6060	3	1	RESISTOR 52.68 .1% .5W F TC=0+-50	28480	0698-6060
	0698-8226	7	2	RESISTOR 2K .1% .5W F TC=0+-50	28480	0698-8226
	0698-8167	5	1	RESISTOR 18K .1% .125W F TC=0+-25	28480	0698-8167
				15 KHZ EQUIVALENT NOISE FILTER COMPONENTS		
	0160-2223	3	1	CAPACITOR-FXD 1600PF +-5% 300VDC MICA	00853	0160-2223
	0757-0442	9	1	RESISTOR 10K 1% .125W F TC=0+-100	19701	5033R

See introduction to this section for ordering information
*Indicates factory selected value

PART NUMBER 9320 3991

4-3 ORDERING INFORMATION

Ordering Listed Parts

To order a part listed in the replaceable parts table, quote the Hewlett-Packard part number (with the check digit (CD)), indicate the quantity required, and address the order to the nearest Hewlett-Packard office (see sales and support offices listing at the back of this manual). The check digit will ensure accurate and timely processing of your order.

Ordering Non-listed Parts

To order a part that is NOT listed in the replaceable parts table, include the instrument model number, instrument serial number, description and function of the part, and the number of parts required. Address the order to the nearest Hewlett-Packard office (see sales and support offices listing at the back of this manual).

Direct Mail Order System

Within the U.S.A., Hewlett-Packard can supply parts through a direct mail order system. Advantages of using this system are:

- Direct ordering and shipment from the HP Parts Center in Mountain View, California.
- No maximum or minimum on any mail order. There is a minimum order for parts ordered through a local HP sales and service office when the orders require billing and invoicing.
- Transportation charges are prepaid. A small handling charge is added to each order.
- No invoicing. A check or money order must accompany each order.

Mail order forms and specific ordering information are available through your local Hewlett-Packard sales and service office. Addresses and phone numbers are located at the back of this manual.

Special Handling

The HP 3326A contains many static sensitive components. Use the appropriate precautions when removing, handling and installing all parts to avoid unnecessary damage.

SECTION V
BACKDATING

SECTION V
BACKDATING

Sub-Section	Title	Page
5-1	Introduction	5-1
5-2	Manual Changes Supplement	5-1

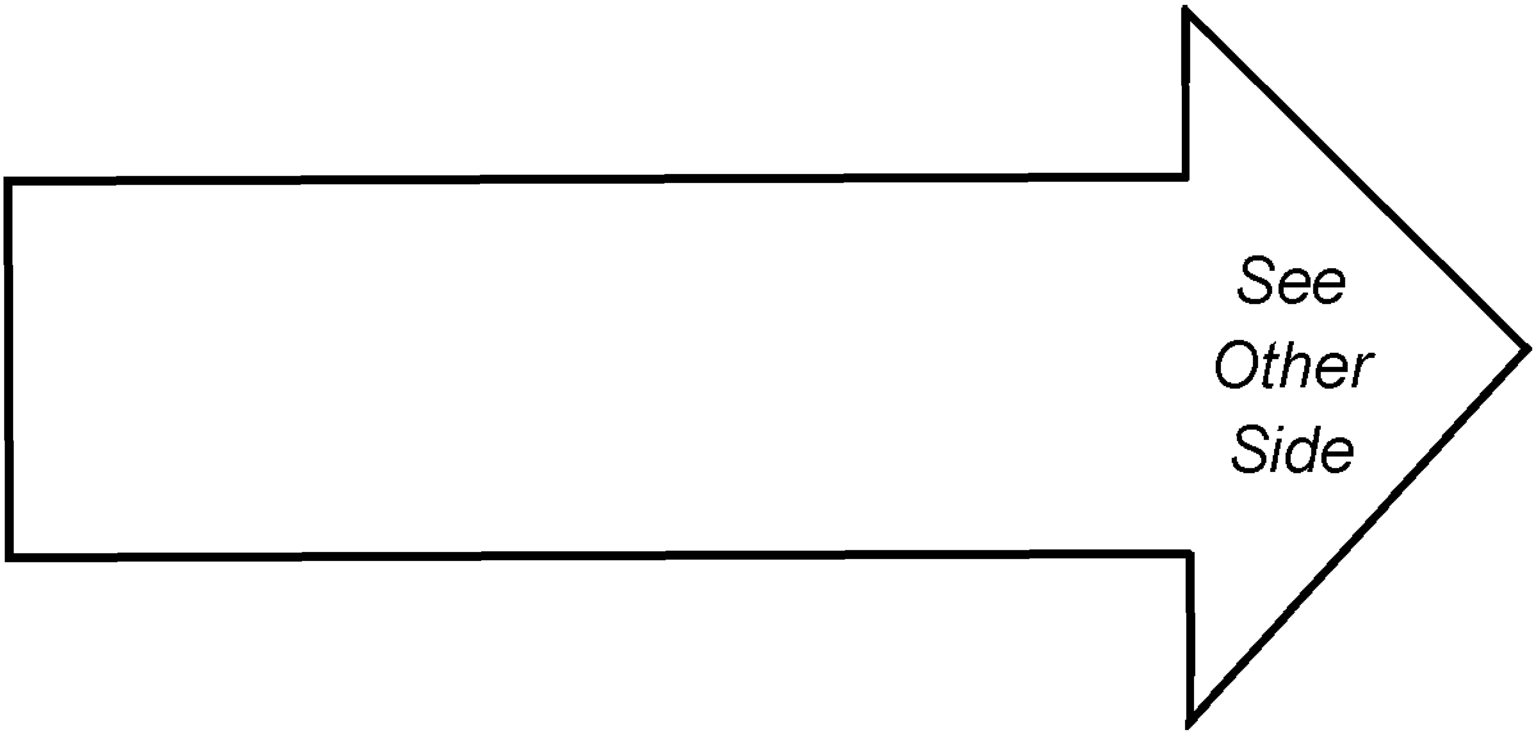
SECTION V
BACKDATING

5-1 INTRODUCTION

The revision of this manual applies directly to all instruments. Earlier versions of this instrument, however, differ in design and appearance from those currently being produced. The information in this section documents the earlier instrument configurations and associated servicing procedures. Also included is information on recommended modifications for improvements to earlier instruments.

5-2 MANUAL CHANGES SUPPLEMENT

As Hewlett-Packard continues to improve the performance of the HP 3326A, corrections and modifications to the manual may be required. Required changes are documented by a yellow Manual Changes supplement and/or revised pages. To keep the manual up-to-date, periodically request the most recent supplement, available from the nearest Hewlett-Packard office (see sales and support offices listing at the back of this manual).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SECTION VI
SERVICE — FAULT ISOLATION

SECTION VI
SERVICE

Fault Isolation to the Board Level

Sub-Section	Title	Page
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SECTION VI
SERVICE

FAULT ISOLATION TO THE BOARD LEVEL

6-1 INTRODUCTION

Each board in the HP 3326A serves a single electrical function and is referred to as a functional block. Component groups within each functional block are referred to as functional sub-blocks. The fault isolation procedures help isolate a defective functional block. The sample waveforms, sample voltages, and troubleshooting procedures provided in the board level repair sub-sections help isolate a defective functional sub-block.

Read sub-section 6-3, "Getting Started," before beginning any troubleshooting. It provides you with a fault isolation flow chart (Figure 6-1) and troubleshooting techniques for turn-on failures (Figure 6-2). After the instrument is running, start the service self tests (sub-section 6-8) and find a group of suspect boards. Perform the fault isolation tests (sub-section 6-13) to isolate the defective board within that group. See Table 6-1.

The other sub-sections provide additional reference material. They are not explicitly written into the fault isolation flow chart (Figure 6-1).

Table 6-1. Section Organization

MAIN FAULT ISOLATION METHOD	
SUB-SECTION	**PURPOSE**
6-3 Getting Started	Figure 6-1 outlines the recommended way to find a defective board. Figure 6-2 shows the trouble-shooting technique to use when there is a turn-on failure and the service self tests can not run.
6-8 Self Test Error Codes	Table 6-9 correlates service self test failures to the boards in the HP 3326A. Use it to find a group of suspect boards.
6-12 Instrument Turn-on Hierarchy	Figure 6-10 shows the interaction of the boards in the HP 3326A, following the main signal flow through the instrument. This hierarchical flow starts with the power supply, since it must function before any other boards can be tested.
6-13 Fault Isolation Tests	Table 6-14 provides a step-by-step procedure to test the printed circuit boards to verify they are working properly. Use it to isolate a defective board from the group of suspect boards found using the service self tests.

NOTE

Tabs are provided at the beginning of the "Self Test Error Codes" and "Instrument Turn-on Hierarchy" sub-sections for your convenience. (Note that the "Fault Isolation Tests" sub-section is located immediately after the "Instrument Turn-on Hierarchy" sub-section.)

Table 6-1. Section Organization Cont.

MECHANICAL ADVANTAGES	
SUB-SECTION	**PURPOSE**
6-4 Identical Boards	Table 6-3 lists the boards that are used in both the A and B channels. These boards may be interchanged between channels for troubleshooting. This is particularly useful for isolating subtle performance problems.
6-5 Waveform Comparison	Put identical circuit boards from the two channels on extenders and compare their waveforms to isolate defective components quickly.
ADDITIONAL REFERENCE MATERIAL	
SUB-SECTION	**PURPOSE**
6-6 Hidden Front Panel Commands	Describes the hidden commands available in the HP 3326A. Use these commands commands are given in internal software corrections temporarily or to view the positive and negative peaks of a reference signal.
6-7 Overall Theory of Operation	Provides a system view of the HP 3326A. Describes each of the modes and features of the instrument. Describes the function of each board following the main signal flow through the instrument. Use to learn the system interactions.
6-11 Service Self Tests	Describes the internal service self tests in detail. Use to clarify results of the self tests.

6-2 SAFETY CONSIDERATIONS

The fault isolation procedures require access to the interior of the HP 3326A while power is supplied to the instrument. Exercise extreme care when performing these procedures.

WARNING

Maintenance described herein is performed with power supplied to the instrument and protective covers removed. Such maintenance should be performed by trained service personnel who are aware of the hazards involved (for example, fire and electrical shock). Primary power is supplied to the instrument whenever the line cord is attached, independent of the power switch position. Where maintenance can be performed without power applied, remove the power cord.

6-3 GETTING STARTED

Fault isolation to the board has been broken into several pieces (Figure 6-1). First, try to run the service self tests. If they can run, use Table 6-9, Service Self Tests Error Codes, to determine the suspect boards, based on the failure codes that appear on the display during the self tests. After you find them, use the fault isolation tests (Table 6-14) to isolate the defective board within the group.

When the self tests cannot run, one of the circuits that controls the tests must be defective. Figure 6-2 shows the steps involved in fixing that type of failure. After the failure is fixed, run the self tests.

Table 6-2. Power Supply Signals for Service Self Tests

Supply Name	Output Location	Return Location	Nominal Voltage	Voltage Tolerance†	Ripple Tolerance
+15V	TP105	GND (TP700) or card nests	+15.000 V	±0.010 V	50 μVrms
−15V	TP205	GND (TP700) or card nests	−15.000 V	±0.020 V	50 μVrms
+5V	TP305	GND (TP700) or card nests	+5.100 V	±0.060 V	75 μVrms
+5VFP	TP900	GNDFP (use card nests)	+5.00 V	±0.25 V	

† The voltage levels and ripple tolerances are given for fully loaded supplies. All PC boards must be in the instrument. Removing individual boards will change the load on the supplies and change the supply levels.

6-4 IDENTICAL BOARDS

The HP 3326A has many boards that are identical in channel A and channel B (Table 6-3). Figure 6-3 shows the locations of these boards. The **identical boards** may be **interchanged** to aid in troubleshooting. This is particularly useful in solving subtle specification errors. For example, when the channel A mixer (A5) appears to be the cause of channel A flatness problems, exchange it with the channel B mixer (A15), and see if the problem is transferred to channel B. If so, the original channel A mixer is truly defective. You can put the two boards on extenders and compare waveforms to help find the defective component. However, if the problem remains in channel A, the defective board must be somewhere else in the channel A chain.

CAUTION

DO NOT insert or remove the circuit boards from the HP 3326A with power applied to the instrument. Power surges to circuit boards may cause unknown instrument states and/or damage the circuitry.

Before interchanging boards, be sure that the correct voltages are being supplied to the board. When a board failure is caused by incorrect voltages powering the board, interchanging boards will only result in a failure of the second board.

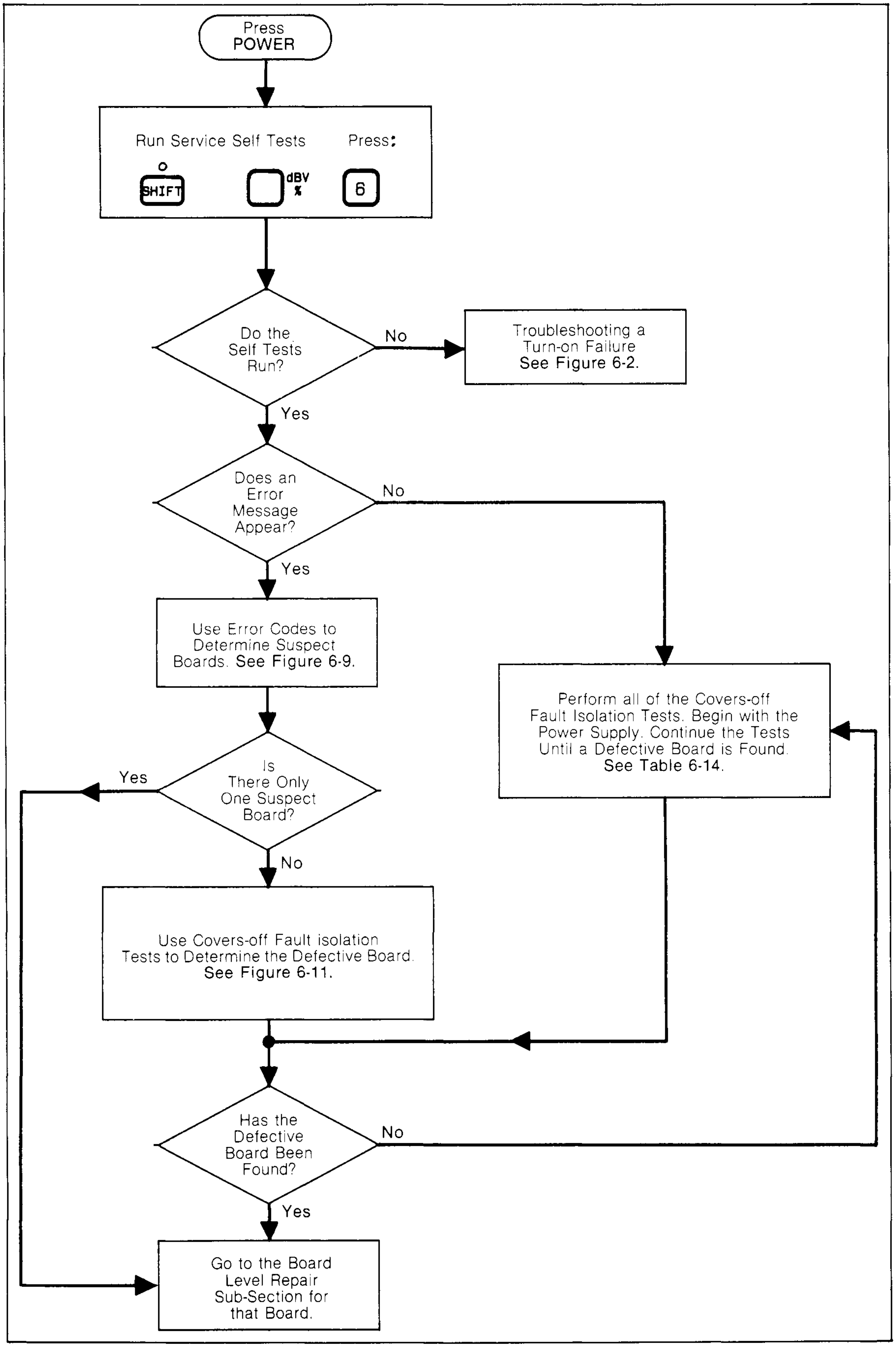


Figure 6-1. Fault Isolation Flow Chart

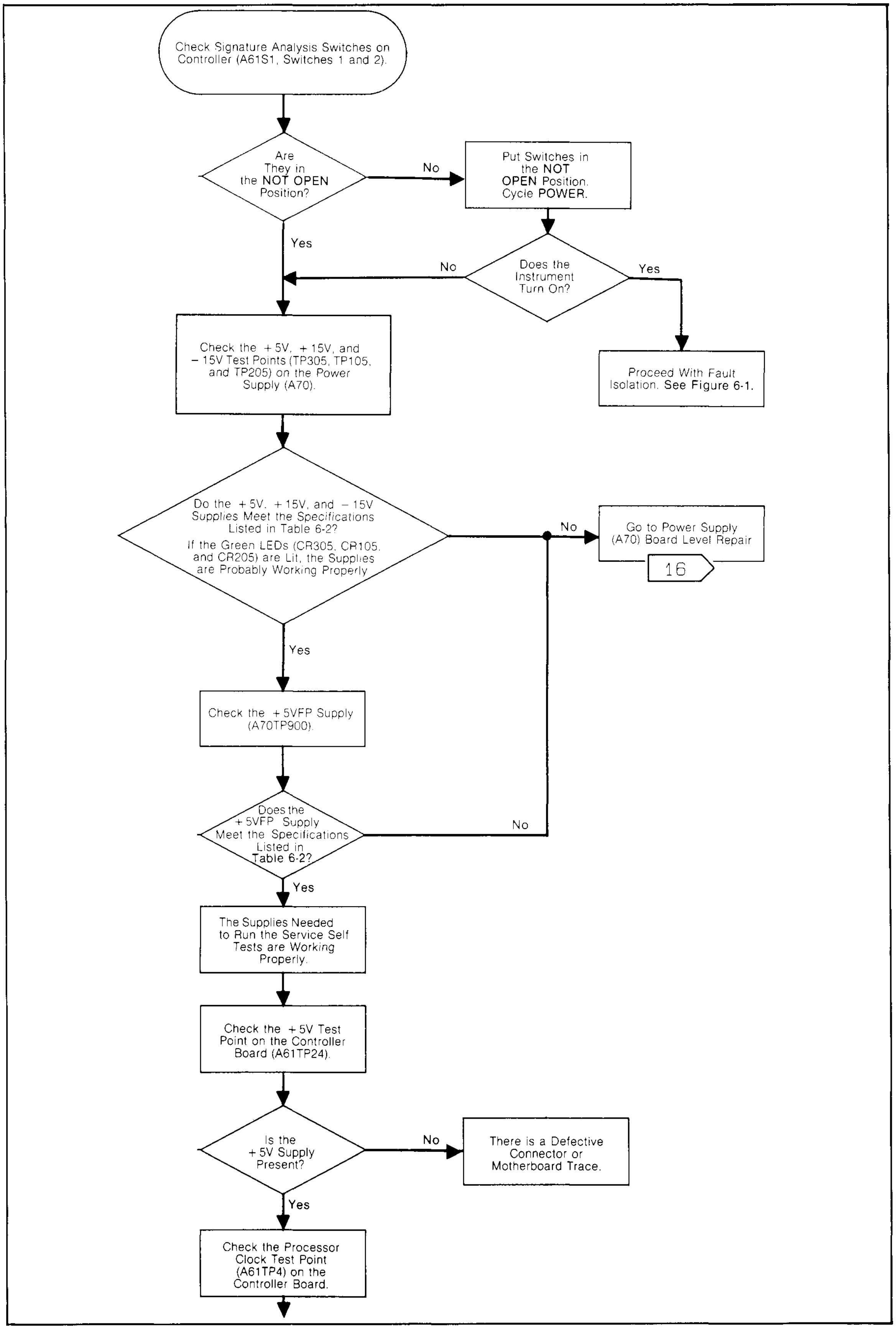


Figure 6-2. Troubleshooting a Turn-on Failure

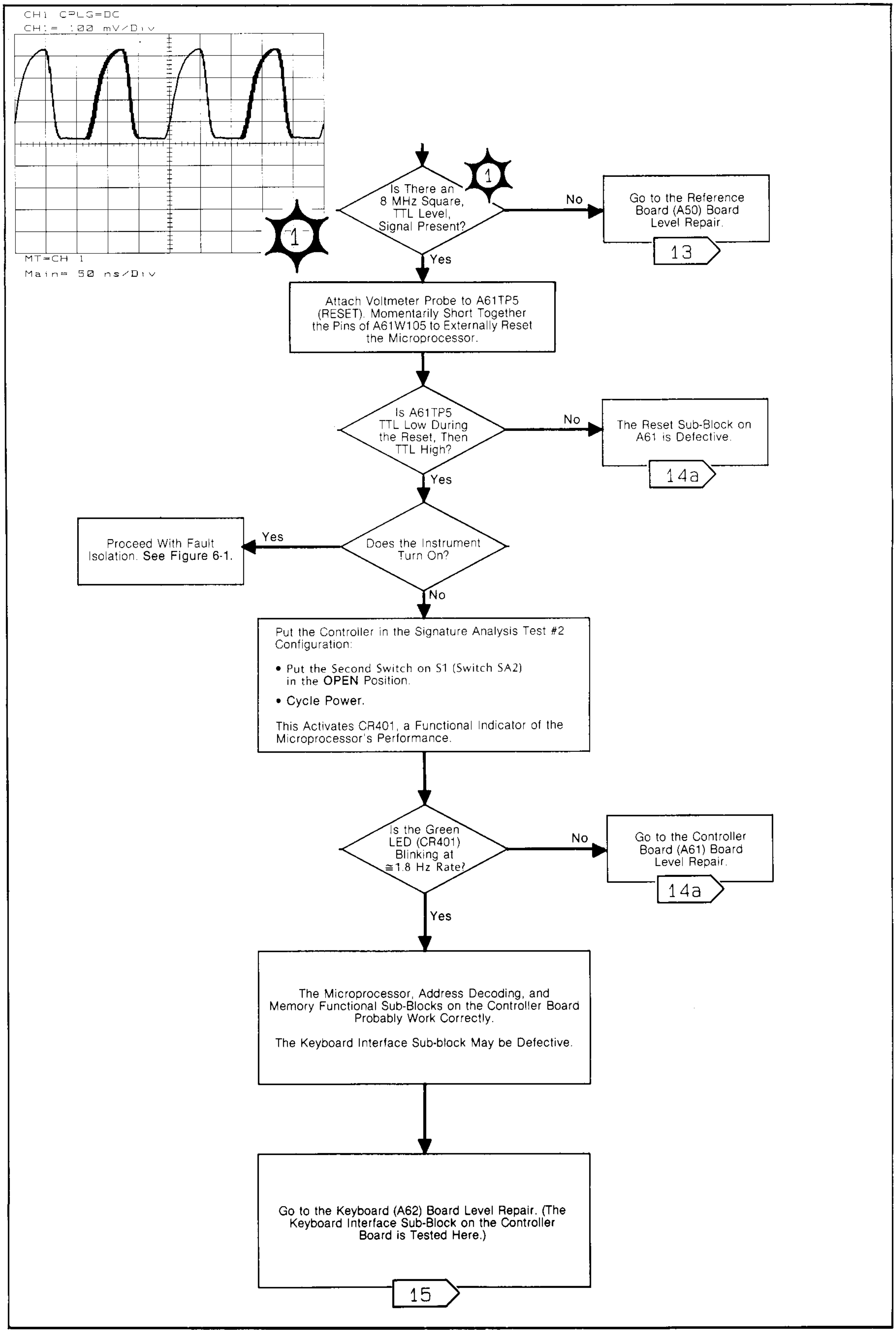


Figure 6-2. Troubleshooting a Turn-on Failure (continued)

NOTE

Identical boards may be interchanged to aid in troubleshooting, but the boards must be returned to their original locations to avoid recalibration of the instrument. See "Adjustments," Section III.

Table 6-3. Identical Boards

Board Name	Reference Designator		HP Part Number
	Channel A	Channel B	
HV Amp	A1	A11	03326-66501
Attenuator†	A2†		03326-66502†
		A12†	03326-66512†
Output Amp	A3	A13	03326-66503
Preamp	A4	A14	03326-66504
Mixer	A5	A15	03326-66505
Modulator	A6	A16	03326-66506
VCO	A31	A41	03326-66531
VCO Control	A32	A42	03326-66532
Phase Detector	A33	A43	03326-66533
FracN Digital	A34	A44	03326-66534
VCO ÷ 2	A35	A45	03326-66535

† The channel A attenuator (A2) and the channel B attenuator (A12) can be interchanged for troubleshooting purposes. Due to slightly different circuitry on the two boards, however, internal phase modulation, internal amplitude modulation, and the combined operation feature do not work. All other features and modes are fully functional. See the schematics for details. When the attenuator boards are not in their correct card nest slots, an error message is displayed during the self tests.

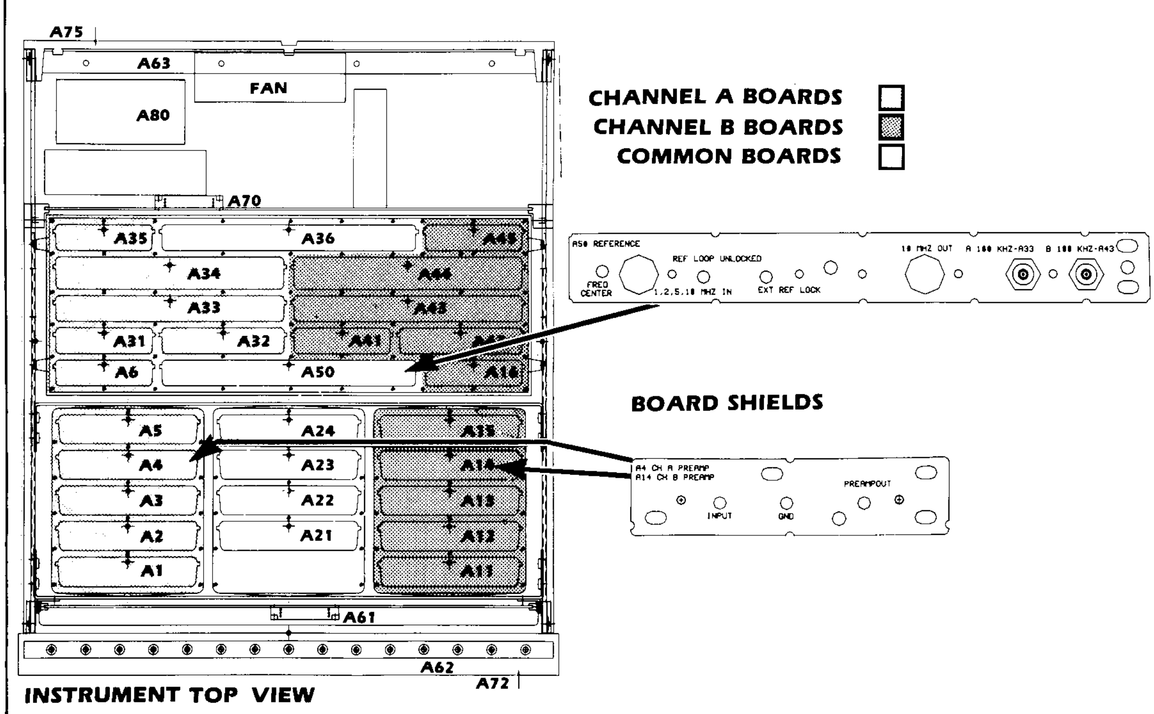


Figure 6-3. Locations of Identical Boards

6-5 WAVEFORM COMPARISON

Two printed circuit board extenders are provided in the service accessory kit (03326-84401) to aid in **two-channel waveform comparison.** For example, when a failure has been isolated to a board that has an identical board in the other channel, the two boards may be placed on extenders and the waveforms compared. This method greatly reduces the time it takes to find a defective component.

6-6 HIDDEN FRONT PANEL COMMANDS

This section summarizes the hidden front panel commands available for troubleshooting (Table 6-4). These commands are used to access the service self tests, and to clear calibration correction constants in the fault isolation tests. They are also referenced in the adjustment procedures and board level repair sub-sections, where specific examples of their uses are given.

Table 6-4. Hidden Commands

Command Name	Front Panel Access	To Restore Normal Operation	HP-IB Mnemonic
Reset Calibration Constants	[SHIFT] [ ] dBV % [0]	Press MANUAL calibration or AUTO calibration or cycle POWER	XD
Range Check Off	[SHIFT] [ ] dBV % [1]	PRESET or cycle power	XC
Error Check Off	[SHIFT] [ ] dBV % [2]	PRESET or cycle power	XE
Modulator Phase Correction Off	[SHIFT] [ ] dBV % [3]	PRESET or press AUTO calibration	XPH
Display Negative Peak Voltage	[SHIFT] [ ] dBV % [4]	Press any key	XNP
Display Positive Peak Voltage	[SHIFT] [ ] dBV % [5]	Press any key	XPP
Service Self Tests †	[SHIFT] [ ] dBV % [6]	Press SHIFT key	XTST

† See "Service Self Tests," sub-section 6-11, for details.

Reset Calibration Constants

This command resets the internal calibration correction constants to their nominal (perfect system) value and reprograms the hardware amplitude and dc offset. Accordingly, the uncorrected amplitude output of the instrument is present on the output connectors. In normal operation, the calibration constants would take the uncorrected level and adjust it to within the instrument specifications.

Range Check Off

This command disables range checking for parameter entry. This allows entries outside of the normal operation limits to be programmed.

Error Check Off

This command disables error reporting in the instrument. None of the continuously monitored hardware faults or user progamming errors are reported. Service self test errors are still displayed.

Modulator Phase Correction Off

This command turns off the modulator phase correction that was determined during automatic calibration. See the overall theory of operation (sub-section 6-7) for details.

Display Negative Peak Voltage

This command configures the instrument to continuously sample and display the negative peaks of the user-supplied reference signal at connector J2 (A INT CAL) on the calibrator board (A36). It is used to adjust the amplitude/offset calibration path.

Display Positive Peak Voltage

This command configures the instrument to continuously sample and display the positive peaks of the user-supplied reference signal at connector J2 (A INT CAL) on the calibrator board (A36). It is used to adjust the amplitude/offset calibration path.

6-7 OVERALL THEORY OF OPERATION

The following is an overview of the HP 3326A which shows the interaction of the instrument's boards and functional blocks. Since many of the functional blocks interact heavily, the more information known about the interaction, the easier troubleshooting becomes. By interpreting self test data and knowing the instrument operation, many problems can be isolated to the defective board quite readily. Table 6-9, Servce Self Tests Error Codes, interprets much of the data for you, and presents the results in a convenient form. This minimizes the amount of system knowledge you need to isolate a defective board.

NOTE

This sub-section provides a theory of operation to the functional block level. The board level repair sub-sections give a description of each board's functional sub-blocks.

A detailed instrument block diagram is located at the end of the schematics. A signal glossary is provided in Appendix A.

Instrument Overview

The HP 3326A is an HP-IB programmable, precision two-channel synthesizer covering the range dc to 13 MHz. The variety of features found in the HP 3326A is made possible by having two independently controlled sources in one instrument, with four different system configurations. These system configurations are referred to as modes: two-channel, two-phase, two-tone and pulse.

Most of the boards operate the same in all modes — only the frequency limits change. An example of this is the entire output chain, from the modulator to the attenuator. This is a very important point to understand. The **four modes** are made possible by **signal switching** and changing **channel B's 20 MHz frequency reference.** The 20 MHz reference signal comes from the reference board (A50) in the two-channel mode, and from the channel B fractional-N local oscillator in all other modes. This is done since the fractional-N local oscillator can provide the variable frequency and variable phase signals required for the two-phase, two-tone, and pulse modes.

The key to the signal switching is the RF switch (A24). The board receives three signals, and routes two of them to the channel B mixer. The two which are routed depend on the programmed mode — the RF switch must route the correct 20 MHz reference signal (B CARRIER) to channel B for the modes to operate. This is explained in great detail in the following board level discussion. It is good to know the basics of the mode switching before you start learning about the modes of the HP 3326A. It makes them easier to understand.

Following is a description of the theory behind the modes and features of the instrument, with a step-by-step description of the board level block diagram.

Instrument Modes

In the **two-channel** mode, the HP 3326A operates as two separate synthesizers that share a common 20 MHz frequency reference and controller. Each channel has its own fractional-N local oscillator which can be tuned from 20 to 33 MHz. The output signal of each fractional-N local oscillator (A LO1, B LO2) mixes with a fixed 20 MHz reference signal (A 20MHz, B 20MHz) to obtain the desired 0 to 13 MHz output frequency. Each mixer output (A MIX OUT, B MIX OUT) is sent through low pass filters to reject the high frequency images, then amplified. Step attenuators (A2, A12) are used to provide an 80 dB dynamic range. See Figure 6-4.

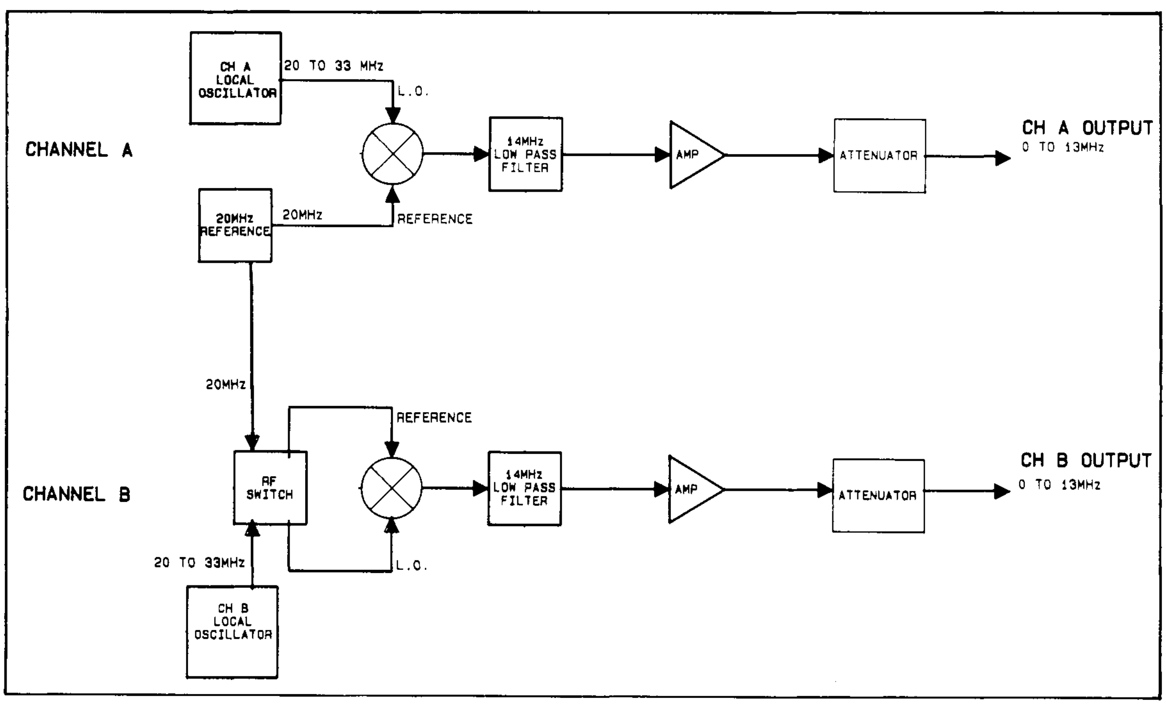


Figure 6-4. Two-Channel Mode Simplified Block Diagram

In the **two-phase** mode, channel A is configured exactly like the two-channel mode. The channel A local oscillator signal (A LO1) is mixed with the 20 MHz signal (A 20MHz) from the reference board (A50), and sent down the output chain. Channel B is configured differently to supply the HP 3326A's phase offset capabilities. The channel B fractional-N local oscillator supplies the 20 MHz reference signal to channel B. It acts as a 20 MHz reference whose phase can be precisely changed relative to the fixed 20 MHz reference signal (A 20MHz) used by channel A. The channel A local oscillator signal is used as the local oscillator signal for channel B. The variable phase reference signal (B LO2) is mixed with the 20 to 33 MHz signal from the channel A local oscillator (A LO2), and sent down the channel B output chain. The RF switch board (A24) performs the signal switching that changes the reference and local oscillator inputs to the channel B mixer board (A15). The system configuration results in two output signals with the same frequency and a discrete **phase offset.** As channel A changes in frequency, channel B tracks the change, and the relative phase offset between the two channels remains constant. See Figure 6-5.

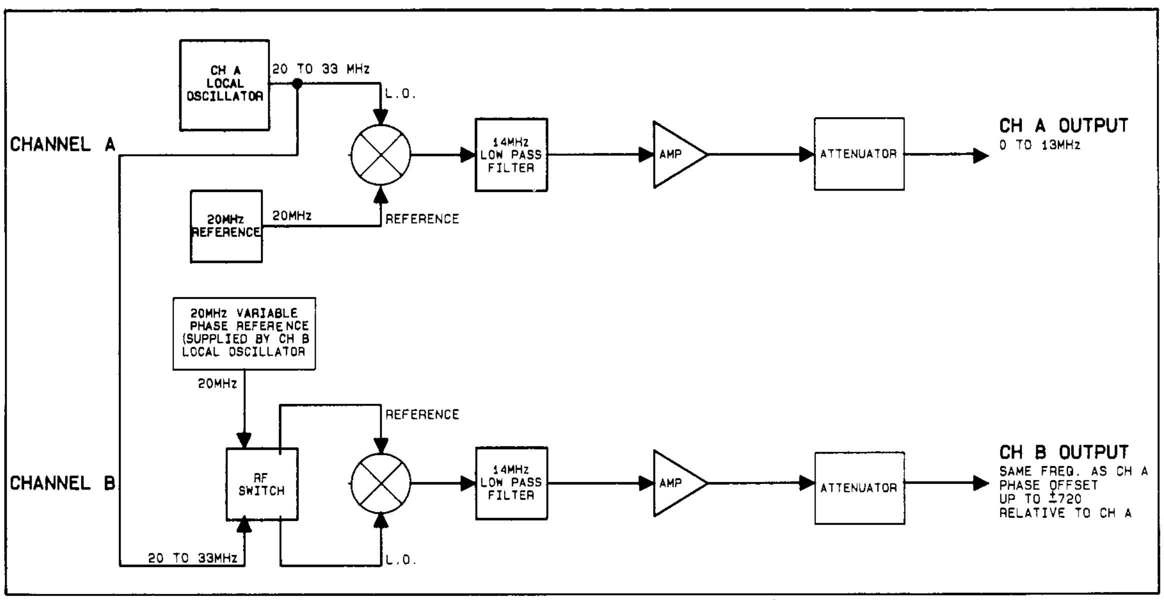


Figure 6-5. Two-Phase Mode Simplified Block Diagram

The **two-tone** mode differs from the two-phase mode only in the action of the channel B fractional-N local oscillator. The oscillator is still used as a reference for the B channel, but it provides a discrete **frequency offset** instead of a phase offset. The channel B oscillator is set to 20 MHz plus an offset of up to 100 kHz. As in the two-phase mode, the channel A local oscillator signal is used as the local oscillator signal for channel B. This 20 to 33 MHz signal (A LO2) is mixed with the variable frequency reference signal (B LO2) from the channel B local oscillator. This system configuration results in output signals which are offset in frequency up to 100 kHz. As channel A changes in frequency, channel B tracks the change, and maintains the precise frequency offset. See Figure 6-6.

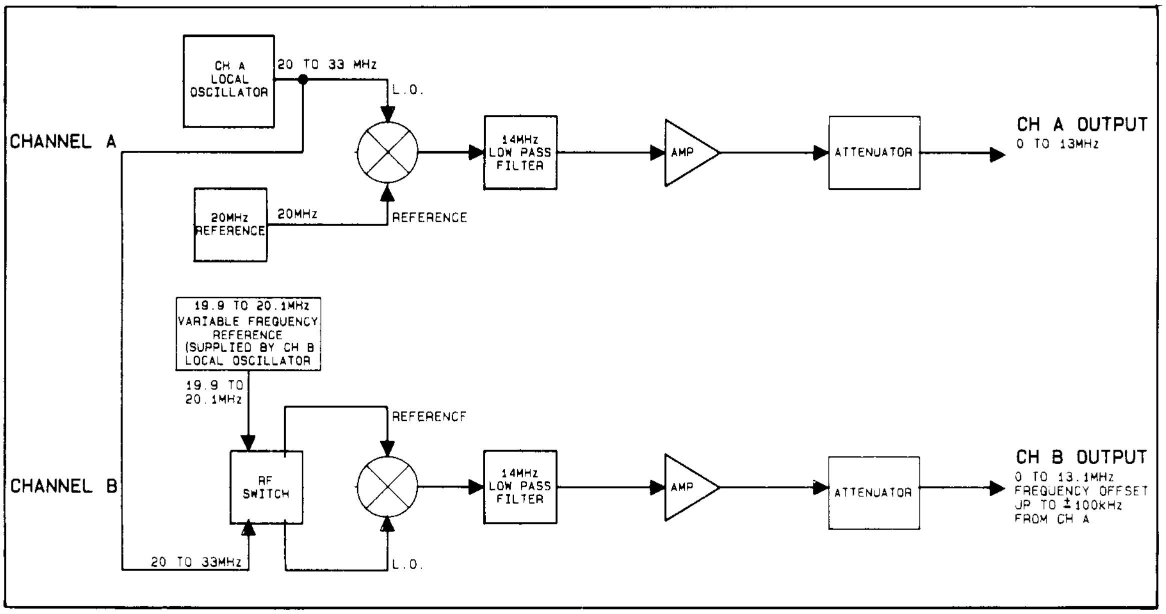


Figure 6-6. Two-Tone Mode Simplified Block Diagram

In the **pulse** mode, the local oscillators and references behave exactly like the two-phase mode. In the output chain, however, the sine wave signals from the two channels are routed through a circuit (A23) which squares the signals and yields two complementary pulse waveforms. The duty cycles of these waveforms are determined by the phase difference between the two channels; the channel A signal controls the rising edge of the pulse and the channel B signal controls the falling edge. See Figure 6-7.

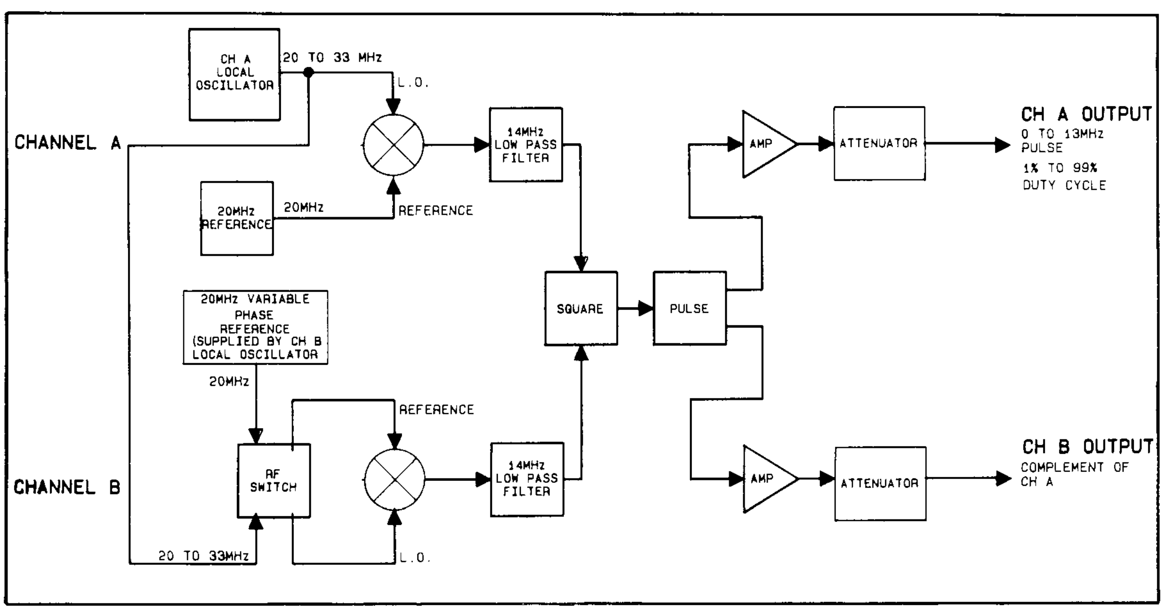


Figure 6-7. Pulse Mode Simplified Block Diagram

Instrument Features

The HP 3326A has many features that can be used in the different modes, including sweeping, modulating, changing the wave shape, and altering the calibration method. The following is a broad description of these capabilities.

There are four signal **functions** available in the HP 3326A: square wave, sine wave, dc only, and off. Any of these functions can be selected on one channel, regardless of the other channel's setting. A sine wave is generated by the mixer board (A5, A15). When the square function is programmed, this sine wave signal is switched through the square wave circuit on A23. The edges of the square wave coincide with the zero-crossings of the sine wave. A pure dc offset signal is generated by suppressing the ac component of the main signal. A relay on the attenuator board turns off the output when the off function is programmed. A nominal 50 ohm source impedance is seen for all functions except off, which looks like an open circuit at the output connector. (When the high voltage option is in place, this impedance is changed to less than two ohms.)

Amplitude is controlled from +23.98 dBm (50 Ω) to −56.02 dBm by a series of attenuators and a DAC control. 10 dB, 20 dB, and 40 dB step attenuators perform the rough amplitude control. A 10 dB attenuator is located before the output amplifier (A3, A13), and 10 dB, 20 dB, and 40 dB attenuators are located after the output amplifier (A2, A12). (The levels at which the attenuators are activated are included in a table near the A2/A12 schematic.) The modulator board (A6, A16) provides the 0 to 10 dB fine tuning of the amplitude.

A user-specified **dc offset** can be added to each channel's ac signal. The maximum levels of dc offset are determined by the level of the ac signal; the combination of the two levels cannot exceed the ±5 Vpk limits of the output amplifiers. The output attenuators (A2 and A12) attenuate both the ac and dc signals. In normal operation, the offset signals (A AMPDCO and B AMPDCO) are injected into the output amplifiers before the attenuators. When the high voltage option is activated, the dc offset signals (A HVDCO and B HVDCO) are injected at the high voltage amplifiers (after the attenuators). Since the dc signals are not attenuated before they reach the high voltage amplifiers, a large dc offset can be obtained (even when the ac signal level has been highly attenuated).

The **sweep** capabilities of the HP 3326A are controlled by the fractional-N oscillators. Arbitrary start and stop frequencies and sweep times can be specified. If desired, the phase continuous sweeps can start from an external trigger.

The HP 3326A provides both internal and external **amplitude modulation** (AM) and **phase modulation** (PM). When internal AM is enabled, the B channel output is disabled. The B channel output signal (INT MOD) is switched internally to become the level control for the channel A 20 MHz reference signal. This allows internal amplitude modulation of channel B on channel A. For internal PM of channel A, the channel B output signal (INT MOD) is switched into the phase control circuit of the channel A fractional-N local oscillator.

Inputs for channel A and channel B external AM and PM signals are available on the rear panel of the HP 3326A. Either channel may be modulated independently.

The outputs of channel A and channel B are combined at the channel A output connector when **combined operation** is programmed. The output signal from the channel B attenuator (B COMBINE) runs to the channel A attenuator's broadband resistive combiner. The maximum output amplitude limit for each channel is reduced by 6.02 dB when combined operation is activated.

The HP 3326A has the capability of calibrating internally or externally. During **calibration**, the channel A and channel B signals are switched off. The main signal is switched to the internal calibration circuit (A36) immediately before it reaches the output connector. The measurements taken by A36 are interpreted by the controller, which adjusts the amplitude level control or the fractional-N phase control. The rear panel contains external phase calibration inputs (A-EXT ϕ CAL IN and B-EXT ϕ CAL IN). This allows for remote sensing of the phase calibration, letting the user eliminate the effects of phase shift that are generated from the system's cable configuration.

The MARKER OUT, Z-BLANK OUT, and X-DRIVE OUT rear panel output signals are generated by the controller (A61) and HP-IB support board (A63). MARKER OUT can be used to initiate a measurement when a certain frequency has been reached or to indicate where a certain frequency is located in a given sweep. Z-BLANK OUT can be used to control an X-Y plotter pen or to blank an oscilloscope signal retrace. X-DRIVE OUT can be used to control the X-axis position of an X-Y plotter.

Board Level Theory

Consult the **overall block diagram** at the end of the schematics and the signal glossary in Appendix A while reading the following board level system theory of operation. They make the explanation clearer. The theory provides you with information about the interactions of the boards in the HP 3326A. The order that the boards are described follows the main signal flow through the instrument (see Figure 6-10). First, the power supply (A70) is described, then the frequency reference board (A50), the controller (A61), and so on. Finally the output amplifier (A3, A13) and attenuator (A2, A12) are described. Detailed theories of each board are given next to the individual schematics in the board level repair sub-sections (6-20 to 6-38).

The linear **power supply** (A70) provides five main outputs: +15V, −15V, and three +5V signals. The +15V supply is the reference for these supplies. The main +5 volt supply is highly regulated (+5V). The main +5 volt supply for the keyboard (+5VFP) to keep the display noise signals from the main +5V supply is provided. The third +5V supply powers the HP-IB interface circuitry (+5V HPIB). This supply has a separate ground (CGND). A raw voltage (+15V RAW) from the power supply is used to power the oven reference board (A80).

Two separate grounds are maintained throughout the instrument. The instrument chassis is connected to the protective earth terminal through the line power cord. This signal is referred to as chassis ground, or CGND. The HP-IB connector, the instrument chassis, and four rear panel connectors (20-33MHz B-L.O. OUT, 10MHz OUT, 10MHz OVEN OUT OPTION 001 and 1,2,5,10MHz REF IN) are connected to chassis ground. The rest of the instrument uses GND, an isolated ground for the printed circuit boards. The two are connected through varistors and capacitors on several boards in the instrument. No more than 42 Vpk potential can appear between them.

The **reference** board (A50) generates all the frequency references and clocks for the instrument. These include:

- Two 20 MHz reference signals (A 20MHz and B 20MHz) which feed the channel A modulator (A6) and the RF switch (A24), and eventually feed the reference ports of the mixers (A5, A15) through the modulators (A6, A16).
- Two 100 kHz clocks (A 100kHz and B 100kHz) which provide the time base for the fractional-N circuitry of the two local oscillators.
- Two 8 MHz clocks (8MHz PROC CLK, 8MHz FRACN CLK) for the controller board (A61) and fractional-N local oscillators.
- A 10 MHz reference output (10MHz OUT) available on the rear panel.

The reference locks to an external signal provided through the rear panel input connector (1,2,5,10MHz REF IN) when the signal frequency is 1, 2, 5 or 10 MHz.

All the functions of the instrument are controlled by the microprocessor on the **controller** board (A61). The controller accepts commands in the form of a keyboard entry or via the Hewlett-Packard Interface Bus (HP-IB), and controls several of the printed circuit boards via the instrument bus (IBUS0-7). This instrument bus is disabled whenever instructions are not actively being written to the hardware. This keeps the processor clock frequency from coupling to sensitive circuits.

The Hewlett-Packard Interface Bus is a bus structure that links the HP 3326A to desktop computers, minicomputers, and other HP-IB controlled instruments to form automated measurement systems. HP-IB is Hewlett-Packard's implementation of the IEEE Standard 488-1978, ANSII Standard MC 1.1, and IEC Recommendation 625-1.

The **keyboard** (A62) includes the switches and indicators that the operator sees while viewing the front panel of the instrument. The controller (A61) feeds the keyboard information in a bit-serial manner.

The identical channel A and channel B fractional-N **local oscillators** (LOs) are comprised of five separate printed circuit boards (A31-A35, A41-A45), with a common decoder circuit (P/O A36). The fractional-N oscillators provide the instrument frequency and the ability to sweep frequencies across a known band. The local oscillators also control the phase and frequency offsets provided in the different modes. These modes are made possible by changing the reference and local oscillator signals for channel B.

In the two-channel mode, each LO is fed into the LO port of a separate mixer. The reference port of each mixer is driven by the same 20 MHz source (A50). Since each LO can independently vary its frequency, the mixer outputs can have different frequencies. However, in the two-phase mode, the channel A LO drives the LO inputs of both mixers. The channel B LO is set to 20 MHz, and drives the reference port of the channel B mixer. (The 20 MHz channel A reference signal is still provided by A50.) Thus, the output frequencies of the two mixers are equal. The phase relationship of the two channels is controlled by changing the phase of the channel B LO. The two-tone and pulse modes of the HP 3326A are variations of the two-phase mode. They use the same LO and reference inputs to the channel B mixer.

The **RF switch** (A24) performs the signal switching necessary to accomplish mode switching. It is the key to understanding the block diagram of the HP 3326A. The outputs of A24, LOBSW and B CARRIER, drive the LO and reference port of the channel B mixer, respectively. The switch has three inputs, B 20MHz (from the reference board (A50)), A LO2 (from the channel A LO), and B LO2 (from the channel B LO). In the two-channel mode, B 20MHz is routed to the reference port of the channel B mixer, and B LO2 is routed to the LO port. In the two-phase mode, B LO2 is routed to the reference port, and A LO2 is routed to the LO port (Figure 6-8, Table 6-5).

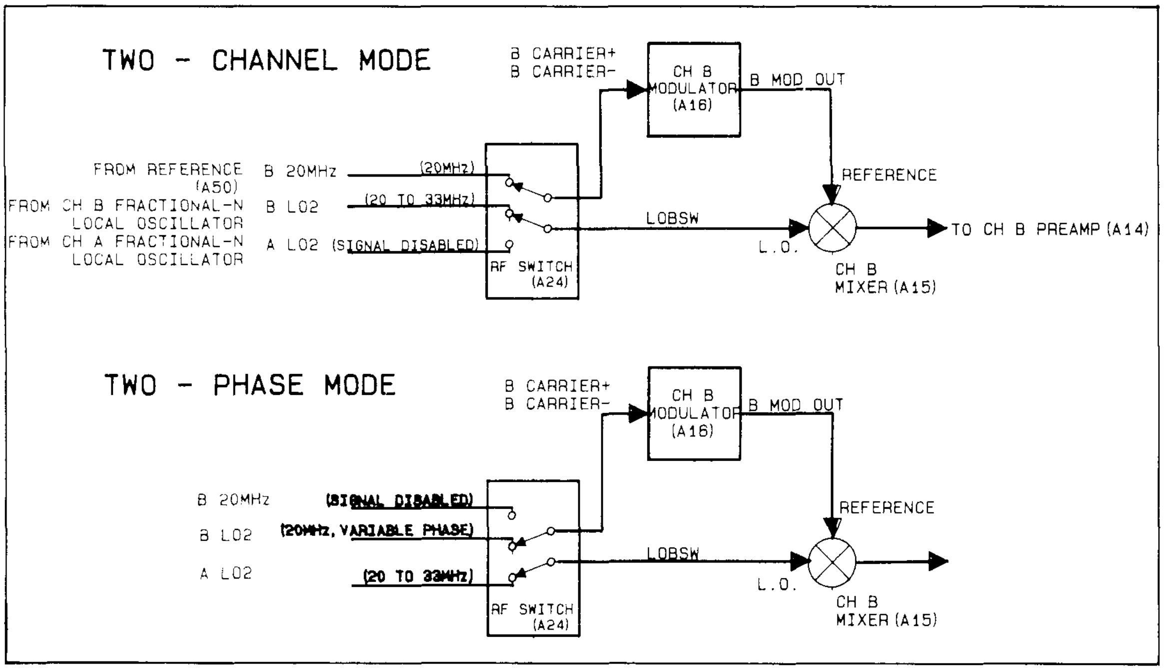


Figure 6-8. RF Switch Configurations

Table 6-5. Frequency Ranges of Main Signals in Different Modes

Modes	Main Signals					
	B 20MHz	**B LO2**	**B CARRIER**	**B MOD OUT**	**A LO2**	**LOBSW**
Two-Channel	20 MHz	20-33 MHz	20 MHz	20 MHz	X	20-33 MHz
Two-Phase	X	20 MHz, Variable Phase	20 MHz, Variable Phase	20 MHz, Variable Phase	20-33 MHz	20-33 MHz
Two-Tone	X	19.9-20.1 MHz	19.9-20.1 MHz	19.9-20.1 MHz	20-33 MHz	20-33 MHz
Pulse	X	20 MHz, Variable	20 MHz, Variable	20 MHz, Variable	20-33 MHz	20-33 MHz

X = signal inhibited

The **level/AM** board (A22) produces a dc voltage proportional to its digital to analog converter (DAC) setting. It provides a signal (A SINLEV, B SINLEV) which drives the modulator (A6, A16) when the sine function is programmed. When the square or pulse functions are programmed, the signals (A SQLEV and B SQLEV) drive the square board (A23).

When a modulation signal is present (either provided internally from channel B or externally from the rear panel inputs), the level outputs of A22 are proportional to the DAC setting and the level of the modulating signal.

Programmable switches on A22 let the controller (A61) specify amplitude modulation. Other switches on A22 direct the output signal of each level control to the sine wave modulator or the square wave circuit, depending on the chosen function.

The channel A and channel B **modulator** boards (A6 and A16) control the level of the instrument's output signals by adjusting the level of each channel's reference signal from 0 to 10 dB. The channel A modulator (A6) receives a 20 MHz input (A 20MHz) from the reference board (A50) and a level control signal (A SINLEV) from the level/AM board (A22). The resulting level-controlled reference is sent through a bandpass filter to eliminate 20 MHz harmonics and noise outside a ±100 kHz bandwidth around 20 MHz. The output signal (A MOD OUT) is sent to the reference port of the channel A mixer (A5).

The channel B modulator's reference input (B CARRIER + and B CARRIER −) comes from the RF switch circuit (A24). The level control signal (B SINLEV) comes from the level/AM board (A22). The channel A and channel B modulators operate in exactly the same manner.

A double-balanced, active **mixer** board (A5, A15) mixes the 20 to 33 MHz local oscillator output (A LO1, LOBSW) with the 20 MHz reference signal (A MOD OUT, B MOD OUT) in a heterodyne fashion. A low pass filter filters out the high sideband (40 to 53 MHz) and the residual 20 MHz reference signals, yielding signals between 0 and 13 MHz only. The low pass filter is divided between the mixer board and the preamplifier board (A4, A14) to minimize the effect of interference along the interconnect path.

After the local oscillator and reference signals are mixed and filtered, they are amplified by a fixed gain amplifier (gain = 10) on the **preamplifier** board (A4, A14). The main signal then travels to the output amplifier (A3, A13) when a sine wave is programmed.

When a pulse or a square wave is programmed, the controller routes the preamplifier output through the square wave circuit on A23 before routing it to the output amplifier. The **square** board (A23) has two functions: square wave generation and pulse generation. When the square wave function is selected, the main signal is directed through the square wave (limiter) circuit and a square wave is produced. The edges of the square wave match the zero-crossings of the sine wave output of the preamplifier. The amplitude is controlled by the level control circuitry on the level/AM board (A22). When the pulse mode is programmed, the channel A output of the square wave circuit is a pulse wave whose pulse width reflects the phase difference between the channel A and channel B preamplifier (A4 and A14) outputs. The channel B output of the square circuit is the complement of the channel A waveform, but with separate amplitude control.

The **offset** control board (A21) generates a separate dc offset for each channel, as determined by its digital-to-analog converters (DACs). The DACs are adjusted for instrument offset errors. Under normal operation, the offset signal (A AMPDCO, B AMPDCO) is injected into the output amplifier (A3, A13) summing node. When the high voltage option is enabled, the offset signal (A HVDCO, B HVDCO) is injected into the high voltage amplifier (A1, A11) summing node. A relay on the offset board directs the signal. Both channels have identical offset operation.

The maximum available dc offset depends on the selected ac amplitude, as shown in Table 6-6. When the high voltage option is activated, ± 20 V dc offset may be programmed, independent of the ac amplitude (dc + ac peak must be less than 20 V).

Table 6-6. DC Offset as a Function of AC Amplitude

AC Amplitude	Maximum AC + DC	Maximum DC Offset
1.0 to 10.0 Vpp	± 5.0 V	± 4.5 V
0.1 to 1.0 Vpp	± 0.5 V	± 0.45 V
10 to 100 mVpp	± 50 mV	± 45 mV
1 to 10 mVpp	± 5 mV	± 4.5 mV

The **output amplifier** board (A3, A13) boosts the main RF signal (A PREAMPOUT, B PREAMPOUT) to its maximum level (±5 Vpk into 50Ω, ±10 Vpk open circuit). It also provides the first 10 dB of signal attenuation with the 10 dB pad and driver sub-block at the input of the board. The attenuator boards (A2 and A12) perform the rest of the attenuation on the amplifier's output signal (A AMPOUT, B AMPOUT). The programmed amplitude determines which pads are activated. (See level control table near the A2/A12 schematic for the amplitude ranges.)

The **synchronous output** (sync) circuit on the keyboard (A62) monitors the output signal (A AMPOUT) from the channel A output amplifier (A3) and generates a square wave with edges coincident with the zero-crossings of sine wave A AMPOUT. The dc offset signal (A AMPDCO) from the offset board (A21) compensates for any amplitude offset that may be present on A AMPOUT. The output (SYNC A) is available on the front panel.

Before leaving the output amplifier boards to go to the attenuator boards, the output signals (A AMPOUT and B AMPOUT) are indirectly monitored by current overload detection circuits. An overload signal from these circuits is sent to the attenuators, then to the offset board (A21), which alerts the processor by pulling the ANALOG FAULT line. See the signal glossary for detailed signal definitions.

The **step attenuator** (A2, A12) allows the amplitude of the output signal to be attenuated in 10 dB steps to a maximum of 60 dB, maintaining a 50Ω output impedance. The main RF signal is monitored by several voltage overload detection circuits and an overload cut-out relay on the attenuator board. When the high voltage option is in place and activated, a relay directs the main signal to the high voltage amplifier (A1, A11) and back again.

When combined operation is activated, the channel A and channel B signals are summed on the channel A attenuator board. The combined signal is provided on the channel A output connector and the channel B output (CH B) is terminated with 50 Ω to ground. This summing network on channel A and the internal modulation relay on channel B are the only differences between the two attenuators.

When internal calibration is required, the main signal (A INT CAL, B INT CAL) is sent to the **calibrator** (P/O A36) through a relay at the output of the attenuator board (after all attenuation and high voltage amplification has taken place). The calibrator performs amplitude, dc offset, and phase calibration. Part of the phase calibration circuitry also determines the modulator board's (A6, A16) phase shift as a function of amplitude.

During internal amplitude calibration and dc offset calibration (which are performed simultaneously), the calibrator precisely measures the signal's positive and negative peaks. As the measurements are being taken, the controller (A61) adjusts the parameter being tested to correct for any error. Sine waves, square waves, and pure dc offsets are all measured and calibrated. Any sine wave or square wave amplitude error is corrected by adjusting the DAC on the level/AM board (A22). Any dc offset error is corrected by adjusting the DAC on the offset board (A21). The calibrator continues to measure the signal and the instrument continues to adjust itself until the signal is within specification, or until it determines that the signal cannot be calibrated.

For **internal phase calibration** of the sine and square functions, the two main signals (A INTCAL, B INTCAL) are input to the phase calibration circuit on A36. The channel A main signal's phase is fixed, while the channel B signal's phase is incremented, until a relative phase offset of 180° is reached. The inputs are switched and the procedure is repeated. Averaging the results eliminates system errors and gives a precise phase measurement. The controller corrects any error by adjusting the fractional-N local oscillators.

External phase calibration and **multiphase calibration** are available through the rear panel inputs A-EXT ϕ CAL IN and B-EXT ϕ CAL IN/MULTI ϕ REF IN. The instrument calibrates itself in the same manner as in internal calibration. For phase calibration, it is expected that the inputs are the channel A and channel B signals measured at the point of interest — that is, at the end of the cables or after being modified by a device under test. For multiphase calibration, the channel A rear panel calibration input is expected to be a signal from another source. This source must be reference-locked with the HP 3326A. The channel B input is expected to be the HP 3326A channel A output. The phase of channel A is adjusted to align with the phase of the external source.

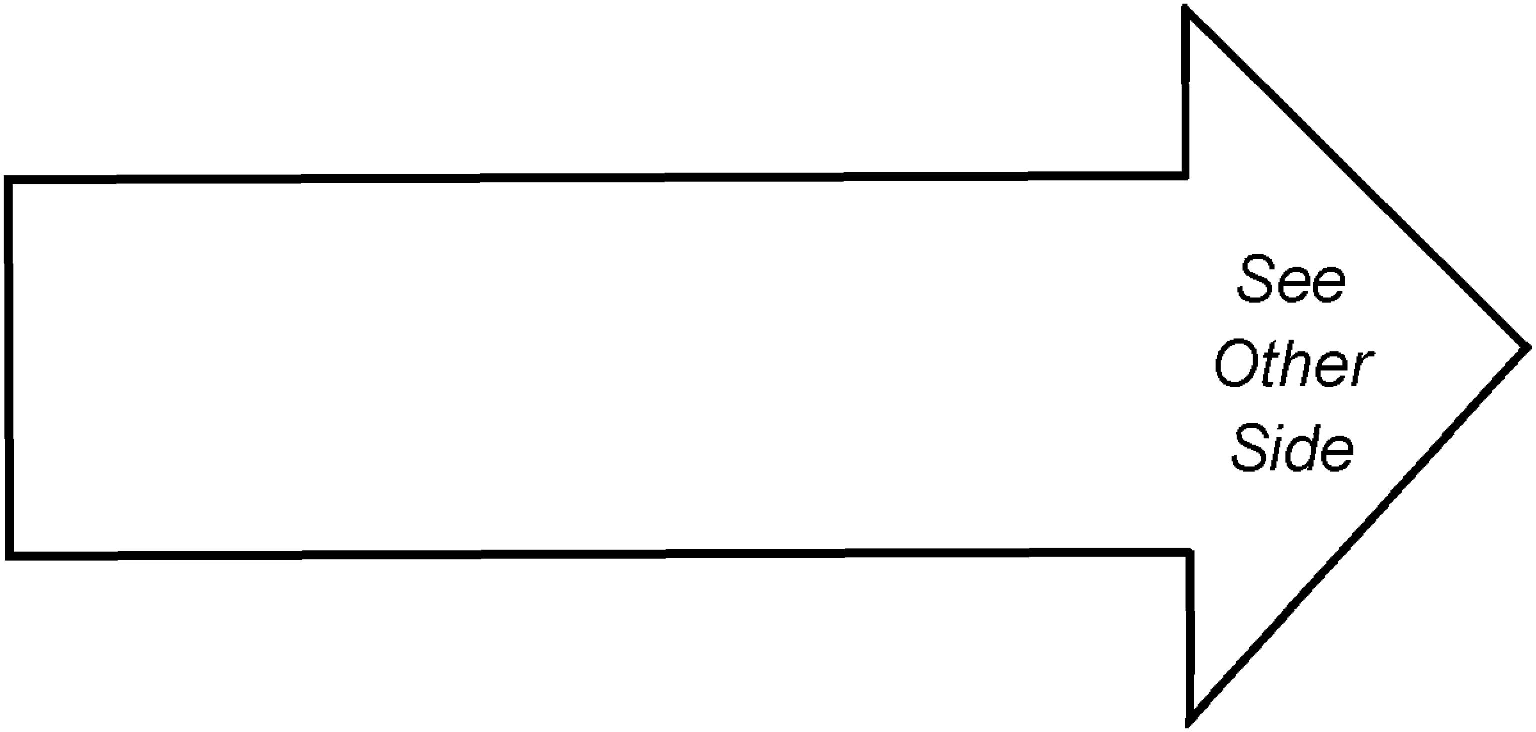
The phase calibration circuitry, in conjunction with the 10 dB attenuator pads on the output amplifier boards, is used for measuring the phase shift that occurs in the modulators (A6 and A16). The modulator under test is set to full scale, and the 10 dB pad is activated. A single pass of the phase calibration procedure is performed. The modulator's level is then reduced by 10 dB, and the 10 dB pad is deactivated. Another pass of phase calibration is performed. The difference between the two phase measurements is the modulator's phase shift, which is corrected by adjusting the local oscillator circuit.

The **oven reference** board (A80) provides an oven-stabilized crystal reference for the instrument (Option 001). The reference output runs directly to the rear panel (10MHz OVEN OUT, OPTION 001). To use the reference, 10MHz OVEN OUT, OPTION 001 must be externally connected to the external reference input, 1,2,5,10MHz REF IN. Both of these outer conductors are tied to chassis ground (CGND). See the signal glossary for a complete description.

The **high voltage amplifier** board (A1, A11) provides four times the normal 50Ω terminated signal level (two times the normal open circuit level). The board is switched on after the main signal has been attenuated, and before the instrument is calibrated. When the high voltage output option is engaged, the dc offset signal (A HVDCO, B HVDCO) is injected into the input of the high voltage amplifier board (instead of the output amplifier board (A3, A13)). This increases the amount of dc offset that can be provided with a small ac signal from the output attenuators. The low impedance ($\cong 0\ \Omega$) output signal (A HVAMPOUT, B HVAMPOUT) of the amplifier runs directly to the front panel output connector (CH A, CH B), without any series resistance. The outputs require a high impedance load.

See Other Side

SERVICE SELF TESTS
ERROR CODES


See
Other
Side

3. **Compile a list** of suspect circuits from the first test that failed. One of the circuits exercised in this test is defective. When any of the circuits are highlighted with a ✖ , they are the most likely suspects. These suspect circuits form the columns that must be examined in step 4.

NOTE

This procedure assumes that there is only ***one*** *failure in the instrument at a time.*

4. **Examine Table 6-9.** Look for the column that has the most correlation between suspect circuits and exercised circuits. For example, when a particular circuit is on your list of suspects (see step 3), and it is exercised in EVERY test that failed, there is a good likelihood that it is defective. Conversely, when a particular circuit is on your list of suspects and it is NOT exercised in one of the other tests that failed, it is probably NOT the defective circuit.

5. **This step depends on the individual situation.** When there is only one highly suspect circuit, go directly to the board level repair sub-section for the board that contains the suspect circuit. When there is more than one suspect, go to Table 6-14, Fault Isolation Tests. Table 6-14 provides a method to test most of the boards in the HP 3326A to see if they are working properly. Start testing the board which appears first on the table. If that board is working properly, go to the next suspect board, and so on.

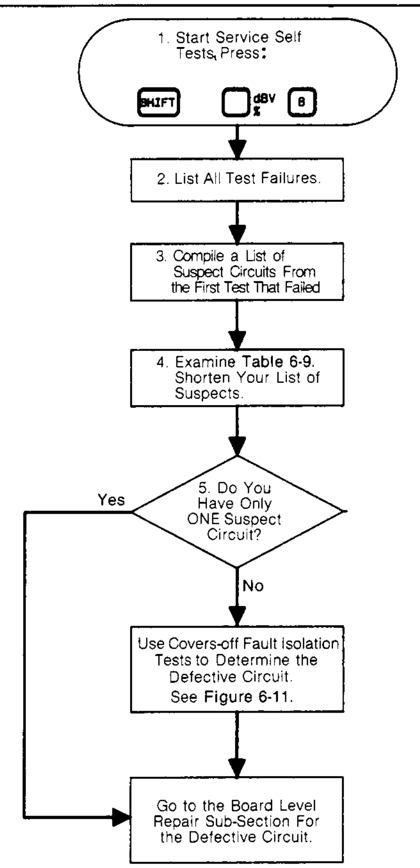


Figure 6-9. How to Use Table 6-9

SERVICE SELF TESTS

NAME	ERROR CODE	REFERENCE, CONTROL, AND CALIBRATION																																		CHANNEL A													CHANNEL B																UNTESTED AREAS												
	BOARD NUMBER	A70	A70	A70	A70	A99	A50	A50	A50	A50	A50	A50	A61	A61	A61	A62	A62	A22	A22	A22	A22	A22	A22	A22	A21	A21	A21	A21	A21	A36	A36	A36	A36	A36	A36	A31	A32	A33	A34	A35	A6	A5	A4	A4	A23	A3	A3	A2	A41	A42	A43	A44	A45	A24	A24	A24	A16	A15	A14	A14	A23	A13	A13	A12	A70	A70	A61	A32	A42	A23	A2	A12	A62	A63	A80	A1	A41
	SUSPECT BOARD	+5V SUPPLY	+15V SUPPLY	−15V SUPPLY	+5VFP SUPPLY	MOTHERBOARD	8MHz PROC CLK SIGNAL	8MHz FRACN CLK SIGNAL	A 100kHz SIGNAL	B 100kHz SIGNAL	A 20MHz SIGNAL	B 20MHz SIGNAL	µP ADDRESS, MEMORY, INTERFACE	INSTRUMENT BUS	SWEEP LIMIT LATCHES	KEYBOARD DISPLAY DRIVE	KEYBOARD DECODE	A + B LEVEL CONTROL	CH A LEVEL	CH B LEVEL	CH A AMP MOD	CH B AMP MOD	CH A SQUARE SWITCH	CH B SQUARE SWITCH	READ DATA, STROBE CONTROL	CH A CONTROL, CH A OFFSET	CH B CONTROL, CH B OFFSET	CH A OFFSET SWITCH	CH B OFFSET SWITCH	VOLTAGE REFERENCE	FRACN DECODER	CAL RW LOGIC	LEVTEST/OFFTEST PATH	AMPLITUDE/OFFSET CAL PATH	PHASE CAL PATH	CH A VCO	CH A VCO CONTROL	CH A PHASE DETECTOR	CH A FRACN DIGITAL	CH A VCO ÷ 2	CH A MODULATOR	CH A MIXER	CH A PREAMP	CH A SIN/SQ MODE RELAY	CH A SQUARE PATH	CH A 10dB PAD AND DRIVER	CH A OUTPUT AMP	CH A ATTENUATOR	CH B VCO	CH B VCO CONTROL	CH B PHASE DETECTOR	CH B FRACN DIGITAL	CH B VCO ÷ 2	SWITCH CONTROLLER	TWO-CHANNEL MODE PATH	TWO-PHASE MODE PATH	CH B MODULATOR	CH B MIXER	CH B PREAMP	CH B SIN/SQ MODE RELAY	CH B SQUARE PATH	CH B 10dB PAD AND DRIVER	CH B OUTPUT AMP	CH B ATTENUATOR	+ 28V, − 28V SUPPLIES	+ 5VHPIB SUPPLY	HP-IB INTERFACE	CH A PHASE MODULATION	CH B PHASE MODULATION	PULSE PATH	CH A COMBINER RELAY	CH B COMBINER/INT MOD RELAY	SYNC	HP-IB SUPPORT	OVEN REFERENCE (OPTION 001)	CH A HV AMP (OPTION 002)	CH B HV AMP (OPTION 002)
	SCHEMATIC NUMBER	18	18	18	18	NO SCH	13	13	13	13	13	13	14a	14b	14b	15	15	8	8	8	8	8	8	8	7	7	7	7	7	12	11f	12	12	12	12	11a	11b	11c	11d	11e	6	5	4	4	9	3	3	2a	11a	11b	11c	11d	11e	10	10	10	6	5	4	4	9	3	3	2b	16	16	14c	11b	11b	9	2a	2b	15	14c	19	1	1
LED	FAIL 01	X	X	X	X	•	X						X			X	X																																																												
STUCK KEY	FAIL 02	•	•	•	•	•	•						X			X	X																																																												
NMOS RAM	FAIL 03	•	•	•	•	•	•						X			•																																																													
CMOS RAM	FAIL 04	•	•	•	•	•	•						X			•																																																													
ROM 1	FAIL 05	•	•	•	•	•	•						X			•																																																													
ROM 2	FAIL 06	•	•	•	•	•	•						X			•																																																													
IBUS	FAIL 07	•	•	•	•	•	•						X	X		•		X							X						X	X							X													X		X																								
A2 POSITIONING	FAIL 08	•	•	•	•	•	•						•	•		•																																X				X																									
FRACN DIGITAL, CH B	FAIL 09	•	•	•	•	•	•	X					•	•		•															X																		X			X																									
FRACN DIGITAL, CH A	FAIL 10	•	•	•	•	•	•	•					•	•		•															•					X			X																																						
VCO LOCKED 1, CH B	FAIL 11	•	•	•	•	•	•	•		X			•	•		•															•																		X	X	X	X																									
VCO LOCKED 1, CH A	FAIL 12	•	•	•	•	•	•	•	X				•	•		•															•					X	X	X	X																																						
VCO LOCKED 2, CH B	FAIL 13	•	•	•	•	•	•	•		•			•	•		•															•																		X	X	X	X																									
VCO LOCKED 2, CH A	FAIL 14	•	•	•	•	•	•	•	•				•	•		•															•					X	X	X	X																																						
SWEEP, CH B	FAIL 15	•	•	•	•	•	•	•					•	•	X	•															X																		•			X																									
SWEEP, CH A	FAIL 16	•	•	•	•	•	•	•					•	•	X	•															•					•			X																																						
OFFSET, CH B	FAIL 17	•	•	•	•	•	•						•	•		•									X	•	X	•	•	X		X	X			•			•																																						
OFFSET, CH A	FAIL 18	•	•	•	•	•	•						•	•		•									•	X	•	•	•	•		•	•			•			•																																						
OFFSET SWITCH, CH B	FAIL 19	•	•	•	•	•	•						•	•		•									•	•		•	X	•		•	•			•			•																																						
OFFSET SWITCH, CH A	FAIL 20	•	•	•	•	•	•						•	•		•									•		•	X	•	•		•	•			•			•																																						
AMPLITUDE, CH B	FAIL 21	•	•	•	•	•	•						•	•		•		X	•	X			X	X						•		•	X			•			•																																						
AMPLITUDE, CH A	FAIL 22	•	•	•	•	•	•						•	•		•		X	X	•			•	•						•		•	•			•			•																																						
SQUARE SWITCH, CH B	FAIL 23	•	•	•	•	•	•						•	•		•		•	•				•	X						•		•	•			•			•																																						
SQUARE SWITCH, CH A	FAIL 24	•	•	•	•	•	•						•	•		•		•		•			X	•						•		•	•			•			•																																						
OUTPUT OFFSET, CH B	FAIL 25	•	•	•	•	•	•						•	•		•									•		•		•	•		•		X		•			•																				X	X				X	X													
OUTPUT OFFSET, CH A	FAIL 26	•	•	•	•	•	•						•	•		•									•	•		•		•		•		X								X	X				X	X																													
OUTPUT AMPLITUDE 1, CH B	FAIL 27	•	•	•	•	•	•	•		•		X	•	•		•		•		•				•	•		•		•	•	•	•		•		•			•										•	•	•	•	X	X	X		X	X	X	•		•	X	•													
OUTPUT AMPLITUDE 1, CH A	FAIL 28	•	•	•	•	•	•	•	•		X		•	•		•		•	•				•		•	•		•		•	•	•		•		•	•	•	•	X	X	X	X	•		•	X	•																													
OUTPUT AMPLITUDE 2, CH B	FAIL 29	•	•	•	•	•	•	•		•		•	•	•		•		•		•				X	•		•		•	X	•	•		•		•			•										•	•	•	•	•	•	•		•	•	•	X	X	•	•	•													
OUTPUT AMPLITUDE 2, CH A	FAIL 30	•	•	•	•	•	•	•	•		•		•	•		•		•	•				X		•	•		•		•	•	•		•		•	•	•	•	•	•	•	•	X	X	•	•	•																													

SERVICE SELF TESTS

● = suspect board; X = most likely failed board. Column headings give board number, suspect board and (schematic number).

REFERENCE, CONTROL, AND CALIBRATION (part 1)

NAME	ERROR CODE	A70 +5V SUPPLY (16)	A70 +15V SUPPLY (16)	A70 −15V SUPPLY (16)	A70 +5VFP SUPPLY (16)	A99 MOTHERBOARD (NO SCH.)	A50 8MHz PROC CLK SIGNAL (13)	A50 8MHz FRACN CLK SIGNAL (13)	A50 A 100kHz SIGNAL (13)	A50 B 100kHz SIGNAL (13)	A50 A 20MHz SIGNAL (13)	A50 B 20MHz SIGNAL (13)	A61 µP ADDRESS, MEMORY, INTERFACE (14a)	A61 INSTRUMENT BUS (14b)	A61 SWEEP LIMIT LATCHES (14b)	A62 KEYBOARD DISPLAY DRIVE, (15)	A62 KEYBOARD DECODE (15)
EXTERNAL AM, CH A	FAIL 31	●	●	●	●	●	●	●		●		●	●	●		●	
EXTERNAL AM, CH B	FAIL 32	●	●	●	●	●	●	●	●		●		●	●		●	
AMPLITUDE CAL 1, CH B	FAIL 33	●	●	●	●	●	●	●		●		●	●	●		●	
AMPLITUDE CAL 1, CH A	FAIL 34	●	●	●	●	●	●	●	●		●		●	●		●	
RESIDUAL OFS CAL 1, CH B	FAIL 35	●	●	●	●	●	●	●		●		●	●	●		●	
RESIDUAL OFS CAL 1, CH A	FAIL 36	●	●	●	●	●	●	●	●		●		●	●		●	
RESIDUAL OFS CAL 2, CH B	FAIL 37	●	●	●	●	●	●	●		●		●	●	●		●	
RESIDUAL OFS CAL 2, CH A	FAIL 38	●	●	●	●	●	●	●	●		●		●	●		●	
AMPLITUDE CAL 2, CH B	FAIL 39	●	●	●	●	●	●	●		●		●	●	●		●	
AMPLITUDE CAL 2, CH A	FAIL 40	●	●	●	●	●	●	●	●		●		●	●		●	
RESIDUAL OFS CAL 3, CH B	FAIL 41	●	●	●	●	●	●	●		●		●	●	●		●	
RESIDUAL OFS CAL 3, CH A	FAIL 42	●	●	●	●	●	●	●	●		●		●	●		●	
RESIDUAL OFS CAL 4, CH B	FAIL 43	●	●	●	●	●	●	●		●		●	●	●		●	
RESIDUAL OFS CAL 4, CH A	FAIL 44	●	●	●	●	●	●	●	●		●		●	●		●	
DC OFFSET CAL, CH B	FAIL 45	●	●	●	●	●	●	●		●		●	●	●		●	
DC OFFSET CAL, CH A	FAIL 46	●	●	●	●	●	●	●	●		●		●	●		●	
AMPLITUDE CAL 3, CH B	FAIL 47	●	●	●	●	●	●	●	●	●	●		●	●		●	
AMPLITUDE CAL 3, CH A	FAIL 48	●	●	●	●	●	●	●	●		●		●	●		●	
PHASE CAL 1	FAIL 49	●	●	●	●	●	●	●	●	●	●		●	●		●	
PHASE CAL 2	FAIL 50	●	●	●	●	●	●	●	●	●	●		●	●		●	

REFERENCE, CONTROL, AND CALIBRATION (part 2)

NAME	ERROR CODE	A22 A + B LEVEL CONTROL (8)	A22 CH A LEVEL (8)	A22 CH B LEVEL (8)	A22 CH A AMP MOD (8)	A22 CH B AMP MOD (8)	A22 CH A SQUARE SWITCH (8)	A22 CH B SQUARE SWITCH (8)	A21 READ DATA, STROBE CONTROL (7)	A21 CH A CONTROL, CH A OFFSET (7)	A21 CH B CONTROL, CH B OFFSET (7)	A21 CH A OFFSET SWITCH (7)	A21 CH B OFFSET SWITCH (7)	A36 VOLTAGE REFERENCE (12)	A36 FRACN DECODER (11f)	A36 CAL R/W LOGIC (12)	A36 LEVTEST/OFFTEST PATH (12)	A36 AMPLITUDE/OFFSET CAL PATH (12)	A36 PHASE CAL PATH (12)
EXTERNAL AM, CH A	FAIL 31	●		●		X		●	●		●		●	●	●	●		●	
EXTERNAL AM, CH B	FAIL 32	●	●		X		●		●	●		●		●	●	●		●	
AMPLITUDE CAL 1, CH B	FAIL 33	●		X				●	●		●		●	●	●	●		X	
AMPLITUDE CAL 1, CH A	FAIL 34	●	X				●		●	●		●		●	●	●		X	
RESIDUAL OFS CAL 1, CH B	FAIL 35	●		●				●	●		X		●	●	●	●		●	
RESIDUAL OFS CAL 1, CH A	FAIL 36	●	●				●		●	X		●		●	●	●		●	
RESIDUAL OFS CAL 2, CH B	FAIL 37	●		●				●	●		●		●	●	●	●		●	
RESIDUAL OFS CAL 2, CH A	FAIL 38	●	●				●		●	●		●		●	●	●		●	
AMPLITUDE CAL 2, CH B	FAIL 39	●		●				●	●		●		●	●	●	●		●	
AMPLITUDE CAL 2, CH A	FAIL 40	●	●				●		●	●		●		●	●	●		●	
RESIDUAL OFS CAL 3, CH B	FAIL 41	●		●				●	●		●		●	●	●	●		●	
RESIDUAL OFS CAL 3, CH A	FAIL 42	●	●				●		●	●		●		●	●	●		●	
RESIDUAL OFS CAL 4, CH B	FAIL 43	●		●				●	●		●		●	●	●	●		●	
RESIDUAL OFS CAL 4, CH A	FAIL 44	●	●				●		●	●		●		●	●	●		●	
DC OFFSET CAL, CH B	FAIL 45	●		●				●	●		X		●	●	●	●		●	
DC OFFSET CAL, CH A	FAIL 46	●	●				●		●	X		●		●	●	●		●	
AMPLITUDE CAL 3, CH B	FAIL 47	●		●				●	●		●		●	●	●	●		●	
AMPLITUDE CAL 3, CH A	FAIL 48	●	●				●		●	●		●		●	●	●		●	
PHASE CAL 1	FAIL 49	●	●	●			●	●	●	●	●	●	●	●	●	●			X
PHASE CAL 2	FAIL 50	●	●	●			●	●	●	●	●	●	●	●	●	●			X

CHANNEL A

NAME	ERROR CODE	A31 CH A VCO (11a)	A32 CH A VCO CONTROL (11b)	A33 CH A PHASE DETECTOR (11c)	A34 CH A FRACN DIGITAL (11d)	A35 CH A VCO ÷ 2 (11e)	A6 CH A MODULATOR (6)	A5 CH A MIXER (5)	A4 CH A PREAMP (4)	A4 CH A SIN/SQ MODE RELAY (4)	A23 CH A SQUARE PATH (9)	A3 CH A 10dB PAD AND DRIVER (3)	A3 CH A OUTPUT AMP (3)	A2 CH A ATTENUATOR (2a)
EXTERNAL AM, CH A	FAIL 31	●			●									
EXTERNAL AM, CH B	FAIL 32	●	●	●	●	●	●	●	●	●		●	●	●
AMPLITUDE CAL 1, CH B	FAIL 33	●			●									
AMPLITUDE CAL 1, CH A	FAIL 34	●	●	●	●	●	X	●	●	●		●	●	●
RESIDUAL OFS CAL 1, CH B	FAIL 35	●			●									
RESIDUAL OFS CAL 1, CH A	FAIL 36	●	●	●	●	●	●	X	●	●		●	●	●
RESIDUAL OFS CAL 2, CH B	FAIL 37	●			●									
RESIDUAL OFS CAL 2, CH A	FAIL 38	●	●	●	●	●	●	●	●	●		X	●	●
AMPLITUDE CAL 2, CH B	FAIL 39	●			●									
AMPLITUDE CAL 2, CH A	FAIL 40	●	●	●	●	●	●	●	●	●	X	●	●	●
RESIDUAL OFS CAL 3, CH B	FAIL 41	●			●									
RESIDUAL OFS CAL 3, CH A	FAIL 42	●	●	●	●	●	●	●	●	●	X	●	●	●
RESIDUAL OFS CAL 4, CH B	FAIL 43	●			●									
RESIDUAL OFS CAL 4, CH A	FAIL 44	●	●	●	●	●	●	●	●	●	●	●	●	●
DC OFFSET CAL, CH B	FAIL 45	●			●									
DC OFFSET CAL, CH A	FAIL 46	●	●	●	●	●	●	●	●	●		●	●	●
AMPLITUDE CAL 3, CH B	FAIL 47	●	●	●	●	●								
AMPLITUDE CAL 3, CH A	FAIL 48	●	●	●	●	●	●	●	●	●		●	●	●
PHASE CAL 1	FAIL 49	●	●	X	X	●	●	●	●	●		●	●	●
PHASE CAL 2	FAIL 50	●	●	X	X	●	●	●	●	●		●	●	●

CHANNEL B

NAME	ERROR CODE	A41 CH B VCO (11a)	A42 CH B VCO CONTROL (11b)	A43 CH B PHASE DETECTOR (11c)	A44 CH B FRACN DIGITAL (11d)	A45 CH B VCO ÷ 2 (11e)	A24 SWITCH CONTROLLER (10)	A24 TWO-CHANNEL MODE PATH (10)	A24 TWO-PHASE MODE PATH (10)	A16 CH B MODULATOR (8)	A15 CH B MIXER (5)	A14 CH B PREAMP (4)	A14 CH B SIN/SQ MODE RELAY (4)	A23 CH B SQUARE PATH (9)	A13 CH B 10dB PAD AND DRIVER (3)	A13 CH B OUTPUT AMP (3)	A12 CH B ATTENUATOR (2b)
EXTERNAL AM, CH A	FAIL 31	●	●	●	●	●	●	●		●	●	●	●		●	●	●
EXTERNAL AM, CH B	FAIL 32																
AMPLITUDE CAL 1, CH B	FAIL 33	●	●	●	●	●	●	●		X	●	●	●		●	●	●
AMPLITUDE CAL 1, CH A	FAIL 34						●	●									
RESIDUAL OFS CAL 1, CH B	FAIL 35	●	●	●	●	●	●	●		●	X	●	●		●	●	●
RESIDUAL OFS CAL 1, CH A	FAIL 36						●	●									
RESIDUAL OFS CAL 2, CH B	FAIL 37	●	●	●	●	●	●	●		●	●	●	●		X	●	●
RESIDUAL OFS CAL 2, CH A	FAIL 38						●	●									
AMPLITUDE CAL 2, CH B	FAIL 39	●	●	●	●	●	●	●		●	●	●	●	X	●	●	●
AMPLITUDE CAL 2, CH A	FAIL 40						●	●									
RESIDUAL OFS CAL 3, CH B	FAIL 41	●	●	●	●	●	●	●		●	●			X	●	●	●
RESIDUAL OFS CAL 3, CH A	FAIL 42						●	●									
RESIDUAL OFS CAL 4, CH B	FAIL 43	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●
RESIDUAL OFS CAL 4, CH A	FAIL 44						●	●									
DC OFFSET CAL, CH B	FAIL 45	●	●	●	●	●	●	●		●	●	●	●		●	●	●
DC OFFSET CAL, CH A	FAIL 46						●	●									
AMPLITUDE CAL 3, CH B	FAIL 47	●	●	●	●	●	X		X	●	●	●	●		●	●	●
AMPLITUDE CAL 3, CH A	FAIL 48						●		●								
PHASE CAL 1	FAIL 49	●	●	X	X	●	●		●	●	●	●	●		●	●	●
PHASE CAL 2	FAIL 50	●	●	X	X	●	●		●	●	●	●	●		●	●	●

UNTESTED AREAS

NAME	ERROR CODE	A70 +28V, −28V SUPPLIES (16)	A70 +5VHPIB SUPPLY (16)	A61 HP-IB INTERFACE (14c)	A32 CH A PHASE MODULATION (11b)	A42 CH B PHASE MODULATION (11b)	A23 PULSE PATH (9)	A2 CH A COMBINER RELAY (2a)	A12 CH B COMBINER/INT MOD RELAY (2b)	A62 SYNC (15)	A63 HP-IB SUPPORT (14c)	A80 OVEN REFERENCE (OPTION 001) (19)	A1 CH A HV AMP (OPTION 002) (1)	A11 CH B HV AMP (OPTION 002) (1)
EXTERNAL AM, CH A	FAIL 31													
EXTERNAL AM, CH B	FAIL 32													
AMPLITUDE CAL 1, CH B	FAIL 33													
AMPLITUDE CAL 1, CH A	FAIL 34													
RESIDUAL OFS CAL 1, CH B	FAIL 35													
RESIDUAL OFS CAL 1, CH A	FAIL 36													
RESIDUAL OFS CAL 2, CH B	FAIL 37													
RESIDUAL OFS CAL 2, CH A	FAIL 38													
AMPLITUDE CAL 2, CH B	FAIL 39													
AMPLITUDE CAL 2, CH A	FAIL 40													
RESIDUAL OFS CAL 3, CH B	FAIL 41													
RESIDUAL OFS CAL 3, CH A	FAIL 42													
RESIDUAL OFS CAL 4, CH B	FAIL 43													
RESIDUAL OFS CAL 4, CH A	FAIL 44													
DC OFFSET CAL, CH B	FAIL 45													
DC OFFSET CAL, CH A	FAIL 46													
AMPLITUDE CAL 3, CH B	FAIL 47													
AMPLITUDE CAL 3, CH A	FAIL 48													
PHASE CAL 1	FAIL 49													
PHASE CAL 2	FAIL 50													

Examples

You have completed steps 1 and 2 of the five step process — you have run the service self tests and compiled a list of all test failures. Here are several examples of how to process the information.

A. Service self test results: FAIL 47, 49, 50.

The first test that failed was test 47, Amplitude Cal 3, Ch B. Table 6-9 indicates that the switch controller and two-phase mode path of the RF switch board (A24) are the most likely suspect circuits. Remember that any of the circuits that are exercised in the test are suspects — A24 is simply the most likely suspect.

Now look at tests 49 and 50. Try to find correlations. Notice that the same circuits in the RF switch board are used in both of them. EVERY test that failed used the two suspect circuits. They must be defective. Go directly to board level repair.

B. Display reads: ERROR 174 BVCO. Service self test results: FAIL 11, 13, 27, 29, 31, 33, 35, 37, 39, 41, 43, 47, 49, 50.

The first test that failed was test 11, VCO Locked 1, Ch B. Table 6-9 indicates that the channel B VCO board (A41), VCO control board (A42), phase detector board (A43), fractional-N digital board (A44), and B 100kHz signal from the reference board (A50) are the most likely suspect circuits. Remember that any of the circuits that are exercised in the test are suspects — these are simply the most likely suspects.

Now look at the other tests that failed. Try to find correlations. Notice that test 13 used all of the suspect circuits. Test 27 does, too. All of the tests that failed use all of the suspect circuits. We cannot make the list of suspects any shorter by using Table 6-9.

Should we begin troubleshooting at the fractional-N circuits or the reference board? Which is really defective? Consult Table 6-14, Fault Isolation Tests, to determine which boards are working properly. Start with the board first in the table — the reference board (A50). If A50 is working correctly, then perform the test for the fractional-N boards.

After you find the defective board, proceed with board level repair.

C. Service self test results: FAIL 26, 28, 30, 42, 34, 36, 38, 40, 42, 44, 46, 48, 49, 50.

The first test that failed was test 26, Output Offset, Ch A. Table 6-9 indicates that the channel A attenuator (A2), output amplifier (A3), preamplifier (A4), mixer (A5), and amplitude/offset calibration path of the calibrator (A36) are the most likely suspect circuits. Remember that any of the circuits that are exercised in the test are suspects — these are simply the most likely suspects.

6-8 SELF TEST ERROR CODES

This sub-section outlines self test error codes. Table 6-9 lists the errors that occur when a user self test or a service self test fails (the user self tests are a subset of the service self tests). Always run the service self tests in the beginning of fault isolation since they isolate most instrument failures to a defective circuit. Table 6-10 lists the errors that occur when a continuously monitored parameter test fails. These tests provide information about operator errors as well as instrument failures. **When a hardware failure message appears, run the service self tests to get detailed troubleshooting information.**

Table 6-7 lists the steps required to run the self tests. Details of the self tests can be found in this section under the sub-sections entitled "User Self Tests," "Continuously Monitored Parameters," and "Service Self Tests." Table 6-8 lists the keystrokes required for local operation of the service self tests.

Table 6-7. HP 3326A Self Tests

Self Tests	Action Required
User Self Tests	Cycle power or push the blue SHIFT key followed by the SELECT key in the CALIBRATION block.
Continuously Monitored Parameters	None.
Service Self Tests	Push the blue SHIFT key, the % units key, and the 6 key, in sequence.

Table 6-8. Service Self Tests Execution

Key	Result
[SHIFT] [ ] dBV/% [6]	Initiates service self tests.
Any key (except [SHIFT])	Restarts the tests after one has failed and the testing has stopped.
[LOCAL]	Repeats the most recently executed test.
[SHIFT]	Stops self test execution.

What is Table 6-9? What do the symbols mean?

The vertical axis of Table 6-9 lists the 50 internal service self tests by failure code and test name, in the order that they are run. The horizontal axis lists the different circuits found in the HP 3326A, grouped into channel A and channel B circuits; reference, control, and calibration circuits; and untested areas. These circuits listed can be grouped into five categories:

- Entire PC boards, e.g., the channel A mixer board (A5). It is most useful to consider this board as serving one function.
- Functional sub-blocks on a PC board, e.g., the channel A level sub-block on the level/AM board. Since it is used only for the channel A amplitude tests, it is most useful to separate it from the channel B circuitry on the A22 board, and help quicken fault isolation between the channels.
- Analog switches or relays on a PC board, e.g., the channel B square switch on the A22 board. One of the self tests specifically exercises this switch. The table is most useful when this switch is separated from the rest of the circuitry.
- Signals generated on a PC board, e.g., the 8MHz PROC CLK signal from the reference board (A50). Instead of outlining the functional sub-blocks needed and running the risk of being too ambiguous, it is more useful to state the signal required. The schematic shows which sub-blocks are needed to produce the signal.
- Certain key signal paths on a PC board, e.g., the amplitude/offset calibration path on the calibrator board (A36). The calibrator board contains several different signal paths which use common circuitry in different ways. To give you a better understanding of how the circuit is being exercised in a given test, the board is divided into signal paths.

There are two symbols used on Table 6-9 — the ● and the ✖ . When either of these symbols is entered on the table, it indicates that the self test exercises that particular circuit. To say that a circuit was "exercised" means that a circuit was "used" in the test. It could mean that the circuit was used to its limit and fully tested. Or it could mean that the circuit was used only to let the main signal pass through to another circuit.

When the symbol used on Table 6-9 is a ✖ , it indicates that it is the FIRST time in the service self tests that the particular circuit is FULLY exercised. Notice that in some cases a particular circuit is highlighted several times, indicating that several distinct functions or portions of the circuit are tested at separate times.

Take the fractional-N decoder circuit (A36) as an example. In test 7, the instrument bus interface portion of the circuit is tested for the first time. Thus, it is highlighted. Then, test 9 exercises the ability of the circuit to write frequencies to the fractional-N IC for the first time. It is highlighted. Test 10 exercises the same circuitry, so it is given the ● symbol, indicating that the circuit is used and could be the cause of a failure, but it is NOT the first time in the service self tests that it was exercised.

The ● symbol indicates one of two things — either it is at least the SECOND time that the circuit is exercised in one particular manner, or the likelihood of the circuit causing a failure of the particular self test is very LOW. For example, the motherboard (A99) is needed for every test to run, but the likelihood of it causing a self test failure is very low.

How to Use Table 6-9

Using Table 6-9 is an easy, five step process (Figure 6-9).

1. **Start the service self tests.** Press: [SHIFT] [ ] dBV/% [6]
2. **List all self test failures.** In manual operation, press any key (except the blue [SHIFT] key) to resume testing after a failure has occurred. See Table 6-8.

Now look at the other tests that failed. Try to find correlations. Notice that test 28 uses all of the suspect circuits, and that several of these circuits are highlighted again, indicating that different functions of the circuits are tested. (Note that the A 20MHz signal from the reference board (A50) is highlighted also. It is probably not defective, however, since we are assuming that there is only one failure at a time. A 20MHz is not used in the first test that failed. This implies that it CANNOT be the defective circuit.) The rest of the tests that failed use all of the suspect circuits. The suspect circuit list remains as is.

Where should we begin troubleshooting? Which board is really defective? Consult Table 6-14, Fault Isolation Tests, to determine which boards are working properly. Start with the board first in the table — the mixer board (A5). If A5 is working correctly, then perform the test for the preamplifier board, and so on.

After you find the defective board, proceed with board level repair.

D. Service self test results: FAIL 33, 47.

The first test that failed was test 33, Amplitude Cal 1, Ch B. Table 6-9 indicates that the channel B modulator board (A16), the channel B level circuit on the level/AM board (A22), and the amplitude/offset calibration path on the calibrator board (P/O A36) are the most likely suspects. Remember that any of the circuits that are exercised in the test are suspects — these are simply the most likely suspects.

NOTE

This is the second time in Table 6-9 that A16 and the channel B level circuit on A22 have been highlighted, and the third time that the amplitude/offset calibration path on A36 has been highlighted. The first time the circuits were tested, they were checked for function only. The calibration tests check for the circuits meeting specification.

Now look at the other test that failed, Test 47. Try to find correlations. Test 47, Amplitude Cal 3, Ch B, exercises all of the suspect circuits. We cannot make the list of suspects shorter by using Table 6-9.

Where should we begin troubleshooting? Which board is really defective? By consulting Figure 6-10, Instrument Turn-on Hierarchy Flow Chart, we find that the channel B level circuit on the level/AM board (A22) is the highest in the turn-on hierarchy. The modulator depends on an input from A22. The calibrator board (P/O A36) depends on an input from the entire channel B chain, including the modulator and the level/AM boards. We should test A22, then A16, then A36.

Consult Table 6-14, Fault Isolation Tests. Notice that the table has no procedures for testing A22 or A36. It only has a procedure for testing the function of A16. It is not going to be easy to isolate this instrument failure. It involves a subtle performance problem.

Look at the format of the self tests. They test channel B first, then channel A. Notice that the channel B modulator board has a duplicate in channel A. **Try interchanging the two identical boards** (A6 and A16), and see if the subtle performance problem moves to channel A. If the failure follows the channel B board (A16), it is defective. Go to the board level repair sub-section.

If the failure stays in channel B (remember the channel A board is in channel B now), the problem is probably NOT with the modulator, but with A22 or A36. You must go to the board level repair sub-sections for these two boards to find the answer.

CAUTION

Two identical boards may be interchanged for troubleshooting, but must be returned to their original locations to avoid recalibration of the instrument.

Before interchanging boards, be sure that the correct voltages are being supplied to the board. If a board failure was caused by incorrect voltages powering the board, interchanging boards will only result in a failure of the second board.

6-9 USER SELF TESTS

The HP 3326A performs the user self tests when power is first applied to the instrument and when the blue SHIFT key is pressed prior to the SELECT key. First, the instrument displays the model number and the numbers of the installed options. For example, "3326A OP. 1 2" is displayed when both the oven reference and high voltage options are in place. Then, the first 14 of the 50 service self tests are attempted. See the "Service Self Tests" sub-section for complete test descriptions.

When one of the tests fails, an error code of the form "FAIL nn" appears on the display. See Table 6-9 for a list of the error codes and the probable boards that caused the failure. These error codes flash for only a few seconds, then the instrument tries to operate. Initiate the service self tests for a more rigorous instrument test.

6-10 CONTINUOUSLY MONITORED PARAMETERS

Several hardware fault conditions and operator programming parameters are continuously monitored while the HP 3326A is operating. Error messages are displayed in the form "ERROR nnn, XXXX", where "nnn" represents a numeric display and "XXXX" represents a four character display. The tests are listed by these error messages in Table 6-10.

It is recommended that the service self tests be run before initiating any board level repair since these tests give you the most detailed troubleshooting information. See "Service Self Tests" sub-section.

Table 6-10. Error Codes for Continuously Monitored Parameters

ERROR#	FRONT PANEL ALPHA	ERROR DESCRIPTION
10	SNTX	Illegal HP-IB code syntax
11	RMOT	Front panel keypress in remote
12	LOCK	LOCAL key pressed in local lockout
20-29	RNGE	Entered parameter out of range
30	B FR	Channel B cannot track Channel A in Two-Tone/HV on
40-49	INTR	Cannot interrogate or display parameter
50	CNVT	Units conversion rounded to zero
60-69	SUFX	Illegal units terminator
70	INC	Entry increment value or terminator error
80	AMPL	Incompatible with amplitude
86	MODL	Incompatible with modulation
87	MODE	Incompatible with mode
88	FREQ	Incompatible with frequency
89	CMBR	Incompatible with combiner
90	SWFR	Start and stop frequencies equal
94	DUTY	Pulse duty cycle too narrow
95	SWFR	Illegal sweep frequencies for HV option
96	SWFR	Illegal sweep frequency for internal modulation
100	RATE	Illegal sweep rate
110-114	DSWP	Illegal discrete sweep due to mode or lack of elements
115	DSHV	Illegal discrete sweep frequency with HV option
116	DSML	Illegal discrete sweep frequency with modulation
117	DSMD	Mode changed after discrete frequency sweep elements entered
120	P OF	Cannot clear Channel A Phase Offset
130-139	H V	Cannot program High Voltage option
140	CSUM	Checksum error indicates bad instrument state
150	———	Requested state is incompatible
160	CRPT	Corrupted power-on state is preset
170	A OL	Channel A overloaded
171	B OL	Channel B overloaded
172	SYOL	Sync output overloaded
173	AVCO	Channel A VCO unlocked
174	BVCO	Channel B VCO unlocked
180	XREF	External Reference unlocked
190	MCAL	Internal AM or PM cal unsuccessful
191	PCAL	Phase cal unsuccessful
192	ACAL	Amplitude cal unsuccessful
193	OCAL	DC Offset cal unsuccessful
194	OCAL	Residual Offset cal unsuccessful

6-11 SERVICE SELF TESTS

The service self tests in the HP 3326A are designed to provide you with very thorough and flexible internal testing capabilities. The service self tests, in conjunction with the fault isolation tests, isolate most faults to a defective board very quickly. Use this powerful serviceability feature EVERY time an instrument needs a repair. See the introduction to the "Self Test Error Codes" sub-section for examples.

A detailed description of each test is included in this sub-section. Error messages are given in Table 6-9.

Local Operation

The self tests are initiated by pressing the blue SHIFT key, the % unit key, and the 6 key, in sequence. When a test passes, "PASS nn" is displayed. When an instrument fails a test, an error message of the form "FAIL nn" ("nn" corresponds to the number of the service self test which failed) appears on the display. See Table 6-9, Service Self Tests Error Codes. Any error code stops the test sequence. Pressing any key (except the blue SHIFT key) causes the testing to resume on the next test in the sequence. The most recently executed self test repeats when the LOCAL key is pressed. Pressing the blue SHIFT key causes the instrument to stop executing the self test and return to normal operation. This information is summarized in Figure 6-11.

Table 6-11. Service Self Tests Execution

Key	Result
[SHIFT] [ ] dBV/% [6]	Initiates service self tests.
Any key (except [SHIFT])	Restarts the tests after one has failed and the testing has stopped.
[LOCAL]	Repeats the most recently executed test.
[SHIFT]	Stops self test execution.

Remote Operation

The HP 3326A can run the service self tests over the HP-IB. Table 6-12 lists the commands required. Connect the HP 3326A to a controller and a printer. When the appropriate command is sent over the HP-IB, the instrument performs all of the self tests and displays the results in the form of a character string of Ps and Fs. The result is a string of 14 characters for the user self tests and 50 characters for the service self tests — one character for each test performed, in numeric order. A "P" indicates the test passed, an "F" indicates the test failed.

Table 6-12. Remote Self Test Operation

Self Tests	HP-IB Command
User Self Tests	TST
Service Self Tests	XTST

The Basics

Certain circuits need to be functioning for the service self tests to be able to run. These include:

- The 8MHz PROC CLK signal produced by the reference board (A50).
- The microprocessor, address decoding, memory, and keyboard interface functional sub-blocks on the controller board (A61). (Note that the non-maskable interrupt line (NMI) is disabled throughout the self tests.)

- The keyboard display row drive and keyboard display column drive sub-blocks on the keyboard (A72).
- The +5V, +15V, −15V, and +5VFP supplies on the power supply board (A70).

When these circuits are functioning, the self test can run. The date of the software revision installed in the instrument appears on the display, and the self tests of the instrument begin.

NOTE

*Each self test description includes a list of the circuits **specifically** exercised by the test. The list corresponds to those circuits marked with a ✖ on Table 6-9. It does NOT include circuits exercised by a test earlier in the self test sequence. This information may be found by consulting Table 6-9, Service Self Tests Error Codes.*

Self Test 01, LED

This test turns on all LED segments, shifts a known pattern through the front panel, and checks for errors.

All of the basic circuits needed for the self tests to operate (see "The Basics" above) are exercised, in addition to the keyboard decode sub-block on the keyboard (A62).

Self Test 02, Stuck Key

This test scans the keyboard (A62) to see if any keys are pressed. Any key which appears to be pressed is considered an error.

This test exercises the keyboard decode, keyboard display row drive, and keyboard display column drive sub-blocks on the keyboard, and the microprocessor, address decoding, memory, and keyboard interface sub-blocks on the controller (A61).

Self Test 03, NMOS RAM

This test stores ones and zeros in the NMOS RAM (memory locations Hex 800 to Hex FFF), and reads this data back from the memory locations. A failure indicates the data read back were incorrect. After the test, the previous RAM contents are restored.

This test exercises A61U303, the microprocessor, address decoding, memory, and keyboard interface sub-blocks on the controller (A61).

Self Test 04, CMOS RAM

This test stores ones and zeros in the CMOS RAM (memory locations Hex 1000 to Hex 17FF), and reads this data back from the memory locations. A failure indicates the data read back were incorrect. After the test, the previous RAM contents are restored.

This test exercises A61U302, the microprocessor, address decoding, memory, and keyboard interface sub-blocks on the controller (A61).

Self Test 05, ROM 1

This test performs a checksum test of ROM #1 (memory locations Hex 1800 to Hex 7FFF), using the preset conditions. A failure indicates the checksums that were calculated were incorrect. After the test, the previous ROM contents are restored.

This test exercises A61U305, the microprocessor, address decoding, memory, and keyboard interface sub-blocks on the controller (A61).

Self Test 06, ROM 2

This test performs a checksum test of ROM #2 (memory locations Hex 8000 to Hex FFFF), using the preset conditions. A failure indicates the checksums that were calculated were incorrect. After the test, the previous ROM contents are restored.

This test exercises A61U306, the microprocessor, address decoding, memory, and keyboard interface sub-blocks on the controller (A61).

Self Test 07, IBUS

This test uses the instrument bus (IBUS0-7) to write various data to and to read the data from a register on the calibrator board (A36). The test fails if the data do not match.

This test specifically exercises the instrument bus sub-block on the controller (A61) and the calibrator read/write logic sub-block on the calibrator/fractional-N decoder board (A36). When the test fails, these circuits could be at fault. The test could also fail, however, if one of the other boards on the instrument bus is pulling down the bus. Hence, the switch controller sub-block on the RF switch board (A24), the A + B level control sub-block on the level/AM board (A22), the read data sub-block on the offset board (A21), the channel A fractional-N digital board (A34), and the channel B fractional-N digital board (A44) are highlighted on Table 6-9.

If this test passes, the instrument bus interface between the controller board and the calibrator board is working properly. The other boards that are highlighted above are NOT pulling down the instrument bus. (No other statement can be made about the functionality of these boards. The individual instrument bus interfaces may still be defective.)

Self Test 08, A2 Positioning

This test checks to see if the channel A attenuator (A2) is in the channel A card nest by using a flag signal ($\overline{\text{A2FLAG}}$). (Recall that A2 and A12 may be interchanged for troubleshooting, but must be returned to their original slots for normal operation.) $\overline{\text{A2FLAG}}$ travels to the channel B fractional-N digital board (A44), goes through some buffering circuitry, and is sent to the controller via the instrument bus. A failure of this test either indicates that the channel B attenuator board (A12) is in the channel A card nest or that there is no board in the channel A card nest or the latch on A44 is defective.

Self Test 09, FracN Digital, Ch B

This test writes data to the channel B fractional-N IC (A44U18), and reads back the data. A failure indicates the returned data are not correct.

This test exercises the channel B VCO board (A41), the channel B fractional-N digital board (A44), and the fractional-N decoder board (P/O A36). The decoder board needs the 8MHz FRACN CLK signal from the reference board (A50).

If this test passes, the input/output path from A36 to the fractional-N IC is functional. The VCO signal from A41 is present on A44. A41 is generating a signal in the 40 to 66 MHz range, but may not be exactly correct. The instrument bus interface circuit on A44 is working properly.

Self Test 10, FracN Digital, Ch A

This test writes data to the channel A fractional-N IC (A34U18), and reads back the data. A failure indicates the returned data are not correct.

This test exercises the channel A VCO board (A31) and the channel A fractional-N digital board (A34).

If this test passes, the input/output path from A36 to the fractional-N IC is functional. The VCO signal from A31 is present on A34. A31 is generating a signal in the 40 to 66 MHz range, but may not be exactly correct. The instrument bus interface circuit on A34 is working properly.

Self Test 11, VCO Locked 1, Ch B

This test exercises the low frequency range of the channel B local oscillator. The VCO is set to 30 MHz (outside the allowed frequency range), and an unlocked condition is expected. Then, the VCO is set to 39.8 MHz (within the allowed frequency range), and a locked condition is expected. (See the VCO UNLOCKED LED on A42.) A failure is indicated when these conditions are not met (i.e., the VCO unlocked detector is working incorrectly or the fractional-N loop is unlocked).

This test exercises A41, A42, A43, and A44. The B 100kHz signal from the reference board (A50) is also required.

If this test passes, the VCO control voltage (B VCO CONT) is changing correctly. The VCO unlocked detector (B VCOF) is working correctly.

Self Test 12, VCO Locked 1, Ch A

This test exercises the low frequency range of the channel A local oscillator. The VCO is set to 30 MHz (outside the allowed frequency range), and an unlocked condition is expected. Then, the VCO is set to 40 MHz (within the allowed frequency range), and a locked condition is expected. (See the VCO UNLOCKED LED on A32.) A failure is indicated when these conditions are not met (i.e., the VCO unlocked detector is working incorrectly or the fractional-N loop is unlocked).

This test exercises A31, A32, A33, and A34. The A 100kHz signal from the reference board (A50) is also required.

If this test passes, the VCO control voltage (A VCO CONT) is changing correctly. The VCO unlocked detector (A VCOF) is working correctly.

Self Test 13, VCO Locked 2, Ch B

This test exercises the high frequency range of the channel B local oscillator. The VCO is set to 90 MHz (outside the allowed frequency range), and an unlocked condition is expected. Then, the VCO is set to 66 MHz (within the allowed frequency range), and a locked condition is expected. (See the VCO UNLOCKED LED on A42.) A failure is indicated when these conditions are not met (i.e., the VCO unlocked detector is working incorrectly or the fractional-N loop is unlocked).

This test exercises A41, A42, A43, and A44.

If this test passes, the VCO control voltage (B VCO CONT) is changing correctly. The VCO unlocked detector (B VCOF) is working correctly.

Self Test 14, VCO Locked 2, Ch A

This test exercises the high frequency range of the channel A local oscillator. The VCO is set to 90 MHz (outside the allowed frequency range), and an unlocked condition is expected. Then, the VCO is set to 66 MHz (within the allowed frequency range), and a locked condition is expected. (See the VCO UNLOCKED LED on A32.) A failure is indicated when these conditions are not met (i.e., the VCO unlocked detector is working incorrectly or the fractional-N loop is unlocked).

This test exercises A31, A32, A33, and A34.

If this test passes, the VCO control voltage (A VCO CONT) is changing correctly. The VCO unlocked detector (A VCOF) is working correctly.

Self Test 15, Sweep, Ch B

This test exercises the channel B fractional-N local oscillator by producing two short sweeps. Both sweeps start at 0 Hz, sweep at a rate of 1 MHz per 100 ms, and have a marker frequency of 1 MHz. In the first sweep, the local oscillator is configured to sweep past the marker frequency; in the second sweep, the local oscillator is configured to stop at the marker frequency. Six tests are made — all must pass for the self test to pass. First, the sweep limit flag for channel B (B SWEEP LIMIT) is checked 50 ms after the start of each sweep to make sure it is high. Second, B SWEEP LIMIT is checked 150 ms after the start of each sweep to make sure it is low. Third, the terminal frequencies 150 ms after the two sweeps are checked to make sure that they are, respectively, not equal to 1 MHz and equal to 1 MHz.

This test exercises the channel B fractional-N digital board (A44, primarily the sweep and sweep limit circuits, B SWPL, and B SWEEP LIMIT), the fractional-N decoder board (P/O A36), and the sweep limit latches on the controller board (A61, B SWEEP LIMIT). The channel B phase detector board (A43) is NOT needed. (The channel B VCO board (A41) is needed, but performs the same functions that were exercised in former tests.)

Self Test 16, Sweep, Ch A

This test exercises the channel A fractional-N local oscillator by producing two short sweeps. Both sweeps start at 0 Hz, sweep at a rate of 1 MHz per 100 ms, and have a marker frequency of 1 MHz. In the first sweep, the local oscillator is configured to sweep past the marker frequency; in the second sweep, the local oscillator is configured to stop at the marker frequency. Six tests are made — all must pass for the self test to pass. First, the sweep limit flag for channel A (A SWEEP LIMIT) is checked 50 ms after the start of each sweep to make sure it is high. Second, A SWEEP LIMIT is checked 150 ms after the start of each sweep to make sure it is low. Third, the terminal frequencies 150 ms after the two sweeps are checked to make sure that they are, respectively, not equal to 1 MHz and equal to 1 MHz.

This test exercises the channel A fractional-N digital board (A34, primarily the sweep and sweep limit circuits, A SWPL, and A SWEEP LIMIT), and the sweep limit latches on the controller board (A61, A SWEEP LIMIT). The channel A phase detector board (A33) is NOT needed. (The channel A VCO board (A31) is needed, but performs the same functions that were exercised in former tests.)

Self Test 17, Offset, Ch B

This test sends a set of incrementing values to the channel B offset digital to analog converter (DAC) on the offset board (A21). (The channel A DAC is set to the middle of the scale, corresponding to 0 V.) The calibrator board (P/O A36) measures the result at the point OFFTEST on A21. To pass, the output voltage must be an increasing function of the channel B DAC setting.

This test exercises the offset board's control circuits (read data and strobe control sub-blocks) and channel B offset DAC (channel B control and channel B offset sub-blocks), and the calibrator board's voltage reference and calibrator read/write logic sub-blocks, and LEVTEST/OFFTEST path. (The calibrator board needs the $\overline{\text{A DLBC}}$ signal from the channel A fractional-N digital board (A34). It is used as a clock for the analog to digital converter. Hence, the A34 and A31 boards are marked on Table 6-9, but not highlighted.)

Self Test 18, Offset, Ch A

This test sends a set of incrementing values to the channel A offset digital to analog converter (DAC) on the offset board (A21). (The channel B DAC is set to the middle of the scale, corresponding to 0 V.) The calibrator board (P/O A36) measures the result at the point OFFTEST on A21. To pass, the output voltage must be an increasing function of the channel A DAC setting.

This test exercises the offset board's channel A offset DAC (channel A control and channel A offset sub-blocks).

Self Test 19, Offset Switch, Ch B

This test repeats self test 17 (offset, channel B) while the channel B high voltage option is activated. To pass, there must be no activity at the point OFFTEST on the offset board (A21). (Recall that the offset output is sent to the channel B high voltage amplifier board (A11), instead of the channel B output amplifier (A13), when the high voltage option is activated, and does not pass through the point OFFTEST.)

This test exercises the channel B offset switch on A21 (A21K21). A11 is NOT needed for this test to pass.

Self Test 20, Offset Switch, Ch A

This test repeats self test 18 (offset, channel A) while the channel A high voltage option is activated. To pass, there must be no activity at the point OFFTEST on the offset board (A21). (Recall that the offset output is sent to the channel A high voltage amplifier board (A1), instead of the channel A output amplifier (A3), when the high voltage option is activated, and does not pass through the point OFFTEST).

This test exercises the channel A offset switch on A21 (A21K1). A1 is NOT needed for this test to pass.

Self Test 21, Amplitude, Ch B

This test sends a set of incrementing values to the channel B level digital to analog converter (DAC) on the level/AM board (A22). (The channel A DAC is set to 20 dB below its highest value.) The calibrator board (P/O A36) measures the result at the point LEVTEST on A22. To pass, the output voltage must be an increasing function of the channel B DAC setting.

This test exercises the level/AM board's A + B level control and channel B level sub-blocks, and the calibrator board's LEVTEST/OFFTEST path. The channel A and channel B square switches on A22 are used to send the B SINLEV signal to the channel B modulator board (A16), instead of sending the B SQLEV signal to the square board (A23). See the overall block diagram.

Self Test 22, Amplitude, Ch A

This test sends a set of incrementing values to the channel A level digital to analog converter (DAC) on the level/AM board (A22). (The channel B DAC is set to 20 dB below its highest value.) The calibrator board (P/O A36) measures the result at the point LEVTEST on A22. To pass, the output voltage must be an increasing function of the channel B DAC setting.

This test exercises the level/AM board's A + B level control and channel A level sub-blocks.

Self Test 23, Square Switch, Ch B

This test repeats self test 21 (amplitude, channel B) while the square function is activated. To pass, there must be no activity at the point LEVTEST on the level/AM board (A22). (Recall that the level output B SQLEV is sent to the square board (A23), instead of the channel B modulator (A16), when the square function is activated, and does not pass through the point LEVTEST.)

This test exercises the channel B square switch on A22 (A22U9). A23 is NOT needed for this test to pass.

Self Test 24, Square Switch, Ch A

This test repeats self test 22 (amplitude, channel A) while the square function is activated. To pass, there must be no activity at the point LEVTEST on the level/AM board (A22). (Recall that the level output A SQLEV is sent to the square board (A23), instead of the channel A modulator (A6), when the square function is activated, and does not pass through the point LEVTEST.)

This test exercises the channel A square switch on A22 (A22U5). A23 is NOT needed for this test to pass.

Self Test 25, Output Offset, Ch B

This test repeats self test 17 (offset, channel B), but changes the point at which the calibrator (P/O A36) measures the result from OFFTEST on the offset board (A21) to the output of the channel B attenuator board (A12). In this way, the output amplifier sub-block of A13 and the channel B attenuator are tested. Only the dc signal path is needed (not the ac signal path) for the test to pass. To pass, the output voltage must be an increasing function of the channel B offset DAC setting.

This test exercises the channel B attenuator and the channel B output amplifier. Since the result is measured at the output of channel B, the normal amplitude/offset calibration path (instead of the LEVTEST/OFFTEST path) is used on the calibrator board.

Self Test 26, Output Offset, Ch A

This test repeats self test 18 (offset, channel A), but changes the point at which the calibrator (P/O A36) measures the result from OFFTEST on the offset board (A21) to the output of the channel A attenuator board (A2). In this way, the output amplifier sub-block of A3 and the channel A attenuator are tested. Only the dc signal path is needed (not the ac signal path) for the test to pass. To pass, the output voltage must be an increasing function of the channel A offset DAC setting.

This test exercises the channel A attenuator and the channel A output amplifier. Since the result is measured at the output of channel A, the normal amplitude/offset calibration path (instead of the LEVTEST/OFFTEST path) is used on the calibrator board.

Self Test 27, Output Amplitude 1, Ch B

This test repeats self test 21 (amplitude, channel B), but changes the point at which the calibrator (P/O A36) measures the result from LEVTEST on the level/AM board (A22) to the output of the channel B attenuator board (A12). In this way, the channel B output chain is tested. The entire channel B ac signal path is needed to the test to run. The instrument is in the two-channel mode. To pass, the output voltage must be an increasing function of the channel B level DAC setting.

This test exercises the signal paths of the channel B VCO ÷ 2 board (A45), modulator (A16), mixer (A15), preamplifier (A14), and output amplifier (A13). Since the instrument is in the two-channel mode, the B 20MHz signal from the reference board (A50) and the switch controller sub-block and two-channel mode path of the RF switch is exercised. (Recall the signal path of the channel B attenuator was tested in self test 25, and the rest of the fractional-N circuits were tested in self tests 9-16.)

Self Test 28, Output Amplitude 1, Ch A

This test repeats self test 22 (amplitude, channel A), but changes the point at which the calibrator (P/O A36) measures the result from LEVTEST on the level/AM board (A22) to the output of the channel A attenuator board (A2). In this way, the channel A output chain is tested. The entire channel A ac signal path is needed for the test to run. The instrument is in the two-channel mode. To pass, the output voltage must be an increasing function of the channel A level DAC setting.

This test exercises the signal paths of the channel A VCO ÷ 2 board (A35), modulator (A6), mixer (A5), preamplifier (A4), and output amplifier (A3). Since the instrument is in the two-channel mode, the A 20MHz signal from the reference board (A50) is needed. (Recall the signal path of the channel A attenuator was tested in self test 26, and the rest of the fractional-N circuits were tested in self tests 9-16.)

Self Test 29, Output Amplitude 2, Ch B

This test repeats self test 27 (output amplitude 1, channel B) while the square function is activated. To pass, the output voltage must be an increasing function of the channel B level DAC setting.

This test exercises the channel B sin/sq mode relay on the preamplifier board (A14), the channel B square switch on the level/AM board (A22), and the channel B square path on the square board (A23). The voltage reference sub-block on the calibrator board (P/O A36) is exercised also. The square board is very sensitive to any errors in the signal produced by this circuit (V REF).

Self Test 30, Output Amplitude 2, Ch A

This test repeats self test 28 (output amplitude 1, channel A) while the square function is activated. To pass, the output voltage must be an increasing function of the channel A level DAC setting.

This test exercises the channel A sin/sq mode relay on the preamplifier board (A4), the channel A square switch on the level/AM board (A22), and the channel A square path on the square board (A23).

Self Test 31, External AM, Ch B

This test activates external amplitude modulation in channel B, and checks for the result at the output of the channel B attenuator (A12). No input signal is sent to the modulation circuit. This causes a 50% reduction in amplitude. The test passes when the amplitude is reduced by one-third or more of its original value. (Recall that in normal operation, an external modulating signal is input through the rear panel connector. This test fails when there is a rear panel input present.)

This test exercises the channel B amplitude modulation circuit on the level/AM board (A22).

Self Test 32, External AM, Ch A

This test activates external amplitude modulation in channel A, and checks for the result at the output of the channel A attenuator (A2). No input signal is sent to the modulation circuit. This causes a 50% reduction in amplitude. The test passes when the amplitude is reduced by one-third or more of its original value. (Recall that in normal operation, an external modulating signal is input through the rear panel connector. This test fails when there is a rear panel input present.)

This test exercises the channel A amplitude modulation circuit on the level/AM board (A22).

Self Test 33, Amplitude Cal 1, Ch B

This test performs an amplitude calibration of channel B in the two-channel mode, with the sine function activated. A failure indicates that either (1) the amplitude cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Amplitude calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle amplitude error in the channel B modulator (A16), the channel B level sub-block on the level/AM board (A22), or the amplitude/offset calibration path of the calibrator (P/O A36).

Self Test 34, Amplitude Cal 1, Ch A

This test performs an amplitude calibration of channel A in the two-channel mode, with the sine function activated. A failure indicates that either (1) the amplitude cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Amplitude calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle amplitude error in the channel A modulator (A6), the channel A level sub-block on the level/AM board (A22), or the amplitude/offset calibration path of the calibrator (P/O A36).

Self Test 35, Residual Ofs Cal 1, Ch B

This test performs a residual offset calibration of channel B in the two-channel mode, with the sine function activated, and the pre-10 dB attenuator pad on A13 deactivated. A residual offset calibration programs 0 V dc offset, and adjusts the instrument accordingly. It corrects for any offset on the ac signal. A failure indicates that either (1) the offset cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Offset calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle offset error in the channel B mixer (A15) or the channel B offset sub-block on the offset board (A21).

Self Test 36, Residual Ofs Cal 1, Ch A

This test performs a residual offset calibration of channel A in the two-channel mode, with the sine function activated, and the pre-10 dB attenuator pad on A3 deactivated. A residual offset calibration programs 0 V dc offset, and adjusts the instrument accordingly. It corrects for any offset on the ac signal. A failure indicates that either (1) the offset cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Offset calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle offset error in the channel A mixer (A5) or the channel A offset sub-block on the offset board (A21).

Self Test 37, Residual Ofs Cal 2, Ch B

This test performs a residual offset calibration of channel B in the two-channel mode, with the sine function activated, and the pre-10 dB attenuator pad on A13 activated. A residual offset calibration programs 0 V dc offset, and adjusts the instrument accordingly. It corrects for any offset on the ac signal. A failure indicates that either (1) the offset cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Offset calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle offset error in the channel B mixer (A15) and/or the channel B offset sub-block on the offset board (A21), which were functionally tested in self test 45, or a hard failure of the pre-10 dB attenuator pad and driver on the channel B output amplifier (A13).

Self Test 38, Residual Ofs Cal 2, Ch A

This test performs a residual offset calibration of channel A in the two-channel mode, with the sine function activated, and the pre-10 dB attenuator pad on A3 activated. A residual offset calibration programs 0 V dc offset, and adjusts the instrument accordingly. It corrects for any offset on the ac signal. A failure indicates that either (1) the offset cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Offset calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle offset error in the channel A mixer (A5) and/or the channel A offset sub-block on the offset board (A21), which were functionally tested in self test 46, or a hard failure of the pre-10 dB attenuator pad and driver on the channel A output amplifier (A3).

Self Test 39, Amplitude Cal 2, Ch B

This test performs an amplitude calibration of channel B in the two-channel mode, with the square function activated. A failure indicates that either (1) the amplitude cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Amplitude calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle amplitude error in the channel B square path on the square board (A23).

Self Test 40, Amplitude Cal 2, Ch A

This test performs an amplitude calibration of channel A in the two-channel mode, with the square function activated. A failure indicates that either (1) the amplitude cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Amplitude calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle amplitude error in the channel A square path on the square board (A23).

Self Test 41, Residual Ofs Cal 3, Ch B

This test performs a residual offset calibration of channel B in the two-channel mode, with the square function activated, and the pre-10 dB attenuator pad on A13 deactivated. A residual offset calibration programs 0 V dc offset, and adjusts the instrument accordingly. It corrects for any offset on the ac signal. A failure indicates that either (1) the offset cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Offset calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle offset error in the channel B square path on the square board (A23).

Self Test 42, Residual Ofs Cal 3, Ch A

This test performs a residual offset calibration of channel A in the two-channel mode, with the square function activated, and the pre-10 dB attenuator pad on A3 deactivated. A residual offset calibration programs 0 V dc offset, and adjusts the instrument accordingly. It corrects for any offset on the ac signal. A failure indicates that either (1) the offset cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Offset calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle offset error in the channel A square path on the square board (A23).

Self Test 43, Residual Ofs Cal 4, Ch B

This test performs a residual offset calibration of channel B in the two-channel mode, with the square function activated, and the pre-10 dB attenuator pad on A13 activated. A residual offset calibration programs 0 V dc offset, and adjusts the instrument accordingly. It corrects for any offset on the ac signal. A failure indicates that either (1) the offset cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Offset calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. All of the circuits exercised in this test have been exercised in above tests. This test provides no new information.

Self Test 44, Residual Ofs Cal 4, Ch A

This test performs a residual offset calibration of channel A in the two-channel mode, with the square function activated, and the pre-10 dB attenuator pad on A3 activated. A residual offset calibration programs 0 V dc offset, and adjusts the instrument accordingly. It corrects for any offset on the ac signal. A failure indicates that either (1) the offset cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Offset calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. All of the circuits exercised in this test have been exercised in above tests. This test provides no new information.

Self Test 45, DC Offset Cal, Ch B

This test performs a dc offset calibration of channel B in the two-channel mode, with the sine function activated. A dc offset calibration programs a non-zero volt dc offset, and measures the result. It corrects for any dc offset error from the offset DAC on A21. A failure indicates that either (1) the offset cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Offset calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle offset error in the channel B offset sub-block on the offset board (A21). The sub-block is exercised in different ways than in any above tests.

Self Test 46, DC Offset Cal, Ch A

This test performs a dc offset calibration of channel A in the two-channel mode, with the sine function activated. A dc offset calibration programs a non-zero volt dc offset, and measures the result. It corrects for any dc offset error from the offset DAC on A21. A failure indicates that either (1) the offset cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Offset calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle offset error in the channel A offset sub-block on the offset board (A21). The sub-block is exercised in different ways than in any above tests.

Self Test 47, Amplitude Cal 3, Ch B

This test performs an amplitude calibration of channel B in the two-tone mode, with the sine function activated. A failure indicates that either (1) the amplitude cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

This test exercises the switch controller and two-phase mode path of the RF switch (A24). Recall that the RF switch has only two possible configurations — the two-channel mode path and the two-phase mode path. The two-phase mode path is used in the two-phase, two-tone, and pulse modes.

Amplitude calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test could also be due to a subtle amplitude error in the two-phase mode path on the RF switch board (A24).

Self Test 48, Amplitude Cal 3, Ch A

This test performs an amplitude calibration of channel A in the two-tone mode, with the sine function activated. A failure indicates that either (1) the amplitude cannot be calibrated to within specification or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Amplitude calibration of a specific channel requires that all of that channel's circuitry and the common control circuitry be working to specification. Failures of this test would be primarily due to a subtle amplitude error in the two-phase mode path on the RF switch board (A24), which was exercised in self test 47. This test provides no new information.

Self Test 49, Phase Cal 1

This test performs a phase calibration at 10 kHz in the two-phase mode, with the sine function activated. A failure indicates that either (1) the phase calibration routine cannot be completed (that is, the comparator loop cannot be broken) or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Phase calibration of the instrument requires that both of the channels and the common control circuitry are working to specification. Very accurate and clean frequencies are needed. Failures of this test would be primarily due to a subtle frequency error in one of the fractional-N oscillators (A34 or A44, in particular), a subtle spurious problem in one of the oscillators (for example, API spurs on A33 or A43), or a problem in the phase calibration path on the calibrator board (A36).

NOTE

Phase calibration is very sensitive to bad ground contacts. When the HP 3326A has poor phase calibration accuracy, check to make sure that (1) all of the top cover screws are firmly in place, (2) all of the motherboard screws are firmly in place, and (3) all of the cable connections are tight (particularly the ground contacts).

Self Test 50, Phase Cal 2

This test performs a phase calibration at 13 MHz in the two-phase mode, with the sine function activated. A failure indicates that either (1) the phase calibration routine cannot be completed (that is, the comparator loop cannot be broken) or (2) the software calibration correction factors that are computed during the calibration routine are out of range.

Phase calibration of the instrument requires that both of the channels and the common control circuitry are working to specification. Very accurate and clean frequencies are needed. Failures of this test would be primarily due to a subtle frequency error in one of the fractional-N oscillators (A34 or A44, in particular), a subtle spurious problem in one of the oscillators (for example, API spurs on A33 or A43), or a problem in the phase calibration path on the calibrator board (A36).

NOTE

Phase calibration is very sensitive to bad ground contacts. When the HP 3326A has poor phase calibration accuracy, check to make sure that (1) all of the top cover screws are firmly in place, (2) all of the motherboard screws are firmly in place, and (3) all of the cable connections are tight (particularly the ground contacts).

6-12 INSTRUMENT TURN-ON HIERARCHY

Figure 6-10 shows the order in which boards are turned on in the HP 3326A. This follows the main signal flow through the instrument. Each board in the instrument depends on the boards that are higher in the hierarchy. For example, the reference board (A50) depends on inputs from the motherboard (A99) and the power supply (A70) to function properly. This hierarchical view is useful in isolating a defective board. It provides a clear overall picture of the instrument, based on board dependencies.

The step-by-step fault isolation tests (Table 6-14) are listed in this hierarchical order. The power supply is listed first, then the reference board, and so on.

6-13 FAULT ISOLATION TESTS

Use the step-by-step fault isolation tests given in this sub-section to determine if a board is working properly. This allows you to narrow down a list of suspect defective boards. The defective board is found by a process of elimination. The procedure requires that the HP 3326A's top and bottom covers are removed. Hazardous signals are present in the HP 3326A, so be sure to take all necessary safety precautions.

WARNING

Maintenance described herein is performed with power supplied to the instrument and protective covers removed. Such maintenance should be performed by service trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Primary power is supplied to the instrument whenever the line cord is attached, independent of the power switch position. Where maintenance can be performed without power applied, remove the power cord.

FAULT ISOLATION TESTS; TURN-ON HIERARCHY

See Other Side

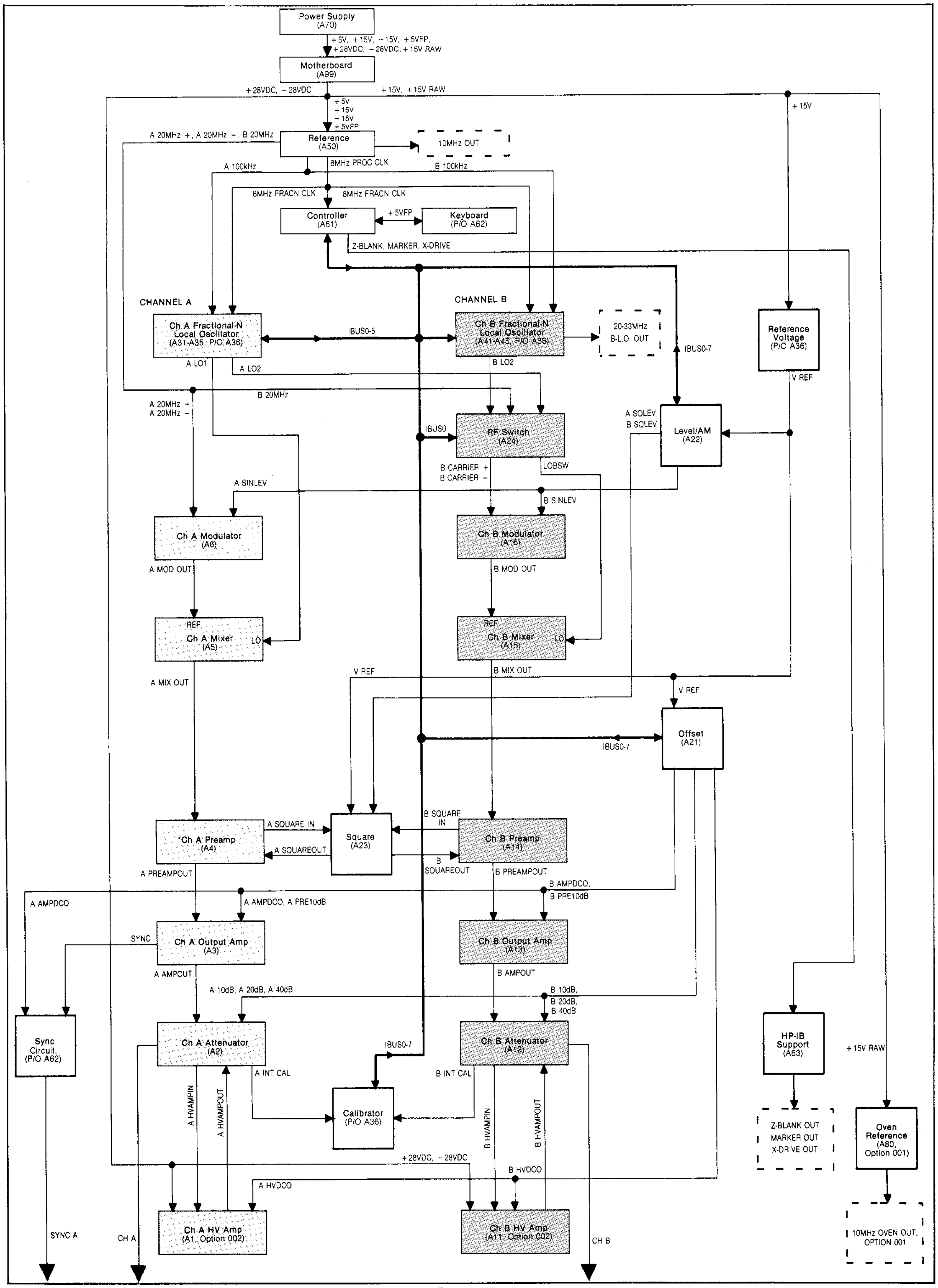


Figure 6-10. Instrument Turn-on Hierarchy Flow Chart

CAUTION

To avoid the possibility of damage to test equipment, read each test thoroughly before starting it. Make any preliminary control settings necessary for correct test equipment operation.

What is Table 6-14?

Table 6-14 lists fault isolation tests that determine if a board is functioning properly. They are mostly analog tests and use only an oscilloscope, voltmeter, logic probe, and assorted cables. The tests provide consolidated information for tracking down hard failures. They do not cover most subtle errors. Subtle faults are most easily found by interchanging identical boards between the two channels (sub-section 6-4).

The tests assume any board can be defective. They are written in a serial fashion following the main signal flow of the instrument (Figure 6-10). The power supply test is first, followed by the tests for the other boards in the instrument.

Each fault isolation test lists the important input AND output signals for a board. This means that many signals are repeated in the table since an output of one board is an input to another. Each test is separate — it does not depend on the results of any other test. You can enter the table at any point.

Table 6-14 provides tests for most of the boards in the instrument. There are no tests for many of the digital boards, however. These boards are thoroughly tested by the service self tests (sub-section 6-11). There are also several features not tested. These features are very time-consuming to test and use a relatively small number of components. They include AM, PM, internal modulation, combined operation, and most of the external rear panel inputs.

NOTE

There is no fault isolation test for the motherboard. A figure of each board's motherboard connector showing signal routing between boards is included near each schematic. Signal names, descriptions, origins, and destinations are given alphabetically in the signal glossary (Appendix A).

How to Use Table 6-14

1. **Turn the instrument on its side.** Remove top and bottom instrument covers. See Figure 6-12.
2. **Review the list of suspect boards you compiled using the service self tests.** Determine which board appears first in the fault isolation tests. Start testing that board.

   If the self tests did not point to a group of suspect boards, all of the boards in the instrument are suspect. Start testing the boards at the top of the table. Begin with the power supply. Continue until you find the defective board.
3. **Follow the instructions given in Table 6-14.**
   - **Set up the HP 3326A.** Only deviations from INSTR PRESET are given.
   - **Set up the test equipment.**
   - **Probe the test locations.** The test locations are in one of two places — on a motherboard connector or on the top of a PC board. See Figure 6-12.

NOTE

Although the +5V, +15V, and −15V supplies are only listed in the power supply test, check them for all boards. All connectors except XA61 and XA70 use pins 1, 2, and 3 for the +5V, +15V, and −15V supplies, respectively. The locations of the supplies on XA61 and XA70 are labeled on the motherboard.

4. **Are the signals normal?** All parameters are required unless denoted by a ≅ character. All ≅ parameters are typical performance parameters of the instrument. Investigate only serious deviations.

   If the signals are normal, cross the board off your list of suspects. Continue testing your list of suspect boards.

   If the signals are abnormal, follow the instructions given in the last column of Table 6-14. The instructions direct you to the board that produces the input signal when an input signal is abnormal. They direct you to the board under test when an output signal is abnormal. When all input signals are normal and an output signal is abnormal, the board under test is defective. When an input signal is abnormal, the board that produces the input is probably defective. Perform the fault isolation test for that board.

5. **Go to the board level repair sub-section for the defective board. The schematic number is given inside the ▭> symbol next to the board name.**

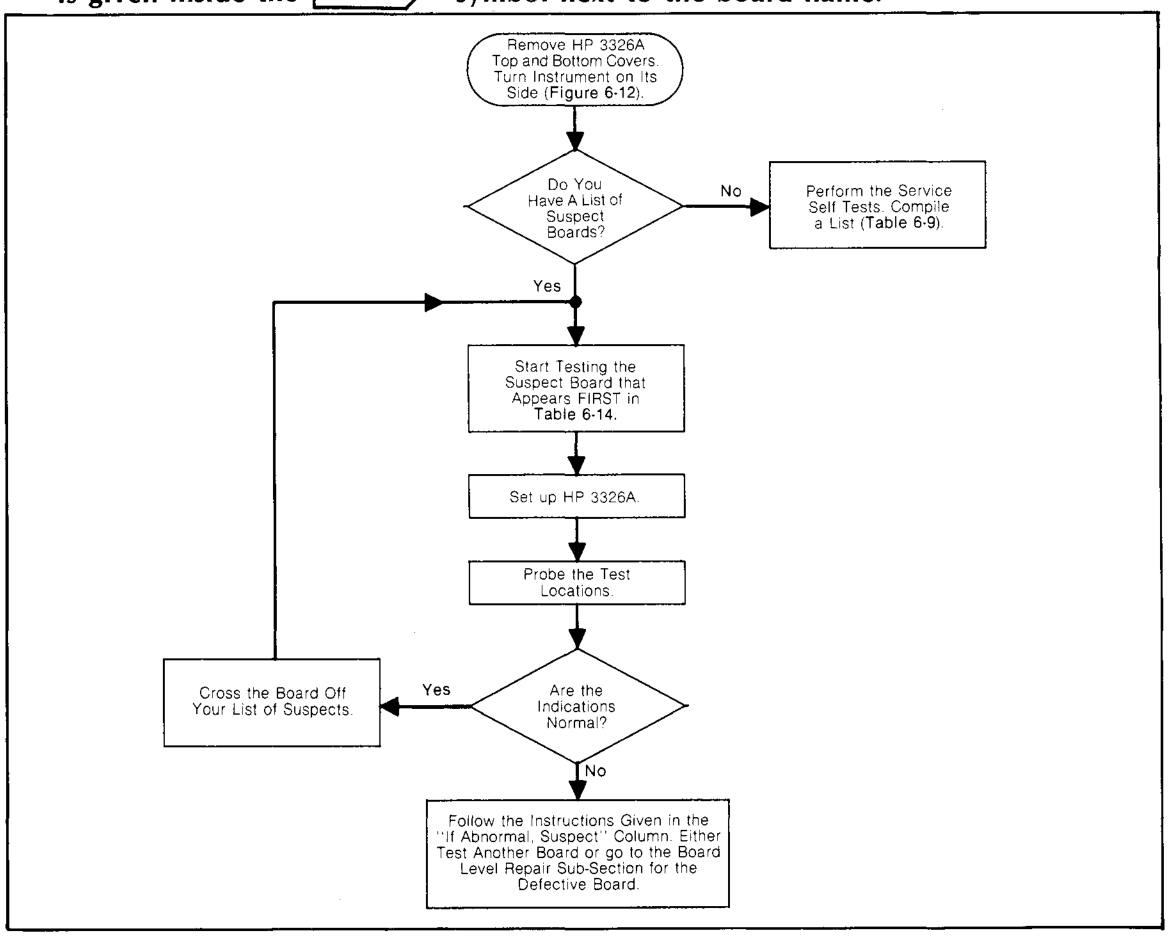


Figure 6-11. How to Use Table 6-14

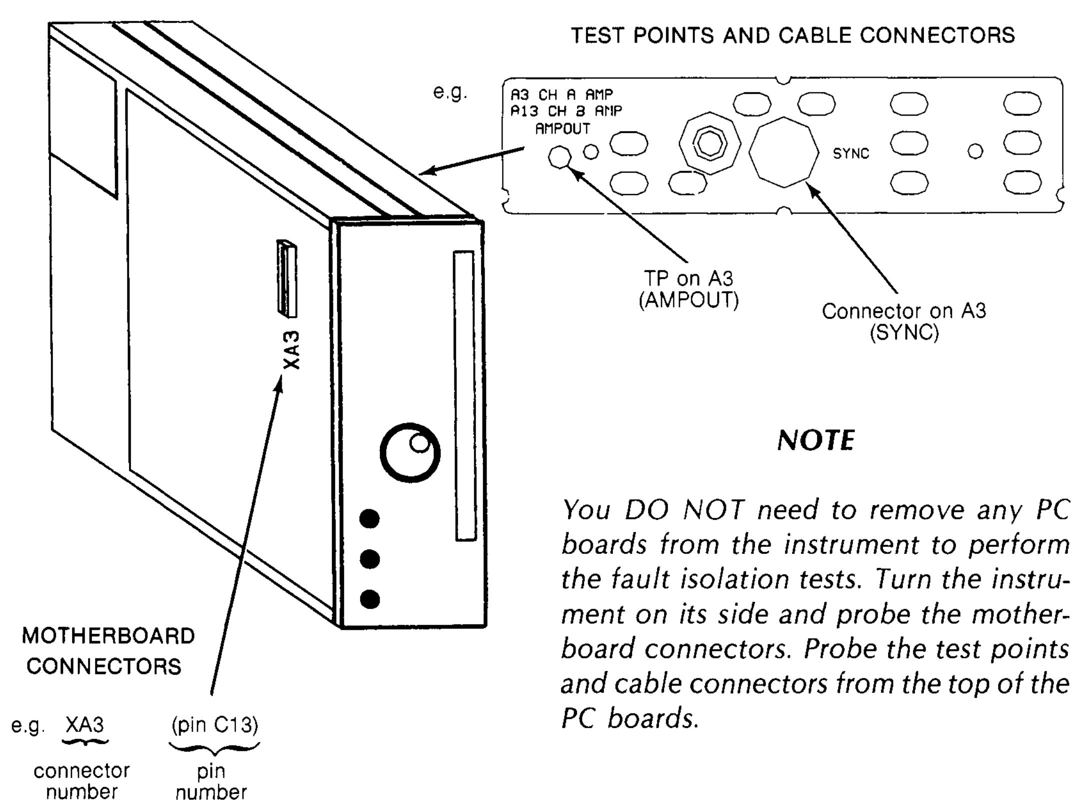
Test Equipment

The fault isolation tests use a minimum amount of equipment (Table 6-13). The recommended model numbers are listed in Table 1-6.

Table 6-13. Fault Isolation Test Equipment

Oscilloscope
Digital Voltmeter
Logic Probe
10:1 Probes (2)
BNC Cables (2)
Service Accessory Kit:
SMB (f) to BNC (m) Adapter Cable
Phono Plug to BNC (m) Adapter Cable
Sine Wave Signal Source †
Spectrum Analyzer ‡

† Used for external trigger.
‡ Used to measure power supply ripple.



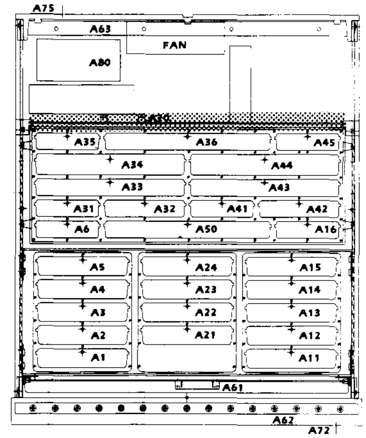
NOTE

You DO NOT need to remove any PC boards from the instrument to perform the fault isolation tests. Turn the instrument on its side and probe the motherboard connectors. Probe the test points and cable connectors from the top of the PC boards.

Figure 6-12. Fault Isolation Test Signal Locations

Table 6-14. Fault Isolation Tests

● Power Supply (A70) 16



Probe the test signal locations. If all signals are normal, A70 is functional.

Test Equipment

Voltmeter
Oscilloscope (or 3585A Spectrum Analyzer)†
10:1 probe

HP 3326A Setup

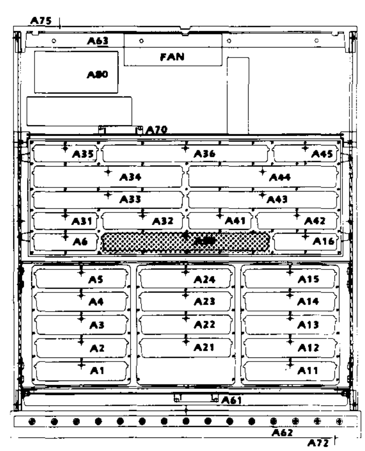
INSTR PRESET

Supply Name	Output Location	Return Location	Nominal Voltage	Voltage Tolerance‡	Ripple Tolerance
+15V	TP105	GND (TP700) or card nests	+15.000 V	±0.010 V	50 μVrms
−15V	TP205	GND (TP700) or card nests	−15.000 V	±0.020 V	50 μVrms
+5V	TP305	GND (TP700) or card nests	+5.100 V	±0.060 V	75 μVrms
+5VFP	TP900	GNDFP (use card nests)	+5.00 V	±0.25 V	—
+5V HPIB	TP401	CGND (TP402) or chassis	+5.00 V	±0.25 V	—
+28VDC	TP501	GND (TP700) or card nests	> 28.5 V	—	—
−28VDC	TP500	GND (TP700) or card nests	< −28.5 V	—	—

† Used for measuring ripple. When the supplies look clean on the oscilloscope, they are probably okay. Perform a complete ripple check when there is a problem with 60 Hz noise on the output.

‡ The voltage levels and ripple tolerances are given for fully loaded supplies. All PC boards must be in the instrument. Removing individual boards will change the load on the supplies and change the supply levels.

● Reference (A50) 13



Probe the test signal locations. If all signals are normal, A50 is functional.

Test Equipment

Oscilloscope
10:1 probes (2)
SMB to BNC adapter cable
Phono plug to BNC adapter cable

Table 6-14. Fault Isolation Tests Cont.

HP 3326A Setup

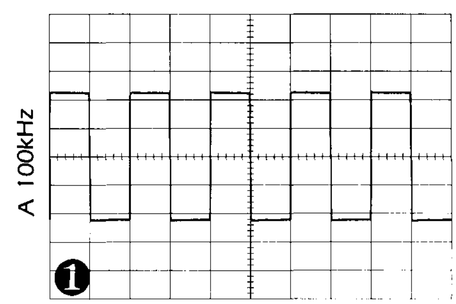
INSTR PRESET

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Inputs: INH BREF	XA50(pins A12, C12)	TTL low.	RF switch (A24).
Outputs: A 100kHz ❶	Connector on A50 (A 100 KHZ-A33)	DC coupled, ECL level, 100 kHz square.	Reference (A50).
B 100kHz	Connector on A50 (B 100 KHZ-A43)	Same as above.	Same as above.
8MHz PROC CLK ❷	XA50(pin C6)	8 MHz, TTL level, square.	Same as above.
8MHz FRACN CLK	XA50(pin A6)	Same as above.	Same as above.
A 20MHz + ❸	XA50(pin A15)	AC coupled, ECL level, 20 MHz square.	Same as above.
A 20MHz −	XA50(pin A14)	Same as above.	Same as above.
B 20MHz	XA50(pin C14)	Same as above.	Same as above.
10MHz OUT ❹	Connector on A50 (10 MHZ OUT) into 50 Ω	10 MHz square, ≥0.5 Vpp.	Same as above.
$\overline{\text{EXT REF FLAG}}$	TP on A50 (EXT REF LOCK)	TTL high.	Same as above.
$\overline{\text{REF LOOP UNLOCKED}}$	TP on A50 (REF LOOP UNLOCKED)	TTL high.	Same as above.

Oscilloscope Setup

SMB to BNC adapter cable

Ch 1 coupling	AC
Ch 1 V/div	200 mV
Time/div	5 μs
Trigger	Ch 1



Oscilloscope Setup

10:1 probe

Ch 1 coupling	DC
Ch 1 V/div	100 mV
Time/div	50 ns
Trigger	Ch 1

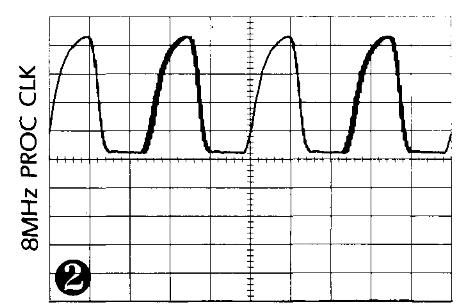
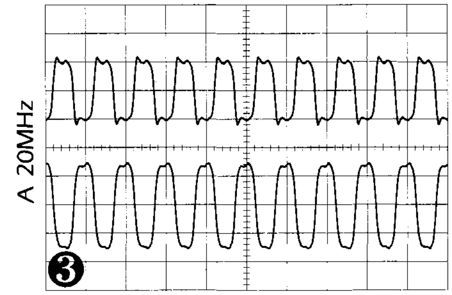


Table 6-14. Fault Isolation Tests Cont.

Oscilloscope Setup

10:1 probes (2)

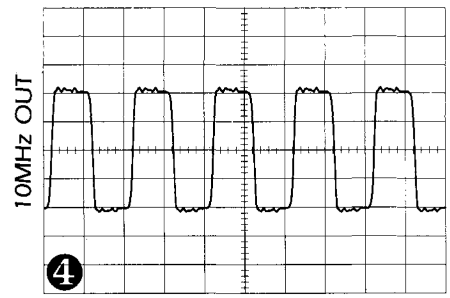
Ch 1 coupling	AC
Ch 1 V/div	40 mV
Ch 2 coupling	AC
Ch 2 V/div	40 mV
Time/div	50 ns
Trigger	Ch 1



Oscilloscope Setup

Phono plug to BNC adapter cable

Ch 1 coupling	50 Ω DC
Ch 1 V/div	200 mV
Time/div	50 ns
Trigger	Ch 1



• Controller (A61) 14

The only fault isolation test for this board is the service self test. If you suspect this board is broken, go to A61 board level repair, sub-section 6-33.

• Keyboard (A62) 15

The only fault isolation test for this board is the service self test. If you suspect this board is broken, go to A62 board level repair, sub-section 6-34.

• Ch A Local Oscillator (A31 - A35, and P/O A36) Ch B Local Oscillator (A41 - A45, and P/O A36) 11

Probe the test signal locations. If all signals are normal, the fractional-N boards are functional.

NOTE

There are components on the motherboard (A99) for power supply decoupling. If there is a problem with the supplies, it may be due to a defective motherboard component. See the schematics for details.

Test Equipment

Oscilloscope
Logic probe
Sine wave generator
10:1 probes (2)
SMB to BNC adapter cable
Phono plug to BNC adapter cable

HP 3326A Setup

INSTR PRESET
(2 CHANNEL mode)
Ch B: FREQ 5 MHz

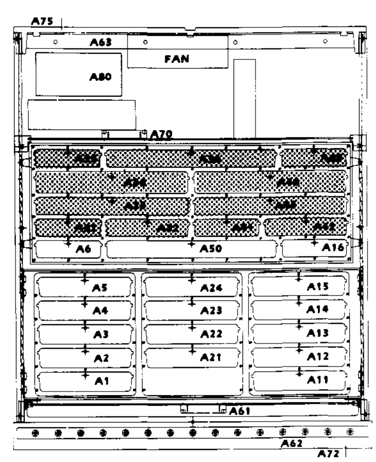


Table 6-14. Fault Isolation Tests Cont.

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Inputs: A 100kHz, B 100kHz ❼	Connectors on A50 (A 100 KHZ-A33, B 100 KHZ-A43)	DC coupled, ECL level, 100 kHz square.	Reference (A50).
❻ 8MHz FRACN CLK	XA36(pin A8)	8 MHz, TTL level, square.	Same as above.
IBUS0-5	XA36(pins C5, C6, C7, C8, C9, B4), XA34(pins A5, A6, A7, A8, B8, B13), XA44(pins A5, A6, A7, A8, B8, B13)	TTL low. Toggles when frequency is modified. Use logic probe.	Controller (A61).
ADD STROBE	XA36(pin A5)	TTL high. Toggles when frequency is modified. Use logic probe.	Same as above.
DATA STROBE	XA36(pin B6)	Same as above.	Same as above.
$\overline{\text{RESET}}$	XA36(pin A6)	TTL high.	Same as above.
Outputs: A LO1 ❶	XA35(pin A15)	20.001 MHz square (≅ 20 MHz), AC coupled, ECL level, > 0.5 Vpp (≅ 0.8 Vpp).	Ch A fractional-N LO (A31-A36).
A LO2 ❷	Connector on A35 (LO 2) into 50 Ω	No signal present.	Same as above.
B LO2	Connector on A45 (LO 2) into 50 Ω	25 MHz square, AC coupled, ECL level, > 0.5 Vpp (≅ 0.8 Vpp).	Ch B fractional-N LO (A41-A45, A36).
IBUS0-5	XA36 (pins C5, C6, C7, C8, C9, B4), XA34 (pins A5, A6, A7, A8, B8, B13), XA44 (pins A5, A6, A7, A8, B8, B13)	TTL low. Toggles when frequency is modified. Use logic probe.	Controller (A61), fractional-N decoder (A36), fractional-N digital (A34, A44).
$\overline{\text{A DLBC}}$ ❽	XA34(pin A10)	100 kHz square, TTL level, 32.5% duty cycle.	Ch A fractional-N LO.
$\overline{\text{ANALOG FAULT}}$	XA32(pin C15), XA42(pin C15)	TTL high.	All boards that activate this line: HV amp (A1, A11), output amp (A3, A13), fractional-N LO boards.
$\overline{\text{A SWEEP LIMIT}}$, B SWEEP LIMIT	XA34 (pin A14), XA44 (pin A14)	TTL low. Toggles when sweeping. Press CONT to verify. Use logic probe.	Fractional-N LO.

Table 6-14. Fault Isolation Tests Cont.

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
OUTPUTS: SWEEP START	XA36(pin A7)	TTL high. Toggles when external trigger is used. To verify, insert 1 kHz sine, TTL level, into EXT TRIG IN rear panel input. Use logic probe. (The LED next to the SINGLE key should be blinking.)	Same as above.

HP 3326A Setup

INSTR PRESET
2 PHASE mode
Ch A: FREQ 10 MHz

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Outputs: A LO1 ❸	XA35(pin A15)	30 MHz square, AC coupled, ECL level, > 0.5 Vpp (≅ 0.8 Vpp).	Ch A fractional-N LO.
A LO2 ❹	Connector on A35 (LO 2) into 50 Ω	Same as above.	Same as above.
B LO2 ❺	Connector on A45 (LO 2) into 50 Ω	20 MHz square, AC coupled, ECL level, > 0.5 Vpp (≅ 0.8 Vpp).	Ch B fractional-N LO.

Oscilloscope Setup

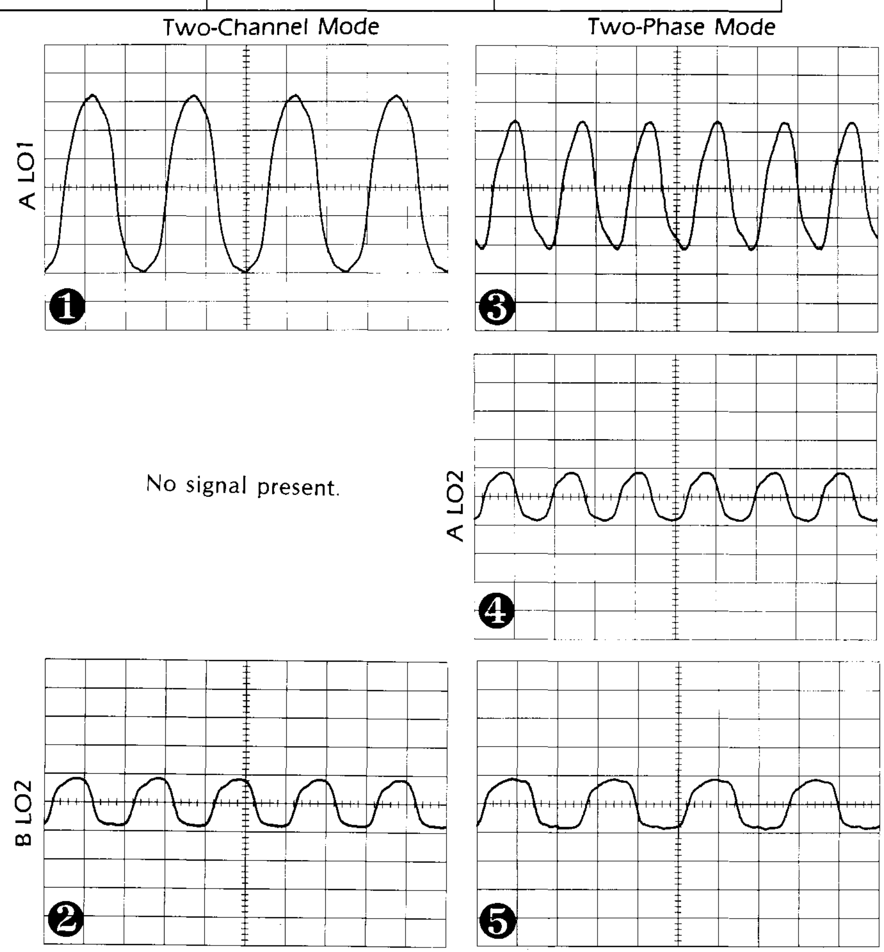
10:1 probe

Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	20 ns
Trigger	Ch 1

Oscilloscope Setup

Phono plug to BNC adapter cable

Ch 1 coupling	50 Ω DC
Ch 1 V/div	500 mV
Time/div	20 ns
Trigger	Ch 1



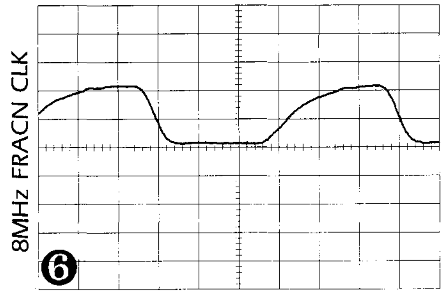
A31-A36, p/o A36

Table 6-14. Fault Isolation Tests Cont.

Oscilloscope Setup

10:1 probe

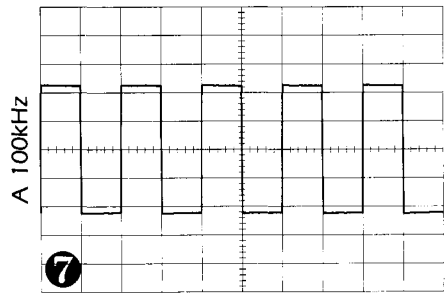
Ch 1 coupling	DC
Ch 1 V/div	200 mV
Time/div	20 ns
Trigger	Ch 1



Oscilloscope Setup

SMB to BNC adapter cable

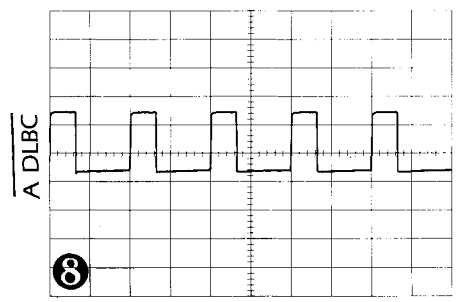
Ch 1 coupling	AC
Ch 1 V/div	200 mV
Time/div	5 μs
Trigger	Ch 1



Oscilloscope Setup

10:1 probe

Ch 1 coupling	DC
Ch 1 V/div	200 mV
Time/div	5 μs
Trigger	Ch 1



● Reference Voltage (P/O A36) 12

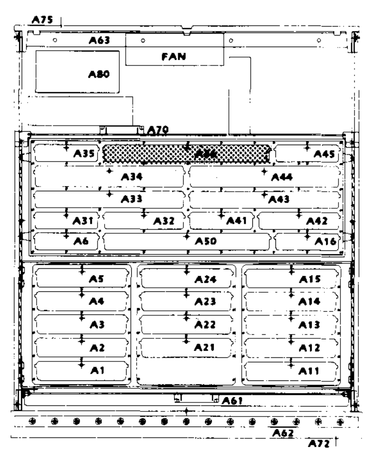
Probe the test signal location. If the signal is normal, the reference voltage sub-block on A36 is functional

Test Equipment

Voltmeter

HP 3326A Setup

INSTR PRESET

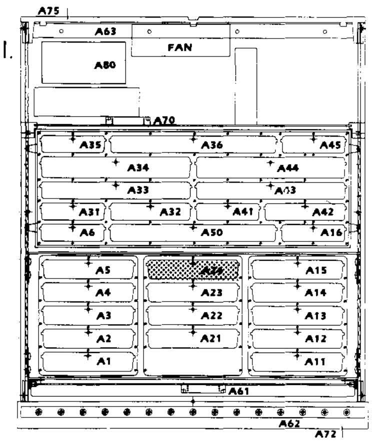


Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Output: V REF	TP on A36 (V REF TEST)	10.240 $\pm$0.010 Vdc.	Voltage reference sub-block on the calibrator (A36).

Table 6-14. Fault Isolation Tests Cont.

● RF Switch (A24) 10

Probe the test signal locations. If all signals are normal, A24 is functional.



Test Equipment

Oscilloscope
Logic probe
10:1 probe
Phono plug to BNC adapter cable

HP 3326A Setup

INSTR PRESET
(2 CHANNEL mode)
Ch B: FREQ 5 MHz

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Inputs: A LO2	Connector on A35 (LO 2) into 50 Ω	No signal present.	$\overline{\text{ENABLE LO2}}$ signal on RF switch (A24). See signal glossary.
❶ B LO2	Connector on A45 (LO 2) into 50 Ω	25 MHz square, AC coupled, ECL level, > 0.5 Vpp (≅ 0.8 Vpp).	Ch B fractional-N LO (A41-A45, A36).
❷ B 20MHz	XA24(pin A11)	20 MHz square, AC coupled, ECL level.	Reference (A50).
IBUS0	XA24(pin C4)	TTL low. Toggles when any hardware configuration changes (e.g. when frequency is modified). Use logic probe.	Controller (A61).
RF SWITCH STROBE	XA24(pin C5)	TTL high. Toggles low when the mode is changed from 2 CHANNEL to 2 PHASE, or from PULSE to 2 CHANNEL. Use logic probe.	Level/AM (A22).
Outputs: ❸ LOBSW	XA24(pin C15)	25 MHz square, AC coupled, ECL level, ≅ 0.4 Vpp.	RF switch (A24).
❹ B CARRIER +	XA24 (pin A7)	20 MHz square, AC coupled, ECL level, > 0.5 Vpp.	Same as above.
B CARRIER −	XA24 (pin A8)	Same as above.	Same as above.
INH BREF	XA24 (pin A4)	TTL low.	Same as above.
$\overline{\text{ENABLE LO2}}$	XA24 (pin A5)	TTL high (complement of INH BREF).	Same as above.

A24

Table 6-14. Fault Isolation Tests Cont.

HP 3326A Setup

INSTR PRESET
2 PHASE mode

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Inputs: A LO2 ❺	Connector on A35 (LO 2) into 50 Ω	20.001 MHz square (≅ 20 MHz), AC coupled, ECL level, > 0.5 Vpp (≅ 0.8 Vpp).	Ch A fractional-N LO (A31-A36).
B LO2 ❻	Connector on A45 (LO 2) into 50 Ω	20 MHz square, AC coupled, ECL level, > 0.5 Vpp.	Ch B fractional-N LO (A41-A45, A36).
B 20MHz	XA24(pin A11)	No signal present.	INH BREF signal on RF switch (A24). See signal glossary.
Outputs: LOBSW ❼	XA24(pin C15)	20.001 MHz square (≅ 20 MHz), AC coupled, ECL level, ≅ 0.4 Vpp.	RF switch (A24).
B CARRIER + ❽	XA24 (pin A7)	20 MHz square, AC coupled, ECL level, > 0.5 Vpp.	Same as above.
B CARRIER −	XA24 (pin A8)	Same as above.	Same as above.
INH BREF	XA24 (pin A4)	TTL high.	Same as above.
$\overline{\text{ENABLE LO2}}$	XA24(pin A5)	TTL low (complement of INH BREF).	Same as above.

Oscilloscope Setup

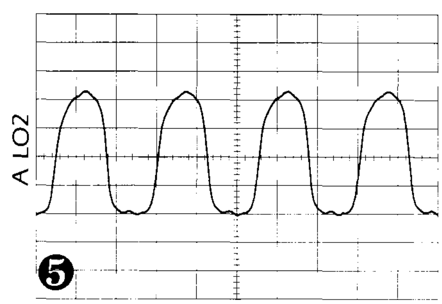
Two-Channel Mode

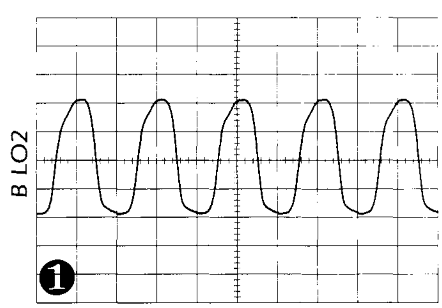
Two-Phase Mode

Phono plug to BNC adapter cable

Ch 1 coupling	50 Ω DC
Ch 1 V/div	200 mV
Time/div	20 ns
Trigger	Ch 1

No signal present.





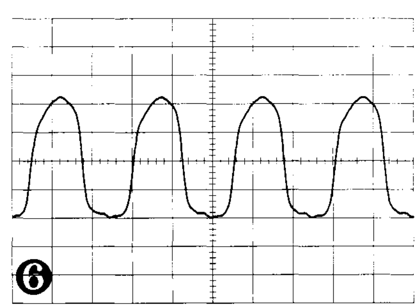


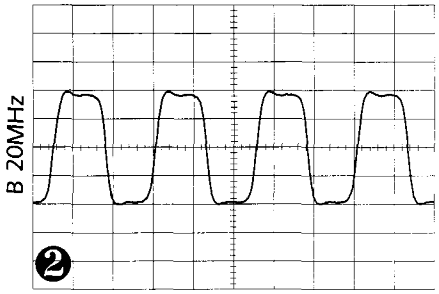
Table 6-14. Fault Isolation Tests Cont.

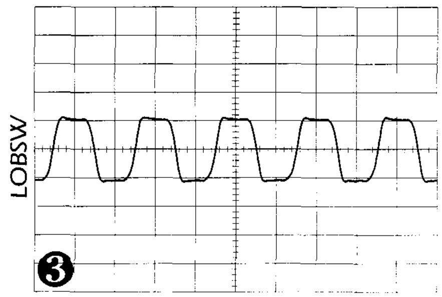
Oscilloscope Setup

10:1 probe

Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	20 ns
Trigger	Ch 1

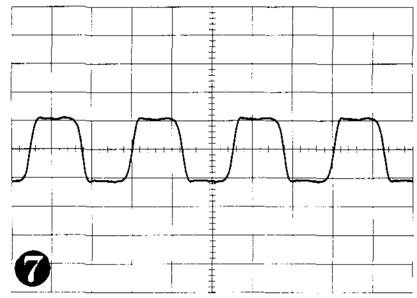
Two-Channel Mode





Two-Phase Mode

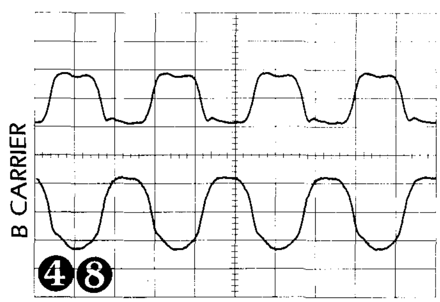
No signal present.



Oscilloscope Setup

10:1 probes (2)

Ch 1 coupling	AC
Ch 1 V/div	40 mV
Ch 2 coupling	AC
Ch 2 V/div	40 mV
Time/div	20 ns
Trigger	Ch 1



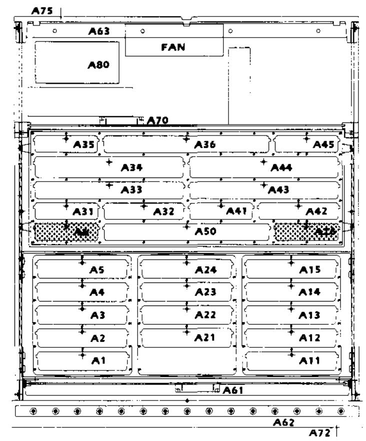
- **Level/AM (A22)** 8

The only fault isolation test for this board is the service self test. If you suspect this board is broken, go to A22 board level repair, sub-section 6-27.

Table 6-14. Fault Isolation Tests Cont.

● Ch A Modulator (A6) Ch B Modulator (A16) 6

Probe the test signal locations. If all signals are normal, A6 and A16 are functional.



Test Equipment

Oscilloscope
Voltmeter
10:1 probes (2)
Phono plug to BNC adapter cable

HP 3326A Setup

INSTR PRESET
Ch A: AMPTD 13.97 dBm
Ch B: AMPTD 13.97 dBm

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Inputs: A 20MHz +, B CARRIER + ❶	XA6 (pin A12), XA16 (pin A12)	20 MHz square, AC coupled, ECL level, ≥ 0.5 Vpp.	Reference (A50), RF switch (A24).
A 20MHz −, B CARRIER −	XA6(pin A13), XA16(pin A13)	Same as above.	Same as above.
A SINLEV, B SINLEV	XA6(pin A5), XA16(pin A5)	3.5 to 4.5 Vdc	Level/AM (A22).
Outputs: A MOD OUT, B MOD OUT ❷	Connector on A6, A16 (MOD OUT) into 50 Ω	20 MHz sine, 100 to 120 mVpp.	Modulator (A6, A16).

HP 3326A Setup

INSTR PRESET
Ch A: AMPTD 13.98 dBm
Ch B: AMPTD 13.98 dBm

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Outputs: A MOD OUT, B MOD OUT	Connector on A6, A16 (MOD OUT) into 50 Ω	20 MHz sine, 30 to 38 mVpp (10 dB shift from first setup).	Modulator (A6, A16).

Oscilloscope Setup

10:1 probes (2)	
Ch 1 coupling	AC
Ch 1 V/div	40 mV
Ch 2 coupling	AC
Ch 2 V/div	40 mV
Time/div	20 ns
Trigger	Ch 1

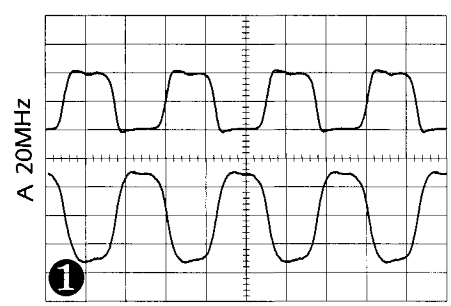
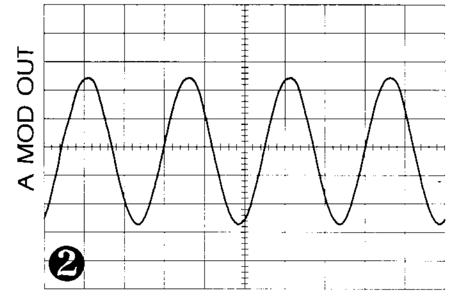


Table 6-14. Fault Isolation Tests Cont.

Oscilloscope Setup

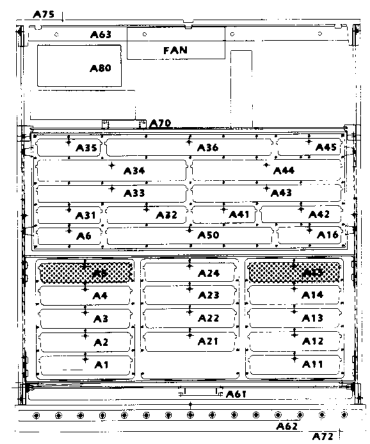
Phono plug to BNC adapter cable

Ch 1 coupling	50 Ω DC
Ch 1 V/div	20 mV
Time/div	20 ns
Trigger	Ch 1



● **Ch A Mixer (A5)**
Ch B Mixer (A15) 5

Probe the test signal locations. If all signals are normal, A5 and A15 are functional.



Test Equipment

Oscilloscope
10:1 probe

HP 3326A Setup

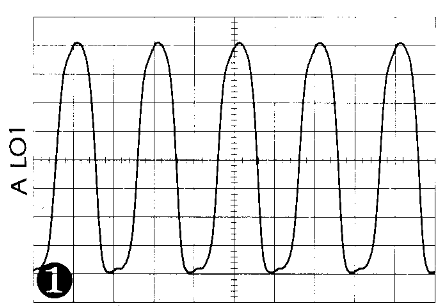
INSTR PRESET
Ch A: FREQ 5 MHz
AMPTD 10 Vpp
Ch B: FREQ 5 MHz
AMPTD 10 Vpp

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Inputs: A LO1 ❶	XA5(pin A5)	25 MHz square, AC coupled, ECL level, 0.5 Vpp (≅ 0.8 Vpp).	Ch A fractional-N LO (A31-A36).
LOBSW ❷	XA15(pin A5)	25 MHz square, AC coupled, ECL level, ≅ 0.4 Vpp.	RF switch (A24).
A MOD OUT, B MOD OUT ❸ (after filter)	TP on A5, A15 (RF)	67 to 83 mVpp, 20 MHz sine.	Modulator (A6, A16).
Outputs: A MIX OUT, B MIX OUT ❹	XA5(pin A16), XA15(pin A16)	225 to 270 mVpp, 5 MHz sine	Mixer (A5, A15).

Oscilloscope Setup

10:1 probe

Ch 1 coupling	AC
Ch 1 V/div	10 mV
Time/div	20 ns
Trigger	Ch 1



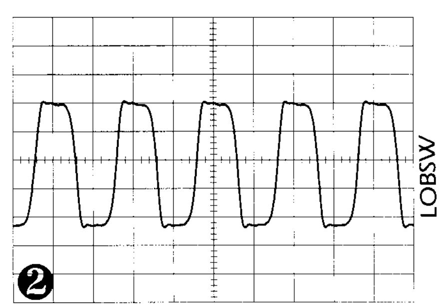
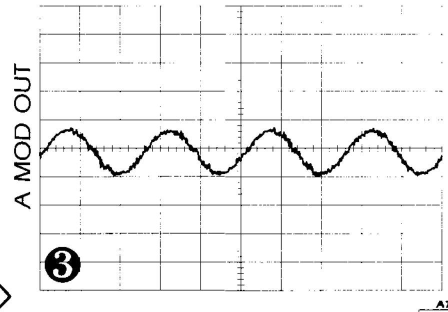
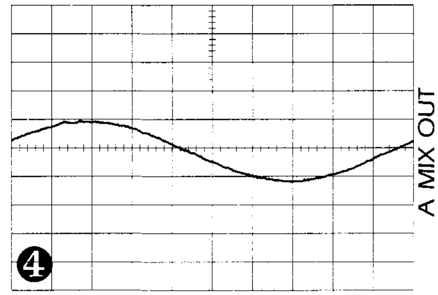


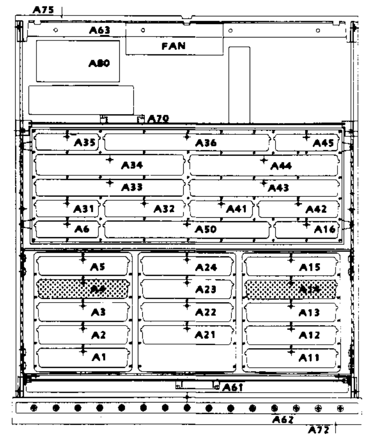
Table 6-14. Fault Isolation Tests Cont.





● **Ch A Preamp (A4)**
Ch B Preamp (A14) 4

Probe the test signal locations. If all signals are normal, A4 and A14 are functional.



Test Equipment

Oscilloscope
10:1 probe

HP 3326A Setup

INSTR PRESET
Ch A: AMPTD 10 Vpp
Ch B: AMPTD 10 Vpp

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Inputs: A MIX OUT, B MIX OUT	TP on A4, A14 (INPUT)	1 kHz sine, ≅200 mVpp.	Mixer (A5, A15).
$\overline{\text{A SIN}}$, $\overline{\text{B SIN}}$	XA4(pin A4), XA14(pin A4)	TTL low.	Level/AM (A22).
Outputs: A PREAMPOUT, B PREAMPOUT	TP on A4, A14 (PREAMPOUT)	1 kHz sine, ≅2 Vpp.	Preamp (A4, A14).

HP 3326A Setup

INSTR PRESET
Ch A: AMPTD 10 Vpp
FUNCTION Square
Ch B: AMPTD 10 Vpp
FUNCTION Square

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Inputs: $\overline{\text{A SIN}}$, $\overline{\text{B SIN}}$	XA4 (pin A4), XA14(pin A4)	TTL high.	Level/AM (A22).
A SQUAREOUT, B SQUAREOUT	XA4 (pin A9), XA14 (pin A9)	1 kHz square, ≅2 Vpp.	Square (A23). Check A SQUARE IN and B SQUARE IN signals below.
Outputs: A SQUARE IN, B SQUARE IN	XA4(pin A12), XA14(pin A12)	1 kHz sine, ≅2.5 Vpp.	Preamp (A4, A14).
A PREAMPOUT, B PREAMPOUT	XA4(pin A6), XA14(pin A6)	1 kHz square, ≅2 Vpp.	Relay on A4, A14.

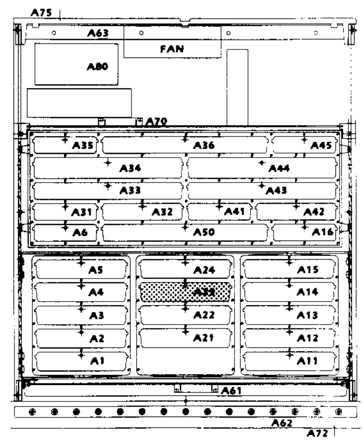
Table 6-14. Fault Isolation Tests Cont.

● Square (A23) 9

Probe the test signal locations. If all signals are normal, A23 is functional.

Test Equipment

Oscilloscope
Voltmeter
10:1 probe



HP 3326A Setup

INSTR PRESET
Clear calibration constants, press:
SHIFT [dBV %] [0]

Ch A:	FUNCTION	Square
	AMPTD	10 Vpp
Ch B:	FUNCTION	Square
	AMPTD	10 Vpp

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Inputs: A SQUARE IN	TP on A23 (A SQUARE IN)	1 kHz sine, ≅2.5 Vpp, < 70 mV dc offset.	Ch A preamp (A4).
B SQUARE IN	TP on A23 (B SQUARE IN)	Same as above.	Ch B preamp (A14).
A SQLEV	XA23 (pin C10)	4.00 to 4.14 Vdc.	Level/AM (A22).
B SQLEV	XA23 (pin C8)	Same as above.	Same as above.
V REF	XA23 (pin A10)	10.240 ±.010 Vdc.	Reference voltage sub-block of calibrator board (A36).
SQUARE/$\overline{\text{PULSE}}$	XA23 (pin C11)	TTL high.	Level/AM (A22).
A COMPAR ENABLE	XA23 (pin C12)	TTL high.	Same as above.
B COMPAR ENABLE	XA23 (pin C13)	TTL high.	Same as above.
Outputs: A SQUAREOUT	XA23 (pin C15)	1 kHz square, ≅2 Vpp, ≅ 0 V dc offset.	Square board (A23).
B SQUAREOUT	XA23 (pin C5)	Same as above.	Same as above.

NOTE

Perform a manual calibration (MANUAL key) or cycle power to reset the calibration correction constants.

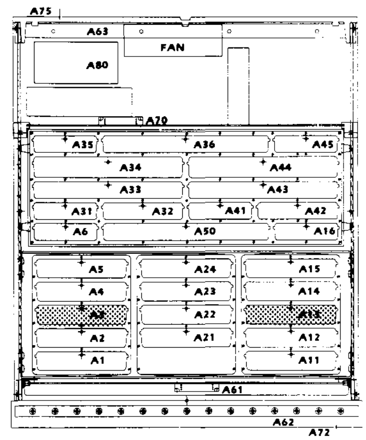
Table 6-14. Fault Isolation Tests Cont.

● Offset (A21) 7

The only fault isolation test for this board is the service self test. If you suspect this board is broken, go to A21 board level repair, sub-section 6-26.

● Ch A Output Amp (A3) Ch B Output Amp (A13) 3

Probe the test signal locations. If all signals are normal, A3 and A13 are functional. (The pre-10 dB pad and driver sub-block is tested with the attenuator boards (A2, A12).)



Test Equipment

Oscilloscope
Voltmeter
10:1 probe
Phono plug to BNC adapter cable

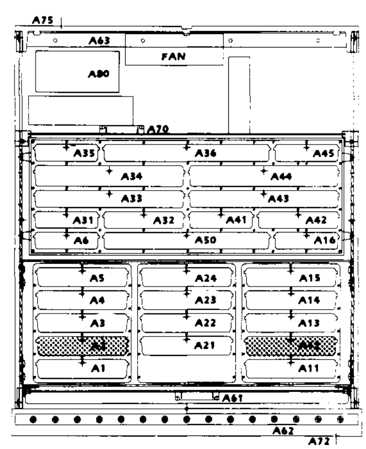
HP 3326A Setup

INSTR PRESET
Ch A: AMPTD 10 Vpp
Ch B: AMPTD 10 Vpp

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Inputs: A PREAMPOUT, B PREAMPOUT	XA3 (pins A5,B5,C5), XA13 (pins A5,B5,C5)	1 kHz sine, ≅2 Vpp.	Preamp (A4, A14).
A AMPDCO, B AMPDCO	XA3 (pins A8, B8, C8), XA13(pins A8, B8, C8)	≅ 0 Vdc.	Offset (A21).
A PRE10dB, B PRE10dB	XA3 (pin C13), XA13 (pin C13)	TTL low.	Offset (A21).
Outputs: A AMPOUT, B AMPOUT	TP on A3, A13 (AMPOUT)	1 kHz sine, ≅20 Vpp.	Output amp (A3, A13).
SYNC	Connector on A3 (SYNC)	1 kHz sine, ≅20 Vpp.	Same as above.
$\overline{\text{A IOVLD}}$, $\overline{\text{B IOVLD}}$	XA3 (pins A13, B13), XA13 (pins A13, B13)	TTL high.	Same as above.

● Ch A Attenuator (A2) Ch B Attenuator (A12) 2

Probe the test signal locations. If all signals are normal, A2, A12, and the pre-10 dB pads on A3 and A13 are functional.



Test Equipment

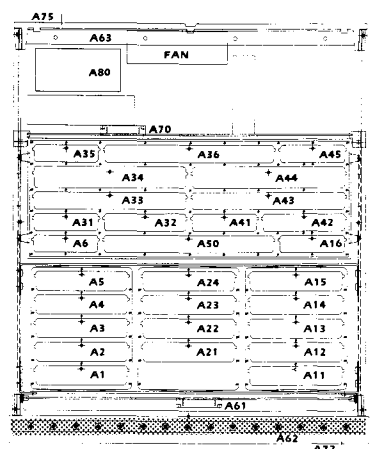
Oscilloscope
BNC cable

Table 6-14. Fault Isolation Tests Cont.

HP 3326A Setup	Test Location	If Amplitude is Abnormal, Suspect
INSTR PRESET Ch A: AMPTD 23.97 dBm Ch B: AMPTD 23.97 dBm	Front panel connector (CH A, CH B) or rear panel connector for Option 003 (CH A OUT, CH B OUT).	One of the four attenuator pads is engaged in error.
Modify tens digit of amplitude at 10 dB intervals. Verify the 10 dB step attenuation is taking place (i.e., the amplitude is being reduced to approximately one-third its original value).	Same as above.	Pre-10dB pad and driver sub-block on output amp (A3, A13). 10 dB, 20 dB, and 40 dB relays on attenuator (A2, A12). See level control table near the A2/A12 schematics for the levels when each attenuator is activated.

Sync Circuit on Keyboard (A62) 15

Probe the test signal locations. If all signals are normal, the synchronous output circuit (sync) on the keyboard (A62) is functional.



Test Equipment

Oscilloscope
Voltmeter
10:1 probe
Phono plug to BNC adapter cable
BNC cable

HP 3326A Setup

INSTR PRESET

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Inputs: SYNC	Connector on A3 (SYNC)	1 kHz sine, > 1.5 Vpp (≅ 2.0 Vpp).	Ch A output amp (A3).
A AMPDCO	XA61(pin C16)	≅ 0 Vdc.	Offset (A21), controller A61), or cable. The signal is produced on the offset board, and travels to the keyboard via the controller.
Output: SYNC A	Front panel connector (SYNC A) into 50 Ω	1 kHz square, ≅ 1.7 Vpp.	Sync circuit on keyboard (A62) or cable from A3 to A62.

Table 6-14. Fault Isolation Tests Cont.

● Calibrator (P/O A36) 12

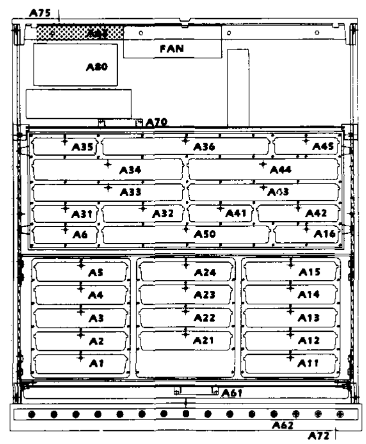
The only fault isolation test for this board is the service self test. If you suspect this board is broken, go to A36 board level repair, sub-section 6-31.

● HP-IB Support (A63) 14c

Probe the test signal locations. If all signals are normal, the external outputs circuit on A63 is functional.

NOTE

See controller/HP-IB support (A61, A63) board level repair sub-section for troubleshooting an HP-IB problem. This procedure tests the rear panel outputs circuitry.



Test Equipment

Oscilloscope
BNC cables (2)

HP 3326A Setup

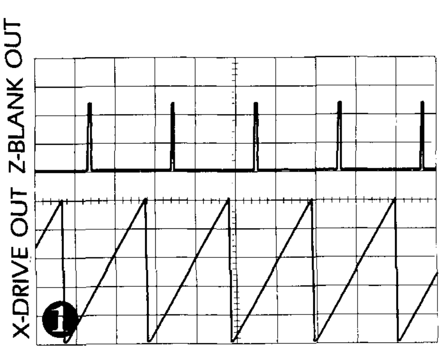
INSTR PRESET
Sweep CONT

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Outputs: Z-BLANK OUT ❶	Rear panel connector	TTL level, normally high, Low while sweeping.	HP-IB support (A63), controller (A61) or cable.
MARKER OUT ❷	Rear panel connector	TTL level, normally high. Low when marker frequency is reached.	Same as above.
X-DRIVE OUT ❶❷	Rear panel connector	Ramps from 0 to 10 V while sweeping. 1 s period.	Same as above.

Oscilloscope Setup

BNC cables (2)

Ch 1 Coupling	DC
Ch 1 V/Div	2 V
Ch 2 Coupling	DC
Ch 2 V/Div	2 V
Time/Div	500 ms
Trigger	Ch 1



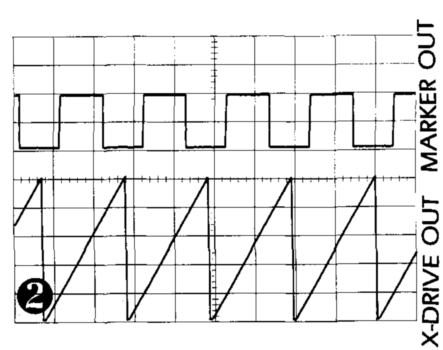
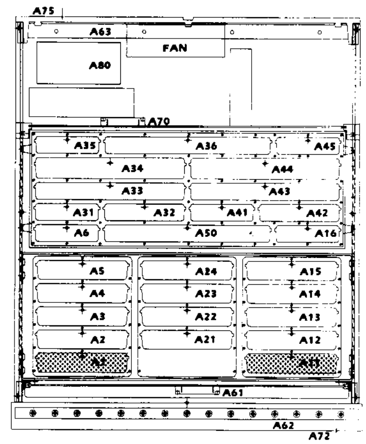


Table 6-14. Fault Isolation Tests Cont.

● Ch A HV Amp (A1, Option 002) Ch B HV Amp (A11, Option 002)

1

Probe the test signal locations. If all signals are normal, A1 and A11 are functional.



Test Equipment

Oscilloscope
Voltmeter
10:1 probe
BNC cable

HP 3326A Setup

INSTR PRESET
Ch A: HV Option Activated
AMPTD 40 Vpp
Ch B: HV Option Activated
AMPTD 40 Vpp

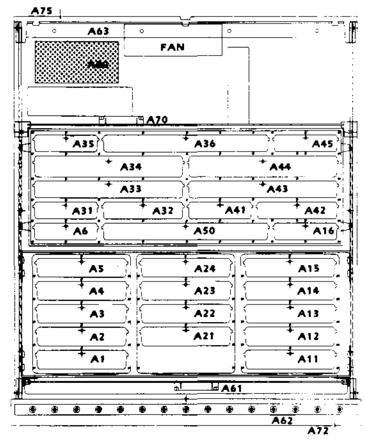
CAUTION

Do not short together the +28VDC and −28VDC supplies when probing on the motherboard.

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Inputs: A HVAMPIN, B HVAMPIN	XA1(pin A5), XA11(pin A5)	≅19 Vpp, 1 kHz sine.	Attenuator (A2, A12).
A HVDCO, B HVDCO	XA1(pin A11), XA11(pin A11)	≅ 0 Vdc.	Offset (A21).
+28VDC	TP on A1, A11 (+28V1)	≅ +27 V.	Power supply (A70).
−28VDC	TP on A1, A11 (−28V1)	≅ −27 V.	Power supply (A70).
Outputs: A HVAMPOUT, B HVAMPOUT	TP on A1, A11 (HVAMPOUT)	40 Vpp, 1 kHz sine.	HV amp (A1, A11).
CH A, CH B	Front panel connector (CH A, CH B) or rear panel connector for Option 003 (CH A OUT, CH B OUT). Use high impedance input.	Same as above.	Hi-voltage option relay on attenuator (A2, A12).
$\overline{\text{A HVOVLD}}$, $\overline{\text{B HVOVLD}}$	TP on A1, A11 ($\overline{\text{HVOVLD}}$)	TTL high.	HV amp (A1, A11).

Table 6-14. Fault Isolation Tests Cont.

● Oven Reference (A80, Option 001) 19



Probe the test signal locations. If all signals are normal, A80 is functional.

Test Equipment

Oscilloscope
Voltmeter
BNC cable

HP 3326A Setup

INSTR PRESET

Test Signal	Test Location	Normal Indication	If Abnormal, Suspect
Input: +15V RAW	A80TP2 (+18V) (accessible from bottom of instrument)	> 17 V.	Power supply (A70).
Output: 10MHz OVEN OUT, OPTION 001	Rear panel connector into 50 Ω	10 MHz sine, > 446.7 mVpk.	Oven reference (A80) or cable.

SECTION VI
SERVICE — BOARD LEVEL REPAIR

Board Level Repair

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SECTION VI
SERVICE (Continued)

BOARD LEVEL REPAIR

6-14 INTRODUCTION

This part of the service section provides troubleshooting and repair information for individual boards in the HP 3326A Two-Channel Synthesizer, including the high stability frequency reference (Option 001) and the high voltage output (Option 002).

Each board in the HP 3326A serves a single electrical function and is called a functional block. The first part of the service section, "Fault Isolation to the Board Level," should be used to find the defective board. "Board Level Repair" may then be used to further isolate the problem to the functional sub-block. At this point, the technician's expertise is relied upon to isolate the defective component in the functional sub-block.

Circuit theory and troubleshooting information for each board is included in this part of the service section. Sample waveforms and voltage levels appear on the schematics (or near the schematics if space is limited). Signal parameters preceded by an ≅ character are typical parameter values and only serious deviations should be investigated. Specific troubleshooting procedures and hints are included when applicable.

Once repaired, it is necessary to perform all adjustments associated with the repaired board. A copy of Table 3-3, Post-Repair Adjustments, is included here. See Table 6-15.

Table 6-15. Post-Repair Adjustments

Repaired Boards		Related Adjustments	
Reference Designator	Name	Number	Name
A1, A11	HV Amp	15	HV Overshoot
A2, A12	Attenuator	13	Flatness
A3, A13	Output Amp	13 14 16	Flatness Overshoot Bias
A4, A14	Preamp	11 12 13	2nd Harmonic DC Offset Flatness
A5, A15	Mixer	10 11 12 13 14 16	2:1 Spur 2nd Harmonic DC Offset Flatness Overshoot Bias
A6, A16	Modulator	10 11	2:1 Spur 2nd Harmonic
A21	Offset	9	A and B Offset
A22	Level/AM	—	—
A23	Square	12 14	DC Offset Overshoot
A24	RF Switch	10 11	2:1 Spur 2nd Harmonic
A31, A41	VCO	4 5 6	VCO Freq 100 kHz APIs
A32, A42	VCO Control	5 6	100 kHz APIs
A33, A43	Phase Detector	5 6	100 kHz APIs
A34, A44	FracN Digital	5 6	100 kHz APIs
A35, A45	VCO ÷ 2	—	—
P/O A36	FracN Decoder	—	—
P/O A36	Calibrator	7 8 9	V Ref Peak Detect Gain A and B Offset
A50	Reference	3	Freq Center
A61	Controller	17	Battery Check
A62	Keyboard	—	—
A63	HP-IB Support	—	—
A70	Power Supply	1 3	+15 V Freq Center
A72	Front ESD	—	—
A75	Rear ESD	—	—
A80	Oven Reference	2	Oven Freq
A99	Motherboard	—	—

6-15 PC BOARD CROSS REFERENCE

The PC board cross reference table shown here lists the boards by numeric order of schematics, as well as numeric order of printed circuit boards. See Table 6-16. A copy of this table appears near the instrument block diagram (after the schematics).

Table 6-16. PC Board Cross Reference

Schematic Number	Board Number			Board Name	HP Part Number
	CH A	CH B	Common		
1.	A1	A11		HV Amp†	03326-66501
2a.	A2			Attenuator	03326-66502
2b.		A12		Attenuator	03326-66512
3.	A3	A13		Output Amp	03326-66503
4.	A4	A14		Preamp	03326-66504
5.	A5	A15		Mixer	03326-66505
6.	A6	A16		Modulator	03326-66506
7.			A21	Offset	03326-66521
8.			A22	Level/AM	03326-66522
9.			A23	Square	03326-66523
10.			A24	RF Switch	03326-66524
11a.	A31	A41		VCO	03326-66531
11b.	A32	A42		VCO Control	03326-66532
11c.	A33	A43		Phase Detector	03326-66533
11d.	A34	A44		FracN Digital	03326-66534
11e.	A35	A45		VCO ÷ 2	03326-66535
11f.			P/O A36	FracN Decoder	03326-66536
12.			P/O A36	Calibrator	03326-66536
13.			A50	Reference	03326-66550
14a.			A61	Controller	03326-66561
14b.			A61	Controller	03326-66561
14c.			A61	Controller	03326-66561
			A63	HP-IB Support	03326-66563
15.			A62	Keyboard	03326-66562
16.			A70	Power Supply	03326-66570
17.			A72	Front ESD	03326-66572
18.			A75	Rear ESD	03326-66575
19.			A80	Oven Reference‡	03326-66580
—			A99	Motherboard	03326-66599

† Option 002 only.
‡ Option 001 only.

6-16 TROUBLESHOOTING HINTS

When troubleshooting the circuit boards in the HP 3326A, keep the following things in mind:

- Use the two channel nature of the HP 3326A to its full advantage. Interchange identical boards between channel A and channel B to help isolate faults. See Table 6-3, Identical Boards.

- Use the two extender boards provided in the service accessory kit (see "Accessories Available" in Section I) to compare waveforms between identical boards in the two channels. See sub-section 6-5, "Waveform Comparison."

- Use a 10:1 probe with a ground spring (HP part number 1460-1476) when making high frequency measurements to minimize distortion.

- A detailed overall block diagram is located at the end of the schematics.

- Poor ground connections in the phono cables can cause intermittent problems that can appear to be subtle hardware failures (for example, poor phase or amplitude calibration accuracy). Crimping the phono connectors to improve the ground connections is recommended.

- It is possible that one circuit board is being loaded by another circuit board, resulting in an apparent failure in the first circuit board.

- Use cool spray to help isolate problems. Circuit cooler sprays are widely available and can be very helpful in isolating problems. The most generally used method is to spray selected components to see if the malfunction can be temporarily cured. If this can be accomplished, the bad component is then isolated. This method does not work all the time, but it can be a great timesaver. It is especially helpful on intermittent problems which get worse with a rise in temperature.

- Use signature analysis to troubleshoot digital circuits when possible. This is an extremely powerful troubleshooting tool that allows a "window" on a digital node to give a go/no-go test. These tests are found in the controller board (A61 troubleshooting (sub-section 6-33).

  If a signature analyzer is not available, keep in mind that most digital failures involve a line that is stuck high or low. Thus, a little guided probing using an oscilloscope in the suspected areas may find the problem.

- Many problems on older instruments are directly traceable to corrosion. Often, simply removing and re-seating the affected printed circuit boards can "cure" a problem. Cleaning connector pins and/or switch contacts with an approved cleaning fluid is a permanent solution to many types of digital and analog circuit problems.

6-17 SAFETY CONSIDERATIONS

The HP 3326A is a Safety Class 1 instrument (provided with a protective earth terminal). The instrument and manuals should be reviewed for safety markings and instructions before operation. Refer to the Safety Symbol table in the preface of this manual.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

WARNING

Maintenance described herein is performed with power supplied to the instrument and protective covers removed. Such maintenance should be performed only by service-trained technicians who are aware of the hazards involved (for example, fire and electrical shock). Primary power is supplied to the instrument whenever the line cord is attached, independent of the power switch position. Where maintenance can be performed without power applied, the power cord should be removed.

6-18 LOGIC CONVENTIONS

Positive logic convention is used in this manual unless otherwise noted. Positive logic conventions define a logic "1" or "high" as the more positive voltage and a logic "0" or "low" as the more negative voltage. Signals which are active low are denoted by a bar over the signal name. Most of the logic devices used in this instrument are either TTL or ECL; notes exist on the schematics indicating devices from these and other logic families. Table 6-17 lists the voltage levels that are associated with the TTL and ECL families.

Table 6-17. Logic Voltage Levels

LOGIC	TTL	ECL
High (1) Low (0)	≥ 2 V ≤ 0.8 V	≥ 4.1 V ≤ 3.25 V

6-19 LOGIC SYMBOLOGY

The logic symbology used in this manual is based on ANSI Y32.14-1973. The reference designations and general schematic notes are shown in Figure 6-13 and Table 6-18, respectively.

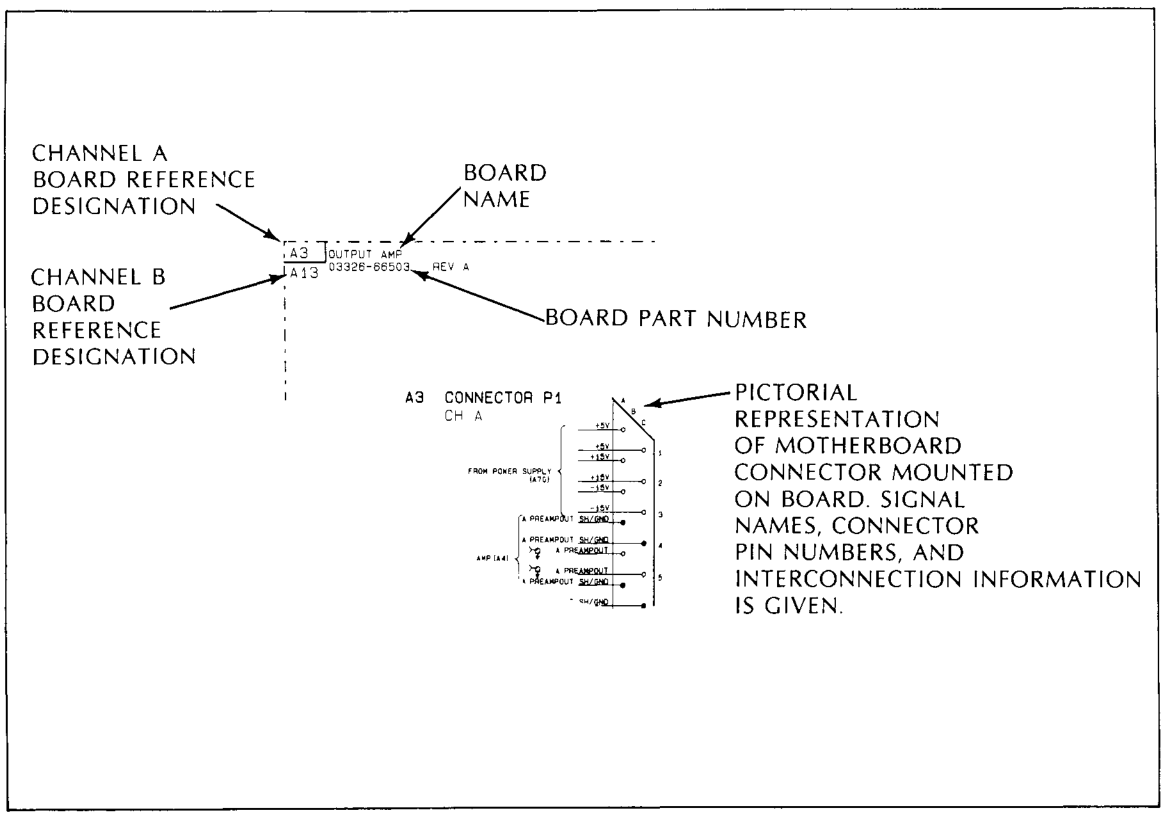


Figure 6-13. Reference Designators

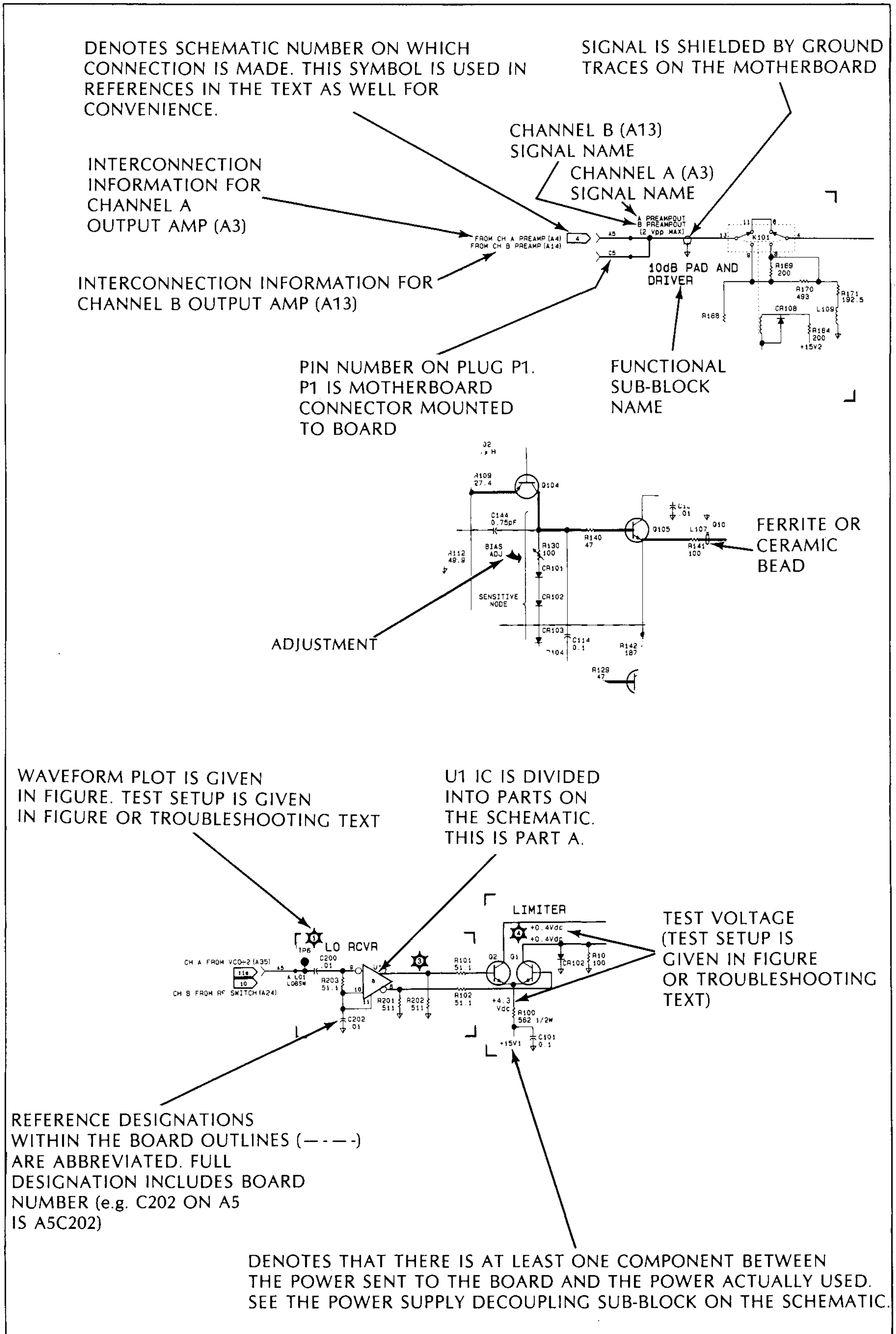


Figure 6-13. Reference Designator (cont.)

Table 6-18. General Schematic Notes

GENERAL SCHEMATIC NOTES

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATIONS(S) OR BOTH FOR COMPLETE DESIGNATION.

2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.

   RESISTANCE IN OHMS
   CAPACITANCE IN MICROFARADS
   INDUCTANCE IN MILLIHENRIES

3. DENOTES EARTH GROUND USED FOR TERMINALS WITH NO LESS THAN A NO. 18 GAUGE WIRE CONNECTED BETWEEN TERMINAL AND EARTH GROUND TERMINAL OR AC POWER RECEPTACLE.

4. DENOTES FRAME GROUND. USED FOR TERMINALS WHICH ARE PERMANENTLY CONNECTED WITHIN APPROXIMATELY 0.1 OHM OF EARTH GROUND.

5. DENOTES GROUND ON PRINTED CIRCUIT ASSEMBLY. (ISOLATED FROM FRAME GROUND).

6. DENOTES ASSEMBLY.

7. DENOTES MAIN SIGNAL PATH.

8. DENOTES FEEDBACK PATH.

9. DENOTES FRONT PANEL MARKING.

10. DENOTES REAR PANEL MARKING.

11.  DENOTES SCREWDRIVER ADJUST.

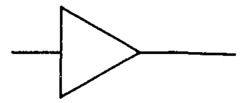
12. * AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY. THE VALUE OF THESE COMPONENTS MAY VARY FROM ONE INSTRUMENT TO ANOTHER. THE METHOD OF SELECTING THESE COMPONENTS IS DESCRIBED IN SECTION V OF THIS MANUAL.

13. DENOTES SECOND APPEARANCE OF A CONNECTOR PIN.

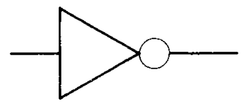
14. 924 DENOTES WIRE COLOR. COLOR CODE SAME AS RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES BASE COLOR, SECOND NUMBER IDENTIFIES WIDER STRIP, THIRD NUMBER IDENTIFIES NARROWER STRIP. (e.g. 924 = WHITE, RED, YELLOW.)

15. ALL RELAYS ARE SHOWN DEENERGIZED.

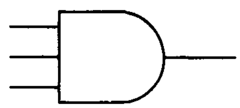
INPUT IMPEDANCE. THE VOLTAGE LEVELS SHOWN ARE NOMINAL AND MAY VARY FROM ONE INSTRUMENT TO ANOTHER DUE TO CHANGE IN TRANSISTOR CHARACTERISTICS. A VARIATION OF ± 10% SHOULD BE ALLOWED.



DENOTES BUFFER

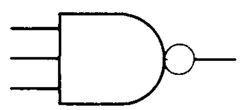


DENOTES INVERTER



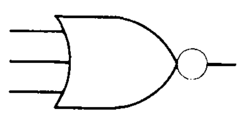
DENOTES AND GATE

A	B	C	Q
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1



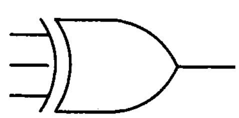
DENOTES NAND GATE

A	B	C	Q
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0



DENOTES NOR GATE

A	B	C	Q
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0



DENOTES EXCLUSIVE OR GATE

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	0

6-20 CHANNEL A AND CHANNEL B HV AMPLIFIER, A1 AND A11 (OPTION 002)

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) is defective.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

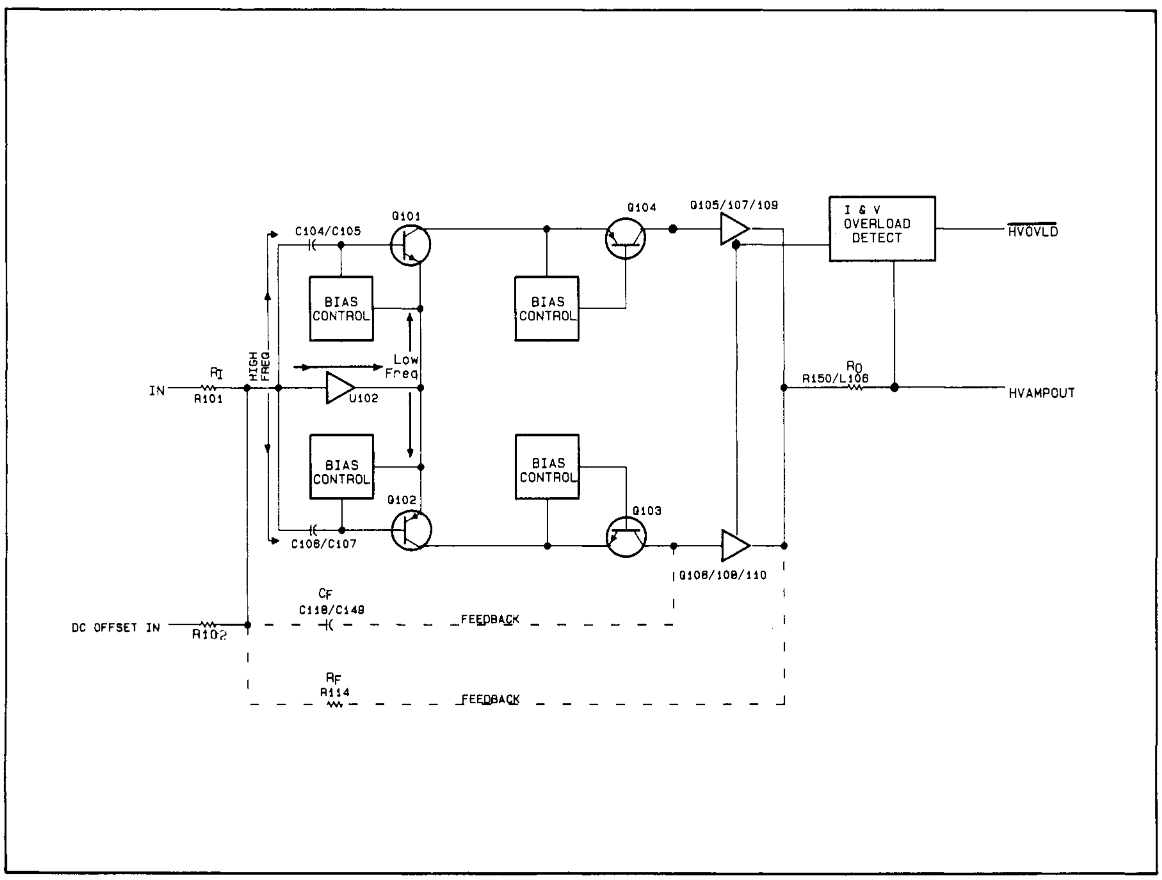


Figure 6-14. High Voltage Amplifier Block Diagram

Theory of Operation

The preamplifiers (A4 and A14), output amplifiers (A3 and A13) and high voltage amplifiers (A1 and A11, Option 002) share the same topology and general theory of operation, as described here. The amplifier can be viewed as a discrete version of an inverting operational amplifier (op amp). The overall gain of the amplifier is established by the ratio of the value of the feedback resistor (R114) to that of the input resistor (R101). The resistors share a common "virtual ground" point at the input to the amplifier. The input impedance of the amplifier is 953 Ω (as set by R101). The output impedance is 0 Ω or "low impedance."

The general operation of the amplifier is understood by separating the small signal operation from the biasing circuitry. The small signal circuits essentially consist of the ten transistors (Q101-Q110). These form a symmetrical "push-pull" configuration which can be further simplified by focusing on the function of the half circuit consisting of transistors Q101, Q104, Q105, and the parallel pair, Q107 and Q109. Transistors Q101 and Q104 form a cascode pair in which the collector of Q104 is a current source providing high voltage gain. The sensitive node marked on the schematic (which includes the collectors of Q103 and Q104, diodes CR103-CR106, and resistors R132, R133, and R140) can be regarded as a single high impedance gain point that is extremely sensitive to any parasitic capacitance. Touching this node severely affects the amplifier performance and stability. The Darlington transistor pair (Q105 and the parallel transistor pair Q107 and Q109) buffers the node and provides the output current drive capability of the amplifier.

The amplifier contains two gain paths. One is ac coupled from the "virtual ground" point to the base circuits of transistors Q101 and Q102 through capacitors C104/C105 and C106/C107, respectively. This path is dominant at high frequencies. At low frequencies and dc the directly coupled path (through U102) is dominant. These signals are amplified and inverted by U102 and passed to the emitter circuits of Q101 and Q102. U102 provides a direct coupled path for biasing the amplifier at dc and provides additional loop gain at low frequencies for improving distortion in the audio range.

Op amps U101, 103, and 104 serve as biasing elements for each of the four cascode transistors (Q101-Q104). The base-emitter junctions are included in the feedback loops to eliminate amplifier sensitivity to temperature changes which cause (biasing) variations in V_{be}. This maintains the emitter voltages of Q101 and Q102 at approximately 0.5 V and −0.5 V and the base voltages of Q103 and Q104 at approximately 24.5 V and −24.5 V.

High frequency stability and compensation is achieved with a Miller capacitance (C118 and C149) which provides feedback from the high gain node to the "virtual ground" point. C149 is a variable capacitor which adjusts the circuit's square wave overshoot. The voltage across R133 establishes the output stage quiescent current level through the transistors Q107 through Q110.

Current and voltage overload detection are provided by the comparator circuitry of U105 which monitors the collector circuits of the Darlington amplifier pairs and the main signal output, HVAMPOUT. IC sections a and b monitor current overload by setting $\overline{\text{HVOVLD}}$ in the event of an overvoltage condition of the output signal. IC sections c and d monitor voltage overloads by setting $\overline{\text{HVOVLD}}$ in the event of a low voltage condition in the collector circuits of the final amplifier stage. (The terms "low voltage" and "overvoltage" in this discussion refer to signal magnitude). The $\overline{\text{HVOVLD}}$ signal goes to the attenuator board where it can activate protection irrespective of other logic conditions.

Troubleshooting

The multiple feedback design and delicate balance of the individual stages of this circuit make them highly interactive. This causes the symptoms of a problem in any part of the amplifier to propagate throughout. Also, due to the high open-loop gain, many of the component connections within the circuit are so sensitive to stray capacitance that the balance would be disturbed by probing with test equipment.

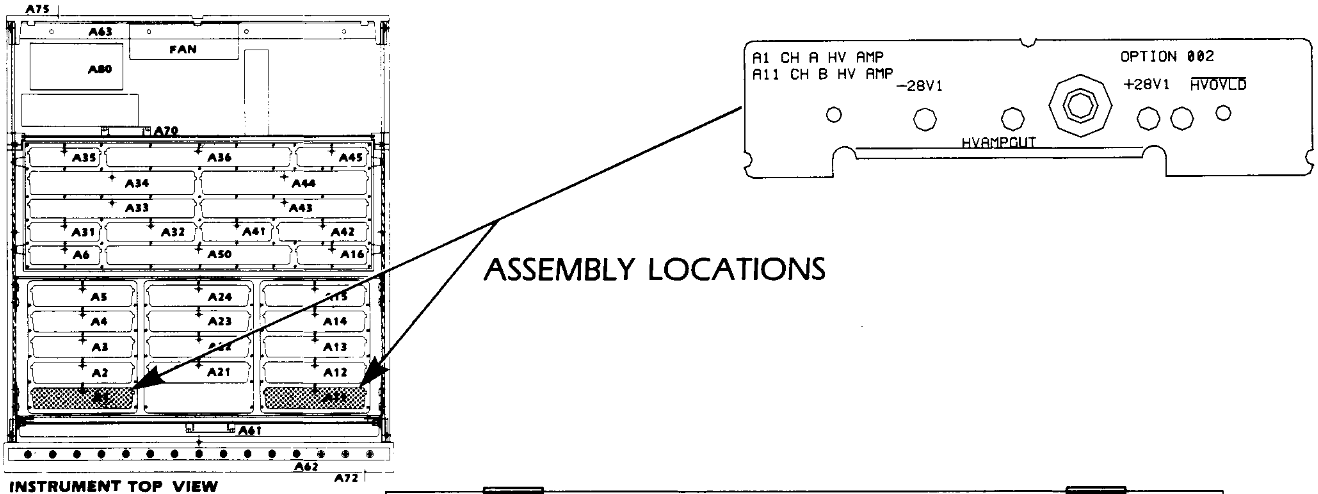
First, make a visual inspection of the board, looking for burned or otherwise damaged parts. Then check the power supplies on the board. It is useful to probe the input and output of the amplifier with an oscilloscope to determine whether the failure is catastrophic or not. The waveform shape of the output may contain a clue as to which half of the push-pull amplifier stages are failing. Test points are provided to measure bias in the base circuits of the first two stages.

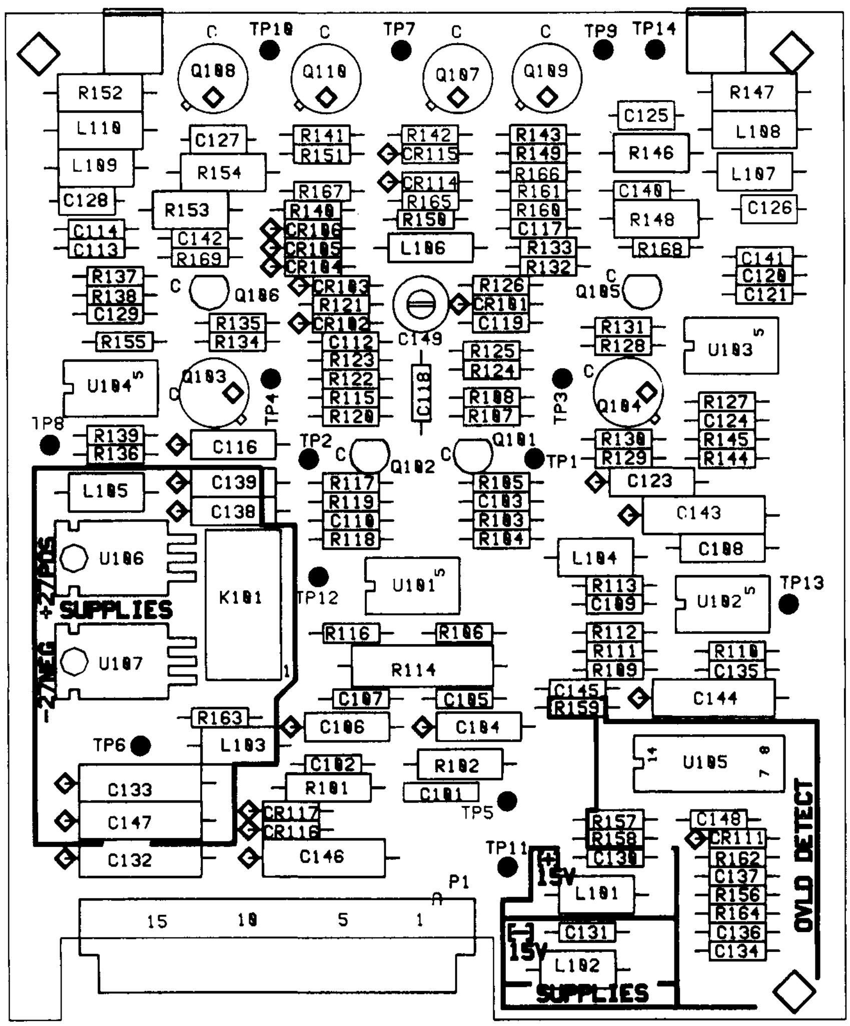
If these basic troubleshooting methods have failed to isolate the problem, the fastest troubleshooting method is to replace components based on their probability of failure. This approach is recommended because of the circuit's troubleshooting difficulties. Replace transistors first, whole stages at a time, beginning at the output. It is recommended that all transistors in a stage be changed at the same time because failure of one tends to stress the performance parameters of the other(s). If Q107 is replaced, Q108 through Q110 should also be replaced. If low-frequency response is out of specification, replace U102. After that, the op amps composing the biasing for the first two stages should be replaced. If these replacements have not fixed the problem, replace the diodes in the sensitive node (see schematic) and check the larger capacitors on the board for shorts or leakage. These last two suggestions have about equal probability of solving the problem.

If the amplifier has failed in a manner that suggests that the overload protection circuitry is not operating properly (i.e., it was overloaded from the front panel), it is recommended that the protection circuitry be exercised and checked for failure. The high voltage amplifier has current and voltage overload detection provided by the comparator circuitry of U105. To exercise this circuit, ground pins 10, 9, 7, and 4, one at a time. Each should cause the instrument to indicate that it has been overloaded. The instrument should reset itself soon after removing the ground. It is recommended that the protection circuitry on the attenuator board be checked, also, as described in the attenuator board level repair sub-section.

Refer to Table 6-15 for recommended post-repair adjustments.

NOTES





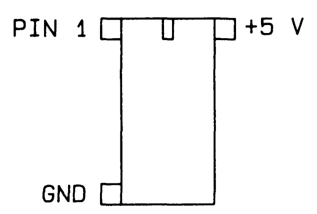
HV AMP BOARDS (A1, A11)

P/N 03326-66501

REV B

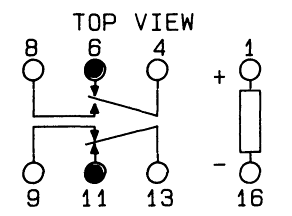
NOTES:

1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).



2. NO COMPONENT IS SUPPOSED TO BE LOADED ON THE FOOTPRINT OF THE JACK. THE FOOTPRINTS ARE USED FOR FACTORY TEST PURPOSES ONLY.

3. RELAYS ARE SHOWN IN THE DE-ENERGIZED STATE.
P/N 0490-1405.



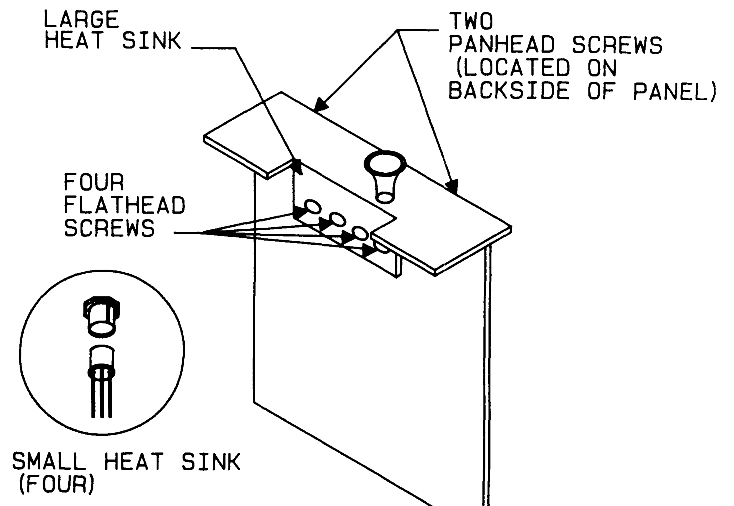
4. THIS BOARD IS USED TWICE IN THE INSTRUMENT - ONCE FOR CHANNEL A, AND ONCE FOR CHANNEL B. THE TWO IDENTICAL BOARDS MAY BE INTERCHANGED FOR TROUBLESHOOTING, BUT MUST BE RETURNED TO THEIR ORIGINAL LOCATIONS TO AVOID RECALIBRATION OF THE INSTRUMENT.

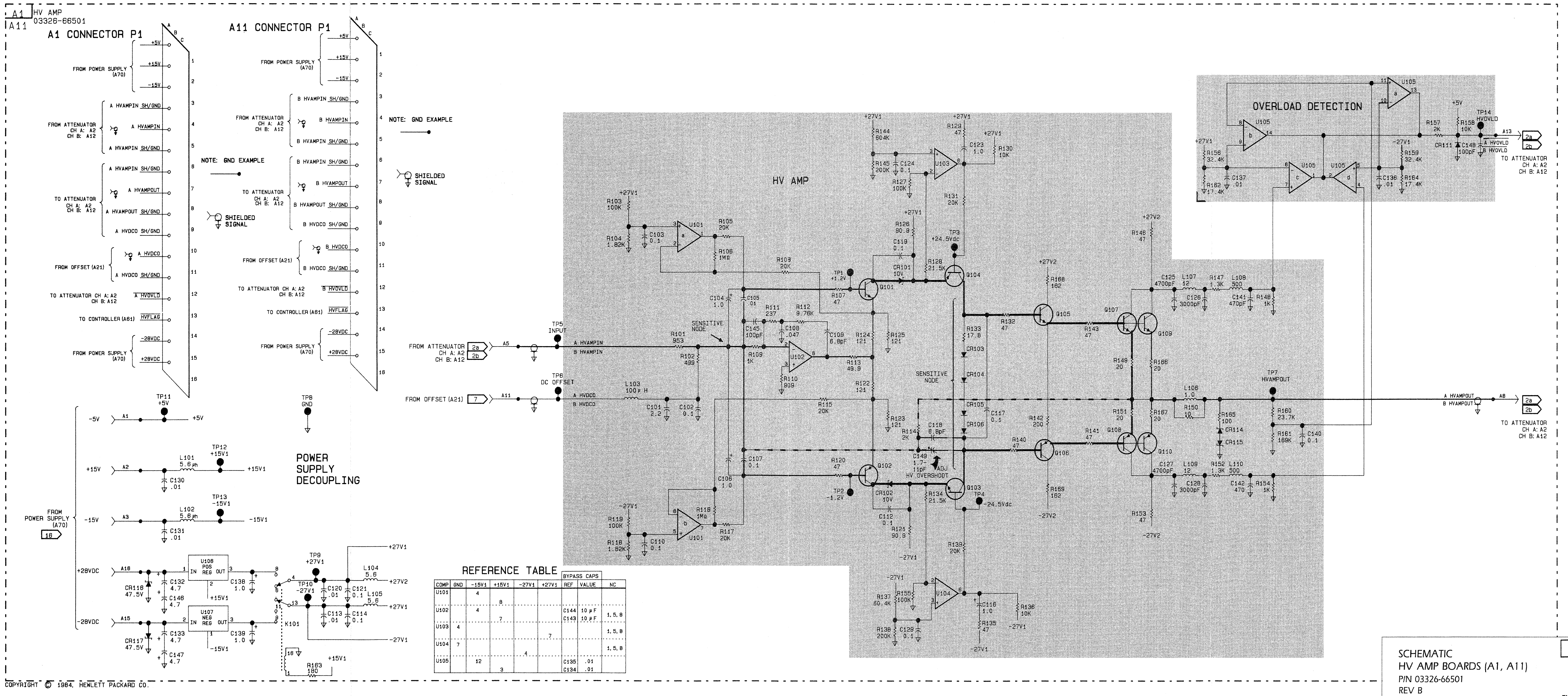
CAUTION

5. REMOVE MAIN POWER CORD WHENEVER YOU ARE PLACING HIGH VOLTAGE AMPLIFIER BOARD (A1 OR A11) ON AN EXTENDER. OTHERWISE, THE +28 Vdc AND -28 Vdc SUPPLIES CAN SHORT THE CORD NESTS (GND) AND BLOW THE LINE FUSE.

6. TOUCHING THE PART OF THE CIRCUIT MARKED "SENSITIVE NODE" WILL AFFECT THE STABILITY AND PERFORMANCE OF THE AMPLIFIER.

7. TO ACCESS TRANSISTORS UNDER LARGE HEAT SINK, REMOVE TOP COVER AND LARGE HEAT SINK. REMOVE TWO PANHEAD SCREWS HOLDING THE COVER AND FOUR FLATHEAD SCREWS HOLDING SMALL HEAT SINKS ONTO THE LARGE HEAT SINK.





REFERENCE TABLE

COMP	GND	-15V1	+15V1	-27V1	+27V1	BYPASS CAPS REF	BYPASS CAPS VALUE	NC
U101		4	8					
U102		4	7			C144 C143	10 μF 10 μF	1, 5, 8
U103	4				7			1, 5, 8
U104	7			4				1, 5, 8
U105		12	3			C135 C134	.01 .01	

SCHEMATIC
HV AMP BOARDS (A1, A11)
P/N 03326-66501
REV B

Figure 6-15.

See Other Side

6-21 CHANNEL A AND CHANNEL B ATTENUATOR, A2 AND A12

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

Theory of Operation

The attenuator board's primary function is to perform the final signal conditioning. This includes attenuating, combining signals, and routing signals to the high voltage amplifiers (if high voltage outputs, Option 002, is installed). This board also routes the output signal to the calibration circuitry during internal calibration and detects signals on the output large enough to damage the output circuitry and automatically protect itself.

Attenuation:

Attenuation is provided by a series of pads which are switched in and out to give step attenuation in increments of 10 dB, up to 60 dB.

Combiner:

When combined operation is selected, the combiner on the channel A attenuator receives the channel B output signal from the channel B attenuator and resistively sums it with the channel A output signal. The sum of the signals appears on the CH A output connector on the front panel.

High voltage outputs option:

The main signal is routed to the high voltage amplifier when the high voltage outputs option is installed and selected. Otherwise, the signal goes directly to the calibration/protection circuit relay.

Calibration/Protection:

After the high voltage amplifier relay, the signal may be routed directly to the output connector on the front panel or to the internal calibration circuits on the calibrator board (A36). The signal path to the calibration circuit has two relays in series (K107 and K108) to reduce crosstalk between channels when the instrument is not calibrating.

The relay used to route the output signal to the calibrator (K107) is also activated to protect the output circuitry from large signals applied to the output connector. This relay is activated by the calibration circuitry or the output protection circuitry.

The protection circuitry consists of the voltage overload sense circuit and the overload protect logic circuit. The overload condition is sensed using comparators which perform 5 V and 10 V overvoltage detection at the output connector. The overload protect logic circuit performs gating of the appropriate overload conditions, combines the various overload flag lines, and sends the result to an RS latch (U102). If an overload occurs, the latch is set, which drives the CAL/PRTCT relay, isolating the output circuitry from the output connector. The OVLD signal is sent to the processor indicating that the attenuator protection circuitry is activated. This state is maintained by the latch until the processor resets it (see A PROTECTCLEAR and B PROTECTCLEAR in the signal glossary).

Troubleshooting

The instrument bus circuit on the controller board (A61) and the control interface on this board can be tested using the Interface SA Test (see Tables 6-52 and 6-53 in the A61 troubleshooting sub-section 6-33). This test exercises the control lines from the controller board to determine if the controller or the control interface circuitry is defective.

If the attenuation is not stepping properly, check the signals used to select relay operation coming from the offset board. These may be manipulated through the use of the front panel and information contained in Table 6-19, which follows. Operation of all relays may be verified by determining whether a signal appears at pin 11, indicating a de-energized relay. If the signals to the drivers (U100) are correct and relay operation is not correct, check for proper operation of U100.

Any time an amplifier circuit is found to be defective such that overloading from the front panel output is a possible cause, the voltage overload and overload protect circuits should be exercised. Some of the inputs to the logic circuits come from the output amplifier and high voltage amplifier boards. These circuits should be tested individually as described in their respective board level repair sub-sections. The attenuator has two overload sensing circuits: the 10 volt overload (used when no attenuator pads are selected **and** the high voltage output is not selected) and the 5 volt overload (used when one or more pads are selected **and** the high voltage output is not selected). To exercise these circuits, put the attenuator on an extender board, make sure the high voltage output is not selected, and perform the following steps:

10V OVLD:

- Enter an amplitude of 4 Vpp on the front panel.
- Exercise the circuit by grounding U101, pin 9 and pin 10. Each should cause the instrument to protect itself. The instrument should reset the protect condition soon after the ground is removed.

5V OVLD:

- Enter an amplitude below 3 Vpp on the front panel.
- Exercise the circuit by grounding U101, pin 7 and pin 4. Each should cause the instrument to protect itself. The instrument should reset the protect condition soon after the ground is removed.

The following table shows the relationship between energization of the attenuator relays and signal output level. Note that the first column refers to the 10 dB pad located on the output amplifier boards, A3 and A13. Also, other relays on this board (used to select the combiner feature, the high voltage option, or calibration) may be exercised by using the front panel controls.

Table 6-19. Level Control

Level	Attenuator Relays			
	Pre- 10 dB	40 dB K103	20 dB K102	10 dB K101
10.0 - 3.16 Vpp	0	0	0	0
3.159 - 1.0 Vpp	1	0	0	0
999.0 - 316.0 mVpp	1	0	0	1
315.9 - 100.0 mVpp	1	0	1	0
99.0 - 31.6 mVpp	1	0	1	1
31.59 - 10.0 mVpp	1	1	0	0
9.99 - 3.16 mVpp	1	1	0	1
3.159 - 1.0 mVpp	1	1	1	0

Where: 1 = relay energized
0 = relay de-energized

Table 6-20 shows the activation of relays for various instrument functions with attenuator board relays highlighted. Table 6-21 shows the activation of relays for instrument calibration with attenuator board relays highlighted.

Refer to Table 6-15 for recommended post-repair ádjustments.

Table 6-20. Function Control

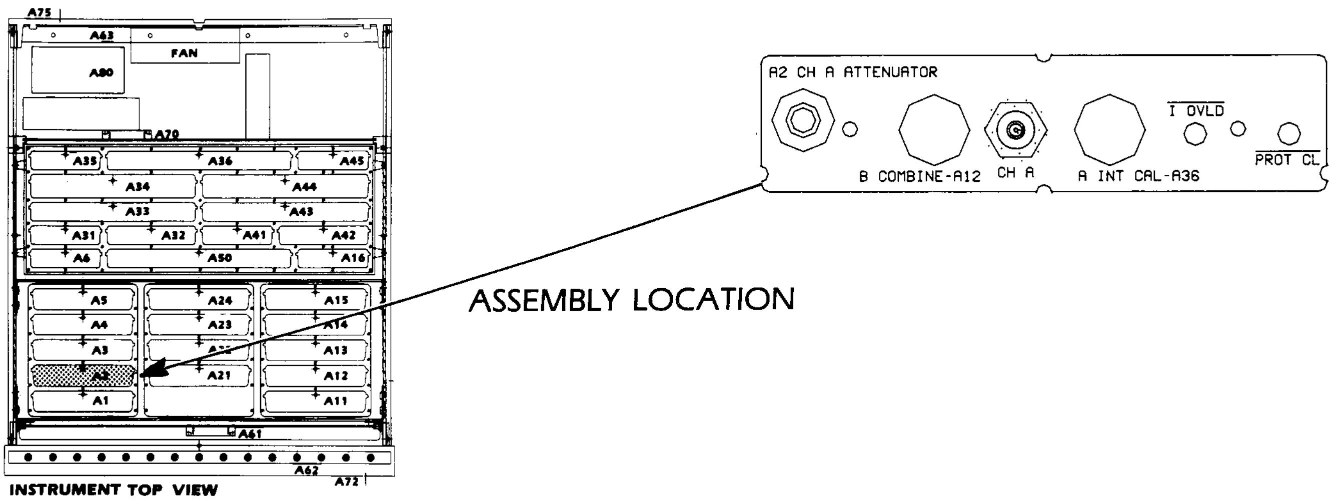
Switch Name †	Reference Designator (pin no.)	Off		Sine		Square		DC		HV		Combined	Int AM	Ext AM		Int PM	Ext PM		Sync PM
		A	B	A	B	A	B	A	B	A	B			A	B		A	B	(AB)
Ch A Cal/Prtct	A2K107	0	X	1	X	1	X	1	X	1	X	1	1	1	X	1	1	X	1
Ch B Cal/Prtct	A12K107	X	0	X	1	X	1	X	1	X	1	1	1	1	1	1	1	1	1
Ch A HV Option	A2K106	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X
Ch B HV Option	A12K106	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X
Ch A Square	A4K101	X	X	0	X	1	X	0	X	X	X	X	X	X	X	X	X	X	X
Ch B Square	A14K101	X	X	X	0	X	1	X	0	X	X	X	X	X	X	X	X	X	X
Ch A Offset	A21K1	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X
Ch B Offset	A21K21	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X
INT AM	A22U2(1)	X	X	X	X	X	X	X	X	X	X	X	ON (L)	OFF (H)	X	X	X	X	X
A EXT AM	A22U2(16)	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	ON (L)	X	X	X	X	X
B EXT AM	A22U6(1,16) A22U6(8,9)	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	X	X	X	X
INT PM	A32U22(1)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	OFF (H)	OFF (H)	OFF (H)
A EXT PM	A32U22(16)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	ON (L)	X	ON (L)
B EXT PM	A42U22(16)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	X
Ch A PM	A32U22(9)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	OFF (H)	X	OFF (H)
Ch B PM	A42U22(9)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	X
Ch A Combiner Isolation	A2K105	X	X	X	X	X	X	X	X	X	X	1	0	X	X	0	X	X	X
Ch A Combiner	A2K104	X	X	X	X	X	X	X	X	X	X	1	0	X	X	0	X	X	X
Ch B Combiner/ INT MOD	A12K104	X	X	X	X	X	X	X	X	X	X	1	1	X	X	1	X	X	X

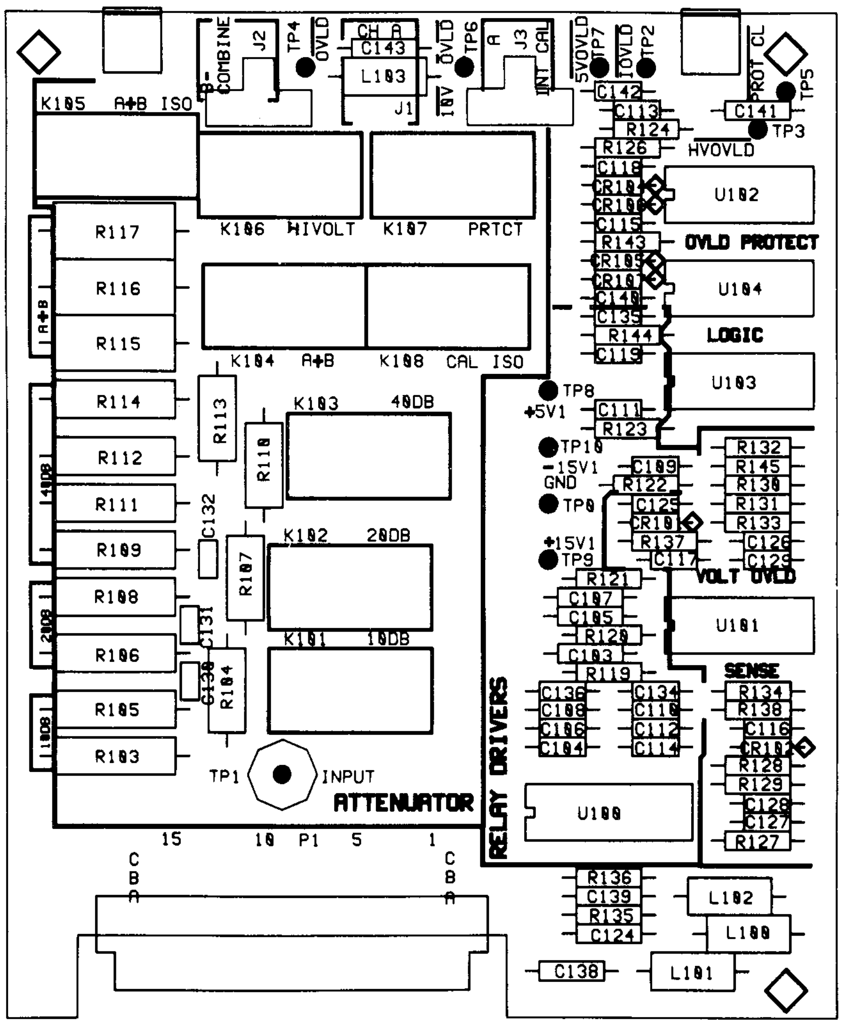
† X = Relay can be in either the de-energized or energized position in this function.
1 = Relay must be in the energized position in this function.
0 = Relay must be in the de-energized position in this function.
ON (L) = Control line for the switch must be TTL low in this function. This activates the switch.
OFF (H) = Control line for the switch must be TTL high in this function. This de-activates the switch.

Table 6-21. Calibration Control

Switch Name†	Reference Designator	Calibration				
		Self Test		Internal		External
		LEVTEST	OFFTEST	Amp/Offset	Phase	Phase
CAL ISOLATION	A2K108, A12K108	X	X	0	0	1
CAL/PRTCT	A2K107, A12K107	X	X	0	0	1
CAL AMP +	A36K1	X	X	X	0	0
CAL AMP −	A36K2	X	X	X	0	0
AMP CAL	A36K3	X	X	X	X	X
PHASE CAL	A36K4	X	X	0	1	1
INT CAL	A36K5	X	X	0	0	1
PEAK DETECTOR INPUT	A36U203(1)	OFF (H)	ON (L)	OFF (H)	X	X
	A36U203(9)	ON (L)	OFF (H)	OFF (H)	X	X
	A36U203(16)	OFF (H)	OFF (H)	OFF (H)	X	X
	A36U203(8)	OFF (H)	OFF (H)	ON (L)	X	X

† 0 = Relay must be in the de-energized position for the calibration to take place.
1 = Relay must be in the energized position for the calibration to take place.
X = Relay can be in either the de-energized or energized position for the calibration to take place.
ON (L) = Control line for the switch must be TTL low for this calibration. This activates the switch.
OFF (H) = Control line for the switch must be TTL high for this calibration. This de-activates the switch.





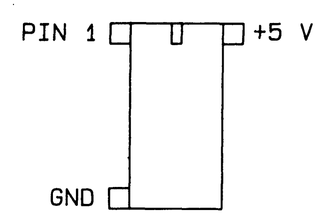
ATTENUATOR BOARD (A2)
P/N 03326-66502
REV A

REFERENCE TABLE

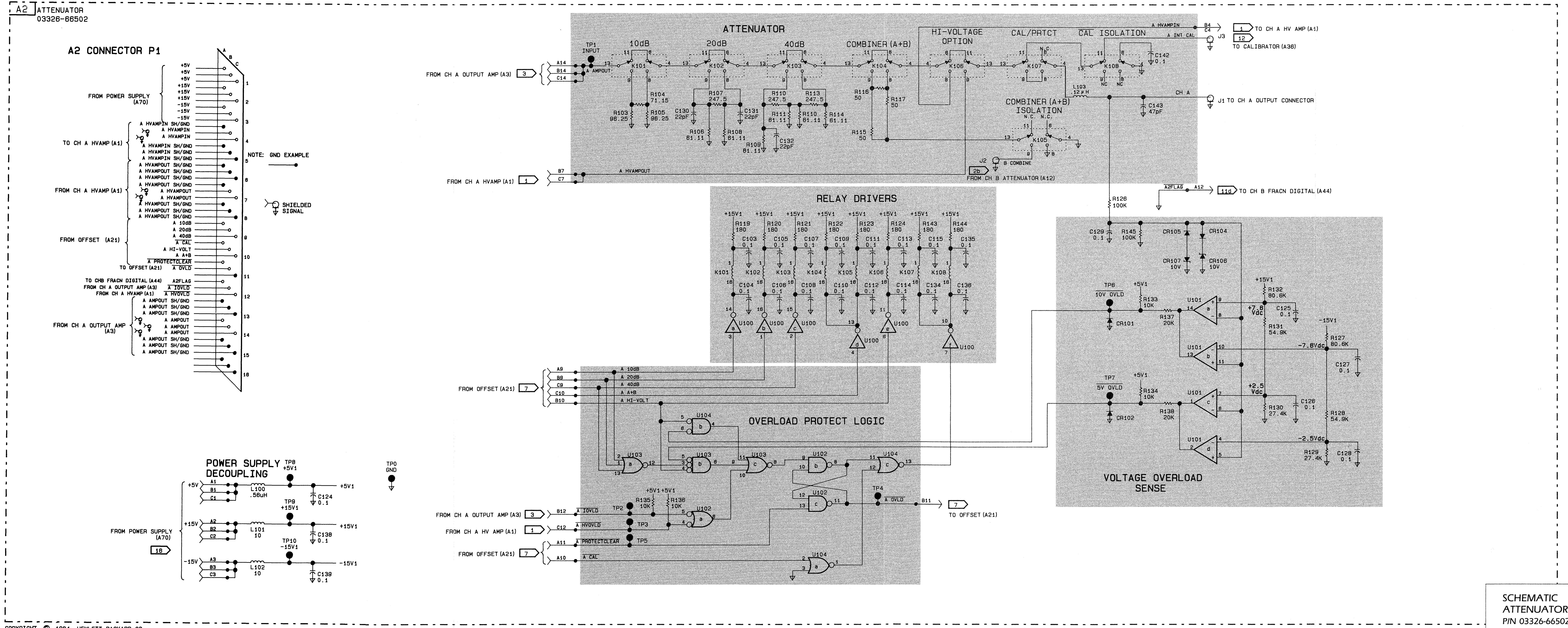
COMP.	+5V1	+15V1	-15V1	GND	BYPASS CAPACITORS REF.DESIG.	VALUE	N.C.
U100				8			5, 12
		9					
U101			12		C117	.01 µF	
		3			C116	.01 µF	
U102				7			1, 2, 3
	14				C118	.01 µF	
U103				7			
	14				C119	.01 µF	
U104				7			8, 9, 10
	14				C140	.01 µF	

NOTES:

1. TTL DEVICES ARE USED IN THIS CIRCUIT.
2. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).



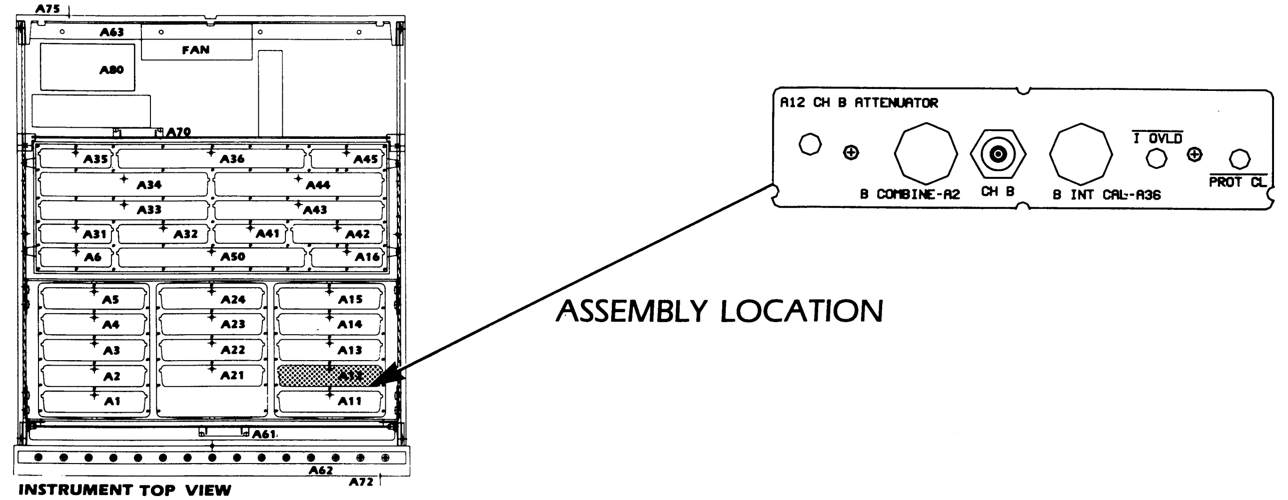
3. NO COMPONENT IS SUPPOSED TO BE LOADED ON THE FOOTPRINT OF THE JACK. THE FOOTPRINTS ARE USED FOR FACTORY TEST PURPOSES ONLY.
4. RELAY IS SHOWN IN THE DE-ENERGIZED STATE.
5. THE CHANNEL A ATTENUATOR (A2) AND THE CHANNEL B ATTENUATOR (A12) MAY BE INTERCHANGED FOR TROUBLESHOOTING PURPOSES. DUE TO SLIGHTLY DIFFERENT CIRCUITRY, HOWEVER, INTERNAL PHASE MODULATION, INTERNAL AMPLITUDE MODULATION, AND THE COMBINER FEATURES WILL NOT WORK. ALL OTHER FEATURES AND MODES WILL BE FULLY FUNCTIONAL.
6. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.
7. WITH COMBINED OPERATION ACTIVATED, THE CHANNEL A AND CHANNEL B OUTPUT SIGNALS ARE SENT THROUGH THE RESISTIVE COMBINER CIRCUIT ON THE A2 BOARD. THIS CIRCUIT ATTENUATES THE SIGNALS BY 6.02 dB. THIS IS COMPENSATED FOR IN THE SOFTWARE, SO THE EFFECT IS TRANSPARENT TO THE USER. HOWEVER, IN SERVICING THE ATTENUATOR BOARD, IT IS AN IMPORTANT ITEM TO NOTE. EXPECT A SIGNAL ATTENUATION ON THE COMBINER CIRCUIT.

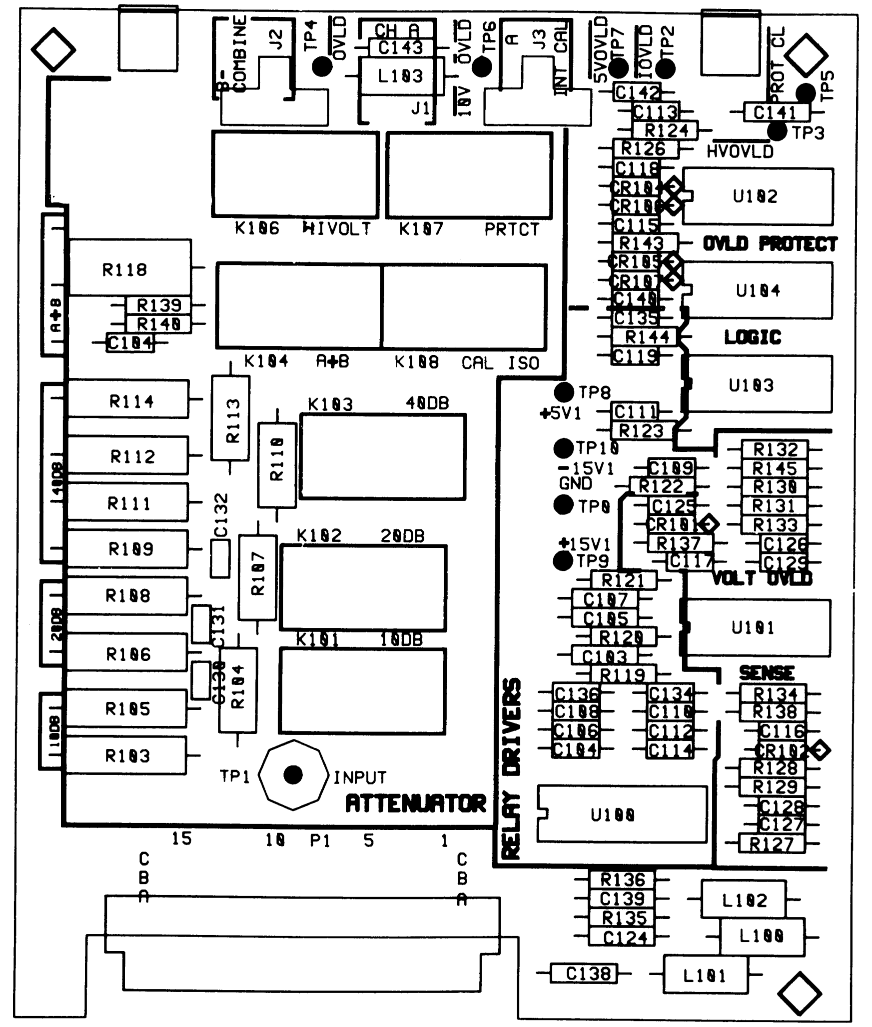


SCHEMATIC
ATTENUATOR BOARDS (A2)
P/N 03326-66502
REV A

2a

Figure 6-16





ATTENUATOR BOARDS (A12)
P/N 03326-66512
REV A

REFERENCE TABLE

COMP.	+5V1	+15V1	-15V1	GND	BYPASS CAPACITORS REF.DESIG.	VALUE	N.C.
U100				8			5, 12
		8					
U101			12		C117	.01 µF	
		3			C116	.01 µF	
U102				7			1, 2, 3
	14				C118	.01 µF	
U103				7			
	14				C119	.01 µF	
U104				7			8, 9, 10
	14				C140	.01 µF	

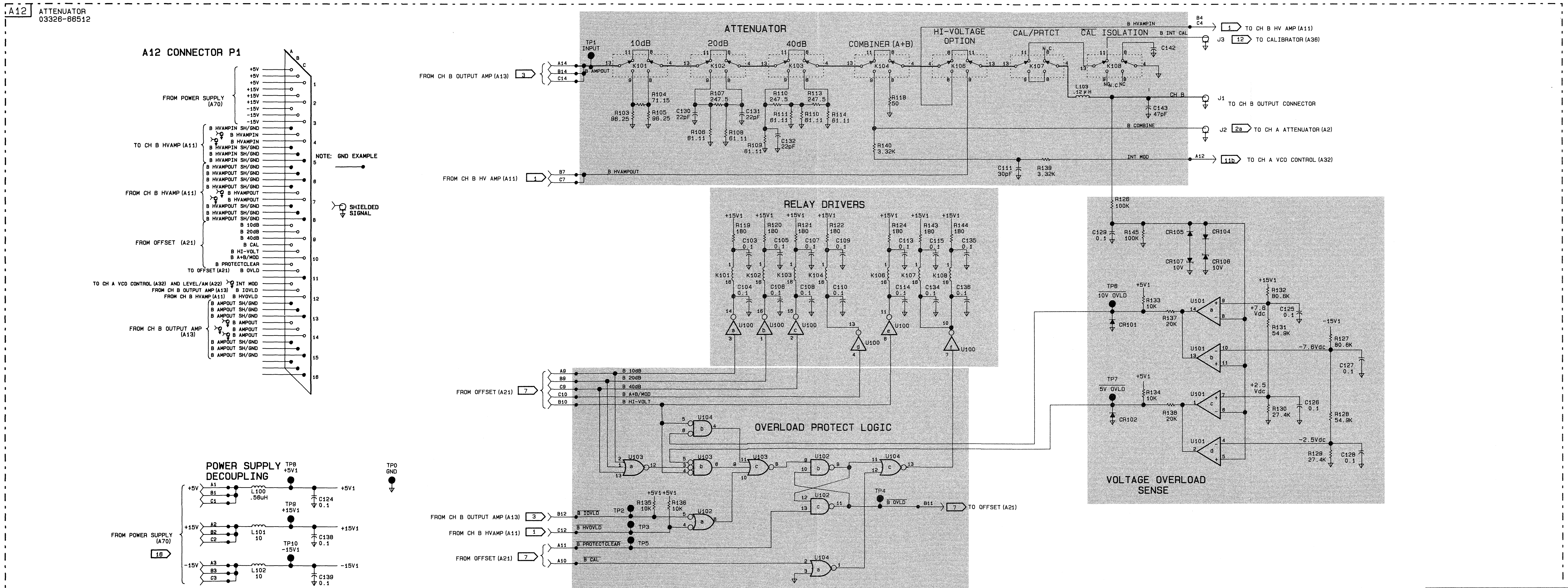
NOTES:

1. TTL DEVICES ARE USED IN THIS CIRCUIT.
2. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).

PIN 1 +5 V

GND

3. NO COMPONENT IS SUPPOSED TO BE LOADED ON THE FOOTPRINT OF THE JACK. THE FOOTPRINTS ARE USED FOR FACTORY TEST PURPOSES ONLY.
4. RELAY IS SHOWN IN THE DE-ENERGIZED STATE.
5. THE CHANNEL A ATTENUATOR (A2) AND THE CHANNEL B ATTENUATOR (A12) MAY BE INTERCHANGED FOR TROUBLESHOOTING PURPOSES. DUE TO SLIGHTLY DIFFERENT CIRCUITRY, HOWEVER, INTERNAL PHASE MODULATION, INTERNAL AMPLITUDE MODULATION, AND THE COMBINER FEATURES WILL NOT WORK. ALL OTHER FEATURES AND MODES WILL BE FULLY FUNCTIONAL.
6. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.
7. WITH COMBINED OPERATION ACTIVATED, THE CHANNEL A AND CHANNEL B OUTPUT SIGNALS ARE SENT THROUGH THE RESISTIVE COMBINER CIRCUIT ON THE A2 BOARD. THIS CIRCUIT ATTENUATES THE SIGNALS BY 6.02 dB. THIS IS COMPENSATED FOR IN THE SOFTWARE, SO THE EFFECT IS TRANSPARENT TO THE USER. HOWEVER, IN SERVICING THE ATTENUATOR BOARD, IT IS AN IMPORTANT ITEM TO NOTE. EXPECT A SIGNAL ATTENUATION ON THE COMBINER CIRCUIT.



SCHEMATIC
ATTENUATOR BOARDS (A12)
P/N 03326-66502
REV A

2b

Figure 6-17.

See Other Side

6-22 CHANNEL A AND CHANNEL B OUTPUT AMPLIFIER, A3 AND A13

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

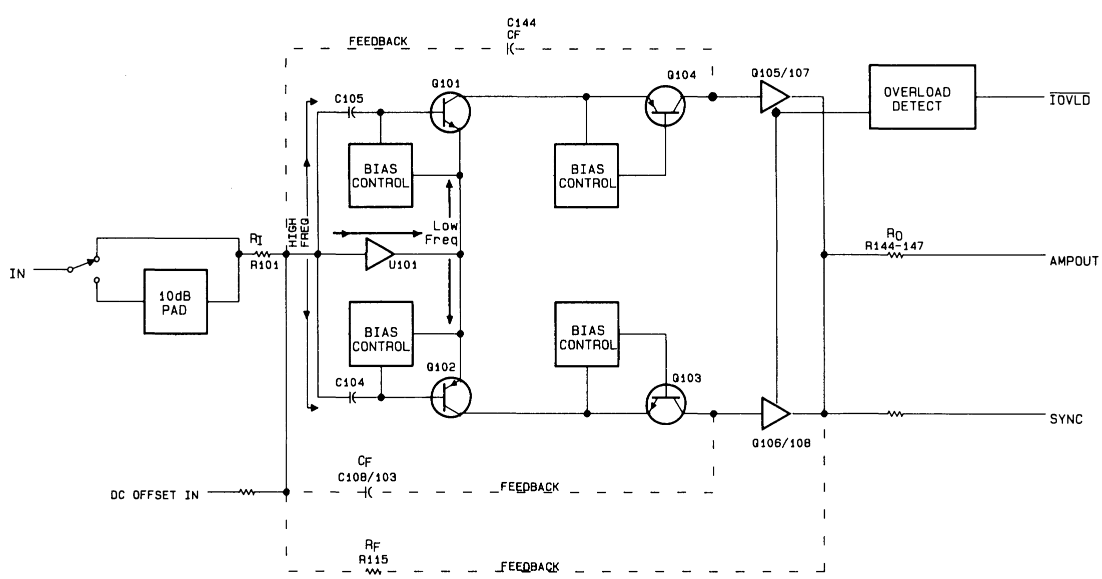


Figure 6-18. Output Amplifier Block Diagram

Theory of Operation

The preamplifiers (A4 and A14), output amplifiers (A3 and A13) and high voltage amplifiers (A1 and A11, Option 002) share the same topology and general theory of operation, as described here. The amplifier can be viewed as a discrete version of an inverting operational amplifier (op amp). The overall gain of the amplifier is established by the ratio of the value of the feedback resistor (R115) to that of the input resistor (R101). The resistors share a common "virtual ground" point at the input to the amplifier. The input impedance of the amplifier is 100 Ω (as set by R101). The output impedance would be 0 Ω, except that four parallel output resistors (R144, R145, R146, and R147) backmatch the output, giving the amplifier an output impedance of 50 Ω.

The general operation of the amplifier is understood by separating the small signal operation from the biasing circuitry. The small signal circuits essentially consist of the eight transistors (Q101-Q108). These form a symmetrical push-pull configuration which can be further simplified by focusing on the function of the half circuit consisting of transistors Q101, Q104, Q105, and Q107. Transistors Q101 and Q104 form a cascode pair in which the collector of Q104 is a current source providing high voltage gain. This node (which includes the collectors of Q103 and Q104, diodes CR101-CR104, and resistors R129, R130, and R140) can be regarded as a single high impedance gain point that is extremely sensitive to any parasitic capacitance. Touching this node severely affects the amplifier performance and stability. The Darlington transistor pair (Q105 and Q107) buffers the node and provides the output current drive capability of the amplifier.

The amplifier contains two gain paths. One is ac coupled from the "virtual ground" point to the "inverting" base inputs of the transistors Q101 and Q102 through capacitors C105 and C104, respectively. This path is dominant at high frequencies. At low frequencies and dc the directly coupled path (through U101) is dominant. These signals are amplified and inverted by U101 and passed to the "non-inverting" emitter inputs of Q101 and Q102. U101 provides a direct coupled path for biasing the amplifier at dc and provides additional loop gain at low frequencies for improving distortion in the audio range.

The dual op amps U102 and U104 serve as biasing elements for each of the four cascode transistors (Q101-Q104). The base-emitter junctions are included in the feedback loops to eliminate amplifier sensitivity to temperature changes which cause (biasing) variations in V_{be}. This maintains the emitter voltages of Q101 and Q102 at approximately 0.5 V and −0.5 V and the base voltages of Q103 and Q104 at approximately 13.3 V and −13.3 V.

High frequency stability and compensation is achieved with a Miller capacitance (C108 and C103) which provides feedback from the high gain node to the "virtual ground" point. The voltage across R130 establishes the output stage quiescent current level through the transistors Q107 and Q108.

The current overload protection circuitry consists of comparators (U103) which monitor the collector circuits of the Darlington amplifier pairs Q105-Q107 and Q106-Q108. If either side of the final amplifier stage exceeds a fixed range, U103 activates the overload signal $\overline{\text{IOVLD}}$. This condition occurs when excessive voltage appears on the instrument output connector and protection is not activated by the overload protect logic on the attenuator. The $\overline{\text{IOVLD}}$ signal goes to the attenuator board where it can activate protection irrespective of other logic conditions.

Troubleshooting

The instrument bus circuit on the controller board (A61) and the control interface on this board can be tested using the Interface SA Test (see Tables 6-52 and 6-53 in the A61 troubleshooting sub-section 6-33). This test exercises the control lines from the controller board to determine if the controller or the control interface circuitry is defective.

Special troubleshooting aids on the board include a jumper to de-energize the 10 dB attenuator at the input and a jumper to disable the DC offset input. The latter allows troubleshooting an offset problem to determine whether the fault is in the preamp or the offset circuits.

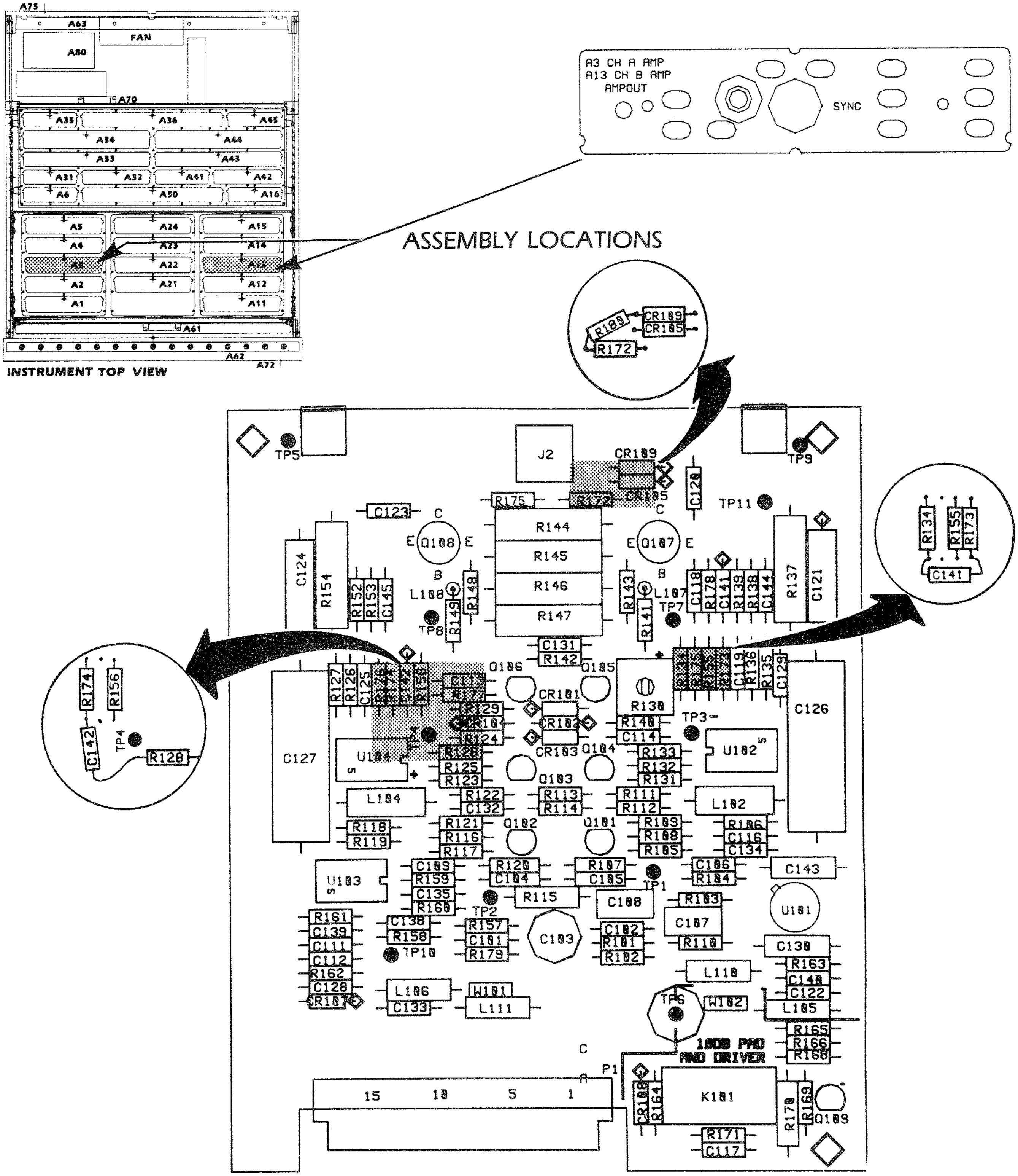
The multiple feedback design and delicate balance of the individual stages of this circuit make them highly interactive. This causes the symptoms of a problem in any part of the amplifier to propagate throughout. Also, due to the high open-loop gain, many of the component connections within the circuit are so sensitive to stray capacitance that the balance would be disturbed by probing with test equipment.

First, make a visual inspection of the board, looking for burned or otherwise damaged parts. Then check the power supplies on the board. It is useful to probe the input and output of the amplifier with an oscilloscope to determine whether the failure is catastrophic or not. The waveform shape of the output may contain a clue as to which half of the push-pull amplifier stages are failing. Test points are provided to measure bias in the base circuits of the first two stages.

If these basic troubleshooting methods have failed to isolate the problem, the fastest troubleshooting method is to replace components based on their probability of failure. This approach is recommended because of the circuit's troubleshooting difficulties. Replace transistors first, whole stages at a time, beginning at the output. It is recommended that all transistors in a stage be changed at the same time because failure of one tends to stress the performance parameters of the other(s). If Q107 is replaced, Q108 should also be replaced. If low-frequency response is out of specification, replace U101. After that, the op amps composing the biasing for the first two stages should be replaced. If these replacements have not fixed the problem, replace the diodes in the sensitive node and check the larger capacitors on the board for shorts or leakage. These last two suggestions have about equal probability of solving the problem.

If the amplifier has failed in a manner that suggests that the overload protection circuitry is not operating properly (i.e., it was overloaded from the front panel), it is recommended that the protection circuitry be exercised and checked for failure. The output amplifier has current overload detection provided by the comparator circuitry of U103. To exercise this circuit, ground pins 2 and 5, one at a time. Each should cause the instrument to indicate that it has been overloaded. The instrument should reset itself soon after removing the ground. It is recommended that the protection circuitry on the attenuator board be checked, also, as described in the attenuator board level repair sub-section.

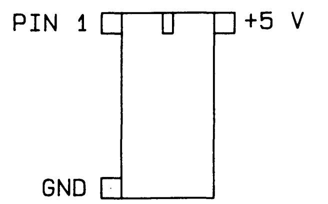
Refer to Table 6-15 for recommended post-repair adjustments.



OUTPUT AMP BOARDS (A3, A13)
P/N 03326-66503
REV A

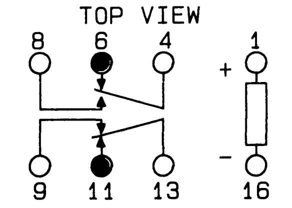
NOTES:

1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).



2. NO COMPONENT IS SUPPOSED TO BE LOADED ON THE FOOTPRINT OF THE JACK. THE FOOTPRINTS ARE USED FOR FACTORY TEST PURPOSES ONLY.

3. RELAYS ARE SHOWN IN THE DE-ENERGIZED STATE.
P/N 0490-1405.

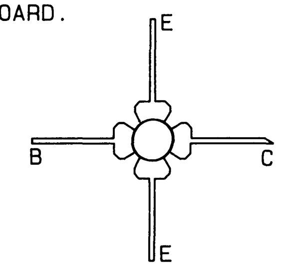


4. THIS BOARD IS USED TWICE IN THE INSTRUMENT - ONCE FOR CHANNEL A, AND ONCE FOR CHANNEL B. THE TWO IDENTICAL BOARDS MAY BE INTERCHANGED FOR TROUBLESHOOTING, BUT MUST BE RETURNED TO THEIR ORIGINAL LOCATIONS TO AVOID RECALIBRATION OF THE INSTRUMENT.

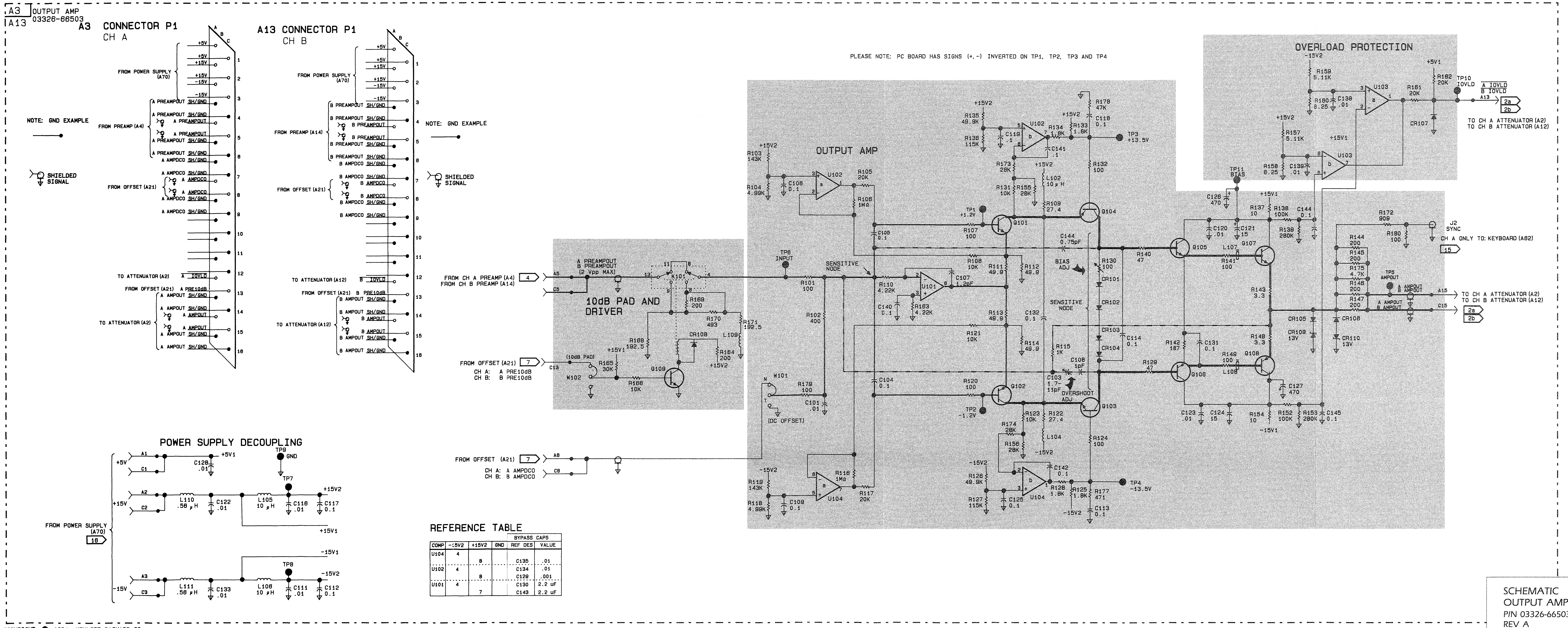
5. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.

6. IF THE HIGH VOLTAGE AMPLIFIER (A1 OR A11, OPTION 002) IS ENGAGED, DC OFFSET IS NOT INJECTED INTO THE OUTPUT AMPLIFIER (A3 OR A13). THE OFFSET IS ROUTED TO THE HIGH VOLTAGE AMPLIFIER SUMMING JUNCTION INSTEAD. SEE THE OVERALL THEORY OF OPERATION FOR MORE DETAILS.

7. INSTALLATION OF Q107 AND Q108 ON A3, A13; WHEN REPLACING THIS COMPONENT, NOTE THAT THE COLLECTOR HAS A SLANTED-ENDED LEAD (INSTEAD OF A BLUNT-ENDED LEAD). PUT THIS LEAD INTO THE HOLE MARKED "C" ON THE PC BOARD.



8. TOUCHING THE PART OF THE CIRCUIT MARKED "SENSITIVE NODE" WILL AFFECT THE STABILITY AND PERFORMANCE OF THE AMPLIFIER.



REFERENCE TABLE

COMP	-15V2	+15V2	GND	BYPASS CAPS REF DES	BYPASS CAPS VALUE
U104	4				
		8		C135	.01
U102	4			C134	.01
		8		C129	.001
U101	4			C130	2.2 uF
		7		C143	2.2 uF

SCHEMATIC
OUTPUT AMP BOARDS (A3, A13)
P/N 03326-66503
REV A

3

Figure 6-19.

See
Other
Side

6-23 CHANNEL A AND CHANNEL B PREAMPLIFIER, A4 AND A14

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

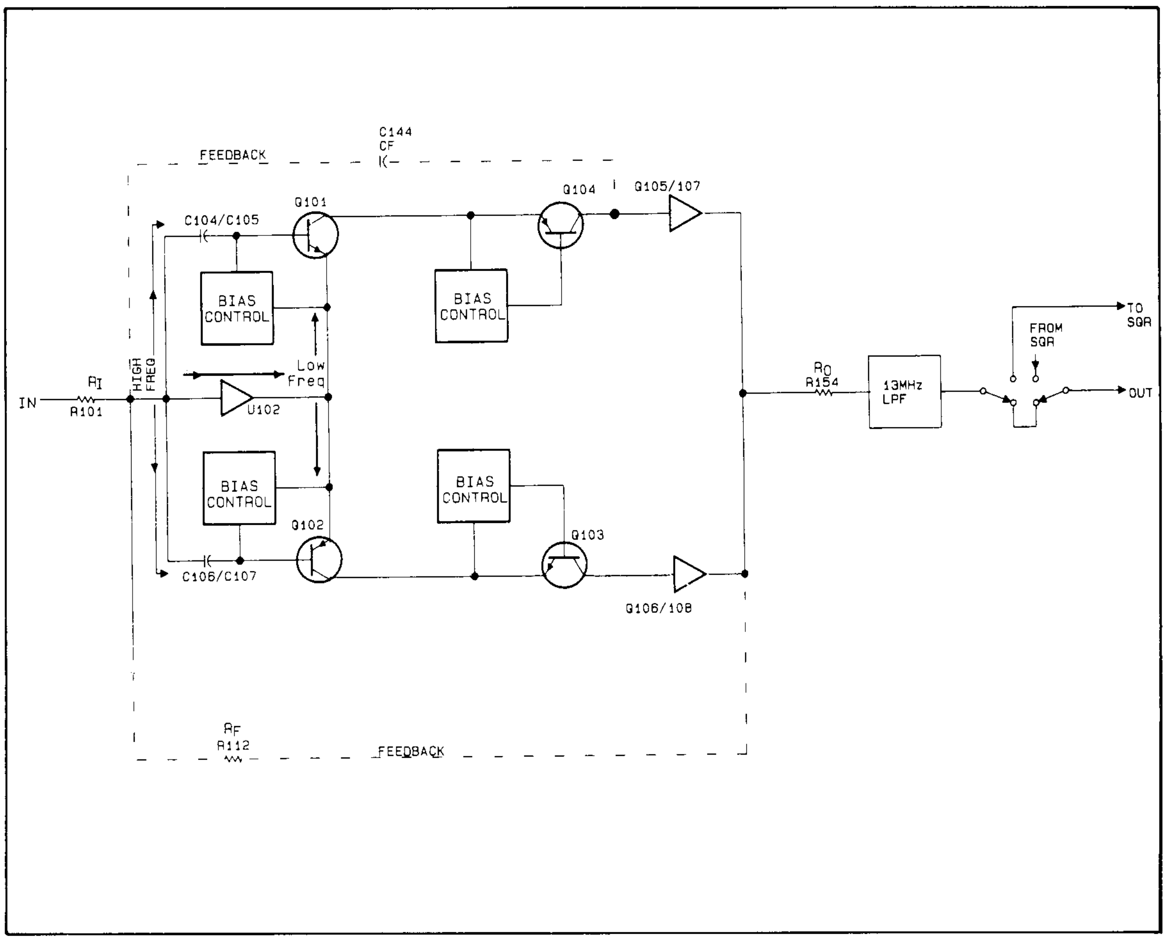


Figure 6-20. Preamplifier Block Diagram

Theory of Operation

The preamplifiers (A4 and A14), output amplifiers (A3 and A13) and high voltage amplifiers (A1 and A11, Option 002) share the same topology and general theory of operation, as described here. The amplifier can be viewed as a discrete version of an inverting operational amplifier (op amp). The overall gain of the amplifier is established by the ratio of the value of the feedback resistor (R112) to that of the input resistor (R101). The resistors share a common "virtual ground" point at the input to the amplifier. The input impedance of the amplifier is 100 Ω (as set by R101). The output impedance would be 0 Ω, except that R163 backmatches the output, giving the amplifier an output impedance of 50 Ω.

The general operation of the amplifier is understood by separating the small signal operation from the biasing circuitry. The small signal circuits essentially consist of the eight transistors (Q101-Q108). These form a symmetrical "push-pull" configuration which can be further simplified by focusing on the function of the "half-circuit" consisting of transistors Q101, Q104, Q105, and Q107. These perform the basic amplification. Transistors Q101 and Q104 form a cascode pair in which the collector of Q104 is a current source providing high voltage gain. This node (which includes the collectors of Q103 and Q104, diodes CR101-CR104, and resistors R130, R131, and R133) can be regarded as a single high impedance gain point that is extremely sensitive to any parasitic capacitance. Touching this node severely affects the amplifier performance and stability. The Darlington transistor pair (Q105 and Q107) buffers the node and provides the output current drive capability of the amplifier.

The amplifier contains two gain paths. One is ac coupled from the "virtual ground" point to the base circuits of transistors Q101 and Q102 through capacitors C110 and C111, respectively. This path is dominant at high frequencies. At low frequencies and dc the directly coupled path (through U101) is dominant. These signals are amplified and inverted by U101 and passed to the emitter circuits of Q101 and Q102. U101 provides a direct coupled path for biasing the amplifier at dc and provides additional loop gain at low frequencies for improving distortion in the audio range.

The dual op amps U102 and U104 serve as biasing elements for each of the four cascode transistors (Q101-Q104). The base-emitter junctions are included in the feedback loops to eliminate amplifier sensitivity to temperature changes which cause (biasing) variations in V_{be}. This maintains the emitter voltages of Q101 and Q102 at approximately 0.5 V and −0.5 V and the emitter voltages of Q103 and Q104 at approximately 10.0 V and −10.0 V.

High frequency stability and compensation is achieved with a Miller capacitance (C144) which provides feedback from the high gain node to the "virtual ground" point. The voltage across R130 establishes the output stage quiescent current level through the transistors Q107 and Q108.

The signal from the preamplifier feeds a passive 13 MHz low pass filter which then passes the signal on to the preamplifier output through a relay. The relay is used to select either the preamplifier's output or the square signal output from the square board (A23) to pass to the output amplifier (A3 or A13).

Troubleshooting

The instrument bus circuit on the controller board (A61) and the control interface on this board can be tested using the Interface SA Test (see Tables 6-52 and 6-53 in the A61 troubleshooting sub-section 6-33). This test exercises the control lines from the controller board to determine if the controller or the control interface circuitry is defective.

The multiple feedback design and delicate balance of the individual stages of this circuit make them highly interactive. This causes the symptoms of a problem in any part of the amplifier to propagate throughout. Also, due to the high open-loop gain, many of the component connections within the circuit are so sensitive to stray capacitance that the balance would be disturbed by probing with test equipment.

First, make a visual inspection of the board, looking for burned or otherwise damaged parts. Then check the power supplies on the board. It is useful to probe the input and output of the amplifier with an oscilloscope to determine whether the failure is catastrophic or not. The waveform shape of the output may contain a clue as to which half of the push-pull amplifier stages are failing. Test points are provided to measure bias in the base circuits of the first two stages.

If these basic troubleshooting methods have failed to isolate the problem, the fastest troubleshooting method is to replace components based on their probability of failure. This approach is recommended because of the circuit's troubleshooting difficulties. Replace transistors first, whole stages at a time, beginning at the output. It is recommended that all transistors in a stage be changed at the same time because failure of one tends to stress the performance parameters of the other(s). If Q107 is replaced, Q108 should also be replaced. If low-frequency response is out of specification, replace U101. After that, the op amps composing the biasing for the first two stages should be replaced. If these replacements have not fixed the problem, replace the diodes in the sensitive node and check the larger capacitors on the board for shorts or leakage. These last two suggestions have about equal probability of solving the problem.

If the amplifier has failed in a manner that suggests that the overload protection circuitry is not operating properly (i.e., it was overloaded from the front panel), it is recommended that the protection circuitry on the attenuator board be exercised and checked for failure as described in the attenuator board level repair.

Table 6-22 shows the activation of relays for various instrument functions with relays on the preamplifier board highlighted.

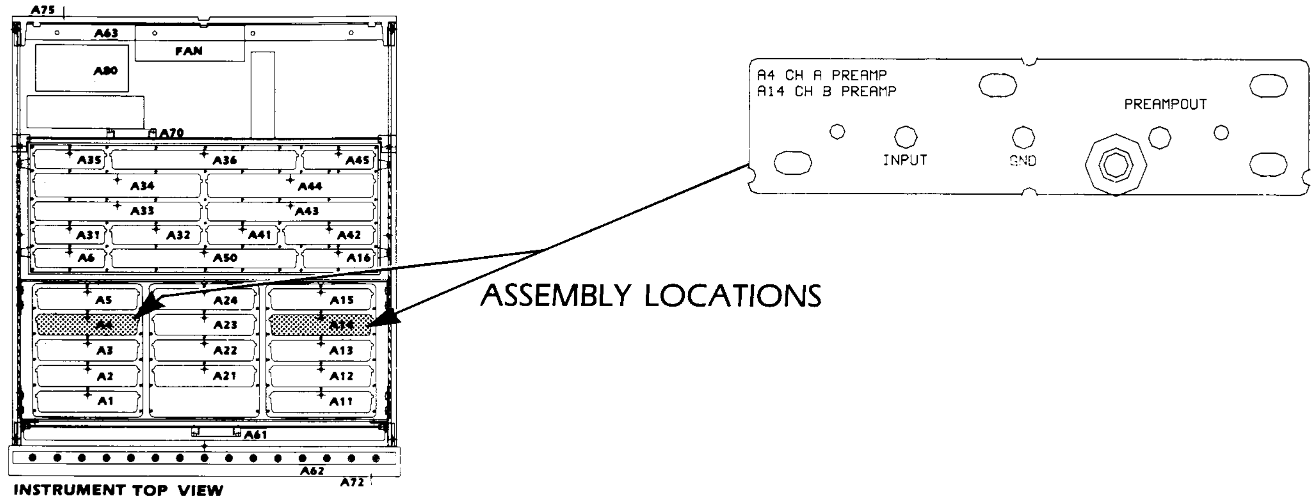
Refer to Table 6-15 for recommended post-repair adjustments.

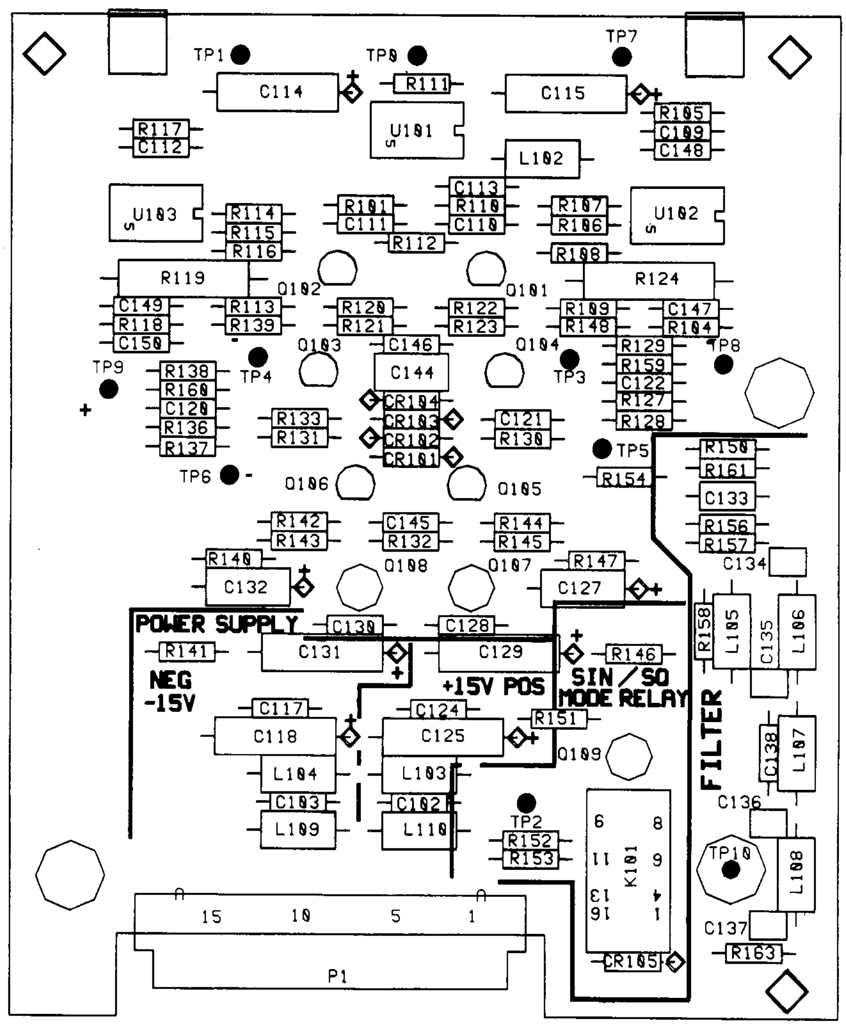
Table 6-22. Function Control

Switch Name †	Reference Designator (pin no.)	Off		Sine		Square		DC		HV		Combined	Int AM	Ext AM		Int PM	Ext PM		Sync PM
		A	B	A	B	A	B	A	B	A	B			A	B		A	B	(AB)
Ch A Cal/Prtct	A2K107	0	X	1	X	1	X	1	X	1	X	1	1	1	X	1	1	X	1
Ch B Cal/Prtct	A12K107	X	0	X	1	X	1	X	1	X	1	1	1	1	1	1	1	1	1
Ch A HV Option	A2K106	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X
Ch B HV Option	A12K106	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X
Ch A Square	A4K101	X	X	0	X	1	X	0	X	X	X	X	X	X	X	X	X	X	X
Ch B Square	A14K101	X	X	X	0	X	1	X	0	X	X	X	X	X	X	X	X	X	X
Ch A Offset	A21K1	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X
Ch B Offset	A21K21	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X
INT AM	A22U2(1)	X	X	X	X	X	X	X	X	X	X	X	ON (L)	OFF (H)	X	X	X	X	X
A EXT AM	A22U2(16)	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	ON (L)	X	X	X	X	X
B EXT AM	A22U6(1,16) A22U6(8,9)	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	X	X	X	X
INT PM	A32U22(1)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	OFF (H)	OFF (H)	OFF (H)
A EXT PM	A32U22(16)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	ON (L)	X	ON (L)
B EXT PM	A42U22(16)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	X
Ch A PM	A32U22(9)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	OFF (H)	X	OFF (H)
Ch B PM	A42U22(9)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	X
Ch A Combiner Isolation	A2K105	X	X	X	X	X	X	X	X	X	X	1	0	X	X	0	X	X	X
Ch A Combiner	A2K104	X	X	X	X	X	X	X	X	X	X	1	0	X	X	0	X	X	X
Ch B Combiner/ INT MOD	A12K104	X	X	X	X	X	X	X	X	X	X	1	1	X	X	1	X	X	X

† X = Relay can be in either the de-energized or energized position in this function.
1 = Relay must be in the energized position in this function.
0 = Relay must be in the de-energized position in this function.
ON (L) = Control line for the switch must be TTL low in this function. This activates the switch.
OFF (H) = Control line for the switch must be TTL high in this function. This de-activates the switch.

NOTES

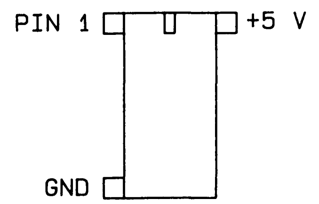




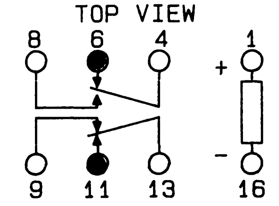
PREAMP BOARDS (A4, A14)
P/N 03326-66504
REV A

NOTES:

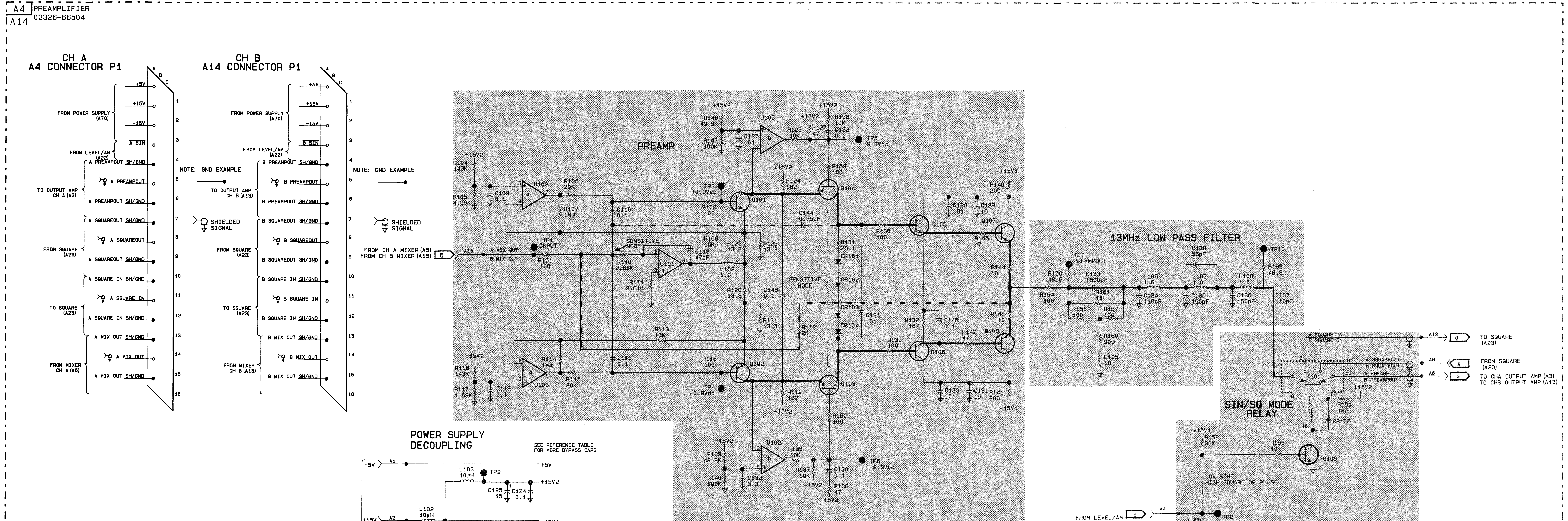
1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).



2. NO COMPONENT IS SUPPOSED TO BE LOADED ON THE FOOTPRINT OF THE JACK. THE FOOTPRINTS ARE USED FOR FACTORY TEST PURPOSES ONLY.
3. RELAYS ARE SHOWN IN THE DE-ENERGIZED STATE.
P/N 0490-1405.



4. THIS BOARD IS USED TWICE IN THE INSTRUMENT – ONCE FOR CHANNEL A, AND ONCE FOR CHANNEL B. THE TWO IDENTICAL BOARDS MAY BE INTERCHANGED FOR TROUBLESHOOTING, BUT MUST BE RETURNED TO THEIR ORIGINAL LOCATIONS TO AVOID RECALIBRATION OF THE INSTRUMENT.
5. TOUCHING THE PART OF THE CIRCUIT MARKED "SENSITIVE NODE" WILL AFFECT THE STABILITY AND PERFORMANCE OF THE AMPLIFIER.



REFERENCE TABLE

COMP.	+5V1	+15V2	-15V2	GND	BYPASS CAPACITORS REF.DESIG.	BYPASS CAPACITORS VALUE	N.C.
U101		7			C114	15 µF	1, 5, 8
			4		C115	15 µF	
U102		8			C117	.01 µF	
			4		C148	.01 µF	
U103		8			C149	.01 µF	
			4		C150	.01 µF	

SCHEMATIC
PREAMP BOARDS (A4, A14)
P/N 03326-66504
REV A
4

Figure 6-21.

See Other Side

6-24 CHANNEL A AND CHANNEL B MIXER, A5 AND A15

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

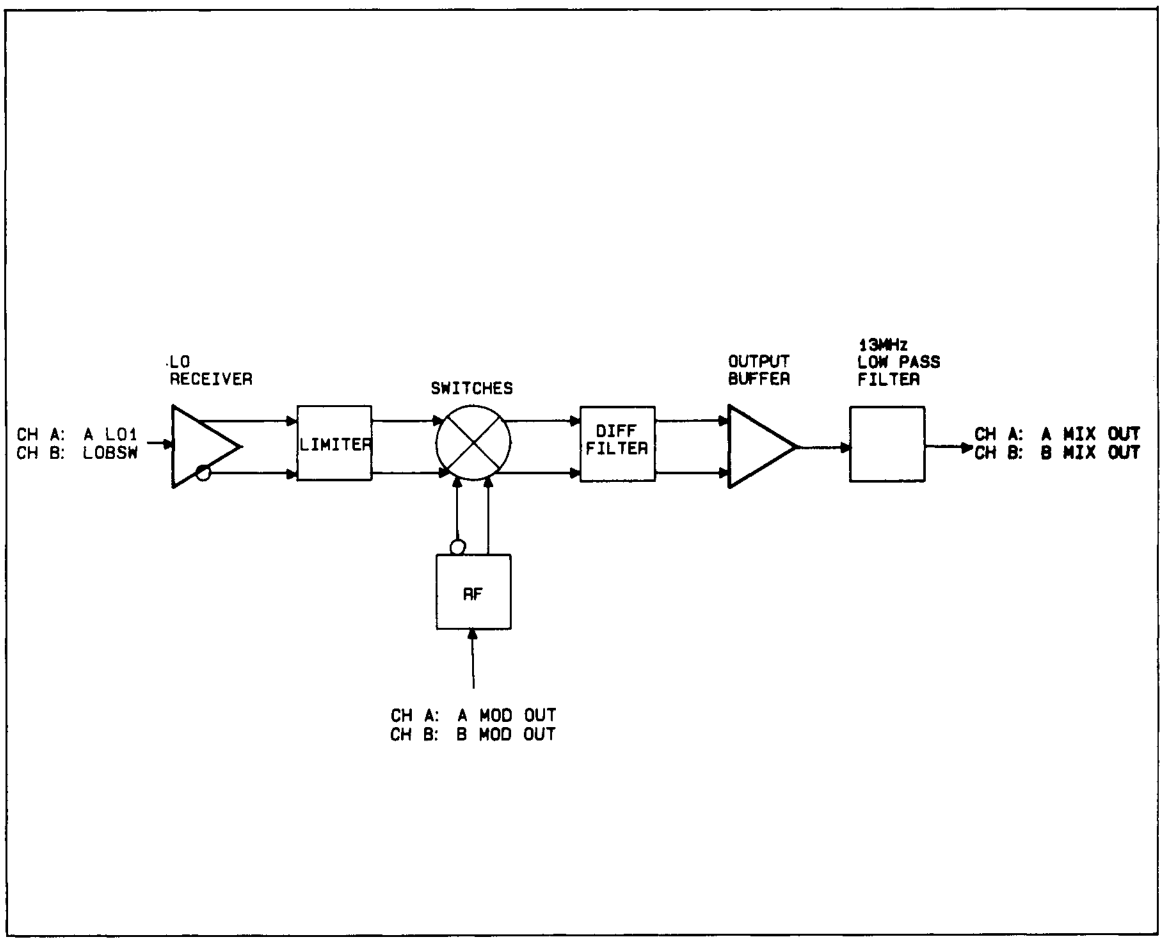


Figure 6-22. Mixer Block Diagram

Theory of Operation

Signal inputs to the channel A mixer are A LO1 and A MOD OUT. Signal inputs to the channel B mixer are LOBSW and B MOD OUT. The output of the mixer (A MIX OUT, B MIX OUT) is the difference frequency between the local oscillator input frequency and the reference input frequency. The output amplitude is set by the amplitude of the reference input (A MOD OUT, B MOD OUT) and the conversion gain of the mixer (MIX OUT/MOD OUT = 7 dB).

The LO receiver sub-block is one section of an ECL line receiver package. Two of the receivers on the IC are not used. The gate's complementary outputs drive the limiter's emitter coupled pair.

The RF sub-block contains a portion of a 50 Ω, 20 MHz, bandpass filter (C21, C22, and L20). The first portion of this filter appears on the modulator board. A transformer (T1) converts the A MOD OUT and B MOD OUT signals from single ended to differential ended to drive the emitter coupled pair (Q3). The RF outputs are equal and 180° out of phase. The 2:1 spur adjustment (R316) affects the balance of the emitter resistance of the differential amplifier (Q3) to reduce the level of an unwanted, in-band, spurious product (the second harmonic of the reference minus the LO frequency).

The switches sub-block consists of two emitter coupled pairs (Q5 and Q6) which are turned on and off by the 20 to 33 MHz limiter output (±0.3 V). This, in conjunction with the complementary RF sub-block output signals, multiplies the reference input by ±1 at the LO rate, mixing the reference and LO together.

The outputs of the switches are the sum ($F_{lo} + F_{rf}$) and difference (F_{lo} F_{rf}) products and residual feedthrough signals (F_{lo} and F_{rf}, individually). The sum product is attenuated by the differential filter composed of L407-L410, C413-C415 and C417.

The output buffer is a unity gain difference amplifier with a single-ended output. The configuration of this sub-block is clarified by the expanded block diagram shown in Figure 6-23. The NPN transistors in the differential amplifier and the current sources are all on the same substrate in transistor array U400.

The adjustments for this sub-block are R400, R424, and C400. R400 adjusts dc offset of the output buffer. This adjusts square wave symmetry and sets the instrument's square wave second harmonic distortion. R424 balances collector currents in the input pair to improve second harmonic distortion of the sine wave output. C400 provides high frequency peaking to flatten the output response.

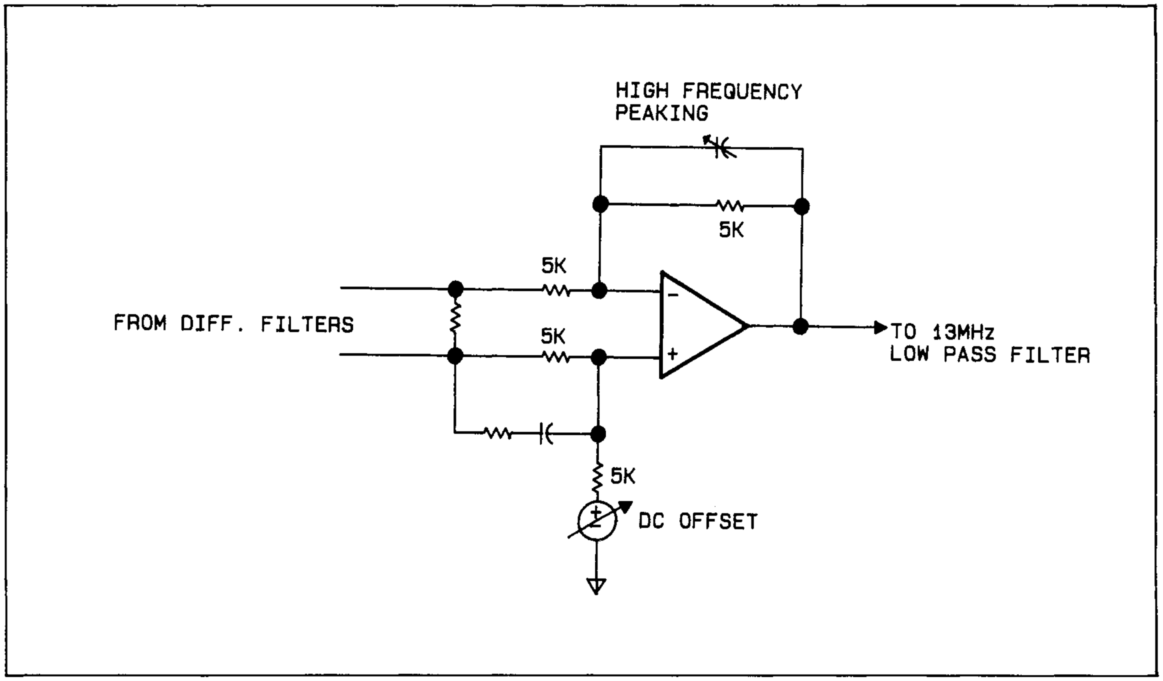


Figure 6-23. Output Buffer Expanded Block Diagram

Troubleshooting

Mixer operation is the same for all modes. The difference between the modes is the point of origin of the channel B LOBSW input from the RF switch board (A24). The RF switch either sends the channel B local oscillator output, the channel A local oscillator output, or the 20 MHz reference signal to the mixer board, depending on the mode. The point of origin of the signal is transparent to the mixer circuitry. The mixer behaves the same in any mode; it receives two inputs and produces one output.

This circuit may be analyzed by putting it on an extender (be sure to turn the power off before removing the board) and comparing the oscilloscope waveforms in Figure 6-24 with those of the defective unit. The instrument setup for these waveforms is given in the figure.

NOTE

Expect high spurious signal levels, particularly 2:1 spurs, when the mixer board is either on an extender board or its top cover plate is not tightly screwed down.

If the channel A and channel B modulator boards (A6 and A16) or mixer boards are interchanged for troubleshooting, the output amplitude of the instrument may change by ± 1 dB. If the channel A and channel B preamplifier boards (A4 and A14) or mixer boards are interchanged, the flatness of the output channel may vary. It is recommended that the boards be returned to their original positions after troubleshooting to reduce post-repair adjustment time.

Refer to Table 6-15 for recommended post-repair adjustments.

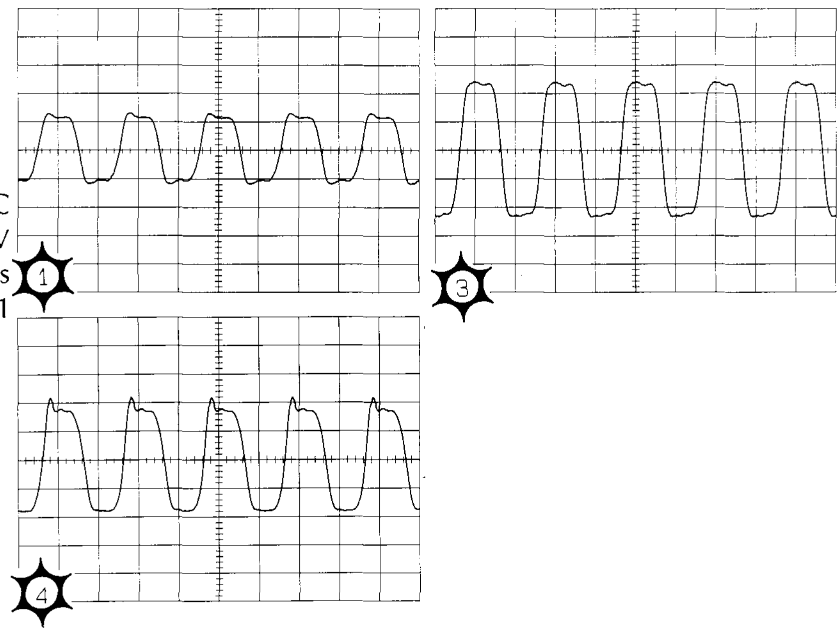
HP 3326A Setup

INSTR PRESET	
Channel	CH A or CH B
Frequency	5 MHz
Amplitude	10 Vpp

Oscilloscope Setup (#1, #3, #4)

10:1 probe†

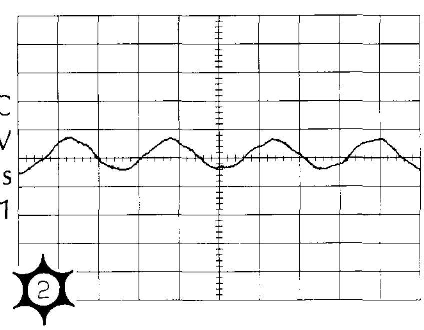
Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	20 ns
Trigger	Ch 1



Oscilloscope Setup (#2)

10:1 probe

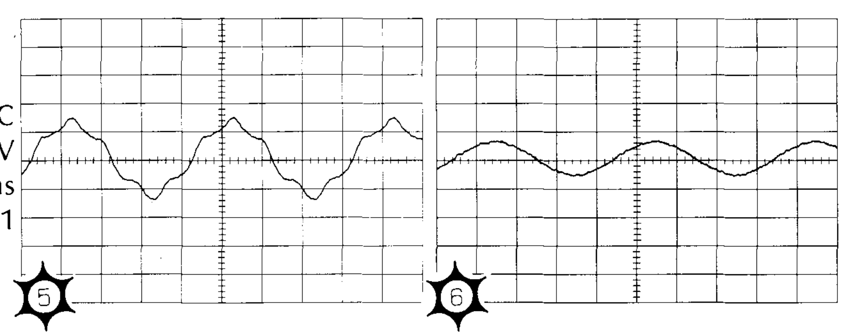
Ch 1 coupling	AC
Ch 1 V/div	10 mV
Time/div	20 ns
Trigger	Ch 1



Oscilloscope Setup (#5, #6)

10:1 probe

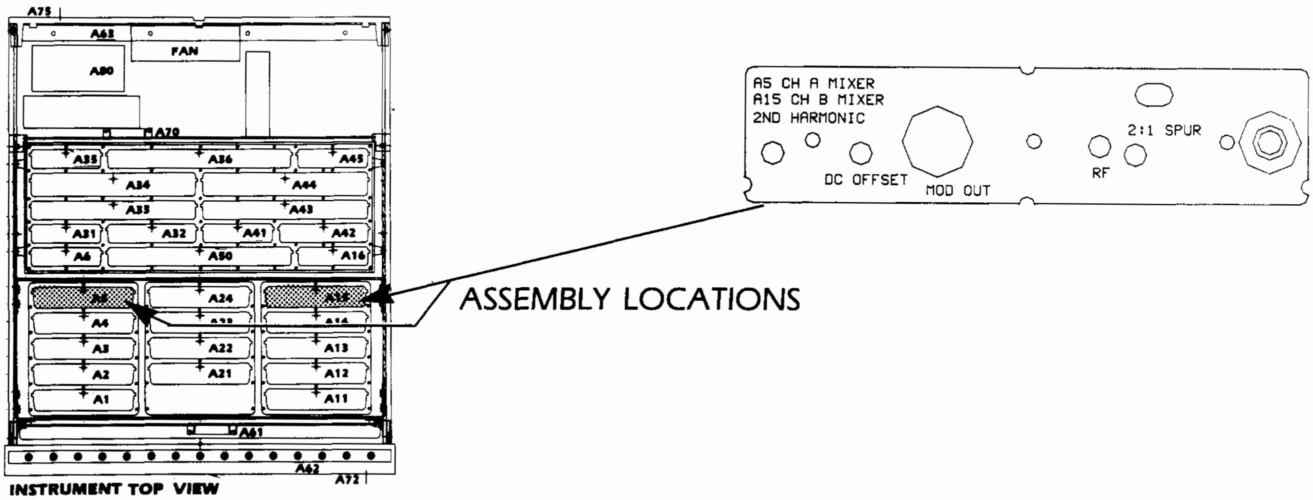
Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	50 ns
Trigger	Ch 1

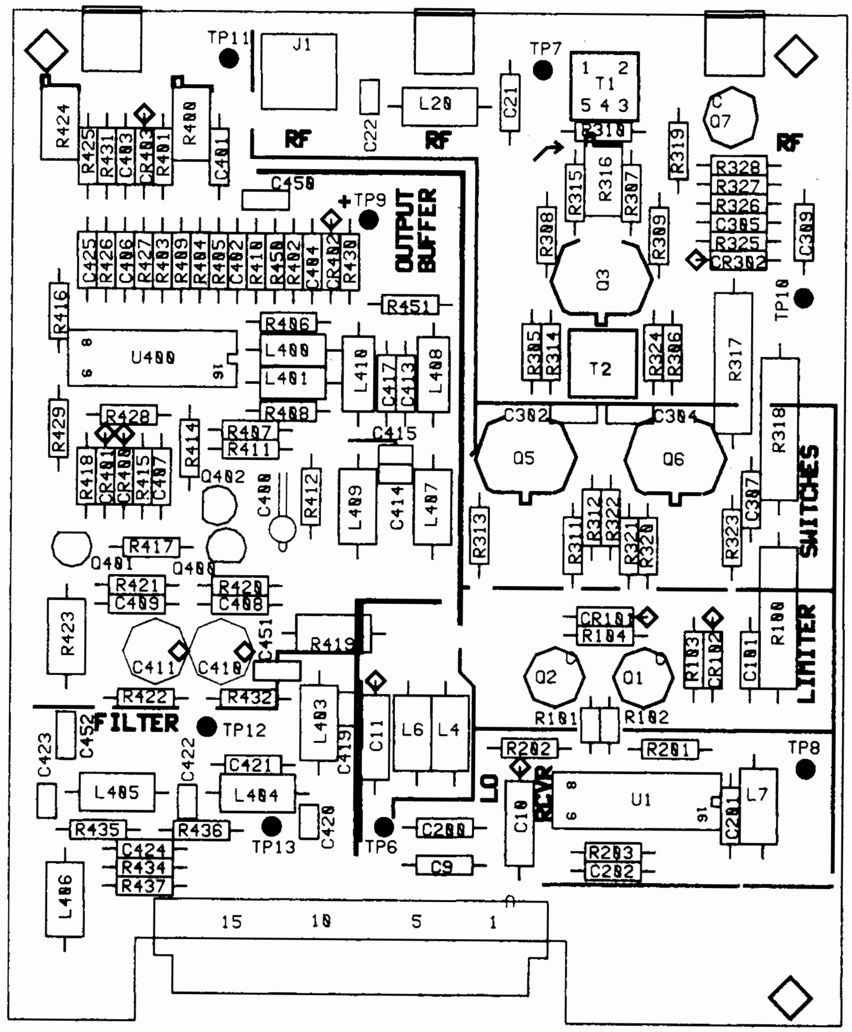


† Use a 10:1 probe with a ground spring (HP part number 1460-1476) when making high frequency measurements to minimize distortion.

Figure 6-24. Mixer Board Waveforms

NOTES





MIXER BOARDS (A5, A15)
P/N 03326-66505
REV B

NOTES:

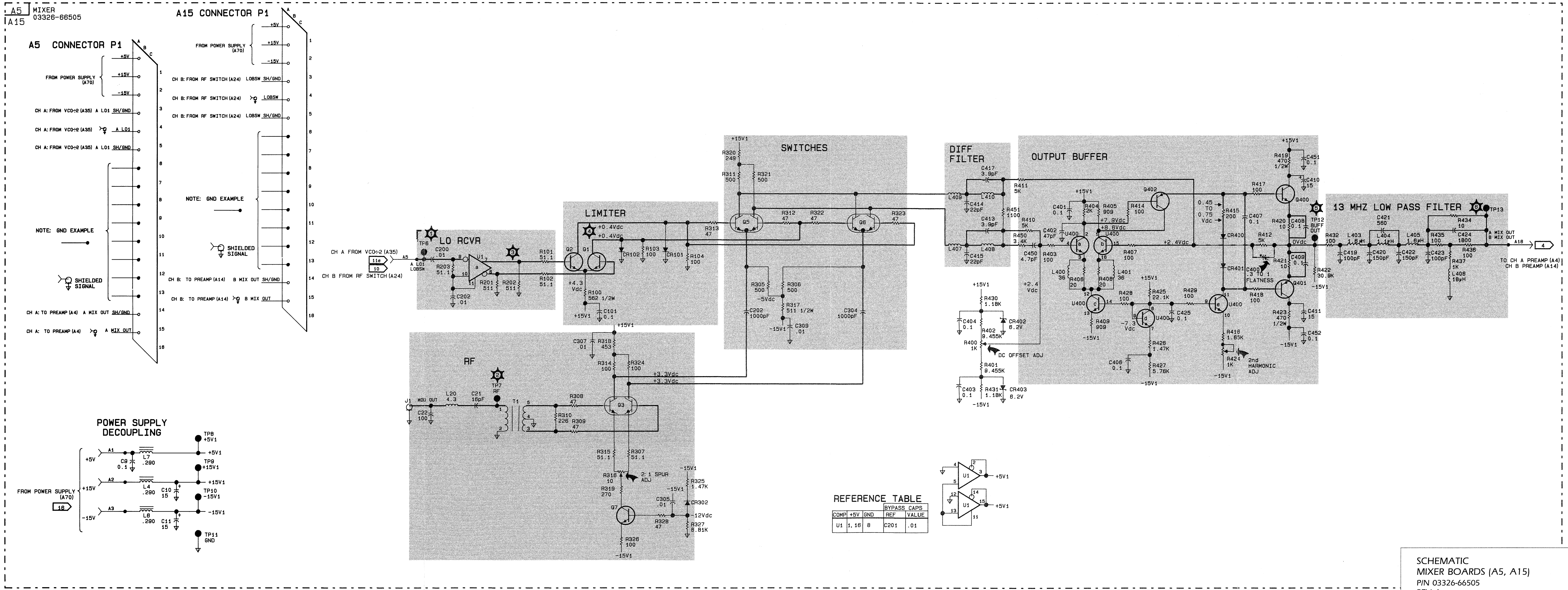
1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).

PIN 1 +5 V

GND

2. THIS BOARD IS USED TWICE IN THE INSTRUMENT - ONCE FOR CHANNEL A, AND ONCE FOR CHANNEL B. THE TWO IDENTICAL BOARDS MAY BE INTERCHANGED FOR TROUBLESHOOTING, BUT MUST BE RETURNED TO THEIR ORIGINAL LOCATIONS TO AVOID RECALIBRATION OF THE INSTRUMENT.

3. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.



COMP	+5V	GND	BYPASS CAPS REF	VALUE
U1	1,16	8	C201	.01

SCHEMATIC
MIXER BOARDS (A5, A15)
P/N 03326-66505
REV A

5

Figure 6-25.

See Other Side

6-25 CHANNEL A AND CHANNEL B MODULATOR, A6 AND A16

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

Theory of Operation

The modulator board serves as the frequency reference for the mixer board and provides level control; the level of the modulator signal output (MOD OUT) defines the channel output level over a 10 dB range (the 10 dB step attenuators provide the coarse level adjustment over a 70 dB range). The modulator changes the level of the input signal (A 20MHz or B CARRIER, depending on the channel), but does not change the frequency. In all modes except two-tone, the frequency of the input signal is 20 MHz. In the two-tone mode, the frequency in the channel B modulator can vary from 19.9 to 20.1 MHz. See the overall theory of operation in sub-section 6-7 for details.

The modulator board has two inputs: a differential ECL level square wave (A 20MHz or B CARRIER) and an amplitude control signal (A SINLEV or B SINLEV). The dc level of the SINLEV signal provides the level control of the output signal. The ac component of SINLEV provides amplitude modulation of the output signal. The modulator output (MOD OUT), a sine wave, goes to the mixer board (A5 or A15).

When SINLEV is +4 Vdc, the modulator output is at nominal full scale (approximately −16 dBm into 50 ohms). Normal dc levels of the SINLEV signal are between +4 and +1.3 Vdc. At +1.3 Vdc, the modulator output level is approximately −26 dBm (−10 dB relative to full scale). When amplitude modulation is selected, the dc level is limited to +2 Vdc and an ac signal is added to the dc signal on SINLEV to produce modulation. Addition and scaling of this signal is provided by the level/AM board.

The six sub-blocks that make up the modulator board are the RF buffer, the SINLEV filtering, the base bias, the current sources, the modulator, and the BP filter (two sections of a three section bandpass filter). The RF buffer receives the differential square wave signal (A 20MHz or B CARRIER) and amplifies it to the full ECL level. The output of the RF buffer is ac coupled to the modulator sub-block. The base bias sub-block provides the dc offset necessary for proper operation of the modulator sub-block. The SINLEV input signal passes through a low pass filter whose break frequency is 1.4 MHz. The modulator is a Gilbert multiplier with emitter degeneration (R30) which increases the linear operating region and sets the circuit gain. Bias for the modulator is provided by two matched current sources (Q1 and Q2). The output of the modulator passes through a bandpass filter, one-third of which exists on the mixer board (A5 or A15). This filter attenuates all harmonics of the 20 MHz signal by 90 dB or more, turning the square wave input of the modulator into a clean sine wave.

Troubleshooting

1. Turn the HP 3326A off, put the defective modulator board on an extender, then turn the instrument on.

2. Set the HP 3326A as follows:

INSTR PRESET	
CHANNEL	CH A or CH B
AMPLITUDE	13.97 dBm

3. Check the RF buffer sub-block. Using two 10:1 probes and an oscilloscope, check the waveforms #1 and #2 (see Figure 6-27).

4. Check the bias voltages present at either side of R30. If they are not as indicated on the schematic, suspect the SINLEV filtering sub-block or U2.

5. Check the modulator sub-block by examining U2(pin 7). The required output is shown in waveform #3. If the output is incorrect, check the bias voltages given on the schematic for the base bias and current sources sub-blocks. If the output is correct, suspect the BP filter sub-block.

Refer to Table 6-15 for recommended post-repair adjustments.

HP 3326A Setup

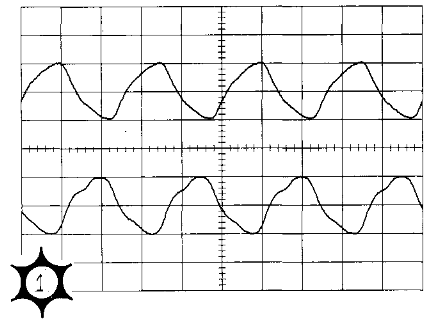
INSTR PRESET

Channel	CH A or CH B
Amplitude	13.97 dBm

Oscilloscope Setup (#1)

10:1 probes (2)†

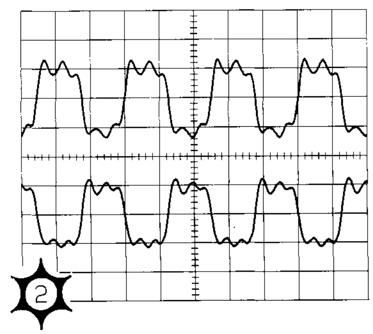
Ch 1 coupling	AC
Ch 1 V/div	20 mV
Ch 2 coupling	AC
Ch 2 V/div	20 mV
Time/div	20 ns
Trigger	Ch 1



Oscilloscope Setup (#2)

10:1 probes (2)

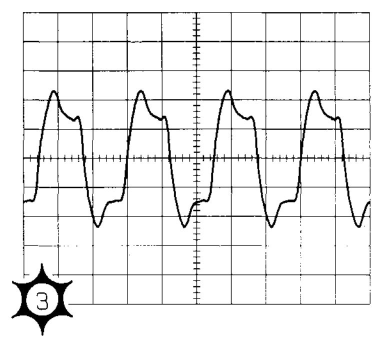
Ch 1 coupling	AC
Ch 1 V/div	40 mV
Ch 2 coupling	AC
Ch 2 V/div	40 mV
Time/div	20 ns
Trigger	Ch 1



Oscilloscope Setup (#3)

10:1 probe

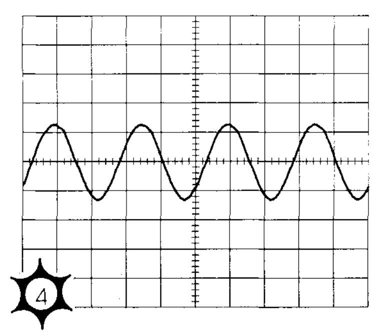
Ch 1 coupling	AC
Ch 1 V/div	40 mV
Time/div	20 ns
Trigger	Ch 1



Oscilloscope Setup (#4)

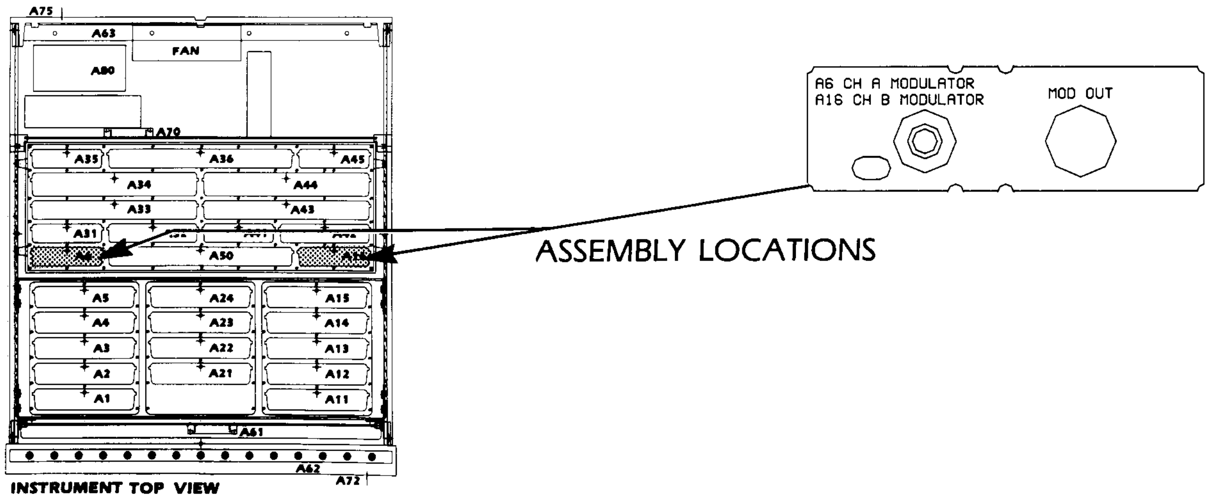
Phono plug to BNC adapter cable

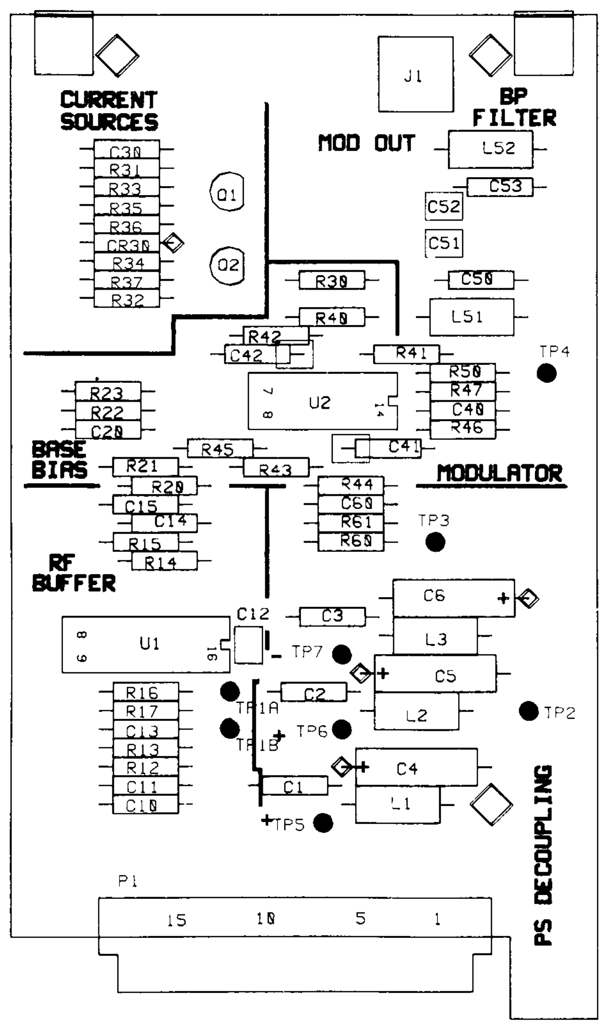
Ch 1 coupling	50 Ω DC
Ch 1 V/div	40 mV
Time/div	20 ns
Trigger	Ch 1



† Use a 10:1 probe with a ground spring (HP part number 1460-1476) when making high frequency measurements to minimize distortion.

Figure 6-26. Modulator Board Waveforms





MODULATOR BOARDS (A6, A16)
P/N 03326-66506
REV A

NOTES:

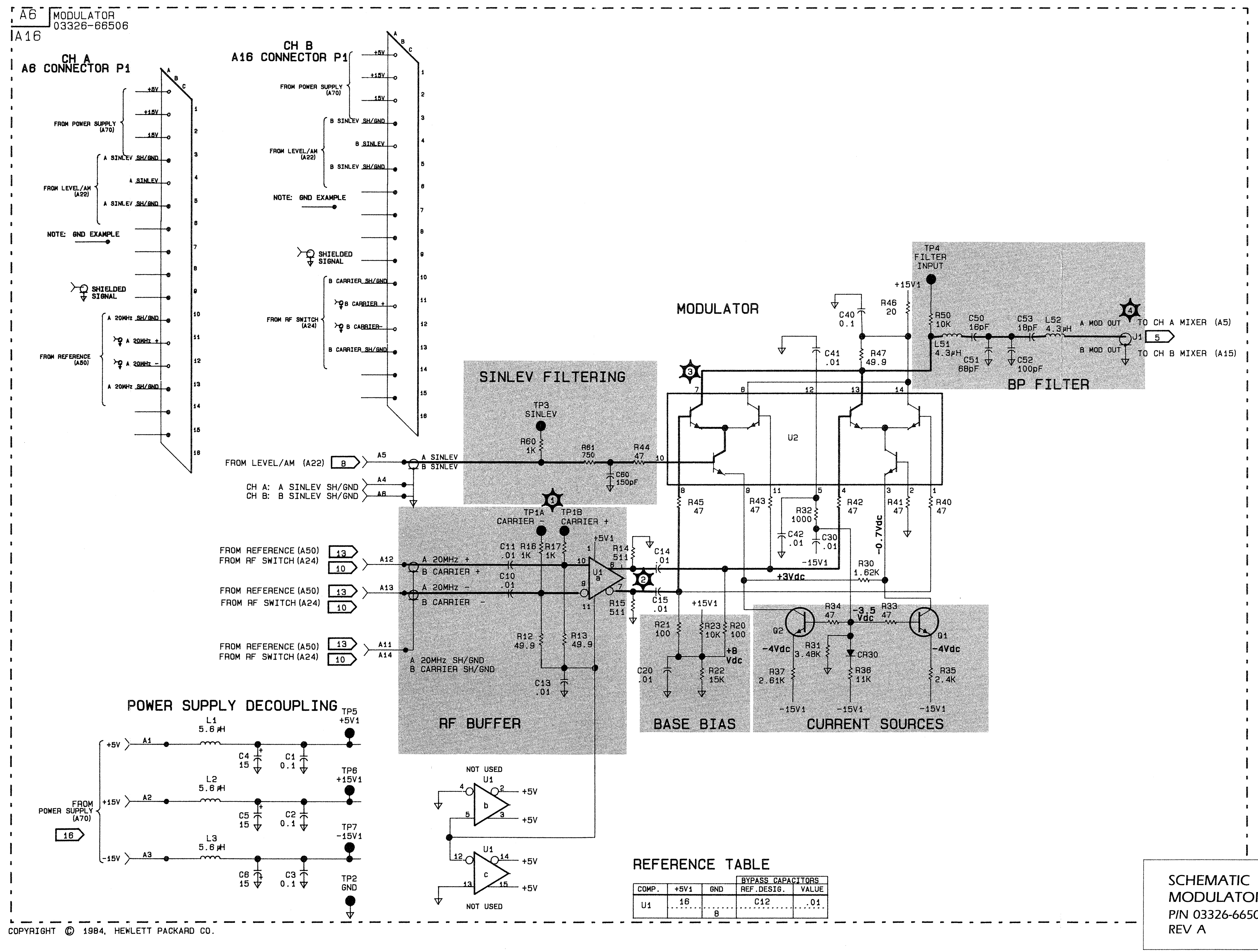
1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).

PIN 1   +5 V

GND

2. THIS BOARD IS USED TWICE IN THE INSTRUMENT - ONCE FOR CHANNEL A, AND ONCE FOR CHANNEL B. THE TWO IDENTICAL BOARDS MAY BE INTERCHANGED FOR TROUBLESHOOTING, BUT MUST BE RETURNED TO THEIR ORIGINAL LOCATIONS TO AVOID RECALIBRATION OF THE INSTRUMENT.

3. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.



SCHEMATIC
MODULATOR BOARDS (A6, A16)
P/N 03326-66506
REV A

6

Figure 6-27.

See
Other
Side

6-26 OFFSET, A21

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

Theory of Operation

The offset board provides the dc offset for the two channels. The 10.24 ref sub-block receives a voltage reference signal (V REF) from the calibrator board (P/O A36). This signal is filtered to remove high frequency components, buffered, and used to derive accurate bias currents for the digital to analog converters (DACs) and bias currents for the current to voltage converters.

The controller sends information to the offset control board via the instrument data bus (IBUS0-7). For a list of all the bits and their definitions, consult the table on the schematic. To send information, the address strobe line (ADD STROBE) is pulled low, and the address of the latch that receives the data is placed on the instrument bus (IBUS0-7). The address is latched into register U42 when ADD STROBE goes high. The outputs of U42 are sent to the select pins of U43, a 3:8 multiplexer. When the instrument bus DATA STROBE line goes low, U43 is enabled, and its selected output goes low. The valid data is placed on the instrument bus, and is latched into the register clocked by the active output of U43 when DATA STROBE goes high.

$\overline{\text{RESET}}$ is sent to the CLR inputs of the data latches. When a $\overline{\text{RESET}}$ occurs, all DAC bits are set to a TTL low level, resulting in an output of the largest possible negative dc offset voltage. See the strobe control sub-block.

The dc offset voltage for each channel is derived with a DAC and a current to voltage converter. See the A offset and B offset sub-blocks. The DAC takes the 1.024 mA reference current, multiplies it by a scaling factor, and sends it to a current to voltage converter. This dc offset voltage (A AMPDCO or B AMPDCO) is sent to the output amplifier (A3 or A13), unless the high voltage option is activated. In that case, the dc offset voltage (A HVDCO or B HVDCO) is sent to the high voltage amplifier (A1 or A11). Both the output amplifier and high voltage amplifier invert the signal, so the dc offset voltage seen on the offset board is opposite in polarity from the offset at the output.

The A control and B control sub-blocks send control information to the attenuating pads on the attenuator boards and output amplifier boards.

The overload signals ($\overline{\text{A OVLD}}$ or $\overline{\text{B OVLD}}$) from the attenuators (A2 and A12) are received by the analog fault sub-block, where they are sent through the equivalent of an OR gate (a wired-OR). When the $\overline{\text{ANALOG FAULT}}$ line is active, the controller interrupts the microprocessor. The processor reads U41 (see the read data sub-block) and determines if an overload condition is causing the interrupt. See the signal glossary in Appendix A for other reasons that an active $\overline{\text{ANALOG FAULT}}$ signal would be sent to the controller.

Troubleshooting

The instrument bus circuit on the controller board (A61) and the control interface on this board can be tested using the Interface SA Test (see Tables 6-52 and 6-53 in the A61 troubleshooting sub-section 6-33). This test exercises the control lines from the controller board to determine if the controller or the control interface circuitry is defective.

Table 6-23 shows how the relays and analog switches in the instrument function. The relays in the offset board are highlighted (K1 and K21). These relays direct the offset signals to the output amplifier boards (A3, A13) under normal instrument operation and to the high voltage amplifier boards (A1, A11) when the high voltage option is activated. See the overall theory of operation (sub-section 6-7) for details.

Table 6-23. Function Control

Switch Name †	Reference Designator (pin no.)	Off		Sine		Square		DC		HV		Combined	Int AM	Ext AM		Int PM	Ext PM		Sync PM
		A	B	A	B	A	B	A	B	A	B			A	B		A	B	(AB)
Ch A Cal/Prtct	A2K107	0	X	1	X	1	X	1	X	1	X	1	1	1	X	1	1	X	1
Ch B Cal/Prtct	A12K107	X	0	X	1	X	1	X	1	X	1	1	1	1	1	1	1	1	1
Ch A HV Option	A2K106	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X
Ch B HV Option	A12K106	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X
Ch A Square	A4K101	X	X	0	X	1	X	0	X	X	X	X	X	X	X	X	X	X	X
Ch B Square	A14K101	X	X	X	0	X	1	X	0	X	X	X	X	X	X	X	X	X	X
Ch A Offset	A21K1	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X
Ch B Offset	A21K21	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X
INT AM	A22U2(1)	X	X	X	X	X	X	X	X	X	X	X	ON (L)	OFF (H)	X	X	X	X	X
A EXT AM	A22U2(16)	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	ON (L)	X	X	X	X	X
B EXT AM	A22U6(1,16) A22U6(8,9)	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	X	X	X	X
INT PM	A32U22(1)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	OFF (H)	OFF (H)	OFF (H)
A EXT PM	A32U22(16)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	ON (L)	X	ON (L)
B EXT PM	A42U22(16)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	X
Ch A PM	A32U22(9)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	OFF (H)	X	OFF (H)
Ch B PM	A42U22(9)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	X
Ch A Combiner Isolation	A2K105	X	X	X	X	X	X	X	X	X	X	1	0	X	X	0	X	X	X
Ch A Combiner	A2K104	X	X	X	X	X	X	X	X	X	X	1	0	X	X	0	X	X	X
Ch B Combiner/ INT MOD	A12K104	X	X	X	X	X	X	X	X	X	X	1	1	X	X	1	X	X	X

† X = Relay can be in either the de-energized or energized position in this function.
1 = Relay must be in the energized position in this function.
0 = Relay must be in the de-energized position in this function.
ON (L) = Control line for the switch must be TTL low in this function. This activates the switch.
OFF (H) = Control line for the switch must be TTL high in this function. This de-activates the switch.

1. Turn power off, place the offset board on an extender, then turn power on.

2. Check the following circuit inputs using a logic probe (see schematic):

   $\overline{\text{RESET}}$ (from A61). Signal should be TTL high.

   ADD STROBE and DATA STROBE (from A61). These signals are normally high and toggle when offset is modified.

3. Check that the buffered voltage reference (TP6) is 10.240 Vdc ± 10 mVdc.

4. Preset the HP 3326A. Check the strobe control sub-block using Table 6-24. This table does not exercise the read data strobe (U43, pin 11). This strobe is normally high. It toggles only when an instrument overload occurs and the ANALOG FAULT line is TTL low. The microprocessor uses the strobe to read data from the offset board to determine if the board caused the fault.

Table 6-24. Strobe Control Sub-block Troubleshooting

Test Location (pin no.)	Test Setup	Normal Indication (TTL)
U42(12) U42(15) U42(2) U42(5) U42(10)	Modify channel A offset	Normally low, toggles when modified
U43(15) U43(14) U43(9)	Modify channel A offset	Normally high, toggles when modified
U43(13) U43(12) U43(7)	Modify channel B offset	Normally high, toggles when modified

5. For channel A offset failures, preset the instrument and check the A control and A offset sub-blocks using Tables 6-25 and 6-26. For channel B offset failures, use the same tables and substitute the corresponding signal names (e.g., B 10dB for A 10dB), reference designators (e.g., U23 for U3, TP2 for TP1),and channel(channel B for channel A).

Table 6-25. A Control Sub-block Troubleshooting

Signal Name	Test Location U45(pin no.)	Normal Indication in INSTR PRESET (TTL)	Test Setup	Normal Indication in Test Condition
A 10dB	U45(16)	Low	Amplitude = 0.0316 V	High
A 20dB	U45(2)	High	Amplitude = 0.0315 V	Low
A 40dB	U45(5)	Low	Amplitude = 0.0315 V	High
$\overline{\text{A CAL}}$	U45(6)	High	Perform MANUAL calibration	Low
A PRE10dB	U45(12)	High	Amplitude = 3.16 V	Low
A HI-VOLT	U45(19)	Low	Channel A high voltage option on	High
A A+B	U45(9)	Low	Combined operation on	High
$\overline{\text{A PROTECTCLEAR}}$	U45(15)	High†	—	—

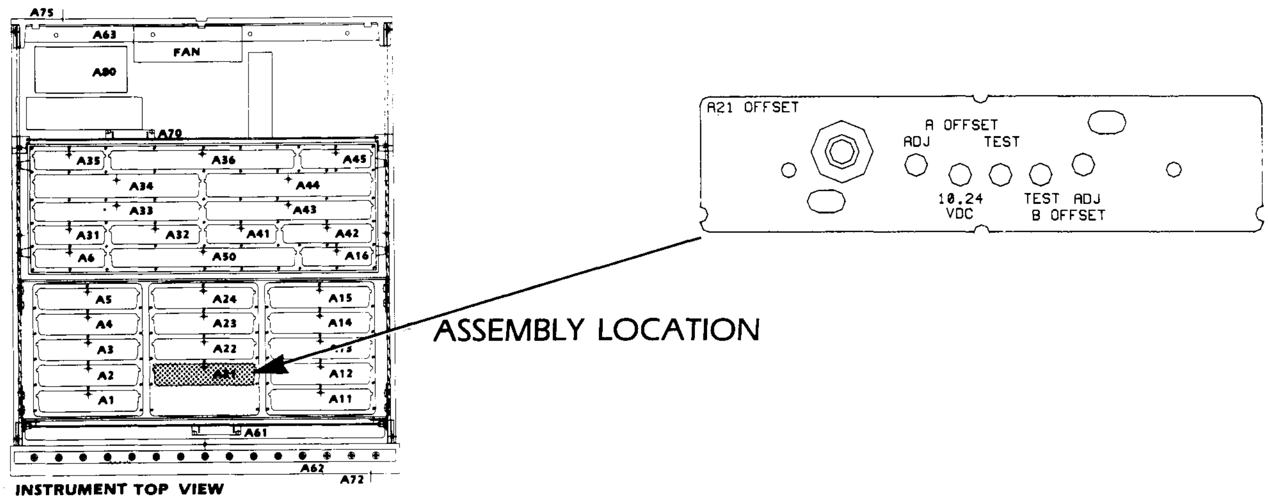
† only changes during instrument overload

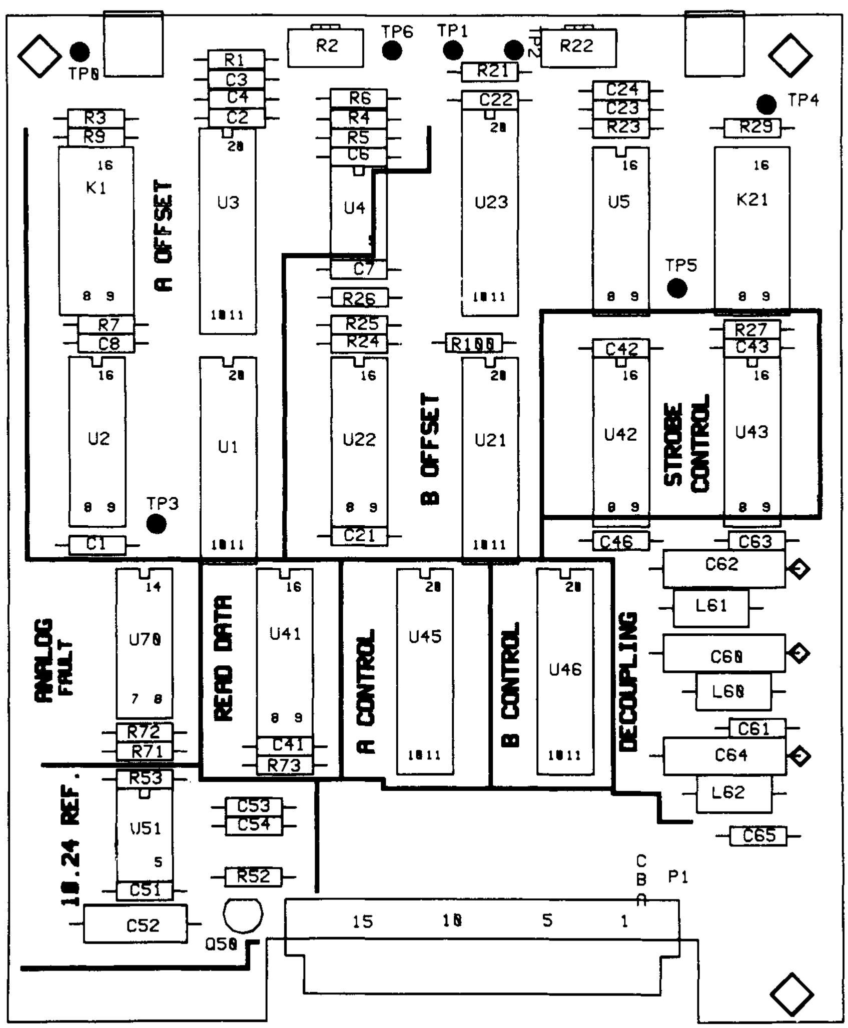
Table 6-26. A Offset Sub-block Troubleshooting

HP 3326A Setup	Pin numbers of DAC inputs (U3)†												DAC Output (TP1)
	MSB 1	2	3	4	5	6	7	8	9	10	11	LSB 12	
INSTR PRESET Channel CH A Function DC DC Offset +5 V Clear calibration constants, press: **SHIFT, %, 0**	0	0	0	1	0	1	1	1	1	1	0	1	−5.0 ± 0.1 V
Change DC Offset to −5 V	1	1	1	0	1	0	0	0	0	0	1	0	+5.0 ± 0.1 V

† 1 = TTL high
0 = TTL low

Refer to Table 6-15 for recommended post-repair adjustments.

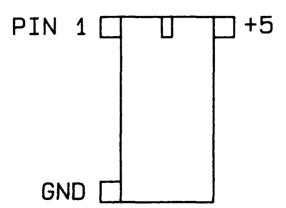




OFFSET BOARD (A21)
P/N 03326-66521
REV B

NOTES:

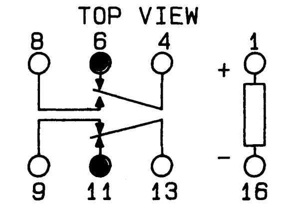
1. TTL DEVICES ARE USED IN THIS CIRCUIT.
2. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).

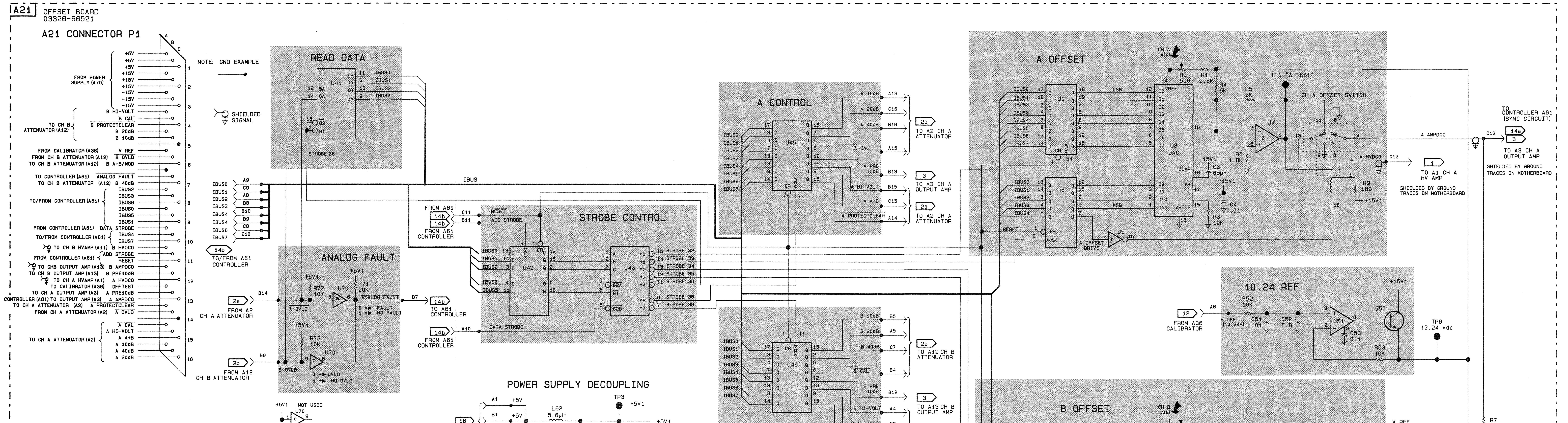


3. BEFORE TROUBLESHOOTING ANY OF THE DIGITAL TO ANALOG CONVERTERS (DACs) IN THE HP 3326A OR THE SIGNALS A SINLEV, B SINLEV, A SQLEV, AND B SQLEV, RESET THE CALIBRATION CORRECTION CONSTANTS. THIS IS DONE BY USING A HIDDEN FRONT PANEL COMMAND. PRESS SEQUENTIALLY:

SHIFT   dBV %   0

4. RELAYS ARE SHOWN IN THE DE-ENERGIZED STATE. P/N 0490-1405.





REFERENCE TABLE

COMP.	+5V1	+15V1	-15V1	GND	BYPASS CAPACITORS REF.DESIG.	BYPASS CAPACITORS VALUE	N.C.
U1	20						
U2	16				C1	.01	
U3		20		13, 19	C2	.01	
U4		8	4		C6 C7	.01 .01	
U5		9		3, 4, 5 6, 7, 8			
U21	20				C21	.01	
U22	16						
U23		20		13, 19	C22	.01	
U41	16				C41	.01	2, 10
U42	16				C42	.01	
U43	16				C43	.01	10
U45	20						
U46	20				C46	.01	
U51		7		4	C54	.01	
U70	14			7			

DATA BUS BIT DEFINITIONS

DECIMAL CODED ADDRESS	IBUS DATA	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
32	A LSBYTE	A7	A6	A5	A4	A3	A2	A1	A0
33	A MSNIB				OFF DRIVE	A11	A10	A9	A8
34	B LSBYTE	B7	B6	B5	B4	B3	B2	B1	B0
35	B MSNIB				OFF DRIVE	B11	B10	B9	B8
36	OVLDS						A OVLD		B OVLD
38	A CONTROL	PC.	A+B	HI VOLT	PRE 10dB	CAL	40dB	20dB	10dB
39	B CONTROL	PC.	A+B/MOD	HI VOLT	PRE 10dB	CAL	40dB	20dB	10dB

PC.= PROTECTCLEAR

SCHEMATIC
OFFSET BOARD (A21)
P/N 03326-66521
REV B

7

Figure 6-28.

See Other Side

6-27 LEVEL/AM, A22

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

Theory of Operation

The 10.24 ref sub-block receives a voltage reference signal (V REF) from the calibrator board (P/O A36). The combination of R1, C1, and C2 forms a low pass filter to filter out any high frequency noise that may be present. V REF is then sent into a voltage follower (U1) to limit the current drain on V REF. The buffered reference voltage provides very accurate bias currents for the digital to analog converters (DACs) and for the modulation input circuit that shifts the level. This signal is also used to derive an accurate +5 V for the A SINLEV and B SINLEV signals when the instrument is programmed for the square function or is in the pulse mode.

There are three AM inputs to this board: two external signals for modulating the two channels with an external source (A AMPTD MOD IN and B AMPTD MOD IN), and one internal input for modulating channel A with channel B (INT MOD). All input signals go into resistor dividers and low pass filters. U2a acts like a 2:1 multiplexer, allowing either the channel A external modulation signal or the internal modulation signal to be sent to a non-inverting amplifier (U3a). The output of U3a, along with R108 and R109, forms a 0 to 1 mA current sink which can take all or part of the current from the 1 mA current source (consisting of the buffered 10.24 volt V REF signal, R110, and R111). The remaining current is the DAC reference current. A +1 V signal at the external or internal modulation port results in a 1 mA, full scale reference current going into the DAC. A −1 V modulation input results in zero reference current.

The channel B external modulation signal works the same as above, except U7a is an inverting amplifier (instead of a non-inverting one). Thus, a −1 V modulation input leads to a 1 mA full scale reference current, while a +1 V input leads to zero reference current.

When the 3326A is modulated by an external source, the output signal varies according to Table 6-27. This shows that channel A is modulated 180° out of phase with respect to channel B and that the modulating signal may not vary beyond the range from −1 V to +1 V.

Table 6-27. Channel Output vs. Modulation Input Signal

Mod Input	Amplitude Channel A	Amplitude Channel B
0 V	A	B
+1 V	2×A	0
−1 V	0	2×B

Diodes CR102 and CR202 prevent the reference current from getting too high and damaging the DAC. Zener diodes CR100 and CR101 prevent ac overvoltage and dc overvoltage damage.

In the output stage, from the node where the DAC reference current is derived to the output of the board, the circuit looks the same for both channels. The DAC multiplies the reference current by a scaling factor, sends this output current to a current to voltage converter (consisting of R113 and U3b for channel A and R209 and U7b for channel B), and sends it to an output multiplexer.

The output multiplexer performs the switching that makes A SINLEV, B SINLEV, A SQLEV, and B SQLEV the correct voltages. Table 6-28 shows the relation between the HP 3326A functions and the required signal voltage levels.

Table 6-28. Level/AM Output Signal Voltage Levels

Function	$\overline{\text{A SIN}}$ $\overline{\text{B SIN}}$ (TTL)	A COMPAR ENABLE B COMPAR ENABLE (TTL)	A SINLEV B SINLEV	A SQLEV B SQLEV
Sine	Low	Low	0 to 5 V	0 V
Square or Pulse	High	High	5 V	0 to 5 V
DC Only	High	Low	Programmed to 0 V	0 V
Off	High	Low	Programmed to 0 V	0 V

The A and B level control sub-block receives information from the microprocessor on the controller board (A61). The processor controls the DAC codes, the RF SWITCH STROBE (which enables the RF switch to change positions), and enable bits (A COMPAR ENABLE and B COMPAR ENABLE) for the square board (A23). To send information over the instrument bus (IBUS0-7), the address of the receiving latch is placed on the bus and latched into the register (U14) when the address strobe line (ADD STROBE) goes high. The outputs of U14 go into U15, a 3:8 multiplexer. When the bus' DATA STROBE line goes low, U15 is enabled and the selected output goes low. The valid data is placed on the bus. When DATA STROBE goes high, the data is latched into one of the U10 to U13 registers.

NOTE

The clear lines for U10 to U13 are tied to the instrument RESET line so the DAC code is 0 when power is applied to the instrument. This prevents any unplanned full scale output.

Troubleshooting

The instrument bus circuit on the controller board (A61) and the control interface on this board can be tested using the Interface SA Test (see Tables 6-52 and 6-53 in the A61 troubleshooting sub-section 6-33). This test exercises the control lines from the controller board to determine if the controller or the control interface circuitry is defective.

Table 6-29 shows how the relays and analog switches in the instrument function. The switches in the level/AM board are highlighted (U2 and U6). These switches control external and internal phase modulation.

Table 6-29. Function Control

Switch Name †	Reference Designator (pin no.)	Off		Sine		Square		DC		HV		Combined	Int AM	Ext AM		Int PM	Ext PM		Sync PM
		A	B	A	B	A	B	A	B	A	B			A	B		A	B	(AB)
Ch A Cal/Prtct	A2K107	0	X	1	X	1	X	1	X	1	X	1	1	1	X	1	1	X	1
Ch B Cal/Prtct	A12K107	X	0	X	1	X	1	X	1	X	1	1	1	1	1	1	1	1	1
Ch A HV Option	A2K106	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X
Ch B HV Option	A12K106	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X
Ch A Square	A4K101	X	X	0	X	1	X	0	X	X	X	X	X	X	X	X	X	X	X
Ch B Square	A14K101	X	X	X	0	X	1	X	0	X	X	X	X	X	X	X	X	X	X
Ch A Offset	A21K1	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X
Ch B Offset	A21K21	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X
INT AM	A22U2(1)	X	X	X	X	X	X	X	X	X	X	X	ON (L)	OFF (H)	X	X	X	X	X
A EXT AM	A22U2(16)	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	ON (L)	X	X	X	X	X
B EXT AM	A22U6(1,16) A22U6(8,9)	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	X	X	X	X
INT PM	A32U22(1)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	OFF (H)	OFF (H)	OFF (H)
A EXT PM	A32U22(16)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	ON (L)	X	ON (L)
B EXT PM	A42U22(16)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	X
Ch A PM	A32U22(9)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	OFF (H)	X	OFF (H)
Ch B PM	A42U22(9)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	X
Ch A Combiner Isolation	A2K105	X	X	X	X	X	X	X	X	X	X	1	0	X	X	0	X	X	X
Ch A Combiner	A2K104	X	X	X	X	X	X	X	X	X	X	1	0	X	X	0	X	X	X
Ch B Combiner/ INT MOD	A12K104	X	X	X	X	X	X	X	X	X	X	1	1	X	X	1	X	X	X

† X = Relay can be in either the de-energized or energized position in this function.
1 = Relay must be in the energized position in this function.
0 = Relay must be in the de-energized position in this function.
ON (L) = Control line for the switch must be TTL low in this function. This activates the switch.
OFF (H) = Control line for the switch must be TTL high in this function. This de-activates the switch.

1. Turn power off, place the level/AM board on an extender, then turn power on.

2. Check the following circuit inputs using a logic probe (see schematic):

   $\overline{\text{RESET}}$ (from A61). Signal should be TTL high.

   ADD STROBE and DATA STROBE (from A61). These signals are normally high and toggle when amplitude is modified.

3. Check that the voltage reference from the calibrator board (TP1) is 10.240 Vdc ± 10 mVdc. Check that the buffered voltage reference (TP2) is present.

4. Check the A and B level control sub-block. Preset the HP 3326A. Check the sub-block using Table 6-30. This table does not exercise the data lines going to the DACs (U4 and U8). This is done in step 5.

Table 6-30. A and B Level Control Sub-block Troubleshooting

Signal Name	Test Location (pin no.)	Normal Indication in INSTR PRESET (TTL)	Test Setup	Normal Indication in Test Condition
—	U14(2) U14(5) U14(7) U14(15) U14(12)	High	Modify channel A or B amplitude	Toggles
—	U15(9)	High	Change mode from 2 CHANNEL to 2 PHASE	Toggles low then high
—	U15(12) U15(14)	High	Modify channel B amplitude	Toggles
—	U15(13) U15(15)	High	Modify channel A amplitude	Toggles
SQUARE/$\overline{\text{PULSE}}$	U10(9)	High	Activate PULSE mode	Low
—	U10(6)	High	Activate channel B external AM	Low
B COMPAR ENABLE	U10(5)	Low	Activate PULSE mode	High
$\overline{\text{B SIN}}$	U10(2)	Low	Change channel B function to square wave	High
—	U11(9)	High	Activate internal AM	Low
—	U11(6)	High	Activate channel A external AM	Low
A COMPAR ENABLE	U11(5)	Low	Activate PULSE mode	High
$\overline{\text{A SIN}}$	U11(2)	Low	Change channel A function to square wave	High

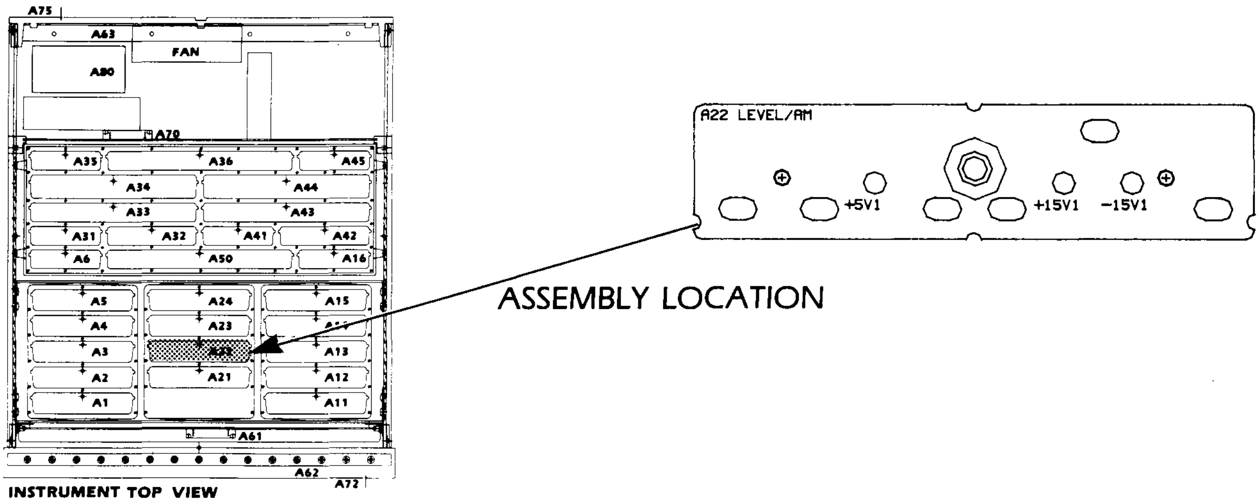
5. For channel A level failures, preset the instrument and check the channel A level sub-block using Table 6-31. For channel B level failures, use the same table and substitute the corresponding reference designators (e.g., U8 for U4, TP12 for TP7) and channel (channel B for channel A).

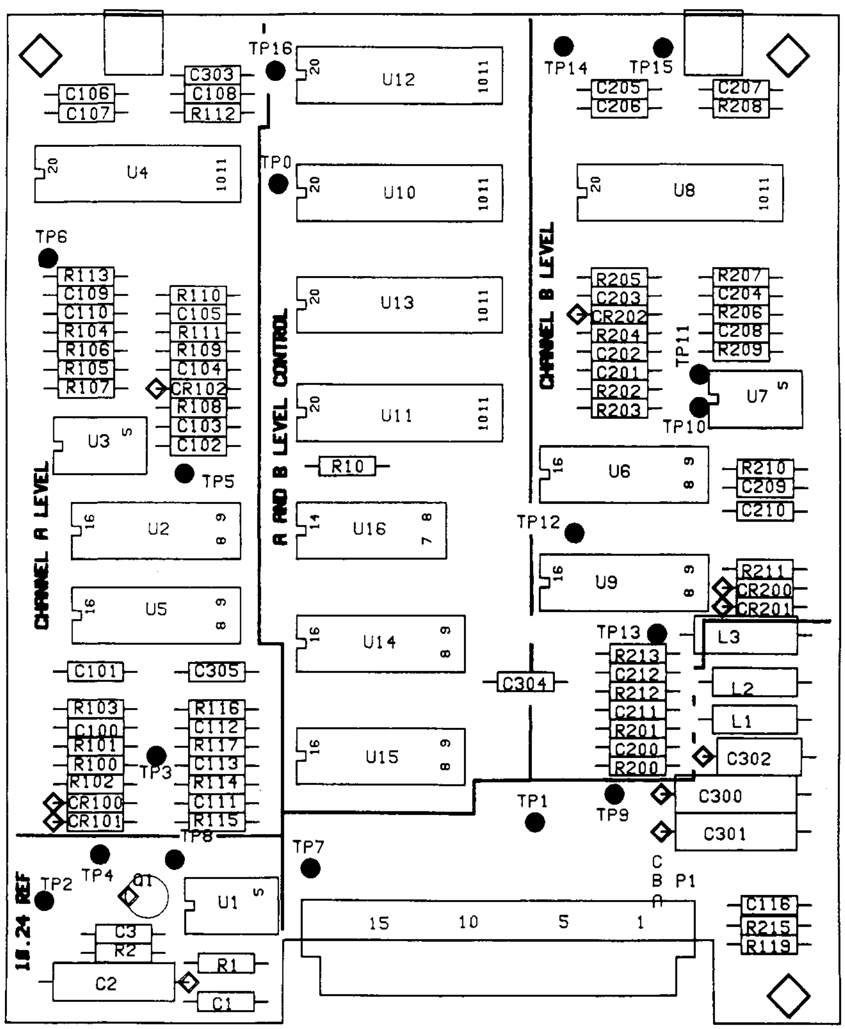
Table 6-31. Channel A Level Sub-block Troubleshooting

HP 3326A Setup	Pin numbers of DAC inputs (U4)†												DAC Output (TP7)
	MSB 1	2	3	4	5	6	7	8	9	10	11	LSB 12	
INSTR PRESET Channel CH A Amplitude 10 V Clear calibration constants, press: **SHIFT, %, 0**	1	1	0	1	0	0	0	0	0	1	0	1	4.07 ± 0.1 V
Change Amplitude to 8.4 V	1	0	1	0	1	1	1	0	1	1	1	1	3.41 ± 0.1 V
Change Amplitude to 5.0 V	0	1	1	0	1	0	0	0	0	0	1	0	2.03 ± 0.1 V
Change Amplitude to 3.16 V	0	1	0	0	0	0	0	1	1	1	0	1	1.28 ± 0.1 V

† 1 = TTL high
0 = TTL low

NOTES





LEVEL/AM BOARD (A22)
P/N 03326-66522
REV A

NOTES:

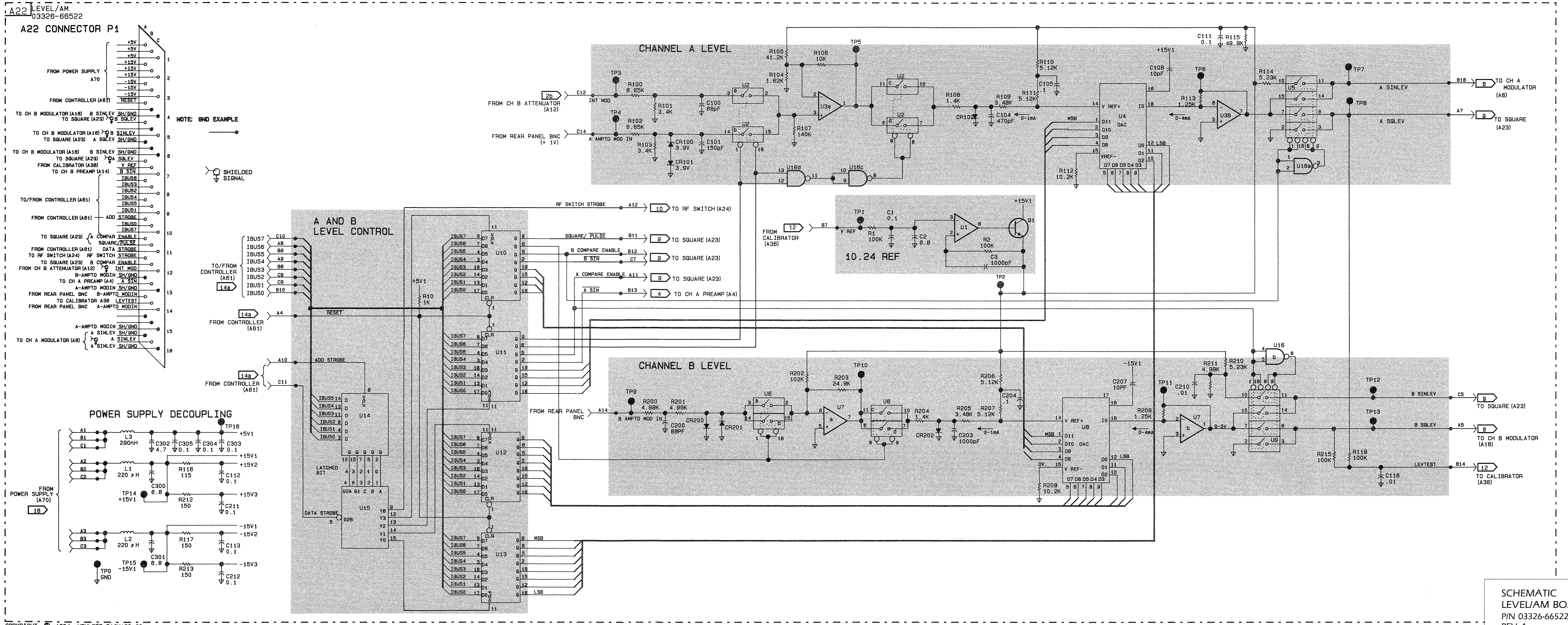
1. TTL DEVICES ARE USED IN THIS CIRCUIT.
2. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).

PIN 1 +5 V

GND

3. BEFORE TROUBLESHOOTING ANY OF THE DIGITAL TO ANALOG CONVERTERS (DACs) IN THE HP 3326A OR THE SIGNALS A SINLEV, B SINLEV, A SQLEV, AND B SQLEV, RESET THE CALIBRATION CORRECTION CONSTANTS. THIS IS DONE BY USING A HIDDEN FRONT PANEL COMMAND. PRESS SEQUENTIALLY:

SHIFT dBV % 0



SCHEMATIC
LEVEL/AM BOARD (A22)
P/N 03326-66522
REV A

8

Figure 6-29.

See
Other
Side

6-28 SQUARE, A23

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

Theory of Operation

The square board has three operation configurations:

1. Square function
2. DC function
3. Pulse mode

1. Square function:

Either or both channels can be configured for square operation. In this configuration, the input and output sub-blocks are identical for the two channels. The following discussion for channel A square function is true for channel B.

U100 is a comparator controlled by the A COMPAR ENABLE signal. The A SQUARE IN signal from the preamplifier board is a sine wave signal whose amplitude is approximately 2.5 Vpp at the frequency selected by the user. U100 turns the sine wave into a square wave at TTL levels. The resistive divider R106 and R107 shifts the output of U100 to ECL levels.

During square operation the SQUARE/$\overline{\text{PULSE}}$ line is TTL high, disabling the U300 flip-flops and activating gate U301a to pass the square wave. U301c buffers this signal and provides differential drive to the A output sub-block. The differential signal lines for the B channel are inverted with respect to the A channel.

The heart of the output circuit (U400) is a balanced modulator IC. The output waveform is the product of the differential drive signal and the voltage across the gain-setting resistor R410. The input signal A SQLEV controls the output amplitude. The full scale value of A SQLEV is 4 Vdc. U401a multiplies A SQLEV by −0.5 and subtracts 8 volts from it so that full scale at TP402 is −10 V. At lowest amplitude (A SQLEV = 0 V), TP402 reads −8 V. The left end of R410 is driven to the voltage at TP402 by U401b. The voltage on the other end of R410 is fixed at −8 V by U401d. At full scale, 2 V appears across R410 and the output (U400 pin 12) swings ±1.5 V. The output at U400 pin 6 is the complement of that at pin 12. These signals are buffered by emitter follower transistor stages and summed by U401c, which forces the sum to be zero. This insures that the output signal (A SQUAREOUT at TP400) is centered about ground, regardless of the duty cycle.

2. DC function:

Either or both channels can be configured for DC output. In this configuration, the squaring circuit is turned off and the square board output is used as a zero volt reference for the output amplifier.

When the DC function is activated the A COMPAR ENABLE signal is TTL low, which disables U100. A SQLEV signal input is set to zero scale or 0 Vdc. No signal propagates through the circuit and the output signal is a dc voltage near ground potential.

3. Pulse mode:

This feature appears in the front panel mode section. In this mode, both A and B square circuits are used to operate a pair of flip-flops such that the duty cycle of the output pulse waveform is directly related to the phase difference between channels A and B. The B output is the complement of output A.

In the pulse mode, the SQUARE/$\overline{\text{PULSE}}$ line is TTL low, enabling flip-flops U300a and b and disabling gates U301a and U302b. The output of the flip-flops is a pulse whose duty cycle is a function of the phase difference between A SQUARE IN and B SQUARE IN. U301b and U302a buffer the output from the flip-flops, feeding the pulse waveform to both output sub-blocks. In pulse mode, the output sub-blocks operate exactly the same as they do in the square function.

Troubleshooting

This circuit may be analyzed by putting it on an extender (be sure to turn the power off before removing the board) and comparing the oscilloscope waveforms in Figure 6-30 with those of the defective unit. The instrument configuration for these waveforms is given in the figure.

Refer to Table 6-15 for recommended post-repair adjustments.

HP 3326A Setup

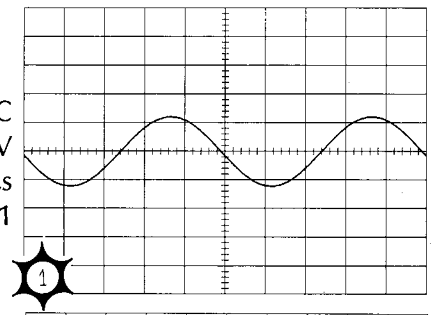
INSTR PRESET

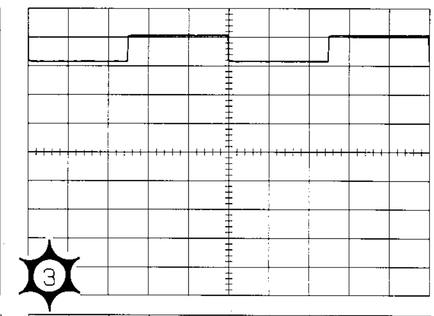
Channel	CH A
Function	Square
Amplitude	10 Vpp
Channel	CH B
Function	Square
Amplitude	10 Vpp

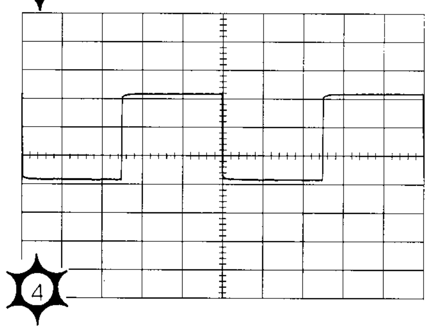
Oscilloscope Setup (#1, #3, #4, #5)

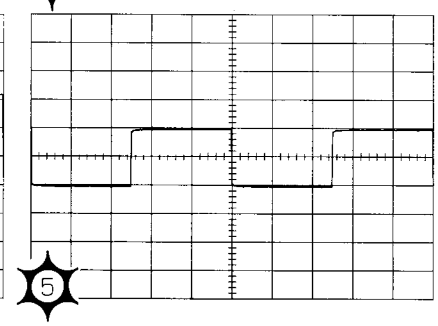
10:1 probe†

Ch 1 coupling	DC
Ch 1 V/div	100 mV
Time/div	200 μs
Trigger	Ch 1





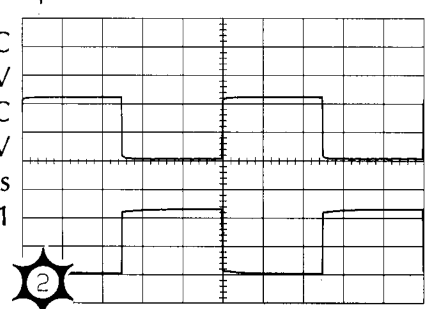




Oscilloscope Setup (#2)

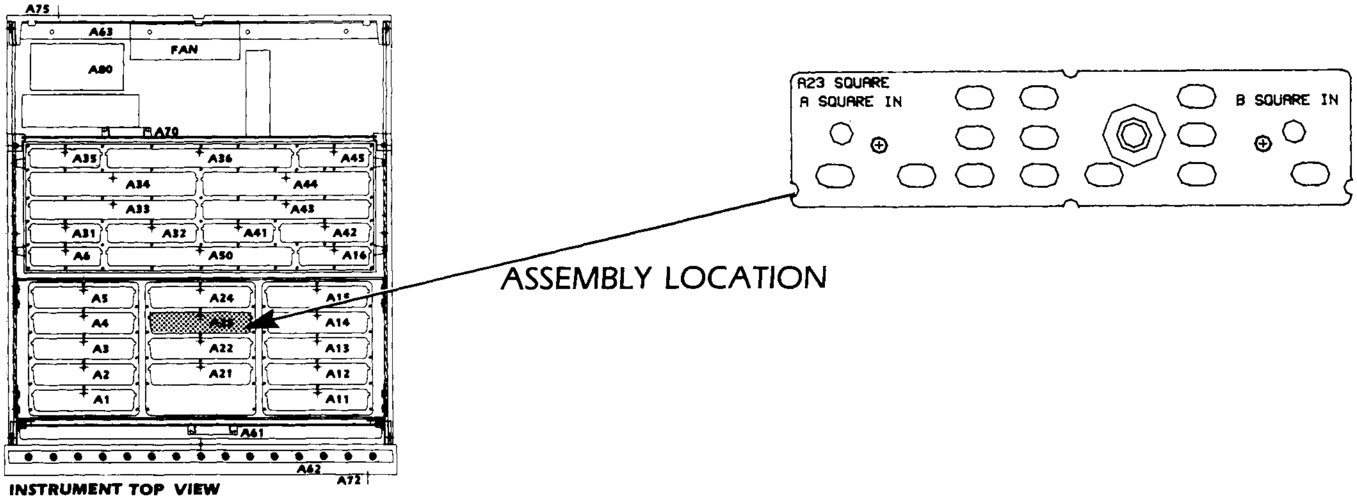
10:1 probes (2)

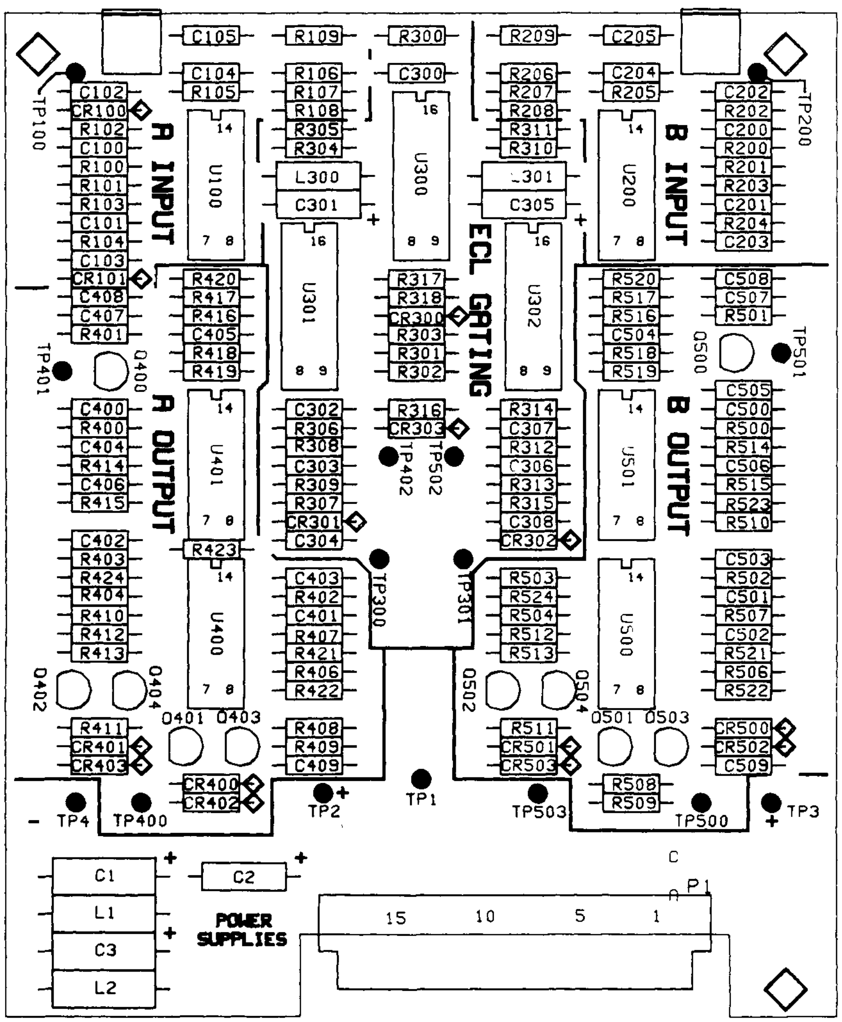
Ch 1 coupling	DC
Ch 1 V/div	200 mV
Ch 2 coupling	DC
Ch 2 V/div	200 mV
Time/div	200 μs
Trigger	Ch 1



† Use a 10:1 probe with a ground spring (HP part number 1460-1476) when making high frequency measurements to minimize distortion.

Figure 6-30. Square Board Waveforms





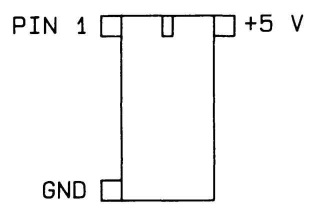
SQUARE BOARD (A23)
P/N 03326-66523
REV A

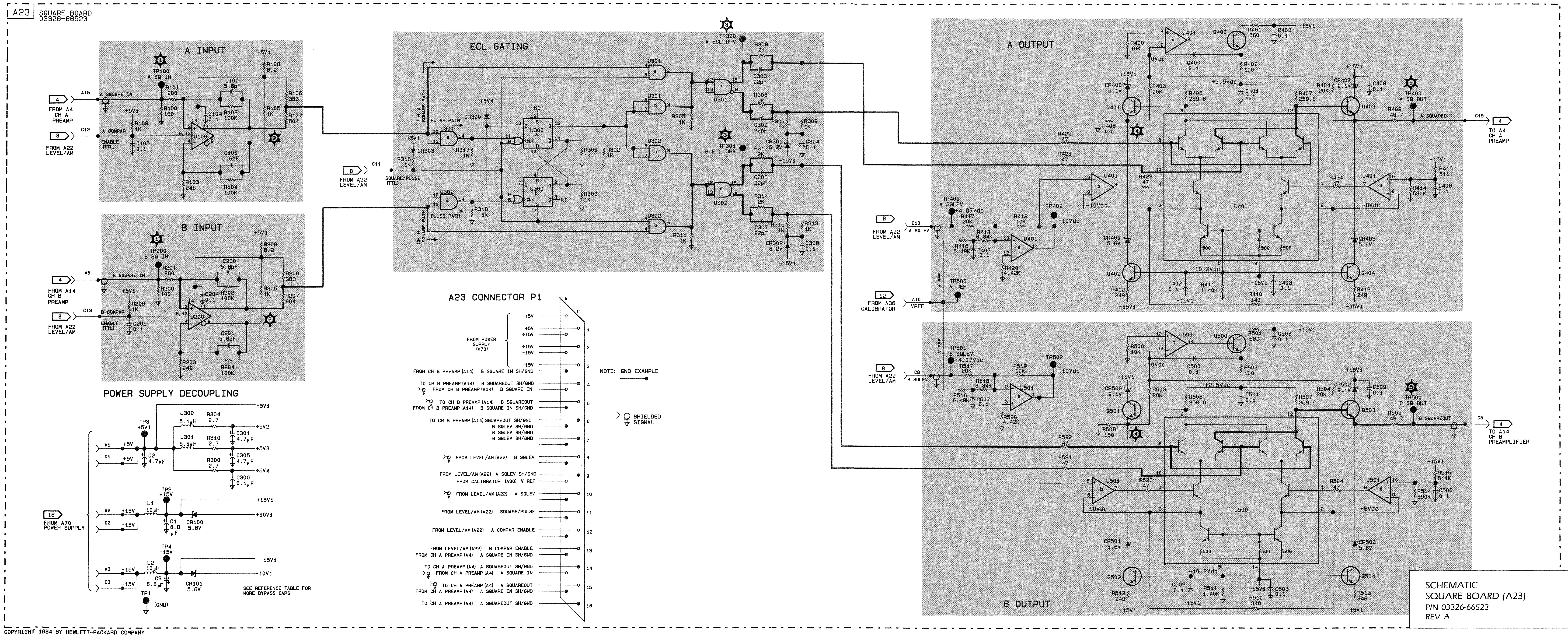
REFERENCE TABLE

COMP.	+5V1	+5V2	+5V3	+5V4	+15V1	-15V1	+10V1	-10V1	GND	BYPASS CAPACITORS DESIG.	BYPASS CAPACITORS VALUE (μF)	N.C.
U100							1	8	10	C102 C103	0.1 0.1	2, 5, 7, 12
U200							1	8	10	C202 C203	0.1 0.1	2, 5, 7, 12
U300				1, 16					8			3, 12
U301		1, 16							8			10, 11, 14
U302			1, 16						8			10, 11, 14
U400						14				C403	0.1	7, 9, 11, 13
U401					4	11				C404 C405	0.1 0.1	
U500						14				C503	0.1	7, 9, 11, 13
U501					4	11				C504 C505	0.1 0.1	

NOTES:

1. EMITTER COUPLED LOGIC (ECL) AND TTL DEVICES ARE USED IN THIS CIRCUIT.
2. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).





SCHEMATIC
SQUARE BOARD (A23)
P/N 03326-66523
REV A

9

Figure 6-31.

See
Other
Side

6-29 RF SWITCH, A24

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

Theory of Operation

The RF switch board is used to change the instrument's configuration between the two-channel and two-phase modes. The HP 3326A has two local oscillators (LOs) and two mixers. In the two-channel mode, the LOs are fed into separate mixers which mix them with a 20 MHz source, resulting in independent frequency control for each channel. In the two-phase mode, the channel A LO drives the local oscillator inputs of both mixers and the channel B LO drives the reference port of the channel B mixer (at 20 MHz). The reference port of the channel A mixer is driven by the reference board (A50). In this mode, the output frequencies of the two mixers are equal. The phase between them is controlled by changing the phase of the channel B LO. In the two-tone and pulse modes, the HP 3326A configuration is as described for the two-phase mode.

The RF switch board operates as four single pole, single throw switches used in combination to form a double pole, double throw switch. The inputs to the board are B 20MHz from the reference board (A50) and A LO2 and B LO2 from the VCO ÷ 2 boards (A35 and A45). The switch outputs (LOBSW and B CARRIER) drive the channel B mixer (A15). LOBSW is connected directly to LO port of the channel B mixer. B CARRIER is routed to the reference port of the mixer after it goes to the modulator board (A16). In the two-channel mode (shown in Figure 6-8), the 20 MHz signal from the reference board (B 20MHz) is sent to the reference port of the channel B mixer and the channel B LO signal (B LO2) is connected to the channel B mixer LO port. In the two-phase mode, B LO2 is routed to the B mixer reference port and A LO2 signal is connected to the B mixer LO port. See Figure 6-8 in the overall theory of operation.

The switch controller sub-block turns the switch blocks either on or off to change instrument modes. Switch configuration is specified by the logic state of internal bus line IBUS0 when the RF SWITCH STROBE line is pulsed. When IBUS0 is low and the strobe pulse arrives, the switch is set to the two-channel mode. When IBUS0 is high and the strobe pulse arrives, the switch is set to the two-phase mode. The sub-block outputs are INH BREF and $\overline{\text{ENABLE LO2}}$. INH BREF goes to the reference board to turn off the B 20MHz signal (not used in the two-phase mode). $\overline{\text{ENABLE LO2}}$ goes to the channel A VCO ÷ 2 board to turn off the A LO2 signal (not used in the two-channel mode). Turning these signals off at the source and in the RF switch keeps crosstalk very low.

Each switch block consists of a diode tee followed by a two-transistor buffer. The diodes perform the actual switching. When a negative bias is applied to their common junction by the control block, the in-line diodes are reverse biased and the diode to ground is forward biased, which effectively disconnects the through path and, further, connects it to ground. When the control block allows the diode junction to float, the in-line diodes become forward biased and the diode to ground is reversed, allowing the signal to pass.

Since only one of the two switches feeding the summing blocks is on at any point in time, the term "sum" is not meant to imply that two signals are combined. The summing blocks are used as a common connection point for the outputs of two switches. In the process, they also convert the signal to ECL levels. When the control block turns a switch off, that switch's companion input to the summing block is also pulled low to enable the other summing input amplifier to function properly. This is accomplished with resistors R16, R17, R46, and R47. The output of the sum 1 block is a signal relative to ground. The output of sum 2 is a differential output.

Troubleshooting

Before beginning troubleshooting, check the control lines $\overline{\text{ENABLE LO2}}$ and INH BREF, comparing them to the values listed in Table 6-32. Similarly, verify that these lines have disabled the appropriate input signals (A LO2 and B 20MHz, depending on the mode). Discrepancies in any of these signals could indicate a defective latch (U5), a defective reference board (A50), or a defective channel A VCO ÷ 2 board (A35).

Table 6-32. RF Switch Control Lines and Inputs

Mode	Signal Description			
	$\overline{\text{ENABLE LO2}}$	A LO2	INH BREF	B 20MHz
2 CHANNEL	TTL high	X	TTL low	20 MHz square, AC coupled, ECL level
2 PHASE	TTL low	20 to 33 MHz, square wave, AC coupled, ECL level	TTL high	X

X = Signal inhibited

Next, probe TP4 (LOBSW) and TP5 (B CARRIER). If either signal is present in one mode but not in others, then a switch sub-block is probably defective. Refer to the block diagram on the schematic to determine the signal path for a given instrument mode. Note that the two-tone and pulse modes use the two-phase mode RF switch configuration. Figure 6-32 gives two instrument setups to test the RF switch. It also shows a table that lists the switches that are on and off in the two RF switch configurations. Use this table and the bias voltages given on the schematic to troubleshoot a defective switch. The bias voltages are the same for all switches. They are listed only once on the schematic, in the switch 1 sub-block. Both the "on" and "off" voltages are given.

If either LOBSW or B CARRIER is not present in ANY mode, one of the summer sub-blocks is probably defective. Use the bias voltages given on the schematic in the sum 1 sub-block to troubleshoot.

When troubleshooting the RF switch on an extender board, the instrument mode may be selected by shorting TP7 to ground (for two-channel mode) or shorting TP8 to ground (for two-phase mode).

Refer to Table 6-15 for recommended post-repair adjustments.

The waveforms and bias voltages are given for one representative switch. All switches perform the same way when they are on or off. The table shows the status of the switches in the two setups.

Mode	Switch Status			
	Switch 1	Switch 2	Switch 3	Switch 4
2 CHANNEL (Setup 1)	ON	OFF	OFF	ON
2 PHASE (Setup 2)	OFF	ON	ON	OFF

HP 3326A Setup 1

INSTR PRESET	
(Mode	2 CHANNEL)
Channel	CH B
Frequency	5 MHz

HP 3326A Setup 2

INSTR PRESET	
Mode	2 PHASE

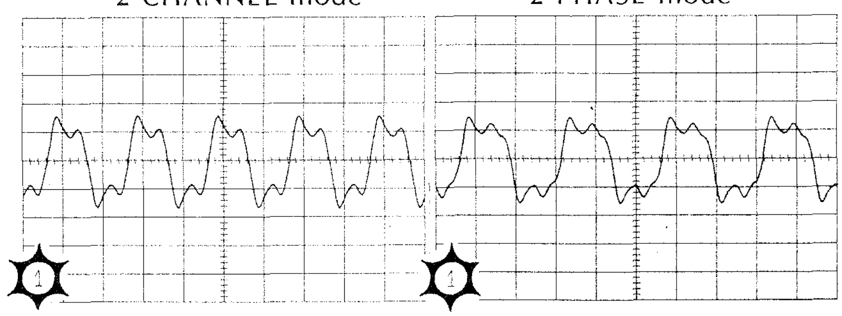
Oscilloscope Setup

10:1 probe†

Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	20 ns
Trigger	Ch 1

HP 3326A Setup 1
2 CHANNEL mode

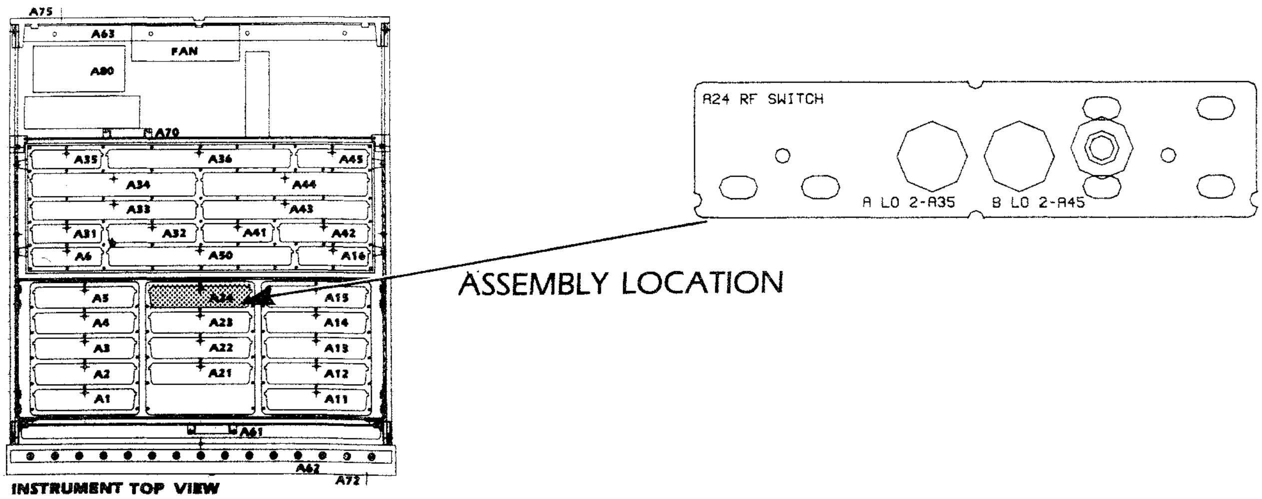
HP 3326A Setup 2
2 PHASE mode

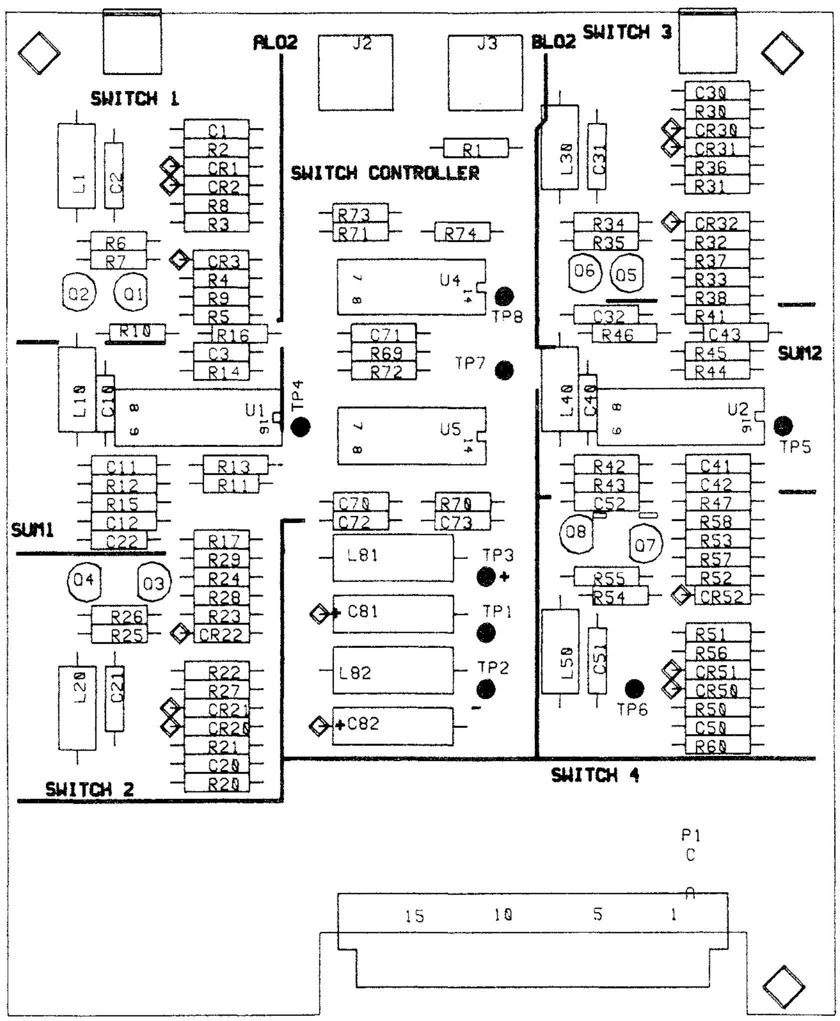


† Use a 10:1 probe with a ground spring (HP part number 1460-1476) when making high frequency measurements to minimize distortion.

Figure 6-32. RF Switch Board Waveforms

NOTES





RF SWITCH BOARD (A24)

P/N 03326-66524

REV A

NOTES:

1. EMITTER COUPLED LOGIC (ECL) AND TTL DEVICES ARE USED IN THIS CIRCUIT.

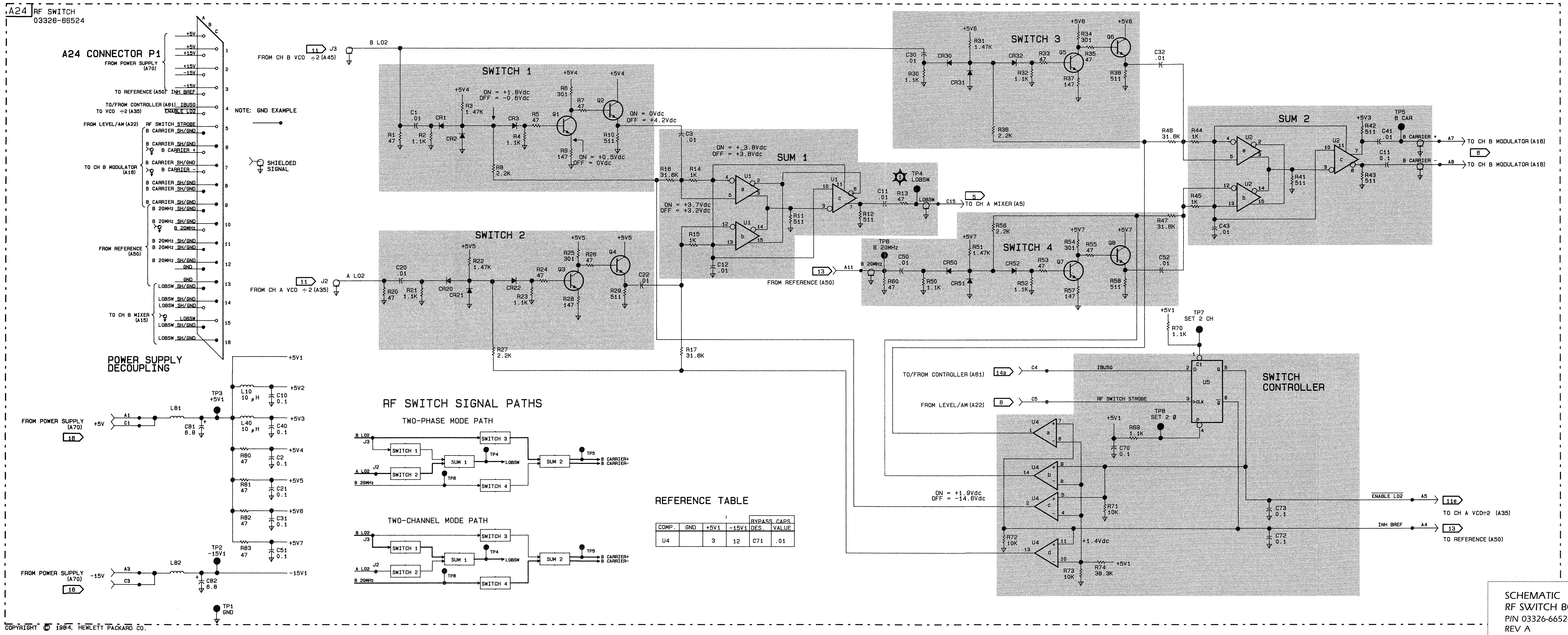
2. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).

PIN 1 — +5 V

GND

3. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.

4. THE RF SWITCH CIRCUIT (A24) HAS THREE MAIN INPUTS AND TWO MAIN OUTPUTS. DEPENDING ON THE MODE, THE CIRCUIT CHOOSES TWO OF THE INPUTS TO ROUTE TO THE MODULATOR (A6 OR A16) AND MIXER (A5 OR A15) BOARDS. THE AVAILABLE INPUTS ARE: A LO2, B LO2 AND B 20MHz. SEE THE SIGNAL GLOSSARY AND THE OVERALL THEORY OF OPERATION FOR MORE INFORMATION.



REFERENCE TABLE

COMP.	GND	+5V1	-15V1	BYPASS CAPS DES.	BYPASS CAPS VALUE
U4		3	12	C71	.01

SCHEMATIC
RF SWITCH BOARD (A24)
P/N 03326-66524
REV A

10

Figure 6-33.

See Other Side

6-30 FRACTIONAL-N LOCAL OSCILLATORS

This section covers boards in the fractional-N local oscillator group, including (for channels A and B) A31, A32, A33, A34, A35, P/O A36, A41, A42, A43, A44, and A45. See Table 6-33 for a cross reference between board names, reference designators, and associated channels. All examples in the text and in the figures use channel A boards. The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

Theory of Operation

The HP 3326A has two separate fractional-N local oscillators. Each local oscillator (LO) operates at a frequency equal to twice the sum of the programmed frequency and the 20 MHz reference frequency, as follows:

$$Fvco = (Fprog + 20\ MHz) \times 2$$

This results in an LO output signal frequency between 40 MHz and 66 MHz. The output of each LO is divided by two (by the VCO ÷ 2 board), resulting in an LO frequency between 20 MHz and 33 MHz. This signal is mixed with a 20 MHz reference signal, resulting in a signal at the programmed frequency. (In the two-tone mode, the channel B LO can run at 39.8 MHz to allow a 100 kHz frequency offset at the output.)

The local oscillators are configured by the controller board (A61). The fractional-N decoder board (P/O A36) synchronously programs each LO to allow phase tracking of frequency steps and sweeps between the two channels. The decoder is also used to synchronize externally triggered sweeps.

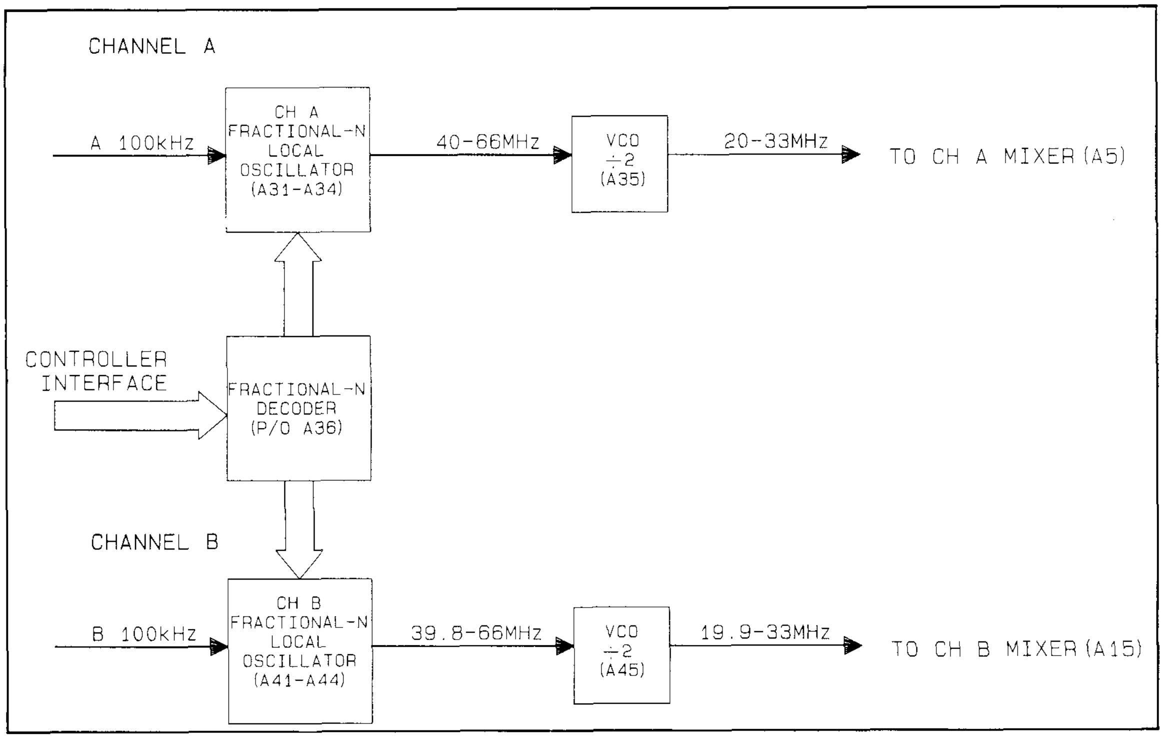


Figure 6-34. HP 3326A Fractional-N Simplified Block Diagram

Phase-locked loop basics:

The frequency of a voltage controlled oscillator (VCO) is determined by the dc voltage from the phase comparator. This voltage is proportional to the phase difference between two 100 kHz input signals. Therefore, a shift in the phase relationship of the inputs signals causes a change in the dc control voltage and results in a new VCO frequency. When the phase relationship changes, the VCO frequency changes to regain the original phase relationship.

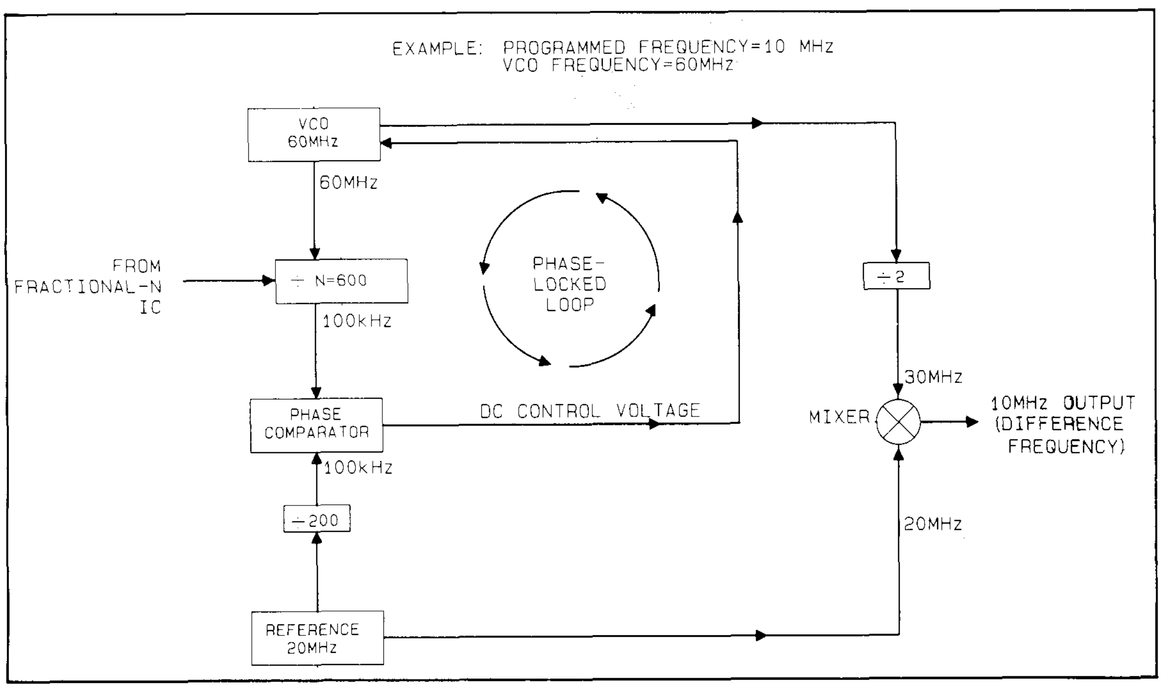


Figure 6-35. Phase-Locked Loop Block Diagram

As an example, consider a programmed output frequency (Fprog) of 10 MHz (Figure 6-35). The VCO must operate at 60 MHz (Fvco) and the divide-by number (N) must be 600 to reduce the Fvco to 100 kHz, as required by the phase comparator. When the desired output changes from 10 MHz to 13 MHz, N must change from 600 to 660. This changes the divided VCO output to approximately 91 kHz. The phase comparator (A33) detects the new phase relationship between the inputs and produces a new dc voltage (A VCO CONT), which changes Fvco to 66 MHz. This returns both phase comparator inputs to 100 kHz and locks the loop.

N is determined by the controller and the fractional-N circuitry in response to front panel or HP-IB inputs. The HP 3326A synthesizes frequencies up to 13 MHz. Consequently, the VCO tuning range must be from 40 MHz to 66 MHz. This dictates N to be between 400 and 660. The VCO tuning range is adjusted by a variable inductor (L1) on the VCO board (A31).

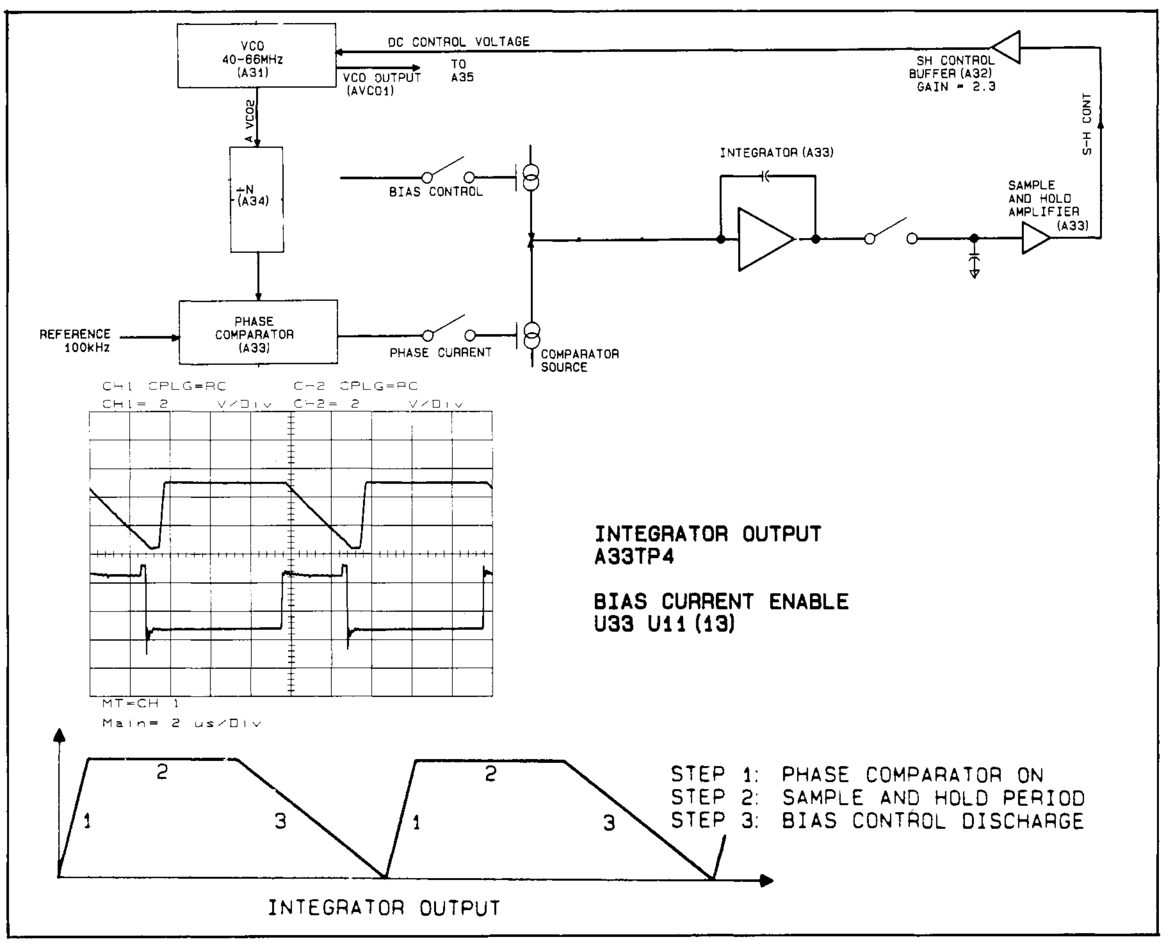


Figure 6-36. Phase-Locked Loop with Sample and Hold Block Diagram

Phase-locked loop circuit description:

The output of the phase comparator on A33 is a current source which charges the integrator capacitor for a specific amount of time. The integrator's output (A33TP4) is then transferred to the sample and hold amplifier. Here, the voltage is stored and amplified for use as the dc control voltage (A VCO CONT, A32) for the VCO (A31). After the integrator voltage has been transferred to the sample and hold amplifier, the bias control current source is turned on by the $\overline{\text{A BIAS}}$ signal to discharge the integrator capacitor; otherwise the integrator capacitor would continue to charge to the limit of the power supply. The phase comparator current source is activated at a 100 kHz rate, making the cycle time of this circuit 10 microseconds.

Fractional-N operation:

The standard phase-locked loop is useful only for three-digit integer values of N. This limits the available output frequencies. Fractional-N frequency synthesis expands the number of allowable frequencies by allowing N numbers that are NOT integers. When a frequency of 20 kHz is programmed, the VCO operates at 40.04 MHz and N changes to a three-digit integer value plus a fractional part (N = 400.4). This fractional number is referred to as N.f. Additional circuits are needed in the loop to allow this fractional number to be used. Analog phase interpolation (API) current sources and pulse-remove circuits operate the VCO at 40.04 MHz while providing a 100 kHz signal to the phase comparator (illustrated in Figure 6-37).

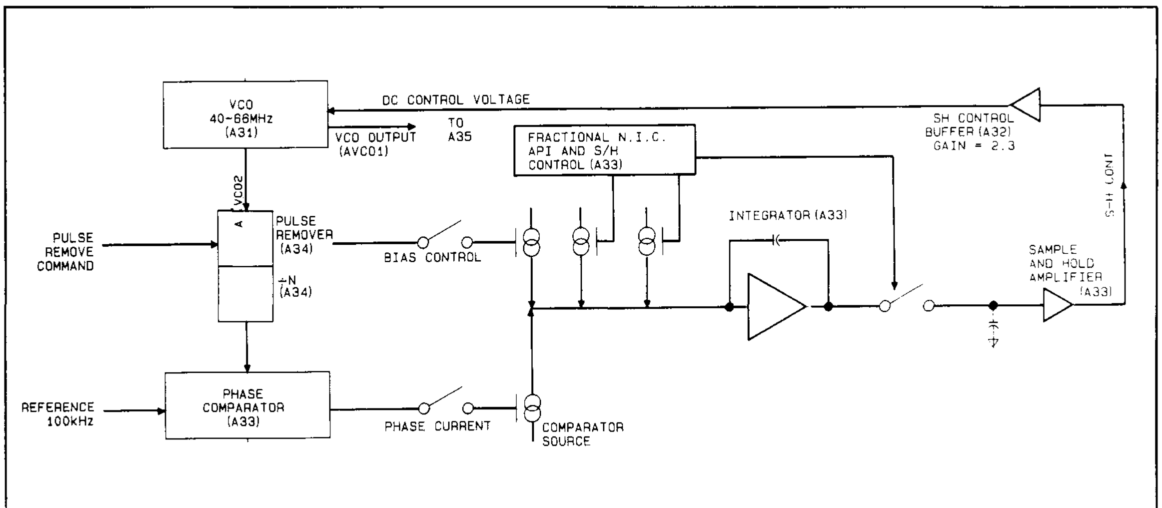


Figure 6-37. Fractional-N Phase-Locked Loop Block Diagram

When the VCO operates at 40.04 MHz, N is 400 and the divided VCO signal to the phase comparator is 100.1 kHz. When compared to the 100 kHz signal from the reference (A 100kHz), a phase difference of increasing magnitude results. Consequently, the phase comparator current source on A33 continues to increase the charge current to the integrator. To compensate for this increasing charge, the discharge current from the bias current source also increases. The desired net result is a constant integrator output voltage. The discharge current from the bias source is adjusted with the analog phase interpolation (API) current sources (on A33), which are controlled by the fractional-N integrated circuit (IC) on A34. This API circuitry is a series of five different-sized current sources. Figure 6-38 illustrates the effect of applying API to the bias current control source.

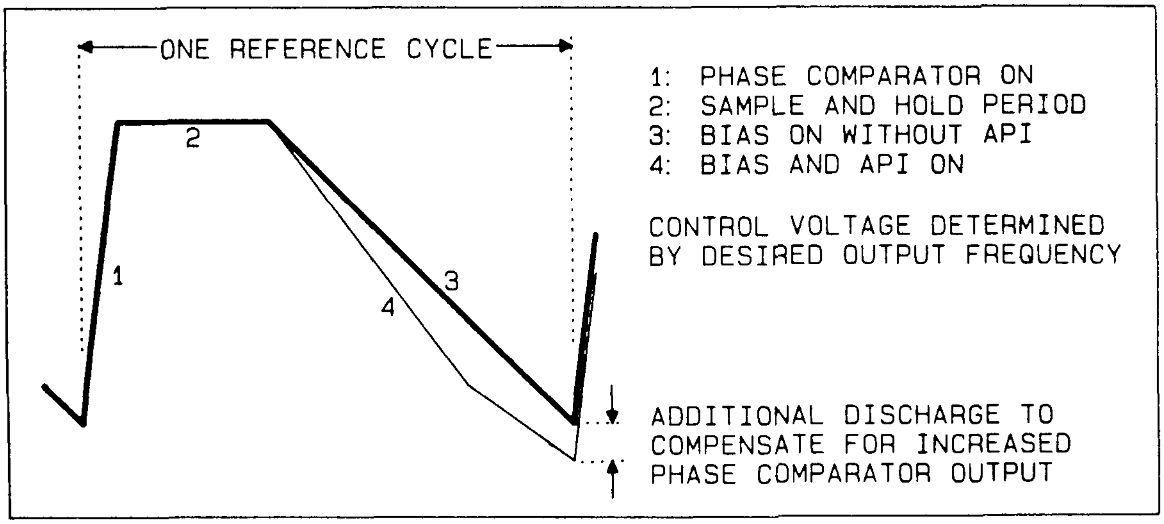


Figure 6-38. Integrator Output with API Applied

The API sources compensate for the increasing phase difference detected by the phase comparator. By using these sources, the VCO can operate at frequencies which would normally cause the loop to lose lock. Figure 6-39 illustrates the operation of the API sources for two programmed frequencies. The waveforms appear at the output of the integrator (A33TP4).

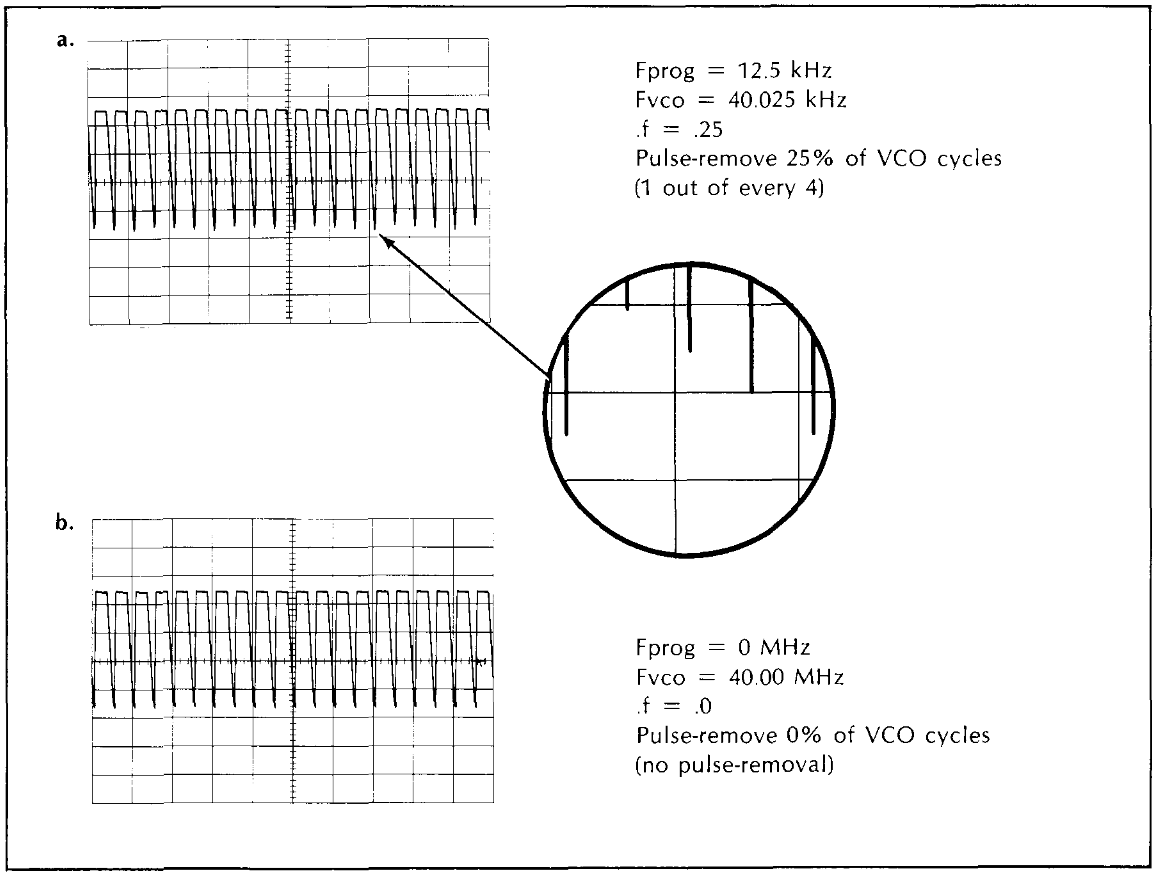


Figure 6-39. Integrator Output

The API scheme only solves part of the problem, however. The phase comparator on A33 does not have the dynamic range to lock the loop by depending solely on the API correction. To compensate for this, a pulse-remove technique is employed. The fractional-N IC on A34 accumulates the phase difference between the VCO signal (A VCO/N.F) and the reference signal (A 100kHz). When the difference becomes 360 degrees (corresponding to unity in the phase accumulation register in the fractional-N IC), the N counter on A34 divides by N+1 for one cycle, effectively removing one cycle of VCO frequency, and causing the frequency of the divided signal going to the phase comparator to average 100 kHz. This pulse-remove command is generated by the fractional-N IC whenever the accumulated phase passes through unity. The .f portion of the N.f number equals the percentage of VCO cycles during which pulse-removal is employed. When the programmed frequency (Fprog) is 45 kHz, Fvco is 40.09 and .f is .9, and pulse-removal is employed during 90% of the cycles. Figure 6-40 illustrates the relationship of the 100 kHz reference frequency, the N phase comparator input, and the phase accumulation register in the fractional-N IC.

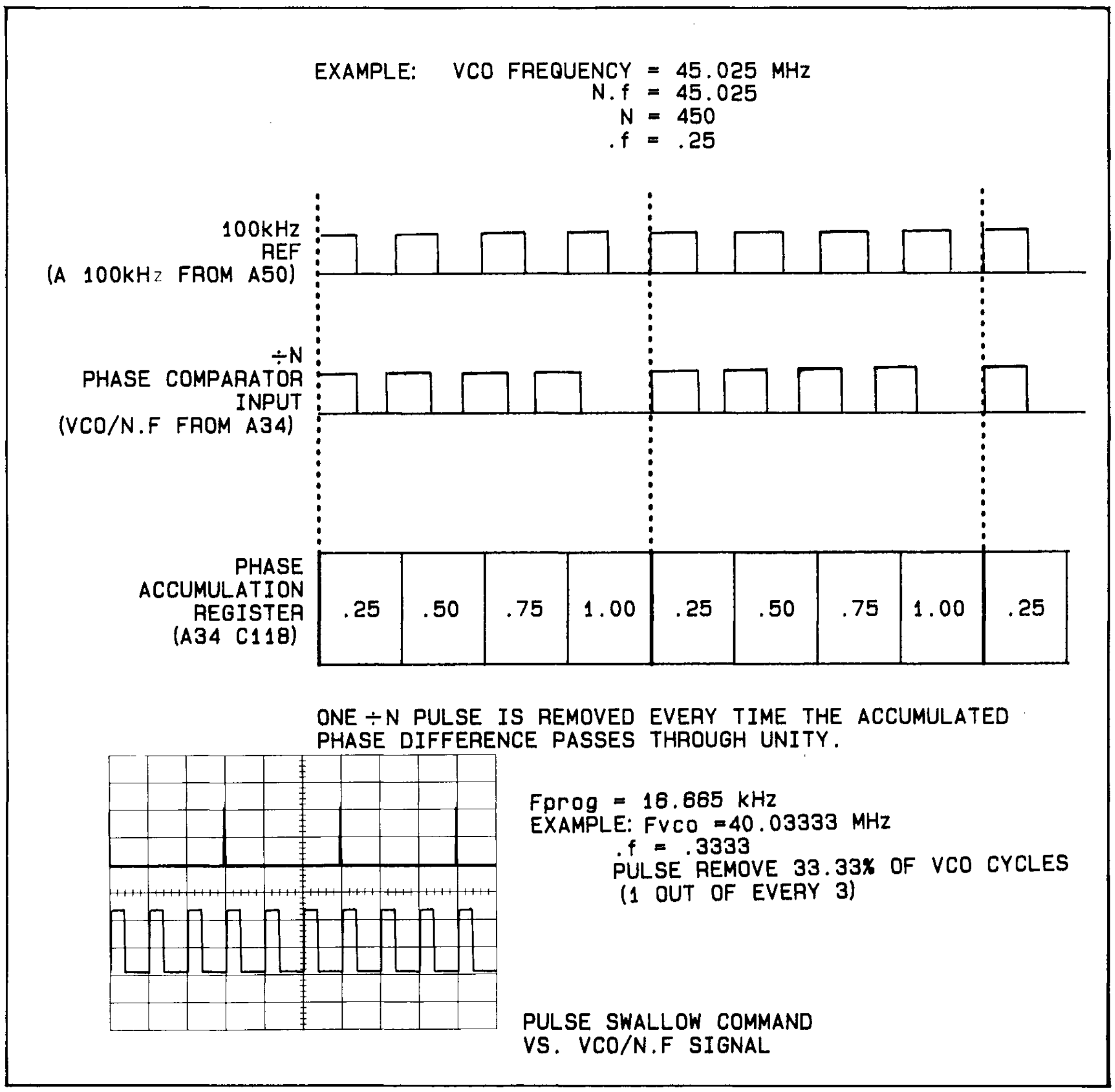


Figure 6-40. Pulse-Remove Command

To accumulate the phase difference in the fractional-N IC (A34U18), the twelve least significant digits in the frequency register are added to the twelve digits in the phase accumulator, and the sum is stored. This addition takes place every 10 microseconds — once for each cycle of the 100 kHz reference. Figure 6-41 illustrates this process. When the accumulated sum exceeds unity, a carry is generated, and a pulse swallow command is given.

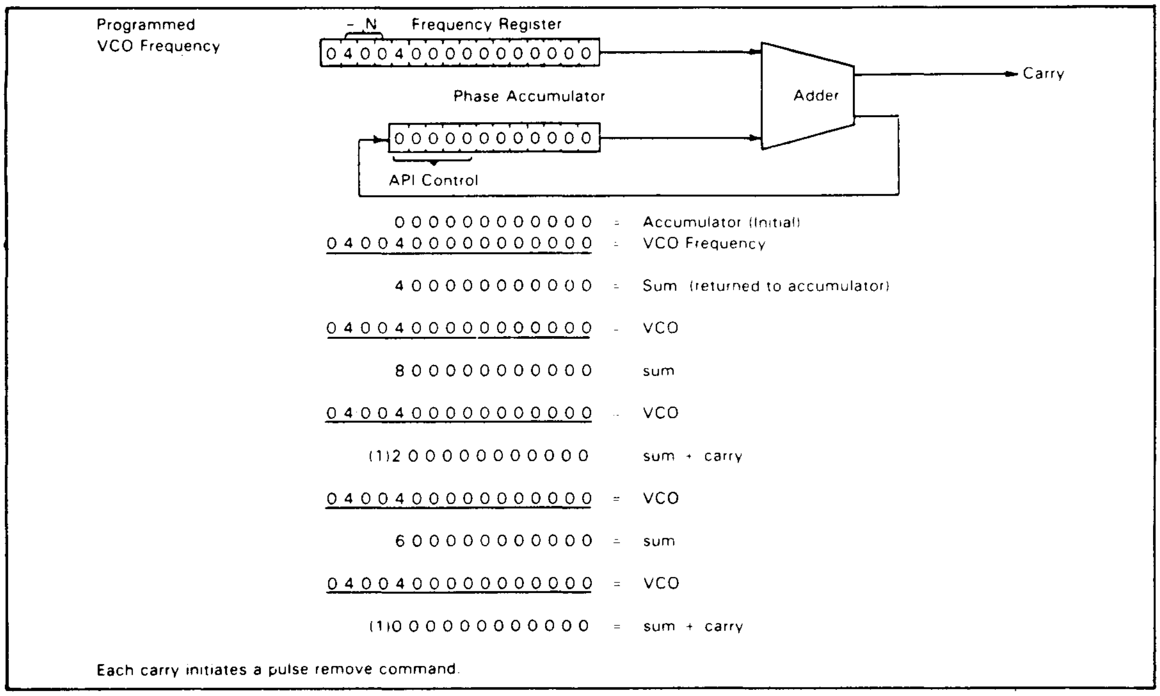


Figure 6-41. Phase Accumulation in the Fractional-N IC

÷N circuit description:

As shown in Figure 6-42, the N counter on A34 consists of three presettable counters in series. Decade counters are used for the two most significant digits. The least significant digit is determined by a ÷5 counter preceded by a ÷2 prescaler. The prescaler momentarily converts to ÷3 when it receives a pulse-remove command. The number loaded into the counter is the 9's complement of N, the three most significant digits of the VCO frequency. To determine the 9's complement, subtract N from 999.

If 20 kHz (Fvco = 40.04 kHz) is the desired output frequency, 599 (9's complement of 400) is loaded into the N counter. The counter counts up to 999, reloads N (599), and sends a pulse to the phase comparator on A33. One pulse is produced every 400 VCO cycles (599 to 999). This pulse is synchronized to the bias current source control $\overline{\text{A BIAS}}$ (to maintain the proper timing relationship) and to the VCO, VCO ÷2, and VCO ÷10 signals (to ensure phase stability).

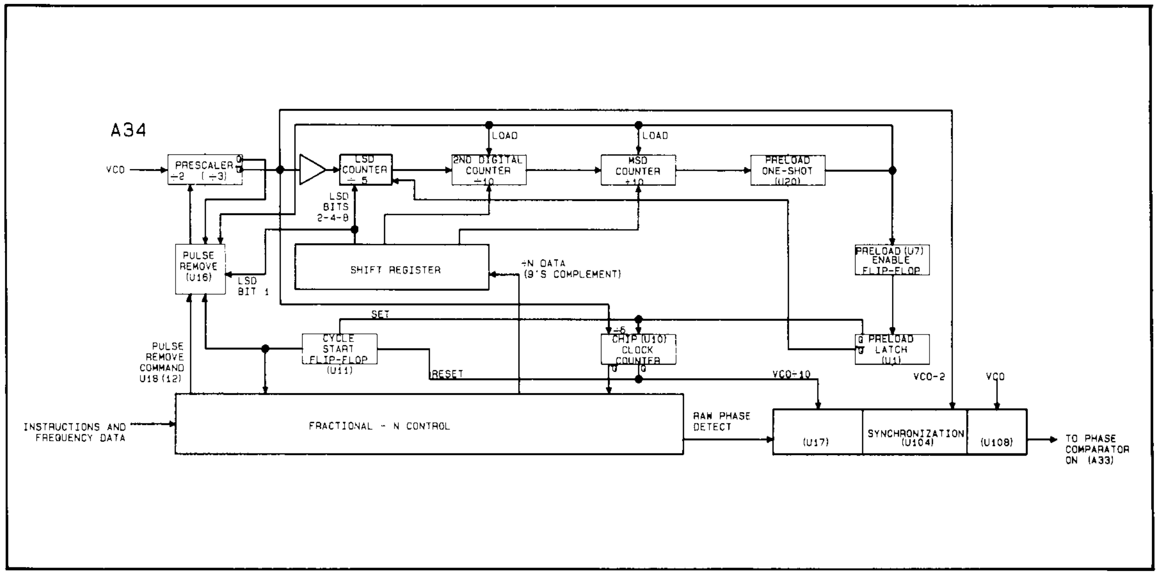


Figure 6-42. Divide-by-N Counter Block Diagram

When N is odd, an extra VCO cycle is removed because the N counter is clocked by VCO ÷ 2. If the extra cycle was not removed at the beginning of each fractional-N cycle, only frequencies that are even multiples of 100 kHz could be produced.

The chip clock counter output shown in Figure 6-42 is the prescaler (VCO ÷ 2 or VCO ÷ 3) output divided by five. One output is applied to the fractional-N IC to clock data in and out of the four shift registers in the IC. The other output is used to synchronize the N.f signal to the phase comparator and to clock the cycle start flip-flop.

The cycle start flip-flop is set by the preload latch and reset by the trailing edge of the next chip clock signal. A cycle start pulse occurs when the LSD counter is preset. Cycle start is used to set the pulse-remove circuit whenever N is odd.

As an example of the dividing sequence, consider a desired output frequency of 20 kHz (a VCO frequency of 40.04 MHz). The VCO frequency is divided by 400 every fractional-N cycle, and the output to the phase comparator has a frequency of 100.1 kHz. To prevent the phase comparator from forcing the VCO back to 40 MHz, pulse-removal is employed during 40% of the VCO cycles (.f = .4). To accomplish this, the fractional-N IC causes the ÷2 prescaler to divide by three for one VCO cycle whenever the phase accumulator generates a carry (for this example, two out of every five fractional-N cycles).

Isolating the Defective Fractional-N Board

When there is a failure in the fractional-N local oscillator, but you are unsure which of the boards is causing the failure, one way to isolate the defect is to interchange the five sets of identical boards, one at a time, until the defective board is found. This is effective, but takes much time. In many cases, the following short fault isolation procedure can help you find the defective board faster.

The fractional-N fault isolation tests given in Table 6-34 are listed for channel A only. Substitute channel B for channel A and vice versa when you are troubleshooting the channel B fractional-N local oscillator. See Table 6-33 for a PC board reference designator cross reference. The tests also assume that the clock signals from the reference board (8MHz FRACN CLK, A 100kHz, and B 100kHz) are present.

Table 6-33. Fractional-N LO Boards Cross Reference

Board Name	Reference Designator		
	Ch A	Ch B	Common
VCO	A31	A41	
VCO Control	A32	A42	
Phase Detector	A33	A43	
FracN Digital	A34	A44	
VCO ÷ 2	A35	A45	
FracN Decoder			A36

Table 6-34. Fractional-N Fault Isolation Tests

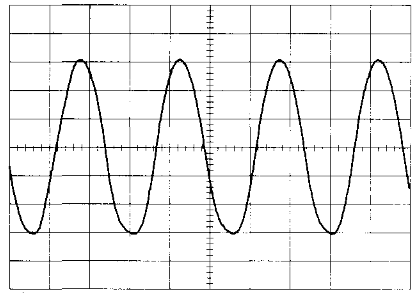
Step	HP 3326A Setup	Test Signal	Normal Indication	If Abnormal,	
				Suspect	Next Step
1	INSTR PRESET 2 PHASE mode Test jumper (J1) on A32 in test position (remove A32 from card nest to access)	A VCO2 Test at TP on A34 top cover (VCO)	40 MHz ±2 MHz, ECL level, dc coupled†	VCO Control (A32) VCO (A31) Cable from A31 to A34 (VCO2)	Interchange the two sets of boards, one set at a time. Determine defective board.
2	Same as above	A LO2 Test at connector on A35 top cover (LO 2) using 50 Ω load	20 MHz ± 1 MHz, ECL level, ac coupled	VCO ÷ 2 (A35)	Repair A35.
3	INSTR PRESET FREQ 0 MHz Test jumper (J1) on A32 in test position (remove A32 from card nest to access)	A PRELOAD Test at TP on A34 top cover (PRELOAD)	TTL level, normally high, low pulse every 10 μs	FracN Decoder (A36) FracN Digital (A34) VCO (A31) VCO Control (A32) (If signal in step 1 is present, A31 and A32 are working properly.)	Run service self tests (sub-section 6-8). If test 10‡ passes, A36 is working properly. If not, interchange A34 and A44. See if failure follows A34.
4	—	—	—	—	If signals in steps 1-3 are normal, suspect phase detector board (A33). Interchange A33 and A43. See if failure follows A33.

† VCO and VCO control boards are working properly if this signal is present. ‡ Service self test 9 for channel B.

Oscilloscope Setup (A VCO2)

10:1 probe†

Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	10 ns
Trigger	Ch 1

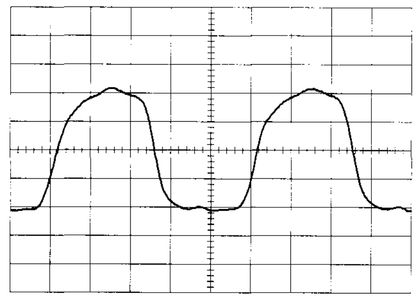


1

Oscilloscope Setup (A LO2)

Phono plug to BNC adapter cable

Ch 1 coupling	50 Ω DC
Ch 1 V/div	200 mV
Time/div	10 ns
Trigger	Ch 1

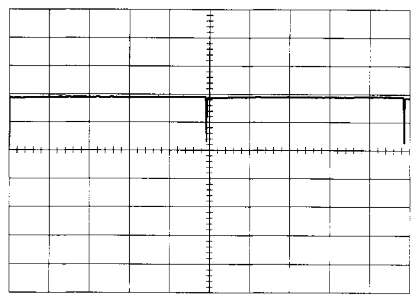


2

Oscilloscope Setup (A PRELOAD)

10:1 probe

Ch 1 coupling	DC
Ch 1 V/div	200 mV
Time/div	2 μs
Trigger	Ch 1



3

† Use a 10:1 probe with a ground spring (HP part number 1460-1476) when making high frequency measurements to minimize distortion.

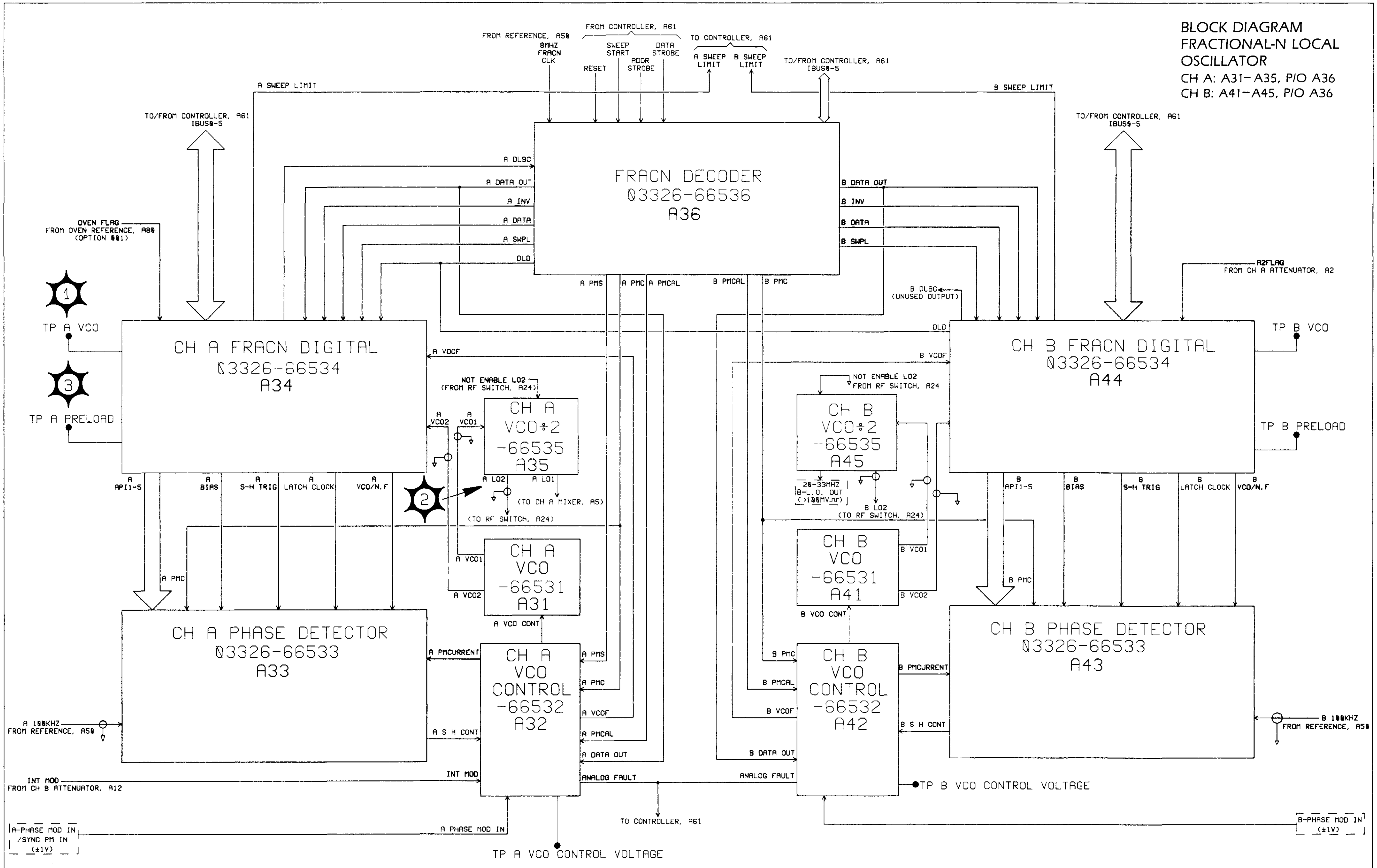


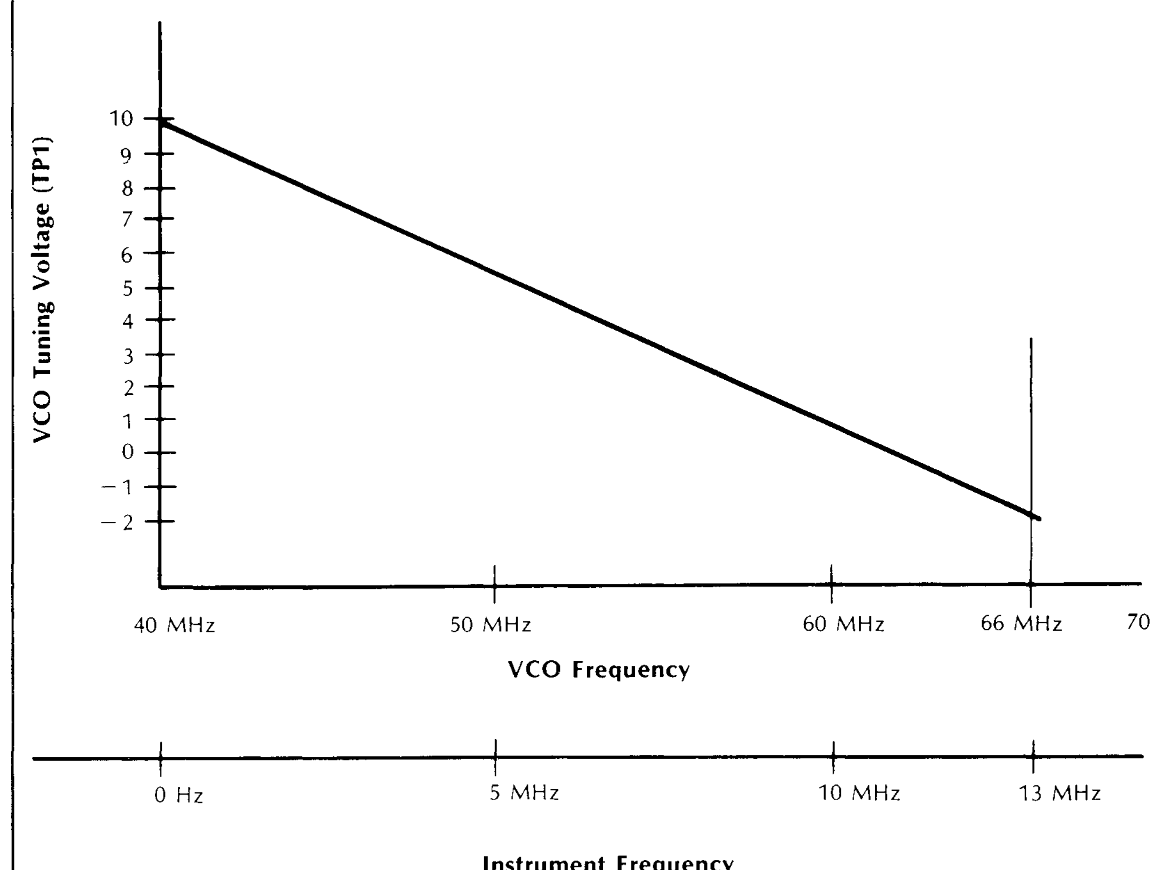
Figure 6-43. Fractional-N Block Diagram

VCO Board Troubleshooting

The dc voltage at test point 1 determines the operating frequency of the oscillator. See the VCO tuning graph in Figure 6-44. To test the operation of the VCO, enter a frequency and compare the voltage measured at TP1 with the tuning graph. This test insures that the fractional-N circuitry is providing the VCO with the correct control voltage for the selected frequency. A quick check may be made using the following table:

Table 6-35. VCO Tuning Range

Frequency Entered	Voltage at TP1
0 Hz	+10 Vdc ± 0.3 Vdc
6 MHz	+4.5 Vdc ± 1 V
13 MHz	−1.7 Vdc ± 2 V



$$\text{Instrument Frequency} = \frac{\text{VCO Freq}}{2} - 20\text{ MHz}$$

Figure 6-44. VCO Tuning Graph

This circuit may be further analyzed by putting it on an extender (be sure to turn the power off before removing the board) and comparing the oscilloscope waveforms in Figure 6-45 with those of the defective unit. The instrument configuration for these waveforms is INSTR PRESET.

Refer to Table 6-15 for recommended post-repair adjustments.

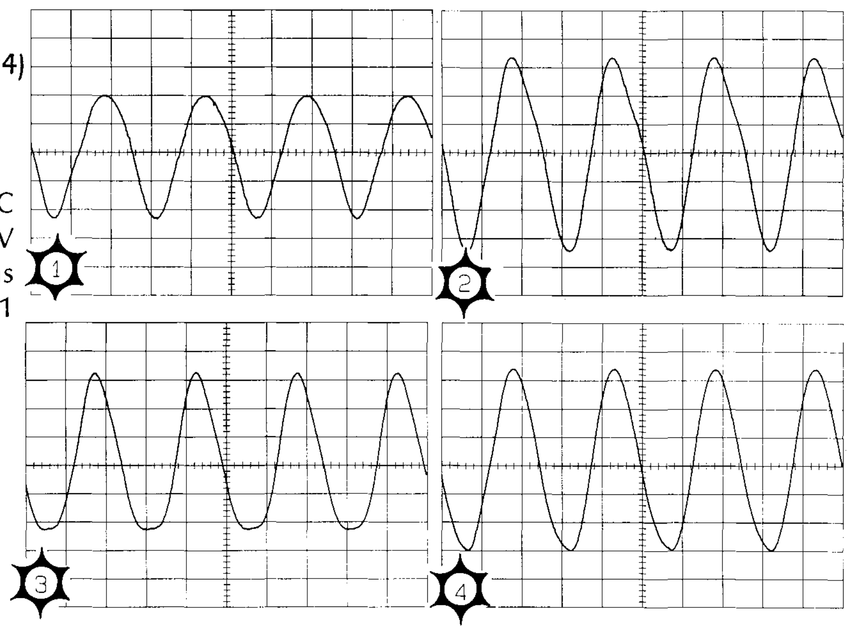
HP 3326A Setup

INSTR PRESET

Oscilloscope Setup(#1, #2, #3, #4)

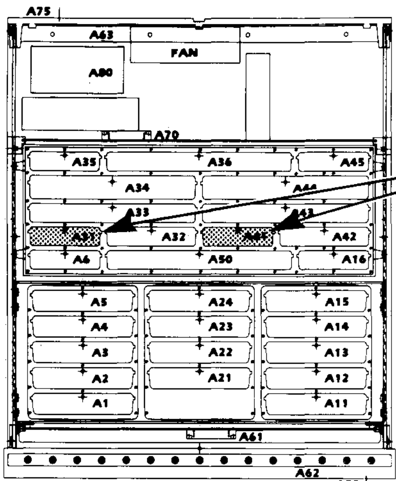
10:1 probe†

Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	10 ns
Trigger	Ch 1

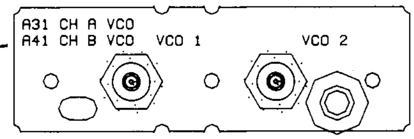


† Use a 10:1 probe with a ground spring (HP part number 1460-1476) when making high frequency measurements to minimize distortion.

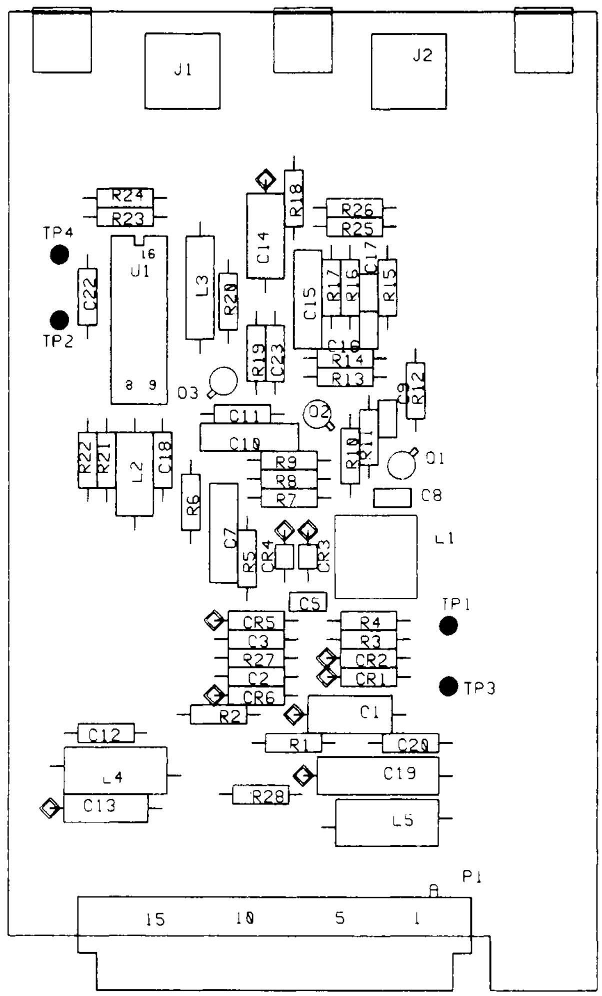
Figure 6-45. VCO Board Waveforms



INSTRUMENT TOP VIEW



ASSEMBLY LOCATIONS



VCO BOARDS (A31, A41)

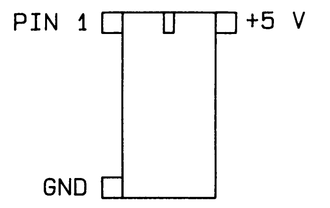
P/N 03326-66531

REV A

NOTES:

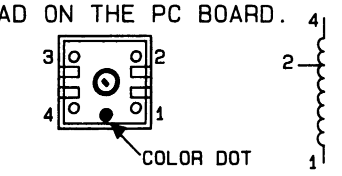
1. EMITTER COUPLED LOGIC (ECL) DEVICES ARE USED IN THIS CIRCUIT.

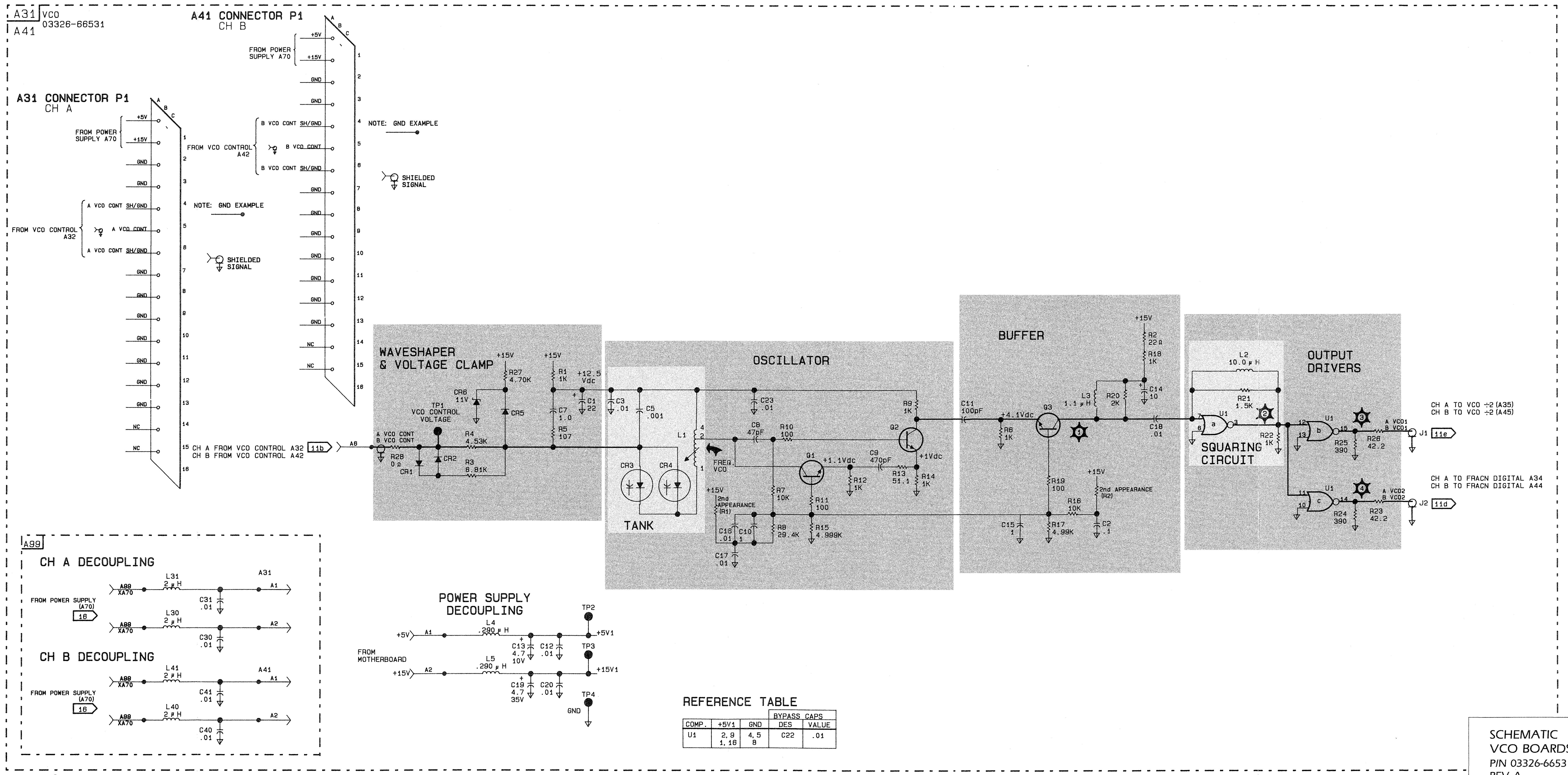
2. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).



3. THIS BOARD IS USED TWICE IN THE INSTRUMENT – ONCE FOR CHANNEL A, AND ONCE FOR CHANNEL B. THE TWO IDENTICAL BOARDS MAY BE INTERCHANGED FOR TROUBLESHOOTING, BUT MUST BE RETURNED TO THEIR ORIGINAL LOCATIONS TO AVOID RECALIBRATION OF THE INSTRUMENT.

4. INSTALLATION OF A31L1, A41L1:
THE COLOR DOT ON THE COMPONENT PACKAGE ALIGNS WITH THE SQUARE PAD ON THE PC BOARD.





REFERENCE TABLE

COMP.	+5V1	GND	BYPASS CAPS DES	BYPASS CAPS VALUE
U1	2, 9 1, 16	4, 5 8	C22	.01

SCHEMATIC
VCO BOARDS (A31, A41)
P/N 03326-66531
REV A

11a

Figure 6-46.

See
Other
Side

VCO Control Board Troubleshooting

The instrument bus circuit on the controller board (A61) and the control interface on this board can be tested using the Interface SA Test (see Tables 6-52 and 6-53 in the A61 troubleshooting sub-section 6-33). This test exercises the control lines from the controller board to determine if the controller or the control interface circuitry is defective.

The VCO control board has a red LED visible from the top of the board. When illuminated, this indicates that the VCO is unlocked. If the indicators on the VCO control boards for both channels are illuminated, the fractional-N decoder circuit (P/O A36) is probably defective.

1. Turn power off, place the VCO control board on an extender, then turn power on.

2. Test the S-H buffer sub-block using Table 6-36. Jumper J1 may be used in place of SH CONT to test the sub-block. It sets the instrument in a test state, equivalent to a 0 Hz output (as if the SH CONT signal was +5 V). Expect TP5 to be approximately 11 V when the jumper is in the "test" position.

Table 6-36. S-H Buffer Sub-block Test

Programmed Frequency	VCO Frequency	SH CONT Signal (P1 pin A11)	VCO CONT Signal (TP5)
13 MHz	66 MHz	≅ 0 V	≅ −1 V
0 Hz	40 MHz	≅ 5 V	≅ 11 V

3. The VCO unlock detector sub-block assumes the VCO is unlocked if SH CONT is < −3 V or > +7 V. (SH CONT is normally between 0 and 5 V.) When the circuit is working properly, TP1 is TTL low when the VCO is locked and TTL high when the VCO is unlocked.

4. Test the phase modulation sub-block by selecting PM on the front panel and checking TP6 and TP7 for the proper bias voltage and waveform (shown in Figure 6-47).

Table 6-37 shows how the relays and analog switches in the instrument control functions, with the switches in the VCO control board (U22) highlighted. U22 is a four section analog switch used to: 1) activate the phase modulation circuitry, 2) select between internal and external modulation inputs (2 switch sections are used), and 3) ground the circuit input when internal PM calibration occurs. The latter switch function is not shown in the function control table. Its control signal (pin 8) is normally high (which keeps the switch open); it goes low (closing the switch), briefly, during internal PM calibration.

Refer to Table 6-15 for recommended post-repair adjustments.

Table 6-37. Function Control

Switch Name †	Reference Designator (pin no.)	Off		Sine		Square		DC		HV		Combined	Int AM	Ext AM		Int PM	Ext PM		Sync PM
		A	B	A	B	A	B	A	B	A	B			A	B		A	B	(AB)
Ch A Cal/Prtct	A2K107	0	X	1	X	1	X	1	X	1	X	1	1	1	X	1	1	X	1
Ch B Cal/Prtct	A12K107	X	0	X	1	X	1	X	1	X	1	1	1	1	1	1	1	1	1
Ch A HV Option	A2K106	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X
Ch B HV Option	A12K106	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X
Ch A Square	A4K101	X	X	0	X	1	X	0	X	X	X	X	X	X	X	X	X	X	X
Ch B Square	A14K101	X	X	X	0	X	1	X	0	X	X	X	X	X	X	X	X	X	X
Ch A Offset	A21K1	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X
Ch B Offset	A21K21	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X
INT AM	A22U2(1)	X	X	X	X	X	X	X	X	X	X	X	ON (L)	OFF (H)	X	X	X	X	X
A EXT AM	A22U2(16)	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	ON (L)	X	X	X	X	X
B EXT AM	A22U6(1,16) A22U6(8,9)	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	X	X	X	X
INT PM	A32U22(1)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	OFF (H)	OFF (H)	OFF (H)
A EXT PM	A32U22(16)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	ON (L)	X	ON (L)
B EXT PM	A42U22(16)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	ON (L)	X
Ch A PM	A32U22(9)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	OFF (H)	X	OFF (H)
Ch B PM	A42U22(9)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OFF (H)	X
Ch A Combiner Isolation	A2K105	X	X	X	X	X	X	X	X	X	X	1	0	X	X	0	X	X	X
Ch A Combiner	A2K104	X	X	X	X	X	X	X	X	X	X	1	0	X	X	0	X	X	X
Ch B Combiner/ INT MOD	A12K104	X	X	X	X	X	X	X	X	X	X	1	1	X	X	1	X	X	X

† X = Relay can be in either the de-energized or energized position in this function.
1 = Relay must be in the energized position in this function.
0 = Relay must be in the de-energized position in this function.
ON (L) = Control line for the switch must be TTL low in this function. This activates the switch.
OFF (H) = Control line for the switch must be TTL high in this function. This de-activates the switch.

To test channel A internal phase modulation (PM) circuitry on A32, preset the HP 3326A and activate internal PM. Use rear panel external PM inputs to test the external phase modulation circuitry on A32 and A42.

Oscilloscope Setup (#1)

10:1 probe

Ch 1 coupling	AC
Ch 1 V/div	10 mV
Time/div	500 μs
Trigger	Ch 1

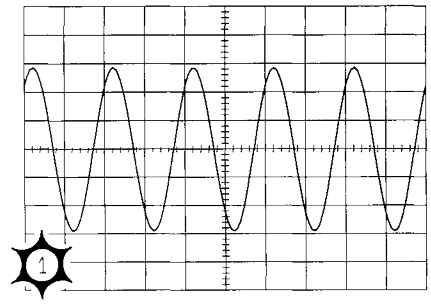
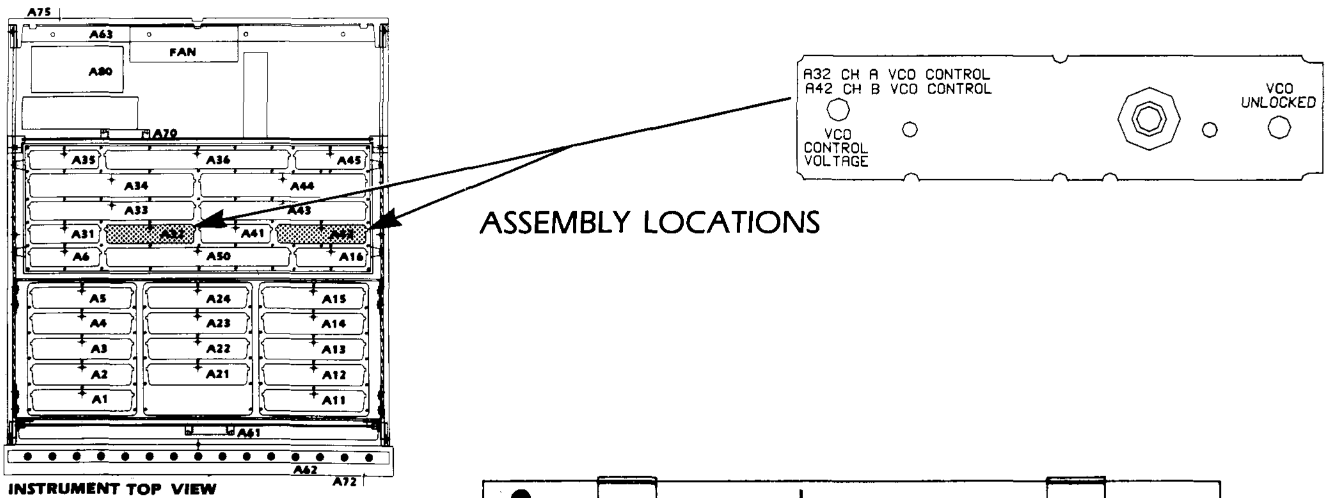
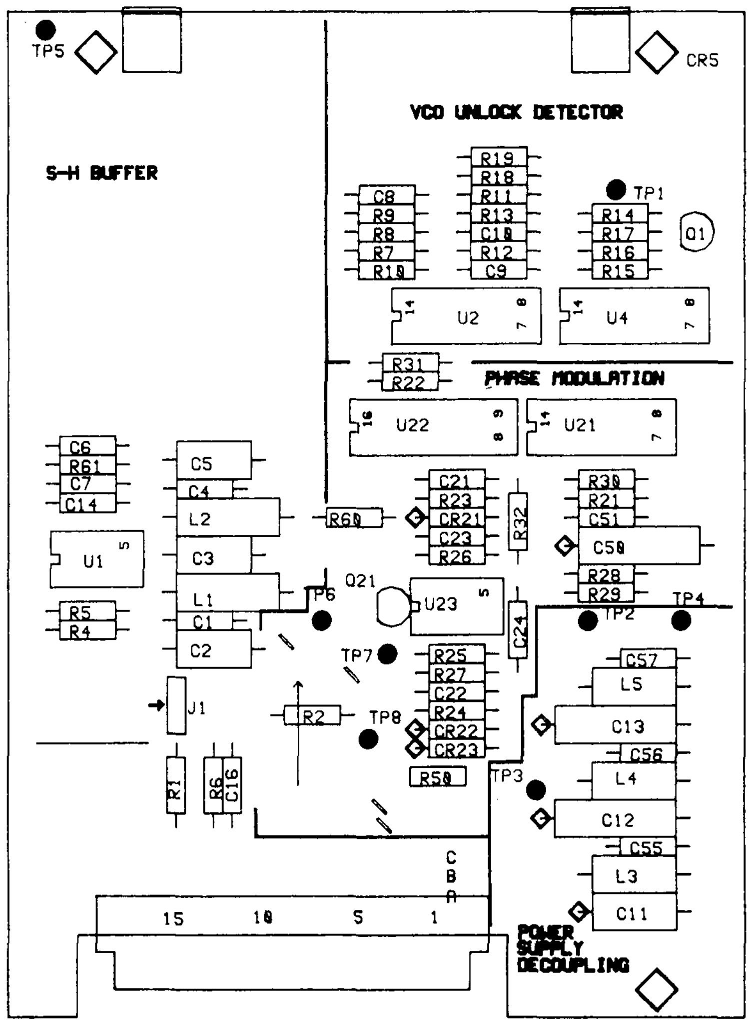


Figure 6-47. VCO Control Board Waveforms





VCO CONTROL BOARDS (A32, A42)

P/N 03326-66532

REV A

NOTES:

1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).

PIN 1 — +5 V

GND

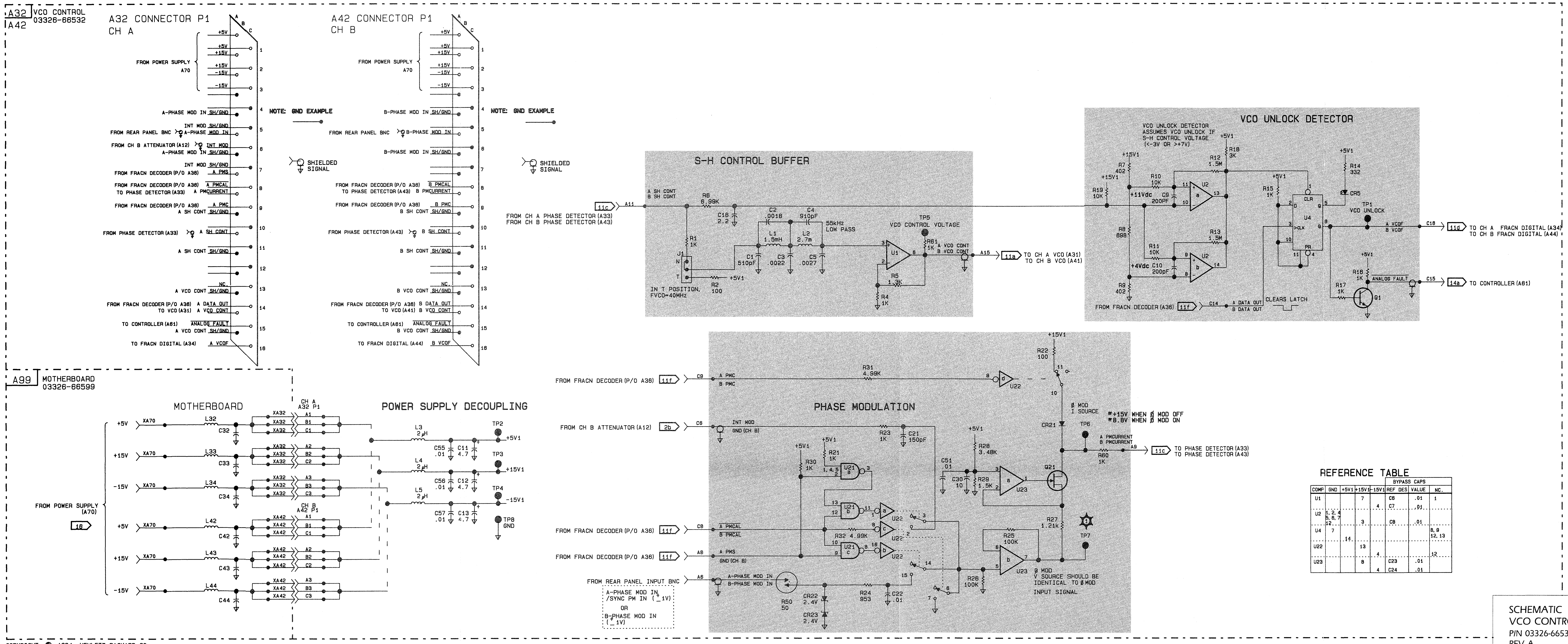
2. THIS BOARD IS USED TWICE IN THE INSTRUMENT - ONCE FOR CHANNEL A, AND ONCE FOR CHANNEL B. THE TWO IDENTICAL BOARDS MAY BE INTERCHANGED FOR TROUBLESHOOTING, BUT MUST BE RETURNED TO THEIR ORIGINAL LOCATIONS TO AVOID RECALIBRATION OF THE INSTRUMENT.

3. THIS SCHEMATIC USES CR AS THE REFERENCE DESIGNATOR FOR AN LED.

4. **CAUTION**

TTL, EMITTER COUPLED LOGIC (ECL), TTL COMPATIBLE NMOS LOGIC, AND TTL COMPATIBLE CMOS LOGIC DEVICES ARE USED IN THIS INSTRUMENT.

USE THE APPROPRIATE PRECAUTIONS WHEN REMOVING, HANDLING, AND INSTALLING ALL STATIC SENSITIVE COMPONENTS TO AVOID DAMAGE.



REFERENCE TABLE

COMP	GND	+5V1	+15V1	-15V1	BYPASS CAPS REF DES	VALUE	NC.
U1			7		C6	.01	1
				4	C7	.01	
U2	1, 2, 4, 5, 6, 7, 12		3		C8	.01	
U4	7	14					8, 9, 12, 13
U22			13				
				4			12
U23			8		C23	.01	
				4	C24	.01	

SCHEMATIC
VCO CONTROL BOARDS (A32, A42)
P/N 03326-66532
REV A

11b

Figure 6-48.

See
Other
Side

Phase Detector Board Troubleshooting

The instrument bus circuit on the controller board (A61) and the control interface on this board can be tested using the Interface SA Test (see Tables 6-52 and 6-53 in the A61 troubleshooting sub-section 6-33). This test exercises the control lines from the controller board to determine if the controller or the control interface circuitry is defective.

1. Turn the instrument off, place the defective phase detector board on an extender. Disconnect the VCO1 cable from the VCO board and VCO ÷ 2 board of the working channel. Using a long cable (from service kit), connect the VCO1 signal from the working VCO board to the VCO2 connector on the fractional-N digital board of the defective channel.

2. Turn on power, preset the instrument, enter an output frequency of 0 Hz for the channel under test, and enter an output frequency of 100 Hz for the other channel.

3. Examine waveform 1 at TP1 (ϕDETECT). See Figure 6-50. Expect a square wave of variable duty cycle with an amplitude of approximately 2.5 Vpk and a period of about 10 μs. If not, troubleshoot the phase detect driver and phase detect functional sub-blocks.

4. Check the operation of the current sources sub-block by measuring the dc voltages at U15, pin 15 and U19, pin 6. These should read approximately −8.8 Vdc and +8.8 Vdc, respectively.

5. Check the operation of the API private supply by measuring the dc voltage at U15, pin 6. This should read +5 Vdc nominally.

6. Check the operation of the current summing circuit of Q31 and Q26 by measuring the voltage at U15, pin 2. This should read approximately +5 Vdc.

7. Check waveforms 2 and 3. Waveform 2 should be a square wave that is high ($\cong$ +2 V) for 3.3 μs and low ($\cong$ −1 V) for 6.7 μs. Waveform 3 should have the same duty cycle, but range from $\cong$ +2 V to $\cong$ −8 V. If these waveforms are incorrect, suspect Q15, Q16, Q17, Q18, and U11.

8. Short TP3 (integrator input) to ground. Waveform 4 at TP5 should now appear as shown, with a variable duty cycle. The most important characteristics of this waveform are the levels. The positive level should be approximately +83 mV, the negative level should be approximately −540 mV, and the middle level should be approximately 0 V.

   If this waveform is correct, troubleshoot the integrator and the sample and hold sub-blocks.

9. Use the waveforms in the timing diagram (Figure 6-52) and the levels in the VCO tuning graph (Figure 6-49) to troubleshoot further.

Spurious signals due to API current sources 1 through 4 may be adjusted (see the adjustments section); number 5 has no adjustment. The following equations may be used to determine the frequencies at which API spurs occur.

$N.f = [2(F_{out} + 20 X 10^6)]/10^5$

Where N.f has the format: $N_2N_1N_0.f_{-1}f_{-2}f_{-3}$

Examples:

$F_{out} = 51$ kHz

$N.f = 2(51{,}000 + 2 X 10^6)/10^5$

$= 401.0200$ where .0200 corresponds to $.f_{-1}f_{-2}f_{-3}f_{-4}$

Spurs are found at the specified frequencies for the following APIs where M indicates harmonics of the fundamental (i.e., M=1, 2, 3, ...).

API#1: $F_{out} \pm M(.f_{-1}f_{-2}f_{-3}...)$

API#2: $F_{out} \pm M(.f_{-2}f_{-3}f_{-4}...)$

API#3: $F_{out} \pm M(.f_{-3}f_{-4}f_{-5}...)$

API#4: $F_{out} \pm M(.f_{-4}f_{-5}f_{-6}...)$

API#5: $F_{out} \pm M(.f_{-5}f_{-6}f_{-7}...)$

Refer to Table 6-15 for recommended post-repair adjustments.

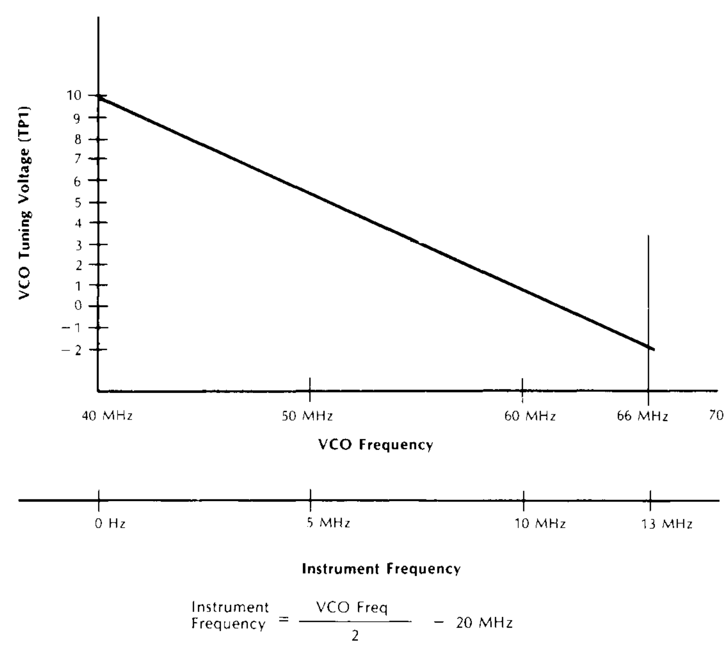


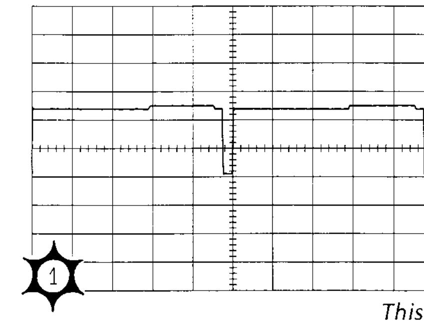
Figure 6-49. VCO Tuning Graph

HP 3326A setups for these waveforms are given in the troubleshooting procedure.

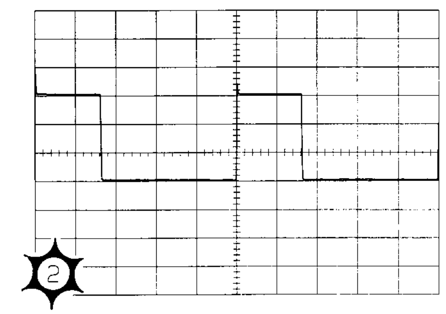
Oscilloscope Setup (#1, #2)

10:1 probe

Ch 1 coupling	DC
Ch 1 V/div	100 mV
Time/div	2 μs
Trigger	Ch 1



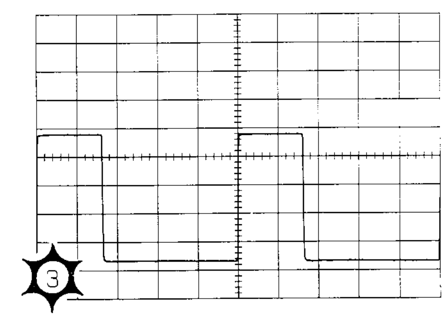
NOTE
This waveform has a variable duty cycle.



Oscilloscope Setup (#3)

10:1 probe

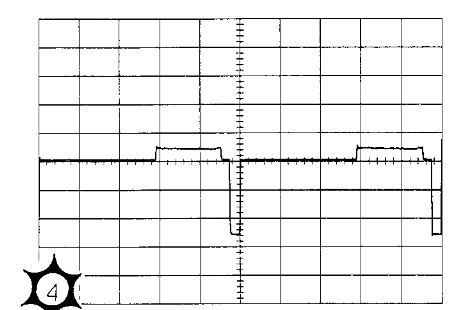
Ch 1 coupling	DC
Ch 1 V/div	200 mV
Time/div	2 μs
Trigger	Ch 1



Oscilloscope Setup (#4)

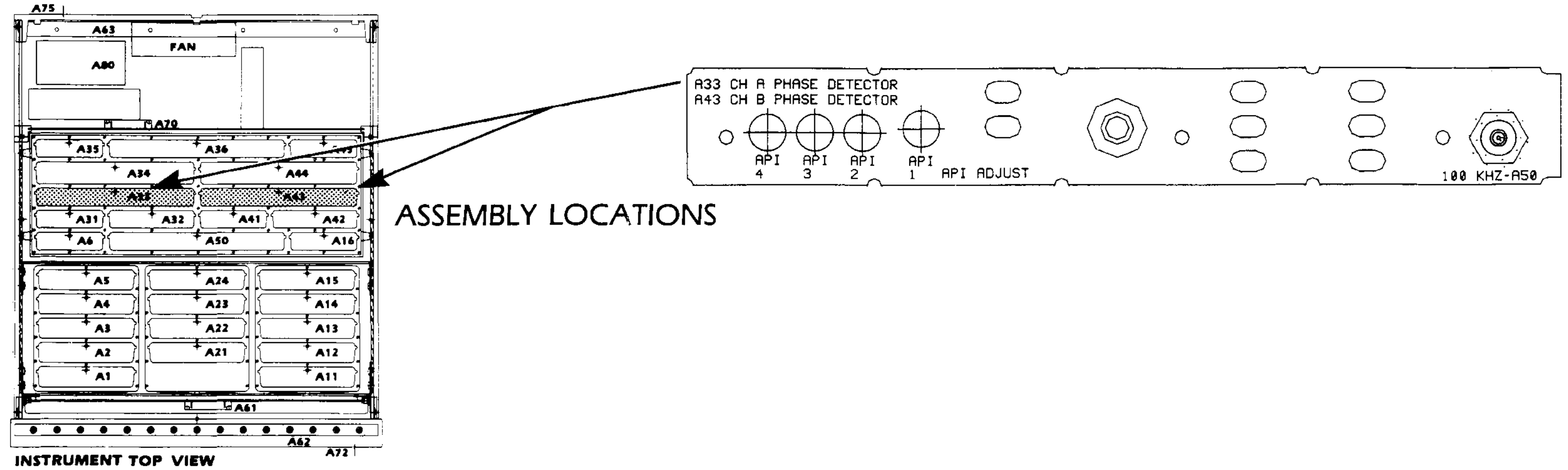
10:1 probe

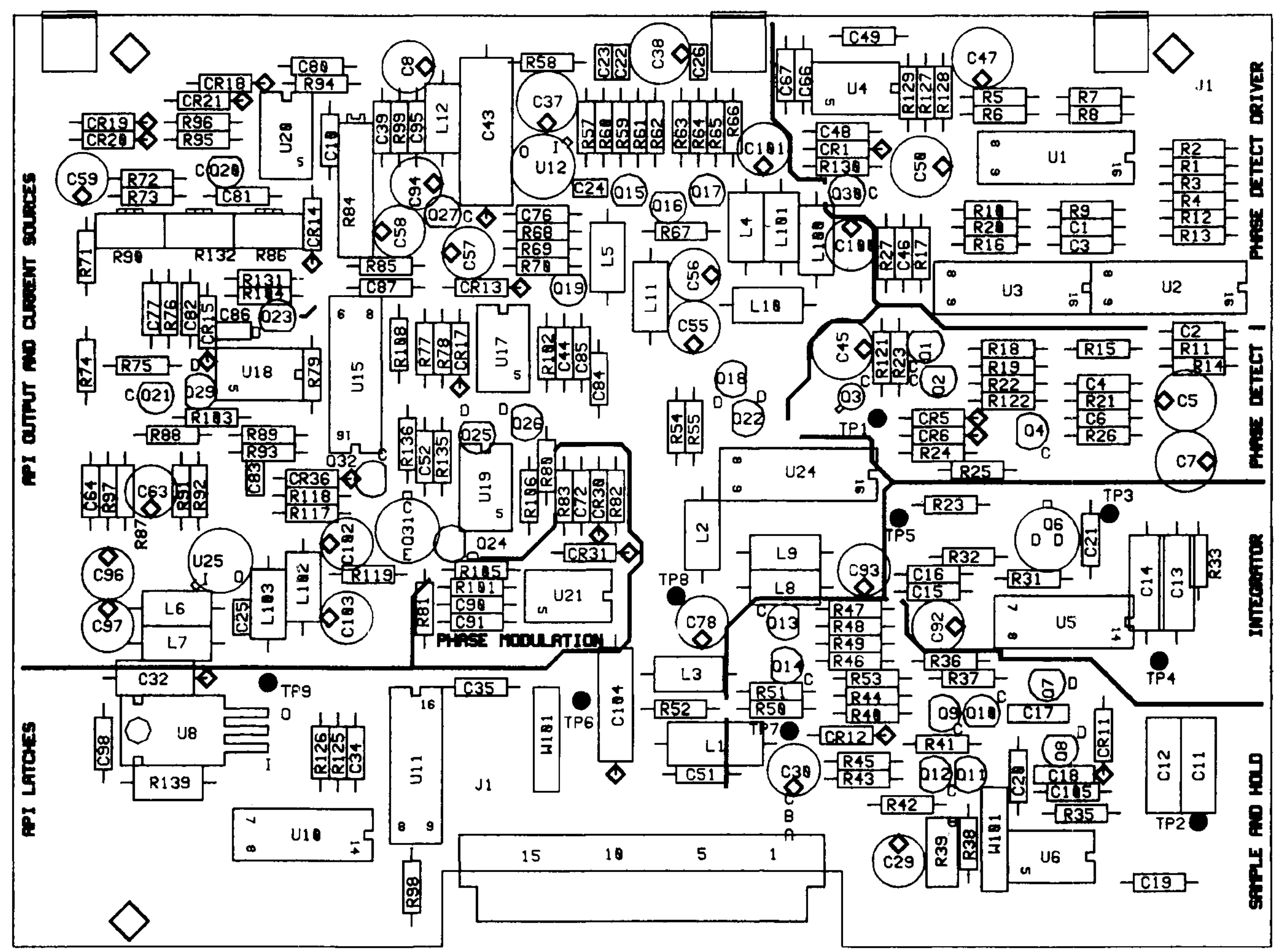
Ch 1 coupling	DC
Ch 1 V/div	20 mV
Time/div	2 μs
Trigger	Ch 1



NOTE
This waveform has a variable duty cycle.

Figure 6-50. Phase Detector Board Waveforms

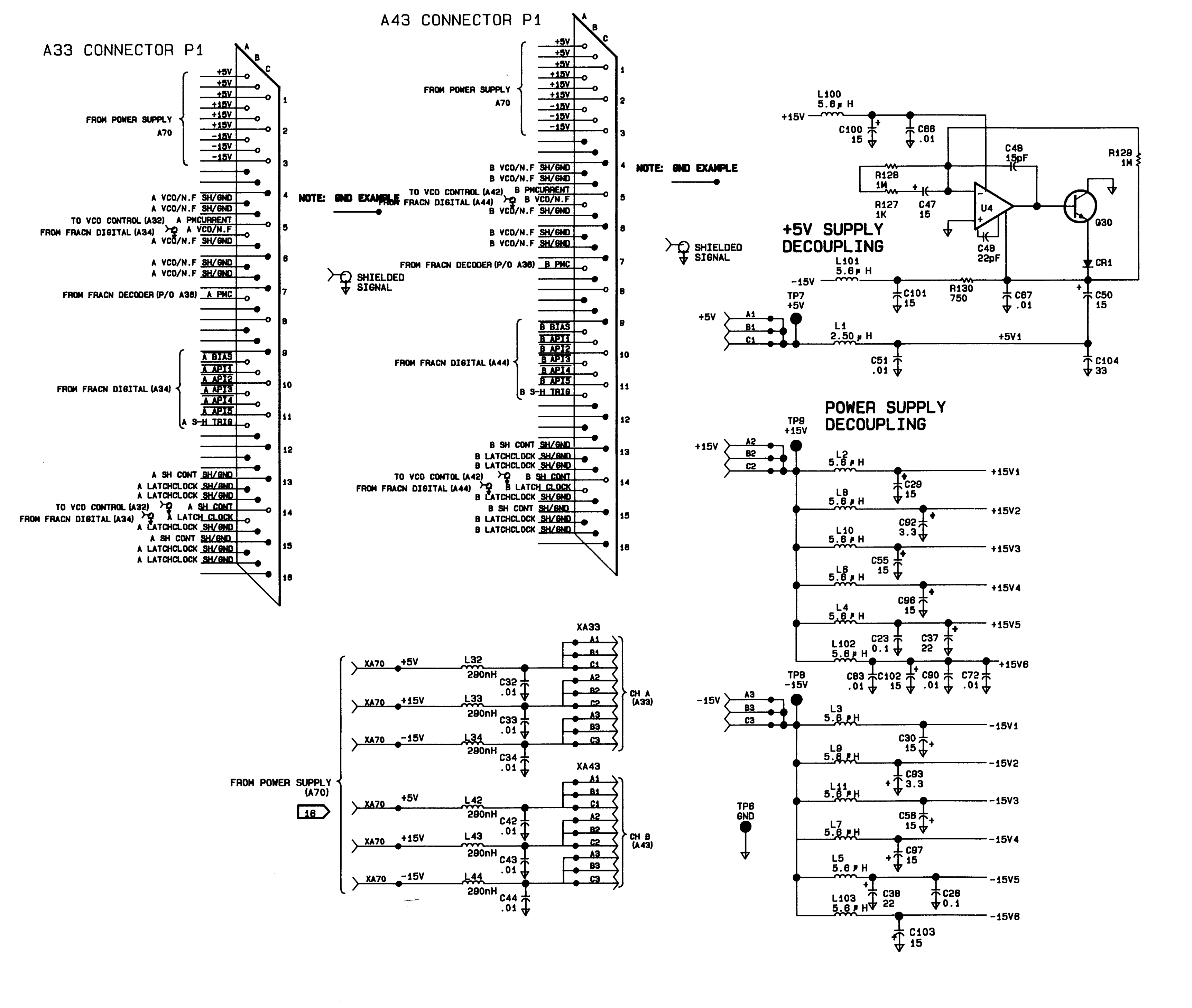


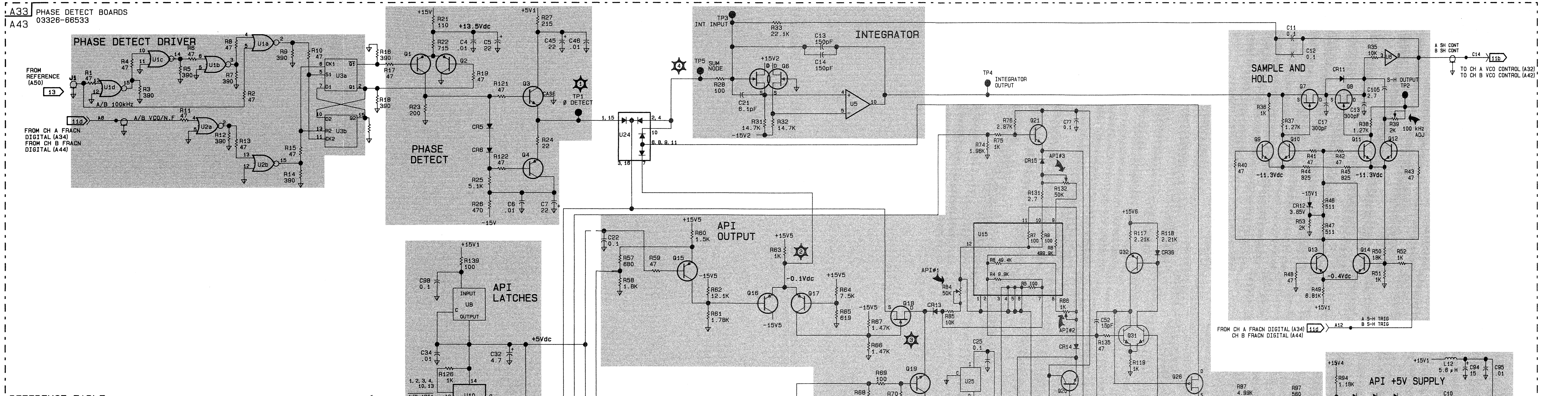


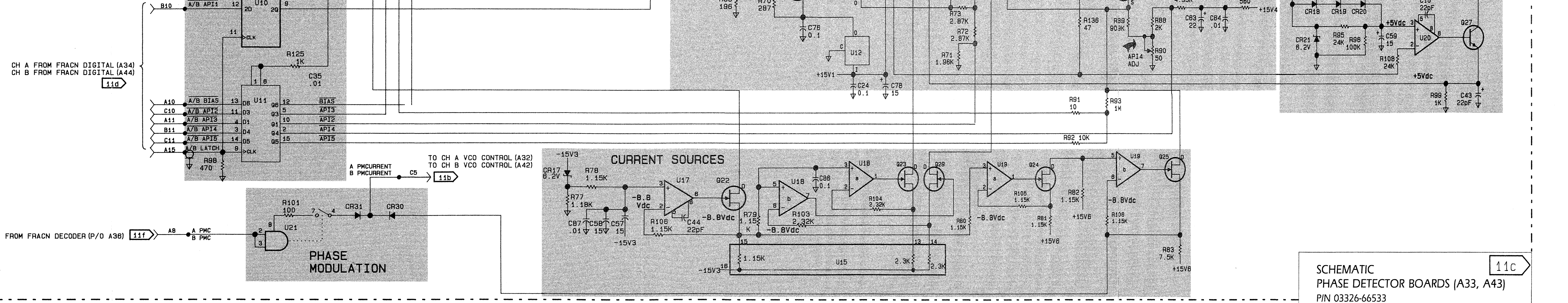
PHASE DETECTOR BOARDS (A33, A43)

P/N 03326-66533

REV A

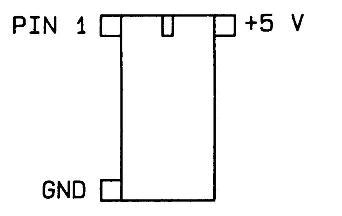






NOTES:

1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).



2. EMITTER COUPLED LOGIC (ECL) AND TTL DEVICES ARE USED IN THIS CIRCUIT.
3. THIS BOARD IS USED TWICE IN THE INSTRUMENT - ONCE FOR CHANNEL A, AND ONCE FOR CHANNEL B. THE TWO IDENTICAL BOARDS MAY BE INTERCHANGED FOR TROUBLESHOOTING, BUT MUST BE RETURNED TO THEIR ORIGINAL LOCATIONS TO AVOID RECALIBRATION OF THE INSTRUMENT.

REFERENCE TABLE

COMP	GND	+5V1	+15V1	+15V2	+15V3	+15V4	+15V6	-15V1	-15V2	-15V3	-15V4	-15V6	BYPASS CAPS DES	VALUE	NC
U1	8	1, 9, 16											C1	.01	
U2	8	1, 3, 9, 14, 16											C2	.01	
U3	4, 8, 9, 12	1, 14, 16											C3	.01	
U5	1, 2, 3, 7, 8, 9, 12, 13, 14			11									C15	.01	
									6				C16	.01	
U6			7										C19	.01	1, 2, 5, 8
								4					C20	.01	
U10	7												C34	.01	5, 8, 10
		14													
U11	8												C35	.01	
		16													
U17					7								C84	.01	1
										4			C85	.01	
U18							8								
												4	C82	.01	
U19							8								
												4			
U20						7							C81	.01	
											4		C80	.01	1
U21							8						C91	.01	
												5	C90	.01	6
U24															5, 12, 13, 14

11c

SCHEMATIC
PHASE DETECTOR BOARDS (A33, A43)
P/N 03326-66533
REV A

Figure 6-51.

Fractional-N Digital Board Troubleshooting

The instrument bus circuit on the controller board (A61) and the control interface on this board can be tested using the Interface SA Test (see Tables 6-52 and 6-53 in the A61 troubleshooting sub-section 6-33). This test exercises the control lines from the controller board to determine if the controller or the control interface circuitry is defective.

1. Turn power off, place the fractional-N digital board on an extender, then turn power on.

2. Verify that waveform 1 (VCO) in Figure 6-53 is present. This is an input to the board.

3. Run the service self tests by pressing the key sequence **SHIFT, %, 6.** Passing self test 9 indicates that the control interface to channel B is functional. Passing self test 10 indicates the same for channel A.

4. Check the performance of the fractional-N IC by comparing waveforms 2, 3, 4, 9, and 5 in Figure 6-53 with those of the board under test. (The instrument setups for these waveforms are given in Figure 6-53.)

5. Check waveform 6 (PRELOAD) to determine the status of the ÷N counters. This is a normally high, TTL level signal with a low level pulse at a 100 kHz (10 μs) rate.

6. To test the N# latches sub-block, use the following table:

Table 6-38. N# Latch Test

Program Frequency	U3 Pin 5	U3 Pin 7	U3 Pin 10	U3 Pin 12
100 kHz	0	1	1	1
50 kHz	1	0	0	0

7. To test the LSD counter sub-block, check TP7 (sub-block input) and TP2 (sub-block output).

8. Use the remaining waveforms in Figure 6-53 and the waveforms in the timing diagram (Figure 6-52) to troubleshoot further.

Refer to Table 6-15 for recommended post-repair adjustments.

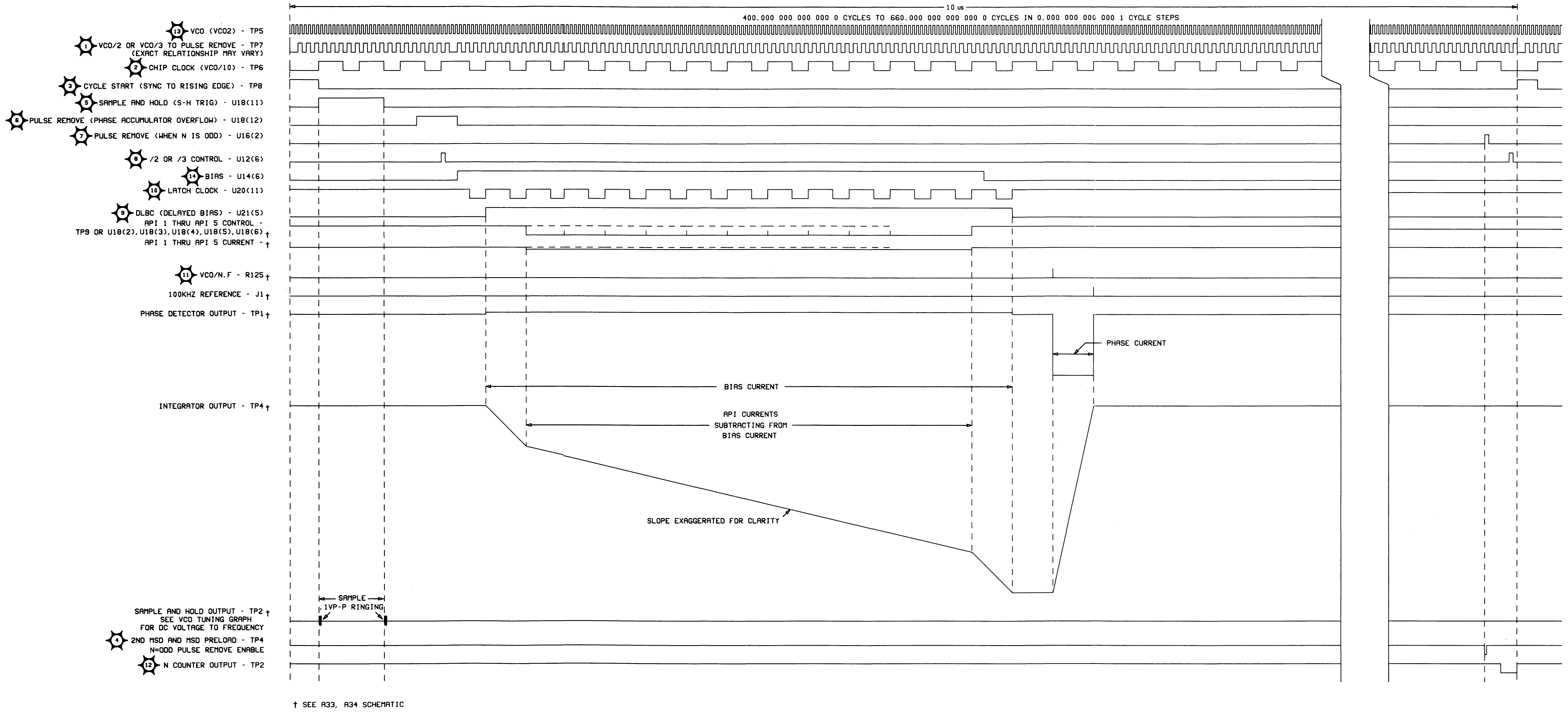


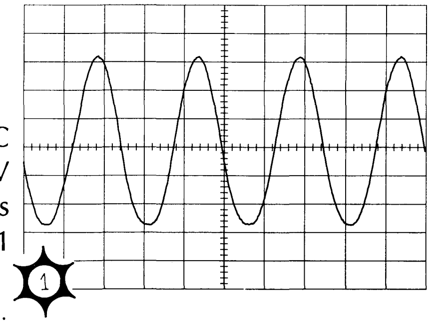
Figure 6-52. HP 3326A Fractional-N Local Oscillator Timing

HP 3326A setup is INSTR PRESET unless noted otherwise.

Oscilloscope Setup (#1)

10:1 probe†

Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	10 ns
Trigger	Ch 1

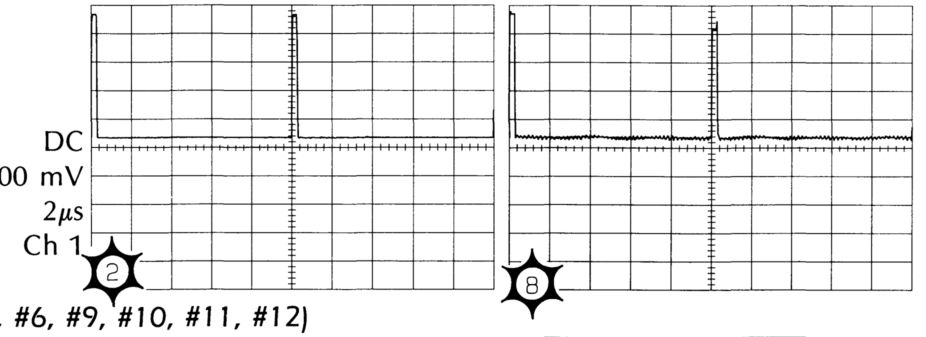


Set HP 3326A frequency to 49 kHz.

Oscilloscope Setup (#2, #8)

10:1 probe

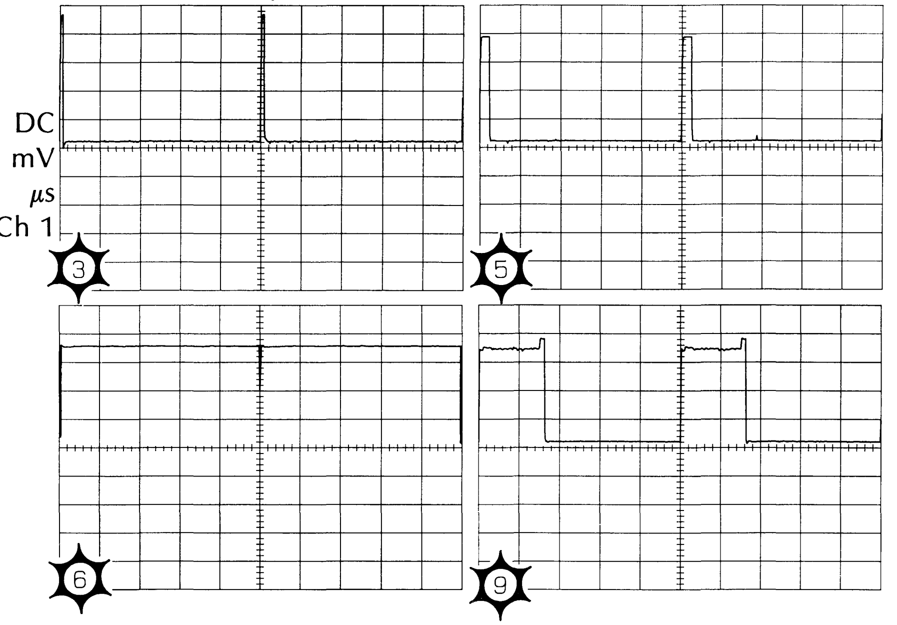
Ch 1 coupling	DC
Ch 1 V/div	100 mV
Time/div	2μs
Trigger	Ch 1

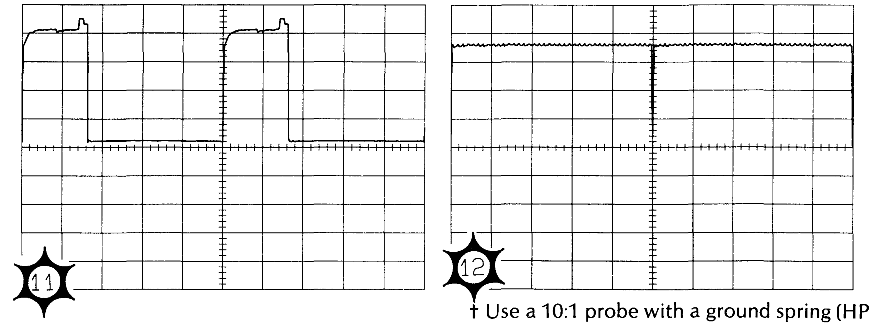


Oscilloscope Setup (#3, #5, #6, #9, #10, #11, #12)

10:1 probe

Ch 1 coupling	DC
Ch 1 V/div	100 mV
Time/div 2	μs
Trigger	Ch 1

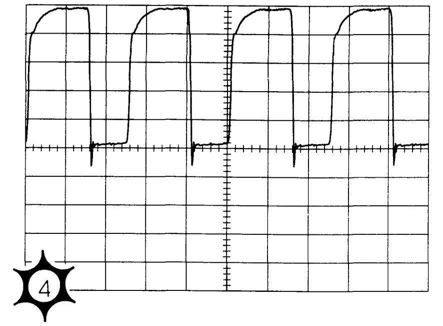




Oscilloscope Setup (#4)

10:1 probe

Ch 1 coupling	DC
Ch 1 V/div	100 mV
Time/div	100 ns
Trigger	Ch 1

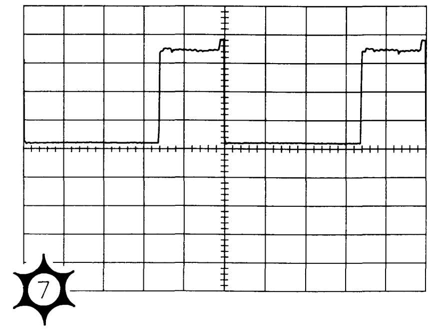


Set HP 3326A frequency to 51 kHz.

Oscilloscope Setup (#7)

10:1 probe

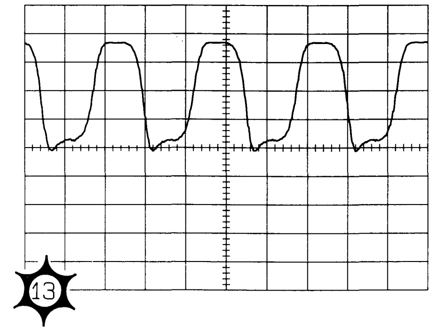
Ch 1 coupling	DC
Ch 1 V/div	100 mV
Time/div	2 μs
Trigger	Ch 1



Oscilloscope Setup (#13)

10:1 probe

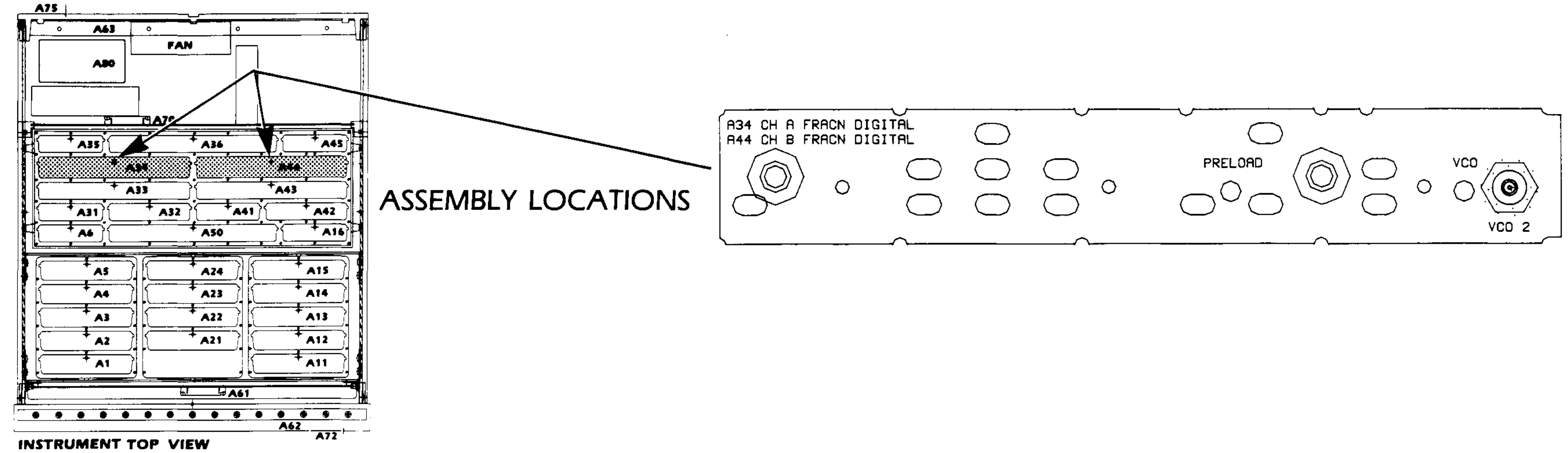
Ch 1 coupling	DC
Ch 1 V/div	100 mV
Time/div	20 ns
Trigger	Ch 1

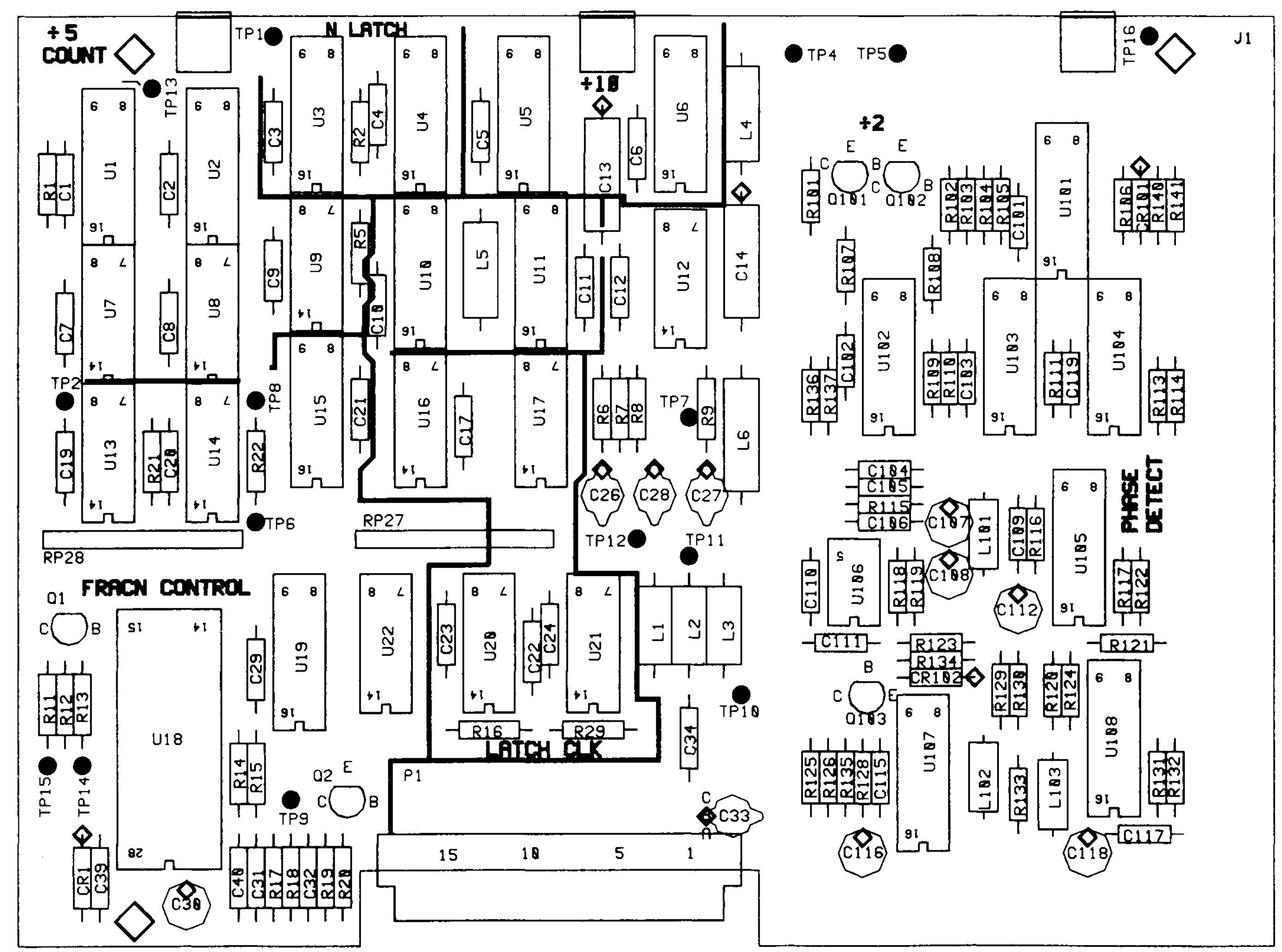


† Use a 10:1 probe with a ground spring (HP part number 1460-1476) when making high frequency measurements to minimize distortion.

Figure 6-53 "Fractional-N" Board Waveforms

NOTES



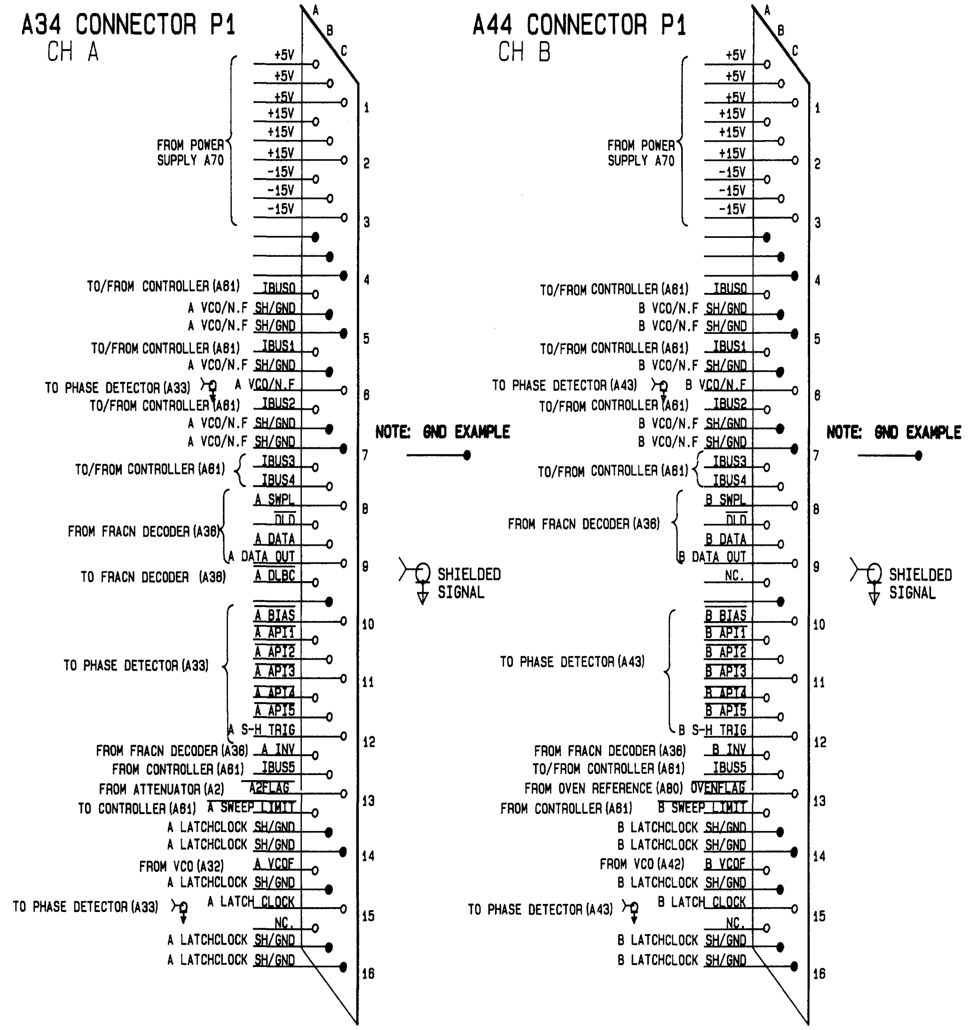


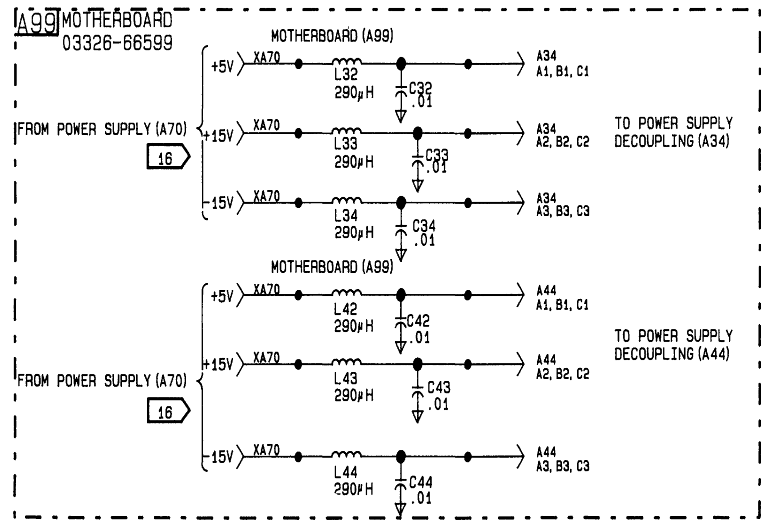
FRACN DIGITAL BOARDS (A34, A44)
P/N 03326-66534
REV A

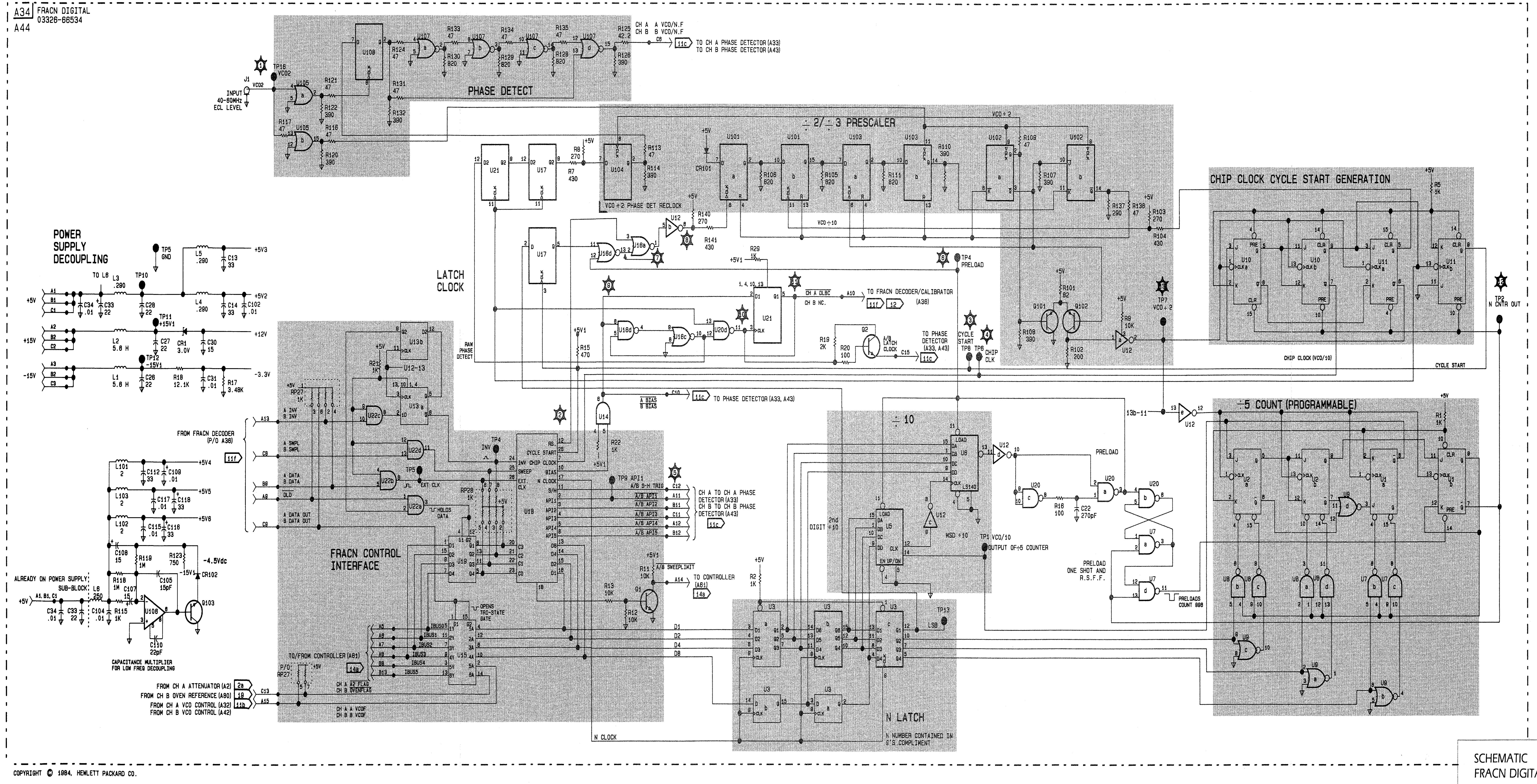
REFERENCE TABLE

COMP	GND	+5V1	BYPASS CAPS REF DES	VALUE	NC.
U1	8	16	C1	.01	5
U2	8	16	C2	.01	
U3	8	16	C3	.01	
U4	8	16	C4	.01	
U5	8	16	C5	.01	2, 3, 6, 7, 13
U6	8	16	C6	.01	2, 3, 6, 7, 12
U7	7	14	C7	.01	
U8	7	14	C8	.01	
U9	7	14	C9	.01	11, 12, 13
U10	8	16	C10	.01	
U11	8	16	C11	.01	7
U12	7	14	C12	.01	4
U13	7	14	C19	.01	8
U14	8	14	C20	.01	1, 2, 3, 7, 9, 10, 11, 12 13
U15	8	16	C21	.01	
U16	7	14	C17	.01	
U17	7	14	C18	.01	6, 8

COMP	GND	+5V1	+5V3	+5V4	+5V5	+5V6	+12V	-3.3V	BYPASS CAPS REF DES	VALUE	NC.
U18	8	9					27	1	C40	.01	19
									C39	.01	
U19	8	16							C29	.01	2, 6, 10 14
U20	7	14							C23	.01	
U21	7	14							C24	.01	6, 8
U101	5, 8 9, 12		1, 3 14, 16						C101	.01	
U102	4, 5, 8 12, 13		1, 15 16								
U103	5, 8, 9 12		1, 3, 15, 16						C103	.01	
U104	4, 5, 8 10, 11 12, 13		1, 3, 14, 15 16						C119	.01	
U105	8, 9, 10, 11			1, 3, 6 7, 14 16							
U107	8					1, 16					9
U108	4, 5, 8 9, 10 11, 12 13				1, 3 14, 15 16						

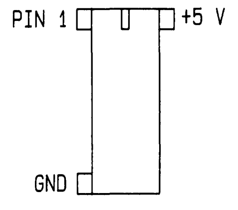






NOTES:

1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).



2. THIS BOARD IS USED TWICE IN THE INSTRUMENT - ONCE FOR CHANNEL A, AND ONCE FOR CHANNEL B. THE TWO IDENTICAL BOARDS MAY BE INTERCHANGED FOR TROUBLESHOOTING, BUT MUST BE RETURNED TO THEIR ORIGINAL LOCATIONS TO AVOID RECALIBRATION OF THE INSTRUMENT.

3. **CAUTION**

TTL, EMITTER COUPLED LOGIC (ECL), AND TTL COMPATIBLE NMOS LOGIC DEVICES (i.e., THE FRACTIONAL-N IC) ARE USED IN THIS FRACTIONAL-N DIGITAL CIRCUIT (A34 AND A44).

USE THE APPROPRIATE PRECAUTIONS WHEN REMOVING, HANDLING, AND INSTALLING ALL STATIC SENSITIVE COMPONENTS TO AVOID DAMAGE.

SCHEMATIC
FRACN DIGITAL BOARDS (A34, A44)
P/N 03326-66534
REV A

11d

Figure 6-54.

See Other Side

VCO ÷ 2 Board Troubleshooting

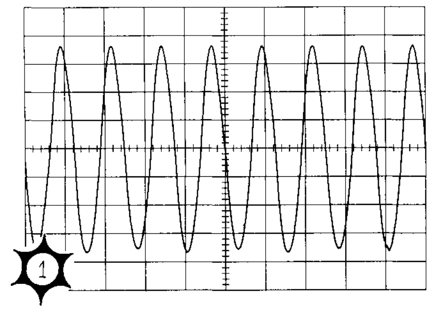
This circuit may be analyzed by putting it on an extender (be sure to turn the power off before removing the board) and comparing the oscilloscope waveforms in Figure 6-55 with those of the defective unit. Unless otherwise noted, the instrument configuration for these waveforms is INSTR PRESET.

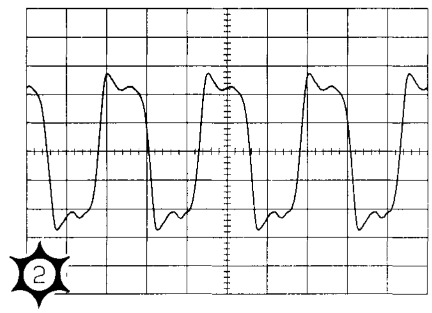
HP 3326A setup is INSTR PRESET. In channel A, set HP 3326A to the 2 PHASE mode for waveforms 2 and 4.

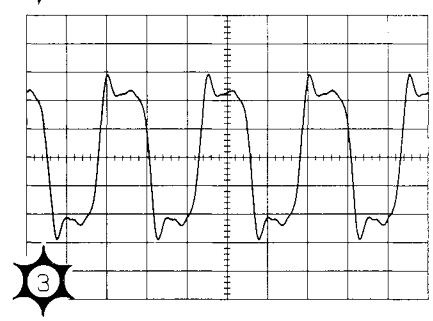
Oscilloscope Setup (#1, #2, #3)

10:1 probe†

Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	20 ns
Trigger	Ch 1



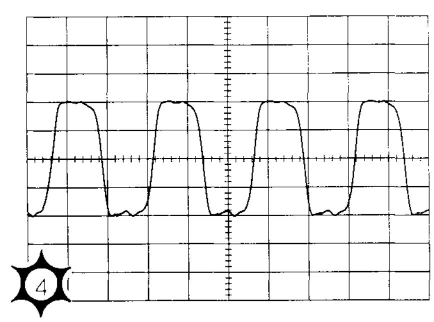




Oscilloscope Setup (#4)

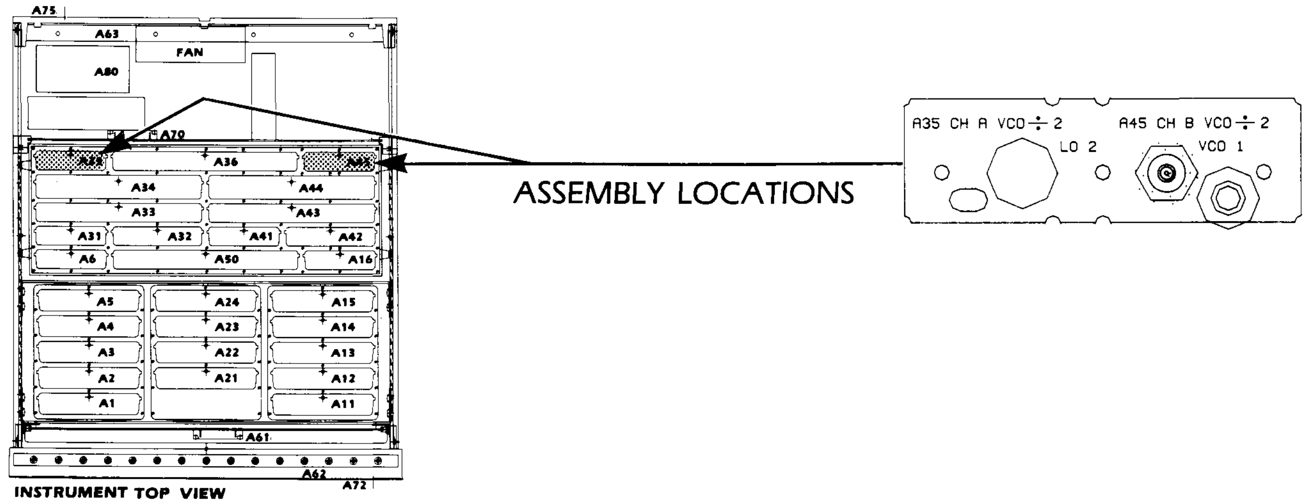
Phono plug to BNC adapter cable

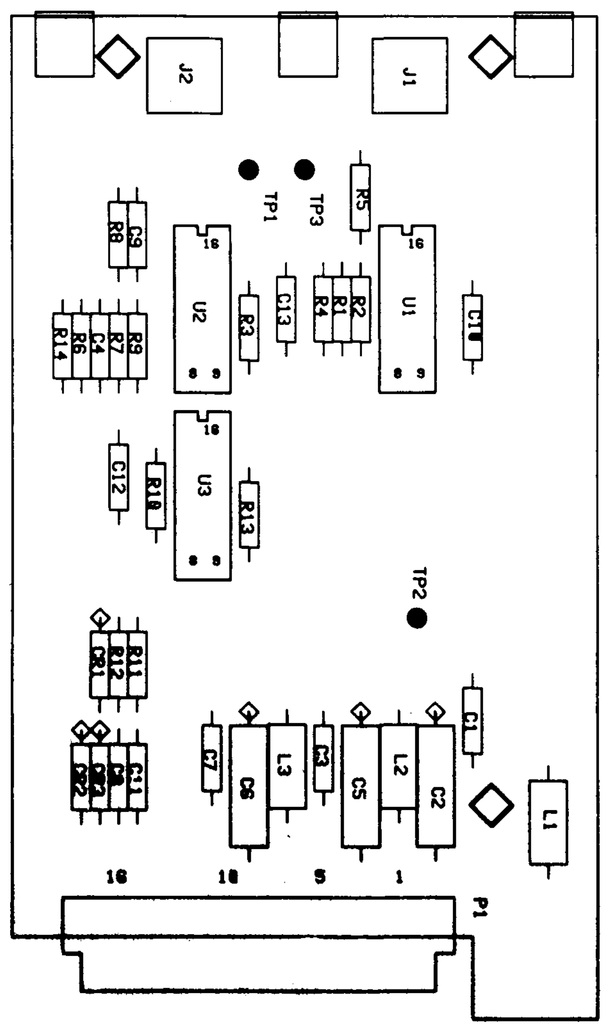
Ch 1 coupling	50 Ω DC
Ch 1 V/div	200 mV
Time/div	20 ns
Trigger	Ch 1



† Use a 10:1 probe with a ground spring (HP part number 1460-1476) when making high frequency measurements to minimize distortion.

Figure 6-55. VCO ÷ 2 Board Waveforms

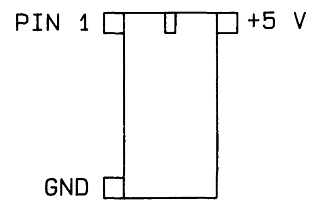




VCO ÷ 2 BOARDS (A35, A45)
P/N 03326-66535
REV A

NOTES:

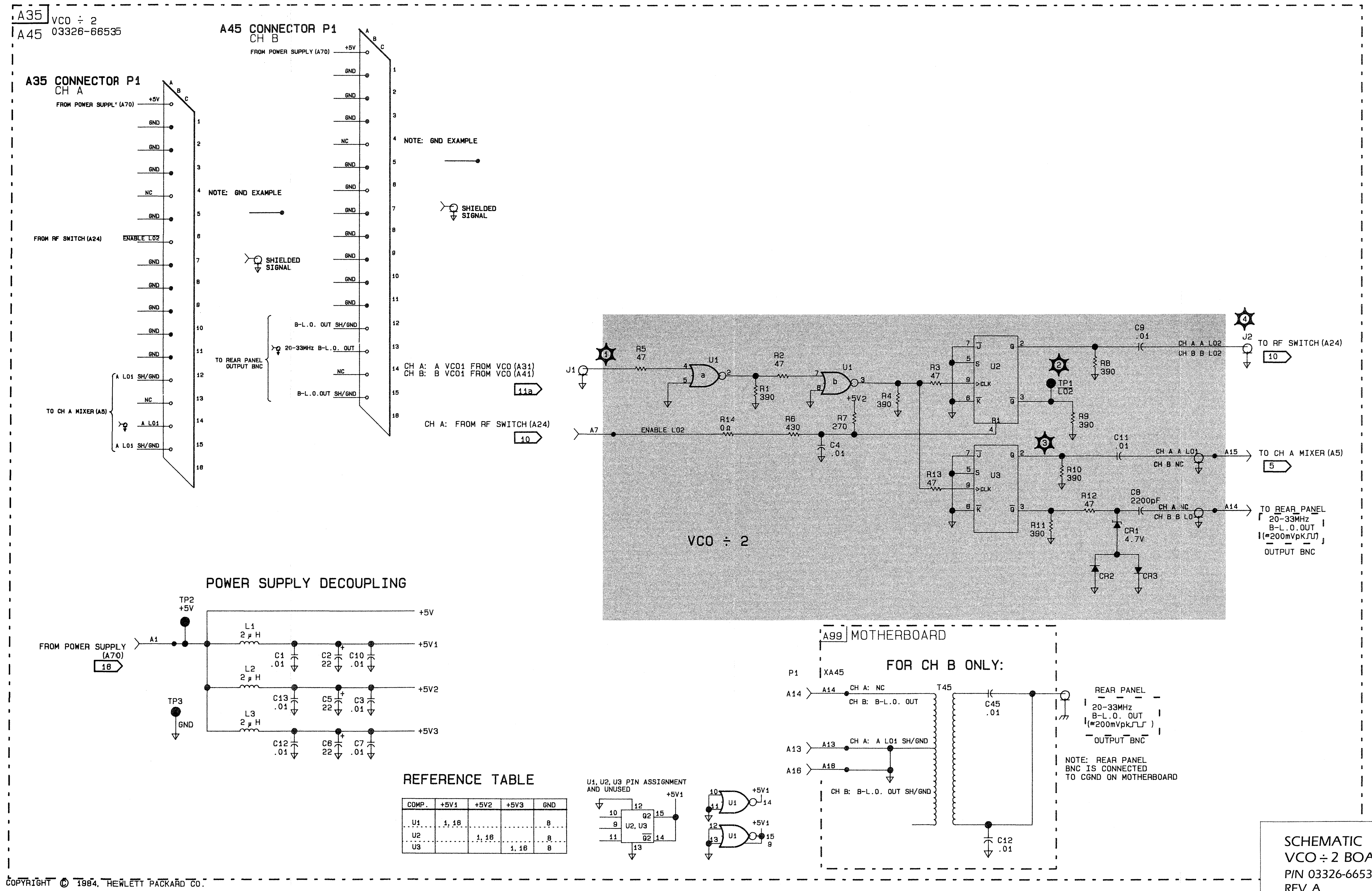
1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).



2. THIS BOARD IS USED TWICE IN THE INSTRUMENT - ONCE FOR CHANNEL A, AND ONCE FOR CHANNEL B. THE TWO IDENTICAL BOARDS MAY BE INTERCHANGED FOR TROUBLESHOOTING, BUT MUST BE RETURNED TO THEIR ORIGINAL LOCATIONS TO AVOID RECALIBRATION OF THE INSTRUMENT.

3. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.

4. EMITTER COUPLED LOGIC (ECL) DEVICES ARE USED IN THIS CIRCUIT.



REFERENCE TABLE

COMP.	+5V1	+5V2	+5V3	GND
U1	1, 16			8
U2		1, 16		8
U3			1, 16	8

SCHEMATIC
VCO ÷ 2 BOARDS (A35, A45)
P/N 03326-66535
REV A

11e

Figure 6-56.

See
Other
Side

Fractional-N Decoder Board Troubleshooting

The instrument bus circuit on the controller board (A61) and the control interface on this board can be tested using the Interface SA Test (see Tables 6-52 and 6-53 in the A61 troubleshooting sub-section 6-33). This test exercises the control lines from the controller board to determine if the controller or the control interface circuitry is defective.

1. Turn power off, place the fractional-N decoder board on an extender, then turn power on.
2. Check the following circuit inputs using a logic probe (see schematic):

   ADD STROBE and DATA STROBE (from A61). These signal lines should toggle when frequency is modified.

   $\overline{\text{RESET}}$ (from A61). Should be TTL high.

   8MHZ FRACN CLK (from A50). Should be an 8 MHz, TTL level square wave.

   $\overline{\text{A DLBC}}$ (from A34). Should be 100 kHz, TTL level square wave with a duty cycle of approximately 30%.

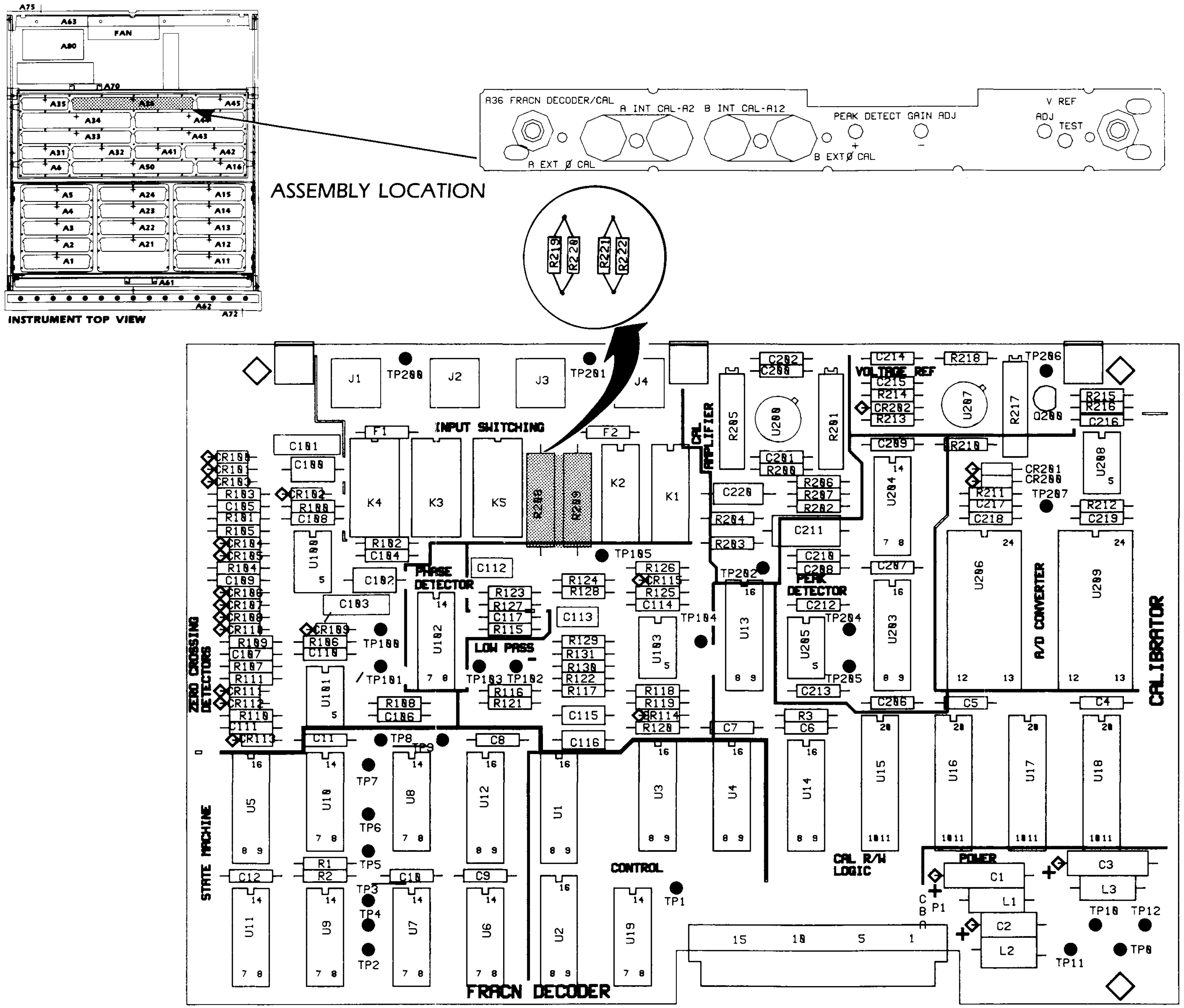
3. Check the outputs of U1 (latch). They should follow the inputs. If frequency is modified, they should toggle.

4. Check outputs of U2 (address decoder):

   Pin 7 should toggle when continuous sweep (CONT) is selected.
   Pin 9 should toggle when phase modulation (internal or external) is selected.
   Pins 10 through 15 should toggle when the frequency is modified for either channel A or channel B.

5. Check the B DATA, B INV, A DATA, A INV, and $\overline{\text{DLD}}$ outputs for toggling signals when the frequency is modified for either channel. If this is not working as described, troubleshoot the logic gates between the outputs and the address decoder, U2.

6. Check the A DATA OUT and B DATA OUT outputs for a low signal at the beginning of a sweep. If this is not working as described, troubleshoot the logic gates between the outputs and the address decoder, U2.



FRACN DECODER/CALIBRATOR BOARD
(A36)
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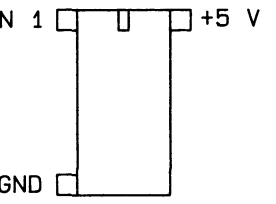
NOTES:

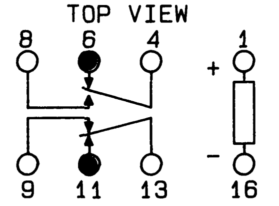
1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).



2. TTL DEVICES ARE USED IN THIS CIRCUIT.
3. RELAYS ARE SHOWN IN THE DE-ENERGIZED STATE.

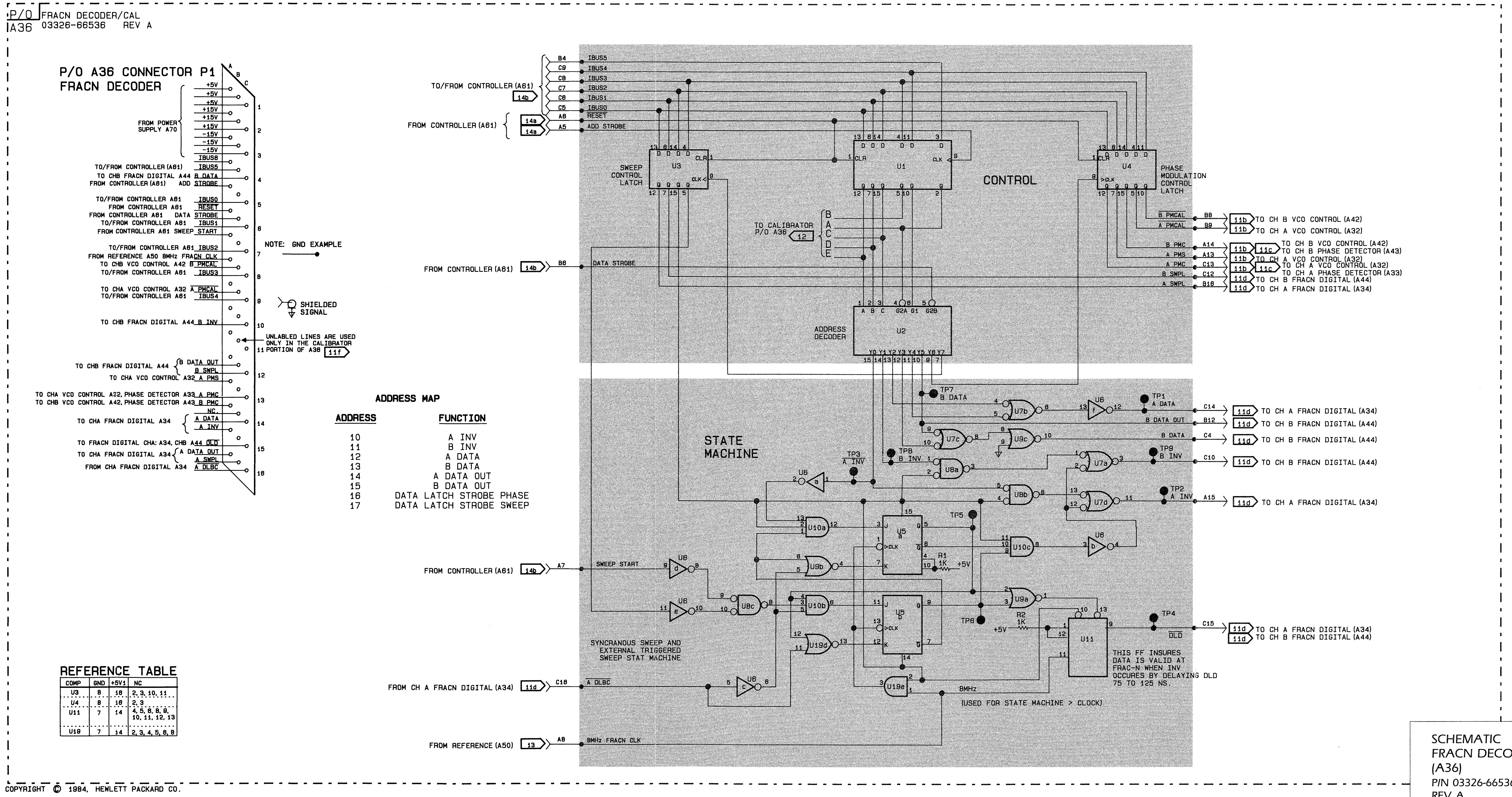
P/N 0490-1405.

TOP VIEW



4. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN'APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.
5. PHASE CALIBRATION IS VERY SENSITIVE TO BAD GROUND CONTACTS. IF THE HP 3326A HAS POOR PHASE CALIBRATION ACCURACY, CHECK TO MAKE SURE THAT (1) ALL OF THE TOP COVER SCREWS ARE FIRMLY IN PLACE, (2) ALL OF THE MOTHERBOARD SCREWS ARE FIRMLY IN PLACE, (3) ALL OF THE CABLE CONNECTIONS ARE TIGHT (PARTICULARLY THE GROUND CONTACTS).
6. BE SURE TO USE THE PROPER CABLES FOR A INT CAL AND B INT CAL SIGNALS THAT RUN FROM THE CHANNEL A AND CHANNEL B ATTENUATORS (A2 AND A12) TO THE CALIBRATOR BOARD (P/O A36). DO NOT SUBSTITUTE ANY OTHER CABLES. THE PRECISION 12 INCH ELECTRICAL LENGTH CABLES ARE REQUIRED FOR INTERNAL CALIBRATION.

TO PREVENT SERVICING PROBLEMS, PRECISION LENGTH CABLES HAVE BEEN USED FOR THE REST OF THE 12 INCH CABLES IN THE INSTRUMENT, EVEN THOUGH THIS LEVEL OF PRECISION IS NOT REQUIRED FOR THEIR APPLICATIONS. SEE THE REPLACEABLE PARTS LIST FOR MORE INFORMATION.



REFERENCE TABLE

COMP	GND	+5V1	NC
U3	8	16	2, 3, 10, 11
U4	8	16	2, 3
U11	7	14	4, 5, 6, 8, 9, 10, 11, 12, 13
U19	7	14	2, 3, 4, 5, 6, 8

ADDRESS MAP

ADDRESS	FUNCTION
10	A INV
11	B INV
12	A DATA
13	B DATA
14	A DATA OUT
15	B DATA OUT
16	DATA LATCH STROBE PHASE
17	DATA LATCH STROBE SWEEP

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REV A

11f

Figure 6-57.

See
Other
Side

6-31 CALIBRATOR, P/O A36

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

Theory of Operation

The A36 board circuits fall into two groups; calibrator and fractional-N decoder. This theory covers the operation of the calibrator.

The calibrator circuits act as a peak detecting voltmeter. They can be configured to measure signals at either of the INT CAL jacks or the points OFFTEST and LEVTEST. The information gathered is sent to the instrument microprocessor through the cal R/W logic sub-block. The A INT CAL jack is connected through a cable to the cal port on the channel A attenuator board (A2). The B INT CAL jack (J3) is similarly connected to the channel B attenuator board (A12). The signals available at these jacks for calibration are the same signals that appear at the CH A and CH B front panel outputs.

The calibrator group is broken into five distinct parts for service self tests, listed below. Figure 6-58 shows the board's three main signal paths.

1. Voltage reference
2. Amplitude/Offset calibration path
3. Levtest/Offtest path
4. Phase calibration path
5. Calibration read/write logic

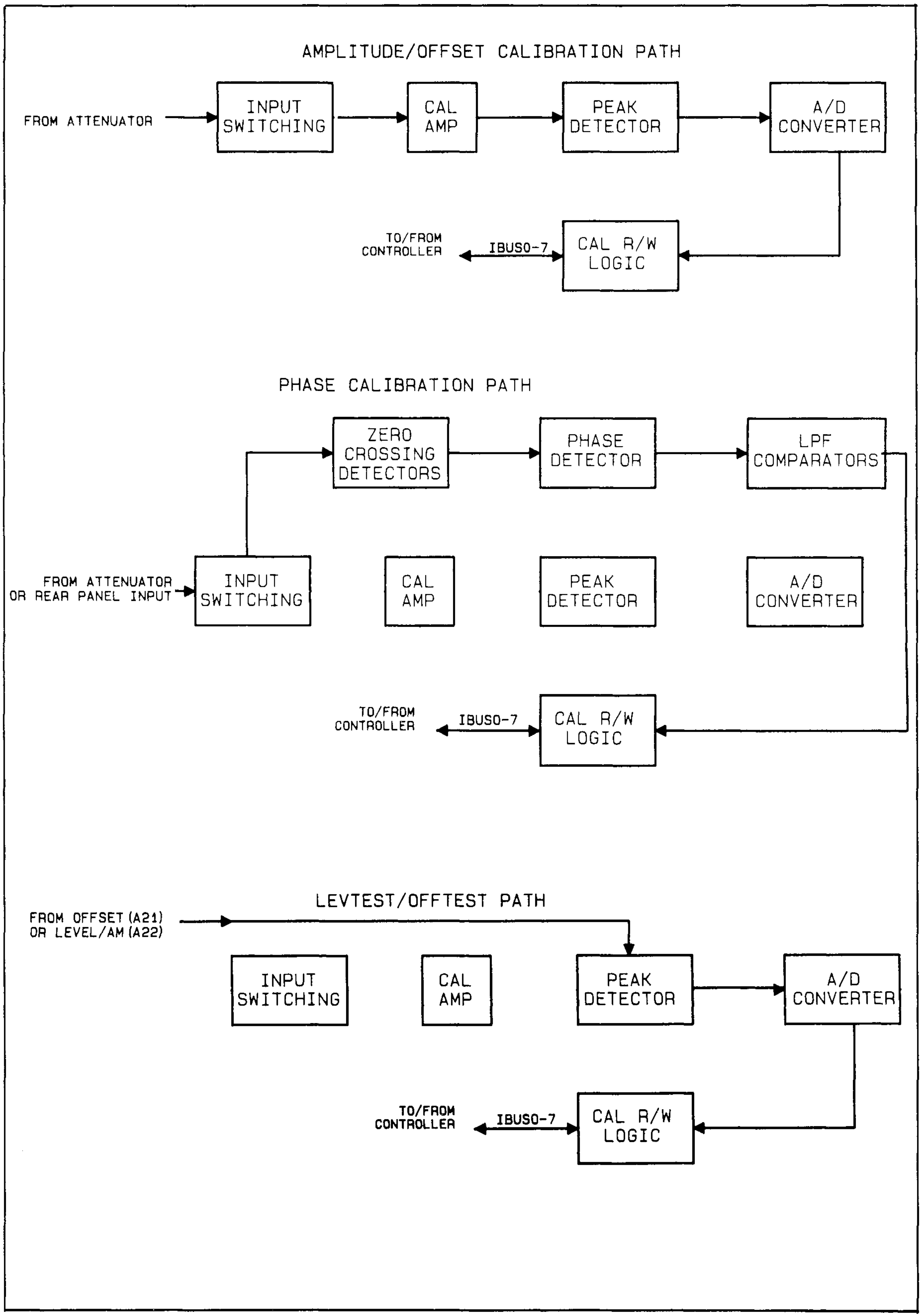


Figure 6-58. Calibrator Board Signal Paths

1. Voltage reference:

The voltage reference is a +10.240 Vdc signal (V REF) used by the offset, level, and square boards to insure amplitude accuracy. A 6.2 V zener is the basis of the circuit. That reference voltage is connected to the non-inverting input of an operational amplifier (op amp) which drives a discreet transistor. The transistor provides a large current source with a low output impedance. The output of the circuit is at the emitter of the transistor, as shown on the schematic. A potentiometer in the feedback circuit allows adjustment of the reference to +10.240 ± 0.010 Vdc.

2. Amplitude/Offset cal path:

The amplitude calibration path consists of five parts. These are:

a. Input switching
b. Calibration amplifier (cal amp)
c. Peak detector
d. A/D converter

a. The input switching sub-block is used to select the calibration input and to reverse the inputs. Reversing the inputs has the effect of reversing the polarity of the input signal. To obtain peak-to-peak and dc information at the INT CAL jacks, both positive and negative peaks must be measured. The peak detector block detects positive peaks, only. Negative peaks are detected by switching the inputs, which effectively configures the cal amplifier for a gain of −1. Table 6-39 shows the configuration of the relays for the various input measurements.

Table 6-39. Calibration Control

Switch Name†	Reference Designator	Calibration				
		Self Test		Internal		External
		LEVTEST	OFFTEST	Amp/Offset	Phase	Phase
CAL ISOLATION	A2K108, A12K108	X	X	0	0	1
CAL/PRTCT	A2K107, A12K107	X	X	0	0	1
CAL AMP +	A36K1	X	X	X	0	0
CAL AMP −	A36K2	X	X	X	0	0
AMP CAL	A36K3	X	X	X	X	X
PHASE CAL	A36K4	X	X	0	1	1
INT CAL	A36K5	X	X	0	0	1
PEAK DETECTOR INPUT	A36U203(1)	OFF (H)	ON (L)	OFF (H)	X	X
	A36U203(9)	ON (L)	OFF (H)	OFF (H)	X	X
	A36U203(16)	OFF (H)	OFF (H)	OFF (H)	X	X
	A36U203(8)	OFF (H)	OFF (H)	ON (L)	X	X

† 0 = Relay must be in the de-energized position for the calibration to take place.
1 = Relay must be in the energized position for the calibration to take place.
X = Relay can be in either the de-energized or energized position for the calibration to take place.
ON (L) = Control line for the switch must be TTL low for this calibration. This activates the switch.
OFF (H) = Control line for the switch must be TTL high for this calibration. This de-activates the switch.

b. The calibration amplifier (U200) is a wideband, high gain op amp. Note that C220 bandlimits the input signal to about 135 kHz to prevent output overshoot when using a square wave input. Also, R206 connects V REF to this circuit, causing the cal amp to have a built-in positive offset voltage of about 40 mV. This allows the calibrator to measure voltages at, and slightly below, ground with a positive-only peak detector. The cal amp output is connected to the peak detector input through an analog switch, U203.

c. U204 is a monolithic peak detector configured for a gain of +1. The microprocessor controls its operation through the cal R/W logic sub-block. Depending on the state of its $\overline{\text{DET}}$ and RST inputs, it can reset its output to ground, detect a positive peak, or hold the detected peak. Table 6-40 shows the state of these lines for the three functions. Table 6-39 shows the state of the analog switch control lines when the phase, amplitude, LEVTEST, and OFFTEST inputs are selected.

Table 6-40. Detector Function vs. Control Line State

Detector Function	Control Line State	
	RST	$\overline{\text{DET}}$
Reset	1	1
Detect peak	0	0
Hold	0	1

d. The A/D converter block is made up of a successive approximation register (SAR, U209), a D/A converter (DAC, U206), and a comparator (U208). Converter operation is as follows: V REF sets up a current internal to the DAC which is a function of the digital code present. This current flows into the DAC from its output pin. The voltage at the V IN input sets up a current which adds to the reference current at the output pin. Current then flows out of the DAC if V IN is greater than V REF times the code and into the DAC if V IN is less. This current is clamped at the comparator input; the comparator output gives the greater-than or less-than indication. Full scale is 5.12 V. Upon receipt of a negative transition on the $\overline{\text{S}}$ input, the SAR alternately outputs digital codes to the DAC and tests the comparator output, initially testing the most significant bit and working its way to the least significant bit.

The SAR clock input ($\overline{\text{A DLBC}}$) is a 100 kHz TTL pulse waveform generated by the channel A fractional-N circuitry.

The sequence of events for an amplitude/offset calibration is:

- The input switching relays and the analog switch are configured for the desired input.
- The peak detector output is reset to ground.
- The peak detector is set to detect a peak for several milliseconds.
- The peak detector is set to hold the detected peak.
- The S input to the SAR is strobed to initiate a conversion.
- The results are read over the cal R/W logic sub-block.

3. Levtest/Offtest Path:

The LEVTEST and OFFTEST signal paths have high impedance inputs and are used during the service self tests to bypass the cal amp to verify operation of the DACs on the offset and level/AM boards, A21 and A22. They are switched directly into the peak detector by the analog switch. Only positive voltages can be measured at these points. A INT CAL and B INT CAL are 50 ohm inputs. See sub-section 6-8, "Self Test Error Codes."

4. Phase calibration path:

The phase detector circuit consists of four main parts. These are:

a. Input switching
b. Zero crossing detectors
c. Phase detector
d. Low pass filter/comparators

a. The input switching sub-block used for phase calibration is the same as that used by the amplitude calibration path. In this circuit, a relay changes polarity by reversing the inputs. The phase detector is either configured normally or has its inputs reversed. By calibrating both ways and averaging, systematic errors are eliminated.

b. The zero crossing detector function takes an analog waveform and converts it to a digital waveform whose transitions reflect the timing of the analog zero crossings. They are optimized for speed, noise rejection, and insensitivity to amplitude and dc offset of input signals.

When the input signal is below the comparator threshold, the inverting output is high, which forward biases the first two diodes in the feedback path and reverse biases the diode nearest the input. This causes the inverting input to be at ground potential and the switching threshold to be zero volts for signals crossing in the positive direction. When the input crosses this threshold, the inverting output goes low and the diodes formerly on are now off, causing the diode near the input to turn off and the inverting input to be biased at -80 mV.

Figure 6-59 shows that the zero crossing detectors output timing is accurate for positive transitions and has a slight delay for the negative transitions. This inaccuracy is eliminated by taking a second measurement with opposite input polarity and averaging the two measurements.

c. Two interconnected flip-flops form the phase detector, which is driven by the two zero crossing detector outputs. Refer to the waveforms in Figure 6-59 for the following discussion.

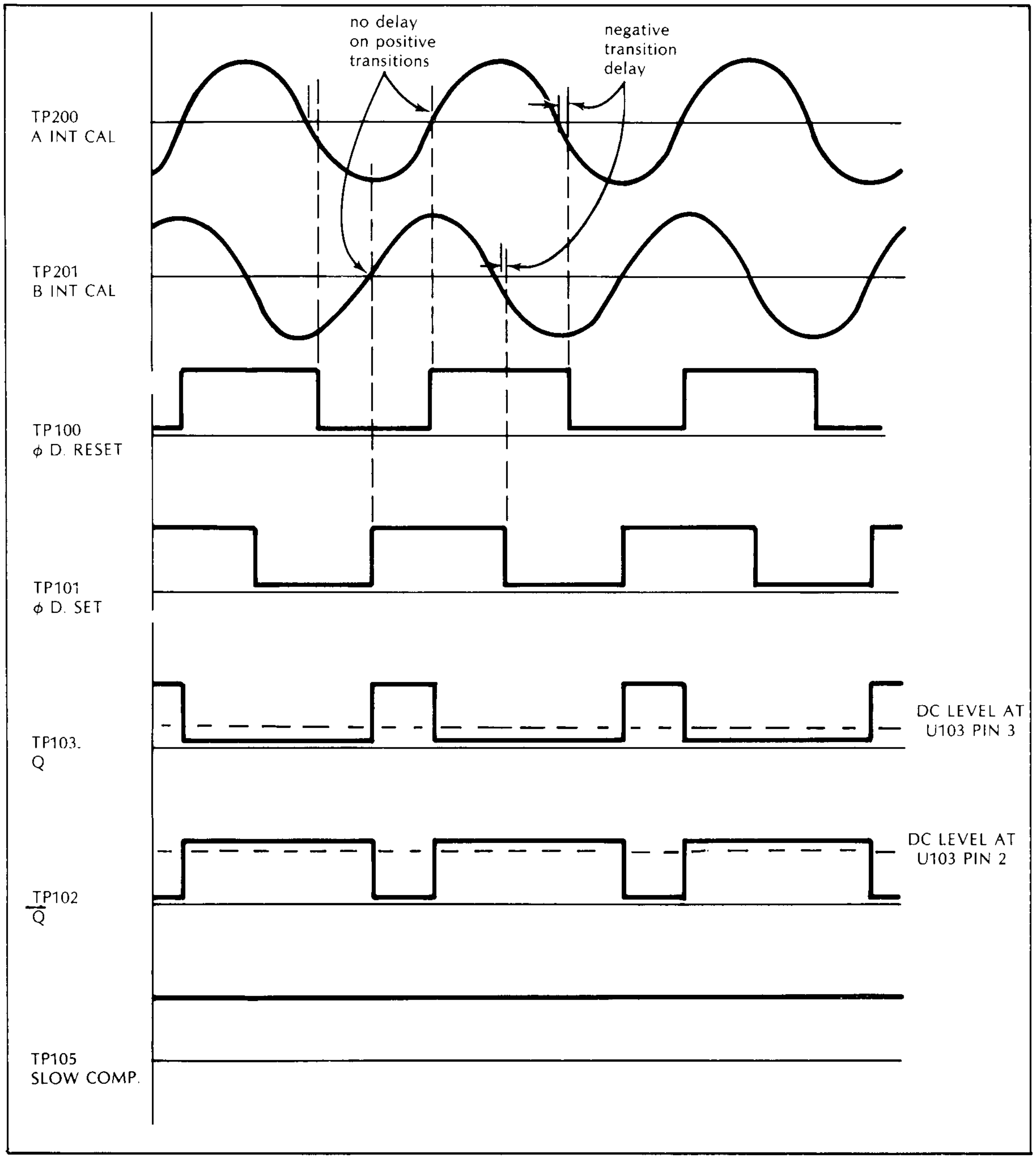


Figure 6-59. Timing Diagram for the Phase Cal Path

The output of zero crossing detector U101 (ϕ D.SET) acts to set the phase detector. The output of U100 (ϕ D.RESET) resets the output. The phase detector output is a square wave whose duty cycle is determined by the timing of its ϕ D.SET and ϕ D.RESET inputs and is an indication of the phase between the two original input signals. An input phase difference of 180° produces a 50% duty cycle in the phase detector output. The timing diagram in Figure 6-60a shows these signals for two sine wave inputs of arbitrary phase. In the case shown, channel B leads A by 90°. The zero crossing detector's negative hysteresis voltage is shown exaggerated for clarity.

d. The two low pass filter/comparators signal the controller when the phase of the input signals passes through 180°. The two circuits described here are identical except for filter cutoff frequencies.

The low pass filters act differentially on the phase detectors true and complementary outputs, removing their ac components and sending their dc components to the comparator inputs. As the phase between the input signals varies between 0° and 360°, the phase detector's true output varies from 0% duty cycle to 100%. This causes its dc component to vary from TTL low to high, with the complement output varying in exactly the opposite manner as the input phase changes (as the duty cycle goes from 100% to 0%, the dc component goes high to low). The two dc components cross each other when the input signal passes through 180°, which causes the comparator output to change state, signaling the controller. This relationship is shown in Figure 6-60b. Two filters are used because low frequency inputs require a filter with a slower response time (and corresponding lower cutoff frequency), while high frequency inputs can save time by using the "fast" filter.

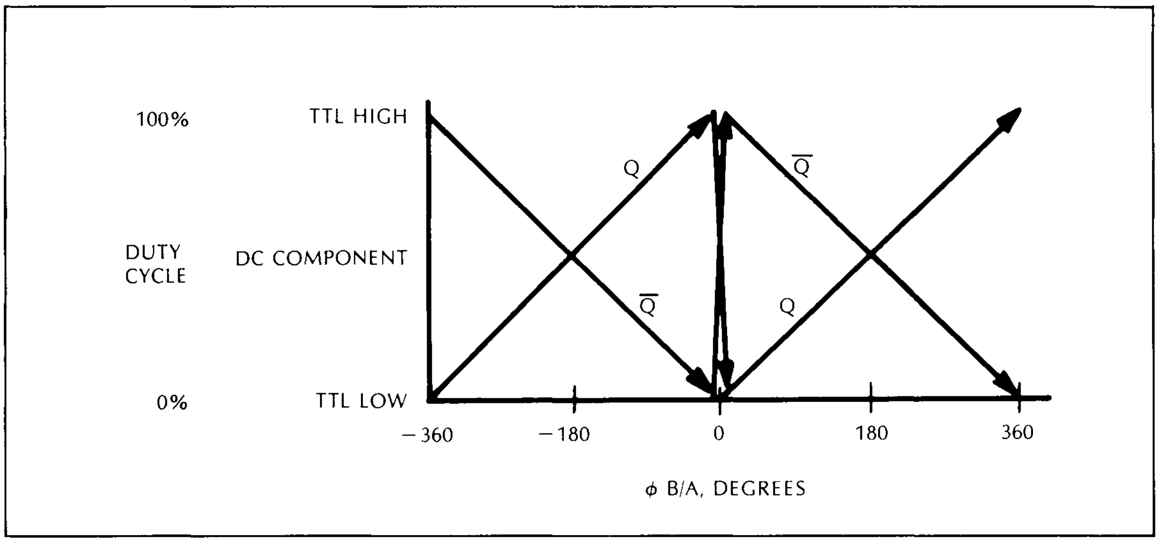


Figure 6-60a. Duty Cycle and DC Components of Phase Detector Outputs vs. Phase of Inputs

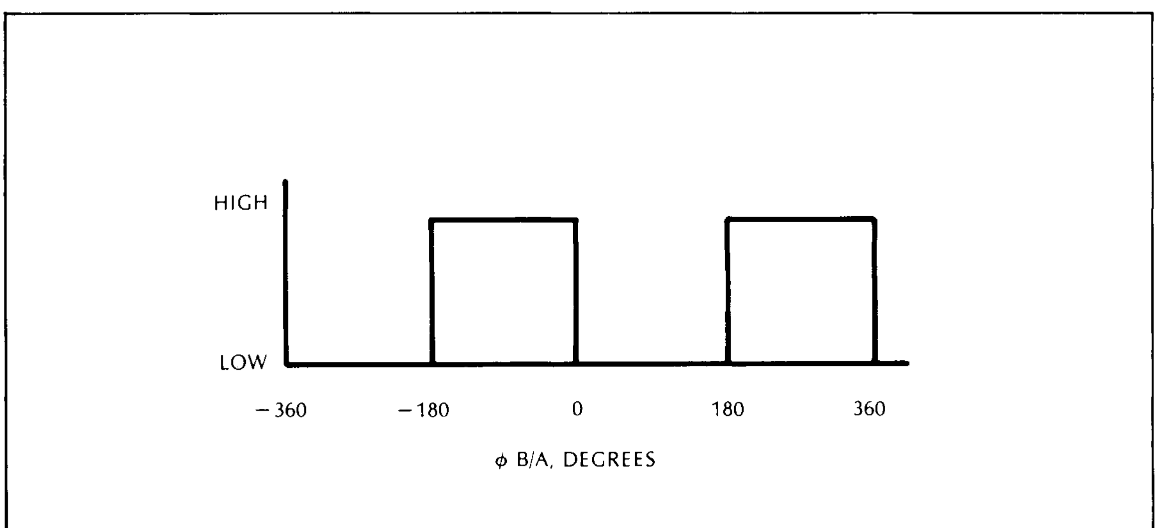


Figure 6-60b. Comparator Output vs. Phase of Inputs

The sequence of events for a phase calibration follows. ϕB denotes channel B phase; ϕB/A denotes the phase of B with respect to A.

- The A and B output signals are connected to the phase detector circuit through relays
- The controller increments ϕB until the phase detector indicates that ϕB/A is between 0 and 180°
- ϕB is incremented until ϕB/A just exceeds 180°
- ϕB is incremented until ϕB/A is just less than 180°
- Steps 3 and 4 are repeated with the phase increments growing smaller
- The final value of ϕB is stored
- The inputs of the phase detector are reversed with a relay
- Steps 3 through 5 are repeated
- The second final value of ϕB is averaged with the first value, resulting in defining ϕB/A to be 180°
- ϕB is updated to reflect ϕB/A which the user has entered (if 0° is entered, ϕB is incremented 180°)
- The output signals are disconnected from the phase detector

5. Calibration read/write logic:

The circuits in the cal R/W logic sub-block form a digital interface used to control the configuration of the calibrator board and to retrieve measurement information from its output circuits.

Troubleshooting the Amplitude/Offset Cal Path

The instrument bus circuit on the controller board (A61) and the control interface on this board can be tested using the Interface SA Test (see Tables 6-52 and 6-53 in the A61 troubleshooting sub-section 6-33). This test exercises the control lines from the controller board to determine if the controller or the control interface circuitry is defective.

1. Probe TP206 to check V REF. This voltage should be 10.240 Vdc ± 10 mV.

2. Connect a 1 kHz, 10 Vpp sine wave source to J2, A INT CAL. If one of the channels is operational, it can be used.

3. Set the calibrator to detect and display a negative peak measurement by pressing the key sequence **SHIFT, %, 4.** This configures the input relays to connect J2 to the calibration amplifier (cal amp) inverting input and grounds the non-inverting input. The controller then takes repetitive measurements with the peak detector and A/D converter and displays the results on the front panel. With an input of 10 Vpp, the display should read approximately −5 V. This configuration may be used to troubleshoot the cal amp, peak detector and A/D converter sub-blocks.

4. Check the input waveform at TP200 with a scope and compare it with the cal amp output at TP202. The frequency and amplitude of the two waveforms should appear identical and there should be a 180° phase offset between them. This setup shows the input and output signals of the cal amp sub-block.

5. Set up the calibrator to detect and display a positive peak by pressing the key sequence **SHIFT, %, 5** (display should read approximately +5 V), and check the waveforms at TP 200 and TP202 again. The input and output waveforms should appear identical (in phase, as well).

   If the output waveforms are incorrect in steps 4 or 5, then troubleshoot the cal R/W logic sub-block, the relays, and the cal amplifier.

6. Probe TP204 and TP202. The waveforms should appear identical. If not, troubleshoot the analog switch or the cal R/W logic sub-block. Note that the service self tests use the LEVTEST and OFFTEST inputs which bypass the relays and cal amplifier (they are switched into the peak detector directly through U203).

7. Probe the waveform at the peak detector output (TP205). It should periodically reset to ground, detect a positive peak, hold it, and repeat the process. If not, troubleshoot the peak detector circuitry or the cal R/W logic.

8. To test for general operation of the A/D converter, probe the various digital lines with a logic probe. All are TTL and should show activity, including TP207 (comparator output), the twelve data lines on the DAC, and the $\overline{S}$ input on the SAR. The SAR clock input is 100 kHz, TTL level pulse waveform which must be present for circuit operation.

   To test A/D accuracy, connect a dc source of 5 V or less to J2, and press the key sequence **SHIFT, %, 5** to display a positive peak on the front panel. The value displayed should equal the voltage measured at TP200 and the reading should be repeatable (within 3 mV) unless there is noise on the dc source. The same should be true for a negative dc source after pressing the key sequence **SHIFT, %, 4**. If the voltages displayed differ from those measured by more than 10 mV, troubleshoot the A/D converter sub-block.

Table 6-41 shows the state of the digital control lines which drive the relays and the analog switches during positive or negative peak detection.

The timing diagram in Figure 6-61 shows the peak detector output and the control signals which drive the peak detector and the A/D converter. The digital logic should be checked before replacing any analog ICs. Check the signals by pressing either the key sequence **SHIFT, %, 4** or **SHIFT, %, 5.** Make sure the channel A and channel B signals are sine waves and the internal calibration cables (A INT CAL and B INT CAL) are connected to A36. Check the signals one at a time. If the signals are not present, troubleshoot the A/D converter sub-block.

Refer to Table 6-15 for recommended post-repair adjustments.

Table 6-41. Relay and Analog Switch Configurations for Internal Phase Calibration Control and Peak Detection

Instrument State	U13, pin: 10	11	12	13	14	U15, pin: 9	19	12	6
PRESET	1 V	15 V	15 V	15 V	15 V	HI	HI	LO	HI
PHASE CAL	15 V	1 V	X	15 V	15 V	X	X	X	X
SHIFT % 4	15 V	15 V	1 V	1 V	15 V	HI	HI	LO	HI
SHIFT % 5	15 V	15 V	15 V	15 V	1 V	HI	HI	LO	HI

HI = TTL high LO = TTL low X = don't care

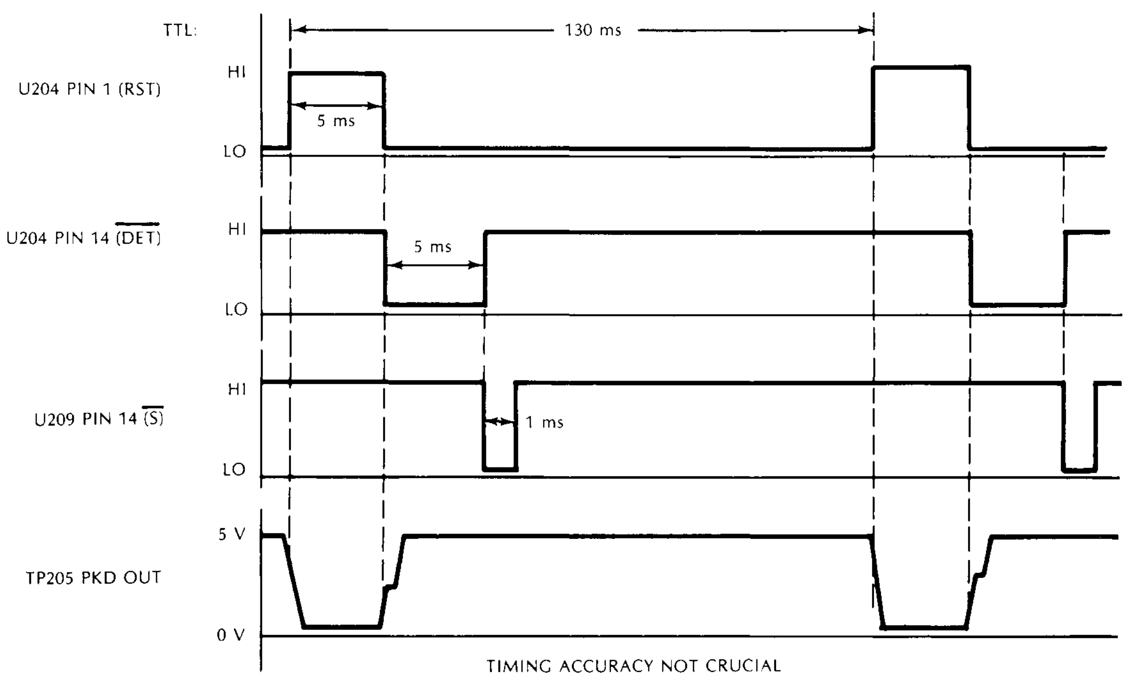


Figure 6-61. Peak Detector and DAC Timing Diagram

Troubleshooting the Phase Calibration Path

If phase calibration has failed catastrophically, the problem is usually easy to locate. If the problem is a slight phase cal inaccuracy, the problem may be difficult to locate. Keep in mind that system grounding is very important to phase performance. In particular, tightness of the top cover and motherboard screws and integrity of cable connections have a definite effect on phase calibration accuracy. Both the inner and outer conductors of all phono cables must make good contact. The outer "fingers" of the phono plugs can be crimped slightly and the inner contact bent slightly to insure good connections. A good measure of contact quality is the torque required to turn the plug when it is inserted. It should be fairly stiff to turn by hand.

NOTE

Phase calibration is very sensitive to bad ground contacts. When the HP 3326A has poor phase calibration accuracy, check that (1) all of the top cover screws are firmly in place, (2) all of the motherboard screws are firmly in place, and (3) all of the cable connections are tight, particularly the ground contacts.

The instrument bus circuit on the controller board (A61) and the control interface on this board can be tested using the Interface SA Test (see Tables 6-52 and 6-53 in the A61 troubleshooting sub-section 6-33). This test exercises the control lines from the controller board to determine if the controller or the control interface circuitry is defective.

1. This repair section assumes that the two output paths are operational and that signals are available to test the phase cal path. If internal phase cal works but external does not, the protection fuses F1 and F2 (on the A36 board) should be checked for continuity.

2. Press the INSTR PRESET key. Configure the scope to display signals present at probe TP200 and TP201 (A INT CAL and B INT CAL) with a scope. No signals should be present.

   Press the MODE key to enter 2 PHASE mode and initiate a phase calibration cycle. During the calibration, two 1 kHz, 3.2 Vpp sine waves should be present at the test points and channel B should change phase with respect to A (scope triggered on channel A, TP200). If this does not occur, the problem exists before the phase cal path.

3. Move the scope probes to the zero crossing detector outputs at TP100 and TP101. Press the MODE key four times to reenter the 2 PHASE mode and initiate another phase calibration cycle. The two signals should be TTL level square waves whose phase corresponds to the phase between the inputs at TP200 and TP201. Problems here indicate that either the input signals are not reaching the zero crossing detectors (due to a relay or cal R/W logic problem) or that the zero crossing detectors are defective. The waveforms for this step appear only during phase calibration.

4. Probe the Q output of the phase detector (TP103; TTL) and initiate another phase cal cycle. The duty cycle of Q should be changing during the cal cycle (particularly in the beginning of the cycle) as the phase of channel B changes with respect to channel A. Note the rising edge of the signal at TP101 sets the Q output and the rising edge of the signal at TP100 resets the Q output.

5. Probe the comparator outputs (TP104 and TP105). Both outputs should be changing state during the cal cycle. This is due to the following: The low pass filters remove the ac components from the Q and $\overline{Q}$ signals. For frequencies below 10 kHz, the "slow" comparator (see theory for definition) is read by the controller. As channel B changes phase with respect to A, the duty cycle (and the dc component) of Q and $\overline{Q}$ also changes. The TTL level comparator outputs change state when the Q and $\overline{Q}$ duty cycles pass through 50%. The comparator outputs are read by the controller through U17.

6. Table 6-41 shows the state of the lines which drive the relays both before and during a phase cal cycle. Remember that a phase calibration cycle must be initiated by pressing the MODE key until the 2 PHASE LED illuminates. The lines shown in Table 6-41 remain in the phase cal state for only a short time, so testing must be done by cycling through modes once for every control line measured.

Refer to Table 6-15 for recommended post-repair adjustments.

HP 3326A Setup

INSTR PRESET

Oscilloscope Setup (#1)

10:1 probe

Ch 1 coupling	DC
Ch 1 V/div	200 mV
Time/div	5 μs
Trigger	Ch 1

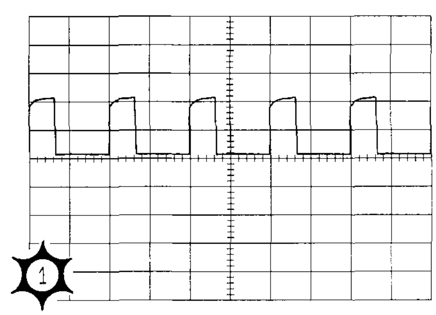
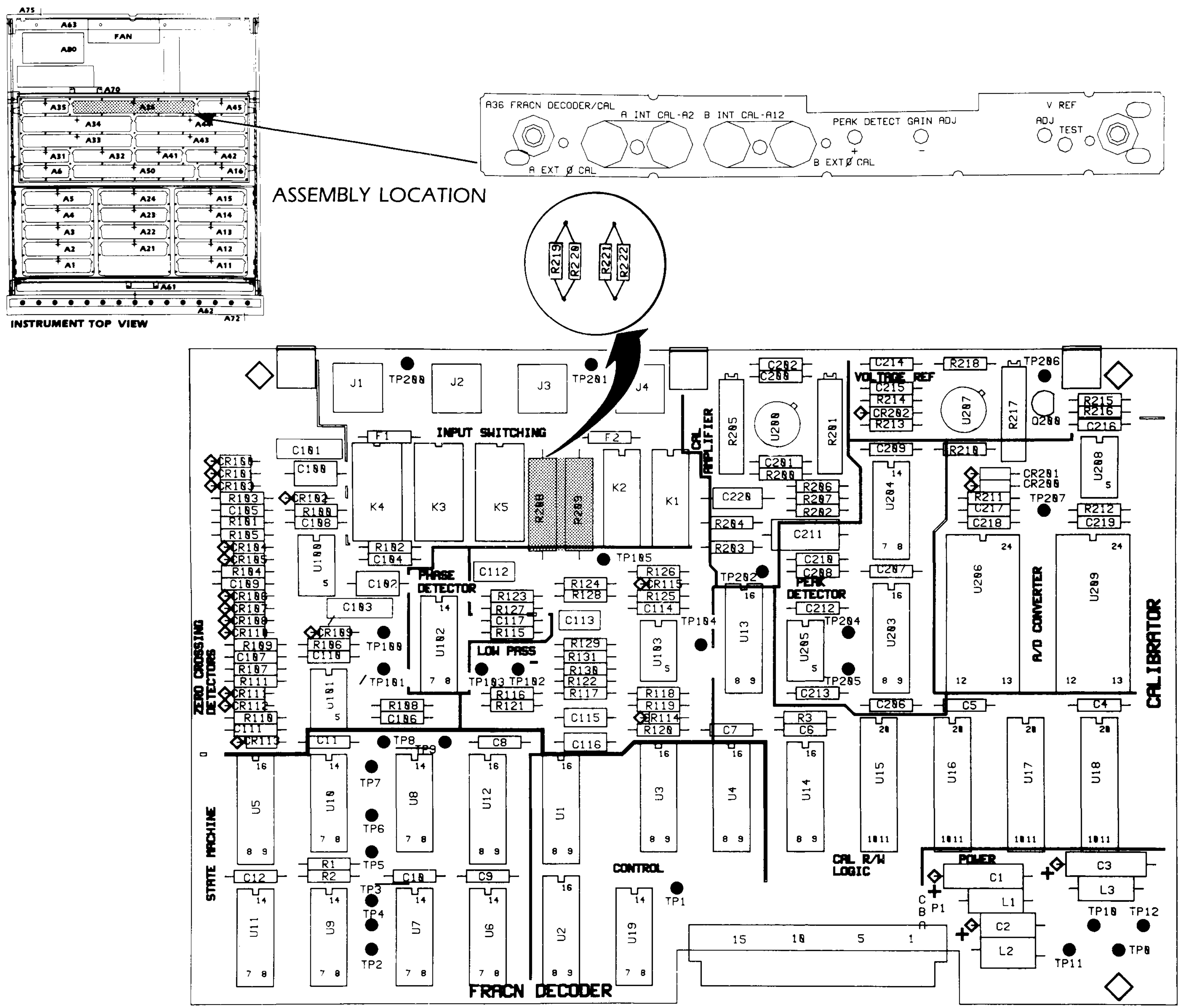


Figure 6-62. Calibrator Board Waveforms

NOTES



FRACN DECODER/CALIBRATOR BOARD
(A36)
P/N 03326-66536
REV A

NOTES:

1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).

   PIN 1 ... +5 V

   GND

2. TTL DEVICES ARE USED IN THIS CIRCUIT.

REFERENCE TABLE

COMP	GND	+5V1	+5V2	+5V3	+15V1	-15V1	REF DES (BYPASS CAPS)	VALUE (BYPASS CAPS)	NC.
U12	8	16							7, 9, 10
U13	1, 8				9				16
U100	5			8			C104	0.1	1
U101	5		8				C106	0.1	1
U102	7								
		14					C117	0.1	
U103	4								
					8		C114	0.1	
U200						4	C201	0.1	1, 5, 8
					7		C200	0.1	
U203		12					C206	0.1	
					13		C207	0.1	
						4	C208	0.1	
	5								
U204	13								10, 11, 12
					2		C209	0.1	
						7	C210	0.1	
C205					7		C212	0.1	1, 2, 5, 8
						4	C213	0.1	
C206	3, 7 12								1, 2, 4, 8
						6	C219	0.1	
C207	4								1, 5, 8
					7		C214	0.1	
U208	1								
						4	C217	0.1	
					8		C216	0.1	
U209	12								2, 3, 10, 22, 23
		24					C219	0.1	

SCHEMATIC
CALIBRATOR BOARD
(A36)
P/N 03326-66536
REV A

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Figure 6-63.

See Other Side

6-32 REFERENCE, A50

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

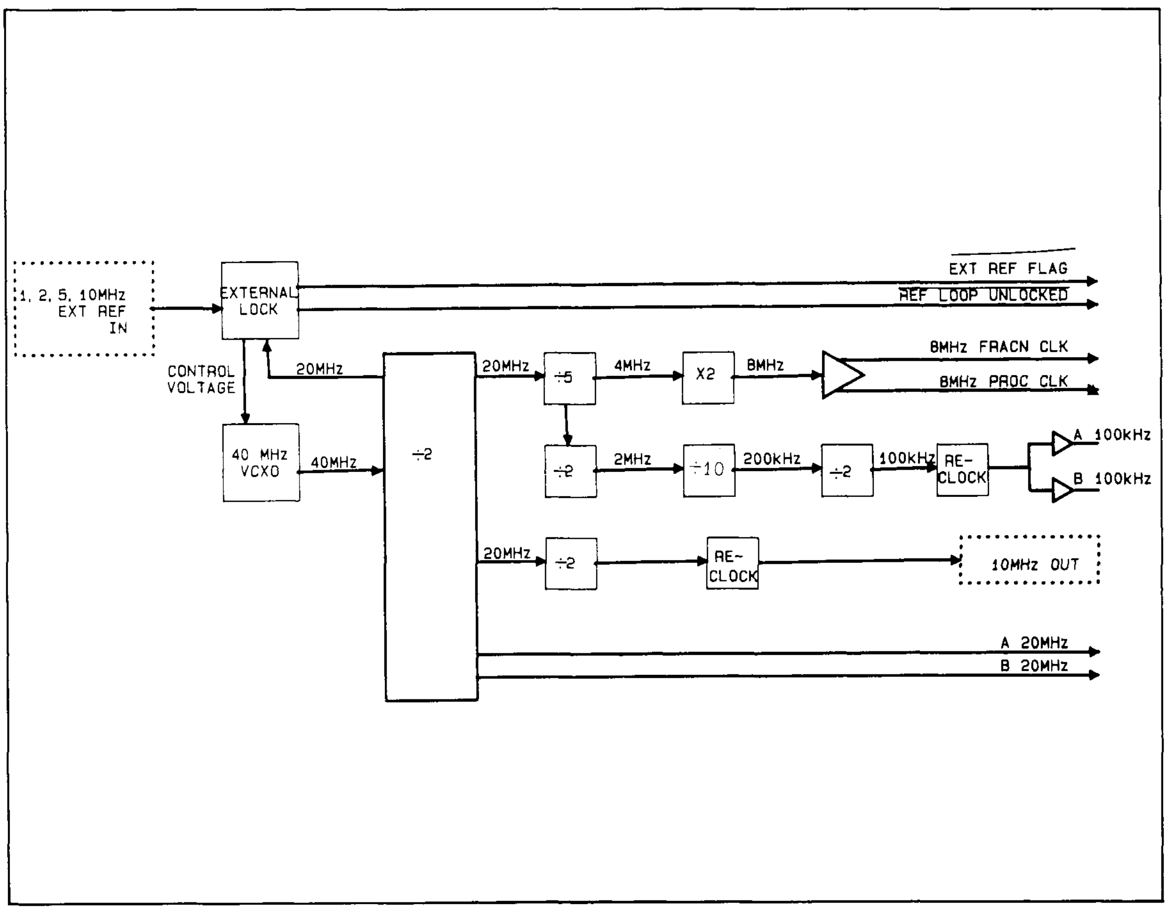


Figure 6-64. Reference Board Block Diagram

Theory of Operation

Oscillator:

The main oscillator is a voltage controlled crystal oscillator (VCXO) operating at 40 MHz. The frequency can vary ±20 ppm (800 Hz) to allow the instrument to lock onto an external frequency reference.

Q100 is configured as an emitter follower. It serves as a voltage source to drive the series admittance of CR100 and Y100, which is resistive at the resonant frequency. Oscillations from the series combination of CR100 and Y100 are amplified by the common base stage (Q103), which drives a 40 MHz tank circuit. The signal from the tank is tapped off of the capacitive voltage divider and fed back to the base of Q103, completing the loop.

The output of the VCXO comes from the collector of Q100. This signal is buffered and amplified by Q101 in a common base configuration. The output of this stage is converted to emitter coupled logic (ECL) levels by C105, R111 and R112.

Varying the voltage across CR100 varies the output frequency of the VCXO. Varying R115 changes the dc voltage on the anode of CR100 and sets the center frequency of the oscillator. The voltage applied to the cathode of CR100 (from the external reference locking circuitry) is a function of the frequency of the external reference input and the frequency of the VCXO. When no external reference is connected to the back panel input, this voltage is approximately 0 V. A positive voltage at TP3 causes the VCXO output to rise in frequency; a negative voltage causes the frequency to decrease.

The circuitry around Q104 shapes the response of the VCXO control signal going to the varactor diode, CR100. When there is either no external reference present or the VCXO is locked to the external reference, the cathode of CR103 is at +5 Vdc which turns on Q104. This adds a lag/lead circuit to the control voltage output to reduce the response of the control signal at high frequencies. When an external reference signal is present and the reference is not locked to it, the voltage at the cathode of CR103 is switched to −15 V. This turns Q104 off, which removes the lag/lead circuit and allows the control voltage to respond faster and the VCXO to lock rapidly.

Frequency dividers and buffers:

U100 divides the 40 MHz signal produced by the VCXO by 2, resulting in a 20 MHz square wave. This signal is used to drive five buffers in U101 and U102. Of these buffers, one drives the external reference lock circuitry, one drives the frequency dividers, one reclocks some of the output signals and two supply 20 MHz signals to the channel A modulator (A6) and the RF switch (A24).

The B 20 MHz signal is used only in two-channel mode. When the instrument is in any other mode, the B 20 MHz signal is turned off to reduce crosstalk. To turn this output off, the processor sets INH BREF high, turning on Q102. This shorts the reference voltage at U102 pin 9 to ground, which inhibits the buffer from switching.

The 20 MHz signal from U101 pin 3 goes to U203 which divides the frequency by 5, yielding 4 MHz, and by 10, yielding 2 MHz. U202 divides the 2 MHz by 2, yielding 200 kHz. This 200 kHz is again divided by 2 in U201 to yield 100 kHz. The second D flip-flop in U201 reclocks this 100 kHz signal, reducing phase noise. The resultant signal is buffered by U200 and routed to the fractional-N phase detectors in both channels (A33 and A43).

The 4 MHz signal from U203 goes to a frequency doubler which produces an 8 MHz signal. This is accomplished by converting the square wave into a pulse to create harmonics, and then driving a tank circuit tuned to 8 MHz. The tank circuit couples the signal out the capacitive voltage divider to U204, whose outputs (signal names 8MHz FRACN CLK and 8MHz PROC CLK) go to the fractional-N decoder and controller boards.

In a similar manner, U300 divides the original 20 MHz by 2 to generate a 10 MHz signal which is reclocked by another D flip-flop in U300. This 10 MHz signal is ac coupled through T300 to supply a 10 MHz reference rear panel output at approximately +3 dBm.

External lock:

The external reference phase lock circuitry has two inputs and three outputs. The inputs are the rear panel external frequency reference and a comparison signal from the 20 MHz buffer U101 (pin 7). The outputs are a control voltage used to vary the frequency of the VCXO and two status signals, $\overline{\text{EXT REF FLAG}}$ and $\overline{\text{REF LOOP UNLOCKED}}$.

The external reference input from J1 on the rear panel may be a square or sine wave whose frequency is 1, 2, 4, 5, or 10 MHz. For best performance, this signal level should be greater than −6 dBm, although the circuit operates using signal levels less than that. To prevent crosstalk problems, the level should be limited to signals no greater than +6 dBm; the damage level is above +20 dBm. This signal should be a high quality, low phase noise signal to avoid degrading performance. The instrument may indicate that it is unlocked when the reference signal has significant phase noise, even though the circuit is locked. This effect is more prevalent at the lower reference frequencies.

The external reference input is ac coupled by T100 to isolate the instrument ground (GND) from the chassis ground (CGND). The transformer secondary is terminated by R421 and clamped to ECL levels by R420, CR413 and CR414. U402 amplifies this signal, which has the effect of converting it to a square wave. This signal goes two directions from the first stage of amplification: to a circuit that detects the presence of a reference signal and to a phase comparator. The detector uses CR410, CR411 and C407 as a dc power supply. When a signal is present at the reference input, the diodes rectify the output of U402 (pin 6) and charge C407 positively. This raises the inverting input of comparator U400 above the reference voltage on CR400 and causes the comparator output to fall to the negative supply (−15 Vdc). This output has two functions: it operates a FET switch in the later stages of the lock circuitry (to be described in a later paragraph) and indicates the presence of an external reference to the processor via the $\overline{\text{EXT REF FLAG}}$ signal.

External lock, phase comparator:

The phase comparator inputs are the external reference (1,2,5,10MHz REF IN) signal and the 20 MHz signal derived from the output of the 40 MHz VCXO. The reference signal is differentiated to get a narrow pulse. This pulse is amplified by Q401, which sends a negative pulse to one side of the diode bridge and a positive pulse to the other side. The diode bridge is a gate used to sample the 20 MHz signal derived from the VCXO. When the VCXO frequency is low with respect to the reference, the sample is taken while the level is high, just before the negative transition. This causes the control voltage going to the VCXO to rise, which increases its operating frequency and counteracts the frequency difference. The inverse occurs when the VCXO frequency is high with respect to the reference frequency.

External lock, loop amplifier:

U401 amplifies the VCXO control voltage. When no external reference is present, the gate of the FET switch Q400 is high, turning it on and shorting the feedback circuit of U401. This reduces U401 to a follower amplifier with unity gain. The absence of pulses from the sampling gate causes the output of U401 to be near 0 V.

When there is an external reference, Q400 is turned off and U401 acts as an integrator. When the instrument is locked to the reference, the output of U401 is 0 V. The pulses from Q401 stay aligned with the 20 MHz signal from U101 even when the external frequency reference operates at a frequency slightly different from the VCXO unlocked center frequency.

Troubleshooting

This circuit may be analyzed by putting it on an extender (be sure to turn the power off before removing the board) and comparing the oscilloscope waveforms in Figure 6-65 with those of the defective unit. Unless otherwise noted, the instrument configuration for these waveforms is INSTR PRESET.

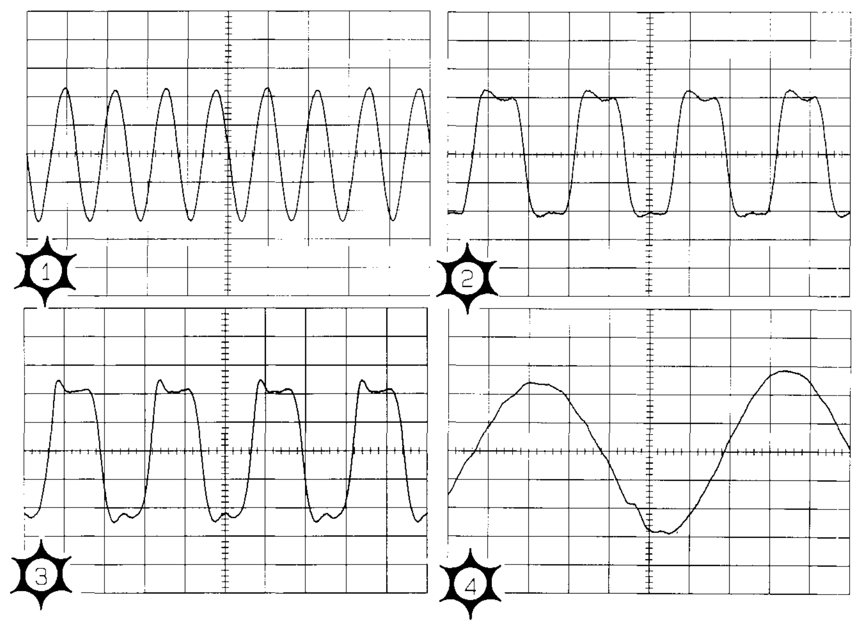
Refer to Table 6-15 for recommended post-repair adjustments.

HP 3326A setup is INSTR PRESET. For voltages and waveform (#9) in the external lock sub-block, connect a 10 MHz sine wave signal to the 1,2,5,10MHz REF IN rear panel input.

Oscilloscope Setup (#1, #2, #3, #4)

10:1 probe†

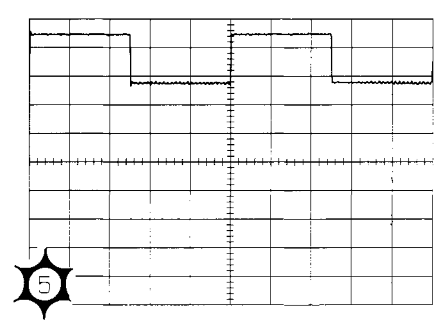
Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	20 ns
Trigger	Ch 1



Oscilloscope Setup (#5)

10:1 probe

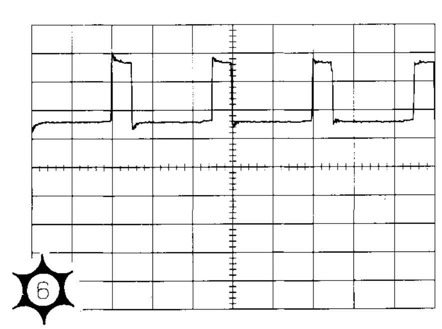
Ch 1 coupling	DC
Ch 1 V/div	50 mV
Time/div	2 μs
Trigger	Ch 1



Oscilloscope Setup (#6)

10:1 probe

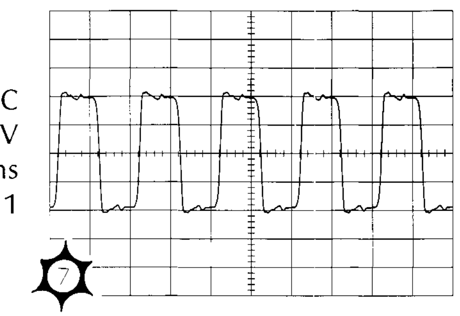
Ch 1 coupling	DC
Ch 1 V/div	40 mV
Time/div	2 μs
Trigger	Ch 1



Oscilloscope Setup (#7)

BNC cable

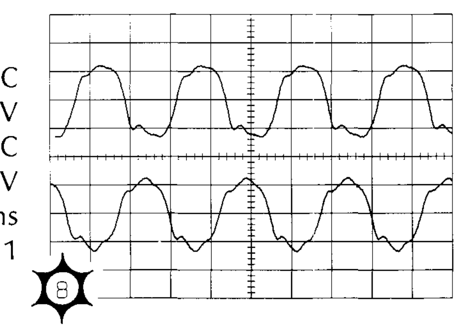
Ch 1 coupling	50 Ω DC
Ch 1 V/div	200 mV
Time/div	50 ns
Trigger	Ch 1



Oscilloscope Setup (#8)

10:1 probes (2)

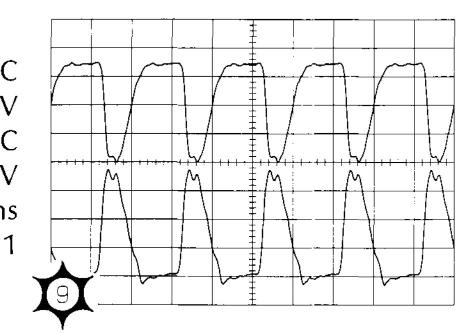
Ch 1 coupling	AC
Ch 1 V/div	40 mV
Ch 2 coupling	AC
Ch 2 V/div	40 mV
Time/div	20 ns
Trigger	Ch 1



Oscilloscope Setup (#9)

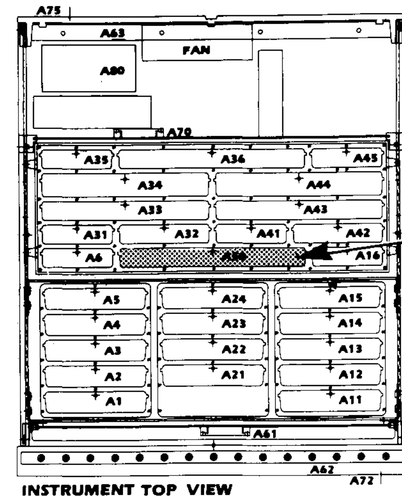
10:1 probes (2)

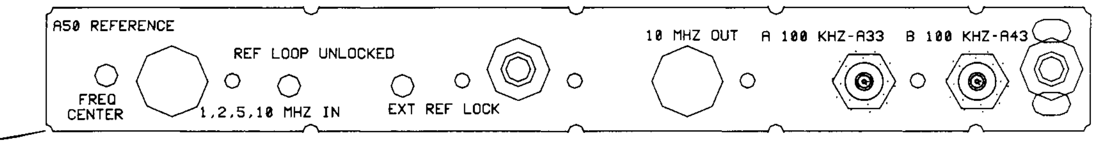
Ch 1 coupling	AC
Ch 1 V/div	50 mV
Ch 2 coupling	AC
Ch 2 V/div	50 mV
Time/div	50 ns
Trigger	Ch 1



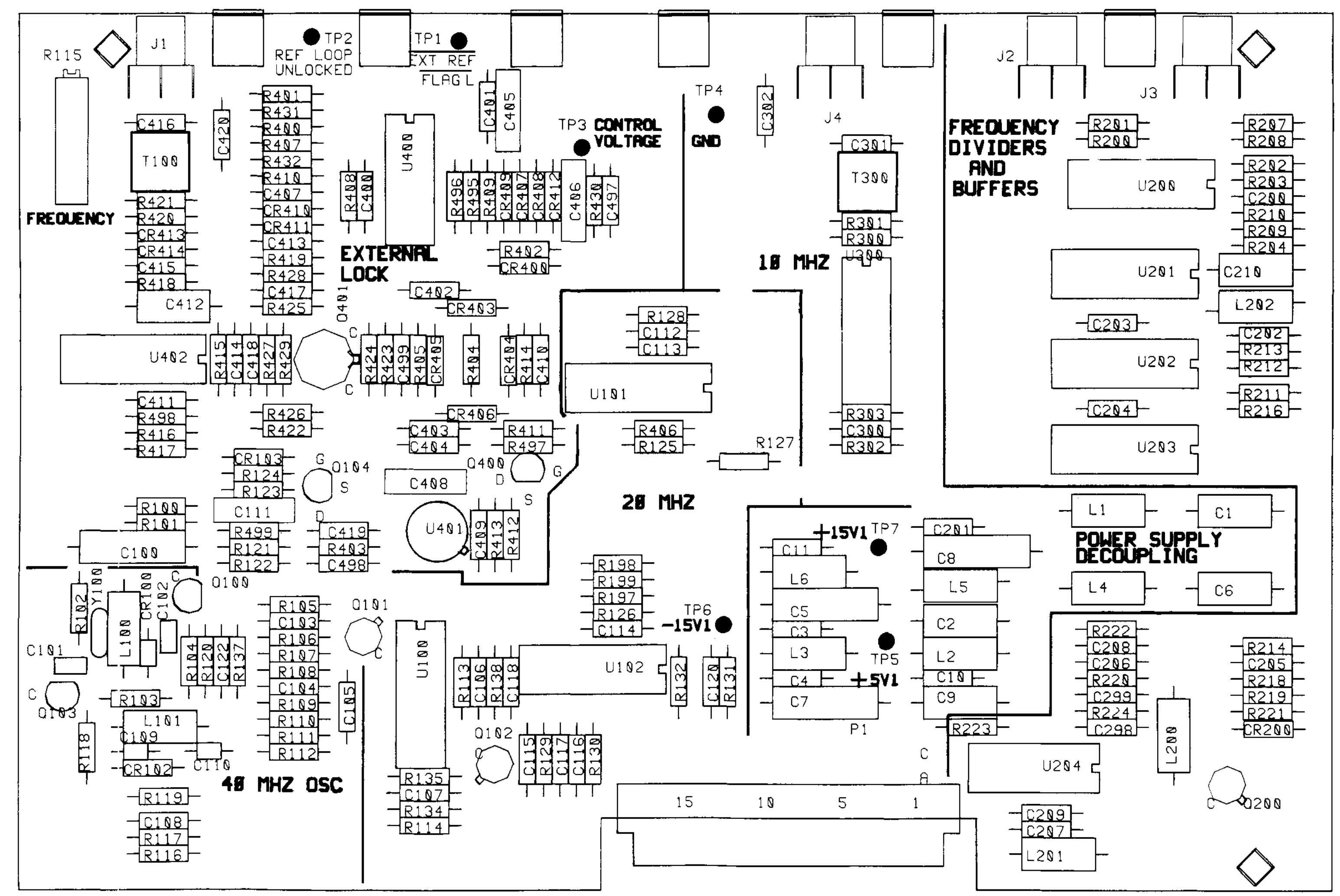
† Use a 10:1 probe with a ground spring (HP part number 1460-1476) when making high frequency measurements to minimize distortion.

Figure 6-65. Reference Board Waveforms





ASSEMBLY LOCATION



REFERENCE BOARD (A50)
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REV A

REFERENCE TABLE

COMP	GND	+5V1	+5V2	+5V3	+5V4	+5V5	+5V6	+15V1	-15V1	BYPASS CAPS REF DES	VALUE	NC.
U100	10, 11, 12, 13	14, 15, 1, 16								C106	0.1	
U101	8, 13	1, 16, 14, 15								C113	0.1	2, 6
U102	8	1, 16								C114	0.1	2
U200	8, 10	1, 6, 7, 16										2, 14
U201	8					1, 16				C202	0.1	3, 15
U202	8	1, 16								C203	0.1	3, 4, 13, 14
U203	8	1, 16								C204	0.1	2, 3, 13, 14
U204							14					2, 5, 7, 8, 12, 13,
U300	8			1, 16						C300	0.1	
U400					3				1, 2, 4, 5, 6, 7, 12	C400 C401	0.1 0.1	
U401								7	4	C419	0.1	5
U402	8				1, 16					C411	0.1	7, 14

NOTES:

1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).

   PIN 1 +5 V GND

2. EMITTER COUPLED LOGIC (ECL) AND TTL DEVICES ARE USED IN THIS CIRCUIT.
3. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.

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Figure 6-66.

See Other Side

6-33 CONTROLLER AND HP-IB SUPPORT, A61 AND A63

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

Theory of Operation

The controller board requires the +5V, +15V, −15V, +5V HPIB, GND, and CGND lines from the power supply and the 8 MHz clock from the reference board (A50) to function. See the signal glossary for definitions.

Microprocessor:

The microprocessor is a Motorola 68B09 running at a clock speed of 8 MHz. The 8 MHz, TTL level clock is generated on the frequency reference board (A50) and buffered on the controller board with a hex inverter (see clock and memory stretch sub-block).

Digital signature analysis (SA) is accessed by using jumper W101 and switch S1. When W101 is in the SA test position, the data buffer driver is disabled and the microprocessor counts through memory addresses from beginning to end, repetitively. The programmed SA test is run by operating switch one on S1, as shown at the end of this discussion. An X-drive troubleshooting test is initiated by using switch 2. All the SA pins are assembled together on W303 to make SA easier to use. The ROM and RAM START and STOP pins are connected to the respective chip select lines. The HPIB and DISP (display) pins are decoded memory data. The SA CLK (clock) pin is the valid memory address ($\overline{\text{VMA}}$) line, the logical NOR of the E and Q signals.

The microprocessor has three interrupts: $\overline{\text{NMI}}$ (non-maskable interrupt), $\overline{\text{FIRQ}}$ (fast interrupt request), and $\overline{\text{IRQ}}$ (interrupt request). The fastest interrupt, $\overline{\text{NMI}}$, is used for the interrupts that require the least amount of delay: the sweep limit signal and the external trigger signal. These are combined in the interrupt multiplexer block, which is enabled by a line from the hardware control block (U412). This allows the instrument to mask the otherwise non-maskable processor interrupt. $\overline{\text{A SWEEP LIMIT}}$, $\overline{\text{B SWEEP LIMIT}}$, and EXT TRIG IN have their own enable lines and provisions for reading their status in the flag register. $\overline{\text{FIRQ}}$ is used for the 1 ms display timer. The timer produces a 1 μs pulse every 1 ms. This sets $\overline{\text{1MS INTFLAG}}$ low. $\overline{\text{IRQ}}$ serves the HP-IB chip (U215).

The power-up reset circuit uses charging capacitors and CMOS buffers to give a delay of approximately 200 ms between power-up and microprocessor operation. A low-power reset consisting of U117, CR103, and C102 protects the CMOS RAM from the processor when the power fails. When the +5V supply drops below approximately 4.5 V, the open collector output on the comparator drives the voltage on C102 to ground, resetting the instrument. In approximately 100 ms the reset line goes high, assuming the power comes on again immediately.

The address decoding for memory selection and I/O interface is accomplished with four 3-to-8 decoders. Two of the decoders are enabled by the reset line to delay access to them for a small period of time after power on.

The clock and memory stretch circuit makes a special provision for I/O addresses which require a timing delay different from that of other memory. This input is fed to MRDY on the processor, effectively "stretching" the E and Q processor output signals.

Battery backup is provided for the CMOS RAM to preserve the machine state and status when power is off. When power is removed, a lithium battery holds the CMOS RAM supply line at about 2.6 V, which is high enough to retain data in RAM. The two transistors and associated hardware are for the +5 V battery switching. This circuit isolates the CMOS supply from the rest of the circuitry so that the battery is only connected to the CMOS RAM when power is off. While power is applied to the instrument, the +5 V provides a back bias to the battery diode and no battery current is drawn. When the power to the instrument is turned off, the diode is forward biased and the battery supplies the CMOS RAM. See "Adjustments," Section III, for a battery check procedure.

To insure that the processor does not corrupt the RAM during power transitions, a CMOS inverter is tied to the reset line and the RAM chip select. While the reset line is low (and the processor is inactive) and the chip select is high, no data can be read from the RAM. After the processor is enabled, the reset line is high and the information in the memory can be read.

Keyboard interface:

The display for the HP 3326A is based on one large serial information loop. Data to the display (FP DATA) is first written to U107, a parallel in-serial out shift register located in the keyboard interface circuit. Then data is read by the processor from the clock start location to start the automatic display clock (DISPLCLK). This clock produces eight shift clocks to shift the data (KB DATA) to the keyboard (A62), without involving the processor. Data is then put into the display registers by strobing the display STROBE line.

The timer chip (U401) generates a 1 ms interrupt signal used for display updating. The required output is a square wave of a time period equal to 1 ms for the half cycle. The output of the chip is run into a D flip-flop and an exclusive OR gate to produce a 1 μs wide pulse during every transition. This pulse sets the RS flip-flop that drives the $\overline{\text{FIRQ}}$ interrupt signal.

The status input circuit contains a flag register and a switch register. The flag register (address 0300) is the processor's access to the LATCHSWPLMT, LATCHSWPLMT, EXT TRIG IN, ANALOG FAULT, HPIBINT, SWEEP START, SYNC OVLD, EXT REF FLAG, and REF LOOP UNLOCKED status lines. The switch register is used for SA tests and the SAVE option. Also, the high voltage option status line (HVFLAG) is sent to the high order bit of this register to indicate if the high voltage boards are in the instrument.

HP-IB circuits:

The HP-IB and HP-IB support circuits work in a relatively straightfoward manner. Be careful to note, however, that the LSB of the processor data bus is connected to bit 7 of the HP-IB chip (U215). This convention does not hold for the HP-IB bus; DIO1 from U215 is also called DIO1 on the data bus. RS0 is the LSB of the register select. Also note that the interrupt line (HPIBINT) is open-collector. If a problem occurs with powering U215, the chip has to be hard reset, which is difficult to do with isolation. For this purpose, bit 6 in the hardware control register is used as the HP-IB reset line. This output is driven low during initialization by software. Note that this same bit is used as the external reference test bit.

Pulse transformers provide isolation between the HP-IB bus and the rest of the instrument. The primary winding of the transformer is connected through a damping circuit to the output of a bus driver buffer. The secondary winding center tap is biased at 2.5 V and the secondary output is connected to the inputs of an RS flip-flop. Thus, the flip-flop inputs are 2.5 V (logic high) when there is no bus activity.

Logic levels are transported across the transformer interface during buffer output voltage transitions, only. If the output of the bus driver buffer changes from a low to a high, a positive voltage develops on the transformer primary, which induces a positive voltage on the secondary. Since the center tap of the secondary is held at 2.5 V, one end of the secondary winding rises to a logical high state and the other end falls to a logic level low state, setting the flip-flop. A high-to-low transition of the buffer output induces the opposite voltages, setting the flip-flop in the opposite state. The D flip-flops on the buffer inputs and the latch on the address lines guard against any transient signals on the input lines of the output buffers which would cause the output to switch.

The Z-BLANK OUT, MARKER OUT, and X-DRIVE OUT rear panel outputs are generated on this board. For a description of these lines, see the signal glossary. The Z-BLANK and MARKER lines are set by bits in the hardware control register. The X-DRIVE output is generated by a 12 bit DAC (U418) that is driven by a 12 bit counter (U415-7). The counter is set by bits in the hardware control register (U412), and has up/down control. U420 makes it possible to stop the counter at zero when the counter is counting down.

The clock source for the X-drive counters, U401 in the timer circuit, is set according to Table 6-42:

Table 6-42. Counter Clock Source Timing

Sweep Time	Timer #2 Count Number	Mode
10 ms − 1 s	(1000 × Sweep Time) − 1	Internal Clock
1 s − 999 s	(10 × Sweep Time) − 1	External Clock

Timer #3 of U401 (O3, pin 6) is in the internal clock mode and always counts to 99. It serves only as the prescaler for timer #2 (O2, pin 3). The outputs of timer #2 and timer #1 (O1, pin 27) are each fed to a D flip-flop and an exclusive OR gate. The output of the timer circuit that is used to clock the X-drive counters is a 1 μs pulse every transition of the output of timer #2. The formula in Table 6-42 requires a count to 1000 for the X-drive, therefore the reference to the DAC is set up for less than full scale (full scale is 1024 counts on the DAC), giving 10.3 V out.

The EXT TRIG IN rear panel input signal is an external means of simulating the HP-IB group execute trigger (GET). It also starts the fractional-N local oscillator $\overline{\text{SWEEP}}$ START signal. (See the signal glossary.) EXT TRIG is a latched signal run to the $\overline{\text{NMI}}$ interrupt line. It is cleared by a bit in the hardware control register.

Instrument bus:

The instrument bus (IBUS0-7) is the microprocessor's communication link to the rest of the instrument. To communicate with another board, the processor first puts the address of the latch to be written to on the bus, using the memory location for the address strobe. Then the data is written into the memory location. To read from the bus the processor puts the address of the latch on the bus and data is read from the data-read address. When the bus is not being used by the processor, it is pulled low by buffer U203. See the instrument bus timing diagram in Figure 6-67.

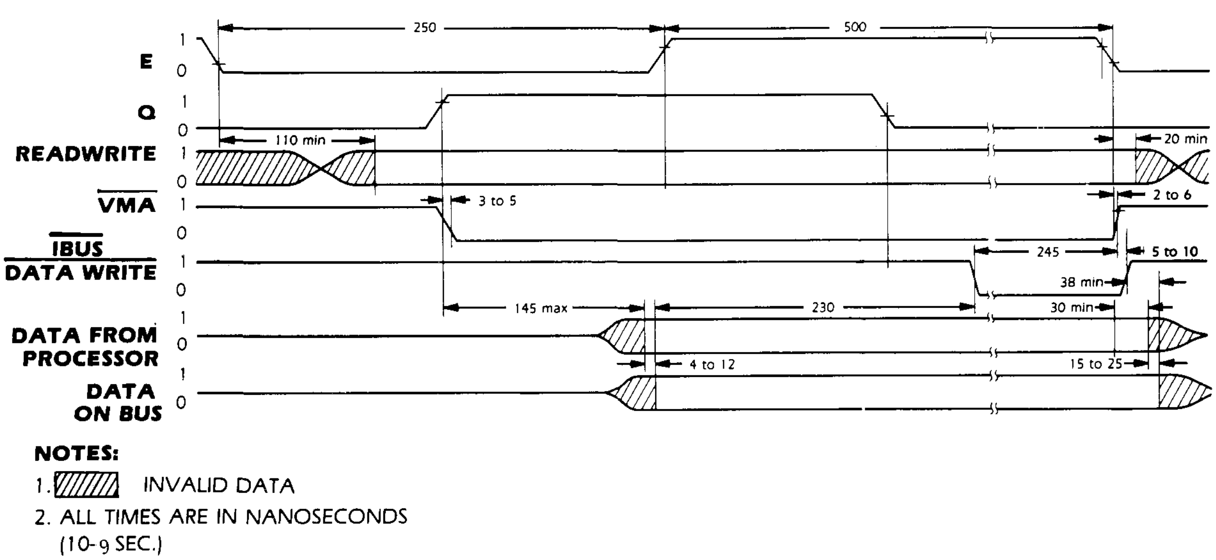


Figure 6-67. Instrument Bus Timing Diagram

S1 switches on the controller board are for the following:

1. Interface SA Test, normally closed
2. X-Drive Test, normally closed
3. SAVE option, normally open (user-selected)
4. Unused

Troubleshooting

For troubleshooting, the controller circuits are divided into four groups. These are:

1. Microprocessor and memory
2. HP-IB circuitry (including HP-IB support board, A63)
3. Keyboard interface circuitry (incuding keyboard, A62)
4. Instrument bus interface (including control interface sub-blocks on other boards)

Group 3 is discussed in keyboard troubleshooting (sub-section 6-34).

1. Microprocessor and memory:

Analyze the microprocessor circuitry using the Free Run SA Test and the Interface SA Test, which follow.

2. HP-IB circuitry:

a. Connect TP28 to TP25. This connects the chassis ground to analog ground so that voltage measurements can be made in either circuit without moving the reference of the voltmeter.

b. Check TP29 for +5 V ±0.25 V (+5V HPIB supply).

c. Check TP13 for a 4 MHz clock (TTL levels).

d. Check TP32 (HPIBRST) for TTL high (normally). This signal is low for a short time after power on.

e. Check U215, pin 9 (HP-IB interrupt; an output) for a signal that goes low periodically during data transfers. If this line is low, check TP1 (the interrupt request line at the processor). It should be low, too. If not, there is a fault in the isolation circuitry for this line.

f. Run the Interface SA Test to test signatures in the HP-IB circuits (see Table 6-51).

3. Keyboard interface circuitry:

See the troubleshooting section for the keyboard (sub-section 6-34).

4. Instrument bus interface:

There are two types of internal bus failures: either one board cannot communicate with the controller or all boards cannot communicate with the controller. In the first case, the problem probably exists in the bus circuitry of the problem board. In the latter case, the problem could be either on the bus circuitry on the controller board or on one of the other boards on the bus. An individual board could fail such that it forces a fixed state on the bus. Pulling all boards and reinstalling them one at a time is recommended for the latter case.

To exercise a board, make front panel entries that change the configuration of the board. The attenuator board is exercised by changing the amplitude; for the fractional-N group, change the instrument output frequency; for the square board and level/AM, select a square wave output; for the calibration circuitry (on A36), press the MANUAL key in the calibration section; for the RF switch, change between the two-channel mode and the two-phase mode.

The instrument bus circuit on the controller board and the control interfaces on the other boards in the instrument can be tested using the Interface SA Test (see Tables 6-52 and 6-53). This test exercises the control lines from the controller board to determine if the controller or the control interface circuitry is defective.

Refer to Table 6-15 for recommended post-repair adjustments.

Signature Analysis Tests

There are two digital signature analysis (SA) tests built into the HP 3326A for troubleshooting digital circuits, the Free Run SA Test and the Interface SA Test. The Free Run SA Test exercises the instrument bus address lines. The Interface SA Test exercises the the RAM circuits, the keyboard, the HP-IB data path, the X-DRIVE control register, the instrument bus (data), the flag and shift registers, and the controller interface circuits on the boards on the instrument bus.

There are two separate ground systems in the instrument, GND and CGND. To assure the correct signatures, connect these together by connecting A61TP25 to A61TP28.

For both SA tests, connect the signature analyzer ground pin to the A61W303 GND pin. When connecting the clock, start, and stop probes, refer to the letters H and L for the proper configuration. L indicates that the signal should be set to trigger on a high-to-low transition and an H indicates that the signal should be set to trigger on a low-to-high transition.

Free Run SA Test

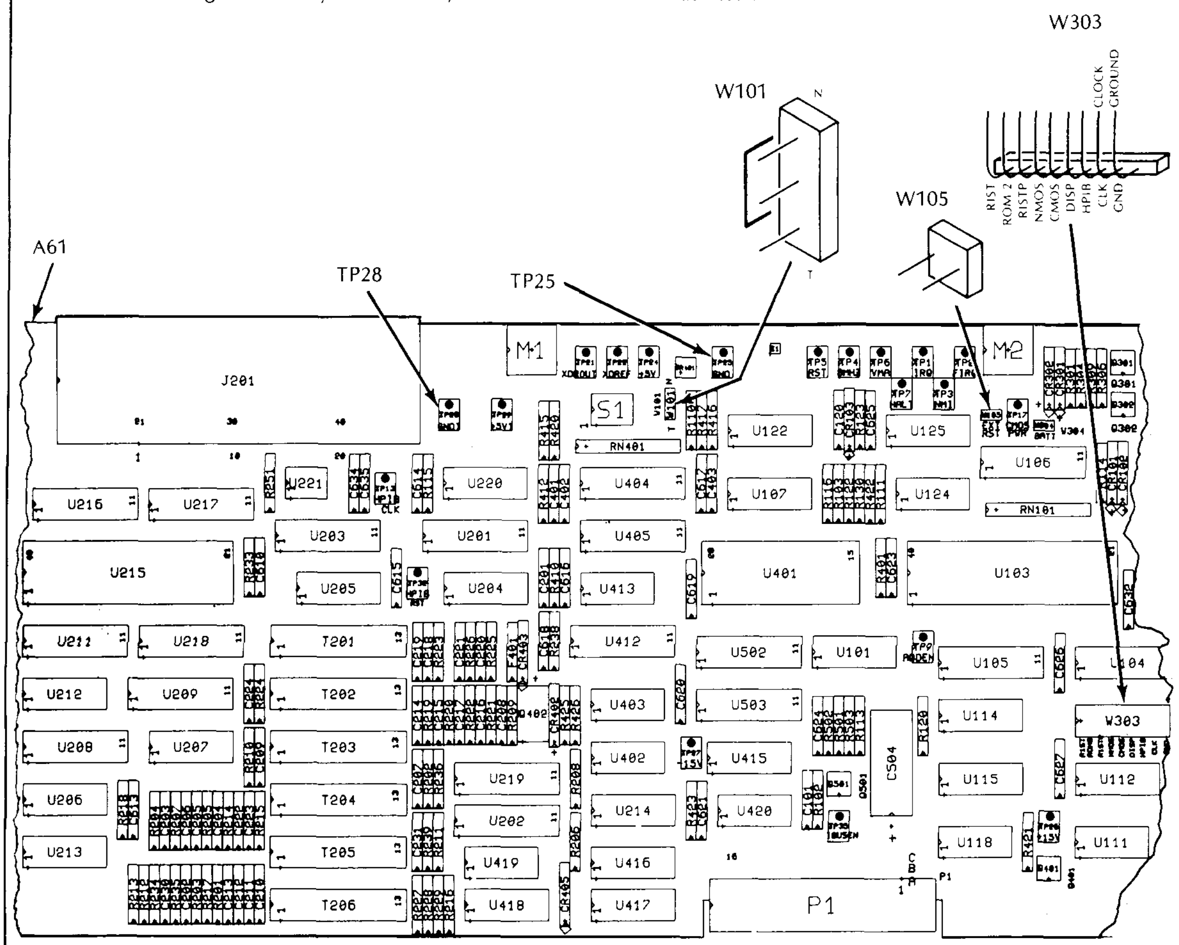
This test does not execute a program in ROM. It lets the processor "free run" only. It is implemented by connecting A61TP25 and A61TP28, moving A61W101 to the "test" position, and resetting the microprocessor (by cycling power or momentarily shorting pins 1 and 2 of A61W105 together), as shown in Figure 6-68. This causes the microprocessor to access memory continuously, from beginning to end (i.e., count up). This sequential counting of the memory addresses continues until A61W101 is returned to the "normal" position and the processor is reset.

NOTE

Moving A61W101 to the "test" position inhibits normal operation of the instrument. Expect a blank display. Be sure to return it to the "normal" position when troubleshooting is complete.

The first time power is turned on after running the SA tests, the error message "ERROR 160 CRPT" appears. All instrument states stored in non-volatile memory are deleted.

- Connect TP25 (GND) to TP28 (GNDI)
- Make sure W101 is in the normal position
- Set switch 1 on S1 to OPEN positin
- Reset processor by momentarily shorting W105 or by cycling power
- Connect signatue analyzer to W303, as described in individual tests



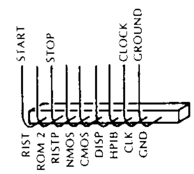
Switches and jumpers are shown in the "normal" position.

Figure 6-68. Free Run SA Test Setup

Testing address lines:

This test may be used to check microprocessor address lines and address buffers (A61U104 and A61U105). If an incorrect signature is found on the buffer output, check the corresponding pin on the buffer input. The signature should be the same at the input and output.

Connections to the SA connector, A61W303:



Clock to CLK (**L**)
Start to **R1ST** (**L**)
Stop to **R1STP** (**L**)

Probe +5V; signature should read **0003**

Table 6-43. Address Line Signatures

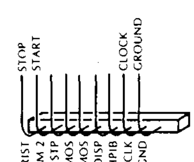
Signal Name	Schematic Number	A61 IC (pin)	Signature
A15	14a	U104 (18)	0001
A14	14a	U104 (3)	9UP1
A13	14a	U104 (16)	4868
A12	14a	U104 (5)	4FCA
A11	14a	U104 (14)	6U28
A10	14a	U104 (7)	37C5
A9	14a	U104 (12)	6321
A8	14a	U104 (9)	7791
A7	14a	U105 (9)	6F9A
A6	14a	U105 (12)	U759
A5	14a	U105 (7)	O356
A4	14a	U105 (14)	1U5P
A3	14a	U105 (5)	P763
A2	14a	U105 (16)	8484
A1	14a	U105 (3)	FFFF
A0	14a	U105 (18)	UUUU

Testing ROMs:

These tests check the contents of the instrument ROM ICs. Since the address lines are changing in a stable manner, the ROM outputs are predictable. The pins given in Tables 6-44 and Table 6-45 are for these ROM outputs. The same signatures should appear on the corresponding lines of the buffer A61U304.

ROM1 signatures:

Connections to the SA connector, A61W303:



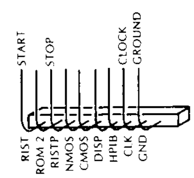
Clock to CLK (**H**)
Start to **ROM2** (**L**)
Stop to **R1ST** (**H**)
Probe +5V; signature should read **5804**

Table 6-44. ROM1 Signatures

Signal Name	Schematic Number	A61 IC (pin)	Signature
PD7	14a	U305 (19)	5U28
PD6	14a	U305 (18)	CCAU
PD5	14a	U305 (17)	3A45
PD4	14a	U305 (16)	C038
PD3	14a	U305 (15)	0396
PD2	14a	U305 (13)	HHFH
PD1	14a	U305 (12)	PA2P
PD0	14a	U305 (11)	A8UO

ROM2 signatures:

Connections to the SA connector, A61W303:



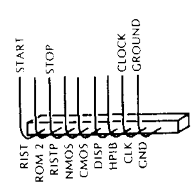
Clock to CLK (**H**)
Start to **R1ST** (**H**)
Stop to **R1STP** (**L**)
Probe +5V; signature should read **0001**

Table 6-45. ROM2 Signatures

Signal Name	Schematic Number	A61 IC (pin)	Signature
PD7	14a	U306 (19)	0363
PD6	14a	U306 (18)	HH1A
PD5	14a	U306 (17)	F993
PD4	14a	U306 (16)	38U9
PD3	14a	U306 (15)	A85P
PD2	14a	U306 (13)	APF9
PD1	14a	U306 (12)	615C
PD0	14a	U306 (11)	568U

I/O enable signatures:

Connections to the SA connector, A61W303:



Clock to CLK (**H**)
Start to **R1ST** (**L**)
Stop to **R1STP** (**L**)
Probe +5V; signature should read **0003**

Table 6-46. I/O Enable Signatures

Signal Name	Schematic Number	A61 IC (pin)	Signature
ROM1	14a	U305 (20)	0002
ROM2	14a	U306 (20)	C00A
CMOS RAM	14a	U302 (20)	2F1U
NMOS RAM	14a	U303 (20)	PF63
MEMENABLE	14a	U304 (19)	7077
TIMER SELECT	14a	U114 (7)	C158
X-DRIVE CONTROL	14a	U114 (9)	4AA2
	14a	U114 (10)	7627
	14a	U114 (11)	3888
IBUS ACTIVE	14a	U102 (6)	4549
IBUS DATA READ	14a	U114 (12)	0CP6
X-DRIVEFS	14a	U114 (13)	P1C5
	14a	U114 (14)	C835
HPIBSTSP	14a	U114 (15)	P29P
CLEARMSFLG	14a	U115 (7)	A837
READFLAGS	14a	U115 (9)	C4U3
READSWITCHES	14a	U115 (10)	U9A8
HPIBWRITE	14a	U115 (11)	3328
HPIBREAD	14a	U115 (12)	457U
DISPSTB	14a	U115 (13)	0352
	14a	U111 (12)	0351
	14a	U115 (14)	F91C
	14a	U115 (15)	2FA8
DATA STROBE	14b	U118 (1)	0CP6
	14c	U208 (1)	5682
	14c	U213 (7)	5682
	14c	U213 (13)	457F

Interface SA Test

This test executes a program in memory that exercises all important input and output registers. It is implemented by connecting TP25 and TP28, setting switch 1 on A61S1 to the OPEN position, and resetting the microprocessor (by cycling power or momentarily shorting pins 1 and 2 of A61W105 together), as shown in Figure 6-69.

NOTE

The first time power is turned on after running the SA tests, the error message "ERROR 160 CRPT" appears. All instrument states stored in non-volatile memory are deleted.

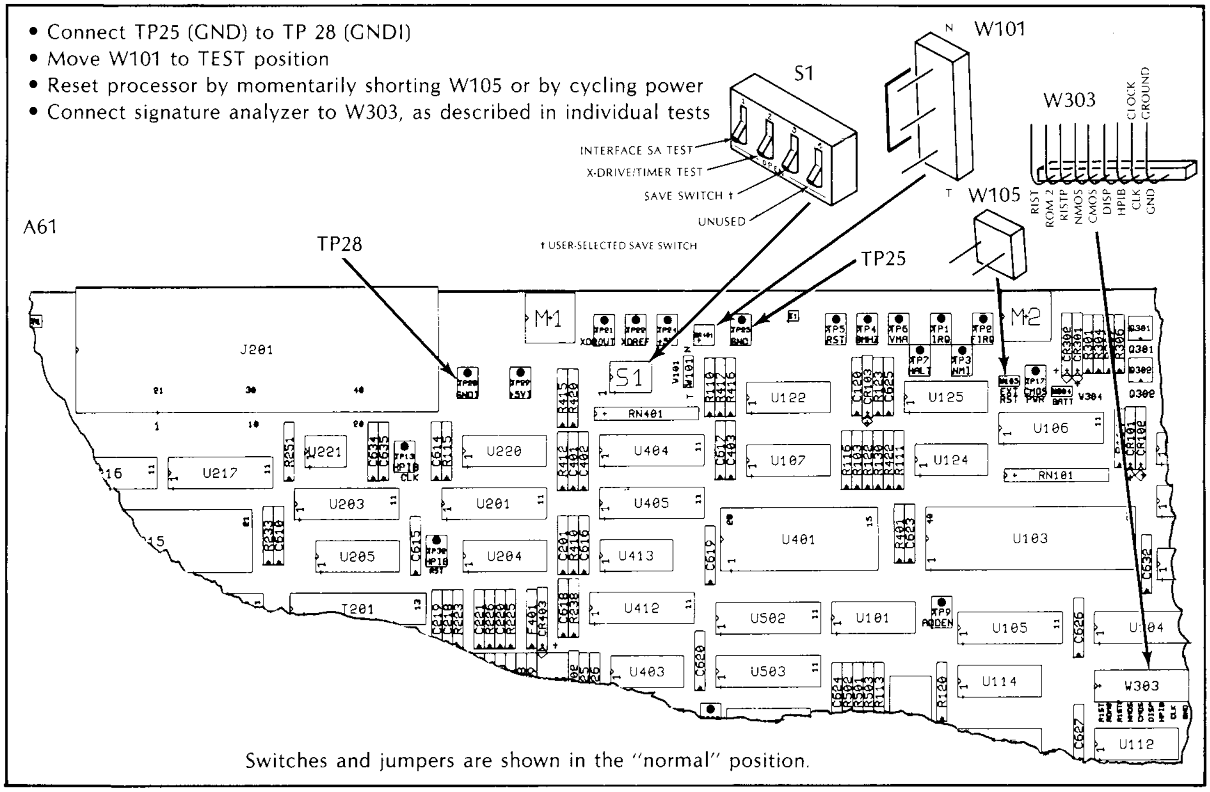
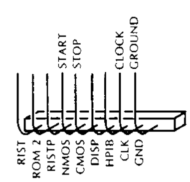


Figure 6-69. Interface SA Test Setup

NMOS RAM signatures:

These signatures are shown in the table as being taken on the main processor IC. They also appear on the corresponding lines of A61U106, the data bus buffer, and A61U304.

Connections to the SA connector, A61W303:



Clock to CLK (**H**)
Start to **NMOS** (**L**)
Stop to **CMOS** (**L**)
Probe +5V; signature should read **4824**

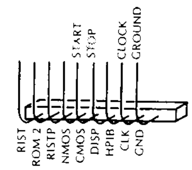
Table 6-47. NMOS RAM Signatures

Signal Name	Schematic Number	A61 IC (pin)	Signature
PD7	14a	U103 (24)	9CUF
PD6	14a	U103 (25)	6CPH
PD5	14a	U103 (26)	A225
PD4	14a	U103 (27)	4CU9
PD3	14a	U103 (28)	9A36
PD2	14a	U103 (29)	PFA4
PD1	14a	U103 (30)	AAA6
PD0	14a	U103 (31)	9H5H

CMOS RAM signatures:

These signatures are shown in the table as being taken on the main processor IC. They also appear on the corresponding lines of A61U106, the data bus buffer, and A61U304.

Connections to the SA connector, A61W303:



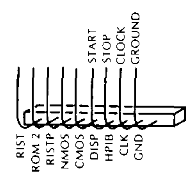
Clock to CLK (**H**)
Start to **CMOS** (**L**)
Stop to **DISP** (**L**)
Probe +5V; signature should read **4824**

Table 6-48. CMOS RAM Signatures

Signal Name	Schematic Number	A61 IC (pin)	Signature
PD7	14a	U103 (24)	9CF3
PD6	14a	U103 (25)	6CFF
PD5	14a	U103 (26)	A239
PD4	14a	U103 (27)	58H0
PD3	14a	U103 (28)	76H6
PD2	14a	U103 (29)	PFCC
PD1	14a	U103 (30)	AACA
PD0	14a	U103 (31)	9H60

Keyboard shift register signatures:

Connections to the SA connector, A61W303:



Clock to CLK (**H**)
Start to **DISP** (**L**)
Stop to **HPIB** (**L**)
Probe +5V; signature should read **A245**

The signatures shown in Table 6-49 represent the serial signals going to and coming from the keyboard (A62). KB DATA is data from the keyboard to the controller board. FP DATA is data from the controller board to the keyboard. Pressing any key or turning the knob changes the KB DATA signature. A key that is stuck does not cause a signature change. If the KB DATA signature is wrong and the FP DATA signature is correct, the keyboard is probably defective.

Table 6-49. Keyboard Signatures From the Controller Board

Signal Name	Schematic Number	A61 IC (pin)	Signature
KB DATA	14a	U108 (11)	UFH2
FP DATA	14a	U107 (9)	4H68

The signatures in Table 6-50 may be taken on the keyboard (A62). The connections to A61W303 are the same as previously described. These signatures do not test A61U108. If these signatures are correct (as well as the signature on A61U115 (14) described in the I/O enable tests), and the display works, but keypresses are not recognized by the instrument, suspect that A61U108 is defective.

To access the keyboard, turn off the power and remove the screws that hold it in place from the top and bottom of the instrument frame. Pull gently on the CH A and CH B connectors to separate the keyboard and dress panel from the instrument. Access the test points and IC pins from the circuit side of the board. All ICs have square pads on pin 1 to help you locate the test pin locations.

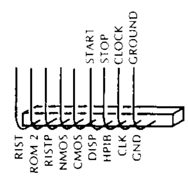
Table 6-50. Keyboard Signatures

Signal Name	Schematic Number	A62 IC (pin)	Signature
FP DATA	15	U1 (2)	4H68
	15	U3 (2)	PHC9
	15	U2 (2)	UAF3
	15	U4 (2)	PF82
	15	U5 (2)	H61U
	15	U7 (11)	FA3U

HP-IB signatures:

These signature tests check the HP-IB IC and the isolation circuitry. Before performing these tests, remove all external HP-IB cable connections from the rear panel.

Connections to the SA connector, A61W303:



Clock to CLK **(H)**
Start to **DISP** **(H)**
Stop to **HPIB** **(H)**
Probe +5V; signature should read **A245**

Table 6-51. HP-IB Signatures

Signal Name	Schematic Number	A61 IC (pin)	Signature
HPIBRST	14c	U215 (19)	1564
RS0	14c	U215 (6)	H292†
RS1	14c	U215 (7)	4322†
RS2	14c	U215 (8)	CU78†
H7	14c	U215 (17)	P483
H6	14c	U215 (16)	118U
H5	14c	U215 (15)	5263
H4	14c	U215 (14)	1HAU
H3	14c	U215 (13)	C023
H2	14c	U215 (12)	85F7
H1	14c	U215 (11)	761C
H0	14c	U215 (10)	2189

† If any of these signatures are incorrect, check for the same signature at U220 (7, 5, 2).

Instrument bus:

Connections to the SA connector, A61W303:

Clock to CLK (**H**)
Start to **DISP** (**L**)
Stop to **HPIB** (**L**)
Probe +5V; signature should read **A245**

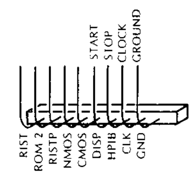


Table 6-52. Instrument Bus Signatures

Signal Name	Schematic Number	A61 IC (pin)	Signature
A1	14b	U502 (2)	5FAF
A2	14b	U502 (3)	H858
A3	14b	U502 (4)	A7PH
A4	14b	U502 (5)	C3UA
A5	14b	U502 (6)	10HA
A6	14b	U502 (7)	8HH2
A7	14b	U502 (8)	U0C6
A8	14b	U502 (9)	6C07

Boards on the instrument bus which have write latches may be tested using this SA test. The information in Table 6-53 may be used to troubleshoot the digital portions of boards identified by the service self tests as potentially defective. This helps determine if the control signal from the controller board is defective or if the controller interface circuitry on the suspect board is defective. Begin taking signatures on the suspect board; if the signatures are incorrect, work back through the circuit toward the controller, taking signatures, until good signatures are found. Use the schematics and the following table.

Table 6-53. Signatures for Boards on the Instrument Bus

Board Number	Board Name	Signal Name	Schematic Number	Test Location IC (pin)	Signature
A2	Channel A Attenuator	10dB	2a	U100 (3)	F168
		20dB		U100 (1)	C8H8
		40dB		U100 (2)	06F6
		COMBINER (A+B)		U100 (4)	U021
		HI-VOLTAGE OPTION		U100 (6)	244H
		CAL/PRTCT		U100 (7)	5369
		$\overline{\text{A PROTECTCLEAR}}$		U102 (13)	34H4
A12	Channel B Attenuator	10dB	2b	U100 (3)	2PFF
		20dB		U100 (1)	1UF7
		40dB		U100 (2)	4C4C
		COMBINER (A+B)		U100 (4)	U7A5
		HI-VOLTAGE OPTION		U100 (6)	A4A4
		CAL/PRTCT		U100 (7)	A1HP
		$\overline{\text{B PROTECTCLEAR}}$		U102 (13)	1971
A3	Channel A Output Amp	A PRE10dB	3	P1 (13C)	95CF
A13	Channel B Output Amp	B PRE10dB	3	P1 (13C)	A324
A4	Channel A Preamp	$\overline{\text{A SIN}}$	4	TP2	8687
A14	Channel B Output Amp	$\overline{\text{B SIN}}$	4	TP2	0811
A21	Offset	D0	7	U3 (12)	FP34
		D1		U3 (11)	12F7
		D2		U3 (10)	1FC0
		D3		U3 (9)	C7C3
		D4		U3 (8)	HH19
		D5		U3 (7)	UP03
		D6		U3 (6)	C1FC
		D7		U3 (5)	3FH8
		D8		U3 (4)	2CP1
		D9		U3 (3)	A7AC
		D10		U3 (2)	1088
		D11		U3 (1)	83P5
		A OFFSET DRIVE		U5 (2)	0H01
		D0		U23 (12)	4259
		D1		U23 (11)	1F49
		D2		U23 (10)	P5HP
		D3		U23 (9)	1F20
		D4		U23 (8)	CC9P
		D5		U23 (7)	C1C7
		D6		U23 (6)	HUC5
		D7		U23 (5)	786P

Table 6-53. Signatures for Boards on the Instrument Bus (Cont'd)

Board Number	Board Name	Signal Name	Schematic Number	Test Location IC (pin)	Signature
		D8		U23 (4)	28C1
		D9		U23 (3)	8H3C
		D10		U23 (2)	2U52
		D11		U23 (1)	6AUA
		B OFFSET DRIVE		U5 (1)	5UAC
		A 10dB		U45 (16)	F168
		A 20dB		U45 (2)	C8H8
		A 40dB		U45 (5)	06F6
		$\overline{\text{A CAL}}$		U45 (6)	5369
		A PRE10dB		U45 (12)	95CF
		A HI-VOLT		U45 (19)	244H
		A A+B		U45 (9)	U021
		$\overline{\text{A PROTECTCLEAR}}$		U45 (15)	34H4
		B 10dB		U46 (16)	2PFF
		B 20dB		U46 (2)	1UF7
		B 40 dB		U46 (5)	4C4C
		$\overline{\text{B CAL}}$		U46 (6)	A1HP
		B PRE10dB		U46 (12)	A324
		B HI-VOLT		U46 (19)	A4A4
		B A+B/MOD		U46 (9)	U7A5
		$\overline{\text{B PROTECTCLEAR}}$		U46 (15)	1971
A22	**Level/AM**	D0	8	U4 (12)	9618
		D1		U4 (11)	H3CH
		D2		U4 (10)	C1AF
		D3		U4 (9)	4134
		D4		U4 (8)	7A88
		D5		U4 (7)	CCF6
		D6		U4 (6)	13U6
		D7		U4 (5)	P45F
		D8		U4 (4)	F611
		D9		U4 (3)	32A0
		D10		U4 (2)	AHHH
		D11		U4 (1)	58CA
		$\overline{\text{A SIN}}$		U11 (2)	8687
		$\overline{\text{A COMPAR ENABLE}}$		U5 (8)	6066
		(A EXT AM)		U2 (16)	PA25
		(A INT AM)		U2 (1)	FFAC
		(A AM)		U2 (8)	PA25
		D0		U8 (12)	UF5P
		D1		U8 (11)	75A1
		D2		U8 (10)	HH83
		D3		U8 (9)	A6A9

Table 6-53. Signatures for Boards on the Instrument Bus (cont'd)

Board Number	Board Name	Signal Name	Schematic Number	Test Location IC (pin)	Signature
		D4		U8 (8)	8737
		D5		U8 (7)	68UU
		D6		U8 (6)	0C44
		D7		U8 (5)	H59F
		D8		U8 (4)	HFP8
		D9		U8 (3)	985U
		D10		U8 (2)	UP4P
		D11		U8 (1)	P457
		$\overline{\text{B SIN}}$		U10 (2)	0811
		$\overline{\text{B COMPAR}}$ $\overline{\text{ENABLE}}$		U9 (8)	2F00
		(B AM)		U6 (1)	F902
		SQUARE/$\overline{\text{PULSE}}$		U10 (9)	02HA
A32	**Channel A VCO Control**	A PMC	11b	U22 (9)	UHU7
		$\overline{\text{A PMCAL}}$		U22 (8)	FPFF
		A PMS		U21 (9)	PH10
A42	**Channel B VCO Control**	B PMC	11b	U22 (9)	F8HF
		$\overline{\text{B PMCAL}}$		U22 (8)	75P7
A33	**Channel A Phase Detector**	A PMC	11c	U21 (2)	UCPP
A43	**Channel B Phase Detector**	B PMC	11c	U21 (2)	HU55
A34	**Channel A FracN Digital**	DATA3	11d	U19 (3)	C3UA
		DATA2		U19 (13)	A7PH
		DATA1		U19 (11)	H858
		DATA0		U19 (5)	5FAF
A44	**Channel B FracN Digital**	DATA3	11d	U19 (3)	C3UA
		DATA2		U19 (13)	A7PH
		DATA1		U19 (11)	H858
		DATA0		U19 (5)	5FAF
A36	**FracN Decoder**	A PMC	11f	U4 (12)	UCPP
		B PMC		U4 (15)	HU55
		$\overline{\text{A PMS}}$		U4 (7)	PH10
		$\overline{\text{A PMCAL}}$		U4 (5)	9H99
		$\overline{\text{B PMCAL}}$		U4 (10)	3689
		A SWPL		U3 (12)	P557
		B SWPL		U3 (7)	C92P
		HSSE		U3 (15)	PCC9
		HETE		U3 (5)	542H

Table 6-53. Signatures for Boards on the Instrument Bus (cont'd)

Board Number	Board Name	Signal Name	Schematic Number	Test Location IC (pin)	Signature
A36	Calibrator	K1 DRIVER	12	U13 (3)	2119
		K2 DRIVER		U13 (4)	C751
		K3 DRIVER		U13 (5)	A6U4
		K4 DRIVER		U13 (6)	5930
		K5 DRIVER		U13 (7)	F7FU
				U16 (4)	C5HP
				U16 (6)	9FU3
				U16 (17)	82C9
				U16 (15)	UFCP
				U16 (13)	6061
				U16 (2)	6F06
				U16 (8)	7645
				U16 (11)	2483

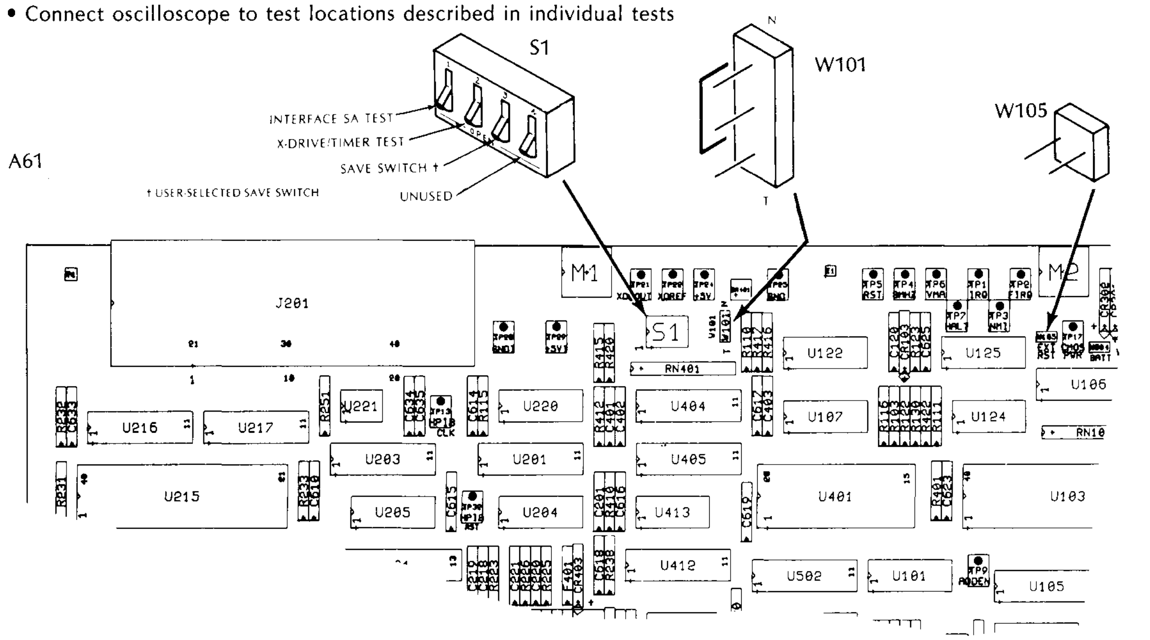
X-Drive Test

This test executes a program in memory that exercises the X-Drive sub-block on the controller board. It is implemented by setting switch 2 on A61S1 to the OPEN position and resetting the microprocessor (by cycling power or momentarily shorting pins 1 and 2 of A61W105 together), as shown in Figure 6-70.

NOTE

The first time power is turned on after running the SA tests, the error message "ERROR 160 CRPT" appears. All instrument states stored in non-volatile memory are deleted.

- Make sure W101 is in the normal position
- Set switch 2 on S1 to OPEN position
- Reset processor by momentarily shorting W105 or by cycling power
- Connect oscilloscope to test locations described in individual tests



Switches and jumpers are shown in the "normal" position.

Figure 6-70. X-Drive Test Setup

The X-Drive sub-block is enabled to ramp from 0 to 10 V and reset without requiring a sweep flag from the local oscillators. This allows the X-Drive circuit to be exercised for troubleshooting. Connect the oscilloscope to A61TP21 (XDROUT). The waveform should match Figure 6-71.

Oscilloscope Setup (#1)

1:1 probe

Ch 1 coupling	DC
Ch 1 V/div	5 V
Time/div	200 ms
Trigger	Ch 1

Oscilloscope Setup (#2)

1:1 probe

Ch 1 coupling	DC
Ch 1 V/div	5 V
Time/div	10 ms
Trigger	Ch 1

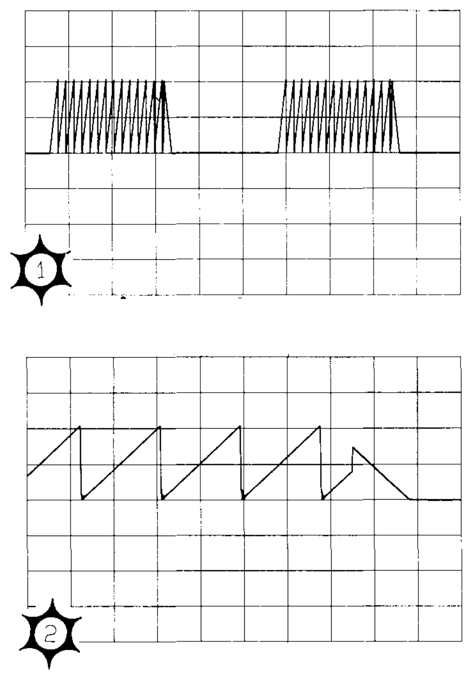


Figure 6-71. X-Drive Test Waveforms

Glossary of Internal Signal Names

1MS INTFLAG (1 MS INTerrupt FLAG) from the timer and display interrupt. Active low.

ADDCLK (ADDress CLocK) latches in A0, A1, and A2 for the HP-IB circuits

ADDEN (ADDress ENable) TP9.

ADDRESS BUS Microprocessor address lines A0 through A15.

A LATCHSWPLMT (Channel A LATCHed SWeeP LiMiT flag) The latched version of A SWEEP LIMIT. See signal glossary.

B LATCHSWPLMT (Channel B LATCHed SWeeP LiMiT flag. The latched version of B SWEEP LIMIT. See signal glossary.

CLEARMSFLG (CLEAR 1 MS timer FLaG) When the millisecond timer interrupts the microprocessor, it also sets an SR flip-flop. This flip-flop can be polled to verify that the millisecond timer generated the interrupt.

CLR A SWEEPLIMIT (CLeaR channel A SWEEP LIMIT flag) A low TTL signal; clears and disables the channel A sweep limit flag to the microprocessor.

CLR B SWEEPLIMIT (CLeaR channel B SWEEP LIMIT flag) A low TTL signal clears and disables the channel B sweep limit flag to the microprocessor.

CLREXTTRIG (CLeaR EXTernal TRIGger) A low TTL signal clears and enables the external trigger input. Located in X-DRIVE control register.

CLR X-DRIVE (CLeaR X-DRIVE) Sets the X-DRIVE counter to zero. Set by X-DRIVE control register.

CMOS RAM (CMOS RAM chip select) This signal selects the nonvolatile CMOS memory that occupies the address space 1000H to 17FFH.

DISPLCLK (DISPLay shift CLocK) Started by memory access. TP10.

DISPSTB (DISPlay STroBe) See STROBE in the signal glossary. TP11.

E (E clock) Signal is generated by the microprocessor and used to time all internal events. The signal is also used for the internal timing of the timer chip (U401).

ENABLE COUNT (Enables the counting of the X-drive counter) Also controls Z-BLANK.

FIRQ (Fast Interrupt ReQuest) Used for the 1 ms display timer. The timer sends out a 1 μs pulse every 1 ms. This pulse sets the 1MS INTFLAG line low. TP2.

HPIBCLK (HP-IB CLocK) 4 MHz clock for the HP-IB chip (U215). Derived from the 8MHz PROC CLK signal from the reference board (A50). TP13.

HPIBINT (Interrupt line from HP-IB chip U125) Set low on HP-IB operation interrupts.

HPIBREAD (HP-IB READ) A high TTL signal allows a read from the HP-IB chip.

HPIB RESET This signal supplies a harware reset signal to the HP-IB chip (U215).

HPIBSTSP (HP-IB STart STop) Used in SA test 1. Enables NMIs. Toggles the working LED.

HPIBWRITE (HP-IB WRITE) A low TTL signal allows a write to the HP-IB chip.

IBUS ACTIVE (Instrument BUS ACTIVE) A low signal enables the instrument bus.

IBUS DATA READ (Instrument BUS DATA READ) A low pulse allows a read from the instrument bus.

IBUS DATA WRITE (Instrument BUS DATA WRITE) A low pulse allows a write to the instrument bus.

IRQ (Interrupt ReQuest) Used to signal the processor when the HP-IB chip needs to talk. TP1.

MEMENABLE (MEMory ENABLE) Enables the ROM and RAM buffer.

NMI (Non-Maskable Interrupt) Fastest processor interrupt. Used for channel A and channel B sweep limit signals (A SWEEP LIMIT and B SWEEP LIMIT) and external trigger (EXT TRIG IN). TP3.

NMI ENABLE (NMI interrupt ENABLE) The hardware enable for NMI.

NMOS RAM (NMOS RAM chip select) This signal selects the NMOS memory.

PROCESSOR DATA BUS Data bus from U103 (microprocessor).

Q (Q clock) Clock signal generated by the microprocessor.

READFLAGS (READ FLAGS strobe) This signal permits the processor to read the status flags latch.

READSWITCHES (READ DIP SWITCHES strobe) This signal permits the pocessor to read the DIP.

READWRITE (READ/WRITE) Buffered version of the R/W line from the microprocessor. A logical high indicates that the processor is reading data; a logical low indicates that the processor is writing data.

RST LVL (ReSeT LeVeL) Approximately 4.5 V. Sets the power-down reset trip level. TP8.

TIMER SELECT (programmable TIMER SELECT) This signal selects the programmable timer chip (U401) to either be written to or read by the microprocessor.

X-DRIVE CONTROL (X-DRIVE CONTROL register strobe) Permits the microprocessor to write to the X-drive control register.

X-DRIVEFS (X-DRIVE Full Scale) Sets the X-drive counter to 1000 (10 V out).

XDREF (X-Drive REFerence voltage) approximately 10.3 V. TP22

XDROUT (X-DRive OUTput) 0-10 volts when sweeping. TP21

$\overline{\text{VMA}}$ (Valid Memory Address) The logical OR of the E and Q signals from the microprocessor. When $\overline{\text{VMA}}$ is low, the address lines from the microprocessor are valid, and they can be used for decoding the ROM, RAM and I/O signals. TP6.

Table 6-54 HP-IB SUPPORT CONNECTION TABLE

CONTROLLER A61 J201		HP-IB SUPPORT A63	
PINS	SIGNAL NAME	TO	FROM
1	$\overline{\text{Z BLANK}}$	►	
2	MARKER	►	
3	EXT TRIG		◄
4	X-DRIVE	►	
5	$\overline{\text{REN}}$	►	◄
6	$\overline{\text{IFC}}$	►	◄
7	$\overline{\text{NDAC}}$	►	◄
8	$\overline{\text{NRFD}}$	►	◄
9	$\overline{\text{DAV}}$	►	◄
10	$\overline{\text{EOI}}$	►	◄
11	$\overline{\text{ATN}}$	►	◄
12	$\overline{\text{SRQ}}$	►	◄
13	$\overline{\text{DIO8}}$	►	◄
14	$\overline{\text{DIO7}}$	►	◄
15	$\overline{\text{DIO6}}$	►	◄
16	$\overline{\text{DIO5}}$	►	◄
17	$\overline{\text{DIO4}}$	►	◄
18	$\overline{\text{DIO3}}$	►	◄
19	$\overline{\text{DIO2}}$	►	◄
20	$\overline{\text{DIO1}}$	►	◄
21	Z-BLANK	►	
22	MARKER	►	
23	EXT TRIG		◄
24	X-DRIVE	►	
25	+15V	►	
26	+15V	►	
27	GND	►	
28	GND	►	
29	GND	►	
30	GND	►	
31	GND	►	
32	GND	►	
33	CGND	►	
34	CGND	►	
35	CGND	►	
36	CGND	►	
37	CGND	►	
38	CGND	►	
39	CGND	►	
40	CGND	►	

Table 6-55 KEYBOARD CONNECTION TABLE

CONTROLLER A61 J104		KEYBOARD A62	
PINS	SIGNAL NAME	TO	FROM
1	GND	►	
2	GND	►	
3	−15V	►	
4	GNDFP	►	
5	STANDBY		◄
6	KB DATA		◄
7	DISPLCLK	►	
8	FP DATA	►	
9	$\overline{\text{EXT REF FLAG}}$	►	
10	STROBE	►	
11	A AMPCO †	►	
12	+5VFP	►	
13	$\overline{\text{SYNC OVLD}}$		◄
14	+15V	►	
15	+5V	►	
16	+5V	►	

† Signal trace is shielded on the motherboard by ground traces.

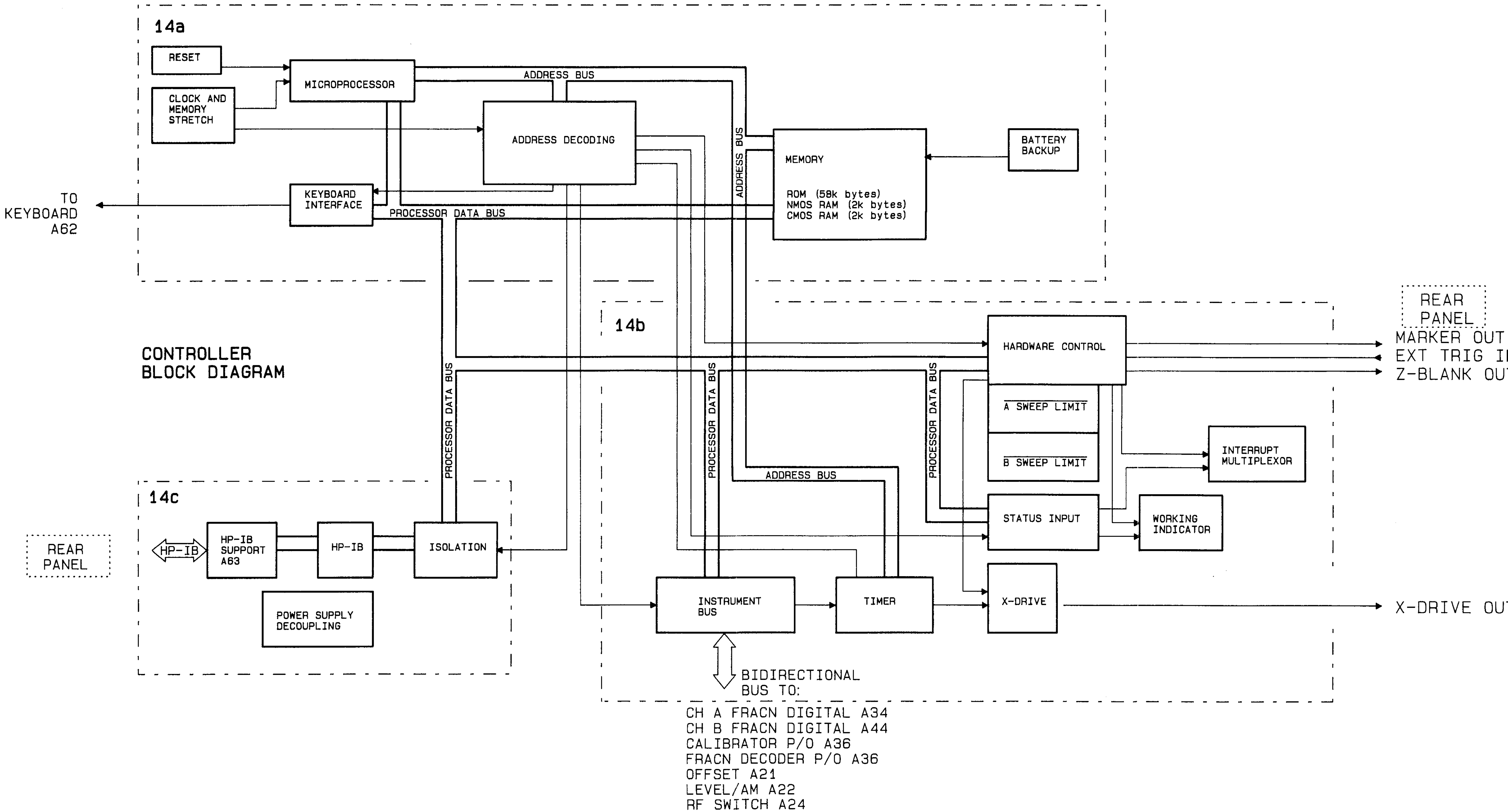
Table 6-56 MOTHERBOARD CONNECTION TABLE

CONNECTOR P501			DESTINATION		SCHEMATIC NUMBER	
Pin	Signal Name	Schematic Number	Board Name	Reference Designator	To	From
A1	IBUS0	14b	OFFSET	A21	7 ►	◄ 7
			LEVEL/AM	A22	8 ►	◄ 8
			RF SWITCH	A24	10 ►	◄ 10
			CH A FRACN DIGITAL	A34	11d ►	◄ 11d
			CH B FRACN DIGITAL	A44	11d ►	◄ 11d
			FRACN DECODER	P/O A36	11f ►	◄ 11f
			CALIBRATOR	P/O A36	12 ►	◄ 12
B1	IBUS4	14b	OFFSET	A21	7 ►	◄ 7
			LEVEL/AM	A22	8 ►	◄ 8
			CH A FRACN DIGITAL	A34	11d ►	◄ 11d
			CH B FRACN DIGITAL	A44	11d ►	◄ 11d
			FRACN DECODER	P/O A36	11f ►	◄ 11f
			CALIBRATOR	P/O A36	12 ►	◄ 12
C1	IBUS7	14b	OFFSET	A21	7 ►	◄ 7
			LEVEL/AM	A22	8 ►	◄ 8
			CALIBRATOR	P/O A36	12 ►	◄ 12
A2	IBUS1	14b	OFFSET	A21	7 ►	◄ 7
			LEVEL/AM	A22	8 ►	◄ 8
			CH A FRACN DIGITAL	A34	11d ►	◄ 11d
			CH B FRACN DIGITAL	A44	11d ►	◄ 11d
			FRACN DECODER	P/O A36	11f ►	◄ 11f
			CALIBRATOR	P/O A36	12 ►	◄ 12
B2	IBUS5	14b	OFFSET	A21	7 ►	◄ 7
			LEVEL/AM	A22	8 ►	◄ 8
			CH A FRACN DIGITAL	A34	11d ►	◄ 11d
			CH B FRACN DIGITAL	A44	11d ►	◄ 11d
			FRACN DECODER	P/O A36	11f ►	◄ 11f
			CALIBRATOR	P/O A36	12 ►	◄ 12
C2	ADD STROBE	14b	OFFSET	A21	7 ►	
			LEVEL/AM	A22	8 ►	
			FRACN DECODER	P/O A36	11f ►	
A3	IBUS2	14b	OFFSET	A21	7 ►	◄ 7
			LEVEL/AM	A22	8 ►	◄ 8
			CH A FRACN DIGITAL	A34	11d ►	◄ 11d
			CH B FRACN DIGITAL	A44	11d ►	◄ 11d
			FRACN DECODER	P/O A36	11f ►	◄ 11f
			CALIBRATOR	P/O A36	12 ►	◄ 12
B3	IBUS6	14b	OFFSET	A21	7 ►	◄ 7
			LEVEL/AM	A22	8 ►	◄ 8
			CALIBRATOR	P/O A36	12 ►	◄ 12
C3	DATA STROBE	14b	OFFSET	A21	7 ►	
			LEVEL/AM	A22	8 ►	
			FRACN DECODER	P/O A36	11f ►	
			CALIBRATOR	P/O A36	12 ►	
A4	IBUS3	14b	OFFSET	A21	7 ►	◄ 7
			LEVEL/AM	A22	8 ►	◄ 8
			CH A FRACN DIGITAL	A34	11d ►	◄ 11d
			CH B FRACN DIGITAL	A44	11d ►	◄ 11d
			FRACN DECODER	P/O A36	11f ►	◄ 11f
			CALIBRATOR	P/O A36	12 ►	◄ 12

MOTHERBOARD CONNECTION TABLE (Cont'd)

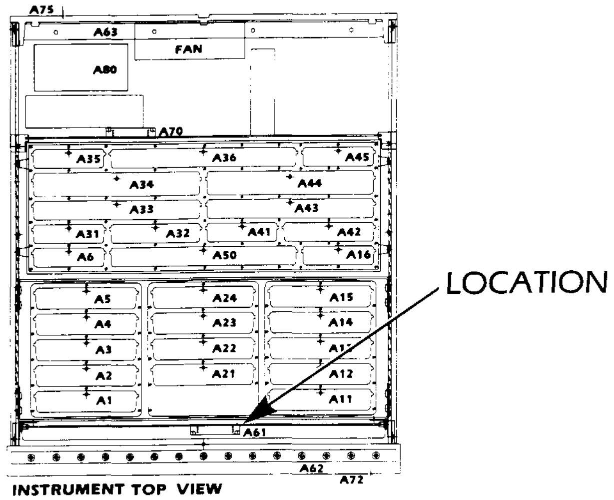
CONNECTOR P501			DESTINATION		SCHEMATIC NUMBER	
Pin	Signal Name	Schematic Number	Board Name	Reference Designator	To	From
B4	ANALOG FAULT	14b	OFFSET CH A VCO CONTROL CH B VCO CONTROL	A21 A32 A42		◄ 7 ◄ 11b ◄ 11b
C4	RESET	14b	OFFSET LEVEL/AM FRACN DECODER CALIBRATOR	A21 A22 P/O A36 P/O A36	7 ► 8 ► 11f ► 12 ►	
A5 B5	B SWEEP LIMIT GNDFP	14b 14a	CH B FRACN DIGITAL POWER SUPPLY	A44 A70		◄ 11d ◄ 16
C5	SWEEP START	14b	FRACN DECODER	P/O A36		◄ 11f
A6	REF LOOP UNLOCKED	14b	REFERENCE	A50		◄ 13
B6	NOT EXT REF FLAG	14b	REFERENCE	A50		◄ 13
C6	+5VFP	14c	POWER SUPPLY	A70		◄ 16
A7 B7 C7	+15V	14c	POWER SUPPLY	A70		◄ 16
A8 B8 C8	−15V	14c	POWER SUPPLY	A70		◄ 16
A9 B9 C9 A10 B10 C10	+5V	14c	POWER SUPPLY	A70		◄ 16
A11 B11 C11 A12 B12 C12	GND	14c				
A13	A SWEEP LIMIT	14b	CH A FRACN DIGITAL	A34		◄ 11d
B13 C13	+5V HPIB	14c	POWER SUPPLY	A70		◄ 16
A14 B14 C14	CGND	14c	POWER SUPPLY	A70		◄ 16
A15	GND	14c				
B15	A HVFLAG	14b	CH A HV AMP	A1		◄ 1
C15	STANDBY	14b	POWER SUPPLY	A70	► 16	
A16	8MHZ PROC CLK†	14b	REFERENCE	A50		◄ 13
B16	B HVFLAG	14b	CH B HV AMP	A11		◄ 1
C16	A AMPDCO†	14a	OFFSET	A21		◄ 7

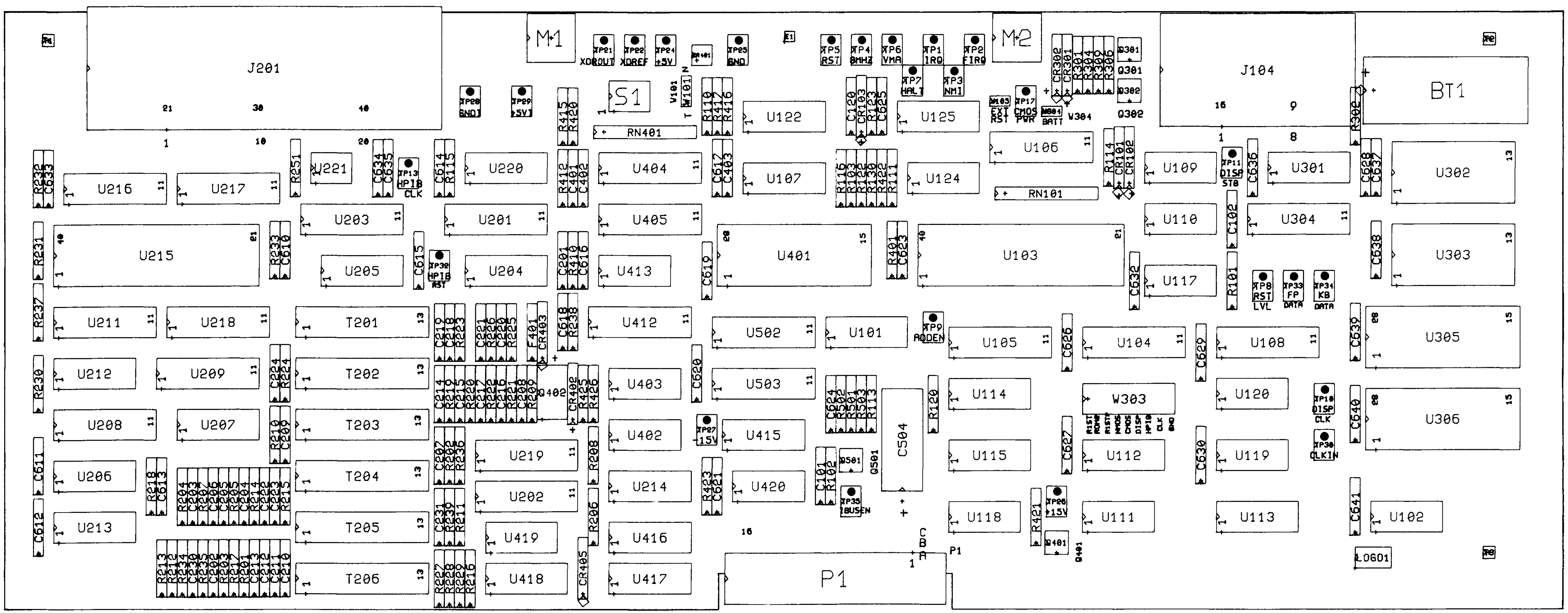
† Signal lead is shielded on the motherboard by ground traces.



BLOCK DIAGRAM
CONTROLLER/HP-IB SUPPORT
(A61, A63)

14





CONTROLLER BOARD (A61)
P/N 03326-66561
REV A

NOTES:

1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).

PIN 1 ☐ ☐ +5 V

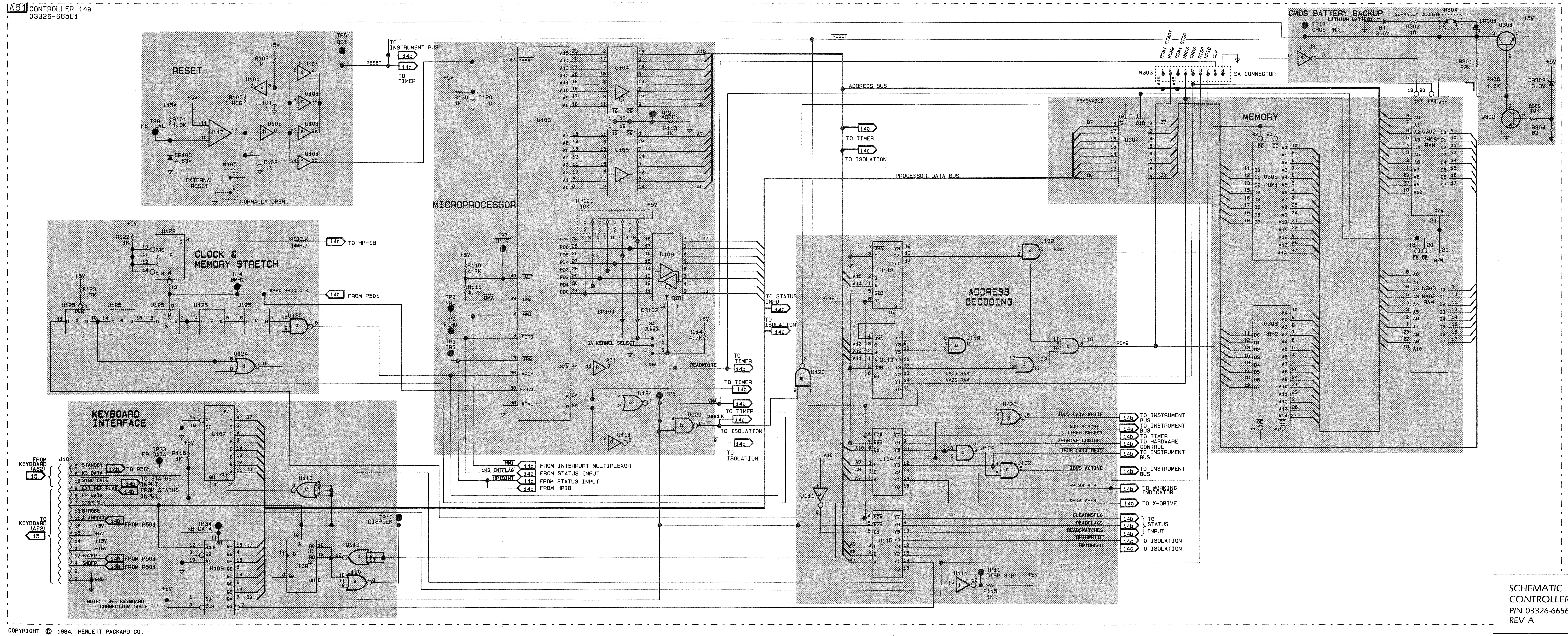
GND ☐

2. THIS SCHEMATIC USES CR AS THE REFERENCE DESIGNATOR FOR AN LED.

3. **CAUTION**

TTL, TTL COMPATIBLE NMOS LOGIC, AND TTL COMPATIBLE CMOS LOGIC DEVICES ARE USED IN THIS CIRCUIT.

USE THE APPROPRIATE PRECAUTIONS WHEN REMOVING, HANDLING, AND INSTALLING ALL STATIC SENSITIVE COMPONENTS TO AVOID DAMAGE.

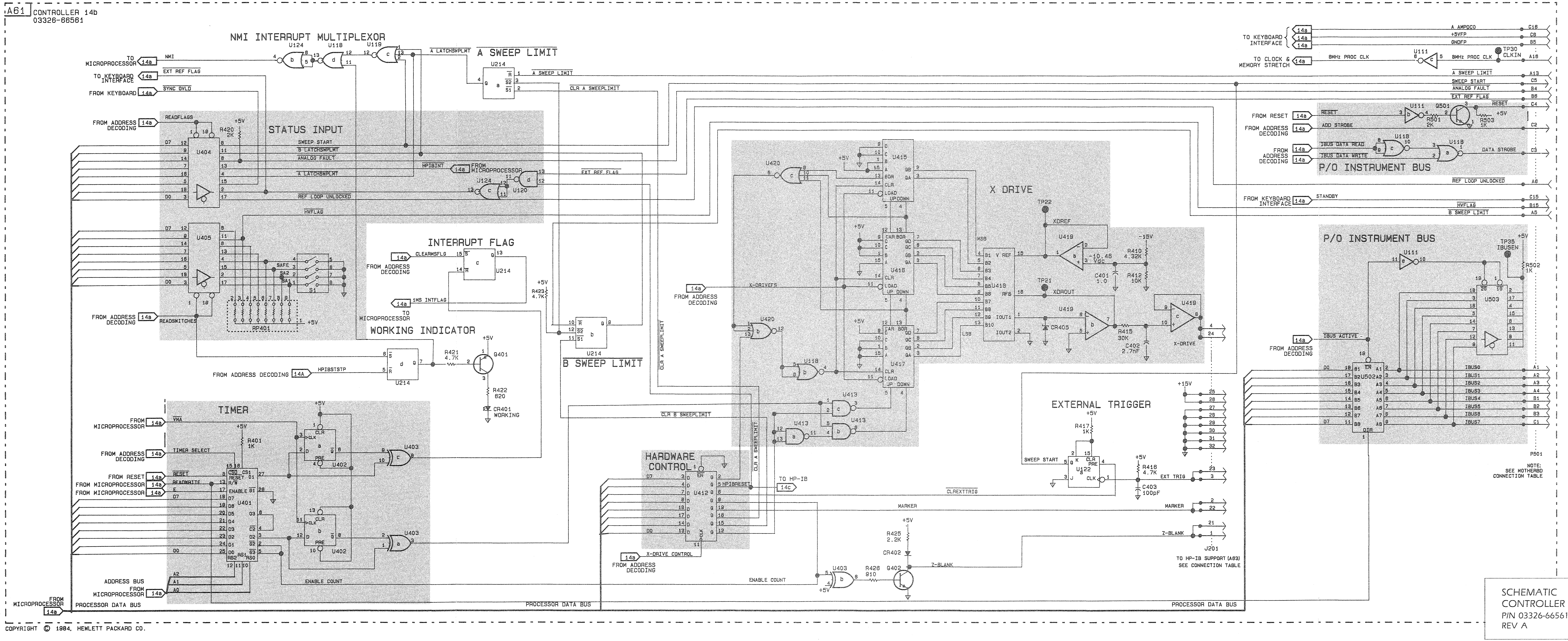


SCHEMATIC
CONTROLLER BOARD (A61)
P/N 03326-66561
REV A

14a

Figure 6-72.

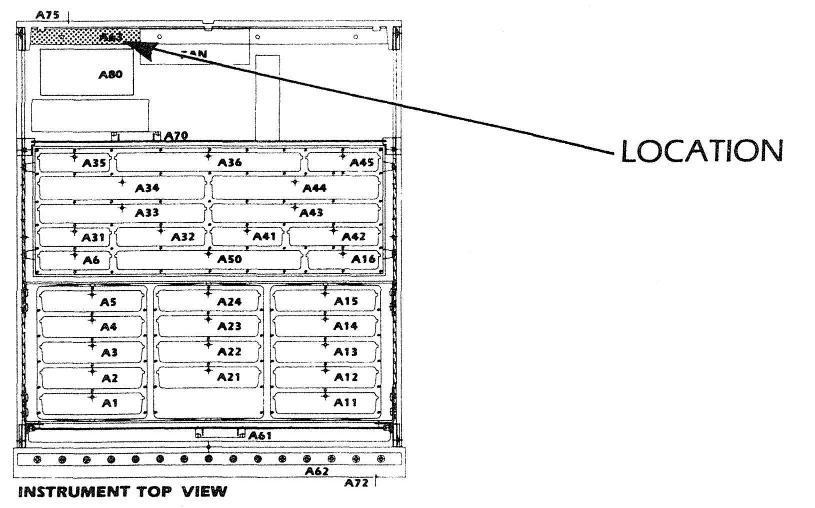
See Other Side

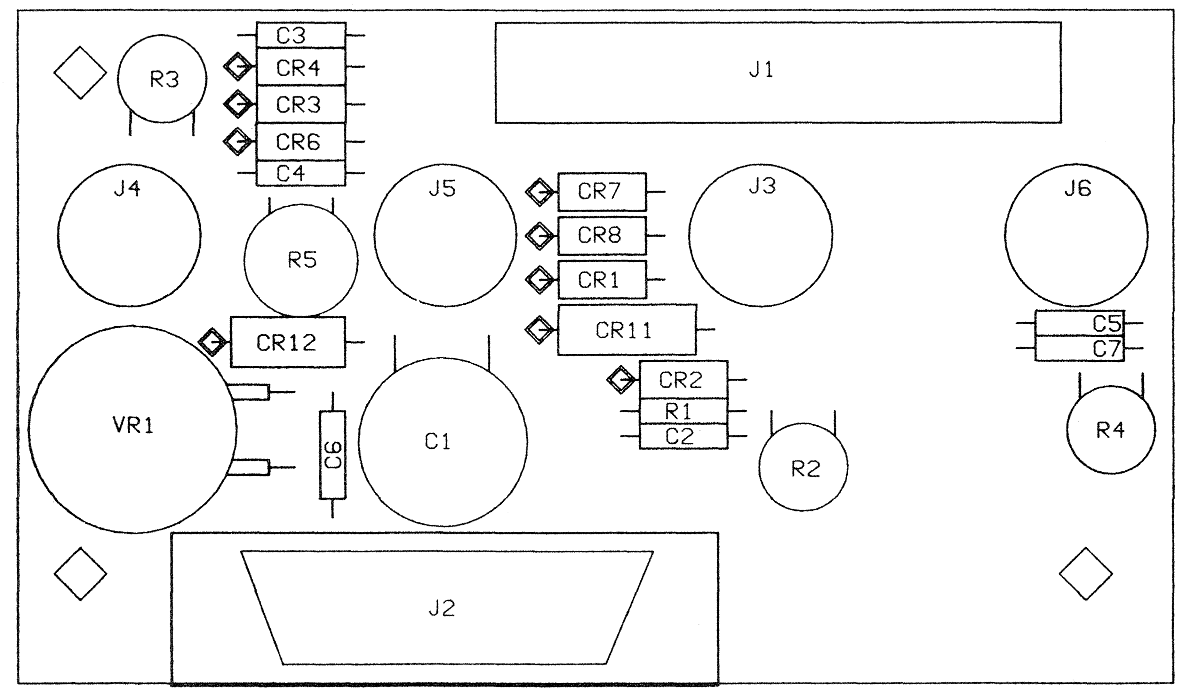


SCHEMATIC
CONTROLLER BOARD (A61)
P/N 03326-66561
REV A

14b

Figure 6-72





HP-IB SUPPORT BOARD (A63)
P/N 03326-66563
REV B

NOTES:

1. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.
2. THIS SCHEMATIC USES VR AS THE REFERENCE DESIGNATOR FOR A VARISTOR.

Table 6-57 CONTROLLER CONNECTION TABLE

HP-IB SUPPORT A63 J1		CONTROLLER A61	
PINS	SIGNAL NAME	TO	FROM
1	Z-BLANK		◄
2	EXT TRIG	►	
3	REN	►	◄
4	NDAC	►	◄
5	DAV	►	◄
6	ATN	►	◄
7	DIO8	►	◄
8	DIO6	►	◄
9	DIO4	►	◄
10	DIO2	►	◄
11	Z-BLANK		◄
12	EXT TRIG	►	
13	+15V		◄
14	GND ⏚		◄
15	GND ⏚		◄
16	GND ⏚		◄
17	CGND ⏚		◄
18	GND ⏚		◄
19	GND ⏚		◄
20	GND ⏚		◄
21	MARKER		◄
22	X-DRIVE		◄
23	IFC	►	◄
24	NRFD	►	◄
25	EOI	►	◄
26	SRQ	►	◄
27	DIO7	►	◄
28	DIO5	►	◄
29	DIO3	►	◄
30	DIO1	►	◄
31	MARKER		◄
32	X-DRIVE		◄
33	+15V		◄
34	GND ⏚		◄
35	GND ⏚		◄
36	GND ⏚		◄
37	CGND ⏚		◄
38	CGND ⏚		◄
39	CGND ⏚		◄
40	CGND ⏚		◄

Table 6-58 HP-IB OUTPUT CONNECTION TABLE

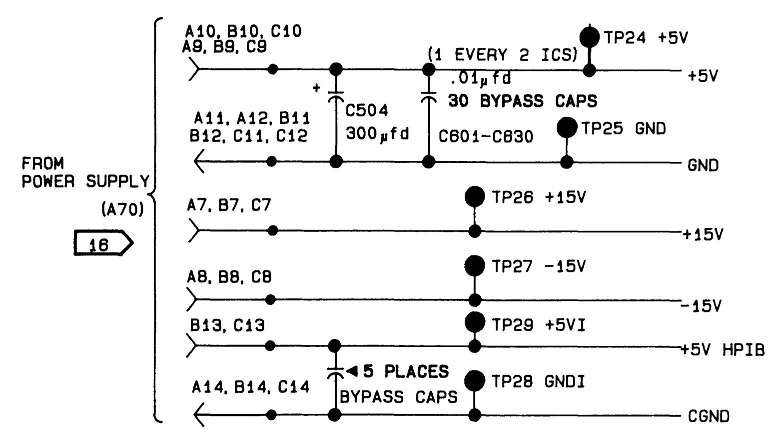
HP-IB SUPPORT A63 J2		HP-IB OUTPUT	
PINS	SIGNAL NAME	TO	FROM
1	DIO1	►	◄
2	DIO2	►	◄
3	DIO3	►	◄
4	DIO4	►	◄
5	EOI	►	◄
6	DAV	►	◄
7	NRFD	►	◄
8	NDAC	►	◄
9	IFC	►	◄
10	SRQ	►	◄
11	ATN	►	◄
12	SHIELD	►	
13	DIO5	►	◄
14	DIO6	►	◄
15	DIO7	►	◄
16	DIO8	►	◄
17	REN	►	◄
18	CGND ⏚	►	
19	CGND ⏚	►	
20	CGND ⏚	►	
21	CGND ⏚	►	
22	CGND ⏚	►	
23	CGND ⏚	►	
24	CGND ⏚	►	

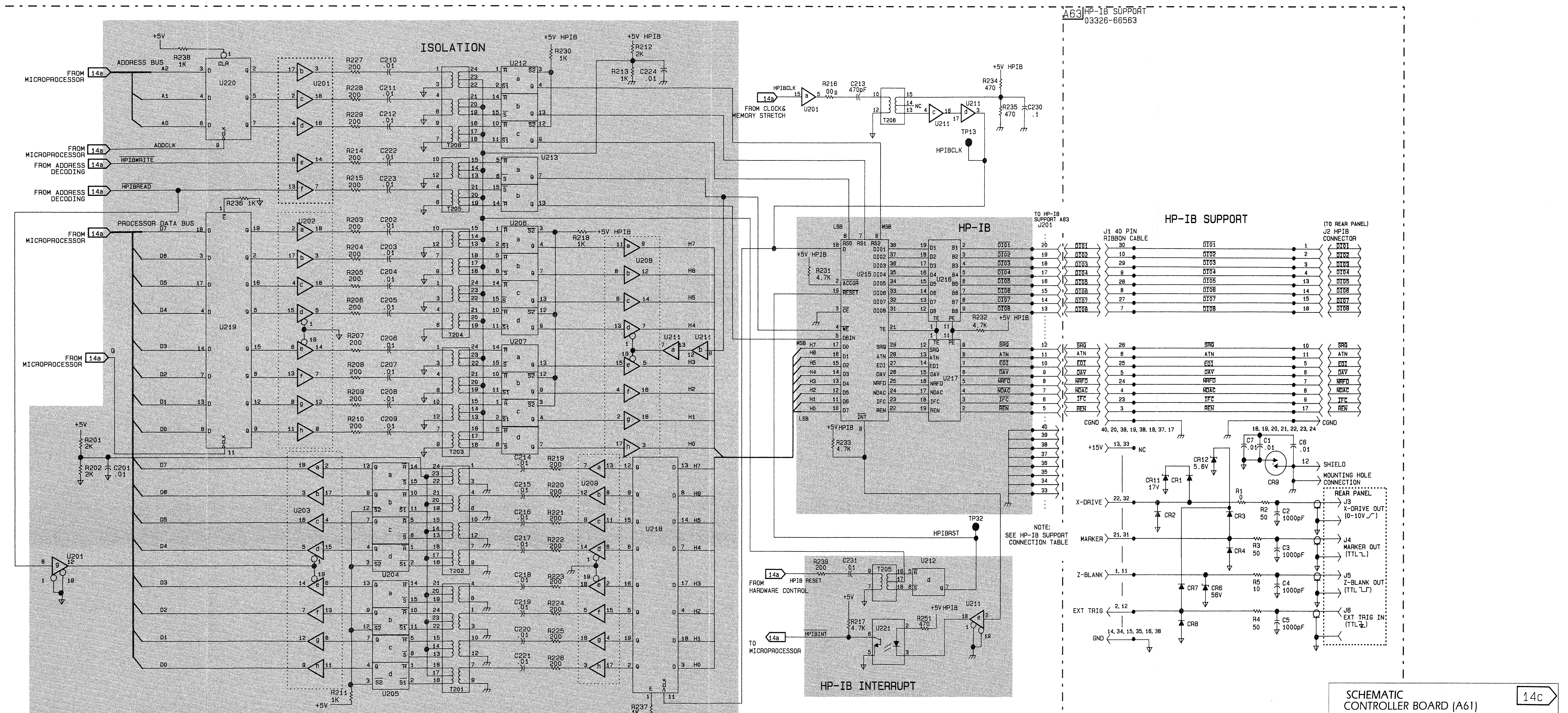
A61 CONTROLLER 14c
03326-66561

REFERENCE TABLE

COMP	+5V	+5V HPIB	+15V	-15V	GND	CGND	NC
U101	1				8		13, 16
U103	7				1		5, 6
U107	16				8		7
U108	20				10		8, 17, 18
U109	14				7		1, 2, 3, 4, 5, 6
U112	16				8		7, 9, 10, 11,
U117			3		12		1, 2, 4, 5, 6, 7, 8, 9
U122	16				8		6, 7
U125	16				8		12, 13
U206		16				8	
U207		16				8	
U208		20				10	
U209		20				10	
U211		20				10	5, 6, 9, 11, 14, 15
U212		16				8	
U213		16				8	1, 2, 3, 4, 9, 10, 11, 12
U215		40				20	1, 30, 39
U216		20				10	
U217		20				10	
U218		20				10	
U220	16				8		10, 11, 12, 13, 14, 15
U221	8						1, 4, 7
U301					8		2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 16
U302					12		
U305	1, 28				14		
U306	1, 28				14		
U401	14				1		7, 9, 28
U402	14				7		5, 9
U403	14				7		11, 12, 13
U413	14				7		8, 9, 10
U415	16				8		6, 7, 12
U418	14				3		
U419			4	11			

POWER SUPPLY DECOUPLING





SCHEMATIC
CONTROLLER BOARD (A61)
HP-IB SUPPORT BOARD (A63)
P/N 03326-66561 P/N 03326-66563
REV A REV B

14c

Figure 6-72

See
Other
Side

6-34 KEYBOARD, A62

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

Theory of Operation

Controller/Keyboard interface:

Interface between the controller and the keyboard is performed by U107 and U108 on the controller board (A61). These are parallel-to-serial and serial-to-parallel shift registers, respectively. The data flow between the the two boards is serial.

Serial data is clocked to the keyboard from the controller, shifted through six shift registers and returned to the controller. Five of the six registers receive information from the controller (to control illumination of the LEDs). The sixth encodes user input (pressed keys or rotation of the knob). Figure 6-73 shows the timing of the interface.

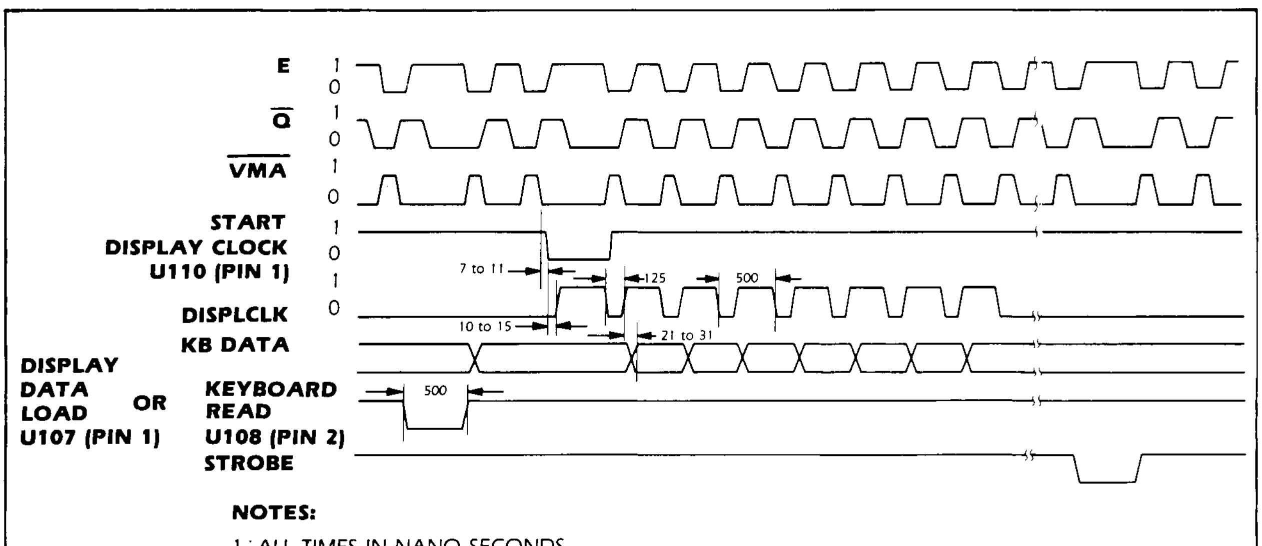


Figure 6-73. Keyboard Timing Diagram

LED drivers:

The LEDs are electrically arranged in 21 columns and 8 rows. Two columns are driven in each display cycle. Each display cycle takes one millisecond and clocks data completely through the serial loop on the keyboard. There are 15 display cycles for a complete display refresh (two of which are for the blinking digit), making the update rate 66 per second.

The keyboard uses PNP transistors and integrated NPN drivers to supply current to the LEDs. The row drive data is shifted into U1 and U3 and the column information is shifted into U2, U5, and U4. An LED is illuminated if its column information is a "1" and the row information is a "0."

Keys:

The keyboard is matrix of eight columns and six rows. The keys are driven (activated) by the display columns in the same manner as the LEDs. They are polled once every display cycle. Pressing a key identifies a row which U6 encodes onto the serial data loop. The data returns to the controller as the KB DATA signal. Since only two columns are activated at a time, the microprocessor can uniquely identify the key pressed based on the column it activated and the row information from U6. The keys are completely scanned every 15 ms.

Knob (rotary pulse generator, RPG):

When the RPG is rotated, it outputs two square waves whose phase relationship is always 90° or 270°. Directional information is available by comparing the two with an edge-triggered flip-flops whose clock is one RPG output and whose data input is the other RPG output. Activity is indicated by another flip-flop whose data input is held high and whose clock is an RPG output. Both flip-flops are reset by data clocked into Q8 of shift register U5. The RPG information and the keypress information is shifted out to the controller.

Synchronous output:

The synchronous output (sync) circuit is derived from the output of channel A (which is input to the keyboard on a phono cable). The dc offset of the channel A signal is subtracted from the input to maintain a 50% duty cycle out of the squaring circuit (U101). U104 buffers the dc offset information coming from the offset board (A21) via the controller board. The SYNC signal is buffered to the keyboard by five parallel drivers (U102).

Sync overload sensing is provided by U103 and overload protection is provided by relay K101. Two comparators on U103 activate relay protection when the signal on the SYNC A output connector becomes negative or exceeds +5 V. A third comparator provides hysteresis such that the protection relay remains open for a short period of time after the overload condition is removed and then closes, automatically returning to normal operation. When an overload occurs at the SYNC A output, a signal to the processor (SYNC $\overline{\text{OVLD}}$) causes the instrument to display the warning "ERROR 172 SYOL."

Troubleshooting

The troubleshooting information which follows assumes you have used the flow chart in Figure 6-2 to determine that the keyboard (A62) or the keyboard interface sub-section on the controller board (A61) has failed. It is recommended that this flow chart be used before proceeding further.

On the controller board:

1. Initiate the Interface Signature Analysis (SA) Test by connecting A61TP25 to A61TP28, setting switch 1 of A61S1 to the open position, and cycling power (as described in Figure 6-69 in controller troubleshooting sub-section 6-33).

2. Check for a 1 ms interrupt signal on A61TP2; there should be a 1 μs pulse every millisecond.

3. Check the signature on A61TP33 (FP DATA) to erify that data is getting to the keyboard. See Table 6-49.

4. If there is no signal on the FP DATA test point (TP33), check the clock circuit composed of U109 and U110.

5. If the front panel LEDs illuminate but the keyboard doesn 't respond to key presses, check TP34 for data coming back from the keyboard (KB DATA). See Table 6-49.

   Also, check for keys that are stuck down. See Table 6-50.
   The instrument microprocessor responds to a keypress when the key is released and it only acknowledges one key pressed at any time. When a key is stuck down, further key presses produce no response because the pressed key has not released.

6. If data appears to leave the controller board but none returns, perform the SA tests for the keyboard listed in the SA tests in the A61 board level repair. See Table 6-50.

7. If data appears at TP34 (i.e., data is returning from the keyboard) then U108 may be the problem. It is important that U108 is a Texas Instruments part as opposed to that of any other manufacturer.

On the keyboard:

Serial data path:

1. Check A62TP3 for an incoming serial clock signal (DISPLCLK) from the controller. This signal consists of five bursts of eight bits every millisecond.

2. Check TP1 for incoming data from the controller. This data (FP DATA) flows serially through all five serial-to-parallel registers on the keyboard (U1, U3, U2, U4, and U5) as well as the parallel-to-serial register (keypress encoder U7) and returns to the controller board as the signal KB DATA. It is not cleared after it is clocked into the registers. Check for this signal between each of these ICs along the main data path with a scope or logic probe.

3. Perform the SA tests listed in Table 6-50 in controller troubleshooting (sub-section 6-33).

Knob (rotary pulse generator, RPG):

If the instrument does not respond to rotation of the knob or responds improperly, troubleshoot U6, U7 and the RPG unit.

1. TTL square waves should appear on pins 6 and 13 of U6 when the RPG is rotated. If the RPG unit has good power and ground and these signals do not appear as stated, troubleshoot the RPG and its interface (U6).
2. Pin 1 of U6 is normally low. It is TTL high when the knob is turned clockwise and TTL low when the knob is turned counterclockwise. Turning the knob counterclockwise results in no apparent change in status at pin 1. The high state remains only until it is reset, which happens once every millisecond.
3. Pin 15 of U6 indicates activity by going high when the knob is turned. This line returns to a low state when reset by the Q8 bit of U5 (once every 1 ms).
4. If the correct information is getting to U7 and the knob still does not function properly, troubleshoot the interface circuitry consisting of A62U7 on the keyboard and A61U108 on the controller board.

Sync circuit:

If there is no signal at the sync output and the display does not indicate that a sync circuit overload (ERROR 172 SYOL) has occurred, then either an overload has occurred that is not being reported properly, or the sync output circuitry is defective.

1. Preset the HP 3326A. A 1 kHz square wave should be present at U103, pins 4 and 7. It is important that this wave is between 0 and 5 volts. Any offset on the wave that brings it outside of these boundaries will trigger the overload circuitry.

   Measure the voltage at pins 1, 2 and 14 of U103. In normal operation these should be TTL high and the protection relay should be closed.

2. Check for SYNC input signal from the channel A output amplifier (A3) and follow it through toward the sync output until the signal disappears or is otherwise defective. See Figure 6-74.

To check the bias voltages and waveform given for the sync circuit on the keyboard, set the HP 3326A as follows:

HP 3326A Setup

INSTR PRESET	
Channel	CH A
Amplitude	5 Vpp
DC Offset	1 V

Oscilloscope Setup (#1)

BNC cable	
Ch 1 coupling	50 Ω DC
Ch 1 V/div	1 V
Time/div	200 μs
Trigger	Ch 1

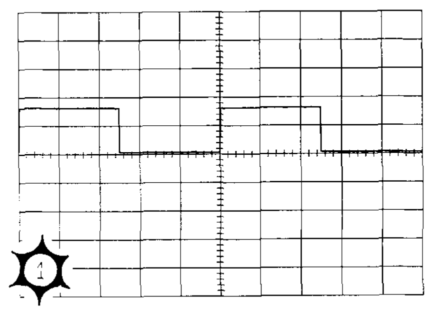
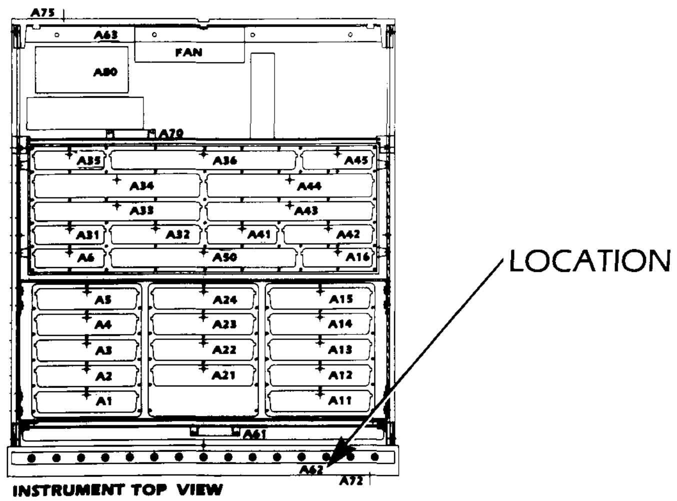
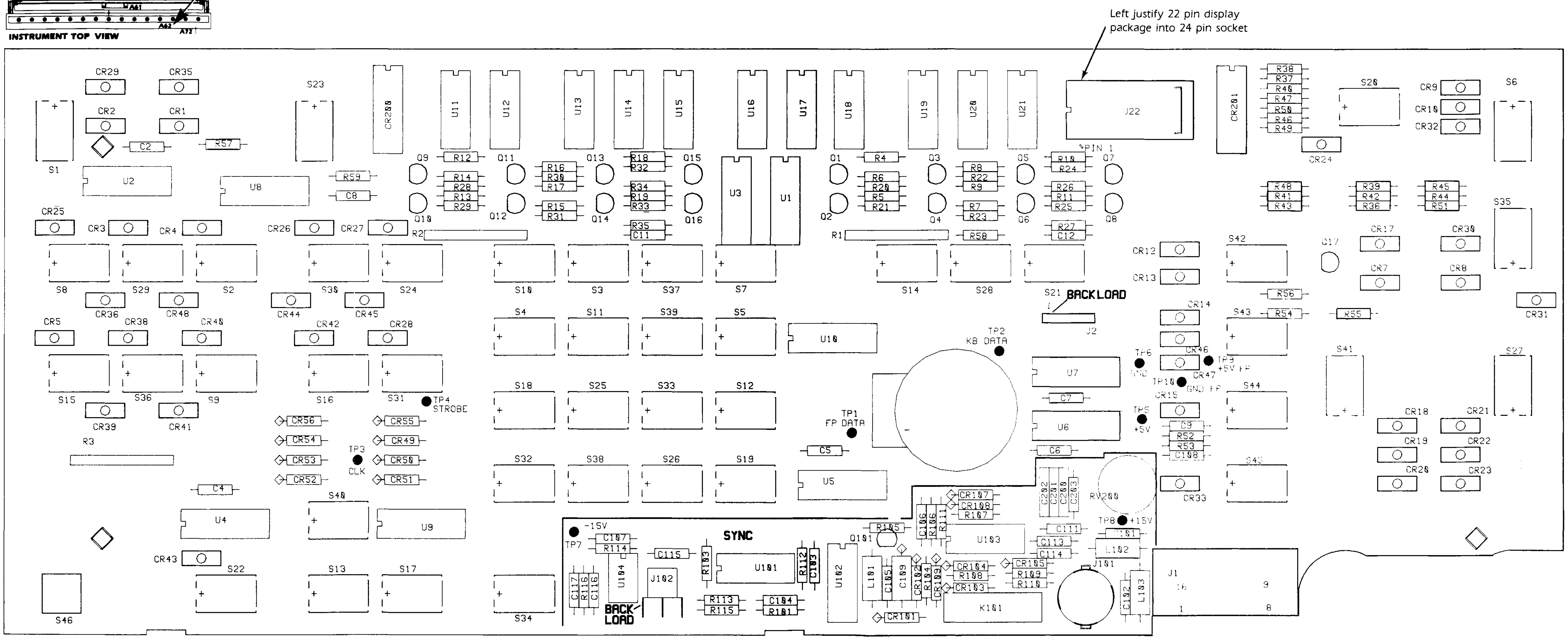


Figure 6-74. Keyboard Waveforms





KEYBOARD (A62)
P/N 03326-66562
REV A

Table 6-59 CONTROLLER CONNECTION TABLE

KEYBOARD A62 J1		CONTROLLER A61	
PINS	SIGNAL NAME	TO	FROM
1	GND ⏚		◄
2	GND ⏚		◄
3	−15V		◄
4	GNDFP		◄
5	STANDBY	►	
6	KB DATA	►	
7	DISPLCLK		◄
8	FP DATA		◄
9	NOT EXT REF FLAG		◄
10	STROBE		◄
11	A AMPDCO †		◄
12	+5VFP		◄
13	SYNC OVLD	►	
14	+15V		◄
15	+5V		◄
16	+5V		◄

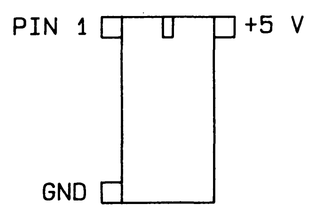
† Signal trace is shielded on the motherboard by ground traces.

REFERENCE TABLE

COMP	GND	+5V1	+15V	−15V	BYPASS CAPS REF	BYPASS CAPS VALUE
U101	10	8, 13, 14				
			1		C103	.01
				6	C104	.01
U102	8	14			C105	.01
					C109	10
U103			3		C114	.01
				12	C113	.01
U104			7		C117	0.1
				4	C115	0.1

NOTES:

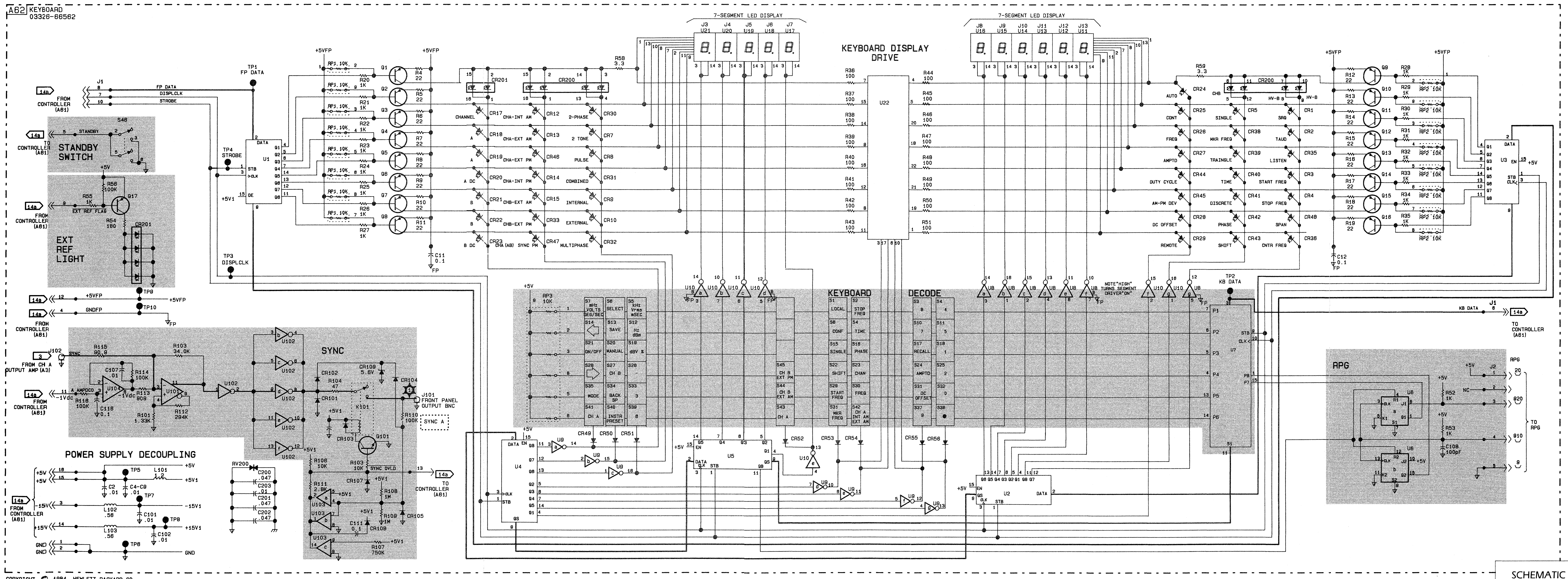
1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).



2. RELAY IS SHOWN IN THE DE-ENERGIZED STATE.
3. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.
4. THIS SCHEMATIC USES CR AS THE REFERENCE DESIGNATOR FOR THE LED AND VR FOR A VARISTOR.
5. **CAUTION**

   TTL COMPATIBLE CMOS LOGIC DEVICES ARE USED FOR THE DRIVER CIRCUITRY ON THE KEYBOARD (A62). U8, U9, AND U10 ARE OPEN COLLECTOR DRIVERS. TTL DEVICES ARE USED FOR THE SYNCHRONOUS OUTPUT CIRCUIT.

   USE THE APPROPRIATE PRECAUTIONS WHEN REMOVING, HANDLING, AND INSTALLING ALL STATIC SENSITIVE COMPONENTS TO AVOID DAMAGE.



SCHEMATIC
KEYBOARD (A62)
P/N 03326-66562
REV A

15

Figure 6-75.

See Other Side

6-35 POWER SUPPLY, A70

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

Theory of Operation

The HP 3326A has a linear power supply with fold-back current limiting and overvoltage protection. When the front panel power switch is in standby (STBY), primary line voltage is still present but the main supply outputs fall to zero. It is important to remember that the secondary (and other) voltages are present any time the instrument is connected to main power. Care must be taken not to short the supplies together when the instrument is connected to the line power.

WARNING

The main power switch does not disconnect power to the power supply. Dangerous voltages are present in the power supply when the switch is in the STBY position.

CAUTION

Care must be taken that the power supplies are not shorted together when troubleshooting. Do not place the power supply on the card nest without adequate insulation between them. Damage to components may result.

There are seven independent supplies on the power supply board: +15V, −15V, +5V, +5V HPIB, 5VFP, +28VDC, and −28VDC. See the signal glossary in Appendix A.

+15V supply:

The +15V supply has an unregulated output (+15V RAW) which supplies the oven reference board (A80) and a regulated output (+15V) which is one of the three main supplies. The +15V power supply also serves as the reference for the −15V and +5V supplies.

Power from the transformer 42 volt, center-tapped secondary is full wave rectified by diodes CR700 and CR701 and filtered by C700. The pass transistor, Q100, is a Darlington with a base-emitter voltage of approximately 2.5 V. The voltage reference zener diode (CR106) is connected to the non-inverting input of the regulator controller (U100). This 6.2 V zener is biased on at turn-on through R111 to the +18V supply. After the +15V supply reaches operating level, the zener is biased on by the +15V supply through CR105.

Regulation is accomplished by feedback through the +15V SENSE line (from the motherboard) and R113, R114, and R115. The feedback voltage is divided down to approximately 6.2 V to equal the zener reference. When the power supply board is not in the instrument, a 10 ohm resistor (R116) provides the voltage sense required to make the circuit function. This resistor is in parallel with the sense line when the board is in the instrument, but the impedance of the sense line is so much less than that of the resistor that its effect is negligible. When setting the +15V supply, the power supply board must be mounted in the instrument for an accurate adjustment to +15 V ± 2 mV.

When the front panel power switch is in standby, Q101 is turned on and the regulator's reference voltage falls to approximately zero. This effectively turns off the output of the power supply. The base circuit of the transistor is pulled high by R118, turning it on whenever the STANDBY line is not grounded. The STBY key on the keyboard signals the controller board to set the STANDBY line appropriately. When either the keyboard or the controller board is removed or the power supply is out of the instrument, jumper W105 may be used to take the power supply out of standby.

Fold-back current limiting is performed by R103, R104, R105, R106, and another section of U100. This circuit senses excessive output current and limits the output voltage to smaller values as the output current increases. A red LED is used to indicate that the instrument is in the current limit condition. This current limiting circuit is repeated in the −15V and +5V supplies. To help protect the instrument from power supply overvoltage, zener clamping diodes exist on each of the three main supplies; +15V, −15V, and +5V. Each of these is disabled by removing the board from the motherboard. This has the effect of moving jumpers built into the motherboard. See Overvoltage Protection which follows.

The pass transistors and regulators are further protected by a thermal cutout mounted on the heat sink. When the heat sink temperature rises above 100 °C the thermal cutout opens the STANDBY line, putting the instrument into standby.

The fan does not operate when the instrument is in standby. Fan switching is accomplished by operating the fan power relay with the +15V supply. When the supply goes to zero volts, the relay is de-energized and power to the fan is disconnected.

−15V supply:

The −15V supply is identical to the +15V supply except that it gets its reference from the +15V supply (comes from the motherboard) instead of using another zener. If the +15V supply goes to zero the −15V supply also shuts down. Sensing of the −15V supply comes from the motherboard (as explained previously for the +15V supply). A 10 ohm resistor is provided to operate the power supply outside the instrument.

Since this supply gets its reference from the +15V supply, no separate adjustment is required. The output should be −15 ± 0.020 V (measured at TP205 with the board in the instrument).

+5V supply:

The +5V supply circuit is approximately the same as previously described for the +15V supply. As with the −15V supply, the reference for the +5V supply is derived from the +15V supply. This supply should be +5.1 V ± 60 mV.

± 18V supplies:

These supplies exist only to power circuits on the power supply board and do not go to any other board. This is a full-wave bridge circuit and dual regulators supplied by the 68 V secondary winding of the main transformer.

+5V HPIB supply:

The analog ground in the HP 3326A (GND) is floating relative to the chassis (safety) ground (CGND) to help eliminate ground-loop problems in measurements. This also preserves isolation when a cable is connected to the HP-IB connector. This supply requires the +5V supply (see schematic). A separate power supply and transformer winding are used for the isolated +5V HPIB supply. This supply should be +5 V ± 0.25V.

This supply uses a full-wave bridge rectifier and filter capacitor, followed by a pass transistor to switch the supply off when the instrument is in standby. The opto-isolator device is used to preserve isolation of the two grounds. U400 is a +5 V regulator for the output. When measuring this supply voltage, CGND (TP402) must be used as the reference.

+5VFP supply:

This supply is used to run the front panel LEDs. It is supplied by U900 which taps the rectified and filtered +5V supply just before it is regulated. +5VFP operates the same as the +5V HPIB supply but has the same ground as the rest of the power supply (GND). +5VFP has a ground path separate from the rest of the return paths (until it gets back to the power supply) to avoid contamination of the other supplies. Also, **this supply does not go into standby.** Its output is present whenever line power is connected to the instrument.

+28 VDC AND −28 VDC SUPPLIES

These supplies are used only by the high voltage amplifier boards (A1 and A11). They consist of the rectified and filtered portion of the 18V supplies; there is no regulation. Fuses protect the supply outputs.

Overvoltage Protection

The overvoltage protection circuit protects the instrument from failure of a pass transistor or from high voltage shorts by sensing the overvoltage condition and turning on an SCR (silicon controlled rectifier). This shorts the +15V supply to ground to blow the main power fuse. Sensing is done by comparators U801 and U802. Sensing of the +15V supply is done indirectly by monitoring the −15V supply, since it uses the +15V for reference. Selection of the wrong power line switch setting activates the overvoltage protection when 110 VAC is selected and 220 VAC is actually supplied to the instrument.

To troubleshoot this circuit, the drive to the SCR is disabled by removing the power supply board from the instrument. This insures that the instrument cannot be damaged while troubleshooting an overvoltage problem. Also, the clamping diodes on each of the +15V, −15V, +5V supplies are disabled by removing the board. Note that the LEDs used to indicate the overvoltage condition illuminate when a problem exists.

Troubleshooting

Red and green LED indicators exist on the board to give a quick indication of the status of the power supply circuits. The green LEDs are in the +15V, −15V, and the +5V supplies. The red LEDs (indicating some type of failure) are in the three main supplies for current limiting or overvoltage (see schematic). Any of the green LEDs which are not lit also indicate a failure.

Check the supply outputs for the voltage levels shown in Table 6-60. Determine which supplies are not working. Use Figure 6-76 to determine which supply is defective. This figure shows the supply hierarchy; that is, it shows which supplies depend on other supplies to run. For example, if the +5V and +5VFP supplies are producing not the proper voltages, the defective supply is probably +5V, since the +5VFP supply cannot run without the +5V supply working properly.

Once the problem area is found, begin by checking the circuit's reference voltages and the voltages at the comparator inputs.

Intermittent failures of the power supply could be due to defective sockets. The pass transistors on the heat sink use sockets.

If the instrument blows fuses as soon as it is turned on, remove the power supply board from the motherboard and move jumper W105 to the "test" position. If the red LED(s) in the overvoltage circuits are illuminated, the problem is that one or more of the supply output values is too large.

NOTE

After troubleshooting, be sure to move jumper W105 back to the "normal" position. If this is not done, the power supply does not go into standby when the STBY key is pressed.

Refer to Table 6-15 for recommended post-repair adjustments.

Table 6-60. Power Supply Voltage Levels

Supply Name	Output Location	Return Location	Nominal Voltage	Voltage Tolerance‡	Ripple Tolerance
+15V	TP105	GND (TP700) or card nests	+15.000 V	±0.010 V	50 μVrms
−15V	TP205	GND (TP700) or card nests	−15.000 V	±0.020 V	50 μVrms
+5V	TP305	GND (TP700) or card nests	+5.100 V	±0.060 V	75 μVrms
+5VFP	TP900	GNDFP (use card nests)	+5.00 V	±0.25 V	—
+5V HPIB	TP401	CGND (TP402) or chassis	+5.00 V	±0.25 V	—
+28VDC	TP501	GND (TP700) or card nests	> 28.5 V	—	—
−28VDC	TP500	GND (TP700) or card nests	< −28.5 V	—	—

‡ The voltage levels and ripple tolerances are given for fully loaded supplies. All PC boards must be in the instrument. Removing individual boards will change the load on the supplies and change the supply levels.

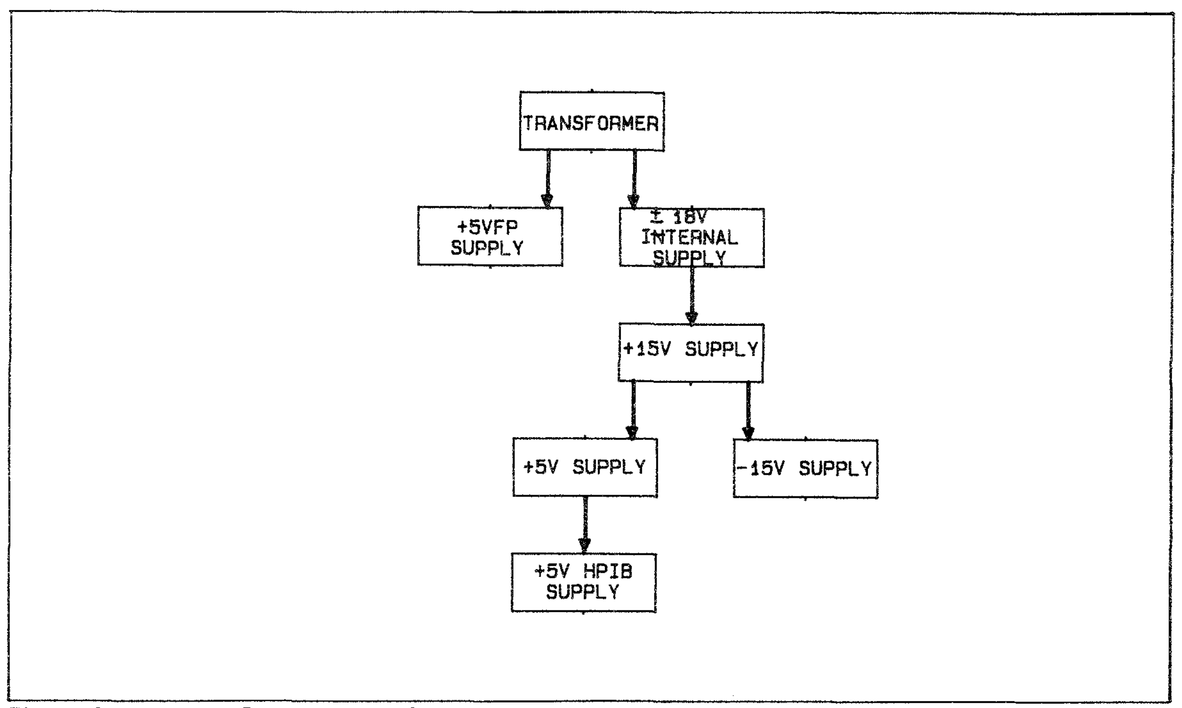
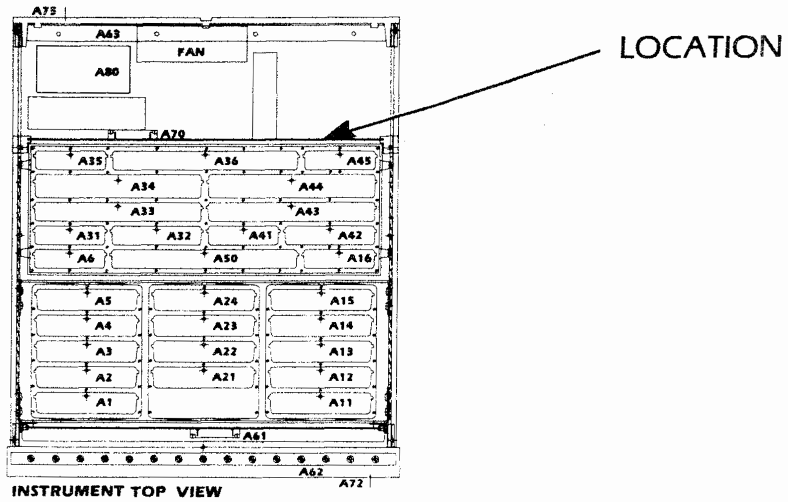
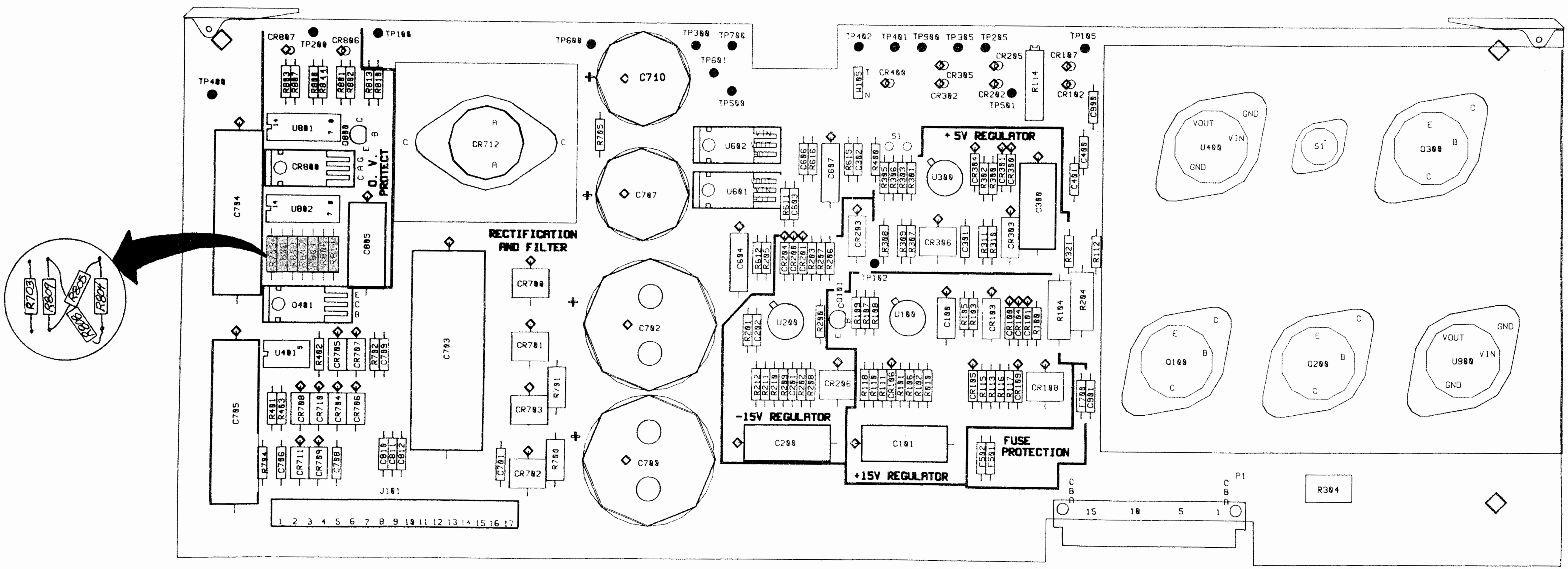


Figure 6-76. Power Supply Hierarchy

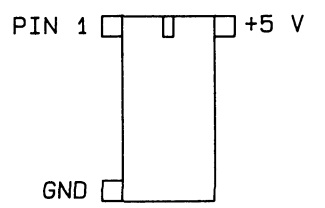




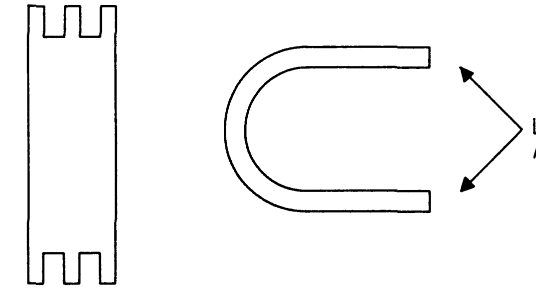
POWER SUPPLY BOARD (A70)
P/N 03326-66570
REV A

NOTES:

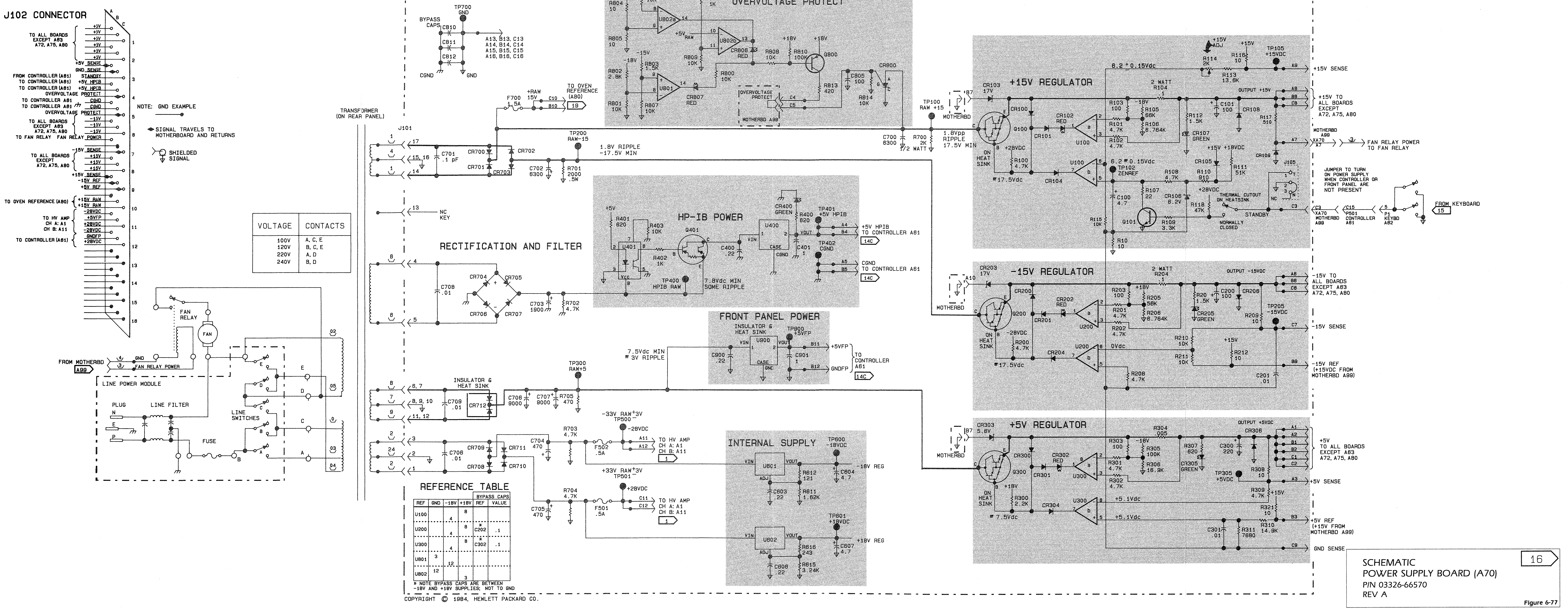
1. ALL INTEGRATED CIRCUITS ARE CORNER POWERED EXCEPT THOSE SHOWN IN THE REFERENCE TABLE. CORNER POWERED ICs HAVE GROUND CONNECTED TO THE LOWER LEFT PIN, AND +5 V CONNECTED TO THE UPPER RIGHT PIN, REGARDLESS OF THE TOTAL PIN COUNT (e.g., FOR A 16 PIN DIP, GROUND IS CONNECTED TO PIN 8 AND +5 V IS CONNECTED TO PIN 16).



2. INSTALLATION OF A70R34: R304 IS A FLAT PIECE OF METAL. IT MUST BE BENT TO FIT ONTO THE PC BOARD.



3. THIS SCHEMATIC USES CR AS THE REFERENCE DESIGNATOR FOR AN LED.



SCHEMATIC
POWER SUPPLY BOARD (A70)
P/N 03326-66570
REV A

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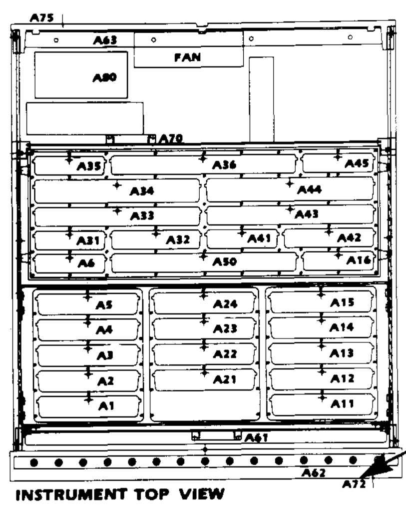
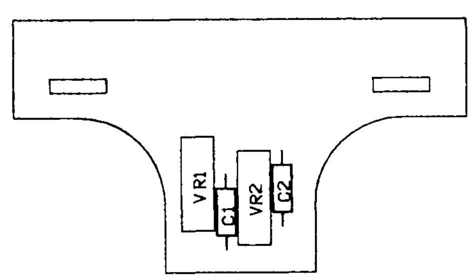
Figure 6-77

See
Other
Side

6-36 FRONT AND REAR ESD, A72 AND A75

The front and rear panel electrostatic discharge (ESD) boards contain circuits which protect the instrument's internal circuitry from static electrical discharge to the front and rear panel connectors.



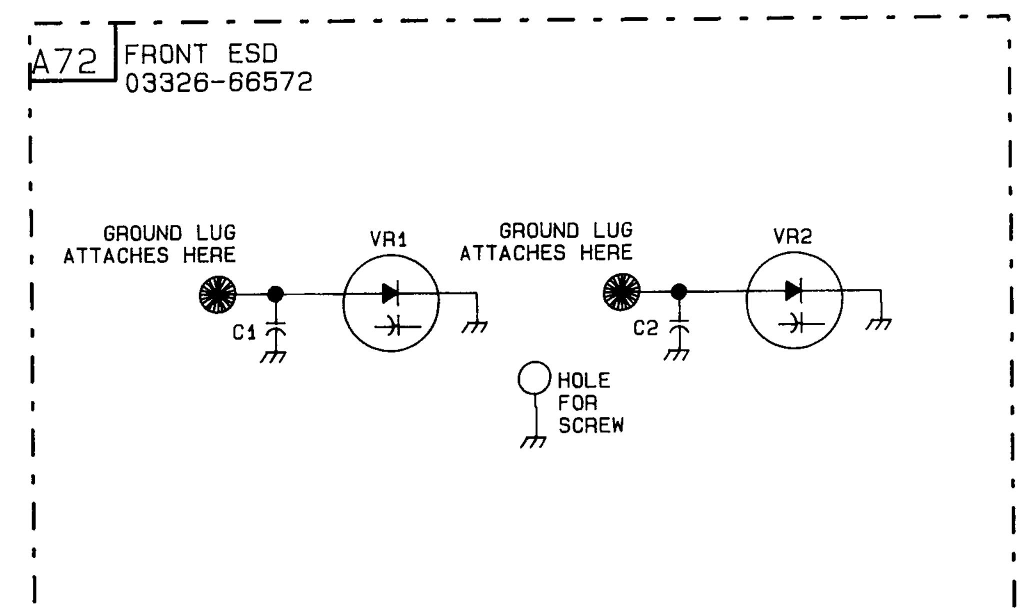


FRONT ESD BOARD (A72)
P/N 03326-66572
REV A

NOTES:

1. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.

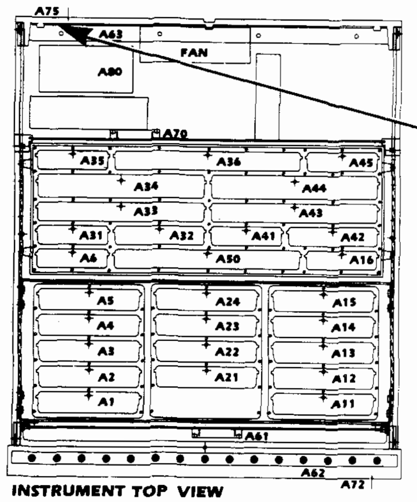
2. THIS SCHEMATIC USES VR AS THE REFERENCE DESIGNATOR FOR A VARISTOR.



SCHEMATIC
FRONT ESD BOARD (A72)
P/N 03326-66572
REV A

17

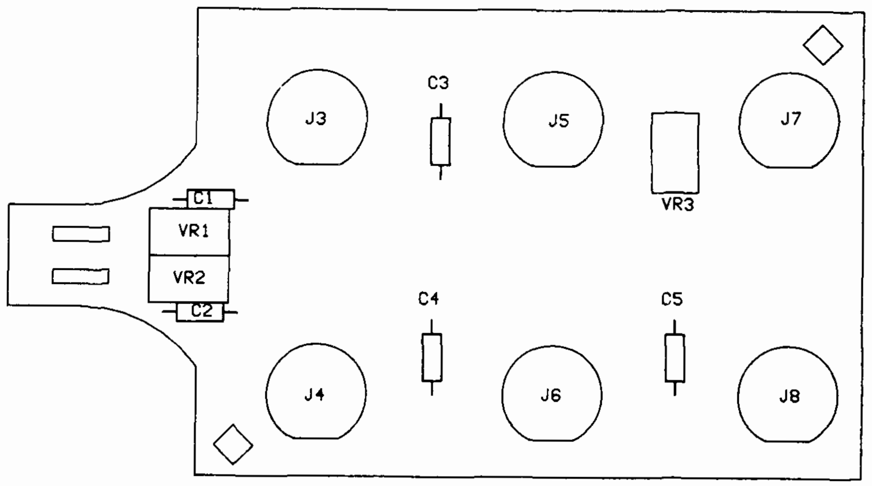
Figure 6-78.

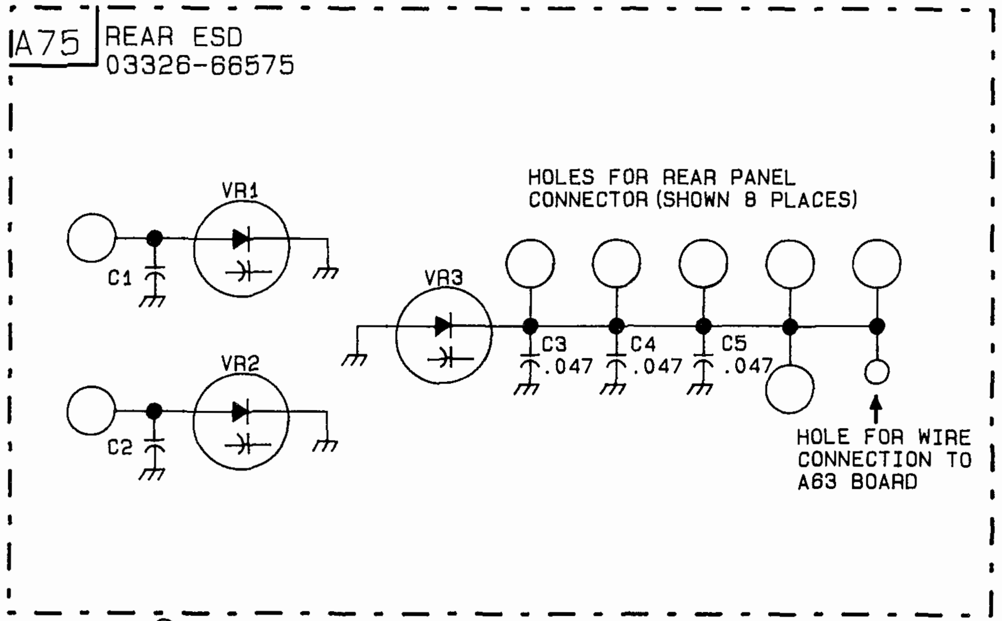


NOTES:

1. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.

2. THIS SCHEMATIC USES VR AS THE REFERENCE DESIGNATOR FOR A VARISTOR.





REAR ESD BOARD (A75)
P/N 03326-66575
REV B

SCHEMATIC
REAR ESD BOARD (A75)
P/N 03326-66575
REV B

18

Figure 6-79.

6-37 OVEN REFERENCE, A80 (OPTION 001)

The information in this section should be used to isolate defective sub-blocks when servicing the HP 3326A. All procedures assume Fault Isolation to the Board Level has been used to determine which functional block (board) has failed.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.

Theory of Operation

The oven reference board receives rectified power (+15V RAW) from the power supply (A70). This raw voltage is filtered by C100 and input to a +15 V regulator (U100). The +15 V regulator requires a heat sink to prevent its junction temperature from approaching 125°C. The regulated 15 volts then is used to power the high stability oven oscillator (U101), to bias Q100, and to provide a level for the resistive divider that establishes the fine tune frequency adjustment.

The crystal oven oscillator generates a highly stable, TTL level, 10 MHz output signal. The signal travels through a PNP emitter follower buffer, then is shaped into a sine wave by a 10 MHz low pass filter. The output signal travels through a phono cable to the rear panel output connector 10MHz OVEN OUT, OPTION 001.

R105 makes the oven output resistance look like 50 Ω at 10MHz. C102 is used to ac couple the output and protect against dc overvoltage. J101 is used for board testing at the factory.

Coarse tuning of the output frequency is accomplished by removing the screw from the oven oscillator and turning the internal adjustment with a non-conductive tool. The frequency range of the adjustment is approximately 110 Hz. The frequency can be fine tuned by adjusting R101. This fine frequency adjustment changes the frequency by a minimum of 0.7 Hz to a maximum of 1.5 Hz.

Troubleshooting

This circuit may be analyzed by comparing the oscilloscope waveforms in Figure 6-80 with those of the defective unit. To access test points and signal lines, turn off the instrument, remove the power cord, and remove the bottom cover of the instrument. Turn on the instrument and probe the circuit side of the board. (Due to the positioning of the board, all test points cannot be accessed from the component side.)

The most likely components to fail on this board are the regulator (U100) and the buffering transistor (Q100). In either case, there would be no output from the rear panel connector (10MHz OVEN OUT, OPTION 001).

Refer to Table 6-15 for recommended post-repair adjustments.

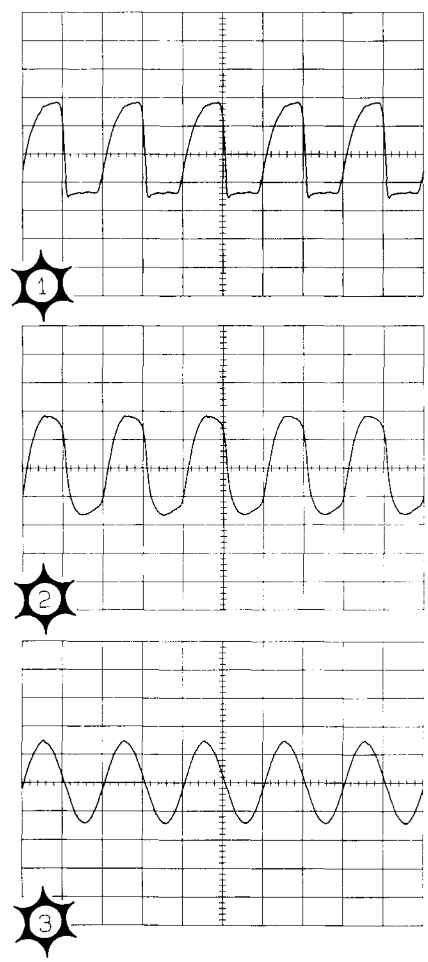
HP 3326A SETUP

INSTR PRESET

Oscilloscope Setup *(#1, #2, #3)*

10:1 probe†

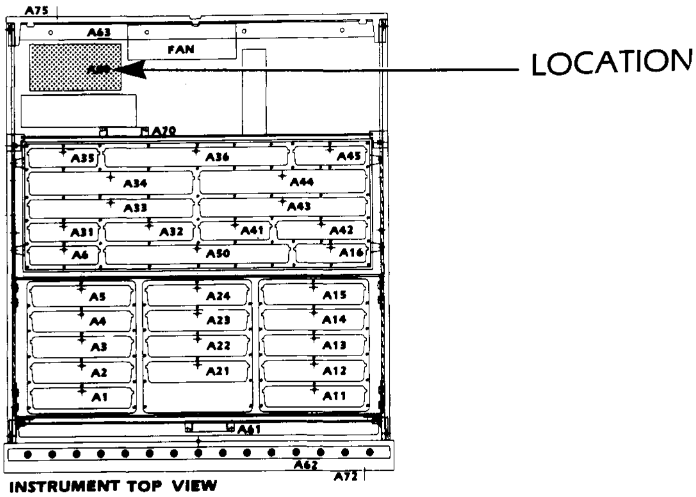
Ch 1 coupling	AC
Ch 1 V/div	100 mV
Time/div	50 ns
Trigger	Ch 1



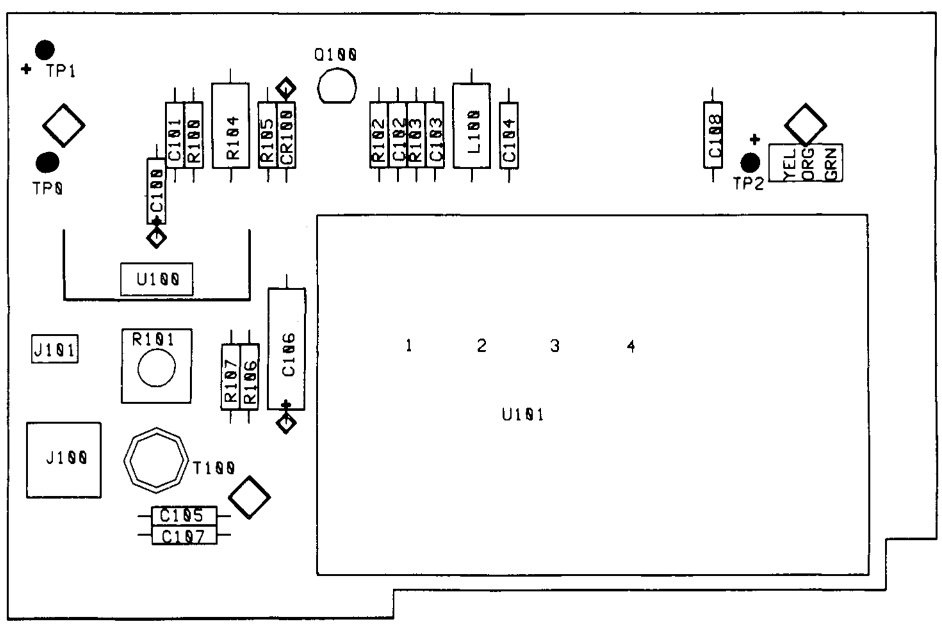
† Use a 10:1 probe with a ground spring (HP part number 1460-1476) when making high frequency measurements to minimize distortion.

Figure 6-80. Oven Reference Board Waveforms

NOTES



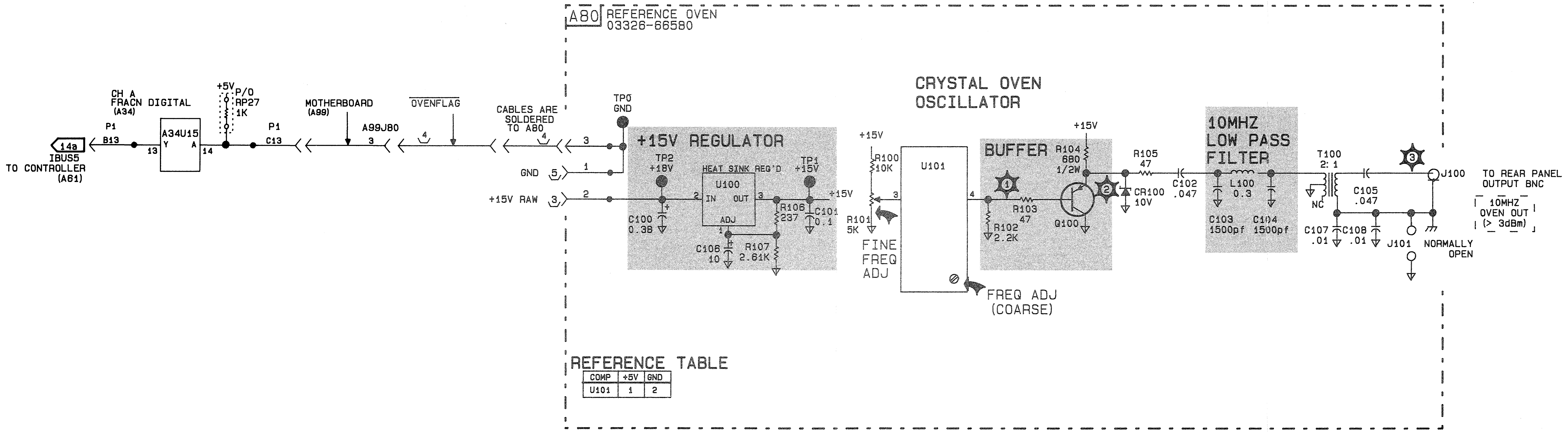
INSTRUMENT TOP VIEW



OVEN REFERENCE BOARD (A80)
P/N 03326-66580
REV A

NOTES:

1. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.
2. THE OVEN REFERENCE BOARD (A80, OPTION 001) IS MOST EASILY REMOVED FROM THE BOTTOM OF THE INSTRUMENT. TO REMOVE, REMOVE THE BOTTOM COVER AND THE SCREWS HOLDING THE BOARD IN PLACE. SLIP THE BOARD OUT FROM THE BOTTOM OF THE INSTRUMENT.



COMP	+5V	GND
U101	1	2

SCHEMATIC
OVEN REFERENCE BOARD (A80)
P/N 03326-66580
REV A

19

Figure 6-81

See Other Side

6-38 MOTHERBOARD, A99

The primary function of the motherboard is to interconnect many of the signals of the HP 3326A boards. In addition, the motherboard contains some power supply decoupling circuitry. These components are shown on the schematics for A21, A22, A31, A32, A33, A34, A41, A42, A43, A44, and A45. Capacitors C1 through C11 connect chassis ground (CGND) to the isolated ground (GND). See the component locator.

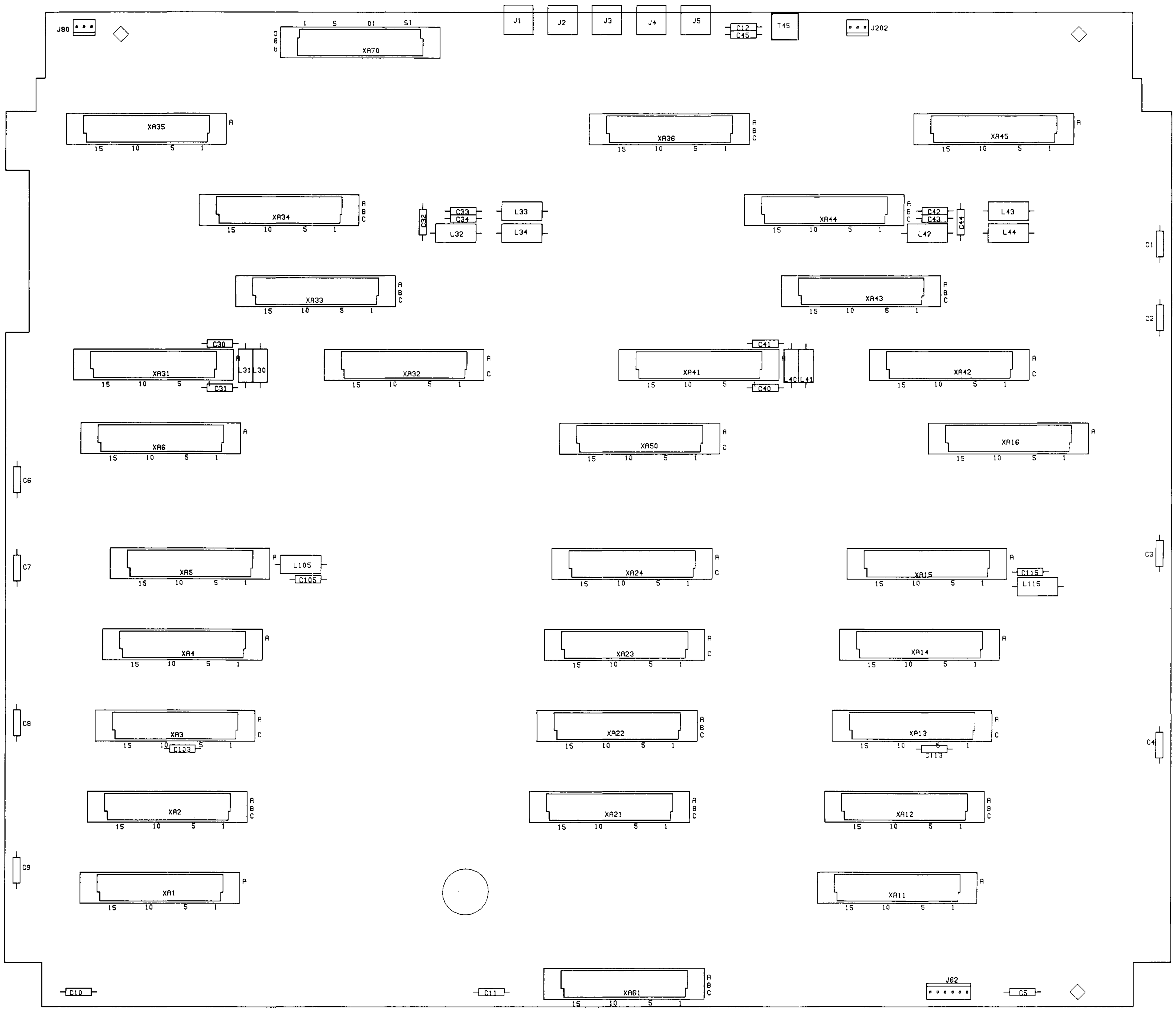
This circuit board contains no active or signal conditioning components. Several passive components are located on the board, however. All signal paths shown in the motherboard connector diagrams on the schematics can be checked for continuity by using an ohmmeter.

WARNING

Service procedures described in this section are performed with the protective covers removed and power applied. Hazardous voltages and energy available at many points can, if contacted, result in personal injury.

CAUTION

Be sure that the power switch is in the STBY position before inserting or removing any circuit board. Power transients caused by insertion or removal may damage the circuit boards.



NOTES:

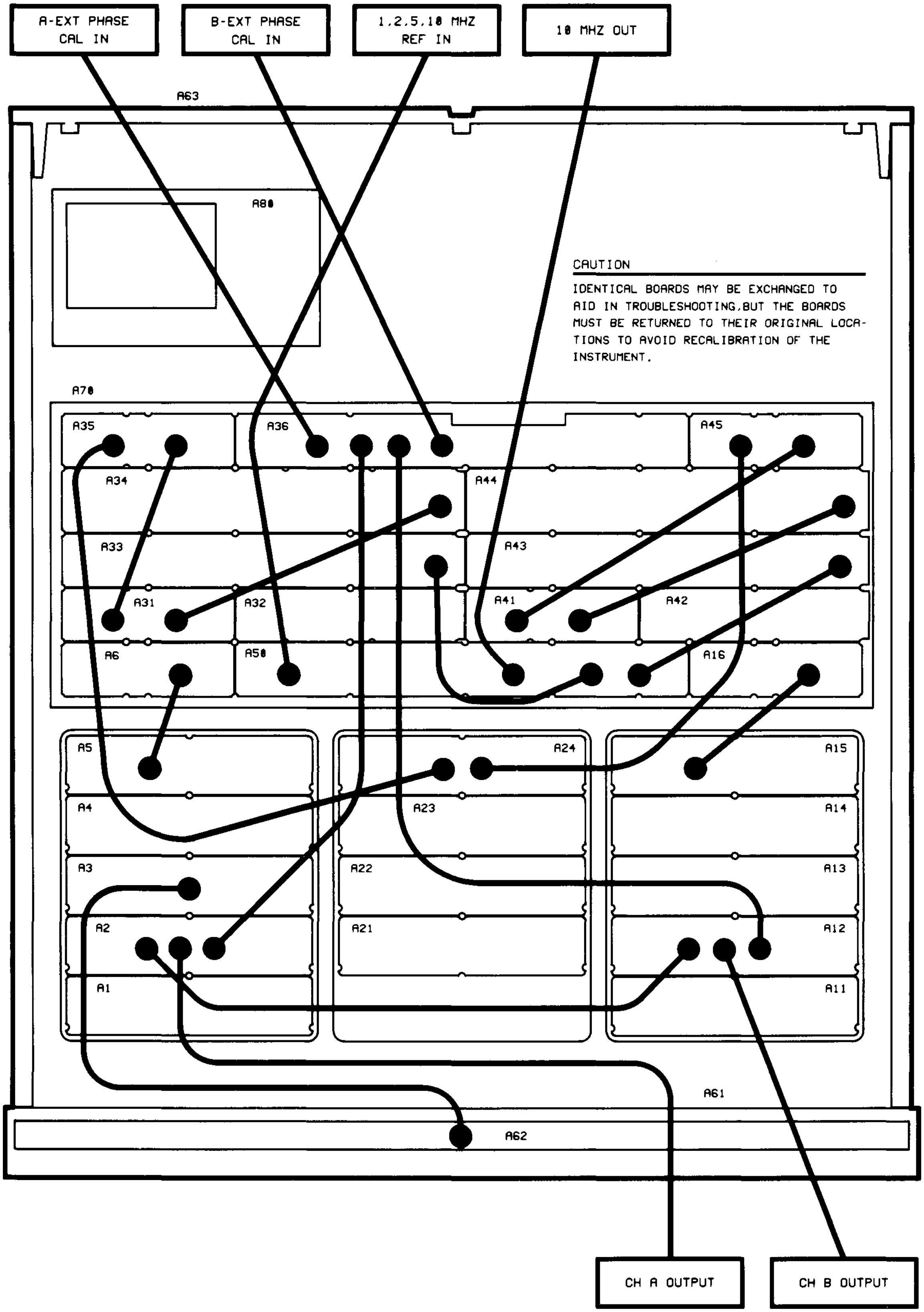
1. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.
2. MOST OF THE TWO-PIECE CONNECTORS ON THE MOTHERBOARD AND DAUGHTER BOARDS HAVE CONSISTENT POWER SUPPLY LINES. THE +5 V LINES ARE ON PINS A1, B1, AND C1. THE +15 V LINES ARE ON PINS A2, B2 AND C2. THE −15 V LINES ARE ON PINS A3, B3 AND C3. THE POWER SUPPLY (A70) AND THE CONTROLLER (A61) ARE EXCEPTIONS. SEE THE SCHEMATICS FOR THE DETAILS.

MOTHERBOARD (A99)
P/N 03326-66599
REV B

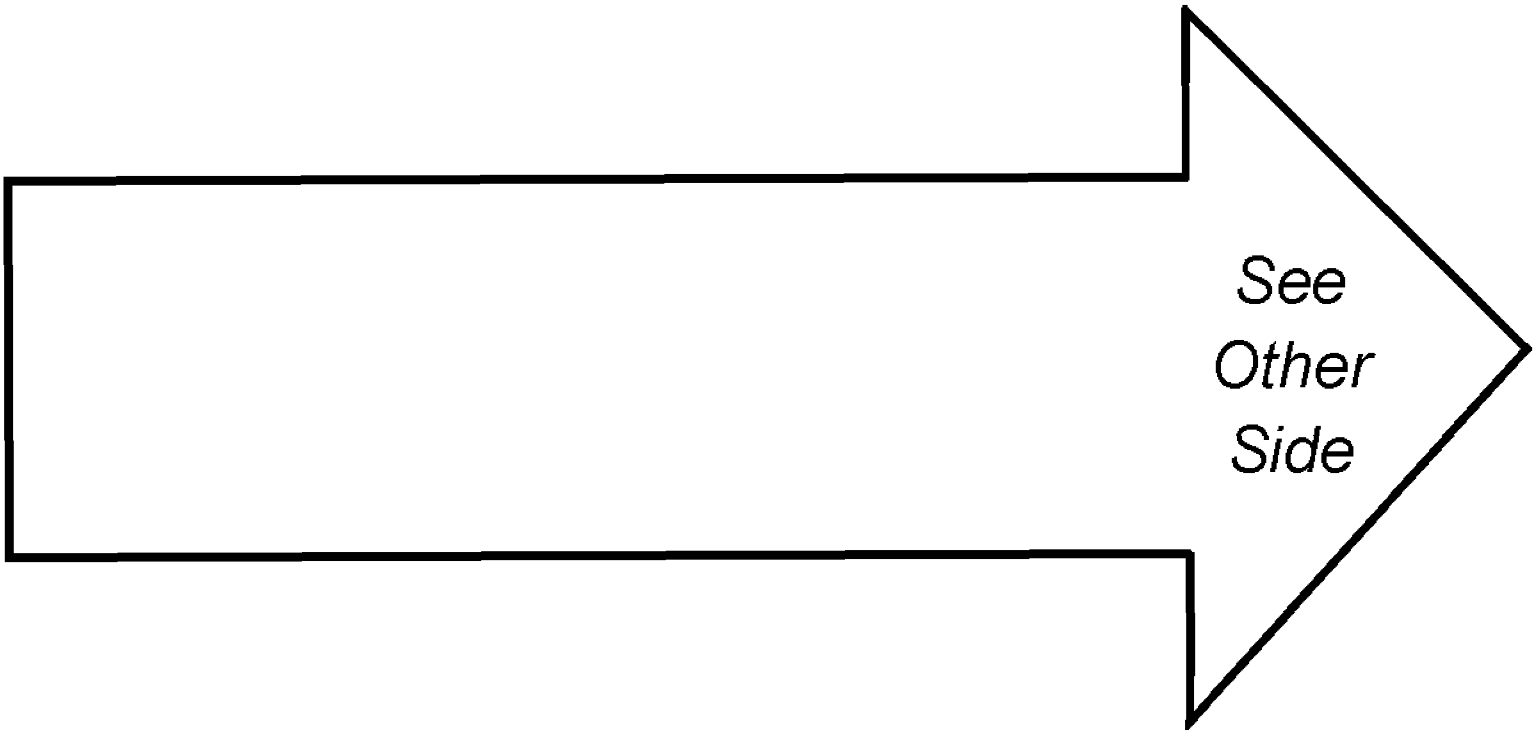
Table 6-61. PC Board Cross Reference

Schematic Number	Board Number			Board Name	HP Part Number
	CH A	CH B	Common		
1.	A1	A11		HV Amp†	03326-66501
2a.	A2			Attenuator	03326-66502
2b.		A12		Attenuator	03326-66512
3.	A3	A13		Output Amp	03326-66503
4.	A4	A14		Preamp	03326-66504
5.	A5	A15		Mixer	03326-66505
6.	A6	A16		Modulator	03326-66506
7.			A21	Offset	03326-66521
8.			A22	Level/AM	03326-66522
9.			A23	Square	03326-66523
10.			A24	RF Switch	03326-66524
11a.	A31	A41		VCO	03326-66531
11b.	A32	A42		VCO Control	03326-66532
11c.	A33	A43		Phase Detector	03326-66533
11d.	A34	A44		FracN Digital	03326-66534
11e.	A35	A45		VCO ÷ 2	03326-66535
11f.			P/O A36	FracN Decoder	03326-66536
12.			P/O A36	Calibrator	03326-66536
13.			A50	Reference	03326-66550
14a.			A61	Controller	03326-66561
14b.			A61	Controller	03326-66561
14c.			A61	Controller	03326-66561
			A63	HP-IB Support	03326-66563
15.			A62	Keyboard	03326-66562
16.			A70	Power Supply	03326-66570
17.			A72	Front ESD	03326-66572
18.			A75	Rear ESD	03326-66575
19.			A80	Oven Reference‡	03326-66580
—			A99	Motherboard	03326-66599

† Option 002 only.
‡ Option 001 only.


A-EXT PHASE CAL IN
B-EXT PHASE CAL IN
1,2,5,10 MHZ REF IN
10 MHZ OUT
A63
A80
CAUTION
IDENTICAL BOARDS MAY BE EXCHANGED TO AID IN TROUBLESHOOTING,BUT THE BOARDS MUST BE RETURNED TO THEIR ORIGINAL LOCATIONS TO AVOID RECALIBRATION OF THE INSTRUMENT.
A70
A35
A36
A45
A34
A44
A33
A43
A31
A32
A41
A42
A6
A50
A16
A5
A24
A15
A4
A23
A14
A3
A22
A13
A2
A21
A12
A1
A11
A61
A62
CH A OUTPUT
CH B OUTPUT

OVERALL BLOCK DIAGRAM


See
Other
Side

NOTES:

1. POOR GROUND CONNECTIONS IN THE PHONO CABLES MAY CAUSE INTERMITTENT PROBLEMS THAT CAN APPEAR TO BE SUBTLE HARDWARE FAILURES (FOR EXAMPLE, POOR PHASE OR AMPLITUDE CALIBRATION ACCURACY). CRIMPING THE PHONO CONNECTORS TO IMPROVE THE GROUND CONNECTIONS IS RECOMMENDED.

2. MOST OF THE TWO-PIECE CONNECTORS ON THE MOTHERBOARD AND DAUGHTER BOARDS HAVE CONSISTENT POWER SUPPLY LINES. THE +5 V LINES ARE ON PINS A1, B1, AND C1. THE +15 V LINES ARE ON PINS A2, B2 AND C2. THE -15 V LINES ARE ON PINS A3, B3 AND C3. THE POWER SUPPLY (A70) AND THE CONTROLLER (A61) ARE EXCEPTIONS. SEE THE SCHEMATICS FOR THE DETAILS.

3. THE IDENTICAL BOARDS IN THIS INSTRUMENT (i.e., THE BOARDS WITH IDENTICAL TOP COVERS) MAY BE INTERCHANGED FOR TROUBLESHOOTING PURPOSES. THE BOARDS MUST BE RETURNED TO THEIR ORIGINAL LOCATIONS TO AVOID RECALIBRATION OF THE INSTRUMENT.

CAUTION

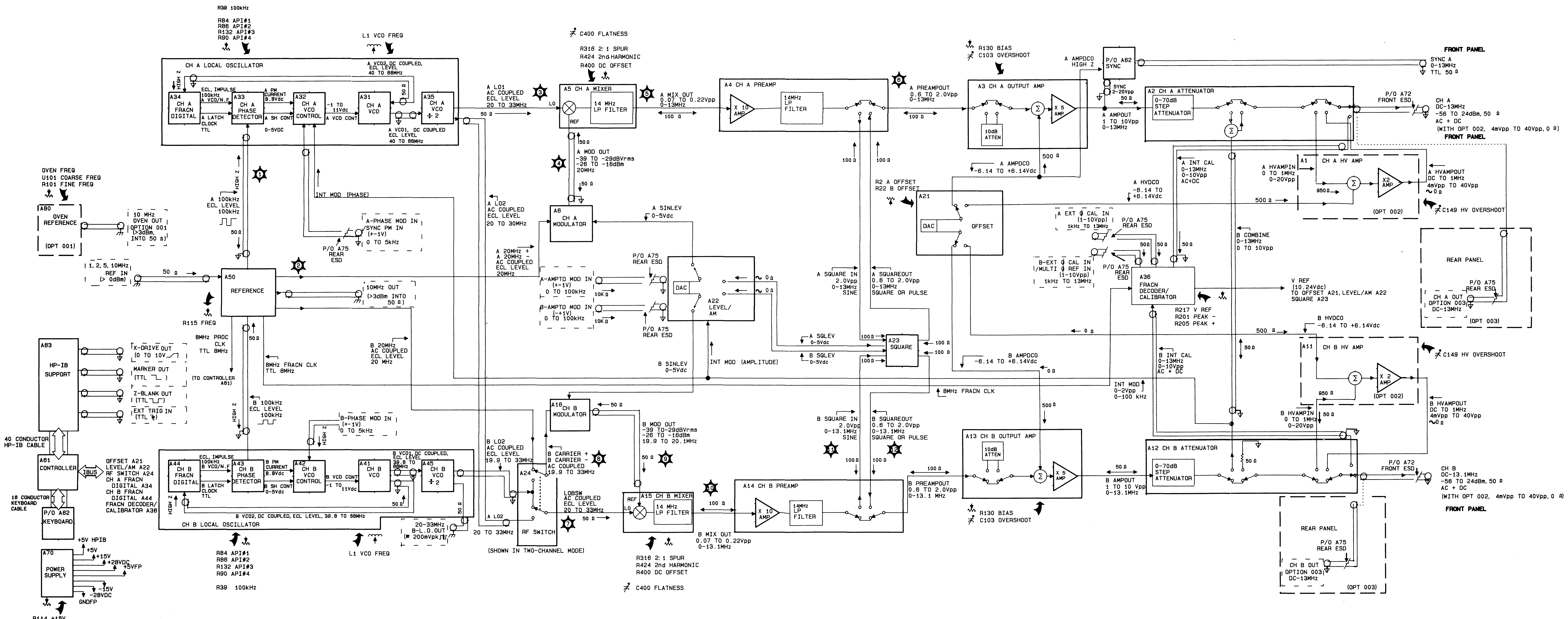
BEFORE INTERCHANGING BOARDS, BE SURE THAT THE CORRECT VOLTAGES ARE BEING SENT TO THE BOARD. WHEN A BOARD FAILURE IS CAUSED BY INCORRECT VOLTAGES POWERING THE BOARD, INTERCHANGING BOARDS WILL ONLY RESULT IN A FAILURE OF THE SECOND BOARD.

4.

CAUTION

TTL, EMITTER COUPLED LOGIC (ECL), TTL COMPATIBLE NMOS LOGIC, AND TTL COMPATIBLE CMOS LOGIC DEVICES ARE USED IN THIS INSTRUMENT.

USE THE APPROPRIATE PRECAUTIONS WHEN REMOVING HANDLING, AND INSTALLING ALL STATIC SENSITIVE COMPONENTS TO AVOID DAMAGE.



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BLOCK DIAGRAM
OVERALL

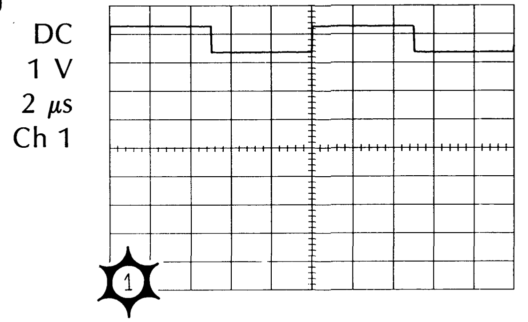
HP 3326A Setup 1

INSTR PRESET	
(Mode	2 CHANNEL)
Channel	CH A
Frequency	5 MHz
Amplitude	5 Vpp

Oscilloscope Setup (#1)

SMB to BNC adapter cable (waveform taken from connector on A50)

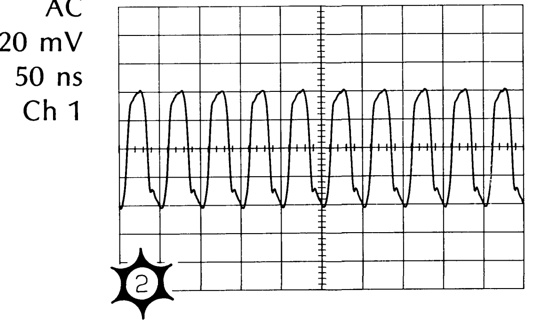
Ch 1 coupling	DC
Ch 1 V/div	1 V
Time/div	2 μs
Trigger	Ch 1

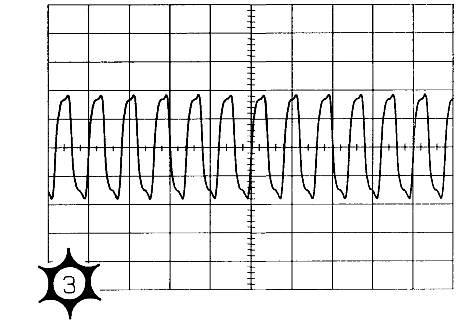


Oscilloscope Setup (#2, #3)

10:1 probe†

Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	50 ns
Trigger	Ch 1

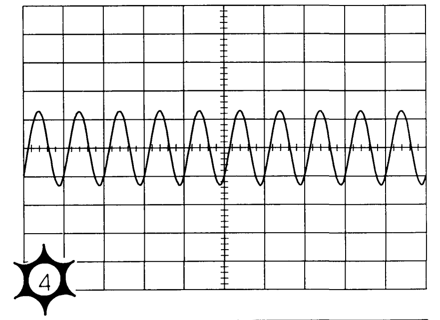




Oscilloscope Setup (#4)

Phono plug to BNC adapter cable (waveform taken from connector on A6)

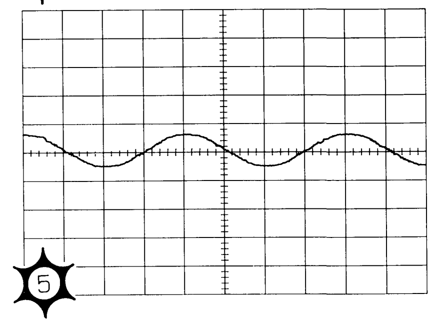
Ch 1 coupling	50 Ω DC
Ch 1 V/div	20 mV
Time/div	50 ns
Trigger	Ch 1



Oscilloscope Setup (#5)

10:1 probe

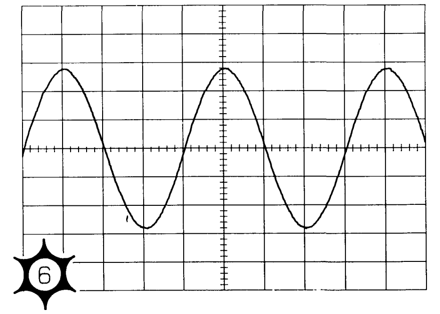
Ch 1 coupling	AC
Ch 1 V/div	10 mV
Time/div	50 ns
Trigger	Ch 1



Oscilloscope Setup (#6)

10:1 probe

Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	50 ns
Trigger	Ch 1



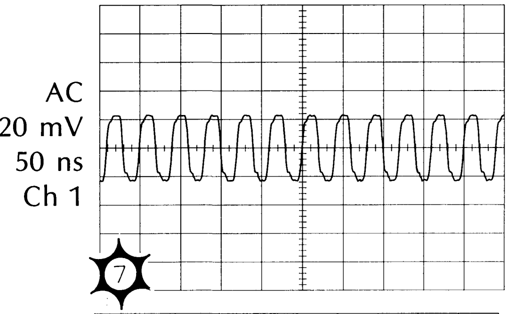
HP 3326A Setup 2

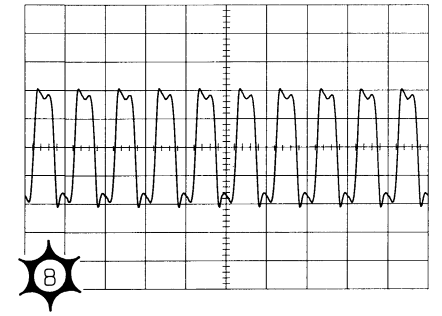
INSTR PRESET	
(Mode	2 CHANNEL)
Channel	CH B
Function	Square
Frequency	5 MHz
Amplitude	5 Vpp

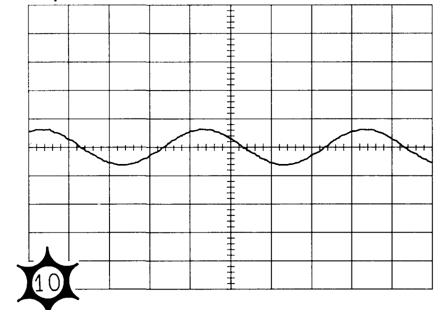
Oscilloscope Setup (#7, #8, #10)

10:1 probe

Ch 1 coupling	AC
Ch 1 V/div	20 mV
Time/div	50 ns
Trigger	Ch 1



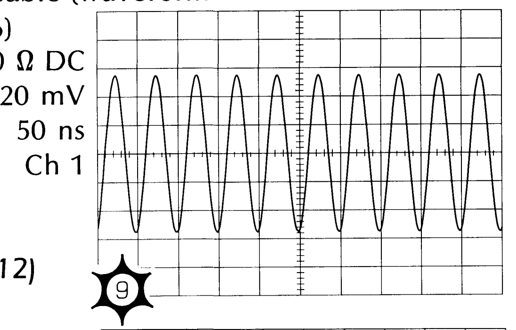




Oscilloscope Setup (#9)

Phono plug to BNC adapter cable (waveform taken from connector on A16)

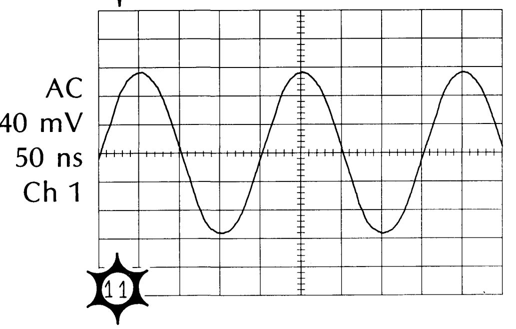
Ch 1 coupling	50 Ω DC
Ch 1 V/div	20 mV
Time/div	50 ns
Trigger	Ch 1

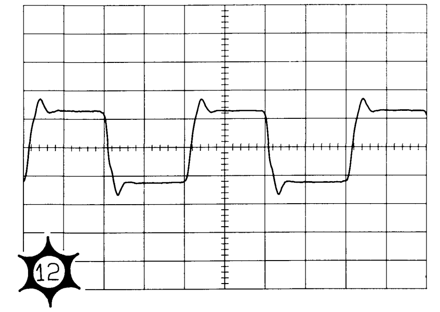


Oscilloscope Setup (#11, #12)

10:1 probe

Ch 1 coupling	AC
Ch 1 V/div	40 mV
Time/div	50 ns
Trigger	Ch 1





† Use a 10:1 probe with a ground spring (HP part number 1460-1476) when making high frequency measurements to minimize distortion.

Figure 6-84. Overall Block Diagram Waveforms

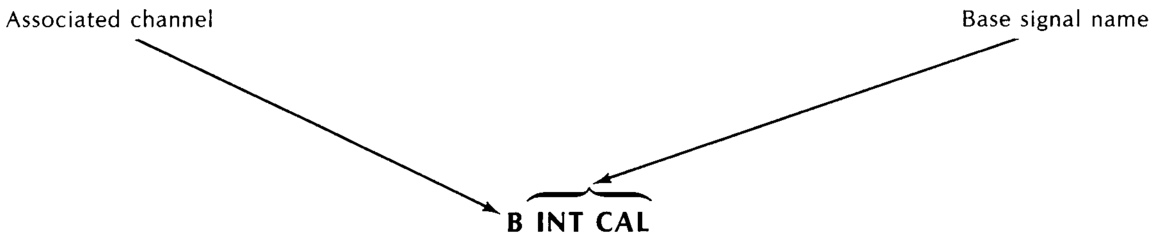
APPENDIX A
GLOSSARY OF SIGNAL NAMES

See Other Side

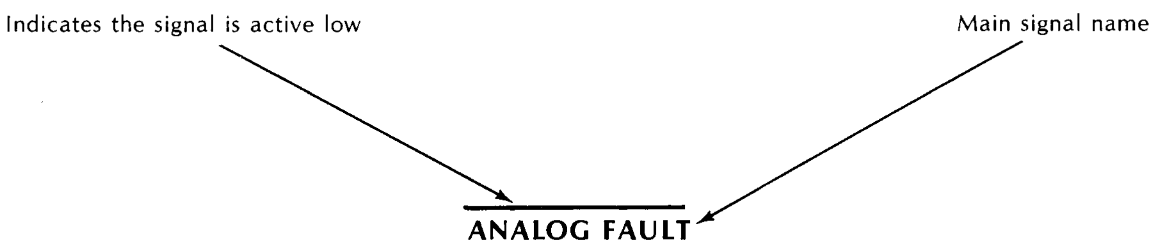
APPENDIX A
GLOSSARY OF SIGNAL NAMES

The following is a list of all signals used in the HP 3326A that travel between printed circuit boards. Active low signals are indicated by bars over the signal name. There are no bars present on active high signals. The motherboard has many of the signal names marked on the connectors to help you locate the signals.

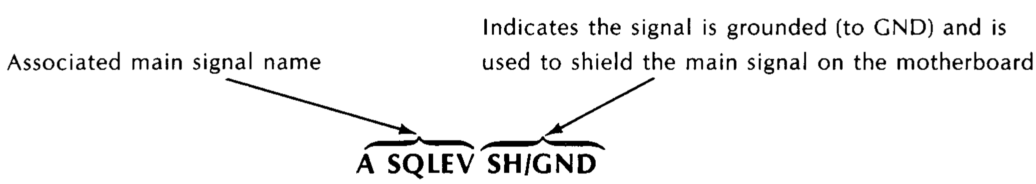
All main signal names have the form:



All active low control signals have the form:



There is a group of grounded signals used to shield the main analog signals as they travel from one destination to another on the motherboard (A99). These signal names have the form:



+15 V (regulated +15 Volt supply) A regulated +15 V supply generated by the power supply (A70). Used in all boards except the front ESD board (A72), the rear ESD board (A75) and the oven reference board (A80).

+15V RAW (RAW, unregulated +15 V supply) Originates on the power supply (A70) and travels to the oven reference (A80, Option 001) via the three conductor cable on the motherboard. Provides unregulated power to the oven reference. The level of the signal is approximately +18 V.

+15V SENSE (+15 Volt SENSing signal) +15 V signal from the motherboard. Used as a remote sense line for the +15 V supply on the power supply board (A70).

+28VDC (unregulated +28 Vdc supply) Generated by the power supply (A70). Used on the channel A and channel B high voltage amplifiers (A1 and A11, Option 002).

+5V (regulated +5 Volt supply) A highly regulated +5 V supply generated by the power supply (A70). Used by all the boards in the instrument except the HP-IB support board (A63), the front ESD board (A72), the rear ESD board (A75) and the oven reference board (A80, Option 001).

+5VFP (regulated +5 Volt Front Panel supply) The +5 V signal to the keyboard (A62), generated by the power supply (A70). This signal is separate from the +5V supply to guarantee that the display scan frequency components do not degenerate the main supply. +5VFP travels to the keyboard via the controller board (A61).

+5V HPIB (regulated +5 Volt HP-IB supply) A +5 V supply generated by the power supply (A70). Used to power the HP-IB interface circuitry on the controller board (A61).

+5V REF (+5 Volt REFerence signal) +15 V signal from the motherboard. Used as a voltage reference for the +5 V supply on the power supply board (A70).

+5V SENSE (+5 Volt SENSing signal) +5 V signal from the motherboard. Used as a remote sense line for the +5 V supply on the power supply board (A70).

−15V (regulated −15 Volt supply) Generated by the power supply (A70). Used by all the boards in the instrument except the HP-IB support board (A63), the front ESD board (A72), the rear ESD board (A75) and the oven reference board (A80, Option 001).

−15V REF (−15 Volt REFerence signal) +15 V signal from the motherboard. Used as the voltage reference for the −15 V supply on the power supply board (A70).

−15V SENSE (−15 Volt SENSing signal) −15 V from the motherboard. Used as a remote sense line for the −15 V supply on the power supply board (A70).

−28VDC (unregulated −28 Vdc supply) Generated by the power supply (A70). Used on the channel A and channel B high voltage amplifiers (A1 and A11, Option 002).

10MHz OUT (>3dBm) ‡ (10 MHz rear panel OUTput) Clean, 10 MHz rear panel output generated on the reference board (A50). Runs to the rear panel connector. Amplitude range is nominally 3 dBm into 50 ohms. The shield of the connector is tied to CGND. See specifications for details.

10MHz OVEN OUT, OPTION 001 (>3dBm) ‡ (10 MHz OVEN reference rear panel OUTput) Very accurate 10 MHz output signal from the oven reference (A80) to the rear panel output connector (when the high stability frequency reference (Option 001) is in place). Used to provide a stable input (1,2,5,10 MHz REF IN) to lock the HP 3326A's frequency reference (A50). See specifications for details. The shield of the connector is tied to CGND.

‡ Signal travels via a cable.

1,2,5,10MHz REF IN (>0dBm) ‡ (external REFerence INput) Input to the reference (A50) from the rear panel. Used to control the internal reference oscillator frequency. The external reference level must be greater than 0 dBm into 50Ω. The frequency must be within 20 ppm of an integer sub-harmonic of 20 MHz. The shield of the connector is tied to CGND.

20-33MHz B-L.O. OUT (≅200 mVpk) † ‡ (20 to 33 MHz channel B Local Oscillator rear panel OUTput) ECL level, ac coupled. The frequency is offset from the front panel frequency by 20 MHz. Overload protection is provided. The signal is generated on the channel B VCO ÷ 2 board (A45) and sent through a transformer to reduce ground current loops before being routed to the rear panel. The shield of the connector is tied to CGND.

8MHz FRACN CLK † (8 MHz fractional-N local oscillator CLocK) An 8 MHz TTL level clock generated by the reference board (A50) and used by the fractional-N decoder board (P/O A36) for programming frequencies and sweeps.

8MHz FRACN CLK SH/GND ★ (8 MHz fractional-N local oscillator CLocK SHield/GrouND)

8MHz PROC CLK † (8 MHz PROCessor CLocK) An 8 MHz TTL level clock generated by the reference board (A50). Used by the controller (A61) as the clock signal for the microprocessor.

8MHz PROC CLK SH/GND ★ (8 MHz PROCessor CLocK SHield/GrouND)

A 100kHz ‡ (channel A 100 kHz reference) 100 kHz, ECL level square wave originating on the reference board (A50) and terminating on the channel A phase detector (A33). Used as the channel A local oscillator's reference signal.

A 10dB (channel A 10 dB attenuator control) This TTL signal from the offset board (A21), when high, drives the relay which engages the 10 dB pad on the channel A attenuator board (A2).

A 20dB (channel A 20 dB attenuator control) This TTL signal from the offset board (A21), when high, drives the relay which engages the 20 dB pad on the channel A attenuator board (A2).

A 20MHz +, A 20MHz − † (channel A 20 MHz reference) Differential 20 MHz reference signal generated on the reference board (A50). Used as an input to the channel A modulator (A6). ECL level, ac coupled, 50 Ω input.

A 20MHz SH/GND ★ (channel A 20 MHz reference SHield/GrouND)

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

$\overline{\text{A2FLAG}}$ (channel A attenuator (A2) FLAG) TTL level. A low signal indicates to the processor that the channel A attenuator is inserted correctly in the channel A card nest. The signal runs from the channel A attenuator (A2) to the channel A fractional-N digital board (A44), where it is placed on the instrument bus and sent to the controller (A61). An error message is displayed when the $\overline{\text{A2FLAG}}$ signal is high (indicating the correct attenuator board is not in the channel A card nest or there is no board in the card nest).

A 40dB (channel A 40 dB attenuator control) When high, this TTL signal from the offset board (A21) drives the relay which engages the 40 dB pad on the channel A attenuator board (A2).

A A+B (channel A and channel B combiner control) When high, this TTL signal from the offset board (A21) engages the combiner relay on the channel A attenuator board (A2). The channel B output signal from the channel B attenuator is summed with the channel A output signal on the channel A attenuator board. Both signals are present on the channel A front panel output connector (CH A).

A AMPDCO † (channel A output AMPlifier DC Offset) Generated by a DAC and a current-to-voltage converter on the offset board (A21). Provides dc offset voltage to the instrument at the channel A output amplifier (A3). Summed with the primary RF signal at the amplifier input. Voltage range is −6.14 to +6.14 Vdc. When the high voltage option is activated, this signal is renamed A HVDCO and routed through the high voltage amplifier (A1, Option 002). Also used to provide a dc signal for the SYNC circuit on the keyboard (A62). It is sent to this circuit through cables on the controller (A61).

A AMPDCO SH/GND ★ (channel A output AMPlifier DC Offset SHield/GrouND)

A AMPOUT † (channel A output AMPlifier OUTput) Primary RF signal from the channel A output amplifier (A3) to the channel A attenuator (A2). Voltage range is 1 to 10 Vpp (unloaded). Frequency range is 0 to 13 MHz. Characteristic impedance of the line is 50 Ω.

A AMPOUT SH/GND ★ (channel A output AMPlifier OUTput SHield/GrouND)

A AMPTD MOD IN (± 1V) † ‡ (channel A external AMPliTuDe MODulation INput) Rear panel input to the level/AM board (A22). Used to amplitude modulate channel A. Level range is ±1 V. Frequency range is 0 to 100 kHz. A 0 V signal produces 0% modulation. A dc or instantaneous input of +1 V produces 100% modulation. A −1 V signal reduces the un-modulated level by 100%, resulting in a 0 V output.

A AMPTD MOD IN SH/GND ★ (channel A external AMPliTuDe MODulation INput SHield/GrouND)

$\overline{\text{A API1}}$ (channel A API #1 control) TTL level control line. Originates on the channel A fractional-N digital board (A34) and terminates on the channel A phase detector board (A33). A low level turns on the API #1 current correction source.

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

A API2 (channel A API #2 control) TTL level control line. Originates on the channel A fractional-N digital board (A34) and terminates on the channel A phase detector board (A33). A low level turns on the API #2 current correction source.

A API3 (channel A API #3 control) TTL level control line. Originates on the channel A fractional-N digital board (A34) and terminates on the channel A phase detector board (A33). A low level turns on the API #3 current correction source.

A API4 (channel A API #4 control) TTL level control line. Originates on the channel A fractional-N digital board (A34) and terminates on the channel A phase detector board (A33). A low level turns on the API #4 current correction source.

A API5 (channel A API #5 control) TTL level control line. Originates on the channel A fractional-N digital board (A34) and terminates on the channel A phase detector board (A33). A low level turns on the API #5 current correction source.

A BIAS (channel A fractional-N local oscillator BIAS control) When low, this TTL level signal from the channel A fractional-N digital board (A34) turns on the bias, which discharges the integrator on the channel A phase detector board (A33).

A CAL (channel A CALibration) When low, this TTL signal from the offset board (A21) engages a relay on the channel A attenuator board (A2) which routes the attenuator's output signal to the calibrator board (P/O A36) for internal amplitude and phase calibration.

A COMPAR ENABLE (channel A COMPARator ENABLE) TTL level signal generated on the level/AM board (A22). Used to enable the comparators on the square board (A23). Active high.

A DATA (channel A DATA strobe) TTL level strobe from the fractional-N decoder board (P/O A36) whose positive edge indicates data is valid at the fractional-N IC. Signal terminates on the channel A fractional-N digital board (A34).

A DATA OUT (channel A DATA strobe OUT) TTL level strobe from the fractional-N decoder board (P/O A36) which enables the tri-state buffer (A34U15) when reading from the fractional-N digital board (A34). This line also clears the VCO unlocked flag (A VCOF).

ADD STROBE (ADDress STROBE) TTL level strobe from the controller (A61) to the fractional-N decoder board (P/O A36), the offset board (A21) and the level/AM board (A22). The signal is normally high and strobes when the microprocessor is writing an address to the instrument bus. The address placed on the bus is latched by all boards attached to the bus on the falling edge of the signal.

A DLBC (channel A DeLayed Bias Clock) 100 kHz pulse waveform. TTL level. Active low. Originates on the channel A fractional-N digital board (A34) and terminates on the calibrator/fractional-N decoder board (A36). Used by the fractional-N decoder to synchronize writing instructions to the two local oscillators. Used by the calibrator to clock the ADC.

A-EXT ϕ CAL IN (1-10Vpp) ‡(channel A EXTernal phase CALibration INput) Rear panel input to the calibrator (P/O A36). Used for external phase calibration in the two-phase mode only, with the square or sine functions. Input frequency range is 1 kHz to 13 MHz. Input voltage range is 1 to 10 Vpp. Requires 50% duty cycle. Fuse protected.

‡ Signal travels via a cable.

A HI-VOLT (channel A HIgh VOLTage option) When high, this TTL line from the offset board (A21) activates the relay on the channel A attenuator board (A2), which routes the output signal through the channel A high voltage amplifier (A1, Option 002).

A HVAMPIN † (channel A High Voltage AMPlifier INput) The primary RF signal from the channel A attenuator (A2) that is routed to the input of the channel A high voltage amplifier (A1, Option 002) when the high voltage option is activated. Voltage range is 0 to 20 Vpp. Frequency range is 0 to 1 MHz. Signal has 950 Ω of input impedance looking into the channel A high voltage amplifier (A1). The amplifier has a gain of two times the HVAMPIN signal level (four times the 50 Ω loaded level).

A HVAMPIN SH/GND ★ (channel A High Voltage AMPlifier INput SHield/GrouND)

A HVAMPOUT † (channel A High Voltage AMPlifier OUTput) Originates on the channel A high voltage amplifier (A1, Option 002) and terminates on the channel A attenuator (A2). Carries the main RF signal. Used only when the high voltage option is activated. Voltage range is 4 mVpp to 40 Vpp. Frequency range is dc to 1 MHz. Approximately 0 Ω output resistance.

A HVAMPOUT SH/GND ★ (channel A High Voltage AMPlifier OUTput SHield/GrouND)

A HVDCO † (channel A High Voltage amplifier DC Offset) Generated by a DAC and a current-to-voltage converter on the offset board (A21). Provides dc offset voltage to the instrument at the channel A high voltage amplifier (A1). A HVDCO is summed with A HVAMPIN at the virtual ground point of the amplifier. Voltage range is −6.14 Vdc to +6.14 Vdc. The amplifier multiplies the offset by four. Input resistance is 499 Ω.

A HVDCO SH/GND ★ (channel A High Voltage amplifier DC Offset SHield/GrouND)

$\overline{\text{A HVOVLD}}$ (channel A High Voltage OVerLoaD) TTL compatible logic signal from the overload detection comparators of the channel A high voltage amplifier (A1, Option 002). A low signal indicates a current or voltage overload condition at the high voltage amplifier output. Signal terminates at the channel A attenuator (A2), which alerts the microprocessor (A61) when an overload has occurred. See $\overline{\text{A OVLD}}$.

A INT CAL ‡ (channel An Internal CALibration) RF output signal from the channel A attenuator (A2) which runs to the calibrator board (P/O A36) for internal amplitude (ac and dc) and phase calibration. Used when internal phase or amplitude calibrations are performed. Characteristic impedance of the line is 50 Ω. Frequency range is 0 to 13 MHz. Voltage range is 0 to 10 Vpp (terminated into the calibrator board).

A INV (channel A INstruction Valid) Normally high, TTL level strobe used to clock instructions to the fractional-N IC. Positive edge triggered. (The signal is negative edge triggered at A34TP14.) Originates on the fractional-N decoder board (P/O A36) and terminates on the channel A fractional-N digital board (A34).

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

A IOVLD (channel A current OVerLoaD) TTL compatible logic signal from the current overload comparators of the channel A output amplifier (A3). A low signal indicates a current overload condition in the output stage of the amplifier. Signal terminates at the channel A attenuator (A2), which signals the microprocessor (A61) when an overload has occurred. See A OVLD.

A LATCH CLOCK † (channel A LATCH CLOCK) TTL level clock generated on the channel A fractional-N digital board (A34). Used on the channel A phase detector board (A33) to re-clock the bias and API signals.

A LATCHCLOCK SH/GND ★ (channel A LATCH CLOCK SHield/GrouND)

A LO1 † (channel A Local Oscillator 1) Input to the channel A mixer (A5) from the channel A local oscillator (VCO÷2, A35). 20 to 33 MHz, ECL compatible, ± 0.5 Vpp. Input impedance is 50 ohms, ac coupled.

A LO1 SH/GND ★ (channel A Local Oscillator 1 SHield/GrouND)

A LO2 ‡ (channel A Local Oscillator 2) 20 to 33 MHz, ECL level, ac coupled. Runs through a cable from the channel A VCO ÷ 2 board (A35) to the RF switch (A24). This primary RF signal is the input to the local oscillator port of the channel B mixer (A15) in the two-tone, two-phase, and pulse modes. In these modes, the channel B local oscillator provides the input to the reference port of the channel B mixer. A LO2 is disabled in the two-channel mode.

A MIX OUT † (channel A MIXer OUTput) Primary RF sine wave signal originating at the output of the channel A mixer (A5) and the 14 MHz lowpass filter (located on the mixer board) and terminating at the input of the channel A preamplifier (A4). Possible amplitude modulation of 100 kHz maximum. Voltage range is approximately 0.07 to 0.22 Vpp. Frequency range is 0 to 13 MHz. Expects 100 Ω termination.

A MIX OUT SH/GND ★ (channel A MIXer OUTput SHield/GrouND)

A MOD OUT ‡ (channel A MODulator OUTput) Input to the channel A mixer (A5) from the output of the channel A modulator (A6) and the half filter (20 MHz bandpass) located on the modulator board. 20 MHz carrier with possible AM of 100 kHz maximum. Voltage range is approximately −39 to −29 dBVrms (−26 to −16 dBm). Should be terminated in 50 ohms.

ANALOG FAULT (ANALOG circuitry FAULT) This TTL level input to the controller board (A61) is the logical OR of the individual circuit faults detected on the offset board (A21), channel A VCO control (A32), and channel B VCO control (A42). A low signal indicates a fault has occurred. The VCO control boards use this line to signal an unlocked local oscillator. The offset board uses this line to signal an overload condition. To determine the source of the problem, each of the boards must be interrogated via the instrument bus (IBUS0-7). ANALOG FAULT is available to the microprocessor on status register, bit D5.

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

A OVLD (channel A OVerLoaD) When low, this TTL logic signal from the channel A attenuator (A2) to the offset board (A21) indicates that an overload condition has occurred somewhere in the instrument. The offset board signals the controller (A61) by pulling the ANALOG FAULT line low.

A PHASE MOD IN SH/GND ★ (channel A external PHASE MODulation rear panel INput SHield/GrouND)

A-PHASE MOD IN/SYNC PM IN (±1V) † ‡ (channel A external PHASE MODulation rear panel INput/SYNC Phase Modulation INput) Input to the channel A VCO control board (A32). Used to phase modulate the channel A local oscillator. Voltage range is ±1 V. Frequency range is 0 to 5 kHz. Input signals of ±1 V correspond to ±360°, respectively.

A PMC (channel A Phase Modulation Control) Originates on the fractional-N decoder board (P/O A36). Terminates on the channel A phase detector board (A33) and the channel A VCO control board (A32). When low, this TTL level signal indicates that no phase modulation is desired. When high, this signal activates the phase modulation circuitry.

A PMCAL (channel A Phase Modulation CALibration) Originates on the fractional-N decoder board (P/O A36). Terminates on the channel A VCO control board (A32). Active low. This line is shorted to ground to permit an internal phase modulation calibration to take place.

A PMCURRENT (channel A Phase Modulation CURRENT) Terminates on the channel A phase detector board (A33). Originates on the channel A VCO control board (A32). Signal is +15 Vdc when phase modulation is off, and +8.8 Vdc when phase modulation is on.

A PMS (channel A Phase Modulation Select) Originates on the fractional-N decoder board (P/O A36). Terminates on the channel A VCO control board (A32). When low, this TTL level indicates internal phase modulation is programmed. When high, this signal indicates external phase modulation is programmed.

A PRE10dB (channel A PRE-10 dB attenuator control) TTL logic line from the offset board (A21) to the channel A output amplifier (A3) which engages the 10 dB attenuation pad when the signal is high. (The level table in the attenuator repair sub-section lists the ranges when the pad is activated.)

A PREAMPOUT † (channel A PREAMPlifier OUTput) Primary RF output signal originating on the channel A preamplifier (A4) and terminating at the relay for the pre-10 dB pad on the channel A output amplifier (A3). Signal may be either a sine wave or a square wave, depending on the position of the relay on the preamplifier (A4K101). In the normal relay position, the main RF signal is a sine wave and travels directly to the output of the preamplifier board. When the square function or the pulse mode is activated, the relay is set and the output is diverted to the square board (A23) and returned to the preamplifier board as a square wave. The characteristic impedance of the line is 100 Ω. The voltage range is 0.6 to 2.0 Vpp when loaded. The frequency range is 0 to 13 MHz.

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

A PREAMPOUT SH/GND ★ (channel A PREAMPlifier OUTput SHield/GrouND)

A PROTECTCLEAR (channel A PROTECT mode CLEAR) When low, this TTL logic signal from the offset board (A21) to the channel A attenuator board (A2) resets the overload protection latch and disables the protect mode. Normal operation is restored.

A SH CONT † (channel A Sample and Hold CONTrol voltage) Originates on the channel A phase detector board (A33). Terminates on the channel A VCO control board (A32). Used to control the VCO frequency. Voltage range is 0 to 5 V. A 0 V level corresponds to approximately 66 MHz on A VCO1 and A VCO2; a 5 V level corresponds to approximately 40 MHz.

A SH CONT SH/GND ★ (channel A Sample and Hold CONTrol voltage SHield/GrouND)

A S-H TRIG (channel A Sample and Hold TRIGger) When high, this TTL level signal from the channel A fractional-N digital board (A34) triggers the channel A phase detector (A33) to sample the integrator output.

A SIN (channel A SINe wave function) TTL level signal from the level/AM board (A22) to the channel A preamplifier (A4). Low level indicates a sine wave ws programmed and the main signal is directed to the channel A output amplifier (A3). High level indicates a square wave was programmed and the signal is directed to the square board (A23).

A SINLEV † (channel A SINe wave LEVel) Generated by the level/AM board (A22). Amplitude control input (0 to 5 Vdc) and AM input (0 to 100 kHz) to the channel A modulator (A6) when the sine function is programmed. (A SINLEV = 5 V when the square function is programmed.) AM signal peak should be within the dc limits of 0 to 5 volts. Amplitude control typically ranges from 4.069 Vdc (calibrated full scale output) to 1.287 Vdc (10 dB below full scale). When the amplitude control is at its highest attenuation (i.e. 1.287 Vdc), a step attenuator is activated and A SINLEV is returned to its un-modulated (≅ 5 Vdc) level. When AM is programmed, the modulating signal is superimposed on A SINLEV, resulting in 0 to 100% modulation.

A SINLEV SH/GND ★ (channel A SINe wave LEVel SHield/GrouND)

A SQLEV † (channel A SQuare wave LEVel) Generated by the level/AM board (A22). Amplitude control input (0 to 5 Vdc) and AM input (0 to 100 kHz) to the channel A square board (A23) when the square or pulse functions are programmed. (A SQLEV = 0 V when the sine function is programmed.) Amplitude control typically ranges from 4.069 Vdc (calibrated full scale output) to 1.287 Vdc (10 dB below full scale). When the amplitude control is at its highest attenuation (i.e. 1.287 Vdc), a step attenuator is activated and A SQLEV is returned to its un-modulated (≅ 5 Vdc) level. When AM is programmed, the modulating signal is superimposed on A SQLEV, resulting in 0 to 100% modulation.

A SQLEV SH/GND ★ (channel A SQuare wave LEVel SHield/GrouND)

A SQUARE IN † (channel A SQUARE board INput) In the square function or pulse mode, this sinusoidal output of the channel A preamplifier (A4) is routed to the square board (A23) with a relay. Signal level is 2.0 Vpp. Frequency range is 0 to 13 MHz.

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

A SQUARE IN SH/GND ★ (channel A SQUARE board INput SHield/GrouND)

A SQUAREOUT † (channel A SQUARE board OUTput) Output of the square board (A23). This square wave signal or pulse signal is sent to the channel A preamplifier (A4), where it is renamed A PREAMPOUT and sent to the channel A output amplifier (A3). Voltage range is 0.6 to 2.0 Vpp. Frequency range is 0 to 13 MHz.

A SQUAREOUT SH/GND ★ (channel A SQUARE board OUTput SHield/GrouND)

$\overline{\text{A SWEEP LIMIT}}$ (channel A SWEEP LIMIT flag) When low, this TTL signal generated by the channel A fractional-N digital board (A34) indicates to the controller (A61) that the sweep destination or marker frequency has been reached. This signal causes an NMI interrupt on the controller board.

A SWPL (channel A SWeeP Limit control) When high, this TTL signal from the fractional-N decoder (P/O A36) determines the point to stop the sweep. It assigns the stop frequency to the marker frequency and instructs the fractional-N IC on the channel A digital board (A34) to stop sweeping at this marker frequency. This occurs whenever the instrument is sweeping.

ATN (ATteNtion) Bidirectional HP-IB signal traveling from the controller (A61), through the HP-IB support board (A63), to the rear panel HP-IB connector. Causes all devices to interpret data on the bus as a controller command and to activate their acceptor handshake function (in the command mode, when ATN is high) or data between addressed devices (in the data mode, when ATN is low).

A VCO1 ‡ (channel A Voltage Controlled Oscillator 1) ECL level, dc coupled. Frequency range is 40 to 66 MHz. Output of the channel A fractional-N local oscillator which is sent to a divide-by-two circuit. Signal travels from the channel A VCO board (A31) to the channel A VCO÷2 board (A35).

A VCO2 ‡ (channel A Voltage Contolled Oscillator 2) ECL level, dc coupled. Frequency range is 40 to 66 MHz. This channel A VCO board (A31) output serves as an input to the channel A fractional-N digital board (A34). It is divided by the N number, compared with the reference frequency, and sent through the fractional-N loop again. This repeats until the two frequencies match. See the fractional-N local oscillator theory of operation for more information.

A VCO CONT † (channel A VCO CONTrol voltage) This dc level signal originates on the channel A VCO control board (A32) and provides a frequency control for the channel A VCO board (A31). It is a buffered version of A SH CONT. The voltage range is −1 Vdc to 11 Vdc. A −1 Vdc level corresponds to approximately 66 MHz on A VCO1 and A VCO2; an 11 Vdc level corresponds to approximately 40 MHz.

A VCO CONT SH/GND ★ (channel A VCO CONTrol voltage SHield/GrouND)

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

A VCOF (channel A VCO unlocked Flag) When high, this TTL level signal indicates the channel A VCO is unlocked. When low, this signal indicates the VCO is locked. Travels from the channel A VCO control board (A32) to the channel A fractional-N digital board (A34).

A VCO/N.F † (channel A VCO/N.F) ECL level, dc coupled. 20 ns pulse. 100 kHz rate. Originates on the channel A fractional-N digital board (A34). Terminates on the channel A phase detector (A33). Compared with A 100kHz on A33. The result of the comparison is used for activating the phase detector.

A VCO/N.F SH/GND ★ (channel A VCO/N.F SHield/GrouND)

B 100kHz ‡ (channel B 100 kHz reference) 100 kHz, ECL level square wave originating on the reference board (A50) and terminating on the channel B phase detector (A43). Used as the channel B local oscillator's reference signal.

B 10dB (channel B 10 dB attenuator control) When high, this TTL signal from the offset board (A21) drives the relay which engages the 10 dB pad on the channel B attenuator board (A12).

B 20dB (channel B 20 dB attenuator control) When high, this TTL signal from the offset board (A21) drives the relay which engages the 20 dB pad on the channel B attenuator board (A12).

B 20MHz † (channel B 20 MHz reference) Generated on the reference board (A50). Used as an input to the RF switch board (A24). The signal is used as the channel B reference signal in the two-channel mode. It is disabled in all other modes. ECL level, ac coupled, 50 Ω input.

B 20MHz SH/GND ★ (channel B 20 MHz reference SHield/GrouND)

B 40dB (channel B 40 dB attenuator control) When high, this TTL signal from the offset board (A21) drives the relay which engages the 40 dB pad on the channel B attenuator board (A12).

B A+B/MOD (channel A and channel B combiner/MODulation control) When high, this TTL signal from the offset board (A21) engages the combiner/modulation relay on the channel B attenuator board (A12). In the combined mode, the channel B output signal from the A12 is summed with the channel A output signal on the channel A attenuator board (A2). Both signals are present on the channel A front panel output connector (CH A). For internal amplitude and phase modulation, the relay directs the main signal (now renamed INT MOD) to the level/AM board (for AM) or to the channel A VCO control board (for PM).

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

B AMPDCO † (channel B output AMPlifier DC Offset) Generated by a DAC and a current to voltage converter on the offset board (A21). Provides dc offset voltage to the instrument at the channel B output amplifier (A13). Summed with the primary RF signal at the amplifier input. Voltage range is −6.14 to +6.14 Vdc. When the high voltage option is activated, this signal is renamed B HVDCO and routed through the high voltage amplifier (A11, Option 002). Also used to provide a dc signal for the SYNC circuit on the keyboard (A62). It is sent to this circuit through cables on the controller (A61).

B AMPDCO SH/GND ★ (channel B output AMPlifier DC Offset SHeild/GrouND)

B AMPOUT † (channel B output AMPlifier OUTput) Primary RF signal from the channel B output amplifier (A13) to the channel B attenuator (A12). Voltage range is 1 to 10 Vpp (unloaded). Frequency range is 0 to 13 MHz. The maximum frequency limit increases to 13.1 in two-tone mode. Characteristic impedance of the line is 50 Ω.

B AMPOUT SH/GND ★ (channel B output AMPlifier OUTput SHield/GrouND)

B AMPTD MOD IN ($\mp$1V) † ‡ (channel B external AMPliTuDe MODulation INput) Rear panel input to the level/AM board (A22). Used to amplitude modulate channel B. Level range is ±1 V. Frequency range is 0 to 100 kHz. A 0 V signal produces 0% modulation. A dc or instantaneous input of −1 V produces 100% modulation. A +1 V signal reduces the un-modulated level by 100%, resulting in a 0 V output.

B AMPTD MOD IN SH/GND ★ (channel B external AMPliTuDe MODulation INput SHield/GrouND)

$\overline{\text{B API1}}$ (channel B API #1 control) TTL level control line. Originates on the channel B fractional-N digital board (A44) and terminates on the channel B phase detector board (A43). A low level turns on the API #1 current correction source.

$\overline{\text{B API2}}$ (channel B API #2 control) TTL level control line. Originates on the channel B fractional-N digital board (A44) and terminates on the channel B phase detector board (A43). A low level turns on the API #2 current correction source.

$\overline{\text{B API3}}$ (channel B API #3 control) TTL level control line. Originates on the channel B fractional-N digital board (A44) and terminates on the channel B phase detector board (A43). A low level turns on the API #3 current correction source.

$\overline{\text{B API4}}$ (channel B API #4 control) TTL level control line. Originates on the channel B fractional-N digital board (A44) and terminates on the channel B phase detector board (A43). A low level turns on the API #4 current correction source.

$\overline{\text{B API5}}$ (channel B API #5 control) TTL level control line. Originates on the channel B fractional-N digital board (A44) and terminates on the channel B phase detector board (A43). A low level turns on the API #5 current correction source.

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

$\overline{\textbf{B BIAS}}$ (channel B fractional-N local oscillator BIAS control) When low, this TTL level signal from the channel B fractional-N digital board (A44) turns on the bias, which discharges the integrator on the channel B phase detector board (A43).

$\overline{\textbf{B CAL}}$ (channel B CALibration) When low, this TTL signal from the offset board (A21) engages a relay on the channel B attenuator board (A12) which routes the attenuator's output signal to the calibrator board (P/O A36) for internal amplitude and phase calibration.

B CARRIER +, B CARRIER − † (channel B reference CARRIER) Differential input to the channel B modulator board (A16) from the RF switch (A24). Provides the reference signal for the B channel. In the two-channel mode, B CARRIER is derived from the reference signal (B 20MHz) from the reference board (A50). In the two-tone mode, B CARRIER is derived from the channel B local oscillator. The frequency range is 19.9 to 20.1 MHz. In the two-phase and pulse modes, B CARRIER is a variable phase 20 MHz reference signal derived from the channel B local oscillators. Expects 50 Ω termination, ac coupled. See the overall theory of operation in Section VI for a description of the operating modes.

B CARRIER SH/GND ★ (channel B reference CARRIER SHield/GrouND)

B COMBINE ‡ (channel B COMBINEd operation) The channel B output signal (CH B) travels from the channel B attenuator to the channel A attenuator when the instrument is in combined operation. This channel B output signal is summed with the channel A output signal (CH A) before the two are sent to the CH A output connector. The channel B output (CH B) is disabled. Both main signals experience a 6.02 dB attenuation due to the resistive combining, so the maximum amplitude limit in combined operation is decreased by 6.02 dB. Voltage range is 0 to 10 Vpp (terminated into the channel A attenuator with the combiner active). Frequency range is 0 to 13 MHz.

B COMPAR ENABLE (channel B COMPARator ENABLE) TTL level signal generated on the level/AM board (A22). Used to enable the comparators on the square board (A23). Active high.

B DATA (channel B DATA strobe) TTL level strobe from the fractional-N decoder board (P/O A36) whose positive edge indicates data is valid at the fractional-N IC. Signal terminates on the channel B fractional-N digital board (A44).

B DATA OUT (channel B DATA strobe OUT) TTL level strobe from the fractonal-N decoder board (P/O A36) which enables the tri-state buffer (A44U15) when reading from the fractional-N digital board (A44). This line also clears the VCO unlocked flag (B VCOF).

B-EXT φ CAL IN/MULTI φ REF IN (1-10Vpp) ‡ (channel B EXTernal phase CALibration INput/MULTIphase REFerence INput) Rear panel input to the calibrator (P/O A36). Used for external phase calibration and for multiphase calibration. Multiphase configuration allows phase calibration of two or more HP 3326As.

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

B HI-VOLT (channel B HIgh VOLTage option) When high, this line from the offset board (A21) activates the relay on the channel B attenuator board (A12), which routes the output signal through the channel B high voltage amplifier (A11, Option 002).

B HVAMPIN † (channel B High Voltage AMPlifier INput) The primary RF signal from the channel B attenuator (A12) that is routed to the input of the channel B high voltage amplifier (A11, Option 002) when the high voltage option is activated. Voltage range is 0 to 20 Vpp. Frequency range is 0 to 1 MHz. Signal has 950 Ω of input impedance looking into the channel B high voltage amplifier (A11). The amplifier has a gain of two times the HVAMPIN signal level (four times the 50 Ω loaded level).

B HVAMPIN SH/GND ★ (channel B High Voltage AMPlifier INput SHield/GrouND)

B HVAMPOUT † (channel B High Voltage AMPlifier OUTput) Originates on the channel B high voltage amplifier (A11, Option 002) and terminates on the channel B attenuator (A12). Carries the main RF signal. Used only when the high voltage option is activated. Voltage range is 4 mVpp to 40 Vpp. Frequency range is dc to 1 MHz. Approximately 0 Ω output resistance.

B HVAMPOUT SH/GND ★ (channel B High Voltage AMPlifier OUTput SHield/GrouND)

B HVDCO † (channel B High Voltage amplifier DC Offset) Generated by a DAC and a current to voltage converter on the offse board (A21). Provides dc offset voltage to the instrument at the channel B high voltage amplifier (A11). B HVDCO is summed with B HVAMPIN at the virtual ground point of the amplifier. Voltage range is −6.14 Vdc to +6.14 Vdc. The amplifier multiplies the offset by four. Input resistance is 499 Ω.

B HVDCO SH/GND ★ (channel B High Voltage amplifier DC Offset SHield/GrouND)

$\overline{\text{B HVOVLD}}$ (channel A High Voltage OVerLoaD) TTL compatible logic signal from the overload detection comparators of the channel B high voltage amplifier (A11, Option 002). A low signal indicates a current or voltage overload condition at the high voltage amplifier output. Signal terminates at the channel B attenuator (A12), which alerts the microprocessor (A61) when an overload has occurred. See $\overline{\text{B OVLD}}$.

B INT CAL ‡ (channel B INTernal CALibration) RF output signal from the channel B attenuator (A12) which runs to the calibrator board (P/O A36) for internal amplitude (ac and dc) and phase calibration. Used when internal phase or amplitude calibrations are performed. Characteristic impedance of the line is 50 Ω. Frequency range is 0 to 13 MHz. Voltage range is 0 to 10 Vpp (terminated into the calibrator board).

B INV (channel B INstruction Valid) Normally high, TTL level strobe used to clock instructions to the fractional-N IC. Positive edge triggered. (The signal is negative edge triggered at A44TP14.) Originates on the fractional-N decoder board (P/O A36) and terminates on the channel B fractional-N digital board (A44).

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

B IOVLD (channel B current OVerLoaD)TTL compatible logic signal from the current overload comparators of the channel B output amplifier (A13). A low signal indicates a current overload condition in the output stage of the amplifier. Signal terminates at the channel B attenuator (A12), which alerts the microprocessor (A61) when an overload has occurred. See B OVLD.

B LATCH CLOCK † (channel B LATCH CLOCK) TTL level clock generated on the channel B fractional-N digital board (A44). Used on the channel B phase detector board (A43) to re-clock the bias and API signals.

B LATCHCLOCK SH/GND ★ (channel B LATCH CLOCK SHield/GrouND)

B LO2 ‡ (channel B Local Oscillator 2) ECL level, ac coupled. This main RF signal is generated in the channel B local oscillator, divided down by the channel B VCO ÷ 2 board (A45), and sent to the RF switch (A24). In the two-channel mode, the signal acts as the channel B local oscillator signal. The frequency range is 20 to 33 MHz. (The 20 MHz signal from the reference board (A50) acts as the channel B reference signal.) In the two-tone mode, the signal acts as the channel B reference signal. The frequency varies between 19.9 and 20.1 MHz to provide a 100 kHz frequency offset. In the two-phase and pulse modes, this signal also acts as the channel B reference. The signal is at 20 MHz, with a variable phase offset. (The channel A local oscillator acts as the channel B local oscillator in these modes.)

B-L.O. OUT SH/GND ★ (20 to 33 MHz channel B Local Oscillator rear panel OUTput SHield/GrouND)

B MIX OUT † (channel B MIXer OUTput) Primary RF sine wave sinal originating at the output of the channel B mixer (A15) and the 14 MHz lowpass filter (located on the mixer board) and terminating at the input of the channel B preamplifier (A14). Possible amplitude modulation of 100 kHz maximum. Voltage range is approximately 0.07 to 0.22 Vpp. Frequency range is 0 to 13 MHz. The maximum frequency limit increases to 13.1 MHz in the two-tone mode. Expects 100 Ω termination.

B MIX OUT SH/GND ★ (channel B MIXer OUTput SHield/GrouND)

B MOD OUT ‡ (channel B MODulator OUTput) Input to the reference port of the channel B mixer (A15) from the output of the channel B modulator (A16) and the half filter (20 MHz bandpass) located on the modulator board. In the two-channel mode, B MOD OUT is 20 MHz. In the two-tone mode, B MOD OUT is 19.9 to 20.1 MHz. In the two-phase and pulse modes, B MOD OUT is a variable phase 20 MHz signal. See the overall theory of operation in Section VI. Possible AM of 100 kHz maximum. Voltage range is approximately −39 to −29 dBVrms (−26 to −16 dBm). Should be terminated in 50 ohms.

B OVLD (channel B OVerLoaD) When low, this TTL logic signal from the channel B attenuator (A12) to the offset board (A21) indicates that an overload condition has occurred somewhere in the instrument. The offset board alerts the controller (A61) by pulling the ANALOG FAULT line low.

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

B-PHASE MOD IN (±1V) † ‡ (channel B external PHASE MODulation rear panel INput) Input to the channel B VCO control board (A42). Used to phase modulate the channel B local oscillator. Voltage range is ±1 V. Frequency range is 0 to 5 kHz. Input signals of ±1 V correspond to ±360°, respectively.

B PHASE MOD IN SH/GND ★ (channel B external PHASE MODulation rear panel INput SHield/GrouND)

B PMC (channel B Phase Modulation Control) Originates on the fractional-N decoder board (P/O A36). Terminates on the channel B phase detector board (A43) and the channel B VCO control board (A42). When low, this TTL level signal indicates that no phase modulation is desired. When high, this signal activates the phase modulation circuitry.

$\overline{\text{B PMCAL}}$ (channel B Phase Modulation CALibration) Originates on the fractional-N decoder (P/O A36). Terminates on the channel B VCO control board (A42). Active low. This line is shorted to ground to permit an internal phase modulation calibration to take place.

B PMCURRENT (channel B Phase Modulation CURRENT)Terminates on the channel B phase detector board (A43). Originates on the channel B VCO control board (A42). Signal is +15 Vdc when phase modulation is off, and +8.8 Vdc when phase modulation is on.

B PRE10dB (channel B PRE-10 dB attenuator control) TTL logic line from the offset board (A21) to the channel B output amplifier (A13) which engages the 10 dB attenuation pad when the signal is high. (The level table in the attenuator repair sub-section lists the ranges when the pad is activated.)

B PREAMPOUT † (channel B PREAMPlifier OUTput) Primary RF output signal originating on the channel B preamplifier (A14) and terminating at the relay for the pre-10 dB pad on the channel B output amplifier (A13). Signal may be either a sine wave or a square wave, depending on the position of the relay on the preamplifier (A14K101). In the normal relay position, the main RF signal is a sine wave and travels directly to the output of the preamplifier board. When the square function or the pulse mode is activated, the relay is set and the output is diverted to the square board (A23) and returned to the preamplifier board as a square wave. The characteristic impedance of the line is 100 Ω. The voltage range is 0.6 to 2.0 Vpp when loaded. The frequency range is 0 to 13 MHz. The maximum frequency limit increases to 13.1 MHz in the two-tone mode.

B PREAMPOUT SH/GND ★ (channel B PREAMPlifier OUTput SHield/GrouND)

$\overline{\text{B PROTECTCLEAR}}$ (channel B PROTECT mode CLEAR) When low, this TTL logic signal from the offset board (A21) to the channel B attenuator board (A12) resets the overload protection latch and disables the protect mode. Normal operation is restored.

B SH CONT † (channel A Sample and Hold CONTrol voltage) Originates by the channel B phase detector board (A43). Terminates at the channel B VCO control board (A42). Used to control the VCO frequency. Voltage range is 0 to 5 V. A 0 V level corresponds to approximately 66 MHz on B VCO1 and B VCO2; a 5 V level corresponds to approximately 40 MHz.

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

B SH CONT SH/GND ★ (channel B Sample and Hold CONTrol voltage SHield/GrouND)

B S-H TRIG (channel B Sample and Hold TRIGger) When high, this TTL level signal from the channel B fractional-N digital board (A44) triggers the channel B phase detector (A43) to sample the integrator output.

$\overline{\text{B SIN}}$ (channel B SINe wave funcction) TTL level signal from the level/AM board (A22) to the channel B preamplifier (A14). Low level indicates a sine wave was programmed and the main signal is directed to the channel B output amplifier (A13). High level indicates a square wave was programmed and the signal is directed to the square board (A23).

B SINLEV † (channel B SINe wave LEVel) Generated by the level/AM board (A22). Amplitude control input (0 to 5 Vdc) and AM input (0 to 100 kHz) to the channel B modulator (A16) when the sine function is programmed. (B SINLEV = 5 V when the square function is programmed.) AM signal peak should be within the dc limits of 0 to 5 volts. Amplitude control typically ranges from 4.069 Vdc (calibrated full scale output) to 1.287 Vdc (10 dB below full scale). When the amplitude control is at its highest attenuation (i.e. 1.287 Vdc), a step attenuator is activated and A SINLEV is returned to its un-modulated (≅ 5 Vdc) level. When AM is programmed, the modulating signal is superimposed on B SINLEV, resulting in 0 to 100% modulation.

B SINLEV SH/GND ★ (channel B SINe wave LEVel SHield/GrouND)

B SQLEV † (channel B SQuare wave LEVel) Generated by the level/AM board (A22). Amplitude control input (0 to 5 Vdc) and AM input (0 to 100 kHz) to the channel B square board (A23) when the square or pulse functions are programmed. (B SQLEV = 0 V when the sine function is programmed.) Amplitude control typically ranges from 4.069 Vdc (calibrated full scale output) to 1.287 Vdc (10 dB below full scale). When the amplitude control is at its highest attenuation (i.e. 1.287 Vdc), a step attenuator is activated and B SQLEV is returned to its un-modulated (≅ 5 Vdc) level. When AM is programmed, the modulating signal is superimposed on B SQLEV, resulting in 0 to 100% modulation.

B SQLEV SH/GND ★ (channel B SQuare wave LEVel SHield/GrouND)

B SQUARE IN † (channel B SQUARE board INput) In the square function or pulse mode, this sinusoidal output of the channel B preamplifier (A14) is routed to the square board (A23) with a relay. Signal level is 2.0 Vpp. Frequency range is 0 to 13 MHz.

B SQUARE IN SH/GND ★ (channel B SQUARE board INput SHield/GrouND)

B SQUAREOUT † (channel B SQUARE board OUTput) Output of the square board (A23). Square wave signal or pulse signal sent to the channel B preamplifier (A14), where it is renamed B PREAMPOUT and sent to the channel B output amplifier (A13). Voltage range is 0.6 to 2.0 Vpp. Frequency range is 0 to 13 MHz.

B SQUAREOUT SH/GND ★ (channel B SQUARE board OUTput SHield/GrouND)

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

B SWEEP LIMIT (channel B SWEEP LIMIT flag) When low, this TTL signal generated by the channel B fractional-N digital board (A44) indicates to the controller (A61) that the sweep destination or marker frequency has been reached. This signal causes an NMI interrupt on the controller board.

B SWPL (channel B SWeeP Limit control) When high, this TTL signal from the fractional-N decoder (P/O A36) determines the point to stop the sweep. It assigns the stop frequency to the marker frequency and instructs the fractional-N IC on the channel B digital board (A44) to stop sweeping at this marker frequency. This occurs whenever the instrument is sweeping.

B VCO1 ‡ (channel B Voltage Controlled Oscillator 1) ECL level, dc coupled. Frequency range is 40 to 66 MHz. The minimum frequency limit decreases to 39.8 MHz in the two-tone mode. Output of the channel B fractional-N local oscillator which is sent to a divide-by-two circuit. Signal travels from the channel B VCO board (A41) to the channel B VCO ÷ 2 byard (A45).

B VCO2 ‡ (channel B Voltage Controlled Oscillator 2) ECL level, dc coupled. Frequency range is 40 to 66 MHz. The minimum frequency limit decreases to 39.8 MHz in the two-tone mode. This channel B VCO board (A31) output serves as an input to the channel B fractional-N digital board (A44). It is divided by the N number, compared with the reference frequency, and sent through the fractional-N loop again. This repeats until the two frequencies match. See the fractional-N local oscillator theory of operation for more information.

B VCO CONT † (channel B VCO CONTrol voltage) This dc level signal originates on the channel B VCO control board (A42) and provides a frequency control for the channel B VCO board (A41). It is a buffered version of B SH CONT. The voltage range is −1 Vdc to 11 Vdc. A −1 Vdc level corresponds to approximately 66 MHz on B VCO1 and B VCO2; an 11 Vdc level corresponds to approximately 40 MHz.

B VCO CONT SH/GND ★ (channel B VCO CONTrol voltage SHield/GrouND)

B VCOF (channel B VCO unlocked Flag) When high, this TTL level signal indicates the channel B VCO is unlocked. When low, this signal indicates the VCO is locked. Travels from the channel B VCO control board (A42) to the channel B fractional-N digital board (A44).

B VCO/N.F † (channel B VCO/N.F) ECL level, dc coupled. 20 ms pulse. 100 kHz rate. Originates on the channel B fractional-N digital board (A44). Terminates on the channel B phase detector (A43). Compared with B 100kHz on A43. The result of the comparison is used for activating the phase detector.

B VCO/N.F SH/GND ★ (channel B VCO/N.F SHield/GrouND)

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

‡ Signal travels via a cable.

CGND (Chassis GrouND) Same as safety ground. Connected to the protective earth ground of the power plug. The instrument chassis, frame, covers, and exposed metal surfaces, the HP-IB connector (pins 12, 18-24), and the shields of four rear panel output connectors are connected to CGND.

CH A ‡ (CHannel A output) Primary RF signal from the channel A attenuator (A2) which connects to the CH A output connector on the front panel of the HP 3326A. The signal depends on the front panel setting. Characteristic impedance of the line is 50Ω. Frequency range is dc to 13 MHz. Voltage range is 0 to 10 Vpp. Option 002 increases the voltage limit to 40 Vpp. Option 003 changes the location of the output connector to the rear panel (CH A OUT).

CH A OUT, OPTION 003 (DC-13MHz) ‡ (CHannel A rear panel OUTput, OPTION 003) See CH A description.

CH B ‡ (CHannel B output) Upper frequency limit changes to 13.1 MHz in the two-tone mode since a frequency offset of 100 kHz is allowed.

CH B OUT, OPTION 003 (DC-13MHz) ‡ (CHannel B rear panel OUTput, OPTION 003) See CH B description.

DATA STROBE (DATA STROBE) Normally high. Strobes when the controller (A61) puts data on the instrument bus (IBUSO-7) and the data is ready to be received by the other boards on the bus.

$\overline{\text{DAV}}$ (DAta Valid) Bidirectional HP-IB signal traveling from the controller (A61), through the HP-IB support board (A63), to the rear panel HP-IB connector. Used to indicate the condition of the information on the data bus ($\overline{\text{DI01-8}}$). Active low. Driven (low) by the source when data is settled and valid and $\overline{\text{NRFD}}$ (high) has been sensed.

$\overline{\text{DIO1}}$, $\overline{\text{DIO2}}$, $\overline{\text{DIO3}}$, $\overline{\text{DIO4}}$, $\overline{\text{DIO5}}$, $\overline{\text{DIO6}}$, $\overline{\text{DIO7}}$, $\overline{\text{DIO8}}$ (Data Input and Output bits) Eight bit, bidirectional bus traveling from the controller (A61), through the HP-IB support board (A63), to the rear panel HP-IB connector. Active low. Used to transfer information from device to device on the interface. Information transferred includes interface commands, addresses, and device dependent data.

DISPLCLK (DISPLay CLocK) From controller (A61) to keyboard (A62). Serves as the clock for display data traveling to the keyboard shift register.

$\overline{\text{DLD}}$ (Data Latch Disable) When low, this TTL level from the fractional-N decoder board (P/O A36) latches instructions to the fractional-N ICs on the digital boards (A34 and A44).

$\overline{\text{ENABLE LO2}}$ (ENABLE the LO2 signal control line) When low, this TTL level signal from the RF switch (A24) enables the channel A VCO ÷ 2 board (A35) to produce A LO2. The signal is disabled in the two-channel mode. (B LO2 is always enabled, since it is used in every mode.)

‡ Signal travels via a cable.

EOI (End Or Identify) Bidirectional HP-IB signal traveling from the controller (A61), through the HP-IB support board, to the rear panel HP-IB connector. Indicates last data byte of a multibyte sequence. Also used with ATN to parallel poll devices for their status bit. Active low.

EXT REF FLAG (EXTernal REFerence input present FLAG) When low, this TTL level signal indicates an external reference is present. Generated on the reference board (A50). Terminates on the controller board (A61).

EXT TRIG (EXTernal TRIGger) Input to the microprocessor on the controller board (A61) from the external input EXT TRIG IN. Used to start events.

EXT TRIG IN (TTL) ‡ (EXTernal TRIGger rear panel input) Negative edge triggered, TTL compatible. Runs through the HP-IB support board (A63) to the controller board, where it is renamed EXT TRIG and used instead of the instrument bus to trigger a sweep or a parameter increment. EXT TRIG IN is ignored during a sweep or when the trigger is turned off.

FAN RELAY POWER (FAN RELAY POWER) Generated on the power supply (A70). Connected to +15 V through a 510 Ω resistor. Used to turn on fan relay to start the fan.

FP DATA (Front Panel DATA) Data from the controller (A61) to the LEDs on the keyboard (A62). TTL level.

GND (isolated GrouND) The isolated ground signal for the printed circuit boards in the instrument. It is tied to chassis ground (CGND) through varistors on the HP-IB support board (A63), the rear ESD board (A70), the front ESD board (A72) and the keyboard (A62). GND is connected to chassis ground through capacitors on the above boards, as well as on the motherboard (A99), the controller (A61) and the power supply (A70).

GNDFP (Front Panel GrouND) GNDFP travels to the keyboard (A62) via the controller board (A61). Serves as a ground return for the keyboard LEDs.

GND SYNC (GrouND for the SYNC circuit) Identical to GND. Used for the "sync" circuit on the keyboard. Has its own separate connection to the motherboard (three pin connector).

GND SENSE (GrouND SENSing signal) Used on the power supply (A70). Ground sense for the power supply reference circuit. Connected to the motherboard ground plane.

HVFLAG (High Voltage option present FLAG) When low, this TTL signal indicates to the controller (A61) that one of the high voltage amplifiers (A1 or A11) is in the instrument and available for use. (It is assumed that either none or both of the amplifiers are in the instrument at a given time. The flag is active when either board is in place.)

IBUS0 (Instrument BUS bit 0) Bidirectional, TTL level instrument bus bit used by the controller (A61) to communicate with the offset board (A21), the level/AM board (A22), the RF switch (A24), the channel A and channel B fractional-N digital boards (A34 and A44), and the fractional-N decoder/calibrator board (A36).

‡ Signal travels via a cable.

IBUS1, IBUS2, IBUS3, IBUS4, IBUS5 (Instrument BUS bit1, 2, 3, 4, and 5) Bidirectional, TTL level instrument bus bit used by the controller (A61) to communicate with the offset board (A21), the level/AM board (A22), the channel A and channel B fractional-N digital boards (A34 and A44), and the fractional-N decoder/calibrator board (A36).

IBUS6, IBUS7 (Instrument BUS bit 6 and 7) Bidirectional, TTL level instrument bus bit used by the controller (A61) to communicate with the offset board (A21), the level/AM board (A22), and the calibrator board (P/O A36).

$\overline{\text{IFC}}$ (InterFace Clear) Bidirectional HP-IB signal traveling from the controller (A61), through the HP-IB support board (A63), to the rear panel HP-IB connector. Active low. Initializes the HP-IB system to an idle state (no activity on the bus).

INH BREF (INHibit channel B REFerence signal) TTL level signal originating on the RF switch (A24) and terminating on the reference board (A50). A high level inhibits the B 20MHz signal from the reference board. (The reference signal is inhibited in the pulse, two-tone, and two-phase modes since it is not being used by channel B.) Internal to the RF switch board, INH BREF places the switches in the two-phase/two-tone/pulse mode.

INT MOD † (INTernal MODulation) When the instrument is programmed for internal amplitude or phase modulation, the output signal from the channel B attenuator (A12) is directed to perform the desired modulation. When internal amplitude modulation is programmed, the signal is sent to the level/AM board (A22) to internally modulate the amplitude of the A channel. Frequency range is 0 to 100 kHz. Voltage range is 0 to 2 Vpp. When internal phase modulation is programmed, INT MOD is sent to the channel A VCO control board (A32) to internally modulate the phase of the A channel. Frequency range is 0 to 5 kHz. Voltage range is 0 to 2 Vpp.

INT MOD SH/GND ★ (INTernal MODulation SHield/GrouND)

KB DATA (KeyBoard DATA) Data from the front panel keyboard (A62) to the controller (A61). TTL level.

LEVTEST (LEVel self TEST signal) Analog input signal generated on the level/AM board (A22) and sent to the calibrator (P/O A36). Used for a service self test of the DACs on the level/AM board. The voltage level sent to the calibrator board is equal to (1/2)(A SQLEV + B SQLEV).

LOBSW † (channel B RF SWitch Local Oscillator output) Input to the channel B mixer (A15) from the RF switch (A24). 20 to 33 MHz, ECL compatible, ± 0.5Vpp. Input impedance is 50 Ω, ac coupled.

LOBSW SH/GND ★ (channel B RF SWitch Local Oscillator output SHield/GrouND)

★ The signal is grounded (to GND) and is used to shield the main signal on the motherboard. See the introduction to this glossary for an example.

† Ground (GND) traces shield the signal trace on the motherboard. These ground traces are denoted by a "SH/GND" (SHield/GrouND) after the main signal name. See the introduction to this glossary for an example.

MARKER (MARKER) Generated on the controller (A61). TTL compatible levels. When the sweep mode is ramp or triangle, MARKER is high at the start of the sweep and low at the selected marker frequency. When the sweep mode is ramp, the sweep marker returns to the initial level during the retrace. When the mode is triangle, the sweep marker returns to the initial level at the selected marker frequency during the retrace. When the sweep mode is discrete, MARKER is high at the start of the sweep, low at the beginning of each sweep element as the new frequency is programmed, and high at the end of each sweep element. MARKER remains high for at least 10 μs in this configuration. Runs to the HP-IB support board (A63), where it is renamed MARKER OUT (TTL), and sent to the rear panel connector.

MARKER OUT (TTL) ‡ (rear panel MARKER OUTput) See MARKER.

NC (No Connection) The IC pin or the connector pin is left unconnected to any other pin.

$\overline{\text{NDAC}}$ (Not Data ACcepted) Bidirectional HP-IB signal traveling from the controller (A61), through the HP-IB support board (A63), to the rear panel HP-IB connector. Active low. Used to indicate the condition of acceptance of data by device(s). The acceptor sets its $\overline{\text{NDAC}}$ (low) to indicate it has not accepted data. When it accepts data from the data bus (DIO1-8) lines, it releases its $\overline{\text{NDAC}}$ line. However, $\overline{\text{NDAC}}$ to the talker does not go high until the last/slowest listener has accepted the data.

$\overline{\text{NRFD}}$ (Not Ready For Data) Bidirectional HP-IB signal traveling from the controller (A61), through the HP-IB support board (A63), to the rear panel HP-IB connector. Active low. Indicates the condition of readiness of device(s) to accept data. Acceptor sets its $\overline{\text{NRFD}}$ (low) to indicate it is not ready to accept data. It releases this line when it is ready to accept data. However, the $\overline{\text{NRFD}}$ line to the talker does not go high until all addressed listeners are ready to accept data.

OFFTEST (OFFset self TEST signal) Analog input to the calibrator board (P/O A36) from the offset board (A21). Used for a service self test of the DACs on the offset board. Provides a voltage to the calibrator equal to (1/2)(A AMPDCO + B AMPDCO).

$\overline{\text{OVENFLAG}}$ (OVEN reference option present FLAG) Signal originates on the oven reference (A80) and travels through the motherboard (via a cable) to the channel A fractional-N digital board (A34). It is then sent to the controller (A61) via the instrument bus (IBUS5). A low signal tells the processor that the high stability frequency reference option (Option 001) is in the HP 3326A.

OVERVOLTAGE PROTECT (OVERVOLTAGE PROTECTion flag) Generated by the overvoltage sense circuit on the power supply (A70). When the +5 V, −15 V, or +15 V supplies exceed +5.6 V, −17 V, or +17 V, respectively, this line goes high and trips the silicon rectifier on the +15 V raw supply. The fuse should blow.

$\overline{\text{REF LOOP UNLOCKED}}$ (REFerence LOOP UNLOCKED) The reference board (A5) produces this signal when an external frequency reference signal is present and the reference board is unable to lock to the signal. Active low. This signal is false (high) when no external reference is present. Terminates at the controller (A61). The microprocessor has access to this signal via the status flags register (SFR), bit D0.

‡ Signal travels via a cable.

$\overline{\mathrm{REN}}$ (Remote ENable) Bidirectional HP-IB signal traveling from the controller (A61), through the HP-IB support board (A63), to the rear panel HP-IB connector. Active low. Used to enable devices to respond to remote control when addressed to listen.

$\overline{\mathrm{RESET}}$ (RESET) This signal is made true (low) during power-up or whenever the regulated +5 V supply (+5V) drops below +4.85 V. The signal originates on the controller (A61), where it resets the microprocessor, prevents ROM access, prevents CMOS RAM access, and disables the front panel display. The signal terminates at the offset board (A21), the level/AM board (A22), and the fractional-N decoder/calibrator board (A36). When $\overline{\mathrm{RESET}}$ is active, these boards are set to the turn-on state.

RF SWITCH STROBE (RF SWITCH STROBE) Generated by the level/AM board (A22). TTL level strobe to the RF switch board (A24). A positive transition latches the current state of bit 0 of the instrument bus (IBUS0), which sets the switches according to the selected operating mode.

SHIELD (HP-IB SHIELD) HP-IB connector line from HP-IB support board (A63). Connected to chassis ground (CGND). Used to reduce noise.

SQUARE/$\overline{\mathrm{PULSE}}$ (SQUARE function vs. PULSE function control) TTL level signal from the level/AM board (A22) to the square board (A24). A high signal enables the square circuitry. A low level signal enables the pulse circuitry.

$\overline{\mathrm{SRQ}}$ (Service ReQuest) Bidirectional HP-IB signal traveling from the controller (A61), through the HP-IB support board (A63), to the rear panel HP-IB connector. Active low. Used to signal the controller that communication is needed.

STANDBY (STANDBY) Originates on the keyboard (A62). Terminates at the power supply (A70). Travels from the keyboard to the controller (A61) via a cable, then travels to the power supply via the motherboard (A99). Used as a control signal to turn on the instrument. STANDBY is actively pulled to ground when the instrument is turned on. When the instrument is in the standby state (only the fan and battery backup are turned on), the STANDBY line floats. There is a pull-up resistor to +28VDC on the power supply.

STROBE (display STROBE) Signal to the keyboard (A62) from the controller (A61) to latch in front panel data. TTL level, 375 ns low pulse, 1 ms period.

SWEEP START (SWEEP START) TTL level strobe from the controller board (A61) used to signal the fractional-N decoder board (P/O A36) that an exernally triggered sweep (using EXT TRIG IN) or a frequency change should be made. SWEEP START starts a synchronous sweep of the two fractional-N LOs on an external triggered event without any processor intervention after the initial set-up.

SYNC ‡ (SYNChronous output) Main ac input to the channel A synchronous output circuit on the keyboard (A62). Derived from A AMPOUT. Voltage range is 2 to 20 Vpp.

SYNC A ‡ (SYNChronous with channel A) TTL level output from the keyboard (A62) to the front panel output connector. Should be terminated in 50 Ω. Frequency range is 0 to 13 MHz.

‡ Signal travels via a cable.

$\overline{\text{SYNC OVLD}}$ (SYNC OVerLoaD) From the keyboard (A62) to the controller (A61). TTL level. Low signal indicates an overload.

V REF (Voltage REFerence) Generated on the calibrator board (P/O A36). Master voltage reference for the entire instrument. Used by the calibrator board, level/AM board (A22), offset board (A21), and square board (A24). Nominal value is 10.24 Vdc ± .01 Vdc.).

X-DRIVE (X-DRIVE) Generated on the controller board (A61). Starts at 0 V and increases linearly to +10 V from sweep start to sweep stop. Decreases linearly from +10 V to 0 V from sweep stop to sweep start. When the sweep mode is ramp or discrete, X-DRIVE returns to the initial level during the retrace. When the total time of the discrete sweep exceeds 1000 s, X-DRIVE increases at its slowest rate and start again at 10.24 V each 1024 seconds. Runs to the HP-IB support board (A63), where it is renamed X-DRIVE OUT (0 to 10V), and sent to the rear panel output connector.

X-DRIVE OUT (0 to 10V) ‡ (X-DRIVE rear panel OUTput) See X-DRIVE.

Z-BLANK (Z-BLANK) TTL compatible, 0 to 3.4 V signal, generated by the controller (A61) which goes high while blanking. Z-BLANK goes low (ON) at the start of a sweep and high (OFF) at the end of a sweep and during the retrace of a ramp. Runs to the HP-IB support board (A63), where it is renamed Z-BLANK OUT (TTL), and sent to the rear panel output connector.

Z-BLANK OUT (TTL) ‡ (Z-BLANK rear panel OUTput) See Z-BLANK.

‡ Signal travels via a cable.

Product Line Sales/Support Key

Key Product Line
A Analytical
CM Components
C Computer Systems Sales only
CH Computer Systems Hardware Sales and Services
CS Computer Systems Software Sales and Services
E Electronic Instruments & Measurement Systems
M Medical Products
MP Medical Products Primary SRO
MS Medical Products Secondary SRO
P Personal Computation Products
*** Sales only for specific product line**
**** Support only for specific product line**

IMPORTANT: These symbols designate general product line capability. They do not insure sales or support availability for all products within a line, at all locations. Contact your local sales office for information regarding locations where HP support is available for specific products.

HP distributors are printed in italics.

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If there is no sales office listed for your area, contact one of these headquarters offices.

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A,M

Blue Star Ltd.
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A

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Blue Star Ltd.
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***SECUNDERABAD** 500 003*
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