HP 83440B/C/D
High-Speed Lightwave Converters

DC-6/20/32 GHz, 1000 to 1600 nm

Product Overview

Fast optical detector for characterizing lightwave signals

- Fast 15, 22, or 73 ps Full-Width Half-Max (FWHM) pulse response
- Broad 6, 20, or 30 GHz bandwidth (3 dB_{opt})
- Small, convenient package
- Low pulse aberrations
- Integral bias regulation
- Ideal for high-speed digitizing oscilloscopes

Make lightwave measurements with traditional electrical instruments; the Hewlett-Packard 83440 family offers a high-speed optical interface for oscilloscopes, spectrum analyzers, and network analyzers.

With as low as 15 ps FWHM pulse response, the HP 83440 accurately converts modulated optical waveforms to electrical signals, enabling electrical instruments to measure time domain pulse parameters and frequency domain spectral content. Characterize and optimize laser and optical modulator output performance for fiber optic telecommunications.

Description

The HP 83440 lightwave converters are fast, accurate, DC-coupled optical-to-electrical (O/E) converters packaged as small optical probes. They mount directly to electrical instrument front panels to simplify integration and minimize distortion and loss from cables, connectors, and signal conditioning components. A simple internal structure ensures very low signal distortion for improved output signal fidelity. By eliminating all unnecessary components along the signal path, the HP 83440 family offers very accurate electrical representations of modulated optical waveforms. The HP 83440 family features hermetically sealed, unamplified, InGaAs photodiodes. The input optical port features the HP universal optical interface, compatible with most common optical connectors (see Connectors, page 6), while the output electrical port features a precision 3.5 mm (HP 83440B/C) or 2.4 mm (HP 83440D) microwave coaxial connector.

Time Domain Applications

Ideal for high-speed laser and modulator testing, the DC-coupled HP 83440 family faithfully reproduces incoming optical signals for accurate pulse parameter characterization. Broad bandwidth, nearly Gaussian response characteristics, and low pulse aberrations make these optical detectors an excellent choice for high-speed time domain measurements. Use them with a high-speed digitizing oscilloscope like the HP 83480 family to accurately measure rise and fall time, overshoot, undershoot, ringing, pulse amplitude (peak power), pulse width, amplitude noise, jitter, and extinction ratio on incoming optical waveforms. Combine the 50-ohm termination version of the HP 83440B, option 050, with the HP 87441 family of fourth-order Bessel-Thomson filters for SDH/SONET transmitter eye diagram measurements.

Frequency Domain Applications

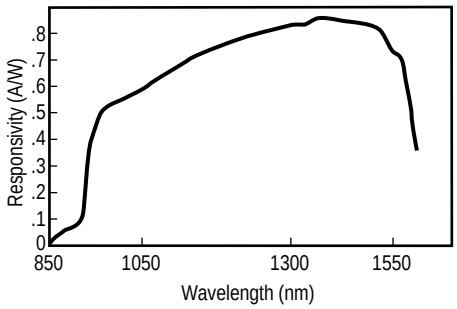
The frequency domain allows users to measure, quantify, and model modulated characteristics such as spectral purity, harmonic content, and noise spectral density. The HP 83440 family allows electrical frequency domain instruments like network and spectrum analyzers to accept optical input signals for basic lightwave measurements.

HP 83440B
Specifications and Characteristics

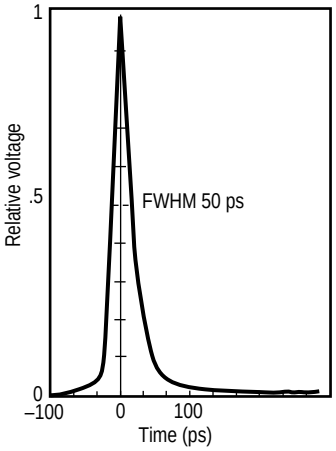
Specifications describe the instrument's warranted performance over the temperature range 0 to 55°C (except where noted). **Supplemental Characteristics** are intended to provide information useful in applying the instrument by giving typical but non-warranted performance parameters. These are denoted as "typical," "nominal," or "approximate."

Typical Response Curves

HP 83440B Responsivity vs Wavelength

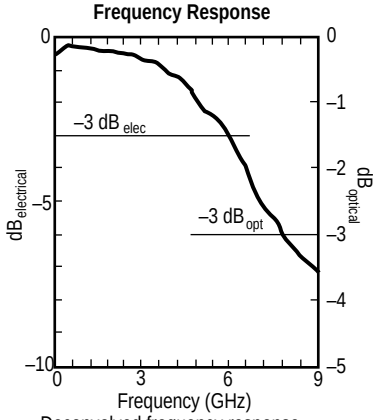


HP 83440B Uncorrected Pulse System Response [13]



Response of a HP 83440B lightwave detector on an HP 54124 oscilloscope due to a 2 ps pulsed YAG laser.

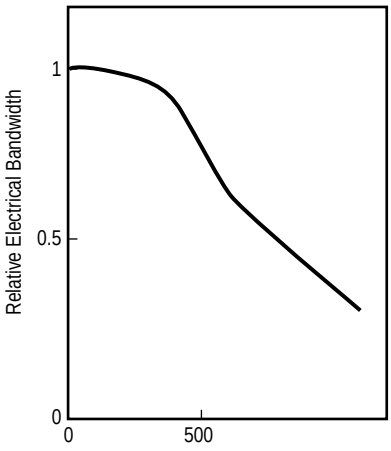
HP 83440B Frequency Response



Deconvolved frequency response from 2 ps pulsed YAG laser measured by HP 83440B and HP 54124 oscilloscope.

Time Domain	Frequency Domain
Conversion Gain[1,4] (min, into 50 Ω load) 1300 nm: 35 V/W 1550 nm: 32.5 V/W Opt 050: 16.5 V/W 15 V/W	**DC Responsivity**[1,4] (min) 1300 nm 1550 nm 0.70 A/W 0.65 A/W –3.1 dB[2] –3.7 dB[2] 0.33 A/W 0.30 A/W –9.6 dB[2] –10.5 dB[2]
Deflection Factor[1] (min, HP 54120 family oscilloscope) 1300 nm: 29 µW/div 1550 nm: 31 µW/div Opt 050: 61 µW/div 65 µW/div	
Pulse Width[3, 4,10] < 73 ps FWHM[6] (calculated:FWHM=0.44/BW_{opt}≈0.312/BW_{el})	**Bandwidth**[3,4] dc to >6 GHz (-3dB optical)
Rise/Fall Time[7,10] (10-90%) <80ps (calculated)	
System Aberrations[4,13] (response to 2 ps FWHM pulse) 10% peak-to-peak max, 5% typical	
Noise[5,11] 2 µW RMS max, equivalent optical noise power	**Noise Equivalent Power**[5,11] < 18 pW/ $\sqrt{Hz}$ typical
Dark Current[11] 50 nA max, <15 nA typical	
Maximum Safe Input Optical Power 10 mW (Peak) +10 dBm (Peak)	
Maximum Operating Input Optical Power (Compression Point) 2 mW (Peak) +3 dBm (Peak) See saturation chart for pulsed power characteristics	
Input Optical Reflection[8] (HMS-10/HP optical connector) 0.05% (1250-1600 nm)	**Input Optical Return Loss**[8] (HMS-10/HP optical connector) >33 dB (1250-1600 nm)
Wavelength Spectral Response[4] 1000 nm - 1600 nm	

Typical HP 83440B Saturation Characteristics



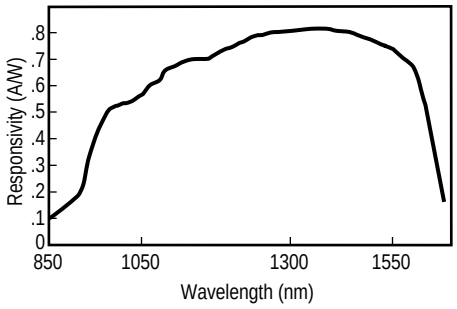
See Notes, page 7

HP 83440C
Specifications and Characteristics

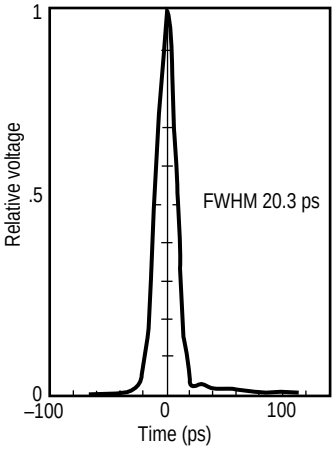
Specifications describe the instrument's warranted performance over the temperature range 0 to 55°C (except where noted). **Supplemental Characteristics** are intended to provide information useful in applying the instrument by giving typical but non-warranted performance parameters. These are denoted as "typical," "nominal," or "approximate."

Typical Response Curves

HP 83440C Responsivity vs Wavelength

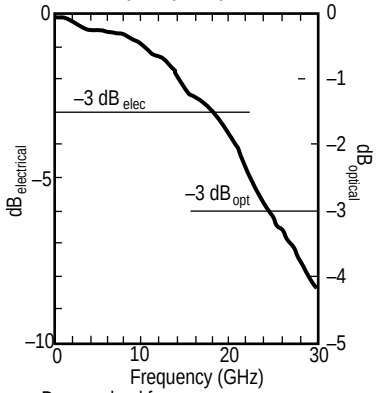


HP 83440C Uncorrected Pulse System Response [13]



Response of a HP 83440C lightwave detector on an HP 54124 oscilloscope due to a 2 ps pulsed YAG laser.

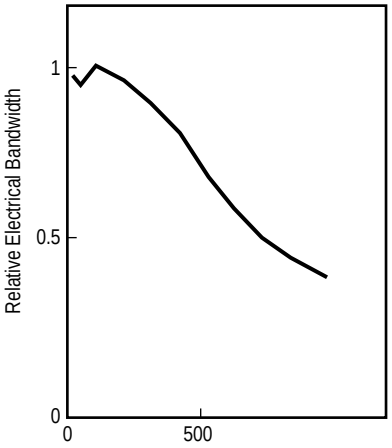
HP 83440C Frequency Response



Deconvolved frequency response from 2 ps pulsed YAG laser measured by HP 83440C and HP 54124 oscilloscope.

Time Domain	Frequency Domain
Conversion Gain[1,4] (min, into 50 Ω load) 1300 nm: 35 V/W 1550 nm: 32.5 V/W	**DC Responsivity**[1,4] (min) 1300 nm 1550 nm 0.70 A/W 0.65 A/W –3.1 dB[2] –3.7 dB[2]
Deflection Factor[1] (min, HP 54120 family oscilloscope) 1300 nm: 29 µW/div 1550 nm: 31 µW/div	
Pulse Width[3, 4,10] < 22 ps FWHM[6] (calculated:FWHM=0.44/BW_{opt}≈0.312/BW_{el})	**Bandwidth**[3,4] dc to >20 GHz (-3dB optical)
Rise/Fall Time[7,10] (10-90%) <24ps (calculated)	
System Aberrations[4,13] (response to 2 ps FWHM pulse) 10% peak-to-peak max, 5% typical	
Noise[5,11] 3.7 µW RMS max, equivalent optical noise power	**Noise Equivalent Power**[5,11] < 18 pW/ $\sqrt{Hz}$ typical
Dark Current[11] 20 nA max, 3 nA typical	
Maximum Safe Input Optical Power 10 mW (Peak) +10 dBm (Peak)	
Maximum Operating Input Optical Power (Compression Point) 2 mW (Peak) +3 dBm (Peak) See saturation chart for pulsed power characteristics	
Input Optical Reflection[8] (HMS-10/HP optical connector) 0.05% (1250-1600 nm)	**Input Optical Return Loss**[8] (HMS-10/HP optical connector) >33 dB (1250-1600 nm)
Wavelength Spectral Response[4] 1000 nm - 1600 nm	

Typical HP 83440C Saturation Characteristics



5 ps pulse width (1060 nm)

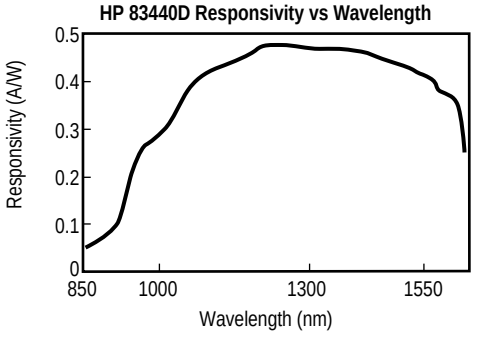
See Notes, page 7

HP 83440D
Specifications and Characteristics

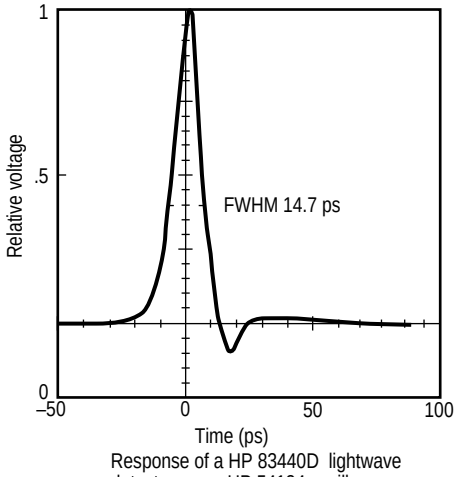
Specifications describe the instrument's warranted performance over the temperature range 0 to 55°C (except where noted). **Supplemental Characteristics** are intended to provide information useful in applying the instrument by giving typical but non-warranted performance parameters. These are denoted as "typical," "nominal," or "approximate."

Typical Response Curves

HP 83440D Responsivity vs Wavelength

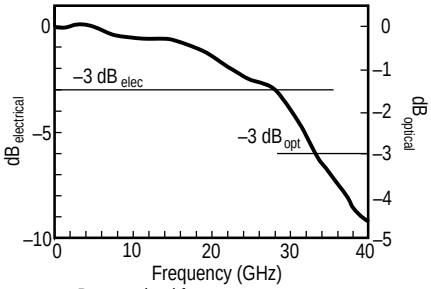


HP 83440D
Uncorrected System Pulse Response[13]



Response of a HP 83440D lightwave detector on an HP 54124 oscilloscope due to a 2 ps pulsed YAG laser.

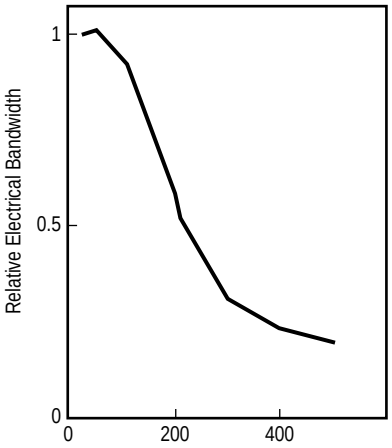
HP 83440D Frequency Response



Deconvolved frequency response from 2 ps pulsed YAG laser measured by HP 83440D and HP 54124 oscilloscope.

Time Domain	Frequency Domain
Conversion Gain[1,4] (min into 50 Ω load) 1300 nm: 20 V/W 1550 nm: 15 V/W	**DC Responsivity**[1,4] (min) 1300 nm 1550 nm 0.3 A/W 0.3 A/W –8 dB[2] –10.5 dB[2]
Deflection Factor[1] (min, HP 54120 family oscilloscope) 1300 nm: 50 µW/div 1550 nm: 67 µW/div	
Pulse Width[4,10,14] (calculated:FWHM=0.44/BW_{opt}≈0.312/BW_{el}) < 13 ps FWHM[6]	**Bandwidth**[4,12,14] dc to 30 GHz nominal (-3dB optical)
Rise/Fall Time[7,10] (10-90%) <15 ps (calculated)	
System Aberrations[4,13] (response to 2 ps FWHM pulse) 20% peak-to-peak max, <12% typical	
Noise[5,11] 8.1 µW RMS max, equivalent optical noise power	**Noise Equivalent Power**[5,11] < 18 pW/ √Hz typical
Dark Current[11] 20 nA max, 4 nA typical	
Maximum Safe Input Optical Power 10 mW (Peak) +10 dBm (Peak)	
Maximum Operating Input Optical Power (Compression Point) 2 mW (Peak) +3 dBm (Peak) See saturation chart for pulsed power characteristics	
Input Optical Reflection[8] (HMS-10/HP optical connector) 0.10 % (1250-1600 nm)	**Input Optical Return Loss**[8] (HMS-10/HP optical connector) >30 dB (1250-1600 nm)
Wavelength Spectral Response[4] 1000 nm - 1600 nm	

Typical HP 83440D
Saturation Characteristics

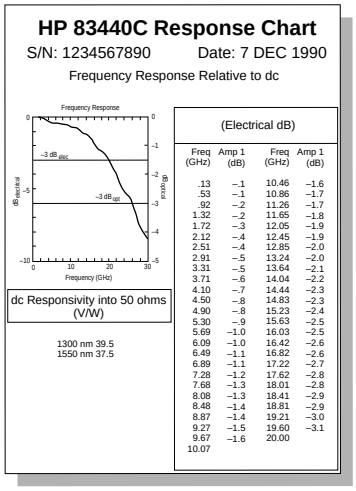


See Notes, page 7

Using the HP 83440B/C/D Lightwave Converter

General

RF Connector	HP 83440B/C (3.5 mm [m]) or 83440D (2.4 mm [m]), 50Ω
ESD Susceptibility at RF Pin[9]	200 V
DC Bias Voltage	+10 to +15V dc (Available from HP 54121/4 test set bias port or HP 87421 Power Supply with 83440-60009 bias cable) For use with ac-coupled instruments a bias tee such as HP 11612A is required to supply dc bias return path.
Power Consumption	< 18 mVA
Weight	0.14 kg (0.31 lb)
Operating Temperature	0-55 deg C
Compatible Fiber	9/125 single mode fiber
Photodiode Package	Hermetically sealed
Output Impedance	Unterminated/50Ω terminated for HP 83440B Opt 050 HP 83440B Opt 050, –15 dB return loss, nominal



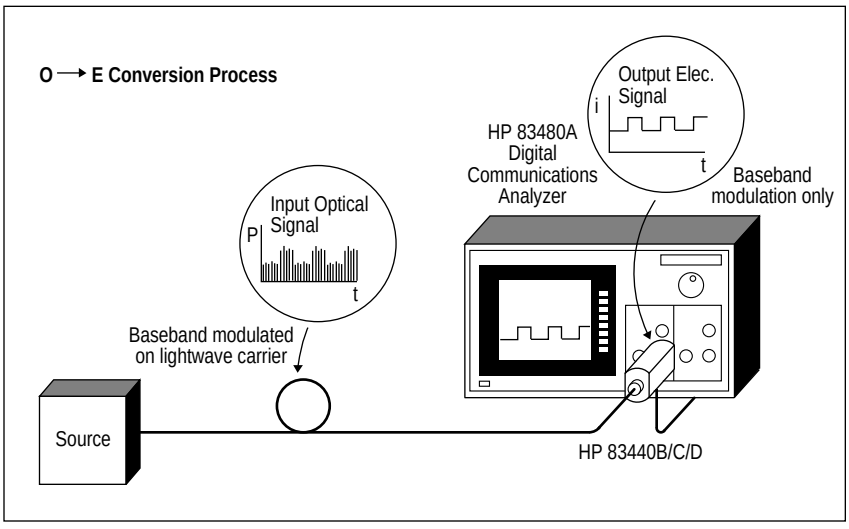
Each HP 83440 is shipped with instrument-specific frequency response and conversion gain (dc responsivity) data.

Eye-Pattern Measurements

Eye-pattern transmitter tests are called for in CCITT (International Telegraph and Telephone Consultative Committee) G.957 and in EIA/TIA OFSTP-4 (Electronics Industry Association/Telecommunications Industry Association Fiber Standard Test Procedure) for SDH and SONET. The HP 83440 family may be used with the HP 87441 SDH/SONET filters to perform these measurements. The HP 83440B option 050 is terminated in 50 ohms to prevent reflections between the receiver's output and the filter's input to maintain the fourth-order Bessel-Thomson response. An input optical signal of at least –4 dBm is recommended to produce an adequate eye pattern on a HP 83480 digital communications analyzer. Standard HP 83440 lightwave converters, which are unterminated, require a 6-dB attenuator between the converter output and the filter to provide reasonable match with the HP 87441. While this helps to achieve good frequency response, overall sensitivity is significantly reduced. The HP 83440B/C/D may be used with the electrical measurement channels on the HP 83480A digital communications analyzer. Fully calibrated, integrated, optical channels are also available with the HP 83480A.

O/E Conversion Process

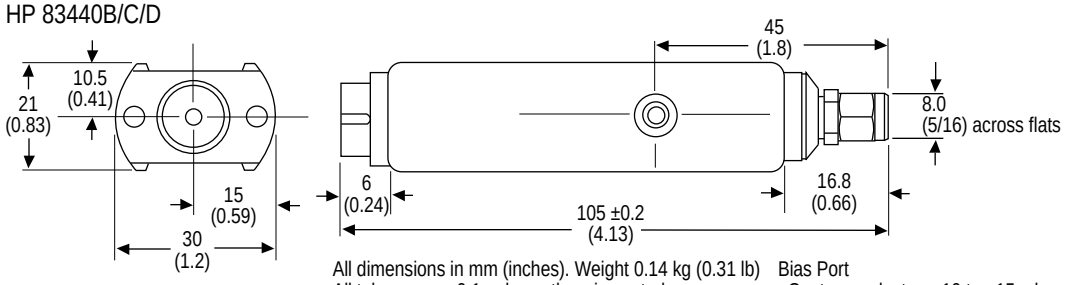
The HP 83440 detects the modulated baseband signal from the lightwave carrier, converting it to an electrical signal for processing. The resultant electrical signal can be analyzed in the time domain or frequency domain using electrical oscilloscopes, signal analyzers, and network analyzers. The 83440B/C/D are DC coupled receivers. For proper operation, a DC path to ground is necessary at the RF ouput. When using the HP 83440 with an AC-coupled instrument (except opt 050), a bias tee such as the HP 11612A is required to supply dc bias return path. Alternatively, a 3 dB fixed attenuator on the output may be used to provide a dc bias return.



See Notes, page 7

Mechanical

HP 83440B/C/D



All dimensions in mm (inches). Weight 0.14 kg (0.31 lb)
All tolerances ± 0.1 unless otherwise noted

Bias Port
Center conductor: +10 to +15 vdc
Outer conductor: Common

Connectors

Optical Input:
Specify optical input connector option when ordering HP 83440B/C/D.

Diamond HMS-10/HP	Opt 011
FC/PC connector	Opt 012
DIN 47256 connector	Opt 013
ST connector	Opt 014
Biconic connector	Opt 015

Electrical Output:
3.5 mm (83440B/C)
2.4 mm (83440D)

DC Bias Input: 2 quick connect bias cables: SMB (HP 54120 compatible) connector to HP 83440 and bare leads (clear: +, black: com) to HP 83440.

ESD Sensitive Parts[9]
The HP 83440 features a captive RF connector cap to protect the RF center pin from electrostatic discharge (ESD). Use proper ESD precautions when working with RF and bias ports. *Keep RF port capped when not in use.*

Contents:

- One HP 83440 Lightwave Detector with response data sheet
- User specified optical connector adapter
- Two dc bias cables

Ordering Information

HP 83440B DC-6 GHz Lightwave Converter
Option 050, 50Ω termination for use with SDH/SONET filters
HP 83440C DC-20 GHz Lightwave Converter
HP 83440D DC-32 GHz Lightwave Converter
Note: All HP 83440 orders must specify an optical connector option.

Recommended Accessories

HP 87421A	DC Power Supply (For non HP 54120 applications)
HP 83440-60009	Power supply bias cable for HP 87421A
HP 11612A	Bias network (for AC-coupled applications)
HP 5952-9654	Fiber Optics Handbook
HP 8493C Opt 003, 006	3 and 6 dB fixed attenuators
HP 83440-60004	Additional DC bias cable (83440-SMB)
HP 83440-60005	Additional DC bias cable (SMB-bare wire)
HP 11901D	2.4 mm (f) to 3.5 mm (m) Coax Adapter
HP 1250-1391	SMB tee to expand HP 54120 oscilloscope test set bias output
HP 87441A/B/D	Fourth-order Bessel-Thomson SDH/SONET filter for STM-16/OC-48 eye-diagram measurements
HP 87490A	Mask Measurement Software for the HP 54120

Optical Connector Adapters

Use to transform the HP 83440 to the connector of interest for increased measurement versatility. One supplied with each HP 83440, depending upon option specified.

HP 81000AI	HMS-10/HP connector adapter (same as Opt 011)
HP 81000FI	FC/PC connector adapter (same as Opt 012)
HP 81000GI	D4 connector adapter
HP 81000JI	SMA connector adapter
HP 81000UI	SC connector adapter
HP 81000SI	DIN 47256 connector adapter (same as Opt 013)
HP 81000VI	ST connector adapter (same as Opt 014)
HP 81000WI	Biconic connector adapter (same as Opt 015)

Other Hewlett-Packard O/E Converters

HP 11982A DC-15 GHz *amplified* converter. 300 V/W conversion gain. See data sheet lit. no. 5952-2166.

HP 83410B 300 kHz-3 GHz *amplified* receiver (9-62.5/125 um fiber). Data sheet lit. no. 5952-0822.

HP 83411A 300 kHz-6 GHz receiver (9/125 um fiber). Data sheet lit. no. 5952-0822.

HP 83411B 300 kHz-6 GHz *amplified* receiver (9/125 um fiber). Data sheet lit. no. 5952-0822.

HP 83412A 300 kHz-3 GHz *amplified* receiver *(850 nm)* (50/125 um fiber). Data sheet lit. no. 5952-0822.

HP 83446A/B 2.4 Gb/s, 622 Mb/s lightwave clock and data receiver. Product overview lit. no. 5962-0116E.

HP 83481A 3 GHz, 155 Mb/s, 622 Mb/s optical/electrical module. Product overview lit. no. 5964-2238E.

HP 83485A/B 20 GHz, 30 GHz, 2.4 Gb/s, 10 Gb/s optical/electrical module. Product overview lit. no. 5964-2238E.

Support Literature

HP 54120-5 Product Note "Configuring an Optical Time-Domain Measurement System for Digital Optical Communication Applications" HP lit. no. 5952-1142.

Notes

1 Stated specs from HP 83440B/C /D into 50Ω load.

2 For an O/E device, responsivity (dB) = $20\log\left[\frac{\text{responsivity A/W}}{1\text{ A/W}}\right]$

3 Measured on HP 8703A lightwave component analyzer. Frequency response verified by deconvolving impulse response of HP 83440C on HP 54124 oscilloscope due to a 2 ps pulse YAG laser.

4 See typical performance trace.

5 Thermal noise limited; equivalent optical power limited by 50 Ω input impedance.

6 Full-Width Half-Max.

7 Calculated from bandwidth measurements; $tr = \frac{.48}{BW_{opt}}$,($\approx \frac{.34}{BW_{elec}}$) Calculation assumes Gaussian pulse.

8 Optical connector limited.

9 ESD susceptibility limited to RF connector center pin. Overall package (other than bias port and RF connector) withstands >25,000 V ESD.

10 Impulse response calculations verified using 2 ps pulsed YAG laser.

11 At room temperature (23°C ± 3°C)

12 All HP 83440D units are tested for 30 GHz minimum bandwidth. Measured frequency response data is supplied with each unit.

13 Uncorrected *System* aberrations include oscilloscope response and source laser aberrations from 2 ps pulsed YAG laser system. Slower pulse width will generate lower aberration levels; high HP 83440D detector bandwidth can excite 50 GHz oscilloscope response.

14 HP 83440D test system consists of 2-3 ps compressed Nd:YAG laser and HP 54124 50 GHz digitizing oscilloscope. HP 83440D frequency response is derived from Fourier transform after correcting for oscilloscope and input pulse frequency response. System verified with YAG heterodyne.

For more information on Hewlett-Packard Test and Measurement products, applications, or services, please call your local Hewlett-Packard sales office. A current listing is available via the World-wide Web through AccessHP at http://www.hp.com. If you do not have access to the internet please contact one of the HP centers listed below and they will direct you to your nearest HP representative.

United States:
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1 800 452 4844

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L4W 5G1
(905) 206 4725

Europe:
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European Marketing Centre
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Hewlett-Packard Japan Ltd.
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