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Agilent Technologies 86030A  
Lightwave Component  
Analyzer System



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Agilent Technologies Part No. 86030-90001  
Printed in USA  
April 2000

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



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



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



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## General Safety Considerations

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### General Safety Considerations

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

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**WARNING**

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

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**WARNING**

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



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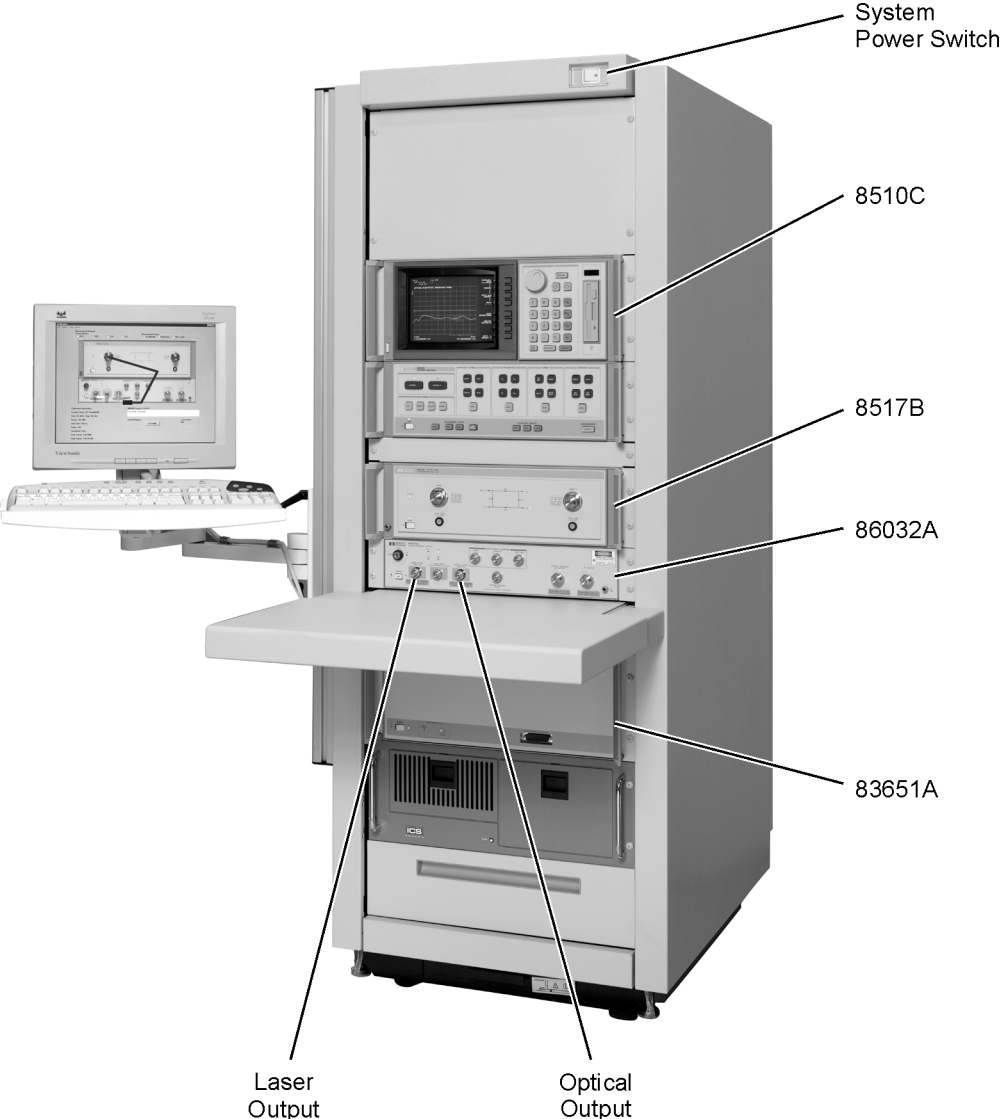
## Getting Started

## System Overview

The Agilent 86030A 50 GHz lightwave component analyzer provides accurate and repeatable characterization of electro-optical, optical, and electrical components.

Components such as O/E photodiode receivers, E/O photodiodes, lightwave modulators, and other optical and electrical components used in 40 Gb/s lightwave systems can be characterized in either a research and development or manufacturing environment.

The Agilent 86030A system consists of an Agilent 85107B vector network analyzer system, an 86032A 50 GHz lightwave test set, system software, and a personal computer serving as the system controller.



### ***Calibrated Measurements***

One of the key benefits of the 50 GHz lightwave component analyzer is its ability to perform calibrated measurements of optical components. The system contains an O/E receiver that has been factory calibrated in magnitude, and characterized in phase. The ability to make calibrated measurements assures accuracy, reliability, and confidence in the components being measured. Additionally, the laser source, optical modulator, and calibrated O/E receiver are temperature stabilized which also improves the accuracy and repeatability of measurements.

### ***Verification Device***

A verification device is included with the system. It consists on an Agilent 83440D O/E photodetector and its associated amplitude and phase data. This verification device can be used at any time to verify the measurement integrity of your system. A guided verification routine is provided which measures the verification device, and displays a graph of its response versus acceptable tolerances. The verification device can be used periodically to monitor system calibration, and indicate when the optical test set needs to be recalibrated. It can also be used to resolve uncertainty if unexpected results are obtained from a test device. This verification capability provides confidence in the measurement integrity of the system.

### ***Measurement Software***

Guided measurement software provides an easy-to-use operator interface. It provides pictorial diagrams of interconnections for configuration, calibration, and measurements. On-screen prompts also guide you through the entire measurement process, from the calibration to the measurement.

### ***Data Management***

Display, analysis, and archiving of data is easy and straightforward with the system. The measured data is displayed on the Agilent 8510C network analyzer. Full use of the analyzer's functions such as markers, data formats, and data scaling features are available. Data can be archived to disk in either ASCII text or Microsoft Excel formats. The include Excel software allows data to be displayed and analyzed using standard Excel features and formats. Data connectivity to a local area network (LAN) is provided via a LAN card in the system's PC.

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## Accessories Supplied

The accessories described below are shipped with your system.

**Table 1-1. System Accessories**

Description	Agilent Model/Part Number	Quantity
<b>86030A Verification Kit</b>		
0 to 32 GHz Light Wave Detector	83440D	1
Cable Assembly	86030-60005	1
Power Supply	87421A	1
Reference Reflector Cable Assembly	81000BR	1
System Software Disk Set	86030-10001	1
Fiber Optic 4M Cable	1005-0173	3
BNC Termination	1250-0207	2
6 dB (2.4 mm) Attenuator	8490D Opt 006	1
50 ohm load (2.4 mm) F	00901-60004	1
Adapter (2.4 mm), F/F	85056-60006	1
<b>Other Accessories</b>		
86030A User's Guide	86030-90001	1
2.4 mm 8510C Calibration Kit	85056A	
2.4 mm Flexible Cables	85133F	

## Configuration Options

The standard Agilent/HP 86030A system is supplied with FC/PC optical connectors. If other optical connectors are desired, ordering one of the following connector options will replace the FC/PC connectors with the desired optical connectors.

**Table 1-2. Available Options for the 86032A System**

<b>Option Number</b>	<b>Description</b>
011	Diamond HMS-10 connector interface
013	DIN 47256 connector interface
014	ST optical connector interface
017	SC optical connector interface
<b>Other Options</b>	
230	220-240 VAC operation
UK6	Test data for ISO 9001/2 commercial calibration

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### **WARNING**

**During measurements, laser light emits from the front-panel OPTICAL OUTPUT connector and the LASER OUTPUT connector. This light originates from the system's laser source. Always keep these connectors covered when not in use.**

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**CAUTION**

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The warranty and calibration will be voided on systems where the individual instruments are removed by the customer. The system should only be disassembled by a Agilent Technologies Customer Engineer. Instruments should not be replaced by non Agilent Technologies personnel.

**Measurement accuracy—it's up to you!**

Fiber-optic connectors are easily damaged when connected to dirty or damaged cables and accessories. The 86030A's front-panel SOURCE OUTPUT and RECEIVER INPUT connectors, 86032A Laser Output and External Laser Input are no exception. When you use improper cleaning and handling techniques, you risk expensive instrument repairs, damaged cables, and compromised measurements. Before you connect any electrical cable to the 86030A, [refer to "Electrostatic Discharge Information" on page 6-19.](#)

## Front Panel Features

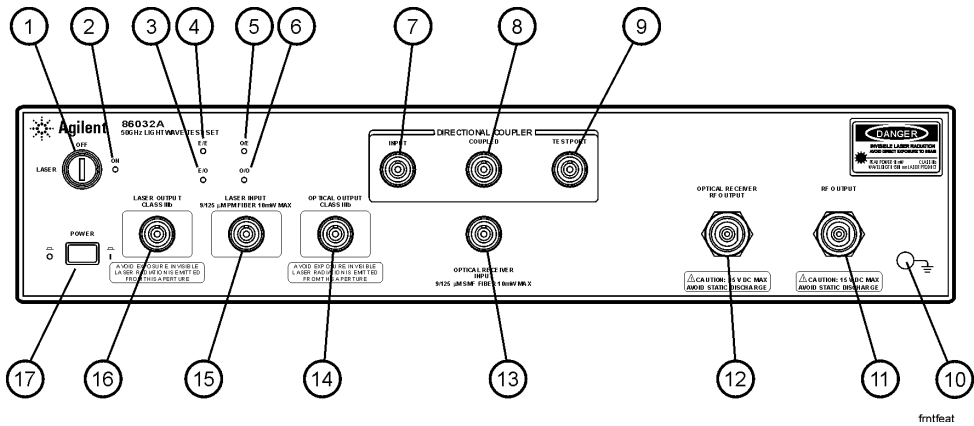


Figure 1-1. 86032A Front Panel

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1. LASER Key	Turns the laser on and off. Note that the laser is not operational until it is activated by the 86030A software program. You can turn on the laser manually from the Diagnostic software. From the Windows Start menu, select Programs, Agilent Technologies 50 GHz LCA, 50 GHz Diagnostics. From the Laser menu, click Laser ON. Make sure the laser key on the 86032A is in the ON position.
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**WARNING**

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**Do NOT, under any circumstances, look into the optical output or any fiber/device attached to the output while the laser is in operation. Refer to “Laser Safety Considerations” on page 1-30.**

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2. Laser LED	Indicates the state of the laser. When the LED is lit, the laser is on. Note that the laser is not operational until it is activated by the 86030A software program. You can turn on the laser manually from the Diagnostic software. From the Windows Start menu, select Programs, Agilent Technologies 50 GHz LCA, 50 GHz Diagnostics. From the Laser menu, click Laser ON.
3. E/O LED	When on, indicates the internal measurement path is selected for an E/O (electrical-to-optical) device.
4. E/E LED	When on, the internal measurement path is selected for an E/E (electrical-to-electrical) device. The test set is in a bypass mode for E/E device selection and the laser is shut down. The test set will need to be in the ON position for use in E/E mode.
5. O/E LED	When on, the internal measurement path is selected for an (optical-to-electrical) O/E device.
6. O/O LED	When on, the internal measurement path is selected for an (optical-to-optical) O/O device.
7. DIRECTIONAL COUPLER INPUT	Input for the optical direction coupler. This port is usually connected to the OPTICAL OUTPUT.
8. DIRECTIONAL COUPLER COUPLED	Port for the coupler output. This port is usually connected to the OPTICAL RECEIVER INPUT.
9. DIRECTIONAL COUPLER TEST PORT	Coupler output port (transmission) or test port (reflection).
10. Grounding Receptacle	Ground path that is provided to connect a static strap.
11. RF OUTPUT	RF output that provides RF drive power for E/O devices.
12. OPTICAL RECEIVER RF OUTPUT	Test set optical receiver output

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**Front Panel Features**

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13. OPTICAL RECEIVER INPUT	Test set optical receiver input
14. OPTICAL OUTPUT	Modulator output.
15. LASER INPUT	External laser input
16. LASER OUTPUT	Output of internal laser
17. POWER Switch	Turns the instrument power on.

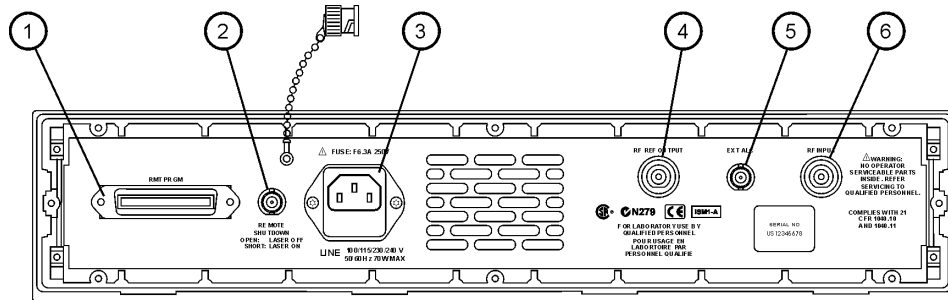
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**CAUTION**

Use care in handling optical connectors. Damage to an optical test port connector can require a costly repair and lost productivity for the system. Keep optical cables connected to the test ports to protect the connectors from damage. Also, make sure to clean the connectors before each use. [Refer to “Accurate Measurements” on page 1-33.](#)

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## Rear Panel Features



rearfeat

**Figure 1-2. 86032A Rear Panel**

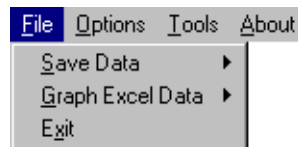
1. Remote Programming Connector	Allows for remote control of the instrument's front panel via the 86030A software installed on the system PC.
2. Laser Remote Shutdown	Turns the laser on or off. When the BNC short is connected, the laser is enabled. When removed, the laser is disabled.
3. Line Module	This assembly houses the line cord connector.
4. RF REF OUTPUT	RF output of the test set that is used to route the 8517B electrical test set for phase locking.
5. EXT ALC	DC output from the levelling detector on the internal ALC circuit. This output is routed to the EXT ALC port of the network analyzer source.
6. RF INPUT	RF input port from the source output of the network analyzer.

## Software Overview

The 86030A software sets up instrument states on the network analyzer and lightwave test set, and guides you through the measurement calibration and measurement procedures. The program combines the measurement calibration traces with the calibration data response of the lightwave receiver, and loads the result back into the network analyzer to provide calibrated lightwave measurements. You can save and view trace data using Microsoft Excel, and manually control the 86032A test set operation.

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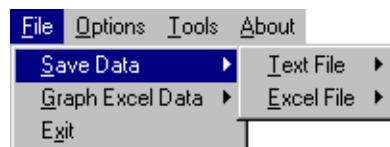
## File Menu



The File menu is used to save data as either an ASCII text file or an Excel worksheet. Using Graph Excel Data allows you to automatically view saved data in an Excel worksheet as tabular data, or as graphical data in log magnitude, phase or delay formats. The File menu is also used to exit the application.

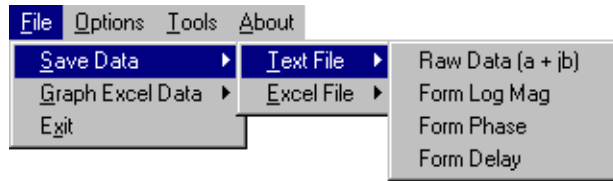
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## Save Data



### **Text File**

Text File allows you to save data as an ASCII text file in four different formats: Raw Data, Log Magnitude, Phase, or Delay.

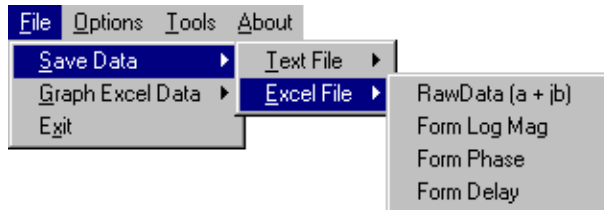
**File Menu**

**Raw Data** saves trace data in a ASCII text format (.txt) known as a CITIFile (common instrumentation transfer and interchange file). The CITIFile format is useful when data will be exchanged with another network analyzer. The data file saves both real and imaginary pairs independent of the format of the active screen. However, any trace smoothing that was applied to the measurement will not be saved (that is, Smoothing On is activated from the 8510C Response menu).

**Formatted Data, Log Mag, Phase, Delay** saves trace data with any trace smoothing that was applied to the measurement (that is, Smoothing On is activated from the 8510C Response menu), but only retains the values of the format that was selected for saving (that is, Log Magnitude, Phase, or Delay).

**Excel File**

Excel File allows you to save the trace display as a Microsoft Excel workbook (.xls extension). The Excel format is useful when you want to view or edit the data in an Excel spreadsheet.



**Raw Data** saves both real and imaginary pairs independent of the format of the active screen. This data can later be viewed in either Log Magnitude or Phase format from the File, Graph Excel Data menu. Any trace smoothing that was applied to the measurement will not be saved (that is, if Smoothing On is activated from the 8510C Response menu).

**Formatted Data** saves trace data and any trace smoothing that was applied to the measurement, but only viewed using the format that the data was originally saved (that is, Log Magnitude, Phase, or Delay).



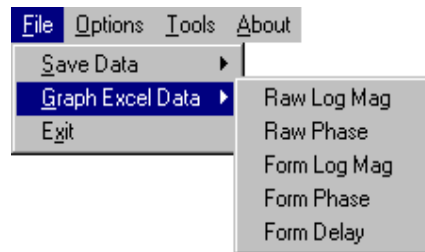
**Log Mag** saves the log magnitude format. This is the standard Cartesian format used to display magnitude-only measurements of insertion loss, return loss, or absolute power in dB versus frequency.

**Phase** saves the phase of data versus frequency in a Cartesian format.

**Delay** saves the group delay format, with marker values given in seconds. Group delay is the measurement of signal transmission time through a test device. It is defined as the derivative of the phase characteristic with respect to frequency. Since the derivative is basically the instantaneous slope (or rate of change of phase with frequency), a perfectly linear phase shift results in a constant slope, and therefore a constant group delay.

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## Graph Excel Data



### Raw Data

Data allows you to view trace data in either Log Magnitude or Phase format. However, any trace smoothing that was applied to the measurement will not be captured. (that is, if Smoothing On was activated from the 8510C Response menu).

**Log Magnitude** displays the trace data in Cartesian format as logarithmic (dB) magnitude versus frequency.

**Phase** displays the trace data in Cartesian format as phase versus frequency.

### Formatted Data,

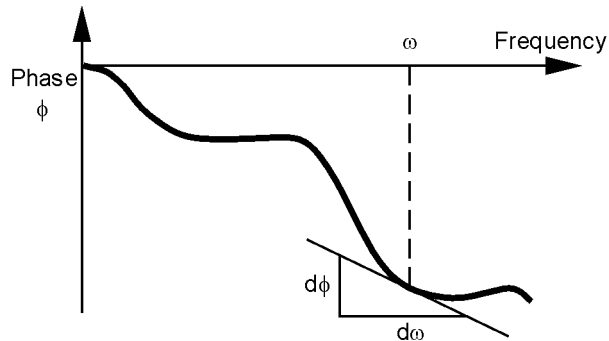
Formatted Data allows you to view trace data in the format that it was saved (that is, Log Magnitude, Phase, or Delay) including any trace smoothing that was applied to the measurement

**File Menu**

**Log Mag** displays the log magnitude format. This is the standard Cartesian format used to display magnitude-only measurements of insertion loss, return loss, or absolute power in dB versus frequency.

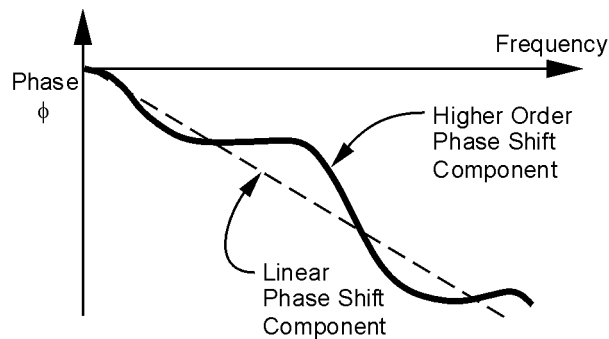
**Phase** displays the phase shift of data versus frequency in a Cartesian format.

**Delay** displays the group delay format, with marker values given in seconds. Group delay is the measurement of signal transmission time through a test device. It is defined as the derivative of the phase characteristic with respect to frequency. Since the derivative is basically the instantaneous slope (or rate of change of phase with frequency), a perfectly linear phase shift results in a constant slope, and therefore a constant group delay. [Figure 1-3](#)



**Figure 1-3.**

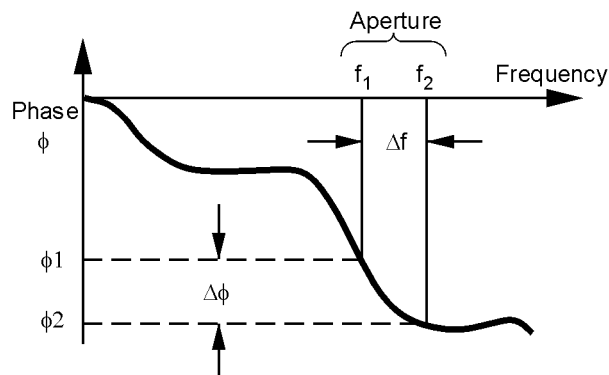
Note, however, that the phase characteristic typically consists of both linear and higher order (deviations from linear) components. The linear component can be attributed to the electrical length of the test device, and represents the average signal transit time. The higher order components are interpreted as variations in transit time for different frequencies, and represent a source of signal distortion. See [Figure 1-4](#).



**Figure 1-4.**

$$\text{Group Delay} = \tau_g = \frac{-d\phi}{d\omega} \quad \begin{array}{l} \text{in Radians} \\ \text{in Radians} \end{array} = \frac{-1}{360^\circ} \cdot \frac{d\phi}{df} \quad \begin{array}{l} \phi \text{ in Degrees} \\ f \text{ in Hz } (\omega = 2\pi f) \end{array}$$

The analyzer computes group delay from the phase slope. Phase data is used to find the phase change,  $\Delta\phi$ , over a specified frequency aperture,  $\Delta f$ , to obtain an approximation for the rate of change of phase with frequency (Figure 1-5). This value,  $\tau_g$ , represents the group delay in seconds assuming linear phase change over  $\Delta f$ . It is important that  $\Delta\phi$  be  $\leq 180^\circ$ , or errors will result in the group delay data. These errors can be significant for long delay devices.

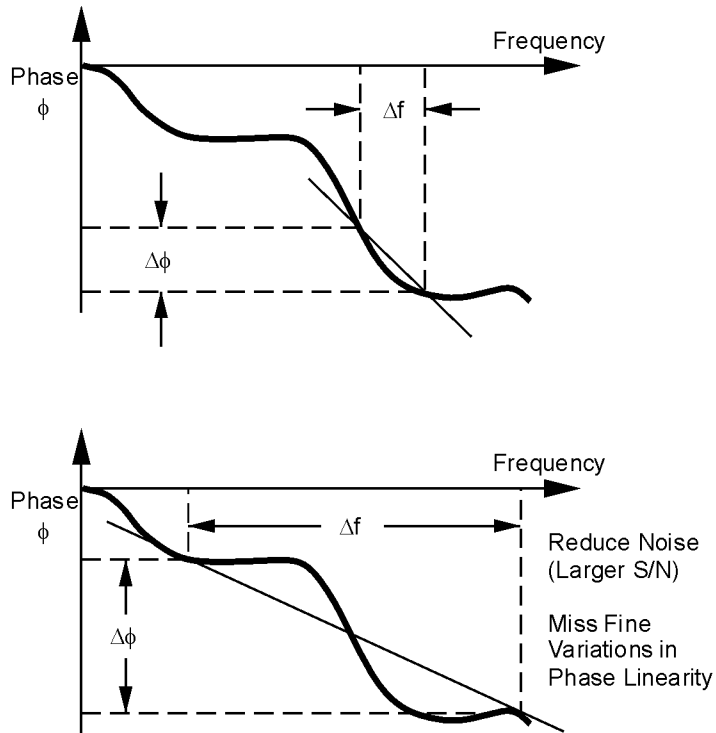


**Figure 1-5.**

When deviations from linear phase are present, changing the frequency step can result in different values for group delay. Note that in this case the computed slope varies as the aperture  $\Delta f$  is increased (Figure 1-6). A wider aper-

**File Menu**

ture results in loss of the fine grain variations in group delay. This loss of detail is the reason that in any comparison of group delay data it is important to know the aperture used to make the measurement.



**Figure 1-6.**

In determining the group delay aperture, there is a trade-off between resolution of fine detail and the effects of noise. Noise can be reduced by increasing the aperture, but this will tend to smooth out the fine detail. More detail will become visible as the aperture is decreased, but the noise will also increase, possibly to the point of obscuring the detail. A good practice is to use a smaller aperture to assure that small variations are not missed, then increase the aperture to smooth the trace.

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## Exit

**Exit** closes the 86030A software application.

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## Options Menu



The Options menu allows you to set and monitor system functions.

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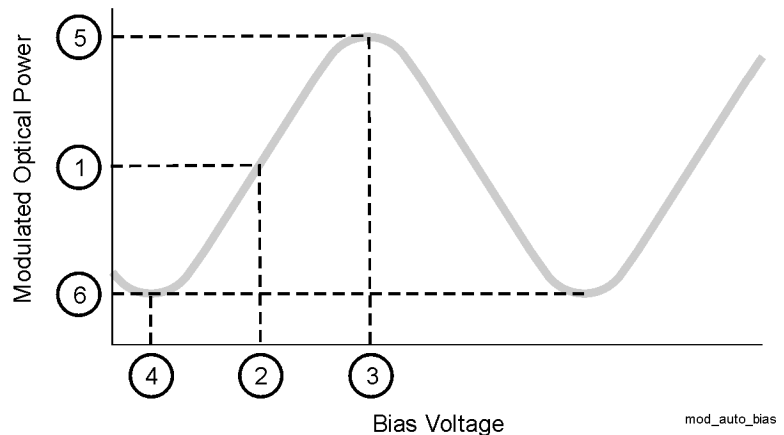
## Auto Bias

Auto Bias allows you bias the modulator to operate at quadrature or at maximum optical power. Under typical circumstances the lightwave modulator is biased to operate at quadrature. Quadrature is the point where the slope of the optical power versus voltage is maximally positive. Refer to [Figure](#) .

**Modulator Auto-Biasing ...**

Power at Quadrature (dBm)	①
Voltage at Quadrature (V)	②
Voltage at Maximum Optical Power (V)	③
Voltage at Minimum Optical Power (V)	④
Maximum Optical Power (dBm)	⑤
Minimum Optical Power (dBm)	⑥

OK



**Figure 1-7. Effect of Bias Voltage on Modulated Optical Power**

**Power at Quadrature (1)**

The power where the optical power versus bias voltage slope is maximum for a positive slope.

**Voltage at Quadrature (2)**

The voltage where the optical power versus bias voltage slope is maximum for a positive slope.

**Voltage at  
Maximum Optical  
Power (3)**

The voltage at which the maximum output power occurs ( $V_{\max}$ ).

**Voltage at  
Minimum Optical  
Power (4)**

The voltage at which the minimum output power occurs ( $V_{\min}$ ).

**Maximum Optical  
Power (5)**

The maximum output power.

**Minimum Optical  
Power (6)**

The minimum output power.

---

## How to Determine if Auto Bias Values are Reasonable

The following formulas will help you to determine if the modulator auto bias settings are valid. Refer to [Figure](#) .

Voltage at Maximum Optical Power – Voltage at Minimum Optical Power should be between 3 and 6 volts.

Voltage at Quadrature should be approximately  $\frac{V_{\max} + V_{\min}}{2}$

Maximum Optical Power should be > 3 dBm

Power at Quadrature should be > 0dBm

**Tip:** You can set the this value manually. From the Tools menu, click on Monitor Test Set. In the Modify Bias Voltage text box, enter the desired value and then click Set Modulator Bias Voltage to.

[Refer to “Modulator Troubleshooting Tips” on page 6-16](#) for more information.



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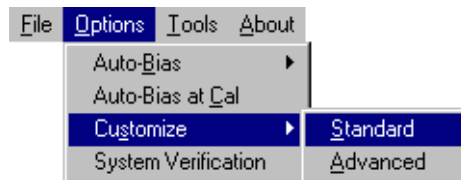
## Auto Bias At Cal



Auto Bias At Cal when selected, an auto bias is performed before each calibration. The auto bias is performed after you click either Resp Cal or Resp-Isol Cal.

---

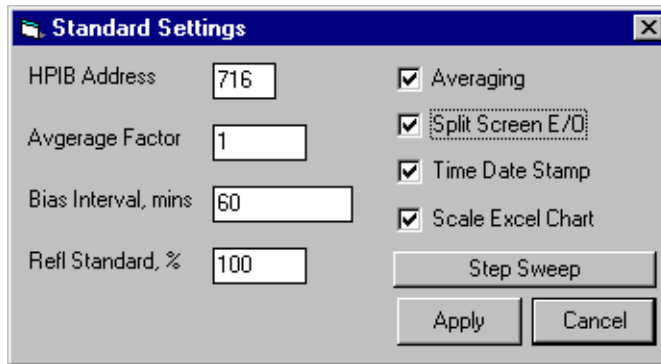
## Customize



Customize allows you to set and monitor certain parameters that affect the operation of the system.

### **Standard**

The Standard Settings dialog box allows you to set and monitor certain parameters controlled by the network analyzer.

**Options Menu**

**GPIB Address** displays the current address setting for the analyzer. This value must correspond to the actual address on the 8510 GPIB address bus. Failure of these two numbers to match will prevent operation.

**Average Factor** is used to improve the sensitivity of the measurement. For the Step Mode of operation for each modulation frequency point, multiple data point samples (equal to the number of averages) are measured by the system, and averaged together to provide a single average value. Averaging multiple data points together reduces the effects of noise on the measurement. The improvement in sensitivity is equal to:

$$\log_{10}(\text{number of averages})$$

Note the 8510C network analyzer only averages with powers of 2 (that is, 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, and so on). Therefore, if an averaging factor of 500 is set on the analyzer, the analyzer will default to 256 averages.

**Bias Interval, mins** corresponds to the number of minutes before prompting you to perform another modulator auto bias.

**Refl Standard%** corresponds to the percent of reflection of the Reflection Standard used in the system. This is useful for O/O reflection modes.

**Averaging** when selected, the network analyzer will perform averaging at each data point.

**Split Screen E/O** when selected, the network analyzer displays both the bandwidth and reflection measurement on the display. *This function is only valid with an E/O Bandwidth and Reflection measurement.* Bandwidth is displayed on channel 1 and Reflection is displayed on channel 2. When this function is cleared, use the network analyzer front panel channel buttons to select between the two measurements.

**Time Date Stamp** when selected, the time and date stamp is applied to the trace on the network analyzer.

**Scale Excel Chart** when selected, the trace data saved from the network analyzer will be auto-scaled to fit into an Excel chart.

**Step Sweep/Ramp Sweep** toggles between step sweep and ramp sweep modes.

**Step Sweep** is a digital sweep beginning at the start frequency and ending at the stop frequency with the source phase locked and the data measured at a frequency interval determined by the number of points selected on the network analyzer (STIMULUS MENU, STEP). An up arrow on the trace identifies the data point just measured. The ramp mode is recommended when you need the best modulation frequency accuracy and repeatability.

Dwell time prior to measurement at each frequency point is controlled by the sweep time setting. Measurement time at each point is determined by the averaging factor.

---

**NOTE**

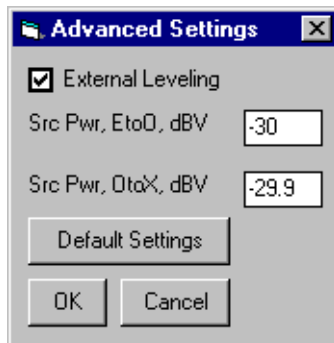
---

System specifications are only warranted when using the Step Sweep mode of operation.

**Ramp Sweep** selects continuous linear analog sweeps beginning at the start frequency and ending at the stop frequency. The rate is determined by the sweep time, measuring data at frequency intervals set by the number of points. (8510 access, STIMULUS MENU, RAMP)

**Advanced**

The Advanced Settings dialog box allows changing of default power values.



## Options Menu

**External Leveling** when checked, the system uses external leveling. When cleared, the system uses internal leveling. Normal system operation uses external leveling.

**Src Pwr, E to X, dBV** for E/O mode and E/E mode, displays the 83651A external leveling source power.

**Src Pwr, O to X, dBV** for O/E mode and O/O mode, displays the 83651A external leveling source power.

**Default Settings** when selected, resets the source power to its factory default values.

---

## System Verification

A System Verification performs a measurement on the verification device over the entire frequency range. The verification device is the 83440D lightwave detector supplied in the system verification kit. Once the verification is completed, the results are displayed in an Excel worksheet along with the error bars that were computed from the factory measurement of the verification device. For the system verification to pass, the verification device trace must fit within the error bars. A pass or fail indicator is displayed at the bottom of the worksheet. [Refer to “Lightwave Verification” on page 5-3](#) for more information.

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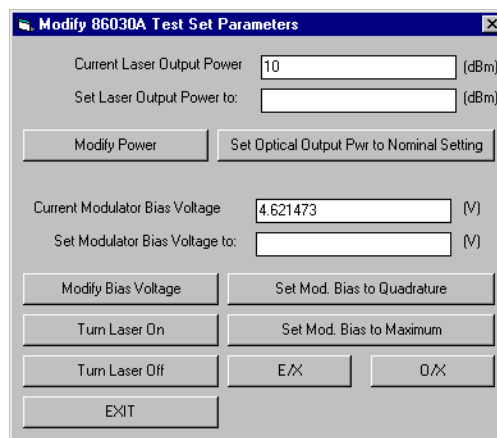
## Tools Menu



The Tools menu is used to monitor and modify 86032A test set parameters.

---

## Modify Test Set



**Current Laser Output Power (dBm)** displays the value of the laser power coming from the LASER OUTPUT port of the test set.

**Set Laser Output Power to:(dBm)**, when Modify Power is selected, the value will be updated to the value specified in this text box.

## Tools Menu

**Modify Power** sets the internal laser of the 86030A test set to the power specified in the Modify Power text box. This value will be used until you restart the 86030A software. Valid settings are from 0 dBm to 10 dBm.

**Set Optical Output Pwr to Nominal Setting** sets the laser to its factory default setting. When the software is started, the power always defaults back to the factory setting.

**Current Modulator Bias Voltage (V)** displays the value last applied to the internal modulator bias tee attached to the optical modulator.

**Set Modulator Bias Voltage to: (V)**, when Modify Bias Voltage is selected, the bias voltage will be updated to the value specified in this text box. The range is -10 to +10 volts.

**Modify Bias Voltage** sets the bias voltage to the value entered in the Set Modulator Bias Voltage text box.

**Turn Laser On** turns on the laser inside the 86032A test set. This command does not change the power of the laser. This function is useful in E/O mode when you may want to use the internal high power laser as a stimulus for testing optical modulators. The optical power is normally off in the E/O mode.

**Turn Laser Off** turns off the laser inside the 86032A test set. This command does not change power of the laser. If the laser is turned off and then turned back on again, the original power of the laser will be used.

**Set Mod. Bias to Quadrature** when clicked, performs an auto bias on the modulator and sets the modulator bias voltage to the midpoint of the average optical power curve and the peak of the modulated optical power curve. Biasing at quadrature maximizes the modulation response and minimizes distortion of the modulated signal.

The power of the laser is assumed to have been previously set. If the laser power is too low or if the laser is turned off, the auto bias routine will fail and display a message indicating that a bias point could not be found. For this command to function properly, the laser power should be left at its default setting or set to a reasonable power value (between 3 and 10 dBm) prior to performing this function.

**Set Mod Bias to Maximum** when selected, performs an auto bias on the modulator and sets the modulator at maximum optical output power.

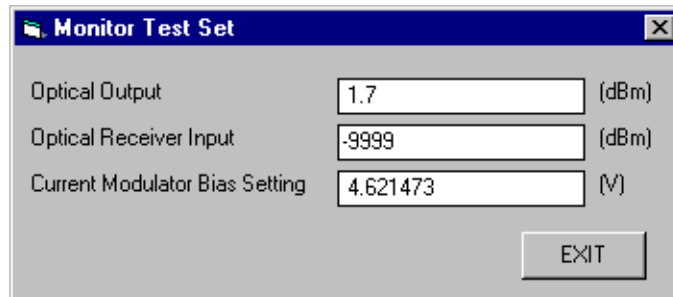
The power of the laser is assumed to have been previously set. If the laser power is too low or if the laser is turned off, the auto bias routine will fail and display a message indicating that a bias point could not be found. For this command to function properly, the laser power should be left to its default setting or set to a reasonable power value (between 3 and 10 dBm) prior to performing this function.

**E/X** when selected, puts the 86032A test set into electrical excitation mode. The RF signal coming into the test set will be routed out of the front panel marked "RF OUTPUT." Therefore, the RF signal will not be routed to the optical modulator in the test set.

**O/X** when selected, puts the 86032A test set into optical excitation mode. The RF signal coming into the test set will be routed to the optical modulator.

---

## Monitor Test Set



The Monitor Test Set dialog box is used to monitor and update the power and voltage levels of the 86032A test set.

**Optical Output Power (dBm)** displays the current optical power coming from the 86032A OPTICAL OUTPUT port.

**Optical Receiver Input (dBm)** displays the current optical power coming into the 86032A OPTICAL RECEIVER INPUT port.

**Current Modulator Bias Setting (V)** displays the current value of the 86032A bias voltage on the modulator.

## Laser Safety Considerations

### **Laser Safety**

Laser radiation in the ultraviolet and far infrared parts of the spectrum can cause damage primarily to the cornea and lens of the eye. Laser radiation in the visible and near infrared regions of the spectrum can cause damage to the retina of the eye.

The CW laser sources use a laser from which the greatest dangers to exposure are:

- 1 To the eyes, where aqueous flare, cataract formation, and/or corneal burn are possible.
- 2 To the skin, where burning is possible.

---

### **WARNING**

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**Do NOT, under any circumstances, look into the optical output or any fiber/device attached to the output while the laser is in operation.**

This system should be serviced only by authorized personnel.

Do not enable the laser unless fiber or an equivalent device is attached to the optical output connector.

---

### **CAUTION**

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Use of controls or adjustments or performance of procedures other than those specified herein can result in hazardous radiation exposure.

### **Laser Classifications**

United States-FDA Laser Class IIIb. The system is rated USFDA (United States Food and Drug Administration) Laser Class IIIb according to Part 1040, Performance Standards for Light Emitting Products, from the Center for Devices and Radiological Health.

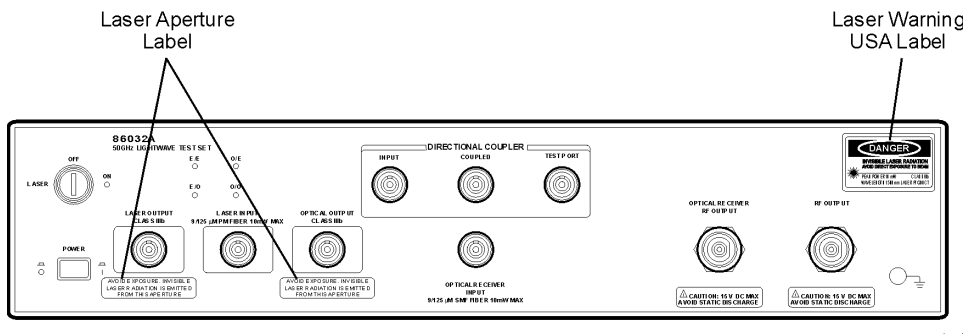
International-IEC Laser Class 3B. The system is rated IEC (International Electrotechnical Commission) Laser Class 3B laser products according to Publication 825.

International-IEC 825. The system helps satisfy the International (IEC825) safety requirements with the use of a REMOTE SHUTDOWN and a KEY SWITCH.



## Laser Warning Labels

The 86030A is shipped with the following warning labels. For systems used outside of the USA, both laser aperture and laser warning labels will be included with the shipment (The labels are located in the same box as this manual). Place these labels directly over the USA laser warning and aperture labels.



**Figure 1-8. Laser safety label locations**

## Electrical Safety

The electrical safety considerations are documented in the section “[General Safety Considerations](#)” on [page -iv](#). Familiarize yourself with the safety markings and instructions before operating this system.

## Service

Limited service may be performed on this system in accordance with information provided in [Chapter 6, “Maintenance”](#). For all other repairs the system must be returned to Agilent Technologies.

## Maintenance

On a daily basis, practice the techniques for proper connector use and care. Refer to the *Lightwave Connection Techniques for Better Measurements* booklet. If you should ever need to clean the cabinet, use a damp cloth only.

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### CAUTION

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Exposure to temperatures above 55°C may cause the front panel fiber to retract. In this case a matching compound can be used to temporarily improve return loss. However, the system should be returned to Agilent Technologies for repair.

---

### CAUTION

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

**Learn proper connector care**

When you use improper cleaning and handling techniques, you risk expensive system repairs, damaged cables, and compromised measurements. Repair of damaged connectors due to improper use is not covered under warranty.

Clean all cables before applying to any connector. Refer to the *Lightwave Connections Techniques for Better Measurements* booklet.

---

## Accurate Measurements

Today, advances in measurement capabilities make connectors and connection techniques more important than ever. Damage to the connectors on calibration and verification devices, test ports, cables, and other devices can degrade measurement accuracy and damage instruments. Replacing a damaged connector can cost thousands of dollars, not to mention lost time! This expense can be avoided by observing the simple precautions presented in this book. This book also contains a brief list of tips for caring for electrical connectors.

---

## Choosing the Right Connector

A critical but often overlooked factor in making a good lightwave measurement is the selection of the fiber-optic connector. The differences in connector types are mainly in the mechanical assembly that holds the ferrule in position against another identical ferrule. Connectors also vary in the polish, curve, and concentricity of the core within the cladding. Mating one style of cable to another requires an adapter. Agilent Technologies offers adapters for most instruments to allow testing with many different cables. The [Figure 1-9 on page 1-34](#) shows the basic components of a typical connectors.

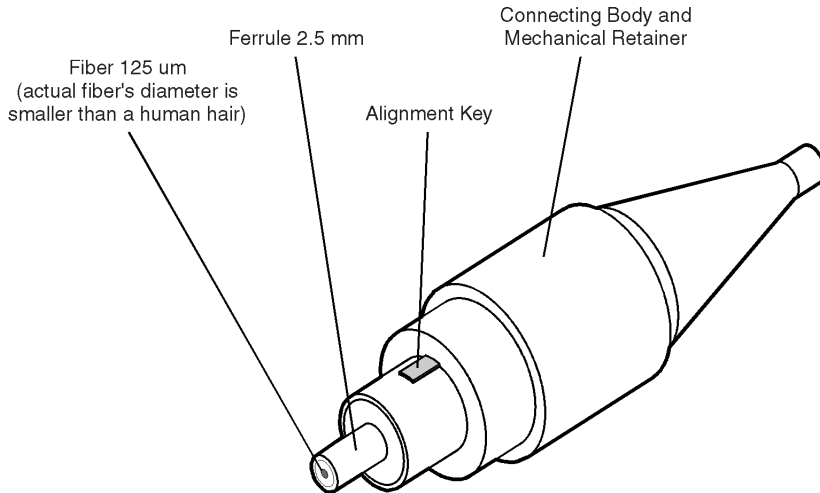
The system tolerance for reflection and insertion loss must be known when selecting a connector from the wide variety of currently available connectors. Some items to consider when selecting a connector are:

- How much insertion loss can be allowed?
- Will the connector need to make multiple connections? Some connectors are better than others, and some are very poor for making repeated connections.
- What is the reflection tolerance? Can the system take reflection degradation?
- Is an instrument-grade connector with a precision core alignment required?
- Is repeatability tolerance for reflection and loss important? Do your specifica-

**Accurate Measurements**

tions take repeatability uncertainty into account?

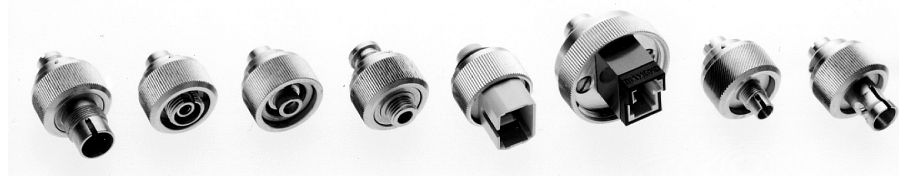
- Will a connector degrade the return loss too much, or will a fusion splice be required? For example, many DFB lasers cannot operate with reflections from connectors. Often as much as 90 dB isolation is needed.



**Figure 1-9. Basic components of a connector.**

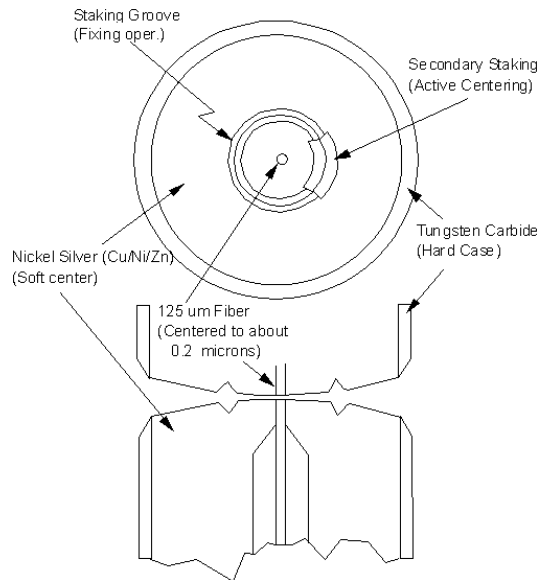
Over the last few years, the FC/PC style connector has emerged as the most popular connector for fiber-optic applications. While not the highest performing connector, it represents a good compromise between performance, reliability, and cost. If properly maintained and cleaned, this connector can withstand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

However, many instrument specifications require tighter tolerances than most connectors, including the FC/PC style, can deliver. These instruments cannot tolerate connectors with the large non-concentricities of the fiber common with ceramic style ferrules. When tighter alignment is required, Agilent instruments typically use a connector such as the Diamond HMS-10, which has concentric tolerances within a few tenths of a micron. Agilent then uses a special universal adapter, which allows other cable types to mate with this precision connector. See [Figure 1-10 on page 1-35](#).



**Figure 1-10. Universal adapters**

The HMS-10 encases the fiber within a soft nickel silver (Cu/Ni/Zn) center which is surrounded by a tough tungsten carbide casing, as shown in [Figure 1-11](#).



**Figure 1-11. Cross-section of the Diamond HMS-10 connector.**

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

## Accurate Measurements

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

---

## Inspecting Connectors

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

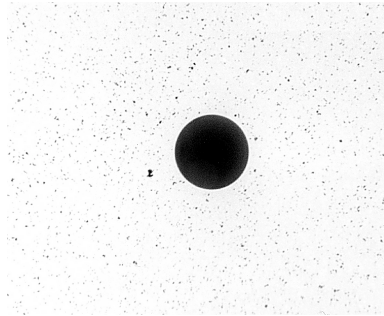
[Figure 1-12](#) shows the end of a clean fiber-optic cable. The dark circle in the center of the micrograph is the fiber's 125  $\mu\text{m}$  core and cladding which carries the light. The surrounding area is the soft nickel-silver ferrule. [Figure 1-13](#) shows a dirty fiber end from neglect or perhaps improper cleaning. Material is smeared and ground into the end of the fiber causing light scattering and poor reflection. Not only is the precision polish lost, but this action can grind off the glass face and destroy the connector.

[Figure 1-14](#) shows physical damage to the glass fiber end caused by either repeated connections made without removing loose particles or using improper cleaning tools. When severe, the damage on one connector end can be transferred to another good connector that comes in contact with it.

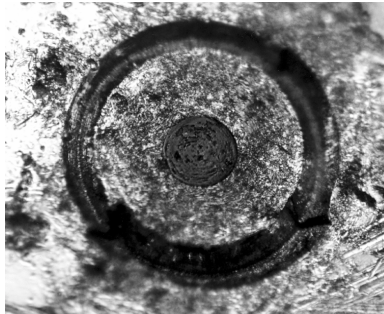
The cure for these problems is disciplined connector care as described in the following list and in [“Cleaning Connectors” on page 1-40](#).

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

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



**Figure 1-12. Clean, problem-free fiber end and ferrule.**



**Figure 1-13. Dirty fiber end and ferrule from poor cleaning.**



**Figure 1-14. Damage from improper cleaning.**

While these often work well on first insertion, they are great dirt magnets. The oil or gel grabs and holds grit that is then ground into the end of the fiber. Also, some early gels were designed for use with the FC, non-contacting con-

## **Accurate Measurements**

nectors, using small glass spheres. When used with contacting connectors, these glass balls can scratch and pit the fiber. If an index matching gel or oil must be used, apply it to a freshly cleaned connector, make the measurement, and then immediately clean it off. Never use a gel for longer-term connections and never use it to improve a damaged connector. The gel can mask the extent of damage and continued use of a damaged fiber can transfer damage to the instrument.

- When inserting a fiber-optic cable into a connector, gently insert it in as straight a line as possible. Tipping and inserting at an angle can scrape material off the inside of the connector or even break the inside sleeve of connectors made with ceramic material.
- When inserting a fiber-optic connector into a connector, make sure that the fiber end does not touch the outside of the mating connector or adapter.
- Avoid over tightening connections.

Unlike common electrical connections, tighter is *not* better. The purpose of the connector is to bring two fiber ends together. Once they touch, tightening only causes a greater force to be applied to the delicate fibers. With connectors that have a convex fiber end, the end can be pushed off-axis resulting in misalignment and excessive return loss. Many measurements are actually improved by backing off the connector pressure. Also, if a piece of grit does happen to get by the cleaning procedure, the tighter connection is more likely to damage the glass. Tighten the connectors just until the two fibers touch.

- Keep connectors covered when not in use.
- Use fusion splices on the more permanent critical nodes. Choose the best connector possible. Replace connecting cables regularly. Frequently measure the return loss of the connector to check for degradation, and clean every connector, every time.

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

### ***Measuring insertion loss and return loss***

Consistent measurements with your lightwave equipment are a good indication that you have good connections. Since return loss and insertion loss are key factors in determining optical connector performance they can be used to determine connector degradation. A smooth, polished fiber end should pro-



duce a good return-loss measurement. The quality of the polish establishes the difference between the “PC” (physical contact) and the “Super PC” connectors. Most connectors today are physical contact which make glass-to-glass connections, therefore it is critical that the area around the glass core be clean and free of scratches. Although the major area of a connector, excluding the glass, may show scratches and wear, if the glass has maintained its polished smoothness, the connector can still provide a good low level return loss connection.

If you test your cables and accessories for insertion loss and return loss upon receipt, and retain the measured data for comparison, you will be able to tell in the future if any degradation has occurred. Typical values are less than 0.5 dB of loss, and sometimes as little as 0.1 dB of loss with high performance connectors. Return loss is a measure of reflection: the less reflection the better (the larger the return loss, the smaller the reflection). The best physically contacting connectors have return losses better than 50 dB, although 30 to 40 dB is more common.

#### ***To Test Insertion Loss***

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

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

#### ***To Test Return Loss***

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

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

**Accurate Measurements*****Visual inspection of fiber ends***

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

---

## Cleaning Connectors

The procedures in this section provide the proper steps for cleaning fiber-optic cables and Agilent universal adapters. The initial cleaning, using the alcohol as a solvent, gently removes any grit and oil. If a caked-on layer of material is still present, (this can happen if the beryllium-copper sides of the ferrule retainer get scraped and deposited on the end of the fiber during insertion of the cable), a second cleaning should be performed. It is not uncommon for a cable or connector to require more than one cleaning.

---

### **CAUTION**

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

---

**Table 1-3. Cleaning Accessories**

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

**Table 1-4. Dust Caps Provided with Lightwave Instruments**

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

***To clean a non-lensed connector***

**CAUTION**

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

- 1** Apply pure isopropyl alcohol to a clean lint-free cotton swab or lens paper.  
Cotton swabs can be used as long as no cotton fibers remain on the fiber end after cleaning.
- 2** Clean the ferrules and other parts of the connector while avoiding the end of the fiber.
- 3** Apply isopropyl alcohol to a new clean lint-free cotton swab or lens paper.
- 4** Clean the fiber end with the swab or lens paper.  
Do *not* scrub during this initial cleaning because grit can be caught in the swab and become a gouging element.
- 5** Immediately dry the fiber end with a clean, dry, lint-free cotton swab or lens paper.
- 6** Blow across the connector end face from a distance of 6 to 8 inches using filtered, dry, compressed air. Aim the compressed air at a shallow angle to the fiber end face.

Nitrogen gas or compressed dust remover can also be used.

**CAUTION**

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

---

## Caring for Electrical Connections

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

### ***Handling and Storage***

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

### ***Visual Inspection***

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

### ***Cleaning***

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

### ***Making Connections***

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

---

## Electrostatic Discharge Information

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

- Conductive table-mat and wrist-strap combination.

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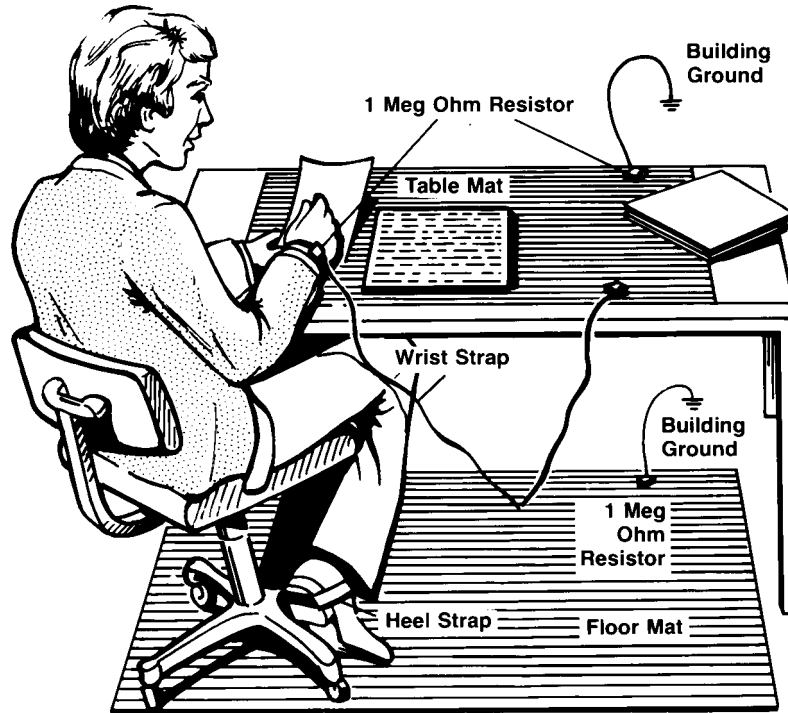
**NOTE**

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For the 86030A 50 GHz LCA system, the static strap is attached to the 86032A front panel grounding receptacle. [Refer to “Front Panel Features” on page 1-8.](#)

- Conductive floor-mat and heel-strap combination.

**Electrostatic Discharge Information**



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

To ensure user safety, the static-safe accessories must provide at least 1 M $\Omega$  of isolation from ground. Refer to [Table 15 on page 1-45](#) for information on ordering static-safe accessories.

---

**WARNING**

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

---

## Reducing ESD Damage

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

- Personnel should be grounded with a resistor-isolated wrist strap before removing any assembly from the unit.
- Be sure all instruments are properly earth-grounded to prevent a buildup of static charge.

**Table 15. Static-Safe Accessories**

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

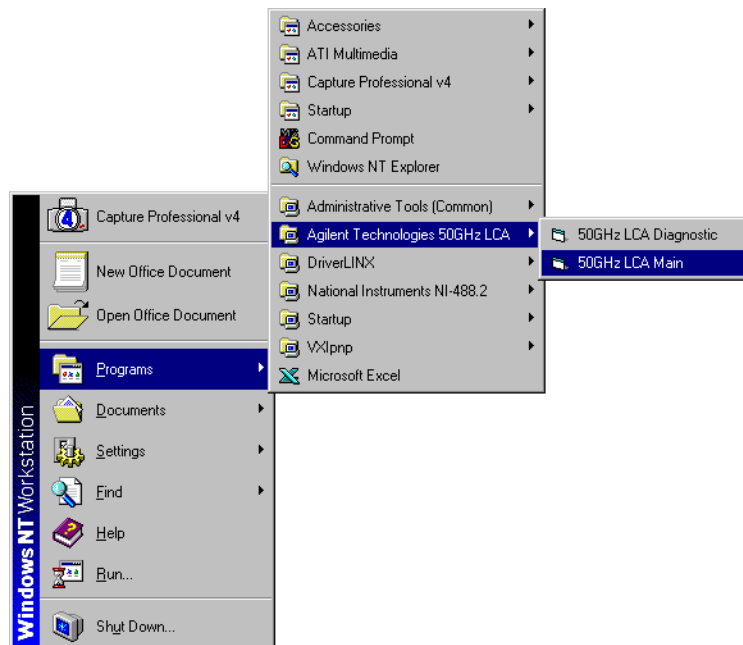
---

## Quick Start

This procedure steps you through the process of making your first measurement. The verification kit supplied with your system contains a photo detector, which we will use to make an optical-to electrical (O/E) bandwidth response measurement.

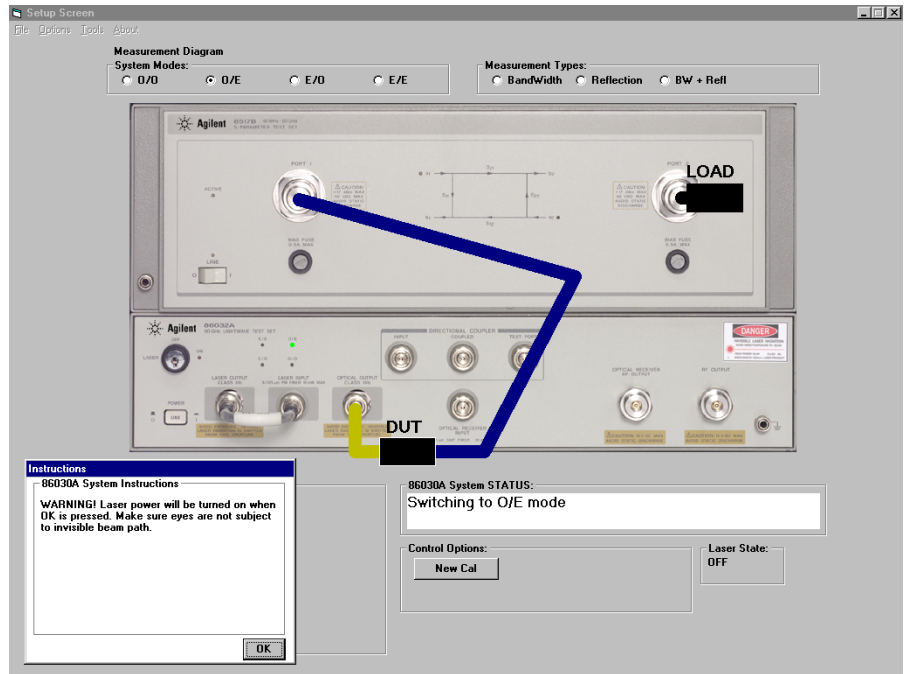
Photodiode responsivity (amps/watt) refers to how a change in optical power is converted to a change in output electrical current. As the frequency of modulation increases, eventually the receiver responsivity will rolloff. Thus, the device has a limited modulation bandwidth. The measurement of modulation bandwidth consists of stimulating the photodiode with a source of modulated light and measuring the output response current with an electrical receiver. The frequency of the modulation is swept to allow examination of the photodiode over a wide range of modulation frequencies.

- 1 From the Windows **Start** menu, select **Programs, Agilent Technologies 50 GHz LCA, 50 GHz LCA Main** to open the software.





- 2 Follow the instructions for the Laser power prompt, then press **OK**.



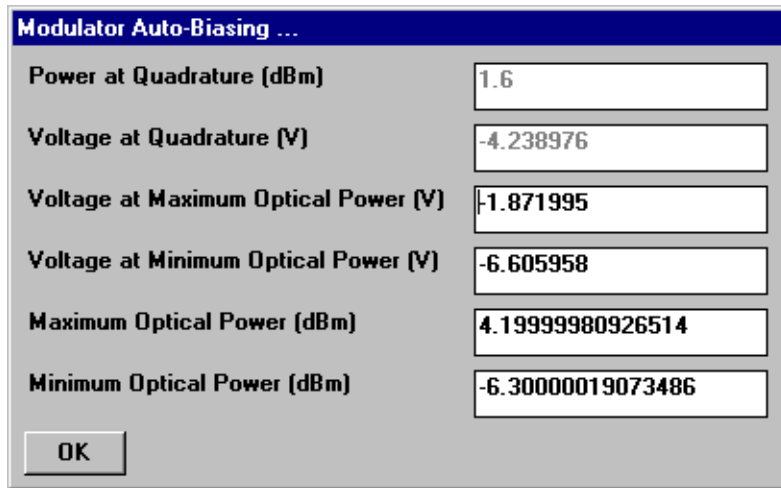
- 3 When the software is first opened, a modulator auto-bias will automatically be performed, which takes approximately 2 minutes. The modulator is automatically biased to the optimum (quadrature) performance condition.

An auto-bias does not need to be performed before each individual measurement but should be performed for any of the following conditions:

- at least once every eight hours
- if the temperature has drifted more than 3°C from the user calibration temperature
- if the jumper between the 86032A LASER OUTPUT and LASER INPUT has been removed and replaced.

This routine takes approximately two minutes and the results will be displayed on the screen. Refer to “Auto Bias” on page 1-20.

**Quick Start**



The image shows a dialog box titled "Modulator Auto-Biasing ...". It contains six input fields with the following values:

Parameter	Value
Power at Quadrature (dBm)	1.6
Voltage at Quadrature (V)	-4.238976
Voltage at Maximum Optical Power (V)	-1.871995
Voltage at Minimum Optical Power (V)	-6.605958
Maximum Optical Power (dBm)	4.19999980926514
Minimum Optical Power (dBm)	-6.30000019073486

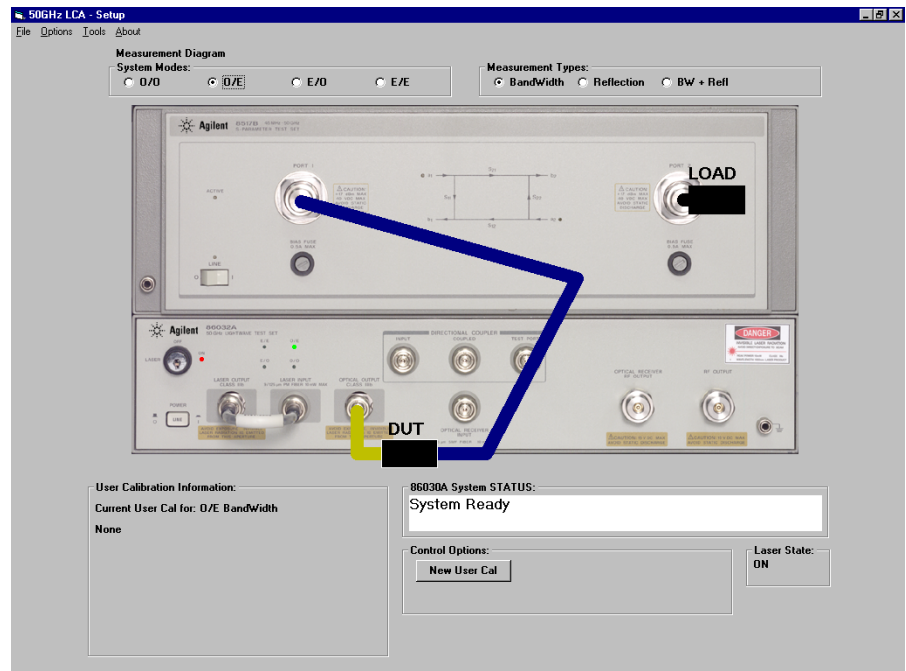
At the bottom left of the dialog box is an "OK" button.

- 4 When the auto bias is finished, click **OK** to close the Modulator Auto Bias window.

The system has finished setup procedures.

## Making an Optical to Electrical Measurement

- 1 In the System Modes area, click on **O/E** (the default mode) to set up for an optical to electrical measurement.



- 2 In the Measurement Types area, click on **BandWidth**.
- 3 In the Control Options area, click on the **New User Cal**.
- 4 The message, “Set 8510 to desired Start Frequency, Stop Frequency, and the Number of Points” appears. To do this:
  - a On the 8510 analyzer under the STIMULUS area, set the Start frequency to 45 MHz and the Stop Frequency to 50 GHz.
  - b From the STIMULUS MENU, select *NUMBER of POINTS*, then *801*.
  - c From the RESPONSE MENU, select AVERAGING ON and set to 128 points.
- 5 Click **OK** in the application message box.

**Quick Start**

- 6 Follow the onscreen instructions to configure the test set for calibration, then press **OK**.
- 7 In the Control Options area, click on **Resp-Isol** to perform a response plus isolation calibration.
- 8 Follow the on-screen instructions for the Response portion of the calibration procedure.
- 9 Follow the on-screen instructions for the Isolation portion of the calibration procedure.

The system first takes an uncorrected measurement of the internal O/E converter in the 86032A test set. This raw data along with factory calibration data for the internal O/E are used to construct a calibration file for the system.

You can monitor the System Status area as the calibration is in progress. Once the calibration is completed, you can view the calibration results in the Calibration Information area.

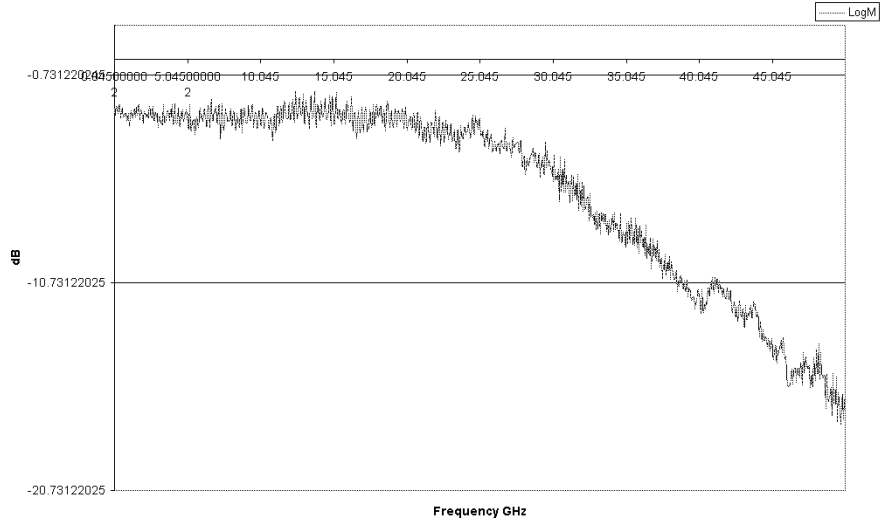
You are now ready to make a bandwidth response measurement.

- 10 Follow the on-screen instructions for the measurement setup.
- 11 From the 8510 RESPONSE menu, adjust the scale to best fit the trace on the screen.
  - a Select *REFVALUE* and use the knob to center the trace around the display line.
  - b Select *SCALE* and decrease the dB/div to expand the trace across the display (approximately 2 dB/div).
  - c Repeat steps a and b to get the best view.
- 12 Select the RESPONSE MENU key, then SMOOTHING ON.
- 13 Save the trace data to an Excel file by selecting **File, Save Data, Excel File**, then, **Form Log Mag**.
- 14 In the Save to Excel dialog box, enter quick\_start as the trace file name then click **OK**.

You can now view the trace by selecting **File, Graph Excel Data, Form Log Mag** and then **Open** the **Quick\_Start** file. Alternately, you can open a session of Excel and view or manipulate the trace file from there.

Or, you can further analyze the trace data by using the controls on the 8510C.

Magnitude Trace: feb3\_ripple\_nopad.xls Time: 9:51:27 AM Date: 2/3/2000



Getting Started

**Quick Start**

“The Calibrations” on page 2-2

“O/O Response and Isolation Bandwidth Calibration” on page 2-5

“O/E Response and Isolation Bandwidth Calibration” on page 2-8

“O/E Response and Match Bandwidth Calibration” on page 2-11

“E/O Response and Isolation Bandwidth Calibration” on page 2-20

“Electrical Mismatch Ripple and its Effects on Measurements.” on page 2-25

“Magnitude Response and Deviation From Linear Phase of a Lightwave Receiver” on page 2-37

“O/E RF Overload Detection Measurement” on page 2-47

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## Measurement Techniques

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## The Calibrations

The 86030A software can perform many different types of calibrations depending on your device type and measurement needs. Following is a list of all of the available calibrations.

- **O/O**
  - Bandwidth Measurement
    - Response
    - Response/Isolation
  - Reflection Measurement
    - Response
    - Response/Isolation
- **O/E**
  - Bandwidth
    - Response
    - Response/Isolation
    - Response/Match
  - Reflection
    - Response
    - Response/Isolation
  - Bandwidth & Reflection
    - Response
    - Response/Isolation
- **E/O**
  - Bandwidth
    - Response
    - Response/Isolation
  - Reflection
    - Response
  - Bandwidth & Reflection
    - Response
    - Response/Isolation
  - Reflection Sensitivity
    - Response
- **E/E**

Use the 8510C for electrical calibrations and measurements.



**Table 2-1. Purpose and Use of Different Calibration Procedures**

<b>Calibration Procedure</b>	<b>Corresponding Measurement</b>	<b>Errors Removed</b>	<b>Standard Procedure</b>
<b>Electrical</b>			
Response	Transmission or reflection measurement when the highest accuracy is not required.	Frequency response	Thru for transmission, open or short for reflection
Response & Isolation	Transmission of high insertion loss devices or reflection of high return loss devices. Not as accurate as 1-port or 2-port calibration.	Frequency response plus isolation in transmission or directivity in reflection.	Same as response plus isolation std (load)
S11 1-port	Reflection of any one-port device or well terminated two-port device.	Directivity, source match, frequency response	Short, open, and load(s)
S22 1-port	Reflection of any one-port device or well terminated two-port device.	Directivity, source match, frequency response	Short, open, and load(s)
Full 2-port	Transmission or reflection of highest accuracy for two-port devices.	Directivity, source match, load match, isolation, frequency response, each in forward and reverse directions.	Short, open, and load(s). Two loads needed for isolation.
<b>Optical (O, O/O)</b>			
Response	Transmission or reflection measurement when the highest accuracy is not required.	Frequency response	Optical thru for transmission, Fresnel or Reflector for reflection
Response & Isolation	Transmission of high insertion loss devices or reflection of high return loss devices.	Frequency response, plus isolation in transmission or directivity in reflection.	Same as response plus disconnect cable or turn off laser.
<b>Optical (O/E)</b>			
Response	Transmission measurement	Frequency response	Optical and/or electrical thrus
Response & Isolation	Transmission of high Insertion loss devices	Frequency response plus isolation	Same as Response plus disconnect cable or turn off laser.

**The Calibrations****Table 2-1. Purpose and Use of Different Calibration Procedures**

<b>Calibration Procedure</b>	<b>Corresponding Measurement</b>	<b>Errors Removed</b>	<b>Standard Procedure</b>
Response & Match	Transmission measurement for devices with large electrical reflectivity.	Frequency response plus electrical mismatch	Same as Response plus short, opens, and loads.
<b>Optical (E/O)</b>			
Response	Transmission or reflection sensitivity measurement.	Frequency response	Optical and /or electrical thru for transmission, optical load for reflection sensitivity
Response and Isolation	Transmission of high insertion loss devices.	Frequency response plus isolation	Same as response plus disconnect the cable or turn off the laser.
<p>Note: If cables, connectors, or adapters are removed from the measurement setup that were used in the calibration, their effect must be accounted for by adding a port extension equivalent to the electrical length of the missing component(s).</p>			

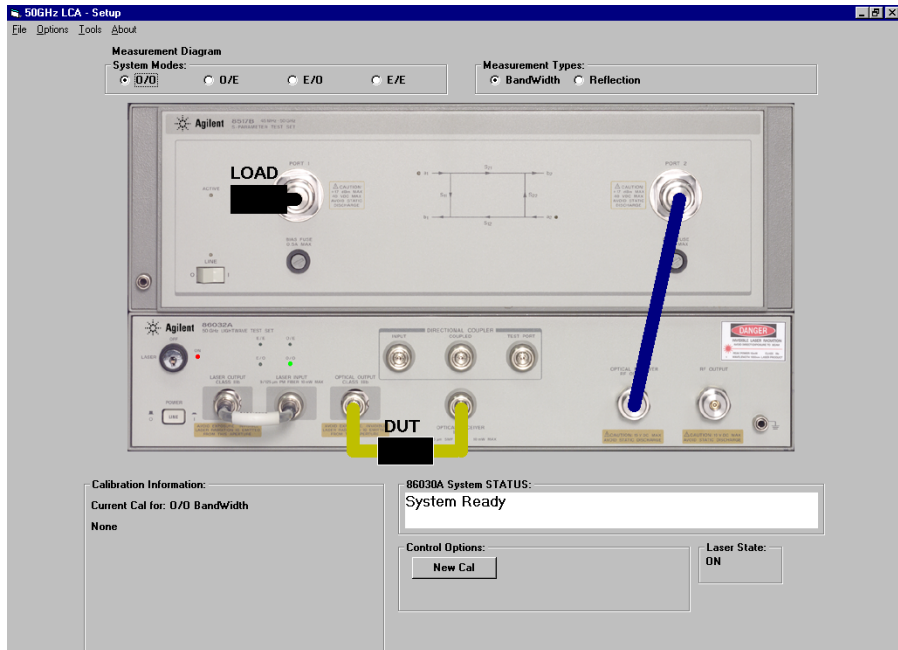
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## O/O Response and Isolation Bandwidth Calibration

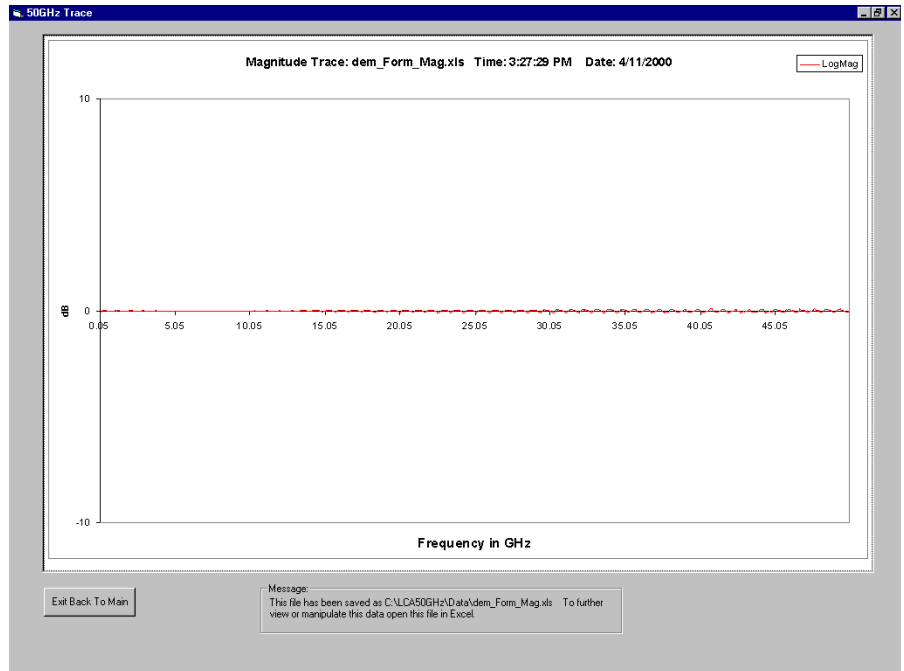
The following procedure shows you how to make a response and isolation bandwidth calibration.

- 1** In the System Modes area in the Setup Screen, click on **O/O** to setup for an optical to electrical measurement.
- 2** In the Measurement Types area, click on **BandWidth**.
- 3** In the Control Options area, click on **New User Cal**.
- 4** The message, “Set 8510 to desired Start Frequency, Stop Frequency, Averaging, and the Number of Points” appears. To do this:
  - a** On the 8510 analyzer under the STIMULUS area, set the Start frequency and the Stop Frequency to the frequency range required for your measurement.
  - b** From the STIMULUS MENU, select *NUMBER of POINTS*, then select the number of data points, for example, 801 points.
  - c** From the RESPONSE MENU, select *AVERAGING ON/restart*, then enter the number of averages. For example, for 128 averages enter 128 x1.
- 5** In the Control Options area, click on **Resp-Isol** to perform a response plus isolation calibration.
- 6** Follow the on-screen instructions to complete the calibration procedure.

## O/O Response and Isolation Bandwidth Calibration



The figure below shows the results of an optical to optical measurement of a through line with 0 dB loss. The magnitude of the trace (that is, the vertical axis) is measured in dB. For more information, refer to “O/O Display Scaling Calculations” on page 3-16.



**Figure 2-1. Measurement results of a through line**

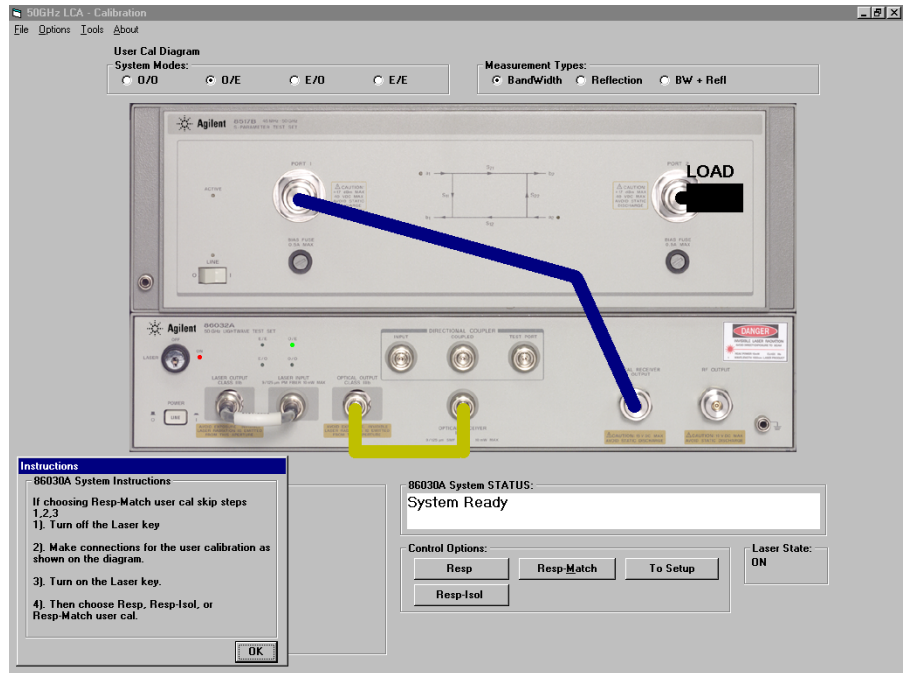
---

## O/E Response and Isolation Bandwidth Calibration

The following procedure shows you how to make an Optical to Electrical response and isolation bandwidth calibration.

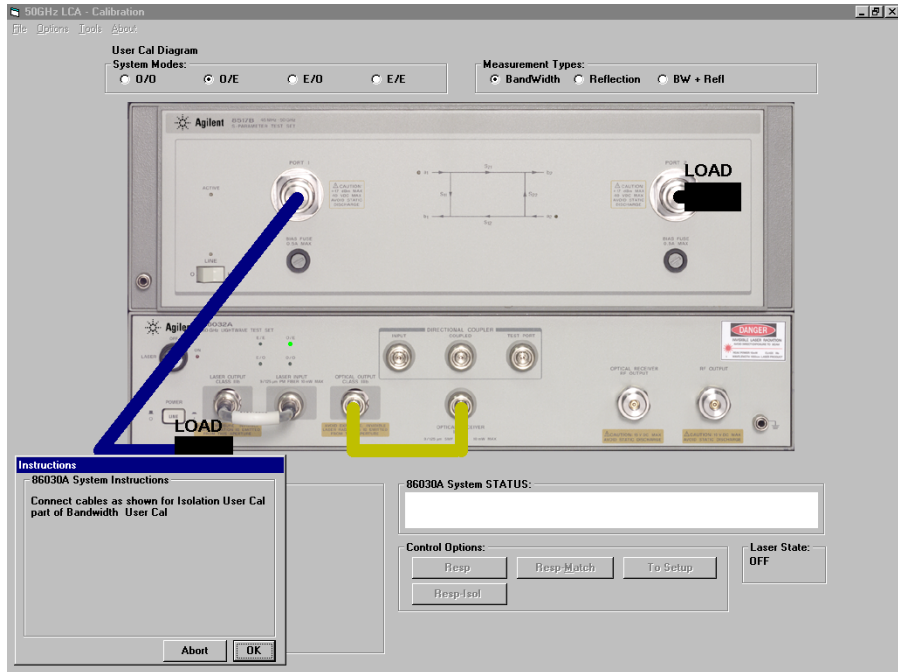
- 1** In the System Modes area in the Setup Screen, click on **O/E** to setup for an optical to electrical measurement.
- 2** In the Measurement Types area, click on **BandWidth**.
- 3** In the Control Options area, click on **New User Cal**.
- 4** The message, “Set 8510 to desired Start Frequency, Stop Frequency, Averaging, and the Number of Points” appears. To do this:
  - a** On the 8510 analyzer under the STIMULUS area, set the Start frequency and the Stop Frequency to the frequency range required for your measurement.
  - b** From the STIMULUS MENU, select *NUMBER of POINTS*, then select the number of data points, for example, 801 points.
  - c** From the RESPONSE MENU, select *AVERAGING ON/restart*, then enter the number of averages. For example, for 128 averages enter 128 x1.
- 5** In the Control Options area, click on **Resp-Isol** to perform a response plus isolation calibration.

- 6 Follow the on-screen instructions for the response portion of the calibration procedure. See figure below.



## O/E Response and Isolation Bandwidth Calibration

- 7 Follow the on-screen instructions for the isolation portion of the calibration procedure. See figure below.





---

## O/E Response and Match Bandwidth Calibration

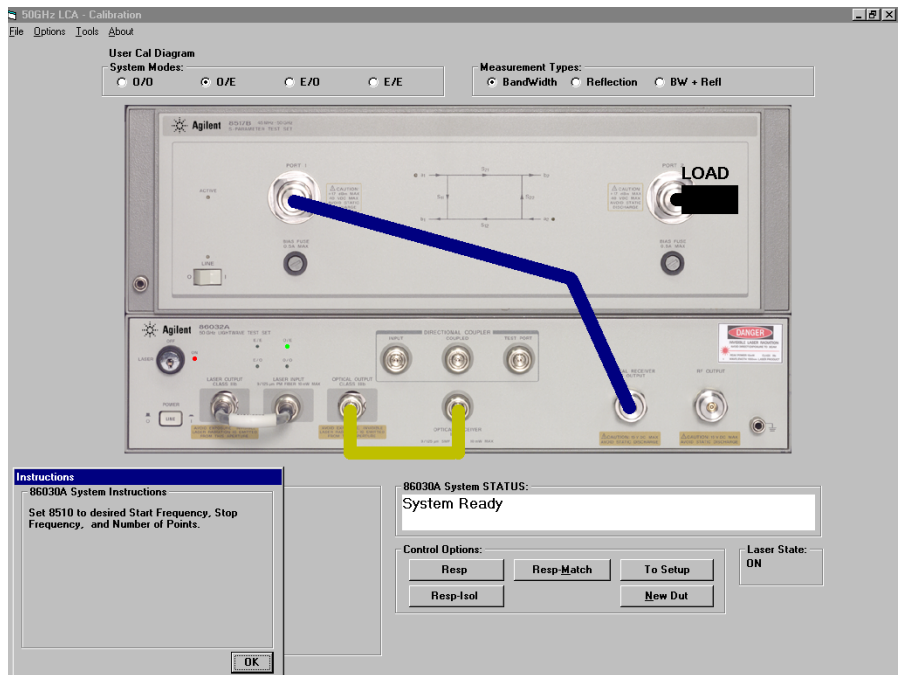
The 86030A provides a capability to mathematically reduce the effects of electrical mismatch. In order to do this, the DUT response information is modified using measurements of the electrical reflectivity of the DUT and the electrical reflectivity of the 86030A. Significant reduction of electrical mismatch error results.

For this calibration, you will need to use some the accessories supplied in the 85056A 2.4 mm Calibration Kit.

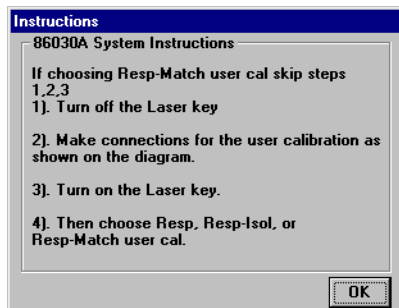
The following procedure shows you how to make an Optical to Electrical response and match bandwidth calibration.

- 1** In the System Modes area in the Setup Screen, click on **O/E** to setup for an optical to electrical measurement.
- 2** In the Measurement Types area, click on **BandWidth**.
- 3** In the Control Options area, click on **New User Cal**.
- 4** The message, “Set 8510 to desired Start Frequency, Stop Frequency, Averaging, and the Number of Points” appears. To do this:
  - a** On the 8510 analyzer under the STIMULUS area, set the Start frequency and the Stop Frequency to the frequency range required for your measurement.
  - b** From the STIMULUS MENU, select *NUMBER of POINTS*, then select the number of data points, for example, 801 points.
  - c** From the RESPONSE MENU, select *AVERAGING ON/restart*, then enter the number of averages. For example, for 128 averages enter 128 x1.

## O/E Response and Match Bandwidth Calibration



5 When the following message appears, click **OK** to continue.

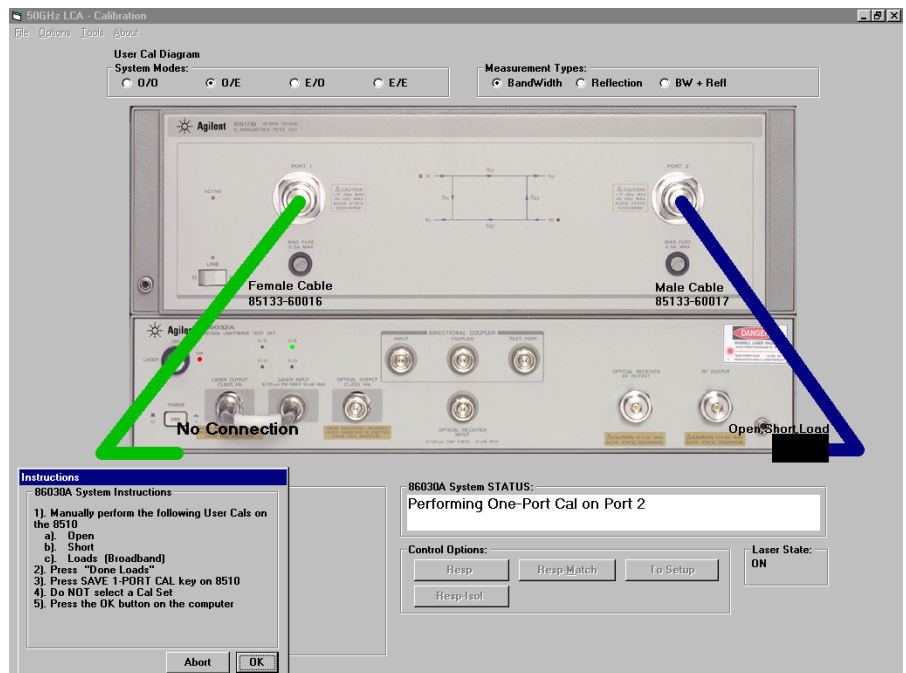


6 In the Control Options area, click on **Resp-Match** to perform a response plus impedance match calibration.



## One-Port Calibration on Port 2

- 7 Connect the equipment as shown on-screen, choosing an Open to connect to the end of the 8517B Port 2 cable.



- 8 From the 8510C function keys, press *Open*.

Once a sweep of the trace is completed, the message "*Connect STD then press key to Measure*" appears, and you will notice that the Open function key on the 8510C is now underlined. This indicates that the Open portion of the

**O/E Response and Match Bandwidth Calibration**

calibration process is completed and you are ready to continue with a Short.

- 9 Connect the equipment as shown onscreen, choosing a Short to connect to the end of the 8517B Port 1 cable.
- 10 From the 8510C function keys, press *Short*.

Once a sweep of the trace is completed, the message “*Connect STD then press key to Measure*” appears, and you will notice that the Short function key on the 8510C is now underlined. This indicates that the Short portion of the calibration process is completed and you are ready to continue with a Load.

- 11 Connect the equipment as shown onscreen, choosing a 50 ohm load to connect to the end of the 8517B Port 1 cable.
- 12 From the 8510C function keys, press *Loads* then *Broadband*.

Once a sweep of the trace is completed, you will notice that the Broadband function key on the 8510C is now underlined. This indicates that the Load Broadband portion of the calibration process is completed.

- 13 From the 8510C function keys, press *Done Loads*.
- 14 From the 8510C function keys, press *Save 1-Port Cal*.

---

**NOTE**

When the 8510C message “Select Calibration Set” appears, *do not* select a cal set to save. This completes the Port 2 portion of the match calibration.

- 15 From the 86030A software, click **OK** to continue with the Port 1 portion of the match calibration.

## One-Port Calibration on Port 1

- 16 Repeat [Step 7](#) through [Step 15](#) by attaching the Open, Short, and Load to the 8517B Port 2 instead of Port 1. Refer to [“”](#) on page 2-15.

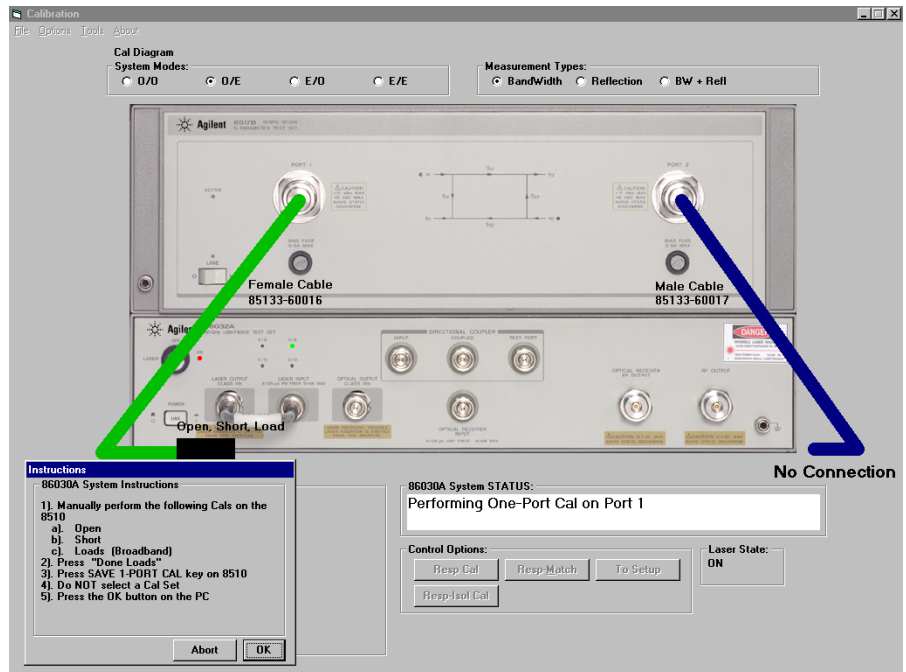
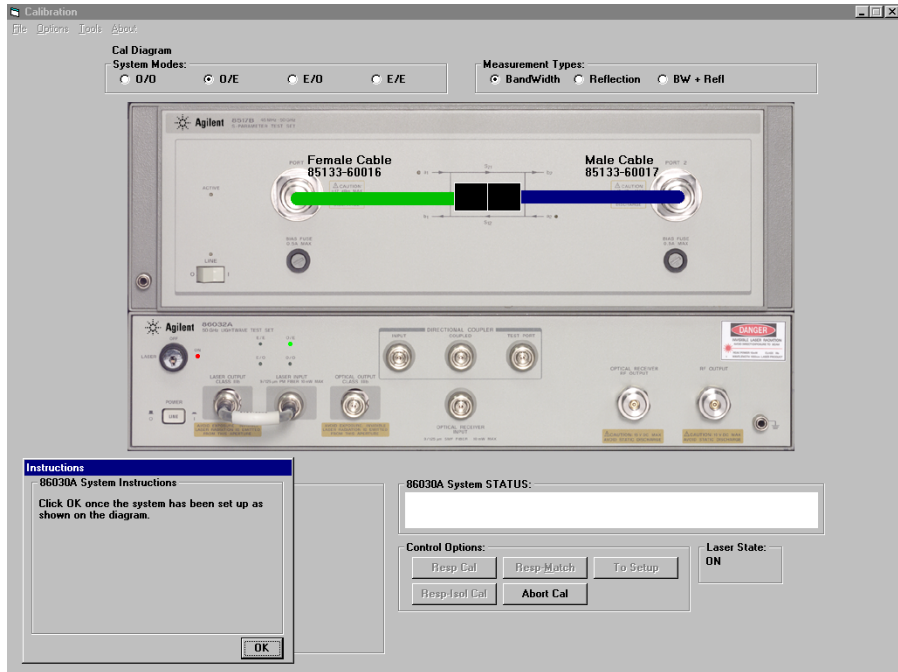


Figure 2-2.

---

## Measurement of Port One Reflectivity

- 17 Connect the equipment as shown in [Figure 2-3](#) then click **OK**.



**Figure 2-3.**

## Measurement of Port 1 Reflectivity

- 18 Connect the equipment as shown in Figure 2-4 then click **OK**.

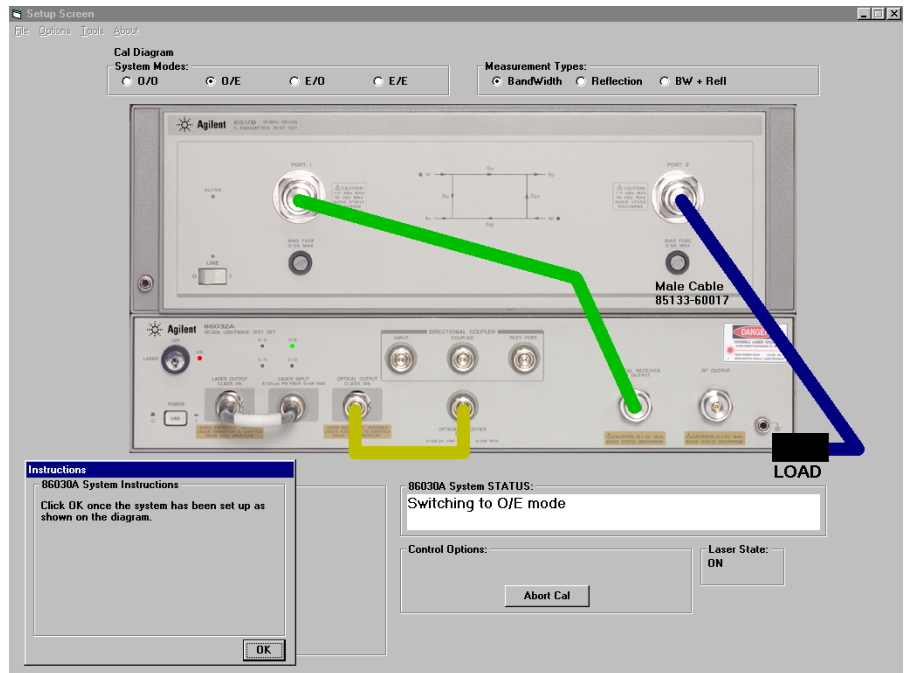
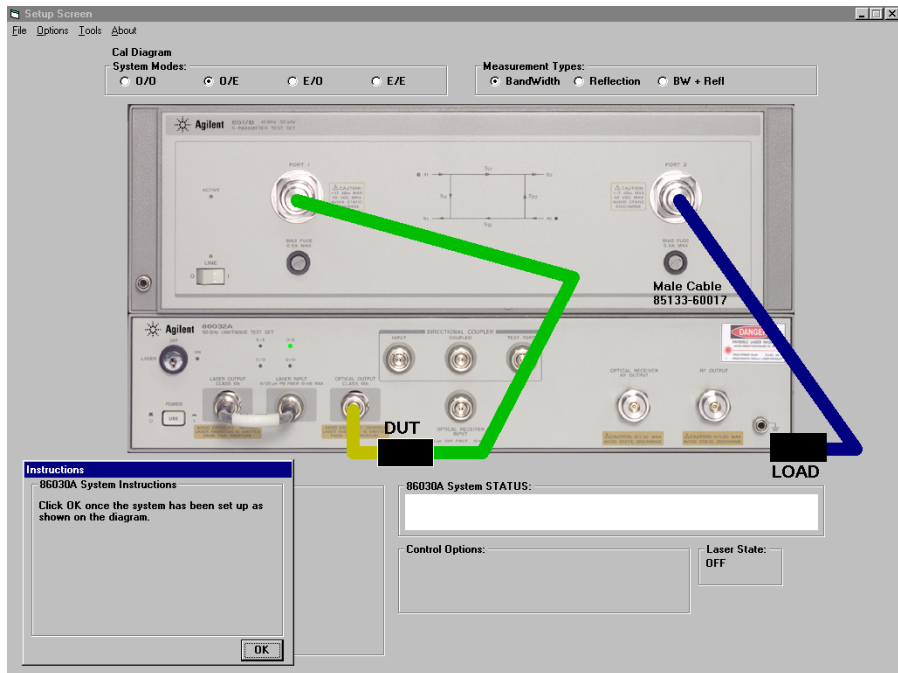


Figure 2-4.

---

## Measurement of 86032A Internal O/E Response

- 19 Connect the equipment as shown in [Figure 2-5](#) then click **OK**.



**Figure 2-5.**

Once the calibration is completed, the results will be displayed in the User Calibration Information area.



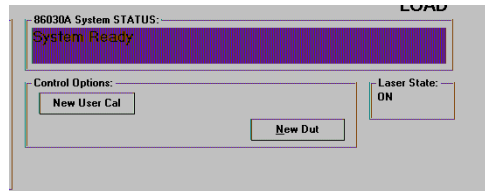
---

## New DUT

The disadvantages of a response plus match calibration is that it is a more complicated and lengthy procedure and it is only valid for a particular DUT.

Using the New Dut function, in the Control Options area, repeats only the DUT reflectivity portion of the calibration. This greatly reduces the calibration time when a measurement of a new test device is desired, or if the electrical port match has changed.

The 86030A also provides a capability to mathematically reduce the effects of electrical mismatch. In order to do this, the DUT response information is modified using measurements of the electrical reflectivity of the DUT and the electrical reflectivity of the 86030A. Significant reduction of electrical mismatch error results.

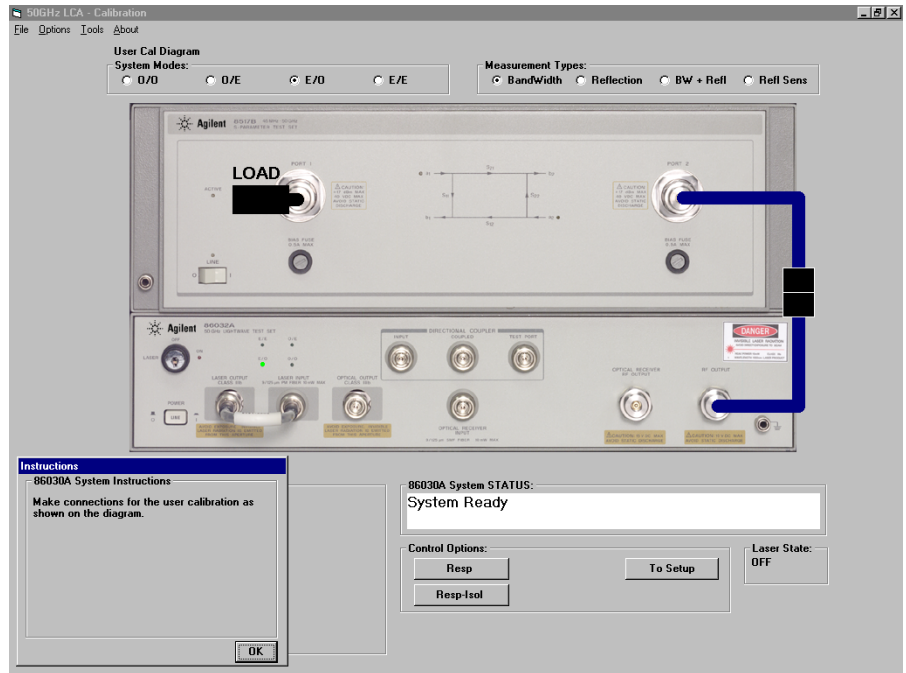


## E/O Response and Isolation Bandwidth Calibration

The following procedure shows you how to make an Electrical to Optical response and isolation bandwidth calibration.

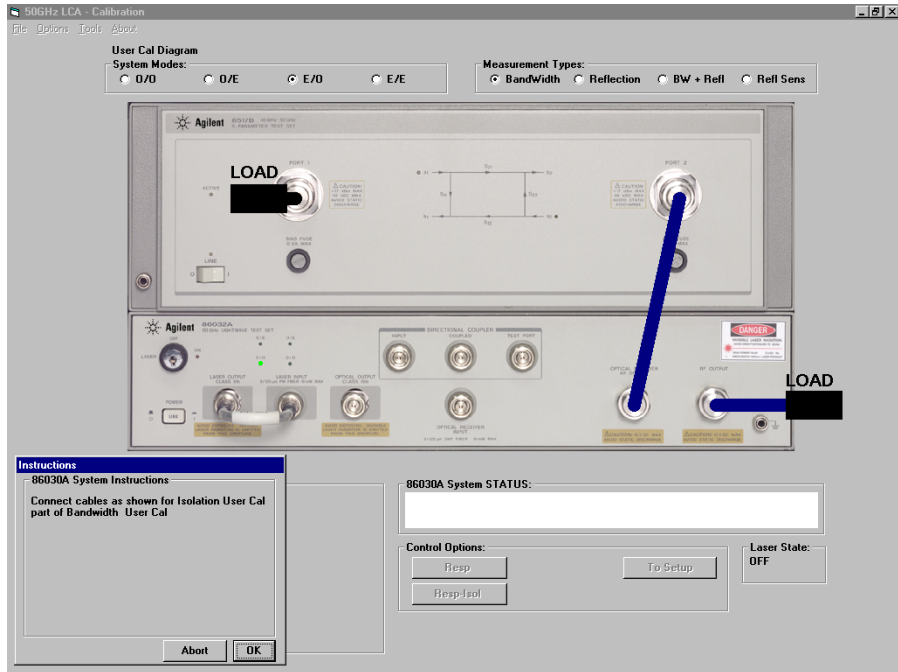
- 1** In the System Modes area in the Setup Screen, click on **E/O** to setup for an optical to electrical measurement.
- 2** In the Measurement Types area, click on **BandWidth**.
- 3** In the Control Options area, click on **New User Cal**.
- 4** The message, “Set 8510 to desired Start Frequency, Stop Frequency, Averaging, and the Number of Points” appears. To do this:
  - a** On the 8510 analyzer under the STIMULUS area, set the Start frequency to and the Stop Frequency to the frequency range required for your measurement.
  - b** From the STIMULUS MENU, select *NUMBER of POINTS*, then select the number of data points, for example, 801 points.
  - c** From the RESPONSE MENU, select *AVERAGING ON/restart*, then enter the number of averages. For example, for 128 averages enter 128 x1.
- 5** In the Control Options area, click on **Resp-Isol** to perform a response plus isolation calibration.

- 6 Follow the on-screen instructions to perform the Response portion of the calibration procedure. See figure below.



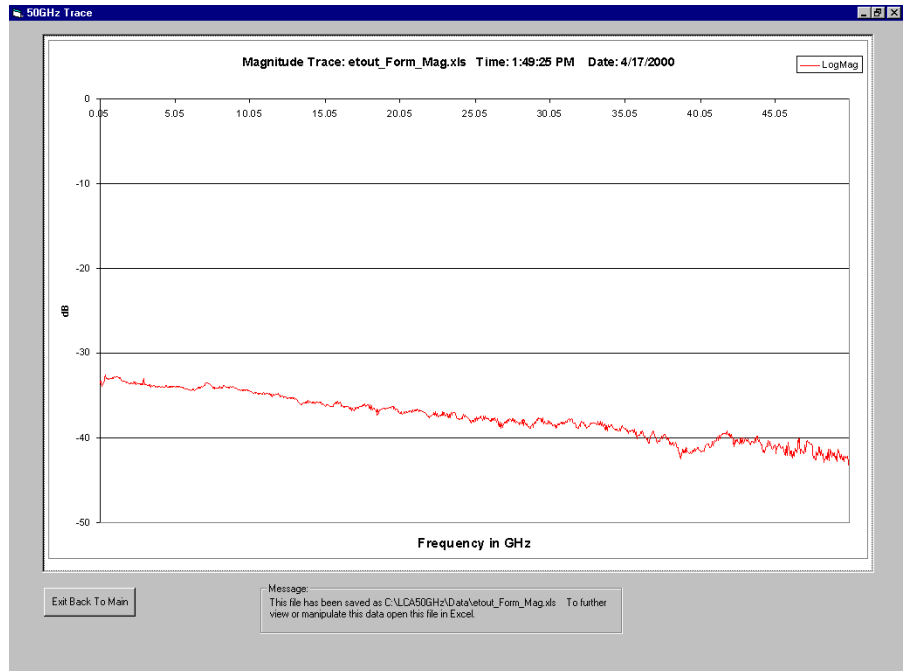
## E/O Response and Isolation Bandwidth Calibration

- 7 Follow the on-screen instructions to perform the Isolation portion of the calibration procedure. See figure below.



**E/O Response and Isolation Bandwidth Calibration**

The figure below shows the results of a measurement of an external E/O modulator. The magnitude of the trace (that is, the vertical axis) is measured in dB. For more information, refer to [“E/O Display Scaling Calculations”](#) on page 3-15.



---

## Agilent 86030A System Example Measurements

This section provides example measurements. These examples are not intended to cover all applications of the systems.

This section contains the following:

- Electrical mismatch ripple and its effects on measurements
- Optical reflection measurement between a splice and a cleave
- Bandwidth and reflection measurement of a lightwave source
- Magnitude response and deviation from linear phase for an optical receiver

---

### **CAUTION**

Costly replacement of an entire lightwave assembly will result from damage to an optical test port connector. Keep optical cables connected to the test ports to protect the connectors from damage.

---

### **CAUTION**

When you use improper cleaning and handling techniques, you risk expensive system repairs, damaged cables, and compromised measurements. Repair of damaged connectors due to improper use is not covered under warranty.

Clean all cables before applying to any connector. [Refer to “Choosing the Right Connector” on page 1-33](#) and to [“Cleaning Connectors” on page 1-40](#).

---

### **WARNING**

**Do NOT under any circumstances, look into the optical output of any fiber/device attached to the output while the laser is in operation. [Refer to “Laser Safety Considerations” on page 1-30](#) for more information.**

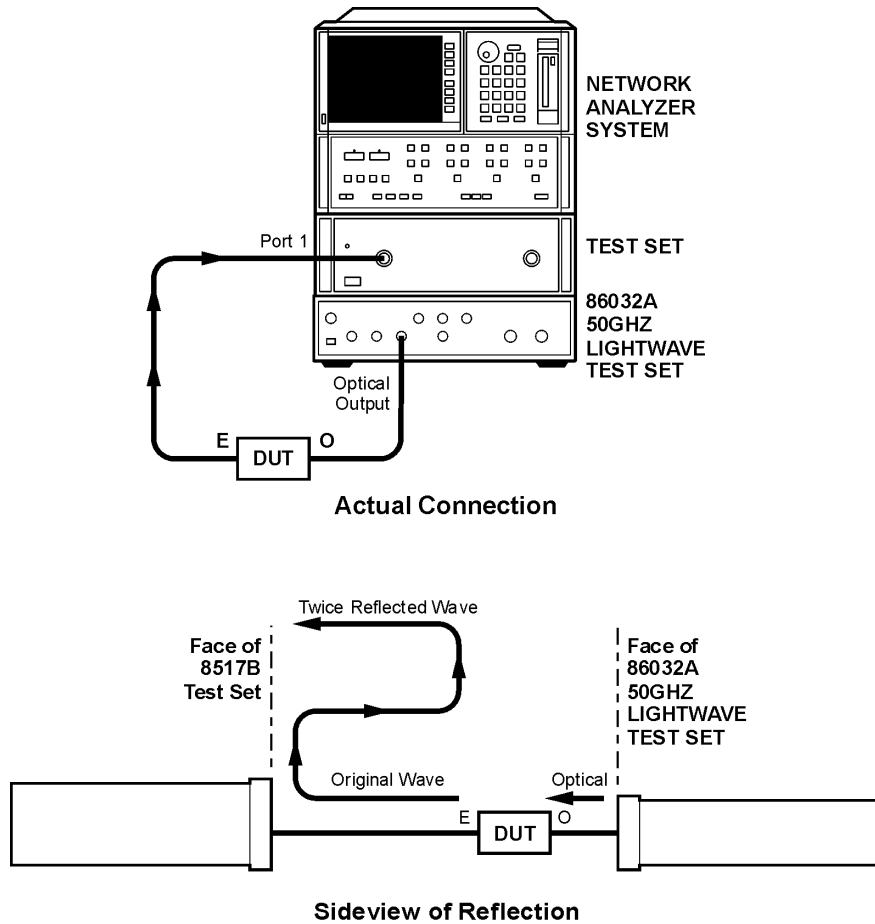
---

## Electrical Mismatch Ripple and its Effects on Measurements.

Trace ripple is caused by a mismatch between the impedance of the device under test and the nominal 50 ohm input port on the 8517B test set. Depending on the phase of the desired (incident signal) and undesired signal (twice reflected signal), the effect either adds or subtracts to the magnitude of the desired signal. This phenomenon, called ripple, causes the trace to periodically deviate above and below the correct value. For devices that have high electrical reflectivity, the ripple is quite apparent. For devices well matched to 50 ohms, the trace ripple is much less visible.

[Figure 2-6](#) will help to explain the effects of the trace ripple.

**Electrical Mismatch Ripple and its Effects on Measurements.**



**Figure 2-6. Effects of Electrical Mismatch Ripple**

reflec



**Electrical Mismatch Ripple and its Effects on Measurements.**

Spacing between successive peaks of this mismatch ripple is described by the equation:

$$\text{ripple period Hz} = \frac{\text{Velocity in cable}}{2 \cdot L_{\text{cable}}}$$

As an example, the 85133-60017 cable has a physical length of approximately 1 meter and a velocity of  $2 \times 10^8 \frac{m}{s}$ . In this case,

$$\text{ripple period Hz} = \frac{2 \times 10^8 \frac{m}{s}}{2 \cdot 1 \text{ meter}} = 1 \times 10^8, \text{ or } 100 \text{ MHz}$$

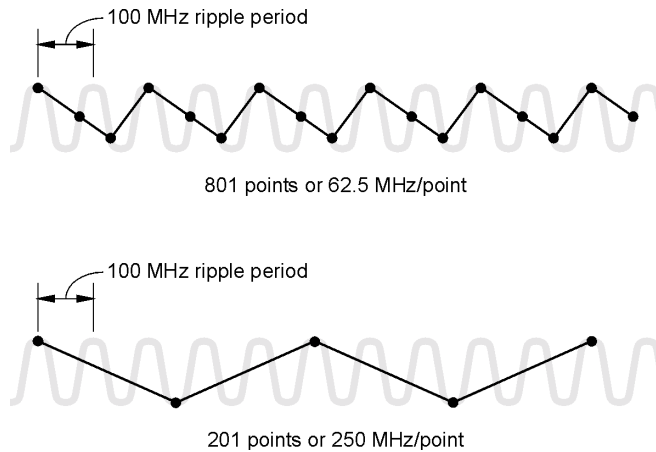
For devices that have high reflectivity in the electrical port, the addition of a 6 dB attenuator on the electrical test port will substantially reduce the trace ripple. (A 6 dB attenuator is supplied in the verification kit.) However, there is a trade off of system sensitivity since the signal to noise floor will be reduced by 6 dB. Refer to “801 Data Points and No Attenuation Added” on page 2-31 and to “Ripple Measurement, 201 Points, with 6 dB Attenuator” on page 2-34.

The appearance of the trace ripple is also affected by the number of points selected for measurement.

When 801 points is used for a 50 GHz frequency span, there is approximately 62.5 MHz between data points. [Figure 2-7](#)

When 201 points is used for a 50 GHz frequency span, there is approximately 250 MHz between data points. Refer to “201 Data Points and 6 dB Attenuator” on page 2-34.

**Electrical Mismatch Ripple and its Effects on Measurements.**



**Figure 2-7. The Number of Points for Measurement Effect Mismatch Ripple**

Compare the trace data taken with 201 points versus the trace data taken with 801 points. Notice that the 201 point trace has more of a sawtooth appearance. When fewer data points are taken, it affects your ability to discern the response of the device under test (DUT) from the effects of the ripple.

To demonstrate the effects of the system ripple, we will measure the 83440D lightwave detector supplied in the verification kit. The lightwave detector was selected for this example since it has high reflectivity (reflectivity = 1) in the electrical port which will show the worst-case ripple.

---

## Ripple Measurement, 801 Points, No Attenuator

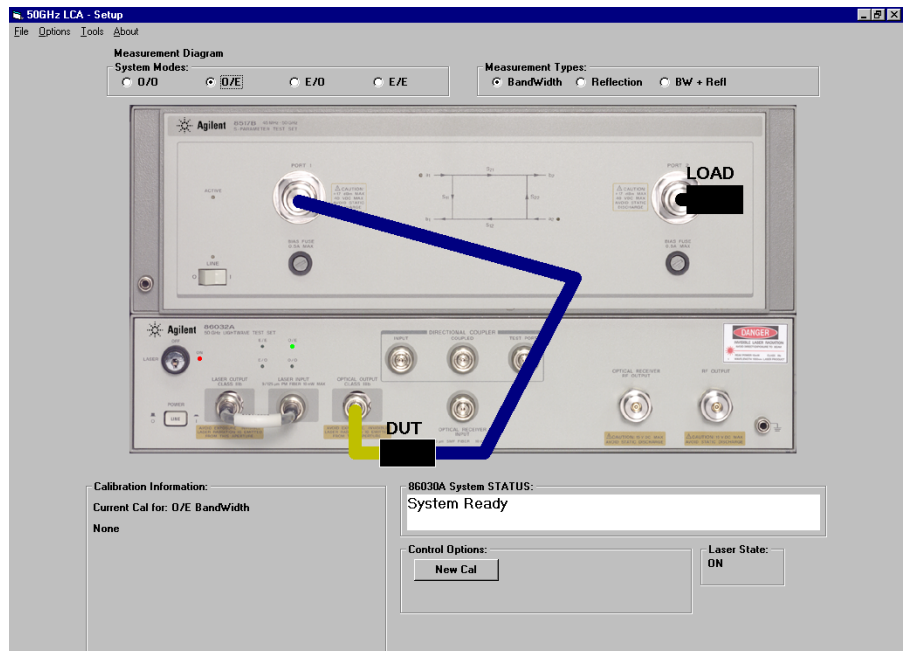
The first measurement example will use the maximum number of data points allowed by the network analyzer, but with no attenuation on the electrical port of the DUT.

### O/E Calibration

- 1 Connect a BNC 50 ohm load on Port 1 Bias on the 86032A rear panel.

A BNC 50 ohm load can be found in the verification kit.

- 2 In the System Modes area, click on **O/E** to setup for an optical to electrical measurement.
- 3 In the Measurement Types area, click on **BandWidth**.
- 4 In the Control Options area, click on New **Cal**.



- 5 Follow the on-screen instructions to configure and perform the test set

**Electrical Mismatch Ripple and its Effects on Measurements.**

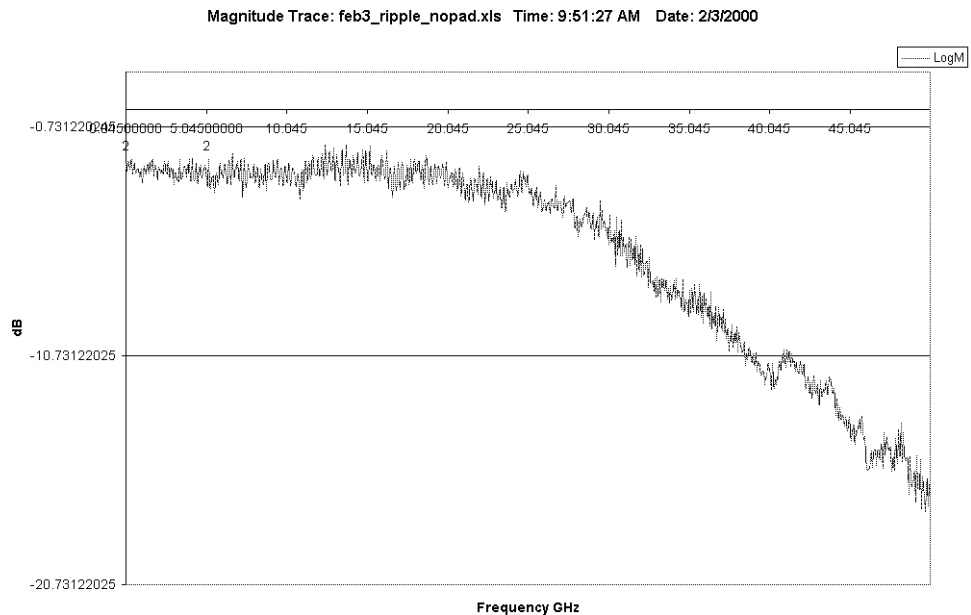
calibration.

- 6 The message, “Set 8510 to desired Start Frequency, Stop Frequency, and the Number of Points” appears. To do this:
  - a On the 8510 analyzer under the STIMULUS area, set the Start frequency to 45 MHz and the Stop Frequency to 50 GHz.
  - b From the STIMULUS MENU, select *NUMBER of POINTS*, then *801*.
- 7 In the Control Options area, click on **Resp-Isol Cal**.



**Detector  
Response  
Measurement**

- 8 When the calibration is complete connect the 83440D lightwave detector as shown. Remember to connect the 87421A power supply (found in the verification kit) to the DC bias port of the detector.
- 9 From the 8510 RESPONSE menu, adjust the scale to display the entire trace with the best sensitivity.
  - a Select *REF VALUE* and use the knob to center the trace around the display line.
  - b Select *SCALE* and decrease the dB/div to expand the trace across the display (approximately 2 dB/div).
  - c Repeat steps a and b to scale the trace across the display.
  - d Note the REF VALUE \_\_\_\_\_ and SCALE \_\_\_\_\_ as these settings will be used for the following comparison measurements.

**Electrical Mismatch Ripple and its Effects on Measurements.****Figure 2-8. 801 Data Points and No Attenuation Added**

- 10** Save the trace data to an Excel file by selecting **File, Save Data, Excel File, Form Mag Log**.
- 11** In the Save dialog box, enter the file name ripple\_801pts\_nopad.

Once the following measurement methods had been completed and the data saved, you can compare the results of the different measurement methods.

## Ripple Measurement, 801 Points, with 6 dB Attenuator

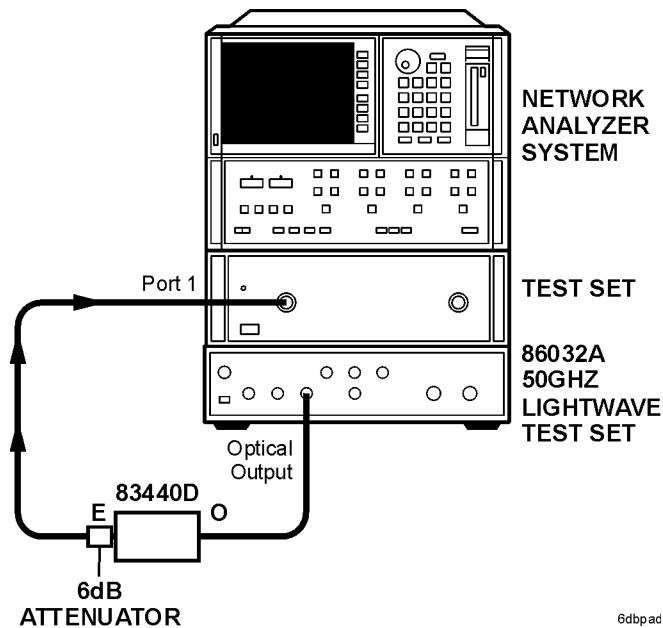
For devices that have a high reflectivity in their electrical port, adding an attenuator will reduce the effects of electrical mismatch ripple. However, you trade off system sensitivity for the reduced ripple since the signal to noise floor will decrease by 6 dB.

- 1 Connect a 6 dB attenuator to the end of the 8517B Port 1 cable that connects to the electrical port of the 83340D lightwave detector.

The attenuator must be present for both the calibration and measurement procedures. Keep the attenuator and cable mated during the entire calibration and measurement procedure.

### NOTE

The addition of the 6 dB attenuator to the test port cable causes this port to have a dc connection to ground. Insure that your DUT is compatible with having a dc path to ground

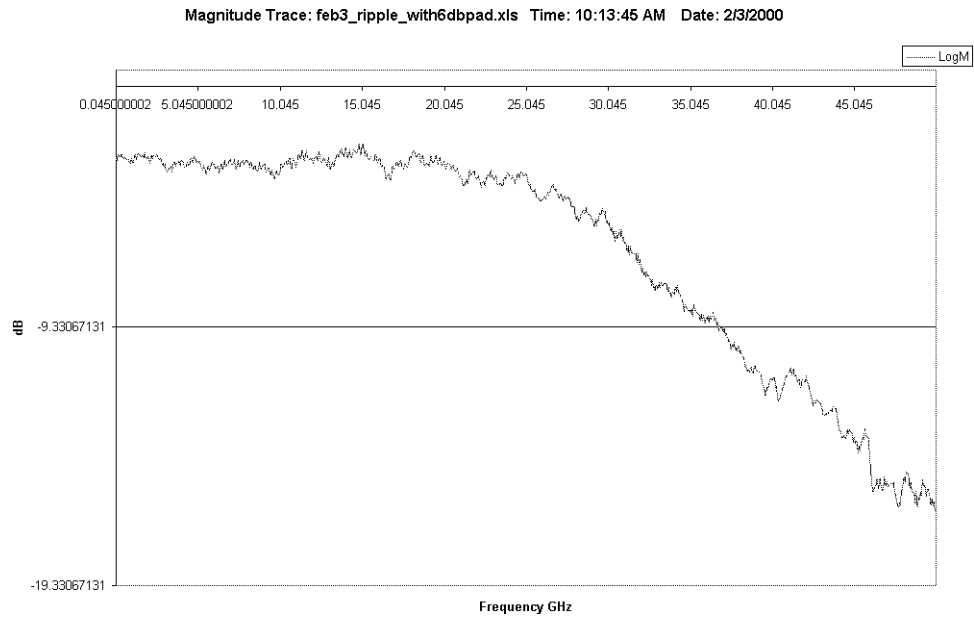


**Figure 2-9. O/E measurement with 6 dB attenuator**

- 2 Repeat “O/E Calibration” on page 2-29.

**Electrical Mismatch Ripple and its Effects on Measurements.**

- 3 Repeat “Detector Response Measurement” on page 2-30. In Step 11, enter the file name ripple\_801pts\_6dbpad.



**Figure 2-10. 801 Data Points and 6 dB Attenuator**

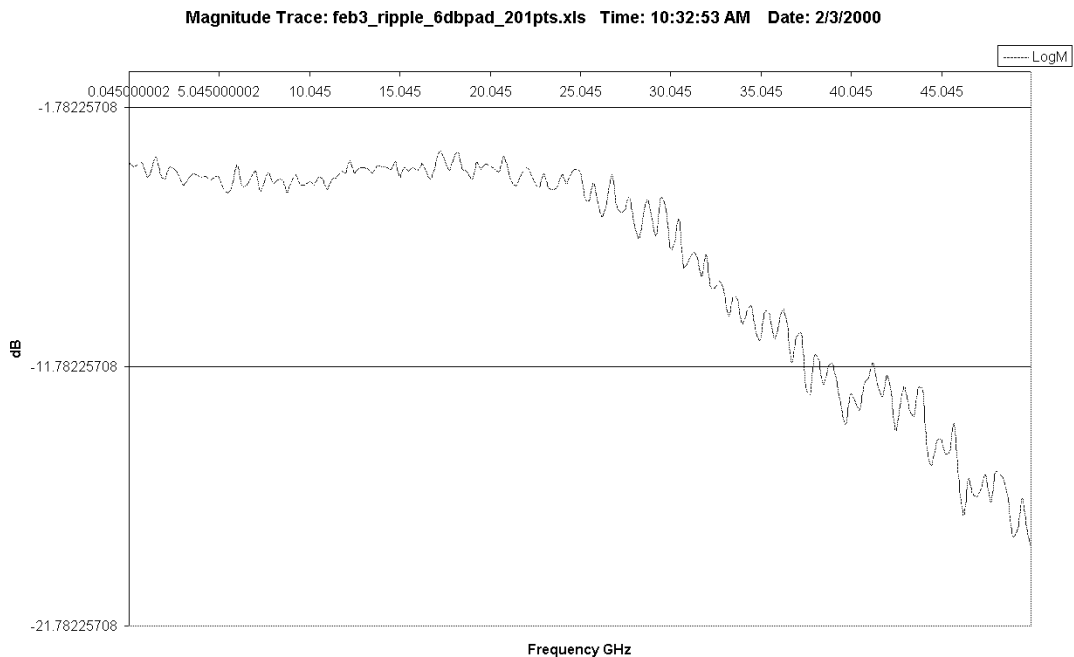
---

## Ripple Measurement, 201 Points, with 6 dB Attenuator

The appearance of trace ripple is affected by the number of data points used for the measurement. When 201 point is selected for a 50 GHz span, there is approximately 250 MHz between data points. Thus, when viewing the trace data, it makes it difficult to discern the effects of the system ripple and the device characteristics.

- 1 Repeat “O/E Calibration” on page 2-29. In Step b of Step 6, select 201 points.
- 2 Repeat “Detector Response Measurement” on page 2-30. In Step 11, enter the file name ripple\_201pts\_6dbpad.

Compare the trace data taken with 201 points versus the trace data taken with 801 points. Notice that the 201 point trace has more of a sawtooth appearance. When fewer data points are taken, it affects your ability to discern the response of the device under test (DUT) from the effects of the ripple.



**Figure 2-11. 201 Data Points and 6 dB Attenuator**



---

## Ripple Measurement, 801 Points, Smoothing On, and 6 dB Attenuator

Turning Smoothing on can also help reduce ripple. Smoothing averages the points within the specified span. For this example, we will smooth the trace using 0.3% of the trace width. In this case, we have a 50 GHz trace width with each segment being 0.3% of 50 GHz or 150 MHz. If the DUT has features that do not vary significantly over a 150 MHz window, accurate measurements will be made. If this is not the case, then some distortion of the measurement will occur. Care should be taken when using this function, as important trace data may be masked by the effects of smoothing.

- 1 Repeat “[O/E Calibration](#)” on page 2-29. In [Step b](#) of [Step 6](#), select 801 points.
- 2 Repeat “[Detector Response Measurement](#)” on page 2-30. In [Step 9](#), select Smoothing On and set to 0.3% of span. In [Step 11](#), enter the file name ripple\_801pts\_smoothingon\_6dbpad.

---

## Use of Response and Match Calibration

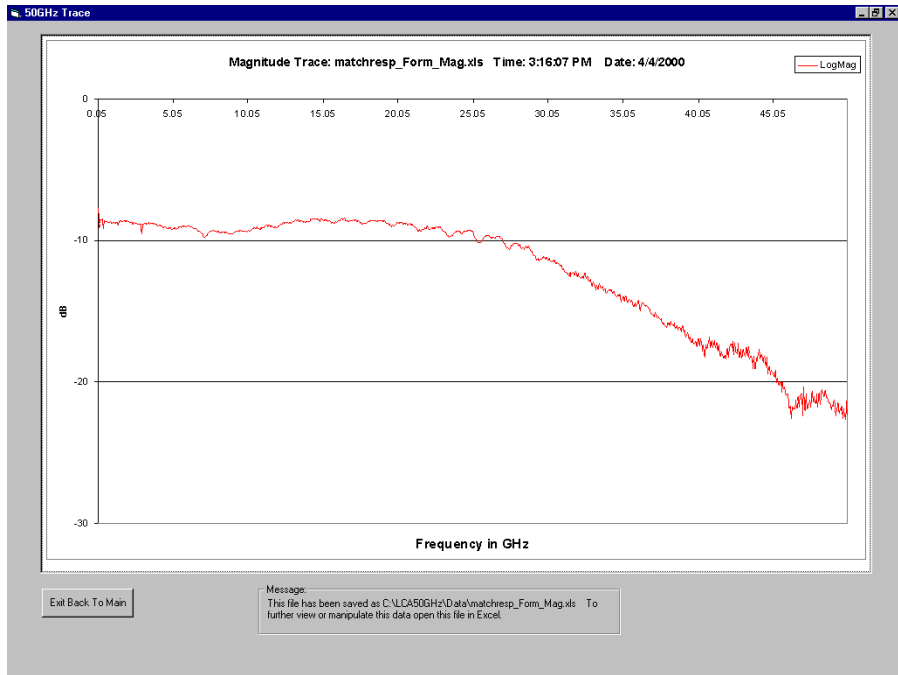
The 86030A also provides a capability to mathematically reduce the effects of electrical mismatch. In order to do this, the DUT response information is modified using measurements of the electrical reflectivity of the DUT and the electrical reflectivity of the 86030A. Significant reduction of electrical mismatch error results.

The disadvantage of a response plus match calibration is that it is a more complicated and lengthy procedure.

A response and match calibration is only valid for a particular DUT. If a measurement of a new DUT is desired, or if the electrical port match has changed, clicking on New DUT, in the Control Options area, will repeat the DUT reflectivity portion of the calibration.

- 1 Perform a Response and Match calibration. Refer to “[Follow the on-screen instructions for the isolation portion of the calibration procedure. See figure below.](#)” on page 2-10.
- 2 Repeat “[Detector Response Measurement](#)” on page 2-30. In [Step 11](#), enter the file name ripple\_matchcal.

**Electrical Mismatch Ripple and its Effects on Measurements.**



---

## Magnitude Response and Deviation From Linear Phase of a Lightwave Receiver

This example measures a lightwave receiver's transfer characteristics and deviation from linear phase. A receiver's transfer function is expressed in terms of receiver slope responsivity. This is the ratio of the RF current out to the intensity-modulated optical power in and is expressed in amp/watt or dB referenced to 1 A/W.

---

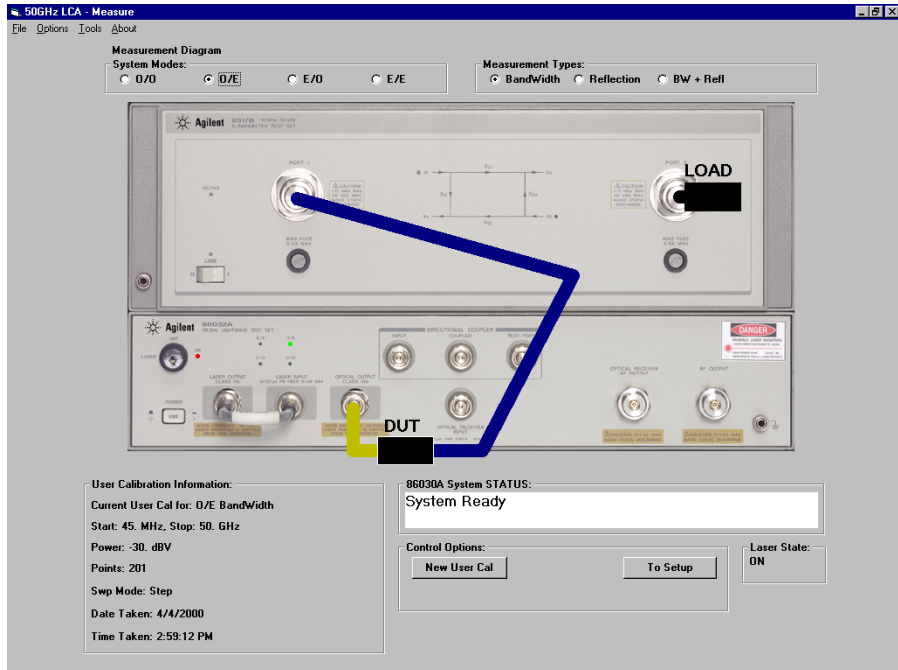
### Calibrating the system

- 1 Perform an O/E Bandwidth calibration. [Refer to "O/E Response and Isolation Bandwidth Calibration" on page 2-8.](#)

---

## Connecting the device

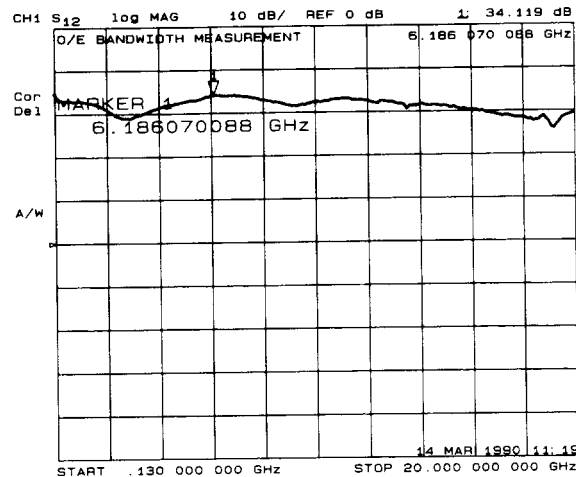
- 2 When the calibration is complete, connect the device as shown in the Measure window.



## Magnitude Response and Deviation From Linear Phase of a Lightwave Receiver

The 8510C displays the transfer characteristics of the lightwave receiver as shown in [Figure 2-12](#). The measured device is an amplified photodiode receiver.

- 3 To locate the maximum amplitude of the receiver, press, *MARKER, MORE*, then *MAXIMUM*.



**Figure 2-12. Maximum Amplitude of the Lightwave Receiver**

## Measuring Deviation from Linear Phase

The analyzer can measure and display phase over the range of  $-180^\circ$  to  $+180^\circ$ . As phase changes beyond these values, a sharp  $360^\circ$  transition occurs in the displayed data. The electrical length effect can be removed to view the deviation from linear phase. To remove length effect, the analyzer mathematically implements a function similar to the mechanical “line stretchers” of earlier analyzers. This feature simulates a variable length of lossless transmission line. The simulation can be added to or removed from the analyzer’s internal reference port to compensate for the length of interconnecting cables, and so forth.

In this example, the electronic line stretcher measures the electrical delay of a lightwave receiver.

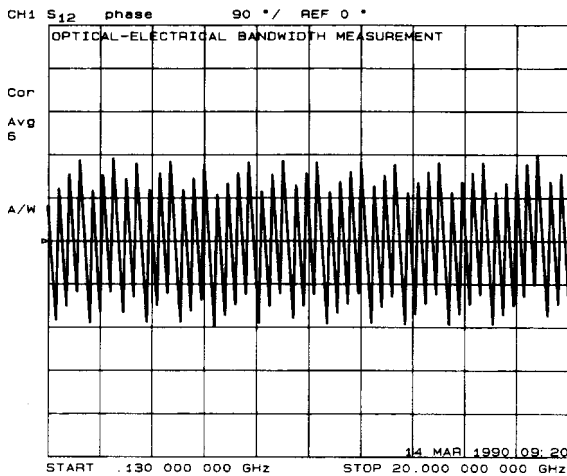
- 1 In the *RESPONSE* area, press *MENU, ELECTRICAL DELAY*.
- 2 Enter the delay time.

**Magnitude Response and Deviation From Linear Phase of a Lightwave Receiver**

Pressing the *AUTO DELAY* function key on the 8510C will correctly perform a delay measurement if the device length is within the alias-free range of the measurement. The alias-free range is the range where you can correctly measure a response.

- 3 To view the insertion phase response of the lightwave receiver, in the FORMAT area, press *PHASE*.

The modulation phase of the lightwave receiver is shown in [Figure 2-13](#).



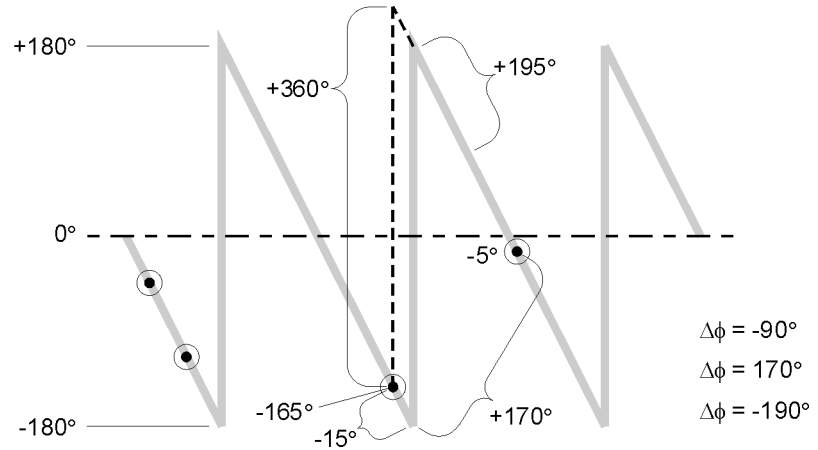
**Figure 2-13. Modulation Phase Response of the Receiver**

The analyzer measures and displays phase over the range of  $-180^\circ$  to  $+180^\circ$ . As phase changes beyond these values, a sharp  $360^\circ$  transition occurs in the displayed data. The  $\Delta$  measured between two adjacent frequency points must be  $<180^\circ$ . If the phase is  $>180^\circ$ , incorrect delay information may result. For example, the first set of frequency points shown in [Figure 2-13](#) has a  $\Delta < 180^\circ$ . If the delta is  $< 180^\circ$  between adjacent frequency points, the network analyzer will be successful in making group delay measurements on the DUT.

[Figure 2-14](#) illustrates an example where the delta is  $> 180^\circ$ . In this example there is a data point measuring  $-165^\circ$  and the following data point measuring  $-5^\circ$  (but on a different tooth of the sawtooth waveform). In order to compare the absolute phase difference between these two points, you must translate the  $-165^\circ$  upward by  $360^\circ$  (one revolution on the cartesian scale). Resulting in a translated phase value of  $+195^\circ$ . The difference between the points can

### Magnitude Response and Deviation From Linear Phase of a Lightwave Receiver

now be compared.  $195^\circ - -5^\circ = 200^\circ$ , Since the delta between points is  $> 180^\circ$ , this situation will lead to erroneous values while making delay measurements.



**Figure 2-14. Phase Samples**

To measure a correct phase response, the electrical delay must be within the alias free range.

- 4 Calculate the alias-free range for the measurement parameters of the analyzer.

This range can be determined by:

$$AFR = \pm \frac{1}{2(\Delta f)}$$

$\Delta f$  = frequency spacing between points

$$\Delta f = \frac{\text{start frequency} - \text{stop frequency}}{\text{number of points} - 1}$$

For example, if:

start frequency = 130 MHz

stop frequency = 20 GHz

number of data points = 201

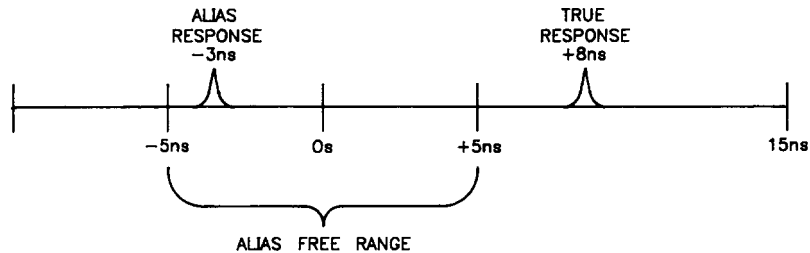
then:

$$AFR = \pm \left[ \frac{1}{\left( \frac{2(20 \times 10^9 - 130 \times 10^6)}{201 - 1} \right)} \right] = \pm 5 \text{ ns}$$

**Magnitude Response and Deviation From Linear Phase of a Lightwave Receiver**

This means that the alias-free range is  $\pm 5$  ns. [Figure 2-15](#) shows a time domain response from an electrical delay of 8 ns with a  $\pm 5$  ns alias free range. Notice the response repeats every 10 ns. The correct response is at 8 ns, but the auto delay function on the 8510C would give delay information of  $-3$  ns since it is closest to zero.

If the electrical delay is set to the true value, the phase response is correct, but the time response is only correct in 1 alias free range around the delay time.



**Figure 2-15. Time Domain Response with the Alias Free Range**

---

## Alias Free Range

The number of data points may be increased to obtain an alias-free range larger than the electrical length of the device. If the number of data points is increased to 401, then the alias-free range is calculated as follows.

$$AFR = \pm \left[ \frac{1}{\left( \frac{2(20 \times 10^9 - 130 \times 10^6)}{401 - 1} \right)} \right] = \pm 10 \text{ ns}$$

**Note**

The frequency span can also be made smaller to increase the alias-free range.



---

## Determining Electrical Length

Before a calibrated measurement is performed, a delay measurement may be taken with a small frequency span and compared to the calculated alias-free range. If the delay measurement result is longer than the alias-free range, the measurement parameters or electrical delay value needs to be changed.

- 5** To narrow the span, in the STIMULUS area, press CENTER 2 [G/n] then SPAN 100 [M/u].

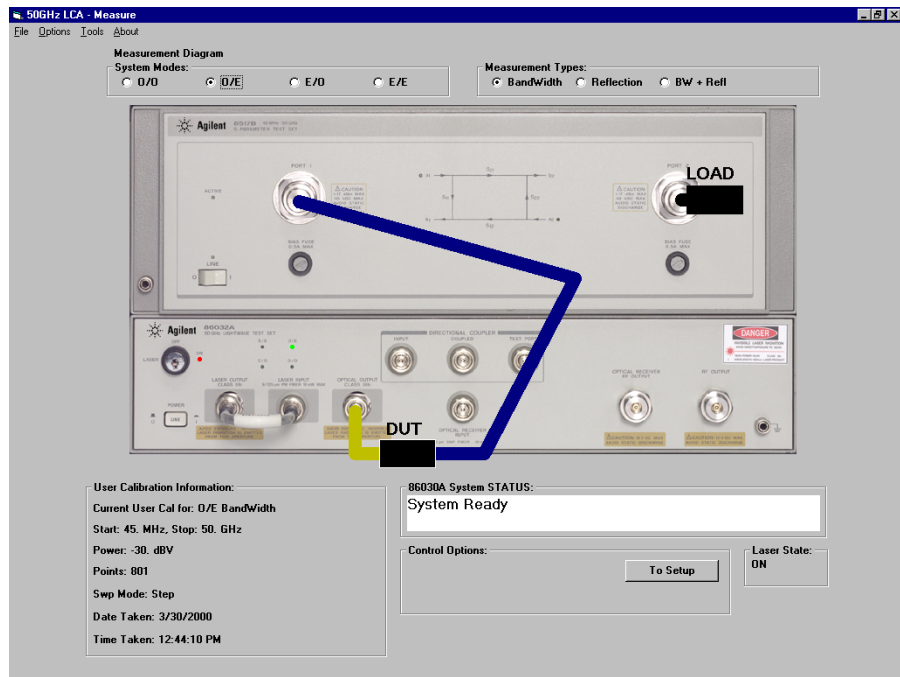
A new calibration can be done at this time. Without a calibration, the delay value may be off by  $\pm 5$  ns.

### Note

A frequency span of 100 MHz with 201 measurement points gives an alias-free range of 1  $\mu$ s (approximately 300 meters). As the frequency span decreases, the alias-free range increases.

- 6** To measure delay, in the RESPONSE MENU, press DELAY, then AUTO DELAY.  
Read the value from the analyzer display.
- 7** To remove delay measurement noise in the RESPONSE area, press MENU, AVERAGING ON/RESTART, then SMOOTHING ON 20 [x1].  
Record the delay value \_\_\_\_\_.
- 8** In the MENUS area, press DOMAIN, then FREQUENCY.
- 9** To change the parameters back to the original setup, in the STIMULUS area, press START 130 [M/u], then STOP 20 [G/n].
- 10** In the FORMAT area, press LOG MAG/.  
When parameters are changed, another measurement calibration must be performed.
- 11** Perform an O/E Bandwidth calibration.
- 12** When the calibration is complete, connect the device between the optical and electrical test ports as shown on the Measure window.

**Magnitude Response and Deviation From Linear Phase of a Lightwave Receiver**



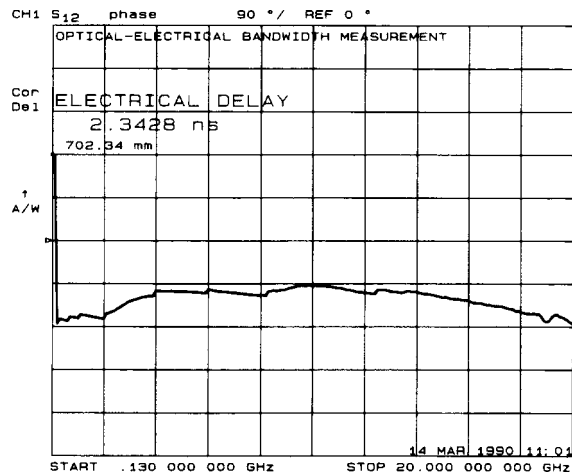
- 13 To measure the delay with the Auto Delay function, in the FORMAT area, press PHASE.
- 14 In the RESPONSE area, press MENU, *AUTO DELAY*, then *ELECTRICAL DELAY*.  
Notice the delay and phase information on the analyzer display.

If the electrical delay of the device is longer than the alias-free range, the Auto Delay function will not give the correct electrical delay, and the phase information will be offset by  $(\text{difference of correct and incorrect delays}) \times (\text{start frequency}) \times (360^\circ)$ .

Enter the electrical delay value recorded in [Step 7](#).

- 15 Turn the front panel knob to change the electrical length until the best flat line is achieved as shown in [Figure 2-16](#).

## Magnitude Response and Deviation From Linear Phase of a Lightwave Receiver



**Figure 2-16. Electrical Length Added**

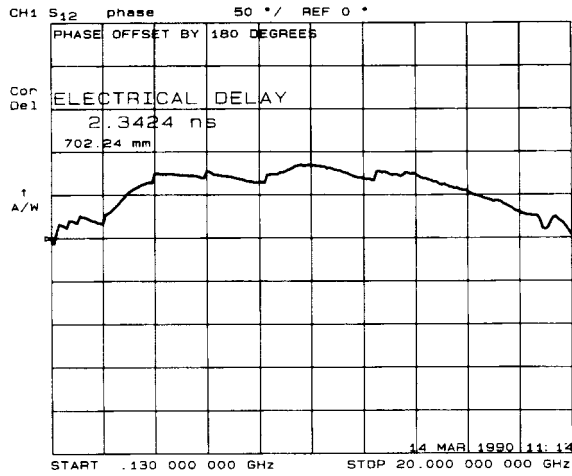
### Note

The drop in the trace at the beginning of the sweep in Figure 5-20 is because of a transition from  $+180^\circ$  to  $-180^\circ$ . The receiver measured is an inverting receiver. The phase of the output is inverted  $180^\circ$  from the input. To view the phase response that is out  $180^\circ$ , you may offset the phase reference.

- 16** To offset the phase by  $180^\circ$ , in the RESPONSE area, press MENU then *PHASE OFFSET* 180 [x1].

Figure 2-17 shows the result of a phase offset.

**Magnitude Response and Deviation From Linear Phase of a Lightwave Receiver**

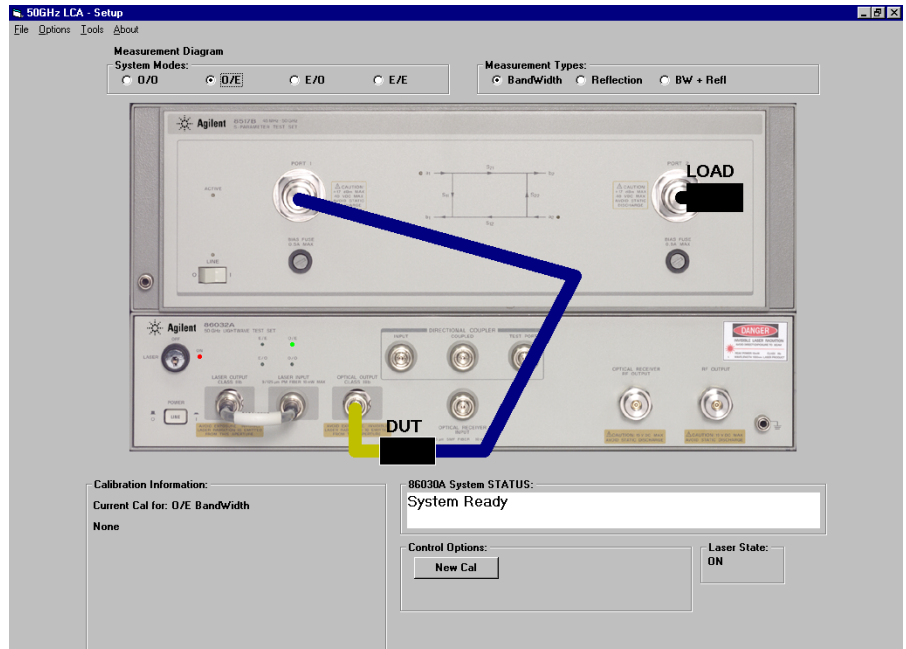


**Figure 2-17. Phase Offset by 180°**

## O/E RF Overload Detection Measurement

High-gain O/E converters may supply too much power to 8517B Port 1 inducing an RF overload condition. This may cause amplitude measurement errors to occur. The following procedure will help you to determine if any signals within the measured frequency range could cause an overload condition.

- 1 Perform an O/E Response and Match calibration. Refer to “O/E Response and Isolation Bandwidth Calibration” on page 2-8.
- 2 Connect the DUT as shown below and wait until an entire sweep of the trace has been taken.



- 3 In the 8510C Menus area, press DISPLAY, DATA and MEMORIES, DATA → MEMORY # to store the active trace.

**O/E RF Overload Detection Measurement**

- 4 From the Display menu press *MATH OPERATIONS*, and select *DIVIDE (/)* for the active memory register.
- 5 From the DISPLAY menu, press *MATH (/)* so that it is underlined.

This operation normalizes the memory to the data. This is useful for ratio comparisons between two traces, for example, measurements of gain or attenuation.

- 6 In the Response area, press SCALE and enter 1 x1 to set the magnitude scale to 1 dB per division.
- 7 From the 50 GHz LCA software, click on the **Tools** menu then **Modify Test Set**.
- 8 In the Modify Test Set dialog box, enter **9** dBm in the Set Laser Output Power box (That is, set the power to 1 dB lower than the value displayed in the Current Laser Output Power box.) and then click **Modify Power**.
- 9 Monitor the change of the stored trace on the 8510C display. For the 1 dB decrease in optical power, you should see a 2 dB decrease in electrical power (that is, 2 divisions) across the entire trace. Any portion of the trace that doesn't drop by 2 dB indicates that there is an overload condition at that point.
- 10 If an overload condition is detected, you will need to reduce the input power to the point where a 1 dB optical change results in a 2 dB electrical change.
- 11 Once you have verified that an overload condition does not exist, set the Laser Output Power to the highest possible power without causing an overload condition.

“Lightwave Test Set Operation” on page 3-3  
“O/O Measurement Calibration” on page 3-7  
“O/E Measurement Calibration” on page 3-9  
“E/O Measurement Calibration” on page 3-11  
“Electrical Measurement Calibration” on page 3-13  
“O/E Display Scaling Calculations” on page 3-14  
“E/O Display Scaling Calculations” on page 3-15  
“O/O Display Scaling Calculations” on page 3-16

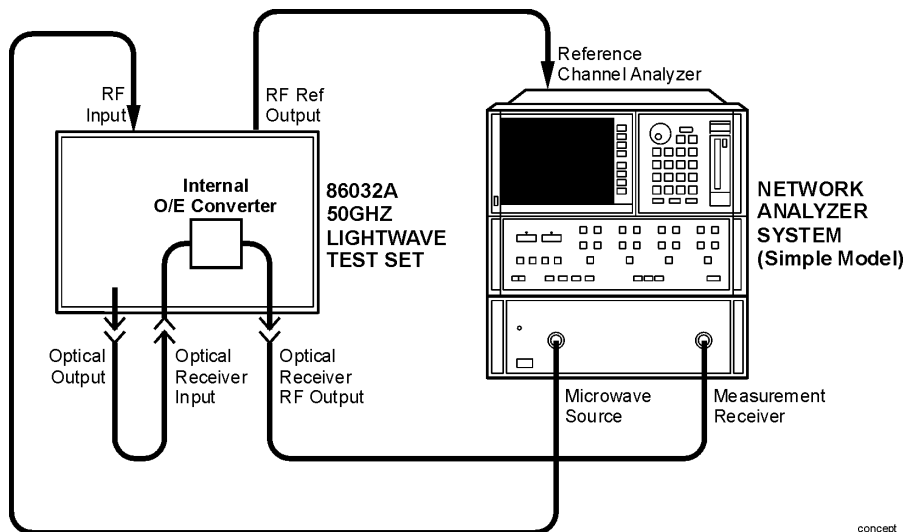
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## Theory of Operation

## System Operation

The lightwave test set is designed to operate with an 8510C microwave network analyzer system. Figure 3-1 shows a conceptual system block diagram. The 8510C network analyzer system consists of a microwave source, a reference receiver, and one or more measurement receivers. The microwave source is applied to the 86032A RF INPUT. The lightwave test set then provides a reference signal to the analyzer reference receiver. The reference receiver is also used for phase lock of the system.

The conceptual system block diagram shows an Optical-to-Optical (O/O) DUT (fiber) measurement configuration. The signal is routed from the OPTICAL OUTPUT through the fiber, demodulated by the test set's optical receiver, and then routed to the analyzer's measurement receiver. A similar configuration is used for Electrical-to-Optical (O/E) DUTs except the device drive signal is the lightwave test set's RF OUTPUT. For O/E DUTs, the drive signal is from the OPTICAL OUTPUT and the DUT signal is routed to the analyzer's measurement receiver.



**Figure 3-1. Conceptual System Block Diagram**

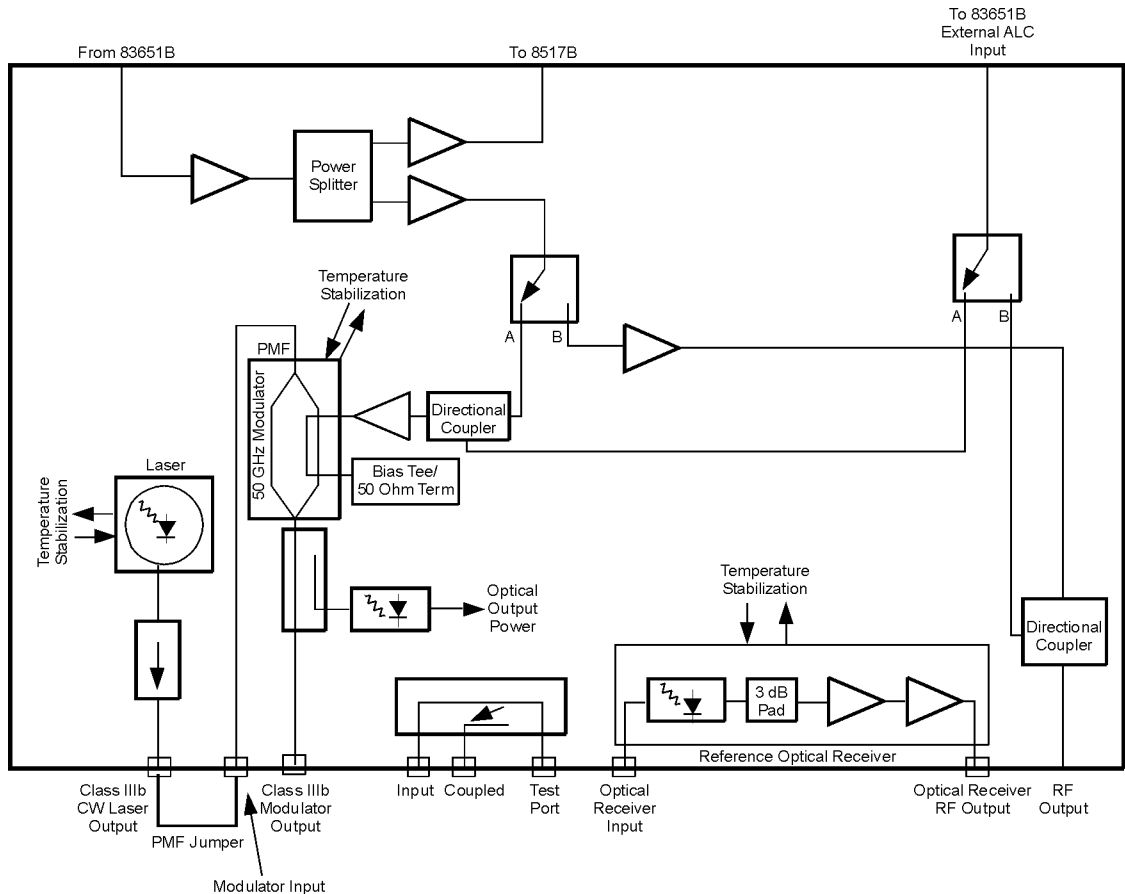
concept



## Lightwave Test Set Operation

The lightwave test set consists of four major functional blocks:

- Lightwave source deck (LSD)
- Amplified lightwave receiver
- RF drive path
- Printed circuit boards containing the internal amplifiers and other microcircuits



**Figure 3-2. 86032A Test Set Block Diagram**

## Lightwave Source Deck

The lightwave source deck converts RF energy into modulated laser light. The source of light is an unmodulated (CW) semiconductor distributed feedback laser (DFB) operating at approximately 1550 nm. The light is directed through a high-performance isolator (greater than 90 dB isolation) to prevent reflections from affecting the semiconductor laser.

A key component of the lightwave source deck is the lithium niobate (LiNbO<sub>3</sub>) modulator. To work correctly, the modulator is biased with a fixed dc offset (quadrature voltage--half way between maximum and minimum intensity) that is supplied by the digital to analog converter. The modulator bias level is under PC control for optimal performance and to reduce unwanted effects such as source signal level drift.

After exiting the modulator, the laser light is routed to the front panel OPTICAL OUTPUT connector via a 5/95 coupler. The 5% arm of the optical coupler is used to monitor the average optical power that is delivered to the OPTICAL OUTPUT of the lightwave test set. Appropriate corrections are made to the modulator bias by the 86030A software to keep the modulator bias point at quadrature. The software initiates the modulator bias adjustment after every Mode Change to O/O and O/E. It can also be user initiated through the Auto Bias feature.

---

## Amplified Optical Receiver

The amplified lightwave receiver completes the lightwave path. This receiver consists of a very high speed photo diode followed by RF amplification.

The lightwave receiver is the key component of the measurement calibration. A factory measurement of the magnitude and phase response of the lightwave receiver is saved on the hard drive of the PC and also on the supplied backup disk. This factory calibrated lightwave receiver becomes the standard for both optical-to-electrical and electrical-to-optical calibrations.

---

## RF Drive Path

The 85107 RF network analyzer's source is applied to the rear-panel RF Input connector of the lightwave test set. This signal is split internally. One path goes to the RF reference output connector for the lightwave test set used to phase lock the 85107 system. The other path from the splitter is routed to an RF switch. The RF switch is controlled by the 86030A software. Depending on the measurement mode selected by the user, the switch routes the signal to either the optical modulator (O/O and O/E modes), or to the RF output port of the 86032A lightwave test set (E/O mode).

---

## Main Printed Circuit Board

The internal printed circuit (PC) board provides the correct drive voltages to the internal microcircuits.

---

## Drive Voltages

The power supply provides five voltages (+15V, -15V, +6V, and +5V).

---

### **NOTE**

The lightwave test set power switch will need to be in the ON state, even for Electrical-to-Electrical (E/E) measurements.

---

## Measurement Calibration

The lightwave test system can provide calibrated measurements of lightwave components. The reference for an E/O (electrical to optical) and an O/E (optical to electrical) measurement is the lightwave receiver.

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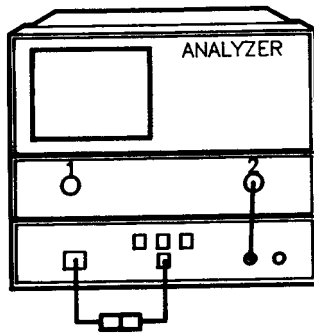
### Calibration Data

The response (magnitude and phase) of the lightwave receiver in your test set is measured at the factory and stored on a disk. This calibration data is combined with the user calibration measurement to provide accurate lightwave component analysis.

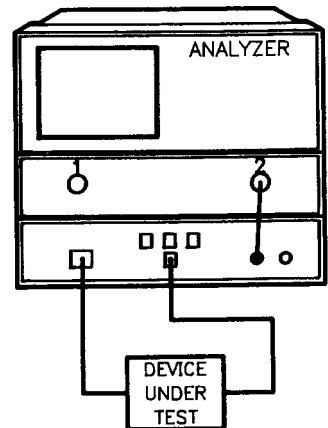
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## O/O Measurement Calibration

A measurement calibration for an optical to optical device type is a response calibration of a thru optical cable. The measurement of the optical device under test (DUT) is normalized to the thru line. When the device is measured the only response displayed is the device under test. The analyzer firmware performs the mathematical operations. The following figure shows the calibration measurement and device measurement configurations.



*a) Calibration Measurement*  
**Optical Configurations**



*b) Device Measurement*

**O/O Measurement Calibration**

These are the equations for the calibration and device measurements:

$$\text{calibration measurement} = (ES)(OS)(LWCABLE)(OR)(ER)$$

$$\text{device measurement} = (ES)(OS)(DUT)(LWCABLE)(OR)(ER)$$

Therefore:

$$\text{device measurement} / \text{calibration measurement} =$$

$$\frac{(ES)(OS)(DUT)(LWCABLE)(OR)(ER)}{(ES)(OS)(LWCABLE)(OR)(ER)} = DUT \text{ response}$$

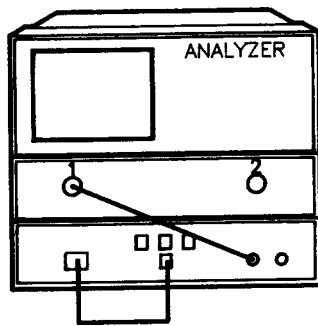
Where:

ES = electrical source, OS = optical source, LWCABLE = lightwave cable,  
OR = optical receiver, ER = electrical receiver, DUT = device under test,  
ECABLE = electrical cable, ORCAL = optical receiver calibration data

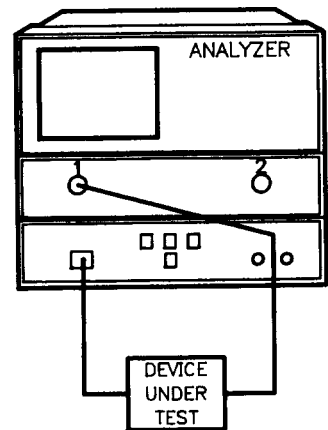
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## O/E Measurement Calibration

A user measurement calibration for an optical to electrical device is combined with the calibration data stored on disk to provide accurate optical to electrical device characterizations. The following figure shows the calibration measurement and device measurement configurations.



*a) Calibration Measurement*  
**Optical to Electrical Configurations**



*b) Device Measurement*

**O/E Measurement Calibration**

These are the equations for the calibration and device measurements:

$$\text{calibration measurement} = (ES)(OS)(LWCABLE)(OR)(ECABLE)(ER)$$

$$\text{device measurement} = (ES)(OS)(LWCABLE)(DUT)(ECABLE)(ER)$$

The calibration measurement is combined with the optical receiver response data (contained on disk) to form a calibration response.

Therefore:

$$\begin{aligned} & \text{device measurement} / \text{calibration measurement} = \\ & \frac{(ES)(OS)(DUT)(LWCABLE)(ECABLE)(ER)}{(ES)(OS)(LWCABLE)(OR)(ECABLE)(ER)(1/ORCAL)} = \text{DUT response} \end{aligned}$$

Where:

ES = electrical source, OS = optical source, LWCABLE = lightwave cable, OR = optical receiver, ER = electrical receiver, DUT = device under test, ECABLE = electrical cable, ORCAL = optical receiver calibration data.

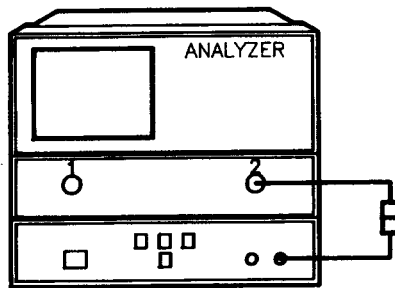
The optical receiver response calibration data (contained on disk) and the optical receiver response are ideally the same:  $(OR)(1/(OR)) = 1$ . Differences between these are reflected in the response uncertainty.



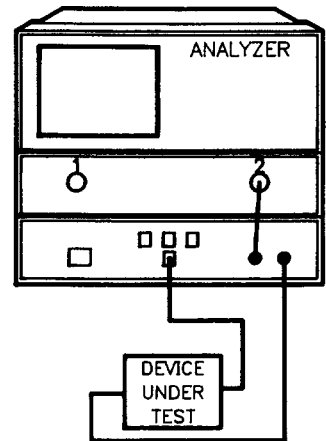
---

## E/O Measurement Calibration

The measurement calibration for an electrical to optical device is accomplished by measuring the microwave path of the lightwave test set and the analyzer. The microwave response of the system is now known, and is combined with the lightwave test set receiver response to provide a complete response calibration. In the device measurement the response calibration is subtracted from the full path measurement, leaving only the response of the DUT. The optical cable connected between the DUT and the lightwave receiver contributes to the DUT response. The following figure shows the calibration measurement and device measurement configurations.



*a) Calibration Measurement*



*b) Device Measurement*

### **Electrical to Optical Configurations**

**E/O Measurement Calibration**

These are the equations for the calibration and device measurements:

$$\text{calibration measurement} = (ES)(ECABLE)(ER)$$

The calibration measurement is combined with the test set optical receiver response data in the analyzer to form a calibration response.

$$\text{calibration response} = (ES)(ECABLE)(ER)(ORCAL)$$

$$\text{device measurement} = (ES)(ECABLE)(DUT)(LWCABLE)(OR)(ER)$$

Therefore:

$$\begin{aligned} &\text{device measurement} / \text{calibration measurement} = \\ &\frac{(ES)(ECABLE)(DUT)(LWCABLE)(OR)(ER)}{(ES)(ECABLE)(ER)(ORCAL)} = (DUT)(LWCABLE) \end{aligned}$$

Where:

ES = electrical source, OS = optical source, LWCABLE = lightwave cable, OR = optical receiver, ER = electrical receiver, DUT = device under test, ECABLE = electrical cable, ORCAL = optical receiver calibration data.

A port extension should be added in order to mathematically remove the electrical length added by the lightwave cable. Lightwave cables less than 10 meters long have negligible frequency response.

## Port Extensions

The 8510C port extension is accessed from the CAL front panel key. To add a port extension and remove the effects of the lightwave cable in an E/O measurement, press:

CAL

MORE

PORT EXTENSIONS 2

Enter the delay time associated with the length of the lightwave cable that is connected between the E/O device and the lightwave receiver. Terminate the entry by pressing the G/n key on the analyzer.

For example: a 40 cm cable with an index of refraction of 1.46 has a delay of:

$$t = Ln/v = ((40 \text{ cm})(1.46)) / 3 \times 10^{10} \text{ cm/s} = 1.95 \text{ ns}$$

---

## Electrical Measurement Calibration

The measurement calibration for electrical devices does not involve the light-wave test set. Refer to the network analyzer documentation.

---

### Bias Voltage to the Modulator

Under typical circumstances the lightwave modulator is biased to operate at quadrature. Quadrature is where the midpoint of the average optical power curve and the peak of the modulated optical power curve occur. Refer to [Figure 3-3](#). This maximizes the modulation response and minimizes distortion of the modulated signal.

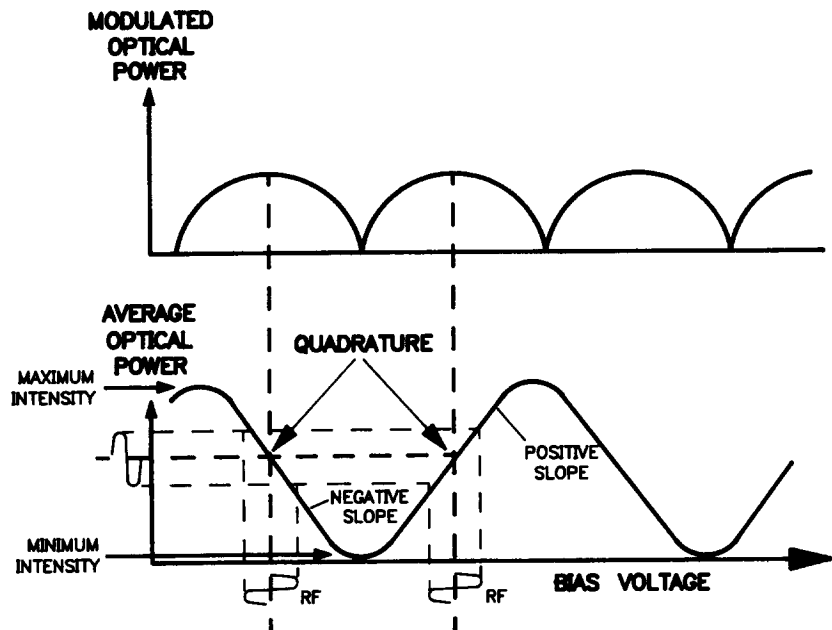


Figure 3-3. The Effect of Bias Voltage on Average and Modulated Optical Power

---

## O/E Display Scaling Calculations

The marker reads out the actual value in dB compared to 1 amp/watt responsivity. Suppose marker 1 has a value of 36 dB, indicating the gain of the receiver at a specific frequency. This corresponds to the responsivity (R) of the receiver in A/W, at the given frequency, that can be calculated as shown below.

*R (dB) = responsivity in dB at a given frequency compared to 1 A/W as read by the 86030A*

*R (A/W) = responsivity in units of amps/watt*

$$R(\text{dB}) = 20 \log_{10} \frac{R(A/W)}{1(A/W)}$$

$$\frac{R(\text{dB})}{20} = \log_{10} \frac{R(A/W)}{1(A/W)}$$

$$1(A/W) \times 10^{R(\text{dB})/20} = \frac{R(A/W)}{1(A/W)} \times 1(A/W)$$

$$R(A/W) = 10^{R(\text{dB})/20} \times 1(A/W)$$

*For example, if R(dB) = +36 dB, then:*

$$R = 10^{(36/20)} = 10^{1.8} = 63.1(A/W) = 63.1 \frac{\text{mA}}{\text{mW}}$$

To read the result directly, in the FORMAT area, press MENU then *LINEAR MAGNITUDE*.

## E/O Display Scaling Calculations

The marker reads out the actual value in dB compared to 1 watt/amp responsivity. Suppose marker 1 has a value of  $-40\text{dB}$ , indicating the efficiency of the transmitter at a specific frequency. (This is a typical value for a  $\text{LiNbO}_3$  optical modulator.) This corresponds to the responsivity ( $R_s$ ) of the transmitter in W/A, at the given frequency, that can be calculated as shown below.

$R_s$  (dB) = *responsivity in dB at a given frequency compared to 1 W/A as read by the 86030A*

$R_s$  (W/A) = *responsivity in units of watts/amp*

$$R_s(\text{dB}) = 20 \log_{10} \frac{R_s(\text{W/A})}{1(\text{W/A})}$$

$$\frac{R_s(\text{dB})}{20} = \log_{10} \frac{R_s(\text{W/A})}{1(\text{W/A})}$$

$$1(\text{W/A}) \times 10^{R_s(\text{dB})/20} = \frac{R_s(\text{W/A})}{1(\text{W/A})} \times 1(\text{W/A})$$

$$R_s(\text{W/A}) = 10^{R_s(\text{dB})/20} \times 1(\text{W/A})$$

For example, if  $R(\text{dB}) = -40 \text{ dB}$ , then:

$$R = 10^{(-40/20)} = 10^{-2} = .01(\text{W/A}) = .01 \frac{\text{mW}}{\text{mA}}$$

To read the result directly, in the FORMAT area, press MENU then *LINEAR MAGNITUDE*.

## O/O Display Scaling Calculations

The O/O mode scales the vertical axis using the formula:

$$Gain(dB) = 10 \log \frac{P}{P_{ref}}$$

Thus, the gain is in optical dBs.

$P_{ref}$  is the power measured in the reference calibration trace. Optical through lines are most often used in the reference calibration.

To read the result directly, in the FORMAT area, press MENU then *LINEAR MAGNITUDE*.

---

# 4

- Step 1. Prepare the site 4-4
- Step 2. Install the monitor mount assembly 4-6
- Step 3. Install the keyboard/mouse transmitter and the work surface 4-8
- Step 4. Confirm front and rear panel connections 4-9
- Step 5. Turn the system on 4-11

---

## Installation

## Installation

The instructions in this chapter show you how to install the 86030A 50 GHz LCA. For overseas sales, the product is shipped *without* an ac power connector. You should have a local electrician provide and install an ac connector that meets the standards for the region. Also, be sure to set all instruments to use the local line voltage.

---

**WARNING**

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

---

**WARNING**

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

---

**WARNING**

**HP/Agilent 86032A: No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock, do not remove covers.**

---

**WARNING**

**HP/Agilent 86032A: For continued protection against fire hazard, replace line fuse only with same type and ratings. Use a 6.3A 250V fuse. The use of other fuses or materials is prohibited.**

---

**WARNING**

**HP/Agilent 86032A and HP/Agilent 86030A: If the system and test set products are not used as specified, the protection provided by the equipment could be impaired. These products must be used in a normal condition (in which all means for protection are intact) only.**

---

**CAUTION**

86032A and HP/Agilent 86030A: This system and test set are designed for use in INSTALLATION CATEGORY II and POLLUTION DEGREE 2, per IEC 1010 and 664 respectively.



---

**CAUTION**

HP/Agilent 86030A: Ventilation Requirements. When installing the product in a cabinet, the convection into and out of the product must not be restricted. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the product by 4×C for every 100 watts dissipated in the cabinet. If the total power dissipated in the cabinet is greater than 800 watts, then forced convection must be used.

---

**CAUTION**

The warranty and calibration will be voided on systems where the individual instruments, including fiber-optic cables, RF cables, or GPIB cables are removed by the customer. The system should only be disassembled by an Agilent Customer Engineer. Instruments should not be swapped or removed by non-Agilent personnel.

---

**Step 1. Prepare the site**

---

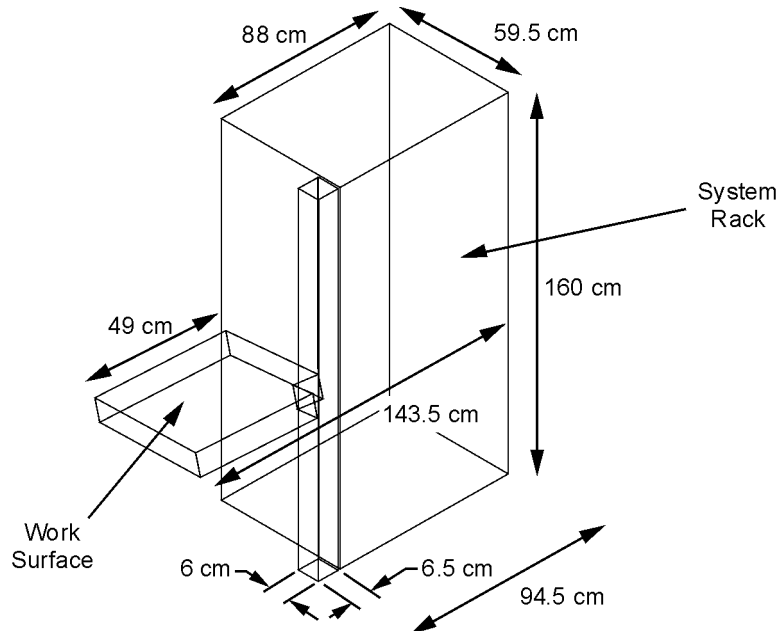
## Step 1. Prepare the site

Your site should accommodate the dimensions, weights, and power consumption limits shown in the following figure.

---

**WARNING**

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



---

**WARNING**

**Install the system so that the power cords are readily identifiable and are easily reached by the operator. The power cords are the disconnecting device. They disconnect the mains circuits from the mains supply before other parts of the system. Alternately, an**

**externally installed switch or circuit breaker (which is readily identifiable and is easily reached by the operator) may be used as a disconnecting device.**

---

**CAUTION**

HP/Agilent 86030A and HP/Agilent 86032A: Install the system and test set according to the enclosure protection provided. This system and test set do not protect against the ingress of water. The system and test set protects against finger access to hazardous parts within the enclosure.

---

**CAUTION**

Before switching on this system, make sure that the line voltage selector switch on the HP/Agilent 86032A lightwave test set's rear panel is set to the voltage of the mains supply, that the correct fuse is installed, and that the supply voltage is in the specified range.

---

## Step 2. Install the monitor mount assembly

- 1 Remove the black end cap from the top of the extrusion.
- 2 Slide the star knob onto the lower part of the extrusion and tighten.
- 3 Loosen the two black levers on the friction plate and slide it onto the extrusion.
- 4 Move the friction plate to the desired height and tighten the two black levers.
- 5 Loosen the star knob and raise it until it stops below the friction plate, then tighten the knob securely to prevent the friction plate, arm, and monitor mount assembly from falling.

---

### **WARNING**

**If the star knob is not installed properly, the friction plate, arm, and monitor mount assembly may fall, causing injury to the user or damage to the monitor and mounting components.**

- 6 Attach the keyboard tray to the monitor mount assembly using 6 provided mounting screws. Tighten with a 1/8" Allen wrench.
- 7 Attach the LCD monitor to the monitor mount assembly with the provided mounting screw. Tighten with a 7/32" Allen wrench. Make sure the monitor is properly oriented with the alignment pin, then tighten with a 7/32" Allen wrench.

---

### **CAUTION**

Tighten all hardware on the arm and monitor mount assembly as necessary to prevent the monitor and keyboard from tipping unexpectedly.

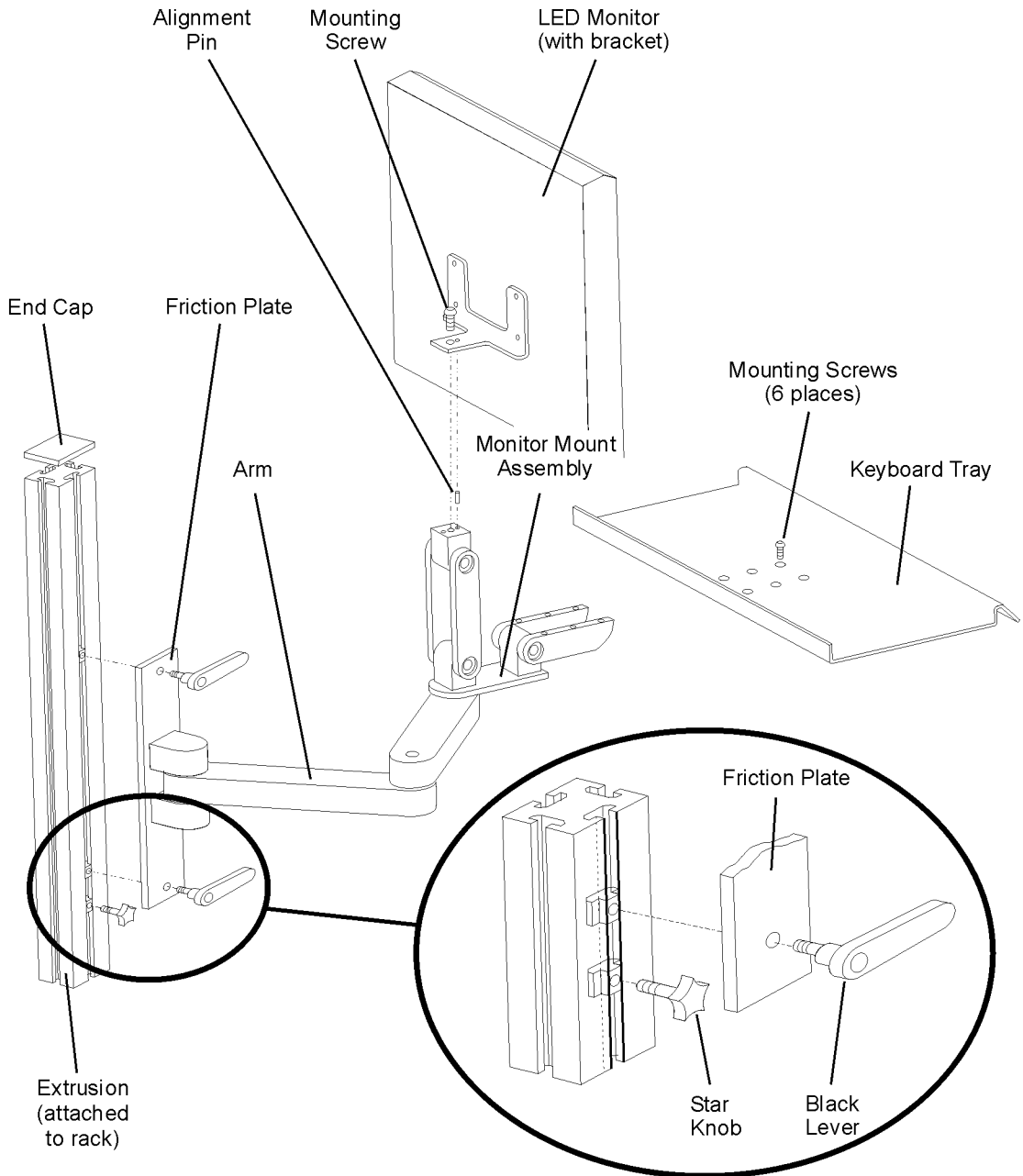
---

### **CAUTION**

Be careful when swinging the arm around in front of the system to avoid striking the 8510C and other system components.

- 8 Replace the black end cap on the extrusion.
- 9 Connect the monitor cables to the LCD monitor and secure the cables to the bottom of the arm using tie wraps.

**Step 2. Install the monitor mount assembly**



**Step 3. Install the keyboard/mouse transmitter and the work surface**

---

## Step 3. Install the keyboard/mouse transmitter and the work surface

- 1** Slide the keyboard/mouse transmitter into the plastic holder on the bottom side of the work surface. Use the cable clamps on the bottom of the work surface to secure the cables.
- 2** Attach the work surface rails to the rack using a T-25 torx driver.
- 3** Slide the work surface over the rails and secure it using provided hardware.
- 4** Route the transmitter cables through the rack and attach to the appropriate computer connectors using extension cables if necessary.

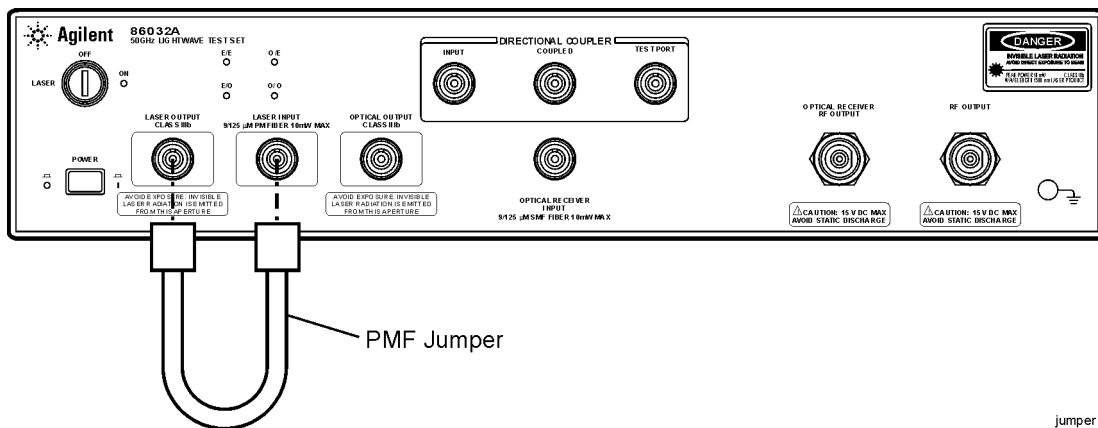
The Connect button on the transmitter should be towards the plastic holder.

**Step 4. Confirm front and rear panel connections****Step 4. Confirm front and rear panel connections**

- 1 Connect the jumper between the LASER OUTPUT and LASER INPUT on the 86032A front panel. Refer to [Figure 4-1](#).

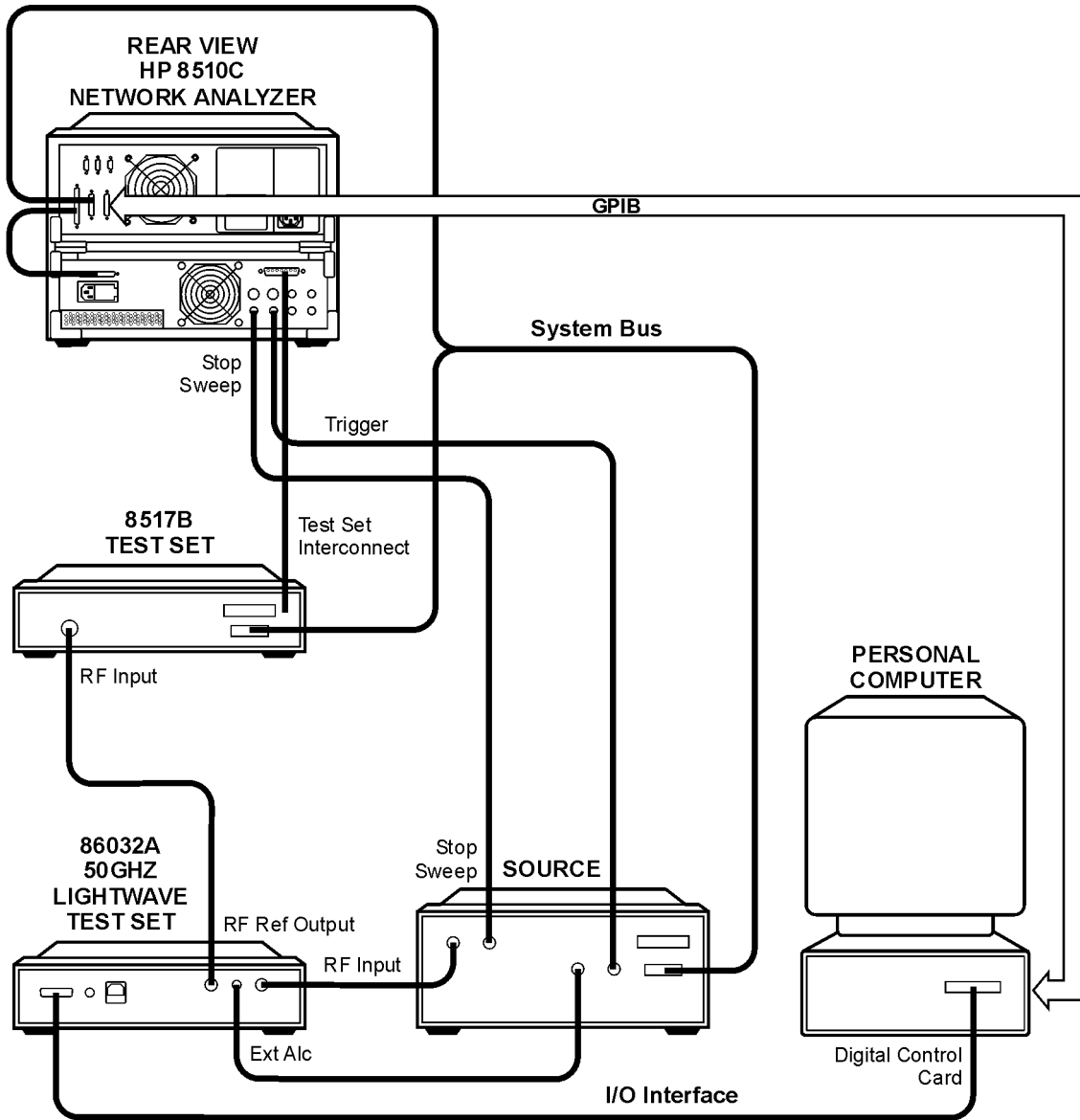
You must clean the connectors every time the jumper is connected. Refer to “Cleaning Connectors” on page 1-40.

- 2 Confirm the cabling of the Agilent/HP 86030A system. Refer to [Figure 4-2](#).



**Figure 4-1. Location of PMF Jumper**

**Step 4. Confirm front and rear panel connections**



syconfig

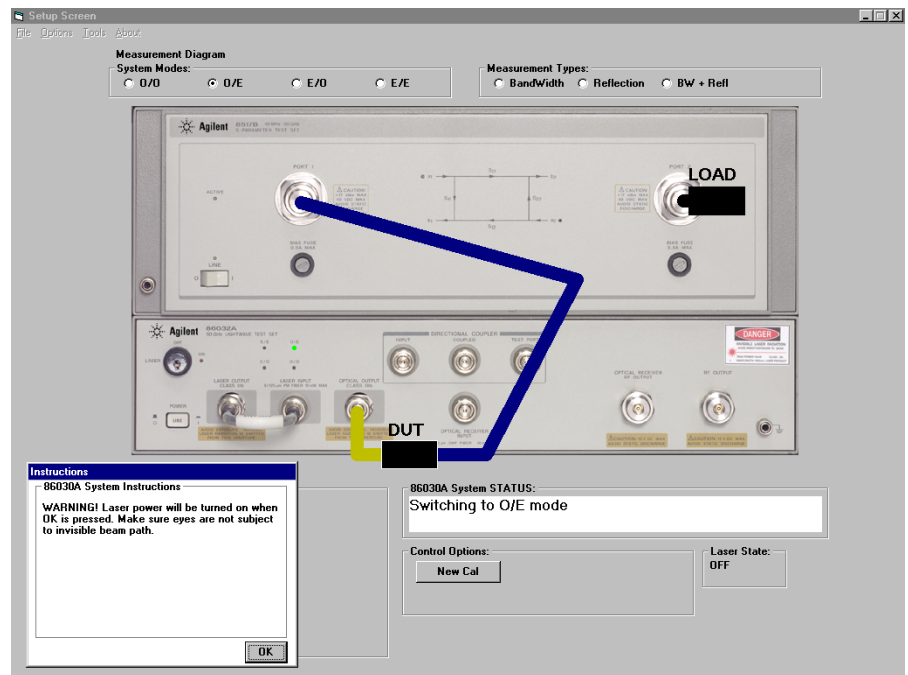
**Figure 4-2. Agilent 86030A Cabling Configuration**



## Step 5. Turn the system on

- 1 Plug in the Power Distribution Units (PDU).
- 2 Turn on the system, and allow it to warm up for two hours.
- 3 From the Windows **Start** menu, select **Programs, Agilent Technologies 50 GHz LCA, 50 GHz LCA Main** to open the software.

A splash screen will appear displaying the software title followed by the application screen shown in the following figure.



- 4 Perform a system verification. Refer to "Lightwave Verification" on page 5-3.

Installation

**Step 5. Turn the system on**

“Lightwave Verification” on page 5-3

“If the Lightwave Verification Test Fails” on page 5-7

---

## System Verification

## Introduction

In order to verify the system, it is necessary to perform the procedures described here. The recommended verification cycle is one year.

The system verification monitors the long-term stability and repeatability of the system hardware. The test compares measurements of the current system status against factory-measured data unique to the system, which is supplied on a disk (found in the 86032A verification kit) with each system.

### **Note**

Although this lightwave verification is a subset of the total process for verifying the system's conformance to specifications, this procedure can be used alone as a functional test and can be helpful in the following ways:

- It can be used at incoming inspection to check that no major degradation has occurred in the system during shipment.
- It provides a means to periodically monitor measurement stability.
- It can help isolate the cause of incorrect measurement results. (When the system passes the test, you will have confidence the system is operating correctly and any problem is in the setup or DUT.)

---

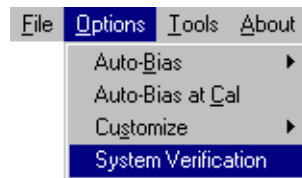
## Lightwave Verification

### Description

A verification device is included with the system. It consists of an Agilent 83440D lightwave detector and its associated amplitude and phase data. This verification device can be used at any time to verify the measurement integrity of your system. A guided verification routine is provided which measures the verification device, and displays a graph of its response versus acceptable tolerances. The verification device can be used periodically to monitor system calibration, and indicate when the optical test set needs to be recalibrated. It can also be used to resolve uncertainty if unexpected results are obtained from a test device. This verification capability provides confidence in the measurement integrity of the system. If the new data measured does not fall within these limits, refer to “[If the Lightwave Verification Test Fails](#)” in this section.

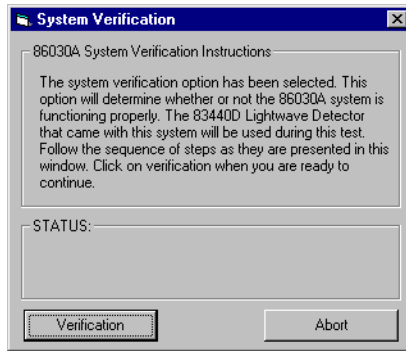
### Procedure

- 1 To perform a system verification, from the **Options** menu select **Verification**.

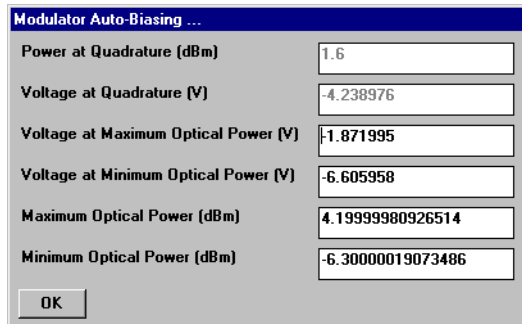


- 2 From the System Verification dialog box, click **Verification**.

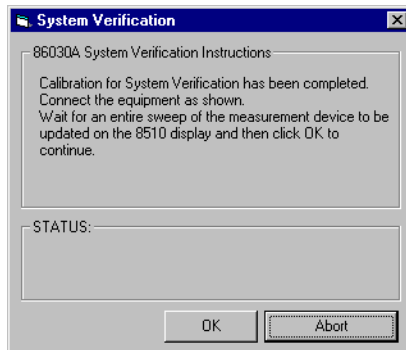
System Verification  
**Lightwave Verification**



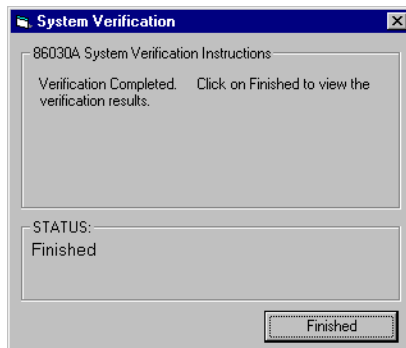
- 3 The System Verification procedure will start by performing an auto-bias routine. Ensure that a BNC 50 ohm load is connected to Port 1 bias tee on the 8517B rear panel.



- 4 Follow the on-screen instructions to perform an O/E response + isolation calibration.
- 5 When the calibration procedure is complete, you will be prompted to connect the equipment as shown. The 83440D lightwave detector will be used as the DUT for the verification procedure. Remember to connect the dc bias port of the detector to the 87421A power supply.

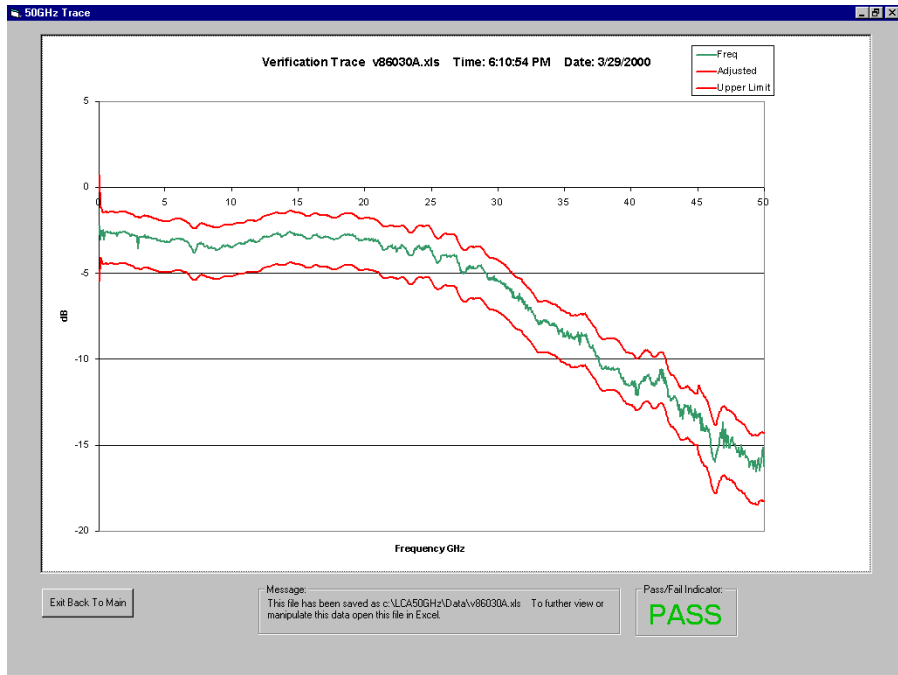


- 6 Once an entire sweep is displayed on the 8510C, click **OK** to continue.



- 7 The verification process is completed. Click on **Finished** to save and view the verification results on an Excel worksheet.

System Verification  
**Lightwave Verification**





## If the Lightwave Verification Test Fails

If any part of the test fails, measurement integrity is not confirmed. Proceed with the following checks.

- 1** Clean all the optical and electrical connectors and make sure the connections are finger tight.

Clean all the RF connectors and make sure the connections are made to the correct torque. [Refer to “Accurate Measurements” on page 1-33.](#)

Run the lightwave verification test again.

- 2** Check electrical connectors for damage. Especially center female pins.
- 3** Check flexible 2.4 mm cables for damage.
- 4** If the test still fails, perform an autobias. Select Options, Autobias from the menu bar.

Allow two hours for the modulator to stabilize, and then run the measurement stability test again.

- 5** If the test still fails, refer to [Chapter 6, “Maintenance”](#).



[“86032A Test Set Troubleshooting Diagnostics” on page 6-6](#)  
[“Verifying the RF Path Integrity of the 86032A” on page 6-12](#)  
[“Modulator Troubleshooting Tips” on page 6-16](#)  
[“Agilent Technologies Support and Maintenance” on page 6-17](#)  
[“Electrostatic Discharge Information” on page 6-19](#)  
[“Returning the System for Service” on page 6-22](#)  
[“Agilent Technologies Sales and Service Offices” on page 6-25](#)  
[“After Repair” on page 6-26](#)  
[“To install the system calibration software disk” on page 6-26](#)

# Maintenance

This chapter shows you how to troubleshoot the system to the instrument level. To prevent voiding product warranty, do not remove any instrument covers. The Agilent 86032A test set is *not* customer serviceable. Do not open the Agilent 86030A covers for any reason.

---

**WARNING**

**These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing unless you are qualified to do so.**

---

**WARNING**

**The opening of the system or removal of parts is likely to expose dangerous voltages. Disconnect the product from all voltage sources while it is being opened.**

---

**WARNING**

**The power cord is connected to internal capacitors that may remain live for 5 seconds after disconnecting the plug from its power supply.**

---

**WARNING**

**This is a Safety Class 1 Product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. Any interruption of the protective conductor inside or outside of the product is likely to make the product dangerous. Intention interruption is prohibited.**

---

**WARNING**

**To prevent electrical shock, disconnect the Agilent Technologies 86030A system from mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean any instrument internally.**

---

**CAUTION**

The warranty and calibration will be voided on systems where the individual instruments, including fiber-optic cables, RF cables, or GPIB cables are removed by the customer. The system should only be disassembled by a Agilent Technologies Customer Engineer. Instruments should not be swapped or removed by non-Agilent Technologies personnel.

# Troubleshooting

**Introduction** Troubleshooting consists of checking the setup and the connections. If a problem persists, contact Agilent Technologies.

**Check the Setup** Plug in the system and listen for the sound of the fan. Even in standby (STBY) mode the E/E LED should be on and the fan should run. Turn on the system. The O/O LED should turn on.

If either LED does not light or if the fan does not run, contact Agilent Technologies.

---

**WARNING** **Do NOT, under any circumstances, look into the optical output or any fiber/device attached to the output while the laser is in operation.**

**Refer to “[Laser Safety Considerations](#)” on page 1-30 for additional information.**

---

**CAUTION** When you use improper cleaning and handling techniques, you risk expensive system repairs, damaged cables, and compromised measurements. Repair of damaged connectors due to improper use is not covered under warranty.

Clean all cables before applying to any connector. Refer to “[Choosing the Right Connector](#)” on page 1-33 and to “[Inspecting Connectors](#)” on page 1-36.

Use the key to turn on the laser. The laser LED should turn on. If not, check the REMOTE SHUTDOWN BNC connector on the rear panel. That connector must be shorted for the laser (and the front panel LED) to turn on. Connect the BNC short to the connector. If the laser LED does not turn on, contact Agilent Technologies. If the LED does turn on, continue.

If the setup has been changed or the optical power output seems low, you may have to check the optical connections.

Optical connections are a critical part of consistent measurements, as detailed in “[Accurate Measurements](#)” on page 1-33. Are all of the connections clean and properly made?

### **To perform a quick check**

Common troubleshooting skills can be used to locate many problems. The following steps are suggested for quickly narrowing down the problem.

- 1** Inquire about recent repairs or changes to the system.

Often, this will help pinpoint current problems even if the system was operating correctly after the repair or change to the system.

- 2** Setup or reinstall the 86030A software to determine whether the problem is a hardware or a software problem. Refer to [Chapter 4, “Installation”](#).

Refer to [Table 6-2 on page 6-5](#) for the correct addresses for the computer and the 86030A lightwave component analyzer system. If reinstalling the software does not solve the problem, the problem may not be a software error.

- 3** Check that system components are wired correctly.
- 4** Remove, clean, and reinstall all optical connections.
- 5** Ensure that all cables are secure.
- 6** Check for a 50Ω load in the two bias ports of the 8517B electrical test set.

---

### **To check the 8510C network analyzer**

- Refer to the 8510C Onsite Service Guide (pn 08510-90282) for 8510C troubleshooting procedures.

---

### **To check the computer**

- For problems with the personal computer that are unrelated to the rest of the 86030A, refer to the computer manual that was shipped with this system, or call your local IT department.
- If either the wireless keyboard or mouse are not responding, check the batteries.
- Troubleshoot the computer's connection to the 86030A:
  - a** Ensure that the GPIB and computer addresses are correct. The correct GPIB and I/O addresses for the computer and system are located in [Table 6-2 on page 6-5](#) and [Table 6-1 on page 6-5](#).
- Perform the following step:

- a With a voltage meter, measure the voltage from the cable. It should be reading between 2 and 4 volts.

**To check the network**

- Make sure the LAN cable is connected properly to the computer.
- Setup the computer LAN card according to the manufacturer's specifications.
- Disconnect the LAN cable, and test it using a LAN cable testing tool.
- Refer to the Windows NT documentation on networking the system. The Windows NT help system also contains a *Networking Troubleshooter* section which will guide you through the most common networking problems.
- Refer to your local IT department, or call the Agilent Test and Measurement Customer Support line at (800) 452-4844.
- Correct GPIB and I/O addresses for the computer and system are located in [Table 6-2 on page 6-5](#) and [Table 6-1 on page 6-5](#).

There are many types of inter-office LANs. Because of this, this manual can only give very basic troubleshooting information.

**Table 6-1. Computer I/O Addresses**

Test Set Component	I/O Address
Modulation Bias DAC	&h300

**Table 6-2. GPIB Addresses**

Instrument Name	GPIB Address
86032A optical test set	24
8510C network analyzer	16
8517B electrical test set	20
83651B synthesized sweeper	19

## 86032A Test Set Troubleshooting Diagnostics

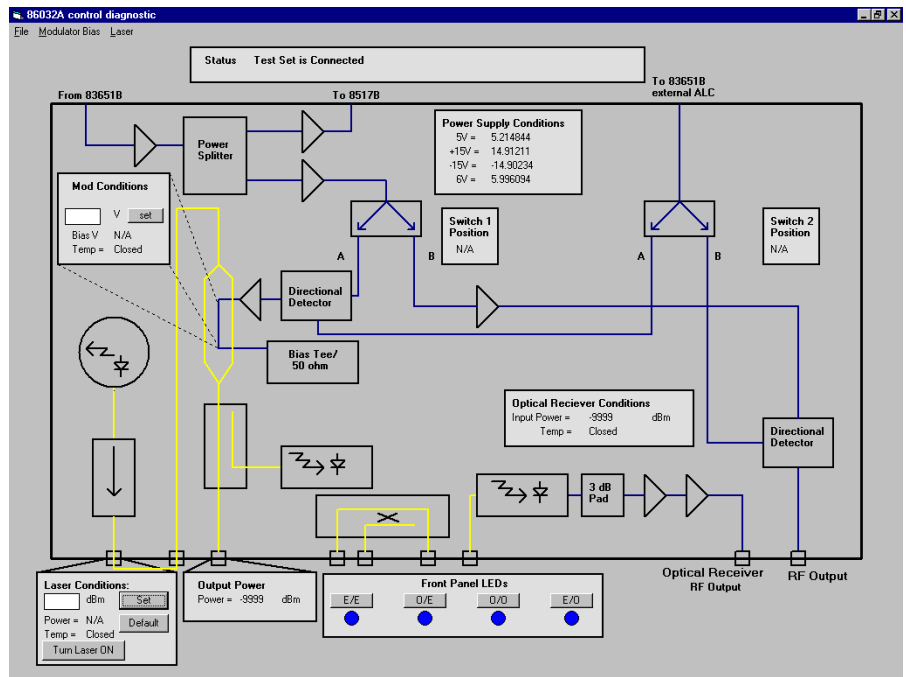
Using the 50 GHz LCA Diagnostic software and an electrical power meter with an Agilent/HP 8487A power sensor (2.4 mm connector), you can do a thorough verification of the Agilent 86032A test set. The Diagnostic software will verify the functionality of the:

- Laser
  - Modulator
  - Receiver
  - RF paths
- 

### Open the Diagnostic Software

- 1 From the **Start** menu, click on **Programs, Agilent Technologies 50 GHz LCA, 50 GHz LCA Diagnostic**.





## Verify Power Supply Operation

The purpose of this test is to verify that the 86032A test set is properly connected to the system computer. Verification of the 86032A power supply functionality is also confirmed.

- 2 In the Power Supply Conditions area of the diagnostic software, the left column lists the power supplies used in the 86032A test set. The right column lists the actual value of these power supplies. Make sure that these values are close to the values in the left column.

Power Supply Conditions	
5V =	5.214844
+15V =	14.91211
-15V =	-14.90234
6V =	5.996094

Tip: When the power supplies are functioning properly, the Status area will display “Test Set is Connected.”

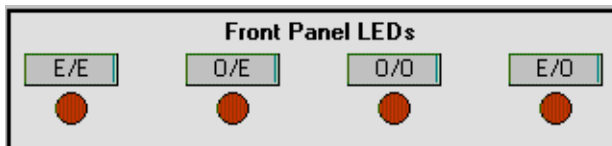
<b>Status</b>	<b>Test Set is Connected</b>
---------------	------------------------------

---

## To Verify System Mode Switching Function

The purpose of this test is to verify that you can control the electrical switch inside the 86032A test set.

- 3 In the Front Panel LEDs area of the diagnostic software, click on each of the four system modes in the following order: **E/E**, **O/E**, **E/O** then **O/O**.



- 4 For each mode, you should hear a clicking noise from the 86032A test set indicating that the switch is working. Also, as each mode is selected verify that the corresponding LED lights up on the test set front panel.

---

## To check Laser Conditions

The purpose of this test is to see if the internal DFB laser is producing the correct amount of output power.

---

### WARNING

**Do NOT, under any circumstances, look into the optical output or any fiber/device attached to the output while the laser is in operation.**

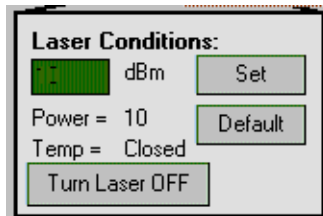
**Refer to “Laser Safety Considerations” on page 1-30 for additional information.**

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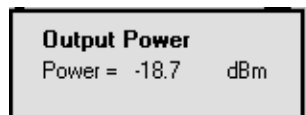
### NOTE

To verify proper operation of the laser, the laser must be controlled via the 50 GHz Diagnostic software. Also, insure that a BNC short is connected to the Laser Remote Shutdown connector on the 86032A rear panel.

- 5 Select a fiber cable from the 86030A verification kit.
- 6 Clean and then connect the cable between the 86032A OPTICAL OUTPUT and the OPTICAL RECEIVER INPUT. Refer to “Cleaning Connectors” on page 1-40.
- 7 On the 86032A front panel, turn the Laser key to the ON position.
- 8 In the Laser Conditions area of the diagnostic software, click the Turn On Laser button. Verify that the 86032A LASER ON LED lights up.



- 9 In the Laser Conditions area, set the Laser Power to 10 dBm and observe the power as indicated in the Output Power area. There should be some indication of power.



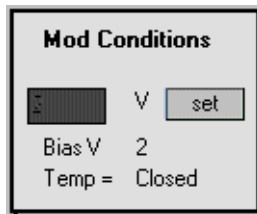
The actual power out is not a fixed value since the state of the modulator cannot be predicted. If the laser is not functioning, the power level will register -9999 or some other extremely low value.

---

## To check Modulator Conditions

The purpose of this test is to see if the electrical input voltage to the modulator can control the modulator loss.

- 10** In the Front Panel LEDs area of the diagnostic software, click on **E/E** to remove the modulation from the lightwave path.
- 11** In the Mod Conditions area, enter 1 Volt in the text box, and then press **Set**. Observe the Output Power level. Now, increase the voltage to 2V. There should be a noticeable change to the Output Power level. There is no way of determining if the power will increase or decrease because it is not known where 1 volt lies on the Modulator Bias Curve. See [Figure 6-1 on page 6-11](#).



- 12** In the 8510C STIMULUS area, select CENTER and enter 25 G (25 GHz), then select SPAN and enter 0 [x1] (0 Hz).
- 13** From the Diagnostic software's **Modulator Bias** menu, select **Trace Out Mod Curve**.

Follow the on-screen instructions. It will take a few minutes to trace the output curve.

- 14 To view the trace, open a session of Excel, then click **File, Open** to open *C:\LCA50GHZ\Data\Pwrcurve*.

This shows the output power versus applied voltage to the optical modulator. The voltage difference between the minimum and maximum power point is referred to as  $V_{\pi}$ . A typical value of  $V_{\pi}$  is between 2.5 and 6 volts. The extinction ratio of the modulator is defined to be the ratio of the maximum power to the minimum power as expressed in dB. The typical value of extinction ratio is between 8 and 20 dB.

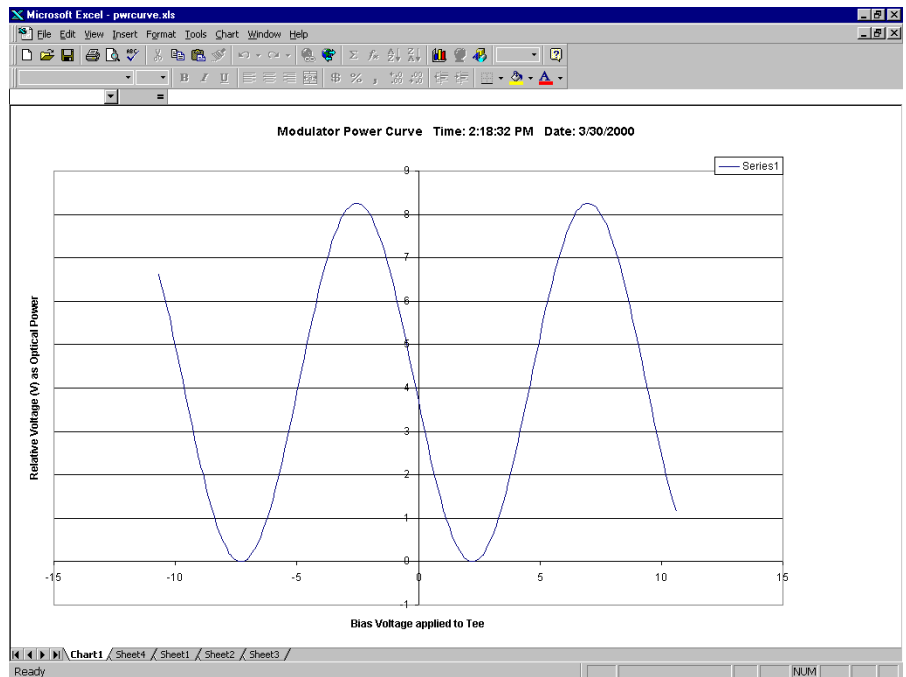
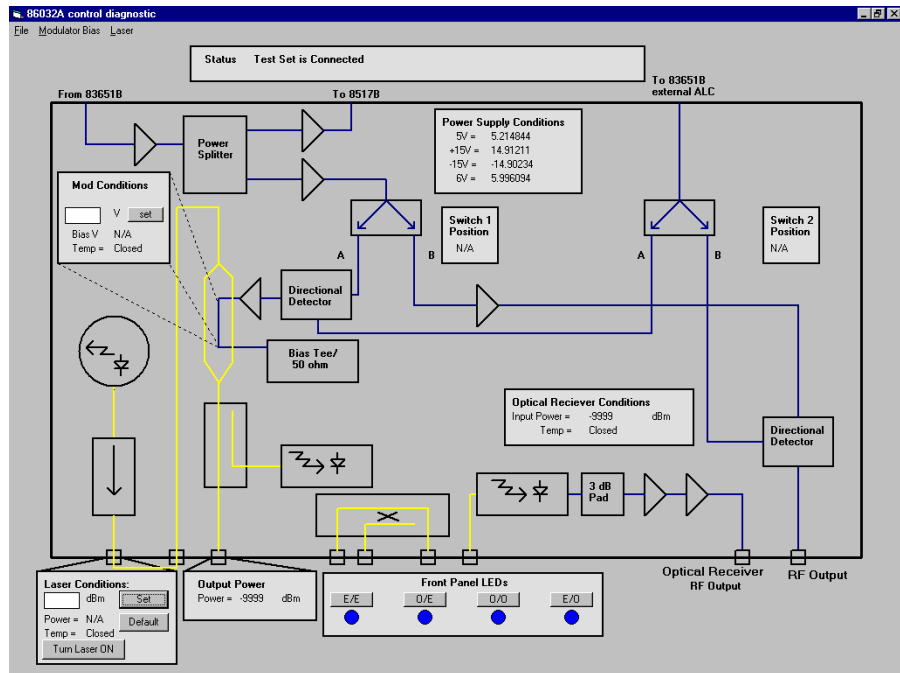


Figure 6-1.

## Verifying the RF Path Integrity of the 86032A



This series of tests will check the RF path integrity for three different routes.

- Path A, *From 83651B* input to *To 8517B* output
- Path B, *From 83651B* input to *Optical Receiver RF Output*
- Path C, *From 83651B* input to *RF Output*

---

## Path A Test

The purpose of this test is to check Path A continuity.

- 15** Connect an electrical power meter to the 86032A rear panel RF REF OUTPUT.
- 16** In the 8510C STIMULUS area, select CENTER and enter 25 G (25 GHz), then select SPAN and enter 0 [x1](0 Hz).
- 17** From the 8510 STIMULUS MENU, select Power Menu, Power Source 1 and enter 0 [X1](0 dBm).
- 18** The power meter should read >5 dBm.

**Tip:** If the power is low, verify that the power out of the 83651A is 0 dBm. You can verify the power to 83651A by connecting the 8487A power sensor directly to the 83651A rear panel output.

---

## Path B Test

The purpose of this test is to check Path B continuity.

- 19** Connect the 8487A power sensor to the 86032A OPTICAL RECEIVER RF OUTPUT.

Ensure that a fiber cable is connected between the Optical Output and Receiver Input connectors on the front panel.

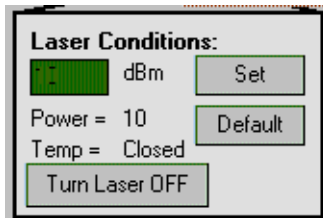
**Tip:** You will need a female-to female 2.4 adapter between the power sensor and the RF output, which you can find in the 85056A 2.4mm calibration kit.

- 20** From the Front Panel LEDs area, click on the O/E mode button.

### *Setting up the Laser Source Power*

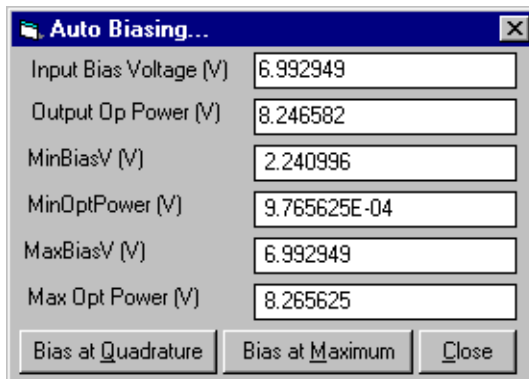
- 21** In the Laser Conditions area of the diagnostic software, enter **10** dBm in the text box, and then click **Set**.

**Verifying the RF Path Integrity of the 86032A**



***Setting Up the Modulator Bias Voltage***

- 22 From the Diagnostic software main menu, select **Modulator Bias, Bias Modulator**.



- 23 In the Auto Bias window, click **Bias at Quadrature**.
- 24 Once the auto bias is completed, the power reading in the Output Power area and Optical Receiver Conditions area should be within 1 dB of each other.

This step verifies that there is a low loss connection between the Optical Output port and Optical Receiver Input port.

- 25 Connect the power meter to the OPTICAL RECEIVER RF OUTPUT. The power meter should read < -20 dBm.



## Path C Test

The purpose of this test is to check Path C continuity.

- 26** From the Diagnostic Front Panel LEDs area, click on **E/O**.
- 27** Connect the 8487A power sensor to the 86032A RF OUTPUT.  
**Tip:** You will need a female-to female 2.4 adapter between the power sensor and the RF output.
- 28** In the 8510C STIMULUS area, select CENTER and enter 25 G (25 GHz), then select SPAN and enter 0 [x1] (0 Hz).
- 29** The power meter should read  $\geq -5$  dBm.
- 30** From the Diagnostic Front Panel LEDs area, click on O/O. The power meter reading should go to a very low value.

---

## Modulator Troubleshooting Tips

- If Maximum Optical Power is not greater than 3 dB, the problem could be one of the following.
  - Clean and reconnect the jumper cable that goes between the LASER OUTPUT to the LASER INPUT
  - From the Start menu, click on Agilent Technologies 50 GHz LCA, and then 50 GHz LCA Diagnostics. In the Diagnostics window, check the Laser Power Setting. The Laser Power should be approximately 10 dBm.
  - If the Voltage at Maximum Optical Power – Voltage at Minimum Optical Power is not between 3 and 6 volts, then try running a manual auto bias. From the Options menu, click on AutoBias, Quadrature.

---

# Agilent Technologies Support and Maintenance

On-site service by an Agilent Technologies customer engineer is available to ensure that your system uptime is maximized. You can order per-incident, contractual, or customized on-site system repair and on-site system calibration services. Just contact your local sales office, and give the operator the name of your company and the city where you're located. Then, ask to speak with a field sales engineer. If you're currently covered by a per-incident, contractual or customized program, contact your customer engineer through your local sales office to obtain on-site service.

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**NOTE**

On-site repair and calibration are available for the 8510C network analyzer portion of the system in many parts of the world. In some areas, the PC also has on-site support. The 86032A lightwave test set must be returned to the factory for repair and calibration. Contact your local CE for more information. [Refer to “Agilent Technologies Sales and Service Offices” on page 6-25.](#)

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***Definition of On-site System Repair***

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

***Definition of On-Site System Calibration***

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

Calibration services for systems include the following:

- Calibration measurements traceable to national and international standards
- U.S. measurements traceable to the National Institute of Standards and Technology (NIST)
- Product performance compared to standards of known accuracy to ensure con-

**Agilent Technologies Support and Maintenance**

formance with published specifications

- Calibration at Agilent-recommended intervals
- Complete data reports for all measured product performance
- Calibration certificate and sticker showing date of next scheduled calibration
- Calibration at no charge after a repair performed by Agilent on products covered under a calibration agreement or under Agilent Support Options

***Other Test and Measurement Support Programs***

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

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

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## Electrostatic Discharge Information

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

- Conductive table-mat and wrist-strap combination.

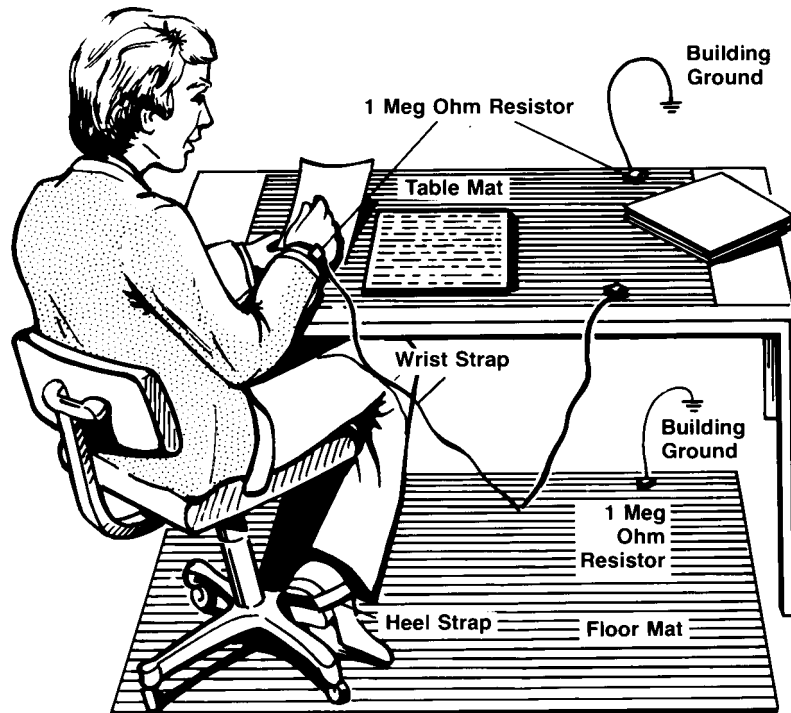
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**NOTE**

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For the 86030A 50 GHz LCA system, the static strap is attached to the 86032A front panel grounding receptacle. [Refer to “Front Panel Features” on page 1-8.](#)

- Conductive floor-mat and heel-strap combination.

**Electrostatic Discharge Information**

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

To ensure user safety, the static-safe accessories must provide at least 1 M $\Omega$  of isolation from ground. Refer to [Table 2 on page 6-21](#) for information on ordering static-safe accessories.

**WARNING**

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

---

## Reducing ESD Damage

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

- Personnel should be grounded with a resistor-isolated wrist strap before removing any assembly from the unit.
- Be sure all instruments are properly earth-grounded to prevent a buildup of static charge.

**Table 2. Static-Safe Accessories**

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

---

## Returning the System for Service

The instructions in this section show you how to properly return the instrument for repair or calibration. Always call the Agilent Instrument Support Center first to initiate service *before* returning your instrument to a service office. This ensures that the repair (or calibration) can be properly tracked and that your instrument will be returned to you as quickly as possible. Call this number regardless of where you are located. Refer to “Agilent Technologies Sales and Service Offices” on page 6-25 for a list of service offices.

Agilent Instrument Support Center . . . . . (800) 403-0801

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

When an instrument is returned to a Agilent service office for servicing, it must be adequately packaged and have a complete description of the failure symptoms attached. When describing the failure, please be as specific as possible about the nature of the problem. Include copies of additional failure information (such as the instrument failure settings, data related to instrument failure, and error messages) along with the instrument being returned.



---

## Preparing the instrument for shipping

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

---

### CAUTION

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

---

### CAUTION

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

- 3 Pack the instrument in the original shipping containers. Original materials are available through any Agilent Technologies office. Or, use the following guidelines:
  - Wrap the instrument in antistatic plastic to reduce the possibility of damage caused by electrostatic discharge.
  - For instruments weighing less than 54 kg (120 lb.), use a double-walled, corrugated cardboard carton of 159 kg (350 lb.) test strength.
  - The carton must be large enough to allow approximately 7 cm (3 inches) on

**Returning the System for Service**

all sides of the instrument for packing material, and strong enough to accommodate the weight of the instrument.

- Surround the equipment with approximately 7 cm (3 inches) of packing material, to protect the instrument and prevent it from moving in the carton. If packing foam is not available, the best alternative is S.D-240 Air Cap™ from Sealed Air Corporation (Commerce, California 90001). Air Cap looks like a plastic sheet filled with air bubbles. Use the pink (antistatic) Air Cap™ to reduce static electricity. Wrapping the instrument several times in this material will protect the instrument and prevent it from moving in the carton.
- 4 Seal the carton with strong nylon adhesive tape.
  - 5 Mark the carton “FRAGILE, HANDLE WITH CARE”.
  - 6 Retain copies of all shipping papers.

---

## Agilent Technologies Sales and Service Offices

Before returning an instrument for service, call the Agilent Technologies Instrument Support Center at (800) 403-0801, visit the Test and Measurement Web Sites by Country page at <http://www.tm.agilent.com/tmo/country/English/index.html>, or call one of the numbers listed below.

### Agilent Technologies Service Numbers

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Austria	01/25125-7171
Belgium	32-2-778.37.71
Brazil	(11) 7297-8600
China	86 10 6261 3819
Denmark	45 99 12 88
Finland	358-10-855-2360
France	01.69.82.66.66
Germany	0180/524-6330
India	080-34 35788
Italy	+39 02 9212 2701
Ireland	01 615 8222
Japan	(81)-426-56-7832
Korea	82/2-3770-0419
Mexico	(5) 258-4826
Netherlands	020-547 6463
Norway	22 73 57 59
Russia	+7-095-797-3930
Spain	(34/91) 631 1213
Sweden	08-5064 8700
Switzerland	(01) 735 7200
United Kingdom	01 344 366666
United States and Canada	(800) 403-0801

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## After Repair

When you first received the 86030A LCA 50 GHz system, the 86030A System Verification kit contained a system calibration software disk (pn 86030-10001). The system software disk contains information that is unique to each 86032A test set. The 86030A system comes from the factory with this information loaded onto the system software disk. You will need to reinstall the system software disk for the following cases:

- If the 86032A test set has been returned to the factory for repair
- If the 86032A test set has been returned to the factory for calibration
- If the system controller (that is, personal computer) has been returned to the factory for repair

---

### To install the system calibration software disk

- 1** Insert the 86030-10001 software disk into the floppy drive of the system controller.
- 2** From the Windows Desktop, double-click My Computer.
- 3** Double-click on the A drive and then setup.bat.

The following files are automatically loaded into their correct directory locations.

- lwcxxxxx - calibration file
  - lwwxxxxx - verification file
  - config86032a.ini - lightwave test set calibration coefficients
  - lca\_k50.ini - pointer file
  - configverif.ini - verification device test limits
- 4** Once the setup.bat file has been executed the 86030A system is now ready for use.

“General Specifications” on page 7-3  
“Electrical Specifications” on page 7-4  
“Optical to Optical (O/O) Specifications” on page 7-6  
“Optical to Electrical (O/E) Specifications” on page 7-7  
“Electrical to Optical (E/O) Specifications” on page 7-12  
“Characteristics” on page 7-16  
“Optical to Electrical (O/E) Characteristics” on page 7-18  
“Electrical to Optical (E/O) Characteristics” on page 7-21  
“Regulatory Information” on page 7-24  
“Declaration of Conformity” on page 7-25

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## Specifications and Regulatory Information

## Specifications and Regulatory Information

This chapter lists specifications and characteristics of the 86030A. Specifications apply over the temperature range +20°C to +30°C after the system's temperature has been stabilized after two hours of continuous operation. The specifications are valid only for a temperature drift of less than  $\pm 3^\circ\text{C}$  from the user calibration temperature. A user calibration *must* be performed at least once every 8 hours.

- Specifications**      *Specifications* described warranted performance.
- Characteristics**      *Characteristics* provide useful, non warranted, information about the functions and performance of the system. *Characteristics are printed in italics.*
- Calibration cycle**      Agilent Technologies warrants instrument specifications over the recommended calibration interval. To maintain specifications, periodic recalibrations are necessary. We recommend that the 86030A be calibrated at an Agilent Technologies service facility every 12 months.

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## General Specifications

**Table 7-1. General System Specifications**

<b>Measurement</b>	<b>Specification</b>
Specified Temperature Range	20 °C to 30 °C
Operating Temperature Range	5 °C to 40 °C
Storage Temperature	−40 °C to +75 °C
Power Dissipation	1940 VA maximum
Supply Requirements	
Nominal Frequency Range	47.5 to 66 Hz
Nominal Voltage	100, 120, 220, 240 Vac, ±10%
Fuse Type and Rating for 86032A test set	6.3A, 250V
System Weight	250 kg/592 lbs.
System Rack Size	
Height	1.6 meters
Width	600 mm
Depth	900 mm

---

## Electrical Specifications

The electrical to electrical specifications are the same as for the 85107B with the following exceptions.

- The user does not have control of the RF power applied to the 8517B test set.
- In the Step mode, when the first point in the trace is in the 45 to 150 MHz range, the accuracy of the first point is significantly degraded.

In the Ramp mode, accuracy of all measurements in the 45 MHz to 150 MHz range will be degraded.

The full performance of the 85107B can be obtained by reconnecting the 50 GHz source directly to the 8517B test set (bypassing the 86032A) using the cable supplied with the 8510C accessories.

Refer to the 85107B System manual for a complete listing of the specifications.

**Table 7-2. General Optical/Electrical Specifications**

Measurement	Specification	Conditions
Modulation Frequency Range	0.045 - 50 GHz	
Optical Source Center Wavelength	1550 -1560 nm	DFB laser falls within these wavelength limits
Optical Output Return Loss	> 30 dB	With factory new straight connectors. Improper connector care will degrade this specification.
Optical Input Return Loss	> 25 dB	With factory new straight connectors. Improper connector care will degrade this specification.



**Table 7-2. General Optical/Electrical Specifications (Continued)**

<b>Measurement</b>	<b>Specification</b>	<b>Conditions</b>
Average Optical Output Power: Modulator at minimum loss	> 3 dBm	Modulator set at minimum insertion loss.
Modulator at quadrature	> 0 dBm	Modulator set at quadrature. Quadrature is the average of the minimum and maximum transmission state of the modulator.
Available power at Laser output port	> 8 dBm	This port has a polarization maintaining fiber (PMF) connected.
Nominal RF modulation power setting for E/O mode	0 dBm	This is the default power that the system will use. This setting will assure that a 85107B receiver overload will not occur during the calibration process. Advanced users may increase the power level however, you will have to manually verify that receiver overload has not occurred.
Maximum available RF Modulation Power for E/O Mode	> 5 dBm	This is the power measured at the RF Output port of the 86032A test set. This value can be set manually from the 86030A program. From the Options menu, click Advanced, Customize, SRC Power E to O dBv and enter a new value. Note that you will need an electrical power meter to set this value as the 86030A software value is a relative number.
Maximum Operating Optical Input Power (to optical receiver input)	Do <b>not</b> exceed 4 mW (6 dBm)	Exceeding this value will cause measurement inaccuracies.
Maximum Optical Input Power to Optical Receiver (without damage)	Do <b>not</b> exceed 15 mW (11.8 dBm)	Power above this level can potentially damage the photodetector of the optical receiver.

---

## Optical to Optical (O/O) Specifications

***Specification conditions:***

- Factory default laser power settings
- Factory default modulation power settings
- Setting of 512 averages on the 85107B
- Response and isolation calibration
- Greater than 20 dBe signal to noise ratio required for these specifications to be valid.
- Specifications are valid only for Step mode operation.

**Table 7-3. Optical to Optical Noise Floor**

<b>Frequency Range (GHz)</b>	<b>Noise Floor (dBo)<sup>a</sup></b>
0.045 - 0.1	< -18
0.1 - 0.2	< -24
0.2 - 0.3	< -27
0.3 - 0.5	< -30
0.5 - 10	< -33
10 - 20	< -30
20 - 30	< -27
30 - 40	< -22
40 - 50	< -18

<sup>a</sup> dB down from the 0 dBo loss reference  $10\log\left(\frac{\text{power}}{\text{optical thru-line power}}\right)$ .

## Optical to Electrical (O/E) Specifications

### ***Relative Frequency Response***

Relative frequency response refers to the amount of error that accumulates when you compare the response of two or more frequency points. This would often be used in calculating the – 3 dB roll-off point of an optical modulator. A large error term for this measurement is dependent on the amount of electrical port reflectivity on the O/E device under test. Thus, relative frequency response is specified as a function of electrical port reflectivity. The electrical reflectivity of any O/E device can be measured using the E/E mode on the 86030A. The following relative frequency response tables are given for several values of O/E device under test electrical port reflectivity. If you do not know the electrical reflectivity, then you must use [Table 7-6, “O/E Relative Frequency Response for the Electrical Port Reflection Coefficient < 1.0,”](#) on page 7-9 as a conservative estimate. The electrical reflectivity of any O/E device can be measured using the E/E mode of the 86030A.

### ***Specification Conditions***

- Factory default laser power settings
- Factory default modulation power settings
- Setting of 512 averages on the 85107B
- Response and isolation calibration
- Greater than 20 dB signal to noise ratio required for these specifications to be valid.

Specifications are valid only for Step mode operation.

**Table 7-4. O/E Relative Frequency Response for the Electrical Port Reflection Coefficient < 0.25**

Frequency Range (GHz)	Relative Frequency Response (dBe)	Relative Frequency Response (dBe) <sup>a</sup>
0.045 - 0.1	±2.3	±2.2
0.1 - 2	± 0.8	± 0.7
2 - 20	± 1.0	± 0.7
20 - 40	± 1.3	± 0.9
40 - 50	± 1.8	± 1.2

<sup>a</sup> With a 6 dB attenuator connected to the electrical receiving port of the 8517B test set. Refer to “O/E measurement with 6 dB attenuator” on page 2-32.

**Table 7-5. O/E Relative Frequency Response for the Electrical Port Reflection Coefficient < 0.5**

Frequency Range (GHz)	Relative Frequency Response (dBe)	Relative Frequency Response (dBe) <sup>a</sup>
0.045 - 0.1	±2.4	±2.2
0.1 - 2	± 0.9	± 0.7
2 - 20	± 1.4	± 0.8
20 - 40	± 1.7	± 1.0
40 - 50	± 2.3	± 1.3

<sup>a</sup> With a 6 dB attenuator connected to the electrical receiving port of the 8517B test set. Refer to “O/E measurement with 6 dB attenuator” on page 2-32.

**Table 7-6. O/E Relative Frequency Response for the Electrical Port Reflection Coefficient < 1.0**

<b>Frequency Range (GHz)</b>	<b>Relative Frequency Response (dBe)</b>	<b>Relative Frequency Response (dBe)<sup>a</sup></b>
0.045 - 0.1	±2.7	±2.3
0.1 - 2	± 1.2	± 0.8
2 - 20	± 2.0	± 1.0
20 - 40	± 2.4	± 1.2
40 - 50	± 3.2	± 1.6

<sup>a</sup> With a 6 dB attenuator connected to the electrical receiving port of the 8517B test set. [Refer to "O/E measurement with 6 dB attenuator" on page 2-32.](#)

**Optical to Electrical (O/E) Specifications*****Relative Frequency Response with Response and Match User Calibration******Specification Conditions***

- Factory default laser power settings
- Factory default modulation power settings
- Setting of 512 averages on the 85107B
- Any electrical port reflection coefficient
- Greater than 20 dBc signal to noise ratio required for these specifications to be valid.
- Specifications are valid only for Step mode operation.

**Table 7-7. O/E Relative Frequency Response for the Electrical Port Reflection Coefficient < 1.0 with Response and Match User Calibration**

<b>Frequency Range (GHz)</b>	<b>Relative Frequency Response (dBc)</b>
0.045 - 0.1	±2.2
0.1 - 10	± 0.7
0.1 - 20	± 0.7
0.1 - 30	± 0.9
0.1 - 40	± 1.2

---

## O/E Absolute Noise Floor

### ***Specification Conditions***

- Factory default laser power settings
- Factory default modulation power settings
- Setting of 512 averages on the 85107B
- Response and isolation calibration
- The internal O/E converter is disconnected from the 8517B input after the user calibration process so that it is not contributing to the noise floor rise. O/E converters with very large responsivities will cause a noise floor rise. This noise floor specification is valid only for O/E converters with responsivities less than 2.0 amps/watt.
- Specifications are valid only for Step mode operation.

**Table 7-8. O/E Absolute Noise Floor**

Frequency Range (GHz)	Noise Floor (dBe) <sup>a</sup>
0.045 - 0.1	- 40
0.1 - 0.2	- 50
0.2 - 0.3	- 60
0.3 - 0.5	- 62
0.5 - 10	- 70
10 - 20	- 62
20 - 30	- 56
30 - 40	- 47
40 - 50	- 42

<sup>a</sup>dBe down from 1amp/watt =  $20\log\left(\frac{DUT\ responsivity}{1\ amp/watt}\right)$

## Electrical to Optical (E/O) Specifications

Relative frequency response refers to the amount of error that accumulates when you compare the response of two or more frequency points. This would often be used in calculating the – 3 dB roll-off point of an optical modulator. A large error term for this measurement is dependent on the amount of electrical port reflectivity on the E/O device under test. Thus, relative frequency response is specified as a function of electrical port reflectivity. The electrical reflectivity of any E/O device can be measured using the E/E mode on the 86030A. The following relative frequency response tables are given for several values of E/O device under test electrical port reflectivity. If you do not know the electrical reflectivity, then you must use [Table 7-11, “E/O Relative Frequency Response for the Electrical Port Reflection Coefficient < 1.0,”](#) on page 7-14 as a conservative estimate. The electrical reflectivity of any E/O device can be measured using the E/E mode of the 86030A.

### ***Specification Characteristics***

- Factory default laser power settings
- Factory default modulation power settings
- Setting of 512 averages on the 85107B
- Response and isolation calibration
- 50 ohm termination on unused 8517B port
- Greater than 20 dBc signal to noise ratio required for these specifications to be valid.
- Specifications are valid only for Step mode operation.



**Table 7-9. E/O Relative Frequency Response for the Electrical Port Reflection Coefficient < 0.25**

<b>Frequency Range (GHz)</b>	<b>Relative Frequency Response (dBe)</b>
0.045 - 0.1	±2.1
0.1 - 2	± 0.6
2 - 20	± 0.9
20 - 40	± 1.0
40 - 50	± 1.4

**Table 7-10. E/O Relative Frequency Response for the Electrical Port Reflection Coefficient < 0.5**

<b>Frequency Range (GHz)</b>	<b>Relative Frequency Response (dBe)</b>
0.045 - 0.1	±2.3
0.1 - 2	± 0.8
2 - 20	± 1.3
20 - 40	± 1.5
40 - 50	± 2.1

**Table 7-11. E/O Relative Frequency Response for the Electrical Port Reflection Coefficient < 1.0**

<b>Frequency Range (GHz)</b>	<b>Relative Frequency Response (dBe)</b>
0.045 - 0.1	±2.8
0.1 - 2	± 1.3
2 - 20	± 2.1
20 - 40	± 2.5
40 - 50	± 3.4

---

## E/O Absolute Noise Floor

### ***Specification Conditions***

- Factory default laser power settings
- Factory default modulation power settings
- Setting of 512 averages on the 85107B
- Response and isolation calibration
- Specifications are valid only for Step mode operation.

**Table 7-12. Absolute Noise Floor**

<b>Frequency Range (GHz)</b>	<b>Noise Floor (dBe)<sup>a</sup></b>
0.045 - 0.1	- 50
0.1 - 0.2	- 55
0.2 - 0.3	- 57
0.3 - 0.5	- 60
0.5 - 10	- 61
10 - 20	- 58
20 - 30	- 55
30 - 40	- 53
40 - 50	- 50

<sup>a</sup>dBe down from 1 watt/amp =  $20\log\left(\frac{DUT\ responsibility}{1\ watt/amp}\right)$

---

## Characteristics

**Characteristics**

*Characteristics* provide useful, non warranted, information about the functions and performance of the system. *Characteristics are printed in italics.*

---

### Maximum Input Power into the 8510 Electrical Port

The following two tables indicate the maximum power the 8510 test port can tolerate before the system begins to overload and cause inaccurate measurements. For any reason, if an IF overload message appears on the 8510 display the input power must be reduced before continuing. Note that once an error message appears on the display, it does not go away until it is manually cleared using the 8510C Entry Off function. To check for an RF overload condition, [refer to “O/E RF Overload Detection Measurement” on page 2-47.](#)

**Table 7-13. Maximum Input Power into the 8517B Test Ports**

<b>Frequency Range (GHz)</b>	<b>Maximum Power (dBm)</b>
0.045 - 2.0	+ 18
2.0 - 20	+ 8
20 - 40	+ 4
40 - 50	- 3

*Typical Performance*

**Table 7-14. Optical Modulation Power from the 86032A Source Output<sup>a</sup>**

<b>Frequency Range (GHz)</b>	<b>Maximum Power (dBm)</b>
0.045 - 0.84	0
0.84 - 20	-3
20 - 40	-5
40 - 50	-10

<sup>a</sup>Typical Performance (this is not a specification)

---

## Optical to Electrical (O/E) Characteristics

### ***O/E Absolute Frequency Response***

The relative frequency response specifications gave information that is helpful in determining parameters such as the  $-3$  dB roll off point of a device under test, however, it did not address the issue of how accurate each frequency point was in terms of absolute response. The absolute frequency response accuracy addresses the absolute error that is present in a responsivity measurement at any particular modulation frequency.

### ***Specification Conditions***

- Factory default laser power settings
- Factory default modulation power settings
- Setting of 512 averages on the 85107B
- Response and isolation calibration
- Greater than 20 dB signal to noise ratio required for these specifications to be valid.
- Specifications are valid only for Step mode operation.

**Table 7-15. O/E Absolute Frequency Response Accuracy for the Electrical Port Reflection Coefficient < 0.25**

<b>Frequency Range (GHz)</b>	<b>Relative Frequency Response (dBe)</b>	<b>Relative Frequency Response (dBe)<sup>a</sup></b>
0.045 - 0.1	±2.8	±2.7
0.1 - 2	± 1.3	± 1.2
2 - 20	± 1.5	± 1.2
20 - 40	± 1.8	± 1.4
40 - 50	± 2.3	± 1.7

<sup>a</sup> With a 6 dB attenuator connected to the electrical receiving port of the 8517B test set. [Refer to "O/E measurement with 6 dB attenuator" on page 2-32.](#)

**Table 7-16. O/E Absolute Frequency Response Accuracy for the Electrical Port Reflection Coefficient < 0.5**

<b>Frequency Range (GHz)</b>	<b>Relative Frequency Response (dBe)</b>	<b>Relative Frequency Response (dBe)<sup>a</sup></b>
0.045 - 0.1	±2.9	±2.7
0.1 - 2	± 1.4	± 1.2
2 - 20	± 1.9	± 1.3
20 - 40	± 2.2	± 1.5
40 - 50	± 2.8	± 1.8

<sup>a</sup> With a 6 dB attenuator connected to the electrical receiving port of the 8517B test set. Refer to “O/E measurement with 6 dB attenuator” on page 2-32.

**Table 7-17. O/E Absolute Frequency Response Accuracy for the Electrical Port Reflection Coefficient < 1.0**

<b>Frequency Range (GHz)</b>	<b>Relative Frequency Response (dBe)</b>	<b>Relative Frequency Response (dBe)<sup>a</sup></b>
0.045 - 0.1	±3.2	±2.8
0.1 - 2	± 1.7	± 1.3
2 - 20	± 2.5	± 1.5
20 - 40	± 2.9	± 1.7
40 - 50	± 3.7	± 2.1

<sup>a</sup> With a 6 dB attenuator connected to the electrical receiving port of the 8517B test set. Refer to “O/E measurement with 6 dB attenuator” on page 2-32.

***Absolute Relative Frequency Response with Response and Match User Calibration***

***Specification Conditions***

- Factory default laser power settings
- Factory default modulation power settings
- Setting of 512 averages on the 85107B
- Any electrical port reflection coefficient
- Greater than 20 dBc signal to noise ratio required for these specifications to be valid.
- Specifications are valid only for Step mode operation.

**Table 7-18. O/E Absolute Frequency Response Accuracy for the Electrical Port Reflection Coefficient < 1.0 with Response and Match User Calibration**

<b>Frequency Range (GHz)</b>	<b>Relative Frequency Response (dBc)</b>
0.045 - 0.1	±2.7
0.1 - 10	± 1.2
0.1 - 20	± 1.2
0.1 - 30	± 1.4
0.1 - 40	± 1.7



---

## Electrical to Optical (E/O) Characteristics

### ***E/O Absolute Frequency Response***

The relative frequency response specifications gave information that is helpful in determining parameters such as the  $-3$  dB roll off point of a device under test, however, it did not address the issue of how accurate each frequency point was in terms of absolute response. The absolute frequency response accuracy addresses the absolute error that is present in a responsivity measurement at any particular modulation frequency.

### ***Specification Characteristics***

- Factory default laser power settings
- Factory default modulation power settings
- Setting of 512 averages on the 85107B
- Response and isolation calibration
- 50 ohm termination on unused 8517B port
- Greater than 20 dBc signal to noise ratio required for these specifications to be valid.
- Specifications are valid only for Step mode operation.

**Table 7-19. E/O Absolute Frequency Response for the Electrical Port Reflection Coefficient  $< 0.25$**

<b>Frequency Range (GHz)</b>	<b>Relative Frequency Response (dBc)</b>
0.045 - 0.1	$\pm 2.6$
0.1 - 2	$\pm 1.1$
2 - 20	$\pm 1.4$
20 - 40	$\pm 1.5$
40 - 50	$\pm 1.9$

Specifications and Regulatory Information  
**Electrical to Optical (E/O) Characteristics**

**Table 7-20. E/O Absolute Frequency Response for the Electrical Port Reflection Coefficient < 0.5**

<b>Frequency Range (GHz)</b>	<b>Relative Frequency Response (dBe)</b>
0.045 - 0.1	±2.8
0.1 - 2	± 1.3
2 - 20	± 1.8
20 - 40	± 2.0
40 - 50	± 2.6

**Table 7-21. E/O Absolute Frequency Response for the Electrical Port Reflection Coefficient < 1.0**

<b>Frequency Range (GHz)</b>	<b>Relative Frequency Response (dBe)</b>
0.045 - 0.1	±3.3
0.1 - 2	± 1.8
2 - 20	± 2.6
20 - 40	± 3.0
40 - 50	± 3.9

---

## Test Set Monitoring Power Accuracy

The following characteristics relate to the accuracy of the test set monitoring capabilities. The test set monitoring functions are found under the Tools menu. Open the Modify Test Set dialog box to view the Current Laser Output Power, and Monitor Test Set dialog box to view the Optical Output Power and Optical Receiver Input Power.

**Table 7-22. Test Set Monitoring Power Accuracy**

<b>Test Set Power Settings</b>	<b>Characteristics</b>	<b>Power Range</b>
Current Laser Output Power	$\pm 0.5$ dB	0 dBm to 10 dBm
Optical Output Power	$\pm 0.5$ dB	- 10 dBm to 5 dBm
Optical Receiver Input Power	$\pm 0.5$ dB	- 10 dBm to 5 dBm

---


## Regulatory Information

- This product is classified as Class I according to 21 CFR 1040.10 and Class I according to IEC 60825-1.
- This product complies with 21 CFR 1040.10 and 21 CFR 1040.11.
- This is to declare that this system is in conformance with the German Regulation on Noise Declaration for Machines (Laermangabe nach der Maschinenlaermverordnung -3.GSGV Deutschland).

### **Notice for Germany: Noise Declaration**

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

## Declaration of Conformity

<b>DECLARATION OF CONFORMITY</b>	
According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014	
<b>Manufacturer's Name:</b>	Agilent Technologies, Inc.
<b>Manufacturer's Address:</b>	1400 Fountaingrove Parkway Santa Rosa, CA 95403-1799 USA
<b>Declares that the product:</b>	
<b>Product Name:</b>	Lightwave Component Analyzer System
<b>Model Number:</b>	86030A
<b>Product Options:</b>	This declaration covers all options of the above product.
<b>Is in conformity with:</b>	
	Safety: IEC 61010-1:1990 +A1:1992+A2:1995 / EN 61010-1:1994+A2:1995 CAN/CSA-C22.2 No. 1010.1-92 IEC 60825-1:1998 21CFR 1040.10 & 1040.11
	EMC: CISPR 11:1990/EN 55011:1991 Group 1, Class A IEC 61000-4-2:1995+A1:1998 / EN 61000-4-2:1995, 4 kV CD, 8 kV AD IEC 61000-4-3:1995 / EN 61000-4-3:1995, 3 V/m, 80-1000 MHz IEC 61000-4-4:1995 / EN 61000-4-4:1995, 0.5 kV sig. lines, 1 kV pow. lines IEC 61000-4-5:1995 / EN 61000-4-5:1995, 0.5 kV I-I, 1 kV I-e IEC 61000-4-6:1996 / EN 61000-4-6:1996, 3V 80% AM, power line IEC 61000-4-11:1994 / EN 61000-4-11:1994, 100 %, 20 ms
<b>Supplementary Information:</b>	
	The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE-marking accordingly.
	
Santa Rosa, CA, USA	25 Apr. 2000
	Greg Pfeiffer/Quality Engineering Manager
For further information, please contact your local Agilent Technologies sales office, agent or	

**Declaration of Conformity**

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