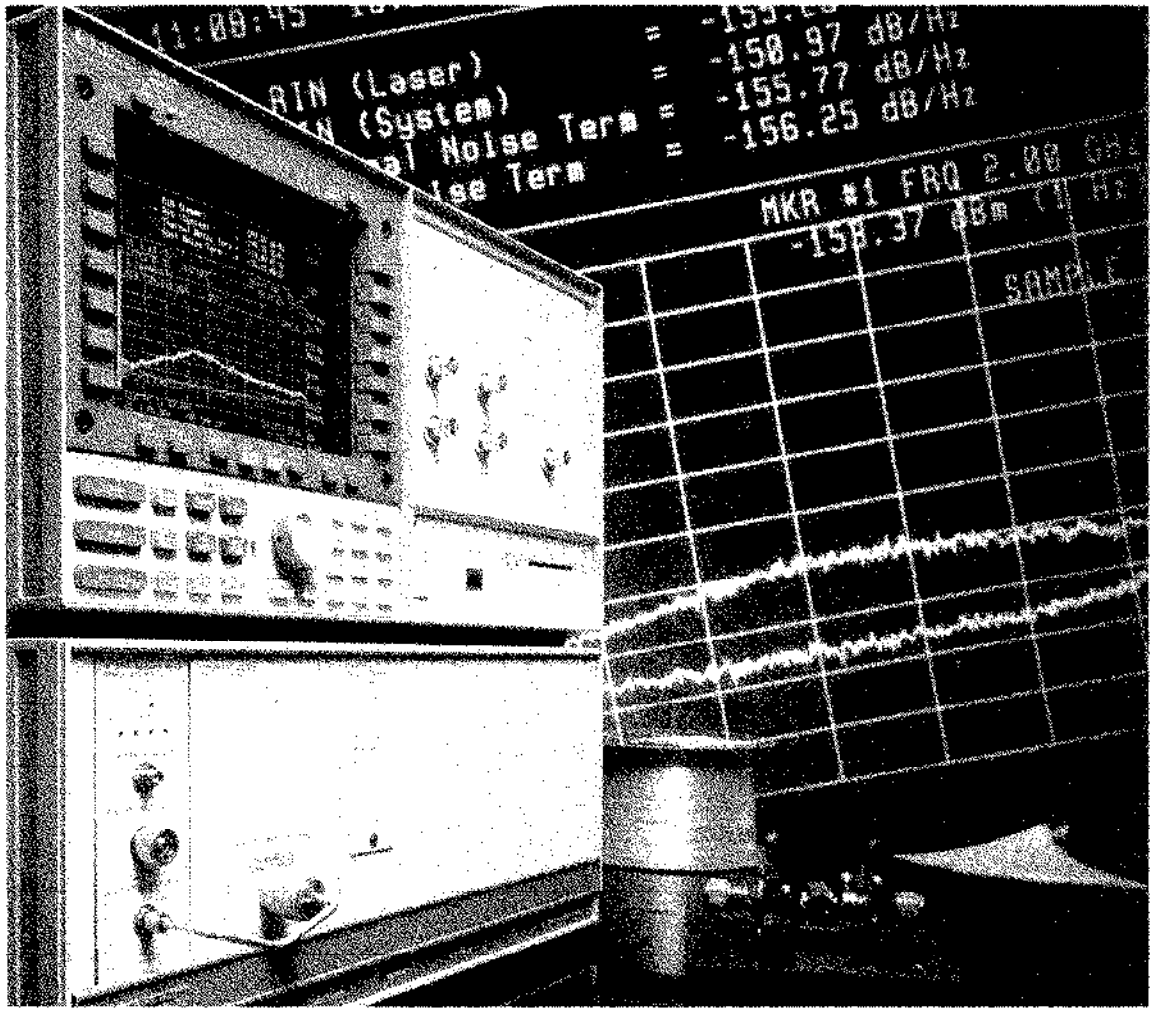
HEWLETT PACKARD

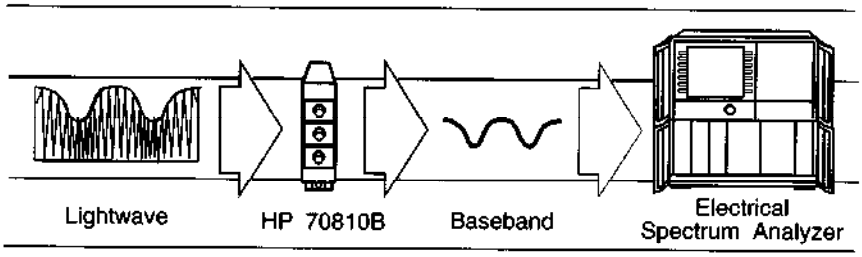
HP 71400C and 71401C Lightwave Signal Analyzers

Technical Data

Calibrated measurements of high-speed modulation, RIN, and laser linewidth



High-Speed Lightwave Analysis

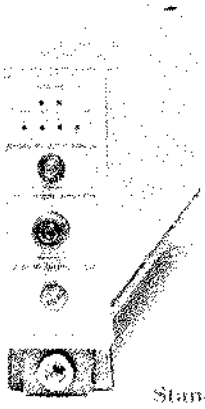


The HP 71400C and 71401C lightwave signal analyzers combine HP's highest-performance RF spectrum analyzers with a sensitive, wide-bandwidth optical-receiver for analyzing lightwave communications systems and components.

Featuring bandwidths from 100 kHz to 22 GHz and wavelength operation from 1200 to 1600 nm, the HP 71400C easily and accurately makes measurements of relative intensity noise (RIN), linewidth, and modulation performance on single-mode optical fiber.

The HP 71401C has an upper frequency limit of 2.9 GHz with the same features and functions as the HP 71400C.

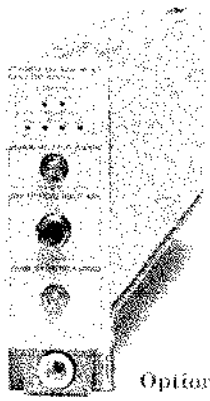
The HP 71400C can achieve a displayed average noise level low enough (-65 dBm optical) to observe and measure intensity noise and RIN produced by semiconductor lasers. Coupled with a built-in attenuator that enables lasers with up to 1 watt of power to be tested, the lightwave signal analyzer provides you with outstanding measurement range.


Standard

The HP 70810B module provides the solution
The key to HP's lightwave signal analyzers is the HP 70810B lightwave module. Consisting of an optical attenuator, broadband photodetector, microwave preamplifier, and optical power meter, the HP 70810B compensates for photodetector responsivity and preamplifier gain variations. Frequency-response corrections and mismatch losses are no longer a worry.

The HP 70810B module has a new optical path with reduced internal reflections and an improved total return loss of 35 dB or better.

The HP 70810B can also be used in stand-alone configurations to provide general-purpose wideband optical to electrical conversion. Insert multiple modules into a single mainframe for parallel conversion.

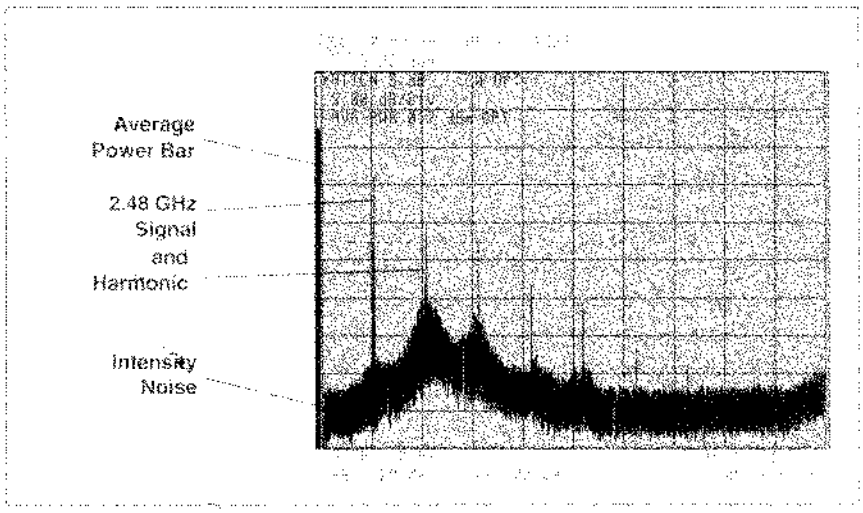

Option 850

850 nm option
Option 850 is a separate module for high-speed analysis on GaAs lasers or other devices in the range from 750 to 870 nm. The analyzer can accommodate both modules to cover all three communication windows.

Power meter adds flexibility
Both analyzers include a built-in power meter. An analog bar gives easy visual indication of power level and carrier-to-noise information. A digital power readout gives you precision power-level monitoring in either optical or electrical units. You may also choose either linear or logarithmic terms. This power meter is especially useful in tests for RIN, relative-modulation, and modulation depth. Now you can adjust your systems for optimum alignment, bias, power level, and modulation characteristics with one connection.

Flexible and easy to use
The HP 71400C and 71401C are easy to operate. A custom key pad provides single key operation for the most often used functions. Logical menus offer quick access to rich function and marker capabilities. You have complete control over all functions. Use the default settings or over ride them. For example, you can display the amplitude information in log or linear format with either optical or equivalent electrical units.

Versatile Measurement Capability



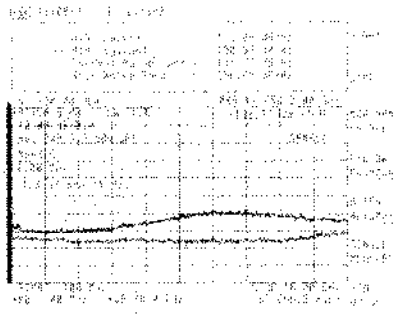
Modulation and signal distortion measurements
With the lightwave signal analyzer you can see the laser's intensity noise, relaxation oscillation peak, baseband intensity modulation, and signal harmonics out to 22 GHz. Monitor analog transmissions and find difficult digital system problems using frequency domain signal analysis. While measuring the signal, monitor the laser's average power. Or, utilize the analyzer's calibrated receiver as a standard to test and evaluate your photodetectors with the electrical input port.

RIN and laser intensity-noise characterization
The HP 71400C and 71401C feature two relative intensity noise (RIN) measurements. A RIN marker reads out the total system RIN, which includes the receiver's shot noise, the thermal noise, and the laser's intensity noise at a marker location. This noise measurement samples, averages, and corrects for analyzer bandwidth and filter shapes. The RIN marker is the fastest measure of RIN and can make measurements to -150 dBc/Hz on a 1 mW laser.

Often over looked, when comparing RIN values, is the dynamic nature of laser noise. RIN can change dramatically with different reflection conditions or when the laser is modulated. It is not enough to know the static RIN value with best-case reflection conditions or to rely on data-sheet RIN specifications to predict the effects of laser noise within an operating system.

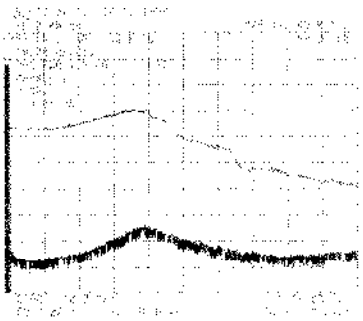
The HP 71400C, with its real-time wide-frequency display, is ideal for helping you observe the interaction of RIN and modulation, determine any problems, and verify their solutions.

Advanced RIN program
To measure lasers with RIN values down to -165 dBc/Hz, an advanced measurement program is provided. This program removes the photodiode's shot noise and the analyzer's thermal noise contributions. The program can provide laser RIN measurement values as much as 16 dB below the thermal and shot noise contributions.



Modulation frequency response
The shape and amplitude of a laser's intensity-noise spectrum provide useful information. The laser's relaxation resonance appears as a peaking in the intensity noise floor of the laser. The maximum modulation rate of the laser is directly related to the location of this resonance peak which is related to the bias-current level. More current will widen the resonance and shift its position higher in frequency.

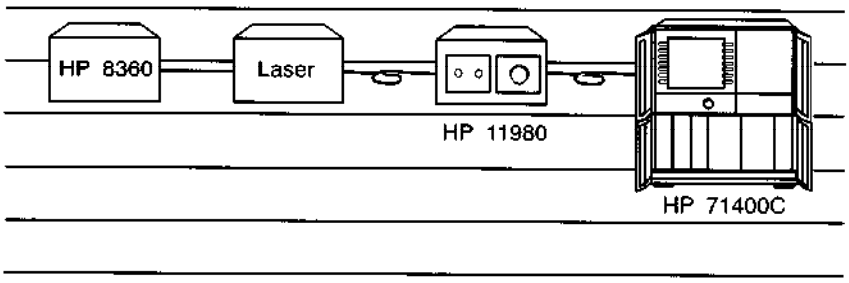
Adding the optional HP 70300A and 70301A tracking generator modules allows you to simultaneously display the laser's frequency response and relaxation oscillation. This display, with both frequency response and noise, will show you if the laser is achieving its full potential or, if there are electrical problems causing response degradations.



Add Linewidth and Chirp Measurements

Accessories extend versatility

Add the HP 11980A fiber optic Mach-Zehnder interferometer and the HP 70880A automatic linewidth personality to a lightwave signal analyzer to fully automate linewidth measurements. Add a modulation source, that can be gated on and off, and you can fully characterize your laser for chirp and frequency modulation (FM).

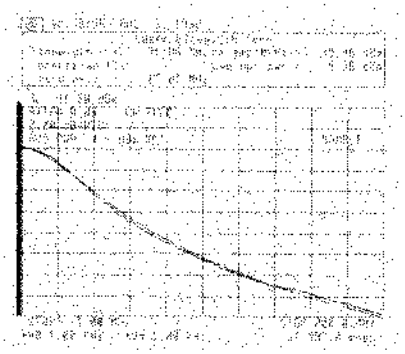


Linewidth

Linewidth is the measure of phase noise present on the laser's output. The HP 11980A uses the self-homodyne technique to translate the spectral line from the terahertz region to 0 Hz.

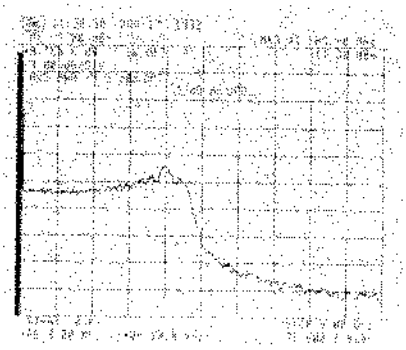
The HP 70880A personality is an advanced measurement program that automatically measures the linewidth of distributed feedback (DFB) lasers, and determines the fit and possible deviation of the laser from the ideal lorentzian lineshape. This linewidth personality makes linewidth measurements automatically from the instrument or remotely across the HP-IP bus. Automatic instrument setup is also provided allowing true hands-off operation.

With this program, every data point is used to determine the linewidth. Specific values, such as the peak or -3 dB points need not be present to determine accurate linewidths. By analyzing and averaging all data points, noise on any single value will not adversely affect the total linewidth evaluation or accuracy.



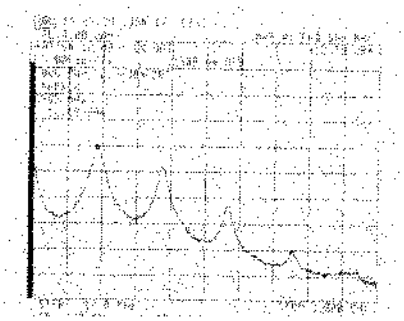
Chirp

Modulating a laser's injection current causes the laser to chirp, or change frequency (FM). This incidental FM, or chirp, can be an unwanted by-product, causing chromatic dispersion on the transmission line or, it can be a desired feature for lightwave systems, allowing frequency shift keying (FSK) or other FM techniques to be employed.



Sinewave, squarewave, and PRBS modulation each cause different chirp levels. But, large amounts of amplitude modulation from any source will cause large FM deviations.

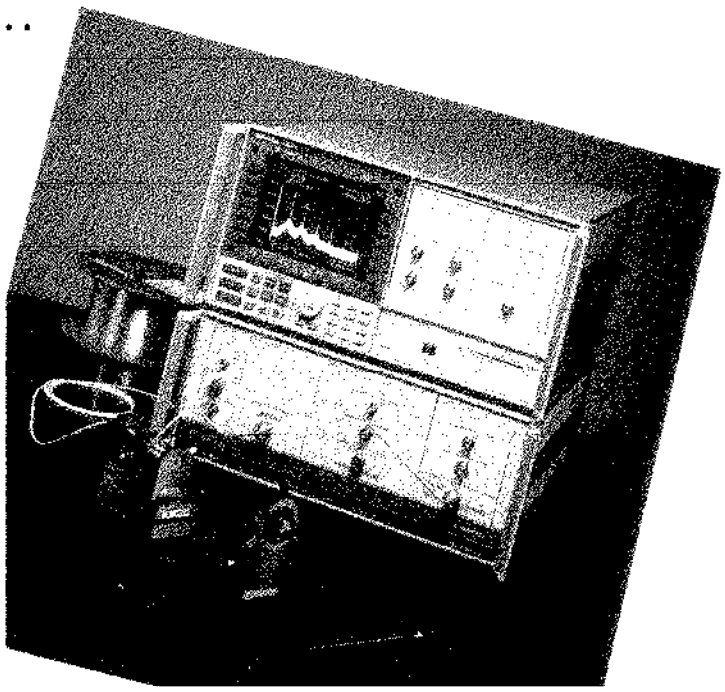
Low levels of modulation allow the individual FM sidebands to become visible. The width of these sidebands is determined by the phase noise or linewidth of the laser.



By using these FM sidebands (changing the modulating amplitude to null a sideband) and knowing the modulation frequency, you can determine the alpha factor (ratio of FM to IM) and other FM characteristics of the laser.

Configure the System for Your Needs. . . .

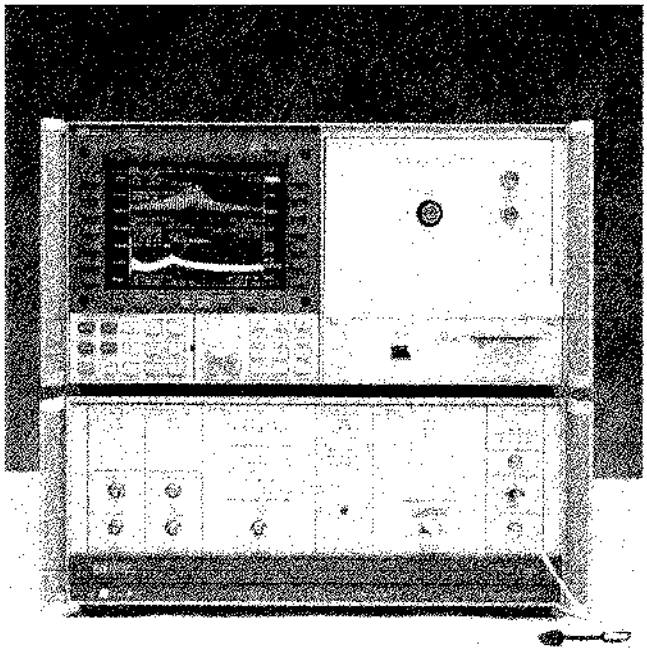
. . . .R & D, Manufacturing, and More.



The HP 71400C and 71401C are part of the modular measurement system (MMS). Because it is modular, it is easy to add additional capability to your lightwave signal analyzer.

Add optical spectrum analysis
One of the most popular additions is the HP 70951A module. Adding this module will provide the full capabilities of the Hewlett-Packard's Optical Spectrum Analyzer. When installed, you can monitor both the spectral and modulation characteristics of the laser. Or, simultaneously measure the linewidth and sidemode suppression ratio of a DFB laser.

Adding this OSA module, you can switch between a dedicated OSA and Lightwave Signal Analyzer with a touch of a button (or remotely over the bus). Identical menus and remote programming commands, for both instruments, enhance your productivity.



Tracking generators provide frequency response
Two tracking generators can be added to the system to add scaler network-analysis capabilities. The HP 70300A operates from 100 Hz to 2.9 GHz and the HP 70301A covers 2.7 GHz to 18 GHz. Use them separately, or combine them to make frequency response measurements of laser transmitters and receivers.

Extended calibration
The HP 71400C and 71401C come standard with extended calibration that provides additional flatness corrections for the analyzer. Option 20 adds this extended calibration to the HP 70810B module bought separately for use in an existing HP 71210 or HP 71100 system.

Specifications

For general and electrical specifications on the systems not given here, refer to data sheets of the HP 71210C (for the HP 71400C) or the HP 71100C (for the HP 71401C). ***Specifications*** describe the instrument's warranted performance over the 0°C-55°C temperature range, except where noted. All specifications apply after the instrument's temperature has stabilized (typically 30 min. from turn-on), and after all self-calibration routines have been run. *Characteristics* provide information about non-warranted instrument performance in the form of ***nominal values***. All amplitude specifications are in optical dB unless noted by an asterisk (*).

HP 71400C and HP 71401C Specifications

	HP 71400C		HP 71401C	
Wavelength Range (Characteristic)	**Standard** 1,200 nm to 1,600 nm **Option 850** 750 nm to 870 nm		**Standard** 1,200 nm to 1,600 nm **Option 850** 750 nm to 870 nm	
Frequency Range	100 kHz to 22 GHz		100 kHz to 2.9 GHz	
Average Power Accuracy At 1,300 and 1,550 nm, or 830 nm for opt. 850	**Factory calibrated:** ± 0.65 dB ± 0.5 nW ± Connnector variation[1] **User Calibrated:** ± 0.05 dB ± 0.5 nW ± power meter accuracy[2] (By external power meter)			
Modulated Power **Amplitude Accuracy** at 100 MHz	**20°C-30°C** ± 1.0 dB **0°C-55°C** ± 1.8 dB		**20°C-30°C** ± 1.0 dB **0°C-55°C** ± 1.8 dB	
Frequency Response[3] Relative to 100 MHz				
100 kHz-2.9 GHz:	**20°C-30°C** ± 1.0 dB **0°C-55°C** ± 1.3 dB		**20°C-30°C** ± 1.0 dB **0°C-55°C** ± 1.3 dB	
2.9 GHz-22 GHz:	**20°C-30°C** ± 1.0 dB **0°C-55°C** ± 3.0 dB			
RF Input Frequency Response[3]				
100 kHz-2.9 GHz	± 2.3 dB*		± 1.8 dB*	
2.9 GHz-22 GHz	± 2.8 dB*			
Displayed Average Optical Noise Level	*Frequency*	*Displayed Noise Level*	*Frequency*	*Displayed Noise Level*
		Std. **Opt. 850**		**Std.** **Opt. 850**
10 Hz Res BW, 3 Hz Vid BW, Ref Level ≤-40 dBm	100 kHz-1 MHz	-51 dBm -47 dBm	100 kHz-1 MHz	-51 dBm -47 dBm
	1 MHz-10 MHz	-57 dBm -53 dBm	1 MHz-10 MHz	-57 dBm -53 dBm
	10 MHz-100 MHz	-62 dBm -58 dBm	10 MHz-100 MHz	-62 dBm -58 dBm
	100 MHz-16 GHz	-66 dBm -62 dBm	100 MHz-2.9 GHz	-66 dBm -62 dBm
	16 GHz-22 GHz	-60 dBm -56 dBm		
Harmonic Distortion with modulated input power				
<-20 dB	≤-50 dBc*		≤-50 dBc*	
<-30 dB	≤-70 dBc*		≤-70 dBc*	
Input Return Loss with HMS10/HP				
Total	≥ 35 dB		≥ 35 dB	
Internal	≥ 40 dB		≥ 40 dB	
Maximum Safe Input Power	+15 dBm		+15 dBm	
Input Connectors[6] Single mode fiber	Diamond HMS10/HP, FC/PC, ST, Biconic, DIN, SC, D4			

Specifications

HP 70810B lightwave section This module is for use in the HP 71400C and 71401C lightwave signal analyzers or with the HP 71210C, 71201C, or 71100C spectrum analyzers. It can also be used in stand-alone applications as a lightwave converter housed in an HP 70001A mainframe. ***Specifications*** describe the instrument's warranted performance over the 0°C-55°C temperature range, except where noted. ***Characteristics*** provide information about non-warranted instrument performance in the form of ***nominal values***. All amplitude specifications are in optical dB unless noted by an asterisk(*).

HP 70810B

Wavelength Range (Characteristic)

Standard	1,200 nm to 1,600 nm
Option 850	750 nm to 870 nm

Frequency Range 100 kHz to 22 GHz

Average Power Accuracy
At 1,300 and 1,550 nm, or 830 nm for opt.850

Factory Calibrated
± 0.65 dB ± 0.5 nW
± Connector variation[1]
User Calibrated (By extrnl pwr mtr)
± 0.05 dB ±0.5 nW
± Pwr mtr accuracy[2]

Responsivity (Characteristic)
Nominal Value at 100 MHz:

The responsivity is given for each instrument and is accurate to ± 20%.

Std.	**Opt.850**
1200 V/W	500V/W

Noise Equivalent Power (dBm/$\sqrt{\text{Hz}}$)

Frequency	*Noise Equivalent Power*	
	Std.	**Opt. 850**
100 kHz-10 MHz	-55	-51
10 MHz-100 MHz	-66	-62
100 MHz-16 GHz	-70	-66
16 GHz-22 GHz	-64	-60

Frequency Response
Relative to 100 MHz

Frequency	**Corrected[4]**
100 kHz-2.9 GHz	± 2.0 dB*
2.9 GHz-22 GHz	± 5.0 dB*

(Uncorrected response is <25 dB*, 100 kHz -22 GHz)[5]

Maximum Safe Input Power with 30 dB atten.

Average Power	**Modulated Power**
+15 dBm	+15 dBm

Harmonic Distortion 43 dB* below fundamental
Output ≤ -10 dBm*

Input Return Loss with HMS10/HP

Total	> 35 dB
Internal	> 40 dB

HP 70810B cont.

Electrical Input Flatness[4] Corrected (Characteristic)

Frequency	**Amplitude Error**
100 kHz-6 GHz	± 1.4 dB*
6 GHz-12 GHz	± 1.6 dB*
12 GHz-16 GHz	± 2.0 dB*
16 GHz-22 GHz	± 2.2 dB*

Electrical Output Return Loss (Characteristic)

Frequency	**Return Loss**
100 kHz-6 GHz	12.0 dB*
6 GHz-12 GHz	10.5 dB*
12 GHz-16 GHz	8.5 dB*
16 GHz-22 GHz	7.5 dB*

Bypass Mode Insertion Loss

Frequency	**Insertion Loss**
100 kHz-6 GHz	2.5 dB*
6 GHz-12 GHz	3.7 dB*
12 GHz-16 GHz	4.9 dB*
16 GHz-22 GHz	5.2 dB*

Input Connectors[6] **Single Mode Fiber Connectors**
Diamond HMS10/HP, FC/PC, ST, Biconic, DIN, SC, D4

The HP 11980A is a Mach-Zehnder fiber-optic interferometer. It is for use with the HP 71400C lightwave signal analyzer to measure linewidth, FM, and chirp of single-frequency lasers.

HP 11980A

Optical Insertion Loss
1,300 nm: 8 dB[1]
1,550 nm: 8 dB[1]

Wavelength Range (Characteristic) 1,250 nm to 1,600 nm

Delay Time (Characteristic)

Standard	3.5 µsec
Option 005	2.5 µsec

Optical Connectors[6] **Single-mode fiber connectors**
Diamond HMS10/HP, FC/PC, ST, Biconic, DIN, SC, D4

[1]Connector reflections and losses vary with such factors as connector type and quality, connector cleanliness, temperature, damage, and wear.
[2]Applies to any wavelength when the average power readout is set to match an external calibrated optical power meter. Does not include VSWR losses.
[3]Specifications assume extended system calibration (Option 020) is applied. If not, use module specifications for frequency response.
[4]Specifications achieved by applying module responsivity and/or frequency correction factors stored in the HP 70810 memory.
[5]Characteristic.
[6]Specified with Diamond HMS10/HP connector.
*Amplitude measurement in electrical dB.

Ordering Information

HP 71400C Lightwave Signal Analyzer
100 KHz-22 GHz
The system includes the HP 71210C and HP 70810B module.
Must order one of the connector options, 11 through 15, listed below.
Option 001 Add the HP 11980A Fiber Optic Interometer
Option 850 Operation for 750 to 870 nm inputs
Option 121 Adds Distribution Amplifier
Option 512 Additional memory for trace and program storage.

HP 71401C Lightwave Signal Analyzer
100 KHz-2.9 GHz
The system includes the HP 71100C opt 02, 04 and HP 70810B module.
Must order one of the connector options 11-15 listed below.
Option 850 Operation for 750 to 870 nm inputs
Option 512 Additional memory for trace and program storage.

HP 70810B Lightwave Section 100 KHz-22 GHz
Must order one of the connector options 11-15 listed below.
Option 20 System adjustment and calibration
Option 850 Operation for 750 to 870 nm inputs
Option 98 or 99 System LO Firmware Upgrade
(Required if current system date code is earlier than 10-21-91, contact Sales Rep)

HP 11980A Fiber Optic Optic Interferometer
Must order one of the connector options 11-15 listed below.
Option 005 An extra 5 km of fiber for a total delay of 25 µsec.

Connector Options for the HP 71400C, HP 71401C, HP 70810B, and HP 11980A
Option 011 Diamond HMS-10/HP Connector Interface
Option 012 FC/PC Connector Interface
Option 013 DIN 47256 Connector Interface
Option 014 ST Connector Interface
Option 015 Biconic Connector Interface
(Other connector adapters available, contact HP sales rep.)

Recommended Accessories
Additonal interface connectors:
HP 81000AI Diamond HMS-10/HP
HP 81000FI FC/PC
HP 81000SI DIN 47256
HP 81000VI ST
HP 81000WI Biconic
HP 81000GI D4
HP 81000UI SC

HP 70950A Optical Spectrum Analyzer
HP 70300A 100 Hz to 2.9 GHz RF Tracking Generator
HP 70301A 2.7 GHz to 18 GHz µ W Tracking Generator

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For more information, call your local HP sales office listed in your telephone directory or an HP regional office listed below for the location of your nearest sales office.

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5201 Tollview Drive
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