User's Guide

HP 70880A Linewidth Measurement Personality

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

Introducing the Linewidth Measurement Personality

The HP 70880A linewidth measurement personality takes advantage of current technologies to calculate laser linewidth. With the personality installed into an HP 71400C lightwave signal analyzer, accurate measurements are achieved. The personality makes linewidth measurements using the laser's lineshape rather than just measuring the nominal -3 dB frequency. The personality includes the following:

- an automatic setup routine

- interferometer output signal polarization adjustment

- calculations to determine Lorentzian lineshape parameters

- real-time display of linewidth calculations in a measurement results window

The program can measure linewidths as narrow as 100 kHz. Linewidths can be measured with an accuracy of 8%. In addition, problems caused by LO-feedthrough are no longer a factor. Some of the advantages of calculating the laser linewidth, versus measuring the -3 dB point of the laser lineshape, are listed below:

- All trace points are used to find the linewidth. The calculations give more accurate, repeatable results.
- Very low start frequencies are not required to display the top of the lineshape and the -3 dB point on the curve.
- Local oscillator feedthrough problems are removed. Using higher start frequency settings avoids the LO feedthrough. Formerly, LO feedthrough was avoided by using low start frequencies, low resolution bandwidths, and long sweep times.
- Linewidth is calculated from data located in a region of the lineshape that contains most of the linewidth information.
- Trace noise is averaged making data from any single trace point insignificant.

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SAFETY SYMBOLS

GENERAL INSTRUMENT SAFETY CONSIDERATIONS

WARNING

Before the spectrum analyzer is switched on, make sure it is properly grounded through the protective conductor of the ac power cable to a socket outlet provided with protective earth contact.

Any interruption of the protective (grounding) conductor, inside or outside the instrument, or disconnection of the protective earth terminal can result in personal injury.

CAUTION

Before the spectrum analyzer is switched on, make sure its primary power circuitry has been adapted to the voltage of the ac power source.

Failure to set the ac power input to the correct voltage could cause damage to the instrument when the ac power cable is plugged in.

User's Guide Key Conventions

The following key conventions are used throughout this guide:

<kbd>FRONT PANEL KEY</kbd>   Boxed text indicates a key physically located on the front-panel of the instrument or on a controller keyboard.

`Softkey`   Shaded text with the first letter capitalized indicates a softkey label called a firmkey. Press the front-panel <kbd>MENU</kbd> key to display firmkeys along the left-hand side of the display. When pressed, firmkeys cause a related set of softkeys to appear along the right-hand edge of the display.

`softkey`   Shaded text with all lowercase letters indicates a softkey label. These keys access a subset menu of softkeys.

`SOFTKEY`   Shaded text in all capital letters indicates a key label that, when pressed, executes its function or requires user input.

`Screen Text`   Bold text in this typeface indicates information that may appear on the display. This typeface usually represents prompts, warnings, and measurement results.

In This Guide . . .

Read the following information to get an idea of what the different chapters of this guide contain.

- Chapter 1, "Getting Started" guides you through installing the linewidth measurement personality (DLP).

- Chapter 2, "Making Measurements" guides you through measurement examples. The recommended test equipment table, methods for optimizing measurements results, and measurement setup information is located in this chapter.

- Chapter 3, "Using the Menu Keys" provides an illustration of the linewidth measurement menu. There are descriptions of the information displayed and the related equations provided in this chapter. In addition, there is an alphabetized reference of the menu key functions.

- Chapter 4, "Programming" contains remote command information. Commands and their descriptions are alphabetically listed in this chapter.

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Getting Started

Getting Started

Use this chapter to get the program started, and to understand:

- Acquiring recommended equipment and upgrades.

- Verifying or editing the HP-IB address.

- Installing the HP 70880A linewidth measurement personality into an HP 71400C lightwave signal analyzer.

- Setting up the personality to make linewidth measurements.

Acquiring Required Equipment

To use the HP 70880A laser linewidth measurement personality, you need an HP 71400C or HP 71401C lightwave signal analyzer and an interferometer, such as an HP 11980A interferometer. The system must include an HP 70810B and HP 70900 LO firmware with the date code 910802 (August 2, 1991) or later. To upgrade your equipment, refer to the information below:

HP 70810A/B upgrade   The HP 70810A/B upgrade kit enhances the capability of the LO in the HP 71400 measurement system. The kit contains new firmware for the HP 70900 LO module and for the HP 70810. New manuals are included in the kit.

New processor board   It is recommended that HP 70900A Local Oscillator modules be upgraded to an HP 70900B to improve the speed of the linewidth calculations. Order HP 70860A to upgrade the HP 70900A to an HP 70900B. To determine if your local oscillator module is an HP 70900B, press these keys:

`State`

`MORE 1 of 3` `MORE 2 of 3`

`show states` `EXTEND STATE`

If the message `FPU: PRESENT` appears and the date code is earlier than 910802, you need to upgrade the firmware only. To upgrade the firmware only, order an HP 70861A *unless* you are already upgrading from an "A" to an HP 70810B. The A/B upgrade kit includes the HP 70816A.

Installing the Measurement Personality

The measurement personality can be installed from a ROM card or from a floppy disk. Insert the HP 119880A linewidth measurement personality ROM card into the card-reader slot, or the 3.5-inch disk into the disk drive.

If you have problems installing the program with the following procedure, refer to specific information in the HP 70900B operation manual, or to the HP 70004A display manual.

Loading the Personality From a ROM Card

With the ROM card inserted, press (MENU), then press the following softkeys:

1. Press `State recall`.

2. Press `recall from . . .`

   - Press `HP-MSIB CARD` to catalog the files on the memory card.

If the message storage device error appears

If you do not get a catalog of the memory card, or if you see the message **storage device error** displayed, check for the following:

- Check that the card is seated firmly in the card-reader slot.
- Check the number displayed after pressing `HP-MSIB CARD`. It must match the MSIB column address of the HP 70004A display. If the numbers do not match, use the numeric keypad to enter the correct column address.

If the condition persists, set the "Mass Storage Is" selector of the HP 70400A display to the memory card, as follows:

a. Press (DISPLAY) `Mass Storage MSI MEMORY CARD`.

b. To return to the catalog display, press (MENU) `Misc more 1 of 3 catalog` and `MSI`.

---

3. Press `LOAD FILE` and enter the file number of the program.

Loading the Personality From the Floppy Disk

With the 3.5-inch disk inserted into the HP 9122A external disk drive (or another CS80-compatible disk drive), press (MENU), then press the following softkeys:

1. Press `State recall`.

2. Press `recall from . . .`.

- Press `HP-IB DISK` to display the 3.5-inch disk files.

If disk catalog does not appear

If you do not get a catalog of the floppy disk, check for the following:

- Make sure the disk is inserted correctly.
- Check the number displayed after pressing `HPIB DISK`. It must match the HP-IB address and unit number of the external disk drive.

The unit number is entered along with the HP-IB address, separated to enter the correct column address. Typically the references are as follows:

- A dual-floppy disk references the left-hand drive as "0" and the right-hand drive as "1".
- A hard disk/floppy device typically references the floppy as "1.")

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3. Press `LOAD FILE`. The file name is displayed, followed by a number indicating the program's memory requirement.

4. Enter the file number with the data keys and press `ENTER`. Wait as the file is installed into memory.

5. Press `(USER)` `LW` to start the lightwave measurement personality.

Editing the disk drive HP-IB address

If you install the personality from a 3.5-inch disk drive, connect an HP 9122 disk drive (or similar CS80-compatible disk drive) to the lightwave signal analyzer with an HP-IB cable. When you copy programs directly from an external disk drive, you must enter the drive's HP-IB address. Use the procedure in this chapter to enter the address when you catalogue files. The default address for the disk drive is 0, the unit is 0, and the volume is 0. Enter new addresses in the form "A.UV," where:

A   is a digit from 1 through 7, representing the drive's HP-IB address.

U   is a digit from 0 through 9, representing the unit number.The unit number is typically 0 or 1 and refers to an individual disk- drive slot.

V   is a digit from 0 through 9, representing the volume number. Hard-disk drives are specified with volume numbers. For disks, the volume number should remain 0.

Returning the Instrument for Service

Refer to the repackaging instructions in the lightwave signal analyzer service guide if it is necessary to return a lightwave signal analyzer or the measurement personality to the factory.

The HP sales and service office personnel often can answer your questions. If you have any error messages copied onto a sheet of paper, have the sheet available when you talk to one of the engineers.

Table 1-1. Hewlett-Packard Sales and Service Offices

US FIELD OPERATIONS			
Headquarters Hewlett-Packard Company 19320 Pruneridge Avenue Cupertino, CA 95014, USA |800| 752-0900	**California, Northern** Hewlett-Packard Co. 301 E. Evelyn Mountain View, CA 94041 |415| 694-2000	**California, Southern** Hewlett-Packard Co. 1421 South Manhattan Ave. Fullerton, CA 92631 |714| 999-6700	**Colorado** Hewlett-Packard Co. 24 Inverness Place, East Englewood, CO 80112 |303| 649-5000
Georgia Hewlett-Packard Co. 2000 South Park Place Atlanta, GA 30339 |404| 955-1500	**Illinois** Hewlett-Packard Co. 5201 Tollview Drive Rolling Meadows, IL 60008 |708| 255-9800	**New Jersey** Hewlett-Packard Co. 120 W. Century Road Paramus, NJ 07653 |201| 599-5000	**Texas** Hewlett-Packard Co. 930 E. Campbell Rd. Richardson, TX 75081 |214| 231-6101

EUROPEAN FIELD OPERATIONS			
Headquarters Hewlett-Packard S.A. 150, Route du Nant-d'Avril 1217 Meyrin 2/Geneva Switzerland |41 22| 780.8111	**France** Hewlett-Packard France 1 Avenue Du Canada Zone D'Activite De Courtaboeuf F-91947 Les Ulis Cedex France |33 1| 69 82 60	**Germany** Hewlett-Packard GmbH Berner Strasse 117 6000 Frankfurt 56 West Germany |49 69| 500006-0	**Great Britain** Hewlett-Packard Ltd. Eskdale Road, Winnersh Triangle Wokingham, Berkshire RF11 5DZ England |44 734| 696622

| INTERCON FIELD OPERATIONS			
Headquarters Hewlett-Packard Company 3495 Deer Creek Rd. Palo Alto, California 94304-1316 |415| 857-5027	**Australia** Hewlett-Packard Australia Ltd. 31-41 Joseph Street Blackburn, Victoria 3130 |61 3| 895-2895	**Canada** Hewlett-Packard |Canada| Ltd. 17500 South Service Road Trans- Canada Highway Kirkland, Quebec H9J 2X8 Canada |514| 697-4232	**China** China Hewlett-Packard Company 38 Bei San Huan X1 Road Shuang Yu Shu Hai Dian District Beijing, China |86 1| 256-6888
Japan Yokogawa-Hewlett-Packard Ltd. 1-27-15 Yabe, Sagamihara Kanagawa 229, Japan |81 427| 59-1311	**Singapore** Hewlett-Packard Singapore |Pte.| Ltd 1150 Depot Road Singapore 0410 |65| 273-7388	**Taiwan** Hewlett-Packard Taiwan 8th Floor, H-P Building 337 Fu Hsing North Road Taipei, Taiwan |886 2| 712-0404	

2

Making Measurements

Making Measurements

This section contains the table of measurement characteristics, an illustration of the measurement-scheme block diagram, and information about using the measurement personality. There is information about using the automatic setup routine and adjusting the interferometer polarization. The linewidth calculations that occur at the end of each sweep are defined in this section as well.

The measurement examples provided here use the equipment listed in "Using Recommended Equipment." Other equipment can be substituted, however, the measurement characteristics will differ from those listed in Table 2-1.

Laser linewidth measurements are made using the delayed self-homodyne scheme illustrated in Figure 2-1. The laser lineshape centered at the optical frequency f_0 is mixed down to the base band (0 Hz).
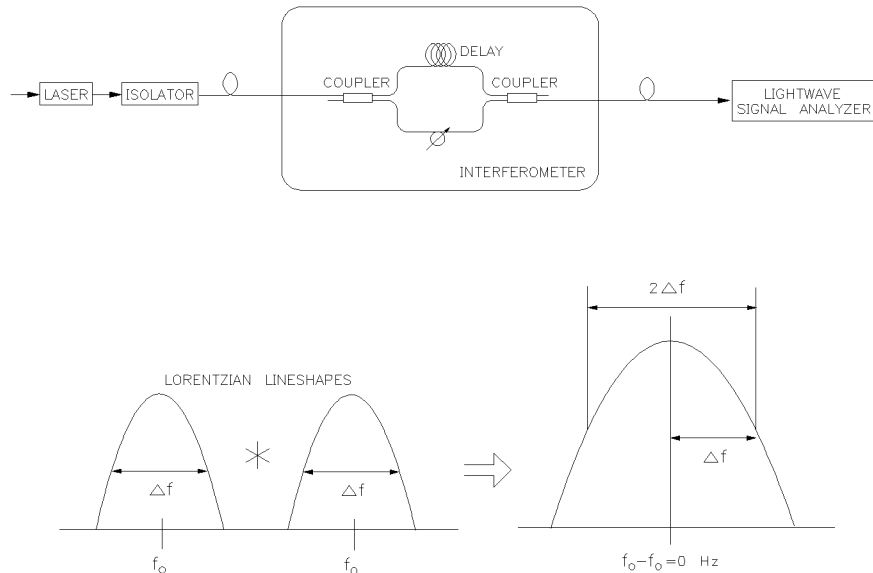
ugmb1a

Figure 2-1. The Measurement-Scheme Block Diagram

Using Recommended Equipment

N O T E

Be sure the optical connections are cleaned before attempting to measure with the linewidth measurement personality.

When the automatic SETUP is used with the equipment listed below, the characteristic performance of the linewidth measurement personality should be as listed in Table 2-1.

Modular measurement system

HP 71400C or HP 71401C lightwave analyzers, or HP 71210C with the HP 70810B lightwave module, or HP 71100C with the HP 70810B lightwave module.
The HP 70900B local-oscillator firmware date-code must be August 2, 1991 (910802), or later. Additional upgrade information is located in "Acquiring Required Equipment" in Chapter 1.

Fiber-optic interferometer

HP 11980A interferometer

Linewidth measurements are made by using the scheme illustrated in Figure 2-1. Refer also to *Application Note 371,* and the HP 71400C optical spectrum analyzer and HP 11980A interferometer reference manuals for additional information.

Measuring Characteristics

Characteristics provide useful, but non-warranted information about instrument performance.

The displayed linewidth results are derived from mathematical calculations performed on data that is obtained with an HP 71400C, HP 71401C, or equivalent lightwave signal analyzer. The linewidth specifications for the particular analyzer in use must be computed from that analyzer's specifications and applied to linewidth calculations. Errors due to the HP 11980A interferometer are also applied.

Table 2-1. Laser Linewidth Measurement Performance

Condition	Characteristic
Linewidth Range	
Using an HP 71400C lightwave signal analyzer	
Using an HP 11980A standard	250 kHz to 20 GHz
Using an HP 11980A *Option 005*	100 kHz to 20 GHz
Using an HP 71401C lightwave signal analyzer	
Using an HP 11980A standard	250 kHz to 2.9 GHz
Using an HP 11980A *Option 005*	100 kHz to 2.9 GHz
Linewidth Accuracy	
Using an HP 11980A interferometer	
250 kHz to 1 MHz	15%
1 MHz to 100 MHz	8%
100 MHz to 20 GHz	10%
Using an HP 11980A *Option 005* interferometer	
100 kHz to 1 MHz	15%
1 MHz to 100 MHz	8%
100 MHz to 20 GHz	10%
Linewidth repeatability	5%
Minimum optical power needed for accurate measurements	-20 dBm
Calculation Times	
With `DISTRIB Off`	3 seconds
With `DISTRIB On`	4 seconds

Measuring Narrow Linewidths

For narrow linewidths, many of the inaccuracies in the measurement are from the homodyne delay line length limitations. When the delay line length is shorter than the laser coherence length, errors occur. The plot in Figure 2-2 illustrates these results.

The two lines in the example are the error range over all polarization states. The "plus-signs" represent experimental results. The actual linewidth is less than the calculated linewidth. For the standard HP 11980A interferometer, the delay time is 3.5 μs; delay time for Option 005 is 25 μs.
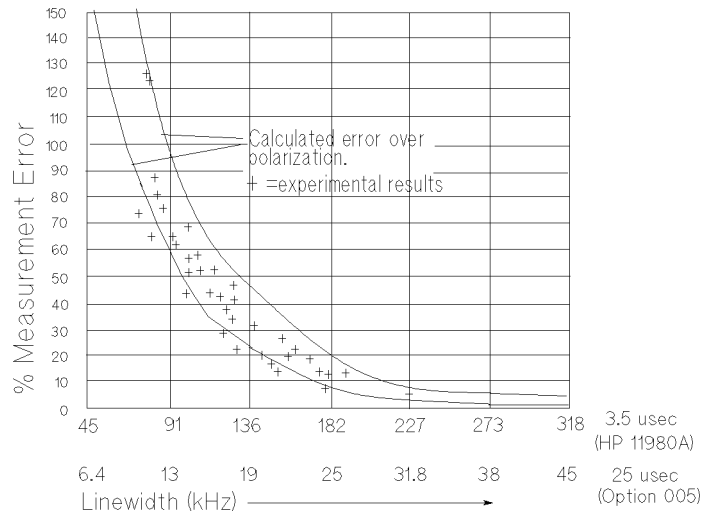

Figure 2-2. Delay-line length limits linewidth accuracy

Interpreting On-Screen Messages

The information provided here defines the messages that may appear on the display during a linewidth measurement. If an error occurs that indicates a malfunctioning instrument, procedures for returning the equipment and the ROM card to the factory are provided in "Returning the Instrument for Service" in Chapter 1. Refer to Table 1-1 the HP Sales and Service Offices.

During the setup routine and the linewidth measurement, messages that may appear are listed alphabetically and described below:

CALCULATING ...   This message appears as the linewidth calculations are being performed at the end of each sweep. The dots simply provide some visual indication of time duration.

Failed to estimate linewidth   This message appears if the linewidth estimation algorithm generated an imaginary result during the automatic setup routine. Imaginary results occur when a trace deviates greatly from a Lorentzian curve.

Failed to find signal   This message appears if the automatic setup routine could not locate a trace that decreases 3 dB during any setup sweep. Make sure the HP 11980A interferometer is correctly connected between the laser and the HP 70810B lightwave module. Verify the rear-panel connection between the lightwave module and the local oscillator module HSWP IN/OUT connectors.

Insufficient optical power   This message appears if the interferometer output is below -50 dBm. Check the connection to the interferometer. Verify the power of the laser output. Be certain the connectors are clean and that the optical fiber is undamaged.

Setup Started   This message informs you that the automatic setup routine is underway. Menu key

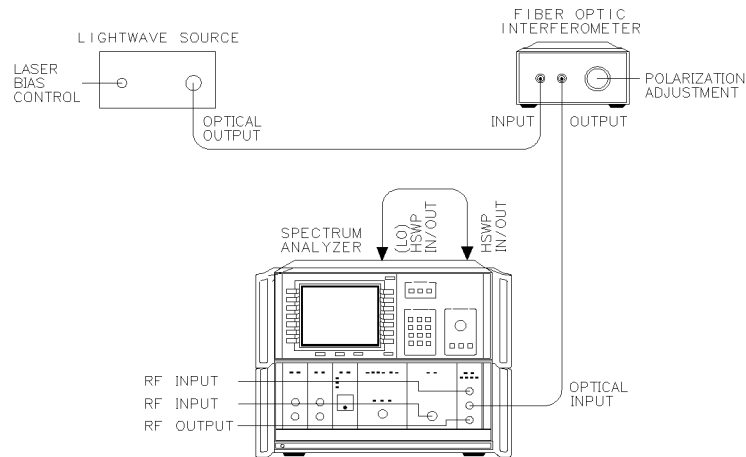|	
	presses are not acknowledged until the setup is completed.
`Setup Complete`	This message informs you that the automatic setup routine is successfully completed. The linewidth is ready to be measured.
`Unable to fit data to Lorentzian curve`	This message appears if the least-squares fit to a Lorentzian curve generates an imaginary linewidth. An imaginary linewidth is due to the trace data being significantly different from a Lorentzian lineshape. Use the automatic SETUP feature to eliminate the problem. Check for sufficient laser isolation.

Making a Laser Linewidth Measurement

Laser linewidth is calculated by the linewidth measurement personality. The steps that precede the calculated measurements include setting up for the measurement (automatically or manually) and peaking the homodyne signal amplitude.

Actual trace data is fitted to a Lorentzian lineshape using the method of least squares. The standard deviation of the actual data from the calculated linewidth is displayed as `Lorentzian fit (std dev) =` in the measurement results window. All linewidth measurement results are displayed in this window.

Avoid Key-Press Delays

Due to the time-consuming complexity of end-of-sweep laser linewidth calculations, set `CALC On Off` to Off when changing measurement parameters. Select `CALC On` to resume calculated measurements.

Figure 2-3. Equipment Connections

Setting up linewidth measurements automatically

After cleaning all optical connectors, connect the equipment as illustrated in Figure 2-3.

When the automatic set up routine is selected, the measurement personality selects `CALC Off`. Several sweeps are taken at increased frequency spans to estimate the linewidth and to choose the sweep parameters detailed below. After parameters are selected, `CALC On` and `CONT SWEEP` are automatically selected, and the end-of-sweep calculations begin.

Values for the following lightwave signal analyzer parameters are set:

Start and stop frequencies   Once the linewidth is estimated, the start frequency is set to about 0.1 times the laser linewidth. The stop frequency is set to about 3.0 times the linewidth. These frequencies allow the

	trace power to decrease by about 10 dB across the frequency span.
Resolution and video bandwidths	The resolution and video bandwidths are set to provide a trace that avoids the LO-feedthrough signal, has low noise-level, and sweeps at a reasonable speed (usually between 0.5 seconds and 5.0 seconds).
dB/DIV and reference level	In addition, the LOG scale is set to 2 dB/div. The reference level is adjusted to place the trace peak at the start frequency three divisions below the reference level.

1. From the (USER) menu, press `LW` to start the measurement personality and display the main menu.

2. Set the laser output to the desired level.

3. Press `SETUP` and wait for the setup routine to complete.

4. Adjust the polarization for maximum homodyne signal.

   • Press `POL ADJ On Off` and underline On.

   • Rotate the HP 11980A interferometer POLARIZATION ADJUST knob to peak the homodyne signal for maximum level.

   • Press `POL ADJ On Off` and underline Off.

N O T E

During the interferometer polarization adjustment, measurement personality settings are automatically changed to allow faster sweeps. As a result, adjustments to the displayed signal are viewed in real time. When `POL ADJ Off` is selected, a reference level is selected to position the peak of the signal at the start frequency, three divisions down from the top graticule.

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5. If desired, you can press `DISTRIB On Off` to underline On and display the Lorentzian curve fit.

Setting Up linewidth measurements manually

After cleaning all optical connectors, connect the equipment as illustrated in Figure 2-3.

1. From the (USER) menu, press `LW` to start the measurement personality and display main menu.

2. Set the laser output to the desired level and enter new instrument parameters.

3. Press `CALC On Off` and underline Off while you are entering measurement settings.

   a. Press `START` and `STOP` to change start and stop frequencies. Use either the front-panel data keys or the step keys to enter the frequency values.

   b. Press `REF LVL` to change the reference level.

   c. Press `LOG dB/DIV` to change the dB/div scale.

   d. Press (MENU) `Bw Swp RES BW AutoMan`, underline Man, and enter the resolution bandwidth.

   e. Press `VID BW AutoMan` and enter the video bandwidth.

4. Adjust the polarization for maximum homodyne signal.

   • Press (USER) `POL ADJ On Off` to underline On . The following conditions are automatically selected to allow the peaking adjustment to be viewed in real-time:

     □ `CALC On Off` is turned off. This function remains off if On was not selected.

     □ Video bandwidth is increased by a factor of 10 to decrease the sweep time.

N O T E

During the interferometer polarization adjustment, measurement personality settings are automatically changed to allow faster sweeps. As a result, adjustments to the displayed signal are viewed in real time. When `POL ADJ Off` is selected, a reference level is selected to position the peak of the signal at the start frequency, three divisions down from the top graticule.

- Rotate the HP 11980A interferometer POLARIZATION ADJUST knob to peak the homodyne signal for maximum level.

- Press `POL ADJ On Off` to underline Off.

After the signal is peaked and settings are determined, begin making linewidth measurements.

1. Press `CALC On Off` to underline On.

2. If desired, press `DISTRIB On Off` to underline On and view the Lorentzian curve fit.

3. Choose the sweep mode. When `CALC On` is selected, calculations occur at the end of each sweep, whether single sweep or continuous sweep mode is chosen.

   - Press `SINGLE SWEEP` for single sweep mode. A new sweep is triggered each time you press the key.

   - Press `CONT SWEEP` for continuous sweep mode.

Reading the Measurement Results Display

The information in the linewidth measurement results window represents calculated values which are explained in this section. When `CALC On` is selected, calculations that determine laser linewidth occur at the end of each sweep.

N O T E

The calculations are quite complex. At the end of each sweep, time is required for the calculations to be completed. During this time you will notice a delayed response to key presses when `CALC On` is selected. Select `CALC Off` while you make changes to measurement settings during a linewidth measurement. When your parameters are set, resume calculated measurements by selecting `CALC On`.
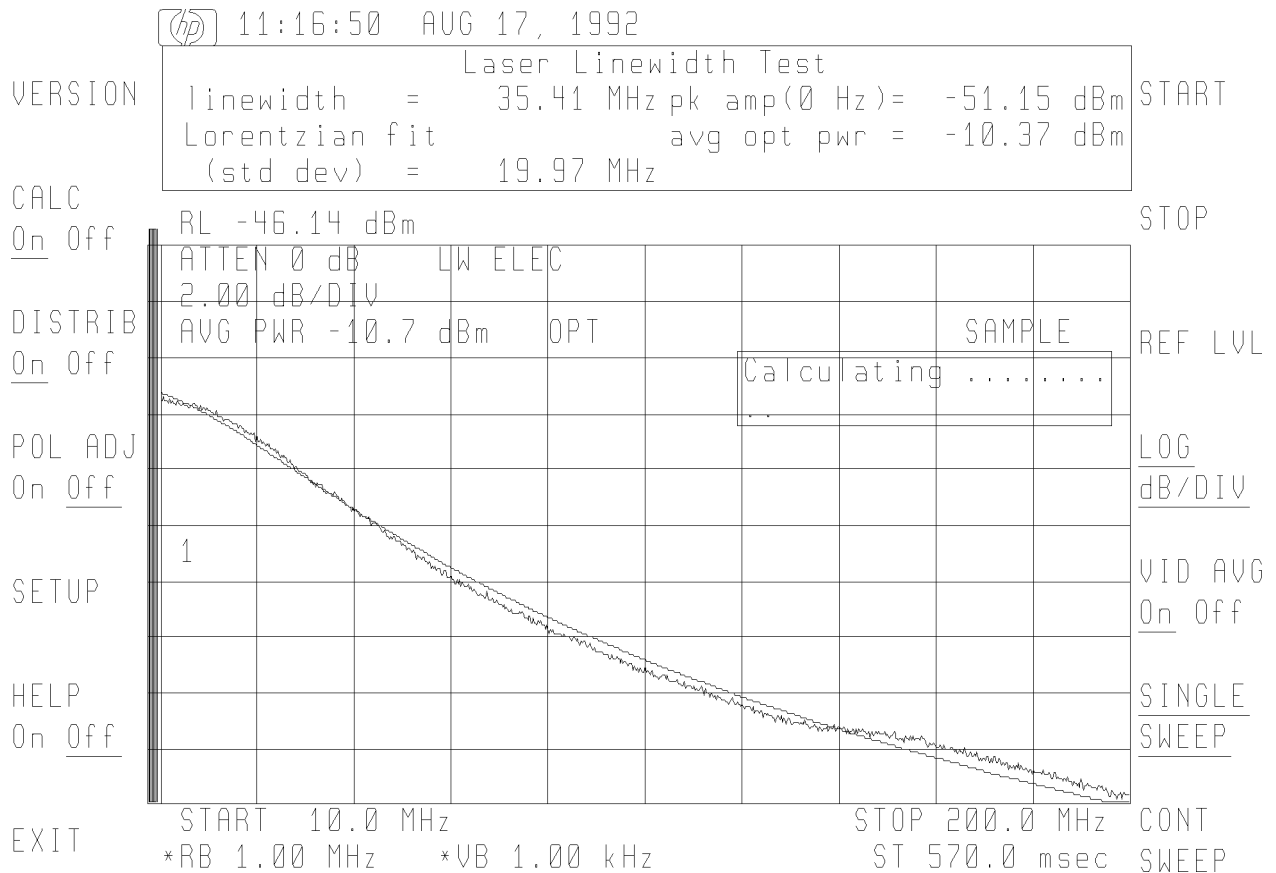

Figure 2-4. The Linewidth Measurement Results Window

Reading the Calculated Laser Linewidth Values

The laser linewidth is determined by a least-squares fit to a Lorentzian lineshape. The two fitted parameters are linewidth and peak amplitude (at 0 Hz). These two parameters are used to generate the Lorentzian distribution power, P, versus frequency, f as illustrated in the following formula. The distribution power is placed in trace C and displayed when `DISTRIB On` is selected.

$$P|f| = \frac{peak\ amplitude\ (0\ Hz)}{1+\left(\frac{f}{linewidth}\right)^2}$$

linewidth

Indicates the laser linewidth (full width at the half maximum point).

$$(\text{linewidth})^2 = \frac{\left(\sum P_i\right)\left(\sum P_i f_i^2\right) - N\left(\sum P_i^2 f_i^2\right)}{N\left(\sum P_i^2\right) - \left(\sum P_i\right)\left(\sum P_i\right)}$$

where there are N data sets of (f_i, P_i) on a trace
N = trace length (default is 800 points)
P_i = power at frequency f_i

all sums are $\sum\limits_{i=1}^{N}$

pk amp (0 Hz)

Indicates the maximum amplitude of the homodyned laser lineshape at frequency = 0 Hz.

$$\text{pk amp (0 Hz)} = \frac{\left(\sum P_i^2\right)\left(\sum P_i f_i^2\right) - \left(\sum P_i\right)\left(\sum P_i^2 f_i^2\right)}{(\text{linewidth})^2 \left[N\left(\sum P_i^2\right) - \left(\sum P_i\right)\left(\sum P_i\right)\right]}$$

`Lorentzian fit`
`(std dev)`
Indicates the standard deviation of the total trace data from the fitted linewidth.

$$(\text{standard deviation})^2 \; = \; \tfrac{1}{N} \sum \left(\Delta\, f_i - linewidth \right)^2$$

$$\text{where } (\Delta\, f_i)^2 \; = \; \frac{(peak\ amplitude\ (0\ Hz))(linewidth)^2}{P_i} - f_i{}^2$$

`avg opt pwr`
Indicates the averaged value of the interferometer output optical power.

Reading the Other On-Screen Information

The information displayed on the screen, outside the measurements results window, is defined below. If the automatic `SETUP` key is used, the values are determined by the program, otherwise, you enter the values manually.

`RL`
This is the reference level used for making the measurement.

`ATTEN 0 dB  LW`
`ELEC`
This is the input attenuator setting in lightwave electrical units. The program chooses the `LW MODE Elec` setting.

`2.00 dB/DIV`
This is the dB/DIV scale setting.

`AVG PWR −4.4 dBm`
`OPT`
This is the average output power in optical units. This reading and the `avg opt pwr` reading displayed in the measurement results window are the same values if `PWR MTR Opt` is selected.

`Calculating.... .`
This is the message window. Measurement progress and related measurement status messages appear here. Refer to "Interpreting On-Screen Messages" in this chapter for information.

Calculating Standard Deviation

To determine Lorentzian fit standard deviation, the program first calculates a linewidth from each trace point (with a default of 800 trace points). The number of points can be adjusted from 3 to 2000 points. The root-mean square (RMS) deviation of the individual linewidths from the least squares fit linewidth results in the standard deviation measurement of the linewidth.

The standard deviation value is dominated by one of two effects:

- For laser lineshapes that are not quite Lorentzian, the trace data and the calculated distribution do not overlap on the display. The standard deviation for this condition then is a measure of the laser's deviation from a Lorentzian lineshape. The calculated standard deviation is the linewidth uncertainty.

- For laser lineshapes that are Lorentzian, the trace data and the distribution curve overlap on the display. The standard deviation for this condition is a measure of average trace noise.

  Increasing the video bandwidth speeds up the measurement, but also increases the trace noise and increases the calculated standard deviation. However, the calculated linewidth does not change significantly, because of the averaging effect of many trace points. Decreasing the video bandwidth decreases the trace noise and decreases the standard deviation, yet the calculated linewidth is essentially unchanged.

  When the trace noise has decreased to a level where the trace data and the distribution curve no longer overlap, the standard deviation is then a measure of the deviation from a Lorentzian lineshape as previously described. Further reduction in trace noise does not significantly reduce the standard deviation. Note that trace noise can be reduced by reducing the video bandwidth or by using video averaging, or by doing both.

3

Using the Menu Keys

Using the Menu Keys

This chapter contains the HP 70880A linewidth measurement personality menu key descriptions. Figure 3-1 illustrates the menu of the personality. All menu keys for the personality are on a single level; there are no additional menu levels.

Displaying the Linewidth Measurement Menu

To display the measurement personality's menu, press (USER) on the front panel, then press **LW** . The information displayed in the linewidth measurement personality's main menu is explained more thoroughly in the next few pages.

To return to lightwave signal analyzer menus, press the front-panel (MENU) key. Press **EXIT** in the measurement personality menu to exit the linewidth personality.
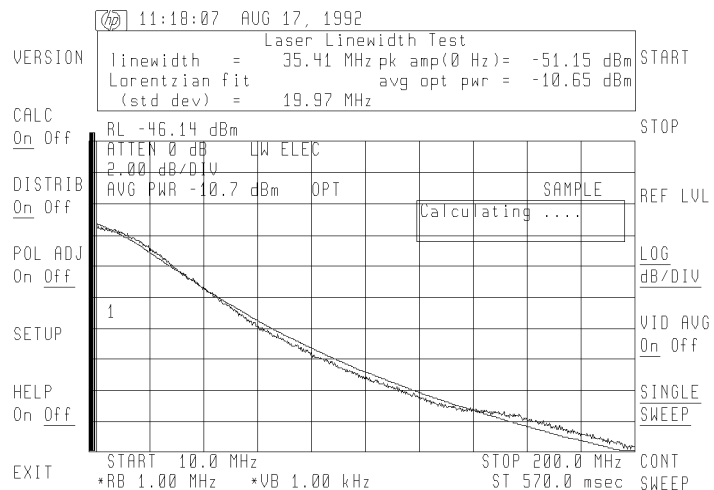

Figure 3-1. Linewidth Measurement Personality Main Menu

Understanding the Menu Keys

The menu keys of the linewidth measurement personality are listed alphabetically in this section. The descriptions are intended to help you understand the functions of the softkeys.

CALC On Off
:   Press this key to turn the linewidth calculations function on or off. The calculations occur at the end of every sweep while CALC On is selected. Until the calculations are completed, the response to any menu key press is delayed. Due to this key-press response delay, select CALC Off while you are entering or changing measurement parameters. Select CALC On to resume measurements.

CONT SWEEP
:   Press this key to select continuous-sweep mode. Continuous sweep is the default setting. Linewidth calculations are made at the end of each sweep when CALC On Off is On.

DISTRIB On Off
:   Press this key to turn the best fit Lorentzian distribution on or off. The default setting is Off. During the measurement, the actual lineshape appears in trace A. The fitted Lorentzian curve is displayed in trace C.

    When DISTRIB Off is selected, the only trace displayed is that of the actual data being measured.

EXIT
:   Press this key to exit the HP 70880A linewidth measurement personality. Press the front panel (MENU) key to use the lightwave signal analyzer menus.

HELP On Off
:   Press this key to display brief descriptions of some of the measurement personality menu keys.

LOG dB/DIV
:   Press this key to change the log scale display of the amplitude. The amplitude range is 0.01 dB to 20 dB per division. Linear mode is not available with this personality.

POL ADJ On Off

Press this key to maximize the amplitude of the HP 11980 interferometer signal. When POL ADJ On is selected, the end-of-sweep calculations function is turned off, video averaging is turned off, video bandwidth is increased by a factor of 10, and continuous-sweep mode is selected. The interferometer POLARIZATION ADJUST knob can now be rotated to adjust the signal for maximum amplitude. Once the signal is maximized, select POL ADJ Off to turn on the end-of-sweep calculations and restore the video bandwidth and video averaging to their original settings. In addition, POL ADJ Off sets the reference level such that the signal's highest point is positioned on the display at the third graticule.

REF LV

Press this key to adjust the reference level value (nominally the top graticule) manually. If the SETUP feature is used, the reference level is automatically set to a specified level. Refer to the description of SETUP for default values and ranges.

SETUP

Press this key to set the lightwave signal analyzer parameters automatically to those needed for making linewidth measurements with the HP 70880A measurement personality. The parameters that are set are listed below:

- dB/div

- resolution bandwidth

- reference level

- start frequency

- stop frequency

- continuous sweep mode

- video bandwidth

SINGLE SWEEP   Press this key to select single-sweep mode. Press the
                      SINGLE SWEEP key to initiate each measurement
                      sweep. It is useful to press SINGLE SWEEP before
                      printing or plotting a linewidth measurement.
                      Single-sweep mode is deactivated by pressing the
                      CONT SWEEP key.

START   Press this key to select the linewidth measurement's
                      start frequency. If SETUP is selected after you have
                      entered a start frequency value, your setting is
                      changed by the setup routine.

STOP   Press this key to select the linewidth measurement's
                      stop frequency. If SETUP is selected after you have
                      entered a stop frequency value, your setting is
                      changed by the setup routine.

VERSION   Press this key to display the current version of
                      the linewidth measurement personality. The
                      information displayed will resemble Rev.A.01.00.
                      After you press this key, the calculation function
                      (CALC On Off) is turned off. Turn the calculations
                      function on by pressing CALC On Off and
                      underline On.

VID AVG On Off   Press this key to average the trace over a number
                      of sweeps. Video averaging reduces trace noise.
                      To average a specified number of sweeps, press
                      VID AVG On Off to select ON. Enter a value for
                      the desired number of sweeps. The default setting is
                      100 sweeps.

N O T E

If you select `VID AVG On` and enter the number of sweeps while `CALC On` is selected, the end-of-sweep calculations occur at the end of each sweep. For faster results, select `CALC Off`, wait for the number of traces to be averaged (at a faster rate), then select `CALC On` to resume accurate measurements.

4

Programming

Programming

Use this chapter to learn about the programming commands for the
HP 70880A linewidth measurement personality.

Each command, in alphabetical order, is described. Syntax diagrams and
examples are included as appropriate. The example program provided uses
all of the linewidth measurement personality remote commands.

Verifying the Local Oscillator's HP-IB address

Verify the HP 70900B local oscillator's HP-IB address setting with the steps below. Its default HP-IB address is 18.

- To display the address in the menu map, press the following keys:

    1. Press (DISPLAY).

    2. Press `Address Map`.

    3. Press 20 (ENTER). The module default settings are as follows:

        □ The HP 70900 local oscillator should appear in column 18, row 0.

        □ The HP 70810B lightwave section should appear in column 20, row 3 or 4.

- To display the local oscillator's address in the configuration window:

    1. Press `State MORE 1 of 3 MORE 2 of 3`.

    2. Press `show states CONFIG`. All modules configured to the LO are listed in the configuration window.

Programming Commands

The commands available with the linewidth measurement personality are listed in Table 4-1.

Table 4-1. Linewidth Measurement Remote Commands

Command	Description
LW_ ;	Start the HP 70880A linewidth measurement personality.
LW_ ?;	Query the measurement results for linewidth and laser power data. The query returns the averaged linewidth, peak amplitude, standard deviation, and the average optical-output power.
LW_ B;	Enable or disable interferometer polarization adjustment.
LW_ C;	Enable or disable display of the calculated Lorentzian distribution trace.
LW_ Q;	Exit the linewidth measurement personality.
LW_ O;	Enable or disable end-of-sweep linewidth calculations.
LW_ T;	Initiate automated measurement setup routine.

Programming Example

The following example demonstrates using the commands to measure linewidth from a controller.

10	`OUTPUT 718;"IP;"`	*Preset the lightwave signal analyzer.*
20	`OUTPUT 718;"LW_;"`	*Start the HP 70880A lightwave measurement personality*
30	`OUTPUT 718;"LW_ T;"`	*Start the automatic set up routine. The measurement begins after the set up routine is finished.*
40	`OUTPUT 718;"LW_ ?;"`	*Query the measured values.*
50	`ENTER 718; MLW,PAMP,STDDEV,APWR`	*Read MLW (measured linewidth), PAMP (peak amplitude), STDDEV (standard deviation or Lorentzian fit), and APWR (average power) values.*
60	`OUTPUT 718;"LW_ O;"`	*Turn off the end-of-sweep calculation function.*
70	`OUTPUT 718;"LW_ B;"`	*Enable polarization adjust. Manually adjust the interferometer polarization adjustment.*
75	`PAUSE;`	*After adjusting polarization, press the continue key on the controller keyboard to resume the measurement.*
80	`OUTPUT 718;"LW_ B;"`	*Turn polarization adjust off and return the bandwidth and sweep time values to their original levels.*
90	`OUTPUT 718;"LW_ T;"`	*Start the automatic set up routine.*

```
100 OUTPUT 718;"LW_ C;"
```
Display the Lorentzian fitted curve.

```
105 PAUSE;
```
Wait to view the fitted curve. Press the continue key on the controller keyboard to resume the measurement.

```
110 OUTPUT 718;"LW_ Q;"
```
Exit the measurement personality.

LW_

Start the linewidth measurement program

x l w

Figure 4-1. LW_ Syntax

Description Use the LW_ command to automatically measure the linewidth characteristics of the laser output. Use the LW_ Q command to terminate the remote linewidth measurement program.

LW_ ?

Query to return linewidth, laser power, standard deviation and average optical power.

xlwquery.

Figure 4-2. LW_ ? Query Syntax

Description Use the LW_ ? command to return the linewidth measurement results and laser power. The results returned are in the following order and completed with a terminator:

- mean linewidth in Hz
- peak amplitude at 0 Hz in dBm
- standard deviation to Lorentzian fit in Hz
- average optical power in optical-dBm

Example

```
1 OUTPUT 718;"LW_ ?;"              Query the measured values.
2 ENTER 718; MLW,PAMP,STDDEV,APWR  Read the values.
```

Query Response
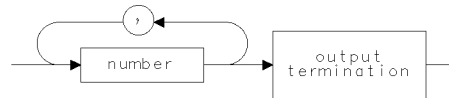
qlwquery.

Figure 4-3. LW_ ? Query Syntax

LW_ B

Interferometer polarization-adjustment on or off mode

xlwb

Figure 4-4. LW_ B Syntax

Description Use the LW_ B command to manually adjust the HP 11980 interferometer's output signal for peak amplitude. The command functions as a binary toggle. If the command is sent when the mode is off, the mode is turned on. The next time the command is sent, the mode is turned off.

When the polarization adjustment is enabled, the following conditions are set so that changes to the polarization are viewed in real-time:

- End-of-sweep calculations are turned off

- The video bandwidth is increased by a factor of 10

- Video averaging is turned off

- Continuous sweep-mode is enabled

- Sweep time is decreased with the video bandwidth increase

Polarization adjustment is turned off by sending LW_ B a second time. When polarization adjust is turned off, linewidth measurement calculations are resumed. In addition the previous video bandwidth, video averaging, and sweep time settings are restored.

In addition, the log scale is set to 2 dB/div and the reference level is adjusted to place the peak of the signal at the start frequency three divisions down from the reference level.

LW_ C

Distribution trace display on or off mode

Figure 4-5. LW_ C Syntax

Description Use the LW_ C command to toggle the calculated distribution curve display (trace C) on or off. If the distribution display is turned off, trace C data is not updated and the curve display calculations are not made.

The command functions as a binary toggle. The default state is the current state of trace C. Turn trace C off by sending the LW_ C command once.

To increase the linewidth measurement rate, turn the distribution curve display off.

Turning trace C on causes a linewidth measurement to start.

LW_ Q

Exits the linewidth measurement DLP

xlwquit .

Figure 4-6. LW_ Q Syntax

Description   Use the LW_ Q command to exit the measurement personality and return to lightwave signal analyzer operations.

LW_ O

Select calculations on or off mode

Figure 4-7. LW_ O Syntax

Description   Use the LW_ O command to turn the end-of-sweep measurement calculations function on or off. The default state is with calculations turned on. When the LW_ O command is sent to turn calculations on, a new measurement is also initiated.

Due to the length of time the calculations take, there is a noticeable delay between entering parameter changes and seeing the actual response to the changes. Turn the calculations off while you are setting any measurement parameters.

LW_ T

Perform automatic measurement setup

Figure 4-8. LW_ T Syntax

Description Use the LW_ T command to automatically set up the linewidth measurement parameters. The automatic setup routine estimates the laser linewidth after taking several sweeps of increasing frequency span (using higher stop-frequencies) until the trace decreases 3 dB across the frequency span. Video averaging is turned off and appropriate values for the following lightwave signal analyzer parameters are set:

- dB/DIV
- resolution bandwidth
- reference level
- start frequency
- stop frequency
- continuous sweep
- video bandwidth

Once the linewidth is estimated, the start frequency is set to about 0.1 times the laser linewidth. The stop frequency is set to about 3.0 times the linewidth. These frequencies distribute the trace such that its power decreases 10 dB across the frequency span.

The resolution and video bandwidths are set to provide a trace that avoids the LO-feedthrough signal, has low noise-level, and sweeps at a reasonable speed (usually between 0.5 seconds and 5.0 seconds). In addition, the LOG scale is set to 2 dB/div. The reference level is adjusted to place the trace peak at the start frequency three divisions below the reference level. If video averaging was on before the automatic setup, it will be turned back on for measurements.

If the setup can not be completed, all returned values are set to 0 and
messages related to the condition are displayed. Refer to "Interpreting
On-Screen Messages" in Chapter 2 for descriptions of messages.

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