User and Service Guide

HP 86037A
Chromatic Dispersion Test System

HEWLETT® PACKARD

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CAUTION
The *caution* sign denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in damage to or destruction of the product. Do not proceed beyond a caution sign until the indicated conditions are fully understood and met.

WARNING
The *warning* sign denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a warning sign until the indicated conditions are fully understood and met.

The instruction manual symbol. The product is marked with this warning symbol when it is necessary for the user to refer to the instructions in the manual.

The laser radiation symbol. This warning symbol is marked on products which have a laser output.

The AC symbol is used to indicate the required nature of the line module input power.

The ON symbols are used to mark the positions of the instrument power line switch.

The OFF symbols are used to mark the positions of the instrument power line switch.

The CE mark is a registered trademark of the European Community.

The CSA mark is a registered trademark of the Canadian Standards Association.

ISM1-A This text denotes the instrument is an Industrial Scientific and Medical Group 1 Class A product.

Typographical Conventions.
The following conventions are used in this book:

Key type for keys or text located on the keyboard or instrument.

Softkey type for key names that are displayed on the instrument's screen.

`Display type` for words or characters displayed on the computer's screen or instrument's display.

User type for words or characters that you type or enter.

Emphasis type for words or characters that emphasize some point or that are used as place holders for text that you type.

General Safety Considerations
This product has been designed and tested in accordance with IEC Publication 1010, Safety Requirements for Electronic Measuring Apparatus, and has been supplied in a safe condition. The instruction documentation contains information and warnings which must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

WARNING
If this product is not used as specified, the protection provided by the equipment could be impaired. This product must be used in a normal condition (in which all means for protection are intact) only.

WARNING
No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock, do not remove covers.

DECLARATION OF CONFORMITY

According to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name:	Hewlett-Packard Co.
Manufacturer's Address:	1400 Fountaingrove Parkway Santa Rosa, CA 95403-1799 USA

Declares that the product:

Product Name:	Chromatic Dispersion Test System
Model Number:	HP 86037A
Product Options:	This declaration covers all options of the above product.

Conforms to the following product specifications:

Safety: IEC 61010-1:1990 / EN 61010-1:1993
CAN/CSA-C22.2 No. 1010.1-92

EMC: CISPR 11:1990/EN 55011:1991 Group 1, Class A
IEC 801-2:1984/EN 50082-1:1992 4 kV CD, 8 kV AD
IEC 801-3:1984/EN 50082-1:1992 3 V/m, 27-500 MHz
IEC 801-4:1988/EN 50082-1:1992 0.5 kV sig. lines, 1 kV power lines

Supplementary Information:

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE-marking accordingly.

Santa Rosa, CA, USA October 1, 1998

Greg Pfeiffer/Quality Engineering Manager

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Abbreviations and Symbols

List of Abbreviations

Abbreviation	Definition
ac	Alternating Current
CD	Chromatic Dispersion
dBm	Decibel with respect to Milliwatt (mW)
EIA	Electronic Industries Alliance
ESD	Electrostatic Discharge
GUI	Graphical User Interface
HP	Hewlett-Packard
HP-CD	Hewlett-Packard Chromatic Dispersion System
HP-IB	Hewlett-Packard Instrument Bus
LCD	Liquid Crystal Dispay
NIST	National Institute of Standards & Technology
PMF	Polarization-Maintaining Fiber
TES	Test Executive Shell
TLS	Tunable Laser Source
VB	Visual Basic
VGA	Video Graphics Array
WDM	Wavelength Division Multiplexing

Symbols

Symbol	Name	Definition
λ	Lambda	Refers to wavelength
$M\Omega$	Mega-ohm	1000000 ohm increments
μW	Microwatt	1/1000000 of a watt increments
Δ	Delta	Refers to a change in something
τ	Tau	Refers to time

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Getting Started

At a glance

The HP 86037A Chromatic Dispersion Test System is shipped in either a single band or a dual band configuration. This chapter describes the basic starting procedures for both systems. For detailed information on these system interfaces please see:

Chapter 5, “The Single Band Interface”
Chapter 6, “The Dual Band Interface”

This chapter includes the procedures to:

- Setup the HP 86037A Chromatic Dispersion Test System hardware
- Start the HP 86037A Chromatic Dispersion Test System software

WARNING **Install the system so that the mains power cord for the system cabinet is readily identifiable and is easily reached by the operator. The power cord is the disconnecting device. It disconnects the mains circuits from the instruments. Alternately, an externally installed switch or circuit breaker (which is readily identifiable and is easily reached by the operator) may be used as a disconnecting device.**

WARNING **This system weighs approximately 600 lbs (270 kg). To avoid injuries, use proper moving equipment and use extreme care when installing.**

WARNING **This is a Safety Class I Product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. Any interruption of the protective conductor inside or outside of the product is likely to make the product dangerous. Intentional interruption is prohibited.**

WARNING **To prevent electric shock, disconnect the system from mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.**

WARNING **If this product is not used as specified, the protection provided by the equipment could be impaired. This product must be used in a normal condition (in which all means for protection are intact) only.**

CAUTION This product is designed for use in INSTALLATION CATEGORY II and POLLUTION DEGREE 2, per IEC 1010 and 664 respectively.

CAUTION Install the system according to the enclosure protection provided. This system does not protect against the ingress of water. The system protects against finger access to hazardous parts within the enclosure.

CAUTION Before switching on this system, make sure that the line voltage selector switch on the HP 83427A Chromatic Dispersion Test Set’s rear panel is set to the voltage of the mains supply, that the correct fuse is installed, and that the supply voltage is in the specified range.

System Setup

Installing the System

Use the following procedure to install the HP 86037A Chromatic Dispersion Test System.

1 Roll the unit into place.

Before shipment of the system, it is recommended that HP personnel survey and prepare the customer site. The customer must maintain space for a 143.5 cm wide by 112 cm tall system rack.

2 Connect the fibers in the fiber management trayto their proper locations.

a Remove the tape securing a fiber to the outside of the fiber management tray housing.

b Remove the protective cover and clean the fiber connector.

Before making the fiber connections, read the section on "Cleaning Connections for Accurate Measurements" on page 3-4.

c Use the label on the fiber to connect it to the correct location.

> The cable should be as straight as possible to avoid damage to the cable and poor readings at the instrument.

If the labels are missing from the fiber cables, use Table 1-1 to run the fiber cables.

Table 1-1. Fiber Cable Connections

From	To	Fiber Type
TLS	Test Set	Polarization-Maintaining Fiber (PMF) cable. (Blue fiber with black strain-relief boots on both ends)
Wavelength Meter	Test Set	Normal Single-Mode Fiber Cable

3 Install the keyboard holder under the work top.

4 Install the keyboard in the keyboard tray, and run the keyboard cable to the personal computer.

5 Connect the mouse to the personal computer.

6 Install the monitor.

a Connect the video cable to the personal computer.

b Connect the power cord to the personal computer.

7 Plug in the Power Distribution Units (PDU).

International Installation

The HP 86037A Chromatic Dispersion Test System is shipped to international markets without an ac power connector. The customer should have a local electrician provide and install an ac connector that meets the standards for the region, and ensure that all instruments are set to the local line voltage.

Reinstalling the Software

In order to run the Hewlett Packard Chromatic Dispersion Test System (HPCD) software, support software for the DAC02 and National Instruments 488 must be installed. To run the HPCD in remote mode, it will be necessary to install and activate the remote shell service.

The files necessary to install these three programs are in the subdirectory names `Related Instructions` located under the main install directory. The file and directory structure is listed below:

```
\DAC02
   Port95NT.exe
\NI-488
   version.txt
   \disk1
      . . .
      setup.exe
      . . .
   \disk2
      . . .
\RSH
   rsh_start.bat
   rshsetup.exe
   rshsvc.dll
   rshsvc.exe
   rshsvc.txt          – Instructions for installation
```

Installing the NI-488

To install the NI-488 code:

1. Run the file `setup.exe` from the `disk1` directory
2. Click `custom installation` from the setup program
3. Click only the `driver` option. After the installation is finished, run the GPIB utility which is found as the GPIB icon in the control panel. When the GPIB utility window is displayed, select `OK`. When the next window is displayed, select `Yes`

Installing the DAC02

To install the DAC02 code:

1. Run the file `Port95NT.exe` from the `DAC02` directory and click `Yes` at the prompt
2. Click `custom installation` from the setup program and select only the relevent files.
3. When the process is complete, reboot the computer.

Installing the CD Software

To install the Chromatic Dispersion Test System Software:

- For a single band, 1300nm HP 86037A Chromatic Dispersion Test System, run the file CD-Low`-Band.exe` from the CD-ROM disk.
- For a high band, 1550nm HP 86037A Chromatic Dispersion Test System, run the file `CD_High_Band.exe` from the CD-ROM disk.
- For a dual band HP 86037A Chromatic Dispersion Test System, run the file `CD_Dual_Band.exe` from the CD-ROM disk.

Starting the Software

To Start the HP 86037A Chromatic Dispersion Test System software:

1. Start the Windows NT operating system.
2. Click on the HP 86037A Chromatic Dispersion Test System icon located on the Windows desktop.
3. A splash screen will appear displaying the software title followed by the `Test Setup` screen shown in Figure 1-1.

> To ensure all system specifications are met, let the system warm up for two hours before making any critical measurements.

The Test Setup Window

The single band HP 86037A Chromatic Dispersion Test System, option 113 main window is shown in Figure 1-1. Please see Figure 6-1 in Chapter 6 for an example of the dual band HP 86037A Chromatic Dispersion Test System main window.

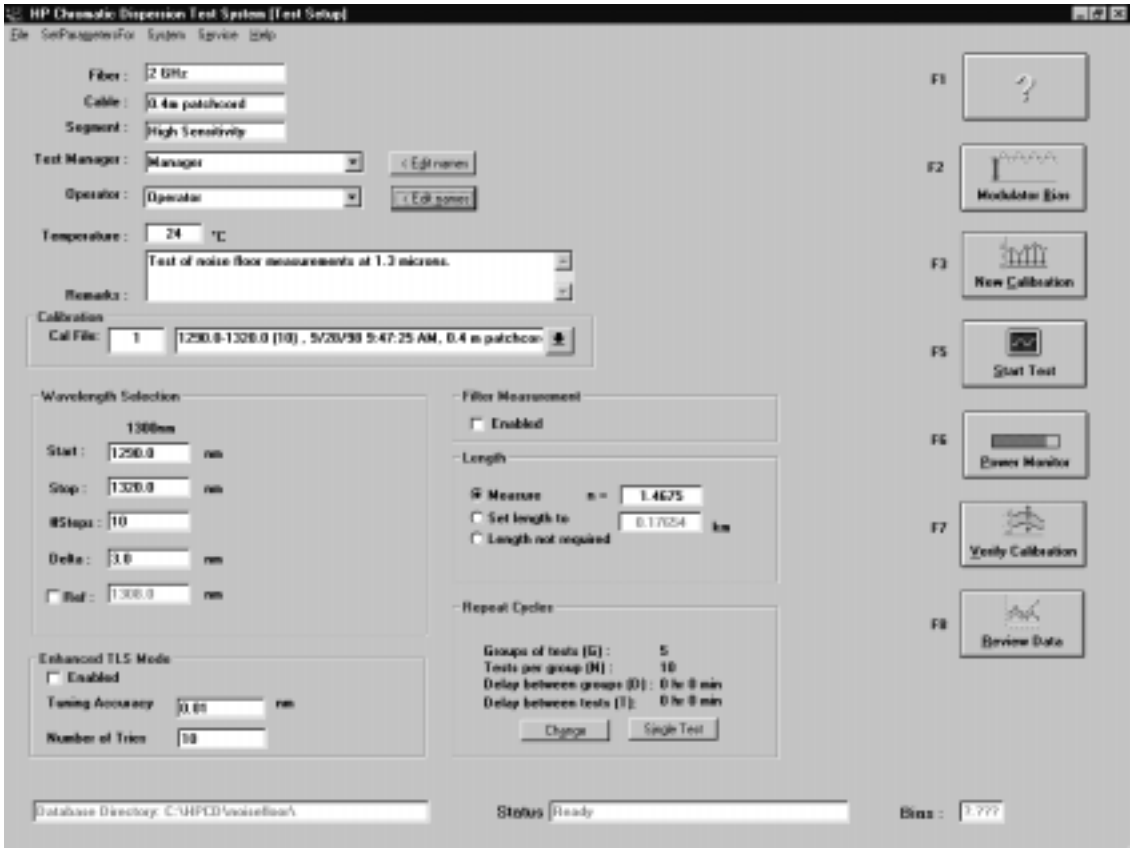

Figure 1-1. HP 86037A Chromatic Dispersion Test System Main Window

Accessing Functions

The Title bar

This bar is located at the top of the HP 86037A Chromatic Dispersion Test System window. It displays the program title and the name of the setup file that is currently open. In Figure 1-1, the setup file is called `Test Setup`.

The Menu bar

The menu bar is located just below the title bar. The menu provides access to the `File, SetParametersFor, System, Service,` and `Help` drop-down menus.

Clicking on any menu displays a drop-down list of commands for accessing that menu's functions.

Command Buttons

Click a command button to cause a process to start. For example in Figure 1-1, the user could push the `Start Test` command button to begin the chromatic dispersion test sequence.

Using Dialog Boxes

HP 86037A Chromatic Dispersion Test System uses standard Microsoft Windows dialog boxes to let you control application and measurement softkeys. If you are familiar with other Windows applications, you will find these dialog boxes easy to use.

Numeric/entries

This type of dialog box is used to enter numeric values. Enter the desired value from the keyboard.

Text boxes

Some fields allow you to enter text strings. Highlight the existing string to select it for editing. Use the keyboard to edit the string.

The Home key moves the cursor to the beginning of the string. The Del key deletes characters following the cursor. Backspace deletes characters before the cursor. To highlight a block of text, drag the cursor across it. Highlighted text can then be deleted by pressing the Del or Backspace key, or replaced by typing in new text.

Drop-down lists/menus

Drop-down menus or lists are included in some of the dialog boxes, and provide you with several options. Select an option from the list by clicking on it.

List boxes

List-boxes allow you to select an item from a list. Scroll through the list using the scroll bar, and then select an item by double-clicking on it.

Option buttons

These buttons present two or more mutually exclusive choices. You must select one of the options by clicking the associated button. When selected, the button is highlighted.

Check boxes

Some check boxes enable or disable a particular option. The option is enabled when a mark is in the box (☒ or ☑). It is disabled when the check box is empty (☐).

System/status bar

The System/status bar displays information about the system database, disk space, modulator bias and date. It also displays help for entering test setup.

Use the TAB key to quickly move from item to item.

For a more detailed discussion of the Windows NT® operating system, refer to your *Microsoft Windows NT User's Guide.*

HP-IB Bus Addresses

Table 1-2 shows the individual HP-IB addresses for the HP 86037A Chromatic Dispersion Test System.

Table 1-2. HPIB Addresses

Instrument Name	HPIB
Tunable Laser Source - 1500nm	24
Tunable Laser Source - 1300nm	23
Wavelength Meter	25
Network Analyzer	16

Table 1-3 shows the computer I/O addresses for the test set in the HP 86037A Chromatic Dispersion Test System.

Table 1-3. Computer I/O Addresses

Test Set Component	I/O Address	
Modulation Bias DAC	&h300	
Switch DAC	&h308	(Only used in dual band systems)

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Specifications 2-3

Specifications

At a Glance

This chapter contains the specifications and other general information pertaining to the HP 86037A Chromatic Dispersion Test System.

Specifications

The specifications in Table 2-1 describe the system's warranted performance at 23 ±3° C after a two-hour warmup.

Definition of Terms

The distinction between specifications and *characteristics* is described as follows:

- Specifications describe warranted performance.
- Characteristics provide useful, but nonwarranted information about the observed functions and performance of the instrument. *Characteristics are printed in italics*.
- '#' indicate options for the HP 86037A Chromatic Dispersion Test System. Refer to Table 4-1 for information on these options.

Table 2-1. Chromatic Dispersion Measurement Specifications

Measurement	Specification
Wavelength Range:	
Standard	1450 – 1590 nm
# 112	1255 – 1365 nm, and 1450 – 1590 nm
# 113	1255 – 1365 nm
# 116	1490 – 1565
Maximum optical power from SOURCE OUTPUT	
Standard	-1 dBm (optical)
# 112	-2 dBm (optical)
# 113	-1 dBm (optical)
# 116	-5 dBm (optical)
System Dynamic Range:	
Standard	40 dB (optical) Typical: 1520 to 1570 nm
# 112	39 dB (optical) Typical: 1310-1350 nm, and 1520 to 1570 nm
# 113	36 dB (optical) Typical: 1310 to 1350 nm
# 116	30 dB (optical) Typical: 1500 to 1565 nm
Optical power range for RECEIVER INPUT	–3 to –43 dBm (optical)
Modulation frequency range	250 MHz to 2.5 GHz
Dispersion range	0.1 ps/nm to D_{max}[a] or 1 ps/nm, whichever is smaller.
Zero dispersion wavelength repeatability[b]	0.05 nm
Dispersion coefficient repeatability[c]	0.1 ps/(nm × km)
Repeatability of dispersion slope at zero dispersion wavelength[c]	0.002 ps/(nm^2 × km)

Table 2-1. Chromatic Dispersion Measurement Specifications (Continued)

Measurement	Specification
Zero dispersion wavelength accuracy[d]	
with wavelength meter	*±0.05 nm*
without wavelength meter (With HP 8168F)	*±0.15 nm*
without wavelength meter (With HP 8168D)	*±0.25 nm*
Relative amplitude accuracy	*±0.25 dB*
Typical measurement time:	
with wavelength meter	3 seconds per point
without wavelength meter[e]	2 seconds per point

a. Maximum dispersion, Dmax (in ns/nm), is given by 25/DI, where DI is the wavelength step size in nm.
b. One standard deviation for 20 measurements on the same spool of 10 km dispersion-shifted fiber for the wavelength range from 1515 to 1580 nm with power into RECEIVER INPUT at -43 dBm (optical). Parameters refer to curve fit traces using the five-term Sellmeier fit.
c. This value is derived from the group delay value.
d. These values are based on measurements of NIST Standard Reference Material 2524, Serial No. 0001, using a quadratic fit to 65 point spaced at 1 nm.
e. This calculation was done for 65 points on a standard spool of 10 km fiber using normal sensitivity. Any change of sensitivity will result in a corresponding change in time. As an example, 10 runs of standard fiber with 65 points per run takes about one hour.

Length Measurement Specifications

Measurement	Specification
Range	0.05 m to 10000 km (amplified system)[a]
Range resolution[b]	*0.05 mm or 0.01% of the measured length, whichever is greater.*
Group refractive index	*1.0000–2.0000 (user adjustable)*

a. For very long lengths of fibers. the use of EDFA amplifiers is assumed. The system's dynamic range is not sufficient to measure long lengths without amplification.
b. Range resolution is a measure of the ability to pinpoint the peak of a response in the length measurement.

Calculation Methods

Method
Five-term sellmeier fit
Quadratic fit
Three-term sellmeier fit
Direct calculation from group delay data

Wavelength Meter Characteristics

Measurement	Specification
Wavelength accuracy	*±0.003 nm*
Input Power Range	*–40 to +10 dBm (optical)*

Operating Characteristics

Use	Specification
Use	*indoor*
Power Requirements	*110, 120, 220, or 240 VAC ±10%* *47 Hz to 66 Hz, 45 WATTS MAX*
Operating temperature	*+10°C to +40°C*
Non-operating storage temperature	*–40°C to +70°C*
Humidity	*15% to 95%, non-condensing*
Weight	*11.4 kg (25 lbs)*
Dimensions (H x W x D)	*90 x 432 x 495 mm (3.5 x 17 x 19.5 in)*

This is to declare that this system is in conformance with the German Regulation on Noise Declaration for Machines (Laermangabe nach der Maschinenlaermrerordnung -3.GSGV Deutschland).

Notice for Germany: Noise Declaration

Acoustic Noise Emission	Geraeuschemission
LpA < 70 dB	LpA < 70 dB
Operator position	am Arbeitsplatz
Normal position	normaler Betrieb
per ISO 7779	nach DIN 45635 t.19

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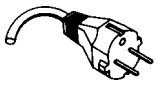
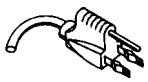
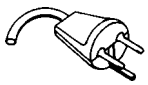
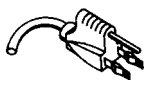
Maintenance

At a Glance

This chapter contains general maintenance procedures for the HP 86037A Chromatic Dispersion Measurement System.

Power Cords

Table 3-1. Power Cord Plugs

Plug Type		Cable Part No.	Plug Description	Length (in/cm)	Color	Country
250V		8120-1351	Straight *BS1363A	90/228	Gray	United Kingdom, Cyprus, Nigeria, Zimbabwe, Singapore
		8120-1703	90°	90/228	Mint Gray	
250V		8120-1369	Straight *NZSS198/ ASC	79/200	Gray	Australia, New Zealand
		8120-0696	90°	87/221	Mint Gray	
250V		8120-1689	Straight *CEE7-Y11	79/200	Mint Gray	East and West Europe, Saudi Arabia, Republic of South Africa, India (unpolarized in many nations)
		8120-1692	90°	79/200	Mint Gray	
		8120-2857p	Straight (Shielded)	79/200	Coco Brown	
125V		8120-1378	Straight *NEMA5-15P	90/228	Jade Gray	United States, Canada, Mexico, Philippines, Taiwan
		8120-1521	90°	90/228	Jade Gray	
		8120-1992	Straight (Medical) UL544	96/244	Black	
250V		8120-2104	Straight *SEV1011	79/200	Mint Gray	Switzerland
		8120-2296	1959-24507 Type 12 90°	79/200	Mint Gray	
220V		8120-2956	Straight *DHCK107	79/200	Mint Gray	Denmark
		8120-2957	90°	79/200	Mint Gray	
250V		8120-4211	Straight SABS164	79/200	Jade Gray	Republic of South Africa
		8120-4600	90°	79/200		India
100V		8120-4753	Straight MITI	90/230	Dark Gray	Japan
		8120-4754	90°	90/230		

* Part number shown for plug is the industry identifier for the plug only. Number shown for cable is the HP part number for the complete cable including the plug.

For overseas sales, power cord plugs are removed. The customer is responsible for ensuring that the proper power cord plug is installed for the area.

Cleaning Connections for Accurate Measurements

Advances in measurement capabilities make connectors and connection techniques more important than ever. Damage to the connectors on calibration and verification devices, test ports, cables, and other devices can increase downtime and expense.

Refer to "Cleaning Optical Connectors" below and to "Cleaning Electrical Connections" on page 3-12 for suggestions which will help you get the best performance from your connectors.

Choosing the Right Connector

A critical but often overlooked factor in making a good lightwave measurement is the selection of the fiber-optic connector. The differences in connector types are mainly in the mechanical assembly that holds the ferrule in position against another identical ferrule. Connectors also vary in the polish, curve, and concentricity of the core within the cladding. Mating one style of cable to another requires an adapter. Hewlett Packard offers adapters for most instruments to allow testing with many different cables. The following figure shows the basic components of a typical connector.

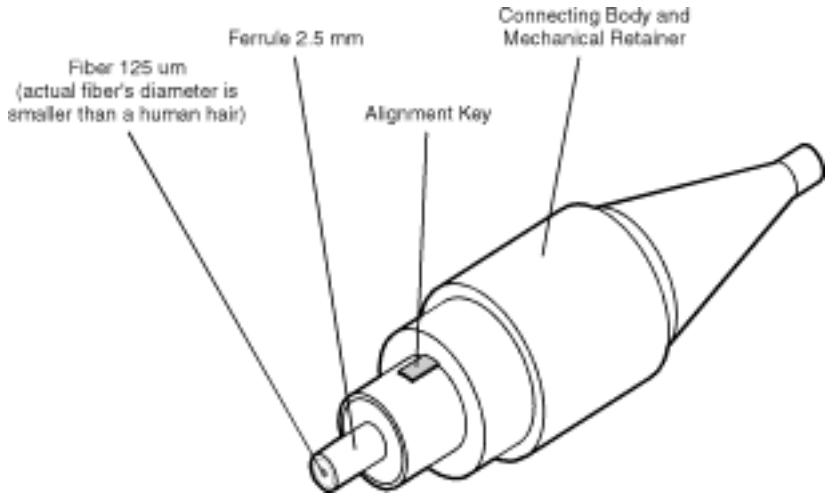


Figure 3-1. Basic Components of a Connector

The system tolerance for reflection and insertion loss must be known when selecting a connector from the wide variety of currently available connectors. Some items to consider when selecting a connector are:

- How much insertion loss can be allowed?
- Will the connector need to make multiple connections? Some connectors are better than

others, and some are very poor for making repeated connections.

- What is the reflection tolerance? Can the system take reflection degradation?
- Is an instrument-grade connector with a precision core alignment required?
- Is repeatability tolerance for reflection and loss important? Do your specifications take repeatability uncertainty into account?
- Will a connector degrade the return loss too much, or will a fusion splice be required? For example, many DFB lasers cannot operate with reflections from connectors. Often as much as 90 dB isolation is needed.

Over the last few years, the FC/PC style connector has emerged as the most popular connector for fiber-optic applications. While not the highest performing connector, it represents a good compromise between performance, reliability, and cost. If properly maintained and cleaned, this connector can withstand many repeated connections.

However, many instrument specifications require tighter tolerances than most connectors, including the FC/PC style, can deliver. These instruments cannot tolerate connectors with the large non-concentricities of the fiber common with ceramic style ferrules. When tighter alignment is required, HP instruments typically use a connector such as the Diamond HMS-10, which has concentric tolerances within a few tenths of a micron. HP then uses a special universal adapter, which allows other cable types to mate with this precision connector.

Figure 3-2. Universal Adapters to Diamond HMS-10

The HMS-10 encases the fiber within a soft nickel silver (Cu/Ni/Zn) center which is surrounded by a tough tungsten carbide casing, as shown in Figure 3-3.

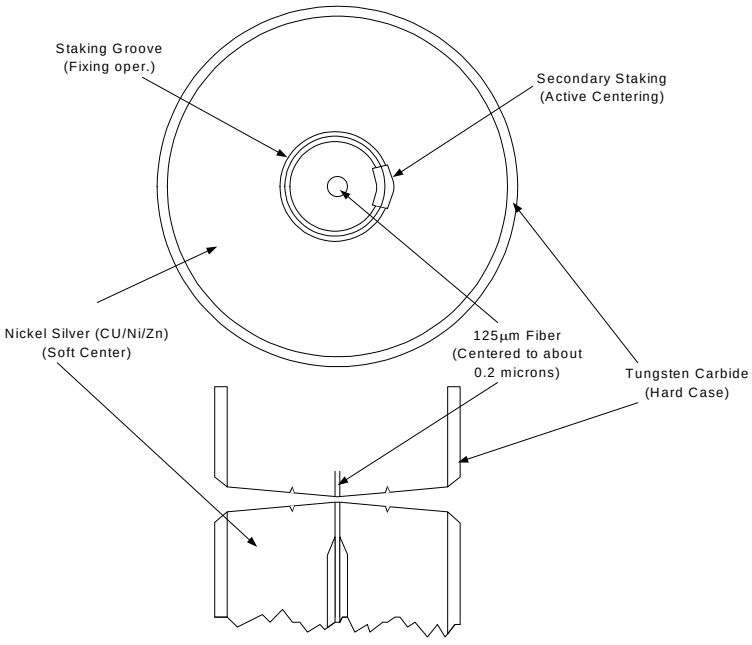


Figure 3-3. Cross-section of the Diamond HMS-10 connector.

The nickel silver allows an active centering process that permits the glass fiber to be moved to the desired position. This process first stakes the soft nickel silver to fix the fiber in a near-center location, then uses a post-active staking to shift the fiber into the desired position within 0.2 µm. This process, plus the keyed axis, allows very precise core-to-core alignments. This connector is found on most HP lightwave instruments.

The soft core, while allowing precise centering, is also the chief liability of the connector. The soft material is easily damaged. Care must be taken to minimize excessive scratching and wear. While minor wear is not a problem if the glass face is not affected, scratches or grit can cause the glass fiber to move out of alignment. Also, if unkeyed connectors are used, the nickel silver can be pushed onto the glass surface. Scratches, fiber movement, or glass contamination will cause loss of signal and increased reflections, resulting in poor return loss.

Inspecting Connectors

Because fiber-optic connectors are susceptible to damage that is not immediately obvious to the naked eye, bad measurements can be made without the user even being aware of a connector problem. Although microscopic examination and return loss measurements are the best way to ensure good connections, they are not always practical. An awareness of potential problems, along with good cleaning practices, can ensure that optimum connector performance is maintained. With glass-to-glass interfaces, it is clear that any degradation of a ferrule or the end of the fiber, any stray particles, or finger oil can have a significant effect on connector performance.

Figure 3-4 shows the end of a clean fiber-optic cable. The dark circle in the center of the micrograph is the fiber's 125 µm core and cladding which carries the light. The surrounding area is the soft nickel-silver ferrule. Figure 3-5 shows a dirty fiber end from neglect or perhaps improper cleaning. Material is smeared and ground into the end of the fiber causing light scattering and poor reflection. Not only is the precision polish lost, but this action can grind off the glass face and destroy the connector.

Figure 3-6 shows physical damage to the glass fiber end caused by either repeated connections made without removing loose particles or using improper cleaning tools. When severe, the damage on one connector end can be transferred to another good connector that comes in contact with it.

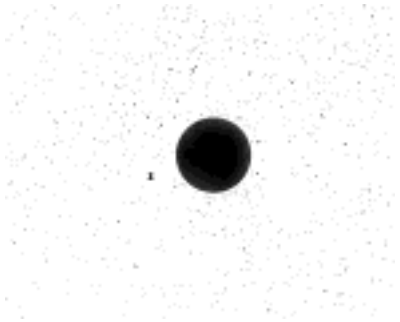


Figure 3-4. Clean, problem-free fiber end and ferrule.

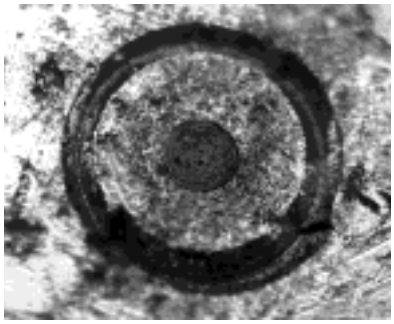


Figure 3-5. Dirty fiber end and ferrule from poor cleaning.

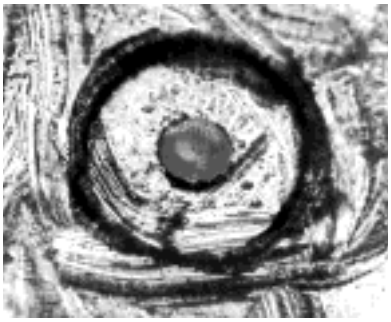


Figure 3-6. Damage from improper cleaning.

The cure for these problems is disciplined connector care as described in the following list and in "Cleaning Optical Connectors" on page 3-10.

Use the following guidelines to achieve the best possible performance when making measurements on a fiber-optic system:

- Never use metal or sharp objects to clean a connector and never scrape the connector.
- Avoid matching gel and oils.

  While these often work well on first insertion, they are great dirt magnets. The oil or gel grabs and holds grit that is then ground into the end of the fiber. Also, some early gels were designed for use with the FC, non-contacting connectors, using small glass spheres. When used with contacting connectors, these glass balls can scratch and pit the fiber. If an index matching gel or oil must be used, apply it to a freshly cleaned connector, make the measurement, and then immediately clean it off. Never use a gel for longer-term connections and never use it to improve a damaged connector. The gel can mask the extent of damage and continued use of a damaged fiber can transfer damage to the instrument.
- When inserting a fiber-optic cable into a connector, gently insert it in as straight a line as possible. Tipping and inserting at an angle can scrape material off the inside of the connector or even break the inside sleeve of connectors made with ceramic material.
- When inserting a fiber-optic connector into a connector, make sure that the fiber end does not touch the outside of the mating connector or adapter.
- Avoid over tightening connections.

  Unlike common electrical connections, tighter is *not* better. The purpose of the connector is to bring two fiber ends together. Once they touch, tightening only causes a greater force to be applied to the delicate fibers. With connectors that have a convex fiber end, the end can be pushed off-axis resulting in misalignment and excessive return loss. Many measurements are actually improved by backing off the connector pressure. Also, if a piece of grit does happen to get by the cleaning procedure, the tighter connection is more likely to damage the glass. Tighten the connectors just until the two fibers touch.
- Keep connectors covered when not in use.
- Use fusion splices on the more permanent critical nodes. Choose the best connector possible. Replace connecting cables regularly. Frequently measure the return loss of the connector to check for degradation, and clean every connector, every time.

  All connectors should be treated like the high-quality lens of a good camera. The weak link in instrument and system reliability is often the inappropriate use and care of the connector. Because current connectors are so easy to use, there tends to be reduced vigilance in connector care and cleaning. It takes only one missed cleaning for a piece of grit to permanently damage the glass and ruin the connector.

Measuring insertion loss and return loss

Consistent measurements with your lightwave equipment are a good indication that you have good connections. Since return loss and insertion loss are key factors in determining optical connector performance they can be used to determine connector degradation. A smooth, polished fiber end should produce a good return-loss measurement. The quality of the polish establishes the difference between the "PC" (physical contact) and the "Super PC" connectors. Most connectors today are physical contact which make glass-to-glass connections, therefore it is critical that the area around the glass core be clean and free of scratches. Although the major area of a connector, excluding the glass, may show scratches and wear, if the glass has maintained its polished smoothness, the connector can still provide a good low level return loss connection.

If you test your cables and accessories for insertion loss and return loss upon receipt, and retain the measured data for comparison, you will be able to tell in the future if any degradation has occurred. Typical values are less than 0.5 dB of loss, and sometimes as little as 0.1 dB of loss with high performance connectors.

Inspecting Fiber-Optic Cables

Consistent measurements with your lightwave equipment are a good indication that you have good connections. However, you may want to know the insertion loss and/or return loss of your lightwave cables or accessories. If you test your cables and accessories for insertion loss and return loss upon receipt, and retain the measured data for comparison, you will be able to tell in the future if any degradation has occurred.

Connector (or insertion) loss is one important performance characteristic of a lightwave connector. Typical values are less than 0.5 dB of loss, and sometimes as little as 0.1 dB of loss with high performance connectors.

Return loss is another important characteristic. It is a measure of reflection: the less reflection the better (the larger the return loss, the smaller the reflection). The best physically contacting connectors have return losses better than 50 dB, although 30 to 40 dB is more common.

Visual inspection of fiber ends

Although it is not necessary, visual inspection of fiber ends can be helpful. Contamination or imperfections on the cable end face can be detected, as well as cracks or chips in the fiber itself. Use a microscope (100X to 200X magnification) to inspect the entire end face for contamination, raised or dented metal, as well as any other imperfections. Inspect the fiber for cracks and chips. Visible imperfections not touching the fiber core may not affect performance, unless the imperfections keep the fibers from contacting.

Signal Losses

To Test Insertion Loss

Use an appropriate lightwave source and a compatible lightwave receiver to test insertion loss. Examples of test equipment configurations include the following equipment:

- HP 71450A or HP 71451A Optical Spectrum Analyzers with Option 002 built-in white light source.
- HP 8702 or HP 8703 Lightwave Component Analyzer system.
- HP 83420 Chromatic Dispersion Test Set with an HP 8510 Network Analyzer.
- HP 8153 Lightwave Multimeter with a source and power sensor module.

To Test Return Loss

Use an appropriate lightwave source, lightwave receiver, and lightwave coupler to test return loss. Examples of test equipment configurations include the following equipment:

- HP 8703 Lightwave Component Analyzer.
- HP 8702 Lightwave Component Analyzer with the appropriate source, receiver, and lightwave coupler.
- HP 8504 Precision Reflectometer.
- HP 8153 Lightwave Multimeter with a source and power sensor module in conjunction with a lightwave coupler.
- HP 81554SM Dual Source and HP 81534A Return Loss Module.

Cleaning Optical Connectors

Accurate and repeatable measurements require clean connections. Use the following guidelines to achieve the best possible performance when making measurements on a fiber-optic system:

- Keep connectors covered when not in use.
- Use dry connections whenever possible.
- Use the cleaning methods described in this section.
- Use care in handling all fiber-optic connectors.
- When inserting a fiber-optic connector into a front-panel adapter, make sure that the fiber end does not touch the outside of the mating connector or adapter.
- Use dry connections. Dry connectors are easier to keep clean. Dry connections can be used with physically contacting connectors (for example, Diamond HMS-10/HP, FC/PC, DIN, and ST). If a dry connection has 40 dB return loss or better, making a wet connection probably will not improve, and can actually degrade, performance.

  Because of the small size of cores used in optical fibers, care must be used to ensure good connections. Poor connections result from core misalignment, air gaps, damaged fiber ends, contamination, and improper use and removal of index-matching compounds.

CAUTION

Hewlett-Packard strongly recommends that index matching compounds *not* be applied to their instruments and accessories. Some compounds, such as gels, may be difficult to remove and can contain damaging particulates. If you think the use of such compounds is necessary, refer to the compound manufacturer for information on application and cleaning procedures.

Table 3-2. Cleaning Accessories

Item	HP Part Number
Isopropyl alcohol	8500-5344
Cotton swabs	5080-5400
Compressed dust remover (non-residue)	8500-6659

Table 3-3. Dust Caps Provided with Lightwave Instruments

Item	HP Part Number
Laser shutter cap	08145-64521
FC/PC dust cap	08154-44102
DIN dust cap	08154-44103
HMS10/HP dust cap	08154-44101

To Clean A Lensed Connector

Lensed connectors do not provide a physically contacting connection; the light is received into a lens rather than into a connecting fiber. These receiving lenses usually have an anti-reflective coating that is very easily damaged. Therefore, these connectors should never have cleaning solutions or any other substance applied to them unless it is specifically recommended by the manufacturer.

1 Use clean compressed air to remove any dust. Direct the compressed air parallel to the surface of the fiber end.

CAUTION Do not shake, tip, or invert compressed air canisters, because this releases particles in the can into the air. Refer to instructions provided on the compressed air canister.

2 Connect or cover the connector for later use.

To Clean A Non-lensed Connector

CAUTION Do not use any type of foam swab to clean optical fiber ends. Foam swabs may leave filmy deposits on fiber ends that can degrade performance.

Apply isopropyl alcohol to a clean lint-free cotton swab or lens paper. Cotton swabs can be used as long as no cotton fibers remain on the fiber end after cleaning. Before cleaning the fiber end, clean the ferrules and other parts of the connector.

1 Clean the fiber end with the swab or lens paper. Move the swab or lens paper back and forth across the fiber end several times.

Some amount of wiping or mild scrubbing of the fiber end can help remove particles when application of alcohol alone will not remove them. This technique can remove or displace particles smaller than one micron.

2 Immediately dry the fiber end with a clean, dry, lint-free cotton swab or lens paper.

3 Blow filtered, dry, compressed air across the connector end face from a distance of 6 to 8 inches. Aim the compressed air at a shallow angle to the fiber end face.

Nitrogen gas or compressed dust remover can also be used.

CAUTION Do not shake, tip, or invert compressed air canisters, because this releases particles in the can into the air. Refer to instructions provided on the compressed air canister.

4 As soon as the connector is dry, connect or cover it for later use.

To Clean An Adapter

1 Apply isopropyl alcohol to a clean foam swab.

> Cotton swabs can be used as long as no cotton fibers remain after cleaning. The foam swabs listed in this section's introduction are small enough to fit into adapters.
>
> Although foam swabs can leave filmy deposits, these deposits are very thin, and the risk of other contamination buildup on the inside of adapters greatly outweighs the risk of contamination by foam swabs.

2 Clean the adapter with the foam swab.

3 Dry the inside of the adapter with a clean, dry, foam swab.

4 Blow through the adapter using filtered, dry, compressed air.

CAUTION Nitrogen gas or compressed dust remover can also be used. Do not shake, tip, or invert compressed air canisters, because this releases particles in the can into the air. Refer to instructions provided on the compressed air canister.

Cleaning Electrical Connections

The following list includes the basic principles of microwave connector care. For more information on microwave connectors and connector care, consult the *Hewlett-Packard Microwave Connector Care Manual*, HP part number 08510-90064.

Handling and Storage

- Keep connectors clean
- Extend sleeve or connector nut
- Use plastic endcaps during storage
- Do *not* touch mating plane surfaces
- Do *not* set connectors contact-end down

Visual Inspection

- Inspect all connectors carefully before every connection
- Look for metal particles, scratches, and dents
- Do *not* use damaged connectors

Cleaning

- Try cleaning connectors with compressed air first
- Clean the connector threads
- Do *not* use abrasives
- Do *not* get liquid onto the plastic support beads

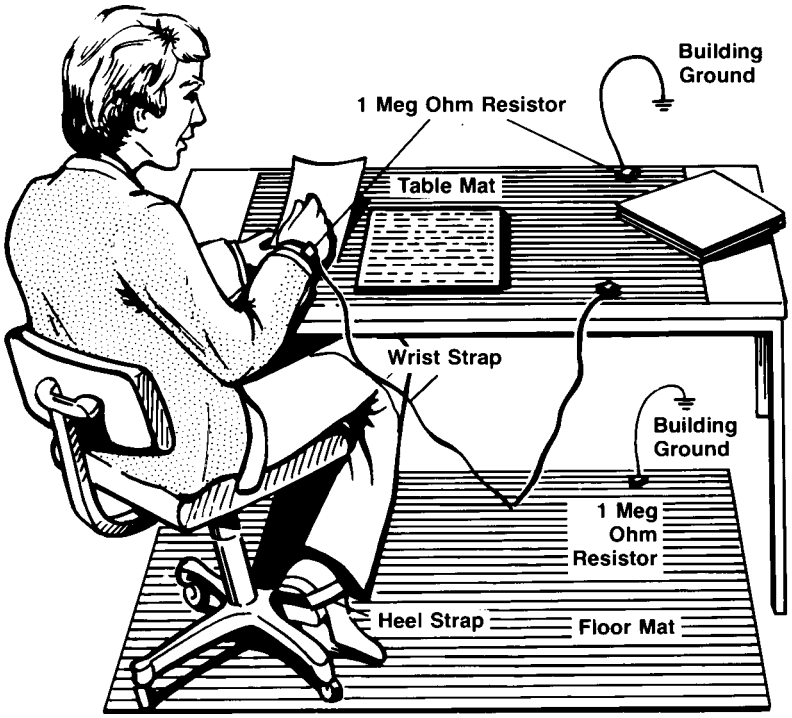
Making Connections

- Align connectors carefully
- Make preliminary connection lightly
- To tighten, turn connector nut *only*
- Do *not* apply bending force to connection
- Do *not* overtighten preliminary connection
- Do *not* twist or screw in connectors
- Do *not* tighten past the "break" point of the torque wrench

Electrostatic Discharge Information

Electrostatic discharge (ESD) can damage or destroy electronic components. All work on electronic assemblies should be performed at a static-safe work station. The following figure shows an example of a static-safe work station using two types of ESD protection:

- Conductive table-mat and wrist-strap combination
- Conductive floor-mat and heel-strap combination



Both types, when used together, provide a significant level of ESD protection. Of the two, only the table-mat and wrist-strap combination provides adequate ESD protection when used alone.

To ensure user safety, the static-safe accessories must provide at least 1 MΩ of isolation from ground. Refer to Table 3-4 on page 3-14 for information on ordering static-safe accessories.

WARNING **These techniques for a static-safe work station should not be used when working on circuitry with a voltage potential greater than 500 volts.**

Reducing ESD Damage

The following suggestions may help reduce ESD damage that occurs during testing and servicing operations.

- Personnel should be grounded with a resistor-isolated wrist strap before removing any assembly from the unit
- All instruments should be properly earth-grounded to prevent a static charge buildup

Table 3-4. Static-Safe Accessories

HP Part Number	Description
9300-0797	Set includes: 3M static control mat 0.6 m × 1.2 m (2 ft × 4 ft) and 4.6 cm (15 ft) ground wire. (The wrist-strap and wrist-strap cord are not included. They must be ordered separately.)
9300-0980	Wrist-strap cord 1.5 m (5 ft)
9300-1383	Wrist-strap, black, stainless steel, without cord, has four adjustable links and a 7 mm post-type connection.
9300-1169	ESD heel-strap (reusable for 6 to 12 months).

HP Support

Services for Test Systems

After you purchase a complex, mission-critical HP test system, you'll want to ensure that system uptime is maximized. This requires on-site service by an HP customer engineer.

To order per-incident, contractual or customized on-site system repair and on-site system calibration services: contact your local sales office, give the operator the name of your company and the city where you're located, then ask to speak with a field sales engineer.

If you're currently covered by a per-incident, contractual or customized program, contact your customer engineer through your local sales office to obtain on-site service.

On-site System Repair

When you order one of HP's on-site system repair options, a customer engineer (CE) is assigned to your company. The CE becomes intimately acquainted with your environment and assumes personal responsibility for managing your system's maintenance program. Your CE will also perform preventive maintenance on a regular basis.

HP offers four distinct levels of support for system repair:

- Priority Plus – Repair service 24 hours a day, seven days a week. Customers within 100 miles of an HP support facility receive an on-site visit within four hours
- Priority – On-site coverage from 8:00 a.m. to 9:00 p.m. Monday through Friday, excluding HP holidays; allows scheduled maintenance to be performed after normal working hours. Customers within 100 miles of an HP support facility receive an on-site visit within four hours
- Next Day – Provides next-day coverage from 8:00 a.m. to 5:00 p.m. Monday through Friday, excluding HP holidays, for customers within 100 miles of an HP support facility
- Cooperative – For customers who maintain their own systems and rely on HP for training, replacement parts, diagnostic support tools, repair documentation, and remote backup support. Available for customers with specific systems, spares and personnel. (Ask your sales representative about prerequisites)

All levels are subject to volume discount pricing. In addition, if you purchase Priority or Next Day support and have a critical support need, you can order a faster response time for an additional fixed charge when you have an open purchase order on file with HP.

On-Site System Calibration

When you order an on-site calibration agreement as part of your on-site system repair program, your assigned customer engineer (CE) will perform calibrations on your system at the same level of quality that is applied to instruments that are returned to HP.

Calibration services for systems include the following:

- Calibration measurements traceable to national and international standards
- U.S. measurements traceable to the National Institute of Standards and Technology (NIST)
- Product performance compared to standards of known accuracy to ensure conformance with published specifications
- Calibration at HP-recommended intervals
- Complete data reports for all measured product performance
- Calibration certificate and sticker showing date of nextscheduled calibration
- Calibration at no charge after a repair performed by HP on products covered under a calibration agreement or under HP Support Options

Other Test and Measurement Support Programs

In addition to Hardware Support, the Test and Measurement division offers a wide range of other service and support programs.

- Software Support
- Application Consulting and Training
- Solution Engineering and Manufacturing Process Consulting

Returning the Instrument for Service

The instructions in this section show you how to properly package the instrument for return to a Hewlett-Packard service office. For a list of offices, refer to "Hewlett-Packard Sales and Service Offices" on page 13-15. In the US, call 1-800-403-0801 for instructions on how to return your instrument.

If the instrument is still under warranty or is covered by an HP maintenance contract, it will be repaired under the terms of the warranty or contract (the warranty is at the front of this manual). If the instrument is no longer under warranty or is not covered by an HP maintenance plan, Hewlett-Packard will notify you of the cost of the repair after examining the unit.

When an instrument is returned to a Hewlett-Packard service office for servicing, it must be adequately packaged and have a complete description of the failure symptoms attached.

When describing the failure, please be as specific as possible about the nature of the problem. Include copies of additional failure information (such as the instrument failure settings, data related to instrument failure, and error messages) along with the original calibration data disks and the instrument being returned.

Please notify the service office before returning your instrument for service. Any special arrangements for the instrument can be discussed at this time. This will help the HP service office repair and return your instrument as quickly as possible.

Preparing the Instrument for Shipping

1. Write a complete description of the failure and attach it to the instrument. Include any specific performance details related to the problem. The following information should be returned with the instrument.
   - Type of service required
   - Date instrument was returned for repair
   - Description of the problem:
     - Whether problem is constant or intermittent
     - Whether instrument is temperature-sensitive
     - Whether instrument is vibration-sensitive
     - Instrument settings required to reproduce the problem
     - Performance data
   - Company name and return address
   - Name and phone number of technical contact person
   - Model number of returned instrument
   - Full serial number of returned instrument
   - List of any accessories returned with instrument
   - The original calibration data disks
2. Cover all front or rear-panel connectors that were originally covered when you first received the instrument.

CAUTION Cover electrical connectors to protect sensitive components from electrostatic damage. Cover optical connectors to protect them from damage due to physical contact or dust.

CAUTION Instrument damage can result from using packaging materials other than the original materials. Never use styrene pellets as packaging material. They do not adequately cushion the instrument or prevent it from shifting in the carton. They may also cause instrument damage by generating static electricity.

3 Pack the instrument in the original shipping containers. Original materials are available through any Hewlett-Packard office. Use the following guidelines if you are not using original shipping containers:

- Wrap the instrument in antistatic plastic to reduce the possibility of damage caused by electrostatic discharge
- For instruments weighing less than 54 kg (120 lb), use a double-walled, corrugated cardboard carton of 159 kg (350 lb) test strength

The carton must be large enough to allow approximately 7 cm (3 inches) on all sides of the instrument for packing material, and strong enough to accommodate the weight of the instrument.

- Surround the equipment with approximately 7 cm (3 inches) of packing material, to protect the instrument and prevent it from moving in the carton. If packing foam is not available, the best alternative is S.D-240 Air Cap™ from Sealed Air Corporation (Commerce, California 90001). Air Cap looks like a plastic sheet filled with air bubbles. Use the pink (antistatic) Air Cap™ to reduce static electricity. Wrapping the instrument several times in this material will protect the instrument and prevent it from moving in the carton

4 Seal the carton with strong nylon adhesive tape.

5 Mark the carton “FRAGILE, HANDLE WITH CARE.”

6 Retain copies of all shipping papers.

4

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System Overview

At a Glance

This chapter is an overview of the HP 86037A Chromatic Dispersion Test System.

Chromatic Dispersion

Chromatic dispersion results from a variation in propagation delay with wavelength that is shaped, in turn, by the interplay of fiber materials and dimensions. The result is that different frequencies of light travel down optical fiber at different speeds. The optical source in a high-speed communication system is typically a single-line diode laser with a nonzero spectral width. Pulse modulation increases the spectral width.

Signal dispersion is a factor in fiber-optic systems. As more information is sent on a wider frequency bandwidth, and for greater distances, the importance of signal dispersion will become greater.

Each wavelength component of the signal travels at a slightly different speed, resulting in the pulse broadening illustrated in Figure 4-1.

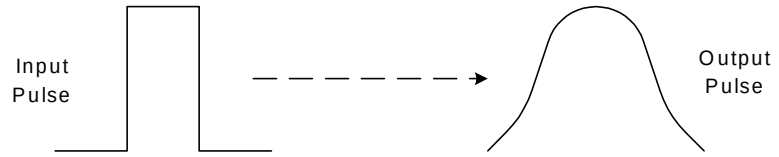


Figure 4-1. Dispersion Effect on a Transmitted Pulse

Chromatic dispersion is the primary dispersive mechanism in singlemode fiber.

In singlemode fiber, chromatic dispersion results from the interplay of the following two underlying effects:

- Material dispersion results from the dependence upon wavelength of the refractive index, and the corresponding group velocity, of doped silica.
- Waveguide dispersion is rooted in the wavelength-dependent relationships of the group velocity to the core diameter and the difference in index between the core and the cladding.

A third component, called second-order PMD (polarization-mode dispersion) or differential group delay dispersion, arises because the velocity of propagation depends on the polarization state of the lightwave signal. The PMD of the fiber optic cable is not constant over time, making compensation difficult. This effect will ultimately limit the highest achievable data rates for a single-wavelength fiber optic system.

Controlling Chromatic Dispersion

Control of the total chromatic dispersion of transmission paths is critical to the design and construction of long-haul, high-speed telecommunications systems. The first objective is to reduce the total dispersion to the point where its contribution to the error rate of the system is acceptable. A system consists of many spans of fiber from different manufacturing runs, each with its own zero-dispersion wavelength and dispersion slope at λ_0 (lambda-zero). The dispersion of a single-channel system can be controlled by connecting fibers of differing dispersion such that the total dispersion is near zero. Alternately, dispersion may be allowed to accumulate along the path and then compensated at the output of the system. For example, if an installed dispersion-shifted fiber system exhibits negative dispersion at the chosen operating wavelength, it can be compensated with a relatively short length of dispersion-unshifted fiber, which has a large, positive dispersion coefficient at the same wavelength. Dispersion can also be compensated with chirped fiber Bragg gratings, made by exposing specially doped fiber to an interference pattern of intense ultraviolet light. Chirping refers to an increase in the period of the index variation as a function of distance along the fiber. Dispersion compensation is more complex in dense WDM (wavelength division multiplexing) systems.

The output power of erbium-doped fiber amplifiers (EDFA's) is sufficient to produce nonlinear effects in singlemode fiber. The second objective of chromatic dispersion compensation is to limit the impairments caused by these nonlinearities. For example, four-wave mixing can be controlled by maintaining a small negative dispersion in those portions of a span that are exposed to high power levels. (Another approach to this problem, in wavelength multiplexed systems, is to space channels in unequal wavelength increments).

In summary, in high-speed, long-haul systems, chromatic dispersion must be compensated for to minimize ordinary pulse broadening. Some chromatic dispersion must be maintained at a small but non-zero level in regions where the optical power is extremely high.

Chromatic dispersion measurements are performed by fiber and cable researchers, manufacturers, and system integrators. Increasingly, chromatic dispersion measurements are also performed during the design, manufacture, and incoming inspection of system components, particularly chromatic dispersion compensators and wavelength division multiplexing components. In the field, chromatic dispersion is measured in connection with the installation of new systems or the upgrade of existing routes to higher bit rates. Some types of measurement systems require local access to both ends of the test fiber, making them more appropriate for factory and laboratory testing and special cases in which it is practical to measure installed fiber in a loop-back arrangement.

System Description

The HP 86037A Chromatic Dispersion Test System uses the modulation phase-shift measurement technique for performing near-end measurements, where there is access to both fiber ends at the same location. A diagram of a measurement apparatus based on the modulation phase-shift technique is shown in Figure 4-2. This system is most useful in fiber, grating and cable manufacturing, as well as for testbed evaluation and system manufacturing.

The HP 86037A is the most accurate and precise chromatic dispersion test system available today. It is a complete solution for testing chromatic dispersion. It comes with the following standard features:

- High wavelength resolution and accuracy
- High repeatability
- Quadratic, 3-term and 5-term Sellmeier curve fitting algorithms
- Direct calculation from group delay data
- NIST backed measurements
- Automatic length measurements
- Integrated Microsoft Access™ database storage of measurements
- Spectral gain/loss measurements
- Transmitted signal strength vs. wavelength measurements
- Windows NT based software
- LAN connection
- Remote file interface control capability
- A full range of installation, training and support options

Figure 4-3 through Figure 4-5 show three block diagrams of the most common system options. There are several other options which are discussed later in this chapter. The RF source of an HP 8753 RF network analyzer drives an optical modulator which modulates the lightwave signal from a tunable laser at a frequency of up to 2.5 GHz. A polarization-maintaining fiber connects the tunable laser to the modulator to maintain a stable modulation index. This modulated lightwave signal passes through the device under test, is detected and converted back into a RF signal by an optical-to-electrical converter.

The HP 8753 RF network analyzer measures the shift in phase of the RF signal by comparing it to a reference derived from the signal driving the modulator. The measured phase is numerically converted into a value for group delay. By tuning the wavelength of the laser, we obtain group delay as a function of wavelength and, after data processing, the dispersion of the device under test. Increased wavelength accuracy is made possible by an external wavelength meter which automatically measures and provides feedback on the wavelength as the laser tunes. The wavelength meter may be supplied by the user.

An HP personal computer operating in the Microsoft Windows NT® operating environment controls all system elements, measurement procedures, temperature compensation algorithms and computations.

Windows NT offers rugged networking capabilities for this chromatic dispersion test system. Most manufacturers have now upgraded their testing facilities to have access to a network. Windows NT also allows greater control of network management for the system administrator as well as enabling functions such as the HP 86037A's remote control option.

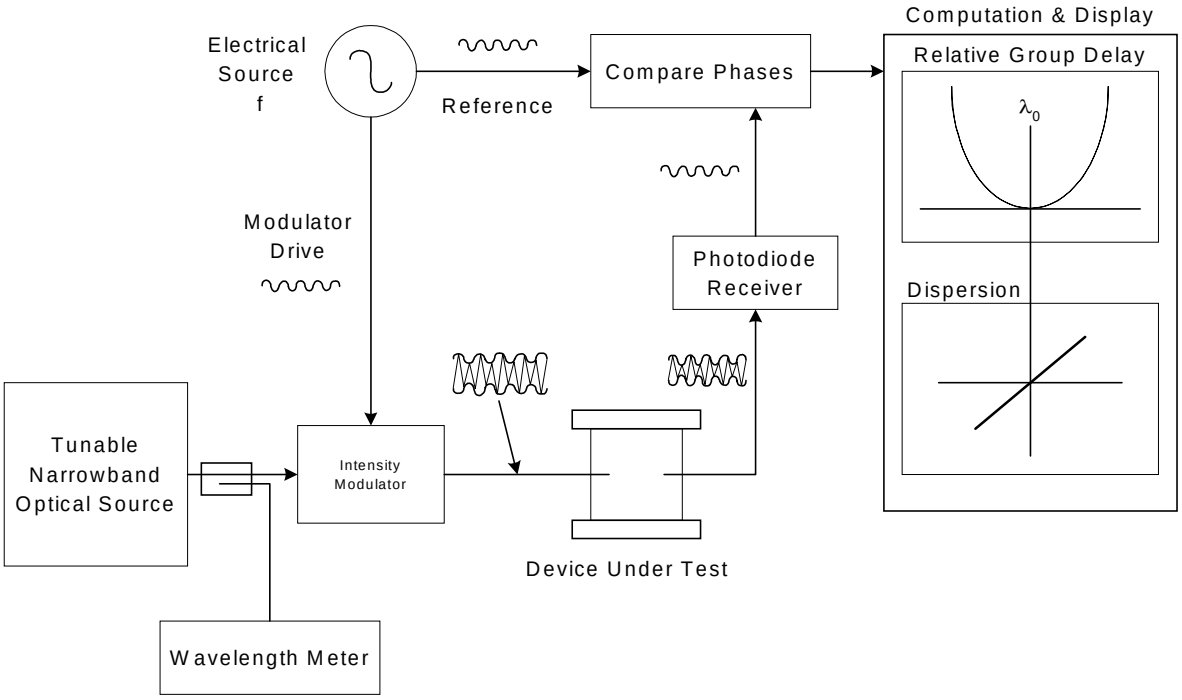


Figure 4-2. Measurement of Chromatic Dispersion Using the Phase-Shift Method

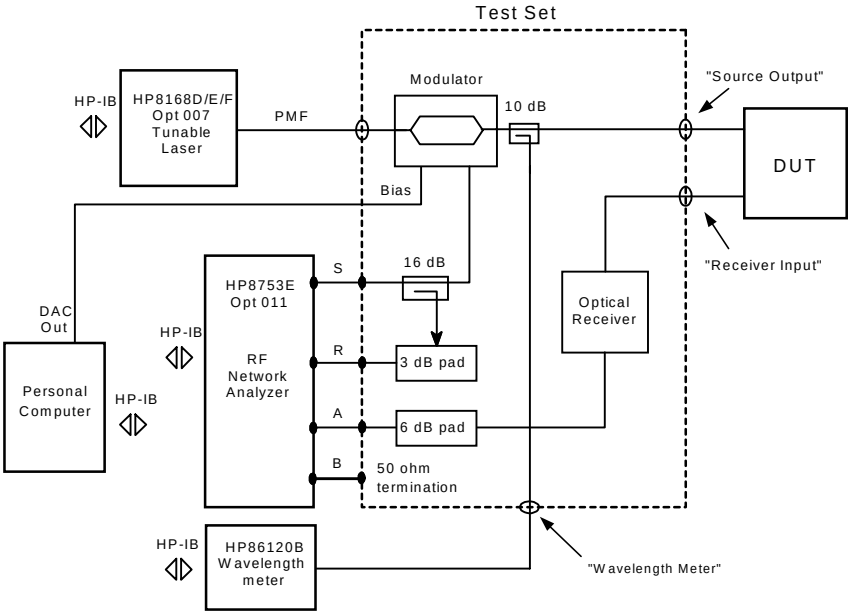


Figure 4-3. Block Diagram for the Standard Chromatic Dispersion Test System

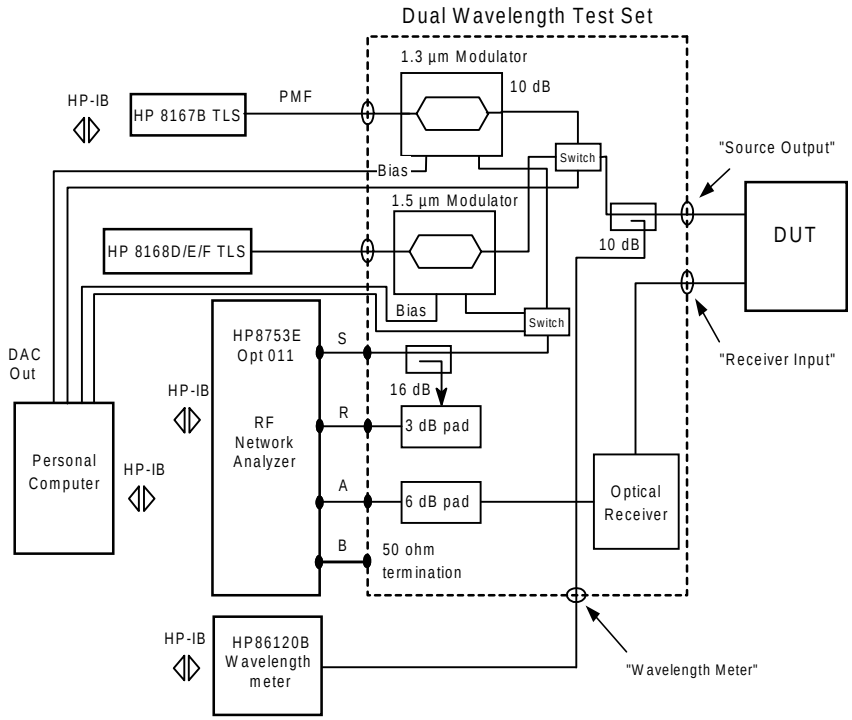


Figure 4-4. The HP 86037A Chromatic Dispersion Test System Option 112 Block Diagram

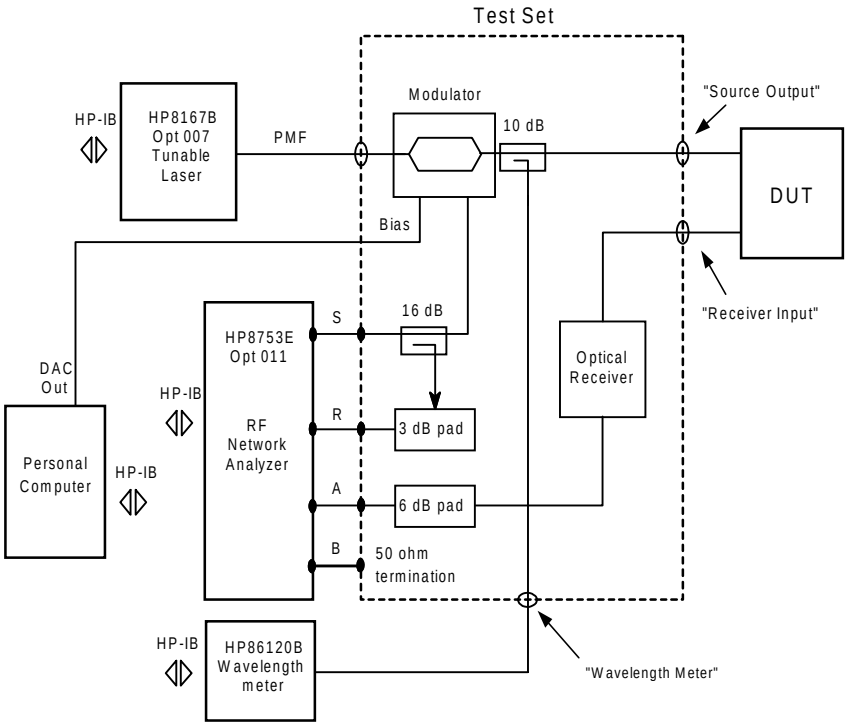


Figure 4-5. The HP 86037A Chromatic Dispersion Test System Option 113 Block Diagram

The HP 86037A Chromatic Dispersion Test System documented in this manual is available in several versions.

The Standard HP 86037A Chromatic Dispersion System

The HP 86037A Chromatic Dispersion Test System is a high performance measurement system designed to provide very high measurement resolution and repeatability required for measuring chromatic dispersion in optically amplified communications systems. The measurement block diagrams for this system are shown in Figure 4-3 through Figure 4-5.

Major components of the standard HP 86037A Chromatic Dispersion Test System are listed below. Refer to the *Implementation and Support Plan* supplied with the HP-CD system for more detailed descriptions of the system components.

- HP 8753x RF Network Analyzer
- HP 8168F Tunable Laser Source (with polarization-maintaining fiber output)
- HP computer
- Computer monitor
- System rack
- HP 83427A Chromatic Dispersion Test Set (1550 nm)
- Windows NT system software
- HP-CD software
- HP 86120x Wavelength Meter

There are several options for the HP 86037A chromatic dispersion system. They are listed in Table 4-1.

Table 4-1. Chromatic Dispersion System Options

Option	Change from Standard System
112	Substitute Dual (1310 nm and 1550 nm) test set Add HP 8167B TLS
113	Substitute 1310 nm test set Substitute HP 8167B TLS
114	Remove HP 86120x Wavelength meter
116	Substitute HP 8168D TLS

Components

Table 4-2. Components in the HP Chromatic Dispersion Test System

Component	Description
HP 8753x Network Analyzer	With an integrated S-parameter test set covering 30 kHz to 3 or 6 GHz, up to 110 dB of dynamic range, and both frequency and power sweeps, the HP 8753E gives you a complete solution for characterizing the linear and nonlinear behavior of active and passive networks, devices, components and sub-systems. A new processor has been incorporated which makes measurement and data-transfer speeds three to seven times faster than the previous model. The network analyzer features two independent measurement channels that can measure and display all four S-parameters simultaneously. You can choose to display any combination of reflection and transmission parameters, with magnitude, phase, group-delay, Smith-chart, polar, SWR, or time-domain formats. Easy-to-use softkeys let you access measurement functions quickly and you can view results in overlay or split-screen format on the crisp, LCD color display (with one, two or four graticules). A VGA-compatible output has been added to drive larger external monitors for optimum viewing. Using a network analyzer to both generate and receive a modulation signal results in higher phase accuracy and resolution, lower cost, and easy length measurements.
HP 8167x and HP 8168x Tunable Laser Sources	These tunable laser sources offer high performance characterization of optical devices over wavelength. They are available in various configurations for the best possible match to the most common applications. They are modified specifically for this application, and they have excellent stability. Features: • Fast and simple set-up of wavelength and power by direct and independent selection of each parameter • Accurate, stable and repeatable wavelength tuning with 1pm tuning linearity and 100MHz stability over hours • True single-mode laser line and low source spontaneous emission with up to 50dB sidemode suppression • Excellent flatness of output power over wavelength for constant and stable power levels over the selected tuning range
HP 83427A Chromatic Dispersion Test Set	The test set contains an instrument grade receiver and modulator to ensure a stable and accurate recovery of the optical signal. This test set was designed to be part of the HP 86037A Chromatic Dispersion Test System.
HP Personal Computer	The computer controls the HP 86037A Chromatic Dispersion Test System. All system elements, measurement procedures, temperature compensation algorithms and computations are performed with the HP personal computer running the HP test GUI under Windows NT.
HP 86120x Multi-Wavelength Meter	The HP 86120x Multi-Wavelength Meter is a Michelson interferometer-based instrument that measures wavelength and optical power of laser light in the 700 to 1650 nm wavelength range. Simultaneous measurements of multiple laser lines are performed allowing measurements of WDM (wavelength division multiplexed) signals and multiple lines of Fabry-Perot lasers. Features: • Multiple and average wavelengths measured • Peak and total powers measured • Automatic signal-to-noise ratios calculated • Power and wavelength of up to 100 channels • Built-in routines for channel spacing and drift • Accurate enough for use in the lab and rugged enough for use in the field

Rack Diagram

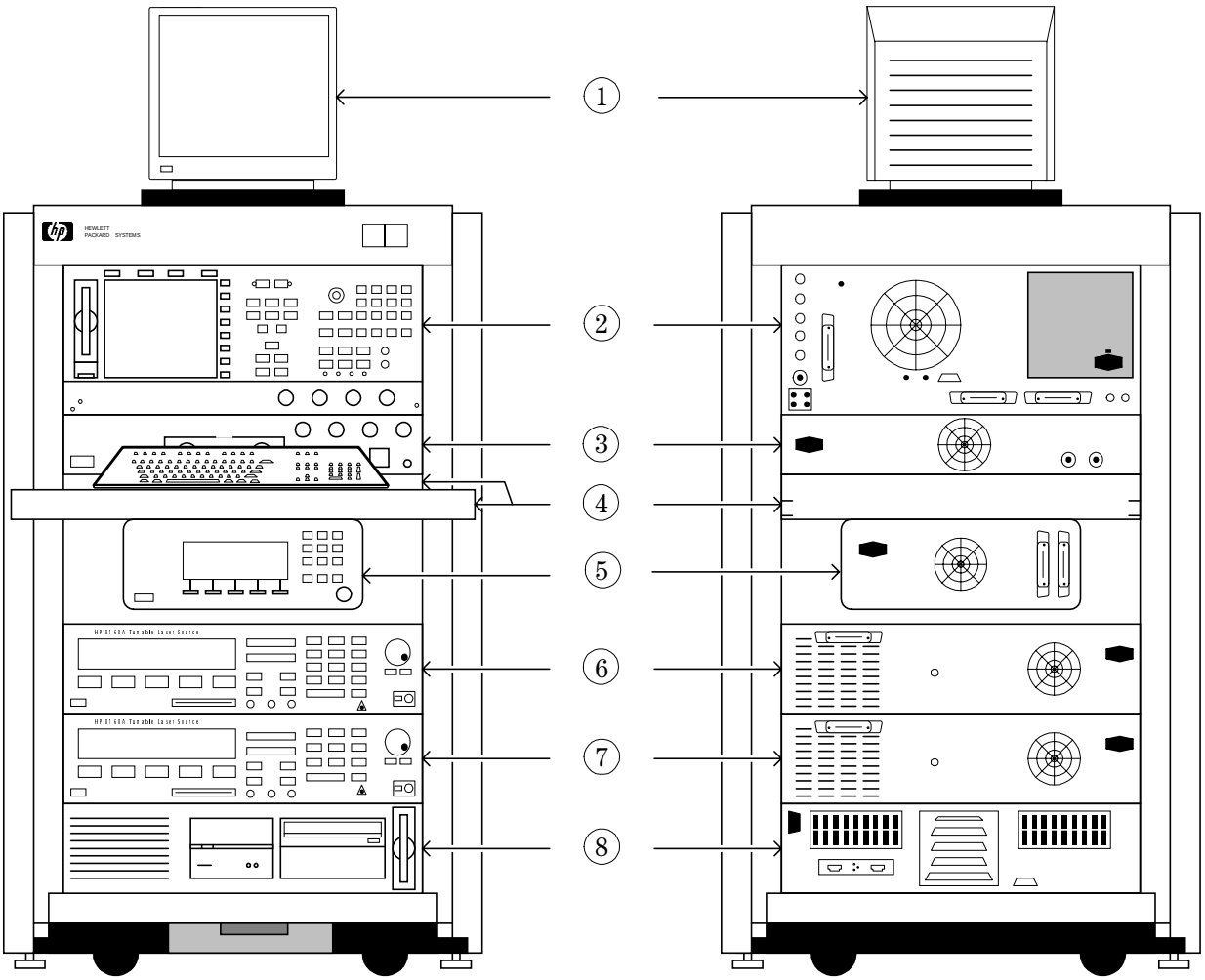
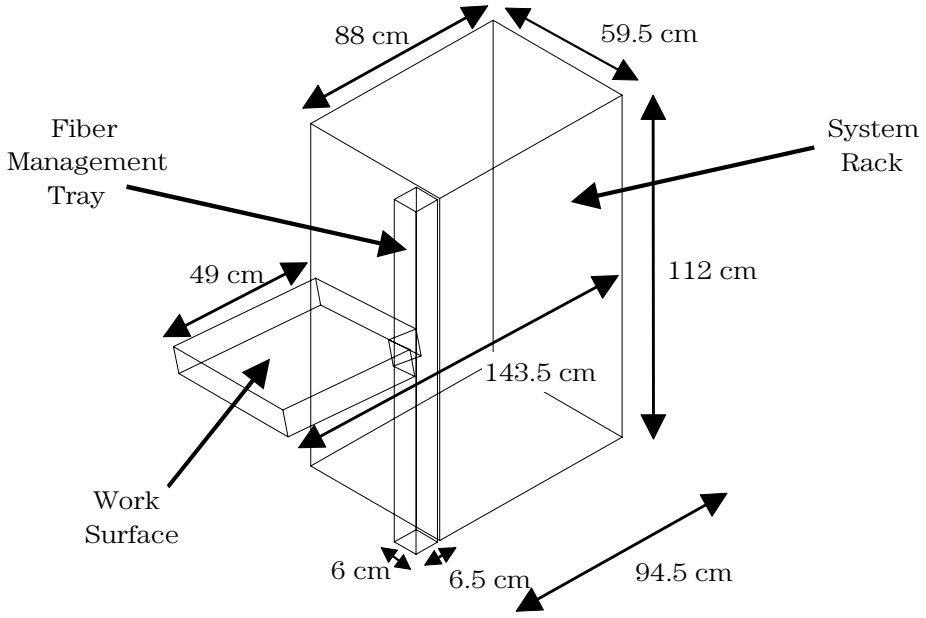


Figure 4-6. Chromatic Dispersion Test System Rack Diagram (Front View)

1. Monitor
2. Network Analyzer
3. Chromatic Dispersion Test Set
4. Work surface / Modified Filler Panel
5. Wavelength meter
6. Tunable Laser Source #1
7. Tunable Laser Source #2
8. HP Personal Computer

Figure 4-6 is a diagram of the dual-band system (option 112). A single band system such as the standard system, option 113, option 114, or option 116, will not contain item #7, the second tunable laser source.

Rack Dimensions



HP86037A System Dimensions

Assembled Dimensions	**Unassembled Dimensions**
H: 112 cm	H: 112 cm
W: 59.5 cm	W: 59.5 cm
D: 143.5 cm	D: 94.5 cm

Power Consumption Figures		**Net Weight**
Single Band System	594 watts	249 kg / 548 lbs.
Dual Band System	726 watts	269 kg / 592 lbs.

Figure 4-7. The HP 86037A Chromatic Dispersion Test System Rack Dimensions

Cabling Diagram

Single Band Cabling Diagram

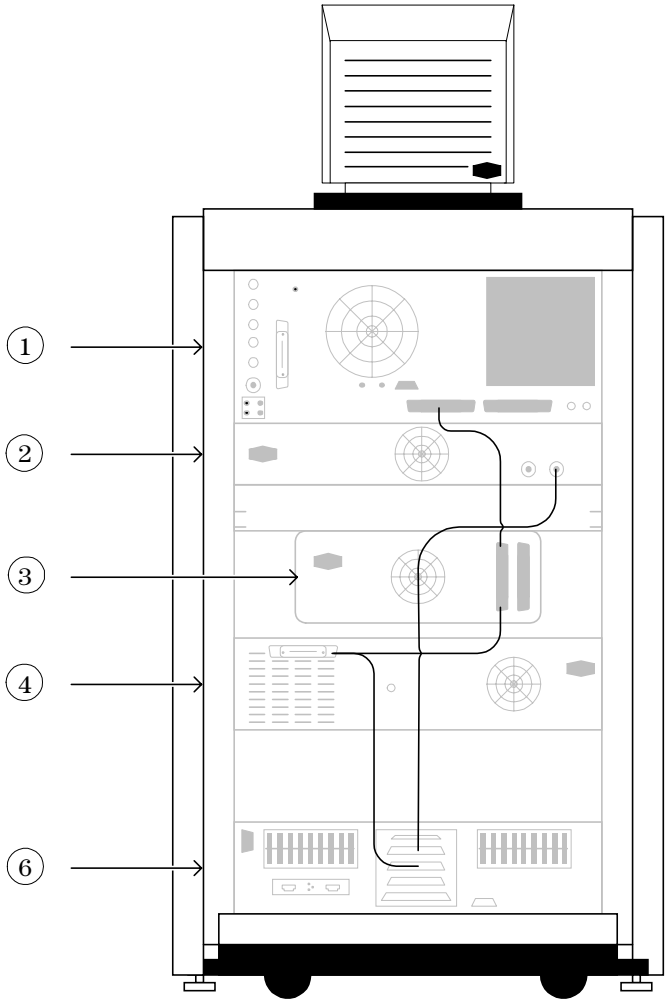


Figure 4-8. Single Band Chromatic Dispersion Test System Cabling Diagram

1. Network Analyzer
2. Chromatic Dispersion Test Set
3. HP 86120B Wavelength meter
4. Tunable Laser Source
5. HP Personal Computer

This diagram is for options 113, and 116. For option 114, the wavemeter is removed.

Dual Band Cabling Diagram

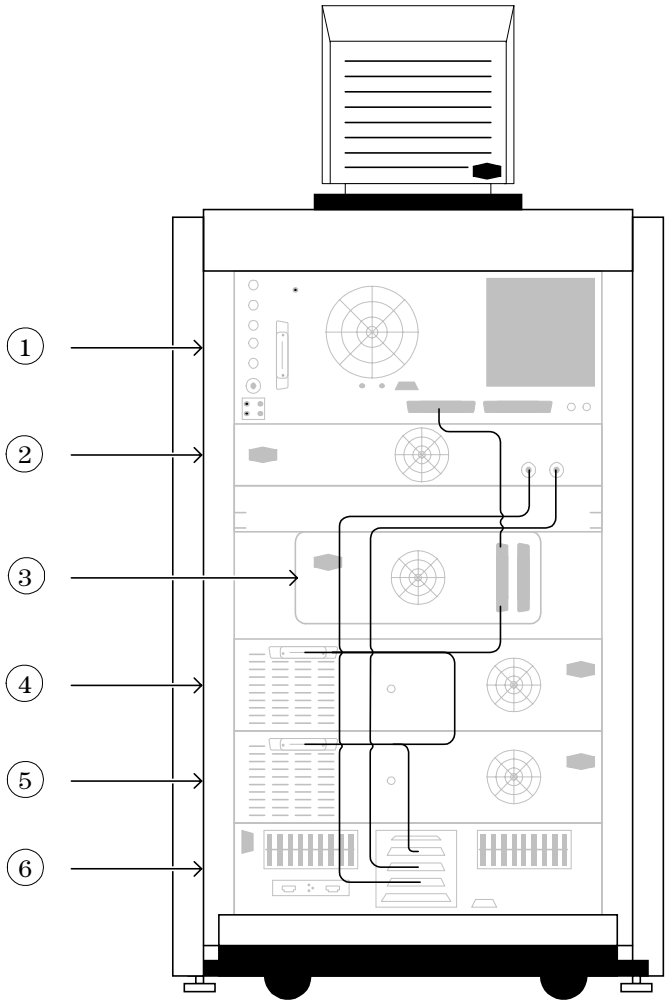


Figure 4-9. Dual Band Chromatic Dispersion Test System Cabling Diagram

1. Network Analyzer
2. Chromatic Dispersion Test Set
3. HP 86120B Wavelength meter
4. Tunable Laser Source #1
5. Tunable Laser Source #2
6. HP Personal Computer

Rack Power Distribution

Single Band Power Distribution Diagram

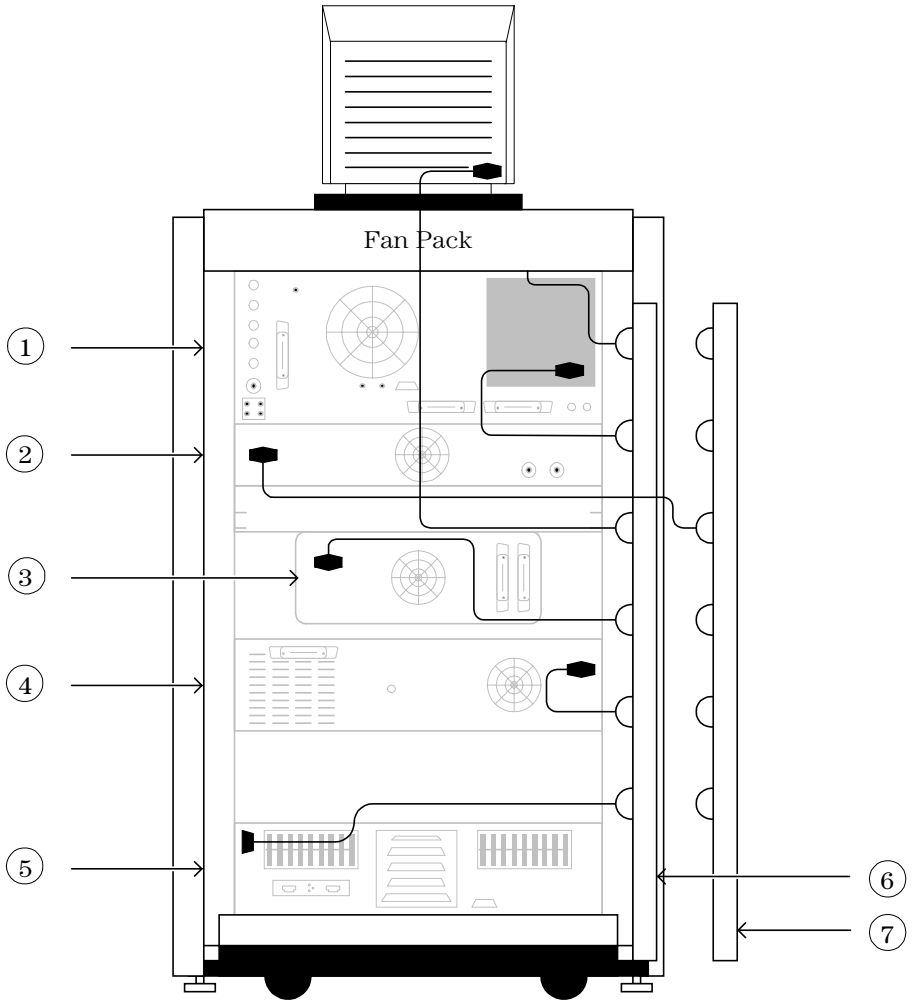


Figure 4-10. Single Band HP 86037A Chromatic Dispersion Test System Power Distribution

1. Network Analyzer
2. Chromatic Dispersion Test Set
3. HP 86120B Wavelength meter
4. Tunable Laser Source
5. HP Personal Computer
6. Power Distribution Assembly #1
7. Power Distribution Assembly #2

This diagram is for options 113, and 116. For option 114, the wavemeter is removed.

Dual Band Power Distribution Diagram

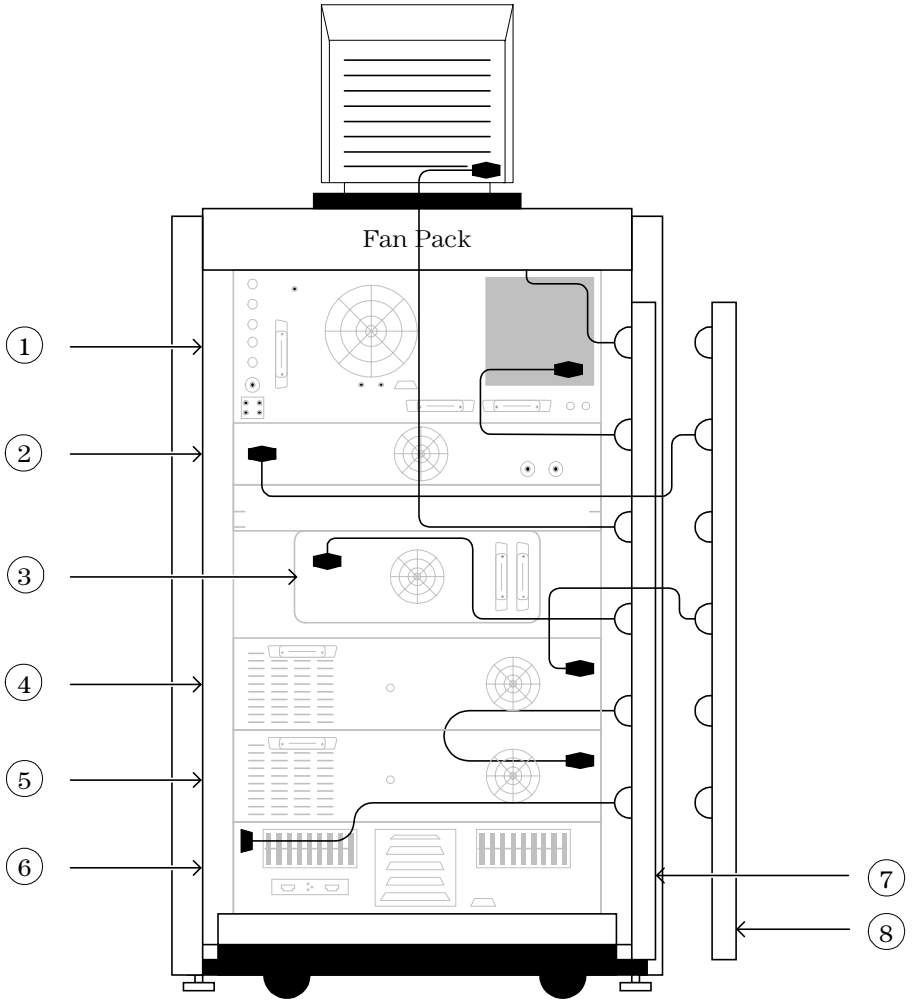


Figure 4-11. Dual Band HP 86037A Chromatic Dispersion Test System Power Distribution

1. Network Analyzer
2. Chromatic Dispersion Test Set
3. HP 86120B Wavelength meter
4. Tunable Laser Source #1
5. Tunable Laser Source #2
6. HP Personal Computer
7. Power Distribution Assembly #1
8. Power Distribution Assembly #2

Instrument Power Requirements

Table 4-3. Instrument Power Requirements

Component	Volts AC Maximum
HP 8753x Network Analyzer	280
HP 83427A CD Test Set	110 VA MAX (115v) 150 VA MAX (220v)
HP 86120x Wavelength meter	110 (115v) 150 (220v)
8168x or 8167x TLS #1	260
8168x or 8167x TLS #1	260
Personal Computer	110 (115v) 150 (220v)
PDU AW3 (110V) or PDU AW5 (220V) #1	110 (115v) 150 (220v)
PDU AW3 (110V) or PDU AW5 (220V) #2	110 (115v) 150 (220v)

HP 83427A Chromatic Dispersion Test Set

The following information is provided for the HP 83427A Chromatic Dispersion Test Set. The HP 83427A has been designed and tested in accordance with IEC Publication 1010, Safety Requirements for Electronic Measuring Apparatus, and has been supplied in a safe condition. The instruction documentation contains information and warnings which must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

Before switching on this instrument, make sure that the line voltage selector switch is set to the voltage of the mains supply. The line voltage selector switch is located next to the rear-panel line cord plug. With the system unplugged from the main power supply, use a flat blade screwdriver to open the voltage selector door and change the voltage selection tumbler. For 115V operation, use type N 1.0A/250V fuse. For 230V operation, use a 0.75A fuse. A special fuse holder is provided for the 0.75A fuse.

Front-Panel Connectors

The SOURCE OUTPUT and RECEIVER INPUT connectors are connected to the device under test for measurements. For information concerning the rating of these connectors, refer to the specifications chapter in this book. The four connectors S, R, A, and B should be connected to the identically labeled connectors on the HP 8753E RF network analyzer. For

information concerning the rating of these connectors, refer to the manual for the network analyzer. The WAVELENGTH METER output is connected to the HP 86120 wavelength meter, and the TUNABLE LASER SOURCE input is connected to the tunable laser.

WARNING **No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock, do not remove covers.**

WARNING **For continued protection against fire hazard, replace line fuse only with same type and ratings. For 115V operation, use type N 1.0A/250V. For 230V operation, use a 0.75A fuse. The use of other fuses or materials is prohibited.**

WARNING **The power cord is the disconnecting device. It disconnects the mains circuits from the mains supply before other parts of the instrument. Alternately, an externally installed switch or circuit breaker (which is readily identifiable and is easily reached by the operator) may be used as a disconnecting device.**

CAUTION The detachable power cord is the instrument disconnecting device. It disconnects the mains circuits from the mains supply before other parts of the instrument. The front panel switch is only a standby switch and is not a LINE switch (disconnecting device).

CAUTION This product is designed for use in INSTALLATION CATEGORY II and POLLUTION DEGREE 2, per IEC 1010 and 664 respectively.

CAUTION Install the instrument according to the enclosure protection provided. This instrument does not protect against the ingress of water. This instrument protects against finger access to hazardous parts within the enclosure.

WARNING **This is a Safety Class I Product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. Any interruption of the protective conductor inside or outside of the product is likely to make the product dangerous. Intentional interruption is prohibited.**

CAUTION Always use the three-prong AC power cord supplied with this product. Failure to ensure adequate earth grounding by not using this cord may cause product damage.

CAUTION Before switching on this instrument, make sure that the line voltage selector switch is set to the voltage of the mains, that the correct fuse is installed, and that the supply voltage is in the specified range.

CAUTION *Ventilation Requirements*. When installing the product in a cabinet, the convection into and out of the product must not be restricted. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the product by 4°C for every 100 watts dissipated in the cabinet. If the total power dissipated in the cabinet is greater than 800 watts, then forced convection must be used.

WARNING **To prevent electric shock, disconnect the instrument from mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.**

WARNING **If this instrument is not used as specified, the protection provided by the equipment could be impaired. This instrument must be used in a normal condition (in which all means for protection are intact) only.**

5

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Measuring Chromatic Dispersion 5-6
Reviewing the Data 5-17
Setup Files 5-26
Export Files 5-28
Setting Parameters 5-31
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The Single Band Interface

At a glance

This chapter includes the procedures to:

- Start the HP 86037A Chromatic Dispersion Test System software
- Examine the HP 86037A Chromatic Dispersion Test System user interface
- Measure chromatic dispersion

You will also learn to use the HP 86037A Chromatic Dispersion Test System program menus to:

- Work with setups
- Set parameters
- Configure the system
- Enter service settings

Adjusting the System

To ensure all system specifications are met, let the system warm up for two hours before making any critical measurements.

An optical power meter is needed for the adjustment procedures described below. The following steps must be performed in the order shown so the system is in the appropriate state for the next adjustment.

Wavelength Meter Selection

1 Start the HP 86037A Chromatic Dispersion Test System software. Refer to the *Getting Started* section at the beginning of this manual for more information. The HP 86037A Chromatic Dispersion Test System main window will be displayed.

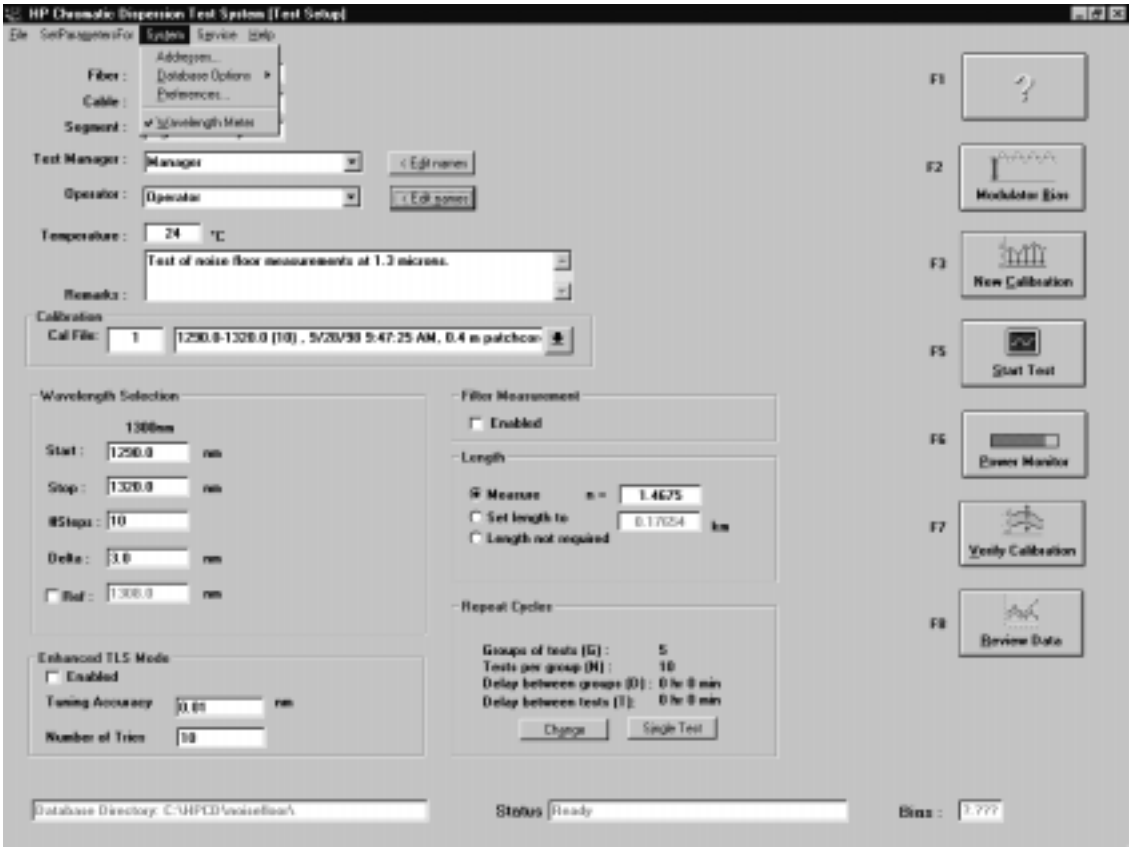

Figure 5-1. HP 86037A Chromatic Dispersion Test System Main Window

2 If the system includes a wavelength meter, a checkmark should appear in front of the wavelength meter item on the drop-down `System` menu as shown in Figure 5-1. The checkmark can be toggled on and off by clicking the `wavelength meter` selection.

Adjust Optical Modulator Bias

3 On the test set, connect the Source Output to the Receiver Input ports using a short fiber cable.

4 Use the mouse to click the `Modulator Bias` button on the main screen of the HP 86037A Chromatic Dispersion Test System application.

> When this modulator bias adjustment is performed, the modulator is automatically biased to the optimum (quadrature) performance condition. Bias adjustment is performed at the beginning of a measurement session. It does not need to be performed before each individual measurement. Bias adjustment can be set to occur automatically when a calibration is performed. Refer to "Calibration/Verification" chapter 9.

Power Calibration Constants

In the HP 86037A Chromatic Dispersion Test System main window:

1 Click `Power Monitor Settings` from the `Service` menu.

Figure 5-2. Service menu

The window shown in Figure 5-3 will be displayed.

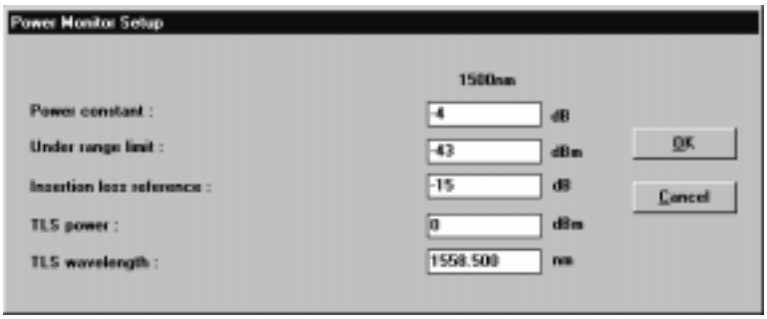

Figure 5-3. Power Monitor Setup Window

2 Enter **0.0** in the `Power constant` field. Click `OK`.

3 Press the Local key on the TLS to put it in local operation mode.

4 Set the TLS to:

—wavelength 1558.5 nm

—TLS power 0 dBm

5 Connect a short fiber cable from the SOURCE OUTPUT port of the HP 83427A Chromatic Dispersion Test Set to an optical power meter. Press the Active key on the TLS.

6 Measure the optical power at 1558.5 nm on the power meter and note the reading P1, in dBm. For example:

P1 = –12 dBm

7 Disconnect the fiber cable from the power meter and connect it to the RECEIVER INPUT port on the HP 83427A Chromatic Dispersion Test Set.

8 Click the `Power Monitor` button on the HP 83427A Chromatic Dispersion Test System main window. Note the power reading P2, in dBm. For example:

$$P2 = -8 \text{ dBm}$$

9 Calculate the difference using the following equation:

$$\Delta P = P1 - P2$$

Using the earlier example:

$$\Delta P = (-12 \text{ dBm}) - (-8 \text{ dBm})$$
$$\Delta P = -4 \text{ dBm}$$

10 Close the `Power Monitor` window by clicking the `Close` button.

11 Choose `Power Monitor Settings` from the Service menu to open the `Power Monitor Setup` dialog box.

12 In the `Power Monitor Setup` dialog box shown in Figure 5-3, enter the following values:

Power constant	ΔP, as calculated above. In that example, ΔP equals **–4** dBm
Under range limit	**–43** dBm
Insertion loss reference	**–15** dBm
TLS power	**0** dBm
TLS wavelength	**1558.5** nm

13 Click `OK`.

14 Click the `Power Monitor` button on the CD main window shown in Figure 5-1. Verify that the displayed power is within ±0.5 dB of value P1.

15 Click the `Set zero` button from within the `Power Monitor` Window. Please see Figure 5-7.

16 Close the `Power Monitor` window by clicking the `Close` button.

The TLS will automatically revert to system control.

Measuring Chromatic Dispersion

Before making a measurement with the HP 86037A Chromatic Dispersion Test System, ensure that:

- The HP 86037A Chromatic Dispersion Test System software has been started. Refer to "System Setup" on page 1-3 for information on starting the HP 86037A Chromatic Dispersion Test System software.
- The HP 86037A Chromatic Dispersion Test System is calibrated. Refer to "Performing a Periodic Calibration" on page 9-3 for information on performing a calibration.
- All the measurement parameters have been set to the appropriate values. If in doubt, click `SetParametersFor` from the menu bar, and set all the parameters to HP defaults using the `Set HP Defaults` button.

Verify the Calibration

Before a measurement session, it is a good idea to verify the current calibration. To select a different calibration file, refer to "Select a Calibration File" on page 5-7. Verification does not need to be performed before each measurement.

1 Connect the appropriate calibration device, such as a short cable, between the source output and receiver input ports of the HP 83427A Chromatic Dispersion Test System test set.

> Patch cords should be used to connect the test set Source Output and Receiver Input to either a DUT or a short test cable to protect the test set fiber connectors from undue and unnecessary wear.

2 Click the `Verify Calibration` button on the right side of the HP 86037A Chromatic Dispersion Test System.

The system will first perform a modulator bias adjustment. Then it will measure ten group delay points in the measurement span and check the maximum group delay against the limit set in the `Calibration Settings` window of the `SetParametersFor` menu.

On completing the measurement, the system will display a message to tell the operator if the calibration verification has passed or failed. It also shows the maximum group delay value obtained during the calibration verification. The system group delay noise floor can vary between 0.05 ps and 2 ps. The test engineer can set the limits by selecting `Calibration` in the `SetParametersFor` menu.

Enter the Test Labels

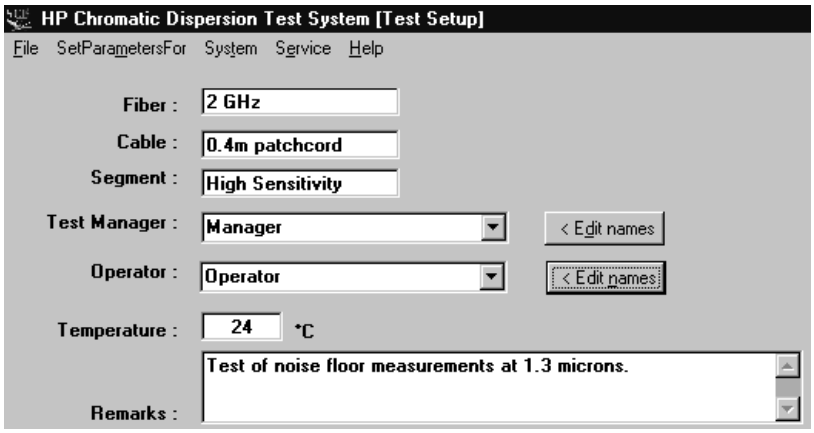

Figure 5-4. Test Label Section of the Main Window

The field headings shown in Figure 5-4 are the default headings. To change any of the field headings, please refer to "Selecting Preferences" on page 5-47.

1 Enter the name of the `Fiber`, `Cable`, and `Segment` into their corresponding fields as shown in Figure 5-4.

2 Enter the name of the `Test Manager` and `Operator`, or select the names from the drop-down list.

To edit a name in the drop-down list, click on the name so that it is displayed in the field, then click `Edit names`.

Select a Calibration File

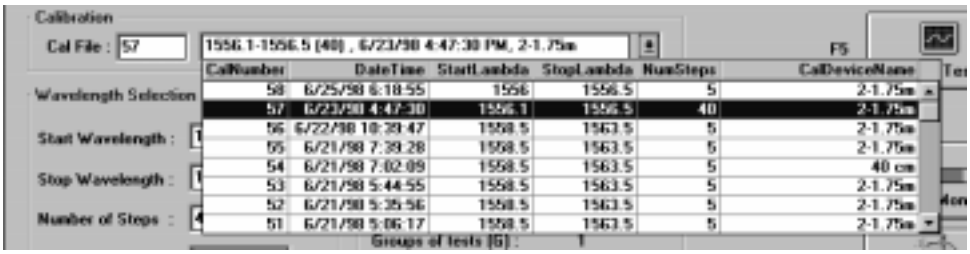

Figure 5-5. Calibration File Section of the Main Window

1 Select the desired calibration file in the calibration section of the HP 86037A Chromatic Dispersion Test System program shown in Figure 5-5 by entering its number in the `Cal File:` box and typing the Enter key, or by selecting it from the drop-down list.

Enhanced TLS Mode

> This feature is only available in systems containing a HP 86120x Wavelength Meter.

`Enhanced TLS Mode` allows the operator to adjust the accuracy of the wavelength used. To enable this feature:

2. Click the `Enabled` checkbox
3. Enter a value in the `Tuning Accuracy` field
4. Enter a value in the `Number of Tries` field

The system will attempt to get a measurement at a wavelength that is within a span of approximately the value that was entered in the `Tuning Accuracy` field. This is achieved by comparing the actual wavelength value as given by the HP 86120x wavelength meter against the desired wavelength, and correcting if the value is outside the bounds indicated by the `Tuning Accuracy` field.

Filter Measurement

The Filter Measurement section of the HP 86037A Chromatic Dispersion Test System main window is used to indicate how to normalize the group delay data that has been collected during the test. The Filter Measurement section of the test system main window is shown in Figure 5-6.

Figure 5-6. Filter Measurement Section of the Main Window

If the check box is not checked, then the smallest value of group delay is set to zero and that value is subtracted from the rest of the data. If the check box is checked, then the group delay data is returned normalized to the actual absolute group delay measured by the system.

To obtain this absolute group delay, the system performs a length measurement after all group delay measurements are complete. The wavelength at which this length measurement is performed is determined by finding the point within the measured wavelength range where the received signal was at a maximum (i.e. the wavelength at which there is a minimum in the loss of the DUT), if gain was measured. If gain was not measured, then the start wavelength is used.

Power Monitor

The `Power Monitor` function in the HP 86037A Chromatic Dispersion Test System is useful for testing the loss of a DUT before measuring, and to ensure that all connections are of good quality.

Click the `Power Monitor` button on the CD main window shown in Figure 5-1.

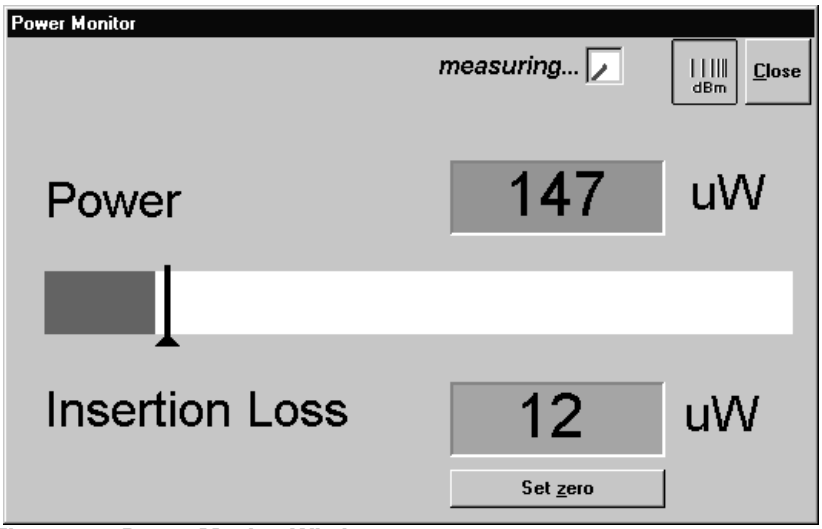

Figure 5-7. Power Monitor Window

Click on the measurement button to the left of the close button to switch between μW and dB.

Enter the Wavelength Information

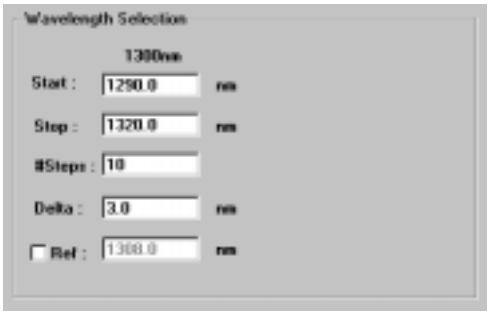

Figure 5-8. Wavelength Selection Section of the Main Window

1 Enter a value in the `Start Wavelength` and `Stop Wavelength` fields.

> An error message will display on the TLS if the values in the `Start Wavelength` and `Stop Wavelength` fields are greater than the tunable laser source can accommodate. There will be no indication of this error in the HP 86037A Chromatic Dispersion Test System software.

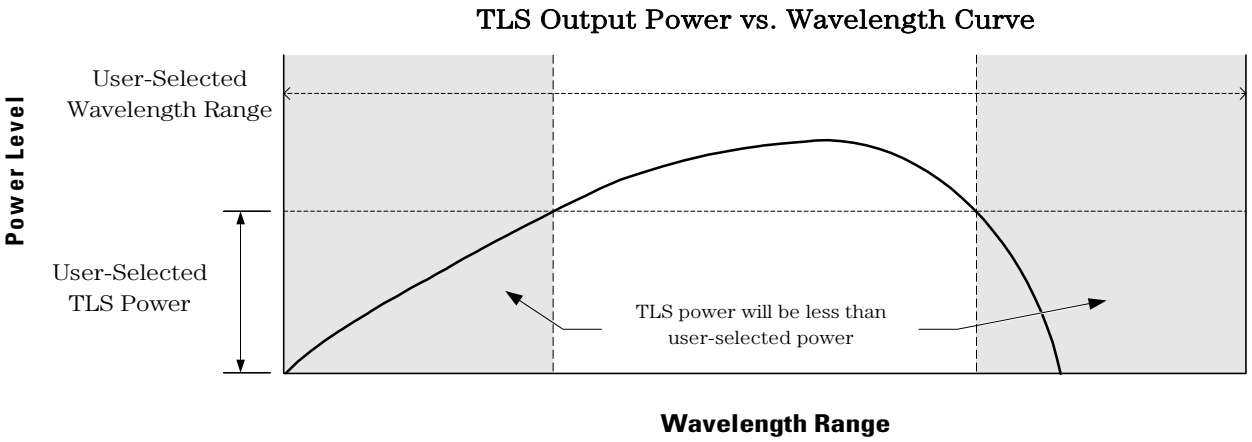

Figure 5-9. TLS Power Roll-off in Relation to Wavelength Range

The shaded area in Figure 5-9 shows the wavelength range where the user-selected TLS power will be more than the TLS can deliver.

If the user selects a wavelength range within the shaded area in Figure 5-9, the TLS will display an error on its display, but will continue to put out as much power as it can.

There will be no indication of this error on the HP 86037A Chromatic Dispersion Test System GUI.

2 Enter the number of steps in the `Step Wavelength` field. The system calculates the step wavelength automatically if the number of steps is entered, or calculates the number of steps if the step wavelength is entered.

The greater the number of data points, or steps, the greater the accuracy of the measurement. However, as the number of steps increases, so does the measurement time. It is important to select enough steps to provide the required accuracy, but still allow for a timely measurement. Typically, using 20 steps will yield good results.

3 If you want to establish a reference wavelength, click the `Ref Wavelength` check box, then enter the wavelength in the field. The reference wavelength is used to correct length drifts of the device under test during the measurement and should be set when measuring fibers. It improves the accuracy of the measurement, but increases measurement time.

Select the Length Information

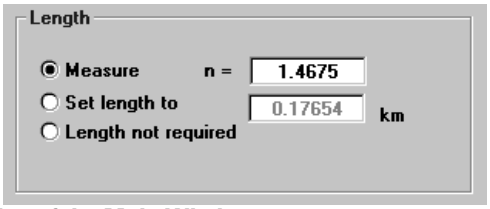

Figure 5-10. Length Section of the Main Window

1 Use one of the following methods to measure the length of the cable:

- Enable the `Measure` function by selecting the option button, and in the field, enter the value of the refractive index.
- To set a specific length, enable the `Set length to` function by selecting the option button, and in the field, enter the length in kilometers.
- Select the `Length not required` option button to remove the length requirement from the measurement.

Examine the Repeat Cycles Information

Change the Repeat Cycles Information

If you are satisfied with the values shown in the `Repeat Cycles` section of the window, there is no action required.

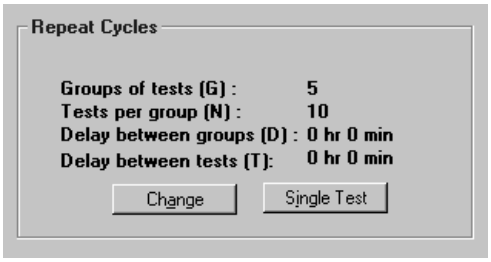

Figure 5-11. Repeat Cycles Section of the Main Window

1 To change the values, click on the `Change` button in the `Repeat Cycles` section of the HP 86037A Chromatic Dispersion Test System setup window shown in Figure 5-11. the `Repeat Measurement Selector` window in Figure 5-12 will be displayed.

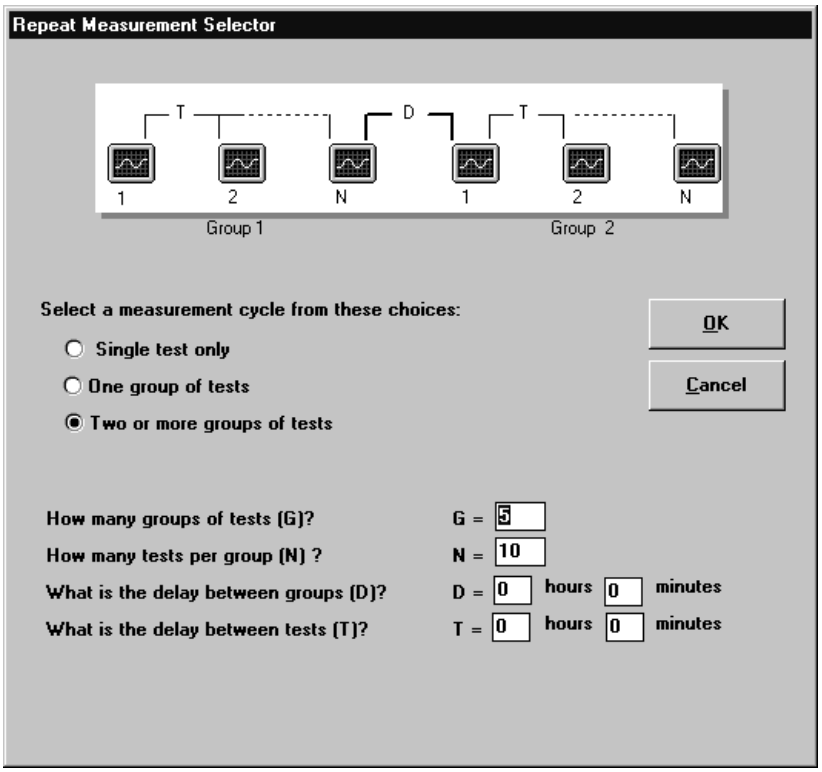

Figure 5-12. Repeat Measurement Selector Window

2 You can select a single test, or several groups of tests. Click on the option button pertaining to `Single test only`, `One group of tests`, or `Two or more groups of tests`. As you move the cursor over the possible choices, they are highlighted on the diagram at the top of the window.

3 Enter the values for the number of tests, the tests per group, the delay between groups, and the delay between tests. Delays specify the time between the end of one test or group and the beginning of the next test or group. Only the boxes applicable to the chosen test selection will be enabled.

4 Click `OK` to accept the new values, or click `Cancel` to return to the HP 86037A Chromatic Dispersion Test System main screen without changing any values.

Make a Single Test

If more than one group of tests has been set up, the operator can elect to run a single test.

5 From the HP 86037A Chromatic Dispersion Test System main window, click the `Single Test` button in the `Repeat Cycles` section shown in Figure 5-13.

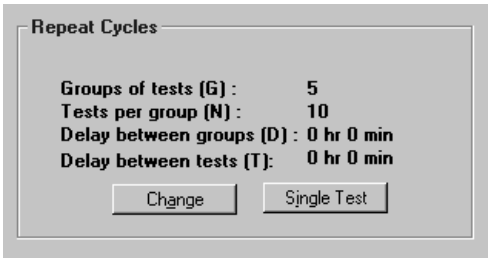

Figure 5-13. Repeat Cycles Section of the Main Window

6 The system will ask you to confirm your selection as shown in Figure 5-14. Click `OK`.

Notice the values for `Groups of tests (G)` and `Test per group (N)` are set to `1` in the `Repeat Measurement Selector` window shown in Figure 5-12. After the test is performed, the values will remain at 1, until they are changed by the user.

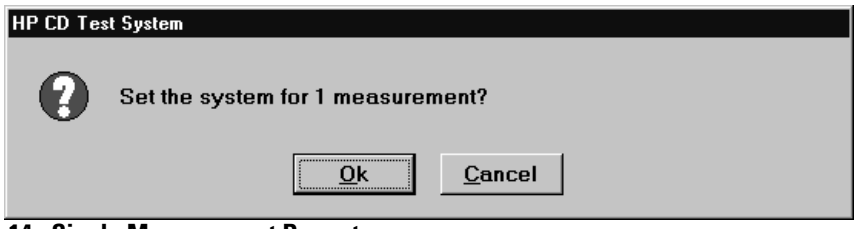

Figure 5-14. Single Measurement Prompt

Start the Test

1 Connect the DUT to the HP 83427A Chromatic Dispersion Test System test set.

> Patch cords should be used to connect the test set Source Output and Receiver Input to either a DUT or a short test cable to protect the test set fiber connectors from undue and unnecessary wear.

2 To begin testing, click the `Start Test` button on the right side of the HP 86037A Chromatic Dispersion Test System software setup window.

The red text in the status line at the bottom of the HP 86037A Chromatic Dispersion Test System software setup window indicates the system's progression. After a few seconds, the `Data Monitor` window will appear as shown in Figure 5-15.

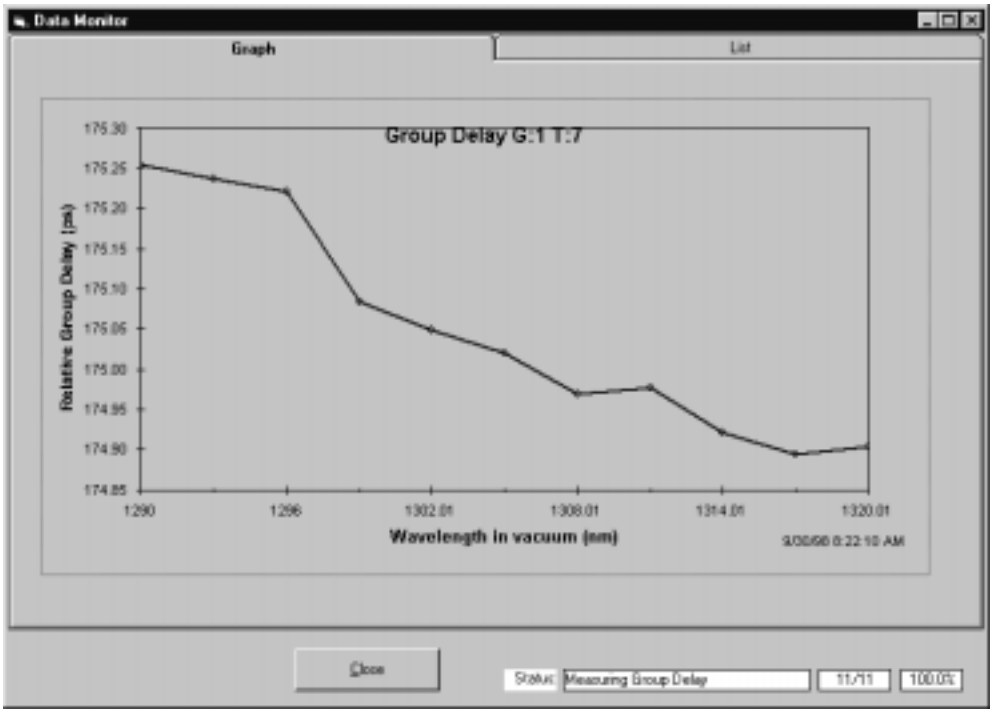

Figure 5-15. Data Monitor Window

The `Data Monitor` graphically displays a diagram of the group delay for the current test. Click on the `Test` tab to view a table of the group delay data as shown in Figure 5-16.

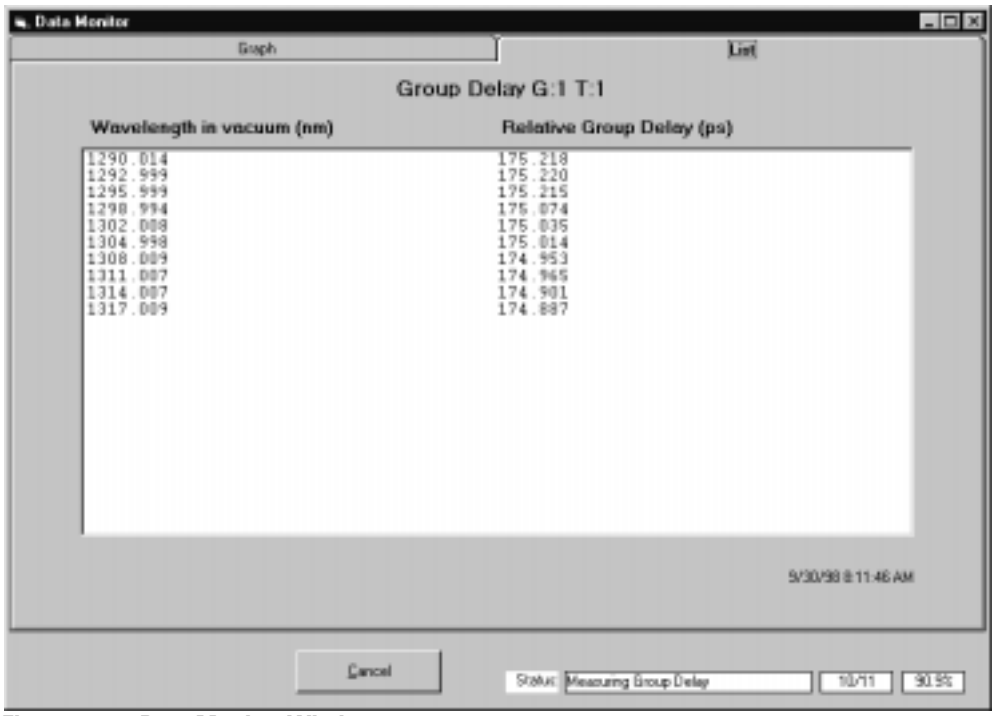

Figure 5-16. Data Monitor Window

Reviewing the Data

1 Click the `Review Data`(`F8`) button from the HP 86037A Chromatic Dispersion Test System software setup window to access the `Data Review` window.

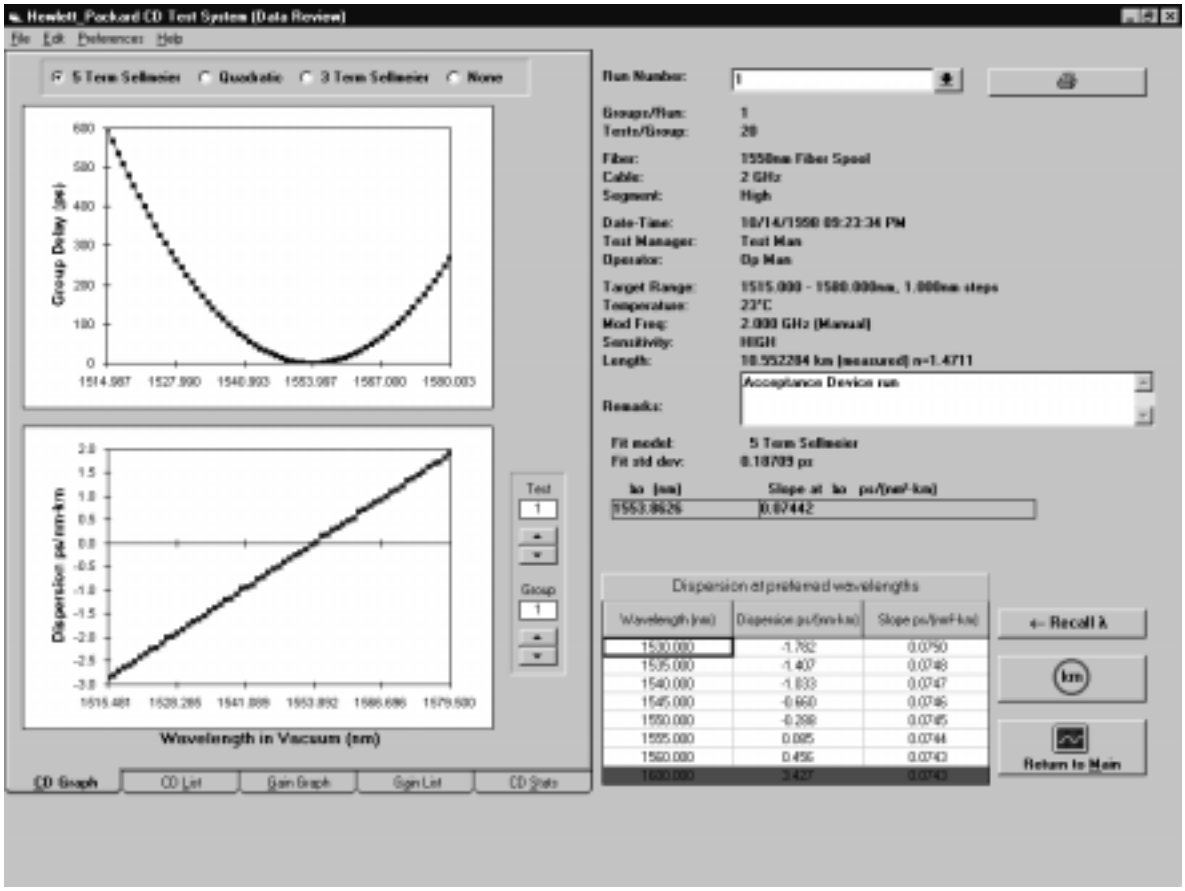

Figure 5-17. Data Review Window

Selecting the Run

1 Select the run number from the `Run Number` list box shown in Figure 5-18.

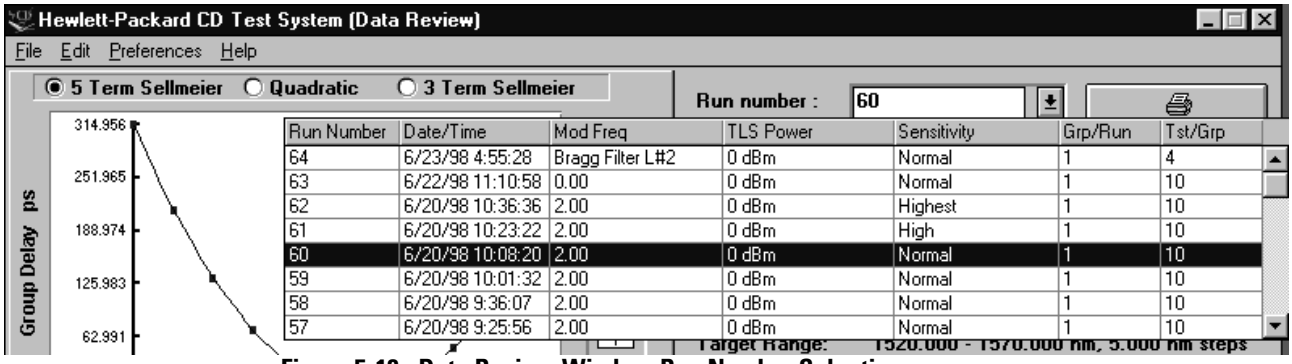

Figure 5-18. Data Review Window Run Number Selection

The software will display all the information about that run.

Graphs and tables of the data can be accessed by clicking the tabs labeled `CD Graph`, `CD List`, `Gain Graph`, `Gain List`, and `CD Stats`.

The user can tailor some of the features in the `Data Review` window by clicking on `Preferences` from the menu bar, then `Data Presentations` in the drop-down menu. The following `Data Presentation Preferences` window will be displayed:

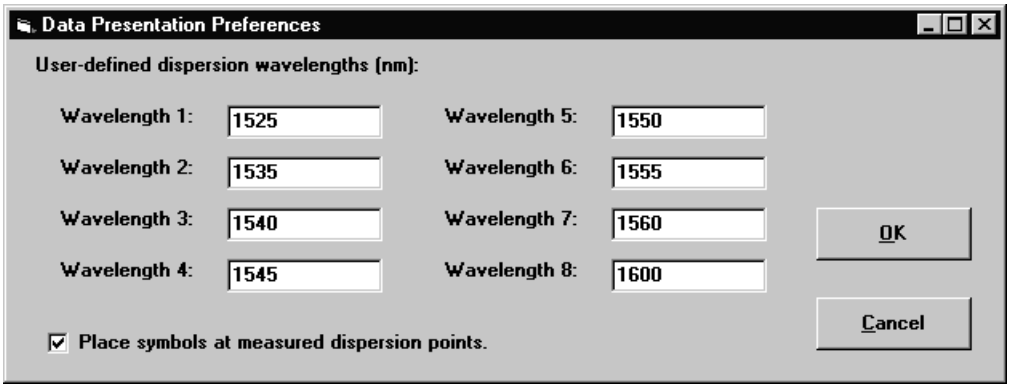

Figure 5-19. Data Presentation Window

The wavelengths to display the dispersion results are entered in this window. The user can also choose to not display the directly calculated dispersion data points. Experiment with these choices to suit your needs.

The five-term Sellmeier fit can yield multiple zero-dispersion wavelengths. All the values and their associated slopes are shown in the `Data Review` window shown in Figure 5-17. The software searches for dispersion zeros in a wavelength range equaling about five times the measurement span—2.5 times each side of the center wavelength. This allows identification of zero-dispersion wavelengths which fall outside of the measurement range. In some cases, due to the peculiarity of the five-term Sellmeier fit, zero-dispersion wavelengths found outside of the measurement range may not correspond to actual zero-dispersion wavelengths of the device under test.

Examine the Dispersion at Selected Wavelengths

1 The dispersion and the dispersion slope at any wavelength can be examined by typing the wavelength directly into the table in the `Data Review` window. These values are calculated using the selected curve fit.

> If the wavelength entered is outside of the measurement range, the results are indicated in red (dark grey in this manual).

2 To return the wavelengths to a set of values previously set up under the `Preferences` menu, click the `Recall λ` button from the lower right of the `Data Review` screen.

3 The user can choose whether or not to have the dispersions and slopes normalized by the length, in km. To do this, click the `km` button to the right of the list box in the `Data Review` window.

Viewing CD Graphs

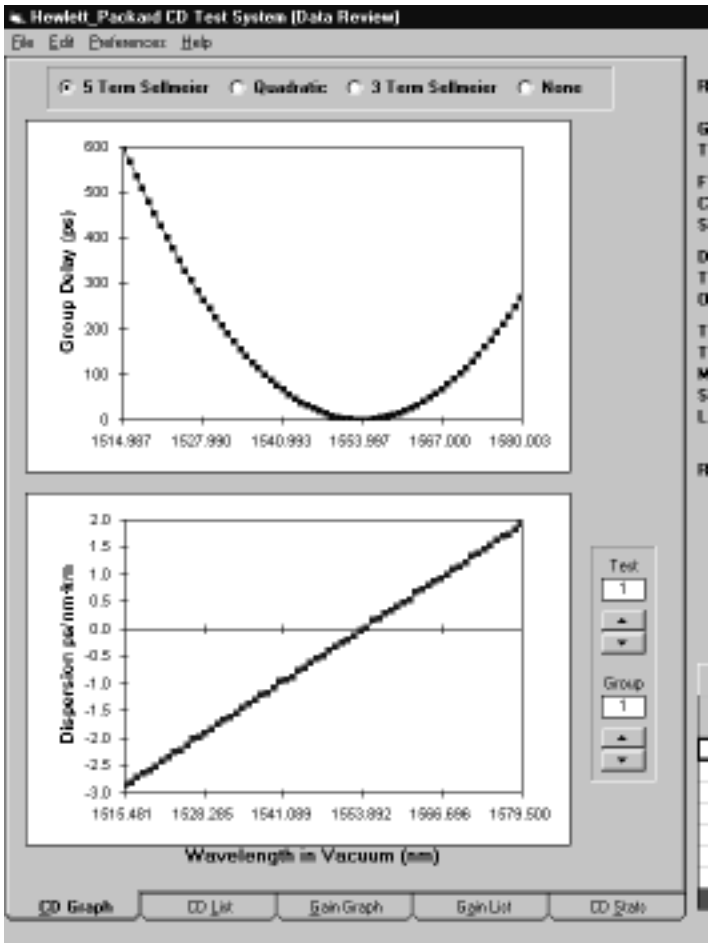

Figure 5-20. Graph Section of the Data Review Window

The results of a chromatic dispersion measurement are shown graphically in the `CD Graphs` display. Use the buttons to the right of the graph to choose the group and test of interest. Click either the `5 Term Sellmeier, Quadratic`, `3 Term Sellmeier`, or `None` option buttons above the graphs to select the type of curve fit.

The top graph shows the relative group delay points and fitted curve. The bottom graph shows the computed dispersion. Dispersion points are computed from pairs of group delay points and are displayed midway between the corresponding wavelengths. The smooth dispersion curve is derived from the fitted group delay curve.

Viewing the CD Data List

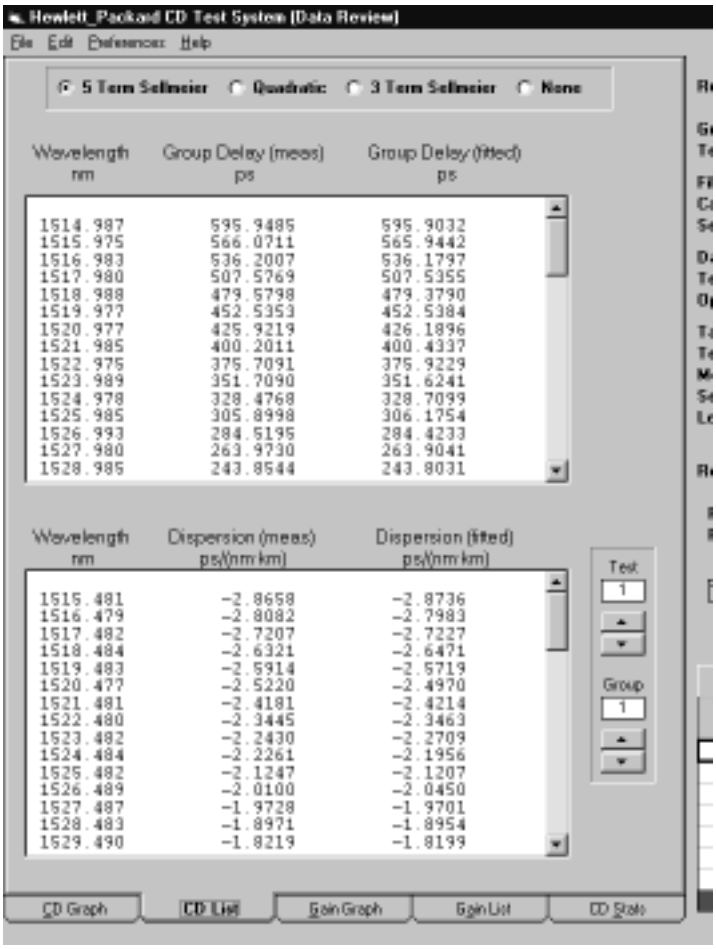

Figure 5-21. CD List Tab of the Data Window

The information under the `CD List` tab is a table display of the information contained in the corresponding graphs. If a wavelength meter was used in the measurement setup, the actual measured wavelengths will be displayed.

The column of data titled `Dispersion (meas.)` is the directly calculated dispersion obtained by calculating the slope of the group delay with respect to wavelength, as follows:

Dispersion (meas.)= $\Delta\tau$ / $\Delta\lambda$

$\Delta\tau$ is the measured difference in group delay and $\Delta\lambda$ is the difference in wavelength between adjacent points. These data points will appear to be noisy when the wavelength step size is less than about 1 nm because the wavelength step is in the denominator of the calculation. Therefore a small wavelength step will tend to amplify any noise in the group delay data. The amount of scatter of the directly calculated dispersion has minimal impact on the accuracy of the zero-dispersion wavelength because the zero-dispersion wavelength is obtained from the fitted curve. When the wavelength step is very small, less than about 0.01 nm, and a wavelength meter is used with the system, it is possible for two or more data points to have the same wavelength due to imperfect tuning of the tunable laser source. When this happens, it is no longer possible to directly calculate the dispersion from adjacent group delays because the denominator in the above equation is zero. In

such cases, the software will take the last data point of the group of data with the same wavelength and use it for the direct calculation of dispersion. However, when the group delay data is automatically stored in the database, all points are saved.

To copy columns of data in the above window to the clipboard:

1. Highlight the section of data to be copied.
2. Press **Ctrl-C**. This copies the highlighted content into the clipboard.

To copy the data to a text editor:

1. Start the text editor of your choice.
2. Position the cursor at the appropriate point in the text editor and press **Ctrl-V** to paste directly into the text editor. The data in the clipboard is inserted into the text editor.

For more detailed information on cutting and pasting in the Windows NT Operating System, please see the Windows NT user's guide.

Viewing Gain Graphs

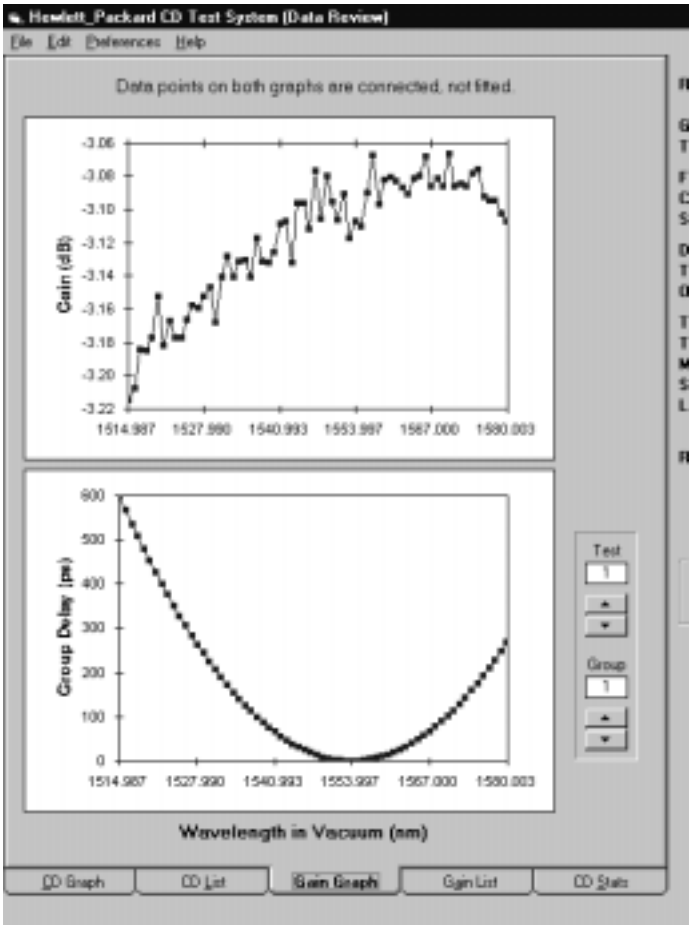

Figure 5-22. CD Graph Tab of the Data Review Window

The information under the `Gain Graph` tab provides a graph of the measured gain and for reference, a graph of the measured relative group delay. In both of these graphs, the displayed points are connected by straight line segments, with no curve fitting.

Viewing the Gain List

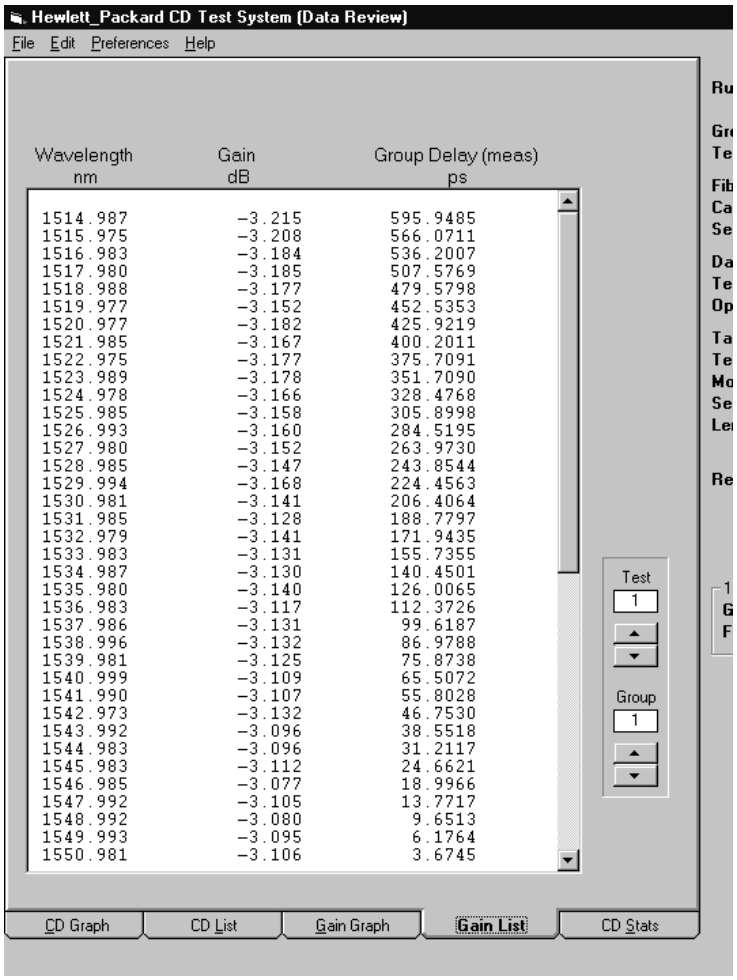

Figure 5-23. Gain List Tab of the Data Review Window

The information under the `Gain List` tab provides a table display of measured gain and measured relative group delay. If a wavelength meter was used in the measurement setup, the actual measured wavelengths will be displayed.

The information from the `Gain Graphs` and the `Gain List` tabs can be viewed only if both the CD and gain measurements have been performed. To select both measurements, select `CD/Gain Meas` on the `SetParametersFor` menu in the HP 86037A Chromatic Dispersion Test System software setup window.

Viewing the CD Statistics

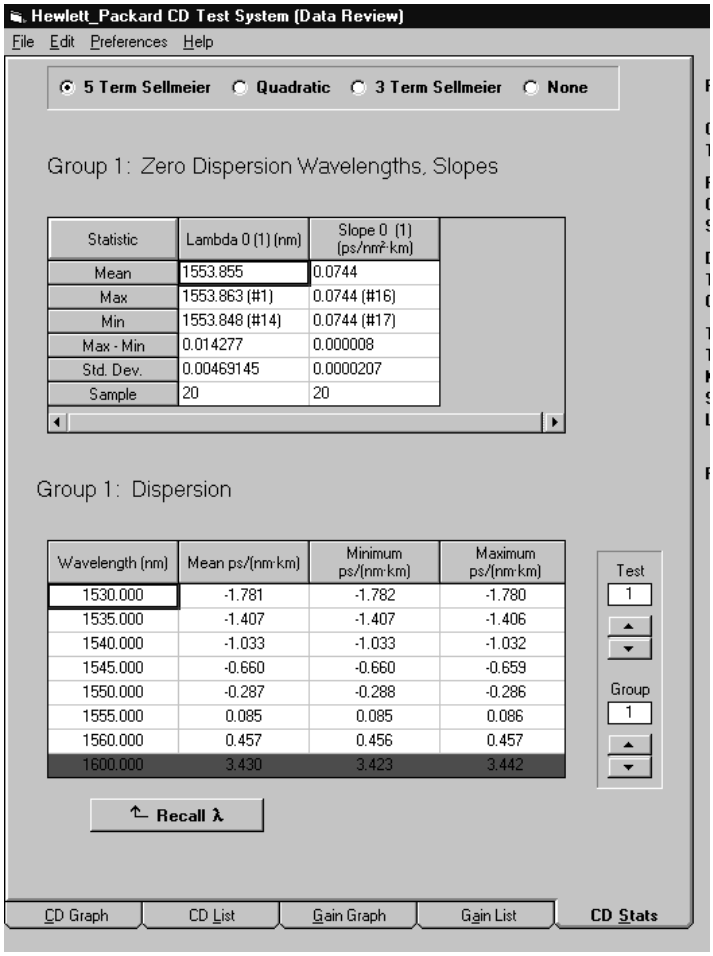

Figure 5-24. CD Stats Tab of the Data Review Window

The information under the `CD Stats` tab shown in Figure 5-24 provides a statistical analysis of a single group of two or more tests. The top table lists the statistics for λ_0 (lambda zero) and the dispersion slope at λ_0. The numbers of the tests from which maximum and minimum values are taken are shown in parentheses beside the listed values. The cell labeled `Sample` indicates the number of tests which exhibited a value of λ_0 equal to or near the displayed value. If the measurements produced multiple values of λ_0 that differ substantially, these values and the corresponding dispersion slopes, can be viewed by adjusting the scroll bar below the display.

The lower table shows the dispersion statistics at a series of user-selectable wavelengths. Wavelengths falling outside of the measurement range are shown in red (dark gray in this manual). The dispersion values listed are computed from the curve fitted to the relative group delay measurements. Use the option buttons above the tables to change the type of curve fit. The statistics for the five-term Sellmeier fit can contain multiple zero-dispersion wavelengths. To view them, scroll horizontally across the `Statistics` list box.

Setup Files

Setup files allow the test parameters to be set up in a predefined manner. The user can recall the setup file prior to performing the test. This makes it possible for measurements to be made without the user having detailed knowledge about the measurement parameters, and saves time because parameters do not have to be reentered.

Under the `System` Menu, there are two functions: `Save Setup` and `Open Setup`. These two functions do not control the selection of the wavelength meter.

Opening a Setup

1 Choose `Open Setup` from the `File` menu as shown in Figure 5-25.

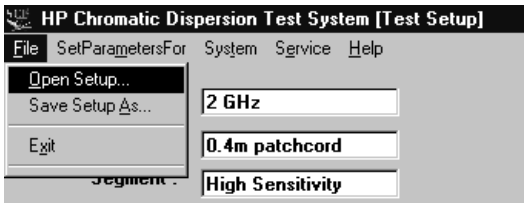

Figure 5-25. Open Setup... Menu

The `Open Setup` dialog box shown in Figure 5-26 will be displayed.

Figure 5-26. Open A Setup Dialog Box

2 In the `File Name` list box, click once on the file you want to open, or type its name in the `File Name` field.

3 Click the filename once and click `Open` to open the setup file.

Saving a Setup

The `Save Setup As...` command in the `File` drop-down menu displays a dialog box that allows you to save a setup in a file and to specify the location in which it is to be stored.

After all test parameters have been set, save them as follows:

1 Choose `Save Setup As...` from the `File` menu as shown in Figure 5-27.

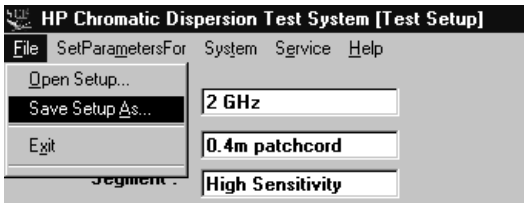

Figure 5-27. Save Setup As... Menu

The `Save Setup As...` dialog box shown in Figure 5-28 will be displayed.

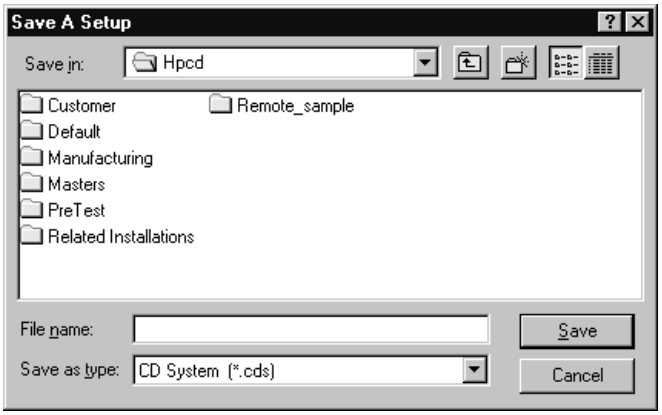

Figure 5-28. Save A Setup Dialog Box

2 To save the setup, ensure that the correct directory is selected in the `Save In:` field and type a name in the `File Name` field. The HP 86037A Chromatic Dispersion Test System application automatically adds the `.cds` extension.

3 Click `Save`. The parameters are saved in the specified file and location. This operation also adds the setup to the file list at the bottom of the `File` menu. This list can be used to quickly access the most recently used files.

Export Files

Export files are ASCII files that contain all the data and results of a test. They allow the user to perform further analysis of the data using other software, such as a spreadsheet.

Exporting the Data

1. Click on the `Review Data` button.
2. Select `Export Data` from the `File` menu as shown in Figure 5-25.

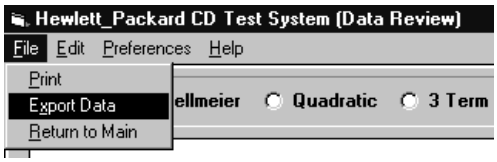

Figure 5-29. Export Data Menu

The `Export Data` dialog box shown in Figure 5-30 will be displayed.

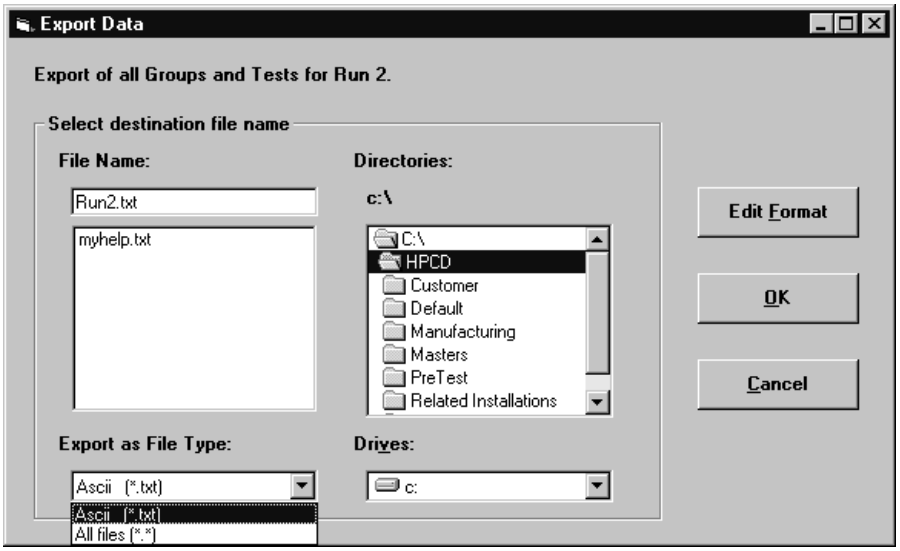

Figure 5-30. Export Data Dialog Box

3. Select a file format in the `Export as File Type` list box. The HP 86037A Chromatic Dispersion Test System software can convert files to ASCII (*.txt) format.
4. Select the location to save the export file by using the `Drives` drop-down menu and `Directories` list box.
5. Enter a name for the exported file in the `File Name` field or highlight a name in the list box.
6. Click `OK`.

Selecting the Export File Format

To customize the file being exported, select the `Edit Format` button in the `Export Data` window.

The `Export File Format` window shown in Figure 5-31 will be displayed.

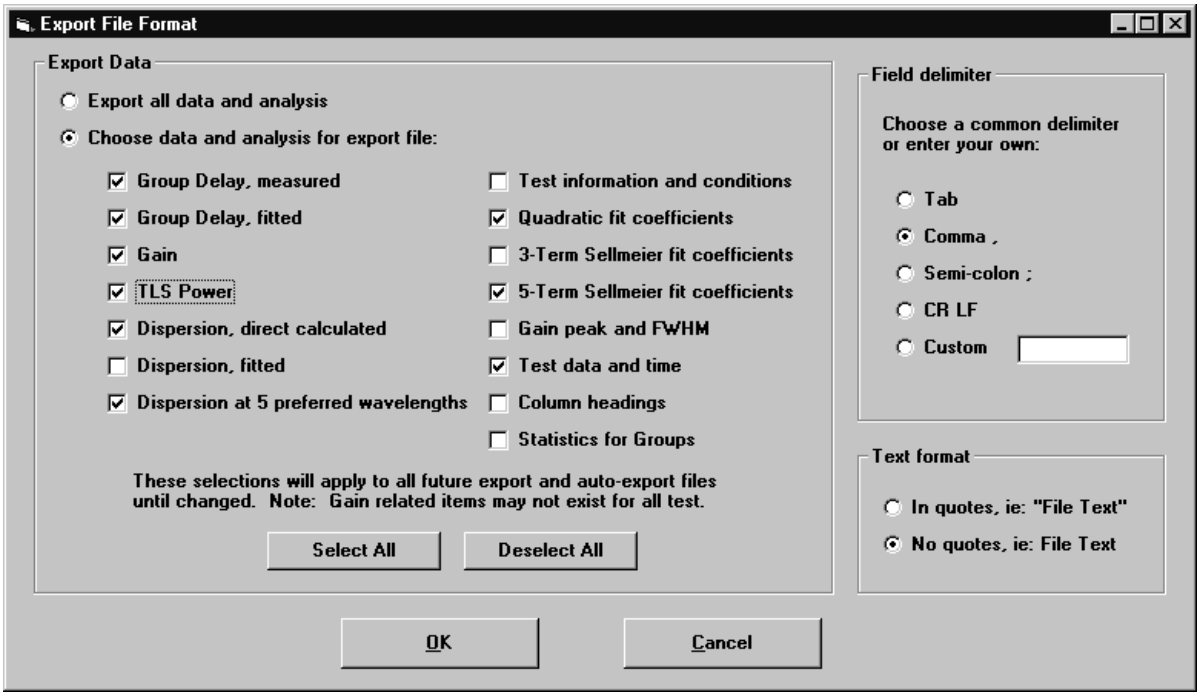

Figure 5-31. Export File Format Window

Table 5-1. Export File Formats

Format	Description
Group Delay, measured	Selecting this option will output a list of measured group delay in raw data format.
Group Delay, fitted	This selection will output a list of measured group delay using the curve fit selected in the `Data Review` window.
Gain	This selection will output a list of gain measured at each wavelength. This option is only available if a gain measurement was performed as part of the test run.
TLS Power	This selection will output the TLS power setting to the file being exported.
Dispersion, direct calculated	This selection will output a list of directly calculated dispersion values, with no curve fitting.
Dispersion, fitted	This selection will output a list of dispersion values, with the appropriate curve fit selected in the `Data Review` window.
Dispersion at 5 preferred wavelengths	This selection will output the list of selected wavelengths chosen in the `Data Review` window.

Table 5-1. Export File Formats (Continued)

Format	Description
Test information and conditions	This selection will export a list of the data found on the right hand side of the `Data Review` window, dealing with test conditions.
Quadratic fit coefficients **3-Term Sellmeier fit coefficients** **5-Term Sellmeier fit coefficients**	Choosing one of these buttons will export the relevant fit coefficients to the export file. For a more detailed explanation of these terms, please see the glossary in the back of this manual.
Gain Peak and FWHM	This selection will export a copy of the measured Gain Peak and Full Width, Half Max. values to the export file. This option is only available if the a gain measurement was performed as part of the test run.
Test Data and Time	This selection will export a copy of the time, date, supervisor, and user information to the export file.
Column Headings	This selection will export the data label information for all the columnar lists to the export file
Statistics for Groups	This selection will export a copy of all the information shown in the `CD Stats` tab of the `Data Review` window.
Field Delimiter and Text Format	These options allow the exported data to be customized for input into a spreadsheet program, such as Microsoft Excel. Please consult your spreadsheet program's user documentation to see what format is best suited for importing the data.

The options in the `Field Delimiter and Text Format` section of the `Export File Format` window allow the exported data to be customized for input into a spreadsheet program, such as Microsoft Excel.

Select whether the exported data will be `in quotes, ie: "File Text"`, or `no quotes, ie: File Text` from the `Text Format` section of the `Export File Format` window.

Please consult your spreadsheet program's user documentation to see what format is best suited for importing the data.

Setting Parameters

This section describes the procedure for changing the measurement parameters.

For a suggestion on the values of the parameters to use for different applications, refer to "Suggestions on Setting the Test Parameters" on page 8-4.

The CD and Gain Measurement Settings

The CD and gain measurements settings are used to perform a measurement.

1 Choose `Length Meas...` from the `SetParametersFor` program menu as shown in Figure 5-32.

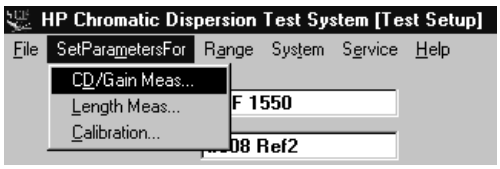

Figure 5-32. SetParametersFor Menu

The `CD and Gain Measurements` window shown in Figure 5-33 will be displayed. To select the HP 86037A Chromatic Dispersion Test System software default settings, click the `Set HP Defaults` button.

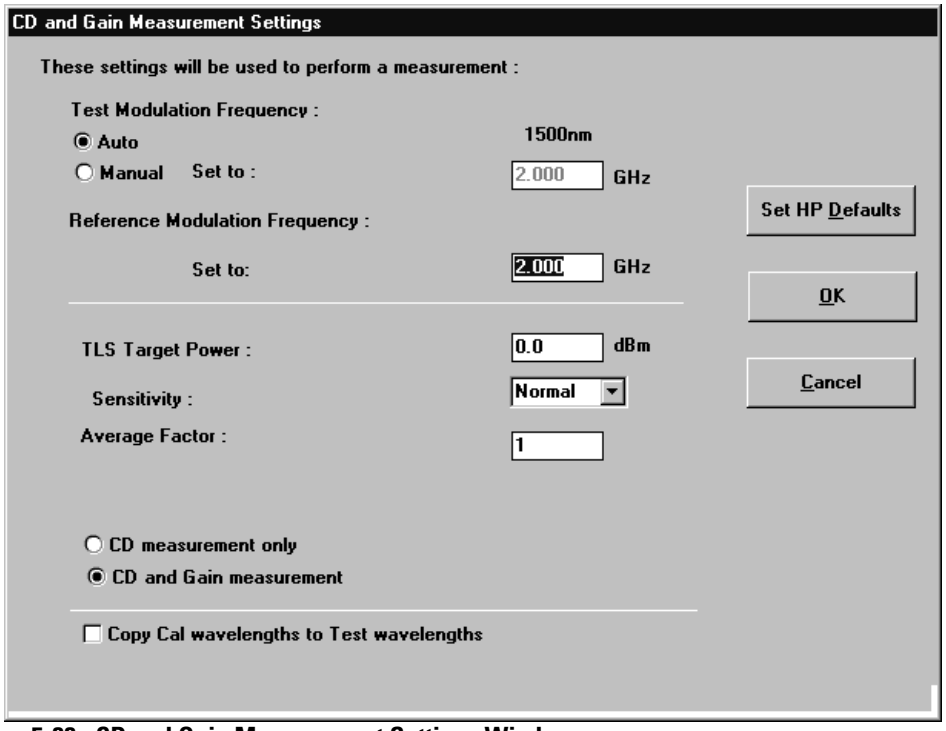

Figure 5-33. CD and Gain Measurement Settings Window

2 Select the method for setting the modulation frequency, either `Auto` or `Manual`. If the `Manual` option is selected, enter a value in the `Test Modulation Frequency` field.

The `Test and Reference Modulation Frequencies` are the RF frequencies used to modulate the optical signal in the test and reference measurement operations.

3 Enter a value for the `TLS Target Power` level.

The `TLS Target Power` is the level requested of the Tunable Laser Source. If it cannot supply the full amount, it will supply as much as it can.

4 Select the `Sensitivity`: `Normal`, `High`, or `Highest`.

The `Sensitivity` setting affects the length of time required to complete a measurement. The higher the sensitivity, the longer the measurement time.

The `Sensitivity` setting determines the IF bandwidth used by the network analyzer. The settings `Normal`, `High` and `Highest` correspond to 300, 100 and 30 Hz, respectively. Noise is reduced at higher sensitivity, but measurement time increases. As an example, a measurement consisting of twenty wavelength steps had these measurement times:

Sensitivity	Measurement Time
Normal	2 min. 50 sec.
High	4 min. 00 sec.
Highest	7 min. 52 sec.

5 The `Average Factor` setting controls the number of network analyzer sweeps which are averaged to measure group delay at each wavelength point. Noise is reduced by one over the square root of the averaging factor, but measurement time increases in proportion to averaging factor.

6 Enable the `CD measurement only` option, or the `CD and Gain measurements` option by clicking on the appropriate radio button. For measurements on fibers, the CD measurement is typically the only measurement of interest. For measurements on filters or systems containing optical amplifiers you may be interested in the passband of the device under test because the CD data is meaningful only within the passband.

Selecting the `CD and Gain measurement` option will increase the measurement time. For example, in a measurement run consisting of 20 wavelength steps, the measurement time was 3 minutes 46 seconds for `CD and Gain measurement`, as compared to 2 minutes 50 seconds for `CD measurement only`. To enable this option, click the `CD and Gain Measurement` option button.

7 Select `Copy Cal wavelengths to Test wavelengths` to copy the wavelength limits in the calibration to the wavelengths for the measurement. This eliminates the need to enter the wavelength limits twice, if they are identical.

8 To accept the displayed values, click `OK`.

These displayed values will be used the next time the program is started, a test is run, or a setup is saved.

The Length Measurement Settings

1 Click `Length Meas` from the HP 86037A Chromatic Dispersion Test System test setup screen `SetParametersFor` menu as shown in Figure 5-34.

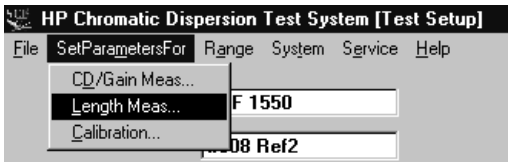

Figure 5-34. SetParametersFor Menu

The `Length Measurement Settings` window shown in Figure 5-35 will be displayed.

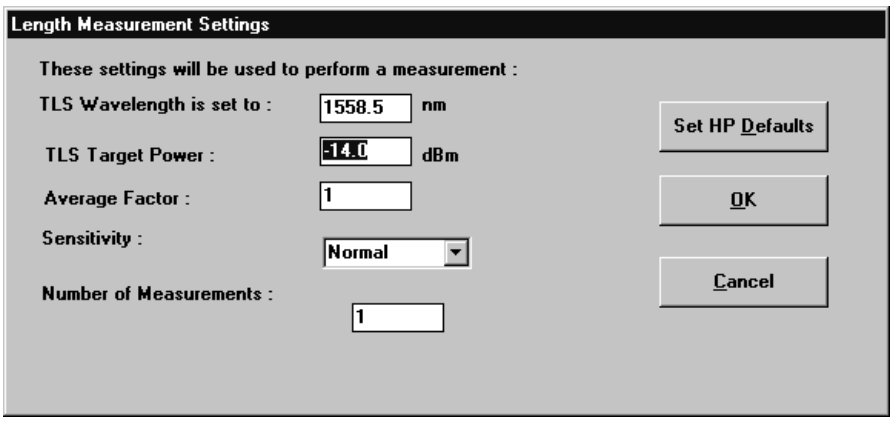

Figure 5-35. Length Measurement Settings Window

To select the HP 86037A Chromatic Dispersion Test System software default settings, click the `Set HP Defaults` button.

2 Enter the desired values for the `TLS Wavelength.`

3 Enter the `TLS Target Power`.

The `TLS Target Power` is the level requested of the Tunable Laser Source. If it cannot supply the full amount, it will supply as much as it can.

4 The `Average Factor` setting controls the number of network analyzer sweeps which are averaged to measure group delay at each wavelength point. Noise is reduced by one over the square root of the averaging factor, but measurement time increases in proportion to averaging factor.

5 Select the `Sensitivity`: `Normal`, `High`, or `Highest`.

The `Sensitivity` setting affects the length of time required to complete a measurement. The higher the sensitivity, the longer the measurement time.

The `Sensitivity` setting determines the IF bandwidth used by the network analyzer. The settings `Normal`, `High` and `Highest` correspond to 300, 100 and 30 Hz, respectively.

6 Enter the desired value for the `Number of Measurements.`

7 To accept the displayed values, click `OK`.

The Calibration Settings

1 Click `Calibration` from the HP 86037A Chromatic Dispersion Test System test setup screen `SetParametersFor` menu as shown in Figure 5-36.

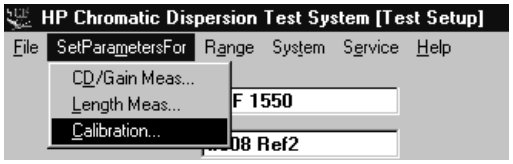

Figure 5-36. SetParametersFor Menu

The `Calibration Settings` window shown in Figure 5-37 will be displayed.

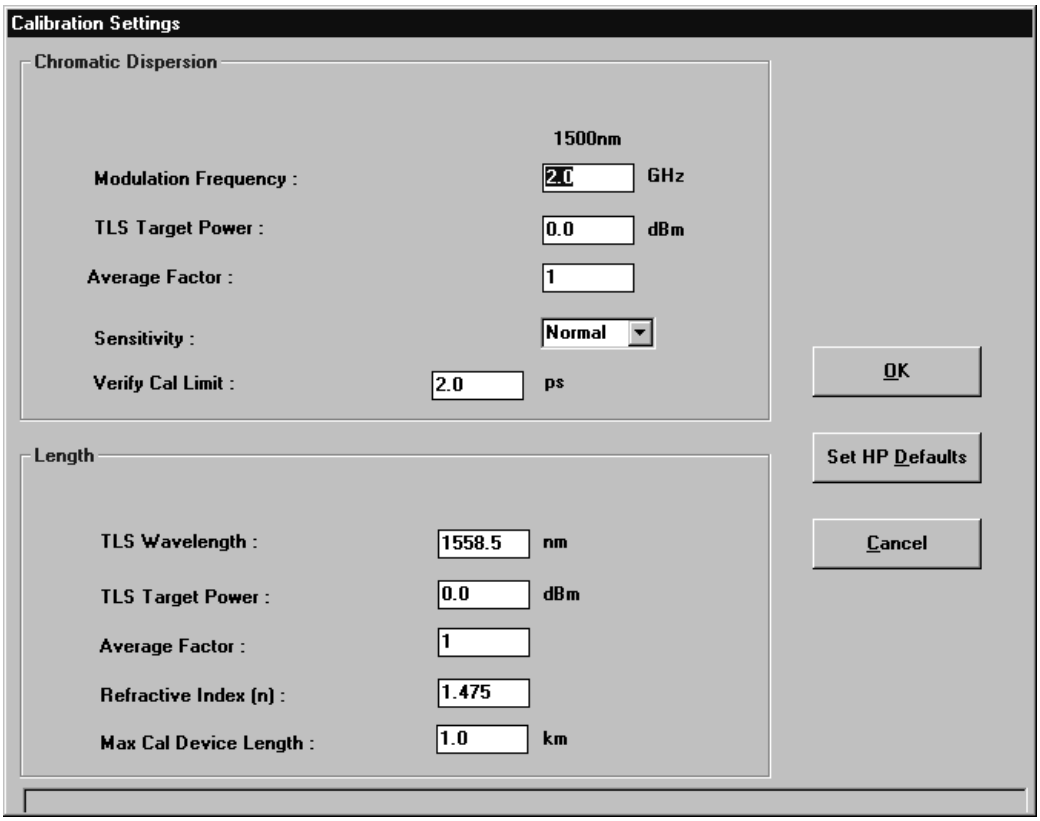

Figure 5-37. Calibration Settings Window

To select the HP 86037A Chromatic Dispersion Test System software default settings, click the `Set HP Defaults` button.

Chromatic Dispersion Settings

2 Enter a value in the `Test Modulation Frequency` field.

The `Test and Reference Modulation Frequencies` are the RF frequencies used to modulate the optical signal in the test and reference measurement operations.

3 Enter a value for the `TLS Target Power` level.

The `TLS Target Power` is the level requested of the Tunable Laser Source. If it cannot supply the full amount, it will supply as much as it can.

4 The `Average Factor` setting controls the number of network analyzer sweeps which are averaged to measure group delay at each wavelength point. Noise is reduced by one over the square root of the averaging factor, but measurement time increases in proportion to averaging factor.

5 The measurement time is proportional to the average factor. Noise reduction is proportional to the square root of the average factor. Select the `Sensitivity`: `Normal`, `High`, or `Highest`.

The `Sensitivity` setting affects the length of time required to complete a measurement. The higher the sensitivity, the longer the measurement time.

The `Sensitivity` setting determines the IF bandwidth used by the network analyzer. The settings `Normal`, `High` and `Highest` correspond to 300, 100 and 30 Hz, respectively. Noise is reduced at higher sensitivity, but measurement time increases.

6 Enter the group delay limit for the calibration verification in the `Verify cal limit` field. This is the limit against which the system compares the data obtained when a calibration verification is performed. Refer to chapter 9 for more details.

Length Settings

These are the parameters the system uses when a length calibration is performed during a calibration. It measures the length of the "thru" cable and stores it for later use.

7 Set the `TLS Wavelength.`

8 Enter the `TLS Target Power`.

The `TLS Target Power` is the level requested of the Tunable Laser Source. If it cannot supply the full amount, it will supply as much as it can.

9 The `Average Factor` setting controls the number of network analyzer sweeps which are averaged to measure group delay at each wavelength point. Noise is reduced by one over the square root of the averaging factor, but measurement time increases in proportion to averaging factor.

The measurement time is proportional to the average factor. Noise reduction is proportional to the square root of the average factor.

10 Enter the `Refractive Index (n)`.

11 Enter the maximum length for the "thru" cable under `Max Cal Device Length`. The smaller this length, the faster the length calibration. However, the time savings typically is only about 1 second. Since setting this value lower than the actual "thru" length will result in an incorrect length calibration, this value should be set well above the maximum "thru" length you expect to use. For example, if the maximum "thru" length in your factory is 120 meters, you can set this equal to 0.5 km to avoid potential problems with length calibration.

Configuring the System

This section describes the procedures for configuring the system.

Opening a Database

1 Select `Database Options` on the `System` menu as shown in Figure 5-38.

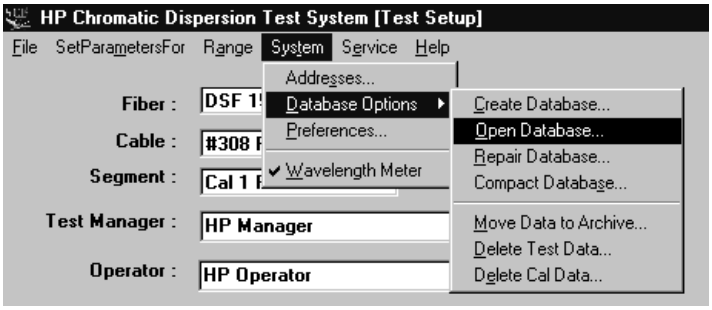

Figure 5-38. Database Options Menu

2 Click on `Open Database` in the drop-down menu.

The window shown in Figure 5-39 will be displayed asking whether you wish to change the current working directory.

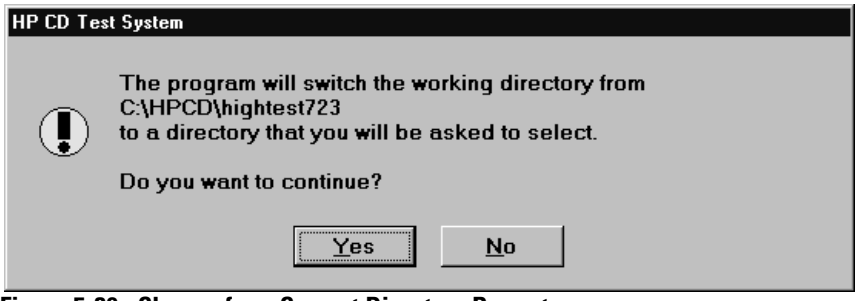

Figure 5-39. Change from Current Directory Prompt

Click `Yes` to display the `Select Directory` window shown in Figure 5-40.

Figure 5-40. Select Directory Dialog Box

3 Use the directory tree in the `Select Directory` window to locate the directory containing the new database file. The directory may also be typed into the `Selected Directory` field.

4 In the directory tree list box, click once on the directory where the file is located, or type its name in the `Selected Directory` field.

5 Click `OK`, or double-click the directory name in the directory tree.

After changing databases, the calibration files, devices, test operator, manager's names, and test data from the previous database are no longer available. To make them available, select the previous database directory.

Creating a Database

1 Select `Database Options` from the `System` menu.

2 Click on `Create Database` on the drop-down menu as shown in Figure 5-41.

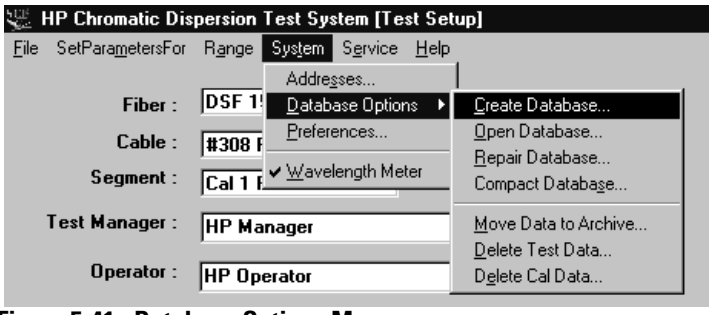

Figure 5-41. Database Options Menu

The window shown in Figure 5-42 will be displayed asking whether you wish to change the current working directory.

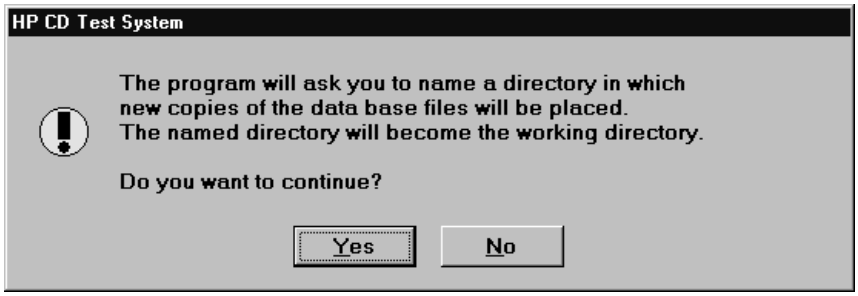

Figure 5-42. Change from Current Directory Prompt

3 Click `Yes` to display the `Select Directory` window in Figure 5-43.

Figure 5-43. Select Directory Dialog Box

4 Use the directory tree in the `Selected Directory` window to locate the directory where the you wish to save the directory.

5 Click `OK` to display the prompt in Figure 5-44.

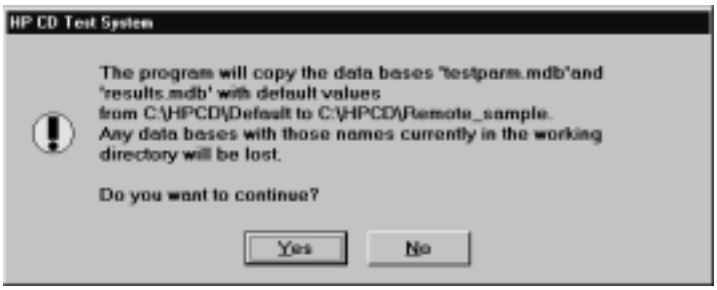

Figure 5-44. Create directory Prompt

6 Click `Yes` to create the new database. This procedure opens the new database automatically.

Repairing a Database

If an error occurs while you are trying to open a database, it indicates that the database file is damaged and must be repaired before it can be opened. Damaged data will be removed during the repair process and is permanently lost and unrecoverable. However, repairing an undamaged database file causes no harm and no data is lost. The database repair function returns a warning if the database file is read only.

The repair function can operate on any database file *other than one that is currently open.* The following procedure describes how to repair a database file.

1 Select `Database Options` on the `System` menu.

2 Click on `Repair Database` on the drop-down menu as shown in Figure 5-45.

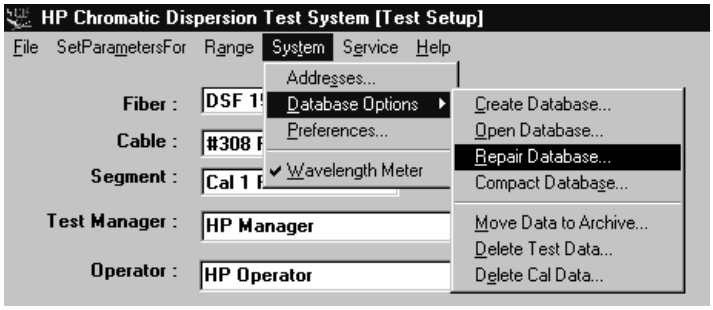

Figure 5-45. Database Options Menu

The prompt shown in Figure 5-46 will be displayed.

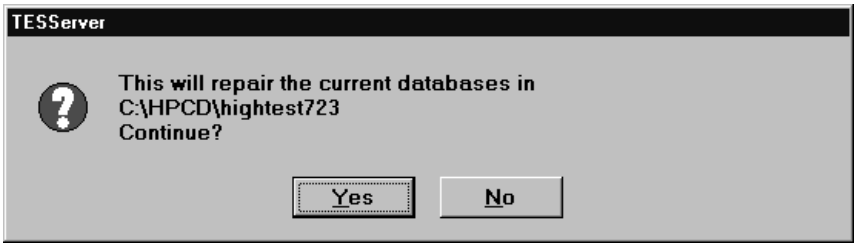

Figure 5-46. Database Repair Prompt

3 Click `Yes` to begin the repair procedure.

During the repair procedure the database file is compacted, which can result in a file that is smaller than the original.

Compacting a Database

A currently opened database file can be compacted to reduce the amount of disk space it occupies. A database file must be open before it can be compacted. The function returns an error if the database file is read-only. Compacting is automatically performed when a database file is repaired. The following procedure describes how to compact a database file.

1 Select `Database Options` on the `System` menu.

2 Click on `Compact Database` in the drop-down menu as shown in Figure 5-47.

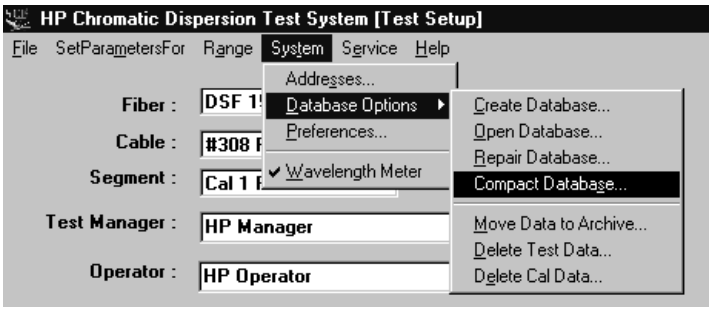

Figure 5-47. Database Options Menu

The following prompt will be displayed:

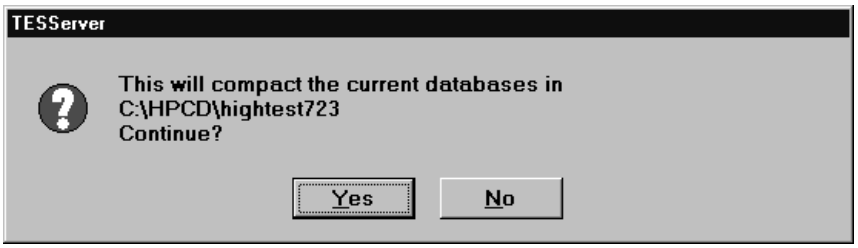

Figure 5-48. Compact Database prompt

3 Click `Yes` to compact the current database file.

Archiving a Database

Large database files are slow and require time to store and retrieve data. The database archive feature helps you manage the size of your database files by allowing you to move test data from the currently opened database file to another database file.

For example, you can create a database file on a floppy disk and then move some tests from your system hard drive to the floppy disk for storage or transport to another system.

You will be asked if you wish to delete the tests after they have been moved.

A database file must be open before it can be archived. The following procedure describes how to archive one or more tests.

1 Select `Database Options` from the `System` menu.

2 Select `Move Data to Archive` from the drop-down menu as shown in Figure 5-49.

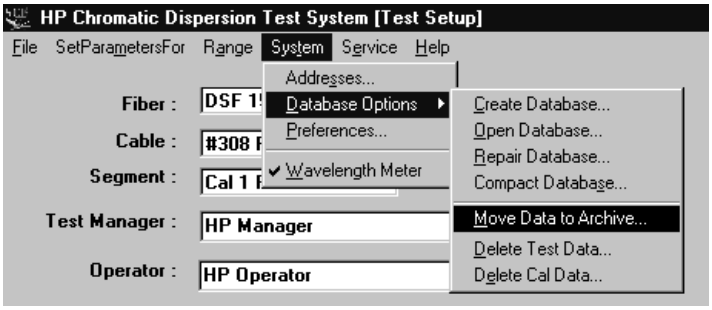

Figure 5-49. Database Options Menu

The following screen will be displayed:

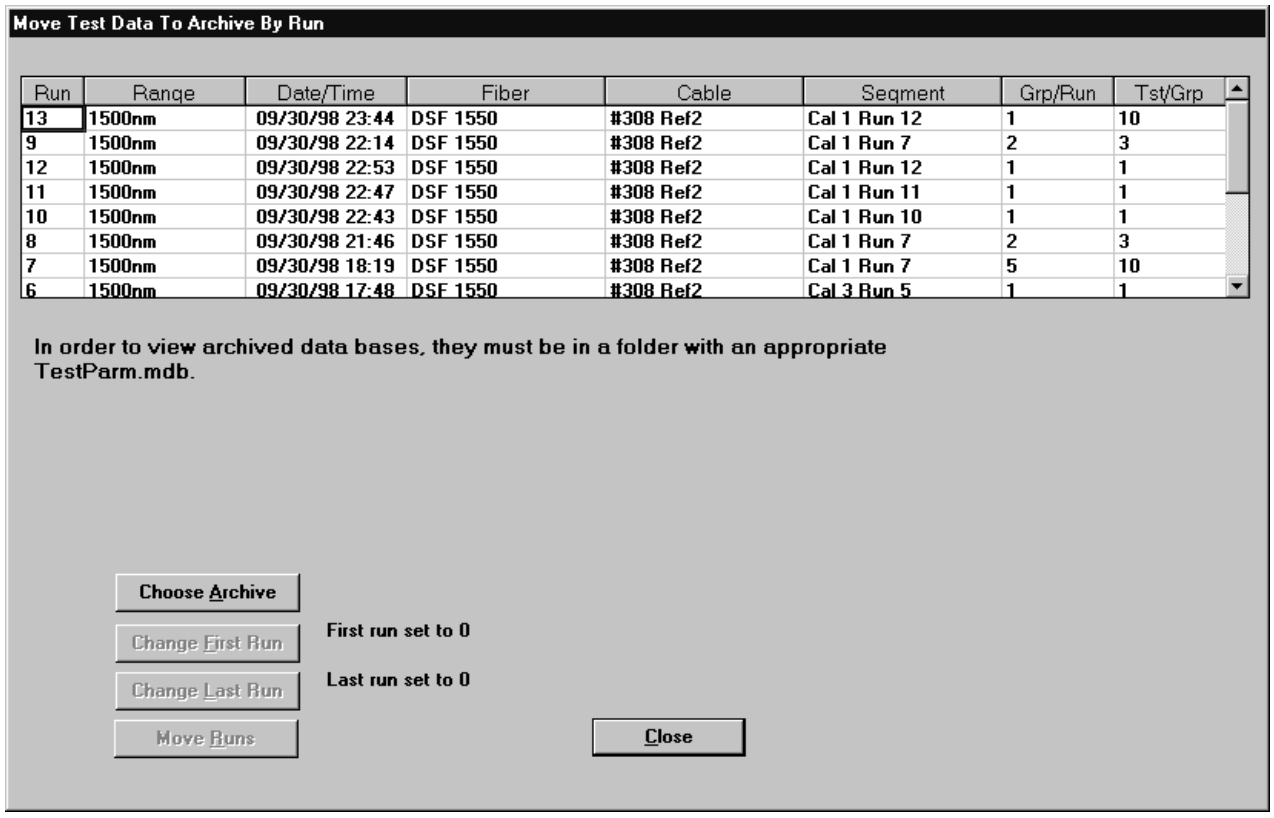

Figure 5-50. Move Test Data to Archive by Run Window

3 Identify the destination database file, including the full path name.

4 Click the `Set First Run` and `Set Last Run` buttons to identify the series of runs you wish to include in the archive.

5 To move the runs, click `Move Runs`.

Following the archive, you can delete the runs from the currently opened database.

Printing Data

The data generated from a chromatic dispersion test can be output to a printer by selecting `Print` from the `File` menu as shown in Figure 5-51.

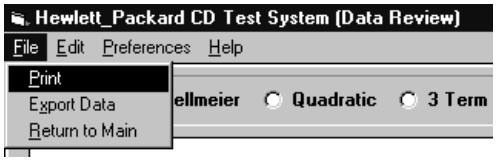

Figure 5-51. Data Review File Menu

The `Print Range` window shown in Figure 5-52 will be displayed.

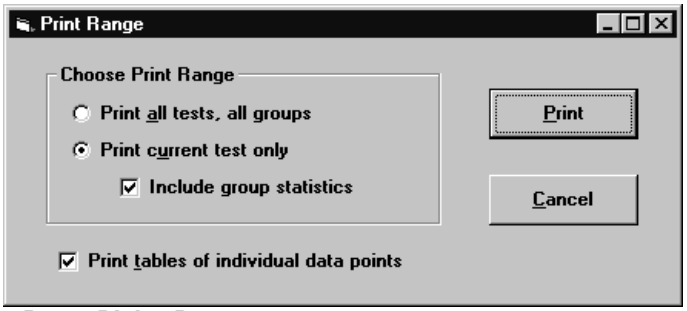

Figure 5-52. Print Range Dialog Box

Click on your choice in the `Choose Print Range` section, and click `Print`

The current window can also be printed by clicking the icon from the `Data Review` window.

Selecting Preferences

The names describing the fields on the `Test Setup` window can be customized for your application.

Changing the Labels

1 From the main screen, select `Preferences` from the `System` menu as shown in Figure 5-53.

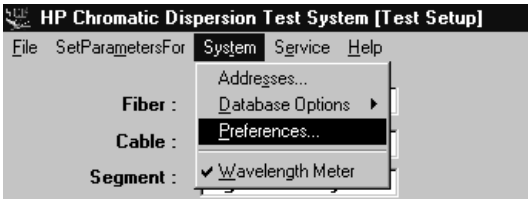

Figure 5-53. System Menu

The `System Preferences` window shown in Figure 5-54 will be displayed.

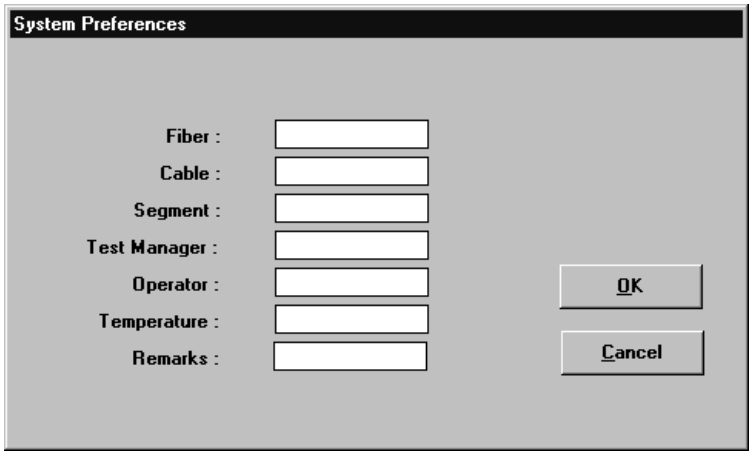

Figure 5-54. Preferences Window

2 Enter the labels you wish to have displayed.

3 Click `OK`.

The `Test Setup` window will display the new labels.

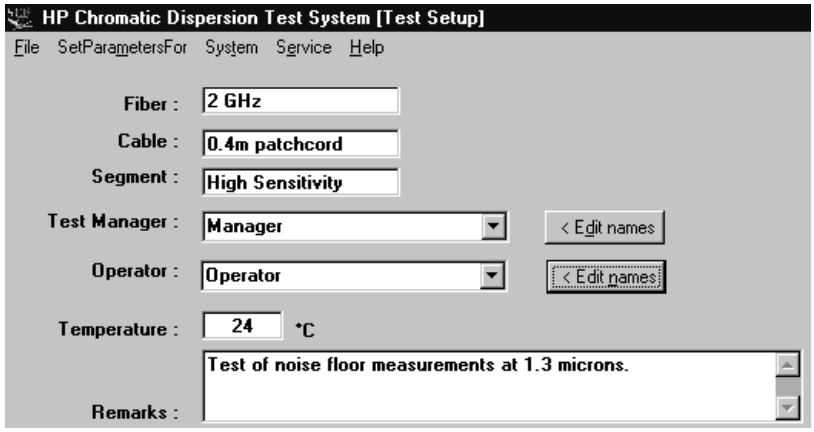

Figure 5-55. Test Label Section in the Main Window

Adding or Removing a Wavelength Meter

1 Select `System` from the HP 86037A Chromatic Dispersion Test System test setup screen menu bar as shown in Figure 5-56.

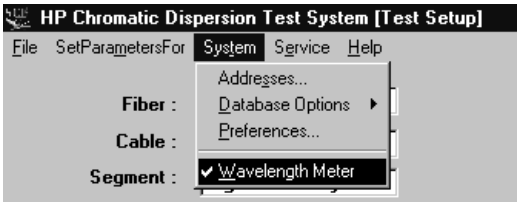

Figure 5-56. System Menu

If a checkmark is displayed next to the `wavelength meter` command, it indicates there is a wavelength meter in the system.

2 To remove a wavelength meter from the system, ensure that `wavelength meter` in the `System` menu does not have a checkmark next to it. Remove the checkmark by clicking on it. The checkmark should not be shown, indicating there is no wavelength meter in the system.

6

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Measuring Chromatic Dispersion 6-7
Reviewing the Data 6-17
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Setting Parameters 6-31
Configuring the System 6-37

The Dual Band Interface

At a glance

This section documents the dual band HP 86037A Chromatic Dispersion Test System GUI.

This chapter includes the procedures to:

- Start the HP 86037A Chromatic Dispersion Test System software
- Examine the HP 86037A Chromatic Dispersion Test System user interface
- Measure chromatic dispersion

You will also learn to use the HP 86037A Chromatic Dispersion Test System program menus to:

- Work with setups
- Set parameters
- Configure the system
- Enter service settings

Adjusting the System

> To ensure all system specifications are met, let the system warm up for two hours before making any critical measurements.

An optical power meter is needed for the adjustment procedures described below. The following steps must be performed in the order shown so the system is in the appropriate state for the next adjustment.

Wavelength Meter Selection

1 Start the HP 86037A Chromatic Dispersion Test System software. Refer to the *Getting Started* section at the beginning of this manual for more information. The HP 86037A Chromatic Dispersion Test System main window will be displayed.

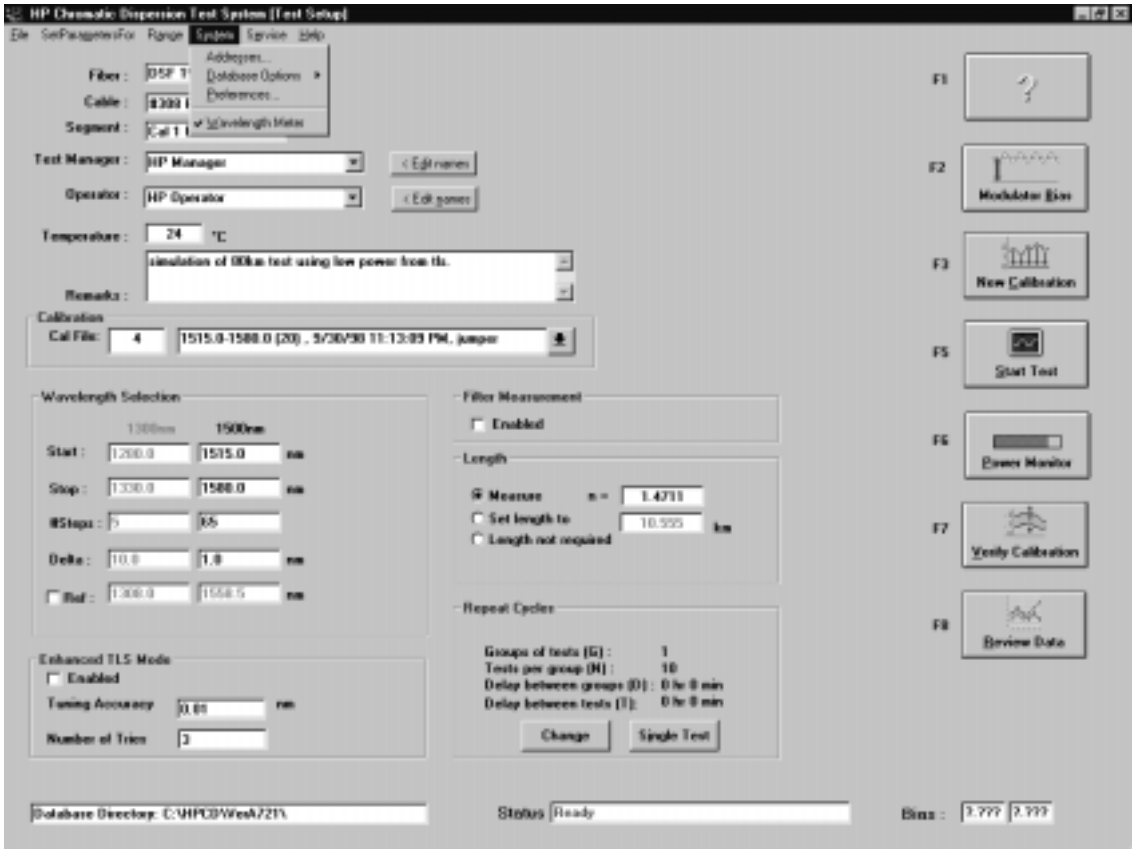

Figure 6-1. HP 86037A Chromatic Dispersion Test System Main Window

2 If the system includes a wavelength meter, a checkmark should appear in front of the wavelength meter item on the drop-down `System` menu as shown in Figure 6-1. The checkmark can be toggled on and off by clicking the `wavelength meter` selection.

Adjust Optical Modulator Bias

3 On the test set, connect the Source Output to the Receiver Input ports using a short fiber cable.

4 Use the mouse to click the `Modulator Bias` button on the main screen of the HP 86037A Chromatic Dispersion Test System application.

> When this modulator bias adjustment is performed, the modulator is automatically biased to the optimum (quadrature) performance condition. Bias adjustment is performed at the beginning of a measurement session. It does not need to be performed before each individual measurement. Bias adjustment can be set to occur automatically when a calibration is performed. Refer to "Calibration/Verification" chapter 9.

Power Calibration Constants

In the HP 86037A Chromatic Dispersion Test System main window:

5 Click `Power Monitor Settings` from the `Service` menu.

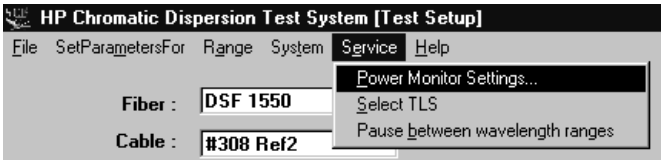

Figure 6-2. Power Monitor Settings Menu

The window shown in Figure 6-3 will be displayed.

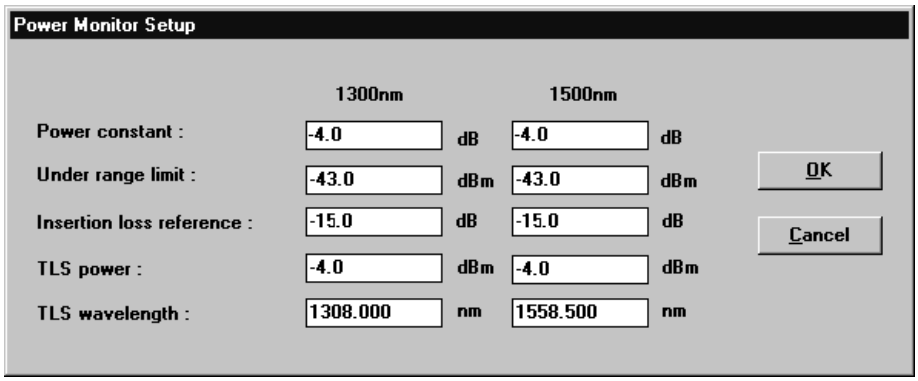

Figure 6-3. Power Monitor Setup Window

Adjusting the High Band Values

1 Enter **0.0** in the `Power constant` field. Click `OK`.

2 Press the Local key on the TLS to put it in local operation mode.

3 Set the TLS to:

—wavelength 1558.5 nm

—TLS power 0 dBm

4 Connect a short fiber cable from the SOURCE OUTPUT port of the HP 83427A Chromatic Dispersion Test Set to an optical power meter. Press the Active key on the TLS.

5 Measure the optical power at 1558.5 nm on the power meter and note the reading P1, in dBm. For example:

P1 = –12 dBm

6 Disconnect the fiber cable from the power meter and connect it to the RECEIVER INPUT port on the HP 83427A Chromatic Dispersion Test Set.

7 Click the `Power Monitor` button on the HP 83427A Chromatic Dispersion Test System main window. Note the power reading P2, in dBm. For example:

P2 = –8 dBm

8 Calculate the difference using the following equation:

$\Delta P = P1 - P2$

Using the earlier example:

$\Delta P = (-12\ dBm) - (-8\ dBm)$
$\Delta P = -4\ dBm$

9 Close the `Power Monitor` window by clicking the `Close` button.

10 Choose `Power Monitor Settings` from the Service menu to open the `Power Monitor Setup` dialog box.

11 In the `Power Monitor Setup` dialog box shown in Figure 6-3, enter the following values:

Power constant	ΔP, as calculated above. In that example, ΔP equals **–4** dBm
Under range limit	**–43** dBm
Insertion loss reference	**–15** dBm
TLS power	**0** dBm
TLS wavelength	**1558.5** nm

12 Click `OK`.

13 Click the `Power Monitor` button on the CD main window shown in Figure 6-1. Verify that the displayed power is within ±0.5 dB of value P1.

14 Click the `Set zero` button from within the `Power Monitor` Window. Please see Figure 6-9.

15 Close the `Power Monitor` window by clicking the `Close` button.

The TLS will automatically revert to system control.

Adjusting the Low Band values

1 Repeat the adjustment for the low band. Set the optical power meter to 1308 nm when reading low band power. Enter the following values into the `Power Monitor Setup` under the `1300nm` column.

2 Enter the following values.

Power constant	ΔP, as calculated above. In that example, ΔP equals **–4** dBm
Under range limit	**–43** dBm
Insertion loss reference	**–15** dBm
TLS power	**-4** dBm
TLS wavelength	**1308** nm

Select TLS

1 Click `Select TLS` from the `Service` menu.

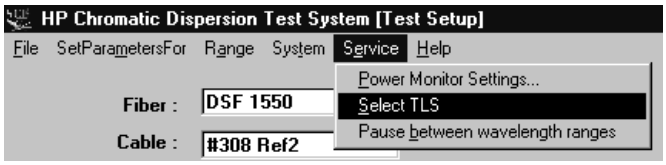

Figure 6-4. Service Menu

2 The dialog box shown in Figure 6-5 will be displayed.

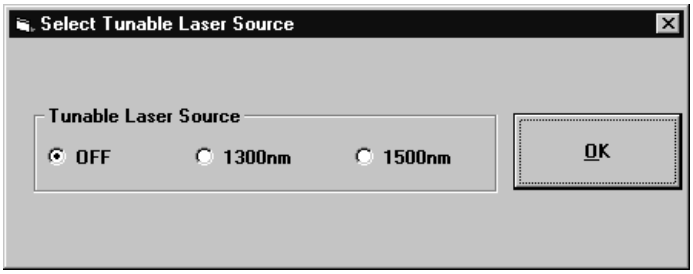

Figure 6-5. Select TLS Window

For safety reasons, the default value for the `Select Tunable Laser Source` window is `OFF`.

3 Select a TLS from the `Select Tunable Laser Source` window.

4 To exit, click `OK`.

Measuring Chromatic Dispersion

Before making a measurement with the HP 86037A Chromatic Dispersion Test System, ensure that:

- The HP 86037A Chromatic Dispersion Test System software has been started. Refer to "Starting the Software" on page 1-6 for information on starting the HP 86037A Chromatic Dispersion Test System software.
- The system has been adjusted. These adjustments must be made prior to a measurement session. Refer to "Adjusting the System" on page 6-3 for information on making this adjustment.
- The HP 86037A Chromatic Dispersion Test System is calibrated. Refer to "Performing a Periodic Calibration" on page 9-3 for information on performing a calibration.
- All the measurement parameters have been set to the appropriate values. If in doubt, click `SetParametersFor` from the menu bar, and set all the parameters to HP defaults using the `Set HP Defaults` button.

Verify the Calibration

Before a measurement session, it is a good idea to verify the current calibration. To select a different calibration file, refer to "Select a Calibration File" on page 6-8. Verification does not need to be performed before each measurement.

1 Connect the appropriate calibration device, such as a short cable, between the source output and receiver input ports of the HP 83427A Chromatic Dispersion Test System test set.

> Patch cords should be used to connect the test set Source Output and Receiver Input to either a DUT or a short test cable to protect the test set fiber connectors from undue and unnecessary wear.

2 Click the `Verify Calibration` button on the right side of the HP 86037A Chromatic Dispersion Test System.

The system will first perform a modulator bias adjustment. Then it will measure ten group delay points in the measurement span and check the maximum group delay against the limit set in the `Calibration Settings` window of the `SetParametersFor` menu.

On completing the measurement, the system will display a message to tell the operator if the calibration verification has passed or failed. It also shows the maximum group delay value obtained during the calibration verification. The system group delay noise floor can vary between 0.05 ps and 2 ps. The test engineer can set the limits by selecting `Calibration` in the `SetParametersFor` menu.

Enter the Test Labels

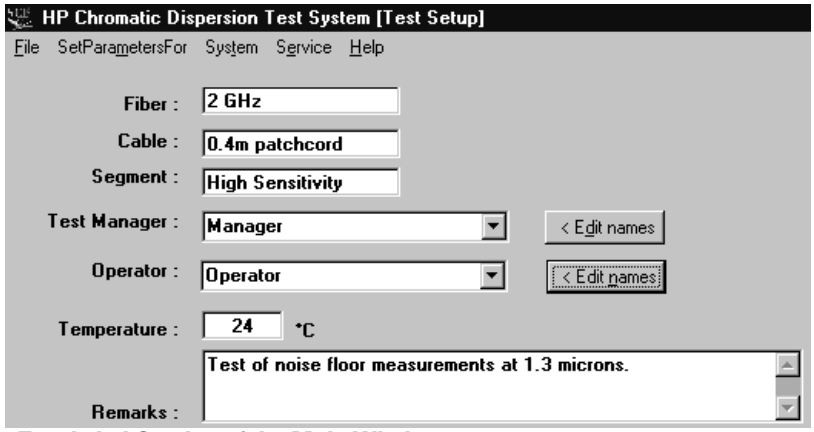

Figure 6-6. Test Label Section of the Main Window

The field headings shown in Figure 6-6 are the default headings. To change any of the field headings, please refer to "Selecting Preferences" on page 6-46.

1 Enter the name of the fiber, cable, and segment into their corresponding fields as shown in Figure 6-6.

2 Enter the name of the test manager and operator, or select the names from the drop-down list.

To edit a name in the drop-down list, click on the name so that it is displayed in the field, then click `Edit names`.

Select a Calibration File

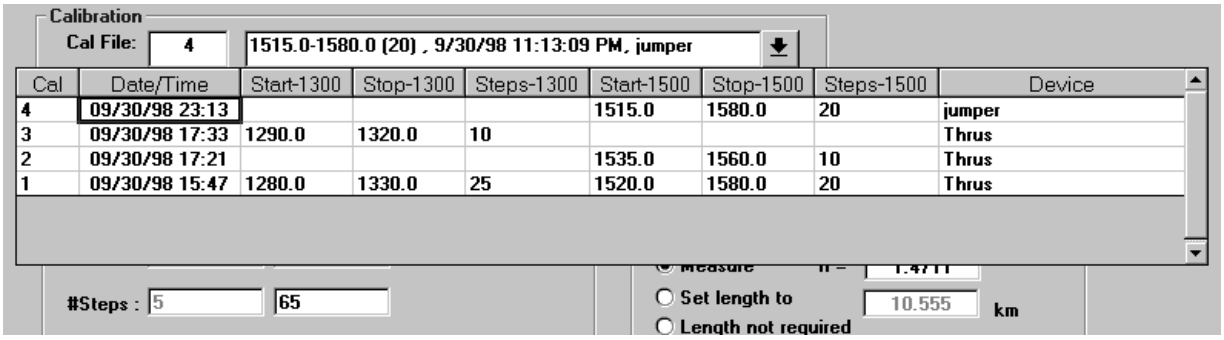

Figure 6-7. Calibration File Section of the Main Window

1 Select the desired calibration file in the calibration section of the HP 86037A Chromatic Dispersion Test System program shown in Figure 6-7 by entering its number in the `Cal File:` box and typing the Enter key, or by selecting it from the drop-down list.

Enhanced TLS Mode

`Enhanced TLS Mode` allows the operator to adjust the accuracy of the test. To enable this feature:

1. Click the `Enabled` checkbox
2. Enter a value in the `Tuning Accuracy` field
3. Enter a value in the `Number of Tries` field

The system will attempt to get a measurement that is within the value that was entered in the `Tuning Accuracy` field by testing the measurement multiple times and doing a comparison.

Filter Measurement

The Filter Measurement section of the HP 86037A Chromatic Dispersion Test System main window is used to indicate how to normalize the group delay data that has been collected during the test. The Filter Measurement section of the test system main window is shown in Figure 6-8.

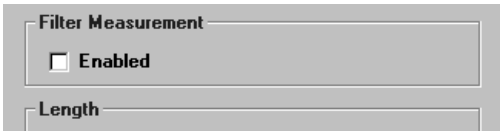

Figure 6-8. Filter Measurement Section of the Main Window

If the check box is not checked, then the smallest value of group delay is set to zero and that value is subtracted from the rest of the data. If the check box is checked, then the group delay data is returned normalized to the actual absolute group delay measured by the system.

To obtain this absolute group delay, the system performs a length measurement after all group delay measurements are complete. The wavelength at which this length measurement is performed is determined by finding the point within the measured wavelength range where the received signal was at a maximum (i.e. the wavelength at which there is a minimum in the loss of the DUT). If gain was not measured, then the start wavelength is used.

Power Monitor

The `Power Monitor` function in the HP 86037A Chromatic Dispersion Test System is useful for testing the loss of a DUT before measuring, and to ensure that all connections are of good quality.

Click the `Power Monitor` button on the CD main window shown in Figure 6-1.

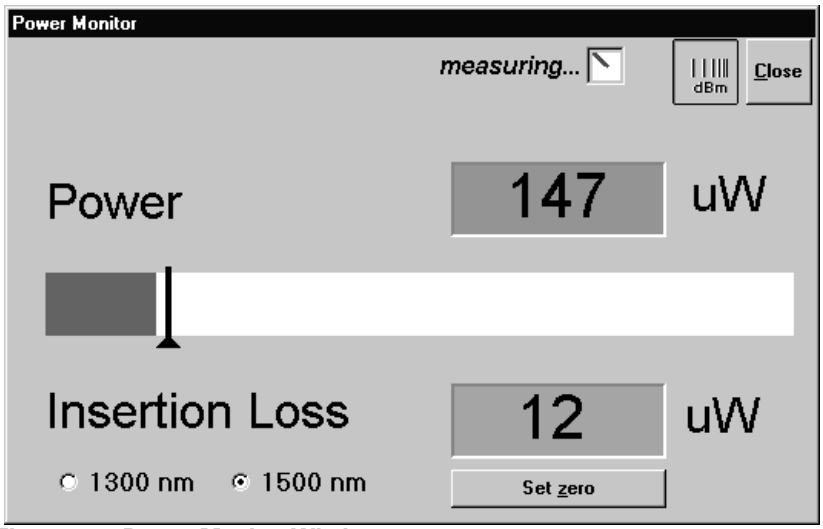

Figure 6-9. Power Monitor Window

Click on either the low band (1300 nm) or high band (1500 nm) option buttons to select the TLS to be measured.

Click on the measurement button to the left of the close button to switch between μW and dB.

Enter the Wavelength Information

Figure 6-10. Wavelength Selection Section of the Main Window

1 Enter a value in the `Start Wavelength` and `Stop Wavelength` fields.

> An error message will display on the TLS if the values in the `Start Wavelength` and `Stop Wavelength` fields are greater than the tunable laser source can accomodate. There will be no indication of this error in the HP 86037A Chromatic Dispersion Test System software.

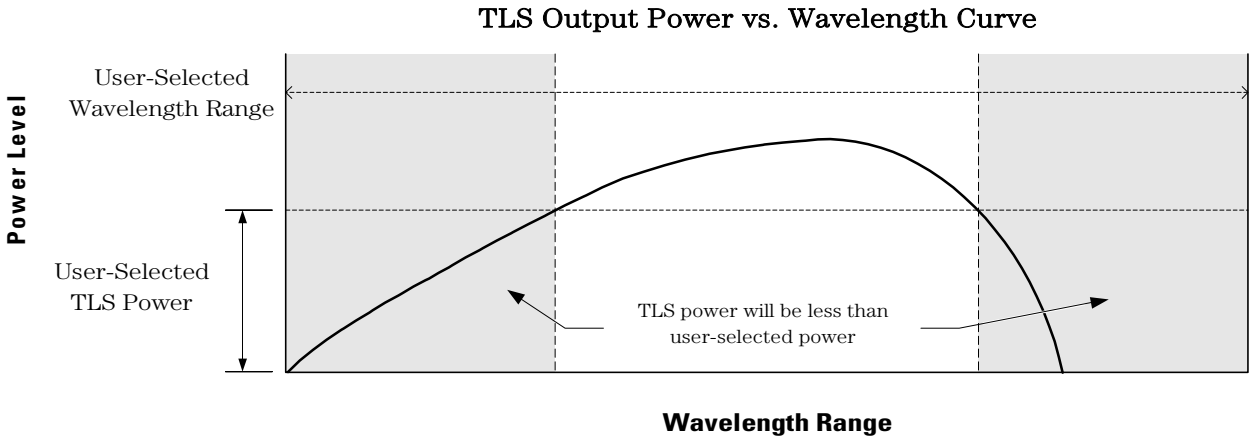

Figure 6-11. TLS Power Roll-off in Relation to Wavelength Range

The shaded area in Figure 6-11 shows the wavelength range where the user-selected TLS power will be more than the TLS can deliver.

If the user selects a wavelength range within the shaded area in Figure 6-11, the TLS will display an error on its display, but will continue to put out as much power as it can.

There will be no indication of this error on the HP 86037A Chromatic Dispersion Test System GUI.

2 Enter the number of steps in the `Step Wavelength` field. The system calculates the step wavelength automatically if the number of steps is entered, or calculates the number of steps if the step wavelength is entered.

The greater the number of data points, or steps, the greater the accuracy of the measurement. However, as the number of steps increases, so does the measurement time. It is important to select enough steps to provide the required accuracy, but still allow for a timely measurement. Typically, using 20 steps will yield good results.

3 If you want to establish a reference wavelength, click the `Ref Wavelength` check box, then enter the wavelength in the field. The reference wavelength is used to correct length drifts of the device under test during the measurement and should be set when measuring fibers. It improves the accuracy of the measurement, but increases measurement time.

Select the Length Information

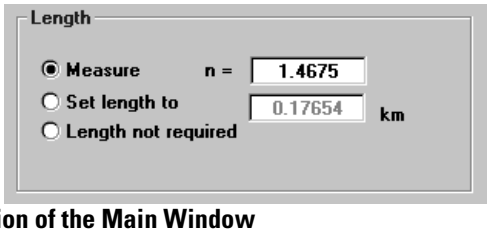

Figure 6-12. Length Section of the Main Window

4 Use one of the following methods to measure the length of the cable:

- Enable the `Measure` function by selecting the option button, and in the field, enter the value of the refractive index.
- To set a specific length, enable the `Set length to` function by selecting the option button, and in the field, enter the length in kilometers.
- Select the `Length not required` option button to remove the length requirement from the measurement.

Examine the Repeat Cycles Information

Change the Repeat Cycles Information

If you are satisfied with the values shown in the `Repeat Cycles` section of the window, no action is required.

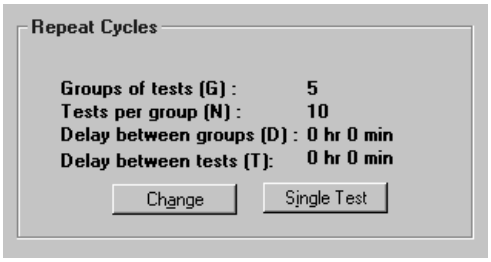

Figure 6-13. Repeat Cycles Section of the Main Window

1 To change the values, click on the `Change` button in the `Repeat Cycles` section of the HP 86037A Chromatic Dispersion Test System setup window shown in Figure 6-13. the `Repeat Measurement Selector` window in Figure 6-14 will be displayed.

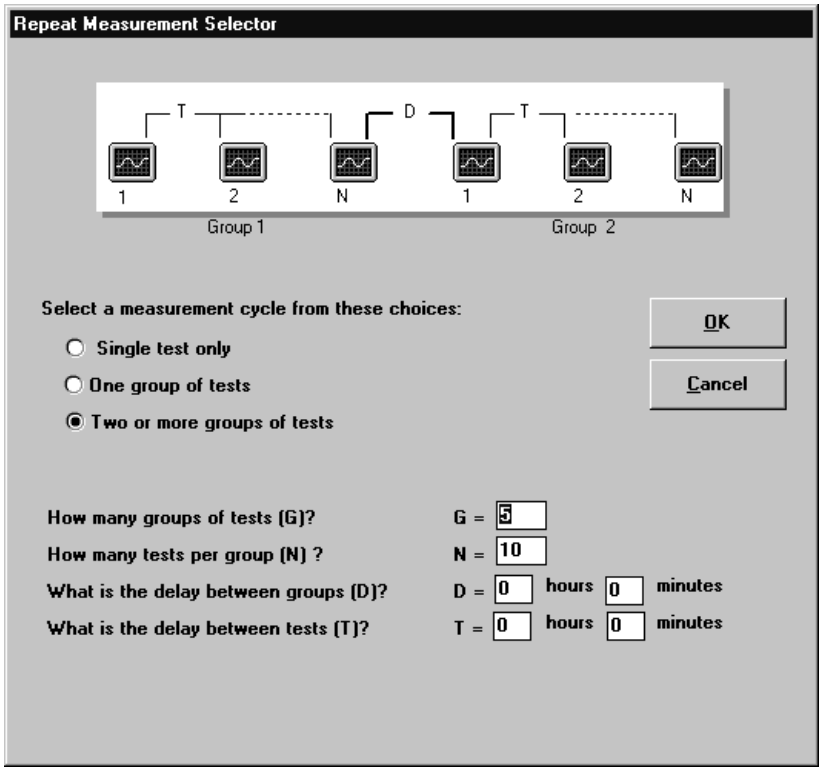

Figure 6-14. Repeat Measurement Selector Window

2 You can select a single test, or several groups of tests. Click on the option button pertaining to `Single test only`, `One group of tests`, or `Two or more groups of tests`. As you move the cursor over the possible choices, they are highlighted on the diagram at the top of the window.

3 Enter the values for the number of tests, the tests per group, the delay between groups, and the delay between tests. Delays specify the time between the end of one test or group and the beginning of the next test or group. Only the boxes applicable to the chosen test selection will be enabled.

4 Click `OK` to accept the new values, or click `Cancel` to return to the HP 86037A Chromatic Dispersion Test System main screen without changing any values.

Make a Single Test

If more than one group of tests has been set up, the operator can elect to run a single test.

5 From the HP 86037A Chromatic Dispersion Test System main window, click the `Single Test` button in the `Repeat Cycles` section shown in Figure 6-15.

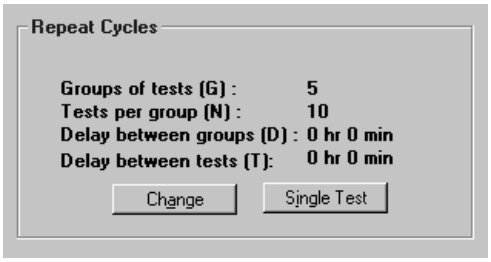

Figure 6-15. Repeat Cycles Section of the Main Window

6 The system will ask you to confirm your selection as shown in Figure 6-16. Click `OK`.

Notice the values for `Groups of tests (G)` and `Test per group (N)` are set to `1` in the `Repeat Measurement Selector` window shown in Figure 6-14. After the test is performed, the values will remain at 1, until they are changed by the user.

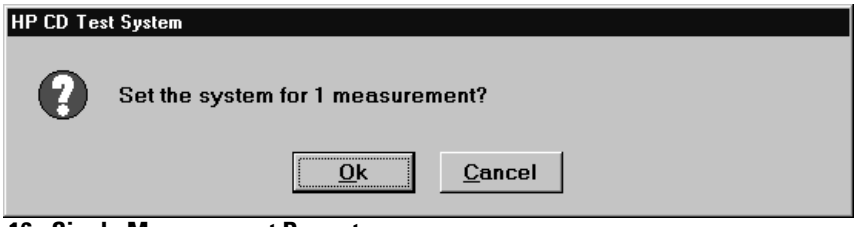

Figure 6-16. Single Measurement Prompt

Start the Test

1 Connect the DUT to the HP 83427A Chromatic Dispersion Test System test set.

> Patch cords should be used to connect the test set Source Output and Receiver Input to either a DUT or a short test cable to protect the test set fiber connectors from undue and unnecessary wear.

2 To begin testing, click the `Start Test` button on the right side of the HP 86037A Chromatic Dispersion Test System software setup window.

The gray text in the status line at the bottom of the HP 86037A Chromatic Dispersion Test System software setup window indicates the system's progression. After a few seconds, the `Data Monitor` window will appear as shown in Figure 6-17.

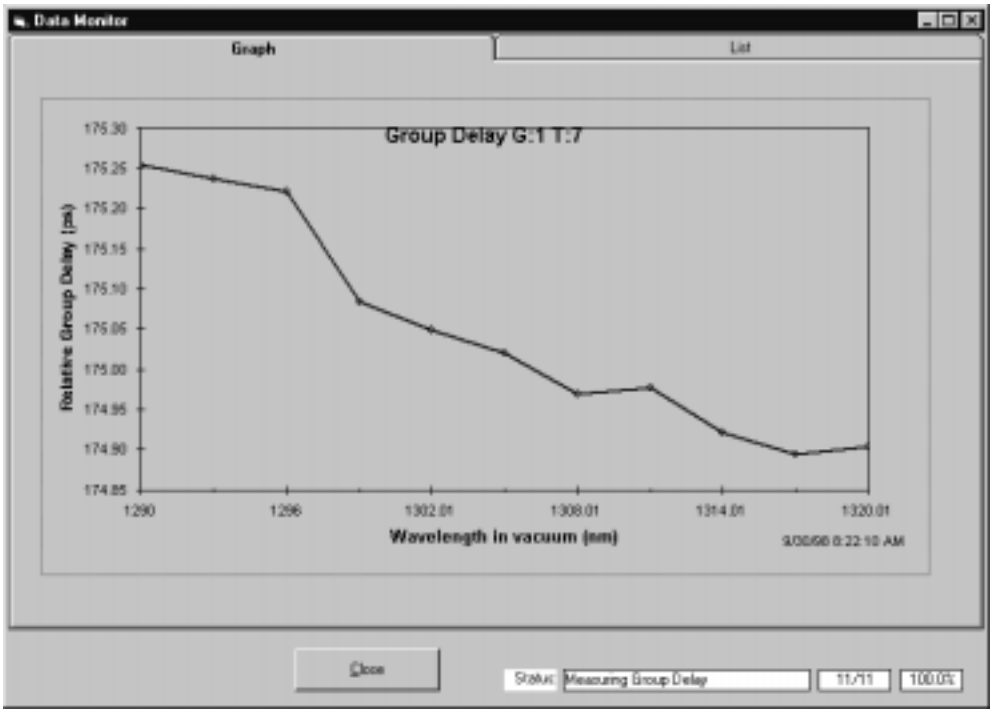

Figure 6-17. Data Monitor Window

The `Data Monitor` graphically displays a diagram of the group delay for the current test. Click on the `Test` tab to view a table of the group delay data as shown in Figure 6-18.

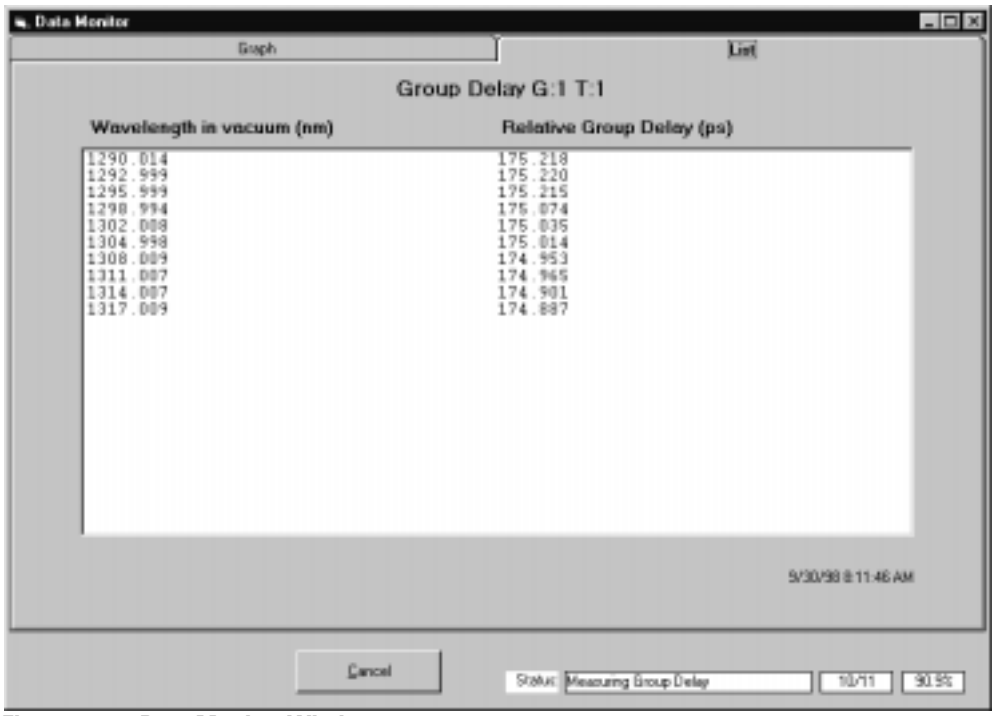

Figure 6-18. Data Monitor Window

Reviewing the Data

1 Click the `Review Data`(`F8`) button from the HP 86037A Chromatic Dispersion Test System software setup window to access the `Data Review` window.

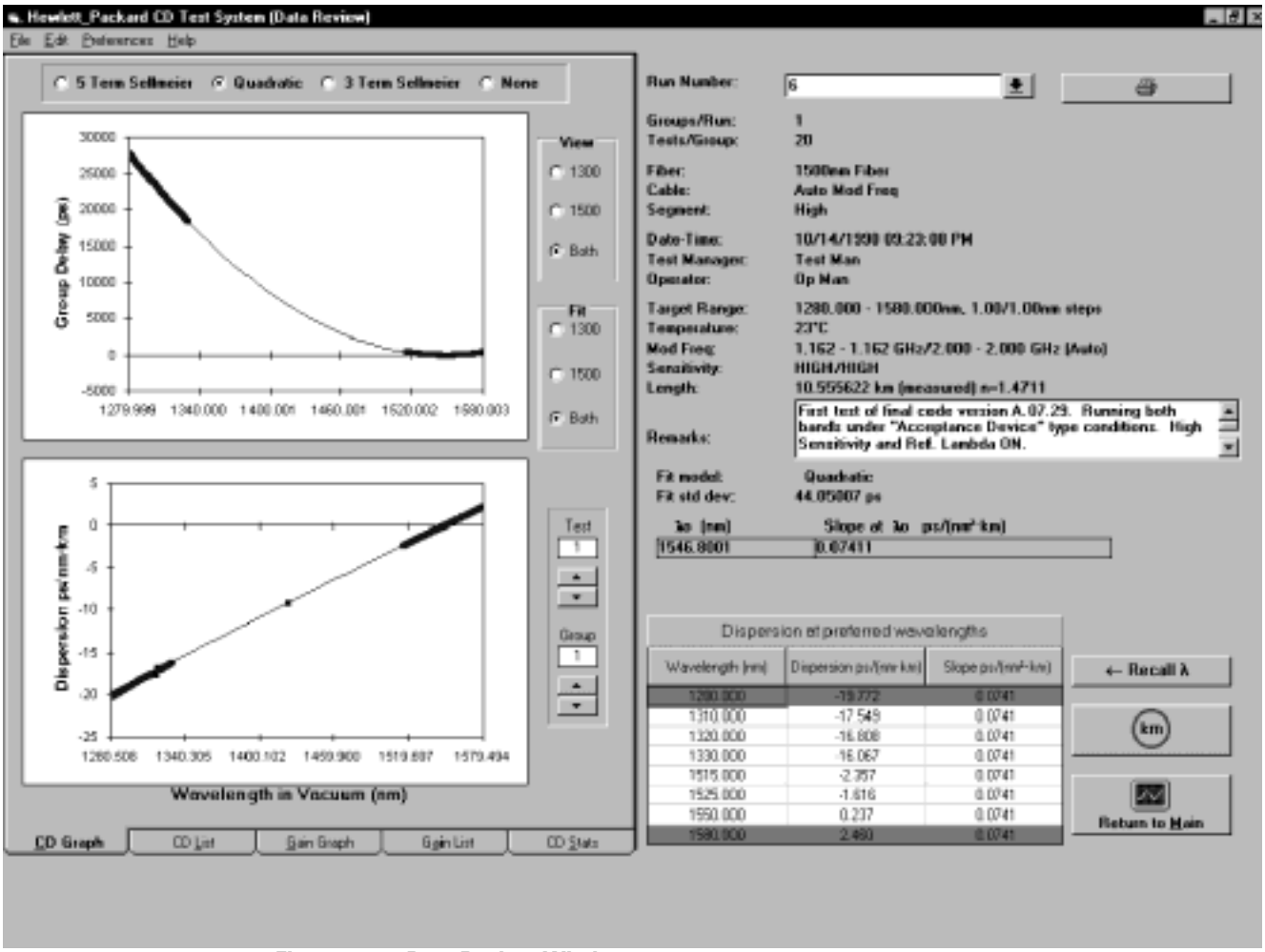

Figure 6-19. Data Review Window

Selecting the Run

2 Select the run number from the `Run Number` list box shown in Figure 6-20.

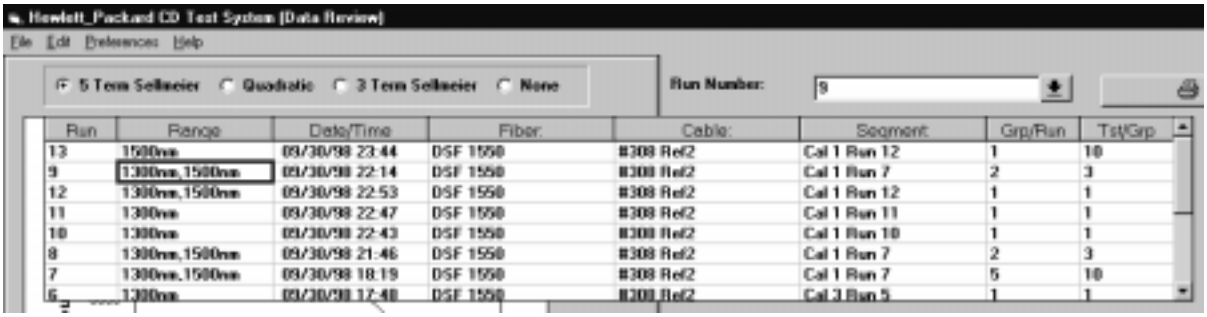

Figure 6-20. Data Review Window Run Number Selection

. The software will display all the information about that run.

Graphs and tables of the data can be accessed by clicking the tabs labeled `CD Graphs`, `CD List`, `Gain Graph`, `Gain List`, and `CD Stats`.

The user can tailor some of the features in the `Data Review` window by clicking on `Preferences` from the menu bar, then `Data Presentations` in the drop-down menu. The following `Data Presentation Preferences` window will be displayed:

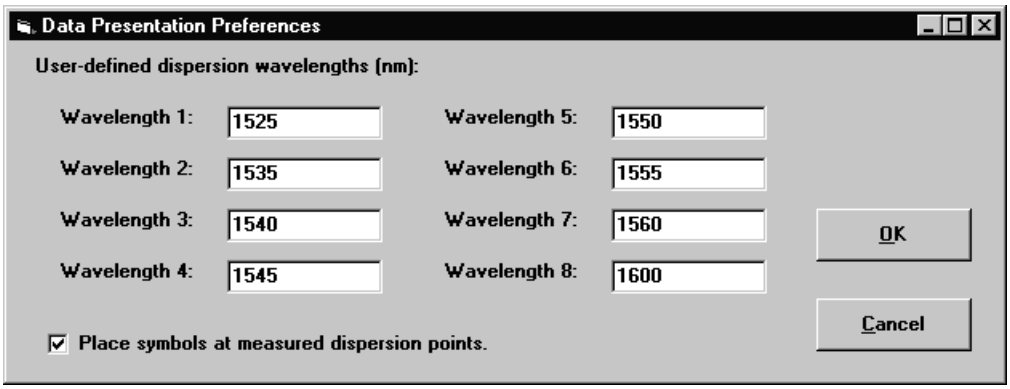

Figure 6-21. Data Presentation Window

The wavelengths to display the dispersion results are entered in this window. The user can also choose to not display the directly calculated dispersion data points. Experiment with these choices to suit your needs.

The five-term Sellmeier fit can yield multiple zero-dispersion wavelengths. All the values and their associated slopes are shown in the `Data Review` window shown in Figure 6-19. The software searches for dispersion zeros in a wavelength range equaling about five times the measurement span—2.5 times each side of the center wavelength. This allows identification of zero-dispersion wavelengths which fall outside of the measurement range. In some cases, due to the peculiarity of the five-term Sellmeier fit, zero-dispersion wavelengths found outside of the measurement range may not correspond to actual zero-dispersion wavelengths of the device under test.

Examine the Dispersion at Selected Wavelengths

1 The dispersion and the dispersion slope at any wavelength can be examined by typing the wavelength directly into the table in the `Data Review` window. These values are calculated using the selected curve fit.

> If the wavelength entered is outside of the measurement range, the results are indicated in red (dark grey in this manual).

2 To return the wavelengths to a set of values previously set up under the `Preferences` menu, click the `Recall λ` button from the lower right of the `Data Review` screen.

3 The user can choose whether or not to have the dispersions and slopes normalized by the length, in km. To do this, click the `km` button to the right of the list box in the `Data Review` window.

Viewing CD Graphs

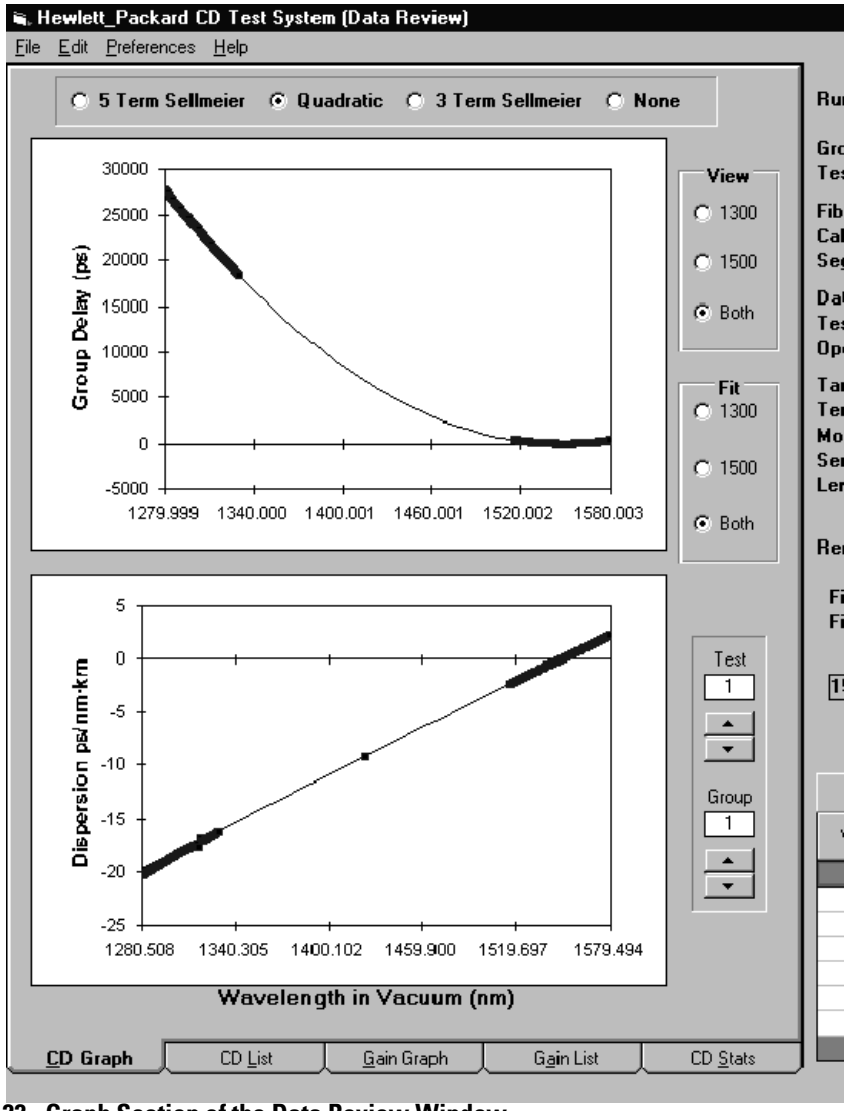

Figure 6-22. Graph Section of the Data Review Window

The results of a chromatic dispersion measurement are shown graphically in the `CD Graphs` display. Use the buttons to the right of the graph to choose the group and test of interest. Click either the `5 Term Sellmeier`, `Quadratic`, `3 Term Sellmeier`, or `None` option buttons above the graphs to select the type of curve fit.

The top graph shows the relative group delay points and fitted curve. The bottom graph shows the computed dispersion. Dispersion points are computed from pairs of group delay points and are displayed midway between the corresponding wavelengths. The smooth dispersion curve is derived from the fitted group delay curve. Length normalization can be changed at any time by clicking the `km` button from the `Review Data` window as shown in Figure 6-19.

Viewing the CD Data List

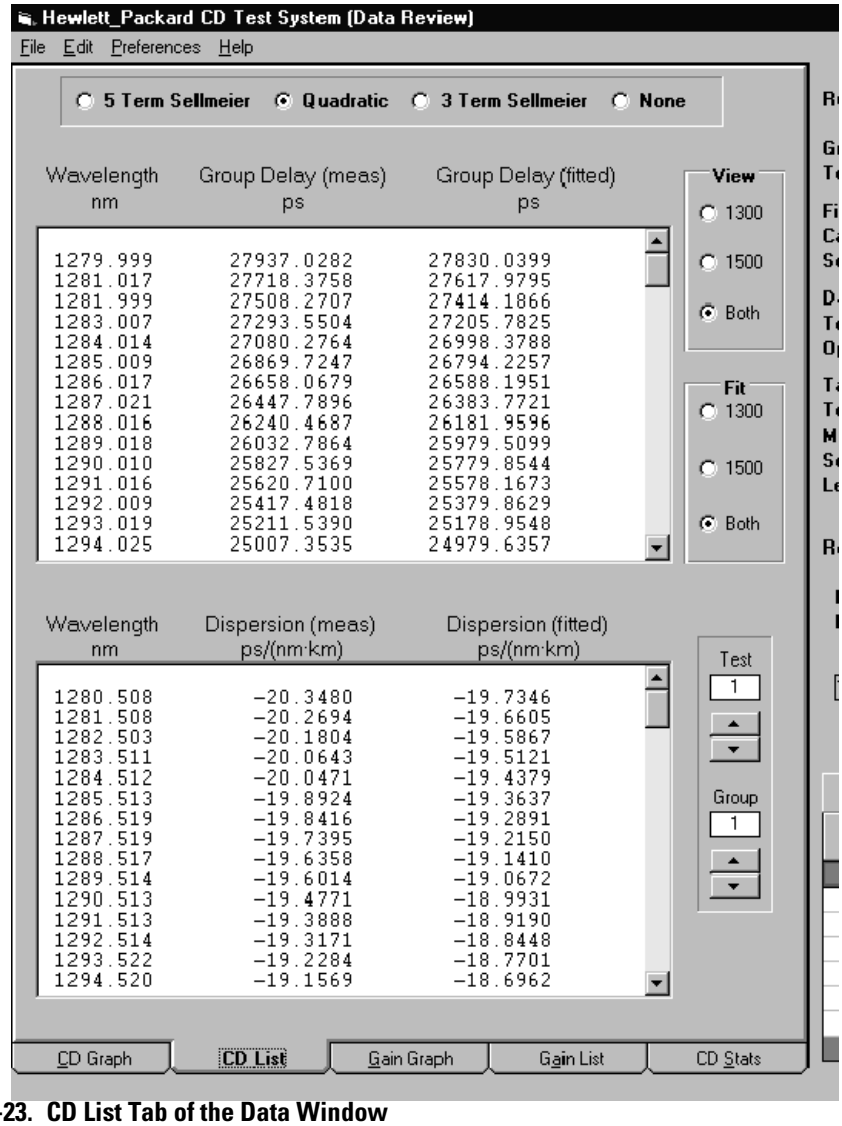

Figure 6-23. CD List Tab of the Data Window

The information under the `CD List` tab is a table display of the information contained in the corresponding graphs. If a wavelength meter was used in the measurement setup, the actual measured wavelengths will be displayed. Length normalization can be changed at any time by clicking the `km` button.

The column of data titled `Dispersion (meas.)` is the directly calculated dispersion obtained by calculating the slope of the group delay with respect to wavelength, as follows:

Dispersion (meas.)= $\Delta\tau / \Delta\lambda$

$\Delta\tau$ is the measured difference in group delay and $\Delta\lambda$ is the difference in wavelength between adjacent points. These data points will appear to be noisy when the wavelength step size is less than about 1 nm because the wavelength step is in the denominator of the calculation. Therefore a small wavelength step will tend to amplify any noise in the group delay data. The amount of scatter of the directly calculated dispersion has minimal impact

on the accuracy of the zero-dispersion wavelength because the zero-dispersion wavelength is obtained from the fitted curve. When the wavelength step is very small, less than about 0.01 nm, and a wavelength meter is used with the system, it is possible for two or more data points to have the same wavelength due to imperfect tuning of the tunable laser source. When this happens, it is no longer possible to directly calculate the dispersion from adjacent group delays because the denominator in the above equation is zero. In such cases, the software will take the last data point of the group of data with the same wavelength and use it for the direct calculation of dispersion. However, when the group delay data is automatically stored in the database, all points are saved.

To copy columns of data in the above window to the clipboard:

1. Highlight the section of data to be copied.
2. Press **Ctrl-C**. This copies the highlighted content into the clipboard.

To copy the data to a text editor:

1. Start the text editor of your choice.
2. Position the cursor at the appropriate point in the text editor and press **Ctrl-V** to paste directly into the text editor. The data in the clipboard is inserted into the text editor.

For more detailed information on cutting and pasting in the Windows NT Operating system, please see the Windows NT user's guide.

Viewing Gain Graphs

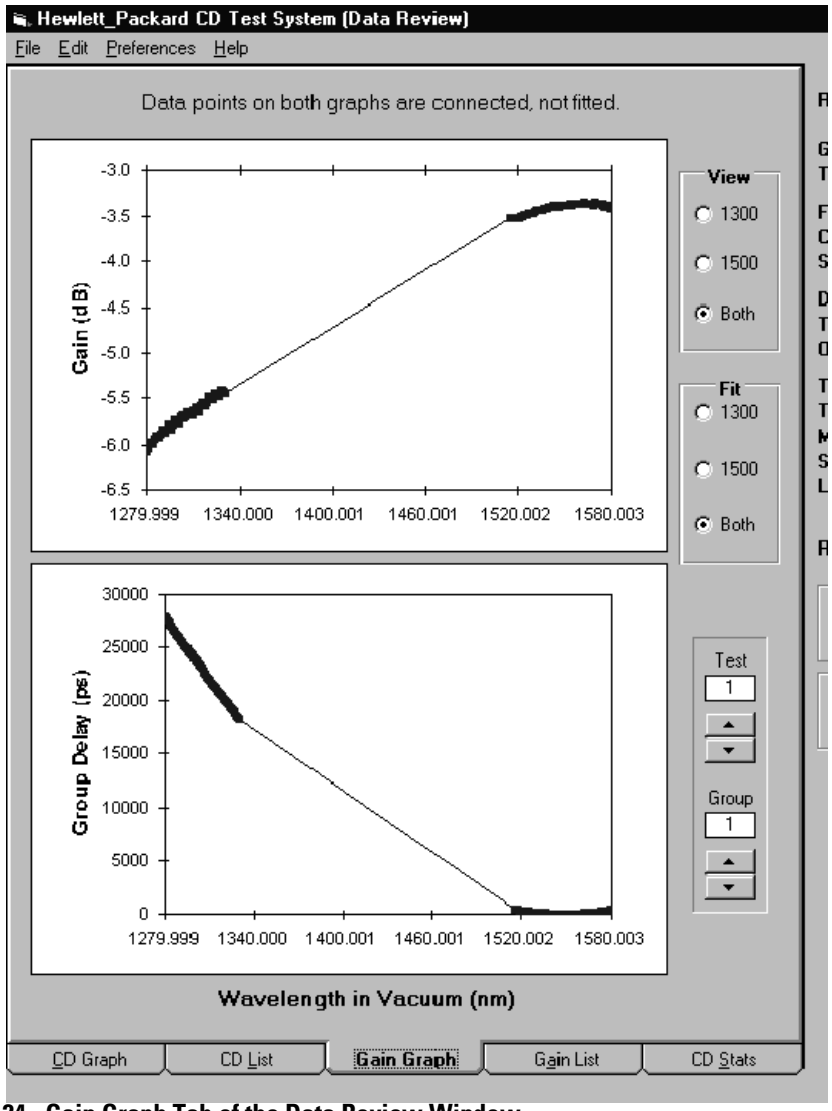

Figure 6-24. Gain Graph Tab of the Data Review Window

The information under the `Gain Graph` tab provides a graph of the measured gain and for reference, a graph of the measured relative group delay. In both of these graphs, the displayed points are connected by straight line segments, with no curve fitting.

Viewing the Gain List

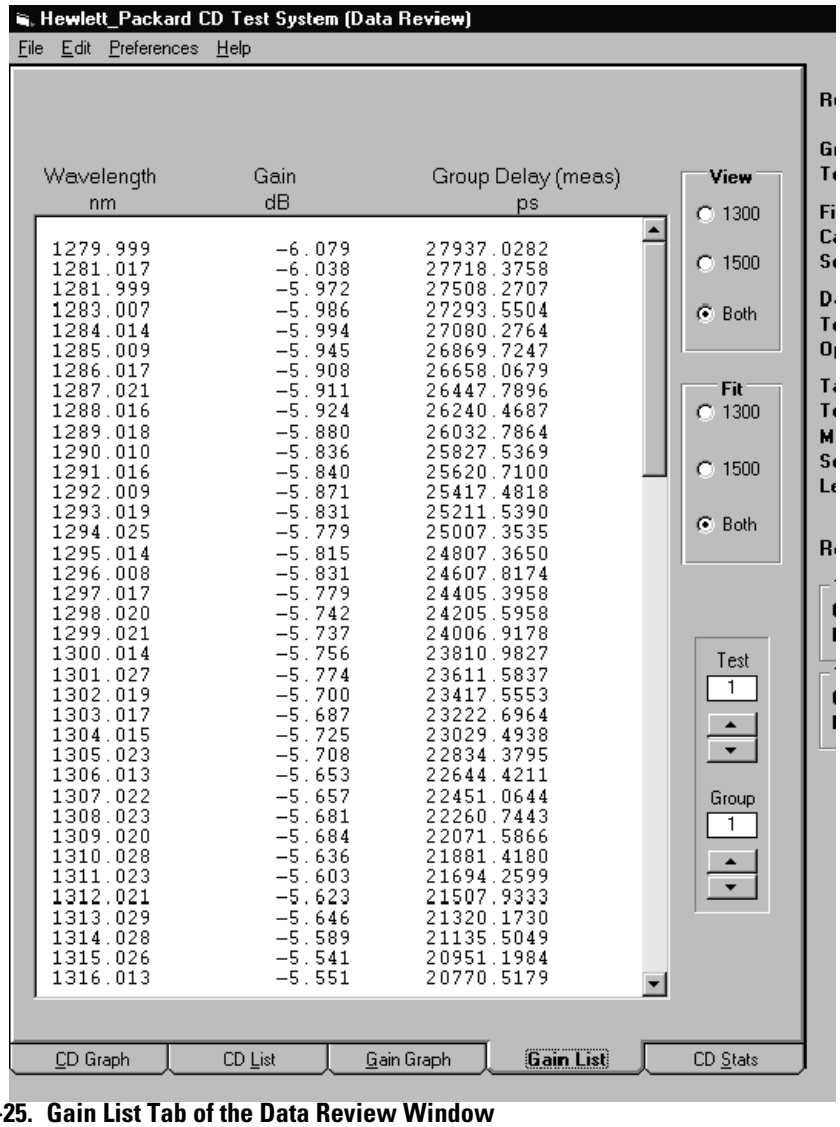

Figure 6-25. Gain List Tab of the Data Review Window

The information under the `Gain List` tab provides a table display of measured gain and measured relative group delay. If a wavelength meter was used in the measurement setup, the actual measured wavelengths will be displayed.

The information from the `Gain Graphs` and the `Gain List` tabs can be viewed only if both the CD and gain measurements have been performed. To select both measurements, select `CD/Gain Meas` on the `SetParametersFor` menu in the HP 86037A Chromatic Dispersion Test System software setup window.

Viewing the CD Statistics

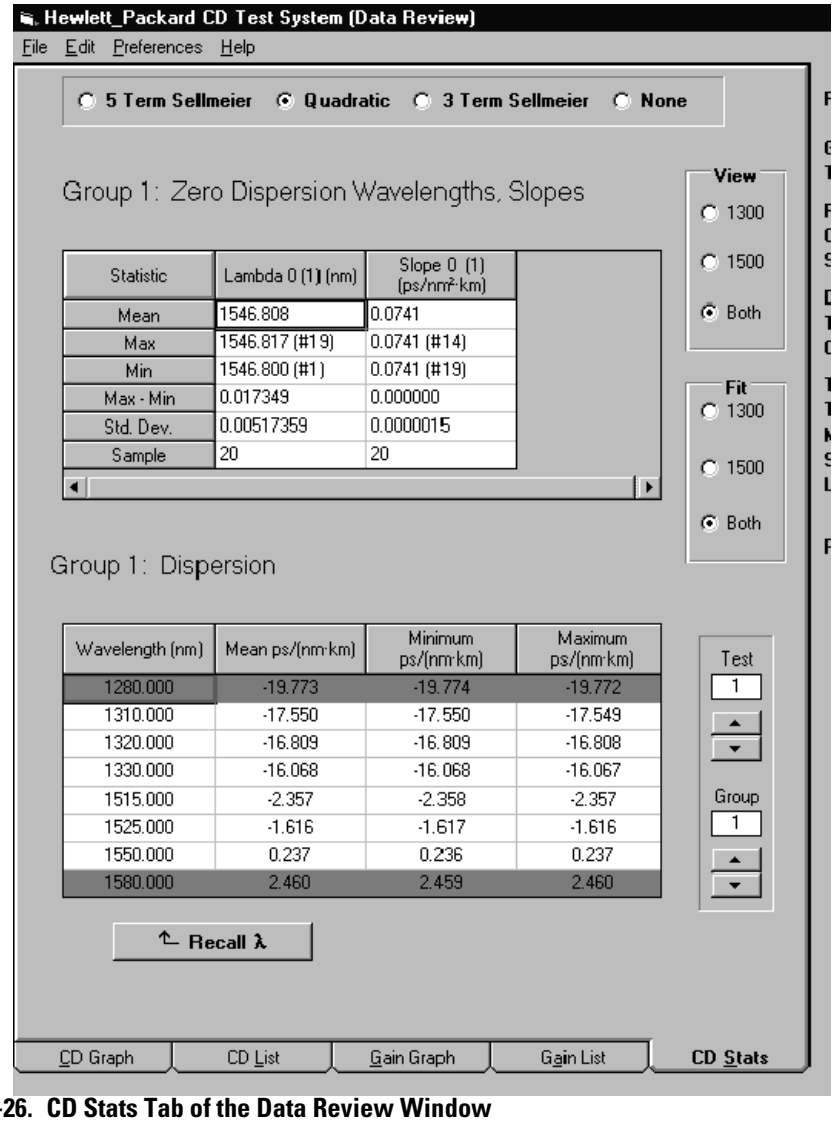

Figure 6-26. CD Stats Tab of the Data Review Window

The information under the `CD Stats` tab shown in Figure 6-26 provides a statistical analysis of a single group of two or more tests. The top table lists the statistics for λ_0 (lambda zero) and the dispersion slope at λ_0. The numbers of the tests from which maximum and minimum values are taken are shown in parentheses beside the listed values. The cell labeled `Sample` indicates the number of tests which exhibited a value of λ_0 equal to or near the displayed value. If the measurements produced multiple values of λ_0 that differ substantially, these values and the corresponding dispersion slopes, can be viewed by adjusting the scroll bar below the display.

The lower table shows the dispersion statistics at a series of user-selectable wavelengths. Wavelengths falling outside of the measurement range are shown in red (dark gray in this manual). The dispersion values listed are computed from the curve fitted to the relative group delay measurements. Use the option buttons above the tables to change the type of curve fit. The statistics for the five-term Sellmeier fit can contain multiple zero-dispersion wavelengths. To view them, scroll horizontally across the `Statistics` list box.

Setup Files

Setup files allow the test parameters to be set up in a predefined manner. The user can recall the setup file prior to performing the test. This makes it possible for measurements to be made without the user having detailed knowledge about the measurement parameters, and saves time because parameters do not have to be reentered.

Under the `System` Menu, there are two functions: `Save Setup` and `Open Setup`. These two functions do not control the selection of the wavelength meter.

Opening a Setup

1 Choose `Open Setup` from the `File` menu as shown in Figure 6-27.

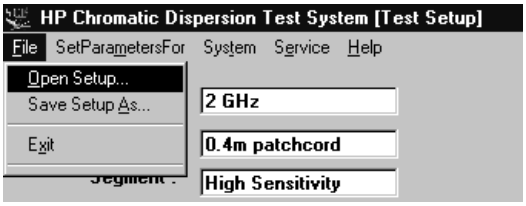

Figure 6-27. Open Menu

The `Open Setup` dialog box shown in Figure 6-28 will be displayed.

Figure 6-28. Open A Setup Dialog Box

2 In the `File Name` list box, click once on the file you want to open, or type its name in the `File Name` field.

3 Click the filename once and click `Open` to open the setup file.

Saving a Setup

The `Save Setup As...` command in the `File` drop-down menu displays a dialog box that allows you to save a setup in a file and to specify the location in which it is to be stored.

After all test parameters have been set, save them as follows:

1 Choose `Save Setup As...` from the `File` menu as shown in Figure 6-29.

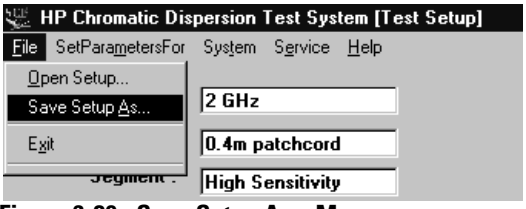

Figure 6-29. Save Setup As... Menu

The `Save Setup As...` dialog box shown in Figure 6-30 will be displayed.

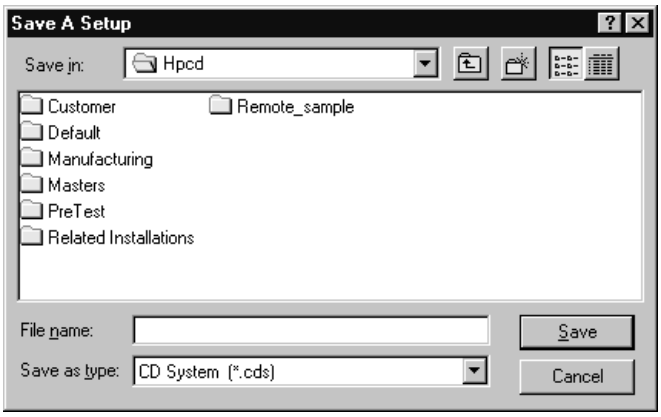

Figure 6-30. Save Setup As... Dialog Box

2 To save the setup, ensure that the correct directory is selected in the `Save In:` field and type a name in the `File Name` field. The HP 86037A Chromatic Dispersion Test System application automatically adds the `.cds` extension.

3 Click `Save`. The parameters are saved in the specified file and location. This operation also adds the setup to the file list at the bottom of the `File` menu. This list can be used to quickly access the most recently used files.

Export Files

Export files are ASCII files that contain all the data and results of a test. They allow the user to perform further analysis of the data using other software, such as a spreadsheet.

Exporting the Data

1. Click on the `Review Data` button .
2. Select `Export Data` from the `File` menu as shown in Figure 6-31.

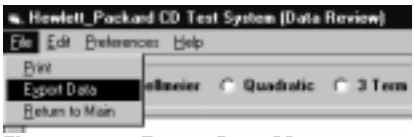

Figure 6-31. Export Data Menu

The `Export Data` dialog box shown in Figure 6-32 will be displayed.

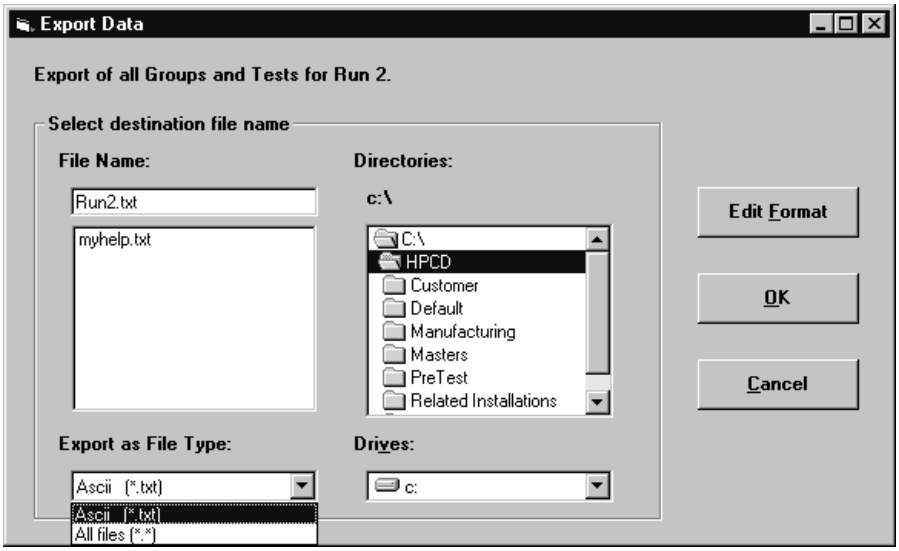

Figure 6-32. Export Data Dialog Box

3. Select a file format in the `Export as File Type` list box. The HP 86037A Chromatic Dispersion Test System software can convert files to ASCII (*.txt) format.
4. Select the location to save the export file by using the `Drives` drop-down menu and `Directories` list box.
5. Enter a name for the exported file in the `File Name` field or highlight a name in the list box.
6. Click `OK`.

Selecting the Export File Format

To customize the file being exported, select the `Edit Format` button in the `Export Data` window.

The `Export File Format` window shown in Figure 6-33 will be displayed.

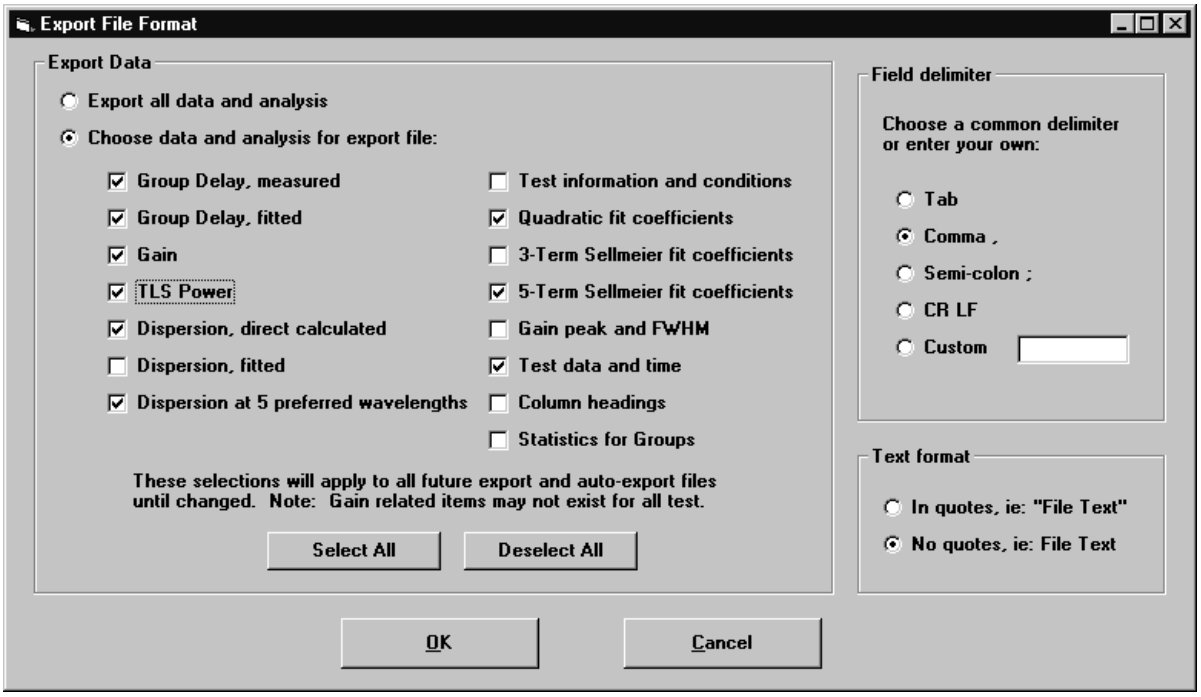

Figure 6-33. Export File Format Window

Table 6-1. Export File Formats

Format	Description
Group Delay, measured	Selecting this option will output a list of measured group delay in raw data format.
Group Delay, fitted	This selection will output a list of measured group delay using the curve fit selected in the `Data Review` window.
Gain	This selection will output a list of gain measured at each wavelength. This option is only available if a gain measurement was performed as part of the test run.
TLS Power	This selection will output the TLS power setting to the file being exported.
Dispersion, direct calculated	This selection will output a list of directly calculated dispersion values, with no curve fitting.
Dispersion, fitted	This selection will output a list of dispersion values, with the appropriate curve fit selected in the `Data Review` window.
Dispersion at 5 preferred wavelengths	This selection will output the list of selected wavelengths chosen in the `Data Review` window.

Table 6-1. Export File Formats (Continued)

Format	Description
Test information and conditions	This selection will export a list of the data found on the right hand side of the `Data Review` window, dealing with test conditions.
Quadratic fit coefficients **3-Term Sellmeier fit coefficients** **5-Term Sellmeier fit coefficients**	Choosing one of these buttons will export the relevant fit coefficients to the export file. For a more detailed explanation of these terms, please see the glossary in the back of this manual.
Gain Peak and FWHM	This selection will export a copy of the measured Gain Peak and Full Width, Half Max. values to the export file. This option is only available if the a gain measurement was performed as part of the test run.
Test Data and Time	This selection will export a copy of the time, date, supervisor, and user information to the export file.
Column Headings	This selection will export the data label information for all the columnar lists to the export file
Statistics for Groups	This selection will export a copy of all the information shown in the `CD Stats` tab of the `Data Review` window.
Field Delimiter and Text Format	These options allow the exported data to be customized for input into a spreadsheet program, such as Microsoft Excel. Please consult your spreadsheet program's user documentation to see what format is best suited for importing the data.

The options in the `Field Delimiter and Text Format` section of the `Export File Format` window allow the exported data to be customized for input into a spreadsheet program, such as Microsoft Excel.

Select whether the exported data will be `in quotes, ie: "File Text"`, or `no quotes, ie: File Text` from the `Text Format` section of the `Export File Format` window.

Please consult your spreadsheet program's user documentation to see what format is best suited for importing the data.

Setting Parameters

This section describes the procedure for changing the measurement parameters.

For a suggestion on the values of the parameters to use for different applications, refer to "Suggestions on Setting the Test Parameters" on page 8-4.

The CD and Gain Measurement Settings

The CD/Gain measurements settings are used to perform a measurement.

1 Choose `CD/Gain Meas...` from the `SetParametersFor` program menu.

The `CD and Gain Measurement Settings` window shown in Figure 6-34 will be displayed. To select the HP 86037A Chromatic Dispersion Test System software default settings, click the `Set HP Defaults` button.

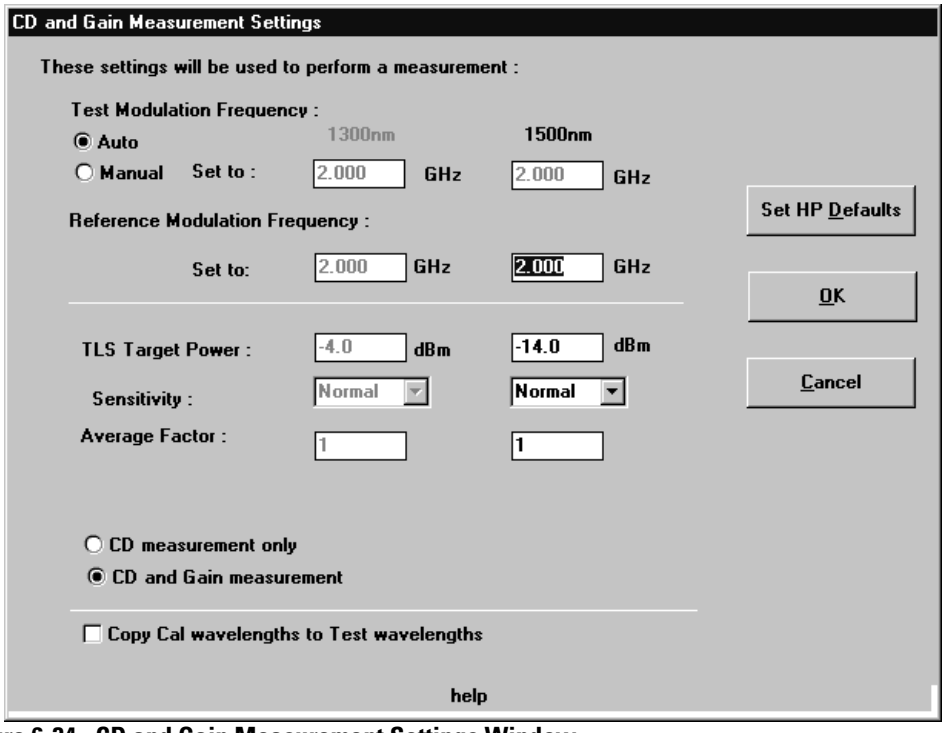

Figure 6-34. CD and Gain Measurement Settings Window

2 Select the method for setting the modulation frequency, either `Auto` or `Manual`. If the `Manual` option is selected, enter a value in the `Test Modulation Frequency` field for the 1500 nm test.

The `Test and Reference Modulation Frequencies` are the RF frequencies used to modulate the optical signal in the test and reference measurement operations.

3 Enter a value for the `TLS Target Power` level.

The `TLS Target Power` is the level requested of the Tunable Laser Source. If it cannot supply the full amount, it will supply as much as it can.

4 Select the `Sensitivity`: `Normal`, `High`, or `Highest`.

The `Sensitivity` setting affects the length of time required to complete a measurement. The higher the sensitivity, the longer the measurement time.

The `Sensitivity` setting determines the IF bandwidth used by the network analyzer. The settings `Normal`, `High` and `Highest` correspond to 300, 100 and 30 Hz, respectively. Noise is reduced at higher sensitivity, but measurement time increases. As an example, a measurement consisting of twenty wavelength steps had these measurement times:

Sensitivity	Measurement Time
Normal	2 min. 50 sec.
High	4 min. 00 sec.
Highest	7 min. 52 sec.

5 The `Average Factor` setting controls the number of network analyzer sweeps which are averaged to measure group delay at each wavelength point. Noise is reduced by one over the square root of the averaging factor, but measurement time increases in proportion to averaging factor..

6 Enable the `CD measurement only` option, or the `CD and Gain measurements` option by clicking on the appropriate radio button. For measurements on fibers, the CD measurement is typically the only measurement of interest. For measurements on filters or systems containing optical amplifiers you may be interested in the passband of the device under test because the CD data is meaningful only within the passband.

Selecting the `CD and Gain measurement` option will increase the measurement time. For example, in a measurement run consisting of 20 wavelength steps, the measurement time was 3 minutes 46 seconds for `CD and Gain measurement`, as compared to 2 minutes 50 seconds for `CD measurement only`. To enable this option, click the `CD and Gain Measurement` option button.

7 Select `Copy Cal wavelengths to Test wavelengths` to copy the wavelength limits in the calibration to the wavelengths for the measurement. This eliminates the need to enter the wavelength limits twice, if they are identical.

8 To accept the displayed values, click `OK`.

These displayed values will be used the next time the program is started, a test is run, or a setup is saved.

The Length Measurement Settings

1 Click `Length Meas` from the HP 86037A Chromatic Dispersion Test System test setup screen `SetParametersFor` menu as shown in Figure 6-35.

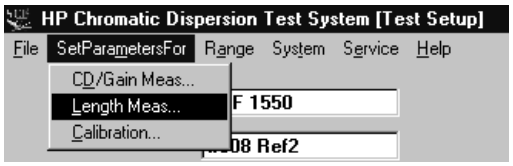

Figure 6-35. SetParametersFor Menu

The `Length Measurement Settings` window shown in Figure 6-36 will be displayed.

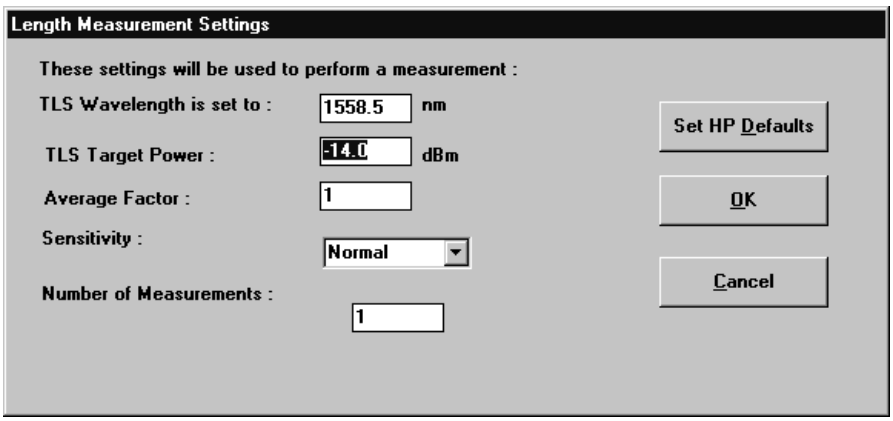

Figure 6-36. Length Measurement Settings Window

To select the HP 86037A Chromatic Dispersion Test System software default settings, click the `Set HP Defaults` button.

2 Enter the desired values for the `TLS Wavelength.`

3 Enter the `TLS Target Power`.

The `TLS Target Power` is the level requested of the Tunable Laser Source. If it cannot supply the full amount, it will supply as much as it can.

4 The `Average Factor` setting controls the number of network analyzer sweeps which are averaged to measure group delay at each wavelength point. Noise is reduced by one over the square root of the averaging factor, but measurement time increases in proportion to averaging factor.

5 Select the `Sensitivity`: `Normal`, `High`, or `Highest`.

The `Sensitivity` setting affects the length of time required to complete a measurement. The higher the sensitivity, the longer the measurement time.

The `Sensitivity` setting determines the IF bandwidth used by the network analyzer. The settings `Normal`, `High` and `Highest` correspond to 300, 100 and 30 Hz, respectively. Noise is reduced at higher sensitivity, but measurement time increases.

6 Enter the desired value for the `Number of Measurements.`

7 To accept the displayed values, click `OK.`

The Calibration Settings

1 Click `Calibration` from the HP 86037A Chromatic Dispersion Test System test setup screen `SetParametersFor` menu as shown in Figure 6-37.

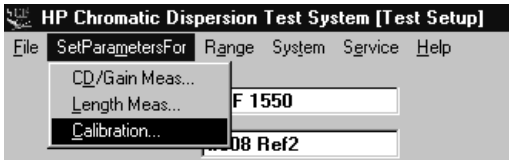

Figure 6-37. SetParametersFor Menu

The `Calibration Settings` window shown in Figure 6-38 will be displayed.

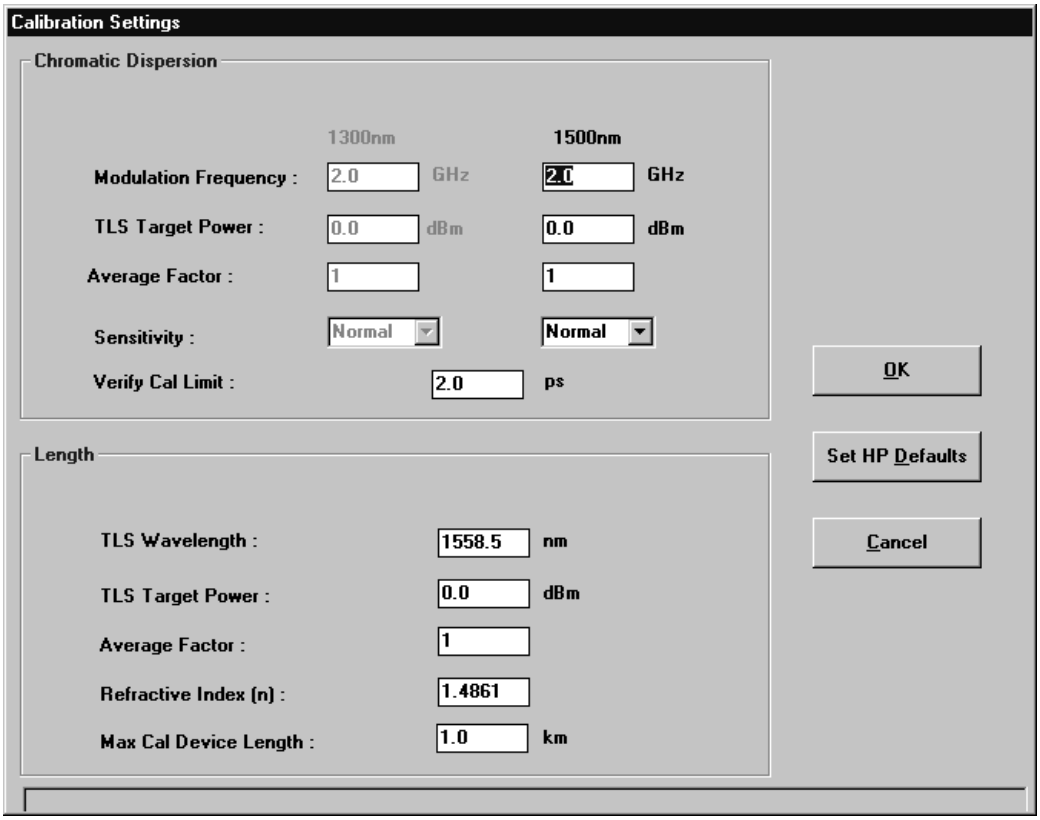

Figure 6-38. Calibration Settings Window

To select the HP 86037A Chromatic Dispersion Test System software default settings, click the `Set HP Defaults` button.

Chromatic Dispersion Settings

2 Enter a value in the `Test Modulation Frequency` field.

The `Test and Reference Modulation Frequencies` are the RF frequencies used to modulate the optical signal in the test and reference measurement operations.

3 Enter a value for the `TLS Target Power` level.

The `TLS Target Power` is the level requested of the Tunable Laser Source. If it cannot supply the full amount, it will supply as much as it can.

4 The `Average Factor` setting controls the number of network analyzer sweeps which are averaged to measure group delay at each wavelength point. Noise is reduced by one over the square root of the averaging factor, but measurement time increases in proportion to averaging factor.

5 The measurement time is proportional to the average factor. Noise reduction is proportional to the square root of the average factor. Select the `Sensitivity`: `Normal`, `High`, or `Highest`.

The `Sensitivity` setting affects the length of time required to complete a measurement. The higher the sensitivity, the longer the measurement time. Refer to the example at the beginning of this section.

The `Sensitivity` setting determines the IF bandwidth used by the network analyzer. The settings `Normal`, `High` and `Highest` correspond to 300, 100 and 30 Hz, respectively. Noise is reduced at higher sensitivity, but measurement time increases.

6 Enter the group delay limit for the calibration verification in the `Verify cal limit` field. This is the limit against which the system compares the data obtained when a calibration verification is performed. Refer to chapter 9 for more details.

Length Settings

These are the parameters the system uses when a length calibration is performed during a calibration. It measures the length of the "thru" cable and stores it for later use.

7 Set the `TLS Wavelength.`

8 Enter the `TLS Target Power`.

The `TLS Target Power` is the level requested of the Tunable Laser Source. If it cannot supply the full amount, it will supply as much as it can.

9 The `Average Factor` setting controls the number of network analyzer sweeps which are averaged to measure group delay at each wavelength point. Noise is reduced by one over the square root of the averaging factor, but measurement time increases in proportion to averaging factor..

The measurement time is proportional to the average factor. Noise reduction is proportional to the square root of the average factor.

10 Enter the `Refractive Index (n)`.

11 Enter the maximum length for the “thru” cable under `Max Cal Device Length`. The smaller this length, the faster the length calibration. However, the time savings typically is only about 1 second. Since setting this value lower than the actual “thru” length will result in an incorrect length calibration, this value should be set well above the maximum “thru” length you expect to use. For example, if the maximum "thru" length in your factory is 120 meters, you can set this equal to 0.5 km to avoid potential problems with length calibration.

Configuring the System

This section describes the procedures for configuring the system.

Opening a Database

1 Select `Database Options` on the `System` menu as shown in Figure 6-39.

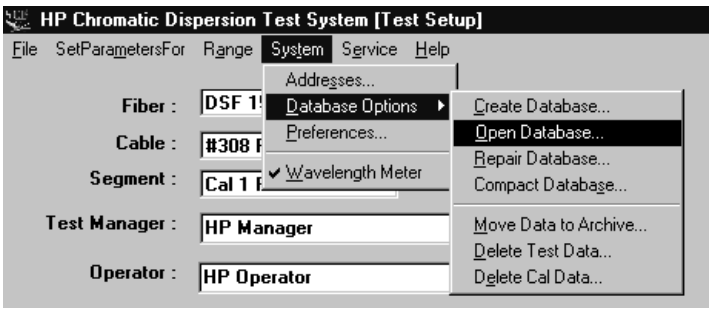

Figure 6-39. Database Options Menu

2 Click on `Open Database` in the drop-down menu.

The window shown in Figure 6-40 will be displayed asking whether you wish to change the current working directory.

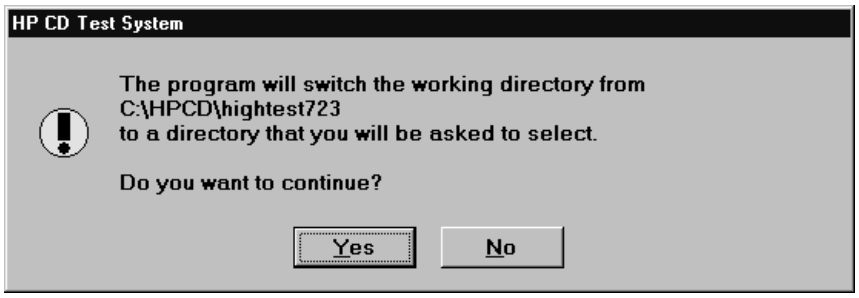

Figure 6-40. Change from Current Directory Prompt

3 Click `Yes` to display the `Select Directory` window shown in Figure 6-41.

Figure 6-41. Select Directory Dialog Box

4 Use the directory tree in the `Select Directory` window to locate the directory containing the new database file. The directory may also be typed into the `Selected Directory` field.

5 In the directory tree list box, click once on the directory where the file is located, or type its name in the `Selected Directory` field.

6 Click `OK`, or double-click the directory name in the directory tree.

After changing databases, the calibration files, devices, test operator, manager's names, and test data from the previous database are no longer available. To make them available, select the previous database directory.

Creating a Database

1 Select `Database Options` from the `System` menu.

2 Click on `Create Database` on the drop-down menu as shown in Figure 6-42.

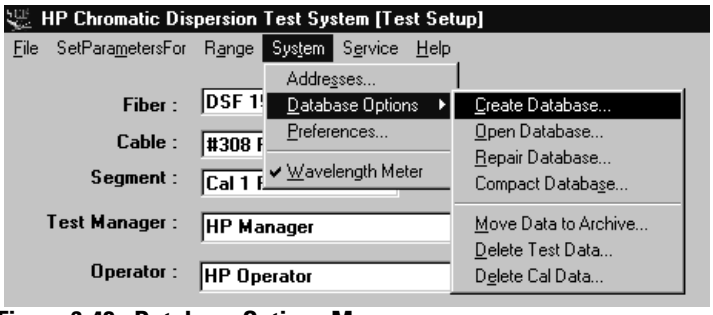

Figure 6-42. Database Options Menu

The window shown in Figure 6-43 will be displayed asking whether you wish to change the current working directory.

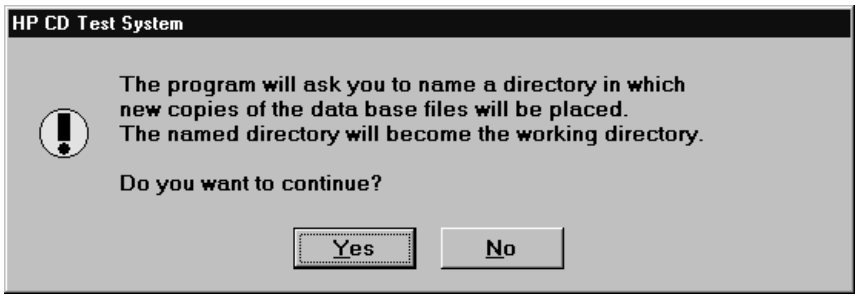

Figure 6-43. Change from Current Directory Prompt

3 Click `Yes` to display the `Select Directory` window in Figure 6-44.

Figure 6-44. Select Directory Dialog Box

4 In the `Selected Directory` field, type the name of the directory where the database resides. If you want to save the database in another directory, select the desired drive and directory using the directory tree list box.

5 Click `OK` to create the new database. This procedure will open the new database automatically.

Repairing a Database

If an error occurs while you are trying to open a database, it indicates that the database file is damaged and must be repaired before it can be opened. Damaged data will be removed during the repair process and is permanently lost and unrecoverable. However, repairing an undamaged database file causes no harm and no data is lost. The database repair function returns a warning if the database file is read only.

The repair function can operate on any database file *other than one that is currently open*. The following procedure describes how to repair a database file.

1 Select `Database Options` on the `System` menu.

2 Click on `Repair Database` on the drop-down menu as shown in Figure 6-45.

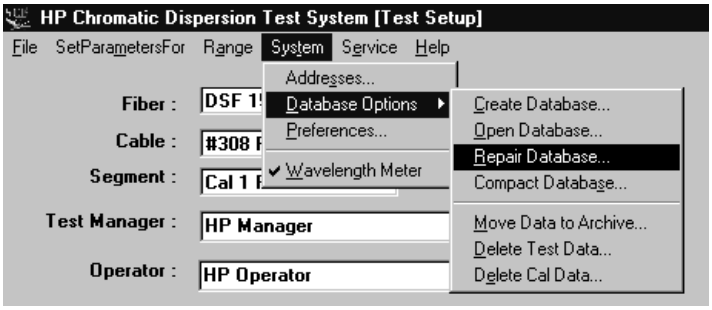

Figure 6-45. Database Options Menu

The prompt shown in Figure 6-46 will be displayed.

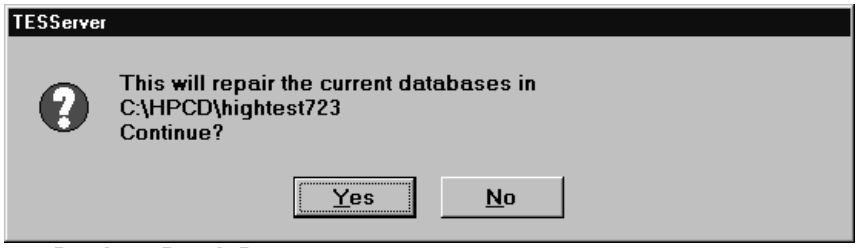

Figure 6-46. Database Repair Prompt

3 Click `Yes` to begin the repair procedure.

> During the repair procedure the database file is compacted, which can result in a file that is smaller than the original.

Compacting a Database

A currently opened database file can be compacted to reduce the amount of disk space it occupies. A database file must be open before it can be compacted. Compacting is automatically performed when a database file is repaired. The following procedure describes how to compact a database file.

1 Select `Database Options` on the `System` menu.

2 Click on `Compact Database` in the drop-down menu as shown in Figure 6-47.

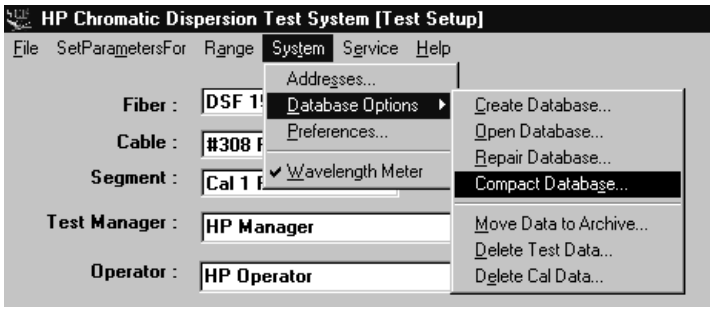

Figure 6-47. Database Options Menu

The following prompt will be displayed:

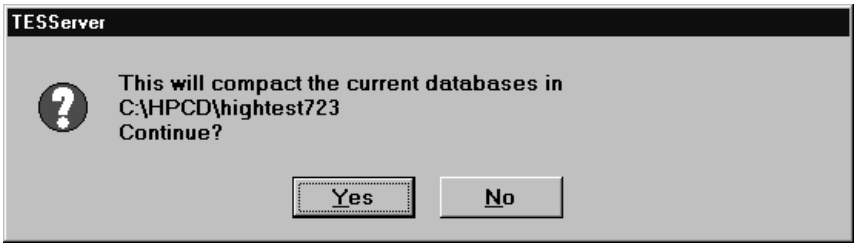

Figure 6-48. Compact Database prompt

3 Click `Yes` to compact the current database file.

Archiving a Database

Large database files are slow and require time to store and retrieve data. The database archive feature helps you manage the size of your database files by allowing you to move test data from the currently opened database file to another database file.

For example, you can create a database file on a floppy disk and then move some tests from your system hard drive to the floppy disk for storage or transport to another system.

You will be asked if you wish to delete the tests after they have been moved.

A database file must be open before it can be archived. The following procedure describes how to archive one or more tests.

1 Select `Database Options` from the `System` menu.

2 Select `Move Data to Archive` from the drop-down menu as shown in Figure 6-49.

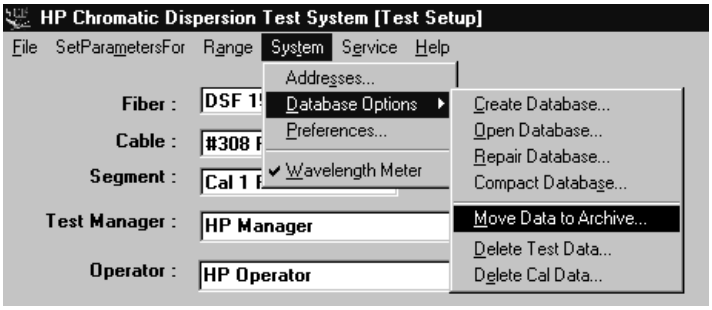

Figure 6-49. Database Options Menu

The following screen will be displayed:

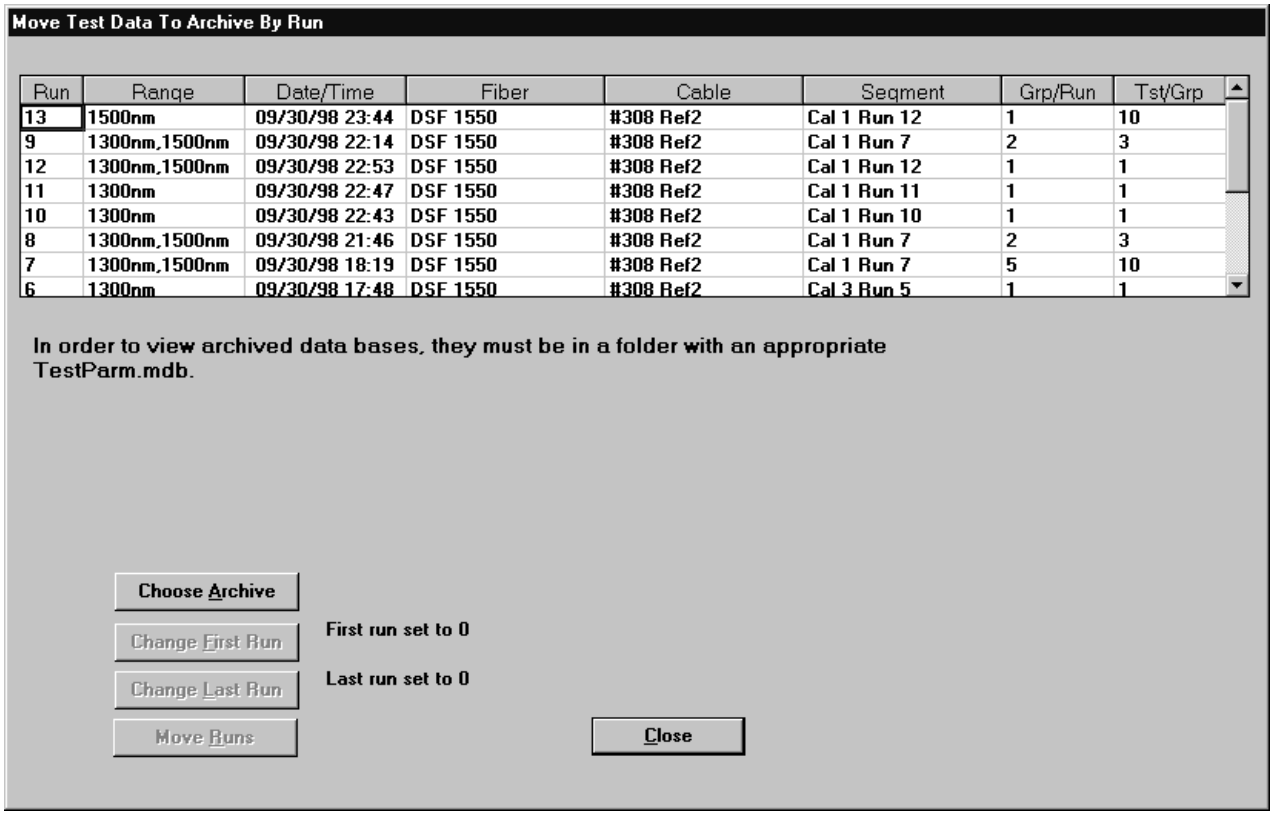

Figure 6-50. Move Test Data to Archive by Run Window

3 Identify the destination database file, including the full path name.

4 Click the `Set First Run` and `Set Last Run` buttons to identify the series of runs you wish to include in the archive.

5 To move the runs, click `Move Runs`.

Following the archive, you can delete the runs from the currently opened database.

Printing Data

The data generated from a chromatic dispersion test can be output to a printer by selecting `Print` from the `File` menu as shown in Figure 6-51.

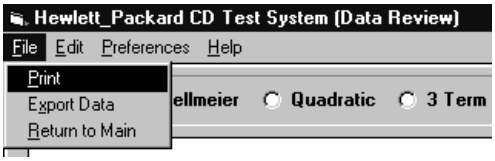

Figure 6-51. Data Review File Menu

The `Print Range` window shown in Figure 6-52 will be displayed.

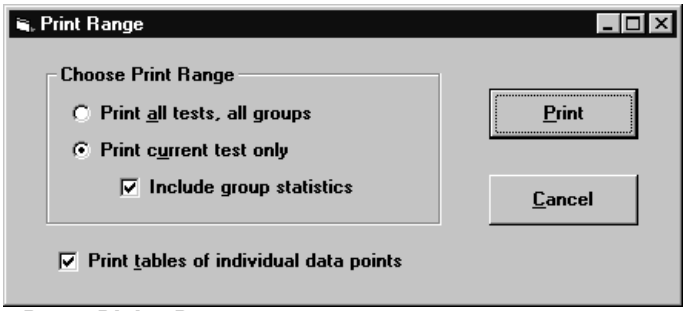

Figure 6-52. Print Range Dialog Box

Click on your choice in the `Choose Print Range` section, and click `Print`

The current window can also be printed by clicking the icon from the `Data Review` window.

Selecting Preferences

The names describing the fields on the `Test Setup` window can be customized for your application.

Changing the Labels

1 From the main screen, select `Preferences` from the `System` menu as shown in Figure 6-53.

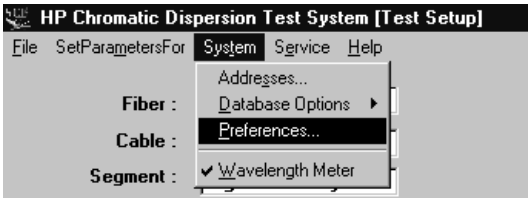

Figure 6-53. System Menu

The `System Preferences` window shown in Figure 6-54 will be displayed.

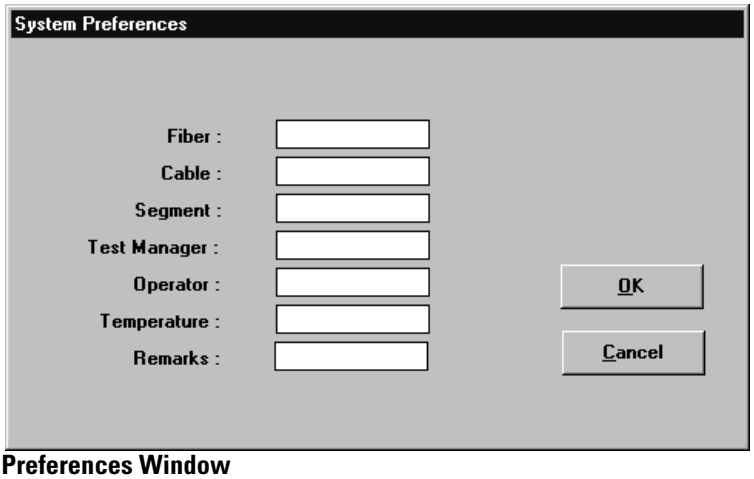

Figure 6-54. Preferences Window

2 Enter the labels you wish to have displayed.

3 Click `OK`.

The `Test Setup` window will display the new labels.

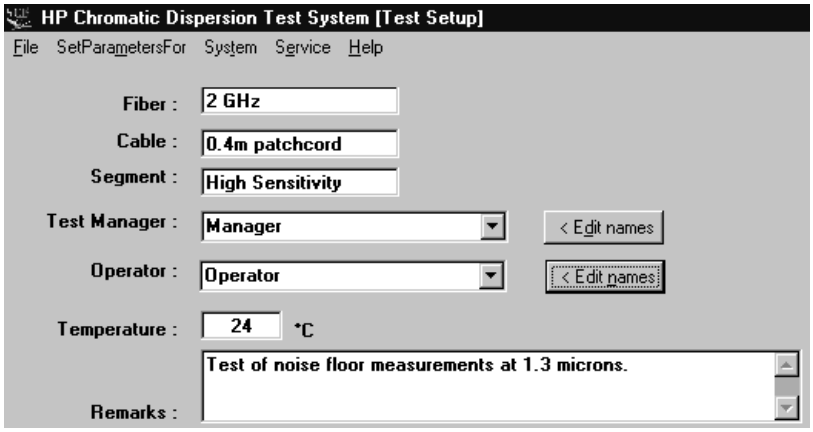

Figure 6-55. Test Label Section of the Main Window

Adding or Removing a Wavelength Meter

1 Select `System` from the HP 86037A Chromatic Dispersion Test System test setup screen menu bar as shown in Figure 6-56.

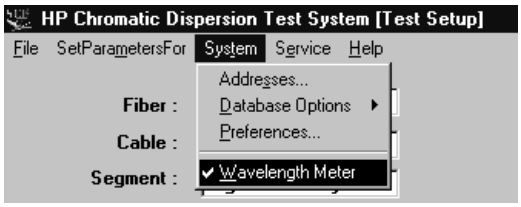

Figure 6-56. System Menu

If a checkmark is displayed next to the `wavelength meter` command, it indicates there is a wavelength meter in the system.

2 To remove a wavelength meter from the system, ensure that `wavelength meter` in the `System` menu does not have a checkmark next to it. Remove the checkmark by clicking on it. The checkmark should not be shown, indicating there is no wavelength meter in the system.

7

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Output Parameter Names 7-34

Remote Interface Documentation

At a glance

This document describes the HP-recommended approach to implementing remote control capability for the HP 86037A Chromatic Dispersion Test System. This documentation supplements the example code included in the directory C:\HPCD\Remote_Sample on the HP 86037A Chromatic Dispersion Test System hard disk.

The procedures in this section should only be attempted by advanced users who have substantial Visual Basic, networking, and Windows NT experience. Always create a backup of the database file before making any changes.

Overview

The HP 86037A Chromatic Dispersion Test System performs three steps during a measurement:

Setup Test	Sets the appropriate parameters in the Test Parameter Database.
Execute Test	Initiates the measurement.
Read Results	Obtains the results of the measurement from the results database.

The HP 86037A Chromatic Dispersion Test System can perform any of these functions while being operated by a remote computer by means of user-supplied software. This is defined as remote operation in this document.

An overview of the interaction between the remote computer and the HP 86037A Chromatic Dispersion Test System is shown in Figure 7-1.

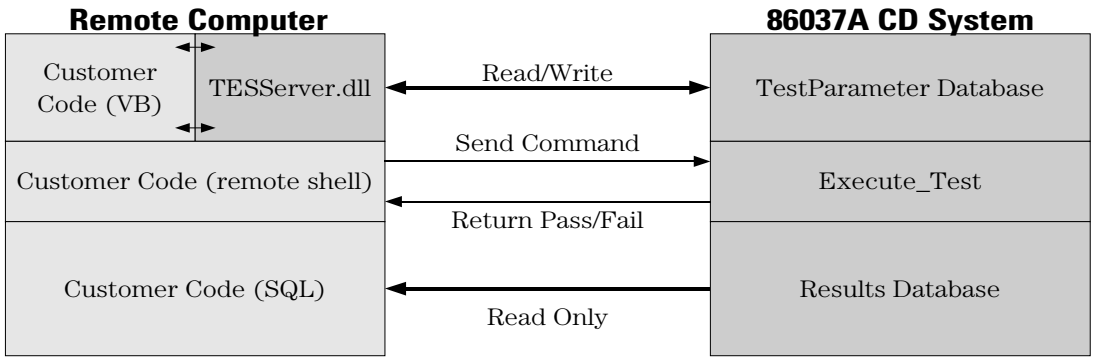

Figure 7-1. Figure 1: Overview of Remote Interaction

Remote Operation

This section describes the important features of remote operation. The next section describes its implementation.

Test Executive

The HP 86037A Chromatic Dispersion Test System software uses a test executive to control the execution of any given measurement. This component is called the Test Executive Shell or TES and is contained in the file TESServer.dll. Remote control of the system interacts with this test executive to edit test parameters and start tests. Results of measurements can be retrieved independently of the test executive.

The test parameter variables that the test executive uses to perform a measurement are grouped according to the internal structure of the test executive. The test executive divides measurements into four hierarchical levels, each having their own corresponding test parameters. These levels are, in order from highest to lowest, the System level, the Test Plan level, the Test Group level, and finally the Test level. The editing of test parameters is discussed in more detail in the Setup Test section of the Implementation section on page 7-5.

Test Setup

To set up the measurement system the customer compiles the interface code with the Visual Basic files and the TESServer.dll file supplied by HP. This allows customer software to read and write test parameters to the Test Parameter database. Communication between the TESServer.dll on the remote machine and the databases on the HP 86037A Chromatic Dispersion Test System is via direct network connection to the hard drive of the HP 86037A Chromatic Dispersion Test System. This network connection is to be supplied by the customer.

Execute Test

Commands to execute, stop, and abort a measurement are issued via a remote shell software interface through the network. The commands are sent to the test executive of the HP 86037A Chromatic Dispersion Test System that executes them. In addition to sending the above commands, the customer software can also receive the pass/fail result of a measurement from the HP 86037A Chromatic Dispersion Test System.

Read Results

The results database can be read directly by the customer using a variety of techniques. The approach documented here uses SQL commands implemented in a Visual Basic example program. As in the Test Parameter database, communication is via a network connection to the HP 86037A Chromatic Dispersion Test system hard drive.

Implementation

To implement in software the three steps described previously, the user requires the following:

- HP 86037A Chromatic Dispersion Test System software (included on the HP 86037A Chromatic Dispersion Test System hard drive and the accompanying CD-ROM) including in particular:
  - TESServer.dll file and associated files (required for the *Setup Test* step)
  - Remote Shell Service software (located in C:\HPCD\RELATED INSTALLATIONS\RSH and required for the *Execute Test* step)
  - Visual Basic source code example files (located in C:\HPCD\REMOTE SAMPLE)
- Visual Basic Professional Version 5.0 development environment (useful for working with the HP example code and required for interaction with the TESServer.dll file used to set the test parameters in the *Setup Test* step).
- Microsoft Access 97, another database tool, or Visual Basic Professional 5.0 (to be used to access the Results.mdb database). The HP example code included with the HP 86037A Chromatic Dispersion Test System uses Visual Basic and SQL commands.

Setup Test

The first step in performing a measurement is setting the test parameters. The basic mechanism for modifying parameters that get passed to a test is:

1 *Extract test parameters*: Request the parameter collection that will be passed to the test.

2 *Edit parameter values*: Modify the test parameter value(s) inthe collection.

3 *Save test parameters*: Return the collection to the TestParameter database (testparm.mdb)after all editing is complete.

When the measurement is executed, the collection is retrieved by the test executive from the Test Parameter database and used to perform the measurement.

Extract Test Parameters

WARNING

The test parameter database is a complicated structure. Damage to the testparm.mdb file can render the HP 86037A Chromatic Dispersion Test System software unusable until the database is replaced or repaired. For this reason, direct access of the testparm.mdb database is not recommended or supported by HP.

The TESServer.dll file provides an approach for reading and writing test parameters to and from the testparm.mdb database without requiring knowledge of the database's underlying structure.

The TESServer.dll can be installed on the remote computer in two ways. A complete set of files can be installed using the installation file on the accompanying CD-ROM. Alternately, the TESServer.dll file along with its companion files: tes.ini, io.mdb and security.mdb may be copied from the HP 86037A Chromatic Dispersion Test System C:\HPCD directory. Once installed the dll should be registered with the MS Windows NT registry on the remote machine. This may be done by simply using a command such as "regsvr32.exe C:\HPCD\TESServer.dll".

The tes.ini file determines the initial settings for the TESServer.dll and an example is shown below. This file is used to set the default locations of the four databases required by the TESServer.dll on startup. None of the other items in the ini file should be changed. Typically, the path of the io and security databases are left at the C:\HPCD directory of the remote machine while the location of the test parameter and results databases are set to the location of the HP 86037A Chromatic Dispersion System that is to be controlled. In this example testparm.mdb and results.mbd are located on the "F" hard drive (redirected via the LAN).

Example TES.INI File:

```
[Reporting]
NonDefault=False
[TestLog]
LogToFileEnabled=False
LogToScreenEnabled=True
MsgLines=100
[OperatorPrompt]
AutoResponseEnabled=False
PromptDuration=0
[SplashScreen]
NonDefault=False
Filename=
[PathNames]
TestParms=F:\HPCD\CUSTOMER
IOConfig=C:\HPCD
Security=C:\HPCD
Results=F:\HPCD\CUSTOMER
TestLog=F:\HPCD\CUSTOMER
[Station]
;StationID=Customer_Low_Band
StationID=Customer_Dual_Band
;StationID=Customer_Dual_Band
;StationID=PreTest
[Version]
VersionNo=A.07.27
```

When the test parameter editor is started, the first action is to login to the TESServer.dll as shown in the following:

```
'First create an instance of the TESManager
Set TESMngr = New TESManager

'Open the TESManager session
TESMngr.OpenSession
```

If the TESServer.dll is not found, check that it is registered under the “project\references” menu in the Visual Basic IDE. Once located, the user must log in with a user ID appropriate for editing the test parameter database as shown below:

```
'Hardcoded userID and password for editing test parameters:
TESMngr.Controller.ShellConfig.sCommandOpts = "-userid editor -passwd parm"
```

This starts the TESServer in a mode useful for editing the test parameters of the Testparm.mdb database. As can be seen from the tes.ini file, the database may be located anywhere on the network as long as its location is shown by the path in the tes.ini file.

Once the user is logged into the TESServer.dll the test parameters may be edited. Typically the parameters are not dealt with individually. The test parameters are returned as a collection of variables, one collection for each level in the test executive. An example of the code for obtaining the collections for a given Test Group is shown below:

```
m_sActiveSystem = m_oController.ActiveSystem    'This line of code returns the active
                                                'system, i.e. HP 86037A
m_sActiveTestPlan = "Standard_Test_Plan"        'This line of code sets the active test
                                                'plan, always '"Standard_Test_Plan"

Set m_colTestsToRun = Nothing                   'These 2 lines clear the collection
Set m_colTestsToRun = New Collection

add_test "Test_Gain_Phase"                      'These 2 lines add the TES Tests to be edited
add_test "Test_Length"                          'to the collection

m_sActiveTestGroup = "Start_Test"               'This sets the Test Group for the 'variables
                                                'to be edited

setup_testplan                                  'The complete code for this subroutine 'is
                                                'given below

m_oController.LoadParms "", "", "", ""          'This obtains the test parameters from
                                                'testparm.mdb

Set colCDSystemParms = m_oController.m_colSystemParms         'The first three collections
                                                              'are Visual Basic collection
Set colTestPlanParms = m_oController.m_colTestPlanParms       'objects.

Set colStartTestGroupParms = m_oController.m_colTestGroupParms
Set colTestParms = m_oController.m_oTestParms                 'This is a TEScollection or
                                                              'a collection of collections.

Set TEScolTestGainPhaseParms = colTestParms("Test_Gain_Phase")
```

The above code works as follows. The main statement is the invocation of

```
m_oController.LoadParms "", "", "", ""
```

In order for this statement to succeed, one must first build a collection of the particular Tests of interest in the Test Group of interest. It is accomplished with the following lines of code:

```
Set m_colTestsToRun = Nothing
Set m_colTestsToRun = New Collection
add_test "Test_Gain_Phase"
add_test "Test_Length"
```

where “add_test“ is

```
Public Sub add_test(str, Optional bReport = False)
'
' Purpose: Adds the test name to the collection of tests to be run.
'           Used when getting TES parameter collections.
'
Dim sTestName As Variant
Dim rsTestTable As Recordset
Dim oTest As TestObjDataType
With TESMngr.ParmMngr
    sTestName = str
    If .GetTestRecord(sTestName, rsTestTable, True) Then
       Set oTest = New TestObjDataType
       oTest.sTestName = rsTestTable!sTestName
       oTest.lTestID = rsTestTable!lTestID
       oTest.sReference = rsTestTable!sReference
       oTest.iIndex = 1
 oTest.bTestEnabled = True
       oTest.bReportEnabled = bReport
       oTest.sDescription = rsTestTable!sDescription
       m_colTestsToRun.Add Item:=oTest, Key:=oTest.sTestName
       Set oTest = Nothing
    End If
    If m_colTestsToRun.count > 0 Then
       .GetTestSeqOptions m_sActiveTestPlan, m_sActiveTestGroup, _
                                  m_colTestsToRun
    End If
End With
End Sub
```

In essence, “add_test” reads information about the test from the parameter database and places several pieces of that information in a structure that is included in the “m_colTestsToRun” collection. The *LoadParms* method will then cause several parameter collections to be populated. These are: the collection of system level parameters, the Test Plan level parameters, the Test Group level parameters as well as the parameter collections for the individual Tests. The first three levels of parameter collections are standard Visual Basic collections and the individual parameters may be accessed as described below. The parameter collections at the Test level are not VB collections, but are TEScollections. These are much like VB collections but are within a wrapper that handles some error conditions more gracefully than VB collections. TEScollections are close enough to VB collections that the items within the TEScollection can be accessed as described in the “Editing test parameters” section.

Once the Tests and Test Group have been setup, the collection is built with the following subroutine:

```
Private Sub setup_testplan()
   '
   ' Purpose: Tells the test executive (TES) the active test plan
and group.
   '          used in connection with extracting parameter
collections
   '          and executing test plans.
   '
   With TESMngr.Controller' The following lines refer back to the
TES Manager object
         .ActiveTestPlan = m_sActiveTestPlan
         .ActiveTestGroup = m_sActiveTestGroup
         Set .TestsToRun = m_colTestsToRun
         .SerialNumber = ""
         .TestPlanNotes = ""
         Set .Devices = TESMngr.InstMngr.Devices
   End With
End Sub
```

The final step in obtaining the parameter collections is to set a local collection equal to the *TES System parameter* collection, the *Test Plan parameter* collection, and the *Test Group* collection to set TEScollections equal to the individual item collections in the Test level TEScollection of TEScollections. That last assignment is illustrated by the following statement:

```
Set TEScolTestGainPhaseParms = colTestParms("Test_Gain_Phase")
```

There is one such member for each Test in the collection of Tests to be run.

Note that it is also possible for the user to access the collections for the System, Test Plan, or Test Group levels individually. In this case one of the following methods can be used:

```
TESMngr.ParmMngr.LoadSystemParms colSystemParms, ""
TESMngr.ParmMngr.LoadTestPlanParms colTestPlanParms, ""
TESMngr.ParmMngr.LoadTestGroupParms colTestGroupParms, ""
```

Each of the above will return just the one collection, whereas the expression used previously,

```
TESMngr.Controller.LoadParms “”,  “”,  “”,  “”
```

loads all levels of the parameter collections.

There are some limitations with using these more primitive statements. First the test executive supports scoping of parameters. That is, if a parameter occurs at the Test Group level with one value and at the Test level with another value, you need to use the value from the lower level (i.e. the second value) when running the test. If the variable is missing from the Test Group level then you need to use the value from the Test Plan level. The other limitation is that the parameter collections at the Test level are expected to be TEScollections and the result of the *LoadTestParms* is a Visual Basic collection. The example file illustrates the procedure for obtaining the collections individually, but once obtained, any changes are saved as a single group.

The above code requires knowledge of the test parameter names in the testparm.mdb database. These test parameters are the same as the information displayed and entered in the HP 86037A Chromatic Dispersion Test System GUI. The testparm.mdb database contains all of the setup information required in the execution of the individual tests. All of the constants required by the GUI for parameter checking are also included in this database. Each parameter is located in a single location in the database. The location depends upon the type of parameter and how it is utilized in the HP 86037A Chromatic Dispersion Test System software. Full information including the definition of the parameter in the database that is associated with each field in the GUI and documentation of the location of the parameter is supplied in "TES GUI Parameters" on page 7-20.

In order to correctly deal with the parameter scoping described above, the complete Test Plan Hierarchy is shown below. The hierarchy names defined below must be used exactly as shown in order to manipulate data within the testparm.mdb database.

```
Systems:          Customer_Dual_Band
                  Customer_High_Band
                  Customer_Low_Band

Test Plans:       Standard_Test_Plan

Groups & Tests:   Initialize
                       Read_TLS_Specs

                  Start_Test
                       Test_Connect
                       Test_Length
                       Test_Gain_Phase
                       Test_CD
                       Add_Run_Number

                  Modulator_Bias
                       Mod_Bias_Connect
                       Mod_Bias_Adjust_LB
                       Mod_Bias_Adjust_HB

                  New_Calibration
                       Cal_Connect
                       Mod_Bias_Adjust_LB
                       Mod_Bias_Adjust_HB
                       Cal_Length
                       Cal_Gain_Phase
                       Cal_Processing
                       Add_Run_Number

                  Verify_Calibration
                       Verify_Connect
                       Mod_Bias_Adjust_LB
                       Mod_Bias_Adjust_HB
                       Cal_Gain_Phase
                       Verify_CD
                       Verify_Processing

                  Power_Monitor
                       PM_Connect
                       Power_Monitor

                  Select_TLS
                       Select_TLS
```

Edit Test Parameters

The editing of individual parameters in a collection is shown in the following example. As an example of a collection consider *colParms*, a collection of parameter objects, one for each parameter accessed in an example test. The parameter objects are collections of variables containing information about an individual parameter. They contain no methods. The data items might be:

```
Public Filter As Boolean
Public Operator As String
Public Start_Wavelength As Variant
Public Stop_Wavelength As Variant
Public Use_Ref_Wavelength As Boolean
Public Use_Wavemeter As Boolean
Public Test_Groups As Integer
Public Tests_Per_Group As Integer
Etc.
```

Each of these items is the contents of one of the fields in the Test Parameter database for one of the parameters. Scalar items are accessed by using an expression of the form,

```
colParms.item("Start_Wavelength").vValue
```

where the crucial part is a string whose value is the name of the parameter. The above expression can be used on the right hand side of an assignment expression to obtain the current value of the parameter attribute. This expression appearing on the left hand side of an assignment changes the attribute.

Accessing an item that is an array of values is done somewhat differently. The rule to note is that you must fetch the whole array parameter first and then get the nth element of that array. For example:

```
Private m_colParms As Variant
Private m_vCalWavelengths As Variant
Private m_dOneOfTheWavelengths as Double

m_colParms = colParms
m_vCalWavelengths = m_colParms.Item("Cal_Wavelength").vValue
m_dOneOfTheCalWavelengths = m_vCalWavelengths(14)
```

Save Test Parameters

When editing is complete, any changes need to be written to the parameter database. The code for accomplishing that is given below:

```
Public Sub save_parm_values()
   '
   ' Purpose:  Returns parameters to the database.
   '
With TESMngr.ParmMngr
      With TESMngr.Controller
         .ActiveTestPlan = sActiveTestPlan
         .ActiveTestGroup = sActiveTestGroup
      End With
      .StoreLevelParms colSystemParms, 3
      .StoreLevelParms colTestPlanParms, 2
      .StoreLevelParms colTestGroupParms, 1
      .StoreLevelParms colTestParms, 0
End With
End Sub
```

The important point here is that “StoreLevelParms” requires that the first parameter be a collection and the second be an integer corresponding to the level in the test plan hierarchy. The System level is 3, the Test Plan level is 2, the Test Group level is 1 and the Test level is 0. Since the parameter collection for the Test level is a TEScollection, rather than a standard VB collection, you must apply the “Items” method or use the method: TESMngr.ParmMngr.LoadTestParms as done in the example file in order to extract the underlying collection from within the TEScollection.

Execute Test

For this document, Remote Execution of the HP 86037A Chromatic Dispersion Test System has the following meaning. The measurement station is the system to which the device under test (DUT) is attached. The computer is the one on which the HP-supplied HP 86037A Chromatic Dispersion Test System software operates when actually supervising measurements. If an operator sits at another computer and performs operations which affect the operation of the HP 86037A Chromatic Dispersion Test System, that is said to be “remote execution”.

When it comes to the actual performance of the tests by an operator at a computer different from the HP 86037A Chromatic Dispersion Test System computer, a remote execution package is invoked which communicates with a custom component of the test executive. The test executive is initiated on the measurement station from the remote computer via a version of remote shell service supported in MS Windows NT 4.0. This Remote Shell Service software is located in the C:\HPCD\RELATED INSTALLATIONS\RSH directory of the HP 86037A Chromatic Dispersion Test System computer.

Successful remote execution of the HP 86037A Chromatic Dispersion Test System includes the following steps:

1. Setup and initiation of the Remote Shell Services software.
2. Initiation of part of the test executive called “MsgCenter” on the measurement system.
3. Initiation of the execution of a Test Plan, a Test Group, or a Test.
4. Issuance of any Cancel or Abort commands, as necessary.
5. Display of pass/fail results.
6. Termination of the “MsgCenter” on the HP 86037A Chromatic Dispersion Test System computer.

The setup and initiation of the Remote Shell Services is described in the “rshsvc.txt” file in the C:\HPCD\ RELATED INSTALLATIONS\RSH directory. Besides moving the files into the “system32” directory and before starting the service, the “.rhosts” files should be setup. The “.rhosts” file on the measurement computer should contain the IP address and user name of the remote computer while the remote computer should have the IP address and user name of the measurement computer. Once the remote shell service has been successfully started and the correct “.rhosts” files exist on both the remote machine and the measurement computer, the message client and server may communicate.

Initiation of the “MsgCenter” part of the test executive on the measurement computer is accomplished by issuing the “rsh” command on the remote machine along with the name of the test program and the appropriate UserID and password. Note, the rsh.exe file is normally installed in the “system32” directory during the installation of networking under Windows NT 4.0. More information on rsh commands may be obtained from the MS Windows NT documentation. The correct syntax is in the example file and is shown below:

```
"rsh.exe " & remote_machine & " -l " & login_name & " c:\hpcd\cd_shell.exe " & "-userid "
                            & userid & " -passwd " & passwd & " -quiet -host " & local_machine
                            & " -port " & PORT
```

The correct user ID and password to use for remote operation of the measurement computer are “**remote_user**” and “**HPCD**” respectively, as shown in the example file.

The communication package, “MsgCenter”, in the test executive control program is called a “server” in TCP/IP terms because the socket is started in Listen Mode awaiting a message from a Client, in our case the user software running on the remote machine. Since the development of the remote test control program is the responsibility of the user, HP provides only a simple example control program that demonstrates the use of the communication function to connect to “MsgCenter”, start a given test, abort a running test, and close “MsgCenter”.

The Message Server and the Message Client communicate over socket 4444. All messages between the two programs, the client and server, are variable length character strings. The first six characters of these messages contain the total length of the message. The maximum length of a single transmission is currently set at 8096 bytes. A message can involve multiple transmissions.

The control program on the remote machine can send the following fixed messages:

- “000015@@ABORT@@”
- “000016@@CANCEL@@”
- “000014@@STOP@@”

The ‘@’ is used to avoid confusion with other messages between the programs. The other messages from the remote control program to the HP 86037A Chromatic Dispersion Test System specify the running of specific tests. These have the following format:

Six characters containing the total length followed by “testplan:” followed by test_plan_name

or

Six characters containing the total length followed by “testgroup:” followed by test_group_name.

Message Server

The Message Server within the HP 86037A Chromatic Dispersion Test System is automatically invoked by the login to the test executive. After opening a window titled MsgCenter, its initial action is to connect to socket 4444. When the connection is completed the Message Server then awaits a read event on the socket.

When messages from the remote control program arrive at the Message Server they are interpreted and appropriate action is taken.

In response to a STOP message, the logout function in the test executive is called and the Message Server is shut down. Similarly, when a CANCEL or ABORT message arrives, the appropriate test parameter variables are set within the test executive.

When messages for running a test are received, built-in functions for creating the list of tests to be performed are called, followed by the creation of the test parameter collections and finally, the function to actually execute the test. Following the execution of a test, the Message Server will await the reception of another message.

Message Client

The message client on the remote machine may be any software that correctly sends the above commands via socket 4444 to the message server on the HP 86037A Chromatic Dispersion Test System.

Read Results

The following section focuses on reading the results database using SQL commands and Visual Basic. The structure of the results.mdb database is simple enough, however, that the user may decide to use another database tool (such as MS Access 97) to access the test results. Note that all access should be *read-only* thus eliminating the possibility of database corruption and possible loss of data. Compared to editing parameters in testparm.mdb, this is relatively easy because of the simpler structure of the results.mdb database. The one unusual aspect of the results.mdb database is the storage of arrays which will be described later in this section.

The structure of the results.mdb database can be investigated with the Visual Data Manager add-in included in Visual Basic 5.0 Professional or any other database tool, such as MS Access 97. The database consists of three tables. The relationship between the tables is shown in Figure 7-2 below:

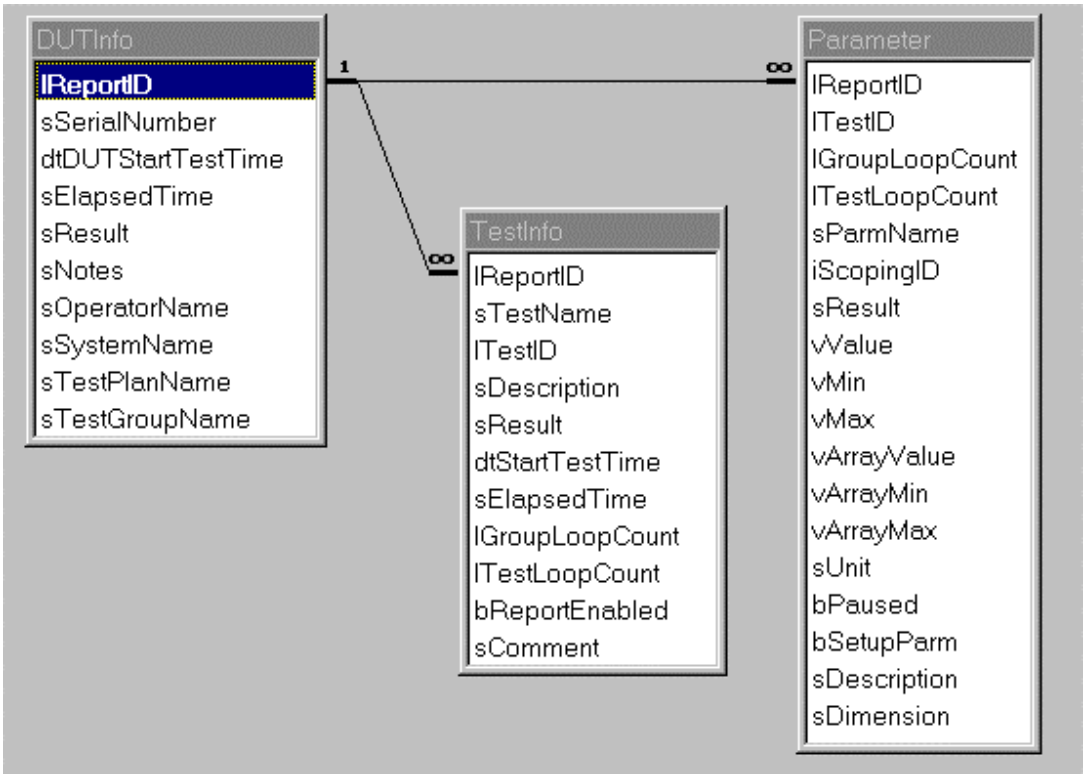

Figure 7-2. Figure 2: Relationship between the three tables of the results.mdb database.

The leftmost table, *DUTInfo*, contains one row for each test run. For each row in *DUTInfo*, there is a set of rows in the *TestInfo*, each of which contains information about the tests which were executed during the run. A record set of rows from the *TestInfo* table for a given run is created by specifying in the WHERE clause of the SQL statement, "lReportID". For each row in *TestInfo*, there is a set of rows in the Parameter table, each of which contains information about each variable stored in that test. A record set of rows

from the Parameter table for a given run and test is created by specifying in the WHERE clause of the SQL statement, “lReportID”and “lTestID”. The ReportID is directly related to the run number of the measurement while the TestID identifies the test group. More details are given in the example file and below.

First, one opens the results database with the following lines of code:

```
Private m_dbResults As Database

dbPath = txtDBPath & "\Results.mdb"

  ' Open the results database
    Set m_dbResults = OpenDatabase(dbPath, False, True) ' Open database as shared, read-only
```

The results database has three linked tables, *DUTInfo*, *TestInfo*, and *Parameter*. The simplest way to handle the linkage is to create a sequence of recordsets. The first might be accessed with something like:

```
sql_command = "SELECT * FROM DUTInfo WHERE sTestGroupName = 'New_Calibration' " & _
     “AND sResult = 'PASSED' ORDER BY lReportID DESC;"
Set rsReportID = dbResults.OpenRecordset(sql_command, dbOpenDynaset)
```

where “rsReportID” will contain all of the rows of the first table *DUTInfo* which contain information about all of the runs where the Test Group name is “New_Calibration” and the test result is “PASSED” Looping through all the members of the recordset one then extracts all of the TestIDs related to those members.

```
With rsReportID
      While Not .EOF
     sql_command = "SELECT lTestID FROM TestInfo WHERE lReportID = “ & !lReportID & _
                   " AND sTestName = 'Cal_Gain_Phase' ORDER BY lTestID;"
     Set rsTestID_gain_phase = dbResults.OpenRecordset(sql_command, dbOpenDynaset)

     While Not rsTestID_gain_phase.EOF
                  sql_command = "SELECT * FROM Parameter WHERE lReportID = " & _
                  !lReportID & “ AND lTestID =  “ & rsTestID_gain_phase
                  !lTestID_cal_gain_phase
     Set rsParam_cal_gain_phase =
               dbResults.OpenRecordset(sql_command,dbOpenDynaset)
```

This code results in a recordset containing all the rows of the table containing data related to the “Cal_Gain_Phase” test in a run of the “New_Calibration” test group which passed. (Data from other such successful tests can be found by looping through the rsReportID recordset.) Now that the desired information is in a recordset, an individual datum can be retrieved.

```
      range = GetParm(rsParam_cal_processing, "Range")
```

The code above gets the value of the variable “range” from the first (and only) row of the recordset “rsParam_cal_gain_phase” that contains the result data for “range”. The routine “GetParm” is given by the following:

```
Public Function GetParm(rsData As Recordset, sParmName As String) As Variant
'  Caution:  All non-array values are returned as strings.  Thus if you are
'       getting a number, it may be necessary for you to use Val(GetParm())
'       so that the parameter is converted to a number.
   Dim btByteArray() As Byte
```

```
   With rsData
      If Not .BOF Then
         .FindFirst "sParmName = '" & sParmName & "'"
         If Not .NoMatch Then
            If !vValue <> "<ARRAY>" Then
               GetParm = !vValue
            Else
               btByteArray = !vArrayValue.GetChunk(0, vArrayValue.FieldSize())
               GetParm = ByteArrayToVariant(btByteArray)
            End If
         Else
            Err.Raise vbObjectError, "GetParm", sParmName & _
" parameter undefined in results database!"
         End If
      Else
            Err.Raise vbObjectError, "GetParm", sParmName & _
               " parameter undefined in results database!"
      End If
   End With
End Function
```

This code finds the first row in the recordset that contains the desired parameter name and returns its value. Note the use of the Visual Basic GetChunk method and the "ByteArrayToVariant" routine. This is the technique used to store array values in the results database. The database treats the long binary as a binary large object (or "BLOB") and in order to obtain the actual array values, the BLOB must be converted. The "ByteArrayToVariant" function uses file I/O to convert between data stored as a long binary and a VB variant array as shown below.

```
Private Function ByteArrayToVariant(ByRef btByteArray() As Byte) As Variant
'
' Purpose: The data has
'   to be assigned to variable length byte array first, and then converted
'   to variant via binary file operation.
'
   Dim sTempFilename As String
   Dim iTempFileNum As Integer
   Dim avParm As Variant
   '
   iTempFileNum = FreeFile
   sTempFilename = App.Path & "\TEMP.BIN"
   '
   If dir(sTempFilename) <> "" Then Kill sTempFilename
   Open sTempFilename For Binary As #iTempFileNum
   Put #iTempFileNum, , btByteArray
   Get #iTempFileNum, 1, avParm
   Close #iTempFileNum
   Kill sTempFilename
   '
   ByteArrayToVariant = avParm

End Function
```

In order to extract a single value from the results database it is necessary to know the name of the value. To this end a list of output parameter names is given in "Output Parameter Names" on page 7-34.

Typically, the user is interested in the results of a run or measurement. This data is located by first finding the appropriate ReportID number corresponding to the desired run number, as demonstrated in the example code. Once the ReportID number is known, the final results data, as seen on the data review screen of the HP 86037A Chromatic Dispersion Test System GUI, is found in the *Test_CD* (see Appendix 2) section of the database that has the TestID number 15. Since it may be useful to look at the raw data,

uncorrected for calibration, this is found in the *Test_Gain_Phase* section that has the TestID number 42. In addition to the final results of a measurement, all of the pertinent parameters used to generate that result are also stored in the results.mdb database.

TES GUI Parameters

The tables below define the TES parameter in the data base associated with each item in the GUI. The table also defines where in the data base hierarchy the parameter is located.

The table defines parameters for a High Band system. Parameters with the "_HB" at the end are parameters that depend upon the type of HP 86037A Chromatic Dispersion Test System (1300, 1500, or DUAL). For a Low Band system, the "_HB" will be replaced with "_LB". A Dual Band system will have two parameters, one with the "_LB" extension and one with the "_HB" extension.

The "Delta" field in the "Wavelength Selection" area of the Main GUI is not used by any test and therefore is not located in the database.

The "Step Wavelength" field in the Calibration GUI is not used by any test and therefore is not located in the data base.

Test Setup GUI

Main Chromatic Dispersion Screen

Table 7-1. Main Chromatic Dispersion Screen

TES Name	Parameter Location	Type	Comments
Title_1	System	String	"Fiber" in current GUI. Selecting System/Preferences in GUI changes this parameter.
Title_2	System	String	"Cable" in current GUI. Selecting System/Preferences in GUI changes this parameter.
Title_3	System	String	"Segment" in current GUI. Selecting System/Preferences in GUI changes this parameter.
Title_4	System	String	"Test Manager" in current GUI. Selecting System/Preferences in GUI changes this parameter.
Title_5	System	String	"Operator" in current GUI. Selecting System/Preferences GUI changes this parameter.
Title_6	System	String	"Temperature" in current GUI. Selecting System/Preferences in GUI changes this parameter.
Title_7	System	String	"Remarks" in current GUI. Selecting System Preferences GUI changes this parameter.
Device_Name_1	System	String	Text entered by operator in field next to Title_1 ("Fiber").
Device_Name_2	System	String	Text entered by operator in field next to Title_2 ("Cable").
Device_Name_3	System	String	Text entered by operator in field next to Title_3 ("Segment").
Test_Manager_List	System	String Array (0:99)	Drop down list of text entries for Test Manager. Selected by the operator. Selected item will be put in Test_Manager TES parameter.
Test_Manager	System	String	Item selected by operator from Test_Manager_List
Operator_List	System	String Array (0:99)	Drop down list of text entries for Operator. Selected by the operator. Selected item will be put in Operator TES parameter.
Operator	System	String Array	Item selected by operator from Operator_List
Temperature	System	Single	Temperature entered by operator.
Remarks	System	String	Remarks entered by operator.
Operator_List	System	String Array (0:99)	Drop down list of text entries for Operator. Selected by the operator. Selected item will be put in Operator TES parameter.
Operator	System	String Array	Item selected by operator from Operator_List
Temperature	System	Single	Temperature entered by operator.
Remarks	System	String	Remarks entered by operator.

Table 7-1. Main Chromatic Dispersion Screen (Continued)

TES Name	Parameter Location	Type	Comments
Cal_File	System	Integer	Number of the calibration file currently selected in the GUI that will be used while performing tests.
Start_Wavelength_HB	Group: Start_Test Test: Test_Gain_ Phase	Single	Number entered by the operator in the "Start" field in the "Wavelength Selection" area of the GUI.
Stop_Wavelength_HB	Group: Start_Test Test: Test_Gain_ Phase	Single	Number entered by the operator in the "Stop" field in the "Wavelength Selection" area of the GUI.
Number_Steps_HB	Group: Start Test Test: Test_Gain_ Phase	Integer	Number entered by the operator in the "# Steps" field in the "Wavelength Selection" area of the GUI.
Use_Ref_Wavelength	Group: Start Test Test: Test_Gain_ Phase	Boolean	Selected by operator in "Ref" checkbox in the "Wavelength Selection" area of the GUI. True = Ref wavelength used False = Ref wavelength not used
Ref_Wavelength_HB	Group: Start Test Test: Test_Gain_ Phase	Single	Number entered by the operator in the field next to "Ref" in the "Wavelength Selection" area of the GUI.
Enhanced	System	Boolean	Selected by operator in "Enabled" checkbox in the "Enhanced TLS Mode" area of the GUI. True = Enhanced TLS mode selected False = Enhanced TLS mode not selected
TuningAccuracy	System	Double	Number entered by the operator in the field next to "Tuning Accuracy" in the "Enhanced TLS Mode" area of the GUI.
TuningAttempts	System	Integer	Number entered by the operator in the field next to "Number of Tries" in the "Enhanced TLS Mode" area of the GUI.
Filter	System	Boolean	Selected by operator in "Enabled" checkbox in the "Filter Measurement" area of the GUI. True = Filter measurement selected False = Filter measurement not selected

Table 7-1. Main Chromatic Dispersion Screen (Continued)

TES Name	Parameter Location	Type	Comments
Length_State	Group: Start_Test Test: Test_Length	Integer	Radio buttons selected by operator in the "Length" area of the GUI. Determines whether to do length test. 0 = Measure 1 = Set length to 2 = Length not required Set to 0 at software startup.
Refractive_Index	System	Double	Refractive index entered by operator as "n=" in the "Length" area of the GUI.
Set_Length	Group: Start_Test Test: Test_Length	Double	Cable length entered by operator in field next to "Set length to:" in the "Length" area of the GUI.
Test_Groups	Group: Start_Test Test: Test_Gain_ Phase	Integer	Number that appears next to "Groups of Tests:" in the "Repeat Cycles" area of the GUI. This parameter can be modified in two ways: 1. Pressing the "Change" button brings up the Repeat Measurement Selector GUI. The entry in the "How many groups of tests (G)?" field controls this parameter. 2. Pressing the "Single Test" button sets this parameter to 1.
Tests_Per_Group	Group: Start_Test Test: Test_Gain_ Phase	Integer	Number that appears next to "Tests Per Group:" in the "Repeat Cycles" area of the GUI. This parameter can be modified in two ways: 1. Pressing the "Change" button brings up the Repeat Measurement Selector GUI. The entry in the "How many tests per group (N)?" field controls this parameter. 2. Pressing the "Single Test" button sets this parameter to 1.
Group_Delay_Hrs	Group: Start_Test Test: Test_Gain_ Phase	Integer	Hours number that appears next to "Delay between groups:" in the "Repeat Cycles" area of the GUI. This parameter is modified in the Repeat Measurement Selector GUI by the hours entry in the "What is the delay between groups (D)" field. Pressing the "Single Test" button sets this parameter to 0.
Group_Delay_Mins	Group: Start_Test Test: Test_Gain_ Phase	Integer	Minutes number that appears next to "Delay between groups" in the "Repeat Cycles" area of the GUI. This parameter is modified in the Repeat Measurement Selector GUI by the minutes entry in the "What is the delay between groups (D)" field. Pressing the "Single Test" button sets this parameter to 0.
Test_Delay_Hrs	Group: Start_Test Test: Test_Gain_ Phase	Integer	Hours number that appears next to "Delay between tests:" in the "Repeat Cycles" area of the GUI. This parameter is modified in the Repeat Measurement Selector GUI by the hours entry in the "What is the delay between tests (T)" field. Pressing the "Single Test" button sets this parameter to 0.

Table 7-1. Main Chromatic Dispersion Screen (Continued)

TES Name	Parameter Location	Type	Comments
Test_Delay_Mins	Group: Start_Test Test: Test_Gain_ Phase	Integer	Minutes number that appears next to "Delay between tests" in the "Repeat Cycles" area of the GUI. This parameter is modified in the Repeat Measurement Selector GUI by the minutes entry in the "What is the delay between tests (T)" field. Pressing the "Single Test" button sets this parameter to 0.
Use_Wavemeter	System:	Boolean	This selection is made on the "System" pull-down list on the Main GUI. The item "Wavemeter" is checked or unchecked. True = item checked (measure wavelength with wavelength meter) False = item unchecked
Range (Dual band system only)	System	String	This selection is made on the "Range" pull-down list on the Main GUI. 1300 = LOW 1500 = HIGH Both = DUAL
Pause_Measurement (Dual band system only)	Group: Start_test Test: Test_Gain_ Phase	Boolean	This selection is made on the "Service" pull-down list on the Main GUI. The item "Pause between wavelength ranges" is checked or unchecked. True = item checked (Pause between ranges) False - item unchecked

CD and Gain Measurement Settings GUI

Selected from the Test Setup GUI by selecting `Set Parameters For` and `CD/Gain Meas`.

Table 7-2. CD and Gain Measurement Settings

TES Name	Parameter Location	Type	Comments
Auto_Mod_Freq	Group: Start_Test Test: Test_Gain_ Phase	Boolean	Radio buttons selected by operator in the "Test Modulation Frequency:" area of the GUI. True = Auto selected False = Manual selected
Test_Mod_Frequency_HB	Group: Start_Test Test: Test_Gain_ Phase	Single	Number entered by the operator in the "Set to:" field in the "Test Modulation Frequency" area of the GUI.
Ref_Mod_Frequency_HB	Group: Start_Test Test: Test_Gain_ Phase	Single	Number entered by the operator in the "Set to:" field in the "Reference Modulation Frequency" area of the GUI.
TLS_PowerLevel_HB	Group: Start_Test Test: Test_Gain_ Phase	Single	Number entered by the operator in the field next to "TLS Target Power" in the GUI.
VNA_IFBandwidth_HB	Group: Start_Test Test: Test_Gain_ Phase	Integer	This parameter is "Sensitivity" on the GUI, but the tests need an IF bandwidth. The IF bandwidth number is stored in the data base. Normal = 300 High = 100 Highest = 30
VNA_AverageFactor_HB	Group: Start_Test Test: Test_Gain_ Phase	Integer	Number entered by the operator in the field next to "TLS Target Power" in the GUI.
Do_Gain	Group: Start_Test Test: Test_Gain_ Phase	Boolean	Radio buttons selected by operator in the GUI. True = "CD and Gain measurement" selected False = "CD measurement only" selected
Copy_Cal_WL	System:	Boolean	Selected by operator in "Copy Cal wavelengths to Test wavelengths" checkbox in the GUI. True = Copy Cal wavelengths False = Do not copy Cal wavelengths

Length Measurement Settings GUI

Selected from the Test Setup GUI by selecting `Set Parameters For`, and then `Length Meas`.

Table 7-3. Length Measurement Settings

TES Name	Parameter Location	Type	Comments
TLS_Wavelength	Group: Start_Test Test: Test_Length	Single	Number entered in field for "TLS wavelength set to:" in GUI
TLS_PowerLevel	Group: Start_Test Test: Test_Length	Single	Number entered in field for "TLS Target Power:" in GUI.
VNA_AverageFactor	Group: Start_Test Test: Test_Length	Integer	Number entered in field for "Average Factor:" in GUI.
VNA_IFBandwidth	Group: Start_Test Test: Test_Length	Integer	This parameter is "Sensitivity" on the GUI, but the tests need an IF bandwidth. The IF bandwidth number is stored in the data base. Normal = 300 High = 100 Highest = 30
NumberOfLengthMeasurements	Group: Start_Test Test: Test_Length	Integer	Number entered in field for "Number of Measurements:" in GUI.

Calibration Settings GUI

Selected from the Test Setup GUI by selecting Set Parameters For - Calibration Settings

Table 7-4. Calibration Settings GUI

TES Name	Parameter Location	Type	Comments
Test_Mod_Frequency_HB	Group: New_ Calibration Test: Cal_Gain_ Phase Group: Verify_ Calibration Test: Verify_Gain_ Phase	Single	Number entered by the operator in the “Modulation Frequency:” field in the “Chromatic Dispersion” area of the GUI.
TLS_PowerLevel_HB	Group: New_ Calibration Test: Cal_Gain_ Phase Group: Verify_ Calibration Test: Verify_Gain_ Phase	Single	Number entered by the operator in the “TLS Target Power:” field in the “Chromatic Dispersion” area of the GUI.
VNA_AverageFactor_HB	Group: New_ Calibration Test: Cal_Gain_ Phase Group: Verify_ Calibration Test: Verify_Gain_ Phase	Integer	Number entered by the operator in the “Average Factor:” field in the “Chromatic Dispersion” area of the GUI.

Table 7-4. Calibration Settings GUI (Continued)

TES Name	Parameter Location	Type	Comments
VNA_IFBandwidth_HB	Group: New_ Calibration Test: Cal_Gain_ Phase Group: Verify_ Calibration Test: Verify_Gain_ Phase	Integer	This parameter is "Sensitivity" on the GUI, but the tests need an IF bandwidth. The IF bandwidth number is stored in the data base. Normal = 300 High = 100 Highest = 30
Cal_Verify_Limit	Test Plan: Standard_Test_Plan	Single	Number entered by the operator in the "Verify Cal Limit:" field in the "Chromatic Dispersion" area of the GUI. **Note:** this number is stored in seconds in the data base.
TLS_Wavelength	Group: New_ Calibration Test: Cal_Length	Single	Number entered by the operator in the "TLS Wavelength:" field in the "Length" area of the GUI.
TLS_PowerLevel	Group: New_ Calibration Test: Cal_Length	Single	Number entered by the operator in the "TLS Target Power:" field in the "Length" area of the GUI.
VNA_AverageFactor	Group: New_ Calibration Test: Cal_Length	Integer	Number entered by the operator in the "Average Factor:" field in the "Length" area of the GUI.
Refractive_Index	Group: New_ Calibration Test: Cal_Length	Double	Number entered by the operator in the "Refractive Index:" field in the "Length" area of the GUI.
Cal_Len_MaxLength	Test Plan: Standard_Test_Plan	Single	Number entered by the operator in the "Max Cal Device Length:" field in the "Length" area of the GUI.

Calibration GUI

Selected when the `New Calibration` button is pressed on Main GUI

Table 7-5. Calibration GUI

TES Name	Parameter Location	Type	Comments
Cal_Device	Group: New_ Calibration	String Array (0:99)	Drop down list of text entries for Cal Device. Selected by the operator. Selected item will be put in Selected_Device TES parameter.
Selected_Device	System	String	Item selected by operator from Cal_Device list.
Start_Wavelength_HB	Group: New_ Calibration Test: Cal_Gain_ Phase	Single	Number entered by the operator in the "Start Wavelength:" field in the GUI.
Stop_Wavelength_HB	Group: New_ Calibration Test: Cal_Gain_ Phase	Single	Number entered by the operator in the "Stop Wavelength:" field in the GUI.
Number_Steps_HB	Group: New_ Calibration Test: Cal_Gain_ Phase	Integer	Number entered by the operator in the "Number Steps:" field in the GUI.
Cal_Mod_Bias	Group: New_ Calibration	Boolean	Selected by operator in "Adjust modulator bias before starting calibration" checkbox in the GUI. True = Adjust mod bias False = Do not adjust mod bias

Power Monitor Setup GUI

Selected from the Test Setup GUI by selecting Service - Power Monitor Settings

Table 7-6. Power Monitor GUI

TES Name	Parameter Location	Type	Comments
PowerConstant_HB	Group: Power Monitor Test: Power Monitor	Single	Number entered by the operator in the “Power Constant:” field in the GUI.
Under_Range_Limit_HB	Group: Power Monitor Test: Power Monitor	Single	Number entered by the operator in the “Under range limit:” field in the GUI.
Insertion_Loss_Ref_HB	Group: Power Monitor Test: Power Monitor	SIngle	Number entered by the operator in the “Insertion loss reference:” field in the GUI.
TLS_PowerLevel_HB	Group: Power Monitor Test: Power Monitor	Single	Number entered by the operator in the “TLS power:” field in the GUI.
TLS_Wavelength_HB	Group: Power Monitor Test: Power Monitor	Single	Number entered by the operator in the “TLS wavelength:” field in the GUI.

System Parameters

Contains various for various system functions and GUIs

Table 7-7. System Parameters

TES Name	Parameter Location	Type	Comments
Setup_Path	System:	String	Path name where setup data base files are located. Path entered here will be used by File pull-down list on Main GUI.
Setup_1	System:	String	Name of last setup file that was saved or retrieved. This name will appear on File pull-down list on Main GUI.
Setup_2	System:	String	Name of next to last setup file that was saved or retrieved. This name will appear on File pull-down list on Main GUI.
Setup_3	System:	String	Name of second to last setup file that was saved or retrieved. This name will appear on File pull-down list on Main GUI.
Setup_4	System:	String	Name of third to last setup file that was saved or retrieved. This name will appear on File pull-down list on Main GUI.

TES GUI Min/Max Parameters

The table below defines the TES parameters in the database that are utilized by the GUI to check values entered in the GUI. All of these parameters are located at the "System" level. The table shows the parameters for a dual band system. For a single band system the parameters with "_LB" and "_HB" extensions will only appear once with either the "_LB" or "_HB" extension for a low band or high band system.

Table 7-8. TES GUI Min/Max Parameters

TES Name	Type	Value	Unit	Description
Vfy_MaxAvgFac	Int32	999		Max Average Factor limit for GUI
Vfy_MaxCalLen	Real64	1000000	m	Max Cal Length limit for GUI
Vfy_MaxCalLim	Real64	0.00000000009	s	Max Verify Cal Limit for GUI
Vfy_MaxLen	Real64	1000000	m	Max Length limit for GUI
Vfy_MaxLenRepeat	Int32	32767		Max No. of Length meas. limit for GUI
Vfy_MaxMaxCalLen	Real64	1000000		Max Length limit for Cal for GUI
Vfy_MaxModFreq	Real64	3000000000	Hz	Max modulation frequency limit for GUI
Vfy_MaxPMIL	Real64	100		Max Power Monitor insertion loss for GUI
Vfy_MaxPMPC	Real64	100		Max Power Monitor power constant for GUI
Vfy_MaxPMUR	Real64	20		Max Power Monitor under range limit for GUI
Vfy_MaxPrefWL	Real32	3000	nm	Max value allowed in wavelength preferences
Vfy_MaxRI	Real32	2		Max Refractive Index limit for GUI
Vfy_MaxSteps	Int32	32767		Max No. of Steps limit for GUI
Vfy_MaxStepWave	Real32	20	nm	Max Wavelength Step size limit for GUI
Vfy_MaxTemp	Real32	100000	Degrees C	Max Temperature limit for GUI
Vfy_MaxTLSPwr_HB	Real32	9.948	dBm	Max TLS Power Level for GUI
Vfy_MaxTLSPwr_LB	Real32	1.501	dBm	Max TLS Power Level for GUI
Vfy_MaxTLSTune	Real32	10	nm	Max tuning accuracy for TLS enhanced mode
Vfy_MaxTuneTries	Int16	100		Max number of tuning tries for TLS enhanced mode
Vfy_MinAvgFac	Int32	1		Min Average Factor limit for GUI
Vfy_MinCalLim	Real64	0	s	Min Verify Cal limit for GUI
Vfy_MinLen	Real64	0.001	m	Min Length limit for GUI
Vfy_MinLenRepeat	Int32	1		Min No. of Length meas. limit for GUI
Vfy_MinMaxCalLen	Real64	0		Min Length limit for Cal for GUI
Vfy_MinModFreq	Real64	10000000	Hz	Min modulation frequency limit for GUI
Vfy_MinPMIL	Real64	-50		Min Power Monitor insertion loss for GUI

Table 7-8. TES GUI Min/Max Parameters (Continued)

TES Name	Type	Value	Unit	Description
Vfy_MinPMPC	Real64	-50		Min Power Monitor power constant for GUI
Vfy_MinPMUR	Real64	-100		Min Power Monitor under range limit for GUI
Vfy_MinPrefWL	Real32	500	nm	Min value allowed in wavelength preferences
Vfy_MinRI	Int32	1		Min Refractive Index limit for GUI
Vfy_MinSteps	Int32	5		Min No. of Steps limit for GUI
Vfy_MinStepWave	Real32	0.001	Hz	Min Wavelength Step size limit for GUI
Vfy_MinTemp	Real32	-273.16	Degrees C	Min Temperature limit for GUI
Vfy_MinTLSPwr_HB	Real32	-20	dBm	Min TLS Power Level for GUI
Vfy_MinTLSPwr_LB	Real32	-20	dBm	Min TLS Power Level for GUI
Vfy_MinTLSTune	Real32	0.0001	nm	Min tuning accuracy for TLS enhanced mode
Vfy_MinTuneTries	Int16	1		Min number of tuning tries for TLS enhanced mode
Vfy_MinCalLim	Real64	0	s	Min Verify Cal limit for GUI
Vfy_MinLen	Real64	0.001	m	Min Length limit for GUI
Vfy_MinLenRepeat	Int32	1		Min No. of Length meas. limit for GUI
Vfy_MinMaxCalLen	Real64	0		Min Length limit for Cal for GUI
Vfy_MinModFreq	Real64	10000000	Hz	Min modulation frequency limit for GUI
Vfy_MinPMIL	Real64	-50		Min Power Monitor insertion loss for GUI
Vfy_MinPMPC	Real64	-50		Min Power Monitor power constant for GUI
Vfy_MinPMUR	Real64	-100		Min Power Monitor under range limit for GUI
Vfy_MinPrefWL	Real32	500	nm	Min value allowed in wavelength preferences
Vfy_MinRI	Int32	1		Min Refractive Index limit for GUI
Vfy_MinSteps	Int32	5		Min No. of Steps limit for GUI
Vfy_MinStepWave	Real32	0.001	Hz	Min Wavelength Step size limit for GUI
Vfy_MinTemp	Real32	-273.16	Degrees C	Min Temperature limit for GUI
Vfy_MinTLSPwr_HB	Real32	-20	dBm	Min TLS Power Level for GUI
Vfy_MinTLSPwr_LB	Real32	-20	dBm	Min TLS Power Level for GUI
Vfy_MinTLSTune	Real32	0.0001	nm	Min tuning accuracy for TLS enhanced mode
Vfy_MinTuneTries	Int16	1		Min number of tuning tries for TLS enhanced mode

Output Parameter Names

The tables below give the names of the output parameters in the results.mdb database sorted by the type of HP 86037A Chromatic Dispersion Test System (Single Band Standard (1500nm) System, or Dual Band System). For a Single Band 1300nm system, use the Single Band Standard (1500nm) System names replacing the "_HB" (High Band) terms shown in the table with "_LB" (Low Band).

Table 7-9. Output Parameters – Customer_High_Band

Standard_Test_Plan	Data Type	Unit	Description
Test_Length			
CableLength	Real64	km	Cable length measured (average for multiples)
CableLengthMeasurements(50)	Real64	km	Array of length measurements for multiples
Test_Gain_Phase			
AbsGDelay_HB(1,1)	Real64	ps	Absolute Group Delay at Stop Wavelength
Filter_AbsGDelay(1,1,1)	Real64	ps	Filter meas abs group delay array
Filter_Wavelength(1,1,1)	Real64	nm	Filter meas wavelength array
Gain_HB(1,1,1)	Real64	dBm	Gain meas array
MaxModFreq_HB(1,1)	Real64	Hz	Max mod frequency used for each test
MinModFreq_HB(1,1)	Real64	Hz	Min mod frequency used for each test
NumGroups	Int32		Number of groups completed
NumTests	Int32		Number of tests in a group completed
TauPhase_HB(1,1,1)	Real64	ps	Relative Group Delay
TestTime(1,1)	String		Start Time of each test
TLSPower_HB(1,1,1)	Real64	dB	TLS power for each meas
Wavelength_HB(1,1,1)	Real64	nm	Gain/Phase meas wavelength array
Test_CD			
Dispersion_Coeff3Term_HB(1,1,1)	Real64		
Dispersion_Coeff5Term_HB(1,1,1)	Real64		
Dispersion_CoeffQuad_HB(1,1,1)	Real64		
Dispersion_Measured_HB(1,1,1)	Real64	ps/nm	

Table 7-9. Output Parameters – Customer_High_Band (Continued)

Standard_Test_Plan	Data Type	Unit	Description
Dispersion_Wavelength_HB(1,1,1)	Real64	nm	
Gain_Corrected_HB(1,1,1)	Real64	dB	
Gain_FWHM_HB(1,1)	Real64	dB	
Number_Steps_HB	Int16		
Phase_Coeff3Term_HB(1,1,1)	Real64		
Phase_Coeff5Term_HB(1,1,1)	Real64		
Phase_CoeffQuad_HB(1,1,1)	Real64		
Phase_StdDev3Term_HB(1,1)	Real64	ps	
Phase_StdDev5Term_HB(1,1)	Real64	ps	
Phase_StdDevQuad_HB(1,1)	Real64	ps	
TauPhase_Corrected_HB(1,1,1)	Real64	ps	
Test_Groups	Int16		
Tests_Per_Group	Int16		
Wavelength_Corrected_HB(1,1,1)	Real64	nm	
WL_GainPeak_HB(1,1)	Real64	nm	
ZeroWL_3Term_HB(1,1,1)	Real64	nm	
ZeroWL_5Term_HB(1,1,3)	Real64	nm	
ZeroWL_Quad_HB(1,1,1)	Real64	nm	
ZWLSlope_3Term_HB(1,1,1)	Real64	ps/nm^2	
ZWLSlope_5Term_HB(1,1,3)	Real64	ps/nm^2	
ZWLSlope_Quad_HB(1,1,1)	Real64	ps/nm^2	

Table 7-10. Output Parameters – Customer_Dual_Band

Standard_Test_Plan	Data Type	Unit	Description
Test Length			
CableLength	Real64	km	Cable length measured (average for multiples)
CableLengthMeasurements(50)	Real64	km	Array of length measurements for multiples
Test_Gain_Phase			
AbsGDelay_HB(1,1)	Real64	ps	Absolute Group Delay at Stop Wavelength
AbsGDelay_LB(1,1)	Real64	ps	Absolute Group Delay at Stop Wavelength
Filter_AbsGDelay(1,1,1)	Real64	ps	Filter meas abs group delay array
Filter_Wavelength(1,1,1)	Real64	nm	Filter meas wavelength array
Gain_HB(1,1,1)	Real64	dBm	Gain meas array
Gain_LB(1,1,1)	Real64	dBm	Gain meas array
MaxModFreq_HB(1,1)	Real64	Hz	Max mod frequency used for each test
MaxModFreq_LB(1,1)	Real64	Hz	Max mod frequency used for each test
MinModFreq_HB(1,1)	Real64	Hz	Min mod frequency used for each test
MinModFreq_LB(1,1)	Real64	Hz	Min mod frequency used for each test
NumGroups	Int32		Number of groups completed
NumTests	Int32		Number of tests in a group completed
TauPhase_HB(1,1,1)	Real64	ps	Relative Group Delay
TauPhase_LB(1,1,1)	Real64	ps	Relative Group Delay
TestTime(1,1)	String		Start Time of each test
TLSPower_HB(1,1,1)	Real64	dB	TLS power for each meas
TLSPower_LB(1,1,1)	Real64	dB	TLS power for each meas
Wavelength_HB(1,1,1)	Real64	nm	Gain/Phase meas wavelength array
Wavelength_LB(1,1,1)	Real64	nm	Gain/Phase meas wavelength array
Test_CD			
Dispersion_Coeff3Term_DUAL(1,1,1)	Real64		
Dispersion_Coeff3Term_HB(1,1,1)	Real64		
Dispersion_Coeff3Term_LB(1,1,1)	Real64		
Dispersion_Coeff5Term_DUAL(1,1,1)	Real64		
Dispersion_Coeff5Term_HB(1,1,1)	Real64		
Dispersion_Coeff5Term_LB(1,1,1)	Real64		
Dispersion_CoeffQuad_DUAL(1,1,1)	Real64		

Table 7-10. Output Parameters – Customer_Dual_Band (Continued)

Standard_Test_Plan	Data Type	Unit	Description
Dispersion_CoeffQuad_HB(1,1,1)	Real64		
Dispersion_CoeffQuad_LB(1,1,1)	Real64		
Dispersion_Measured_DUAL(1,1,1)	Real64	ps/nm	
Dispersion_Measured_HB(1,1,1)	Real64	ps/nm	
Dispersion_Measured_LB(1,1,1)	Real64	ps/nm	
Dispersion_Wavelength_DUAL(1,1,1)	Real64	nm	
Dispersion_Wavelength_HB(1,1,1)	Real64	nm	
Dispersion_Wavelength_LB(1,1,1)	Real64	nm	
Gain_Corrected_DUAL(1,1,1)	Real64	dB	
Gain_Corrected_HB(1,1,1)	Real64	dB	
Gain_Corrected_LB(1,1,1)	Real64	dB	
Gain_FWHM_DUAL(1,1)	Real64	dB	
Gain_FWHM_HB(1,1)	Real64	dB	
Gain_FWHM_LB(1,1)	Real64	dB	
Number_Steps_DUAL	Int16		
Number_Steps_HB	Int16		
Number_Steps_LB	Int16		
Phase_Coeff3Term_DUAL(1,1,1)	Real64		
Phase_Coeff3Term_HB(1,1,1)	Real64		
Phase_Coeff3Term_LB(1,1,1)	Real64		
Phase_Coeff5Term_DUAL(1,1,1)	Real64		
Phase_Coeff5Term_HB(1,1,1)	Real64		
Phase_Coeff5Term_LB(1,1,1)	Real64		
Phase_CoeffQuad_DUAL(1,1,1)	Real64		
Phase_CoeffQuad_HB(1,1,1)	Real64		
Phase_CoeffQuad_LB(1,1,1)	Real64		
Phase_StdDev3Term_DUAL(1,1)	Real64	ps	
Phase_StdDev3Term_HB(1,1)	Real64	ps	
Phase_StdDev3Term_LB(1,1)	Real64	ps	
Phase_StdDev5Term_DUAL(1,1)	Real64	ps	
Phase_StdDev5Term_HB(1,1)	Real64	ps	
Phase_StdDev5Term_LB(1,1)	Real64	ps	

Table 7-10. Output Parameters – Customer_Dual_Band (Continued)

Standard_Test_Plan	Data Type	Unit	Description
Phase_StdDevQuad_DUAL(1,1)	Real64	ps	
Phase_StdDevQuad_HB(1,1)	Real64	ps	
Phase_StdDevQuad_LB(1,1)	Real64	ps	
TauPhase_Corrected_DUAL(1,1,1)	Real64	ps	
TauPhase_Corrected_HB(1,1,1)	Real64	ps	
TauPhase_Corrected_LB(1,1,1)	Real64	ps	
Test_Groups	Int16		
Tests_Per_Group	Int16		
Wavelength_Corrected_DUAL(1,1,1)	Real64	nm	
Wavelength_Corrected_HB(1,1,1)	Real64	nm	
Wavelength_Corrected_LB(1,1,1)	Real64	nm	
WL_GainPeak_DUAL(1,1)	Real64	nm	
WL_GainPeak_HB(1,1)	Real64	nm	
WL_GainPeak_LB(1,1)	Real64	nm	
ZeroWL_3Term_DUAL(1,1,1)	Real64	nm	
ZeroWL_3Term_HB(1,1,1)	Real64	nm	
ZeroWL_3Term_LB(1,1,1)	Real64	nm	
ZeroWL_5Term_DUAL(1,1,3)	Real64	nm	
ZeroWL_5Term_HB(1,1,3)	Real64	nm	
ZeroWL_5Term_LB(1,1,3)	Real64	nm	
ZeroWL_Quad_DUAL(1,1,1)	Real64	nm	
ZeroWL_Quad_HB(1,1,1)	Real64	nm	
ZeroWL_Quad_LB(1,1,1)	Real64	nm	
ZWLSlope_3Term_DUAL(1,1,1)	Real64	ps/nm^2	
ZWLSlope_3Term_HB(1,1,1)	Real64	ps/nm^2	
ZWLSlope_3Term_LB(1,1,1)	Real64	ps/nm^2	
ZWLSlope_5Term_DUAL(1,1,3)	Real64	ps/nm^2	
ZWLSlope_5Term_HB(1,1,3)	Real64	ps/nm^2	
ZWLSlope_5Term_LB(1,1,3)	Real64	ps/nm^2	
ZWLSlope_Quad_DUAL(1,1,1)	Real64	ps/nm^2	
ZWLSlope_Quad_HB(1,1,1)	Real64	ps/nm^2	
ZWLSlope_Quad_LB(1,1,1)	Real64	ps/nm^2	

8

Test Procedures 8-3
Suggestions on Setting the Test Parameters 8-4

Function Test

At a glance

This chapter details the procedures for functionality testing.

Test Procedures

1 Install and adjust the system following the procedures described in the *Getting Started* section in the front of this manual.

2 Connect a short "through" fiber cable across the SOURCE OUTPUT and RECEIVER INPUT ports of the 83427A Chromatic Dispersion Test Set.

3 From the `HP Chromatic Dispersion Test System` Window menu bar shown in Figure 8-1, click on `SetParametersFor` to display the `SetParametersFor` drop-down menu.

4 In the `SetParametersFor` drop-down menu, click on `Set all the measurement parameters to HP defaults`.

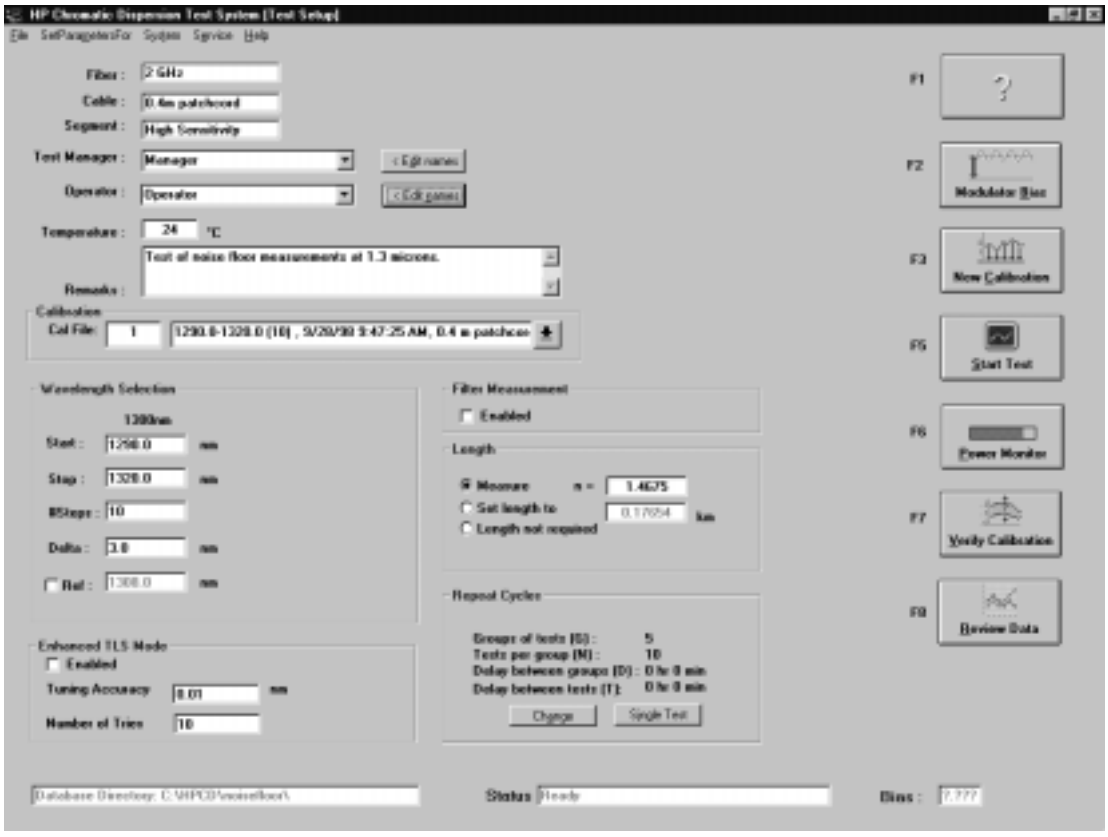

Figure 8-1. HP-CD Test Setup Window

5 Calibrate the system between 1515 nm and 1580 nm, in 1 nm steps.

6 Perform a Cal Verify. Refer to “Verify the Calibration” on page 5-6.

If the Cal Verify does not pass, note the maximum group delay value obtained during Cal Verify and report the failure to HP.

Suggestions on Setting the Test Parameters

The test parameter recommendations in this section are meant as a guide. They can be used as a starting point. You can then tailor the parameters to your specific situation.

Test Parameters for Testing Optical Fibers

Setting Up CD/Gain Measurement Parameters

The CD/Gain measurement settings are used to perform a measurement.

Choose `CD/Gain Meas...` from the `SetParametersFor` drop-down menu:

1. From the `HP Chromatic Dispersion Test System` window menu bar shown in Figure 8-1, click on `SetParametersFor` to display the `SetParametersFor` drop-down menu.
2. Click on `CD/Gain Meas...` from the `SetParametersFor` program menu.

   The `CD and Gain Measurement Settings` window shown in Figure 8-2 will open. To select the default settings, click the `Set HP Defaults` button.

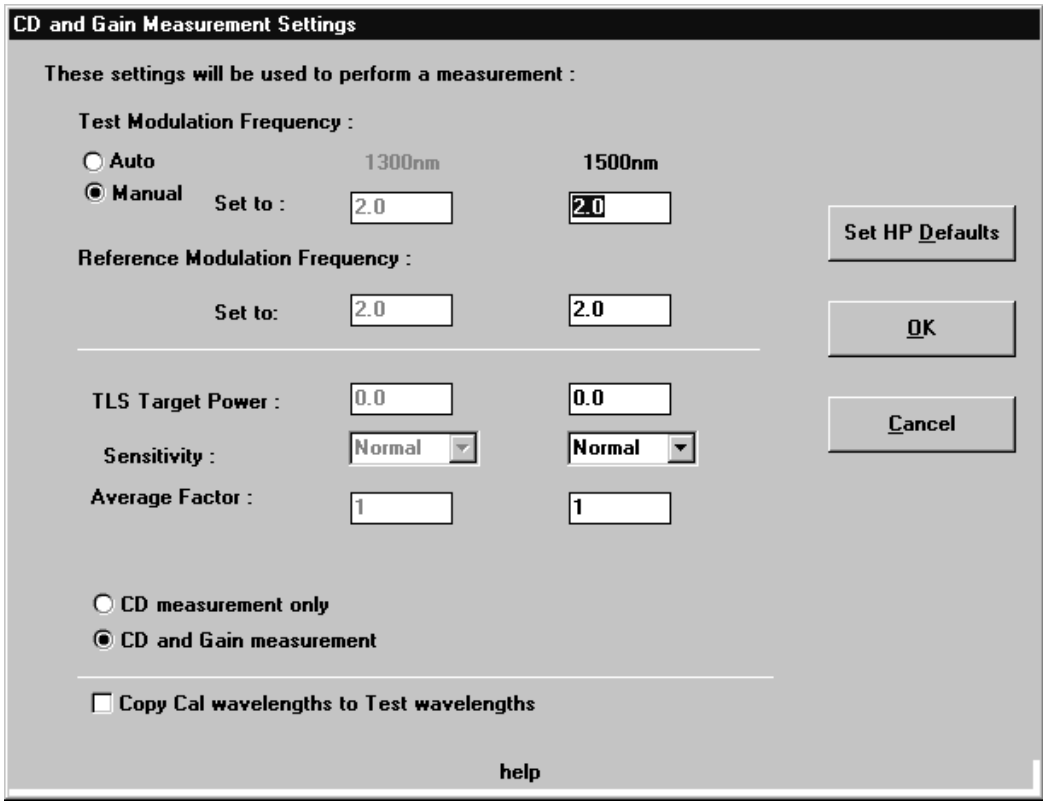

Figure 8-2. HP-CD Software Test Settings Window

The parameters in Table 8-1 are recommended as a starting point for entering test parameters into the `Test Settings` window.

Table 8-1. Recommended Parameters for the Test Settings Window

Option	Setting	Notes
Test Modulation Frequency	Auto	This causes the system to adapt the modulation rate to the level of dispersion exhibited by the test device, resulting in good precision and preservation of the phase reference. Use of the `Auto` mode slightly increases measurement time.
Reference Modulation Frequency	2 GHz	The reference measurement is designed to compensate for drift of the fiber length during the measurement. It is only necessary to lower the reference modulation frequency if the length of the fiber under test is drifting very rapidly, at more than about 50 mm/second. You may need to lower this modulation frequency if the data looks incorrect *and* your measurements are made under the following conditions: The fiber/system under test is longer than 200 km. The temperature of the fiber fluctuates at more than 0.2°/second or if the fiber is moved during the measurement to cause a large and rapid length change. The measurement time at each wavelength is more than a few seconds. If all of the above apply to your situation, try lowering the modulation frequency and see if the data improves.
TLS Target Power	0 dBm	
Sensitivity	Variable	This depends on the insertion loss of your device under test. If the insertion loss is greater than 20 dB, try changing the sensitivity to `High` to see if the results are more repeatable. For insertion losses of much greater than 20 dB, it may be necessary to use the `Highest` sensitivity. The Sensitivity setting determines the IF bandwidth used by the network analyzer. The settings, `Normal`, `High` and `Highest`, correspond to 300, 100 and 30 Hz, respectively. Noise is reduced at higher sensitivity, but measurement time increases.
Averaging Factor	1	It is necessary to increase the averaging factor only if there is so much noise that you cannot get good measurements even with the `Highest` sensitivity. The measurement time will be proportional to the averaging factor, but the reduction in noise is only proportional to the square root of the averaging factor.
CD Measurement Only	Enabled	Generally, the CD measurement is the only measurement of interest.
Copy Cal wavelengths to Test wavelengths	Enabled	Enabling this function eliminates the need to reenter the wavelength data twice, if both the Cal and Test wavelength data are the same.

Setting Up Length Measurement Parameters

Choose `Length Meas` from the `SetParametersFor` program menu:

1. From the `HP Chromatic Dispersion Test System` window menu bar shown in Figure 8-1, click on `SetParametersFor` to display the `SetParametersFor` drop-down menu.
2. Click on `Length Meas` from the `SetParametersFor` program menu.

   The `Length Measurement Settings` window shown in Figure 8-3 will open. To select the default settings, click the `Set HP Defaults` button.

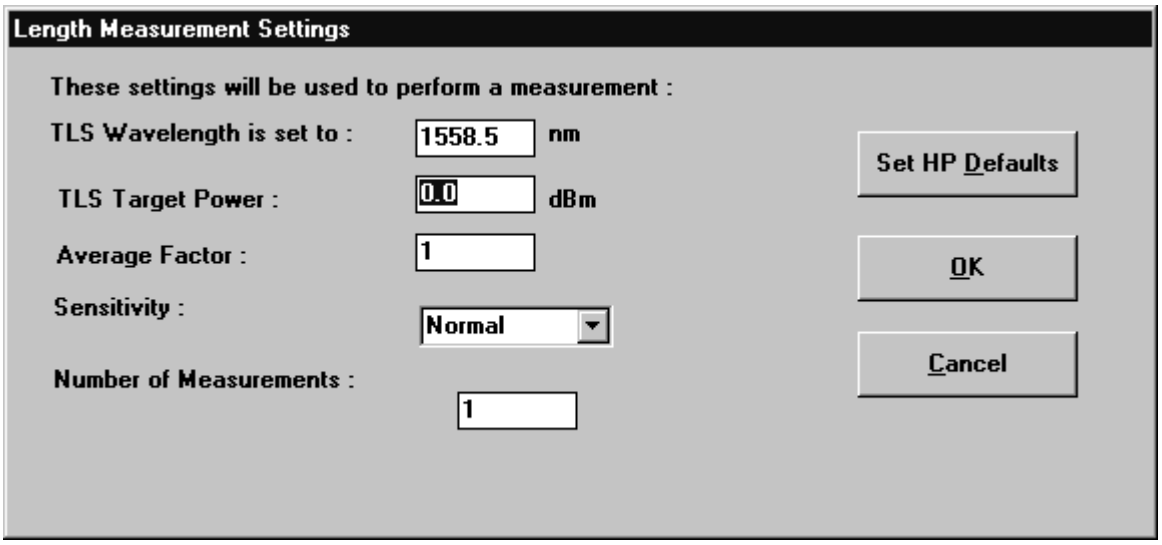

Figure 8-3. HP-CD Software Length Measurement Settings Window

The parameters in Table 8-2 are recommended as a starting point for entering test parameters into the `Length Measurement Settings` Window.

Table 8-2. Recommended Parameters for the Length Measurement Settings Window

Option	Setting	Notes
TLS Wavelength	1558.5 nm	This wavelength should correspond to the wavelength used in the calibration for accurate measurements.
TLS Target Power	0 dBm	
Averaging Factor	1	It is necessary to increase the averaging factor only if there is so much noise that you cannot get good measurements even with the `Highest` sensitivity. The measurement time will be proportional to the averaging factor, but the reduction in noise is only proportional to the square root of the averaging factor.
Sensitivity	Variable[a]	This depends on the insertion loss of your device under test. If the insertion loss is greater than 20 dB, try changing the sensitivity to `High` to see if the results are more repeatable. For insertion losses of much greater than 20 dB, it may be necessary to use the `Highest` sensitivity. The Sensitivity setting determines the IF bandwidth used by the network analyzer. The settings, `Normal`, `High`, and `Highest`, correspond to 300, 100 and 30 Hz, respectively. Noise is reduced at higher sensitivity, but measurement time increases.

a. This should be set the same as in the Test Settings window.

Setting Up Calibration Parameters

Select `Calibration` from the `SetParametersFor` menu:

1. From the `HP Chromatic Dispersion Test System` window menu bar shown in Figure 8-1, click on `SetParametersFor` to display the `SetParametersFor` drop-down menu.
2. Click on `Calibration` from the `SetParametersFor` program menu.

   The `Calibration Settings` window shown in Figure 8-4 will open. To select the default settings, click the `Set HP Defaults` button.

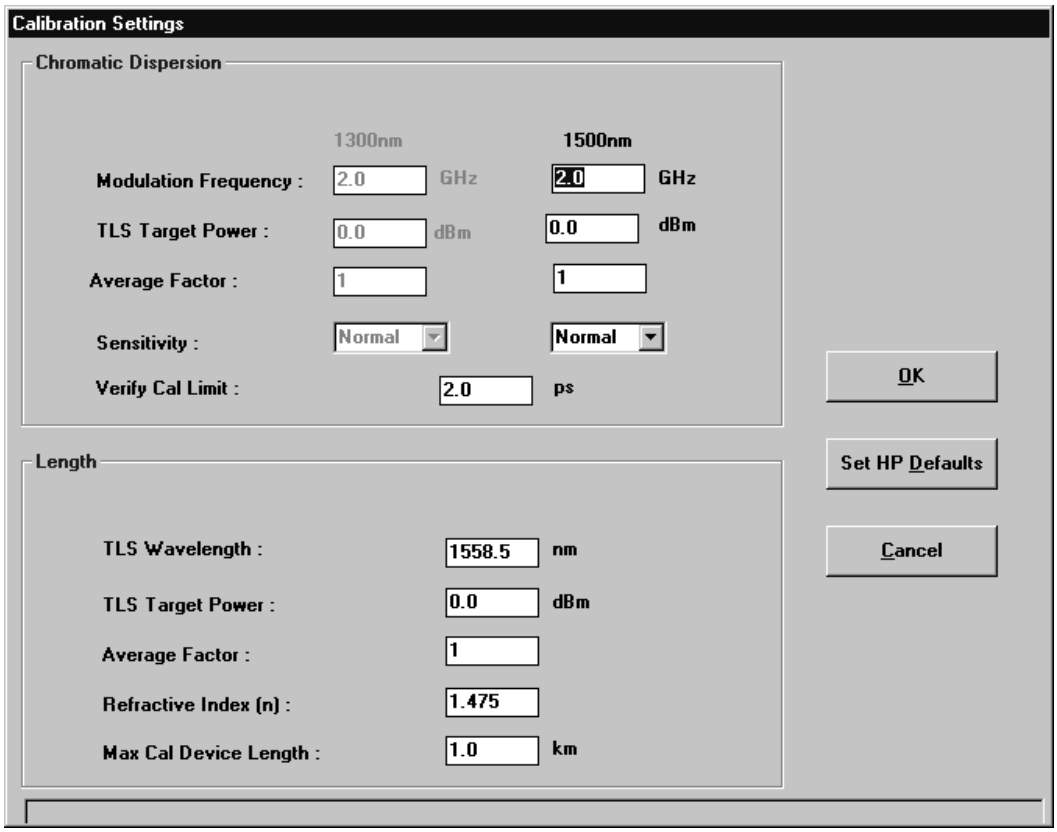

Figure 8-4. HP-CD Software Calibration Settings Window

Use the parameters in Table 8-3 as a starting point for entering test parameters into the `Calibration Settings` Window.

Table 8-3. Recommended Parameters for the Calibration Settings Window

Option	Setting	Notes
	In Chromatic Dispersion Section:	
Modulation Frequency	2 GHz[a]	It is necessary to lower this only if the product of the length of your calibration device (the "through" cable) and the wavelength step is more than 12.5 km/nm. For example, if your wavelength step is 2 nm, then the maximum allowed "through" cable length is 6.25 km.)
TLS Target Power	0 dBm	
Averaging Factor	1	It is necessary to increase the averaging factor only if there is so much noise that you cannot get good measurements even with the `Highest` sensitivity. The measurement time will be proportional to the averaging factor, but the reduction in noise is only proportional to the square root of the averaging factor.
Sensitivity	Variable	This depends on the insertion loss of your device under test. If the insertion loss is greater than 20 dB, try changing the sensitivity to `High` to see if the results are more repeatable. For insertion losses of much greater than 20 dB, it may be necessary to use the `Highest` sensitivity. The Sensitivity setting determines the IF bandwidth used by the network analyzer. The settings, `Normal`, `High` and `Highest`, correspond to 300, 100 and 30 Hz, respectively. Noise is reduced at higher sensitivity, but measurement time increases.
	In Length Section:	
TLS Wavelength	1558.5 nm	
TLS Target Power	0 dBm	
Averaging Factor	1	It is necessary to increase the averaging factor only if there is so much noise that you cannot get good measurements even with the `Highest` sensitivity. The measurement time will be proportional to the averaging factor, but the reduction in noise is only proportional to the square root of the averaging factor.
Refractive Index	Set to 1.475	
Max Cal Device Length	Maximum length of your "through" cable used for calibration	

a. The above is based on the assumption that the "through" cable is made of non-dispersion-shifted fiber whose dispersion does not exceed 20 ps/(nm×km). (Typical dispersion of non-dispersion-shifted fiber varies between 16 and 19 ps/(nm×km).) If the "through" cable you use has higher dispersion, the maximum allowed length will be less. On the other hand, if you use dispersion shifted fiber for the "through" cable, it can be more. The numbers quoted above apply to most cases.

Test Parameters For Testing Optically Amplified Systems

Setting Up CD/Gain Measurement Parameters

The CD/Gain measurements settings are used to perform a measurement.

Choose `CD/Gain Meas...` from the `SetParametersFor` program menu:

1. From the `HP Chromatic Dispersion Test System` window menu bar shown in Figure 8-1, click on `SetParametersFor` to display the `SetParametersFor` drop-down menu.
2. Click on `CD/Gain Meas...` from the `SetParametersFor` program menu.

   The `Test Settings` window shown in Figure 8-5 will open. To select the default settings, click the `Set HP Defaults` button.

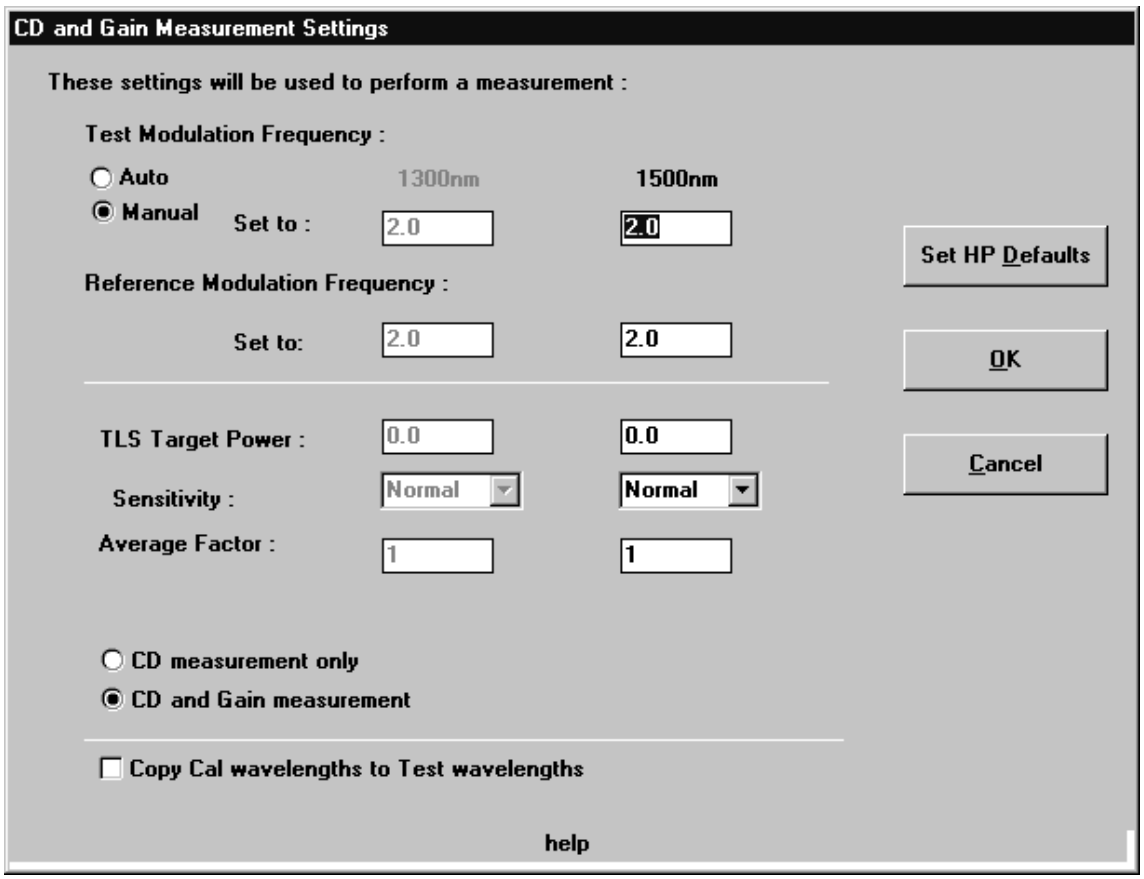

Figure 8-5. HP-CD Software Test Settings Window

The parameters in Table 8-4 are recommended as a starting point for entering test parameters into the `Test Settings` window.

Table 8-4. Recommended Parameters for the Test Settings Window

Option	Setting	Notes
Test Modulation Frequency	Auto	This causes the system to adapt the modulation rate to the level of dispersion exhibited by the test device, resulting in good precision and preservation of the phase reference. Use of the `Auto` mode slightly increases measurement time.
Reference Modulation Frequency	2 GHz	The reference measurement is designed to compensate for drift of the fiber length during the measurement. It is only necessary to lower the reference modulation frequency if the length of the fiber under test is drifting very rapidly, at more than about 50 mm/second. You may need to lower this modulation frequency if the data looks incorrect *and* your measurements are made under the following conditions: The fiber/system under test is longer than 200 km. The temperature of the fiber fluctuates at more than 0.2°/second or if the fiber is moved during the measurement to cause a large and rapid length change. The measurement time at each wavelength is more than a few seconds. If all of the above apply to your situation, try lowering the modulation frequency and see if the data improves.
TLS Target Power	0 dBm	
Sensitivity	Variable	This depends on the insertion loss of your device under test. If the insertion loss is more than 20 dB, try changing the sensitivity to *High* to see if the results are more repeatable. For insertion losses of much greater than 20 dB, it may be necessary to use the `Highest` sensitivity. The Sensitivity setting determines the IF bandwidth used by the network analyzer. The settings, `Normal`, `High` and `Highest`, correspond to 300, 100 and 30 Hz, respectively. Noise is reduced at higher sensitivity, but measurement time increases. For optically amplified systems with output greater than -3 dBm, the receiver will saturate. It may be necessary to use an optical attenuator in the test path.
Averaging Factor	1	It is necessary to increase the averaging factor only if there is so much noise that you cannot get good measurements even with the `Highest` sensitivity. The measurement time will be proportional to the averaging factor, but the reduction in noise is only proportional to the square root of the averaging factor.
CD and Gain Measurement	Enabled[a]	Select this if you would like to know the passband of your system. To obtain meaningful results on the CD measurement, the measurement wavelength span must be within the passband of the component.
Copy Cal wavelengths to Test wavelengths	Enabled	Enabling this function eliminates the need to reenter the wavelength data twice, if both the Cal and Test wavelength data are the same.

a. The software does not allow re-fitting of the data based on a user-selected wavelength range. Therefore, if the first-pass data includes points outside of the passband, retake the measurement using a smaller wavelength span.

Setting Up Length Measurement Parameters

Choose `Length Meas` from the `SetParametersFor` program menu:

1. From the `HP Chromatic Dispersion Test System` window menu bar shown in Figure 8-1, click on `SetParametersFor` to display the `SetParametersFor` drop-down menu.
2. Click on `Length Meas` from the `SetParametersFor` program menu.

   The `Length Measurement Settings` window shown in Figure 8-6 will open. To select the default settings, click the `Set HP Defaults` button.

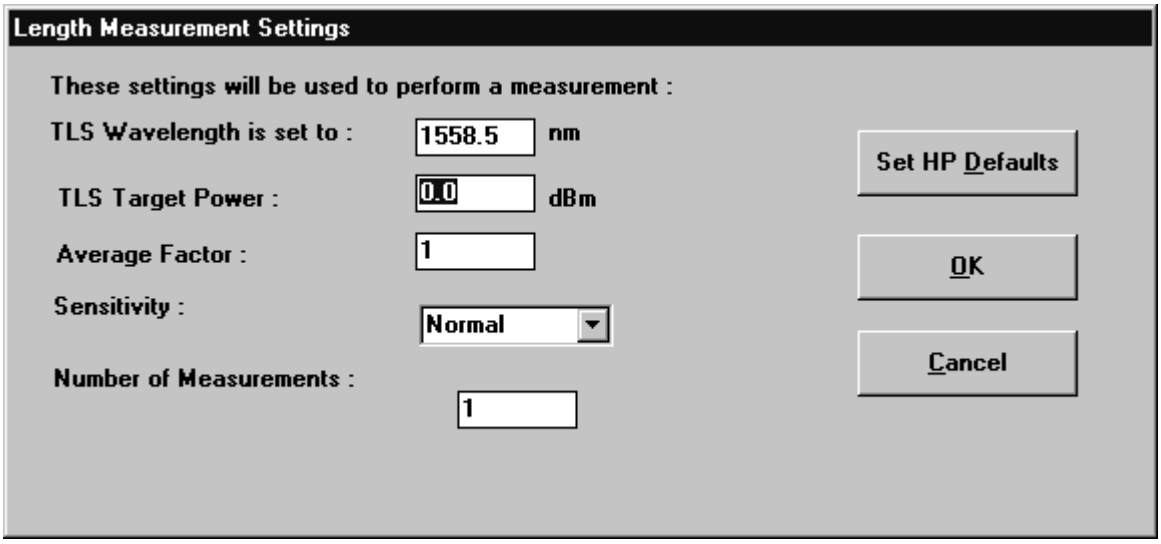

Figure 8-6. HP-CD Software Length Measurement Settings Window

The parameters in Table 8-5 are recommended as a starting point for entering test parameters into the `Length Measurement Settings` window.

Table 8-5. Recommended Parameters for the Length Measurement Settings Window

Option	Setting	Notes
TLS Wavelength	1558.5 nm	This wavelength should correspond to the wavelength used in the calibration for accurate measurements.
TLS Target Power	0 dBm	
Averaging Factor	1	It is necessary to increase the averaging factor only if there is so much noise that you cannot get good measurements even with the `Highest` sensitivity. The measurement time will be proportional to the averaging factor, but the reduction in noise is only proportional to the square root of the averaging factor.
Sensitivity	Variable[a]	This depends on the insertion loss of your device under test. If the insertion loss is greater than 20 dB, try changing the sensitivity to `High` to see if the results are more repeatable. For insertion losses of much greater than 20 dB, it may be necessary to use the `Highest` sensitivity. The Sensitivity setting determines the IF bandwidth used by the network analyzer. The settings, `Normal`, `High` and `Highest`, correspond to 300, 100 and 30 Hz, respectively. Noise is reduced at higher sensitivity, but measurement time increases.

a. This should be set the same as in the Test Settings window.

Test Parameters for Testing Optical Components such as Filters

Setting Up CD/Gain Measurement Parameters

The CD/Gain measurements settings are used to perform a measurement.

Choose `CD/Gain Meas...` from the `SetParametersFor` program menu:

1. From the `HP Chromatic Dispersion Test System` window menu bar shown in Figure 8-1, click on `SetParametersFor` to display the `SetParametersFor` drop-down menu.
2. Click on `CD/Gain Meas...` from the `SetParametersFor` program menu.

   The `Test Settings` window shown in Figure 8-7 will open. To select the default settings, click the `Set HP Defaults` button.

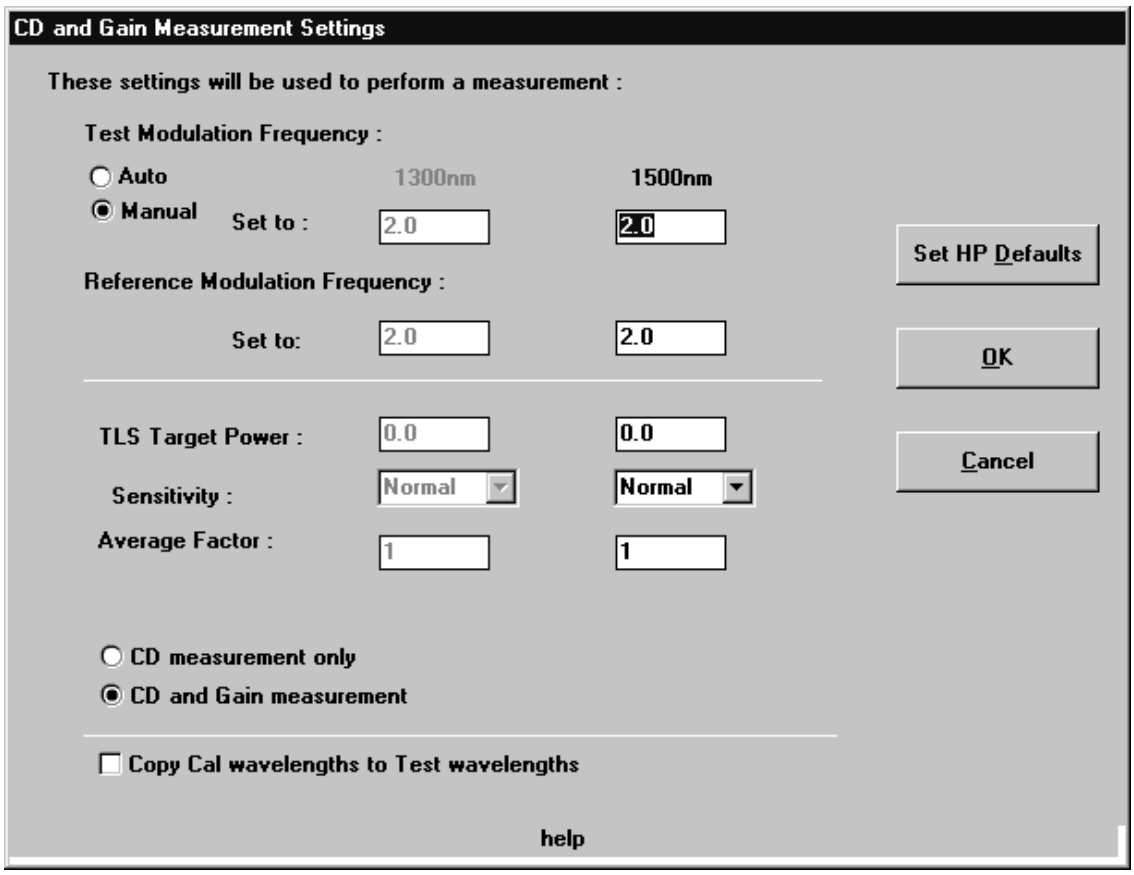

Figure 8-7. HP-CD Software Test Settings Window

The parameters in Table 8-6 are recommended as a starting point for entering test parameters into the `Test Settings` window.

Table 8-6. Recommended Parameters for the Test Settings Window

Option	Setting	Notes
Test Modulation Frequency	Auto	This causes the system to adapt the modulation rate to the level of dispersion exhibited by the test device, resulting in good precision and preservation of the phase reference. Use of the `Auto` mode slightly increases measurement time.
Reference Modulation Frequency	2 GHz	The reference measurement is designed to compensate for drift of the fiber length during the measurement. It is only necessary to lower the reference modulation frequency if the length of the fiber under test is drifting very rapidly, at more than about 50 mm/second. You may need to lower this modulation frequency if the data looks incorrect *and* your measurements are made under the following conditions: The fiber/system under test is longer than 200 km. The temperature of the fiber fluctuates at more than 0.2°/second or if the fiber is moved during the measurement to cause a large and rapid length change. The measurement time at each wavelength is more than a few seconds. If all of the above apply to your situation, try lowering the modulation frequency and see if the data improves.
TLS Target Power	0 dBm	
Sensitivity	Variable	This depends on the insertion loss of your device under test. If the insertion loss is more than 20 dB, try changing the sensitivity to `High` to see if the results are more repeatable. For insertion losses of much greater than 20 dB, it may be necessary to use the `Highest` sensitivity. The Sensitivity setting determines the IF bandwidth used by the network analyzer. The settings, `Normal`, `High` and `Highest`, correspond to 300, 100 and 30 Hz, respectively. Noise is reduced at higher sensitivity, but measurement time increases. For optically amplified systems with output greater than -3 dBm, the receiver will saturate. It may be necessary to use an optical attenuator in the test path.
Averaging Factor	1	It is necessary to increase the averaging factor only if there is so much noise that you cannot get good measurements even with the `Highest` sensitivity. The measurement time will be proportional to the averaging factor, but the reduction in noise is only proportional to the square root of the averaging factor.
CD and Gain Measurement	Enabled[a]	Select this if you would like to know the passband of your component. To obtain meaningful results on the CD measurement, the measurement wavelength span must be within the passband of the component.
Copy Cal wavelengths to Test wavelengths	Enabled	Enabling this function eliminates the need to reenter the wavelength data twice, if both the Cal and Test wavelength data are the same.

a. The software does not allow re-fitting of the data based on a user-selected wavelength range. Therefore, if the first-pass data includes points outside of the passband, retake the measurement using a smaller wavelength span.

Setting Up Length Measurement Parameters

Choose `Length Meas` from the `SetParametersFor` program menu:

1. From the `HP Chromatic Dispersion Test System` window menu bar shown in Figure 8-1, click on `SetParametersFor` to display the `SetParametersFor` drop-down menu.
2. Click on `Length Meas` from the `SetParametersFor` program menu.

   The `Length Measurement Settings` window shown in Figure 8-8 will open. To select the default settings, click the `Set HP Defaults` button.

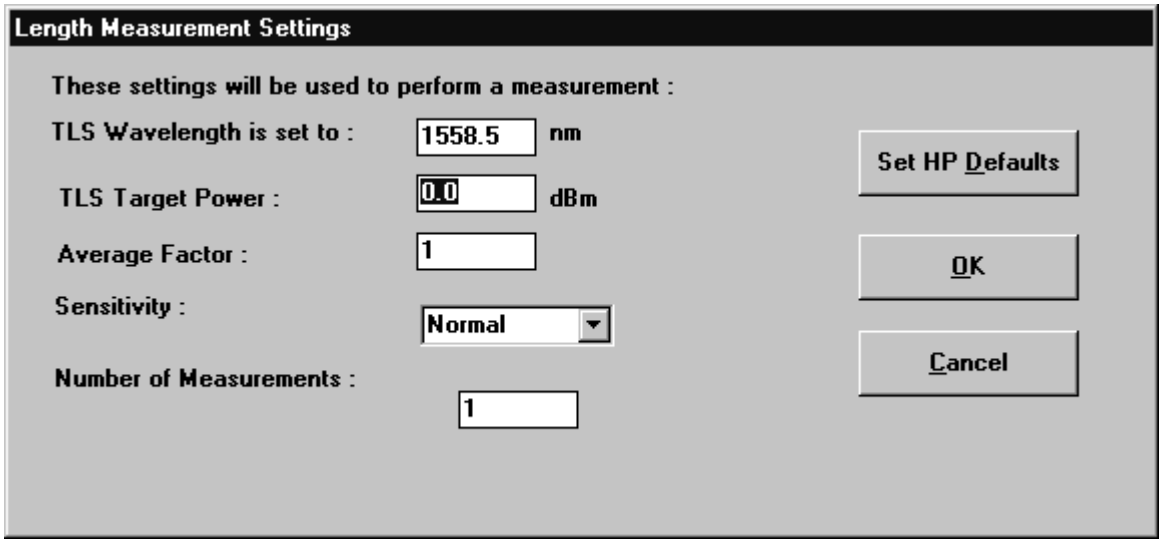

Figure 8-8. HP-CD Software Length Measurement Settings Window

The parameters in Table 8-7 are recommended as a starting point for entering test parameters into the `Length Measurement Settings` window.

Table 8-7. Recommended Parameters for the Length Measurement Settings Window

Option	Setting	Notes
TLS Wavelength	Center of component passband	This wavelength should correspond to the wavelength used in the calibration for accurate measurements.
TLS Target Power	0 dBm	
Averaging Factor	1	It is necessary to increase the averaging factor only if there is so much noise that you cannot get good measurements even with the `Highest` sensitivity. The measurement time will be proportional to the averaging factor, but the reduction in noise is only proportional to the square root of the averaging factor.
Sensitivity	Variable[a]	This depends on the insertion loss of your device under test. If the insertion loss is greater than 20 dB, try changing the sensitivity to `High` to see if the results are more repeatable. For insertion losses of much greater than 20 dB, it may be necessary to use the `Highest` sensitivity. The Sensitivity setting determines the IF bandwidth used by the network analyzer. The settings, `Normal`, `High` and `Highest`, correspond to 300, 100 and 30 Hz, respectively. Noise is reduced at higher sensitivity, but measurement time increases.

a. This should be set the same as in the Test Settings window.

Setting Up Calibration Parameters

Select `Calibration` from the `SetParametersFor` menu:

1. From the `HP Chromatic Dispersion Test System` window menu bar shown in Figure 8-1, click on `SetParametersFor` to display the `SetParametersFor` drop-down menu.
2. Click on `Calibration` from the `SetParametersFor` program menu.

   The `Calibration Settings` window shown in Figure 8-9 will open. To select the default settings, click the `Set HP Defaults` button.

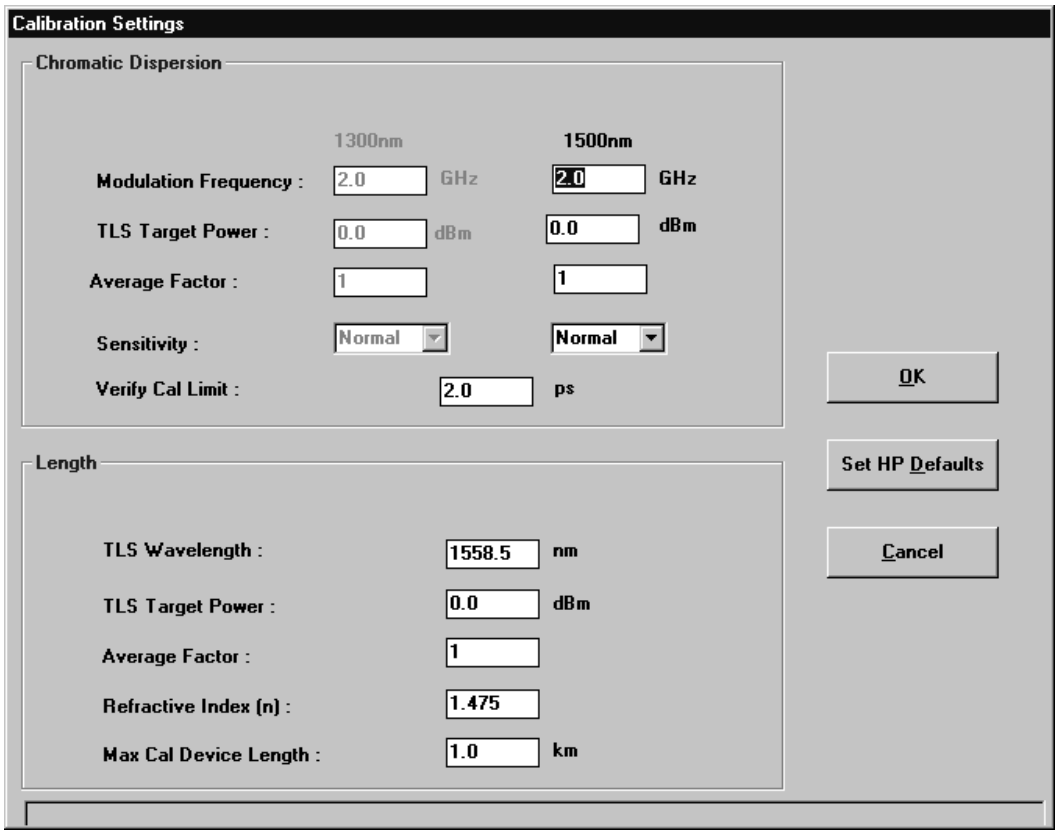

Figure 8-9. HP-CD Software Calibration Settings Window

The parameters in Table 8-8 are recommended as a starting point for entering test parameters into the `Calibration Settings` window.

Table 8-8. Recommended Parameters for the Calibration Settings Window

Option	Setting	Notes
	In Chromatic Dispersion Section:	
Modulation Frequency	2 GHz[a]	It is necessary to lower this only if the product of the length of your calibration device (the "through" cable) and the wavelength step is more than 12.5 km/nm. For example, if your wavelength step is 2 nm, then the maximum allowed "through" cable length is 6.25 km.)
TLS Target Power	0 dBm	
Averaging Factor	1	It is necessary to increase the averaging factor only if there is so much noise that you cannot get good measurements even with the `Highest` sensitivity. The measurement time will be proportional to the averaging factor, but the reduction in noise is only proportional to the square root of the averaging factor.
Sensitivity	Normal–unless the insertion loss of your calibration device is more than 10 dB (opt.)	It is recommended that the insertion loss of your calibration device be kept to less than 10 dB to obtain a good cal file. (Bad cal data will affect all subsequent measurements that use the same cal.).
	In Length Section:	
TLS Wavelength	1558.5 nm	This wavelength should correspond to the wavelength used in the calibration for accurate measurements.
TLS Target Power	0 dBm	
Averaging Factor	1	It is necessary to increase the averaging factor only if there is so much noise that you cannot get good measurements even with the `Highest` sensitivity. The measurement time will be proportional to the averaging factor, but the reduction in noise is only proportional to the square root of the averaging factor.
Refractive Index	Set to 1.475	
Max Cal Device Length	Maximum length of your "through" cable used for calibration	

a. The above is based on the assumption that the "through" cable is made of non-dispersion-shifted fiber whose dispersion does not exceed 20 ps/(nm×km). (Typical dispersion of non-dispersion-shifted fiber varies between 16 and 19 ps/(nm×km).) If the "through" cable you use has higher dispersion, the maximum allowed length will be less. On the other hand, if you use dispersion shifted fiber for the "through" cable, it can be more. The numbers quoted above apply to most cases.

Performing a Periodic Calibration 9-3

Calibration/Verification

At a glance

This chapter describes the calibration procedure which removes any systematic effects of the HP 86037A Chromatic Dispersion Test System and fiber patch cords from a chromatic dispersion measurement.

Performing a Periodic Calibration

The calibration process compensates for sources of systematic uncertainty in the measurement system. The calibration path must include any fiber jumper cables which will be used to connect the device under test to the test set. This allows the system to remove the effects of these jumper cables from the measurement itself.

To perform a calibration, follow these steps:

1 Click on the New Calibration button on the HP 86037A Chromatic Dispersion Test System Setup window.

The dual band `New Calibration` window shown in Figure 9-1 will open. The single band window will only contain one column of data.

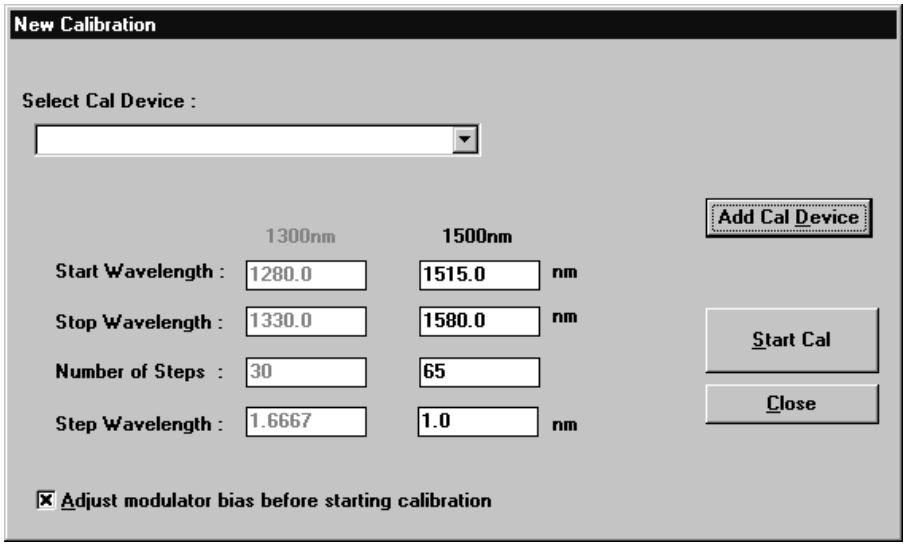

Figure 9-1. New Calibration Window

2 Select the name of the calibration device from the Select `Cal Device` field or highlight a name in the list box. To add another calibration device, click on the `Add Cal Device` button. Repeat this step for each device you wish to add.

3 Enter the start and stop wavelengths in the appropriate fields.

4 Enter the number of steps or step wavelength.

5 If you wish to adjust the modulator bias before starting the calibration, click `Adjust modulator bias` before starting a calibration. Enabling this selection is recommended.

If you change the wavelength values and then click `Add Cal Device` in the `New Calibration` window, the wavelength values will reset to the default values and must be reentered.

6 Connect the chosen calibration device.

> Before making the fiber connections, read the section on "Cleaning Connections for Accurate Measurements" on page 3-4.

Below are two examples of calibration devices:

- A fiber jumper connected between the test ports of the CD system. Following the calibration an end of the jumper will be disconnected and the device under test inserted.
- If a pair of fiber extension cables will be used to connect a test device to the system, the calibration device will consist of the two extension cables connected by a through adapter. Following the calibration, the through adapter is removed and the test device inserted.

7 Start the calibration by clicking the *Start Cal* button. A calibration can take 5 to 10 minutes to complete, depending on the number of steps selected.

During calibration, the Status display at the bottom of the Test Setup window will show `Calibrating. Please stand by...` in red letters. The data monitor graph is visible during actual collection of the calibration data. When the calibration is completed, the graph display automatically closes and the Status display indicates `Ready`. If no other calibrations are required, close the calibration window and continue with your measurement.

Calibration must be performed prior to making measurements with the system, but does not need to be performed before each individual measurement. Usually, if the system has remained ON since the last calibration, a calibration only needs to be performed once a day. It is sometimes possible to use calibration files four or five days old and still obtain good results. When in doubt, perform a calibration verification.

Assembly Replacement

At a Glance

This chapter documents the procedures for removal and replacement of components in the HP 86037A Chromatic Dispersion Test system.

The warranty and calibration will be voided on systems where the individual instruments, including fiberoptic cables, RF cables, or HP-IB cables are removed by the customer. The system should only be disassembled by a Hewlett-Packard Customer Engineer. The instruments should not be swapped or removed by non-Hewlett-Packard personnel.

Removal and Replacement Procedures

The HP 86037A Chromatic Dispersion Test System is composed of many instruments, each with a specific procedure for removal. In most instances the replacement procedure is the reverse of the removal procedure. If there are any special steps for replacement, they will be specified in the removal procedure.

Because all the components in this system follow the EIA unit standard, most components housed in these cabinets are removed in the same way.

HP 8167 or HP 8168 Tunable Laser Source

Preparation

The system must be turned off and the power must be removed by disconnecting the power cord. There can be an HP 8167 tunable laser source and an HP 8168 tunable laser source in the HP 86037A Chromatic Dispersion system.

Removal

The following steps outline the procedure for removal of the tunable laser source.

1. Open the rear door of the system rack and unplug the power cord from the instrument.
2. Disconnect the cable attached to the Mod. Out port on the back panel of the tunable laser source.
3. Disconnect the HP-IB cable(s) from the rear of the instrument. To reduce the risk of damage, loosen one nut a few turns, then the other. On cables that are stacked, make sure the inner nut does not turn when loosening the outer nut.
4. Disconnect the fiber cable from the output connector of the TLS. Cover both the fiber end and the connector on the TLS.
5. Remove the four Phillips screws in the front of the unit that secure the TLS to the rack.
6. Slide the TLS from the rack, being careful not to pinch or damage any system cables.
7. Remove the rack flange from the front of the instrument if the instrument is to be replaced with another tunable laser source.

Installation

The replacement procedure is the reverse of the removal procedure.

HP 8753 Network Analyzer

Preparation

The system must be turned off and the power must be removed by disconnecting the power cord.

Removal

The following steps outline the procedure for removal of the network analyzer.

1. Open the rear door of the system rack and unplug the power cord from the instrument.
2. Disconnect the Y-cord on the rear panel of the network analyzer. If necessary, label the cable ends with a designation denoting which port to reconnect them to.
3. Remove the coaxial cables from the front of the network analyzer.
4. Remove the four Phillips screws in the front of the unit that secure the network analyzer to the rack.
5. Slide the network analyzer from the rack, being careful not to pinch or damage any system cables.
6. Remove the rack flange from the front of the instrument if the instrument is to be replaced with another network analyzer.

Installation

The replacement procedure is the reverse of the removal procedure.

> Remove the rubber feet from the bottom of the instrument before installing into the system.

HP 83427A CD Test Set

Preparation

The system must be turned off and the power must be removed by disconnecting the power cord.

Removal

The following steps outline the procedure for removal of the test set.

1. Open the rear door of the system rack and unplug the power cord from the power strip.
2. Remove the coaxial cables from the front and rear of the test set.
3. Disconnect the fiber cable assemblies from the optical ports on the HP 83427A Chromatic Dispersion test set. Cover the loose fiber cable ends and the connectors on the test set.
4. Remove the four Phillips screws in the front of the rack that secure the HP 83427A Chromatic Dispersion test set to the rack.
5. Slide the HP 83427A Chromatic Dispersion test set from the rack, being careful not to pinch or damage any system cable.
6. Remove the rack flange from the front of the component if the test set is to be replaced with another test set.

Installation

The replacement procedure is the reverse of the removal procedure.

> Remove the rubber feet from the bottom of the instrument before installing into the system.

HP 86120x Wavemeter

Preparation

The system must be turned off and the power must be removed by disconnecting the power cord.

Removal

The following steps outline the procedure for removal of the wavemeter.

1. Open the rear door of the system rack and unplug the power cord from the instrument.
2. Disconnect the HP-IB cable(s) from the rear of the instrument. To reduce the risk of damage, loosen one nut a few turns, then the other. On cables that are stacked, make sure the inner nut does not turn when loosening the outer nut.
3. Disconnect the keyboard and mouse cables from the computer.
4. Pull the cables through the rack.
5. Slide the work surface and keyboard tray assembly from the rails attached to the rack so that the wavemeter can be removed.
6. Remove the four Phillips screws in the front of the rack that secure the wavemeter rack-mount assembly to the rack.
7. Remove the wavemeter rack-mount assembly, being careful not to pinch or damage any system cables.

Once the wavemeter rack-mount assembly is removed from the system, follow the steps below to remove the wavemeter from the rack-mount assembly.

1. Remove the rack flange from the front of the instrument if the instrument is to be replaced with another tunable laser source.
2. Remove the four screws securing the front dress panel to the rack-mount assembly front mount brackets.
3. Remove the handle from the side of the wavemeter cover.
4. Remove the four screws securing the rack-mount assembly to the rear of the wavemeter.

Installation

The replacement procedure is the reverse of the removal procedure.

Performance and Verification Tests

At a Glance

This chapter contains information and procedures for testing components in the HP 86037A Chromatic Dispersion Test System.

Component Verification

Performing a Self Test on the Tunable Laser Source

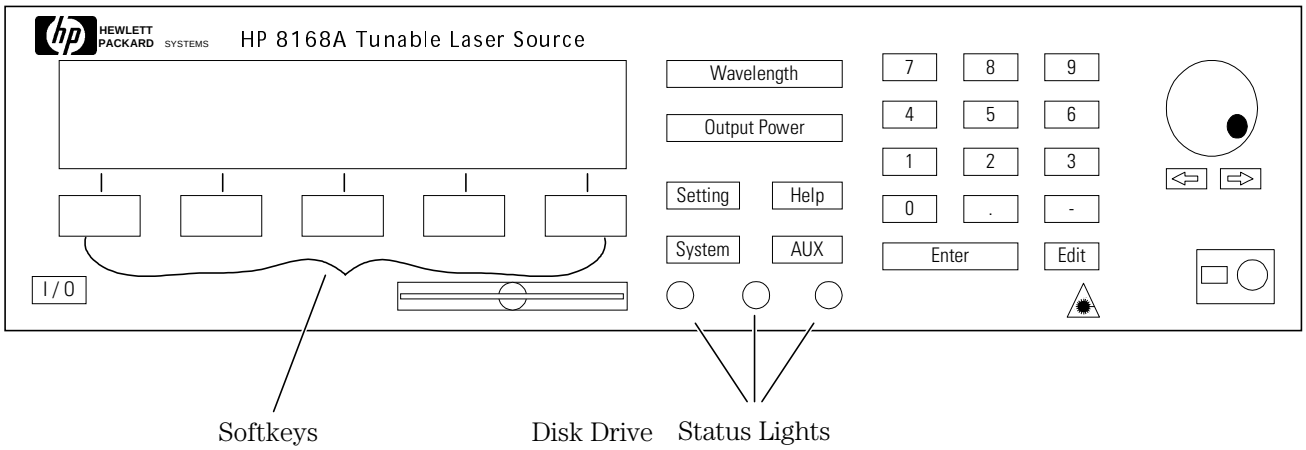

Figure 11-1. The HP 8168E/F Tunable Laser Source

Press the *SelfTst* softkey to start the internal instrument self test. The instrument performs a full self test, indicating after each test that the test has been performed, and the results of that test (`PASS` or `FAIL`).

µP1 Board	Indicates the test of the first microprocessor board.
µP2 Board	Indicates the test of the second microprocessor board.
Calibration Data	The test of the calibration data stored in the instrument.
HW-Interface	Tests the hardware interface.
ADC	The test of the analog to digital converter.
Laser Board	Tests the laser driver board.
Motor 1	Tests the first of two motors used to control the tuning of the laser.
Motor 2	Tests the second of two motors used to control the tuning of the laser.
Motor 3	Tests the motor used to control the attenuation.

When the test is completed, the message `Self test. . . . . passed` is shown on display.

Self Test Failure

If the instrument fails a self test, the end of the test is signaled by three short beeps and the message `Self test. . . . . failed` is displayed. Even if the instrument fails the self test, it will continue to operate to the extent of its capabilities.

Performing a Self Test on the Network Analyzer

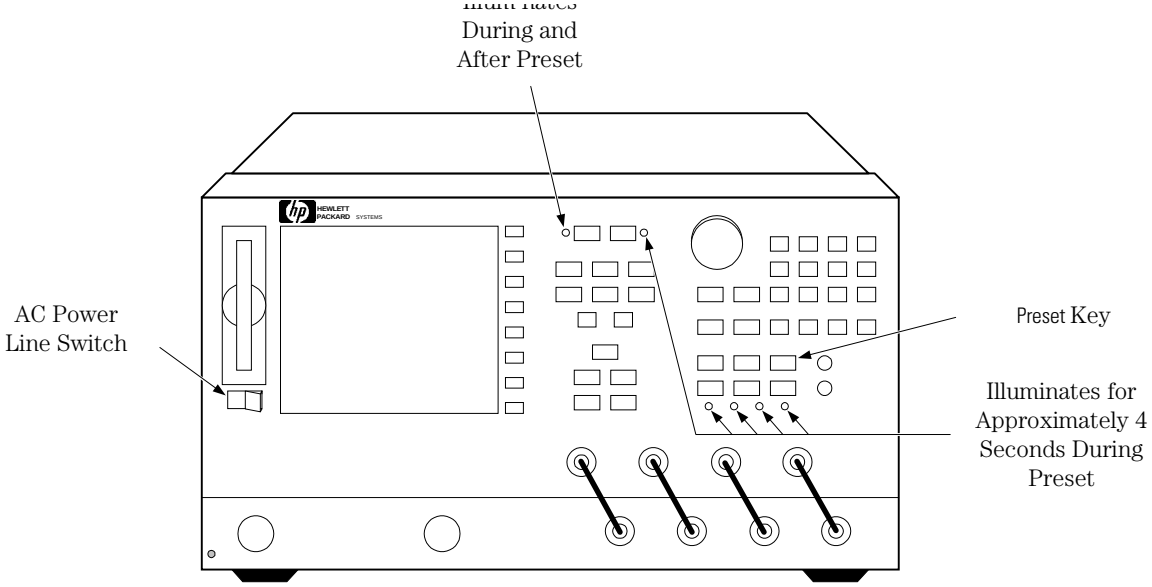

Figure 11-2. Self Test for the HP 8753 Network Analyzer

To begin the self test on the HP 8753 Network Analyzer:

1. Disconnect all devices and peripherals from the analyzer (including all test set interconnects).
2. Turn on the unit and press the Preset key. Figure 11-2 shows the indications that the analyzer is working properly.

   After the Preset is complete, the following parameters will appear on the network analyzer display:

   `CH1, S`$_{11}$`, log MAG, 10dB, REF 0dB`

   `START 30kHz, STOP 3GHz` (or `6GHz` for Option 006)

Self Test Failure

If the self test failed, please see the HP 8753E Network Analyzer service manual for instructions on testing the individual components of the network analyzer, or call your HP service center.

Running the Operator's Check on the Network Analyzer

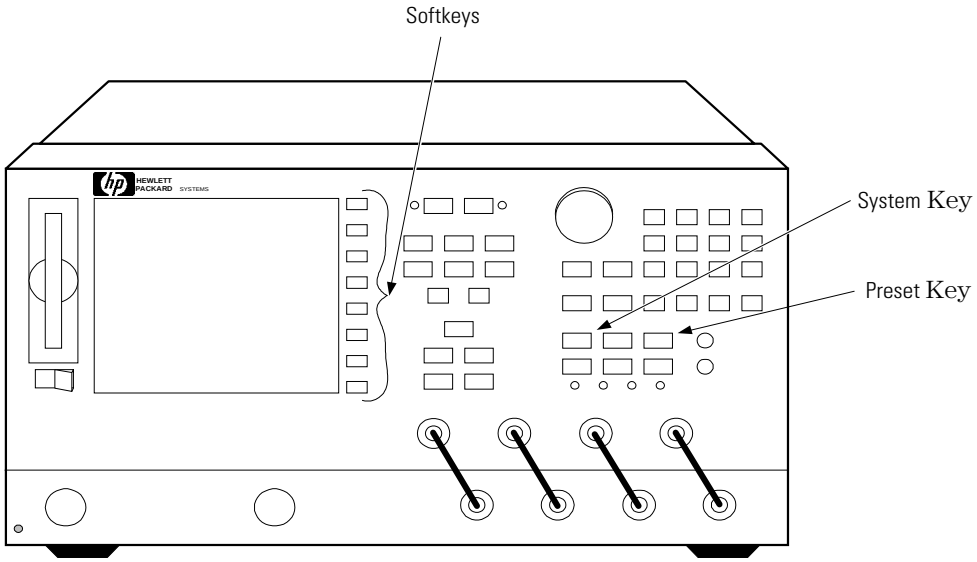

Figure 11-3. Operator's Check for the HP 8753 Network Analyzer

The operator's check determines that:

- the source is phase locked across the entire frequency range.
- All three samplers are functioning properly.

Equipment

20 dB attenuator	HP 8491A Option 020
RF cable set	HP 11851B
Two-way power splitter	HP 11667A Option 001

Procedure

1. Disconnect all devices, peripherals, and accessories (including adapters and limiters) from the analyzer
2. Switch on the analyzer
3. Press the Preset button on the HP 8753 Network Analyzer
4. Press the System button on the HP 8753 Network Analyzer
5. From the column of softkeys to the right of the HP 8753 Network Analyzer:
   a. Press the softkey corresponding to the *Service* menu
   b. Press the softkey corresponding to the *Tests* menu
   c. Enter '21' on the network analyzer keypad
   d. Press the 'x1' button on the HP 8753 Network Analyzer
   e. Press the softkey corresponding to the *External Tests* function
6. Press the Execute Test key on the HP 8753 Network Analyzer

7 At the prompt, connect the equipment as shown in Figure 11-4, with power to inputs R and A. Press the *Continue* softkey as prompted until the analyzer displays PASS or FAIL.

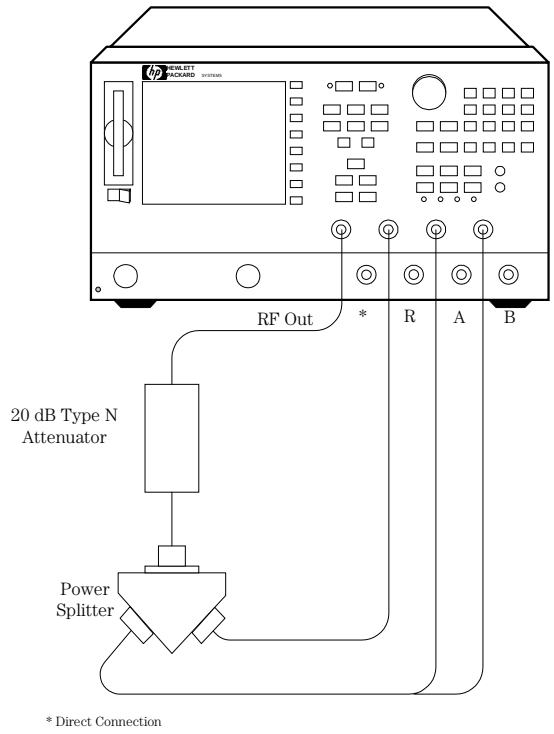

Figure 11-4. Operator's Check Setup

8 Press 22 and then the x1 button on the network analyzer to access the input R and B operator's check. When the title appears, press the *Execute Test* softkey. Move the RF cable from input A to B. Press the *Continue* softkey as prompted until the analyzer displays PASS or FAIL.

Operator's Check Failure

If the operator's check fails:

- recheck the equipment configuration and connections.
- Confirm the attenuator, splitter, and cables meet their published specifications. Visually inspect the connectors.

Please see the HP 8753E Network Analyzer service manual for instructions on testing the individual components of the network analyzer, or call your HP service center.

HP-IB Systems Check on the Network Analyzer

Check the network analyzer's HP-IB functions with a known working passive peripheral such as a plotter, printer, or disk drive.

1. Connect the peripheral to the network analyzer using a good HP-IB cable.
2. Press the Local button, then the *System Controller* softkey to enable the analyzer to control the peripheral.
3. Press the *Set Addresses* softkey and the appropriate softkeys to verify that the device addresses will be recognized by the analyzer. The factory default addresses are listed in Table 11-1.

Table 11-1. HP-IB Addresses

Device	HP-IB Address
HP 8753E	16
Plotter port - HP-IB	5
Printer port - HP-IB	1
Disk (external)	0
Controller	21
Power meter - HP-IB	13

You may use other addresses with two provisions:

- Each device must have its own address.
- The address set on each device must match the one recognized by the analyzer (and displayed).

Peripheral addresses are often set with a rear panel switch. Refer to the manual of the peripheral to read or change its address.

Plotter or Printer

1. If you are using a plotter or printer, ensure that it is set up correctly:
   - **a** Power in on
   - **b** Pens and paper are loaded
   - **c** Pinch wheels are down
   - **d** If needed, set the P1 and P2 positions set
2. Press the copy button, then the *Plot* or *Print Monochrome* softkeys

   If the result is a copy of the network analyzer display, the printing/plotting features are functional in the analyzer.

   If the printer or plotter does not print correctly, suspect the HP-IB function of the analyzer. Refer to the troubleshooting section of the HP 8753E service manual.

External Disk Drive

1. Select the external disk drive. Press the Save/Recall button, then the *Select Disk* and *External Disk* softkeys.
2. Verify that the address is set correctly. Press the Local button, then the *Set Addresses* and *Address:Disk*.
3. Ensure that the disk drive is set up correctly:
   - **a** Power is on
   - **b** An initialized disk in the correct drive
   - **c** Correct disk unit number and volume number (press the Local button to access the softkeys that display the numbers; default is 0 for both)
   - **d** With hard disk (Winchester) drives, make sure the configuration switch is properly set (see drive manual)
4. Press the Start button, '1' on the number pad, M/μ button, the Save/Recall button, then the *Save State* softkey. Then press the Preset button, Save/Recall button, then the *Recall State* softkey.
   - **a** If the resultant trace starts at 1 MHz, HP-IB is functional in the analyzer.
   - **b** If the resultant trace does not start at 1 MHz, suspect the HP-IB function of the analyzer. Refer to the troubleshooting section of the HP 8753E service manual.

12

Common Problems 12-3
General Troubleshooting 12-5
Troubleshooting the Network 12-9

Troubleshooting

At a glance

This section contains information to help troubleshoot the HP 86037A Chromatic Dispersion Test System.

This chapter shows you how to troubleshoot the system to the instrument level. To prevent voiding product warranty, do not remove any instrument covers. The HP 83427A Chromatic Dispersion Test Set is *not* customer serviceable. Do not open the HP 83427A's covers for any reason.

WARNING **These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing unless you are qualified to do so.**

WARNING **The opening of the system or removal of parts is likely to expose dangerous voltages. Disconnect the product from all voltage sources while it is being opened.**

Common Problems

Some wavelengths are 0
The wavelength meter may not have an optical input level high enough to ensure correct operation. Check the power at the wavelength meter at those wavelengths where the problem occurred. It should be greater than –25 dBm.

Some wavelengths are grossly wrong
If the tunable laser source requires several seconds to settle at a selected wavelength, an erroneous wavelength meter reading may result. If this behavior is observed, send the laser to HP for repair.

Laser protection error on TLS
The TLS has degraded. To continue making measurements in the short term, try lowering the target power by –2 dBm and see if the problem goes away. If not, send the laser back to HP for repair. Even if this works, the laser should be sent back to HP for repair to ensure good long term performance of the system.

Low power
First check to make sure all the connectors are clean. If the power is still low, check the power from the tunable laser source directly at its output with an optical power meter. It should read very close to the power indicated on the front panel.

Low RF signal
Make sure a modulator bias has been performed.

Data looks incorrect
If the test path contains an optical amplifier, check for possible overdriving of the receiver input of the CD test set. The input level should be less than –3 dBm. Also assure the measurement wavelength range is appropriate for the pass band of the amplified system.

Problems with narrowband device testing
The five-term Sellmeier fit is generally inappropriate for very narrowband devices, such as Fabry-Perot filters. The result can be roughness in the fitted curve and multiple values of lambda zero. This is not a problem when testing fibers.

Results of different curve fit models do not agree
The three curve fit types differ in their ability to conform to the actual dispersion curve of the tested fiber. As a result, a variation on the order of a few hundredths to a few tenths of a nanometer can be observed in the value of lambda zero. The three-term Sellmeier curve fit tends to yield a lower lambda zero value than the other two fits.

Although the five-term Sellmeier curve fit has greater ability to fit the measured data, it is also more easily affected by noise. Therefore, the quadratic fit will generally give a more repeatable value of lambda zero. For most DSF, the mean values of lambda zero returned by the five-term and quadratic curve fits are in good agreement while the three-term fit yields a lower value.

Fitted curve does not follow the actual data

The shape of the curve fitted to the relative group delay data depends upon the device under test and the type of fit selected. Conditions of high DUT insertion loss, low DUT dispersion or narrow wavelength range can also affect the quality of the fit. The system will always try to fit the selected curve to the data. Because the 5-term Sellmeier curve fit has more freedom to follow the shape of the data, it may display multiple zero dispersion wavelengths under some conditions.

The three types of curve fit are appropriate in different situations, as shown in the table below:

Table 12-1. Types of Fitted Curves

Wavelength Range of Measured Data	Type of Fiber	Suggested Curve Fit
1300 nm	non-dispersion shifted (SMF)	3-term Sellmeier
	dispersion shifted (SMF/DS)	Quadratic or 3-term
1500 nm	non-dispersion shifted (SMF)	Quadratic or 3-term
	dispersion shifted (SMF/DS)	Quadratic
1300 and 1500 nm	non-dispersion shifted (SMF)	5-term Sellmeier
	dispersion shifted (SMF/DS)	5-term Sellmeier

For most optical fibers, only the 5-term Sellmeier curve can provide a good fit over the combined (1300 and 1500 nm) wavelength ranges. A fitted 3-term Sellmeier or Quadratic curve follow the data quite closely in one wavelength range but diverge from the data in the other wavelength range. This is to be expected from the capabilities of the curve fit "model equations".

Fitted curve does not appear in relative group delay graph

Depending upon the device under test and the setup conditions, the fitted curve may closely follow the data in one of the wavelength ranges and diverge from the data in the other wavelength range. This is more likely to happen when the 3-term Sellmeier or Quadratic curve fit is applied to data collected in the combined wavelength ranges. See the previous topic (above).

General Troubleshooting

Common troubleshooting skills can be used to locate many problems. The following steps are suggested for quickly narrowing down the problem.

1 Inquire about recent repairs or changes to the system.

Often, this will help pinpoint current problems even if the system was operating correctly after the repair or change to the system.

2 Determine whether the problem is a hardware or a software problem.

If the problem is software related, refer to the *Getting Started* section in the beginning of this manual to either setup, or reinstall the HP 86037A Chromatic Dispersion Test System software. The correct addresses for the computer and the HP 86037A Chromatic Dispersion Test System are located in the back of that section. If reinstalling the software does not solve the problem, the problem may not be a software error.

If the problem is hardware related:

3 Check that the system components are wired correctly.

4 Remove, clean, and reinstall all optical connections.

5 Ensure that all cables are secure.

6 Check for a 50Ω load at the back of each TLS.

Troubleshooting the TLS

WARNING **Prior to disconnecting any optical fibers on the TLS, ensure that the TLS is turned off.**

The following tests must be made in order to accurately troubleshoot the system.

Testing TLS Power

The first step is to test the output power from the TLS. There should be a minimum of distance between TLS and the optical power meter used to test the power, and the original cable from the TLS should not be used.

1 Disconnect the TLS from the test set and use an optical power meter to test the TLS power.

a Turn off the power on the TLS. Failure to comply can cause personal injury.

b Remove the cable connecting the TLS to the test set.

c Connect a jumper cable between the power meter and the TLS.

d Turn on the TLS.

e Test the TLS power.

Table 12-2. Results Table

Results	Description
Power is good	The TLS is not the problem. Continue to the next TLS test, "Testing TLS to Test Set Cabling"
Power is bad	The TLS is bad

Testing TLS to Test Set Cabling

This step will test the optical cable linking the TLS and the HP 86037A Chromatic Dispersion Test System test set. This step assumes that the optical power meter received a correct power level from the TLS in the previous step.

2 Test the optical cable linking the TLS and the HP 86037A Chromatic Dispersion Test System test set.

a Turn off the power on the TLS. Failure to comply can cause personal injury.

b Remove the jumper installed in step 1 that connected the TLS and the optical power meter.

c Reconnect the original optical cable that you removed in step 1 to the TLS.

d Connect the open end of the optical cable to the optical power meter.

e Turn on the TLS.

f Test the TLS power.

Table 12-3. Results Table

Results	Description
Power is good	The optical cable is not the problem. Continue to the next section, "Troubleshooting the Test Set"
Power is bad	The optical cable is bad

Troubleshooting the Test Set

WARNING **Prior to disconnecting any optical fibers on the TLS, ensure that the TLS is turned off.**

To accurately troubleshoot the system, make sure the TLS is working properly prior to testing the test set. Refer to "Troubleshooting the TLS" on page 12-6.

To check the test set:

1 Check the connectors on the test set.

a Use a microscope to check the connections on the test set. If using a microscope is not practical, a jeweler's loop may be used instead.

Figure 12-1 shows the end of a clean fiber-optic cable. The dark circle in the center of the micrograph is the fiber's 125 µm core and cladding which carries the light. The surrounding area is the soft nickel-silver ferrule.

Figure 12-2 shows a dirty fiber end from neglect or perhaps improper cleaning. Material is smeared and ground into the end of the fiber causing light scattering and poor reflection. Not only is the precision polish lost, but this action can grind off the glass face and destroy the connector.

Figure 12-3 shows physical damage to the glass fiber end caused by either repeated connections made without removing loose particles or using improper cleaning tools. When severe, the damage on one connector end can be transferred to another good connector that comes in contact with it.

See Chapter , "Maintenance" for information on inspecting and care of connectors.

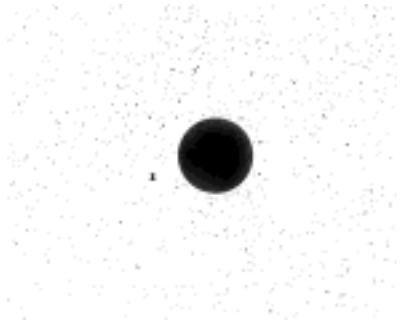

Figure 12-1. Clean, problem-free fiber end and ferrule.

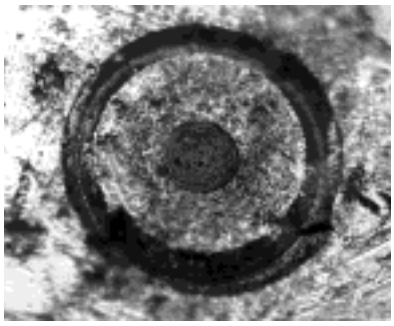

Figure 12-2. Dirty fiber end and ferrule from poor cleaning.

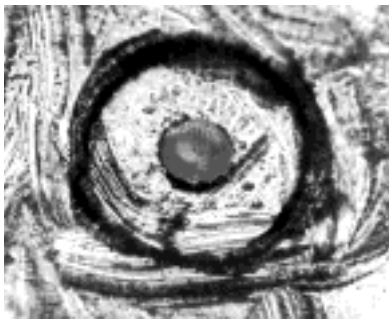

Figure 12-3. Damage from improper cleaning.

2 Run the self test for the HP 8753E Network Analyzer. This test is located in Chapter , "Performance and Verification Tests".

If the self test passes, then the problem must be in the test set.

Table 12-4. Results Table

Results	Description
Self-Test passes	The problem is mostly likely in the test set
Self-Test fails	The HP 8753 Network Analyzer is bad

Troubleshooting the Computer

For problems with the personal computer that are unrelated to the rest of the HP 86037A Chromatic Dispersion Test System, please see the personal computer manual that was shipped with this system, or call your local IT department.

To troubleshoot the computer's connection to the HP 86037A Chromatic Dispersion Test System, first:

1. Make sure that the BNC cable (or a serial cable on the dual band system) running to the test set is connected properly.
2. Ensure that the HP-IB and computer addresses are correct. The correct addresses for the computer and the HP 86037A Chromatic Dispersion Test System are located in the *Getting Started* section in the beginning of this manual.

If the system still does not seem to be working correctly, do the following test:

1. Disconnect the BNC cable (or a serial cable on the dual band system) from the test set.
2. With a voltage meter, measure the voltage from the cable. It should be reading between 2 and 4 volts.

Troubleshooting the Network

There are many types of inter-office LANs. Because of this, this manual can only give very basic troubleshooting information. If the HP 86037A Chromatic Dispersion Test System is not communicating with the LAN, refer to the Windows NT documentation on networking the system. The Windows NT help system also contains a *Networking Troubleshooter* section which will guide you through the most common networking problems.

For additional help, refer to your local IT department, or call the HP Test and Measurement Customer Support line at (800) 452-4844.

There are some simple troubleshooting steps that can be helpful in solving general networking problems. They are:

- Make sure the LAN cable is connected properly to the computer.
- Setup the computer LAN card according to the manufacturer's specifications.
- Disconnect the LAN cable, and test it using a LAN cable tester tool.

13

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Optimizing Measurement Accuracy 13-5
Stability of the Test Fiber 13-8
Material List 13-11
Hewlett-Packard Sales and Service Offices 13-15

Reference

At a Glance

This chapter contains reference material for the HP 86037A Chromatic Dispersion System. This material includes the product material list and information on how to contact HP representatives.

Repeatability Performance

Introduction

This is a comparison of the measurement repeatability of one of HP's precision chromatic dispersion test systems with and without the wavelength meter. The measurements were performed on the same spool of 22-km dispersion-shifted fiber. The wavelength range was from 1525 to 1575 nm in 1 nm steps. The data were analyzed with the five-term Sellmeier fit.

Repeatability results

Table 13-1. Repeatability Data for 20 Runs With the Wavelength Meter

Table 13-2.

Parameter	**λ_0 (nm)**	**S_0 [ps/ ($nm^2 \times km$)]**
Mean	1550.8938	0.0733825
Maximum	1550.9062	0.0734366
Minimum	1550.8829	0.0733237
Max-min	0.0233	0.0001129
Standard Deviation	0.008116	0.0000318

Table 13-3. Repeatability Data for 20 Runs Without the Wavelength Meter

Parameter	**λ_0 (nm)**	**S_0 [ps/ ($nm^2 \times km$)]**
Mean	1550.8850	0.0733461
Maximum	1550.8906	0.0734181
Minimum	1550.8789	0.0732212
Max-min	0.0117	0.0001969
Standard Deviation	0.00354	0.0000553

Table 13-4. Comparison Between the Mean Values

Parameter	Mean λ_0 (nm)	Mean S_0 [ps/ (nm2 × km)]
With wavelength meter	1550.8850	0.0733461
Without wavelength meter	1550.8938	0.0733875
Δ	0.0088	0.0000364

Comments

The standard deviation for λ_0 is actually higher for the measurements taken with the wavelength meter than for those without. This is most likely because the measurements made with the wavelength meter take longer, and therefore are more susceptible to fiber length drifts. The particular HP tunable laser source used in the measurement was so accurate that it did not introduce much wavelength error. These results are based on one system, therefore we cannot guarantee them as specifications for all systems since the absolute wavelength accuracy of HP's tunable laser sources is specified to be ±0.1 nm. For best accuracy, a system with a wavelength meter is still recommended.

Optimizing Measurement Accuracy

Introduction

The purpose of this section is to communicate the results of our evaluations of the HP 86037A Chromatic Dispersion Test System and to outline a method for optimizing the measurement accuracy. The evaluations revealed that the system's accuracy varies as a function of modulation frequency. Based on this data, we have concluded that for optimum accuracy, the modulation frequency should be kept above 1 GHz and preferably at 2 GHz.

Key assumptions

The following assumptions must be satisfied in order to use the optimization method outlined in "Optimizing for best accuracy" on page 13-6.

1 The group delay can be modeled by the quadratic equation:

$$\tau_g(\lambda) = \frac{S_o}{2}(\lambda - \lambda_o)^2 L$$

Where S_0 is the dispersion slope, λ the wavelength, λ_0 the zero dispersion wavelength, and L the fiber length. The precise details of the quadratic fit to the data are not critical; the only requirement is that the group delay curve should have the shape of a parabolic curve. In fact the results presented here are valid even if the three-term or the five-term Sellmeier fits are used, as those two models also have the parabolic shape. This assumption is valid for systems consisting mostly of dispersion-shifted fiber.

2 The dispersion slope S_0 [in ps/(nm2×km)] is known. For example, $S_0 \approx 0.07$ ps/ (nm^2×km) for most dispersion shifted fiber. The zero dispersion wavelength λ_0 need not be known but should lie within the spectral range of the measurement.

Optimizing for best accuracy

The basic strategy for optimizing accuracy is to keep the modulation frequency above 1 GHz, and at 2 GHz if possible. This will put some restrictions on the wavelength step size because too large a step size will result in a phase "wrap-around" where the phase jump exceeds 360° as the wavelength is stepped. The maximum step size can be determined as follows:

$$(\Delta\lambda)_{MAX} = \frac{500}{S_o f_m \lambda_{SPAN} L}$$

where:

$(\Delta\lambda)_{MAX}$	=	Maximum allowed step size (in nm) to keep the modulation frequency at the desired value f_m
f_m	=	Desired modulation frequency (in GHz)
S_0	=	Dispersion slope in ps/(nm^2×km)
λ_{SPAN}	=	Spectral span of the measurement in nm [= (stop λ – start λ)]
L	=	Length of the system/fiber in km

Example

To make a chromatic dispersion measurement on a 70 km spool of dispersion shifted fiber between 1515 and 1575 nm at the optimum modulation frequency of 2 GHz, we will use the above equation to determine the maximum allowed wavelength step size. Assuming the fiber's dispersion slope is 0.07 ps/(nm^2 km), then:

f_m	=	2 GHz
S_0	=	0.07 ps/(nm^2 × km)
λ_{SPAN}	=	60 nm
L	=	70 km

Substituting these into the above equation, we have:

$$(\Delta\lambda)_{MAX} = \frac{500}{\frac{0.07\ ps}{nm^2 \cdot KM}\ X\ 2\ GHz\ X\ 60nm\ X\ 70km}$$

Note that this is the maximum allowed step size. Steps shorter than 0.85 nm are permitted. The 0.85 nm step size will result in about 70 steps for the measurement.

If a shorter measurement time is desired, the following approaches can be considered:

1 Sacrifice accuracy for measurement speed by choosing a lower modulation frequency.

For the example above, if we make f_m= 1 GHz, the step size can be increased to 1.7 nm, resulting in about 35 steps for the measurement and thereby halving the measurement time.

2 Another approach is to make a survey measurement with a wide wavelength range and a lower modulation frequency, for example, 500 MHz, and then raise the modulation frequency, for example, to 2 GHz, but narrow down λ_{SPAN} by zooming into the wavelength range of interest.

From the above equation, we see that a reduction of λ_{SPAN} by a factor of 2 will increase the maximum allowed step size $(\Delta\lambda)_{MAX}$ by 2. The number of steps, $\propto \lambda_{SPAN} / (\Delta\lambda)_{MAX}$, and therefore the measurement time, will decrease by a factor of 4.

For the example above, reducing the measurement span from 60 to 30 nm will increase the maximum allowed step size from 0.85 nm to 1.7 nm. The measurement time will decrease from about 9 minutes to about 2 min. 15 sec.

Stability of the Test Fiber

The HP-CD system provides a method for examining the length stability of the test fiber to high precision and in real time. This technique can be used prior to a CD measurement to determine whether the test fiber has reached thermal equilibrium. Stability is examined by measuring modulation phase at the output of the test fiber relative to the electrical modulation source, as a function of time. The change in group delay required to produce a change in modulation phase is given by:

$$\Delta\tau = \frac{\textit{Change in phase}}{\textit{360 x Modulation Frequency}}$$

In convenient units, this relation becomes:

$$\Delta\tau\ (\mathrm{ps}) = \frac{\textit{Change in phase (degrees)}}{\textit{Modulation Frequency (GHz)}}$$

An observed phase change of 0.36 degrees at a modulation frequency of 1 GHz is evidence of a 1 ps change in the group delay of the test fiber. For convenience, you can set the Scale/Div to 0.36 degrees so each vertical division corresponds to 1 ps of drift in the group delay.

If you prefer to analyze the stability of the test fiber in terms of length, use the following relation:

$$\Delta L\ (mm) = \frac{\textit{Change in phase (degrees)}}{n \textit{ x Modulation Frequency (GHz)}}$$

Using this relation, an observed phase change of 1.45 degrees at a modulation frequency of 1 GHz is evidence of a 1 mm change in the length of the test fiber, assuming a refractive index of n = 1.45. For convenience, set the Scale/Div to 1.45 degrees so that each vertical division corresponds to 1 mm of drift in the length of the test fiber.

To Monitor Fiber Length Stability

Adjusting Modulator Bias

Perform a Modulator Bias adjustment, if one has not already been performed.

1. Click on the `Modulator Bias` button.

   You will be prompted by the system to install a short thru fiber between test ports.

2. When you have finished making the connections, click `OK`.

3 When the Modulator Bias adjustment is complete, remove the thru fiber and connect the fiber to be tested between the test ports.

Setting The Laser Output Power

4 On the front panel of the HP 8168 tunable laser source, press the *LOCAL* key.

5 Verify the laser output power is set to at least –4 dBm at a wavelength in the passband of the test device.

Measuring Modulation Phase

1 On the front panel of the HP 8753 network analyzer, press the *LOCAL* key.

2 Enter the CW frequency by pressing:

MENU
CW FREQ
1 G/n

3 Enter the number of points by pressing:

MENU
NUMBER of POINTS
401 X1

4 Enter a convenient sweep time, such as 60 seconds, by pressing:

MENU
SWEEP TIME
60 X1

5 To select continuos sweep, press:

MENU
TRIGGER MENU
CONTINUOUS

6 Begin a new sweep by pressing:

MENU
MEASURE RESTART

7 To autoscale the displayed trace, wait until the first sweep is complete, and then press:

SCALE/REF
AUTOSCALE
The displayed trace is a history of the modulation phase over the selected time period (sweep time).

8 You can change the scale factor or reference value, by pressing:

SCALE/REF
SCALE/DIV or REFERENCE VALUE

Saving the Setup

9 To save the setup, so it is available when making length stability measurements in the future, press:

SAVE
SAVE REG#

10 To title the register, press:

SAVE
TITLE REGISTER#

11 Enter the title and then press:

DONE
RETURN

12 To save the title and the setup, press:

SAVE **your title**

Recalling the Setup

13 To recall a previously stored setup, press:

RECALL
RECALL **your title**

14 To adjust the vertical axis of the display, press:

SCALE/REF
SCALE/DIV or REFERENCE VALUE or AUTOSCALE

Control of the instruments will return to the HP-CD test system, when you return to using the mouse or keyboard. The network analyzer and tunable laser source are automatically initialized for all of the system measurements.

Material List

The material list for the Standard HP 86037A Chromatic Dispersion Test System is shown in Table 13-5. The changes for each of the system options will be shown in Table 13-5 through Table 13-6.

Table 13-5. Standard System Material List

Description	Part Number	Quantity	Units
SMM5.0 10 CWPNTX	0515-0386	4	EA
SM 1032 CWPNPH	0570-1366	22	EA
FC/PC CONNECTOR	08154-61702	1	EA
BOARD-DAC CONN	0960-0988	1	EA
ADPT-FBR OPT. SM	1005-0089	1	EA
CBL FBR SPC 1.75M	1005-0172	1	EA
CBL FBR SPC .40	1005-0173	1	EA
CBL FBR SPC SPC 1.25M	1005-0177	1	EA
CA FBROPT FC/PC	1005-0384	1	EA
FO VERI SPOOL	1005-0387	1	EA
OPT FIBER 1310NM	1005-0421	1	EA
CONN PWR M 5-15	1251-4218	1	EA
CAP-PROT .812ID	1401-0247	13	EA
CAP-COND .612ID	1401-0247	13	EA
SM1032 5CWPNTX	2680-0278	31	EA
1U BLANK	40101A	1	EA
RK FLR PNL-5.25	40103A	1	EA
WORK SURFACE AY	46298N	1	EA
HPIB CABLE ADAP	5060-9462	2	EA
KIT-RACK MT FLAG	5062-3974	1	EA
RACK MT FLG	5062-3974	1	EA
RCK MNT KIT	5062-3977	1	EA
RK MOUNT KIT	5062-3979	1	EA
RACK FLANGE KIT	5062-6450	1	EA
CA 03C 03F-03M	8120-1405	3	EA
CA BNC/BNC 48C	8120-2582	1	EA
CA 24C 24F-24F	8120-3444	1	EA

Table 13-5. Standard System Material List (Continued)

Description	Part Number	Quantity	Units
CA 24C 24F-24F	8120-3445	2	EA
CBL M-N M-N7.5IN	8120-4782	4	EA
PWR CRD 0	8120-5178	1	EA
TNBL LSR SRCE	8167B	0	EA
TNBL LSR SRCE	8168D	0	EA
TNBL LSR SRCE	8168E	0	EA
TNBL LSR SRCE + OD	8168E OPT 007	1	EA
TNBL LSR SRCE	8168F	1	EA
HPIB INTFC BD	82335B	1	EA
RFCA AY-OPSW OUT	83427-60003	0	EA
MOD BIAS CA-OUT	83427-60001	0	EA
CHROM DISP-TS	83427A	1	EA
BRKT KEYBD HLDR	83467-00005	1	EA
COVER-RIGHT	83467-00016	1	EA
SOFTWARE-CD	83467-10001	1	EA
FIBER MNGMT TRAY	83467-60001	1	EA
DAC TO BNC ADPTR	83467-60002	1	EA
USER GDE-86037A	86037-90001	1	EA
SERV GDE-86037A	86037-90002	1	EA
OPT MLT-WV METER OPT. UK6	86120B	1	EA
RF NTWK ANALYZER OPT. 011 & OPT. UK6	8753E	1	EA
MOUSEPAD 11.5×9	9300-1498	1	EA
FAN ASSY 110 V	C2786-60024	1	EA
HP ULTRA VGA1024 OPT ABA	D2825A	1	EA
CD ROM DRIVE	D4383B	1	EA
32MB SDRAM DIMM	D5362A	1	EA
VECTRA VL	D5721N	1	EA
LAN CARD	D6692A	1	EA
1100 MM EIA 19IN AW3 (FOR 110 V) 1100 MM EIA 19IN AW5 9for 220 V)	33660A	1	EA
RAIL	E3663-00001	6	EA

Table 13-6 is the changes to the standard material list for option 112 of the HP 86037A Chromatic Dispersion Test System.

Table 13-6. Option 112 System Material List

Description	Part Number	Quantity	Units
RACK FLANGE KIT	5062-6450	1	EA
CA 03C 03F-03M	8120-1405	3	EA
CA BNC/BNC 48C	8120-2582	1	EA
CA 24C 24F-24F	8120-3444	1	EA
CA 24C 24F-24F	8120-3445	2	EA
CBL M-N M-N7.5IN	8120-4782	4	EA
PWR CRD 0	8120-5178	1	EA
TNBL LSR SRCE	8167B	0	EA
TNBL LSR SRCE	8168D	0	EA
TNBL LSR SRCE	8168E	0	EA
TNBL LSR SRCE + OD	8168E OPT 007	1	EA
TNBL LSR SRCE	8168F	1	EA
HPIB INTFC BD	82335B	1	EA
RFCA AY-OPSW OUT	83427-60003	0	EA
MOD BIAS CA-OUT	83427-60001	0	EA
CHROM DISP-TS	83427A	1	EA
BRKT KEYBD HLDR	83467-00005	1	EA
COVER-RIGHT	83467-00016	1	EA
SOFTWARE-CD	83467-10001	1	EA
FIBER MNGMT TRAY	83467-60001	1	EA
DAC TO BNC ADPTR	83467-60002	1	EA
USER GDE-86037A	86037-90001	1	EA
SERV GDE-86037A	86037-90002	1	EA
OPT MLT-WV METER OPT. UK6	86120B	1	EA
RF NTWK ANALYZER OPT. 011 & OPT. UK6	8753E	1	EA
MOUSEPAD 11.5×9	9300-1498	1	EA
FAN ASSY 110 V	C2786-60024	1	EA
HP ULTRA VGA1024 OPT ABA	D2825A	1	EA
CD ROM DRIVE	D4383B	1	EA
32MB SDRAM DIMM	D5362A	1	EA
VECTRA VL	D5721N	1	EA
LAN CARD	D6692A	1	EA
1100 MM EIA 19IN AW3 (FOR 110 V) 1100 MM EIA 19IN AW5 9for 220 V)	33660A	1	EA

Table 13-6. Option 112 System Material List (Continued)

Description	Part Number	Quantity	Units
RAIL	E3663-00001	6	EA

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