User's Guide

HP 83475A Lightwave Communications Analyzer

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HP Part Number: 83475-90001
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1400 Fountaingrove Parkway, Santa Rosa, CA 95403-1799, USA

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Declaration of Conformity

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, California 95403 U.S.A.

Declares that the product:

Product Name:	Lightwave Communications Analyzer
Model Numbers:	HP 83475A
Product Options:	This declaration covers all options of the above products.

Conforms to the following product specifications:

Safety:	IEC 348:1978/HD 401:1980
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, 3V/m, 27-500 MHz IEC 801-4:1988 /EN 50082-1:1992, 500 V signal, 1000 V AC

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	6/9/94	[signature]
Location	**Date**	**Dixon Browder / Quality Manager**

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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.

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.

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 83475A Lightwave Communications Analyzer.

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

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The Analyzer at a Glance

The Analyzer at a Glance

The HP 83475A Lightwave Communications Analyzer is an easy-to-use measurement tool for lightwave and electrical digital communication applications. The HP 83475A measures signal compliance to a variety of optical and electrical communication standard mask and template specifications. The optical input of the HP 83475A 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 83475A accurately measures the important parameters of laser and LED transmitters for SDH/SONET, ATM, and Fibre Channel.

The HP 83475A 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 MΩ and 50Ω 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
  - FC-133 and FC-266
- Automatic mask and template scaling, positioning, and testing
- Statistical waveform analysis
- FFT (with Options 201 or 202)

The familiar controls and real time display make the HP 83475A 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 83475A 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 word processing and spread sheet programs.

Ordering Information

Supplied accessories

- Demod jumper cable
- One connector option
- Power cord for country of destination
- *HP 83475A Lightwave Communications Analyzer User 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, 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, 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	Rackmount kit
	Option OB1	Additional *HP 83475A Lightwave Communications Analyzer User Guide*

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.

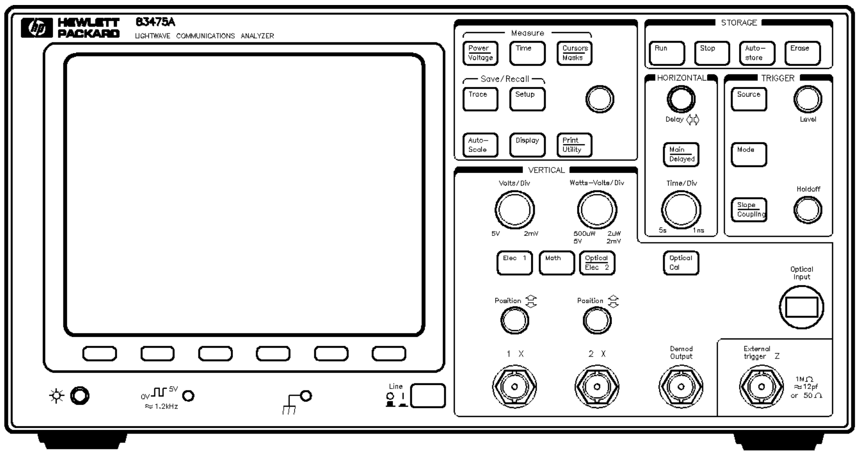
Throughout this manual front-panel keys are indicated by a box around the key label, for example, (Mode). Softkeys are indicated by shading on the key label, for example, `Opt Pmtr Off On`. The softkeys displayed depend on the front-panel key pressed and which menu is selected.

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 underlined. 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 On Off` 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



frntpnl

Figure 1-1. The HP 83475A 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.

For a complete list of the front-panel keys and their associated softkeys refer to Chapter 3.

The Rear-Panel

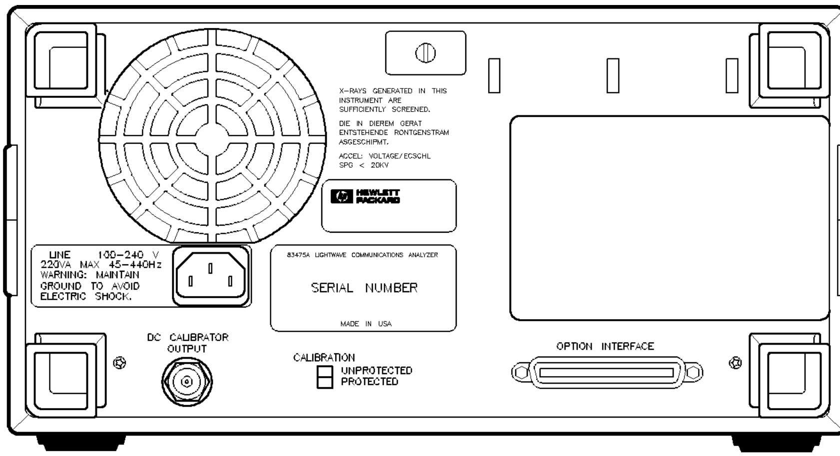


Figure 1-2. The HP 83475A rear-panel.

The HP 83475A 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.

Connecting a signal to the analyzer

What you'll learn in this tutorial

This tutorial is divided into three sections:

- Lightwave connector care
- Connecting an optical signal.
- Connecting an electrical signal.

Lightwave Connector Care

Introduction

Lightwave cable interfaces can be damaged by improper cleaning and connection procedures. Dirty or damaged lightwave interfaces can result in nonrepeatable or inaccurate measurements. This chapter will suggest some best practices to clean, care for, connect, and inspect lightwave connectors.

Lightwave connectors are used to connect two fiber ends together. These connections may be used to join cables between optical ports on devices, laser sources, receivers, patch panels, terminals and many other types of systems or components.

Fiber optic cables are used at different wavelengths, in single or multi-mode, and in different environments. There are a variety of sizes, core/cladding combinations, jackets, and indexes of refraction. In general, different types of cables do not work well together. Cables should match each other and the system.

However, regardless of the cable type, the connectors have only one function: to provide a direct and low-loss optical signal transition from one fiber end to another. When these connectors are used in a measurement system, repeatability becomes an important factor.

Lightwave connectors differ from electrical or microwave system connectors. In a fiber optic system, light is transmitted through an extremely small fiber core. Because fiber cores are often 62.5 microns (0.0625 mm) or less in diameter, and dust particles range from tenths of a micron to several microns in diameter, dust and very minute contamination on the end of the fiber core can degrade the performance of the connector interface (where the two cores meet). Therefore, the connector must be precisely aligned and the connector interface free of trapped foreign material.

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 40 dB, although 20 to 30 dB is more common.

Causes of connector loss and reflections include core misalignment, differences in the numerical aperture of two fibers, spacing and air gaps, reflections caused by damaged, worn, or loose fiber ends, and the improper use and removal of index matching compounds.

Achieving the best possible connection, where the fiber end faces are flush (no air gap) and properly aligned, depends on two things:

1. the type of connector
2. using the proper cleaning and connecting techniques. If the connection is lossy or reflective, light will not make a smooth transition. If the transition is not smooth or the connection is not repeatable, measurement data will be less accurate. For this reason, lightwave connections can make a critical difference in optical measurement systems.

Cleaning and handling

Proper cleaning and handling of lightwave connectors is imperative for achieving accurate and repeatable measurements with your Hewlett-Packard lightwave equipment. Lightwave interfaces should be cleaned before each measurement using the techniques described in this handbook. Information on protecting and storing your connectors/cables and tips on how to properly mate connectors are also included in this section.

Definition of terms

To avoid confusion, the following definitions are used in this handbook.

Connector	Houses the fiber end, most open at the end of a lightwave cable or on the front panel of an instrument or accessory.
Adapter	Does not contain optical fiber. Used to mate two optical connectors.

Handling

Always handle lightwave connectors and cable ends with great care. Fiber ends should never be allowed to touch anything except other mating surfaces or cleaning solutions and tools.

Always keep connectors and cable ends covered with a protective cap when they are not in use. (See "Storage.")

Cleaning

Three cleaning processes are provided. The first process describes how to clean non-lensed lightwave connectors. The second process describes how to clean lightwave adapters. The third process describes how to care for lensed lightwave connections.

CAUTION

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

Cleaning non-lensed lightwave connectors

Equipment

The following is a list of the items that should be used to clean non-lensed lightwave connectors.

Isopropyl alcohol .... HP part number 8500-5344
Cotton swabs .... HP part number 8520-0023
Compressed air .... HP part number 8500-5262

CAUTION

Hewlett-Packard recommends that you 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.

Process

Before cleaning the fiber end, clean the ferrules and other parts of the connector. Use isopropyl alcohol, clean cotton swabs, and clean compressed air. Then use alcohol to clean the fiber end. 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 can be done by applying the alcohol to a cotton swab and moving it back and forth across the fiber end several times. This technique can help remove or displace particles smaller than one micron.

Allow the connector to dry (about a minute) or dry it immediately with clean compressed air. Compressed air lessens the chance of deposits remaining on the fiber end after the alcohol evaporates. It should be blown horizontally across the fiber end. Visually inspect the fiber end for stray cotton fibers. As soon as the connector is dry, the connection should be made.

CAUTION

Inverting the compressed air canister while spraying will produce residue on the sprayed surface. Refer to instructions provided on the compressed air canister.

Cleaning lightwave adapters

Equipment

All of the items listed above for cleaning connectors may be used to clean lightwave adapters. In addition, small foam swabs may be used along with isopropyl alcohol and compressed air to clean the inside of lightwave connector adapters.

NOTE

As noted in a previous caution statement, the foam swabs can leave filmy deposits. These deposits are very thin however, and the risk of other contamination buildup on the inside of adapters greatly outweighs the risk of contamination of foam swab deposits left from cleaning the inside of adapters.

Process

Clean the adapter by applying isopropyl alcohol to the inside of the connector with a foam swab. Allow the adapter to air dry, or dry it immediately with clean compressed air.

Cleaning lensed connections

Some instruments may have a connector that is "lensed." in other words: the connection does not provide a physically contacting connection, but the light is received into a lens rather than into a connecting fiber. These receiving lenses usually have an anti-reflective coating that is very easily damaged. Therefore, these connectors should NEVER have cleaning solutions or any other substance applied to them unless it is specifically recommended by the manufacturer. You may wish to use clean compressed air to rid them of dust from time to time.

Storage

All of Hewlett-Packard's lightwave instruments are shipped with either laser shutter caps or dust caps on the lightwave adapters that come with the instrument. Also, all of the cables that are shipped have covers to protect the cable ends from damage or contamination. These dust caps and protective covers should be kept on the equipment at all times except when in use.

The adapters that were shipped on your instrument can be removed from the connectors on the instrument. If you remove these adapters you should keep the exposed connector of your instrument covered until the next use. Protective covers for these exposed connectors are not provided with the instruments, so it is best to keep the adapters on the instrument with the dust covers on.

The list below provides the HP part numbers for the laser shutter cap and dust caps that are provided with lightwave instruments and accessories.

Item	HP Part No.	Connector Option
Laser shutter cap	08145-64521	All options
FC/PC dust cap	08154-44102	opt 012
Biconic dust cap	08154-44105	opt 015
DIN dust cap	5040-9364	opt 013
HMS 10/HP dust cap	5040-9361	opt 011
ST dust cap	5040-9366	opt 014
SC dust cap	1401-0253	opt 017

Making connections

Proper connection technique requires attention to connector compatibility, insertion technique and torque requirements. Connectors must be the same connector type in order to ensure mechanical and optical compatibility. Attempting to connect incompatible connector types may prevent the connection from functioning properly and even cause damage to the fiber surfaces. A visual inspection of the mechanical interfaces may not be enough because some connector types have the same mechanical interface but have different optical fiber interfaces (for example, angled-no-contact, angled-contact or straight-contact fiber interfaces). Refer to the manufacturer's data sheet to confirm connector type compatibility before connecting.

When you insert the ferrule into a connector or adapter, make sure that the fiber end does not touch the outside of the mating connector or adapter. In this way, you will not rub the fiber end against any undesirable surface. Many connectors have a keyed slot provided for optimum measurement repeatability that also helps to align and seat the two connectors. After the ferrule is properly seated inside the other connector, use one hand to keep it straight, rotate it to align the key, and tighten it with the other hand.

Most connectors using springs to push fiber ends together exert one to two pounds of force. Over-tightening or under-tightening these connectors can result in misalignment and nonrepeatable measurements. Always finger tighten the connector in a consistent manner. Refer to the manufacturer's data sheet for any torque recommendations.

Summary

When making measurements with lightwave instruments or accessories, the following precautions will help to insure good, reliable, repeatable measurements:

- Confirm connector type compatibility.
- Use extreme care in handling all lightwave cables and connectors.
- Be sure the connector interfaces are clean before making any connections.
- Use the cleaning methods described in this handbook.
- Keep connectors and cable ends covered when not in use.

Inspection

Visual inspection

Although it is not necessary, visual inspection of fiber ends can be helpful. Contamination and/or imperfections on the cable endface can be detected as well as cracks or chips in the fiber itself.

Several fiber inspection scopes are on the market, but any microscope with an enlargement range of 100X to 200X can be used. It is helpful to devise some method to hold the fiber in place while viewing in this range.

Inspect the entire endface for contamination, raised metal, or dents in the metal, as well as any other imperfections. Inspect the fiber core for cracks and chips.

Visible imperfections not touching the fiber core may not affect the performance of the lightwave connection (unless the imperfections keep the fibers from contacting). Consistent optical measurements are the best assurance that your lightwave connection is performing properly.

Optical performance testing

Introduction

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.

Insertion loss

Insertion loss can be tested using a number of different test equipment configurations. Some of these are:

- an HP 8702B or HP 8703A lightwave component analyzer system with a lightwave source and receivers
- an HP 83420 lightwave test set with an HP 8510 network analyzer
- an HP 8153A lightwave multimeter with a source and a power sensor module

Many other possibilities exist. The basic requirements are an appropriate lightwave source and a compatible lightwave receiver. Refer to the manuals provided with your lightwave test equipment for information on how to perform an insertion loss test.

As mentioned earlier in this handbook, typical insertion loss for cables is less than 1 dB, and can be as little as 0.1 dB. For actual specifications on your particular cable or accessory, refer to the manufacturer.

Return loss

Return loss can be tested using a number of different test equipment configurations. Some of these are:

- an HP 8703A lightwave component analyzer
- an HP 8702B lightwave component analyzer with the appropriate source, receiver and lightwave coupler
- an HP 8504A precision reflectometer
- an HP 8153A lightwave multimeter and HP 81534A return loss module

Many other possibilities exist. The basic requirements are an appropriate lightwave source, a compatible lightwave receiver, and a compatible lightwave coupler.

Refer to the manuals provided with your lightwave test equipment for information on how to perform a return loss test.

As mentioned earlier in this handbook, typical return loss is better than 20 to 30 dB, and can be better than 40 dB. For actual specifications on your particular cable or accessory, refer to the manufacturer.

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 MΩ 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 4 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:

   (Optical/Elec 2)
   More 1/2
   Ext 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
   1300 nm

   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 peazk 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 4.

To connect an electrical signal

When using the HP 83475A 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 MΩ. 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 MΩ 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 see Chapter 4.

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 50 Ω)

   More 1/2

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

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.

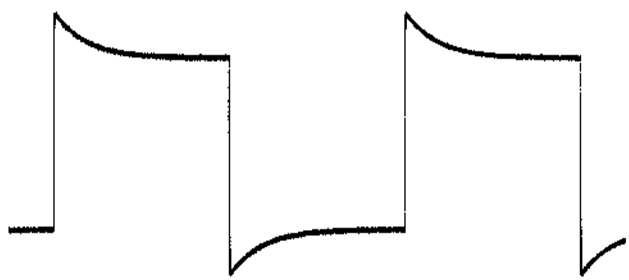


Figure 1-3. Overcompensation causes pulse peaking.

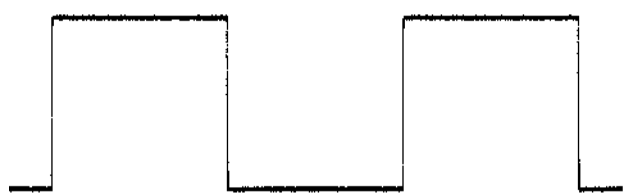


Figure 1-4. Correct compensation with a flat pulse top.

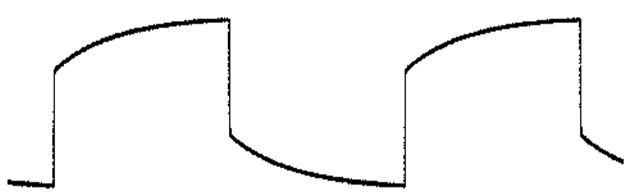


Figure 1-5. Undercompensation causes pulse roll off.

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 83475, then it is selected as the trigger source. Autoscale will reset in both 50Ω and 1 MΩ impedance modes.

Coupling .... DC
Bandwidth limit .... Off
Verniers .... Off
Signal inversion .... Off

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

Using 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.

Setting up the window

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.

Selecting the time base

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 (▼) symbol and an open triangle (▽) symbol. The ▼ 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 (▼).

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 4, 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 83475A 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 such as ringing on a fast signal.

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

   Source
   `Ext`

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

4. To view the external trigger waveform, press:

   `Menu`

   `Ext Trig View Off On` On

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

   `Input 50Ω 1 MΩ` 50Ω

   `Coupling DC AC Gnd` DC

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

   - you are in the External Trigger menu
   - you have pressed:
     (SOURCE)
     `Ext`

7. Use the trigger level knob to adjust the level to the desired point on the trigger waveform.

8. Display the trigger mode choices by pressing (Mode).

9. 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.

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 free runs.

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, such as 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 Cntr Rght

   The analyzer fills $\frac{1}{2}$ of the display if Time Ref Cntr Rght 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 (nontriggered) 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.

2

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 Genl Wvfm, 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 threshlold 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 Genl Wvfm 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.

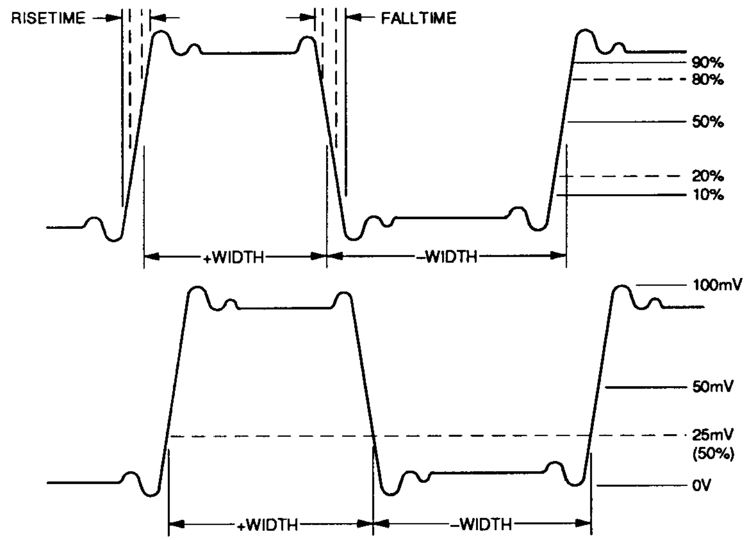


Figure 2-1. User thresholds measurement

To set the thresholds, press:

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

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.

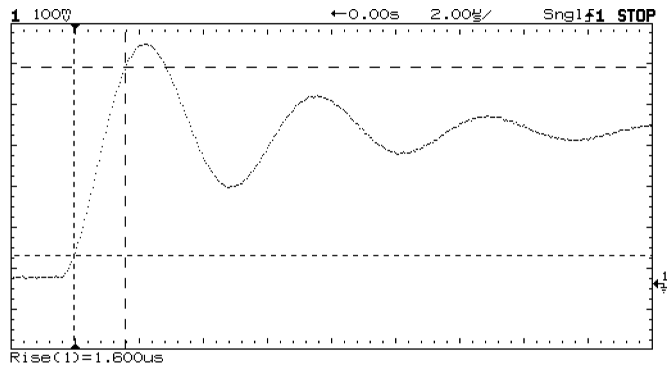


Figure 2-2. User threshold rise time measurement

Making Voltage and Power Measurements

The HP 83475A 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 slelected 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.

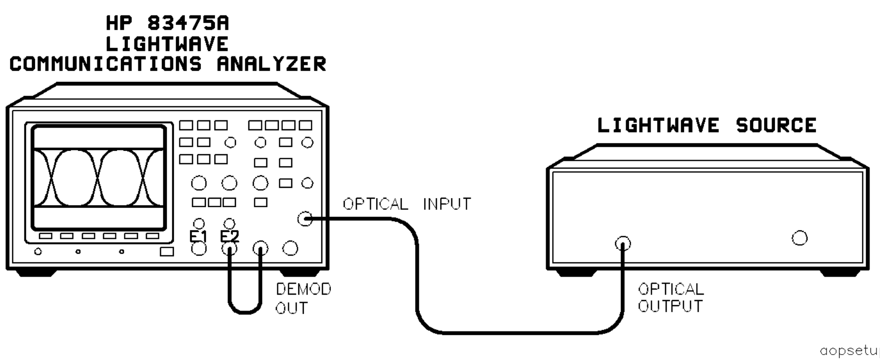


Figure 2-3. Average optical power measurements setup

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 μW 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.

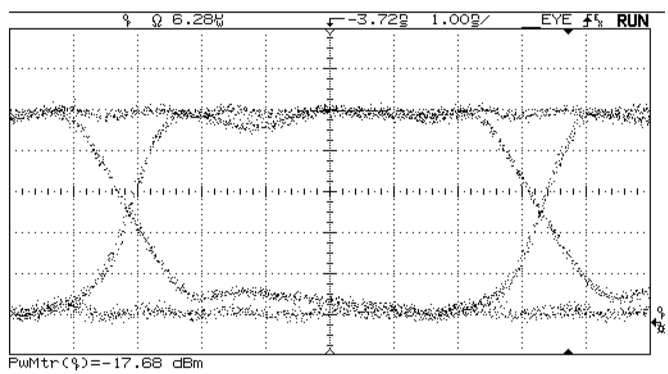


Figure 2-4. Power measurement display

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 5.

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.

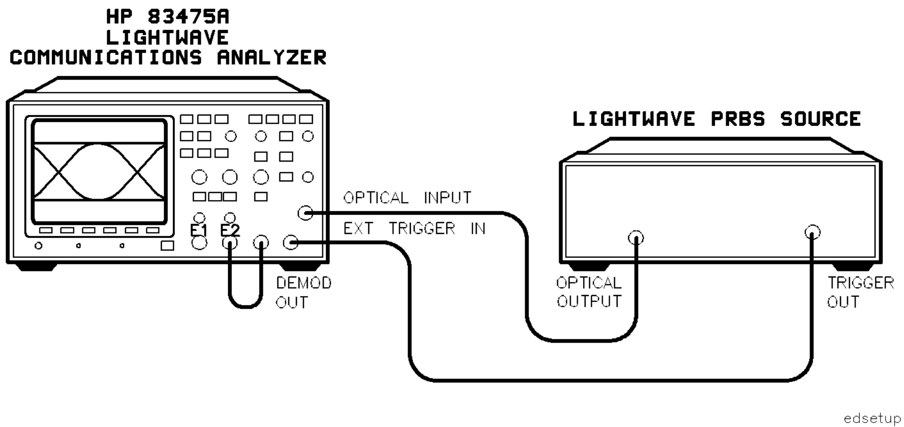


Figure 2-5. Eye diagram measurement setup

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` 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`
   `uW`
   `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)
   `More 1/4`
   `More 2/4`
   `More 3/4`
   `Time Samp`

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`

   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 beriod.

Measuring eye height percent

6. To measure the eye height percent, press:

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

   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 Level`

   `Zero Level`

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.

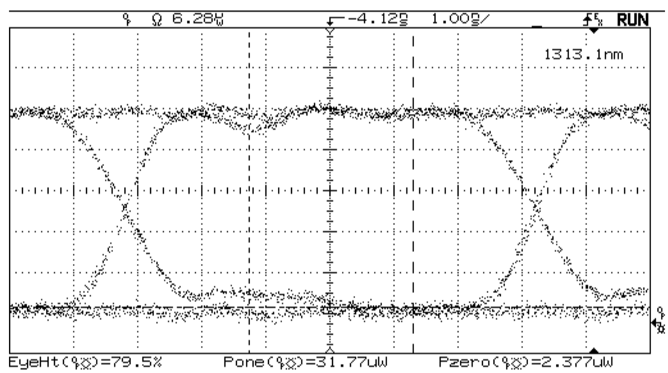


Figure 2-6. Display with measurements active

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 5.

This exercise assumes the setup shown in Figure 2-7. For additional setup information refer to “To connect an electrical signal” in Chapter 1.

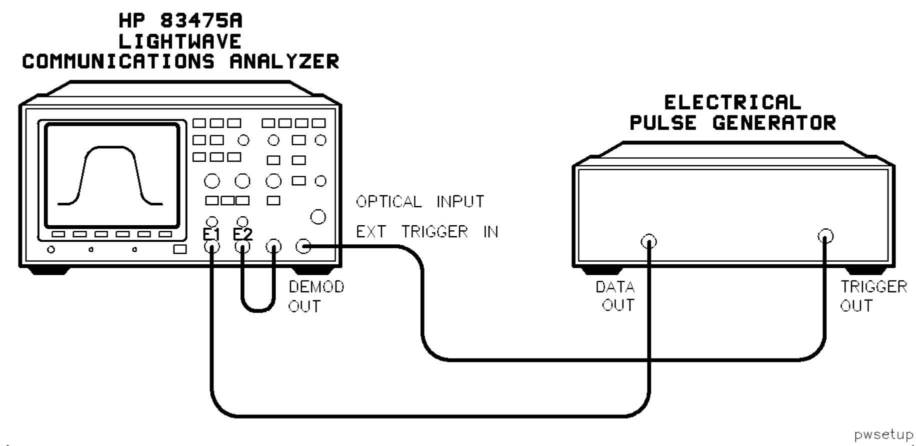


Figure 2-7. Pulse waveform measurements setup

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` 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:

   `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`

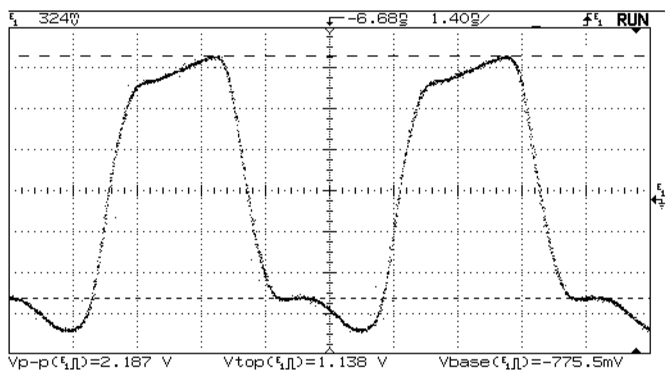


Figure 2-8. Pulse with pk-pk, top, and base level measurements

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)
JITTERpp
JITTERrms

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 5.

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.

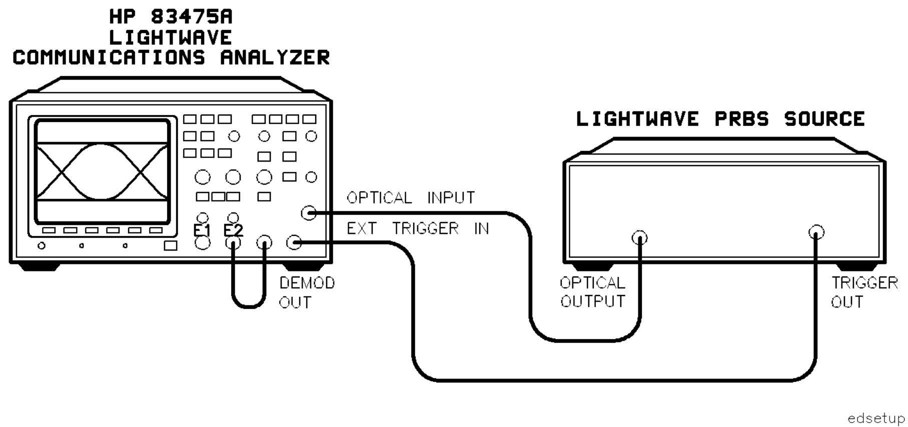


Figure 2-9. Eye diagram measurements setup

Selecting the measurement type

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

   (Time)
   `Input 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` 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`

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

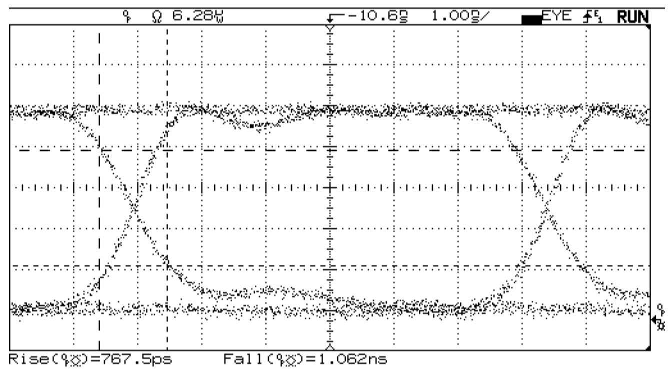


Figure 2-10. Rise time and fall time measurements

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 acqusition 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`

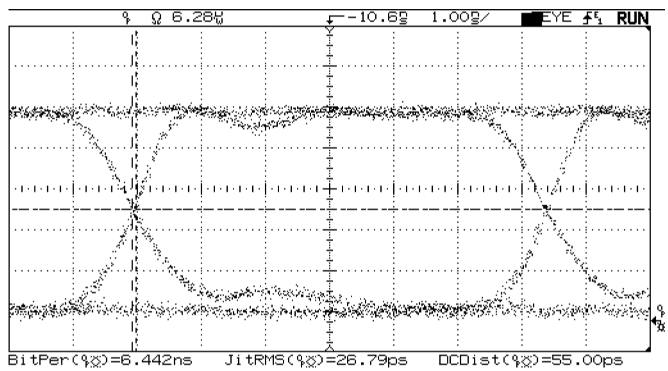


Figure 2-11. Eye diagram with bit period, jitter rms and DCD measurements

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 measurements algorithms refer to Chapter 5.

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.

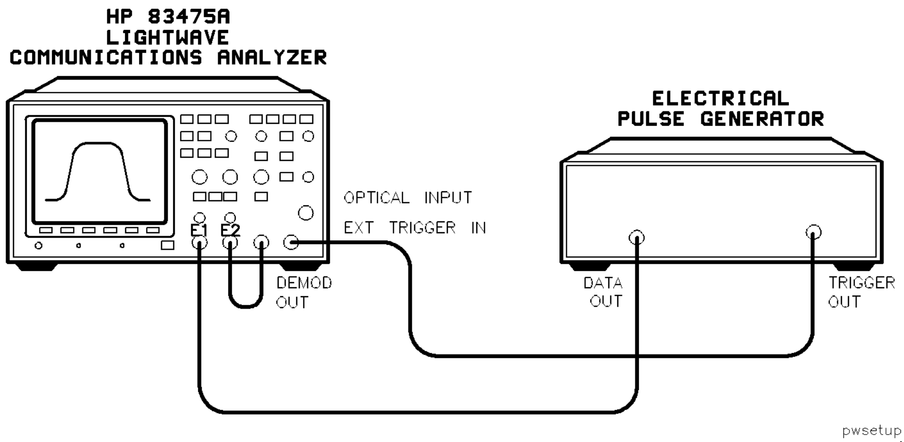


Figure 2-12. Pulse waveform measurements setup

Selecting the measurement source

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

   (Time)

   `Meas Type 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`.

2. To set the measurement source, press:

   `Source E1 Op` 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:

   `More 1/4`

   `+Width`

   `−Width`

Measuring the duty cycle

7. To measure the duty cycle, press:

   `More 2/4`

   `Duty Cycle`

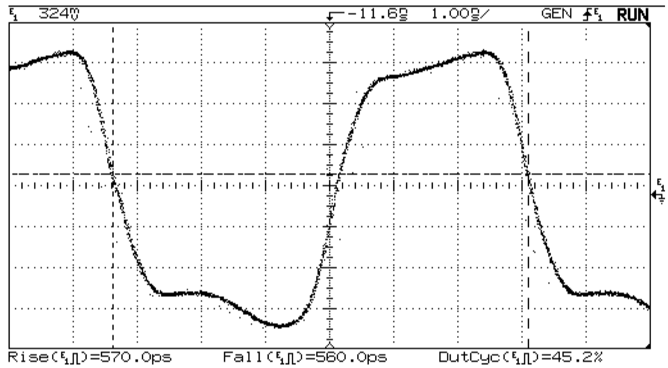


Figure 2-13. Pulse waveform with rise time, fall time and duty cycle measurements

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`

4. 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).

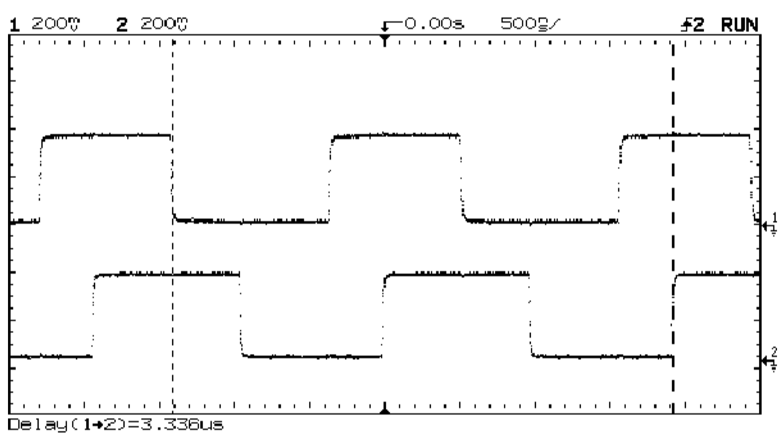


Figure 2-14. Automatic delay measurement

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
   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.

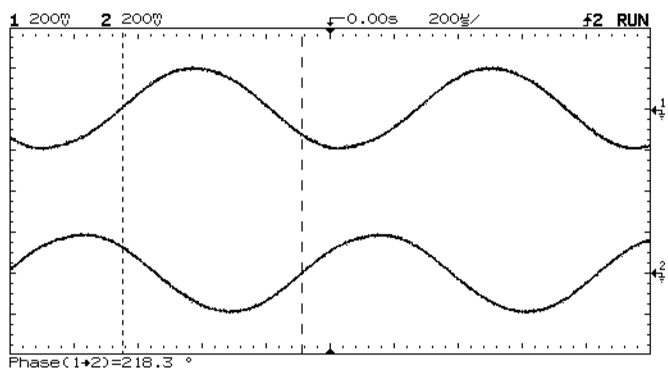


Figure 2-15. Automatic phase measurement

Making Extinction Ratio Measurements

This section contains information on making extinction ratio measurements with the lightwave communications analyzer. For additional information and recommended practices refer to Appendix A.

To perform an offset calibration

1. To perform an offset calibration, press:

   Optical Cal

   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 Genl Wvfm Eye:NRZ` Eye:NRZ
   `Source E1 Op` 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 percent, press:

   `More 1/4`
   `More 2/4`
   `More 3/4`
   `Select Units`
   `%`

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%.

5. When the limits are adjusted, press:

   `Previous Menu`

Measuring the extinction ratio

6. 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.

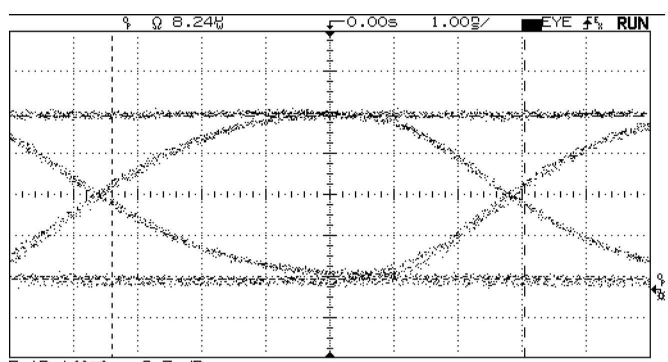


Figure 2-16. Eye diagram extinction ratio measurement results.

To 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 2-17 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:
     - V1 (P1) and V2 (P2) are voltage or power 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 V1 V2 V1 V2 (P1 P2 P1 P2) or T1 T2 T1 T2.
   - Clear Cursors

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

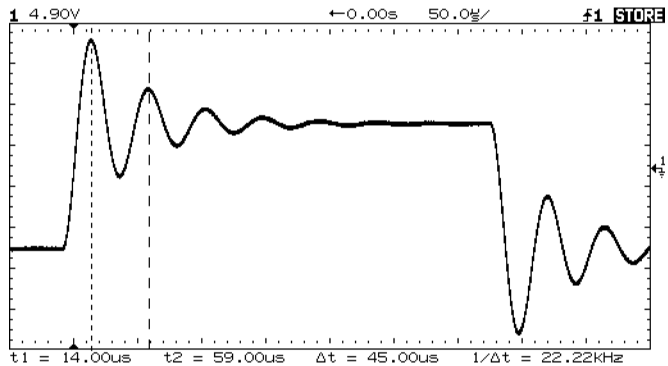


Figure 2-17. Cursors used to measure the frequency of the ringing on a pulse

To use masks and templates

The analyzer measures signal compliance to several standard defined masks and templates. For a complete list of the masks and templates available, refer to Chapter 4.

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 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. Use the general purpose knob to set:

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

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

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

   Select the OC3/STM1 mask by pressing:

Previous Menu
Select Mask
OC3/STM1
Done

5. 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 2-18 shows an OC-3/STM-1 mask conformance measurement.

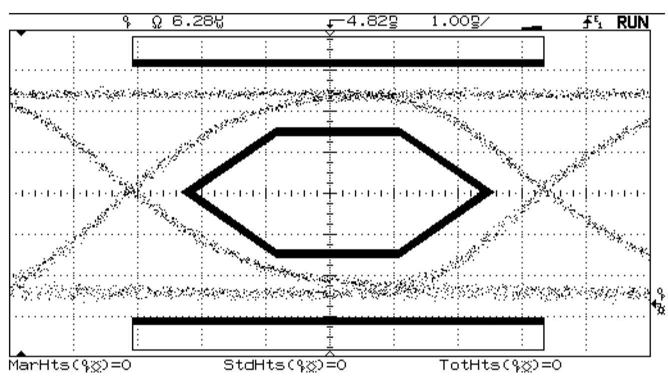


Figure 2-18. An OC-3/STM-1 mask conformance measurement

6. When the test is finished set the analyzer so the mask is continuously scaled to the data by pressing Show Mask Only Once Continuous <u>Continuous</u>.

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.

NOTE

Electrical templates for bipolar signals only function for positive pulses. For proper scaling only positive pulses should be displayed on the screen. Typically it is best to test a positive pulse that is preceeded by one or two zeros and followed by one or two zeros.

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 Genl 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.
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 2-19 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.

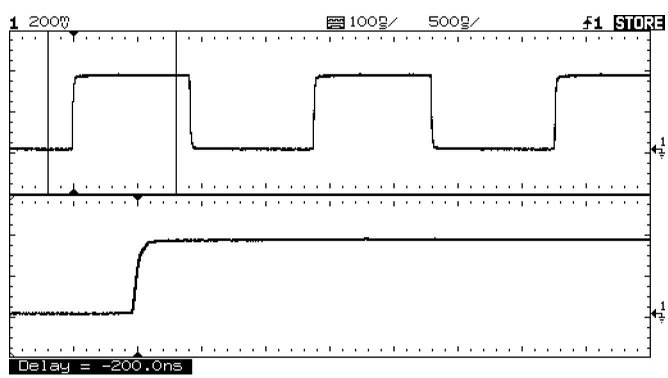


Figure 2-19. Time reference set to left

Figure 2-20 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.

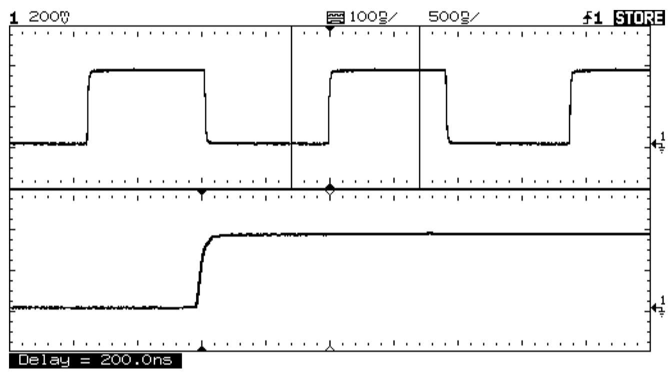


Figure 2-20. Time reference set to center

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 Mem#` softkey. The current display is saved to the selected memory location.
5. Turn on the `Trace Mem` 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 the `Recall Setup#` softkey. 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. Press (Setup).
2. To change the selected memory location, press either the left-most softkey or turn the knob closest to the Cursors key.
3. Press the Save softkey to save a front-panel setup, then press the Recall softkey to recall a front-panel setup.

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, 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 2-23), you can set up the analyzer to reduce the noise on the waveform (Figure 2-24).

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 Reject) adds a low pass filter with the 3dB point at 50 kHz (see Figure 2-21). Use HF reject to remove high frequency noise such as AM or FM broadcast stations from the trigger path.

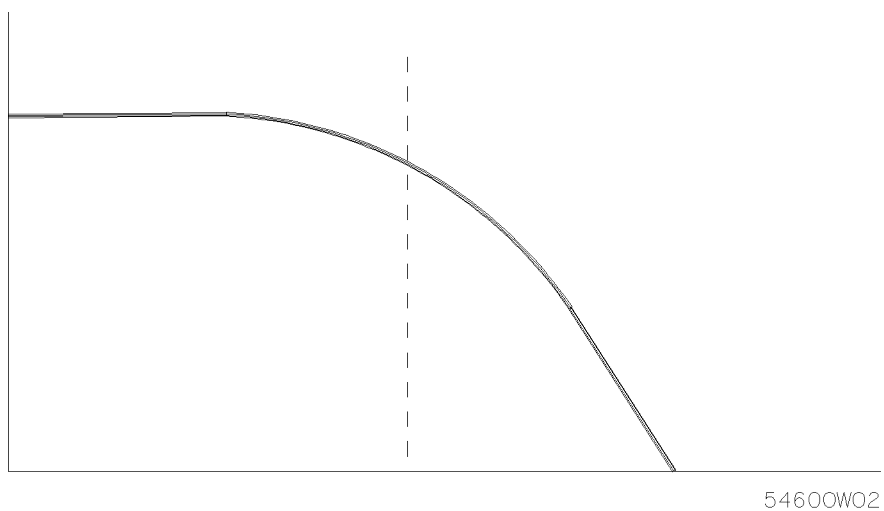


Figure 2-21. HF reject

Low frequency reject, LF Reject, adds a high pass filter with the 3-dB point at 50 kHz (see Figure 2-22). Use low frequency reject to remove low frequency signals such as power line noise from the trigger path.

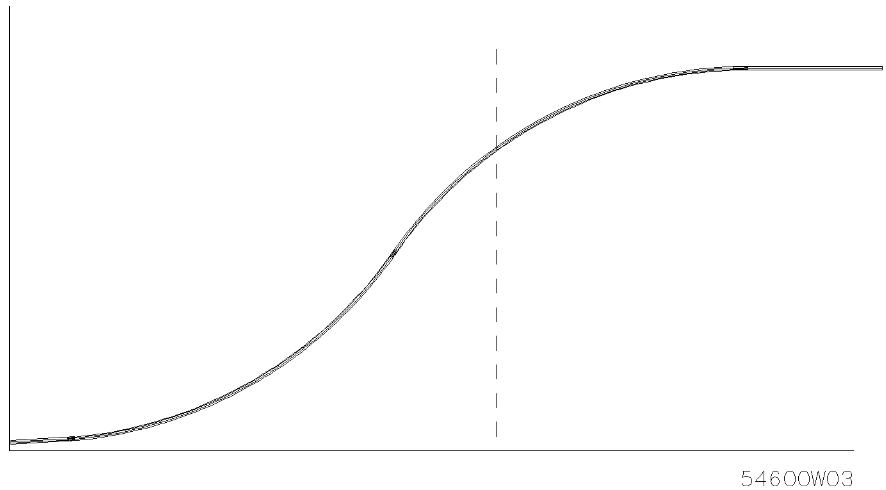


Figure 2-22. LF reject

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

   Noise Rej Off On <u>On</u>

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.

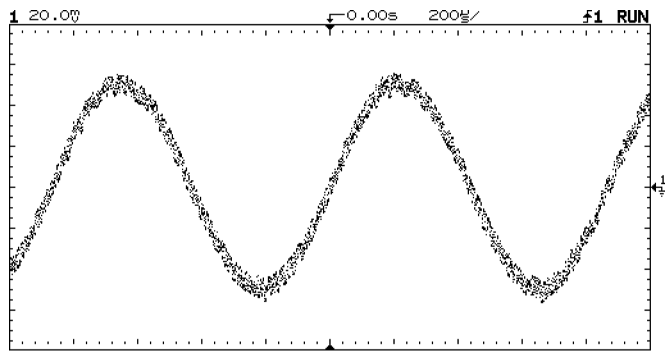


Figure 2-23. Random noise on the displayed waveform

Using averaging

4. To use averaging to reduce noise, press (Display).
5. Press the `Average` softkey. Notice `Av` appears in the status line.
6. Toggle the `# Average` softkey to select the number of averages that best eliminates the noise from the displayed waveform.

7. 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.

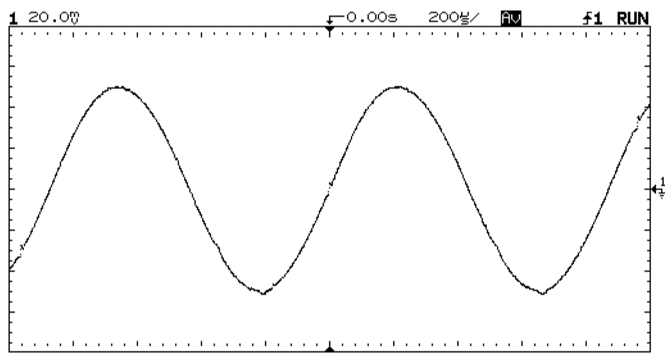


Figure 2-24. On this waveform, 256 averages were used to reduce the noise

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. Select Time Reference to Center, with the Graticule turned on.
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. Press Print/Utility, then select the `Self Cal` menu. This gives you access to the calibration and skew adjustments.
4. Select `Skew 1 → 2` to adjust channel 2 with respect to channel 1. Use the knob to bring the channels into time alignment.
5. Select `Skew 1 → E` to adjust the external trigger with respect to channel 1. 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 2-25 shows a waveform with asynchronous noise at the top of the pulse.

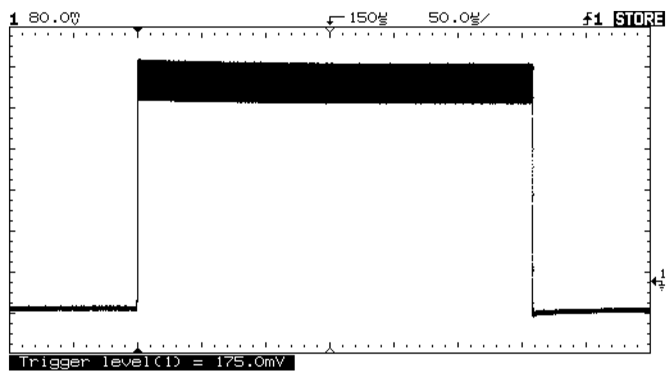


Figure 2-25. Asynchronous noise at the top of the pulse

2. Press (Autostore). Notice that STORE is displayed in the status line.
3. Set the Trigger Mode to 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.

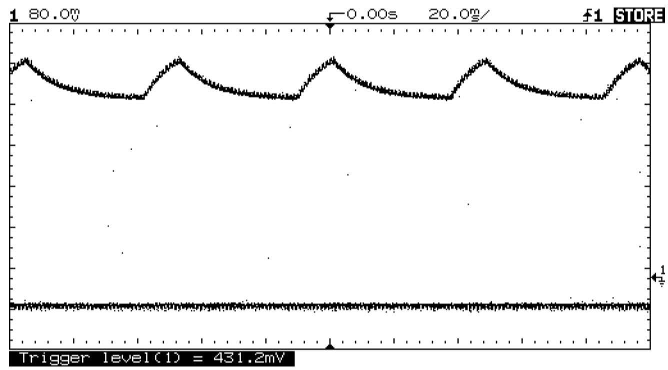


Figure 2-26. A triggered view of the asynchronous noise shown in Figure 2-25.

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). Next, press the `Peak Det` softkey. 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 μs/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 follow these steps.
6. Press (Main/Delayed). Next press the `Delayed` softkey.
7. Expand the time base to obtain a better resolution of the glitch.
8. Use the Delay knob to set the expanded portion of the main sweep over the glitch.
9. 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 2-27 shows a complex waveform that is not synchronized with the trigger.

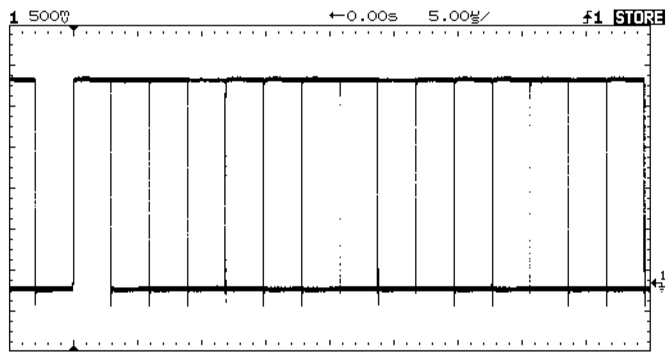


Figure 2-27. Stable trigger, but the waveform is not synchronized with the trigger

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 2-27 and waits for the trigger that results in Figure 2-28. Also notice in Figure 2-27 the trigger is stable, but the waveform is not synchronized with the trigger.

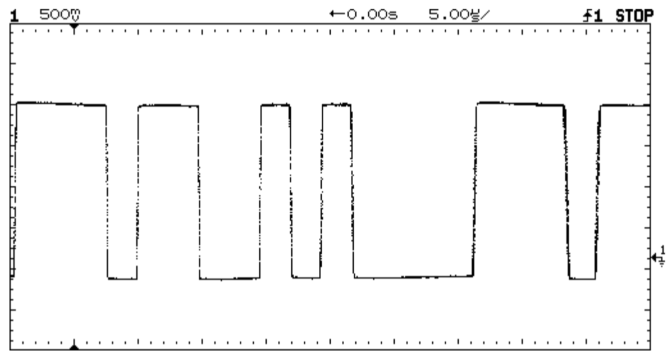


Figure 2-28. Holdoff synchronizes the waveform with the trigger

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. Press [Mode], then press the `Single` softkey.
7. Press [Erase] to clear previous measurements from the display.
8. Press [Run].

   Pressing the [Run] key arms the trigger circuit. 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. If you need 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 either [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.
4. Press the XY softkey.
5. 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.

$$sin\,\Theta = \frac{A}{B} or \frac{C}{B}$$

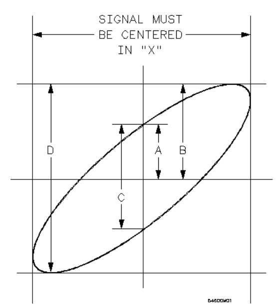


Figure 2-29.

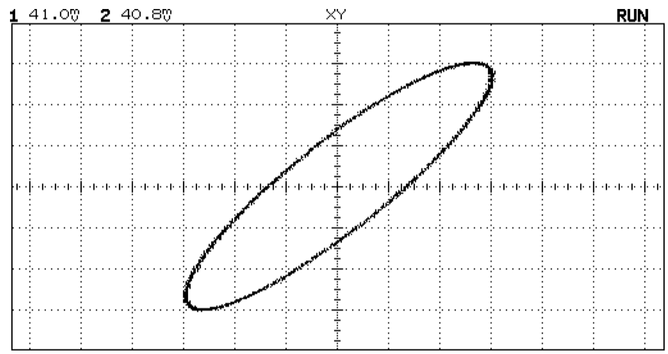


Figure 2-30.

6. Press (Cursors).
7. 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.

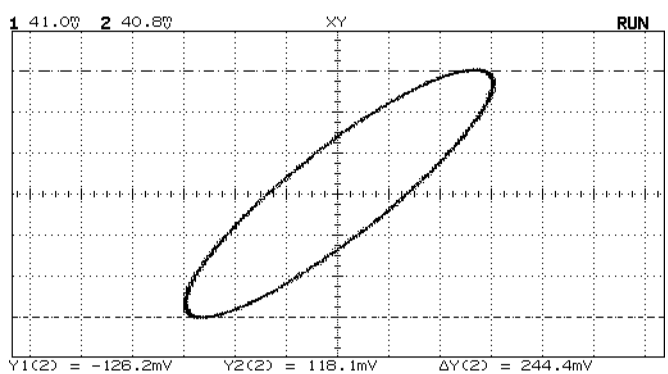


Figure 2-31.

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

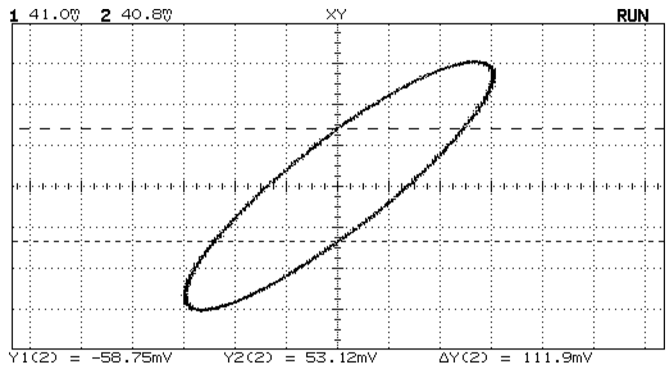


Figure 2-32.

9. Calculate the phase difference using formula below.

$$sin\,\Theta = \frac{second\ \Delta Y}{first\ \Delta Y} = \frac{111.9}{2444.4} = 27.25\ degrees\ of\ phase\ shift$$

N O T E

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

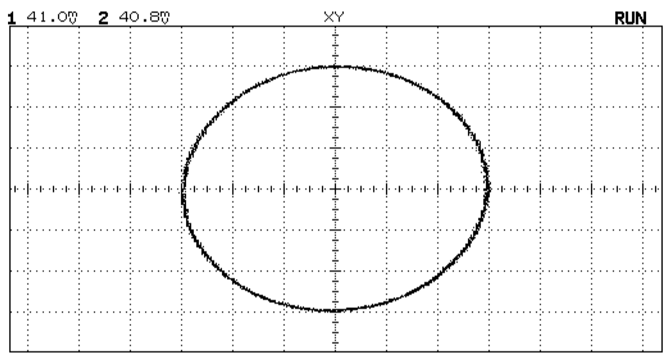


Figure 2-33. Signals are 90° out of phase

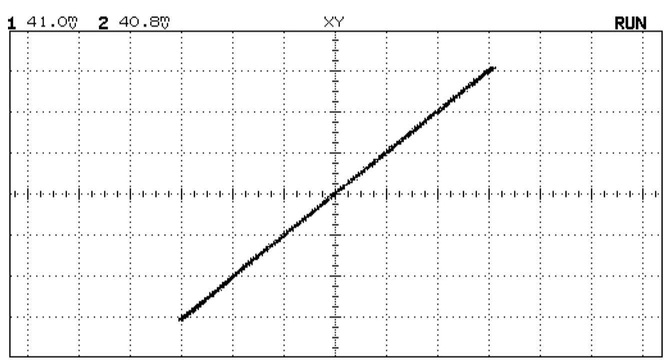


Figure 2-34. Signals are in phase

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 83475A 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 setup 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 oscilloscope 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 scope 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.

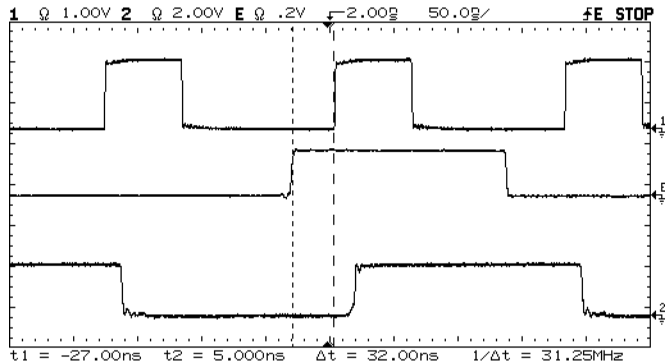


Figure 2-35. Setup time measurement

In Figure 2-35 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].
2. Press [Display].
3. Press the `Peak Det` softkey.
4. Press [Mode].
5. Press the `TV` softkey.
6. 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.

7. Press the `Field 2` softkey.
8. Set the time base to 200 μs/div, then center the signal on the display with the delay knob (delay about 800 μs).
9. Press [Main/Delayed].

10. Press the `Delayed` softkey.

11. Set the delayed sweep to 20 μs/div, then set the expanded portion over the VITS (delay about 988.8 μs).

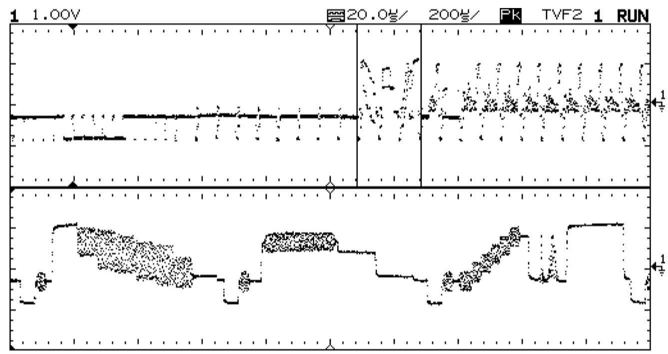


Figure 2-36. Frame 2 windowed on the VITS in Line 18

12. Press (Main/Delayed), then press the `Main` softkey.

13. Use the horizontal vernier to change the time base to 7 μs/div, then center the signal on the display with the delay knob (delay about 989 μs).

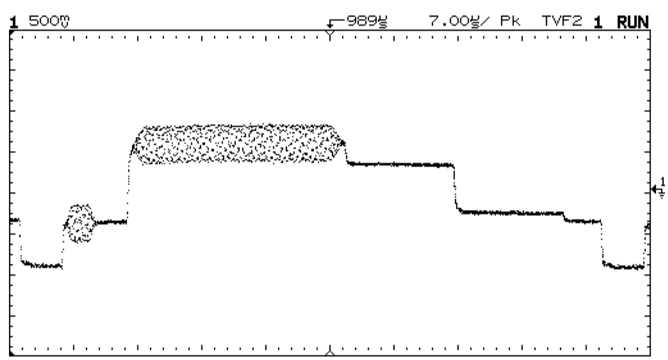


Figure 2-37. Full screen display of the IRE

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 83475A 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.

3

Menus and Reference Dictionary

Menus and Reference Dictionary

This chapter contains menu trees and a dictionary reference of front and rear-panel connectors, front panel keys, and softkeys. This chapter is designed so you can quickly access the information. Menu trees are in the front of the chapter. Keys that begin with a symbol are listed at the front of the dictionary, and all other keys and functions are listed alphabetically.

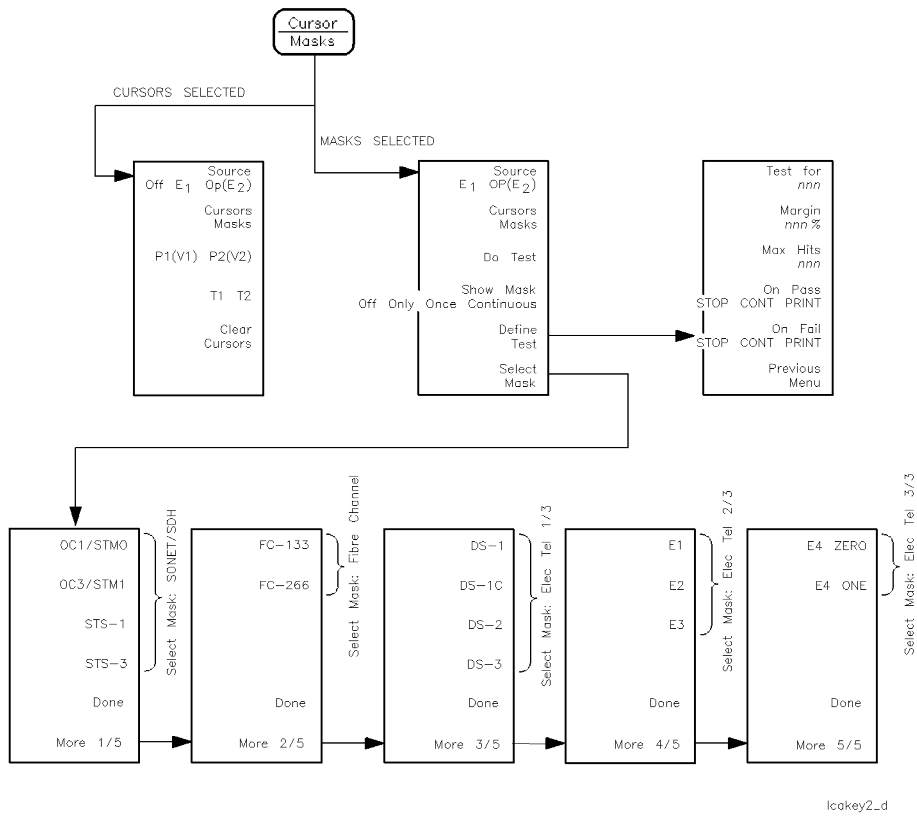


Figure 3-1. Cursor/Mask softkey menu

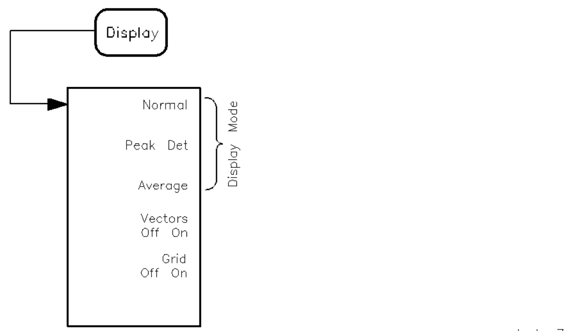


Figure 3-2. Display softkey menu

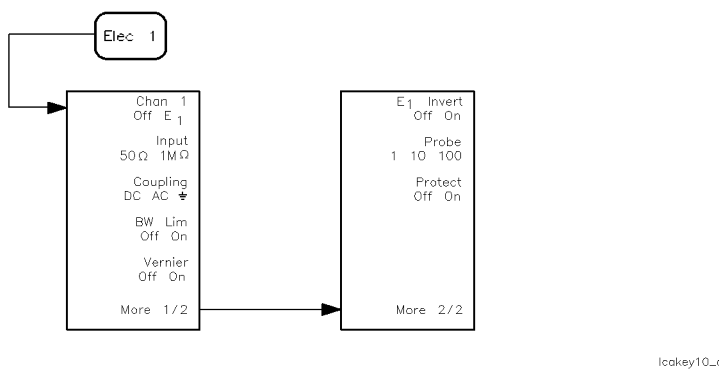


Figure 3-3. Elec 1 softkey menu

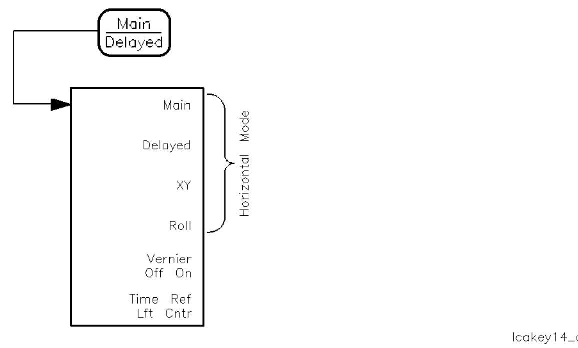


Figure 3-4. Main/Delayed softkey menu

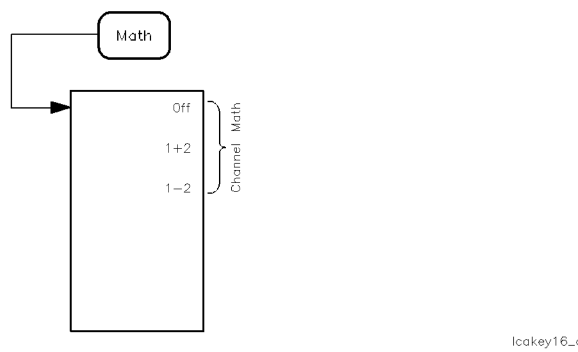


Figure 3-5. Math softkey menu

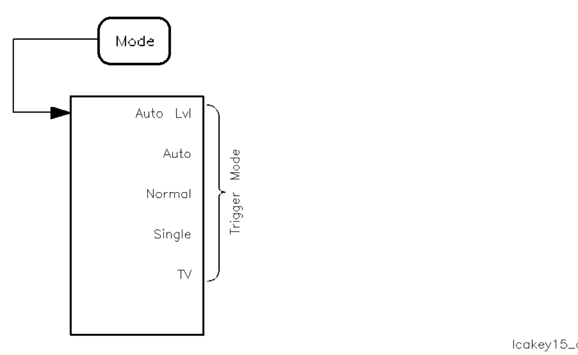


Figure 3-6. Mode softkey menu

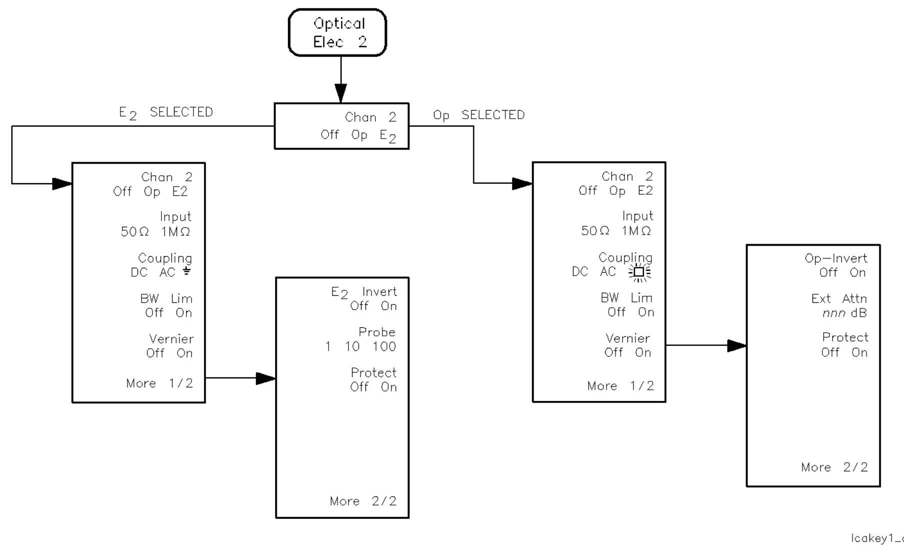


Figure 3-7. Optical/Elec 2 softkey menu

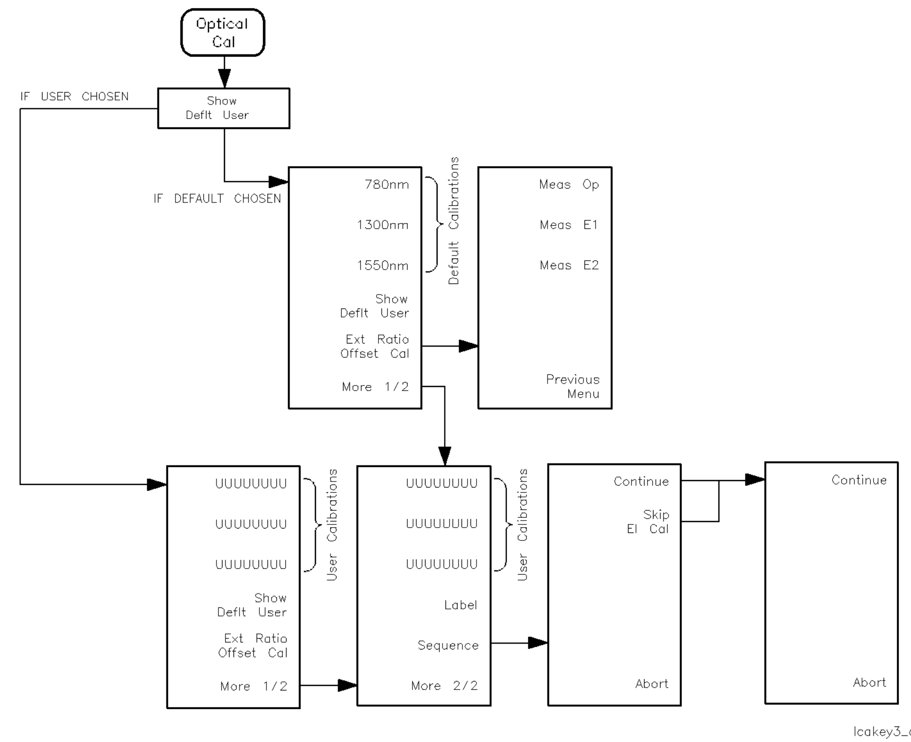


Figure 3-8. Optical Cal softkey menu

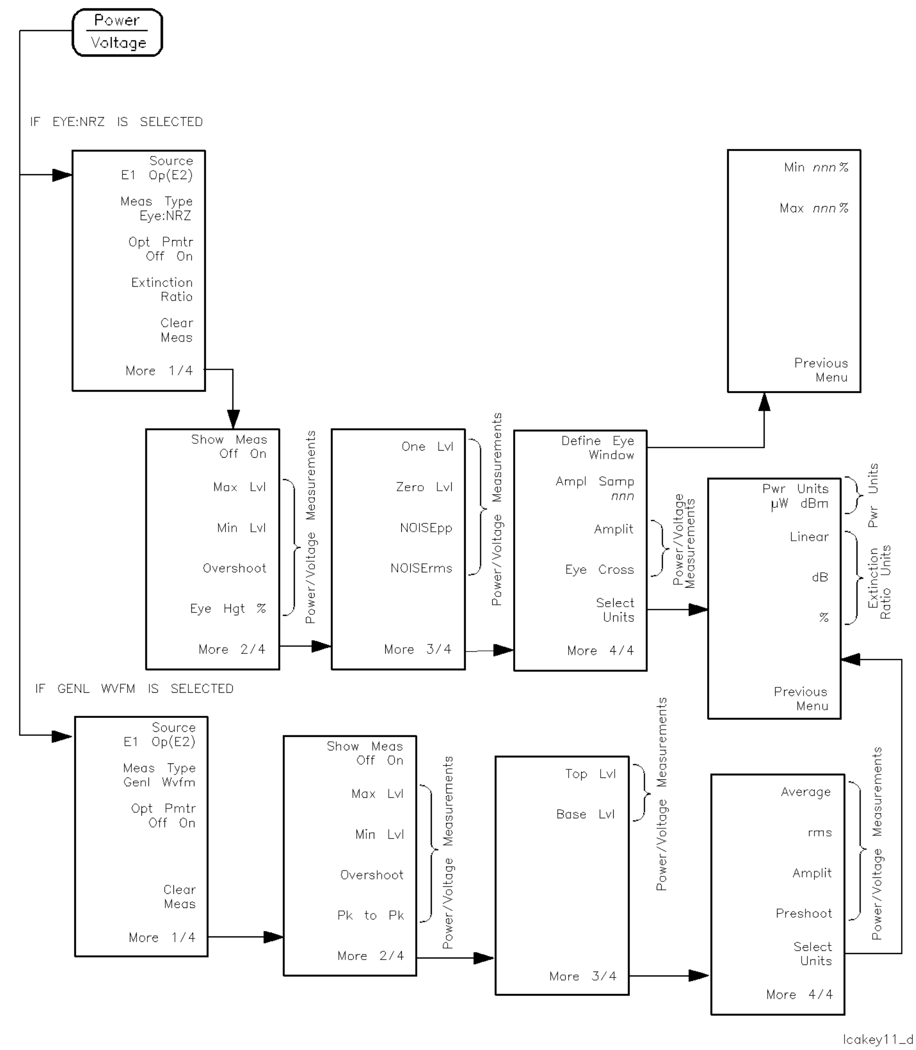


Figure 3-9. Power/Voltage softkey menu

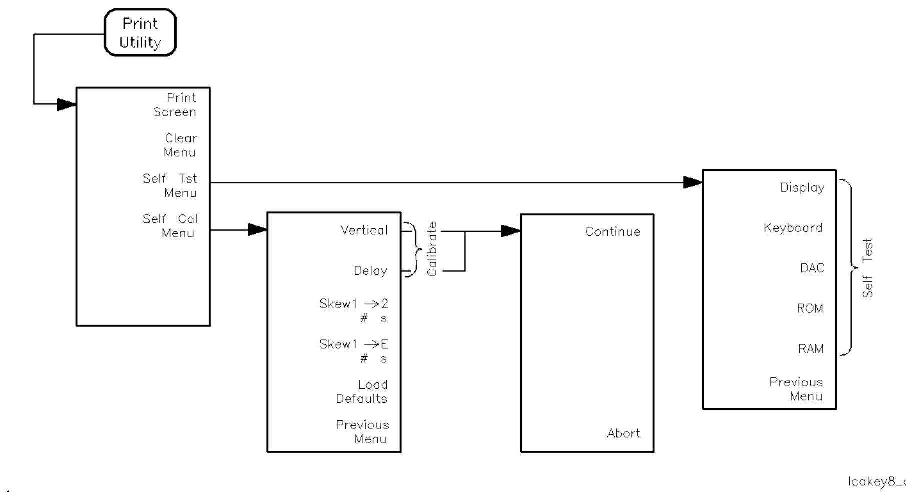


Figure 3-10. Print/Utility softkey menu

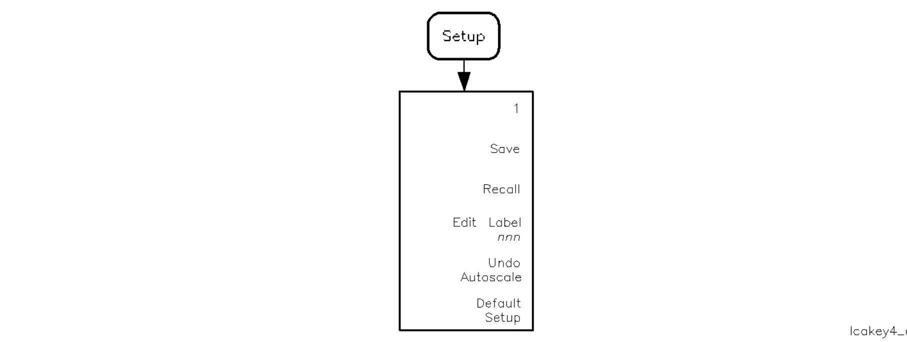


Figure 3-11. Setup softkey menu

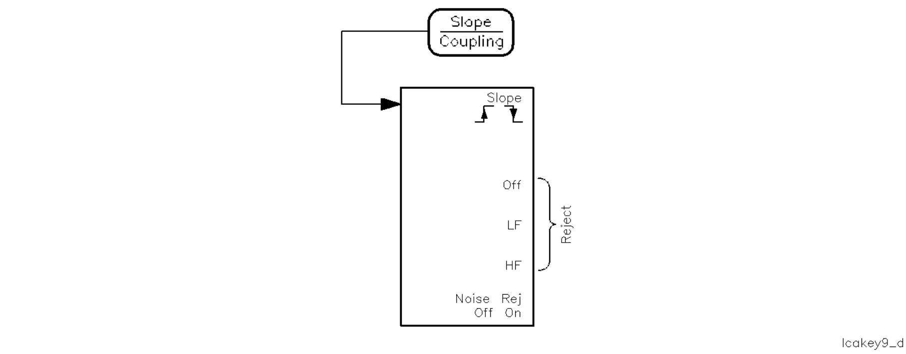


Figure 3-12. Slope/Coupling softkey menu

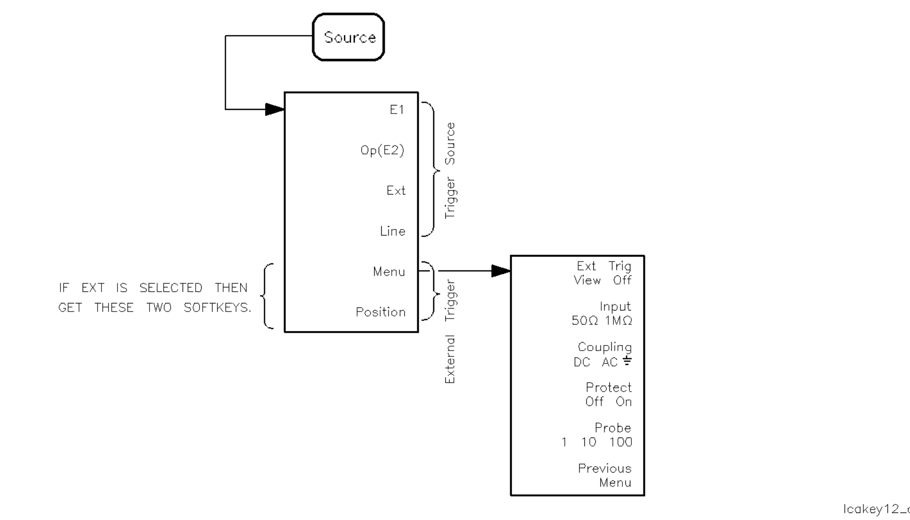


Figure 3-13. Source softkey menu

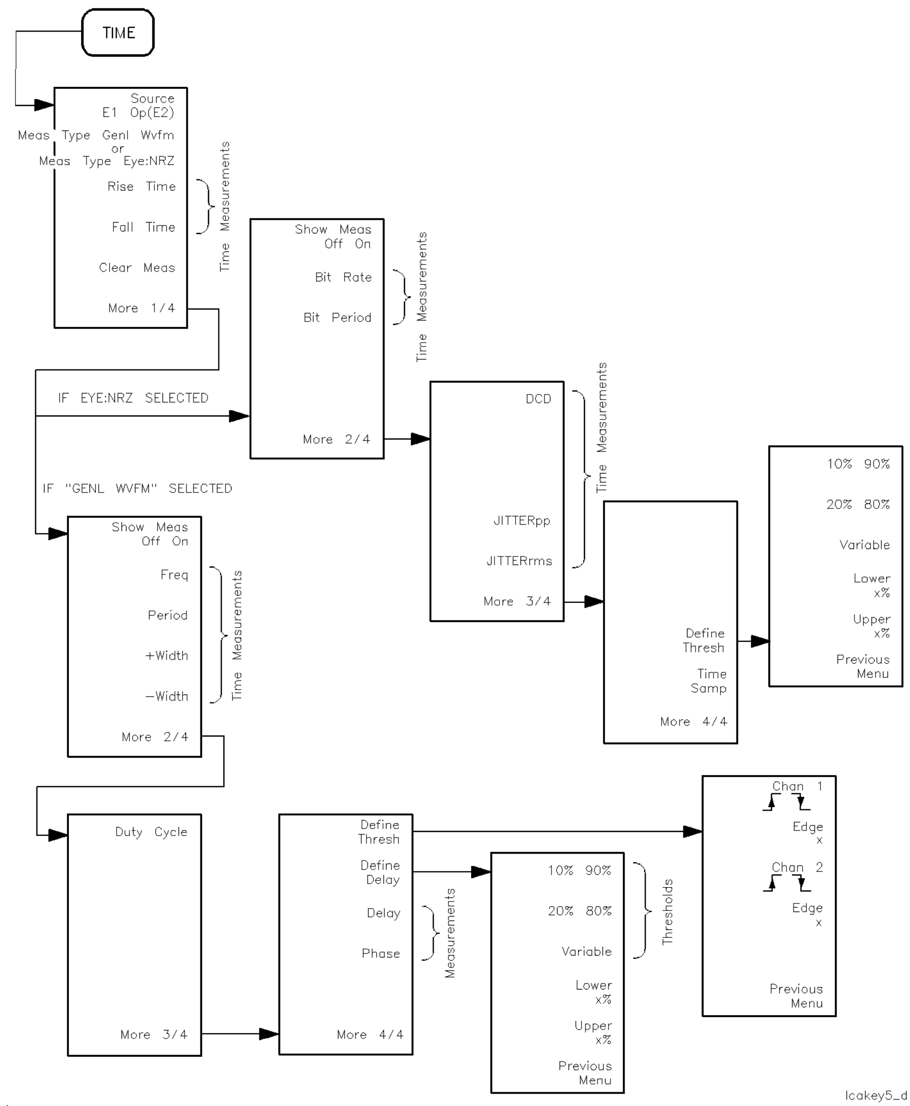


Figure 3-14. Time softkey menu

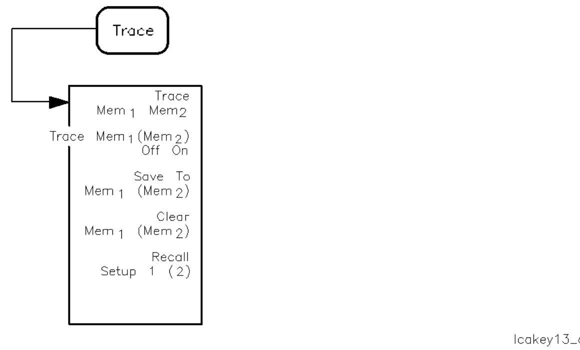


Figure 3-15. Trace softkey menu

+Width

Measures the time interval between the 50% level of the first rising edge and the 50% level of the next falling edge.

Key Path: (Time) More 1/4 +Width

−Width

Measures the time interval between the 50% level of the first falling edge and the 50% level of the next rising edge.

Key Path

Time More 1/4 —Width

%

Sets the extinction ratio measurement units to percent.

Key Path

Power/Voltage More 1/4 . . . More 3/4 Select Units %

1+2

Adds channel 1 and channel 2 and displays the resulting waveform. This function is not available when optical channel 2 is active.

Key Path

Math 1+2

1−2

Subtracts channel 2 from channel 1 and displays the resulting waveform. This function is not available when optical channel 2 is active.

Key Path

Math 1−2

10% 90%

Sets the time measurement thresholds to the 10% and 90% amplitude points on the waveform.

Key Path

Time More 1/4 . . . More 3/4 Define Thresh 10% 90%

13XX nm

Selects the 1300 nm factory calibration. The calibration is applied to both the vertical watts scale and the average optical power meter. The calibration is performed at 1310 nm ±20 nm.

Key Path

Optical Cal Show Deflt 1300 nm

15XX nm

Selects the 1550 nm factory calibration. The calibration is applied to both the vertical watts scale and the average optical power meter. The calibration is performed at 1550 nm ±20 nm.

Key Path

Optical Cal Show Deflt 1550 nm

20% 80%

Sets the time measurement thresholds to the 20% and 80% amplitude points on the waveform.

Key Path

Time More 1/4 ... More 3/4 Define Thresh 20% 80%

780 nm

Selects the 780 nm band factory calibration. The vertical watts scale and the average optical power meter are both calibrated for 780 nm −10/+20 nm.

Key Path

Optical Cal Show Deflt 780 nm

Abort

Halts a measurement or calibration sequence. Information is not saved.

Key Path

Optical Cal Show Deflt User User More 1/2 Sequence Abort

Optical Cal Ex Ratio Offset Cal Meas Op Abort

Print/Utility Self Cal Menu Vertical Abort

Print/Utility Self Cal Menu Delay Abort

Ampl Samp

Allows you to adjust the number of amplitude samples used when performing eye diagram statistical measurements. Use the general purpose knob (located below the front-panel Measurements section) to adjust the number of samples.

Key Path

(Power/Voltage)
Meas Type Eye:NRZ More 1/4 More 2/4 More 3/4 Ampl Samp

Amplit

Measures the voltage or power difference between the mean "1" and "0" levels of an eye diagram when Meas Type Eye:NRZ is selected.

Measures the voltage or power difference between the top level and base level of a waveform when Meas Type Genl Wvfm is selected.

Key Path

(Power/Voltage)
Meas Type Eye:NRZ More 1/4 ... More 3/4 Amplit

(Power/Voltage)
Meas Type Genl Wvfm More 1/4 ... More 3/4 Amplit

Auto

Selects the Auto Trigger mode. When this mode is selected, the analyzer free runs when the trigger concitions are not met.

Key Path

(Mode) Auto

Auto Lvl

Selects the Auto Level Trigger mode. In this mode the trigger level is automatically set to either the center of the signal, when dc coupled, or to the middle of the screen, when ac coupled.

Key Path

(Mode) Auto Lvl

(Auto-Scale)

Automatically optimizes the display of the input signal. Auto-scale requires signals with a frequency $\geq$50 Hz and a duty cycle >1.0%.

See Also

Undo Autoscale

Autostore

The most recently acquired data is displayed as a full-bright trace and previously acquired data is displayed at a half-bright level. To exit the Auto-trace mode either press Autostore again or press Run. To clear the display, press Erase.

Average

Number of averages The analyzer averages successive waveform data acquisitions. The number of data acquisitions averaged can be set to 8, 64, or 256.

Key Path Display Average

Average measurement Measures the average level of the displayed waveform.

Key Path Power/Voltage Meas Type Genl Wvfm More 1/4 . . . More 3/4 Average

Base Lvl

Measures the mean lowest level of a repetitive waveform.

Key Path Power/Voltage Meas Type Genl Wvfm More 1/4 More 2/4 Base Lvl

Bit Period

Measures the time interval between the two crossing points of the displayed eye diagram. The measurement is made on the left-most displayed eye diagram.

Key Path (Time) Meas Type Eye:NRZ More 1/4 Bit Period

See Also Bit Rate

Bit Rate

The inverse of the result obtained in a bit period measurement reported in bits/s units.

Key Path (Time) Meas Type Eye:NRZ More 1/4 Bit Rate

See Also Bit Period

BW Lim Off On

Turns a lowpass input filter (30 MHz cutoff) on and off.

Key Path (Elec 1) BW Lim Off On

(Optical/Elec 2) BW Lim Off On

Chan 1 ↑ ↓

Selects a rising or falling edge as the starting point for the delay measurement between channel 1 and channel 2.

Key Path

(Time) Meas Type Genl Wvfm More 1/4 ... More 3/4 Define Delay Chan 1 ↑ ↓

Chan 1 Off E1

Used to either turn channel 1 off or to activate electrical channel 1 (vertical scale displayed as volts).

Key Path

(Elec 1) Chan 1 Off E1

Chan 2 ↑ ↓

Selects a rising or falling edge as the starting point for the delay measurement between channel 1 and channel 2.

Key Path

(Time) Meas Type Genl Wvfm More 1/4 ... More 3/4 Define Delay Chan 2 ↑ ↓

Chan 2 Off Op E2

Used to:

- turn channel 2 off
- activate the optical channel (vertical scale displayed as watts)
- activate electrical channel 2 (vertical scale displayed as volts)

Key Path

Optical/Elec 2 Chan 2 Off Op E2

Clear Cursors

Removes all active measurement cursors from the display.

Key Path

Cursors/Masks Cursors Masks Cursors Clear Cursors

Clear Meas

Deactivates and erases all currently active automatic waveform measurements.

Key Path

Time Clear Meas

Power/Voltage Clear Meas

Clear Mem1 (2)

Clears the stored trace from memory location 1 (or 2).

Key Path

(Trace) Clear Mem1 (2)

Clear Menu

Clears the softkey menu display.

Key Path

(Print/Utility) Clear Menu

Continue

Continues an optical, electrical, or delay calibration sequence.

Key Path

(Optical Cal) Show User More 1/2 Sequence Continue

(Print/Utility) Self Cal Menu Vertical Continue

(Print/Utility) Self Cal Menu Delay Continue

Coupling DC AC Gnd

Selects the type of coupling for the external trigger and electrical channel 1 or 2; DC, AC, or ground.

Key Path

(Elec 1) Channel 1 Off E1 E1 Coupling DC AC Gnd

(Optical/Elec 2) Chan 2 Off E2 E2 Coupling DC AC Gnd

(Source) Ext Menu Coupling DC AC Gnd

Note

When the optical channel is active AC coupling is not accessible.

Key Path

(Optical/Elec 2) Chan 2 Off E2 Op Coupling DC Light/No Light

Cursors Masks

Selects between the Cursors and Masks measurement functionality.

Key Path

(Cursors/Masks) Cursors Masks Cursors

(Cursors/Masks) Cursors Masks Masks

(Cursors/Masks)

Provides access to the analyzer's cursor and mask measurement functions.

DAC

Performs the DAC self test.

Key Path

(Print/Utility) Self Tst Menu DAC

dB

Selects dB as the extinction ratio units.

Key Path

(Power/Voltage) More 1/4 ... More 3/4 Select Units dB

DCD

Performs a duty cycle distortion measurement on an eye diagram. Measures the time between the rising and falling edges of the eye diagram crossing at the 50% amplitude level.

Key Path

(Time) Meas Type Eye:NRZ More 1/4 More 2/4 DCD

Default Setup

Sets the instrument to the default state.

Table 3-1. Default Setup Conditions

Timebase Menu		**Display Menu**	
time/division	100 μs	mode	norm
delay	0.00 s	grid	on
reference	cntr	vectors	off
mode	main	**Cursors/Masks Menu**	
		ΔV markers	off
Channel Menu		Δt markers	off
Channel 1	on		
Channel 2	off	**Trace Menu**	
volts/division	100 mV	Trace	Mem 1
offset	0.00	Memory	off
coupling	dc		
probe attenuation	×1	**Measure Menu**	
vernier	off	Source	Channel 1
invert	off	Meas Type	Genl Wvfm
BW limit	off		
Trigger Menu			
Mode	auto level		
coupling	dc		
source	Channel 1		
level	0.0 V		
slope	positive		
reject and noise reject	off		
holdoff	200 ns		

Key Path (Setup) Default Setup

Define Delay

Accesses the Delay Measurement Definition menu.

Key Path

Time Meas Type Genl Wvfm More 1/4 . . . More 3/4 Define Delay

Define Thresh

Accesses the Threshold Definition menus for eye diagram and general waveform time measurements.

Key Path

Time Meas Type Genl Wvfm More 1/4 . . . More 3/4 Define Thresh

Time Meas Type Eye:NRZ More 1/4 . . . More 3/4 Define Thresh

Define Test

Accesses the Mask Test Parameters menu. This menu is used to set the following parameters:

test time
mask margin
max hits allowed to pass
on pass → stop, continue, or print
on fail → stop, continue, or print

Key Path

Cursors/Masks Cursors Masks Masks Define Test

Define Eye Window

Accesses the Eye Diagram Window Definition menu. This menu is used to set the minimum and maximum amplitude histogram window limits. Both limits are set in time as a percentage of the bit period. Samples are acquired within the specified boundaries for calculating Eye: NRZ statistical measurements.

Key Path

(Power/Voltage)
Meas Type Eye:NRZ More 1/4 ... More 3/4 Define Eye Window

Delay

Delay measurement

Measures the delay between signals applied to the channel 1 and channel 2 inputs.

Key Path

(Time) Meas Type Genl Wvfm More 1/4 ... More 3/4 Delay

Delay calibration

Starts an instrument delay calibration.

Key Path

(Print/Utility) Self Cal Menu Delay

Delayed

Selects the delayed horizontal sweep mode.

Key Path

(Main/Delayed) Delayed

(Display)

Accesses the Display menu.

Display

Performs the Display self test.

Key Path

(Print/Utility) Self Tst Menu Display

Done

Used to finalize the mask selection operation.

Key Path

(Cursors/Masks)
Cursors Masks Masks Select Mask Select desired mask, Done

(Cursors/Masks)
Cursors Masks Masks Select Mask More 1/5 Done

(Cursors/Masks)
Cursors Masks Masks Select Mask More 1/5 More 2/5 Done

(Cursors/Masks)
Cursors Masks Masks Select Mask More 1/5 . . . More 3/5 Done

(Cursors/Masks)
Cursors Masks Masks Select Mask More 1/5 . . . More 4/5 Done

(Cursors/Masks)
Cursors Masks Masks Select Mask More 1/5 . . . More 5/5 Done

Do Test

Performs a mask/template test as defined under the Define Test softkey.

Key Path

(Cursors/Masks) Cursors Masks Masks Do Test

See Also

Define Test

DS-1

Selects the ANSI T1.102 specified template for the 1.544 Mb/s rate.

Key Path

Cursors/Masks
Cursors Masks Masks Select Mask More 1/5 More 2/5 DS-1

DS-1c

Selects the ANSI T1.102 specified template for the 3.152 Mb/s rate.

Key Path

Cursors/Masks
Cursors Masks Masks Select Mask More 1/5 More 2/5 DS-1C

DS-2

Selects the ANSI T1.102 specified template for the 6.312 Mb/s rate.

Key Path

Cursors/Masks
Cursors Masks Masks Select Mask More 1/5 More 2/5 DS-2

DS-3

Selects the ANSI T1.102 specified template for the 44.736 Mb/s rate.

Key Path

Cursors/Masks
Cursors Masks Masks Select Mask More 1/5 More 2/5 DS-3

Duty Cycle

Performs a duty cycle measurement on a general or pulsed waveform. Measures the percentage of the period occupied by the first rising edge to first falling edge transition.

Key Path

Time Meas Type Genl Wvfm More 1/4 More 2/4 Duty Cycle

E1

Selects the ITU-TS G.703 specified template for the 2.048 Mb/s rate.

Key Path

Cursors/Masks
Cursors Masks Masks Select Mask More 1/5 . . . More 3/5 E1

E2

Selects the ITU-TS G.703 specified template for the 8.448 Mb/s rate.

Key Path

Cursors/Masks
Cursors Masks Masks Select Mask More 1/5 . . . More 3/5 E2

E3

Selects the ITU-TS G.703 specified template for the 34.368 Mb/s rate.

Key Path

Cursors/Masks
Cursors Masks Masks Select Mask More 1/5 . . . More 3/5 E3

E4 ONE

Selects the ITU-TS G.703 specified template for a binary "1" at the 139.264 Mb/s rate.

Key Path

Cursors/Masks
Cursors Masks Masks Select Mask More 1/5 . . . More 4/5 E4 ONE

E4 ZeroZERO

Selects the ITU-TS G.703 specified template for a binary "0" at the 139.264 Mb/s rate.

Key Path

Cursors/Masks

Cursors Masks Masks Select Mask More 1/5 . . . More 4/5 E4 ZERO

Edge

Selects the edge numbers for both the channel 1 and channel 2 inputs, from which the delay measurement is derived. The delay measurement is made from the specified edge on the channel 1 waveform to the specified edge on the channel 2 waveform.

Key Path

Time

Meas Type Genl Wvfm More 1/4 . . . More 3/4 Define Delay Edge #

Elec 1

Accesses the menus for the Channel 1 Electrical Input.

Edit Label _______

Allows you to label instrument setups with unique names so they can be recalled when desired.

Key Path

(Setup) Edit Label _______

(Erase)

Removes the current trace, stored information, displayed mask or displayed template from the screen.

Ext Ratio Offset Cal

Accesses the Extinction Ratio Offset Calibration menu.

(Optical Cal) Ext Ratio Offset Cal

Ext Attn

Provides 0 to 20 dB of correction, in 0.1 dB increments, when external attenuation is used on the optical input channel. The correction is applied to the vertical watts scale, power meter measurements, and all cursor and automatic amplitude measurements.

Key Path

(Optical/Elec 2) Chan 2 Off E2 Op Op More 1/2 Ext Attn dB

Ext Trig View Off On

Turns the view of the external trigger on, (Ext Trig View Off On On), and off, (Ext Trig View Off On Off).

Key Path

(Source) Ext Menu Ext Trig View Off On

Extinction Ratio

Measures the extinction ratio of the displayed eye diagram. For more information, refer to Appendix A.

Key Path

(Power/Voltage) Meas Type Eye:NRZ Extinction Ratio

Eye Cross

Measures the crossing point on the displayed eye diagram as a percentage of the eye diagram mean "0" to mean "1" level amplitude.

Key Path

(Power/Voltage) Meas Type Eye:NRZ More 1/4 ... More 3/4 Eye Cross

Eye Hgt %

Measures the eye opening as a percentage of the mean "0" to mean "1" level separation. Amplitude histograms are used in the mean "1" and "0" level calculations. The eye opening is defined as the separation between three standard deviations above the mean "0" level and three standard deviations below the mean "1" level.

Key Path

(Power/Voltage) Meas Type Eye:NRZ More 1/4 Eye Hgt %

Fall Time

Measures the fall time of the displayed waveform. On both eye diagrams and general waveforms, the fall time can be measured between the 90%–10% thresholds, the 80%–20% thresholds, or user-defined thresholds. Histograms are used to locate the thresholds on the eye. User-defined thresholds are entered as a percentage of the waveform amplitude.

Key Path

(Time) Meas Type Eye:NRZ Fall Time

(Time) Meas Type Genl Wvfm Fall Time

FC-133

Selects the Fibre Channel standard mask for the 133 MBaud/s rate.

Key Path

Cursors/Masks Cursors Masks Masks Select Mask More 1/5 FC-133

FC-266

Selects the Fibre Channel standard mask for the 266 MBaud/s rate.

Key Path

Cursors/Masks Cursors Masks Masks Select Mask More 1/5 FC-266

Freq

Measures the frequency of a displayed waveform and displays the results in Hertz.

Key Path

Time Meas Type Genl Wvfm More 1/4 Freq

Grid Off On

Turns the display of the grid on and off.

Key Path

(Display) Grid Off On

HF

Removes the noise from the trigger path by turning on high frequency noise rejection.

Key Path

(Slope/Coupling) HF

Input 50 1MΩ

Selects either 50Ω or 1 MΩ input impedance for the electrical channel inputs.

Key Path

(Elec 1) Input 50Ω 1 MΩ

(Optical Elec 2) Chan 2 Off Op E2 E2 Input 50Ω 1 MΩ

Invert Off On

Inverts the signal connected to the channel 1 (or 2) input. Inversion does not function when the optical channel is active.

Key Path

(Elec 1) More 1/2 E1 Invert Off On

(Optical/Elec 2) Chan 2 Off Op E2 E2 More 1/2 Op Invert Off On

JITTERpp

Measures the peak-to-peak jitter at the eye diagram crossing point. Histograms are used to locate the crossing point and calculate the peak-to-peak jitter as six times the RMS jitter.

Key Path

(Time) Meas Type Eye:NRZ More 1/4 More 2/4 JITTERpp

JITTERrms

Measures the rms jitter at the eye diagram crossing point. The rms jitter is equal to the standard deviation of a time histogram taken at the crossing point.

Key Path

(Time) Meas Type Eye:NRZ More 1/4 More 2/4 JITTERrms

Keyboard

Performs the keyboard self test.

Key Path

(Print/Utility) Self Tst Menu Keyboard

Label

Allows you to label calibrations with unique names so they can be recalled when desired.

Key Path

(Optical Cal) Show User More 1/2 Label

LF

Removes the noise from the trigger path by turning on low frequency noise rejection.

Key Path

(Slope/Coupling) LF

Line

Selects an internal signal of the same frequency as the power line signal, (50–60 Hz), as the trigger source.

Key Path

(Source) Line

Linear

Displays the extinction ratio results as the linear ratio between the "1" and "0" levels.

Key Path

(Power/Voltage) More 1/4 . . . More 3/4 Select Units Linear

Load Defaults

Loads the default vertical calibration and delay calibration factors for the electrical channels.

Key Path

(Print/Utility) Self Cal Menu Load Defaults

Lower __ %

Selects the lower time measurement threshold. Use the general purpose knob to adjust the threshold. The threshold is used in time measurements such as rise time and fall time.

Key Path

(Time)
Meas Type Genl Wvfm More 1/4 ... More 3/4 Define Thresh
Variable Lower __ %

Main

Selects the main horizontal sweep mode.

Key Path

(Main/Delayed) Main

(Main/Delayed)

Accesses the Horizontal Sweep Mode menu.

Margin x %

Margins can be added to the mask/template tests. This margin is added as a percent of the mask. Zero percent margin corresponds to the default mask. One hundred percent margin corresponds to the mean of the histograms of the one and zero levels, and the crossing points.

Negative mask margins can also be implemented. These can be used to gain an idea of the severity of the encountered errors.

Key Path: Cursors/Masks Cursors Masks Masks Define Test Margin x %

Math

Accesses the Math Functions menu for functions such as channel addition and channel subtraction.

Max Hits __

Sets the maximum number of hits allowed to pass.

Key Path: Cursors/Masks Cursors Masks Masks Define Test Max Hits __

Max Lvl

Measures the peak amplitude of the most recent waveform acquisition. This measurement can be performed on either eye diagram or general waveforms.

Key Path

(Power/Voltage) Meas Type Eye:NRZ More 1/4 Max Lvl

(Power/Voltage) Meas Type Genl Wvfm More 1/4 Max Lvl

Max___

Sets the marker defining the upper limit of the horizontal histogram window when performing a power or voltage eye diagram measurement. The limit is set as a percentage of the bit period.

Key Path

(Power/Voltage) Meas Type Eye:NRZ More 1/4 . . . More 3/4 Define Eye Window Max ___

Meas E1 (or E2)

Determines and corrects the residual DC offset of electrical channel 1 (or 2). This measurement is performed during the extinction ratio offset calibration on channel 1 (or 2).

Key Path

(Optical Cal) Ext Ratio Offset Cal Meas E1 (or E2)

Meas Op

Determines and corrects the residual DC offset of the optical channel. This measurement is performed during the extinction ratio offset calibration of the optical channel.

Key Path

(Optical Cal) Ext Ratio Offset Cal Meas Op

Meas Type Genl Wvfm Eye:NRZ

Selects the type of measurements that can be performed on the input signal.

Select Meas Type Genl Wvfm Eye:NRZ Genl Wvfm to perform measurements, such as frequency or phase, on general repetitive waveforms.

Select Meas Type Genl Wvfm Eye:NRZ Eye:NRZ to perform eye diagram measurements such as bit rate or eye crossing point.

Key Path

(Power/Voltage) Meas Type Genl Wvfm Eye:NRZ

(Time) Meas Type Genl Wvfm Eye:NRZ

Measure

Starts the measurement sequence when an optical channel user-calibration is being performed.

Key Path

(Optical Cal)
Show User More 1/2 Sequence Continue Measure

(Optical Cal)
Show User More 1/2 Sequence Skip Elec Cal Measure

Menu

Displays the External Trigger menu. The menu includes functions such as external trigger view, coupling and protection.

Key Path

(Source) Ext Menu

Min Lvl

Measures the lowest amplitude of the most recent waveform acquisition. This measurement can be performed on either eye diagram or general waveforms.

Key Path

(Power/Voltage) Meas Type Eye:NRZ More 1/4 Min Lvl

(Power/Voltage) Meas Type Genl Wvfm More 1/4 Min Lvl

Min___

Sets the marker defining the lower limit of the horizontal histogram window when performing a power or voltage eye diagram measurements. This limit is set as a percentage of the bit period.

Key Path

(Power/Voltage) Meas Type Eye:NRZ More 1/4 . . . More 3/4 Define Eye Window Min ___

(Mode)

Accesses the Trigger Mode menu which includes the Auto Lvl , Auto Normal , Single and TV trigger mode functions.

NOISEpp

Measures the peak-to-peak noise on the "1" level of an eye diagram waveform. The peak-to-peak is six times the rms noise.

Key Path

(Power/Voltage) Meas Type Eye:NRZ More 1/4 More 2/4 NOISEpp

Noise Rej Off On

Turns noise rejection on and off. When activated, it reduces the effects of noise by increasing the trigger hysteresis band.

Key Path

(Slope/Coupling) Noise Rej Off On

NOISErms

Measures the rms noise on the "1" level of an eye diagram waveform. THe rms noise is the standard deviation of an amplitude histogram taken at the "1" level amplitude of the eye diagram under analysis.

Key Path

(Power/Voltage) Meas Type Eye:NRZ More 1/4 More 2/4 NOISErms

Normal

Selects the normal display and normal trigger modes. In normal mode, the analyzer acquires data when a trigger event is detected.

Key Path

(Display) Normal

(Mode) Normal

OC1/STM0

Selects the SONET/SDH 51.84 Mb/s optical line interface standard mask (as defined by the Bellcore TA-NWT-000253 standard document).

Key Path

(Cursors/Masks) Cursors Masks Masks Select Mask OC1/STM0

OC3/STM1

Selects the SONET/SDH 155.52 Mb/s optical line interface standard mask (as defined by the ITU-TS G.957 standard document).

Key Path

(Cursors\Masks) Cursors Masks Masks Select Mask OC3/STM1

One Lvl

Measures the mean "1" level of an eye diagram waveform. The histogram window used in the measurement is defined under the Define Eye Window softkey.

(Power/Voltage) Meas Type Eye:NRZ More 1/4 More 2/4

One Lvl

On Fail Stop Cont Print

Select the action desired if the mask test fails. Selections include:

STOP Stops the display when the measurement fails. To restart, press (RUN).

CONT The measurement result is given and the analyzer continues normal data display.

PRINT Sends the test results to the printer.

Key Path (Cursors Masks)
Cursors Masks Masks Define Test On Fail STOP CONT PRINT

On Pass Stop Cont Print

Select the action desired if the mask test is passed. Selections include:

STOP Stops the display when the mask measurement fails. To restart, press (RUN).

CONT The measurement result is given and the analyzer continues normal data display.

PRINT Sends the test results to the printer.

Key Path (Cursors Masks)
Cursors Masks Masks Define Test On Pass STOP CONT PRINT

Optical/Elec 2

Accesses the Optical Channel and Electrical Channel 2 menus.

Optical Cal

Accesses the Optical Calibration menus.

Opt Pmtr Off On

Turns the optical power meter on and off. To insure proper operation, make sure the desired optical calibration is selected under the Optical Cal key.

Key Path Power/Voltage Opt Pmtr Off On

Overshoot

Measures overshoot as a percentage of the base-to-top waveform amplitude. This measurement can be performed on either eye diagram or general waveforms.

Key Path Power/Voltage More 1/4 Overshoot

P1(V1) P2(V2)

Selects power (or voltage) cursors for making amplitude measurements.

Key Path

(Cursors/Masks) Cursors Masks Cursors P1(V1) P2(V2)

Peak Det

Selects the peak detect display mode.

Key Path

(Display) Peak Det

Period

Measures the period between the first and second rising edges of a repetitive signal.

Key Path

(Time) Meas Type Genl Wvfm More 1/4 Period

Phase

Measures the phase shift between the channel 1 and channel 2 signals. The measurement is made from the rising edge of the first full cycle on the channel 1 input to the rising edge of the first full cycle on the channel 2 input.

Key Path

(Time) Meas Type Genl Wvfrm More 1/4 More 2/4 More 3/4 Phase

Pk to Pk

Measures the peak-to-peak amplitude of a general waveform. Measures the difference between the maximum and minimum amplitude levels.

Key Path

(Power/Voltage) Meas Type Genl Wvfm More 1/4 Pk to Pk

Position

Select to adjust the external trigger offset position. After pressing this key, use the general purpose knob (located below the front-panel Measurements section) to adjust the external trigger offset.

This function is only available when the external trigger is selected as the trigger source.

Key Path

(Source) Ext Position

Power/Voltage

Accesses the Amplitude Measurement menus.

Preshoot

Measures preshoot on a general waveform as a percentage of the base-to-top amplitude separation.

Key Path

Power/Voltage
Meas Type Genl Wvfm More 1/4 ... More 3/4 Preshoot

Print Screen

Sends the current display to the selected printer or plotter.

Key Path

Print/Utility Print Screen

Print/Utility

Accesses the Print Utility menus.

Probe 1 10 100

Selects the appropriate electrical probe attenuation so the vertical voltage scale is displayed correctly.

Key Path

(Elec 1) More 1/2 Probe 1 10 100

(Optical/Elec 2) Chan 2 Off OP E2 E2 More 1/2 Probe 1 10 100

Protect Off On

Turns input protection on and off. When protection is on and Input 50Ω 1 MΩ 50Ω is selected, the 50Ω load will disconnect if greater than 5 Vrms is detected at either the channel 1 or channel 2 electrical input.

Key Path

(Elec 1) More 1/2 Protect Off On

(Optical/Elec 2) More 1/2 Protect Off On

PwrUnits μW dBm

Selects the measurement units for average optical power meter measurements and instantaneous power amplitude measurements.

Key Path

(Power/Voltage)
More 1/4 ... More 3/4 Select Units PwrUnits μW dBm

RAM

Performs the RAM self test.

Key Path

(Print/Utility) Self Tst Menu RAM

Recall

Recall an instrument setup from the displayed list of previously saved setups.

Key Path

(Setup) Recall

Recall Setup1 (2)

Recall a trace setup from memory location 1 (or 2).

Key Path

(Trace) Recall Setup 1 (2)

Rise Time

Measures the rise time of the displayed general waveform or eye diagram. The measurement threshold can be specified using the Define Thresh softkey.

Key Path: (Time) Rise Time

See Also: Define Thresh

Roll

Selects roll mode for the horizontal sweep. Automatic General Waveform measurements can be made in 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.

Key Path: (Main/Delayed) Roll

ROM

Performs the ROM self test.

Key Path: (Print/Utility) Self Tst Menu ROM

rms

Measures the root mean squared value of a repetitive general waveform.

Key Path

(Power/Voltage)
Meas Type Genl Wvfm More 1/4 . . . More 3/4 rms

(Run)

Restarts the display after the (Stop) key has been pressed and deactivates the Autostore mode.

Save

Saves the current instrument setup using the filename entered with the Edit Label function.

Key Path

(Setup) Save

Save to Mem1 Mem2

Saves the currently displayed trace to memory location 1 or 2.

Key Path

Trace Save to Mem1 Mem2

Select Mask

Accesses the Mask/Template Selection menu. Standard masks or templates can be selected for testing and analysis.

Key Path

Cursors/Masks Cursors Masks Masks Select Mask

Select Units

Displays the menu used to select the display units for both power and extinction ratio measurements.

Key Path

Power/Voltage
More 1/4 . . . More 3/4 Select Units

Self Cal Menu

Accesses the Self Cal menu for vertical and horizontal calibration functions.

Key Path

(Print/Utility) Self Cal Menu

Self Tst Menu

Accesses the Self Test menu.

Key Path

(Print/Utility) Self Tst Menu

Sequence

Starts the process for performing an optical power user calibration. The calibration is applied to both the power meter and the watts vertical scale.

Key Path

(Optical Cal) Show User More 1/2 Sequence

(Setup)

Accesses the Setup menu used for saving and recalling instrument setups.

Show Deflt User

Selects either the default optical calibrations or the user-performed calibration.

Key Path

Optical Cal Show Deflt User

Show Mask Off Only Once Cont

Selects the mode of operation for mask scaling.

Off	Erases and de-activates the currently displayed mask or template.
Only Once	Scales the selected mask or template to the displayed waveform after a single data acquisition.
Cont	Automatically rescales the mask or template whenever the waveform changes or when vertical or horizontal instrument settings are adjusted.

Key Path

Cursor\Masks Cursors Masks Masks Show Mask Off Only Once Cont

Show Meas Off On

Turns on and off the display of markers indicating the location of the waveform parameters used when making the currently active measurement.

Key Path

(Time) More 1/4 Show Meas Off On

(Power/Voltage) More 1/4 Show Meas Off On

Single

Captures 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.

Key Path

(Mode) Single

See Also

(Slope/Coupling)

Skew 1→2 # s

Select to remove cabling errors from timing measurements between channels 1 and 2. Use the general purpose knob to correct the delay of channel 2 with respect to channel 1.

Key Path

(Print/Utility) Self Cal Menu Skew 1→2 # s

Skew 1→E # s

Select to remove cabling errors from timing measurements between channels 1 and the external trigger. Use the general purpose knob to correct the delay of the external trigger with respect to channel 1.

Key Path

(Print/Utility) Self Cal Menu Skew 1→E # s

Skip El Cal

Skips the electrical calibration portion of an optical calibration.

Key Path

(Optical Cal)
Show Deflt User User More 1/2 Sequence Skip El Cal

Slope ↑ ↓

Selects the rising or falling edge as the slope for the trigger source.

Key Path

(Slope/Coupling) Slope ↑ ↓

Slope/Coupling

Accesses the Trigger menu used to select trigger settings such as noise rejection, coupling and slope.

Source E1 Op(E2)

Selects the source to be used for general waveform and eye diagram measurements. Op is available as a source selection when the optical channel is selected (Chan 2 Off Op E2 Op).

Key Path

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

Power/Voltage Source E1 Op(E2)

Time Source E1 Op(E2)

Source Off E1 Op(E2)

Selects the source for making cursor measurements.

Key Path

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

Stop

Freezes the waveform display. To restart, press Run.

STS-1

Selects the SONET 51.84 Mb/s electrical line interface standard mask (as defined by the ANSI T1.102-199X standard document).

Key Path Cursors/Masks Cursors Masks Masks Select Mask STS-1

STS-3

Selects the SONET 155.52 Mb/s electrical line interface standard mask (as defined by the ANSI T1.102-199X standard document).

Key Path Cursors/Masks Cursors Masks Masks Select Mask STS-3

Test for x Sec

Sets the length of the mask conformance test in seconds.

Key Path Cursors/Masks Cursors Masks Masks Define Test Test for x sec

T1 T2

Selects the T1, T2, or both T1 and T2 time cursors when making timing measurements. Use the general purpose knob (located below the Measurements section of the front-panel) to move the cursor.

Key Path

(Cursors/Masks) Cursors Masks Cursors T1 T2

(Time)

Accesses the Time Measurements menu.

Time Ref Left Cntr

Sets the horizontal time reference point to the left or to the center of the display. Left sets the time reference graticule in from the left of the display. Center sets the time reference in the middle of the display.

Key Path

(Main/Delayed) Time Ref Left Cntr

Time Samp

Allows you to adjust the number of time samples used when performing eye diagram statistical measurements. Use the general purpose knob (located below the front-panel Measurements section) to adjust the number of samples.

Key Path

Time
Meas Type Eye:NRZ More 1/4 . . . More 3/4 Time Samp

Top Lvl

Measures the mean highest level of a repetitive general waveform.

Key Path

Power/Voltage Meas Type Genl Wvfm More 1/4 More 2/4 Top Lvl

Trace

Accesses the Trace Storage menu.

Trace Mem1 Mem2

Selects trace memory 1 or 2.

Key Path Trace Trace Mem1 Mem2

Trace Mem1(Mem2) Off On

Turns the display of the stored trace on and off.

Key Path Trace Trace Mem1(Mem2) Off On

TV

Selects TV trigger mode. TV trigger is allowed only when triggering on channel 1 or channel 2.

Key Path Mode TV

Undo Autoscale

Cancels the Autoscale function and recalls the instrument settings that were being used just prior to selecting Autoscale.

Key Path

(Setup) Undo Autoscale

See Also

(Autoscale)

Vectors Off On

Turns vector display on and off.

Key Path

(Display) Vectors Off On

Vernier Off On

Turns the vernier display on and off. Vernier is available for both the vertical and the horizontal scales.

Key Path

(Main Delayed) Vernier Off On

(Elec 1) Vernier Off On

(Optical/Elec 2) Vernier Off On

Vertical

Starts the electrical vertical calibration. The calibration is performed on channel 1, channel 2, and the external trigger.

Key Path

Print/Utility Self Cal Menu Vertical

XY

Selects the XY horizontal sweep mode. Channel 1 is the X-axis input and channel 2 is the Y-axis input.

Key Path

Main/Delayed XY

Zero Lvl

Measures the mean zero level on an eye diagram waveform. The mean zero level is determined from an amplitude histogram taken at the zero level amplitude.

Key Path

Power/Voltage Meas Type Eye:NRZ More 1/4 More 2/4 Zero Lvl

4

Performance Characteristics

Performance Characteristics

The performance characteristics describe the performance capabilities of the HP 83475A 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 ±10°C.

Vertical system

Optical Input Channel[1]

Bandwidth[2]: dc to 500 MHz −3 dB
Optical input: 62.5/125 μm fiber
Calibrated wavelengths:
780 nm, 1310 nm, 1550 nm[3]
(Actual calibration may be at ±20 nm from the specified wavelengths.)
Vertical power scale accuracy[4]:
Range:
2 μW/div to 50 μW/div at 1310/1550 nm
20 μW/div to 500 μW/div at 780 nm
1 cursor:
at 1310/1550 nm[1, 5]: ±7.5% (±4.7% typical)
at 780 nm: ±4.9%
2 cursor:
at 1310/1550 nm[1, 6]: ±6.5% (±3.7% typical)
at 780 nm: ±4.1%
Optical return loss[2]: 27 dB (30 dB typical)
Noise (rms):
at 1310/1550 nm:
0.80 μW ($\leq$20 μW/div)
2.0 μW (>20 μW/div)
at 780 nm
8.0 μW ($\leq$200 μW/div)
15.0 μW (>200 μW/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±5°C.
2 Tested characteristic.
3 Functionality available for up to three user calibrations. Refer to Appendix B.
4 Does not include optical input connector repeatability.
5 Use a full scale of 48 μW for less than 6 μW/div range and ±0.5% of position value.
6 Use a full scale of 48 μW for less than 6 μW/div range.

Vertical system, continued

Optical Power Meter[1]

Accuracy[2]:
- 780 nm: <±4.1% of reading
- 1310 nm[3]: <±6.0% of reading (±2.5% typical)
- 1550 nm[3]: <±6.0% of reading (±2.5% typical)

Dynamic range[4]:
- 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±5°C.
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.

Vertical system, continued

Electrical Channels 1 and 2

Bandwidth[1]:

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 MΩ or 50Ω selectable

Input capacitance: ≈8 pf

Maximum input voltage:

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

Upper bandwidth reduced 2 MHz/°C above 35° C.

1 Tested characteristic.

Vertical system, continued

Channels 1 and 2, continued

Range: 2 mV/div to 5 V/div

Accuracy[1, 2]: ±2.0% of reading

Verniers[1]: Fully calibrated, accuracy ±2.0 % of reading

Cursor accuracy[1, 2, 3]:

Single cursor accuracy:
vertical accuracy ±1.2% of full scale ±0.5% of position value
Dual cursor accuracy:
vertical accuracy ±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 Sense: Automatic readout of 1×, 10× and 100× probe correction

1 When temperature is within ±10°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: ±0.01% of reading

Vernier (Both main and delayed sweep):

Accuracy ±0.05% of reading

Horizontal resolution: 25 ps

Cursor accuracy (Δt and 1/Δt)[1]:

±0.01% ±0.2% of full scale ±200 ps

Delay jitter: 10 ppm

Pretrigger delay (negative time): $\geq$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

Sensitivity[1]:

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.

Trigger system, continued

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

Sensitivity[1]:

dc to 25 MHz: 50 mV
dc to 500 MHz: 100 mV

Trigger View:

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

Trigger View Bandwidth: ≥350 MHz

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

Input resistance: 1 MΩ or 50 Ω

Input capacitance: ≈12 pf

Maximum safe input voltage:

250 V (dc + peak ac) into 1 MΩ
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 × 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 μs/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-TS G.957 and Bellcore TA-NWT-000253)	OC-1, 51.84 Mb/s OC-3/STM-1, 155.52 Mb/s STS-1, 51.84 Mb/s STS-3, 155.52 Mb/s STM-1 one, 155.52 Mb/s STM-1 zero, 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-TS G.703	E-1, 2.048 Mb/s E-2, 18.448 Mb/s E-3, 34.368 Mb/s E-4 one, 139.264 Mb/s E-4 zero, 139.264 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 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: ±0.41%/°C
Optical cw vertical scale (one cursor): 0.045%/°C of full scale at 1310 nm and 1550 nm.

Offset voltage drift at Demod output: 0.2 mV/°C into 50 Ω

Optical system vertical gain drift with no input:

0.075% of full screen/°C at 1310/1550 nm

BW drift: −2 MHz/°C

Offset voltage at Demod output: ≤±3 mV (into 50Ω)

Return loss at Demod output: >15 dB (dc–500 MHz)

Demod output impedance: 50 Ω 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)
Nonoperating: −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)

Altitude:

(Tested to MIL-T-28800E paragraph 4.5.5.2)
Operating: to 4,500 m (15,000 ft)
Nonoperating: 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

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

General, continued

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)

5

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 diagrm bit period.
- 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 can not be simultaneously done on two channels at a time.
- Recommended practices for extinction ratio measurements are provided in Appendix A.

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.

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 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% level crossing of first falling edge − 50% level crossing of first rising edge

Else:

+width = 50% level crossing of second falling edge − 50% level crossing of first rising edge

−width

The −width algorithm has standard considerations:

If first edge is rising, then:

−width = second rising edge − first falling edge

Else:

−width = first rising edge − first falling edge

Amplitude

Amplitude measurement is made using the entire waveform. When performing a measurement on a particular cycle, set the controls to 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:

amplitude = mean high − mean low

Average

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.

Base Level

base level = most prevalent point below waveform midpoint

Bit Period

The bit period algorithm has standard considerations.

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

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.

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)

Extinction Ratio

For a detailed description of the considerations in making extinction ratio measurements refer to Appendix A.

extinction ratio = (one level amplitude – DC offset)/(zero level amplitude – DC offset)

Eye Height

The Eye Height measurement has standard considerations.

$$eye\ height = \left(\frac{(One\ Level - 3\ standard\ deviations) - (Zero\ Level - 3\ standard\ deviations)}{(One\ Level - Zero\ Level)}\right) 100$$

Fall time

fall time = time at 10% (or 20%) level – time at 90% (or 80%) level

Frequency

frequency = 1/period

Jitter Pk to Pk

jitter pk to pk = 6 × jitter rms

Jitter RMS

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.

Max Level

max level = voltage or power of the highest point on the screen

Min Level

min level = voltage or power of the lowest point on the screen

Noise rms

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.

Noise Pk to Pk

noise pk to pk = 6 × noise rms

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:

$$percent\ overshoot = \left(\frac{Max - Top}{Top - Base}\right) 100$$

Period

If first edge is rising, then:

period = time at second rising edge − time at first rising edge

Else:

period = time at second falling edge − time at first falling edge

Pk-to-Pk

pk-to-pk = Vmax − Vmin

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:

$$percent\ preshoot = \left(\frac{Min - Base}{Base - Top}\right) 100$$

Rise time

rise time = time at 90% (or other%) level − time at 10% (or other%) level 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.

A

Optimizing Extinction Ratio Measurements

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 straight forward, the measurement methodology to determine the mean logic levels is not clearly specified in standards such as SDH standard ITU-TS 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. 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:

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

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. Because of the lightwave communications analyzer's fast data processing architecture, it has superior extinction ratio measurement throughput, which is a real asset in manufacturing applications.

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 must have a minimum extinction ratio of 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
- Oscilloscope 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 oscilloscope 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 is 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.
- Adjust the horizontal scale so one entire eye diagram (two crossing points) is displayed.

  Because the lightwave communications analyzer switches to 7-bit resolution at the smallest vertical scale settings (approximately 3 uW/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.
- Whenever the room temperature varies by a few degrees C, perform the electrical vertical channel calibrations. Refer to Appendix C.
- To minimize the error introduced by system noise take at least 2,000 histogram amplitude samples.
- In some cases trigger feedthough into the measurement channel can be a significant source of error. To minimize trigger feedthrough reduce the trigger amplitude as much as is possible within the trigger sensitivity specifications.

B

Performing Optical Channel Calibration

Performing Optical Channel Calibration

The HP 83475A 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 B-1.

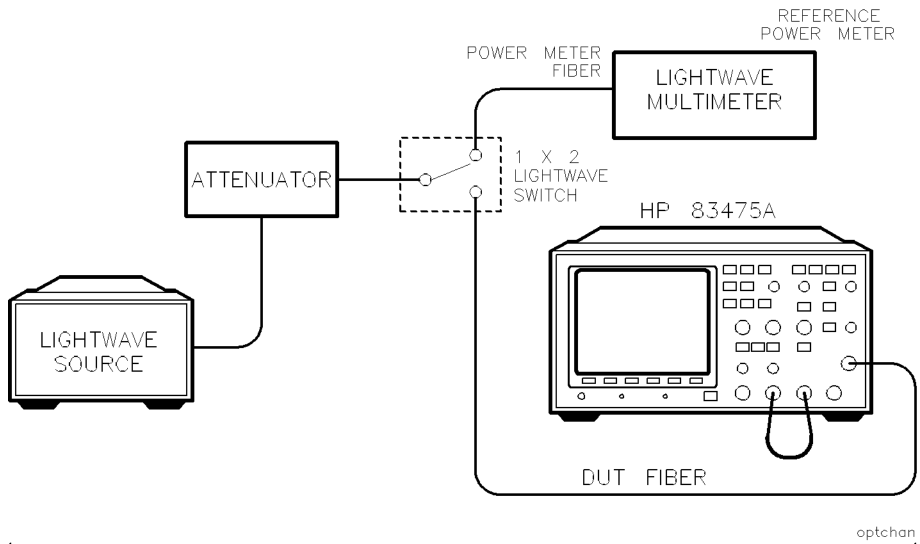


Figure B-1. Block diagram of a calibration setup.

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

To Correct for Insertion Loss

If the setup shown in Figure B-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 83475A.
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 uncertainity is minimized.**

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

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

where:

P = power, in microwatts, at the specified points

During the calibration procedure, several power levels must be input into the HP 83475A 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 83475A.

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

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

Manual Calibration Sequence

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

NOTE

Press the Abort key at any point in the calibration sequence to discontinue the calibration and rest the instrument to its pervious state.

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

   Optical Cal
   More 1/2

2. Select the desired user calibration by highlighting one of the user calibration softkeys and then pressing 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 asks 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 B-1. You may choose to apply insertion loss correction as discussed in the "To Correct Insertion Loss" section of this appendix.

   Dial in the precise power level using the general purpose knob under the front-panel Measure section. Press Measure to record the power reading.

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`.

C

Performing the Electrical Vertical Channel Calibration

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.*

Table C-1. 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 Test
   DAC

   The multimeter should measure 0.00 V dc $\pm$500 μV.
3. Press any key to continue the test. The multimeter should read 5.000 V $\pm$10 mV.

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 oscilloscope'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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