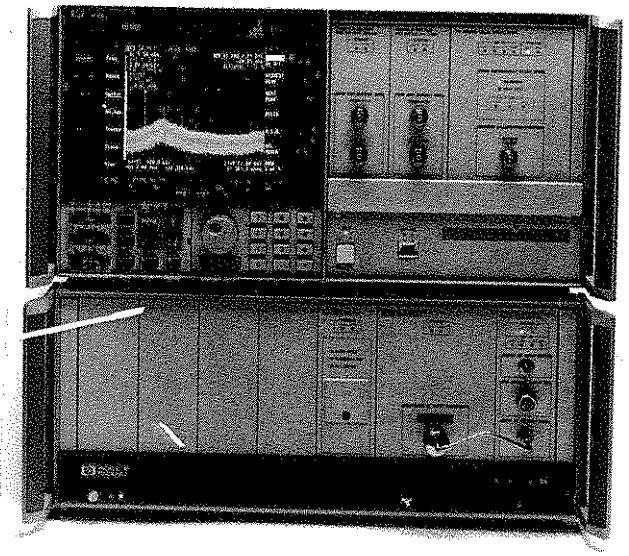
- Calibrated measurements of intensity modulation
- 22 GHz bandwidths
- RIN measurements
- Interferometer for laser linewidth and chirp measurements



The Agilent 71400C system is a part of the flexible MMS system

Calibrated Measurements of High-Speed Modulation, Laser Linewidth, and Chirp

The Agilent 71400C and 71401C lightwave signal analyzers combine Agilent Technologies' high-performance microwave and RF spectrum analyzers with a sensitive, wide-bandwidth optical-receiver module, producing calibrated instrumentation for characterizing semi-conductor lasers, laser transmitters, optical modulators, and detectors.

Featuring bandwidths from 100 kHz to 22 GHz and wavelength operation from 1200 to 1600 nm, the Agilent 71400C easily and accurately makes measurements of relative intensity noise (RIN), linewidth, and modulation performance on a single-mode optical fiber. The Agilent 71401C has an upper frequency limit of 2.9 GHz with the same features and functions as the Agilent 71400C.

The key to Agilent Technologies' lightwave signal analyzers is the Agilent 70810B lightwave module. As shown in the block diagram in Figure 1, it consists of an optical attenuator, broadband photodetector, microwave preamplifier, and optical power meter. The Agilent 70810B compensates for photodetector responsivity and preamplifier gain variations. Frequency-response and mismatch losses are corrected.

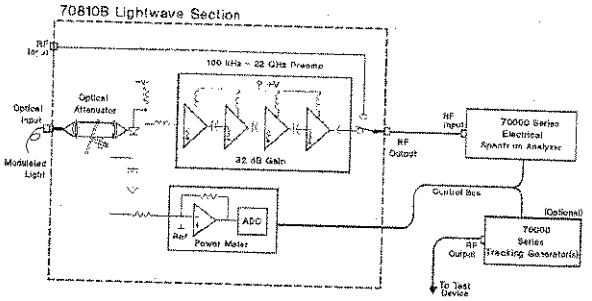


Figure 1. Block diagram of an Agilent 71400 system showing detail of an Agilent 70810 module

The Agilent 71400C incorporates the fundamentally mixed Agilent 71210C microwave analyzer and can achieve a displayed average noise level better than -65 dBm (optical) in a 10 Hz bandwidth. This is low enough to observe and measure the intensity noise and RIN levels of most semiconductor lasers. The built-in attenuator enables you to test lasers with up to 1 watt of power, providing you with outstanding measurement dynamic range.

Versatile Measurement Capability

Modulation and Signal Distortion Measurements

The Agilent 71400C and 71401C display baseband intensity modulation, harmonics, and laser noise floor. You can see the laser's intensity noise, relaxation oscillation peak, baseband intensity modulation, and signal harmonics out to 22 GHz. Monitor your analog transmissions and find difficult digital system problems with the time-proven power of frequency-domain signal analysis. At the same time, monitor the laser's average power with the vertical power bar. Or you can utilize the analyzer's calibrated receiver as a standard to test your photodetectors, with the electrical input port. Refer to Figure 2.

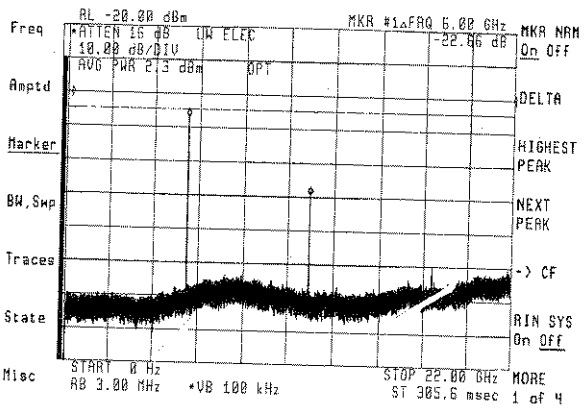


Figure 2. Harmonic distortion on an analog modulated laser

RIN and Laser Intensity-Noise Characterization

The Agilent 71400C and 71401C feature two relative intensity noise (RIN) measurement capabilities: total RIN and laser RIN. The total RIN capability reads out the total system RIN at a frequency. This measurement includes the receiver shot noise, the thermal noise, and the laser's intensity noise at a marker location. The total RIN measurement can be performed quickly and can measure RIN values to –150 dBc/Hz on a 1 mW laser.

The laser RIN measurement is an advanced measurement routine that removes the photodiode's shot noise and the analyzer's thermal noise contributions from the total noise. This provides laser RIN measurement values as much as 16 dB below the thermal-noise and shot-noise contributions, and values up to –165 dBc/Hz can be measured, as shown in Figure 3.

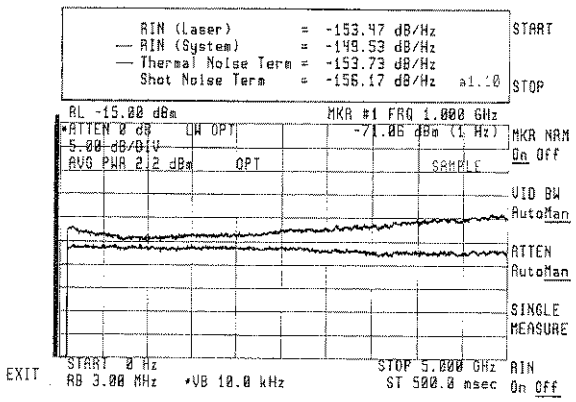


Figure 3. RIN measurement personality

Modulation Frequency Response

The shape and amplitude of a laser's intensity-noise spectrum provides 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 Agilent 70300A and 70301A tracking generator modules allows you to simultaneously display the laser's frequency response and relaxation oscillation, or intensity noise resonance, for any laser-bias level. This display will show you if the laser is achieving its full frequency response potential or if there are electrical problems causing response degradations.

Add Linewidth and Chirp Measurements

Linewidth

Add the Agilent 11980A fiber-optic Mach-Zehnder interferometer and the Agilent 70880A automatic linewidth personality to a lightwave signal analyzer to measure linewidth. The Agilent 11980A uses the self-homodyne technique to translate the spectral line from the terahertz region to 0 Hz. The Agilent 70880A automatic linewidth personality is an advanced measurement program that measures the linewidth of distributed feedback (DFB) lasers and determines the fit and deviation of the laser from the ideal Lorentzian lineshape. This linewidth personality makes linewidth measurements automatically from the instrument keys and remotely across the GPIB bus.

Chirp

With the Agilent 11980A, and a modulation source that can be gated on and off, you can measure chirp and frequency modulation (FM) characteristics of single-line lasers. 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 FSK (frequency shift keying) or other FM communications techniques to be used.

Sinewave, squarewave, and PRBS modulation will each cause different amounts of chirp. But large amounts of amplitude modulation from any source will cause large FM deviations. The Agilent 71400C can measure FM deviations up to 44 GHz.

Extended Calibration

The Agilent 71400C and 71401C come standard with extended calibration that provides additional flatness corrections for the analyzer. Option 020 adds this extended calibration to the Agilent 70810B module, bought separately for use in an existing Agilent 71210C or Agilent 71100C system.

Specifications

Specifications describe the instrument's warranted performance over the 0° to 55°C temperature range, except where noted. All specifications apply after the instrument temperature has stabilized and after self-calibration routines have been run. All amplitude specifications are in optical dB, except where noted. *Supplementary performance characteristics provide information about non-warranted instrument performance in the form of nominal values, and are printed in italic typeface.*

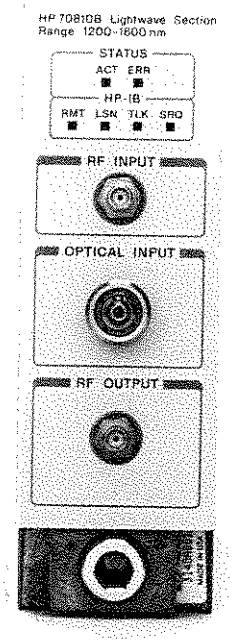
	71400C	71401C
Wavelength Range	*1200 to 1600 nm*	*1200 to 1600 nm*
Frequency Range	100 kHz to 22 GHz	100 kHz to 2.9 GHz
Modulated Power		
Amplitude Accuracy at 100 MHz	20° to 30°C, ±1.0 dB 0° to 55°C, ±1.8 dB	20° to 30°C, ±1.0 dB 0° to 55°C, ±1.8 dB
Frequency Response relative to 100 MHz		
100 kHz to 2.9 GHz	20° to 30°C, ±1.0 dB 0° to 55°C, ±1.3 dB	20° to 30°C, ±1.0 dB 0° to 55°C, ±1.3 dB
2.9 to 22 GHz	20° to 30°C, ±1.0 dB 0° to 55°C, ±3.0 dB	
RF Input Frequency Response[a]		
100 kHz to 2.9 GHz	±2.3 dB (electrical)	±1.8 dB (electrical)
2.9 to 22 GHz	±2.8 dB (electrical)	
Displayed Average Optical Noise Level (10 Hz RBW, 3 Hz VBW)		
Reference Level ≤ - 40 dBm		
100 kHz to 1 MHz	- 51 dBm	- 51 dBm
1 MHz to 10 MHz	- 57 dBm	- 57 dBm
10 MHz to 100 MHz	- 62 dBm	- 62 dBm
100 MHz to 8 or 2.9 GHz	- 66 dBm	- 66 dBm
8 to 16 GHz	- 66 dBm	
16 to 22 GHz	- 60 dBm	
Input Return Loss (with HMS-10)		
Internal	< 40 dB	
Total	< 35 dB	
Maximum Input Power (with 30 dB attenuation)		
Average Power	+15 dBm	
Modulated Power	+15 dBm	
Harmonic Distortion (10 MHz to 22 or 2.9 GHz)	70 dB below fundamental with modulated power ≤- 30 dBm	
Average Power Accuracy (at 1300 and 1550 nm)	Factory-calibrated: ±0.65 dB ±5.0 nW ± connector variation[b] User-calibrated: ±0.05 dB ±5.0 nW ± power meter accuracy (by external power meter)[c]	
Input Connectors	Single-mode fiber connectors: Diamond HMS-10, FC/PC, ST, DIN, Biconic	

a. Assumes extended system calibration, Option 020. Otherwise, use module specifications for frequency response.
b. Connector reflections and losses vary with factors, such as connector type, quality, cleanliness, temperature, damage, and wear.
c. Applies to any wavelength with average power readout set to match external calibrated optical power meter. Does not include VSWR losses.

Refer to page 84 for Ordering Information for the Agilent 71400C and Agilent 71401C.

Agilent 70810B Lightwave Section

- Analog power meter display (with the Agilent 70004 display)
- Optical-to-electrical conversion with variable optical attenuation and amplified RF output



The Agilent 70810B lightwave section is a lightwave receiver module for the Agilent 70000 modular measurement system (MMS). Consisting of an optical attenuator, broadband photodetector, microwave preamplifier, and optical power meter, the module combines with an Agilent 70000-series spectrum analyzer to create an Agilent 71400-series lightwave signal analyzer.

The lightwave section has a wavelength range of 1200 to 1600 nm, a detected modulation bandwidth of 100 kHz to 22 GHz, and a built-in RF amplifier of 32 dB that provides optical sensitivity of –60 dBm in a 10 Hz bandwidth. The module also features both optical and electrical input capability.

As a slave module to the MMS local oscillator, the Agilent 70810B allows you to access the functions of the electrical spectrum analyzer in an Agilent 71400-series system.

Features

The Agilent 71400C and 71401C lightwave signal analyzers add a number of features to the Agilent 70810B lightwave section. These include downloadable programming capability, which allows the analyzer to perform simple or complex tasks and calculations without an external controller. Downloadable programs (DLPs) can be written or loaded into the analyzer.

Other features are a memory card reader, which allows traces, states, and DLPs to be read from or stored on ROM and RAM cards; an HP-HIL keyboard interface; screen titles; mass storage to an external disk; limit lines; panning; and operation with non-lightwave modules.

Measurement Enhancements

A DLP is provided with the Agilent 70810B lightwave section for measuring the RIN of lasers to –165 dB/Hz. The program subtracts receiver shot noise and thermal noise contributions from the total noise of the system.

The Agilent 70810B contributes several other enhancements to the lightwave signal analyzers. Measurement of relative power is now independent of the power-bar display. A linear graphic display has been added with an optical mode in power units or an electrical mode in power or voltage units. Trace information can be displayed in lightwave-electrical units, and optical power meter information can be displayed in lightwave-optical units.

A user-power function allows the lightwave signal analyzer to be referenced to another calibrated optical-power standard. The adjustment range of the user power function has been extended from ±2 dB to ±300 dB around the factory calibration point.

Specifications

The Agilent 70810B lightwave section is for use with the Agilent 71400C and 71401C lightwave signal analyzers or the Agilent 71210C or 71100C spectrum analyzers. It can be used as a standalone optical-to-electrical converter housed in an Agilent 70001A mainframe.

Specifications describe the instrument's warranted performance. *Supplementary performance characteristics provide information about non-warranted instrument performance in the form of nominal values, and are printed in italic typeface.*

	70810B
Wavelength Range	*1200 to 1600 nm*
Frequency Range	100 kHz to 22 GHz
Responsivity (given for each instrument and accurate to ±20%)	
Nominal value at 100 MHz	*1200 V/W*
Noise Equivalent Power (dBm / $\sqrt{Hz}$)	
100 kHz to 1 MHz	- 55
1 to 10 MHz	- 61
10 to 100 MHz	- 66
100 MHz to 8 GHz	- 70
8 to 16 GHz	- 68
16 to 22 GHz	- 64
Maximum Input Power (with 30 dB attenuation)	Average, +15 dBm Modulated, +15 dBm
Average Power Accuracy (at 1300 and 1550 nm)	Factory-calibrated: ±0.65 dB ±5.0 nW ± connector variation[a] User-calibrated (by external power meter): ±0.05 dB ±5.0 nW ± power meter accuracy[b]
Frequency Response (relative to 100 MHz)[c]	
Corrected	
100 kHz to 2.9 GHz	±2.0 dB (electrical)
2.9 to 22 GHz	±5.0 dB (electrical)
(characteristic uncorrected response is < 25 dB electrical, 100 kHz to 22 GHz)	
Harmonic Distortion (output ≤ - 10 dBm)	43 dB (electrical) below fundamental
Input Return Loss (with HMS-10)	
Internal	< 40 dB
Total	< 35 dB
Electrical Input Flatness, Corrected[c]	
	Amplitude Error
100 kHz to 6 GHz	*±1.4 dB (electrical)*
6 to 12 GHz	*±1.6 dB (electrical)*
12 to 16 GHz	*±2.0 dB (electrical)*
16 to 22 GHz	*±2.2 dB (electrical)*
Electrical Output Return Loss	
100 kHz to 6 GHz	*±12.0 dB (electrical)*
6 to 12 GHz	*±10.5 dB (electrical)*
12 to 16 GHz	*±8.5 dB (electrical)*
16 to 22 GHz	*±7.5 dB (electrical)*
Bypass Mode Insertion Loss	
100 kHz to 6 GHz	±2.5 dB (electrical)
6 to 12 GHz	±3.7 dB (electrical)
12 to 16 GHz	±4.9 dB (electrical)
16 to 22 GHz	±5.2 dB (electrical)
Input Connectors	Single-mode fiber connectors: Diamond HMS-10, FC/PC, ST, DIN, Biconic

a. Connector reflections and losses vary with factors such as connector type, quality, cleanliness, temperature, damage, and wear.
b. Applies to any wavelength with average power readout set to match external calibrated optical power meter. Does not include VSWR losses.
c. Specifications achieved by applying module responsivity or frequency correction factors stored in module memory. This is available with the Agilent 71201C or 71100C only.

Ordering Information

71400C	Lightwave Signal Analyzer, 100 kHz to 22 GHz
Option 001	Add Agilent 11980A Fiber-Optic Interferometer
71401C	Lightwave Signal Analyzer, 100 kHz to 2.9 GHz
70810B	Lightwave Section, 100 kHz to 22 GHz
Option 020	System Adjustment and Calibration

Connector Interface Options
For all models, choose one:

Option 011	Diamond HMS-10 Connector
Option 012	FC/PC Connector
Option 013	DIN 47256 Connector
Option 014	ST Connector
Option 015	Biconic Connector

Additional Interface Connectors
Compatible with Agilent 71400C, 71401C, and 70810B

81000AI	Diamond HMS-10
81000FI	FC/PC
81000SI	DIN 47256
81000VI	ST
81000WI	Biconic

Recommended Accessories

11980A	Fiber-Optic Interferometer
70880A	Linewidth Measurement Personality