INSTRUCTION MANUAL
FOR
WJ-9472 TWO-CHANNEL FSK DEMODULATOR SYSTEM

WATKINS-JOHNSON

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FOR

WJ-9472 TWO-CHANNEL FSK DEMODULATOR SYSTEM

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GENERAL DESCRIPTION

1.1 ELECTRICAL CHARACTERISTICS

The WJ-9472 Two-Channel FSK Demodulator System is a compact modular series of plug-in units in a control rack frame that offers:

1) Operational flexibility.

2) High performance demodulation approaching the theoretical optimum.

3) Optional remote control capabilities.

4) Optional tuning display to enable detailed signal analysis.

The WJ-9472 is designed to demodulate two independent Frequency Shift Keyed (FSK) or On/Off Keyed (OOK) signals in the frequency range of 200 to 9999 Hz. Space and Mark or Center Frequency and Shift parameters can be selected to facilitate locating and tuning the signal. Space and mark frequencies can be set with high resolution 1 Hz synthesized control. The independent mark and space detection filters are matched to baud rates from less than 10 to greater 4000 baud. Filter bandwidths are selected by entering either the keying speed or element length. The unit is EMI quiet. Figure 1-1 is a functional block diagram of the WJ-9472 Demodulator System.

1.1.1 CONTROL RACK FRAME

The WJ-9472/CRF Control Rack Frame can accommodate:

1) Two WJ-9472/DU Demodulator Units.

2) WJ-9472/SMU Signal Monitor Unit (optional).

3) WJ-9472/DDU/DFSK Diversity Unit (optional).

4) WJ-9472/DRU Data Regenerator Unit (not yet available).

Specifications for all units are listed in Table 1-1. The WJ-9472/CRF contains control and display circuitry to operate the basic unit. The CRF supplies power for the entire system. Front panel controls are interpreted by a preprogrammed microprocessor. The displays and indicator lights on the front panel provide complete information on system status. The IEEE-488 or EIA RS-232 options offer remote control capability. All signal connections are located on the rear panel. Figure 1-2 shows the Control Rack Frame with all plug-in modules inserted.

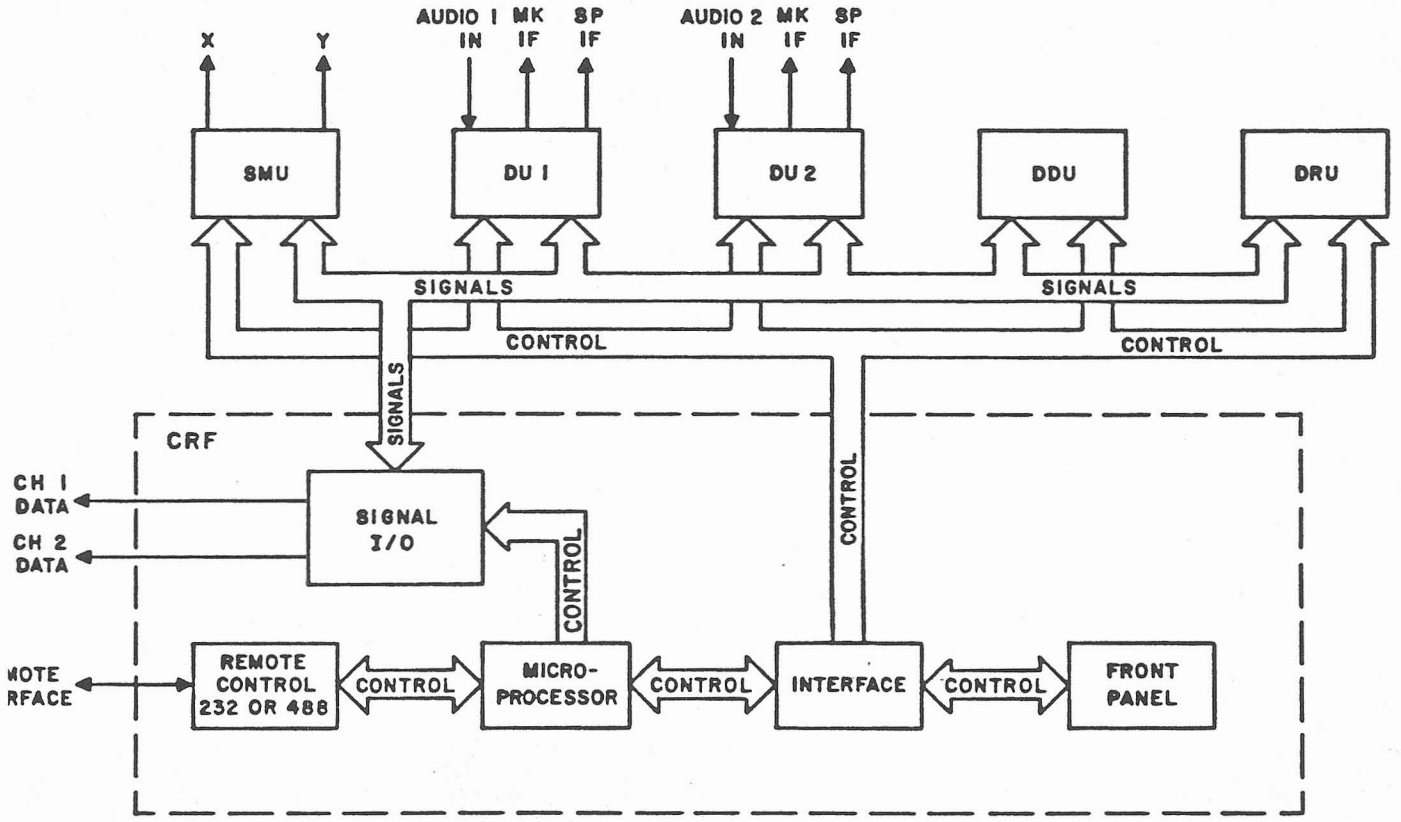


Figure 1-1. WJ-9472 Functional Block Diagram

Table 1-1. WJ-9472 Demodulator System Specifications

INPUT:	
Number of Inputs	2
Input Frequency Range	200 Hz to 9999 Hz
Input Impedance	600 ohms BNC input standard Other input impedances available
Input Level	-40 dBm to +10 dBm in 600 ohms +30 dBm in 600 ohms without damage
Remote Control	RS-232 or IEEE-488 interfaces optional
FSK Mode:	
Demodulation Method	Independent mark and space detection with sixth order, baud rate matched filters
Tone Frequencies	Mark/Space frequencies from 200 to 9999 Hz in 1 Hz steps
Tuning Mode	Tone selection by specifying either mark and space frequencies or center frequency and shift
Baud Rate	Less than 10 to greater than 4000 baud
Threshold	Automatic adaptive threshold selection
OOK MODE:	
Demodulation Method	Sixth order, baud rate matched filters
Tone Frequency	200 to 9999 Hz in 1 Hz steps
Baud Rate	Less than 10 to greater than 4000 baud
Threshold	Automatic adaptive threshold selection
OUTPUTS:	
Digital	Bipolar keyed data, EIA RS-232C or MIL-STD-188C; or monopolar, MOS/TTL compatible, 50Ω impedance
Analog	Translated and filtered mark and space IF outputs 50 kHz at -10 dBm nominal into 50 ohms
GENERAL:	
WJ-9472 System with all Options:	
Power Requirements	115/220 Vac ±10%, 48-420 Hz
Power Consumption	60 Watts, approximately (max),
Dimensions	5.22 inches high, 19 inches wide, 18 inches deep

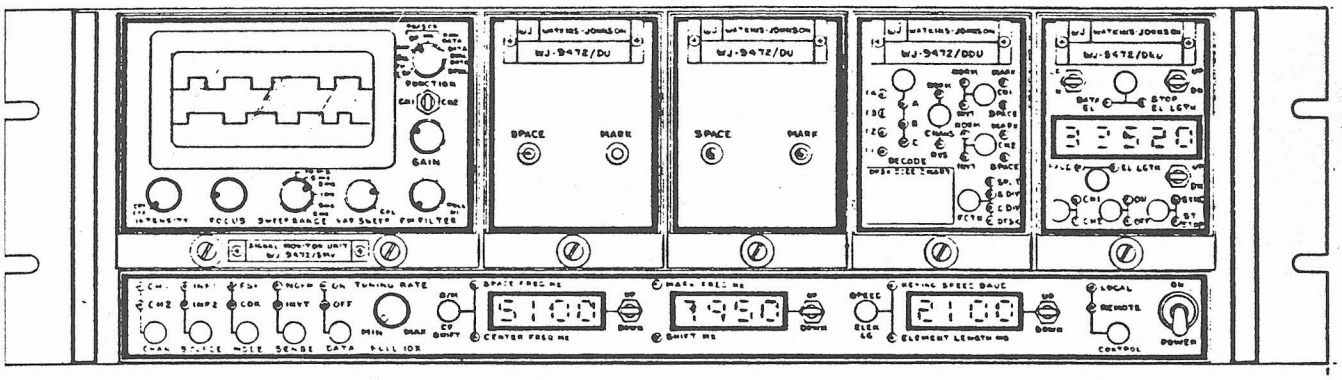


Figure 1-2. WJ-9472 Front Panel

1.1.2 WJ-9472/DU

Each of the WJ-9472/DU Demodulator Units is a plug-in module capable of demodulating FSK and OOK signals in a 200 to 9999 Hz frequency range. Signal parameters for each DU can be set independently. The synthesized filters are matched to the signal baud rate in selectable 1 baud increments with an optimum range of 10 to 4000 baud. Baud rate can be selected by either keying speed or element length in milliseconds. Tone selection by specifying either mark and space frequencies or center frequency and shift in 1 Hz increments provides ease of tuning.

1.1.3 WJ-9472/SMU (Optional)

The WJ-9472/SMU Signal Monitor/Oscilloscope is an optional unit which plugs into and is powered by the CRF. The SMU provides several signal displays which enable the operator to quickly determine the signal type, achieve proper tuning, and determine the parameters of the signal. It is possible to measure frequency shifts to better than 1 Hz accuracy with the SMU. 50 ohm X and Y SMU signal outputs are available on the WJ-9472/CRF rear panel to drive a user provided auxiliary display.

1.1.4 WJ-9472/DDU (Optional)

The WJ-9472/DDU, DFSK Diversity Unit is an optional unit which plugs into and is powered by the CRF. The DDU accepts the input from the two WJ-9472/DU's and provides four operating modes:

1) Split - The two demodulators operate independently.

2) Selection Diversity - The stronger of the two demodulator inputs is dynamically selected.

3) Combination Diversity - The output of the two demodulators is summed and detected.

4) DFSK - Demodulates DFSK (four frequency FSK) providing two digital data channels out, with synchronous or asynchronous operation to greater than 2500 baud and with front panel selection of the decoding rule (all 24 permutations).

1.1.5 WJ-9472/DRU (Optional)

Space in the WJ-9472/CRF has been allocated for an optional WJ-9472/DRU, Data Regeneration Unit. This unit will regenerate digital data from two digital data streams (each WJ-9472/DU) independently in a synchronous or asynchronous fashion. For synchronous data, the baud clock is regenerated.

1.1.6 WJ-9472/232 REMOTE INTERFACE OPTION

The WJ-9472/232 Option gives the Demodulator remote control capability. The RS-232 rear panel connector links the Demodulator with any remote terminal or modem. All Demodulator settings can be controlled and monitored by remote control.

1.1.6.1 WJ-9472/232-1 "Daisy Chain" Option

With the WJ-9472/232-1 "Daisy Chain" option the Demodulator can be connected in a series chain allowing one remote controller to address up to 16 Demodulators.

1.1.7 WJ-9472/488 REMOTE INTERFACE OPTION

The WJ-9472/488 Option gives the Demodulator remote control capability. The IEEE-488 connector links the Demodulator with any remote terminal or modem. All Demodulator settings can be controlled and monitored by remote control.

1.2 MECHANICAL CHARACTERISTICS

The Demodulator System mounts in a standard 19-inch equipment rack, occupies 5.22 inches of vertical space, and extends 18 inches into the rack. The main chassis, front, rear, top, bottom, and internal compartment panels are constructed of aluminum. All operating controls and indicators are on the front panel, all cable connections are on the rear. The DU's, SMU, and DDU all plug-in for easy removal and troubleshooting.

The front panel is overlaid with a black bezel, etched with control markings. All connectors, the power supply cord, and the line fuse are mounted on the rear panel.

1.3 EQUIPMENT SUPPLIED

The WJ-9472/FSK Demodulator System consists of the control rack frame, two WJ-9472/DU demodulator units, and a detachable line cord.

1.4 EQUIPMENT REQUIRED BUT NOT SUPPLIED

Interfacing devices must be supplied by the user according to the particular demodulator application.

1.5 OPTIONAL EQUIPMENT

The following optional equipment is available for use with the WJ-9472/FSK Demodulator System. For additional information concerning these options and others, contact the Watkins-Johnson Company, Gaithersburg, Maryland or your Watkins-Johnson representative.

1) Oscilloscope Signal Monitor Unit - WJ-9472/SMU
2) DFSK/Diversity Unit - WJ-9472/DDU
3) Data Regeneration Unit - WJ-9742/DRU
4) Remote Control Interface - WJ-9472/488
5) Remote Control Interface - WJ-9472/232
6) Remote Control Interface - WJ-9472/232-1 "Daisy Chain" Option

SECTION II

INSTALLATION AND OPERATION

2.1 UNPACKING AND INSPECTION

Examine the shipping carton for damage before the equipment is unpacked. If the carton has been damaged, try to have the carrier's agent present when the equipment is unpacked. If not, retain the shipping cartons and padding material for the carrier's inspection if damage to the equipment is evident.

See that the equipment is complete as listed on the packing slip. Contact Watkins-Johnson Company, Gaithersburg, Maryland, or your Watkins-Johnson representative with details of any shortage.

The unit was thoroughly inspected and factory adjusted for optimum performance prior to shipment. It is, therefore, ready for use upon receipt. After uncrating and checking contents against the packing slip, visually inspect all exterior surfaces for dents and scratches. If external damage is visible, remove the protective cover and inspect the internal components for apparent damage. At this point, check the internal cables for loose connections. Check plug-in items such as printed wiring boards, which may have been loosened from their receptacles.

2.2 INSTALLATION

2.2.1 EQUIPMENT LOCATION

The WJ-9472 FSK Demodulator System is designed to be mounted in a standard 19-inch equipment rack. The CRF occupies 5.22 inches of vertical rack space and extends 18 inches into the rack. The CRF should be installed in a location which allows a free flow of air through and around the control and demodulator units. Space should be allowed to the rear of the CRF for making interface connections and for easy access to the fuse mounted on the rear panel.

2.2.2 POWER REQUIREMENTS

A power source of 115 or 220 Vac ±10%, 48-420 Hz is required. With optional equipment installed, power consumption is approximately 60 watts.

2.2.2.1 Line Cord Receptacle and Voltage Selector Fuse Block

This multi-functioned assembly should always be inspected before installation of the receiver in a new location. With the line cord unplugged, the clear plastic window can be slid over the male power receptacle prongs. This exposes the line fuse and a hinged plastic fuse pull lever.

Swinging the lever to the left ejects the fuse from the holder and frees a line-voltage-select pc wafer, at the bottom of the assembly. Looking down on the pc wafer, at a slight angle, the selected line voltage for the receiver will show on the left side (either 100, 120, 220, 240 Vac). If the voltage shown does not match the available line voltage, remove the pc wafer and install it so the visible voltage matches the line voltage as follows:

Nominal Voltage	Recommended Operating Voltage
100	97 - 120 Vac
120	105 - 130 Vac
220	202 - 240 Vac
240	210 - 260 Vac

Install the fuse suitable for the line voltage: 3/4 ampere slow-blow for 100 or 120 Vac, and 3/8 ampere for 220 or 240 Vac.

2.2.3 GROUND REQUIREMENTS

All necessary grounding is provided by the detachable 115/220 Vac power cord, additional ground wires are unnecessary. A rear panel grounding stud is provided for attachment of a ground cable if desired.

2.2.4 REAR PANEL CONNECTIONS

The rear panel signal jacks are BNC connectors. The rear panel connectors are as follows:

FL1 J1 - Line voltage input, 115 V or 220 V

CH1

SP IF J5 - Channel 1 Space IF output
MK IF J6 - Channel 1 Mark IF output
INPUT J7 - Channel 1 200 to 9999 Hz audio input
DATA J8 - Channel 1 Demodulated data output

CH2

SP IF J1 - Channel 2 Space IF output
MK IF J2 - Channel 2 Mark IF output
INPUT J3 - Channel 2 200 to 9999 Hz audio input
Data J4 - Channel 2 Demodulated data output

EXTERNAL MONITOR (Optional)

X J9 - Signal Monitor X axis output
Y J10 - Signal Monitor Y axis output

REMOTE INTERFACE (Optional)

RS-232-C	-	Connector for WJ-9472/232 interface option
RS-232-C INPUT	-	Input connector for WJ-9472/232-1 interface option
EXTENSION	-	Output connector for "Daisy Chain" option
IEEE-488	-	Connector for IEEE-488 interface option

2.2.5 CRF SIGNAL I/O BOARD JUMPER CONNECTIONS

The CRF Signal I/O board contains three jumper plugs that can be varied to control the voltage and polarity of the demodulated digital output.

2.2.5.1 Channel 1 and Channel 2 Jumper Plugs (P2 and P3)

These jumpers control the output voltage swing of each channel independently. The connection on the Signal I/O board can be made as follows:

CHAN 1	CHAN 2	
J5-J4	J7-J6	Voltage swings symmetrically about zero, ±5.5 V. RS-232-C/MIL-STD-188-C compatible.
or		
J3-J13	J8-J9	Voltage swings from 0 to 4.8 V, TTL compatible

2.2.5.2 NORM/INVT Jumper Plug (P4)

This connection controls the output polarity for both channels. The connection can be made as follows:

J10-J11	Invert
J11-J12	Normal

With the Signal I/O board set to normal and the front panel control set to NORM, Mark will produce positive output voltages. With the Signal I/O board set to invert and the front panel set to NORM, Space will produce positive output voltages.

2.3 OPERATION

All controls and indicators are located on the front panel. All controls for the WJ-9472 DU are on the CRF, optional units have separate controls. Table 2-1 lists front panel controls and indicators. See Figure 1-2 for location of controls and indicators.

Table 2-1. WJ-9472/CRF and DU Controls and Indicators

CONTROL/INDICATOR		FUNCTION
CHANNEL	Pushbutton	Selects demodulator channel to be controlled.
CHAN 1 CHAN 2	Indicator Lights	Displays which channel is currently selected.
SOURCE	Pushbutton	Selects input source.
INP 1 INP 2	Indicator Lights	Displays which input source is currently selected.
MODE	Pushbutton	Selects either FSK or OOK mode of operation.
FSK OOK	Indicator Lights	Displays which mode of operation is selected.
SENSE	Pushbutton	Selects normal or inverted data output.
NORM INV	Indicator Lights	Displays output mode currently selected.
DATA	Pushbutton	Controls output data for the currently selected channel.
ON OFF	Indicator Lights	Indicates whether demodulated data or continuous mark level is being output.
TUNING RATE	Tuning Knob potentiometer	Controls rate of change for three UP/DOWN Switches. Pull knob out for 10x increase in rate of change.
S/M CF SHIFT	Pushbutton	Selects frequency parameter data mode.
SPACE FREQ Hz CENTER FREQ Hz	Indicator Lights	Indicates which frequency parameter is displayed.
MARK FREQ Hz SHIFT Hz	Indicator Lights	Indicates which frequency parameter is displayed.
UP/DOWN	Switch	Increases or decreases displayed frequency. TUNING RATE controls rate of change.
SPEED ELEM LG	Pushbutton	Selects time parameter display mode.
KEYING SPEED BAUD ELEMENT LENGTH ms	Indicator Lights	Indicates which time parameter is displayed.

Table 2-1. WJ-9472 CRF and DU Controls and Indicators (Cont'd)

CONTROL/INDICATOR		FUNCTION
UP/DOWN	Switch	Increases or decreases displayed value. TUNING RATE controls rate of change.
CONTROL	Pushbutton	Selects local or remote control.
LOCAL REMOTE	Indicator Lights	Displays control mode currently selected.
POWER	Switch	Controls power to unit.
SPACE MARK	Indicator Light on DU	Indicates DU is receiving space or mark frequency.

.3.1 CONTROLS AND INDICATORS

.3.1.1 Control Rack Frame

The following controls and indicators are used to operate and display the onfiguration of the WJ-9472 FSK Demodulator:

1) CHANNEL: pushbutton selects demodulator channel. CHAN 1 or CHAN 2 indicator lights show which channel is currently selected. Once a channel is selected the other CRF indicators show the status of that channel.

2) SOURCE: pushbutton selects inputs to the System. INP 1 or INP 2 indicator lights show which input is currently selected.

3) MODE: pushbutton selects either FSK or OOK mode of operation. FSK or OOK indicator lights show which mode is currently selected.

4) SENSE: pushbutton selects either normal or inverted data output. NORM or INVT indicator lights show which state is currently selected.

5) DATA: pushbutton controls output of data for the currently selected channel. ON light lit indicates demodulated data is being output. OFF light lit indicates a continuous mark level is being output. Useful when it is desirable to turn off the flow of data, such as for printer control.

6) TUNING RATE: potentiometer operates in conjunction with UP/DOWN switches. Controls speed in which each of three UP/DOWN switches change their respective digital displays. Pull knob out to 10X position for ten times increase in the rate of change.

7) Frequency Parameters:

S/M-CF SHIFT: pushbutton controls frequency parameters. Either space and mark frequencies or center frequency and shift can be selected and displayed.

SPACE FREQ Hz and CENTER FREQ Hz: lights indicate which frequency parameter is shown on digital display.

MARK FREQ Hz and SHIFT Hz: lights indicate which frequency parameter is shown on digital display.

UP/DOWN: spring loaded switches next to each digital display. Pushing switch up increases displayed frequency by 1 Hz. Holding switch up increases displayed frequency continuously. Pressing switch down decreases display by 1 Hz. Holding switch down decreases displayed frequency continuously. Tuning rate knob controls speed of frequency change.

8) Time Parameters:

SPEED/ELEM LG: pushbutton controls data time parameters. Either keying speed in baud or element length in milliseconds can be selected and displayed.

KEYING SPEED BAUD or ELEMENT LENGTH ms: lights indicate which time parameter is shown on digital display.

UP/DOWN: spring loaded switch next to the digital display. Pushing switch up increases displayed value by one increment. Holding switch up increases displayed value continuously. Pressing switch down decreases display by one increment. Holding switch down decreases displayed value continuously. TUNING RATE knob controls speed of displayed value change.

9) CONTROL: pushbutton selects local or remote control.

LOCAL or REMOTE indicator lights show current control mode. In REMOTE mode all other front panel controls are disabled.

10) POWER: two position toggle switch controls power to the unit. When the switch is down power is off; when the switch is up, power is on.

11) Reset: simultaneously pressing S/M-CF SHIFT and SPEED-ELEM LG pushbuttons actuates a reset to return all channels to the following preset state:

SOURCE	INP 1
MODE	FSK
SENSE	NORM
DATA	ON

SPACE FREQ	1000 Hz
MARK FREQ	1000 Hz
KEYING SPEED BAUD	100
CONTROL	LOCAL

2.3.1.2 Demodulator Unit

All controls for the WJ-9472/DU's are located on the CRF. SPACE and MARK indicator lights are located on the DU. The respective indicators light when the decision circuit determines that a space or mark frequency has been received.

SECTION V

WJ-9472/232 and WJ-9472/232-1 INTERFACE OPTION

5.1 GENERAL DESCRIPTION

The WJ-9472/232 Interface option enables a remote unit to monitor and control all parameter settings of the WJ-9472. With the WJ-9472/232-1 "Daisy Chain" option, up to 16 Demodulators in a series chain can be monitored and controlled by one remote unit. Both Interface options are EIA-RS-232-C compatible, using standard ASCII characters and baud rates from 50 to 19.2 k baud.

5.2 INTERFACE CONNECTIONS

The WJ-9472 Demodulator with the RS-232 option installed is configured as a data terminal, for remote operation the 25 pin connector from a remote unit must plug into the rear panel receptacle of the Demodulator. Table 5-1 lists the RS-232-C connection pin numbers with their respective interchange signals and functions. The WJ-9472 can interface with a modem (data set) or another data terminal, each requiring a different connection.

Table 5-1. RS-232-C Connector Pin Assignments.

Pin Number	Signal	Description
1	P-GND	Protective Ground
2	TxD	Transmitted Data
3	RxD	Received Data
4	RTS	Request to Send
5	CTS	Clear to Send
6	DSR	Data Set Ready
7	S-GND	Signal Ground
15	TxC	Transmit Clock
17	RxC	Receive Clock
20	DTR	Data Terminal Ready

5.2.1 WJ-9472-TO-MODEM CONNECTION

The WJ-9472 connects directly to a modem (data set) via the 25 pin connectors and a one-to-one cable. Figure 5-1 shows this connection.

5.2.2 WJ-9472-TO-DATA TERMINAL CONNECTION (NULL MODEM)

To connect the WJ-9472 Demodulator to another RS-232 compatible data terminal a null modem is required. Figure 5-2 shows the connection using the null modem. The null modem arranges the pin connections to enable both data terminals to send and receive data. The crossing of pin connections established by the null modem is shown in Figure 5-3.

FIGURE 5-1
FIGURE 5-2

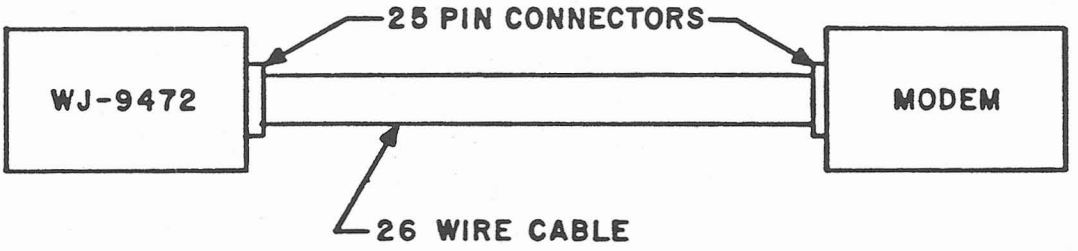


Figure 5-1. WJ-9472 Demodulator-to-Modem Connection

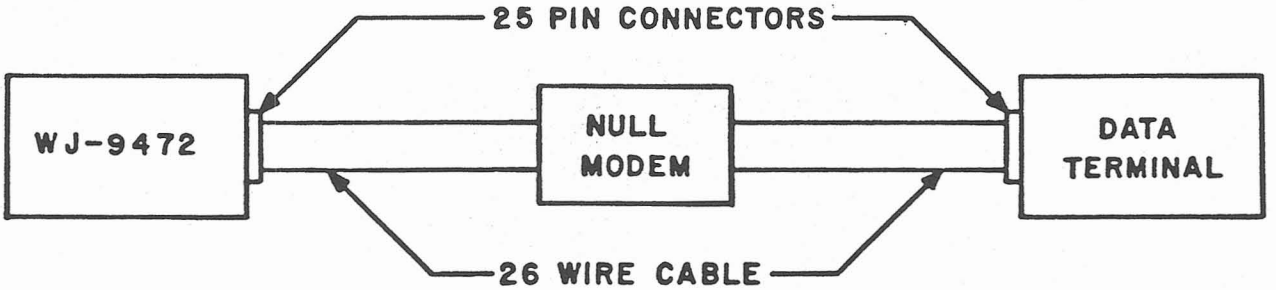


Figure 5-2. WJ-9472 Demodulator-to-Data Terminal Null Modem Connection

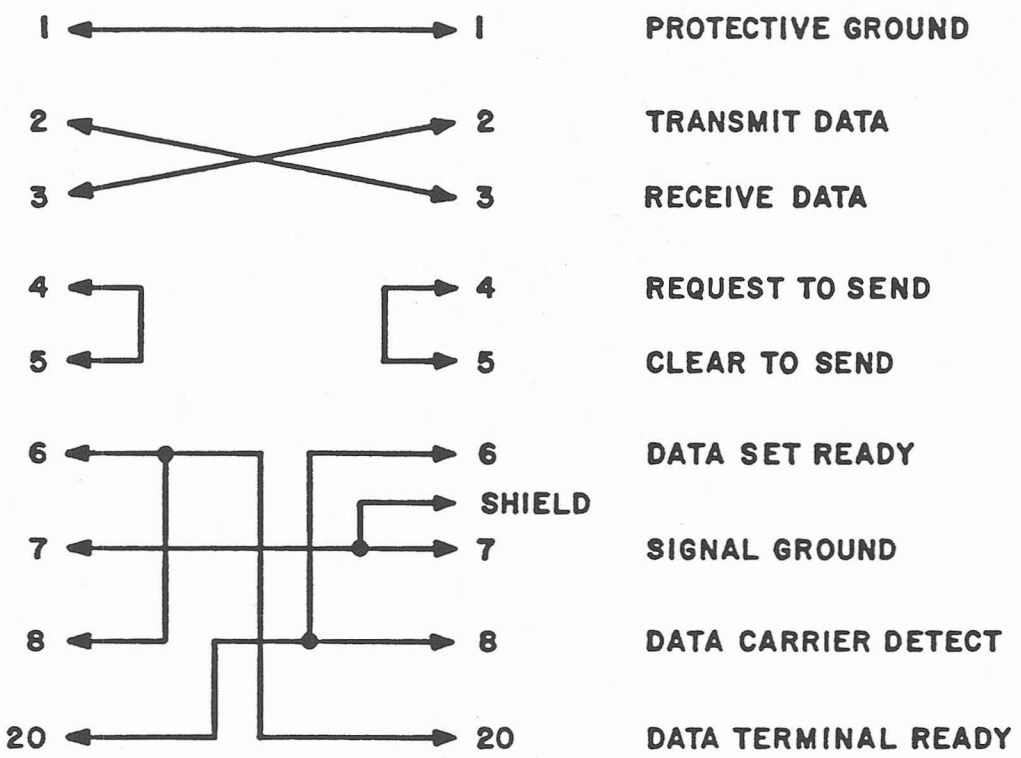


Figure 5-3. Null Modem Pin Connections

5.2.3 WJ-9472/232-1 "DAISY CHAIN" CONNECTION

The WJ-9472/232-1 Daisy Chain option permits the connection of up to 16 WJ-9472 Demodulators, all controlled by a remote unit. The connections between a modem or a data terminal is the same as with the RS-232 Interface. For the "Daisy Chain" configuration the rear panel RS-232-C INPUT port is connected to the EXTENSION port to form a series chain as shown in Figure 5-4.

5.3 232 SWITCH SETTINGS

Several parameters essential to remote communication between the WJ-9472 and remote units must be established by switch settings and jumpers on the WJ-9472/232 Control I/O Board (A1A2).

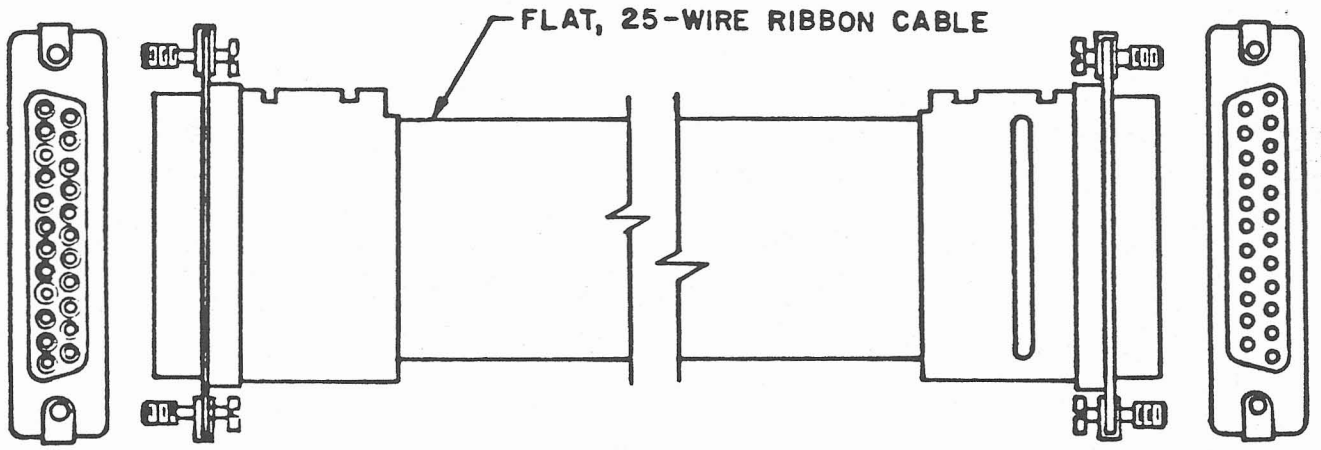


Figure 5-4A. RS-232-1 "Daisy Chain" Cable Connection

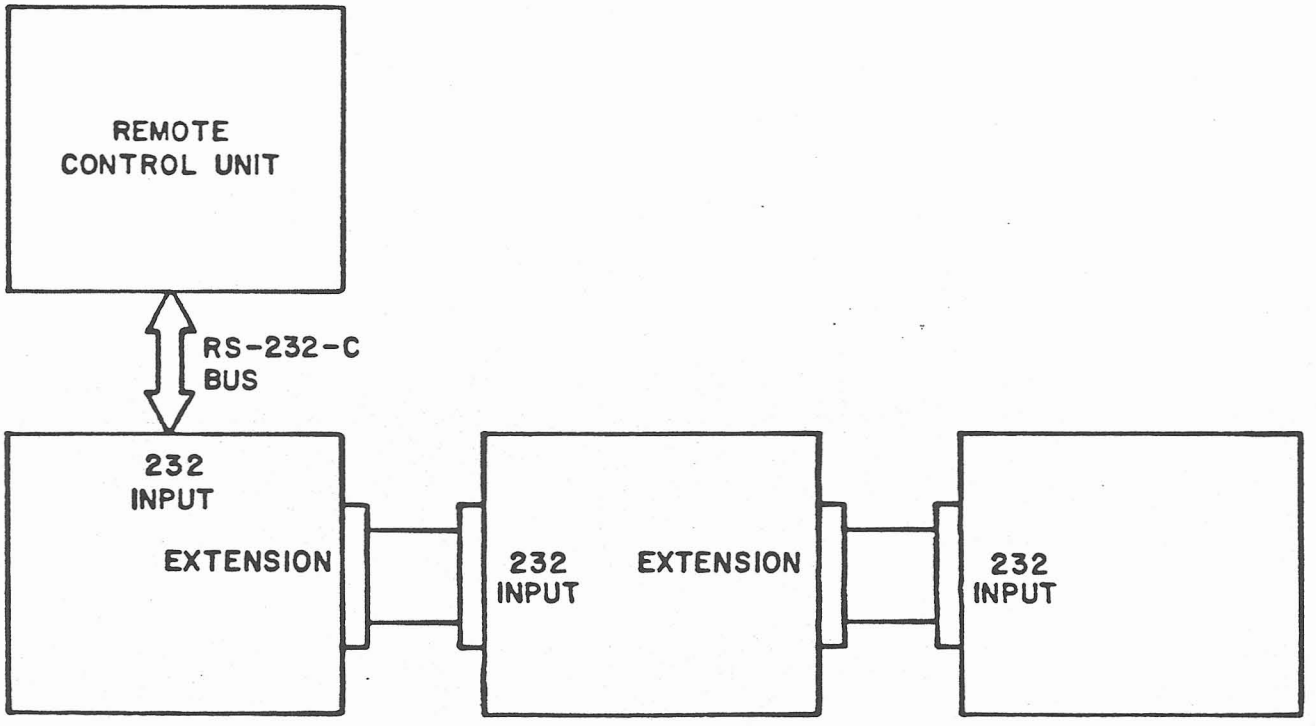


Figure 5-4B. RS-232-1 "Daisy Chain" Configuration

5.3.1 BAUD RATE

Baud rate is established by precoded entries to the S1 switch assembly on the Control I/O Board (A1A2). An open (off) switch denotes binary 1 and a closed (on) switch denotes binary 0. Table 5-2 lists the baud rate codes.

Table 5-2. Baud Rate Codes

Baud Rate	S1-4	S1-3	S1-2	S1-1
50	0	0	0	0
75	0	0	0	1
110	0	0	1	0
134.5	0	0	1	1
150	0	1	0	0
300	0	1	0	1
600	0	1	1	0
1200	0	1	1	1
1800	1	0	0	0
2000	1	0	0	1
2400	1	0	1	0
3600	1	0	1	1
4800	1	1	0	0
7200	1	1	0	1
9600	1	1	1	0
19200	1	1	1	1

5.3.2 SYNCHRONOUS OPERATION

The WJ-9472/232 Option is normally wired for asynchronous operation. Alternate connections on the Control I/O Board allow application of synchronous receive and transmit timing signals from the remote control equipment; however, if synchronous operation is desired, the program memory devices must be returned to Watkins-Johnson for re-programming. For synchronous operation, P2 is connected between J4 and J5, and P3 is connected between J7 and J8.

5.3.3 RECEIVER ADDRESS AND PARITY CHECK

With the WJ-9472/232-1 "Daisy Chain" option up to 16 properly addressed Demodulators can be controlled by one remote device. The units are series-connected, as shown in Figure 5-4, and only one Demodulator is interfaced directly to the remote control equipment. The serial data stream from the remote control equipment is actively repeated to all units in the chain, but only the addressed receiver "recognizes" its address and accepts the data. Table 5-3 lists the function of the Control I/O Board S2 switch assembly. A closed switch denotes a binary 0 and an open switch a binary 1. Demodulator address, zero through 15, is established by setting switches S2-1 through S2-4 (Table 5-4). Switches S2-5 and S2-6 control parity. If S2-5 is open parity is enabled and must be sent with the remote transmission; if S2-5 is closed parity is ignored. Switch S2-6 is set open to establish even parity. S2 parameters are entered into the microprocessor automatically at power up. To affect S2 setting changes, the unit must be turned on from a power off condition.

Table 5-3. Control I/O Board Switch (S2) Functions

S2-8 S2-7 Stop Element Length			S2-6 Parity Sense	S2-5 Parity Enable	S2-4 S2-3 S2-2 S2-1 Demodulator Address			
0	0	Invalid			2^3	2^2	2^1	2^0
0	1	1	0 Odd	0 Disable				
1	0	1.5	1 Even	1 Enable				
1	1	2						

Table 5-4. Address Codes

Address	S2-4	S2-3	S2-2	S2-1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	1
15	1	1	1	1

5.3.4 CHASSIS AND RS-232-C PROTECTIVE GROUND CONNECTION

Connection of chassis ground and RS-232-C protective ground is controlled by jumper P4 on the 232 board and jumpers P4 and P5 on the 232-1 board. For the 232 Interface board; P4 connected to J9 and J10 connects protective and chassis ground, P4 connected to J10 and J11 separates protective and chassis ground. For the RS-232-1 Interface board: P4 connected to J9 and J10, and P5 connected to J12 and J13 connects protective and chassis ground; P4 connected to J10 and J11, and P5 connected to J13 and J14 separates protective and chassis ground.

5.4 REMOTE INPUT/OUTPUT FORMAT

The WJ-9472/232 Interface option uses the mnemonic commands listed in Table 5-5. Each command line must begin with the device address and end with Carriage Return (CR) and Line Feed (LF). The maximum length of any command line is 82 characters, not including blanks, which are ignored. Upper case or lower case characters may be used. Commands may be made in any order, except for XX and RS, which must be the last commands on any line where they are used. Commands act only in the remote mode, except XX, RS, RE, and LO which can be executed in either remote or local modes. Figure 5-5 provides an example of communication between the WJ-9472 and a remote controller.

Table 5-5. WJ-9472/232 Remote Input/Output Format

DATA	CODE(ASCII)
CRF	
Channel Number	CHxx
Source Number	SOxx
FSK/OOK	FK, OK
Norm/Invert	NM, IN
Data ON/OFF	ON, OF
Space Frequency	SPxxxx
Mark Frequency	MKxxxx
Center Frequency	CFxxxx
Shift Frequency	SFxxxx
Baud Rate	BRxxxx
Element Length	ELxxxx
Remote/Local	RE, LO
Reset	RS
DDU	
Decode A, B, C	DA, DB, DC
Chans Norm/Reverse	NO, RV
FCTN: IDEP, DFSK, C DIV, S DIV	ID, DF, CD, SD

xxxx indicates string of numbers

When transmitting data leading zeros need not be included. Leading zeros are included in data read back.

COMMAND:

AD12 RS CRLF
This command resets the unit at address 12. (CRLF is Carriage Return and Line Feed)

COMMAND:

AD12 XX CRLF
Queries the state of the unit at address 12.

RESPONSE:

CH1 SO1 FK NM ON SP1000 MK1000 BR0100 DA NO CN1 CN2 ID LO CRLF

Active Channel State | DDU Status (If DDU is installed) | Control Status

COMMAND:

AD12 RE MK2875 SP2125 SO2 BR45 XX CRLF

RESPONSE:

CH1 SO2 FK NM ON SP2125 MK2875 BR0045 DA NO CN1 CN2 ID RE CRLF

COMMAND:

AD12CH2CF5000SF50EL2000INLOXXCRLF

RESPONSE:

CH2 SO1 FK IN ON CF5000 SF0050 EL2000 DA NO CN1 CI2 ID LO CRLF

Figure 5-5. Example of WJ-9472/232 Remote Communication

5.4.1 COMMAND ERRORS

There are two types of command errors encountered in remote operation: the unrecognizable command and the parameter violation error.

5.4.1.1 Unrecognizable Command Error

If a command is not recognized; for example, using the letter Q (no valid command contains Q), processing of the command line is halted and the remainder of the line is not processed.

5.4.1.2 Parameter Violation Error

If a command line specifies a parameter which exceeds the valid range, that parameter will not be changed; however, the rest of the line is processed normally. For example, if the current baud rate is 500 baud and the command "BR6600" (baud rate, 6600 baud) is transmitted, the error will be recognized as exceeding the 4000 baud limit and the baud rate of 500 baud will be retained. All other legal commands in the command line would be processed normally.

A more subtle parameter error can occur in the Center Frequency/Shift mode. If the center frequency or shift command would require the mark or space frequency to be out-of-range (less than 200 Hz or greater than 9999 Hz), an error will occur. This could occur in two ways:

1) The command "CF9800 SF1000" is illegal because it would require a mark frequency of:

   9800 + 1000/2 = 10,300 Hz, which is out of range.

2) The order in which the commands are entered can create a parameter violation. For example, with the center frequency set at 9800 Hz, the command "SF1000 CF5000" is illegal because the commands are processed in the order in which they are received. A 1000 Hz shift from a center frequency of 9800 Hz exceeds valid parameters. However, the command "CF5000 SF1000" is legal because the 1000 Hz shift is from the center frequency of 5000 Hz. This type of error is rare due to the large acceptable range of space and mark frequency parameters.

5.4.2 ERROR CORRECTION

Errors detected on a command line before it is entered can be deleted by using the BACKSPACE key (Control H or 8 HEX). Each time the terminal key is pressed, the last character in the WJ-9472 buffer memory is deleted (note that blank spaces are not stored). RUBOUT (7F HEX) and CANCEL (Control X or 18 HEX) keys are interpreted similarly.

SECTION VI

WJ-9472/488 INTERFACE OPTION

6.1 GENERAL DESCRIPTION

The WJ-9472/488 Interface Option enables two-way asynchronous communication between the WJ-9472 and a wide range of IEEE 488 compatible units. Up to 14 demodulators can be controlled by one remote controller. Instrumentation protocol of standard ASCII characters is used for all information transfer.

6.2 INTERFACE CONNECTIONS

To connect the WJ-9472 Demodulator with the IEEE 488 option for remote operation the 25 pin connector from a remote unit must plug into the rear panel receptacle of the demodulator. Figure 6-1 shows the IEEE 488 connector pin locations and lists their functions.

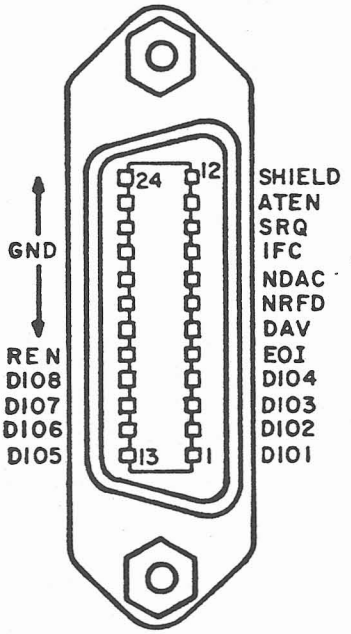


Figure 6-1. IEEE 488 Interface Connector

6.3 ADDRESS SWITCH SETTING

Talker and Listener addresses for remote communications between the WJ-9472 and a remote controller are established by setting switch S1 on the 488 board. The ASCII address codes are listed in Table 6-1.

6.4 IEEE 488 INTERFACE SIGNAL LINES

The WJ-9472/488 Interface Bus consists of 8 data bus lines, 3 data byte transfer lines, and 3 interface management lines. The formats for addresses and control bytes are defined by the IEEE 488 Standard.

6.4.1 DATA BUS

The data bus lines DIO1 through DIO8 are used to transfer addresses, control information, and data. Data formats are in strings of ASCII characters. DIO1 is the least significant bit. A binary 1 is low and zero is high.

6.4.2 DATA BYTE TRANSFER LINES

1. NRFD - The Not Ready for Data handshake line is set low by a Listener to indicate that it is not yet ready for the next data or control byte. The controller does not notice the NRFD set high until all devices have set the NRFD line high.

2. NDAC - The Not Data Accepted handshake line is set low by a Listener to indicate that it has not accepted the data or control byte on the DIO lines. The controller does not notice the NDAC line set high until all devices have set NDAC lines high.

3. DAV - The Data Valid handshake line is set low by the Talker to indicate that a data or control byte has been placed on the DIO lines and has had the minimum specified settling time.

6.4.3 INTERFACE MANAGEMENT LINES

1. ATN - The Attention line is set low by the controller to indicate that it is placing an address or control byte on the data bus. The ATN line is set high to allow the assigned Talker to place status information or data on the data bus. The controller regains control by resetting the ATN line low.

2. EOI - The End or Identify line is only used when the WJ-9472/488 is a Talker. When the WJ-9472/488 is a Listener the EOI line is ignored. EOI indicates the end of data.

Table 6-1. IEEE 488 Address Codes

Decimal	Listen Address ASCII	Talker Address ASCII	S1 Switch Setting* 5	4	3	2	1
0	(space)	@	0	0	0	0	0
1	!	A	0	0	0	0	1
2	"	B	0	0	0	1	0
3	#	C	0	0	0	1	1
4	$	D	0	0	1	0	0
5	%	E	0	0	1	0	1
6	&	F	0	0	1	1	0
7	'	G	0	0	1	1	1
8	(	H	0	1	0	0	0
9	)	I	0	1	0	0	1
10	*	J	0	1	0	1	0
11	+	K	0	1	0	1	1
12	,	L	0	1	1	0	0
13	-	M	0	1	1	0	1
14	.	N	0	1	1	1	0
15	/	O	0	1	1	1	1
16	0	P	1	0	0	0	0
17	1	Q	1	0	0	0	1
18	2	R	1	0	0	1	0
19	3	S	1	0	0	1	1
20	4	T	1	0	1	0	0
21	5	U	1	0	1	0	1
22	6	V	1	0	1	1	0
23	7	W	1	0	1	1	1
24	8	X	1	1	0	0	0
25	9	Y	1	1	0	0	1
26	:	Z	1	1	0	1	0
27	;	[	1	1	0	1	1
28	<	/	1	1	1	0	0
29	=	]	1	1	1	0	1
30	>	^	1	1	1	1	0
31	Not Used	Not Used	1	1	1	1	1

* S1-6, -7, -8 are not used.

0 = Switch closed (on)

1 = Switch open (off)

3. IFC - The Interface Clear is set low only by the controller to initialize all device interfaces to a known state. After setting the IFC line high the controller has active control of the system. The IFC line is used mainly at system start-up and following failures.

4. The SRQ and REN management lines are not enabled.

.5 INTERFACE FUNCTIONS

There are ten interface functions specified by the IEEE-488 Standard, not all are nabled by the WJ-9472/488.

1. SH - The Source Handshake function allows a device to properly transfer data from a Talker to one or more Listeners using the three handshake lines.

2. AH - The Acceptor Handshake function allows a device to properly receive data from the Talker using the three handshake lines. The AH function may also delay the beginning (NRFD) or end (NDAC) of any transfer.

3. T - The Talker function allows a device to send status and data bytes when addressed to talk. An address consists of one byte.

4. L - The Listener function allows a device to receive data when addressed to listen.

5. The following 488 functions are not enabled on the WJ-9472/488:

   - SR - Service Request
   - RL - Remote Local
   - PP - Parallel Poll
   - DC - Device Clear
   - DT - Device Trigger
   - C - Controller

.6 REMOTE INPUT/OUTPUT FORMAT

The WJ-9472/488 Interface option uses the mnemonic commands listed in able 6-2. Each command line must end with Carriage Return (CR) and Line Feed (LF). The aximum length of any command line is 82 characters, not including blanks, which are ignored. pper case or lower case characters may be used. Commands may be made in any order, xcept for RS which must be the last command on any line where it is used. Commands are xecuted only in the remote mode, except RS, RE, and LO which can be executed in either emote or local modes. Figure 6-2 provides an example of communication between a controller nd the WJ-9472/488.

Table 6-2. WJ-9472/488 Remote Input/Output Format

Data	Code (ASCII)
CRF	
Channel Number	CHxx
Source Number	SOxx
FSK/OOK	FK, OK
Norm/Invert	NM, IN
Data ON/OFF	ON, OF
Space Frequency	SPxxxx
Mark Frequency	MKxxxx
Center Frequency	CFxxxx
Shift Frequency	SFxxxx
Baud Rate	BRxxxx
Element Length	ELxxxx
Remote/Local	RE, LO
Reset	RS
DDU	
Decode A, B, C	DA, DB, DC
Chans Norm/Reverse	NO, RV
FCTN: SPLIT (Independent), DFSK, C DIV, S DIV	ID, DF, CD, SD

xxxx indicates string of numbers

When transmitting data leading zeros need not be included.
Leading zeros are included in data read back.

COMMAND: Listen Address 3*

RS CRLF
This command resets the unit at address 3. (CRLF is Carriage Return and Line Feed)

COMMAND: Write Address 3**

Queries the state of the unit at address 3.

RESPONSE:

CH1 SO1 FK NM ON SP1000 MK1000 BR0100 DA NO CN1 CN2 ID LO CRLF

Active Channel State — DDU Status (If DDU is installed) — Control Status

COMMAND: Listen Address 3*

RE MK2875 SP2125 SO2 BR45 CRLF

COMMAND: Write Address 3**

RESPONSE:

CH1 SO2 FK NM ON SP2125 MK2875 BR0045 DA NO CN1 CN2 ID RE CRLF

COMMAND: Listen Address 3*

CH2CF5000SF50EL2000INLOCRLF

COMMAND: Write Address 3**

RESPONSE:

CH2 SO1 FK IN ON CF5000 SF0050 EL2000 DA NO CN1 CI2 ID LO CRLF

* The state of the interface bus for "Listen Address 3" is:
ATN (low), 23 HEX on data bus (#), DAV (low), wait for NDAC (high), DAV (high), remove data, ATN (high)

** The state of the interface bus for "Write Address 3 is:
ATN (low), 43 HEX on data bus (C), DAV (low), wait for NDAC (high), DAV (high), remove data, ATN (high)

Figure 6-2. Example of WJ-9472/488 Remote Communication

6.6.1 COMMAND ERRORS

There are two types of command errors encountered in remote operation: the unrecognizable command and the parameter violation error.

6.6.1.1 Unrecognizable Command Error

If a command is not recognized; for example, using the letter Q (no valid command contains Q), processing of the command line is halted and the remainder of the line is not processed.

6.6.1.2 Parameter Violation Error

If a command line specifies a parameter which exceeds the valid range, that parameter will not be changed; however, the rest of the line is processed normally. For example, if the current baud rate is 500 baud and the command "BR6600" (baud rate, 6600 baud) is transmitted, the error will be recognized as exceeding the 4000 baud limit and the baud rate of 500 baud will be retained. All other legal commands in the command line would be processed normally.

A more subtle parameter error can occur in the Center Frequency/Shift mode. If the center frequency or shift command would require the mark or space frequency to be out-of-range (less than 200 Hz or greater than 9999 Hz), an error will occur. This could occur in two ways:

1) The command "CF9800 SF1000" is illegal because it would require a mark frequency of:

   9800 + 1000/2 + 10,300 Hz, which is out of range.

2) The order in which the commands are entered can create a parameter violation. For example, with the center frequency set at 9800 Hz, the command "SF1000 CF5000" is illegal because the commands are processed in the order in which they are received. A 1000 Hz shift from a center frequency of 9800 Hz exceeds valid parameters. However, the command "CF5000 SF1000" is legal because the 1000 Hz shift is from the center frequency of 5000 Hz. This type of error is rare due to the large acceptable range of space and mark frequency parameters.

6.6.2 ERROR CORRECTION

Errors detected on a command line before it is entered can be deleted by using the BACKSPACE key (Control H or 8 $_{HEX}$). Each time the terminal key is pressed, the last character in the WJ-9472 buffer memory is deleted (note that blank spaces are not stored). RUBOUT (7F $_{HEX}$) and CANCEL (Control X or 18 $_{HEX}$) keys are interpreted similarly.

6.7 REPLACEMENT PARTS LIST

SECTION VII

WJ-9472/SMU SIGNAL MONITOR UNIT OPTION

7.1 GENERAL DESCRIPTION

The WJ-9472/SMU Signal Monitor Unit is an optional unit which plugs into the WJ-9472/CRF Control Rack Frame. It provides a selection of nine displays which aid in proper tuning of the WJ-9472 FSK Demodulator System, determining signal type and determining the parameters of the signal. With this unit installed, it is possible to measure frequency shifts to better than 1 Hz accuracy. To provide greater resolution, the SMU provides X and Y axis information to the rear panel of the WJ-9472/CRF to drive an external display.

7.2 OPERATING PROCEDURES

The WJ-9472/SMU Signal Monitor Unit functions in conjunction with the WJ-9472 FSK Demodulator system. The operating controls provide CRT displays which aid an operator in tuning and analyzing signals processed by the system.

7.2.1 CONTROLS AND INDICATORS

INTENSITY - Adjusts the brightness of the CRT trace. Full clockwise rotation provides maximum trace brightness, with brightness decreasing as the control is rotated counter-clockwise. Maximum counter-clockwise rotation turns off the WJ-9472/SMU CRT. The intensity affects only the CRT intensity and has no effect on SMU operation or the external display outputs of the Control Rack Frame.

FOCUS - Controls the sharpness of the trace on the SMU CRT.

SWEEP RANGE - Controls the speed of the horizontal sweep when one of the swept displays is selected by the Function control. It provides operator selectable sweep times of .1, .2, .5, 5 or 10 msec per division on the CRT horizontal axis.

VAR SWEEP - Permits the sweep speed, selected by the Sweep Range Control, to be varied from the selected range. Full clockwise rotation places the sweep speed into the CAL position, causing the horizontal trace to sweep at the speed selected by the Sweep Range control. Counter-clockwise rotation of this control reduces the sweep speed. The push-pull function of this control selects a free-running sweep (push) or a triggered sweep (pull).

FM FILTER - Controls the frequency response of the Signal Monitor Unit when the FM MK or FM SP displays are selected by the Function control. Maximum clockwise rotation of this control provides maximum frequency response, with counter-clockwise rotation decreasing the response bandwidth to reduce the effects of noise on the trace. Pulling the FM

Filter control to the HI (OUT) position increases the FM Filter bandwidth by a factor of ten.

GAIN - Controls the signal gain within the Signal Monitor Unit. When swept displays are selected by the Function control, the Gain control adjusts the vertical amplitude of the CRT display. When AMP, PHASOR or DFSK displays are selected, this control varies the X and Y axis of the trace simultaneously.

CH1/CH2 - Selects an input to the Signal Monitor Unit from either channel 1 or channel 2.

FUNCTION - Selects one of nine possible traces to be displayed on the CRT of the Signal Monitor Unit.

FM SP	Provides a swept display of the Space IF from the selected channel after FM detection.
FM MK	Provides a swept display of the Mark IF from the selected channel after FM detecton.
AMP	Provides an amplitude vector display of the mark and space detector outputs.
PHASOR SP	Provides a phasor display of the space frequency, showing instantaneous signal amplitude and phase.
PHASOR MK	Provides a phasor display of the mark frequency, showing instantaneous signal amplitude and phase.
RAW DATA	Provides a swept display of the RAW DATA output of the demodulator unit selected by the CH1/CH2 switch.
DATA	Provides a swept display of the demodulated data at the digital output of the demodulator.
DUAL DATA	Provides two swept displays of the demodulated data at the channel 1 and channel 2 outputs of the demodulator. The top trace is the channel 2 data and the bottom trace is the channel 1 data.
DFSK	Provides an amplitude vector display of the four tone filter detector outputs. This is used as a tuning and analysis aid for DFSK signals.

7.2.2 SIGNAL TUNING

7.2.2.1 Receiver Tuning

1. Tune the receiver to the desired RF frequency and set the receiver BFO for a -5 kHz BFO offset frequency.

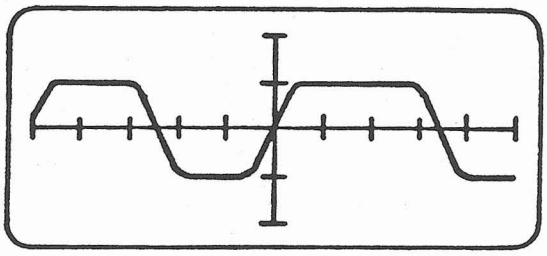
2. Preset the FSK Demodulator system controls as follows:

KEYING SPEED :	4000 BAUD
MARK FREQ :	5000 Hz (receiver BFO offset)

3. Preset the WJ-9472/SMU as follows:

INTENSITY :	As required
FOCUS :	As required
SWEEP RANGE :	5 msec.
VAR SWEEP :	Free-running (push in)
FM FILTER :	3 o'clock position, low range (push in)
GAIN :	12 o'clock position
CH1 CH2 :	To channel to be tuned
FUNCTION :	FM MK

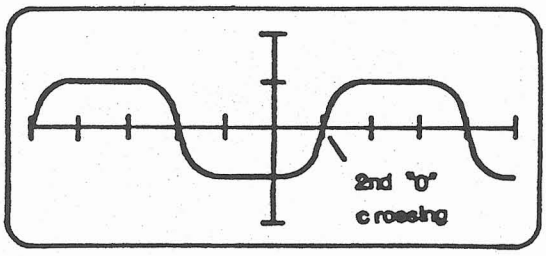
4. Adjust the frequency control of the receiver until the signal in the FM MK display is centered on the CRT. This assures that the signal being tuned is centered in the IF passband of the receiver.



7.2.2.2 Determining Element Length

1. Set the VAR SWEEP to CAL and pull the control to the out (triggered) position to provide a calibrated, triggered sweep.

2. Adjust the SWEEP RANGE control such that the second zero crossing afer the start of the sweep is as far to the right of the display as possible. Note the control setting and the point where the second zero crossing occurred.



3. Calculate the element length as follows:

$$\text{ELEMENT LENGTH} = \frac{\text{\# of Horizontal Division X SWEEP RANGE}}{2}$$

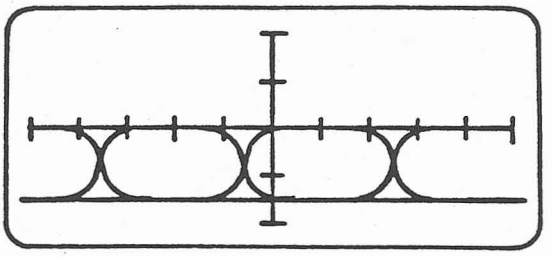
7.2.2.3 Tuning Mark and Space Frequencies with the FM Display

1. Select a free-running sweep by pushing the VAR SWEEP control to the in position.

2. Set the SWEEP RANGE control to .2 msec/Div. to provide an overlapping trace on the CRT.

3. Adjust the FM FILTER control for distinct upper and lower lines on the trace.

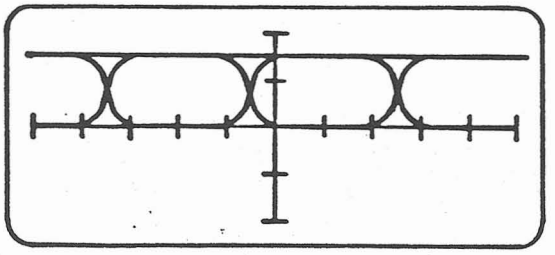
4. Adjust the MARK FREQ of the channel being tuned until the higher signal frequency (upper edge of the trace) coincides with the center horizontal line of the CRT.



5. Increase the SMU GAIN setting and repeat step 4 to improve the sensitivity of the adjustment.

6. Return the GAIN setting to the 12 o'clock position and set the FUNCTION control to FM SP.

7. Adjust the SPACE FREQ of the channel being tuned until the lower signal frequency (lower edge of the trace) coincides with the center horizontal line of the CRT.



8. Increase the SMU GAIN Setting and repeat step 7 to improve the sensitivity of the adjustment.

7.2.2.4 Final Demodulation Settings

1. Select the ELEMENT LENGTH display on the WJ-9472/CRF.

2. Enter the element length determined in step 3 of paragraph 7.2.2.2.

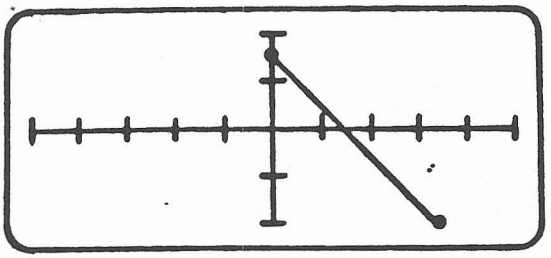
3. Select the KEYING SPEED display. The keying, speed, in baud, will now be displayed on the CRF display.

4. To monitor the signal data afer the keying speed is set, set the Function control to DATA.

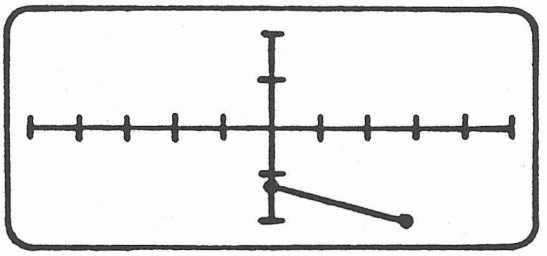
7.2.3 DISPLAY ANALYSIS

7.2.3.1 AMP

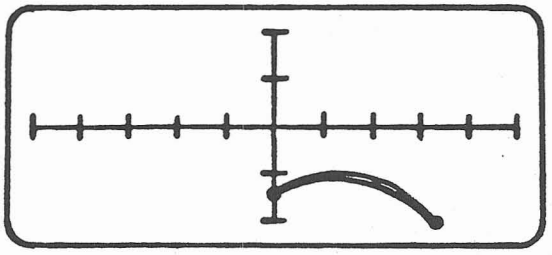
The AMP function provides an amplitude vector of the mark and space frequencies, with the mark amplitude represented as vertical deflection and space amplitude represented as horizontal deflection. With properly tuned mark and space frequencies, the resulting display is a diagonal vector extending across the CRT. The vector angle represents the relative amplitudes of the mark and space signals (equal mark and space amplitudes produce a 45° angle).



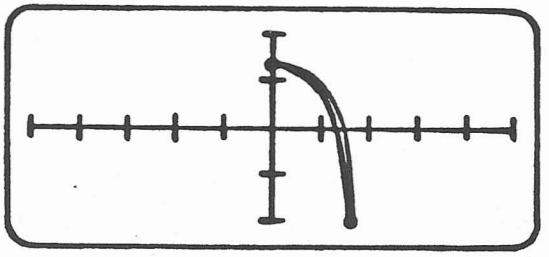
Correctly Tuned FSK Signal



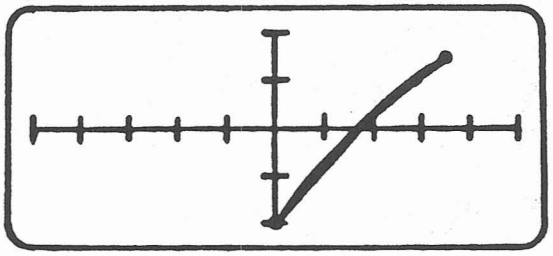
FSK Signal with Selective Signal Fading (Mark Fade Dominant)



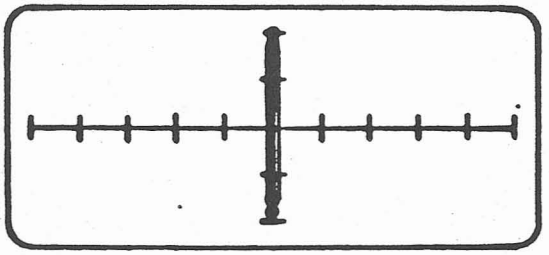
Mark Frequency Mistuned



Space Frequency Mistuned



Identical Mark and Space Frequencies

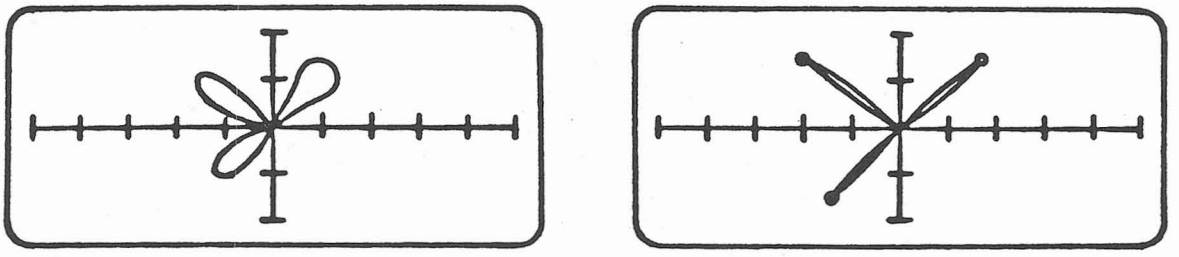


Mark Frequency Only (OOK)

Figure 7-1 Typical AMP Displays

7.2.3.2 PHASOR MK/PHASOR MK

The Phasor functions provide a phasor display of the space frequency (PHASOR SP) or mark frequency (PHASOR MK), showing instantaneous signal amplitude and phase. These functions permit mark and space tuning with greater precision than the FM displays to allow precise analysis of phasor shift. Precision tuning of the mark or space frequency can be accomplished by incrementing or decrementing the appropriate tuning control while observing the display. A properly tuned FSK mark or space frequency produces a phase display with minimum looping of the phasor lobes and sharp bright points at the lobe tips. Mistuning causes increased looping of the lobes and an increase in the rotation of the phasor display. The speed and direction of the phasor rotation also provides an indication of the degree and direction of mistuning. Clockwise rotation indicates that the signal frequency is greater than the demodulator tuned frequency and counter-clockwise rotation indicates that the signal frequency is less than the tuned frequency of the demodulator.



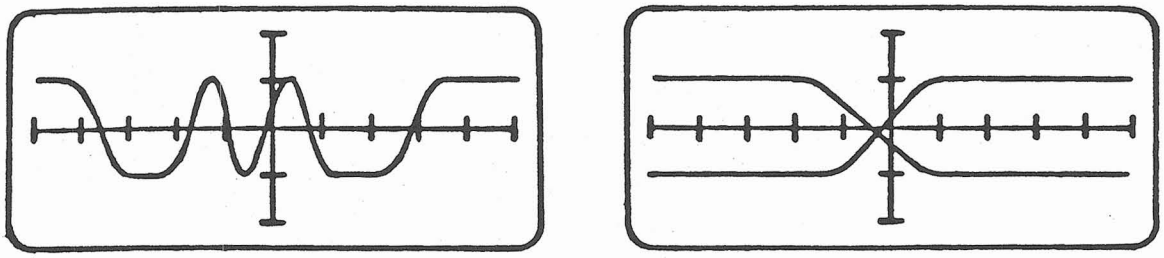
Looping of Phasor lobes due To mark or space frequency Mistuning

Properly tuned mark or space FSK tone

Figure 7-2. Typical Phasor Displays

7.2.3.3 RAW DATA

The RAW DATA function provides a swept display of the demodulated data before it is squared by the decision circuitry of the demodulator unit. This trace permits the Raw Data output of the demodulator to be viewed and also permits the Keying Speed to be determined to within .05% accuracy. To determine the Keying Speed using the raw data display, set the sweep to free-running (VAR SWEEP pushed in) and adjust the VAR Sweep control for a stable display. Connect a frequency counter to the External Monitor "X" output of the WJ-9472/CRF. The frequency displayed on the frequency counter is equal to the keying speed, in baud.



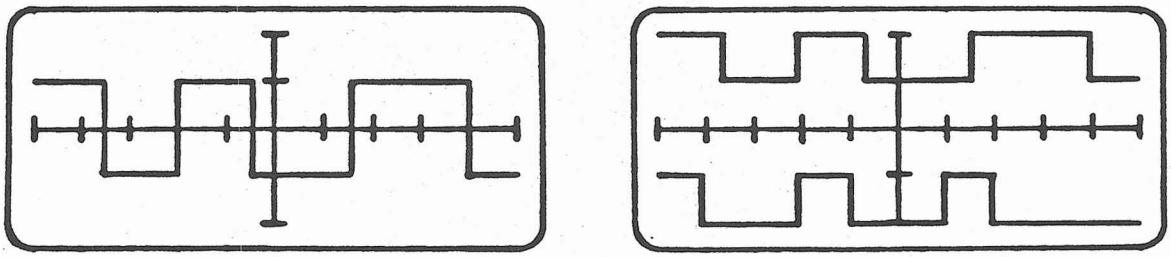
Triggered Raw Data Display

Free Running Display for Speed Measurement

Figure 7-3. Typical Raw Data Displays

7.2.3.4 DATA/DUAL DATA

The DATA and DUAL DATA functions provide swept displays of the demodulated data after being squared by the decision circuitry of the demodulator unit. These displays provide squared waveforms with distinct mark and space transitions to simplify monitoring of the received signal. The DATA function provides a single data trace of either the channel 1 or channel 2 data as selected by the CH1/CH2 switch on the Signal Monitor Unit fron panel. In the DUAL DATA function, both the channel 1 and channel 2 data are displayed. The channel 2 data is represented on the top trace and the channel 1 data is represented on the bottom trace.



Data Display

Dual Data Display

Figure 7-4. Typical Data Displays

7.2.3.5 DFSK

The DFSK function provides an amplitude vector display of the mark and space frequencies from channel 1 and channel 2 simultaneously. When the DFSK signal is properly tuned, this display is used to determine the permutation of the DFSK signal.

7.2.3.5.1 DFSK Tuning

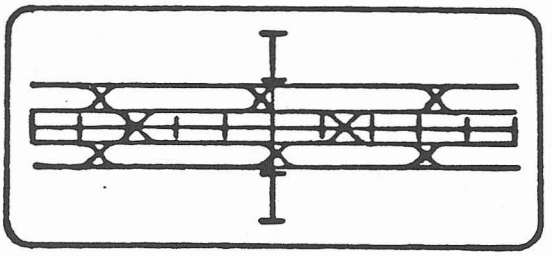
1. Preset the FSK Demodulator system controls as follows:

CH 1 :	to the desired input (input 1 or input 2)
CH 2 :	to the same input as CH 1
CH 1 MARK FREQ :	to the receiver BFO offset frequency

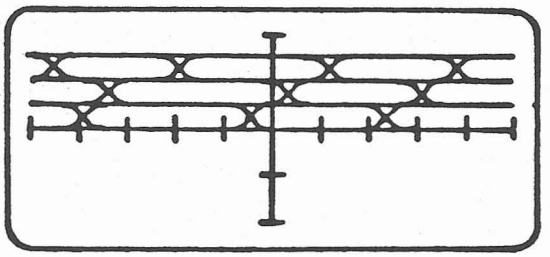
2. Preset the WJ-9472/SMU as follows:

INTENSITY :	As required
FOCUS :	As required
SWEEP RANGE :	.2 msec
VAR SWEEP :	Free-running (push-in)
FM FILTER :	3 o'clock position, low range (push-in)
GAIN :	11 o'clock position
FUNCTION :	FM SP

3. Adjust the frequency control of the receiver until the DFSK signal in the FM MK display is centered on the CRT. This assures that the signal being tuned is centered in the IF passband of the receiver.



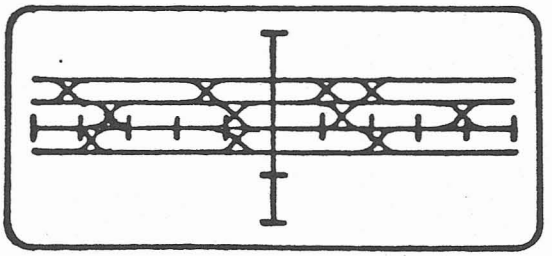
4. Select CH 1 on the WJ-9472/CRF and tune the SPACE FREQ until the lowest signal frequency (bottom edge of trace) coincides with the center horizontal line of the CRT.



5. Increase the SMU Gain setting and repeat step 4 to improve the sensitivity of the adjustment.

6. Return the GAIN setting to the 11 o'clock position and set the FUNCTION control to FM MK.

7. Adjust the MARK FREQ until the higher signal frequency of channel 1 (second trace from the bottom edge of the display) coincides with the center horizontal line of the CRT.

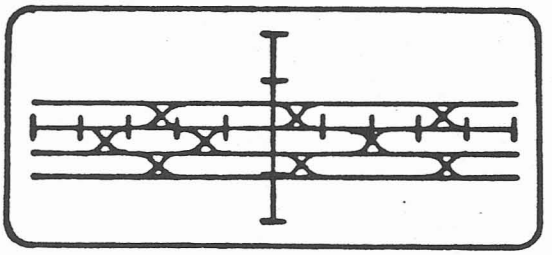


8. Increase the SMU GAIN Setting and repeat step 7 to improve the sensitivity of the adjustment.

9. Return the GAIN setting to the 11 o'clock position and set the FUNCTION control to FM SP.

10. Select CH 2 on the WJ-9472/CRF.

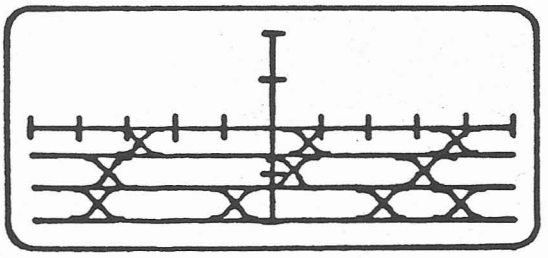
12. Adjust the SPACE FREQ until the lowest signal frequency of channel 2 (second trace from the top of the display) coincides with the center horizontal line of the CRT.



13. Increase the SMU GAIN setting and repeat step 12 to improve the sensitivity of the adjustment.

14. Return the GAIN setting to the 11 o'clock position and set the FUNCTION control to FM MK.

15. Adjust the MARK FREQ until the highest signal frequency of channel 2 (top edge of the trace) coincides with the center horizontal line of the CRT.

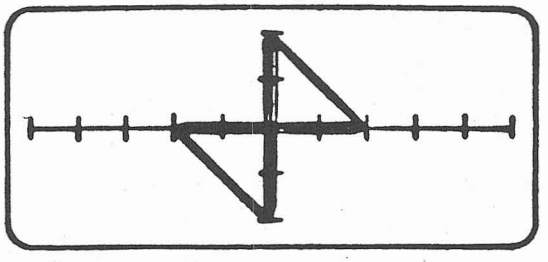


16. Select CF SHIFT on the WJ-9472/CRF and note the SHIFT frequency. Set the KEYING SPEED BAUD to the SHIFT noted.

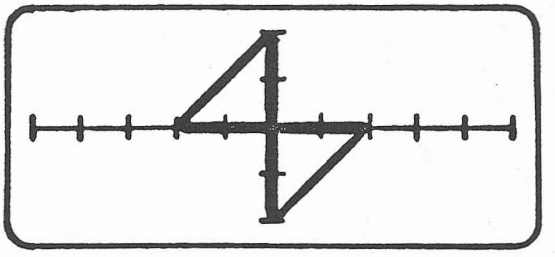
17. Select CH 1 and CF SHIFT on the WJ-9472/CRF. Note the SHIFT frequency. Set the KEYING SPEED BAUD to the SHIFT noted.

18. Set the SMU FUNCTION control to the DFSK position and adjust the GAIN to provide a usable display.

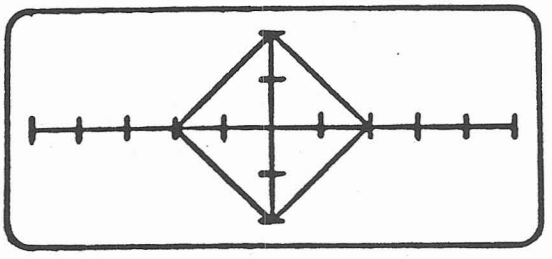
19. Compare the display with the examples provided in Figure 7-5 to determine the type Permutation.



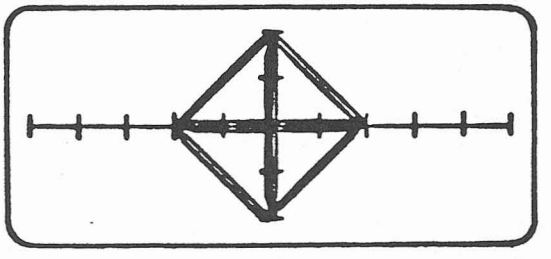
Permutation A



Permutation B



Permutation C



Permutation Indeterminate

Figure 7-5. Typical DFSK Displays

7.3 PARTS LIST

SECTION VIII

WJ-9472/DDU, DFSK DIVERSITY UNIT

8.1 GENERAL DESCRIPTION

The WJ-9472/DDU is an optional unit which plugs into and is powered by the WJ-9472/CRF. It accepts inputs from the two FSK system demodulator units and provides DFSK operation or a diversity combination of the two demodulator outputs.

8.2 OPERATING PROCEDURES

The WJ-9472/DDU contains five front-panel pushbuttons which control the DDU operation. These pushbutton controls, as illustrated in Figure 8-1, select the DDU operating mode, permutation decoding scheme, data sense and the data path assignments of the decoded data.

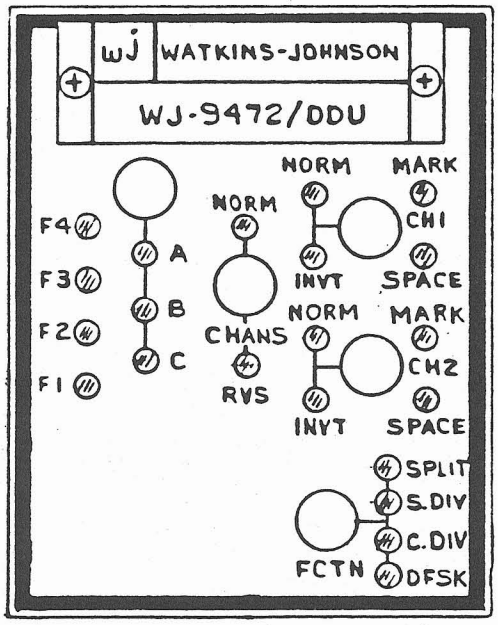


Figure 8-1. WJ-9472/DDU Front Panel.

3.2.1 CONTROLS AND INDICATORS

3.2.1.1 FCTN - Function-Selects one of four DFSK/Diversity Unit operating modes as follows:

SPLIT - In this mode, each of the WJ-9472 FSK System demodulators function independently. When this mode is active, the SPLIT LED is illuminated.

S.DIV - Selection Diversity - The DDU selects data from the demodulator with the stronger signal. Constant-Ratio-Hysteresis is utilized to control channel selection depending on the ratio of the channel signal strengths, rather than their absolute amplitudes, to minimize bobble between channels. This mode is best utilized when the two signals are not aligned in time, bit-for-bit; for example, where time delays occur due to differences in propagation paths between signals. The S.DIV LED is illuminated when this mode is selected.

C.DIV - Combination Diversity - This mode combines the outputs of the two system demodulators using a summation process. It is best used when the channels are aligned in time bit-for-bit. For example, with slow data rates where antenna diversity or in-band frequency diversity are used, such as a multi-tone VFT signal. The C.DIV LED is illuminated when this mode is selected.

DFSK - Double Frequency Shift Keying - This mode is used to demodulate four frequency (Quaternary) FSK signals into two binary channels. When this mode is selected, the DFSK LED is illuminated.

3.2.1.2 Permutation (unlabeled on DDU front panel) - Selects one of three decoding families which are used to properly decode DFSK signals. Indicator LED's A, B and C indicate which of the three code families has been selected by the Permutation pushbutton. The decoding scheme for each decoding family is illustrated in Table 8-1. In the table, F1 corresponds to the lowest frequency and F4 corresponds to the highest frequency.

Within each of the three code families (A, B and C), the two channels may be reversed in order i.e.; channel 1 exchanged for channel 2, and each of the channel polarities may be inverted independently. The combination of three code families, two channel orderings and two polarities in each of the channels yields a total of twenty-four decoding rules. For a quaternary signaling system there are exactly four factorial or twenty-four coding rules. The most common coding rule is that of CCIR recommendation 346-1. This corresponds to permutation family A, with the CH1, CH2 and CHAN controls in their normal state. Refer to the DFSK tuning procedure, using the WJ-9472/SMU option, as described in Section VIII, paragraph 7.2.3.5.1.

Table 8-1 WJ-9472/DDU Permutation Scheme

FREQ	Perm. A (CCIR Std.)		Perm. B		Perm. C	
	CH1	CH2	CH1	CH2	CH1	CH2
F4	0	0	1	0	0	1
F3	0	1	0	1	0	0
F2	1	0	0	0	1	0
F1	1	1	1	1	1	1

Note: CHAN, CH1, CH2 control settings in NORM mode

.2.1.3 Indicators F1 thru F4 - LED's F1 through F4 provide an indication of the signal trength of the four DFSK tones. These indicators indicate which of the four tone signals are trongest at any given instant. F1 corresponds to the lowest tone frequency and F4 corresponds o the highest frequency. With a properly tuned DFSK signal the assignments of these ndicators are as follows:

F4 - DU2 MK
F3 - DU2 SP
F2 - DU1 MK
F1 - DU1 SP

.2.1.4 CH1 - Controls the output data sense for Channel 1. The NORM and INVT LED's ndicate whether the normal or inverted data sense is selected. The MARK and SPACE LED's ndicate the data states for this channel.

.2.1.5 CH2 - Controls the output data sense for Channel 2. The NORM and INVT LED's ndicate whether the normal or inverted data sense is selected. The MARK and SPACE LED's ndicate the data states for this channel.

.2.1.6 CHAN - The channel switch controls the data path assignments to Channel 1 and 'hannel 2 after decoding. The NORM and RVS LED's indicate whether the normal data path is elected or if the data paths have been reversed.

.2.2 DIVERSITY TUNING

1. Using the SPLIT mode, tune both system demodulators to properly receive the FSK signals using the WJ-9472/SMU, as described in Sectin VII, paragraph 7.2.2

2. Set the baud rates of both channels to the same value.

3. Use the RAW DATA display to verify that both channels are tuned with the same signalling sense.

4. Select the DUAL DATA display on the SMU to view the bit alignment of each of the channel signals. If the two channels are aligned bit-for-bit, select Combination Diversity (C.DIV) on the DDU FCTN control. If the two channels are not bit aligned, Selection Diversity (S. DIV) mode is selected. Both data outputs will be driven by the diversity output when either S. DIV or C. DIV is selected..

8.2.3 DFSK TUNING

8.2.3.1 Tuning Signals When Parameters Are Known

1. Select the DFSK mode on the DDU.

2. Select the Center Frequency/Shift (CF/SHIFT) mode on the WJ-9472/CRF and enter the center frequency and shift frequency of the signal into the system.

3. Select the DFSK display on the signal monitor and adjust the center frequency control on the CRF for maximum display deflection.

4. Select the appropriate permutation on the DDU. Refer to Section VII, Figure 7-5, as a guide if the permutation scheme is not known.

5. Enter the keying speed for each channel, in baud, into the CRF.

8.2.3.2 Tuning Signals When Parameters Are Not Known

8.2.3.2.1 Four Tone Tuning Method

1. Select the SPLIT mode on the WJ-9472/DDU and the Space/Mark (S/M) tuning mode on the WJ-9472/CRF.

2. Tune each of the four DFSK tones, using the WJ-9472/SMU signal monitor as described in Section VII, paragraph 7.2.3.5.1.

3. Using the signal monitor DFSK display, compare the obtained display with the illustrations provided in Section VII, Figure 7-5, to determine the permutation type.

4. Select the DFSK mode on the DDU and select the appropriate permutation (A, B, or C) as determined in Step 3. If the permutation type cannot be determined, try permutation A (CCIR Standard) first.

5. Select the Raw Data display on the signal monitor and determine the keying speed of each of the channels as follows.

a. Set the signal monitor for a triggered sweep (VAR SWEEP pulled-out) and rotate the VAR SWEEP control fully clockwise to provide a calibrated trace. Display SMU channel one (CH1).

b. Set the SWEEP RANGE control such that the second zero crossing after the start of the sweep is as far to the right of the display as possible. Note the SWEEP RANGE setting and the point on the trace where the second zero crossing occurred.

c. Calculate the element lenght as follows:

$$\text{ELEMENT LENGTH} = \frac{\text{\# of Horizontal Divisions x SWEEP RANGE}}{2}$$

d. Repeat steps c and d fc 'CH2).

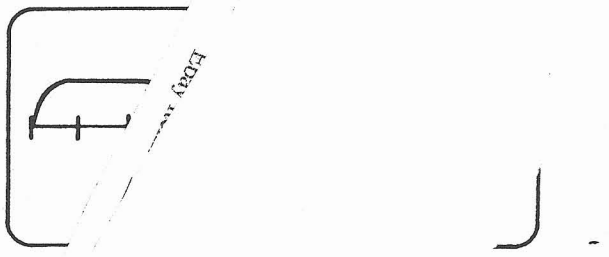


Figure 8-2. RAW D LENGTH Measurement.

6. Enter the e. .1 channel into the WJ-9472/CRF.

7. Select the data po RM/INVT) for each channel as required to provide a printable ou .t. If the permutation or data polarity is incorrect, at least one of the channels will be unprintable.

8.2.3.2.2 Two Tone Tuning Method

The Two Tone Tuning method provides a means of quickly tuning a DFSK signal when the DFSK tones are equally spaced. In this procedure the F1 (DU1 SP) and F2 (DU1 MK) frequencies are entered into the system as in the Four Tone Tuning Method (8.2.3.2.1) then the

FSK mode is selected. When the CRF tuning control is placed into the CF SHIFT mode, the nter frequency and shift is calculated by the system and the Four Tone frequencies are tuned ıtomatically.

1. Set the FCTN control of the WJ-9472/DDU into the SPLIT mode and place the WJ-9472/CRF into the Space/Mark (S/M) tuning mode.

2. Tune the F1 and F2 tones using the DFSK tuning procedures described in paragraph 7.2.3.5.1, Steps 1 through 8.

3. Set the FCTN control of the WJ-9472/DDU into the DFSK mode.

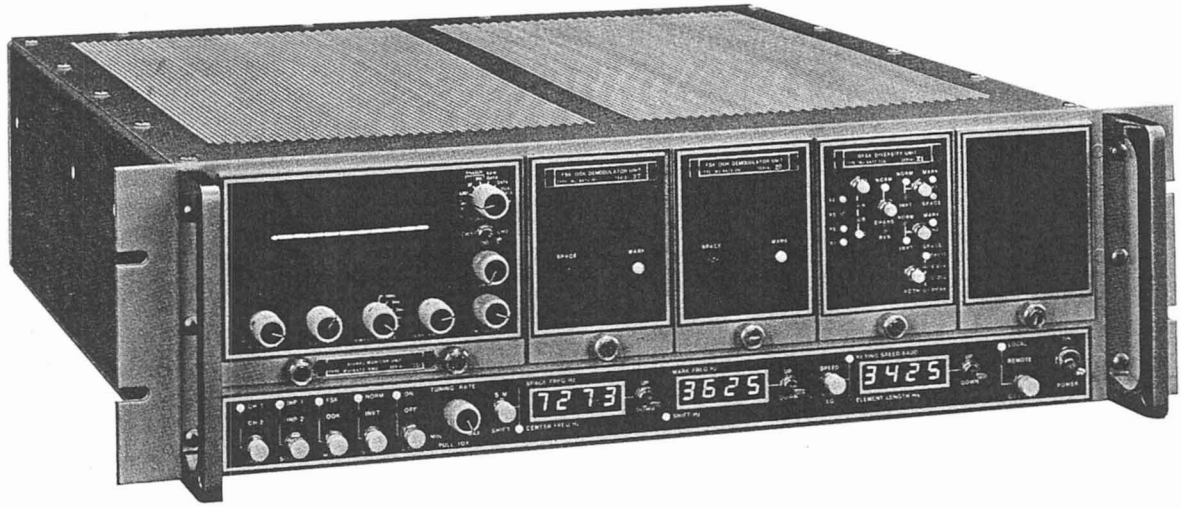
4. Select the CF SHIFT tuning mode on the WJ-9472/CRF.

5. Determine the permutation type and element length as described in the Four Tone Tuning Method (paragraph 8.2.3.2.1, Steps 3 through 7).

PARTS LIST

952.00

WJ-9472 TWO-CHANNEL FSK DEMODULATOR SYSTEM



FEATURES

- FSK or OOK Demodulation
- 1 Hz Mark and Space Frequency Control, 200 to 9999 Hz
- Multipole Baud Rate Matched Filters, 10 to 4000 Baud
- Microprocessor Control for Operational Flexibility
- Modular Construction for Easy Maintenance

OPTIONAL FEATURES

- Oscilloscope Tuning Display With WJ-9472/SMU Plug-In
- DFSK or Diversity Demodulation With WJ-9472/DDU Plug-In
- Data Regeneration With WJ-9472/DRU Plug-In
- IEEE-488 or RS-232 Control With WJ-9472/488 or WJ-9472/232

DESCRIPTION

The WJ-9472 Two-Channel FSK Demodulator System provides a maximum of flexibility in a minimum of space. The basic WJ-9472 System consists of one WJ-9472/CRF Control Rack Frame and two WJ-9472/DU Plug-In FSK Demodulator Units.

The WJ-9472/CRF will accept and provide power for the two WJ-9472/DU Demodulator Units as well as the optional WJ-9472/SMU Plug-In Oscilloscope Tuning Display and the optional WJ-9472/DDU Plug-In DFSK/Diversity Unit. The WJ-9472/CRF contains the control and display circuitry to operate the basic system. This control is exercised through front panel switches which are interpreted by the system microprocessor.

All of the signal parameters for each of the two WJ-9472/DU Plug-In FSK Demodulator Units can be set independently. Front panel controls allow selection of input source, signal sense, and mode, i.e.: FSK (Frequency Shift Keying) or OOK (On-Off Keying).

Mark and space frequencies may be entered independently in the 200 to 9999 Hz range with 1 Hz resolution; alternately, the frequencies can be entered in terms of center frequency and shift. The optimal sixth order mark and space filters are electronically matched to the signal by entering the keying speed in baud from 10 to 4000 baud or by entering the element length in milliseconds.

The analytical capability of the WJ-9472 may be enhanced with the addition of the WJ-9472/SMU Signal Monitor Unit. This unit provides seven signal display formats which allow the operator to quickly determine the signal type, achieve proper tuning and parameterize the signal. With the WJ-9472/SMU it is possible to determine frequency shifts to better than 1 Hz accuracy.

urther Information Please Contact:

KINS-JOHNSON COMPANY
uince Orchard Road, Gaithersburg, Maryland 20878
948-7550 TWX: 710-828-0546 Telex: 89-8402 Cable: WJCEI
d in U.S.A.

NOVEMBER 1982

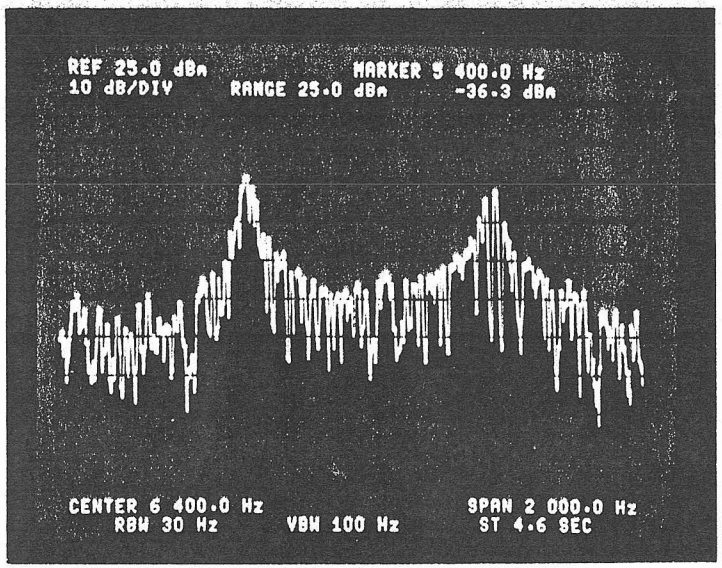
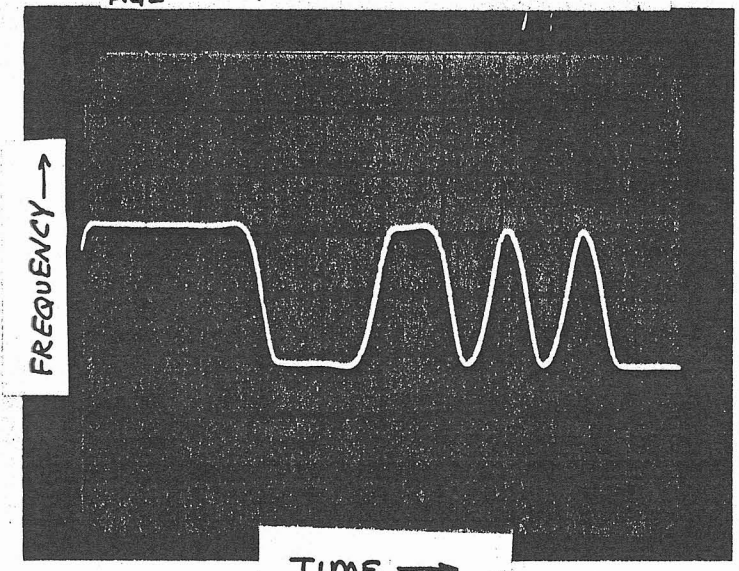


FIG 1 ORDINARY SPECTRUM ANALIZER DISPLAY

FSK

FIG 2 WJ-9472/SMU "FM" DISPLAY



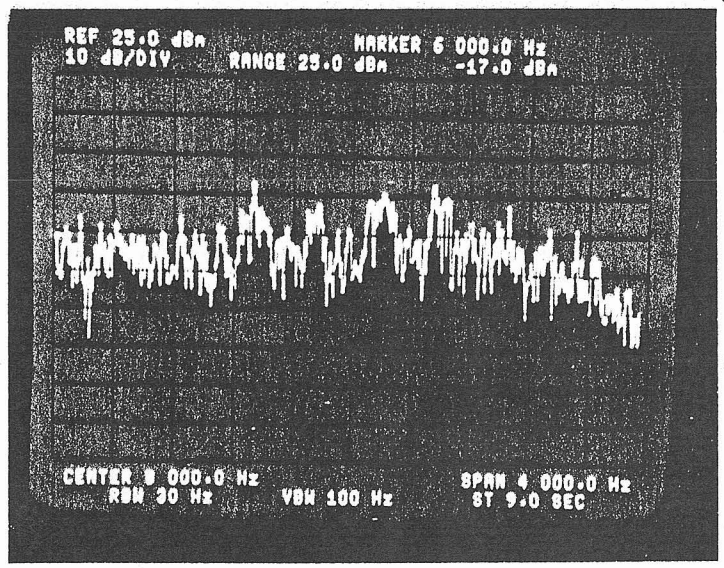
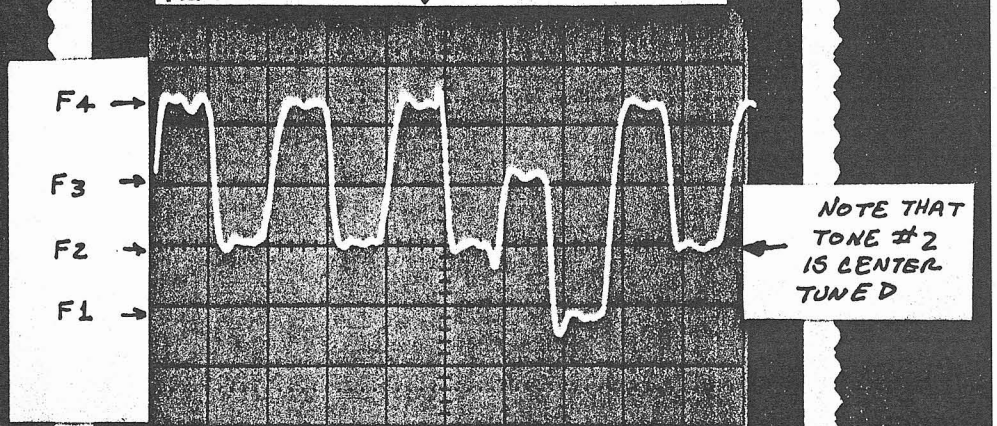


FIG 3 ↑ SPECTRUM ANALIZER

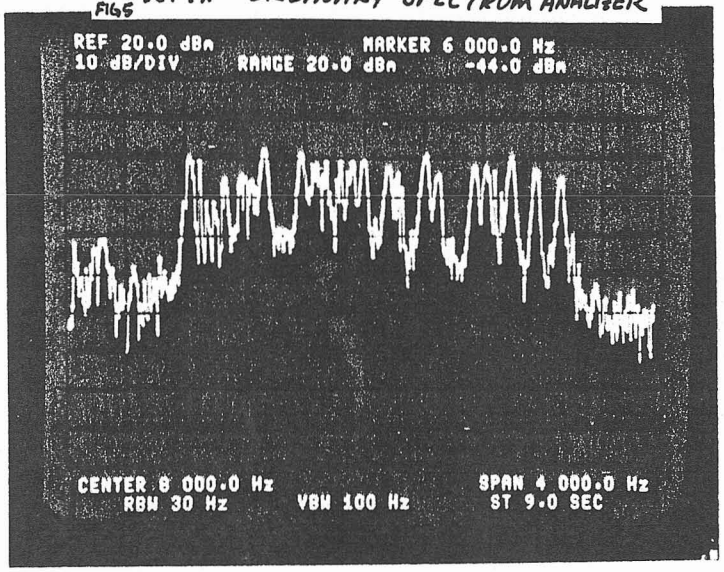
DFSK
(4 FREQ. FSK)

FIG 4 ↓ "FM" DISPLAY



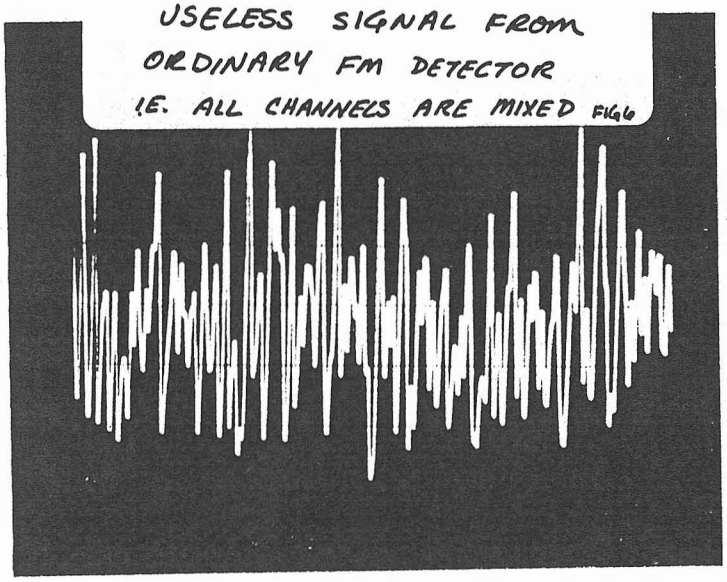
16 CHANNEL 170 Hz SPACING
85 Hz SHIFT (±42.5Hz) VFT

FIG5 WITH ORDINARY SPECTRUM ANALIZER

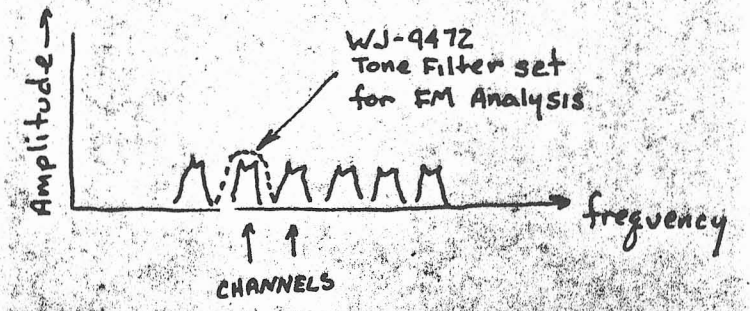


85Hz SHFT 170Hz SPACING

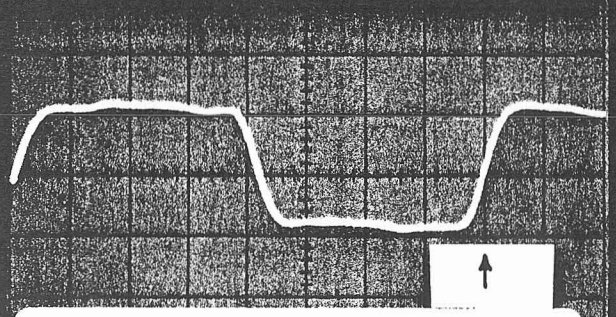
USELESS SIGNAL FROM
ORDINARY FM DETECTOR
IE. ALL CHANNELS ARE MIXED FIG6



Because the bandwidth of the tone filters is equal to the selected baud rate, the WJ-9472 can be used as a narrow-band receiver. If the bandwidth is set equal to the shift of a VFT signal, the FM detector can examine a single channel at a time. For example, with an 85Hz shift (±42.5 Hz deviation), a tone filter setting of 85 baud would be appropriate. The VFT signal may be scanned by slewing the center frequency of the tone filter, stopping at each channel as desired. In this way, it is possible To quickly determine the sort of signalling present in each channel.



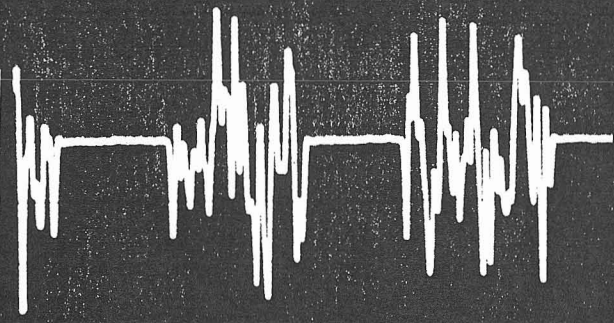
FM DISPLAY WITH
CALIBRATED, TRIGGERED SWEEP

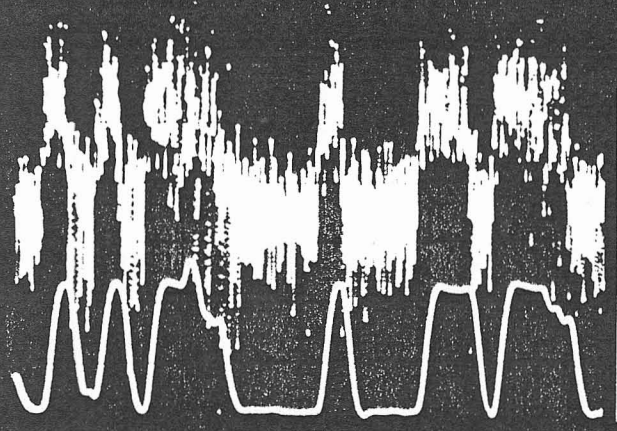


8 DIVISIONS @ 5mS/DIV = 40MS
⇒ 20 millisecond ELEMENT LENGTH
NOTE SLIGHT MARK BIAS

CW (OOK) "FM" DISPLAY

NOTE:
CENTER TUNED →



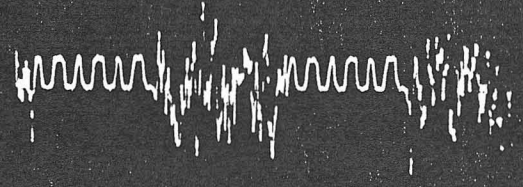


HIGH BANDWIDTH

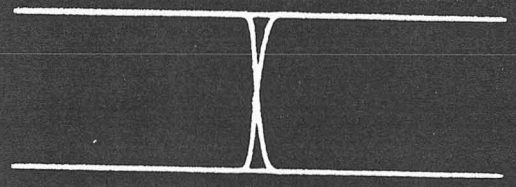
FM FILTER

LOW BANDWIDTH

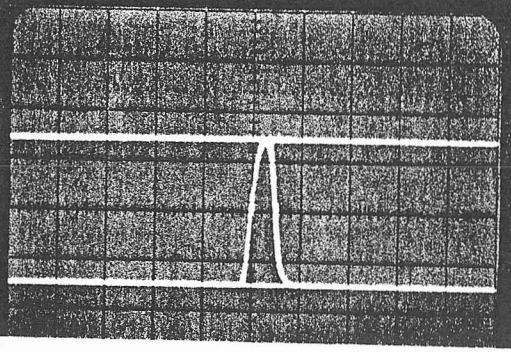
EFFECT OF POST-DETECTION FM FILTERING ON A NOISEY FSK SIGNAL



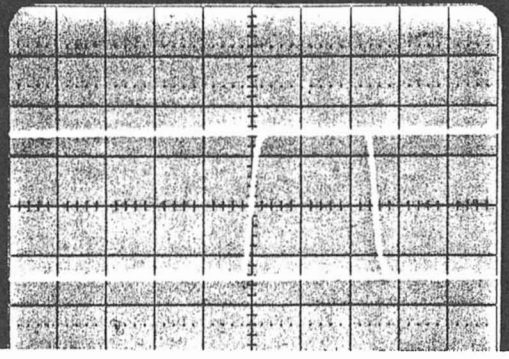
BURSTING FSK
"FM" DISPLAY



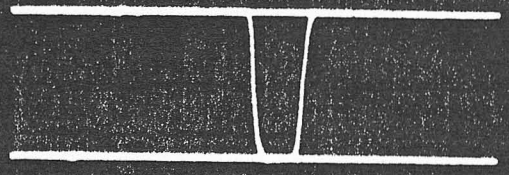
"FM" DISPLAY – FSK
HORIZONTAL SWEEP IN FREE RUN
ADJUSTED FOR STABLE DISPLAY
OF TRANSITION – NO BIAS



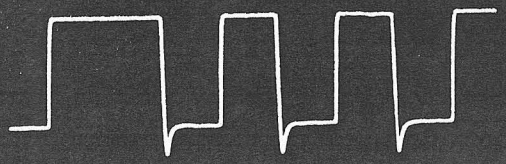
5% MARK BIAS



25% MARK BIAS

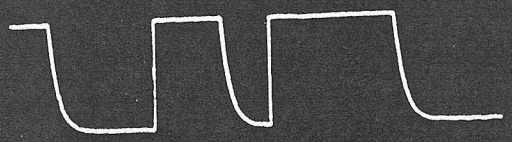


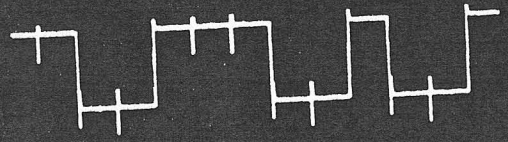
10% SPACE BIAS



"FM" DISPLAY - FSK

TRANSITION ANOMALIES

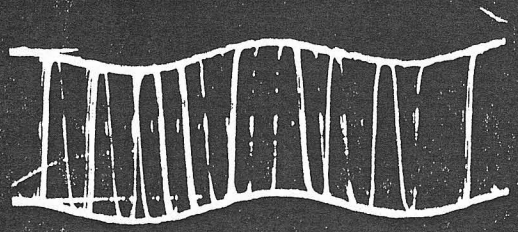




"FM" DISPLAY - FSK

"FM" DISPLAY

60 Hz POWER RIPPLE ON SIGNAL



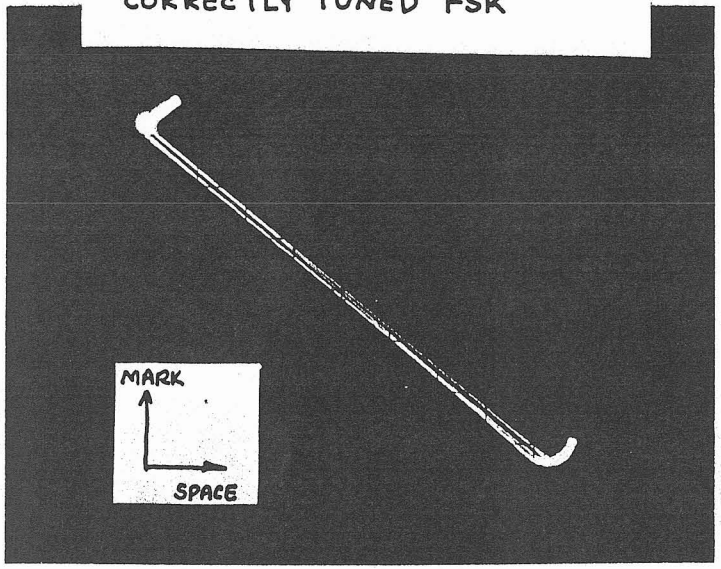
"FM" DISPLAY

HORIZONTAL SWEEP ADJUSTED

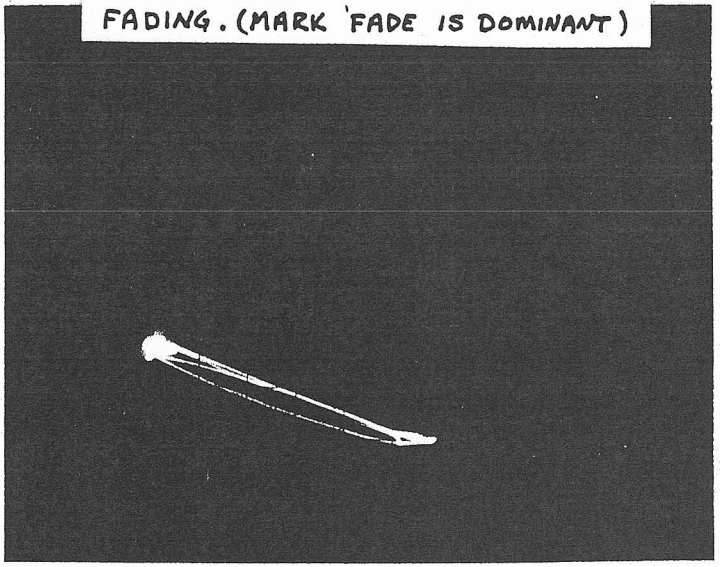
FOR STABLE DISPLAY OF RIPPLE

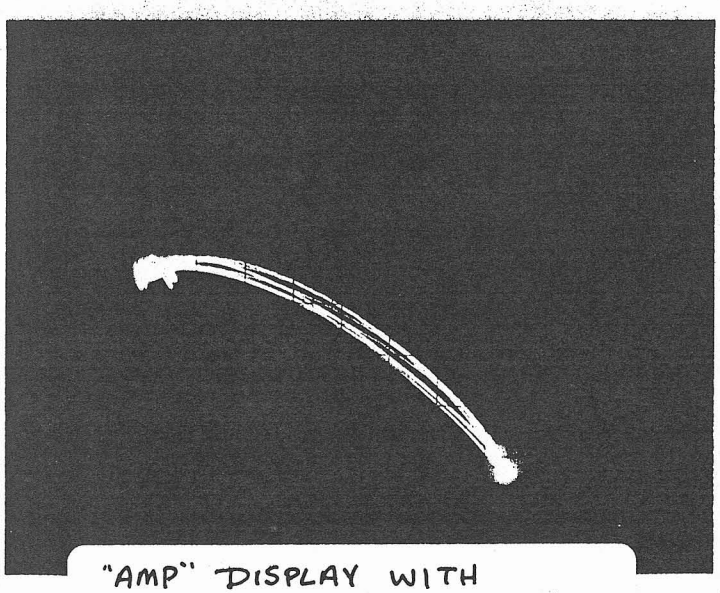
AMPLITUDE VECTOR DISPLAY ("AMP")

CORRECTLY TUNED FSK

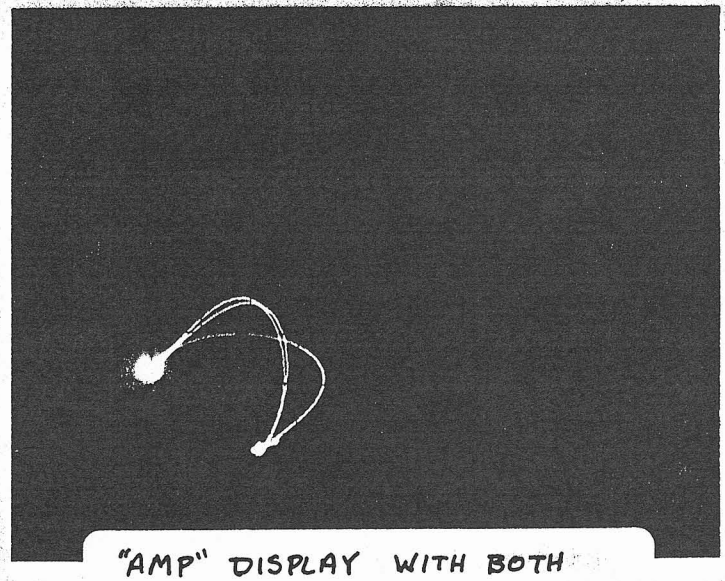


AMPLITUDE VECTOR DISPLAY ("AMP") WITH SELECTIVE SIGNAL FADING. (MARK FADE IS DOMINANT)



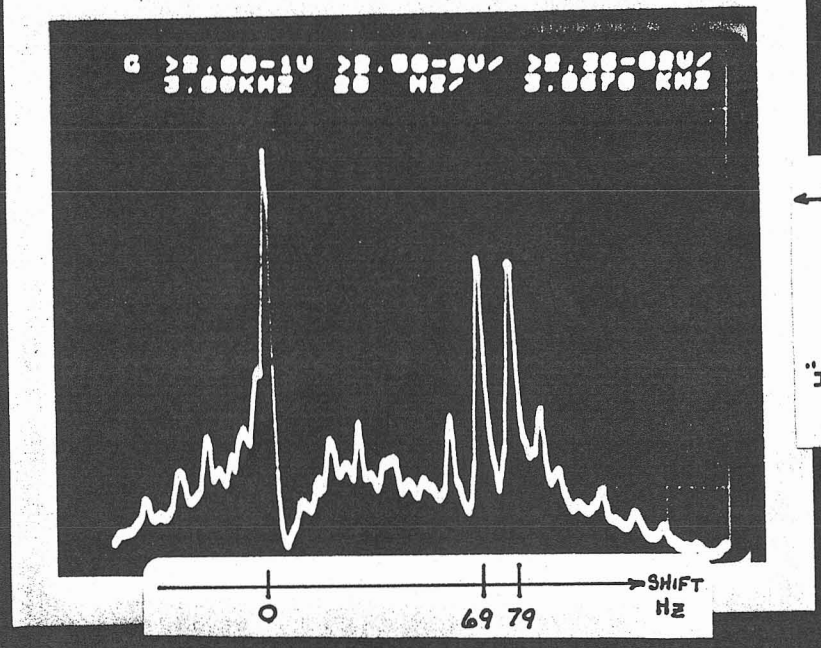


"AMP" DISPLAY WITH MARK TONE SLIGHTLY MISTUNED NOTE CHARACTERISTIC CURVATURE



"AMP" DISPLAY WITH BOTH MARK AND SPACE TONES MISTUNED INDICATES SHIFT OR CENTER FREQ ERROR

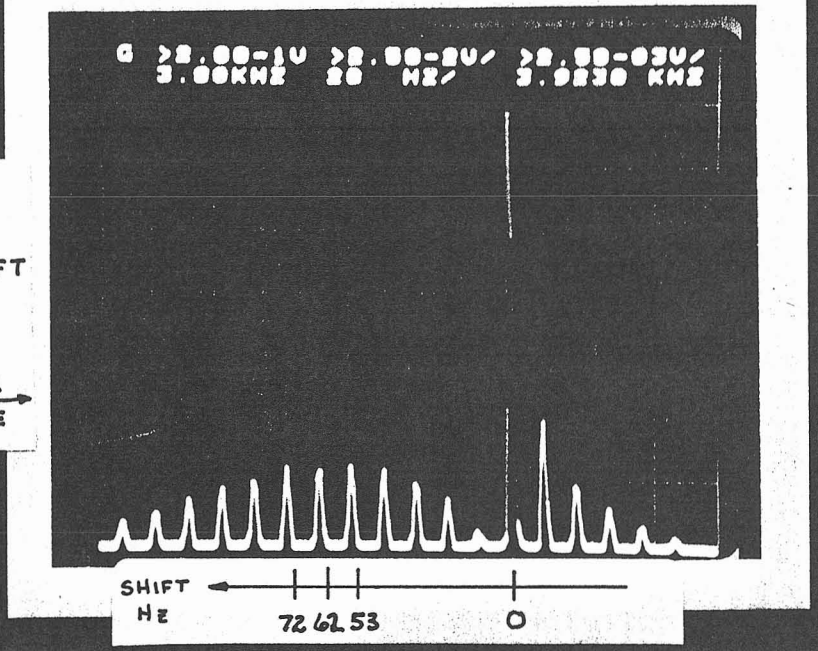
LAZY DOGS BACK 1234567890 WJ SENDING

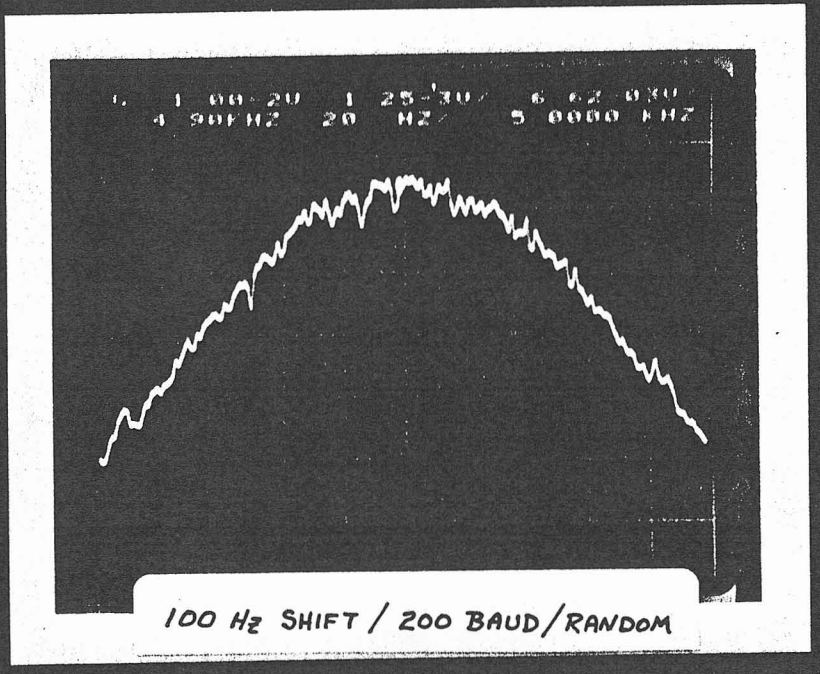


"FOX" TEST

85.0 Hz SHIFT
74.2 BAUD

"IDLE" { 6 MARK →
1 SPACE

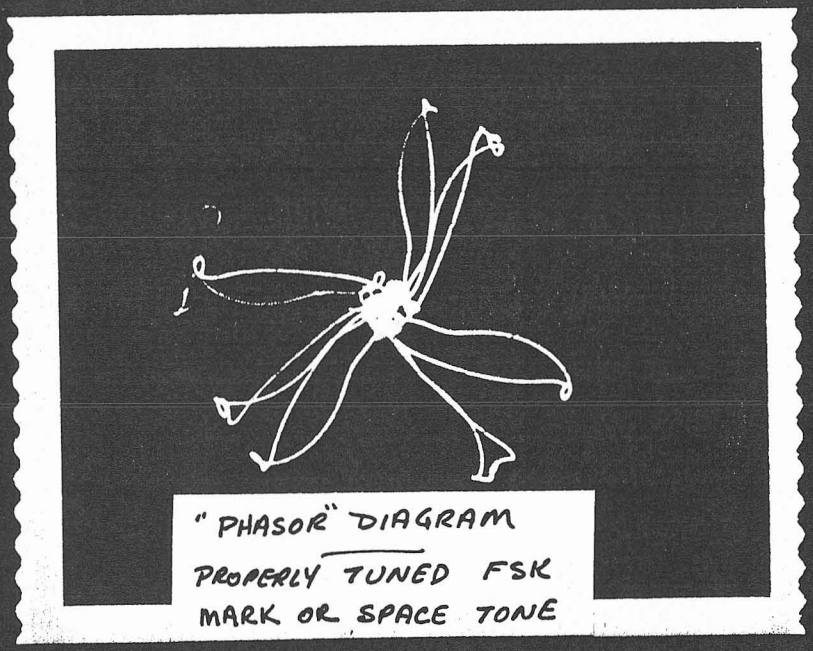




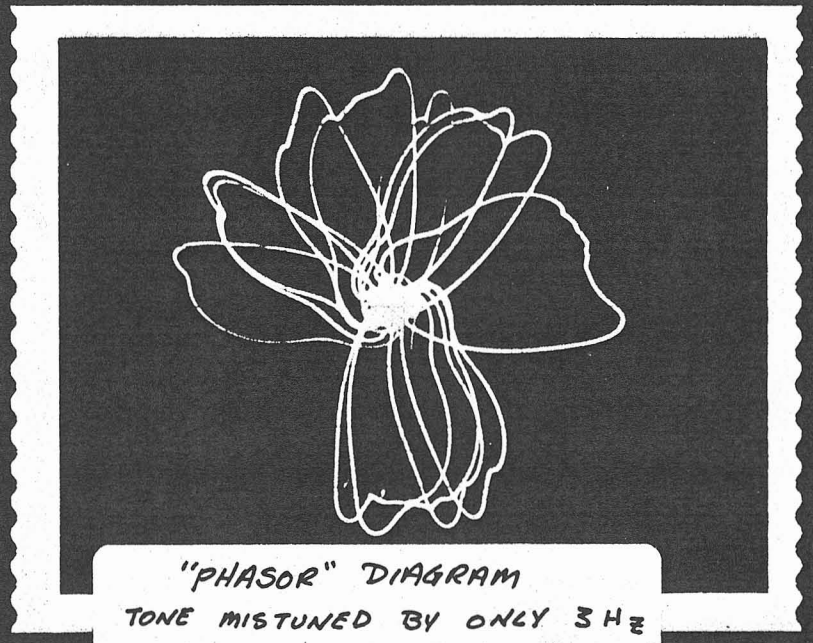
100 Hz SHIFT / 200 BAUD/RANDOM

EFFECTS OF DATA RATE AND PATTERN ON SPECTRAL DISPLAYS

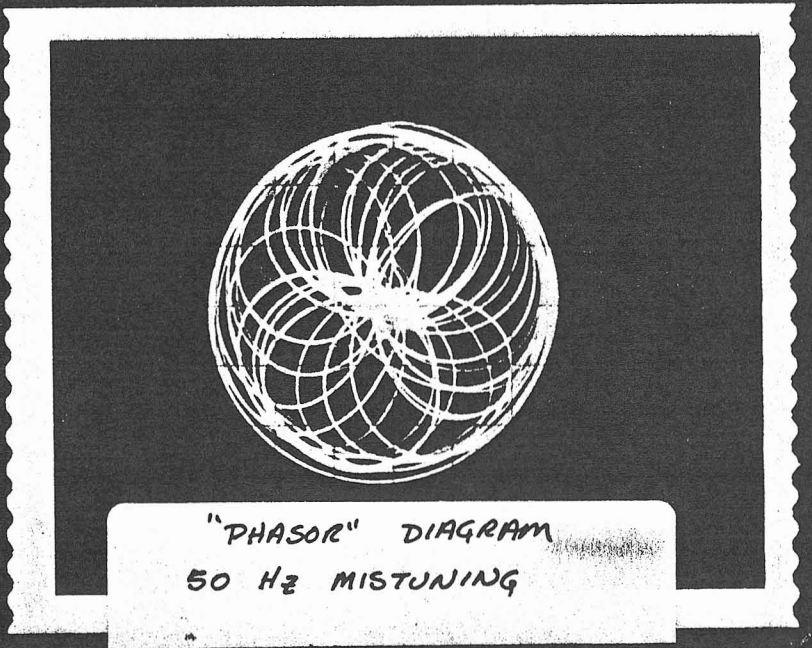
DISPLAYS FROM FFT ANALYZER
1 Hz RESOLUTION, 20 Hz PER DIVISION
AVERAGE OF 256 SAMPLE INTERVALS
LINEAR AMPLITUDE SCALE



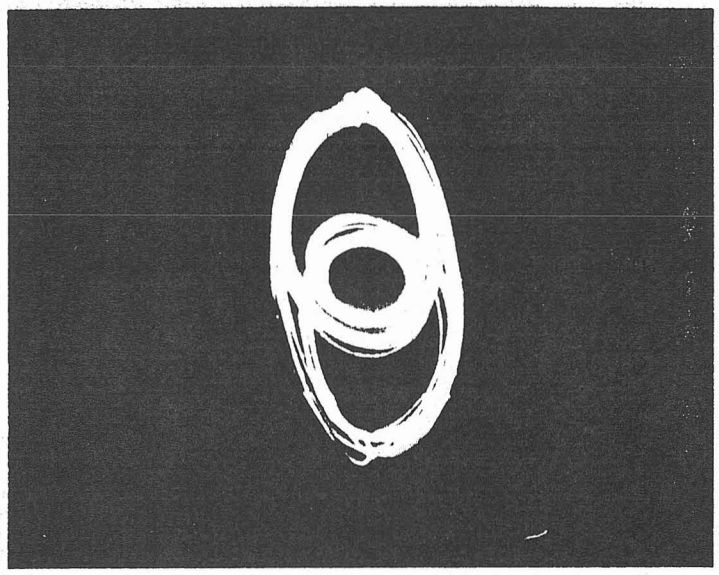
"PHASOR" DIAGRAM
PROPERLY TUNED FSK
MARK OR SPACE TONE



"PHASOR" DIAGRAM
TONE MISTUNED BY ONLY 3 Hz
MISTUNING INDICATED BY VECTOR "LOOPING"



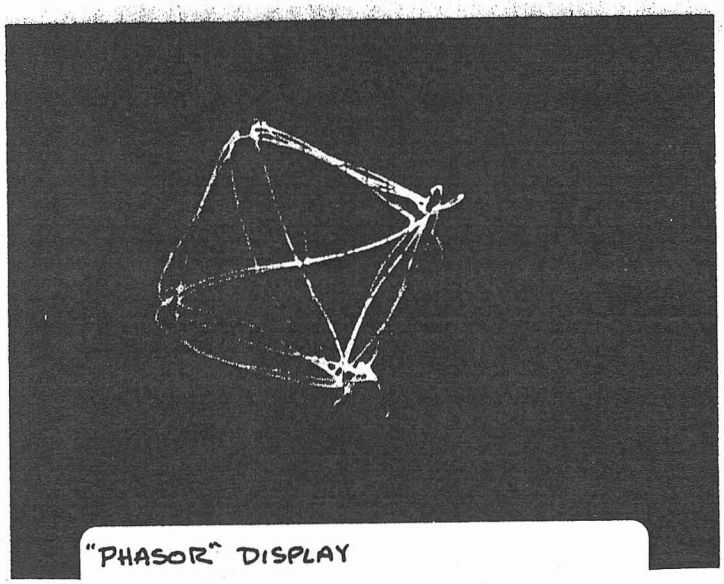
"PHASOR" DIAGRAM
50 Hz MISTUNING



"PHASOR" DISPLAY

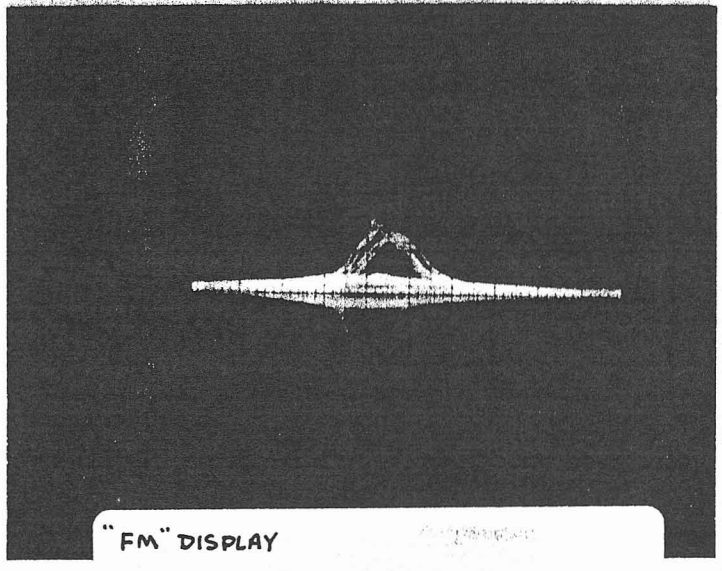
100 Hz SHIFT FSK
200 BAUD RANDOM DATA

NOTE CHARACTERISTIC "BI-PHASE" PATTERN



"PHASOR" DISPLAY

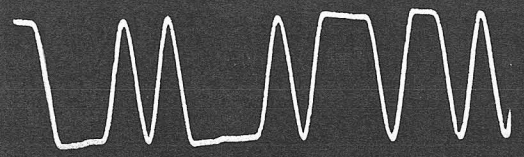
4 PHASE PSK 100 BAUD
(FROM 12 CHANNEL 200 Hz SPACING MUX)

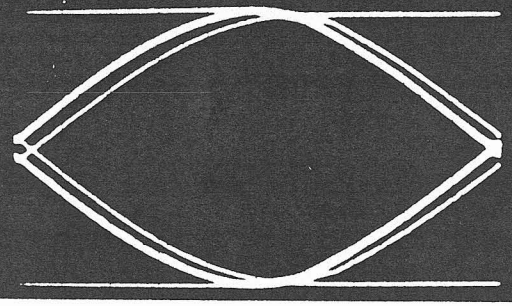


"FM" DISPLAY

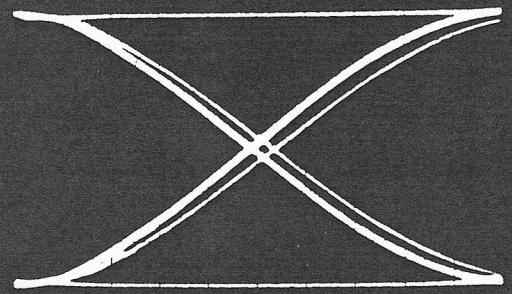
4 PHASE PSK 100 BAUD
HORIZONTAL SWEEP = 100/SEC

TO THE OPTIMAL BANDWIDTH FILTERS



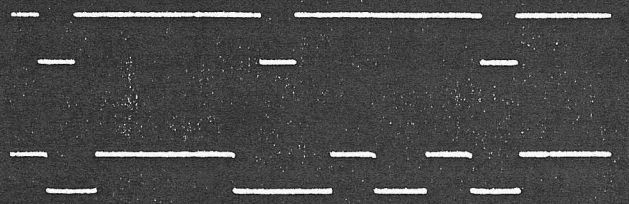


"EYE" DIAGRAM – RAW DATA DISP.
FREE RUNNING SWEEP ADJUSTED
FOR DISPLAY OF ELEMENT COMPOSITE



"CRISS-CROSS" DISPLAY—SHIFTED
EYE DIAGRAM FOR SPEED MEASUREMENT

"DATA" DISPLAY



"DUAL DATA" DISPLAY
UPPER CHANNEL : IDLE (SYNC)
LOWER CHANNEL : TRAFFIC (DATA)