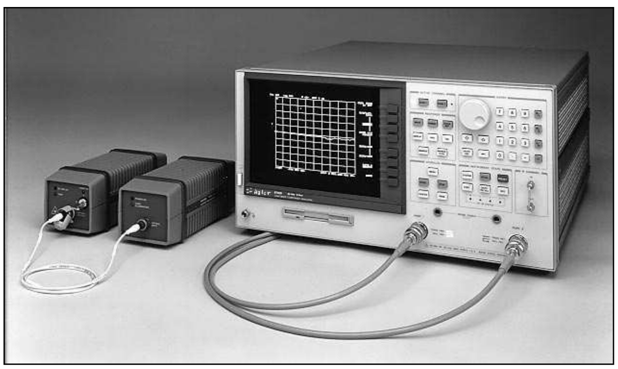
Agilent 8702D
Lightwave Component Analyzer
Technical Specifications

300 kHz to 3 GHz or 6 GHz



This technical data sheet describes the measurement accuracy and operating conditions of the 8702D lightwave component analyzer system.

Additional information about applications and ordering can be found in the 8702D brochure and configuration guide (Agilent literature numbers 5965-5624E and 5965-6403E) and application note 1550-6 (Agilent literature number 5091-6478E.)

The 8702D lightwave component analyzer makes calibrated measurements of the small-signal-sinusoidal transmission and reflection characteristics of optical to electrical, electrical to optical, electrical to electrical and optical to optical devices and systems. It operates by analyzing the swept frequency signal modulating an 850, 1300, or 1550 nm carrier. This magnitude and phase data can be shown in appropriate frequency and distance-time domain formats.

The performance of the system depends upon the specific lightwave source and receiver used with the 8702D analyzer. Refer to the lightwave source characteristics and the lightwave receiver characteristics section of this document for detailed information.

Agilent 8702D Maximizes Versatility and Performance

The 8702D offers improved flexibility and measurement capability in the following areas:

- Superb accuracy. The most comprehensive calibration available guarantees accurate measurements.
- Accurately characterized NIST traceable lightwave sources and receivers with double density calibration data.
- Built-in 3.5 inch floppy disk drive provides convenient storage of instrument states, data, and optical calibration data.
- Modulation frequency range from 300 kHz to 3 GHz, or optionally 6 GHz.
- Built-in S-parameter test set provides complete forward and reverse electrical measurements, allowing you to completely characterize your component with a single connection.
- 50 and 75 ohm impedance.
- Parallel and serial ports provide interfaces to popular printers and plotters. The parallel port can also be used as a general I/O bus, with user-controllable TTL inputs and outputs. Users can also connect a DIN keyboard to speed up entry of titles, labels, or file names, or for remote front panel operation.
- Test sequencing. Analyzer “learns” keystrokes for automation without external computer control.
- Mixer testing. Quickly and easily characterize frequency translating devices such as mixers.
- Add swept harmonic measurements. Characterize amplifier parameters — gain, 1 dB compression, match — and 2nd and 3rd harmonic distortion with the same test setup.

Definitions and Test Conditions

This document provides two types of performance information:

Specifications describe the instrument's warranted performance over the temperature range of 23 ±3°C, unless otherwise stated. Specifications for frequencies above 3 GHz do not apply to instruments with Option 075 (75 ohm impedance).

Characteristics provide useful, but non-warranted information about the functions and performance of the instrument or system. When both specifications and characteristics appear in the same table the characteristics are italicized.

Dynamic Range

System dynamic range is limited by the maximum RF output power, maximum lightwave source output power, lightwave receiver maximum input power and the system noise floor. System dynamic range applies to transmission measurements only, since reflection measurements are limited by the directivity of the optical or electrical coupler used.

Electrical noise floor is specified as the mean of the noise trace over frequency. A signal at this level would have a signal/noise power ratio of 3 dB. Noise floor is measured with the test ports terminated in loads, full two-port error correction (with 16 averages used during isolation), 10 Hz IF bandwidth (BW), maximum test port power, and no averaging during the measurement. Opto-electrical measurement noise floor includes lightwave receiver sensitivity.

Responsivity

Responsivity is the term used to describe how efficiently an electrical signal is converted to modulated light by a lightwave transmitter, or how efficiently modulated light is converted to an electrical signal by a lightwave receiver. Responsivity is a static and dynamic parameter. In the static sense, it is simply the ratio of the average optical power to average electrical current. In the dynamic case, responsivity refers to the change in the output parameter due to the change of the input para-meter. This is sometimes called "slope" responsivity.

For a lightwave source, slope responsivity is calculated as:

$$R_s = \Delta P_{out}/\Delta I_{in}$$

The units of source responsivity are Watts per Amp.

Similarly, receiver responsivity is calculated as:

$$R_r = \Delta I_{out}/\Delta P_{in}$$

The units of receiver responsivity are Amps per Watt.

It is often convenient to express responsivity in decibels, particularly when transducers are used in a complete communications link. Source and receiver responsivities, when expressed in decibels, are related to levels of 1 W/A and 1 A/W respectively.

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

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

The fact that a "20log" factor is used when relating optical and electrical signals, as opposed to "10log", can be understood intuitively by considering a simple photodiode. If the optical input power is doubled, the output electrical current will also double. However, the output electrical power, proportional to the square of the current, will increase by a factor of four. Thus a three dB change in optical power produces a six dB change in electrical power. Similarly, a six dB change in electrical power into a source produces a three dB change in optical output power.

Measurement Uncertainty

Electrical-to-electrical curves show the worst-case magnitude and phase uncertainty for reflection and transmission measurements, after a full two-port calibration (including isolation with an averaging factor of 16) using the specified cal kit, with 10 Hz IF bandwidth (BW) and no averaging for measurements.

Opto-electrical measurement curves show the non-warranted magnitude and phase uncertainty for transmission measurements, after a response & match calibration (including isolation with an averaging factor of 16) using the selected lightwave source and receiver pair, with 10 Hz IF bandwidth and no averaging for measurements.

Calibration is the process of measuring known standards from a calibration kit to characterize a network analyzer's systematic (repeatable) errors. Opto-electrical measurements require measurement of a factory characterized lightwave source or receiver as well.

Opto-electrical measurement uncertainty is plotted as a function of device responsivity (dBe). The curves assume an RF test port power of +10 dBm, a device optical return loss of 30 dBo and electrical return loss of 14 dBe.

Electrical reflection measurement uncertainty is plotted as a function of S_{11} (reflection coefficient, linear). The curves assume a one-port device ($S_{21} = S_{12} = 0$).

Electrical transmission measurement uncertainty is plotted as a function of S_{21} (transmission gain/loss) in dB from the reference level. The curves assume that the device is well-matched ($S_{11} = S_{22} = 0$).

The reference level for 8702D electrical to electrical transmission measurements is –2 dBm test port power.

Organization of Data

The information in this document is organized into the following sections. All data is subject to change.

System Performance Summary

These pages describe specifications and characteristics that apply to complete 8702D measurement systems with various lightwave source and receiver combinations. The measurement uncertainty curves are given for the standard (3 GHz) 8702D system as well as the 8702D Option 006 (6 GHz) system.

Lightwave Measurement Accuracy and Repeatability

A single point uncertainty analysis illustrates how the nominal slope responsivity curves are determined. Response and response & match calibration techniques are compared. System drift and measurement repeatability characteristics are provided.

Agilent Lightwave Source and Receiver Performance Summary

Contains detailed Agilent 834XXX information as well as typical modulation and demodulation frequency response plots.

8702D Accessories

This section contains information about lightwave directional couplers and a polarization controller.

Test Port Output and Test Port Input

Separate sections are provided for an 8702D (without Option 011) and an 8702D with Option 011.

Supplemental Characteristics

This section provides the general and environmental characteristics as well as interconnect information.

Additional Sources of Information

Refer to the Agilent 8752C and 8753D Network Analyzers Technical Specifications (Agilent literature #5962-9770E) for information on test sets that are available for use with the 8702D Option 011, calibration kits, cables, adapters, and other accessories.

System Performance Summary for Optical-to-Electrical Devices Agilent 8702D (50 ohm system)

The following characteristics describe the system performance of the 8702D lightwave component analyzer with an integrated 50 ohm s-parameter test set configuration. System hardware includes the following:

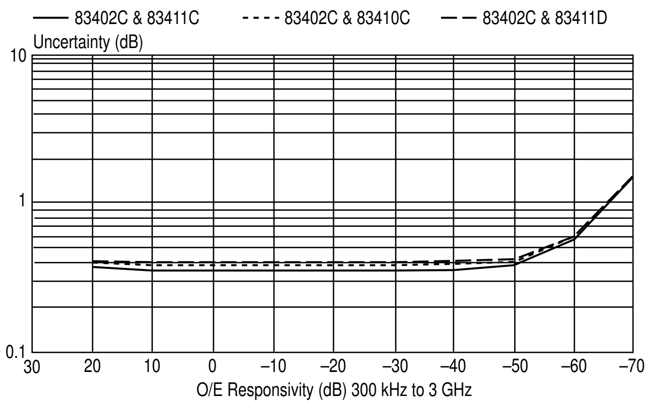
- Network analyzer: Agilent 8702D Option 006
- Lightwave source: Agilent 8340XX
- Lightwave receiver: Agilent 8341XX
- Interconnect Cable Kit (HMS-10): Agilent 11886A
- Calibration kit: Agilent 85033D
- Test port cables: Agilent 11857D

Measurement Uncertainty Characteristics

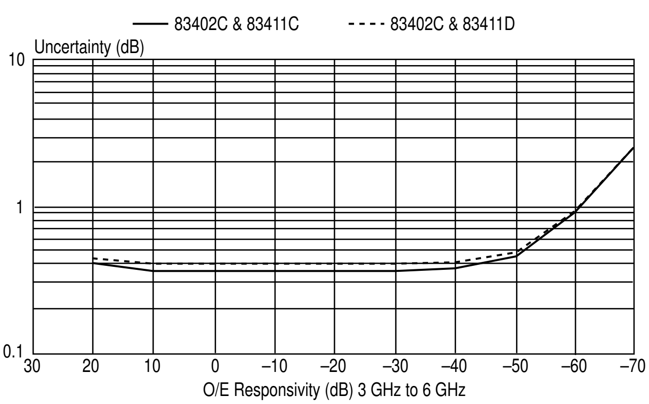
The following graphs show the measurement uncertainty characteristics for the 8702D over 3 and 6 GHz modulation frequency ranges under the following mea-surement conditions:

- Response and match calibration,
- 8702D RF power = +10 dBm
- DUT optical input return loss = 30 dBo
- DUT electrical output return loss = 14 dBe

1300 nm O/E Transmission Measurements



Responsivity flatness uncertainty
300 kHz to 3 GHz (characteristic)



Responsivity flatness uncertainty
3 to 6 GHz (characteristic)

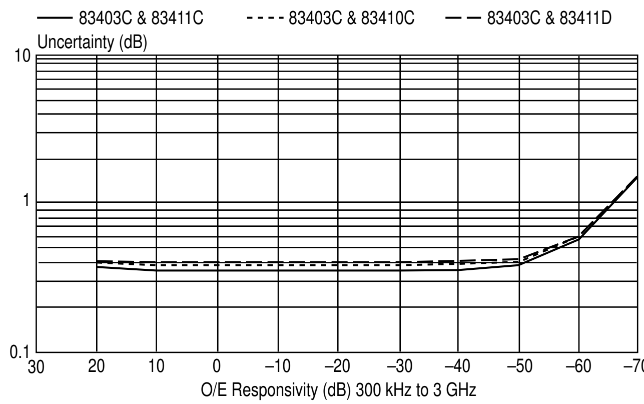
Included in the total relative uncertainty represented by the graphs are the following individual contributing uncertainties:

- Drift with temperature (23 ±3° Centigrade)
- System dynamic accuracy[1]
- Reflection sensitivity
- Wavelength accuracy
- Factory test system
- Electrical mismatches or reflections between:
  RF source/lightwave source RF input
  RF receiver/lightwave receiver RF output
- Optical mismatches or reflections between:
  lightwave source/lightwave receiver
  lightwave source/DUT

Absolute magnitude uncertainty includes additional error contributors, the greatest of which is optical connector loss uncertainty. An absolute uncertainty value for a specific data point can be calculated by adding ±0.76 dB to the value found on the uncertainty graphs.

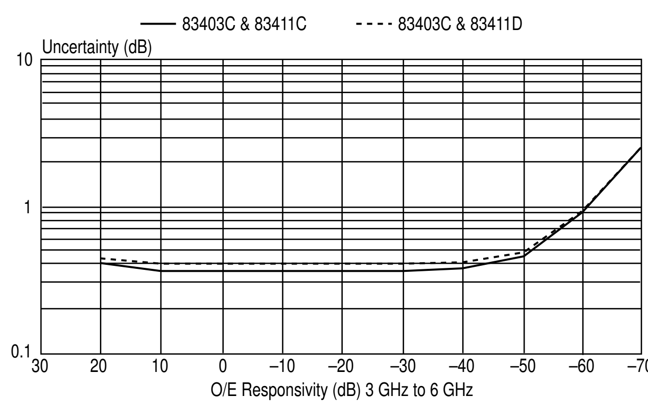
1550 nm O/E Transmission Measurements

Responsivity flatness uncertainty



300 kHz to 3 GHz (characteristic)

Responsivity flatness uncertainty

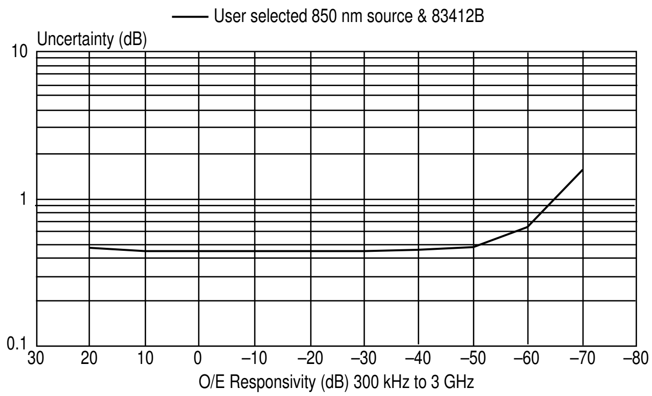


3 to 6 GHz (characteristic)

[1] Crosstalk and noise effects are included in the dynamic accuracy.

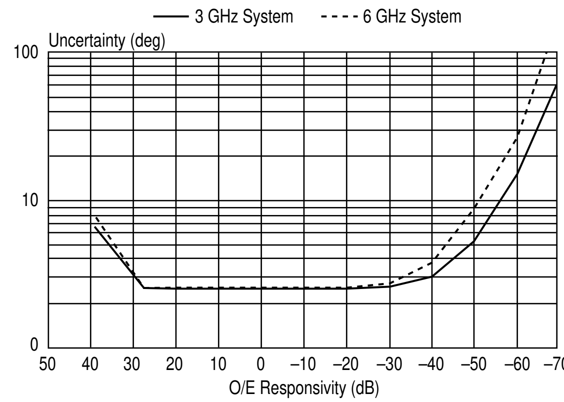
System Performance Summary for Optical-to-Electrical Devices Agilent 8702D (50 ohm system)

850 nm O/E Transmission Measurements*



Responsivity flatness uncertainty 300 kHz to 3 GHz (characteristic)

O/E Transmission Phase



Deviation from linear phase at 3 and 6 GHz (characteristic)

* User selected 850 nm source with following conditions:
- Electrical input port return loss = 14 dBe
- Optical output return loss = 34 dBo
- Responsivity = –26 dBe

O/E Dynamic Range (Characteristic)

Minimum transmission test level is limited by the maximum RF output power, maximum lightwave source output power, lightwave receiver maximum input power and the system noise floor. It is determined with a response & match calibration (including isolation with an averaging factor of 16) using the selected lightwave source and receiver pair, with 10 Hz IF bandwidth and no averaging for measurements.

	Minimum Transmission Test Level (dBe) (Characteristic)	
System Configuration	**300 kHz to 3 GHz**	**3 to 6 GHz**
Agilent 83402C and 83403C	–89	–84

System Performance Summary for Electrical-to-Optical Devices Agilent 8702D (50 ohm system)

The following characteristics describe the system performance of the 8702D lightwave component analyzer with an integrated 50 ohm s-parameter test set config-uration. System hardware includes the following:

- Network analyzer: Agilent 8702D Option 006
- Lightwave source: Agilent 8340XX
- Lightwave receiver: Agilent 8341XX
- Interconnect Cable Kit (HMS-10): Agilent 1886A
- Calibration kit: Agilent 85033D
- Test port cables: Agilent 11857D

Measurement Uncertainty Characteristics

The following graphs show the measurement uncertainty characteristics for the 8702D over 3 and 6 GHz modulation frequency ranges under the following mea-surement conditions:

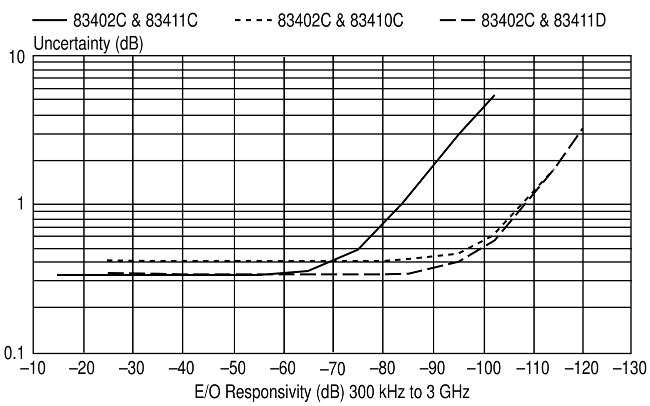
- Response and match calibration,
- 8702D RF power = +10 dBm
- DUT optical output return loss = 30 dBo
- DUT electrical input return loss = 14 dBe

Included in the total relative uncertainty represented by the graphs are the following individual contributing uncertainties:

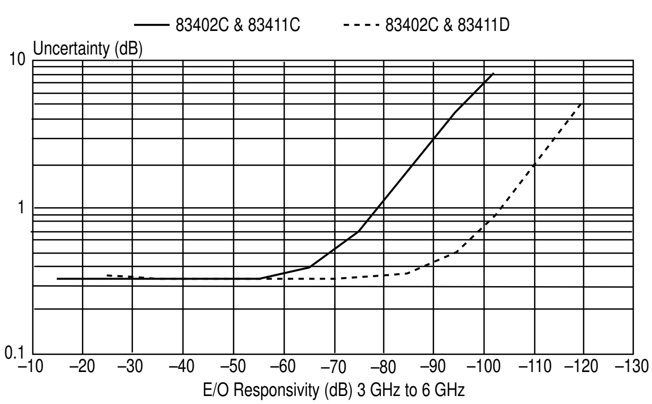
- Drift with temperature (23 ±3° Centigrade)
- System dynamic accuracy[1]
- Reflection sensitivity
- Wavelength accuracy
- Factory test system
- Electrical mismatches or reflections between:
  RF source/lightwave source RF input
  RF receiver/lightwave receiver RF output
- Optical mismatches or reflections between:
  lightwave source/lightwave receiver
  DUT/lightwave receiver

Absolute magnitude uncertainty includes additional error contributors, the greatest of which is optical connector loss uncertainty. An absolute uncertainty value for a specific data point can be calculated by adding ±0.76 dB to the value found on the uncertainty graphs.

1300 nm E/O Transmission Measurements

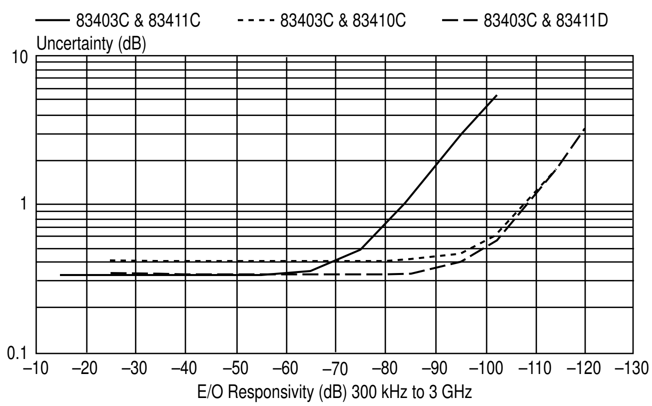


Responsivity flatness uncertainty 300 kHz to 3 GHz (characteristic)

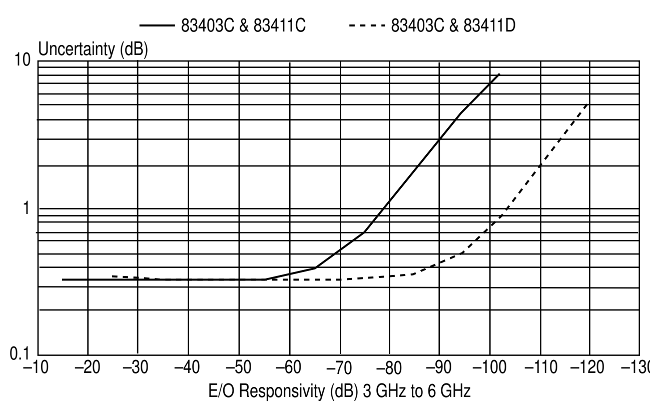


Responsivity flatness uncertainty 3 to 6 GHz (characteristic)

1550 nm E/O Transmission Measurements



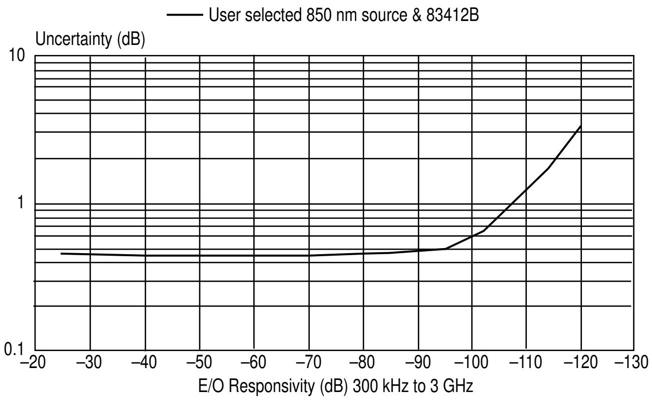
Responsivity flatness uncertainty 300 kHz to 3 GHz (characteristic)



Responsivity flatness uncertainty 3 to 6 GHz (characteristic)

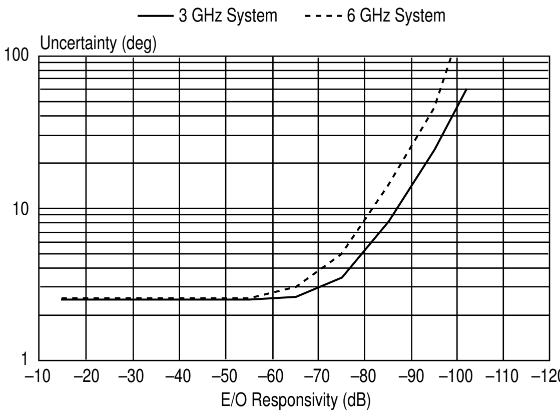
System Performance Summary for Electrical-to-Optical Devices Agilent 8702D (50 ohm system)

850 nm E/O Transmission Measurements*



Responsivity flatness uncertainty 300 kHz to 3 GHz (characteristic)

E/O Transmission Phase



Deviation from linear phase at 3 and 6 GHz (characteristic)

* Conditions:
- DUT electrical input return loss = 14 dBe
- DUT optical output return loss = 34 dBo
- DUT responsivity = –26 dBe
- Source response and match calibration using thru-receiver technique and disk data for Agilent 83412B

E/O Dynamic Range (Characteristic)

Minimum transmission test level is limited by the maximum RF output power, maximum lightwave source output power, lightwave receiver maximum input power and the system noise floor. It is determined with a response & match calibration (including isolation with an averaging factor of 16) using the selected lightwave source and receiver pair, with 10 Hz IF bandwidth and no averaging for measurements.

	Minimum Transmission Test Level (dBe) (Characteristic)	
System Configuration	**300 kHz to 3 GHz**	**3 to 6 GHz**
Agilent 83410C	–132	—
Agilent 83411C	–78	–78
Agilent 83411D	–110	–110
Agilent 83412B	–126	—

System Performance Summary for Optical-to-Optical Devices Agilent 8702D (50 ohm system)

The following characteristics describe the system performance of the 8702D lightwave component analyzer with an integrated 50 ohm s-parameter test set config-uration. System hardware includes the following:

- Network analyzer: Agilent 8702D Option 006
- Lightwave source: Agilent 8340XX
- Lightwave receiver: Agilent 8341XX
- Interconnect Cable Kit (HMS-10): Agilent 11886A
- Test port cables: Agilent 11857D
- Adapters: Agilent 85052-60004

Measurement Uncertainty Characteristics

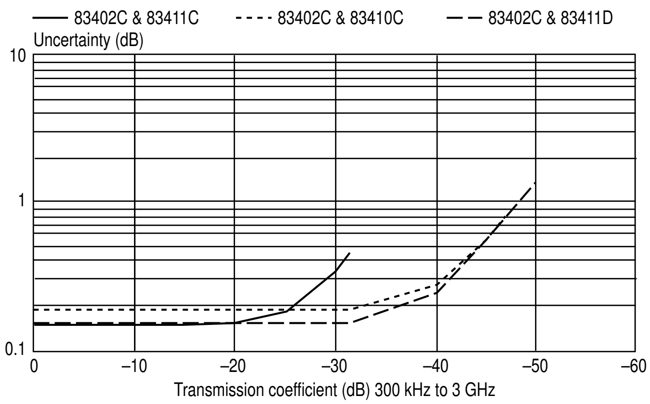
The following graphs show the measurement uncertainty characteristics for the 8702D over 3 and 6 GHz modulation frequency ranges under the following measurement conditions:

- Response calibration,
- HP 8702D RF power = +10 dBm
- DUT optical input return loss = 30 dBo
- DUT optical output return loss = 30 dBo

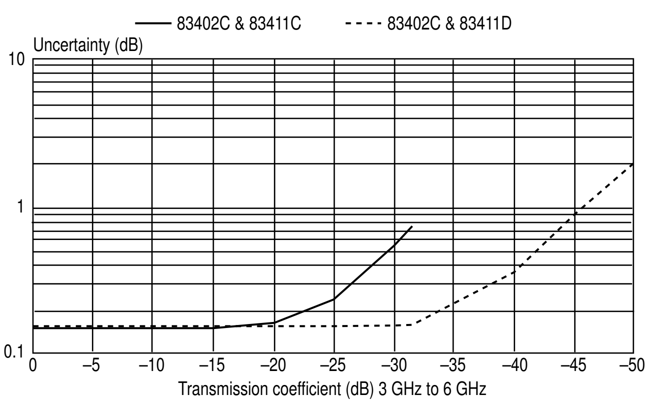
Included in the total relative uncertainty represented by the graphs are the following individual contributing uncertainties:

- Drift with temperature (23 ±3° Centigrade)
- System dynamic accuracy[1]
- Reflection sensitivity
- Wavelength accuracy
- Factory test system
- Optical mismatches or reflections between:
  lightwave source/lightwave receiver
  lightwave source/DUT
  DUT/lightwave receiver

1300 nm O/O Transmission Measurements

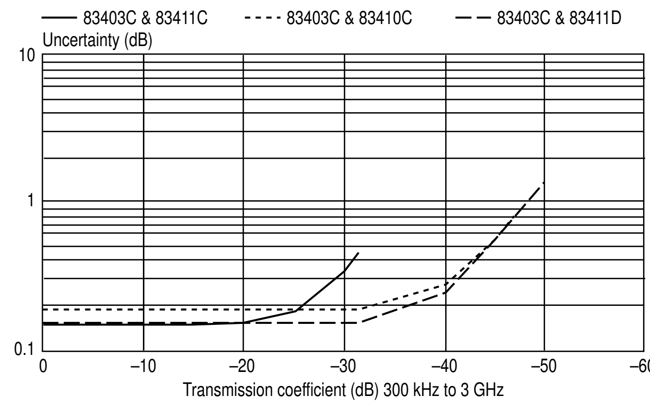


Relative transmission coefficient uncertainty 300 kHz to 3 GHz (characteristic)

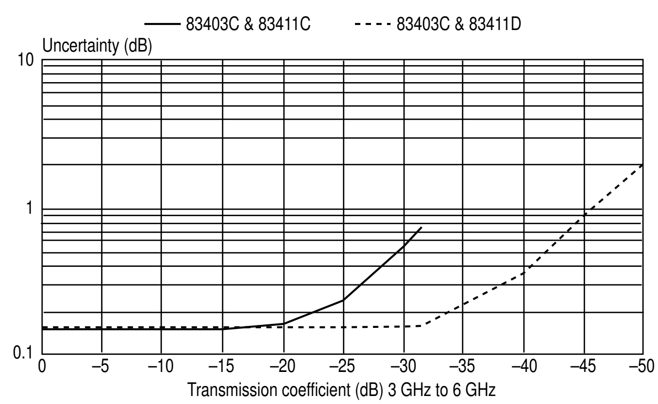


Relative transmission coefficient uncertainty 3 to 6 GHz (characteristic)

1550 nm O/O Transmission Measurements



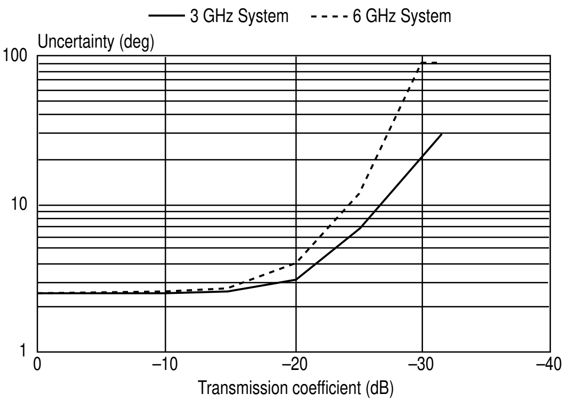
Relative transmission coefficient uncertainty 300 kHz to 3 GHz (characteristic)



Relative transmission coefficient uncertainty 3 to 6 GHz (characteristic)

System Performance Summary for Optical-to-Optical Devices Agilent 8702D (50 ohm system)

O/O Transmission Phase



Deviation from linear phase at 3 and 6 GHz (characteristic)

O/O Dynamic Range (Characteristic)

Minimum transmission test level is limited by the maximum RF output power, maximum lightwave source output power, lightwave receiver maximum input power and the system noise floor. It is characterized with a response calibration (including isolation with an averaging factor of 16) using the specified lightwave source and receiver pair, with 10 Hz IF bandwidth and no averaging for measurements.

	Minimum Transmission Test Level (dBo) (Characteristic)	
System Configuration	**300 kHz to 3 GHz**	**3 to 6 GHz**
Agilent 83410C	–54	—
Agilent 83411C	–27	–27
Agilent 83411D	–43	–43

[2] Measured with the Agilent 1189X lightwave directional coupler.

Optical Reflection Minimum Test Levels[2] (Characteristic)

	Minimum Reflection Test Level (dBo) (Characteristic)	
System Configuration	**300 kHz to 3 GHz**	**3 to 6 GHz**
Agilent 83410C	–48	—
Agilent 83411C	–21	–21
Agilent 83411D	–37	–37

System Performance Summary for Electrical-to-Electrical Devices Agilent 8702D (50 ohm system) 3.5 mm Test Ports

The following specifications and characteristics describe the system performance of the 8702D lightwave component analyzer with an integrated 50 ohm s-parameter test set configuration. System hardware includes the following:

- Network analyzer: Agilent 8702D Option 006
- Calibration kit: Agilent 85033D
- Test port cables: Agilent 11857D

Dynamic Range

These specifications apply to transmission measurements in the 30 kHz to 6 GHz frequency range at 10 Hz IF BW with full two-port error correction. Dynamic range is limited by maximum receiver input level and the receiver's noise floor.

System dynamic range

30 kHz to 300 kHz: 100 dB[3]
300 kHz to 1.3 GHz: 110 dB[4]
1.3 GHz to 3 GHz: 110 dB
3 GHz to 6 GHz: 105 dB

Measurement Uncertainty Characteristics[5]

The following graphs show the measurement uncertainty characteristics for the 8702D over the full frequency range using full two-port error correction.

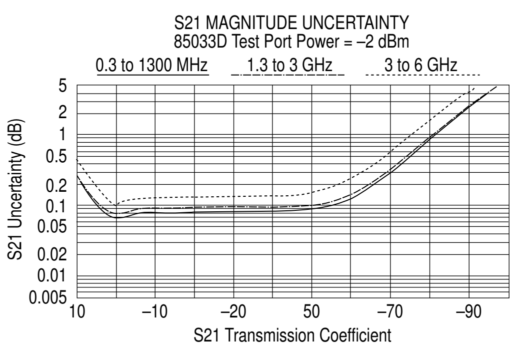
Measurement Port Characteristics

The following characteristics show the residual 8702D system uncertainties for corrected performance after accuracy enhancement using full two-port error correction. These characteristics apply for an environmental temperature of 25 ±5°C, with less than 1°C deviation from the calibration temperature.

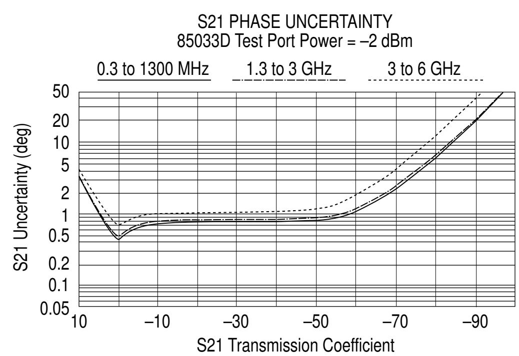
	Frequency Range			
Corrected	**30–300 kHz**	**300 kHz–1.3 GHz**	**1.3–3 GHz**	**3–6 GHz**
Directivity	49 dB	46 dB	44 dB	38 dB
Source Match	49 dB	44 dB	41 dB	37 dB
Load Match	49 dB	46 dB	44 dB	38 dB
Refl. tracking	±0.010 dB	±0.005 dB	±0.007 dB	±0.009 dB
Trans. tracking	±0.016 dB	±0.014 dB	±0.022 dB	±0.048 dB

[3] 90 dB, 30 kHz to 50 kHz
[4] 100 dB, 300 kHz to 16 MHz due to fixed spurs
[5] These measurement uncertainty curves utilize an RSS model for the contribution of random errors such as noise, connector repeatability, and test set switch; with a worst-case model for the contributions of dynamic accuracy and residual systematic errors.
[6] The graphs shown for transmission measurements assume a well-matched device ($S_{11} = S_{22} = 0$).
[7] The graphs shown for reflection measurements apply to either a one-port device or a two-port device with more than 6 dB insertion loss.

Transmission Measurements[6]

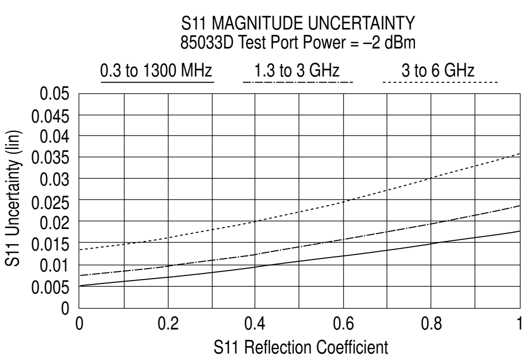


Magnitude (characteristic)

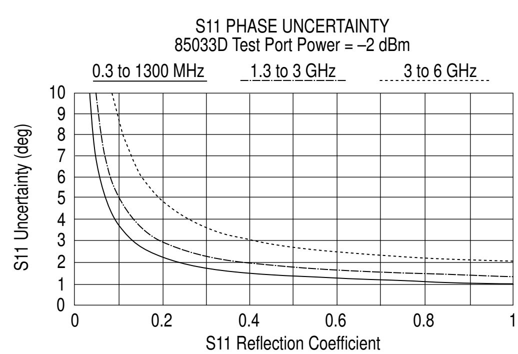


Phase (characteristic)

Reflection Measurements[7]



Magnitude (characteristic)



Phase (characteristic)

Lightwave Measurement Accuracy Example

Single point uncertainty

Individual uncertainty elements are shown below for a 3 GHz modulation frequency data point of a photodiode receiver slope responsivity measurement performed on an 8702D, 83403C, 83411C system. It is assumed that a lightwave response and match calibration has been performed. The uncertainty graph on page 4 summarizes the result of this same type of analysis for optical-to-electrical device measurements.

Device description

Device: photodiode receiver
Data point slope responsivity: –10 dBe
RF output port return loss: 14 dBe
Optical input port return loss: 30 dBo

The measurement uncertainty is calculated as follows:

$$[(\text{Receiver cal error})^2 + (\text{Source reflection sensitivity})^2 + (\text{Source/Receiver mismatch} + \text{Source/DUT mismatch})^2 + (\text{Receiver/8702D mismatch} + \text{DUT/8702D mismatch})^2 + (\text{System drift})^2]^{1/2}$$

Description of uncertainty terms

Receiver cal error can be found on page 14 as the corrected (disk) demodulation frequency response of the 83411C (±0.34 dBe.)

Source reflection sensitivity can be found on page 13 under reflection sensitivity of the 83403C (±0.04 dBe.)

Source/Receiver mismatch is the optical mismatch between the lightwave source and receiver and is calculated from the 83403C optical port match (return loss) of 35 dBo (page 13) and the 83411C optical port match (return loss) of 30 dBo (page 14.)

Source/DUT mismatch is the optical mismatch calculated from the 83403C optical port match of 35 dBo and the DUT optical input port return loss of 30 dBo.

Receiver/8702D mismatch is the RF mismatch calculated from the 83411C electrical input port match (return loss) of 13 dB (page 14) and the 8702D corrected load match for 3.5 mm test ports at 3 GHz (44 dB from page 10.)

DUT/8702D mismatch is the RF mismatch calculated from the DUT RF output port return loss of 14 dB and the 8702D corrected load match for 3.5 mm test ports at 3 GHz (44 dB.)

System drift can be found on page 12 (0.09 dBe for the 83403C/83411C pair.)

All uncertainty terms must be converted to their linear values using the following equation:

$$\text{linear uncertainty} = 10^{(\text{log uncertainty}/20)} - 1$$

Therefore:
receiver cal error = 0.040
source reflection sensitivity = 0.0046
system drift = 0.0104

The mismatch values are calculated using this equation:

$$\text{mismatch} = \rho 1 \rho 2 \quad \text{where } \rho = 10^{(\text{return loss}/-20)}$$

For example the DUT/8702D RF mismatch is

$$\rho 1 \rho 2 = 10^{(14\ \text{dBe}/-20)} * 10^{(44\ \text{dBe}/-20)} = 0.0013$$

Therefore:
Receiver/8702D RF mismatch = 0.0014
Source/DUT mismatch = 0.0006
Source/Receiver mismatch = 0.0006

Inserting the linear terms into the uncertainty equation yields:

$$[(0.040)^2 + (0.0046)^2 + (0.0006+0.0006)^2 + (0.0014+0.0013)^2 + (0.0104)^2]^{1/2} = 0.0417$$

Convert the linear term to a logarithmic value:

Responsivity flatness uncertainty (Characteristic)
= 20 log (0.0417 + 1) = **±0.35**

This same number could have been read from the 83403C/83411C curve of the O/E slope responsivity uncertainty curve found on page 4.

For a measured slope responsivity of –10 dBe the slope responsivity uncertainty window would be –10.35 dBe to –9.65 dBe.

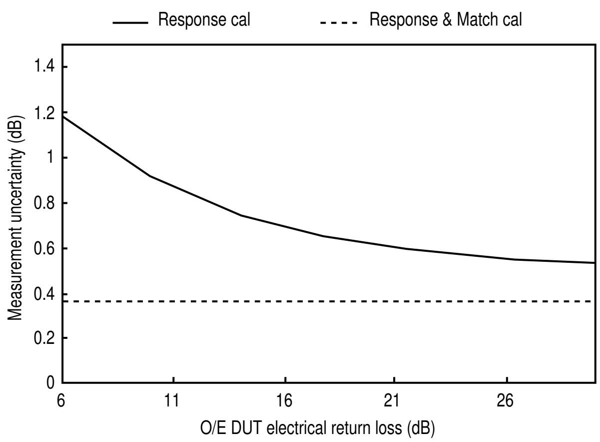
Absolute magnitude uncertainty includes additional error contributors, the greatest of which is optical con-nector loss uncertainty. An absolute uncertainty value for a specific data point can be calculated by adding ±0.76 dB to the value found on the uncertainty graphs.

Lightwave Measurement Accuracy and Repeatability

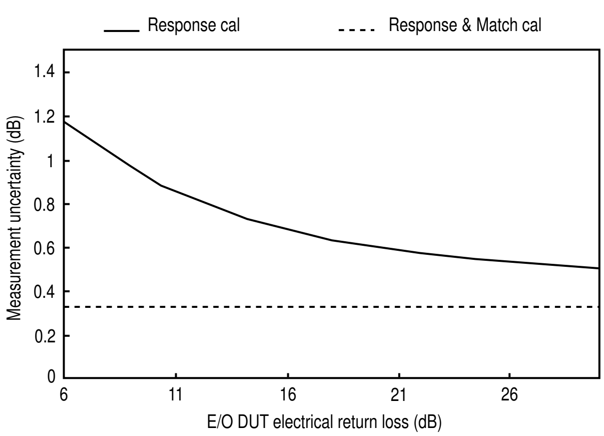
Comparison of Response and Response & Match Calibration

These graphs compare the measurement uncertainty in an O/E and E/O measurement using a response calibration and a response and match calibration. Measurement uncertainty for each calibration type is plotted as a function of the return loss of the DUT's electrical port. The plots show that measurement uncertainty is relatively insensitive to electrical port match when a response & match calibration is performed. Furthermore, measurement uncertainty is always smaller for a response & match calibration than it is for a response calibration, even for DUTs with excellent return loss values.

The results shown are for an 8702D system with an 83402C and 83411C at 6 GHz.



Measurement accuracy vs. O/E electrical return loss (characteristic)



Measurement accuracy vs. E/O electrical return loss (characteristic)

System Drift (Characteristic)

The following values of system drift were measured on an 8702D and the various combinations of lightwave source and receiver pairs listed in the table. Measurements were made over the modulation bandwidth of the lightwave receiver. The temperature of the 8702D was held constant at the ambient temperature while the source and receiver temperature was varied ±3° C.

Magnitude (characteristic)

	Drift in DATA/MEMORY (dBe)
	Agilent 83402C and 83403C
Agilent 83410C	0.25
Agilent 83411C	0.09
Agilent 83411D	0.1

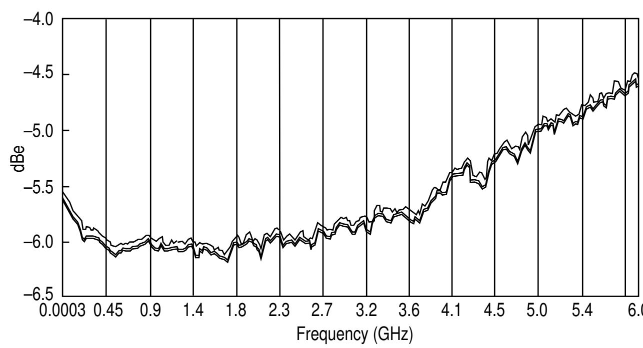
Phase (characteristic)

	Drift in DATA/MEMORY (deg)
	Agilent 83402C and 83403C
Agilent 83410C	1.5
Agilent 83411C	2.2
Agilent 83411D	1

Measurement Repeatability (Characteristic)

Typical measurement repeatability represents how measurement uncertainties can affect measurements made on different 8702D systems. Three systems consisting of an 8702D Option 006 (6 GHz frequency extension), 83403C, and 83411C each, was used to make measurements on an 83411C. The three traces in the graph below show three measurements of the same DUT (83411C) on the three systems. The following measurement conditions existed for each system:

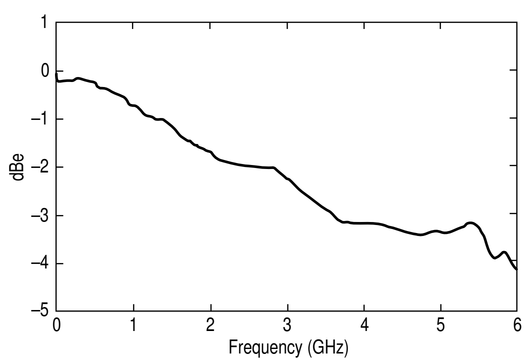
- response & match calibration
- 401 data points
- +10 dBm RF output power
- 300 kHz to 6 GHz modulation frequency
- 10 Hz IF bandwidth
- no averaging
- ambient temperature



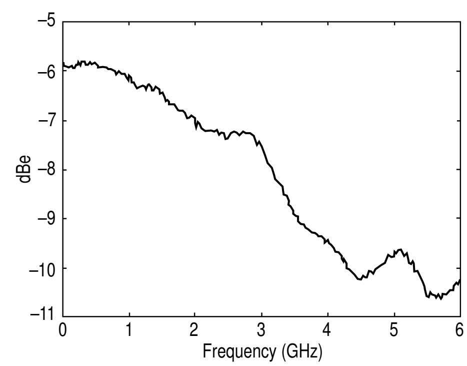
Agilent 8702D system repeatability of O/E measurement

Lightwave Source Performance Summary

Specifications and *Characteristics* (in italics)	**Agilent 83402C**	**Agilent 83403C**
Center wavelength[8,9]	1310 ±30 nm	1550 ±30 nm
Center wavelength stability[9]	*0.3% per year*	*0.3% per year*
Spectral Width[8,9]	*<50 MHz*	*<50 MHz*
Average optical output power[8,9]	2000–3000 µW	2000–3000 µW
Optical port return loss	*≥35.0 dBo*	*≥35.0 dBo*
Modulation range	300 kHz to 6 GHz	300 kHz to 6 GHz
RF input power (max)	*+11 dBm*	*+11 dBm*
DC into RF port (max)	20 V	20 V
Electrical port return loss[10]	≥11 dB	≥11 dB
Modulation frequency response (300 kHz to 6 GHz)[8]		
Corrected (disk) (specification)	±0.5 dBe	±0.5 dBe
Corrected (disk)	*±0.31 dBe*	*±0.31 dBe*
Corrected (polynomial)	*±1.5 dBe*	*±1.5 dBe*
Uncorrected	*±0.2/–4.8 dBe*	*+0.2/–4.8 dBe*
Responsivity at 140 MHz modulation frequency	*0.053 W/A (–25.5 dBe)*	*0.053 W/A (–25.5 dBe)*
Modulation (harmonic) distortion[11]		
300 kHz to 1 GHz	*25.0 dBc*	*25.0 dBc*
1 GHz to 3 GHz	*(footnote 12)*	*(footnote 12)*
1 GHz to 6 GHz	*8.0 dBc*	*8.0 dBc*
Third order intercept (min)[11]	*23 dBm*	*23 dBm*
1 dB modulation compression level at 50 MHz	—	—
Equivalent Input Noise		
0.01 to 5 GHz	*–124 dBm/Hz*	*–124 dBm/Hz*
5 to 6 GHz	*–119 dBm/Hz*	*–119 dBm/Hz*
Reflection Sensitivity (300 kHz to 6 GHz)[13]	*±0.04 dBe*	*±0.04 dBe*
Laser Type	DFB	DFB
Laser Class	FDA Class I and IEC Class IIIB	FDA Class I and IEC Class IIIB
Optical Fiber	9/125 µm	9/125 µm

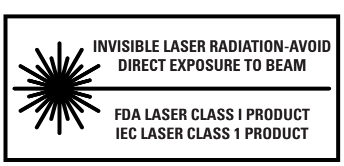


Agilent 83402C modulation frequency response (characteristic)



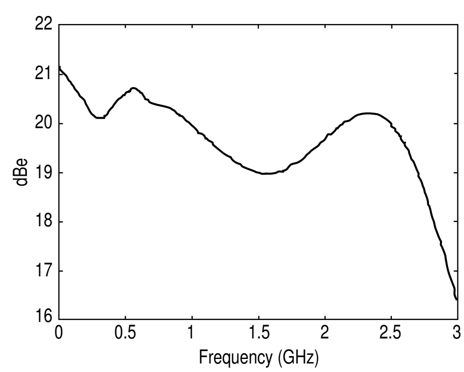
Agilent 83403C modulation frequency response (characteristic)

8 Factory test system
9 No intensity modulation applied.
10 Measured on 8703 from 130 MHz to 6 GHz.
11 Measured with +10 dBm RF input power 0.01 to 6 GHz.
12 Changes linearly from 25 dBc at 1 GHz to 8 dBc at 3 GHz.
13 To a Fresnel reflection using a 9:1 optical coupler, averaging factor = 16

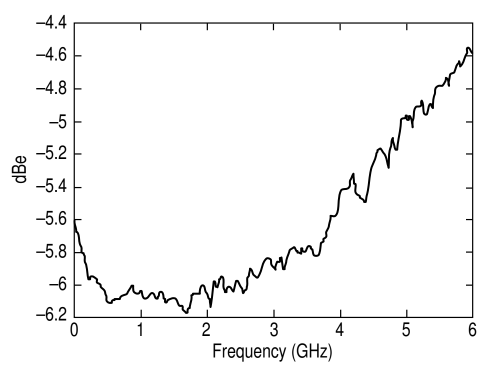


Lightwave Receiver Performance Summary

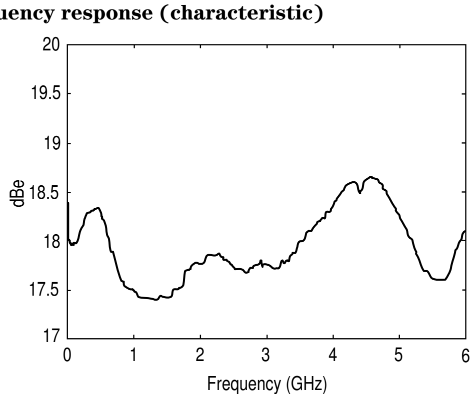
Specifications and *Characteristics* (in italics)		Agilent 83410C	Agilent 83411C	Agilent 83411D	Agilent 83412B
Input calibrated wavelength		1300/1550 nm	1300/1550 nm	1300/1550 nm	850 nm
Average optical input power (max)[14]		5 mW	5 mW	5 mW	5 mW
Optical port return loss[15]		*≥30 dBo*	*≥30.0 dBo*	*≥30.0 dBo*	*≥30 dBo*
Average Output Noise		*–135 dBm/Hz*	*–135 dBm/Hz*	*–85 dBm/Hz*	*–135 dBm/Hz*
Reverse RF power into RF OUT		20 dBm	20 dBm	20 dBm	20 dBm
Electrical port return loss	**300 kHz to 3 GHz**	≥13 dB	—	—	≥13 dB
	300 kHz to 6 GHz	—	≥13 dB	≥9.0 dB	—
Demodulation range		300 kHz to 3 GHz	300 kHz to 6 GHz	300 kHz to 6 GHz	300 kHz to 3 GHz
Demodulation frequency response					
Corrected (disk) (specification)	**300 KHz to 6 GHz**	±0.5 dBe	±0.5 dBe	±0.5 dBe	—
Corrected (disk)	***300 kHz to 3 GHz***	*±0.29 dBe*[16]	—	—	*±0.5 dBe*
	300 kHz to 6 GHz	—	*±0.34 dBe*[16]	*±0.38 dBe*[16]	—
Corrected (polynomial)	***300 kHz to 2 GHz***	*±1.5 dBe*[16]	—	—	*±2.5 dBe*
	2 GHz to 3 GHz	*±1.5 dBe*[16]	—	—	*±1.5 dBe*
	300 kHz to 6 GHz	—	*±1.5 dBe*[16]	*±1.5 dBe*[16]	—
Uncorrected	***300 kHz to 2 GHz***	*±3.0 dBe*[16]	—	—	*+3.0/–13.0 dBe*
	2 GHz to 3 GHz	*+3.0/–12.0 dBe*[16]	—	—	*+3.0/–13.0 dBe*
	300 kHz to 6 GHz	—	*+2.0/–3.0 dBe*[15]	*±3.0 dBe*[16]	—
Responsivity	***1300 and 1550 nm***	*10 A/W (20 dBe)*	—	—	*6.5 A/W (16.5 dBe)*[17]
	1300 nm	—	*0.45 A/W (–7 dBe)*	*7.0 A/W (17.0 dBe)*	—
	1550 nm	—	*0.40 A/W (–8 dBe)*	*6.3 A/W (16.0 dBe)*	—
Modulation (harmonic) distortion[18]					
300 kHz to 3 GHz		*25 dBc*	*25 dBc*	—	*25 dBc*
300 kHz to 10 GHz		—	—	*25 dBc*	—
1 dB modulation compression level					
300 kHz to 2 GHz		*>1 mW*	—	*>5 mW*	*>1 mW*
Average Power Out[19]	***Scale***	*2 V/mW*	*2 V/mW*	*2 V/mW*	*2 V/mW*
	Offset	*50 mW*	*1 mW*	*1 mW*	*50 mW*
8702 system receiver sensitivity[20]		*5.6 nW (–52 dBm)*	*141.6 nW (–38 dBm)*	*56.4 nW (–42 dBm)*	*8.9 nW (–50 dBm)*
Optical Fiber		62.5/125 µm	62.5/125 µm	62.5/125 µm	62.5/125 µm



Agilent 83410C demodulation frequency response (characteristic)



Agilent 83411C demodulation frequency response (characteristic)



Agilent 83411D demodulation frequency response (characteristic)

14 To achieve published characteristic system measurement uncertainty do not exceed 3 mW.
15 Measured on an 8702 System using time domain.
16 1300 nm
17 850 nm
18 With –5 dBm output power
19 8341XX models include an average optical input power measurement capability via a proportional DC voltage output (BNC connector interface). Offset voltage refers to the DC voltage offset during no optical input.
20 10 Hz IF bandwidth, 16 averages, p-p

Agilent 8702D Accessories

Agilent 11890A and 11891A
lightwave directional coupler characteristics

A lightwave directional coupler is required to measure optical return loss and for locating discontinuities in optical devices.

Wavelength: 820 to 1570 nm
Coupling factor (“test port” to “coupled port”): 3 dB
Main arm loss (“input port” to “test port”): 3 dB
Directivity[21]: 37 dB (with HMS-10 lightwave connectors)
Isolation (“input port” to “coupled port”): 40 dB
Return loss, all ports: 37 dBo (with HMS-10)
Compatible fiber:
HP 11890A: 9/125 um
HP 11891A: 50/125 um
Dimensions: 57 mm H x 143 mm W x 171 mm L
(2.25” x 5.63” x 6.75”)
Weight: 0.91 kg (2 lb)

21 Directivity (dB) = isolation (dB) - coupling factor (dB). Characteristic assumes a 37 dB return loss connector match at the coupler “test port.”

Coupler’s isolation will be degraded reducing directivity when a connector of less than 37 dB return loss is connected to the “test port.”
22 Option 025 is one meter pigtail fiber with FC/PC connector interface.

Agilent 11896A
polarization controller specifications

The 11896A adjusts polarization without adjusting power. Its optical fiber loop design provides all states of polarization with extremely small optical insertion loss variations (±0.002 dB) over a wide spectral range (1250 to 1600 nm). This performance combination maximizes measurement accuracy for power sensitive applications such as polarization-dependent loss and gain.

Operating wavelength range: 1250 to 1600 nm
Insertion loss variation: <1.5 dB (Opt. 025)[22]
with adjustment/rotation: ≤ ±0.002 dB (Opt. 025)[22]
Polarization extinction ratio: >40 dB
Polarization adjustment resolution: 0.18° (180°/1000 encoder positions)
Angular adjustment accuracy:
(minimum step size) ±0.18°
(greater than minimum step size) ±0.18°
Optical port return loss (characteristic):
Total reflections >55 dB (Opt. 025)[22]
Individual reflections >60 dB (Opt. 025)[22]
Dimensions: 100 mm H x 213 mm W x 360 mm D (3.9” x 4” x 14.2”)
Weight: 4.5 kg (10 lb)

Agilent 8702D Specifications

Test Port Output

Frequency Range: 30 kHz to 3 GHz (6 GHz with Opt. 006)
Frequency Resolution: 1 Hz
Frequency Stability: *(Characteristic)*
±7.5 ppm 0° to 55°C
±3 ppm/year
With Option 1D5:
±0.05 ppm 0° to 55°C
±0.5 ppm/year
Frequency Accuracy: ±10 ppm at 25°C±5°C
Power range: –85 to +10 dBm
Resolution: 0.05 dB
Level accuracy[23,27]: ±1.0 dB
Level linearity[23,24,27]: (–15 dBm to +5 dBm) ±0.2 dB
(5 dBm to 10 dBm) ±0.5 dB
Impedance: *50Ω (Characteristic)*
≥16 dB RL (<1.38 SWR) to 3 GHz
≥14 dB RL (<1.50 SWR) to 6 GHz
Spectral purity:
2nd harmonic[25]: <–25 dBc at 10 dBm
<–40 dBc at 0 dBm (typical)
<–50 dBc at –10 dBm (typical)
3rd harmonic[26]: <–25 dBc at 10 dBm
<–40 dBc at 0 dBm (typical)
<–50 dBc at –10 dBm (typical)
Nonharmonic spurious:
Mixer related: <–30 dBc at 10 dBm (typical)
<–55 dBc at –10 dBm (typical)

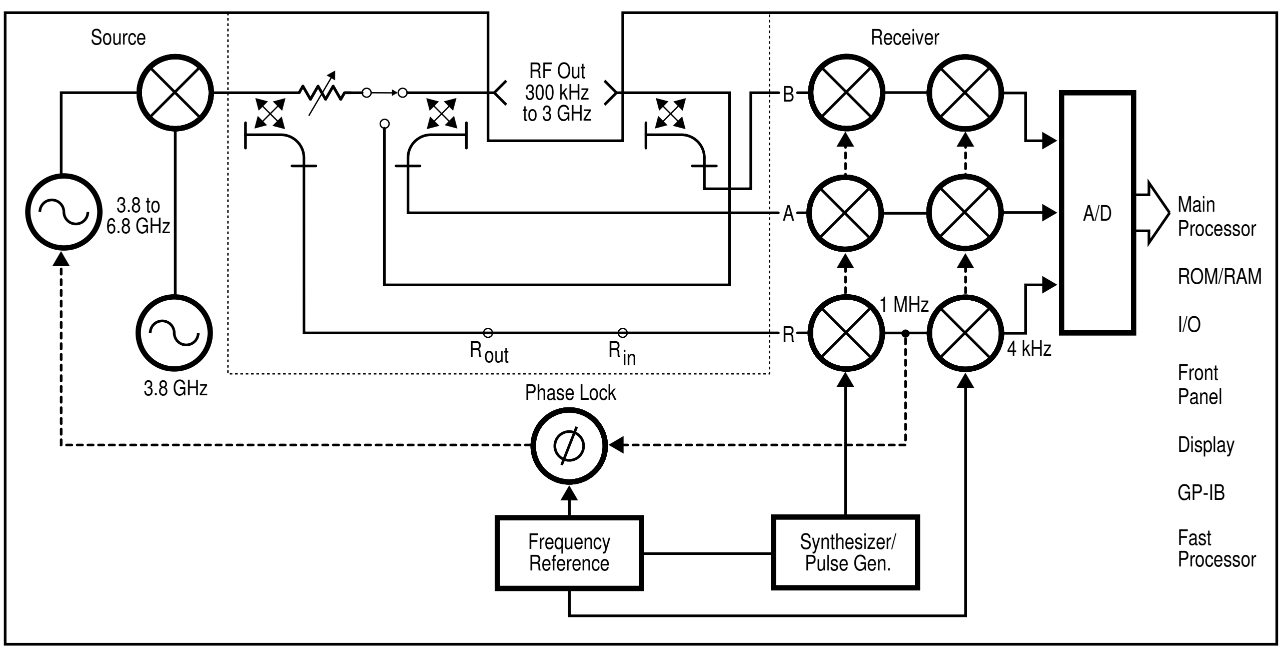
23 At 25°C ±5°C, relative to 0 dBm output power for the 8702D or +10 dBm output power for the 8702D Option 011.
24 Characteristic below 300 kHz
25 16 MHz to 3 GHz
26 16 MHz to 2 GHz
27 Characteristic from 2 to 3 GHz for instruments with Option 075

Test Port Input

Frequency range: 30 kHz to 3 GHz (6 GHz with Opt. 006)
Average noise level: –82 dBm (3 kHz BW, <3 GHz)
–102 dBm (10 Hz BW, <3 GHz)
–110 dBm (10 Hz BW, <3 GHz) (typical)
–77 dBm (3 kHz BW, 3 to 6 GHz)
–97 dBm (10 Hz BW, 3 to 6 GHz)
–105 dBm (10 Hz BW, 3 to 6 GHz) (typical)
Maximum input level: *(Characteristic) 10 dBm*
Damage level: *(Characteristic) 26 dBm or 35 VDC*
Impedance: *50Ω (Characteristic)*
≥10 dB RL, 30 kHz to 50 kHz
≥20 dB RL, 50 kHz to 300 kHz
≥18 dB RL, 300 kHz to 1.3 GHz
≥16 dB RL, 1.3 GHz to 3 GHz
≥14 dB RL, 3 GHz to 6 GHz
Frequency response[27]: (25° ±5°C)
±1.0 dB, 300 kHz to 3 GHz
±2.0 dB, 3 GHz to 6 GHz

Harmonics (Option 002):

2nd harmonic: <–15 dBc at +8 dBm
<–35 dBc at 0 dBm (typical)
<–45 dBc at –15 dBm (typical)
3rd harmonic: <–30 dBc at +8 dBm
<–50 dBc at 0 dBm (typical)
<–50 dBc at –15 dBm (typical)
Harmonic Measurement Accuracy: *(25° ±5°C)*
(Characteristic)
16 MHz to 3 GHz: + 1 dB
3 GHz to 6 GHz: + 3 dB (with Opt. 006)
Harmonic Measurement Dynamic Range:
(Characteristic)
–40 dBc (output = –10 dBm, input <–15 dBm)



Agilent 8702D block diagram

Agilent 8702D Specifications

Test Port Input (continued)

Frequency Offset Mode[29]

Frequency range: 300 kHz to 3 GHz
(6 GHz with Opt. 006)
R channel input requirements:
Power level: 0 to –35 dBm to 3 GHz
0 to –30 dBm, 3 GHz to 6 GHz
Spectral purity:
Maximum spurious input: <–25 dBc
Residual FM: <20 kHz
LO Frequency accuracy: –1 to +1 MHz of nominal frequency

External Source Mode[30] (CW Time sweep only)

Frequency range: 300 kHz to 6 GHz
R channel input requirements[28]:
Power level: 0 to –25 dBm
Spectral purity:
Maximum spurious input: <–30 dBc
Residual FM: <20 kHz
Typical settling time: 500 ms (auto)
50 ms (manual)
Frequency readout accuracy: 0.1% typical (auto)
Input frequency margin[28]: Manual: –0.5 to 5 MHz
Auto: ≤50 MHz, ±5 MHz
>50 MHz, ±10% CW freq.
Accuracy: (See Magnitude and Phase Characteristics)

28 Performance characteristic
29 The 8702D RF source performance and measurement accuracy in this mode are dependent on the stability of the external LO source. The RF source tracks the LO to maintain a stable IF signal at the R channel receiver input. Degradation in accuracy is negligible when using an 8642A/B or 8656B RF signal generator as the LO source.
30 See the 8702D descriptions and options for a functional description. Measurement accuracy is dependent on the stability of the input signal.
31 Marker resolution for magnitude, phase and delay is dependent upon measured value. Resolution is limited to five digits.

Magnitude Characteristics

Display resolution: 0.001 dB/division
Marker resolution[31]: 0.001 dB
Trace noise: < 0.006 dB rms, 30 kHz to 3 GHz
< 0.010 dB rms, 3 GHz to 6 GHz
(+5 dBm at test port, ratio measurement, 3 kHz BW)
Reference level: Range: ±500 dB
Resolution: 0.001 dB
Stability: 0.02 dB/°C, 30 kHz to 3 GHz
0.04 dB/°C, 3 GHz to 6 GHz

Phase Characteristics

Range: ±180 degrees
Display resolution: 0.01°/division
Marker resolution[31]: 0.01°
Trace noise: < 0.038° rms to 3 GHz
< 0.070° rms to 6 GHz
(5 dBm at test port, ratio measurement, 3 kHz BW)
Reference level: Range: ±500 degrees
Resolution: 0.01 degree
Stability: 0.05°/°C, 30 kHz to 3 GHz
0.20°/°C, 3 GHz to 6 GHz

Polar Characteristics

Range: 10 x 10^{-12} to 1000 units full scale
Reference: ±500 units

Agilent 8702D Option 011 Specifications

Test Port Output

Frequency Range: 300 kHz to 3 GHz
30 kHz to 6 GHz (with Option 006)
Frequency Resolution: 1 Hz
Frequency Stability: *(Characteristic)*
±7.5 ppm 0° to 55°C
±3 ppm/year
With Option 1D5:
±0.05 ppm 0° to 55°C
±0.5 ppm/year
Frequency Accuracy: ±10 ppm at 25°C±5°C
Power range: –5 to +20 dBm
–5 to +18 dBm (with Option 006)
Resolution: 0.05 dB
Level accuracy[23]: ±1.0 dB
Level linearity[23,24,32]: (–15 dBm to +5 dBm) ±0.2 dB
(5 dBm to 10 dBm) ±0.5 dB
Impedance: *50Ω (Characteristic)*
≥16 dB RL (<1.38 SWR) to 3 GHz
≥14 dB RL (<1.50 SWR) to 6 GHz
Spectral purity:
2nd harmonic[25]: <–25 dBc at 20 dBm
<–40 dBc at 10 dBm (typical)
<–50 dBc at 0 dBm (typical)
3rd harmonic[26]: <–25 dBc at 20 dBm
<–40 dBc at 10 dBm (typical)
<–50 dBc at 0 dBm (typical)
Nonharmonic spurious:
Mixer related: <–30 dBc at 20 dBm (typical)
<–55 dBc at 0 dBm (typical)

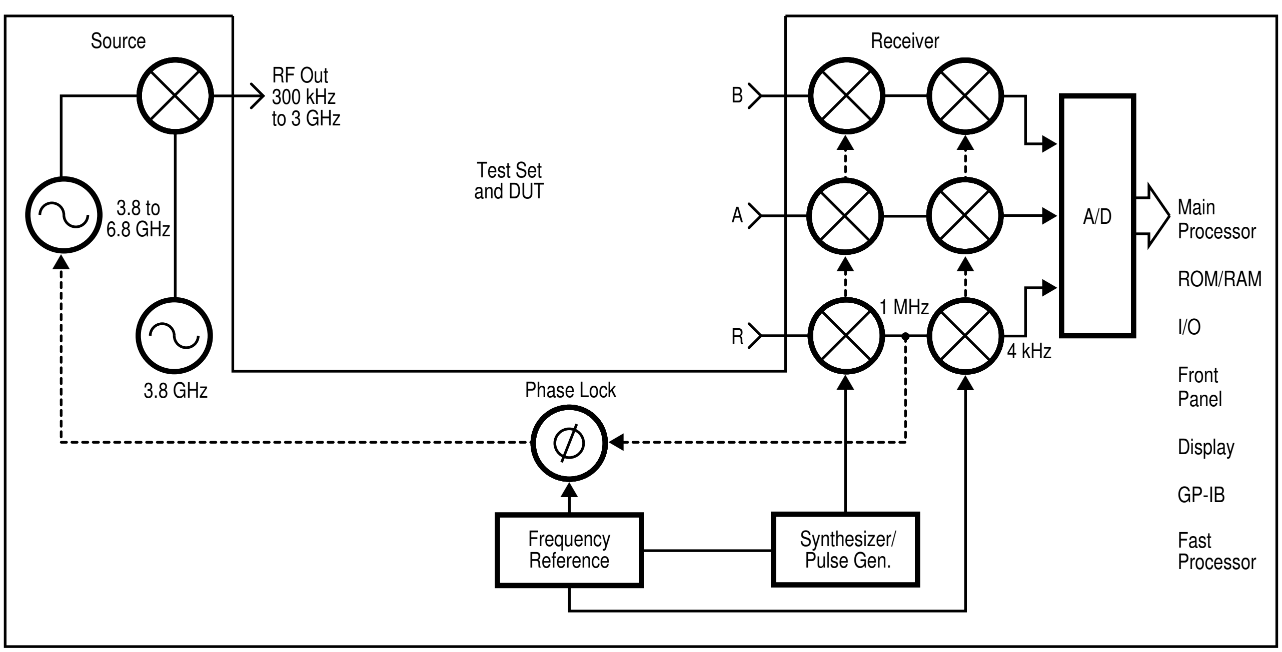
32 For 8702D Option 011 and Option 006, linearity is determined for the ranges of (–5 to +13 dBm) and (+13 to +18 dBm).

Test Port Input

Frequency range: 300 kHz to 3 GHz
30 kHz to 6 GHz (with Option 006)
Average noise level:
–95 dBm (3 kHz BW, 50 kHz to 3 GHz)
–115 dBm (10 Hz BW, 50 kHz to 3 GHz)
–120 dBm (10 Hz BW, 50 kHz to 3 GHz) (typical)
–90 dBm (3 kHz BW, 3 to 6 GHz)
–110 dBm (10 Hz BW, 3 to 6 GHz)
–115 dBm (10 Hz BW, 3 to 6 GHz) (typical)
Maximum input level: *(Characteristic) 0 dBm*
Damage level: *(Characteristic) 20 dBm or 35 VDC*
Impedance: *50Ω (Characteristic)*
>10 dB RL, 30 kHz to 50 kHz
>20 dB RL, 50 kHz to 300 kHz
>23 dB RL, 300 kHz to 1.3 GHz
>20 dB RL, 1.3 GHz to 3 GHz
>8 dB RL, 3 GHz to 6 GHz
Frequency response: (25° ±5°C)
±1.0 dB, 300 kHz to 3 GHz
±2.0 dB, 3 GHz to 6 GHz

Harmonics (Option 002):

2nd harmonic: <–15 dBc at 0 dBm
<–30 dBc at –10 dBm (typical)
<–45 dBc at –30 dBm (typical)
3rd harmonic: <–30 dBc at 0 dBm
<–50 dBc at –10 dBm (typical)
<–50 dBc at –30 dBm (typical)
Harmonic Measurement Accuracy: *(25° ±5°C)*
(Characteristic)
16 MHz to 3 GHz: ±1 dB
3 GHz to 6 GHz: ±3 dB (With Option 006)
Harmonic Measurement Dynamic Range:
(Characteristic)
–40 dBc (output = –10 dBm, input <–15 dBm)



Agilent 8702D Option 011 block diagram

Agilent 8702D Option 011 Specifications

Test Port Input (continued)

Frequency Offset Mode[29]

Frequency range: 300 kHz to 3 GHz
(6 GHz with Opt. 006)
R channel input requirements:
Power level: 0 to –35 dBm to 3 GHz
0 to –30 dBm, 3 GHz to 6 GHz
Spectral purity:
Maximum spurious input:<–25 dBc
Residual FM: <20 kHz
LO Frequency accuracy: –1 to +1 MHz of nominal frequency

External Source Mode[30] **(CW Time sweep only)**

Frequency range: 300 kHz to 6 GHz
R channel input requirements[28]:
Power level: 0 to –25 dBm
Spectral purity:
Maximum spurious input: <–30 dBc
Residual FM: <20 kHz
Typical settling time: 500 ms (auto)
50 ms (manual)
Frequency readout accuracy: 0.1% typical (auto)
Input frequency margin[28]:
Manual: –0.5 to 5 MHz
Auto: ≤50 MHz, ±5 MHz
>50 MHz, ±10% CW freq.
Accuracy: (See Magnitude and Phase Characteristics)

Magnitude Characteristics

Display resolution: 0.001 dB/division
Marker resolution[31]: 0.001 dB
Trace noise: < 0.006 dB rms, 30 kHz to 3 GHz
< 0.010 dB rms, 3 GHz to 6 GHz
(+5 dBm at test port, ratio measurement, 3 kHz BW)
Reference level: Range: ±500 dB
Resolution: 0.001 dB
Stability: 0.02 dB/°C, 30 kHz to 3 GHz
0.04 dB/°C, 3 GHz to 6 GHz

Phase Characteristics

Range: ±180 degrees
Display resolution: 0.01°/division
Marker resolution[31]: 0.01°
Trace noise: <0.038° rms to 3 GHz
<0.070° rms to 6 GHz
(5 dBm at test port, ratio measurement, 3 kHz BW)
Reference level: Range: ±500 degrees
Resolution: 0.01 degree
Stability: 0.05°/°C, 30 kHz to 3 GHz
0.20°/°C, 3 GHz to 6 GHz

Polar Characteristics
Range: 10 x 10^{-12} to 1000 units full scale
Reference: ±500 units

Agilent 8702D Supplemental Characteristics

Measurement

Number of display channels:
Two display channels available

Measurement parameters:
Agilent 8702D: S11, S21, S12, S22, A, B, R, A/R, B/R, A/B. Conversion to impedance or admittance

Formats:
Cartesian: log/linear magnitude, phase, group delay, SWR, real and imaginary.
Smith chart: with log/linear amplitude and phase, R + jX, G + jB, or real/imaginary markers.
Polar: with linear/log amplitude, phase, or real and imaginary markers.

Data markers:
Each display channel has five independent markers which can be displayed simultaneously. Markers can indicate data at actual data points or they can interpolate between data points to allow the setting of a marker at an exact frequency. Any one of the five markers can be the reference marker for delta marker operation. Markers can be coupled or uncoupled between display channels. Ten independent markers can be displayed simultaneously on a single measurement in dual channel mode when markers are uncoupled.

Marker functions:
Markers can be used in various functions: Marker search (Mkr to max, Mkr to min, Mkr to target), Mkr bandwidth with user-defined target values, mkr → start, mkr → stop, mkr → center, mkr → span, mkr → reference, mkr → delay, and trace statistics (average value, stan-dard deviation, and peak-to-peak deviation of the data trace between two markers). The tracking function enables continuous update of marker search values on each sweep.

Group delay characteristics
(For Electrical-to-Electrical Devices)

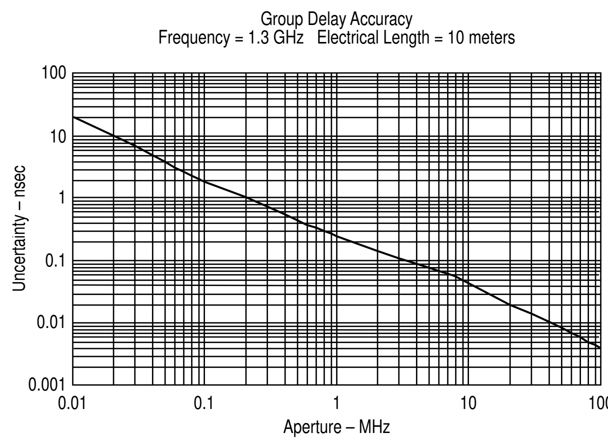
Group delay is computed by measuring the phase change within a specified frequency step (determined by the frequency span, and the number of points per sweep).

Aperture: selectable
maximum aperture: 20% of frequency span
minimum aperture: (freq. span) / (number of points –1)

Range:
The maximum delay is limited to measuring no more than 180° of phase change within the minimum aperture.

Range = 1 / (2 x minimum aperture)

Accuracy:
The following graph shows group delay accuracy at 1.3 GHz with Type-N full two-port calibration and 10 Hz IF bandwidth. Insertion loss is assumed to be < 2 dB and electrical length to be ten meters.



Group delay accuracy vs. aperture (characteristic)

In general, the following formula can be used to determine the accuracy, in seconds, of a specific group delay measurement.

±(0.003 x Phase accuracy (deg)) / Aperture (Hz)

Depending on the aperture and device length, the phase accuracy used is either incremental phase accuracy or worse case phase accuracy. The above graph shows this transition.

Agilent 8702D Supplemental Characteristics

Source Control

Sweep limits:
Set start/stop or center/span of the stimulus parameter (frequency, power, time) directly through the source control keys and the control knob, the step keys or the data entry keyboard.

Sweep type:
Set a linear or logarithmic sweep, an arbitrarily defined frequency list, a power sweep or a CW (single frequency) type of sweep.

Measured number of points per sweep:
Linear frequency: choose 3, 11, 26, 51, 101, 201, 401, 801, or 1601 points.

Arbitrary frequency list:
Define up to 30 different sub-sweep frequency ranges in any combination of CW, CW-Delta F, or Start-Stop sweep modes.

Sweep modes:
Set a coupled channel sweep (same stimulus conditions on both channels) or an uncoupled channel sweep (alternate sweep).

Chop/alternate:
Select whether to alternately or simultaneously (chop) measure channels when in dual channel mode. Chop mode is faster, while alternate mode optimizes dynamic range. The analyzers default to chop mode.

Sweep time:
Set sweep time in seconds, minutes or hours. Minimum sweep time is dependent on number of data points per sweep and selected IF bandwidth.

Auto sweep time:
Select auto sweep time by entering zero seconds sweep time. The analyzer will sweep at the minimum sweep time for any subsequently selected stimulus conditions. Auto sweep time is the default condition.

Sweep trigger:
Set to either continuous, hold, single, group sweep, or external trigger. Set external trigger to take a complete sweep or to measure individual points in a frequency, power or list sweep.

Power:
Set source power (–85 to +10 dBm). Power slope can be set in dBm/GHz. Control the test port signal by setting the internal attenuator of the test set over a 70 dB range. Power trip automatically reduces source power to its minimum value when excessive signal levels are incident on the receiver test port. A caution message is also displayed. (Source power range differs depending on the selected options. Refer to the "Test Port Output Characteristics" section for the appropriate instrument for more information.)

Power Meter Calibration

Description:
Use a power meter to set leveled input or output power at the device-under-test at a single point or an entire sweep. With an Agilent 436A, 437B or 438A power meter connected, the Cal Sweep measures the actual test port power. After the calibration is enabled, the internal RF source power is adjusted (within the range of –85 to +10 dBm) to achieve the selected power at the input of the device under test rather than at the test port output. GP-IB control of the power meter for normalization or leveling is built-in. Logarithmic, linear, CW, and list sweeps can be calibrated.

Update calibration:
Select continuous leveling (requires a power splitter) by measuring and updating source power on each sweep or use a correction table (to modify source power) which is created with an initial single sweep.

Number of readings:
Make single or multiple power meter readings at each frequency.

Data accuracy enhancement

Measurement calibration:
Measurement calibration is the process through which measurement uncertainty due to errors caused by system directivity, source and load match, tracking, and cross-talk are significantly reduced. A wide range of calibrations are available for the 8702D. A lightwave response and match calibration is used to achieve the most accurate measurements on electro-optical devices (Option 011 requires an s-parameter test set). Full two-port calibration removes all the systematic errors to obtain the most accurate measurements on electrical-to-electrical devices.

Calibration types available:

Frequency response:
Simultaneous magnitude and phase correction of frequency response errors for either reflection or transmission measurements. Requires a short or open circuit termination (reflection) or a through connection (transmission).

Response and isolation:
Compensates for frequency response and directivity (reflection) or frequency response and crosstalk errors. Requires an open, short, and load circuit termination (reflection) and a through connection and load termin-ation (transmission).

One-port calibration
(also lightwave response and match calibration):
Uses test set port 1 or port 2 to correct for directivity, frequency response and source match errors. Requires open, short, and load.

Agilent 8702D Supplemental Characteristics

Two-port calibration:
Compensates for directivity, source match, reflection frequency response, load match, transmission frequency response and crosstalk for an S-parameter test set. Crosstalk calibration can be eliminated. Requires open, short, and load terminations for both ports plus a through connection.

TRL*/LRM* calibration:
Compensates for directivity, reflection and transmission frequency response, and crosstalk in both the forward and reverse directions. Especially suitable for calibrating non-coaxial environments, such as in test fixtures. Requires through, reflect, and line or match standards. TRL*/LRM* is a special implementation of TRL/LRM calibration, modified for the three-sampler receiver in the 8702D.

One-port, two-path calibration:
A two-port cal for the one-port reflection/transmission test sets. Provides a full two-port error corrected measurement when the device under test is turned around and measured in both directions.

Interpolated error correction:
With any type of accuracy enhancement applied, interpolated mode recalculates the error coefficients when the test frequencies are changed. The number of points can be increased or decreased and the start/stop frequencies can be changed, but the resulting frequency span must be equal to or less than the original calibration frequency span. System performance is not specified for measurements with interpolated error correction applied.

Set Z_O:
Can redefine the characteristic impedance of a measurement to a value other than 50 or 75 ohms.

Velocity factor:
Enters the velocity factor to calculate equivalent electrical length.

Reference plane extension:
Redefine the plane of measurement reference to other than port 1 or port 2 of the 8702D. A new reference plane is defined in seconds of delay from the test set port and ranges between ±1 seconds.

Select default calibration kit:
Select from a list of standard calibration kits: 7 mm, 3.5 mm (choose 85033C or 85033D), Type-N 50 ohm, and Type-N 75 ohm. You can also define the standards (e.g., open circuit capacitance coefficients, offset short length, or fixed loads) of a user-defined kit.

Data averaging:

IF bandwidth:
The IF bandwidth is selectable from 3 kHz to 10 Hz bandwidth to reduce the effective displayed noise floor of the instrument.

Weighted sweep-to-sweep averaging:
Averages vector data on each successive sweep. A(n) = S(n)/F + (1-1/F)*A(N-1) where A(n) is the current average, S(n) is the current input signal and F is the averaging factor. Averaging factors range from 1 to 999.

Trace smoothing:
Similar to video filtering, this function computes the moving average of adjacent data points. Advantageous in reducing relatively small peak-to-peak noise values on large broadband measured data. Smoothing aperture defines the trace width (number of points) to be averaged, and ranges from 0.25% to 20% of the trace width. This function also sets the aperture for group delay measurements.

Display Control

CRT formats:
Single channel, dual channel overlay (both traces on one graticule), dual channel split (each trace on separate graticules).

Trace functions:

Display data: Display current measurement data, memory data, or current measurement with measurement and memory data simultaneously.
Trace math: Vector division or subtraction of current linear measurement values and memory data.

Display annotations:
Start/stop, center/span, or CW frequency, source level, scale/div, reference level, marker data, soft key functions, warning and caution messages, trace identification, and pass/fail indication.

Reference position:
Ranges from the 0 (bottom) to 10 (top) graticule position.

Autoscale:
Automatically selects scale resolution and reference value to center the trace on the CRT graticules for easy viewing.

Electrical delay:
Offset measured phase or group delay by a defined amount of electrical delay, in seconds. Operates similarly to an electronic line stretcher. Amount of electrical delay can range between ±1 seconds.

Agilent 8702D Supplemental Characteristics

Frequency blanking:
Blank out all frequency information on the display. Requires an instrument preset to re-enable frequency information on the display.

Title:
Add custom titles (49 characters maximum) to the display. Titles will be plotted when making hardcopies of displayed measurements. Titles can also be used to display operator messages or prompts for a manual adjustment during a test sequence.

Adjust display:
Control the intensity and background intensity values of the display. Also, customize the color, value, and brightness of the data traces, memory traces, reference lines, graticules, text, and warning messages. Default colors can be recalled along with one set of user-defined display values. Control is in % of full range.

Storage

Instrument state:
Up to 31 instrument states can be stored internally or recalled via the SAVE/RECALL menu. Instrument states include all control settings, active limit lines, active list frequency tables, memory trace data, active calibration coefficients, and custom display titles. Storage is in non-volatile memory.

Test sequences:
Six measurement sequences can be stored or recalled via the sequencing menu. Sequences may also be recalled from Preset menu. Sequence register 6 is part of non-volatile storage and is not erased during a power cycle. If sequence 6 is titled AUTO, it will be executed when power is turned on.

Disk drive:
Data, instrument states (including calibration data), user graphics, data plots (HP-GL commands), and test sequences can also be stored on disk, using the 8702D's built-in disk drive or an external disk drive with command subset CS/80. Data files can be stored in MS-DOS format or Hewlett-Packard's standard LIF format, which can be read by a wide variety of computers, including the HP 9000 series 300 and 400. Files can be stored in binary or ASCII formats. A disk to be used for data storage can be initialized directly by the 8702D.

Data Hardcopy

Data plotting:
Hard copy plots are automatically produced with HP-GL compatible digital plotters and compatible graphics printers such as most HP DeskJets or LaserJets (in single color or multi-color format). The 8702D provides Centronics, RS-232C, and GP-IB interfaces.

Data listings:
Printouts of instrument data are directly produced with a printer such as most HP DeskJets or PaintJets. Select a standard (single color) or color print (with color printers).

Configure plots:
Configure plots completely from the 8702D by defining pen color and line type for data, text markers, graticules, and memory traces.

Functions:
Plot trace(s), graticule(s), markers(s), or text including operating and system parameters.

Quadrants:
Plot entire display in one of four different quadrants of the plotter paper.

System Capabilities

Limit lines:
Define test limit lines that appear on the display for go/no go testing. Lines may be any combination of horizontal, sloping lines, or discrete data points. Limit test TTL output available for external control or indication.

Operating parameters:
Display, print or plot current instrument operating parameters.

Transform:
With time domain capability, selects the Time Domain transform menu.

Harmonic measurements:
When harmonic measurement (Option 002) is present, selects the 2nd or 3rd harmonic measurement menu.

Instrument mode:
Select external source, tuned receiver or frequency offset mode.

External source mode:
The receiver (input R) detects and phase-locks to any externally generated CW signal. Receiver inputs A and B will measure this same frequency for comparison or tracking measurements.

Auto: The input signal frequency is counted and displayed.

Manual: Measures the input signal closest to the frequency specified by the user (within –0.5 to +5 MHz).

Tuned receiver:
Tunes the receiver for a synthesized CW input signal at a precisely specified frequency. The time bases of the external RF source or sources must be tied to the external reference input (rear panel BNC). The built-in RF source is not used.

Agilent 8702D Supplemental Characteristics

Frequency offset on/off:
Sets the RF source to be swept at a fixed offset frequency above the receiver as required in a swept RF/IF, fixed LO, mixer test. The maximum delay between the RF source and the R channel input is 0.3 microseconds. Frequency offset mode has a 6 GHz maximum source limitation.

Offset value:
Set the offset frequency value.

Service menu:
Select the desired service test, service diagnostic, service or verification mode.

Test Sequences

Description:
Create, edit, save or recall a series of front-panel keystrokes to automate a measurement. Each of the six sequence registers can hold approximately 200 instructions. Create or edit a sequence by selecting the sequence menu and then simply performing the front-panel keystrokes that would normally be used to make a manual measurement. Test sequences may contain basic stimulus and measurement functions (frequency, power, parameter, format, scale) advanced operations (time domain, limit testing, display marker values) and basic logical branching (IF limit test fails DO sequence 5). Completed sequences are then saved and can be executed when you are ready to repeat the test.

Storage:
Test sequences can be stored internally to a disk drive and can be loaded from a computer over the GP-IB interface. Sequence 6 is saved in non-volatile storage and can be used as an autostart routine when titled AUTO.

Branching:
Branch to another sequence on limit test pass/fail, or the loop counter value. Subroutines are also possible via GOSUB.

Other GP-IB instruments:
Send simple commands to GP-IB instruments via the title string.

Test sequence BNC output:
Set TTL high or low on the 8702D's test set rear panel output.

General purpose input/output:
Read or write bits to the output port to control external devices such as part handlers. Eight output and five input TTL lines are available on the parallel port of the 8702D.

Other functions:
PAUSE/continue, wait, title sequence, print sequence, duplicate sequence, pause and select.

Time Domain

Description:
With time domain, data from transmission or reflection measurements in the frequency domain is converted to the time domain using a Fourier transformation technique (Chirp Z) and presented on the display. The time domain response shows the measured parameter value versus time. Markers may also be displayed in electrical length (or physical length if the relative propagation velocity is entered).

Time stimulus modes

Standard stimulus:
Two types of time excitation stimulus waveforms can be simulated during the transformation — a step and an impulse.

External stimulus:
The definition of other time excitation stimulus waveforms can be accomplished using an external controller.

Low pass step:
This stimulus, similar to a traditional time domain reflectometer (TDR) stimulus waveform, is used to measure low pass devices. The frequency domain data should extend from DC (extrapolated value) to a higher value, the upper limit being defined by the test set used. The time domain response shows the parameter value versus time (multiply by the speed of light, c, to obtain electrical length or by c and Vrel to obtain physical length). The step response is typically used for reflection measurements only.

Low pass impulse:
This stimulus is also used to measure low pass devices. The frequency domain data should extend from DC (extrapolated value) to a higher value, the maximum frequency determined by the test set. The time domain response shows changes in the parameter value versus time. The impulse response can be used for reflection or transmission measurements.

Bandpass impulse:
The bandpass impulse stimulates a pulsed RF signal (with an impulse envelope) and is used to measure the time domain response of band-limited devices. The start and stop frequencies are selectable by the user to any values within the limits of the test set used. The bandpass time domain response also shows changes in the parameter values versus time. Bandpass time domain responses are useful for both reflection and transmission measurements.

Agilent 8702D Supplemental Characteristics

Time domain range:
The range over which the display is free of response repetition depends on the frequency span and the number of points. Range, in nanoseconds, is determined by:

$$Range = 1/\Delta F = \frac{(\text{Number of points in Frequency Domain} -1)}{\text{Frequency Span (GHz)}}$$

Range resolution:
Range-resolution is how closely in time that a response can be located.

Range-resolution = time span/(number of points –1)

As the time span is reduced, the single-event measurement resolution will eventually be limited by the phase accuracy of the instrument. The measurement resolution, in seconds, due to phase accuracy uncertainty is then:

Range-resolution = 0.003* phase uncertainty (deg)/aperture (Hz)

Windows:
The windowing function can be used to modify (filter) the frequency domain data and thereby reduce over-shoot and ringing in the time domain response. Three types of windows are available — minimum, normal, and maximum.

Gating:
The gating function can be used to selectively remove reflection or transmission time domain responses. In converting back to the frequency domain the effects of the responses outside the gate are removed. The location and span of the gate can be controlled by setting either the center position and time span of the gate or by setting the start and stop time of the gate.

Agilent 8702D Options

Harmonic measurements (Option 002)

Description:
Measures amplifier 2nd and 3rd harmonics on a swept-frequency basis for fundamental signals above 16 MHz. Harmonics are measured up to the maximum frequency range of the receiver. The second harmonic of 1.5 GHz fundamental and 3rd harmonic of a 1 GHz fundamental can be measured and displayed. If option 006 is installed, the 2nd harmonic of a 3 GHz fundamental and 3rd harmonic of a 2 GHz fundamental can be measured.

RF dynamic range
(source at –10 dBm, receiver <–30 dBm):
–40 dBc (minimum)

Accuracy:[33] ±1 dB (<6 GHz)

6 GHz operation (Option 006)

Description:
The 6 GHz option provides a fundamental 6 GHz RF source and an RF receiver capable of measuring signals up to 6 GHz. When external source, tuned receiver or harmonic mode is used, the receiver is capable of measuring signals up to 6 GHz.

High Stability Frequency Reference (Option 1D5)

Description:
This option adds an ovenized 10 MHz frequency reference output to the 8702D. It is connected to the external reference input on the rear panel. See the "General Characteristics" section for more information.

Measurement Throughput Summary

The following table shows measurement time characteristics in milliseconds.

Time for completion (msec)
(Characteristic)

	Number of Points			
	51	**201**	**401**	**1,601**
Measurement				
Uncorrected, 1-port cal[34]	125	200	300	900
Two-port cal[35]	245	510	855	2,940
Time domain conversion[36]	80	350	740	1,790
GP-IB data transfer[37]				
Internal binary	20	35	55	205
ASCII	140	510	1,000	3,960
IEEE 754 floating point format:				
32-bit	25	85	150	590
64-bit	40	115	220	840

Remote Programming

Interface:
GP-IB interface operates to IEEE 488-1978 and IEC 625 standards and IEEE 728-1982 recommended practices.

Addressing:
The GP-IB address of the 8702D can be verified or set from the front panel via the local menu and can range from 0 to 30 decimal (factory set at 16).

Pass control:
Allows the 8702D to request control of the GP-IB (when an active controller is present) whenever it needs to output to a plotter or printer.

33 Does not include error from the 8702D source and receiver harmonics
34 One-port calibration, with a 3 kHz IF bandwidth. Includes system retrace time, but does not include bandswitch time. Time domain gating is assumed off.
35 Same as footnote 35, but for an S21 measurement with full two-port calibration. Includes RF switching time
36 Time domain only, gating off
37 Measured with an HP 9000 Series 300 computer.

Agilent 8702D Supplemental Characteristics

System controller:
Lets an 8702D become a controller on the GP-IB to directly control a plotter or a printer.

Talker/listener:
Lets the 8702D become an GP-IB talker/listener when an external controller is present.

Transfer formats:
Binary (internal 48-bit floating point complex format)
ASCII
32- or 64- bit IEEE 754 floating point format

User-accessible graphics:
Using a subset of HP graphics language (HP-GL), vector or text graphics may be written on the 8702D via GP-IB. Up to 5 kbytes of data can be stored at one time (4 bytes per vector, 2 bytes per character).

Interface function codes:
SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT0, C1, C2, C3, C10, E2

General Characteristics

Front Panel Connectors

8702D test ports (without Option 011):
Connector type: 7 mm precision
Impedance: 50 ohms
Connector conductor depth: 0.000 to 0.003 in.
Option 011 test ports:
Connector type: Type-N
Impedance: 50 ohms
Connector center pin protrusion: 0.204 to 0.207 in.
Option 075 test ports:
Connector type: Type-N
Impedance: 75 ohms
Connector center pin protrusion: 0.204 to 0.207 in.
Probe power:
+15V ±2% 400 mA (combined load for both probe connections)
–12.6V ±5.5% 300 mA (combined load for both probe connections)

Rear Panel Connectors

External reference frequency input (EXT REF INPUT):
Frequency: 1, 2, 5, and 10 MHz (±200 Hz at 10 MHz)
Level: –10 dBm to +20 dBm
Impedance: 50 ohms
High-stability frequency reference output (Option 1D5)
Frequency: 10.0000 MHz
Frequency Stability (0°C to 55°C): ±0.05 ppm
Daily Aging Rate (after 30 days): $<3\times10^{-9}$/day
Yearly Aging Rate: 0.5 ppm/year
Output: 0 dBm minimum
Nominal Output Impedance: 50Ω

External auxiliary input (AUX INPUT)
Input Voltage Limits: –10V to +10V
External AM input (EXT AM): ±1 volt into a 5 kW resistor, 1 kHz maximum, resulting in 8 dB/volt amplitude modulation.
External trigger (EXT TRIGGER): Triggers on a negative TTL transition or contact closure to ground.

Test sequence output (TEST SEQ)
By default, this connector outputs a TTL end-of-sweep signal. It can also be programmed by the user in a test sequence to output a user-defined TTL signal.

Limit test output (LIMIT TEST):
This connector outputs a TTL signal of the limit test results. Pass: TTL high. Fail: TTL low.

Test port bias input (BIAS CONNECT)
Maximum voltage: +30 VDC
Maximum Current (no degradation in RF performance): ±200 mA
Maximum current: ±1 A

Video output (EXT MON)
The R, G, and B connectors drive external monitors with these characteristics:
- R, G, B with synch on green.
- 75 ohm impedance.
- 1Vp-p (0.7V = white; 0V = black; –0.3V = synch).

GP-IB
This connector allows communications with compatible devices including external controllers, printers, plotters, disk drives, and power meters.

Parallel port
This 25-pin female connector is used with parallel (or Centronics interface) peripherals such as printers and plotters. It can also be used as a general purpose I/O port, with control provided by test sequencing functions.

RS-232C
This 9-pin male connector is used with serial peripherals such as printers and plotters.

DIN keyboard
This connector is used for adding an IBM PC-AT compatible keyboard for titles and remote front-panel operation.

Test set interconnect
This connector is used to connect an 8702D Option 011 to the Agilent 85046A/B or 85047A test set. On other 8702D analyzers you can use signal levels on this connector for sequencing or general purpose I/O appli-cations with an adapter.

Agilent 8702D Supplemental Characeristics

Internal Memory
Data retention time characteristic with 3V, 1.2 A battery:
- At 25°C: 11904 days (32.6 years)
- At 40°C: 1244 days (3.4 years)
- At 70°C: 250 days (0.68 year)

Line power
48 Hz to 66 Hz
115V nominal (90V to 132V) or 230V nominal (198V to 264V)
280 VA max

Environmental Characteristics

General conditions
RFI and EMI susceptibility: defined by VDE 0730, CISPR Publication 11, and FCC Class B Standards.

ESD (electrostatic discharge): must be eliminated by use of static-safe work procedures and an anti-static bench mat (such as an Agilent 92175T). The flexible rubber keypad protects key contacts from dust, but the environment should be as dust-free as possible for optimal reliability.

Operating conditions

Temperature (unless otherwise noted): 0° to 55°C
Humidity: 5% to 95% at 40°C (non-condensing)
Altitude: 0 to 4500 meters (15,000 feet)

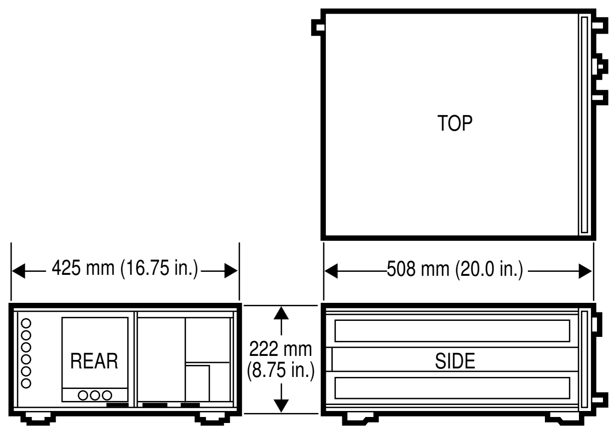
Non-Operating Storage Conditions

Temperature: –40°C to +70°C
Humidity: 0 to 90% relative at +65°C (non-condensing)
Altitude: 0 to 15,240 meters (50,000 feet)

Weight: (8702D without Option 011)

Net: 34 kg (75 lb)
Shipping: 37 kg (82 lb)

Cabinet dimensions
(These dimensions exclude front and rear panel protrusions.)



Agilent 8702D without Option 011:
222 mm H x 425 mm W x 508 mm D
(8.75 in x 16.75 in x 20.0 in)

For more information about Agilent Technologies test and measurement products, applications, services, and for a current sales office listing, visit our web site,

www.agilent.com/comms/lightwave

You can also contact one of the following centers and ask for a test and measurement sales representative.

United States:
Agilent Technologies
Test and Measurement Call Center
P.O. Box 4026
Englewood, CO 80155-4026
(tel) 1 800 452 4844

Canada:
Agilent Technologies Canada Inc.
5150 Spectrum Way
Mississauga, Ontario
L4W 5G1
(tel) 1 877 894 4414

Europe:
Agilent Technologies
Test & Measurement
European Marketing Organisation
P.O. Box 999
1180 AZ Amstelveen
The Netherlands
(tel) (31 20) 547 2000

Japan:
Agilent Technologies Japan Ltd.
Measurement Assistance Center
9-1, Takakura-Cho, Hachioji-Shi,
Tokyo 192-8510, Japan
(tel) (81) 426 56 7832
(fax) (81) 426 56 7840

Latin America:
Agilent Technologies
Latin American Region Headquarters
5200 Blue Lagoon Drive, Suite #950
Miami, Florida 33126, U.S.A.
(tel) (305) 267 4245
(fax) (305) 267 4286

Australia/New Zealand:
Agilent Technologies Australia Pty Ltd
347 Burwood Highway
Forest Hill, Victoria 3131
(tel) 1-800 629 485 (Australia)
(fax) (61 3) 9272 0749
(tel) 0 800 738 378 (New Zealand)
(fax) (64 4) 802 6881

Asia Pacific:
Agilent Technologies
24/F, Cityplaza One, 1111 King's Road,
Taikoo Shing, Hong Kong
(tel) (852) 3197 7777
(fax) (852) 2506 9284

Printed in U.S.A. 3/00
5965-6404E

Agilent Technologies
Innovating the HP Way