HP 37741A DS1 Tester

User's Manual

WARNING

Read section 0! It tells you about warranty, service, and support, and about hazards that may endanger your safety.

IMPORTANT

Write the serial number of your instrument here. It will help you identify your instrument and manual needed to operate it.

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HEWLETT PACKARD

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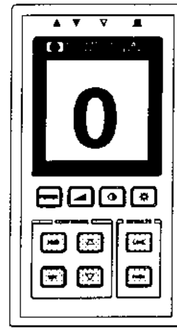


Warranty, Service, and Support

0.1 Scope

This document details the product specifications, describes the software and hardware functionality, and contains user operating instructions and calibration procedures for the HP 37741A DS1 tester. This manual covers the features of version 3 of the instrument firmware.[1]

WARNING

This instrument may be used to test span powered repeatered T1 lines. Voltages of 135 Vdc may be present on these lines. Ensure the span power is switched off before inserting or removing the bantam connectors.

This manual covers the two products in the family:

- The standard product (HP 37741A) is a handheld instrument, intended for portable applications.
- The second product (HP 37741A option H01) is a rackmountable product, intended for semi-permanent, or permanent installation.

The measurement capabilities of the two products are identical. The standard product can be operated from the front panel, or externally over a serial port. The rackmountable product can be operated only over the serial port.

1 Section 0.7 describes the product revisions.

0.2 Limited Warranty

0.2.1 One year Limited Warranty

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

0.2.2 Exclusions

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the customer, customer supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the products, or improper site preparation or maintenance.

Hewlett-Packard assumes no responsibility for the use or reliability of interconnected equipment that is not furnished by Hewlett-Packard.

0.2.3 Obtaining Warranty Service

For warranty service or repair, this product must be returned to a service facility designated by HP. HP may repair on-site at the option of the customer. The customer is then responsible for travel charges when on-site repair is requested.

Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

Information on how to return hardware to HP is in section 1 of this User's Manual.

0.2.4 Software and Firmware

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

0.2.5 Limitation on Warranty

HP makes no other warranty, either expressed or implied, concerning this product. HP specifically disclaims the implied warranties of merchantability and fitness for a particular purpose. Some states or provinces do not allow limitations on how long an implied warranty lasts, so the above limitation or exclusion may not apply to you. However, any implied warranty of merchantability or fitness is limited to the one year duration of this written warranty.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state, or province to province.

0.2.6 Exclusive Remedies

The remedies provided herein are the customer's sole and exclusive remedies. HP shall not be liable for any direct, indirect, special incidental, or consequential damages, whether based on contract, tort, or any other legal theory.

0.3 Document Accuracy

The information contained in this document is subject to change without notice.

Hewlett-Packard shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

0.4 Certification

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

0.5 Assistance

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

For any assistance, contact your local Hewlett-Packard Sales or Service Office. Addresses are provided in appendix F of this manual.

0.6 Servicing Your HP 37741A

0.6.1 Calibration

You can ask HP to calibrate your instrument. Contact your local HP sales office for current prices and lead times. You can calibrate the instrument yourself. The calibration procedure is detailed in section 17.

0.6.2 Electrostatic Discharge (ESD) Precautions

Almost all electronic components can be damaged by ESD during handling. Component damage can occur at ESD voltages as low as 50 V. A person walking across a nylon carpet can easily generate voltages in excess of 5 000 V.

Observe the following guidelines to help prevent ESD damage when servicing this or any other electronic device.

- Disassemble instruments *only* in a static free work area.
- Use a conductive work area (such as an antistatic mat) to dissipate static charge.
- Use a conductive wrist strap to dissipate static charge accumulation.
- Minimize handling of assemblies and components.
- Keep replacement parts in their original static free packaging.
- Remove all plastic, styrofoam, vinyl, paper, and other static generating materials from the immediate work area.
- Use tools only which do not themselves create ESD.

In addition to these precautions, do not handle connector pins, to avoid contamination.

0.6.3 Battery Replacement

The battery has a finite life, and it may need to be replaced during the instrument's lifetime.[1] HP can do this for you, or you can follow the steps outlined here.

CAUTION

Observe the precautions for ESD in the preceding section.

1. Obtain a new battery from HP. Ordering information is given in appendix D.
2. Connect the ac adapter, and verify that the instrument is charging the battery (see section 6.1.3).

CAUTION

Ensure that the ac adapter remains connected while you change the battery. Otherwise, you may lose data, and your instrument may need to be re-calibrated.

3. Turn the unit off.
4. Remove the four screws on the bottom of the case. Do not let the bottom become separated from the unit.
5. Turn the unit over, so the LCD window is on the top. Lift up the top part of the case. Gently disconnect the top membrane switch. Put the top of the case to one side.
6. Lift up the old battery, and disconnect it from the instrument.

IMPORTANT

Do not pull on the wires of the battery. Grasp the connector body.

7. Connect the new battery. The connector is polarized to prevent it being connected backwards. Ensure all four pins are seated properly.
8. Gently push the battery into the cavity. Squeeze the shock absorbent foam down the sides of the instrument case.

1 Section 14 discusses the battery lifetime in detail.

9. Push the battery wires into the recess between the case and the battery, to ensure that they are not trapped by the lid of the case.
10. If you have touched the LCD panel or the inside of the LCD window, you should clean it before proceeding. Use a special lens cleaning solution (generally formulated with isopropyl alcohol), and a soft, lint free, tissue.
11. Remove all dust particles from inside the case. If you use an air hose, ensure it does not generate ESD.
12. Connect the front panel membrane switch. This requires some patience, but do not use any tools because you may damage the unit. Ensure the connector is fully seated.
13. Seat the instrument lid. Ensure you have not trapped the battery cable, or the shock absorbent foam.
14. Turn the instrument over, and replace the four screws which hold the case together. Do not overtighten these – they are screwed into plastic.
15. With the ac adapter still connected, turn on the unit. If the instrument reports that calibration is invalid, you lost power while replacing the battery. You will need to re-calibrate the instrument.
16. Verify that the unit is still being charged.
17. Remove the ac adapter, and verify that the unit remains powered on. If it does not, you have not connected the battery correctly.
18. Replace the ac adapter, and verify operation of all the keys. If they do not all work, you have incorrectly connected the front panel membrane switch.
19. Verify complete operation of the unit by conducting the performance verification tests outlined in section 16.
20. Dispose of the battery properly. See section 14.1.4.

0.6.4 Exchange Program

If your HP 37741A DS1 tester fails within one year of original purchase, HP will repair or replace it free of charge.[1] If your unit fails after your one year warranty expires, HP will repair or replace it at a very competitive price.

1 Read section 0.2 for complete warranty details.

The standard repair policy is to replace a faulty instrument with a restored exchange instrument. Follow these instructions whether your instrument is still covered by warranty or not.

1. Verify that the instrument is faulty by conducting the performance verification tests outlined in section 16.
2. Contact your local HP sales office, and order an exchange unit. A list of sales offices is given in appendix F. The part number of a replacement unit is given in appendix D.
3. HP will send you the replacement unit within three business days.
4. On receipt of the replacement unit, peel off the serial number from the back of your unit, and fix it to the rear of the replacement unit. Included with the shipment is a blank serial number plate. If you destroy the old serial number label when removing it, write the serial number on the blank label, and stick it to the rear of the replacement instrument.
5. Verify that the replacement instrument is functional by conducting the performance verification tests outlined in section 16.
6. Configure the unit ID on your replacement instrument. The procedure is described in 6.3.11.
7. Complete the Exchange Failure Report which accompanied the replacement unit. Return it to HP with your faulty unit.
8. Return the faulty unit to HP using the packaging from the exchange unit. HP will provide a shipping label for you to send the instrument to a designated HP service center. HP will notify you when your failed unit has been received.[1]
9. If you do not return the faulty unit within 30 days, you may be billed the fee for a new HP 37741A.

If your instrument was in warranty, the replacement unit will continue the warranty to the end of the original one year standard warranty.

If your one year warranty had expired, HP will bill you for the HP 37741A exchange price, which is less than a new unit price. HP warrants the exchanged unit against defects for 90 days.

1 See section 1.3.6 for other shipping information.

0.7 Product Revisions

You can identify the revision of your instrument by looking at screen 1000. This is described in section 3.3.1.

The new features added with hardware and software revisions 2.00 were as follows. These were introduced in November 1992.

- user programmable operating modes (preconfigured settings)
- separate results screen for loopbacks, with the ability to send codes from that screen
- decoding the SLC-96 data link
- use of icons to indicate the transmit status
- measurement of the amplitude of a tone in a channel
- indication on the results screens of the input frame setting and the termination mode
- measurement of resync milliseconds
- inclusion of 4-bit loop code

The new features added with hardware and software revisions 3.00 were: as follows. These were introduced in November 1993.

- fractional T1 (FT1), both n × 56 kb/s and n × 64 kb/s
- pattern sequence testing – bridge tap, multipattern, and user programmable
- results summary screen
- 1 to 24 bit user programmable, bi-directional, patterns
- CRC error injection
- $2^{11}-1$ PRBS test pattern (2047)
- help screens
- increased information on results screens, including bandwidth of a test pattern and timeslot map
- improved test time display screen for continuous tests

On instruments with serial numbers before xxxxx00485, the RTS lead on the 9-pin serial port connector was used to turn the instrument on. The DTR lead is now used; this is described in section 14.2.

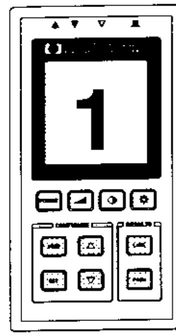
0.8 Colophon

This document was produced on HP Vectra personal computers, using Ami Pro software running under the HP NewWave Operating System. The camera ready copy was printed at actual size on an HP LaserJet printer.

The headings are set in Swiss 721, Bitstream's version of the Helvetica™ typeface; the copy is set in Zapf Calligraphic, Bitstream's version of the Palatino™ typeface; notices are set in Swiss 721 or News Gothic, Bitstream's version of the Kingsley-ATF Type Corporation typeface. Other characters were produced using the SoftCraft font editor. The drawings were produced using CorelDRAW.

0.9 Trademarks

Introduction, Unpacking, and Installation



1.1 Product Description, HP 37741A

1.1.1 Functions

The HP 37741A DS1 tester is a handheld, full duplex T1 and FT1 test set. The unit has two DS1 inputs, one DS1 output, and a serial port.

The instrument identifies the signal type and format of the main (primary) input, and switches its internal electronics accordingly. The signal type, format, and error conditions are displayed to the user in an easy to understand manner.

The second input accepts a DS1 signal that is used as a timing reference for the primary input. When a signal is present on this input, timing slips can be measured between the two sides of a T1 line pair or between the main input and a reference timing source.

The DS1 output can be independent of the inputs, or can use them to derive its framing, payload, loopback status, line code, timing, or any combination of these features.

The unit is compatible with virtually all DS1 and T1 systems in use in the world today (including fractional T1). It can (without operator intervention) identify the format of a received signal, frame to that format, and lock onto any test signals that may be present. The HP 37741A acts as a full-function BERT, counting the errors on the line, and presenting the information in a clear, unambiguous format.

The instrument has a variety of channel access features including the ability to send a channel to an internal speaker and inject an internally generated tone into a channel.

Results and setups can be saved and recalled using the instrument's memory. The HP 37741A is equipped with an EIA-232 serial port, which allows the instrument to be externally controlled, and which can be used to obtain a hard copy printout of the results and configuration.

1.1.2 Features

The instrument can generate a wide variety of signal patterns and frame formats. It can regenerate a received signal, and respond to loop-back commands. Errors can be injected on the transmitted signal if desired.

The HP 37741A is unusual in that the transmitted line code, bandwidth usage, frame format, and test pattern do not have to be same as those received.

In addition to the factory default instrument configuration, five user defined and user named configurations can be stored. These are available for recall at any time.

A minimal amount of intervention is required from the user to get an accurate, sensible reading. The results may be stored in the unit's internal memory for later comparison, analysis, or printing. This ease of use, coupled with the unit's small size and weight, makes it a perfect tool for the unskilled craftsperson and seasoned professional alike.

The HP 37741A, besides meeting the specifications of ESF and B8ZS, also meets the newer requirement of ZBTSI. The compliance with the latest specifications, along with a wide feature set, helps to ensure that:

- in most cases the HP 37741A will be the only instrument you will need
- the HP 37741A will have a long service life

The HP 37741A is a truly handheld unit and may be carried in a pouch tied to the user's waist. Despite its small size and weight, the unit does not compromise on measurement performance.

1.1.3 User Interface

A unique user interface is used on the HP 37741A. This has resulted in:

- a minimum number of keys on the front panel – a total of nine excluding the power switch
- a totally menu driven unit, that lets you see **all** possible combinations **before** you select one
- a style that is very similar to that used for window and mouse driven user interfaces running on personal computers

1.2 Product Description, HP 37741A Option H01

This instrument has all the functionality and measurement capabilities of the standard handheld instrument. It is packaged in a metal chassis, and is intended for semi-permanent, or permanent, installations. It can be controlled only through the serial port. The commands used to control the instrument are identical to those used for the standard product.

When mounted in an equipment rack, the instrument consumes very little rack height, and can be fitted within a depth of 300 mm (12 inches). Multiple instruments can be mounted side by side if dense packing is required.

Optional software (described in appendix D) is available to control the instrument. Alternatively, you can write your own software – all of the commands are documented in section 13.

1.3 Shipments

1.3.1 Initial Inspection

Inspect the shipping container for damages. Save the box and packing material in case you need to ship the instrument in future. Always retain the packing materials if you suspect that the instrument is damaged – the carrier may need to inspect them.

WARNING

Do not attempt to use the HP 37741A or the ac adapter if either appears damaged.

1.3.2 Shipment Contents: HP 37741A

Items that are shipped are:

a. the HP 37741A DS1 tester
b. a black cordura carrying pouch
c. a shoulder strap for the carrying pouch
d. this book, the HP 37741A User's Manual
e. a foldout card, the HP 37741A Instruction Guide
f. an ac plug-in adapter and battery charger
g. a single grey bantam cable (300 mm long), or a single red bantam cable (1.5 m) long
h. a dual bantam cable (300 mm long), or a single yellow bantam cable (1.5 m) long

Ensure that all items are present. Satisfy yourself that the instrument is functional. Complete performance tests are given in section 16.

1.3.3 Shipment Contents: HP 37741A Option H01

Items that are shipped are:

a. the HP 37741A DS1 option H01 tester
b. this book, the HP 37741A User's Manual
c. a foldout card, the HP 37741A Instruction Guide
d. an ac plug-in adapter and battery charger
e. a 15 pin male to 15 pin female shielded cable, 750 mm long

Ensure that all items are present. Satisfy yourself that the instrument is functional. Complete performance tests are given in section 16.

1.3.4 Accessories

You can order some of the shipped items as spare parts. These, and other accessories, are listed in appendix D.

IMPORTANT

When you have finished unpacking the instrument, write the instrument's serial number on the title page of this book, and on the cover of the HP 37741A Instruction Guide.

1.3.5 In case of Damage or Malfunction

Notify your Hewlett-Packard Sales or Service Representative under any of the following conditions:

- if the shipping container or any of the contents appear damaged
- if any item is missing
- if the instrument does not function correctly

Your local HP office will arrange for repair or replacement, at HP's option, without waiting for any claim settlement that might be required.

1.3.6 Returning to HP

1.3.6.1 Detailing the Problem

If the instrument is being returned to HP for service, attach a label to the instrument giving the following details:

- Your company or institution's name, address, and phone number.
- The main person to contact, an alternative contact, and these persons' phone numbers if different from the main phone number.
- The return shipping address, and any special shipping instructions.
- The model number and serial number of the unit being sent.
- What the problem is. If failure is intermittent, describe its frequency, and whether any special conditions initiate the failure.
- Any additional comments.

1.3.6.2 Out of Warranty Repairs

If the instrument is no longer covered by warranty, and if you do not have an HP maintenance contract, you will have to pay for the repairs. Contact your Hewlett-Packard Sales or Service Representative to obtain the current repair prices and payment terms.

1.3.6.3 Accessories

Do not return any of the accessories with the instrument, unless you suspect that one of them is faulty. If you do return an accessory, place a tag on it that clearly identifies it as yours, and that briefly explains the problem.

1.3.6.4 Packing

Wherever possible, use the original packing materials to ship the instrument. If these are not available, containers and cushioning material similar to those originally used are available from HP.

If it is inconvenient to obtain supplies from HP, use a strong, double-walled shipping carton. Place about 70 mm (3 in) of cushioning material around all sides of the instrument.

Place the sheet detailing the problem in the container, and securely seal the shipping container.

Obtain the correct address for returning the instrument from your nearest HP Sales or Service office. Clearly mark the container with HP's address, and your own address. Insure the package before sending it to HP.

In any subsequent correspondence, always refer to the instrument by model number and serial number.

1.4 Document Overview

1.4.1 Organization

In essence, this book tells you:

a. how to use the HP 37741A to get results
b. how to interpret those results
c. how to be sure that those results are correct
d. what to do when you are convinced there is a problem

To accomplish this, this book is logically divided into three sub-books:

Operation	Sections 2 to 7 tell you how to use the instrument. The sections describe the functions of the keys, and the screens that you will see.
Reference	Sections 8 to 15 detail the features and capabilities of the instrument. These sections describe the instrument's specifications and limitations. There is also some background information about why a feature is necessary, and how the HP 37741A performs its measurement.
Maintenance	Section 16 details tests that you can perform to ensure that the HP 37741A is meeting its specifications. Section 17 describes how you can calibrate the instrument, and the recommended calibration interval. Section 0 describes how you can service the unit, either by yourself, or by sending it to HP for repair.

In addition, this book has a number of appendices, with information that does not logically fit into any one section.

1.4.2 Manual Usage for HP 37741A Option H01 Owners

This manual is primarily written for the standard handheld product. Sections 2 to 7 inclusive describe how the instrument can be operated from the front panel. This information is not irrelevant to owners of the rackmountable product, because it gives you a feel for how the instrument performs its measurements.[1]

1 If you have purchased the HP 15726A software to control the instrument, the software is organized in a similar manner to the screens on the handheld instrument.

The remainder of the book describes the instrument's capabilities, and as such is equally relevant to both the handheld instrument and the rackmountable instrument.

Installing the HP 37741A option H01 is described in section 1.5.

1.4.3 Nomenclature

1.4.3.1 Jargon

Many technical terms are used throughout this book. The use of very specialized terms has been kept to a minimum, and, where used, their meaning is explained.

1.4.3.2 Acronyms

Acronyms are widely used throughout the book. Because the sections (and, to a certain extent, the subsections also) can be read in any sequence, acronyms are not defined in the text.

A complete list of acronyms can be found in appendix B – this is the only place that they are defined.

1.4.3.3 Line and Path, T1 and DS1

The term "line" refers to things like voltage, frequency, and line code – that is, properties of the transmission medium. The term "path" refers to things like frame format, payload and DS0 channels – that is, properties of the data content and structure of the signal.

In this book, the term "T1" is used when referring to line properties, for example: *The voltage on the T1 line is 6.0 V.* The term "DS1" is used when referring to path properties, for example: *The frame format of the DS1 signal is ZBTSI.* This distinction cannot always be made, for example: *The received DS1 signal has both BPV errors and CRC errors.*

1.4.4 Notices

The following notices are used to set text off from the main body of the manual:

IMPORTANT

This notice contains special information that should not be ignored.

CAUTION

This notice calls attention to a condition or procedure which, if not observed, could result in damage to the HP 37741A or could result in loss of data.

WARNING

This notice indicates that if a specific procedure or practice is not correctly followed, personal injury could occur.

DANGER

This notice warns you of imminent hazard not only to yourself, but also to others, if proper procedures are not followed.

1.5 Care and Handling, Standard Product

The handheld unit is not intended for permanent installations. It can, however be used for temporary installations, and operated remotely using the optional control software. For longer term installations, it is preferable to use the rackmountable unit. Section 1.6 describes how that unit is installed.

Your HP 37741A instrument has been designed and manufactured to high quality levels. It is a portable unit, but nonetheless an instrument with delicate electronics. Care should be taken in the usage and storage of the test set.

When not in use, keep the instrument in the pouch, and store in a cool environment. Never store the unit in direct sunlight, or on the dash board of a car. Elevated temperatures will reduce the life of the display and the battery.

The case is made of high impact ABS; the membrane switch flat panel is made of polyester. Both are fairly impervious to most chemicals. However, you should never immerse the unit in any liquid, or allow rain to seep in. Always wipe the unit clean and dry if it becomes dirty or wet, to prevent any long term damage.

1.6 Installation of Option H01

1.6.1 Rackmounting

The instrument may be placed on an equipment tray, but it is preferable to bolt it to the equipment rack. HP supplies an optional panel for this purpose. Appendix D lists the optional accessories. Figure 1-1 indicates the position of the mounting holes, so that you can supply your own panel if desired.

Mount the panel in the rack and use the 3 mm screws provided to hold the instrument to the panel. Do not overtighten these, and do not substitute with longer screws. The maximum allowable protrusion of a screw into the case is 10 mm.

Ensure that you can see the yellow LED on the instrument through the hole in the mounting panel. This LED indicates that the instrument is on, not that power is applied.

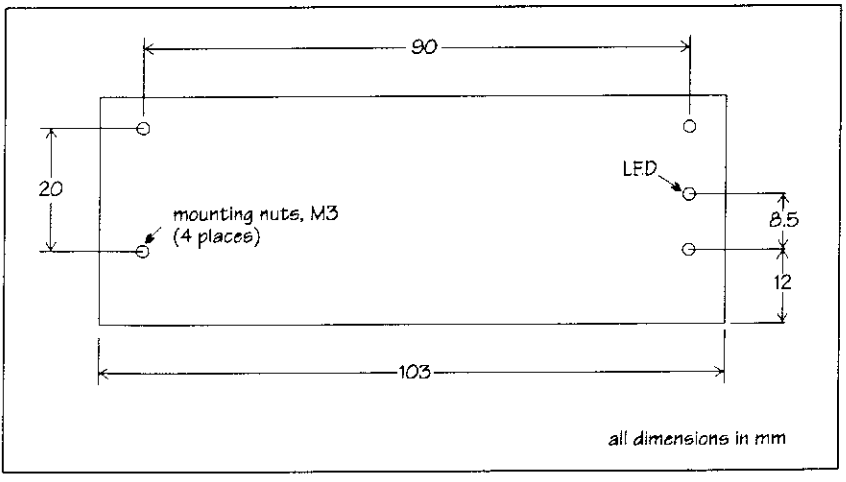


Figure 1-1 Mounting Holes for Option H01

1.6.2 Connecting Power and Control

Connect the ac adapter as described in section 3.2.5. Put the plastic clip over the connector body to hold the cable in place.

Connect the communications interface to the instrument's 9 pin female connector. The interface is described in detail in section 13, and cables are listed in appendix D.

The HP 37741A option H01's serial port is permanently configured for external control, 9600 b/s, no parity, 8 data bits, 1 stop bit, and CTS/RTS handshake. You must ensure that your communications interface is compatible.

1.6.3 Connecting the T1 Lines

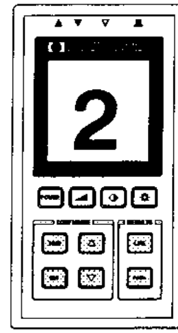
A 15 pin male D type connector is provided for the T1 connections.

You can use the cable supplied to connect to most types of equipment. If you need to break out the connections to bantam connectors or to an RJ45 connector, HP supplies an accessory to permit this.

The pin assignment of the DB15 is shown in figure 1-2. The instrument is wired as a piece of equipment (DTE) as defined by the ANSI standards. The test set can therefore connect to an NCTE (such as a CSU) with a straight (one to one) cable. A crossover cable is required to connect to another DTE (such as a multiplexer). You can use two Bantam Telecom Adapters (BTA) wired back to back to create a crossover cable. The BTA is described in section D.3.9.

Circuit	Source	Pin	Description	Function in HP 37741A
AA	common	2	Shield (Frame Ground)	connected to chassis
AA	common	4	Shield (Frame Ground)	connected to chassis
AA	common	6	Shield (Frame Ground)	connected to chassis
AA	common	8	Shield (Frame Ground)	connected to chassis
BAa	HP 37741A	1	Transmitted Data, Tip	output
BAb	HP 37741A	9	Transmitted Data, Ring	output
BBa	NCTE	3	Received Data, Tip	main input
BBb	NCTE	11	Received Data, Ring	main input
SBAa	–	5	2nd Transmitted Data	no connection
SBAb	–	13	2nd Transmitted Data	no connection
SBBa	NCTE	7	2nd Received Data, Tip	reference input
SBBb	NCTE	15	2nd Received Data, Ring	reference input
–	–	10	unassigned	–
–	–	12	unassigned	–
–	–	14	unassigned	–

Figure 1-2 T1 Signals, and DB15 Pin Assignments



Quick Start

2.1 General

If you are familiar with DS1 testing, and feel comfortable with new products, then this section may be for you. If not, skip this section, and read sections 3, 4, 5, and 6 instead. Those sections describe in greater detail how to operate the HP 37741A.

Once you have become familiar with operating the test set, use this section to refresh your memory. This section should be read as a tutorial. Get the instrument, the instruction guide, and the single bantam cable all of which came with the original shipment.

Follow the steps in this section in sequence. You will need about 45 minutes to read this section, and perform the examples. When you have finished you will have a good understanding of the instrument's capabilities and how to use those capabilities.

2.2 Screen Numbers

Turn on the test set by pressing [POWER]. A copyright notice is displayed followed by a screen showing the current time and manufacturing revision numbers.[1] Look at the HP 37741A Instruction Guide that was shipped with the product. On the first page inside, you will see a box (labelled "Product identify") depicting that screen. Above it is the number 1000.

1 If you see a different screen, your battery needs recharging. Turn off the instrument, connect the ac adapter, and turn the instrument on again.

Each screen is assigned a number. This is for documentation purposes only – the screen numbers are never displayed by the test set.

The unit ID is an alphanumeric string (of at most 13 characters), which identifies your test set. When shipped from the factory, the unit ID is set to the instrument's serial number. You can program this string to be your name if you wish. Details on how to do so are given in section 6.3.

All screens that display the date and time do so in the same formats. You can select these formats to be other than that programmed at the factory. Again, this is described in section 6.3.

Press [POWER] to turn the power off.

2.3 Setting to the Default Configuration

In the absence of an input signal, the factory default configuration sends an AIS.[1] The AIS is used in the subsequent procedures.

The instrument's present condition is:

- Power is off.

1. Remove any T1 connections from the instrument.
2. Press [POWER] to turn on the instrument.
3. Press [SET].
   - Screen 2000 is displayed.
   - ➔ is pointing to transmitter.
4. Press [▲] or [▼] to move ➔ to to preconfig.
5. Press [SET].
   - Screen 2600 is displayed.
6. Choose factory dflt (by moving the ➔).
7. Press [SET].
   - The factory default instrument settings are used.
   - Screen 2000 is displayed.
8. We will need to terminate the T1 receiver inputs. Move ➔ to point to receiver.

1 The default configurations are described in section 5.

9. Press [SET] three times.
   - ▸ Screen 2210 is displayed.
   - ▸ Move ➔ to terminate.
10. Press the [SET] key five times.
   - ▸ Screen 2000 is displayed.
   - ▸ You may hear the line relay click as the change takes place.

2.4 Returning to a Top Level Screen

The instrument's present condition is:

- Screen 2000 is displayed.
- ➔ is pointing to receiver.

1. Move ➔ to miscellanea.
2. Press [SET] three times.
   - ▸ Screen 2420 is displayed, in the middle of the SET menu system.
3. Press *and hold* the [SET] key.
   - ▸ Screen 2000 is once again displayed.
   - ▸ If you press and hold any of the function (or menu) keys ([TEST], [SET], [LINE], or [PATH]), the test set displays the first screen for that function key.
   - ▸ For example, when you terminated the line (in the previous section), you could have pressed and held [SET] to return to the top menu.

2.5 Starting and Stopping a Test

The instrument's present condition is:

- Screen 2000 is displayed.
- No test is running.

1. Press [TEST].
   - ▸ Screen 3000 is displayed.
   - ▸ ➔ is pointing to start.
2. Press [TEST] again.
   - ▸ The test starts running.
   - ▸ Screen 6000 (results summary) is displayed.

- ▸ The hour glass, ⌛, on the top line indicates that the test is running.

3. Press [PATH].
   - ▸ Screen 5000 is displayed; the ⌛ is displayed on this screen also.
4. Press [TEST].
   - ▸ Screen 3001 is displayed.
   - ▸ ➔ is pointing to `s t o p`.
5. Press [TEST] again.
   - ▸ The test stops.
   - ▸ Screen 3000 is displayed.
   - ▸ The stop sign (the flashing ✋) indicates that a test is not running.
6. Press [PATH].
   - ▸ Screen 5000 is again displayed; the ✋ is displayed on this screen also.

IMPORTANT

The instrument is making measurements and updating the results only when a test is running. When a test is running, the hour glass, ⌛ is displayed on each of the results screens. When the flashing ✋ is displayed, the results do not change.

2.6 Viewing the Results

The instrument's present condition is:

- Screen 5000 is displayed.
- No test is running.

1. Connect the main T1 input of the HP 37741A to its output.
   - ▸ These connections are identified by the solid triangles printed on the top of the front panel.
   - ▸ The other input is the reference input.
2. Start a test.

- Screen 6000 is displayed.
- R S L T is flashing, indicating that an alarm is being received.
- A I S is also flashing, to indicate that the alarm is AIS.
- The alarm bell, 🔔, on the top line indicates that the unit is sending an alarm.
- The hour glass, ⧗, is on the top line, indicating that the test is running.
- The test set is receiving a valid signal, at about 0 dBdsx.
- This results summary screen gives an overview of the circuit conditions. Detailed information is seen on the five line results screens and the six path results screens.

3. Press [LINE].
   - Screen 4000 is displayed.
   - 1 / 5 is displayed, indicating that this is the first of five line results screens.
   - L I N E is flashing to indicate the unit is receiving an alarm.
   - On this screen, the level is also indicated in Vpp – it is reading about 6.0.
4. Press [▲] or [▼].
   - Screen 6000 is again displayed.
5. Press [PATH].
   - Screen 5000 is displayed.
   - P A T H is flashing, to indicate there is an alarm.
   - The AIS counter is increasing; other counters are zero.
6. Press [LINE] six times.
   - Screens 4000, 4100, 4200, 4300, 4400 and then 4000 (again) are displayed.
   - As you continue to press a function key ([TEST], [SET], [LINE], or [PATH]), the displayed screen is replaced by its successor screen, as shown on the instruction guide.
   - After the last screen in a sequence is displayed, the next press of the same function key returns you to the first screen of the sequence.
7. Press [PATH] seven times.
   - All six of the path results screens are displayed, followed by screen 5000 again.

8. Press [▲] or [▼].
   - Screen 6000 is displayed.
   - This results summary screen is available from most line and path results screens by pressing [▲] or [▼].

2.7 Configuring the Transmitter

The instrument's present condition is:

- The test set is in its factory default condition (except that the receiver is terminated).
- A test is running.
- The output signal is connected to the main input.

1. Press [SET] to display screen 2000.
2. Press [▲] or [▼] to move ➔ to transmitter.
3. Press [SET].
   - Screen 2100 is displayed.
   - ➔ is pointing to change, by default assuming that you want to change the configuration.
   - When making selections in the SET menu system, [SET] is used as the "enter" key to activate your selection.
   - Screen 2100 is a summary screen, telling you how the transmitter is currently configured.
   - You can go back to the first SET screen by choosing exit.
4. Press [SET].
   - Screen 2110 is displayed.
5. Move ➔ to PATH and press [SET].
   - Screen 2130 is displayed.
   - ➔ is pointing to none.
   - All the alarms that the HP 37741A can transmit are displayed.
6. Press [SET].
   - Screen 2131 is displayed.
   - You have "passed through" screen 2130 without making any change to the alarms – none is still selected.
7. Move ➔ to ESF and press [SET].
   - The test set is now transmitting an ESF signal.

- ▸ Screen 2132 is displayed.
- ▸ Pressing [SET] not only made your choice effective, but also took you to the next screen.
  Later, you will see other ways of making a choice effective.

8. Move ➔ to QRW and press [SET].
   - ▸ The test set is now transmitting a QRW test pattern.
9. Leave the data link set to its default state by pressing [SET].
   - ▸ Screen 2000 is displayed.
10. Press [SET] again, to display the transmit summary screen.
    - ▸ The test set is now configured to transmit a ESF framed QRW test pattern, with no alarms.
11. Move ➔ to e x i t , and press [SET] to return to screen 2000.
12. Press [PATH] and then [▲] or [▼].
    - ▸ Verify that no alarms are being received, that the received frame format is ESF (and there are no frame errors), the received test pattern is QRW (and there are no logic errors), the received line code is AMI (and there are no BPVs).
13. Press [LINE] and [PATH] repeatedly to view the results in detail.
    - ▸ PATH 1/6 shows no alarms.
    - ▸ PATH 2/6 shows no frame errors.
    - ▸ PATH 3/6 shows no CRC errors (the count of EFS is increasing).
    - ▸ PATH 4/6 shows no logic errors (the count of EFS is increasing).
    - ▸ LINE 2/5 shows no BPVs (the count of EFS is increasing).

2.8 Configuring the Receiver

The instrument's present condition is:

- The test set is transmitting an ESF framed, QRW test pattern.
- A test is running.
- The output signal is connected to the main input.

1. Display screen 2000, move ➔ to r e c e i v e r , and press [SET].

- Screen 2200, the receiver configuration summary screen, is displayed.
- The instrument's input circuits are shown to be in terminate mode.

2. Press [SET] twice.
   - Screen 2210 is displayed.
   - → is pointing to terminate.
   - → always points to the currently selected option on screens that have an option, or the safest, or most probable choice.
3. Press [SET].
   - Screen 2220 is displayed.
   - You have "passed through" screen 2210 without making any change to the T1 input termination state.
4. Press [SET] again to display screen 2230.
   - The receiver of the HP 37741A is currently in auto frame mode. This is the default setting – the test set will automatically identify the incoming frame format.
5. Move → to D3/D4, but *do not* press [SET].
   - The test set is still in auto identify mode. The change that you want to make does not take effect until you *activate* the change. As you have seen, you can activate the change by pressing [SET].
   - You can also activate a change to a [SET] menu by pressing [LINE] or [PATH].
6. Press and hold [PATH], and look at screen 5000.
   - There is a frame loss because the instrument is transmitting ESF frame format, and you have configured the receiver to synchronize only to a D4 frame format.
7. Press [SET].
   - Screen 2230 is again displayed.
   - When you move from any screen in the SET menu to a results screen (by pressing [LINE] or [PATH]), you do the following two things:
     - any changes made in the SET screen take effect
     - you can return to the same SET screen after viewing the results
8. Leave the receiver in D4 mode.

2.9 Setting the Test Time

The instrument's present condition is:

- A test is running.

1. Press [TEST].
   - Screen 3001 is displayed.
   - Whenever you leave the TEST menu screens and return, you always return to the first screen (either 3000 or 3001).
   - Also, whenever you get to one of the first TEST screens, ➔ always points to start or stop.
2. Press [TEST].
   - The test stops, and the display changes to show screen 3000.
3. Move ➔ to cfg tst time and press [TEST].
4. Move ➔ to fixed time in seconds in screen 3500.
5. Press [TEST], and in screen 3520 select the test time to be 1000 (seconds).
6. Press [TEST] twice to start the test.
   - The screen changes to 6000.
7. Press [TEST], move ➔ to show times and press [TEST].
   - You can see in screen 3200 that the elapsed test time, Elps, is increasing, and that the test time remaining, Left, is decreasing.
8. Press [TEST] twice to stop the test.
   - Look at the test times again. The test time left is zero. The elapsed time indicates how long the test actually ran.

2.10 Accessing a Channel

The instrument's present condition is:

- A test is not running (idle).
- The output is connected to the main input, and the inputs are terminated.
- The receiver is configured to frame to a D4 frame format.

1. Configure the HP 37741A to transmit a D4 frame, from screen 2131 ([SET]/transmitter/change/PATH/none) and the TmSlt payload (screen 2132).
   - You will need to move ➔ to more▼, to access the TmSlt pattern.
2. Set the test time for continuous (screen 3500, [TEST]/ cfg tst time), and start the test ([TEST]/ start)
3. Press and hold [◢].
   - The big triangle displayed on the screen lets you know that you are increasing the volume.
4. Release the key when the volume is at level 5 (don't worry if you overshoot).
5. Press and hold [◢] again.
   - This time the big arrow on the screen is pointing down, indicating that the volume is decreasing.
   - Each time that you press [◢] you reverse the direction of the big arrow.
6. Adjust the volume to be at level 5.
   - You are listening to channel 1 of the signal. Because the signal is a repeating pattern, there is no sound.
7. Use [SET], move ➔ to transmitter, press [SET] twice, move ➔ to CHANNEL ACCS, and press [SET] once to display screen 2140.
8. Use [▲] or [▼] to select channel 19.
9. Press [SET] to activate your choice and display screen 2141.
10. Move ➔ to –6 dBm0, and press [SET].
    - Again, you cannot hear the tone, because you are listening to channel 1.
11. Move ➔ to 820 Hz and press [PATH] (not [SET])
    - Pressing [PATH] initiated the frequency change.
    - The quaver, ♪, on the top line lets you know you are sending a tone.
12. Display screen 5501, the path results screen, PATH 6/6.
13. Use [▲] and [▼] to select channel 19.
    - You can now hear the tone.
    - The measured tone level is about −6 dBm0.

- The signaling bits are changing. These are not really signaling bits, but are bits created by the transmitted tone.

14. Press [SET] to return to screen 2142, transmit tone frequency selection.
15. Move → to sweep and press [PATH].
    - The tone change took effect when you pressed [PATH].
16. Press [SET] twice to display screen 2143, the transmit signaling screen.
17. Use [▲] and [▼] to set the signaling bits to ABCD = 1010.
    - The HP 37741A allows you to toggle the signaling bits in SF frame format. That is, in D4 mode, ABCD is equivalent to ABAB.
18. Press [PATH] to display screen 5501.
    - The signaling bits on channel 19 are now static, at ABAB = 1010.
19. Turn the speaker volume off.
20. Turn the tone off using screen 2141 ([SET] / transmitter / change / CHANNEL ACCS), and set the signaling bits to unmodified (screen 2143).

2.11 Loop Codes

The instrument's present condition is:

- A test is running (active).
- The output is connected to the main input, and the inputs are terminated.
- The instrument is configured to transmit and receive a D4 frame format.

1. Set the transmitter to send a D4 QRW (screens 2131 and 2132).
2. Display the loopbacks results screen LINE 4/5.
   - The instrument is neither sending nor receiving any alarms (LINE is not flashing, and 🔔 is not displayed).
3. Press [▲].
   - The instrument indicates it is sending the NI loop up signal (NI ↑).
   - The instrument then momentarily displays that the far end is looped up.[1]

4. Look at the logic results screen, PATH 4/6.
   - The EFS count is small, indicating the test has just restarted.
   - The HP 37741A *always* automatically restarts a test if the frame format or test pattern changes. Any errors that were in existence before the loop up are not relevant. You can immediately get the results, without having to restart the test manually.
5. Press and hold [SET].
6. Move → to transmitter, and press [SET] twice.
7. Move → to LINE:, and press [SET] three times to display screen 2122, the transmit loop code type screen.
8. Move → to line, and press [SET].
   - You have selected the loopback type to be line (or CSU) loopback.
   - You can activate a loopback from this screen, also. This screen allows you to send the loop code continuously (cont), or for 8 seconds (8s)
9. Again display the loopbacks results screen LINE 4/5.
   - Now, when you press [▲] or [▼], you will send a line loopback code rather than an NI loopback code.

2.12 Error Injection

The instrument's present condition is:

- A test is running (active).
- The output is connected to the main input, and the inputs are terminated.
- The instrument is configured to transmit a D4 framed QRW test pattern.

1. Press and hold [SET].
2. Move → to transmitter, and press [SET] twice.
3. Move → to ERRORS, and press [SET].
4. Press [SET] again. This will leave BPV errors turned off.
5. Press [▼], until the instrument is set to transmit 8 logic errors.
   - You can send just a few errors, or turn errors on continuously.
6. Press [PATH], and display the screen 5300, PATH 4/6.

1 The test set does not respond to the received loopcode, but remains unlooped. See section 9.3.8 for details.

- The ☹ is displayed on the top line, to indicate that you are injecting errors into the transmitted signal.
- The error count is increasing, and stops increasing when it reaches 8.

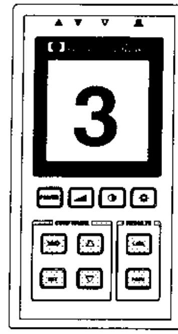
2.13 Conclusion

This brief tour of the HP 37741A has taught you:

- how to start and stop a test
- how to configure the instrument's transmitter and receiver
- how to view the results, and switch between viewing the results and configuring the test set
- how to identify whether a test is running, and whether there are any alarms, from any results screen
- how to inject a tone and access a channel
- how to send a loopback code
- how to inject errors
- how to interpret displayed icons

This section has not told you all about the HP 37741A. More detailed operational instructions are contained in sections 3 to 6. Saving, recalling, and printing results are covered in section 7.

Basic Instrument Functions



3.1 General

The external elements of the HP 37741A are shown in figure 3-1. These are as follows:

Output — Used to transmit the T1 signal, which may be dependent on or independent of the input signals.

Main Input — Used to connect the primary T1 signal for timing extraction, framing, pattern identification, and error analysis

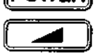
Reference Input — Used to connect a T1 signal that can be used as a timing source to clock the transmitted signal, and as a reference to measure timing (bit) slips on the main input.

Serial Port — Used to connect to a computer (for external control) or to a printer (to permit a hard copy of the results). The port is configured as a DCE.

DC power — Used to recharge the internal batteries. The unit can be operated at the same time as the batteries are being charged.

LCD — Used to display signal analysis results, and to display or alter the test set configuration. The display is normally organized as 8 lines of 13 characters per line.

POWER — Used to turn the test set on or off.

 — Used to adjust the volume of the test set's speaker when listening to a DS0 channel.

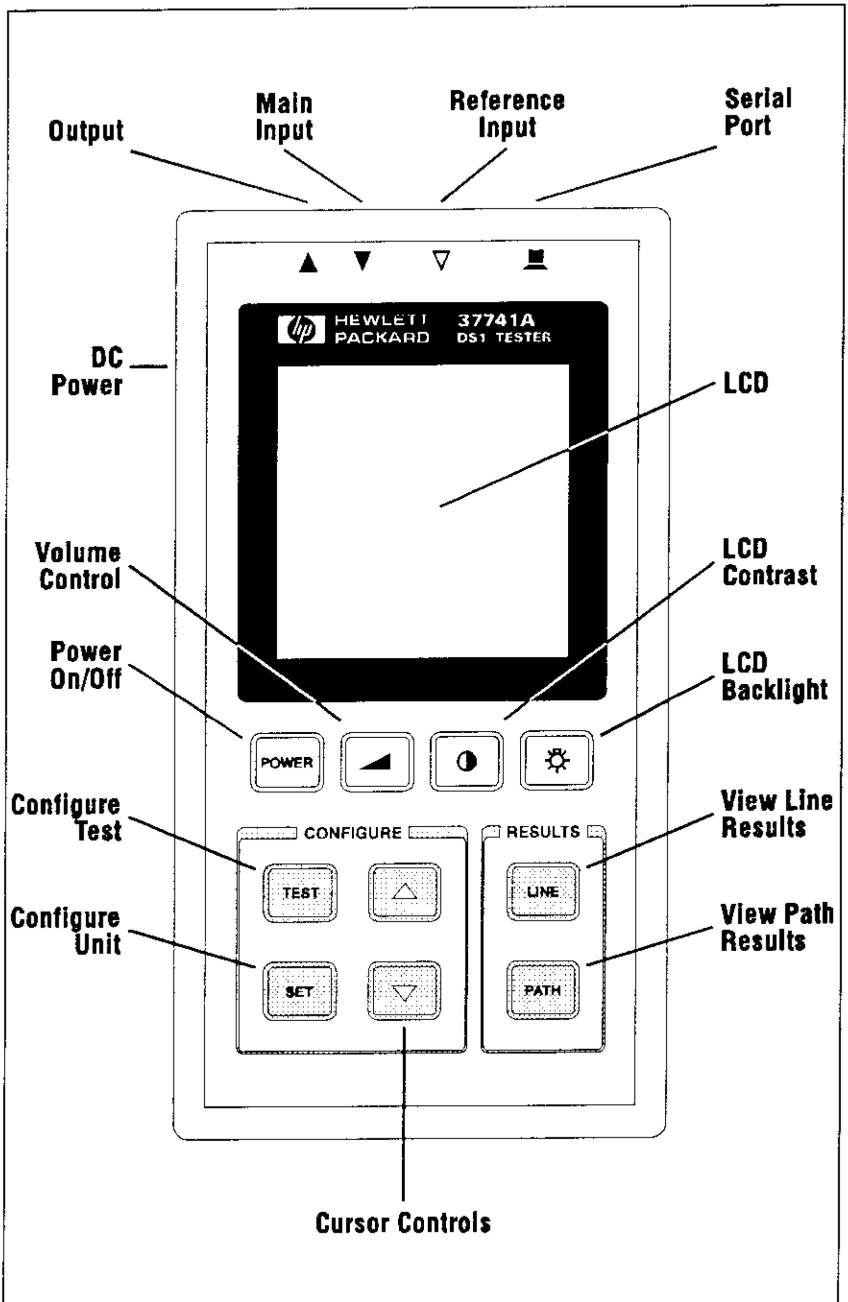


Figure 3-1 HP 37741A Layout

[◑]	Used to adjust the LCD viewability. The contrast is altered to suit the ambient temperature and lighting conditions, and the viewing angle.
[☼]	Used to turn the display illumination (LCD backlight) on or off. Automatically turned off if you don't use the test set.
[TEST]	Used to configure the test time, print, save, and recall test results, and to start or stop a test. Also used to initiate an instrument self test.
[SET]	Used to configure the T1 input and output signals, the EIA-232 serial port, and other parameters associated with the instrument.
[▲] [▼]	Used to point to a choice in a menu. Moves the displayed arrow, ➔, up or down.
[LINE]	Used to view the received signal line results – voltage, frequency, line code, BPVs, and slips.
[PATH]	Used to view the received signal path results – frame format, test pattern, alarms, and errors.

3.2 Laying the Groundwork

3.2.1 The Screens and Screen Numbers

A sample screen is shown below. There are eight lines, each of 13 characters.

```
2000
SET          ⧖
 transmitter    2100
 receiver       2200
 EIA-232        2300
 miscellanea    2400
➔sys summary    2500
 to preconfig   2600
 show outputs   2700
```

This screen is a *menu* screen. The [SET] and [TEST] keys lead you through a sequence of menus. The screen shown above is the top level SET menu.

An arrow character, ➔, appears on the screen to the left of the currently selected item in the menu. The item pointed to is that which will be selected.

[LINE] and [PATH] cause *results* screens to be displayed – ordinarily, there is no ➔ on these screens. A sample results screen is shown below:

5400

PATH 5/6	⧗	5500 or 5501
LOGIC (G.821)		
UAS	99	
SES	1063	
CSES	751	
%SES	17.62%	
%avl	88.49%	
DM	6	

Each screen has been assigned a unique four digit number (0000 to 9999). This number is used for documentation purposes only – it is never shown on the display of the HP 37741A. The screen number is shown just above the picture of the screen. Shown above are screens 2000 (for [SET]), and screen 5400 (for [PATH]).

The numbers to the right of the screen picture indicate the follow on screens. For example, if [SET] is pressed when ➔ is pointing to receiver (on screen 2000), the next screen to be displayed is screen 2200. If [PATH] is pressed when screen 5400 is displayed, either screen 5500 or screen 5501 is displayed.

All the screens are shown on the HP 37741A Instruction Guide. There, arrows are used to indicate the follow on screens. Conversely, you can find a screen on the guide, and follow back through the menu structure, to find out how to access any function.

As the guide clearly indicates, the functions are broken down by key type. Thus, to see the line results, you only ever have to press [LINE], *and no other key*. To configure a test, you only ever have to press [TEST], in conjunction with [▲] and [▼], *and no other keys.*

3.2.2 The Major Icons

Icons are used so that you can more easily assess the status of the instrument. Their use is divided among three categories, described in the following sections. Appendix E contains a summary of all the icons and special characters.

3.2.2.1 Test Status – ✋, ⌛, BT, MP, US

On all results screens, and some configuration screens, is shown an icon to indicate whether the test is running (active) or not (idle). These two states are described in more detail in sections 4.1.2 and 4.1.3.

When a standard (non-special) test is running, an hour glass, ⌛, is displayed on the top line. The ⌛ is removed when the test ends, and is replaced with a flashing ✋. The displayed values are then frozen.

When a sequential test is running, one of the following icons is used instead of ⌛:

- BT — to indicate bridge tap
- MP — to indicate multipattern
- US — to indicate user programmable sequence

When the icon flashes, the HP 37741A is waiting to synchronize on the received pattern, and results are not being accumulated. When the icon is displayed steadily, the instrument is accumulating errors, and the results can change. These indications are summarized in figure 3-2.

Icon	Steady	Flashing
✋	never steady	Test is idle All results are frozen
⌛	Standard (not sequential) test is running	never flashes
BT	Bridge tap running – synchronized to pattern	Bridge tap running – waiting to get into sync
MP	Multipattern running – synchronized to pattern	Multipattern running – waiting to get into sync
US	User sequence running – synchronized to pattern	User sequence running – waiting to get into sync

Figure 3-2 Summary of Test Status Icons

3.2.2.2 Transmit Status – ☹, ↩, Nx56, Nx64, ▲, ♪

The following icons are also displayed on the top line of the results screens and some configuration screens. These are used to indicate the current *transmit* status:

☹	the instrument is injecting errors
↩	the instrument is looped back
Nx56	the instrument is sending a fractional T1 signal (n × 56 kb/s)
Nx64	the instrument is sending a fractional T1 signal (n × 64 kb/s)
▲	the instrument is sending an alarm
♪	the instrument is modifying a channel (sending a tone or changing signaling bits)

For example, the top line of the first line results screen looks like this when the transmit signal is not being disturbed, and a non-sequential test is running:

```
LINE 1/5      ⧗
```

The top line looks like this when errors are injected into the transmitted signal, an alarm is being sent, and a tone is being injected:

```
LINE 1/5 ☹▲♪⧗
```

IMPORTANT

These icons *always* represent the current state of the transmitted signal. The results are frozen at the end of a test, but the icons are not.

The displayed icons may appear to contradict the displayed line or path results when a test is not running. See section 4.1.3 for an explanation.

3.2.2.3 Miscellaneous – 24/24, ⏲, ☺, ☹, ↑, ↓

The following icons are also used. Each is discussed in more detail in the section describing the screen in which the icon appears:

24/24	to indicate a full T1 signal
⏲	to indicate the source of the timing for the transmitted T1 signal
☺	to mean good, or no error
☹	to mean loss or corruption of data
↑, ↓	to mean up and down

3.2.3 The Keys

Each of the keys operates by momentary action. Therefore, you need only to press the key briefly. However, depending on the key, pressing and holding the key will initiate secondary functions. Those secondary functions are dealt with in the relevant sections that follow.

Each time you press a key, the instrument's internal speaker can emit a tone or click. You can program this "key beep" to be tone, click, or off. When shipped from the factory, the key beep is set to tone.

3.2.4 The T1 Connections and Cables

Bantam connectors are used for the T1 connections. The transmit and receive signals are grouped together so that the dual bantam cable supplied with the test set can be used to perform tests at the DSX bay.

The portability of the HP 37741A allows you to take the test set to the problem, rather than to have to use a long cable to take the problem to the test set. The cables provided with the unit are designed with this in mind, and they also fit neatly into the envelope of the carrying pouch. Longer cables may be ordered as accessories. These are listed in appendix D.

The HP 37741A option H01 uses a DB15 connector to connect to the T1 lines. The pin assignment is given in section 1.6.3.

3.2.5 The Serial Port

You can configure the serial port (EIA-232) to function in one of two modes:

- As a control port, permitting a computer to control the instrument externally. Remote control over modems is possible.
- As a printer port, permitting hard copy printout of results. This is compatible with most serial printers.

The serial port is configured as a DCE, so that a straight cable is used to connect to a DTE (such as a computer), and a null-terminal (cross-over) cable is used to connect to a DCE (such as a modem). Some serial printers have DCE interfaces, others have DTE interfaces.

3.2.6 The DC Power Jack

Use the supplied ac adapter to recharge the instrument's batteries. Connect the 2 mm dc power jack, and then plug the adapter into a 110 Vac outlet. Do not use any adapter other than that supplied with the instrument.

WARNING

> Using a non-approved adapter may void your warranty, damage the instrument, or result in personal injury.

For maximum battery life, it is advisable to let the batteries discharge each time before charging them. This is not always possible, and no damage will be done to the instrument by leaving it permanently on charge. After the unit has become fully charged, it may get warm. This is normal.

When the batteries are nearly discharged, the test set will beep every minute. The battery state can be checked on screen 2500.

3.3 Using the Top Row of Keys

3.3.1 Power, POWER

The HP 37741A is turned on by pressing POWER. A copyright screen is displayed followed by the unit ID screen. This is screen 1000:

```
1000
Unit ID:
    nnnnAnnnnn
Now: hh:mm:ss
 yy/mm/dd Www
H/W ver: w.xx
S/W ver: y.zz

    ▼: help
```

The instrument beeps when this screen is displayed. If screen 1001 or 1002 is displayed instead (see below), the instrument does not beep.

You can press ▼ to obtain basic information on the usage of the instrument's keys.

The unit ID is intended to distinguish your instrument from others. When it leaves the factory, the unit ID is programmed with the serial number assigned by HP. You can program the unit ID to be any 13 character alphanumeric string, such as your name. The procedure is explained in section 6.3.11.

Following Now is the current date and time. On the pictures of the screens shown in this manual, hh:mm:ss indicates the hours, minutes, and seconds; yy/mm/dd represents the year, month, and day; and Www represents the weekday. Your HP 37741A will display the appropriate values. You can configure the display format for both the date and the time. How to do so is described in section 6.

The hardware and software versions of the instrument are displayed on the last two lines.

If the battery is too low to operate the instrument, you will see screen 1001 instead:

1001

```
Battery is
too low to
operate unit.

Power will be
turned off.
```

You should charge the batteries soon, or you may lose saved data, instrument configuration, and instrument calibration. The HP 37741A turns itself off after five seconds.

If the batteries have discharged totally, the stored data may have been corrupted, so that screen 1002 is displayed:

1002

```
Saved data
is corrupted.
Calibration  ☺
Tx,Rx setup  ☹
Test config  ☺
Results      ☺
Date & time  ☺
Misc config  ☺
```

The status of six different areas of battery backed memory is shown here. A ☹ indicates that the corresponding memory has been corrupted.

To make accurate measurements you should re-calibrate the test set if the calibration is lost. Calibration is discussed in section 17. You will need to set the test set's real time (time of day) clock if the sad face is on the line with the date and time.

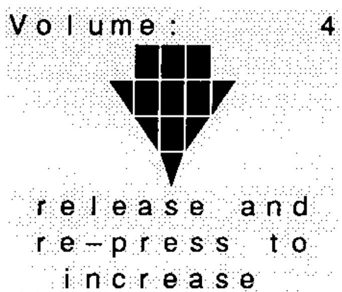
If you press [▲] or [▼] when this screen is displayed, you can see the unit ID and revision numbers. Pressing any other key will have its normal effect.

3.3.2 Volume,

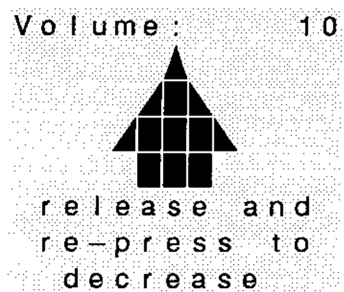
There is a speaker built in to the HP 37741A. This is used for three purposes:

- To beep with each key press. You can turn this function on or off. The volume control has no effect on the sound level of the beep.
- To beep under certain alarm conditions. You cannot disable this function. The volume control has no effect on the sound level of the beep.
- To output a DS0 channel of a received DS1 signal. You use the volume control to adjust the sound level, or to turn the sound off completely.

To adjust the volume, press and hold . One of the following screens is displayed:



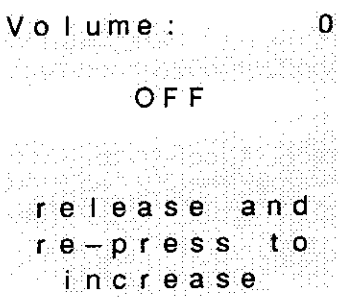
decreasing



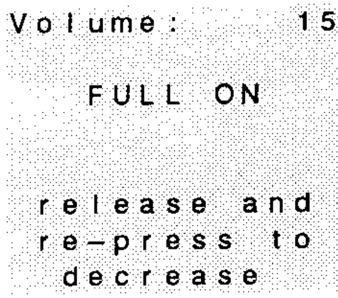
increasing

The big arrow symbol shown on the screen indicates whether the volume is increasing or decreasing. The volume has 16 steps. As you continue to press , the volume is adjusted at a rate of about two steps per second for the first two seconds, and thereafter at a rate of four steps per second.

The number in the top right corner of the screen indicates the volume setting. 0 is off, and 15 is loudest. When at these limits, the following screens are displayed:



minimum



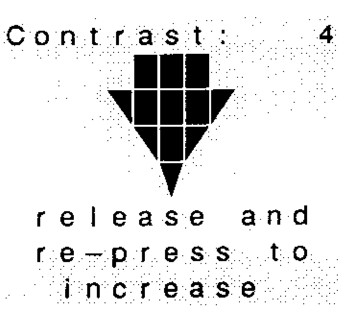
maximum

The volume is always off immediately after power on. Therefore, the first time you press after power on, the volume increases. To reduce the volume, release , and press it again. Each time you press the volume changes in the opposite direction from the last time that it was adjusted, regardless of when the volume was last adjusted.

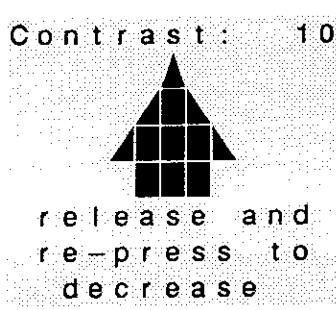
3.3.3 Contrast,

You will need to adjust the contrast to suit the ambient conditions. When the instrument is turned on, the contrast is set to the value it had before being turned off.

To adjust the contrast, press and hold . One of the following screens is displayed:



decreasing



increasing

The big arrow symbol shown on the screen indicates whether the contrast is increasing or decreasing. The contrast has 16 steps. As you continue to press [◑], the contrast is adjusted at a rate of about two steps per second for the first two seconds, and thereafter at a rate of four steps per second.

The number in the top right corner of the screen indicates the contrast setting. 0 is lightest, and 15 is darkest. When at these limits, the screens below are displayed:

minimum	maximum
Contrast: 0 MINIMUM release and re-press to increase	Contrast: 15 MAXIMUM release and re-press to decrease

The first time you adjust the contrast after power on, the contrast increases. To reduce the contrast, release [◑], and press it again. Each time you press [◑] the contrast changes in the opposite direction from the last time that it was adjusted, regardless of when the contrast was last adjusted.

3.3.4 LCD Backlight, [☼]

Press [☼] to turn on or off the light behind the LCD. In a brightly lit room or in sunlight you will not notice any difference – use the backlight in dimly lit environments.

The light is an EL type, and consumes much power. Therefore, the light is automatically turned off if you have not used the instrument for about two minutes. The light is also turned off when the instrument's power is turned off.

When you press [☼] the displayed screen does not change – the key serves as a true on and off switch, and has no effect on any other instrument function.

3.4 The Condition After Power on

The HP 37741A is powered by a rechargeable battery. When the power is turned off, the battery continues to power the instrument's memory and real time (time of day) clock. When you turn the main instrument power back on, some of the settings that the instrument had before power off are restored.[1]

Under normal circumstances, the following describes the condition of the HP 37741A after power on:

a. Screen 0000 (the copyright notice) is briefly displayed. Screen 1000 is then displayed, and will remain displayed until you press any key except [☼].

b. The current time and date are displayed.

c. All the keys are functional, even if they had been disabled before power off by an external command.

d. The status of the key beep (tone, click, or off) is restored to the value that it had before power off.

e. The first screen displayed when you press [TEST] is screen 3000, except if a test resumes as described in paragraph (p).

f. The first screen displayed when you press [SET] is screen 2000.

g. The first screen displayed when you press [LINE] is screen 4000.

h. The first screen displayed when you press [PATH] is screen 5000.

i. The volume is turned off, so that irrespective of whether a test had been running or a DS0 channel had been accessed, the instrument is quiet.

j. The first time you press [◢], the volume will turn on, and start to increase when you hold [◢].

k. The contrast is restored to the setting it had at power off.

l. The first time you press [◑], the contrast will increase (get darker), unless it had been left at maximum, in which case it will decrease.

m. The backlight remains off.

n. The first time you press [☼], the backlight will turn on.

---

1 If the battery becomes discharged to the point where it cannot maintain the memory and clock, data will be lost.

o. If a sequential test (for example, multipattern or bridge tap) was running when the instrument was last turned off, that sequential test is not resumed when power is turned on.

p. If a non-sequential test had been running, and you turned the test set off by pressing [POWER], the test was terminated when [POWER] was pressed, and will not restart. However, if the batteries had become discharged so that the test set turned itself off, any test that was running was suspended, and will be resumed when power is restored.

q. The results of the previous test, whether that test continues to run or not, are restored, and are available for viewing. If the test is resumed, error counts will be updated as if there had been no power loss interruption.

r. If a sequential test had been running, the errors which are displayed on the results screens are the aggregate errors from the sequential test. The individual counts of bit errors and errored seconds are displayed on screen 5600.

s. All previously saved test results are unaltered.

t. The [TEST] configuration of test duration and print frequency are unchanged.

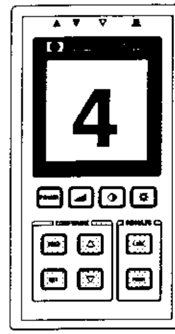
u. The [SET] configuration of T1 transmitter (output), T1 receivers (main and reference inputs), EIA-232 (serial port), and miscellanea (date and time format, and unit ID) are all unchanged.

v. The T1 transmitter (output) will be restored to the condition it had before power off, with the following exceptions

   If the test set had been looped (by an externally generated loopback command), and a test had been running at the time of power off, but is not running now, the loopback will not be restored. The output will instead transmit the signal that was being transmitted before the loopback command was received.

   If a sequential test had been running, the payload of the transmitted signal is restored to the payload set prior to the start of the sequential test.

How to Run a Test and View the Results



4.1 Test Configuration Screens, 3xxx

The *configure test* menu system is accessed by pressing [TEST]. All selections are made within this menu system by using [▲] and [▼] to select a choice, and [TEST] to activate that choice.

4.1.1 How to Display the Main TEST Menu, Screen 3000 or 3001

There are two top level (main) TEST screens. Screen 3000 is displayed if there is presently no test running, and screen 3001 is displayed if a test is in progress (these are shown on the next page). The test time cannot be altered while a test is in progress, and you cannot save results to, or recall results from, the memory while a test is in progress.

To access the top level TEST menu, press [TEST]. If another test menu screen is displayed you can do one of three things:

- Press and hold [TEST]. Screen 3000 or 3001 will be displayed after one second.
- Press [TEST] repeatedly until its top level screen is displayed. Each menu system returns to its top level screen, after reaching the last screen in that menu branch.
- Press [◢], [◑], [SET], [LINE], or [PATH], and then press [TEST]. Each of those keys causes the TEST menu system to return to the top level screen.

In addition, the top level TEST menu is always the first that can be accessed after turning on the instrument power.

3000

TEST IDLE ✋	
→ start	6000
printer	3100 or 3101
show times	3200 or 3201
save	3300 or 3310
recall	3400 or 3410
cfg tst time	3500
special	3010

3001

TEST ACTIVE ⧗	
→ stop	3000
printer	3100 or 3101
show times	3200 or 3201
Configd time:	
hh:mm:ss	
Time left:	
hh:mm:ss	

- By default, → points to start or stop.

4.1.2 How to Start or Stop a Non-Sequential Test

1. Display the top level TEST screen.
2. Press [▲] or [▼] to move → to point to start or stop.
3. Press [TEST].
   - Normally, to start or stop a test, you would press [TEST] twice. This applies whenever a SET, LINE, or PATH screen is being displayed.

You can tell whether a test is running by either looking at the top level TEST screen, or by looking at any of the LINE or PATH results screens. When a test is not running, the flashing hand, ✋, is displayed on these screens. The ✋ is replaced by a different icon when a test is running.[1]

[1] The icons are described in section 3.2.2.

4.1.3 Test Active vs Test Idle

The transmitter and receiver of the HP 37741A are always active.

When the test is started, the HP 37741A resets all the error counters, and monitors the received signal for errors. All LINE and PATH results are frozen when a test is stopped. No matter what happens to the input signal, none of the results displayed by the test set is updated when the test is idle (not running).

The output signal is what you have configured it to be, regardless of whether a test is running or not. If you have configured the test set so that the output is dependent upon the input, that dependence is maintained regardless of whether a test is running or not.

The displayed transmit icons reflect the current transmitted signal. Any interdependence between the transmitted and received signal will be reflected in all results screens, as long as a test is currently `active`. If the test is `idle`, this interdependence may appear to be lost, simply because the icons show current status, while the displayed results then show historical status.

4.1.4 How to Configure the Test Time, Screens 35xx

For non-sequential tests, the test time is completely configurable from one second to 24 hours, or a test can run continuously. You can adjust the test time only when a test is not running.

1. If a test is running, stop the test.
2. Choose `cfg tst time` from screen 3000, and press [TEST].
   - Screen 3500 is displayed:

```
3500
Test duration

→continuous          3000
 fixed time          3510
   in hh:mm:ss
 fixed time          3520
   in seconds
```

- ➜ always points to the current configuration.

3. Move ➜ to point to your choice.
   - `fixed time in seconds` allows you to choose from 10 pre-selected time periods.
   - `fixed time in hh:mm:ss` allows you to choose any period from 1 second to 24 hours.
4. Press [TEST] to activate your selection.
5. If you selected `fixed time in seconds`, screen 3520 is displayed.

```
3520
Test duration
seconds:
 3      10       100
 5    ➜300       500
  1000      5000
  10000     50000      3000
Totl   00:05:00
           300  s
```

   - ➜ always points to the current configuration.
   - Choose the desired time and press [TEST].
   - The main test menu, screen 3000, is displayed.
6. If you selected `fixed time in hh:mm:ss` screen 3510 is displayed.

```
3510
Test duration
hours:

➜00                    3511


Totl   00:05:00
           300  s
```

   - The hour that is displayed is the last that was selected.
7. Press [▲] or [▼] to change the hour, and press [TEST].

- The → does not move – the number changes. The number rolls from 24 to 0 and vice versa.
- Screen 3511 is displayed:

```
3511
Test duration
minutes:

→05                3512


Totl 00:05:00
          300 s
```

- The minutes that are displayed are the last that were selected.

8. Press [▲] or [▼] to change the minute and press [TEST].
   - → does not move – the number changes. The number rolls from 60 to 0 and vice versa.
   - Screen 3512 is displayed:

```
3512
Test duration
seconds:

→00                3000


Totl 00:05:00
          300 s
```

   - The seconds that are displayed are the last that were selected.

9. Press [▲] or [▼] to change the second and press [TEST].
   - The → does not move – the number changes. The number rolls from 60 to 0 and vice versa.

In screens 3510, 3511, 3512, and 3520, the configured test duration is shown in both hours:minutes:seconds, and total seconds. If you configure the test time in seconds, the HP 37741A will display and print the test times (duration, elapsed, and remaining) in seconds. If you configured the times in hours:minutes:seconds, that format is displayed and printed.

If you set the hours:minutes:seconds to all zeroes (screens 3510, 3511, and 3512), you will not be able to start a test. When instrument power is turned off and then on, the test time will be set to five minutes.

4.1.5 How to Run a Special Test

The special tests are suites of tests which the HP 37741A automatically runs for you. There are two types of special tests:

- self test (which is described in section 16.6)
- sequential tests – bridge tap, multipattern, and user programmable

1. If you are going to run a sequential test, configure the frame format for the line under test. Also, turn off any transmitted tones or signaling, and stop any error insertion.[1]
2. Display the top level TEST screen.
3. Stop the test, if one is running.
4. Press [▲] or [▼] to move ➔ to point to special.
5. Press [TEST].
   ▸ Screen 3010 is displayed:

```
3010
Select
special test:

  self test        3600
➔bridge tap        3700
 multipattern      3700
 user 1            3710
 user 2            3710
```

▸ ➔ always points to the current configuration.

▸ user 1 and user 2 are programmable test sequences. When the test sequence is programmed, the name can also be changed, so that your screen may not look like that shown.

1 A quick way to achieve such a state is to use a preconfigured setting, as described in section 5.2.

- The default sequences are described in section 9.

6. Press [▲] or [▼] to move ➔ to point to the required test sequence. Self test is discussed in section 16.6.
7. Press [TEST].
   - If you selected a user programmable sequence, you cannot adjust the test time for the individual patterns, and screen 3710 is displayed.
   - Screen 3700 is displayed if you selected bridge tap or multipattern:

3700

```
Select test
time for each
pattern:

➔23  seconds

Normal:   23 s
```

3710

   - ➔ always points to the last selected test time for the sequence. The factory defaults are 23 seconds for bridge tap and 175 seconds for multipattern. These values are compatible with older style equipment and are indicated on the bottom of the screen.
   - The time for each sequence of patterns is approximately equal to the number of patterns in the sequence multiplied by the test time for each pattern.
8. Use [▲] and [▼] to change the test time, and then press [TEST] to select that choice.
   - ➔ does not move, the time changes.
   - The time wraps round from 255 to 1 and vice versa.
   - Screen 3710 is displayed:

3710

```
Select number
of iterations
of special
test:

→continuous
```

3000 or 3001

- → always points to `continuous`.

9. Use [▲] and [▼] to change the number of iterations, and then press [TEST] to select that choice.
   - → does not move; the displayed values are `cancel`, `1`, `2`, ... , `8`, `9`, and `continuous`.
   - Screen 3000 is displayed if you select `cancel`. If you make another selection, screen 5600 is displayed and the test starts.
   - The total test time (for one to nine iterations), is approximately equal to the sequence test time multiplied by the number of iterations.

When a sequential test is running, the instrument changes only the test patterns, and displays aggregate results for all the patterns in the test sequence on the standard results screens. In addition, a supplementary special purpose screen (5600) displays selected results for the individual patterns which make up the sequence.

4.1.6 How to View the Test Times, Screens 320x

You can view the test times regardless of whether a test is running or not. The displayed information is dependent on whether the test period is fixed or continuous.

4.1.6.1 Non-Sequential Test

1. Display the top level test screen.
2. Choose `show times` and press [TEST].
   - If the test duration is fixed, screen 3200 is displayed:

3200

```
 TEST  TIMES  ⧖   3000 or 3001
Cfg   hh:mm:ss
Strt  hh:mm:ss
 yy/mm/dd  Www
Left  hh:mm:ss
Elps  hh:mm:ss
Stop  hh:mm:ss
 yy/mm/dd  Www
```

Cfg This is the test duration that you have configured. If the time was configured in seconds, the value is displayed in seconds; otherwise, the time is displayed in hours:minutes:seconds.

Strt This is the date and time when the last test was started, irrespective of whether a test is running or not. Both the date and time are displayed in the currently configured format.

Left This is the amount of test time remaining. If a test is not running, the time is zero.
If a test is running, the time is decremented every second; the value is displayed in seconds, or hours:minutes:seconds.

Elps This is the elapsed test time for the current, or most recent test. If a test is running, the time is incremented every second.
The value is displayed in seconds, or hours: minutes:seconds.

Stop If a test is running, this is the estimated date and time when the test will end. If a test is not running, this is the date and time when the last test ended. Both the date and time are displayed in the currently configured format.

- If the test duration is continuous, screen 3201 is displayed:

3201 (test running)

```
 TEST  TIMES ⧗   3001
Cfg    continue
Strt  hh:mm:ss
 yy/mm/dd  Www
Elps    nn  days
        hh:mm:ss
```

3201 (test idle)

```
 TEST  TIMES ✋   3000
Cfg    continue
Strt  hh:mm:ss
 yy/mm/dd  Www
Elps    nn  days
        hh:mm:ss
Stop  hh:mm:ss
 yy/mm/dd  Www
```

- The Strt, Elps, and Stop times are interpreted as above.

4.1.6.2 Sequential Test

When a sequential test runs, the instrument starts and stops the test automatically for you as each pattern changes. The dates and times indicated on these screens take on slightly different meanings. While running the sequential test, the instrument alternates between a fixed test, and a continuous test.

The Strt time is the time the sequential test started. The Elps time is the sum of the times for which all of the patterns in the sequence have been tested, which is not the same as the time since the test was started. For example, a multipattern test which has been running for 12 minutes may show an elapsed time of 8 minutes 45 seconds. The remaining time is consumed in pattern synchronization and other overhead. Error accumulation is inhibited during this overhead time.

At the end of the sequential test, the test period for a non-sequential test is restored to that which was selected prior to the sequential test.

4.2 How to View the Results Summary, Screen 6000

4.2.1 General

When you start a non-sequential test, the results summary screen is automatically displayed.

When most of the results screens are displayed you can press [▲] or [▼] to view the results summary screen.[1]

6000

```
RSLT SUM       ⧗   see text
FullT1 NoAlrm
D3/D4         3
3in24        57
B8ZS        162
Level  -16.4dB
Slips   -1;190
Ch→03   +0.6dB
```

As with all results screens, the results on this screen are frozen at the end of the test. This summary screen then indicates the status of the received signal at the end of the last test.

Pressing [SET], [LINE], or [PATH] causes the last viewed SET screen, line results screen, or path results screen to be displayed. Therefore, you can concentrate on some detailed results, easily see the overall summary of the received signal, and return to the detailed results.

This is shown in figure 4-1. For example, if you are viewing a particular SET screen, and you press [PATH], a path results screen is shown. If you then press [▲], the results summary screen is shown. When you press [SET], the original SET screen is shown.

1 While a test is running, these keys are used for different purposes on screens 4300, 5500, and 5501. When the test is stopped, the up and down arrow keys allow you to access the results summary from these screens.

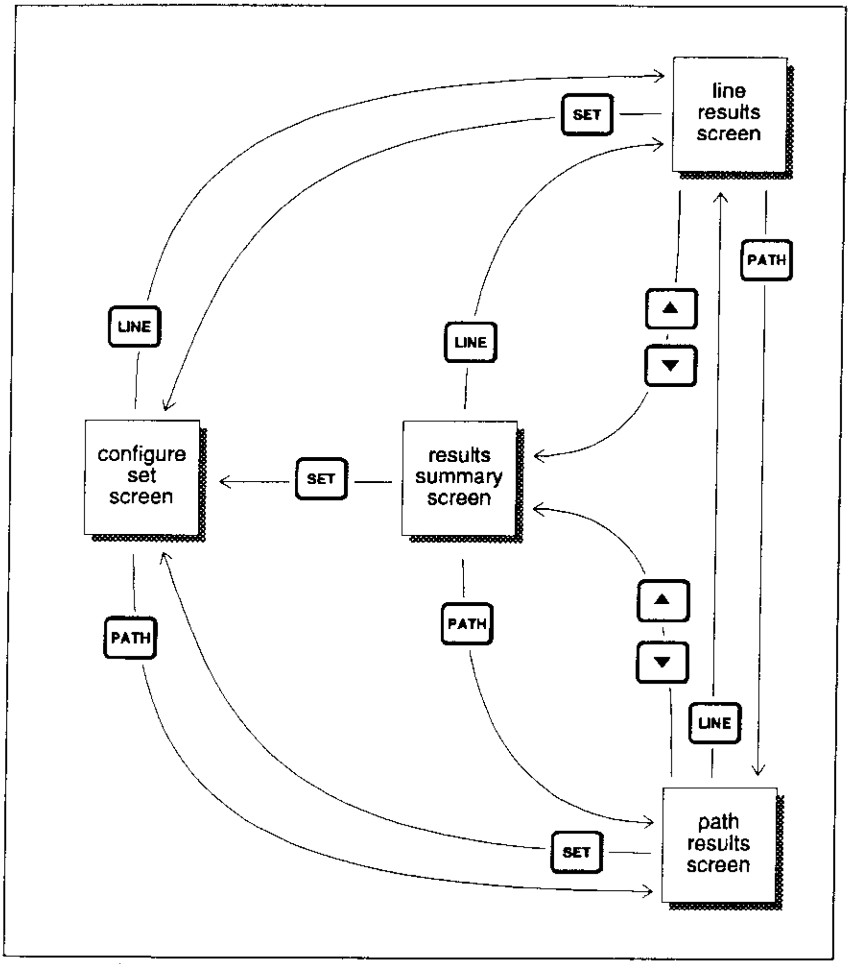


Figure 4-1 Accessing the Results Summary Screen

4.2.2 Screen Title , Line 1

The title line indicates this is the results summary screen. The top right position contains the test status icon; adjacent to it are the three positions for the transmit icons.

When an alarm is being received, the word R S L T flashes. The alarm type (on line 2) also flashes. If the alarm is a frame loss, the frame type (on line 3) flashes. If the alarm is a pattern loss, the pattern type (on line 4) flashes.

Pressing [TEST] causes screen 3000 or 3001 to be shown.

4.2.3 T1 Mode, Line 2

The mode of the received T1 signal is shown in the left field on line 2. This is one of:

Full T1	receiving a full T1 signal
FT1/56	receiving an N × 56 signal
FT1/64	receiving an N × 64 signal

4.2.4 Alarm Indications, Line 2

Any alarm conditions currently being received are shown in the right field of line 2. This is one of:

NoAlrm	no alarms being received
LOS	receiving LOS (no input signal present)
AIS	receiving AIS
FrmLos	receiving frame loss
PtnLos	receiving pattern loss
Yellow	receiving yellow alarm

If a pattern loss exists at the same time as a yellow alarm (as is typical when the frame format is D3/D4), this summary screen indicates that a yellow alarm is being received.

4.2.5 Frame Type and Error Count, Line 3

This indicates the received frame type and frame error count. Examples of this line are:

SLC-96	0	SLC-96 frame (no frame errors)
ESF	123	ESF frame (123 frame errors)
D3/D4	0	D4 frame (no frame errors)
Frm=?	0	frame format has not yet been identified
Unfrmd	0	receiving an unframed signal

4.2.6 Pattern Type and Error Count, or CRC Error Count, Line 4

When the HP 37741A receives a recognized test pattern, this line indicates the received pattern type and logic error count.

If the payload is unrecognized, and the frame format is ESF, the line indicates the CRC error count. Otherwise, the pattern type indicates Ptn=?.

4.2.7 Line Code Type and BPV Count, Line 5

This indicates the received line code type (AMI or B8ZS) and BPV error count.

If the line code has not yet been positively identified, the line code type indicates Code=?.

4.2.8 Input Signal Level, Line 6

This is the same as that indicated in screen 4000. The measurement units are dBdsx, but for brevity are indicated simply as dB.

4.2.9 Slip Counter, Line 7

This is similar to line 3 of screen 4200. When slips are being received, the number changes. When the two inputs have the same frequency, the number is steady.

When there is no signal at the reference input, the number is replaced by NoRef.

4.2.10 Channel Access, Line 8

When a test is running, the ➔ is displayed next to the channel number. You can monitor a different channel by pressing [▲] or [▼].

The level of the amplitude in the channel is indicated. This is identical to the value shown on line 6 of screen 5500 or 5501. The measurement units are dBm0, but for brevity are indicated simply as dB.

4.3 How to View the Line Results, Screens 4xxx

4.3.1 Identifying the Screens and the Icons

The line results are viewed by pressing [LINE]. There are five screens of results, each viewed by successive pressings of [LINE].

On each of the line results screens, the word LINE is on the top line. On the same line, the position of the current screen in the line result screen sequence is given. For example, 3 / 5 means the third of five screens.

When a test is running, a test icon, ⌛, BT, MP, or US, is also displayed on the top line. The test icon is removed when the test ends, and replaced with a flashing ✋. The displayed values are then frozen.

Thus, the displayed values reflect the *current* state of the input signal only when a test is running. If a test is not running, they represent the state when the test was stopped.

The transmit icons are also displayed on the first line. The icons are described in section 3.2.2.

At the start of a test, all error counts and error rates are set to zero, and availabilities are set to 100%.

Whenever any input alarm condition is currently active (the instrument is *receiving* an alarm and a test is running), the word LINE flashes once per second.

4.3.2 How to Display the Top Level Screen, 4000

To access the top level LINE screen, press [LINE]. If a screen other than 4000 is displayed you can do one of two things:

- Press and hold [LINE]. Screen 4000 will be displayed after one second.
- Press [LINE] repeatedly until its top level screen is displayed. Each sequence of results screens returns to its top level screen after reaching the last screen in that sequence.

In addition, the top level screen is always the first that can be accessed after turning the power on.

4.3.3 Signal Screen, 4000

```
4000
LINE 1/5       ⌛ 4100
 SIGNAL(brg)
Lvl    0.15 Vpp
    -35.7 dBdsx
Frq      +65 ppm
     1544100 Hz
Smplx current
         128 mA
```

Next to the screen title is displayed the configuration of the receiver input. This is one of:

(mon)	monitor
(trm)	terminate
(brg)	bridge

IMPORTANT

This indication changes only when a test is running. When the test has stopped (the ✋ is displayed), the indication is frozen, and may not represent the current state. Like the results, it then represents the status of the signal at the end of the last test.

Lvl indicates the signal level of the main input. The absolute level and the level relative to the nominal level of 6.0 Vpp at the cross-connect bay are given. In monitor mode, the level indication is the same as that which would be read if bridged across the line. When no signal is present, the test set will indicate a low value for the level.

Frq indicates the frequency of the clock recovered from the main input, and the offset in ppm from the nominal frequency of 1.544 MHz. When no signal is present, these numbers are zero.

Smplx current indicates the simplex current flowing between the main input and the output. The current direction is not indicated. When no current is flowing, the test set will indicate a low value.

4.3.4 Line Code, Screen 4100

```
4100
LINE 2/5        ⧗  4200
    CODE
Rx          AMI
BPV        1234
ES           97
EFS         251
%EFS     72.13%
BER    2.3E-06
```

The received code indicates what has been identified by the test set, and can be one of:

AMI	No B8ZS signatures have been received, or strings of eight or more zeroes have been received.
B8ZS	B8ZS signatures are being received, and strings of eight or more zeros are not being received.
None	No signal has yet been received, so the line code has not been identified.

If, having received a signal and identified the line code, the signal is removed (LOS), the received line code indication of AMI or B8ZS will not be replaced by None.

IMPORTANT

A T1 line may be configured for B8ZS, and not sending any B8ZS signatures, because there is a high ones density (for example AIS). In these cases, the HP 37741A may indicate that the signal is AMI.

4.3.5 Bit Slips, Screen 4200

```
4200
LINE 3/5          ⌛ 4300
   BIT SLIPS
Total     -1;190
CurDir      slow
Est. frame
  slips        1
Relative bit
  slips        2
```

The Total bit slips are the difference between the total number of bits received (since the start of the current test) on the main input and the reference input. The sign is + if, on average, more bits have been received on the main input than the reference input, and – if the converse is true. The number is displayed modulo 193, the number to the left of the ; being the more significant number (effectively, therefore, a count of frames).

CurDir is the current direction of the main input rate with respect to the reference input. This will show fast if the main input frequency is currently higher than the reference input frequency, and slow if the converse is true. When the two signals have the same frequency the line will show sync. If no signal is being received on the reference input, NoRef will be shown.

Thus, the words slow or fast indicate the *instantaneous* difference between the bit rates of the two inputs, and the signs + or – indicate the *long term* difference.

Each time there have been 193 bit slips in either direction, the Est. frame slips counter is incremented, and the Relative bit slips counter is set to zero. As bit slips continue to occur, the relative bit slips will increase until again they total 193.

The counter values are not reset by LOS on either input. They are reset only at the start of a test.

4.3.6 Loopbacks, Screen 4300

4300	4300
LINE 4/5 ⧗	LINE 4/5 ✋ 4400
LOOPBACKS	LOOPBACKS
Instrument	Instrument
not looped	not looped
Press:	Text is printed in a small size. See below for details.
▲ for line↑	
▼ for line↓	
when a test is running	when a test is not running

4.3.6.1 Active and Passive Functions

This screen allows you to transmit loopback codes.[1] Loopback codes that are received are displayed. The instrument will tell you whether the loopback command was successful or not. When the test is not running, the screen indicates the status of any received loopback codes at the end of the last test.

4.3.6.2 Instrument Status, Line 4

This line indicates whether the test set is currently sending any loopback code, or whether the test set is looped in response to a received loopback code.

When not looped, and not receiving a code, the status is not looped. When sending a loopback code, the status is one of:

snding line↑	line up
snding line↓	line down
snding 4bit↑	4 bit up
snding 4bit↓	4 bit down
snding NI↑	network interface up
snding NI↓	network interface down
snding pyld↑	payload up
snding pyld↓	payload down

1 You can therefore actively change the transmitted signal from this screen. All other results screens are passive, in that you cannot affect the transmitted signal.

When the test set has responded to a loopback code, the status is one of:

```
Line looped
4bit looped
NI looped
Pyld looped
```

4.3.6.3 Far End Status, Line 5

This line indicates the receive status, and the status of the device at the far end. The line is normally blank, and the status is normally displayed only momentarily.

When receiving a loopback code, the status is one of:

rcving line↑	line up
rcving line↓	line down
rcving 4bit↑	4 bit up
rcving 4bit↓	4 bit down
rcving NI↑	network interface up
rcving NI↓	network interface down
rcving pyld↑	payload up
rcving pyld↓	payload down

After sending a loopback command, one of the following is displayed for a short time:

FarEnd looped	when a loop up command is successful, or a loop down command is unsuccessful
FarEnd un-lpd	when a loop down command is successful, or a loop up command is unsuccessful

4.3.6.4 Sending Loopback Commands, Lines 7 and 8

You can use this screen to send a loopback code.

When you press [▲] the loop up command is sent for 8 seconds; when you press [▼], the loop down command is sent for 8 seconds. The type of loopback code that is transmitted is pre-selected in screen 2122.[1] The display changes to reflect the loopback type that will be transmitted.

Loopback code transmission is inhibited when any of the following is true:

a. a test is not running[2]
b. the instrument has been remotely looped back
c. the loopback code type is selected to be "as input"
d. you have selected the loopback type to be "payload", but the instrument is not transmitting an ESF or ZBTSI signal
e. you have set the instrument to send an alarm

If any of these conditions holds, the bottom half of the screen indicates (in small text) what operations must be performed to enable loopcode transmission from this screen.

4.3.7 Miscellaneous Data, Screen 4400

```
4400
LINE 5/5        ⧗  4000
     MISC

XsOs           76
Dense         638

Last resync
time        45 ms
```

The number of excess zeros violations, XsOs, and density violations, Dense, are indicated.

The Last resync time indicates for how long synchronization was lost during the last signal disturbance. This is used to measure APS switchover time, or other momentary periods of signal interruption.

1 Described in section 5.3.5.
2 This function is inhibited when a test is not running because none of the results is then updated. You would not be able to tell whether the loopback command had been successful or not.

4.4 How to View the Path Results, Screens 5xxx

4.4.1 Identifying the Screens and the Icons

The path results are viewed by pressing [PATH]. There are six screens of results, each viewed by successive pressings of [PATH].

On each of the PATH results screens, the word PATH is on the top line. On the same line, the position of the current screen in the path result screen sequence is given. For example 3 / 6 means the third of six screens.

When a test is running, a test icon, ⧖, BT, MP, or US, is also displayed on the top line. The test icon is removed when the test ends, and replaced with a flashing ✋. The displayed values are then frozen.

Thus, the displayed values reflect the *current* state of the input signal only when a test is running. If a test is not running, they represent the state when the test was stopped.

At the start of a test, all error counts and error rates are set to zero, and availabilities are set to 100%.

Whenever any input alarm condition is currently active (the instrument is *receiving* an alarm and a test is running) the word PATH flashes once per second.

The transmit status icons are also displayed on the top line of all results screens. Refer to section 3.2.2 for details.

4.4.2 How to Display the Top Level Screen, 5000

To access the top level PATH screen, press [PATH]. If a screen other than 5000 is displayed you can do one of two things:

- Press and hold [PATH]. Screen 5000 will be displayed after one second.
- Press [PATH] repeatedly until its top level screen is displayed. Each sequence of results screens returns to its top level screen after reaching the last screen in that sequence.

In addition, the top level screen is always the first that can be accessed after turning the power on.

4.4.3 Alarm Seconds Screen, 5000

```
5000
PATH 1/6        ⧖   5100
ALARM SECONDS

LOS              0
AIS             14
FrmLos           0
PtnLos          17
Yellow           2
```

The following alarms are displayed:

LOS	loss of signal
AIS	alarm indication signal
FrmLOS	frame loss
PtnLOS	pattern loss
Yellow	yellow, or remote, alarm

Associated with each alarm is a count of the number of seconds during which the alarm occurred.

If the alarm is currently active the alarm label will flash synchronously with the word PATH.

If an alarm is currently not active, a non-zero value for the alarm seconds count indicates that the alarm has occurred (alarm history).

4.4.4 Frame Screen, 5100

```
5100
PATH 2/6        ⧖   5200 or 5201
 FRAME(auto)
ZBTSI    FullT1
EC         1234
ES           97
OOF cnt       2
COFAcnt       1
avgER  1.1E-05
```

Next to the screen title is displayed the configuration of the receiver frame mode. Examples of this are:

(a u t o)	auto frame (the factory default condition)
(D 3 / D 4)	D4 frame
(E S F)	ESF frame

If you have not set the receiver to auto frame, and the receiver has not framed to the received signal, you are reminded that you have explicitly set the receiver frame format.

IMPORTANT

This indication changes only when a test is running. When the test has stopped (the ✋ is displayed), the indication is frozen, and may not represent the current state. Like the results, it then represents the status of the signal at the end of the last test.

Line 3 shows the received frame format, and received mode.

If you have configured the received frame format to autodetect the incoming frame type (screen 2230), the received frame format indication is dependent on the input superframe DS0 channel sequence that you have configured (screen 2240). This is indicated in figure 4-2. The receive DS0 setting does not affect the instrument's ability to frame.

For example, if you are working on an older channel bank, you can set the receiver DS0 sequence to be D2. When the test set receives a D4 frame, it will indicate that the frame format is D2, which allows you to correctly access the DS0 channels. If you have set the HP 37741A's receive DS0 sequence to SLC-96, and a D4 frame is received, the test set displays D L C again allowing you to access the channels correctly.[1]

If, at the start of a test, no signal or no frame was received, the indication F r m = ? is displayed. If the frame format of a signal was identified, and framing is subsequently lost, the frame format indication is not changed.

If you have explicitly specified the receive frame format type in screen 2230, the specified format will be displayed.

1 This is explained further in sections 8.3, 8.4, and 12.1.

If framing is lost, the frame format type flashes synchronously with the word P A T H, and the frame loss seconds (on screen 5000) increases.

Received Frame	Receive Super Frame DS0 Sequence Set by User			
	D1D	D2	D3/D4	SLC-96
D4	D1D	D2	D3/D4	DLC
SLC-96	SLC96			
ESF	ESF			
ZBTSI	ZBTSI			
no frame	UnFrmd			
no signal	None			

Figure 4-2 Frame Format Displayed for Different Channel Sequence Settings

4.4.5 CRC Screen, 5200

```
5200
P A T H   3 / 6         ⧖  5300
          C R C

E C             1 2 3 4
E S                 9 7
E F S             2 5 1
% E F S       7 2 . 1 3 %
a v g E R   2 . 3 E − 0 6
```

If the received frame format is not ESF or ZBTSI, all the numbers remain fixed at zero. If the received frame format is SLC-96, screen 5201 is displayed instead.

4.4.6 SLC-96 Data Link Screen, 5201

```
5201
PATH 3/6      ⌛ 5300
  SLC-96 DL
Alarm -------
FELP  -----
   1234567891011
C  11111110000
S  1111=idle
M  111      (16)
```

This screen indicates the status of the SLC-96 data link. The two bit alarm field (A1 and A2) is demultiplexed, and the various messages are indicated on the lines labelled Alarm and FELP. When no alarm messages are being received (all are inactive), a - is indicated, as shown in the screen above.

The active state of each of the messages is indicated by a character. When all the alarms are active, the alarm line reads:

```
Alarm ABCDMmP
```

A, B, C, and D represent the individual shelf alarms. M and m are the major and minor alarms, and P is the power and miscellaneous alarm.

If all the far end loop messages were active, the FELP line would read:

```
FELP  ABCDP
```

A, B, C, D, and P represent the individual lines.

The C bits (concentrator field), the S bits (protection switch field), and the M bits (maintenance field) are shown on a bit by bit basis. Bit 1 is the MSB.

The S bits are decoded, and follow the bits after the = sign. The decoded value is one of:

idle	no activity
ARx	switch line A receive
BTx	switch line B transmit
CTx	switch line C transmit

D T x	switch line D transmit
B T & R	switch line B transmit and receive
C T & R	switch line C transmit and receive
D T & R	switch line D transmit and receive
i n v d	invalid

On the bottom right of the screen (1 3) or (1 6) is shown. This indicates the length of the received alarm message frame.

4.4.7 Logic Screen, 5300

```
5300
PATH  4/6        ⌛  5400
 LGC(FT1/64)
3in24      896kb
EC          1234
ES            97
EFS          251
%EFS     72.13%
BER     2.3E-06
```

Line 2 indicates the setting of the receive mode (screen 2205).[1]

Line 3 indicates the received test signal, and its bandwidth. Examples are:

P t n = ?	1 5 4 4 k b	test pattern is unrecognized
3 i n 2 4	1 5 3 6 k b	3 in 24 pattern being received, at 1536 kb/s
$2^{11} - 1$	6 4 k b	PRBS being received with a single channel active (64 kb/s)

If, at the start of the test, the test signal is not recognized by the instrument, P t n = ? is indicated. The count of pattern loss seconds (on screen 5000) does not increment. All the numbers on screen 5300 remain fixed at zero.

However, if a recognizable test pattern has been received, and is now lost, the PLS count increments, and the instrument continues to display the pattern type that had been received. At the same time, the

1 This is described in section 5.4.2.

received pattern indication flashes synchronously with the word PATH.

When a recognizable pattern is being received, and logic errors are received, the error counts and rates will change accordingly. The HP 37741A cannot detect a received channel word pattern (unless that pattern is the same as one of the eleven standard or four user defined transmitted patterns).

4.4.8 G.821 Logic Analysis Screen, 5400

```
5400
PATH 5/6          ⧗   5500 or 5501
LOGIC  (G.821)
UAS              99
SES            1063
CSES            751
%SES         17.62%
%avl         88.49%
DM                6
```

The numbers on this screen are displayed according to the rules outlined for screen 5300.

4.4.9 Channel Screens, 5500 and 5501

Screen 5500 is displayed when the received frame format is ESF or ZBTSI; screen 5501 is displayed when the received frame format is SF (D1D, D2, D3/D4, SLC-96).

```
5500                        5501
PATH  6/6        ⧗          PATH  6/6        ✋   5000
     CHANNEL                     CHANNEL
ZBTSI   FullT1              D3/D4    FT1/56
Ch→01  Time slot map,       Ch  01  Time slot map,
TS  01  see below           TS  01  see below
Lvl    -6.0  dBm            Lvl   -12.9  dBm
Hi  +102    ABCD            Hi  +084    ABAB
Lo  -102    0101            Lo  -084    0000
ZBTSI, test running         D4, test not running
```

The frame format displayed is the same as that displayed in screen 5100.

When a test is running, the ➔ is displayed next to the channel number. You can select another channel number by pressing [▲] or [▼].

Lvl indicates the amplitude of the signal in the channel. When a test pattern (or other signal) is being received which does not change the code in the channel, the instrument displays – – – – –.

Hi and Lo indicate the largest digital number received and the lowest digital number received during the last second.[1] Some instruments have flashing lights to indicate activity. This scheme gives more information – if the high value is different from the low value there is activity in the channel. If the high value equals the low value, the word in the channel is not changing.

The signaling bits are shown as A B A B (for SF) or A B C D (for ESF). For SF frame formats, this indicates whether signaling bits are toggling. For example, if A B A B is 0 1 0 0, the B bit is toggling.[2]

The timeslot map is in small characters, and indicates which timeslots are in use. Examples are:

TS MAP	TS MAP
********	******..
********	....
********	....
All time slots used	Only time slots 1 to 6 used

The timeslot map is relevant whether the signal is full T1 or FT1. The . character indicates that a channel is idle. This can help, for example, with the diagnosis of problems on a multiplexer. If a channel card has failed, the timeslot map will easily allow you to pinpoint the problem.

When an unframed signal is received, screen 5501 is displayed, and the channel and time slot numbers are set to – –.

1 Appendix G lists tables that translate the Hi and Lo figures into binary words.

2 If the frame format is SLC-96, this indicates a positive coin check sequence for a payphone.

```
5501
PATH 6/6          ⧗ 5000
   CHANNEL
UnFrmd FullT1
Ch  --     Time slot map,
TS  --     all slots used
Lvl  -----  dBm
Hi   ---   ABAB
Lo   ---   ----
```

4.5 Sequential Test Results, Screen 5600

When you start a sequential test, the special test results summary screen (5600) is automatically displayed.

You can view screen 5600 when a sequential test is running, or when it has just stopped, by pressing [PATH] when screen 5500 (channel results) is displayed. Screen 5600 is not available at other times.

For a multipattern test, the results are contained on a single screen. For a bridge tap test, there are two pages of results. These separate pages are viewed by pressing [▲] or [▼]. One or two pages of results are required for a user programmable test sequence, depending on the number of patterns in that sequence.

The screens are shown in small characters. The screen for a multipattern test is shown here:

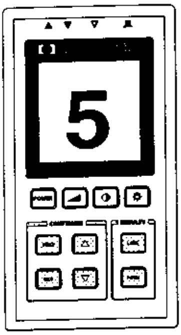
```
5600
SPECIAL SUM       MP
On loop:3
Ptn:3in24     15 s

Ptn    Lgc EC   SS
all 1      124  525
1in8        53  525
2in8#       19  525
3in24        4  365
QRW          0  350
```

The number of iterations is indicated on the second line. This is set to 1 for the first loop. For example, the screen above would be shown when the instrument has completed two loops and is on its third iteration.

The pattern name flashes when that pattern is currently being transmitted. On that line are shown the logic error counts and logic sync seconds for that particular pattern. This is an accumulated total for all iterations of the sequence. The other results screens show aggregate errors for all of the patterns.

The test status icon is steady when the received pattern matches that being transmitted. The icon flashes when the instrument is waiting to synchronize to the transmitted pattern. This is explained in more detail in section 8.

How to Configure the Transmitter and Receiver



5.1 General

This section describes the keys you will use, and the displays you will see, when configuring the transmitter and receiver. See sections 8 to 12 for detailed information on the capabilities of the transmitter and receiver.

5.1.1 What Configuring the Transmitter Does

When you configure the transmitter, you configure:

- the T1 output line code and timing
- the operating mode (full T1 or FT1)
- the frame format and payload of the transmitted DS1 signal
- the loopback codes that are to be transmitted
- the tone and signaling to be injected on a DS0 channel
- the generation of any alarms or errors

5.1.2 What Configuring the Receiver Does

When you configure the receiver, you configure:

- the operating mode (full T1 or FT1)
- the termination impedances of the main and reference inputs
- the expected frame format of the DS1 signal on the main input
- the reaction to a received loopback code

- the received DS0 channel to be accessed
- the reaction to any received alarms

5.1.3 The Keys You Will Use

The set transmitter and set receiver menu systems are accessed from the main SET menu (screen 2000) by pressing [SET]. All selections are made within this menu system by using [▲] and [▼] to move the arrow, ➔, to point to a choice, and [SET], [LINE], or [PATH] to select that choice.

5.1.4 The Difference Between Configured and Actual

The HP 37741A has a very large number of operating configurations. You can configure the output signal to be dependent on, or independent of, the input signal. You can configure the test set so that alarms are automatically inserted in the output signal when alarms are received at the input.

Some of these various configurations do not, therefore, explicitly specify what the transmitted signal actually is. The HP 37741A has a screen (accessed by pressing [SET]) that lets you know at any instant exactly what is being transmitted. This is screen 2700, and is described in section 5.5. In addition, the transmit status icons which are displayed on many screens also reflect the current transmit status. The transmit status icons are described in section 3.2.2.

5.1.5 How to Display the Main SET Menu, Screen 2000

To access the top level SET menu, press [SET]. If a screen other than 2000 is then displayed, you can do one of three things:

- Press and hold [SET]. Screen 2000 will be displayed after one second.
- Press [SET] repeatedly until the top level screen is displayed. Each menu system returns to its top level screen, after reaching the last screen in that menu branch.
- Press [TEST], and then press [SET]. Pressing the [TEST] key when the SET menu system is displayed causes the SET menu system to return to its top level screen.

In addition, the top level SET menu is always the first that can be accessed after turning on the instrument power.

```
2000
SET                    ⌛
  transmitter          2100
  receiver             2200
  EIA-232              2300
  miscellanea          2400
➜sys summary           2500
  to preconfig         2600
  show output          2700
```

- ➜ always points to the current configuration, except after power on, when it points to `transmitter`.
- The top line has icons to indicate the transmit status.

5.2 How to Set the Transmitter and Receiver to a Preconfigured Setting, Screen 2600

1. Select `to preconfig` from the main SET menu, screen 2000.
   - Screen 2600 is displayed:

```
2600
Config to:             2000
➜no change
  factory dflt
  orginate D4
  orginate ESF
  terminate
  through
  emulate
```

   - ➜ always points to `no change`.

2. Move ➜ to the pre-defined configuration that you want, and press [SET].

The factory default setting cannot be modified. The other settings can be modified over the serial port.[1] When the settings are modified, the name can also be modified. Therefore, your screen may not look like that shown above.[2]

Any of the settings can modify the programmable bit patterns (channel words and user words), and the SLC-96 data link bits.

The factory default setting not only resets the configuration of the transmitter and receiver, but also the test duration and print frequency. The *special* factory default configurations are:

- The test duration is set to continuous.
- The printing of results is turned off.
- If the instrument had been looped (by an external loopback command), the loop will be removed (un-looped).

None of the following is disturbed by the factory default setting:

- the EIA-232 usage, parity, word length, flow control, and bit rate
- the key beep status
- the format used to display the date and time
- the current date and time
- the unit ID

The other (user programmable) settings can modify only the transmit and receive settings (including the user words, channel words, and data link). In addition to the parameters that are not disturbed by the factory default setting, none of the following is disturbed by any of the user programmable settings:

- the test duration
- the printing of results
- the instrument's looped state (if it had been looped, it will remain looped)

If you want to affect these parameters, first set the HP 37741A to the factory default setting, and then set it to the setting you require.

1 The procedure is described in section 13. Alternatively, you can purchase software from HP – detailed in appendix D – which will allow you to modify these settings.

2 From the front panel, you can save a configuration with results. See section 7 for details.

The settings programmed at the factory are shown in figure 5-1. These are described in the following sections. None of the factory programmed settings alters the SLC-96 data link – it is always set to idle.

5.2.1 Factory Default

This is a safe setting which will work most of the time when the test set is receiving a signal from the network, and is sending the same signal back to the network.

- The transmit mode is set to full T1.
- When transmit FT1 is subsequently enabled, all channels are active.
- The transmit line code is set to as input.
- The transmit timing is set to internal.
- The transmit loopback code is set to NI, and no code is sent.
- The transmit alarms are set to none.
- The transmit frame format is set to as input.
- The transmit payload is set to as input.
- The user words are set to 1in8o, 1in15, 1in16, and idle.[1]
- The channel words are set to TmSlt and LoDns.[2]
- The transmit DS0 tone injection is set to off.
- When a DS0 tone is subsequently enabled, the default frequency is 1004 Hz, and the default channel is 1.
- Transmitted signaling bits are unmodified.
- No errors are injected in the transmitted signal.
- The SLC-96 data link is reset to the default values described in section 8.4.
- The transmit signaling reinsertion is disabled (off).
- The transmitted data link is set to be the default (idle).
- The receive mode is set for full T1, which speeds up operation of the instrument because it is not hunting for the mode type.
- When receive FT1 is subsequently enabled, all channels are active.

1 The pre-defined user words are described in section 9.2.8.
2 The pre-defined channel words are described in section 9.2.9.

- The receive T1 inputs are set to `bridge` mode so that tapping into a line with live traffic will not disturb it.
- The receive loopback code status is such that received codes will not be acted on.
- The receive frame format is set to `auto`. This is the most useful setting, but might not work with very noisy circuits.[1]
- The receive DS0 channel sequence is set to D3/D4, and channel 1 is selected.

Alarms will be sent at the output when there is no signal at the input.[2] This is because the transmitter is set to mimic the receiver, and cannot do so when nothing is being received.

5.2.2 Originate D4

Use this mode when you have split a D4 circuit, and want to verify the circuit functionality. You can immediately go to the loopback results screen, send a loopback, and then check for errors.

5.2.3 Originate ESF

Use this just as you would use the originate D4 setup, but for ESF circuits. B8ZS line encoding is selected.

The "Originate D4" and "Originate ESF" setups will cover most requirements for day to day intrusive testing by an operating company's craftsperson.

5.2.4 Terminate

This is used when the test set is receiving a signal for testing, but it is not necessarily that which it is generating.

5.2.5 Through

This is used when the test set is placed in series with the circuit under test. The HP 37741A acts as a repeater, passing through all essential signals, including signaling and the facility data link. The test set can then be used to modify any or all of these parameters, including the ability to perform drop and insert testing.

---

1 See section 8.1.1 for more information.
2 See section 11.5 for more information.

	factory default	originate D4	originate ESF	terminate	through	emulate
Transmit						
mode, channels	full T1, all	full T1, all	full T1, all	full T1, all	full T1, all	full T1, all
line code	as in	AMI	B8ZS	as in	as in	as in
timing	internal	internal	internal	reference	main	reference
loop code type	NI	NI	NI	line	as in	NI
loop code time	off	off	off	off	off	off
alarms	none	none	none	none	as in	none
frame	as in	D4	ESF	as in	as in	as in
payload	as in	QRW	QRW	as in	through	TmSlt
signal reinsertion	off	off	off	off	on	off
FDL	default	default	default	default	through	default
DS0 channel	1	1	1	1	1	19
tone amplitude	off	off	off	off	off	−6 dBm0
tone frequency	1004 Hz	1004 Hz	1004 Hz	3 tone	1004 Hz	sweep
signaling	unmodfd	unmodfd	unmodfd	unmodfd	unmodfd	1111
BPV errors	off	off	off	off	off	off
logic errors	off	off	off	off	off	off
Receive						
mode, channels	full T1, all	full T1, all	full T1, all	full T1, all	full T1, all	full T1, all
inputs	bridge	terminate	terminate	terminate	terminate	terminate
loopback	no rspnd	no rspnd	no rspnd	no rspnd	no rspnd	auto
frame	auto	auto	auto	auto	auto	auto
DS0 sequence	D3/D4	D3/D4	ESF	D3/D4	D3/D4	D3/D4
DS0 channel	1	1	1	1	1	19
User Patterns						
user word 1	1 in 8 old	1 in 8 old	1 in 8 old	1 in 8 old	1 in 8 old	1 in 8 old
user word 2	1 in 15	1 in 15	1 in 15	1 in 15	1 in 15	1 in 15
user word 3	1 in 16	1 in 16	1 in 16	1 in 16	1 in 16	1 in 16
user word 4	idle	idle	idle	idle	idle	idle
channel word 1	TmSlt	TmSlt	TmSlt	TmSlt	TmSlt	TmSlt
channel word 2	LoDns	LoDns	LoDns	LoDns	LoDns	LoDns
Tx SLC96 data link	idle	idle	idle	idle	idle	idle

Figure 5-1 Factory Preconfigured Settings

5.2.6 Emulate

This configures the HP 37741A to emulate an NI device or a CSU. It will automatically respond to received loop up or loop down commands, returning the signal to the source.

A tone is transmitted in channel 19, and the signaling bits in that channel are set to the idle state. The payload is set to the timeslot identification pattern, so that you can easily verify correct operation of a circuit.

5.3 How to Configure the Transmitter, Screens 21xx

5.3.1 How to View the Transmitter Summary, Screen 2100

5.3.1.1 Tester Looped or Special (Sequential) Test

When the instrument has been looped by an external loopback command, or you are running a sequential test, you cannot access any of the transmit configuration screens, and you cannot therefore modify the transmit status.

To indicate these states, either the transmit status loopback icon, ↩, or a special test icon is displayed on screen 2000:[1]

```
SET          ↩   ⧗
SET              BT
SET              MP
SET              US
```

The word `transmitter` on screen 2000 is replaced by text in small characters indicating why you are unable to change the transmit configuration.

If you are displaying a transmit configuration screen when the instrument becomes looped back, screen 2000 is automatically displayed.

A loopback can be deactivated by:

- receipt of a loop down code on the main T1 input

1 The transmit status icons are described in section 3.2.2.

- selecting u n l o o p from the receiver setup screen 2220
- an external command on the serial port

The sequential (special) test can be stopped from screen 3001.

5.3.1.2 Tester Not Looped or Not a Sequential Test

1. Display screen 2000
2. Move ➔ to t r a n s m i t t e r, and press SET.

```
2100
SET  Tx          ⧗
24/24 D4        AMI
Ch:01  No  tone
Sig  ABCD:----
Payload:    QRW
Loop:    NI  off
⏲:intnl  🔔:  no
➔change    exit   2110   2000
```

- ➔ always points to c h a n g e.
- If you press SET with ➔ pointing to c h a n g e, you can modify any of the parameters.
- If you choose e x i t, screen 2000 is displayed.

5.3.1.3 Status vs Configuration, Line 1

The transmit icons displayed on the top line indicate the current *status* of the transmitted signal. This screen summarizes the current *configuration.*. The two are not necessarily the same.

For example, if you configure the transmitter to retransmit the input, and yet there is no input connected, the unit will transmit an AIS alarm. The status icon will indicate this, but you have not directly configured the unit to send an alarm.

5.3.1.4 Frame Format and Line Code, Line 2

Examples of the frame format are:

24/24 UnFrmd configured to transmit an unframed signal

24/24 Frm=In transmit frame format equals the input frame format

Nx 64 ESF	transmitting an ESF frame format, in FT1 mode (n × 64 kb/s)
Nx 56 D3/D4	transmitting a D4 frame format, in FT1 mode (n × 56 kb/s)
24 24 SLC-96	transmitting a SLC-96 frame format, in full T1 mode

The line code is one of:

Cd=In	equal to the input code format
B8ZS	
AMI	

5.3.1.5 DS0 Tone Injection, Line 3

Examples of this line are:

Ch:01 No tone	channel 1 is selected, but no tone is being injected
Ch:17 1004 Hz	1004 Hz tone is being injected on channel 17
Ch:19 sweep	a swept tone is being injected on channel 19

5.3.1.6 Signaling, Line 4

Examples of this line are:

Sig ABCD:----	the signaling bits are not being modified
Sig ABCD:1011	the signaling bits are set to 1011

5.3.1.7 Payload, Line 5

Examples of this line are:

Payload: =In	equal to input payload
Payload: QRW	transmit QRW test signal
Payload: $2^{23}-1$	transmit $2^{23}-1$ test signal

5.3.1.8 Loopback Code, Line 6

Examples of this line are:

Loop:line off	line loop back code is selected, but the code is not being transmitted

Loop: NI↑ 8s	NI loop up code is being transmitted for 8 seconds
Loop: pyld↓ on	payload loop down code is being transmitted continuously

When a loopback code is transmitted for eight seconds, the code being sent will be indicated during that period. At the end of that time, the display will revert to off.

5.3.1.9 Timing Source, Line 7

This will be one of:

⌚: intnl	internal timing
⌚: main	from main input
⌚: ref	from reference input

5.3.1.10 Alarms, Line 7

Examples are:

🔔: no	not transmitting any alarms
🔔: AIS	transmitting AIS
🔔: ylw	transmitting yellow alarm

There are cases when the HP 37741A automatically transmits an alarm because of LOS at the input.[1] This will be indicated in the transmit status icons on screen 2100, but not in the body of the screen, which is used to indicate the current configuration. The actual transmit status is displayed in screen 2700.

5.3.2 How to Access the Transmitter Main Menu, Screen 2110

1. From screen 2100, choose change and press SET.
   - Screen 2110 is displayed:

1 More details can be found in section 11.5.

```
2110
SET Tx                  ⧗
 MODE: T1,FT1         2115
 LINE: code,          2120
   timng, loop
→PATH: alarm,         2130
   frm, TstSig
 CHANNEL ACCS         2140
 ERRORS               2150
```

2. To access one of the sub-menus, move → to that choice, and press [SET].

5.3.3 How to Change the Transmitted Mode, Screen 2115

1. Display screen 2115:

```
2115
Tx mode:

 as receiver     2000
→full T1         2000
 FT1 64 kb/s     2116
 FT1 56 kb/s     2116
```

- → always points to the current configuration.

2. Press [SET], [LINE], or [PATH] when → points to your choice.

When as receiver is selected, the transmitted mode will be the same as that identified on the input when the input mode is set to auto, or will be the same as that set for the input otherwise. If there is no input, the mode will be full T1.

When either of the fractional T1 modes is selected, you can then configure the timeslots which are active.

5.3.4 How to Select the Active Timeslots, Screen 2116

1. Display screen 2116:

```
2116
Tx time slots  2000
   (instructions are in
   small characters –
   see below)
TS:01   ➔SAVE
█*******
**......
........
```

- ➔ always points to the first timeslot.
- The bottom three lines represent a timeslot map, with a * (to indicate active) or . (to indicate idle) representing the state of the timeslot. The first line of the map is for timeslots 1 to 8, the second for timeslots 9 to 16, and the third for timeslots 17 to 24.
- The timeslot that is going to be changed is marked by a █ character. The █ alternates with the * or . representing the state of the timeslot.
- The instructions are given in smaller than normal characters, as follows:

```
▲▼       to view
SET      to select
Choose   "SAVE"
         when done
```

2. Use [▲] and [▼] to change the state of the timeslot indicated by the number following TS:.
   - The following choices are displayed in sequence: off(.), on(*), BACK, SAVE. The sequence then repeats.
3. When the ➔ points to the action that you want, press [SET].
   - The timeslot map is updated where the flashing █ was, and the flashing █ is advanced one character.

- The character pointed to by ➜ is then set to be the same as that which is now marked by the flashing █.

4. Continue to set each of the timeslots in turn.
5. If you need to go back and change a timeslot, choose BACK, and press [SET].
6. When you have finished all the characters, use [▲] and [▼] to point ➜ at SAVE, and then press [SET].
7. The new timeslot map is saved in memory, and screen 2000 is displayed.

5.3.5 How to Change the Transmitted Line Code, Screen 2120

1. Display screen 2120:

```
2120
Tx line code:   2121

 as input
 B8ZS
➜AMI
```

- ➜ always points to the current configuration.

2. Press [SET], [LINE], or [PATH] when ➜ points to your choice.

When as input is selected, the transmitted line code will be the same as that identified on the input. If there is no input, the code will be AMI.

5.3.6 How to Change the Transmitter Timing, Screen 2121

1. Display screen 2121.

```
2121
Tx timing:          2122

→internal
 from ref
 from main
 (loop timed)
```

- → always points to the current configuration.

2. Press SET, LINE, or PATH when → points to your choice.

5.3.7 How to Select the Loopback Code Type, Screen 2122

1. Display screen 2122.

```
2122
Tx loop type:

 as input           2000
 line (CSU)         2123
 4 bit              2123
→NI (smrtjk)        2123
 payload (for       2123
     ESF/ZBTSI)
```

2. Press SET, LINE, or PATH when → points to your choice.
   - The loopcode type selected in this screen is the one that you can transmit from the loopback results screen 4300.

When you choose as input, any received loopback code is re-transmitted. If necessary, frame format conversion will be performed.

5.3.8 How to Send a Loopback Code, Screen 2123

You can send a loopback code by either using this screen, or by using the loopback results screen 4300.[1] This screen (2123) allows you to send a loopback code regardless of whether a test is running, and it also allows you to send a loopback code continuously.

1. Display screen 2123.
   - You cannot access this screen if sending an alarm. That is, if in screen 2130, you have selected `LOS`, `AIS`, or `yellow`. The transmit alarm icon, ▲, is displayed in the high level menu screens and in all results screens.

```
2123
Send Tx loop:  2000

→none
 loop up 8s
 loop up cont
 loop dn 8s
 loop dn cont
```

2. Press [SET], [LINE], or [PATH] when → points to your choice.

When you choose `8s`, the loopback code is transmitted for eight seconds. At the end of that period, → automatically points to `none`

When you choose `cont`, the loopback code is transmitted continuously, and → remains pointing to `cont`.

When the loopback code is no longer transmitted, the signal is restored to what it was before transmitting the loopback code.

If you return to this screen, after initiating the transmission of a loopback code, and initiate another loopback code, or select `none`, the new command immediately supersedes the old command.

1 This is described in section 4.2.6.

5.3.9 How to Transmit an Alarm, Screen 2130

1. Display screen 2130.

```
2130
Tx alarm:

→none              2131
 as input          2131
 LOS               2000
 AIS               2000
 Yellow            2131
     (remote)
```

- → always points to the current configuration.

2. Press SET, LINE, or PATH when → points to your choice.

When you choose as input, any alarm received on the main input will be reproduced at the output. In the case of yellow alarm, this may involve frame format translation, which the HP 37741A will perform automatically for you.

When you transmit an LOS, this is the same as an unframed all zeroes signal, with AMI line coding. The simplex current continues to pass through the instrument. When you select LOS, you cannot then change the transmit frame format or payload.

The DS1 AIS signal is all ones, with no framing. When you select AIS, you cannot then change the transmit frame format or payload.

Under certain conditions, the test set automatically transmits alarms on the basis of an input signal condition. This is discussed in section 11. You can see whether any alarms are being transmitted by displaying the transmit status icons, or viewing screen 2700.

5.3.10 How to Configure the Transmit Frame Format, Screen 2131

1. Display screen 2131.

```
2131
Tx frame:              2132

 unframed
→as input
 D1D        SLC96
 D2         ESF
 D3/D4      ZBTSI
```

- → always points to the current configuration.

2. Press SET, LINE, or PATH when → points to your choice.

When you select `as input`, the transmitted frame format will be the same as that received on the input.

Although D1D, D2, and D3/D4 all have the same frame format, the channel sequences differ. The channel assignment is important when injecting a tone onto a channel.

5.3.11 How to Configure the Transmit Payload, Screen 2132

1. Display screen 2132 (there are two "pages" to this screen):

```
2132 (1 of 2)
Tx payload:            2000 or 2133 (see
 more▲     3in24       below)
 as in     QRW
 all 0     2^11-1
 all 1     2^15-1
 1/0       2^20-1
 1in8      2^23-1
 2in8      more▼
```

2132 (2 of 2)

```
Tx payload:
 more▲      user1
 thru       user2
 ChWd1     →user3
 ChWd2      user4



            more▼
```

2000 or 2133 (see below)

- → always points to the current configuration, on the correct page.

2. Press [SET], [LINE], or [PATH] when → points to your choice.
   - When you move the → to more▲ or more▼ the next page is displayed.

When you select as in, the transmitted payload will be similar to that received on the input. If a recognized test pattern is received, the HP 37741A retransmits it (regenerates it) error free.

When you select thru, the transmitted payload will be the same as that received on the input. If a recognized test pattern is then received, errors will be passed through..

Use the all zeroes pattern with care. This is normally used only when the frame format is ZBTSI, or the line code is B8ZS.

The channel words and user words are programmable only from the external control port.[1] The names are also user programmable, so that the second page will probably not look like that shown above. The default patterns are described in section 9.2. The default names are:

ChWd1	TmSlt	to verify correct timeslots
ChWd2	LoDns	no excess zeroes, but low density
user1	2in8o	2 in 8 compatible with older equipment
user2	1in15	stress test
user3	1in16	stress test
user4	idle	idle code for FT1

1 The command is described in section 13.4. External control software is available (see appendix D) which allows you to view and edit the user words.

The channel words should be sent only when the transmit signal is framed.

Some of the time, screen 2000 is displayed when you press SET. When the payload is as in or thru, and the transmit frame format (screen 2131) is not unframed, screen 2133 will be displayed. When the transmit frame is as input, SLC-96, ESF, or ZBTSI, screen 2134 is displayed.

5.3.12 How to Enable Signaling Reinsertion, Screen 2133

1. Display screen 2133.

```
2133
Tx signaling          2000 or 2134
reinsertion:

→off
 on
```

- → always points to the current configuration.

2. Press SET, LINE, or PATH to select your choice.

When you select off, signaling reinsertion is disabled. This setting is normally used when carrying data traffic. When the instrument is in through mode, and carrying voice traffic, you should normally leave the signaling reinsertion on. This is explained in detail in section 12.4.

5.3.13 How to Select the Transmit Data Link, Screen 2134

1. Display screen 2134.

```
2134
Tx data link:          2000

→default
  (normal)
 through
```

- → always points to the current configuration.

2. Press SET, LINE, or PATH to select your choice.

When you select default the data link sent on SLC-96, ESF, or ZBTSI signals will be set to the instrument's default setting. When the instrument leaves the factory, the default setting is set to the idle code, but the SLC-96 default setting can be modified over the serial port.

When you select through, and the received frame format is the same as the transmitted frame format, the received data link will be copied to the transmitted data link. This setting is normally used when the instrument is being used in a through mode.

5.3.14 How to Configure the DS0 Channel for Injected Tones or Signaling, Screen 2140

1. Display screen 2140.

```
2140
Select DS0 Tx
channel
(1 to 24):

→01                    2141

Frame: Frm=In
Time slot: ??
```

- → always points to the current configuration.

2. Use ▲ and ▼ to change the channel number, and then press SET, LINE, or PATH to select that choice.

- → does not move, the channel number changes.

- The channel number rolls from 2 4 to 1 and vice versa.

The bottom line indicates the time slot of the channel number currently being used for tone injection.

When the transmit frame format is set to u n f r a m e d, the bottom line always shows – –, to indicate that no tone is being injected. You can still configure the frequency and level, because it is assumed that you will subsequently configure a valid frame format.

When the transmit frame format is a s i n p u t, the bottom line shows ? ?, to indicate that the time slot is undefined. The HP 37741A will use the correct time slot when a signal is received. When the input frame format is D1D, D2, D3/D4 or SLC-96, you can view the time slot number in screen 5501; for ESF and ZBTSI frame formats, the time slot number is the same as the channel number, which is displayed in screen 5500.

If you do not want to disturb the DS0 channel, set the injected tone amplitude to o f f (screen 2141), and set the signaling bits to u n – m o d i f i e d (screen 2143).

5.3.15 How to Configure the Injected Tone Amplitude, Screen 2141

1. Display screen 2141.

```
2141
Tx  inject
tone (dBm0):

→off              2143
   0      -13     2142
  -3      -16     2142
  -6      -24     2142
  -10     idle    2142
```

- → always points to the current configuration.

2. Press SET, LINE, or PATH when the → points to your choice.

5.3.16 How to Configure the Injected Tone Frequency, Screen 2142

1. Display screen 2142.

```
2142
Tx tone (Hz):    2143
    304     2280
    404     2600
    420     2713
    820     2804
  →1004     3404
   1020     3tone
   1800     sweep
```

▸ → always points to the current configuration.

2. Press SET, LINE, or PATH when → points to your choice.

5.3.17 How to Configure the Transmitted Signaling Bits, Screen 2143

1. Display screen 2143.

```
2143
Tx signaling:    2000


→unmodified


Frame: Frm=In
Channel    : 01
Time slot: 01
```

▸ → always points to the current configuration.

2. Use ▲ and ▼ to modify the bits.
   - ▸ The bits roll over from 1111 to unmodified to 0000, and vice versa.
   - ▸ The bits are labelled ABCD.
   - ▸ In SF frame formats, the A bit alternates with the C bit, and the B bit alternates with the D bit.

- Therefore, if the instrument is transmitting a D4 frame, and ABCD are set to 0100, the A bit is constantly 0, and the B bit toggles 0/1

3. Press SET, LINE, or PATH when → points to your choice.

5.3.18 How to Inject BPV Errors, Screen 2150

1. Display screen 2150.

```
2150
Tx inject          2000
BPV errors:

→off


One error
per second.
```

2. Use ▲ and ▼ to change the injected errors, and then press SET, LINE, or PATH to select that choice.
   - → does not move; the displayed values are off, 1, 2, ... , 8, 9, and continuous.
3. If you select 1 to 9, and then return to this screen after all the errors have been transmitted, the setting will be off. If you return to this screen before all the errors have been transmitted, the number that you chose earlier will still be displayed.

5.3.19 How to Inject Logic Errors, Screen 2151

1. Display screen 2151.

```
2151
Tx inject          2152
logic errors:

→off


One error
per second.
```

2. Use [▲] and [▼] to change the injected errors, and then press [SET], [LINE], or [PATH] to select that choice.
   - ➔ does not move; the displayed values are off, 1, 2, ... , 8, 9, and continuous.
3. If you select 1 to 9, and then return to this screen after all the errors have been transmitted, the setting will be off. If you return to this screen before all the errors have been transmitted, the number that you chose earlier will still be displayed.

5.3.20 How to Inject CRC Errors, Screen 2152

1. Display screen 2152.

```
2152
Tx inject         2000
CRC errors:

➔off


One error
per second.
```

2. Use [▲] and [▼] to change the injected errors, and then press [SET], [LINE], or [PATH] to select that choice.
   - ➔ does not move; the displayed values are off, 1, 2, ... , 8, 9, and continuous.
3. If you select 1 to 9, and then return to this screen after all the errors have been transmitted, the setting will be off. If you return to this screen before all the errors have been transmitted, the number that you chose earlier will still be displayed.

CRC errors are injected only on an ESF format signal (ESF or ZBTSI). If, when the errors are set, the HP 37741A is not transmitting an ESF signal, the errors will be sent once that frame format is selected.

5.4 How to Configure the Receiver, Screens 22xx

5.4.1 How to View the Receiver Summary, Screen 2200

1. Display screen 2000
2. Move → to `receiver`, and press [SET].
   - ▸ Screen 2200 is displayed:

```
2200
SET Rx       ⧗
Mode   :FullT1
Inputs:bridge
Loop   :   off
Frame  :  auto
Seqnce: D3/D4
DS0 ch:     01
→change   exit   2205, 2000
```

- ▸ → always points to `change`.
- ▸ If you press [SET] with → pointing to `change`, you can modify any of the parameters.
- ▸ If you select `exit`, screen 2000 is displayed.

5.4.1.1 Transmit Status, Line 1

The icons displayed on the top line reflect the current transmit status. They do not directly reflect the receive configuration or status. The icons are described in section 3.2.2.

5.4.1.2 Receive Mode, Line 2

This is one of:

`Mode   :FullT1`	
`Mode   :FT1/64`	
`Mode   :FT1/56`	
`Mode   :M=Auto`	automatically identify the mode

5.4.1.3 Input Impedances, Line 3

This is one of:

`Inputs:bridge`	
`Inputs:  term`	terminate
`Inputs:   mon`	monitor

5.4.1.4 Loopback Response, Line 4

This is one of:

`Loop  :   off`	do not auto respond to loopcodes
`Loop  :respnd`	auto respond

5.4.1.5 Frame Format, Line 5

Examples of this line are:

`Frame :  auto`	
`Frame :unfrmd`	unframed
`Frame : ZBTSI`	

5.4.1.6 SF Channel Sequence, Line 6

This is one of:

`Seqnce:   D1D`	
`Seqnce:    D2`	
`Seqnce: D3/D4`	
`Seqnce: SLC96`	
`Seqnce:   n/a`	not applicable

- The value is set to `n/a` if the receive frame format is configured to be `unframed`.

The value is meaningless unless the received frame format is configured to be `auto`. For explicitly specified frame formats, the frame type is used to select the channel sequence.

5.4.1.7 DS0 Channel, Line 7

This indicates which receive channel you have currently selected. You can monitor the signaling bits of, and listen to, the specified channel. When a test is running, you can modify the channel number from the path results screen 6 / 6 (screen 5500 or 5501), or the results summary screen (screen 6000).

The received channel number does not need to be the same as the transmitted channel number.

The indication is set to n / a if the receiver frame format is set for unframed.

5.4.2 How to Change the Received Mode, Screen 2205

1. Display screen 2205:

```
2205
Rx mode:

➔full T1          2210
 FT1 64 kb/s      2206
 FT1 56 kb/s      2206
 auto             2210
```

- ➔ always points to the current configuration.

2. Press SET, LINE, or PATH when ➔ points to your choice.

When full T1 is selected, the HP 37741A identifies a test pattern only if it occupies all of the channels of the received signal.

When FT1 64 kb/s or FT1 56 kb/s is selected, the HP 37741A identifies a test pattern only if it occupies the channels which you specify (with screen 2206).

When auto is selected, the HP 37741A searches all of the channels, looking for those which are idle, and identifies a test pattern in those channels of the received signal which are not idle. The instrument automatically identifies whether the signal is being sent in N × 56 or N × 64 mode.

The mode setting does not alter the instrument's ability to frame, and does not restrict you from viewing any channel's status, or from listening to a channel. When a test is running, this setting is shown on the path results 4 / 6 (screen 5300).

5.4.3 How to Select the Active Timeslots, Screen 2206

1. Display screen 2206:

```
2206
Rx time slots      2210
   (instructions are in
   small characters –
   see below)
TS:01    →SAVE
█*******
**......
........
```

- → always points to the first timeslot.
- The bottom three lines represent a timeslot map, with a * (to indicate active) or . (to indicate idle) representing the state of the timeslot. The first line of the map is for timeslots 1 to 8, the second for timeslots 9 to 16, and the third for timeslots 17 to 24.
- The timeslot that is going to be changed is marked by a █ character. The █ alternates with the * or . representing the state of the timeslot.
- The instructions are given in smaller than normal characters, as follows:

```
▲▼       to view
SET      to select
Choose   "SAVE"
        when done
```

2. Use [▲] and [▼] to change the state of the timeslot indicated by the number following TS:.
   - The following choices are displayed in sequence: off(.), on(*), BACK, SAVE. The sequence then repeats.
3. When the → points to the action that you want, press [SET].
   - The timeslot map is updated where the flashing █ was, and the flashing █ is advanced one character.

- The character pointed to by ➜ is then set to be the same as that which is now marked by the flashing █.

4. Continue to set each of the timeslots in turn.
5. If you need to go back and change a timeslot, choose BACK, and press [SET].
6. When you have finished all the characters, use [▲] and [▼] to point ➜ at SAVE, and then press [SET].
7. The new timeslot map is saved in memory, and screen 2210 is displayed.

5.4.4 How to Configure the Input Impedances, Screen 2210

1. Display screen 2210.

```
2210
Rx T1 inputs:   2220

 DSX monitor
 terminate
➜bridge
```

- ➜ always points to the current configuration.

2. Press [SET], [LINE], or [PATH] when ➜ points to your choice.

When a test is running, this setting is shown on the line results screen 1/5 (screen 4000).

5.4.5 How to Configure the Response to a Received Loopback, Screen 2220

1. Display screen 2220.

```
2220
Rx loopback:          2230

→detect, but
   don't rspnd
 detect, and
   auto rspnd
 unloop
```

- → always points to the current `detect` configuration.

2. Press SET, LINE, or PATH when → points to your choice.

If the test set receives a loopback code when the auto response is not selected, the test will indicate in screen 4300 that the loopback code is being received, but will not act on the loopback code.

None of the results screens is updated when a test is not running. To check for a received loopback code you must start a test.

If you configure the test set to respond automatically to a received loopback command, it will act on that command, and will return the signal to the sender. This looped back condition will be shown in screen 4300, and on the transmit status icons as ⮐.

If the HP 37741A has been looped by a signal received on its input, selecting `unloop` will drop that loopback. Selecting `unloop` when the test set is not looped has no effect.

5.4.6 How to Configure the Received Frame Format, Screen 2230

1. Display screen 2230.

```
2230
Rx frame:

 unframed              2000
→auto                  2240
 D1D        SLC96      2250
 D2         ESF        2250
 D3/D4      ZBTSI      2250
```

- → always points to the current configuration.

2. Press SET, LINE, or PATH when → points to your choice.

auto is the factory default selection, and is the safest. The HP 37741A automatically identifies the received frame format, and adjusts its electronics accordingly.

With any other selection, the test set will try to frame to only the selected frame format. Use this method to improve the operating speed of the test set, and to synchronize in the presence of high errors.

When you select the frame format to be unframed, the test set does not attempt to obtain frame synchronization.

When a test is running, this setting is shown on the path results screen 2/6 (screen 5100).

5.4.7 How to Configure the Received DS0 SF Channel Sequence, Screen 2240

You can configure the channel sequence only if the received frame format is configured to be auto (screen 2230). Otherwise, the frame format that you have selected implicitly specifies the channel sequence.

1. Display screen 2240.

```
2240
If input is          2250
Super Frame,
DS0 channel
sequence is:

 D1D      →D3/D4
 D2        SLC96
```

- → always points to the current configuration.

2. Press [SET], [LINE], or [PATH] when → points to your choice.

5.4.8 How to Select the DS0 Channel to be Monitored, Screen 2250

When a test is running, you can look at different DS0 channels from the results summary screen or the channel results screen (6000, 5500 or 5501).[1] This screen allows you to select a channel number before a test is started.

1. Display screen 2250.

```
2250
Select DS0 Rx        2000
channel
(1 to 24):

→01

Frame:       auto
Time slot:   01
```

- → always points to the current configuration.
- As you press [▲] and [▼], the channel number changes, but → does not move.
- The number rolls from 24 to 01 and vice versa.

2. Press [SET], [LINE], or [PATH] when → points to your choice.

1 This is described in sections 4.2 and 4.4.9.

The time slot indicates the translation that the test set will do, to ensure that you access the correct channel. This is relevant only in SF mode. The HP 37741A uses the channel sequence that you selected in screen 2230 or 2240. For ESF and ZBTSI signals, the channel number and time slot number are identical.

When the instrument is set to `auto` frame mode, the time slot number is replaced by `??`.

5.5 How to View What is Currently Being Transmitted, Screen 2700

1. Display screen 2000.
2. Move ➔ to `show output`, and press [SET].
   - Screen 2700 is displayed:

```
2700
SIG OUT       ♪⌛  2000
D4            AMI
Ch:01  1004  Hz
Sig  ABCD:0000
Payload:     QRW
Loop     :   off
⏲: intnl  ♟: no
BPV☺Lgc☺CRC☺
```

   - ➔ is not displayed. Pressing [SET], [▲], or [▼] will display screen 2000. Pressing [◢], [◑], [☼], [TEST], [LINE], or [PATH] will have their normal effect.

This screen has a format similar to that of screen 2100. The meaning of each item is similar. However, this screen shows what is *actually being transmitted*, screen 2100 shows how the transmitter is configured.

The payload will indicate either `?+sig` or `?−sig` when the transmit payload is configured to be the same as the input payload, and the test set cannot identify the received payload. The `+` indicates that signaling is preserved in the transmitted payload (reinserted); the − indicates that signaling reinsertion is disabled.

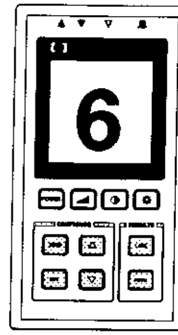
The timing icon, ⏲, flashes when the timing source that is being used is not that which you have specified. This happens, for example, when you have specified the source of the transmit timing to be derived from the main input, but that there is no signal connected to the main input.

The alarm icon, 🔔, flashes when the instrument is transmitting smart alarms, which are not as you have specified.[1] This happens, for example, when you have specified that the transmitted frame format mimic that being received, and yet there is no signal connected to the main input.

Following BPV, Lgc, or CRC is a happy face, ☺ when errors are not being injected. A sad face, ☹, is displayed when errors are being added to the transmitted signal.

1 Smart alarms are discussed in detail in section 11.5.

How to Configure the Interfaces



6.1 General

This section describes the keys you will use, and the displays you will see, when configuring the interfaces. See sections 13 to 15 for detailed information on the capabilities of the interfaces.

6.1.1 What Configuring the Interfaces Does

When you configure the interfaces, you configure:

- the key beep to be on or off
- the usage and transmission parameters of the serial port
- the format in which the date and time are displayed and printed
- the current date and time
- the unit ID

6.1.2 The Keys You Will Use

The set EIA-232 and set miscellanea menu systems are accessed from the main SET menu (screen 2000) by pressing [SET]. All selections are made within this menu system by using [▲] and [▼] to move the arrow, ➔, to point to a choice, and [SET], [LINE], or [PATH] to select that choice.

The main SET menu is described in section 5.1.

6.1.3 How to View the System Summary, Screen 2500

1. Display screen 2000.
2. Move ➔ to sys summary, and press [SET].

```
2500
 SYS SUMMARY    2000
Battery:     OK
Calibrated:
 yy/mm/dd Www
PwrOff:   hh:mm
 yy/mm/dd Www
PwrOn:    hh:mm
 yy/mm/dd Www
```

- No ➔ is displayed.
- Pressing any key other than [☼] exits this screen. Pressing [▲], [▼], or [SET] causes screen 2000 to be displayed. The keys [◢], [◑], [TEST], [LINE], and [PATH] are treated normally.

You cannot directly modify any of these values. When the battery needs recharging, the internal speaker beeps every minute, and the word LOW appears on line 2. When the battery is charging, the word CHRG appears on line 2.

You should calibrate the instrument periodically. The recommended period, and details on how to calibrate the instrument, are given in section 17.

6.2 How to Configure the EIA-232, Screens 23xx

6.2.1 How to View the EIA-232 Summary, Screen 2300

1. Display screen 2000.
2. Move ➔ to EIA-232, and press [SET].

2300
```
 SET EIA-232
Usage:     off
Bit rate:9600
Parity:   none
Data bits:   8
Stop bits:   1
Flow:     none
→change   exit
```
2310 2000

- → always points to `change`.
- If you press [SET] with → pointing to `change`, you can modify any of the parameters except the number of stop bits.
- If you select `exit`, screen 2000 is displayed.

A discussion of the serial port parameters, and recommended settings, are in section 13.

6.2.1.1 Usage, Line 2

The usage is one of:

`off`	not used
`ext ctl`	configured for external control
`print N`	configured as a printer port, to output to narrow paper
`print W`	configured as a printer port, to output to wide paper

6.2.1.2 Bit Rate, Line 3

The bit rate is one of:

`1200`
`2400`
`4800`
`9600`

6.2.1.3 Parity, Line 4

The parity is one of `none`, `even`, or `odd`

6.2.1.4 Data Bits, Line 5

The data bits setting is either 7 or 8.

6.2.1.5 Stop Bits, Line 6

The stop bits setting is always 1. This parameter is not user configurable.

6.2.1.6 Flow Control, Line 7

The flow control is one of:

```
     none
  RTS/CTS
  ENQ/ACK
XON/XOFF
```

6.2.2 How to Change the EIA-232 Usage, Screen 2310

1. Display screen 2310.

```
2310
EIA-232 usage

→off              2000
 ext control      2350
 printer -        2320
    narrow
 printer -        2320
    wide
```

▸ → always points to the last selection.

2. Press SET, LINE, or PATH when → points to your choice.

When you are not using the serial port, you should turn it off, to save power.

If you are configuring the port to be used for printing, you can also configure the parity, data bits, and flow control. These are all fixed if the port is used for external control. Sample printouts (both narrow and wide) are shown in section 13.

6.2.3 How to Change the EIA-232 Parity, Screen 2320

1. Display screen 2320 (possible only for printer configuration).

```
2320
EIA-232              2330
parity:

→none
 even
 odd
```

- → always points to the last selection.

2. Press SET, LINE, or PATH when → points to your choice.

6.2.4 How to Change the EIA-232 Data Bits, Screen 2330

1. Display screen 2330 (possible only for printer configuration).

```
2330
EIA-232              2340
data bits:

 7
→8
```

- → always points to the last selection.

2. Press SET, LINE, or PATH when → points to your choice.

6.2.5 How to Change the EIA-232 Flow Control, Screen 2340

1. Display screen 2340 (possible only for printer configuration).

```
2340
EIA-232              2350
flow control:

→none
 RTS/CTS
 ENQ/ACK
 XON/XOFF
```

- → always points to the last selection.

2. Press SET, LINE, or PATH when → points to your choice.

6.2.6 How to Change the EIA-232 Bit Rate, Screen 2350

1. Display screen 2350.

```
2350
EIA-232              2000
bit rate:

 1200
 2400
 4800
→9600
```

- → always points to the last selection.

2. Press SET, LINE, or PATH when → points to your choice.
   - 9600 b/s is strongly recommended for remote control.

6.3 How to Configure the Miscellaneous Interface Settings, Screens 24xx

6.3.1 How to View the Miscellanea Summary, Screen 2400

1. Display screen 2000.
2. Move → to miscellanea, and press SET.

```
2400
   SET MISC.
Key beep:tone
Now: hh:mm:ss
 yy/mm/dd Www
Unit ID:
    nnnnAnnnnn

→change   exit  2410  2000
```

- → always points to change.
- If you press SET with → pointing to change, screen 2410 is displayed, and you can modify any of the parameters.
- If you choose exit, screen 2000 is displayed.

6.3.1.1 Date and Time Formats

Following Now is the current date and time. hh:mm:ss represents the current hours, minutes, and seconds; yy/mm/dd represents the current year, month, and day; Www represents the current weekday. All the screen pictures in this book and on the HP 37741A Instruction Guide are shown in these formats.

You can modify the formats in which the date and time are displayed and printed, as described later. When you do so, all the screens will display the date and time in the formats that you have chosen. In 12 hour time mode, am or pm follows the seconds. On some screens, there is insufficient room, and just a or p is shown instead.

6.3.2 How to Change the Key Beep, Screen 2410

1. Display screen 2410.

```
2410
Key beep:              2420

 off
 click
→tone
```

- → always points to the last selection.

2. Press SET, LINE, or PATH when → points to your choice.

When on, the beep is made with each key that is pressed. The volume control affects neither whether the beep is on or off, nor the volume of the beep.

6.3.3 How to Change the Format for Date Display, Screen 2420

1. Display screen 2420.

```
2420
Format for             2421
date display:

→yy/mm/dd
 mm/dd/yy
 dd/mm/yy
```

- → always points to the last selection.

2. Press SET, LINE, or PATH when → points to your choice.

6.3.4 How to Change the Current Year, Screen 2421

1. Display screen 2421.

```
2421
Set year:          2422

→1992
```

- → always points to the current year.
- Use [▲] and [▼] as normal to change the choice. → does not move, but the year changes. The year rolls from year 2091 to 1992 and vice versa.

2. Press [SET], [LINE], or [PATH] when → points to your choice.

6.3.5 How to Change the Current Month, Screen 2422

1. Display screen 2422.

```
2422
Set month:          2423

→January
```

- → always points to the current month.
- Use [▲] and [▼] as normal to change the choice. → does not move, but the month changes. The month rolls from December to January and vice versa.

2. Press [SET], [LINE], or [PATH] when → points to your choice.

6.3.6 How to Change the Current Day, Screen 2423

1. Display screen 2423.

```
2423
Set day:              2424

→01
```

- → always points to the current day.
- Use [▲] and [▼] as normal to change the choice. → does not move, but the day changes. The day rolls from the last of the month to the first of the month and vice versa.

2. Press [SET], [LINE], or [PATH] when → points to your choice.

6.3.7 How to Change the Current Weekday, Screen 2424

1. Display screen 2424.

```
2424
Set weekday:          2430

→Tuesday
```

- → always points to the current weekday.
- Use [▲] and [▼] as normal to change the choice. → does not move, but the weekday changes. The weekday rolls from Sunday to Monday and vice versa.

2. Press [SET], [LINE], or [PATH] when → points to your choice.

6.3.8 How to Change the Format for Time Display, Screen 2430

1. Display screen 2430.

```
2430
Format for          2431
time display:

 12 hour
→24 hour
```

- → always points to the last selection.

2. Press SET, LINE, or PATH when → points to your choice.

6.3.9 How to Change the Current Hour, Screen 2431

1. Display screen 2431.

```
2431
Set hour:           2432

→12
```

- → always points to the current hour.
- In 12 hour format, the hour is followed by a m or p m.
- Use ▲ and ▼ as normal to change the choice. → does not move, but the hour changes. The hour rolls from the 24th hour to the first and vice versa.

2. Press SET, LINE, or PATH when → points to your choice.

6.3.10 How to Change the Current Minute, Screen 2432

1. Display screen 2432.

```
2432
Set minute:          2440

→00
```

- → always points to the current minute.
- Use [▲] and [▼] as normal to change the choice. → does not move, but the minute changes. The minute rolls from 59 to 0 and vice versa.

2. Press [SET], [LINE], or [PATH] when → points to your choice.
   - You cannot change the current seconds.

6.3.11 How to Change the Unit ID, Screen 2440

The unit ID is a 13 character alphanumeric string, intended to distinguish your HP 37741A from others. When the test set leaves the factory, the unit ID is programmed to be the serial number assigned by HP. This serial number comprises four numerals, followed by the letter A, followed by five numerals. The string is preceded by three space characters, to give the impression that the string is right justified.

You can change the unit ID to be any other string – for example, your name. The unit ID is displayed at power on, and is also printed with the test results.

1. Display screen 2440.

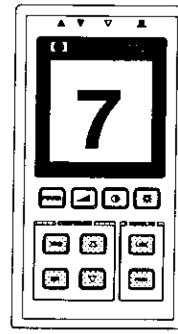
```
2440
Set unit ID:        2000
   (instructions are in
   small characters –
   see below)

→SPACE

█    nnnnAnnnnn
```

- → always points to the first character of the unit ID.
- The character that is going to be changed is marked by a █ character. The █ alternates with the actual character.
- The instructions are given in smaller than normal characters, as follows:

```
▲▼          to view
SET         to select
Choose      "SAVE"
            when done
```

2. Use [▲] and [▼] to change the character pointed to by →.
   - The following characters are displayed in sequence:
     0, 1, 2, ... 8, 9, A, B, C, ... , Y, Z, SPACE, BACK, SAVE.
     The sequence then repeats.
3. When the → points to the character that you want, press [SET].
   - That character is placed on the bottom line where the flashing █ was, and the flashing █ is advanced one character.
   - The character pointed to by → is then set to be the same as that which is now marked by the flashing █.
4. Continue to set each of the characters in turn.
5. If you need to go back and change a character, choose BACK, and press [SET].
6. When you have finished all the characters, use [▲] and [▼] to point → at SAVE, and then press [SET].
   - The new unit ID is saved in memory, and screen 2000 is displayed.

How to Save, Recall, and Print Results



7.1 General

The HP 37741A is capable of storing for future reference the results from five previous tests. In addition, the HP 37741A automatically saves the results of the most recent test (if a test is not running), or the current test (if a test is running), in temporary storage.

All of these results are retained during power off. On power on, the results in temporary storage are displayed.

Results that have been saved can be recalled from the long term storage. The temporary storage for results is overwritten when results are recalled, or when a new test is started.

7.1.1 Saved Configuration

Besides saving the LINE and PATH results, the instrument configuration is saved. When results are recalled, you have the option of recalling only the test results, or both the test results and the instrument configuration. When the instrument configuration is recalled, it replaces the current instrument configuration. Therefore, you can use the save and recall capability to memorize test setups instead of, or as well as, results.

The configuration that is saved is that which existed *at the end of the last test*. This ensures that the exact configuration that was used to obtain a set of results is saved with those results. If you change the configuration while a test is running, only the final configuration is saved. If you change the configuration and want to save the instrument setup, run a brief (dummy) test before saving the results.

This feature is similar to the capability to recall predefined configurations, as described in section 5.2. The differences are that this type of stored configuration

- is referenced by date and time, not by name
- can be saved from the front panel
- is always stored together with a set of test results
- does not save or recall the user words or SLC-96 DL

You can therefore have as many as 11 stored instrument configurations available for recall at any time:

a. the factory default
b. five named configurations
c. five time stamped configurations

7.1.2 Printing

Results that are displayed (either from a current test, recent test, or recalled results) can be printed. When results are recalled from memory for printing, you do not need to recall the saved configuration if you do not want to. If you recall results without the configuration, and you then print the results, the HP 37741A always prints the configuration that was saved in memory with those results.

7.1.3 Values Recalled

When you recall only the results, you recall:

- the test start time, elapsed time, remaining (left) time, and stop time
- all of the line results
- all of the path results[1]

When you recall the results and configuration, you recall in addition:

- the print frequency
- the configured test duration
- all of the transmit configuration

1 The results of a sequential test (such as multipattern or bridge tap) cannot be saved, and are therefore not recalled.

- all of the receive configuration
- the calibration date
- the power off and power on time

The following configurations are never overwritten by a recall of the results:

- the EIA-232 serial port
- the key beep
- the format for date and time
- the current date and time
- the unit ID
- the display of the transmit status icons
- the bit patterns and names of the user words
- the instrument calibration

7.1.4 Displayed Values

Sections 4, 5, and 6 of this manual have described how results and configurations can be viewed. When you have recalled these from memory, they overwrite the existing values, and can be viewed as described in the earlier sections.

7.1.5 Power On, Power Off, and Calibration Dates and Times

When you recall the configuration, the power on and power off dates and times and the calibration date are also recalled. These are the dates and times that were associated with the test. When you view or print the results, these values (which were meaningful when the test was run) are displayed.

As soon as a new test is run, the true dates and times of power on and power off will be displayed once more. If power is turned off while the recalled values were displayed, the true values will be used when power is restored.

7.2 How to Save the Results, Screens 3300 and 3310

1. If a test is running, stop the test.
2. Select `save` from the main TEST menu, screen 3000.
   - If the results have not previously been saved, screen 3300 is displayed. If the results have already been saved, screen 3310 is displayed (the HP 37741A will not allow you to save the same results more than once).

```
3300
Save results,
overwrite:
 mm/dd hh:mm     3310
 mm/dd hh:mm     3310
 mm/dd hh:mm     3310
 mm/dd hh:mm     3310
➔mm/dd hh:mm     3310
  cancel         3000
```

   - The `mm/dd` represents the month and day that the test was stopped. This may be shown as `dd/mm`, depending on the date format configured with the configure set selection. The `hh:mm` represents the hour and minute that the test was stopped. If 12 hour format had been configured, an `a` or `p` will follow the time. The year and seconds that the results were saved are not shown.
   - The results are ordered chronologically – with the most recent results on line 3, and the oldest results on line 7. Even though the year is not displayed, the year is considered when displaying the dates. Thus, a date of November 1991 might be on line 5, and a date of January 1992 could appear on line 4.
   - ➔ always points to the results indicated on line 7, assuming that you will want to overwrite the oldest results.
   - You can exit the save function by pointing ➔ to `cancel`, and pressing [TEST], or by pressing any other key except [☼].
3. Move ➔ to point to the results that you want to overwrite, and press [TEST].
   - Screen 3310 is displayed.

3310

```
Current test          3000
results have
been saved as

      hh:mm:ss
 yy/mm/dd Www

Press any key
```

▸ No ➔ is displayed. Pressing any key other than [☼] exits this screen. Pressing [▲], [▼], or [TEST] causes screen 3000 to be displayed. The keys [◢], [◑], [SET], [LINE], and [PATH] are treated normally.

7.3 How to Recall the Results, Screens 34xx

1. If a test is running, stop the test.
2. Select `recall` from the main TEST menu, screen 3000.
   ▸ If you have not saved the current test results, screen 3400 is displayed. If you have saved the current results, screen 3410 is displayed.

3400

```
Current test
results have
not been
saved. OK to
overwrite?

 no                   3000
➔yes                  3410
```

▸ ➔ always points to `yes`, assuming that you do indeed want to recall results. You can cancel the recall procedure by selecting `no`.

3. Press [TEST].
   ▸ Screen 3410 is displayed:

3410

```
Recall test
results:
→mm/dd hh:mm      3410
 mm/dd hh:mm      3410
 mm/dd hh:mm      3410
 mm/dd hh:mm      3410
 mm/dd hh:mm      3410
  cancel          3000
```

- The mm/dd represents the month and day that the results were stored in the memory. This may be shown as dd/mm, depending on the date format configured with the configure set selection. The hh:mm represents the hour and minute that the results were stored. If 12 hour format had been configured, an a or p will follow the time. The year and seconds that the results were saved are not shown.
- The results are ordered chronologically – with the most recent results on line 3, and the oldest results on line 7. Even though the year is not displayed, the year is considered when displaying the dates. Thus, a date of November 1991 might be on line 5, and a date of January 1992 could appear on line 4.
- → always points to the most recent results that have not been recalled. When all the results have been recalled, the instrument behaves as if none has been recalled, and will therefore point to the most recent results. This allows you easily to recall different results one after the other, for possible comparison or printing.
- You can exit the recall function by pointing → to cancel, and pressing [TEST], or by pressing any other key except [☼].

4. Move → to point to the results that you want to recall, and press [TEST].
   - Screen 3420 is displayed.

```
3420
Recall from:     3000
     hh:mm:ss
 yy/mm/dd Www

→results only
 results and
    config
 cancel
```

- The → always points to `results only`.
- You can exit without recalling the results by selecting `cancel`.

5. If you want to recall the setup as well as the results, move → to `results and config`.
6. Press [TEST].

7.4 How to Print the Results, Screens 31xx

7.4.1 General

Test results can be printed irrespective of whether a test is running.[1] The results that are printed are those which are currently displayed. The instrument configuration associated with the results is always printed. To print results that have been saved, you must first recall the results.

You can configure the instrument to print the results:

- periodically during a test
- when high errors are received
- at the end of the test
- immediately, or "on demand"

The configuration can be modified while a test is running.

The printer menus are accessed by selecting `printer` from the main TEST menu, screen 3000 or 3001.

1 Complete details about printing, including pictures of sample printouts, are given in section 13.3.

7.4.2 Serial Port Not Configured, Screen 3100

If the EIA-232 port is not configured to be a printer port, screen 3100 is displayed.[1]

3100

```
Serial port
is not
configured
for printing.


Press any key
to continue.
```

3000 or 3001

- No ➔ is displayed. Pressing any key other than [☼] exits this screen. Pressing [▲], [▼], or [TEST] causes screen 3000 to be displayed. The keys [SET], [LINE], and [PATH] are treated normally.

7.4.3 Already Printing, Screen 3101

If the EIA-232 serial port is configured for printing, screen 3101 is displayed if the test set is currently printing, and screen 3102 is displayed if the test set is not printing.

3101

```
Print process
is active.

 cancel
➔continue
```

3000

- ➔ always points to `continue`.

1. Choose `continue` to allow the print job to complete. Choose `cancel` if you want the job stopped.
   - You can also terminate a print job by setting the instrument to the factory default settings, as described in section 5.2.

1 See section 6.2 for details on how to configure the port for printing.

7.4.4 Not Currently Printing, Screen 3102

When the instrument is not printing, screen 3101 is displayed, and you can select the conditions under which a printout will occur:

3102

Print results	
➔off now	3000 or 3001
on event	3110
every 15 min	3000 or 3001
every 30 min	3000 or 3001
every hour	3000 or 3001
every 2 hour	3000 or 3001
at test end	3000 or 3001

- ➔ points to the last setup, except that it does not point to now) on screen entry.

1. Move ➔ to point to the print condition that you want, and press TEST.
   - If you selected on event, screen 3110 is displayed. If you selected any other possibility, screen 3000 is displayed if the test is idle, and screen 3001 is displayed if the test is running.
   - If the print frequency is adjusted when a test is running, the results are printed at the new time interval starting from the time that you made the change.

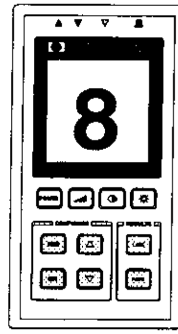
3110

Print if:	3000 or 3001
high errors	
any alarm	
➔either	

- The HP 37741A can print when error thresholds are exceeded or removed. Alternatively, the instrument can print when an alarm condition is recognized or when it retires. The third option causes the instrument to print if either of these conditions is satisfied.

- If a condition exists that satisfies the `on event` criteria when screen 3110 is exited, the results are immediately printed.

Frame Format Capabilities



8.1 General

The HP 37741A is compatible with all standard DS1 frame formats in use. These are listed in figure 8-1. In addition the instrument can operate with unframed signals.

Any of these frame formats can be detected and generated. Unlike the majority of DS1 test instruments that you may have used in the past, the generation of any one frame format by the HP 37741A is not associated with (or coupled to) the receiver of the test set. Therefore, the transmitted frame format need not match the received frame format. Further, either or both could be unframed.

This subsection (8.1) describes capabilities common to all types of frame formats. Later subsections describe features unique to each supported frame format. FT1 is dealt with in sections 9 and 12.

Frame Format	Frames per Superframe	CRC Error Check	Data Link	Clear Channel
Unframed	n/a	○	○	○
D1D	12	○	○	○
D2	12	○	○	○
D3/D4	12	○	○	○
SLC-96	12	○	●	○
ESF	24	●	●	○
ZBTSI	24	●	●	●

Figure 8-1 Supported Frame Formats

8.1.1 Received Frame

You can set the HP 37741A to synchronize automatically to whichever frame format is received, or to synchronize to a specific format of your choosing.

When the instrument is configured to find automatically the receive frame format, it will generally do so within 250 ms. In the presence of errors, this may take longer. When high error rates are present (above 10^{-4}), the HP 37741A may not be able to find automatically the frame format. If this condition exists, it is better to force the HP 37741A to frame to a specific format. You can also pre-select the receive frame format when you are sure of the format (for example, if you are working at the DSX bay, and there is only D4 present).

Pre-selecting the frame format also will speed the process of locking to the incoming frame. When the incoming signal is framed with a different format from that selected, the test set may erroneously frame to the pre-selected format. This is because the framing criterion is deliberately loosened compared with the autoframe selection.

8.1.2 Transmit Frame

The transmitter operates independently of the receiver. You can set the frame format to replicate that of the received signal, or to be a predetermined format irrespective of the received frame format. When the transmit frame format is set to mimic that received, the signal is transmitted without any frame errors.

Regardless of whether the transmit frame format is the same as or different from the received signal, there is no relationship between frame bit positions or signaling bit positions.

8.1.3 Transmit Payload

The payload of a framed DS1 signal comprises the 192 bits between the framing bits. This represents an available bandwidth of 1 536 kb/s. On an unframed signal, each bit is considered to be part of the payload. You can set the entire payload of a DS1 signal transmitted by the HP 37741A to be one of the following:

- an internally generated test signal
- an internally generated loopback code pattern

- the payload of the received signal

The test signal, and the payload, are configured as path parameters. The loopback code is configured as a line parameter.[1] You can cause a loopback code to be transmitted temporarily. In this case, and when the loopback code is in-band,[2] the payload will revert to that which was transmitted before the loopback code.

8.1.4 Test time

A test period will commence after the unit has achieved both frame and pattern synchronization. If the incoming signal is not framed, or there is no recognizable pattern (or both), the test period will start within one second after you have initiated the test by pressing [TEST].

If, having started a test, the HP 37741A loses frame or pattern synchronization, the instrument will initially try to regain synchronization. After a period of 250 ms, if the instrument has not successfully regained synchronization, it will search for an alternative frame format or pattern format.[3]

If the HP 37741A succeeds in synchronizing to a *different* frame or pattern format, the test period will be restarted, and any accumulated errors are zeroed.

The test period is derived from the instrument's real time clock. Therefore, the test time accuracy is governed by the clock accuracy, which is detailed in section 14.5. In addition, any test interval is timed to within ± 5 ms of the configured time.

8.2 Unframed Format

With the exception of the user words, the HP 37741A will recognize any of the patterns described in section 9, and shown in screen 2132, when the DS1 signal is framed or unframed. Further, the instrument can transmit any pattern framed or unframed.

1 Although the loopback code is generally transmitted in the payload of a signal (the DS1 path), its effect is to alter the T1 line characteristics. This distinction is dealt with in sections 9.2.2 and 9.3.2.

2 In-band and out-of-band codes are discussed in section 9.3.4.

3 If you have forced the HP 37741A to lock to a specific frame format, the instrument will not hunt for an alternative frame format.

8.3 D4 Frame Format

8.3.1 Overview

The abbreviations D1, D2, D3, and D4 originally referred to the channel banks manufactured by Western Electric. D1 stood for Digital, first generation, and ushered in a new era of telephone communications when it was introduced in 1962.

Subsequent generations of channel banks (D2, D3, and D4) maintained frame format compatibility with the original design, although the channel sequencing within the frame differed.[1] The first three generations offered a relatively modest set of features. For example, toll quality transmission started with D2.[2]

The D4 channel bank was introduced in late 1976. It was designed to offer a broad complement of functions and features through the use of plug-in circuit packs. In time, the D4 bank grew to include:

- integrated interfaces for direct connection to T1, T1C, and T2
- integrated interfaces for special service connections
- direct access for DDS, with, for the first time, error correction
- an expanded carrier system, SLC-96, to extend the T-carrier technology to the loop

The flexibility and cost effectiveness of the D4 channel bank led to its widespread use. The frame format used has subsequently been popularly referred to as the D4 frame format.

8.3.2 Frame Structure

Twelve frames (each of 193 bits) are grouped together to create a superframe. Six of the frame bits are used to identify the frame positions. These bits alternate between 1 and 0, and are called the terminal frame, or FT, bits.[3] The other six frame bits are called the signaling frame, or FS, bits, and identify the sixth and twelfth frames that have the signaling information. This is shown in figure 8-2.

1 Channel sequencing is discussed in Section 12.1.
2 It was later offered as an option for the D1 bank as the D1D bank.
3 They are also referred to as the channel framing bits, because they identify the position of channel number one.

The twelve frame format is also referred to as the SF format, and the term applies not only to D1 to D4 frame formats, but also to the SLC-96 frame format. This term is used to distinguish the frame format from the ESF format.

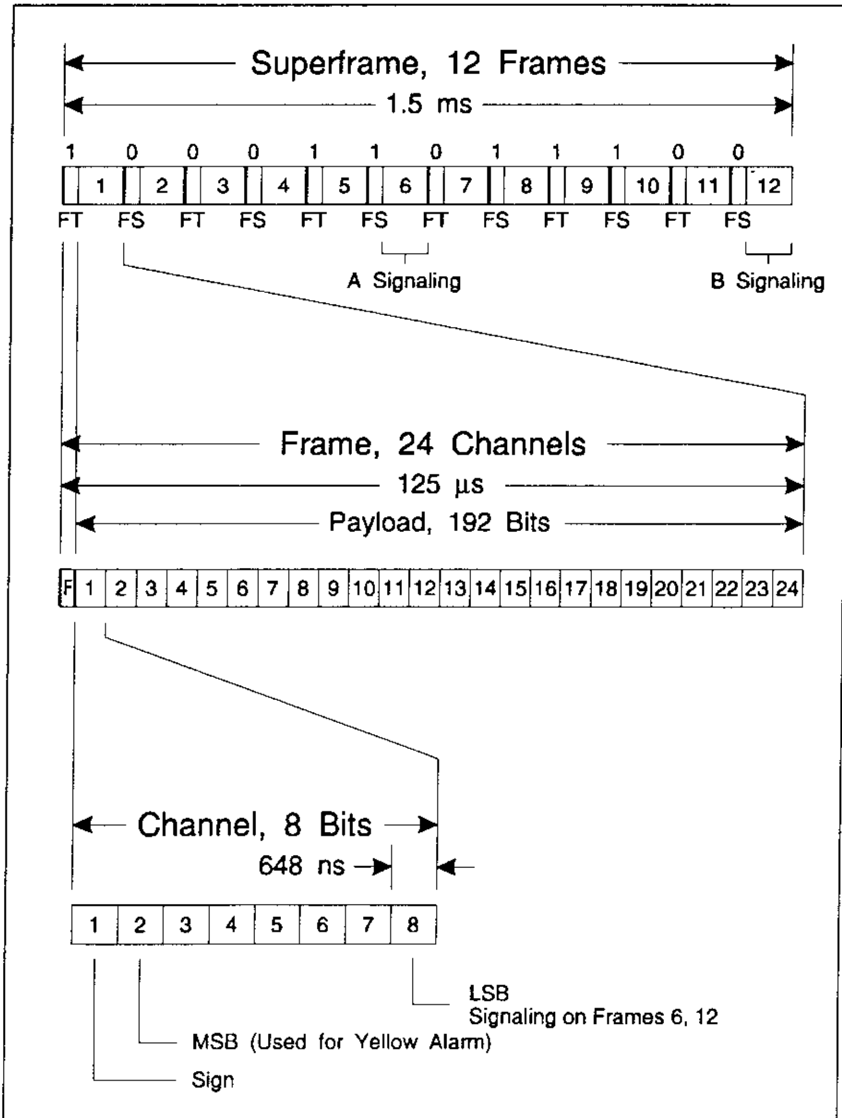


Figure 8-2 D4 Frame Format

8.4 SLC-96 Frame Format

8.4.1 Overview

The original T-carrier systems served the purpose of trunk communications (central office to central office). The SLC-96 system was introduced in the spring of 1979 to capitalize on the advantages of T-carrier within the local loop. The system provides for 96 subscriber channels to be transmitted over multiple T1 lines between a remote terminal and the central office. Thus was the acronym derived, meaning subscriber loop carrier for 96 channels.

The SLC-96 system was an extension of the D4 channel bank family, and initially used many of the same plug-in circuit packs and mechanics. The D4 family was unsuitable for local loop use, and the SLC-96 system was implemented to:

- integrate the T1 line interface and span powering into the same shelf in order to save physical space
- provide single ended system maintenance, because crafts people would not be available at both ends of the link
- provide subscriber line concentration, so that 96 subscribers could share six metallic pairs (3 in each direction)

There are three operational modes for SLC-96:

Mode 1 Four T1 lines each carry signals from 24 subscribers without concentration. A fifth T1 line is use for protection switching (redundancy).

Mode 2 Two T1 lines are used for main communications, with a third being used for protection switching. 48 subscribers share each main T1 line on a first come first served basis.

Mode 3 There are two main T1 lines and a third for redundancy. The system is used for special services (nailed-up connections) or pay phone use, and is limited to a maximum of 48 channels (24 on each T1 line).

Since 1986, the Series 5 Digital Loop Carrier system has gained popularity as an alternative to SLC-96 for new installations. Of the total SLC-96 systems installed, approximately two thirds are mode 1, with the remainder split between mode 2 and mode 3.

8.4.2 Frame Structure; Data Link

Information between the remote terminal and the central office terminal regarding the status of the system is carried in the data link.[1] This 2.2 kb/s link is obtained by partially overwriting the FS bits of the D4 frame format, and is synchronous with the superframe. The FT bits are retained, and as before alternate 1, 0.

The DL and remaining FS bits carry the following status information:

- Identification of frames 6 and 12, so that signaling may still be extracted.
- Alarms and circuit loopbacks, carried in a 2 bit alarm field (A1 and A2). Alarms include circuit alarms, power alarms, and miscellaneous alarms (for example, a smoke detector).
- Channel testing, carried in a 3 bit maintenance field (M1 to M3).
- T1 line protection switching, carried in a 4 bit field (S1 to S4).
- Concentration of subscriber lines, carried in an 11 bit concentrator field (C1 to C11).

The format for this information is shown in figure 8-3. When receiving a SLC-96 framed signal, the HP 37741A correctly frames to the FT framing bits, and then synchronizes to the FS bits. The data link bits can be viewed under path results.

Whereas the C, M, and S fields are held constant over many frames, the A field has a further framing sequence of its own. The sequence

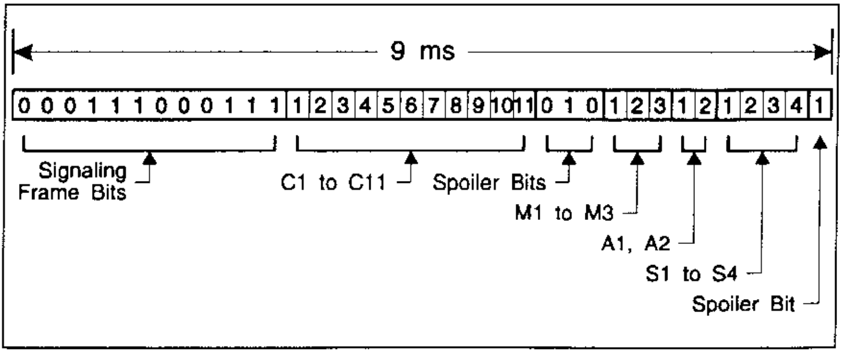


Figure 8-3 SLC-96 Data Link

1 This data link is not present on all the T1 lines between the COT and the RT. This fact is important when accessing a channel on a SLC-96 circuit, as described in section 12.

repeats every 13 or 16 frames of the overall SLC-96 data link.[1] The start of the A field sequence is indicated by A1 and A2 both being 1. For the remaining frames of the sequence, A1 is set to 0. A2 is normally 1, and is reset to 0 to indicate that an individual alarm message is active. There are 12 defined messages, so that 3 positions are not used on the 16 frame sequence.

The HP 37741A will automatically synchronize to either a 13 frame or 16 frame format. The test set displays the status of the alarm messages (and the received sequence length) in screen 5201, described in section 4.3.6.

On transmit, all the data link bits are set to the current default state when normal mode is selected. You can modify the default state from the serial port, and save it in one of the instrument's predefined configurations. In each of the predefined configurations set at the factory, the data link default state is set as follows:

C field (concentrator)	Idle – octal 3760 (7F0 hex)
M field (maintenance)	No test – octal 7
A field (alarm)	No alarm messages, 16 frame
S field (protection switch)	No switch – octal 17 (0F hex)

The alarm sequence is set to the repeating 16 block sequence. This default sequence length can be programmed over the serial port.[2] When the HP 37741A is currently receiving a SLC-96 signal with a frame sequence length different from that programmed, it automatically adjusts the transmit alarm frame length to conform to that received. If you change the sequence length while the instrument is receiving a SLC-96 signal, the change takes effect only after the received SLC-96 signal is removed.

When the sequence length is modified by the HP 37741A, none of the alarm messages is modified.

In summary, you can access all the received data link information from either the front panel or over the serial port. You can control the

1 If the two A bits are left at a constant 10, no receiver will be able to frame reliably on the signal. The data link information is updated on the screen only when A1 and A2 are both set to 1. If the signal is received in error, such that the 11 condition does not happen, the screen is never updated.

2 Software is available from HP which allows you easily to configure the length. This is described in appendix D. The commands needed to change the length are described in section 13.

transmitted data link information from the front panel by configuring the transmitter to be as follows:

- through mode (transmitted data link is as received)
- factory default (as indicated in the table above)
- one of the five default states (each derived from a named unit predefined configuration)

8.5 ESF Frame Format

8.5.1 Overview

The ESF format was introduced in 1979 to provide the following features not found in the D4 format:

- error detection by using a CRC
- a facility data link for operations
- four signaling bits (the D4 format has two)

Since the divestiture of the Bell System in 1983, the first two of these features have become more significant. They permit carriers to check the quality of a transmitted DS1 signal (by using the CRC), and to return that information (over the FDL) to the originator of the signal.

The use of the FDL was not defined when the ESF format was originally specified, and there now exist two standards for its use:

- A message oriented protocol (MOP), based upon the CCITT LAPD protocol. This was originally proposed by AT&T, and is popularly referred to as "54016".
- A bit oriented protocol (BOP), with fixed positions for status and error information. This was originally proposed by the ANSI accredited T1 committee, and is popularly referred to as "T1E1".

8.5.2 Frame Structure

The individual frames are the same as those in D4 – a frame bit precedes twenty-four eight-bit channels. The channels are placed consecutively within the frame so that channel one is in time slot one, channel two is in time slot two, and so on.

Twenty-four frames are grouped to form an extended superframe (the superframe is extended because it contains twice as many frames as the D4 superframe). The twenty-four frame bits are divided among three functions:

- the frame alignment sequence (FAS) – 6 bits, 2 kb/s
- the error detection sum check (CRC) – 6 bits, 2 kb/s
- the facility data link (FDL) – 12 bits, 4 kb/s

The locations of these bits are shown in figure 8-4.

The FAS serves the function that both the FT bits and the FS bits serve in the D4 frame format. That is, these bits not only permit the identification of the framing bits but also identify the frames that carry the signaling information. As with the D4 format, signaling bits can be carried in every sixth frame, which therefore permits four bits. These are labelled A, B, C, and D, and appear in the frames 6, 12, 18, and 24. Many applications duplicate the A and B bits in frames 18 and 24. When signaling is carried in a separate data stream (CCS), no bits are robbed from the traffic. Whatever signaling scheme is in use, the HP 37741A always shows the signaling as four separate bits.

When receiving an ESF signal, the HP 37741A will calculate the CRC on each received superframe. It will check the calculated CRC with that transmitted in the following superframe, and declare a CRC error if the numbers differ.

The test set does not permit you to manipulate directly the bits of the FDL, nor can you view the received bits. On transmit, the HP 37741A sets the FDL to an idle code of all ones if you have selected the default setting in screen 2134. Through mode of the data link is discussed in section 8.7.7.

The instrument monitors the FDL for the yellow alarm signal as discussed in section 11.2.

Frame Number	F Bit Assignments, ESF			F Bit Assignments, ZBTSI		
	FAS	FDL	CRC	FAS	FDL	CRC
1	–	M1	–	–	Z	–
2	–	–	C1	–	–	C1
3	–	M2	–	–	M1	–
4	F1 = 0	–	–	F1 = 0	–	–
5	–	M3	–	–	Z	–
6	–	–	C2	–	–	C2
7	–	M4	–	–	M2	–
8	F2 = 0	–	–	F2 = 0	–	–
9	–	M5	–	–	Z	–
10	–	–	C3	–	–	C3
11	–	M6	–	–	M3	–
12	F3 = 1	–	–	F3 = 1	–	–
13	–	M7	–	–	Z	–
14	–	–	C4	–	–	C4
15	–	M8	–	–	M4	–
16	F4 = 0	–	–	F4 = 0	–	–
17	–	M9	–	–	Z	–
18	–	–	C5	–	–	C5
19	–	M10	–	–	M5	–
20	F5 = 1	–	–	F5 = 1	–	–
21	–	M11	–	–	Z	–
22	–	–	C6	–	–	C6
23	–	M12	–	–	M6	–
24	F6=1	–	–	F6 = 1	–	–

Figure 8-4 ESF and ZBTSI Frame Overhead Structures

8.6 ZBTSI Frame Format

8.6.1 Overview

The ZBTSI frame format was introduced in 1987 as an extension of the ESF format. It was developed to permit the transmission of strings of zeroes in the payload without the need for B8ZS line coding.[1] This bit

[1] B8ZS encoding, and the transmit capabilities of lines without this coding scheme are discussed in section 10.5.

sequence independence permits network operators to obtain clear channel capability without having to replace line equipment.

The ZBTSI frame format still provides the advantages of ESF. The 6-bit CRC remains, and there can be four signaling bits. There are, however, disadvantages with the frame format, which have impeded its wide-spread use:

- It is complex to encode and decode.
- The signal incurs a delay of four frames when encoded and then decoded. Speech traffic may be noticeably impaired if the signal passes through many DACSs.
- The FDL is reduced from 4 kb/s to 2 kb/s.

8.6.2 Frame Structure

The ZBTSI frame format identifies strings of zeroes that would cause a signal to violate the pulse density requirement. Those octets so identified are replaced with non-zero octets. Half of the FDL bits contain flags (referred to as Z-bits), used to indicate whether a substitution has taken place.

Four consecutive frames of an ESF formatted signal are used to encode and decode ZBTSI. There are thus 96 octets in each ZBTSI encoded block, numbered 1 to 96. These blocks are indicated by the horizontal lines shown in figure 8-4. The Z-bits replace the odd numbered FDL bits, that is M1, M3, M5, and so on. The other F-bits of the ESF formatted signal are unaltered.

The payload data is scrambled, and then octet number 96 is moved to the front, so that the sequence is now 96, 1, 2, ... , 94, 95. This data is now examined for octets that violate the pulse density and excess zeroes requirements of a T1 line.[1] If there is not a VAZO (violating all-zero octet) in the block, the Z-bit is set to a one, and the block transmitted.

If there is a VAZO in the block, the octet number of the VAZO (its address) is inserted into the first octet (immediately following the Z-bit), where octet 96 had been placed. If there are no more VAZOs, the MSB of the VAZO address is set to one. Octet 96 replaces the VAZO, the Z-bit is set to zero, and the block is transmitted.

1 The criteria are not exactly the same, but close enough for the purposes of this discussion.

If there are more VAZOs, each is sequentially replaced by the address of the next VAZO, to create a linked list. The MSB of each address is set to zero, except the last address, where the MSB is set to one. Octet 96 is placed in the last VAZO. The Z-bit is set to zero, and the block is transmitted.

Decoding the signal is performed in the reverse sequence.

8.6.3 The FDL and CRC

Only a 2 kb/s data link exists in the ZBTSI frame format. When converting from ESF to ZBTSI, some MOP messages may be discarded. This rarely happens in practice however, because the FDL is not normally fully utilized. When converting from ZBTSI to ESF, MOP messages are buffered, so that they retain the same format. Unused message bandwidth is filled with the FDL idle code.

The CRC is calculated prior to scrambling and ZBTSI encoding. The HP 37741A therefore decodes the received signal before calculating CRC errors.

8.7 Through Mode

8.7.1 General

When you connect the test set in series with the DS1 signal, the set is said to be in through mode. In most instances, the received signal format will be the same as the transmitted frame format, so that the test set acts like a piece of wire. You can then modify certain parameters of the signal to test the circuit. The HP 37741A allows you to set the transmitter differently from the receiver, so that various parameters are converted from one format to another.

8.7.2 Frame As Input

Frame format conversion takes place when the transmit frame format of the HP 37741A is different from that received. If you select the transmit frame format to be the same as that received (as input), frame format conversion never takes place, because the test set ensures that the transmit and receive formats are the same. With this setting, the transmitted frame is error free, even when there are frame errors on the input signal.

8.7.3 Time Delays When As Input

When you set the transmitted frame format to be as input, the set identifies the received frame format, then adjusts its output accordingly. The instrument then assumes that the received signal will continue to be the same, and will ignore minor disturbances in the received signal.

Specifically, when the input loses frame synchronization, the receiver remains locked to the same frame format. The transmit frame format is not disturbed. After 250 ms of OOF, the receiver hunts for a different frame format. It still continues to try to find the original format as well. This continues for two seconds, during which time the transmit frame format is preserved. After that time, the transmitter is set to unframed mode.

If a new frame format is received, the transmitter is instantly set to the new frame format.

8.7.4 Frame Format Conversion

When you explicitly specify the transmit frame format, and the received format is not the same, the test set automatically performs frame format conversion.

Frame format conversion is usually relevant only when you want the payload of the transmitted signal to be the same as that of the received signal, so that the instrument is indeed passing the bulk of the signal through.

For example, suppose you have set the transmitter to D4 format, and you receive an ESF format signal. Assume the payload of the ESF signal is carrying 24 speech channels. The output will be a D4 signal with the speech channels correctly preserved. You can optionally choose to preserve the signaling in the transmitted signal by turning on signaling reinsertion.[1]

Because the instrument's receiver operates independently of its transmitter, it is quite an easy matter to make the frame formats different. However, when you do not want the payloads to be the same, this would not be described as format conversion.

1 See section 12.4.4 for details.

8.7.5 Unframed to Framed Conversion

When the input signal is unframed, the output signal is framed, and the output payload is the same as that received, bits of the original payload may be lost.

When the payload is set to as in, the HP 37741A will transmit an error free version of a test pattern if it recognizes the received pattern. For example, suppose the test set is receiving an unframed QRW, and is set to transmit the payload as input with D4 framing. The instrument will generate an error free D4 QRW signal.

If the signal is not recognized (for example, when a unique test pattern or computer data is sent), the payload will be copied to the output, and every 193rd bit will be overwritten with a framing bit. This is what will happen when the payload is set to thru. In the earlier example, the signal transmitted would be a D4 signal with an errored QRW.

8.7.6 Framed to Unframed Conversion

Again, when the instrument's payload is set to as in, and the payload is recognized, an error free version of the signal is transmitted. If the payload is not recognized, or if it is set to thru, all the received bits will be transmitted without modification. This will include the framing bits that were in the original signal, because they are not now overwritten.

It will therefore appear as if no conversion had been done on the signal, because a framed signal can still be detected at the output of the HP 37741A.

This mode can be used if you have an unusual signal, and want the test set to regenerate it free of line coding violations.

8.7.7 Data Link

For ESF, ZBTSI, and SLC-96 formats, you can select whether the data link is passed through, or set to a default value. When set to a default value, the ESF and ZBTSI FDLs are set to the idle code. The SLC-96 DL is set to the default value. When shipped from the factory, this is an idle code, but it can be modified over the test set's serial port.

Through mode is applicable only when the receive and transmit frame formats are the same. Then, the data received on the data link is copied to the transmit data link. For ESF and ZBTSI, only BOP is supported.

8.7.8 Timing

Whenever the test set is in a through mode, you should set the transmitter timing to be derived from the input signal. If the transmit timing is obtained from another source, you may see the following errors:

- slips (controlled when both sides are framed)[1]
- erroneous data link messages, when in SLC-96, ESF, or ZBTSI

8.8 Error Analysis, Frame Errors

The HP 37741A can perform frame error analysis when receiving any framed signal.[2] A single bit frame error occurs when a received F-bit (excluding data link bits and CRC bits, if the frame format is SLC-96, ESF, or ZBTSI) does not match that which is expected.

Besides frame bit error analysis, the instrument provides a count of OOF and COFA events, and frame loss seconds.[3]

8.8.1 Out of Frame, OOF, Loss of Frame, LOF, Frame Loss Seconds, FLS, and Change of Frame Alignment, COFA

When the test set is in frame, and any two of four consecutive frame bits are received in error, the HP 37741A declares an OOF event. The test set then searches the incoming bit stream for a better frame position. During this search, the test set is declared to be in an LOF condition.

After the LOF condition has persisted for 2.0 seconds, the test set declares frame loss, and increments the FLS counter. This is considered to be a CGA inside a telephone central office.

The LOF condition is retired, and frame loss is no longer declared, as soon as the instrument regains framing. If another LOF condition is detected within 2.0 seconds of the frame loss being undeclared, it

1 This is discussed in section 10.2.
2 No frame error analysis can be performed on an unframed signal.
3 Frame loss seconds are described in section 11.2.

needs to persist for only as long as the frame loss was undeclared, to be recognized again as a frame loss. This integration of the LOF counter "smooths" the alarm indication, and prevents an errored signal from being declared in and out of frame.

Once frame loss is declared, any second in which there existed an LOF condition causes the FLS counter to increment. Thus, on a noisy line, which is causing the receiver to jump quickly in and out of frame, the frame loss is permanently declared.

At the end of the frame search after an OOF event, (when the instrument has received an entire superframe without any frame errors), the HP 37741A compares the current frame position with the old frame position. If they are the same, this implies that the frame bits just happened to be in error. If a different frame position has been found, the test set declares that a COFA event has occurred.

If the transmit signal has been configured to be dependent on the input signal, the HP 37741A still transmits according to the *old* frame position during the search for a new frame position.

A difference between an OOF and a COFA is that an OOF event occurs as soon as the framing bit error condition is met, whereas a COFA event occurs only after the correct frame bit position has been found. The OOF count will always be greater than, or equal to, the COFA count.

The maximum average time taken by the test set to reframe to the various frame formats is given in figure 8-5.

Frame Format	Reframe Time
D4	10 ms
ESF	15 ms
ZBTSI	20 ms
SLC-96	25 ms

Figure 8-5 Maximum Average Reframe Times

The maximum number of each event that can be accumulated is 999 998. When this number is exceeded, the display will show 999 999, and thereafter will not change. If there are ten OOF events every minute, this number is reached after 69½ days.

The accumulation of further frame bit errors is inhibited when the test set is in an LOF condition. Neither the OOF count nor the COFA count increments when there is no received signal (LOS).

8.8.2 Error Count, EC

This is a count of total frame bit errors received during the test. The maximum number that can be accumulated is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change.

The time taken before the counter overflows is dependent on the frame format being received, as indicated in figure 8-6.

Frame	Max Frame errors per s	Counter overflows after
D4	2000	83 minutes
SLC-96	1000	167 minutes
ESF, ZBTSI	500	5½ hours

Figure 8-6 Frame EC Overflow Period

8.8.3 Errored Seconds, ES

This is a count of the number of seconds in which there was at least one frame bit error and in which there was not an LOS, AIS, or LOF. Because the one second interval is not necessarily related to either the time of day, nor to the occurrence of the errors, this value is sometimes referred to as asynchronous errored seconds. The equation is thus:

ES + EFS + LOF time + LOS time + AIS time = elapsed time

The maximum count on the HP 37741A is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. If errors are continuously being received, this number is reached after 115 days.

8.8.4 Average Error Rate, avgER

This is the ratio of the frame error count to the total number of frame bits examined during errored seconds. Because the number of F-bits in a second differs between the various frame formats, a single F-bit error will result in a different average error rate for the various frame formats. This is indicated in figure 8-7.

Frame Format	1 F-bit error in 10 seconds	10 F-bit errors in 1 min
D4	1.2×10^{-5}	2.1×10^{-5}
SLC-96	2.5×10^{-5}	4.2×10^{-5}
ESF, ZBTSI	5.0×10^{-5}	8.3×10^{-5}

Figure 8-7 Example of Frame Error Rates for Different Frame Formats

8.9 Error Analysis, CRC Errors

A CRC error occurs when the HP 37741A is receiving an ESF or ZBTSI frame sequence, and the sum check calculated by the test set does not match that received in the DS1 path. This error indicates there has been an error in the 3 ms block of traffic; it does not indicate the number of errored bits in that block – it merely indicates that at least one bit was received in error.

When an LOS, AIS or LOF is declared by the test set, the accumulation of CRC errors is inhibited.

As indicated in figure 8-1, no CRC exists for frame formats other than ESF or ZBTSI. Therefore no analysis is performed if another frame format type is received.

8.9.1 Error Count, EC

This is a count of total CRC errors received during the test.

The maximum number that can be accumulated is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. If errors are continuously being received, this number is reached after 500 minutes.

8.9.2 Errored Seconds, ES

This is a count of the number of seconds during which there was no alarm, and in which there was at least one CRC error. The equation is:

$$ES + EFS + LOF\ time + LOS\ time + AIS\ time = elapsed\ time$$

The maximum count on the HP 37741A is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. If errors are continuously being received, this number is reached after 115 days.

8.9.3 Error Free Seconds, EFS

This is a count of the number of seconds during which a valid frame sequence was maintained, and in which no CRC errors or alarms were received.

The maximum count on the HP 37741A is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. If no errors are being received, this number is reached after 115 days.

8.9.4 Percent Error Free Seconds, %EFS

The sum of errored seconds, error free seconds, and alarm seconds equals the currently elapsed test time:

$$\text{Elapsed test time} = \text{ES} + \text{EFS} + \text{alarm seconds}$$

An alarm second, as used in this context, is one in which there was either a frame loss, signal loss, or AIS.

The percent error free seconds is the ratio of EFS to elapsed test time excluding alarm seconds:

$$\%\text{EFS} = \frac{\text{EFS}}{\text{ES} + \text{EFS}} \times 100$$

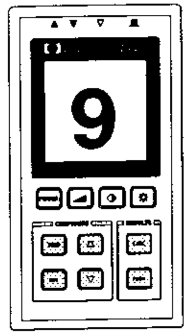
This number can be anywhere from 0 to 100.

8.9.5 Average Error Rate, avgER

This is the ratio of the CRC error count to the total number of extended superframes examined during the test.

Do not misinterpret this value as a bit error rate. For example, if a single bit error occurs every second, there would be one CRC error every second. The bit error rate would be 6.5×10^{-7}, and the average CRC error rate would be 3.0×10^{-3}.

Pattern Capabilities



9.1 General

The HP 37741A can detect and generate a wide variety of standard test signals and loopback codes, collectively referred to as patterns. The generation of a pattern by the test set is not associated with (or coupled to) the receiver of the test set. Therefore, the transmitted pattern need not match the received pattern.

Any pattern can be sent framed or unframed. When framed, the pattern can fill the entire payload (full T1), or part of the payload (FT1 n × 56 or n × 64). The instrument can receive the pattern in any of these modes, and can automatically recognize a pattern in a full or fractional T1 payload.

This section (section 9.1) describes capabilities common to both types of patterns (test signals and loopback codes). Section 9.2 describes test signals in particular. Section 9.3 describes sequential pattern testing, listing any special patterns used. Section 9.4 describes loopback codes in particular.

9.1.1 Pattern Reception

9.1.1.1 Synchronization Criteria

You do not need to configure the HP 37741A to receive a pattern. The instrument automatically synchronizes to any recognized test signal or loopback code. You cannot force the unit to hunt for only one pattern – it always searches for any recognized pattern when it is not in sync.

The test set requires that there be fewer than 4 errors in 512 consecutive bits of the pattern to synchronize the pattern receiver. Loss of synchronization occurs when 15 or more errors are received in at most 1024 bits. These different criteria make it easier to gain sync than to lose it. They equate to an average error rate of about 1% (10×10^{-3}) to get into sync, and 1.5% (15×10^{-3}) to get out of sync.

The received pattern bits are counted, so that in FT1 (n × 64) these ratios are maintained. In n × 56, the ratios are modified by about 12%.

9.1.1.2 Synchronization Time

The maximum time to get into sync for any recognized pattern at the full T1 rate is less than 400 ms. The average time is 200 ms. These times increase with the error rate of the signal. At very high errors (about 10^{-2}) synchronization may not be possible.

These times are not modified with an FT1 signal with 12 or more active channels. When fewer than 12 channels are used, the synchronization times increase approximately linearly. When only one channel is selected, the maximum sync time is 900 ms for all patterns other than QRW and $2^{20}-1$. For those patterns, it can take 7 seconds to synchronize.

When synchronization is lost, the HP 37741A assumes that the pattern will return, and keeps the receiver locked onto the same pattern. Then, when the pattern is restored, it will synchronize to it within 3 ms. In this way, short disturbances in the signal are tolerated.

If the pattern does not return within 250 ms, the test set starts to hunt for a different pattern. Thus, if the pattern changes during a test, the instrument will synchronize to the new pattern, and restart the test.

9.1.1.3 Measurement of Resync Time

This is a measurement of how long the received signal had been disturbed. The last resync time is displayed – this is not an accumulated value. This parameter is considered to be a line parameter on the HP 37741A, because it is typically a measurement of a physical activity – the toggling of a switch.

The parameter reflects the time for which the pattern synchronizer of the HP 37741A was out of sync. Therefore, this measurement can be made only when a recognized pattern is received.[1]

When the received signal is unframed, the measurement is accurate to ±3%. The resolution is ±3 ms, and the displayed value is a multiple of 3 ms. To attain an accurate value, repeat the measurement a number of times and take the average value. When the signal is framed, the frame resync time *may* add to the time taken for the pattern synchronizer to regain sync. This may increase the measured value. The additional time incurred by using a framed pattern depends on the frame format as follows:

- 0 to 10 ms for D4
- 0 to 15 ms for ESF
- 0 to 20 ms for ZBTSI
- 0 to 25 ms for SLC-96

The maximum value displayed is 250 ms.

This measurement can be used to measure APS switchover times. Use two test instruments to generate identical test patterns in full T1 mode. Slowly increase the errors on the test instrument connected to the active circuit of the APS device under test, until the APS device switches to the spare line. To that line is connected the second pattern generator. The HP 37741A will record the switchover time.

9.1.2 Pattern Transmission

The HP 37741A can transmit any of the patterns shown in figure 9-1 (test signals) or figure 9-2 (loopback codes). You can pre-select the pattern to be transmitted, or have the test set transmit the same payload as the received payload.

9.1.2.1 Explicit Selection

When you explicitly decide what the pattern should be, the HP 37741A immediately transmits that pattern using the frame format that you have chosen. This is now transmitted until you change the pattern.

1 Because of the special nature of all zeroes, $2^{20}-1$, and QRW, these patterns are not recommended to be used for accurate results. You should also set the transmitter and receiver for full T1 mode.

9.1.2.2 Through Modes

When you choose the transmitted payload to be the same as that received, the transmit signal will depend on the input signal. It is then possible for the transmitted pattern to be the same as the received pattern, even including errors.

This re-transmission of the received payload is not the same as a loopback. Loopbacks are discussed in section 9.4.

There are two modes for which the transmitted pattern depends on the received pattern – "as input" and "through". These modes are dealt with in more detail in section 9.4.

9.1.2.3 Error Injection

You can inject logic errors into the transmitted signal. These are inserted randomly in the bit pattern, occurring approximately coincidentally with the instrument's real time clock.

Errors can be inserted into most test signals and into all in-band loopback codes. Logic errors cannot be inserted into the channel words.

The errors are temporarily stopped when the instrument becomes looped back, so that no errors are then introduced by the test instrument.

9.1.2.4 Hierarchy of Patterns

When you set the instrument to send both a loopcode and a test signal, the loopcode will be transmitted. This is true irrespective of whether you sent the loopcode first and then configured the instrument to send the test signal, or vice versa.

If you send a tone, this will be inserted into a framed test signal. Any tone is inhibited while you are sending a loopcode. If the test set is transmitting alarms, these may take precedence over the pattern. This is discussed in detail in section 11.6.

9.1.3 Test Time

A test period starts after the unit has achieved both frame and pattern synchronization. If the incoming signal is not framed, or there is no recognizable pattern (or both), the test period will start within one second after you have initiated the test by pressing [TEST].

If, having started a test, the HP 37741A loses frame or pattern synchronization, the instrument will initially try to regain synchronization to the same pattern and frame format. After a period of less than 250 ms, if the instrument has not successfully regained synchronization, it will search for an alternative frame format or pattern format.[1]

If the HP 37741A succeeds in synchronizing to a *different* frame or pattern format, the test period will be restarted, any accumulated errors are zeroed, and error analysis will restart.

The test period is derived from the instrument's real time clock. Therefore, the test time accuracy is governed by the clock accuracy, which is detailed in section 14.5. In addition, any test interval is timed to within ± 5 ms of the configured time.

9.2 Test Signals

9.2.1 General

Figure 9-1 lists the properties of the test signals that the HP 37741A can generate or recognize.[2] The table shows the repeat period for unframed signals.

The user words and channel words listed are those programmed at the factory. You can create your own user words and channel words. The bit densities of the user words and channel words are therefore programmable.

In addition to the patterns shown in figure 9-1, other test signals are used for the sequential tests. These are described in section 9-3. You cannot normally select to transmit those test signals.

Each test signal is used to test various aspects of the T1 circuit. It may be unwise to use some of the test signals that the HP 37741A can generate. In figure 9-1, those signals that violate the ones density requirement or which transmit excess zeroes are identified. You should check with your transmission carrier before sending any of these signals.

1 If you have forced the HP 37741A to lock to a specific frame, the instrument will not hunt for an alternative frame format.
2 The test set cannot recognize the channel word patterns.

Test Signal	Length	Repeat Period	Excess Zeroes		Violates Density	
			Framed	Unframed	Framed	Unframed
Repeating patterns, fixed						
all 1s	1	648 ns	○	○	○	○
alt 1/0	2	1.3 μs	○	○	○	○
1 in 8	8	5.2 μs	○	○	○	○
3 in 24	24	15 μs	○	○	○	○
2 in 8	8	5.2 μs	○	○	○	○
all 0s	1	648 ns	●	●	●	●
PRBS patterns, fixed						
$2^{11}-1$	2047	1.3 ms	○	○	○	○
$2^{15}-1$	32,767	21 ms	○	○	○	○
$2^{20}-1$	1,048,575	680 ms	●	●	○	○
$2^{23}-1$	8,388,607	5.4 s	●	●	○	○
QRW	1,048,575	680 ms	○	○	○	○
User words, programmable						
2 in 8 old	8	5.2 μs	○	○	○	○
1 in 15	15	9.7 μs	○	○	●	●
1 in 16	16	10 μs	●	○	●	●
idle	8	5.2 μs	○	○	○	○
Channel words, programmable						
TmSlt	192	124 μs	○	○	○	○
LoDns	192	124 μs	○	○	●	○

Figure 9-1 Supported Test Signals

The repeat period, excess zeroes, and density conditions shown in figure 9-1 apply to a full T1 signal, and may not be valid for fractional T1.

9.2.2 Line vs Path

Test signals are strictly associated with the DS1 path characteristics, and are treated as such on the HP 37741A.

9.2.3 Full T1 and Fractional T1

With the exception of the channel words, you can send any of the patterns shown in figure 9-1 in full T1 mode or in fractional T1 mode. When the receive mode setting matches that of the pattern being received, or when the receive mode is set to automatic, any of these patterns is recognized.

The mode, frame format, and pattern being transmitted need not match the mode, frame format, and pattern being received. For example, you can send a 1/0 pattern with ESF framing in timeslots 1, 9 and 15 in n × 56 mode, and at the same time, receive an unframed QRW.

9.2.4 All Ones

An unframed all ones pattern is used in DS1 as the AIS, and may create alarms if used unintentionally. When transmitted with any frame pattern it is used to verify that a terminating equipment can distinguish the signal from a true AIS.

The signal also causes equipment to use the maximum transmission power. This is useful for testing repeatered lines, where a faulty power supply might not deliver the correct amount of power, which can then result in bit errors.

9.2.5 Alternating 1/0, 2 in 8, 1 in 8, 3 in 24

These are basic test signals of decreasing signal density. The alternating 1/0 pattern (sometimes called the 1 in 2 pattern) is the minimal stress test for clock recovery circuits.

The 1 in 8 signal is one that has the minimum density permissible without the maximum sequence of zeroes. The 2 in 8 signal is the lowest density signal that can be transmitted on a B8ZS line, without invoking any B8ZS substitutions. These patterns identify whether a line is equipped for B8ZS, and whether the B8ZS function is working correctly.

The 3 in 24 signal not only has the minimum density, but also has the maximum sequence of zeroes permissible. This pattern is used to stress the circuit under test, especially older style repeaters.

The bit patterns are as follows, where F represents the framing bit:

alt 1/0	F 0101 0101
1 in 8	F 0100 0000
2 in 8	F 0100 0010
3 in 24	F 0100 0100 0000 0000 0000 0100

When the test signal is sent framed, the frame bit is inserted at pattern boundaries. This prevents the repeating pattern from being interpreted as a yellow alarm when D4 framing is used.

When the signal is transmitted without framing, the pattern is simply repeated.

9.2.6 All Zeroes

This is used to verify that a circuit has been properly equipped with B8ZS or ZBTSI (clear channel) capability. You should not transmit this test signal unless you have selected one of these coding methods on the test set, since errors or alarms may be generated.[1] When the signal is sent over a properly equipped circuit, no errors should be received. On a B8ZS circuit, the pattern is encoded as a 50% ones density signal.

Transmitting an unframed all zeroes with AMI line encoding, or without ZBTSI, is equivalent to transmitting no signal, and will be seen as an LOS by a receiving device. This is, however, different from simply disconnecting the test instrument, because simplex current (see section 10.3.4) can still flow through the HP 37741A.

9.2.7 PRBS Signals

These pseudo-random signals test a circuit under typical operating conditions. They are created by a digital feedback shift register circuit having defining equations as given below.

Each of the PRBS signals suppresses the occurrence of all zeroes within the generator. Hence each shift register circuit is capable of generating the maximum number of combinations minus one. Because the test sequence length is not a multiple of the frame length, when these test signals are framed, there is no relationship between the pattern and the frame bit. The clock to the signal generator is effectively stopped when the frame bit is sent, so that the signal itself is not corrupted.

1 The HP 37741A does not inhibit you from sending the test signal without having selected B8ZS or ZBTSI, because you might want to check the alarms.

The following notation is used in these equations:

^ represents an exclusive OR;

+ represents an OR;

! represents a negation.

9.2.7.1 $2^{11}-1$ (2047)

The $2^{11}-1$ signal is typically referred to as "2047" by data communications personnel, because the pattern length is 2047 bits long. It is the pattern recommended for testing an individual channel (especially on international links). It is also used to test FT1 links of more than one channel, because the pattern is commonly available on data communications test equipment.

$$Q_n(k+1) = Q_{n-1}(k) \quad \text{for } n = 2 \text{ to } 11$$
$$Q_1(k+1) = (Q_9(k) \wedge Q_{11}(k)) + !(Q_1(k) + Q_2(k) \ldots + Q_{11}(k))$$
$$Q_{out}(k+1) = Q_{11}(k)$$

9.2.7.2 $2^{15}-1$

The $2^{15}-1$ signal has (with the exception of 15 zeroes) all possible 15 bit binary combinations. It violates neither the excess zeroes nor the pulse density requirements (when framed or unframed), and as such it is the longest "pure" PRBS that can be used on a T1 line.

$$Q_n(k+1) = Q_{n-1}(k) \quad \text{for } n = 2 \text{ to } 15$$
$$Q_1(k+1) = (Q_{14}(k) \wedge Q_{15}(k)) + !(Q_1(k) + Q_2(k) \ldots + Q_{15}(k))$$
$$Q_{out}(k+1) = Q_{15}(k)$$

9.2.7.3 $2^{20}-1$

The $2^{20}-1$ signal has a maximum of 19 sequential zeroes. It therefore violates the excess zeroes requirement.[1] It provides a good stress test for clock recovery circuits. When the T1 circuit being tested is equipped for B8ZS or ZBTSI, you should use this test pattern in preference to the QRW pattern.

$$Q_n(k+1) = Q_{n-1}(k) \quad \text{for } n = 2 \text{ to } 20$$
$$Q_1(k+1) = (Q_{17}(k) \wedge Q_{20}(k)) + !(Q_1(k) + Q_2(k) \ldots + Q_{20}(k))$$
$$Q_{out}(k+1) = Q_{20}(k)$$

1 This signal creates about 11 excess zeroes violations per second.

9.2.7.4 $2^{23}-1$

The $2^{23}-1$ signal has a maximum of 22 sequential zeroes. It too violates the excess zeroes requirement but not the minimum ones density requirement. Over long lines, where there is much accumulated jitter, you can expect to see a large number of errors when using this signal.

$$Q_n(k+1) = Q_{n-1}(k) \quad \text{for } n = 2 \text{ to } 23$$
$$Q_1(k+1) = (Q_{18}(k) \wedge Q_{23}(k)) + !(Q_1(k) + Q_2(k) \ldots + Q_{23}(k))$$
$$Q_{out}(k+1) = Q_{23}(k)$$

9.2.7.5 QRW

The QRW signal is a "stuffed" $2^{20}-1$ signal. Selected bits of the signal are forced to a one to limit the maximum number of sequential zeroes to be 14. When transmitted as a framed signal, there will be a maximum of 15 consecutive zeroes, which does not violate the excess zeroes requirement.

It is the most commonly used test signal, and is also used as a "keep alive" signal on lines that are not in service.

$$Q_n(k+1) = Q_{n-1}(k) \quad \text{for } n = 2 \text{ to } 20$$
$$Q_1(k+1) = (Q_{20}(k) \wedge Q_{17}(k)) + !(Q_1(k) + Q_2(k) \ldots + Q_{20}(k))$$
$$Q_{out}(k+1) = Q_{20}(k) + !(Q_6(k) + Q_7(k) \ldots + Q_{19}(k))$$

When the HP 37741A receives a QRW or $2^{20}-1$ pattern, it automatically discriminates between them by looking at the stuff opportunities (places in the bit stream where the pattern could be stuffed). There are about 10 such opportunities in each repetition of the pattern, so that, at low bit rates (FT1 with a small number of channels), this process of discrimination takes a relatively long time.

9.2.8 User Words

9.2.8.1 General

The user words are repeating patterns that can be from 3 bits to 24 bits long. There are four words available. They are called user words to emphasize that they are *user programmable*.

The HP 37741A always searches for the presence of a received user word pattern, just as it searches for any of the fixed patterns. Logic errors can be injected into a transmitted user word.

9.2.8.2 Programming the User Words

The user word bit patterns cannot be viewed or programmed from the instrument's front panel. These functions are done by sending an external command over the serial port, as detailed in section 13.4.5.[1]

You can assign a name to a user word when the word is programmed. The name can be up to 5 characters long (for example, 7 i n 1 9 or M y P t n), and is displayed on screens 2100, 2132, 2700, and, when received, on screens 5300 and 6000.

The user words are saved as part of the pre-defined configurations,[2] and when recalled, overwrite the existing user words. When the test set leaves the factory, four user words are defined, and saved with the pre-defined configurations.

9.2.8.3 Old 2 in 8

This pattern is compatible with an earlier definition of the 2 in 8 test pattern, and is provided for compatibility. The bit sequence is:[3]

2 in 8 o F 0110 0000

9.2.8.4 1 in 15, 1 in 16

These patterns are stress patterns. The 1 in 15 and 1 in 16 violate the density requirement when sent framed; the 1 in 16 violates the excess zeroes requirement when sent framed.

The bit patterns are as follows, where F represents the framing bit:

1 in 15 F 0100 0000 0000 000

1 in 16 F 0100 0000 0000 0000

9.2.8.5 Idle

This is sometimes used as the idle code for channels which are not used on an FT1 system.[4] When all channels contain this pattern, the HP 37741A displays i d l e as the recognized pattern.

1 The external control software available as an accessory allows you to view, edit, and program the user words and their names. This is listed in appendix D.
2 This is described in section 5.2.
3 This pattern was used on revision 1 and revision 2 of the HP 37741A.
4 In other cases, all ones fills unused timeslots.

The bit pattern is 7F hex:

idle F 0111 1111

9.2.8.6 Frame Boundary

When any of the old 2 in 8, the 1 in 16, or the idle test signals is sent framed, the frame bit is inserted at pattern boundaries. This prevents the repeating pattern from being interpreted as a yellow alarm when D4 framing is used. When sent framed, the 1 in 15 pattern bears no relationship to the framing bit positions.

When any of the user words is transmitted without framing, the pattern is simply repeated.

9.2.9 Channel Words

9.2.9.1 General

The channel words are repeating 192 bit patterns that can be transmitted as the payload of a framed signal. By grouping in multiple octets, the word can appear to be a repeating 3, 4, 6, 8, 12, 16, 24, 32, 48, 64, 96, or 192 bit pattern. These words allow you complete control over the octet sent in any channel – you can set any bit in any channel to be a 1 or a 0.

If a channel word is transmitted as an unframed signal, a 1 is inserted every 193 bits. The HP 37741A cannot detect the presence of a received channel word pattern. Logic errors cannot be injected into a transmitted channel word.

If the HP 37741A is configured to transmit an FT1 signal, and you then send a channel word, the channel word is sent in all channels, not just those which are selected as active.

9.2.9.2 Programming the Channel Words

The channel word bit patterns cannot be viewed or programmed from the instrument's front panel. These functions are done by sending an external command over the serial port, as detailed in section 13.4.5.[1]

You can assign a name to a channel word when the word is programmed. The name can be up to 5 characters long (for example,

1 The external control software available as an accessory allows you to view, edit, and program the channel words and their names. This is listed in appendix D.

2 4 o c t or 5 i n 4 8), and is displayed on screens 2132, 2100, and 2700.

The channel words are saved as part of the pre-defined configurations,[1] and when recalled, overwrite the existing channel words. When the test set leaves the factory, two channel words are defined, and saved with the pre-defined configurations.

9.2.9.3 Timeslot Identification, T m S l t

This is a timeslot identification sequence, in that each channel has the PCM code of the timeslot number. Thus, timeslot one contains FE hex, timeslot two contains FD hex, and so on.[2]

This pattern can be used to verify correct alignment of timeslots through a multiplexer or DACS, or to check correct assembly of a path through a fractional T1 network. To do this, send a framed T m S l t pattern, start a test, and look at screen 5500 or 5501. Use [▲] and [▼] to move through the channels. The high and low values will be the same, and will indicate the transmitted timeslot number.

9.2.9.4 Low Density, L o D n s

This is a pattern that will generate the smallest number of pulse density violations when sent framed with AMI line coding.[3] There are no excess zeroes violations. The pattern has 23 ones in the 192 bits. Therefore, when the framing bit is a zero, there will be instances of 22 ones in 192 bits.[4]

The bit pattern is as follows. F represents the frame bit position; the bytes are given in hex values:

F, 08, 08, 04, 04, 04, 02, 02, 02, 01, 01, 01, 00, 80, 80, 80, 40, 40, 40, 20, 20, 20, 10, 10, 10

When the HP 37741A is configured to transmit this pattern unframed, a 1 is substituted for the F bit, so that there are 24 ones in 193 bits. This is not a violation of the density requirements.

1 This is described in section 5.2.
2 A table of PCM codes is given in appendix G.
3 This generates about 700 density violations per second with D4 framing, and about 500 per second with ESF framing, when using the HP 37741A as a measurement tool.
4 The pulse density violations will be detected only by a test instrument that has a sliding window for its density measurement, as specified in the ANSI standard.

9.3 Sequential Tests

9.3.1 General

The sequential tests are used to semi-automate testing of the span line. When started, the test set maintains the current frame format, line code, and channel parameters on the transmitted signal.[1] The test set then sequentially tests the line with each of the test patterns in the pre-defined suite.

When the test runs, the HP 37741A transmits the next test pattern in the sequence. It then waits until that pattern is being received, and restarts the test, with the test time fixed to that which you set. When that test stops (after the assigned duration), the instrument starts a continuous test, and changes the test pattern. The loop then repeats.

The design allows you to test a span line with two HP 37741As. One instrument is placed at each end of the line to be tested. One unit gathers results for the transmit path, and the other gathers results for the receive path. Because the design is robust, there is no need for synchronization between the start times of the tests on the instruments at each end of the link. In fact, you can set up the HP 37741A to run a sequential test, then travel to the other end of the link and set up the second unit. The results will be automatically gathered.

9.3.2 Error Accumulation

Errors are accumulated only during the times that the fixed test time is running. Similarly, the elapsed test time increments only during these times also, and this elapsed time is used to calculate the error rates. The time for which the test has been running is longer than this elapsed test time, because it includes synchronization time for each pattern on the sequence and for the code word (see section 9.3.3).

The results displayed in the five PATH results screens and the six LINE results screens are the aggregate results for the test. For example, the bipolar violation error count represents the sum of the BPVs received during the sequential test with all of the test patterns. If you have set the instrument to run more than one iteration of the sequence, errors received during the second and subsequent iterations are added to the totals.

1 It is therefore important that you set these parameters before running the special sequential test.

For each pattern in the test suite, the HP 37741A maintains a separate count of logic error counts, logic errored seconds, and logic synchronous seconds. When a sequential test is running, or has just ended, you can access the special test summary screen (5600).[1] This shows the error counts, and synchronous seconds for each of the patterns. When you initiate a printout of the results, the error counts, errored seconds, and synchronous seconds for each pattern are printed.[2]

The maximum displayed value for error counts is 999 999; the maximum displayed value for errored seconds or synchronous seconds is 999. When these numbers are reached, the number remains fixed, although the test continues to operate.

9.3.3 Code Words

At the start of the sequential test, and between patterns, a special code word is transmitted. This is used for compatibility with older style equipment.

The code words are as follows, where F indicates the frame bit position:

bridge tap	F 1111 1010
multipattern	F 1110 1110
user sequence	F 0101 0101 0101 0101 0101 010

These patterns are always recognized by the HP 37741A, but they are not available as standard patterns which you can transmit. If you set the user words to match these patterns, the sequential test may not work properly. When these patterns are received, the following are displayed for the received pattern:[3]

bridge tap	BrgTap
multipattern	MltPat
user sequence	UsrSeq

Unfortunately, the code word for the multipattern test is the same as the 4-bit loop down code. When this pattern is received, the HP 37741A initially displays MltPat as the received pattern. If the signal continues to be received for longer than two seconds, the

1 There may be two pages to this screen. This is described in section 4.5.
2 Sample printouts are shown in section 13.3.
3 These patterns are identified regardless of whether the instrument is running a sequential test or not.

instrument then changes the display to read 4 b i t ↓. The results screen showing the received loopcode always indicates that a 4-bit loopcode is being received.

The HP 37741A does not accumulate errors until the code word has been received at least once. After it has been received, the instrument expects to receive the next pattern in the sequence.

The transmitter usually sends the code word for 1.5 seconds before sending the next pattern in sequence. However, if the code word is received earlier than expected, the code word is sent for 0.6 seconds. This situation occurs when two instruments are being used, one at each end of a T1 circuit, and the test time on one instrument is faster than the test time on the other.

When there is a disruption to the received signal, the receiver of the HP 37741A automatically re-synchronizes to the pattern.

9.3.4 Test Time

For bridge tap and the standard multipattern test sequences, you can adjust the period for which each pattern is tested from the instrument's front panel. The times which are compatible with older style equipment are shown as defaults, but the instrument saves the selected time, and shows it the next time that test is run.

For the user programmable test sequences, the test time for each pattern is selected when the sequence is programmed. The times for which each pattern is tested may be different. That programming is done by a command over the serial port, and cannot be done from the instrument's front panel. Therefore, when you select a user programmable test sequence from the front panel, you cannot then control the test times.

9.3.5 Iteration Counter

Each time all of the patterns have been sent, the iteration counter (loop counter) is incremented. When the instrument has executed the number of loops that you programmed, the sequential test terminates. When two HP 37741As are being used, the instruments terminate the sequential test approximately simultaneously, so the results are unambiguous.

Older style equipment loops endlessly until stopped by the user, and this mode is also available on the HP 37741A. However, when you stop the sequential test, the test patterns may not have been tested for the same period, and errors might be recorded to the pattern which was being received when you stopped the sequential test.

9.3.6 Test Patterns Used in Bridge Tap

The bridge tap test is a special sequence of 21 pre-defined test patterns. The sequence comprises signals which are of various lengths and densities.

This special test is used to identify the presence of unwanted metallic connections to a span line. Such connections are usually the result of the metallic circuit having been previously used to provide service to a different location. When a service is disconnected and its line is re-used, a stub, or tap, may be left connected to the span line.

Depending on the position of the tap, and the length of the tap, the signal on the main line may be distorted because of reflections caused by the tap. Such distortions can result in bipolar violations and logic errors. Testing the span line with the standard suite of test patterns may not always indicate that a bridge tap is present.

The sequence of patterns used in the bridge tap is as follows, where F indicates the frame bit position. The frame bit position is stable only for patterns whose lengths are divisors of 192. For example, the 2 in 16 pattern repeats 12 times in a frame, but the 2 in 15 pattern has no fixed relationship to the frame bit position. In this case, the indicated sequence shows the alignment in the first frame containing the pattern.

This list also indicates the frequency of the repeating (unframed) signal is the frequency equivalent to that of an analog tone.

all 1	F 1	772 kHz
alt 1/0	F 01	386 kHz
1 in 4	F 0100	193 kHz
1 in 6	F 0100 00	129 kHz
1 in 7	F 0100 000	111 kHz
1 in 8	F 0100 0000	96 kHz
2 in 10	F 1100 0000 00	154 kHz
2 in 11	F 1100 0000 000	140 kHz

2 in 12	F 1100 0000 0000	129 kHz
2 in 13	F 1100 0000 0000 0	119 kHz
2 in 14	F 1100 0000 0000 00	110 kHz
2 in 15	F 1100 0000 0000 000	103 kHz
2 in 16	F 1100 0000 0000 0000	96 kHz
3 in 18	F 1101 0000 0000 0000 00	43 kHz
3 in 19	F 1100 1000 0000 0000 000	41 kHz
3 in 20	F 1100 0100 0000 0000 0000	39 kHz
3 in 21	F 0100 0100 0000 0000 0000 1	37 kHz
3 in 22	F 0100 0100 0000 0000 0000 10	35 kHz
3 in 23	F 0100 0100 0000 0000 0000 100	34 kHz
3 in 24	F 0100 0100 0000 0000 0000 0100	32 kHz
QRW	*see section 9.2.6.4*	

None of these signals has strings of excess zeroes, and none violates the pulse density requirements. You should set the line code to be AMI before running this test, because the B8ZS coding greatly reduces the effectiveness of the patterns.

From the payload selection screen (2132) you can select only some of these patterns, namely all ones, alternating 1/0, 1 in 8, 3 in 24, and QRW.

9.3.7 Test Patterns Used in Multipattern

This special test runs a limited number of patterns in sequence, and is used as a quick indication that the line is satisfactory. It provides no extra information that running the tests by themselves would not provide. It is, however, automatic.

The five patterns used are as follows, where again, F represents the F bit position:

all 1	F 1111 1111
1 in 8	F 0100 0000
2 in 8#	F 0100 1000
3 in 24	F 0100 0100 0000 0000 0000 0100
QRW	*see section 9.2.6.4*

The 2 in 8 pattern used in the multipattern sequence is not the standard one, which is selectable in screen 2132. It is therefore denoted on the screen of the HP 37741A as 2 i n 8 #. This pattern is used to provide compatibility with older style equipment.[1]

9.3.8 User Programmable Test Sequences

9.3.8.1 General

The HP 37741A has two user programmable test sequences. These allow you to select a sequence of patterns which will be sent. The instrument will provide logic error counts for the individual patterns which you selected, and an aggregate of the total errors received. You can select the patterns, their sequence, and the time for which each will be tested. The times can be all different for the patterns in the sequence.

The maximum number of patterns in a sequence is 21. The maximum test time for a pattern is 255 seconds. You can program the sequence externally, by a command over the instrument's serial port.

When the test set leaves the factory, the user sequences are defined, and saved in memory. They are not saved as part of the pre-defined configurations.

9.3.8.2 All Except 0

This sequence sends all of the selectable patterns, including the programmable user words, except the all zeroes pattern.[2] Each pattern is tested for 100 seconds.

The sequence is as follows:

all 1, alt 1/0, 1 in 8, 2 in 8, 3 in 24, user1, user2, user3, user4, $2^{11}-1$, $2^{15}-1$, $2^{20}-1$, $2^{23}-1$, QRW

9.3.8.3 All PRBS

This sequence sends all of the PRBS patterns. Each pattern is tested for 60 seconds. The sequence is as follows:

$2^{11}-1$, $2^{15}-1$, $2^{20}-1$, $2^{23}-1$, QRW

1 When shipped from the factory, the instrument has three different 2 in 8 patterns.

2 The all zeroes pattern is excluded so that it is safe to use this sequence with AMI or B8ZS encoding. The channel words are excluded so that the sequence can be used for fractional as well as full T1 modes.

9.3.9 Recommended Settings

You should always ensure that the instrument's transmitter is correctly configured before starting a sequential test. It is better to not leave any transmitter setting to as in. You should always ensure that an active channel is not being disturbed by a tone being inserted or signaling being modified. You should turn off any error injection.

A quick way to set the instrument to a known state is to use a predefined configuration, as described in section 5.2.

The bridge tap test should be run in full T1 mode, with AMI line coding. The test can be run framed or unframed. You may get better results running the test framed. This is because in unframed mode, any disturbances are repetitive, and therefore typically cause the pattern to either gain synchronization without errors, or to fail to synchronize. When framed, the framing bits break the repetitive nature of the errors, and therefore allow the instrument to gain pattern sync.

The other sequential tests can operate in full T1 mode or FT1 mode, with AMI or B8ZS coding.

9.4 Loopback Codes

9.4.1 General

A loopback code causes the far end equipment to return a signal to the sender, so that the sender can then verify the signal integrity. Loopbacks are used by carriers of the T1 signal and users of the transport medium as a maintenance tool to aid in fault location, error diagnostics, and problem resolution.

The capability to loopback a signal is built in to equipment normally resident at the end user's facility. The loopback can be activated manually (that is, with switches on the equipment) or electronically by sending unique codes in the DS1 signal to the far end equipment.

The HP 37741A can respond to loopback codes received in the DS1 signal. You can manually set a "pseudo-loopback" by configuring the transmitted signal to reproduce the received signal's line code, timing, framing, and payload. This does not emulate a mechanical switch because coding violations and framing errors are removed.

9.4.2 Line vs Path

Traditionally, loopbacks have been associated with the T1 line characteristics. A manual switch could have been used to return the signal to the sender. Loopbacks are treated as a line characteristic on the HP 37741A.

The payload loopback (see below) is strictly a path characteristic. It is, however, grouped with the other loopbacks in the HP 37741A for consistency.

9.4.3 Supported Loopbacks

Four different types of loopback schemes are supported by the HP 37741A. The HP 37741A can detect the presence of these codes, transmit the codes (with or without errors), and, if desired, automatically respond to any of the loopback commands.[1]

9.4.3.1 Line

This is resident in a CSU, typically owned by the end user. The DS1 signal received from the network is regenerated and transmitted back to the network. Timing for the transmitted signal is derived from the received signal. There is no change to the frame format, and BPVs are not removed. This is sometimes referred to as CSU loopback.[2]

9.4.3.2 4 bit

This is the forerunner of the network loopback described below. After initial deployment, it was displaced by the standard NI loopback. This is because of problems associated with the code. An NTE cannot guarantee to frame on a D4 signal sending a 4 bit loopcode. If it does frame, it may recognize the code as sending a yellow alarm.

This code is the same as that used for the code word of the standard multipattern test, and can lead to confusion.[3]

You should therefore use this code with caution.

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1 Response to line loopback is sometimes referred to as CSU emulation. This is ambiguous terminology because modern CSUs also respond to payload loopback.

2 Use of the term CSU loopback is confusing, and is avoided in this document, because the actual type of loopback is not specified.

3 See section 9.3.2 for details.

9.4.3.3 Network (NI)

This is resident in the NI connector (smart-jack), and should be used only by the local T1 carrier. As with line loopback the signal is regenerated, but there is no change to the frame format, and BPVs are not removed. Timing for the transmitted signal is derived from the received signal.

9.4.3.4 Payload

Again resident in a CSU or CPE, but available only with ESF or ZBTSI frame formats. The payload of the received signal is transmitted back to the network. Therefore, any logic errors received by the HP 37741A are returned to the sender. Timing for the transmitted signal is derived from the received signal.

The framing bits are recreated, and are therefore new and error free. The FDL is set to the idle code. However, if you have enabled CRC errors (screen 2152), these will continue to be created by the instrument.

There are no BPVs on the looped back signal.

9.4.4 Loop Codes: In-Band and Out-of-Band

The loopback commands are in-band (that is, they use the payload space) for SF type frame formats, and out-of-band (that is, they use the FDL) for ESF type frame formats. The codes used are indicated in figure 9-2. Separate codes exist to activate the loop (loop-up), and deactivate the loop (loop-down).[1]

Loopback Type	Activate		Deactivate	
	In-Band	Out-of-Band	In-Band	Out-of-Band
Line	10000	0000 1110	100	0011 1000
4 bit	1100	0001 0010	1110	0010 0100
Network, NI	11000	0001 0010	11100	0010 0100
Payload	n/a	0001 0100	n/a	0011 0010

Figure 9-2 Supported Loopback Codes

1 Equipment exists in service that may prevent the in-band line loopback deactivate command from reaching its destination. In such cases, the loopback will need to be de-activated manually.

In figure 9-2, only eight bits of the out-of-band loop code are shown. These bits are sent as a BOP message in the FDL, and alternate with eight ones. The eight ones are transmitted as a synchronization byte.

In the case of in-band codes, the transmitted signal comprises the entire payload of the signal, overwriting whatever signal was there before. The signal may be framed or unframed. When framed, the framing bits overwrite the loopback code.[1] The HP 37741A transmits in-band codes when the signal is unframed or framed. The in-band codes are recognized, and can be acted upon, irrespective of the received signal frame format.

In the case of codes used with ESF type framing (ESF or ZBTSI), the code is transmitted in the FDL (out-of-band) ***in addition to*** transmitting the in-band signal in the payload. As with in-band codes, the out-of-band message normally overwrites any message currently being transmitted in the FDL.

There is not an equivalent in-band code for a payload loopback. When a payload loopback is sent, the in-band signal is not disturbed.

When the 4 bit loop code is sent with ESF framing, the NI loop code is sent in the FDL.

9.4.5 Full T1 and Fractional T1

Regardless of whether the transmitter is configured to transmit a signal in full T1 or FT1 mode, an in-band loop code is always transmitted in full T1 mode. If the transmit mode was configured for FT1, that mode is restored after the loop code has been sent.

If you have specifically configured the receiver to an FT1 mode, the instrument will not recognize a received in-band loop code. This is because the instrument looks at the specified channels, and the loop code fills all channels. To recognize a loop code, you must therefore set the instrument to `full T1` or `auto` on screen 2205.

9.4.6 Loopback Response Times

Network equipment must respond to an in-band loopback code only after it has been continuously received for no less than five seconds. The HP 37441A will detect the presence of the pattern within 500 ms. If

1 This is not the same as the transmission of test signals, where the framing bits are merged into the bit sequence, without overwriting any bits.

the test set is configured to emulate a piece of network equipment (and therefore respond to the loopback commands), it will do so only after the signal has been present for five seconds.

An out-of-band code transmitted in the FDL may be acted on by a piece of network equipment when it has been repeated no less than 10 times. This equates to a response time of 40 ms for ESF, and 80 ms for ZBTSI. Equipment typically responds when the pattern is received for about one second. The HP 37741A recognizes the codes after 10 sequences have been received, and will respond immediately.

The HP 37741A can send any loop code either continuously or timed. When timed, the codes (in-band and out-of-band) are transmitted for between 7 and 8 seconds. At the end of that period, the signal reverts to that previously transmitted.

When the instrument receives a loopback command, it displays it on the loopbacks screen (4300). This is displayed for as long as the code is received. If a device sends an FDL code for only a short time, this may be displayed on the screen for a brief moment, or not be displayed at all. This will not affect whether the instrument responds to the loopback command.

9.4.7 Response to Different Loopbacks

Regardless of what type of transmit loopback has been configured, when the instrument is set to auto respond to loopback commands, it will do so whatever loopback command is received. For example, if the transmitter is configured for NI loopbacks, and the receiver is set to auto respond, the HP 37741A will respond to a received line loopback command.

When the instrument has responded to one type of loopback (that is, the instrument is itself looped), it will respond to a new loop up command. Suppose, for example, the instrument is receiving an ESF signal, and is currently payload looped. If the instrument now receives a line loop up command it will respond, and become line looped.

When the instrument is looped, the loop can be dropped only by the correct type of loop down command. For example, if the instrument is line looped, and it receives an NI loop down, it will recognize the command but will not respond to it.

The instrument will not respond to a received loopcode if any of the following is true:

- it is set to not respond
- it is transmitting a loopcode
- it is configured to frame to one frame format type, and the loopcode is carried by a different frame format type

9.4.8 Unloop

When you choose unloop from screen 2220, the loop is dropped irrespective of its type, or of the transmit configuration. You can also unloop the HP 37741A by setting the instrument to the factory default setting.[1]

9.4.9 Transmitting and Receiving Loop Codes

When the HP 37741A is transmitting a loop code, it will not respond to a loopback command. This applies regardless of the loop code types, or of the instrument configuration. This prevents an instrument from entering an endless loop, if there is a direct connection between the transmitter and receiver.

When an instrument is looped, the transmit configuration cannot be altered.[2] In this case, the loop icon is displayed, to alert you to the fact that the test set is looped.

When the instrument is sending a tone, and you command it to send a loopcode, transmission of the tone is suspended. However, any signaling which you had previously configured will continue to be sent.

When the instrument is looped, the transmission of logic errors or BPVs generated by the HP 37741A is suspended. Depending on the received signal, and the type of loopback, these errors may be seen at the unit's output.

9.4.10 Determination of Far End Status

When a loop up command is issued, the HP 37741A looks at the returned payload to determine whether the loop up was successful.

1 See section 5.2 for complete details.
2 It cannot be altered from the front panel, but can be altered over the serial port.

When sending line, 4 bit, or NI loop up codes, the test set sends the loopback code in the payload regardless of the frame format. The test set checks whether the code is being returned. If it is, it declares that the far end device is looped. If the code is not returned after six seconds, the test set declares that the loop up was unsuccessful.

The converse is true when sending a loop down command. When the test set no longer gets the loop code returned from the far end device, it declares that the loop down was successful. If it still receives the loop down code after six seconds, it declares that the loop down was unsuccessful.

When the HP 37741A sends a payload loop code, it uses a similar algorithm. Because the payload is not disturbed, it checks whether the received payload matches the transmitted payload, and displays the far end status as described above. If the received payload is not recognized, the instrument does not indicate the status of the far end.[1]

9.4.11 Recommended Instrument Settings

When you are activating a loop on a remote device, you should take care to set the HP 37741A correctly. The quickest way to do this is to use a pre-configured setting. You should define the transmitted payload and frame format, and not leave them set to "as in".

You should time the instrument's transmitter from the internal clock, or from the reference input if there is an independent signal there. If it is timed from the main input (loop timed), the timing will get into an endless loop. The frequency of the key beep rises to inform you of this condition.

With ESF, ZBTSI, and SLC-96 frame formats, you should ensure that the data link is set to transmit the default, and is not in through mode. If it is in through mode, it will get into an endless loop. For ESF and ZBTSI, this will circulate the loopcode continuously, regardless of the setting. For SLC-96, the receiver may periodically misframe.

1 The HP 37741A cannot recognize the channel word patterns.

9.5 As Input and Through Modes

9.5.1 General

There are two main uses of these modes:

- to simplify instrument configuration
- to be able to pass a DS1 signal through the instrument

Instrument setup is simplified by setting the transmitted signal to be the same as the input signal (as in). When the receive side of the test set is connected to a DS1 circuit, the transmit side is automatically adjusted to have the same frame format, line code, and payload.[1]

If the test set is in series with the T1 line, it is normally essential that the transmitted signal replicate that received. You can then modify some parameters to test various aspects of the circuit.

In either case, the transmitted frame format will be that which you have previously configured. Therefore, a pattern can have framing added, removed, or changed, depending on the settings, and the transmitted signal will not then be identical to that received.[2]

When there is no signal at the input, or there are other problems with the received signal, the transmitted payload is modified. This is discussed in section 11.5.

9.5.2 As Input

There are different settings to select the payload to be as input, and the loop codes to be as input. When set, if a pattern is received which the HP 37741A recognizes, the test set will transmit an error free version of that pattern.[3] If the test set does not recognize the signal in the received payload, it will retransmit the received payload (switch to through mode).

You can block loopcodes from passing through the test set (to prevent unknown side effects) by setting the payload to be as input, and not setting the loopcode to be as input. Now, when the test set receives an in-band loopcode, it will continue to transmit the previous pattern, or

1 Each of these has a different setting. This section deals only with the payload. See section 8.7 regarding frame format as in mode, and 10.5 regarding line code as in mode.

2 This may cause frame slips. This subject is dealt with in sections 8.7 and 10.2.

3 The transmitted pattern is not necessarily synchronized to the received pattern.

a QRW if it could not recognize that pattern. Examples of this are shown in figure 9-3.

The figure shows the four possible combinations of payload and loop-code as in. On the left is shown a sequence of input signals, and on the right is shown the corresponding output signals.

9.5.3 Through Mode

When this mode is selected, the received payload is always retransmitted. This is true regardless of the payload, be it a test pattern (error free or errored), or a loopcode, or an unrecognized signal (such as speech).

You need to set independently whether you want signaling preserved in the output signal. This is discussed in section 12.4.4.

Sometimes, when the HP 37741A is set for as input, it will identify a signal as a test pattern erroneously. For example, if you have a channel bank, in which nearly all channels are idle, the signal might be recognized as a framed all ones (with errors). When the payload is set to "as in", the instrument would set the output to framed all ones. Information in the DS1 signal (for example signaling bits) would not then be passed through.

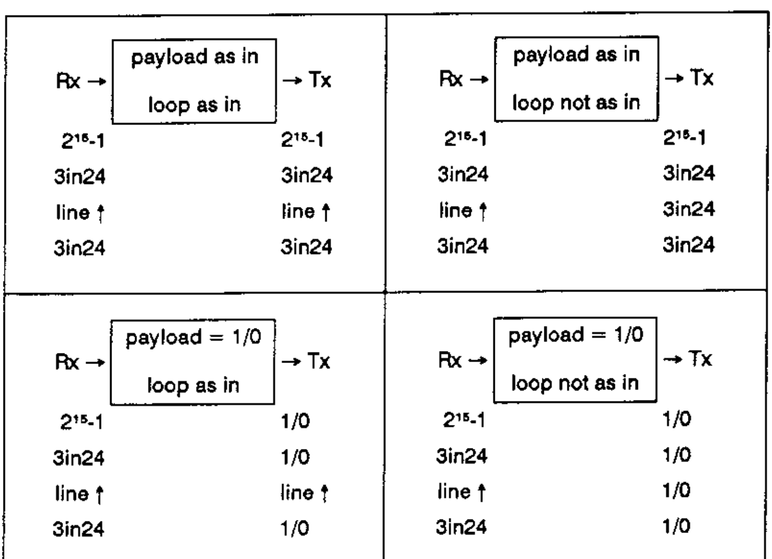


Figure 9-3 Examples of Payload As In and Loop Code As In

9.6 Error Analysis, Logic Errors and G.821

9.6.1 General

The HP 37741A can perform error analysis when receiving any of the test signals described in Section 9.2. A single bit logic error occurs when a received bit (excluding frame bits, if the signal is framed) does not match that which is expected for the pattern. When a LOS or AIS is declared by the test set, the accumulation of logic errors is inhibited.[1]

Besides standard logic error analysis, the instrument provides G.821 analysis, as described below. If an unrecognized pattern is received, no analysis can be performed.

A one second period (derived from the instrument's real time clock) is used as a time base for analysis of all logic errors. This one second period is synchronous for all result measurement activities and alarm detection functions, but is not necessarily synchronized to any external event (such as loss of signal).

9.6.2 In-Band Loop Codes

When an in-band loop code is received, the HP 37741A treats it similarly to a test pattern, and will accumulate bit errors on the signal.[2] With most signal generators (including the HP 37741A), the framing bits overwrite the bit pattern – these bits will be seen as errors.

If the loopcode pattern is received unframed, no errors will be accumulated on an error free signal.

9.6.3 Bandwidth

The bandwidth of a received pattern (indicated in kb/s) is defined as:

$$\text{bandwidth} = \text{number of channels used by the pattern} \times \text{rate of each channel}$$

The rate of each channel is either 56 kb/s or 64 kb/s. When full T1 mode is selected, all 24 channels are used and the rate is 64 kb/s, so the bandwidth is 1536 kb/s. The maximum bandwidth for a test pattern is achieved with an unframed signal (1544 kb/s).

1 LOS and AIS alarm conditions are discussed in section 11.

2 Normally, this will also restart the test when the loop code is received, and again restart the test when the loop code ceases to be received (see section 9.1).

9.6.4 Error Count, EC

This is a count of total bit errors received during the test. The maximum number that can be accumulated is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change.

A full T1 signal having a continuous error rate of 10^{-3} will reach this maximum value after 108 minutes of testing. An average error rate of 10^{-6} (about 1½ errors per second) will reach the maximum after 75 days of testing.

9.6.5 Errored Seconds, ES

This is a count of the number of seconds during which there was no alarm, and in which there was at least one logic error. Because the one second interval is not necessarily related to the occurrence of the errors, this value is sometimes referred to as asynchronous errored seconds.

The maximum count on the HP 37741A is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. If errors are continuously being received, this number is reached after 115 days.

9.6.6 Error Free Seconds, EFS

This is a count of the number of seconds during which there was no alarm, and in which pattern synchronization was maintained, and in which no errors were received.

The maximum count on the HP 37741A is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. If no errors are being received, this number is reached after 115 days.

9.6.7 Percent Error Free Seconds, %EFS

The sum of errored seconds, error free seconds, and alarm seconds equals the currently elapsed test time:

$$\text{Elapsed test time} = \text{ES} + \text{EFS} + \text{alarm seconds}$$

An alarm second, as used in this context, is one in which there was either a pattern loss, signal loss, or an AIS. The percent error free seconds is the ratio of EFS to elapsed test time excluding alarm seconds:

$$\%EFS = \frac{EFS}{ES + EFS} \times 100$$

This number can be anywhere from 0 to 100.

9.6.8 Bit Error Rate, BER

This is the ratio of the errors received during errored seconds to the total number of bits received, excluding any alarm time. It is displayed in a floating point format with limits of 9.0×10^{-3} to 1.0×10^{-12}. In practice, however, a DS1 signal is useless at a rate of 9.0×10^{-3}, and is a very good circuit at 1.0×10^{-9}.

0 is displayed when there have been no errors.

9.6.9 Unavailable Seconds, UAS

This is a count of the number of seconds during which the DS1 path is considered unavailable.

A period of unavailable time begins when the BER in each second is worse than 1×10^{-3} for ten consecutive seconds. These ten seconds are considered to be unavailable time. The period of unavailable time terminates when the BER in each second is better than 1×10^{-3} for ten seconds. These ten seconds are considered to be available time.[1]

When the error rate is high, pattern synchronization may be lost. Pattern synchronization will also be lost when an LOS, AIS, or LOF is detected. Therefore such periods are included in the calculation of unavailable time.

Unlike errored seconds and error free seconds, the sum of unavailable seconds and available seconds always equals the total elapsed test time:

$$\text{Elapsed test time} = UAS + AS$$

Because a sliding time window is used to perform these calculations, you might notice the displayed number jump in increments of 10. The maximum count on the HP 37741A is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. If errors are continuously being received, this number is reached after 115 days.

1 CCITT recommendation G.821, Annex A.

9.6.10 Severely Errored Seconds, SES

This is a count of the number of seconds ***during available time*** in which error rate is worse than 1×10^{-3}.

Since the transition from available time to unavailable time (and vice versa) is based on a ten second sliding window, the count of SES may also jump by a count of 9. This is because the nine seconds preceding a declaration of unavailable time are included in the count of SES.

On the tenth second, 10 is added to the count of UAS, and 9 is subtracted from the count of SES.

The maximum count on the HP 37741A is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. It will always take at least 128 days to reach this count.[1]

9.6.11 Consecutive Severely Errored Seconds, CSES

This is a count of the number of occurrences of three to nine consecutive severely errored seconds. If there are ten or more consecutive severely errored seconds, the circuit is considered to be unavailable, and therefore does not increment this count.

The maximum count on the HP 37741A is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. It will always take at least 460 days to reach this count.

9.6.12 Percent Severely Errored Seconds, %SES

This is the ratio of SES to currently elapsed test time:

$$\%SES = \frac{SES}{\text{elapsed time}} \times 100$$

The number can be anywhere from 0 to 100.

1 The observant reader will note that this is different from the time for errored seconds.

9.6.13 Percent Available Time, %avl

This is the ratio of available time to currently elapsed test time:

$$\%avl = \frac{\text{available time}}{\text{elapsed time}} \times 100$$

This number can be anywhere from 0 to 100.

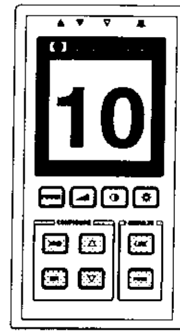
9.6.14 Degraded Minutes, DM

This is a count of the number of 60 second intervals having a bit error rate better than 1×10^{-3} and worse than 1×10^{-6} during available time.

The time interval is derived by excluding periods of unavailable time and severely errored seconds from the total time, then consecutively grouping remaining time into blocks of 60 seconds. The average BER is calculated for the block, and if worse than 1×10^{-6} the time interval is counted as a degraded minute.

The maximum count on the HP 37741A is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. If (low rate) errors are continuously being received, this number is reached after 19 years.

Line Capabilities



10.1 General

The term "line" refers to properties associated with the transmission medium, as opposed to the data content or structure of the signal. The T1 signal voltage and frequency are line properties. Signal characteristics such as line coding and pulse density are also line properties, because the ability to extract a clock is essential to signal transmission.

The HP 37741A can measure the voltage and frequency of the main T1 input. The instrument can also detect a frequency variation between the main input and the reference input (timing slips). It can also detect and accumulate BPVs, automatically recognizing and discounting deliberate BPVs introduced as a result of B8ZS encoding.

As an aid to the diagnosis of problems on special services circuits, the HP 37741A can detect and accumulate both density violations and excess zeroes violations.

The transmitted signal is always at 0 dBdsx; the line coding (AMI or B8ZS) can be the same as, or different from, that of the input signal. Timing for the transmitted signal can be derived from an internal crystal, or from either of the T1 inputs.

The electronic circuits on the main T1 input and the reference T1 input are identical. Unless otherwise indicated, specifications outlined in this section apply to either input. The termination setting affects both inputs identically.

10.2 Timing

If the received signal meets normal pulse density requirements, a clock is recovered from the signal and is used to process the data. If a reference input signal is present, a clock is recovered from it too. These clocks, and an internally generated clock, are used to process the received data, and to generate the transmit signal.

10.2.1 Timing Recovery

When a QRW test signal is being received without jitter, the HP 37741A can recover the clock from a T1 signal with a bit rate of 1.544 Mb/s ± 1004 b/s (650 ppm). Signals that have a lower ones density, or which have appreciable jitter will reduce the recovery frequency range.

In the absence of jitter, the test set can recover clock from any of the test signals that it is capable of generating (except for the all zeroes pattern) over a range of 1.544 Mb/s ± 502 b/s (325 ppm).

If the clock recovered from one of the inputs is configured to be used for the output timing, and the signal on that input is not present (LOS), the HP 37741A will substitute its internal clock to generate the output signal. The test set will revert to using timing derived from the input signal when that signal has been present for at least one second.

10.2.2 Jitter Tolerance

Jitter is a modulation of the carrier frequency, caused by variations in timing references, signal path lengths and delays, and by intermediate equipment in the signal path.

The HP 37741A can accommodate the jitter shown in figure 10-1. The relationship of this jitter to key specifications is also shown in the figure. As can be seen, the instrument exceeds the requirements of terminal equipment.

Some of the measurements made by the HP 37741A are accurate only when the received signal falls within the range of jitter accommodation shown in figure 10-1.

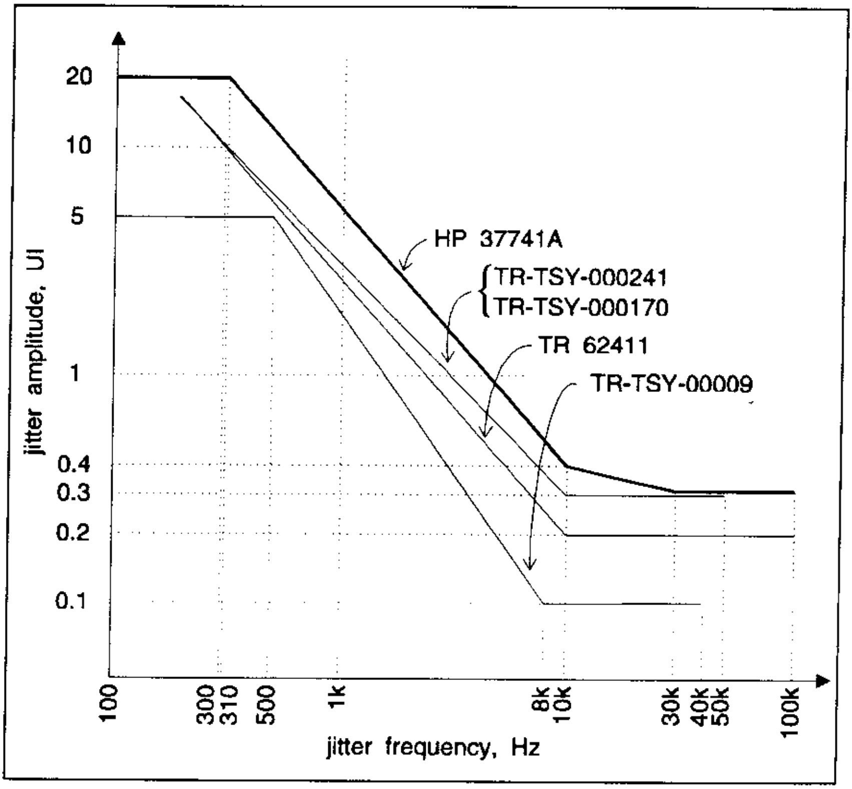


Figure 10-1 Input Jitter Tolerance

10.2.3 Receive Frequency Measurement

The frequency of the clock recovered from the main input signal is measured. The frequency must be approximately at the nominal DS1 rate if accuracy is required. For frequencies of 1.544 MHz ± 502 Hz (325 ppm), the frequency is measured to an accuracy of ± 10 Hz (6 ppm). The resolution is 1 Hz.

The stability over time of the frequency measurement is governed by the real time clock.[1] The frequency measurement is calibrated when the instrument leaves the factory.

The frequency is automatically measured – no intervention is required from the user. The measurement of frequency is integrated over time, and is slew rate limited. Therefore, you should wait 10 seconds after connecting a signal before recording the measured value.

1 The real time clock is discussed in section 14.5.

10.2.4 Transmit Frequency

The timing for the transmit T1 signal can be derived from either of the T1 inputs, or from the instrument's internal crystal.[1]

You would normally select the clock recovered from the main input when at a remote terminal unit, so that timing received from the central office is used for the signal returned to the CO. This timing method is sometimes referred to as loop timing.

A common use for the clock recovered from the reference input is when you are at the CO, and want to ensure that the timing for signals that you are generating is very accurate. In this case, connect the BITS to the reference input.

When either of the input signals is used to derive the timing, jitter is not attenuated from the recovered clock. The transmitted jitter will equal the received jitter plus a small amount introduced by quantization noise.

The crystal internal to the HP 37741A can be used to generate the timing for the transmitted signal. The accuracy of this clock depends on the operating temperature of the instrument as follows:

Temperature	Accuracy	
°C	Hz	ppm
20 to 30	±30	±19
0 to 40	±46	±30
0 to 50	±70	±45

Figure 10-2 Frequency Accuracy

10.2.5 Bit Slips: Network Objectives

The DS1 network is a digital network and relies upon the ability to recover a clock from a received signal. Digital switches and multiplexers are extensively used to connect various DS1 signals. When two DS1 signals that are being connected have exactly the same frequency, this cross connection can be accomplished without complication.

When the basic frequencies differ, or either input has jitter, there may eventually be more bits coming in than are going out (or vice versa).

1 When the timing is derived from either of the two T1 inputs, the signal level should be greater than −6 dBdsx.

The differences between the two frequencies are measured by the HP 37741A as bit slips.

To accommodate different receive and transmit frequencies, a piece of terminal equipment usually has a buffer that is used to hold the data temporarily. This buffer is small in some cases (16 bits), but for a typical DACS is usually 193 bits. The size of the buffer is not limited by the available technology, but by the amount of time delay that is introduced by the buffer in the signal path.

If the buffer is large enough, short term differences between the two signals can be accommodated provided the average frequencies of the two signals are identical. However, long term variations will result in the buffer either overflowing or depleting. If the buffer overflows, data will be lost. If the buffer becomes empty, the terminal equipment will repeat data previously transmitted. An occurrence of this action is called a frame slip.[1] Frame slip occurrences are not in themselves detected by the HP 37741A, but the bit slips that lead up to the frame slip are detected.[2]

Frame slips are audible on a speech circuit as faint clicks. On a circuit carrying data, frame slips will reduce the throughput. In either case the slips are undesirable. For end user equipment, the general solution is to loop time the terminal equipment. Thus, at the central office, the average frequency of the received data will equal that transmitted.

For other equipment, a hierarchy of highly stable frequency sources is used to ensure that equipment operates at approximately the same frequency. Multiple, highly accurate (1×10^{-11}) clocks are used. Because a single clock is not used, the network is called plesiochronous (instead of synchronous).

10.2.6 Slip Detection

10.2.6.1 General

Frequency deviations between the main input and a reference signal can be measured by the HP 37741A. The test set records the whole number of bit slips and accumulates these to estimate frame slips. In

1 When the number of bits repeated or lost is equal to 193, and the framing bits are not disturbed, this is referred to as a controlled frame slip. When the number of bits repeated or lost is not equal to 193, this is referred to as an uncontrolled frame slip.

2 Contact your nearest HP sales office for a list of HP test instruments that do detect frame slips.

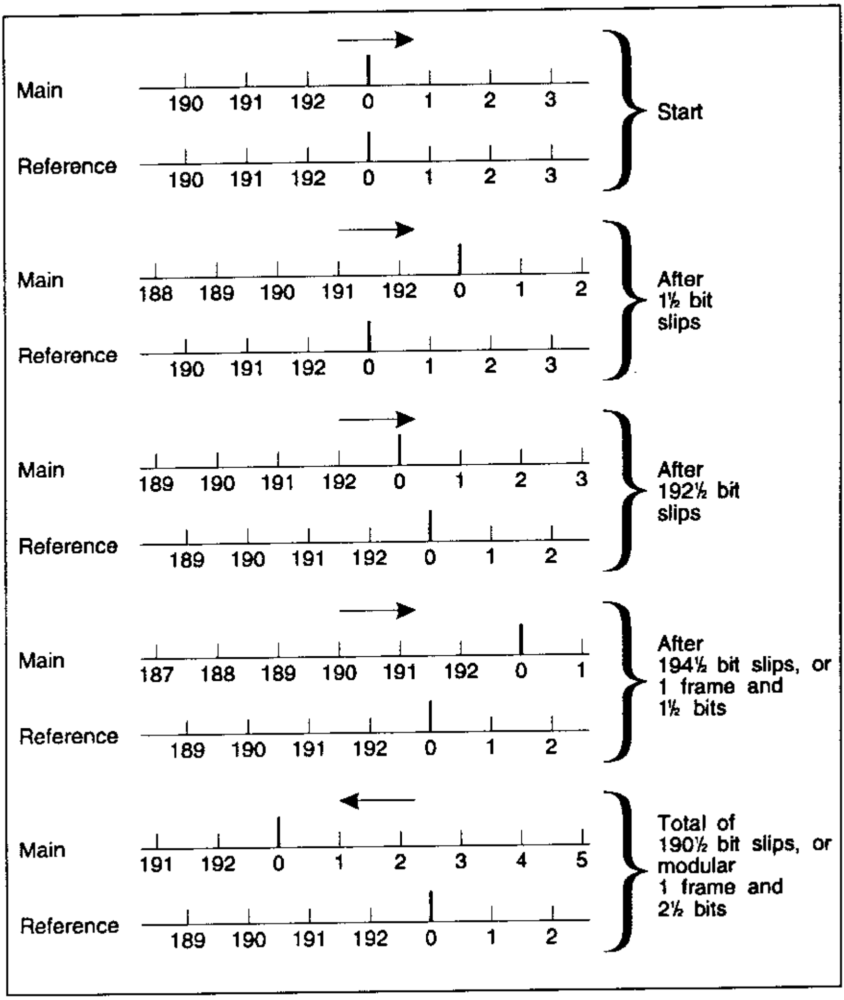


Figure 10-3 Example of Slips

this case, a frame is considered to be a block of 193 bits. This applies irrespective of whether either or both input signals are framed. When the signal is framed, the 193 bit block is not necessarily aligned with the framing bits.

The slips are indicated in accordance with two methods. The first calculates the difference between the total number of bits received on the main input and on the reference input, since the start of the test. The second method assumes that a slip of 193 bits is non recoverable, and indicates bit slips in relation to the most recent period of slippage of 193 bits. These are depicted in figure 10-3.

Imagine a signal received on the main input that has a frequency faster than the reference input signal. At the start of the test, no slips have occurred, and the counters are set to 0. As the test progresses, the unit will show one bit slip, then two, and so on until there have been 192½ bit slips. After two more bit slips, there has been one entire frame slip plus 1½ bit slips.

Suppose now, that the received signal becomes slower than the reference signal, so that there are four more bit slips, but this time in the opposite direction.

There are two methods of indicating the total number of slips. In the first, the bit counter retains no history that the signal had in the past exceeded a frame (or multiple frame) count. This method results in a display of the total accumulated bits slipped as 190½.

Using the second method, which has reset the bit counter as soon as the bit slips exceeded 193, the HP 37741A displays that there has been 1 frame slip, and 2½ bit slips.

The count of total bit slips on screen 4200 uses a semicolon to separate the frame slips from the bit slips. A + or − sign preceding the numbers indicates which of the two signals is faster. The sign is positive if, during the elapsed time of the test, the main input signal has on average been faster than the reference input signal. The sign is negative if the main input has been slower than the reference.

On the count of slips relative to the last frame slip, the word `fast` indicates that the frequency of the main input is currently faster than the frequency of the reference input. The word `slow` indicates that the frequency of the main input is currently slower than the frequency of the reference input. The word `sync` indicates that the frequencies of the two inputs are currently the same.

As illustrated by the example above, the two slip values will not necessarily be the same. If the test was stopped at the time of the last picture in figure 10-3, the screen on the HP 37741A would be:

```
4200
LINE 3/5        ✋
   BIT SLIPS
Total    +0;190
CurDir     slow
Est. frame
  slips       1
Relative bit
  slips       2
```

10.2.6.2 Maximum Counts

The maximum number of total frame slips is +99; the minimum number is −99. When these limits are exceeded, the HP 37741A displays >MIN and <MIN respectively. The maximum number of estimated frame slips is 250. When this limit is exceeded, the test set shows >250. In each case, the bit slips counter, and the current direction indication, continue to function.

10.2.6.3 Maximum Frequency Differences

The HP 37741A can detect a maximum of 5 bit slips in three milliseconds, or an average slip rate of 1700 bit slips per second. This corresponds to a difference between the two clocks of 1000 ppm.

10.3 Receiver AC and DC Characteristics

10.3.1 Terminate

When you choose to terminate the inputs of the HP 37741A, the impedance of both T1 inputs on the test set equals 100 Ω ± 10 Ω.[1] This should be selected when there exists no other termination on the T1 line. If multiple terminations exist, the signal may be distorted to the point where errors are introduced. You should therefore ensure that no other termination exists before selecting this option.

The 100 Ω termination is designed to match the characteristic impedance of the T1 cable, and as such results in minimal reflections on PIC and ICOT cables, which represent the bulk of the lines in service. Some older T1 systems used MAT cabling, with a characteristic

1 This is the ac impedance measured at 772 kHz.

impedance of 120 Ω. In such cases, some reflections might occur when terminating in 100 Ω.

10.3.2 Bridge

When bridged, the HP 37741A presents a high impedance on both T1 inputs. This impedance is more than 1000 Ω, and is designed to cause minimal disturbance to a signal that is already terminated elsewhere.

Because the test set does not terminate the line, the cable between the actual T1 line and the test instrument should be short – less than 3 m (10 ft). If the line is too long, reflections will occur, which may disturb the signal on the T1 line. Where possible, you should use the cable supplied with the unit to prevent this from happening.

It makes little difference whether the characteristic line impedance is 100 Ω or 120 Ω when bridging to the line.

10.3.3 Monitor

A monitor point on a piece of equipment has two resistors, each of nominally 450 Ω, between the T1 line and the monitor jack. The monitor jack is provided primarily for testing purposes.

Traditionally, test instruments have presented a termination impedance of 100 Ω when connected in monitor mode. Then, the total impedance presented across the T1 line is 1000 Ω, and therefore has negligible effect on the T1 signal. The voltage seen at the input to the instrument is one tenth of, or at −20 dB with respect to, the signal on the T1 line.

When the inputs of the HP 37741A are configured in monitor mode, both inputs present a high input impedance (more than 1000 Ω) to the T1 lines. The instrument expects that there is an external resistance of nominally 900 Ω in the monitor path, and will calculate the signal level on the T1 line based upon this assumption.

Some manufacturers of terminal equipment have used a resistor value that is not exactly equal to 450 Ω. Equipment exists in service that has resistors of between 430 Ω and 460 Ω. Because of this, the HP 37741A is calibrated at the factory assuming external resistors of 442 Ω. The various values used will introduce a slight voltage level measurement inaccuracy when the test set is in monitor mode.

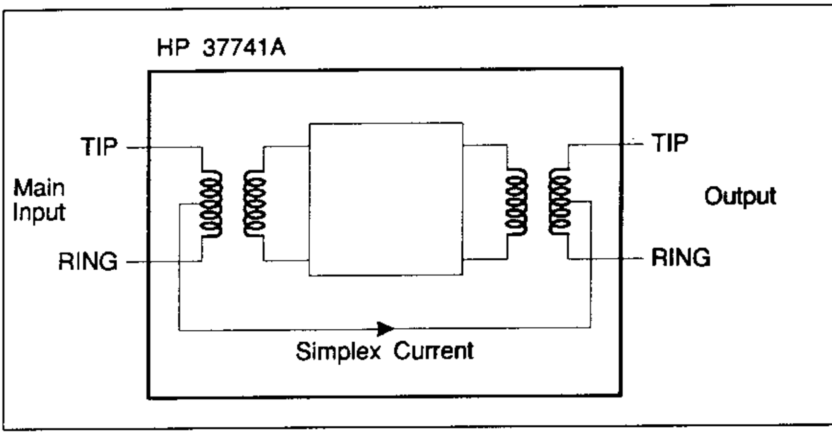


Figure 10-4 Simplex Current Arrangement

The high impedance presented by the HP 37741A when in monitor mode precludes the use of long cables to connect the test set to the monitor jack. This was discussed in the section on bridging above. Again, whenever possible, use the cables supplied with the unit.

10.3.4 Simplex Current

Simplex current is the dc current that flows from the receive side of a repeater to the transmit side of the repeater. Its purpose is to provide power to one or more repeaters positioned along the span line. This current may be reversed for testing purposes. The term "simplex" is used because only one side of the current flow path is available.

WARNING

The simplex current may be generated by a voltage of 135 V dc. This voltage can kill you. Ensure that repeater power is turned off when connecting the HP 37741A to a span powered T1 line.

No power is applied to T1 lines at the DSX bay, intra-building equipment, or multiplexers.

The HP 37741A can pass simplex current and measure it. The path of the current flow within the instrument is shown in figure 10-4. When measuring the current, the test set does not indicate the direction of the current flow.

CAUTION

If you incorrectly connect the HP 37741A to a span powered T1 line, you may damage the instrument. Ensure that the connections are correct before restoring the repeater power.

When calibrated, the instrument meets the following specifications:

Current direction	either Rx to Tx or Tx to Rx, not indicated
Measurable current	5 mA to 200 mA[1]
Voltage drop @ 60 mA	8.0 V ± 15%
Voltage drop @ 130 mA	9.5 V ± 15%
Accuracy, 50 to 175 mA	± 5%
Accuracy <50 mA	± 15%
Accuracy >175 mA	± 15%
Resolution	1 mA

10.3.5 DC Paths

There exists a dc path between the main T1 input and the T1 output; this is used to measure simplex current, and was discussed in section 10.3.4. The reference T1 input is electrically isolated from the other two T1 connections.

All the T1 connections are isolated from the instrument electronics and from the sleeve – detailed specifications are given in section 15. The three sleeves are connected together and also to the shield of the DB9 serial port connector.

IMPORTANT

When inserting or removing a bantam cable into a bantam socket, the ring is temporarily shorted to the sleeve of the connector. If repeater power is present, and another bantam cable is already connected, the repeater power is then shorted to protective ground. This may damage the upstream repeater, and remove power from downstream repeaters.

1 An internal fuse may blow if the current exceeds 250 mA.

A dc path exists between the tip and ring of each T1 line. On the main input, and on the output, this ensures that the simplex current is correctly passed. This symmetric dc path on all connections helps to ensure that the HP 37741A does not present an imbalance to the T1 circuit being tested.

CAUTION

Ensure that no dc voltage is placed across tip and ring. Otherwise, the test set may be damaged and results may be erroneous.

Circuitry exists within the HP 37741A to protect against voltage or current surges that may be encountered in normal use. Abnormal surges (for example, lightning strikes) may damage the test set.

10.3.6 Power Off

The ac and dc characteristics are maintained when the instrument is powered off.

The impedance presented to the line on power off still reflects the last configuration of the port as bridge, terminate, or monitor. The impedance may differ by no more than 10% from the power on impedance. However, the HP 37741A introduces no glitches or hits to the T1 line when the instrument power is removed.

When power is restored, the impedance presented to the line is still unchanged. The HP 37741A introduces no glitches or hits to the T1 line when the instrument power is restored.

Simplex current can still flow when the instrument power is off. The current is not disturbed when power is turned off or on, and the voltage drop across the HP 37741A is the same in either case.

The dc paths between tip and ring, and between the input sleeves, are unaffected by the state of the power.

10.4 Signal Amplitude

10.4.1 The DSX Reference

The DS1 signal amplitude is referenced to the level it should have at the cross connect. The nominal amplitude is 6.0 Vpp, and is referred to as 0 dBdsx. A picture of an ideal 0 dBdsx signal is shown in figure 16-3.

10.4.2 Receive Amplitude and LBO

When a T1 signal is passed through a cable the signal is reduced in amplitude, and is distorted. This distortion happens because higher frequency components of the transmitted signal are attenuated more than lower frequency components.

Based on the amplitude of the signal that the HP 37741A receives, the test set compensates for the expected distortion. The test set can therefore receive T1 signals that have passed through various lengths of cables. This compensation is referred to as line build out (LBO). Because the input signal compensation requires no action on the user's part, it is sometimes referred to as automatic line build out (ALBO).

At a monitor jack (discussed in section 10.3.3) the signal is attenuated without distortion, and therefore does not require an LBO to receive the signal correctly.

The amplitudes of signals that can be correctly received without error are listed below. In bridge and terminate mode it is assumed that a low level signal is distorted. In monitor mode, the value in the table is the amplitude of the signal on the T1 line, not at the monitor point.

Termination	Input Signal Range	
Mode	dBdsx	Vpp
Bridge	−36 to 0	0.1 to 6.0
Terminate	−36 to 0	0.1 to 6.0
Monitor	−3 to +6	4.2 to 12.0

Figure 10-5 Receive Signal Ranges

In bridge and terminate mode an input signal of +6 dBdsx will not damage the instrument, and will usually be correctly received by the HP 37741A. However, as the signal amplitude is increased from 0 dBdsx the input impedance may change, and at large signal levels this change may cause a disturbance to the T1 signal being measured.

In monitor mode, an increase in signal amplitude significantly above the standard DSX level will also modify the input impedance. This will not disturb the T1 signal being measured because the instrument is isolated from the T1 line by two 450 Ω (nominal) resistors.

Although guaranteed to operate only with signals greater than −3 dBdsx in monitor mode, the instrument will nominally operate with signals as low as −12 dBdsx.

10.4.3 Level Measurement

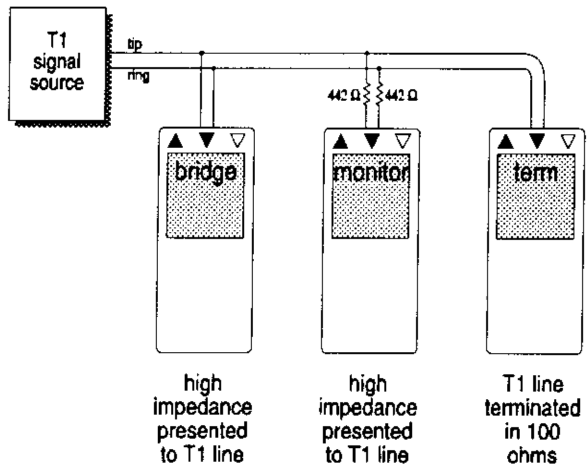
In any termination mode, the amplitude of the T1 signal is measured. When the inputs of the HP 37741A are in monitor mode, compensation is made for the external resistors, so that the displayed value reflects that of the T1 circuit being tested. The monitor mode measurement is calibrated using resistors of 442 Ω.

Signal level measurement in the various modes is shown in figure 10-7. The three HP 37741s shown in the figure will nominally indicate the same value for the signal level. With some older style test instruments, the user (instead of the instrument) is required to compensate for the external monitor mode resistors, by adding 20 dB to the indicated value.

Measurement capabilities are given in figure 10-6.

Termination	Input Signal Range		Accuracy		Resolution
Mode	dBdsx	Vpp	dB	%	mV
Bridge or Terminate	−6 to +6	3.0 to 12.0	±0.5	±6	25
	−20 to −6	0.6 to 3.0	±1.0	±12	25
	−36 to −20	0.1 to 0.6	±2.0	±24	25
Monitor	−6 to +6	3.0 to 12.0	±1.0	±12	75
	−36 to −6	0.1 to 3.0	±3.0	±40	75

Figure 10-6 Level Measurement Accuracies



Signal level measured by the HP 37741A is nominally the same in each case.

Figure 10-7 Different Modes of Level Measurement

10.4.4 Measurement During LOS Alarm

Loss of signal may be characterized as either a line alarm or as a path alarm – both are affected. The HP 37741A displays the LOS status as a path parameter – the signal level is a line parameter. LOS, and other alarms, are discussed in detail in section 11.

When an LOS is declared by the test set, the signal may be present, but at such a low level that the data cannot be recovered. The level measurement circuitry is independent of the data recovery circuitry. Therefore, with such a low level signal, the test set may still be able to measure the amplitude of the incoming signal correctly. Because the level measurement circuitry is never disabled, it will try to measure the input signal level even when the main input bantam cable is removed.

10.4.5 Transmit Level

The T1 output of the HP 37741A is nominally 0 dBdsx. The output impedance is nominally 100 Ω. When the output is terminated in a 100 Ω resistor the amplitude of a pulse (measured at the center) is 3.0 V ± 0.6 V. The maximum pulse imbalance is 0.1 V.

The shape of the transmitted signal meets that specified in ANSI standard T1.102-1987. The signal also meets the requirements of:

- AT&T publication TR 62411, 1988
- ANSI standard T1.403-1989
- Bellcore technical advisory TA-TSY-000754, 1988
- CCITT recommendation G.703, 1985

These are all less stringent specifications than T1.102-1987. A complete list of references appears in appendix C.

10.5 Line Codes

10.5.1 AMI and B8ZS

The T1 signal is transmitted as a succession of positive and negative pulses on the copper pair.

With AMI encoding, the presence of a pulse of either polarity indicates a "one" bit is transmitted, and the absence of a pulse in the data position indicates a "zero" bit is transmitted. A positive pulse must always be followed by a negative pulse (and vice versa), regardless of the number of intervening zeroes.

This alternating mark inversion achieves two goals which lead to a simpler network interface:

- there is no average dc voltage on the copper pair
- the fundamental frequency is half of the carrier frequency – 772 kHz instead of 1544 kHz

The disadvantage with the AMI format is that data containing long strings of zeroes cannot be transmitted. This is because zeroes do not generate pulses, and the pulses are required to recover the clock, and thereby extract the data. There are restrictions on the number of zeroes that can be transmitted as discussed in section 10.5.2.

In the late 1970s, B8ZS line encoding was proposed to overcome the limitation of AMI. The alternating pulses are maintained except when eight consecutive zeroes need to be transmitted. The eight "zeroes" are replaced with an eight bit sequence containing deliberate coding violations, introduced to create a unique signature. This signature is detected by a receiving device, and the original string of eight zeroes is restored.

These two methods of line coding are shown in figure 10-8.

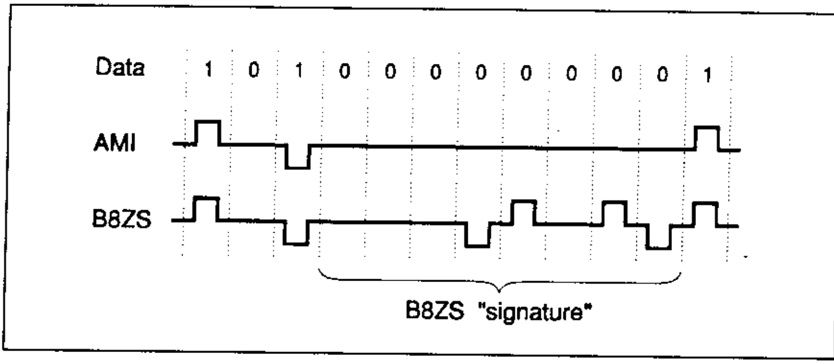


Figure 10-8 AMI and B8ZS Line Coding

The HP 37741A can be configured to transmit either AMI or B8ZS line codes. If you transmit B8ZS codes on a T1 line that is not equipped to accept B8ZS, you will create errors, and possibly initiate alarms at the telephone company central office.

The T1 receiver of the HP 37741A always looks for a B8ZS signature and will decode it appropriately. When the instrument receives at least four such signatures in one second it will indicate that the line code is B8ZS. It will subsequently indicate that the line code is AMI if it receives four strings each of eight successive zeroes in one second. Therefore, on a line with a high coding violation (or BPV) error rate, this indication may toggle.

If the signal being received is all ones, or other high pulse density signal, no B8ZS signature will be transmitted. In this case, the HP 37741A may indicate that an AMI line code is being received, even though the T1 line may be equipped for B8ZS.

You can set the output line code of the test set to equal that being received. Because of the cases described above, this may cause unpredictable behavior when either high errors are received or a high pulse density signal is received.

10.5.2 Pulse Density and Excess Zeroes

The pulses on the T1 line are used to recover the clock, which in turn is used to extract the data. In the absence of pulses, the data cannot be correctly recovered. Requirements therefore exist to ensure a minimum quantity of pulses in a given period (pulse density requirement) and a maximum number of successive zeroes (excess zeroes avoidance).

The HP 37741A will detect the occurrence of more than 15 consecutive zeroes, and will display the number of these occurrences. A string of 16 zeroes to 31 zeroes will increase the count by one. A string of 32 zeroes to 47 zeroes will increase the count by two. Once an LOS is declared by the test set, the accumulation of further excess zeroes is inhibited until the LOS is retired.

The HP 37741A accumulates all occurrences of less than 23 ones in 192 bits, and displays the number of these occurrences. The 192 bits that are examined are not synchronized to the frame bit, and each block of 192 bits is consecutive. This measurement detects a short term pulse density less than 12%.

Current specifications differ on the pulse density requirement. Some require that the minimum pulse density be 12.5% (or one in eight). Others require a minimum of n ones in $8 \times (n+1)$ bits, where n is between 1 and 23. A measurement window of 192 bits is a good compromise – it ensures that unframed test signals such as 3 in 24 will not be detected as violating the density specification.

The standard T1 QRW pattern violates the more stringent pulse density requirement. However, this test signal has been used for years as a "keep alive" signal, and as such has earned special status. It is exempt from meeting the pulse density requirement. When the QRW pattern is received by the HP 37741A, the instrument inhibits the accumulation of these errors.

The maximum counts on the HP 37741A for either pulse density violations or excess zeroes violations are 9 999 998. When either is exceeded, the display will show 9 999 999, and thereafter will not change. If pulse density violations are continuously being received, this number is reached after 20 minutes If excess zeroes are being received at the maximum rate, the maximum count is reached after 110 seconds..

10.5.3 Error Injection (BPV)

You can create line errors at a rate of one per second with the instrument. The error is injected at any point in the bit stream, and may therefore be on a frame bit.

If the instrument is currently transmitting B8ZS signatures, the BPV may be injected in the middle of the signature. This may create more than a single error, and can also introduce logic errors.

Error injection is suppressed when the test set is looped back. The ↩ is visible in most screens in this case.

10.6 Error Analysis

The HP 37741A will perform error analysis on received line code violations, CVs. A CV is a bipolar violation (BPV) which has not been deliberately introduced for B8ZS encoding.[1]

This analysis is performed, irrespective of the line code, frame format, or payload pattern. However, accumulation of CVs is inhibited when the test set has declared LOS.

10.6.1 Error Count, EC

This is a count of the total CVs received during an errored second. The maximum count on the HP 37741A is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change.

The maximum number of errors that can be accommodated by the test set is 20 in a 1 ms period. If errors are continuously being received at this maximum rate, the counter will reach its maximum value after 500 seconds.

10.6.2 Errored Second, ES

This is a count of the number of seconds during which LOS was not declared, and in which there was at least one CV. Because the one second interval is not necessarily related to the occurrence of the CV, this value is sometimes referred to as asynchronous errored seconds.

---

1 The instrument identifies the errors as BPVs, because this is how some specifications define a BPV.

The maximum count on the HP 37741A is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. If CVs are continuously being received, this number is reached after 115 days.

10.6.3 Error Free Seconds, EFS

This is a count of the number of seconds during which an LOS was not declared, and in which no CVs were received.

The maximum count on the HP 37741A is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. If no CVs are being received, this number is reached after 115 days.

10.6.4 Percent Error Free Seconds, %EFS

The sum of errored seconds, error free seconds, and LOS seconds equals the currently elapsed test time:

$$\text{Elapsed test time} = \text{ES} + \text{EFS} + \text{LOS seconds}$$

The percent error free seconds is the ratio of EFS to elapsed test time excluding LOS seconds:

$$\%\text{EFS} = \frac{\text{EFS}}{\text{ES} + \text{EFS}} \times 100$$

This number can be anywhere from 0 to 100.

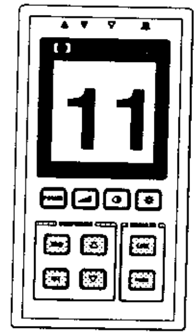
10.6.5 Bit Error Rate, BER

This is the ratio of the error count to the total number of bits received, excluding LOS time. It is displayed in a floating point format with limits of 1.3×10^{-2} to 1.0×10^{-9}. In practice, however, a DS1 signal is useless at a rate of 1.3×10^{-2}, and is a very good circuit at 1.0×10^{-9}.

The maximum error rate is limited by the number of errors that can be received in 1 ms, as described in section 10.7.1.

0 is displayed when there have been no errors.

Alarm Capabilities



11.1 General

The HP 37741A has a comprehensive set of features relating to alarms. The instrument can recognize all the common alarms and any alarm condition is unambiguously displayed to the user. Each of these alarms (including LOS) can also be generated. Because of the HP 37741A's ability to perform frame format translation, a yellow alarm can be translated from one frame format to another.

Alarms affect the gathering of performance parameters. Depending on the alarm, some error counts are not incremented for the duration of the alarm. This prevents the results from being misinterpreted, and is in accordance with standard PTT procedures.

Because you can use the test set as a piece of terminal equipment, or as a repeater, the test set handles received alarms in a similar manner to the devices it is emulating. Therefore, received alarm conditions can affect the transmitted signal.

11.2 Alarm Detection

The alarms are indicated in screen 5000. A counter is associated with each alarm to count the number of seconds during which the error was present. The number of times during the second that the alarm was detected, and the length of time in the second that the alarm persisted are not recorded.

The one second period is synchronous for all result measurement activities and alarm detections, but is not necessarily synchronized to any event. The maximum count on the HP 37741A for each of the alarm seconds is 9 999 998. When this is exceeded, the display will show 9 999 999, and thereafter will not change. If an alarm is continuously present, this number is reached after 115 days.

With the exception of yellow alarm, each of the alarms is mutually exclusive. This is explained in the following sections.

11.2.1 Loss of Signal, LOS

An LOS is declared when 150 consecutive, non-encoded zeroes have been received, or the equivalent time passes without any valid pulses being detected. If at the start of a test LOS is declared, the test automatically restarts when the LOS is retired.

Ordinarily, an LOS is retired when the pulse density requirements outlined in section 10.5.2 have been met for at least 100 ms. However, it is important that a test instrument recognize low density signals, so the HP 37741A retires the LOS after there have been no consecutive strings of zeroes of 150 bits for at least 100 ms.

LOS inhibits the accumulation of all errors.

11.2.2 Alarm Indication Signal, AIS

The AIS signal for DS1 is an unframed all ones pattern, and indicates that the transmitting device is not receiving a valid signal from further "upstream".

The HP 37741A declares an AIS when an LOF condition is present and two groups of 193 bits each contain all ones. The AIS is retired when there have been more than three zeroes in any two consecutive frames for at least 100 ms. This implementation ensures that an AIS is detected in the presence of a BER of 10^{-3}.

AIS inhibits the accumulation of most path errors, but not the accumulation of line errors.

If at the start of a test AIS is declared, the test automatically restarts when the AIS is retired.

11.2.3 Frame Loss, FrmLos

This is a count of the number of seconds in which frame is declared to be lost. The exact definition is given in section 8.8.1. This counter is not incremented if an unframed signal is received at the start of a test.

The accumulation of FLS is inhibited when an AIS is received, to prevent the misinterpretation of the data. The condition of frame loss inhibits the accumulation of frame bit errors, and OOF events.

11.2.4 Pattern Loss, PtnLos

This is a count of the number of seconds during which the test signal pattern detection circuit lost synchronization at least once. Pattern synchronization criteria are given in section 9.1.1.1.

If the pattern was not recognized when the test was started, this counter will not increment.

This count is inhibited whenever there is an LOS, LOF, or AIS, to prevent the misinterpretation of the data. It is, however, possible to have a pattern loss at the same time as a yellow alarm.

11.2.5 Yellow (Remote)

Yellow alarm is used to indicate to a sender of a signal that its signal is not being correctly received. The recipient of the signal superimposes the yellow alarm on the signal that it is transmitting to the sender.

With the SF frame formats (D1D, D2, D3, D4, and SLC-96), the yellow alarm is indicated by setting bit 2 of each octet of the payload to 0 (see figure 8-2). This is transmitted for as long as the trouble condition persists, but for no less than one second. The HP 37741A declares a yellow alarm when all bit 2s in any two frames received within 3 ms have been zero. The alarm is removed when this condition is no longer present.

With the ESF frame formats (ESF and ZBTSI), the yellow alarm is indicated by a BOP message on the FDL. The message is a repeating 16 bit pattern of eight ones followed by eight zeroes. The message is transmitted for as long as the trouble persists, but for no less than one second. The message may be briefly interrupted by other messages to help identify the fault. The HP 37741A detects the presence of a yellow alarm after 10 consecutive sequences of the pattern (40 ms for ESF and

80 ms for ZBTSI). The alarm indication is removed when the alternating pattern has not been received for 10 sequences.

The receipt of a yellow alarm does not inhibit the accumulation of any errors.

11.2.6 Performance Monitoring

As detailed in sections 11.2.1 to 11.2.5, certain alarm conditions inhibit the measurement of certain performance monitoring parameters. These cases are summarized in figure 11-1.

Parameter	Trouble				
	LOS	AIS	LOF	Pattern loss	Yellow
Alarms					
LOS seconds	●	●	●	●	●
AIS seconds	○	●	●	●	●
FLS	○	○	●	●	●
PLS	○	○	○	●	●
yellow alarm seconds	○	○	○	●	●
Line					
EC (BPV count), ER	○	●	●	●	●
ES, EFS	○	●	●	●	●
Xs0s, density violation	○	●	●	●	●
bit slips	○	●	●	●	●
Path — Frame or CRC					
EC, ER	○	○	○	●	●
ES, EFS	○	○	○	●	●
OOF, COFA	○	○	○	●	●
Path — Logic and G.821					
EC, ER	○	○	○	○	●
ES, EFS	○	○	○	○	●
UAS, %avl	●	●	●	●	●
SES, CSES	○	○	○	○	●
DM	○	○	○	○	●

Figure 11-1 Performance Monitoring During Trouble Conditions

11.3 Alarm Output

The HP 37741A can transmit any of the following alarms:

- LOS
- AIS
- yellow

11.3.1 LOS

Transmitting an LOS is exclusive, in that no other signal can coexist with it. The signal can be sent regardless of whether the transmitter is configured for framed or unframed operation.

When the test set transmits an LOS, this is not equivalent to removing the bantam jack, because simplex current can still flow between the main input jack and the output jack.

11.3.2 AIS

As with an LOS, no other signal can exist with an AIS. Further, the AIS can be sent regardless of whether the transmitter is configured for framed or unframed operation.

11.3.3 Yellow (Remote)

A yellow alarm can be sent only with framed signals. The yellow alarm is imposed on top of the existing signal, and therefore coexists with that signal.

When a yellow alarm is sent with an SF type signal, the payload is disturbed. If a pattern is being transmitted (test signal or loopback code) it is unlikely that it will be recognized by a receiving unit.

When a yellow alarm is sent with an ESF type signal, the payload is not disturbed. A pattern can therefore be received error free. However, the transmission of out-of-band loop codes is prevented while the yellow alarm is being sent.

11.4 Alarm Translation (As In)

You can select the transmit alarms to be equal to the received alarms. When one of the following alarms appears at the input, it will be reproduced at the output:

- LOS
- AIS
- yellow

11.4.1 LOS

No translation is required – when the LOS is detected at the input, an error free LOS is created at the output.

11.4.2 AIS

No translation is required – when the AIS is detected at the input, an error free AIS is created at the output.

11.4.3 Yellow (Remote)

A yellow alarm is translated from SF format to ESF format (or vice versa), if required.

11.5 Effect of Input Signal on Output Alarms (Smart Alarms)

Under certain circumstances, an alarm will be automatically inserted into the output DS1 signal. This insertion is performed only when you have configured the output of the HP 37741A to be dependent on the main input, and happens irrespective of whether a test is running or not.

There are two prime uses for this feature, as indicated in figure 11-2. The first example is where the HP 37741A is in series with the signal, that is, the signal passes through the instrument. The frame format, and payload are set to `as in`, or `thru`. The timing for the transmitted signal is derived from the received signal. The instrument will alert the receiving NTE of a problem by issuing AIS when there is a LOS at the input to the instrument.

The second example is where the instrument is loop timed, but the frame and pattern are pre-determined. Again, the HP 37741A will alert the far end of a problem. This time, however, it will send a yellow alarm to the generator of the signal, because the instrument is not in a through mode.

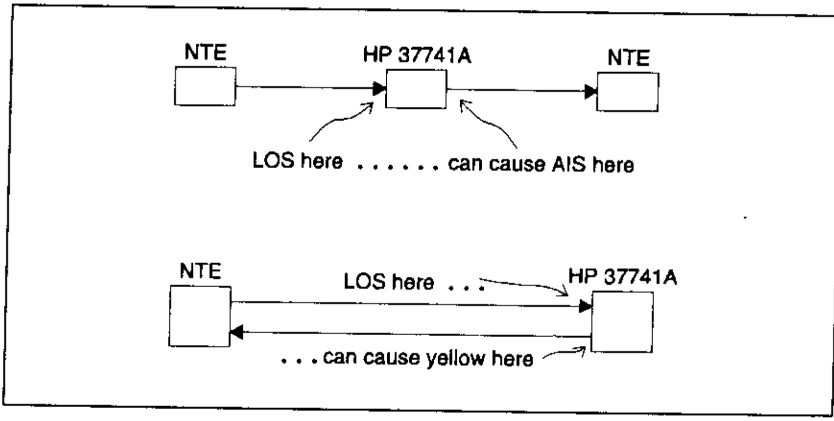


Figure 11-2 Examples of Smart Alarm Usage

11.5.1 No Frame and LOS

The effect of these alarms when received at the input is summarized in figure 11-3. The transmitted alarm is dependent on the transmit configuration as shown.

Transmit Configuration		Output Signal					
		When LOS at Input		When LOF at Input		When Input is Unframed	
Frame	Payload	Loop timing	Other timing	Loop timing	Other timing	Loop timing	Other timing
FO	PO	FO, PO, Y	FO, PO	FO, PO, Y	FO, PO	FO, PO	
FO	as in	FO, All1s, Y	FO, All1s	FO, PI, Y	FO, PI	FO, PI	
as in	PO	UnF, PO		FI, PO		UnF, PO	
as in	as in	AIS		FI, Tr		Tr	

Figure 11-3 Automatic Alarm Insertion

The column headed **When LOF at Input** applies only when either of the following conditions is true:

a. The receiver is configured to frame to a specific frame format and is not currently framed to that format.

b. A test is running, and the incoming signal was framed but is no longer framed.

The column headed **When Input Is Unframed** is applicable at other times when the receiver is not framed.

The meanings of the table entries are as follows:

FO	Frame Out. Indicates a specific frame format that the transmitter is configured to output.
PO	Pattern Out. Indicates a specific test pattern that the transmitter is configured to output.
as in	As Input. Indicates that the transmitter is configured to output what is received.
FI	Frame Input. Indicates the frame format that is actually received on the input.
PI	Pattern Input. Indicates the pattern that is actually received on the input.
UnF	Unframed. Indicates that the output signal is unframed.
Y	Yellow. Indicates that a yellow alarm is transmitted (if the output signal is framed).
AIS	AIS. Indicates an AIS is transmitted.
Tr	Transparent. Indicates the entire received signal is re-transmitted.

The yellow alarm and AIS are thus used to signify to a downstream device that there is a trouble condition.

If framing bits are received with a high error rate, an LOF condition may result. In this case, PI will include the intended framing bits. Double framing, and bit slips, will occur.

11.5.2 No Pattern

When the HP 37741A loses pattern synchronization, but not the signal (that is, LOS is not present) no alarms are injected into the output signal.

11.5.3 Line Code and Timing

No alarms are injected because of line code or timing effects.

When the output timing is configured to be derived from one of the inputs, and there is LOS at that input, the transmit timing will automatically be derived from the internal clock. If the input signal becomes valid, the transmit timing will revert to using the configured signal after the signal has been valid for one second.

If the line code is configured to be the same as the input, and there is LOS at the input, the transmitted line code will be AMI.

11.6 Hierarchy of Alarms and Payload Use

There is only one payload of a DS1 signal, and the HP 37741A uses that payload to carry test patterns, tones, signaling bits, injected logic errors, loopback codes, and alarms. The alarms can be configured from the instrument front panel, or be set up to mimic received alarms, or be smart alarms injected because of a trouble condition at the instrument's receiver. Within the HP 37741A, there is a pre-defined hierarchy for use of the payload.[1]

The hierarchy is as follows:

a. **Alarms configured from the front panel.**
   If you set the transmitter to send an AIS, LOS, or yellow alarm, that indication will always be transmitted, irrespective of any other setting. AIS and LOS can exist only on their own, but yellow alarm coexists with other signals.[2]

b. **Signaling bits**
   These can be sent with test patterns or loopback codes. The signaling bits overwrite the existing payload.

c. **Loopback codes.**
   When not configured to send an alarm, the loopback code will be transmitted, either because of an "as input" setting, or because you directly configured it from the front panel. Logic errors can be created in a loopcode signal.

1 The hierarchy for test patterns and loopback codes is explained in section 9.1.2.
2 See section 11.3.

d. **As input alarms.**
When you have configured the transmission of alarms to be `as input`, these are sent if a loop code is not being sent.

e. **Smart alarms.**
If a trouble condition at the input prevents the transmitter from functioning as you have set it, a smart alarm will be transmitted.[1]

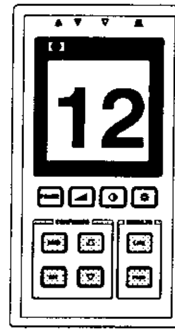
f. **Reinserted Signaling.**
These are the signaling bits extracted from the received payload. When signaling reinsertion is on, the bits can overwrite a tone in a channel.

g. **Tones.**
A tone is inserted into the channel of a framed signal, overwriting whatever was there before.

h. **Test signals.**
When none of the above conditions hold, the test signal that you have configured for the payload is transmitted. Logic errors can be created in a test signal.

1 See section 11.5.

Channel Capabilities



12.1 General

12.1.1 Introduction

The HP 37741A can insert a tone on a channel and drop a channel to the built in speaker. You can see the highest and lowest PCM codes received, and the amplitude of a received tone. You can modify signaling bits, and can view the received signaling bits of a channel in real time.

Fractional T1 capability allows you to restrict pattern generation and recognition to selected timeslots, and to choose whether 7 or 8 bits of each channel octet are used.

With any of the settings, the time slots (or channel numbers) for the receive side and the transmit side need not be the same.

12.1.2 Channel Sequences

There are 24 time slots available in a framed DS1 signal. Each of these time slots comprises 8 consecutive bits in each frame. Each time slot corresponds to an information bearing channel carrying 8000 bytes per second. The earlier generations of the D–Series channel banks did not put consecutive channels into consecutive time slots. This was because of the limitations of the electronics available then.

Figure 12-1 shows how the time slots are allocated for the various frame formats supported by the HP 37741A.

When a signal is unframed, there can be no channels. The test set cannot insert a tone on an unframed DS1, nor can it send a signal to the built in speaker when receiving an unframed DS1. An unframed DS1 signal carries no signaling information.

Time Slot	D1D	D2	D3, D4	SLC-96 Mode 1	ESF, ZBTSI
1	1	12	1	1	1
2	13	13	2	13	2
3	2	1	3	2	3
4	14	17	4	14	4
5	3	5	5	3	5
6	15	21	6	15	6
7	4	9	7	4	7
8	16	15	8	16	8
9	5	3	9	5	9
10	17	19	10	17	10
11	6	7	11	6	11
12	18	23	12	18	12
13	7	11	13	7	13
14	19	14	14	19	14
15	8	2	15	8	15
16	20	18	16	20	16
17	9	6	17	9	17
18	21	22	18	21	18
19	10	10	19	10	19
20	22	16	20	22	20
21	11	4	21	11	21
22	23	20	22	23	22
23	12	8	23	12	23
24	24	24	24	24	24

Figure 12-1 Channel and Time Slot Number Assignments

12.1.2.1 Receive

When accessing a channel, the HP 37741A needs to know the correspondence between channels and time slots. When receiving an ESF or ZBTSI signal the sequence is fixed – the channel numbers correspond to the time slot numbers as indicated in figure 12-1.

When receiving a SLC-96 signal, the HP 37741A assumes that the equipment is configured for mode 1 (that is, the same as D1D), and will use the sequence shown in figure 12-1.

If the HP 37741A receiver framing is explicitly set, the corresponding channel sequence is used.

When the HP 37741A is set for auto frame mode, and receives a D4 framed signal, the instrument is unable to identify the channel sequence automatically. By using screen 2240 you indicate what sequencing should be used to access a channel. You can choose SLC-96 on this menu. As described in section 8.5, the SLC-96 data link is not present on all circuits associated with a SLC-96 installation. Therefore, the HP 37741A is unable to identify the circuit as being part of a SLC-96 installation, and you need to configure the instrument appropriately.

The available selections are summarized in figure 12-2. As indicated, when receiving a D4-type frame, you can select the sequencing to be D1D, D2, D3/D4, or SLC-96. For any other received frame, the sequencing is fixed by the test set.

Received Frame	Selectable Channel Sequences
D4	D1D, D2, D3/D4, SLC-96
SLC-96	SLC-96 (D1D)
ESF	ESF
ZBTSI	ZBTSI

Figure 12-2 Available Received Channel Sequences

12.1.2.2 Transmit

Because the time slot number and channel number are not necessarily identical, the test set offers the user a choice of channel bank types when choosing the transmitted frame format, even though (for D1 to D4) the frame formats are identical.

12.1.2.3 Frame Format Conversion

When you make the transmitted payload equal the received payload, and the test set is performing frame format conversion, the test set does not perform time slot translation. That is, if a signal containing channels is received, time slot number one is transmitted in time slot number one, received time slot number two is transmitted in time slot number two, and so on. This creates no problems when frame format conversion is performed between D3, D4, ESF, and ZBTSI signals. Signaling is dealt with in section 12.4.

12.1.3 Drop and Insert

The HP 37741A possesses a number of traits associated with comprehensive Drop and Insert test instruments. A DS1 signal can be passed through the HP 37741A, with the signal regenerated and errors removed.

One channel of a received DS1 signal can be sent to the built in speaker ("dropped") for audio monitoring. A tone, or signaling, or both, generated within the instrument, can be substituted in that channel ("inserted") on the transmitted DS1 signal.

Using two HP 37741As you can perform full duplex drop and insert, with the added flexibility of frame format conversion.

12.2 Fractional T1 Capabilities

12.2.1 Receive

In full T1 mode, the instrument sends the data in all of the timeslots to the pattern recognition circuitry.

In FT1 mode, only those timeslots which you specify are used by the pattern recognition circuitry. All 8 bits of the selected timeslot are sent to the pattern recognition circuit when you specify n × 64 mode, but only bits 1 to 7 are sent to the circuit in n × 56 mode.[1] In this case, the signaling bits can be used by the transmission equipment without disturbing your data.

When you set the HP 37741A to auto detect the mode of the received signal, it can do so only when a recognizable pattern exists in the payload. The instrument first looks for all timeslots which contain FF hex or 7F hex, and considers those timeslots to be idle. It then tries to sync on any recognized pattern both in n × 56 and n × 64 modes.

1 See figure 8-2 for definitions of the bit numbers.

Irrespective of the received mode, you can display the digital codes and signaling bits of a timeslot which is not selected. You can also listen to any channel.

The displayed timeslot map (on screen 5500) indicates which timeslots are being used by the pattern recognition circuitry. When you specify the receive mode to be full T1, all of the timeslots are shown as being active. When you enable and disable the timeslots (in one of the FT1 modes), this map is the same as that which you created in screen 2206. When the receiver mode is configured for auto mode, the map shows which slots are active and which are idle.

12.2.2 Transmit

The transmit mode can be independent of, or dependent on, the receiver mode.

When you configure the transmitter to be in one of the FT1 modes, you specify the bit rate and active channels.

When you configure the transmitter to be the same as the receiver, all the timeslots are used when the receiver is configured for full T1. When the receiver is configured for FT1, the transmit configuration matches it, both in bit rate and active timeslots. When the receiver is in auto mode, the active transmit timeslots are set to be the same as those recognized on the input signal. The timeslot map is not updated during an alarm condition, but if an LOS exists at the start of a test, all transmit timeslots are made active.

The output of the pattern generator circuitry is fed to only those channels which are active. If bit 8 is not being used (n × 56 mode), this bit is set to a 1.[1] All inactive channels are filled with eight ones.

Irrespective of the mode setting, you can still modify the signaling on any channel, and inject a tone on any channel. When you modify an inactive channel, it may not be recognized as being idle by an HP 37741A which has been configured for auto mode detection.

1 Signaling may overwrite this bit.

12.3 Audio Frequency Capabilities

12.3.1 Receive

The HP 37741A can decode one channel of the DS1 signal (assuming μ-law encoding) and feed the analog signal to an internal speaker. Regardless of the T1 mode (full or fractional), all 8 bits of the channel are fed to the DtoA converter. The maximum speaker output of 200 mW is obtained with the maximum digital signal on the DS1 line (3.17 dBm0).

The instrument's volume control provides a total variation in signal amplitude of 24 dB in sixteen 1½ dB steps. A digital signal on the DS1 line corresponding to about −6 dBm0 can be varied between the maximum speaker output and a very quiet audible level. Regular conversational speech in a DS1 channel (at about −16 dBm0) will not normally overload the internal speaker when the volume is set to maximum.

The audible signal is retimed to the transmit clock. Slips may occur (detectable as clicks) if the instrument's transmitter is not loop timed.

When you are not listening to a channel you should turn the volume to off, to save battery power.

See section 12.3.3 for details about tone amplitude measurement.

12.3.2 Transmit

A sinewave tone is generated internally by the HP 37741A and can be transmitted in any channel. The tone is encoded with μ-law encoding. Regardless of the T1 mode (full or fractional), all 8 bits of the channel are used by the tone's digital signal.

When the tone is inserted into a channel, it overwrites what was there before. Therefore, if an error free test signal was being transmitted, it will be disturbed, and not error free.

Any one of the following frequencies may be sent. A brief note on the tone's use is given:

304 Hz	Almost the lowest frequency that can be sent through the network.
404 Hz	Used for North American 3-tone slope.

420 Hz	Used for signal to noise testing.
820 Hz	Used for signal to noise testing.
1004 Hz	Widely used as the digital milliwatt signal. Also, one of the tones used for North American 3-tone slope.
1020 Hz	Used for signal to noise testing.
1800 Hz	Used as a guard tone to disable echo cancellers.
2280 Hz	Used as a signaling frequency to terminate long distance calls. Also used as an in-band signaling frequency in some European countries.
2600 Hz	Used as an in-band signaling frequency.
2713 Hz	Used as a tone to activate older style loopback units.
2804 Hz	Used for North American 3-tone slope.
3404 Hz	Used to test high frequency performance (the highest frequency that can typically be sent through the network).
3-tone slope	Used to obtain a plot of transmission loss against frequency, by sequentially sending 3 different tones. The tones are 404 Hz, 1004 Hz, and 2804 Hz, with each tone being sent for 5 seconds. This is the standard North American slope test.
sweep	Used to characterize the gain and phase response of a line. The tone generator sweeps through a series of frequencies, starting at 204 Hz, and increasing in 100 Hz steps until 3504 Hz. The sequence then repeats. Each frequency is transmitted for one second.

The amplitude can be selected to be any one of the following:

0 dBm0	High level, used to create a digital milliwatt.
−3 dBm0	Half of the power of a digital milliwatt – used to test universal SLC-96 systems.
−6 dBm0	Quarter of the power of a digital milliwatt.
−10 dBm0	CCITT recommended level to test characteristics.
−13 dBm0	Bell System recommended level to test voice circuits.
−16 dBm0	Bell System recommended level to test voice circuits.
−24 dBm0	Low level used to verify linearity of signal with amplitude.
idle	No audible output, used to check inherent noise. The signal is approximately −60 dBm0.

The following specifications apply to any of the fixed tones:

Amplitude accuracy	± 0.4 dB
Frequency accuracy	± 1.0 Hz
Signal to noise + distortion	40 dB

The amplitudes of the 3404 Hz tone, and of the 204 Hz and 3504 Hz tones used in the sweep are accurate to + 1.0 dB to – 3.0 dB.

12.4 Digital Codes

12.4.1 General

The coding of a speech signal in a PCM stream is optimized to give the maximum number of ones in the signal. High amplitude speech will contain low density bit sequences at peak swings, and high density sequences near zero crossings.

The coding is symmetric around 0. Therefore, the 8 bit word represents codes ranging from −127 to +127, and includes both −0 and +0. A table translating PCM codes to binary values is given in appendix G.

12.4.2 Hi and Lo Values

These values are sampled by the test set approximately 400 times a second. The highest and lowest values received during the second are displayed. The test set converts from the binary value to the code value before displaying the number – therefore, the numbers range from −127 to +127.

This measurement allows you to see activity of data in a channel, and is an improvement on the LEDs provided for that purpose on other test instruments. If the high value and the low value are the same, there is no activity on the channel. You can use the table in appendix G to convert the indicated value to binary data to identify the steady state of the bits in that channel. If the high and low values differ, there is activity in the channel, and this measurement indicates the type of activity. For example, if the values indicated +10 and +50, there is an offset in the channel.

The measurement is made on alternate frames. If you are receiving a signal which alternates between two values, one of the two values will not be recorded. If you remove the signal and then reconnect it, the instrument may indicate the other value. This is because the selection of which frame is examined is random.

12.4.3 Tone Level Measurement

At the end of each second, the instrument calculates the difference between the high and low values, and from that, calculates the amplitude of the signal in the channel.

The number ranges between −81 dBm0 (for a code difference of 1) to +3.0 dBm0 (for a code difference of 255). The maximum theoretical value of any signal using μ-law encoding is 3.2 dBm0 (for a code difference of 256).

This is not a true measurement of the signal amplitude, but in the majority of applications the value is accurate to within ±0.2 dB.[1] The test set assumes that a tone is being received, and that the tone is centered about 0. If the magnitude of the displayed high value is not approximately equal to the magnitude of the low value, or if you are not receiving a tone, the HP 37741A may indicate an erroneous measurement.

When the high and low codes are equal in both magnitude and sign, the instrument displays no indication for the level.

12.4.4 Channel Words

These are user programmable patterns which are transmitted as the payload of a framed signal.[2] They are 192 bits long, and are guaranteed to have a one for one timeslot mapping. This allows you to set or reset any bit of any channel. When you send a tone or modify signaling, the channel word is overwritten.

12.4.5 Timeslot Identification

A preprogrammed channel word can be used to identify timeslots. This is described in section 9.2.9.3.

1 See appendix G for details about the quantization of PCM codes, and the theoretical accuracies.

2 The channel words are described in detail in section 9.2.9.

12.5 Signaling

12.5.1 General

You can display and modify the A and B signaling bits from SF signals and the A, B, C, and D signaling bits from ESF signals.[1]

For all frame format types, you have access to 16 state signaling. This means that for SF signals, four bits are displayed or can be modified instead of just two. This gives access to signaling schemes that use a toggling bit.

The SF bits are displayed as ABAB. The first set of AB bits is received or transmitted in one superframe, the second set of AB bits is received or transmitted in the successive superframe.

For example, on a SLC-96 circuit, a channel connected to a payphone would send a toggling A bit and a 1 on the B bit to return a coin. This could be sent or viewed as ABAB = 1101. Because there is no alignment of the AB bits to a master sequence, this pattern could also be sent or viewed as ABAB = 0111.

12.5.2 Receive

The channel whose signaling bits are to be displayed is the same as that selected for audible monitoring.

These bits are updated as they change on the DS1 circuit. When the incoming signal is no longer present, or there is a frame loss, the HP 37741A will display the state of the last valid signaling bits.

12.5.3 Transmit

The channel whose signaling bits are to be modified is the same as that selected for audible monitoring. When you modify the signaling bits, they overwrite the bits in the channel. When the HP 37741A is generating the payload of the transmitted DS1 signal, and the instrument is set not to modify the signaling bits, the signaling bits will equal whatever is created by the pattern or tone.

When you send signaling bits that are toggling, and you use the HP 37741A to view those bits, they may at first appear different. This is because there is no alignment of the "first" and "second" set of AB bits.

1 A discussion of these frame formats is in section 8.

Therefore, if you are transmitting ABAB = 0010, you may receive ABAB = 1000 (A is toggling 1/0, and B is 0).

12.5.4 Signaling Reinsertion

When the following four conditions are all satisfied you have the choice to enable or disable signaling reinsertion:

a. the received signal is framed
b. the transmitted signal is framed
c. the transmitted payload is configured to be equal to the received payload ("as input" or "through")
d. the received payload is not a pattern recognized by the HP 37741A

These conditions generally occur when you are using the test set in through mode, to regenerate a signal, or to perform frame format conversion, and the payload contains voice or data traffic. Depending on the traffic, you may need to preserve the signaling bits in the transmitted DS1 signal (signaling reinsertion enabled), or leave the transmitted signal unmodified (signaling reinsertion disabled).

You need to make this choice because the superframes of the received and transmitted signals are not necessarily aligned. Therefore, the frames that contain the signaling bits are not guaranteed to be transmitted at the same time as the frames that contain the signaling bits are received.

When you enable (turn on) signaling reinsertion, the HP 37741A extracts the signaling bits and temporarily buffers them. The instrument sets those bits that had contained signaling information to be 1. On transmit, the extracted signaling information is put into the outgoing DS1 signal (reinserted) in the correct frames.

When you disable (turn off) signaling reinsertion, no bits in the outgoing DS1 signal are modified by signaling information. Assuming no frame slips, the received and transmitted payload will be identical. If signaling information was present in the received payload, it may not be correctly transmitted.

12.5.5 Signaling and Tone Transmission

When the four conditions described in section 12.4.4 are satisfied, and in addition you are generating a tone on a channel, signaling will be preserved on the channel if signaling reinsertion is enabled. The signaling on the channel could incur a maximum delay of 256 frames (32 ms).

When signaling is not reinserted in the transmitted DS1 signal, the tone will use all eight bits of the channel, and will therefore have less distortion.

12.5.6 Signaling Translation

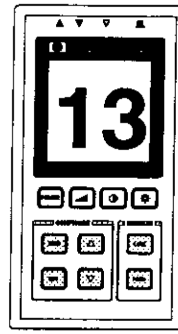
When the HP 37741A is doing frame format conversion from an SF framed signal to an ESF framed signal (or vice versa), the test set assumes 16 state signaling in both directions. Thus, in conversion from SF to ESF, the second set of A and B bits is transmitted in frames 18 and 24. In conversion from ESF to SF, the C and D bits alternate in super frames with the A and B bits.

This means that ABAB = ABCD.

Because the channels of a DS1 signal undergo no time slot reassignment[1], the signaling bits also undergo no time slot changes. This presents no problem when regenerating a signal, or converting between D3, D4, ESF, and ZBTSI frame formats.

1 This is described in section 12.1.2.

Serial Port Capabilities



13.1 General

The serial data communications port on the HP 37741A can be used to print test results directly or can be used as a control port. When the test set is controlled externally, the software on the external controller can perform further analysis if desired, and print the test results.

If the serial port is not used, you should turn it off. This will save battery power.

Brief information on serial communications, including a table of ASCII characters, can be found in appendix A.

HP supplies a range of cables to connect your test instrument to a variety of printers or computers. These, and other optional accessories, are listed in appendix D.

13.2 Physical and Electrical Interface

13.2.1 Port Configuration

The serial port is configured as a DCE, which enables direct connection to a DTE.

The DTR lead can turn on the HP 37741A. This is discussed in detail in section 14.2.

13.2.2 Signal Levels

The signal levels of the port meet V.28 and EIA-232-D standards. The interchange circuits are a subset of those specified in V.24 and EIA-232-D, and the functionality of the interchange control circuits follows those standards.

13.2.3 Pin Assignment

A 9-pin female D-type connector is fitted to the HP 37741A. The pin assignment is compatible with that used on the IBM PC/AT, so that readily available cables can be used to connect the instrument to a PC or other system controller.[1] The pin assignment is shown in figure 13-1.

Circuit	Source	Pin	Description	Function in HP 37741A
AB	common	5	Signal Ground	supported
BA	DTE	3	Transmitted Data	supported
BB	HP 37741A	2	Received Data	supported
CA	DTE	7	Request to Send	supported
CB	HP 37741A	8	Clear to Send	supported
CC	HP 37741A	6	DCE Ready	+10 V when power is on
CD	DTE	4	DTE Ready	can turn on the HP 37741A
CF	HP 37741A	1	Carrier Detect	+10 V when power is on
CE		9	Ring Indicator	no connection

Figure 13-1 EIA-232 Signals, and DB9 Pin Assignments

The voltages on pins 1 and 6 are approximately +10 V into an open circuit. Each is capable of driving an EIA-232 compatible receiver to a recognized high state.

1 To conform to the EIA-232 specification, devices configured as a DCE should have a female connector. It is preferable that devices configured as a DTE have a male connector.

13.2.4 Connection to a DTE

To connect the HP 37741A to a computer or controller (configured as a DTE) a straight cable is used (pin 1 to pin 1, pin 2 to pin 2, and so on). When connecting to a 25 pin EIA-232 port, a 9 pin to 25 pin cable or adapter is required. These connection arrangements are shown in figure 13-2.

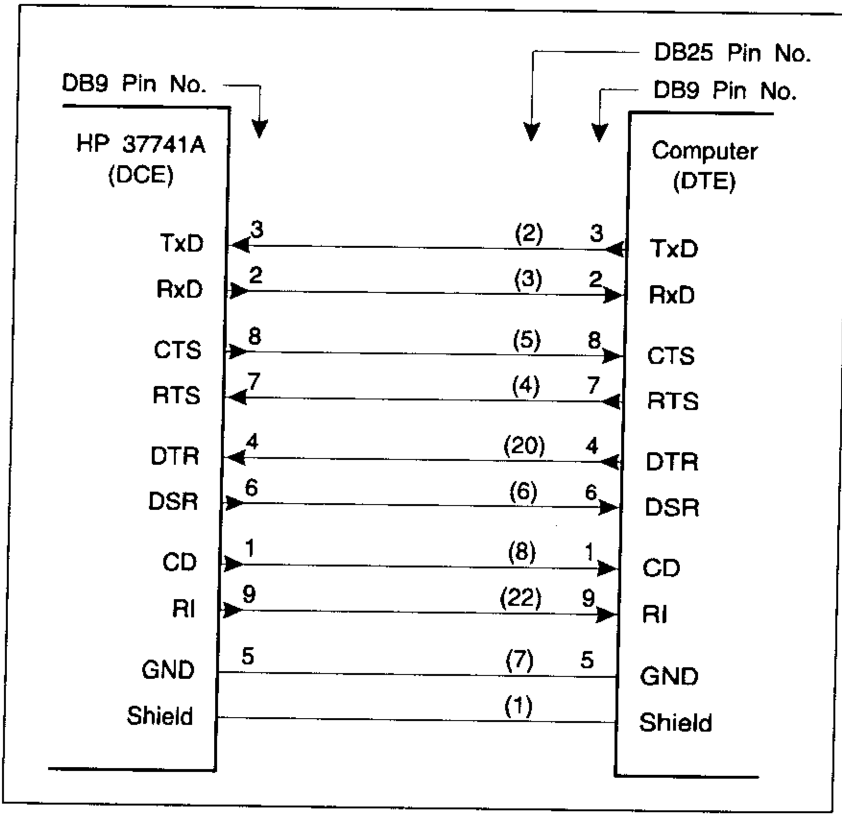


Figure 13-2 Connecting the HP 37741A to a DTE

Because RI is not supported on the HP 37741A, the cable need not support this signal.

13.2.5 Connection to a DCE

When connecting the unit to another DCE, such as a modem or printer, a null-terminal cable is required. This crosses over the signals, so that at the other end of the cable each piece of equipment appears to be configured as a DTE. A suitable cable arrangement is shown in figure 13-3.[1]

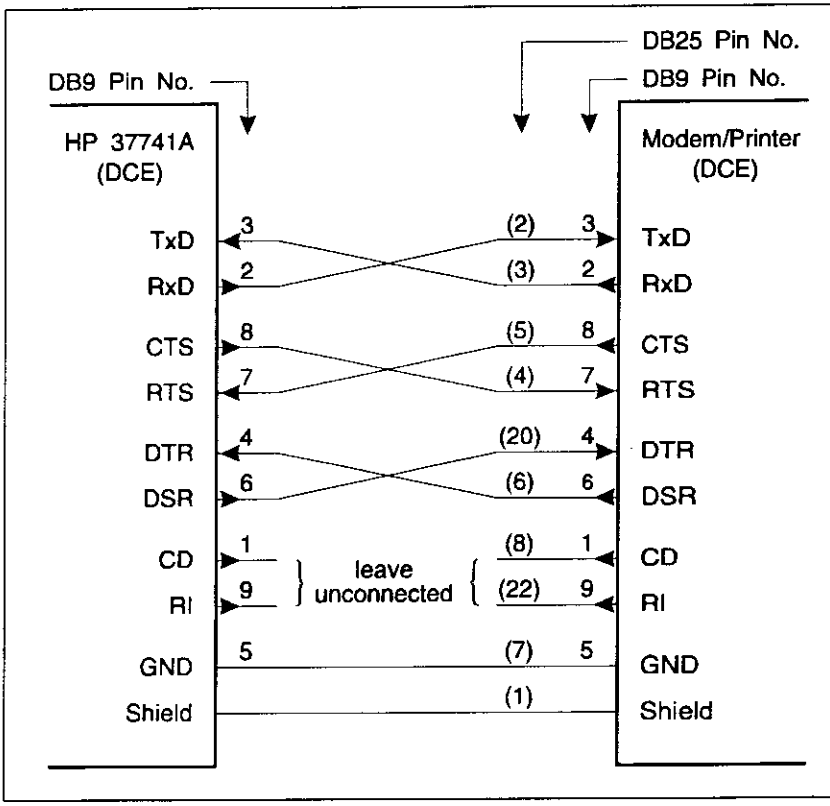


Figure 13-3 Connecting the HP 37741A to a DCE

Ring indicator is not supported. When connecting to a modem, the HP 37741A cannot identify when an incoming call is being attempted by monitoring the interchange control leads. Therefore, a software programmable modem should be used. Because only limited error correction is used by the external control protocol, an error correcting modem (MNP-3 or V.42) should be used. Data compression will only

1 Do not confuse a null-terminal cable with a null-modem cable. The latter connects two DTEs together, and if used to connect two DCEs together may short out some signals, and damage the equipment. See appendix A for more details.

marginally improve performance. The communications protocol is discussed later in this section.

IMPORTANT

Some printers are configured as a DTE, not as a DCE. If a male connector is used on the equipment it is probably a DTE. If a female connector is used, check the manufacturer's documentation.

13.2.6 Bit Rate, Word Size, and Parity

The bit rate may be selected to be 1200 b/s, 2400 b/s, 4800 b/s, or 9600 b/s.

Data sent to a printer uses ASCII characters (discussed in appendix A), and therefore only seven data bits are required. You can select seven or eight data bits, with or without parity. When you select eight bits, the MSB is set to 0. The recommended setting is eight bits, no parity.

Transfers in external control mode use eight bit binary data, and therefore the word size is fixed at eight bits, and no parity is used. If you are using a modem to remotely control the HP 37741A, ensure that it is appropriately set.

Figure 13-4 summarizes the available choices:

	Serial Port Used For				
	Printer Output				External Control
Start Bit	1				
Data Bits	7		8		8
Parity	none	even, odd	none	even, odd	none
Stop Bits	2	1			
Total Character Length	10	10	10	11	10
Bit Rate	1200, 2400, 4800, 9600				

Figure 13-4 Serial Port Configuration Possibilities

13.2.7 Flow Control

You can select one of the following choices for flow control when using a printer:

- none
- RTS/CTS (hardware)
- ENQ/ACK (software)
- XON/XOFF (software)

The recommended flow control is RTS/CTS.

When the serial port is configured for external control, RTS/CTS flow control must be used, and none of the other types is supported. This is because the characters used by the software flow controls could be misinterpreted as binary data.

13.2.7.1 RTS/CTS

As soon as this mode is configured, the HP 37741A will assert (take to the ON condition) the CTS circuit. This circuit will subsequently be taken ON within one second of the test set's power being turned on.

When configured for external control, and when receiving data, the HP 37741A will take the CTS circuit inactive (to the OFF condition) when the receive data buffer becomes full. The transmitting device should then stop transmitting, and resume only when the CTS circuit has been asserted again.

The HP 37741A will transmit data only when the RTS circuit is active, and will suspend its transmission within 25 ms of the circuit being taken inactive.

13.2.7.2 ENQ/ACK

For ENQ/ACK flow control, the HP 37741A ignores the state of the incoming control circuits, and it will permanently assert the CTS circuit.

The test set will send to the external equipment an ENQ character before the transmission of any data, and will subsequently send an ENQ character every 128 data characters. The test set will not transmit data to the external equipment unless it receives an ACK character in response to an ENQ character, but instead will regularly send the ENQ character.

If it receives an ENQ character from the external equipment, the HP 37741A does not respond with an ACK character.

13.2.7.3 XON/XOFF

For XON/XOFF flow control, the HP 37741A ignores the state of the incoming control circuits, and permanently asserts the CTS circuit.

The test set sends data to the printer until it receives a DC3 (XOFF) character from the printer. The test set will resume transmission when it receives a DC1 (XON) character, or when more than one second has passed since the receipt of a DC3 character.

The test set never transmits an XON or XOFF character.

13.2.8 Port on the HP 37741A Option H01

The rackmountable version of the instrument has its serial port parameters pre-defined as follows:

- usable only for external control
- configured as a DCE (the same as the handheld unit)
- 9600 b/s, no parity, 8 data bits, 1 stop bit, RTS/CTS flow control (96,N,8,1,H)

These parameters cannot be modified.

13.3 Printer Output

The HP 37741A has been designed to operate with a variety of printers, including small handheld thermal printers, dot matrix printers, HP ThinkJet printers, and HP LaserJet printers. No special control codes are used, and two widths are available for printouts.

13.3.1 Print Format

13.3.1.1 Narrow Width

The format for this printout is shown in figure 13-5. The test set sends 27 characters per line followed by a carriage return and line feed. There are 100 lines, and at the end of the printout, three CR LF combinations are sent.

13.3.1.2 Wide Width

The format for this printout is shown in figure 13-6. The test set precedes each line of text with five space characters to allow room to punch holes in the paper. There are 57 characters of text; a carriage return line feed is sent at the end of each line except the last. There are 60 lines of text. A form feed character is sent at the end of the last line.

13.3.1.3 During a Test

The print formats shown in figures 13-5 and 13-6 apply to only the first printout during a test, unless you have modified the set configuration during the test.

The second and subsequent printouts do not repeat the configuration data, but instead print the current time and elapsed test time, and then print the results, starting with the signal results. As with the first print out, three CR LF combinations end a narrow printout, and a FF ends a wide printout.

When you have changed the instrument's configuration during a test (in the [SET] menus), the abbreviated format is not used for the subsequent printout.

13.3.1.4 Sequential Test Results

When you print the results of a sequential test, they are printed at the end of the standard printout. Samples are shown in figure 13-7 for the narrow format, and 13-8 for the wide format. When a sequential test has fewer than 21 patterns, fewer lines are printed than shown in the examples.

The printed results include the logic errored seconds for each pattern, which cannot be viewed from the instrument's display.

13.3.2 Initiating a Printout

You can initiate a printout in any of four ways:

- on demand
- at a fixed time frequency during a test
- at the end of a test
- on certain events, such as alarms or high errors

```
=========================
  HP 37741A DS1 Tester
 Unit ID: 1234567890123

Cct ID ________________

Person ________________
Now  hh:mm:ss  yy/mm/dd Www
Unit last calbrtd  yy/mm/dd
Pwr On   hh:mm:ss  yy/mm/dd
Pwr Off  hh:mm:ss  yy/mm/dd
-------------------------
  Transmit Config: FullT1
TS ************************
Frame  D3/D4  DataLnk  dflt
Code  AMI     Timing  intnl
Payload 2^20-1 (SigReins N)
LoopCode   Payload      off
Ch 12     -13 dBm0, 1004 Hz
ABCD=----       Alarm  none
Errors  BPV:N logic:N CRC:N
-------------------------
  Receive Config: M=Auto
TS ************************
Inputs               bridge
LoopBack       auto respond
Frame         auto identify
-------------------------
      Test Status:
Test duration      hh:mm:ss
Elapsed            hh:mm:ss
Started  yy/mm/dd  hh:mm:ss
Will end yy/mm/dd  hh:mm:ss
-------------------------
         Signal:
Lvl    0.1 Vpp, -35.7 dBdsx
Freq   +065 ppm, 1544100 Hz
Simplex Current      128 mA
Unit Loop Stts   not looped
-------------------------
       Code: B8ZS
BPV                    1234
ES                       97
EFS                     251
%EFS                 72.16%
BER                2.3 E-06
Last resync time      63 ms
```

```
Excess zeroes count      76
Density viol count      638
-------------------------
        Bit Slips:
Total                +0;190
Current direction      slow
Estimated frame slips     1
Relative bit slips        2
-------------------------
         Alarms:
LOS                0 s  OFF
AIS               14 s   ON
Frame Loss         0 s  OFF
Pattern Loss      17 s  OFF
Yellow             2 s  OFF
-------------------------
   Frame: ZBTSI, Full T1
TS ************************
EC                     6341
ES                       17
OOF count                45
COFA count                2
average ER          2.3E-06
-------------------------
          CRC:
EC                     1234
ES                       97
EFS                     251
%EFS                 72.97%
average ER          2.3E-06
-------------------------
  Logic: 3in24, 1536 kb/s
EC                     1234
ES                       97
EFS                     251
%EFS                 72.41%
BER                  2.3 E-6
UAS                      99
SES                    1063
CSES                    751
%SES                 17.45%
availability         88.54%
DM                        6
-------------------------
 Channel:17   Time Slot:17
Tone amplitude    -6.0 dBm0
Hi=+102  Lo=-102  ABCD=0101
=========================
```

Figure 13-5 Narrow Print Format

```
              HP 37741A DS1 Tester - Unit ID: 1234567890123

Cct ID ____________________        Person ____________________
Now  hh:mm:ss  yy/mm/dd Www        Unit last calbrtd  yy/mm/dd
Pwr On    hh:mm:ss  yy/mm/dd       Pwr Off  hh:mm:ss  yy/mm/dd
-----------------------------------------------------------------
                    Transmit Config: FT1/64
TS ********................        Frame    D3/D4  DataLnk dflt
Code  AMI        Timing intnl      Payload 2^20-1 (SigReins N)
LoopCode        4bit up     8s     Ch 22       -13 dBm0, 1004 Hz
ABCD=----        Alarm    none     Erors    BPV:N logic:N CRC:N
-----------------------------------------------------------------
                    Receive Config: M=Auto
TS ************************        Inputs                 bridge
LoopBack          auto respond     Frame           auto identify
-----------------------------------------------------------------
                          Test Status:
Test duration         hh:mm:ss     Elapsed              hh:mm:ss
Started  yy/mm/dd     hh:mm:ss     Will end yy/mm/dd    hh:mm:ss
-----------------------------------------------------------------
                            Signal:
Lvl    0.1 Vpp, -35.7 dBdsx        Freq    +065 ppm, 1544100 Hz
Simplex Current         128 mA     Unit Loop Stts     not looped
-----------------------------------------------------------------
                          Code: B8ZS
BPV                       1234     ES                         97
EFS                        251     %EFS                   72.34%
BER                    2.3E-06     Last resync time        63 ms
Excess zeroes count         76     Density viol count        638
-----------------------------------------------------------------
                          Bit Slips:
Total                   +0;190     Current direction        slow
Estimated frame slips        1     Relative bit slips          2
-----------------------------------------------------------------
                            Alarms:
LOS                  0 s  OFF      AIS                  14 s  ON
Frame Loss           0 s  OFF      Pattern Loss         17 s  OFF
Yellow               2 s  OFF
-----------------------------------------------------------------
                     Frame: ZBTSI, FT1/64
TS ****************........        EC                      6341
ES                          17      OOF count                 45
COFA count                   2      average ER           2.3E-06
-----------------------------------------------------------------
                             CRC:
EC                        1234      ES                        97
EFS                        251      %EFS                  72.34%
average ER             2.3E-06
-----------------------------------------------------------------
                  Logic: 3in24, 1024 kb/s
EC                        1234      ES                        97
EFS                        251      %EFS                  72.34%
BER                   2.3 E-6       UAS                       99
SES                       1063      CSES                     751
%SES                    17.18%      availability          88.34%
DM                           6
-----------------------------------------------------------------
                  Channel:17    Time Slot:17
Tone amplitude     -6.0 dBm0    Hi=+102 Lo=-102      ABCD=1010
```

Figure 13-6 Wide Print Format

Bridge Tap

On loop	63
Pattern	3in20

Ptn	LgcEC	LgcES	SyncS
all 1	0	0	315
1/0	0	0	315
1in4	0	0	315
1in6	0	0	315
1in7	4137	315	315
1in8	0	0	315
2in10	0	0	315
2in11	0	0	315
2in12	0	0	315
2in13	0	0	315
2in14	0	0	315
2in15	0	0	315
2in16	0	0	315
3in18	147639	315	315
3in19	0	0	315
3in20	0	0	310
3in21	0	0	310
3in22	62128	310	310
3in23	53194	310	310
3in24	0	0	310
QRW	0	0	310

Figure 13-7 Sequential Test Print Format (Narrow)

Bridge Tap

On loop	63	Pattern	3in22

Ptn	LgcEC	LgcES	SyncS	Ptn	LgcEC	LgcES	SyncS
all 1s	0	0	315	2in15	0	0	315
1/0	0	0	315	2in16	0	0	315
1in4	0	0	315	3in18	147639	315	315
1in6	0	0	315	3in19	0	0	315
1in7	4137	315	315	3in20	0	0	315
1in8	0	0	315	3in21	0	0	315
2in10	0	0	315	3in22	68941	315	315
2in11	0	0	315	3in23	53194	310	310
2in12	0	0	315	3in24	0	0	310
2in13	0	0	315	QRW	0	0	310
2in14	0	0	315				

Figure 13-8 Sequential Test Print Format (Wide)

The action that triggers a printout does not affect the data printed, nor the print format.

When a printout is initiated, the data is temporarily saved in memory. Thus, the data printed on the last line is captured at the same time as the data printed on the first line, and the values printed are independent of printer speed.

13.3.2.1 On Demand, "Now"

A printout will immediately be started. To print results that have been saved in memory from a previous test, recall the results, and then use the print now function.

Initiating a printout while a test is running, and the printer is configured to periodically print, does not affect the time at which the next periodic print will occur. For example, suppose you configure the instrument to print every hour, and a scheduled printout occurs at 9:00. If you initiate an immediate printout at 9:15, the next scheduled printout would occur at 10:00.

13.3.2.2 At a Fixed Period

A printout will be made periodically. If the print period was set up before the start of the test, the first printout will happen at the chosen time period after the start of the test. If the print frequency was set up during the test, the first printout will happen at the chosen time period after the print period was set up.

When the test ends because the test has run for the chosen test time duration, another printout will be issued. This will happen irrespective of when the last printout occurred. You should therefore take care when setting the print frequency. For example, if the test time is 16 minutes, and the print period is 15 minutes, you will get two printouts one minute apart.

If a printout is still in progress at the end of the test, the final results will be printed when the other printout is complete, provided you do not start another test in the meantime.

If the periodic results printout coincides with the end of the test (for example, if the print frequency is 15 minutes and the test time is 30 minutes), the HP 37741A will cause only one printout at the end of the test.

The accumulated time for the periodic printout is based on real time (time of day) and not on elapsed test time. If a test automatically restarts, or when sequential tests are run, these two times are not the same.

If you manually stop a test, the results are not automatically printed. You can print them by selecting "print now", if desired.

13.3.2.3 At the End of a Test

This causes a printout of the results when the test has run for the preset duration. If you stop the test before it has run for the preset duration, no printout is made. This setting has no effect when the test time is set for continuous.

If a sequential test is running, this setting causes a printout when the test has run for the specified number of loops of the sequence.[1]

13.3.2.4 On Certain Events

You can select the "event" to be when high errors occur, or an alarm occurs, or both. The maximum rate at which a printout will be initiated is every 100 seconds, irrespective of the rate that the events are occurring.

If, because of the high rate at which events are occurring, there have been ten successive printouts (each 100 s apart), printouts caused by events will be suspended for 10 minutes. The alarm events that can trigger a printout are:

- LOS
- AIS
- FLS (provided that the test set was in frame at the start of the test)
- PLS (provided that the test set was in pattern sync at the start of the test)
- yellow

The high errors that can trigger a printout are:

- received frequency being more than 50 ppm from nominal
- more than 1544 BPVs received in a second
- more than 10 frame bit errors or 100 CRC errors received in a second
- a logic SES

Printing on certain events is valid when running sequential tests. This may be a problem when running a bridgetap test and the line under test has faults. It is then preferable to print periodically, or at the end of the test.

1 During a sequential test, the instrument stops and starts the test frequently. Printing is suppressed during these times.

13.3.3 Print Error

If the HP 37741A is unable to print because the printer does not respond to the selected flow control, the printout will be suspended. The instrument will then give two short beeps on the internal speaker every minute. The print results will be kept until:

- you cancel the printout
- another printout is automatically initiated
- the printer responds to the flow control, and the results are printed
- you manually stop the test if one was running
- the test set is turned off

13.3.4 Connecting to the HP 15727A Battery Operated Thermal Printer

To connect to this printer (which is the Seiko DPU-201GS printer), set the HP 37741A EIA-232 port's usage to printer – narrow, no parity, 8 data bits, RTS/CTS flow control, 9600 b/s.

Configure the DIP switches on the side of the printer to be as shown in figure 13-9.

SW1	SW2	SW3	SW4	SW5	SW6
ON	ON	OFF	OFF	OFF	ON

Figure 13-9 DIP Switch Settings for HP 15727A Printer

Connect the HP 37741A DS1 Tester to the HP 15727A Battery Operated Thermal Printer with the HP 15734A cable or equivalent.

13.3.5 Connecting to the HP 15733A Battery Operated Thermal Printer

To connect to this printer (which is the Seiko DPU-411 printer), set the HP 37741A EIA-232 port's usage to printer – wide, no parity, 8 data bits, RTS/CTS flow control, 9600 b/s.

Configure the DIP switches on the base of the printer to be as shown in figure 13-10.

SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8
OFF	OFF	OFF	ON	OFF	OFF	ON	ON

Figure 13-10a 8 Position DIP Switch

SW1	SW2	SW3	SW4	SW5	SW6
ON	ON	OFF	OFF	OFF	OFF

Figure 13-10b 6 Position DIP Switch

Figure 13-10 DIP Switch Settings for HP 15733A Printer

Connect the HP 37741A DS1 Tester to the HP 15733A Battery Operated Thermal Printer with the HP 15750A cable or equivalent.

13.4 External Control

13.4.1 General

An efficient protocol is used by the HP 37741A to allow the instrument to be externally controlled. The protocol uses binary data, and requires a computer as a controller. Control software is available as an accessory – this is listed in appendix D.

Most of the functions that can be done from the instrument front panel can be done with external control. The following are the exceptions:

- Configuring the serial port. Also, you cannot use the serial port to obtain a printout when the port is used for external control.
- Running any of the special tests (self test, bridge tap, multipattern, or user programmable sequences). These functions can be emulated by the remote control software.

Additional functions that can be performed externally which cannot be done from the front panel are:

- disabling the front panel keys
- programming the user words and channel words
- programming the user test sequences
- saving pre-defined configurations

- changing the SLC-96 data link
- performing calibration

The HP 37741A responds only to a command issued from the host computer – it never sends an unsolicited message to the host.

The message length is variable, with a maximum length in either direction of 72 bytes. The message length is transmitted as part of the message. Apart from the simple check on the length of the message, there is no error checking involved in the protocol in either direction. Therefore, when using modems to remotely control the HP 37741A, you should use modems with built-in error correction, such as V.42 (or better) or MNP-3 (or better).

If a screen is being displayed by the test set, and an external command modifies parameters on that screen, the displayed parameters are updated to reflect the received command.

13.4.2 Message Format: Computer to HP 37741A

The three byte header contains one byte for the message length, one byte for the opcode, and one byte for the message sequence number. The message length, L, is the number of message bytes, including the header. The minimum is therefore three. The maximum message length is 72 bytes, so the maximum instruction length is 69 bytes. This is shown in figure 13-11.

The message sequence number, MSN is always returned in the response to the host. The MSN must be changed by the host whenever it receives a valid reply to a command.[1] When the host fails to get a reply from the test set, the host should re-transmit the message using the same MSN. When the MSN changes, the test set will clear status bits that were reported to the host with the previous message. This prevents duplicate bad status messages being returned and obviates the requirement for an acknowledge status command from the host.

1 The same command may be repeated with the same MSN.

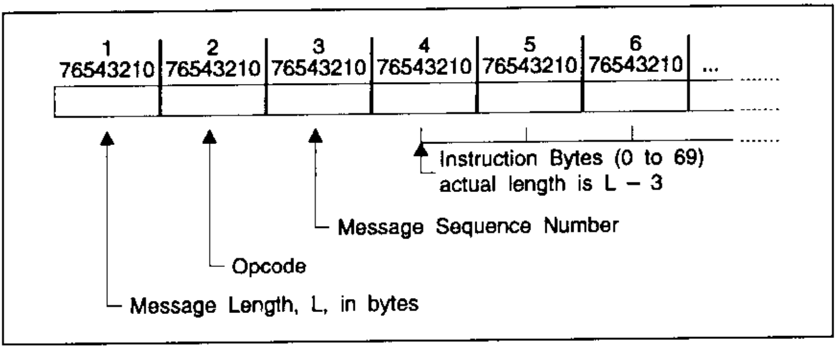


Figure 13-11 Computer to HP 37741A

13.4.3 Message Format: HP 37741A to Computer

The HP 37741A ignores commands in which the number of characters received does not match that indicated in the command, or commands with an invalid opcode. The reply format is shown in figure 13-12.

The **message sequence number** is an echo of that which was received. This is not used for queued messages.

The two byte header contains one byte for the message length, and one byte for the message sequence number. The **message length**, L, is the number of message bytes, including the header. The minimum is therefore two. The maximum message length is 72 bytes, so the maximum response length is 70 bytes. This is shown in figure 13-12.

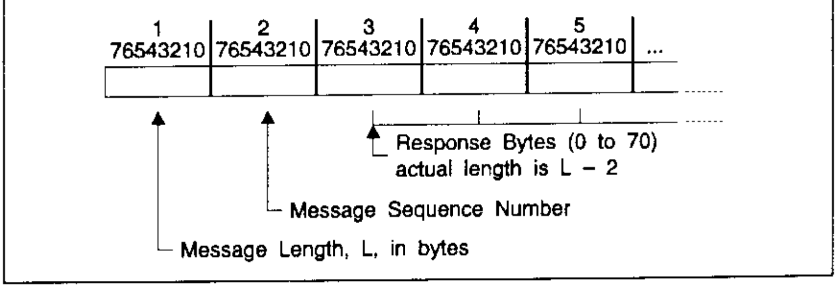


Figure 13-12 HP 37741A to Computer

The test set replies to *all* commands that are legal and valid. In the details of each command that follows, where the response is listed, this means the contents of the reply (if any). If the comment "None" is shown, this means that the response length is 0, but the **message length** and MSN are always returned.

13.4.4 Timeouts

The test set responds to valid commands. If an erroneous command is received, the instrument will ignore it. The host should then time out, and resend the command.

When a command has been partially received by the HP 37741A, the instrument waits 200 ms (at 9600 b/s) for the command to be completed. It will discard the partially received part of the command if no further parts of the command are received. This permits use of the instrument remotely, over a packet network, or error correcting modems, for which byte reception may be sporadic. At 4800 b/s the timeout is 400 ms, at 2400 b/s the timeout is 800 ms, and at 1200 b/s the timeout is 1.6 s.

When the instrument believes it has received a valid command, it will wait 12.5 ms (at 9600 b/s). If further characters are received in this period, it will discard the command. This prevents a longer command, whose start has been corrupted, from emulating a shorter command. At 4800 b/s the wait period is 25 ms, at 2400 b/s the wait period is 50 ms, and at 1200 b/s the wait period is 100 ms.

It is therefore recommended that the host wait at least 250 ms (at 9600 b/s) after sending a command before timing out and resending the command. This period will need to be longer if operating over congested packet networks, or over satellites.

13.4.5 Instrument Memory Map: Results

Figure 13-13 shows how the storage within the HP 37741A is organized. There are eight distinct memory areas, identified as 0 to 7. The arrows in the figure indicate in which directions the data can flow.

All results and configurations passed to the host are taken through the *temporary* buffer, number 6. It is the host's responsibility to move the correct data into the buffer for uploading. Results cannot be downloaded; all downloaded configurations take effect immediately. Data is moved by using the **Save or Recall Results** command.

The *temporary* buffer allows the host to take a snapshot of the results, and then gather the data at a suitable pace. When results are moved to the *temporary* buffer, they are guaranteed to be time aligned.

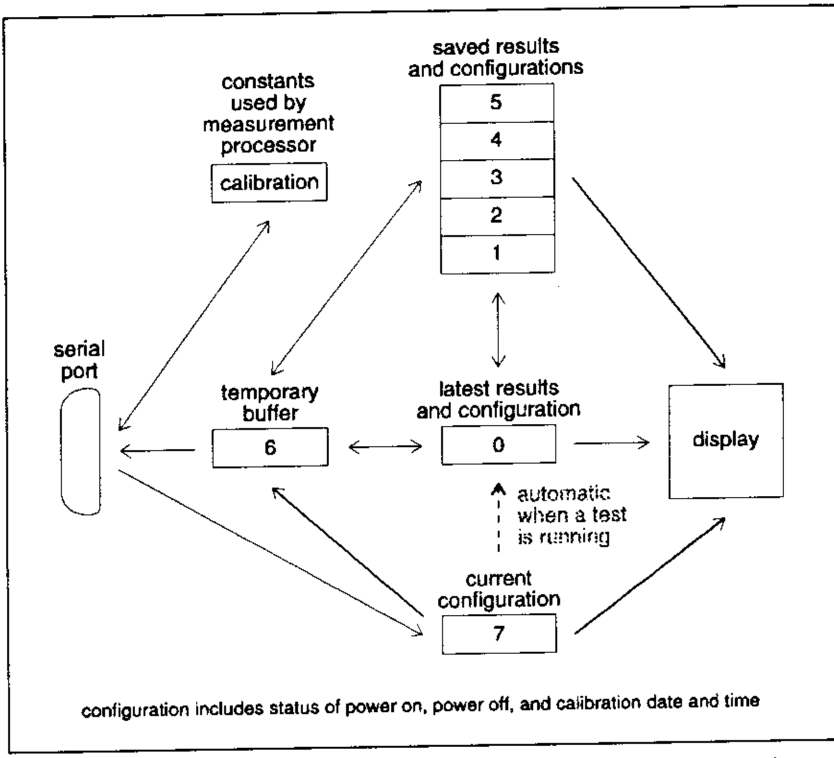


Figure 13-13 Internal Memory Map for Results and Configurations

When a test is running, the *latest results and configuration* buffer holds the results of the test in progress. Also, the configuration saved in that buffer is equal to the data in the *current configuration* buffer. When the test is stopped, the current configuration can be different from that in the *latest results and configuration* buffer. When the *current configuration* buffer is copied to the *temporary* buffer, the results in the *temporary* buffer become meaningless.[1]

13.4.6 Instrument Memory Map: Setups

Figure 13-14 shows how the storage within the HP 37741A is organized for the pre-defined setups. There are six distinct memory areas, identified as 0 to 5. Areas 6 and 7 are the same areas described in section 13.4.5. The arrows in the figure indicate in which directions the data can flow.

1 There may be up to a one second delay following a change in configuration, and the data being copied to the latest results buffer.

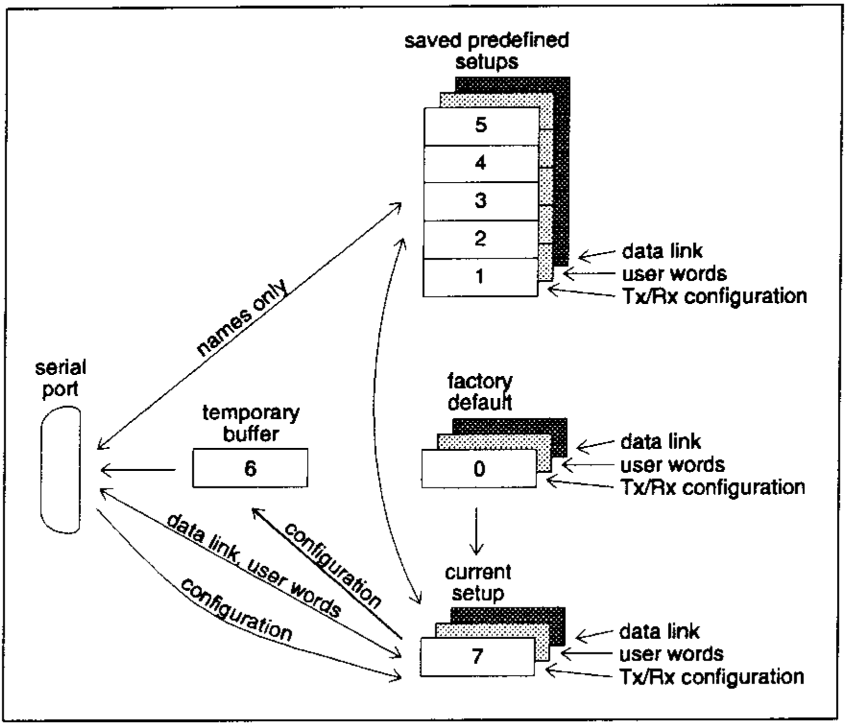


Figure 13-14 Internal Memory Map for Setups

The *factory default* setting can never be overwritten. The pre-configured setups can be saved in memory only by a command over the serial port. Names are assigned at the time that the setup is saved.

The setups can be recalled from either the front panel,[1] or by an external command.

The programmable test patterns (user words and channel words) and the programmable data link are also saved and recalled when these commands are executed.

1 Screen 2600, which is described in section 5.2.

13.4.7 Values

The following notation is used to denote the size and format of the values passed between the HP 37741A and the computer:

ushrt — 1 byte, unsigned

char — 1 byte, unsigned. This can be only one of the following valid characters: 0 to 9, A to Z, a to z, and the space character (20H). When a string of char is specified, the string must be the exact length specified, and unused bytes can be filled with space characters or the null character (\0). A null character must terminate the string.

char — 1 byte, unsigned. This can be only one of the following valid characters: 0 to 9, A to Z, and the space character (20H). When a string of char is specified, the string must be the exact length specified, and unused bytes can be filled with space characters or the null character (\0). A null character must terminate the string.

shrt — 1 byte, signed (2s complement)

uint — 2 bytes, unsigned

int — 2 bytes, signed (2s complement)

ulong — 4 bytes, unsigned

long — 4 bytes, signed (2s complement)

float — 4 bytes, bit 31 is the sign, bits 22 to 30 are the biased exponent, and bits 0 to 21 are the significand

time — 3 byte structure as follows:

1 byte	hour	0 to 23 (0 to 24 if a test time)
1 byte	minute	0 to 59
1 byte	second	0 to 59

stime — 7 byte structure as follows:

1 byte	year	92 is 1992, 93 is 1993, ...
1 byte	month	1 is January, 2 is February, ...
1 byte	day	1 to 31 (0 to 255 if a test time)
1 byte	weekday	0 is Sunday, 1 is Monday, etc.
1 byte	hour	0 to 23 (0 to 24 if a test time)
1 byte	minute	0 to 59
1 byte	second	0 to 59

The transmission order for quantities longer than one byte passed between the test set and the computer is the same in both directions. The least significant byte is transmitted first, and would therefore be saved in memory in the lowest byte. Higher order bytes are transmitted later, and are saved in the high memory (assuming that the buffer goes up in memory). This sequence is compatible with native C compilers running on a PC.

13.4.8 Error Responses

All commands which specify values are checked by the HP 37741A. If any value is out of range, the command will be rejected, and the response will indicate that the command was not accepted. The settings of the error code byte are as follows:

- 0 to indicate no error
- 1 to indicate a bad value (command ignored)
- 2 to indicate that a test is running, and the command is ignored (used only by commands 6 and 9)

13.4.9 Commands

13.4.9.1 Echo

Function	Allows the host to determine the instrument type. This command can be sent periodically to prevent the test set from turning off (see section 14.3 for more information).	
Opcode	1	
Instruction	None.	
Response	char[17]	"HP 37741A", followed by a null character and 7 other characters if the standard product, or "HP 37741A H01" followed by a null character and 3 other characters if the rackmountable product.

13.4.9.2 Upload System Summary

Function	Allows the host to obtain data from screen 2500. This information is taken through the test set's temporary buffer.
Opcode	2
Instruction	None

Response	stime	calibration date and time
	stime	power on date and time
	stime	power off date and time
	char[6]	hardware revision
	char[6]	software revision

13.4.9.3 Disable or Enable Keys

Function: Disables or enables some or all of the instrument's front panel keys. On power on, all of the keys are re-enabled.

Opcode: 3

Instruction: ushrt — Selection as follows:

0	disable all keys except POWER
1	disable all keys
2	enable all keys

Response: ushrt — error code

13.4.9.4 Turn Power Off

Function: Turns off the instrument power. This will stop (not suspend) any test in process. The power can subsequently be turned on by asserting DTR as described in section 14.2.3.

Opcode: 4

Instruction: None.

Response: None – the test set completes the transmission of its reply before turning itself off.

13.4.9.5 Upload Test Times

Function: Retrieves the test times from the test set's temporary buffer.

Opcode: 5

Instruction: None.

Response: 24 bytes:

time	total test duration *(configured time)*
stime	start date and time
stime	stop date and time
time	test time left
ushrt	elapsed test duration, days
time	elapsed test duration, hh:mm:ss

When the test is continuous, the three bytes of the ***total test duration*** are all set to zero, and the ***stop date and time*** value is meaningless. The ***elapsed test duration in days*** may take any value from 0 to 255.

When the test period is fixed, the hour value in the ***total test duration*** may be in the range 0 to 24. If set to 24, the minutes and seconds are both zero.

When no test is running, regardless of whether the test period is fixed or continuous, all three bytes of the ***test time left*** are set to zero. When a test is running, at least one of these bytes is non-zero.

When a sequential test is running, the most significant bit of the hour value of the ***total test duration*** is set to one. The rest of that byte represents the number of loops that has been programmed. 0 is used to indicate a setting of continuous. The hour value of the ***elapsed test duration*** is then used to indicate the number of loops so far executed. This may take the value from 0 to 255. The instrument can display up to 999 loops. When the number of loops executed is greater than 255, this number remains at 255.

13.4.9.6 Set Test Time

Function	Host can change the instrument's test duration. The HP 37741A will not act on this command if a test is running.	
Opcode	6	
Instruction	time	Test time duration. All bytes are set to zero to indicate continuous.
Response	ushrt	error code

13.4.9.7 Start or Stop Test

Function	Host can start, stop, or restart a test. If a command to start a test is received while the test is running, the test will be stopped, the results cleared, and a new test started.		
Opcode	7		
Instruction	ushrt	Start or stop:	
		0	stop test
		1	start test

Response ushrt error code

13.4.9.8 Upload Result Times

Function: Host can retrieve the times when each of the stored test results were stopped. The result times may not be ordered in chronological order, but their order is important, and must be recorded for use with the **Save or Recall Results** command.

Opcode: 8

Instruction: None.

Response: 35 bytes:

stime[5] time structures

13.4.9.9 Save or Recall Results

Function: Host can cause the current results to be copied to the instrument's long term storage, or cause a previously stored result to be retrieved from storage. You cannot use the latest results storage as a destination when a test is running.

The temporary results location is used to upload the current, or any saved, results and configurations.

The current configuration can be used only as a source, and copied only to the temporary results buffer.

Opcode: 9

Instruction:

Instruction	ushrt	Result number – source:	
		0	latest results
		1 to 5	saved result buffer – in the same order as was retrieved with the **Upload Result Times** command
		6	temporary results buffer
		7	current configuration
	ushrt	Result number – destination:	
		0	latest results
		1 to 5	saved result buffer – in the same order as was retrieved with the **Upload Result Times** command
		6	temporary results buffer

Response ushrt error code

13.4.9.10 Upload Transmit Configuration

Function: Retrieves the transmit configuration from the test set's temporary buffer.

Opcode: 10

Instruction: None.

Response: 28 bytes:

ushrt	Mode (this byte is ignored if the frame format is unframed):		
	0	as receiver	
	1	full T1	
	2	FT1 n × 64 kb/s	
	3	FT1 n × 56 kb/s	
ushrt[3]	Timeslot map. The 24 bits are set to a 1 if the timeslot is used, and set to 0 if unused. The MSB of the first byte represents timeslot 01, the LSB of the third byte represents timeslot 24.		
ushrt	reserved for idle code		
ushrt	Line code:		
	0	as input	
	1	B8ZS	
	2	AMI	
ushrt	reserved for attenuation		
ushrt	Timing:		
	0	internal	
	1	from reference	
	2	from main (loop timed)	
ushrt	Loop code type:		
	0	as input	
	1	line	
	2	4 bit	
	3	NI	
	4	payload	
ushrt	Loop code duration:		
	0	none (off)	
	1	loop up, 8 seconds	
	2	loop up continuous	
	3	loop down, 8 seconds	
	4	loop down continuous	
ushrt	Alarms:		
	0	none	
	1	as input	

	2	LOS
	3	AIS
	4	yellow
ushrt	Frame:	
	0	unframed
	1	as input
	2	D1D
	3	D2
	4	D3/D4
	5	SLC-96
	6	ESF
	7	ZBTSI
ushrt	Payload:	
	0	as input
	1	through
	2	all 0s
	3	all 1s
	4	alternating 1/0
	5	1 in 8
	6	2 in 8
	7	3 in 24
	8	QRW
	9	$2^{11}-1$
	10	$2^{15}-1$
	11	$2^{20}-1$
	12	$2^{23}-1$
	13	channel word 1
	14	channel word 2
	15 to 20	invalid
	21	user word 1
	22	user word 2
	23	user word 3
	24	user word 4
	25	1 in 4
	26	1 in 6
	27	1 in 7
	28	2 in 10
	29	2 in 11
	30	2 in 12
	31	2 in 13
	32	2 in 14
	33	2 in 15

	34	2 in 16
	35	3 in 18
	36	3 in 19
	37	3 in 20
	38	3 in 21
	39	3 in 22
	40	3 in 23
	41	2 in 8#
	42	bridge tap code word
	43	multipattern code word
	44	user sequence code word
ushrt	Signaling reinsertion:	
	0	off
	1	on
ushrt	Data Link:	
	0	default (normal)
	1	through
ushrt	Channel:	
	1 to 24	channel number
ushrt	Tone amplitude:	
	0	off (no tone injected)
	1	0 dBm0
	2	−3 dBm0
	3	−6 dBm0
	4	−10 dBm0
	5	−13 dBm0
	6	−16 dBm0
	7	−24 dBm0
	8	idle
ushrt	Tone frequency (ignored if the tone is off):	
	0	304 Hz
	1	404 Hz
	2	420 Hz
	3	820 Hz
	4	1004 Hz
	5	1020 Hz
	6	1800 Hz
	7	2280 Hz
	8	2600 Hz
	9	2713 Hz
	10	2804 Hz
	11	3404 Hz

	12	3 tone slope
	13	sweep
ushrt	Signaling	
	0	A = 0 B = 0 C = 0 D = 0
	1	A = 0 B = 0 C = 0 D = 1
	2	A = 0 B = 0 C = 1 D = 0
	...	...
	15	A = 1 B = 1 C = 1 D = 1
	16	unmodified
ushrt	reserved for other signaling	
	16	unmodified
ushrt	Bipolar violation error insertion	
	0	no errors
	1 to 9	insert errors one per second
	10	insert continuously
ushrt	Logic error insertion	
	0	no errors
	1 to 9	insert errors one per second
	10	insert continuously
ushrt	reserved for frame error insertion	
	0	no errors
ushrt	CRC error insertion	
	0	no errors
	1 to 9	insert errors one per second
	10	insert continuously
ulong	reserved	

13.4.9.11 Download Transmit Configuration

Function: Allows the host to configure the current transmit configuration. This new data is not placed in the test set's temporary buffer, but is instead acted on directly. This command can be issued even when the instrument is looped back. It will not then normally affect the output.

Opcode: 11

Instruction: 28 bytes — same sequence and meaning as for the **Upload Transmit Configuration** command. However, you cannot command the unit to send a payload greater than number 24.

Response: ushrt — error code

13.4.9.12 Upload Receive Configuration

Function	Retrieves the receive configuration from the test set's temporary buffer.		
Opcode	12		
Instruction	None.		
Response	13 bytes:		
	ushrt	Mode (this byte is ignored if the frame format is unframed):	
		0	invalid
		1	full T1
		2	FT1 n × 64 kb/s
		3	FT1 n × 56 kb/s
		4	automatic
	ushrt[3]	Timeslot map. The 24 bits are set to a 1 if the timeslot is used, and set to 0 if unused. The MSB of the first byte represents timeslot 01, the LSB of the third byte represents timeslot 24.	
	ushrt	Input:	
		0	DSX monitor
		1	terminate
		2	bridge
	ushrt	Loopback:	
		0	do not respond
		1	auto respond
		2	unloop
	ushrt	Frame:	
		0	none (unframed)
		1	auto frame
		2	D1D
		3	D2
		4	D3/D4
		5	SLC-96
		6	ESF
		7	ZBTSI
	ushrt	Superframe channel sequence:	
		0	D1D
		1	D2
		2	D3/D4
		3	SLC-96
	ushrt	DS0 receive channel:	
		1 to 24	channel number

ulong	reserved

13.4.9.13 Download Receive Configuration

Function Allows the host to configure the current transmit configuration. This new data is not placed in the test set's temporary buffer, but is instead acted on directly.

Opcode 13

Instruction 13 bytes same sequence and meaning as for the **Upload Receive Configuration** command

Response ushrt error code

13.4.9.14 Upload Signal Output

Function Allows the host to obtain the actual state of the transmitted signal. This is the current status, and is not passed through the temporary buffer.[1]

Opcode 14

Instruction None

Response 28 bytes. The response is similar to that of the **Upload Transmit Configuration** command. The differences are given below; the meanings of the other bytes are identical:

ushrt	Mode:	
	0	none (not yet identified)
	1	full T1
	2	FT1 n × 64 kb/s
	3	FT1 n × 56 kb/s
ushrt[3]	timeslot map	
ushrt	reserved for idle code	
ushrt	Line code:	
	0	none (not yet identified)
	1	B8ZS
	2	AMI
ushrt	timing	
ushrt	Loop code:	
	0	none
	1	line up
	2	line down
	3	4 bit up

1 The signal output is not saved as part of the results.

	4	4 bit down
	5	NI up
	6	NI down
	7	payload up
	8	payload down
ushrt	Loopback second counter: When a timed loop code has been configured, this counts down by 1 (from 8 to 0) every second.	
ushrt	alarms	
ushrt	Frame:	
	0	unframed
	1	as input
	2	D1D
	3	D2
	4	D3/D4
	5	SLC-96
	6	ESF
	7	ZBTSI
	8	DLC
ushrt	Payload:	
	0	unknown
	1	through
	2	all 0s
	3	all 1s
	4	alternating 1/0
	5	1 in 8
	6	2 in 8
	7	3 in 24
	8	QRW
	9	$2^{11}-1$
	10	$2^{15}-1$
	11	$2^{20}-1$
	12	$2^{23}-1$
	13	channel word 1
	14	channel word 2
	15	line up
	16	line down
	17	4 bit up
	18	4 bit down
	19	NI up
	20	NI down

	21	user word 1
	22	user word 2
	23	user word 3
	24	user word 4
	25 to 44	same as used in the **Upload Transmit Configuration** command

ushrt	signaling reinsertion
ushrt	data link
ushrt	channel
ushrt	tone amplitude
ushrt	Tone frequency (ignored if the tone is off). If the test set is configured to transmit a continuous tone, the values have the same meaning as for the **Upload Transmit Configuration** command. If a 3 tone slope or a sweep has been configured, this byte represents the currently transmitted frequency divided by 100. For example, the byte is set to 12 if 1204 Hz is currently being transmitted.
ushrt	signaling
ushrt	reserved for other signaling
ushrt	Bipolar violation error insertion:

	0	no errors
	1 to 9	the number of errors which have been sent out; reset after preprogrammed number of errors have been sent
	10	insert continuously

ushrt	Logic error insertion:

	0	no errors
	1 to 9	the number of errors which have been sent out; reset after preprogrammed number of errors have been sent
	10	insert continuously

ushrt	reserved
ushrt	CRC error insertion:

	0	no errors

	1 to 9	the number of errors which have been sent out; reset after preprogrammed number of errors have been sent
	10	insert continuously
ushrt	Far end loop indication	
	0	unknown
	1	looped
	2	un-looped
ulong	reserved	

13.4.9.15 Upload Miscellanea

Function: Allows the host to obtain miscellaneous data on the test set's configuration. This data is not taken through the temporary buffer.

Opcode: 15

Instruction: None

Response: 31 bytes:

ushrt	Key beep:	
	0	off
	1	click
	2	tone
stime	current date and time	
ushrt	Date display mode:	
	0	yy/mm/dd
	1	mm/dd/yy
	2	dd/mm/yy
ushrt	Time display mode:	
	0	12 hours
	1	24 hours
char[14]	unit ID	
ushrt	Volume:	
	0	off
	1 to 15	on
ushrt	contrast, 0 to 15	
ushrt	Backlight:	
	0	off
	1	on
ulong	reserved	

13.4.9.16 Download Miscellanea

Function	Allows the host to set the miscellaneous data. This does not go through the test set's internal buffer, but is instead acted on directly.	
Opcode	16	
Instruction	31 bytes	in the same sequence and meaning as for the Upload Miscellanea command.
Response	ushrt	error code

13.4.9.17 Upload Date, Time, and Battery

Function: Allows the host to read the instrument's real time clock value, and the state of the battery. This is the current status, and is not passed through the temporary buffer.

Opcode: 17

Instruction: None

Response: 8 bytes:

stime	current date and time	
ushrt	Battery state:	
	0	battery OK
	1	battery low
	2	charging

13.4.9.18 Upload Channel Words

Function: Allows the host to retrieve the channel words.

Opcode: 18

Instruction: None

Response: 60 bytes

char[6]	name of channel word number one
24 bytes	channel word 1, the first byte being sent after the frame bit (the first timeslot)
char[6]	name of channel word number two
24 bytes	channel word 2 the first byte being sent after the frame bit (the first timeslot)

13.4.9.19 Download Channel Words

Function: Allows the host to set the channel words. The new words will take effect within 100 ms.

Opcode 19

Instruction 60 bytes in the same sequence and meaning as for the **Upload Channel Words** command.

Response ushrt error code

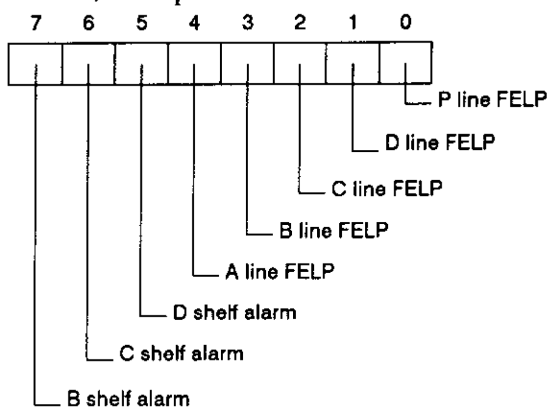
13.4.9.20 Upload Default SLC-96 Data Link

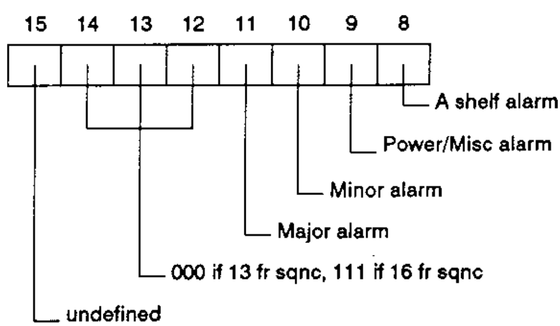
Function Allows the host to read the bits that will be sent on the SLC-96 data link. This command is accepted irrespective of whether SLC-96 frame format is currently being transmitted. See the **Upload Path Results 1** command for details on uploading the received SLC-96 data link.

Opcode 20

Instruction None

Response
uint C field, the LSB is C1
ushrt M field, the LSB is M1
uint A field, bitmap as follows:





ushrt S field, the LSB is S1

13.4.9.21 Download Default SLC-96 Data Link

Function	Allows the host to set the bits that will be sent on the SLC-96 data link. This command is accepted irrespective of whether SLC-96 frame format is currently being transmitted. This takes effect within 100 ms.	
Opcode	21	
Instruction	6 bytes	in the same sequence and meaning as for the **Upload Default SLC-96 Data Link** command.
Response	ushrt	error code

13.4.9.22 Upload Pre-defined Setup Names

Function	Retrieves the names of the five pre-defined configurations from the test set's storage. The order of the names reflects the sequence in memory. This positional information is used for the **Recall Pre-defined Setup** and **Save as Pre-defined Setup** commands.
Opcode	22
Instruction	None
Response	65 bytes: char[5][13] (a two dimensional array)

13.4.9.23 Recall Pre-defined Setup

Function	Copies the saved setup from the unit's memory to the current setup. The change takes place immediately. The setup includes the programmed test patterns (*user words and channel words*), and the saved facility data link setting (see figure 13-14).		
Opcode	23		
Instruction	ushrt	Source location:	
		0	factory default
		1 to 5	saved setting (pre-config)
Response	ushrt	error code	

13.4.9.24 Save as Pre-defined Setup

Function	Copies the current setup to the test set's memory as a saved setup. The setup includes the current configuration, the programmed test patterns (*user words and channel words*), and the saved facility data link setting (see figure 13-14).		
Opcode	24		
Instruction	ushrt	Destination location:	
		1 to 5	saved setting (pre-config)
	char[13]	pre-configured setup name	
Response	ushrt	error code	

13.4.9.25 Upload Line Results

Function	Retrieves the line results from the test set's temporary buffer.		
Opcode	25		
Instruction	None		
Response	50 bytes:		
	uint	Vpp times 100:	
		0FFFFH	over range
		. . .	normal
		0	under range
	int	dBdsx times 10, invalid if the *Vpp times 100* value is over or under range	
	int	Frequency offset, ppm:	
		>+999	over range
		. . .	normal
		<−999	under range
	ulong	frequency, in Hz, invalid if the *frequency offset, ppm* value is over or under range	
	ushrt	simplex current, in mA, invalid if over 250	
	ushrt	Line code:	
		0	none
		1	B8ZS
		2	AMI
	ulong	EC (BPV count)	
	ulong	ES	
	ulong	EFS	
	uint	%EFS times 100	

float	BER	
shrt	Total frame slips:	
	+100	greater than maximum
	+99	+99
	. . .	
	+0	+0
	−1	−0
	. . .	
	−100	−99
	−101	less than minimum
ushrt	total bit slips	
ushrt	Current slip direction:	
	0	no reference input
	1	in sync
	2	fast
	3	slow
	4	overflow, all slip results are invalid
ushrt	Estimated frame slips:	
	0 to 250	normal
	>250	over range
ushrt	relative bit slips	
ushrt	Instrument loop status:	
	0	not looped
	1	line looped
	2	4 bit looped
	3	NI looped
	4	payload looped
ushrt	Received loop code:	
	0	none
	1	line up
	2	line down
	3	4 bit up
	4	4 bit down
	5	NI up
	6	NI down
	7	payload up
	8	payload down
ulong	density violation count	
ulong	excess zeroes count	
ushrt	Resync time in ms:	
	0 to 250	normal
	>250	over range

ulong reserved

13.4.9.26 Upload Path Results 1

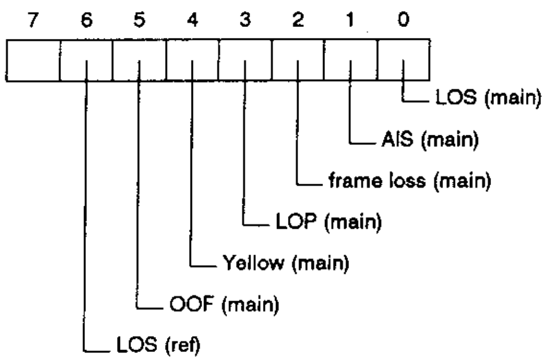
Function: Retrieves the first half of the path results from the test set's temporary buffer.

Opcode: 26

Instruction: None

Response: 61 bytes:

ulong	LOS seconds
ulong	AIS seconds
ulong	frame loss seconds
ulong	pattern loss seconds
ulong	yellow alarm seconds
ushrt	Alarm status at end of last one second:



ushrt	alarm status during the last one second period, bit map as above for alarm status at end 1 s	
ushrt	Received frame format:	
	0	unframed
	1	none, or not identified
	2	D1D
	3	D2
	4	D3/D4
	5	SLC-96
	6	ESF
	7	ZBTSI
	8	DLC-96
ulong	frame EC	
ulong	frame ES	
ulong	OOF count	

ulong	COFA count
float	average frame ER

The following 18 bytes assume different meanings depending on the currently received frame format.

If the frame format is SLC-96:

uint	C field
2 bytes	set to 0
ushrt	M field
3 bytes	set to 0
uint	A field (bit map)
2 bytes	set to 0
ushrt	S field
5 bytes	set to 0

If the frame format is any other frame:

ulong	CRC EC
ulong	CRC ES
ulong	CRC EFS
uint	CRC %EFS times 100
float	CRC average ER

13.4.9.27 Upload Path Results 2

Function: Retrieves the second half of the path results from the test set's temporary buffer.

Opcode: 27

Instruction: None

Response: 50 bytes:

ushrt Received pattern:

0	unknown
1	not used
2	all 0s
3	all 1s
4	alternating 1/0
5	1 in 8
6	2 in 8
7	3 in 24
8	QRW
9	$2^{11}-1$
10	$2^{15}-1$
11	$2^{20}-1$
12	$2^{23}-1$

	13, 14	not used
	15	line up
	16	line down
	17	4 bit up
	18	4 bit down
	19	NI up
	20	NI down
	21	user word 1
	22	user word 2
	23	user word 3
	24	user word 4
	25	1 in 4
	26	1 in 6
	27	1 in 7
	28	2 in 10
	29	2 in 11
	30	2 in 12
	31	2 in 13
	32	2 in 14
	33	2 in 15
	34	2 in 16
	35	3 in 18
	36	3 in 19
	37	3 in 20
	38	3 in 21
	39	3 in 22
	40	3 in 23
	41	2 in 8#
	42	bridge tap code word
	43	multipattern code word
	44	user sequence code word
ulong	logic EC	
ulong	logic ES	
ulong	logic EFS	
uint	%EFS times 100	
float	logic BER	
ulong	logic UAS	
ulong	logic SES	
ulong	logic CSES	
uint	logic %SES times 100	
uint	logic %avl times 100	
ulong	logic DM	

int	tone amplitude, dBm0 times 10
ushrt	signaling status; D is in bit 0, C is in bit 1, B is in bit 2, and A is in bit 3
shrt	high word
shrt	low word
ushrt	Receive mode: 0 unknown mode 1 full T1 2 FT1 n × 64 kb/s 3 FT1 n × 56 kb/s
ushrt[3]	Timeslot map. The 24 bits are set to a 1 if the timeslot is used, and set to 0 if unused. The MSB of the first byte represents timeslot 01, the LSB of the third byte represents timeslot 24.
uint	bandwidth of payload in kb/s

13.4.9.28 Upload Calibration Constants

Function: This allows the host to obtain the current calibration constants from the test set. The calibration procedure is described in section 17.

Opcode: 28

Instruction: None.

Response:

float	Simplex current multiplier, default is 1.00. The number must be in the range 0.5 to 1.5.
shrt	T1 line frequency offset in Hz, default is 0. The value must be in the range −128 to +127.
shrt	DS0 tone amplitude offset in tenths of a dB, default is 0. The value must be in the range −4 to +10. This value is ***subtracted*** from the instrument's default setting to arrive at the value to be transmitted.
int[7]	T1 line level (terminate mode) measurement offsets in dB times 1000. This is an array of values, location zero is for +3 dBdsx. The defaults are all 0. The modulus of each value must be less than 1000 × (*i* + 1), where *i* is the array position.

	int[7]	T1 line level (monitor mode) measurement offsets in dB times 1000. This is an array of values, location zero is for +3 dBdsx. The defaults are all 0. The modulus of each value must be less than 1500 + ($i \times 1000$), where i is the array position.

13.4.9.29 Download Calibration Constants

Function	This sends calibration constants from the host to the test set. The new values are immediately used, irrespective of whether a test is running. The test set records the calibration date and time, returning it to the host.	
Opcode	29	
Instruction	34 bytes	in the same sequence and meaning as for the **Upload Calibration Constants** command.
Response	ushrt	error code
	stime	Current instrument date and time. This is the same as the calibration date and time, if the error code is 0.

13.4.9.30 Upload User Words

Function	This allows the host to obtain the current user word bit patterns.	
Opcode	30	
Instruction	None.	
Response	44 bytes. The following is repeated four times, once for each user word. The first set of parameters in the command is for user word 1, the second is for user word 2, and so on.	
	char[6]	name
	ushrt	Length + 3. The word must be 13 bits or longer. For example, if you wanted to send a repeating word of length 9 bits, you must send it as an 18 bit word. This byte would then be set to 21 (15H).
	ushrt[3]	Pattern. Don't care bits fill the array from the MSB of the first byte. The first bit transmitted is the first non-don't care bit.

ushrt	Sync time:	
	0	normal
	1	long time (for unusual patterns or noisy lines)

13.4.9.31 Download User Words

Function: Allows the host to set the user words. A new word will take effect when it is next selected.

Opcode: 31

Instruction: 44 bytes in the same sequence and meaning as for the **Upload User Words** command.

Response: ushrt error code

13.4.9.32 Upload User Test Sequence

Function: This allows the host to obtain the current user test sequence data.

Opcode: 32

Instruction: ushrt Selection of sequence:

0	user sequence one
1	user sequence two

Response: 56 bytes:

ushrt error code

char[13] name

ushrt[21][2] Pattern list. This is organized as a list of 21 patterns. The first byte is the pattern type as described in the *payload* variable of the Upload **Transmit Configuration** command. If fewer than 21 patterns are used, the pattern type for the first unused pattern is set to 0. The second byte is the time in seconds for which that pattern is to be tested. This time must be between 1 and 255.

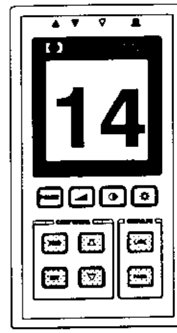
13.4.9.33 Download User Test Sequence

Function: Allows the host to set the user test sequence. A new sequence will take effect when it is next selected.

Opcode: 33

Instruction	56 bytes:		
	ushrt	Selection of sequence:	
		0	user sequence one
		1	user sequence two
	char[13]	name	
	ushrt[21][2]	pattern list (as described in the **Upload User Test Sequence** command)	
Response	ushrt	error code	

Power Requirements



14.1 Batteries

14.1.1 Powering Period

The HP 37741A is powered by a custom nickel-cadmium (NiCd) battery pack. When fully charged, and at normal ambient temperatures, the battery will power the test set for nominally 6 hours.[1] As the temperature is reduced, the capacity is reduced: at 0°C about 90% of the capacity is available.

As the battery ages, its capacity is reduced.

When the EL backlight is used, the unit consumes 15% more power. When the internal speaker is on full volume, the power consumption doubles. In each case, the operational time is reduced accordingly. It makes little difference to the operation time whether the instrument is transmitting a T1 signal or not. The all ones power on a T1 line is about 45 mW (17 dBm), and represents a small fraction of the power consumed by the instrument.

14.1.2 Low Battery

When the battery becomes discharged, the HP 37741A will beep every minute. This period lasts for at least 15 minutes, before the battery is too low to operate the unit, at which point the unit will turn itself off as discussed in section 14.3.3.

1 A new instrument may give you 8 hours of continuous use.

If you turn the unit on when the battery is too low to operate the instrument, the instrument will display a warning message (screen 1010), and then turn itself off after five seconds.[1]

14.1.3 Storage

The storage temperature of the HP 37741A is limited largely by the battery characteristics. The nickel-cadmium battery used on the HP 37741A can be stored at temperatures ranging from –30°C to 50°C without essential degradation in performance. The organic materials within the cells may deteriorate or become deformed at high temperatures during prolonged storage. It is therefore recommended that the instrument be stored at temperatures below 35°C if there is a possibility of storage surpassing more than a couple of months.

Short time interval excursions in temperature to 70°C, while not likely to cause a hazard, should be avoided whenever possible.

The unit may be stored indefinitely with the battery either charged or discharged, without any major detrimental effect to the battery in either case.[2] It is, however, advisable to discharge the battery fully for prolonged storage (more than a year). This is because the individual cells that make up the battery have different self discharge rates, and on removal from storage, polarity reversal may occur when charging. To discharge the battery on the HP 37741A, turn the instrument on, set the test time for continuous, run a test, and leave it. For short term storage (less than six months or so), charge the battery first, to prevent potential loss of data and calibration information.

During any period of storage, the battery self discharges. The rate of discharge is dependent on the temperature. A charged battery will maintain the instrument's configuration for about nine months when stored below 15°C. At temperatures above 30°C, the configuration might be kept for less than half that time.

When removed from long term storage, you should charge and discharge the battery about five times to recover its discharge capacity. Typically, 97% of the capacity can be restored after storing a fully discharged battery for 2 years at 30°C.

1 If the battery is fully discharged to a point where this message cannot be displayed, operation is unpredictable.

2 However, as described in section 14.4, the unit will lose its configuration and calibration when stored with a discharged battery.

14.1.4 Service Life, Replacement, and Disposal

The service life of the battery will depend on usage conditions. The most important factor affecting the service life is operation of the instrument at high temperatures.

Frequent use that fully discharges the battery has a minor effect on battery life. In fact, charging the battery each time after only a half hour or an hour of use will have a more detrimental effect on service life. Special circuitry in the HP 37741A permits continual (trickle) charge, with negligible battery deterioration.

In normal service the battery will last between 5 and 15 years. You can replace the battery yourself, or HP can do it for you.[1] The HP part number for a replacement battery is listed in appendix D.

For environmental reasons, you should dispose of the battery pack in a proper manner at the end of equipment life. If you do not have access to proper disposal methods, return the instrument to your nearest HP sales office or HP service center. HP will dispose of the unit at no charge. HP sales offices are listed in appendix F.

14.1.5 Adapters for Recharging

The battery is recharged by an external adapter. An ac adapter for 110 V, 60 Hz is provided with the HP 37741A when purchased. Adapters for different ac voltages or for a dc car cigarette lighter are optionally available.[2]

The adapter provides about 7.5 Vdc at 1 A, and is equipped with a 2.0 mm connector. The maximum open circuit voltage of the charger is 13.5 V. The inner pin of the connector is positive with respect to the sleeve. If the adapter fails, you should replace it with a new adapter from HP, which is guaranteed to meet the performance objectives, and which is both UL and CSA listed.

WARNING

Using a non-approved adapter may void your warranty, damage the instrument, and result in personal injury.

1 The procedure describing how to replace a battery is given in section 0.6.3.
2 These, and other accessories are listed in appendix D.

14.1.6 Recharge Time

When the battery has been discharged, any of the available adapters for the HP 37741A can be used to recharge it. The test set may be operated when charging the batteries.

After being discharged through normal use, the unit will recharge in about nine hours if the instrument is turned off, or in about ten hours if it is turned on. As a guideline, if you use the instrument for an hour, you need to charge it for 1½ hours.

No damage is done to the battery if the charger is continually plugged in and turned on. Under these conditions, the battery will get warm – this is normal.

14.1.7 Memory Effect

The battery used in the HP 37741A, in conjunction with its electronics, exhibits no "memory effect", a fault that was common with early NiCd batteries. Capacity can be restored after storage by charging and discharging, as described in section 14.1.3.

14.2 Turning On the Test Set

There are three ways in which the instrument can be turned on, irrespective of the means by which the instrument was turned off:

- by pressing the [POWER] key
- by applying power to the dc jack
- by asserting DTR on the EIA-232 port

Each of these is discussed below.

14.2.1 Pressing the [POWER] Key

This key toggles the instrument between off and on. To turn on the HP 37741A, press the key for about half a second. A copyright notice is briefly displayed, followed by the identification screen. The test set is now ready for use.

If the key is depressed for more than about half a second, the copyright notice is retained on the screen for as long as [POWER] is pressed.

14.2.2 Applying Power to the DC Jack

A transition from no power at the dc jack to power at the dc jack will turn on the HP 37741A. This could be achieved either by connecting the 2 mm jack with the ac adapter already plugged in, or by applying power to the adapter when the jack is in.[1]

It is a transition (of the applied power) that turns the instrument on. A steady state condition of having power applied with an external charger will not keep the HP 37741A powered up.

This feature is designed to permit a long term test to be run. Suppose you want to gather performance statistics over a one month period at an unattended site. The instrument is configured for a continuous test, and the ac adapter is connected.

On, say, the tenth day, the ac power fails for 6 hours. After five hours the battery of the HP 37741A becomes nearly discharged, and the unit turns itself off. When ac power is restored one hour later, the instrument will continue to monitor the line and record the results.

If you want to charge the batteries as quickly as possible, you should turn the instrument off after connecting the ac adapter.

14.2.3 Asserting DTR on the EIA-232 Port

When this signal is taken from the inactive to the active condition (off to on) the HP 37741A will be turned on. A transition of at least 5 V is required. This is achieved by any terminal device that meets the EIA-232 specification (which calls for a minimum voltage swing of 6 V). The rise time of the signal should also meet the EIA specification.

This feature is provided to allow the unit to be placed at a site and be controlled remotely. The test instrument will then normally remain off, except when a remote user wants to use it. Then, when the DTR lead is asserted the HP 37741A powers up. It takes about one second after asserting the lead until the test set is ready to accept commands over the serial link. The test set asserts CTS then.

It is a transition on this lead that turns the unit on. A steady state assertion of the lead will not keep the unit turned on.

1 The same holds true for the optional car cigarette lighter charger.

14.3 Turning Off the Test Set

There are four ways in which the instrument can be turned off:

- by pressing the [POWER] key
- by issuing a command over the serial port
- inactivity of the unit
- low battery voltage

Each of these is discussed below.

14.3.1 Pressing the [POWER] Key

To turn the HP 37741A off, press [POWER] once.

You need to press the [POWER] key longer than any of the other keys for the action to be recognized. This prevents you from turning off the instrument unintentionally. If you press and hold the key, the instrument will not turn off until you release the key.

14.3.2 Over the Serial Port

You can turn the instrument off remotely. The command that you need to send is detailed in section 13.4.9.4. The software available from HP as an accessory (see appendix D) permits this function.

14.3.3 Inactivity

When the HP 37741A is not running a test, and there has been no user activity for two minutes, the test set will automatically turn off.

User activity occurs when any of the following happens:

- a user presses any key
- a command is received on the serial port when configured for external control[1]
- a print process is active[2]

When a test is running (either fixed period or continuous) the instrument will not turn itself off because of user inactivity. This is true even if there has been no signal received for the entire duration of the test.

1 The command does not need to be a valid command.
2 The instrument need not actually be printing.

Automatic turn off when there has been no activity conserves battery power. If you want to make use of this feature, it is suggested that you either:

- stop the test when you have obtained sufficient results; or
- set the test time to be a short fixed period (for example 15 minutes or less).

14.3.4 Low Battery

The HP 37741A continually monitors the battery voltage, and will automatically turn off when the measurement results are likely to be unreliable.

The instrument will turn off irrespective of whether a test is running or not, and irrespective of any user activity. The charger must be connected before the unit can be used again.

The HP 37741A can detect that the battery is nearly discharged, and will display this on screen 2500. You will receive at least 15 minutes warning of the battery becoming discharged. During this period, the test set will emit a single, short, high pitched tone on the internal speaker every minute.

14.4 During Power Off

14.4.1 Real Time Clock

The instrument's real time clock continues to operate when the main power is off. Clock accuracy is not affected by the unit being either on or off. The instrument saves the date and time of the last power down, and of the last power up. These times can be viewed by the user (on screen 2500), and are printed with the test results.

14.4.2 Parameter Save

When the HP 37741A is powered down the data in memory is retained. The data saved comprises

- current instrument configuration
- current test results
- transmitter and receiver settings

- user defined setups, including configurations, user words, and data links
- saved test results and configurations
- test set calibration

14.4.3 Test in Progress

If you turn the instrument off by pressing [POWER], the test is stopped. When the instrument is turned on, the test will not resume, but the results of last test are available.

If the HP 37741A turns off because of low battery voltage, the current test status and intermediate test results are saved in memory. Any test that was running is suspended, not stopped.

Then, when the unit is turned on again, the test is resumed and will continue for the amount of time that was remaining before the instrument was powered off. The test times are displayed in screen 3600 (3601 if continuous). The elapsed time that is displayed reflects how long the test has actually been running, which is not necessarily the same as the time that has passed since the test was started. These times are indicated in screen 3600 or 3601.

The stop time will be updated to reflect that power has been turned off. Therefore, adding the total run time to the start time will not equal the stop time if there was a power loss during the test:

Stop time = start time + power loss period + elapsed time.

14.4.4 Impedance Presented to the T1 Line

When the instrument power is turned off, it maintains the same impedance to the T1 line as was presented when power was on. Therefore, if you leave the HP 37741A connected to a T1 line for a long term test, power failure of the instrument will not disturb the traffic on the T1 line. This subject is discussed in detail in section 10.3.6.

14.4.5 Retention of Data When Off

With a fully charged battery the memory and clock will function correctly for a period in excess of one year, in normal climatic storage conditions. When the battery is discharged to the point where the HP 37741A has turned itself off, the memory is still retained and the clock still operates. If you do not attempt to turn the unit on, the memory and clock will function correctly for a minimum of 24 hours and typically a month.

14.4.6 Discharged Battery

When the battery is too low to operate the instrument you should recharge the battery soon unless you plan to store the HP 37741A for a year or more. Failure to do so may result in loss of data, and the following may be affected:

a. the real time clock
b. test results, both from the most recent test and from those that have been saved
c. test status and intermediate test results, if a test was running
d. the current instrument configuration both for TEST and SET
e. instrument calibration

If these data have been corrupted due to a fully discharged battery, the HP 37741A will power up with factory default settings. The unit may not meet all the measurement specifications detailed in this manual. The clock will be set to midday on 1 January 1992. Screen 1020 informs you of this state.

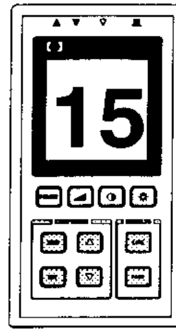
14.5 Real Time Clock

The instrument's real time clock is continually powered by the system battery. The clock's accuracy is not affected by the instrument being turned on or off.

The clock accuracy is affected by temperature and age, as follows:

Accuracy at room temperature	±50 ppm maximum
Accuracy over operating temperature range	±130 ppm maximum
Accuracy over storage temperature range	±170 ppm maximum
Aging, assuming room temperature usage	±7 ppm maximum per year

In normal usage, the time will typically be accurate to within 25 ppm, which equates to about one minute a month.



Environmental and Physical

15.1 User Interface (Physical)

Keyboard	polyester panel 10 keys with stainless steel domes, 3.2 N nominal force – provides tactile and audible response
LCD	128 × 128 dots 62 × 62 mm viewing area 8 lines × 13 characters 6 mm character height
Speaker	plastic cone 200 mW maximum output

15.2 Size and Mass

HP 37741A size	190 × 100 × 45 mm
HP 37741A mass	900 g
110 Vac adapter size	60 × 60 × 50 mm
110 Vac adapter mass	375 g
Carrying pouch size	200 × 125 × 60 mm
Carrying pouch mass	85 g

15.3 Power Consumption

110 Vac adapter	90 to 130 Vac 47 to 72 Hz 10 W
HP 37741A	8 to 10 Vdc 1 A (maximum, charging while operating)

15.4 Isolation and Continuity

15.4.1 Isolation

110 Vac to ground	1500 Vac
T1 main to T1 ref	500 Vdc
T1 inputs to ground	500 Vdc

To provide continuity for simplex current, and to allow for its measurement, the main input is not isolated from the output.

15.4.2 Continuity

The sleeves of all three bantam connectors are connected together, to the shield of the DB9 connector, and to the system ground point. System ground is also accessible externally on the outer connection of the power jack, and on pin 5 of the DB9 connector.

15.5 Temperature and Humidity

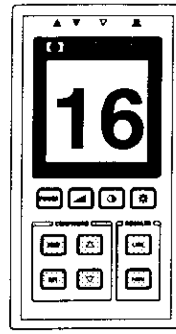
15.5.1 Temperature

Operating	0°C to 50°C
Charging	0°C to 45°C
Storage	−20°C to 60°C (short term) 0°C to 35°C (long term)

15.5.2 Humidity

Operating	5% to 90% non condensing
Charging	5% to 90% non condensing
Storage	5% to 90% non condensing (short term) 5% to 70% non condensing (long term)

Performance Verification



16.1 General

The tests described in this section enable the user to assess the operational status of an HP 37741A DS1 tester, referred to in the remainder of this section as the UUT. There are three levels of tests that accomplish this. They each give varying confidence levels in the instrument's functionality, as indicated below:

- power on self test (POST) – 55% confidence
- built in self test (BIST) – 96% confidence
- performance tests – 100% confidence

If all of the tests pass, the UUT is fully operational. The failure of the BIST or the performance tests may indicate the need for factory service, or it may indicate the need for UUT calibration, which is described in section 17.

16.1.1 Power On Self Test

This test is executed automatically every time you turn the instrument on. The test takes less than one second, and tests the major parts of the instrument's electronics. The instrument beeps the internal speaker as part of this test.

If the test fails, the display will blink every second, as the instrument tries the test again. Normal operation is started if the test is successful.

16.1.2 Built In Self Test

This test is described in section 16.6. You will need a single bantam cable and a serial port loopback adapter to conduct this test. The bantam cable is provided as a standard accessory, and the adapter is described in section 16.2.1. This test takes about 5 minutes.

16.1.3 Performance Tests

Full performance verification consists of all of the tests in this section, performed in sequence. You need external equipment, described in section 16.2, in addition to the accessories shipped with the product, listed in section 1.3. The tests take about three hours to perform. You should start with the user interface test, and follow the procedures through to the channel access test.

16.2 Equipment Required

The following list includes all equipment required for the performance tests. Wire and other standard laboratory materials are not included on the list. Also missing from the list are banana plug to binding post adapters (which may or may not be needed with the digital multimeter, depending on what model is selected). It is assumed that all materials shipped with the product, such as the single and dual bantam cables are available.

The T1 generator requirements are not fully met by either of the two example models listed. However, an HP 37701A and an HP 37741A together will satisfy all requirements. An HP 37741A can always be used for the T1 monitor, and it can be used for the T1 generator when programmable error rate generation, and low level signals are not required.

16.2.1 Description of Equipment

To execute the performance tests and to calibrate the HP 37741A, a number of standard instrumentation products are required. These items are listed below. The tests in which each item is used are given ("Used for"), followed by the major requirements of that item ("Features"), and lastly at least one commercial source for the item ("Examples"). Appendix D list accessories available for the HP 37741A.

16.2.1.1 T1 Generator

Used for
- pattern test
- framing test
- mode test
- line code test
- loopback test
- error analysis test
- alarms test
- input signal tolerance test

Features
- generate all HP 37741A patterns
- generate all HP 37741A frame formats
- generate all HP 37741A modes (T1 and FT1)
- generate all HP 37741A line codes
- generate all HP 37741A loop codes
- generate errors (BPVs, frame, bit, CRC) at 10^{-4} rate
- generate user defined patterns of bit length 4 to 17
- generate AIS and yellow alarms (all framing formats)
- generate DS1 signal levels of 0, −7.5, and −15 dBdsx

Examples
- HP 37741A (but cannot generate programmable errors, or low level signals)
- HP 37701A (but cannot generate ZBTSI or SLC-96 frame formats)

16.2.1.2 T1 Monitor

Used for
- pattern test
- framing test
- mode test
- line code test
- loopback test
- error analysis test
- alarms test

Features
- recognize all HP 37741A patterns
- recognize all HP 37741A frame formats
- recognize all HP 37741A modes (T1 and FT1)
- recognize all HP 37741A line codes
- recognize all HP 37741A loop codes
- recognize AIS and yellow alarms (all framing modes)

Examples
- HP 37741A

- HP 37701A (but cannot recognize ZBTSI frame format, cannot unambiguously discern a SLC-96 frame format, and cannot differentiate between different ESF loop-back types)

16.2.1.3 Function Generator (Two Required)

Used for
- line frequency measurement test
- line level measurement test
- slips test
- transmit timing test

Features
- generate signals by digital synthesis, with at least 104 points
- generate sine waves
- generate user defined signals to 1 MHz (±0.5 ppm frequency accuracy)
- signal point spacing of 25 ns maximum
- generate 0.1 to 10 Vpp (± 5% accuracy)
- reference clock output and reference clock input

Examples
- Stanford Research Systems DS345-02

16.2.1.4 10 MHz Frequency Source

Used for
- line frequency measurement test
- transmission frequency test

Features
- long and short term stability better than 10^{-10}
- 10 MHz clock output

Examples
- Stanford Research Systems FS700 locked to LORAN-C ground wave

16.2.1.5 Power Supply

Used for
- simplex current test

Features
- 0 to 15 V output (± 5% accuracy)
- current limit range: 20 to 200 mA (± 5% accuracy)

Examples
- HP 6216C

16.2.1.6 Digital Multimeter

Used for
- simplex current test
- line level measurement test

Features
- dc voltage measurement: 0.1 to 12 V (± 0.5% accuracy)

- current measurement: 10 to 300 mA (± 0.5% accuracy)

Examples
- HP 34401A

16.2.1.7 Oscilloscope

Used for
- line frequency measurement test
- line level measurement test
- transmit pulse test
- transmit timing test

Features
- dual channel
- 100 MHz bandwidth (3 dB)
- voltage measurement accuracy: ± 2%
- time base accuracy: ± 1%

Examples
- HP 54501A

16.2.1.8 Personal Computer

Used for
- user interface test

Features
- IBM AT compatible
- MS-DOS 3.3 or later, or DR-DOS 5.0 or later
- EIA-232 port

Examples
- HP Vectra

16.2.1.9 External Control PC Software

Used for
- user interface test

Features
- see section D.3.2

Examples
- HP 15726A

16.2.1.10 Narrow Printer

Used for
- user interface test

Features
- EIA-232 interface (or parallel interface with serial-to-parallel converter)

Examples
- HP 15727A or Seiko DPU-201GS

16.2.1.11 Wide Printer

Used for
- user interface test

Features
- EIA-232 interface (or parallel interface with serial-to-parallel converter)

Examples • HP 15733A or Seiko DPU-411

16.2.1.12 Serial DTE to DCE Cable

Used for • user interface test

Features see section 12.2.4

Examples HP 15736A, HP 15737A

16.2.1.13 Serial DCE to DCE Cable

Used for • user interface test

Features see section 12.2.5

Examples HP 15734A, HP 15750A

16.2.1.14 Serial Port Loopback Adapter

Used for • self test

Features • male 9 pin D-subminiature connector with the following pin connections: 2 to 3 and 7 to 8 (it is acceptable if pin 4 is wired to pin 6 also)

16.2.1.15 BNC Cable

Used for
- line frequency measurement test
- transmit timing test

Features
- length: 300 mm
- impedance: 50 Ω

Examples
- E-Z-Hook 1026-12
- HP 8120-1838

16.2.1.16 BNC "T" Adapter (Two Required)

Used for
- line frequency measurement test
- transmit timing test
- slips test

Features
- 1 male to 2 female
- impedance: 50 Ω

Examples
- E-Z-Hook 9238
- HP 1250-0781

16.2.1.17 Dual Test Clip to Bantam Patch Cord (Two Required)

Used for
- simplex current test
- line frequency measurement test
- line level measurement test
- transmit timing test
- slip count measurement test

Features
- length: 450 mm

Examples
- E-Z-Hook 2628 (450 mm)

16.2.1.18 Dual Test Clip to BNC Adapter (Three Required)

Used for
- line frequency measurement test
- line level measurement test
- transmit timing test
- slip count measurement test

Features
- length: 80 mm
- impedance: 50 Ω
- male BNC connector

Examples
- E-Z-Hook 1010XM

16.2.1.19 50 Ω Resistor (Four Required)

Used for
- simplex current measurement test

Features
- resistance tolerance: ± 5%
- power rating: 1 W

16.2.1.20 100 Ω Resistor

Used for
- line frequency measurement test
- line level measurement test
- transmit pulse test
- transmit timing test

Features
- resistance tolerance: ± 1%
- power rating: 250 mW

16.2.1.21 442 Ω Resistor (Two Required)

Used for
- line frequency measurement
- line level measurement

Features
- resistance tolerance: ± 1%
- power rating: 125 mW

16.3 Accuracy and Signal Integrity

16.3.1 Measurement Accuracy

Many of the following tests verify quantitative specifications for which a specific accuracy is guaranteed. For each of these tests, one or more of the pieces of equipment used is critical to the test's accuracy. In order for such a test to be meaningful, the critical equipment must be more accurate than the tolerance of the parameter being measured. In general, the parameter:

meets specification if	abs(Pmeas − Pnom) ≤ (Utol − Etol)
does not meet specification if	abs(Pmeas − Pnom) ≥ (Utol + Etol)
is unknown if	neither condition holds

where:

Utol	≡ specified accuracy of UUT parameter,
Etol	≡ specified accuracy of critical test equipment,
Pnom	≡ nominal value of UUT parameter,
Pmeas	≡ measured value of UUT parameter.

Because the performance test procedure is intended to guarantee that the UUT meets specifications, the basis of comparison must be the first of these three criteria. If Etol is not much smaller than Utol, there is a danger that a significant number of good units may be rejected. (In the extreme case, when Etol exceeds Utol, it is impossible to ever be sure that a UUT meets its specifications.)

16.3.2 Critical Equipment

The performance verification tests have been designed to minimize the number of highly accurate test instruments required. Three such instruments are specified:

- function generator, for timing measurements
- digital multimeter, for voltage and current measurements
- oscilloscope, for pulse shape measurements

Each of these critical instruments must have a measurement uncertainty of no more than one tenth of the smallest tolerance it is required to verify. Of course, all equipment used must be calibrated.

The error and slip count tests use the internal test duration timer of the HP 37741A. In these cases, the displayed error or slip count is proportional to the selected test time. For this reason, the accuracy of the HP 37741A's real time clock is taken into account in the pass or fail limits specified for these tests.

16.3.3 Signal Integrity

The nominal impedance of a T1 line is 100 Ω. Most test instrumentation, including that used in the tests specified here, is designed to operate in a 50 Ω environment. Whenever two impedance environments are mixed in this way, the question arises as to what signal degradation might result. In the tests described here, one must consider two mechanisms of signal degradation, which can alter signal phase and pulse shape, but not frequency. Both mechanisms are dealt with by limiting the length of any 50 Ω signal path.

The first signal distortion mechanism arises from reflections at the boundaries between signal path sections of different impedances. In these tests, lengths of 50 Ω signal path are limited to "T" adapters, 80 mm test-clip adapters, and a 300 mm cable. The longest double transit time across any such length is about 3 ns. The DS1 signals under investigation have transition times on the order of 50 ns. Thus, transmission line effects can be neglected.

The second distortion mechanism is the behavior of the adapters and stubs as lumped elements, which can filter the signals that pass through them. For these tests, the worst effect of this kind comes from the 300 mm stub connecting the function generator and the oscilloscope in the transmit timing test. This stub represents a capacitance of about 30 to 40 pF, creating a low pass filter with a time constant of 4 ns or less. Again, this effect is small enough to be neglected, especially since only the frequency is of interest on this signal path.

16.3.4 Stability

It is important that a stable environment be used for the measurements. There should not be wide variations in the operating temperature and humidity during the test. You should allow all equipment to warm up prior to making any measurements. A typical time might be half an hour, but you should consult the manufacturer's documentation first. The area should be free from stray electromagnetic fields and radiation.

16.4 Function Generator Test Patterns

This section defines user programmed test patterns for use in performance verification and unit calibration. Three types of pattern are used: all ones, alternating 1/0, and 1 in 8. These patterns and their generation are described in the following three subsections.

16.4.1 Function Generator Level Calibration

The "all ones" and "alternating 1/0" patterns are generated using the function generator. To guarantee accurate T1 waveform amplitudes, adjusted amplitudes must be determined. These adjusted amplitudes will be used in setting up the function generator for generation of the individual waveforms. The adjusted amplitudes are not the same as the nominal T1 amplitudes for three reasons:

a. Because of overshoot, the peak amplitude of an ideal DSX pulse is not equal to its nominal value (for amplitudes greater than or equal to −6 dBdsx).

b. The source impedance of the function generator is 50 Ω so that the amplitude setting must be adjusted for a 100 Ω load.

c. The amplitude accuracy of the function generator must be bettered.

A table of adjusted amplitudes is therefore generated as follows:

1. Set up the equipment as shown in figure 16-1, with RL = 100 Ω.
2. Set the function generator to generate a 1 kHz sine wave, and the digital multimeter for ac (rms) voltage measurement.

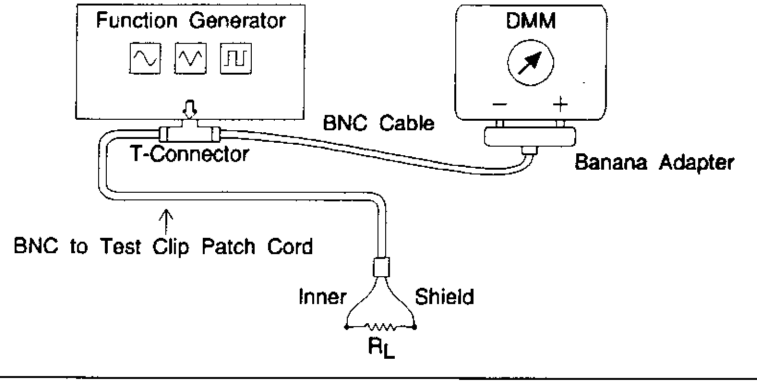


Figure 16-1 Test Pattern Setup

3. For each entry in the following table, adjust the function generator voltage until the digital multimeter reads the value indicated. Make a note of each voltage setting, and designate each as shown in the table. These designations are used in later sections.

Desired dBdsx	Designation	Desired Vpp at terminals	Ideal Vpp programmed	DMM mV rms Reading
+3.0	Vadj(+3)	9.323	6.992	3300
0.0	Vadj(0)	6.600	4.950	2330
−3.0	Vadj(−3)	4.672	3.504	1650
−9.0	Vadj(−9)	2.129	1.597	753
−15.0	Vadj(−15)	1.067	0.800	377
−21.0	Vadj(−21)	0.5348	0.400	189
−27.0	Vadj(−27)	0.2680	0.201	94.8
−33.0	Vadj(−33)	0.1343	0.101	47.4

16.4.2 All Ones

These patterns are all generated using the function generator. Set up the function generator for a 772000 Hz sine wave. For each entry of the following table, create the indicated waveform by using the indicated Vpp setting.

Waveform Name	Vpp Setting
−9dBall1s	Vadj(−9)
−15dBall1s	Vadj(−15)
−21dBall1s	Vadj(−21)
−27dBall1s	Vadj(−27)
−33dBall1s	Vadj(−33)

16.4.3 Alternating 1/0

These patterns are all generated using the function generator. They use the arbitrary waveform feature. The normalized waveform is a repeating pattern with point spacing of 25 ns and period of 2600 ns.[1] There are 104 points characterizing the repeating pattern. These points are tabulated in figure 16-2, normalized so that the midpulse base-to-peak amplitude is one Volt. The waveform is illustrated in figure 16-3.

1 This corresponds to a T1 alternating 1/0 pattern with a bit rate of 1538461 b/s, rather than 1544000 b/s. Because these patterns are used only for level calibration, this is not a concern.

For each entry of the following table, create the indicated waveform by using the indicated Vpp setting.

Waveform Name	Vpp Setting
+3dBalt01	Vadj(+3)
0dBalt01	Vadj(0)
−3dBalt01	Vadj(−3)

ns	V	ns	V	ns	V	ns	V
0	0	650	0.5	1300	0	1950	−0.50
25	0	675	0	1325	0	1975	0
50	0	700	−0.25	1350	0	2000	0.25
75	0	725	−0.25	1375	0	2025	0.25
100	0	750	−0.24	1400	0	2050	0.24
125	0	775	−0.23	1425	0	2075	0.23
150	0	800	−0.20	1450	0	2100	0.2
175	0	825	−0.17	1475	0	2125	0.17
200	0	850	−0.13	1500	0	2150	0.13
225	0	875	−0.11	1525	0	2175	0.11
250	0	900	−0.09	1550	0	2200	0.09
275	0.15	925	−0.07	1575	−0.15	2225	0.07
300	0.45	950	−0.05	1600	−0.45	2250	0.05
325	0.75	975	−0.04	1625	−0.75	2275	0.04
350	1.05	1000	−0.03	1650	−1.05	2300	0.03
375	1.1	1025	−0.02	1675	−1.10	2325	0.02
400	1.1	1050	−0.01	1700	−1.10	2350	0.01
425	1.05	1075	0	1725	−1.05	2375	0
450	1.02	1100	0	1750	−1.02	2400	0
475	1	1125	0	1775	−1.00	2425	0
500	1	1150	0	1800	−1.00	2450	0
525	0.99	1175	0	1825	−0.99	2475	0
550	0.98	1200	0	1850	−0.98	2500	0
575	0.97	1225	0	1875	−0.97	2525	0
600	0.95	1250	0	1900	−0.95	2550	0
625	0.9	1275	0	1925	−0.90	2575	0

Figure 16-2 Tabulated DSX-level Waveform

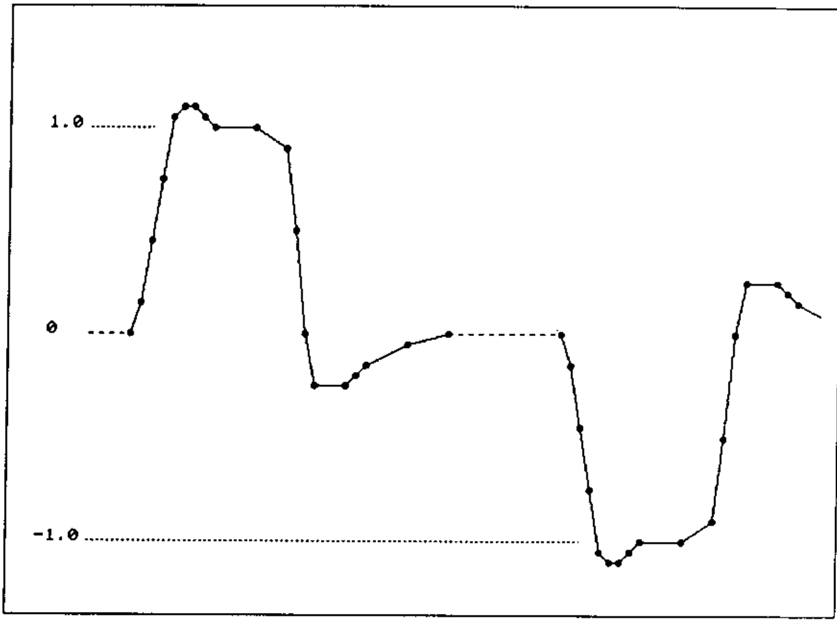


Figure 16-3 Alternating 1/0 DSX Test Waveform

16.4.4 1 in 8

Generation of these patterns requires both the T1 generator and the function generator. Set the T1 generator so that its transmit timing is derived from its reference input. Drive the external reference input from the function generator, set for a sine wave output (frequency = 772000 Hz; amplitude = 1 Vpp). Set the T1 generator to transmit a "1 in 8" pattern, with output level as shown in the following table.

Waveform Name	Output Level (dBdsx)
0dB1in8	0
−15dB1in8	−15

16.5 User Interface Test

16.5.1 Purpose

This test verifies the UUT's ability to communicate with the user, with an external personal computer, and with a printer. The following capabilities are tested:

a. keys
b. display
c. speaker and volume control
d. test time duration control
e. save and recall of test results
f. real time clock
g. LCD contrast, backlight, and backlight auto-turnoff
h. serial port external control and printout

16.5.2 Procedure

1. Install the single bantam cable between the T1 output and the main T1 input.
2. Install the ac adapter.
3. Press [POWER] to turn on the HP 37741A.
4. Use [◑] to adjust the LCD contrast. Verify that the contrast of the UUT appears to have all 16 steps.
5. Set the LCD contrast to a comfortable viewing level.
6. Press [SET], verify that screen 2000 is shown, and verify that the cursor moves in response to [▲] and [▼].
7. Set the UUT to its factory default state.
8. Use [TEST] to start a test.
9. In a darkened room, use [☼] to turn on the backlight.
10. Wait for two minutes without pressing any keys, and verify that the backlight is automatically turned off.
11. Set the T1 inputs for terminate.
12. Set the UUT to transmit a D4 TmSlt with a 1004 Hz, −16 dBm0 tone on channel 1.

13. Turn the speaker on, verify that the tone is audible, and that the volume can be controlled using [◢]. The volume should range from soft to unpleasantly loud.
14. Remove the tone, and set the real time clock to 23:59 on 99/12/31.
15. Set the test duration time for 5 seconds.
16. Start the test.
17. Verify that `TEST ACTIVE` is displayed for 5 seconds, after which `TEST IDLE` is displayed.
18. Save the test results.
19. Using screen 3510, set the test duration time for 20 seconds.
20. Start a test, verify that `TEST ACTIVE` is displayed for 20 seconds, after which `TEST IDLE` is displayed.
21. Set the test duration time to be continuous, start a test, and verify that `TEST ACTIVE` is still displayed after 5 minutes.
22. Remove the bantam cable, wait 1 minute and replace it.
23. Use [PATH] to display screen 5000.
24. Verify that an LOS has been reported.
25. Use [LINE] to display screen 4000.
26. Verify that the displayed signal voltage level is between 4.3 V and 7.7 V.
27. Press [POWER], and verify that the display goes blank.
28. Turn on the UUT.
29. In screen 1000, verify that the time is reported as early morning, 00/01/01.
30. In screen 5000, verify that the LOS is still being reported.
31. Recall the test results stored in step 18, and verify that the LOS alarm is no longer displayed.
32. Reset the real time clock to the correct date and time.
33. Connect the narrow width printer to the serial port, and set the port parameters as appropriate for the printer.
34. From screen 3110, use the `now` command to obtain a printout.
35. Repeat steps 33 and 34 with the wide printer.
36. From screen 2310, set the serial port for `ext control`, 9600 b/s.

37. Connect to the personal computer running the HP 15726A external control software.
38. Using the PC to control the UUT, start a test, and verify that no LOS alarm is reported.
39. Remove the bantam cable, and verify that an LOS is reported on the PC.
40. Stop the test from the PC, then exit the control software.
41. Wait 2 minutes, and verify that the UUT turns itself off.

16.6 Built In Self Test

16.6.1 Purpose

The built in self test allows you to perform a quick operational check of the UUT, without the need for any additional equipment, and with only minimal intervention. If the self test passes, the UUT is functional, although it is not guaranteed to meet all of its specifications.

If the self test fails, it probably means that the instrument requires servicing, but it may mean that it simply requires calibration.

The following capabilities are tested:

a. serial port functionality
b. pattern generation and detection
c. framing generation and detection
d. line code generation and detection
e. loopback code generation and detection
f. excess zeroes detection and analysis
g. pulse density violation detection and analysis
h. alarm generation and detection
i. level generation and measurement (at the DSX level)
j. channel access tone generation and level measurement, signaling generation and reception, and speaker output

Each loop of the main test takes about 6 minutes. If you set the instrument to run the test continuously, it will execute about 216 loops in 24 hours. To stop the test at any time, press [SET]. If you press [POWER], some values may not be restored.

16.6.2 Procedure

1. Install the ac power adapter.
2. Install the single bantam cable between the T1 output and the main T1 input.
3. Set the speaker volume to a comfortable listening level.[1]
4. Select special in screen 3000 and then self test in screen 3010.
   - Screen 3600 is displayed.

```
3600
   SELF  TEST
       1
 Connect  T1
 output  to
 main  input.


→cancel                3000, 3610
```

5. Press [▲] or [▼] until 01 is displayed.
   - You can select how many times the self test should run. You can let the instrument endlessly repeat the test by choosing continuous.
6. Press [TEST].
   - Screen 3610 is displayed.

```
3610
   SELF  TEST
    RUNNING
       1

  Test  number
     nnnnn

 Please  wait.
```

- The number nnnnn will change as each test is performed.
- If all of the tests pass, screen 3601 is displayed.

1 Some of the tests send a tone to the speaker. If you leave the volume set to off, the BIST will set the volume to 1 during the tests.

3601

```
  SELF TEST
      2
 Connect T1
 output to
 ref input.


→cancel
```

3000, 3610

7. Move the bantam cable from the main input to the reference input.
8. Press [▲] or [▼] until 0 1 is displayed.
   - You can select how many times the self test should run. You can let the instrument endlessly repeat the test by choosing continuous.
9. Press [TEST].
   - Screen 3610 is again displayed (this is a very short test, so the screen may be displayed only briefly).
   - If all of the tests pass, screen 3602 is displayed.

3602

```
  SELF TEST
      3
 Loop serial
 port.



→cancel
```

3000, 3610

10. Install the serial port loopback adapter on the serial port.
11. Press [▲] or [▼] until 0 1 is displayed.
    - You can select how many times the self test should run. You can let the instrument endlessly repeat the test by choosing continuous.
12. Press [TEST].

- Screen 3610 is again displayed (this is a very short test, so the screen may be displayed only briefly).
- When all tests are complete, screen 3630 is displayed.

```
3630
   SELF TEST        3000
   COMPLETED


All tests OK.


Press any key
```

13. Press TEST to display screen 3000.

16.6.3 Self Test Failures

If any of the tests fails, the HP 37741A stops the BIST, and screen 3620 is displayed.

```
3620
   SELF TEST
    STOPPED
       1
  Test number
nnnnn failed.

  cancel            3000
→continue           3610
```

The test number is interpreted as the error code, and indicates the nature of the problem. The error codes are listed in appendix E.

The instrument continues to transmit the signal defined by the test number. The results can be viewed to identify the nature of the problem. In most cases, factory repair or replacement will be required. In some cases, recalibration will solve the problem.

By pressing TEST, you can continue the self test.

16.7 Pattern Test

16.7.1 Purpose

This test verifies that the UUT can generate and recognize the industry standard stress and quasi-random patterns.

16.7.2 Procedure

1. Set the UUT to its factory default state, and then set it to terminate the T1 input.
2. Connect the output of the T1 generator test set to the main input of the UUT.
3. Connect the input of the T1 monitor test set to the output of the UUT.
4. Start a continuous test.
5. Set the T1 generator test set for unframed DSX-level signal generation, with B8ZS encoding.
6. Use the T1 generator test set to generate each of the following signals in succession, verifying that each pattern is correctly identified by the UUT (by displaying screen 5300). Verify also that the T1 monitor receives the same pattern.
   - all zeroes
   - alternating 1/0
   - 1 in 8
   - 2 in 8
   - 3 in 24
   - QRW
   - 2^{15} - 1
   - 2^{20} - 1
   - 2^{23} - 1
7. Set the output of the UUT for unframed signal transmission, and generate each of the above signals in turn, verifying that each pattern is correctly recognized by the T1 monitor test set. For each transmitted pattern, also verify that the $2^{23}-1$ signal is still being correctly received without errors by the UUT.

16.8 Framing Test

16.8.1 Purpose

This test verifies that the UUT can generate and recognize all specified framing formats, and can act as a framing translator. Because many T1 test sets cannot generate and recognize ZBTSI or SLC-96 framing, the best choice for T1 generation and monitoring is to use the independent transmitter and receiver of a second HP 37741A.

16.8.2 Procedure

1. Set the UUT to its factory default state, and then set it to terminate the T1 input.
2. Connect the output of the T1 generator test set to the main input of the UUT.
3. Start a continuous test.
4. Set the T1 generator test set for DSX-level QRW generation.
5. Set the T1 generator test set to generate each of the following framing formats in succession, verifying that each framing format is correctly identified by the UUT (by viewing screen 5100).
    - unframed
    - D4
    - ESF
    - SLC-96
    - ZBTSI
6. Repeat steps 4 and 5 with an all ones payload.
7. Repeat steps 4 and 5 with an all zeroes payload with B8ZS coding.
8. Repeat step 5 with an all zeroes payload, with AMI coding. With the exception of ZBTSI framing, LOS should be declared, and all error accumulation inhibited.
9. Set the UUT to receive D4 framing.
10. Use the T1 generator test set to generate QRW with each of the above framing formats in turn, and verify that only the D4 signal is received without loss of framing.
11. Set the T1 generator test set to generate D4 framing again.
12. Connect the output of the UUT to the input of the T1 monitor test set.

13. Set the UUT for QRW transmission, and generate each of the above framing formats in turn, verifying that each framing format is correctly recognized by the T1 monitor test set. For each transmitted framing format, also verify that the D4 signal is still being correctly received without errors by the UUT.
14. Set the UUT to transmit the same framing format that it receives (as input).
15. Set the UUT receiver to auto frame mode (auto).
16. Use the T1 generator test set to generate each of the above framing formats in turn, and verify that, in each case, the same framing format is transmitted from the UUT.
17. Set the UUT for as input transmit payload.
18. Use the T1 generator test set to send an unframed 3 in 24 pattern to the UUT.
19. Set the UUT to transmit each of the above framing formats in turn, verifying that each framing format is correctly recognized by the T1 monitor test set, with a 3 in 24 payload in each case.

16.9 Mode Test (Fractional T1)

16.9.1 Purpose

This test verifies that the UUT can generate and recognize all specified modes, and can act as a mode translator. The T1 generator must be capable of fractional T1 generation, with 0xFF or 0x7F as the idle channel code. It is desirable that the T1 monitor be capable of automatically detecting the mode and channel map. If not, you will have to explicitly reconfigure it for each test.

16.9.2 Procedure

1. Set the UUT to its factory default state, and then set it to terminate the input and to autodetect the input mode.
2. Connect the output of the T1 generator test set to the main input of the UUT.
3. Start a continuous test.
4. Set the T1 generator test set for DSX-level D4 QRW generation.
5. Set the T1 generator test set to generate each of the following modes in succession, verifying that each mode is correctly

identified by the UUT (by viewing screen 5300). Also verify that the QRW pattern is received error free.

- full T1
- fractional T1: 12 × 64, all odd channels
- fractional T1: 4 × 56, channels 1 through 4
- fractional T1: 1 × 56, channel 1 only

6. Set the UUT receiver mode to 4 × 56 with channels 1 through 4 active.
7. Use the T1 generator to generate D4 QRW with each of the above modes in turn, and verify that only the 4 × 56 signal is received without loss of pattern synchronization.
8. Set the T1 generator test set to generate 1 in 15, with SLC-96 framing and mode set to 4 × 56.
9. Connect the output of the UUT to the input of the T1 monitor test set.
10. Set the UUT for ESF 3 in 24 transmission, and generate each of the above modes in turn, verifying that, in all cases, the T1 monitor recognizes an error free 3 in 24. For each transmitted mode, also verify that the 4 × 56 1 in 15 is still being received without errors by the UUT.
11. Set the UUT transmitter to `as receiver`, and the UUT receiver mode to `auto`.
12. Use the T1 generator test set to generate a ZBTSI 2^{23} - 1, in each of the above modes in turn, and verify that, in each case, the same mode is transmitted from the UUT, still carrying the 3 in 24 pattern.
13. Set the UUT for `as input` transmit payload.
14. Use the T1 generator test set to send an unframed 1 in 8 pattern to the UUT.
15. Set the UUT to transmit each of the above modes in turn, verifying that an error free 1 in 8 is recognized in each case.

16.10 Line Code Test

16.10.1 Purpose

This test verifies that the UUT can generate and recognize both specified line codes, and can act as a line code translator.

16.10.2 Procedure

1. Set the UUT to its factory default state, and then set it to terminate the T1 input.
2. Connect the output of the T1 generator test set to the main input of the UUT.
3. Set the T1 generator test set for DSX-level unframed QRW generation, and use it to transmit using each of the following line codes in succession, verifying that each line code is correctly identified by the UUT (by viewing screen 4100).
   - AMI
   - B8ZS
4. Connect the output of the UUT to the input of the T1 monitor test set.
5. Set the UUT for QRW transmission, and generate each of the above line codes in turn, verifying that each line code is correctly recognized by the T1 monitor test set. For each line coding format, also verify that the B8ZS QRW signal is still being correctly received without errors by the UUT.
6. Set the UUT to transmit the same line code that it receives (as input).
7. Use the T1 generator test set to generate each of the above line codes in turn, and verify that, in each case, the same line code is transmitted from the UUT.
8. Set the UUT for as input payload and framing transmission.
9. Use the T1 generator test set to send a D4 framed AMI 3 in 24 pattern to the UUT.
10. Set the UUT to transmit each of the above line codes in turn, verifying that each line code is correctly recognized by the T1 monitor test set.

16.11 Loopback Test

16.11.1 Purpose

This test verifies that the UUT can generate and recognize all standard loopback codes, and can translate loopback codes between framing formats. For steps 9 to 11 of this test, a single T1 test set must function as both a T1 transmitter and a T1 monitor. This instrument is referred to in this test as the T1 test set.

16.11.2 Procedure

1. Set the UUT to its factory default state, and then set it to terminate the T1 input.
2. Connect the output of the T1 test set to the main input of the UUT.
3. Connect the output of the UUT to the input of the T1 test set.
4. Set the T1 test set for DSX-level AMI 1 in 8 generation.
5. Use the T1 test set to transmit using each of the following loop codes in succession, verifying that each loop code is reported correctly in screen 4300:
    - D4 line loop up
    - D4 line loop down
    - D4 4 bit loop up
    - D4 4 bit loop down
    - D4 NI loop up
    - D4 NI loop down
    - ESF line loop up
    - ESF line loop down
    - ESF 4 bit loop up
    - ESF 4 bit loop down
    - ESF NI loop up
    - ESF NI loop down
    - ESF payload loop up
    - ESF payload loop down
6. Set the UUT to respond to loopback signals.
7. Set the UUT for AMI QRW transmission.
8. Use the T1 test set to transmit each of the above loop codes in succession, verifying that the UUT responds correctly to each loop

code. The pattern received at the T1 test set will be 1 in 8 if the UUT is looped, and QRW if it is not.

9. Set the UUT to not auto respond to received loopback signals.
10. Set the T1 test set to respond to loopback signals.
11. From screen 4300 of the UUT, send each of the above loop codes in turn, verifying that each loop code is correctly recognized by the T1 monitor test set. Verify also that the far end loop status is correctly reported by the UUT.
12. Set the UUT for `as input` loop code transmission, and for ESF framing.
13. Use the T1 generator test set to send each of the above D4 framed loop codes to the UUT. Verify that, in each case, the UUT transmits the correct loop code, but with altered framing.

16.12 Error Analysis Test

16.12.1 Purpose

This test verifies that the UUT can detect line and path errors, and can report the results as industry standard counts, rates, and availability parameters.

16.12.2 Procedure

1. Set the UUT to its factory default state, and then set it to terminate the T1 input.
2. Connect the output of the T1 generator test set to the main input of the UUT.
3. Set the T1 generator test set for DSX-level AMI unframed QRW generation, with a BPV error rate of 10^{-4}.
4. On the UUT, set the test time to 100 seconds and start a test. Display screen 4100, and verify that errors are accumulating.
5. After 100 seconds, the test will be complete, and the display should read:

	min	max
BPV	15438	15442
ES	100	100
EFS	0	0
%EFS	0	0
BER	1.0E−04	1.0E−04

6. Set the T1 generator test set for DSX level D4 AMI QRW generation, with a frame error rate of 10^{-4}.
7. On the UUT, set the test time to 100 seconds and start a test. Display screen 5100, and verify that errors are accumulating.
8. After 100 seconds, the test will be complete, and the display should read:

	min	max
EC	79	81
ES	79	81
OOFcnt	0	0
COFAcnt	0	0
avgER	9.9E−05	1.0E−04

9. Set the T1 generator test set for DSX-level ESF AMI QRW generation, with a frame error rate of 10^{-4}.
10. On the UUT, set the test time to 100 seconds and start a test. Display screen 5100, and verify that errors are accumulating.
11. After 100 seconds, the test will be complete, and the display should read:

	min	ax
EC	19	21
ES	19	21
OOFcnt	0	0
COFAcnt	0	0
avgER	9.5E−05	1.1E−04

12. Set the T1 generator test set for DSX-level D4 AMI QRW generation, with a logic error rate of 10^{-4}.
13. On the UUT, set the test time to 100 seconds and start a test. Display screen 5300, and verify that errors are accumulating.
14. After 100 seconds, the test will be complete, and the display should read:

	min	max
EC	15358	15362
ES	100	100
EFS	0	0
%EFS	0	0
BER	1.0E−04	1.0E−04

15. Set the T1 generator test set for DSX-level ESF AMI QRW generation, with a CRC error rate of 10^{-4}.
16. On the UUT, set the test time to 300 seconds and start a test. Display screen 5200, and verify that errors are accumulating.
17. After 300 seconds, the test will be complete, and the display should read:

	min	max
EC	9	11
ES	9	11
EFS	289	291
%EFS	96	97
avgER	9.0E−05	1.1E−04

18. Set the T1 generator test set for DSX-level unframed AMI generation, with a repeating 1000 0000 0000 0000 0 pattern (17 bits).
19. On the UUT, set the test time to 10 seconds and start a test. Display screen 4400, and verify that errors are accumulating.
20. When the test is complete, the display should read:

	min	max
Xs0s	908117	908353
Dense	80000	81000

21. Set the T1 generator test set for DSX-level AMI generation, with a D4 framed LoDns pattern
22. On the UUT, set the test time to 10 seconds and start a test. Display screen 4400, and verify that errors are accumulating.
23. When the test is complete, the display should read:

	min	max
Xs0s	0	0
Dense	7082	7086

24. Set the T1 generator test set for DSX-level unframed AMI generation, with a repeating 1 in 8 pattern. On the UUT, set the test time

to 10 seconds and start a test. Display screen 4400, and verify that errors are accumulating.

25. When the test is complete, the display should read:

	min	max
XsOs	0	0
Dense	0	0

16.13 Alarm Test

16.13.1 Purpose

This test verifies the UUT's ability to generate and recognize all specified alarm signals.

16.13.2 Procedure

1. Set the UUT to its factory default state, and then set it to terminate the T1 input.
2. Connect the output of the T1 generator test set to the main input of the UUT.
3. Set the UUT test time to `continuous`.
4. For each entry in the following table, use the T1 generator test set to generate the designated input signal, and set up the receive configuration of the UUT as shown.
5. Display screen 5000 on the UUT, and check that the correct entry, and only that entry, of the display is incrementing at the rate of one per second. After each resetting of the input signal or receive mode, restart the test.

T1 Generator Output				UUT Receive Frame	Display
none (remove signal)				auto	LOS incrementing
–	–	–	AIS	D4	AIS incrementing
–	–	–	AIS	ESF	AIS incrementing
D4	AMI	QRW	yellow	D4	Yellow incrementing
D4	AMI	QRW	yellow	ESF	FrmLos incrementing
ESF	AMI	QRW	yellow	D4	FrmLos incrementing
ESF	AMI	QRW	yellow	ESF	Yellow incrementing
unfr	AMI	QRW	no alarms	auto	static display

6. While the final test is still running, change the input signal to unframed AMI repeating 1000 (user defined).
7. Verify that the `PtnLos` count is now incrementing (one per second) on the display.
8. Connect the output of the UUT to the input of the T1 monitor test set.
9. For each entry in the following table, transmit the indicated signal from the UUT, and use the T1 monitor test set to verify that the designated output signal is being received correctly.

	UUT output			Check for
–	–	–	AIS	AIS
D4	AMI	QRW	yellow	yellow
ESF	AMI	QRW	yellow	yellow
unfr	AMI	all zeroes	no alarms	LOS

16.14 Receive Interface Test

16.14.1 Purpose

This test verifies the ability of the UUT receive circuitry to tolerate the full range of acceptable DS1 signals, and to measure level and frequency accurately.

16.14.2 Procedure

16.14.2.1 Pattern Recognition

1. Set the UUT to its factory default state, and then set it to terminate the T1 input.
2. Use the bantam cable to connect the output of the T1 generator test set to the main input of the UUT, and start a continuous test.
3. Set the T1 generator test set for D4 framing, and use it to generate each of the following signals in succession.
4. Verify that each pattern is correctly identified by the UUT and received without errors (by viewing screen 5300)

Pattern	Level
All ones	0 dBdsx
All ones	−7.5 dBdsx
All ones	−15 dBdsx
1 in 8	0 dBdsx
1 in 8	−7.5 dBdsx
1 in 8	−15 dBdsx
3 in 24	0 dBdsx
3 in 24	−7.5 dBdsx
3 in 24	−15 dBdsx

16.14.2.2 Line Frequency Measurement

1. Set the UUT to its factory default state, and then set it to terminate the T1 input.
2. Set up the first function generator and the UUT as shown in figure 16-4.
3. Start a continuous test on the UUT.
4. For each entry of the following table, adjust the function generator signal (as defined in section 16.4) and the resistors as indicated, and place the UUT in the correct termination mode.
5. Verify that the frequency displayed on screen 4000 is correct within the limits shown:

Waveform	RL	RS	UUT	Frequency (min)	Frequency (max)
0dB1in8	∞	0	terminated	1543992	1544008
−15dB1in8	∞	0	terminated	1543992	1544008
0dB1in8	100	0	bridge	1543992	1544008
−15dB1in8	100	0	bridge	1543992	1544008
0dB1in8	100	442	monitor	1543992	1544008
−15dB1in8	100	442	monitor	1543992	1544008

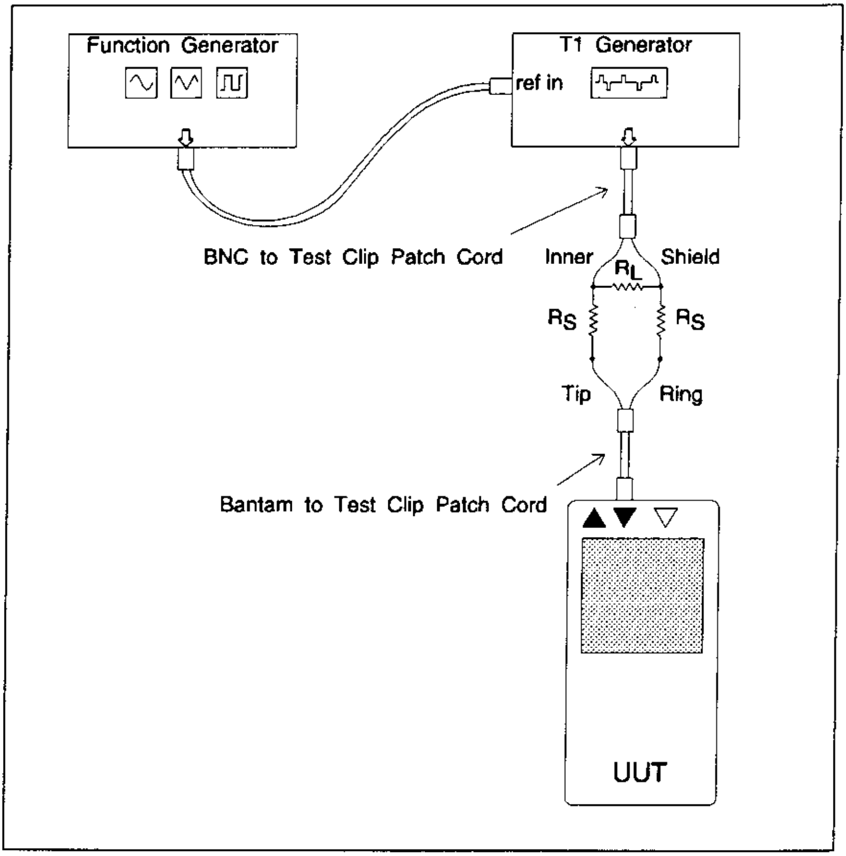


Figure 16-4 Line Frequency Measurement

16.14.2.3 Line Level Measurement

1. Set up the first function generator and the UUT as shown in figure 16-5.
2. Display screen 4000 of the UUT. For each entry of the following table, adjust the function generator signal (as defined in section 16.4) and the resistors as indicated, and place the UUT in the correct termination mode.
3. Verify that the displayed level is correct within the limits shown:

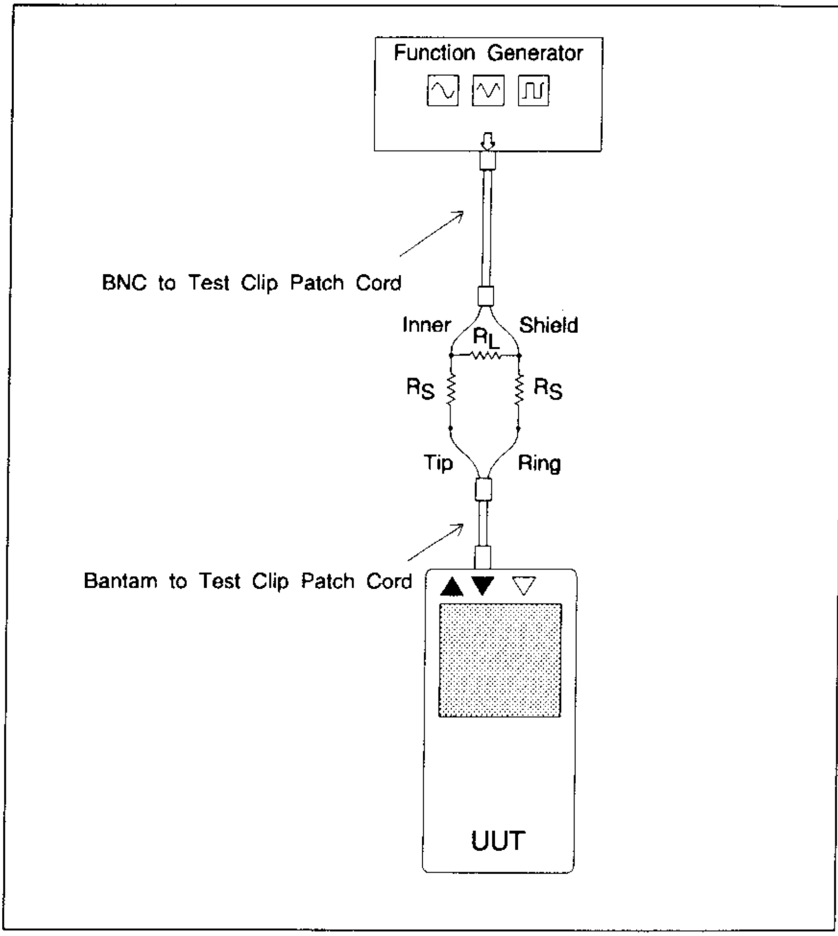


Figure 16-5 Line Level Measurement

Waveform	RL	RS	UUT	Level (min)	Level (max)
0dBalt0/1	∞	0	terminated	5.6 Vpp	6.4 Vpp
−15dBall1s	∞	0	terminated	0.94 Vpp	1.2 Vpp
−33dBall1s	∞	0	terminated	0.10 Vpp	0.17 Vpp
0dBalt0/1	100	0	bridge	5.6 Vpp	6.4 Vpp
−15dBall1s	100	0	bridge	0.94 Vpp	1.2 Vpp
−33dBall1s	100	0	bridge	0.10 Vpp	0.17 Vpp
0dBalt0/1	100	442	monitor	5.6 Vpp	6.4 Vpp
−15dBall1s	100	442	monitor	0.94 Vpp	1.2 Vpp
−33dBall1s	100	442	monitor	0.10 Vpp	0.17 Vpp

16.14.2.4 Simplex Current Measurement

CAUTION

Do the following simplex current measurement test carefully. A fuse internal to the UUT may blow if the simplex current exceeds 250 mA.

1. Set the open circuit voltage on the power supply to 15 V, and the current limit to 0 A.
2. Connect the digital multimeter to the power supply as shown in figure 16-6, but without the UUT.
3. Short the positive side of the power supply to the positive side of the digital multimeter, and set the digital multimeter to read current.

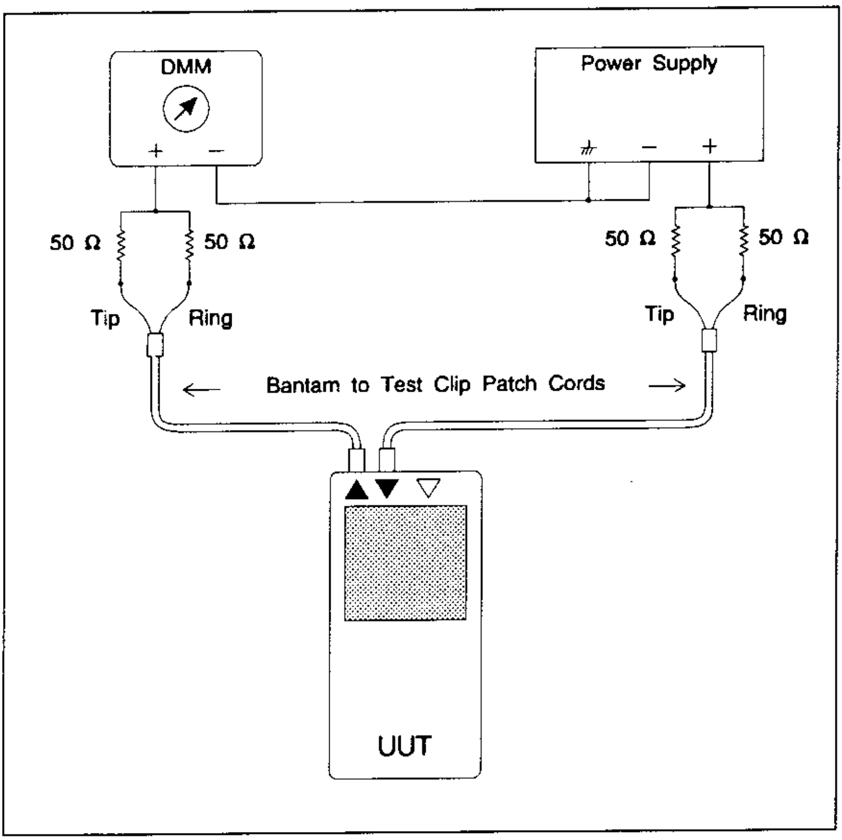


Figure 16-6 Simplex Current Measurement

4. Gradually increase the current limit until the multimeter reads 130 mA.
5. Remove the wire shorting the positive side of the multimeter to the power supply, and connect the UUT as shown in figure 16-6.
6. Display screen 4000 on the UUT.
7. For each entry of the following table, carefully adjust the current limit until the multimeter reads the specified current (*Is*), and verify that the value displayed by the UUT is within the limits indicated:

Is (mA)	Displayed current (min)	Displayed current (max)
130	120 mA	140 mA
60	55 mA	65 mA

16.15 Transmit Interface Test

16.15.1 Purpose

This test verifies the ability of the T1 transmit circuitry to transmit acceptable DSX-level signals with the correct selected timing.

16.15.2 Procedure

16.15.2.1 Transmit Pulse

1. Set the UUT to its factory default state, and then set it to terminate the T1 input.
2. Set up the first function generator, the oscilloscope, and the UUT as shown in figure 16-7.
3. Start a continuous test on the UUT.
4. Set up the UUT to transmit an unframed 1 in 8 pattern, with internal timing. Adjust the oscilloscope to display channel 2, so that a single positive pulse fills the screen.

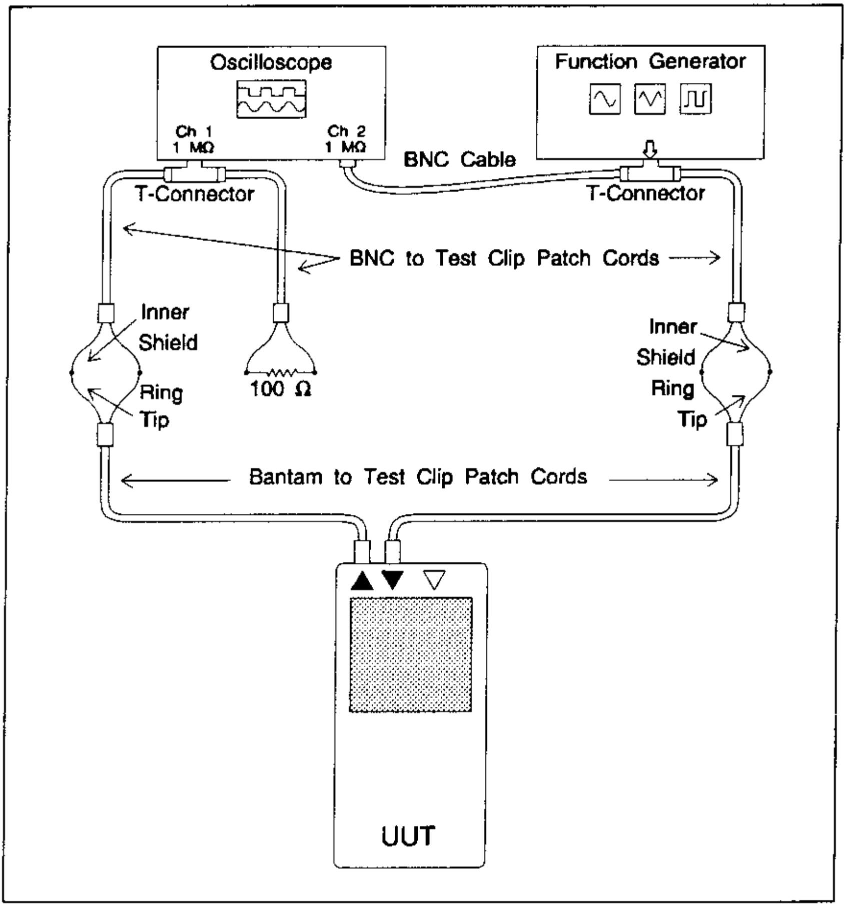


Figure 16-7 Transmit Timing Measurement

5. Verify that the pulse is within the limits indicated in the following table:

Parameter	Minimum	Maximum
Pulse height (at pulse center)	2.4 V	3.6 V
Pulse width (at mid height)	294 ns	354 ns
Rise time (10% to 90%)	0 ns	75 ns
Fall time (90% to 10%)	0 ns	75 ns
Overshoot (above pulse height)	0 ns	15% of pulse height
Undershoot (below base line)	0 ns	45% of pulse height

6. Verify the same set of parameters for the negative pulse.

16.15.2.2 Transmit Timing

1. Set the UUT for unframed all ones generation, and set the oscilloscope to display channels 1 and 2. For each line of the following table:
   - Move the cable carrying the function generator signal to the designated input of the UUT.
   - Generate the designated pattern with the function generator.
   - Set the transmit timing on the UUT as indicated.
   - By observing the oscilloscope, verify that the indicated pass condition is met.

signal	input	Tx timing	pass condition
−21dBall1s	main	from main	output synchronous with main input
−21dBall1s	ref	from ref	output synchronous with ref input

2. Set the function generator to send 1 Vpp sine wave with a frequency of 772 000 Hz. Set the UUT for internal timing, and adjust the frequency of the function generator until the two oscilloscope traces are drifting with respect to each other by at most one period in 10 seconds.
3. Verify that the function generator frequency is between 771 970 Hz and 772 030 Hz.

16.16 Bit Slips Test

16.16.1 Purpose

This test verifies the ability of the UUT to detect and report bit slips between the two T1 inputs.

16.16.2 Procedure

1. Set up the two function generators and the UUT as shown in figure 16-8. Ensure that the second function generator is locked to the first.
2. Set the UUT to its factory default state, and then set it to terminate the T1 input.
3. Set both function generators to send 1 Vpp sine waves with frequencies of 772 000 Hz.
4. Display screen 4200, and verify that no slips are detected.

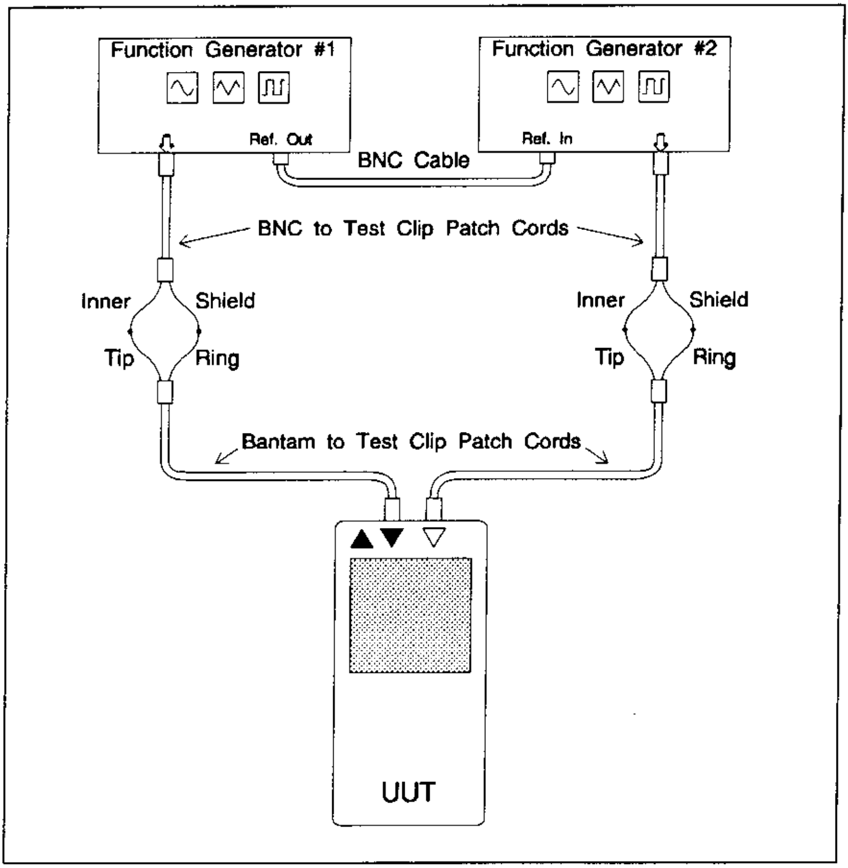


Figure 16-8 Slip Count Measurement

5. Set the UUT test time for 60 seconds.
6. Set the frequency on the first function generator to 772 492 Hz.
7. Set the frequency on the second function generator to 772 500 Hz.
8. Start the test.
9. At the end of the test, verify that the bit slips are displayed as follows:

Parameter	Minimum	Maximum
Total	−4;187	−4;189
Current Direction	slow	slow
Estimated Frame Slips	4	4
Relative Bit Slips	187	189

10. Set the frequency on the first function generator to 771 508 Hz.
11. Set the frequency on the second function generator to 771 500 Hz.
12. Start the test.
13. At the end of the test, verify that the BIT SLIPS display is as follows:

Parameter	Minimum	Maximum
Total	+4;187	+4;189
Current Direction	fast	fast
Estimated Frame Slips	4	4
Relative Bit Slips	187	189

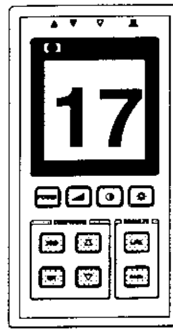
16.17 Channel Access Test

16.17.1 Purpose

The ability of the UUT to generate and detect voice frequency signals embedded in a specified DS1 channel has already been tested in the user interface test and the built in self test.

16.17.2 Procedure

No further testing is required.



Calibration

17.1 Introduction

17.1.1 General

Performance of the following calibration procedures will ensure that the following will meet their accuracy specifications:

- measurement of received T1 signal level
- measurement of received T1 signal frequency
- measurement of simplex current
- transmitted DS0 tone amplitude

This instrument employs "closed-box" electronic calibration. There are no internal mechanical adjustments. The calibration constants are kept in the instrument's battery backed up memory. After complete discharge of the battery the instrument will need to be recalibrated.

17.1.2 Hewlett-Packard Calibration Services

When your HP 37741A DS1 tester is due for recalibration, contact your local HP sales office for a low cost recalibration.

17.1.3 Calibration Interval

The HP 37741A should be calibrated on a regular interval determined by the measurement accuracy requirements of your application. For the most demanding applications, a 90 day or 180 day interval is recommended. However, for the majority of applications, a one year, or even 18 months interval may be adequate. HP does not recommend extending calibration intervals beyond two years in any application.

Each instrument is calibrated before it leaves the factory.

17.1.4 Accuracy When Not Calibrated

HP does not guarantee the accuracy of your instrument when uncalibrated. However, the following will give you an idea of the approximate accuracies of the HP 37741A when it is not calibrated:

Level Measurement	± 1½ dB
Frequency measurement	± 40 ppm
Simplex current measurement	± 2½ mA
DS0 tone amplitude	± 0.4 dB

17.1.5 Automating Calibration Procedures

The complete verification and adjustment procedures may be automated if a computer and programmable test equipment are available. The HP 37741A is controlled through its serial port. The HP 15726A external control software[1] is intended for use with an MS-DOS based system and includes a semi-automated interface for calibrating the HP 37741A DS1 tester. Alternatively, you can write your own software. In this case, there is no restriction on computer type, except that it must support EIA-232 serial communication as defined in section 13. All serial messages (commands and replies) required to perform calibration are included in section 13.4.

If you are using the HP 15726A software, you need read only sections 17.1 and 17.2.

17.1.6 Time Required for Calibration

When all the equipment is available, an instrument can be calibrated in about 10 minutes if fully automated, about 15 minutes if semi-automated (by using the HP 15726A software), or about 50 minutes if manually performed.

1 The software is available as an optional accessory. It is described in appendix D.

17.1.7 Calibration Date and Time

You can see when the instrument was last calibrated by displaying the system summary (screen 2500), as described in section 6.1.3.

When the HP 37741A receives a calibration command over its serial port, it updates the calibration date and time with the test set's current date and time. When performing calibration, it is recommended that you start by setting the current date and time to an obscure value (the HP 15726A software uses 00/12/31). Then, if the calibration procedure fails, a user would not think that the instrument was calibrated when in fact it is not.[1]

Before writing the final calibration offsets, set the instrument's date and time back to the correct values.

As described in section 7.1.5, the displayed calibration date is that associated with the last set of test results. You must therefore run a (dummy) test, before the actual calibration date is displayed.

17.1.8 Equipment Required

The full calibration procedure requires performing the entire performance verification test, as defined in section 16. For this reason, the full set of equipment and accessories given in section 16.2 will be needed. Each instrument used to calibrate the unit must itself be calibrated.

Procedures described in this section require the function generator, the T1 generator, the power supply, and the external control PC software.

The HP 37741A that is being calibrated is referred to as the UUT in the rest of this section.

17.1.9 Function Generator Test Patterns

The function generator test patterns referenced in the calibration procedures are defined in section 16.4.

These patterns are provided as files with the HP 15726A software, and are automatically downloaded to the function generator as required.

1 The software also changes the unit ID to "UNCALIBRATED".

17.2 Setup for Semi-Automated Calibration

This describes how to use the HP 15726A external control PC software to calibrate the HP 37741A DS1 tester. The software is semi-automated in that it does not switch the T1 signals to the UUT. This must be performed manually.

The function generator must be an SRS DS345-02.

1. Set the UUT's EIA-232 port for external control, 9600 b/s.
2. Set the Function Generator's EIA-232 port for external control, 9600 b/s.
3. Connect the UUT to the PC's COM1 with a serial DTE to DCE cable.
4. Connect the Function Generator to the PC's COM2 with a serial DTE to DCE cable.
5. Invoke the calibration software as described in the HP 15726A User's Manual.
6. Follow the instructions on the screen.
7. When completed, you can disconnect the instrument.
8. The software writes a report to the PC's hard disk, which can be viewed or printed if desired.

17.3 Manual Calibration

17.3.1 Calibration Reset

1. If you want to calibrate only one parameter, read the current calibration constants and record their values.
2. Send a **Download Calibration Constants** command to the UUT with the following arguments:
   - reset the 14 level measurement offsets to all zeroes
   - reset the frequency offset to zero
   - set the simplex current calibration to 1.00
   - reset the tone amplitude offset to zero
3. In the following sections, you will record the new calibration arguments. These are transferred to the instrument at the end of the calibration procedure, described in section 17.3.6.

17.3.2 Level Calibration Array

1. Set up the first function generator and the UUT as shown in figure 16-5.
2. Start a test on the UUT.
3. For each entry of the following table, adjust the function generator signal and the resistors as indicated, and place the UUT in the correct termination mode.

Waveform	RL	RS	UUT	Expected Level
+3dBalt10	∞	0	terminated	+3.0
−3dBalt10	∞	0	terminated	−3.0
−9dBall1s	∞	0	terminated	−9.0
−15dBall1s	∞	0	terminated	−15.0
−21dBall1s	∞	0	terminated	−21.0
−27dBall1s	∞	0	terminated	−27.0
−33dBall1s	∞	0	terminated	−33.0
+3dBalt10	100	442	monitor	+3.0
−3dBalt10	100	442	monitor	−3.0
−9dBall1s	100	442	monitor	−9.0
−15dBall1s	100	442	monitor	−15.0
−21dBall1s	100	442	monitor	−21.0
−27dBall1s	100	442	monitor	−27.0
−33dBall1s	100	442	monitor	−33.0

4. Record the value displayed by the UUT.
   - Wait for the reading to stabilize before recording the value.[1]
   - For improved accuracy, read the voltage level, and convert to dB.
5. For each entry, record the offset between the expected value and the recorded value in each case. For example, if you are generating −3.0 dBdsx, and the instrument reads −3.2 dBdsx, record an offset of +0.2 dBdsx.

17.3.3 Frequency Calibration Offset

1. Set up the first function generator and the UUT as shown in figure 16-4, with all resistors removed (RL = ∞ Ω, and RS = 0 Ω). Set the function generator to generate the −15dBall1s signal.
2. Install the ac adapter, set the UUT to its default state, and then set it to terminate the T1 input.

[1] The HP 15726A software requires four readings to be very close before recording the value.

3. Start a test on the UUT.
4. Record the value displayed by the UUT.
   - Wait for the reading to stabilize before recording the value.[1]
5. Record the offset between 1 544 000 Hz and the recorded frequency. For example, if the UUT reads 1 544 007 Hz, record an offset of −7 Hz.

17.3.4 Simplex Current Calibration

CAUTION

Perform the following calibration carefully. A fuse internal to the UUT may blow if the simplex current exceeds 250 mA.

1. Before connecting the equipment, set the open circuit voltage on the power supply to 15 V, and the current limit to 0 A.
2. Connect the digital multimeter as shown in figure 16-6, but without the UUT.
3. Short the positive side of the power supply to the positive side of the digital multimeter, and set the digital multimeter to read current.
4. Gradually increase the current limit until the multimeter reads 100 mA ± 4 mA.
5. Remove the wire shorting the positive side of the multimeter to the power supply, and connect the UUT as shown in figure 16-6.
6. Install the ac adapter, set the UUT to its default state, and then set it to terminate the T1 input.
7. Start a test on the UUT.
8. Record the simplex current value displayed by the UUT.
   - Wait for the reading to stabilize before recording the value.[2]
9. Record the multiplication offset. This is the result of the division of the multimeter recorded current and the UUT's recorded current. For example, if the UUT reads 102 mA and the multimeter reads 98.7 mA, record an offset of 0.968.

---

1 The HP 15726A software waits 20 seconds, and then requires five readings to be very close before recording the value.

2 The HP 15726A software requires three readings to be very close before recording the value.

17.3.5 DS0 Tone Amplitude Calibration

1. Connect the UUT's output to its input with the bantam cable.
2. Set the UUT to transmit the following:
   - D4 framing
   - TmSlt payload
   - 1004 Hz tone at −10 dBm0 in channel 1
   - unmodified signaling
3. Set the UUT's receiver as follows:
   - terminate the T1 line
   - D4 framing
   - DS0 receive channel 1
4. Record the tone amplitude value displayed by the UUT in screen 5501.
5. Record the offset between −10 dBm0 and the recorded amplitude. For example, if the measured amplitude is −9.7 dBm0, record an offset of +0.3 dBm0.

17.3.6 Calibration Download

1. Send a **Download Calibration Constants** command to the UUT, using the 17 numbers recorded in the preceding measurements. See section 13.4.9.29 for the format of this command.

17.4 Performance Verification

Charge the battery, according to the procedure given in section 14. Perform the full performance verification test, as defined in section 16.

If any test fails, return the unit for repair.

Serial Communications

A.1 General

A.1.1 DTE and DCE

In serial transmission, such as EIA-232, data is sent one bit at a time between two devices.[1] One end of the link is referred to as the DTE, and is normally a computer. The other end is normally a modem, and is referred to as the DCE.

A.1.2 Asychronous Data

With serial data, sometimes just seven data bits are sent to represent each character. In asynchronous communications, a start and a stop bit are added, to make 9 bits in all. It is possible to add multiple stop bits (with two being the usual alternative); this allows a slow receiving device more time to process the characters that have been sent.

Usually, an eight bit data word is sent, with the most significant bit being 0 for normal characters. The MSB can be set to a 1 to indicate extended characters, such as fractions or ligatures, and there exist multiple standards for this type of use.

A.1.3 Parity

Parity bits are commonly used for data transmission as a simple form of error detection. The parity bit is set to a 1 if there exist an even number

[1] In parallel communications, such as a printer port or a HP-IB port, all bits that make up a byte of information are sent at the same time.

of ones in the information word (*odd parity*), or it is set to a 1 if there exist an odd number of ones in the information word (*even parity*). Sometimes, the parity bit is forced to a 0 or to a 1, irrespective of the state of the other bits in the word.

The parity bit may be transmitted as the MSB of an 8 bit transmission scheme (be it serial or parallel). When a start and a stop bit are added for asynchronous serial transmission, there are a total of 10 bits in the word to be transmitted. If the transmission medium has a speed of 2400 bits per second, 240 characters can be sent in a second.

If an information word of eight bits is used, the parity bit is added as a ninth bit, which results in a total of 11 bits for asynchronous serial transmission.

A.1.4 Synchronous Data

When serial data is transmitted synchronously, the clock is sent either encoded in the signal, or as a separate circuit. The throughput can be faster because there is no overhead for start and stop bits, but the receiving circuitry is more complex.

A.2 ASCII Code

Both serial and parallel forms of transmission have tended to standardize on a coding format known as ASCII. This defines 128 characters, by using a seven bit code.[1]

In general, eight bits are used to represent a word of information, and this is the preferred format for most parallel transmission media, such as HP-IB[2] (for test equipment control), and Centronics (for computer to printer data).

The table on the opposite page shows the 128 ASCII characters. Character 26 decimal is shown as EOF (instead of its strict definition of SUB), because it is more commonly used to indicate end of file. Character 127 decimal is commonly used to print "▒", instead of being used to indicate "delete".

1 Other formats still in use include EBCDIC and Baudot.
2 HP-IB is Hewlett-Packard's implementation of IEEE-488.

765	000	001	010	011	100	101	110	111
Bits 4321	Control		Numbers, Symbols		Upper Case		Lower Case	
0000	0 NUL 0 0	20 DLE 10 16	40 sp 20 32	60 0 30 48	100 @ 40 64	120 P 50 80	140 ' 60 96	160 p 70 112
0001	1 SOH 1 1	21 DC1 11 17	41 ! 21 33	61 1 31 49	101 A 41 65	121 Q 51 81	141 a 61 97	161 q 71 113
0010	2 STX 2 2	22 DC2 12 18	42 " 22 34	62 2 32 50	102 B 42 66	122 R 52 82	142 b 62 98	162 r 72 114
0011	3 ETX 3 3	23 DC3 13 19	43 # 23 35	63 3 33 51	103 C 43 67	123 S 53 83	143 c 63 99	163 s 73 115
0100	4 EOT 4 4	24 DC4 14 20	44 $ 24 36	64 4 34 52	104 D 44 68	124 T 54 84	144 d 64 100	164 t 74 116
0101	5 ENQ 5 5	25 NAK 15 21	45 % 25 37	65 5 35 53	105 E 45 69	125 U 55 85	145 e 65 101	165 u 75 117
0110	6 ACK 6 6	26 SYN 16 22	46 & 26 38	66 6 36 54	106 F 46 70	126 V 56 86	146 f 66 102	166 v 76 118
0111	7 BEL 7 7	27 ETB 17 23	47 ' 27 39	67 7 37 55	107 G 47 71	127 W 57 87	147 g 67 103	167 w 77 119
1000	10 BS 8 8	30 CAN 18 24	50 (28 40	70 8 38 56	110 H 48 72	130 X 58 88	150 h 68 104	170 x 78 120
1001	11 HT 9 9	31 EM 19 25	51) 29 41	71 9 39 57	111 I 49 73	131 Y 59 89	151 i 69 105	171 y 79 121
1010	12 LF A 10	32 EOF 1A 26	52 * 2A 42	72 : 3A 58	112 J 4A 74	132 Z 5A 90	152 j 6A 106	172 z 7A 122
1011	13 VT B 11	33 ESC 1B 27	53 + 2B 43	73 ; 3B 59	113 K 4B 75	133 [5B 91	153 k 6B 107	173 { 7B 123
1100	14 FF C 12	34 FS 1C 28	54 , 2C 44	74 < 3C 60	114 L 4C 76	134 \ 5C 92	154 l 6C 108	174 | 7C 124
1101	15 CR D 13	35 GS 1D 29	55 - 2D 45	75 = 3D 61	115 M 4D 77	135] 5D 93	155 m 6D 109	175 } 7D 125
1110	16 SO E 14	36 RS 1E 30	56 . 2E 46	76 > 3E 62	116 N 4E 78	136 ^ 5E 94	156 n 6E 110	176 ~ 7E 126
1111	17 SI F 15	37 US 1F 31	57 / 2F 47	77 ? 3F 63	117 O 4F 79	137 _ 5F 95	157 o 6F 111	177 DEL 7F 127

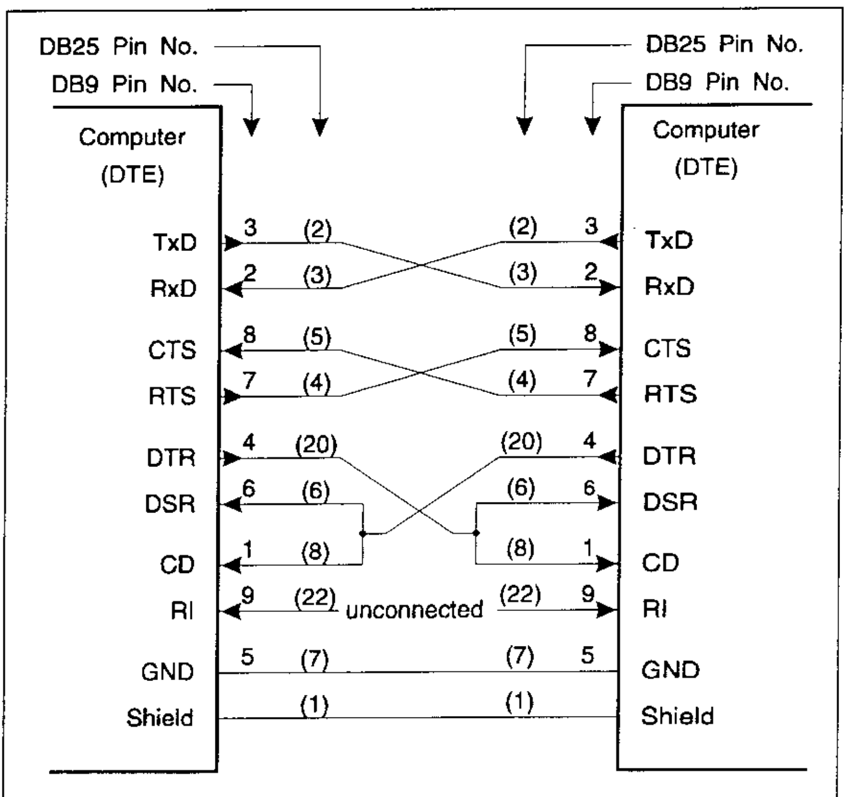
Key:		
Octal	77	
	?	ASCII Character
Hex	3F 63	Decimal

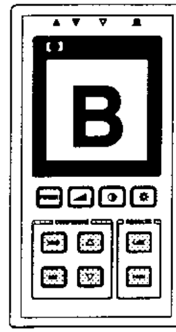
A.3 Connecting Two Serial Devices

The serial communications standards clearly define the physical requirements needed to connect two serial devices. Much confusion exists, however, resulting in an abundance of cable types, connector types, and assorted adapters being required.

The EIA-232 standard specifies the use of 25 pin connectors. A computer is a DTE, and it should preferably be fitted with a male connector. All PCs obey this rule. A modem is a DCE, and it should be fitted with a female connector. All modems obey this rule. Thus to connect a PC to a modem, you need a standard (straight) cable, with a male connector on one end, and a female connector on the other end. Modern PCs use a 9 pin male connector, configured as a DTE.

Wiring for a straight cable, and a null terminal cable are shown in figures 13-2 and 13-3. For completeness, a null modem cable is shown below, but this is not used to connect to the HP 37741A.





Acronyms

To avoid repetition, and in recognition that this book may be read in any sequence, acronyms have not been defined where first used. They are listed here with their definitions.

μ	micro (10^{-6})
Ω	ohm
A	ampere
ABAM	a 22 awg twisted pair cable for CO use
ac	alternating current
ACO	alarm cutoff
ADMX	add-drop multiplexer
AGC	automatic gain control
AIS	alarm indication signal
AI	alarm interface
ALBO	automatic line build-out
am	before midday
AMI	alternating mark inversion
ANSI	American National Standards Institute
APS	automatic protection switch
AS	available seconds
ASCII	American standard code for information interchange
AtoD	analog to digital (conversion)
avgER	average error rate
%avl	percent available time
b/s	bits per second
B8ZS	bipolar with 8 zeroes substitution

BER bit error rate
BERT bit error rate test
BIST built in self test
BITS building integrated timing supply
BLERT block error rate test
BOC Bell operating company
BOP bit oriented protocol
BPV bipolar violation
BRI basic rate interface

CB channel bank
CCC clear channel capability
CCITT Comité Consultatif International Télégrahique et Téléphonique (The International Telegraph and Telephone Consultative Committee). {The new name is ITTS.}
CCS common channel signaling
CD carrier detect
CEPT European Conference of Postal and Telecommunications Administrations
CGA carrier group alarm
CO central office
COFA change of frame alignment
COT central office terminal
CPE customer premises equipment
CR carriage return
CRC cyclic redundancy check code
CSA Canadian Standards Administration
CSES consecutive severely errored seconds
CSU channel services unit
CTS clear to send
CV coding violation

D1, D1D, D2, D3, D4 various generations of channel banks manufactured by Western Electric
D4 commonly used to refer to a DS1 frame format
DACS digital access and cross-connect switch
dB decibel
DB25 25 pin D-type connector
DB9 9 pin D-type connector
dBdsx decibel, with respect to the level at the DSX point
dBm decibel, with respect to one milliwatt

dBm0	decibel, with respect to one milliwatt referenced to the 0 transmission level point
dBrnC0	decibel above reference noise, measured with C-message weighting at 0 transmission level point
dc	direct current
DC1	device control number one
DC3	device control number three
DCD	data carrier detect
DCE	data circuit terminating equipment
DDS	digital data service
DES	data encryption standard
DIP	dual in-line package
DIW	D-type inside wire
D&I	drop and insert
DL	data link
DLC	digital loop carrier
DM	degraded minutes
DMM	digital multimeter
DOS	disk operating system
DS0	digital signal level 0 (64 kb/s – speech channel)
DS1	digital signal level 1 (1.544 Mb/s)
DS1C	digital signal level 1C (3.152 Mb/s)
DS2	digital signal level 2 (6.312 Mb/s)
DS3	digital signal level 3 (44.736 Mb/s)
DSR	data set (DCE) ready
DSU	data services unit
DSX	digital signal cross-connect
DSX-1	digital signal cross-connect for DS1 signals
DSX-3	digital signal cross-connect for DS3 signals
DtoA	digital to analog (conversion)
DTE	data terminal equipment
DTR	data terminal (DTE) ready
DVM	digital voltmeter
EC	error count
EDSX	electronic digital signal cross-connect
%EFS	percent error free seconds
EFS	error free seconds
EIA	Electronic Industries Association
EL	electro-luminescent
EMI	electromagnetic interference
EOC	embedded operations channel

ER error rate
ESD electro static discharge
ESF extended superframe format
ETSI European Telecom Standards Institute

FAS frame alignment sequence
FCC Federal Communications Commission
FDDI fiber distributed data interface
FDL facility data link
FEBE far end block error
FF form feed
FLS frame loss seconds
FMAC facility maintenance and administration center
ft feet
FT1 fractional T1

g gram; acceleration due to gravity
GND ground

HP-IB Hewlett-Packard Interface Bus
Hz hertz

ICOT inter-city and outstate trunk
ID identity (or identification)
IDF intermediate distribution frame
IEC International Electrotechnical Commission
IEEE Institute of Electrical and Electronic Engineers
in inch
I/O input/output
ISDN integrated services digital network
ISO International Organization for Standardization
ITTS ITU Telecommunications Standardization Sector (formerly the CCITT)
ITU International Telecommunication Union
IXC interexchange carrier

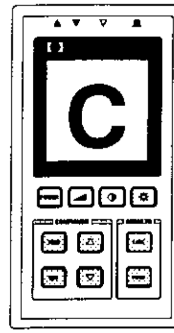
k kilo (1000)
K 1024
kb/s kilobits per second
kg kilogram
kHz kilohertz
km kilometer

LAN	local area network
LAPD	link access protocol, level D
LBO	line build out
LCD	liquid crystal display
LED	light emitting diode
LF	line feed
LOF	loss of frame
LOS	loss of signal
LSB	least significant bit
LT	line termination
m	meter
M13	DS1 to DS3 multiplexer
M1C	DS1 to DS1C multiplexer
mA	milliampere
MAN	metropolitan area network
MAT	metropolitan area trunk
Mb/s	million bits per second
MDF	main distribution frame
MHz	megahertz
mm	millimeter
MML	man machine language
MNP	Microcom Networking Protocol
MOP	message oriented protocol
MOS	manually out of service
ms	millisecond
MSB	most significant bit
MTBF	mean time between failure
mW	milliwatt
N	Newton
N × 56	FT1: a number of channels each carrying 56 kb/s
N × 64	FT1: a number of channels each carrying 64 kb/s
n/a	not applicable
NCTE	network circuit-terminating equipment
NEBS	network equipment building system
NI	network interface
NiCd	nickel-cadmium
NIST	National Institute of Science and Technology
ns	10^{-9} of a second
NSA	non-service affecting

NT	network termination
NTE	network terminal equipment
NTS	network test system
OAMP	operations, administration, maintenance, and provisioning
OOF	out of frame
ORB	office repeater bay
OS	operations system
OSI	open systems interconnection
OSS	operations support system
OTGR	operation technology generic requirements
PABX	private automatic branch exchange
PAD	packet assembler/disassembler
PC	personal computer
PCB	printed circuit board
PCM	pulse code modulation
PDS	premises distribution system
PIC	polyethylene insulated conductor
PLS	pattern loss seconds
pm	after midday
PNO	private network operator
POP	point of presence
POST	power on self test
POTS	plain old telephone service
ppm	parts per million
PRBS	pseudo-random binary sequence
PRI	primary rate interface
PSU	power supply unit
PSTN	public switched telephone network
PTT	post, telephone, and telegraph administration
QRSS	quasi-random signal source
QRW	quasi-random word (the signal output by a QRSS)
RAI	remote alarm indicator (yellow alarm)
RAM	random access memory
RBOC	regional Bell operating company
RI	ring indicator
RFI	radio frequency interference
rms	root mean square

RT	remote terminal
RTC	real time clock
Rx	receive
RxD	receive data
μs	microsecond
s	second
SA	service affecting
SARTS	switched access remote testing system
SES	severely errored seconds
%SES	percent severely errored seconds
SF	superframe format (D4)
SIO	serial input and output
SLC	subscriber loop carrier
SMAS	switched maintenance access system
S/N	signal to noise
SNR	signal to noise ratio
SONET	synchronous optical network
T1	T-carrier, 1.544 Mb/s
TA	technical advisory (Bellcore document)
TAD	test access digroup
TAP	test access point
TASC	telecommunications alarms surveillance and control system
TC	trunk conditioning
TCAS	T-carrier administration system
TDM	time division multiplexer
TE	terminal equipment
TIRKS	trunk integrated record keeping system
TL1	transaction language number one
TLP	transmission level point
TR	technical recommendation (Bellcore document)
Tx	transmit
TxD	transmit data
UAS	unavailable seconds
UI	unit interval
UL	Underwriters Laboratory
USOC	universal service ordering code
UTP	unshielded twisted pair
UUT	unit under test

V	volt
Vac	volts alternating current
VAZO	violating all-zero octet
Vbp	volts base to peak
Vdc	volts direct current
VF	voice frequency
Vpp	volts peak to peak
VT	virtual tributary
W	Watt
WAN	wide area network
WATS	wide area telephone service
XOFF	an ASCII DC3 character
XON	an ASCII DC1 character
Xs0s	excess zeroes
ZBTSI	zero byte time slot interchange



References

C.1 General

Many documents have been used to assist in the definition, development, and manufacture of the HP 37741A, and also to assist in the preparation of this book. These are listed here as a guide for the reader interested in pursuing any topic further.

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TR-TSY-000754 Transport Systems Generic Requirements (TSGR): ISDN Primary Rate Access Transport System Requirements. Issue 1, April 1991.

TR-TSY-000820 Operations Technology Generic Requirements (OTGR): Network Maintenance: Transport Surveillance: Generic Digital Transmission Surveillance, Section 5.1. Issue 1, June 1990.

TR-TSY-000821 Operations Technology Generic Requirements (OTGR): Network Maintenance: Transport Surveillance: Additional Transport and Transport-Based Surveillance, Section 5.2. Issue 1, June 1990.

TR-NWT-000870 Reliability and Quality Generic Requirements (RQGR): Electrostatic Discharge Control in the Manufacture of Telecommunications Equipment. Issue 1, February 1991.

TR-TSY-000929 Reliability and Quality Generic Requirements (RQGR): Reliability and Quality Measurements for Telecommunications Systems. Issue 1, June 1990 and Supplement 1, March 1991.

C.6 CCITT Recommendations

In March 1993, the ITU reorganized. The CCITT was renamed, and is now known as the ITTS. The procedure of issuing recommendations every four years, in books referred to by their color, was also terminated.

G.703 Physical/Electrical Characteristics of Hierarchical Digital Interfaces. April 1991

G.711 Pulse Code Modulation (PCM) of Voice Frequencies. Blue Book, Fascicle III.4.

G.821 Error Performance of an International Digital Connection Forming Part of an Integrated Services Digital Network. Blue Book, Fascicle III.5.

G.822 Controlled Slip Rate Objectives on an International Digital Connection. Blue Book, Fascicle III.5.

O.171 Specification for Instrumentation to Measure Timing Jitter on Digital Equipment. Blue Book, Fascicle IV.4.

Q.502 Interface Requirements for Digital Transit Exchanges in Integrated Services Digital Networks (ISDN). Blue Book, Fascicle VI.5.

Q.921 ISDN User-Network Interface Data Link Layer. Blue Book, Fascicle VI.10.

V.24 List of Definitions for Interchange Circuits between Data Terminal Equipment and Data Circuit-Terminating Equipment. Blue Book, Fascicle VIII.1.

V.28 Electrical Characteristics for Unbalanced Double-Current Interchange Circuits. Blue Book, Fascicle VIII.1.

C.7 Electronic Industries Association (EIA)

EIA-232-D Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange. EIA Engineering Department. January 1987. (Superseded RS-232-C.)

EIA-547 Network Channel Terminal Equipment for DS1 Service. EIA Engineering Department. March 1989.

C.8 Federal Communications Commission (FCC) Rules

Volume II Code of Federal Regulations Part 15, Subpart J, Class A Computing Devices. July 1981.

C.9 Institute of Electrical and Electronics Engineers (IEEE)

IEEE 1007 Standard Methods and Equipment for the Transmission Characteristics of Pulse-Code Modulation (PCM) Telecommunications Circuits and Systems. January 1992.

C.10 International Business Machines (IBM)

PC/AT TRG Technical Reference Guide. Serial Parallel Adapter. August 1984.

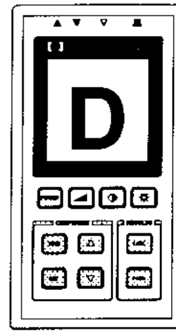
C.11 International Electrotechnical Commission (IEC)

CISPR 11 Limits and Methods of Measurement of Electromagnetic Disturbance Characteristics of Industrial, Scientific, and Medical (ISM) Radio-frequency Equipment. Issue 1, March 1991.

IEC 801-2 Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment – Part 2: Electrostatic Discharge Requirements. Issue 2, April 1991.

C.12 Underwriters Laboratory (UL)

UL 1459 Standard for Telephone Equipment. Second Edition, October 1990. (Similar to UL 478, Standard for Information Processing and Business Equipment. Issue 2, December 1987.)



Accessories

D.1 General

Hewlett-Packard supplies a wide variety of instrumentation products and accessories. The parts described in this section are not meant to be an exhaustive list of the items that you might need when using the HP 37741A.

Section D.2 gives you ordering information. Section D.3 gives a description of some of the items. For more information, or to order any item listed here, or any HP product, contact your local sales office. A list of sales offices is given in appendix F.

D.2 Ordering Information

D.2.1 Original Shipments

The following items, initially shipped with the product, may be ordered separately. Complete shipment details are contained in section 1.2.

Not all of these items may have been shipped with your unit.

Accessory	Reorder Number
Cordura carrying pouch, and shoulder strap	HP 15728A
HP 37741A User's Manual and Instruction Guide	37741-90000
110 Vac plug-in adapter and battery charger	HP 15729A
Single bantam cable, 300 mm	HP 15731A
Dual bantam cable, 300 mm	HP 15732A
Single bantam cable (red), 1.5 m	E4291
Single bantam cable (yellow), 1.5 m	E4292

D.2.2 HP 37741A Options

The following items may be ordered as options to the purchase of a new HP 37741A, or they may be ordered separately:

Item	Order Number
Car cigarette lighter charging system	HP 15725A
External control PC software	HP 15726A
Battery operated thermal printer, 27 columns	HP 15727A
Battery operated thermal printer, 80 columns	HP 15733A
Large carrying pouch	HP 15741A
Rackmountable version of the HP 37741A	HP 37741A opt H01
19" rackmount panel for option H01	HP 37741A opt K01

D.2.3 Documentation

The following table lists documentation available for the HP 37741A:

Item	Order Number
HP 37741A User's Manual and Instruction Guide	37741-90000

D.2.4 Cables and Adapters

The following cables and accessories are useful not only for use with the HP 37741A, but with a variety of HP products:

Item	Order Number
Serial Cables (all 2 m long unless indicated):	
25-pin female (DTE) to 9-pin male (DCE)	HP 15737A
9-pin female (DTE) to 9-pin male (DCE)	HP 15736A
25-pin male (DTE) to 9-pin male (DCE)	HP 15735A

9-pin male (DCE) to 9-pin male (DCE), 0.5 m	HP 15734A
9-pin male (DCE) to 25-pin male (DCE), 0.5 m	HP 15750A
T1 Cables and Adapters	
Single bantam to bantam, 3 m long	HP 15670A
Bantam to WECO 310, 3 m long	HP 15513A option H07
Bantam telecom adapter	HP 15738A

Descriptions are given in D.3.

D.2.5 Service Replacement Parts

The following replacement parts are available. See section 0 for service information.

Item	Order Number	Check Digit
Restored HP 37741A	37741-69001	4
New HP 37741A	37741-60001	6
Battery Pack	37741-60005	5

D.3 Descriptions

This section contains descriptions of selected accessories (those whose names are not self explanatory).

D.3.1 Car Cigarette Lighter Charging System, HP 15725A

This is a 12 V (automotive) to 9 V (1 A) converter unit. There is a cigarette lighter plug on a short cable connected to the unit. There is a 2 mm dc adapter plug for the HP 37741A on a separate 1½ m cable connected to the unit.

D.3.2 External Control PC Software, HP 15726A

This runs on an IBM/AT compatible personal computer with serial port and hard disk. The software is distributed on 3½ inch and 5¼ inch diskettes, and comes complete with a User's Manual. The memory requirement is 512 Kbytes.

This software provides a menu and window driven environment to control the HP 37741A – color video is automatically supported. A mouse is also automatically supported, permitting complete control of the instrument by using a mouse. This ease of use yields very low training time.

The software reads all of the results every second. Results and configurations can be saved to disk. When recalled, setups can be downloaded to the instrument. In addition to allowing you full control of the instrument, the software allows you to modify the user words, channel words, pre-defined configurations, and SLC-96 data link.

Your instrument can be directly connected to the PC, or operated remotely. Dial up modems are fully supported. It is recommended you use error correcting modems, with a line rate of 2400 baud or greater.

The software can also be used during performance verification (detailed in section 16) and instrument calibration (detailed in section 17).

D.3.3 Battery Operated Thermal Printer, HP 15727A

This is the Seiko DPU-201GS printer.

Size	135 mm (W) × 100 mm (D) × 35 mm (H)
Weight	400 g
Type	thermal
Interface	9 pin EIA-232 serial, configured as a DCE
Character size	2.4 mm (H) × 1.3 mm (W)
Line	27 characters
Speed	0.8 lines/s
Charger	ac adapter supplied
Temperature	5° C to 40° C (operating)

You need to purchase cable part number HP 15734A to connect this printer to the HP 37741A.

D.3.4 Battery Operated Thermal Printer, HP 15733A

This is the Seiko DPU-411 printer.

Size:	240 mm (W) × 162 mm (D) × 59 mm (H)
Weight:	950 g
Type:	thermal
Interface	25 pin EIA-232 serial, configured as a DCE
Character size:	2.4 mm (H) × 0.9 mm (W) (in 80 column mode)
Line:	40 or 80 characters
Speed:	0.8 lines/s
Charger:	ac adapter supplied
Temperature:	5° C to 40° C (operating)

You need to purchase cable part number HP 15750A to connect this printer to the HP 37741A.

D.3.5 Large Carrying Pouch, HP 15741A

This pouch, made from nylon, will hold the HP 37741A, its ac adapter, cables, and manual. It is shipped with a shoulder strap. The size is 200 mm (W) × 260 mm (D) × 110 mm (H).

D.3.6 Rackmountable Version, HP 37741A Option H01

This has all the functionality of the hand held unit. There is no display or keyboard on the unit, and the unit is shipped without a pouch. The T1 lines connect to the unit with a 15 pin D-type connector.

The instrument is controlled with the PC based software (HP 15726A), ordered separately.

D.3.7 19" Rackmount Panel for Option H01, HP 37741A Option K01

This is a 1 RU high panel that can accept one to three HP 37741A option H01 instruments.

The rack can also accommodate one Bantam Telecom Adapter (HP 15738A) and one HP 37741A Option H01.

D.3.8 Serial Cables (5 types)

This describes the purpose for each of the cables listed in section D.2.4.

HP 15737A	DTE (PC or similar) with 25 pin connector, to HP 37741A. This is a straight cable, the pin assignment is shown in figure 13-2.
HP 15736A	DTE (PC or similar) with 9 pin connector, to HP 37741A. This is a straight cable, the pin assignment is shown in figure 13-2.
HP 15735A	HP 37741A to HP ThinkJet printer .
HP 15734A	HP 37741A to DCE with a 9 pin connector (HP 15727A battery operated thermal printer, or Seiko DPU-201GS printer, or small modem). This is a null-terminal cable, the pin assignment is shown in figure 13-3.
HP 15750A	HP 377741A to DCE with a 25 pin connector (HP 15733A battery operated thermal printer, or Seiko DPU-411 printer, or standard modem). This is a null-terminal cable, the pin assignment is shown in figure 13-3.

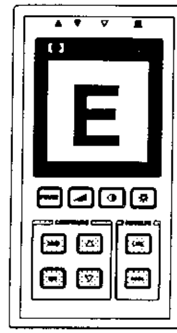
D.3.9 Bantam Telecom Adapter, HP 15738A

The BTA is a multipurpose interconnection box. It can be used to connect bantam cables from the HP 37741A to a CSU (DB15). Similarly, it can be used to connect the DB15 on the HP 37741A option H01 to bantam cables. The adapter can also be used to connect either instrument to a smartjack or ISDN PRI (USOC RJ-45). You can easily use the adapter to bridge to a full duplex DS1 circuit. Two dual bantam jacks are connected to a male DB15 and a female DB15. The two DB15s are wired together, so that you can bring a circuit into the adapter, and continue to carry the circuit on to its original destination.

Because the RJ-45 connector is wired to both bantam connectors, the adapter can be used to connect a voice circuit to bantam connectors. The RJ-45 connector can accept RJ-11 plugs without damage.

The BTA can be mounted on the 19" rackmount panel (HP 37741A K01).

User Indications



E.1 Speaker Beeps

The instrument can be configured to beep with each key press. You can configure the sound to be a tone or a click.

Regardless of whether the key beep is enabled or not, the instrument will issue beeps under the following conditions:

1 beep — The instrument will beep at power on if the POST is successful, and no stored data has been lost.
The instrument beeps once every minute when the battery is getting low.

2 beeps — The instrument cannot print. The printer may be not connected, or turned off, or it may be out of paper, or there may be a cabling problem.

3 beeps — You have not used the instrument for two minutes and a test is not running. The HP 37741A will turn itself off in five seconds unless you press a key.

The frequency of the key beep rises if the test set is loop timed, and the equipment to which it is connected is also loop timed.

E.2 Icons

This section summarizes the icons used on the various displays.

→ This is an arrow used to point to a selection. Use the [▲] and [▼] keys to change the variable pointed to. In most cases, the ➔ icon will move, and in the other cases, the variable pointed to will change.

24/24 This is shown on the transmit summary screen to indicate that the instrument is sending a full T1 signal (all 24 of the channels are used).

Nx 64 This is shown on the results screens and high level TEST and SET screens to indicate that the instrument is sending a fractional T1 signal in n × 64 mode.

Nx 56 This is shown on the results screens and high level TEST and SET screens to indicate that the instrument is sending a fractional T1 signal in n × 56 mode.

⌛ The hour glass is shown on the results screens and high level TEST and SET screens when a non-sequential test is running. When the ⌛ is displayed, the instrument accumulates errors, and the results can change.

✋ The flashing hand is shown on the results screens and high level TEST and SET screens when no test is running. When the ✋ is displayed, none of the results screens will change.

BT This is shown on the results screens and high level TEST and SET screens when a bridge tap test is running. When the BT is steady, the instrument accumulates errors, and the results can change. When the BT flashes, the instrument is trying to synchronize to the next pattern in the sequence.

MP This is shown on the results screens and high level TEST and SET screens when a standard multipattern test is running. When the MP is steady, the instrument accumulates errors, and the results can change. When the MP flashes, the instrument is trying to synchronize to the next pattern in the sequence.

US This is shown on the results screens and high level TEST and SET screens when a user defined sequential test is running. When the US is steady, the instrument accumulates errors, and the results can change. When the US flashes, the instrument is trying to synchronize to the next pattern in the sequence.

↑ Indicates "up". Used in conjunction with a loop code name. For example, line↑ means line loop up loopback code.

↓ Indicates "down". Used in conjunction with a loop code name. For example, line↓ means line loop down loopback code.

▲ Used to represent the [▲] key.

▼ Used to represent the [▼] key.

☺ The happy face indicates that things are normal, or good. It is displayed on screen 1002 to indicate those parts of the data that have not been corrupted. It is displayed on screens 2100 and 2700 to indicate that no logic, BPV, or CRC errors are being injected.

☹ The sad face indicates that there is a problem, or that things are not normal. It is displayed on screen 1002 to indicate those parts of the data that have been corrupted. It is displayed on high level SET screens and each result screen, to indicate that logic, BPV, or CRC errors are being injected.

🕓 The clock indicates the source of the timing for the T1 transmitter. The source is either derived from the internal crystal, or from one of the T1 inputs.

When the 🕓 flashes on the Signal Out screen (2700), you have configured the HP 37741A to use one of the T1 inputs as the source of the transmitter clock, and that signal is not present.

🔔 The transmit alarm bell icon indicates whether the instrument is transmitting any alarms. The icon is displayed on high level SET screens and each results screen. In screens 2100 and 2700, the word none indicates that no alarm is being transmitted.

When the 🔔 flashes on the Signal Out screen (2700), you have configured the transmitter of the HP 37741A to be dependent on the T1 input. There is a problem with the input signal, and the instrument is sending an alarm automatically.

↩ This icon is shown when the instrument is looped back. The icon is shown in screen 2700. When the icon is displayed, the transmit summary screen continues to show the signal that is actually being transmitted (or regenerated).

The loopback icon is also shown on the high level SET screens and each of the results screens. When it is, you cannot modify the transmit configuration.

♪ The musical note is shown to indicate that one of the transmit channels is being modified, either by the transmission of a tone, or by the insertion of signaling bits. It is displayed on the high level SET screens and each of the results screens when the condition is true.

E.3 BIST Error Codes

When the built in self test runs, the display indicates the test being performed. If a test fails, the number may remain the same or change. Use this section to interpret the displayed number.

The self test procedure is described in section 16.6.

E.3.1 CPU

The microprocessor tests itself and the associated peripherals.

00001	RAM test. A complex sum check and bit read-modify-write sequence is performed.
00002	Real time clock. The processor verifies that the clock's one second tick is within 5%.
00003	Real time clock. The clock is set to 99-12-31 23:59:59. The processor waits for two seconds to ensure that the date rolls over. The instrument's time is restored (plus two seconds), and the processor ensures that the clock advances one second.
00004	Beep. Three beeps are created. The processor cannot verify that a tone is emitted from the speaker. This is your responsibility.
00005	Contrast. The contrast is adjusted to maximum, then minimum, and back to the preset value. You should check the operation.
00006	Backlight. The back light is turned on and off three times, with the on time being half a second.

E.3.2 Framing

The instrument configures the transmitter to send each frame format in sequence. The transmitter is configured to transmit a QRW, and the line code is B8ZS.

The receiver is configured for auto mode. The microprocessor first verifies that each frame type can be recognized by the receiver, then verifies that each frame type does not receive any frame errors. The processor waits a maximum of two seconds to get into frame, and then accumulates errors for 150 ms.

01100	D4: can't sync
01150	D4: framing errors
01200	SLC-96: can't sync
01250	SLC-96: framing errors
01300	ESF: can't sync
01350	ESF: framing errors
01400	ZBTSI: can't sync
01450	ZBTSI: framing errors

E.3.3 Pattern and FT1

The instrument configures the transmitter to send each pattern in sequence. The transmitter is configured for unframed mode, and the line code is B8ZS.

The receiver is configured for auto mode. The microprocessor first verifies that each pattern can be recognized by the receiver, then that each pattern is received error free.

The processor then repeats the sequence using FT1.

02001	unframed all zeroes: can't sync
02002	unframed all ones: can't sync
02003	unframed alternating 1/0: can't sync
02004	unframed 1 in 8: can't sync
02005	unframed 2 in 8: can't sync
02006	unframed 3 in 24: can't sync
02007	unframed QRW: can't sync
02008	unframed $2^{11}-1$: can't sync
02009	unframed $2^{15}-1$: can't sync
02010	unframed $2^{20}-1$: can't sync
02011	unframed $2^{23}-1$: can't sync
02051	unframed all zeroes: logic errors
02052	unframed all ones: logic errors
02053	unframed alternating 1/0: logic errors
02054	unframed 1 in 8: logic errors
02055	unframed 2 in 8: logic errors
02056	unframed 3 in 24: logic errors

02057	unframed QRW: logic errors
02058	unframed $2^{11}-1$: logic errors
02059	unframed $2^{15}-1$: logic errors
02060	unframed $2^{20}-1$: logic errors
02061	unframed $2^{23}-1$: logic errors
021xx	D4, 23 channels in n × 64 mode, as above

E.3.4 Coding

The instrument sends an unframed QRW. It waits for 150 ms after receiving sync, and verifies that no line code violations (BPVs) are received.

03001	B8ZS: can't sync
03002	AMI: can't sync
03051	B8ZS: errors
03052	AMI: errors

E.3.5 Loopbacks

The instrument sends a QRW with AMI line code. The instrument configures the receiver to not auto respond to a received loopback code. The loopback code is sent, and the processor verifies that it is received. In-band loop codes are checked for errors when sent unframed. No error checking is performed on framed in-band codes, nor on out-of-band codes.

04001	unframed line loop up: can't sync
04051	unframed line loop up: errors
04002	unframed line loop down: can't sync
04052	unframed line loop down: errors
04003	unframed 4 bit loop up: can't sync
04053	unframed 4 bit loop up: errors
04004	unframed 4 bit loop down: can't sync
04054	unframed 4 bit loop down: errors
04005	unframed NI loop up: can't sync
04055	unframed NI loop up: errors
04006	unframed NI loop down: can't sync
04056	unframed NI loop down: errors

04101	D4 line loop up: can't sync
04102	D4 line loop down: can't sync
04103	D4 4 bit loop up: can't sync
04104	D4 4 bit loop down: can't sync
04105	D4 NI loop up: can't sync
04106	D4 NI loop down: can't sync
04201	SLC-96 line loop up: can't sync
04202	SLC-96 line loop down: can't sync
04203	SLC-96 4 bit loop up: can't sync
04204	SLC-96 4 bit loop down: can't sync
04205	SLC-96 NI loop up: can't sync
04206	SLC-96 NI loop down: can't sync
04301	ESF line loop up: can't sync
04302	ESF line loop down: can't sync
04303	ESF 4 bit loop up: can't sync
04304	ESF 4 bit loop down: can't sync
04305	ESF NI loop up: can't sync
04306	ESF NI loop down: can't sync
04307	ESF payload loop up: can't sync
04308	ESF payload loop down: can't sync
04401	ZBTSI line loop up: can't sync
04402	ZBTSI line loop down: can't sync
04403	ZBTSI 4 bit loop up: can't sync
04404	ZBTSI 4 bit loop down: can't sync
04405	ZBTSI NI loop up: can't sync
04406	ZBTSI NI loop down: can't sync
04407	ZBTSI payload loop up: can't sync
04408	ZBTSI payload loop down: can't sync

E.3.6 Alarms

The instrument sends a D4 QRW with AMI line code. The alarm condition is created, and the processor waits 4 seconds. The alarm is retired, and the processor waits a further three seconds. The next alarm is then created.

05001	LOS: not detected
05002	AIS: not detected
05103	D4 Yellow: not detected
05203	SLC-96 Yellow: not detected
05303	ESF Yellow: not detected
05403	ZBTSI Yellow: not detected

E.3.7 Channel Integrity

The instrument sends a D4 framed TmSlt. It verifies that each channel is correctly received by comparing the received Hi and Lo values. These should correspond with the timeslot number.

06101	timeslot 1
06102	timeslot 2
. . .	. . .
06124	timeslot 24

E.3.8 Tone Amplitude and Volume Control

The instrument sends a TmSlt pattern with AMI line code. A 1004 Hz tone is inserted into channel one. The receiver is configured to send the channel to the speaker; the speaker volume is swept from off to maximum and back. You should verify that the volume control is functional. The instrument measures the amplitude of the received tone, and passes the test if it is within ±0.5 dB if calibrated, and ±1.0 dB if uncalibrated.

The process is repeated for each of the fixed tone levels. Each volume control step is accessed for 50 ms, so that each transmitted tone amplitude is sent for 1.6 s. The tone is then transmitted at the idle level, and the instrument verifies that it is received below −40 dBm0.

07101	tone sent at 0 dBm0
07102	tone sent at −3 dBm0
07103	tone sent at −6 dBm0

07104	tone sent at −10 dBm0
07105	tone sent at −13 dBm0
07106	tone sent at −16 dBm0
07107	tone sent at −24 dBm0
07108	tone sent at idle level

E.3.9 Channel Access

The instrument sends a TmSlt pattern with AMI line code. A tone is inserted into one of the channels at −10 dBm. The receiver is configured to send the channel to the speaker; the speaker volume is set to level 3. You should verify that the tone is received. The instrument also sends signaling on the channel being tested, and verifies that the signaling bits are correctly received. Each channel is accessed for about 500 ms.

08101	D4 channel 1, 304 Hz, AB(CD) = 00(00)
08102	D4 channel 2, 404 Hz, AB(CD) = 00(01)
08103	D4 channel 3, 420 Hz, AB(CD) = 00(10)
08104	D4 channel 4, 820 Hz, AB(CD) = 00(11)
08105	D4 channel 5, 1004 Hz, AB(CD) = 01(00)
08106	D4 channel 6, 1020 Hz, AB(CD) = 01(01)
08107	D4 channel 7, 1800 Hz, AB(CD) = 01(10)
08108	D4 channel 8, 2280 Hz, AB(CD) = 01(11)
08109	D4 channel 9, 2600 Hz, AB(CD) = 10(00)
08110	D4 channel 10, 2713 Hz, AB(CD) = 10(01)
08111	D4 channel 11, 2804 Hz, AB(CD) = 10(10)
08112	D4 channel 12, 3400 Hz, AB(CD) = 10(11)
08113	D4 channel 13, 304 Hz, AB(CD) = 11(00)
08114	D4 channel 14, 404 Hz, AB(CD) = 11(01)
08115	D4 channel 15, 420 Hz, AB(CD) = 11(10)
08116	D4 channel 16, 820 Hz, AB(CD) = 11(11)
08117	D4 channel 17, 1004 Hz, AB(CD) = 00(00)
08118	D4 channel 18, 1020 Hz, AB(CD) = 00(01)
08119	D4 channel 19, 1800 Hz, AB(CD) = 00(10)
08120	D4 channel 20, 2280 Hz, AB(CD) = 00(11)
08121	D4 channel 21, 2600 Hz, AB(CD) = 01(00)

08122	D4 channel 22, 2713 Hz, AB(CD) = 01(01)
08123	D4 channel 23, 2804 Hz, AB(CD) = 01(10)
08124	D4 channel 24, 3400 Hz, AB(CD) = 01(11)
08201 to 08224	SLC-96 channels 1 to 24, as above, but with the signaling starting at AB(CD) = 10(00)
08301 to 08324	ESF channels 1 to 24, as above, but with the signaling starting at ABCD = 0000
08401 to 08424	ZBTSI channels 1 to 24, as above, but with the signaling starting at ABCD = 1000

E.3.10 Error Injection and Detection

The instrument sends an ESF QRW with AMI line code. The errors are introduced one at a time for a total of three errors. The processor verifies that the errors are received.

09101	BPV errors
09102	logic errors
09103	CRC errors

E.3.11 Line Parameters

The instrument sends a ESF QRW with AMI line code. The line parameters are checked.

10101	Line frequency. The processor verifies that the measured frequency is within 40 ppm if the instrument is calibrated, or 100 ppm if uncalibrated.
10102	Signal level. The processor verifies that the measured level when terminated is 0 dBdsx ± 1.5 dBdsx if calibrated, or 0 dBdsx ± 3.0 dBdsx if uncalibrated.
10103	Signal level. The processor verifies that the measured level when in monitor mode is greater than 3.0 dBdsx.
10104	Simplex current. The processor verifies that the measured level is less than 1 mA.

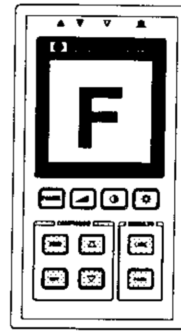
E.3.12 Reference Input

The processor sends an unframed QRW with AMI line code. The inputs are set to terminate mode.

11101	No signal on reference input detected.
11102	Crosstalk to main input detected.

E.3.13 Serial Port

12002	Serial port loopback. CTS is toggled, and the processor reads RTS. Then, the characters 00H to FFH are sent 32 times, and verified for correct reception.



HP Sales Offices

For more information, call your local HP sales office listed in your telephone directory or an HP regional office listed below for the location of your nearest sales office.

United States of America:
Hewlett-Packard Company
4 Choke Cherry Road, Rockville, MD 20850
(301) 670 4300

Hewlett-Packard Company
5201 Tollview Drive, Rolling Meadows, IL 60008
(708) 255 9800

Hewlett-Packard Company
5651 W. Mancheste, Los Angeles, CA 90045
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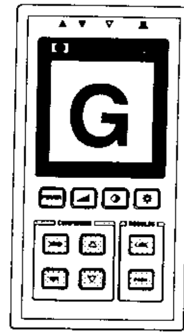
PCM Codes



G.1 PCM Quantization

When an audio signal is digitized for transmission over a DS1 channel, μlaw encoding is used. This law, briefly described in the following paragraphs, is more fully treated and tabulated in CCITT G.711.

8000 times per second, an amplitude sample is taken and encoded as a byte. The most significant bit is a sign bit (1 for positive, 0 for negative). The remaining seven bits represent the signal amplitude in a quasi-logarithmic way. This method represents low level audio signals more faithfully (with greater resolution) than a linear encoding scheme.

The 128 code values available to represent signal amplitude are divided into eight segments of 16 codes each. These segments are numbered from 1 to 8, with the lowest signal levels in segment 1 and the highest in segment 8.

Within each segment, the 16 codes are linearly spaced, but the spacing interval is twice that of the segment below. Thus the amplitude range of segment 8 (4096 quantization units) is 128 times that of segment 1 (32 quantization units). The full positive range is 8159 quantization units. The negative range is the same. The amplitude is normalized so that the peak signal (±8159 units, represented by decoder values of ±127) corresponds to 3.17 dBm0.

The actual 8-bit code transmitted does not correspond directly to the decoder value, but is encoded as shown in the following table. For example a 1 in 8 pattern yields Hi = Lo = −63 in all channels.

Displayed Value	PCM Code		Displayed Value	PCM Code		Displayed Value	PCM Code	
	Binary	Hex		Binary	Hex		Binary	Hex
+127	10000000	80	+84	10101011	AB	+41	11010110	D6
+126	10000001	81	+83	10101100	AC	+40	11010111	D7
+125	10000010	82	+82	10101101	AD	+39	11011000	D8
+124	10000011	83	+81	10101110	AE	+38	11011001	D9
+123	10000100	84	+80	10101111	AF	+37	11011010	DA
+122	10000101	85	+79	10110000	B0	+36	11011011	DB
+121	10000110	86	+78	10110001	B1	+35	11011100	DC
+120	10000111	87	+77	10110010	B2	+34	11011101	DD
+119	10001000	88	+76	10110011	B3	+33	11011110	DE
+118	10001001	89	+75	10110100	B4	+32	11011111	DF
+117	10001010	8A	+74	10110101	B5	+31	11100000	E0
+116	10001011	8B	+73	10110110	B6	+30	11100001	E1
+115	10001100	8C	+72	10110111	B7	+29	11100010	E2
+114	10001101	8D	+71	10111000	B8	+28	11100011	E3
+113	10001110	8E	+70	10111001	B9	+27	11100100	E4
+112	10001111	8F	+69	10111010	BA	+26	11100101	E5
+111	10010000	90	+68	10111011	BB	+25	11100110	E6
+110	10010001	91	+67	10111100	BC	+24	11100111	E7
+109	10010010	92	+66	10111101	BD	+23	11101000	E8
+108	10010011	93	+65	10111110	BE	+22	11101001	E9
+107	10010100	94	+64	10111111	BF	+21	11101010	EA
+106	10010101	95	+63	11000000	C0	+20	11101011	EB
+105	10010110	96	+62	11000001	C1	+19	11101100	EC
+104	10010111	97	+61	11000010	C2	+18	11101101	ED
+103	10011000	98	+60	11000011	C3	+17	11101110	EE
+102	10011001	99	+59	11000100	C4	+16	11101111	EF
+101	10011010	9A	+58	11000101	C5	+15	11110000	F0
+100	10011011	9B	+57	11000110	C6	+14	11110001	F1
+99	10011100	9C	+56	11000111	C7	+13	11110010	F2
+98	10011101	9D	+55	11001000	C8	+12	11110011	F3
+97	10011110	9E	+54	11001001	C9	+11	11110100	F4
+96	10011111	9F	+53	11001010	CA	+10	11110101	F5
+95	10100000	A0	+52	11001011	CB	+9	11110110	F6
+94	10100001	A1	+51	11001100	CC	+8	11110111	F7
+93	10100010	A2	+50	11001101	CD	+7	11111000	F8
+92	10100011	A3	+49	11001110	CE	+6	11111001	F9
+91	10100100	A4	+48	11001111	CF	+5	11111010	FA
+90	10100101	A5	+47	11010000	D0	+4	11111011	FB
+89	10100110	A6	+46	11010001	D1	+3	11111100	FC
+88	10100111	A7	+45	11010010	D2	+2	11111101	FD
+87	10101000	A8	+44	11010011	D3	+1	11111110	FE
+86	10101001	A9	+43	11010100	D4	+0	11111111	FF
+85	10101010	AA	+42	11010101	D5			

Displayed Value	PCM Code		Displayed Value	PCM Code		Displayed Value	PCM Code	
	Binary	Hex		Binary	Hex		Binary	Hex
			−42	01010101	55	−85	00101010	2A
−0	01111111	7F	−43	01010100	54	−86	00101001	29
−1	01111110	7E	−44	01010011	53	−87	00101000	28
−2	01111101	7D	−45	01010010	52	−88	00100111	27
−3	01111100	7C	−46	01010001	51	−89	00100110	26
−4	01111011	7B	−47	01010000	50	−90	00100101	25
−5	01111010	7A	−48	01001111	4F	−91	00100100	24
−6	01111001	79	−49	01001110	4E	−92	00100011	23
−7	01111000	78	−50	01001101	4D	−93	00100010	22
−8	01110111	77	−51	01001100	4C	−94	00100001	21
−9	01110110	76	−52	01001011	4B	−95	00100000	20
−10	01110101	75	−53	01001010	4A	−96	00011111	1F
−11	01110100	74	−54	01001001	49	−97	00011110	1E
−12	01110011	73	−55	01001000	48	−98	00011101	1D
−13	01110010	72	−56	01000111	47	−99	00011100	1C
−14	01110001	71	−57	01000110	46	−100	00011011	1B
−15	01110000	70	−58	01000101	45	−101	00011010	1A
−16	01101111	6F	−59	01000100	44	−102	00011001	19
−17	01101110	6E	−60	01000011	43	−103	00011000	18
−18	01101101	6D	−61	01000010	42	−104	00010111	17
−19	01101100	6C	−62	01000001	41	−105	00010110	16
−20	01101011	6B	−63	01000000	40	−106	00010101	15
−21	01101010	6A	−64	00111111	3F	−107	00010100	14
−22	01101001	69	−65	00111110	3E	−108	00010011	13
−23	01101000	68	−66	00111101	3D	−109	00010010	12
−24	01100111	67	−67	00111100	3C	−110	00010001	11
−25	01100110	66	−68	00111011	3B	−111	00010000	10
−26	01100101	65	−69	00111010	3A	−112	00001111	0F
−27	01100100	64	−70	00111001	39	−113	00001110	0E
−28	01100011	63	−71	00111000	38	−114	00001101	0D
−29	01100010	62	−72	00110111	37	−115	00001100	0C
−30	01100001	61	−73	00110110	36	−116	00001011	0B
−31	01100000	60	−74	00110101	35	−117	00001010	0A
−32	01011111	5F	−75	00110100	34	−118	00001001	09
−33	01011110	5E	−76	00110011	33	−119	00001000	08
−34	01011101	5D	−77	00110010	32	−120	00000111	07
−35	01011100	5C	−78	00110001	31	−121	00000110	06
−36	01011011	5B	−79	00110000	30	−122	00000101	05
−37	01011010	5A	−80	00101111	2F	−123	00000100	04
−38	01011001	59	−81	00101110	2E	−124	00000011	03
−39	01011000	58	−82	00101101	2D	−125	00000010	02
−40	01010111	57	−83	00101100	2C	−126	00000001	01
−41	01010110	56	−84	00101011	2B	−127	00000000	00

G.2 Quantization Error

When the HP 37741A decodes the tone, it interprets each octet as representing a signal amplitude corresponding to the center of its quantization interval. Thus, there is an inherent uncertainty caused by the size of each quantization interval. This uncertainty, expressed in dB, is roughly constant throughout the range.[1] The uncertainty is always smallest at the top of a segment and greatest at the bottom, as shown in the table below.

This quantization error contributes as much as ±0.53 dB to the inaccuracy of the audio channel amplitude measurement, for signals as low as −46 dBm0. Another measurement error occurs whenever there is a non-zero DC offset in the audio signal. The measurement algorithm determines the highest and lowest decoder values transmitted in the channel. It uses half their difference to estimate the positive amplitude, which is then used to determine the signal amplitude. This approach is exact when the maximum positive and negative levels are in corresponding segments. The gain setting of the tone injection circuit is calibrated at −10 dBm0. This amplitude corresponds to decoder levels of ±92, which correspond to −10.0008 dBm0.

Segment	Decoder Number	dBm0	uncertainty (dB)
8 (top)	127	3.03	±0.14
8 (bottom)	112	−2.62	±0.26
7 (top)	111	−3.02	±0.14
7 (bottom)	96	−8.7	±0.27
6 (top)	95	−9.12	±0.14
6 (bottom)	80	−14.86	±0.27
5 (top)	79	−15.28	±0.14
5 (bottom)	64	−21.17	±0.28
4 (top)	63	−21.6	±0.15
4 (bottom)	48	−27.79	±0.30
3 (top)	47	−28.26	±0.16
3 (bottom)	32	−35.15	±0.36
2 (top)	31	−35.69	±0.19
2 (bottom)	16	−44.69	+0.51, −0.55
1 (top)	15	−45.59	±0.29
1 (2nd)	1	−69.04	+3.52, −6.02
1 (bottom)	0	−81.08	+6.02, −∞

1 It would be constant for a perfectly logarithmic encoding scheme.

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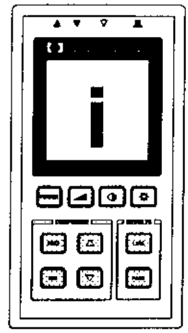

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