OPERATING MANUAL

HEWLETT PACKARD

HP 4945A

TRANSMISSION IMPAIRMENT MEASURING SET

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed 2521A and 2621A.

For additional important information about serial numbers, see INSTRUMENTS COVERED BY THIS MANUAL in Section I.

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PRINTING HISTORY

New editions of this manual will incorporate all material updated since the previous editions. Update packages may be issued between editions and contain replacement and additional pages to be merged into the manual by the user. Each update page will be indicated by a revision date at the bottom of the page. A vertical line in the margin indicates the changes on each page. Pages which are rearranged due to changes on a previous page are not considered revised.

The manual printing date and part number indicate its current edition. The printing date changes when a new edition is printed. The manual part number changes when extensive technical changes are incorporated.

November 1983 - First Edition
May 1985 - Second Edition

HP-IL (Hewlett-Packard Interface Loop)

The HP-IL is a two-wire loop. Communications over the loop is asynchronous and serial with the data traveling from one device to the next around the loop in only one direction. In this configuration each device receives the message, acts up on it if required, and retransmits it to the next device until the message returns to the originator. For further information refer to Chapter VI of this manual.

RS-232C

The RS-232C interface allows the HP 4945A to be controlled remotely from an external device that is configured for RS-232C serial communications. The interface also allows the HP 4945A to control other RS-232C devices such as printers. For further information refer to Chapter VII of this manual.

ACCESSORIES

The following accessories are available and can be ordered through your local HP Sales and Service Office. The addresses are located at the back of this manual.

HP-IB Interface	HP 18162A
RS-232C Interface	HP 18163A
HP-IL	HP 18165A
HP-IB Cable 1 metre	HP 10833A
RS-232C Terminal Cable	HP 13242N
RS-232C Modem Cable	HP 13242G
36-inch 310 to 310 Cable	HP 15513A
Rack Mounting Kit 19-inch	HP 18169A
Soft Carrying Case	HP 18170A
23-inch Rack Adapter	HP 18176A
Rugged Transit Case	HP 9211-2650

OPTIONS

The following option is available and can be ordered through your local HP Sales and Service Office. The addresses are located at the back of this manual.

Service Manual	Option 915
100/200 Volt Operation	Option 001

Table 1-1. Specifications

GENERAL

Power Requirements:	115/230 Vac +-11%, 48 to 63 Hz 150 watts maximum.
Dimensions: (excluding feet)	Height: 18.4 cm (7.25 in) Width: 45.1 cm (17.75 in) Depth: 48.9 cm (19.25 in)
Weight:	15 Kg (33 lbs)
Operating Environment:	Temperature: 0° to +50° C (+32° to 122° F) Humidity: 10% to 90%, non-condensing Altitude: up to 4600 m (15,000 ft) Warm-up time: 5 minutes for stated accuracy
Interfaces:	HP-IB (IEEE 488), RS-232C, HP-IL
HP-IB Capabilities:	AH1, SH1, C0, L4, T5, SR1, RL1, PP1, DC1, DT0
RS-232C Capabilities:	Bit Rates: 50, 75, 110, 150, 300, 600, 1200, 2400, 4800, 9600 bps. Asynchronous half or full duplex. 7 or 8 bit word. Parity: none, odd, even, mark or space.
HP-IL Capabilities:	R, AH, SH, D, T1-T5, L1, AA1, C0, DC2, DT0, PP1, SR2, RL2, PD0, DD0
Termination Impedance: (receiver and transmitter)	135, 600, 900 or 1200 ohm
Hold Circuits:	Two circuits, each independent; > 20 mA for applied open circuit voltages from 42.5 to 105 volts dc, either polarity, through an external resistance of <=1700 ohms. Nominal: 23 mA, 48 V, 1300 ohms.
Return Loss: (receiver and transmitter)	>20 dB from 20 Hz to 110 kHz >30 dB from 800 Hz to 110 kHz at 135 ohms >30 dB from 200 Hz to 20 kHz

CHAPTER III. OPERATION

This chapter contains both general information about the instrument and specific information on how to use it for making measurements on your network. Below is a brief synopsis of the main features of this chapter.

HP 4945A Features

This contains front panel, rear panel, and display descriptions.

Data Entry Procedure

This contains instructions on how to change the transmit level, frequency, or volume of the instrument. It also covers changing parameters which are located inside a menu.

Set Up and Turn On Procedure

This covers how to initially set up your instrument. Some of the areas covered are: termination impedance selection, calibration, hold coils, and data/time settings.

Measurements

Each measurement is covered separately. Each section contains a general description of the measurement menu and specific instructions on how to perform the measurement. Following the measurements are instructions on how to use the OUTPUT hardkey to dump your results to a printer. Also in this chapter is a brief description of all of the messages that appear on the display.

Master/Slave

The final section contains information on Master/Slave. It includes a description of what it is, how it works, how to use it, and all the error messages. Also included are notes on operation when using an HP 4943A or an HP 4944A with the HP 4945A.

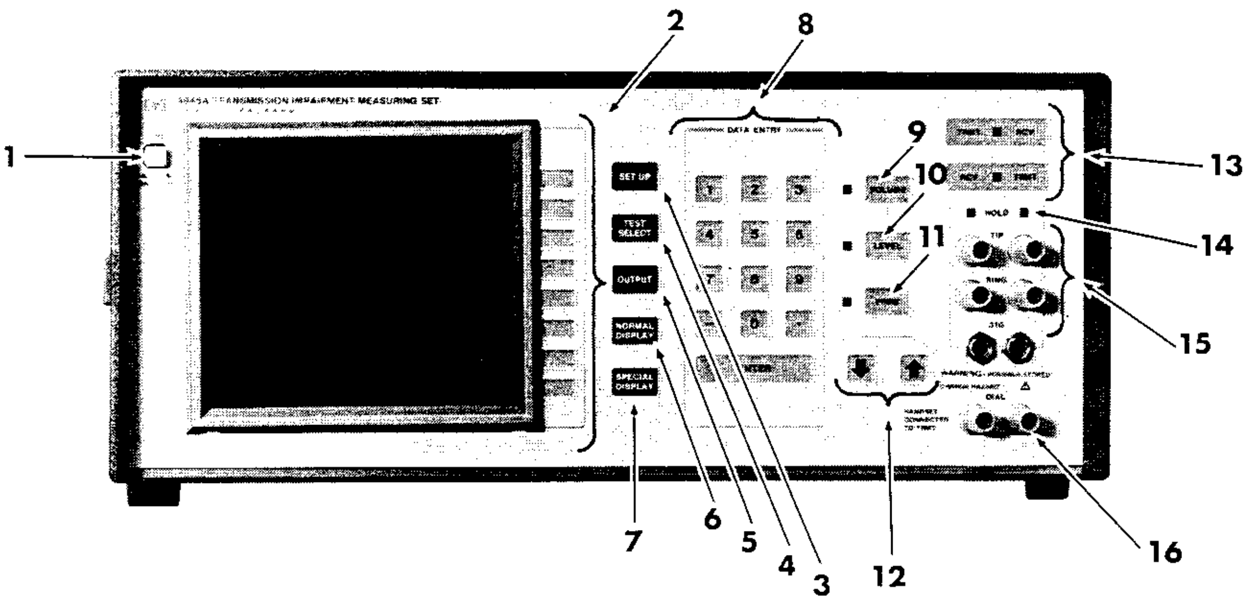


Figure 3-1. Front Panel Controls, Connectors, and Indicators

HP 4945A Features

FRONT PANEL DESCRIPTION

1. LINE ON/OFF - When pressed IN, the instrument is powered ON. When pressed again, the power is turned on.

2. SOFTKEYS - The function of each softkey is labelled on the screen. When a selection is made, the next level of choices appears.

3. SET UP Hardkey - Pressing this key presents all of the set-up choices. All of the set-up parameters can be changed from the menu selections available on the screen.

4. TEST SELECT Hardkey - Pressing this key presents all of the measurements selections.

5. OUTPUT Hardkey - Pressing this key will automatically print the data on the screen to a printer which is connected through any of the optional I/O interfaces.

6. NORMAL DISPLAY - This returns the display to the normal display mode after being in special display mode.

7. SPECIAL DISPLAY - Pressing this key enables the bold mode. This mode displays the measurement data in characters five times larger than normal display and in inverse video. The special display mode can be used when the measurement data becomes difficult to read (because of ambient light conditions or because of the distance from the display screen). The SPECIAL DISPLY is designed to be used in the local mode. When a controller is being used with the HP 4945A the measurements should be viewed in NORMAL DISPLY.

8. DATA ENTRY Keys - These keys are used to enter numeric values when prompted by the DATA ENTRY block on the display. After the desired value has been keyed in, the ENTER key must then be pressed to end the data entry mode.

9. VOLUME Hardkey - The volume level can be adjusted by the data entry keys or the up/down arrow keys. Also, the keyboard beep can be turned ON or OFF.

10. LEVEL Hardkey - Pressing this key enables you to change the existing output level by a number of methods: Along the right side of the screen, 5 programmable levels and a quiet termination selection are labelled. By pressing any of these, the level automatically changes to the desired value. In addition, the data entry block, which is in inverse video, indicates that the data entry keys are active. The up/down arrow keys allow you to step to the desired level. The step size used is set on softkey #7 on this menu.

11. FREQUENCY Hardkey - Pressing this key allows you to change the transmit frequency by a number of methods: Along the right side of the screen, 6 programmable frequencies are labelled. Pressing any of these changes the frequency to the desired value. In addition, the data entry block, which is in inverse video, indicates that the data entry keys are active. The up/down arrow keys allow you to step to the desired level. The step size used is set on softkey #7 on this menu.

12. UP/DOWN Arrow Keys - These are active when in DATA ENTRY mode. These will increment or decrement the value of each press of the hardkey.

13. TRMT/RCV Hardkeys (or normal/reverse keys) - The LED illuminated determines which terminals are connected to the transmitter and which are connected to the receiver. To reverse the connections, simply press the alternate hardkey.

14. HOLD Coil LEDs - These LEDs are directly associated with the jacks located below them. These indicate that the hold coils are active (LED illuminated) on the left and/or right set of terminals.

15. Transmitter and Receiver Jacks - Connections can be made using either the standard Western Electric 310 jacks or the binding posts. The LEDs noted (13) indicate which terminals are the transmitter and which are the receiver.

16. DIAL Posts - These posts are provided for connection of a linesman's handset. The dial post, when activated, are connected to the transmit terminals.

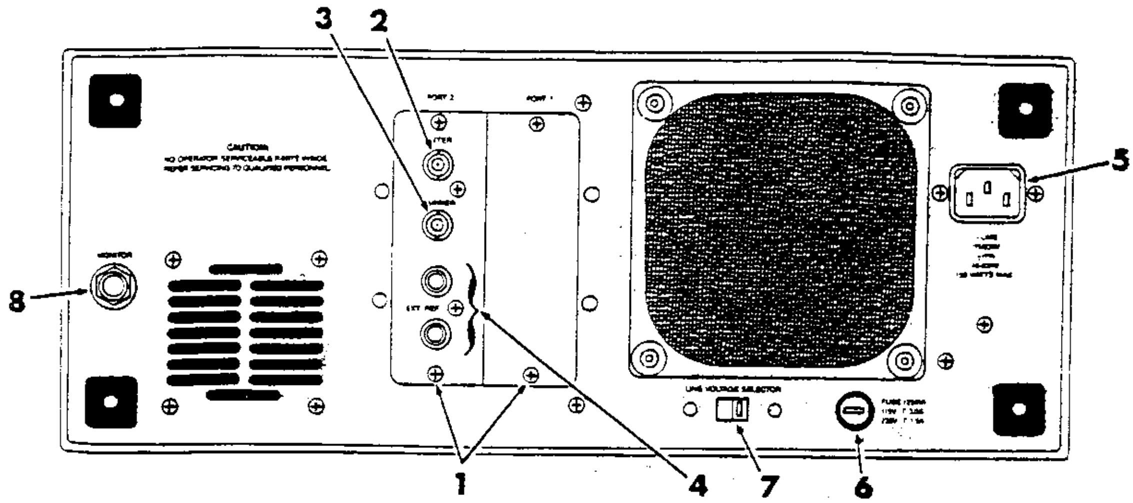


Figure 3-2. Rear Panel Control, Connectors, and Features

REAR PANEL DESCRIPTION

1. I/O Module Panels - These panels can be removed and the I/O modules can be inserted in their place.

2. Jitter Output - This is the demodulated jitter output. By using this output, you are able to directly observe what is causing the jitter impairment (60 Hz, random noise, etc.). This output is directly affected by the jitter bandwidth selected.

Note

> If both amplitude and phase jitter are on, this will not be a stable output.

3. CARRIER Output - The CARRIER output provides a square-wave output signal whose frequency corresponds to the received carrier signal.

4. EXTERNAL REFERENCE - This is active only in 2-wire return loss. The HP 4945A has the capability of using an external reference in place of the standard 600 ohms or 900 ohms, which are in series with a 2.16 uF capacitor. This option is selected using the softkeys in the Return Loss measurement set up menu.

5. Ac power line connector

6. Fuse

7. Voltage selector switch, 115 or 230 VAC

8. Monitor Jack - External headphones or speaker can be connected to this jack. When the headphone jack is inserted, the internal speaker is disabled.

CRT DISPLAY FUNCTIONS

The HP 4945A display screen is divided into functional areas that allow for quick and accurate interpretation of the displayed data. Figure 3-3 identifies these functional areas.

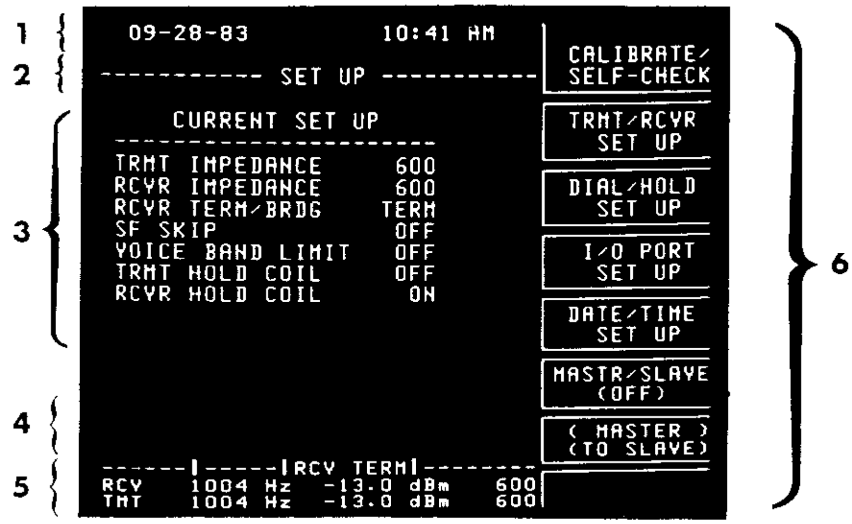


Figure 3-3. Display Features

Area 1

This line is dedicated to the date and time. In the 24 hour clock mode, the AM/PM indication is not displayed.

Area 2

This area contains three lines. The middle line labels the menu you are in and designates the softkeys to specific functions. The other two lines are designated for informational messages.

Area 3

This area is reserved for the measurement data or set-up information.

Area 4

This area contains three lines. The types of messages that may be found here are data entry messages, power-on messages, calibrate/self-check messages.

Area 5

Referring to this area will quickly tell you the transmitter and receiver configuration.

Area 6

This area defines the functions of each of the softkeys. Since the HP 4945A is menu driven, each of these softkeys are redefined when a new selection is made.

OPERATING THE HP 4945A

DATA ENTY PROCEDURE

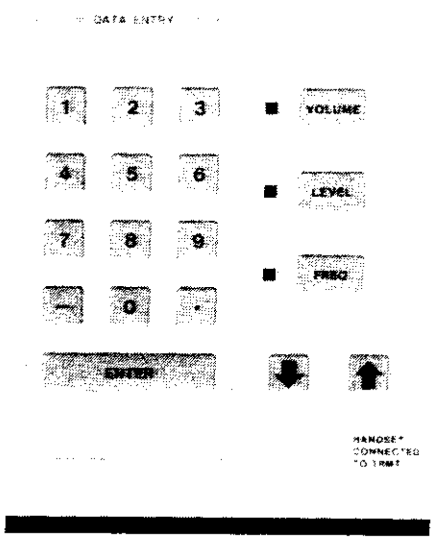


Figure 3-4. Data Entry, Level, Frequency, Volume Hardkeys

Level

To change the transmitter's level, press the LEVEL hardkey. The following selections will appear.

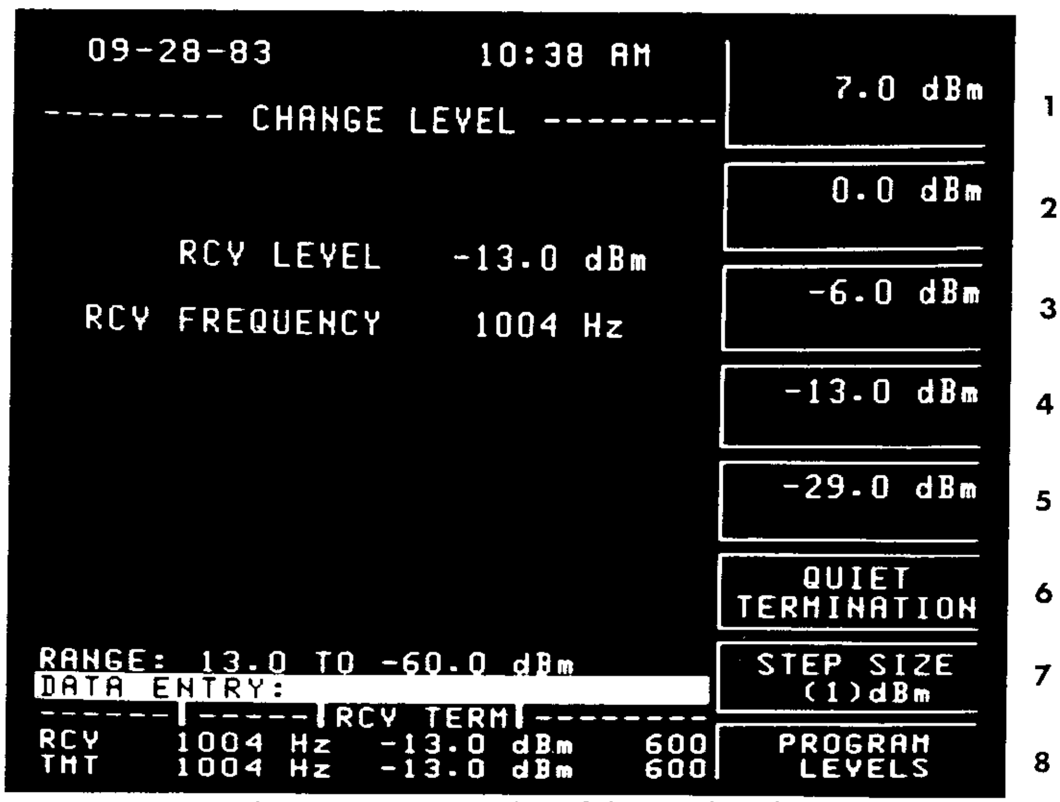


Figure 3-5. Level Softkey Selections

Notice that the LED next to the hardkey will illuminate when this key is active. There are three ways of changing the level of the instrument. They are: The DATA ENTRY keys, the up/down arrow keys, or selection of one of the preprogrammed levels. The procedure for each of these is discussed below.

DATA ENTRY Keys - When making a specific entry, first press the LEVEL hardkey; the DATA ENTRY lock will come up on the screen in inverse video with an acceptable entry range on the line above it. Next, press the appropriate keys on the keypad to make the level entry. The entries will show up in the DATA ENTRY block. To finalize your selection, press the ENTER key.

Up/Down Arrow Keys - These are located right below the LEVEL, FREQuency, and VOLUME hardkeys on the front panel. The up/down arrow keys can single step up or down a value. The amount of the step size is set in this menu by pressing the STEP SIZE softkey (#7). The choices available are .1, .5, 1 dBm.

Programmable Levels - When the LEVEL hardkey is pressed, the softkey selections shown in figure 3-5 appear (Note: The values may be different). To change the level, press the corresponding softkey.

The values shown that correspond to softkeys #1 - #5 can be reprogrammed as follows:

- Press softkey #8 which is labelled PROGRAM LEVELS. Notice that each of the levels is in parentheses.

- To change any of the values, press the corresponding softkeys. Now, use the data entry keys or the up/down arrow keys to change it to the desires value.

Frequency

Changing the frequency is very similar to changing the level. When the FREQuency hardkey is pressed, the following selections appear:

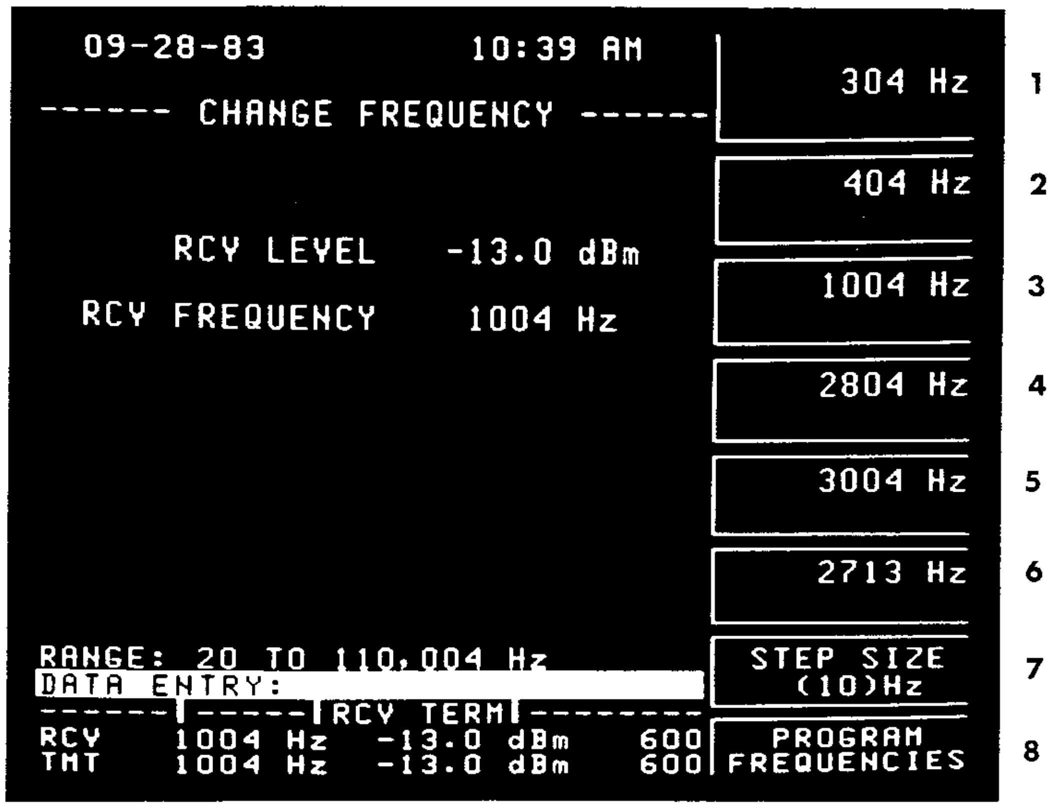


Figure 3-6. Frequency Softkey Selections

Notice that the LED next to the hardkey will illuminate when this key is active. There are three ways of changing the frequency of the instrument. They are: the Data ENTRY keys, the up/down arrow keys, or selection of one of the preprogrammed frequencies. The procedure for each of these is discussed below.

DATA ENTRY Keys - When making a specific entry, first press the FREQuency hardkey: the DATA ENTRY block will come up on the screen in inverse video with an acceptable entry range on the line above it. Next, press the appropriate keys on the keypad to make the frequency entry. The entries will show up in the DATA ENTRY block. To finalize your selection, press the ENTER key.

Up/Down Arrow Keys - These are located right below the LEVEL, FREQuency and VOLUME hardkeys on the front panel. The up/down arrow keys can single step up or down a value. The amount of the step size is set in this menu by pressing the Step Size softkey (#7). The choices available are 10, 50, 100, and 1000 Hz.

Programmable Frequencies - When the FREQuency hardkey is pressed, the **softkey** selections shown in figure 3-6 appear (Note: The values may be different). To change the frequency, press the cooresponding softkey.

The values shown that correspond to softkeys #1 - #6 can be programmed as follows:

- Press softkey #8 which is labelled PROGRAM FREQUENCIES. Notice that each of the frequencies is in parentheses.
- To change any of the values, press the corresponding softkey. Now, use the data entry keys or the up/down arrow keys to change it to the desired value.

Volume VOLUME

To control the speaker volume or the keyboard beep, press the VOLUME hardkey. The following selections will appear.

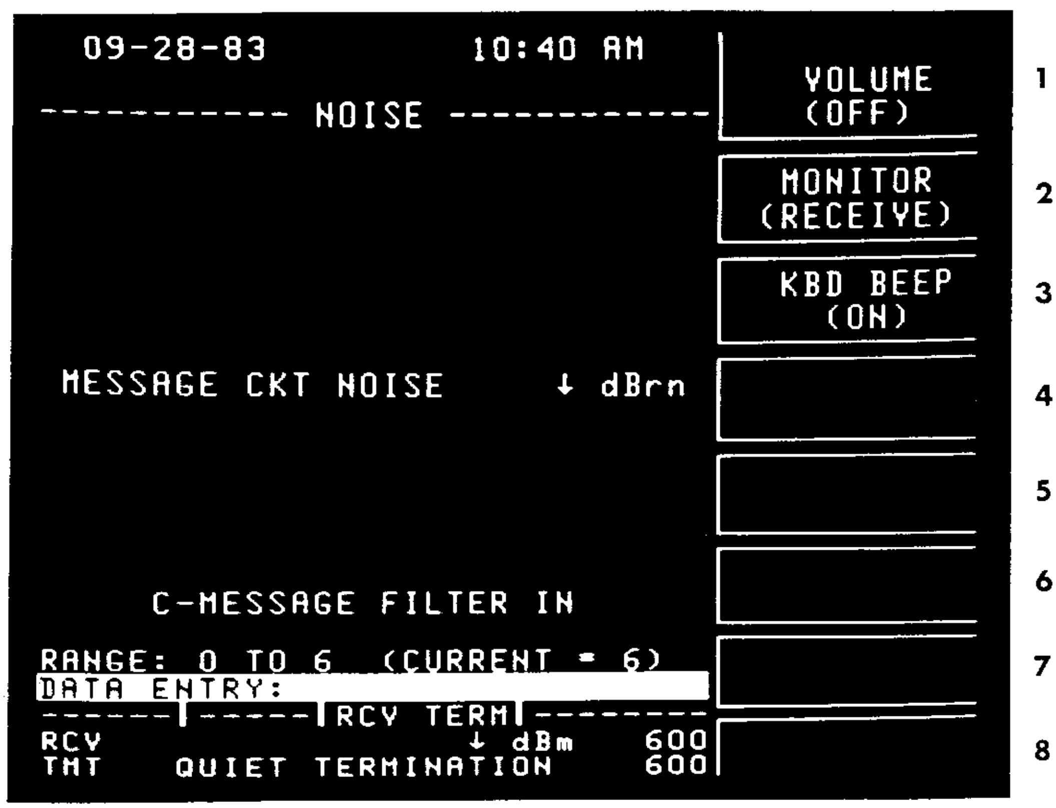


Figure 3-7. Volume Softkey Selections

Notice that the LED next to the hardkey will illuminate when this key is active.

Use softkey #1 to turn the VOLUME ONE. The volume range is from 0 to 6, with 6 being the loudest. The level can be changed by using either the up/down arrow keys or the DATA ENTRY keys.

Softkey #2 (MONITOR) selects whether the speaker is connected to the receiver or the transmitter.

Softkey #3 selects whether the keyboard beep is ON or OFF. This does not affect warning beeps.

Changing Parameters Located Inside a Menu (thresholds, timers, etc.)

Any parameter which has the option of being changed will be inside parentheses. If the parameter has a pre-determined set of choices, then when the softkey is pressed it will cycle through the selections. If there is a range that exists for that parameter, then when the softkey is pressed a data entry block will appear on the screen. You can now make either a numerical entry using the keypad or use the up/down arrow keys to change the parameter. To end the entry mode, either press the ENTER key or any key other than the DATA ENTRY keys.

POWER-ON SELF CHECK

The HP 4945A performs an automatic self check on power-on. During power-on a series of beeps will indicate that the self check is in progress. In addition to the beeps, the LED indicators located on the front panel will flash.

The power-on self check verifies the performance of the major circuitry. In the event of a hardware failure, an error code(s) will be displayed on the screen. Error codes are listed and explained in the HP 4945A Service Manual in Section VIII.

If power-on self-echck errors are displayed, it may still be possible to continue using the instrument by pressing any key. The cause of the errors, however, should be corrected as soon as possible.

SET UP AND TURN ON PROCEDURE

General

1. Connect the power cord to the receptacle on the rear panel of the instrument.

2. Press the LINE button in to turn the instrument on. A series of beeps at power on indicates that the self-check is in progress.

CAUTION

> Do not operate the instrument inside the carrying case. Restriction of air from the fan can cause overheating and damage to the test set.

3. Select the terminals that will be used for transmit and receive by using the appropriate hardkey located above the terminals.

4. Connect the HP 4945A to the circuit under test.

5. To initially configure the instrument, press the SET UP hardkey. The following menu will appear.

Note

> The HP 4945A contains nonvolatile memory which "saves" your set up information after power-down. It does not retain your hold coil settings or measurement results. If you are in master/slave mode when you power-down, you will return to normal operation upon power-up.

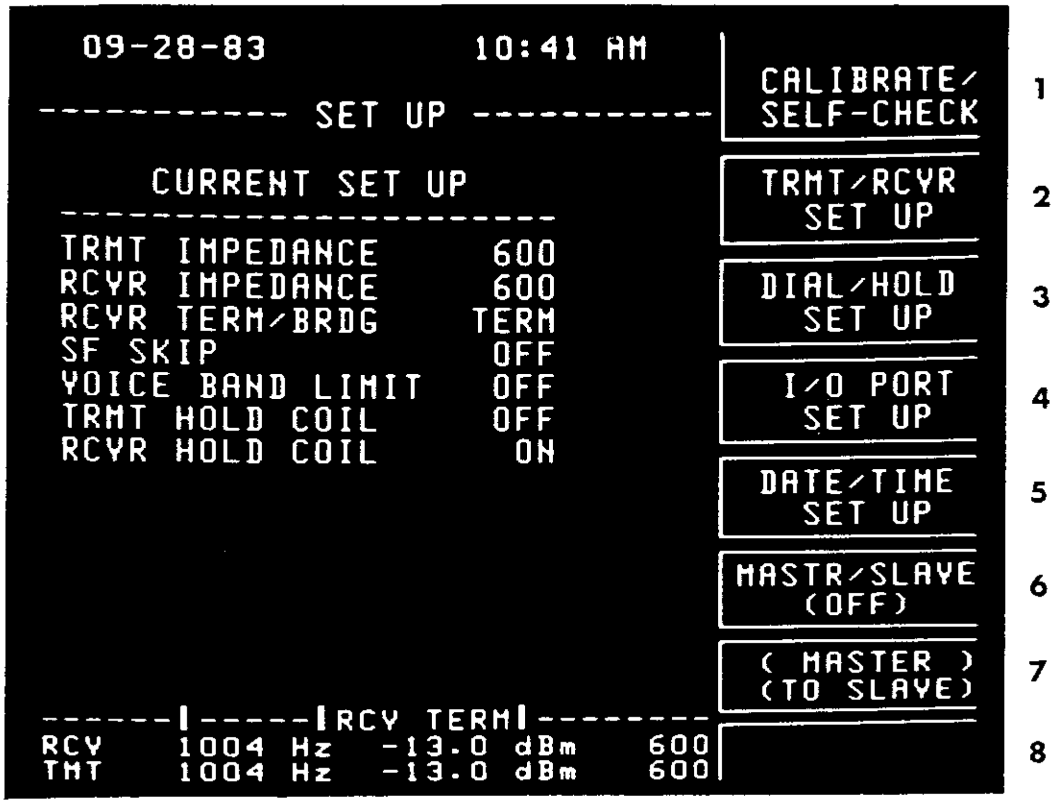


Figure 3-8. Set Up Menu

1. This softkey accesses the menu to run the calibration and self check routines.

2. This softkey accesses the menu to configure the transmitter and receiver.

3. This softkey accesses the menu for the dial/talk, talk battery and holding capabilities.

4. This softkey accesses the menu to set up the I/O ports.

5. This softkey accesses the menu to set the date and and time shown at the top of the display.

6. This softkey selects the mode of operation (e.g. OFF, MASTER or SLAVE).

7. If master/slave mode is selected, this softkey will determine the direction of test (e.g. MASTER TO SLAVE or SLAVE TO MASTER).

8. Not Used

Calibration

The HP 4945A has the capability of calibrating the major circuitry in the instrument. To perform the calibration procedure:

- Press the SET UP hardkey.
- Press the CALIBRATE/SELF-CHECK softkey (#1).
- Press the CALIBRATE softkey (#6). The message CALIBRATING will flash on the display while this is in progress. If there are any problems, refer to the Service Manual.

To Set Up the Transmitter and Receiver Configuration

1. Set the MASTER/SLAVE softkey (#6) to read OFF in the parentheses.
2. Press the TRMT/RCVR SET UP softkey (#2). The menu shown below will appear. Set each of the softkeys to the appropriate settings.

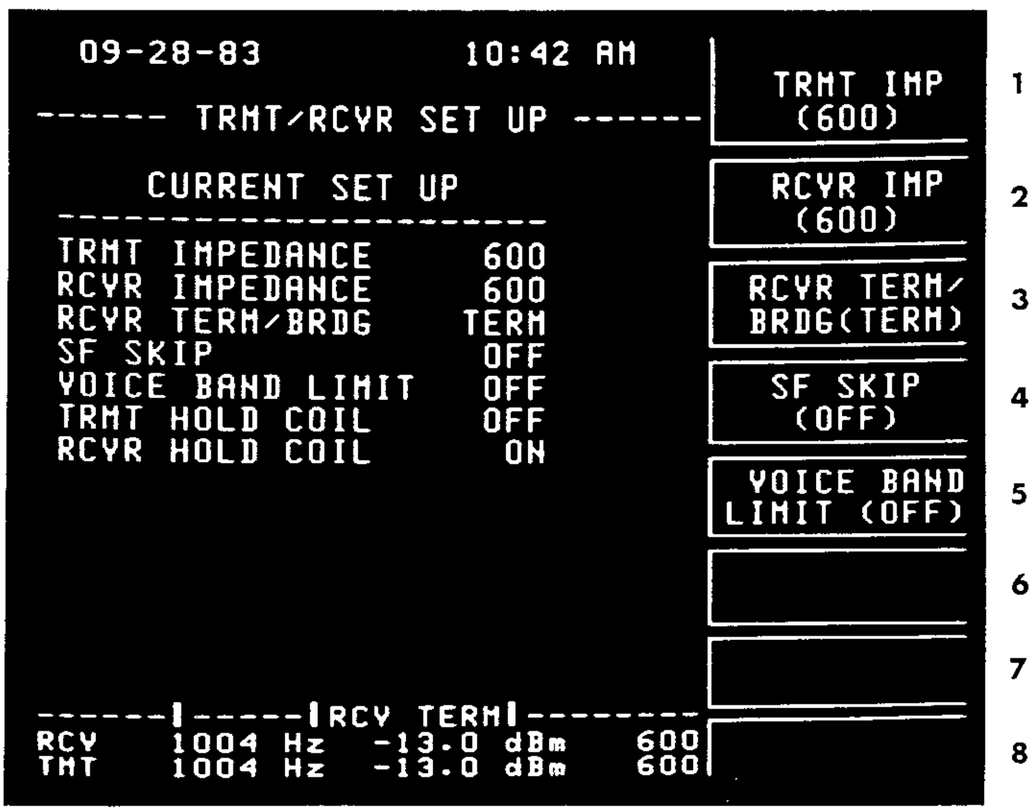


Figure 3-9. Transmitter and Receiver Set Up Menu

1. This softkey sets the transmitter termination impedance. The selections it cycles through are 135, 600, 900, and 1200 ohms. Select the impedance that matches the line to which the transmitter is connected.

2. This softkey sets the receiver termination impedance. The selections it cycles through are 135, 600, 900, and 1200 ohms. Select the impedance that matches the line to which the receiver is connected.

3. Set this softkey to TERM if the instrument is to be used to terminate the receive line. If the instrument is to bridge across the receive line, select BRIDGE. When the receiver is bridged, it presents a high impedance to the line. This ensures that the test set will not disturb the circuit which is under test.

4. Turn SF SKIP ON if transmitting over a dial up network where single frequency signalling units are used. SF SKIP prevents the instrument from transmitting frequencies between 2450 to 2750 Hz.

5. This softkey turns the VOICE BAND LIMIT function ON or OFF. When ON, it limits the high end output frequency to 3904 Hz and sets the current output frequency to 1004 Hz. This is used on N3 carrier facilities to prevent interference with 4 kHz pilot tones.

6. Not Used

7. Not Used

8. Not Used

Transmitter and Receiver Set Up When in Master/Slave

In master/slave, the slave's configuration can be set at the master unit. If you are configured for master/slave operation, then when the TRMT/RCVR SET UP softkey (#2) is pressed, the additional choices shown below will appear. Set each of these to the appropriate setting.

Note

These keys will not appear when operating with an HP 4943A or an HP 4944A slave unit.

SLAVE TRMT IMP

6. This softkey sets the slave unit's transmitter IMP termination impedance. The selections it cycles through are 135, 600, 900, and 1200 ohms. Select the impedance that matches the line to which the slave's transmitter is connected.

SLAVE RCVR IMP — 7. This softkey sets the slave unit's receiver IMP termination impedance. The selections it cycles through are 135, 600, 900, and 1200 ohms. Select the impedance that matches the line to which the slave's receiver is connected.

SLAVE TERM/ BRDG — 8. This softkey selects whether the receiver on the slave unit is BRIDGEd or TERMinated. If the slave's receiver is bridged, it presents a high impedance to the line. This ensures that the test set will not disturb the circuit which is under test.

If desired, the slave can be configured at the slave box. Upon initial link, the master will display the slave's set-up configuration. It will not change unless one of the softkeys #6 - #8 are pressed.

You should be aware that the following actions will cause you to lose link:

- Running the diagnostic self check routine
- Running the calibration routine
- Reversing the transmit and receive lines using the hardkeys located above the terminals.

In order to recover, you must go through the initial link-up process again.

To Set the Date and Time:

1. Press the DATE/TIME SET UP softkey (#5). The menu shown below will appear. Set each softkey to the appropriate setting. The numerical values can be changed by pressing the softkey that you want to change and entering a value using the DATA ENTRY keys.

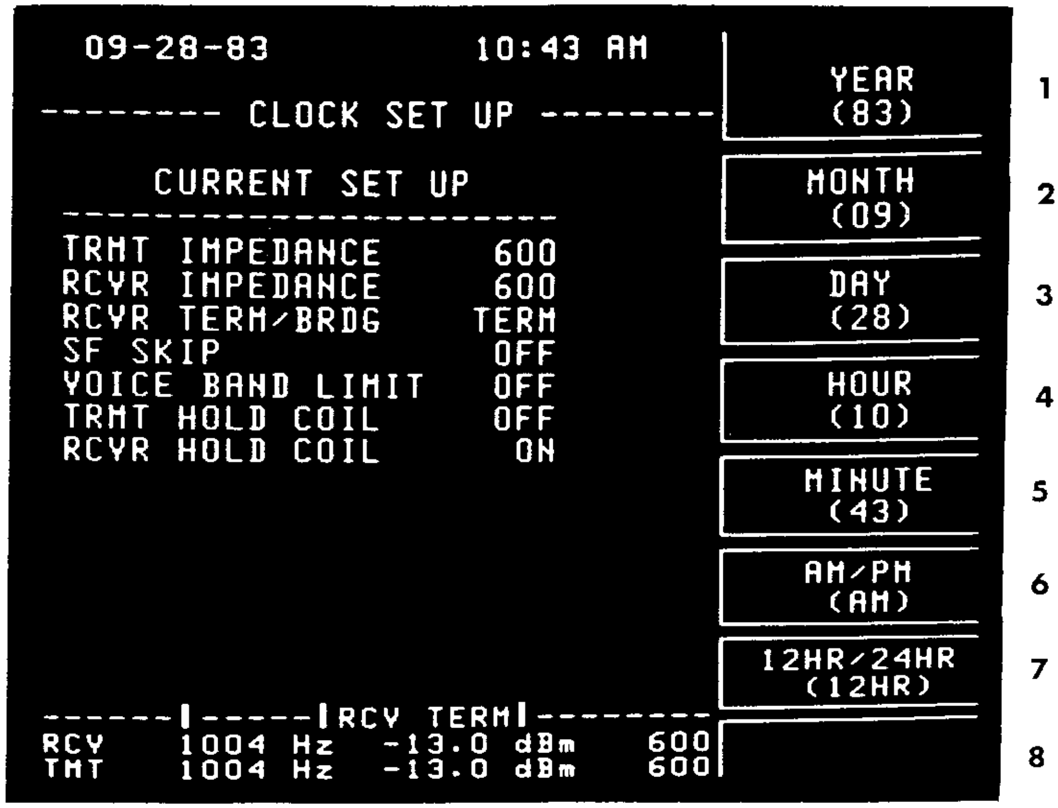


Figure 3-10. Clock Set Up Menu

1. Enter the last two digits of the year you want displayed.
2. Enter the month you want displayed.
3. Enter the day of the month you want displayed.
4. Enter the hour you want displayed. The allowable range will depend on whether you choose to have a 12 or 24 hour clock on softkey #7.
5. Enter the minutes after the hour you want displayed.
6. This key is only active when you are set up to display the time in 12 hour mode. It toggles between AM and PM.
7. This determines whether you are using a 12 or 24 hour clock mode.
8. Not Used

Dial, Talk, Listen and Hold Procedures

1. Perform SET UP AND TURN ON PROCEDURES.

2. Connect lineman's handset (butt-in) to DIAL terminals.

3. Press VOLUME hardkey. Next, press softkey #1 until the selection (OFF) appears.

4. Press the SET UP hardkey. Verify that the MASTER/SLAVE softkey (#6) is set to (OFF).

5. Press the DIAL/HOLD SET UP softkey (#3). The following menu will appear.

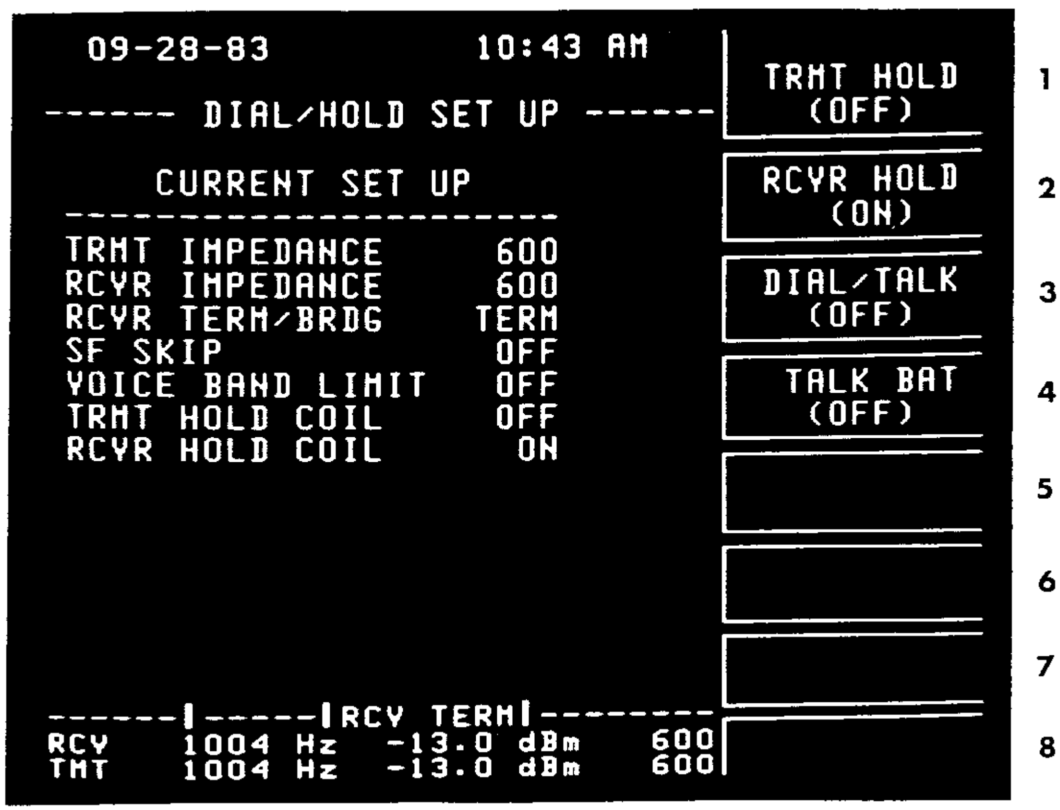


Figure 3-11. Dial/Hold Set Up Menu

1. This softkey will turn the transmitter hold coil ON or OFF. The hold coil LED located above the transmit terminals will be illuminated when the hold coil is active.

2. This softkey will turn the receiver hold coil ON or OFF. The hold coil LED located above the receive terminal will be illuminated when the hold coil is active.

3. Turning DIAL/TALK ON will connect the handset to the transmit line to permit dialing, talking and listening over the line. Dialing must be done using the handset. The level autorange is fixed when in this menu to prevent autoranging when talking over the line.

4. The HP 4945A will supply the handset with +15 Vdc to energize the microphone.

5. Not Used

6. Not Used

7. Not Used

8. Not Used

Refer to Table 3-1 for the proper control settings for your application.

Table 3-1. Circuit Control Settings

Mode	2-Wire Wet (DDD)	2-Wire Dry	4-Wire Dry
Dial (through butt-in)	TRMT HOLD (OFF) RCVR HOLD (OFF) DIAL/TALK (ON) TALK BAT (OFF)		
Talk (through butt-in)	TRMT HOLD (OFF) RCVR HOLD (OFF) DIAL/TALK (ON) TALK BAT (OFF)	TRMT HOLD (OFF) RCVR HOLD (OFF) DIAL/TALK (ON) TALK BAT (ON)	TRMT HOLD (OFF) RCVR HOLD (OFF) DIAL/TALK (ON) TALK BAT (ON)
Listen (through butt-in)	TRMT HOLD (OFF) RCVR HOLD (OFF) DIAL/TALK (ON) TALK BAT (OFF)	TRMT HOLD (OFF) RCVR HOLD (OFF) DIAL/TALK (ON) TALK BAT (ON)	TRMT HOLD (OFF) RCVR HOLD (OFF) DIAL/TALK (ON) TALK BAT (ON)
Test	TRMT HOLD (ON) RCVR HOLD (ON) DIAL/TALK (OFF) TALK BAT (OFF)	TRMT HOLD (OFF) RCVR HOLD (OFF) DIAL/TALK (OFF) TALK BAT (OFF)	TRMT HOLD (OFF) RCVR HOLD (OFF) DIAL/TALK (OFF) TALK BAT (OFF)
Next, press the TEST SELECT hardkey and proceed with the measurement.			

Note

The hold coils do not switch lines with the line reverse switch. This is to prevent the line from being dropped.

LEVEL AND FREQUENCY

Description

This section describes the following types of level and frequency measurements:

- 1000 Hz Loss Measurement
- Frequency Shift Measurement
- Attenuation Distortion
- Gain Slope Measurement

To enter the Level Frequency menu, press the TEST SELECT hardkey and then the LEVEL FREQuency softkey (#1). The following menu will appear:

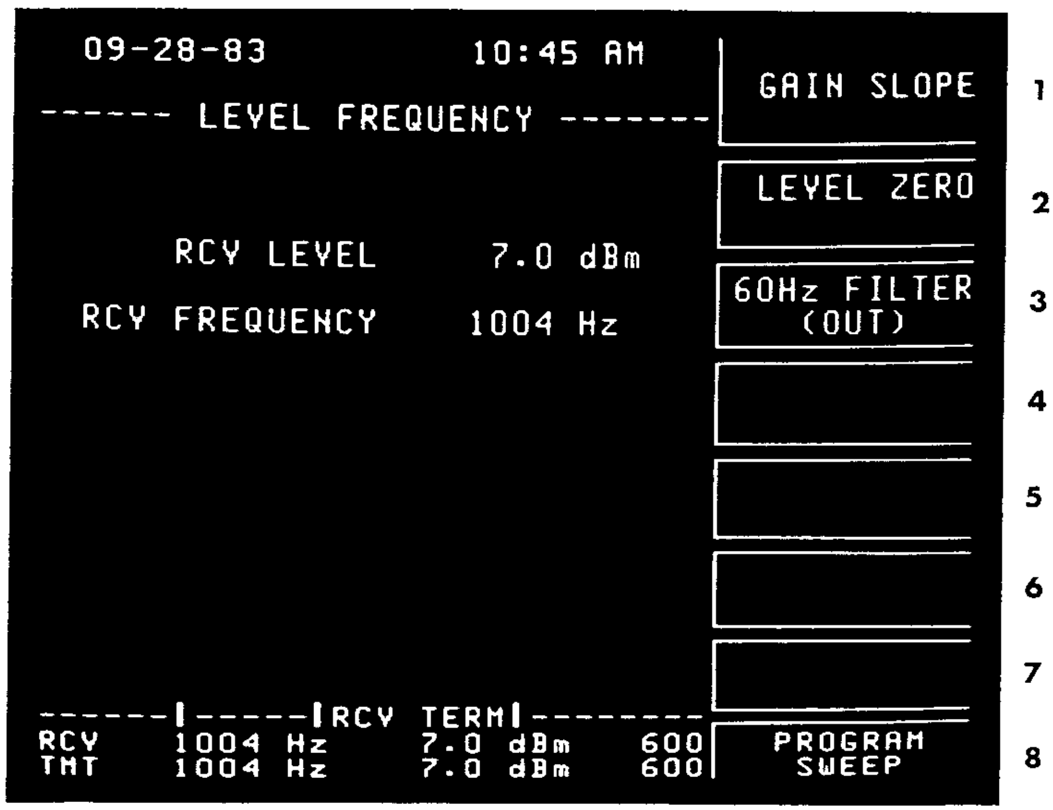


Figure 3-12. The Level Frequency Measurement Menu

1. This softkey begins the GAIN SLOPE measurement.

2. This softkey establishes a zero reference at the current level reading.

3. This softkey inserts a 60 Hz high pass filter in the receive path. This attenuates 60 Hz by at least 20 dB without affecting the holding tone (1004 Hz) measurements.

4. Not Used

5. Not Used

6. Not Used

7. Not Used

8. This softkey accesses the programmable frequency sweep menu.

To set up a programmmable frequency sweep when making the Level Frequency measurement, press the PROGRAM SWEEP softkey (#8). The menu is shown below with explanations of each of the selections. After setting up softkeys #2 through #6 to the appropriate settings, start the sweep by pressing softkey #1 until it reads SWEEPING in parentheses.

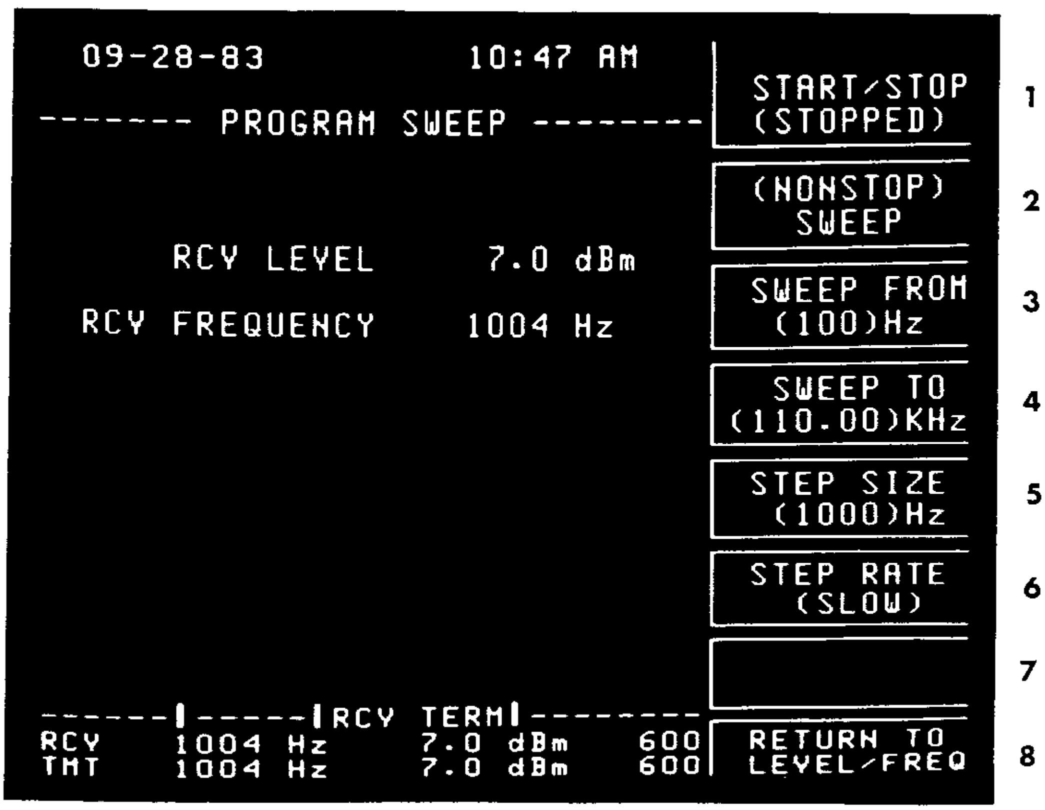


Figure 3-13. Programmable Sweep Menu for Level Frequency Measurement

1. This softkey starts and stops the sweep. It toggles between STOPPED and SWEEPING.

2. This softkey toggles between SINGLE and NONSTOP. NONSTOP allows you to continuously sweep.

3. Enter the frequency you want the sweep to start from.

4. Enter the frequency you want the sweep to end on.

5. Enter the step size you want between the frequencies.

6. Select how fast you want the sweep to step. This key cycles through slow (.3 steps/second), medium (1 step/second), and fast (3 steps/second).

7. Not Used

8. This softkey will return you to the level frequency menu.

General Instructions - Transmitter

1. Press the TEST SELECT hardkey.

2. Press the LEVEL FREQUENCY softkey (#1). The Level Frequency menu will appear.

Note

The transmitter is automatically set to 1004 Hz when entering the Level Frequency menu.

3. Adjust the level to the "Data Level".

Note

All transmission measurements should be made at Data Level. The Data Level for all presently specified data circuits is a power of 13 dB below the Transmission Level Point (TLP). For example, if the TLP is -16 dB, the Data Level would be -29 dBm. Therefore, an output level of -29 dBm would be applied in this case.

4. When requested by the receiver operator, transmit the agreed upon test frequencies. The frequency can be changed by entering a specific frequency, using the up/down arrow keys (both of these methods are explained in Data Entry Procedure Section) or by using the programmable sweep capability shown on softkey #8 above (refer to the Description Section).

Gain Slope Measurement

If you press GAIN SLOPE (softkey #1 in the Level Frequency menu), the transmitter will automatically cycle through 404 Hz, 1004 Hz, and 2804 Hz (2 seconds/step).

General Instructions - Receiver

1. Press the TEST SELECT hardkey.
2. Press the LEVEL FREQUENCY softkey (#1). The Level Frequency menu will be displayed.

1000 Hz Loss Measurement

3. Instruct transmitter operator to send 1004 Hz tone.
4. Observe RCV LEVEL and RCV FREQUENCY in center of the display.
5. Press 60 Hz FILTER softkey until IN appears in parentheses. If the received level changes more then +-0.2 dBm, the 60 Hz filter should be left IN throughout the measurement. This will eliminate the effect of a 60 Hz signal interfering with your measurement.

Frequency Shift Measurement

6. Observe the received frequency while communicating with the transmitter operator, comparing any difference between the transmitted and received frequencies.

Note

The transmitting test set must be a test set capable of transmitting a signal which is known within +-0.5 Hz.

Attenuation Distortion

7. Instruct the transmitter operator to send 1004 Hz tone. If you want this measurement to be made in absolute dBm, then skip to step #9.
8. Press the LEVEL ZERO softkey. This establishes a 0 dB reference at the current frequency (1004 Hz).
9. Observe RCV LEVEL and RCV FREQUENCY in the center of the display while the agreed upon frequencies are transmitted. +dB indicates more loss and -dB indicates less loss, relative to the reference frequency.

Gain Slope Measurement

10. Select the GAIN SLOPE measurement softkey (#1). If the transmitting test set is not an HP 4945A, then the transmitter operator must transmit the tones (404 Hz, 1004 Hz, and 2804 Hz) individually. The receiving HP 4945A will recognize each of the frequencies and display the relative level to 1004 Hz on the screen.

Note

The transmitted frequencies can be sent in any order, but the relative level (dB) cannot be calculated until 1004 Hz is sent. As soon as the receiver recognizes 1004 Hz, it displays the relative levels of the tones it has previously received, if any. The measurement is continuously updated using the last 1004 Hz reference.

NOISE

Description

The noise measurements which can be performed with the HP 4945A are:

- Noise-with-Tone
- Signal-to-Noise Ratio
- Message Circuit Noise
- Noise-to-Ground
- Single Frequency Interference

Along with these measurements, there are five filters which can be selected. They are:

- C-message
- 3 kHz flat
- 15 kHz flat
- Program
- 50 kBit

To enter the noise menu, press the TEST SELECT hardkey and then the NOISE softkey (#2). The following menu will appear.

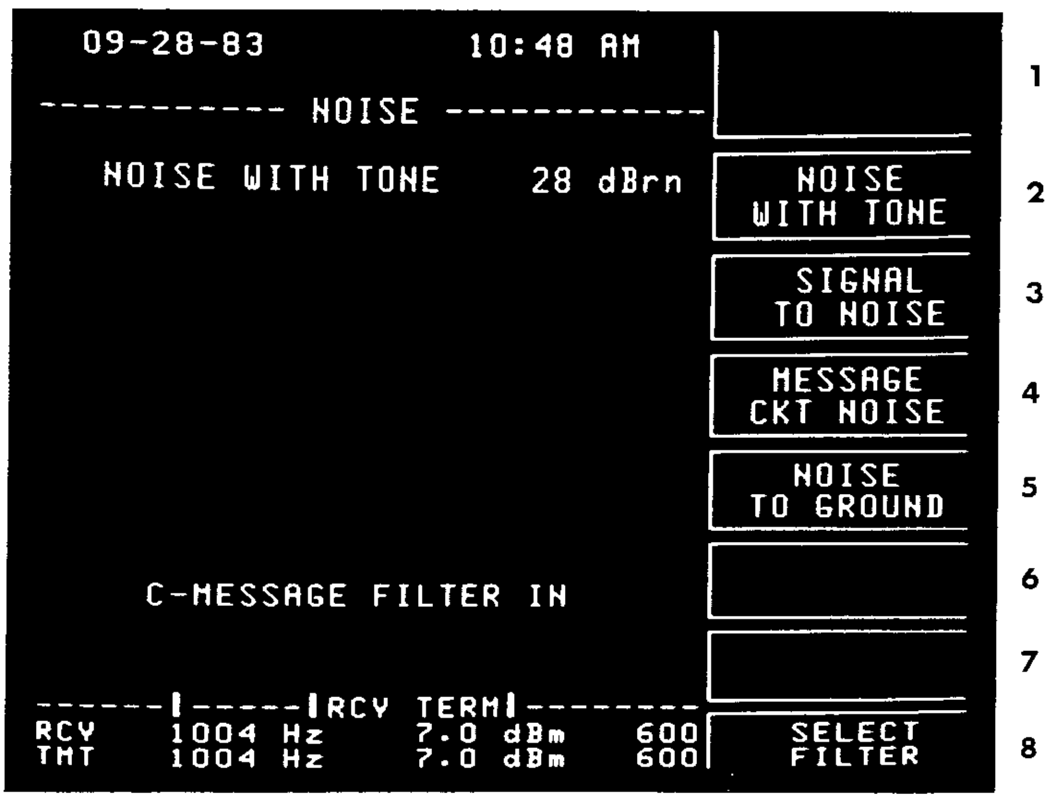


Figure 3-14. The Noise Measurement Menu

1. Not Used

2. This softkey selects the noise-with-tone measurement. It measures the telephone cicuit noise (in dBrn) in the presence of a 1004 Hz tone.

3. When this softkey is pressed, the signal-to-noise ratio of the circuit is calculated.

4. This softkey selects the message circuit noise measurement. It measures the telephone circuit noise with the line quiet terminated.

5. This softkey selects the noise-to-ground measurement. This can be used as an indication of line balance.

6. Not Used

7. Not Used

8. This softkey accesses the noise filters menu.

If you press softkey #8 (SELECT FILTER), you will access the following menu.

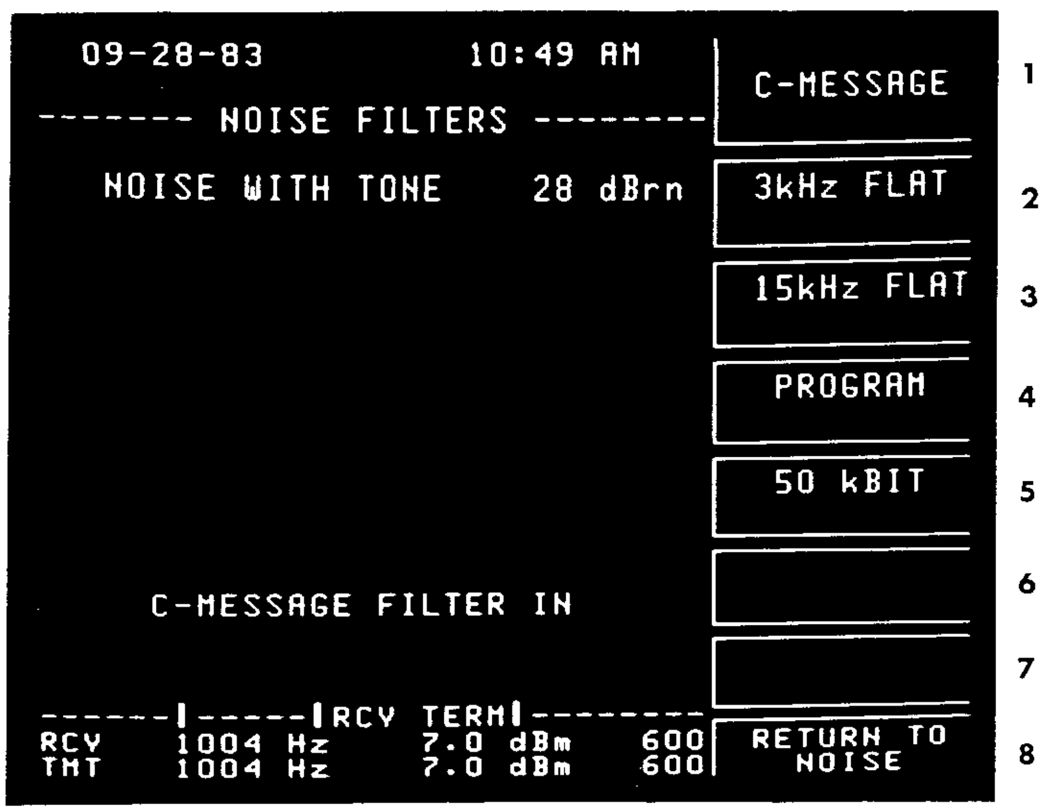


Figure 3-15. The Noise Filters Menu

1. This softkey selects the C-message filter. This filter weights the noise to similulate what the human ear would detect.

2. This softkey selects the 3 kHz flat filter. This filter is used to detect the presence of low frequency noise on voice circuits.

3. This softkey selects the 15 kHz flat filter. This filter is used when making unweighted measurements of noise on program circuits.

4. This softkey selects the Program filter. This filter is used for the weighted measurement noise on program circuits which have bandwidths up to 8 kHz.

5. This softkey selects the 50 kBIT filter. This filter is used on circuits which handle wideband data and DDS circuits.

6. Not Used

7. Not Used

8. This softkey returns you to the measurement menu.

General Instructions - Transmitter

1. Press the TEST SELECT hardkey.

2. Press the NOISE softkey (#2). The Noise menu will be displayed.

Message Circuit Noise

3. Press the MESSAGE CKT NOISE softkey (#4). This will quiet terminate the transmitter.

Signal-to-Noise Ratio

4. Press the SIGNAL TO NOISE softkey (#3). The transmitter is now transmitting a 1004 Hz holding tone.

5. Adjust the output level to the "Data Level" using the LEVEL hardkey.

Note

All transmission measurements should be made at Data Level. Data Level for all presently specified data circuits is a power of 13 dB below the Transmission Level Point (TLP). For example, if the TLP is -16 dB, the Data Level would be -29 d Bm. Therefore, an output level of -29 dBm would be applied in this case.

Noise-to-Ground

The HP 4945A must be properly grounded for valid noise to ground measurements. Ground can be established through the power cord ground if there is a reliable power line bond or through the sleeve connections on the 310 transmit/receive jacks.

6. Press the NOISE TO GROUND softkey (#5). The transmitter is now quiet terminated.

Noise-With-Tone

7. Press the NOISE WITH TONE softkey (#2). The transmitter is now transmitting a 1004 Hz holding tone.

8. Adjust the output level to the "Data Level" using the LEVEL hardkey (refer to "Data Level" above).

General Instructions - Receiver

1. Press the TEST SELECT hardkey.

2. Press the NOISE softkey (#2).

3. The current filter selected is displayed on the lower portion of the screen. If you want to change to another filter, press the SELECT FILTER softkey (#8) and select the desired weighting or press the RETURN TO NOISE softkey (#8).

Message Circuit Noise

4. Press the MESSAGE CKT NOISE softkey (#4). The reading in dBrn will be displayed.

Single Frequency Interference

While performing a message circuit noise measurement, a single frequency interference check can be done.

5. Press the VOLUME hardkey.

6. Press the VOLUME softkey (#1) until ON appears in parentheses.

7. Adjust the volume level by using either the up/down arrow keys or the DATA ENTRY keys.

8. Press the MONITOR softkey (#2) until RECEIVE appears in parentheses. Listen for any predominant tone which will indicate a potential single frequency interference problem. A LEVEL FREQUENCY measurement can be made (Don't change the transmitter - keep it quiet terminated) to further analyze the tone. Press VOLUME hardkey to end the entries.

Signal-to-Noise Ratio

9. Press the SIGNAL TO NOISE softkey (#3). The HP 4945A will automatically display the signal-to-noise ratio.

Noise-to-Ground

10. Press the NOISE TO GROUND softkey (#5) and observe the dBrn reading on the display.

Line Balance Calculation

The relative line balance of an end loop can be calculated by message circuit noise (Nm) and noise to ground (Ng) and applying the following formula:

$$\text{Balance in dB} = Nm - Ng$$

Note

This calculation is only valid if the measurements are made on a physical pair and if it is assumed that the message circuit noise is caused by longitudinal noise converted to message circuit noise by a line imbalance. It is recommended that both of these measurements be made using the 3 kHz flat filter to account for the effects of power line related noise.

Noise-With-Tone

11. Press the NOISE WITH TONE softkey (#2) and observe the dBrn reading on the display.

TRANSIENTS

Description

The HP 4945A performs the following transient measurements:

- Impulse Noise (3 level)
- Phase Hits
- Gain Hits
- Dropouts

The HP 4945A will also perform a noise with tone measurement and latch the results to aid you in setting the impulse noise thresholds. The noise with tone measurement is always in progress whenever the transients measurement is STOPPED.

To enter the transients menu, press the TEST SELECT hardkey and then the TRANSIENTS softkey (#3). The following menu will appear.

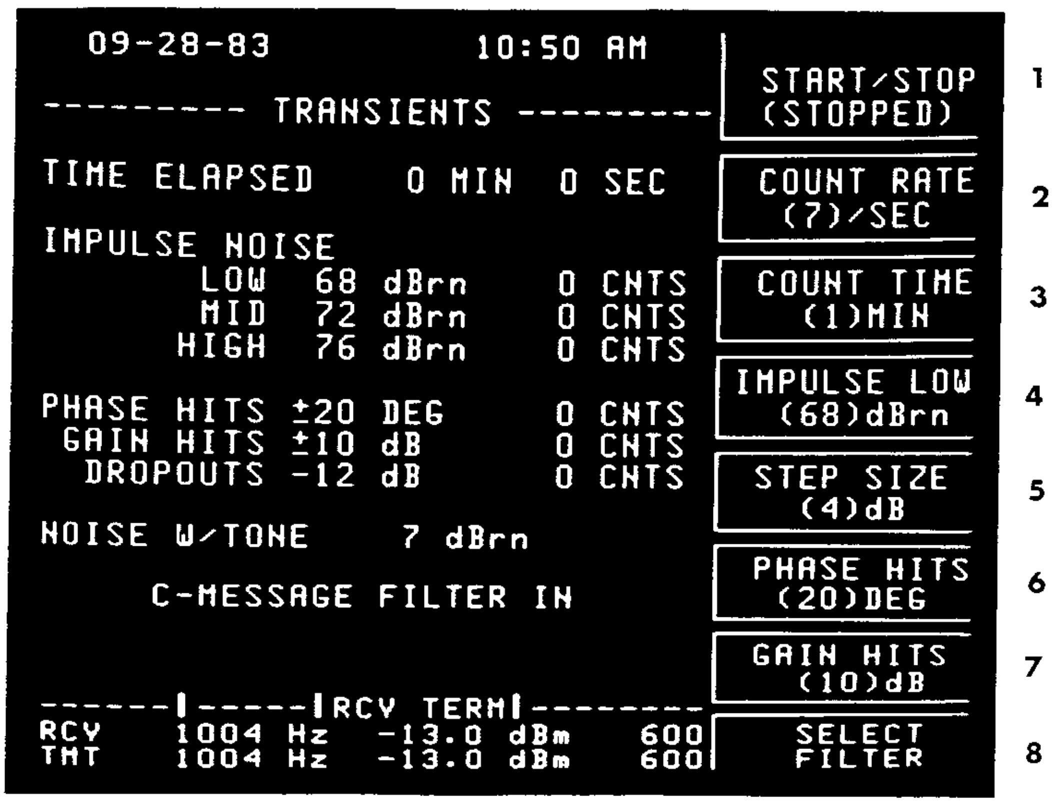


Figure 3-16. The Transients Measurement Menu

1. This softkey starts and stops the timer on the transients measurement. It toggles between STOPPED and RUNNING.

2. This softkey sets the count rate for transient measurements. It cycles through 7, 8, and 100 counts per second.

3. This softkey sets the timer for the transient measurement. The range is programmable from 0 (nonstop) to 9999 minutes.

4. This softkey sets the LOW threshold for impulse noise. The range is programmable from 30 to 110 dBrn.

5. This softkey sets the step size between the LOW to MID and MID to HIGH impulse noises thresholds. It cycles through 2, 3, 4, 5 and 6 dB.

6. This softkey sets the phase hits threshold. It cycles through 5, 10, 15, 20, 25, 30, 35, 40 and 45 degrees.

7. This key sets the gain hits threshold. It cycles through 2, 3, 4, 5, 6, 7, 8, 9, and 10 dB.

8. This softkey accesses the noise filters menu. For further explanation of this menu, refer to the NOISE measurement section. The noise filter selected affects the impulse noise measurement only.

General Instructions - Transmitter

1. Press the TEST SELECT hardkey.

2. Press the TRANSIENTS softkey (#3). The transmitter is now transmitting a 1004 Hz holding tone.

3. Adjust the output level to the "Data Level" using the LEVEL hardkey

Note

All transmission measurements should be made at Data Level. The Data Level for all presently specified data circuits is a power of 13 dB below the Transmission Level Point (TLP). For example, if the TLP is -16 dBm, the Data Level would be -29 dBm. Therefore, an output level of -29 dBm would be applied in this case.

General Instructions - Receiver

1. Press the TEST SELECT hardkey.

2. Press the TRANSIENTS softkey (#3).

3. Press the COUNT RATE softkey (#2) until the desired rate appears in parentheses. It cycles through 7, 8, and 100 counts per second.

4. Press the COUNT TIME softkey (#3) and set the timer for the desired limit using the DATA ENTRY keys or the up/down arrow keys. The allowable range is from 0 to 9999 minutes with 0 being nonstop. The up/down arrow keys will step in 5 minute steps.

5. Press IMP THLD LO softkey (#4). Enter the desired low threshold for impulse noise using the DATA ENTRY keys or the up/down arrow keys (1 dBrn step).

6. Press the IMP THLD STEP softkey (#5) until the desired step size between the impulse noise thresholds appears. Your choices are 2, 3, 4, 5, and 6 dB.

7. Press the PHASE HITS THLD softkey (#6) until the desired phase hit threshold is obtained. This key cycles in 5 degree steps from 5 to 45 degrees.

8. Press the GAIN HITS THLD softkey (#7) until the desired gain hits threshold is obtained. This key cycles in 1 dB steps from 2 to 10 dB.

9. The current filter which is selected for the noise measurements is displayed on the lower portion of the screen. If you want to change to another filter, press the SELECT FILTER softkey and select the desired weighting or press the RETURN TO TRANSIENTS softkey (#8).

10. Press the VOLUME hardkey. Press the VOLUME softkey (#1) until ON appears in parentheses.

11. Press the MONITOR softkey (#2) until RECEIVE appears in parentheses.

12. Using the DATA ENTRY keys or the up/down arrow keys, change the volume to the desired level. Listen for any predominant noise which can provide a clue as to the noise source. If you decide not to change the volume level, press the VOLUME hardkey again to return to the measurement menu.

13. Start the measurement by pressing the START/STOP softkey (#1) until RUNNING appears in parentheses. The current status of the counters can be observed on the screen. When the timer is done, STOPPED will appear in the parentheses under softkey (#1). Any softkey change will restart the measurement.

Note

The noise-with-tone reading will be latched while the transients measurement is running.

ENVELOPE DELAY DISTORTION

Description

The HP 4945A performs the envelope delay distortion measurement, which is an indirect method of measuring the phase response of a channel. It has a programmable frequency sweep capability to aid you in characterizing a line.

The following figure is included to quickly familarize you with the measurement procedure and terms.

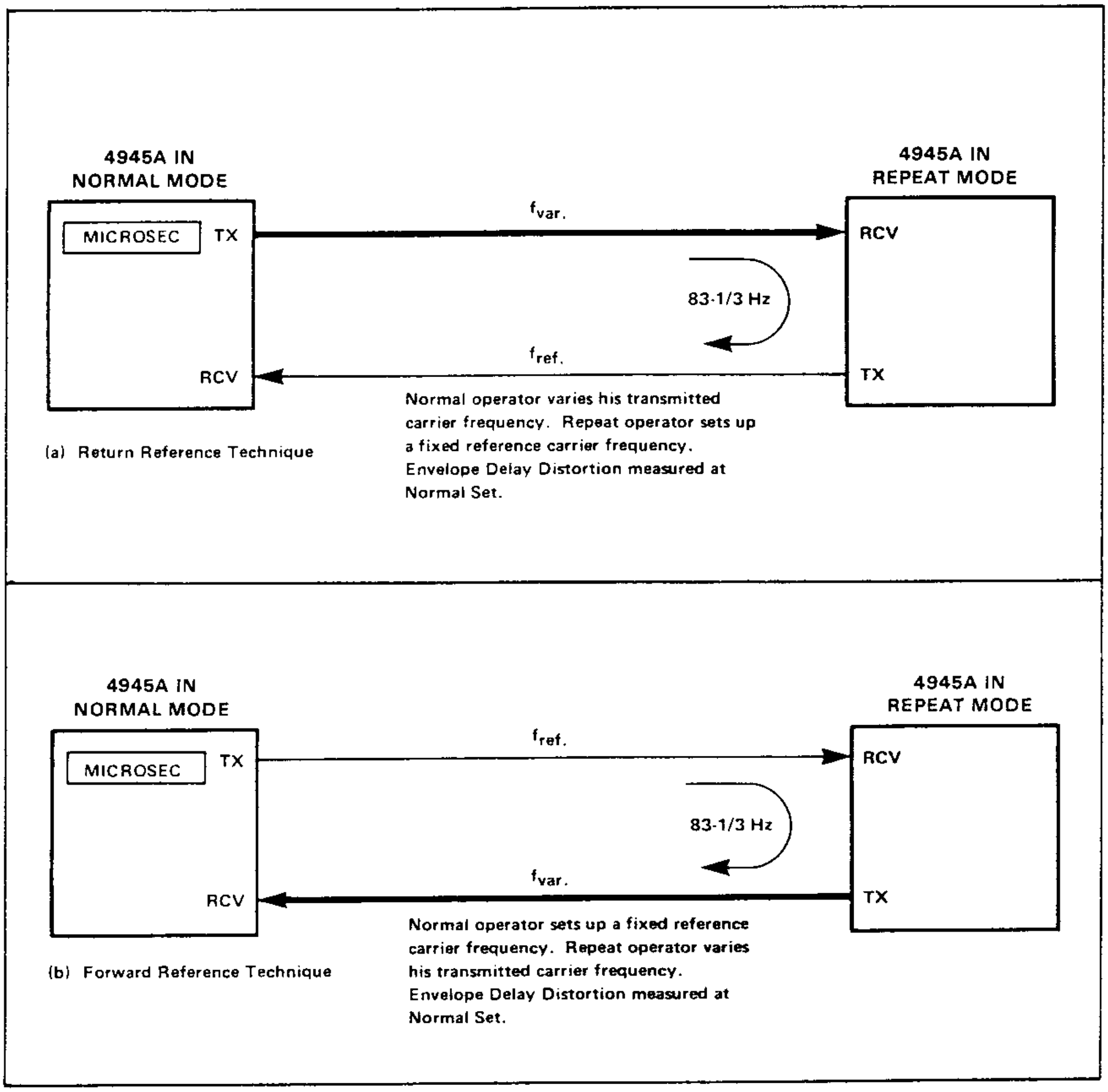


Figure 3-17. The Envelope Delay Test Set Up

To enter the envelope delay menu, press the TEST SELECT hardkey and then the **ENVELOPE DELAY** softkey (#4). The following menu will appear.

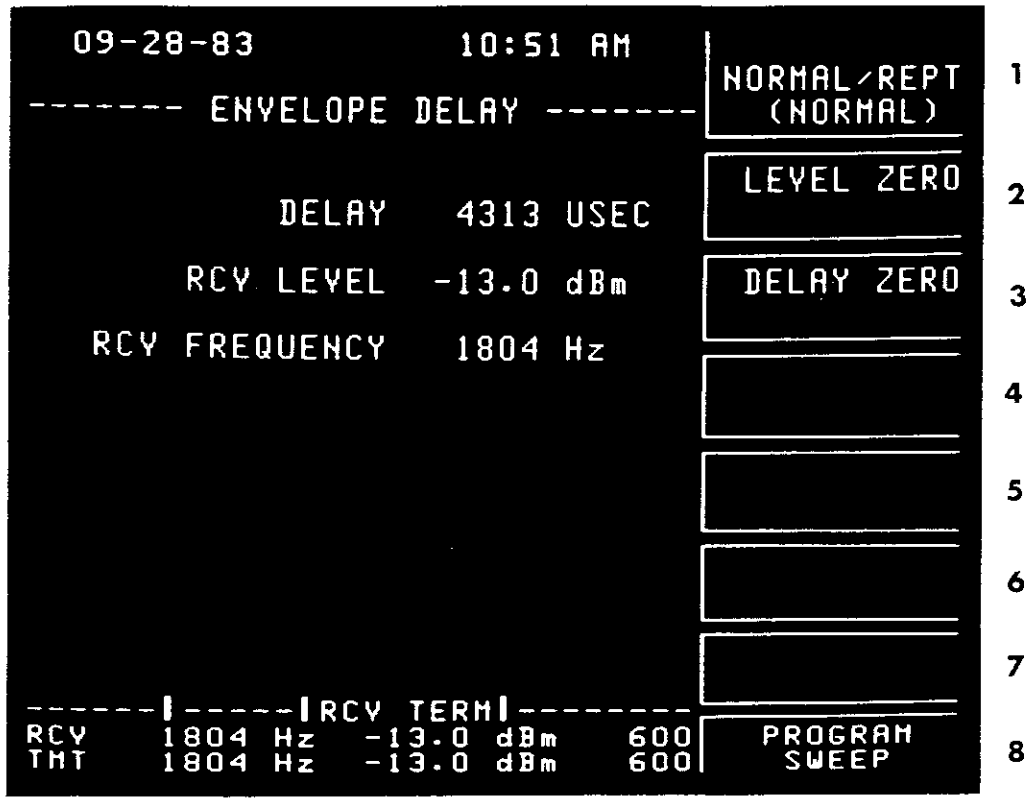


Figure 3-18. The Envelope Delay Measurement Menu

1. This softkey sets up the instrument as the NORMAL or as the REPEAT test set. This key is blanked in master/slave mode.

2. This softkey establishes a zero reference at the current level reading.

3. This softkey establishes a zero reference at the current delay reading.

4. In master/slave mode this softkey is labelled LEVEL/FREQ DATA (ON). This feature allows you to choose whether or not to view the slave's level and frequency readings. If you do not have a need to view this data, set the softkey to OFF. By choosing not to view the remote readings, the measurement cycle is significantly faster.

5. Not Used

6. Not Used

7. Not Used

8. This softkey accesses the programmmable frequency sweep menu.

To set up a programmable frequency sweep when making the envelope delay measurement, press the PROGRAM SWEEP softkey (#8). The menu is shown below with explanations of each of the selections. After setting up softkeys #2 through #6 to the appropriate settings, start the sweep by pressing softkey #1 until it reads SWEEPING in parentheses.

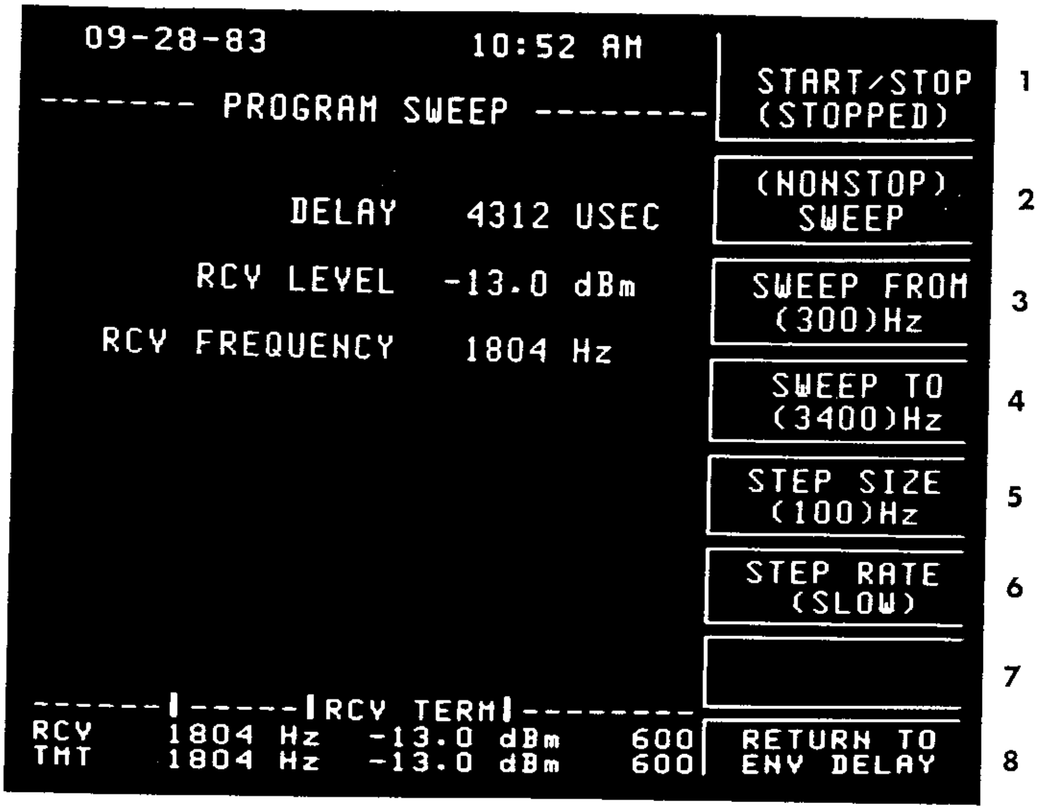


Figure 3-19. The Programmable Sweep Menu for Envelope Delay Distortion

1. This softkey starts and stops the sweep. It toggles between STOPPED and SWEEPING.

2. This softkey toggles between SINGLE and NONSTOP. NONSTOP allows you to continuously sweep.

3. Enter the frequency you want the sweep to start from.

4. Enter the frequency you want the sweep to end on.

5. Enter the step size you want between the frequencies.

6. Select how fast you want the sweep to step. The key cycles through slow (.3 steps/second), medium (1 step/second), and fast (3 steps/second).

7. Not Used

8. This softkey will return you to the envelope delay menu.

Note

Due to the amount of time the receiver of the HP 4945A needs to correctly measure a level and frequency, some points will not be displayed when using the medium or fast sweep rates.

Master/Slave Operation

When using the instrument in master/slave mode, the STEP RATE softkey (#6) will be blank. The step rate is not selectable in this mode of operation.

General Instructions - Return Reference - Normal Test Set

1. Press the TEST SELECT hardkey.
2. Press the ENVELOPE DELAY softkey (#4). The Envelope Delay menu will be displayed.
3. Press the NORMAL/REPT softkey (#1) until NORMAL appears in parentheses.
4. Connect the pair to be tested to the TRMT terminals. Connect the return reference pair to the RCV terminals.
5. Adjust the output level to the "Data Level" using the LEVEL hardkey.

Note

All transmission measurements should be made at Data Level. The Data Level for data circuits is a power of 13 dB below the Transmission Level Point (TLP). For example, if the TLP is -16 dB, the Data Level would be -29 dBm. Therefore, an output level of -29 dBm would be applied in this case.

6. When the Repeat Test Set operator has completed step 6, continue to step 7.
7. Observe the RCV LEVEL (in dBm) on the display. For valid measurements, this level must be greater than or equal to -40 dBm.
8. Adjust the transmit frequency to the reference frequency (e.g., 1804 Hz, or the frequency of minimum delay) using the FREQuency hardkey.

Note

The transmitter of the HP 4945A is automatically set to 1804 Hz when the envelope delay menu is accessed.

Note

If SF signaling units are used in the network under test, SF SKIP should be ON (refer to the Set Up Procedure).

9. Observe the delay reading on the display. Arrows will be displayed until the reading stabilizes. Press the DELAY ZERO softkey (#3). This establishes a zero reference at the reference frequency. This can be verified by noting the display under ZERO REFERENCE.

10. If you want a zero reference for the received level, press the LEVEL ZERO softkey (#2). The level which you selected as the reference is displayed under ZERO REFERENCE on the lower portion of the display.

11. Transmit the desired test frequencies using the FREQuency hardkey or the programmable sweep capability.

12. At each test frequency, observe the relative delay in microseconds. If the readings vary, take the average.

General Instructions - Return Reference - Repeat Test Set

1. Press the TEST SELECT hardkey.

2. Press the ENVELOPE DELAY softkey (#4). The envelope delay menu will be displayed.

3. Press the NORMAL/REPT softkey (#1) until REPEAT appears in parentheses.

4. Connect the pair to be tested to the RCV terminals. Connect the return reference pair to the TRMT terminals.

5. Adjust the output level to the "Data Level" using the LEVEL hardkey.

Note

All transmission measurements should be made at data level. The Data Level for data circuits is a power of 13 dB below the Transmission Level Point (TLP). For example, if the TLP is -16 dB, the Data Level would be -29 dBm. Therefore, an output level of -29 dBm would be applied in this case.

6. Adjust the transmit frequency to the reference frequency (e.g.,1804 Hz or the frequency of minimum delay) using the FREQuency hardkey.

Note

The transmitter of the HP 4945A is automatically set to 1804 Hz when the envelope delay menu is accessed.

7. Notify the Normal Test Set operator that you have completed Step 6.

General Instructions - Forward Reference - Normal Test Set

1. Press the TEST SELECT hardkey.
2. Press the ENVELOPE DELAY softkey (#4). The envelope delay menu will be displayed.
3. Press the NORMAL/REPT softkey until NORMAL appears in parentheses.
4. Connect the pair to be tested to the RCV terminals. Connect the reference pair to the TRMT terminals.
5. Adjust the output level to the "Data Level" using the LEVEL hardkey.

Note

All transmission measurements should be made at Data Level. The Data Level for data circuits is a power of 13 dB below the Transmission Level Point (TLP). For example, if the TLP is -16 dB, the data level would be -29 dBm. Therefore, an output level of -29 dBm would be applied in this case.

6. Adjust the transmit frequency to the reference frequency (e.g. 1804 Hz, or the frequency of minimum delay) using the FREQuency hardkey.

Note

The transmitter of the HP 4945A is automatically set to 1804 Hz when the envelope delay menu is accessed.

7. When the Repeat Test Set operator has completed step 6, continue to step 8.

8. Observe the RCV LEVEL (in dBm) on the display. For valid measurements, this level must be greater than or equal to -40 dBm.

9. Observe the delay reading on the display. Arrows will be displayed until the reading stablilizes. Press the DELAY ZERO softkey (#3). This establishes a reference at the reference frequency. This can be verified by noting the display under ZERO REFERENCE.

10. If you want a zero reference for the received level, press the LEVEL ZERO softkey (#2). The level which you selected as the reference is displayed under ZERO REFERENCE on the lower portion of the display.

11. Notify the repeat test set operator to begin sending the agreed upon test frequencies.

12. At each test frequency, observe the relative delay in microseconds. If the readings vary, take the average.

General Instructions - Forward Reference - Repeat Test Set

1. Press the TEST SELECT hardkey.

2. Press the ENVELOPE DELAY softkey (#4). The envelope delay menu will be displayed.

3. Press the NORMAL/REPT softkey until REPEAT appears in parentheses.

4. Connect the pair to be tested to the TRMT terminals. Connect the reference pair to the RCV terminals.

5. Adjust the output level to the "Data Level" using the LEVEL hardkey.

Note

All transmission measurements should be made at Data Level. The Data Level for data circuits is a power of 13 dB below the Transmission Level Point (TLP). For example, if the TLP is -16 dB, the Data Level would be -29 dBm. Therefore, an output level of -29 dBm would be applied in this case.

6. Adjust the transmit frequency to the reference frequency (e.g. 1804 Hz, or the frequency of minimum delay) using the FREQuency hardkey.

Note

The transmitter of the HP 4945A is automatically set to 1804 Hz when the envelope delay menu is accessed.

Note

If SF signaling units are used in the network under test, SF SKIP should be ON (refer to the Set Up Procedure).

7. Notify the normal test operator that you have completed step 6.

8. When the Normal Test operator has notified you step 10 has been completed, transmit the desired test frequencies using the FREQuency hardkey or the programmable sweep capability.

INTERMODULATION DISTORTION MEASUREMENT

Description

The HP 4945A performs the intermodulation distortion measurement using the 4-tone technique.* This measurement determines the effect of line nonlinearities on the transmitted signal. The HP 4945A will transmit a multifrequency signal and measure the second and third order distortion products. The HP 4945A has the capability to run a signal-to-noise check and correct the readings based on the results. This option is enabled when you select CHECK SIGNAL in the IMD menu.

To enter the intermodulation distortion menu, press the TEST SELECT hardkey and then the IMD/NLD softkey (#5). The following menu will appear.

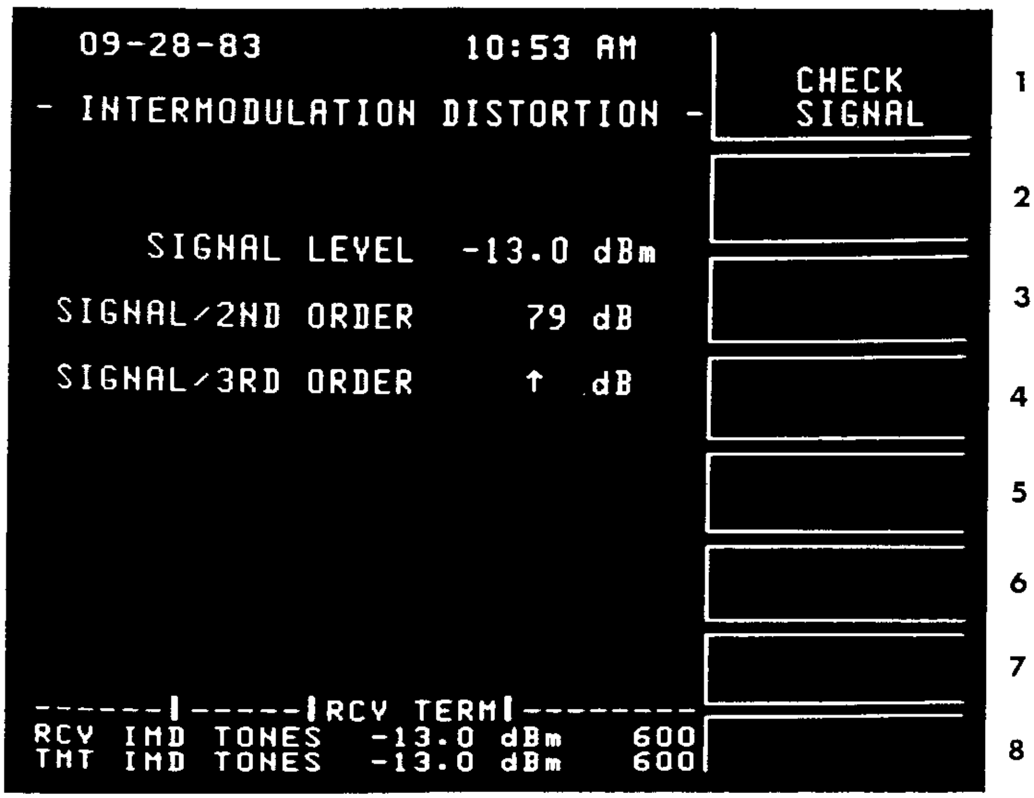


Figure 3-20. The Intermodulation Distortion Measurement Menu

1. This softkey enables a 12 second check signal with each press which is used to determine the signal-to-noise correction factor.

*Licensed under Hekimian Laboratories, Inc. U.S. Patent No. 3,862,380 for nonlinear distortion analyzer.

2. Not Used

3. Not Used

4. Not Used

5. Not Used

6. Not Used

7. Not Used

8. Not Used

General Instructions - Transmitter

1. Press the TEST SELECT hardkey.

2. Press the IMD/NLD softkey (#5). The IMD menu will be displayed.

3. Adjust the output level to the "Data Level" using the LEVEL hardkey.

Note

All transmission measurements should be made at Data Level. The Data Level for data circuits is a power of 13 dB below the Transmission Level Point (TLP). For example, if the TLP is -16 dB, the Data Level would be -29 dBm. Therefore, an output level of -29 dBm would be applied in this case.

4. When requested by the receiver operator, press the CHECK SIGNAL softkey (#1). This will transmit the check signal for 12 seconds. Each press of this key will add an additional 12 seconds to the transmission time.

General Instructions - Receiver

1. Press the TEST SELECT hardkey.

2. Press the IMD/NLD softkey (#5). The IMD menu will be displayed.

3. Instruct the transmitter operator to send the check signal. When this is in progress the status line of your display will read RCV CHECK SIG (in Area 5). When it is done, the message NOISE CORRECTED will appear on your screen. This indicates that the data is now automatically corrected for noise.

4. Observe the readings on the display. Note that the 2nd and 3rd order products are displayed in dB relative to the SIGNAL LEVEL.

Master/Slave Operation

The instrument will automatically alternate between the CHECK SIGNAL and the IMD signal. Therefore, the CHECK SIGNAL softkey (#1) will be blank when in master/slave operation.

JITTER

Description

The HP 4945A performs both amplitude and phase jitter measurements in three different bandwidths. They are 20 to 300 Hz (Bell), 4 to 300 Hz (Bell + Low Frequency), and 4 to 20 Hz (Low Frequency). The jitter measurements can be made individually; or, using the measure-all feature, you can make both measurements in all three bandwidths sequentially.

To enter the jitter menu, press the TEST SELECT hardkey and then the JITTER soft key (#6). The following menu will appear.

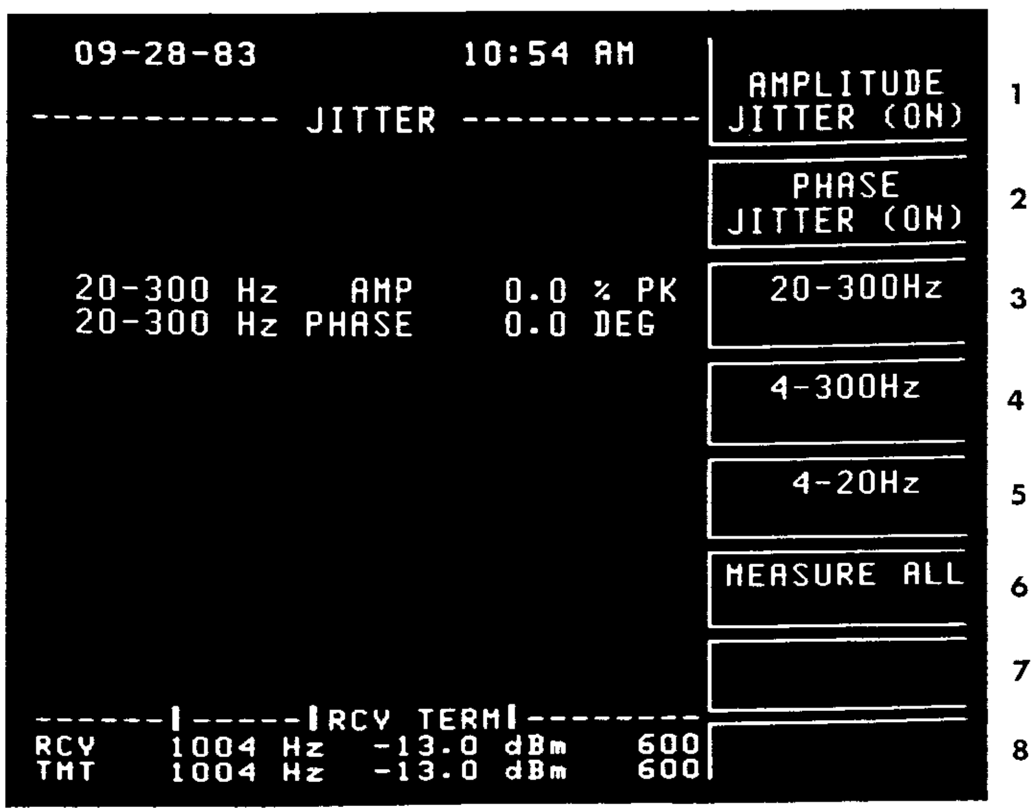


Figure 3-21. The Jitter Measurement Menu

1. This softkey enables the amplitude jitter measurement. When it is ON, the amplitude jitter measurement will be displayed in the selected bandwidths.
2. This softkey enables the phase jitter measurement. When it is ON, the phase jitter measurement will be displayed in the selected bandwidths.
3. This softkey selects jitter in the 20 to 300 Hz bandwidth.
4. This softkey selects jitter in the 4 to 300 Hz bandwidth.
5. This softkey selects jitter in the 4 to 20 Hz bandwidth.
6. This softkey selects the desired jitter measurement in all three bandwidths.
7. Not Used
8. Not Used

General Instructions - Transmitter (Same for both amplitude and phase jitter)

1. Press the TEST SELECT hardkey.
2. Press the JITTER softkey (#6). The Jitter menu will be displayed.

Note

The transmitter of the HP 4945A will be automatically set to 1004 Hz when this menu is accessed. No further adjustment is needed here.

3. Adjust the output level to the "Data Level" using the LEVEL hardkey.

Note

All transmission measurements should be made at Data Level. The Data Level for data circuits is a power of 13 dB below the Transmission Level Point (TLP). For example, if the TLP is -16 dB, the Data Level would be -29 dBm. Therefore, an output level of -29 dBm would be applied in this case.

General Instructions - Receiver

1. Press the TEST SELECT hardkey.

2. Press the JITTER softkey (#6). The Jitter menu will be displayed.

3. To perform the amplitude jitter measurement, press softkey #1 until ON appears in parentheses.

4. To perform the phase jitter measurement, press softkey #2 until ON appears in parentheses.

5. To perform the selected measurement in all three bandwidths, press the MEASURE ALL softkey (#6) and skip to step 7.

6. Select the desired measurement bandwidth by pressing the appropriate softkey, #3 (20-300Hz), #4 (4-300Hz) or #5 (4-20Hz).

7. Observe the jitter readings on the display. If the readings vary, take the average.

P/AR (PEAK-TO-AVERAGE RATIO) MEASUREMENT

Description

P/AR should not be used as a conclusive troubleshooting tool but only as a quick check of a line's performance. The P/AR signal is sensitive to attenuation distortion, phase distortion and noise.

To enter the P/AR menu, press the TEST SELECT hardkey and then the P/AR softkey (#7). The following menu will appear.

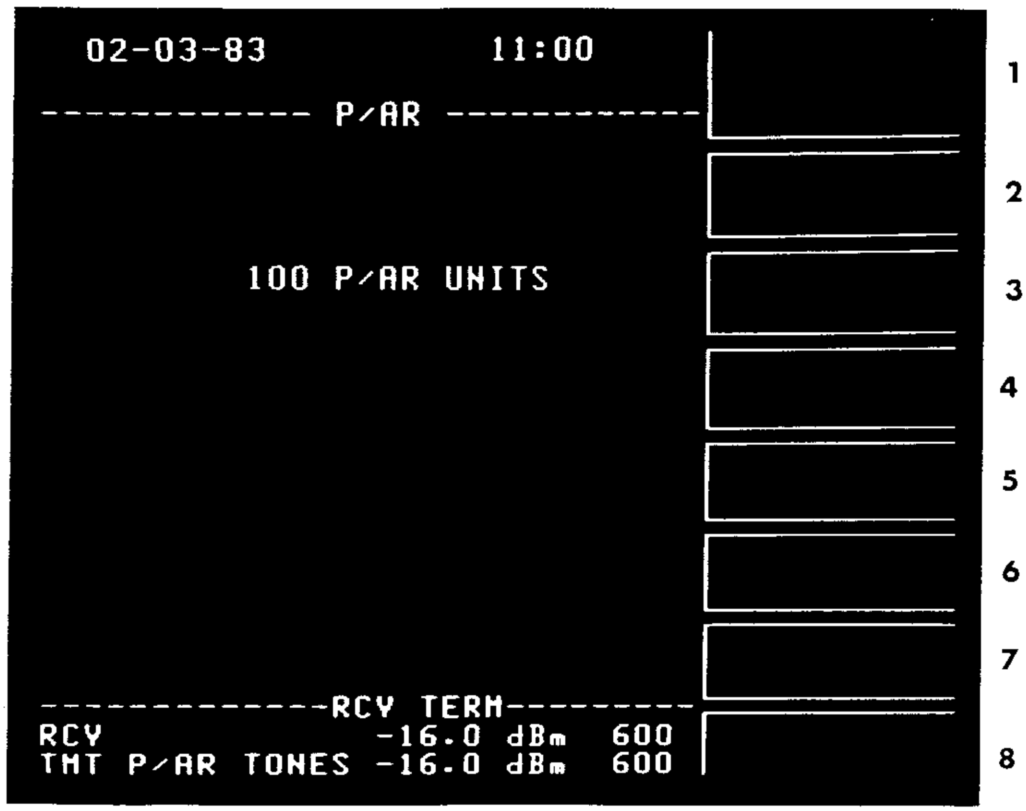


Figure 3-22. The P/AR Measurement Menu

1. Not Used

2. Not Used

3. Not Used

4. Not Used

5. Not Used

6. Not Used

7. Not Used

8. Not Used

There are no softkey selections for this measurement.

General Instructions - Transmitter

1. Press the TEST SELECT hardkey.

2. Press the P/AR softkey (#7). The P/AR menu will be displayed.

3. Adjust the output level to the "Data Level" using the LEVEL hardkey.

Note

All transmission measurements should be made at Data Level. The Data Level for data circuits is a power of 13 dB below the Transmission Level Point (TLP). For example, if the TLP is -16 dB, the Data Level would be -29 dBm. Therefore, an output level of -29 dBm would be applied in this case.

General Instructions - Receiver

1. Press the TEST SELECT hardkey.

2. Press the P/AR softkey. The P/AR menu will be displayed.

3. Observe the P/AR UNITS on the display.

RETURN LOSS

Description

The HP 4945A performs both 2- and 4-wire return loss. In 2-wire return loss you have the capability of using an external reference impedance in addition to the standard 600 and 900 ohm selections. In 4-wire return loss, there is an adjustment for transhybrid loss. You can perform the return loss meaurement using one of the noise waveforms (ERL, SRL HIGH, SRL LOW) or using a single frequency tone. To facilitate characterizing a line, you can run a programmable frequency sweep over the band of interest in sine wave return loss.

Note

This measurement is not available when operating in master/slave mode.

To enter the return loss menu, press the TEST SELECT hardkey and then the RETURN LOSS softkey (#8). The following menu will appear.

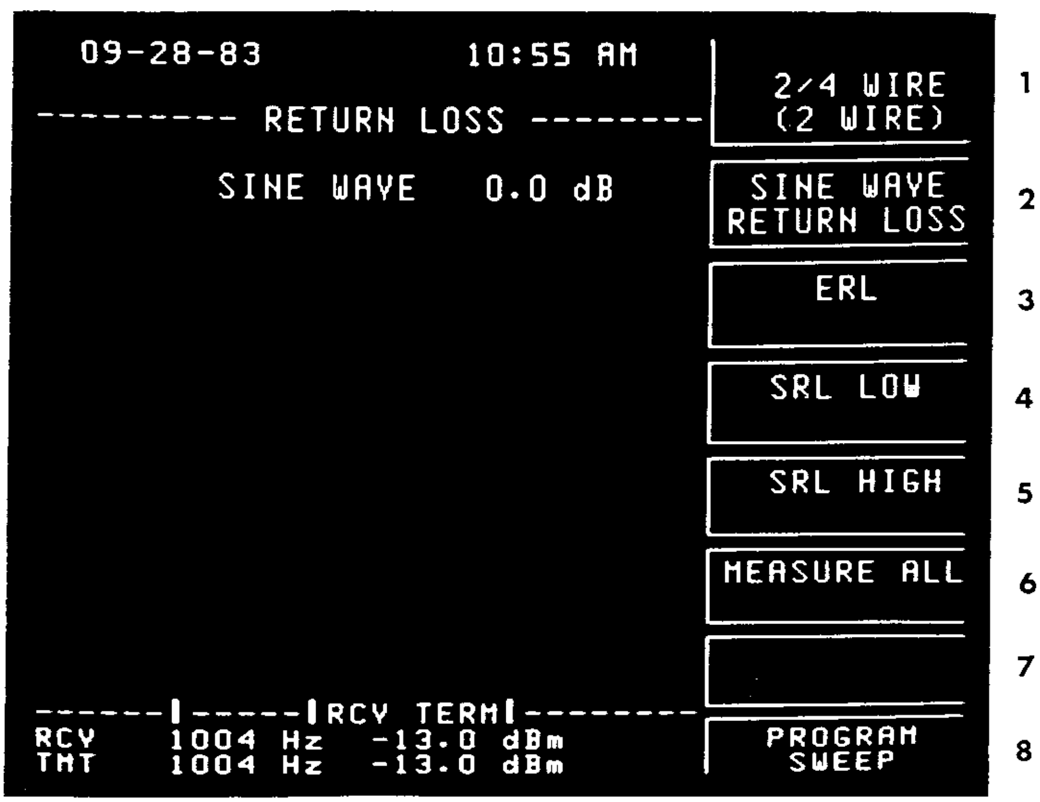


Figure 3-23. The Return Loss Measurement Menu

1. This softkey cycles through 2 WIRE, 4W 0 TLP, 4W -16 TLP. It selects 2- or 4-wire and adjusts the levels according to the point in the circuit you are testing at.

2. This softkey selects sine wave return loss.

3. This softkey selects echo return loss (ERL).

4. This softkey selects singing return loss - low (SRL LOW).

5. This softkey selects singing return loss - high (SRL HIGH).

6. This softkey selects ERL, SRL LOW, and SRL HIGH simultaneously.

7. What is displayed on this softkey depends on whether you have selected 2- or 4-wire mode on softkey #1.

   If you are in 2-wire mode, this key is labelled REFERENCE IMP. It sets the reference impedance of the internal hybrid. It cycles through 600, 900 ohms and EXT. EXT means that you can use an external reference impedance which can be connected to the jacks on the rear panel.

   If you are in 4-wire mode, this softkey is labelled HYBRID LOSS. You can enter the transhybrid loss of your network using the DATA ENTRY keys.

8. This softkey is displayed with SINE WAVE return loss only (softkey #2). It accesses the programmable frequency sweep menu.

When you select SINE WAVE (softkey #2) in the Return Loss menu, softkey #8 becomes PROGRAM SWEEP. When this is pressed the menu shown below is displayed. After setting softkeys #2 through #6, start the sweep by pressing softkey #1 until it reads SWEEPING in parentheses.

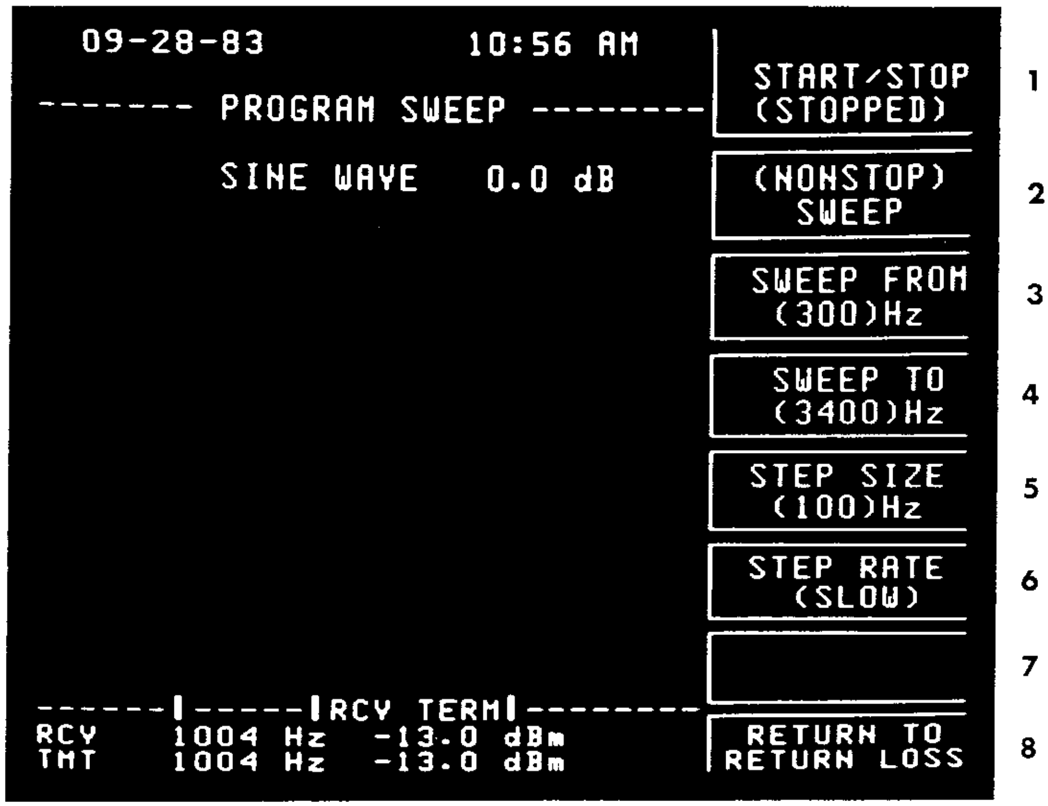


Figure 3-24. Programmable Sweep Menu for Return Loss

1. This softkey starts and stops the sweep. It toggles between STOPPED and SWEEPING.

2. This softkey toggles between SINGLE and NONSTOP. NONSTOP allows you to continuously sweep.

3. Enter the frequency that you want the sweep to start from.

4. Enter the frequency you want the sweep to end on.

5. Enter the step size you want between the frequencies.

6. Select how fast you want the sweep to step. The key cycles through slow (.3 steps/second), medium (1 step/second), and fast (3 steps/ second).

7. Not Used

8. This softkey will return you to the return loss menu.

Note

Due to the amount of time the receiver of the HP 4945A needs to correctly measure return loss, some points will not be displayed when using the medium or fast sweep rates.

General Instructions - 2-Wire Return Loss

The HP 4945A contains an internal resistive hybrid which is used to measure the impedance mismatch of a 2-wire circuit. The internal hybrid is on the transmit side of the HP 4945A

1. Connect the line under test to the TRMT terminals.

2. Press the TEST SELECT hardkey.

3. Press the RETURN LOSS softkey (#8). The Return Loss menu will be displayed.

4. Press the 2/4 WIRE softkey (#1) until 2 WIRE appears in parentheses.

5. Select the appropriate reference impedance by pressing REFERENCE IMP (softkey #7) until the desired selection appears in parentheses. If you want to use your own reference impedance, press the softkey until EXT appears in parentheses. The reference impedance should be connected to the jacks on the rear panel of the instrument.

Note

The 600 and 900 ohm selections are each in series with a 2.16 uF capacitor.

Note

When using either of the internal reference impedances, the EXTernal reference jacks are connected in parallel with the internal reference. This is for the purpose of adding shunt capacitance (e.g. NBO - Network Build-Out capacitance).

WARNING

DO NOT place a dc voltage across the external reference jacks; or a dc path using internal reference.

6. Adjust the output level using the LEVEL hardkey.

Note

The HP 4945A uses the reference impedance selected on softkey #7 to determine the level in dBm. If you have selected the external reference impedance option, it uses the impedance which was previously selected for the transmitter.

7. Select the desired test signal by choosing between softkeys #2 through #6. If performing sine wave return loss, select the measurement frequency using the FREQuency hardkey.

Note

The HP 4945A automatically begins transmitting a 2150 Hz tone when SINE WAVE return loss is accessed. This will disable any echo suppressors on the line. Also, the HP 4945A has the programmable sweep capability which comes up on softkey #8 after SINE WAVE return loss has been selected. This is explained in the previous section. The return loss readings will be displayed on the screen.

General Instruction - 4-Wire Return Loss

1. Connect the TRMT and RCV terminals to the hybrid under test.

2. Press the TEST SELECT hardkey.

3. Press the RETURN LOSS softkey (#8). The return loss menu will be displayed.

4. The HP 4945A has two different four-wire selections on softkey #1. The selections are labelled 4W-0 TLP and 4W-16 TLP. Select the one which matches the transmit TLP at the point you are going to test in the circuit.

Note

When testing at a -16 dBm0 TLP point, a receive TLP at +7 dBm0 is assumed, and the return loss results are adjusted accordingly.

5. Select the desired test signal by choosing between softkeys #2 through #6. If performing sine wave return loss, select the measurement frequency using the FREQuency hardkey.

Note

The HP 4945A automatically begins transmitting a 2150 Hz tone when SINE WAVE return loss is accessed. This will disable any echo suppressors on the line. Also, the HP 4945A has the programmable sweep capability which comes up on softkey #8 after SINE WAVE return loss has been selected. This is explained in the previous section.

6. Adjust the output level using the LEVEL hardkey to the level desired in dBm0 (referenced to TLP).

7. If the transhybrid loss of the circuit is known, press HYBRID LOSS and enter the appropriate value using the DATA ENTRY keys. If it isn't known, short the 2-wire arm of the hybrid under test. Note the reading on the display and enter this reading as indicated above. Don't forget to remove this short before proceeding.

8. Observe the readings displayed.

If you are using 2 instruments to perform this measurement:

If you are using 2 instruments to perform this test, you must set the transmit level on both, even though only one transmitter is being used. The HP 4945A at the receive side must know what the transmit level was in order to perform the return loss calculation.

Also, make sure the impedances on both instruments are set to the same values; otherwide you will receive erroneous readings.

If you want to run a frequency sweep between the 2 instruments only, set up the sweep function (softkey #8) on the transmitting instrument. The receiving instrument should be set up for SINE WAVE return loss. The receiving instrument will recognize the incoming frequencies and display the return loss reading.

HOW TO DUMP THE DISPLAY TO A PRINTER USING THE OUTPUT HARDKEY

Using the OUTPUT hardkey, an image of the display can be sent to a printer. The only part of the screen that will not be printed are the softkey selections. On your printout there will be a line of *'s, and then the display will be printed followed by another line of *'s. While it is printing, the word PRINTING will be flashing at the bottom portion of the screen. The instrument will still be making measurements even though the screen is frozen while printing. When the printing process is finished, the screen will automatically update the results on the screen. Pressing any key on the front panel will stop the printing action. Also, because there is not an ASCII equivalent to the up and down arrows which are displayed occasionally, + and - signs will be printed in their place. Notes for each of the different types of printers are contained below.

When using an HP-IL printer:

If your printer is already connected to the HP-IL module on your HP 4945A, skip to step 3.

1. With the HP 4945A turned OFF, insert the HP-IL module (HP-18165A) into one of the ports on the rear panel.

2. Connect the cables between the module and the printer.

3. Press the LINE button IN to power ON the instrument.

4. After the POWER ON SELF-CHECK has PASSED, then proceed to step 5.

5. Press the SET UP hardkey.

6. Next, press the I/O PORT SET UP softkey (#4). If you plugged the module into PORT 2, then press PORT 2 SET UP softkey (#8). The module should now be identified at the top of the screen.

7. Press I/O MODE softkey (#1) until OUTPUT appears in parentheses.

8. Configure your printer for LISTEN ALWAYS mode.

Note

For the HP 82162A printer, hold the PRINT button and the PAPER ADVANCE button down while powering on.

Your instrument is now ready to print any display by simply accessing the display (perform the measurement) and then pressing the OUTPUT hardkey.

Note

Since the print buffer on the HP 82162A printer cannot hold all of the information on one line on the HP 4945A display, some of the information will wrap around and be printed on the next line.

When using an HP-IB printer:

If your printer is already connected to the HP-IB module on your HP 4945A then skip to step 3.

1. With the HP 4945A turned OFF, insert the HP-IB module (HP-18162A) into one of the ports on the rear panel.

2. Connect the cables between the module and the printer.

3. Press the LINE button IN to power ON the instrument.

4. After the POWER ON SELF CHECK has PASSED then proceed to step 5.

5. Press the SET UP hardkey.

6. Next, press the I/O PORT SET UP softkey (#4). If you plugged the module into PORT 2, then press PORT 2 SET UP softkey (#8). The module should now be identified at the top of the screen.

7. Press I/O MODE softkey (#1) until OUTPUT appears in parentheses. The HP-IB ADDRESS set on softkey #2 is ignored when you set the instrument into this mode.

8. Configure your printer for LISTEN ALWAYS mode.

Your instrument is now ready to print any display by simply accessing the display (perform the measurement) and then pressing the OUTPUT hardkey.

When using an RS-232SC printer:

If your printer is already connected to the RS-232C module on your HP 4945A, skip to step 3.

1. With the HP 4945A turned OFF, insert the RS-232C module (HP-18163A) into one of the ports on the rear panel.

2. Connect the cables between the module and the printer.

3. Press the LINE button IN to power ON the instrument.

4. After the POWER ON SELF CHECK has PASSED, then proceed to step 5.

5. Press the SET UP hardkey.

6. Next, press the I/O PORT SET UP softkey (#4). If you plugged the module into PORT 2, then press PORT 2 SET UP softkey (#8). The module should now be identified at the top of the screen.

7. Press I/O MODE softkey (#1) until OUTPUT appears in parentheses.

8. Set up softkeys #2 through 7 to reflect your situation.

Your instrument is now ready to print any display by simply accessing the display (perform the measurement) and then press the OUTPUT hardkey.

DISPLAY MESSAGES

Following is a list of messages with their explanations. It is divided by the area on the display where it occurs.

AREA 2 MESSAGES

REMOTE - This will be displayed in inverse video when a controller has control of the instrument.

REMOTE WITH LOCAL LOCKOUT - This is displayed when a controller has control of the instrument and the keyboard is locked out.

SERVICE REQUEST - Refer to chapter 5, 6, or 7.

NO HOLDING TONE - In a measurement where a holding tone is used (e.g., Jitter) , a loss of tone will cause the warning message NO HOLDING TONE to appear in inverse video. "Loss of Tone" is defined as a receive level below -40 dBm or a receive frequency that is not between 995-1025 Hz.

IMD SIGNAL NOT RECEIVED - In the intermodulation distortion measurement, the receiver will check to see if a valid IMD signal is being received. If not, the above warning message will be displayed in inverse video.

NO MODULE, HP-IB, RS-232, HP-IL - In the I/O port set up menu, the display will identify what module, if any, is plugged in.

2ND ORDER DIST/NOISE < 2dB
3RD ORDER DIST/NOISE < 2dB
2ND, 3RD ORDER DIST/NOISE < 2dB - These messages indicate that the distortion level is within 2 dB of the background noise.

MASTER/SLAVE WARNING MESSAGES - Refer to the master/slave section.

AREA 4 MESSAGES

POWER ON SELF-CHECK PASSED - This means that the instrument has successfully completed the power on self-check with no errors. This message will disappear after the first key press.

POWER ON SELF-CHECK FAILED - If the instrument fails power on self-check, the entire display is blanked and the above message will appear with a list of the failures. You may be able to continue using the instrument by pressing any key.

RECEIVER NOT CALIBRATED - This warning message indicates that the receiver is not calibrated. The instrument will still operate using default values. This can be corrected by running the calibration routine with no errors in the diagnostic self check menu.

LAST SET UP NOT RETAINED - This indicates that there is a problem with the HP 4945A's nonvolatile memory. The instrument will still operate, but the set up parameters have been reset to default values. If the problem continues, refer to Section 8 of the Service Manual.

DATA ENTRY - Whenever making a data entry, this message will appear in inverse video. This indicates that both the data entry keypad and the up/down arrow keys are active.

FREQ. CHANGE NOT ALLOWED HERE - In certain measurements, the definition of the measurement defines the frequency or frequencies used (e.g. P/AR). In these cases, the above warning message will be displayed with a warning beep if you attempt to change the frequency.

RANGE: XX TO XX/XX OUT OF RANGE - When making a data entry, the HP 4945A automatically displays the allowable range for that parameter. If you try to exceed this range, the XX OUT OF RANGE indication appears with a warning beep.

TURN DIAL TALK OFF TO EXIT - If you are in DIAL/HOLD SET UP menu, you are not allowed to exit unless you turn DIAL TALK OFF. This is to prevent you from making a measurement without the instrument connected to the line.

NO I/O MODULE IN OUTPUT MODE - This indicates that the OUTPUT hardkey was pressed, but an I/O module is not installed or was not set up in output mode.

PRINTING - This occurs when data is being sent out to a printer.

The HP 4945A is equipped with self-diagnostics and self-calibration capability. When running either of these routines one of the following messages will be displayed.

CALIBRATING - This message is displayed when running the calibration routine.

SINGLE (or REPEATING) CHECK IN PROGRESS - This message is displayed when running the diagnostic self-check.

LINKING - PLEASE WAIT - This message indicates that it is performing the initial master/slave linkup.

AREA 5 MESSAGES

SELF-CHECKS PASSED/SELF-CHECKS FAILED - These messages are displayed in the diagnostic self-check mode. They are followed by the number of times it has passed and/or failed.

RCV TERM or RCV BRDG -This indicates whether your receiver is bridged or terminated.

SF SKP - This indicates that the SF (signalling frequency) SKIP is active.

VOICE - This indicates that the voice band limit function is active.

RCV (or TMT) MNTR - If the volume is on, this indicates whether you are listening to the receiver or the transmitter.

MS TO SL or SL TO MS - When in Master/Slave, this indicates the direction of the test that is selected.

LINKING - This message will flash while the instrument is re-linking while in master/slave mode.

LOOPBACK - This indicates that the slave unit is repeating the received signal at the level selected. This only occurs in master/slave mode.

The lower two lines contain the current level (in dBm), frequency and terminating impedance of both the transmitter and receiver. If the handset terminals are active on the front panel then the message HANDSET will be displayed on the transmitter line.

MASTER/SLAVE
GENERAL INFORMATION

What is it?

Master/Slave is a method for remotely controlling a distant TIMS using the lines under test. Master/Slave can only be utilized on 4-wire circuits. This technique virtually eliminates the need for another person at the far end after the instrument is powered up. Another direct advantage is that a separate dial up link isn't required for communication purposes. Also, testing time is reduced by eliminating the coordination time needed when running a test using two people. Testing can be done on either pair of the four wire circuit. The "handshaking " that takes place between the two instruments is transparent to the user. The details of how it actually works and how to use it are contained in the following sections.

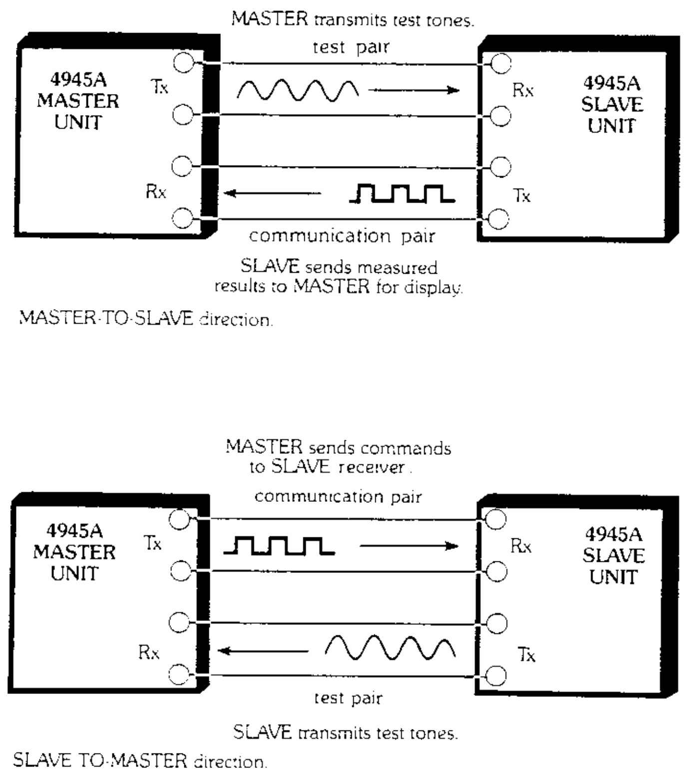


Figure 3-25. Master/Slave Test Set Up

FSK Technique

The two units communicate their information using internal lowspeed modems. The modems employ a technique called frequency shift keying (FSK) to code the data going over the line. They transmit 800 Hz to represent a "space" or a 0, and 1200 Hz to represent a "mark" or a 1. In addition a 1990 Hz pilot tone (also referred to as the "carrier") is used to alert the receiving unit that FSK data is coming. This is to prevent "noise" from being interpreted as data.

Direction of Test

This term is only applicable when you are performing a measurement. "Direction of test" refers to the direction that the measurement is taking place. "Master-to-Slave" means that the Master unit will transmit the test signals and the Slave unit will receive them and perform the measurement. "Slave-to-Master" is just reversed. An easy way to think about it is to visualize the test signal moving in the direction that is listed. "Master-to-Slave" means that the test signal is being generated (transmitted) at the "Master" end and is being received at the "Slave" end.

Initial Link-up

In the initial link-up, the Master requests identification from the Slave. The HP 4945A needs to know if it is interfacing with another HP 4945A, or an HP 4943A or HP 4944A, so it can configure itself accordingly. (Note that Master/Slave operation with the last two instruments mentioned is covered at the end of this chapter). Next, the Slave sends back the type of instrument it is and what its current parameters are. These parameters consist of its current level, impedances, and measurement information. During this process the message "LINKING - PLEASE WAIT" will be displayed on the screen. If an error or "no response" is detected in any of the above transmissions then the process will start over. If a link is not established after a reasonable length of time, then the message "UNABLE TO COMPLETE M/S LINK" will be displayed. The Master will continue trying to link until it is taken out of Master/Slave mode.

Re-link

Once linked, when an action takes place which affects the Slave, a "re-link" takes place. The message "LINKING" will flash on the screen. This will happen when entering a measurement, changing the Slave's impedances, changing the direction of test, etc. When entering a measurement, the Master will request the Slave to enter a specific measurement, designate the direction of test, and will include any setup parameters associated with that measurement. The Slave in turn will send back whether or not it has the capability to perform the measurement (if not it will go into "loopback" mode) and its level and frequency ranges for that measurement. After the re-link process is done, the measurement takes place.

Communication Pair vs Test Pair

During the link-up process, communication takes place over both pairs as was discussed above. When performing a measurement, the test is being run over one pair, which is referred to as the test pair. The other pair is used for communication between the Master and the Slave. In the Master-to-Slave direction, the Slave will send back the measurement results over the communication pair. In the Slave -to-Master direction, the Master will be sending measurement commands to the Slave over the communication pair. Communication is done using the FSK technique described earlier.

Envelope Delay Distortion

Since the envelope delay distortion measurement requires four wires, it is handled slightly different. Following is a brief description of what takes place when in the Master/Slave mode.

Master to Slave (Return Reference)

The Master sends an FSK signal requesting the Slave to perform a level and frequency measurement. Next, it sends the envelope delay signal using a variable frequency carrier.

The Slave performs level and frequency measurement and sends the information to the Master. Next, it shifts the received modulation to a fixed frequency carrier (1804 Hz) and sends it back to the Master.

The Master receives the current level and frequency, information, performs the delay measurement, and updates the screen.

Slave to Master (Forward Reference)

The Master sends an FSK signal telling the Slave the carrier frequency it should use. Next, it sends the envelope delay signal using a fixed frequency carrier (1804 Hz).

The Slave shifts the received modulation to the carrier frequency requested by the Master. This signal is sent to the Master.

The Master performs a level, frequency and delay measurement on the incoming signal and displays the results.

Note

An FSK signal will be sent from the Master unit to the Slave unit everytime you change the frequency.

HOW TO CONFIGURE THE INSTRUMENT FOR MASTER/SLAVE OPERATION

Let's look at how you put the instrument in Master/Slave mode.

First, press the SET UP hardkey to enter the Set Up menu.

Notice that softkeys #6 and #7 control Master/Slave operation. Softkey #6, which is labelled MASTR/SLAVE, cycles between OFF (normal operation) MASTER and SLAVE. Select the operating mode for your instrument. If you select MASTER, the initial linking process will begin.

Note

To act as the slave in Master/Slave, the unit does not need to be set to SLAVE. This will automatically happen when the unit at the far end is set to MASTER. This is called "capturing" the slave. This avoids the need to have a person at the Slave site. You will not be able to "capture" an instrument that is in calibration, self-check, or 2-wire return loss mode.

Note

On the Master unit, all keys except the MASTER/SLAVE softkey on the front panel will be locked out during initial link-up.

Note

The FSK signal level will track the measurement signal level down to -29 dBm. Below that the FSK signal level will remain at -29 dBm regardless of the measurement signal level which is set.

Softkey #7 toggles between (MASTER TO SLAVE) and (SLAVE TO MASTER). This is setting the "direction of test" as shown in figure 3-25. You should set this to the desired testing configuration. Notice that changing this setting causes the instruments to re-link.

Now, you can proceed through the normal operating sections. This manual is organized so that any additional notes pertaining to Master/Slave operation are included at the end of each section. Basically, you operate the instrument just as you would in normal operation.

Note

If you are using the HP 4945A with either an HP 4943A or an HP 4944A, then refer to the next Section for additional information.

MASTER/SLAVE WHEN USING AN HP 4943A OR AN HP 4944A WITH THE HP 4945A

Why is it Different?

The HP 4943A and HP 4944A are the original Hewlett-Packard instruments designed with the Master/Slave capability. Each contains only a subset of the HP 4945A's measurements. Also, they have LED displays and their front panels have switches and knobs. Due to these constraints, they are unable to display error messages in plain English (they display H codes) and some of their switches are not programmable through Master/Slave operation.

What is "Loopback mode"?

As mentioned before, the measurement capability is limited when using an HP 4943A or HP 4944A. When an HP 4943A or HP 4944A is instructed to perform a function that is beyond its capabilities, it will go into loopback mode. This means that the incoming signal to the Slave will be looped around and sent back to the master at the level which has been set on the Slave unit. To get out of loopback mode, press a different key and the instruments will re-link.

Configuration Considerations When Master is an HP 4943A or HP 4944A and Slave is an HP 4945A.

In this configuration the HP 4945A is limited to the capabilities of the Master.

Examples of these limitations are:

- Frequency and level range limitations of the HP 4943A or HP 4944A
- No amplitude jitter measurements
- No automatic gain slope measurement
- 7 counts/sec in impulse noise
- No phase hits, gain hits or dropouts measurements

The following items must be set on the HP 4945A Slave before it is put into Master/ Slave mode:

- Transmitter and Receiver Impedances
- Transmitter and Receiver Hold Coils
- Receiver BRIDGED or TERMINATED Setting
- The VOLUME Control
- Impulse Noise Thresholds
- Transmitter Level

Note

> If the HP 4945A transmit level is outside the range of the HP 4943A or HP 4944A then the two instruments will not be able to establish a link-up.

During the initial link-up, error codes may appear momentarily. First, the error code H-01 will appear which signifies that no response was received from the Slave. This occurs because the HP 4945A must take time to verify that it is configured as another HP 4943A or HP 4944A (depending on which unit you are using for the Master). This code will disappear if everything is functioning correctly and an other error code may appear momentarily if you are set up in MASTER TO SLAVE direction of test. This may be either an H-09 or an H-10. This occurs because the HP 4945A will not send back test results until it has valid data. These error codes should all disappear and the Master/Slave operation should be no different than it would be with an HP 4943A or an HP 4944A acting as the Slave.

Configuration Considerations When Master is an HP 4945A and Slave is an HP 4943A or an HP 4944A

The following items must be set on the HP 4943A or HP 4944A slave unit before it is in Master/Slave mode:

- Transmitter/receiver impedance setting
- Hold coils
- Receiver BRIDGED or TERMINATED setting
- Impulse noise threshold
- Transmitter level

Note

If the HP 4945A transmit level is outside the range of the HP 4943A or HP 4944A then the two instruments will not be able to establish link-up.

DIRECTION OF TEST = MASTER TO SLAVE

You are limited to the range limitations of the HP 4943A or HP 4944A since it is performing the measurement (receive end).

The receiver's (Slave) frequency field will always be blank.

The HP 4945A will only display counts in the impulse noise low area since the HP 4943A or HP 4944A only has one threshold setting (which must be set manually).

When doing the envelope delay measurement, you do not have the capability of performing a LEVEL ZERO. This calculation must be done manually.

If you enter a menu with a parameter set to an illegal choice then the slave will go into loopback mode. Always set up all parameters before entering into Master/Slave mode.

DIRECTION OF TEST = SLAVE TO MASTER

In this configuration you have additional capabilities. You are limited to the receivers capabilities. Therefore, you are able to do the following:

- Amplitude jitter
- All 3 jitter bandwidths
- Noise-to-ground measurement
- 3 level impulse noise
- Phase hits, gain hits, and dropouts measurements

MASTER/SLAVE ERROR MESSAGES

Why Do They Occur?

What could cause the Master/Slave errors to occur? There may be an operational problem with your test set. In this case you should run through the self-diagnostic capabilities of each unit which is being used. Also, it is recommended that you use the test set at transmission levels > -40 dBm and a S/N ratio > 20 dB since impairments on the lines being used could disturb your Master/Slave operation. Always check your connections to ensure continuity.

Descriptions

All error messages (along with the equivalent H-code used by the HP 4943A and HP 4944A) are contained is this section. These messages are generated by the master unit. This section is organized to highlight some of the key differences between each of the error messages. Below is a brief explanation of each of the areas.

When? - This refers to whether the error will occur while linking is in progress (LINKING is flashing on the display) or after link-up.

Pilot Tone? - This will tell you whether you are receiving the pilot tone (1990 Hz).

Data? - Data refers to the FSK information which is being sent between the instruments on the communications pair. This will tell you if the error message is being caused because no data is being received by the Master from the Slave.

Direction of Test? - This is only applicable after link-up. Certain messages are suseptible to the direction of test which was selected. This will list whether it will only happen when the instrument is making a measurement in a certain direction or if it occurs independent of the direction of test setting.

Problem Channel? - Occasionally you can isolate the problem to a specific channel. The channel we refer to here is the pair and the transmitter and receiver connected to that pair.

No Answer Received From Slave (H-02)

When? - During link-up or re-link only.

Pilot tone? - Yes.

Data? - No.

Direction of Test? - Either direction.

Problem Channel? - Either channel.

Additional Comments - When you receive this message you are receiving the pilot tone back but not any data. This message is only displayed during the linking process.

Data Errors In Slave Response (H-03)

When? - Anytime.

Pilot Tone? - Yes.

Data? - The data received has parity and/or framing errors.

Direction of Test? - During Link-up - Either. After Link-up M - S only.

Problem Channel? - If it occurs during link-up then either channel may be causing a problem. After link-up has taken place the error is being caused on the communications channel.

Additional Comments - In this case we are receiving data back from the slave but it contains parity and/or framing errors.

Bad Data In Slave Response (H-04)

When? - During link-up or re-link only.

Pilot Tone? - Yes.

Data? - Yes.

Direction of Test? - Either.

Problem Channel? - Either.

Additional Comments - This error will occur if the master receives a negative acknowledge (NAK), a bad block of data, or the incorrect response from the initial inquiry sent to the slave unit.

Incorrect Response From Slave* (H-05)

When? - During link-up or re-link only.

Pilot Tone? - Yes.

Data? - It is good in terms of parity and framing but it is the incorrect response.

Direction of Test? - Either.

Problem Channel? - Either.

Additional Comments - In this case, the master has requested the slave to enter a measurement mode and the slave did not respond correctly.

Slave Fails To Execute Command* (H-06)

When? - During link-up or re-link only.

Pilot Tone? - Yes.

Data? - Yes.

Direction of Test? - Either.

Problem Channel? - Communications Channel.

Additional Comments - This error message occurs if the master receives no response from the initial inquiry sent to the slave.

Slave Looped Back (H-07)

When? - After link-up.

Pilot Tone? - Yes.

Data? - Slave is in loopback mode.

Direction of Test? - Either.

Problem Channel? - No.

Additional Comments -This error occurs when the master requests the slave to perform a measurement which is beyond its capabilities. The slave will automatically go into loopback mode. This occurs when interfacing with an HP 4943A or an HP 4944A because of their limited measurement capability.

* Applicable only if using an HP 4943A or an HP 4944A.

No Data Received From Slave (H-09)

When? - After link-up.

Pilot Tone? - Yes.

Data? - No.

Direction of Test? - M - S only.

Problem Channel? - Communications Channel.

Additional Comments - In this case, the master unit is expecting a response from the slave but it is only receiving the pilot tone.

Receiver Level Out of Range (H-10)

When? - After link-up.

Pilot Tone? - Yes.

Data? - No.

Direction of Test? - Either.

Problem Channel? - Test Channel.

Additional Comments - This error means that the instrument acting as the receiver is unable to perform the measurement because the test signal is out of range.

No Carrier Received From Slave (H-11)

When? - During link-up only.

Pilot Tone? - No.

Data? - ---

Direction of Test? - During link-up - Either.

Problem Pair? - Either.

Additional Comments - The master unit in this case is receiving a signal but it is not the correct frequency (1990 Hz).

Slave Initiated M/S Link Abort (H-13)

When? - Anytime.

Pilot Tone? - Yes.

Data? - Yes.

Direction of Test? - Either.

Problem Channel? - No.

Additional Comments - This message occurs if the slave sends an "abort" to the master. This only happens when the slave is taken out of slave mode at the far end.

Dropout > 1 Sec - Test Aborted* (H-14)

When? - After link-up.

Pilot Tone? - Yes.

Data? - No.

Direction of Test? - Either.

Problem Channel? - Test Channel.

Additional Comments - This error will only occur when you are in impulse noise and you lose the holding tone (1004 Hz). The instruments will terminate the test.

Phase Jitter Overrange* (H-15)

When? - After Link Up.

Pilot Tone? - Yes.

Data? - No.

Direction of Test? - Either.

Problem Channel? - Test Channel.

Additional Comments - This message is displayed only if the HP 4943A is making the phase jitter measurement and the reading is greater than 40 degrees.

* Applicable only if using an HP 4943A or an HP 4944A.

Invalid Test Signal* (H-16)

When? - After link-up.

Pilot Tone? - Yes.

Data? - ?

Direction of Test? - Either.

Problem Pair? - Either.

Additional Comments - In certain measurements the instrument is able to detect if it is receiving the correct test signal. These measurements are impulse noise, IMD, and the jitter measurements.

Unable To Complete M/S Link

When? - During initial link-up or re-link

Pilot Tone? - Maybe.

Data? - Maybe.

Direction of Test? - Either.

Problem Channel? - Either.

Additional Comments - This message is displayed if the instruments are unable to establish a link after a reasonable period of time. You may not be receiving the pilot tone or data because of one of the other errors causing a problem.

Slave Not Capable*

When? - After link-up

Pilot Tone? - Yes.

Data? - Yes.

Direction of Test? - See comments below.

Problem Channel? - No.

Additional Comments - This message will occur in two situations, both when using an HP 4943A or an HP 4944A as a Slave. The first is when you are set up in the Slave-to-Master direction of test and you try to change the Slave's transmit level.

The other situation is when you are set up in the Master to Slave direction of test and you try to change the impulse noise threshold settings.

* Applicable only if using an HP 4943A or an HP 4944A.

Slave Unable To Do Measurement

When? - After link-up

Pilot Tone? - Yes

Data? - Yes

Direction of Test? - Either

Problem Channel? - No

Additional Comments - This error occurs when the Master requests the Slave to perform a measurement which is beyond its capabilities. The Slave will not go into loopback mode.

DTMF SIGNALING CAPABILITIES

The HP 4945A provides Dual Tone Multi-Frequency (DTMF) signaling. This feature allows touch tone dialing. The following table lists the segments and their corresponding function.

Segment	Function
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	0
11	*
12	#
13	Erases memory
14	Adds pause to dialing
15	Resumes dialing after pause
16	Dials number automatically

To access the feature, enter the diagnostics self-check menu and select SEGMENT self-check, MODE 99. Then set the segment number to SEGMENT 13 and press the START/STOP key.

SEGMENT 13 clears out any previous number stored in the memory. A telephone number of up to 50 digits can be entered in memory.

Each digit is entered by selecting the SEGMENT for that digit and pressing START/STOP.

After the entire number has been entered, select segment 16 and press START/STOP. The number will then be dialed automatically.

A controller can be set up in a programming loop to dial the number automatically. Following is a sample command that would dial the number 9-(pause)1-800-987-6543.

```
SC399;SC413;SC1;EXC
   <ENDST 0>
SC49;SC1;EXC
   <ENDST 0>
SC414;SC1;EXC
   <ENDST 0>
SC41;SC1;EXC
   <ENDST 0>
SC48;SC1;DXC
   <ENDST 0>
SC410;SC1;EXC
   <ENDST 0>
SC410;SC1;EXC
   <ENDST 0>
SC49;SC1;EXC
   <ENDST 0>
SC48;SC1;EXC
   <ENDST 0>
SC47;SC1:EXC
   <ENDST 0>
SC46;SC1;EXC
   <ENDST 0>
SC45;SC1;EXC
   <ENDST 0>
SC44;SC1;EXC
   <ENDST 0>
SC43;SC1;EXC
   <ENDST 0>
```

To dial the number, the controller would then send:

```
SC416;SC1;EXC
   <ENDST 0>
[WAIT FOR PBX RESPONSE]
SC415;SC1;EXC
   <ENDST 0>
```

CHAPTER IV. MEASUREMENT PRINCIPLES

INTRODUCTION

This section describes the principles of all measurements made by the HP 4945A. Included are explanations of the need for the measurements, plus the effect of certain voice channel parameters on data transmission. Block diagrams and functional descriptions are provided to explain the HP 4945A input-output switching and the different measurements that the test set make.

For further information concerning the voice channel measurements described in this section, refer to the following Bell System Technical References: PUB 41008, Analog Parameters Affecting Voiceband Data Transmission - Description of parameters, and PUB 41009, Transmission Parameters Affecting Voiceband Data Transmission - Measuring Techniques. These publications are available from District Manager - information American Telephone and Telegraph Co., P.O. Box 915, Florham Park, New Jersey 07932.

INPUT-OUTPUT SWITCHING

The RECEIVE/TRANSMIT JACKS provide for interconnection of the HP 4945A to the circuit under test. See Figure 4-1. The RECEIVE/TRANSMIT switch provides for selection of either the transmit or receive function for the left jacks and simultaneously selects the opposite for the right jacks. Both the left and right sets of jacks provide parallel connections, the standard five-way binding posts on top and the Western Electric 310 type jacks on the bottom. Either the binding posts or the 310 jacks may be used; they will not normally be used at the same time.

The hold current coil allows the application of a 23-mA current source to both the right and left set of jacks (TIP and RING connections). This allows for latching of telephone switching equipment. Either the right or left set of jacks may be used for 2-wire dry circuit. If a 4-wire circuit is under test, the left jacks may be used for either transmit or receive, and the right set for the opposite.

The transmit and receive impedance of the HP 4945A is selectable at 135, 600, 900, or 1200 ohms (termination resistors figure 4-1),which are standard telephone circuit values. The impedance of the test set must be selected to match the circuit under test, or erroneous measurement values will be obtained.

The receive input may be terminated or bridged across the circuit under test. The termination mode provides a resistive termination on the receive circuit to provide proper loading. When a termination is provided by some other device, it is not necessary to provide a termination. In this case the receiver input should be used in the bridged mode.

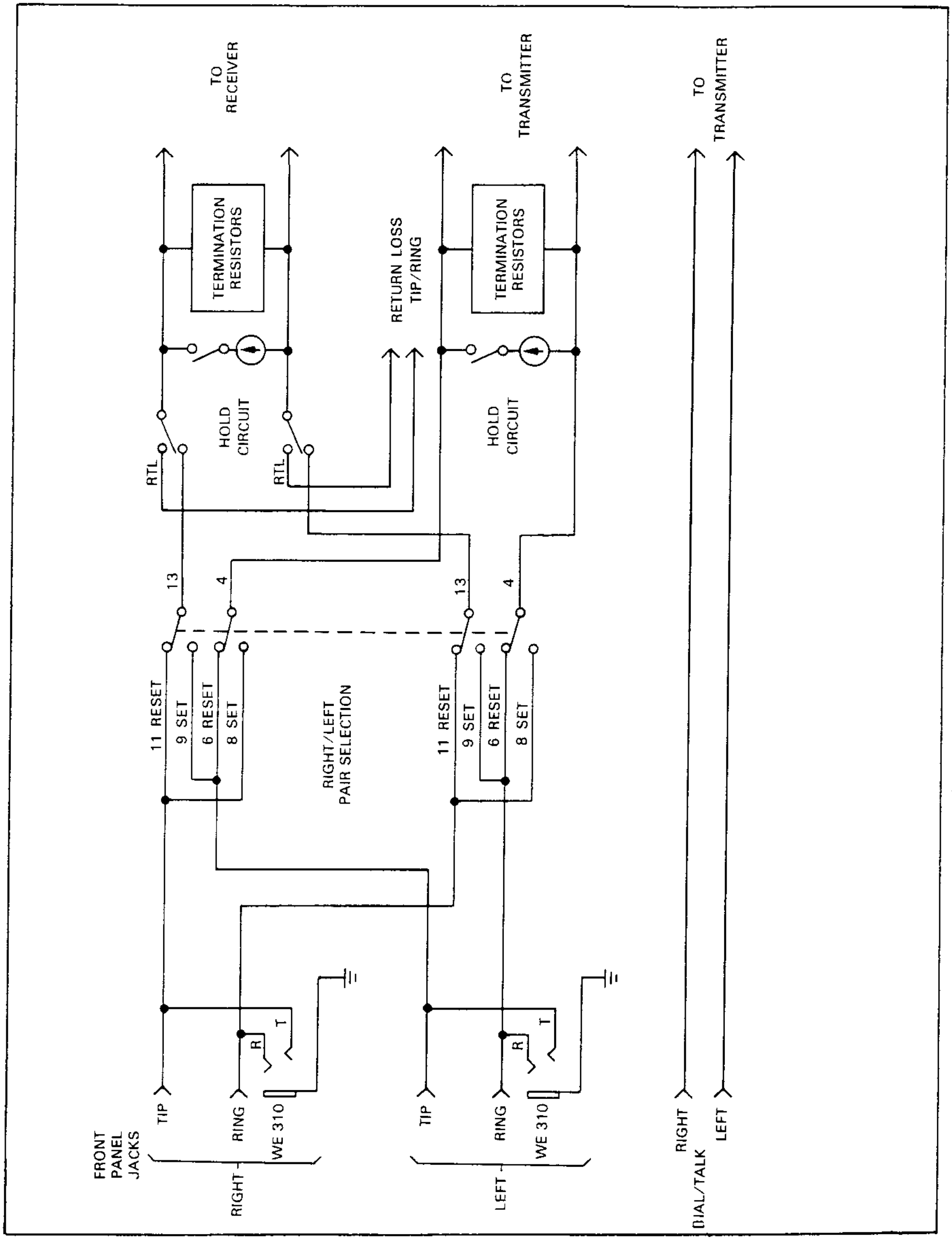


Figure 4-1. Input-Output Switching

The HP 4945A input and output circuits are balanced to match standard telephone voice channel lines. A balanced line is one that is electrically symmetrical; the two sides of the line have equal series resistance, series inductance, shunt capacitance, and leakage to ground. Only test sets (or other devices) with balanced inputs and outputs will operate properly when connected to a balance line.

To allow dialing, talking, and listening over the circuit under test, handset terminals are provided for the connection of a lineman's handset. In addition, talk battery is selectable for use on dry circuits (circuits which do not incorporate a power source to provide direct current flow for the microphone).

DATA LEVEL

Transmission measurements on data circuits use test signals applied at data level (the standard Bell System data level is -13 dBm0). Data level is used to prevent overload on carrier systems. Data level is a power 13 dB below the transmission level point (TLP) where the tests are being made. For example, at a -16 dB TLP, the data level would be -29 dBm (-16 -13 = 29). A test power of -29 dBm would be applied here. At the zero transmission level point (0 TLP), the data level would be -13 dBm, or -13 dBm0.

LEVEL AND FREQUENCY MEASUREMENTS

The level and frequency mode allows measurement of 1000 Hz loss, attenuation dis tortion, and gain slope. These measurements define the amplitude versus frequency response of a voice channel. The level and frequency mode also allows measurement of frequency shift. Figure 4-2 illustrates the basic setup for thse measurements.

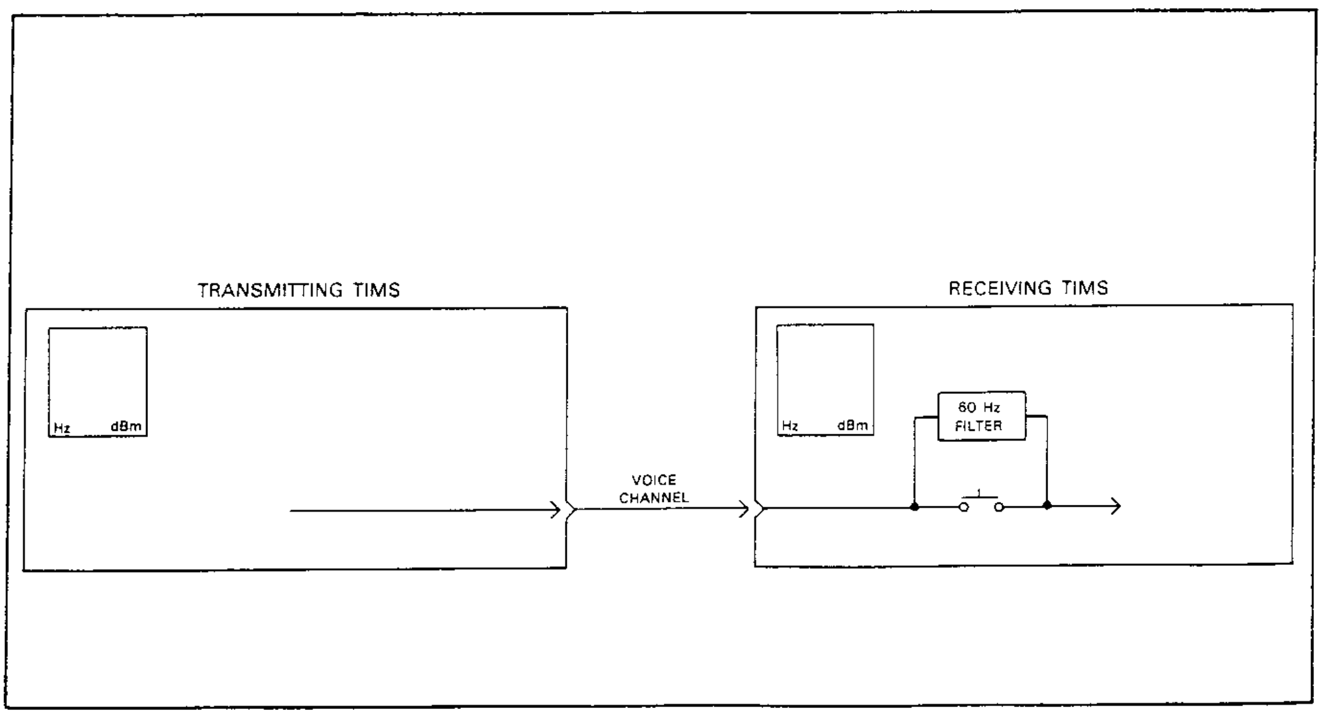


Figure 4-2. Level and Frequency Measurement

1000 Hz Loss

The 1000 Hz loss measurement determines the point-to-point loss (or gain) of a 1000 Hz test tone transmitted over a voice channel. To make this measurement, a 1004 Hz test frequency is transmitted at data level. At the receiving TIMS, th e received power is measured (in dBm) and substracted from the transmitted level to determine 1000 Hz loss (in dB).

The transmitted frequency is actually 1004 Hz (not 1000 Hz), to prevent measurement errors which would occur over T-carrier systems. This 4 Hz offset avoids measurement errors caused by test frequencies which are submultiples of the T-carrieer sampling rate. This measurement error is not representative of actual conditions which are present when multiplfrequency signals like voice and data are transmitted over voice channels.

The accuracy of the received power measurement depends on the tolerance of the receiving and resistive termination. A terminating resistance of 0.1 percent tolerance is required to assure accurate measurements. Therefore, received level measurements should generally be made using the HP 4945A internal termination.

A switch-selectable 60 Hz high-pass receiving filter is provided for use with the level and frequency measurements. The 60-Hz filter is used to detect and remove excessive 60 Hz interference. The filter has an attenuation characteristic greater than 20 dB at 60 Hz, and a 4-dB attenuation characteristic at 180 Hz (3rd harmonic of 60 Hz).

Frequency Shift

The frequency shift measurement checks for any difference in the received frequency with reference to the transmitted frequency (frequency translation) as caused by carrier facilities. To make this measurement, a test tone of known frequency is transmitted. At the receiving end, the received frequency is observed and compared with the transmitted frequency. Any difference between transmitted and received frequencies indicates a frequency shift in the test signal. This measurement is not valid when on looped around carrier facilities, since the frequency shift in one direction (near-end to far-end) may be cancelled by the frequency shift in the other direction (far-end to near-end).

GAIN SLOPE

This is a measurement of the loss of received level versus frequency. Gain slope is the measurement of the received level at 404 Hz, 1004 Hz, and 2804 Hz. Gain slope is calculated by taking the difference between levels at 2804 Hz and 1004 Hz. This measurement determines the usable bandwidth of the voice channel. To make this measurement the transmitter automatically steps through 1004 Hz, 404 Hz, and 2804 Hz at 2 seconds per step. The frequency received must be within + or -26 Hz in order to be displayed on the CRT.

The gain slope or relative loss will then be displayed after the 1004 Hz reference is measured. The loss at 404 Hz and 2804 Hz will be displayed once all three frequencies have been received. The gain slope measurement runs continously.

The SF (single-frequency) SKIP setup softkey is provided to automatically prevent the test set from transmitting frequencies within the range of 2450 Hz to 2750 Hz. This feature is used to prevent loss of voice channel connection when transmitting over a dial-up network incorporating single frequency signaling units.

NOISE MEASUREMENTS

The noise measurements determine the interfering effects of background noise and tones. Figure 4-3 illustrates the basic setup for these measurements.

Noise

The message circuit noise mode measures the noise present on a voice channel, which has a quiet termination on one end (supplied by transmitting TIMS) and a weighted measuring device on the other end (received TIMS). The quiet termination is a simple resistive termination on the wire pair and the transmitter is off.

At the measurement end of the voice channel a choice of frequency weighting filters is available. The filters that can be selected are; C-message, 3-kHz flat, 15-kHz flat, 50 Kbit, or program(see figures 4-4 thru 4-8). The required measurement range for noise is a function of the type of filter selected. Table 4-1 list the filter noise range. The C-message filter allows measurement of only those noise signals that are of annoyance to the "typical" subscriber of standard telephone service. The C-message weighting is also used to evaluate the effects of noise on voice grade data circuits. The C-weighting is valid for data transmission since the response characteristic is relatively flat over most of the frequency range of concern for data transmission (600 to 3000 Hz).

Table 4-1. Filter Noise Ranges

Filter	Noise (dBrn)	Noise-to-Ground (dBrn)
C-message	10 to 90	40 to 130
3-kHz Flat	10 to 90	40 to 130
15-kHz Flat	10 to 90	
C-notched noise	10 to 90	
50 Kbit (135 ohm impedance)	10 to 90	

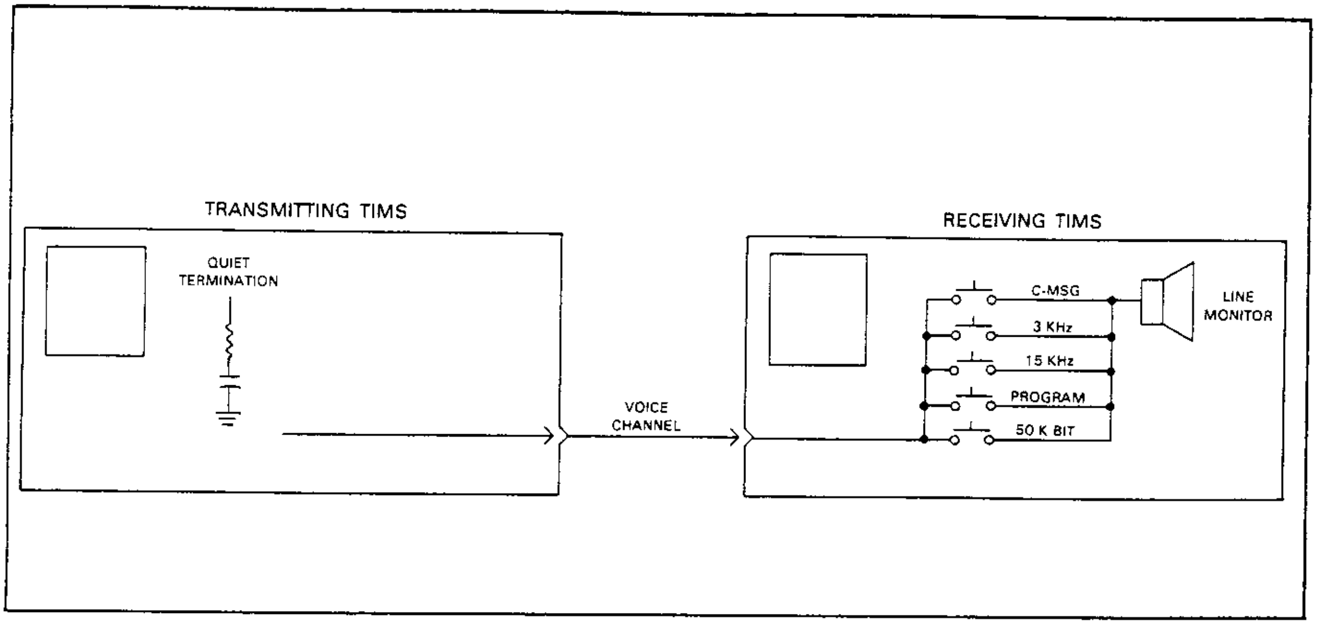


Figure 4-3. Message Circuit Noise Measurement

The 3-kHz flat filter has a response that provides much less attenuation to the low frequencies (60 Hz to 500 Hz) than the C-message filter. By comparing a 3-kHz flat noise measurement to a C-message noise measurement, the relative influence of low frequency noise (60-Hz commercial power, 20-Hz ring,etc.) can be determined.

The program filter is used for weighted measurements of noise on program circuits that have bandwidths up to approximately 8 kHz. It is not used on voice message circuits.

The 15-kHz flat filter is used when making unweighted measurements of noise on program circuits. It is a 15-kHz, low pass filter and it is not ordinarily used on voice message circuits.

The 50-Kbit filter is used to measure noise on facilities using up to 56-Kbit data service. The filters are used on wideband data circuits at an impedance of 135 ohms.

Received noise levels are displayed in units of dBrn,(dB with respect to noise where 0 dBrn=-90 dBm). For example, a noise reading of 20 dBrn has an RMS power of -70 dBrn (20-90 = -70). With the C-message filter selected, displayed readings are interpreted as being in units of dBrnC (noise level in dBrn with a C-message weighted measuring device).

Single frequency interference refers to unwanted steady tones which may appear on voice channels. Occassional burst of low level tones which may occur from crosstalk of multifrequency signaling, for example, do not fall in this category. Single frequency tones may interfere with certain data signals, particularly narrowband signals which are multiplexed onto a voiceband channel.

A simple audio monitoring arrangement will usually detect this interference, since tones exceeding acceptable levels are easily heard if the C-message noise is within limits. The single frequency interference check is made with the set up as shown in Figure 4-3. After the receiver noise signal passes through the C-message filter, the resultant signal is applied to the line monitor speaker. The TIMS operator listens for any predominant tone, which may indicate a single frequency interference problem.

If a single frequency tone (or tones) of long duration is heard, single frequency interference may be present and should be measured. To precisely determine the frequency and level of the interfering tone, a frequency selective voltmeter or spectrum analyzer must be used. The requirement for single frequency interference is that, when measured through a C-message filter, it will be at least 3 dB below C-message noise limits.

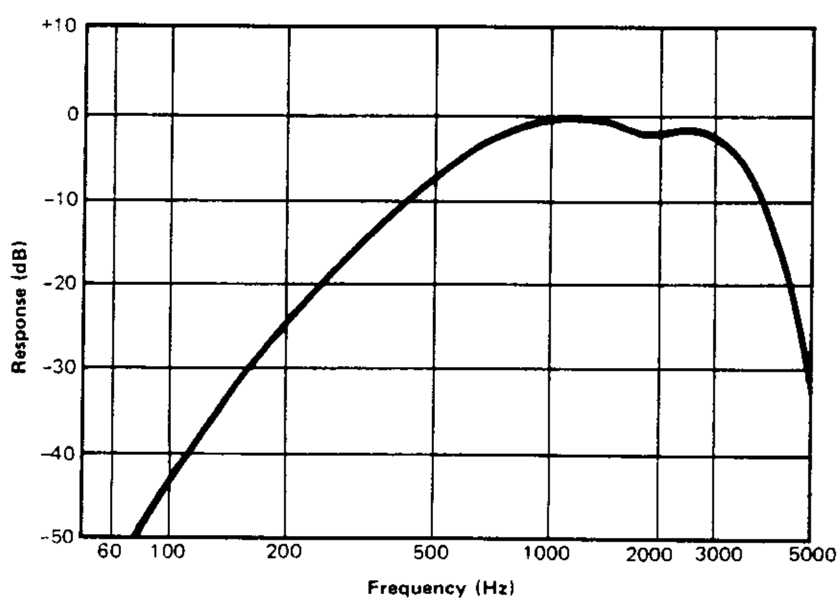


Figure 4-4. C-message weighting characteristic

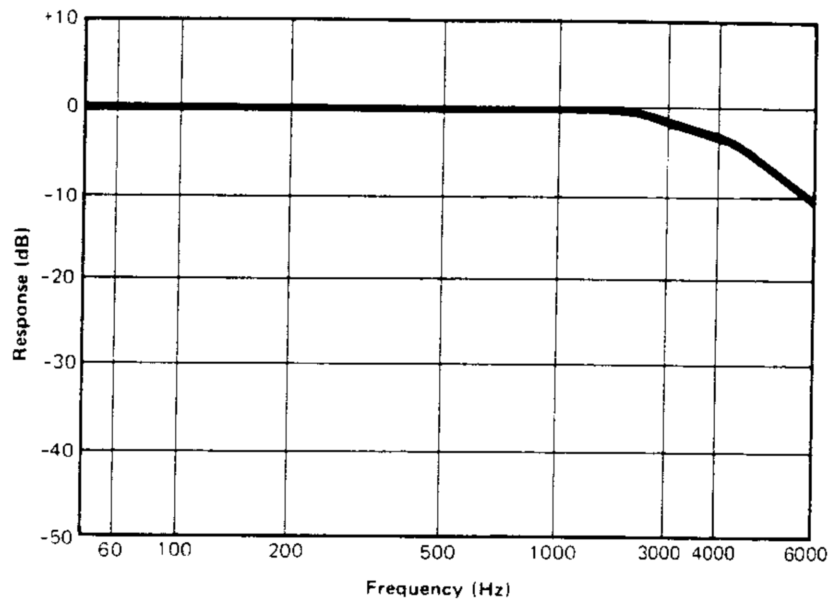


Figure 4-5. 3-kHz Flat Filter Weighting Characteristic

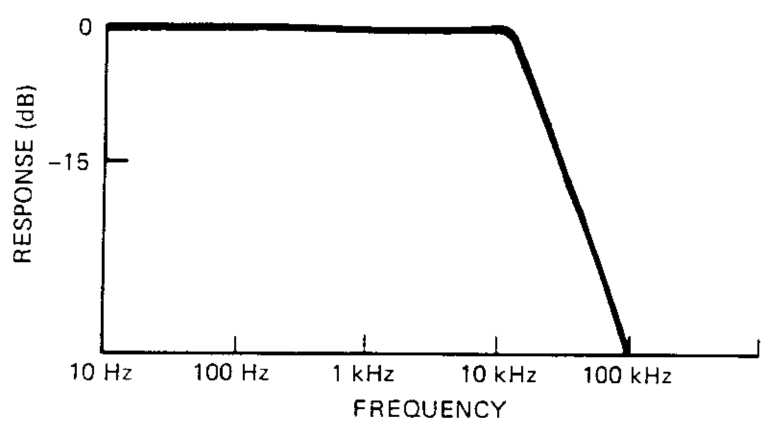


Figure 4-6. 15-kHz Flat Filter Weighting Characteristic

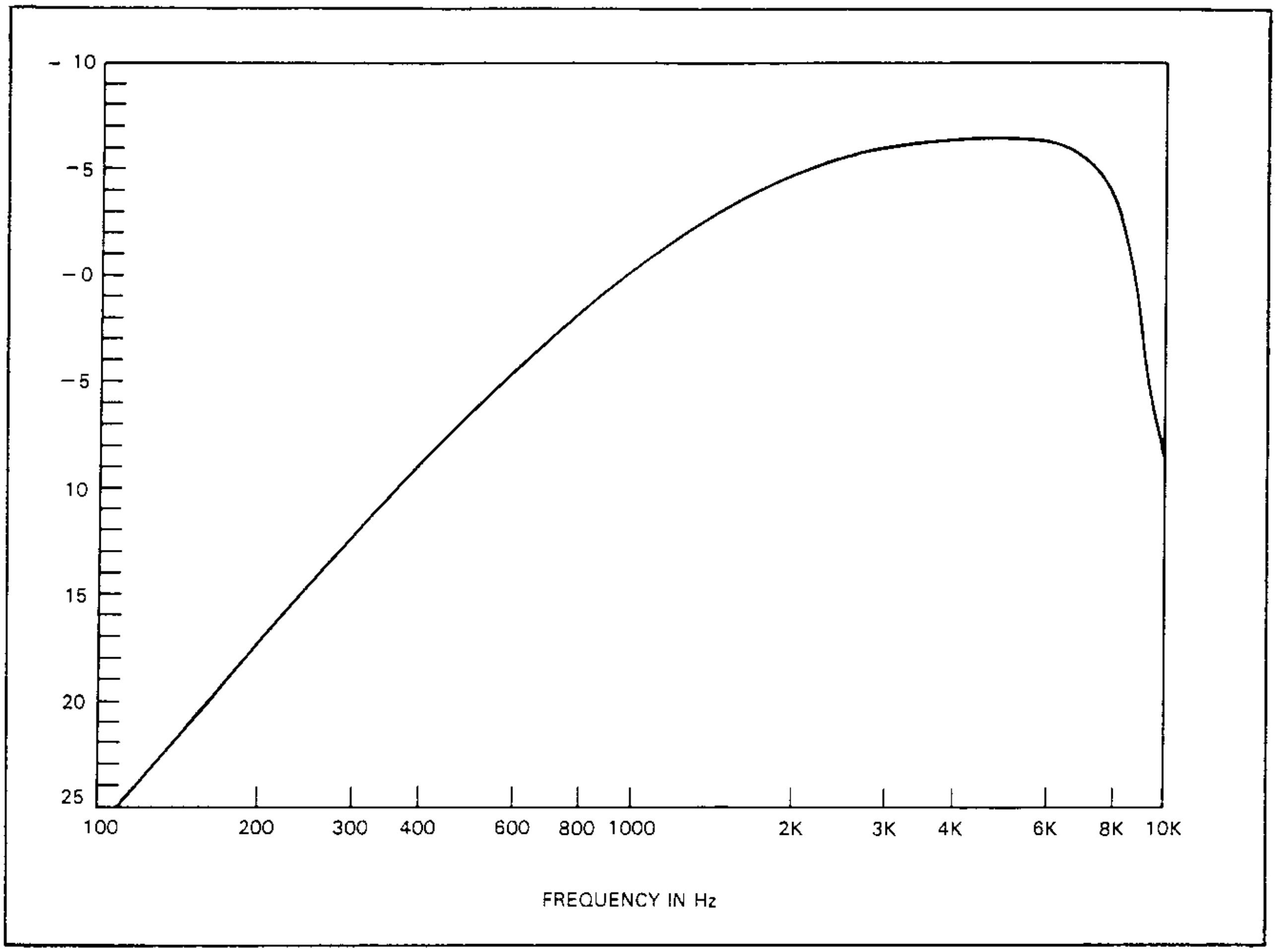


Figure 4-7. Program Filter Characteristic

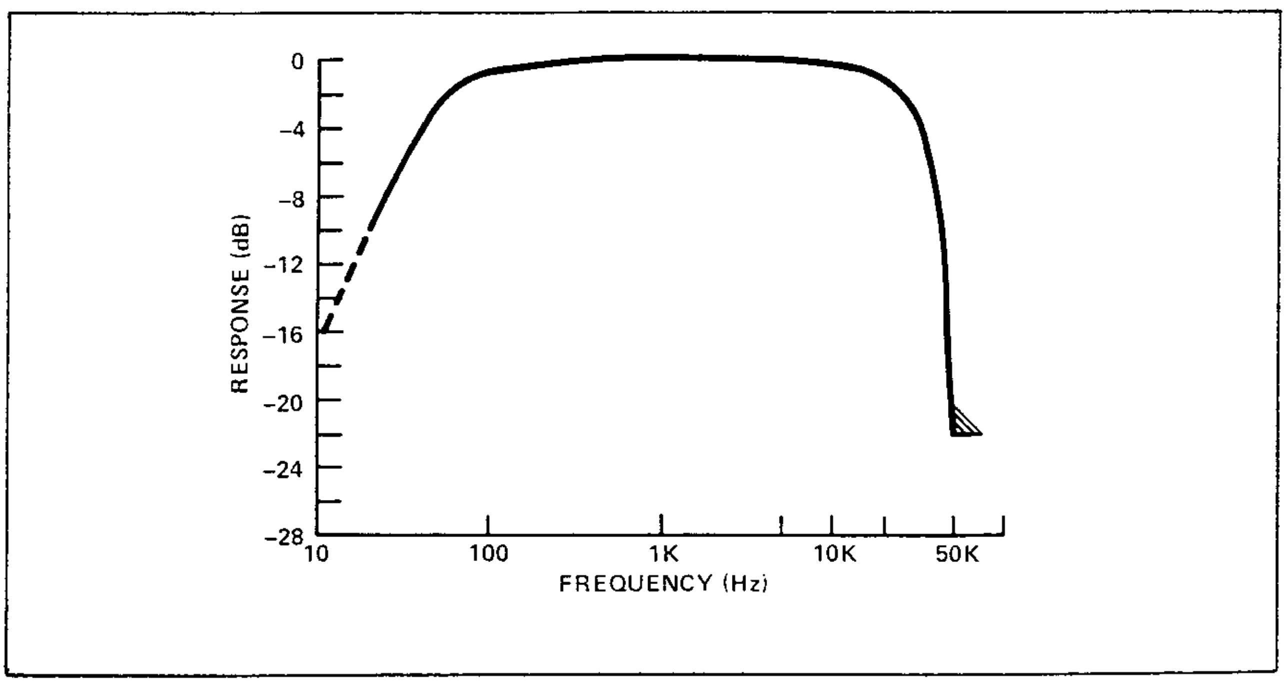


Figure 4-8. 50-Kbit Filter Characteristic

Noise-With-Tone

The noise-with-tone mode allows measurement of signal-to-noise ratio. The noise with-tone measurement is used to condition compandors and quantizers in the transmission system to their normal operating levels for continuous data signals. Therefore, noise levels are received which duplicate levels present under operating conditions.

To make this measurement, a 1004-Hz test frequency (holding tone) is transmitted at data level. At the receiving TIMS, the 1004-Hz holding tone is selectively attenuated by >50 dB using a notch filter (all frequencies between 995 Hz and 1025 Hz are attenuated by >50 dB). The remaining received signal (noise) is passed through one of the weighting filters for measurement. The received noise level is displayed in units of dBrn. Figure 4-9 illustrates the notch filter characteristic.

Signal-To-Noise Ratio

The signal-to-noise ratio of the voice channel under test is determined by comparing the noise-with-tone level with the holding tone level. This measurement is done automatically by the HP 4945A. Pressing the SIGNAL-TO-NOISE softkey will display the signal-to-noise ratio.

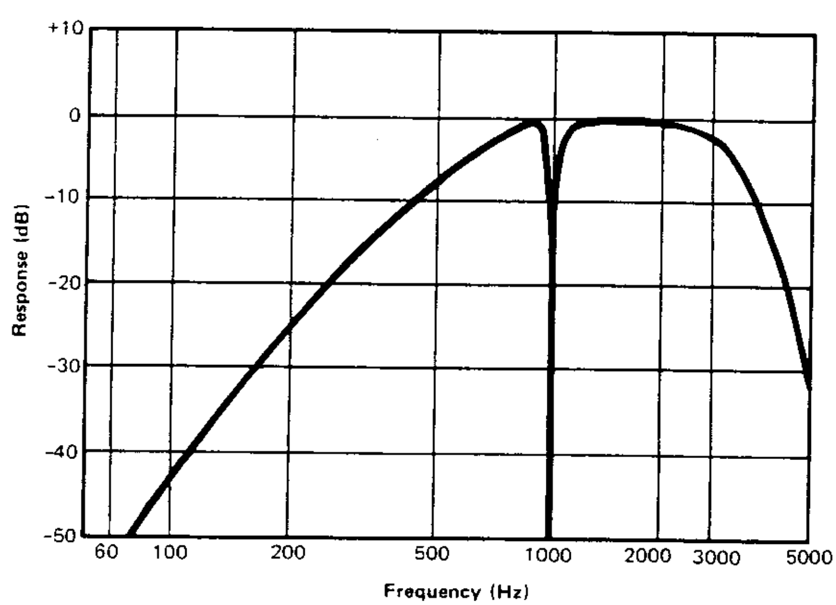


Figure 4-9. Notch Filter Characteristic

NOISE TO GROUND MEASUREMENT

The noise to ground mode allows measurements of the longitudinal noise present on a voice channel, with reference to ground. The transmitting TIMS provides a quiet termination at one end of the voice channel, and the receiving TIMS provides a frequency weighted filter and detector at the other end. The basic measurement technique for the noise to ground measurement is very similar to the message circuit noise measurement. The main difference lies in the use of a ground reference. Figure 4-10 illustrates this difference.

Noise to ground measurements are usually made for troubleshooting purposes and to measure the magnitude of longitudinal signals, which may indicate the susceptibility of a cable pair to electrical coupling from external sources.

The relative line balance of an end loop can be calculated by substracting the measured noise to ground (Ng) value from the measured message circuit noise (Nm) value. It is recommended that both message circuit noise and noise to ground be measured with the 3-kHz flat weighted filter to include the effects of power line related noise.

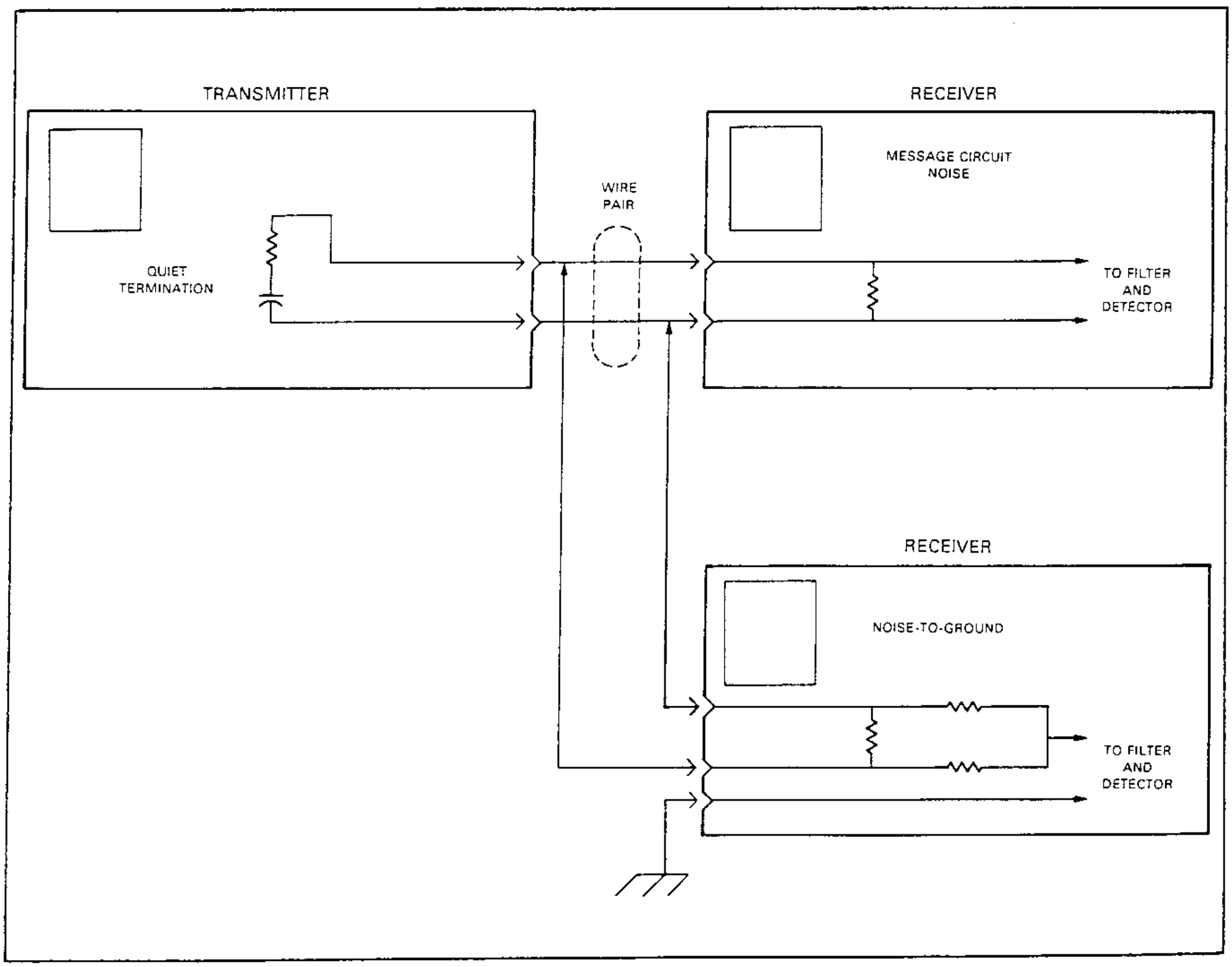


Figure 4-10. Noise-to-Ground Related to Message Circuit Noise

TRANSIENTS MEASUREMENTS

The 3-level impulse noise, hits and dropouts mode measures the interfering effects of transients phenomena. These transient phenomena can cause data transmission errors and interruptions to data communication systems. This measurement mode allows simultaneous detemination of: impluse noise counts at three different thresholds, phase hit counts,gain hit counts, and dropout count. The simultaneous measurement of these transient phenomena allows the HP 4945A to reliably differentiate between each of them.

Impulse Noise

Impulse noise is that component of the received noise signal which is much greater in amplitude than the normal peaks of the message circuit noise, and that occurs as short duration spikes or burst of energy. Studies by Bell Telephone Laboratories have shown that the impluse noise spikes have duration of less than one millisecond, and that all significant effects of the noise spikes disappear within four milliseconds. Waveform (b) in Figure 4-11 illustrates a received holding tone (or test signal) that includes interfering impulse noise spikes. The impluse noise measurement allows determination of impluse noise count on a voice channel, given a specified measurement period (all are selectable on the HP 4945A).

Customers initiating and terminating calls cause relays and switches to operate and release, giving rise to impulse noise from the associated electrical transients. Normal installation and repair activies also introduce impluse noise.

Impulse noise affects data transmission by causing the loss of the information signal which results in errors. In slow data rate systems few errors occur due to impluse noise because the receiving device can distinguish a data pluse from an impluse noise pluse. As the data rate of a system increases, it becomes more difficult for the receiving device to distinguish the data pulse from the noise; resulting in impluse noise caused errors.

Phase Hits, Gain Hits, and Dropouts

A phase hit is a sudden change (increase or decrease) in the received signal phase (or frequency). Phase hits may be as small as tenths of a degree or as large as 360 degrees. The phase of the received signal may return to its original value in a short time, or it may remain indefinitely at a changed value. Waveform (c) in figure 4-11 illustrates a received holding tone that includes interfering phase hits.

Some of the more common causes of phase hits (and also gain hits and dropouts) are automatic switching to standby facilities or carrier supplies, patching out working facilities to perform maintenance, and noise transients coupled into carrier frequency sources.

Two common modulation techniques used by data modems are phase and frequency modulation. Phase hits create errors by appearing like information carried by data signal. For example, in a system using an 8-phase modulation technique (45 degrees between states), frequent 25-degree phase hits would make it very diffcult for the receiving modem to distinguish between the interfering phase hits and the phase modulation; resulting in phase hits caused errors.

A gain hit is a sudden change (increase or decrease) in the received signal level. Gain hits can be less than a dB or as large as several dBs. The level of the received signal can return to its orginal value in a short time, or it can remain indefinitely at the changed value. Waveform (d) in Figure 4-11 illustrates received holding tone that includes interfering gain hits.

Amplitude modulation of a carrier signal is another common technique used by modems to transmit data. Because the information is contained in the level of the signal, gain hits can appear like the information carrier by the data signal; resulting in gain hit caused errors.

A dropout is a sudden drop in recieived signal level (>12 dB). During a dropout, the signal often becomes undetectable. Some dropouts are difficult to observe because the background noise can rise to a level near the orginal signal level. The level of the received signal can return to its orginal value in a short time or remain undetectable indefinitely. Waveform(e) in figure 4-11 illustrates a received holding tone that includes interfering dropouts.

All communication crease during a dropout and data can be lost. The receiving mode must re-reference itself to the signal before data communication can resume. Most modems can track the received signal to a level as low a 12 dB below their normal receiving power. Beyond 12 dB the information signal is considered lost.

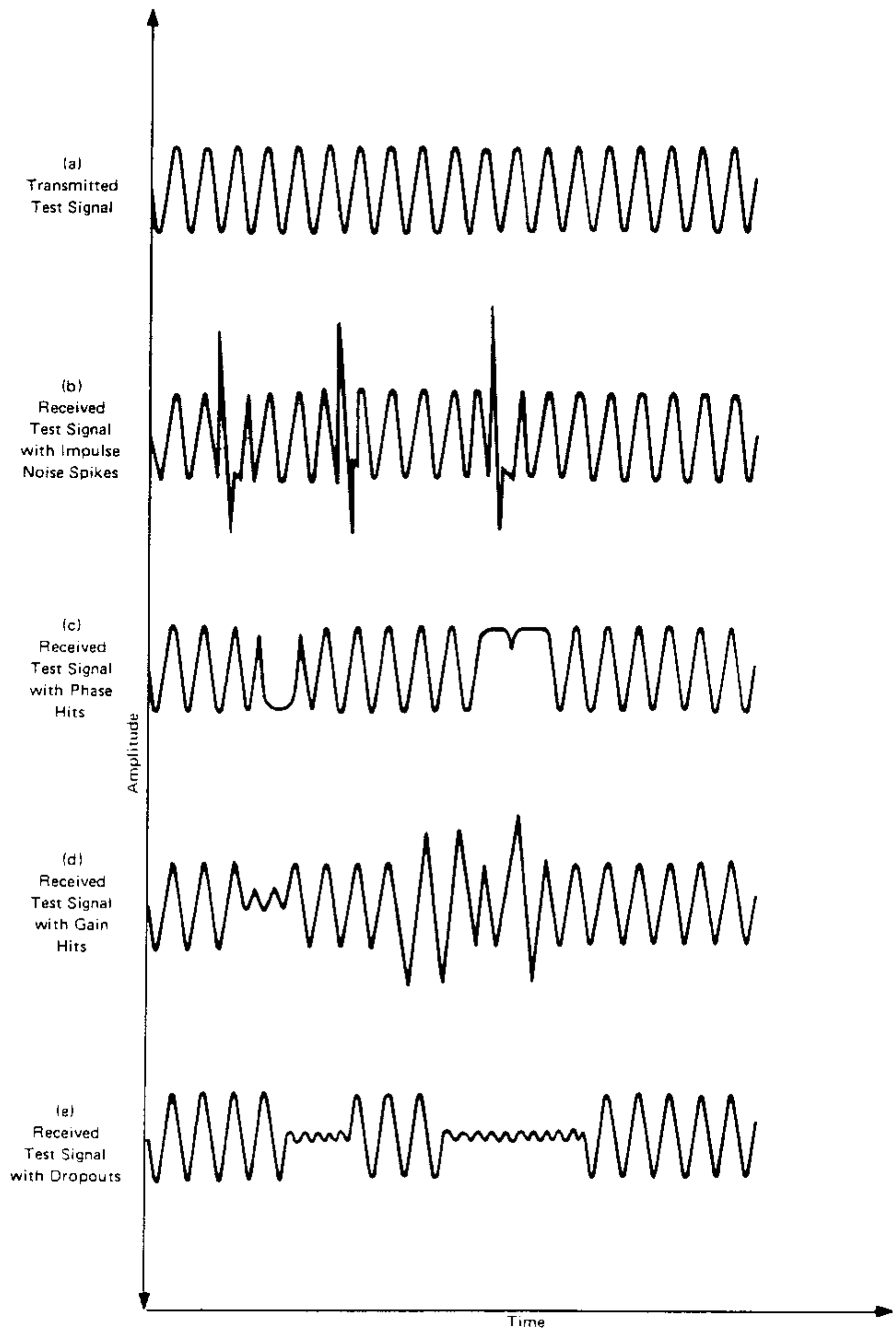


Figure 4-11. Impulse Noise, Hits, and Dropouts Waveforms

Simultaneous Measurement of Impulse Noise, Hits and Dropouts

The relationship between each of the transient disturbances is summerized in table 4-2. The best way to distinguish impulse noise from dropouts is the 4 ms maximum duration of the impulse noise. Phase hits can be distinguished from gain hits and dropouts because phase hits cause change in phase. Dropouts have to be distinguished from gain hits by definition, since dropouts are a special case of gain hits. Table 4-3 summarizes the measurement definitions necessary for implementing a practical measuring instrument.

The information needed about each disturbance is how often they occur. The measuring instrument is required to total each disturbances over a specified time. The nominal count rate for electromechanical counters is 7 counts per second with a blanking interval of 143 milliseconds. The nominal fast counting rate is 100 counts per second with a blanking interval of 10 milliseconds. All of the transients can occur at any time because they are caused by random sources. They can also occur in clusters with only a few milliseconds between each impulse noise spike.

Because not all disturbances are of sufficient magnitude to cause data communication problems, it is necessary to be able to set thresholds that will discriminate against small disturbances. The thresholds in the HP 4945A are adjustable so that measurements can be made at different test level points; and also so that the test set can be made to be susceptible to certain disturbances depending on the effect those disturbances have on current data communications.

This test set is capable of identifying all four disturbances simultaneously. Each is counted individually as shown in Figure 4-12.

Table 4-2. Transient Phenomena Summary

DISTURBANCE	SIGNAL RELATED	CHARACTERISTIC	DURATION
Impulse noise	No	Level and Phase	<0.1ms to 4ms
Phase hit	Yes	Phase	<0.1ms to >hours
Gain hit	Yes	Level	<0.1ms to >hours
Dropout	Yes	Level	≈1ms to >hours

Table 4-3. Measurement Definitions

DISTURBANCE	SIGNAL RELATION	DURATION
Impulse noise	Level change not related to signal	Less than 4ms
Phase hit	Phase change to the signal	Greater than 4ms
Gain hit	Level change to the signal	Greater than 4ms
Dropout	Decrease in signal level of 12 dB	Greater than 4ms

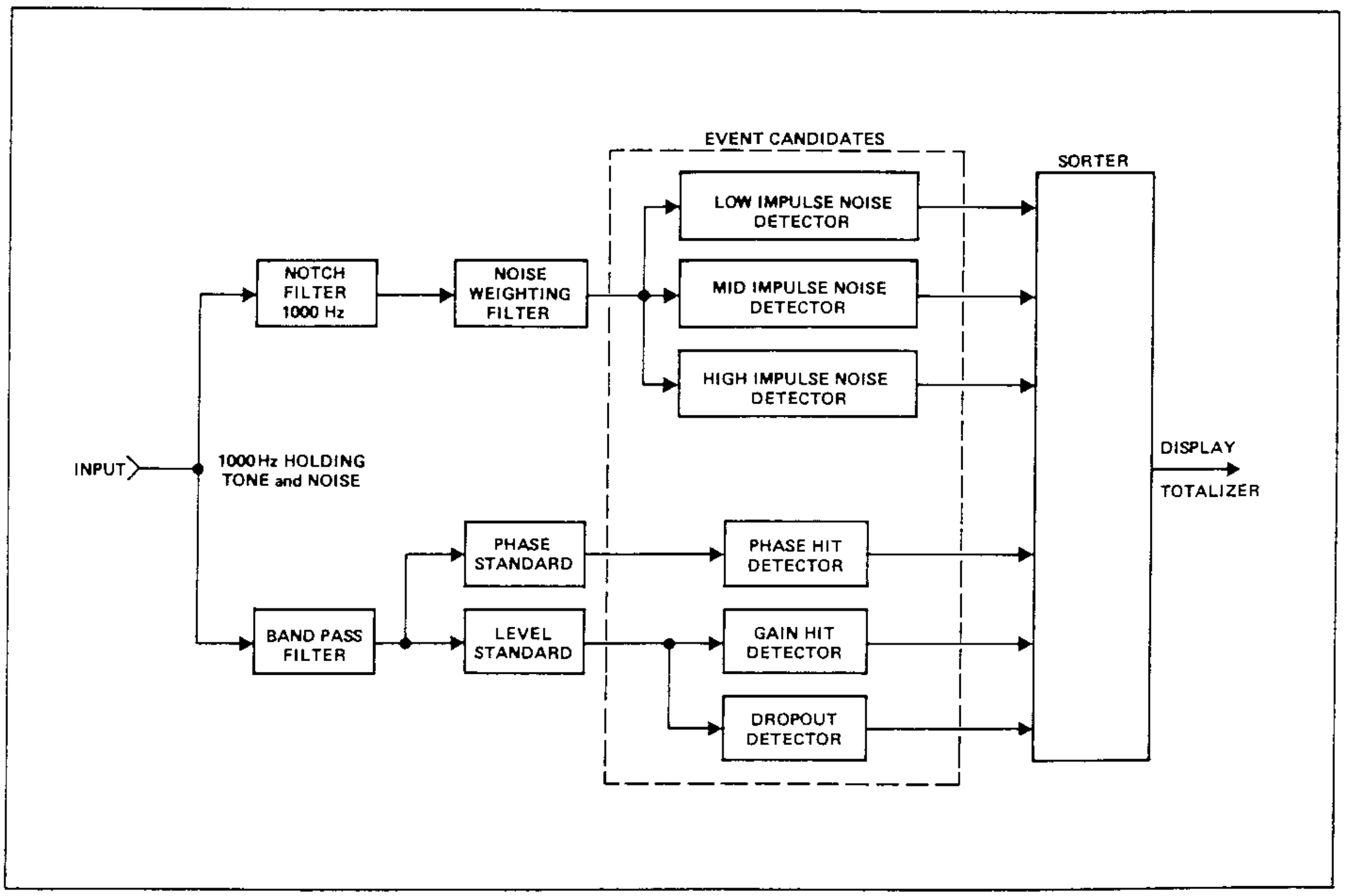


Figure 4-12. Impulse Noise, Hits, and Dropouts

JITTER MEASUREMENTS

Phase Jitter

The phase jitter mode allows measurement of the peak-to-peak phase deviation of a 1004 Hz holding tone on a voice channel. Phase jitter is unwanted phase (or frequency) modulation that a signal may pick up as it traverses a communication channel.

Phase jitter has an insignificant effect on voice transmission, however phase jitter can seriously affect data transmission. Phase jitter is especially interfering to data communications systems that use phase modulation as the transmission scheme. If large phase variations occur, one data pulse can occupy the allotted time slot of another pulse (intersymbol interference), causing an error to occur. Figure 4-13a illustrates the effect of phase jitter on a reference holdling tone.

Different sources cause the instantanous phase of a signal to jitter at rates normally less than 300 Hz. Phase jitter is typically caused by ripple in the dc power supply of the master oscillator of long haul carriers. Some phase jitter can also occur in short haul systems form incomplete filtering of image sidebands. The most commonly found frequency components of phase jitter are 20 Hz (ringing current), 60 Hz (commerical power), and the harmonics of these. A bandwidth of about 800 Hz centered about a carrier near 1 kHz will recover the major suspected phase jitter without incurring large amounts of uncorrelated interference.

To measure phase jitter, a 1004-Hz holding tone is transmitted at data level. At the receiving end of the voice channel is the test set configured to measure phase jitter. Figure 4-14a illustrates the receiving TIMS functional configuration. The received signal passes through the 600 to 1400 Hz band-pass filter. This filter reduces the effective measurement bandwidth to approximately one-fourth the total channel width, centered on the test tone frequency. This in turn reduces the effects of noise and other interference on hte jitter measurement.

The phase-locked loop will not follow fast phase changes that occur at a rate greater than 20 Hz. The slow response amplifier will not react fast enough to change the oscillator frequency to match the received frequency. Fast phase change will cause an error to be generated by the phase detector.

The error signal appearing after the 300-Hz low-pass filter is limited in frequency between 20 Hz and 300 Hz. This pass band is a Bell Standard and includes the phase jitter interference caused by 20-Hz ringing and 60-Hz power, plus their first several harmonics. Phase jitter components rarely occur above 300 Hz. When they do, they are normally accompanied by large amounts of jitter below 300 Hz, which allows detection by the HP 4945A.

In addition to the Bell Standard, 20-to 300-Hz band, the HP 4945A also measures phase jitter in the low frequency(LF) 4- to 20-Hz band and in the Bell Standard plus LF 4- to 300- Hz.

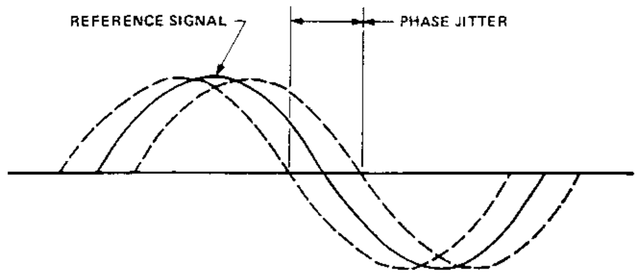
Amplitude Jitter

Amplitude jitter is the summation of incidental amplitude modulation and the effects of interference and noise. Amplitude jitter is measured by examining amplitude disturbances on a 1004 Hz test tone. Figure 4-13b shows the effects of amplitude jitter on the 1004-Hz.

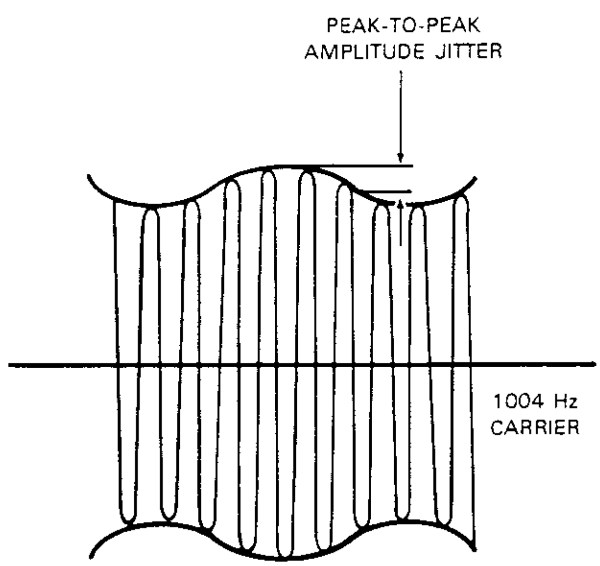
The most commonly round signal-frequency components of amplitude jitter are 20 Hz (ringing), 60 Hz (commerical power), and their second through fifth harmonics. A bandwidth of about 600 Hz centered about a carrier near 1 kHz will recover the major suspected amplitude jitter without incurring large amounts of uncorrelated interference.

Because group delay distortion of a channel can cause amplitude jitter to be created from phase jitter, and vice versa, amplitude jitter should be measured in conjunction with phase jitter. Also noise can cause what would appear to be amplitude jitter, so a C-notch weighted noise measurement should always be made in conjunction with amplitude jitter measurements.

Amplitude jitter is measured in the Bell standard 20 to 300 Hz band, the low frequency (LF) 4-20 Hz band and in the Bell standard plus LF 4 to 300 Hz band. Figure 4-14b shows the functional configuration of amplitude jitter measurements.

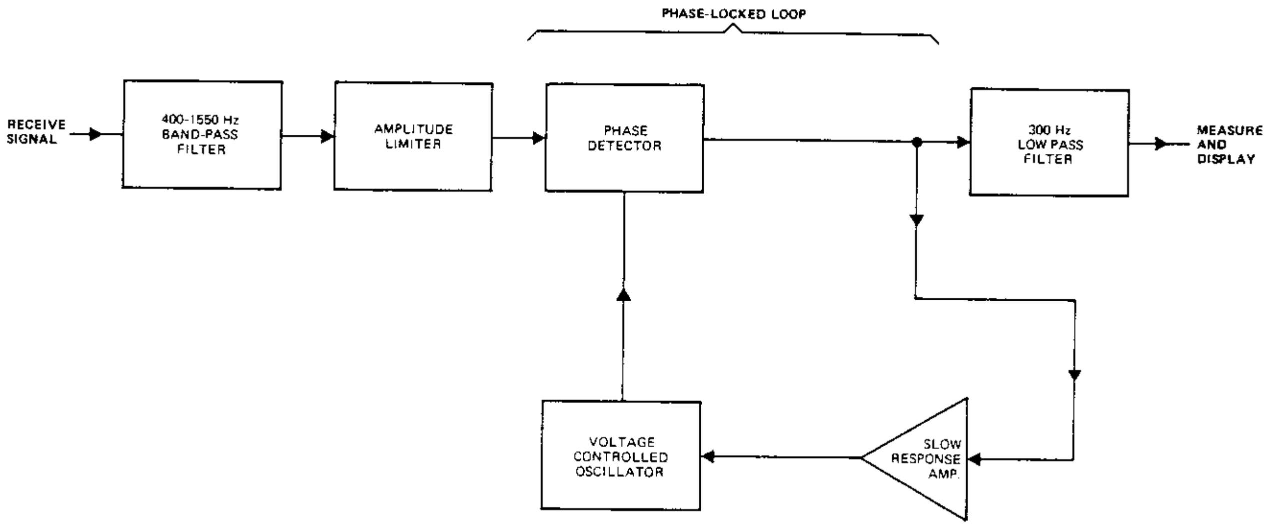


(a) Effects of phase jitter on 1004-Hz holding tone

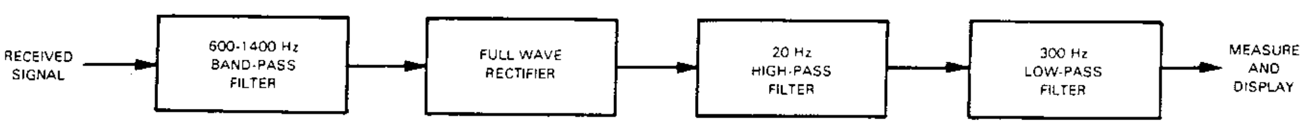


(b) Effects of amplitude jitter on 1004-Hz holding tone

Figure 4-13. Effects of Phase and Amplitude Jitter on Holding Tone



(a) Phase jitter measurement



(b) Amplitude jitter measurement

Figure 4-14. Phase and Amplitude Jitter Measurements

ENVELOPE DELAY MEASURMENT

The envelope delay mode allows measurement of the linearity of the phase versus frequency of a voice channel.

Phase information has an insignificant effect on voice transmission, but can seriously affect data transmission. At data transmission greater then 2400 bits per second, over a voice channel without proper delay compensation, the data bits tend to smear out in time and overlap each other causing inter symbol interference which produces errors.

An ideal circuit which has a linear phase shift characteristic will produce a straight line slope (a linear relationship between a change in frequency and a cooresponding change in phase) as shown in Figure 4-15a. The practical circuit is never ideal and will produce a nonlinear phase shift characteristic (phase distortion) as shown in Figure 4-15b.

Conventional measurement techniques make it difficult to measure the phase characteristic of a transmission system, because a phase reference is difficult to establish at the receiving end of the circuit. It is possible however, to measure relative phase shift at the receiving end using the envelope delay measurement technique. This technique makes it possible to measure the envelope delay distortion of a voice channel, which provides a relative measure of the phase linearity (or nonlinearity) of the circuit.

Relating Phase Shift to Envelope Delay

Amplitude modulating a low frequency sine wave (fm) onto a carrier frequency (fc) produces an amplitude modulated (am) signal as shown by waveforms (a), (b), and (c) in Figure 4-16. The envelope of the AM signal is the outline (or shape) of the peak excursions of the modulated signal as shown in waveform (d) of Figure 4-16. The AM process produces a signal whose spectrum consist of the carrier frequency plus an upper sideband (fc+ fm) and a lower sideband (fc-FM). Figure 4-17 illustrates this relationship. Since the upper sideband is of a higher frequency than the carrier, it undergoes a greater phase shift than the carrier; since the lower sideband is of a lower frequency, it undergoes less phase shift.

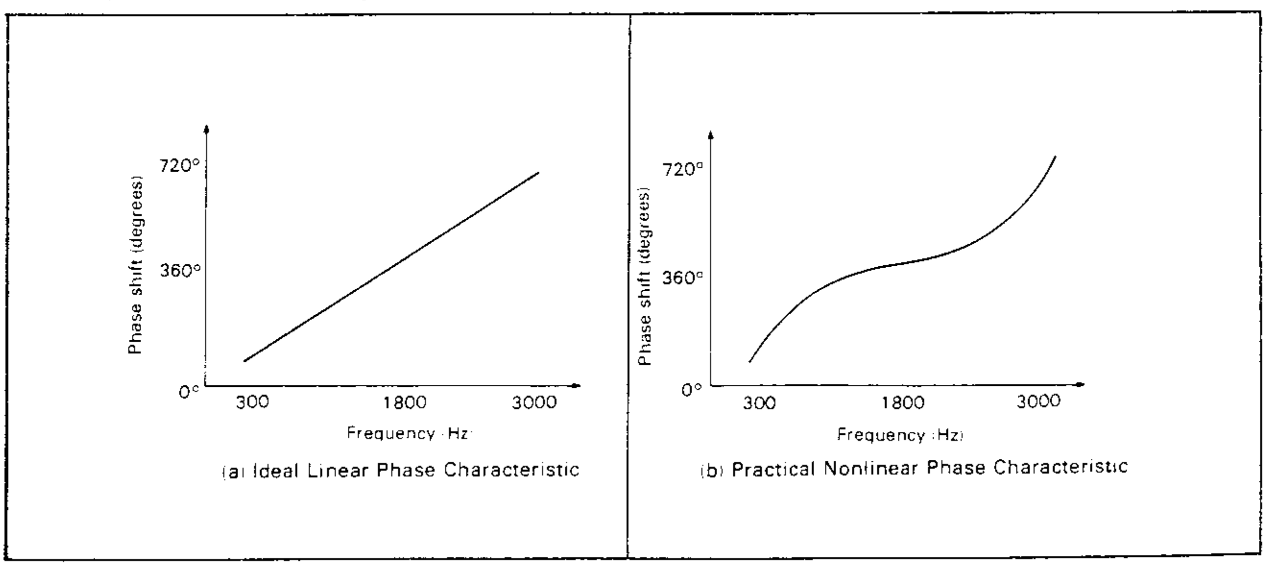


Figure 4-15. Phase Versus Frequency Relationship

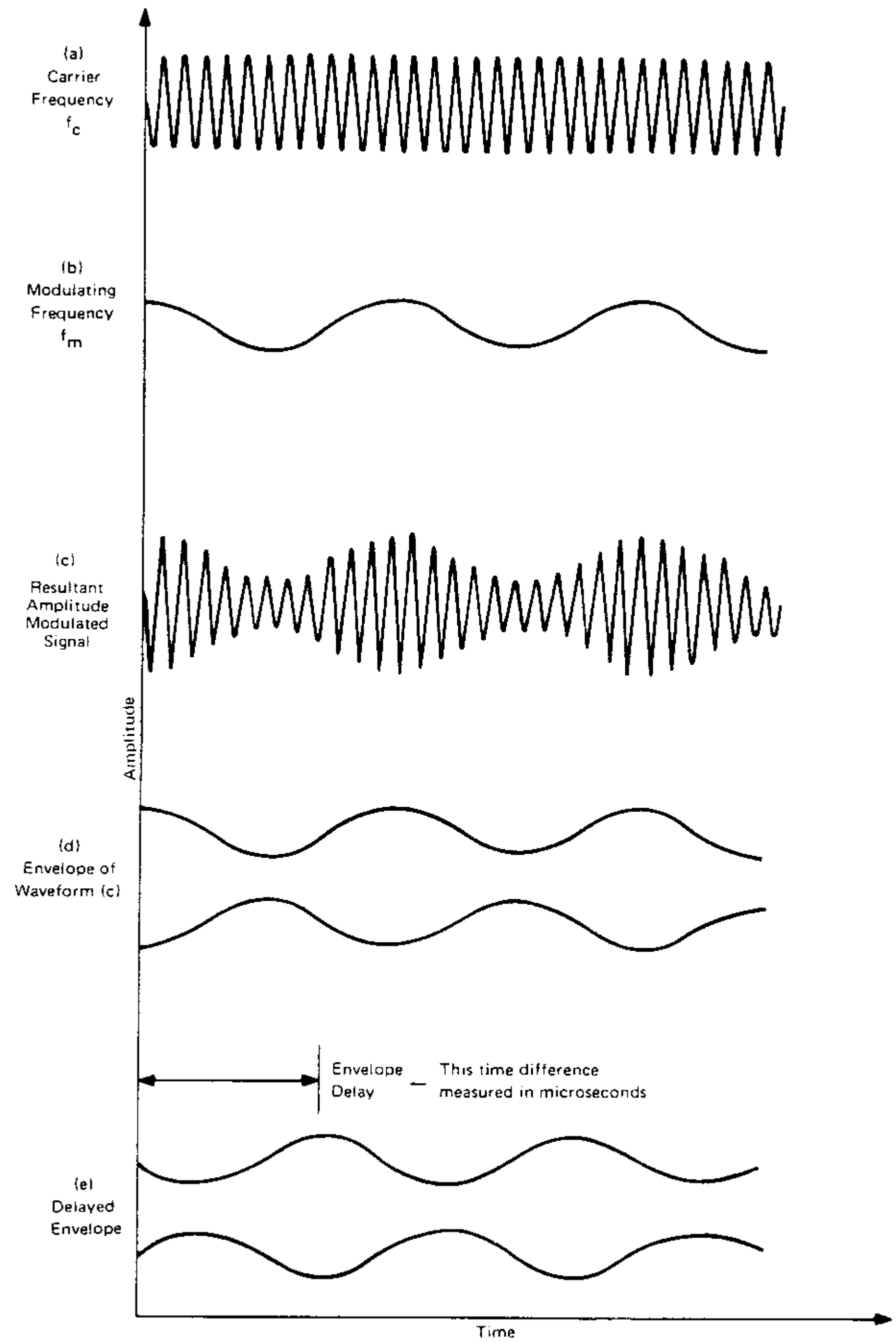


Figure 4-16. Envelope Delay Waveforms

If the AM signal is passed through a circuit having a phase shift characteristic which increases linearity with frequency (figure 4-15), the envelope of the AM signal experiences a shift in time (or delay) as shown in waveforms (d) and (e) of Figure 4-16. This occurs because the lower sideband experiences less phase shift than the carrier, while the upper sideband encounters more. The net result of these phase shifts is that the modulation envelope is shifted in phase (or delayed) wher traversing a transmission medium.

The amount of envelope delay is related to the difference in phase between the two sidebands. If the phase versus frequency characteristic of the transmission medium is linear, then any carrier frequency used (with a fixed modulation frequency) will produce a constant envelope delay value. Plots (a) and (b) in Figure 4 -18 illustrates this relationship. However, if the phase versus frequency characteristic is nonlinear, then the different carrier frequencies will produce different values. Plots (c) and (d) in Figure 4-18 illustrate this relationship. When different values of envelope delay occur, the difference between delay values at two different carrier frequencies is termed "envelope delay distortion".

Envelope Delay Distortion Measurement

To make this measurement, two TIMS are used in the configuration shown in Figure 4-19. The TIMS normal test set transmits a test signal over the voice channel under test to the TIMS repeat test set. The repeat set responds by transmitting envelope delay information back to the normal set over the return reference voice channel. The normal set compares its received signal with its transmitted signal to determine envelope delay distortion values.

The normal set transmits an amplitude modulated test signal consisting of a various frequency carrier (300-to 65004-Hz) and a fixed modulation frequency (83 1/3 Hz). The carrier frequency is varied over the band of interest, usually in 100 Hz steps. The test signal traverses the voice channel under test and is received by the repeat set. The receiver of the repeat set amplitude demodulates the incoming test signal to produce the AM envelope. Changing the carrier frequency as mentioned above will result in a change in the delay of the 83 1/3 Hz envelope at the repeat set, if envelope distortion exists. The envelope delay values received at the repeat set must now be trasnmitted back to the normal set without the introduction of a changing envelope delay, as would be introduced by changing the return reference carrier frequency.

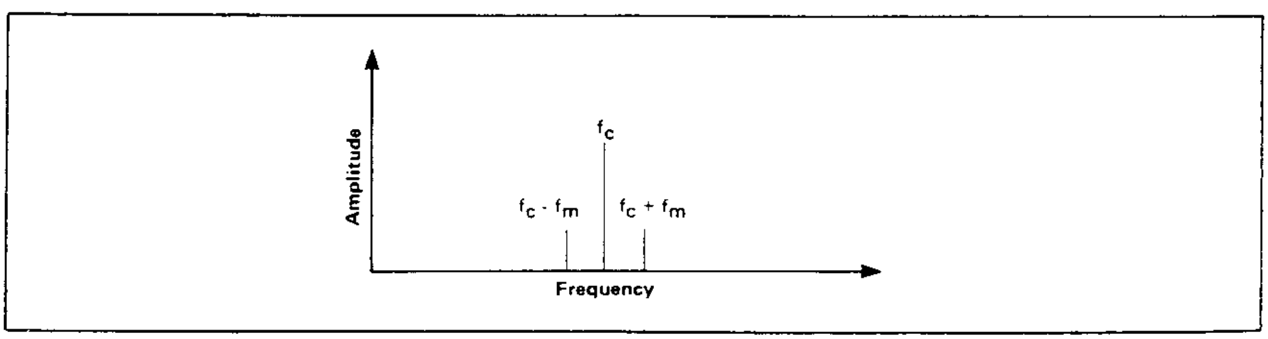
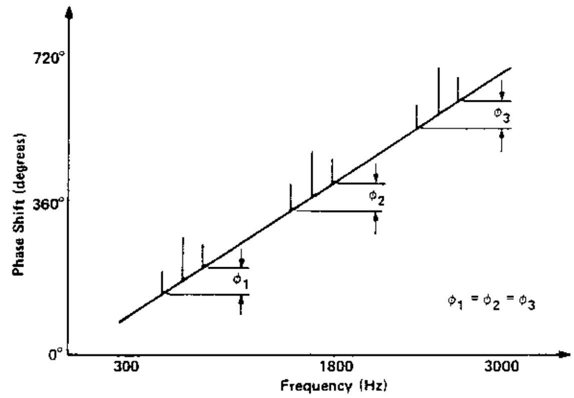
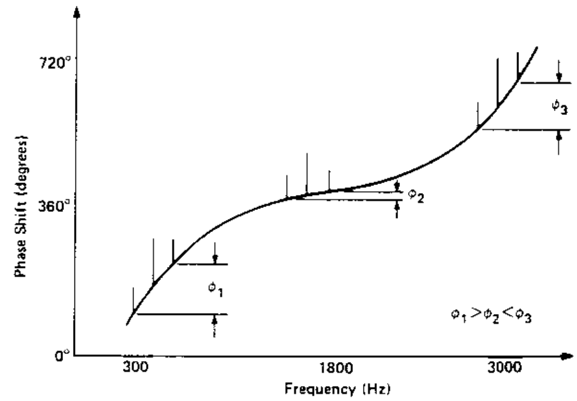


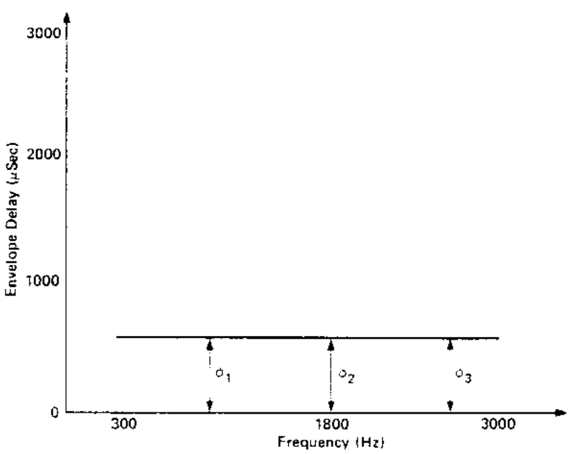
Figure 4-17. AM signal frequency spectrum



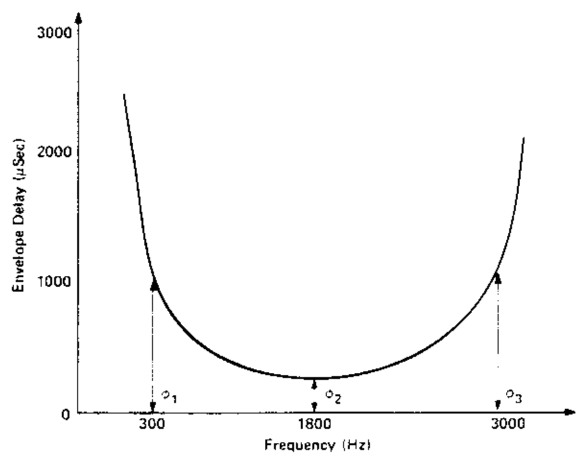
(a) Linear Phase Characteristic with Superimposed AM Signal Components



(c) Nonlinear Phase Characteristic with Superimposed AM Signal Components



(b) Envelope Delay Characteristic of (a) above.



(d) Envelope Delay Characteristic of (c) above.

NOTE: The symbol phi (ϕ) represents the difference in phase between the upper and lower sidebands of the AM signal superimposed on the phase characteristic plots.

Figure 4-18. Relating Phase Shift to Envelope Delay

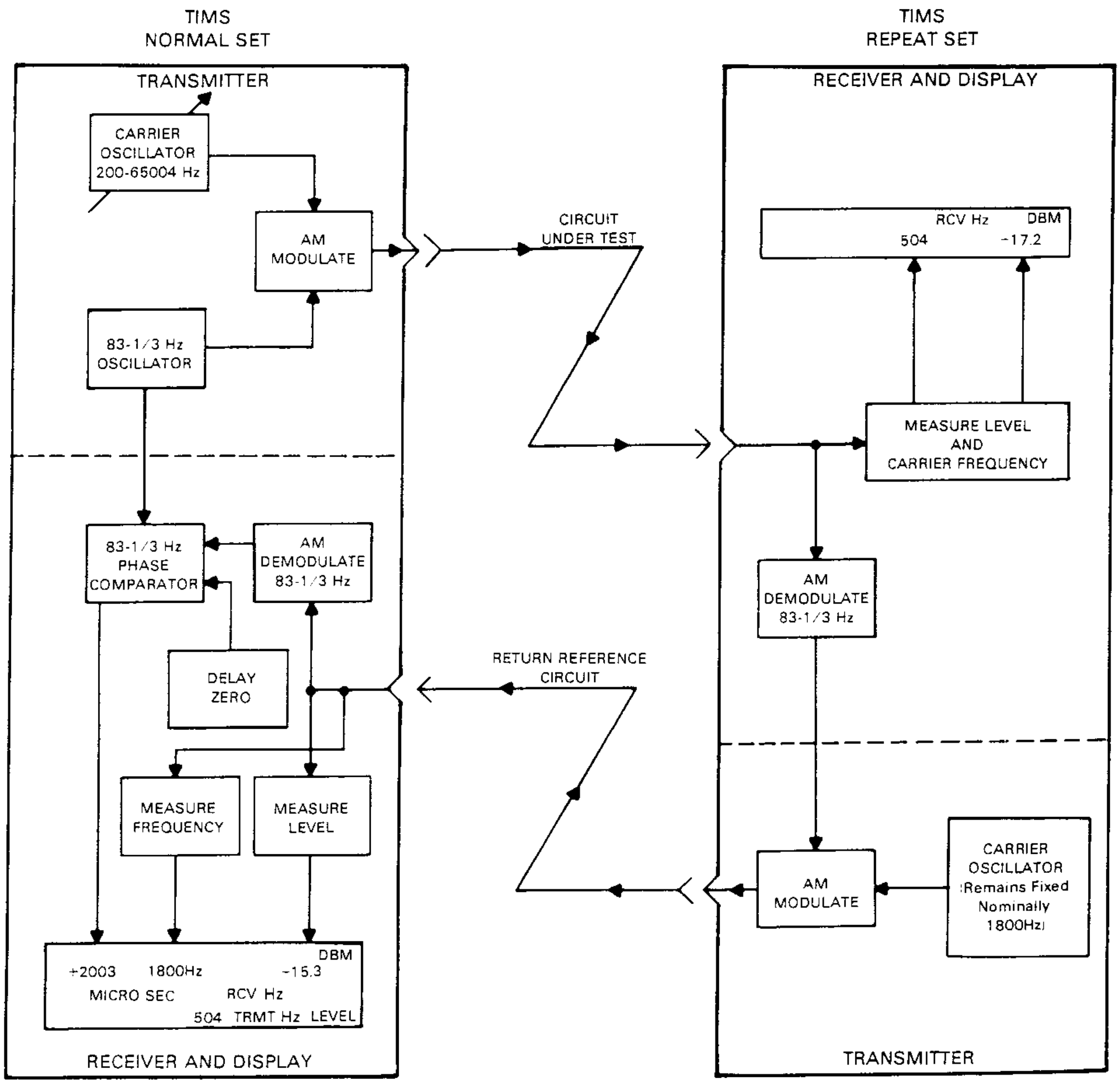


Figure 4-19. Envelope Delay Measurement

In the repeat set, the demodulated AM signal is used to amplitude modulate the fixed frequency carrier that is transmitted back to the normal set. The carrier oscillator in the repeat set remains fixed at one frequency during the envelope delay measurement.The carrier frequency is usually selected at midband (normally 1800 Hz) because envelope delay characteristic are fairly constant and attenuation distortion characteristics are fairly flat. Because a constant return reference carrier frequency is used by the repeat set, there will be no envelope delay distortion encountered by the return signal (although there will be a fixed envelope delay). Therefore, the envelope delay value received at the normal set will represent the envelope delay value received at the repeat set, plus the constant envelope delay of the return reference channel.

The receiver of the normal set amplitude demodulates the incoming return reference signal. The phase of the incoming return reference envelope is then compared to the original 83 1/3 Hz oscillator signal to determine the difference in phase (envelope delay) between the two signals.

To measure the change in envelope delay from the normal set to the repeat set (with a change in carrier frequency), a delay zero control is used to "zero out" the envelope delay of the entire measurement loop. The delay zero control sets the phase difference (or envelope delay) between the 83 1/3 Hz oscillator and the demodulated return reference envelope to zero was set. By changing the normal set carrier frequency from the delay zero reference value, the only changing envelope delay (envelope delay distortiion) occuring in the measurement loop is that incurred by the test signal traversing the voice channel under test.

The delay zero function is usually implemented at a normal set carrier frequency of around 1800 Hz. For some tests it is convenient to set an arbitrary zero and vary the test frequency while looking for the largest negative envelope delay value. By setting a new zero value at this frequency of minimum delay, all other envelope delay measurements (on the channel under test) will have positive values of power line related noise.

INTERMODULATION DISTORTION MEASUREMENT

The intermodulation distortion mode allows measurement of the second and third order intermodulation distortion products of two test tone pairs transmitted over a voice channel. The test tone pairs are selected to closely approximate the nonlinear distortion properties encountered by data signals; to minimize the effects of channel roll-off phase jitter, frequency translation; and to avoid inaccurate readings on PCM carrier systems. Figure 4-20 illustrated the spectrum of the transmitted intermodulation distortion test signal.

Intermodulation distortion is the generation of new signal components not present in the original transmitted signal. This usually happens when a channel's loss in nonlinear with respect to input level. The main cause of nonlinear distortion are electronic devices such as modulators, demodulators, compandors, and amplifiers.

With a single frequency (f1) applied to the input of a nonlinear device, the nonlinear distortion appears as harmonics of the input frequency, such as 2f1, 3f1, 4f1, etc. This type of distortion is termed "harmonic distortion". With a multiple frequency signal (f1 and F2) applied to the device input, the nonlinear distortion appears as harmonics of the individual input frequencies plus intermodulation (or mixing) products of the input frequencies, as listed in Table 4-4. This type of distortion is termed "intermodulation distortion" or "nonlinear distortion", and is the type measured by the HP 4945A.

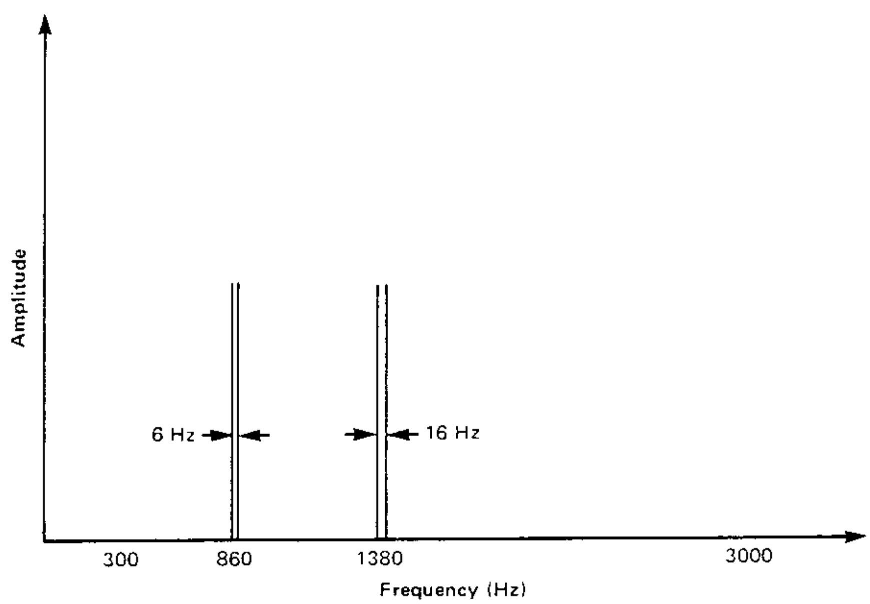


Figure 4-20. Intermodulation Distortion Signal Frequency Sprectrum

Table 4-4 shows the harmonics of a multiple frequency signal (f1 and f2).

Table 4-4. Harmonics and Intermoduation Products of a Multiple Frequency Signal (f1 and f2)

TYPE OF DISTORTION	OUTPUT DISTORTION THRU THE THIRD ORDER
Harmonics	$2f_1$, $3f_1$, $2f_2$, $3f_2$
Intermodulation Products	$f_1 + f_2$, $f_2 - f_1$, $2f_1 + f_2$, $2f_1 - f_2$, $2f_2 + f_1$, $2f_2 - f_1$

Intermodulation distortion and harmonic distortion measurement techniques will yield the same value for second and third order distortion in the simple case involving only one source of distortion. However, with a telephone channel there are normally multiple surces of distortion joined together by linear networks with delay distortion. This creates measurement problems in obtaining valid distortion values. Bell Telephone Laboratory studies have shown that the intermodulation distortion technique is less susceptible to these measurement problems.

The check signal provision is included in the HP 4945A to permit correction of error caused by the presence of high background noise, an interferring tone, or T-carrier quantizing noise. When the CHECK SIGNAL softkey is pressed the second tone pair shown in Figure 4-20 (as centered at 1380 Hz) is suppressed, and the lower tone pair is doubled in power. This allows the channel to be checked with a test signal of the same power. Without the two tone pairs being generated, the intermodulation process (as measured by the HP 4945A) does not occur. The receiving TIMS looks for the second and third order products, but since these are not present, the measured received signals consist of noise. The second and third order products as measured with the two tone pairs may then be corrected accordingly to achieve accurate values.

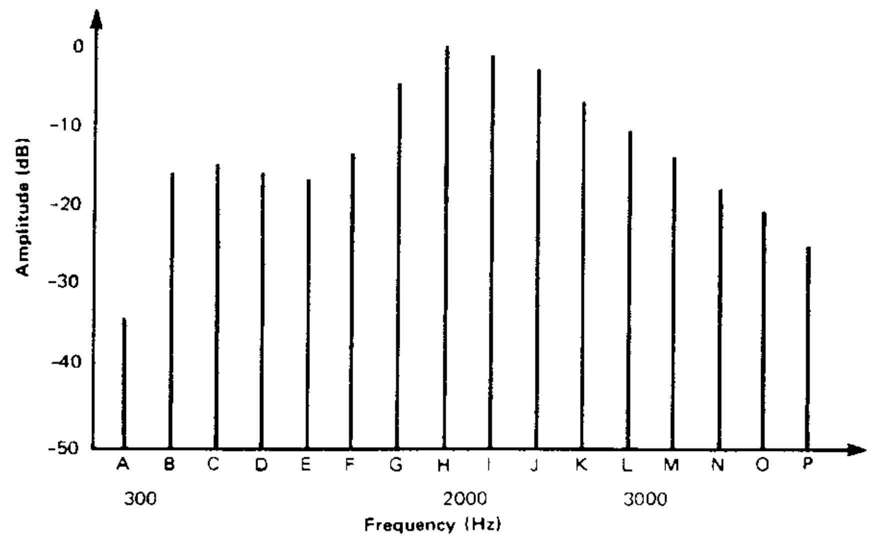
PEAK-TO-AVERAGE RATIO MEASUREMENT

The peak-to-average ratio (P/AR) mode allows measurement of the channel dispersion (spreading in time of signal amplitude) due to transmission imperfections. The test signal has a peak-to-average ratio and a spectral content that approximates a data signal. As the P/AR signal traverses a dispersive medium, the peak-to-average ratio will deteriorate. Then by measuring the peak-to-average ratio at the receiving end, a simple measure of dispersion is obtained. Figure 4-21 illustrates the frequency spectrum of the transmitted P/AR test signal, and Figure 4-22 illustrates the signal envelope.

The P/AR rating is a single number rating of the fidelity of a channel and is a weighted measure of the total attenuation, phase distortion, and noise. The P/AR rating is derived by comparing the P/AR of an ideal signal with the P/AR of the output signal of the system under test. The P/AR measurement is most sensitive to envelope delay distortion and is also affected by noise, bandwidth reduction, gain ripples, nonlinearities such as compression and clipping, and other impairments. The P/AR rating is an indication of the general transmissions quality of the voice-band channel. If the P/AR signal were received entirely undistorted, the P/AR rating would be 100, while a circuit that causes a 10 percent reduction in the peak-to-average ratio has a P/AR rating of 90.

The P/AR measurement provides little information about the nature of the fault condition of any particular case. However, since P/AR is a figure of merit for the channel, it can be used as a benchmark for future reference. After other measurements are made and a channel is considered acceptable, the P/AR rating can be recorded for future reference. In case of a suspected trouble on the channel, P/AR may be measured first and be compared to the benchmark P/AR value. Deviations in excess of + or -4 P/AR units from an initial P/AR value provides sufficient reason to suspect that some channel characteristic has changed significantly.

The P/AR rating can also be useful in trouble-shooting on the DDD network where a number of connections are to be surveyed and full data recorded on only the worst connections experienced. In private line circuits, P/AR can help to identify the worst transmission direction (near to far, or far to near) such that measurement of the parameters in the worst direction can be completed first, since it is more probably that any transmission impairment will be in that direction.



KEY	FREQUENCY
A	140.625
B	390.625
C	640.625
D	890.625
E	1140.625
F	1390.625
G	1640.625
H	1890.625
I	2140.625
J	2390.625
K	2640.625
L	2890.625
M	3140.625
N	3390.625
O	3640.625
P	3890.625

Figure 4-21. P/AR Transmit Signal Frequency Spectrum

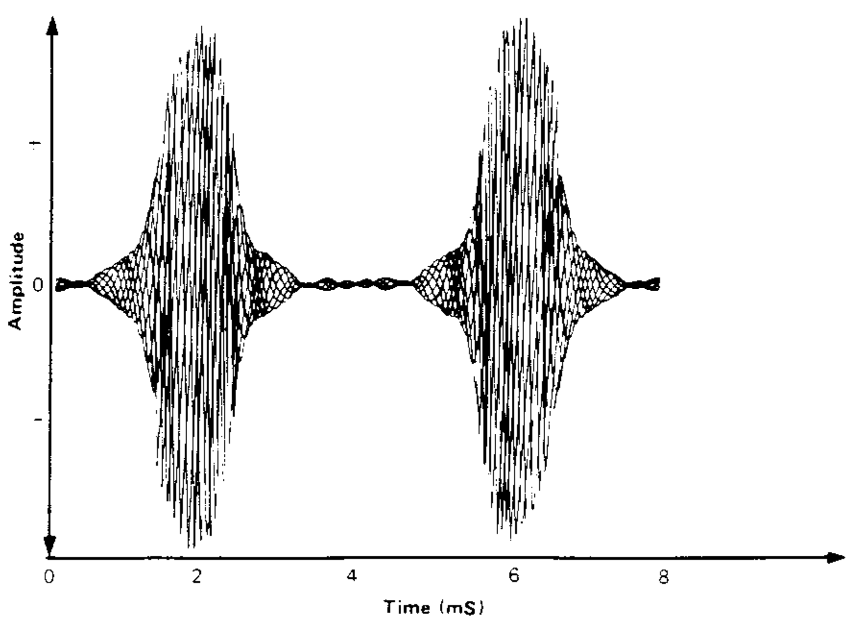


Figure 4-22. P/AR Transmit Signal Envelope

RETURN LOSS

see 3-50

Return loss is the ratio, in decibels, of the power incident upon a transmission system discontinuity to the power reflected from the discontinuity. Return loss measurements are made on both 2-wire and 4-wire circuits. The measurement indicates how well the input and the output impedances are matched throughout a circuit.

Four measurements are made when measuring return loss: echo return loss (ERL), singing return loss low (SRL low), singing return loss high (SRL high), and sine wave return loss (SWL). ERL is the most critical of the four measurements. SRL low and SRL high are designed to protect against circuit instability. Figure 4-23 shows the filter shapes for the measurements.

Echo return loss (ERL) and singing return loss (SRL) are band average return loss measurements made with a band limited noise signal.

Sine wave return loss is measured by transmitting a single frequency and then measuring the difference between the transmitted frequency and the received frequency. A series of single frequencies can also be transmitted by using the SINE WAVE SWEEP function of the HP 4945A.

Return loss measurements require a quiet termination at the distant end of the circuit.

The result of a single frequency return loss measurement must specify the measurement frequency. Return loss as a measure of impedance match is usually specified as the minimum for any frequency within a specified band.

Average return loss over a specified band of frequencies may be measured using a sweep frequency. The average return loss over the band is a power average noise signal.

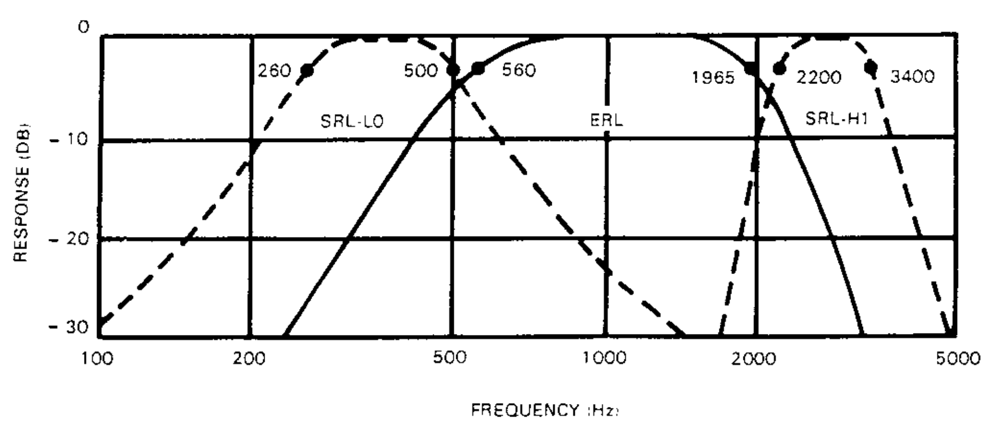


Figure 4-23. Filter Shapes for ERL, SRL low, and SRL high

HEWLETT PACKARD

MANUAL CHANGES

For the HP 4945A Transmission Impairment Measuring Set

Operating Manual

HP Part Number 04945-90023

The attached pages contain new information. Please insert these new pages in your manual and remove the corresponding old pages.

The pages included in this change sheet are:

Page i/ii

Page 1-3/1-4

Page 3-3/3-4

Change-Sheet Part No: 5957-4454-A

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