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7912AD PROGRAMMABLE DIGITIZER

OPERATORS

INSTRUCTION MANUAL

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TABLE OF CONTENTS

SECTION 3 PROGRAMMING

SAFETY SUMMARY

This summary contains safety information that the user must observe to operate the 7912AD safely. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary.

TERMS AND SYMBOLS

In This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER -- High voltage.

Protective ground (earth) terminal

WARNING

Power Source

This instrument is intended to operate from a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

WARNING

Grounding the Instrument

The 7912AD is grounded through the grounding conductor of the power cord. To avoid electric shock, plug the power cord into a properly wired receptacle before connecting to the 7912AD input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Use the Proper Power Cord

Use only the power cord and connector specified in the parts list for your instrument. Use only a power cord that is in good condition.

Refer cord and connector changes to qualified service personnel.

Use the Proper Fuse

To avoid fire hazard, use only the fuse specified in the parts list for your instrument. It must be identical in type, voltage rating, and current rating.

Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmosphere

To avoid explosion, do not operate this product in an atmosphere of explosive gases unless it has been specifically certified for such operation.

Do Not Remove Covers or Panels

To avoid personal injury, do not remove the 7912AD covers or panels. Do not operate the 7912AD without the covers and panels properly installed.

PREFACE

This manual provides operating and programming information for the 7912AD Programmable Digitizer. It is intended for use by operating and programming personnel. Servicing information, intended for qualified personnel only, is covered in the 7912AD Service Manual.

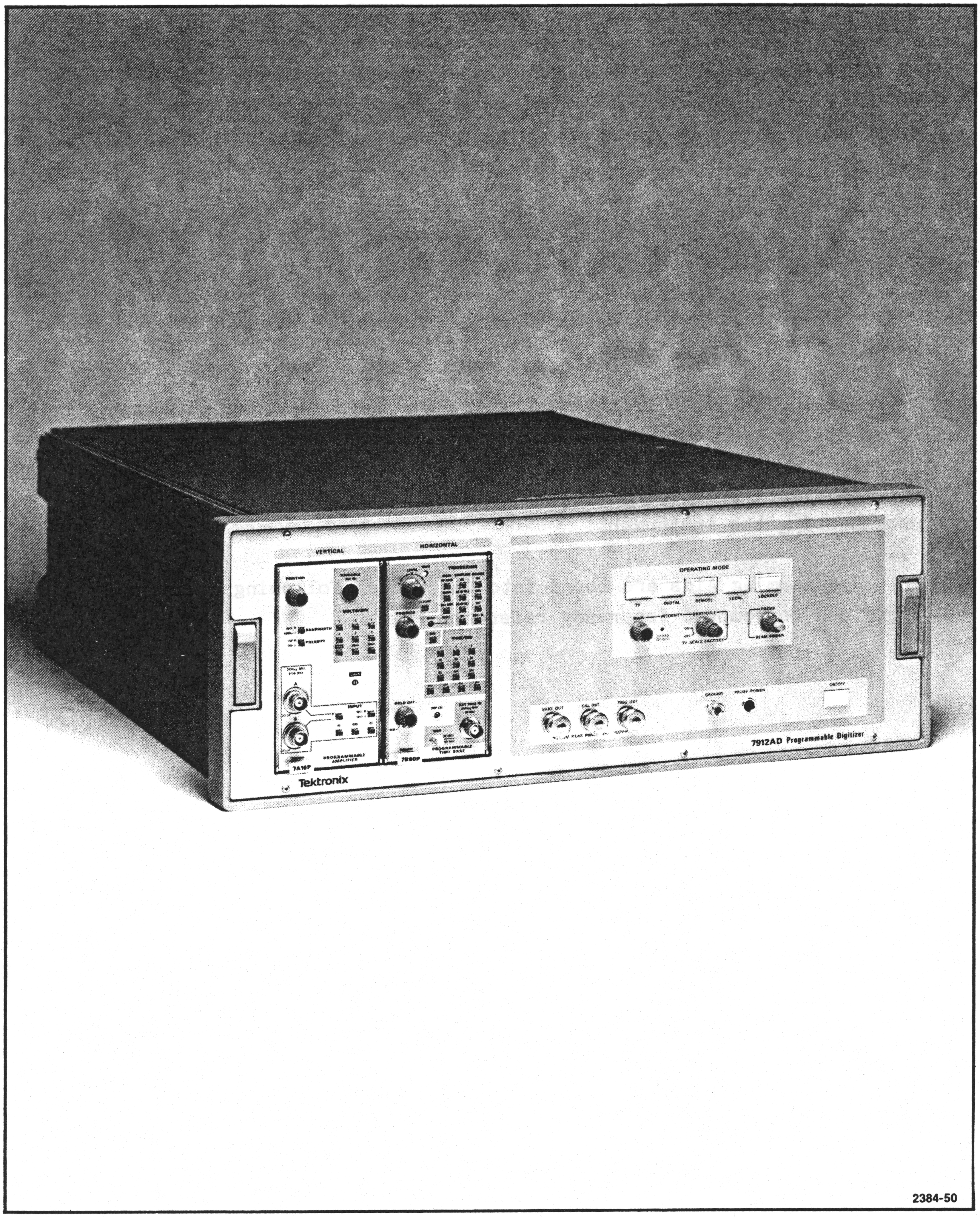
Section 1 of this manual includes a description of the instrument, its specifications, options, and accessories.

Section 2 contains operating instructions for the 7912AD under local control.

Section 3 is the programming guide for the 7912AD and contains instructions for remote control of the instrument.

Section 4 provides installation instructions, including those for rackmounting the instrument.

Programming Aids are bound into the manual following Section 4. These can be removed for ready reference.



2384-50

The TEKTRONIX 7912AD Programmable Digitizer with programmable plug-ins.

SECTION 1

INTRODUCTION

The TEKTRONIX 7912AD Programmable Digitizer is a wide-bandwidth waveform acquisition instrument with both analog and digital outputs. Programming is accomplished over the bus specified in IEEE Standard 488-1975.

Two operating modes are provided. In the digital mode, the 7912AD digitizes either a single-shot or repetitive waveform and stores it for internal processing or for output on the IEEE 488 bus. Analog outputs are also provided to display the waveform data on an X-Y-Z monitor. In the TV mode, the 7912AD converts a waveform to a composite video output. This allows the input waveform to be displayed on a TV monitor such as the TEKTRONIX 634 Monitor, one of the 650- and 670-series of color Picture Monitors.

In either the TV or digital mode, the 7912AD can acquire waveforms with high bandwidths: up to 500 MHz with the TEKTRONIX 7A19 Amplifier plug-in, for instance, or 1 GHz with the TEKTRONIX 7A21N Direct Access plug-in. The time window can be selected between 10 milliseconds and 5 nanoseconds using a TEKTRONIX 7000-series time base plug-in. This is equivalent to sampling rates (in digital mode) from 50 kHz to 100 GHz.

Remote control and data output via the IEEE 488 bus is simplified by two microprocessor systems in the 7912AD. The firmware operating systems for these microprocessors is designed to let the programmer talk to the 7912AD in as simple and obvious a manner as possible.

Design of the firmware that controls the IEEE 488 interface is consistent with the IEEE 488-1975 standard. Extended addresses are used so that the 7912AD can act as a transparent interface for programmable plug-ins (if installed). These plug-ins include the 7A16P Programmable Amplifier and the 7B90P Programmable Time Base.

The 7912AD operates in many respects like an oscilloscope such as those in the TEKTRONIX 7000-series. The input signal is connected to a vertical plug-in to drive the vertical deflection amplifer. A number of 7000-series plug-ins are available to tailor the 7912AD for bandwidth, input impedance, differential or single-ended input, and input voltage. On most vertical plug-ins, a wide range of deflection factors (amplification) can be selected on the front panel. A number of 7000-series time base plug-ins are available to drive the horizontal deflection amplifier at calibrated sweep rates.

Although the vertical and horizontal deflection systems of the 7912AD are similar to those of an oscilloscope, the similarity ends there. In place of the oscilloscope CRT, there is a scan converter tube. Instead of displaying the input waveform as a trace on the phosphor-coated face of a CRT, the input waveform is written on a silicon diode matrix and read from this target as in a vidicon TV camera.

The Scan Converter

Because of the high writing rate of the scan converter, the 7912AD performs at high bandwidths and sampling rates not usually obtained with other digitizing techniques. The high writing rate stems from several factors that can be understood only by considering the design of the scan converter. The scan converter is an electron tube with dual electron guns, one at each end of the tube. Between the two guns is the target (Fig. 1-1).

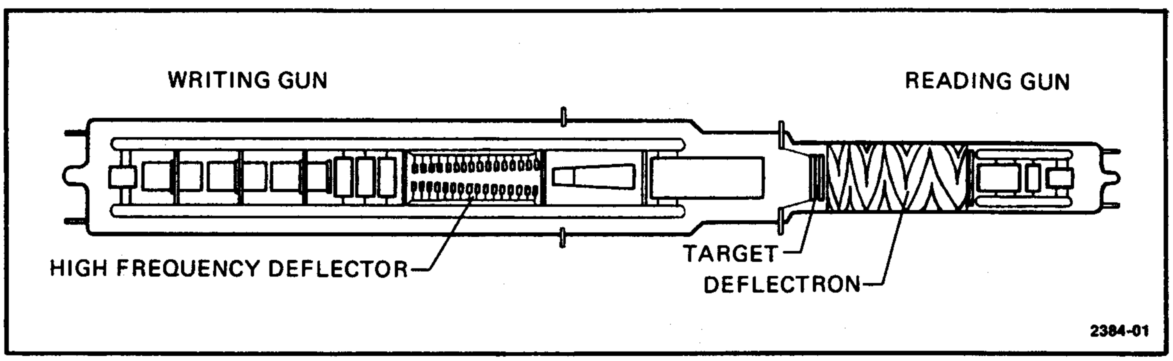


Fig. 1-1. The 7912AD scan converter tube.

The target is an array of diodes formed on an n-type silicon wafer by integrated circuit techniques (Fig. 1-2). In operation, the target substrate is held positive with respect to the reading gun cathode by the target lead. The target is scanned continuously by the reading beam, charging each diode toward the more negative cathode potential to reverse-bias it.

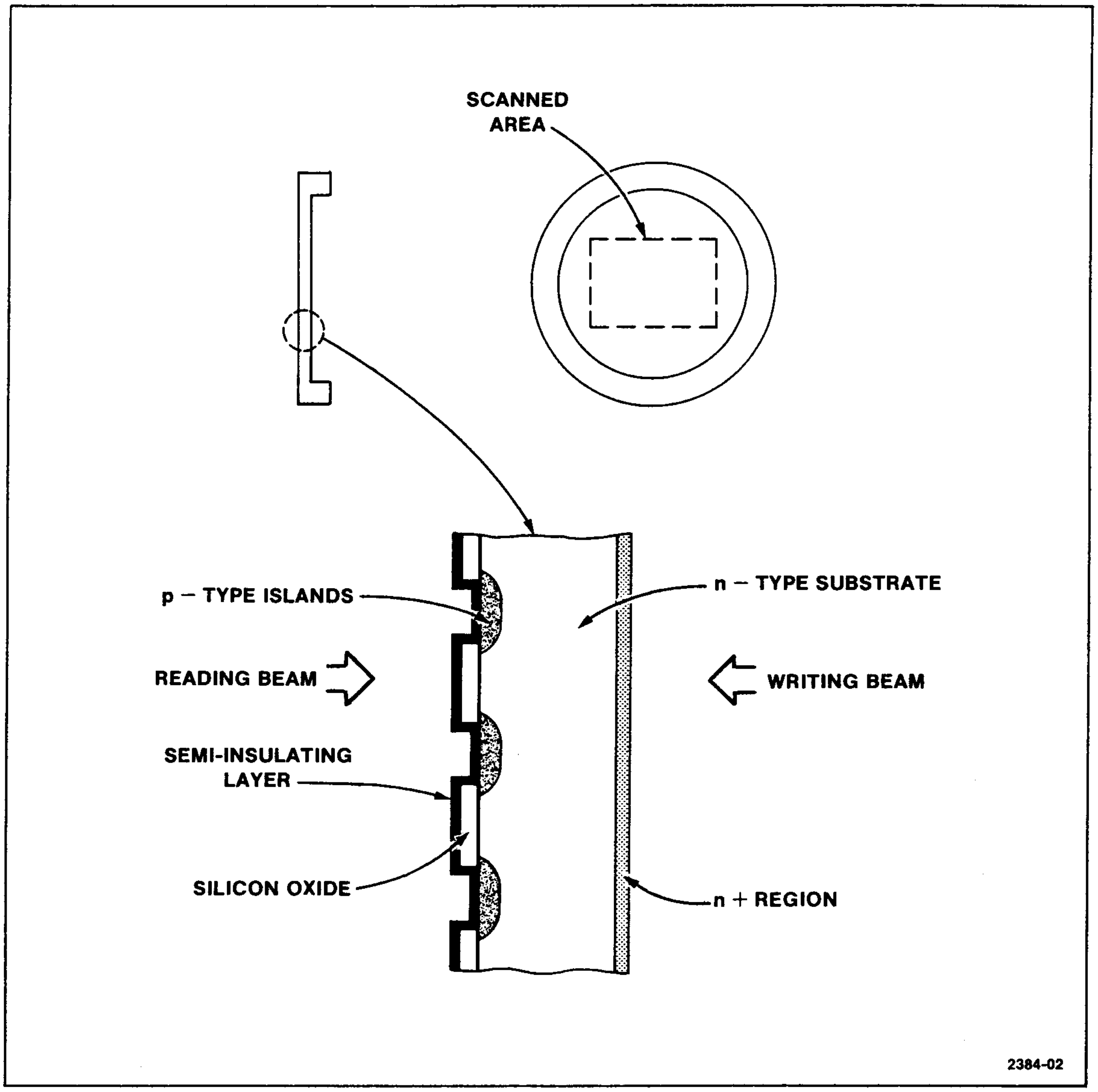


Fig. 1-2. The 7912AD scan converter target. The area scanned is approximately 1.3 X 0.95 centimeters with a diode density of about 800 per centimeter.

When the time base is triggered, it unblanks the writing gun and applies a ramp to the horizontal deflection plates of the writing gun to write a trace across the target. At the same time, the input signal is applied to the vertical deflection plates to vary the height of the trace according to the amplitude of the input signal.

The writing gun electrons, accelerated by the 10-kilovolt potential between the gun and target, bombard the target (Fig. 1-3). Each electron creates many electron-hole pairs near the surface. The holes diffuse through the target and drift across the depletion region at the p-n junction, causing the adjacent diodes to conduct and discharge. When the reading beam next scans the target, little or no current flows at points that were not written. Where the target was written, however, the diodes are recharged and a signal current can be detected in the target lead. This output signal is amplified for further processing.

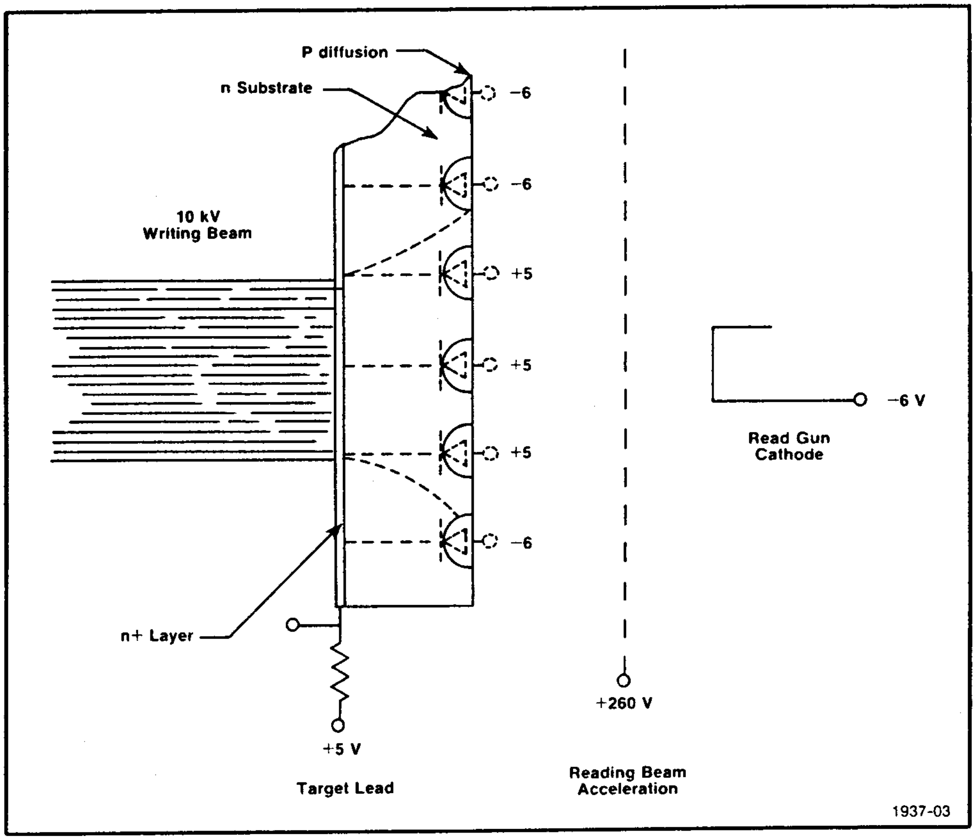


Fig. 1-3. The scan converter tube in operation showing the effect of the reading beam.

Since the energy required to create an electron-hole pair in silicon is about 3.6 electron volts, roughly 2,780 electron-hole pairs are created by each 10-kV electron that strikes the target. Accounting for certain losses, the effective charge gain in the target is about 2,000. This gain is responsible for the high-speed performance of the scan converter because few electrons need to strike the target to record a waveform, allowing the writing trace to be deflected at high speeds.

Other advantages stem from writing and reading the waveform on the target. Because the target is small, the writing beam need only be deflected over a small area (about 1.3 X 0.95 centimeters). Only the writing beam need be high-velocity; the reading beam can be scanned more slowly.

TV Mode

In TV mode, the target is scanned horizontally by the reading beam in a conventional television format with a 525-line (625 lines with option 13) raster. This scan mode is shown in Fig. 1-4. The output signal is amplified, a sync waveform is added, and the composite video signal is provided to two output connectors on the 7912AD rear panel.

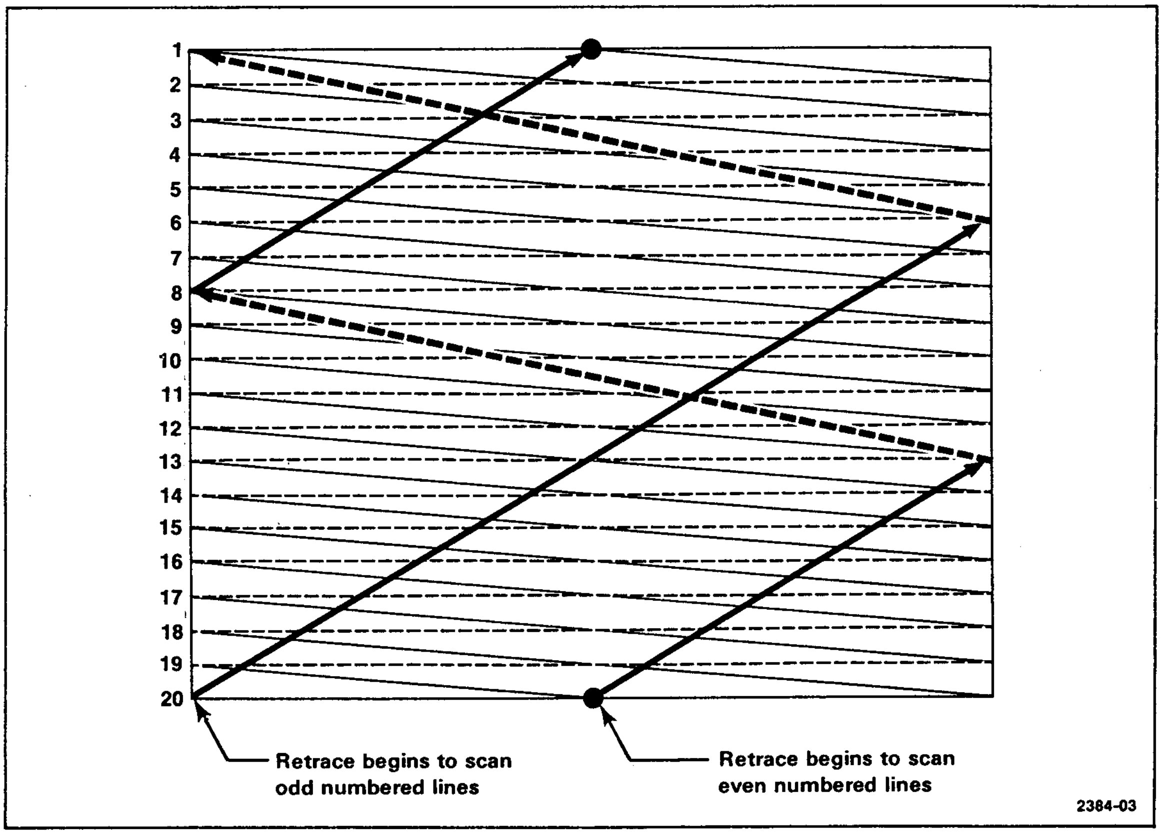


Fig. 1-4. A small-scale example of an interlaced horizontal scan such as is used in 7912AD TV mode.

One output, LINEAR, is a replica of the output of the target lead. The signal goes positive (white) whenever the reading beam crosses a portion of the target that is written; its amplitude varies with the intensity with which that portion of the target was written.

The other output, BINARY, is a two-level output derived from the LINEAR signal. A comparator sets the video level high when it detects that the writing beam crosses a portion of the target that is written. The comparator sets the video level low at all other times during the scan.

To provide the waveform scale factors as part of the monitor display, a character generator adds the readout from the plug-ins to the composite video outputs.

The TV mode provides several advantages over a conventional oscilloscope display. The monitor can be larger and it can be located some distance from the 7912AD. The TV monitor can be used to set up the 7912AD and plug-in controls for data acquisition. The effect of the intensity controls can be observed, for instance. If the BINARY output is used, the output of the comparators can be displayed to assure that all parts of the waveform will be digitized in the digital mode at a particular intensity setting.

Digital Mode

In the digital mode, the target is scanned vertically by the reading beam in a 512 X 512 point format (Fig. 1-5). The signal from the target lead is amplified and fed to a comparator. If the signal is above the comparator threshold, the comparator switches to a high state to indicate that the reading beam is crossing a portion of the target that is written. If the signal is below the threshold, the comparator switches low to indicate that no trace is detected.

The 7912AD begins to store data on the next time base trigger after either the DIGITAL button is pressed (local mode) or a digitize command is received (remote mode). Two counters are the source of the data. One counter is incremented from 0 to 511 as the reading sweeps down the target. Each time the counter is incremented, the output of the comparator is sampled. If the comparator has changed state since the last sample, the count is complemented and stored in memory in the Y (vertical) array.

As a result, two data values are usually stored during each vertical scan, one for the top of the trace and one for the bottom of the trace.

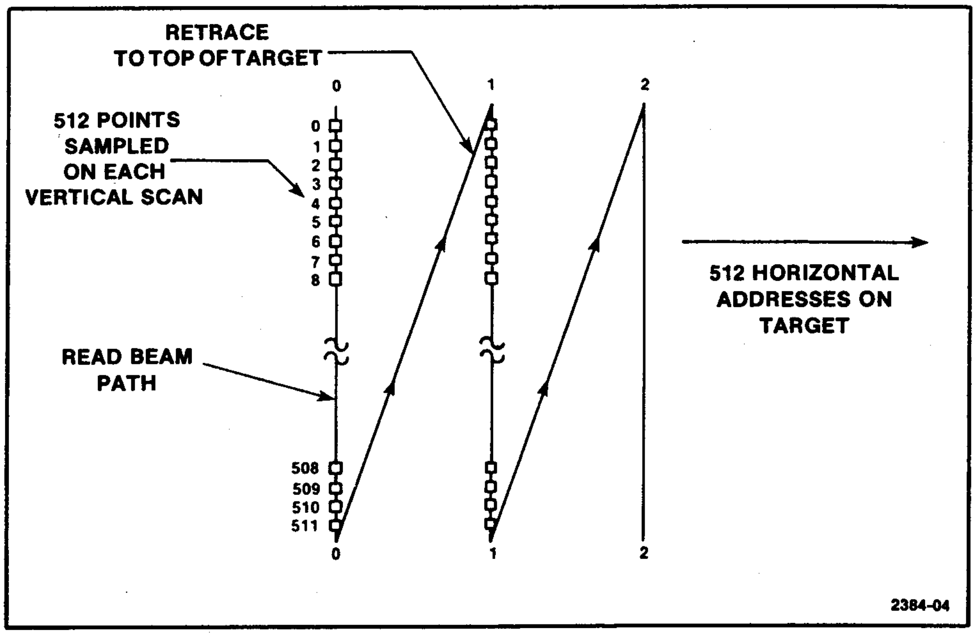


Fig. 1-5. In digital mode, the target is scanned along 512 vertical lines from left to right.

Data are always stored in pairs. If the top of a written portion of the target is detected, the bottom will be detected as well. Up to 30 data can be stored to handle graticule and dual traces. The data are complemented so 511 corresponds to the top of the target and zero to the bottom.

Meanwhile, another counter is incremented each time the reading beam begins another vertical scan. The value of the counter is used to address a location in an X (horizontal) array where the number of data points detected by that vertical scan is stored. When read, the X and Y arrays are used by 7912AD microprocessor routines or external data processing to recover the X and Y coordinates of all points detected as data on the target.

Block Drawing

The 7912AD block drawing (Fig. 1-6) indicates signal and data flow in the instrument. It also relates the scan converter to the other analog circuitry and the two microprocessor systems. The scan converter is shown in two pieces, the writing gun on the left-hand portion of the figure and the reading gun on the right-hand portion.

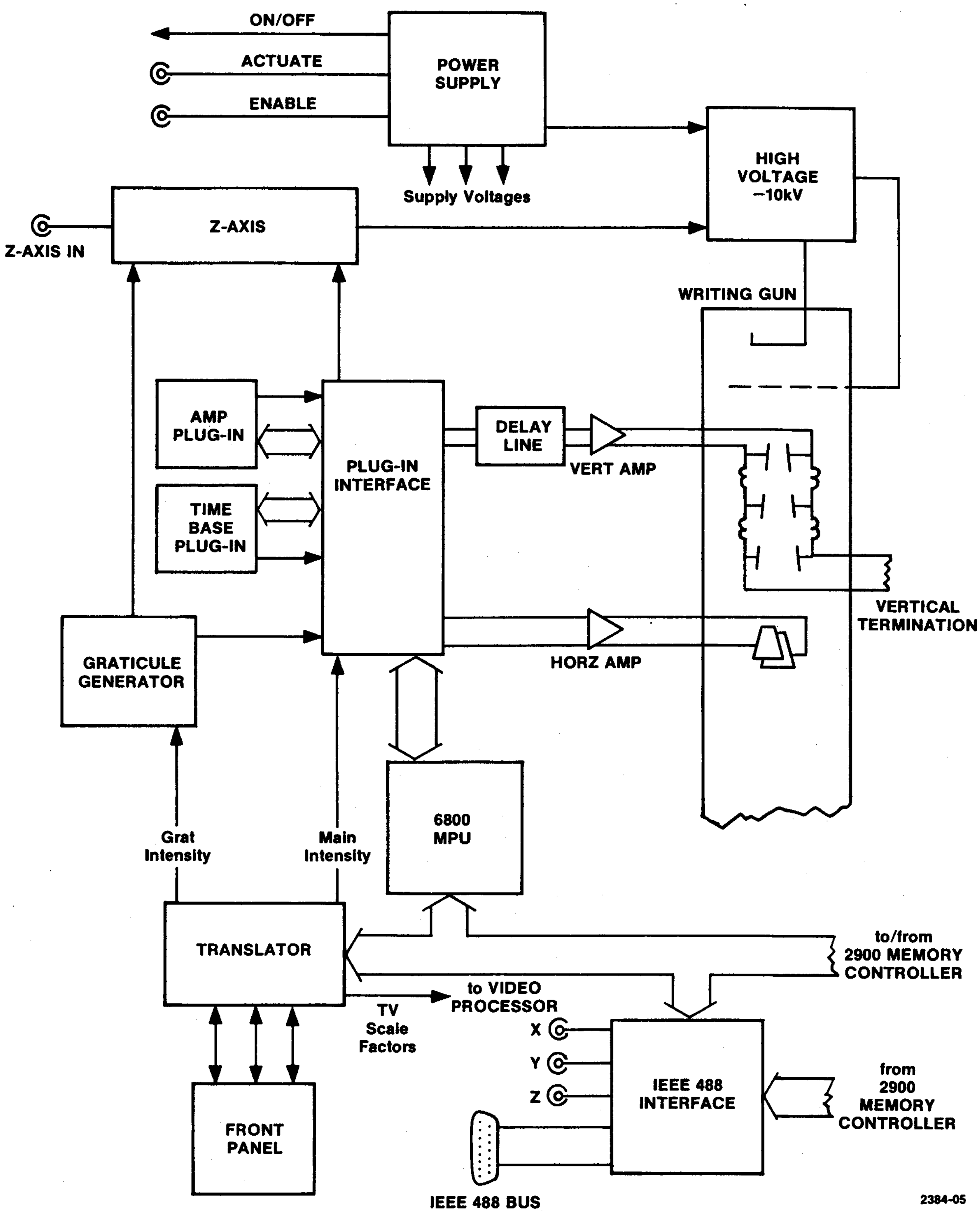
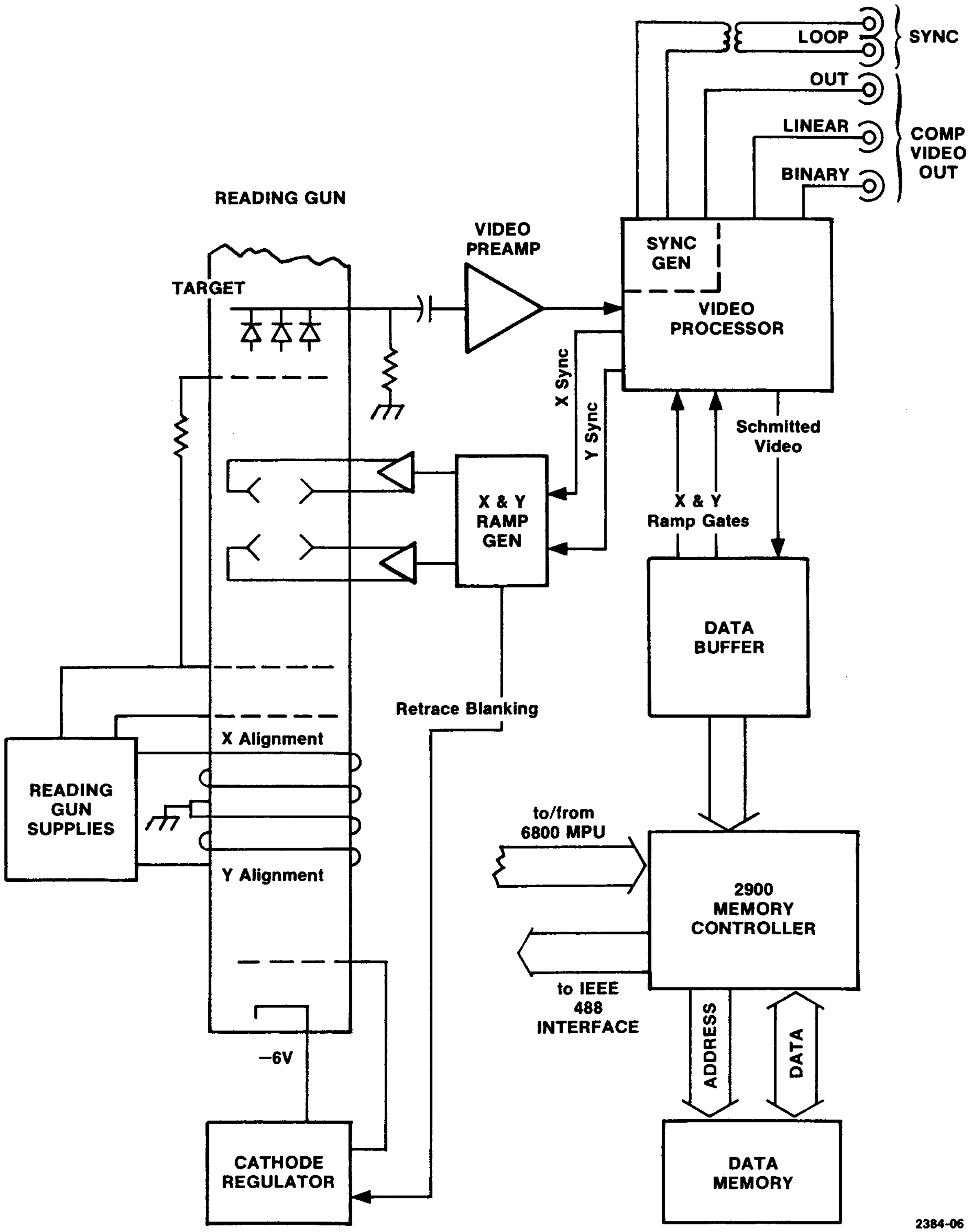


Fig. 1-6. A block drawing of the 7912AD with plug-ins showing the



relationship between the analog and microprocessor systems.

Power Supply. The power supply provides regulated voltages for the analog and digital circuitry as well as the plug-ins. It also supplies the drive to the writing gun high-voltage section. In addition to the ON/OFF switch, it can be turned on and off through the ACTUATE connector. The ENABLE output can, in turn, control another instrument's ACTUATE input.

Analog Signal Flow. Input signals to drive the writing gun come from either the amplifier (vertical) and time base (horizontal) plug-ins or from the graticule generator. The plug-in interface switches in the graticule generator as the signal source for a short period of time following each sweep from the plug-ins to write a dot matrix on the target. This provides a frame of reference for the waveform.

The vertical and horizontal amplifiers are driven by the outputs from the plug-in interface and, in turn, drive the vertical and horizontal deflection plates in the writing gun. The vertical signal is delayed so the leading edge of a fast pulse can be written on the target without a pretrigger. The delay allows time for triggering on the input signal and for the time base sweep to begin before the input signal reaches the vertical deflection plates. These plates are actually helical delay lines designed for high-frequency response. The deflecting field appears in the gap between the helices.

Separate intensity lines from the plug-in interface and from the graticule generator control the writing gun Z-axis. Two lines are needed because the writing gun intensity must be controlled independently during the times it writes the graticule and the waveform. The intensity control signals come from the translator rather than from the front panel (as discussed below).

The Z-axis drive goes to the high-voltage assembly to be translated to the very high negative voltage necessary on the writing gun grid. The writing gun is operated at a very high negative potential so the target and deflection amplifiers can be near ground potential. The monoaccelerator (single accelerating potential) design holds spot size of the writing beam to a minimum (0.001 inch).

When read from the target, the waveform and/or graticule is preamplified and then output as composite video for display or passed on to the data buffer. The clock that controls reading the target originates in the data buffer. X and Y ramp gates derived from the clock are used by the video processor to generate sync pulses for the X and Y ramp generators. The sync generator puts out a TV sync signal based on the ramp gate signals or can use an external signal applied to the LOOP input to override the X and Y ramp gates.

The X and Y ramp generators drive the reading gun deflection plates (through amplifiers) and send a signal to the cathode regulator to blank the reading beam during retrace. The deflection plates are part of the deflectron shown in Fig. 1-2 as is the magnetic yoke for focusing and aligning the beam. Accelerating voltages provided by the reading gun supplies are much lower for the low-velocity reading gun than that required for the writing gun.

Data Flow. In digital mode, data values are recovered by the data buffer. A Y counter keeps track of the vertical position of the reading beam as it scans the target. When the beam crosses the edge of a written portion of the target, the Schmitted video signal changes state. The transition causes the data buffer to latch the contents of the Y counter as a data point. Although the 2900 memory controller is fast, it could not keep up with the data without buffering. So all points detected during a single scan are stored temporarily in a high-speed cache memory to reduce the data rate out of the data buffer.

The 2900 stores the Y data from the cache memory along with the number of points stored for each vertical scan in the data memory. Once stored, the waveform data can be processed by the memory controller (averaged, for example). The processed data is also stored in the data memory.

The data memory can be read out over the IEEE 488 bus. The 2900 controls a high-speed data bus going to the IEEE 488 interface to enable fast data transfers over the bus. The data can also be converted to XYZ outputs for a refreshed display on a monitor.

Instrument Control. The 7912AD firmware operating system runs on the 6800 microprocessor (MPU). It controls instrument status and command input/output through either the front panel or the IEEE 488 interface.

Front panel controls for programmable functions do not set operating parameters directly. For instance, the intensity levels are controlled by lines from the translator labeled Grat Intensity and Main Intensity in Fig. 1-6. These control signals are set by the 6800 MPU through digital-to-analog (D/A) converters in the translator.

In remote mode, the 6800 sets the levels according to values programmed over the IEEE 488 bus. In local mode, the 6800 compares the intensity levels to levels selected through the front panel controls and adjusts the D/A outputs to match the front panel controls. Whether in local or remote mode, the 6800 monitors the writing beam duty cycle and automatically limits the intensity, if necessary, to prevent damage to the target.

Scale factors are also handled by the 6800, whether in TV or digital mode. The 6800 reads the scale factors from the plug-ins through the plug-in interface. In TV mode, it outputs the scale factors through a character generator on the translator as video to the video processor. There the scale factor video is added to the composite video display. In digital mode, the 6800 reads out the scale factors on request over the IEEE 488 bus.

The 6800 MPU performs several other tasks. It acts as a transparent interface for programmable plug-ins; command I/O for the plug-ins passes through the MPU onto a bus between the MPU and plug-in interface. This path continues via the bus shown in Fig. 1-6 going to each plug-in. The 6800 also initiates data storage or processing by the memory controller in response to commands over the IEEE 488 bus (remote mode) or data storage when the front panel DIGITAL button is pressed (local mode).

Waveform Storage

The 7912AD waveform data memory is divided between a raw data area of 10-bit words and a processed data area of 16-bit words as shown in Fig. 1-7. The memory is semiconductor, so data is lost when power is turned off.

Raw Arrays. Vertical data values are stored in the vertical array during a digitize operation. The values include all points detected on the target, whether the edge of a waveform trace, graticule dot, or a defect. Since the reading beam scans the target continuously and is not synchronized with the writing beam, it may be anywhere on the target when

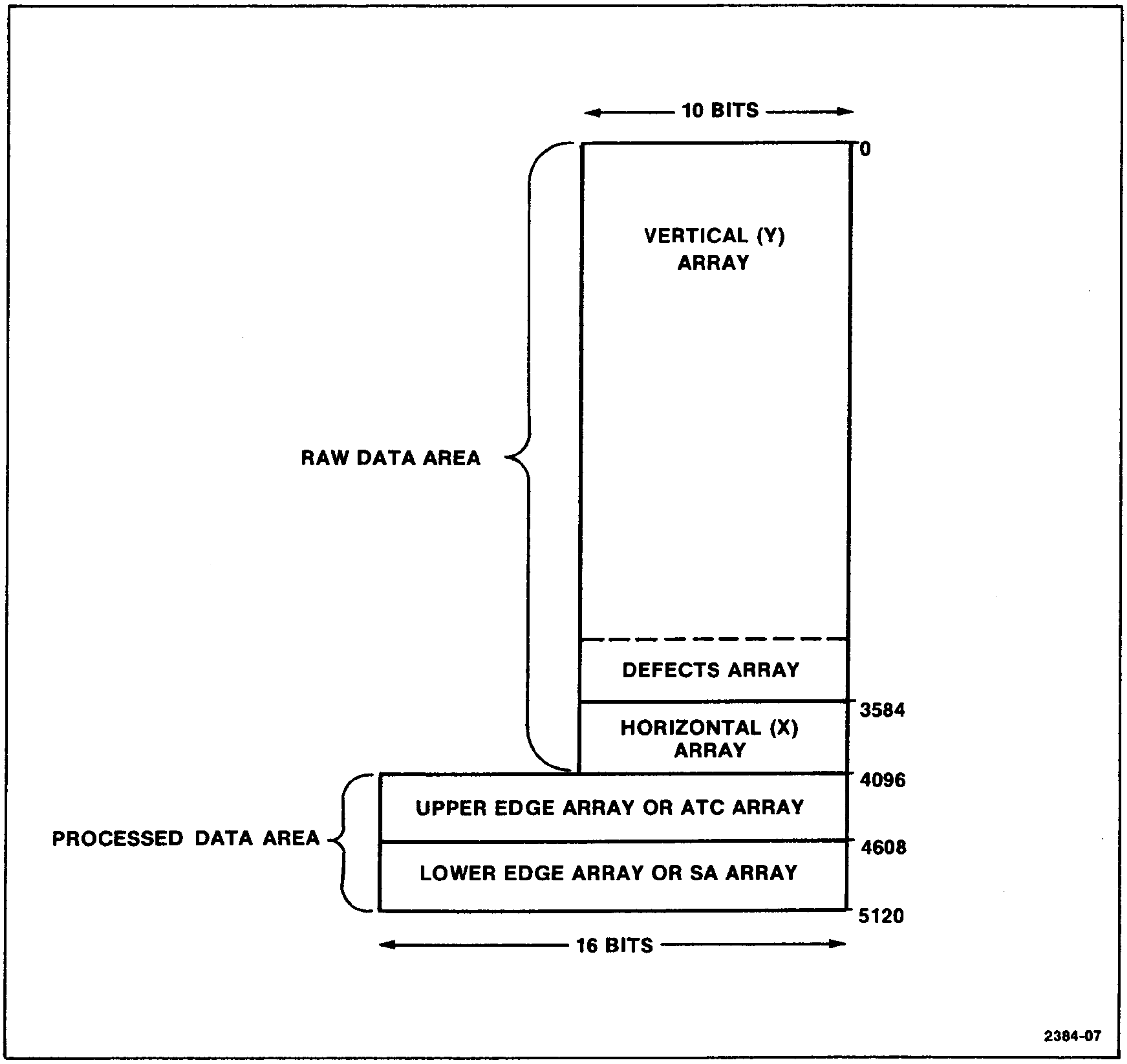


Fig. 1-7. 7912AD data memory map showing arrays used for raw and processed waveforms.

the 7912AD begins storing data. The data are stored starting at the top of the raw vertical array and are stored continuously until the reading beam returns to where storage began. Data are stored in the order they are detected from top to bottom of each of the 512 vertical scans of the target moving from left to right.

Because of the way data are stored, the raw vertical array may wrap around. That is, the data may start anywhere within the time window (where the target represents a time frame), continue in order to the end of the window, but then return to the beginning and continue until reaching the starting point. This is corrected by internal data processing so the data is output by the READ commands from left to right of trace. It is not corrected, however, if the raw area of the memory is DUMPed, as noted in Section 3, Programming.

The 7912AD keeps track of the number of vertical data values stored during each vertical scan (that is, for each horizontal location of the target) in an X (horizontal) counter array. The counts are stored so that the first X array location contains the number of data values stored during the left-most vertical scan, the next address contains the number of values for the next vertical scan to the right, and so on. When output by the READ command, this array is converted to a pointers array to be used to interpret the vertical array.

A defects array located just above the pointers array can identify target defects (points detected as data whether written or not). Defects are stored in reverse order, that is, the first defect value is written at the highest address in the array and the array is written upward. Values in the defect array between 512 and 1023 are horizontal locations on the target where 512 is the left-most vertical scan and 1023 is the right-most vertical scan. Each horizontal value is followed by values between 0 and 511 to represent defects at that horizontal position on the target.

Using the standard 7912AD's defects capability, vertical raw data that matches data in the defect array can be flagged by setting bit 10 of the word. Further internal processing can reject the defects.

Processed Array. The processed data area does double duty. It can be used either as a single 1K block for the two edge arrays, or split into two 512-word blocks for the average-to-center (ATC) array and the signal-averaged (SA) array. In either case, the arrays are single-valued functions processed by the memory controller. Each array contains 512 points, reordered so they represent the function from left to right of trace. The edge arrays define the top and bottom of the trace. The ATC array is the average of the top and bottom of the trace. The signal-averaged array is the average of a number of ATC arrays from a repetitive waveform.

Because they share the same memory space, it is not possible to store all four processed arrays at one time. Either the edge arrays or the average-to-center and signal-averaged arrays can exist at any time.

Options

The following options are available for the 7912AD. They are not field-installable; instructions are not provided in the 7912AD manuals to modify the 7912AD for these options. Changes to the replaceable parts lists are detailed in the service manual for the 7912AD.

Option 4. Change to fast digitize mode. The scan time to read a waveform from the target and into local memory is reduced by compressing the scan. The target is written on and read from a 256 X 256 point matrix with a maximum of 14 points stored per vertical scan. However, the data are normalized to a 512 by 512 point matrix before further processing or output. Vertical values are multiplied by two and the data are blown up to 512 points horizontally by treating every other point as if it is empty.

Graticule resolution is cut by one-half; every other major division is marked in digital mode, and every other major and minor division is marked in TV mode. Both the TV and XYZ displays are restored to the same size as the non-option 4 displays.

This option changes the minimum sweep rate to 200 microseconds/ division. This is the lower limit on sweep rate for digitizing reliable data in fast-digitize mode.

Option 9. Set instrument for 230 VAC operation; substitute a 230 volt power cord.

Option 13. Change TV scan rate. The TV mode reading scan of the target is changed to 625 lines per frame with a 50 hertz field rate. The composite video outputs, sync input, and sync output are changed to match this scan rate.

Option 30. Delete cable. The IEEE 488 bus cable that is a standard accessory is deleted.

Specifications

Electrical characteristics of the 7912AD are listed in Table 1-1, Table 1-2, and Table 1-3. To be valid, the following conditions apply:

1) The 7912AD and plug-ins must be calibrated at an ambient temperature between +20 and +30 degrees C.

2) The 7912AD and plug-ins must be allowed to warm up for at least 20 minutes with all covers installed.

3) The calibration of the 7912AD must be checked according to the calibration procedure within each 1000 hours of operation or every six months if operated infrequently. Any adjustments that cause performance outside the limits allowed by the calibration procedure must be readjusted. The plug-ins must also be operated within their calibration intervals.

4) The 7912AD and plug-ins must be operated within their specified environmental limits (Table 1-4). In some cases, an electrical characteristic applies only to a limited temperature range or must be derated to apply to the entire temperature range. These cases are noted.

Statements in the Performance Requirements column are verified by the steps marked with a √ in the calibration procedure (7912AD Service Manual). Statements listed in the Supplemental Information column are not verified in the calibration procedure and are not to be construed as performance requirements of the 7912AD.

Physical characteristics are listed in Table 1-5.

TABLE 1-1

Electrical Specifications

Characteristics	Performance Requirements	Supplemental Information
VERTICAL DEFLECTION SYSTEM		
Deflection factor	Compatible with all 7000-Series amplifier plug-in units.	Full-scale deflection is ±4 divisions.
Relative accuracy	See Table 1-2.	
Centering	Zero-volt input can be centered by plug-in position control.	Within 0.5 division of electronic graticule center with no plug-in (1 division, option 4).
Low-frequency linearity	0.1 division or less compression or expansion of a centered, two-division waveform. This limit is not exceeded if the waveform is positioned anywhere within the electronic graticule area.	
Bandwidth	See Table 1-2.	
Rise time	See Table 1-2.	
Isolation, signal to graticule	At least 100:1 up to 250 MHz; at least 40:1 from 250 MHz to 500 MHz.	

TABLE 1-1 (cont.)

Characteristics	Performance Requirements	Supplemental Information
Delay line	Adds approximately 60-nanosecond delay in vertical signal path to permit viewing or digitizing of leading edge of triggering waveform.	
GRATICULE		
Format	8 vertical divisions X 10 horizontal divisions.	
TV mode	Both major and minor divisions marked, five minor divisions per major division.	
Digital mode	Only major divisions marked.	
TV mode, option 4	Only every other major and minor division marked.	
Digital mode, option 4	Only every other major division marked.	
Writing time		Requires 3 milliseconds, gated immediately after waveform is acquired. Locks out vertical signal and main sweep and disables Z-axis.

TABLE 1-1 (cont.)

Characteristics	Performance Requirements	Supplemental Information
Position		Adjustable horizontally and vertically ±5%.
Amplitude		Adjustable horizontally and vertically ±5%.
Intensity	Controlled from front panel or by programmed command separately from main intensity.	
Stability		
0 to +40 degrees C		0.5%.
+20 to +30 deg. C		0.1%.

HORIZONTAL DEFLECTION SYSTEM

Characteristics	Performance Requirements	Supplemental Information
Deflection factor	Compatible with all 7000-Series plug-in units. See Table 1-3 for recommended time base plug-ins.	Full scale deflection is ±5 divisions.
DC linearity	0.05 division or less error at each graticule line after adjusting for no error at the second and tenth graticule lines (0.1 division, option 4).	

TABLE 1-1 (cont.)

Characteristics	Performance Requirements	Supplemental Information
Fastest calibrated sweep rate (with 7B90P, 7B92A, or 7B80 MOD GB Time Base)	0.5 nanosecond/division.	
Slowest sweep rate	1 millisecond/division (200 microseconds/division, option 4).	
Centering	Center of sweep can be centered in graticule by time base Position control.	
Bandwidth, 10 division reference	DC to at least 1 megahertz.	

EXTERNAL Z-AXIS INPUT

Characteristics	Performance Requirements	Supplemental Information
Polarity	Positive-going signal decreases trace intensity of writing gun; negative-going signal increases trace intensity. Zero-volt (approximate) input produces no intensity change.	
Sensitivity	Two volts peak-to-peak provides trace modulation over full intensity range.	

TABLE 1-1 (cont.)

Characteristics	Performance Requirements	Supplemental Information
Low-frequency limit		DC
DC input resistance		550 ohms, ±10%.
Maximum Input voltage		15 volts (DC + peak AC).

CRT TARGET AND WRITING GUN

Gun type	Mono accelerator.	
Light defects		
Distribution	No more than six points digitized or displayed other than those written by input waveform. No two light defects on same vertical line within ±3 degrees of deflection.	
Size	No light defects larger then four TV lines.	
Geometry	A straight-line input is read from the target as a straight line within 0.1 division.	

TABLE 1-1 (cont.)

Characteristics	Performance Requirements	Supplemental Information
Writing Rate (+10 to +40 degrees C)		
TV mode	Writes an 8-division sine wave of at least 500 MHz in a single sweep.	At least 12.5 divisions per nanosecond; 30 divisions per nanosecond, typical.
Digital mode	Writes a single 8-division pulse with a rise time of 1 nanosecond or less (2 nanoseconds or less from 0 to +10 degrees C).	At least 8 divisions per nanosecond, typical.
Option 4		
TV mode	Writes an 8-division sine wave of at least 1 GHz in a single sweep.	At least 25 divisions per nanosecond; 60 divisions per nanosecond, typical.
Digital mode	Writes a single 10-division pulse with a risetime of 0.5 nanosecond or less (1 nanosecond or less from 0 to +10 degrees C.)	At least 20 divisions per nanosecond, typical.

TABLE 1-1 (cont.)

Characteristics	Performance Requirements	Supplemental Information
READING GUN		
Type	Monoaccelerator	
RAMP GENERATOR AND SCAN AMPLIFIER		
Scan time, digital mode		Approximately 16.4 milliseconds per waveform to read waveform and store in memory (approximately 4.5 milliseconds, option 4).
VIDEO SYSTEM		
Resolution		
TV mode		At least 400 TV lines per picture width. Video signal is down less than 50% at linear output.
Ultimate resolution, TV mode		At least 500 TV lines when viewed on a TEKTRONIX 632 Monitor or equivalent.

TABLE 1-1 (cont.)

Characteristics	Performance Requirements	Supplemental Information
Digital mode		
Horizontal	Two signals, each including a step with a risetime of 10 nanoseconds, are digitized separately at a sweep speed of 50 nanoseconds/division if the steps are delayed 1.25 nanoseconds with respect to each other.	400 lines.
Vertical	A 50 milivolt square wave is resolved at 2 volts/division.	320 lines.

VIDEO OUTPUTS

Composite video		
Linear	1 volt into 75 ohms for full white signal. Conforms to EIA RS-170.	
Binary		
Low level	0 to +0.3 volts into 75 ohms.	
High level	+1 volt ±0.1 volt into 75 ohms.	

TABLE 1-1 (cont.)

Characteristics	Performance Requirements	Supplemental Information
Scan rate		
Standard		525 lines/frame, 60 Hz field rate (interlaced).
Option 13		625 lines/frame, 50 Hz field rate (interlaced).
Scale factor readout	Up to eight characters per channel.	
VERTICAL plug-in	Channel 1 appears in upper left corner of graticule, channel 2 in lower left corner of graticule.	
HORIZONTAL plug-in	Channel 1 appears in upper right corner of graticule, channel 2 in lower right corner.	
Return losses, sync loop		At least 40 dB to 4 megahertz.

IEEE 488 Interface

Characteristics	Performance Requirements	Supplemental Information
Data connector	Conforms to IEEE Standard 488-1975.	
Signal levels		Conform to IEEE Standard 488-1975.
Signal timing		Conforms to IEEE Standard 488-1975.

TABLE 1-1 (cont.)

Characteristics	Performance Requirements	Supplemental Information
Data transfer rate, max.		710 kilobytes/second.
Waveform transfer time, min.		9 milliseconds for 1024 vertical and 512 pointer data.
Waveform acquisition and transfer rate, max.		5-20 waveforms/second (Intensity dependant)
X-Y-Z analog display outputs of waveform data		
X and Y	1 volt peak-to-peak into 100 kilohms or greater; adjustable from 0.75 to 1.3 volts.	8-bit resolution
Z	Zero volts (blanked), 1 volt (unblanked) into 100 kilohms or greater. Blanked between data points.	
Z_{out}, X and Y		50 ohms, ±5%.

FEEDTHROUGH CONNECTORS

VERT IN, CAL IN, TRIG IN (rear-panel connectors)	Connect to front panel connectors through coaxial cable.	

TABLE 1-1 (cont.)

Characteristics	Performance Requirements	Supplemental Information
Z_0		50 ohms, ±2%.
Attenuation of VERT IN/OUT and CAL IN/OUT signal paths		0.33 dB at 400 MHz; 0.54 dB at 1 GHz.

POWER SUPPLY

Remote control		
ACTUATE	TTL low level (<0.8V) applied between center conductor and outer conductor turns on power supply. A return to a TTL high level (>2V) turns off power supply. Outer conductor is isolated from chassis by approximately 100 ohms.	
ENABLE	Provides TTL low level (<0.4V) between center conductor and outer conductor approximately 150 milliseconds after power-up. Maximum sink current is 16 milliamps. Goes to TTL high level after power supply is turned off.	

TABLE 1-1 (cont.)

Characteristics	Performance Requirements	Supplemental Information
POWER INPUT		
Line voltage		
115, nominal		90 to 132 volts AC.
230, nominal		180 to 250 volts AC.
Line frequency		48 to 440 Hz.
Power consumption		
Typical, not including plug-ins		250 watts
Maximum, including plug-ins		360 watts
Line current, max		5.2 amps (90 VAC)
SAFETY		
Power line fuse	6 amps, 250 volt, fast-blow.	

TABLE 1-2

7912AD SYSTEM ELECTRICAL CHARACTERISTICS

Plug-in Amplifier	Performance Feature	Minimum Deflection Factor	Bandwidth	Rise Time (Calculated)	Relative Accuracy*
7A11	Low-capacitance FET probe built-in	5 mV/div	250 MHz (225 MHz, +30 to +40 degrees C)	1.4 ns (1.6 ns, +30 to +40 degrees C)	2%
7A13	Differential input; DC offset	1 mV/div	105 MHz	3.4 ns	1.5%
7A16A	1-megohm input	5 mV/div	225 MHz	1.6 ns	2%
7A16P	Programmable	10 mV/div	200 MHz	1.8 ns	2%
7A18	Dual-channel, 1-megohm input	5 mV/div	75 MHz	4.7 ns	2%
7A19	Wide bandwidth, 50-ohm input	10 mV/div	500 MHz (400 MHz, +30 to +40 degrees C)	0.8 ns (0.9 ns +30 to +40 degrees C)	3%
7A24	Dual-channel, wide bandwidth, 50-ohm input	5 mV/div	350 MHz (300 MHz, +30 to +40 degrees C)	1.0 ns (1.2 ns, +30 to +40 degrees C)	2%
7A21N	Direct access, 50-ohm input	Less than 4 V/div	1 GHz	0.35 ns	--
7A26	Dual-channel 1-megohm input	5 mV/div	200 MHz (160 MHz, +30 to +40 degrees C)	1.8 ns (2.2 ns, +30 to +40 degrees C)	2%

*Applies to all deflection factors when the plug-in gain is set at the deflection factor designated on each plug-in. The calibration signal must be supplied by an external calibrator whose accuracy is within 0.25%.

TABLE 1-3
RECOMMENDED TIME BASE PLUG-IN

Plug-in	Maximum Sweep Rate	Triggering Frequency Range	Notes
7B80	1 ns/div	400 MHz	
7B80GB	500 ps/div	400 MHz	Slowest sweep rate is 10 us/div
7B90P	500 ps/div	400 MHz	Programmable
7B92A	500 ps/div	500 MHz	Both normal and delayed sweep; set intensity carefully in alternate mode

TABLE 1-4

ENVIRONMENTAL CHARACTERISTICS

Characteristics	Description
Temperature	
Operating	0 to +40 degrees C.
Nonoperating	-55 to +75 degrees C.
Altitude	
Operating	Up to 4570 meters (15,000 feet).
Nonoperating	Up to 15,200 meters (50,000 feet).
Electromagnetic compatibility (EMC) with plug-ins or EMC-shielded blank plug-ins installed	Meets all applicable parts of MIL-STD-461A when tests are performed according to MIL-STD-462 for radiated and conducted electromagnetic emissions and susceptibility from 30 hertz to 1 gigahertz.

TABLE 1-5

PHYSICAL CHARACTERISTICS

Characteristics	**Description**
Size	Can be mounted in standard 19-inch rack. See Fig. 1-8.
Weight (no plug-ins)	Approximately 24.7 kilograms (54.6 pounds).
Air intake at fan	2.83 meters^3/min. (100 feet^3/min), max; typically 2.40 meters^3/min. (85 feet^3/min).

Accessories

The following accessories are supplied with the 7912AD; part numbers are given in the 7912AD Service Manual:

1 power cord, 2.4 meters (8 feet)

1 set of rack slides with hardware

1 IEEE 488 bus cable, 2 meters (6.6 feet)

1 operators manual

1 service manual

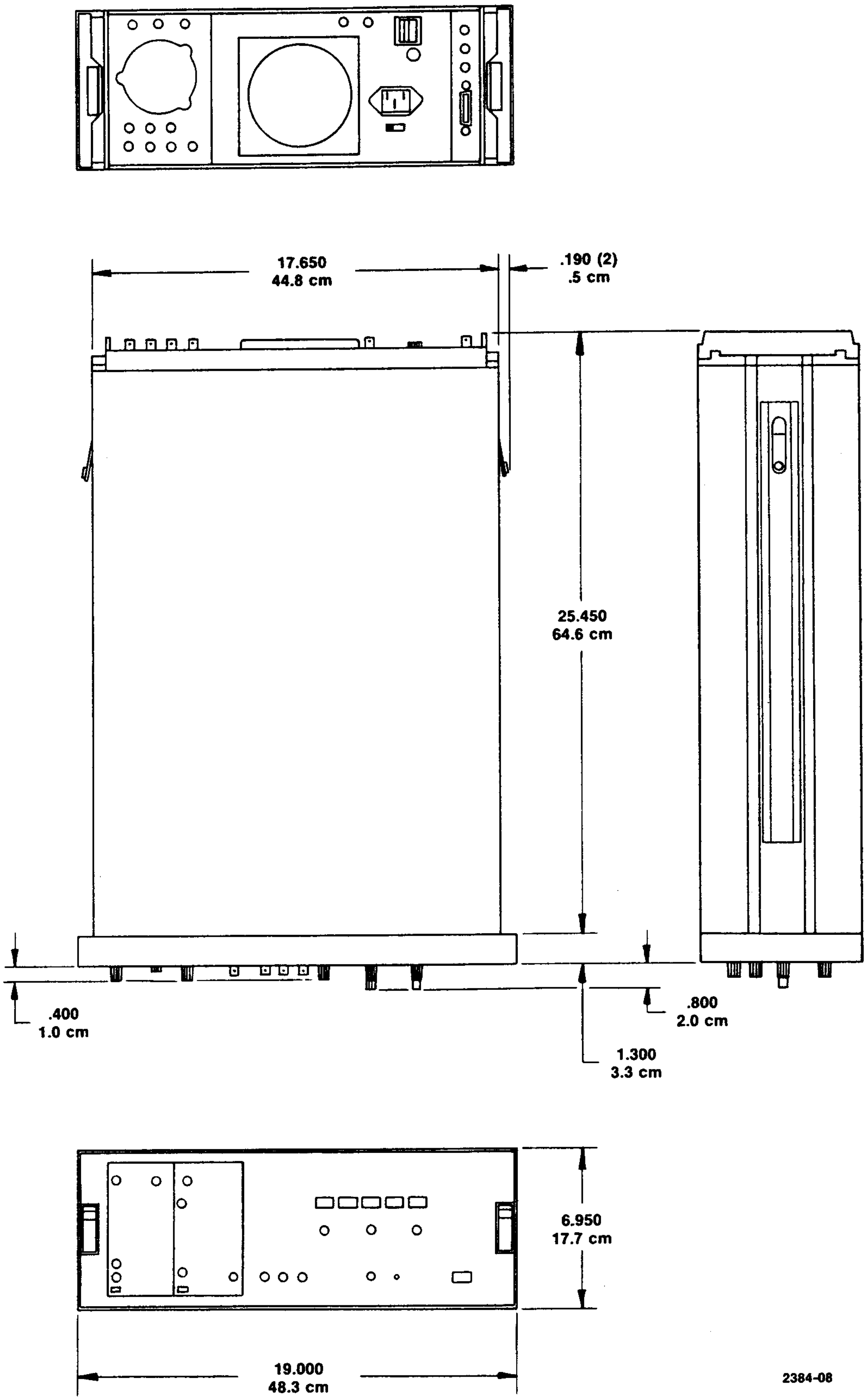


Fig. 1-8. 7912AD outside dimensions shown in both inches and centimeters.

SECTION 2

OPERATION

This section contains a description of 7912AD controls and connectors and instructions for local (operator) control of the instrument. Turn to Section 3 for instructions for remote (programmed) control. However, instructions for acquiring data whether under local or remote control are given in this section.

The 7912AD is based on the TEKTRONIX 7000-series plug-in concept. Signal-conditioning plug-ins are used. These have their own operating controls; see the plug-in operators manuals for a description of the controls and instructions for operating the plug-ins. Although some of the plug-in controls are referenced in this manual, they are not fully described, nor are full instructions for their use provided.

Controls and Connectors

Front Panel

The front panel controls and connectors are shown in Fig. 2-1. The numbers in the following descriptions refer to Fig. 2-1.

OPERATING MODE

(1) TV: Sets the 7912AD to TV mode. Lights when in TV mode. If, when the TV button is pressed, the 7912AD is performing a digitize operation, it waits until completed before switching to TV mode.

(2) DIGITAL: Sets the 7912AD to digital mode and initiates a digitize operation. Lights when in digital mode. There is a two-second delay for set-up when switching from TV to digital mode. Once DIGITAL is pressed, the 7912AD is readied to digitize but waits for a sweep gate from the time base to store data detected on the target. To be detected, the input waveform and/or graticule must have been written on the target with sufficient intensity (set by the INTENSITY controls).

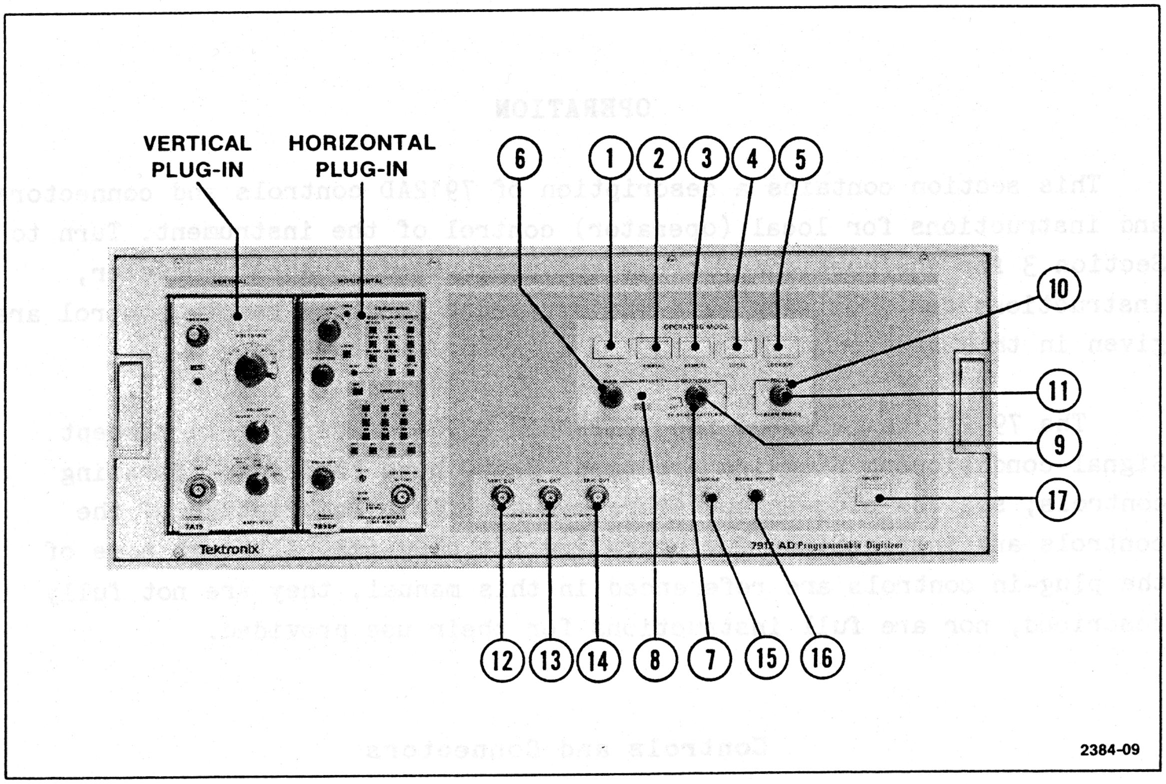


Fig. 2-1. Front panel controls and connectors. The numbers refer to descriptions in the text of the controls and connectors.

(3) REMOTE: Lights to indicate when the 7912AD is set to remote mode by the IEEE 488 bus system controller. When REMOTE is pressed, the 7912AD requests service from the IEEE 488 bus controller if the interrupt is enabled.

(4) LOCAL: Returns the 7912AD from remote mode to local control if not in remote with lockout state (see LOCKOUT). Lights when in local mode. If the instrument is executing a remote command or performing a digitize operation, it waits until finished to return to local.

(5) LOCKOUT: Lights to indicate the 7912AD is set to either local with lockout state or remote with lockout state by the IEEE 488 bus system controller. In remote with lockout state (both REMOTE and LOCKOUT are lighted), the LOCAL button does not return the instrument from remote to local control.

INTENSITY

(6) MAIN: Sets writing beam intensity to control input waveform definition on the converter tube target.

(7) GRATICULE: Sets writing beam intensity when the graticule is written on the converter tube target (outer knob). When set to minimum, the graticule is not written, so it is not displayed (TV mode) or digitized (digital mode).

DECREASE INTENSITY

(8) Lights to warn that the 6800 MPU is automatically limiting beam current because either or both intensity controls are set too high. Also lights if the 6800 MPU turns off the writing beam because it detects an invalid sweep rate or missing horizontal plug-in readout. Blinks when a hardware protection circuit becomes active; in this condition, the beam is automatically deflected outside the graticule area.

(9) TV SCALE FACTORS

Turns on or off the display of scale factors when in TV mode (inner knob).

(10) FOCUS

Sets focus of writing beam to affect trace definition (outer knob).

(11) BEAM FINDER

Compresses the input waveform into the graticule area, even if the waveform is overdriving the 7912AD input (inner button). Used to determine how the plug-in controls should be changed to match the input waveform. Can not be set under remote control.

(12) VERT OUT

Connects through 50-ohm coaxial cable to rear panel VERT IN.

(13) CAL OUT

Connects through 50-ohm coaxial cable to rear panel CAL IN.

(14) TRIG OUT

Connects through 50-ohm coaxial cable to rear panel TRIG IN.

(15) GROUND

Connects to chassis ground.

(16) PROBE POWER

Provides power for TEKTRONIX active probes.

(17) ON/OFF

Turns on/off the 7912AD power supply if the rear-panel PRINCIPAL POWER SWITCH is on (can be overridden by rear-panel ACTUATE connector). Lights when the power supply is turned on.

Rear Panel

The rear panel controls and connectors are shown in Fig. 2-2. The numbers in the following descriptions refer to Fig. 2-2.

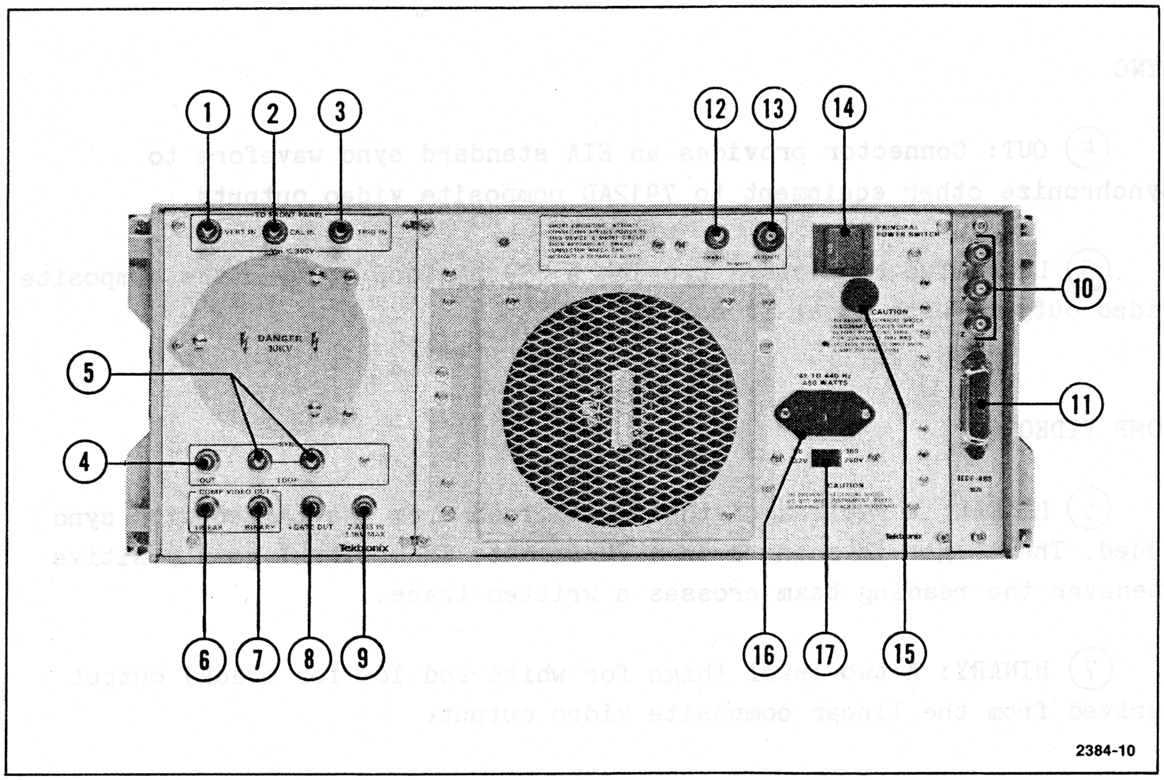


Fig. 2-2. Rear panel controls and connectors. The numbers refer to descriptions in the text of the controls and connectors.

(1) VERT IN

Connects through 50-ohm coaxial cable to front panel VERT OUT.

(2) CAL IN

Connects through 50-ohm coaxial cable to front panel CAL OUT.

(3) TRIG IN

Connects through 50-ohm coaxial cable to front panel TRIG OUT.

SYNC

(4) OUT: Connector provides an EIA standard sync waveform to synchronize other equipment to 7912AD composite video outputs.

(5) LOOP: Two connectors provide a 75-ohm loop to sync the composite video outputs with other TV equipment.

COMP VIDEO OUT

(6) LINEAR: A replica of the signal read from the target with sync added. The target is scanned in a TV format. This signal goes positive whenever the reading beam crosses a written trace.

(7) BINARY: A two-level (high for white and low for black) output derived from the linear composite video output.

(8) + GATE OUT

Provides a positive pulse with a duration equal to and coincident with the time base sweep. The amplitude is approximately 0.5 volts into 50 ohms and 10 volts into 1 megohm.

(9) Z-AXIS IN

± 1 volt input modulates the writing gun intensity over its full range; a zero volt input causes no change in the intensity selected by the intensity controls. A positive signal reduces intensity; a negative signal increases intensity.

CAUTION

Signals connected to Z-AXIS IN control writing beam intensity independently of the 6800 MPU, bypassing the firmware intensity protection. The effect of this input depends on sweep speed and the input waveform; use it with caution to prevent damage to the scan converter target. Connect only low-amplitude signals (±100 millivolts) until the effect on writing beam intensity is monitored.

(10) X,Y,Z

Provide X-Y-Z analog equivalents of the waveform data stored in memory for a refreshed display on a monitor. The outputs are disabled if there is no valid data to display, also while the 7912AD is digitizing or busy with waveform data input or output on the IEEE 488 bus. Scale factors are not displayed. There is no local control of the XYZ display -- it is programmed by the XYZ command as described in Section 3.

(11) J13 IEEE 488-1975

Provides connection to the bus specified in IEEE Standard 488-1975.

(12) ENABLE

Applies a TTL low level between the center and outer conductors after the power supply is turned on; allows power-up of a system to be daisy-chained.

(13) ACTUATE

A TTL low level applied between the center and outer conductors turns on the 7912AD power supply. A return to a TTL high level turns off the 7912AD power supply.

(14) PRINCIPAL POWER SWITCH

Power line switch that turns on or off power input to power supply.

(15) FUSE

Replaceable power line fuse.

(16) Power Connector

CAE-22 three-prong power connector; IEC-coded.

(17) Line Voltage Selector

Selects either 115 VAC or 230 VAC operation.

Operating the 7912AD

Before operating the 7912AD, check the environmental and physical specifications at the end of Section 1; the operating temperature and airflow requirements of the instrument must be met. Be sure there is nothing blocking the fan intake (screen on rear panel) or the air exhaust holes on the sides of the instrument.

Plug-Ins

The 7912AD accepts two Tektronix 7000-series plug-ins. These can be selected to tailor the bandwidth, sweep speed, and other characteristics of the 7912AD for your application. See the specifications in Section 1 for recommended plug-ins and their performance in the 7912AD.

CAUTION

Always turn off the 7912AD power before removing or installing plug-ins to prevent damage to the circuitry.

Install an amplifier plug-in in the VERTICAL compartment and a time base plug-in in the HORIZONTAL compartment. Either programmable or non-programmable plug-ins may be used. The time base must provide readout for the 7912AD to determine that a valid sweep rate is selected. If the time base has no readout, the 7912AD main and graticule intensities are turned off.

CAUTION

Intensity and contrast controls of a dual time base plug-in bypass the firmware intensity protection, setting writing beam intensity independently of the 6800 MPU. Before installing the 7B92A Dual Time Base, reduce its Intensity and Contrast controls to minimum. Monitor the effect of these controls on writing beam intensity and use them carefully when operating the 7B92A in intensified or alternate sweep modes to avoid burning the scan converter target. Do not use other dual time base plug-ins such as the 7B52, 7B53A, or 7B92 in intensified or alternate (mixed) sweep modes because they lack a contrast control.

The 7912AD can display scale factor readout from the plug-ins in TV mode as shown in Fig. 2-3. Channel 1 of an amplifier in the VERTICAL compartment is displayed as vertical channel 1. If channel 2 of a dual amplifier is selected, it is displayed as vertical channel 2. Sweep rates of a time base in the HORIZONTAL compartment may be displayed in either horizontal channel 1 or 2, depending on the plug-in.

The readout display may differ from that obtained with a given plug-in in other 7000-series mainframes in two respects:

1) Only eight characters per channel can be displayed. This does not affect plug-ins recommended in the specifications in Section 1. It may, however, omit characters from some digital plug-ins. Also, special characters from such plug-ins may be garbled.

2) An amplifier operated in inverted mode is indicated by a minus sign in front of the scale factor, rather than a down arrow. Special characters used by 7000-series plug-ins to indicate uncalibrated readout are displayed by the 7912AD. Usually this is the greater-than sign (>) for amplifier and time base scale factors, although some plug-ins use the less-than sign (<) or X to indicate uncalibrated readout.

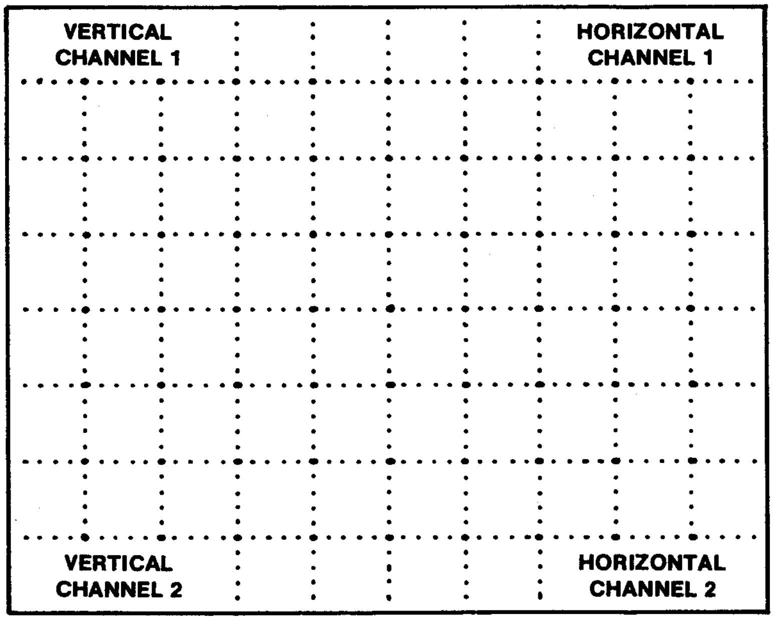


Fig. 2-3. Position of plug-in readout on the TV display.

NOTE

If a 7A21N Direct Access Plug-in is installed, no graticule information can be generated or displayed.

Supplying Power

The 7912AD power cord must be connected to an outlet with a securely grounded protective-ground contact and the correct single-phase voltage. To connect power to the 7912AD, follow the instructions in Section 4.

For either the front-panel ON/OFF switch or the rear-panel ACTUATE connector to power up the instrument, the PRINCIPAL POWER SWITCH must be turned on.

WARNING

To avoid electric shock, be sure that the protective-ground circuit is not interrupted. This can allow the chassis to float to hazardous potentials. Be sure that the power cord, plug, and outlet provide a secure path to earth (ground) for the protective-ground circuit of the 7912AD.

Waveform Monitors

Waveforms acquired by the 7912AD can be viewed on monitors. A TV monitor is used to display waveforms in real-time as they are acquired in TV mode. An XYZ monitor is used to display waveforms stored in memory. An example of each monitor is shown in use with a 7912AD in Fig. 2-4. Instructions to connect the monitors are given under Cabling in Section 4.

Getting a Picture (TV Mode)

1. Set the INTENSITY controls (MAIN and GRATICULE) to minimum (counterclockwise). Although the 7912AD has protection circuitry to prevent damage to the scan converter tube by high intensity levels, set the intensity controls to minimum before turning on power to be safe.

2. Check that the 7912AD is connected to a compatible video monitor. For instructions to connect a monitor, see Section 4.

3. Turn on the video monitor and set for normal brightness.

4. Set the TV SCALE FACTORS switch to ON.

5. Set the time base plug-in for an automatic sweep at 1 millisecond/division or faster.

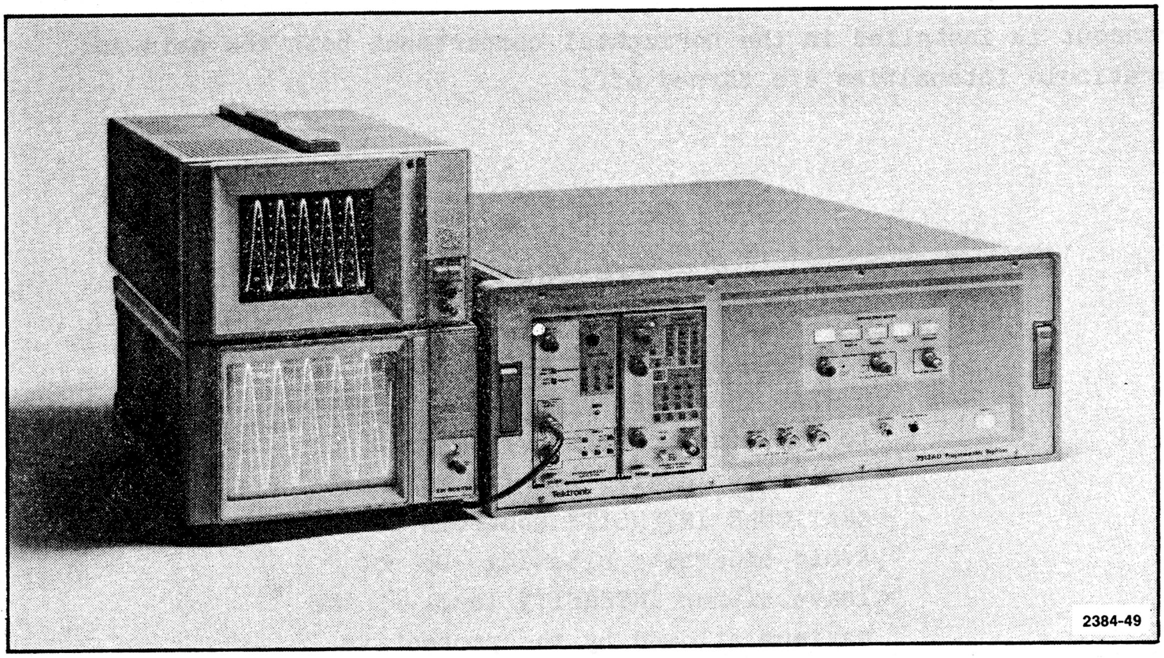


Fig. 2-4. The 7912AD is shown operating with an XYZ monitor (top) and a TV monitor (bottom).

6. Set the amplifier plug-in position control midrange.

7. Press the ON/OFF button or apply a TTL active low on the ACTUATE connector. The button should light and the fan should start. If not, check that the PRINCIPAL POWER SWITCH is ON. The 7912AD is automatically set to the local and TV modes following power-up. If not, check that the 7912AD is not under remote control. To prevent this, disconnect the instrument from the IEEE 488 bus. Scale factors set by the plug-in controls should be displayed on the monitor after a short warm-up. If not, check the monitor connections and operating controls and that the plug-ins have readout capability.

The 6800 MPU performs a self-test on power-up before setting the operating modes to local and TV. If the test fails, the 6800 does not light LOCAL and TV, but hangs at the 6800 bus address where the test failed as a clue for diagnosing the problem.

8. After a short wait to allow the scan converter tube to warm up, increase the GRATICULE INTENSITY slowly until the graticule appears on the monitor. The TV mode graticule is shown in Fig. 2-3. Check that the DECREASE INTENSITY light does not come on. Note: If a time base without

readout is installed in the horizontal compartment both the main and graticule intensities are turned off.

CAUTION

Although protective circuitry in the 7912AD is designed to prevent damage to the scan converter from high intensity levels, set the MAIN and GRATICULE INTENSITY controls carefully. Avoid excessive blooming. Do not leave either INTENSITY level at the maximum allowed by the protective circuitry for extended periods.

9. Increase the MAIN INTENSITY slowly and watch for a trace. Check that the DECREASE INTENSITY light does not come on. The trace should appear within one-half to one full turn of the MAIN INTENSITY control.

10. If the trace does not appear, press the BEAMFINDER control. This compresses the waveform within the viewing area to detect an over-scanned signal. Use the plug-in controls to bring the trace within the graticule.

11. If a trace still does not appear, recheck the instructions performed in the steps above.

12. Either or both intensity controls may need to be changed for different sweep speeds and input signals. If intensity is too high, blooming occurs. If intensity is too low, portions of the display are missing.

13. Set the FOCUS control for a well-defined trace.

14. Allow the 7912AD to warm up for 20 minutes for specified performance. During warm-up, the intensities must normally be increased slightly over their values shortly after turn-on.

Storing and Viewing Data (Digital Mode)--Repetitive Sweep

1. Check that the 7912AD is connected to a compatible display monitor. For instructions to connect a monitor, see Section 4.

2. Turn on the monitor and set for normal viewing level (erase the display if a storage monitor is used).

The following steps through 7 can be skipped if you have already turned on the 7912AD and gotten a picture in the TV mode.

3. Set the INTENSITY controls (MAIN and GRATICULE) to minimum (counterclockwise). Although the 7912AD has protection circuitry to prevent damage to the scan converter tube by high intensity levels, set the intensity controls to minimum before turning on power to be safe.

4. Set the time base plug-in for an automatic sweep of 1 millisecond/division or faster.

5. Set the amplifier plug-in position control to midrange.

6. Press the ON/OFF button or apply a TTL active low on the ACTUATE connector. The button should light and the fan should start. If not, check that the PRINCIPAL POWER SWITCH (rear-panel) is ON. The 7912AD should go to the local and TV modes when it powers up. If not, check that the 7912AD is not under remote control. To prevent this, disconnect the instrument from the IEEE 488 bus. There is normally no display on the monitor after power up because no valid data exists in memory. Allow the 7912AD and monitor a short warm up before going to the next step.

The 6800 MPU performs a self-test on power-up before setting the operating modes to local and TV. If the test fails, the 6800 does not light LOCAL and TV, but hangs at the 6800 bus address where the test failed as a clue for diagnosing the problem.

7. Increase the MAIN and GRATICULE INTENSITY controls a small amount from minimum.

8. Press the DIGITAL button. A waveform is digitized and stored in memory on the next time base sweep, following approximately two-seconds delay for set up if changing from the TV mode.

9. If the INTENSITY controls are set too low, no data is stored, so there is no display on the monitor. Increase the INTENSITY levels a small amount and repeat step 8. Check that the DECREASE INTENSITY light does not come on. Continue to repeat steps 8 and 9 until a trace and graticule are displayed. This should occur within one-half to one turn of the MAIN INTENSITY control and about a half-turn of the GRATICULE INTENSITY control. If not, check the monitor connections and controls.

CAUTION

Although protective circuitry in the 7912AD is designed to prevent damage to the scan converter from high intensity levels, set the MAIN and GRATICULE INTENSITY controls carefully. Avoid excessive blooming. Do not leave either INTENSITY level at the maximum allowed by the protective circuitry for extended periods.

10. In digital mode, only the major divisions are marked on the graticule. If the graticule is displayed, but not the waveform, press DIGITAL while holding in the BEAMFINDER control. This compresses the waveform and the graticule to detect an overscanned signal. Use the plug-in controls to bring the waveform within the graticule. If no signal is applied, the waveform is only a baseline.

11. If no waveform is displayed, recheck the instructions above.

12. Either or both intensity controls may need to be changed for different sweep speeds and input signals. If intensity is too high, blooming occurs. If the intensity is too low, portions of the display are missing.

13. Set the FOCUS control for a well-defined trace. Each time the control is changed, a new waveform must be digitized to see the effect.

14. Allow the 7912AD to warm up for 20 minutes for specified performance. The intensities must normally be increased slightly as the instrument warms up.

Storing a Single-Sweep Waveform

Instructions already given for storing a waveform called for the time base to be set to automatic sweep mode. Although this is the easiest mode for set-up, it does not take advantage of the 7912AD's ability to capture very fast transient events with the time base in single-sweep mode. To use the single-sweep mode, however, further set-up of the triggering and intensity controls is necessary. If the 7912AD and plug-ins are already set to store a waveform with automatic sweep as discussed above, follow these instructions to acquire a waveform with a single sweep:

1) Change the time base triggering mode to normal and set the triggering level, slope, and coupling controls for a triggered sweep (triggered light on).

2) Step 1 works only if the signal to be acquired is repetitive. If not, set the time base trigger source to line and set the controls for a triggered sweep. Triggered on line, the display in step 4 or 5 may not show a stable waveform.

3) Set the time base to single-sweep mode.

4) If in TV mode using a TV monitor, watch the monitor while repeatedly pressing the time base single-sweep reset button. Increase the 7912AD MAIN INTENSITY and GRATICULE INTENSITY until the waveform and graticule are fully displayed.

5) If in digital mode using a display monitor, watch the monitor after pressing DIGITAL and then the time base single-sweep reset button. Increase the 7912AD MAIN INTENSITY and GRATICULE INTENSITY while repeatedly pressing DIGITAL and single-sweep reset in sequence until the waveform and graticule are displayed. Some graticule dots may be missing because the digitize operation begins before the graticule is written.

NOTE

Once DIGITAL is pressed, the 7912AD begins a digitize operation; it can not be reset to TV mode until finished. This requires that the time base sweep be gated. Therefore, if the time base plug-in is not in auto, but in normal or single-sweep modes, the trigger conditions (level, slope, etc.) must be met in order to digitize. The 7912AD operating modes can then be reset, if desired.

6) If the triggering source was set to line in step 2, set the time base triggering source, level, slope, and coupling controls to match the trigger expected to be acquired with the waveform.

7) To acquire the transient event, press DIGITAL, then single-sweep reset. This arms the 7912AD and time base to acquire a waveform when the time base sweep is triggered.

8) To store very fast transients at fastest sweep rates, very high MAIN INTENSITY levels are required. Try resetting FOCUS to achieve maximum writing rate so the trace is fully written.

Local Control in an IEEE 488 System

Some pointers are given here to operate the 7912AD locally when it is interfaced to an IEEE 488 system.

Taking Control. The 7912AD goes to local state automatically at power-up. All local operating controls are active, and the LOCAL button lights. An IEEE 488 bus controller can then set the instrument to remote state. In remote state, all front panel controls are inactive except ON/OFF, BEAMFINDER, LOCAL, and REMOTE; the REMOTE button is lighted. Local control can be restored by pressing LOCAL.

To prevent local control, the controller can set the 7912AD to remote with lockout state. All front panel controls are inactive except

BEAMFINDER, ON/OFF, and REMOTE; the REMOTE and LOCKOUT buttons are lighted. Pressing LOCAL does not restore local control.

The REMOTE button has another function besides indicating remote control. When this button is pressed, the 7912AD asserts SRQ on the IEEE 488 bus if the interrupt is enabled. The controller may be programmed to respond to this request as desired. For example, one use for the button could be to signal the controller to restore local control when the 7912AD is in the remote with lockout state.

If both LOCAL and LOCKOUT are lighted, the 7912AD is in the local with lockout state. To the operator, this state appears the same as the local state.

When the 7912AD returns from remote to local control, the current value of all local controls is assumed. However, several programmed operating modes, such as graticule-only and XYZ, are not controlled from the front panel and do not change from their condition under remote control.

CAUTION

Immediately check the settings of the MAIN and GRATICULE INTENSITY controls when the 7912AD is returned from remote to local control. Sweep rate or the input signal may be different than when the 7912AD was last operated under local control and the intensity levels may no longer be correct.

Graticule-Only Mode. The 7912AD can be switched to a graticule-only mode. This may be used to digitize the graticule in the absence of a triggered sweep. In this mode, the graticule is written at a repetition rate that simulates the graticule intensity written after a single-sweep; the waveform is not written on the target. This mode can only be selected through the IEEE 488 Interface by the GRAT ON command. Once selected, it can not be defeated from the front panel without turning off power. (The 7912AD powers up with the graticule-only mode cleared). The IEEE 488 bus controller should be programmed to reset the graticule-only mode when restoring local control for the operator to acquire waveforms.

XYZ Outputs. The 7912AD automatically switches the XYZ display to show the results of the last digitize operation or waveform processing operation. For instance, in local mode when the DIGITAL button is pressed, the XYZ display shows whatever is digitized as soon as the operation completes. Under remote control, waveform processing operations can be called. These include digitize and signal average, determine trace edges, and digitize defects. The display shows the results of the processing as soon as it is completed. If the digitize and signal average operation is called, for example, the signal-averaged waveform is displayed automatically.

The XYZ display mode can be changed under remote, but not local, control. For instance, the display can be changed from that of the last waveform digitized to show a signal-averaged waveform previously acquired if it is still in memory. Or the display can be turned off.

Whatever XYZ display was called under remote control, the XYZ display automatically changes to show the results of digitize or waveform processing operations that follow. So when the 7912AD is returned to local control and another waveform is digitized by pressing DIGITAL, the XYZ display automatically switches to show the waveform.

Acquiring Data

The 7912AD operates much like other 7000-series oscilloscopes when acquiring a waveform for viewing, either in TV or digital mode. Although this similarity carries over to acquiring data in digital mode, some further considerations apply.

Graticule. When acquired as data, the dot graticule may serve a different purpose than when it is viewed as a yardstick to measure a waveform displayed on a monitor. As data, the graticule may be used to correct inaccuracies in the 7912AD analog-to-digital conversion. These could be due to nonlinearities in the 7912AD amplifiers or the scan converter or due to variations in target geometry affecting the signal path shared by the input and the graticule.

To subtract out such subtle inaccuracies, the graticule can be compared to an ideal graticule and the difference used to correct the digitized waveform. To do this, however, the waveform and graticule should be acquired separately. Otherwise, the data would have to be sorted first to separate the graticule and waveform. This is also true of data acquired for internal processing by the 7912AD memory controller. If the graticule is mixed in data that is signal-averaged, for example, the graticule corrupts the results.

Defects. A portion of the scan converter target that is read as data whether or not it is struck by the writing beam is called a defect. While the ideal is no defects, a few may exist on the target (see the CRT target and writing gun specification in Section 1).

Defects can be caused by burns that result from too-high intensity levels for extended periods. Apparent defects can be caused by improper calibration. Refer calibration to qualified service personnel for adjustment of the instrument within the limits stated in the service manual. Attempts to enhance performance by adjusting the instrument outside these limits can instead degrade performance, causing such problems as apparent defects.

If possible, position the trace away from defects so later processing can more easily remove them from the data. The 7912AD contains firmware routines to flag defects for such processing. The programming commands to handle defects are explained in Section 3.

Sweep Speed and Intensity. The critical parameter in acquiring data with the scan converter is writing intensity. This is affected by the intensity and focus controls, sweep speed (set by the time base sweep rate), and trace slope (caused by changes in amplitude of the input signal).

A step transition can result in missing data during the transition or blooming before and after the transition (or both). If intensity is set too low, a portion of the trace is missing as shown in Fig. 2-5b. If intensity is set too high, the trace blooms where it travels more slowly, and the top and bottom portions of the waveform overlap. The solution is to increase the sweep rate, reducing the slope of the transition, and to increase the intensity enough to write the transition.

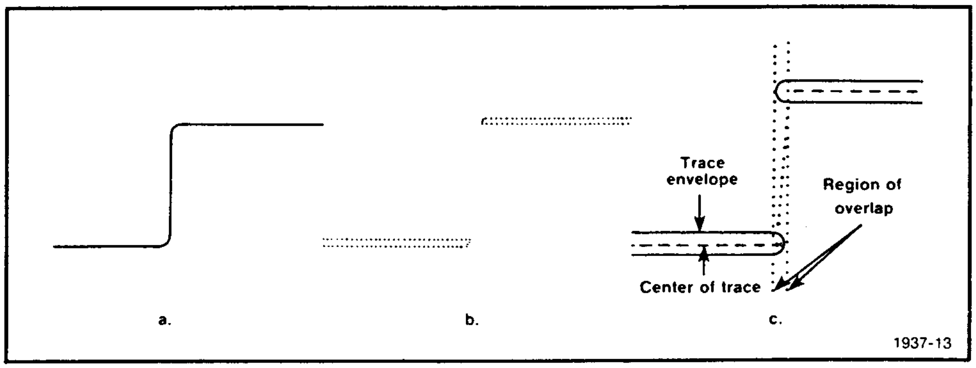


Fig. 2-5. Blooming on a step transition.

The MAIN INTENSITY control requires careful attention when digitizing a waveform with a fast transition. Although blooming on the slow portion (top and bottom) of the trace should be avoided, sufficient intensity should be achieved during the fast transition. A good compromise is shown in Fig. 2-6. Note, however, that the reading beam vertical scan through the transition (part c of the figure) may detect multiple data points. Because of lower intensity during the transition, the trace may be read as a collection of dots rather than as an envelope.

How the transition in Fig. 2-6 would be detected is shown in Fig. 2-7. Part a of the figure shows a typical signal read from a strongly written portion of the target. In part b, the signal from a fast transition is weaker, but still above the detection level. However, if this signal is degraded by noise, as in part c of the figure, multiple edges of the trace are detected. It may not be possible to correct this situation by increasing intensity and/or sweep speed, but a firmware routine is provided to determine the trace edge. Other routines allow missing data to be interpolated if intensity can not be increased to fully write fast transitions.

Another waveform that requires a careful balance between intensity and sweep speed is shown in Fig. 2-8. If the intensity is increased to capture the abrupt transition at the top and bottom of the waveform as

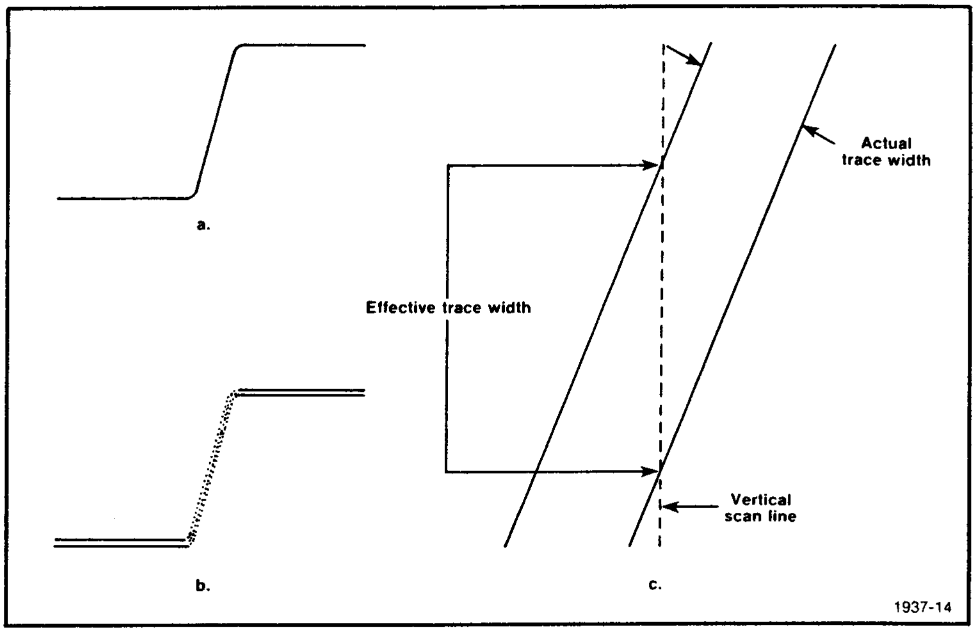


Fig. 2-6. A vertical scan through a fast transition.

shown in part b of the figure, bloom causes the peak value to be underestimated if the top and bottom of the trace are averaged. Increasing the sweep speed to reduce the number of cycles for less abrupt transitions would improve the data.

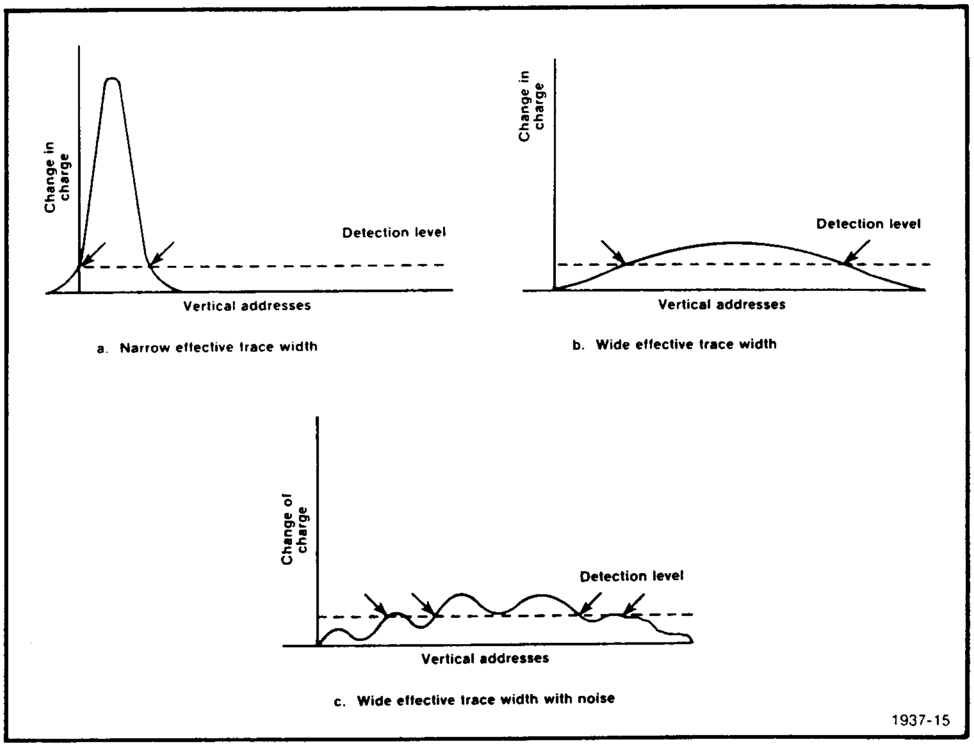


Fig. 2-7. The effect of noise on the signal detected from the target.

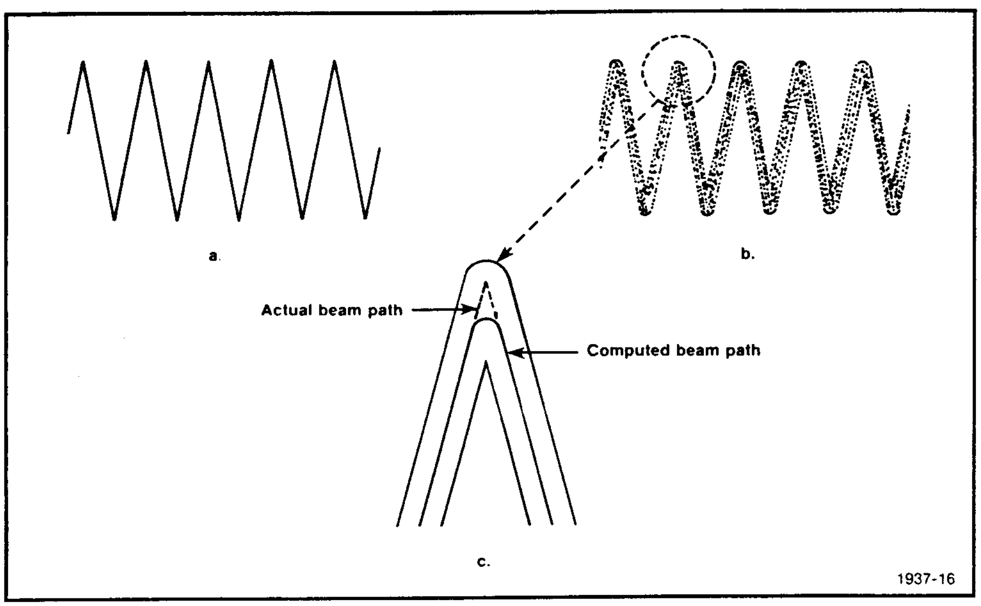


Fig. 2-8. Underestimation of trace peak due to blooming.

SECTION 3

PROGRAMMING

Introduction to IEEE Standard 488-1975

IEEE Standard 488-1975 describes a general purpose bus for instrument systems. Called the IEEE 488 bus in this manual, it is also known as the General Purpose Interface Bus (GPIB). Its purpose is to provide an effective communications link over which messages can be carried between instruments in a clear and orderly manner. Instruments designed to operate according to the standard can be connected directly to the bus and operated by a controller with appropriate programming.

IEEE 488 System

The bus uses eight data and eight control lines. Information is transferred bit-parallel, byte-serial by an asynchronous handshake. This allows instruments with different transfer rates to operate together if they conform to the handshake state diagrams and other protocols defined in the IEEE standard.

A typical system (Fig. 3-1) could include a controller, such as the TEKTRONIX CP4165 Controller with the CP4100/IEEE 488 Interface, a talker, such as a counter or digital multimeter, and a listener, such as a line printer or signal generator. More than one function can be combined in a single instrument. For example, the TEKTRONIX 7912AD Programmable Digitizer has both a listener and talker function.

Up to 15 devices, distributed over no more than 20 meters total cable length, can be connected to a single IEEE 488 bus. More than 15 devices can be interfaced if they do not connect to the bus but are interfaced through another device. Such a scheme is used for programmable plug-ins housed in the 7912AD mainframe; the 7912AD provides a transparent interface between the bus and the plug-ins.

IEEE 488 is a flexible system -- it works either in a star or linear configuration (Fig. 3-2). To maintain the bus electrical characteristics,

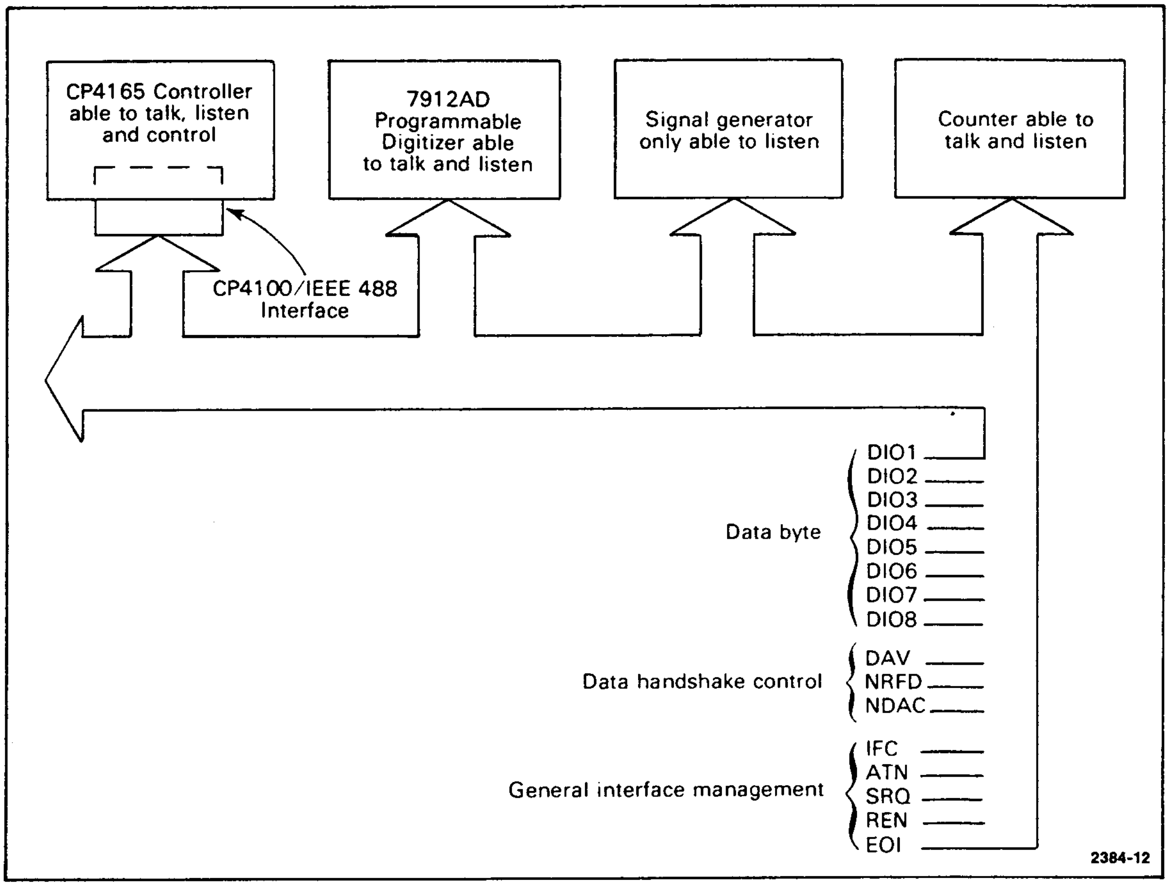


Fig. 3-1. An IEEE 488 system showing some typical instruments and the bus signal lines.

a device load must be connected for each two meters of cable, and more than half the devices connected at any time must be powered up. Although devices are usually spaced no more than two meters apart, they can be separated farther if the required number of device loads are lumped at any point. Also, if the system includes only the 7912AD and a controller, they can be separated by four meters total cable length since each provides a device load.

Messages on the bus are either interface messages or device-dependent messages. Interface messages are used to manage the interface functions of the instruments. They designate talkers and listeners, for

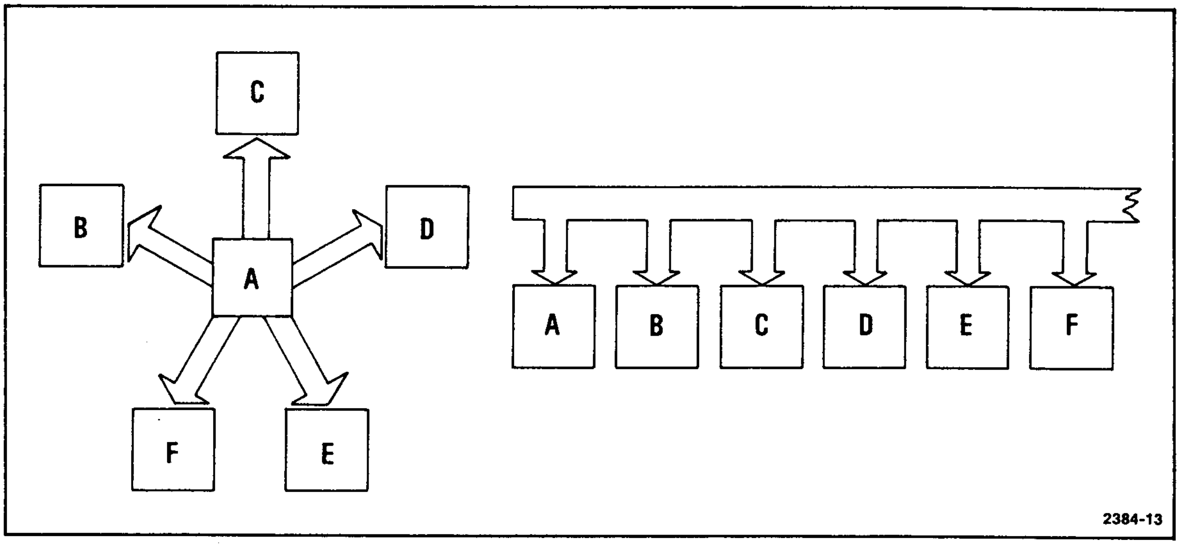


Fig. 3-2. An IEEE 488 system can be configured in either a star or linear manner without impairing the bus electrical characteristics.

example. Device-dependent messages, by contrast, are not used by the interfaces to change their state or configuration, but are passed on to the device functions of the instruments. Such messages can be data, such as a waveform acquired by the 7912AD, or remote-control messages, such as the setting of the 7912AD's operating mode (TV or digital).

IEEE 488 Bus Signal Lines

The IEEE 488 bus contains three groups of signal lines: data, handshake, and control.

Eight lines, DI01 through DI08, are used to carry data (message) bytes on the bus.

The asynchronous, three-wire handshake is controlled by these lines:

DAV (data valid) -- asserted by the transmitting device.

NRFD (not ready for data) and NDAC (not data accepted) -- asserted by the receiving device.

Five interface lines are used for other control functions:

ATN (attention) specifies how data on the DIO lines is to be interpreted: as interface messages when asserted; as device dependent messages when unasserted.

IFC (interface clear) is used to initialize the interface functions of all instruments and return control to the system controller.

SRQ (service request) is asserted to request service from the controller-in-charge.

REN (remote enable) allows remote control of devices on the bus.

EOI (end or identify) indicates the last byte of a message or, when asserted with ATN, polls devices connected to the bus.

See IEEE Standard 488-1975 (ANSI MC 1.1-1975), IEEE Standard Digital Interface for Programmable Instrumentation, for full definition of these lines and protocol for their use. A brief discussion is presented here.

A Byte at a Time

The data and handshake lines are used for the source and acceptor handshake. Actually, they are two parts of the same handshake. Figure 3-3 shows the states of these lines as they are set by a talker using the source handshake and a listener using the acceptor handshake. Note that the timing diagram relates the elctrical signals on the bus to the states of the source and acceptor handshakes. By looking at both, it may be easier to grasp the sequence of the interlocked handshakes than it is to absorb by themselves the state diagrams in the standard.

1) To begin, the source goes to the Source GeNerate State (SGNS). In this state, the source is not asserting a data byte on the data lines or DAV. When no bus driver is asserting a line, it rises to the high level set by the bus terminating network. The acceptors are in the Acceptor Not Ready State (ANRS), asserting both NRFD and NDAC. In this condition, NRFD and NDAC are low.

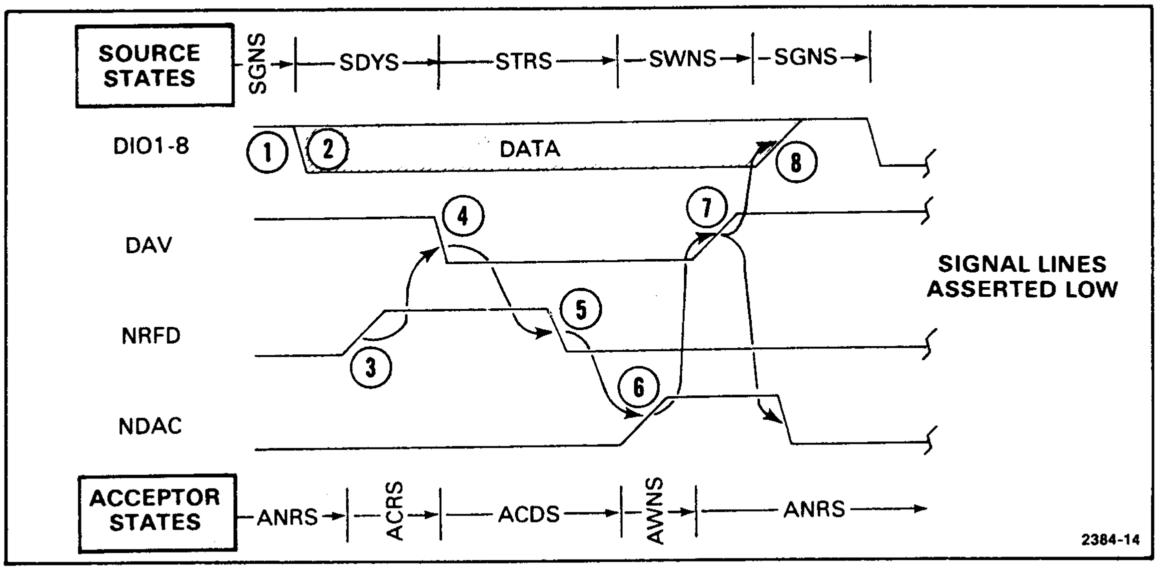


Fig. 3-3. Handshake cycle to move a byte over the IEEE 488 bus. The numbers refer to steps described in the text.

2) The source sets the data byte on the data lines and enters the Source DelaY State (SDYS). If this is the last data byte in the message, the source may assert the EOI line at the same time. The source waits for the data to settle on the lines and for all acceptors to reach the ACceptor Ready State (ACRS).

3) Each acceptor says, "I'm ready" by releasing NRFD to move to ACRS. This is one of the points in the handshake designed to accomodate slower listeners. The NRFD line can be thought of as a wired-OR input to the source handshake logic. Any acceptor can delay the source handshake by asserting this line.

4) When the source sees NRFD high, it enters the Source TRansfer State (STRS) by validating the data with DAV. The source then waits for the data to be accepted.

5) When the receiving devices see DAV true, they go to the ACcept Data State (ACDS). Each device asserts NRFD because it is busy with the current data byte and is not ready for another.

6) As each device accepts the data, it releases NDAC to move from the ACDS to the Acceptor Wait for New cycle State (AWNS). Again, all receivers must release the NDAC line for the source to see a high level. When the source sees NDAC high (all have accepted the data), it enters the Source Wait for New cycle State (SWNS).

7) In the SWNS, the source can unassert DAV. This causes the acceptors to proceed to the ANRS, their initial state in the handshake. In ANRS, they assert NDAC.

8) The source continues to the SGNS, its initial state in the handshake. In this state, it can change the data lines to prepare a new byte for transmission.

This is a typical sequence. The exact sequence is defined by the state diagrams in the standard. The only requirement is that if what happens on the signal lines differs from the above sequence, it must still conform to the state diagrams.

Although the above sequence involved a talker and listener(s), they're not the only ones allowed to use the handshakes. The source handshake is also used by the controller-in-charge to send system control messages; these are called interface messages to distinguish them from device dependent messages sent from talkers to listeners (see Fig. 3-4). The controller asserts ATN to get the attention of all devices on the bus and then uses the source handshake to send interface messages on the data lines.

The interface messages that constitute the controllers vocabulary are defined by the standard. They can be thought of as ASCII codes given a new meaning when sent by the controller with ATN asserted.

Three groups of interface messages are reserved for the listen, talk, and secondary addresses. When a device sees its talk address (called My Talk Address) and ATN simultaneously, it must become a talker, for instance. When the controller removes ATN, the device begins the source handshake to transmit its data. Similarly, My Listen Address and ATN tell a device to listen to the data sent by a talker. Secondary addresses provide unique addresses for devices that share a single listen or talk address. In the TEKTRONIX 7912AD Programmable Digitizer, for example, secondary addresses select among the mainframe and plug-ins, all

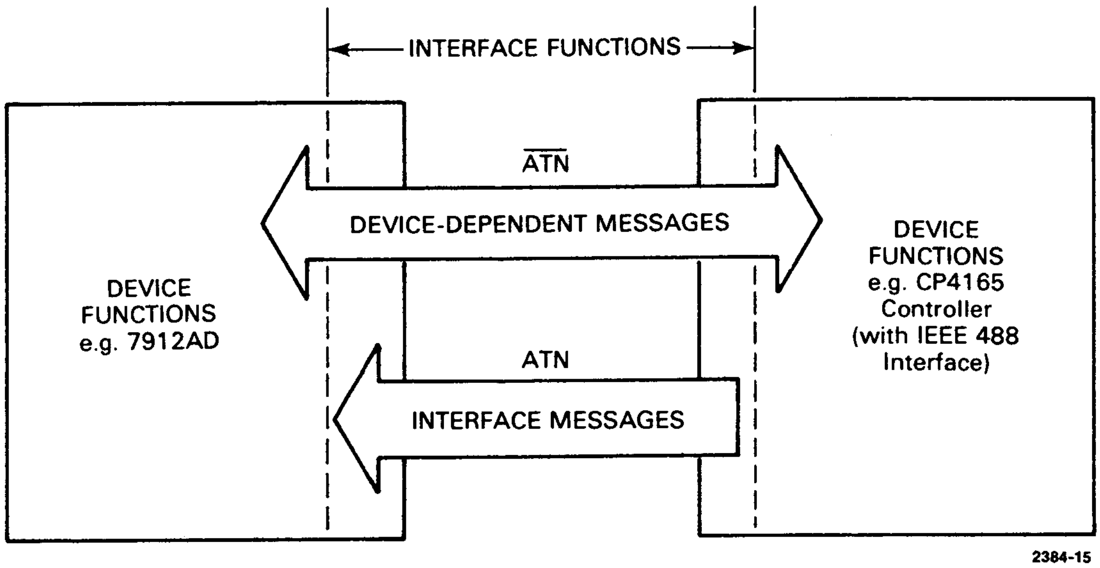


Fig. 3-4. The controller-in-charge asserts the ATN line when sending interface messages.

of which share the same IEEE 488 bus interface.

The controller uses other kinds of interface messages for other tasks. One is the Serial Poll Enable command (SPE) used by the service request interface function. Suppose an instrument is designed to assert SRQ when it has acquired some data. The controller must poll the devices to find the interrupting device since any one (or more than one) can assert SRQ. To conduct the poll, the controller sends SPE, a universal command, and then addresses each device in turn and reads a status byte from each. If the device asserted SRQ, it can code the status byte to tell the controller why.

Parallel Poll Configure (PPC) is an example of an addressed command. It prepares addressed devices to indicate who is requesting service. When ready, the devices respond together so a parallel poll is quicker than a serial poll, though more complicated. Parallel poll is an optional function not implemented in the 7912AD.

Device trigger is another function that uses an addressed command: Group Execute Trigger (GET). It's up to the instrument designer to decide whether to use this function and for what purpose. This function is provided in the 7912AD to synchronize, when desired, a digitize operation with the GET command.

The controller issues the Device CLear message (DCL) to initialize internal functions of devices on the bus. A universal command, DCL applies to all devices. Its effect on each instrument, however, is decided by the designer, who can choose to initialize any device function to any state that suits the purpose of the instrument.

Programming the 7912AD

The 7912AD can be operated by remote control over the bus specified in IEEE Standard 488-1975. After the 7912AD is set to remote mode by the system controller, front-panel operating controls are disabled and their functions can be set with mnemonics sent to it in ASCII over the bus.

Data can be output by the 7912AD at the maximum data rate allowed by the slowest listener. Waveform data is output in binary rather than ASCII. This enables greater throughout, in that data is moved in fewer bytes so data transfers require less bus time.

The 7912AD provides a transparent interface between the IEEE 488 bus and TEKTRONIX 7000-series programmable plug-ins installed in the 7912AD. In effect, the IEEE 488 bus is extended to the plug-ins through the 7912AD plug-in interface.

IEEE Interface Function Subsets

IEEE Standard 488-1975 identifies the interface function repertoire of a device on the bus in terms of interface function subsets. These subsets are defined in the standard. The subsets that apply to the 7912AD are shown in Table 3-1.

How these functions are implemented is explained as part of the description of the commands used to program the 7912AD and its response to interface control messages.

TABLE 3-1

7912AD INTERFACE FUNCTIONS

FUNCTION	SUBSET	CAPABILITY
Source handshake	SH1	Complete. Instrument allows minimum settling time on the DIO (data) lines before asserting DAV (T_1 in the SH state diagram in the standard): $\geq$ 1100 ns for the first byte after ATN is released and $\geq$ 500 ns for the remaining bytes in a message.
Acceptor handshake	AH1	Complete.
Extended talker	TE6	Complete except instrument can not be set to talk-only mode locally; includes response to serial poll; requires secondary address.
Extended listener	LE4	Complete except instrument can not be set to listen-only mode locally; requires secondary address.
Service request	SR1	Complete.
Remote/local	RL1	Complete.
Parallel poll	PPØ	No response to parallel poll.
Device clear	DC1	Complete.
Device trigger	DT1	Complete.
Controller	CØ	None.

Addressing

7912AD IEEE 488 bus addresses are selected by internal switches. Primary bus addresses can be set over the full range allowed by the IEEE 488 standard: 32 to 62 (decimal) for My Listen Address (MLA) and 64 to 94 for My Talk Address (MTA). However, the values of the 7912AD MLA and MTA are not independent of each other since they share the same lower five bits. If the switches are set for a MLA of 33, for instance, MTA is set to 65.

Secondary addresses are used to identify which of the three units, the mainframe, the vertical plug-in, or the horizontal plug-in, is addressed by MLA or MTA. The 7912AD My Secondary Address (MSA) can be set over the full range allowed by the IEEE 488 standard: 96 to 126 (decimal).

The bus addresses of programmable plug-ins are also determined by the 7912AD MLA, MTA, and MSA. The plug-ins share the 7912AD MLA and MTA. The plug-in MSAs are set by the 7912AD MSA in the following manner:

Compartment	**Plug-in MSA**
Vertical	7912AD MSA + 1
Horizontal	7912AD MSA + 2

If the 7912AD internal switches are set for a MSA of 97, for instance, the vertical plug-in MSA is 98, and the horizontal plug-in MSA is 99. If programmable plug-ins are used, the 7912AD MSA should not be set higher than 124 to allow address space for the plug-ins.

Some controllers are programmed for a 7912AD primary and secondary address derived from the 7912AD's MLA, MTA, and MSA, but not equal in value. With such a controller, primary and secondary addresses are entered in the range of 0 to 30. These addresses are the values of only the lower five bits of MLA, MTA and MSA. (These are the bits set by internal 7912AD switches.) The program converts these values to the 7912AD's MLA when sending data to the 7912AD and to the 7912AD's MTA when reading data from the 7912AD, tagging either with the 7912AD's MSA. To do this, the program adds 32 to the primary address to obtain the MLA, 64 to the primary address for the MTA, and 96 to the secondary address for the MSA.

Since the instrument covers must be removed to set the address switches, refer selection to qualified personnel. Instructions are given in the 7912AD Service manual.

Remote/Local Function

The remote/local function of the 7912AD and its programmable plug-ins (if installed) is controlled by the system controller and the LOCAL button. The remote/local function includes four states: local, remote with lockout, and local with lockout. These states are commonly referred to as local mode for local and local with lockout states and remote mode for remote and remote with lockout states.

Local. The 7912AD and programmable plug-ins enter the local state as part of the power-up routine. To enter local state from remote state, one of the following three conditions must occur:

1) The LOCAL button is pressed.

2) The remote enable (REN) line changes from asserted to unasserted.

3) The instrument receives the GTL interface message (ATN asserted) while addressed as a listener.

If the 7912AD is executing a command or is performing a digitize operation, it waits until finished to return to local. The plug-ins return to local with the 7912AD.

When the 7912AD enters the local state, it lights the LOCAL button and assumes the settings of the MAIN INTENSITY, GRATICULE INTENSITY, FOCUS, TV SCALE FACTORS, and BEAM FINDER controls. Other programmable functions, such as XYZ output, remain in their current condition when switching from remote to local. (At power-up, they assume the conditions noted in Table 3-2).

Although the instrument continues to process messages it receives over the bus, it does not execute device-dependent commands that affect local operating controls or alter the state of data memory. Those commands that are ignored are noted in Table 3-2.

Remote. The 7912AD and programmable plug-ins make the local to remote state transition when the 7912AD receives MLA with ATN and REN asserted. Since the plug-ins and the 7912AD share MLA, all three switch to remote state after power-up when the controller addresses any one as a listener with REN asserted.

When the 7912AD enters the remote state, it lights the REMOTE button and continues conditions of all operating functions, whether set by local controls or commands over the bus. Changes in local controls are ignored, except for BEAM FINDER, ON/OFF, LOCAL, and REMOTE. All commands received over the bus are executed.

Lockout. When the local lockout (LLO) interface message is received with ATN asserted, the 7912AD lights the LOCKOUT button and enters the remote with lockout state from remote state, or the local with lockout state from local state. Programmable plug-ins remain in either remote or local state, whichever they were in when LLO was received.

In remote with lockout state, both REMOTE and LOCKOUT are lighted. There is no change in the condition of operating functions. The front panel operates the same as in remote state except that the LOCAL button is not active. All commands are executed.

In local with lockout state, both LOCAL and LOCKOUT are lighted. Since this state allows full local control of the 7912AD and plug-ins, it appears the same as the local state to the operator. There is a difference to the programmer, however. When the 7912AD receives MLA with ATN asserted in local with lockout state (assuming REN has not been unasserted), it goes to the remote with lockout state; if in local state under the same conditions, it goes to remote state.

Remote Control Messages

7912AD remote control messages are device-dependent messages on the IEEE 488 bus. As such, they are not specified in the IEEE standard. 7912AD messages do, however, conform to Tektronix standards intended to enhance compatibility with other IEEE 488 bus-interfaced instruments. To accomplish this, codes and syntax are intended to be unambiguous, correspond to those used by similar devices, and be as simple and obvious as possible. This minimizes the cost and time required to program the 7912AD by making it easier for the programmer to write and understand the needed device-dependent code.

The 7912AD responds to device-dependent messages that contain one or both of two types of commands, set and query. A set command causes the instrument either to set an operating mode or to begin a memory control operation. A query command causes the instrument to return the status of a specified operating parameter.

7912AD remote control messages are sent in ASCII (alpha in upper case) except for the binary block input by one command (LOAD). The 7912AD responds in ASCII, except when transmitting a waveform array; arrays are sent in binary as explained under Waveform Data I/O. The 7912AD ignores the parity bit on ASCII input and always sets it to zero on ASCII output.

Input Buffering and Execution. Messages are input and commands executed under control of the 6800 MPU. A remote control message begins when the 7912AD is addressed as a listener, ATN is unasserted, and the transmitting device begins talking. The message ends when the message terminator is detected by the 7912AD. The 6800 MPU buffers all messages it receives. It does not begin execution of the commands until:

1) The buffer becomes full, or

2) The message delimiter is received.

When either of these conditions occurs, the 7912AD busy status is set; the instrument asserts NRFD unless it is unlistened and reports busy status (bit five of the status byte) if polled. No more commands are accepted until all commands in the buffer are executed; then the busy status is reset and the 7912AD can continue to listen.

The 6800 MPU executes input messages containing multiple commands one command at a time. Commands in a string are handled according to these rules:

1) If a command sets an operating parameter, further commands are not executed until the current command is completed.

2) If the 6800 MPU decodes a digitize command, it initiates the memory controller operation and proceeds to execute further commands that do not conflict with the digitize. Such commands are a set command that would affect the data (such as intensity) or would initiate another memory controller operation.

3) Once any memory controller operation except XYZ is begun, the 6800 MPU waits to execute further memory control commands until the current operation completes. XYZ is an exception because it is an ongoing activity of the memory controller when it has no other task. If the memory controller operation does not digitize or output data, however, the 6800 is free to execute other commands that set or query operating parameters. If there are no further commands, it resets the busy status.

4) When the 6800 MPU decodes a command requesting output, such as a query or output command (READ, DUMP, or REP), it remains busy until allowed to complete the data transfer. It refuses further input until talked and the data is read. If the 7912AD is untalked while transmitting data, it remains busy and waits to finish the transmission. The controller can interupt and reset the talker function by sending the UNT interface message or addressing the 7912AD as a listener. To reset the 6800 output buffer and busy status, however, the controller must perform a device clear with the DCL or SDC interface messages.

Command Syntax. Formats given for the set and query commands are intended as guides and are not intended to fully define the format.

The following format symbols are used:

<> indicates a defined element

[] indicates the element or group of elements are optional and may be omitted

... follows an element or group of elements that may be repeated

The following delimiters are used to punctuate 7912AD commands:

Delimiter	**Follows**
<space>	Header
<comma>	Argument
<semicolon>	Message unit (command)

When listening, the 7912AD responds to either of two message delimeters:

1) The EOI line asserted concurrently with the last byte in the message whether data, a format character, or a lower-order delimiter such as semicolon. This is the standard delimiter for Tektronix instruments.

2) The ASCII code for line feed (LF) sent as a byte following the message and any format character or lower-order delimiter. This is an alternate delimiter provided for compatibility with some instruments from other manufacturers.

The 7912AD responds to either EOI or LF according to the position of an internal jumper. Since the cover must be removed to get at the jumper, refer selection to qualified service personnel; instructions are found in the 7912AD Service Manual.

With EOI selected as the message terminator, any combination of format characters can be inserted at the beginning or end of a message or after a delimiter. Format characters are carriage return (CR), LF, or space.

Format characters can also be used with LF selected as the message terminator. However, the 7912AD interprets LF as the end of the message; it holds up the data transfer by asserting NRFD and executes all commands in the buffer before continuing to handshake data.

When talking, the 7912AD uses EOI to delimit a message. It asserts the EOI line concurrently with the last byte in the message, normally the message unit delimiter (semicolon). However, if the internal jumper is set for LF as the message delimiter, the 7912AD adds CR and LF beyond the normal end of the message (semicolon) and asserts EOI with LF. The 7912AD does not source more data until retalked or serial polled. If the 7912AD has no message to send when it is talked, it responds with a single data byte, hex value FF -- all data lines asserted, along with EOI.

Numbers. Numbers are assumed to be ASCII-coded decimal digits (except for waveform data). Two kinds of numbers are used:

Representation	**Description**
<NR1>	Unsigned integers including 0
<NR3>	Signed scientific notation

Numbers in NR1 notation are signed or unsigned integers; for positive integers, the plus sign is optional.

Numbers in NR3 notation are used only for 7912AD output in response to some queries. These are floating-point numbers expressed in scientific notation. The mantissa includes a decimal point and is preceded by a sign. The exrad following the mantissa begins with the character E, followed by a plus or minus sign and then one or more digits for the exponent of the multiplier. Examples are:

+1.37E-3	(for 1.37×10^{-3})
-1.E+4	(for -1×10^{4})
<space>0.E+0	(for Ø)

An explicit definition of these number types is given in ANSI X 3.42-1975, "American National Standard for Representation of Numeric Values in Character Strings for Information Exchange."

Set Commands. Unless noted as query only, headers and arguments in Table 3-2 can be used as set commands. The last letter of four-letter headers and arguments can be omitted from set commands.

The format for a single set command is:

<header><space><argument>[<semicolon>]

More than one argument can be used with the READ and DUMP commands. For example:

READ<space><argument>[<comma><argument>]...[<semicolon>]

Examples of single set commands are:

MODE DIG
READ VER,PTR,SC1;

More than one set command can be sent as part of a single message. This requires the following syntax:

<set command><semicolon><set command>[<semicolon><set command>]...
[<semicolon>]

An example of multiple set commands in a single message is:

MOD DIG;GRAT OFF;DIG DATA;

One rule must be followed if more than one set command is transmitted as part of the same message: only one command that requires the 7912AD to output data can be contained in a single message. Such a command must be placed last in the message; READ, REP, and DUMP are examples of this kind of command. See Input Buffering and Execution above.

Query Commands. Unless noted as set only, headers in Table 3-2 can be used as query commands. A query is executed in either remote or local mode. A message that contains only a query command requires the following syntax:

<header><question mark>[<semicolon>]

An example is:

MODE?

A message can contain only one query command. The query may be preceded by one or more set commands, however. In this case, the query must be the last message unit (command) and must not be preceded by a set command that requires output, such as READ. A message that contains both set commands and a query command requires the following syntax:

<set command><semicolon>[<set command><semicolon>]...
<query command>[<semicolon>]

An example is:

MODE DIG;MODE?

Any commands in a message following a query are ignored as explained under Input Buffering and Execution earlier.

The 7912AD responds to a query with a message similar to the set command format when it is next made a talker. Unless noted in Table 3-2, the syntax is:

<header><space><argument><semicolon>

For example, the query:

MODE?

is answered (in digital mode):

MODE DIG;

TABLE 3-2

7912AD COMMAND SET

Header	Argument	Description	Notes
MOD[E]	TV	Set instrument to TV mode	3,8
	DIG	Set instrument to digital mode	8
DIG	DAT[A]	Digitize data	1,4,8
	GRA[T]	Digitize graticule only	1,4,8
	SSW	Digitize on single sweep trigger	1,4,8
	DEF,<NR1>	Digitize only defects n times	1,4,8
	SA,<NR1>	Digitize and signal average 1 to 64 times	1,4,8
DT	ON	Wait for GET interface message to digitize	
	OFF	Do not wait for GET interface message to digitize	3
GRAT	ON	Write only the graticule on the target	8
	OFF	Reset graticule-only mode	3,8
XYZ	ON	Enable XYZ outputs to display raw data	4,8
	OFF	Disable XYZ outputs	3,4,8
	RAW	Same as ON argument	4,8
	ATC	Enable XYZ outputs to display ATC data	4,8
	SA	Enable XYZ outputs to display signal-averaged data	4,8
	EDG[E]	Enable XYZ outputs to display edge-determined data	4,8
	DEF	Enable XYZ outputs to display defects data	4,8
MAI	<NR1>	Set main intensity from 0 to 1023	8
GRI	<NR1>	Set graticule intensity from 0 to 255	8
FOC	<NR1>	Set focus from 0 to 63	8
SSW	ARM	Arm single-sweep trigger	8
	DIS	In single-sweep mode, but disarmed	2
	NSS	Not in single-sweep mode	2

TABLE 3-2 (cont.)

Header	Argument	Description	Notes
TV	ON	Turn on TV display of scale factors	8
	OFF	Turn off TV display of scale factors	8
REM	ON	Assert SRQ when REMOTE pressed	
	OFF	Do not assert SRQ when REMOTE pressed	3
OPC	ON	Assert SRQ when operation complete	
	OFF	Do not assert SRQ when operation complete	3
DEF	ON	Flag defects in raw vertical data	4,8
	OFF	Reset defect flags in raw vertical data	3,4,8
LOA[D]	<BINARY BLOCK>	Load defects array from IEEE 488 bus	1,4,6,8
ATC		Perform simple ATC on raw vertical data	1,4,8
INT	<NR1> or NONE	Max. no. of consecutive interpolated data points	2
EDG[E]		Determine edges of raw waveform	1,4,8
TW	<NR1>	Set max. trace width for EDGE from zero to 512	4
RT	<NR1>	Set max. ratio of trace widths for EDGE from 1 to 32767	5
SET	<MESSAGE UNITS>	Settings of programmable functions (header is omitted)	2
TES[T]		Self-test data memory	1,4,8
REA[D]	VER	Transmit vertical data array	1,4,7
	PTR	Transmit pointers data array	1,4,7
	SC1	Transmit channel 1 scale factors	1,7
	SC2	Transmit channel 2 scale factors	1,7
	ATC	Transmit average-to-center data	1,4,7
	SA	Transmit signal-averaged data	1,4,7
	EDG[E]	Transmit edge-determined data	1,4,7
	DEF	Transmit defect data	1,4,7
REP	<NR1>	Repeat DIG DAT/READ PTR,VER sequence 1 or more times	1,4,8

TABLE 3-2 (cont.)

Header	Argument	Description	Notes
LIMITS	<NR1>,<NR1>	Main Intensity limit and Graticule Intensity limit	2
DUM[P]	RAW PR	Dump raw data memory area Dump processed data memory area	1,4,7 1,4,7
VS1	<NR3> or NONE	Scale factor for vertical channel 1	2
VS2	<NR3> or NONE	Scale factor for vertical channel 2	2
HS1	<NR3> or NONE	Scale factor for horiz. channel 1	2
HS2	<NR3> or NONE	Scale factor for horiz. channel 2	2
VU1	<CHARACTERS>	Units for vertical channel 1	2
VU2	<CHARACTERS>	Units for vertical channel 2	2
HU1	<CHARACTERS>	Units for horizontal channel 1	2
HU2	<CHARACTERS>	Units for horizontal channel 2	2
ERR	<NR1> or NONE	Code for error indicated in last status byte reported	2
SRQ	NULL	Service request code (7912AD provides no other response)	2
ID	<CHARACTERS>	Identity of instrument	2

NOTES:

1 -- Can only be used as set command.
2 -- Can only be used as query command.
3 -- Power-up condition.
4 -- Memory control operation.
5 -- Divided by 32 when received by 7912AD.
6 -- BINARY BLOCK is defined under Waveform Data I/O.
7 -- More than one argument allowed, arguments delimited by commas.
8 -- Not executed in local state as set command (does not apply to query)

Command Description

The commands listed in Table 3-2 are defined more fully by the following descriptions.

MODE

The set mode command selects the specified mode of operation. It is not executed in local mode. The instrument may be set to either:

TV - In TV mode the input waveform and graticule can be displayed on a TV monitor; the front-panel TV button is lighted. This is the power-up condition.

DIG - In digital mode the TV display is blanked and the instrument is readied to acquire data. The front panel DIGITAL button is lighted. There is a two-second delay for setup when switching from TV to digital mode.

The query mode command returns the current mode, TV or DIG.

DIG

The digitize command (set only) initiates the acquisition of data. Because it is a memory control operation that changes the state of data memory, it is not executed in local mode. See DT and OPC for other commands related to the digitize operation.

When the 6800 MPU executes the digitize command, it sets the busy bit and resets the operation complete status in the status byte. It resets the busy status after it initiates the memory controller digitize operation (if it has no further commands to execute). For the digitize operation to complete when the DATA, SSW, or SA argument is specified in the DIG command, the time base plug-in must provide a sweep. In normal and single-sweep modes, this requires that the sweep be triggered.

If the 7912AD is in TV mode when it begins to execute DIG, the mode is first set to digital, requiring a two-second setup time. If other commands follow DIG in the command string, they are not executed until the digitize completes if they would affect the data being digitized. Such commands are GRAT, MAI, GRI, FOC, and MODE as well as other memory control operations as explained earlier under Input Buffering and Execution.

For more general instructions that apply to digitizing waveforms, see Acquiring Data at the end of Section 2.

Valid arguments for the DIG command are:

DATA - Digitize data. Data is acquired beginning with the next sweep gate and stored in the raw data area of the data memory. Both the waveform and graticule are digitized if the main and graticule intensities are set high enough to write the target.

GRAT - Digitize graticule. The instrument is first set to the graticule-only mode (see the GRAT command). After a half-second delay to allow any trace on the target to decay, the graticule is written. Graticule data is acquired and stored in the raw data area if the graticule intensity is set high enough to write the target. Then the graticule-only mode is reset to its prior state.

SSW - Digitize on single sweep. If the time base plug-in is set to single-sweep mode, the 7912AD is readied to acquire data and the time base sweep is armed. When the sweep is triggered, data is acquired and stored in the raw data area. Both the waveform and graticule are digitized if the main and graticule intensities are set high enough to write the target.

DEF, NR1 - Digitize defects. Both the main and graticule intensities are turned off so only light defects on the target are detected. A half-second delay allows any trace on the target to decay. Then persisting defects are digitized the specified number of times and the composite of the points is stored in the defects array. After the digitize completes, the intensities are restored to their previous levels. Any positive integer up to 65535 can be sent as an argument.

SA, NR1 - Digitize and signal average a repetitive waveform. The digitize data operation is performed the specified number of times. Each time, defect flags are set (DEF ON), and the ATC algorithm is performed on the raw data (see the DEF, ATC, and INT commands). The resulting ATC data are summed in the SA array. Since the ATC operation sums each pair of vertical data values (top and bottom edges of trace) from the raw waveform data, the signal average algorighm performs a divide-by-two on the data after all waveforms have been summed in the SA array. This also prevents the summed data values in SA from setting bit 16 of a data word, making later processing in a 16-bit controller much more convenient. When the operation is completed, the last waveform acquired resides in the raw data arrays and its simple ATC in the ATC array. Any data previously stored in either edge array is overwritten during the SA operation.

Note that no division is performed to scale the SA data by the number of averages performed. Since all averages must be performed in integer powers of two, an implied binary point can be used to scale the data to values from zero to 511. See Waveform Data I/O in this section.

Any positive number can be sent as an argument; if the number is not an integer power of 2 (64 or less), the greatest integer power of two less than the number (up to 64) is assumed.

DT

The set device trigger command controls the instrument's response to the group execute trigger (GET) interface message when under remote control. Valid arguments are:

ON - Wait for the GET command to digitize. DIG commands are executed only after the GET command is received. Mode should be set to digital before sendng DIG or the two-second set-up time to switch from TV to digital occurs after the GET command is received.

OFF - Do not wait for GET to digitize. DIG commands are executed normally; the GET interface message is ignored. This is the power-up condition.

The query device trigger command returns the current device trigger condition, ON or OFF.

GRAT

The set graticule command controls a graticule-only writing mode (not executed in local mode). Valid arguments are:

ON - The main sweep is locked out and the writing beam writes only the graticule on the target.

OFF - The graticule-only writing mode is reset. This is the normal writing mode -- the waveform and graticule are both written on the target in an alternating sequence during data acquisition. This is the power-on condition.

The query graticule command returns the condition of the graticule-only writing mode, ON or OFF.

XYZ

The set XYZ command selects the source of the data to be displayed by a display monitor (not executed in local mode). The data is used by digital-to-analog converters to drive the XYZ outputs for a point-by-point refreshed display. The display is blanked between data points; missing points are not filled in. No scale factor readout is displayed. The display is blanked while the memory controller is busy (with a READ operation, for instance).

Although the XYZ display automatically switches to show the data stored by the last DIG, ATC, EDGE, or LOAD operation, the XYZ command can be used to override this automatic feature. Any XYZ mode can be selected, whether or not valid data exists. If the data is destroyed (by a memory overwrite or self-test, for instance), the display is set to OFF automatically until reset by a DIG, ATC, EDGE, or LOAD operation or an XYZ command. Valid arguments are:

ON - Enable the XYZ outputs and select the raw data for conversion into an X-Y display based on the internal X and Y arrays. The graticule is displayed if digitized. Since data are ordinarily stored for both the top and bottom of the trace, the waveform display is usually an envelope showing the top and bottom of the trace. Defects flagged by the DEF command are not displayed.

OFF - Disable the XYZ outputs; this is the power-up condition.

RAW - Same as ON argument.

ATC - Enable the XYZ outputs and display the data stored in the ATC array. For valid data, the display is a single-valued function that represents the simple average of the top and bottom of the trace (see the ATC command). The graticule is not displayed (if it was digitized, it is averaged into the display).

SA - Enable the XYZ outputs and display the data stored in the SA array. For valid data, the display is a single-valued function that represents the average of successive waveforms, each of which was first averaged to center of trace (see the DIG SA command). No graticule is displayed. If it was digitized, it is averaged into the display.

EDGE - Enable the XYZ outputs and display the data stored in the upper and lower EDGE arrays. For valid data, the display is an envelope defining the top and bottom edges of the trace (see the EDGE command). No graticule is displayed. If it was digitized, the edge algorithm rejects it except where the graticule is adjacent to the trace.

DEF - Enable the XYZ outputs and display the data stored in the defects array, if any. For valid data, the display consists of points where light defects exist on the target (see the DIG DEF and LOAD commands). No graticule is displayed unless it is loaded by the LOAD command.

The query XYZ command returns the current XYZ mode: ON, OFF, RAW, ATC, SA, EDGE, or DEF.

MAI

The set main intensity command sets the main intensity to the value specified by the <NR1> argument (not executed in local mode). Valid intensity values are in the range Ø-1Ø23; Ø is off and 1Ø23 is the highest intensity level. The 6800 MPU automatically limits the value of the MAI argument, if necessary, to prevent damage to the target. If the 6800 MPU does not detect a valid sweep rate ($\geq$1 millisecond/division) from the horizontal plug-in readout, it turns off the main intensity.

The query main intensity command returns the main intensity setting, Ø to 1Ø23.

CAUTION

Set intensity levels with the MAI or GRI commands carefully. Avoid excessive blooming. Do not leave either the main or graticule intensity at the maximum allowed by the protective circuitry for extended periods.

GRI

The set graticule intensity command sets the graticule intensity to the value specified by the <NR1> argument (not executed in local mode). Valid intensity values are in the range Ø-255; Ø is off and 255 is the highest intensity level. The 6800 MPU automatically limits the value of the GRI argument, if necessary, to prevent damage to the target. If the 6800 MPU does not detect a valid sweep rate (≥1 millisecond/division) from the horizontal plug-in readout, it turns off the graticule intensity.

The query graticule intensity command returns the graticule intensity setting, Ø to 255.

FOC

The set focus command sets the writing beam focus to the value specified by the <NR1> argument (not executed in local mode). Valid focus values are in the range Ø-63.

The query focus command returns the focus setting, Ø to 63.

SSW

The set single-sweep command arms the time base plug-in sweep if it is in the single-sweep mode (not executed in local mode). The valid argument is:

ARM - Arms the time base sweep (time base must be single-sweep mode).

The query single-sweep command returns the condition of the time base single-sweep mode. The arguments are:

ARM - The time base plug-in is in single-sweep mode and the sweep is armed.

DIS - The time base plug-in is in single-sweep mode, but the sweep is not armed.

NSS - The time base plug-in is not in single-sweep mode.

TV

The set TV scale factors command controls the display of scale factors on the TV monitor (not executed in local mode). Valid command arguments are:

ON - Turns on the TV scale factors display.

OFF - Turns off the TV scale factors display.

The query TV scale factors command returns the condition of the TV scale factors display, ON or OFF.

REM

The set remote request command controls the instrument's response when the front panel REMOTE button is pushed. Valid arguments are:

ON - Assert SRQ when REMOTE button is pressed and set remote request status.

OFF - Do not assert SRQ when REMOTE button is pressed, but set remote request status (see Status Byte). This is the power-on condition.

The query remote request command returns either ON (SRQ enabled on remote request) or OFF (remote request not enabled).

OPC

The operation complete command controls the instrument's action when it completes a DIG or TEST command. Valid command arguments are:

ON - Assert SRQ when the DIG or TEST command is completed and set operation complete status.

OFF - Do not assert SRQ when the DIG or TEST command is completed, but set operation complete status (see Status Byte). This is the power-on condition.

The query operation complete command returns either ON (SRQ enabled on operation complete) or OFF (SRQ not enabled on operation complete).

DEF

The set defect flags command controls whether defects data are flagged in the raw vertical data array. The defects data must already be loaded in the defects array (see the DIG, DEF and LOAD commands). Because it is a memory control operation that can change the state of the data memory, it is not executed in local mode. Valid arguments are:

ON - Flag data in the raw vertical data array that match data points in the defects array. Bit 10 of the vertical data is set as the flag. This affects data output by the READ VER and DUMP RAW commands, data displayed by XYZ ON, and data processed by the ATC, DIG SA, and EDGE commands.

DEF ON affects only the current vertical data and is canceled by a subsequent digitize (except DIG SA, which automatically sets DEF ON).

OFF - Reset all defect flags in the vertical data array, canceling the effect of the DEF ON command; this is the power-up condition.

The query defect flags command returns the current state of the defect flags, ON (flags set) or OFF (flags not set).

LOAD

The load defects command (set only) causes the instrument to input a binary block of data from the IEEE 488 bus and store it in the defects array. The previous defects array is lost. Because this is a memory control operation that changes the state of the data memory, it is not performed in local mode.

The format of the binary block is defined under Waveform Data I/O in this section. Because it is the same as the READ DEF output, the defects array can be read, stored externally, and then reloaded when needed. When the load operation is completed the array resides between the vertical and horizontal arrays as discussed under Waveform Storage in Section 1.

ATC

The average-to-center command (set only) causes the instrument to process the raw vertical array to obtain a simple average of the top and bottom edges of the waveform. Because it is a memory control operation that changes the state of the data memory, it is not executed in local mode.

The ATC routine sums the highest and lowest values, point-by-point, from the raw vertical data. Data with the defect flag set are rejected. The routine fills in missing points by linear interpolation or horizontal extrapolation, that is, missing end points are set equal to the values of the nearest valid data point. The averaged data are reordered left-to-right of trace, yielding a single-valued, time-ordered function of 512 elements. The effect of the ATC command is shown in Fig. 3-5.

Because the values are a sum of the top and bottom of trace, they range from 0 to 1023. However, an implied block binary point between bits 0 and 1 scales the data to the range 0 to 511. To be useful, raw data should not include the graticule, since the graticule data would be averaged into the waveform data.

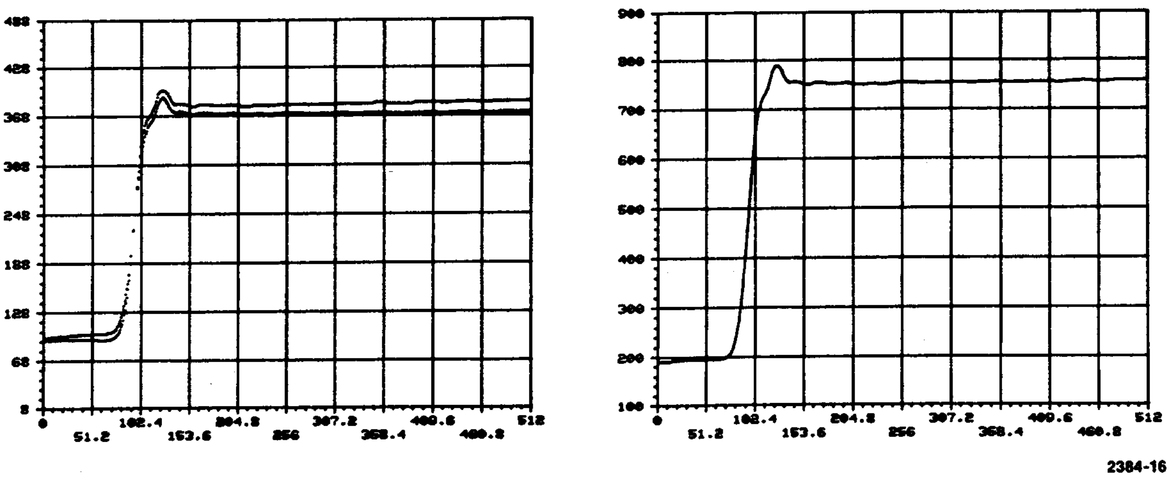


Fig. 3-5. A waveform before and after processing by the ATC command.

When completed, the ATC data resides in the ATC array. Because the ATC array and the upper-edge array (see the EDGE command) share the same portion of the processed memory area, they are mutually exclusive. The ATC operation destroys the upper edge array. The memory allocation is discussed further under Waveform Storage in Section 1.

See also the INT command.

INT

The interpolate command (query only) returns the maximum number of consecutive data points interpolated by the ATC routine during an ATC or DIG SA operation. For DIG SA, the value returned is the maximum number of consecutive points interpolated for any of the waveforms in the average. The argument is returned in NR1 notation; its value indicates the amount of distortion in the waveform that may have been introduced by interpolation.

EDGE

The waveform edges determination command (set only) reduces the raw vertical data to values for the top and bottom of the waveform, rejecting noise and defects. Because it is a memory control operation that changes the state of data memory, it is not executed in local mode.

Raw data to be processed by the EDGE command should be digitized from a single trace without graticule. It should not be digitized in the chopped or alternate mode of a dual amplifier or alternate mode of a dual time base.

The raw data are tested beginning with data digitized on the left-most vertical scan and continuing to the right until all vertical data are processed. The results are stored in the upper and lower edge arrays. The raw data are handled scan-by-scan in the following manner.

1) Defects flagged by the DEF ON command are rejected. If no data exist or if all the data are flagged as defects, a value of -1 is stored for that horizontal location in both edge arrays. If a valid data point is found for only one edge because all other data are flagged, that point is stored in the corresponding array and a -1 is stored in the other array.

2) If two or more valid data exist, the maximum and minimum non-defect values are tested. First, the current trace width (CTW) is determined by subtracting the minimum from the maximum:

$$CTW = MAX - MIN \qquad (1)$$

For the maximum and minimum values to be accepted as data, CTW must not exceed two constraints. The first constraint is maximum trace width (TW) set by the TW command:

$$CTW \leq TW \qquad (2)$$

The second constraint is the maximum ratio of trace widths (RT) set by the RT command. The previous trace width is determined by taking the difference between the maximum and minimum values of the last pair of data points accepted by the edge operation. For the first scan and until the first pair of points is accepted, the initial value of PTW is set by:

$$PTW = \frac{TW}{RT} \qquad (3)$$

The ratio test is applied by comparing the ratio of the two trace widths to the parameter RT:

$$\frac{CTW}{PTW} \leq RT \qquad (4)$$

For speed, the edge algorithm actually combines the TW and RT tests into the single step given in equation 4 by limiting PTW to the initial value given in equation 3 for all vertical scans. Thus, CTW is not allowed outside the bounds set by TW, even though the two values are never directly compared.

As a result of these two tests, data outside a window set by the TW and RT parameters are rejected as shown in Fig. 3-6. This is a dynamic test that rejects noise or defects, but allows the trace width to vary as it does before, during, and after a fast transition. Refer back to the discussion of sweep speed and intensity under Acquiring Data in Section 2 for an illustration of this trace width variation.

If the current trace width passes both the trace width and ratio of trace width tests, the maximum value is stored in the upper edge array and the minimum value in the lower edge array. If the current trace width fails either of the tests, a -1 is stored in both arrays.

As a result of this processing, the edge data reside in two 512-point arrays, the upper edge array and the lower-edge array. Each array is ordered from left-to-right of trace. Because the edge arrays reside in the same processed memory space as the SA and ATC arrays, the pairs of arrays are mutually exclusive. The edge operation destroys the ATC and SA arrays. When read out, the edge data are ready for normalizing or geometry correction.

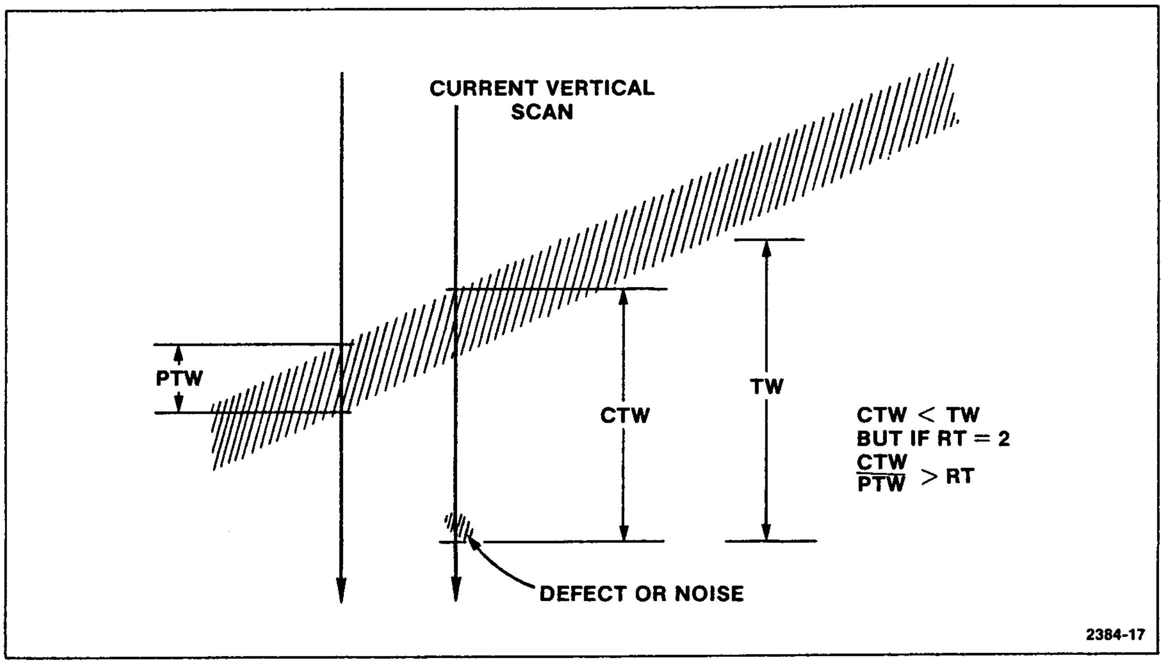


Fig. 3-6. A small portion of a trace is shown to relate the parameters PTW, CTW, and TW to the data on the target. As shown, data for the current scan fit within the limits set by TW, but fall outside the limits set by RT (the defect was not flagged). The data are rejected.

The power-up value of TW is 100; the power-up value of RT is 2 (although it is input or output by the 7912AD as a value multiplied by 32 for greater resolution -- see the RT command). These power-up values may not be optimum in all cases. Try larger values if a portion of the waveform is rejected during processing; try smaller values if noise or defects creep into the processed data. If the trace width is expected to stay within a given limit, for instance, set TW to that limit, then set RT for best results.

TW

The set trace width command selects the maximum trace width allowed by the edge routine. The argument should be sent in NR1 notation in the range zero to 512. However, trace width is always one or greater for valid data, so a TW value of zero causes all data to be rejected. The power-on value is 100.

The query trace width command returns the NR1 value of the maximum trace width parameter.

RT

The set ratio of trace widths command selects the maximum ratio of CTW to PTW for the edge algorithm (see EDGE). The argument should be sent in NR1 notation in the range of one to 32767. On input, it is divided by 32; this allows more resolution of the parameter. For example, if 64 is sent as the RT argument, it is divided by 32 on input; this sets a maximum ratio of 2 between CTW and PTW. The value of the RT parameter at power-up is 2.

The query ratio of trace widths command returns the NR1 value of the RT parameter, multiplied by 32 before output. For example, if the current maximum ratio of CTW and PTW is 2 (the power-up value), the 7912AD would send 64 as the argument in its response to the query RT command.

SET

The settings command (query only) returns the status of the instrument's programmable settings. The message units returned are:

MODE<CHARACTERS>;**GRAT**<CHARACTERS>;**TV**<CHARACTERS>;**XYZ**<CHARACTERS>;
DT<CHARACTERS>;**REM**<CHARACTERS>;**OPC**<CHARACTERS>;**MAI**<CHARACTERS>;
GRI<CHARACTERS>;**FOC**<CHARACTERS>;**TW**<CHARACTERS>;**RT**<CHARACTERS>;

The header (**SET**) is omitted in the response string. If the string is stored, it can later be transmitted without modification to restore the "learned" programmable settings.

TEST

The test data memory command (set only) causes the 7912AD to test the memory controller and data memory. Because this is a memory control operation that changes the state of the data memory, it is not executed in local mode. TEST exercises the 2900 CPU, constant PROMs, and memory controller RAM. Each word in the data memory is set so its bits are alternate ones and zeros and then verified. A marching ones and zeros pattern is then used to stimulate each memory cell, repeatedly verifying the pattern to check for address decoding, access time, and data retention problems.

The test requires about 10 seconds; delays take most of this time to check for data retention. The 7912AD can be set to assert SRQ when finished -- see OPC.

Any failure causes the 7912AD to assert SRQ, set the appropriate abnormal system status to be reported during the next serial poll, and prepare to report a data memory fault error when queried. The test destroys the data in memory, causing the XYZ display to be turned off. A READ command would return unpredictable data, as would the DUMP command (except for the defects pointer, which is reset).

READ

The read data command (set only) causes the instrument to transmit data over the IEEE 488 bus; it is executed in either local or remote mode. More than one argument is allowed, each delimited by a comma. Valid arguments are:

VER - Output vertical data array in block binary format. This is a memory control operation. See the Waveform Data I/O discussion for the format and meaning of the array.

PTR - Output pointer array values in block binary format. This is a memory control operation. See the Waveform Data I/O discussion for the format and meaning of the array.

SC1 - Output waveform scale factors. The scale factor of the vertical plug-in (volts/division) is transmitted, followed by the scale factor of the horizontal plug-in (time/division). The format is:

V/D <NR3>;**T/D** <NR3>;

With a dual amplifier in the VERTICAL compartment, the vertical scale factor is that of amplifier channel 1 unless channel 2 is selected. In the latter case, the vertical scale factor in <NR3> is replaced by the word **NONE**.

With a dual time base in the HORIZONTAL compartment, the horizontal scale factor is the main sweep rate in the normal and intensified sweep modes and is the delayed sweep rate in the delayed sweep mode. Either the main or delayed sweep rate may be returned as the horizontal scale factor in the alternate and mixed sweep modes.

SC2 - Output waveform scale factors. The scale factor of the vertical plug-in channel 2 (volts/division) is transmitted, followed by the scale factor of the horizontal plug-in (time/division). The format is:

V/D <NR3>;**T/D** <NR3>;

With a single-channel amplifier in the VERTICAL compartment, the vertical scale factor in <NR3> is replaced by the word **NONE**; this is also true with channel 1 selected of a dual amplifier in the VERTICAL compartment. The horizontal scale factor is the same as described for the SC1 argument.

ATC - Output the ATC data array. This is a memory control operation. See the Waveform Data I/O discussion for the format and meaning of the array.

SA - Output the SA data array. This is a memory control operation. See the Waveform Data I/O discussion for the format and meaning of the array.

EDGE - Output the upper and lower edge data arrays. This is a memory control operation. See the Waveform Data I/O discussion for the format and meaning of the array.

DEF - Output the defects array stored in memory by the LOAD or DIG DEF command. This is a memory control operation. See the Waveform Data I/O discussion for the format and meaning of the array.

REP

The repeat digitize/read data command (set only) causes the 7912AD to repeatedly digitize and output data the number of times specified by the <NR1> argument. This is a memory control operation that is not executed in local mode. This command is equivalent to repeating the combined commands: **DIG DAT;READ PTR, VER**. Valid arguments are 0 through 65535; if 0, the digitize and read sequence is repeated indefinitely (it can be terminated by the DCL or SDC interface message).

The 7912AD sends the message delimiter at the end of each waveform output and stops talking, so the 7912AD must be talked (receive its talk and secondary addresses) to read out data for each repetition.

If SRQ is enabled on operation complete **(OPC ON)**, SRQ is asserted after each digitize operation and the operation complete status reported. If the device trigger function is enabled **(DT ON)**, the 7912AD waits for the GET interface message before repeating each digitize read sequence.

DUMP

The dump memory command (set only) causes the 7912AD to output the contents of the specified area of memory along with pointers to interpret the data. This is a memory control operation that is executed in local mode. Multiple arguments are allowed if delimited by a comma. The following arguments are valid:

RAW - Output the necessary pointers, followed by the raw vertical and horizontal arrays in block binary format. See the Waveform Data I/O discussion for the format and meaning of the arrays. These are not the same arrays returned by the READ VER, PTR command, for which the data are reordered and processed before transmission.

PR - Output the processed data arrays in block binary format. See the Waveform Data I/O discussion for the format and meaning of the arrays. The arrays transmitted depend on what is stored in this area of memory. Either the edge arrays or the average-to-center and signal-averaged arrays are transmitted.

VS1

The vertical scale factor 1 command (query only) returns the scale factor of the vertical plug-in. The scale factor is returned in NR3 notation and is obtained from the plug-in's channel 1 readout (as shown in Fig. 2-3). If the scale factor is missing, the word **NONE** is returned in place of the NR3 scale factor. If the plug-in is an amplifier operating in inverted mode, the scale factor is negative. For instance, the query **VS1?** would be answered **VS1 NONE;** if there is a dual amplifier in the VERTICAL compartment set to channel 2. The query **VS1?** would be answered **VS1 -500.E-3;** if there is a single-trace amplifier in the VERTICAL compartment set to inverted mode with a scale factor of 500 millivolts/division.

VS2

The vertical scale factor 2 command (query only) returns the vertical plug-in scale factor from the vertical channel 2 readout in the same manner as **VS1?** does for channel 1.

HS1

The horizontal scale factor 1 command (query only) returns the scale factor of the horizontal plug-in. The scale factor is returned in NR3 notation and is obtained from the horizontal plug-in's channel 1 readout. If the scale factor is missing, the word **NONE** is returned in place of the NR3 scale factor.

For most time base plug-ins, **HS1?** returns the sweep rate if the time base is in normal mode. For the 7B92A Dual Time Base, however, **HS1?** returns a sweep rate only in the alternate mode; the sweep rate is that of the delaying sweep.

HS2

The horizontal scale factor 2 command (query only) returns the horizontal plug-in scale factor from the horizontal channel 2 readout in the same manner as **HS1?** for channel 1.

For most time base plug-ins **HS2?** returns the delayed sweep rate if in delayed sweep or alternate sweep mode. For the 7B92A Dual Time Base, however, **HS2?** returns either the main (delaying) or delayed sweep rate, depending on the time base mode that is selected.

VU1

The vertical scale factor 1 units command (query only) returns the first character from the vertical plug-in channel 1 readout units. If there are no units, the word **NONE** replaces the character. If the plug-in variable control is set for an uncalibrated scale factor, a > character is returned following the units character. For instance, if the plug-in is set to 500 millivolts/division (channel 1 selected if dual amplifier), with the variable knob set to the uncalibrated postion, **VU1?** would return **VU1 V>;**.

VU2

The vertical scale factor 2 units command (query only) returns the first character from the vertical plug-in channel 2 readout units in the same manner as **VU1?** does for channel 1.

HU1

The horizontal scale factor 1 units command (query only) returns the first character from the horizontal plug-in channel 1 readout units. If there are no units, the word **NONE** replaces the character. If the plug-in variable control is set for an uncalibrated scale factor, a > character is returned following the units character.

For most time base plug-ins, **HU1?** returns the sweep rate units if the time base is in normal mode. For the 7B92A Time Base, however, **HS1?**

returns HU1 **NONE;** except in alternate mode.

HU2

The horizontal scale factor 2 units command (query only) returns the first character from the horizontal plug-in channel 2 readout units in the same manner as HU1? does for channel 1.

For most time base plug-ins HU2? returns the delayed sweep rate units if in delayed sweep or alternate sweep mode. For the 7B92A Dual Time Base, however, HU2? returns either the units for the normal or delayed sweep rate, depending on the time base mode that is selected.

ERR

The error command (query only) returns an error code in NR1 notation or the word **NONE** if there is no error condition to report. The response always refers to the last status byte reported. See Table 3-4 under Error Handling for the meaning of the code.

SRQ

The service request command (query only) returns **NULL** as an argument to be compatible with a device-dependent function used by some other instruments.

ID

The identify command (query only) returns the following ID message: **ID TEK/7912AD,V77.1,FXX.YY;** where XX represents the 6800 MPU firmware release number and YY represents the 2900 memory controller firmware release number. **XX** and **YY** are sent as single characters for release numbers less than 10.

LIMITS

The limit query returns two present limits in integer: one for Main Intensity, another for the Graticule Intensity.

Response to Interface Control Messages

The 7912AD does not respond to the following interface control messages:

PPC - Parallel poll configure
PPU - Parallel poll unconfigure
TCT - Take Control

The 7912AD responds to the following interface control messages in the following manner when the messages are sent as required by the IEEE 488 standard:

GTL - Go to local. This causes the instrument to go to local mode as described under Remote/Local Function earlier in this section.

LLO - Local lockout. If in the remote state, this causes the instrument to go to remote with lockout state. If in local state, this causes the instrument to go to local with lockout state. See Remote/Local Function earlier in this section.

SDC, DCL - Selected device clear and device clear. Either of these messages resets the IEEE 488 bus input and output buffers, halts any memory controller operation, and resets the status byte (except power-up status). If the memory controller was not modifying the data memory in response to a DIG, ATC, LOAD, TEST, or DEF command, it resumes the XYZ display.

SPE, SPD - Serial poll enable and disable. Instrument has full serial poll capability; the response by the 7912AD to a serial poll is described under Status Byte.

GET - Group execute trigger. If enabled by **DT ON**, this command causes a current digitize operation to proceed on the next time base sweep. If the GET response was not enabled or was disabled by **DT OFF**, or the instrument is not currently executing a DIG command, the GET has no effect.

IFC - Interface clear. This resets interface functions only and does not affect operating modes of the instrument. If the instrument was a talker, for instance, it returns to the talker idle state.

Interface messages are shown in the code chart, Table 3-3.

TABLE 3-3
ASCII CODES AND
IEEE 488 (GPIB) MESSAGES

BITS B7 B6 B5 →				Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
B4	B3	B2	B1	CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER	
Ø	Ø	Ø	Ø	0 NUL 0 (0)	20 DLE 10 (16)	40 SP 20 (32)	60 0 30 (48)	100 @ 40 (64)	120 P 50 (80)	140 ` 60 (96)	160 p 70 (112)
Ø	Ø	Ø	1	1 SOH GTL 1 (1)	21 DC1 LLO 11 (17)	41 ! 21 (33)	61 1 31 (49)	101 A 41 (65)	121 Q 51 (81)	141 a 61 (97)	161 q 71 (113)
Ø	Ø	1	Ø	2 STX 2 (2)	22 DC2 12 (18)	42 " 22 (34)	62 2 32 (50)	102 B 42 (66)	122 R 52 (82)	142 b 62 (98)	162 r 72 (114)
Ø	Ø	1	1	3 ETX 3 (3)	23 DC3 13 (19)	43 # 23 (35)	63 3 33 (51)	103 C 43 (67)	123 S 53 (83)	143 c 63 (99)	163 s 73 (115)
Ø	1	Ø	Ø	4 EOT SDC 4 (4)	24 DC4 DCL 14 (20)	44 $ 24 (36)	64 4 34 (52)	104 D 44 (68)	124 T 54 (84)	144 d 64 (100)	164 t 74 (116)
Ø	1	Ø	1	5 ENQ PPC 5 (5)	25 NAK PPU 15 (21)	45 % 25 (37)	65 5 35 (53)	105 E 45 (69)	125 U 55 (85)	145 e 65 (101)	165 u 75 (117)
Ø	1	1	Ø	6 ACK 6 (6)	26 SYN 16 (22)	46 & 26 (38)	66 6 36 (54)	106 F 46 (70)	126 V 56 (86)	146 f 66 (102)	166 v 76 (118)
Ø	1	1	1	7 BEL 7 (7)	27 ETB 17 (23)	47 ' 27 (39)	67 7 37 (55)	107 G 47 (71)	127 W 57 (87)	147 g 67 (103)	167 w 77 (119)
1	Ø	Ø	Ø	10 BS GET 8 (8)	30 CAN SPE 18 (24)	50 (28 (40)	70 8 38 (56)	110 H 48 (72)	130 X 58 (88)	150 h 68 (104)	170 x 78 (120)
1	Ø	Ø	1	11 HT TCT 9 (9)	31 EM SPD 19 (25)	51) 29 (41)	71 9 39 (57)	111 I 49 (73)	131 Y 59 (89)	151 i 69 (105)	171 y 79 (121)
1	Ø	1	Ø	12 LF A (10)	32 SUB 1A (26)	52 * 2A (42)	72 : 3A (58)	112 J 4A (74)	132 Z 5A (90)	152 j 6A (106)	172 z 7A (122)
1	Ø	1	1	13 VT B (11)	33 ESC 1B (27)	53 + 2B (43)	73 ; 3B (59)	113 K 4B (75)	133 [5B (91)	153 k 6B (107)	173 { 7B (123)
1	1	Ø	Ø	14 FF C (12)	34 FS 1C (28)	54 , 2C (44)	74 < 3C (60)	114 L 4C (76)	134 \ 5C (92)	154 l 6C (108)	174 ¦ 7C (124)
1	1	Ø	1	15 CR D (13)	35 GS 1D (29)	55 – 2D (45)	75 = 3D (61)	115 M 4D (77)	135] 5D (93)	155 m 6D (109)	175 } 7D (125)
1	1	1	Ø	16 SO E (14)	36 RS 1E (30)	56 . 2E (46)	76 > 3E (62)	116 N 4E (78)	136 ∧ 5E (94)	156 n 6E (110)	176 ~ 7E (126)
1	1	1	1	17 SI F (15)	37 US 1F (31)	57 / 2F (47)	77 ? UNL 3F (63)	117 O 4F (79)	137 _ UNT 5F (95)	157 o 6F (111)	177 RUBOUT (DEL) 7F (127)

ADDRESSED COMMANDS (octal 0–17) · UNIVERSAL COMMANDS (octal 20–37) · LISTEN ADDRESSES (octal 40–77) · TALK ADDRESSES (octal 100–137) · SECONDARY ADDRESSES OR COMMANDS (octal 140–177)

KEY TO CHART

octal — 25		PPU — GPIB code
	NAK — ASCII character	
hex — 15		(21) — decimal

Error Handling

Errors are reported whether in local or remote mode. They are reported in the following manner.

Command or Execution Error. If a command or execution error is detected:

1. Command execution is halted at the point where the error is detected.

2. The command input buffer is cleared until the message delimiter is detected.

3. The status byte is set to show the error when read by controller-in-charge.

4. No memory data output is started after the error is detected.

5. The instrument asserts SRQ to report the error status.

6. The instrument remains ready for further input.

Internal Error. If an internal error is detected:

1. The status byte is set to show the error when polled.

2. The instrument asserts SRQ to report the error status.

3. If data output is in progress, it may be interrupted.

4. The instrument remains ready for input.

Power Fail Error. If a power fail error is detected:

1. Command execution is immediately halted.

2. Power fail status is set.

3. The instrument asserts SRQ.

4. The instrument remains halted until restarted.

If the instrument detects either a command or execution error and an internal error, the internal error is reported first. If more than one internal error is detected, the last one to occur is the only one of that type reported. If more than one execution or command error is detected, the last one of either type to occur is the only one of either type reported.

Error codes returned in response to an error command query are shown in Table 3-4. Three digits are used. The first digit identifies the type of error and corresponds to the abnormal system status byte: 1XX = command error, 2XX = execution error, 3XX = internal error, and 4XX = power fail error. The code always refers to the last status byte reported.

TABLE 3-4

ERROR CODES

CODE	DESCRIPTION
NONE	No error to report.
102	Invalid command header.
103	Invalid command argument.
201	Attempt to arm single sweep while time base is not in single-sweep mode.
202	Checksum error for binary block input by LOAD command.
203	Byte count error for binary block input by LOAD command.

TABLE 3-4 (cont.)

CODE	DESCRIPTION
206	Attempt to digitize with invalid sweep rate (slower than 1 milli-second/division).
302	Data memory fault detected in 2900 microprocessor system while performing TEST command or power-up initialization.
304	Invalid or missing readout data from plug-ins.
305	Waveform data memory overwritten.
306	No data for signal averaging.
307	Defects array is full (it is not allowed to overflow into vertical array).
308	6800 MPU received an interrupt that it can not identify.
401	Power failure is imminent.

Status Byte

The status byte obtained from the instrument during a serial poll contains the following information:

Bit	**Meaning**
8	Device status = 1; system status = Ø
7	Service requested
6	Abnormal condition = 1; normal condition = Ø
5	Busy
4	Device/system status code

3 Device/system status code
2 Device/system status code
1 Device/system status code

Bits 7 and 5 are flags. Bit 7 indicates the instrument asserted SRQ for the condition being reported. Bit 5 indicates the 6800 MPU is busy executing a command or its input buffer is full. If bit 5 is set, the 7912AD holds up the handshake of any more device-dependent messages by asserting NRFD if it is addressed as a listener.

Any existing abnormal system status is reported first. Both an internal error and either an execution or command error can be saved and reported as discussed under Error Handling. One normal system status byte and one device dependent status byte can also be saved and reported (in that order). Power-up overrides all other status as noted below.

The instrument always asserts SRQ for abnormal system status and power-up. It can be programmed to assert or not assert SRQ for remote request status and operation complete status with the REM and OPC commands. The instrument unasserts SRQ when it has reported the condition for which SRQ was asserted or when it is cleared by the DCL or SDC interface messages.

Device Dependent Status. This is reported only when there is no system status to report. The following status byte is returned:

8 7 6 5 4 3 2 1

1 X 0 X 0 0 0 1 - Remote Request

Remote request indicates that the REMOTE front-panel button has been pushed. Remote request becomes set when the button is pushed and is reset when the instrument status is read or a device clear performed.

Normal Condition System Status. The following status bytes are returned:

8 7 6 5 4 3 2 1

0 0 0 X 0 0 0 0 - No Condition
0 1 0 X 0 0 0 1 - Power Up

0 X 0 X 0 0 1 0 - Operation Complete

The power-up condition replaces any other status. It exists after the instrument has been turned on and continues until the status is read.

Operation complete indicates that a DIG or TEST operation has completed. It is set upon completion of the operation and is reset when the status is read, another such operation is requested, or a device clear is performed.

Abnormal Condition System Status. Abnormal conditions (errors) are reported before other status (except when replaced by power-up status). The following status bytes are returned:

<u>8 7 6 5 4 3 2 1</u>

0 1 1 X 0 0 0 1 - Command Error
0 1 1 X 0 0 1 0 - Execution Error
0 1 1 X 0 0 1 1 - Internal Error
0 1 1 X 0 1 0 0 - Power Fail Error

Command error indicates that the instrument has received a command that it can not understand or implement under any circumstances. The command does not affect the state of the instrument.

Execution error indicates that the instrument has received a command that it understands but can not implement due to the current state of the instrument. The command does not affect the state of the instrument. For example, this error would be reported if the instrument received the DIG SSW command while the time base plug-in was not in single-sweep mode.

Internal error indicates that the instrument has detected a hardware failure, an invalid configuration of the instrument (such as a missing plug-in), or an invalid memory state (such as a memory overwrite during a digitize).

Power fail error indicates that a power failure is imminent. The instrument remains capable of responding to a serial poll for at least 10 milliseconds. If power is restored at any time, this condition is replaced by the power-up condition.

Codes for errors of the above types can be read by the error command. For the codes, see Error Handling.

Waveform Data I/O

Output in response to query commands is covered under Remote Control Messages and Command Description earlier in this section. This discussion concerns output of waveform data that has been acquired by the 7912AD. It also covers the only case of waveform data input, that of the LOAD command. Waveform data is output from the 7912AD data memory to the IEEE 488 bus by the memory controller. The LOAD command, however, requires the action of both the 6800 microprocessor and the 2900 memory controller. These systems and the data memory are discussed in the Block Drawing and the Waveform Storage descriptions in Section 1.

In general, waveform data are transferred in order from left-to-right of trace. Although the data is not acquired from the scan converter in this order, it is reordered by the memory controller for output. The DUMP RAW command is an exception to this, however. In this case the data is transmitted just as it was detected from the target.

Block Binary Format. Waveform data is transferred by the 7912AD in binary blocks. The block binary format is:

%<BYTE COUNT>[<DATA VALUE>. . .]<CHECKSUM>;

where:

% is the ACSII percent character indicating a binary block.

BYTE COUNT is a 16-bit binary number indicating how many bytes remain to be transmitted in the block including the checksum, but not including the message unit delimiter (semicolon). It is sent in two bytes, more significant byte first.

DATA VALUE is a 16-bit binary number sent in two bytes, more significant byte first. If the data value is less than 16 bits in length, it is sent right-justified with unused bits set to zero. For example, the decimal number 511 would be sent in two bytes: 00000001 and 11111111.

CHECKSUM is an eight-bit binary number sent in a single byte. It is computed by taking the modulo-256 sum of all preceding bytes in the block except %, that is, by summing in eight bits the value of the preceding bytes but throwing away the carry each time it occurs. The sum is converted to its 2's complement before transmission. This allows the receiver to compute the sum in the same manner and merely check that it is zero after the checksum byte is received.

; is the ASCII semicolon character delimiting the message unit. If this is the only or last message unit in the message, the message terminator is also sent.

The binary block for a simple two-value array is shown in Fig 3-7.

READ PTR,VER and REP Commands. The READ PTR,VER command and the REP command that incorporates the REP PTR,VER command return two arrays, the pointer and vertical arrays. These can be used to reconstruct the waveform acquired by the 7912AD. The arrays are processed from the raw data stored during a 7912AD digitize operation and are equivalent to the vertical and pointer arrays used by TEK SPS BASIC Software to handle 7912AD waveforms.

Two arrays are necessary because the waveform acquired by the 7912AD is a multi-valued function. It typically contains at least two vertical (Y) values for each horizontal (X) point because of the nature of the scan converter (see Section 1). Y values normally represent voltage, and X points normally represent time.

The pointer array is based on the X (horizontal) array that is stored during a digitize operation. The pointer array is computed using the X array, which records the number of Y values stored for each X (horizontal location or point in time). 512 data values are sent in the pointer array, one for each horizontal point on the waveform. They are sent in order from left to right. Each pointer value points to the last data word in the vertical array sent for the corresponding X (horizontal) location. Pointers for empty X locations are set to -1 until the first vertical data value is stored. A pointer with the same value as the previous pointer indicates there is no vertical data for that X location. The relationship between the pointer and vertical arrays is shown in Fig. 3-8.

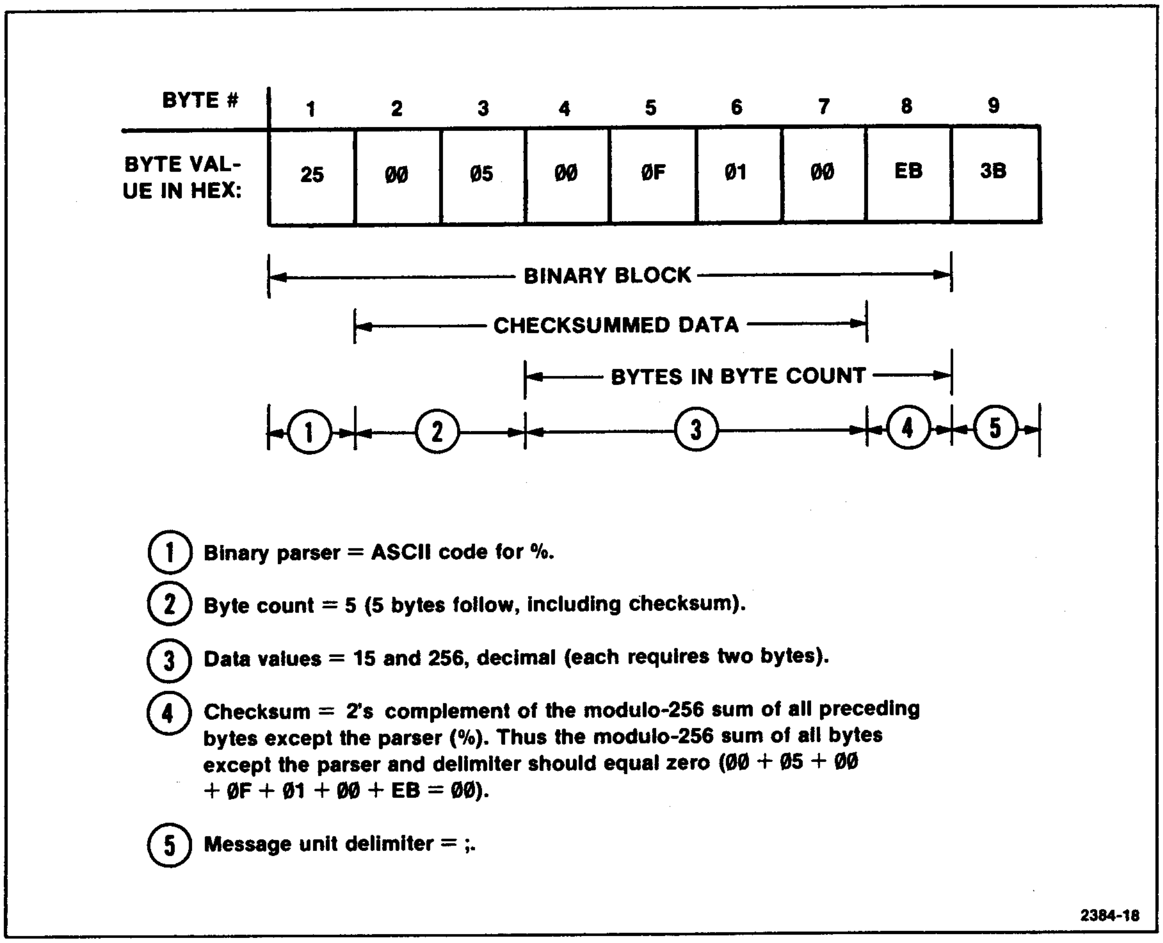


Fig. 3-7. A simple binary block showing the format elements.

The vertical array returned by the 7912AD contains up to 3584 data values. These are the values detected during the last digitize operation. They are reordered by internal processing so they are sent in order from left to right of trace. For an X location with more than one vertical data point (typically there are two--one for the top and one for the bottom of trace), the highest value (top of trace) is sent first. Other values for that X follow in descending order. Thus, the first value transmitted is the upper left-most data element, and the last value is the lower right-most data element as viewed on an X-Y graph. Such a graph is provided by the XYZ outputs when connected to a display monitor.

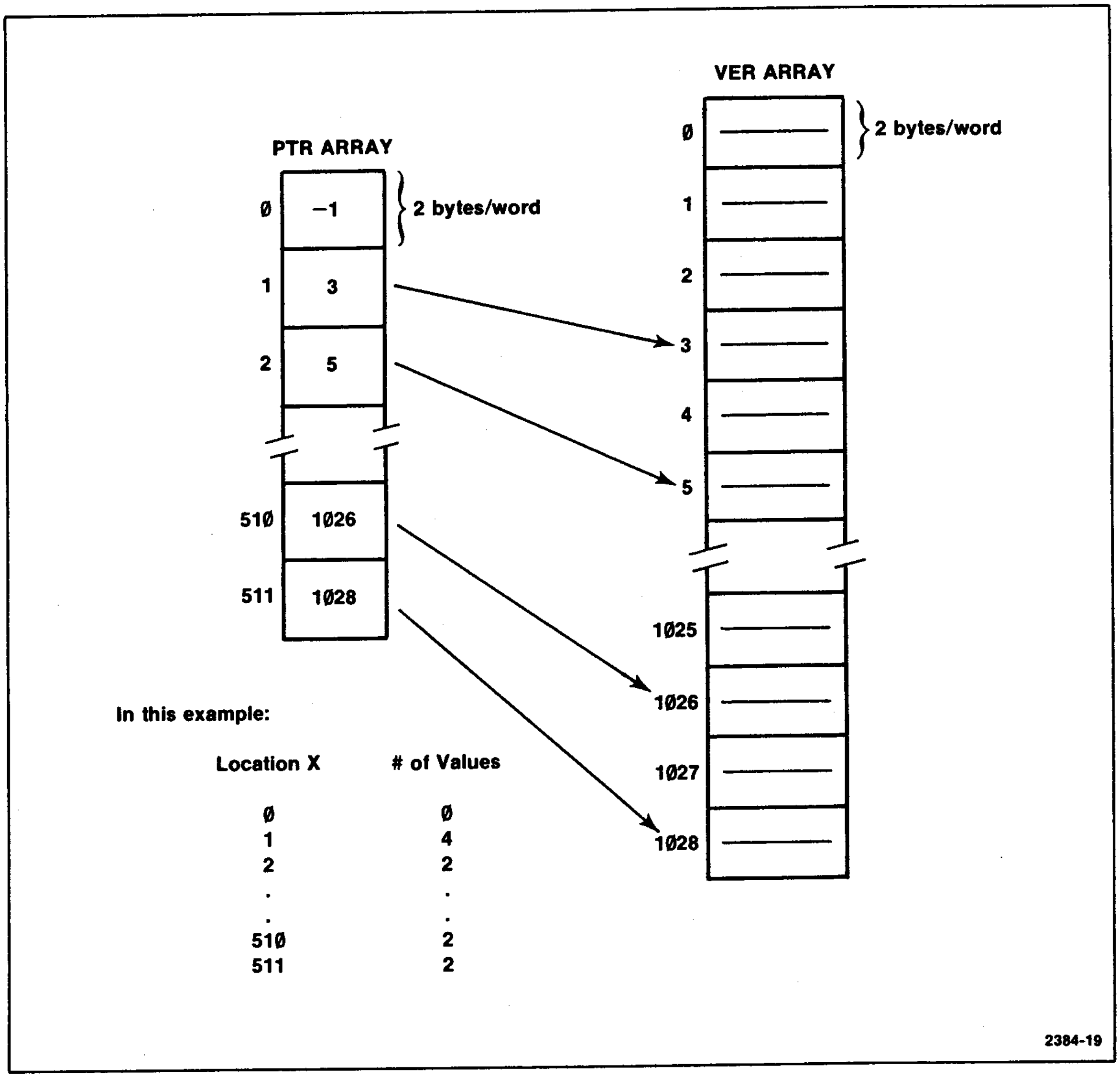


Fig. 3-8. The PTR array is an index to the VER array. The pointer values indicate how many vertical data values are output from each horizontal (X) location on the target.

Because vertical values range from zero to 511, they fill only the lower nine bits of a data word; all bits except the LSB in the first byte of the word are unused (set to zero). However, the DEF ON command, sets bit 10 as a flag for data that match data in the defects array. Data that are flagged are treated as negative values and output as 16-bit, 2's complement binary numbers when read by the READ VER command. As a result, some or all of the bits in the first byte may be ones. Thus the value 255 in the vertical array would be transmitted as:

00000000	(first byte)
11111111	(second byte)

If flagged as a defect, however, the value 255 would be complemented:

11111111	00000000	(1's complement)
	+ 1	
11111111	00000001	(2's complement)

and transmitted as:

11111111	(first byte)
00000001	(second byte)

READ ATC. The READ ATC command outputs a simplified array stored as the result of an ATC operation (see the ATC command). The 512-point array is the averaged value of the waveform with a single value per sampling point. Data values can range from zero to 1023; the data word is sent with the two most significant bits as the two least significant bits in the first byte (unused bits set to zero) and the remaining bits in the second byte. The data values are time-ordered; that is, they are sent in order from left-to-right of trace.

Although the data values range up to 1023, they can be rescaled to values from zero to 511 by assuming a block binary point between bits zero and one.

The ATC and READ ATC commands allow read-out of waveforms in a simpler format for a controller with limited processing capability. The data also requires less storage. For both of these reasons, these commands may be useful for data logging and automatic test applications. The tradeoff is less external processing for simpler, therefore less rigorous, normalizing.

READ SA. The READ SA command outputs a simplified array stored as the result of a DIG SA (digitize and signal-average) operation (see the DIG SA command). The 512-point array is the averaged value of the waveforms that are digitized by the DIG SA operation; the array has a single value for each sampling point. The data values are sent in order from left to right-of-trace.

Because the data are summed (as explained for the DIG SA command), the data can be 10 to 15 bits wide (unused high-order bits are set to zero). The data are not divided by the number of signal averages so no precision is lost. Since the number of averages is always a power of two, a block binary point can be assumed to rescale the data to the range of zero to 511. The location of the binary point is implied by the number of averages called by the last DIG SA command:

Number of Averages	Binary Point located to right of bit
1	0
2	1
4	2
8	3
16	4
32	5
64	6

The DIG SA and READ SA commands provide signal-averaging more quickly than the waveforms could be digitized, read out and averaged externally. Also, internal signal-averaging by the 7912AD removes the load from an external processor, making this level of waveform processing available in a system with a simpler controller and with less data storage than would otherwise be required.

READ EDGE. The READ EDGE command outputs two processed arrays stored as the result of an edge processing operation (see the EDGE command). The two 512-point arrays represent the top and bottom of the trace; the top is sent as a binary block, followed by the binary block for the bottom. Each array has a single value for each sampling point sent in order from left-to-right of trace.

Valid data range from zero to 511, sent in the same format as for the READ VER data. Missing or rejected points are sent as -1 in 2's complement notation (-1 = all ones in both bytes).

The EDGE and READ EDGE commands relieve part of the burden on an external processor when more sophisticated normalizing is needed. The edge data is ready for normalizing or geometry correction, such as that done by TEK SPS BASIC Software routines.

READ DEF. The READ DEF command outputs an array with both horizontal and vertical values to represent defects by their X-Y coordinates on the target. The data may have been loaded in the defects array either by a DIG, DEF or LOAD operation.

Values in the array from 512 to 1023 represent X coordinates on the target where 512 is at the far left of the target and 1023 is at the far right. If bit 10 of the data value is considered to be a horizontal flag, the remaining bits can be interpreted as the X coordinates directly, ranging from zero to 511. This can be done in an external processor by clearing this bit after it is detected. Each X value is followed by one or more Y values to represent where the top or bottom of a defect is located. Y values range from 0 to 511.

The array is ordered in time, left to right, so that horizontal values are transmitted in increasing order. Multiple vertical values for an X location are transmitted in descending order.

LOAD. The LOAD defects command is the only case of waveform data input to the 7912AD. It allows a binary block of data values to be stored in the defects array in the 7912AD data memory. This array identifies known defects on the 7912AD target. The data format is the same as that output by the 7912AD for a READ DEF command. In fact, one use of the LOAD command is to reload a defects array previously digitized by the 7912AD with a DIG DEF operation. This allows the defects array to be saved on an external storage device, since it is lost when the 7912AD power is turned off.

To assure that all data values in the array (and only those values) are loaded, the byte count must be accurate when the 7912AD is set to use the line feed character as a message terminator. As explained under Command Syntax earlier in this section, using a data byte for a terminator, as required by some controllers, can cause confusion. When the ASCII code for a line feed occurs in a binary block, it may be either a data byte or the message terminator. To avoid this confusion, the 7912AD, when set to use line feed as a terminator, uses the byte count to decide when a message is terminated. An incorrect byte count can cause the 7912AD to store either too little or too much data, depending on whether it is too high or too low a value.

To illustrate the two invalid conditions, consider the use of the byte count. This value at the beginning of the LOAD binary block tells the 7912AD to input that number of bytes minus one and store them in the defects array. The byte following this block is then input as the checksum. Therefore: 1) If the byte count is too low, not all bytes are stored and the last one accepted is used as the checksum. 2) If the byte count is too large, the checksum and any format or terminator characters sent are stored as data in the defects array and the instrument either hangs (if further data is not sent) or stores invalid data (if further data is sent before it is unlistened).

With the 7912AD set to observe the EOI line for the message terminator, the invalid conditions described above are avoided; the instrument continues to input data until it receives EOI and interprets the checksum properly.

DUMP RAW. The DUMP RAW command returns the internal Y and X arrays from 7912AD memory without reordering or processing. The contents of four internal registers are included as pointers to interpret the Y and X arrays.

The peculiar format of the Y array results from the way the scan converter is read as described in Section 1. During a digitize operation, values are stored in the 7912AD data memory in order as they are read from top to bottom of the target on each of 512 vertical scans. The scans are made sequentially from left to right of the target. However, the reading beam is asynchronous with the writing beam; data elements detected by the reading beam are stored beginning when the time base sweep is triggered, regardless of the position of the reading beam at that time. For this reason, the Y array may wrap around -- the data may start anywhere within the time window, continue to the end of the window (end of the written trace), then continue from time-zero (left of trace) to the starting point.

The X array is a counter array. Each element is a count of the number of Y elements stored at the corresponding X location on the target. The data in the X array is in order from left to right of trace: the first element in the array is the count of Y data during the left-most vertical scan of the reading beam, the next element is the count from the next vertical scan to the right, and so on.

The binary block format for the DUMP RAW output is:

%<BYTE COUNT><CHZYPTR><FSTYPTR><LSTYPTR><LSTDPTR>
<4096 DATA VALUES><CHECKSUM>;

%, BYTE COUNT, CHECKSUM, and ; are defined above under Block Binary Format.

CHZYPTR is a 16-bit binary word pointing to the first data value stored during the left-most vertical scan of the target.

FSTYPTR is a 16-bit binary word pointing to the first valid word in the Y data array.

LSTYPTR is a 16-bit binary word pointing one past the last valid word in the Y array.

LSTDPTR is a 16-bit binary word pointing one address above the last element in the defects array.

The above-described pointers are sent in two bytes, more significant byte first, right-justified with unused bits set to zero.

The DATA VALUES are consecutive words of data memory beginning with address zero and continuing through 4095. This area of 7912AD memory is 10 bits wide. The memory word is sent in two bytes, more significant byte first, right-justified with unused bits set to zero.

DUMP PR. The DUMP PR command returns the processed data arrays from the 7912AD memory without further processing. Since they are already processed into single-valued, time-ordered functions, no pointers are included. The entire processed data memory area is dumped as a single binary block with 1024 data values.

The arrays dumped are those stored by the last processed data operation. For instance, the EDGE command fills the entire processed memory area, while the ATC command fills only the top half and DIG SA fills only the bottom half. The data memory space is defined under Waveform Storage in Section 1.

Programming Examples

Programming examples are given here for a serial poll, setting and querying 7912AD functions, and reading waveform data from the instrument. These examples show only the messages exchanged over the IEEE 488 bus by the 7912AD and a controller, so are independent of the type of controller used. The sequences of data bytes shown are intended as a guide; the sequences for performing these tasks with a particular controller may differ in some respects.

If the 7912AD is used with Tektronix software, such as TEK SPS BASIC, many details shown such as addressing the 7912AD and setting control lines (ATN, REN, etc.) are implemented by high-level commands. This makes the task much easier than it appears to be from these examples, since many details are automatically done for the programmer. Refer to the software manuals for instructions in using Tektronix software with the 7912AD.

For the examples that follow, traffic on the IEEE 488 bus was recorded byte-by-byte using the TEKTRONIX 7D01 Logic Analyzer and DF2 Display Formatter plug-ins in a TEKTRONIX 7000-series oscilloscope. The first column shows the state of the ATN line (the mnemonic appears if the line is asserted and is blank if the line is unasserted). The second column is decoded from the data byte transferred on the bus. Bus addresses are identified as being from the talk address group (TAG), listen address group (LAG), or secondary address group (SAG). Interface messages such as untalk (UNT) and unlisten (UNL) are decoded. Bytes transferred without ATN are assummed to be ASCII.

The third column shows the value of the data byte transferred. The value is a hexadecimal number if preceded by a dollar sign ($); it is a decimal number if there is no dollar sign. In the case of bus addresses, the lower five bits are decoded as a decimal number. In the IEEE 488 standard, these bits are called T1 through T5 for the talk address, L1 through L5 for the listen address, and S1 through S5 for the secondary address. Columns four, five, and six represent the state of the EOI, SRQ, and REN lines, respectively.

These examples were obtained using a TEKTRONIX CP4165 Controller connected to the 7912AD as system controller. The CP4165 included a CP4100/IEEE 488 Interface and was operated with TEK SPS BASIC Software with the IEEE 488 Driver. To guarantee a clear communications path, this software untalks and unlistens all devices both before and after transmitting and receiving messages. This results in some superfluous UNT and UNL bytes, which cause no harm, but need not be duplicated.

The 7912AD was set to assert and to recognize EOI as the message terminator as discussed under Command Syntax earlier in this section. The lower five bits of the 7912AD bus addresses were set to zero. Therefore, in the following examples, the 7912AD and plug-in talk and listen addresses are shown as ØØ, while the 7912AD, vertical plug-in, and horizontal plug-in secondary addresses are shown as ØØ, Ø1, and Ø2, respectively.

In the following examples, 7912AD output is printed in bold.

Power-Up SRQ. When the 7912AD powers-up, it asserts SRQ and reports power-up status when serial polled. The following sequence shows how this can be handled and indicates how an SRQ for other conditions can be handled. For this example, programmable plug-ins were installed; this serial poll handles them as well. The routine repeats the serial poll until it no longer detects SRQ. Each poll begins with the lowest numbered device and continues until a device responds with bit seven (service requested) of the status byte asserted. In the case of the 7912AD and each of the programmable plug-ins, the status byte for the service requested condition and the power-up condition has a value of $41.

ATN	UNT	$5F		**SRQ**	REN
ATN	UNL	$3F		**SRQ**	REN
ATN	SPE	$18		**SRQ**	REN
ATN	TAG	ØØ		**SRQ**	REN
ATN	SCG	ØØ		**SRQ**	REN
	A	**$41**		**SRQ**	REN
ATN	UNT	$5F		SRQ	REN
ATN	SPD	$19		SRQ	REN

ATN	UNT	$5F	SRQ	REN
ATN	UNL	$3F	SRQ	REN
ATN	SPE	$18	SRQ	REN
ATN	TAG	00	SRQ	REN
ATN	SCG	00	SRQ	REN
	NUL	**$00**	SRQ	REN
ATN	TAG	00	SRQ	REN
ATN	SCG	01	SRQ	REN
	A	$41	SRQ	REN
ATN	UNT	$5F	SRQ	REN
ATN	SPD	$19	SRQ	REN
ATN	UNT	$5F	SRQ	REN
ATN	UNL	$3F	SRQ	REN
ATN	SPE	$18	SRQ	REN
ATN	TAG	00	SRQ	REN
ATN	SCG	00	SRQ	REN
	NUL	**$00**	SRQ	REN
ATN	TAG	00	SRQ	REN
ATN	SCG	01	SRQ	REN
	NUL	$00	SRQ	REN
ATN	TAG	00	SRQ	REN
ATN	SCG	02	SRQ	REN
	A	$41		REN
ATN	UNT	$5F		REN
ATN	SPD	$19		REN

Set/Query. In the following example, the graticule intensity parameter is set and then verified by a query. The query response of the 7912AD is also shown.

ATN	UNT	$5F	REN
ATN	UNL	$3F	REN
ATN	LAG	00	REN
ATN	SCG	00	REN
	G	$47	REN
	R	$52	REN
	I	$49	REN
		$20	REN
	8	$38	REN
	7	$37	REN
	;	$3B	REN

	G	$47		REN
	R	$52		REN
	I	$49		REN
	?	$3F	EOI	REN
ATN	UNT	$5F		REN
ATN	UNL	$3F		REN
ATN	UNT	$5F		REN
ATN	UNL	$3F		REN
ATN	TAG	ØØ		REN
ATN	SCG	ØØ		REN
	G	**$47**		REN
	R	**$52**		REN
	I	**$49**		REN
		$2Ø		REN
	8	**$38**		REN
	7	**$37**		REN
	;	**$3B**	**EOI**	REN
ATN	UNT	$5F		REN
ATN	UNL	$3F		REN

READ PTR,VER. This example shows a read of waveform data. Two arrays are requested: the vertical array (data detected on the target) and the pointer array (an index to the vertical array).

After the 7912AD receives the READ PTR,VER command, it is made a talker. When it sends the percent sign (%) to signal that a binary block is to follow, the CP4165 program untalks the 7912AD to get ready for binary data. The CP4165 then reads the byte count and stops the transfer again to ready an array of the proper size for the block. The byte count is 1025 ($0401) to indicate that 512 pointers (two bytes/pointer) and the checksum (one byte) are to follow. (Note that in this example, the pointers that are shown indicate two vertical data/scan.)

When the CP4165 is ready, it retalks the 7912AD and reads in the pointers block. This block and the one to follow, the vertical array, are separated by a semicolon (;). When the semicolon is received, the CP4165 again interrupts to prepare to receive the vertical binary block. This sequence is similar to that for the pointers. The byte count and checksum have different values, of course, and when the 7912AD completes the transmission, it asserts EOI concurrently with the last byte.

Here's how it looks (the middle of the blocks are deleted to save space):

ATN	UNT	$5F		REN
ATN	UNL	$3F		REN
ATN	LAG	00		REN
ATN	SCG	00		REN
	R	$52		REN
	E	$45		REN
	A	$41		REN
	D	$44		REN
		$20		REN
	P	$50		REN
	T	$54		REN
	R	$52		REN
	,	$2C		REN
	V	$56		REN
	E	$45		REN
	R	$52	EOI	REN
ATN	UNT	$5F		REN
ATN	UNL	$3F		REN
ATN	UNT	$5F		REN
ATN	UNL	$3F		REN
ATN	TAG	00		REN
ATN	SCG	00		REN
	%	**$25**		REN
ATN	UNT	$5F		REN
ATN	UNL	$3F		REN
ATN	UNT	$5F		REN
ATN	UNL	$3F		REN
ATN	TAG	00		REN
ATN	SCG	00		REN
	EOT	**$04**		REN
	SOH	**$01**		REN
ATN	UNT	$5F		REN
ATN	UNL	$3F		REN
ATN	UNT	$5F		REN
ATN	UNL	$3F		REN
ATN	TAG	00		REN
ATN	SCG	00		REN
	NUL	**$00**		REN

	SOH	**$Ø1**	REN
	NUL	**$ØØ**	REN
	ETX	**$Ø3**	REN
	NUL	**$ØØ**	REN
	ENQ	**$Ø5**	REN
	NUL	**$ØØ**	REN
	BEL	**$Ø7**	REN
	NUL	**$ØØ**	REN
	HT	**$Ø9**	REN
	NUL	**$ØØ**	REN
	VT	**$ØB**	REN
	...	...	...
	...	...	...
	...	...	...
	...	...	...
	ETX	**$Ø3**	REN
	<[>	**$FB**	REN
	ETX	**$Ø3**	REN
	<]>	**$FD**	REN
	ETX	**$Ø3**	REN
	DEL	**$FF**	REN
ATN	UNT	$5F	REN
ATN	UNL	$3F	REN
ATN	UNT	$5F	REN
ATN	UNL	$3F	REN
ATN	TAG	ØØ	REN
ATN	SCG	ØØ	REN
	<[>	**$FB**	REN
ATN	UNT	$5F	REN
ATN	UNL	$3F	REN
ATN	UNT	$5F	REN
ATN	UNL	$3F	REN
ATN	TAG	ØØ	REN
ATN	SCG	ØØ	REN
	;	**$3B**	REN
ATN	UNT	$5F	REN
ATN	UNL	$3F	REN
ATN	UNT	$5F	REN
ATN	UNL	$3F	REN
ATN	TAG	ØØ	REN
ATN	SCG	ØØ	REN

	%	**$25**	REN
ATN	UNT	$5F	REN
ATN	UNL	$3F	REN
ATN	UNT	$5F	REN
ATN	UNL	$3F	REN
ATN	TAG	ØØ	REN
ATN	SCG	ØØ	REN
	BS	**$Ø8**	REN
	SOH	**$Ø1**	REN
ATN	UNT	$5F	REN
ATN	UNL	$3F	REN
ATN	UNT	$5F	REN
ATN	UNL	$3F	REN
ATN	TAG	ØØ	REN
ATN	SCG	ØØ	REN
	SOH	**$Ø1**	REN
	STX	**$Ø2**	REN
	NUL	**$ØØ**	REN
	<^>	**$FE**	REN
	SOH	**$Ø1**	REN
	STX	**$Ø2**	REN
	NUL	**$ØØ**	REN
	<^>	**$FE**	REN
	SOH	**$Ø1**	REN
	ETX	**$Ø3**	REN
	NUL	**$ØØ**	REN
	<^>	**$FE**	REN
	...	..	...
	...	..	...
	...	..	...
	...	..	...
	SOH	**$Ø1**	REN
	ETX	**$Ø3**	REN
	SOH	**$Ø1**	REN
	HT	**$Ø9**	REN
	SOH	**$Ø1**	REN
	ETX	**$Ø3**	REN
	BS	**$Ø8**	REN
	SOH	**$Ø1**	REN
ATN	UNT	$5F	REN
ATN	UNL	$3F	REN

ATN	UNT	$5F		REN
ATN	UNL	$3F		REN
ATN	TAG	00		REN
ATN	SCG	00		REN
	<H>	**$E8**		REN
ATN	UNT	$5F		REN
ATN	UNL	$3F		REN
ATN	UNT	$5F		REN
ATN	UNL	$3F		REN
ATN	TAG	00		REN
ATN	SCG	00		REN
	;	**$3B**	**EOI**	REN
ATN	UNT	$5F		REN
ATN	UNL	$3F		REN

READ Output Examples

Some examples of data output in response to READ commands are given here to illustrate the waveform processing and output done by the 2900 memory controller. The examples are a raw waveform and two processed waveforms, ATC and EDGE, derived from the raw data. The data values from the first portion of each of the arrays for the waveforms are printed in decimal; block binary elements that precede the data values (percent sign and the byte count) are omitted.

PTR,VER. The raw waveform is shown in Fig. 3-9. It includes a defect detected near the left edge of the target.

Here are the first 19 elements in the pointers array:

1
3
5
7
9

11
13
15
17

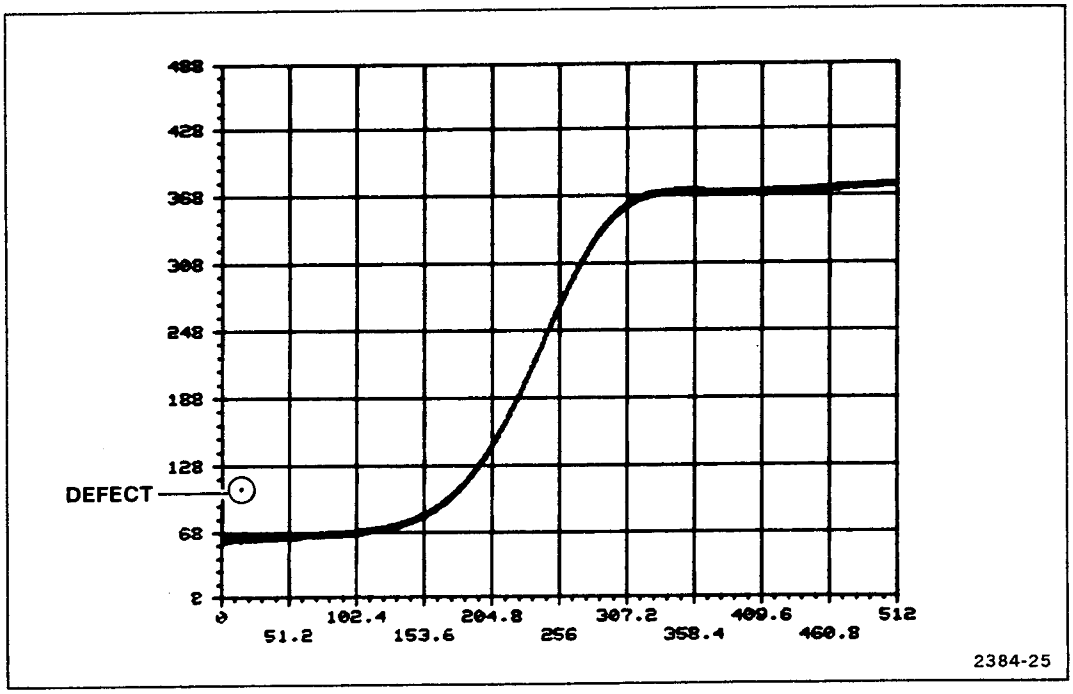


Fig. 3-9. Graph of raw waveform using the pointer and vertical data arrays.

19

21
23
25
27
31

33
35
37
39

Note that the difference between the value of element 13 and element 14 is four (31-27), indicating there are four data values in the vertical array for this horizontal location on the target (detected on the same vertical scan of the reading beam). There are four values instead of two because of the defect. Values for the top and bottom of the defect were detected as well as values for the top and bottom of the trace.

Here are the data values in the vertical array that correspond to the above pointers:

62
59
63
59
63

59
63
59
63
59

63
59
63
59
63

60
63
60
63
60

63
60
63
60
63

60
63
60
108
106

64
59

64
60
64

60
64
60
64
60

The defect values (108 and 106) are elements 28 and 29. The values for the trace detected during the same vertical scan follow as elements 30 and 31. If the defects had been flagged, they would have been output as -108 and -106.

ATC. The waveform after processing by the ATC command is shown in Fig. 3-10. The graph is rescaled from Fig. 3-9, changing the shape of the waveform slightly. Before calling the ATC command, the defect values were digitized and stored in the defects array by the DIG DEF command and the values flagged by the DEF ON command. The ATC algorithm then rejected the defect values and summed the top and bottom of the trace, yielding a single-valued function.

Here are the first 19 elements of the ATC data:

121
122
122
122
122

122
122
123
123
123

123
123
123
123

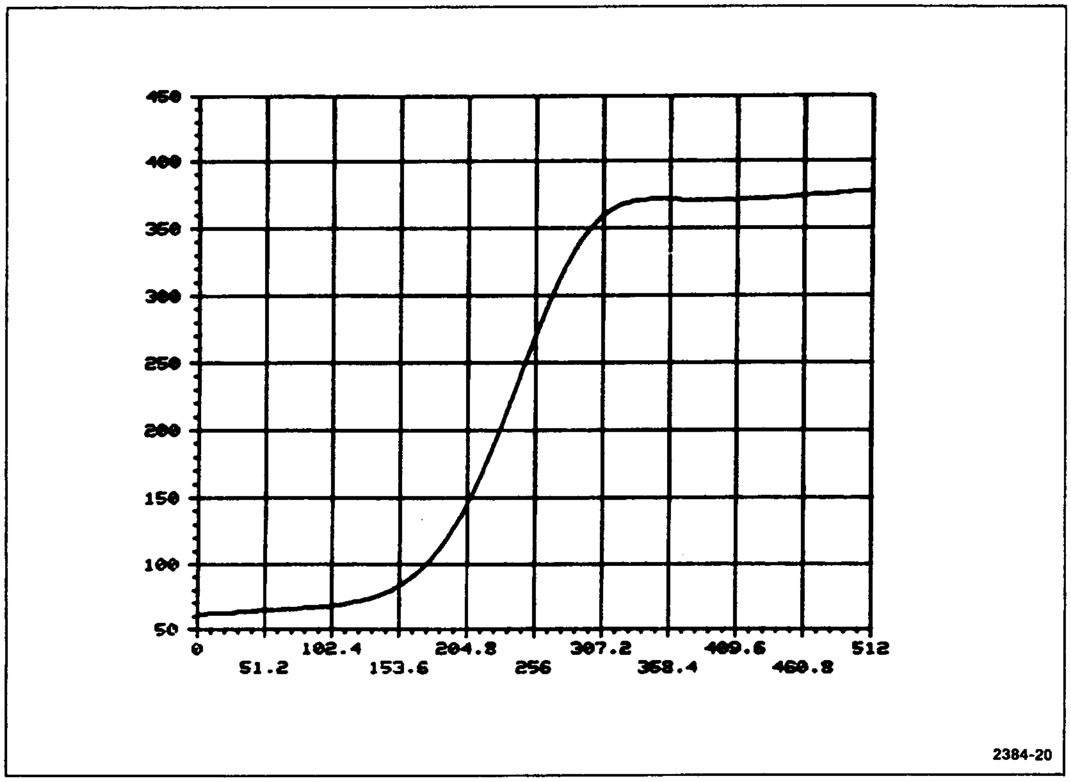


Fig. 3-10. The ATC waveform derived from the waveform shown above. The ATC values were divided by two before graphing.

123

124
124
124
124
124

124
124
124
124

Values in the ATC array are approximately double those in the vertical array because they are summed from the top and bottom values of the trace. For instance, the first value in the ATC array (121) is the sum of the first two elements in the vertical array (62 and 59).

EDGE. The EDGE arrays derived from the raw data are shown in Fig. 3-11. Defect values were flagged by the DEF ON command, so were rejected by the EDGE routine.

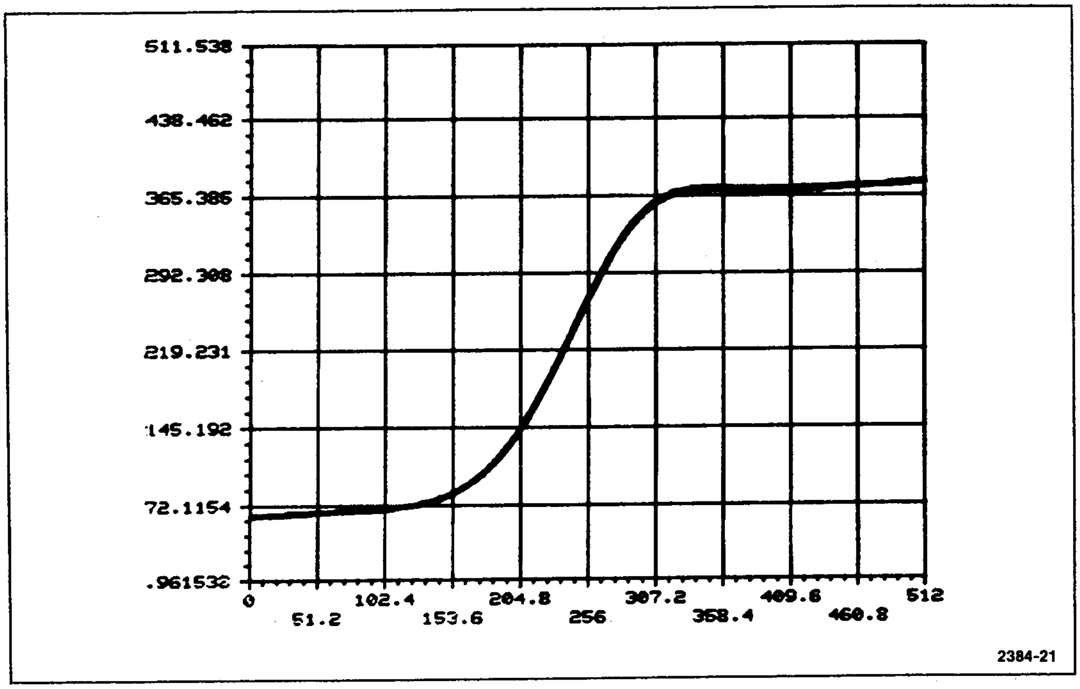


Fig. 3-11. A graph of the upper and lower edge arrays derived from the raw waveform shown above.

Here are the two EDGE arrays:

Upper EDGE	Lower EDGE
62	59
63	59
63	59
63	59
63	59
63	59
63	59
63	60
63	60
63	60

63	60
63	60
63	60
63	60
64	59
64	60
64	60
64	60
64	60

If the defect flags had not been set, the EDGE routine would have rejected the data for element 14 in both arrays, assuming the parameter RT was left at its power-up value of 2. The data for this element (where the defect is located) would have failed the RT test, since the trace width would have gone from 3 (63-60) to 48 (108-60), a ratio of 16 (48/3). Element 14 in both arrays would then have been printed as -1.

The EDGE arrays can be normalized in two steps: 1) Reject values of -1 and interpolate between the nearest valid data (extrapolate to fill in end points). 2) Compute the mean by adding the upper and lower EDGE arrays, element-by-element, and dividing by 2.

Scaling the Output Waveform

The ATC array or normalized EDGE arrays can be scaled using a ground reference and the vertical plug-in scale factor. If the ATC array is used, divide each value by 2 before scaling.

First, acquire the ground reference by digitizing a waveform with the amplifier plug-in input grounded. Normalize the ground waveform with the ATC command, read it out (READ ATC), and divide the ATC waveform by 2. Compute the ground level by taking the average value of a portion of the center of the trace. A TEK SPS BASIC command, ZREF, can be used for this task if the EDGE ground waveform is acquired, rather than the ATC ground waveform.

Second, input the scale factor with the appropriate READ or query command: READ SC1 or VS1? for a single-trace plug-in or channel one of a dual amplifier; use READ SC2 or VS2? for channel 2 of a dual amplifier plug-in. Note: this returns the current scale factor; it is not stored with the waveform.

Then, scale the data, point-by-point, by subtracting the ground reference, multiplying by the scale factor (i.e., the number of volts/division), and dividing by the number of data points per division (512/8):

$$SC = \frac{(VAL - GR) \times SF}{64}$$

where:

SC = Scaled data value

VAL = Normalized data value

GR = Ground reference data value

With TEK SPS BASIC, the NORMAD command can be used to normalize and scale the edge arrays directly. See the TEK SPS BASIC Software manuals for instructions.

Programming Reports

The following programming report applies to instruments with 6800 MPU release number 1 firmware, which corresponds to the ID query response: ID TEK/7912AD,V77.1,F1.Y; (where Y = 2900 memory controller firmware release number).

REPORT NO: 5

DESCRIPTION: Contact bounce in the REMOTE button can cause the 7912AD to report more than one remote request when the button is pressed. As a result, if the remote-request SRQ is enabled (REM ON) the 7912AD may continue to assert SRQ even after the remote-request status is read.

SUGGESTIONS to USERS: Continue to poll the 7912AD until it returns a status byte with bit 7 equal to zero and recognize only the first remote-request status byte received.

General Programming and Operating Information

1. The 7912AD accepts both lower-case and upper-case characters in all commands. If lower-case characters are used, the instrument executes the commands as if they were in upper case.

2. The 7912AD has a built-in timeout on the main and graticule intensities. When the instrument is in repetitive sweep mode, the intensities will timeout in approximately five minutes. TIMEOUT OCCURRED message will appear on the TV monitor.

Activating any mainframe pushbutton (except LOCKOUT), or TV SCALE FACTOR on-off switch or receiving a message over GPIB will reset the intensities.

3. When the 7912AD is in TV mode and the REMOTE button pushed, the mainframe primary and secondary GPIB addresses will be displayed on the TV monitor as:

```
PA   XX   SA   YY
```

where XX is the mainframe primary address and YY is the mainframe secondary address, the address readout replaces the normal readout on the TV monitor for about five seconds.

4. In case of power-up error, the TV monitor will display the cause and location of the error, such as:

```
RAM     R/W ERROR
ADDRESS    XXXX
```

where XXXX is the address of byte where error occurred

```
CHECKSUM  ERROR
ADDRESS    YYYY
```

where YYYY is the address of the ROM with bad checksum

```
ROM ADDR  ERROR
ADDRESS    ZZZZ
```

where ZZZZ is the address of the msiplaced ROM.

SECTION 4

INSTALLATION

Instructions in this section for installing the 7912AD are limited to those that can be perfomed without removing the instrument covers. Other instructions intended for qualified service personnel are found in the 7912AD Service Manual. These include setting internal jumpers and switches.

WARNING

Do not remove the instrument covers. Dangerous voltages exist inside the 7912AD. Refer service that requires removing the covers to qualified personnel.

Installing the 7912AD in a Rack

WARNING

During rackmount installation, interchanging the left and right slide-out track assemblies defeats the extension stop (safety latch) feature of the tracks. Equipment could, when extended, come out of the slides and fall from the rack, possibly causing personal injury and equipment damage.

When mounting the supplied slide-out tracks, inspect both assemblies to find the LH (left hand) and RH (right hand) designations to determine correct placement. Install the LH assembly to your left side as you face the front of the rack and install the RH assembly to your right side. Refer to the rackmounting instructions in this manual for complete information.

Hardware is supplied with the 7912AD to mount it in a standard 19-inch rack. Part numbers and drawings of the hardware are shown with the accessories in the mechanical parts list found in the 7912AD Service Manual. The 7912AD is supplied with the chassis slide tracks already in place.

The following dimensions in the rack are required:

Rack rail hole spacing	0.500 inches	(1.27 cm)
Min. rack depth	27.5 inches	(70 cm)
Min. width between rack rails	17.650 inches	(44.8 cm)

To attach the hardware to the rack, refer to Fig. 4-1 and follow this procedure:

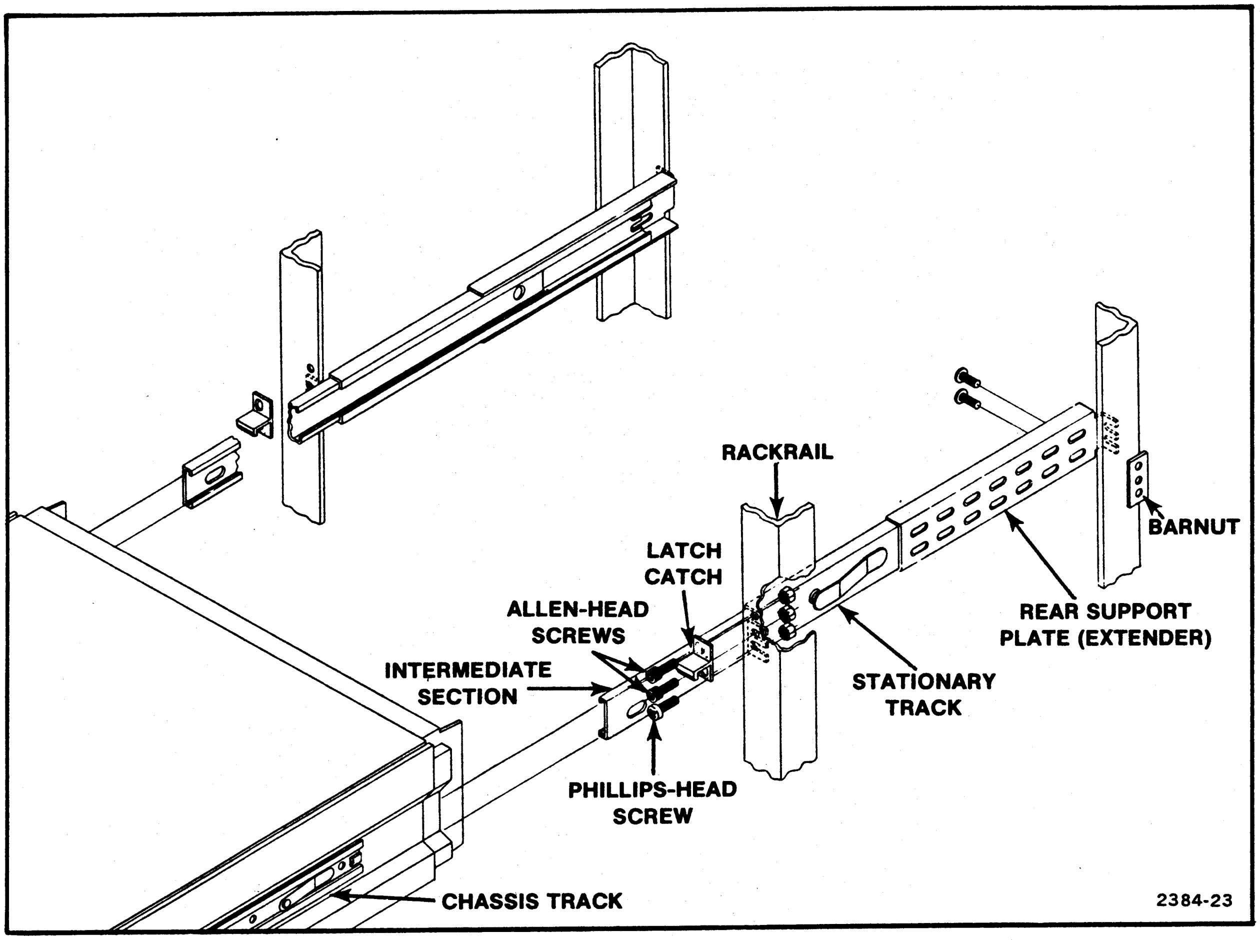


Fig. 4-1. Assembling the 7912AD rackmounting hardware.

1. Adjusting for the depth of the rack, attach the rear support plates to the stationary slide tracks with bolts and barnuts. Do not fully tighten the bolts. For shallow racks, the rear support plates can be reversed as shown in Fig. 4-2. However, the rack cabinet must allow the 7912AD to extend out the rear of the rack.

2. Install the latch catches on the front rack rails. The catch for the right and the one for the left are not the same. Install each so the slots are toward the ouside and the lip of the catch points down. Install a nut on the top screw of each if the rack rail is not threaded.

3. Install the assembled stationary tracks and rear supports. The right and left tracks are not the same; compare them to the chassis slide tracks on the sides of the 7912AD to install correctly. Use nuts or barnuts at the rear if the rack rail holes are not threaded.

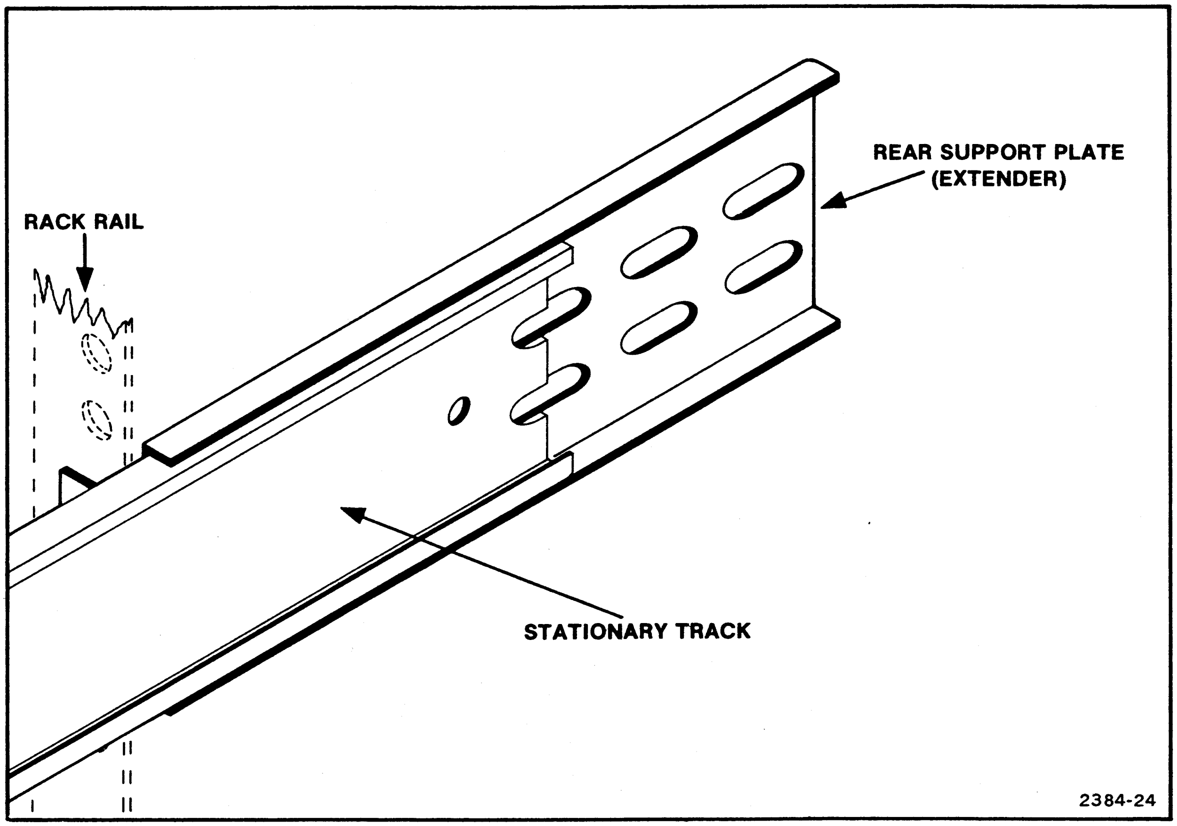


Fig. 4-2. Reversing the rear support plates for a shallow rack.

4. Tighten the rack rail bolts enough to secure the stationary track and rear support, but still allow movement. Fully tighten the bolts that attach the rear supports to the stationary tracks.

5. Slide the intermediate sections into the stationary tracks so they lock in their extended positions.

6. Carefully lift the 7912AD into place so the chassis tracks align with the intermediate sections (this may require two people). Slide the 7912AD chassis tracks into the intermediate sections and push the instrument part way into the rack.

7. The sliding track sections should align themselves as the 7912AD is pushed into the rack. Tighten all bolts with the sections aligned.

8. Push the 7912AD into place in the rack and check that the latches catch properly. The tracks are prelubricated and should slide freely.

Before operating the 7912AD, check the environmental and physical specifications at the end of Secion 1; the operating temperature and airflow requirements of the instrument must be met. Be sure there is nothing blocking the fan intake (screen on rear panel).

Cabling

Depending on the use of the 7912AD, make some or all of the following connections.

1. Connect one of the COMPosite Video OUTputs (either LINEAR or BINARY) to a compatible video monitor with a 75-ohm coaxial cable. Compatible monitors include the TEKTRONIX 634 Monitor and the 650- and 670-Series Picture Monitors. See the video output specifications in Section 1 to determine compatibility with other monitors. Refer to the monitor manuals for correct connection at the monitor and for operating information. Normally, a 75-ohm termination is required.

2. Connect the SYNC OUTput to the monitor external sync input, if desired. Also, external sync can be applied to the 7912AD video output through the LOOP connectors. If the sync signal is not daisy-chained to another instrument, terminate LOOP in 75 ohms.

3. Connect the X, Y, and Z outputs to a compatible display monitor with coaxial cable. Compatible monitors include the TEKTRONIX 600-Series monitors. See the IEEE 488 Interface specifications in Section 1 to determine compatibility with other monitors. Refer to the monitor manuals for correct connection at the monitor and for operating information. Because the signals are not very high frequency, the cable and termination impedances are normally not critical.

4. Connect the IEEE 488 cable to the bus controller or the nearest instrument on the bus, as desired. More information on configuring a system is given as part of the IEEE 488 system discussion at the beginning of Section 3.

5. Connect input signals at the rear panel, if desired. Three inputs are provided: VERT IN, CAL IN, and TRIG IN. These connect directly through 50-ohm coaxial cable to, respectively, VERT OUT, CAL OUT, and TRIG OUT on the front panel. These straight-through connections are intended for routing signals through the instrument to the front panel for connection to the plug-ins. The VERT and CAL paths are very high bandwidth through rigid coaxial cable. For details, see the Feedthrough Connectors specification in Section 1.

Connecting Power

1. With the power cord disconnected from the power source, set the line voltage selector switch to the correct position for the local AC power line voltage. Either 115 VAC, nominal, or 230 VAC, nominal, can be selected.

2. The 7912AD power cord is provided with a polarized, three-terminal power connector. If the connector does not match the power outlet, refer to qualified service personnel.

3. Connect the 7912AD power cord to an AC power line with the correct voltage and frequency. See the power input specifications in Section 1 for more information on the power requirements of the 7912AD. Failure to supply the correct voltage and frequency on the AC power input can damage the instrument.

WARNING

To avoid electric shock, be sure that the protective-ground circuit is not interrupted. This can allow the chassis to float to hazardous potentials. Be sure that the power cord, plug, and outlet provide a secure path to earth (ground) for the protective-ground circuit of the 7912AD.

4. Set the PRINCIPAL POWER SWITCH on the 7912AD rear panel to ON.

Power Control

If remote power control of the 7912AD is desired, connect a device capable of placing a TTL active low on the 7912AD ACTUATE connector (rear panel). The 7912AD asserts a TTL active low on its ENABLE output when turned on to provide a daisy-chain path for the remote power control signal. The ENABLE signal is delayed slightly to space out the power-up surges if more than one instrument in the system is connected in this manner. See the power supply specifications in Section 1 for more information.

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.

7912AD COMMANDS

Header	Argument	Description	Set Only	Query Only
VS2	<NR3> or NONE	Vertical channel 2 scale factor		X
HS1	<NR3> or NONE	Horizontal channel 1 scale factor		X
HS2	<NR3> or NONE	Horizontal channel 2 scale factor		X
VU1	<CHARACTERS> or NONE	Vertical channel 1 units		X
VU2	<CHARACTERS> or NONE	Vertical channel 2 units		X
HU1	<CHARACTERS> or NONE	Horizontal channel 1 units		X
HU2	<CHARACTERS> or NONE	Horizontal channel 2 units		X
ERR	<NR1> or NONE	Error code indicated by status byte		X
SRQ	NULL	Service request query		X
ID	<CHARACTERS>	Identity of instrument		X

Numbers

<NR1> Integers with or without signs

<NR3> Signed scientific notation

IEEE 488 Interface Messages

The 7912AD responds to the following messages:

GTL, LLO, SDC, DCL, SPE, SPD, GET, IFC

The 7912AD does **not** respond to the following messages:

PPC, PPU, TCT

7912AD

Status Byte

Bit 7 = Service Requested; Bit 5 = Busy

	8	7	6	5	4	3	2	1
Remote request	1	X	0	X	0	0	0	1
No condition	0	0	0	X	0	0	0	0
Power up	0	1	0	X	0	0	0	1
Operation complete	0	X	0	X	0	0	1	0
Command error	0	1	1	X	0	0	0	1
Execution error	0	1	1	X	0	0	1	0
Internal error	0	1	1	X	0	0	1	1
Power fail error	0	1	1	X	0	1	0	0

Error Codes

Code	Description
NONE	No error to report
102	Invalid command header
103	Invalid command argument
201	Attempt to arm single sweep while time base is not in single-sweep mode
202	Checksum error for binary block input by LOAD command
203	Byte count error for binary block input by LOAD command
206	Attempt to digitize with invalid sweep rate (slower than 1 millisecond/division)
302	Fault detected in data memory or 2900 memory controller
304	Invalid or missing readout from plug-ins
305	Data memory (waveform) overwritten
306	No data to average
307	Defects array full
308	6800 MPU interrupt fault
401	Power failure is imminent

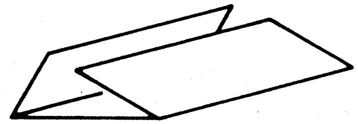
7912AD PROGRAMMABLE DIGITIZER

PROGRAMMING AID

Tektronix®
COMMITTED TO EXCELLENCE

070-2838-00

Remove programming aid at perforation. Fold along crease as shown:



FOLD

FOLD

7912AD COMMANDS

Header	Argument	Description	Set Only	Query Only
MOD[E]	TV	Set to TV mode		
	DIG	Set to digital mode		
DIG	DAT[A]	Digitize data	X	
	GRA[T]	Digitize graticule only	X	
	SSW	Digitize single-sweep	X	
	DEF,<NR1>	Digitize defects n times	X	
	SA,<NR1>	Signal average 1 to 64 times	X	
DT	ON	Wait for GET to digitize		
	OFF	Do not wait for GET to digitize		
GRA[T]	ON	Write only the graticule		
	OFF	Reset graticule-only mode		
XYZ	ON	Enable raw data display		
	OFF	Disable XYZ outputs		
	RAW	Enable raw data display		
	ATC	Enable ATC data display		
	SA	Enable signal-averaged data display		
	EDG[E]	Enable EDGE data display		
	DEF	Enable defects data display		
MAI	<NR1>	Set main intensity (0-1023)		

7912AD COMMANDS

Header	Argument	Description	Set Only	Query Only
GRI	<NR1>	Set graticule intensity (0-255)		
FOC	<NR1>	Set focus (0-63)		
SSW	ARM	Arm single-sweep trigger		
	DIS	In single-sweep mode, but disarmed		X
	NSS	Not in single-sweep mode		X
TV	ON	Turn on TV scale factors		
	OFF	Turn off TV scale factors		
REM	ON	Assert SRQ when REMOTE pressed		
	OFF	Do not assert SRQ when REMOTE pressed		
OPC	ON	Assert SRQ when operation completes		
	OFF	Do not assert SRQ when completed		
DEF	ON	Flag defects in raw vertical data		
	OFF	Reset defect flags		
LOA[D]	<BINARY>	Load defects array from IEEE 488 bus	X	
ATC		Average raw vertical data for center of trace	X	
INT	<NR1> or NONE	Max. no. of consecutive interpolated data points by ATC or DIG SA		X

7912AD COMMANDS

Header	Argument	Description	Set Only	Query Only
EDG[E]		Determine trace edges from raw vertical data	X	
TW	<NR1>	Set EDGE max. trace width		
RT	<NR1>	Set EDGE max. rate of increase		
SET	<MESSAGE>	Settings of programmable functions		X
TES[T]		Self-test data memory	X	
REA[D]	VER	Transmit vertical data array	X	
	PTR	Transmit pointers data array	X	
	SC1	Transmit channel 1 scale factors	X	
	SC2	Transmit channel 2 scale factors	X	
	ATC	Transmit averaged-to-center data	X	
	SA	Transmit signal-averaged data	X	
	EDG[E]	Transmit edge-determined data	X	
	DEF	Transmit defect data	X	
REP	<NR1>	Repeat DIG DAT/READ PTR, VER sequence (0-65535)	X	
DUM[P]	RAW	Dump raw data memory area	X	
	PR	Dump processed data memory area	X	
VS1	<NR3> or NONE	Vertical channel 1 scale factor		X

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