
User's Guide

HP 83475B Lightwave Communications Analyzer

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Safety Symbols

The following safety symbols are used throughout this manual. Familiarize yourself with each of the symbols and its meaning before operating this instrument.

CAUTION

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

WARNING

The *warning* sign denotes a life-threatening 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 symbol when it is necessary for the user to refer to the instructions in the manual.



This symbol denotes that the instrument uses alternating current.



This symbol denotes that the power supply is turned on.



This symbol denotes that the power supply is turned off.



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



This symbol denotes that the instrument is an Industrial Scientific and Medical Group 1 Class A product.

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



General Safety Considerations

WARNING

Before this instrument is switched on, make sure it has been 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.

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 instrument is likely to make the instrument dangerous. Intentional interruption is prohibited.

WARNING

There are many points in the instrument which can, if contacted, cause personal injury. Be extremely careful.

Any adjustments or service procedures that require operation of the instrument with protective covers removed should be performed only by trained service personnel.

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.

CAUTION

Before this instrument 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.

NOTE

Clean the cabinet using a damp cloth only.

Certification

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

Assistance

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

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office.

Warranty

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

For warranty service or repair, this product must be returned to a service facility designated by Hewlett-Packard. Buyer shall prepay shipping charges to Hewlett-Packard and Hewlett-Packard shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to Hewlett-Packard from another country.

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

LIMITATION OF WARRANTY

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

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

Typeface conventions

Front-Panel Key This represents a key physically located on the instrument.

Softkey This indicates a “softkey,” a key whose label is determined by the firmware of the instrument.

Screen Text This indicates text displayed on the instrument’s screen.

WARNING

This symbol will appear along with bold print to highlight a warning.

CAUTION

This symbol will appear when special care is required.

NOTE

This symbol will appear to call attention to an important point in the text.

In This Book

This manual provides information about the HP 83475B Lightwave Communications Analyzer.

- Chapter 1 is a quick start guide that gives you a brief overview of the analyzer.
- Chapter 2 contains menu maps and a series of exercises that guide you through the operation of the analyzer. Information on optimizing extinction ratio measurements is also included.
- Chapter 3 lists the characteristics of the analyzer.
- Chapter 4 provides details on the measurement algorithms.
- Chapter 5 provides information on performing an optical channel calibration and a vertical channel calibration.

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The Analyzer at a Glance

The Analyzer at a Glance

The HP 83475B lightwave communications analyzer is an easy-to-use measurement tool for lightwave and electrical digital communication applications. The HP 83475B measures signal compliance to a variety of optical and electrical communication standard mask and template specifications. Furthermore, through HP-IB or RS-232 control, custom mask creation and testing can be performed. The optical input of the HP 83475B measures datacom and telecom signals at wavelengths ranging from 780 nm up to 1600 nm. With its low distortion, PIN-based optical receiver and low instrument noise floor, the HP 83475B accurately measures the important parameters of laser and LED transmitters for SDH/SONET, ATM, and Fibre Channel.

The HP 83475B lightwave communications analyzer offers superior waveform viewing and measurements in a small, lightweight package. The analyzer provides you with the necessary capabilities to test and measure analog and digital circuits. The analyzer provides:

- Optical and electrical measurement channels
- 780 nm to 1600 nm optical input wavelength
- Integrated average optical power meter
- Calibrated vertical watts scale
- 1 GHz integrated optical receiver bandwidth
- 1 M Ω and 50 Ω electrical input resistances
- 500 MHz bandwidth
- Standard masks and templates, including:
 - DS-1, DS-1c, DS-2, and DS-3
 - E-1, E-2, E-3, E-4 one, and E4 zero
 - STS-1 and STS-3
 - OC-1
 - STM-1/OC-3
 - STM-1 electrical (one and zero pulses)
 - FC-133 and FC-266
- Automatic mask and template scaling, positioning, and testing
- Custom mask testing through HP-IB or RS-232 control
- Statistical waveform analysis
- FFT (with Options 201 or 202)

The familiar controls and real time display make the HP 83475B an easy to use measurement tool. Storage is as simple as pressing a button. View events before the trigger using negative time. Cursors and automatic measurements greatly simplify your analysis tasks.

With the HP-IB or RS-232 option, the HP 83475B allows you to output hard copies to a printer or plotter or interface to a computer. Using HP 34810A BenchLink software, you can easily upload waveform data to your personal computer for preparing a report, creating an analysis, or storing the waveforms for later use. These capabilities work on some of the most popular wordprocessing and spreadsheet programs.

Ordering Information

Supplied accessories

- Demod jumper cable
- One connector option
- Power cord for country of destination
- *HP 83475B Lightwave Communications Analyzer User's Guide*
- One year warranty

NOTE

Options 050, 051, and 052 provide measured compliance to the SDH/SONET and/or Fibre Channel reference receiver specifications. A compliance calibration document is provided for the combination of the integrated optical receiver, the electrical channel, and a hardware filter. The appropriate hardware filter is provided with each of the options.

Option 050 Optical channel SONET OC-1 reference receiver calibration

Option 051 Optical channel SDH/SONET STM-1/OC-3 reference receiver calibration

Option 052 Optical channel Fibre Channel-133 MBaud reference receiver calibration

NOTE

The hardware filter (option 053) is provided for diagnostic testing of 266 MBaud Fibre Channel signals.

Option 053 Fibre Channel-266 MBaud filter

	Option 201	HP-IB interface module	Provides full remote control, custom mask testing, hard copy output, extended math, FFT, and makes pixel trace storage memories non-volatile. Programming as described in IEEE 488.2. The module is supplied with a programmer's guide.
	Option 202	RS-232 interface module	Provides full remote control, custom mask testing, hard copy output, extended math, FFT, and makes pixel trace storage memories non-volatile. The module is supplied with a programmer's guide.
Connector interface options (choose one)	Option 011	Diamond HMS-10/HP connector	
	Option 012	FC/PC connector	
	Option 013	DIN 47256 connector	
	Option 014	ST connector	
	Option 015	Biconic connector	
	Option 017	SC connector	
Optional accessories	Option 101	Accessory pouch and front-panel cover	
	Option 102	Adds one HP 10073A 10:1 high impedance probe	
	Option 104	Carrying case	
	Option 908	Rack mount kit	
	Option OB1	Additional <i>HP 83475B Lightwave Communications Analyzer User's Guide</i>	
	Option UK6	Calibration and measurement performance data	
Recommended accessories	HP 34810A	BenchLink software	

Menu and Softkey Overview

The keys labeled Mode, Power/Voltage, and Run are all examples of front-panel keys. Pressing some front-panel keys accesses menus of functions that are displayed along the sides of the display screen. These menus are called softkey menus.

Softkey menus list functions other than those accessed directly by the front-panel keys. To activate a function on the softkey menu, press the unlabeled key immediately next to the annotation on the screen. The unlabeled keys next to the annotation on the display are called softkeys.

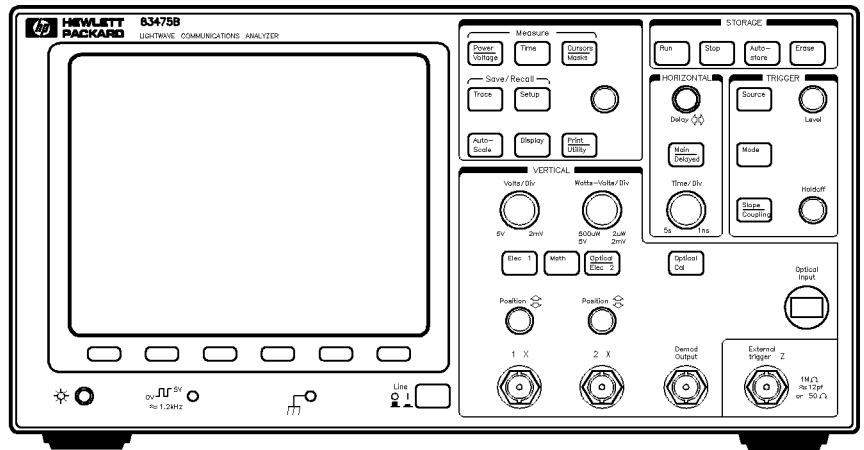
Throughout this manual, front-panel keys are indicated by a box around the key label, for example, **Mode**. Softkeys are indicated by shading on the key label, for example, **Opt Pmtr Off On**. The softkeys displayed depend on the front-panel key pressed and which menu is selected.

A softkey with On and Off in its label can be used to turn the softkey's function on or off. To turn the function on, press the softkey so On is highlighted. To turn the function off, press the softkey so Off is highlighted. An On or Off softkey function will be indicated throughout this manual as: **Opt Pmtr Off On On**.

A softkey such as **Coupling DC AC** offers you a choice of functions. In this case you could choose AC coupling by pressing the softkey until AC is highlighted, or choose DC coupling by pressing the softkey until DC is highlighted. A choices softkey will be indicated throughout this manual as: **Coupling DC AC AC**.

When some softkeys, such as **Bit Rate**, are pressed the first time, a measurement will be made and the result will be provided. Some softkeys, such as **Ampl Samp** require the entry of a numeric value. To enter or change the value, use the general purpose knob located below the front-panel Measure section.

The Front Panel

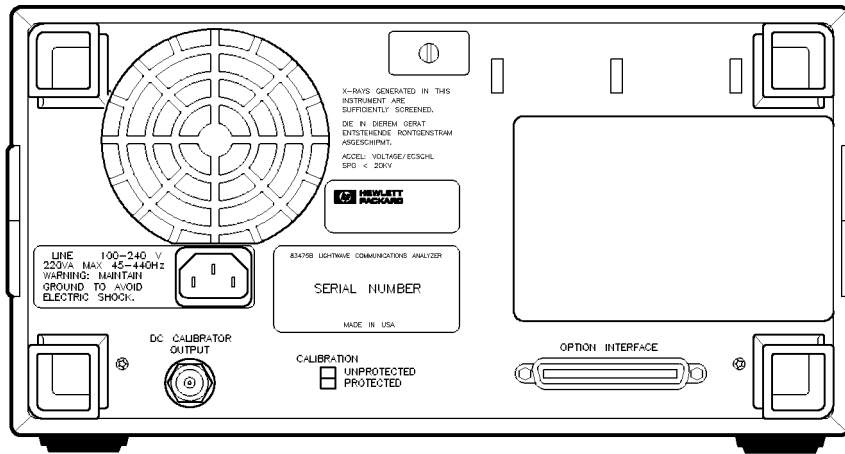


frntpn1

Figure 1-1. The HP 83475B front panel.

The front panel has knobs, grey keys, and white keys. The knobs are used most often and are similar to the knobs on analog oscilloscopes. The grey keys bring up softkey menus on the display allowing you to access many of the analyzer features. Some of the grey keys include both optical (red type) and electrical (black type) functions. Keys that include both red and black type are used to provide both optical and electrical functions. The white keys are instant action keys and menus are not associated with them.

The Rear Panel



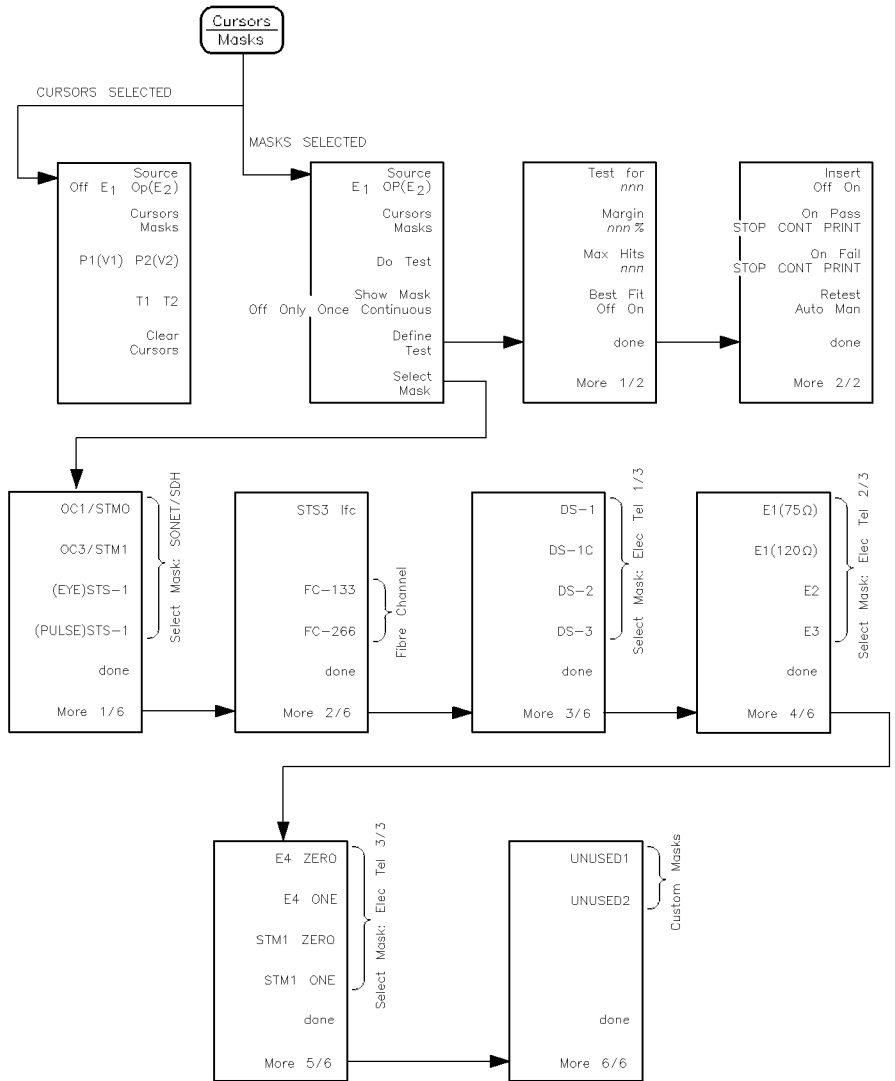
rearpan1

Figure 1-2. The HP 83475B rear panel.

The HP 83475B rear panel provides access to some of the instrument's important capabilities.

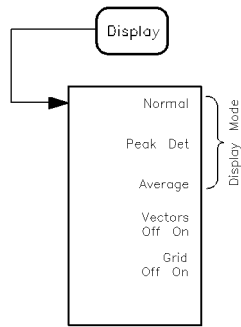
- 1 **DC CALIBRATOR OUTPUT** provides a reference signal used for the electrical calibration of the input channels and external trigger input.
- 2 **PROTECTION SWITCH** allows or denies access to the instrument's calibration functionality, depending on its setting.
- 3 **OPTION INTERFACE** connector is an interface for either an HP-IB (Option 201) or an RS-232 (Option 202) module that supports remote instrument operation and direct plotting or printing of screen data.
- 4 **LINE** power module is the input for the line power source. Make sure the line-power source outlet has a protective ground contact. The primary line-power fuse is also located in this module.

The Menu Trees



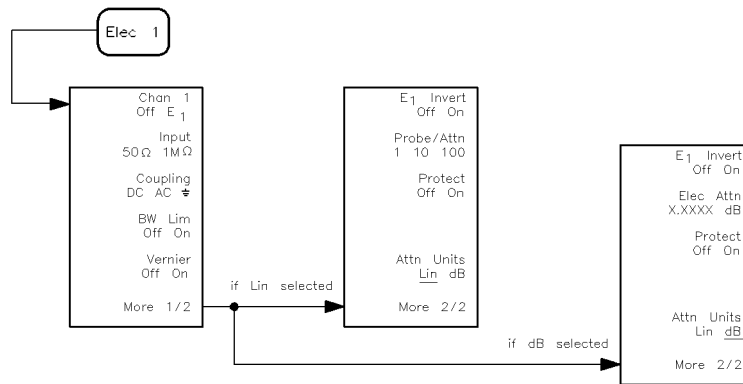
lcakey2...d

Figure 1-3. Cursors/Mask softkey menu.



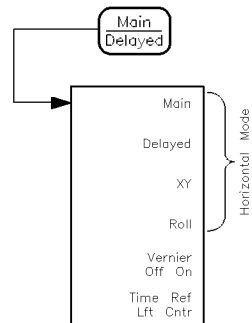
lcakey7_d

Figure 1-4. Display softkey menu.



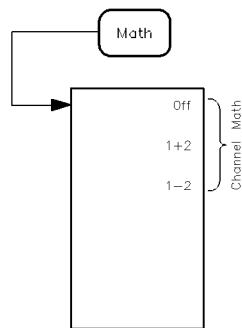
lcakey10_d

Figure 1-5. Elec 1 softkey menu.



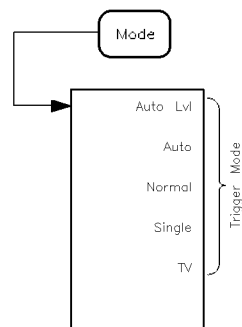
lcakey14_d

Figure 1-6. Main/Delayed softkey menu.



lcakey16_d

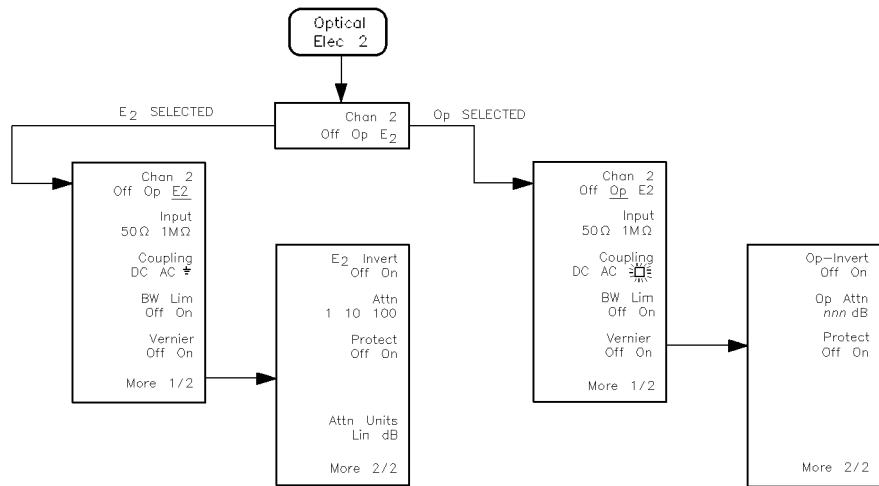
Figure 1-7. Math softkey menu.



lcakey15_d

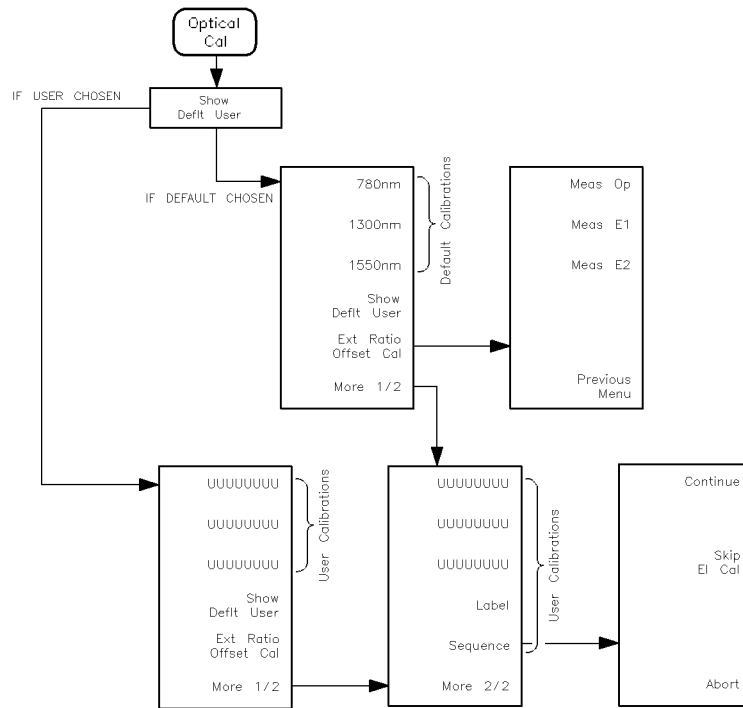
Figure 1-8. Mode softkey menu.

The Menu Trees



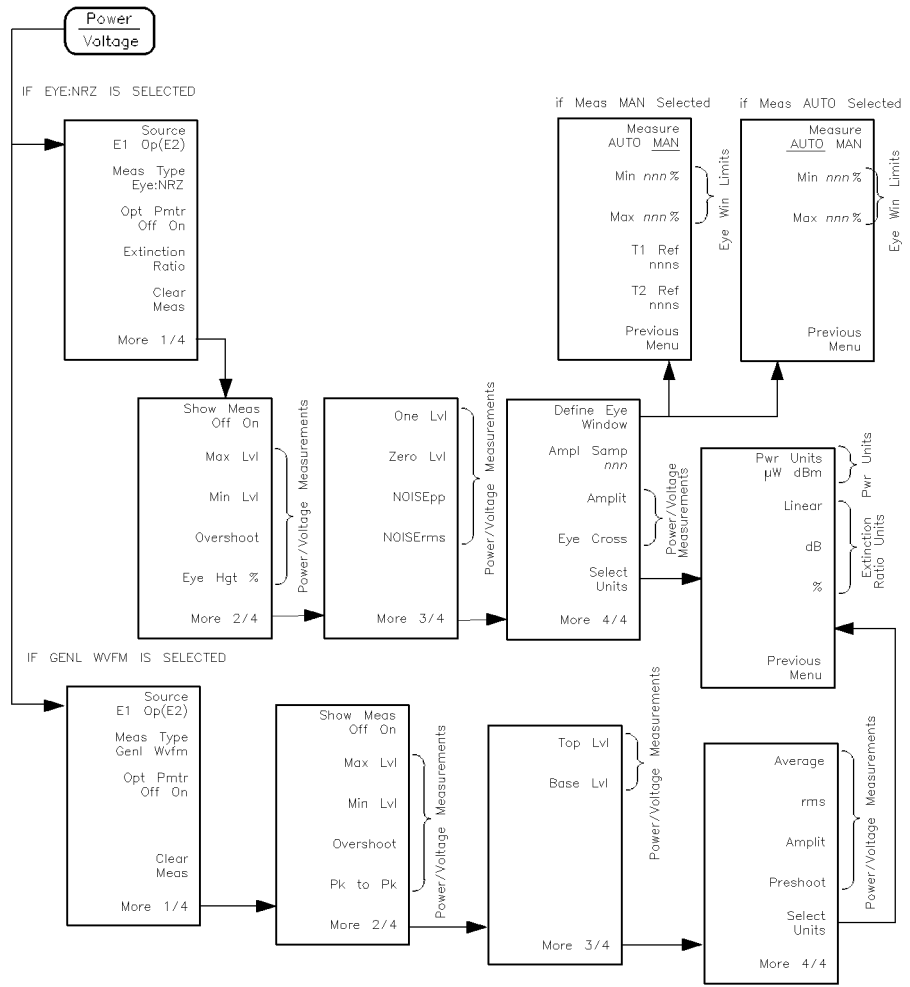
lcakey1_d

Figure 1-9. Optical/Elec 2 softkey menu.



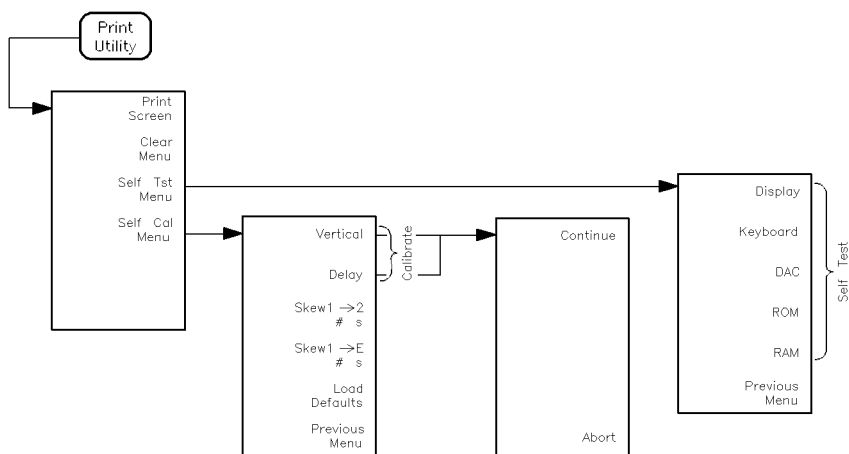
lcakey3_d

Figure 1-10. Optical Cal softkey menu.



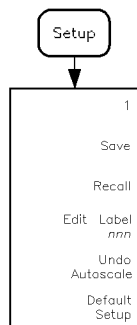
lcakey11_d

Figure 1-11. Power/Voltage softkey menu.



lcakey8_d

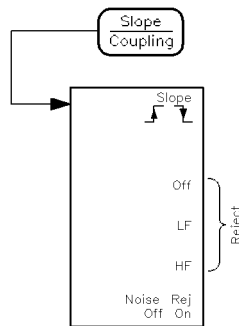
Figure 1-12. Print/Utility softkey menu.



lcakey4_d

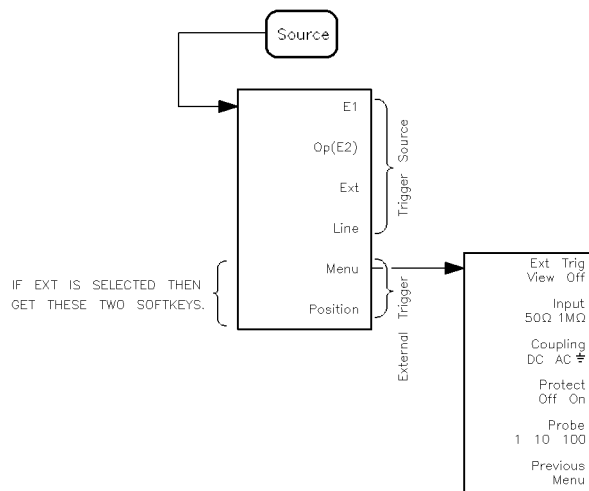
Figure 1-13. Setup softkey menu.

The Menu Trees



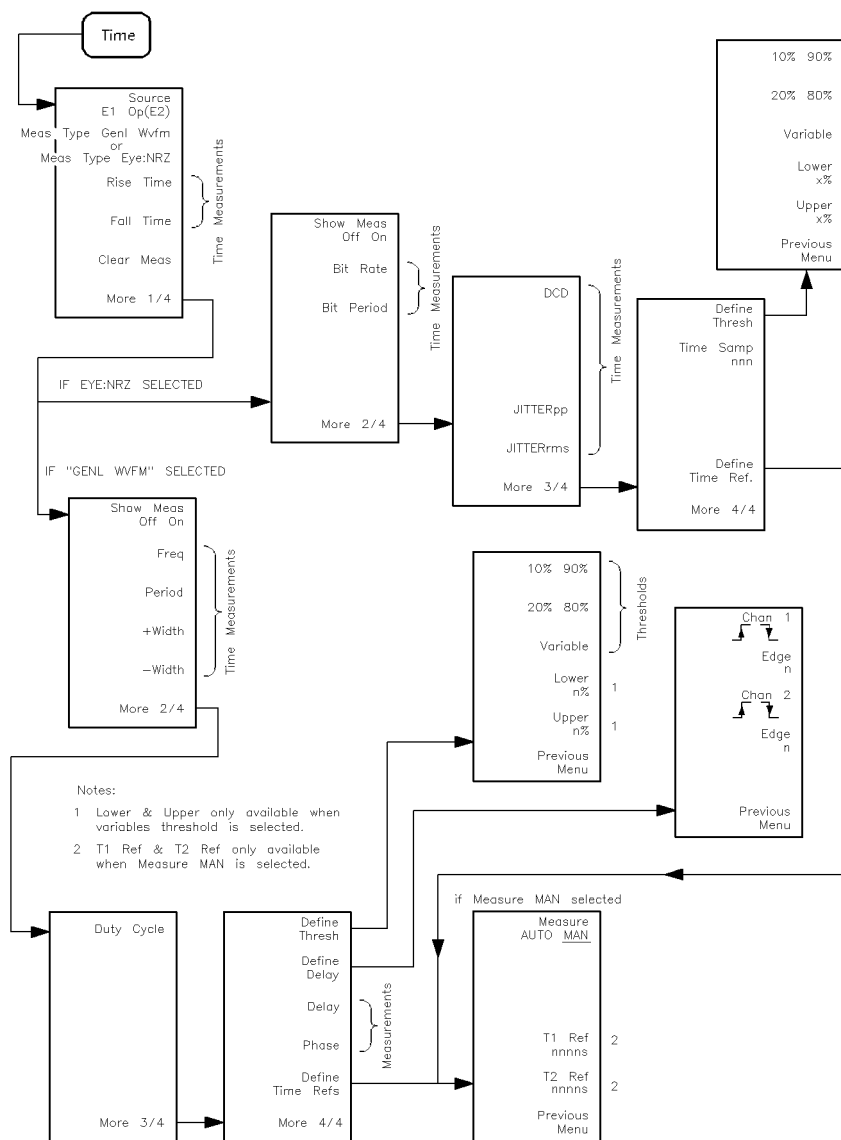
lcakey9_d

Figure 1-14. Slope/Coupling softkey menu.



lcakey12_d

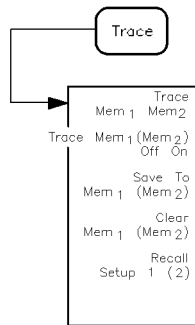
Figure 1-15. Source softkey menu.



lcakey5_d

Figure 1-16. Time softkey menu.

The Menu Trees



lcakey13_d

Figure 1-17. Trace softkey menu.

Cleaning Connections for Accurate Measurements

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.

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.

Use dry connections. Dry connectors are easier to clean and 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 will probably not improve (and can degrade) performance.

CAUTION

Hewlett-Packard strongly recommends that index-matching compounds *not* be applied to their instruments and accessories. Some compounds, for example, 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.

Cleaning Accessories

Item	HP Part Number
Isopropyl alcohol	8500-5344
Cotton swabs	8520-0023
Small foam swabs	9300-1223
Compressed dust remover (non-residue)	8500-5262

Cleaning Connections for Accurate Measurements**Dust Caps Provided with Lightwave Instruments**

Item	HP Part Number
Laser shutter cap	08145-64521
FC/PC dust cap	08154-44102
Biconic dust cap	08154-44105
DIN dust cap	5040-9364
HMS10/HP dust cap	5040-9361
ST dust cap	5040-9366

Inspecting Fiber-Optic Cables

Consistent measurements with your lightwave equipment are a good indication that you have good connections. However, you may wish 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 1 dB of loss, and sometimes as little as 0.1 dB of loss with high performance connectors. Return loss is another important factor. 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.

You can visually inspect your cables

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 metal, or dents in the 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).

To clean a non-lensed connector

CAUTION

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

1. 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.
2. Before cleaning the fiber end, clean the ferrules and other parts of the connector.
3. Apply isopropyl alcohol to a new clean lint-free cotton swab or lens paper.
4. 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.

5. Immediately dry the fiber end with a clean, dry, lint-free cotton swab or lens paper.
6. Blow across the connector end face from a distance of 6 to 8 inches using filtered, dry, compressed air. Aim the compressed gas 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.

7. 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.

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.

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 lightwave 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, a 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 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

To Connect an Optical Signal

When using the OPTICAL INPUT of the analyzer with an external trigger, the following procedures should be followed. To activate the optical channel, the input impedance must be set to 50Ω . Switching to an input impedance of $1\text{ M}\Omega$ is not possible. The 50Ω impedance assures a match between the 50Ω DEMODULATED OUTPUT and ELECTRICAL CHANNEL 2 INPUT. Make sure the BNC jumper (or an SDH/SONET or Fibre Channel filter) is connected between the front panel DEMODULATED OUTPUT and the ELECTRICAL CHANNEL 2 INPUT.

CAUTION

To avoid damage to the analyzer, make sure the average optical power level of the signal into the OPTICAL INPUT is less than +4 dBm. Refer to Chapter 3 for a complete list of performance characteristics.

Selecting the optical input

1. Connect a fiber cable to the OPTICAL INPUT connector of the analyzer.
2. Set the channel 2 input resistance to 50Ω by pressing:

```
Optical/Elec 2  
Input 50Ω 1MΩ 50Ω
```

3. Select the optical channel as the input by pressing:

```
Optical/Elec 2  
Chan 2 Off Op E2 Op
```

Correcting external attenuation

4. To correct external attenuation, press:

```
More 1/2  
Op Attn
```

Use the adjustment knob in the front-panel Measurement section to set the external attenuation correction for the optical channel. The external attenuation setting corrects the vertical scale, the power meter, cursor and automatic measurements for losses, and any external attenuation that may be in the optical signal path preceding the instrument.

Selecting wavelength calibration

The appropriate wavelength calibration should be selected when using the optical channel. The wavelength calibration activates the correct vertical scale and power meter calibration for the optical signal at the input. For example, if a 1300 nm signal is being analyzed, the 1300 nm vertical channel and power meter calibration should be activated.

5. Activate the 1300 nm factory calibration, press:

```
Optical Cal
Show Deflt User Deflt
1300nm
```

After activating the optical channel, the vertical scale is displayed in calibrated watts, rather than volts.

NOTE

At 1300 nm and 1550 nm, the maximum peak input power, before vertical gain compression occurs, is -5 dBm. At 780 nm, the level is -2 dBm. For the dynamic range of the average optical power meter, refer to Chapter 3.

To Connect an Electrical Signal

When using the HP 83475B electrical channels with an external trigger input, the following procedures should be followed. The input impedance of this analyzer is selectable—either 50Ω or $1\text{ M}\Omega$. The 50Ω mode matches 50Ω cables commonly used in making high frequency measurements. Impedance matching provides the most accurate measurements since reflections are minimized along the signal path. The $1\text{ M}\Omega$ mode is for use with high impedance probes and for general purpose measurements. The higher impedance minimizes the loading effect of the analyzer on the circuit under test. In this exercise you connect a signal to the ELECTRICAL CHANNEL 1 input.

To avoid damage to the analyzer, make sure the voltage level of the signal being used is less than or equal to 250 V (dc plus the peak ac). For a complete list of the characteristics, refer to Chapter 3.

CAUTION

Do not exceed 5 Vrms in 50Ω mode. When input protection is enabled in 50Ω mode, the 50Ω load will disconnect if greater than 5 Vrms is detected. However the inputs could still be damaged, depending on the time constant of the signal.

CAUTION

The 50Ω input protection mode only functions when the analyzer is powered on.

Selecting the electrical input

1. Use a cable or a probe to connect a signal to ELECTRICAL CHANNEL 1 input.
2. Select the electrical channel as the input by pressing:

Elec 1

Chan 1 Off E1 E1

**Selecting input
impedance and
attenuation**

3. To select the input impedance and the probe attenuation, press:

Elec 1 (or **Optical/Elec 2** **Elec 2**)

Input **50Ω** **1MΩ** **1 MΩ** (or **50Ω**)

More **1/2**

Probe/Atn **1**, **10**, or **100** depending on the probe used.

To Connect an Electrical Signal

Compensating the probes

Compensate the 10:1 probes to match their characteristics to the analyzer. A poorly compensated probe can introduce measurement errors.

4. Connect the 10:1 probe from ELECTRICAL CHANNEL 1 to the front-panel probe adjust signal on the analyzer, and then press **(Autoscale)**.
5. Use a nonmetallic tool to adjust the trimmer capacitor on the probe for the flattest pulse possible as displayed on the analyzer. Refer to the following figures.

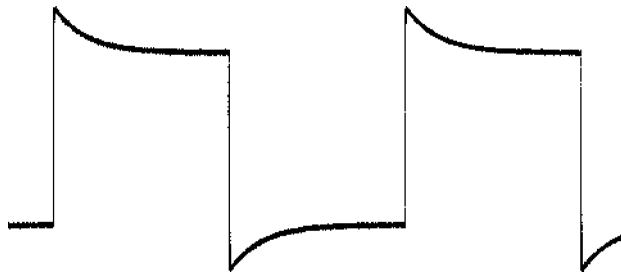


Figure 1-18. Overcompensation causes pulse peaking.

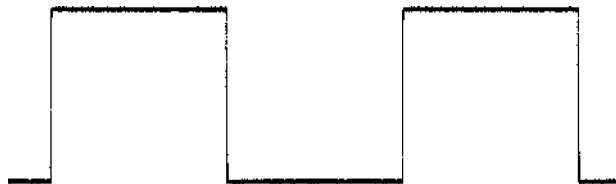


Figure 1-19. Correct compensation with a flat pulse top.

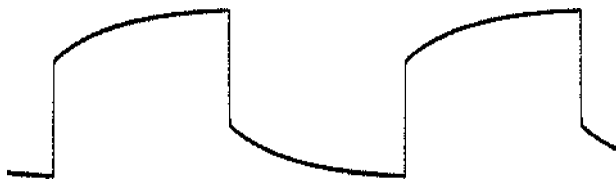


Figure 1-20. Undercompensation causes pulse roll off.

To Display a Signal Automatically

The analyzer has an Autoscale function that automatically adjusts the analyzer so the display of the input signal is optimized. Using autoscale requires signals with a frequency greater than or equal to 50 Hz and a duty cycle greater than 1 percent.

When you press the **Autoscale** key, the analyzer scales all channels that have signals applied and selects a time base range based on the trigger source. The trigger source selected is the highest numbered input that has a signal applied.

If a signal is connected to the external trigger input on the HP 83475B, then it is selected as the trigger source. Autoscale will reset in both 50 Ω and 1 M Ω impedance modes.

Coupling	DC
Bandwidth limit	Off
Verniers	Off
Signal inversion	Off

Input protection in 50 Ω mode is not affected by autoscale.

1. Connect an optical or electrical signal to the analyzer.
2. To display the signal on the screen, press **Autoscale**.
3. To undo the autoscale, press:

Setup
Undo Autoscale

The analyzer returns to the configuration in effect before you pressed the **Autoscale** key.

To Set Up the Vertical Window

This procedure can be applied to either an optical or an electrical signal. If an optical signal is connected to the OPTICAL input *and* the optical channel is activated, the vertical scale is displayed in watts rather than volts.

1. Center the signal on the display with the Position knob.

The Position knob moves the signal vertically, and is calibrated. Notice that as you turn the Position knob, a voltage (watts) value is displayed for a short time indicating how far the ground (or zero light) reference is located from the center of the screen. Also notice the ground symbol (or zero light) on the right side of the display moves in conjunction with the Position knob.

Measurement hints

If the channel is dc coupled, the dc component of the signal can be measured by simply noting its distance from the ground symbol. If the channel is ac coupled, the dc component of the signal is removed, allowing you to use greater sensitivity to display the ac component of the signal.

2. Change the vertical setup and notice that each change affects the status line differently. You can quickly determine the vertical setup from the status line in the display.
3. Change the vertical sensitivity with the Volts/Div (Watts/Div) knob and notice it causes the status line to change.

4. Select the input channel by pressing:

```
Elec 1  
Chan 1 Off E1 E1
```

5. Toggle each of the softkeys and notice which keys cause the status line to change.

The input channels have a vernier softkey that allows the Volt/Div (Watts/Div) knob to change the vertical step size in smaller increments. These smaller increments are calibrated in volts (watts), which results in accurate measurements even with the vernier turned on.

6. To turn the channel off, press:

```
Chan 1 Off E1 Off
```

Invert operating hint

When triggering on the signal being inverted, the inversion also applies to the trigger signal (a rising edge becomes a falling edge). If the signal has a 50% duty cycle (square wave or sine wave), the displayed waveform does not appear to be inverted. However, for signals with a duty cycle other than 50%, the waveform display does appear inverted. Signal inversion works only on electrical channels.

To Set Up the Time Base

This procedure can be applied to either an optical or an electrical signal. If the optical channel is activated, the vertical scale for that channel is displayed in watts rather than volts.

1. Turn the Time/Div knob and notice the change it makes to the status line.

The Time/Div knob changes the sweep speed from 1 ns to 5 s in a 1-2-5 step sequence, and the value is displayed in the status line.

2. Change the horizontal setup and notice that each change affects the status line differently.

3. Press **Main/Delayed**.

A softkey menu appears on the display with six softkey choices.

4. Toggle each of the softkeys and notice which keys cause the status line to change.

The horizontal vernier softkey allows the Time/Div knob to change the sweep speed in smaller increments. These increments are calibrated, which results in accurate measurements even with the vernier turned on.

5. Turn the Delay knob and notice its value is displayed in the status line.

The Delay knob moves the main sweep horizontally. At the top of the display is a solid triangle (\blacktriangledown) symbol and an open triangle (∇) symbol. The \blacktriangledown symbol indicates the trigger point and moves in conjunction with the Delay knob. The ∇ symbol indicates the time reference point. If the time reference softkey is set to left, the ∇ is located one graticule in from the left side of the display. If the time reference softkey is set to center, the ∇ is located at the center of the display. The delay number tells you how far the reference point (∇) is located from the trigger point (\blacktriangledown).

All events displayed left of the trigger point (▼) happened before the trigger occurred. This feature is useful for viewing the events leading up to the trigger point. Everything to the right of the trigger point (▼) is called post-trigger information. The amount of delay range (pretrigger and post-trigger information) available is dependent on the sweep speed selected. Refer to “Horizontal system” in Chapter 3, for more details.

To Trigger the Analyzer

This procedure can be applied to either an optical or an electrical signal. If the optical channel is activated, the vertical scale for that channel is displayed in watts rather than volts.

Using the trigger level knob

1. Turn the trigger level knob and notice the changes it makes to the display.

When you turn the trigger level knob or press a trigger key, the trigger level is displayed in inverse video. If the trigger is dc coupled, it is displayed in watts on the optical channel, in volts on the electrical channels or external trigger. If the trigger is ac coupled or if LF reject is selected, it is displayed as a percentage of the trigger range. If the trigger source is turned on, a line is displayed showing the location of the trigger level (as long as ac coupling or low frequency reject is not selected).

2. Change the trigger setup and notice that each change affects the status line differently.

Setting the external trigger

The HP 83475B has a viewable external trigger, which is useful for making timing measurements. It is also useful for setting a trigger level that provides a stable display when viewing events, for example, ringing on a fast signal.

3. Set the external trigger as the trigger source by pressing:



Selecting **Ext** displays two additional softkeys which are used for the external trigger setup.

- To view the external trigger waveform, press:

```
Menu  
Ext Trig View Off View
```

- Set the external trigger to dc coupling and an impedance of 50Ω by pressing:

```
Input 50Ω 1MΩ 50Ω  
Coupling DC AC Gnd DC
```

- To adjust the offset of the trigger signal use the general purpose knob. The general purpose knob can be used to adjust the external trigger offset level if:

- you are in the External Trigger menu
- you have pressed:

```
Source  
Ext
```

- Use the trigger level knob to adjust the level to the desired point on the trigger waveform.
- Display the trigger mode choices by pressing **Mode**.
- Observe the status line as you toggle the **Single** and **TV** softkeys. (You can only select TV if the trigger source is E1, E2 or Op.)

When the analyzer is triggering properly, the trigger mode portion of the status line is blank.

If Auto Lvl, Auto, Normal, or Single is selected as the trigger mode, six softkey choices are displayed. If TV is selected as the trigger source, five softkey choices are available.

To Trigger the Analyzer

What happens if the analyzer loses trigger?

If Auto Level is the trigger mode, Auto flashes in the status line. If dc coupled, the analyzer resets the trigger level to the center of the signal. If ac coupled, the analyzer resets the trigger level to halfway between the minimum and maximum amplitudes as displayed on the screen. In addition, every time you press the Auto Level softkey, the analyzer resets the trigger level.

If Auto is the trigger mode, Auto flashes in the status line and the analyzer freeruns.

If either Normal or TV is the trigger mode, the trigger setup flashes in the status line.

Display slope and coupling options

10. Display the slope and coupling options by pressing **Slope/Coupling**.
11. Toggle each of the softkeys and notice which keys affect the status line.
12. Adjust the Holdoff knob and observe how the display changes.

Holdoff keeps the trigger from rearming for a user-specified amount of time. Holdoff is used to stabilize the display of complex waveforms. The holdoff range is from 200.0 ns to about 13.5 s. When you adjust the holdoff knob, the current holdoff time is briefly displayed in inverse video near the bottom of the display. For an example of using holdoff, refer to “To Trigger on a Complex Waveform” in Chapter 2.

To set a long holdoff time, go to a slower sweep speed.

The value used to increment the holdoff depends upon the sweep speed or time/div selection. However, the actual holdoff value is a fixed number; it is not a percentage of sweep speed. For a time/div setting of 5 ns/div, the holdoff increment is about 50 ns. For a time/div setting of 5 s/div, the holdoff increment is about 100 ms.

To Use Roll Mode

Roll mode continuously moves data across the display from right to left. Roll mode allows you to see dynamic changes on low frequency signals, for example, when you adjust a potentiometer. Two frequently used applications of roll mode are transducer monitoring and power supply testing.

Using roll mode

1. Select roll mode by pressing:

```
Mode
Auto Lvl or Auto
Main/Delayed
Roll
```

The analyzer is now untriggered and runs continuously.

2. Select the time reference by pressing:

```
Mode
Single
Main/Delayed
Time Ref Lft Cntr
```

The analyzer fills $\frac{1}{2}$ of the display if `Time Ref Lft Cntr Cntr` is selected ($\frac{9}{10}$ if `Time Ref Lft Cntr Lft` is selected) and then searches for a new trigger. After a trigger is found, the remainder of the display is filled and the analyzer stops acquiring data. Automatic measurements can also be made in the roll mode. The analyzer briefly interrupts the moving data while making the measurement, however the acquisition system does not miss any data during the measurement. The slight shift in the display, after the measurement is complete, occurs when the display is catching up to the acquisition system.

Roll mode operating hints

Math functions, averaging, and peak detect are not available.

Holdoff and horizontal delay are not active.

Both a free running (non-triggered) display and a triggered display (available in the single mode only) are available.

Roll mode is available at sweep speeds of 200 ms/div and slower.

Roll mode is available only when **Meas Type** Genl Wvfm is selected.

Making Measurements

Making Measurements

Setting Thresholds

Rise time and fall time measurements are performed at 10%/90%, 20%/80%, or at user-defined threshold levels. When the measurement type is set to General Waveform, other time measurements are performed at the center point of the currently selected upper and lower threshold values. When the measurement type is Eye:NRZ, the threshold levels only affect the rise time and fall time measurements.

NOTE

User-defined threshold levels are set, for both eye diagram and general waveforms, in percent of waveform amplitude. Time measurements, other than rise time and fall time, are affected only when General Waveform measurement type is selected.

- If 10%/90% is selected, the center is 50%.
- If 20%/80% is selected, the center is 50%.
- If Variable is selected, the center is dependent on the current lower and upper percent values.

For example, if the lower value is set to 20%, and the upper value is set to 90%, then the 50% level is 55% of the amplitude. The 55% amplitude point is the point that frequency, period, duty cycle, positive pulse width, and negative pulse width will be measured. The point of measurement is dependent on the amplitude of the input signal.

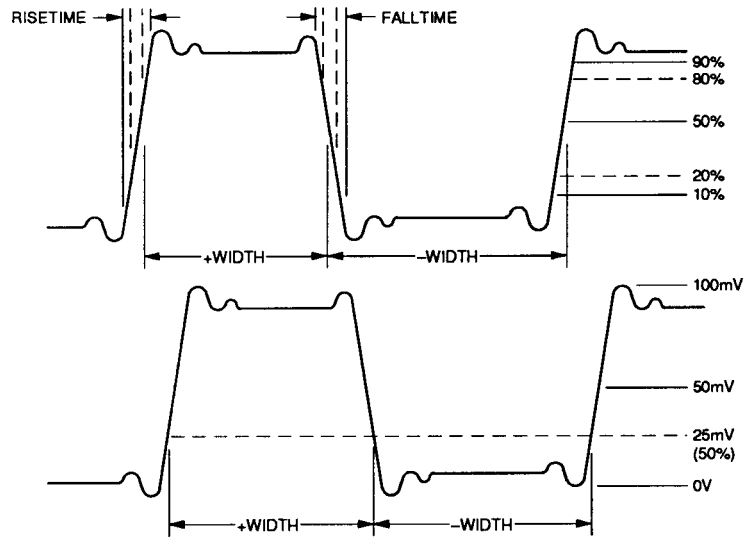


Figure 2-1. User thresholds measurement.

To set the thresholds, press:

- Time
- More 1/4
- More 2/4
- More 3/4
- Define Thresh

Making Measurements

Five threshold selections are available.

10% 90%

Rise time/fall time measurements performed at the 10% (lower) and 90% (upper) levels. Frequency, period, duty cycle, positive pulse width, and negative pulse width measurements will be performed at the 50% level.

20% 80%

Rise time/fall time measurements performed at the 20% (lower) and 80% (upper) levels. Frequency, period, duty cycle, positive pulse width, and negative pulse width measurements will be performed at the 50% level.

Variable

For both eye diagram and general waveforms, rise time/fall time measurements are performed at the lower and upper levels specified by the user. General waveform measurements, such as frequency, period, duty cycle, positive pulse width, and negative pulse width, will be performed at the center of both entered levels. Eye diagram measurements, such as bit rate and DCD, are not affected.

Lower _%

This softkey is displayed only when the **Variable** softkey is selected. Select and rotate the knob closest to the **Masks/Cursors** key to set the lower threshold to the desired value.

Upper _%

This softkey is displayed only when the **Variable** softkey is selected. Select and rotate the knob closest to the **Masks/Cursors** key to set the upper threshold to the desired value.

Selecting user threshold hints

Lower threshold level cannot be set to a value higher than the current upper threshold level.

Upper threshold level cannot be set to a value lower than the current lower threshold level.

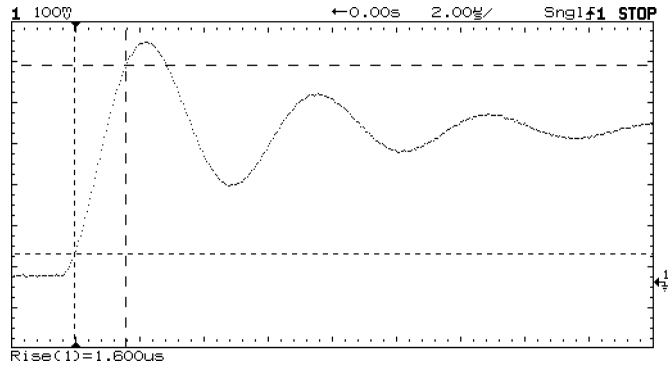


Figure 2-2. User threshold rise time measurement.

Making Voltage and Power Measurements

The HP 83475B lightwave communications analyzer has an integrated optical channel which allows you to perform both voltage and optical power measurements. The measurements described in this section include average optical power and a series of measurements based on voltage and instantaneous optical power levels. Depending on the input source and the instrument settings, the measurement results will be displayed in either volts (electrical) or watts (optical). When performing optical measurements, make sure the correct optical calibration is selected under the **Optical Cal** front-panel key.

To make average optical power measurements

The lightwave communications analyzer has a built-in average optical power meter. Average optical power measurements are made by monitoring the photodiode current of the integrated optical to electrical receiver.

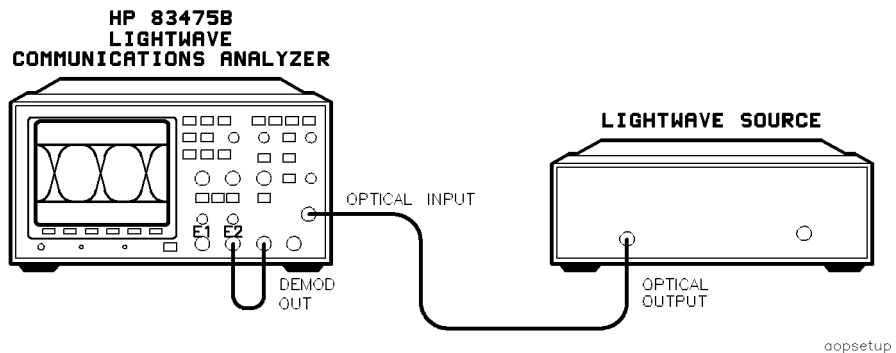


Figure 2-3. Average optical power measurements setup.

This exercise assumes the set-up shown in Figure 2-3. Refer to “To Connect an Optical Signal” in Chapter 1 for additional information.

1. To set the power measurement units, press:

```
Power/Voltage  
More 1/4  
More 2/4  
More 3/4  
Select Units  
Pwr Units  $\mu$ W dBm dBm
```

2. To activate the optical power meter, press:

```
Power/Voltage  
Opt Pmtr Off On On
```

The average power of the signal at the optical input of the lightwave communications analyzer is shown in the results section of the display.

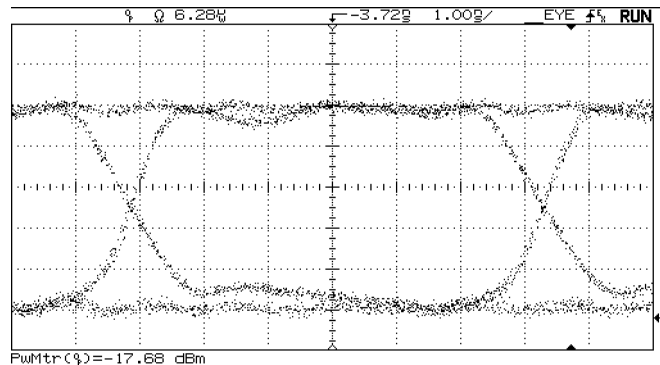


Figure 2-4. Power measurement display.

Making Voltage and Power Measurements

NOTE

The power meter is activated independently of the **Chan 2 Off E2 Op** input setting. When the **Opt Pmtr Off On** key is pressed, the signal level present at the OPTICAL INPUT of the analyzer is measured. If no signal is present, or if the signal level is below the power meter measurement range, the result ********* is displayed.

NOTE

When the power meter is active, the update rate of the display is decreased due to the additional data processing. To increase the update rate of the display, the power meter can be set to **Off**. This will *not* clear the measurement from the Results section of the display. Set the power meter to **On** to reactivate the measurement.

To make eye diagram measurements

The following amplitude eye diagram parameters are single-button measurements:

- Extinction ratio
- Mean “1” level
- Mean “0” level
- Amplitude
- RMS noise
- Peak-to-peak noise
- Eye height %
- Eye crossing level %
- Maximum level
- Minimum level
- Overshoot

These one-button eye diagram measurements are made using histogram-based algorithms. When one of the measurements is activated, histogram data is automatically acquired on the eye diagram at locations dictated by the measurement algorithm. For a description of the measurement algorithms, refer to Chapter 4.

This exercise assumes the set-up shown in Figure 2-5. Activate the optical channel and load the appropriate optical calibration. Refer to “To Connect an Optical Signal” in Chapter 1 for additional information.

NOTE

Eye diagram measurements can be made on only one measurement source at a time. For example, if an eye diagram measurement is active with E_2 as the source, an eye diagram measurement cannot be performed on E_1 .

Making Voltage and Power Measurements

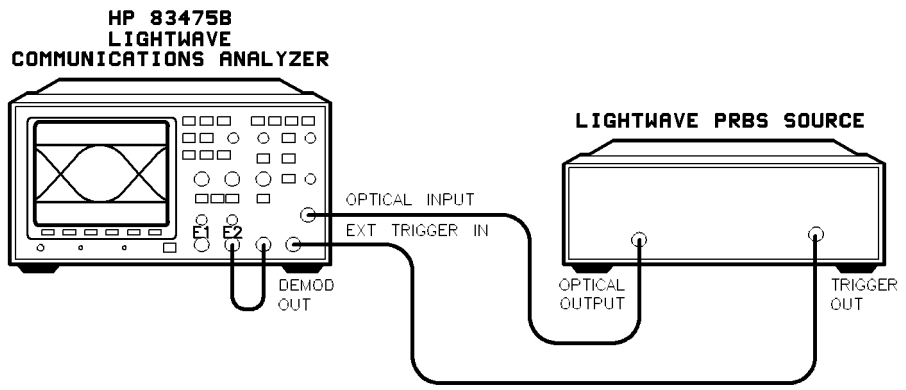


Figure 2-5. Eye diagram measurement setup.

Selecting the measurement type

1. To access the eye diagram measurement capability of the lightwave communications analyzer, press:

`Power/Voltage`

`Meas Type Genl Wvfm Eye:NRZ Eye:NRZ`

NOTE

Only one type of measurement (Genl Wvfm or Eye:NRZ) can be made at a time. If measurements of a given type are active and that measurement type is changed, the measurements are automatically deactivated and the Results section displays **Genl off** or **Eye off**.

Selecting the measurement source

2. To set the measurement source, press:

Source E1 Op(E2) Op (or E2)

Amplitude measurements are displayed in optical power units, μW or dBm, when Op is set as the source.

Setting the number of samples and activating measurement tracking

3. To set the number of amplitude samples, select the power measurement units, and activate measurement tracking with markers, press:

Power/Voltage
More 1/4
Show Meas Off On On
More 2/4
More 3/4
Select Units
Pwr Units μW dBm μW
Previous Menu
Ampl Samp

Adjust the number of samples using the general purpose knob located under the measurements section.

Adjusting time samples

4. When making eye diagram measurements, time samples should also be adjusted. This adjustment is necessary because the calculation of the time location of parameters, such as eye diagram crossing points, are affected. To adjust time samples, press:

Time
Meas Type Genl Wvfm Eye:NRZ Eye:NRZ
More 1/4
More 2/4
More 3/4
Time Samp

Making Voltage and Power Measurements

The throughput of the histogram measurement is dependent on the type of measurement and the number of samples. A larger number of samples can improve measurement repeatability but increases measurement time. Typically, for good repeatability, amplitude samples should be set to approximately 1000 and time samples should be set to approximately 300.

Define the amplitude histogram window

5. To define the amplitude histogram window, press:

```

Power/Voltage
More 1/4
More 2/4
More 3/4
Define Eye Window
Measure AUTO MAN AUTO
  
```

Highlight **Min** and use the general purpose knob to adjust to 30%.

Highlight **Max** and adjust to 70%. Two time markers show the location of the histogram window. The window has been set in the middle 40% of the eye diagram bit period.

Measuring eye height percent

6. To measure the eye height percent, press:

```

Previous Menu
More 4/4
More 1/4
Eye Hgt %
  
```

Notice the Eye Height % value displayed on the screen is being continuously updated after each data acquisition is completed. The data acquisition status is shown graphically, as a bar that fills, on the status line. Acquisition continues as long as measurement type Eye:NRZ is selected. Data acquisition is re-started if the vertical and horizontal settings are changed or the **(Erase)** key is pressed.

Measuring the one and zero level amplitudes

7. To measure the one and zero level amplitudes, press:

More 2/4

One Lvl

Zero Lvl

Measuring eye cross

8. To measure the eye cross percentage, press:

More 3/4

Eye Cross

Continue to make one-button measurements such as Max Lvl, Min Lvl, Overshoot, and so forth by scrolling through the Eye:NRZ menu and pressing the appropriate buttons. Figure 2-6 shows the display with some of the measurements activated.

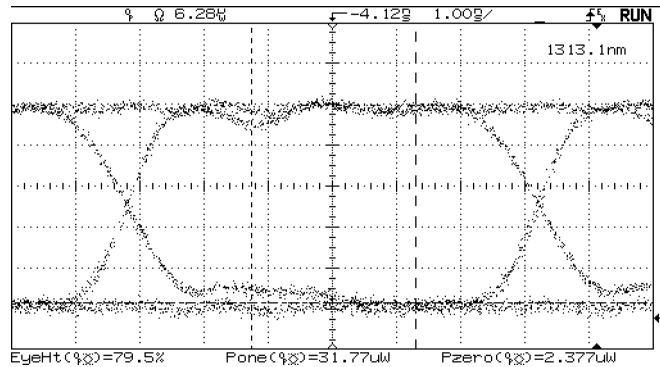


Figure 2-6. Display with measurements active.

To make pulse waveform measurements (general waveform)

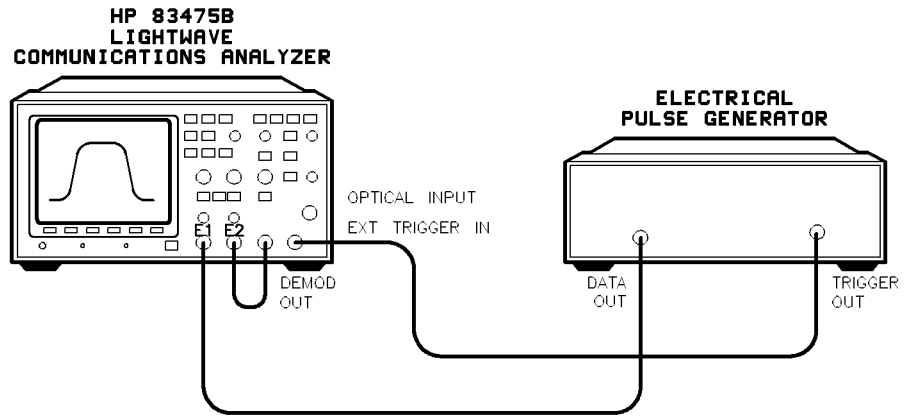
The analyzer performs several measurements on general, repetitive pulse waveforms.

The following amplitude parameters can be measured automatically with the analyzer:

- peak-to-peak
- overshoot
- average
- rms
- maximum level
- minimum level
- amplitude
- preshoot
- top level
- base level

These one-button waveform measurements are made using histogram-based algorithms. When one of the measurements is activated, histogram data is automatically acquired on the waveform at locations dictated by the measurement algorithm. For a description of the measurement algorithms, refer to Chapter 4.

This exercise assumes the setup shown in Figure 2-7. For additional setup information, refer to “To Connect an Electrical Signal” in Chapter 1.



pwsetup

Figure 2-7. Pulse waveform measurements setup.

Making Voltage and Power Measurements

Selecting the measurement type

1. To access the general waveform measurement capability of the lightwave communications analyzer, press:

Power/Voltage

Meas Type Genl Wvfm Eye:NRZ Genl Wvfm

NOTE

Only one type of measurement (Genl Wvfm or Eye:NRZ) can be made at a time. If measurements of a given type are active and that measurement type is changed, the measurements are automatically deactivated and the Results section displays **Genl off** or **Eye off**.

Selecting the measurement source

2. To set the measurement source, press:

Source E1 Op(E2) E1

Activating measurement tracking

3. To activate measurement tracking, with markers, press:

Time

More 1/4

Show Meas Off On On

Making a peak-to-peak measurement

4. To make a peak-to-peak measurement, press:

Power/Voltage

More 1/4

Pk to Pk

Making top and base level measurements

5. To make a Top Level and Base Level measurement, press:

More 2/4

Top Lvl

Base Lvl

Making an rms measurement

6. To make an rms measurement, press:

More 3/4

rms

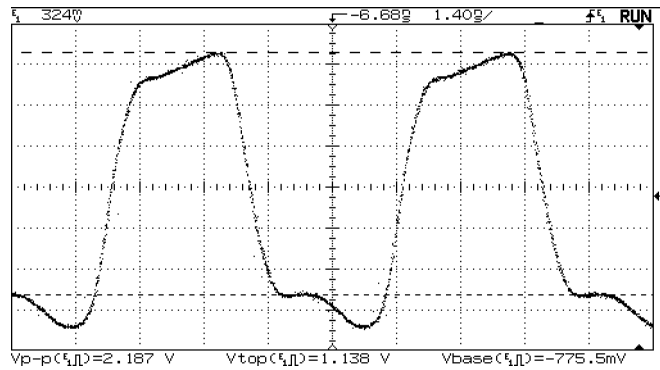


Figure 2-8. Pulse with pk-pk, top, and base level measurements.

Making Time Measurements

This section includes information on how to perform eye diagram and general pulse waveform time measurements.

To make eye diagram measurements

The following eye diagram time parameters are single-button measurements:

- rise time
- fall time
- bit rate
- bit period
- DCD (duty cycle distortion)
- JITTER_{pp}
- JITTER_{rms}

These one-button eye diagram measurements are made using histogram-based algorithms. When one of the measurements is activated, histogram data is automatically acquired on the eye diagram at locations dictated by the measurement algorithm. For a description of the measurements algorithms, refer to Chapter 4.

NOTE

Eye diagram measurements can be made on only one measurement source at a time. For example, if an eye diagram measurement is active with E_2 as the source, an eye diagram measurement cannot be performed on E_1 .

The following exercise guides you through the Time measurement keys by characterizing the eye diagram. The exercise assumes the setup shown in Figure 2-9. Activate the optical channel and load the appropriate optical calibration. Refer to “To Connect an Optical Signal” in Chapter 1 for additional information.

Making Time Measurements

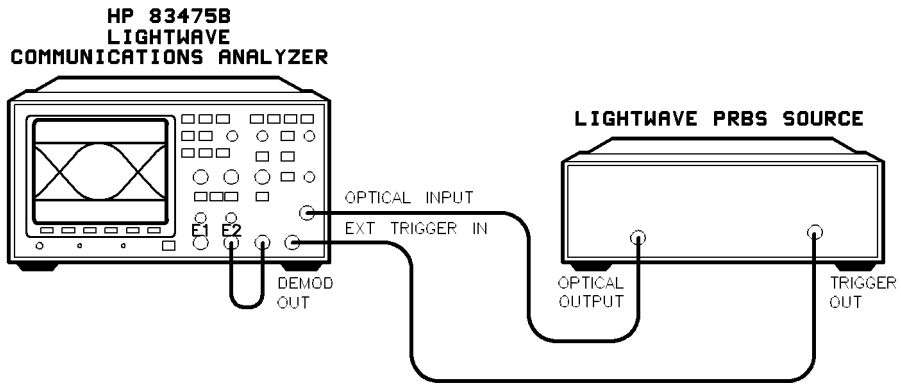


Figure 2-9. Eye diagram measurements setup.

Selecting the measurement type

1. To access the eye diagram measurement capability of the lightwave communications analyzer, press:

```
Time
Meas Type Genl Wvfm Eye:NRZ Eye:NRZ
```

NOTE

Only one type of measurement (Genl Wvfm or Eye:NRZ) can be made at a time. If measurements of a given type are active and that measurement type is changed, the measurements are automatically deactivated and the Results section displays **Gen off** or **Eye off**.

Selecting the measurement source

2. To set the measurement source, press:

```
Source E1 Op(E2) Op
```

**Activating
measurement tracking**

3. To activate measurement tracking, with markers, press:

```
More 1/4  
Show Meas Off On On
```

**Setting thresholds and
time samples**

4. To set the upper and lower thresholds, press:

```
More 2/4  
More 3/4  
Define Thresh  
20% 80%  
Previous Menu
```

5. To set the number of time samples, press:

```
Time Samp
```

Use the general purpose knob located below the front-panel Measure section to adjust the number of time samples.

The throughput of the histogram measurements is highly dependent on the number of time samples. A large number of samples (>500) can improve measurement repeatability but will also significantly increase measurement time. Time samples take a longer time to acquire than amplitude samples because of the narrow histogram windows used in the time data acquisition. Time samples are used to calculate the time location of the eye diagram crossing points which are important in the calculation of eye diagram parameters and mask placement.

**Measuring the rise time
and fall time**

6. To measure the rise time and fall time, press:

```
More 4/4  
Rise Time  
Fall Time
```

Making Time Measurements

Figure 2-10 shows rise time and fall time measurements on an eye diagram waveform.

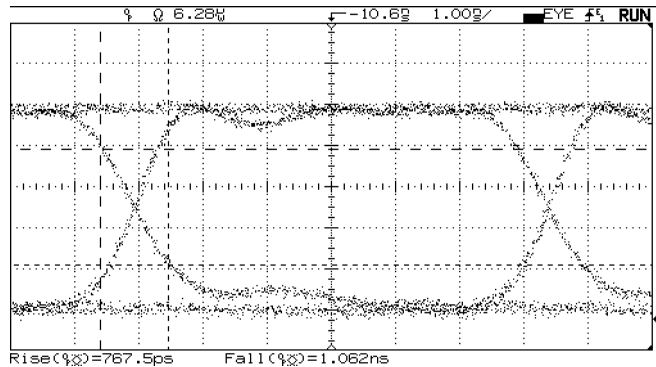


Figure 2-10. Rise time and fall time measurements.

Measuring the bit period

7. To measure the bit period, press:

More 1/4

Bit Period

Notice the bit period value displayed on the screen. It is updated after each data acquisition is completed. The data acquisition status is shown graphically, as a filling bar, on the status line. Acquisition continues as long as measurement type Eye:NRZ is selected. Data acquisition is re-started if the vertical and horizontal settings are changed or the **Erase** key is pressed.

Measuring RMS jitter and duty cycle distortion

8. To measure RMS jitter and duty cycle distortion, press:

More 2/4

JITTERrms

DCD

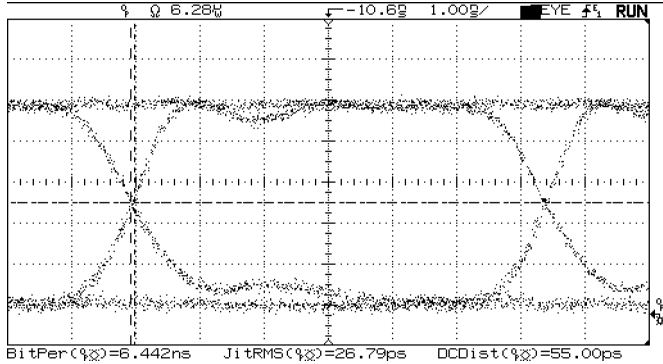


Figure 2-11. Eye diagram with bit period, jitter rms and DCD measurements.

To make pulse waveform measurements

The analyzer performs several measurements on general, repetitive pulse waveforms.

The following pulse waveform time parameters are single-button measurements:

- frequency
- period
- duty cycle
- + width
- width
- rise time
- fall time
- delay
- phase

These one-button waveform measurements are made using histogram-based algorithms. When one of the measurements is activated, histogram data is automatically acquired on the waveform at locations dictated by the measurement algorithm. For a description of the measurement algorithms, refer to Chapter 4.

The following exercise guides you through the time measurement keys by making several measurements.

This exercise assumes the setup shown in Figure 2-12. For additional setup information, refer to “To Connect an Electrical Signal” in Chapter 1.

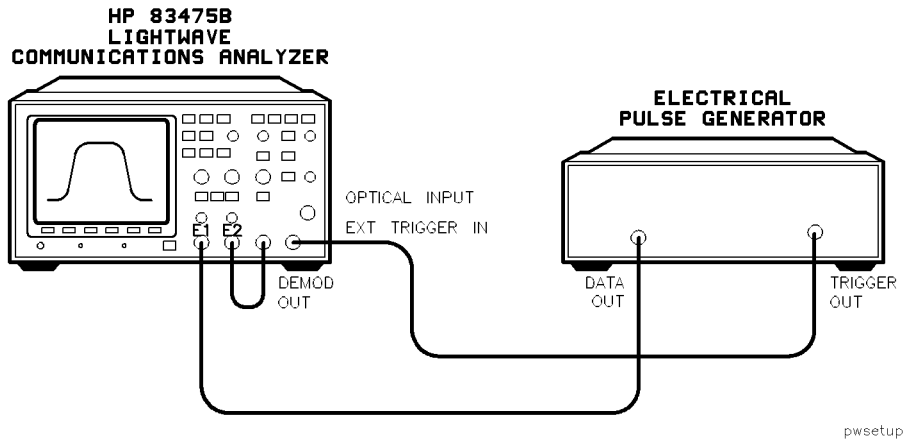


Figure 2-12. Pulse waveform measurements setup.

Selecting the measurement source

1. To access the general waveform measurement capability of the lightwave communications analyzer, press:

Time

Meas Type Gen1 Wvfm Eye:NRZ Gen1 Wvfm

NOTE

Only one type of measurement (Gen1 Wvfm or Eye:NRZ) can be made at a time. If measurements of a given type are active and that measurement type is changed, the measurements are automatically deactivated and the Results section displays **Gen1 off** or **Eye off**.

Making Time Measurements

2. To set the measurement source, press:

Source E1 Op(E2) E1

Activating measurement tracking

3. To activate measurement tracking, with markers, press:

More 1/4

Show Meas Off On On

Setting the measurement thresholds

4. To set the upper and lower thresholds, press:

More 2/4

More 3/4

Define Thresh

20% 80%

Previous Menu

Measuring the rise time and fall time

5. To measure the rise time and fall time, press:

More 4/4

Rise Time

Fall Time

Measuring the pulse width

6. To measure the positive and negative pulse widths, press:

Meas Type Genl Wvfm Eye:NRZ Genl Wvfm

More 1/4

+Width

-Width

Measuring the duty cycle

7. To measure the duty cycle, press:

More 2/4

Duty Cycle

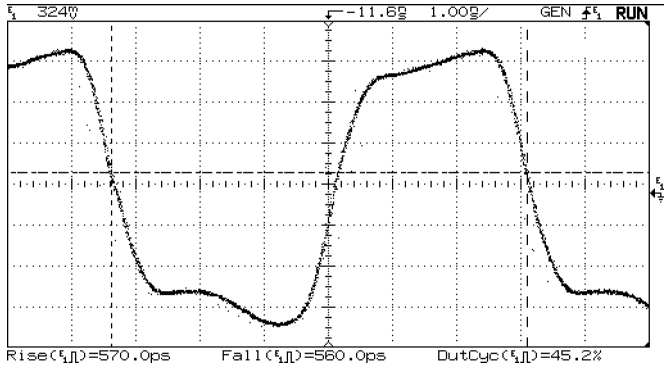


Figure 2.13. Pulse waveform with rise time, fall time and duty cycle measurements.

To make delay measurements automatically

You can measure the delay of signals connected to the analyzer's electrical input 1 and electrical input 2 connectors.

Delay is measured from the user-defined slope and edge count of the signal connected to input 1, to the defined slope and edge count of the signal connected to input 2.

1. Adjust the controls so a minimum of six full cycles of the signals connected to inputs 1 and 2 are displayed and then, press:

Time
More 1/4
More 2/4
More 3/4
Define Delay

The selections available for defining the delay measurement are:

Chan 1	Selects the channel 1 slope (rising or falling) where the delay measurement will START. Threshold level is always 50%.
Edge	Selects the edge count (from 1 to 5) where the delay measurement will START.
Chan 2	Selects the channel 2 slope (rising or falling) where the delay measurement will STOP. Threshold level is always 50%.
Edge	Selects the edge (from 1 to 5) count where the delay measurement will STOP.

2. Use the displayed softkeys to specify the starting (from) and stopping (to) slope and edge count. Transition point (measurement threshold level) is fixed at 50%.
3. Return to the previous menu by pressing:

Previous Menu

- To measure the delay, press:

Delay

The delay is measured and displayed on the screen.

Negative delay values indicate the defined edge on channel 1 occurred after the defined edge on channel 2.

Automatic delay measurement hints

If an edge is selected that is not displayed on the screen, delay will not be measured.

User thresholds have no effect on automatic delay measurements. Delay is always measured at the 50% transition point (measurement threshold level).

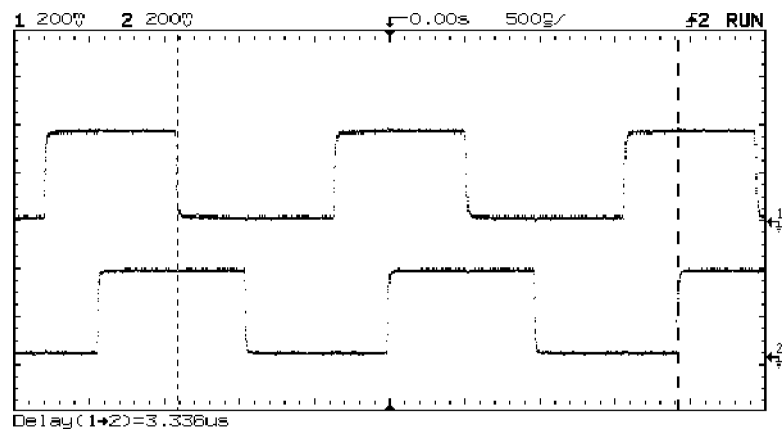


Figure 2-14. Automatic delay measurement.

To make phase measurements automatically

Phase shift between two signals can be measured using the Lissajous method.

The measurement is automatically made from the rising edge of the first full cycle on the input 1 signal, to the rising edge of the first full cycle on the input 2 signal. The method used to determine phase is to measure delay and period, then calculate phase as follows:

$$Phase = \left(\frac{delay}{period\ of\ input\ 1} \right) 360$$

1. Adjust controls to display a minimum of one full cycle of the signal connected to input 1.
2. To measure the phase, press:

```

Time
Meas Type Gen1 Wvfm Eye:NRZ Gen1 Wvfm
More 1/4
More 2/4
More 3/4
Phase
  
```

Phase is measured and displayed on the screen.

Negative phase values indicate the displayed signal on channel 2 is leading the signal on channel 1.

Automatic phase measurement hints

If one full cycle of the signal connected to input 1 is not displayed, phase will not be measured.

User thresholds has no effect on automatic phase measurements. Phase is always measured at the 50% transition point (threshold level).

When using the delayed timebase, the instrument will attempt to perform the measurement using the delayed window. If the selected channel 1 edge, channel 2 edge, and channel 1 period cannot be found in the delayed window, the main window is used. See "Making Time Measurements" for more information.

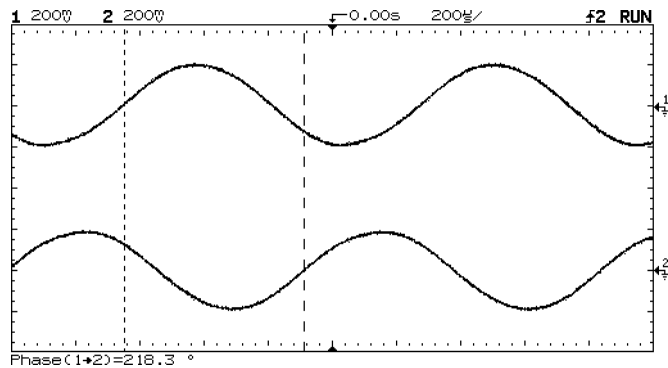


Figure 2-15. Automatic phase measurement.

Making Extinction Ratio Measurements

This section contains information on making extinction ratio measurements with the lightwave communications analyzer. It also contains information on optimizing the measurements.

To perform an offset calibration

1. To perform an offset calibration, press:

```
Optical Cal
Show Deflt User Deflt
Ext Ratio Offset Cal
Meas Op
```

2. Follow the on-screen instructions for performing an offset calibration. When the calibration is complete, press:

```
Previous Menu
```

NOTE

To abort the offset calibration, press **Abort**. The DC offset value will *not* be saved.

To measure extinction ratio

Performing the offset calibration

Before proceeding with the extinction ratio measurement follow the procedure described in “To perform an offset calibration”.

This measurement assumes the set-up shown in Figure 2-5.

Selecting the measurement type and source

1. To access the eye diagram measurement capability of the lightwave communications analyzer and set the measurement source, press:

```
Power/Voltage
Meas Type Gen1 Wvfm Eye:NRZ Eye:NRZ
Source E1 Op(E2) Op
```

Activating measurement tracking

2. To activate measurement tracking, press:

```
More 1/4
Show Meas Off On On
```

Setting the measurement display units

3. To set the measurement display units to dB, press:

```
More 2/4
More 3/4
Select Units
dB
```

Setting the measurement window

4. To define the measurement window, press:

```
Previous Menu
Define Eye Window
```

Highlight the min and max limits by pressing the appropriate keys. Use the general purpose knob to adjust the minimum limit to 0% and the maximum limit to 100%.

Making Extinction Ratio Measurements

- When the limits are adjusted, press:

Previous Menu

Measuring extinction ratio

- To measure the extinction ratio, press:

More 4/4

Extinction Ratio

The extinction ratio is shown in the results section of the display.

NOTE

If an extinction ratio offset calibration has *not* been performed since the instrument was turned on, pressing **Extinction Ratio** will start the offset calibration procedure for the currently selected measurement source, E_1 , E_2 , or O_p .

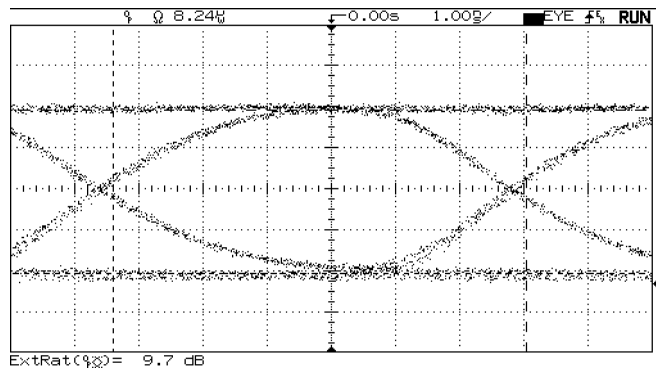


Figure 2-16. Eye diagram extinction ratio measurement results.

To measure extinction ratio with manual eye crossing settings

Manually setting the eye crossings for extinction ratio measurements

Several steps are required to calculate extinction ratio. One step is finding the time location of the eye diagram crossing points. The HP 83475B extinction measurement algorithm can automatically find the locations of these points. However, under certain circumstances, the algorithm can have difficulty finding the time location of the crossing points. When making extinction ratio measurements on eye diagrams that have a high level of distortion, noise, and/or jitter, it is more practical for you to manually set the location the instrument should consider as the eye diagram crossing points. This can be done using the markers, which indicate to the instrument algorithm, the time locations to be used as the crossing points when calculating extinction ratio.

NOTE

When the crossing points locations are set manually, other eye diagram measurements such as One Level, Noise, and Jitter are also affected.

Before proceeding with the extinction ratio measurement, follow the procedure described in “To perform an offset calibration”.

This measurement assumes the set-up shown in Figure 2-5.

1. To access the eye diagram measurement capability of the lightwave communications analyzer and set the measurement source, press:

Power/Voltage

Meas Type Gen1 Wvfm Eye:NRZ Eye:NRZ

Source E1 Op(E2) Op

Making Extinction Ratio Measurements

2. To activate measurement tracking, press:

More 1/4

Show Meas Off On On

3. To set the measurement units to dB, press:

More 2/4

More 3/4

Select Units

dB

4. To define the eye diagram crossing point locations, press:

Previous Menu

Define Eye Window

Measure AUTO MAN MAN

Highlight the T1 Ref and T2 Ref sofkeys by pressing the appropriate keys. Use the general purpose knob to place the markers on the time locations of the crossing points.

5. To define the measurement window, highlight the min and max limits by pressing the appropriate keys. Use the general purpose knob to set the minimum and maximum limits within the center of the eye. To measure in the middle 20%, for example, set the min limit to 40% and the max limit to 60%.
6. When limits are adjusted, press:

Previous Menu

7. To measure the extinction ratio, press:

More 4/4

Extinction Ratio

The extinction ratio is shown in the results section of the display.

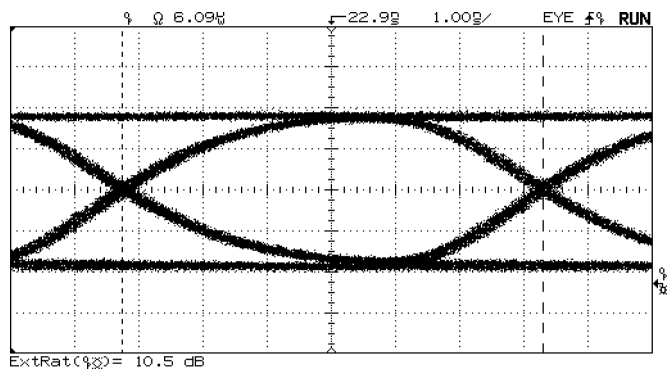


Figure 2-17. Eye diagram extinction ratio measurement with manual eye crossing settings.

Optimizing Extinction Ratio Measurements

The measurement of lightwave transmitter extinction ratio, in addition to mask conformance, is required by the SONET/SDH standards. Extinction ratio is typically defined as ten times the logarithm of the ratio of the mean or average optical power level of the logic “1” level to the mean or average optical power level of the logic “0” level. Extinction ratio can also be expressed in percentage units. This is simply the linear ratio of the “0” level to the “1” level multiplied by 100 and expressed as a percentage.

Extinction ratio overview

Though the definition of extinction ratio is relatively straightforward, the measurement methodology to determine the mean logic levels is not clearly specified in standards, such as SDH standard ITU-T G.957. The TIA/EIA (Telecommunications Industries Association/Electronics Industries Association) has developed a recommended methodology for making eye diagram measurements called OFSTP-4 (Optical Fiber Standard Test Procedure # 4). It recommends that extinction ratio be determined using voltage histograms on a digital sampling oscilloscope while using a reference O/E converter with a specified fourth-order Bessel-Thomson frequency response. The reference receiver must fit a narrow tolerance window and have a 3 dB cut-off at $\frac{3}{4}$ of the line rate. The logic “1” and “0” levels can be determined, from the optical eye diagram, as the most prevalent logic “1” and “0” voltage levels measured across an entire bit period. In effect, a voltage histogram window is specified from one eye diagram crossing point to the other.

NOTE

Care must be taken to assure the number of samples acquired for the histograms is sufficiently large to overcome the uncertainty caused by noise on the waveform.

The OFSTP-4 also points out the importance of removing any residual system DC offset from the extinction ratio measurement. Either before or after the histograms of the most prevalent “1” and “0” levels are taken, the DC offset must be subtracted from the levels before the extinction ratio is computed. In effect, the measured extinction ratio in percent is given by:

$$ER = \left(\frac{V_{zero} - V_{offset}}{V_{one} - V_{offset}} \right) 100\%$$

Optimizing Extinction Ratio Measurements

The lightwave communications analyzer provides an extinction ratio measurement which takes into account the recommendations of OFSTP-4. Voltage histograms are used to make the measurement, and functionality is also available to measure and correct system DC offset. In addition, the instrument allows user definition of the voltage histogram window. The window can be set anywhere within the waveform bit period.

An extinction ratio specification does exist within the SDH and SONET standards and for this reason, it must be measured in the manufacturing process of compliant lightwave transmitters. SDH/SONET compliant transmitters, depending on bit rate and application, must have a minimum extinction ratio of 8.2 or 10 dB. Extinction ratio can also provide some valuable insight into transmitter performance.

- Since extinction ratio measurements are directly related to the transmitter bias current setting, extinction ratio variations can indicate problems with the transmitter biasing which, in turn, may relate to BER floors.
- Extinction ratio also gives, at a given average power level, feedback on the “1” level and “0” level separation, which is directly related to transmitter Bit Error Ratio performance.
- Extinction ratio also directly maps into a power penalty which affects system power budget analysis and design.

Measurement challenges

It is challenging to obtain repeatable extinction ratio measurements. Specifically, it is difficult to obtain measurement correlation between different test systems. There are several reasons for this. Primarily, there are several error sources contributing to the measurement uncertainty. These error sources limit the test system correlation and the overall measurement accuracy. It is important to realize extinction ratio measurements, when measured in dB, are very sensitive to the denominator or “0” level term as shown in the following equation.

$$ER (log) = 10 \log \left(\frac{V_1 - V_{offset}}{V_0 - V_{offset}} \right)$$

Usually, system DC offset and transmitter “0” levels provide very small values. In general, the chief factors contributing to extinction ratio uncertainty are:

- Receiver frequency response
- System noise
- DC offset drift
- Quantization
- Measurement algorithm
- Electrical return loss

Small differences in the frequency response of the different test systems can translate to significant variations in measured extinction ratio. The biggest contributors to measurement uncertainty are reference O/E receiver variations in DC and AC gain. These variations can contribute significant error to the measurement and, due to the lack of repeatability between systems, also contribute to a lack of correlation between measurement systems.

DC to AC gain variations are minimized in the lightwave communications analyzer by assuring that, with the appropriate filter option attached, the frequency response of the integrated O/E, a hardware filter, and the electrical analyzer channel fit within the SDH/SONET reference receiver specified window. However, variations within even this tightly specified window can cause extinction ratio differences as high as 1 dB (or approximately two percent) on a 10 dB input extinction ratio. Such variations are to be expected with present measurement solutions.

Measurement guidelines

The following guidelines are recommended to minimize uncertainties when making extinction ratio measurements.

- Warm up the system for at *least* one hour. To stabilize the DC offset of the system and ensure optimum performance, we recommended the lightwave communications analyzer be warmed up for one hour.
- To optimize the measurement resolution over the analyzer's 8-bit ADC, adjust the vertical scale so the eye diagram covers at least 80% of the scale.

Because the lightwave communications analyzer switches to 7-bit resolution at the smallest vertical scale settings (approximately 3 uV/div for the optical channel, 3 mV/div for the electrical channels) we recommend the measurement at the smallest settings be taken *before* the analyzer switches to 7-bit resolution.

- Adjust the horizontal scale so one entire eye diagram (two crossing points) is displayed.
- Whenever the room temperature varies by a few degrees C, perform the electrical vertical channel calibrations. Refer to “Performing the Electrical Vertical Channel Calibration” in Chapter 5.
- To minimize the error introduced by system noise, take at least 2,000 histogram amplitude samples.
- In some cases, trigger feedthrough into the measurement channel can be a significant source of error. To minimize trigger feedthrough, reduce the trigger amplitude as much as possible within the trigger sensitivity specifications.
- When measuring extinction ratio on a filtered eye diagram, it is recommended to do the measurement over the middle 20% of the eye. This provides results better aligned with the physical definition of extinction ratio.

To Make Cursor Measurements

The cursors can be used to make custom voltage, power, or time measurements on the signal. Examples of custom measurements include rise time measurements from reference levels other than 10–90%, frequency and width measurements from levels other than 50%, channel-to-channel delay measurements, and amplitude measurements. Refer to Figure 2-18 for an example of a custom measurement.

1. Connect a signal to the analyzer and obtain a stable display.
2. Select the cursor functions by pressing:

Cursors/Masks

Cursors **Masks** Cursors

Several cursor functions are now available.

- **Source Off E1 Op(E2)**

Selects a channel for the cursor measurements.

- **Active Cursor**

There are four cursor choices:

- P1 (V1)** and **P2 (V2)** are power or voltage cursors.
- T1** and **T2** are time cursors.

Use the knob below the **Cursors/Masks** key to move the cursors. To lock the cursors together so they can be moved at the same time, select

P1 P2 **P1 P2** (**V1 V2** **V1 V2**) or **T1 T2** **T1 T2**.

- **Clear Cursors**

Erases the cursor readings and removes the cursors from the display.

To Make Cursor Measurements

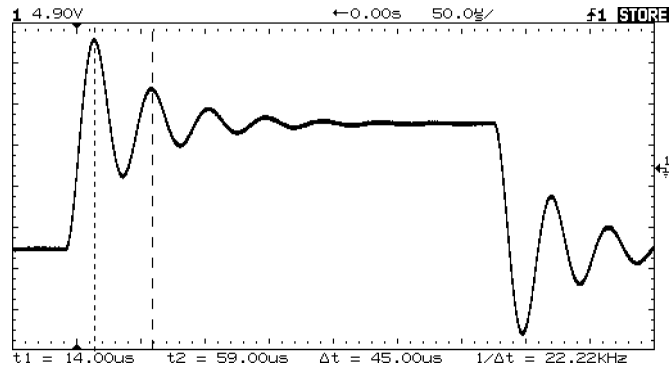


Figure 2-18. Cursors used to measure the frequency of the ringing on a pulse.

To Use Masks and Templates

The analyzer measures signal compliance to several standard defined masks and templates. For a complete list of standard masks and templates available, refer to Chapter 3.

The example below assumes the same setup shown in Figure 2-5. Adjust the horizontal and vertical scales so one complete eye diagram is on the display.

NOTE

The SDH/SONET and Fibre Channel standards require the use of a reference receiver for mask testing. Options 050, 051, and 052 provide, respectively, reference receivers for the 51.84 Mb/s and 155 Mb/s SDH/SONET standards and the 133 MBaud Fibre Channel standard.

1. To select the mask menu functions and set the measurement source, press:

```
Cursors/Masks
Cursors Masks Masks
Source E1 Op(E2) Op
```

2. To specify the test parameters, press:

```
Define Test
```

3. Highlight the appropriate softkey and use the general purpose knob to set:

```
Test for ..... 2 s
Margin ..... 20%
Max Hits ..... 0
```

To Use Masks and Templates

- Set the analyzer to continue on pass and fail by pressing:

```
More 1/2
```

```
On Pass STOP CONT PRINT CONT
```

```
On Fail STOP CONT PRINT CONT
```

- Select the OC3/STM1 mask by pressing:

```
done
```

```
Select Mask
```

```
OC3/STM1
```

```
done
```

- To perform the mask conformance test, press:

```
Do Test
```

The lightwave communications analyzer records and displays the number of hits on:

the standard mask

the margin

the standard mask + the margin = total hits

Figure 2-19 shows an OC-3/STM-1 mask conformance measurement.

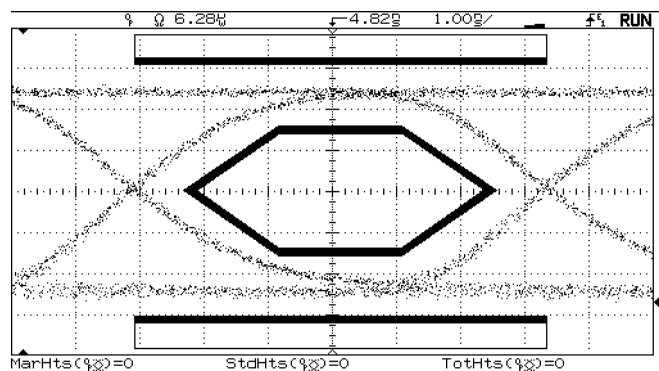


Figure 2-19. An OC-3/STM-1 mask conformance measurement.

7. When the test is finished, set the analyzer so the mask is continuously scaled to the data by pressing:

Show Mask Off Only Once Continuous Continuous

Change the watts/div or time/div settings and observe the effects of the mask scaling function. The speed of this function depends on the number of samples in the histograms which find and calculate the time and amplitude crossing points, and the “1” and “0” levels. The sample values are set in the **(Time)** and **(Power/Voltage)** menus.

To perform a custom mask test

Creating a custom mask requires an external controller and either Option 201 HP-IB interface or Option 202 RS-232 interface. Custom masks can be downloaded to the internal non-volatile memory of the HP 83475B. Once in memory, the mask can be automatically scaled and positioned to the waveform under test and automatic pass/fail testing can be performed.

Refer to the *HP 83475B Programmer's Guide* for information on creating and downloading a custom mask.

Electrical Telecom Pulse Mask Testing

The signal shape for electrically transmitted signals is typically specified in terms of a pulse mask, or template. The pulse template, like an eye-diagram mask, seeks to combine many pulse parameters in a single test. The specified shape is optimized to provide proper circuit operation and to allow for multi-vendor network equipment matching at different network interfaces.

Pulse matching characteristics are defined by industry standards and recommendations such as ITU-T Recommendation G.703, ITU-T Recommendation I.430, ANSI T1.102-1987, the current revision of T1.102-199X, and the T1.403-1988. The ITU-T (formerly CCITT) recommendations refer to what is typically known as the PDH (Plesiochronous Digital Hierarchy) network. These standards are typically used throughout most of the world, with the exception of North America. The ANSI standards deal with the specifications for the North American network.

Though most of the electrical signal masks/templates are for pulse shape specification, some of the masks are for eye-diagram shapes. The electrical side of the Bellcore SONET standard, for the 51.84 Mb/s (STS-1) and 155 Mb/s (STS-3) line rates, specifies both eye diagram and pulse masks to test signal characteristics. The eye-diagram masks are provided for versatility and convenience. An eye-diagram test needs less sophisticated measuring technology because it utilizes the entire signal.

The ANSI T1 and Bellcore standards require that pulse mask testing be performed on isolated “1” pulses. An isolated “1” pulse is a pulse unaffected by intersymbol interference or corrupted by noise. In most cases, due to line coding constraints, an ideal isolated pulse can only be approximated. Typically, an isolated pulse is approximated by a pulse that is preceded and followed by zero states.

When testing live traffic, the HP 83475B does not have the capability to trigger or find an isolated “1” pulse. In effect, in order to perform a pulse mask test, the HP 83475B requires a set of conditions. The conditions are geared to provide a stable sequence of pulses from which an isolated “1” can be identified.

Electrical interfaces

Data transmission through electrical media is typically accomplished through either twisted-pair or coaxial cable. The twisted-pair cables typically have impedances of 100, 110, or 120 ohms, while the coaxial cables have an impedance of 75 ohms. When doing a pulse mask test, these impedances must be interfaced with the analyzer input.

When interfacing a symmetrical or twisted-pair port to the HP 83475B, a wideband 100Ω twisted-pair to 50Ω BNC transformer provides the greatest versatility. The transformer twisted-pair leads can be soldered to any twisted-pair cable assembly to configure a test probe.

When interfacing a 75Ω test port to the HP 83475B input, two options are available:

- Set the input impedance of the HP 83475B to 50Ω and use a 75Ω to 50Ω minimum loss pad

- or

- Set the input impedance to $1\text{ M}\Omega$ and use a 75Ω feedthrough termination.

When using a minimum loss matching pad, or a wide band transformer, at the HP 83475B electrical input, the vertical scale can be corrected for the external attenuation. This is useful when measurements of pulse amplitude are desired or when a fixed amplitude, PDH pulse mask test is being performed for the E1, E2, E3 and E4 line rates. The correction is similar to the probe correction feature available in many digital sampling oscilloscopes. If, for example, a 3 dB matching pad is being used at the input, the 3 dB correction can be entered and the voltage vertical scale is multiplied by 1.414. The displayed voltage is then the voltage at the input of the matching pad.

To make electrical pulse mask tests

1. To select the mask menu functions and set the measurement source, press:

```

Cursors/Masks
Cursors Masks Masks
Source E1 Op(E2) E1

```

2. The signal under analysis must be repetitive. For example, the signal could be a repeating PRBS, a repeating section of an SDH/SONET frame, an all “1”s AMI pattern, or just a repetitive NRZ “1010” sequence.
3. A trigger signal must be available. Two conditions are possible for a trigger, depending on the waveform under analysis, which provide a stable sequence of pulses:
 - a. If the signal under analysis provides a rising or falling edge at a fixed rate, that is, an NRZ “1010” sequence, the instrument can be triggered from the data. In other words, the internal channel trigger can be used to obtain a stable sequence of pulses.
 - b. If the waveform under analysis is a repeating long pattern, for example, a repeating 2^{23} PRBS pattern, a trigger signal must be obtained which is synchronized with the repetition rate of the pattern and this signal must be used as the input to the HP 83475B external trigger channel. For example, if a 128 bit pattern is the data under analysis, a trigger signal that repeats every 128 bits, or a multiple of this, must be used as the external trigger.
4. Once a stable trigger is acquired, and a stable sequence of bits is shown on the display, the horizontal time/div and the delay must be adjusted to obtain the pulse to which the pulse mask is to be scaled.

With the desired pulse centered on the display, the pulse mask test can be performed using the following procedure:

5. To correct external attenuation at the input of channel 1 or 2 press:

```

(Elec1) or (Optical/Elec2)
More 1/2
Probe/Attn

```

6. Use the general-purpose knob to dial in the external attenuation.
7. To specify the test parameters, press:

Define Test

8. Highlight the appropriate softkey and use the general purpose knob to set:

Test for 2 s
Margin 10%
Max Hits 0

9. Activate the mask placement best fit algorithm by pressing:

Best Fit Off On On

The best fit algorithm will optimize the mask placement on the waveform. This decreases test throughput but can increase test accuracy.

10. Set the analyzer to continue on pass and fail by pressing:

More 1/2
On Pass STOP CONT PRINT CONT
On Fail STOP CONT PRINT CONT

11. Select the E1 75Ω pulse mask by pressing:

done
Select Mask
More 1/6
More 2/6
More 3/6
E1(75Ω)
done

12. To perform the pulse mask conformance test, press:

Do Test

Electrical Telecom Pulse Mask Testing

The lightwave communications analyzer records and displays the number of hits on:

- the standard mask
- the margin
- the standard mask + the margin = total hits

Figure 2-19 shows an E1 (75 Ω) pulse mask conformance measurement.

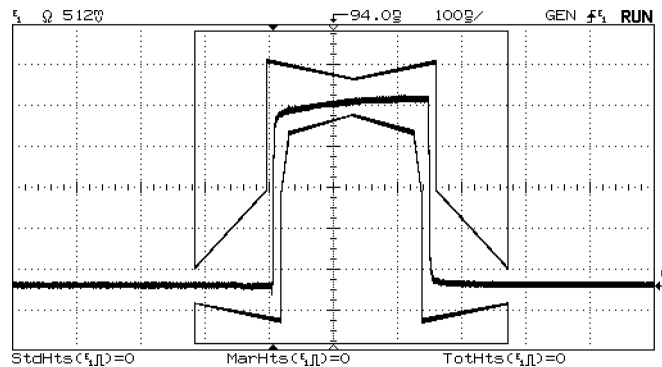


Figure 2-20. An E1 (75 Ω) pulse mask conformance measurement.

13. When the test is finished, set the analyzer so the mask is continuously scaled to the data by pressing:

Show Mask Off Only Once Continuous Continuous

14. Change the volts/div or time/div settings and observe the effects of the mask scaling function.

To Use Delayed Sweep

Delayed sweep is a magnified portion of the main sweep. Use delayed sweep to locate and horizontally expand part of the main sweep for a more detailed (high resolution) analysis of signals. The following steps show you how to use delayed sweep.

NOTE

Delayed sweep is *only* available in general waveform measurement mode. An error message will be displayed if you try to select:

Power/Voltage or **Time**

Meas Type Gen1 Wvfm Eye:NRZ Eye:NRZ

when using delayed sweep.

1. Connect a signal to the analyzer and obtain a stable display.
2. Press **Main/Delayed**.
3. Press the **Delayed** softkey.

The top half of the screen displays the main sweep, and the bottom half displays an expanded portion of the main sweep. The expanded portion of the main sweep is called the delayed sweep. The top half also has two solid vertical lines called markers. The markers show the portion of the main sweep expanded in the lower half of the display. The size and position of the delayed sweep are controlled by the Time/Div and Delay knobs. The Time/Div, next to the waveform symbol, is the delayed sweep in sec/div. The delay value is displayed for a short time at the bottom of the display.

To Use Delayed Sweep

4. To change the main sweep Time/Div, you must turn off the delayed sweep.

Since both the main and delayed sweeps are displayed, there are half as many vertical divisions so the vertical scaling is doubled. Notice the changes in the status line.

5. To display the delay time of the delayed sweep, press **Main/Delayed** or turn the delay knob. The delay value is displayed near the bottom of the display.

6. Set the time reference to either:

Time Ref Lft Cntr Lft

or

Time Ref Lft Cntr Cntr

Figure 2-21 shows the time reference set to left. The operation is like the delayed sweep of an analog oscilloscope, where the delay time defines the start of the delayed sweep.

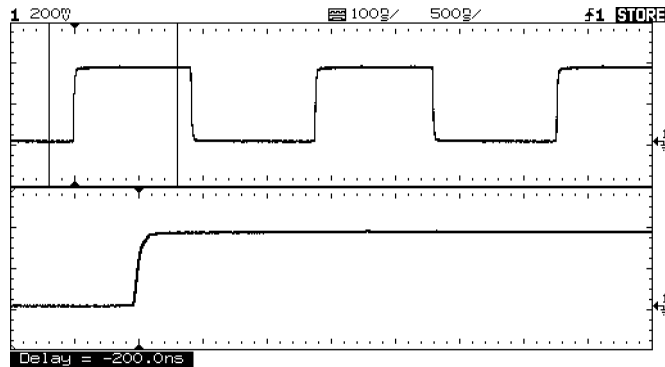


Figure 2-21. Time reference set to left.

Figure 2-22 shows the time reference set to center. Notice the markers expand around the area of interest. You can place the markers over the area of interest with the delay knob, then expand the delayed sweep with the time base knob to increase the resolution.

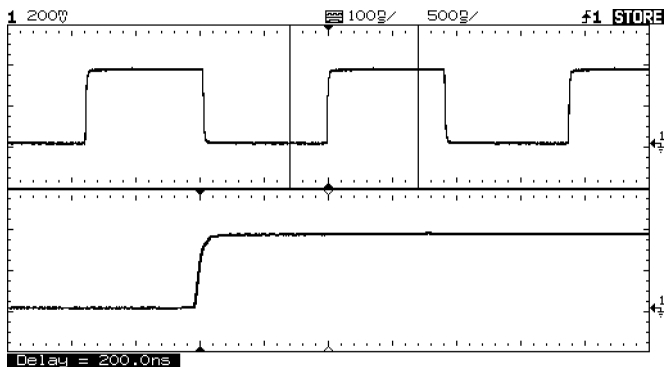


Figure 2-22. Time reference set to center.

To Use Storage Analyzer Operation

There are four front-panel storage keys. They are white instant action keys that change the operating mode of the analyzer. The following steps demonstrate how to use these storage keys.

1. Connect a signal to the analyzer and obtain a stable display.
2. Press **Autostore**.

Notice that **STORE** replaces **RUN** in the status line.

For easy viewing, the stored waveform is displayed in half bright and the most recent trace is displayed in full bright. Autostore is useful in a number of applications.

- Displaying the worst-case extremes of varying waveforms
 - Capturing and storing a waveform
 - Measuring peak-to-peak noise and jitter
 - Capturing events that occur infrequently
3. Using the position knob in the Vertical section of the front panel, move the trace up and down about one division.

Notice the last acquired waveform is in full bright and the previously acquired waveforms are displayed in half bright.

4. To characterize the waveforms, use the cursors. Refer to “To Make Cursor Measurements”.
5. To exit the Autostore mode, press either **Run** or **Autostore**.
6. To clear the display, press **Erase**.

Summary of storage keys

Run	The analyzer acquires data and displays the most recent trace.
Stop	The display is frozen.
Autostore	The analyzer acquires data, displaying the most recent trace in full bright and previously acquired waveforms in half bright.
Erase	Clears the display.

To Save and Recall Traces

The analyzer has two pixel memories for storing waveforms. The following exercise guides you through storing and recalling waveforms from pixel memories.

1. Connect a signal to the analyzer and obtain a stable display.
2. Press **Trace**. A softkey menu appears with five softkey selections. Four of the softkeys are trace memory functions.
3. Toggle the **Trace Mem1 Mem2** softkey to select memory 1 or memory 2.
4. Press the **Save To Mem1 (Mem2)** softkey. The current display is saved to the selected memory location.
5. Turn on the **Trace Mem1 (Mem2)** softkey to view the stored waveform. The trace is recalled from the selected trace memory location and displayed in half-bright video.

The automatic measurement functions do not operate on stored traces. Remember, the stored waveforms are pictorial information rather than stored data.

- If you have not changed the analyzer setup, use the cursors to make the measurements.
- If you have changed the analyzer setup, press:

Recall Setup1 (2)

Then, use the cursors to make the measurements.

Trace memory operating hint

The standard analyzer has volatile trace memories. When you add an interface module to the analyzer (Options 201 and 202), the trace memories become nonvolatile.

To Save and Recall Front-Panel Setups

There are sixteen memories for storing front-panel setups. Saving front-panel setups can save you time in situations where several setups are repeated many times.

1. To save and recall front-panel setups, press:

Setup

2. To change the selected memory location, press either the left-most softkey or turn the knob closest to the **Cursors/Masks** key.
3. To save a front-panel setup, press:

Save

4. To recall a front-panel setup, press:

Recall

To Create a Label

There are sixteen memories for storing front-panel setups. Each setup can be identified by a unique label.

1. To create a label for a user-defined setup, press:

Setup
Edit Label

A list of alphanumeric characters is displayed.

2. Use the general purpose knob to select the first character of the label, then press:

Enter

3. Continue selecting characters (eight characters, maximum) for your label.
4. When you have finished entering characters for your label, press:

Done Edit

To Reduce Random Noise on a Signal

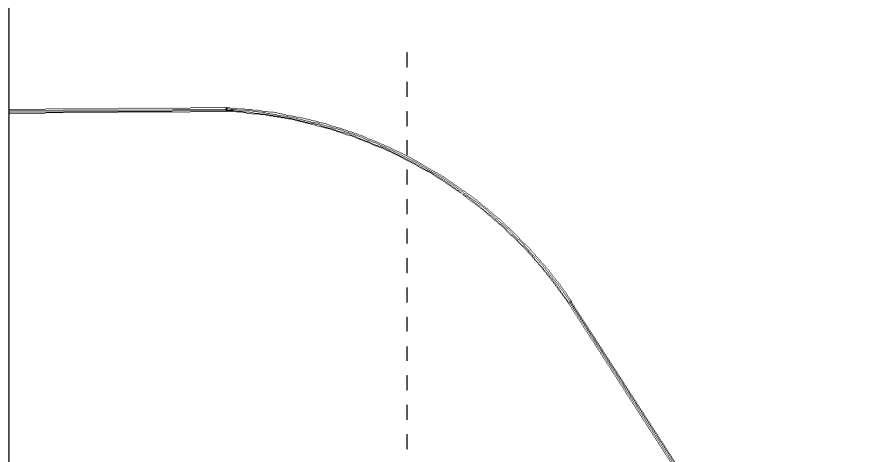
If the signal being applied to the analyzer is noisy (Figure 2-25), you can set up the analyzer to reduce the noise on the waveform (Figure 2-26).

1. Connect a signal to the analyzer and obtain a stable display.
2. Remove the noise from the trigger path by turning on either high frequency reject or noise reject by pressing:

Slope/Coupling

LF (or **HF**)

High frequency reject (**HF**) adds a low pass filter with the 3 dB point at 50 kHz (see Figure 2-23). Use HF reject to remove high frequency noise such as AM or FM broadcast stations from the trigger path.

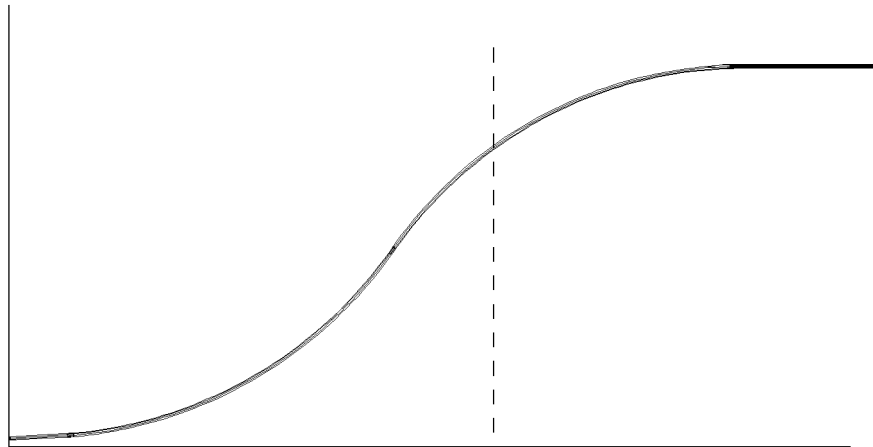


54600W02

Figure 2-23. HF reject.

To Reduce Random Noise on a Signal

Low frequency reject, **LF**, adds a high pass filter with the 3 dB point at 50 kHz (see Figure 2-24). Use low frequency reject to remove low frequency signals such as power line noise from the trigger path.



54600W03

Figure 2-24. LF reject.

3. The Noise Rejection function can also be activated by pressing:

Noise Rej Off On On

Noise reject increases the trigger hysteresis band. Increase the trigger hysteresis band to reduce the possibility of triggering on noise. However, this also decreases the trigger sensitivity so a slightly larger signal is required to trigger the analyzer.

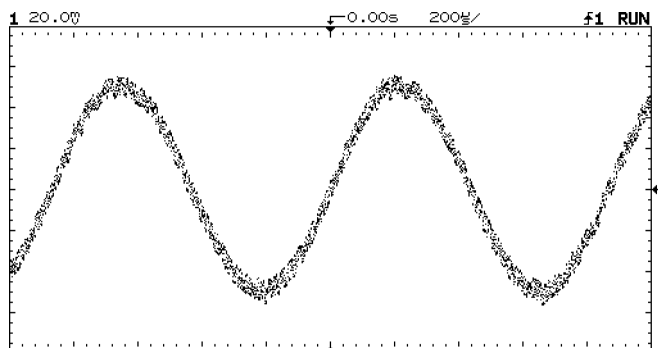


Figure 2-25. Random noise on the displayed waveform.

Using averaging

- To use averaging to reduce noise, press:

Display

Average

Notice **Av** appears in the status line.

- Toggle the **# Average** softkey to select the number of averages that best eliminates the noise from the displayed waveform.

To Reduce Random Noise on a Signal

The **Av** letters in the status line indicate how much of the averaging process is finished by turning to inverse video as the analyzer performs averaging. The higher the number of averages, the more noise that is removed from the display. However, the higher the number of averages, the slower the displayed waveform responds to waveform changes. You need to choose between how quickly the waveform responds to changes and how much noise there is on the signal.

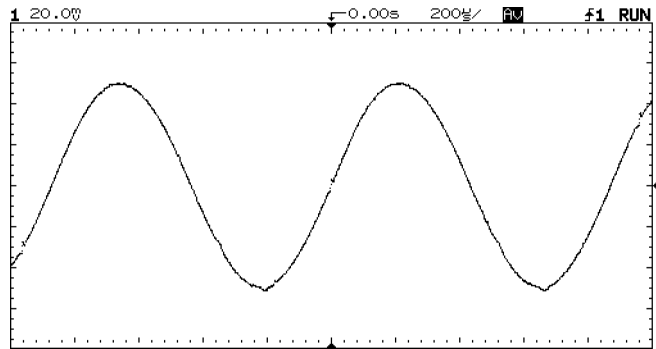


Figure 2-26. On this waveform, 256 averages were used to reduce the noise.

To Remove Cabling Errors From Time Interval Measurements

When measuring time intervals in the nanosecond range, small differences in cable length can totally obscure the measurement. The following exercise shows how to remove errors that different cable lengths or characteristics introduce into the measurement. The Skew control makes it possible to remove this offset error from the measurement.

1. With the Graticule turned on, press:

Main/Delayed
Time Ref Left Cntr Cntr

2. Connect the channels to be nulled to a common test point and obtain a stable display. A fast edge is a good choice.
3. To access the calibration and skew adjustments, press:

Print/Utility
Self Cal Menu

4. To adjust channel 2 with respect to channel 1, press:

Skew1 →2

Use the knob to bring the channels into time alignment.

5. To adjust the external trigger with respect to channel 1, press:

Skew1 →E

Use the knob to bring these channels into time alignment.

NOTE

This adjustment is not affected by pressing **Autoscale**. Only the default setup will return the skew values to zero seconds.

To View Asynchronous Noise on a Signal

The following exercise shows how to use the analyzer to characterize the asynchronous noise on a signal.

1. Connect a noisy signal to the analyzer and obtain a stable display.

Figure 2-27 shows a waveform with asynchronous noise at the top of the pulse.

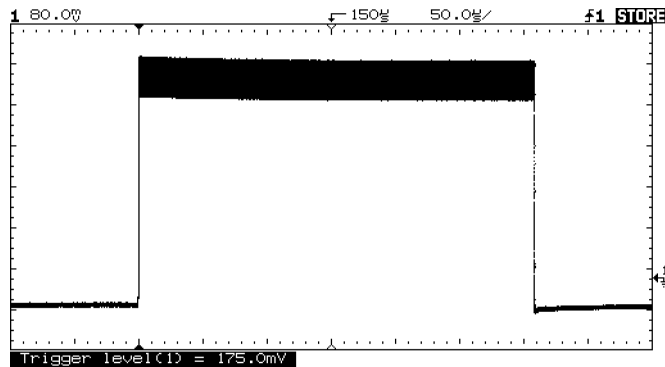


Figure 2-27. Asynchronous noise at the top of the pulse.

2. Press **Autostore**. Notice that STORE is displayed in the status line.
3. To set the trigger mode to normal, press:

Mode

Normal

Then adjust the trigger level into the noise region of the signal.

4. Decrease the sweep speed for better resolution of the asynchronous noise.
Use the cursors to characterize the asynchronous noise signal.

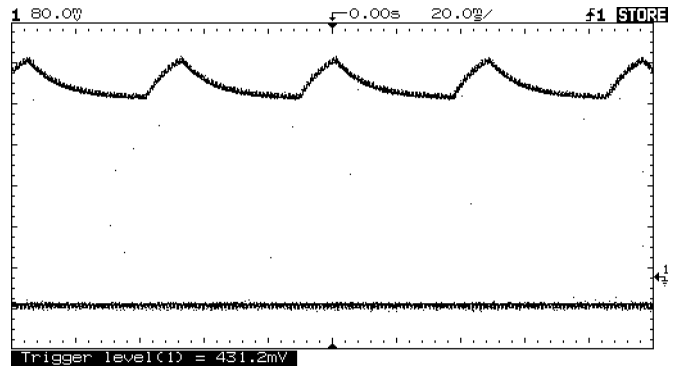


Figure 2-28. A triggered view of the asynchronous noise shown in Figure 2-25.

To Capture Glitches or Narrow Pulses

A glitch is a rapid change that is narrow compared to the waveform. This analyzer has two modes of operation you can use for glitch capture: peak detect and Autostore.

1. Connect a signal to the analyzer and obtain a stable display.
2. Find the glitch. Use peak detect for narrow pulses or glitches that require sweep speeds slower than 50 ms/div.
3. To select peak detect, press:

Display
Peak Det

Peak detect operates at sweep speeds from 5 s/div to 50 ms/div.

When operating, the initials **Pk** are displayed in the status line in inverse video. At sweep speeds faster than $\mu\text{s}/\text{div}$, the **Pk** initials are displayed in normal video, which indicates that peak detect is not operating.

Use Autostore for the following cases:

- waveforms that are changing
- waveforms you want to view and compare with stored waveforms
- narrow pulses or glitches that occur infrequently but require the use of sweep speeds outside the range of peak detect

4. Press **Autostore**.

Peak detect and Autostore can be used together. Peak detect will capture the glitch, and Autostore will retain the glitch on the display in half-bright video.

5. Characterize the glitch with delayed sweep. Peak detect functions in the main sweep only, not in the delayed sweep. To characterize the glitch with delayed sweep, press:

Main/Delayed
Delayed

6. Expand the time base to obtain a better resolution of the glitch.

7. Use the Delay knob to set the expanded portion of the main sweep over the glitch.
8. Use the cursors or the automatic measurement capabilities of the analyzer to characterize the glitch.

To Trigger on a Complex Waveform

The difficulty in viewing a complex waveform is triggering on the signal. Figure 2-29 shows a complex waveform that is not synchronized with the trigger.

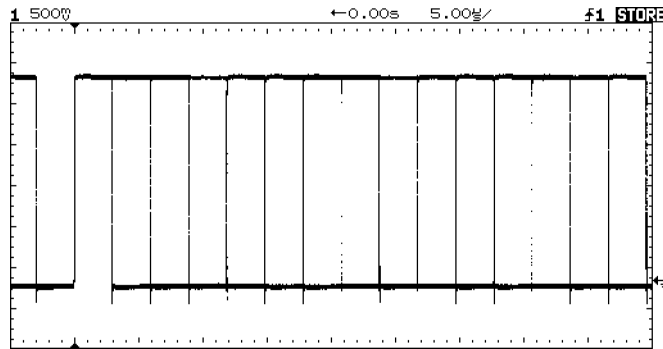


Figure 2-29. Stable trigger, but the waveform is not synchronized with the trigger.

The simplest trigger method is to trigger the analyzer on a sync pulse that is associated with the waveform. Refer to “To Trigger the Analyzer” in Chapter 1. If there is no sync pulse, use the following procedure to trigger on a periodic complex waveform.

1. Connect a signal to the analyzer.
2. Set the trigger level to the middle of the waveform.
3. Adjust the Holdoff knob to synchronize the trigger of the analyzer with the complex waveform. By setting the Holdoff to synchronize the trigger, the analyzer ignores the trigger that results in Figure 2-29 and waits for the trigger that results in Figure 2-30. Also notice, in Figure 2-29, the trigger is stable but the waveform is not synchronized with the trigger.

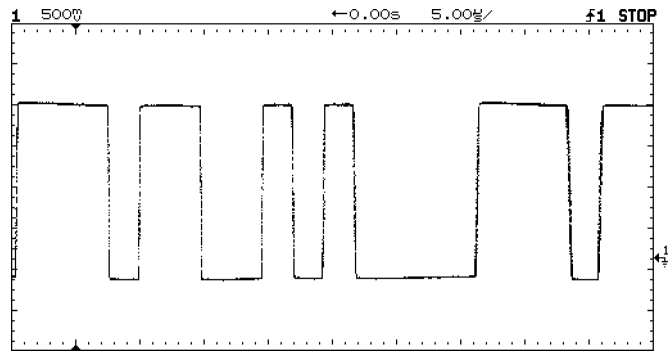


Figure 2-30. Holdoff synchronizes the waveform with the trigger.

Holdoff operating hints

1. The advantage of digital holdoff is that it is a fixed number. As a result, changing the time base settings does not affect the holdoff number; so the analyzer remains triggered.
2. The rate of change of the holdoff adjustment knob depends on the time base setting selected. If a lengthy holdoff setting is needed, increase the time/div setting on the time base, then make the coarse holdoff adjustment. Switch back to the original time/div setting and make the fine adjustment to set the exact amount of holdoff required.

To Capture a Single Event

To capture a single event, you need some knowledge of the signal in order to set up the trigger level and slope. For example, if the event is derived from TTL logic, a trigger level of 2 volts should work on a rising edge. The following steps show you how to use the analyzer to capture a single event.

1. Connect a signal to the analyzer.
2. Set up the trigger.
3. Press **(Source)**. Select a trigger source with the softkeys.
4. Press **(Slope/Coupling)**. Select a trigger slope with the softkeys.
5. Turn the Level knob to a point where you think the trigger should work.
6. To change to single mode, press:

(Mode)
Single

7. To clear previous measurements from the display, press:

(Erase)

8. To arm the trigger circuit, press:

(Run)

When the trigger conditions are met, data appears on the display representing the data points that the analyzer obtained with one acquisition. Pressing the **(Run)** key again rearms the trigger circuit and erases the display.

9. To compare several single-shot events, press:

(Autostore)

Like the **(Run)** key, the **(Autostore)** key also arms the trigger circuit. When the trigger conditions are met, the analyzer triggers. Pressing the **(Autostore)** key again rearms the trigger circuit without erasing the display. All the data points are retained on the display in half bright with each trigger allowing you to easily compare a series of single-shot events.

After you have acquired a single-shot event, pressing a front-panel key, softkey, or changing a knob can erase the event from the display. If you press the **(Stop)** key, the analyzer will recover the event and restore the analyzer settings.

10. To clear the display, press:

(Erase)

11. To exit the Autostore mode, press:

(Run) or **(Autostore)**

Notice that **RUN** replaces **STORE** in the status line, indicating the analyzer has exited the Autostore mode.

Operating hint

The single-shot bandwidth is 2 MHz for single-channel operation, and 1 MHz for two-channel operation. There are twice as many sample points per waveform on the one-channel acquisition than on the two-channel acquisition.

To Use the XY Display Mode

The XY display mode converts the display from volts versus time to volts versus volts. You can use various transducers so strain versus displacement, flow versus pressure, volts versus current, or voltage versus frequency may be displayed. When using the optical input, optical watts versus volts are displayed. This feature can be used to characterize laser output power versus bias current.

This exercise shows a common use of the XY display mode by measuring the phase shift between two signals of the same frequency using the Lissajous method.

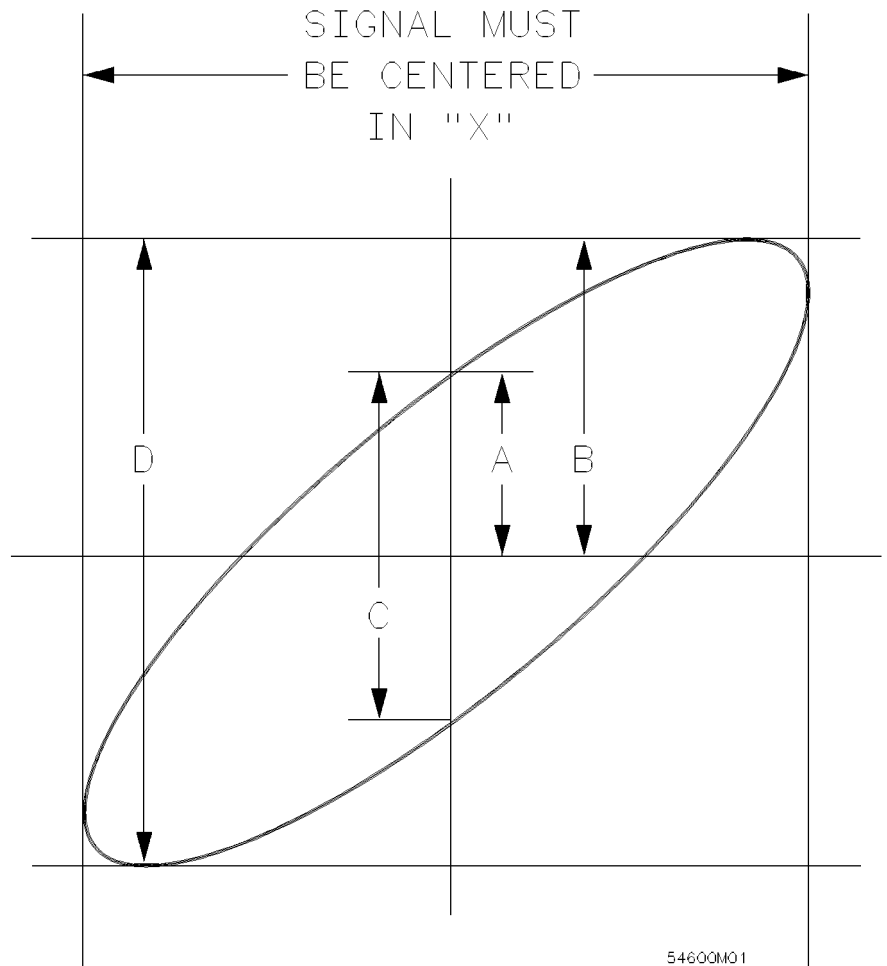
1. Connect a signal to channel 1 and a signal of the same frequency, but out of phase, to channel 2.
2. Press **Autoscale**.
3. Press:

Main/Delayed

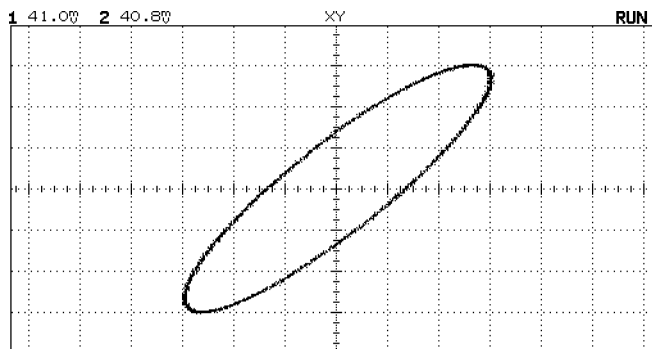
XY

4. Center the signal on the display with the Position knobs, and use the Volts/Div (Watts/Div) knob and the vertical **Vernier** softkeys to expand the signal for convenient viewing.

$$\sin \theta = \frac{A}{B} \text{ or } \frac{C}{B}$$



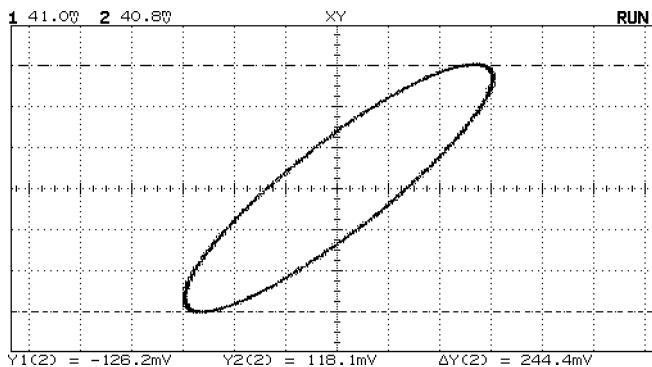
To Use the XY Display Mode



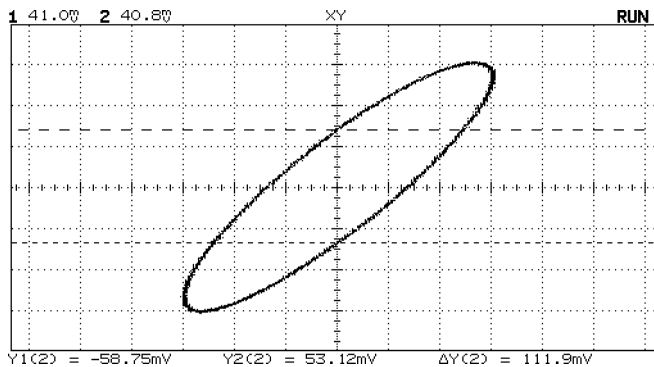
5. Press **Cursors**.

6. Set the Y2 cursor to the top of the signal, and set Y1 to the bottom of the signal.

Note the ΔY value at the bottom of the display. In this example we are using the Y cursors. If you use the X cursors, make sure the signal is centered in the Y axis.



7. Move the Y1 and Y2 cursors to the center of the signal. Again, note the ΔY value.



8. Calculate the phase difference using the formula below.

$$\sin \Theta = \frac{\text{second } \Delta Y}{\text{first } \Delta Y} = \frac{111.9}{244.4} = 27.25 \text{ degrees of phase shift}$$

Making Measurements
To Use the XY Display Mode

NOTE

The XY display mode is *not* available when Meas Type Gen Wvfm Eye:NRZ Eye:NRZ is selected.

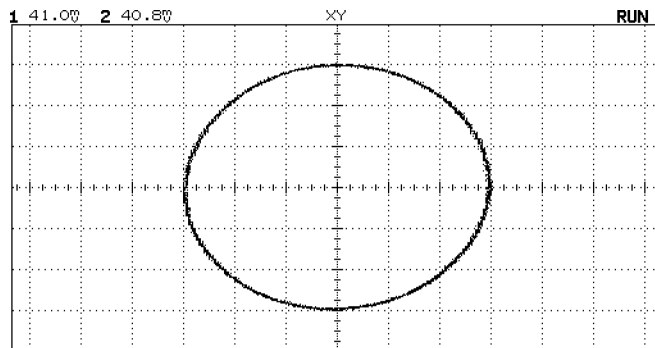


Figure 2-31. Signals are 90° out of phase.

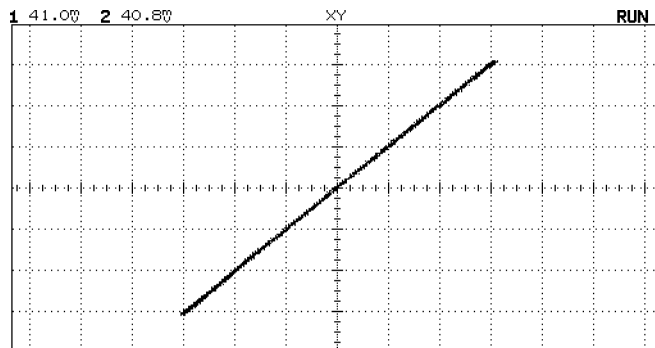


Figure 2-32. Signals are in phase.

XY display mode operating hint

When you select the XY display mode, the time base is turned off. Channel 1 is the X-axis input, channel 2 is the Y-axis input, and the external trigger in the HP 83475B is the Z-axis input. If you only want to see portions of the Y versus X display, use the Z-axis input. Z-axis turns on and off the trace. When Z is low (<1.3 V), Y versus X is displayed; when Z is high (>1.3 V), the trace is turned off.

To Make Set-up and Hold-time Measurements

One method of testing a device for its setup and hold times limits uses a variable pulse generator to provide the time varying pulses, and an analyzer to monitor when the setup and hold times are violated. Selecting the trigger for this measurement is important. The clock is not a good choice for a trigger because it is not unique. Triggering on the Q output results in loss of trigger when the setup and hold time is violated. Triggering on the D input is the best choice. In this example, the flip-flop is clocked on the rising edge.

1. Set time skew to remove errors introduced by different cables for this time interval measurement.
2. Connect the D input of the flip-flop to the External Trigger on your analyzer. Set the analyzer to trigger on the rising edge.
3. Connect the flip-flop's clock signal to channel 1.
4. Connect the Q output to channel 2 of the analyzer.
5. Press **Autoscale**, then turn on the External Trigger so that can be viewed.
6. Use the time cursors to measure the difference between the rising edge of the clock and the D input to determine setup and hold time.

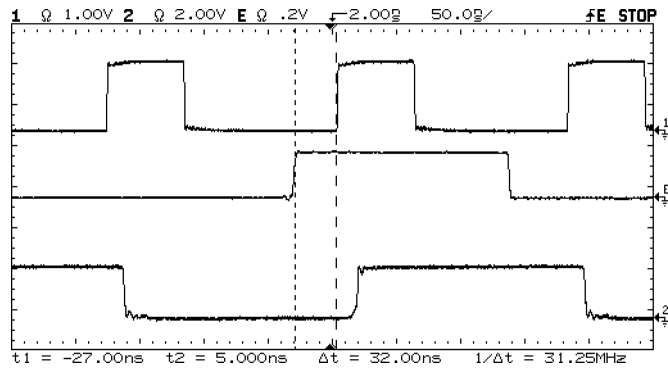


Figure 2-33. Setup time measurement.

In Figure 2-33 displayed above:

- Channel 1 = clock
- Channel 2 = Q output
- External Trigger = D input

To Analyze Video Waveforms

The TV sync separator in the analyzer has an internal clamp circuit. This removes the need for external clamping when you are viewing unclamped video signals. TV triggering requires two vertical divisions of display, either channel 1 or channel 2 as the trigger source, and the selection of internal trigger.

Turning the trigger level knob, in TV trigger, does not change the trigger level because the trigger level is automatically set to the sync pulse tips.

For this exercise, connect the analyzer to the video output terminals on a television. Then set up the analyzer to trigger on the start of Frame 2. Use the delayed sweep to window in on the vertical interval test signals (VITS), which are in Line 18 for most video standards (NTSC, PAL, SECAM).

1. Connect a TV signal to channel 1, then press:

Autoscale
Display
Peak Det

2. To change to TV mode, press:

Mode
TV

3. Press **Slope/Coupling**.

Polarity	Selects either positive or negative sync pulses.
Field 1	Triggers on the field 1 portion of the video signal.
Field 2	Triggers on the field 2 portion of the video signal.
Line	Triggers on all the TV line sync pulses.
HF Rej	Controls a 500 kHz low pass filter in the trigger path.

4. Press the **Field 2** softkey.
5. Set the time base to 200 $\mu\text{s}/\text{div}$, then center the signal on the display with the delay knob (delay about 800 μs).

6. Press **Main/Delayed**.
7. Press the **Delayed** softkey.
8. Set the delayed sweep to $20\ \mu\text{s}/\text{div}$, then set the expanded portion over the VITS (delay about $988.8\ \mu\text{s}$).

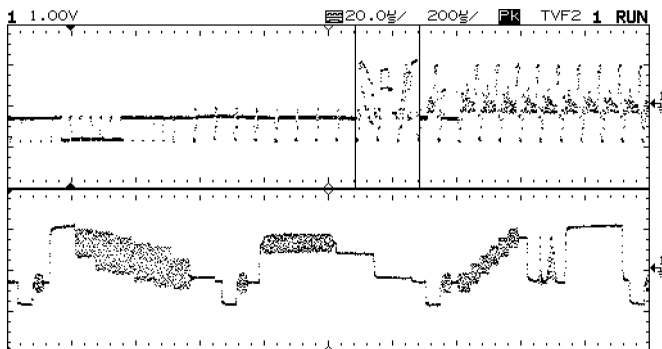


Figure 2-34. Frame 2 windowed on the VITS in Line 18.

9. Press **Main/Delayed**, then press the **Main** softkey.
10. Use the horizontal vernier to change the time base to $7\ \mu\text{s}/\text{div}$, then center the signal on the display with the delay knob (delay about $989\ \mu\text{s}$).

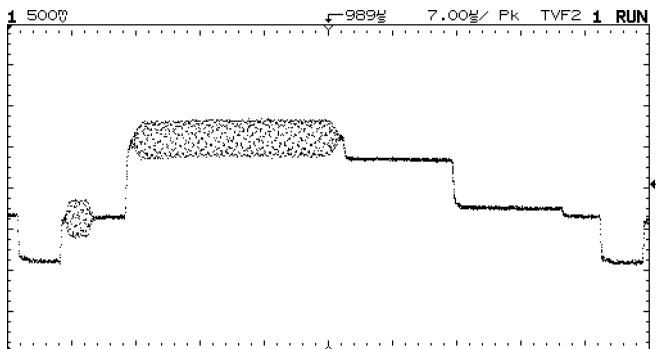


Figure 2-35. Full screen display of the IRE.

Delay in TV line units hint

The analyzer has the ability to display delay in TV-line units. Using the TV field trigger mode activates this line-counting feature. When Field 1 or Field 2 is selected as the trigger source, delay can be set in terms of time or line number.

Both-fields triggering in the HP 83475B hint

The analyzer can trigger on the vertical sync pulse in both TV fields at the same time. This allows you to view noninterlaced video signals which are common in computer monitors. To trigger on both sync pulses, press Field 1 and Field 2 at the same time.

TV trigger operating hints

The color burst changes phase between odd (Fields 1 and 3) and even (Fields 2 and 4). It looks double-triggered. Increase the holdoff to greater than the frame width to fine tune your trigger stability. For example, use a holdoff value of around 63 ms for NTSC, and around 76 ms for PAL.

When looking at live video (usually a field), use peak detect to improve the appearance of the display.

When making cursor measurements, use Autostore since you are usually looking for pulse flatness and extremes.

When using line trigger, use minimum holdoff to display all the lines. Due to the relationship between the horizontal and vertical sync frequencies the display looks like it is untriggered, but it is very useful for TV waveform analysis and adjustment because all of the lines are displayed.

Performance
Characteristics and
Regulatory Information

Performance Characteristics and Regulatory Information

Performance Characteristics

The performance characteristics describe the performance capabilities of the HP 83475B lightwave communications analyzer. Some of the characteristics are marked as tested. These are guaranteed performance characteristics and can be verified with performance tests. Unless noted, performance characteristics are given at the calibration temperature $\pm 10^{\circ}\text{C}$.

Vertical system

Optical Input Channel¹Bandwidth²: dc to 500 MHz –3 dBOptical input: 62.5/125 μm fiber

Calibrated wavelengths:

780 nm, 1310 nm, 1550 nm³(Actual calibration may be at ± 20 nm from the specified wavelengths)Vertical power scale accuracy⁴:

Range:

2 $\mu\text{W}/\text{div}$ to 50 $\mu\text{W}/\text{div}$ at 1310/1550 nm20 $\mu\text{W}/\text{div}$ to 500 $\mu\text{W}/\text{div}$ at 780 nm

1 cursor:

at 1310/1550 nm^{1, 2, 5, 7}: $\pm 7.5\%$ ($\pm 4.7\%$ typical)at 780 nm⁷: $\pm 4.9\%$

2 cursor:

at 1310/1550 nm^{1, 2, 6, 7}: $\pm 6.5\%$ ($\pm 3.7\%$ typical)at 780 nm⁷: $\pm 4.1\%$ Optical return loss²: 27 dB (30 dB typical)

Noise (rms):

at 1310/1550 nm:

0.80 μW (≤ 20 $\mu\text{W}/\text{div}$)2.0 μW (> 20 $\mu\text{W}/\text{div}$)

at 780 nm

8.0 μW (≤ 200 $\mu\text{W}/\text{div}$)15.0 μW (> 200 $\mu\text{W}/\text{div}$)

Optical attenuation correction:

Automatic readout from 0 to 20 dB attenuation

Damage input power level: +4 dBm (2.5 mW)

1 When temperature is at $23 \pm 5^\circ\text{C}$.

2 Tested characteristic.

3 Functionality available for up to three user calibrations. Refer to Chapter 5.

4 Does not include optical input connector repeatability.

5 Use a full scale of 48 μW for less than 6 $\mu\text{W}/\text{div}$ range and $\pm 0.5\%$ of position value.

6 Use a full scale of 48 μW for less than 6 $\mu\text{W}/\text{div}$ range.

7 As a % of full scale.

Optical Power Meter^{1, 5}

Accuracy²:

780 nm: $<\pm 4.1\%$ of reading

1310 nm³: $<\pm 6.0\%$ of reading ($\pm 2.5\%$ typical)

1550 nm³: $<\pm 6.0\%$ of reading ($\pm 2.5\%$ typical)

Dynamic range⁴:

780 nm: -10 dBm to 0 dBm

1310 nm: -24 dBm to -3 dBm

1550 nm: -24 dBm to -3 dBm

1 When temperature is at $23\pm 5^{\circ}\text{C}$ measured using a $50\ \mu\text{m}$ fiber with an HMS-10 diamond connector.

2 Does not include optical input connector repeatability.

3 Tested characteristic.

4 Higher power levels can be measured if user calibrations are performed with a higher power source.

5 Measured using a $50/125\ \mu\text{m}$ fiber with an HMS-10 diamond connector.

**Electrical Channels
1 and 2**

Bandwidth¹:

dc to 500 MHz -3 dB

ac coupled, 10 Hz to 500 MHz -3 dB

Rise time: 700 ps (calculated)

Dynamic range: ± 12 divisions

Math functions: Channel 1 + or $-$ Channel 2

Input resistance: 1 M Ω or 50 Ω selectable

Input capacitance: ≈ 8 pf

Maximum input voltage:

250 V (dc + peak ac) into 1 M Ω

5 Vrms into 50 Ω

Upper bandwidth reduced 2 MHz/ $^{\circ}$ C above 35 $^{\circ}$ C

¹ Tested characteristic.

Performance Characteristics and Regulatory Information

Channels 1 and 2, continued

Range: 2 mV/div to 5 V/div

Accuracy^{1, 2}: $\pm 2.0\%$ of reading

Verniers¹: Fully calibrated, accuracy $\pm 2.0\%$ of reading

Cursor accuracy^{1, 2, 3}:

Single cursor accuracy:

vertical accuracy $\pm 1.2\%$ of full scale $\pm 0.5\%$ of position value

Dual cursor accuracy:

vertical accuracy $\pm 0.4\%$ of full scale

Bandwidth limit: ≈ 30 MHz

Coupling: Ground, ac, and dc

Inversion: Channel 1 and channel 2

CMRR (common mode rejection ratio): ≈ 20 dB at 50 MHz

Probe Correction: Readout of 1 \times , 10 \times and 100 \times probe correction

External Attenuation Correction:

Readout of external attenuation correction up to 40 dB or 100 \times linear ratio

1 When temperature is within $\pm 10^\circ\text{C}$ from the calibration temperature.

2 Tested characteristic.

3 Use a full scale of 40 mV for < 5 mV/div ranges.

Horizontal system

Sweep speeds: 5 s/div to 1 ns/div main and delayed

Accuracy: $\pm 0.01\%$ of reading

Vernier (Both main and delayed sweep):

Accuracy $\pm 0.05\%$ of reading

Horizontal resolution: 25 ps

Cursor accuracy (Δt and $1/\Delta t$)¹:

$\pm 0.01\% \pm 0.2\%$ of full scale ± 200 ps

Delay jitter: 10 ppm

Pretrigger delay (negative time): ≥ 10 divisions

Posttrigger delay (from trigger point to start of sweep):

The greater of 2560 divisions or 50 ms, but not to exceed 100 s

Delayed sweep operation:

From 2 times up to 200 times main sweep

Delayed sweep can be as fast as 1 ns/div but must be at least 2 times main sweep.

Horizontal modes: Main, Delayed (Alt), X-Y, and Roll

¹ Tested characteristic.

Trigger system

Sources

Channels 1, 2, line, and external

Internal trigger

Sensitivity¹:

dc to 25 MHz 0.35 div or 3.5 mV

dc to 500 MHz 1 div or 10 mV

Coupling: ac, dc, LF reject, HF reject, and noise reject

LF reject attenuates signals below 50 kHz

HF reject attenuates signals above 50 kHz

Modes: Auto, Autolevel, Normal, Single, and TV

TV triggering: Available on channels 1 and 2

TV line and field: 0.5 division of composite sync for stable display

Holdoff: Adjustable from 200 ns to ≈ 13 s

¹ Tested characteristic.

External trigger

Range:

± 18 V when used with electrical channel 1 or 2
500 mV pk-to-pk when used for the optical input channel

Sensitivity¹:

dc to 100 MHz: <75 mV
dc to 500 MHz: <150 mV

Trigger View:

External trigger input is displayed along with channel 1 and channel 2

Trigger View Bandwidth: ≥ 300 MHz

Coupling: ac, dc, LF reject, HF reject, and noise reject

Input resistance: 1 M Ω or 50 Ω

Input capacitance: ≈ 12 pf

Maximum safe input voltage:

250 V (dc + peak ac) into 1 M Ω
5 Vrms into 50 Ω

¹ Tested characteristic.

XY operation

Operating mode: X = Ch 1, Y = Ch 2, Z = Ext. Trigger

Z Blanking: TTL high blanks trace

Bandwidths:

X-axis and Y-axis same as vertical system

Z-axis is dc to 100 MHz

Phase difference: ± 3 degrees at 100 kHz

Display system

Display: 7-inch raster CRT

Resolution: 256 vertical by 500 horizontal points

Controls: Front-panel intensity control

Graticule: 8 \times 10 grid or frame

Storage Scope:

Autostore saves previous sweeps in half bright display and the most recent sweep in full bright display. This allows easy differentiation of current and historic information.

Acquisition system

Maximum sample rate:

- 10 GSa/s for repetitive signals
- 20 MSa/s for single shot signals on a single channel
- 10 MSa/s for single shot signals on dual channels

Resolution: 8 bits

Simultaneous channels: Channels 1 and 2

Record length: 4,000 points (2,000 single shot)

Maximum update rate: 1,000,000 samples/s with sufficient trigger rate

Single-shot bandwidth: 2 MHz single channel, 1 MHz dual channel

Acquisition modes: Normal, Peak Detect, and Average

Peak detect:

- 50 ns glitch capture (100 ns dual channel)
- Operates at sweep speeds of 50 μ s/div and slower

Average: Number of averages selectable at 8, 64, and 256

Roll mode:

At sweep speeds of 200 ms/div and slower, waveform data moves across the display from right to left with no dead time. Display can be either free-running (non-triggered) or triggered to stop on a trigger event.

Mask/template measurements

Automatic testing, scaling, and placement of mask and templates for the following standards:

**SONET/SDH
(ITU-T G.957 and
Bellcore
TA-NWT-000253)**

OC-1, 51.84 Mb/s
OC-3/STM-1, 155.52 Mb/s
STS-1 (eye), 51.84 Mb/s
STS-1 (pulse), 51.84 Mb/s
STS-3 (eye), 155.52 Mb/s

ANSI T1.102

DS-1, 1.544 Mb/s
DS-1c, 3.152 Mb/s
DS-2, 6.312 Mb/s
DS-3, 44.736 Mb/s

ITU-T G.703

E-1, 2.048 Mb/s
E-2, 8.448 Mb/s
E-3, 34.368 Mb/s
E-4 one, 139.264 Mb/s
E-4 zero, 139.264 Mb/s
STM-1 one, 155.52 Mb/s
STM-1 zero, 155.52 Mb/s

ANSI X3.88

Fibre Channel 133 MBd
Fibre Channel 266 MBd

**Reference Receivers
(Options 050, 051, 052)**

Provides measured compliance to the SONET/SDH and/or Fibre Channel reference receiver specifications for the combination of the optical channel and a hardware filter. The frequency response of the system is measured to make sure it meets the standard specified tolerance window. The appropriate hardware filter is provided with each of the options.

SONET OC-1, 51.84 Mb/s
SDH/SONET STM-1/OC3, 155.52 Mb/s
Fibre Channel 133 MBaud

Advanced functions

Eye diagram measurements

Time:

Rise/fall time, bit rate, bit period, duty cycle distortion, jitter (rms and pk-to-pk)

Voltage/Power:

Extinction ratio, amplitude, overshoot, eye height, noise (rms and pk-to-pk), one level, zero level, max level, min level, eye crossing %

General waveform measurements

Time:

Rise/fall time, frequency, period, +width, -width, delay, phase, duty cycle

Voltage/Power:

Amplitude, max level, min level, pk-to-pk, top level, base level, average, rms, preshoot, overshoot

Cursor Measurements:

Four cursors can be positioned on the display to make time, voltage, or power measurements. The cursors will track changes in position and delay controls. Readout in V, T, or W.

Setup functions:

Autoscale:

Sets vertical and horizontal deflections and trigger level. Requires a signal with a frequency ≥ 50 Hz, duty cycle $> 1\%$ and voltage level channels 1 and 2 > 20 mVp-p, external trigger > 100 mVp-p.

Save/Recall:

16 front-panel setups can be stored and recalled from nonvolatile memory.

Trace memory:

Two volatile pixel memories allow storage of multi-valued waveforms.

Supplemental characteristics

Optical accuracy drift

Optical power meter: $\pm 0.41\%/^{\circ}\text{C}$

Optical cw vertical scale (one cursor): $0.045\%/^{\circ}\text{C}$ of full scale at 1310 nm and 1550 nm.

Offset voltage drift at Demod output: $0.2\text{ mV}/^{\circ}\text{C}$ into 50Ω

Optical system vertical gain drift with no input:

0.075% of full screen/ $^{\circ}\text{C}$ at 1310/1550 nm

BW drift: $-2\text{ MHz}/^{\circ}\text{C}$

Offset voltage at Demod output: $\leq \pm 3\text{ mV}$ (into 50Ω)

Return loss at Demod output: $> 15\text{ dB}$ (dc-500 MHz)

Demod output impedance: 50Ω nominal

1 dB compression: -5 dBm at 1310/1550 nm

Power requirements

Line voltage range: 100 Vac to 250 Vac

Line voltage selection: Automatic

Line frequency: 45 Hz to 440 Hz

Maximum power consumption: 220 VA

General

Environmental characteristics

The instrument was type tested to the environmental requirements of MIL-T-28800D for Type III, Class 5, Style D equipment as described below.

Ambient temperature:

(Tested to MIL-T-28800D paragraphs 4.5.5.1.1 Alternate T/H)

Operating: 0°C to +55°C (+14°F to +131°F)

Non-operating: -51°C to +71°C (-60°F to +160°F)

Humidity:

(tested to Hewlett-Packard environmental specification section 758

MIL-T-28800D paragraph 4.5.5.1.1 Alternate T/H)

Operating up to 95% humidity (non-condensing) at +40°C (+104°F)

Non-operating up to 90% relative humidity at +65°C (+149°F)

Altitude:

(Tested to MIL-T-28800E paragraph 4.5.5.2)

Operating: to 4,500 m (15,000 ft)

Non-operating: to 15,000 m (50,000 ft)

Vibration

Operating: (tested to Mil-T-28800D paragraph 4.5.5.3.1)

15 minutes along each of the 3 major axes; 10 Hz to 55 Hz at 55 Hz

Shock

Operating:

30 g, 1/2 sine, 11 ms duration, 3 shocks per axis along major axis. Total of 18 shocks.

Sound Pressure Level: Less than 60 dBA

Performance Characteristics and Regulatory Information

EMC CISPR 11:1990 /EN 55011:1991, Group 1 Class A
IEC 801-2:1991 /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, 500 V signal, 1000 Vac

Safety Conforms to IEC 348: 1978/HD 401:1980

Physical characteristics Size (excluding handle):
Height 172 mm (6.8 in)
Width 322 mm (12.7 in)
Depth 317 mm (12.5 in)
Weight: 7.25 kg (16 lbs)

Regulatory Information

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: Lightwave Communications Analyzer

Model Number: HP 83475A/B

Product Options: This declaration covers all options of the above products.

conforms to the following Product specifications:

Safety: IEC 348:1978/HD 401:1980
CAN/CSA-C22.2 No. 231 Series-M89

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 products herewith comply with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC.

Santa Rosa, California, USA

9/20/95


Dixon Browder/Quality Manager

European Contact: Your local Hewlett-Packard Sales and Service Office or Hewlett-Packard GmbH,
Department ZQ/Standards Europe, Herrenberger Strasse 130, D-71034 Böblingen, Germany (FAX:
+49-7031-14-3143)

Performance Characteristics and Regulatory Information



Algorithms

Algorithms

Introduction One of the primary features of the analyzer is the ability to make automatic measurements on displayed waveforms. This chapter provides details on how automatic measurements are calculated and offers some tips on how to improve results.

Measurement setup

General Waveform measurement setup

Measurements typically should be made at the fastest possible sweep speed for the most accurate measurement results. The entire portion of the waveform that is to be measured must be displayed on the analyzer.

- At least one complete cycle must be displayed for period or frequency measurements.
- The entire pulse must be displayed for width measurements.
- The leading edge of the waveform must be displayed for rise time measurements and all other edge measurements.
- The trailing edge of the waveform must be displayed for fall time measurements and all other edge measurements.

Eye: NRZ measurement setup

In order to increase measurement accuracy, measurements typically should be made at the fastest possible sweep speed. The sweep speed should be selected such that at least one complete eye diagram is shown in the display. A complete eye diagram consists of at least two crossing points.

- The Eye:NRZ measurements are based on histogram algorithms. The instrument constructs histograms based on a user-defined number of amplitude and time samples. Amplitude and time samples can both be separately specified. Large sample populations increase measurement accuracy but decrease measurement speed.

- Eye diagram amplitude measurements allow for the setting of the histogram window within which amplitude samples are taken for the measurements. The window is defined using minimum and maximum time markers. The markers can be positioned on the eye as a percentage of the eye diagram bit period.
- When performing eye diagram measurements, the instrument must first locate the eye diagram crossing points. The crossing points can be automatically calculated by the instrument or markers can be set to specify the crossing point locations. By manually setting the crossing points, measurement throughput can be increased. Care must be taken to position them correctly on the eye.
- The rise time and fall time measurements require the display of a complete eye diagram. In addition, the crossing point should be at least 5% above the lower threshold and 5% below the upper threshold. The rise and fall time measurement algorithms may not work for highly distorted eye diagrams.
- Eye diagram measurements can be made on only one channel. Eye measurements cannot be simultaneously done on two channels at a time.
- Recommended practices for extinction ratio measurements are provided in “Optimizing Extinction Ratio Measurements” in Chapter 2.

Making measurements

Making General Waveform measurements

If more than one waveform, edge, or pulse is displayed, the measurements are made on the first (leftmost) portion of the displayed waveform that can be used. If there are not enough data points, the analyzer displays \leq with the measurement results. This is to remind you that the results may not be as accurate as possible. It is recommended that you re-scale the displayed waveform and make your measurement again.

Algorithms

When any of the standard measurements are requested, the analyzer first determines the top-base amplitude levels at 100%-0%. From this information, it can determine the other important amplitude values (10%, 90%, and 50%) needed to make the measurements. The 10% and 90% amplitude values are used in the rise time and fall time measurements, as well as in all other edge measurements. The 10% and 90% values are also used to determine the 50% value. The 50% amplitude value is used for measuring frequency, period, pulse width, and duty cycle.

Automatic Top-Base

Top-Base is the heart of most automatic measurements. It is used to determine VTop and VBase, the 0% and 100% voltage levels at the top and bottom of the waveform. From this information the analyzer can determine the 10%, 50%, and 90% levels, which are also used in most measurements. The top or base of the waveform is not necessarily the maximum or minimum amplitude present on the waveform. Consider a pulse that has slight overshoot. It would be wrong to select the highest point of the waveform as the top since the waveform normally rests below the perturbation.

Top-Base performs a histogram on the waveform and finds the most prevalent point above and below the waveform midpoint. The most prevalent point is one that represents greater than approximately 2% of the total waveform points (4000) and is considered to be either the top or base. If no point accounts for more than 2% of the total, then the top is chosen as the absolute maximum and the base is chosen as the absolute minimum.

Edge Definition

Both rising and falling edges are defined as transitional edges that must cross three thresholds.

A rising edge must cross the 10% level in a positive direction (defining it as a rising edge), cross the 50% level (any number of crossings, both positive and negative are permissible) and then cross the 90% level without any additional crossing of the 10% level.

A falling edge must cross the 90% level in a negative direction, cross the 50% level (any number of times), and then cross the 10% level without any additional crossing of the 90% level.

NOTE

Most time measurements are made based on the position of the first crossing of the 50% level.

Making Eye:NRZ measurements

If more than one eye diagram is displayed, the measurements are made on the first (left-most) complete eye diagram. Measurement results are given after a complete acquisition. A complete acquisition consists of acquiring enough amplitude and time samples to satisfy the user-defined sample settings. If an eye diagram measurement is activated, you will notice that, on the right hand side of the status line, there is a bar that fills in. As the acquisition proceeds, the bar fills. The bar is a gauge of the status of the acquisition. When the bar completely fills, the acquisition is complete and the measurement result is updated.

For amplitude measurements, an amplitude histogram window can be defined within which the histogram data is acquired. The histogram window is defined, on the displayed eye diagram, in terms of percent of the bit period through a min and a max time marker. The left crossing point is defined as 0% while the right crossing point is defined as 100%. Data is acquired within this window for amplitude measurements such as One Level, Noise rms, Eye Height, and Extinction Ratio.

Eye diagram measurement speed is quite sensitive to the number of time samples. Typically, in most measurements, 300 time samples are sufficient for good accuracy. Time measurements, such as jitter and duty cycle distortion,

may require more than 300 time samples depending on the desired accuracy and repeatability.

When any eye diagram measurement is activated, the instrument first determines the time location of the eye diagram crossing points and then the “1” and “0” levels at 100% and 0%. From this information, the amplitude location of the crossing points, and the 50%, 10%, and 90% levels can be determined. This information is used in making both time and amplitude measurements.

The time location of the eye diagram crossing points can be determined by the instrument measurement algorithm or specified by the user. Specification of the crossing point, through markers, can be useful to increase measurement throughput or when analyzing distorted or noisy waveforms.

The One and Zero Levels are the average or most prevalent values at, respectively, the high and low eye diagram states. These values are determined based on the histogram window location which, in turn, is located relative to the time locations of the eye diagram crossing points. The One and Zero Levels are not equivalent to the Max and Min Levels. The Max and Min Level measurements determine the highest and lowest data points in the measurement data acquisition. They are not average or most prevalent locations.

Algorithm definitions

This section lists the measurement definitions of the analyzer.

+width

The +width algorithm has standard considerations.

If first edge is rising, then:

$$+width = 50\% \text{ level crossing of first falling edge} - 50\% \text{ level crossing of first rising edge}$$

Else:

$$+width = 50\% \text{ level crossing of second falling edge} - 50\% \text{ level crossing of first rising edge}$$

–width	<p>The –width algorithm has standard considerations:</p> <p>If first edge is rising, then:</p> $-width = second\ rising\ edge - first\ falling\ edge$ <p>Else:</p> $-width = first\ rising\ edge - first\ falling\ edge$
Amplitude	<p>Amplitude measurement is made using the entire waveform. When performing a measurement on a particular cycle, set the controls so only that cycle is displayed. The method used to determine amplitude is to measure the mean high level and the mean low level, and then calculate amplitude as follows:</p> $amplitude = mean\ high - mean\ low$
Average	<p>The average of the first cycle of the displayed signal is measured. If a complete cycle is not present, the analyzer averages all data points.</p>
Base Level	$base\ level = most\ prevalent\ point\ below\ waveform\ midpoint$
Bit Period	<p>The bit period algorithm has standard considerations.</p> $bit\ period = second\ crossing\ point\ time\ location - first\ crossing\ point\ time\ location$
Bit Rate	$bit\ rate = 1/bit\ period$
Duty Cycle	$duty\ cycle = (pulse\ width/period) \times 100$
Duty Cycle Distortion	<p>The Duty Cycle Distortion algorithm has standard considerations. It is measured at the eye diagram crossing point using the 50% level time locations on the falling and rising edges which compose the eye diagram crossing point.</p> $duty\ cycle\ distortion = time\ location\ of\ 50\ \% \ level\ on\ rising\ edge - time\ location\ of\ 50\ \% \ level\ on\ falling\ edge\ (both\ levels\ are\ taken\ at\ the\ same\ crossing\ point)$

Algorithms

Extinction Ratio	<p>For a detailed description of the considerations in making extinction ratio measurements refer to “Optimizing Extinction Ratio Measurements” in Chapter 2.</p> $\text{extinction ratio} = (\text{one level amplitude} - \text{DC offset}) / (\text{zero level amplitude} - \text{DC offset})$
Eye Height	<p>The Eye Height measurement has standard considerations.</p> $\text{eye height} = \left(\frac{(\text{One Level} - 3 \text{ standard deviations}) - (\text{Zero Level} - 3 \text{ standard deviations})}{(\text{One Level} - \text{Zero Level})} \right) 100$
Fall Time	$\text{fall time} = \text{time at 10\% (or 20\%) level} - \text{time at 90\% (or 80\%) level}$
Frequency	$\text{frequency} = 1/\text{period}$
Jitter Pk to Pk	$\text{jitter pk to pk} = 6 \times \text{jitter rms}$
Jitter RMS	<p>The Jitter RMS measurement has standard considerations. The measurement is made at the eye diagram crossing point. A time histogram window, of 5% of the amplitude, is set around the crossing point. The user-defined number of samples are collected within this window and the time histogram data is used in the jitter calculation. RMS jitter is given as one standard deviation of the histogram data collected at the eye diagram crossing point.</p>
Max Level	$\text{max level} = \text{voltage or power of the highest point on the screen}$
Min Level	$\text{min level} = \text{voltage or power of the lowest point on the screen}$
Noise Pk to Pk	$\text{noise pk to pk} = 6 \times \text{noise rms}$
Noise rms	<p>The Noise rms measurement has standard considerations. The measurement is made at the eye diagram “1” level amplitude. The RMS noise is given as one standard deviation of the amplitude histogram taken in the calculation of the mean “1” level.</p>

- One Level** The One Level measurement has standard considerations. The measurement is taken as the mean of an amplitude histogram taken at the “1” state of the eye diagram. The data for the histogram is taken over the defined histogram window limits. The limits can be set through the `Define Eye Window` softkey.
- Overshoot** A minimum of one edge must be displayed in order to perform an overshoot measurement. If more than one waveform, edge, or pulse is present, the measurement is made on the first edge acquired. The method used to determine overshoot is to make three different amplitude measurements, then calculate overshoot as follows:
- $$\text{percent overshoot} = \left(\frac{\text{Max} - \text{Top}}{\text{Top} - \text{Base}} \right) 100$$
- Period** If first edge is rising, then:
- $$\text{period} = \text{time at second rising edge} - \text{time at first rising edge}$$
- Else:
- $$\text{period} = \text{time at second falling edge} - \text{time at first falling edge}$$
- Pk-to-Pk** $\text{pk-to-pk} = V_{\text{max}} - V_{\text{min}}$
- Preshoot** A minimum of one edge must be displayed in order to perform a preshoot measurement. If more than one waveform, edge, or pulse is present, the measurement is made on the first edge acquired. The method used to determine preshoot is to make three different voltage measurements, then calculate preshoot as follows:
- $$\text{percent preshoot} = \left(\frac{\text{Min} - \text{Base}}{\text{Base} - \text{Top}} \right) 100$$
- Rise Time** $\text{rise time} = \text{time at 90\% (or other\%) level} - \text{time at 10\% (or other\%) level}$

Algorithms

rms (dc)

The true rms amplitude of the first cycle of the displayed signal is measured. If a complete cycle is not present, the analyzer averages all data points.

$$A_{rms}(dc) = \left[\frac{1}{n} \sum_{j=0}^{n-1} (A_n)^2 \right]^{1/2}$$

Top Level

top level = most prevalent point above waveform midpoint

Zero Level

The Zero Level measurement has standard considerations. The measurement is taken as the mean of an amplitude histogram taken at the “0” state of the eye diagram. The data for the histogram is taken over the defined histogram window limits. The limits can be set through the **Define Eye Window** softkey.

———— Calibrating the analyzer

Calibrating the analyzer

Performing Optical Channel Calibration

The HP 83475B lightwave communication analyzer allows you to perform optical channel calibrations. In addition to the three factory default calibrations, three user calibrations can be performed and saved. To ensure the watts vertical scale functions properly, the user calibrations should be performed *at least ± 20 nanometers* from the standard wavelengths of 780 nm, 1310 nm, and 1550 nm.

Each calibration requires making a sequence of power measurements. The first measurement is for the calculation of the receiver conversion gain. The next measurement measures the system dark noise level. High and low measurements are then performed for each of the three power meter ranges.

Required Equipment

HP 815545M	1300/1550 nm source
HP 81530A	450-1020 nm detector
HP 81532A	800-1700 nm detector
HP 8153A	lightwave multimeter
HP 8158B Option 001	600-1200 nm attenuator (MM, FC-PC connector)
HP 8158B Option 002	1200-1650 nm attenuator (MM, FC-PC connector)

A block diagram of a calibration setup is shown in Figure 5-1.

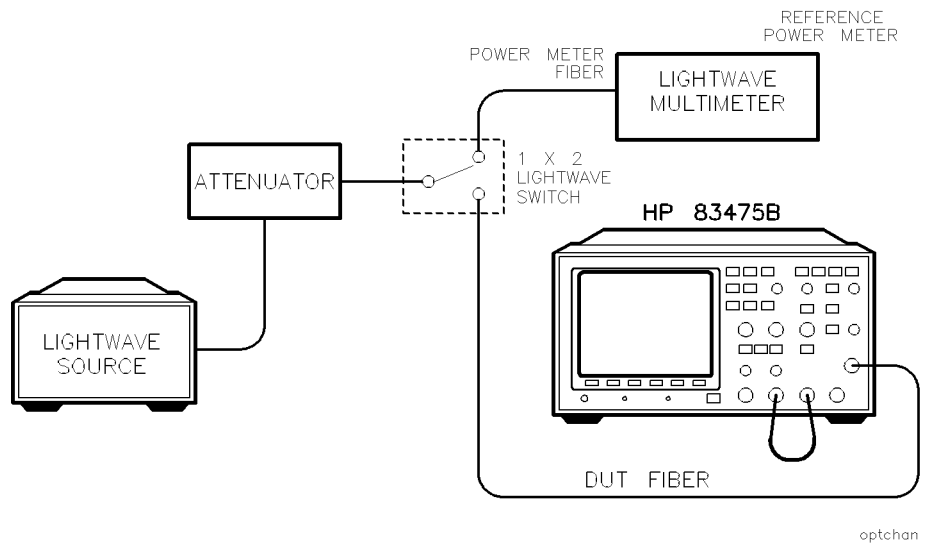


Figure 5-1. Block diagram of a calibration setup.

To improve calibration accuracy, lightwave switches are recommended for signal routing. Clean connectors are necessary to assure the best accuracy. Refer to “Cleaning Connections for Accurate Measurements” in Chapter 1 for information on lightwave connector care.

To correct for insertion loss

If the setup shown in Figure 5-1 is used, the insertion loss of the power meter and device-under-test (DUT) signal paths should be corrected for. This provides a more accurate calibration. The following procedure can be used to correct for the insertion loss of the signal paths.

1. Adjust the attenuator to a set level (0.0 dB is good).
2. Connect the DUT fiber to the reference power meter.
3. Measure and record the power at the DUT fiber signal path output.
_____ μW
4. Connect the DUT fiber to the optical input of the HP 83475B.
5. Connect the power meter fiber to the reference power meter.
6. Measure and record the power at the power meter fiber signal path output.

_____ μW

WARNING

Do not disconnect the power meter fiber from the reference power meter. It is important to maintain the connection so repeatability uncertainty is minimized.

7. Calculate the insertion loss correction, in percent, using the following formula:

$$\text{Correction Factor} = \frac{(P \text{ at DUT path} - P \text{ at power meter path})}{(P \text{ at DUT path})}$$

where:

P = power, in microwatts, at the specified points

During the calibration procedure, several power levels must be input into the HP 83475B optical channel. The instrument must be “told” what these power levels are. Use the following formula to calculate the actual power levels and enter them into the HP 83475B.

Use the correction factor, as calculated earlier, in the following equation to determine the actual power input, in microwatts, into the HP 83475B optical channel:

$$\text{Input power to HP 83475B} = \frac{(\text{Reference power meter reading})}{(1 - \text{correction factor})}$$

Manual Calibration Sequence

This procedure guides you through an optical channel calibration. It assumes the setup shown in Figure 5-1.

NOTE

Press the **Abort** key at any point in the calibration sequence to discontinue the calibration and reset the instrument to its previous state.

1. To access the user calibration menu and begin an optical channel calibration, press:

Optical Cal

More 1/2

2. To select the desired user calibration, highlight one of the user calibration softkeys and then press:

Sequence

NOTE

Make sure you select the softkey location pertaining to the desired calibration wavelength. From left to right, the softkeys are for 780 nm, 1310 nm and 1550 nm.

3. An on-screen message instructs you to either skip the electrical vertical system calibration or press **Continue** to perform the electrical vertical system calibration. If the electrical calibration is not recent (<48 hours) you should press **Continue**.

When **Continue** is pressed, a menu for performing an electrical calibration is displayed.

4. Follow the on-screen instructions.

NOTE

Before starting an electrical calibration, connect the DC Calibrator Output (on the rear panel) to the external trigger input on the front panel.

5. After either completing or skipping an electrical calibration, follow the on-screen instructions to perform a dark noise level calibration.
6. Perform an Optical Channel Gain calibration by following the on-screen instructions.

Make sure the power to the optical input is sufficient to complete the calibration. If the input power is too low, the calibration will be aborted.

7. When the Optical Channel Gain calibration is finished, the Power Meter calibration sequence is initiated.

Six power measurements are requested by the analyzer. Each measurement pertains to a specific low and high level within the three power meter calibration ranges. Follow the on-screen instructions with each power measurement to complete the calibration.

The instructions ask you to input a power level within a specific microwatt range. You are then asked to dial in the actual power level at the optical input. The power level should be determined from a reference power meter reading as shown in Figure 5-1. You may choose to apply insertion loss correction as discussed in the “To correct insertion loss” section of this chapter.

Manual Calibration Sequence

Dial in the precise power level using the general purpose knob under the front-panel Measure section. To record the power reading, press:

Measure

NOTE

The optical channel calibration accuracy is heavily dependent on the accuracy of the reference power meter and the insertion loss correction.

8. To save the calibration after the measurements are complete, press:

done

If you do not wish to save the calibration, press:

Abort

Performing the Electrical Vertical Channel Calibration

In this procedure the default calibration factors are loaded to give a known starting point for the firmware calibration.

CAUTION

Once the default calibration factors are loaded, *the remainder of the firmware calibration must be performed to maintain the accuracy of the analyzer.*

Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Pulse generator	100 kHz, 1 V p-p, rise time <5 ns	HP 8112A
Digital multimeter	0.1 mV resolution, accuracy <0.01%	HP 34401A
Cable	BNC, 3 feet	HP 10503A
Cable	BNC, 9 inches, Qty 2	HP 10502A
Adapter	BNC tee m f f	HP 1250-0781
Adapter	BNC f-f	HP 1250-0080

Checking the DC CALIBRATOR output level

1. Connect a multimeter to the rear panel DC CALIBRATION connector.
2. To check the output level of the DC CALIBRATOR, press:

```
Print/Utility
Self Tst Menu
DAC
```

The multimeter should measure 0.00 V dc $\pm 500 \mu\text{V}$.

3. Press any key to continue the test. The multimeter should read 5.000 V $\pm 10 \text{ mV}$.

Calibrating the analyzer

Loading the default calibration factors

4. Set the rear-panel CALIBRATION switch to UNPROTECTED (up position).
5. To load the default calibration factors, press:

```
Print/Utility
Self Cal Menu
Load Defaults
```

Performing the vertical self-cal

6. When the message “Default calibration factors loaded” is displayed, press:

```
Vertical
```

7. Follow the instructions on the display, then press:

```
Continue
```

8. When the message “Press Continue to return to calibration menu” is displayed, press:

```
Continue
```

Performing the delay self-cal

9. Set the pulse generator to 100 kHz, 1 V p-p, with a rise time of less than 5 ns.
10. Set the analyzer’s input impedance to 50Ω.
11. Making sure the cables are of equal length, connect a pulse generator to channels 1 and 2, then press:

```
Delay
```

12. Follow the instructions on the display.
13. Set the rear-panel CALIBRATION switch to PROTECTED.

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