Errata

Title & Document Type: **4947A Transmission Impairment Measuring Set Operating Manual**

Manual Part Number: **04947-90000**

Revision Date: **June 1986**

About this Manual

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HP References in this Manual

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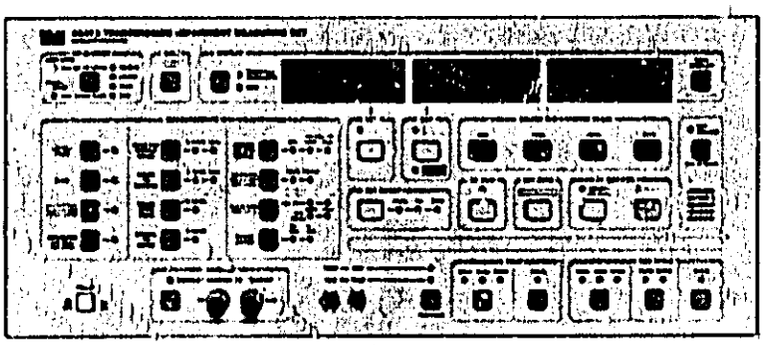
Agilent Technologies

OPERATING MANUAL

4947A

TRANSMISSION IMPAIRMENT MEASURING SET



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

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OPERATING MANUAL

4947A

TRANSMISSION IMPAIRMENT MEASURING SET

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed 2606U.

For additional important information about serial numbers, see INSTRUMENTS COVERED BY MANUAL in Section 5.

Manual Part Number: 04947-90000
Microfiche Part Number:04947-90025

Printed: June 1986

WARNING

READ THE FOLLOWING NOTES BEFORE INSTALLING OR SERVICING THE INSTRUMENT.

1. IF THIS INSTRUMENT IS TO BE ENERGIZED VIA AN AUTO-TRANSFORMER MAKE SURE THAT THE COMMON TERMINAL OF THE AUTO-TRANSFORMER IS CONNECTED TO THE NEUTRAL POLE OF THE POWER SOURCE.

2. THE INSTRUMENT MUST ONLY BE USED WITH THE MAINS CABLE PROVIDED. IF THIS IS NOT SUITABLE, CONTACT YOUR NEAREST HP SERVICE OFFICE. THE MAINS PLUG SHALL ONLY BE INSERTED IN A SOCKET OUTLET PROVIDED WITH A PROTECTIVE EARTH CONTACT. THE PROTECTIVE ACTION MUST NOT BE NEGATED BY THE USE OF AN EXTENSION CORD (POWER CABLE) WITHOUT A PROTECTIVE CONDUCTOR (GROUNDING).

3. THE SERVICE INFORMATION FOUND IN THIS MANUAL IS OFTEN USED WITH POWER SUPPLIED TO AND PROTECTIVE COVERS REMOVED FROM THE INSTRUMENT. ENERGY AVAILABLE AT MANY POINTS MAY, IF CONTACTED, RESULT IN PERSONAL INJURY.

4. BEFORE SWITCHING ON THIS INSTRUMENT:

   (a) Make sure the instrument input voltage selector is set to the voltage of the power source.

   (b) Ensure that all devices connected to this instrument are connected to the protective (earth) ground.

   (c) Ensure that the line power (mains) plug is connected to a three-conductor line power outlet that has a protective (earth) ground. (Grounding one conductor of a two-conductor outlet is not sufficient).

   (d) Check that the instrument fuse(s) is of the correct type and rating.

5. SERVICING INFORMATION:

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

   (b) Any adjustment, maintenance, and repair of the opened instrument under voltage should be avoided as much as possible and, when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

   (c) Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

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

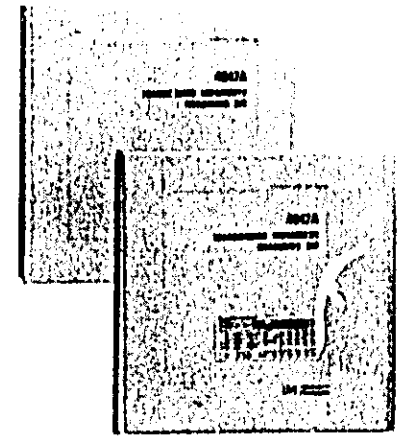
Section 3

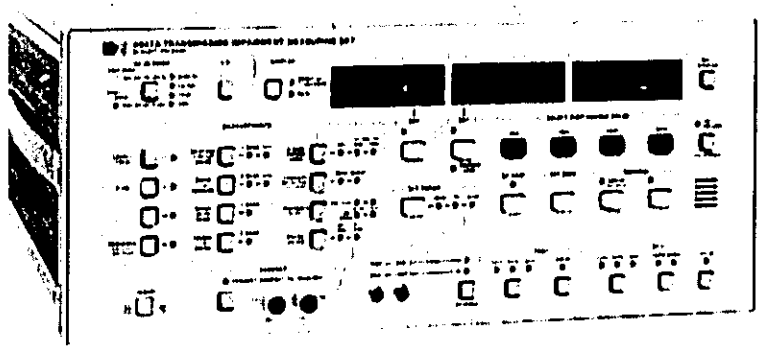
PRINTING/PLOTTING RESULTS

Section 4

REMOTE CONTROL

INITIAL INSPECTION





CONTENTS

Transmission Impairment Measuring Set
Power Cord
Extender Board (inside 4947A)
Service Manual
Operating Manual

WARNING

TO AVOID HAZARDOUS ELECTRICAL SHOCK, DO NOT PERFORM ELECTRICAL TESTS WHEN THERE ARE SIGNS OF SHIPPING DAMAGE TO ANY PORTION OF THE OUTER ENCLOSURE (COVERS, PANELS, METERS, ETC.).

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. Procedures for checking electrical performance are given in Section 4 of the Service Manual. If the contents are incomplete, if there is mechanical damage or defect or if the 4947A does not pass the Performance Tests, notify the nearest Hewlett-Packard office. If the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carriers inspection. The HP office will arrange for repair or replacement at HP option without waiting for claim settlement.

INSTRUMENT DESCRIPTION

The 4947A is a voice band (50Hz to 5004Hz) Transmission Impairment Measuring Set. The transmission impairment measurements which can be made using the 4947A are listed below.

- Level/Frequency (fixed or swept frequency)
- Message Circuit Noise (Idle noise) - C-message filter
- Message Circuit Noise (Idle noise) - 3 kHz flat filter
- Noise to Ground - C-message filter
- Noise to Ground - 3kHz flat filter
- Envelope Delay Distortion
- 4 wire Return Loss - ERL, SRL LOW & SRL HIGH
- Transients - Gain hits, Phase Hits and Dropouts
- 3 level Impulse Noise - with or without holding tone
- Intermodulation Distortion (NLD 4-tone)
- Noise with Tone (C-message filter)
- Signal to Noise Ratio (C-message filter)
- P/AR (Peak to Average Ratio)
- Phase Jitter (20-300 Hz)
- Phase Jitter (4-300 Hz)
- Sequence

The sequence is a series of measurements with fixed timings (based on the 107 type test line) to allow end-to-end synchronization of a pair of instruments.

The 4947A can make measurements directly on leased or dial up lines and has loop holding capability, a monitor loudspeaker, a butt-in connection and DTMF dialing.

There are four permanently stored frequencies 404Hz, 1004Hz, 2804Hz and 2713Hz. Any other four frequencies may be temporarily assigned and stored by the user.

A print or plot of measurement results may be obtained via the HP-IB connector on the rear panel when the instrument is configured in the "TALK ONLY" mode.

The 4947A has HP-IB capability for remote operation.

GETTING STARTED

SECTION 1

INTRODUCTION

This chapter aims to get you ready to make measurements. It takes you through switch-on, introduces operating features and provides simple procedures to demonstrate how easy the 4947A is to use.

SWITCH-ON

CAUTION

Before connecting the instrument to the ac power source, ensure that the rear panel VOLTAGE SELECTOR SWITCH is set for the power-line voltage to be used and that a fuse of the correct rating is installed (refer to INSTALLATION section).

For this demonstration, prior to switch-on, check that the rear panel HP-IB switch is set to TALK ONLY.

Switch on the 4947A by pressing the POWER key to ON. Check that Prnt and PLot are briefly displayed and that the PRINT/PLOT mode led is lit.

The 4947A now performs a calibration routine which takes approximately 20 seconds, and then enters an idle state. The following messages are displayed during this period:

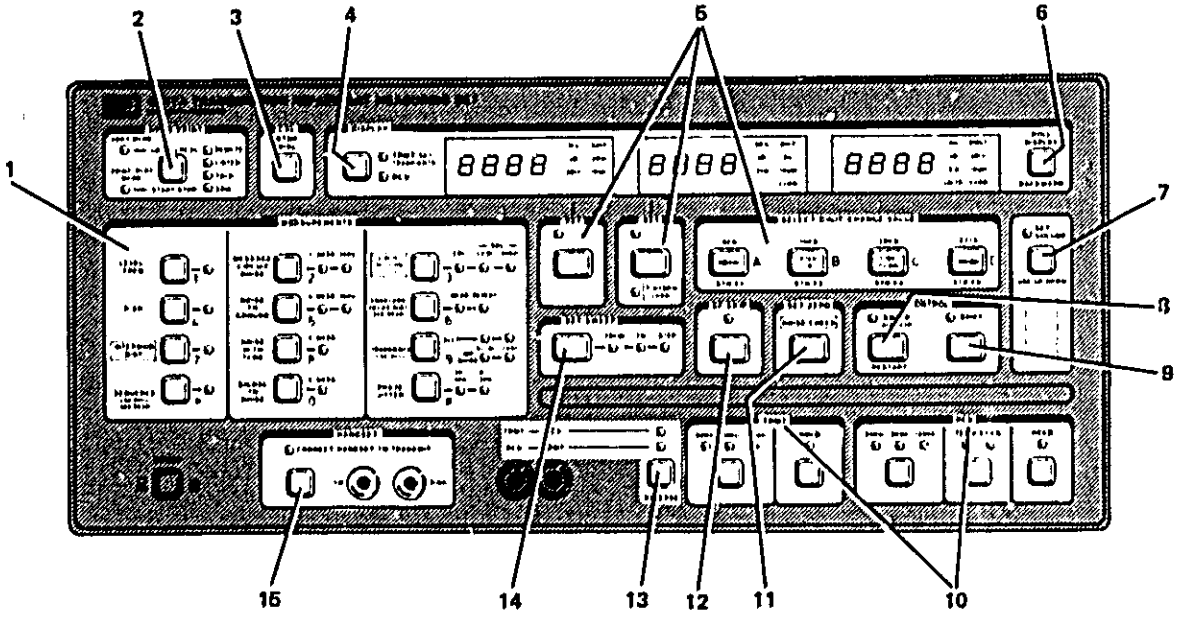
```
CAL  Pt 1 oF 4
CAL  Pt 2 oF 4
CAL  Pt 3 oF 4
CAL  Pt 4 oF 4
IdLE
```

} If initial calibration fails an error code is displayed (see APPENDIX A).

NOTE

If the SEQUENCE *measurement was selected prior to the last power down, the 4947A automatically re-selects* SEQUENCE *after initial calibration (see page 2-19 for details of* SEQUENCE).

FRONT PANEL OPERATING FEATURES



1 **MEASUREMENT keys:** directly select the measurement you want to make. In dialing mode, they form a key pad.

2 **HP-IB/PRINT/PLOT key:** action depends on the mode selected on the rear panel HP-IB switch before power up.

- If the switch is set for TALK ONLY mode, the key prints or plots the measurement results via the rear panel HP-IB connector.
- If the switch is set to ADDRESSABLE mode, the key returns the 4947A to local control when it is remotely controlled via the HP-IB.

3 **CAL key:** initiates internal calibration routines. To select multifrequency dialing, press SHIFT followed by DTMF DIAL. (To return the 4947A to the measurement mode press DTMF DIAL then select the measurement you want.)

4 **DISPLAY key:** selects for display either the transmitter settings (level, frequency and so on - for transients, this also includes thresholds) or the measurement results from the receiver. It also switches the loudspeaker between TRMT or RCV ports.

5 **SET and SELECT DIGIT/CHANGE VALUE keys:** lets you change values of test parameters, for example, level and frequency. Use the appropriate SET key to select the display, the -> and <- keys to select the digit, and STEP UP and STEP DOWN to change the value of the digit. End by pressing SET again. These keys are also used to select preset frequencies or, used along with the SHIFT key, allow you to store new frequencies.

During return loss, you can use the SET T/HYBRID LOSS and SELECT DIGIT/CHANGE VALUE keys. To compensate the result for transhybrid loss, or for overall channel gain (to give Equal Level Echo Path Loss results). Pressing the SET T/HYBRID LOSS a second time completes the correction.

When LEVEL/FREQ is selected the SELECT DIGIT/CHANGE VALUE keys directly access four common frequency values (used to measure gain slope and activate loopback devices). You can directly change a "direct access" value by entering a frequency in the normal way, then pressing SHIFT followed by the appropriate STO F1 to STO F4 key.

6 ROLL DISPLAY key: Repeated use of this key lets you scroll through the parameters and results obtained during TRANSIENTS or SEQUENCE measurements. Press SHIFT first to scroll backwards.

7 SET VOLUME key: controls the loudspeaker volume in conjunction with the STEP UP and STEP DOWN keys.

8 SWEEP/RESTART key: is used during TRANSIENTS measurement to reset the counters and timer and restart the measurement; and during the LEVEL/FREQ or ENVELOPE DELAY DISTortion measurement to control the frequency sweep. SWEEP starts or stops the sweep at the frequency shown on the display; SHIFT RESTART starts the sweep at the FROM frequency. In SEQUENCE, pressing SWEEP causes the 4947A to "Transmit Only". If you want to restart the sequence press SHIFT RESTART then SWEEP.

9 SHIFT key: selects the "blue" function of a dual function key. When SHIFT is pressed, the led lights and when the function is selected the led then goes out.

10 TRMT and RCV key: lets you match the 4947A to the channel under test. TERM terminates the line under test with the impedance selected; BRDG makes the 4947A input high impedance for bridging across a line already terminated. If the 4947A operates on lines which pass dc current, the HOLD keys activate the 4947A loop holding circuits to sink the current.

11 SET ZERO key: lets you store the current receiver level reading as a 0dB reference: subsequent readings are relative to this value. In ENVELOPE DELAY DIST and LEVEL/FREQ, readings are attenuations (positive readings indicate a lower level than the reference level). In LEVEL/FREQ, pressing SET ZERO again brings back absolute level readings in dBm. In ENVELOPE DELAY DIST, the SET ZERO key establishes the current delay result as a reference. SET ZERO is used during the RETURN LOSS measurement when an unknown transhybrid loss (THL) correction value is being measured. Subsequent RETURN LOSS results are corrected by this value. Also labeled NOISE CHECK, this key additionally lets you correct for noise effects on a channel during an INTERMOD DIST measurement.

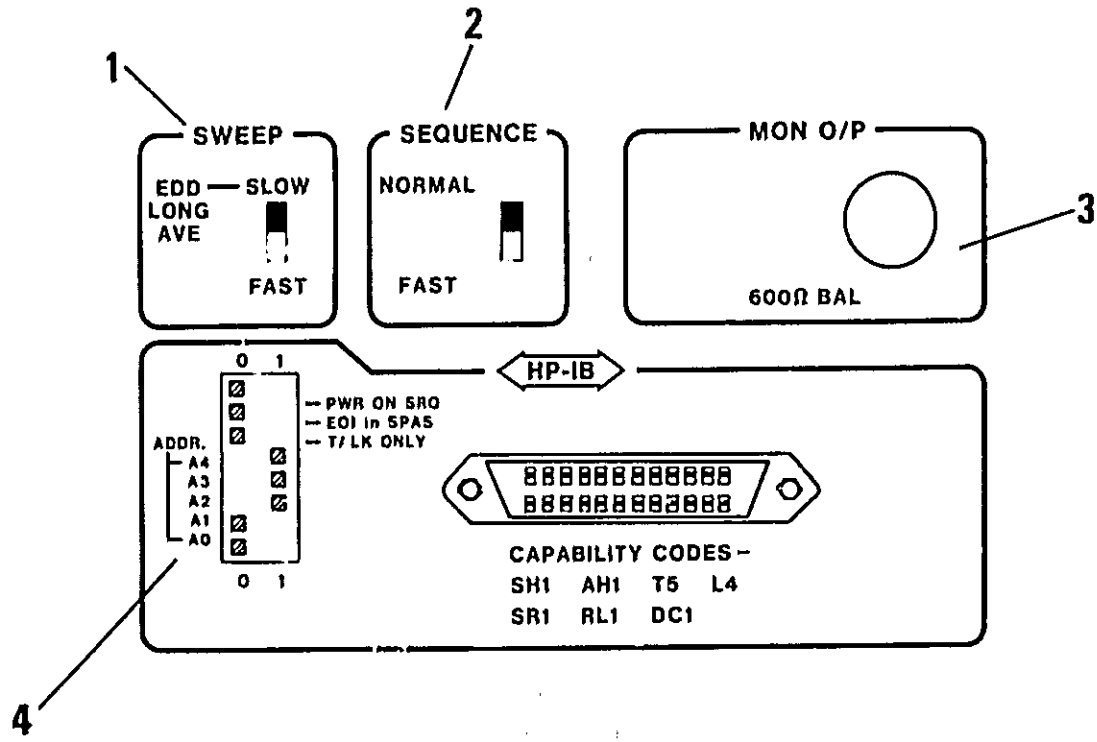
12 SF SKIP key: is used when testing circuits using single frequency (SF) signaling: this key prevents the HP4947A from transmitting frequencies between 2450 and 2750 Hz.

13 REVERSE key: reverses the function of the two measurement ports. TRMT-RCV becomes RCV-TRMT or vice versa.

14 SET SWEEP key: lets you enter the frequency sweep parameters in the middle display.

15 HANDSET key: lets you dial up a line using a butt-in.

REAR PANEL OPERATING FEATURES



1 **SWEEP:** sets the sweep rate for a swept measurement in **LEVEL/FREQ** and the delay averaging in an **ENVELOPE DELAY DIST** measurement (12 seconds/measurement point in SLOW position for high accuracy, and 3 seconds/measurment point in **FAST** position).

2 **SEQUENCE:** set to **NORMAL**, the sequence is modeled on the type 107 test line timing and takes approximately 20 minutes to complete and can be used for end-to-end and loopback testing. Set to **FAST**, the transient measurements are omitted and the sequence lasts approximately 2 minutes and is suitable only for loopback testing.

3 **MON O/P:** provides a demodulated phase jitter output.

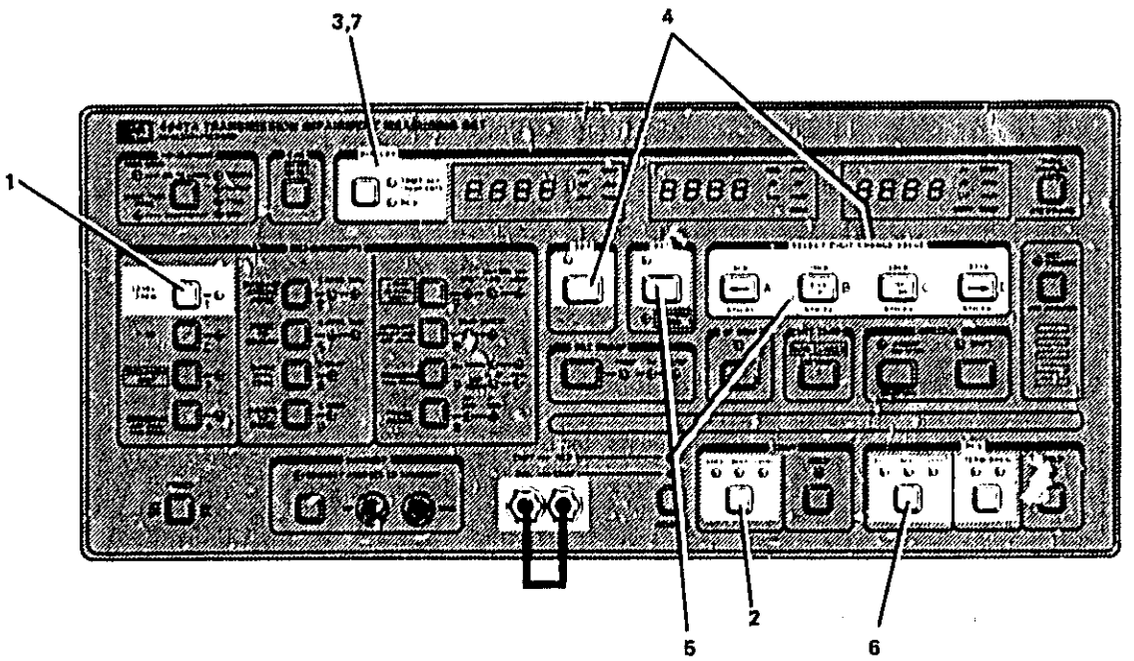
4 **HP-IB:** sets the 4947A to either the **TALK ONLY** mode or **ADDRESSABLE** mode. You must select the mode you want prior to power up. To output printed or plotted results to a printer, the 4947A must be set to **TALK ONLY**. (The printer must be set to **LISTEN ALWAYS.**) If the 4947A is to be controlled remotely, it must be in the **ADDRESSABLE** mode (4947A address must be set prior to power up).

DEMONSTRATING THE 4947A

The following demonstrations show how easy it is to use the 4947A. A detailed explanation of the 4947A measurement capability is given in Section 2. The 4947A transmitter and receiver ports are connected by a looping cable in these demonstrations (see diagram below).

Demonstration 1

A single tone measurement with the transmitter level set to -10dBm and the frequency set to 1804Hz.



1. Press LEVEL/FREQ.

TRANSMITTER

2. Use the TRMT key to set the transmitter output impedance to 600 ohm.

3. Display the transmitted level and frequency using the DISPLAY key, (TRMT led lit).

4. Change the transmitted level to -10dBm using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys. The -> and <- keys select the digit you want to change. The STEP UP and STEP DOWN keys change the value.

5. Change the transmitter frequency to 1804Hz using the SET key for the middle display and the SELECT DIGIT/CHANGE VALUE keys.

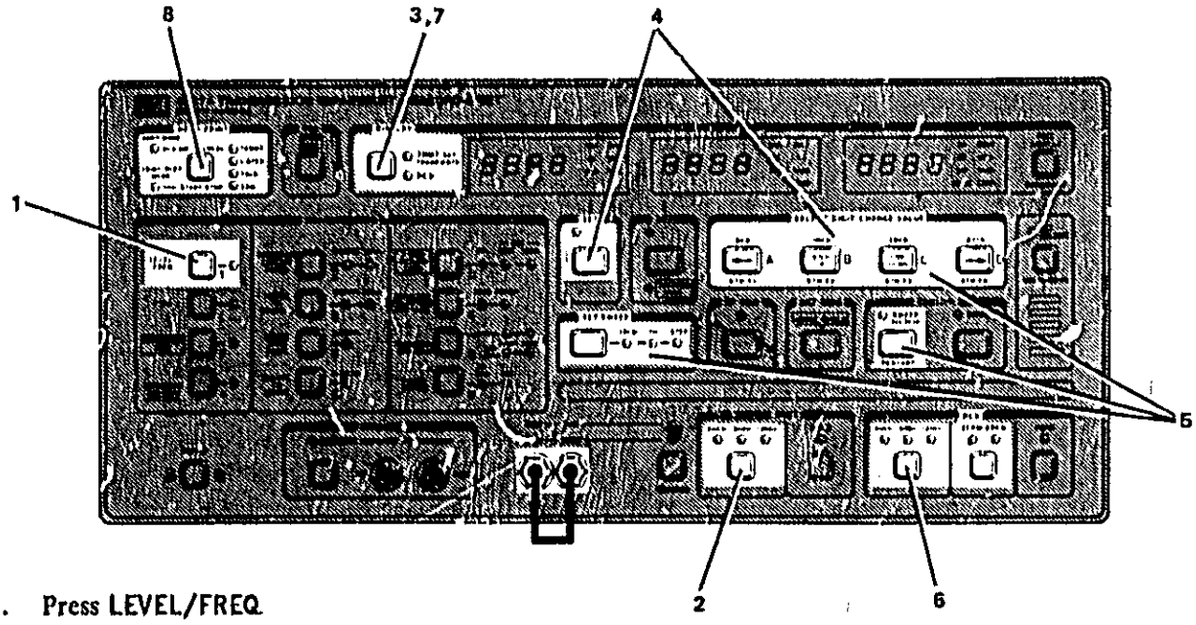
RECEIVER

6. Use the RCV keys to set the receiver input impedance to 600 ohm and TERMinated.

7. Display the received level and frequency using the DISPLAY key (RCV led lit). The level reading is in the left hand display and the middle display indicates the received frequency.

Demonstration 2

A single tone measurement with the transmitter level set to -10dBm and the frequency swept between 304Hz and 3004Hz in 50Hz steps. Print and plot the results. Before commencing with the demonstration connect a printer, (HP2225A ThinkJet), in the LISTEN ALWAYS mode, to the 4947A rear panel HP-IB connector and set the 4947A HP-IB switch to TALK ONLY before turning the 4947A on.



1. Press LEVEL/FREQ.

TRANSMITTER

2. Use the TRMT key to set the transmitter output impedance to 600 ohm.

3. Display the transmitted level and frequency using the DISPLAY key, the TRMT led should be lit.

4. Change the transmitted level to -10dBm using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys. The -> and <- keys select the digit you want to change. The STEP UP and STEP DOWN keys change the value.

5. Set the sweep limits and start the sweep as follows (check the rear panel SWEEP switch is set to FAST):

   Sweep Limits

   Use the SET SWEEP key to:

   a) Light the FROM led, then change the reading on the middle display to 304Hz (start frequency) using the SELECT DIGIT/CHANGE VALUE keys.

   b) Light the TO led, then change the display reading to 3004Hz (stop frequency).

   c) Light the STEP led, then change the display reading to 50Hz (incremental step frequency).

   d) Extinguish the STEP led.

Start Sweep

Press SWEEP/RESTART to start the sweep from the frequency displayed in the middle display. Alternatively, you can start the sweep fom 304Hz by pressing SHIFT followed by SWEEP/RESTART.

RECEIVER

6. Use the RCV keys to set the receiver input impedance to 600 ohm and TERMinated.

7. Display the received level and frequency using the DISPLAY key (RCV led lit). The level reading is in the left hand display and the display indicates the received frequency.

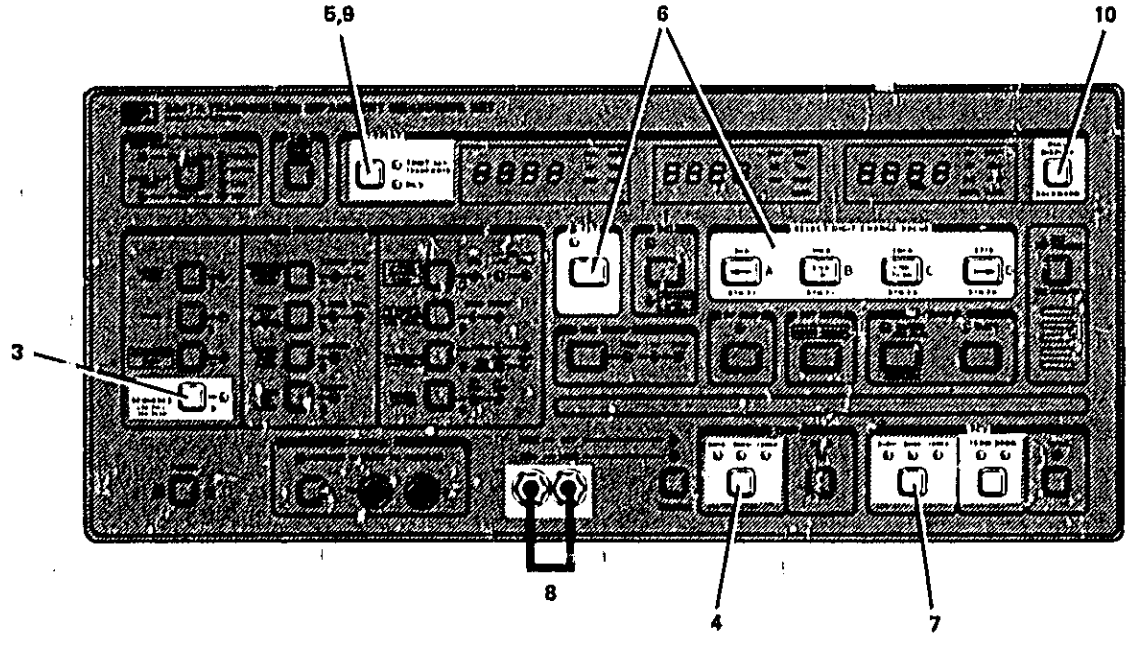
8. Press the front panel HB-IB/PRINT START/STOP key for print (TALK led should be lit). Press the PRINT key again to stop printing.

9. Alternatively, wait until the 4947A has swept all measurement points between 304Hz and 3004Hz and then plot results by pressing the SHIFT key followed by the HP-IB/PRINT START/STOP key.

Demonstration 3

A SEQUENCE measurement with the transmitter level set to -13dBm. Results are read from the display and printed.

The SEQUENCE is a series of measurements performed in order, starting with P/AR and modeled on a 107 type test line sequence. The MEASUREMENTS leds light to indicate the current measurement. It takes approximately 2 minutes to complete the sequence in FAST mode.



1. Connect a HP2225A ThinkJet printer in the LISTEN ALWAYS mode to the 4947A rear panel HP-IB connector.

2. Set the rear panel SEQUENCE switch to FAST and disconnect the RCV port from the TRMT port.

3. Press SEQUENCE. The right hand display will display FAST.

TRANSMITTER

4. Use the TRMT key to set the transmitter output impedance to 600 ohm.

5. Use the DISPLAY key to display the transmitted level (TRMT led should be lit).

6. Set the transmitted level to -13dBm using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

RECEIVER

7. Use the RCV keys to set the receiver input impedance to 600 ohm and TERMinated.

8. Connect the RCV port to the TRMT port using a 310 type (ring-tip-sleeve) test cord. The sequence test will begin automatically.

9. Use the DISPLAY key to display the received results (RCV led should be lit).

10. When End is displayed, use the ROLL DISPLAY key to scroll through the results which are arranged in an endless loop, i.e. the first result follows on after the last. You can identify a result by checking which measurement led is lit. To obtain a hard copy of the results, press PRINT START/STOP.

ERROR CODES

Error codes may be displayed while operating the 4947A. They will appear in the right hand display and take the form Err xx, where xx is the code number. Refer to APPENDIX A for Error Codes descriptions.

MAKING MEASUREMENTS

SECTION 2

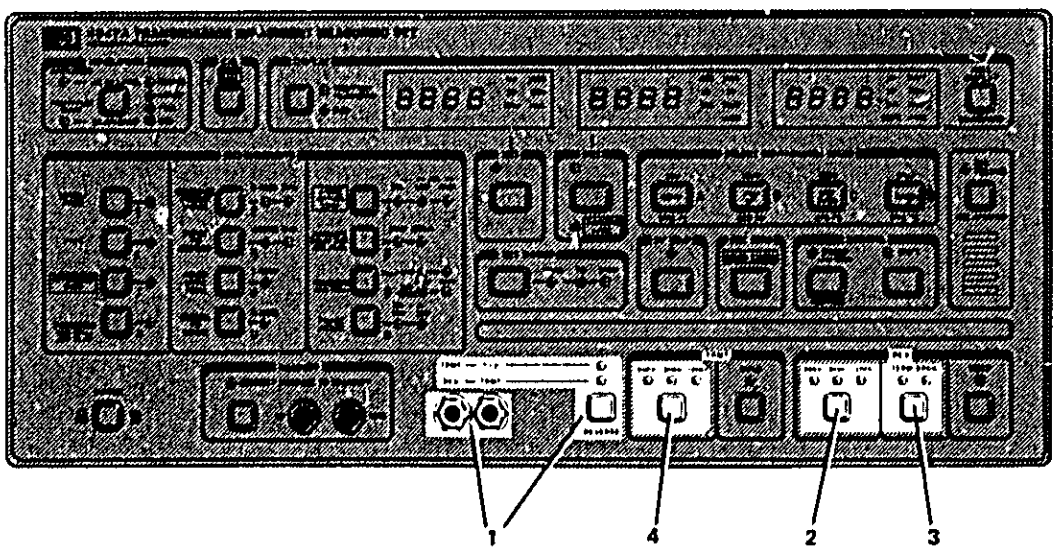
INTRODUCTION

This chapter is organised into 15 MEASUREMENT sections. Each section contains measurement principles and operating instructions.

Use the "numbered tabs" on this page to look up the measurement you are interested in.

1

PRELIMINARY SETUP



Connecting the 4947A to the Test Circuit

CAUTION

Ensure no more than 150Vdc transversal voltage is present on the circuit before connecting to it.

1. Each of the test ports of the 4947A can function as Transmitter output or Receiver input. Pressing the REVERSE key to the right of the test connectors, causes the function to be reversed (left side TRMT, right side RCV becomes left side RCV, right side TRMT and vice versa). The status of the ports is indicated by the leds above the REVERSE key.

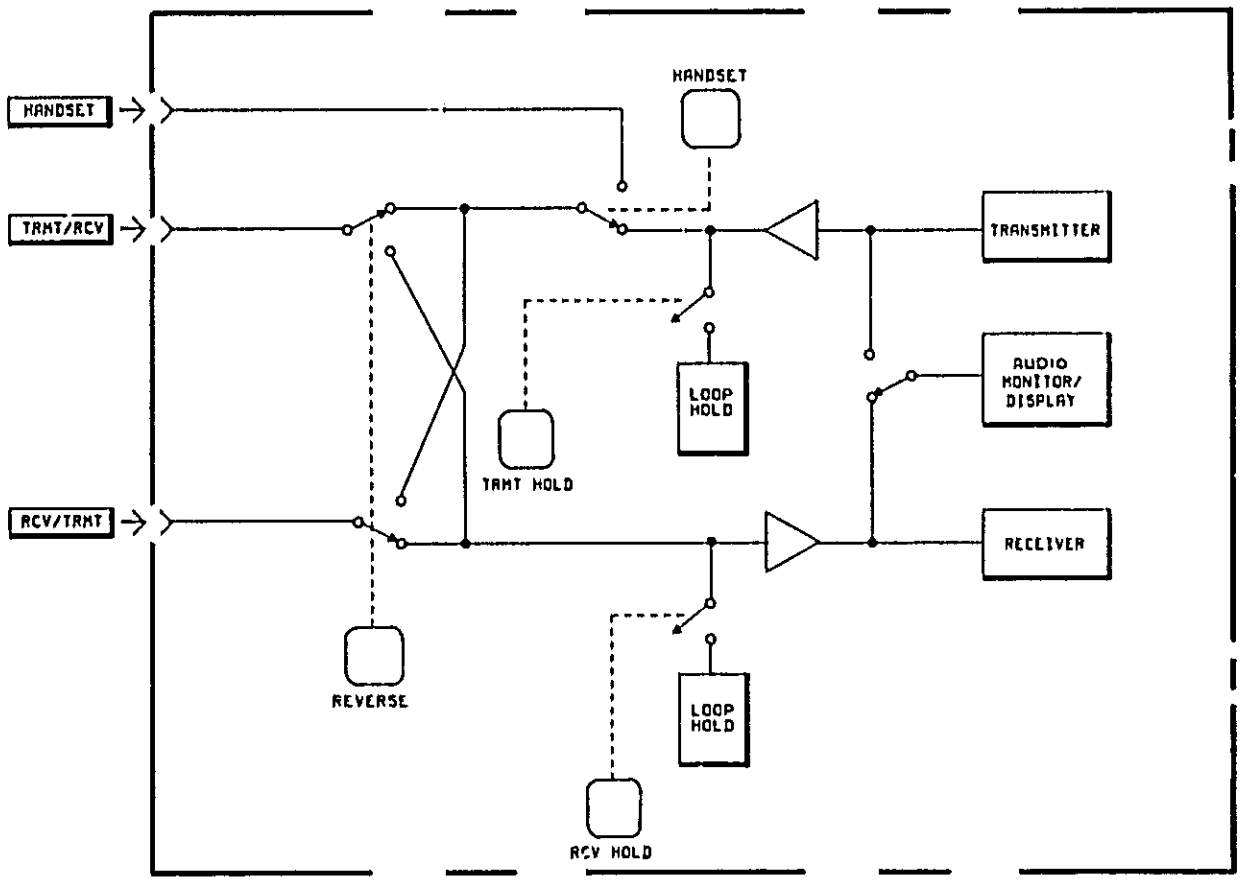
Matching the 4947A to the Test Circuit

2. Select the receiver input impedance using the RCV (600Ω, 900Ω, 1200Ω) key.
3. Select the type of termination required using the TERM/BRDG key (terminated or bridged).
4. Select the transmitter output impedance using the TRMT (600Ω, 900Ω, 1200Ω) key.

DIAL AND HOLD

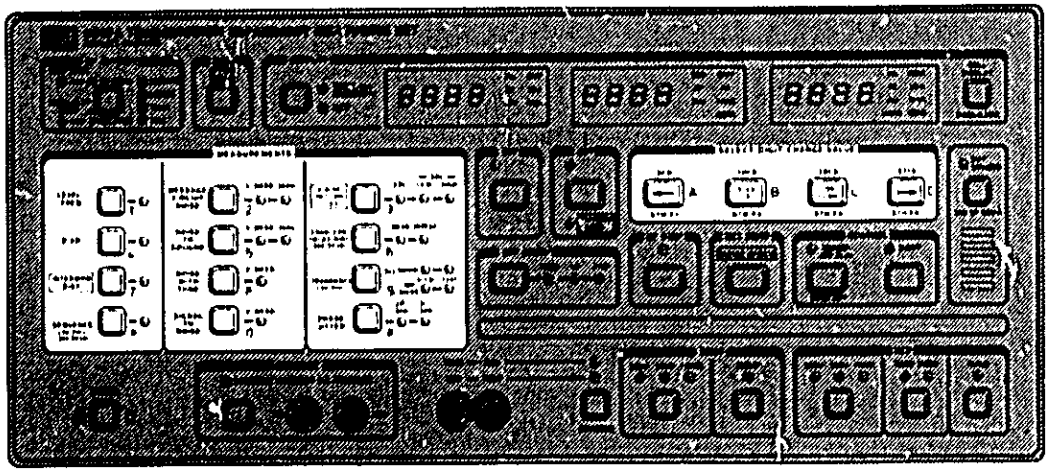
The 4947A and a butt-in can be used to dial up lines. The 4947A can send multifrequency dialing, but you will need the butt-in for pulse dialing or if you want to talk down the line. The 4947A can also hold "wet" lines (i.e. lines which pass dc current when the telephone handset goes off-hook) by sinking between 20 and 30mA (see Service Manual about setting current). The holding current is factory set at 24mA.

The diagram below illustrates the operation of the "hold" capability (both TRMT and RCV lines) and the dial capability (using a butt-in).



Front Panel Dialing Keys

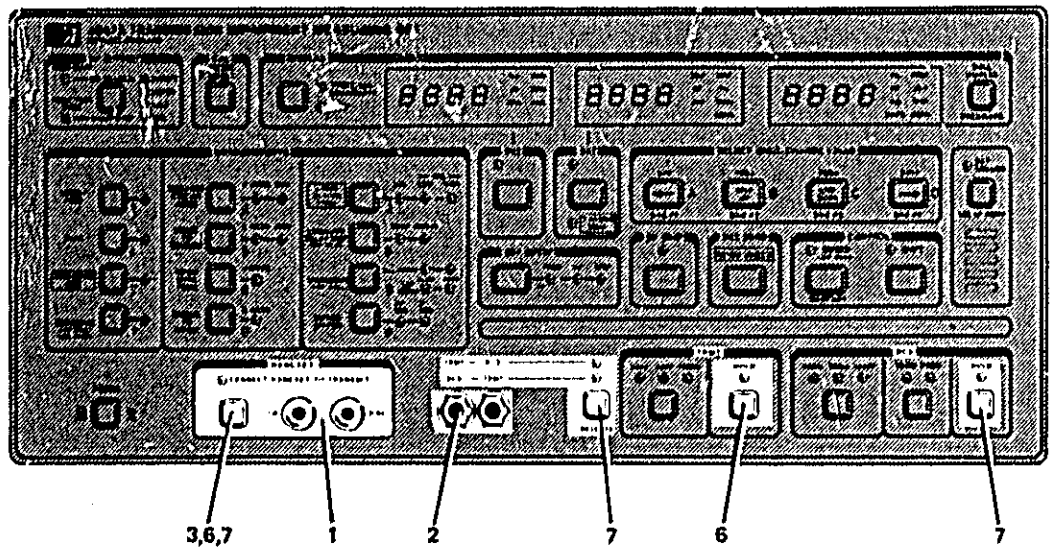
In the DTMF DIAL mode, the 4947A keys (labeled as shown below) transmit tone pairs to dial multifrequency digits. At shipment, these are set to the North American DTMF standard, but they may be re-programmed using the remote control MD command (see Page 4-26).



TONE 1 \ TONE 2	1209Hz	1336Hz	1477Hz	1633Hz
697Hz	1 (1)	2 (2)	3 (3)	A (13)
770Hz	4 (4)	5 (5)	6 (6)	B (14)
852Hz	7 (7)	8 (8)	9 (9)	C (15)
941Hz	* (11)	0 (10)	# (12)	D (16)

TONE PAIR SHOWN IN ( )

Dialing using the 4947A and a Butt-In



1. Connect the butt-in to the **HANDSET** port.

2. Connect the test circuit to the **TRMT** port.

3. Press **HANDSET** to connect the butt-in through to the **TRMT** port. The **CONNECT HANDSET TO TRANSMIT** led will light.

NOTE

HANDSET *cannot be selected in the* **IdLE** *state, select a measurement (e.g. Message Circuit Noise) before you select* **HANDSET**.

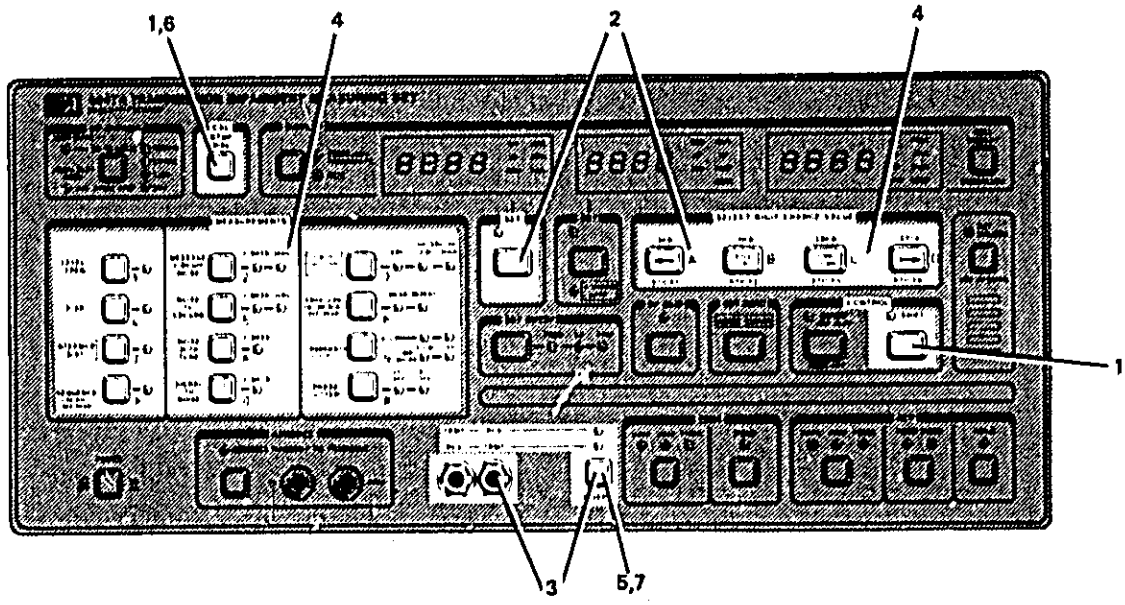
4. Dial up the line you want using the butt-in.

5. When the far end goes off-hook you can use the butt-in for voice communication.

6. To continue to hold the line and connect the 4947A transmitter to it, press **TRMT HOLD** (led should be lit) then **HANDSET**. You can now transmit test signals along the line. To re-establish the speech path, press **HANDSET** . To drop the line, press **TRMT HOLD**.

7. Alternatively, to continue to hold the line and connect the 4947A receiver to it, press **RCV HOLD** then **REVERSE**. You can now receive test signals from the line. To re-establish the speech path press **REVERSE** and **HANDSET**. To drop the line, press **RCV HOLD**.

DTMF dialing a 2-Wire Circuit using a 4947A



1. Press SHIFT followed by DTMF DIAL. The TRMT and RCV HOLD led's and the TRMT and RCV DISPLAY led's will light. dIAL will appear in the middle display and the dialing signal level in the left hand display.

2. Change the transmitted dial tone level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

3. Connect the test circuit to the RCV port and listen for the "dialing tone" (you may have to adjust audio monitor), then press REVERSE to connect the TRMT port to the test line.

4. Use the MEASUREMENTS and SELECT DIGIT/CHANGE VALUE keys to dial the number you want (the digits are printed in white on the front panel). As each digit is entered it is displayed in the right hand display. You can also hear each digit being dialed on the audio monitor (you may have to adjust the volume).

NOTE

If you have to re-dial, drop the line by pressing TRMT HOLD *(the led will go off). To seize the line again, press* TRMT HOLD *(the led will light) and re-dial the number you want.*

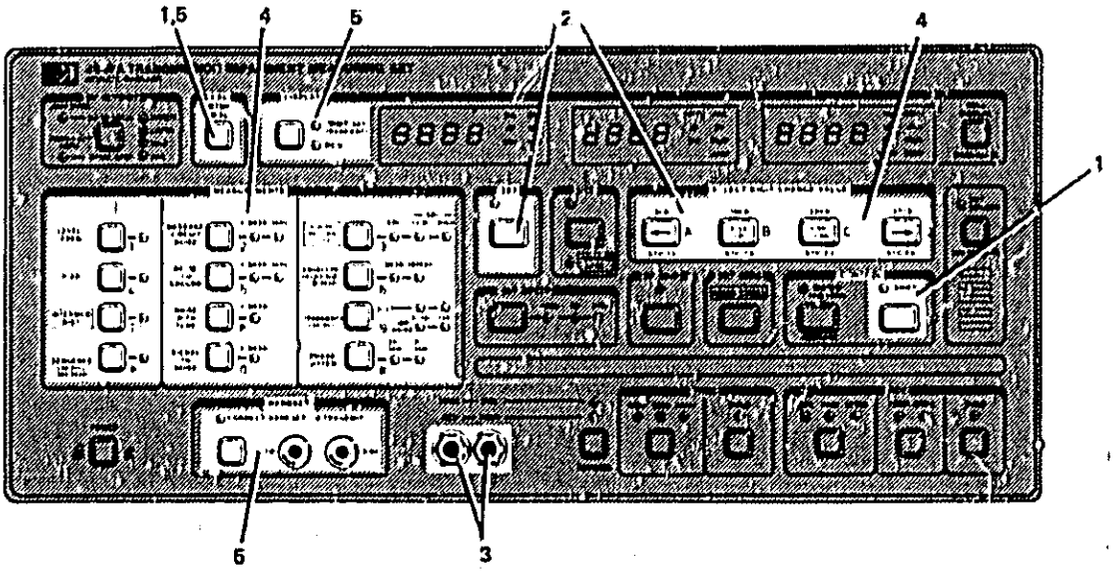
5. To listen to the ringing tone on the audio monitor, press REVERSE. The test circuit is now connected to the RCV port.

6. When the far end goes off-hook, press DTMF DIAL to exit DIAL mode. Your 4947A receiver is now connected and you can measure test signals from the line.

7. Alternatively, if you want to transmit a test signal, press REVERSE to re-connect the TRMT port to the test circuit. You can now transmit test signals along the line.

8. Select the measurement you want.

DTMF dialing a 4-Wire Circuit using a 4947A



1. Press SHIFT followed by DTMF DIAL. The TRMT and RCV HOLD led's and the TRMT and RCV DISPLAY led's will light. dIAL will appear in the middle display and the dialing signal level in the left hand display.

2. Change the transmitted dial tone level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

3. Connect the go path of the test circuit to the TRMT port and connect the return path to the RCV port and listen for the "dialing tone" on the audio monitor.

4. Use the MEASUREMENTS and SELECT DIGIT/CHANGE VALUE keys to dial the number you want (the digits are printed in white on the front panel). As each digit is entered it is displayed in the right hand display. You can also hear each digit being dialed on the audio monitor (you may have to adjust the volume).

NOTE

If you have to re-dial, drop the line by pressing the TRMT HOLD *key (the led will go off). To seize the line again, press* TRMT HOLD *(the led will light) and re-dial the number you want.*

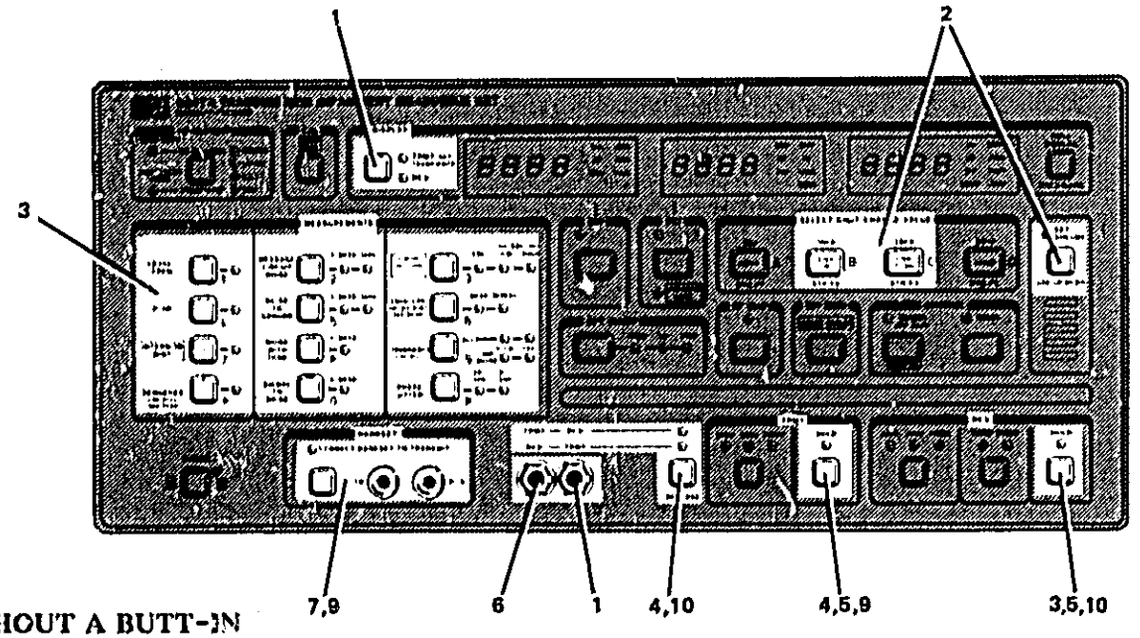
Having dialed the number you want, you should also hear the ringing tone on the audio monitor.

5. When the far end goes off-hook, press DTMF DIAL to exit DIAL mode. You can now perform measurements if you have a 4947A (or some other test set) at the far end.

If you want to talk to the far end, you will need to use a butt-in. Connect the butt-in to the HANDSET ports and go off-hook on the handset, then press HANDSET. You can now talk to the far end on the butt-in and listen to the far end on the audio monitor by setting the DISPLAY mode to RCV.

6. Select the measurement you want.

Receiving an Incoming Call and Holding the Line



WITHOUT A BUTT-IN

1. Connect the RCV port to the test line. Use the DISPLAY key to light the RCV led.

2. Set the volume of the audio monitor so that you can hear any received signal, using the SET VOLUME and STEP UP and STEP DOWN keys.

3. When a call comes in, you will hear a "buzzing" on the audio monitor. To seize the line, press RCV HOLD. The caller can now speak to you or transmit test signals. To make measurements, press the appropriate MEASUREMENTS key.

4. To transmit test signals while continuing to hold the line, press TRMT HOLD then REVERSE.

5. To drop the line, press the appropriate HOLD key.

WITH A BUTT-IN (if you want to talk)

6. Connect the TRMT port to the test line.

7. Connect the butt-in to the HANDSET port and press HANDSET to connect the butt-in through to the TRMT port. The CONNECT HANDSET TO TRANSMIT led will light.

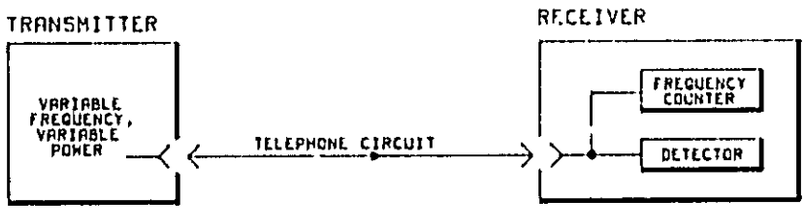
8. When you receive a call, the butt-in will ring. Go off-hook to receive the call.

9. To connect the 4947A transmitter to the line, press TRMT HOLD then HANDSET. You can now transmit test signals along the line. To re-establish the speech path, press HANDSET. To drop the line, press TRMT HOLD.

10. Alternatively, to connect the 4947A receiver to the line, press RCV HOLD then REVERSE. You can now receive test signals from the line. To re-establish the speech path, press REVERSE. To drop the line, press RCV HOLD.

LEVEL AND FREQUENCY ..... Principles

LEVEL/FREQUENCY encompasses 4 related measurements: loss, attenuation distortion, gain slope and frequency shift. All use the same measurement configuration.



1004Hz Loss

This measurement determines the point-to-point loss (or gain) of a channel at 1004Hz. 1004Hz is transmitted instead of 1000Hz to avoid measurement errors caused by signals which are submultiples of the 8kHz PCM sample rate.

1. The transmitter sends 1004Hz at the normal data level (usually -13dBm0).

2. The receiver measures the level and frequency of the received signal. The loss is the difference between the transmitted and received levels.

NOTE

If the channel is already terminated, the receiver can measure the level via a high impedance input (bridging mode). There is a small loading error which is compensated for in the result.

Attenuation Distortion

Attenuation distortion defines the flatness and useable bandwidth of the circuit.

1. The transmitter sends 1004Hz (or other suitable frequency) at the normal data level. The level received at this frequency is set as the reference level.

2. The transmitter sweeps through a range of spot frequencies over the channel bandwidth. At each frequency, the receiver computes the difference between the level received and the level at the reference frequency.

Gain Slope

This is a quick method for assessing the flatness of a channel using only 3 frequencies, 2 of which are close to the edges of the channel bandwidth. The level is measured at 1004Hz and established as the reference level; then the attenuation is measured at 404Hz and 2804Hz relative to the reference level.

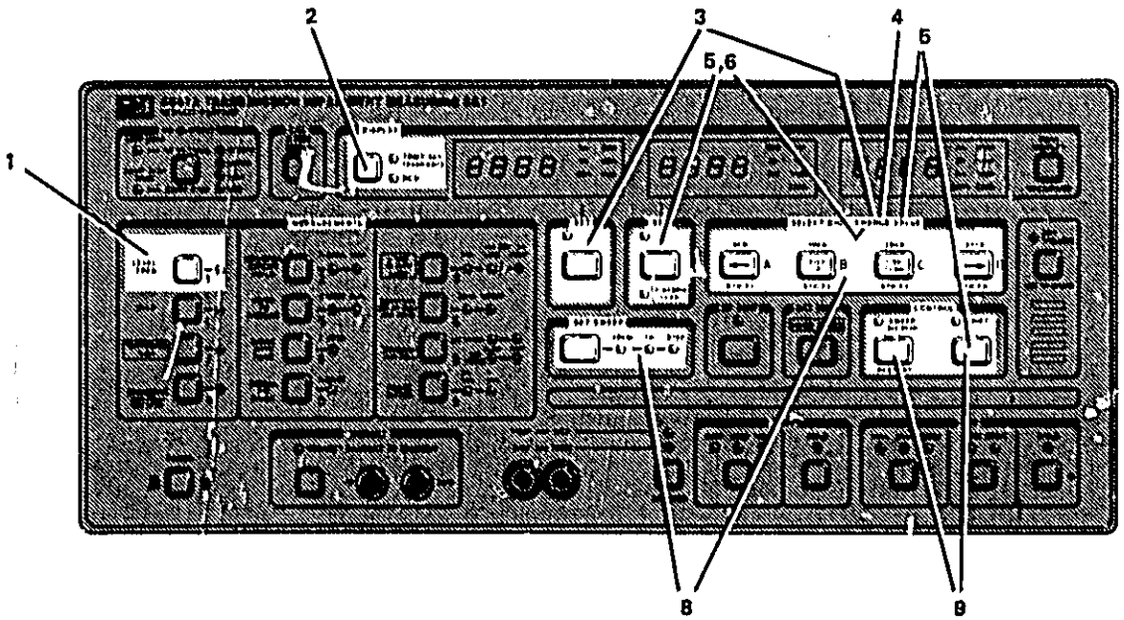
Frequency Shift

Frequency shift can occur over facilities such as FDM carrier systems and is measured by comparing the frequency sent into the channel with the frequency received at the far end of the channel.

NOTE

The measurement may not be valid when measured on looped-around carrier facilities since the frequency shift in one direction may be cancelled by frequency shift in the return direction.

LEVEL AND FREQUENCY ..... Instrument Operation



1. Press LEVEL/FREQ.

Transmitter

2. Display the transmitted level and frequency using the DISPLAY key. The TRMT led should be lit.

   A frequency of 1004Hz is transmitted whenever LEVEL/FREQ is selected. The level remains at whatever was last used.

3. Change the transmitted level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

NOTE

In some systems it is not desirable to transmit signal levels above -13dBm0 as interference with other channels may result.

Decide whether you want to use a single point frequency of your choice, a preset frequency, or a multipoint sweep, then follow the appropriate procedure.

PRESET FREQUENCIES

The 4947A gives single-keystroke access to four preset frequencies. At switch-on the preset frequencies are initialised to: 404Hz, 1004Hz, 2804Hz and 2713Hz.

4. To select a preset frequency:

   - Ensure all SET functions are inactive, i.e. all SET leds should be off.
   - Select your preset frequency by pressing the appropriate SELECT DIGIT/CHANGE VALUE key.

5. To store a different preset frequency:

   - Change the preset frequency by using the SET key for the middle display and the SELECT DIGIT/CHANGE VALUE keys.
   - Store the value by pressing SHIFT followed by one of the STO F1 to STO F4 key.
   - These new frequency values will remain until changed, or until the power is turned off. Frequency values indicated on the front panel are re-established at power-up.

SINGLE POINT

6. Change the value of the transmitted frequency using the SET key for the middle display and the SELECT DIGIT/CHANGE VALUE keys.

MULTIPOINT SWEEP

7. Select the sweep rate you want, by setting the rear panel SWEEP switch to either FAST or SLOW. (FAST gives one measurement per point; SLOW gives five measurements per point, thus slowing the sweep rate).

8. Set the sweep parameters by using the SET SWEEP and SELECT DIGIT/CHANGE VALUE keys:

   start frequency . . . . . FROM
   stop frequency . . . . . TO
   incremental step . . . . . STEP

   After setting the sweep limits, re-display the transmitter frequency using SET SWEEP (all sweep leds are extinguished).

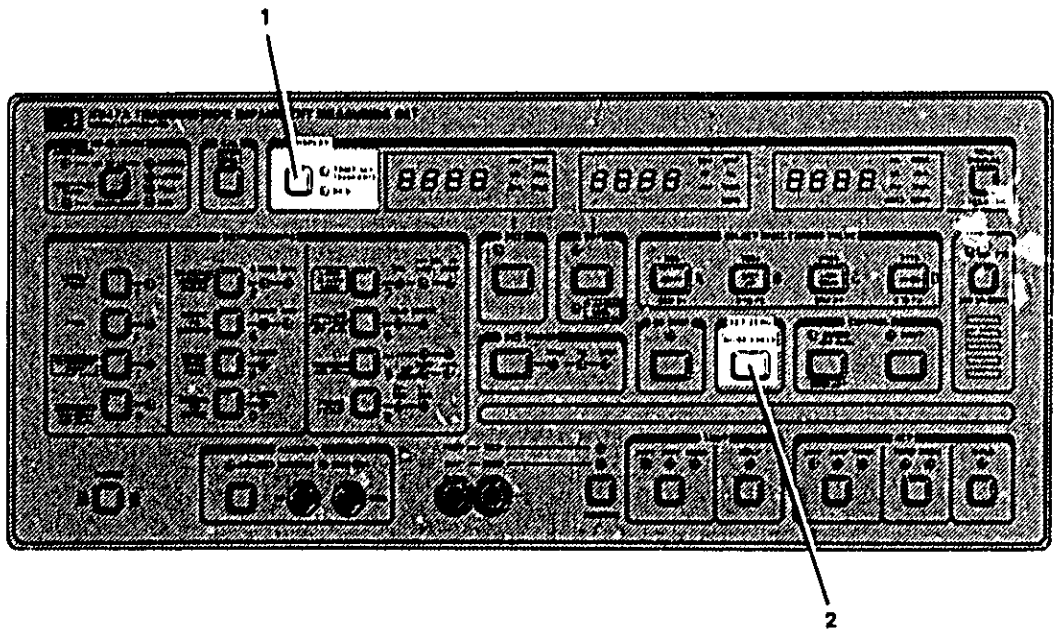
9. To start the sweep from the start frequency, press SHIFT followed by SWEEP/RESTART. To start the transmitter sweeping from its current frequency, press SWEEP/RESTART. When the sweep is in progress the SWEEP led is lit. To stop the sweep, press SWEEP/RESTART again.

NOTE

1. If a receiver reference is required, set this up before starting the sweep (see next page).

2. Sweep parameters can be changed while the transmitter is sweeping.

Receiver



1. Display the received level and frequency using the **DISPLAY** key. The **RCV** led should be lit.

RECEIVER REFERENCE

2. When the reference signal is received (for attenuation distortion measurements this is normally 1004Hz), press **SET ZERO** to change the level reading from an absolute value in **dBm** to a relative attenuation value in **dB**. All subsequent received level readings are relative to this value.

NOTE

A negative reading indicates a level higher than the reference level.

Pressing **SET ZERO** a second time changes the level reading back to absolute units in **dBm**.

3. Results can be printed or plotted on an external device. See Printing/Plotting in Section 3.

NOTE

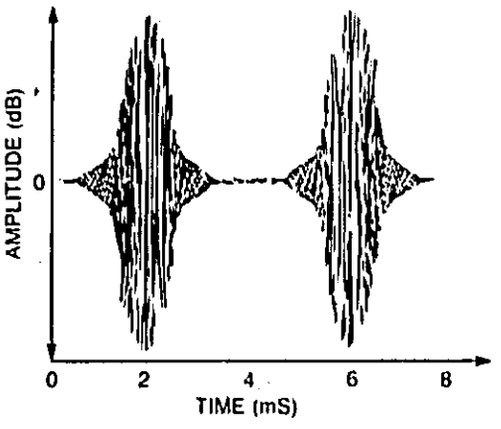
Error codes will be displayed if the input level to the receiver is too high or unstable (see error codes in APPENDIX A).

P/AR (PEAK TO AVERAGE RATIO) ..... Principles

P/AR is a good quick measure of the combined effect of impairments which produce intersymbol interference on a data signal (for example, phase/delay distortion, attenuation distortion, intermodulation distortion and noise).

P/AR cannot determine which impairment is causing the problem - its value is solely as a benchmark measurement to show up degradations with time in the transmission quality of a line.

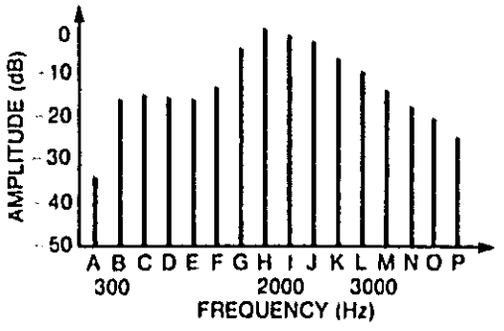
A deviation of ±4 P/AR units from the bench mark value usually indicates a suspect channel.



P/AR WAVEFORM

KEY	FREQUENCY
A	140.625 Hz
B	390.625
C	640.625
D	890.625
E	1140.625
F	1390.625
G	1640.625
H	1890.625

KEY	FREQUENCY
I	2140.625 Hz
J	2390.625
K	2640.625
L	2890.625
M	3140.625
N	3390.625
O	3640.625
P	3890.625



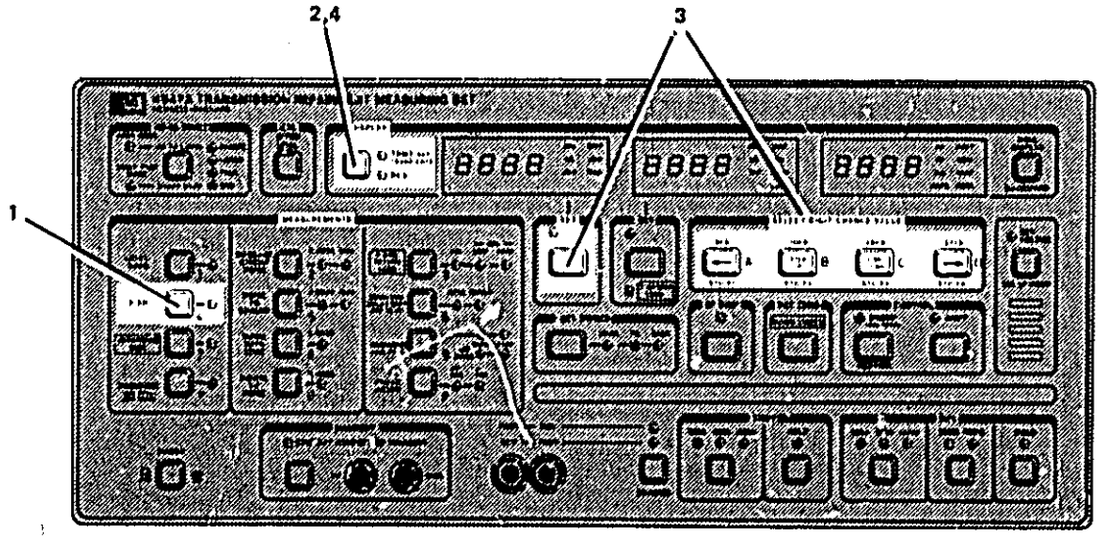
P/AR SPECTRUM

How It Is Measured

1. The transmitter sends a complex signal which closely approximates a modem signal (16 frequencies with a known envelope shape).

2. From the received signal envelope, the receiver calculates the peak-to-average ratio. This is compared with the known peak-to-average ratio of the transmitted signal. A scaling factor ensures that a P/AR of 100 indicates no signal degradation.

P/AR (PEAK TO AVERAGE RATIO) ..... Instrument Operation



1. Press P/AR.

Transmitter

2. Display the transmitted P/AR signal level in dBm using the DISPLAY key. The TRMT led should be lit.

3. Change the transmitted signal level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

Receiver

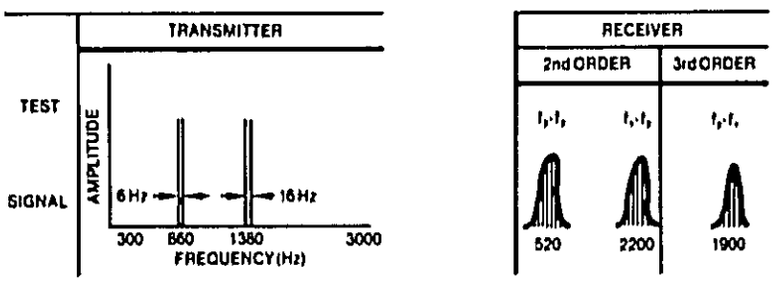
4. Display the received signal level in the left hand display and the P/AR reading (in UNITS) in the right hand display using the DISPLAY key. The RCV led should be lit.

NOTE

A P/AR reading of zero indicates that the P/AR of the incoming signal is out-of-range of the 4947A's receiver.

INTERMOD DISTORTION (NLD)..... Principles

Non-linearities in a telephone channel generate signals not present in the original signal. When the original signal contains multi-frequencies, the frequencies and their harmonics mix to form intermodulation distortion products. In N. America, the 4-tone method* is normally used to measure intermodulation distortion.



How it is Measured

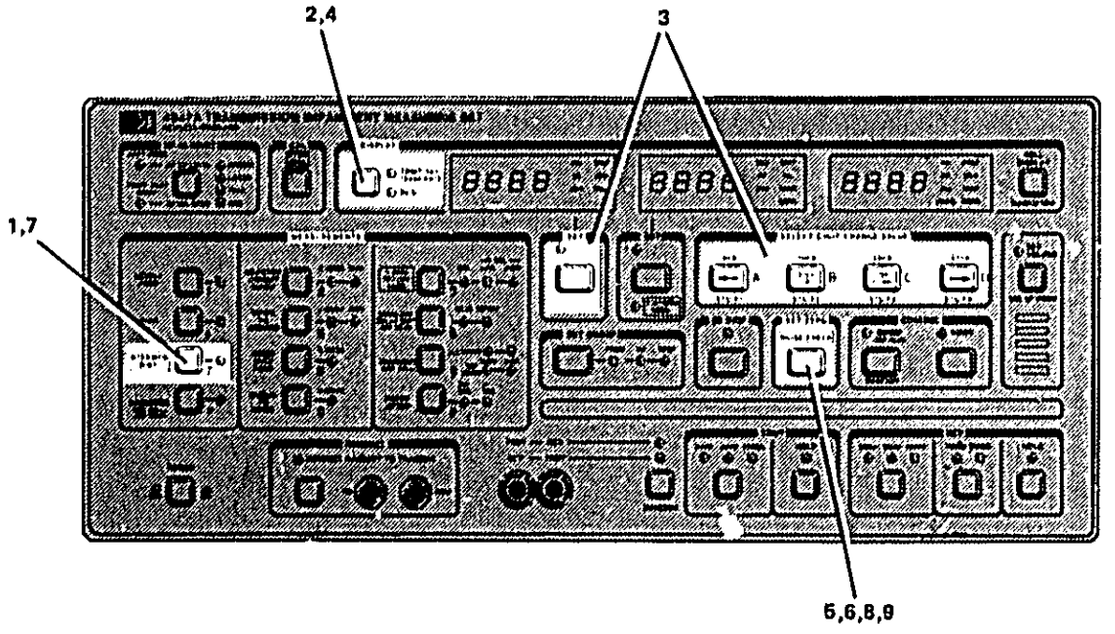
1. The transmitter sends a test signal which comprises four tones arranged as two frequency pairs, A and B, centered at 860 and 1380Hz, respectively. (This scheme produces distortion products similar to that generated by a modem signal; also interference from other impairments is minimized.)

2. The receiver measures only three groups of distortion products. They are the second order distortion products centered on A + B (2240Hz) and A - B (520Hz) and the third order products centered on 2B - A (1900Hz). (This set is reckoned to be a sufficient measure of channel non-linearities.) The results are presented as the ratio of total received power to the power of the distortion product. The powers in the two second order bands are averaged.

If the distortion products are down near the noise level, the noise measured along with the distortion products gives erroneous distortion results. The 4947A includes a NOISE CHECK key to get round this difficulty: when the key is pressed, the noise is measured; when it is pressed again, the noise component is removed from the distortion result. The noise is measured by transmitting a single tone pair (to activate the channel but avoid producing intermodulation products in the filter bands) and measuring the noise power in the intermodulation measurement filters. To keep channel loading constant, the transmitter sends the single tone pair at the same level as the two tone pairs.

* The non-linear distortion measurement is licensed under Hekimian Laboratories Inc., U.S. Patent No. 3862380.

INTERMOD DISTORTION (NLD)..... Instrument Operation



1. Press INTERMOD DISTortion.

Transmitter

2. Display the transmitted level using the DISPLAY key. The TRMT led should be lit.

   The 4947A indicates that 4 tones are being transmitted by displaying the transmitted level in the left hand display and 4t (4 tone) in the middle display.

3. Change the transmitted level by using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

Receiver

4. Display the received 4 tone level, and the 2nd and 3rd order intermod ratios on the display using the DISPLAY key. The RCV led will be lit.

   left hand display . . . . . received power in dBm
   middle display . . . . . 2nd order intermod + noise in dB
   right hand display . . . . . 3rd order intermod + noise in dB

NOTE

If the 2nd or 3rd order intermod ratio are -70dB or (out-of-range) HI *is displayed*

NOISE CORRECTION (loopback)

The results on the display also include the effects of noise. The following steps correct the readings for these effects in loopback.

5. To apply noise correction, first switch the transmitter from 4 tone to 2 tone operation by pressing the **NOISE CHECK** key.

   The display shows the effects of channel noise in the 2nd and 3rd order intermod bands.

   left hand display . . . . . n.ch (noise check)
   middle display . . . . . signal/noise in the 2nd order band in dB
   right hand display . . . . . signal/noise in the 3rd order band in dB

6. Display the intermod readings with noise correction applied by pressing **NOISE CHECK** again. All subsequent reading will be noise corrected.

   The displays should now show the following units:

   left hand display . . . . . dBm
   middle display . . . . . dB CORR (corrected)
   right hand display . . . . . dB CORR (corrected)

7. If it is necessary to again measure intermod with noise (no correction), the measurement must be repeated by pressing the **INTERMOD DIST** key.

NOISE CORRECTION (end-to-end)

To provide noise correction in end-to-end operation, communication between the operators at the Transmit and Receive Ends is necessary.

NOTE

Noise correction cannot be made simultaneously in both directions.

Transmitting End 4947A

8. To apply noise correction, switch the transmitter from 4 tone to 2 tone operation by pressing the **NOISE CHECK** key. The Transmitting End operator informs the Receiving End operator "2 tone is being transmitted" (uses a butt-in or other telephone line). Wait until Receiving End operator tells you to return to 4 tone transmission and then press **NOISE CHECK** again.

Receiving End 4947A

9. Listen for the change from 4 Tone to 2 Tone on the audio monitor. Then press **NOISE CHECK** and allow the 4947A to settle, by letting the 4947A measure the 2 Tone signal a few times before pressing **NOISE CHECK** again to to store noise correction values.

10. Tell the Transmitting End operator to return to 4 Tone transmission.

11. Listen for the 4 Tone signal and monitor the corrected results on the display.

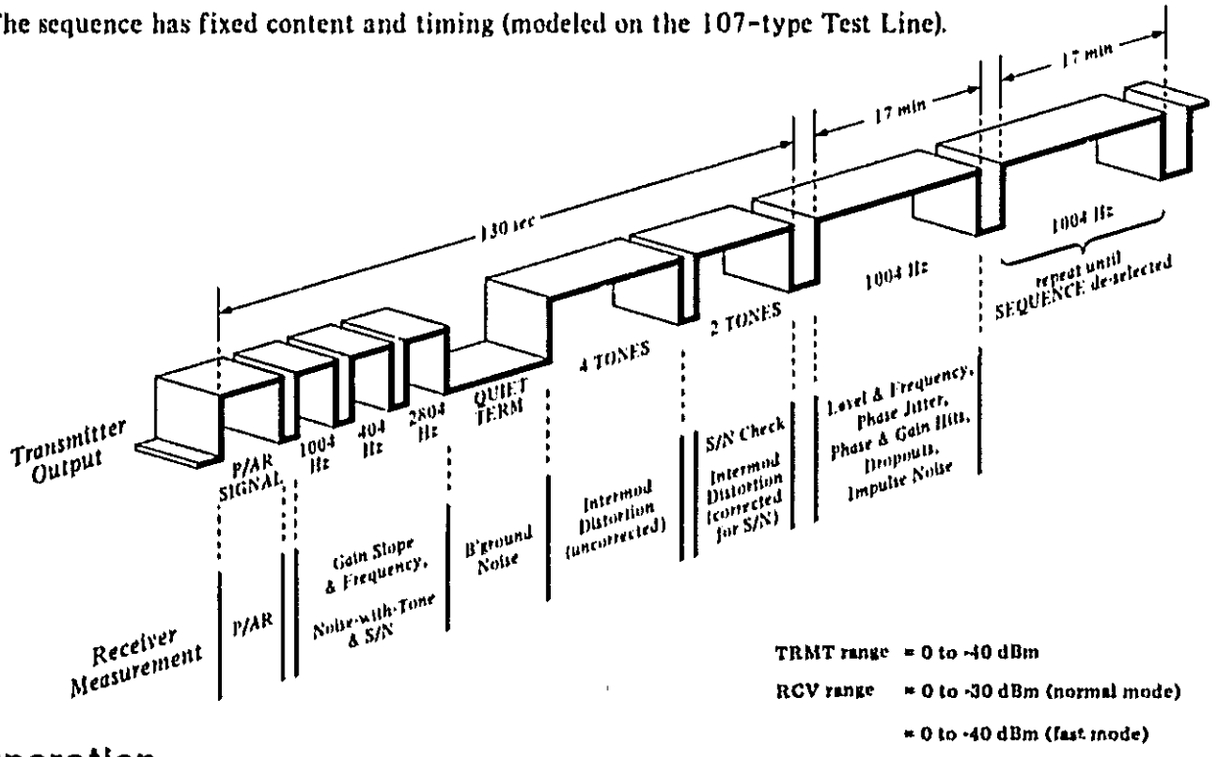
SEQUENCE ..... Principles

This one-keystroke measurement runs a sequence of tests which measure all the key data transmission parameters. The measurement is useful because it allows automation of loopback and end-to-end testing.

The sequence does not include direct measurement of attenuation distortion and delay distortion. But it does show up problems in these areas by including gain slope and P/AR, which run much faster. The sequence is therefore an excellent fast quality check.

Content

The sequence has fixed content and timing (modeled on the 107-type Test Line).



Operation

1. **Start up:** The transmitter sends out a P/AR signal but measurement does not begin until the receiver recognizes the start of a sequence. After that, the receiver keeps pace simply by knowing what the transmitter will send next.

2. **Signal loss:** If the received signal drops below -30dBm (fast mode, -40dBm) during a measurement interval (excluding the background noise interval), signal loss is deemed to have occurred and the 4947A displays SIG LOSS. The transmitter switches off and the receiver looks for the P/AR signal. Once it is found, the 4947A returns to start up.

3. **Power loss:** If this occurs during a sequence measurement, the 4947A powers up as normal but, instead of entering the idle state, returns to sequence and assumes signal loss.

4. **End of sequence:** At the end of the 17 min of 1004Hz, the transmitter starts another 17 min of 1004Hz and the receiver looks for the P/AR signal. If it is found, the 4947A returns to start up.

Transmit Only Operation

When SEQUENCE is pressed, the 4947A transmits the P/AR signal until its receiver has recognized the start of a sequence. This is the way a synchronized startup is achieved. However, when the operator just wants to send out the sequence, he can trigger it manually by pressing SEQUENCE followed by SHEEP.

2-wire End-to-end Operation

Two 4947As are required. First the Receive End operator selects SEQUENCE to initiate a search for the start of a sequence. Then the Transmit End operator selects SEQUENCE followed by SHEEP to initiate transmit only.

4-wire End-to-end Operation

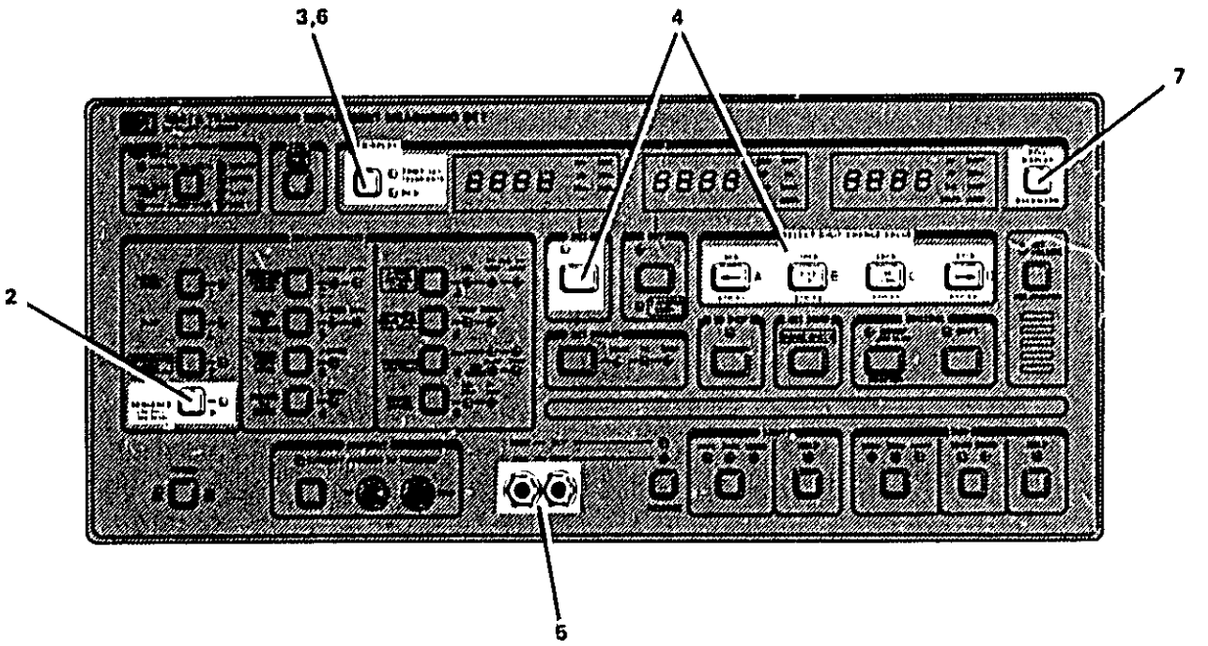
Two 4947As are required. The operator at one end selects SEQUENCE on his 4947A which initiates the sequence and waits for a response. This comes from the other end when the operator there selects SEQUENCE. Two-way testing then proceeds without further operator intervention.

Each 4947A stores the results of its own measurements in non-volatile memory. Later, results can be dumped to a printer or a controller or scrolled through and read from the display.

Fast Mode

For faster loopback testing, only one 4947A is required, so synchronization of the receiver and transmitter is easy. This makes it possible to run the elements of the sequence much faster. The fast mode sequence runs in less than 90 seconds, has the same content as the 107 Test Line but ends with phase jitter. There are no transient measurements. If these are required, normal mode must be used.

SEQUENCE (Loopback)..... Instrument Operation



1. Set the rear panel **SEQUENCE** switch to **FAST**.

2. Press **SEQUENCE**.

Transmitter

3. Use the **DISPLAY** key to display the transmitted level. The **TRMT** led should be lit.

4. Set the transmitted level using the **SET** key for the left hand display and the **SELECT DIGIT/CHANGE VALUE** keys.

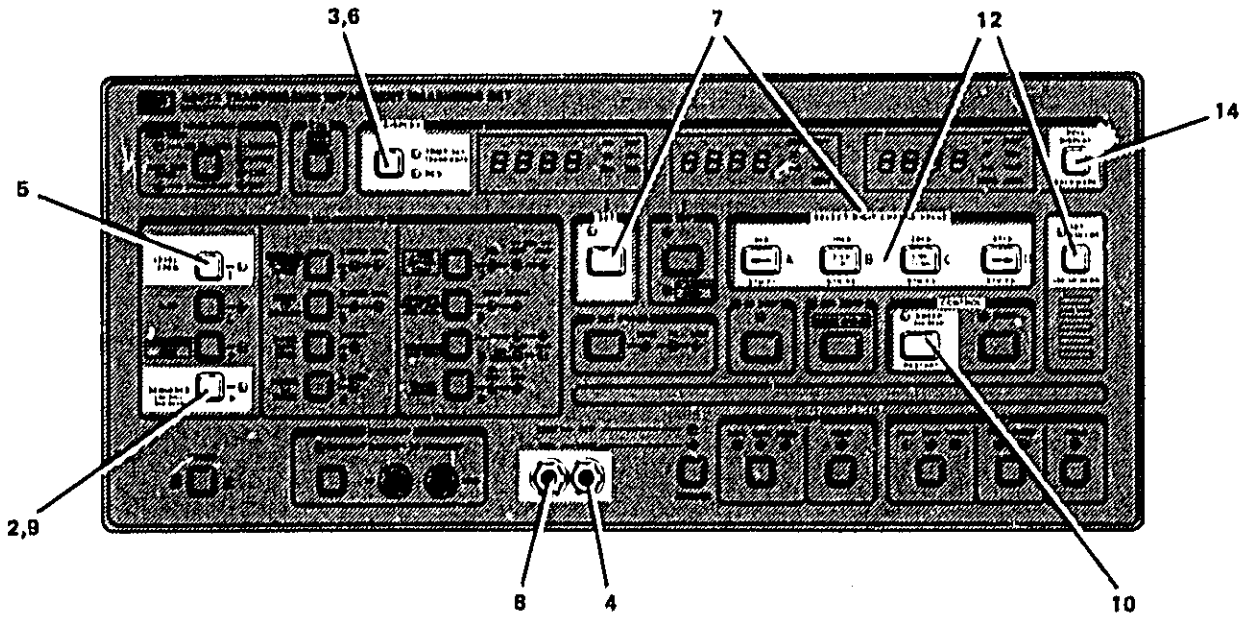
Receiver

5. Connect the **RCV** port and **TRMT** port to the loopback circuit.

6. Use the **DISPLAY** key to display received results, the **RCV** led should be lit. All results will be available after 2 minutes when **End** is displayed. During the sequence, results are displayed as each measurement is made.

7. Use the **ROLL DISPLAY** key to scroll the results.

SEQUENCE (2-Wire End-to-End)..... Instrument Operation



'wo 4947A's are required.

Set the rear panel **SEQUENCE** switch to **NORMAL** on both 4947A's.

NOTE

Setting the **SEQUENCE** *switch to* **FAST** *is invalid for end-to-end operation.*

Receiving End 4947A (set up)

2. Press **SEQUENCE**. The **SEQUENCE** and **P/AR** leds will light and **SLo** appears in the right hand display.

3. Select the **RCV** display mode using the **DISPLAY** key. The **RCV** led will light.

4. Connect the **RCV** port to the test circuit.

Transmitting End 4947A (set up)

5. Press **LEVEL/FREQ**.

6. Display the transmitted level using the **DISPLAY** key. The **TRMT** led will light.

7. Change the level using the **SET** key for the left hand display and the **SELECT DIGIT/CHANGE VALUE** keys.

8. Connect the **TRMT** port to the test circuit.

9. Press SEQUENCE. The SEQUENCE and P/AR leds will light and SLo appears in the right hand display.

10. Press SWEEP/RESTART to start the sequence timing. The 4947A lets you know where you are in the SEQUENCE by lighting the appropriate MEASUREMENTS led.

Receiving End 4947A (reading results)

11. The P/AR result is the first to be received and is displayed in the right hand display.

12. If you want to hear the received signal use the SET VOLUME and STEP UP and STEP DOWN keys to set the audio monitor level.

13. The 4947A lets you know where you are in the SEQUENCE by lighting the appropriate MEASUREMENTS led. The measurement is complete when End is displayed.

14. Use the ROLL DISPLAY key to scroll forward through the results. SHIFT followed by ROLL DISPLAY allows you to scroll backwards (see Table of results).

15. Wait until End is displayed before printing results.

NOTE

A useful feature of SEQUENCE *is that results are stored in NVM (non-volatile memory). This allows you to move the 4947A to another location (if you want) before you read or print out results. When you power-up at the new location:*

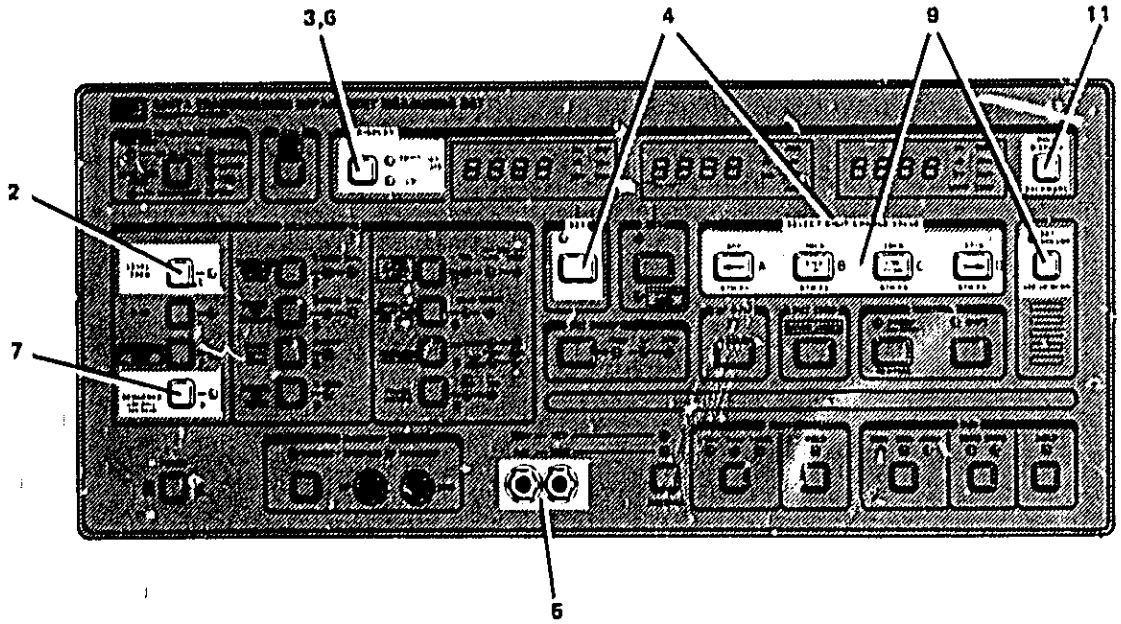
1. *Ensure the 4947A ports are not connected.*
2. *Press* SEQUENCE
3. *Read or Print results.*

Step 1 ensures that the 4947A cannot detect a new sequence before the stored results are read or printed. If new sequences were to be detected, the stored results in NVM would be overwritten.

Sequence Results

	RECEIVER DISPLAY		
MEASUREMENT	left hand	middle	right hand
P/AR			P/AR UNITS
LEVEL/FREQ:			
NOISE WITH TONE (C-MESS)	level dBm	1004Hz	noise dBm
SIGNAL TO NOISE (C-MESS)	level dBm	1004Hz	signal/noise dB
ATTEN. DIST. (w.r.t. 1004Hz)	atten.dist.dB	404Hz	
	atten.dist.dB	2804Hz	
MESSAGE CIRCUIT NOISE:			
3kHz	noise dBrn		
C-MESS	noise dBrn		
INTERMOD DISTORTION:			
4 Tone	level dBm	2nd Order+noise dB 2nd	3rd Order+noise dB 3rd
2 Tone (noise correction)	n.ch.(noise check)	noise 2nd Band dB 2nd	noise 3rd Band dB 3rd
4 Tone (noise corrected)	level dBm	2nd Order dB 2nd CORR	3rd Order dB 3rd CORR
LEVEL/FREQ:	level dBm	1004Hz	
PHASE JITTER:			
20-300Hz	level dBm	phase jitter DEG	
4-300Hz	level dBm	phase jitter DEG	
TRANSIENTS -ALL SLOW	transient period Hrs		
	gain hits GHIT	phase hits ∮ HIT	dropouts DOUT
	impulse low ImpL	impulse medium ImpM	impulse high ImpH

SEQUENCE (4-Wire End-to-End). . . . . Instrument Operation



Two 4947A's are required. The following procedure applies to both the Far and Near End 4947A's.

1. Set the rear panel **SEQUENCE** switch to **NORMAL** (or incorrect results will be obtained).

NOTE

Setting the **SEQUENCE** *switch to* **FAST** *is invalid for end-to-end operation.*

2. Select **LEVEL/FREQ**.
3. Select the **TRMT** display mode using the **DISPLAY** key. The **TRMT** led will be lit.
4. Set the transmitted level using the **SET** key for the left hand display and **SELECT DIGIT/CHANGE VALUE** keys.
5. Connect both the **TRMT** and **RCV** ports to the test circuit.
6. Select the **RCV** display mode using the **DISPLAY** key. The **RCV** led will be lit.
7. Press **SEQUENCE**. Both 4947A's will now progress through the **SEQUENCE** measurements with 107 timing.

Reading Results

8. The **P/AR** result is the first to be measured and is displayed in the right hand display.

9. If you want to hear the received signal use the SET VOLUME and STEP UP and STEP DOWN keys to set the audio monitor level.

10. The 4947A lets you know where you are in the SEQUENCE by lighting the appropriate MEASUREMENTS led. When the measurement is complete End is displayed.

11. Use the ROLL DISPLAY keys to scroll forward through the results. SHIFT followed by ROLL DISPLAY allows you to scroll backwards (see table of results given on Page 2-27).

12. Wait until End is displayed before printing results.

NOTE

A useful feature of SEQUENCE *is that results are stored in NVM (non-volatile memory). This allows you to move the 4947A to another location (if you want) before you read or print out results. When you power-up at the new location:*

1. Ensure the 4947A ports are not connected.

2. Press SEQUENCE

3. Read or Print results.

Step 1 ensures that the 4947A cannot detect a new sequence before the stored results are read or printed. If new sequences were to be detected, the stored results in NVM would be overwritten.

Signal Loss

If the receiving end 4947A does not receive the expected signal, the SEQUENCE measurement stops and SIG LOSS is displayed. The transmitter goes idle and the receiver monitors the line, waiting to see if a new sequence is received from the Far End. If it is, the sequence is restarted.

2-WIRE END-TO-END OPERATION

To re-start the measurement, press SEQUENCE then SWEEP/RESTART on the transmitting end 4947A.

NOTE

It can take up to 2 minutes for the receiving end 4947A to notice that it has lost the signal and display SIG LOSS, *due to 107 timing.*

4-WIRE END-TO-END OPERATION

If there is an operator at each end and SIG LOSS is displayed on one of the 4947A's, then press SEQUENCE on both 4947A's to re-start.

If there is only one operator and SIG LOSS is displayed, the SEQUENCE can be re-started if the operator waits 2 minutes before pressing SEQUENCE. The 2 minute wait ensures that the other 4947A is ready to start a new SEQUENCE (i.e. it also is displaying SIG LOSS). It is always helpful to monitor the progress of the Far End 4947A, by using the audio monitor at the Near End receiver.

RE-STARTING SEQUENCE

If for some reason during **SEQUENCE** you want to re-start the measurement, press **MESSAGE CIRCUIT NOISE** to abort the measurement, wait 2 minutes then press **SEQUENCE** to re-start the measurement.

Sequence Results

	RECEIVER DISPLAY		
MEASUREMENT	**left hand**	**middle**	**right hand**
P/AR			P/AR UNITS
LEVEL/FREQ:			
NOISE WITH TONE (C-MESS)	level dBm	1004Hz	noise dBm
SIGNAL TO NOISE (C-MESS)	level dBm	1004Hz	signal/noise dB
ATTEN. DIST. (w.r.t. 1004Hz)	atten.dist.dB	404Hz	
	atten.dist.dB	2804Hz	
MESSAGE CIRCUIT NOISE:			
3kHz	noise dBrn		
C-MESS	noise dBrn		
INTERMOD DISTORTION:			
4 Tone	level dBm	2nd Order+noise dB 2nd	3rd Order+noise dB 3rd
2 Tone (noise correction)	n.ch.(noise check)	noise 2nd Band dB 2nd	noise 3rd Band dB 3rd
4 Tone (noise corrected)	level dBm	2nd Order dB 2nd CORR	3rd Order dB 3rd CORR
LEVEL/FREQ:	level dBm	1004Hz	
PHASE JITTER:			
20-300Hz	level dBm	phase jitter DEG	
4-300Hz	level dBm	phase jitter DEG	
TRANSIENTS -ALL SLOW	transient period Hrs		
	gain hits GHIT	phase hits ∮ HIT	dropouts DOUT
	impulse low ImpL	impulse medium ImpM	impulse high ImpH

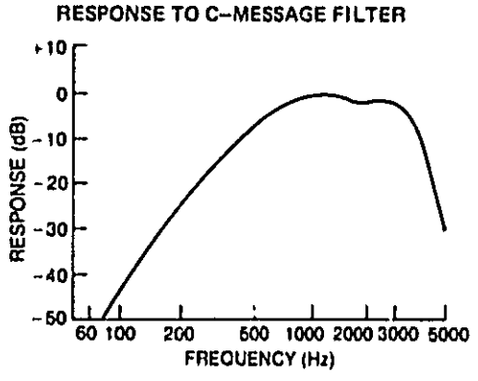
MESSAGE CIRCUIT NOISE ..... Principles

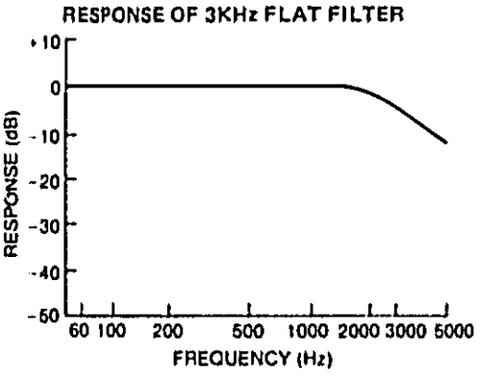
This measurement uses no test signal and quantifies background noise with a choice of band limiting filter (3kHz flat or C-message).

Weighting Filters

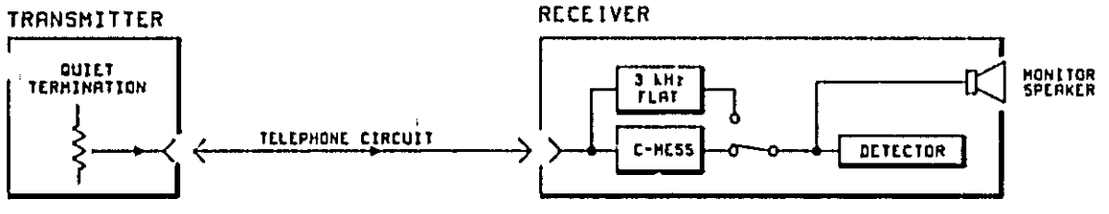
C-message: This filter measures noise signals that annoy the ordinary telephone user. However, it is also used to evaluate the effects of noise on voice-grade data circuits because its response is relatively flat over the frequency range used for data transmission.

3kHz flat: This filter attenuates much less at low frequencies (60Hz to 500Hz) than the C-message filter. By performing a 3kHz measurement after a C-message measurement, the effect of low frequency noise (60Hz commercial power, 20Hz ringing, etc) can be determined.





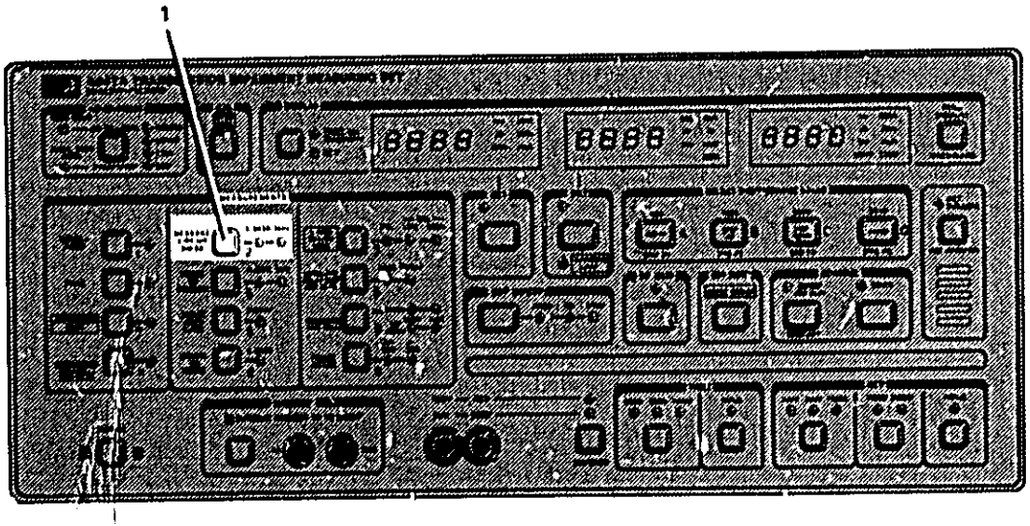
How it is Measured



1. At one end of the line, the transmitter provides a quiet termination of the appropriate impedance.

2. At the other end, the receiver measures the noise via a band limiting or weighting filter. Noise levels are displayed in dBrn (0dBrn = -90dBm). When the C-message filter is selected, the noise is weighted and the result is equivalent to dBrnC.

MESSAGE CIRCUIT NOISE ..... Instrument Operation



During this measurement the transmitter is off (quiet termination).

Receiver

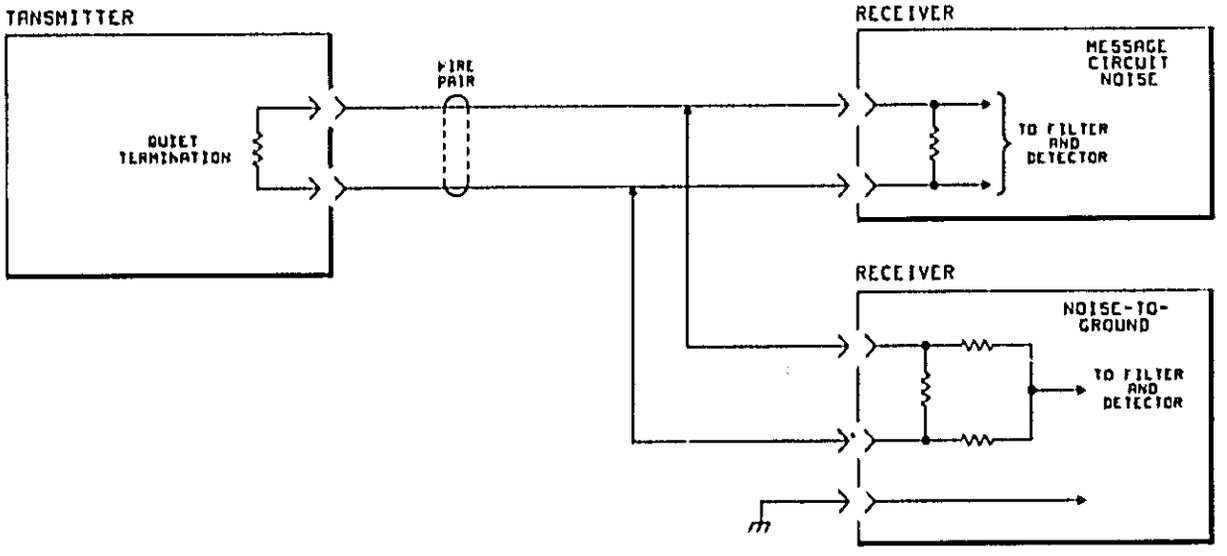
1. Use the MESSAGE CIRCUIT NOISE key to select the required filter.

   The 4947A automatically selects the RCV display mode. The noise level, in dBrn, is displayed in the left hand display. If the C-MESSage filter is selected the result is referred to as dBrnC.

NOISE TO GROUND . . . . . Principles

This measurement determines the longitudinal (common mode) noise present on a circuit (with reference to ground) and is a measure of the susceptibility of the circuit to electrical coupling from external sources. Often these are power-line related and so are best seen using the 3kHz flat filter.

Common mode noise can be converted to transverse noise in the circuit by line imbalance.

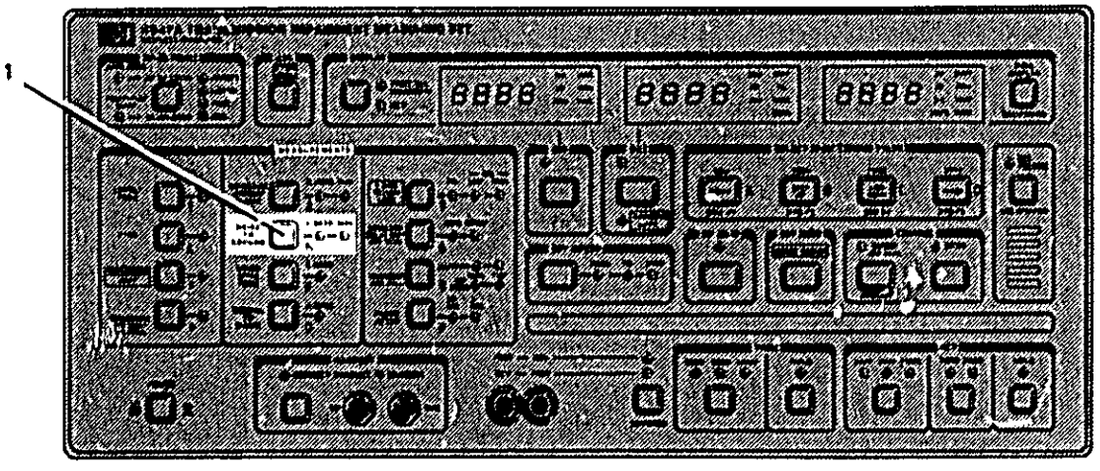


8

How It Is Measured

The measurement technique is similar to the message circuit noise measurement but the input configuration is different (the line pair is commoned up). The ground used as the signal reference is the sleeve of the test cord, which is also connected to the instrument chassis and the power line ground.

NOISE TO GROUND . . . . . Instrument Operation



During this measurement the transmitter is off (quiet termination).

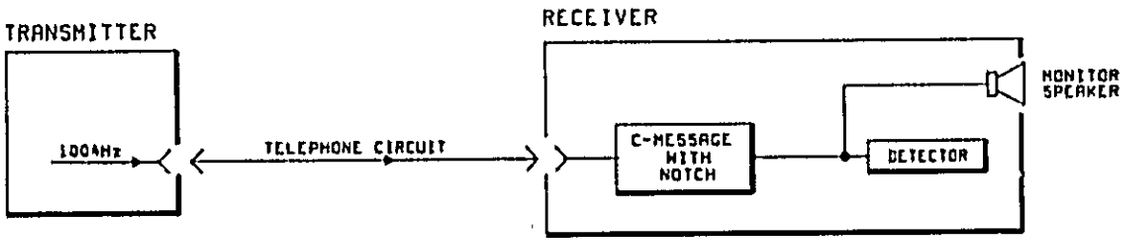
Receiver

1. Use the **NOISE TO GROUND** key to select the required filter.

   The 4947A automatically selects the RCV display mode. The noise level, in **dBrn**, is displayed in the left hand display. If the **C-MESSage** filter is selected the result is referred to as dBrnC.

NOISE WITH TONE (NOTCHED NOISE). . . . . Principles

This measurement quantifies total noise which includes background noise and noise generated only when a signal is present, such as when the circuit includes compandors and/or quantizers.



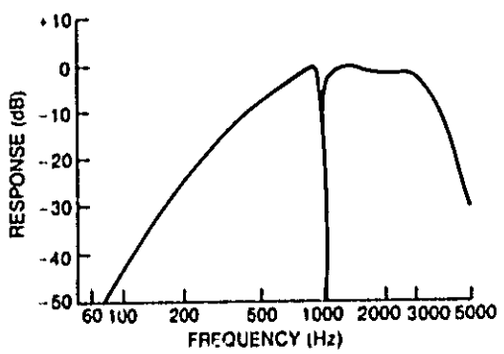
How It Is Measured

1. The transmitter sends a 1004Hz holding tone at the normal data level.

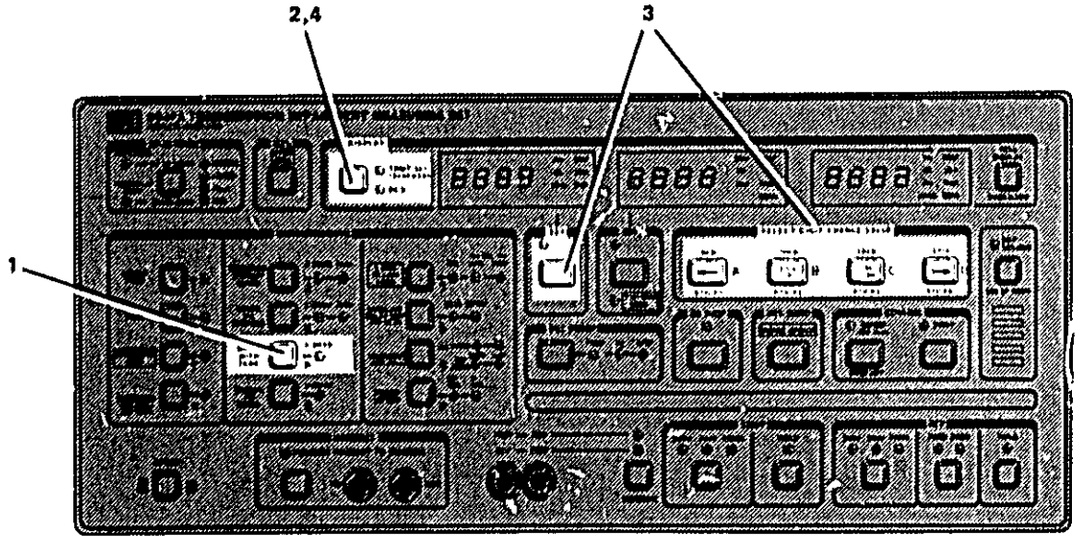
2. The receiver notches out the 1004Hz holding tone and what is left is measured via a weighting filter (3kHz or C-message). The received noise level is displayed in dBrn. (0dBrn = -90dBm). When the C-message filter is used, the noise is weighted and the result is equivalent to dBrnC.

   The notch attenuates all frequencies in the range 995Hz to 1025Hz by at least 50dB.

FREQUENCY RESPONSE - C-MESSAGE FILTER WITH 1004Hz NOTCH



NOISE WITH TONE (NOTCHED NOISE). . . . . Instrument Operation



1. Press NOISE WITH TONE. The C-MESSage led should be lit.

Transmitter

2. Display the transmitted level and frequency using the DISPLAY key. The TRMT led should be lit.

   Level, in dBm, is in the left hand display. The frequency in the middle display is fixed at 1004Hz.

3. Change the transmitted level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

Receiver

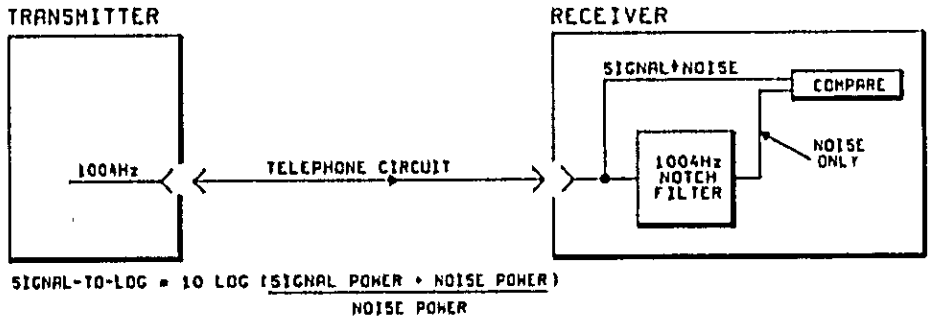
4. Display the received signal level, frequency and noise level using the DISPLAY key. The RCV led should be lit.

   left hand display . . . . . level in dBm
   middle display . . . . . frequency in Hz
   right hand display . . . . . noise level in dBrn

9

SIGNAL TO NOISE. . . . . Principles

The signal-to-noise measurement determines the ratio of received signal-plus-noise power to noise power and gives a measure of the margin between the data signal and the background noise.

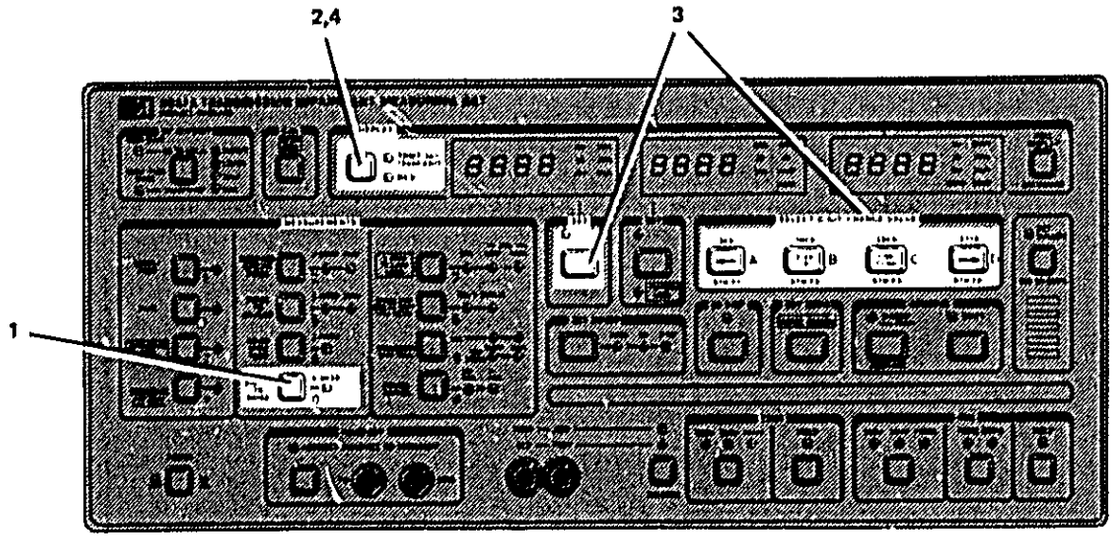


How It Is Measured

1. The transmitter sends a 1004Hz holding tone at the normal data level.

2. The receiver notches out the 1004Hz holding tone and what is left is measured via a C-message filter then compared with the original signal-plus-noise signal. The computed ratio is displayed in dB.

SIGNAL TO NOISE. . . . . Instrument Operation



1. Press SIGNAL TO NOISE.

Transmitter

2. Display the transmitted level and frequency using the DISPLAY key. The TRMT led should be lit.

   Level, in dBm, is in the left hand display. The frequency in the middle display is fixed at 1004Hz.

3. Change the transmitted level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys. This measurement is usually performed at -13dBm0. Check the TLP where you are and set the 4947A level to (-13+TLP) dBm.

Receiver

4. Display the received level, frequency and signal/noise ratio using the DISPLAY key. The RCV led should be lit.

   left hand display . . . . . level in dBm
   middle display . . . . . frequency in Hz
   right hand display . . . . . signal/noise ratio in dB

NOTE

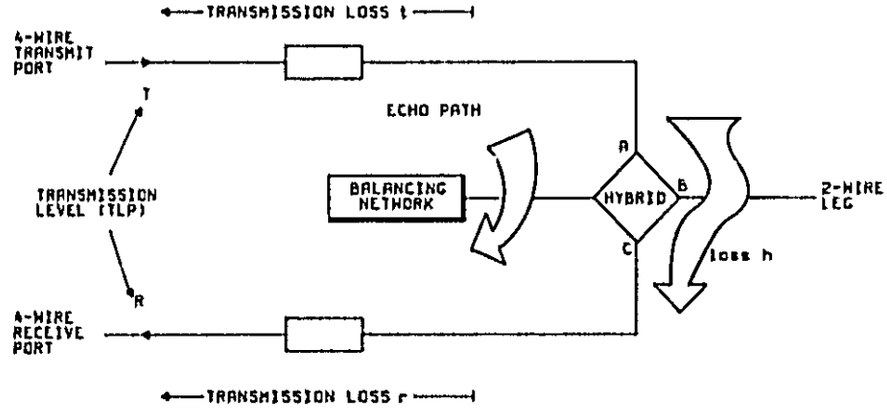
If the received holding tone frequency falls outside the range 994 to 1026Hz, no result will be displayed.

4-WIRE RETURN LOSS . . . . . Principles

The telephone network consists of a mixture of 2-wire and 4-wire circuits with the bulk of local and toll traffic carried on 2-wire circuits. Conversion between the two types of circuit occurs at the junction between the toll and inter-toll networks and also at points within the 2-wire network where, for example, amplification is carried out. The device used to convert a two-way path into separate transmit and receive paths is a hybrid.

Hybrids can cause problems. For example, echoes will occur in a 4-wire telephone circuit if some of the signal power transmitted into the hybrid gets reflected into the receive path due to hybrid imperfections or poor matching of the 2-wire leg. The "echo path" is shown in the diagram below.

The 4-wire return loss measurement checks out the characteristics of a hybrid. The measurement is made from the 4-wire side of the hybrid and, depending on the frequency spectrum of the test stimulus, measures the potential of the hybrid to cause echoes or send a transmission circuit into oscillation.



NOTE

The loss h is the sum of the return loss of the 2-wire leg and the losses in the hybrid paths A to B and B to C. If the 2-wire leg is shorted out, its return loss is zero and h becomes h0, the loss in the path A to B to C.

Definitions

1. **4-wire Return Loss (general definition):** The ratio in dB of the power transmitted into the transmit port of a 4-wire transmission circuit to the power returned from the receive port. This is corrected for different circuit losses depending on which of the measurement definitions, 2, 3 or 5 given below, is applied.

2. **Echo Path Loss (EPL):** This is the loss experienced by an echo and is simply the 4-wire return loss with no compensation for circuit losses.

$$EPL = t + h + r$$

3. **Equal Level Echo Path Loss (ELEPL):** This is EPL corrected for the difference in transmission levels between the transmit and receive ports. ELEPL is therefore independent of the point of measurement.

$$ELEPL = EPL - T + R$$

4. **Transhybrid Loss:** This is found by shorting out the 2-wire side of the hybrid and measuring the 4-wire return loss. It therefore includes the transmission losses of the 4-wire legs and the loss h in the presence of a total mismatch at the 2-wire port.

$$THL = t + r + h0$$

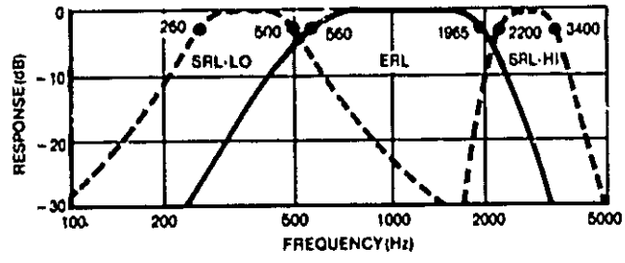
5. **4-wire Return Loss corrected for Transhybrid Loss:** If the directly measured 4-wire return loss (with the 2-wire leg in its normal state) is corrected for THL, the value obtained is the return loss on the 2-wire side.

How It Is Measured

1. The transmitter sends band-limited white noise. A choice of bandpass filter shapes the noise to test different aspects of the hybrid. (ERL characterizes the hybrid from an echo standpoint; SRL-lo and SRL-hi determine the hybrid's tendency to cause oscillations - frequencies at the extremes of the channel bandwidth are more likely to cause singing.)

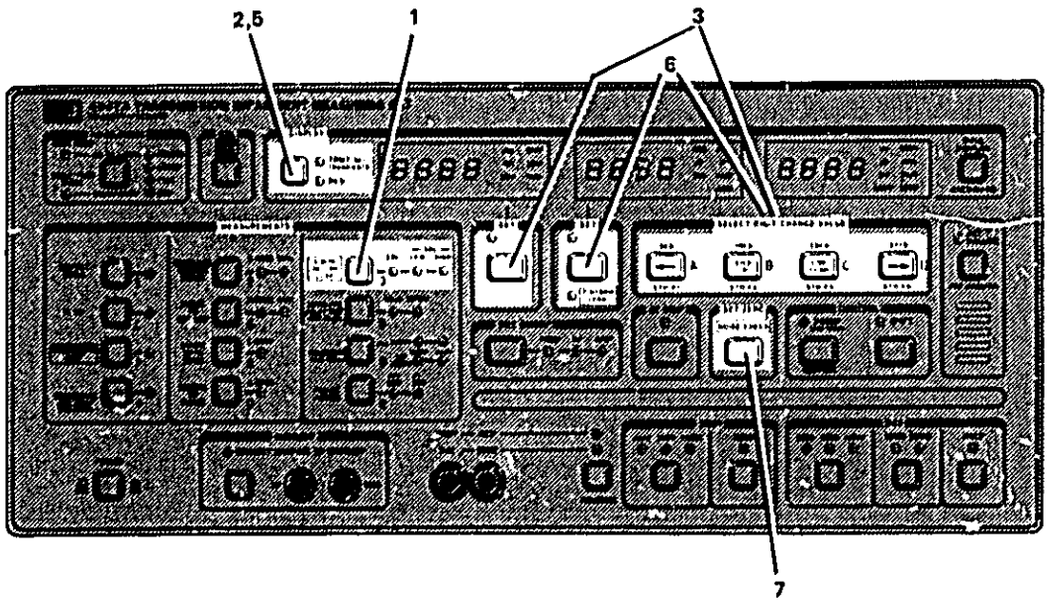
2. The receiver compares the signal level sent into the hybrid with the level returned from the hybrid and automatically rolls into the result any corrections entered in or measured by the operator.

- If no correction is entered, the result is EPL.
- If a correction is entered beforehand for the difference in transmission levels, the result is ELEPL.
- If a correction is made for transhybrid loss (entered beforehand or measured as part of the return loss measurement), the result is 4-wire return loss as in definition 5 above.



Return Loss Noise Bandwidths

4-WIRE RETURN LOSS . . . . . Instrument Operation



1. Use the **4-HIRE RETURN LOSS** key to select **ERL** (echo return loss) or **SRL** (singing return loss) **LOW** or **HIGH**. The corresponding led shou'd be lit.

Transmitter

2. Display the transmitted level using the **DISPLAY** key. The **TRHT** led should be lit.

   Level, in **dBm**, is in the left hand display.

3. Change the transmittcd level using the **SET** key for the left hand display and the **SELECT DIGIT/CHANGE VALUE** keys.

4. Correct for Transhybrid loss if desired (see steps 6 and 7).

Receiver

5. Display the return loss result using the **DISPLAY** key. The **RCV** led should be lit.

   left hand display. . . . . return loss in **dB**
   middle display . . . . . transhybrid loss in **dB** (if entered using steps 6 and 7)

TRANSHYBRID LOSS CORRECTION

The 4947A will correct the result for THL (transhybrid loss) of the circuit under test if the THL value is entered in the middle display (this display contains the value zero when 4-WIRE RETURN LOSS is first selected).

Alternatively, the expected overall channel loss can be entered in the transhybrid loss display (Tx TLP - Rx TLP), so that the result is compensated only for channel TLP's and not transhybrid loss. The result obtained is then known as Equal Level Echo Path Loss (ELEPL). The procedure for setting overall channel loss is the same as that for setting transhybrid loss in step 6 below.

6. If you know the THL value, use the T/HYBRID LOSS key and the SELECT DIGIT/CHANGE VALUE keys to enter the value into the middle display.

7. If the THL value is unknown, do the following:

   - Short-circuit the 2-wire side of the hybrid (see Page 2-36 for more details). The return loss result displayed under these conditions equals the THL.
   - Press SET ZERO to transfer the THL value in dB to the middle display.
   - Remove the short circuit from the hybrid. The true return loss is now shown in the left hand display.

NOTE

Further return loss measurements can now be performed without losing the THL value as long as no other measurement is selected. The THL correction may be removed or changed by using the SET *key for the middle display and the* STEP UP *and* STEP DOWN *keys.*

ENVELOPE DELAY DISTORTION (EDD)..... Principles

Most channels, being imperfect, have a non-linear phase shift vs frequency characteristic which can affect data transmission. However, measurement of phase shift over a transmission link is not practical because a phase reference is difficult to establish at the receive end. Envelope delay is measured instead because it has a theoretical relationship to phase shift and is convenient to measure end-to-end over a link.

Definitions

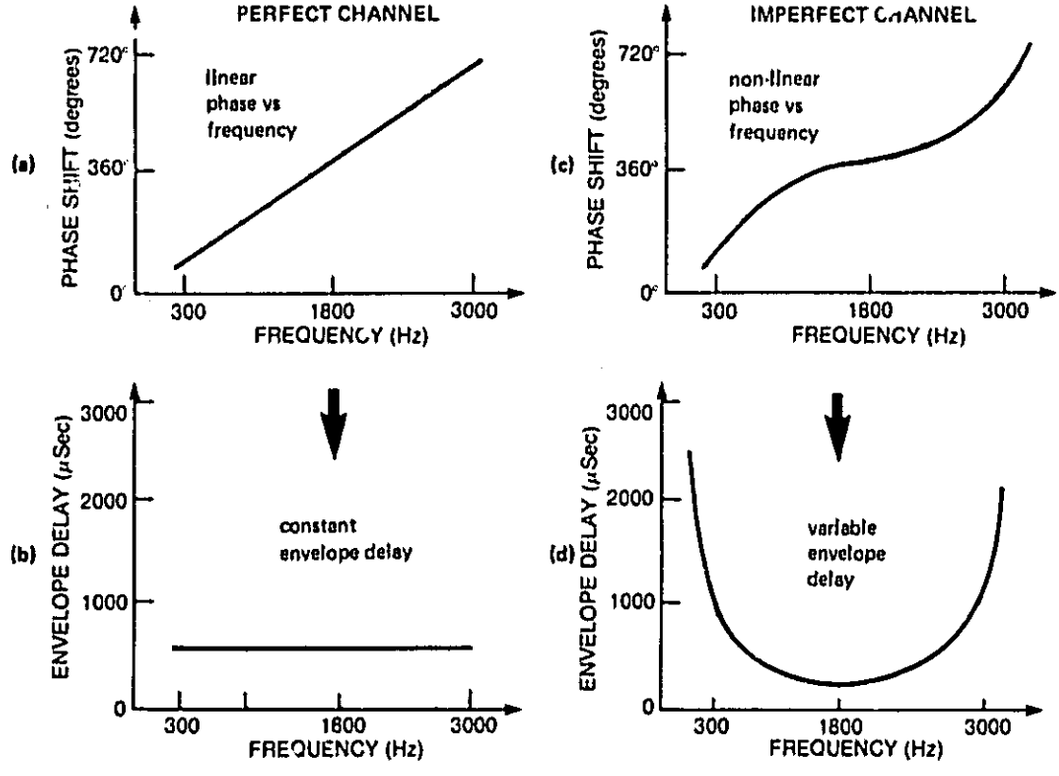
1. Envelope delay closely approximates the slope of the phase versus frequency curve of a channel at a particular frequency and is measured using an amplitude-modulated signal. The modulating sinewave is much lower in frequency than the carrier so that the upper and lower sidebands lie very close in to the carrier.

2. Envelope delay distortion is the variation in envelope delay when the carrier frequency is swept over the channel bandwidth. It is usually measured relative to the delay at a reference frequency of 1804Hz. (Frequencies around 1800Hz normally give minimum delay.)

How Envelope Delay and Phase Shift affect Datacom

The perfect channel (fig a) exhibits a linear phase/frequency relationship, i.e. the delay is constant for all frequencies (fig b). This means (assuming no other distortion) that a modem signal would arrive at the far end of a channel delayed but with the shape preserved.

On the other hand, a channel with a non-linear phase characteristic (fig c) distorts the shape as well as delaying the modem signal. The envelope delay characteristic of fig d maps to the phase characteristic of fig c.



How It Is Measured

Loopback: This mode is the simplest, requires only one TIMS and measures the delay characteristics of the combined go and return paths.

1. The transmitter sends 1804Hz amplitude modulated with 83-1/3Hz. The delay of the envelope at this frequency is stored as the reference delay.

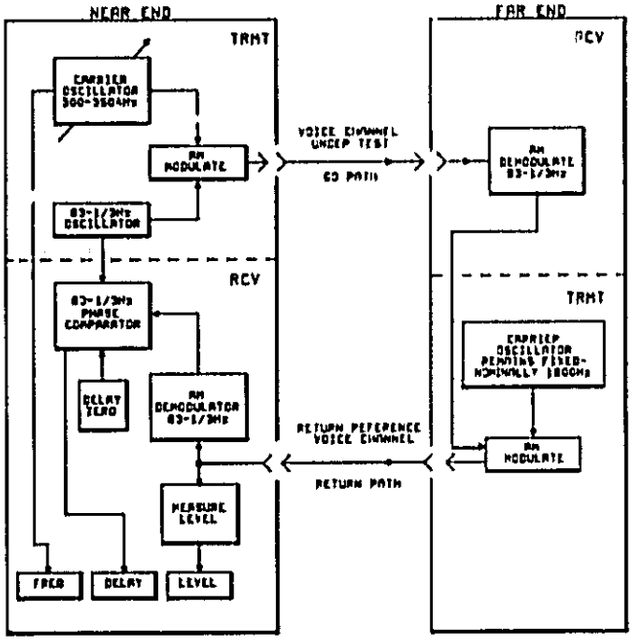
2. The transmitter sweeps the carrier frequency typically between 504 and 2804Hz. At each frequency, the receiver compares the envelope delay at that frequency with the envelope delay at the reference frequency.

Return Reference Mode: This mode measures the envelope delay from the near end (where the TIMS is set for measurement mode) to the far end (where the TIMS is set for repeat mode).

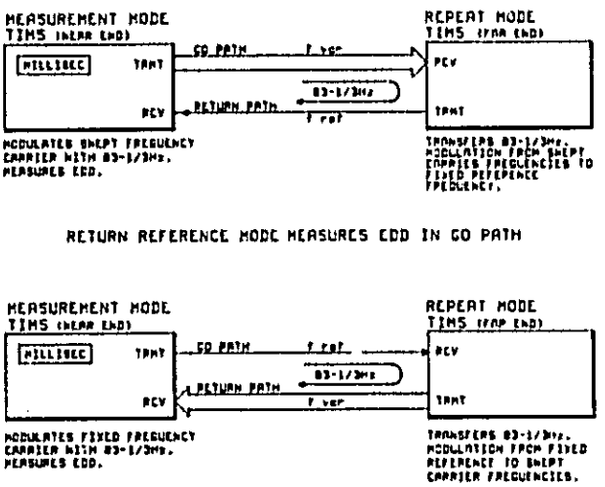
1. The measurement mode TIMS sends 1804Hz which the repeat mode TIMS demodulates. This 83-1/3Hz modulation is then impressed onto a fixed frequency carrier (actually 1804Hz) and sent back to the measurement mode TIMS. Here, the round trip delay of the 1804Hz envelope is stored as the reference delay.

2. The measurement mode TIMS sweeps the carrier frequency typically between 504Hz and 2804Hz. The 83-1/3Hz modulation is automatically stripped off the carrier frequencies by the repeat mode TIMS which returns it to the measurement mode TIMS via the 1804Hz fixed frequency carrier. The return trip delay is thus always constant. To obtain the relative delay, the measurement mode TIMS compares the phase of the received modulation with the phase of the transmit modulator to get the overall delay then subtracts out the reference delay.

Forward Reference Mode: This mode measures the envelope delay from the far end to the near end. The setup is similar to the return reference mode but this time the measurement mode TIMS sends the fixed frequency and the repeat mode TIMS sweeps the carrier frequencies.



ENVELOPE DELAY MEASUREMENT - BLOCK DIAGRAM
(Return Reference Shown)

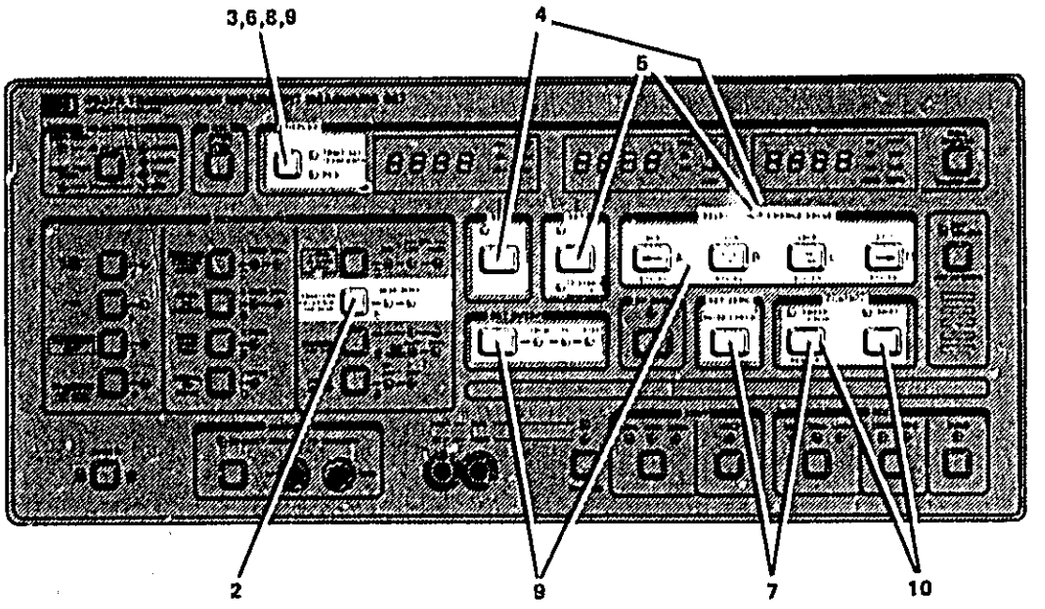


RETURN REFERENCE MODE MEASURES EDD IN GO PATH

FORWARD REFERENCE MODE MEASURES EDD IN RETURN PATH

12

EDD (Loopback) . . . . . Instrument Operation



1. Set the rear panel SWEEP switch to FAST. (When testing channels where long propagation delays are expected, use the ND network delay command over HP-IB to match the channel delay).

2. Use the ENVELOPE DELAY DISTortion key to select the MEAS mode.

Transmitter

3. Display the transmitted level and frequency using the DISPLAY key. The TRMT led should be lit.

   left hand display . . . . . level in dBm
   middle display . . . . . reference frequency in Hz
   right hand display . . . . . measurement rate FASt

   When the test circuit is connected, the right hand display displays FASt followed by the measurement result.

4. Change the transmitted level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

REFERENCE FREQUENCY

5. The reference frequency is 1804Hz when ENVELOPE DELAY DISTortion is first selected (from switch-on), to change it use the SET key for the middle display and the SELECT DIGIT/CHANGE VALUE keys.

Receiver

6. Display the received signal using the DISPLAY key. The RCV led should be lit.

left hand display	level in dBm
middle display	reference frequency in Hz
right hand display	the difference between the current delay and the previous delay measurement at the reference frequency and should be 0.00ms when the circuit has settled.

7. If you are making SINGLE FREQUENCY measurements you store the reference frequency delay by pressing SET ZERO, all subsequent readings are with respect to this stored value.

   SET ZERO also stores the current level; all subsequent readings are relative to the stored value. The display units change to dB.

left hand display	0.0dB
middle display	reference frequency in Hz
right hand display	0.00ms CORR (corrected)

   If you are making a SWEPT FREQUENCY measurement you can use SET ZERO as above to store both the reference frequency delay and level or you can store the reference frequency delay only, when you start the sweep using the SWEEP/RESTART key.

Transmitter

SINGLE FREQUENCY

8. Change the transmitted frequency over the band of interest, using the SET key for the middle display and the SELECT DIGIT/CHANGE VALUE keys.

   The right hand display momentarily displays FASt then the received ELD reading (in ms CORR) for each frequency.

   Select the RCV mode, if both the received level and delay results are required.

SWEPT FREQUENCY

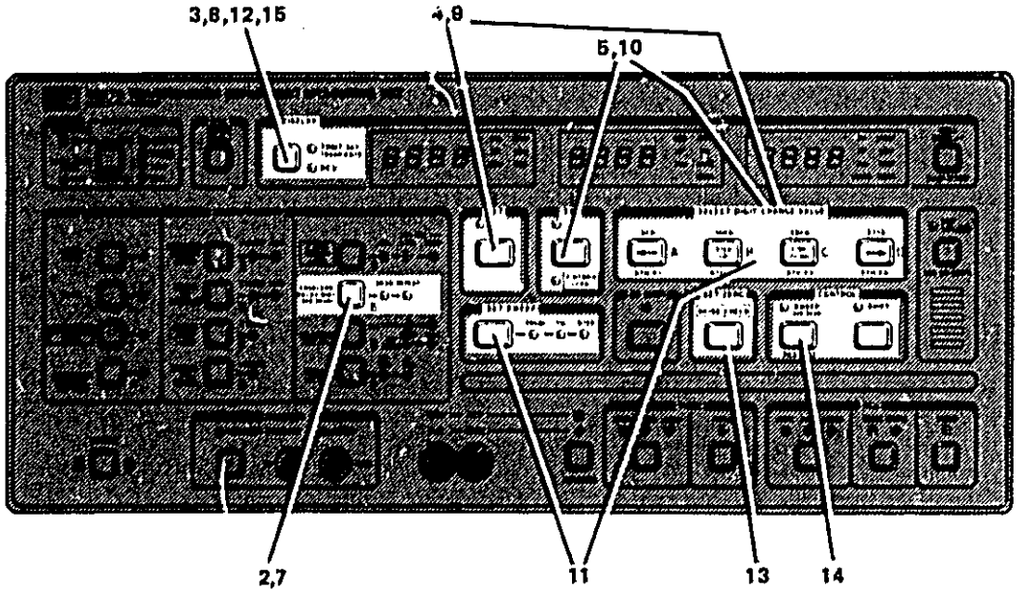
9. Set the sweep limits using the SET SWEEP and SELECT DIGIT/CHANGE VALUE keys.

from frequency	FROM
to frequency	TO
incremental step	STEP

10. Start the sweep by pressing SHIFT then SWEEP/RESTART. The reference frequency delay is stored automatically prior to the 4947A starting the sweep.

    The right hand display momentarily displays FASt then displays each ENVELOPE DELAY DISTORTION reading across the swept range. Select the RCV mode, if both the received level and delay are required.

EDD (Return Reference Mode) . . . . . Instrument Operation



This is an end-to-end measurement in the NEAR to FAR direction (go path). Two 4947A's (NEAR END and FAR END) are required for this measurement. Results can be read from the display or printed.

1. Set up the FAR END 4947A first.

Far End 4947A Transmitter

2. Use the ENVELOPE DELAY DISTortion key to select REPEAT.

3. Display the level and frequency of the fixed carrier signal to be transmitted to the NEAR END 4947A using the DISPLAY key. The TRMT led should be lit.

   left hand display . . . . . level in dBm
   middle display . . . . . frequency in Hz

4. Change the level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

5. The frequency displayed is 1804Hz when ENVELOPE DELAY DISTortion is is first selected (from switch-on): to change it use the SET key for the middle display and the SELECT DIGIT/CHANGE VALUE keys.

Near End 4947A Transmitter

6. Select the measurement sweep rate you want, FAST or SLOW, using the rear panel SWEEP switch.

NOTE

It is possible that large changes in level may occur as the frequency is swept over the channel bandwidth. To obtain accurate results under these conditions, you must allow time for the REPEAT *mode 4947A and the line to settle between measurement points. To do this use* SLOW *sweep or change the frequency manually.*

7. Use the ENVELOPE DELAY DISTortion key to slect MEAS.

8. Display the transmitted level and frequency using the DISPLAY key. The TRMT led should be lit.

left hand display	level in dBm
middle display	reference frequency in Hz
right hand display	measurement rate FAST or SLo

9. Change the transmitted level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

REFERENCE FREQUENCY

10. The reference frequency is 1804Hz when EDD is first selected (from switch-on), to change it use the SET key for the middle display and the SELECT DIGIT/CHANGE VALUE keys. (If you change the reference frequency, it should match the value set in step 5.)

SWEEP LIMITS

11. Set the sweep limits using the SET SWEEP keys and SELECT DIGIT/CHANGE VALUE keys.

start frequency	FROM
stop frequency	TO
incremental step	STEP

After setting the sweep limits, re-display the reference frequency using the SET SWEEP key (all SET SWEEP leds extinguished).

Near End 4947A Receiver

12. Display the received signal from the FAR END 4947A using the DISPLAY key. The RCV led should be lit.

left hand display	level in dBm
middle display	reference frequency in Hz
right hand display	the difference between the current delay and the previous delay measurement at the reference frequency and should be 0.00ms.

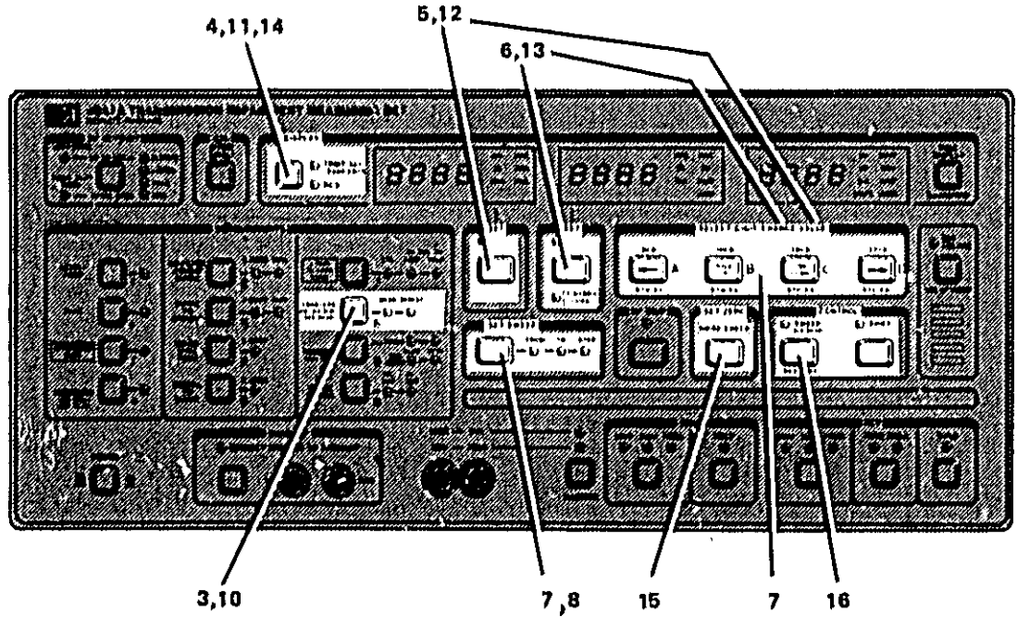
13. If you want to reference all subsequent level readings to the level of the reference signal (1804Hz), press SET ZERO (reading in dB).

14. Start the sweep by pressing SWEEP/RESTART.

    If you are making a SWEPT FREQUENCY measurement you can use SET ZERO as in step 13 to store both the reference frequency delay and level, or you can store the reference frequency delay only, when you start the sweep using the SWEEP/RESTART key.

15. You can obtain results using a printer or you can read received ENVELOPE DELAY DISTORTION against frequency directly on the 4947A when its DISPLAY mode is set to TRMT.

EDD (Forward Reference Mode)..... Instrument Operation



This is an end-to-end measurement in the FAR to NEAR direction (return path). Two 4947A's (NEAR END and FAR END) are required for this measurement.

1. Set up the FAR END 4947A first.

Far End 4947A Transmitter

2. Set the measurement rate to SLOW using the rear panel SWEEP switch.

3. Use the ENVELOPE DELAY DISTortion key to select REPEAT.

4. Display the signal being transmitted to the NEAR END 4947A using the DISPLAY key. The TRMT led should be lit.

   left hand display . . . . . level in dBm
   middle display . . . . . frequency in Hz

5. Change the transmitted level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

6. The reference frequency is 1804Hz when ENVELOPE DELAY DISTortion is first selected (from switch-on), to change it use the SET key for the middle display and the SELECT DIGIT/CHANGE VALUE keys.

12

7. Set the sweep limits using the SET SWEEP and SELECT DIGIT/CHANGE VALUE keys.

start frequency	FROM
stop frequency	TO
incremental step	STEP

8. After setting the sweep limits, re-display the reference frequency by using SET SWEEP (no SET SWEEP leds lit).

Near End 4947A Transmitter

9. Set the measurement rate to FAST using the rear panel SWEEP switch.

10. Use the ENVELOPE DELAY DISTortion key to select MEAS.

11. Display the transmitted level and frequency using the DISPLAY key. The TRMT led should be lit.

left hand display	level in dBm
middle display	reference frequency in Hz
right hand display	before the ports are connected FAST is displayed.

12. Change the transmitted level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

13. The transmitted frequency is 1804Hz when ENVELOPE DELAY DISTortion is first selected (from switch-on), to change it use the SET key for the middle display and the SELECT DIGIT/CHANGE VALUE keys. (If you change the reference frequency, it should match the value in step 6.)

Near End 4947A Receiver

14. Display the received signal from the FAR END 4947A using the DISPLAY key. The RCV led will light.

left hand display	level in dBm
middle display	frequency in Hz
right hand display	0.00ms (the difference between the current and previous delay measurements)

15. Store the delay of the current reference signal received from the FAR END 4947A by pressing SET ZERO. All subsequent readings are relative to the stored value.

SET ZERO also stores the currently received level, all subsequent readings are relative to the stored value. The displays are as follows:

left hand display	level in dB
middle display	frequency in Hz
right hand display	0.00ms CORR (corrected)

Far End 4947A Transmitter

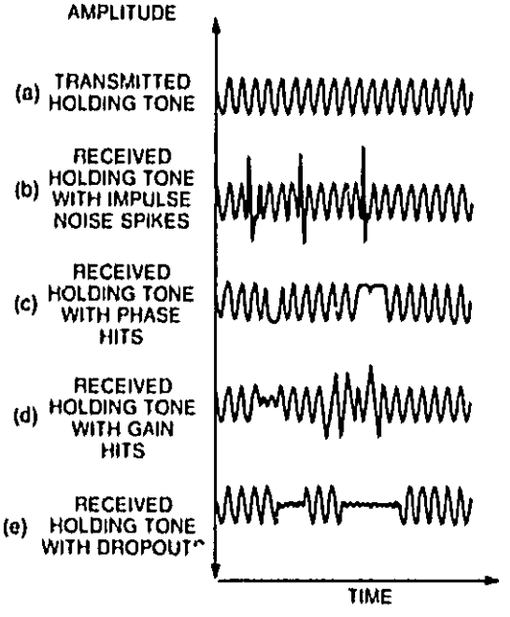
16. Start the FAR END 4947A sweep, by pressing SHEEP/RESTART.

17. The received frequency and relative delay are displayed on the NEAR END 4947A.

TRANSIENTS . . . . . Principles

Transients can cause data errors and, sometimes, interruptions to data communication. With holding tone present, the 4947A simultaneously counts phase and gain hits, dropouts and impulse noise. With no holding tone present, the 4947A measures impulse noise only.

For all transient measurements, the count rate is selectable (8 or 100 counts/sec) and so is the counting period (1 to 599 minutes or continuous).



Phase Hits

A phase hit is a sudden changes in the phase of the received test tone, often caused by automatic switching to standby facilities. To qualify as a hit, the phase change must exceed the threshold for more than 4ms.

Gain Hits

A gain hit is a sudden change (increase or decrease) in the level of the received test tone, again often caused by facility switching. To qualify as a gain hit the level change must exceed a selected threshold for more than 4ms.

Dropouts

A dropout is a gain hit with a drop in level of more than 12dB, ie the drop is large enough to be deemed a loss in signal causing most modems to retrain. Counting of impulses and hits is inhibited until 1 second after the end of a dropout.

Impulse Noise

Impulse noise includes noise spikes like the clicks and pops we often hear when we use the telephone. The spikes are much higher in level than the background noise and, generally, last less than one millisecond. They are often caused by signaling relays in central offices.

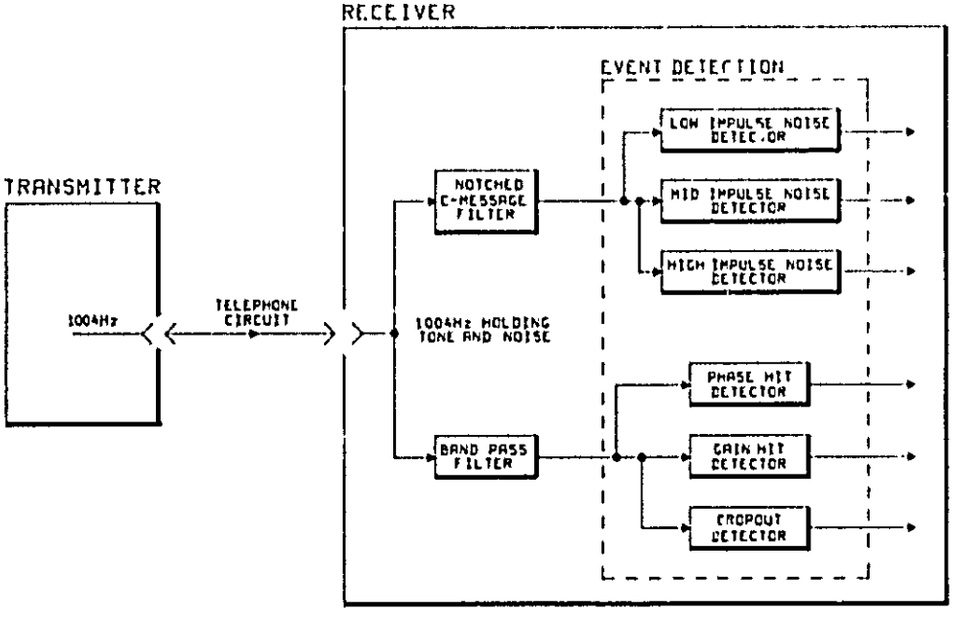
The impulse noise measurement counts the number of noise spikes against 3 threshold levels simultaneously. The low level threshold is selectable; the medium and high thresholds are fixed at 4 and 8dB, respectively, above the low threshold.

How transients are Measured

1. The transmitter sends a 1004Hz holding tone at the normal data level.

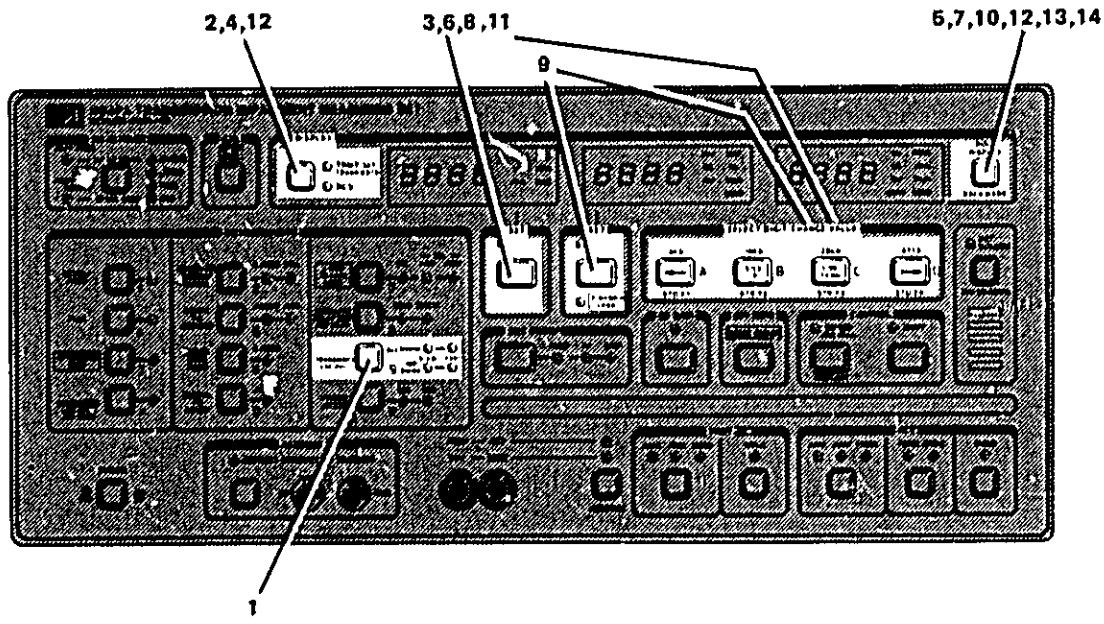
2. To detect impulses, the receiver notches out the holding tone using a notched C-message filter and presents what is left to the threshold detectors. Each threshold detector has its own individual counter which, after registering a count, is blocked from counting another for a fixed period (10 ms if FAST count rate is selected, 125 ms if SLOW count rate is selected). The counters function independently of each other which, in some situations, produces unexpected results. For example, a large impulse following on the heels of a small impulse might get registered by the high and mid counters only - because the low counter could still be blocked following the detection of the small impulse.

3. For the other transients, the receiver uses a bandpass filter to minimise the effects of single frequency interference and noise. Separate circuits detect hit and dropout events by comparing the input signal against threshold limits. An output from the dropout detector is used to lockout the other detectors.



middle display . . . . . transhybrid loss in dB (if entered using steps 6 and 7)

TRANSIENTS . . . . . Instrument Operation



In the TRANSIENTS ALL mode the 4947A measures GAIN HITS, PHASE HITS, DROPOUTS and IMPULSE NOISE in the presence of a Holding Tone. To measure IMPULSE NOISE only (without a holding tone) see Page 2-56.

1. Set the transient counting rate using the TRANSIENT key. Select ALL SLOW for 8 counts per second or ALL FAST for 100 counts per second.

Setting the Holding Tone Level

2. Display the transmitted holding tone level and frequency using the DISPLAY key. The TRMT led should be lit.

   Level, in dBm, is in the left hand display. The frequency in the middle display is fixed at 1004Hz.

3. Change the transmitted level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

Setting Transient Thresholds

4. Set the transient thresholds on the 4947A making the measurement, by first using the DISPLAY key to select the SET TRANSIENT mode (led will be lit).

5. Display measurement period, in hrs (hours), in the left hand display using the ROLL DISPLAY key. The display indicates H-MM, where H is hours and MM are minutes, or Cont (for continuous).

6. Change the measurement period using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

7. Display the gain hits, phase hits and dropout thresholds using the ROLL DISPLAY key.

left hand display . . . . . gain hits in dB GHIT
middle display . . . . . phase hits in DEG ØHIT
right hand display . . . . . dropouts in dB LOUT

8. Change the gain hits threshold (2,3,4 or 6dB) using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

9. Change the phase hits threshold (5 to 40 DEG in 5 DEG steps) using the SET key for the middle display and the SELECT DIGIT/CHANGE VALUE keys.

NOTE

The dropouts threshold is fixed at -12dB.

10. Display the impulse threshold by pressing ROLL DISPLAY again.

11. Change the "low" impulse threshold using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

The "low" impulse threshold is in dBrn. The middle and high thresholds are automatically set to 4dB and 8dB above the "low" threshold.

NOTE

To maintain measurement accuracy, the impulse "low" threshold should be no more than 25dB below the holding tone level and no more than 10dB above the holding tone level. If the above limits are exceeded Err 4 *may be displayed.*

Measuring Transients

NOTE

A new measurement starts each time a parameter is changed or when SHEEP/RESTART *is pressed on the receiving 4947A.*

12. Display the elapsed time using the DISPLAY and ROLL DISPLAY key. The RCV led should be lit.

The elapsed time is shown in the left hand display. The flashing dot in the right hand display indicates that the measurement is in progress.

13. Display the interim transient results using the ROLL DISPLAY key. Two sets of results appear in the displays in turn. They are:

Counts of gain hits, phase hits and dropouts.
Counts of impulses crossing low, medium and high thresholds.
The initial, received level and frequency are also held in the 3rd display.

NOTE

The dropout counts indicate how often the holding tone is lost during the measurement.

End is displayed when the measurement period is complete. The receiver stops measuring, but the transmitter continues to send its holding tone.

14. Press the ROLL DISPLAY key to view the results.

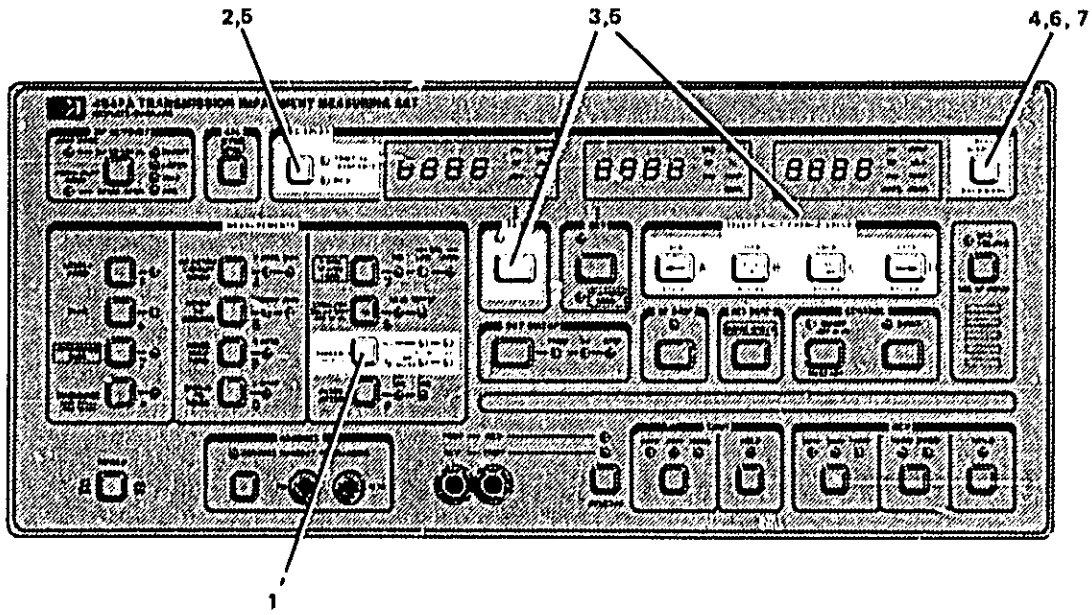
IMPULSE NOISE. . . . . Principles

Impulse Noise

Impulse noise includes noise spikes like the clicks and pops we often hear when we use the telephone. The spikes are much higher in level than the background noise and, generally, last less than one millisecond. They are often caused by signaling relays in central offices.

The impulse noise measurement counts the number of noise spikes against 3 threshold levels simultaneously. The low level threshold is selectable; the medium and high thresholds are fixed at 4 and 8dB, respectively, above the low threshold.

IMPULSE NOISE. . . . . Instrument Operation



The following procedure allows you to measure impulse noise without a holding tone. The transmitter is off during this measurement (quiet termination). The presence of a holding tone of up to 25dB above the lowest threshold will not affect this measurement.

1. Set the impulse noise counting rate using the **TRANSIENT** key. Select **IMP NOISE SLOW** for 8 counts per second or **IMP NOISE FAST** for 100 counts per second.

NOTE

The transmitter is idle in this measurement.

Setting Impulse Thresholds

2. Display the impulse noise measurement period using the **DISPLAY** key. The **SET TRANSIENTS** led should be lit.

   The display indicates H-MM, where H is in hours and MM are in minutes, or **Cont** (for continuous).

3. Change the measurement period using the **SET** key for the left hand display and the **SELECT DIGIT/CHANGE VALUE** keys.

4. Display the impulse thresholds using the **ROLL DISPLAY** key.

   The "low" threshold, in **dBrn**, is in the left hand display.

5. Change the "low" threshold using the **SET** key for the left hand display and the **SELECT**

DIGIT/CHANGE VALUE keys.

The "middle" and "high" impulse thresholds are automatically set to 4dB and 8dB above the "low" threshold.

left hand display . . . . . low threshold dBrn ImpL
middle display . . . . . middle threshold ImpM
right hand display . . . . . high threshold ImpH

NOTE

If a holding tone exists on the line:
To maintain measurement accuracy, the impulse "low" threshold should be no more than 25dB below the holding tone level. If the above limit is exceeded Err 4 *may be displayed.*

Measuring Impulse Noise

NOTE

A new measurement is started each time a parameter is changed or when SHEEP/RESTART *is pressed.*

6. Display the impulse measurement elapsed time using the DISPLAY and ROLL DISPLAY keys. The RCV led should be lit.

   The time, in Hrs, is displayed in the left hand display. The flashing dot in the right hand display indicates that the measurement is in progress.

7. Display the impulse noise results using the ROLL DISPLAY key.

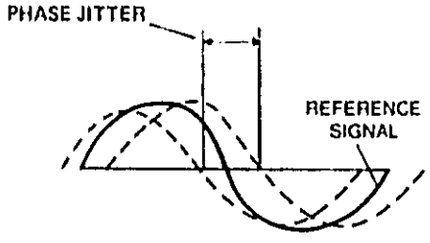
   left hand display . . . . . ImpL
   middle display . . . . . ImpM
   right hand dispiay . . . . . ImpH or End

When the measurement period is complete End is displayed and the receiver stops measuring.

PHASE JITTER ..... Principles

Incidental phase modulation has an insignificant effect on voice transmission but can seriously affect high speed data transmission especially if the modem uses phase modulation to encode data. The power of the unwanted modulation sidebands is difficult to measure directly so peak-to-peak phase jitter is measured instead. Unfortunately, phase jitter measurements are affected by noise in the channel so the signal-to-noise ratio is usually checked at the same time.

Jitter frequencies are usually below 300Hz. Phase jitter is typically caused by the ripple of dc power supply of the master oscillator of long haul carriers. Some phase jitter can also occur in short haul systems from incomplete filtering of image sidebands. The most commonly found frequency components of phase jitter are 20Hz (ringing current), 60Hz (commercial power) and the harmonics of these. The measurement bandwidths are chosen to cover the major sources of jitter while rejecting uncorrelated noise.

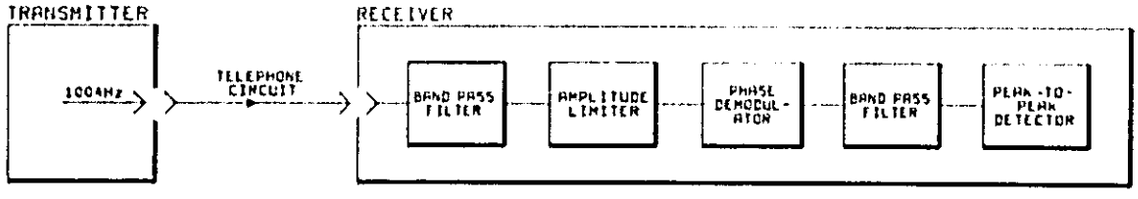


How it is Measured

1. The transmitter sends a 1004Hz holding tone at the normal data level.

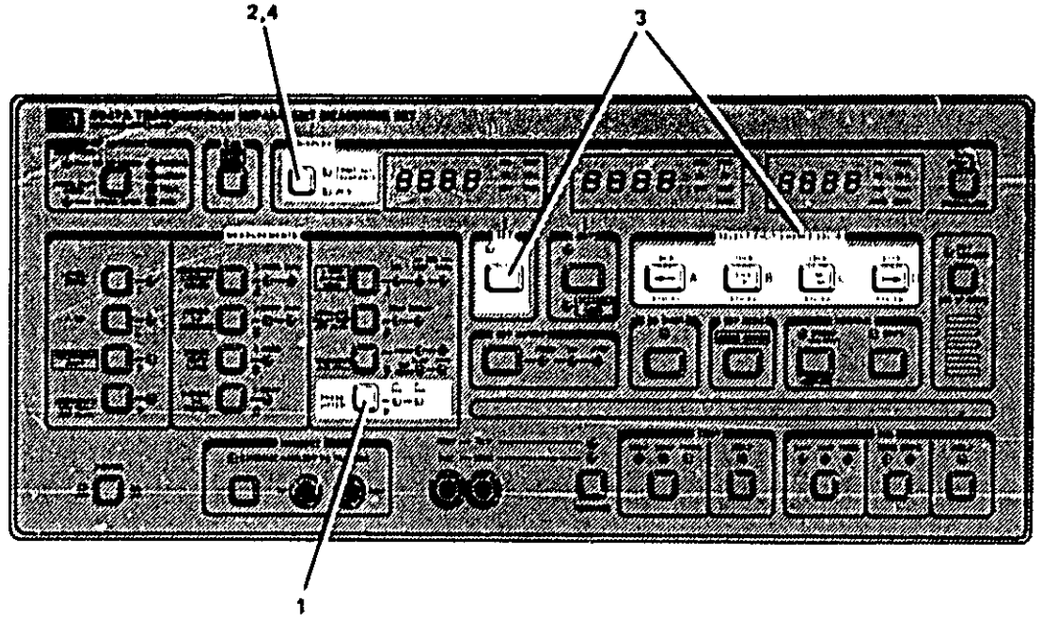
2. The receiver performs the phase jitter measurement in five stages:

   - **Band-pass Filtering (400 to 1500Hz):** This chops the measurement bandwidth to about one-fourth to reduce the effect of noise and other interference on the jitter measurement.
   - **Amplitude Limiting:** This produces a constant amplitude signal and thereby removes amplitude jitter.
   - **Phase demodulation:** This produces an error signal in response to phase changes.
   - **Band Pass Filtering:** This selects frequencies between 20 and 300Hz or between 4 and 300Hz.
   - **Measurement:** This measures and displays the peak-to-peak value of demodulated signal.



PHASE JITTER MEASUREMENT

PHASE JITTER ..... Instrument Operation



1. Use the PHASE JITTER key to select the required filter.

   20-300Hz is the "standard" band.
   4-300Hz is the "standard + low frequency" band.

Transmitter

2. Display the transmitted level and frequency using the DISPLAY key. The TRMT led should be lit.

   Level, in dBm, is in the left hand display. The frequency in the middle display is fixed at 1004Hz.

3. Change the transmitted level using the SET key for the left hand display and the SELECT DIGIT/CHANGE VALUE keys.

Receiver

4. Display the received level and phase jitter using the DISPLAY key. The RCV led should be lit.

   Level, in dBm, is in the left hand display. The phase jitter, in DEG, is in the middle display.

   NOTE

   The 4947A has to settle before accurate readings are available:

   Allow 4 seconds for the 20 to 300Hz filter
   and 25 seconds for the 4 to 300Hz filter

5. If the received holding tone falls outside the acceptable level and frequency units, this will be indicated in the left hand display.

PRINTING/PLOTTING RESULTS

SECTION 3

INTRODUCTION

You can print results of any measurement or plot results of swept measurements on a HP2225A ThinkJet printer.

PRINTING RESULTS

1. Connect the printer to the 4947A HP-IB connector. Set the HP-IB switches for **TALK ONLY** on the 4947A and **LISTEN ALWAYS** on the printer, before powering up.

2. Switch on the 4947A and the printer. **Prnt** and **PLot** are briefly displayed on the 4947A and the **PRINT/PLOT MODE** led will light.

3. Select the measurement you want. All measurements are available for printing. If you are performing a **SEQUENCE** measurement, wait until the measurement is complete before printing (see Making Measurements section).

NOTE

A useful feature of **SEQUENCE** *is that results are stored in NVM (non-volatile memory). This allows you to move the 4947A to another location (if you want) before you read or print out results. When you power-up at the new location:*

1. Ensure the 4947A ports are not connected.

2. Press **SEQUENCE**

3. Read or Print results.

Step 1 ensures that the 4947A cannot detect a new sequence before the stored results are read or printed. If new sequences were to be detected, the stored results in NVM would be overwritten.

4. To initiate printing press the **HP-IB/PRINT START/STOP** key. The **TALK** led lights and results are automatically printed as they become available.

NOTE

There may be a delay between pressing the PRINT START/STOP *key and getting a print.*

5. To stop printing, press the START/STOP key again. The TALK led goes off.

NOTE

The printer may continue printing for some time after the PRINT START/STOP *key is pressed while the printer catches up with all the measurements made by the 4947A.*

PLOTTING RESULTS (Level/Frequency or EDD)

1. Connect the ThinkJet to the 4947A HP-IB connector. Set the HP-IB switches for TALK ONLY on the 4947A and LISTEN ALWAYS on the printer, before powering up.

2. Switch on the 4947A and the printer. Prnt and Plot are briefly displayed on the 4947A and the PRINT/PLOT MODE led is lit.

3. Only LEVEL/FREQ and ENVELOPE DELAY DISTortion measurements can be plotted.

NOTE

If the 4947A is requested to plot and the current measurement has no plot capability, the 4947A defaults to printing.

4. Wait until the 4947A has swept over the selected sweep range before plotting. Pressing the SHIFT key followed by the HP-IB/PRINT START/STOP key starts the plot (TALK led is lit). The led goes off when the plot is completed. To stop the plot prematurely, press the START/STOP key at any time (it may take a while to stop).

NOTE

The 4947A stops measuring while the results are being plotted.

SAMPLE PRINTS/PLOTS

LEVEL / FREQUENCY HP4947A

TX Level: 0.0 dBm

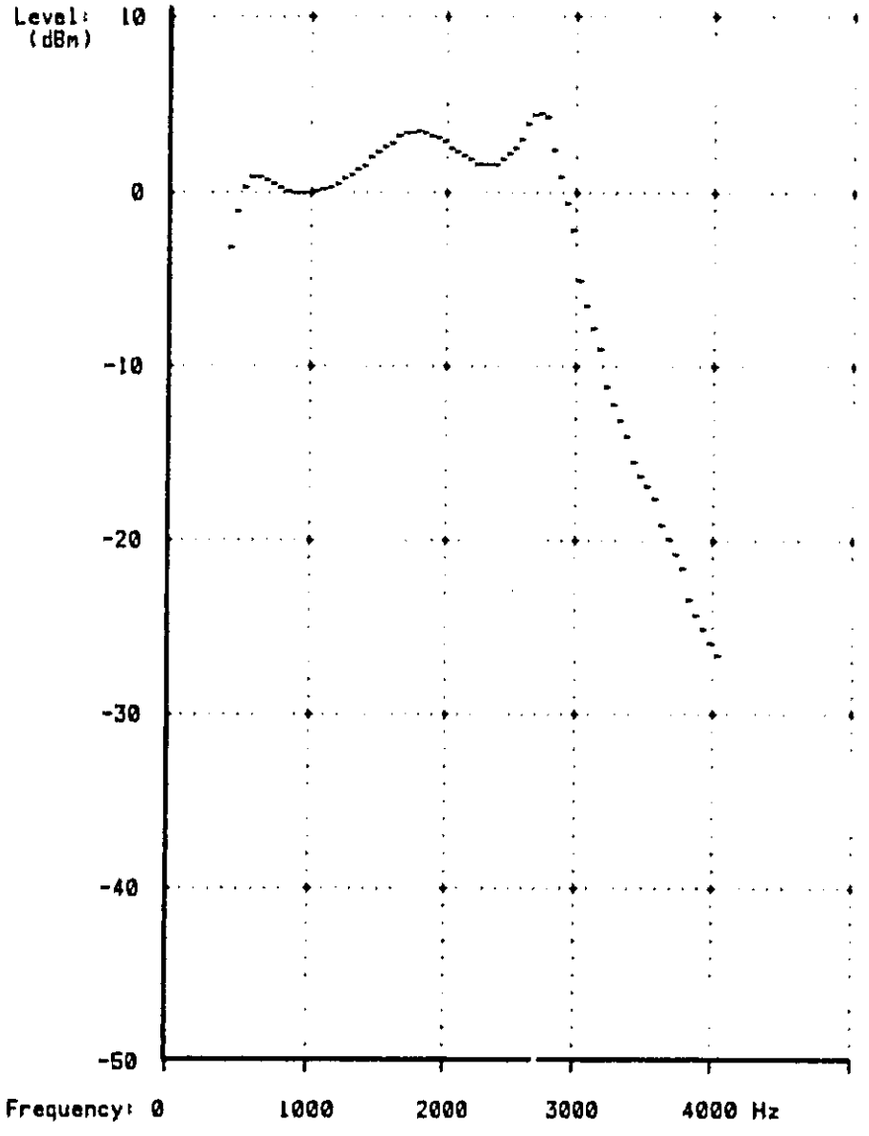
Date:

Location:

Circuit:

Operator:

Comments:



LEVEL / FREQUENCY HP4947A

TRANSMITTED SIGNAL		RECEIVED SIGNAL	
FREQUENCY	LEVEL	FREQUENCY	LEVEL
404 Hz	0.0 dBm	404 Hz	-5.9 dBm
444 Hz	0.0 dBm	444 Hz	-3.2 dBm
484 Hz	0.0 dBm	484 Hz	-1.1 dBm
524 Hz	0.0 dBm	524 Hz	0.3 dBm
564 Hz	0.0 dBm	564 Hz	0.9 dBm
604 Hz	0.0 dBm	604 Hz	1.0 dBm
644 Hz	0.0 dBm	644 Hz	0.9 dBm
684 Hz	0.0 dBm	684 Hz	0.7 dBm

P/AR HP4947A

TRANSMITTED SIGNAL	RECEIVED SIGNAL	
LEVEL	LEVEL	P/AR READING
-13.0 dBm	-10.4 dBm	72 units
-13.0 dBm	-10.4 dBm	72 units
-13.0 dBm	-10.4 dBm	72 units
-13.0 dBm	-10.4 dBm	72 units
-13.0 dBm	-10.4 dBm	72 units
-13.0 dBm	-10.3 dBm	72 units
-13.0 dBm	-10.4 dBm	72 units

4 TONE INTERMOD DISTORTION HP4947A

TRANSMITTED SIGNAL	RECEIVED SIGNAL			
LEVEL	LEVEL	2nd	3rd	
-13.0 dBm	-12.1 dBm	67 dB	71 dB	n.corr
-13.0 dBm	-12.1 dBm	66 dB	71 dB	n.corr
-13.0 dBm	-12.1 dBm	69 dB	71 dB	n.corr
-13.0 dBm	-12.1 dBm	71 dB	71 dB	n.corr
-13.0 dBm	-12.1 dBm	71 dB	71 dB	n.corr

SEQUENCE HP4947A

TRANSMITTED SIGNAL	RECEIVED SIGNAL	
TRANSMIT LEVEL IS 0.0 dBm		
P/AR	100 units	-0.3 dBm
1004 Hz	1004 Hz	-0.3 dBm
Noise with Tone	30 dBrnC	
Signal to Noise	60 dB	
Atten wrt 1004Hz		
404 Hz	404 Hz	0.0 dB
2804 Hz	2804 Hz	0.0 dB
Quiet Termination		
3 kHz noise	-11 dBrn	
C message noise	-18 dBrnC	
4 Tone Intermod Distortion		
Received level	-0.3 dBm	
2nd order (corr)	>70 dB	
3rd order (corr)	>70 dB	
1004 Hz	1004 Hz	-0.3 dBm
Phase jitter 20 - 300 Hz	0.1 deg p-p	
4 - 300 Hz	0.1 deg p-p	
Gain hits 3 dB	0	
Phase hits 20 deg	0	
Dropouts -12 dB	0	
Imp noise 67 dBrn	0	
Imp noise 71 dBrn	0	
Imp noise 75 dBrn	0	

MESSAGE CIRCUIT NOISE - C mess HP4947A

RECEIVED SIGNAL
LEVEL
; dBrnC
5 dBrnC
5 dBrnC

NOISE to GND - C message HP4947A

RECEIVED SIGNAL
LEVEL
18 dBrnC
20 dBrnC
18 dBrnC
17 dBrnC
20 dBrnC
19 dBrnC
18 dBrnC
19 dBrnC
20 dBrnC

NOISE with TONE - C message HP4947A

TRANSMITTED SIGNAL		RECEIVED SIGNAL		
FREQUENCY	LEVEL	FREQUENCY	LEVEL	NOISE LEVEL
1004 Hz	-13.0 dBm	1004 Hz	-13.0 dBm	18 dBrnC
1004 Hz	-13.0 dBm	1004 Hz	-13.0 dBm	18 dBrnC
1004 Hz	-13.0 dBm	1004 Hz	-13.0 dBm	18 dBrnC
1004 Hz	-13.0 dBm	1004 Hz	-13.0 dBm	18 dBrnC

SIGNAL to NOISE RATIO - C mess HP4947A

TRANSMITTED SIGNAL		RECEIVED SIGNAL		
FREQUENCY	LEVEL	FREQUENCY	LEVEL	SIG TO NOISE
1004 Hz	-13.0 dBm	1004 Hz	-13.0 dBm	59 dB
1004 Hz	-13.0 dBm	1004 Hz	-13.0 dBm	59 dB
1004 Hz	-13.0 dBm	1004 Hz	-13.0 dBm	59 dB
1004 Hz	-13.0 dBm	1004 Hz	-13.0 dBm	59 dB

ECHO RETURN LOSS HP4947A

TRANSMITTED SIGNAL	RECEIVED SIGNAL	
LEVEL	RETURN LOSS	TRANSHYBRID LOSS
0.0 dBm	24.9 dB	6.0 dB
0.0 dBm	24.9 dB	6.0 dB
0.0 dBm	24.9 dB	6.0 dB
0.0 dBm	24.9 dB	6.0 dB
0.0 dBm	24.9 dB	6.0 dB
0.0 dBm	24.9 dB	6.0 dB
0.0 dBm	24.9 dB	6.0 dB
0.0 dBm	24.9 dB	6.0 dB
0.0 dBm	24.9 dB	6.0 dB
0.0 dBm	24.9 dB	6.0 dB
0.0 dBm	24.9 dB	6.0 dB
0.0 dBm	24.9 dB	6.0 dB

ENVELOPE DELAY DISTORTION HP4947A

TRANSMITTED SIGNAL		RECEIVED SIGNAL				
FREQUENCY	LEVEL	REF FREQ	REF LEVEL	MEAS FREQ	REL LEVEL	REL DELAY
Delay and Level zero key pressed						
404 Hz	0.0 dBm	1804 Hz	3.4 dBm	404 Hz	9.0 dB	0.80 ms
444 Hz	0.0 dBm	1804 Hz	3.4 dBm	444 Hz	6.5 dB	0.90 ms
484 Hz	0.0 dBm	1804 Hz	3.4 dBm	484 Hz	4.5 dB	0.90 ms
524 Hz	0.0 dBm	1804 Hz	3.4 dBm	524 Hz	3.2 dB	0.84 ms
564 Hz	0.0 dBm	1804 Hz	3.4 dBm	564 Hz	2.6 dB	0.73 ms
604 Hz	0.0 dBm	1804 Hz	3.4 dBm	604 Hz	2.5 dB	0.58 ms
644 Hz	0.0 dBm	1804 Hz	3.4 dBm	644 Hz	2.5 dB	0.42 ms
684 Hz	0.0 dBm	1804 Hz	3.4 dBm	684 Hz	2.7 dB	0.28 ms
724 Hz	0.0 dBm	1804 Hz	3.4 dBm	723 Hz	2.9 dB	0.1[illegible] ms
764 Hz	0.0 dBm	1804 Hz	3.4 dBm	764 Hz	3.1 dB	0.0[illegible] ms
804 Hz	0.0 dBm	1804 Hz	3.4 dBm	804 Hz	3.2 dB	0.01 ms
844 Hz	0.0 dBm	1804 Hz	3.4 dBm	844 Hz	3.4 dB	-0.04 ms

ENVELOPE DELAY DISTORTION HP4947A

TX Level: 0.0 dBm
Ref Freq: 1804 Hz

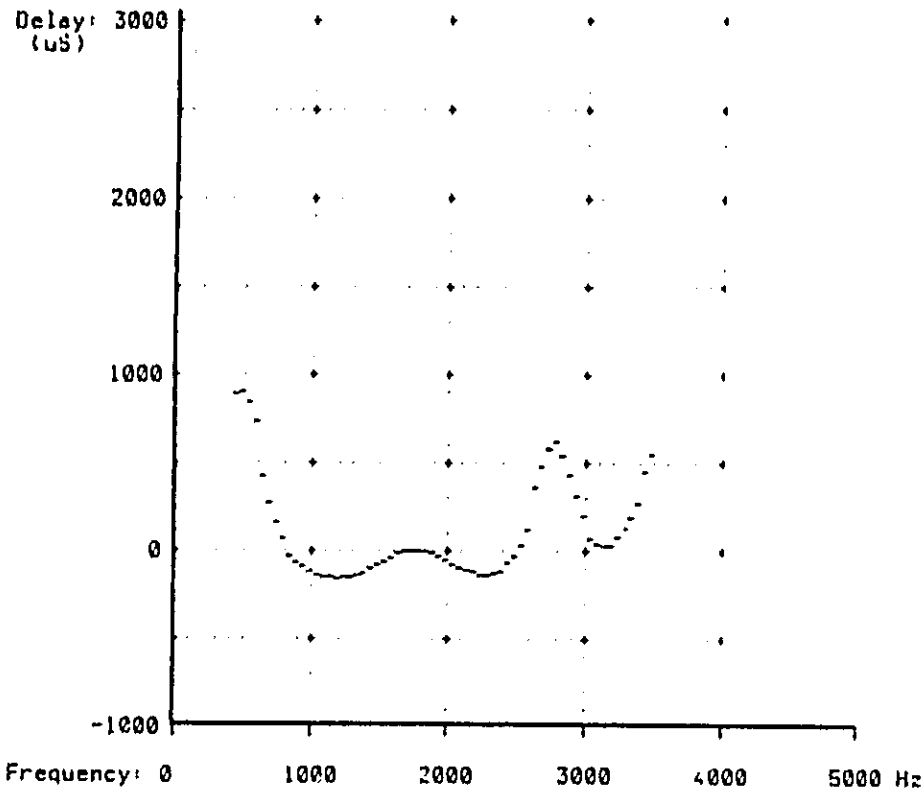
Date:

Location:

Circuit:

Operator:

Comments:



TRANSIENTS HP4947A

TRANSMITTED SIGNAL		RECEIVED SIGNAL	
FREQUENCY	LEVEL	FREQUENCY	LEVEL
1004 Hz	-13.0 dBm	1004 Hz	-13.0 dBm

TIME	G HITS	P HITS	D OUTS	IMPULSE COUNTS		
0:05	2 dB	5 deg	-12 dB	60 dBrn	64 dBrn	68 dBrn
0:00	0	0	0	0	0	0
0:01	1	1	5	5	5	5
0:02	3	1	6	8	7	7
0:03	3	1	7	9	8	8
0:05	3	1	7	9	8	8

PHASE JITTER 20--300 Hz HP4947A

TRANSMITTED SIGNAL		RECEIVED SIGNAL	
FREQUENCY	LEVEL	LEVEL	PHASE JITTER
1004 Hz	0.0 dBm	0.0 dBm	15.3 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.8 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.1 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.0 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.0 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.0 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.0 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.0 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.0 deg p-p
1004 Hz	0.0 dBm	-38.2 dBm	unsettled
1004 Hz	0.0 dBm	-1.4 dBm	unsettled
1004 Hz	0.0 dBm	0.0 dBm	16.4 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.9 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.1 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.0 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.0 deg p-p
1004 Hz	0.0 dBm	0.0 dBm	0.0 deg p-p

REMOTE CONTROL

SECTION 4

INTRODUCTION

This chapter aims to get you running the 4947A remotely via the HP-IB (HEWLETT-PACKARD INTERFACE BUS).

Use the "numbered tabs" on this page to look up the information you are interested in.

WHAT IS THE HP-IB

The Hewlett-Packard Interface Bus provides compatibility between a controller and external devices, such as the 4947A, which conform to the IEEE 488-1978 standard. Electrical, mechanical and timing compatibility are all satisfied by this interface (see Page 4-37).

The HP-IB interface is easy to use and allows great flexibility in communicating data and controlling information between the controller and the 4947A. It is one of the easiest methods of constructing automatic test systems.

CONNECTING THE 4947A TO THE HP-IB

You should consider the following when connecting the 4947A to the bus:

- Operating distances
- Communicating with other devices on the bus

Operating Distances

2

The total length of HP-IB cable used to interconnect devices on the HP-IB must not exceed 2 metres (6 feet) times the number of devices in the system.

The total length of HP-IB cable used to interconnect all devices must not exceed 20 metres (65 feet).

Refer to INSTALLATION section for more details on HP-IB cables.

Operating distances can be extended using bus extenders.
Up to 1000m : two HP 37203A or two HP 37201A or two HP 37204A
Beyond 1000m: two HP 37201A

Communicating with the Bus Controller

Usually, each device on the bus must have a unique **address**, so that the controller can access each one. On the 4947A, this address is set on switches on the rear panel. The procedure for setting the 4947A primary address is given in the INSTALLATION section (see HP-IB section).

NOTE

The 4947A has no secondary addresses.

A program running in a controller usually identifies each bus device by a **device select code**.

The device select code is made up of two parts:

- The first part is the **interface select code**. This indicates which I/O port the required device is connected to.
- The second part is the **address** which identifies which device on that port is to be selected.

EXAMPLE

In the **Demonstration Programs** 1 to 4 (see Pages 4-17 to 4-21), the 4947A device select code is 702.

interface select code = 7 (in the example, this selects an HP-IB port).
primary address = 02
device select code = 702

PROGRAMMING THE 4947A

Programming commands are received from the HP-IB when the instrument is in the addressable mode.

Command Format

The programming commands have three parts:

- an alpha header mnemonic
- a list of command parameters (if required)
- a command terminator

Spaces within the command string are ignored provided they do not occur within a mnemonic or number.

Command Parameters

Parameter lists consist of decimal numbers separated by commas (,).

Combining Commands

It is possible to combine several commands into one string by using a semicolon (;) as a command seperator. The whole string is executed only when the final terminator is received (see Command Validity). In most controllers this is written as OUTPUT 702; "command1; command2; etc".

Command Terminators

A command string is terminated by one of three things:

- ASCII newline (identical to the linefeed character <lf>).
- ASCII carriage return + 1 linefeed <cr lf>.
- An interface EOI with the last byte of the command.

In most controllers a BASIC statement of the form OUTPUT 702; "---" includes a linefeed/CRLF.

The 4947A does not execute a command line until one of these terminators is received.

Command Validity

A command will be rejected if:

- it contains a syntax error
- it cannot be identified
- it is too long
- it has too few or too many parameters
- a numeric parameter is out of range
- it is out of context

All subsequent commands in the same string will be ignored.

INITIALIZING THE 4947A

Regardless of the current set up, the following commands initialize the 4947A. They set the 4947A to its idle state and clear all HP-IB input and output buffers.

DCL : device clear
SDC : selective device clear
ME0 : idle measurement state

MATCHING THE 4947A TO THE TEST CIRCUIT

- Normally, the 4947A transmitter is connected to the left hand front panel jack and the receiver to the right hand one. This configuration may be reversed. This, together with the transmitter impedance and loop holding conditions, are controlled by the AT (analog transmitter) command.
- Control the receiver impedance, termination and loop holding conditions using the AR (analog receiver) command.

Command Formats

Description	Command Format	Example
Set analog transmitter	AT <imped>,<loop hold>,<conn>	AT 600,1,0
Set analog receiver	AR <imped>,<term>,<loop hold>	AR 600,0,0

These commands are used to select the port configurations.

<imped> : Select either 600, 900 or 1200 ohm.
<term> : 0 selects terminated input, 1 selects bridged input.
<loop hold> : 0 turns off loop hold circuit, 1 turns it on.
<conn> : Choice of port connections;

0 : TRMT is left hand port, RCV on the right.
1 : HANDSET connected to left hand port, RCV on the right.
2 : TRMT is right hand port, RCV on the left.
3 : HANDSET connected to right hand port, RCV on the left.

CONTROLLING THE DISPLAY AND AUDIO MONITOR

- Select the display and monitor mode (TRMT/RCV) using the DP (display mode) command.
- Set the loudspeaker volume using the SV (set volume) command.

Command Formats

Description	Command Format	Example
Select display mode	DP <display>	DP 1
Set speaker volume	SV <vol>	SV 5

<display> : 0 selects TRMT, 1 selects RCV.

<vol> : 0 to 7, where 0 is off, 1 is quiet and 7 is very loud.

CALIBRATING THE 4947A REMOTELY

The 4947A automatically runs a calibration cycle at switch-on. However, it is good practice to re-calibrate under the following conditions:

- After the 4947A has warmed up (after switch-on).
- Whenever maximum accuracy is required (especially during warm up).
- When enviromental conditions change (temperature, pressure, etc).
- When the 4947A is located in the same place all the time, calibrate at least once per day or once per shift.

To calibrate the 4947A remotely use the TE1 (self-test) command. Other tests may also be run remotely (for more details see Page 4-35).

NOTE

The 4947A TRMT *and* RCV *ports are high impedance during calibration.*

DIALING REMOTELY

Using the 4947A with a controller, you can dial over systems which use either single frequency (SF) or dual tone multifrequency dialing (DTMF).

In multifrequency dialing, the 4947A has 16 frequency pairs stored in NVM (non-volatile memory). These are set on shipment from the factory to match the North American DTMF standard, but may be altered by the MD command. On shipment the 16 stored pairs represent the DTMF digits 1 to 9, 0, *, #, A, B, C and D.

In single-frequency dialing, level and pulse timing are also held in NVM within the 4947A. These parameters can be changed using the SF command.

Listed below are the commands used to set up the dialing.

Description	Command	Page Reference
Set up dual tone multi-frequency dialing (DTMF) parameters	MD <parameter list>	4-26
Set up single frequency dialing (SF) parameters	SF <parameter list>	4-31
Select Dialing	ME 22	4-28
Select type of dialing and dial number	MP # <type>,<digit 1> to <digit 30>	4-28

<type> = 1 or 2 — 1 for DTMF dialing; 2 for SF dialing

In multifrequency dialing, <digit 1> etc., are numbers in the range 1 to 16 and call out a particular pair of frequencies from the multifrequency parameter store in the 4947A (see MD command on Page 4-26). In SF dialing, <digit 1> etc., are numbers in the range 1 to 10 and represent the digits 0 to 9.

Example: DTMF dialing (2-Wire Circuit – see Page 2-6).

Procedure	Command
1. Set the dialing parameters if they are different from the values stored in the 4947A.	MD <parameter list>
2. Connect the RCV port to the test circuit. Ensure the receiver and transmitter loop holding are on (off hook condition).	AT 600, 1, 0 AR 600, 0, 1
3. Listen for dialing tone or (detect dial tone by measuring tone using LEVEL/FREQ measurement).	SV4 or (ME1 and OR)
4. Reverse port connections to dial, select DTMF DIAL mode and dial number.	AT 600, 0, 2 ME22 MP1, <digit 1>... <digit 30 max.>
5. Re-connect RCV port to test circuit and listen for the Far End going off-hook.	AT 600, 0, 1
6. Make the measurement you want.	ME <meas#>; MP <parameter list>

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RUNNING MEASUREMENTS REMOTELY

"Running measurements" splits into two distinct sections: measurement setup and outputting results.

Measurement Setup

The ME command selects a measurement. The <meas#> parameter should be a number between 0 and 22. A value of 0 puts the 4947A into the idle state (useful in systems applications). A value of 22 (not shown below) corresponds to dialing mode (see Page 4-8).

The MP command sets the measurement parameters for the currently selected measurement (see specification on Page 5-3 for parameter limits).

Measurement Setup - Command Formats

Measurement : ME <meas#> Description	<meas#>	Measurement Parameter : MP <format variable> <format variable>	Example
Idle	0	no parameters	ME0
LEVEL AND FREQUENCY **Δ	1	<tx freq>,<tx level>	ME1;MP1004,-10
NOISE WITH TONE	2	<tx level>	ME2;MP-10
SIGNAL TO NOISE RATIO	3	<tx level>	ME3;MP-10
P/AR	4	<tx level>	ME4;MP-10
INTERMOD Δ	5	<tx level>	ME5;MP-10
SEQUENCE Δ	6	<tx level>	ME6;MP-10
MESSAGE CIRCUIT NOISE - C message	7	no parameters	ME7
MESSAGE CIRCUIT NOISE - 3kHz	8	no parameters	ME8
NOISE TO GROUND - C message	9	no parameters	ME9
NOISE TO GROUND - 3kHz	10	no parameters	ME10
ECHO RETURN LOSS Δ	11	<tx level>	ME11;MP-10
SINGING RETURN LOSS - LOW Δ	12	<tx level>	ME12;MP-10
SINGING RETURN LOSS - HIGH Δ	13	<tx level>	ME13;MP-10
ENVELOPE DELAY DISTORTION **Δ	14	<tx freq>,<tx level>	ME14,MP1004,-10
EDD - repeat mode Δ	15	<tx freq>,<tx level>	ME15;MP1004,-10
TRANSIENTS - 8 counts/sec	16	<tx level>,<duration>,	ME16;
TRANSIENTS - 100 counts/sec	17	<*gain hit thresh code>, <β hit thresh>,<imp Lo thresh>	MP-10,5.1,5,70
IMPULSE NOISE - 8 counts/sec	18	# <duration>,<imp Lo thresh>	ME18;MP5
IMPULSE NOISE - 100 counts/sec	19		
PHASE JITTER - 20 to 300Hz filter	20	<tx level>	ME20,MP-10
PHASE JITTER - 4 to 300Hz filter	21	<tx level>	ME21;MP-10

Δ These measurements may need extra setup commands, see Page 4-12.

* Gain hit threshold code: 0 = 2dB, 1 = 3dB, 2 = 4dB, 3 = 6dB.

\# duration >599 minutes is continuous.

** All measurements are Single Point except ME11 which can be a single point or swept; and ME14 which can be single point or swept plus a reference point taken at start of measurement.

Outputting Results

When a result becomes available, **primary status bit 0** (result ready) is set. (This bit is subsequently cleared by the **ME, MP** or **OR** commands). You can monitor the result ready bit using the **OS** (output status) command or by using an SRQ/serial poll routine (see Page 4-15).

A result is put out in response to the **OR** command. The result response is measurement dependent (see table below). Transients and impulse noise results can be read at any time.

You may want to request a header before results are available. The 4947A outputs a header in response to the **OH** command, it contains the measurement number <meas#> and the parameter values. The header format returned is measurement dependent (see table below).

Outputting Results - Command Formats

Measurement : ME <meas#> Description	<meas#>	Output header : OH Response Format	Output Result : OR Response Format
Idle	0		
LEVEL AND FREQUENCY	1	1 <tx freq><tx level>	<rx freq><rx level>
NOISE WITH TONE	2	2 <tx level>	<rx noise><rx freq>
SIGNAL TO NOISE RATIO	3	3 <tx level>	<rx s/n><rx freq><rx level>
P/AR	4	4 <tx level	<rx level><p/ar value>
INTERMOD	5	5 <tx level>	<rx level><2nd intermod> <3rd intermod>
SEQUENCE	6	6 <tx level>	Returns 25 items, see #
MESSAGE CIRCUIT NOISE - C message	7	7	<rx noise>
MESSAGE CIRCUIT NOISE - 3kHz	8	8	<rx noise>
NOISE TO GROUND - C message	9	9	<rx noise>
NOISE TO GROUND - 3kHz	10	10	<rx noise>
ECHO RETURN LOSS	11	11 <tx level>	<return loss>
SINGING RETURN LOSS - LOW	12	12 <tx level>	<return loss>
SINGING RETURN LOSS - HIGH	13	13 <tx level>	<return loss>
ENVELOPE DELAY DISTORTION	14	14 <tx freq><tx level>	<ref freq><ref level> <rx freq><rx level> <delay>
EDD - repeat mode	15	15	<rx freq><rx level>
TRANSIENTS - 8 counts/sec	16	16 or 17 <duration>	<level><freq><duration>
TRANSIENTS - 100 counts/sec	17	<gain hit thresh> <ϕ hit thresh> <imp thresh>	<Ghits><PH hits><Douts> <imp Lo><imp Mid><imp Hi>
IMPULSE NOISE - 8 counts/sec	18	18 or 19 <duration>	<duration><imp Lo>
IMPULSE NOISE - 100 counts/sec	19	<imp thresh>	<imp Mid><imp Hi>
PHASE JITTER - 20 to 300Hz filter	20	20 or 21 <tx level>	<rx level><jitter>
PHASE JITTER - 4 to 300Hz filter	21		

<P/AR><P/AR level><1004 freq><1004 level><C-notch noise><S/N><404 freq> <404 rel level><2804 freq> <2804 rel level><C-mess noise><3kHz noise><4T level><2nd corr><3rd corr> <1004 freq><1004 level><Ghit><PH hit> <dout><imp Lo><imp Mid><imp Hi>

Other Measurement Related Commands

Listed below are the additional commands needed when making measurements remotely.

Other Measurement Command Formats

Measurement	Description	Command Format	Reference
LEVEL/FREQ & EDD	set frequency sweep limits	SP <from>,<to>,<step>	4-32
	start/stop frequency sweep	SW <param>	4-34
	set sweep rate	RA <sweep rate>,<sequence speed>	4-30
	set zero	ZE <type>	4-36
	compensating for network delay (loopback testing)	ND <time>	4-28
	set reference level	TH <level>	4-36
	single frequency skip	SK <flag>	4-32
SEQUENCE	start sequence (TRMT only)	SW <enable>	4-34
	sequence speed	RA <sweep rate>,<sequence speed>	4-30
RETURN LOSS/ELEPL	set transhybrid loss	TH <level>	4-36
	set zero	ZE <type>	4-36
INTERMOD	noise check	ZE <type>	4-36

Example: A swept EDD measurement using the Return Reference Mode on Page 2-44.

Procedure	Commands
Far End 4947A Transmitter	
1. Select EDD REPEAT mode and set the level to -13dBm and frequency to 1004Hz.	ME15; MP1004,-13
Near End 4947A Transmitter	
2. Set the measurement rate to SLOW for accuracy.	RA1, 0
3. Select EDD MEAS and set the transmitter level to -13dBm and frequency to 1004Hz.	ME14, MP1004,-13
4. Set sweep limits from 304Hz to 3004Hz in 40Hz steps.	SP 304, 3004, 40
5. Reference the result.	ZE 1
6. Start sweep.	SW 1
7. Output results.	OP

INPUT AND OUTPUT DATA FORMATS

The 4947A is programmable directly in ASCII and accepts parameter values in free format, seperated by commas, in units shown below. Similarly, the normal 4947A output is in ASCII (there is an optional GRAPHICS format for results, see Page 3-2). Data value, units and format are shown below. In the following, "D" stands for ASCII character, although leading zeros may be replaced by spaces.

Parameter	Input and Output Units	Output Format
FREQUENCY	Hz	DDDD
LEVEL	dB, dBm, dBrn	DDDD.DD
PHASE	This is in degrees p-p. For input, phase hit thresholds must be in steps of 5 degrees.	DD.D
ENVELOPE DELAY	seconds	D.DDDDDD
TIME	seconds (signaling parameter and network delay)	DD.DDD
DURATION	minutes (transients/impulse noise)	DDD
COUNT		DDDD

READING THE 4947A CURRENT SETTINGS

Enquiries about the current set up or measurements may be made by using the enquiry ? commands (see table on Page 4-22 for complete list of commands).

EXAMPLE

The 4947A receiver is set as follows: 600 ohm, terminated with no loop holding. The command to set up these conditions is "AR 600,0,0".

The command to enquire about the receiver is AR?. The response to "AR?" is AR 600,0,0.

The output commands listed below also return information about the 4947A.

Information Required	Command	Reference
error code	OE	4-25
result header	OH	4-29
instrument identifier	OI	4-26
current results	OR	4-29
instrument status	OS	4-30

STATUS REPORTING

The status reporting capability of the 4947A comes in the form of the **primary status byte** (see Page 4-16). This byte can be interrogated for the information you are interested in. For example, you can run a measurement on the 4947A and at the same time be monitoring for errors and the LOCAL key being pressed.

There are three ways to request the primary status byte:

- Repeated polling of the **OS** (output status) command (see Page 4-30).
- Repeated serial poll (SPOLL)
- Using a service request (**SRQ**) interrupt which uses the controller dependent **SPOLL** (serial poll) command (see Page 4-38).

See **Demonstration Programs** 3 and 4 for more details, pages 4-19 and 4-20.

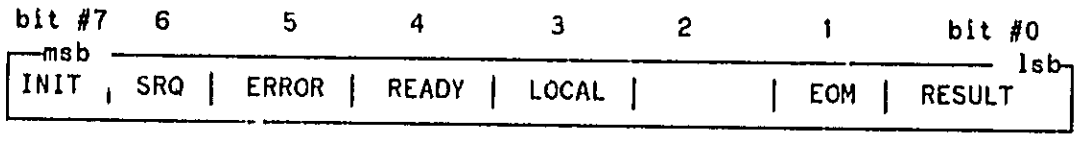
Service Request (SRQ)/Interrupt Routine

The procedure you should follow to get your SRQ/Interrupt Routine working is given below:

- Select the condition(s) you want the 4947A to request service on, by using the **SRQ** **<mask>** command.
- Enable the 4947A request service using the **RQS** **<enable>** command.
- Specify the action you want the controller to take when the 4947A issues an **SRQ** by using the controller dependent **ON INTR** (on interrupt) and **ENABLE INTR** BASIC statements in your program.
- Acquire the **primary status byte** by using the controller dependent **SPOLL** (serial poll) BASIC statements.

Primary Status Byte

This is the layout of the **primary status byte** returned by the 4947A in response to a **serial poll** request. It is also returned in response to an **OS** command.



bit #	Mnemonic	Meaning when bit is set
7	INIT	The 4947A has just powered up. This bit is cleared by a device clear message or any command that changes the configuration of the instrument.
6	SRQ	The 4947A is requesting service (SRQ is asserted). This bit is cleared by a serial poll or when all conditions which are causing the SRQ are cleared.
5	ERROR	An error has occurred. This bit is cleared when the error code list is read via either the **OE** or the **ERR?** commands. A serial poll does not clear this bit.
4	READY	The 4947A has completed the execution of the most recent command line. This bit is cleared again when the 4947A receives the first character of the next command line. READY is also set by the HP-IB device clear message (DCL).
3	LOCAL	This bit will be set when the LOCAL key on the front panel of the 4947A is pressed. The bit is cleared by the **OS** command.
1	EOM	This bit is set at the END OF MEASUREMENT time or when dialed number is complete.
0	RESULT	The result of a measurement point is available. This is cleared by using the **OR** command to read the result or by any command which changes the configuration of the instrument (see Page 4-11).

DEMONSTRATION PROGRAMS

Before looking at the four demonstration programs written for a HP200 Series controller (in BASIC), you should be aware of the following items:

- Command syntax (Page 4-5)
- Measurement parameter formats (Page 4-10)
- Input/Output data formats (Page 4-13)
- Controller dependent statements (OUTPUT, ENTER, INTERRUPT, SPOLL, etc.)

Before running Programs 1 to 4, set the 4947A address to 2 then power up.

Program 1

Sets the 4947A TRMT and RCV ports to 600Ω with loop holding off and with the RCV port terminated. The **audio monitor** is enabled and the **DISPLAY** mode is set to receive (RCV). The program then sends a tone. There is no result requested via HP-IB.

```
10    !     PROGRAM1                    DESCRIPTION
20    !
30    !
40    !
50    CLEAR 702                    ! Clears the 4947A to a known condition.
60    REMOTE 702                   ! Sets the 4947A to remote.
70    OUTPUT 702;"AT 600,0,0"      ! Set the transmitter parameters.
80    OUTPUT 702;"AR 600,0,0"      ! Sets the receiver parameters.
90    OUTPUT 702;"SV2"             ! Sets the audio monitor level.
100   OUTPUT 702;"DP1"             ! Sets the display mode to RCV.
110   OUTPUT 702;"ME1;MP1004,-13"  ! Runs a LEVEL/FREQ measurement.
120   END                          !
```

Program 2

Calibrates the 4947A (for optimum accuracy) prior to sending a tone. No result requested via HP-IB.

NOTE

While the 4947A is self calibrating the **TRMT** *and* **RCV** *ports are high impedance*

The following points are important:

- You must allow the 4947A to complete self calibration before running your measurement (takes approximately 20 seconds) or look for the EOM bit.
- The **end-of-measurement** (EOM) bit of the **primary status byte** is set true when the self-calibration is complete. The following program interrogates the EOM bit and when it is set the measurement command is issued.
- See Program 3 for details on **WAIT** statements.

```
10    !     PROGRAM2                    DESCRIPTION
20    !
30    !
40    !
50    CLEAR 702                    ! Clears the 4947A to a known condition.
60    REMOTE 702                   ! Sets the 4947A to remote.
70    OUTPUT 702;"AT 600,0,0"      ! Sets the transmitter port.
80    OUTPUT 702;"AR 600,0,0"      ! Sets the receiver port.
90    OUTPUT 702;"SV2"             ! Sets the audio monitor level.
100   OUTPUT 702;"DP1"             ! Sets the display mode to RCV.
110   OUTPUT 702;"TE1"             ! Calibrates the 4947A.
120   WAIT 18                      ! Approx time to calibrate 4947A.
130   OUTPUT 702;"OS"              ! Acquire the primary status byte.
131   ENTER 702;S                  ! Store primary status byte.
140   IF NOT BIT(S,1) THEN         !  Check the EOM bit every 1
150     WAIT 1                     !  second to see if calibration is
160     GOTO 130                   !  complete.
170   END IF                       !
180   OUTPUT 702;"ME1;MP1004,-13"  ! Runs a LEVEL/FREQ measurement.
190   END                          !
```

Program 3

Runs a LEVEL/FREQ measurement at a frequency of 1004Hz and level of -10dBm.

The following program repeatedly uses the OS command to interrogate the result ready bit (bit 0) of the primary status byte which is set when results become available. Repeated polling of OS ties up the processor, leaving very little time for the 4947A to make the measurement. This problem is overcome by introducing a WAIT statement in line 110 which sets a fixed time between polling. During this period the 4947A makes measurements and sets the result ready bit.

To illustrate the above points, you may run the following program **with** and then **without** line 110.

An alternative method to the above, is to repeated serial poll (SPOLL) the 4947A by replacing line 90 with P = SPOLL (702) and deleting line 100 in **Program 3.**

Another method is to get the 4947A to interrupt the program when results become available, and this is illustrated in **Program 4.**

```
10    !   PROGRAM3                          DESCRIPTION
20    !
30    !
40    !
50    OUTPUT 702;"ME1;MP1004,-10"! Selects LEVEL/FREQ and parameters.
60    OUTPUT 702;"OH"            ! Requests header to precede results.
70    ENTER 702;A$               ! Stores response to OH in A$.
80    DISP A$                    ! Displays header on CRT.
90    P=SPOLL(702)               ! Requests the 4947A status.
100   IF NOT BIT(P,0) THEN       ! If result ready bit is set then acquire
110     WAIT .1                  ! result otherwise wait 100ms then re-check
120     GOTO 90                  ! OS.
130   END IF
140   OUTPUT 702;"OR"            ! Requests results from the 4947A
150   ENTER 702;F,L              ! Stores results in F and L.
160   DISP F;"Hz",L;"dBm"        ! Displays results.
170   END
```

The above program produces the following print:

```
1004 Hz  -10.5 dBm
```

13

Program 4

Runs a LEVEL/FREQ swept measurement from 40kHz to 150kHz in 40Hz steps and at a level of -10dBm. This program also monitors the LOCAL key and indicates when errors have occurred.

Program 4 illustrates a more realistic operating situation, where, in addition to running a measurement you monitor other conditions you want to know about. This is achieved by using a service request (SRQ)/interrupt routine to monitor:

- When errors occur
- When the LOCAL key is pressed
- When measurement results become available

The SRQ/interrupt routine of Program 4 works as follows:

- First, you have to set the 4947A's service request (SRQ) mask for the above conditions. Then you enable the 4947A's to request service (RQS command).
- Next you program the controller to find the device requesting service by using the on interrupt (ON INTR), interrupt enable (ENABLE INTR) and serial poll (SPOLL) statements. These commands are all controller dependent.
- Finally, you find the cause of the interrupt(s) by interrogating the primary status byte of the interrupting device (in this instance the 4947A).

```
10    !   PROGRAM4                        DESCRIPTION
20    !
30    !
40    !
50    !
60    CLEAR 702                          ! Sets the 4947A to a known condition.
70    REMOTE 702                         ! Sets the 4947A to remote.
80    OUTPUT 702;"SRQ41;RQS1"            ! Sets & enables the service request mask.
90    ENABLE INTR 7;2                    ! Allows interface 7 to interrupt on SRQ.
100   ON INTR 7 GOSUB Service            ! Calls SRQ handler on interrupt.
110   OUTPUT 702;"ME1;MP1004,-10"        ! Selects LEVEL/FREQ and parameters
120   OUTPUT 702;"SP404,1504,40"         ! Selects sweep limits and step.
130   OUTPUT 702;"SW1"                   ! Enables sweep.
140   ENABLE INTR 7;2                    ! Re-enables interrupt.
150   GOTO 140                           ! Idle loop.
160   STOP                               !
170                                      ! Service request interrupt handler routine
180 Service:  S=SPOLL(702)               ! Acquire primary status byte.
190           IF BIT(S,5) THEN           ! Checks for errors.
200             OUTPUT 702;"OE"          ! Outputs error code.
210             ENTER 702;E              ! Stores error code.
220             PRINT "ERROR=",E         ! Prints error message.
230             GOTO 350                 ! Exit program on error.
240           END IF                     !
250           IF BIT(S,3) THEN           ! Checks LOCAL key.
260             PRINT "LOCAL key pressed"
270             GOTO 350                 ! Exit program when LOCAL is pressed.
280           END IF                     !
290           IF BIT(S,0) THEN           ! Checks for results.
300             OUTPUT 702;"OR"          ! Outputs results.
310             ENTER 702;F,L            ! Stores results.
320             PRINT F;"Hz",L;"dBm"     ! Prints results.
330           END IF                     !
340           RETURN                     ! Returns to main program.
350           END                        !
```

The above programing produces the following:

```
 1004 Hz   -10.63 dBm
 1044 Hz   -10.63 dBm
 1084 Hz   -10.63 dBm
 1124 Hz   -10.63 dBm
 1164 Hz   -10.63 dBm
 1204 Hz   -10.63 dBm
 1244 Hz   -10.63 dBm
 1284 Hz   -10.63 dBm
 1324 Hz   -10.63 dBm
 1364 Hz   -10.63 dBm
 1404 Hz   -10.62 dBm
 1444 Hz   -10.63 dBm
 1484 Hz   -10.63 dBm
 404 Hz    -10.63 dBm
 444 Hz    -10.63 dBm
 484 Hz    -10.63 dBm
 524 Hz    -10.63 dBm
 564 Hz    -10.64 dBm
 604 Hz    -10.63 dBm
LOCAL key pressed
```

COMMANDS IN ALPHABETICAL ORDER

All the programming commands are in the following table. Pages 4-24 to 4-36 contain a detailed description of each command.

Command Description	Mnemonic	Page Reference
Set receiver port conditions	AR	4-24
	AR?	
Set transmitter port conditions	AT	4-24
	AT?	
Set display and monitor mode (TRMT/RCV)	DP	4-25
	DP?	
Output errors	ERR?	4-25
Output instrument identifiers	ID?	4-26
Set multifrequency dialing parameters	MD	4-26
	MD?	
Select measurement	ME	4-28
	ME?	
Set measurement parameters	MP	4-28
	MP?	
Set network delay time	ND	4-28
	ND?	
Output error code	OE	4-29
Output header	OH	4-29
Output instrument identifier	OI	4-29
Output result	OR	4-29
Output instrument status	OS	4-30
Set sweep/averaging rate/sequence speed	RA	4-30
	RA?	
Enable/Disable SRQ response	RQS	4-31
Set SF dialing parameters	SF	4-31
	SF?	
Select SF skip	SK	4-32
	SK?	
Change power-on values of measurement parameters (store mask)	SM	4-32
Set frequency sweep parameters	SP	4-32
	SP?	
Set SRQ response mask	SRQ	4-33
Set monitor volume	SV	4-34
	SV?	

Command Description	Mnemonic	Page Reference
start/stop frequency sweep	SW SW?	4-34
Perform self-test/CAL	TE TE?	4-35
Set reference level or transhybrid loss value	TH TH?	4-36
"set zero"/"noise check" key function (L/F,EDD,NLD)	ZE ZE?	4-36

AR .. .. Set Receiver Port Conditions

AR <imped>,<bridge>,<loop hold>

<imped> = 600 or 900 or 1200
<bridge> = 0 or 1
<loop hold> = 0 or 1

AR?

These commands are used to select or read the receiver port conditions.

<imped> : Select either 600, 900 or 1200 ohm.
<bridge> : 0 selects terminated input, 1 selects bridged input.
<loop hold> : 0 turns off loop hold circuit, 1 turns it on.

The query form of the command AR? will cause the 4947A to return the current settings. For example, if 600 ohm terminated without loop hold is selected, the string returned is AR 600,0,0.

AT .. .. Set Transmitter Port Conditions

AT <imped>,<loop hold>,<conn>

<imped> = 600 or 900 or 1200
<loop hold> = 0 or 1
<conn> = 0 : TRMT is left hand port, RCV on the right
1 : HANDSET connected to left hand port, RCV on the right
2 : TRMT is right hand port, RCV on the left
3 : HANDSET connected to right hand port, RCV on the left

AT?

For normal operation the TRMT port is on the left and the RCV port is on the right. When the connection is reversed, TRMT is on the right RCV is on the left. You can also connect a HANDSET to the transmitter port.

These commands are used to select or read the transmitter port conditions.

<imped> : Selects either 600, 900 or 1200 ohm.
<loop hold> : 0 turns off the loop hold current, 1 turns it on.
<conn> : Choice of port connections, see above.

The query form of the command AT? will cause the 4947A to return the settings. For example, if impedance is 600 ohms, with no loop holding and the transmitter is connected to the left hand port, the string returned will be AT 600,1,0.

DP .. .. Select Display and Monitor Mode

DP <display> <display> = 0 or 1
DP?

These commands are used to set or indicate the 4947A display and monitor mode. The parameter values are: 0 = TRMT 1 = RCV.

The query form of the command DP? will cause the instrument to return the currently set display and monitor mode. For example, if this is RCV, the string returned will be DP 1.

ERR? & OE .. .. Error Reporting

OE
ERR?

There are two commands available for error reporting. The OE command is the simpler of the pair. It causes the 4947A to return the current error code, in decimal (see APPENDIX A). If there are no errors pending the value zero is returned.

The ERR? command is more sophisticated than the OE command. It enables errors to be split into one of four categories and returns the current error code in each. On receipt of ERR? the 4947A will return the following string:

"ERR <meas error>,<idle error>,<oper error>,<pon error><crlf>"

<meas error> : Errors detected by the 4947A measurement routines during execution of a measurement are returned in this field.

<idle error> : Errors detected by the 4947A measurement routines when setting up the idle state of the instrument are returned here.

<oper error> : This field returns operator and HP-IB programming erro--

<pon error> : Power-on self test errors are returned here.

Both the OE and the ERR? commands clear the error code buffer within the instrument firmware and reset bit #5 (Error) of the primary status byte.

The choice of which error command to use will depend on the complexity of the application of which the 4947A is a part.

Simple systems where complex error handling capabilities are not required, you should make use of the OE command. Here error codes will be passed straight on to some operator or logging device.

In a sophisticated automatic system the ERR? command may be more suitable because of its classification of errors. A controller should always check for measurement and idle state errors. They are generally caused by an undesirable receive signal. In a fully debugged and working system operator errors and power-on self test errors should never occur.

NOTE

The ERR? *command is not compatible with the "ERR?" defined in the IIP standard for HP-IB codes and format.*

ID & OI .. .. Output Instrument Identification

OI
ID?

There is a choice of instrument identification commands. The OI command is the simpler of the two and only returns the instrument model number. The ID command returns the model number and the firmware revision code.

On receipt of the command ID? the 4947A will respond with the following string:

"HP4947A OPT <code><crlf>".

<code> : Firmware revision code.

MD .. .. Set Parameters For Multifrequency Dialing

MD <parameter list>
MD?

The parameters are:

<on time>	:	Tone ON time, in seconds, to a resolution of 0.001s.
<off time>	:	Tone OFF time, in seconds, to a resolution of 0.001s.
<level>	:	Transmit level of the two tone signal in dBm.
<tone pair 1> ⎫ ⎪ ⎪ ⎪ <tone pair 16> ⎭		Sixteen pairs of frequencies (in Hz) to be used to dial the digits "1" x "16" respectively.

The 4947A stores 16 tone pairs to represent digits used in multifrequency dialing, for example, DTMF. The tone pairs are retained when the instrument is turned off. They are numbered 1-16 in an MP command used for multifrequency dialing, the digits are referred to by these numbers. On shipment, the tone pairs are set to the North American DTMF standard, with the tone pair numbers associated with the digits as shown in the diagram. The tone pairs and timing can be modified by this MD command. The modified tone pairs are retained when the instrument is turned off. Page 4-8 describes how to program the 4947A to dial.

The query form of the command MD? will cause the 4947A to return the current multifrequency dialing parameters.

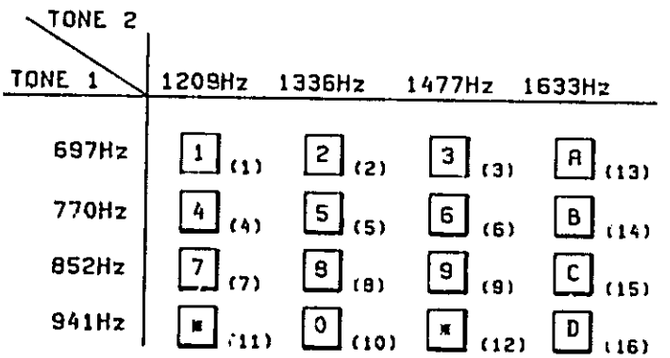
Front Panel DIAL Mode

CAUTION

In front panel DTMF DIAL mode (see Page 2-4), the 4947A keys labeled 1 to 9,0,*,#,A,B,C and D call out the same 16 tone pairs as associated in the diagram below. As described above, at shipment, these represent DTMF; but front panel dialing can be altered by the MD command.

Example: To set up the North American standard DTMF tone pairs below, the 4947A should be sent the following:

```
"MD 0.15, -2.0, 0.0, 697, 1209, 697, 1336, 697, 1477, 770, 1209, 770,
    1336, 770, 1477, 852, 1209, 852, 1336, 852, 1477, 941, 1336, 941,
    1209, 941, 1477, 697, 1633, 770, 1633, 852, 1633, 941, 1633 <crlf>"
```



DTMF Standard

ME .. .. Select Measurement

ME <meas #> <meas #> = 0 .. 22
ME?

The ME command selects a measurement. The <meas #> parameter should be a number between 0 and 22. A value of 0 puts the 4947A into the idle state with the TRMT and RCV ports disconnected. A value of 22 is used to dial (see Page 4-8). For other values, see the table on Page 4-10.

The query form of the command ME? will cause the 4947A to return the currently selected measurement number. For example, if the LEVEL/FREQ measurement is selected, the string returned will be: ME 1.

MP .. .. Set Measurement Parameters

MP <parameter list>
MP?

The MP command sets the measurement parameters for the currently selected measurement. Because the 4947A runs a wide range of measurements, the items in the <parameter list> vary from measurement to measurement. The <parameter list> for each measurement is contained on Page 4-10.

The query form of the command MP? will cause the 4947A to return the parameters of the currently selected measurement. For example, if a LEVEL/FREQ measurement is currently selected with parameters 1004Hz and -10dBm, the string will be MP 1004, -10.0.

ND .. .. Set Network Delay Time

ND <time> <delay> = 0 .. 30.000
ND?

The ND command is used to inform the 4947A of the signal propagation delay of the network under test. This is the time taken for a signal originated by the 4947A transmitter to travel through the network and re-appear at the receiver. When running a measurement, the 4947A will wait this length of time between programming its transmitter and making a measurement at its receiver.

The command parameter <time> specifies the network delay in seconds (to a resolution of 0.001 s).

CAUTION

The network delay time is stored in the instrument's non-volatile memory area and is retained on power-down. It is not possible to change the network delay time from the front panel of the instrument.

The query form of the command ND? will cause the 4947A to return the currently set network delay time. For example, if this is 500ms the string returned will be ND 0.500.

OE .. .. Output Error

OE

See ERR? on Page 4-25.

OH .. .. Output Header

OH

This command causes the 4947A to output a data list, describing the currently running measurement (see Page 4-11).

OI .. .. Output Instrument Identifier

OI

See ID? on Page 4-26.

OR .. .. Output Result

OR

This command causes the 4947A to output the result of the current measurement point. It should be used after the instrument indicates a result is available by the setting of bit #0 (Result Ready) in the **primary status byte**.

The layout of the result data list depends on the measurement (see Page 4-11 for details).

In general a result is only available when bit #0 of the **primary status byte** is set. Trying to read a result at any other time will generate a context error. The exception to this is during measurements that produce a continuous stream of results, such as Transients or Phase Jitter. When these measurements are running a result may always be read.

OS .. .. Output Instrument Status

OS

This command causes the 4947A to output a value describing the state of the instrument. This value is the decimal equivalent of the **primary status byte** value as returned in response to a serial poll. The value is returned in decimal form and is the sum of the enabled bits.

A complete description of the **primary status byte** can be found on Page 4-16.

After this data has been read, primary status bit #3 (LOCAL) is cleared. Bit #6 (SRQ) is normally only cleared by a serial poll. It will, however, also be cleared if all the causes for the service request are removed.

RA .. .. Set Sweep/Sequence Speeds/EDD Averaging Time

RA <sweep-rate>,<sequence speed>
RA?

<sweep rate>
<sequence speed> = 0, 1 or 2

The RA command is used to set up the sweep and sequence speeds in the 4947A. When set to 0 the instrument obeys the appropriate rear panel switch. If the relevant rate is set to 1 then the sweep or sequence speed will be slow; if set to 2, the speed will be fast.

The fast sequence speed should only be used when measuring loopback (see Page 2-20).

In the EDD measurement: long averaging is used with the slow sweep,
short averaging is used with the fast sweep.

The fast sweep rate should not be used on the repeat instrument in a EDD Forward Reference Mode measurement.

The slow sweep rate/long averaging time provides the best possible accuracy in EDD; it takes four times longer than the fast rate.

The query form of command RA? returns the two values set up. It does not read the rear panel switches as these should not be relied on for remote operation.

RQS .. .. Enable/Disable SRQ

RQS OFF
RQS ON

These commands enable or disable the capacity of the 4947A to issue service requests.

"RQS OFF" will inhibit the issuing of service requests.

"RQS ON" will enable the 4947A to send service requests specifically for the conditions given in the most recently received srq mask (see the "SRQ" command). Note that "RQS ON" does not reset this mask, but merely re-enables it.
The power-on condition is service request enabled.
The 4947A will accept the messages "RQS 0" and "RQS 1" as alternatives to "RQS OFF" and "RQS ON" respectively.

SF .. .. Set Parameters For Single Frequency (SF) Dialing

SF <parameter list>
SF?

The SF command is used to set up the parameters for SF dialing. It takes five parameters as follows:

<tone level> : Transmit level of the SF tone in dBm.
<tone frequency> : The SF dialing frequency in Hz.
<mark time> : Tone-on time, in seconds, to a resolution of 0.001s.
<space time> : Tone-off time, in seconds, to a resolution of 0.001s.
<interdigit time> : Inter-digit time (pause between sending each digit), in seconds, to a resolution of 0.001s.

The default parameters of SF are: **0.0, 2600, 0.06, 0.04, 0.8**

These dialing parameters are stored in non-volatile memory and so are retained when the 4947A is powered down.

The query form of the command SF? will cause the 4947A to return the current signaling dialing parameters.

Note that normal telecommunications practice characterises the SF tone pulses by their repetition frequency and % break. The formulae to convert repetition frequency and % break to <mark time> and <space time> are:

<mark time> = (1/repetition frequency) + (% break/100)
<space time> = (1/repetition frequency) - <mark time>

Note also that the <interdigit time> is not strictly in accordance with normal practice. The actual time delay between the last tone pulse of one digit and the first tone pulse of the next digit is <interdigit time> + <space time>.

SK .. .. Select SF Skip

SK <flag> <flag> = 0 or 1
SK?

These commands are used to set the 4947A in and out of SF Skip mode. With <flag> set to 1 the instrument will never transmit any frequency in the range 2451Hz to 2749Hz.

The query form of the command SK? will cause the 4947A to return the currently set SF Skip parameter. For example, if SF skip is ON, the string returned will be SK1.

SM .. .. Store Mask

SM

This command changes the power on values of measurement parameters (stored in the non-volatile memory area within the 4947A).

SP .. .. Set Frequency Sweep Parameter

SP <from>,<to>,<step>
SP?

From, To : 50Hz to 5004Hz

Step : 1 to 5000Hz

This command sets the frequency sweep parameters.

SRQ .. .. Set SRQ Response Mask

SRQ <mask> <mask> = 0 .. 63 (decimal)
SRQ?

These commands enable the 4947A to SRQ the HP-IB controller when a specific condition(s) occur or return the SRQ enable mask. The following table gives the parameter <mask> value for the various conditions. To combine conditions, add the appropriate values. For example **SRQ 33** will enable SRQ on **error** or **result ready**. Note that each bit in the SRQ mask corresponds to a bit in the **primary status byte**. An SRQ will be generated on a 0 -> 1 transition of an enabled primary status byte bit.

Primary Status Byte Bit #	<mask value>	SRQ condition enabled
0	1	Result ready.
1	2	End of point.
3	8	LOCAL key.
4	16	Ready for next command.
5	32	Error.

The 4947A can also be configured to SRQ at power-on. This is set by the P ON SRQ switch (part of the HP-IB switch) on the rear panel of the instrument and cannot be altered by remote programming.

At power-on the bits #0 thru #5 of the SRQ mask are set to zero. The 4947A will accept the SRQ command in any state.

CAUTION

If the 4947A is enabled to SRQ on more than one condition, care must be taken designing the interrupt service routine in the controller. (See pages 4-15 and 4-20).

The query form of the command **SRQ?** will cause the 4947A to return the current value of the SRQ enable mask.

SV .. .. Set Loudspeaker Volume

SV <vol> <vol> = 0 .. 7
SV?

These commands are used to set the volume of the internal monitor loud speaker of the instrument or returns the <vol> parameter. The parameter values are:
0 = OFF, 1 = QUIET..... 7 = VERY LOUD.

The query form of the command SV? will cause the 4947A to return the currently set speaker volume. For example, if this is QUIET, the string returned will be SV 1.

SW .. .. Start/Stop Frequency Sweep or Start Sequence

SW <param> <param> = 0, 1 or 2
SW?

0 = normal (sweep off)
1 = starts the sweep from the current setting
or starts transmitting sequence
2 = starts the sweep from the "From" frequency
(see SP command)

This command starts or stops the 4947A sweep mode. In sequence mode, SW1 causes the 4947A to start operating as a sequence transmitter only.

TE .. .. Select Self Test or Perform Calibration

TE <test #> <test #> = 0 .. 17
TE?

This command puts the 4947A into the Self Test state or returns the currently selected Self-Test number. The TE command is identical to pressing the CAL key on the front panel.

The parameter <test #> selects an initial test point - see Table below. A parameter value of 0 has a special meaning; it takes the instrument out of the Self Test state (if selected) back to previously selected mode and measurement.

<test #>	Description
1	Full self calibration.
2	TX gain check.
3	RX gain check.
4	RX autorange paths gain check.
5	RX autorange calibration.
6	TX attenuator paths gain check.
7	TX attenuator calibration.
8	TX flatness check.
9	RX flatness check.
10	Transients circuit gain check.
11	RX flatness check.
12	Processor roms CRCs check.
13	Non-volatile RAM (A13) test.
14	RAM test.
15	Internal instrument bus test.
16	Front panel test.
17	Digital filter test.

Some self-tests have a number of "subpoints". The end of each subpoint causes the RESULT bit of the primary status byte to go true, the last subpoint in a test causes the EOM (end-of-measurement) bit to go true. The OR command can then be used to recover the results of the self-test.

To step from one subpoint to the next, SW1 must be sent. This allows control over the remote running of self-test.

The query form of the command TE? will cause the 4947A to return the currently selected Self-Test number. For example, if point #7 is selected the string returned will be TE 7. If the instrument is in Self-Test state the TE 0 form of the command can be used to select the previous operating mode and measurement. Alternatively the ME command can be used to select a new measurement.

TH .. .. Set Reference Level or Transhybrid Loss Values

TH <level>
TH?

<level> = -99.9 .. +99.9

These commands are used to set up or read the stored values of the reference level during LEVEL/FREQ and EDD, or transhybrid loss during RETURN LOSS. The parameter <level> should be in dBm or dB to a precision of one decimal place.

These values are set either by the TH command directly or by using the ZE command to identify a measurement as a reference (see ZE).

The query form of the command TH? will cause the 4947A to return the current value of the setting. For example, if the transhybrid loss level is -7.8dB, the TH? command will cause the 4947A to return TH -7.80.

ZE .. .. Set Zero

ZE <type>
ZE?

<type> = 0 .. 1

This command is used to store reference points in swept measurements or correction values for INTERMOD and RETURN LOSS.

In LEVEL/FREQ, 0 = Absolute mode, 1 = Relative mode. When <type> = 0, results are in dBm. When <type> is programmed to 1, all following results are in dB referenced to the last measurement before it was programmed. The TH command can be used to modify this reference if required.

In EDD, each delay result is initially referenced to the previous delay result. When ZE1 is sent, the instrument uses its most recent result as a reference for all future results, for both delay and level. Sending ZE1 again establishes a new reference.

In INTERMOD the measurement starts with <type> set to 0 and performs the measurement without a noise check. Setting type to 1 causes the two tone noise check to be performed repeatedly. Upon returning <type> to 0 all following measurements are noise corrected.

In RETURN LOSS, ZE works like the SET ZERO key. This can be used to correct the results for transhybrid loss, or total channel loss.

GENERAL HP-IB INFORMATION

Types of Devices on the Bus

There are three types of bus devices: talkers, listeners or controllers.

- A talker is a device which can send out data.
- A listener is a device which can receive data.
- A controller is a device which controls the actions of the talker and listeners on the bus.

The 4947A operates in the following two modes:

Addressable (Talk/Listen) mode - for use with a controller (see this section).
Talk Only mode - for use with a listen only device (see Section 3).

The 4947A has no LISTEN ONLY capability.

Useful Reference Publications

IEEE Interface Standard 488-1978
ANSI Interface Standard MC1.1
"Improving Measurements in Engineering and Manufacturing" (HP Part No 5952-0058)
"Condensed Description of the Hewlett-Packard Interface Bus" (HP Part No 59401-90030)

HP-IB Capability

The interface functions of the 4947A (as defined in IEEE 488-1978) are listed below.

HP-IB Capability

Code	Description
SH1	Complete capability
AH1	Complete capability
T5	Basic talker, serial poll, talk only mode, unaddress if MLA
TE0	No extended talker capability
L4	Basic listener, unaddress if MTA
LE0	No extended listener capability
SR1	Complete SRQ capability
RL1	Complete remote-local capability
PP0	No parallel poll capability
DC1	Complete device clear capability
DT0	No device trigger capability
C0	No controller capability

Local & Remote States and Messages

In the "Addressable" mode the instrument can operate under either local or remote control.

LOCAL OPERATION: All front and rear panel controls (except the HP-IB switch) are responsive and control the instrument.

REMOTE OPERATION: Most front and rear panel controls are inoperative, the instrument is controlled by the HP-IB controller. The front panel indicators will reflect the remote programming commands received.

At switch-on the instrument assumes the local state. Under local control all HP-IB commands will be accepted, but those that attempt to change the state of the instrument will not be obeyed.

The 4947A is put into the remote state by setting the REN signal line and by addressing the 4947A to listen. The instrument then responds to all valid HP-IB commands.

The instrument can be returned from "remote" to "local" operation by either pressing the "GO TO LOCAL" key on the front panel or by the controller sending the "go to local" (GTL) message, or by de-asserting REN.

It is highly recommended that the 4947A be in "remote with local lockout" state (RWLS) when being controlled via the HP-IB. This will disable the front panel GO TO LOCAL key and guarantee that the system controller has sole control of the instrument at all times. To do this, the controller should send the REN message followed by the LLO message.

When in the RWLS state the GO TO LOCAL key will cause bit #3 of the primary status byte to be set. It is then up to the discretion of the controller whether to return the instrument to local control or ignore the request.

Pressing the GO TO LOCAL key when already under local control will abort the execution of any HP-IB commands. This provides a way out of a potential hang up should the controller go down when the instrument is sending it a data list.

Device Clear & Serial Poll

Device Clear (DCL) and Selective Device Clear (SDC)

The 4947A responds to the DCL and SDC messages by returning the instrument to its initialised condition regardless of the current state. The initialised configuration is as follows:

- The HP-IB input and output buffers are cleared, as is the error queue.
- Idle state is selected.

Serial Poll (see also Pages 4-15 and 4-20)

The 4947A can be serial polled at any time to retrieve the value of the primary status byte. A serial poll will also clear the request service (rsv) message (SRQ line) if this is set.

The meaning of each bit in the primary status byte is given on Page 4-16.

If required, the operator can make the 4947A send EOI with the serial poll status byte by re-setting the HP-IB switch on the 4947A.

SPOLL (device selector) is the statement used by many controllers to carry out serial poll. To poll the 4947A, the device selector must be a combination of the interface select code and device address, e.g. in Program 2 SPOLL (702).

This will return the 4947A's primary status byte. If bit 6 of the primary status byte is set, it indicates that the 4947A is requesting service.

GENERAL INFORMATION

SECTION 5

INTRODUCTION

This manual contains information which allows the user to operate the Hewlett-Packard Model 4947A Transmission Impairment Test Set. A 4947A together with the accessories supplied and initial inspection information, are shown on Page vi.

On the title page of this manual is a Microfiche Part Number. This number can be used to order 4 X 6 inch microfilm transparencies of the manual. Each microfiche containes up to 96 photo duplicates of the manual pages.

SPECIFICATION

Instrument specifications are listed on Page 5-3. These specifications are the performance standards or limits against which the instrument is tested.

SAFETY CONSIDERATION

This product is a Safety Class I instrument (provided with a protective earth terminal). The instrument and manual should be reviewed for safety markings and instructions before operation. Also read the Warning on Page ii.

INSTRUMENTS COVERED BY MANUAL

Attached to the instrument is a serial number plate. This serial number is in the form XXXXUXXXXX. It is in two parts; the first four digits and the letter are the serial prefix and the last five are the suffix. The prefix is the same for all identical instruments, it changes only when a change is made to the instrument. The suffix however, is assigned sequentially and is different for each instrument. The contents of this manual apply to instruments with the serial number prefix(es) listed under SERIAL NUMBERS on the title page.

An instrument manufactured after the printing of this manual may have a serial number prefix that is not listed on the title page. The unlisted serial number prefix indicates the instrument is different from those described in this manual. The manual for this new instrument is accompanied by a Manual Changes supplement. This supplement contains "change information" that explains how to adapt the manual to the new instrument.

In addition to change information, the supplement may contain information for correcting errors in the manual. To keep this manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. The supplement for this manual is identified with the manual print date and part number, both of which appear on the manual title page. Complimentary copies of the supplement are available from Hewlett-Packard. For information concerning a serial number prefix that is not listed on the page or in the Manual Changes supplement, contact your nearest Hewlett-Packard office.

EQUIPMENT AVAILABLE

A printer/plotter and external controller can be used with this instrument. A typical example of each is listed here:

HP9816S Model 216S . . . . . Computer with BASIC
HP2225A . . . . . ThinkJet Printer

SPECIFICATIONS

GENERAL

IMPEDANCES (balanced) : 600Ω, 900Ω, 1200Ω with TRMT and RCV independent.

BRIDGING LOSS (RECEIVER) : < 0.2 dB.

HIGH VOLTAGE PROTECTION (AC and DC) : per IEEE 743 - 1984.

RETURN LOSS (TRMT and RCV) :
50 Hz to 5 kHz : > 15 dB
200 Hz to 4 kHz : > 30 dB

LONGITUDINAL BALANCE (TRMT and RCV) : > 90 dB, 50 Hz to 120 Hz, decreasing less than 6 dB per octave to 5 kHz.

HOLD CIRCUITS : TRMT and RCV, independent. Hold current: 24 mA, nominal, resettable 20 to 30 mA.

DIALING : Dialing mode converts 16 front panel keys to a keypad for transmitting multifrequency digits (normally DTMF but reprogrammable via HP-IB).

SF SKIP (Level/Frequency and EDD) : Skips a band from 2450 to 2750 Hz.

HOLDING TONE :
Frequency : 1004 ± 0.1 Hz.
Range : -40 to +10 dBm.
Resolution : 0.1 dB.
Accuracy : ±0.1 dB, -19 to 0 dBm.
Elsewhere ± 0.2 dB.

SIGNAL LEVEL DETECTOR : True RMS.

POWER REQUIREMENTS : 100-120/200-240 VAC, +6%/-10%, 48 to 66 Hz; 85 watts nominal.

OPERATING ENVIRONMENT :
Temperature : 0 ° to +50 °C.
Humidity : 10% to 90%, non-condensing.
Altitude : Up to 4600 m (15000 ft).
Internal Calibration : At power up and on demand.

DIMENSIONS (excluding feet) :
178 H x 425 W x 438 mm D (7.0 x 16.75 x 17.25 in).

INSTRUMENT WEIGHT : 15 kg (33 lb).

HP-IB (IEEE 488) CAPABILITIES :
All, SH1, L4, T5, SR1, RL1, DC1.

Note : The measurement resolutions stated are for display and printout. The resolution of most results returned to a controller is ten times better.

MONITOR OUTPUT (rear panel) :
Connector : WECO 310.
Impedance : 600Ω nominal.
Signal : Demodulated phase jitter.

LEVEL/FREQUENCY

Transmitter Level

RANGE : -60 to +10 dBm.

RESOLUTION : 0.1 dB.

ACCURACY (in dB) :
At 1004 Hz, -19 to 0 dBm : ± 0.1;
50 to 200 Hz, -50 to +10 dBm : ± 0.5;
200 to 5004 Hz, -50 to +10 dBm : ± 0.2.

FLATNESS : 0.2 dB peak to peak (-50 to 10 dBm, 200 Hz to 5 kHz).

TOTAL DISTORTION (1004 Hz, level > -40 dBm) : > 50 dB down on fundamental.

Transmitter Frequency

RANGE : 50 to 5004 Hz.

RESOLUTION : 1 Hz.

ACCURACY : ± 0.01% of output Frequency.

SWEEP :
Step Size : Programmable from 1 Hz to 5 kHz.
Step Rate (nominal) :
Level/Frequency : 1 or 5 sec/step.
(Rate set by switch on rear panel or via HP-IB.)

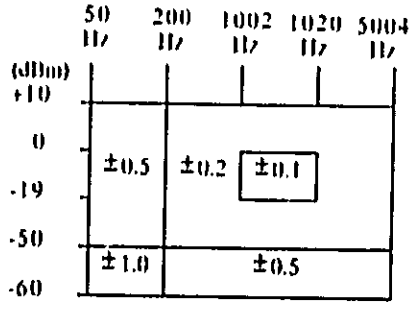
4 PREPROGRAMMED FREQUENCIES : 404 Hz (F1), 1004 Hz (F2), 2804 Hz (F3), 2713 Hz (F4) at power up. Subsequently, new values can be set for F1 to F4.

Receiver Level

RANGE : -60 to +10 dBm

RESOLUTION : 0.1 dB.

ACCURACY (in dB) :



Receiver Frequency

RANGE : 200 to 5004 Hz.

RESOLUTION : 1 Hz.

ACCURACY : ± 1 Hz typical (level > -50 dBm; S/N > 20 dB).

MESSAGE CIRCUIT NOISE

TRANSMITTER : Terminated.

RECEIVER :
Filters : C-message and 3 kHz flat per IEEE 743 - 1984.
Range : 10 to 90 dBrn.
Resolution : 1 dB.
Accuracy : ± 1 dB.

NOISE WITH TONE

TRANSMITTER :
Holding Tone : See General.

RECEIVER :
Filters : Notch and C-message per IEEE 743 - 1984.
Range : 10 to 90 dBrn (S/N Ratio > 45 dB).
Resolution : 1 dB.
Accuracy : ± 1 dB.

SIGNAL-TO-NOISE-RATIO

TRANSMITTER :
Holding Tone : See General.

RECEIVER :
Filters : Notch and C-message per IEEE 743 - 1984.
Signal Level Range : -40 to +10 dBm.
S/N Ratio Range : 10 to 45 dB.
Resolution : 1 dB.
Accuracy : ± 1 dB (noise > -80 dBm).

NOISE-TO-GROUND

TRANSMITTER : Terminated.

RECEIVER :
Filters : C-message and 3 kHz flat per IEEE 743 - 1984.
Range : 40 to 130 dBrn.
Resolution : 1 dB.
Accuracy : ± 1.5 dB.

SPECIFICATIONS (continued)

INTERMODULATION DISTORTION

TRANSMITTER :
Signal : 4-tone, non-linear distortion.*
Range : -40 to 0 dBm
Resolution : 0.1 dB
Accuracy : ± 1 dB.

RECEIVER :
Level Range : -40 to 0 dBm.
Distortion Display Range : 10 to 70 dB.
Second order filters centered at 520 Hz and 2240 Hz. Third order filter centered at 1900 Hz.
Resolution : 1 dB.
Accuracy : ± 1 dB from 10 to 55 dB.
Noise Check : Manually selected; compensation then applied automatically.

*Licensed under Hekimian Laboratories, Inc. US Patent No. 3,862,380 for non-linear distortion analyzer.

P/AR (PEAK TO AVERAGE RATIO)

TRANSMITTER :
Signal : Per IEEE 743 - 1984.
Level Range : -40 to 0 dBm.
Resolution: 0.1 dB.
Accuracy : ± 0.25 dB.

RECEIVER :
Level Range : -40 to 0 dBm.
P/AR Range : 0 to 120 units.
Resolution : 1 P/AR unit.
Accuracy : ± 2 P/AR units from 40 to 110 P/AR units;
± 4 P/AR units elsewhere.

PHASE JITTER

TRANSMITTER :
Holding Tone : See General.

RECEIVER :
Holding Tone : -40 to 10 dBm, 990 to 1030 Hz.
Jitter Range : 0° to 30° peak-to-peak.
Jitter Accuracy : ± 0.2°, ± 5% of reading (frequency weighting as IEEE 743 - 1984).
Bandwidths : 20 to 300 Hz (Bell standard).
4 to 300 Hz (Bell standard + LF).
Output : Demodulated Jitter available.

TRANSIENTS

TRANSMITTER :
Holding Tone : See General.

RECEIVER :
General :
HOLDING TONE : -40 to 10 dBm, 995 to 1025 Hz.
COUNTER :
Rate : 8 or 100 counts/sec (nominal), selectable.
Range : 0 to 9998 counts.
Qualification Interval : > 4 ± 0.5 ms.
TIMER : 1 to 599 minutes or continuous.
Phase Hits :
CARRIER LEVEL : > -40 dBm.
THRESHOLD : 5 to 40° in 5° steps.
ACCURACY (8 counts/sec rate) : ± 0.5°, ± 10% of threshold setting.
Gain Hits :
CARRIER LEVEL : > -40 dBm.
THRESHOLD : 2, 3, 4 or 6 dB
ACCURACY (8 counts/sec rate) : ±0.5 dB.
Dropouts :
CARRIER LEVEL : > -30 dBm at start of measurement.
THRESHOLD : 12 dB.
ACCURACY (8 counts/sec rate) : ± 1 dB.
INTERLOCK TIME : 1 sec.
Impulse Noise (with or without holding tone) :
THRESHOLD RANGE :
Low : 30 to 92 dBrn in 1 dB steps.
Mid and High Thresholds : 4 dB and 8 dB above Low, respectively.
If holding tone present,
- min setting of low threshold is 25 dB below holding tone level.
- if ALL TRANSIENTS selected, max setting of low threshold is 10 dB above holding tone level.
THRESHOLD ACCURACY : ± 1 dB.

4-WIRE RETURN LOSS

MODES : FRL, SRL High, SRL Low.

TRANSMITTER :
Signal : Per IEEE 743 - 1984.
Level Range : -40 to 0 dBm.

RECEIVER :
Range : 0 to 50 dB.
Resolution : 0.1 dB.
Accuracy : ± 0.5 dB.
Transhybrid Loss Compensation : -99.9 to +99.9 dB.

ENVELOPE DELAY

TRANSMITTER :
Carrier Frequency Range : 1000 to 3504 Hz.
Resolution : 1 Hz.
Frequency Sweep : As Level/Frequency but step rate is 3 or 12 sec/step, nominal. (Rate set by switch on rear panel or via HP-IB.)
Level Range : -40 to 0 dBm.
Resolution : ± 0.1 dB
Modulation Frequency : 83-1/3 Hz, ± 0.1%.

RECEIVER:
Level Range : -40 to 0 dBm.
Level Accuracy : ± 0.5 dB
Measurement Range : -3000 to 9000 µs.
Resolution : 10 µs.
Accuracy : (S/N > 24 dB)

Averaging	300 Hz	600 Hz	3504 Hz
Short	± 30 µs		± 20 µs
Long	± 30 µs		± 10 µs

Short averaging is 3 sec nominal. Short or long averaging selected by switch on rear panel or via HP-IB.
Repeat Mode, Return Reference : Error twice that shown in the table.

OPTIONS

907 : Front handle kit.
908 : Rack flange kit.
910 : Extra set of manuals.

ACCESSORIES

HP 18182A : 36 inch test cord, WECO 310 connector to alligator clips.
HP 15513A : 36 inch test cord, WECO 310 connector at each end
HP 2225A : Think Jet printer with HP-IB interface.
HP10833A : HP-IB cable, 3ft.

INSTALLATION

SECTION 6

INTRODUCTION

This section provides installation instructions for the Hewlett-Packard Model 4947A Transmission Impairment Measuring Set and its accessories. This section also includes information about preparation for use, packaging, storage and shipment.

PREPARATION FOR USE

WARNING

TO AVOID THE POSSIBILITY OF INJURY OR DEATH, THE FOLLOWING PRECAUTIONS MUST BE FOLLOWED BEFORE THE INSTRUMENT IS SWITCHED ON.

(A) NOTE THAT THE PROTECTION PROVIDED BY GROUNDING THE INSTRUMENT CABINET MAY BE LOST IF ANY POWER CABLE OTHER THAN THE THREE-PRONGED TYPE SUPPLIED IS USED TO COUPLE THE AC LINE VOLTAGE TO THE INSTRUMENT

(B) IF THIS INSTRUMENT IS TO BE ENERGIZED VIA AN AUTO-TRANSFORMER TO REDUCE OR INCREASE THE LINE VOLTAGE, MAKE SURE THAT THE COMMON TERMINAL IS CONNECTED TO THE NEUTRAL POLE OF THE POWER SOURCE.

(C) THE POWER CABLE PLUG SHALL ONLY BE INSERTED INTO A SOCKET OUTLET PROVIDED WITH A PROTECTIVE EARTH CONTACT. THE PROTECTIVE ACTION MUST NOT BE NEGATED BY THE USE OF AN EXTENSION CORD WITHOUT A PROTECTIVE CONDUCTOR (GROUNDING).

Power Requirements

The instrument requires a power source of 100 to 120V or 200 to 240V ac, +6% -10%, 48 to 66Hz single phase. The maximum power consumption is 100VA.

Line Voltage Selection and Fuse

The line voltage is selected by the rear panel switch labelled 100 - 120V and 200 - 240V.

CAUTION

Before connecting the instrument to a power outlet ensure that the line voltage selector is correctly set, and that a fuse of the correct rating is fitted.

Fuse ratings are given in the table below.

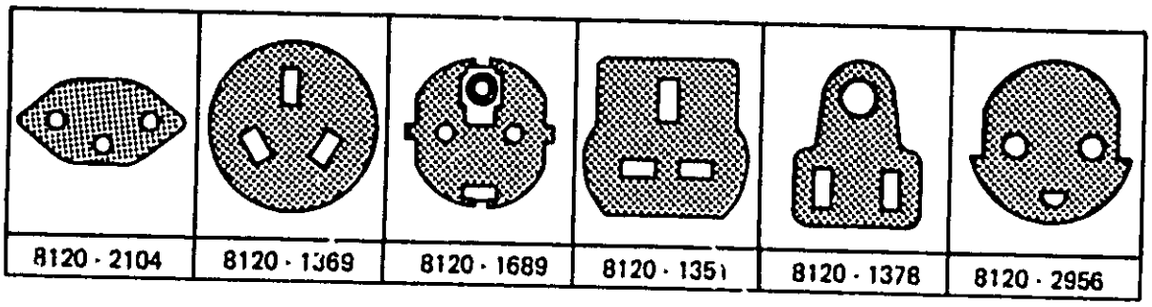
Fuse Ratings

Nominal Line	Fuse Rating	HP Part Number
115V	3AT/250V	2110-0381
230V	2AT/250V	2110-0303

Power Cable

This instrument is equipped with a three-wire power cable. When connected to a power outlet, this cable grounds the instrument case. The type of power cable shipped with each instrument depends on the country of destination. Refer to the table below for part numbers of the power cable and plug configurations available. The number shown below each plug is the Hewlett-Packard part number of a power cord equipped with that plug. If the appropriate power cord is not included with the instrument, notify the nearest Hewlett-Packard Sales and Service Office and a replacement will be provided.

Power Receptacles



The colour code used in each power cable is given below:

Line : Brown
Neutral : Blue
Ground : Green/Yellow

Internal Battery

WARNING

DO NOT INCINERATE OR MUTILATE THE BATTERY. IT MIGHT BURST OR RELEASE TOXIC MATERIALS CAUSING PERSONAL INJURY.

The lithium battery on A13 used as a power supply for the non-volatile memory, should be checked annually. Life expectancy of the battery is approximately 5 years.

Operating Environment

Temperature - The instrument may be operated in temperatures from 0 degrees centigrade to +50 degrees centigrade.

Humidity - The instrument may be operated in environments with humidity up to 90%. However, the instrument should also be protected from temperature extremes which may cause condensation within the instrument.

Altitude - The instrument may be operated at altitudes up to 4600m (15,000ft.)

Air flow - The air intake to the instrument is via a fan mounted on the rear panel. The air exhaust is via the perforated side panels. To provide adequate cooling, an air gap of approximately 3 inches should be maintained around the instrument.

The fan filter should be removed from the instrument and cleaned in hot soapy water every six months or more frequently if the instrument is operated in a hostile environment.

FRONT PANEL CONNECTORS

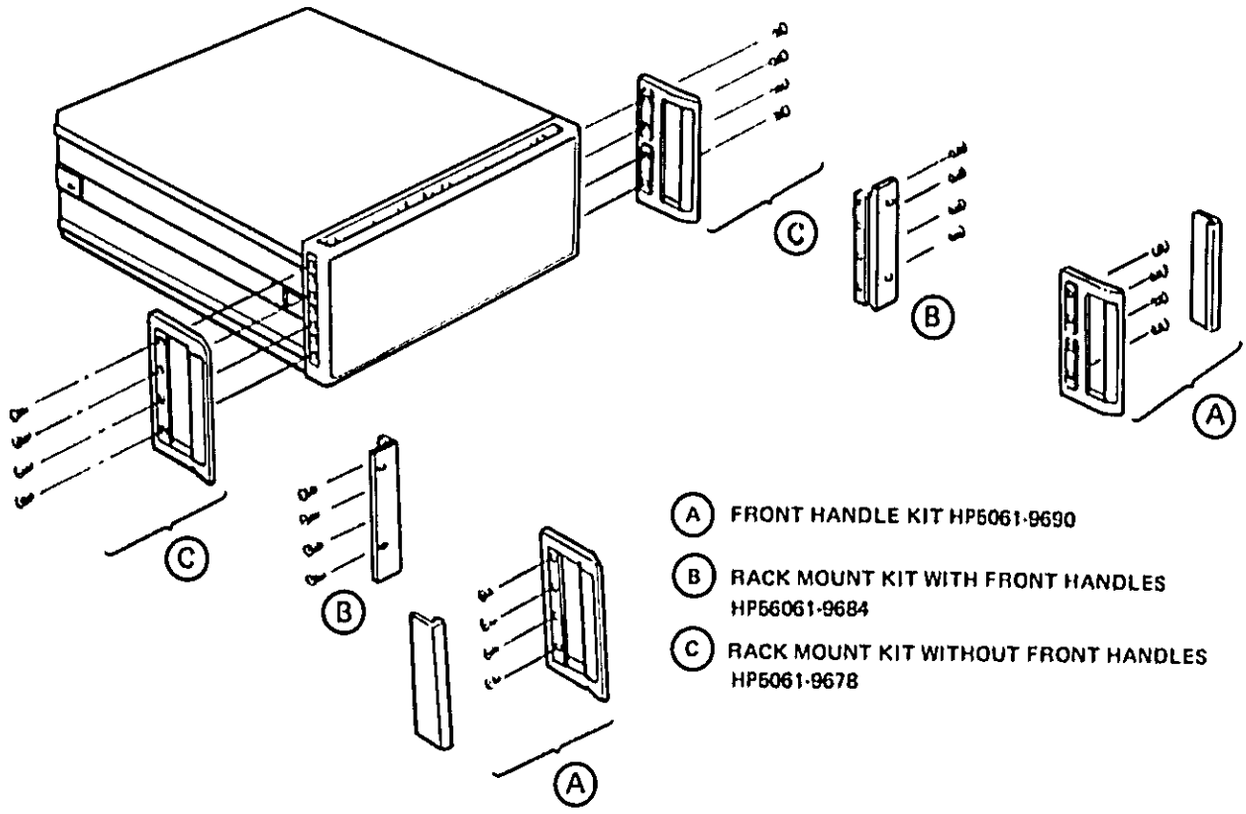
The mating connectors for the 4947A front panel connectors are listed below.

Front Panel Connectors

Description	Connector	Mating Connector Part Number
Receiver Port	Weco 310	1251-0695
Transmitter Port	Weco 310	1251-0695

RACK MOUNTING

Illustrated below are the three Rack Mount Kits available for use with the 4947A. Refer to Page 6-3 regarding the cooling of rack mounted instruments.



Rack Mount Kits

HEWLETT-PACKARD INTERFACE (HP-IB) BUS

This section contains information for installing the 4947A Transmission Impairment Measuring Set into a Hewlett-Packard Interface Bus (HP-IB) system.

The HP-IB is Hewlett-Packard's implementation of the IEEE Standard 488-1978 (Digital Interface for Programmable Instrumentation). This standard defines a physical interface and protocol which enables the remote control of instrumentation systems.

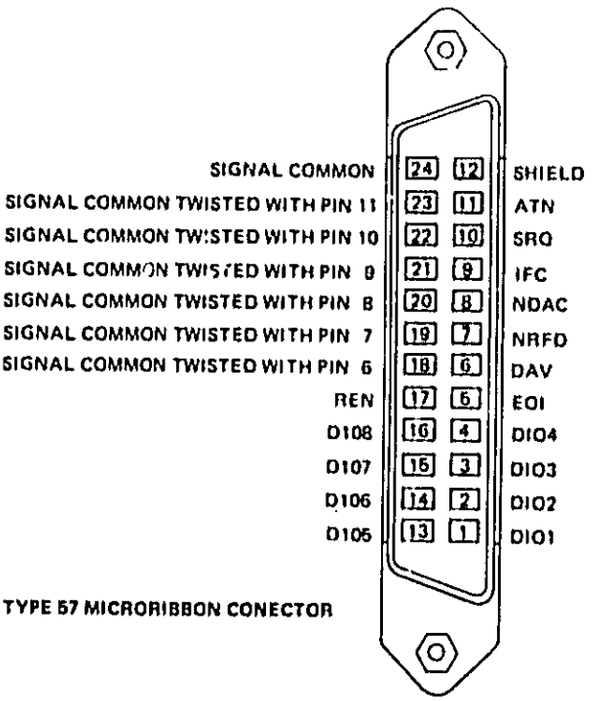
Connection to the HP-IB

Logic Levels

The HP-IB logic levels are TTL compatible i.e. the true (1) state is 0V dc to 0.5 dc and the false (0) state is +2.5V to 5V dc.

Mating Connector

HP1251-0293;
Amphenol 57-302040



HP-IB (rear panel) Connector

The HP-IB connector on the rear panel of the 4947A provides the physical interface to connect the 4947A into an HP-IB system. The figure above illustrates the connector pin configuration. Devices in the HP-IB system may be interconnected in any suitable arrangement (star, delta, etc) using the HP-IB cables listed in the table below.

HP-IB Interface Cables

Part Numbers	Cable Lengths
HP10833A	1m (3.3ft)
HP10833B	2m (6.6ft)
HP10833C	4m (13.2ft)
HP10833D	0.5m (1.6ft)

To meet design performance, restrictions are placed on the length of HP-IB system cable as follows:

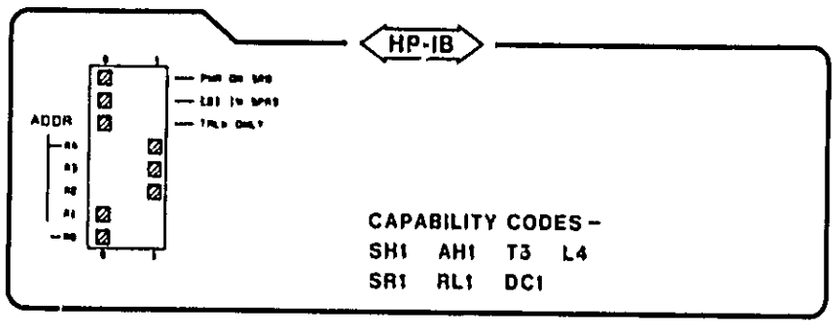
- The total length of HP-IB cable used to interconnect devices on the HP-IB must not exceed 2 metres (6 feet) times the number of devices in the system.
- The total length of HP-IB cable used to interconnect all devices must not exceed 20 metres (65 feet).

The 4947A In the Talk Only Mode

Setting the 4947A rear panel HP-IB switch to the TALK ONLY (1) position enables you to print or plot results on a HP2225A ThinkJet Printer.

Results are output in ASCII format to the printer via the rear panel HP-IB connector. Ensure that the printer is set to LISTEN ALWAYS and that it is the only device connected to the rear panel HP-IB connector.

The 4947A as an Addressable Device



HP-IB Switches - 4947A as an Addressable Device

Setting the rear panel HP-IB switch to the ADDR (0) position configures the 4947A as an HP-IB addressable device under the remote control of a separate HP-IB controller. Each device in the HP-IB system requires a unique address to enable the system controller to differentiate between the devices. The address switches A0 to A4 define the HP-IB address (addresses range from 0 to 30). The following table provides HP-IB address information.

HP-IB Address Information

Address Characters		Address Code	Address Switch Settings				
Listen	Talk	Decimal	A4	A3	A2	A1	A0
Space	@	0	0	0	0	0	0
!	A	1	0	0	0	0	1
"	B	2	0	0	0	1	0
#	C	3	0	0	0	1	1
$	D	4	0	0	1	0	0
%	E	5	0	0	1	0	1
&	F	6	0	0	1	1	0
'	G	7	0	0	1	1	1
(	H	8	0	1	0	0	0
)	I	9	0	1	0	0	1
*	J	10	0	1	0	1	0
+	K	11	0	1	0	1	1
,	L	12	0	1	1	0	0
-	M	13	0	1	1	0	1
.	N	14	0	1	1	1	0
/	O	15	0	1	1	1	1
1	P	16	1	0	0	0	0
1	Q	17	1	0	0	0	1
2	R	18	1	0	0	1	0
3	S	19	1	0	0	1	1
4	T	20	1	0	1	0	0
5	U	21	1	0	1	0	1
6	V	22	1	0	1	1	0
7	W	23	1	0	1	1	1
8	X	24	1	1	0	0	0
9	Y	25	1	1	0	0	1
:	Z	26	1	1	0	1	0
;	[	27	1	1	0	1	1
<	/	28	1	1	1	0	0
=	]	29	1	1	1	0	1
>	↑	30	1	1	1	1	0

STORAGE AND SHIPMENT

Environment

The instrument may be stored or shipped in environments within the following limits:

Temperature	-40 degrees centigrade to +75 degrees centigrade
Humidity	90%
Altitude	15,300m (50,000ft)

The instrument should also be protected from temperature extremes which may cause condensation within the instrument.

Packaging

Tagging for Service - If the instrument is being returned to Hewlett-Packard for service, please complete one of the blue repair tags located at the front of the service manual and attach it to the instrument.

Original Packaging - Containers and material identical to those used in the factory packaging are available through Hewlett-Packard offices. If the instrument is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required, return address, model number and full serial number. Also mark the container "FRAGILE" to ensure careful handling.

Other Packaging - The following general instructions should be used for re-packing with commercially available materials:

(a) Wrap instrument in heavy paper or plastic. (If shipping to Hewlett-Packard office or service centre, attach a tag indicating type of service required, return address, model number and full serial number.)

(b) Use strong shipping container. A double-walled carton of 350-pound test material is adequate.

(c) Use a layer of shock absorbing material 70 to 100mm (3 to 4 inch) thick around all sides of the instrument to provide firm cushioning and prevent movement inside the container. Protect the control panel with cardboard.

(d) Seal shipping container securely.

(e) Mark the shipping container securely.

(f) In any correspondence, refer to instrument by model number and full serial number.

ERROR CODES

APPENDIX A

The error codes and the conditions which will cause them to be displayed are listed below. If you require more information refer to the troubleshooting section of the Service Manual.

Error Codes

Code	Cause
Err 1	Received level too high to measure.
Err 2	Received level too low to measure.
Err 3	Received level unstable or drifting out-of-range.
Err 4	Impulse noise threshold setting invalid for current received level.
Err 5	HP-IB command string invalid (see Command Validity, Page 4-5).
Err 6	HP-IB command ignored, 4947A under local control or 4947A addressed to talk but no listener present.
Err 7	Processor RAM faults (A13 U58)
Err 8	Processor ROM faults.
Err 9	Processor or instrument bus fault.
Err 10	Measurement Hardware fault.
Err 11	Bus Hardware fault.
Err 12	Calibration errors.
Err 13	Digital filter self-test errors.
Err 14	System software errors.
Err 15	System software errors.
Err 16	Measurement software errors.

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