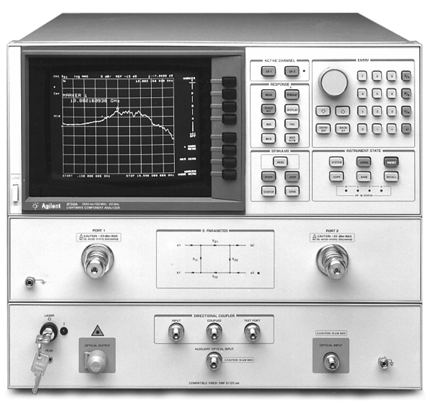
Agilent 8703A
Lightwave Component Analyzer
Technical Specifications

1300 nm or 1550 nm carrier

130 MHz to 20 GHz modulation bandwidth



Single wavelength configuration

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Introduction

A powerful combination of calibrated 20 GHz lightwave and microwave measurement capabilities is described in this Agilent 8703A technical specifications. This includes the following models and options:

Agilent 8703A Lightwave Component Analyzer
- Option 100 Adds External Lightwave Source Input
- Option 210 1550 nm DFB[1] Laser
- Option 220 1300 nm DFB Laser
- Option 300 Adds One Lightwave Receiver

Agilent 83424A Lightwave CW Source
- Option 100 Adds External Lightwave Source Input

Agilent 83425A Lightwave CW Source
- Option 100 Adds External Lightwave Source Input

With accuracy, speed and convenience, the 8703A performs the optical, electrical, and electro-optical measurement types listed below. This data can be shown in magnitude, phase and distance-time measurement formats. A performance summary is in Table 2. Following Table 2 is a block diagram and detailed operating conditions and specifications.

Additional configuration information can be found in the 8703A configuration guide (Agilent literature number 5966-4827E).

[1] "DFB" is an abbreviation for Distributed Feedback Laser.

Table 1. Types of measurements performed with the Agilent 8703A

Lightwave source characterization
(electrical-in and optical-out)

Source slope responsivity tests
- Modulation bandwidth
- Modulated output power flatness
- Step response
- Modulation signal group delay and differential phase
- Reflected signal sensitivity
- Distance-time response

Optical reflection tests
- Port return loss
- Distance-time response

Electrical reflection tests
- Port impedance or return loss
- Distance-time response

Lightwave receiver characterization
(optical-in and electrical-out)

Receiver slope responsivity tests
- Modulation bandwidth
- Modulated output power flatness
- Step response
- Modulation signal group delay and differential phase
- Distance-time response

Optical reflection tests
- Port return loss
- Distance-time response

Electrical reflection tests
- Port impedance or return loss
- Distance-time response

Optical device characterization
(optical-in and optical-out)

Optical transfer function tests
- Insertion loss or gain
- Modulated output power flatness
- Step response .
- Modulation signal group delay and differential phase
- Distance-time response
- Modal dispersion

Optical reflection response tests
- Port return loss
- Distance-time response

Microwave device characterization
(electrical-in and electrical-out)

Electrical transfer function tests
- Insertion loss or gain
- Output power flatness
- Step response
- Group delay and deviation from linear phase
- Distance-time response

Electrical reflection response tests
- Port impedance or return loss
- Distance-time response

Agilent 8703A Performance overview

Table 2. Agilent 8703A performance overview[2]

System dynamic range..(see pages 5, 11, 14)

Transmission test (typical)
Optical-to-optical: 38 to 51 dBo
Optical-to-electrical: 105 to 110 dBe
Electrical-to-optical: 75 to 95 dBe
Electrical-to-electrical: 100 to 110 dBe

Reflection test (typical)
Optical: 31 to 44 dBo
Electrical: 36 to 56 dBe

Distance-time domain........... (see page 13)

Length/location (typical)
Range: 10 ns to 0.5 ms (2 m to 50 km)
Range resolution: 0.5 ps (0.1 mm)
Response resolution: 24 to 48.5 ps (5 to 10 mm)

Stimulus types
Low pass step: 50 ps minimum rise time
Low pass impulse: 48.5 ps minimum pulse width
Bandpass impulse: 97 ps minimum pulse width

Group delay measurements............................ (see page 15)

Minimum aperture: 1 Hz

Maximum 1 Hz aperture delay: 500 ms

Lightwave source...................... (see page 6)

Wavelength: 1308 or 1550 nm, ±10 nm

Spectral width: 3 nm RMS (FP) or 50 MHz (DFB) (typical)

Average optical output power: 70 to 600 µW

Modulation bandwidth: 130 MHz to 20 GHz

Modulation frequency resolution: 1 Hz

Modulated optical output power (p-p): 90 to 130 µW (typical)

Modulation index: 25% (typical)

Optical return loss: 15 dBo (typical)

Lightwave receiver.................. (see page 7)

Wavelength: 1298 to 1560 nm

Input modulation bandwidth: 130 MHz to 20 GHz

Maximum average input power operating level: 5 mW

System sensitivity (typical): 20 nW

Input port return loss (typical): 20 dBo

Microwave source................... (see page 11)

Frequency bandwidth: 130 MHz to 20 GHz

Frequency resolution: 1 Hz

Output power range: +5 to –70 dBm

Harmonics: <–15 dBc (typical)

Microwave receiver............... (see page 11)

Frequency bandwidth: 130 MHz to 20 GHz

Maximum input power operating level: 0 dBm

System sensitivity: –110 dBm

Connector types

Lightwave:
HMS-10
FC/PC
DIN 47256
ST
Biconic
SC

Microwave: 3.5 mm (male)

Data accuracy enhancement............................... (see page 15)

Calibration types:
Response calibration
Response and match calibration
Response and isolation calibration
1-port calibration
Full 2-port calibration
Reference plane extensions

Data averaging:
IF bandwidth control
Sweep-to-sweep averaging

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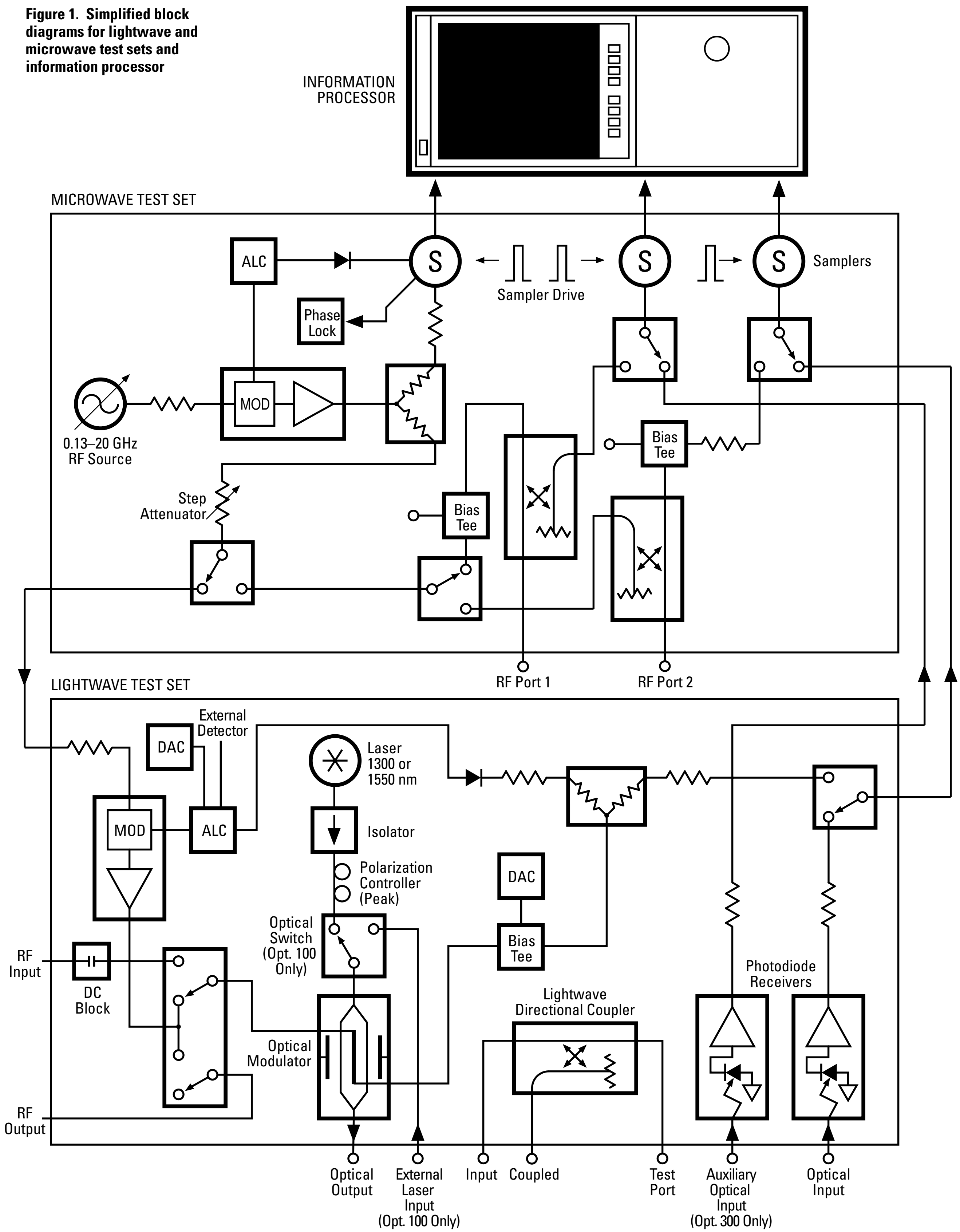
[2] Final performance depends upon the 8703A configuration. For example, performance will vary according to the type of lightwave source used. Refer inside for further information.

Agilent 8703A Block diagram

Figure 1. Simplified block diagrams for lightwave and microwave test sets and information processor



Frequency domain lightwave dynamic range

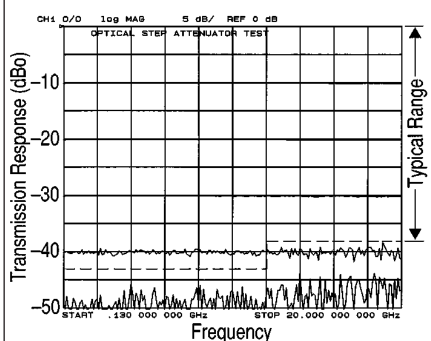
Specifications describe the instrument's warranted performance for the temperature range of 23 ±3°C after a three hour warm-up. Supplemental characteristics describe useful, non-warranted performance parameters. These are denoted as "typical" or "nominal".

Measurement examples

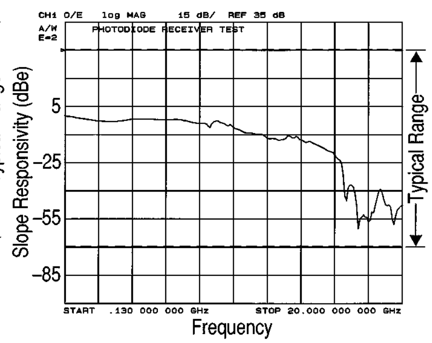
The following graphs show device (DUT) measurements compared to typical (– – –) 8703A measurement ranges[9].

Table 3. System dynamic range (typical)[3]

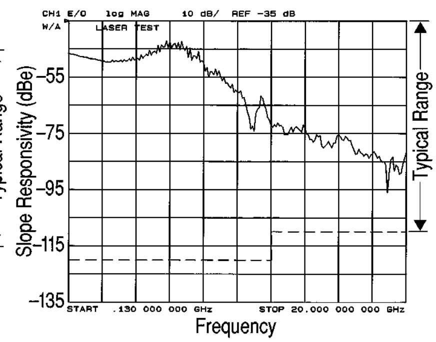
	Frequency range (GHz)	
	0.13 to 12.0	**12.0 to 20**
Lightwave transfer function test		
Optical-to-optical[4]	43 dBo[5]	38 dBo
Optical-to-electrical[4]	105 dBe[6]	105 dBe
Electrical-to-optical	85 dBe[7]	75 dBe
Lightwave reflection test		
Optical[4]	36 dBo[5]	31 dBo



Optical-to-optical transmission test (DUT = 10, 20, 30, 40 and 50 dB attenuators)



Optical-to-electrical transfer function test (DUT = photodiode receiver)



Electrical-to-optical transfer function test (DUT = laser source)

3 Limited by maximum lightwave source output power, maximum lightwave receiver input power, maximum microwave output power and system noise floor. Specified for an IF bandwidth of 10 Hz and an averaging factor of 16 after an appropriate calibration has been performed (i.e. response & isolation calibration for optical tests, response & match and isolation calibration for electrical-to-optical and optical-to-electrical tests).

4 8703A Option 100 systems will typically see 1 dBo less dynamic range than is shown for optical transfer function and reflection measurements. Optical-to-electrical transfer function measurements will typically see 2 dBe less.

5 For optical-to-optical devices, (dBo) = 10 log (#2 optical power (W p-p) / #1 optical power (W p-p))

6 For optical-to-electrical devices, slope responsivity (dBe) = 20 log ((Δ current (A p-p) / Δ optical power (W p-p)) / 1 A/W)

7 For electrical-to-optical devices, slope responsivity (dBe) = 20 log ((Δ optical power (W p-p) / Δ current (A p-p)) / 1 W/A)

8 Measurement range can be shifted upward by externally adding attenuation in the signal path during calibration and measurement.

Lightwave source and receiver characteristics

Table 4.
Lightwave source characteristics[9]

Description	**Opt 210 (DFB laser)**[10]	**Opt 220 (DFB laser)**[10]	**Opt 100 with Agilent 83424A**	**Opt 100 with Agilent 83425A**
Wavelength	1550 ±10 nm	1308 ±10 nm	1550 ±10 nm	1308 ±10 nm
Spectral width (typical)	<50 MHz	<50 MHz	<50 MHz	<50 MHz
Average optical output power[11]				
Maximum:	600 µW (–2.2 dBm)	600 µW (–2.2 dBm)	500 µW (–3.0 dBm)	500 µW (–3.0 dBm)
Typical:	260 µW (–5.9 dBm)	260 µW (–5.9 dBm)	180 µW (–7.4 dBm)	180 µW (–7.4 dBm)
Minimum:	125 µW (–9.0 dBm)	125 µW (–9.0 dBm)	70 µW (–11.6 dBm)	70 µW (–11.6 dBm)
Modulation bandwidth	130 MHz to 20 GHz	130 MHz to 20 GHz	130 MHz to 20 GHz	130 MHz to 20 GHz
Modulated frequency resolution	1 Hz	1 Hz	1 Hz	1 Hz
Modulated optical output power (typical)[12]				
Peak-to-peak:	130 µW (–8.9 dBm)	130 µW (–8.9 dBm)	90 µW (–10.5 dBm)	90 µW (–10.5 dBm)
Peak:	65 µW (–11.9 dBm)	65 µW (–11.9 dBm)	45 µW (–13.5 dBm)	45 µW (–13.5 dBm)
Modulation index (typical)[13]	25%	25%	25%	25%
Reflection sensitivity (typical)[14]	±0.1 dB	±0.1 dB	±0.1 dB	±0.1 dB
Laser isolation[15]	80 dB	80 dB	80 dB	80 dB
Degree of polarization (typical)	20:1	20:1	20:1	20:1
Port return loss (typical)	15 dBo	15 dBo	15 dBo	15 dBo
Harmonics (typical)[16]	<–9 dBc	<–9 dBc	<–9 dBc	<–9 dBc
Compatible fiber	9/125 µm	9/125 µm	9/125 µm	9/125 µm

9 Lightwave source characteristics are described given a >30 dB return loss optical termination.
10 Output power is 1 dBo less for systems with Option 100. This is a class I (FDA (U.S.A.)) and class IIIb (IEC (Europe)) laser.
11 Average optical output power level can be controlled with an external optical attenuator like the 8157A. The 8703A does not have an internal optical attenuator.
12 The modulated optical output power level is set by the 8703A and cannot be adjusted by the user.
13 Modulation index is defined as peak modulated optical power divided by average optical power. For example, the 8703A FP configuration of Table 4 shows an index of 25% (= 65 µW / 260 µW).
14 Laser reflection sensitivity is tested using a 95 % reflection, an optical coupler (15 dB coupling factor and 1.5 dB main arm loss) and the optical output powers shown in Table 4.
15 Isolation refers to the isolation between the 8703A's optical modulator and the internal laser. External sources must have built-in isolation. Refer to the block diagram, Figure 1.
16 Harmonic levels are given for average optical powers and modulation powers listed in Table 4. dBc rating is for dBe below the fundamental modulation components.

External lightwave sources[22]

Option 100 allows external lightwave sources to be used with the Agilent 8703A lightwave component analyzer. The external sources must conform to the following characteristics.

Wavelengths[17]:
1530 to 1570 nm Option 210
1290 to 1330 nm Option 220
Reflection sensitivity: external laser input port typical optical return loss >15 dBo
Average output power range[18]: 100 µW to 5 mW (–10 dBm to +7 dBm)
Compatible fiber: 9/125 um
Degree of signal polarization: >20:1
Polarization controller: two quarter-wavelength elements required

Lightwave receiver characteristics[19]

Input wavelength[20]: 1298 to 1560 nm
Input modulation bandwidth: 130 MHz to 20 GHz
Maximum average input power operating level: 5 mW (+7 dBm)
Average input power damage level: 10 mW (+10 dBm)
System sensitivity (using 10 Hz IF bandwidth, 16 averages, p-p): 20 nW (–47 dBm) (typical)
Polarization sensitivity: ±0.05 dB (typical)
Input port return loss: >20 dBo (typical)

Lightwave directional coupler characteristics

Wavelength: 1298 to 1560 nm
Coupling factor (“test port” to “coupled” port): 3 dB (typical)
Main arm loss (“input” port to “test port”): 3 dB (typical)
Directivity[21]: 37 dB (typical)
Isolation (“input” port to “coupled” port): 40 dB (typical)
Return loss, all ports: 37 dBo (typical with HMS-10 connector types)

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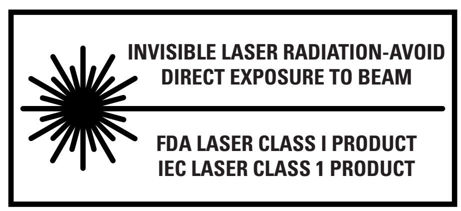
17 Caution! Do not input wavelengths below 1200 nm. Damage to the 8703A optical modulator will result.
18 9 dB optical loss is typical for the external lightwave source path through the optical modulator shown in Figure 1. This will affect system dynamic range. Compare cases to 83424A and 83425A configurations (Table 3 and 4) to calculate dynamic range for systems using different external sources.
19 Lightwave receiver characteristics are tested in an environment of >15 dBo optical source match return loss.
20 Lightwave receiver will operate beyond the system’s specified 1308 or 1550 ±10 nm and a normalized calibration can be done. However, complete 8703A performance cannot be warranted outside of 1308 or 1550 ±10 nm.
21 Directivity (dB) = Isolation (dB) - Coupling Factor (dB). Specification assumes a 37 dB return loss connector match at the coupler’s “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



Lightwave measurement accuracy summary

Lightwave measurement uncertainty is presented in the following graphs and tables. This covers three types of measurements: optical (transmission and reflection) measurements, optical-to-electrical measurements, and electrical-to-optical measurements. Data is recorded after an 8703A accuracy enhancement has been performed using the indicated calibration type. This analysis accounts for the following errors[23]:

- Residual systematic errors (Table 5)
- System dynamic accuracy (dB from reference)[24]
- 3.5 mm connector repeatability[25]
- Lightwave source stability
- Lightwave source and receiver factory calibration uncertainty[26]
- Switch repeatability
- Noise

A 10 Hz IF bandwidth, a 16 averaging factor and a 23 ±3°C temperature range are used in all cases. Data applies to all 8703A internal source configurations of Table 4.

The following table shows 8703A residual systematic errors after accuracy enhancement using the same calibration and setup as stated for each of the three lightwave measurement types.

Table 5. Residual lightwave measurement systematic errors.

	Frequency range (GHz)	
	0.13 to 12.0	**12.0 to 20**
Optical residual characteristics (typical)		
Lightwave source port return loss	15 dBo	15 dBo
Lightwave receiver port return loss	20 dBo	20 dBo
Transmission tracking[27]	±0.55 dB	±0.55 dB
Lightwave directional coupler test port return loss	37 dBo	37 dBo
Directivity	37 dB	37 dB
Reflection tracking[27]	±0.45 dB	±0.45 dB
Electrical residual characteristics (typical)		
Microwave source port return loss	29 dBe[28]	29 dBe
Microwave receiver port return loss	30 dBe	30 dBe

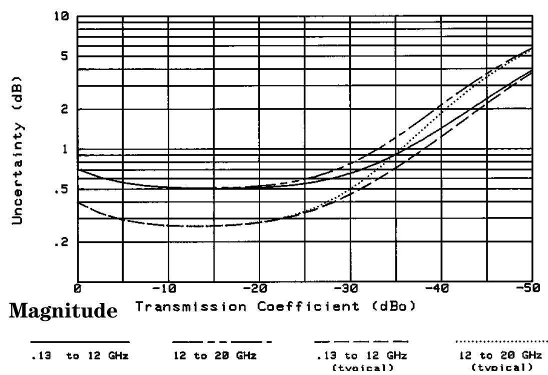
Optical transmission and reflection

Measurement setup

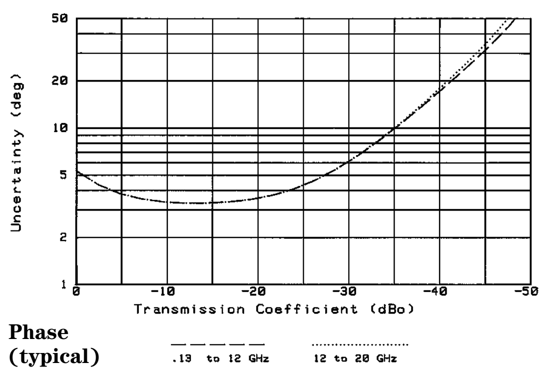
Calibration type: response & isolation
Calibration standards:
14.5 dB return loss Fresnel standard
Connectors and cables:
HMS-10 lightwave connectors
40 cm single mode fiber cables

Measurement uncertainty[29]

Transmission test

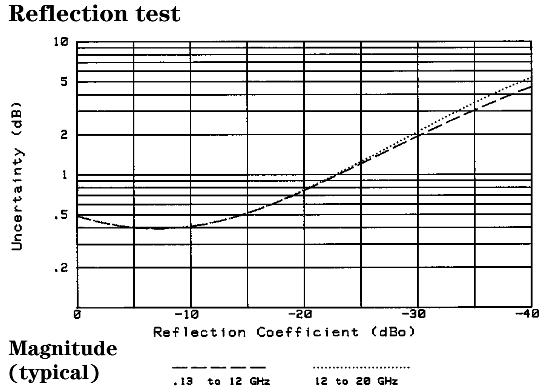


Magnitude



Phase (typical)

Reflection test



Magnitude (typical)

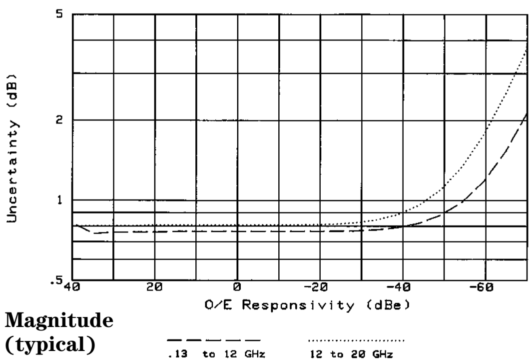
Optical-to-electrical[30]

Measurement setup

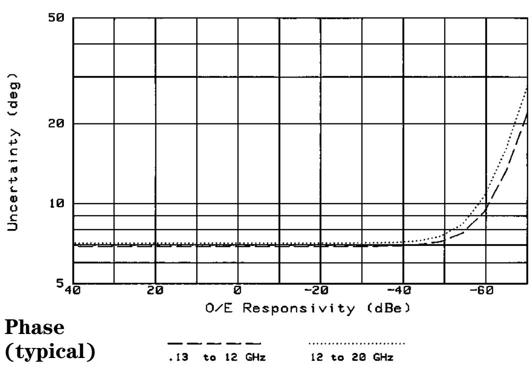
Calibration type: response & match
Calibration standards:
Lightwave receiver factory calibration data
Agilent 85052D RF calibration kit
Connectors and cables:
HMS-10 lightwave connectors
40 cm single mode fiber
3.5 mm RF connectors
Agilent 85131E RF cable

Measurement uncertainty[29]

Transfer function test



Magnitude (typical)



Phase (typical)

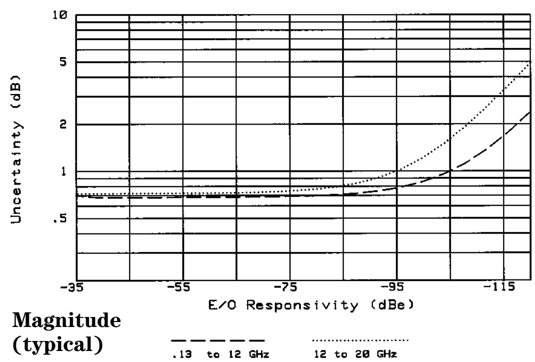
Electrical-to-optical[30]

Measurement setup

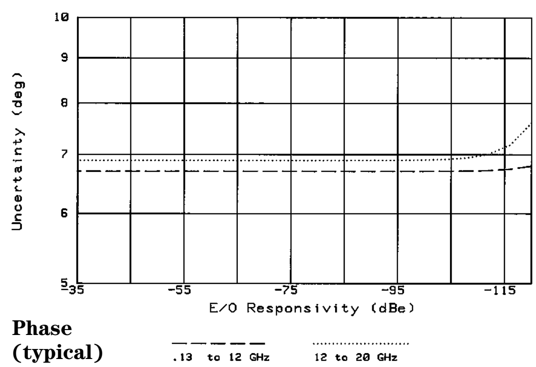
Calibration type: response & match
Calibration standards:
Lightwave source calibration data
Agilent 85052D RF calibration kit
Connectors and cables:
HMS-10 lightwave connectors
40 cm single mode fiber
3.5 mm RF connectors
Agilent 85131E RF cable

Measurement uncertainty[29]

Transfer function test



Magnitude (typical)



Phase (typical)

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23 Additional technical information about lightwave measurement error analysis and calibration is available upon request from an Agilent Technologies representative.
24 Crosstalk effects are included in the dynamic range and dynamic accuracy specifications.
25 Optical connector repeatability, cable stability, and system drift are not included. Transmission and transfer function measurements assume a well-matched device that produces no reflection from its input port.
26 These calibrations are verified with Agilent's in-house NIST traceable reference receiver.
27 Tracking accounts for switch repeatability and frequency response differences between the measurement reference path and test path.
28 For electrical-to-electrical devices:
Return loss (dBe) = –20 log (ρ)
Transmission (dBe) = 20 log (V2/V1) = 20 log (I2/I1) = 10 log (P2/P1)
29 Lightwave measurement uncertainty is defined as:
Warranted uncertainty = ((system errors)^2 + (random RSS errors)^2)^0.5. Typical uncertainty is the RSS combination of all system and random errors.
30 Uncertainty graphs below refer to relative flatness and modulation bandwidth measurements. An absolute uncertainty value for a specific data point can be calculated by adding 1.5 dB to the value found on the uncertainty graphs.

Lightwave measurement accuracy examples

Single point uncertainty

Individual uncertainty elements are shown below for a 10 GHz modulation frequency data point of a photodiode receiver transfer function measurement done on an 8703A. The uncertainty graphs on pages 8 and 9 summarize the results of this same analysis for optical and electro-optical device measurements across wide modulation bandwidths.

Device description

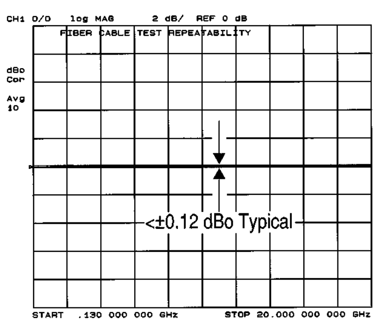
Device: photodiode receiver
Data point slope responsivity: –10 dBe
RF output port return loss: 50 dB
Optical input port return loss: 50 dB

Description of uncertainty term

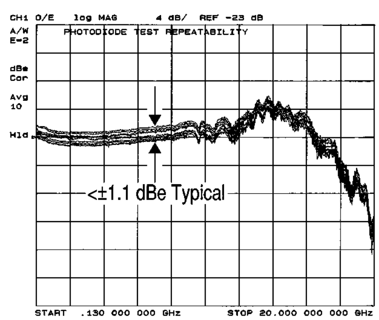
Description of uncertainty term	Value
Lightwave source port return loss	15 dB
Transmission tracking	0.25 dB
Microwave receiver port return loss	30 dB
System dynamic accuracy	0.3 dB
Connector repeatability	0.005 dB
Lightwave source stability	0.1 dB
Lightwave receiver factory calibration uncertainty	0.65 dB
Switch repeatability	0.03 dB
Noise	0.01 dB
Total measurement uncertainty value	±0.76 dB (RSS)

Measurement repeatability

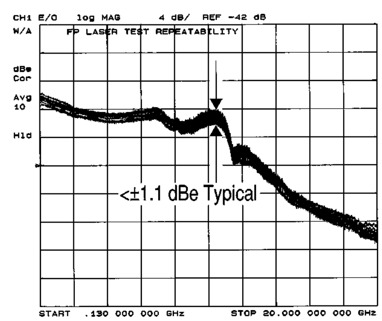
Typical measurement repeatability represents how measurement uncertainties can affect measurements made on different 8703A instruments. Each graph below shows data of the same device tested on 10 different 8703A instruments. All measurements were done using a 30 Hz IF bandwidth, a 10 averaging factor and a 23 ±3°C temperature range.



Optical-to-optical measurement repeatability (typical) (DUT = 2 meter single mode fiber)



Optical-to-electrical measurement repeatability (typical) (DUT = photodiode receiver)



Electrical-to-optical measurement repeatability (typical) (DUT = FP laser source)

Frequency domain microwave performance summary

Specifications describe the instrument's warranted performance for the temperature range of 23 ±3°C after a three hour warm-up. Supplemental characteristics describe useful, non-warranted performance parameters. These are denoted as "typical" or "nominal".

Table 6. System dynamic range[31]

	Frequency range (GHz)			
	0.13 to 0.5	**0.5 to 2**	**2 to 8**	**8 to 20**
Forward transmission (S21)	105 dBe	103 dBe	102 dBe	100 dBe
Reverse transmission (S12)	45 dBe	62 dBe	75 dBe	75 dBe

Microwave source characteristics

Frequency

Bandwidth: 130 MHz to 20 GHz
Resolution:
Start/stop/center/CW: 1 Hz
Stability: ±0.8 ppm (typical) at 23 ±3°C
±3.0 ppm/year (typical) at 23 ±3°C
Accuracy: 10 ppm

Output

Power range:
+5 to –50 dBm (3.2 mW to 0.01 µW) in 5 dB steps from port 1
–15 to –70 dBm (32 µW to 0.1 nW) in 5 dB steps from port 2
Power flatness: ±3 dB (at 0 dBm port 1 output power, at –20 dBm port 2 output power (plus coupler roll-off))
Harmonics power level:
<–15 dBc at 0 dBm output power (typical)
Impedance: 50 ohms (nominal)

Bias port

DC bias: 500 mA, 40 VDC maximum

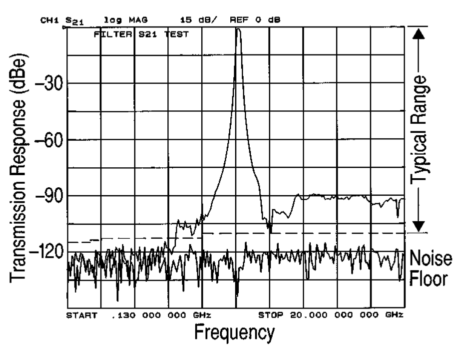
Microwave receiver characteristics

Frequency

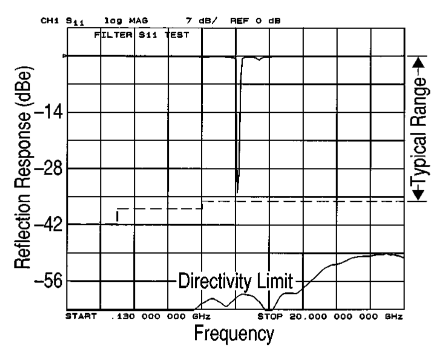
Bandwidth: 130 MHz to 20 GHz
Impedance: 50 ohms (nominal)
Maximum input power operating level: 0 dBm (1.0 mW)
Input power damage level: +20 dBm (100 mW)
System sensitivity (using 10 Hz IF bandwidth, 16 averages): –110 dBm (0.01 pW) (typical)

Measurement examples

The following graphs show device (DUT) measurements compared to typical (– – –) 8703A measurement ranges[32].



Electrical-to-electrical transmission test (DUT = filter)



Electrical reflection test (DUT = filter)

[31] Limited by maximum output power and system noise floor. Specified for an IF bandwidth of 10 Hz, using a full 2-port measurement calibration (including an isolation calibration performed with an averaging factor of 16). Dynamic range is tested for transmission measurements only; dynamic range for reflection measurements is limited in practice by directivity.

[32] The 85052D RF Calibration Kit was used for this measurement calibration.

Microwave measurement accuracy summary

Microwave measurement accuracy for the 8703A analyzer is presented in the following graphs and tables. All data is taken after an 8703A accuracy enhancement using the calibration type shown. This analysis accounts for the following errors[33]:

- Residual systematic errors (Table 7)
- System dynamic accuracy (dB from reference)[34]
- 3.5 mm connector repeatability
- Switch repeatability[35]
- Noise

A 10 Hz IF bandwidth, a 16 averaging factor and a 23 ±3°C temperature range are used in all cases.

Microwave transmission and reflection

Measurement setup

Calibration type: full 2-port & isolation
Calibration Standards: Agilent 85052D RF calibration kit
Connectors and cables: 3.5 mm RF connectors
85131E RF cable

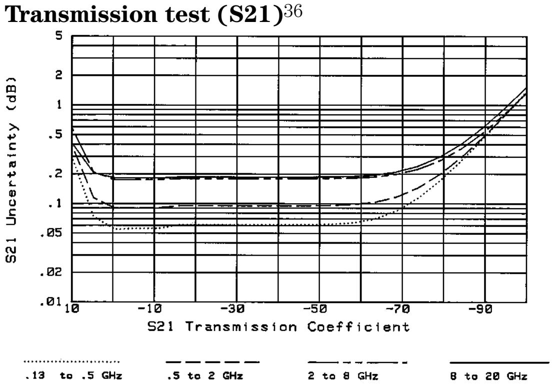
The following table shows 8703A residual systematic errors after accuracy enhancement using the same calibration and setup as for the microwave measurements below.

Table 7. Residual microwave measurement systematic errors.

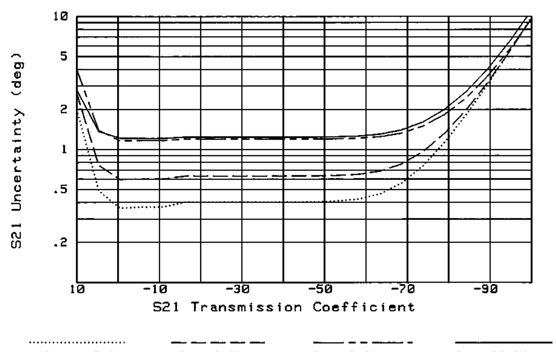
	Frequency range (GHz)			
	0.13 to 0.5	**0.5 to 2**	**2 to 8**	**8 to 20**
Directivity	40 dB	40 dB	38 dB	36 dB
Source port return loss[38]	30 dB	30 dB	30 dB	29 dB
Receiver port return loss[38]	35 dB	35 dB	30 dB	30 dB
Reflection tracking[39]	±0.10 dB	±0.10 dB	±0.10 dB	±0.20 dB
Transmission tracking[39]	±0.10 dB[40]	±0.10 dB[40]	±0.12 dB	±0.15 dB

Measurement uncertainty

Transmission test (S21)[36]

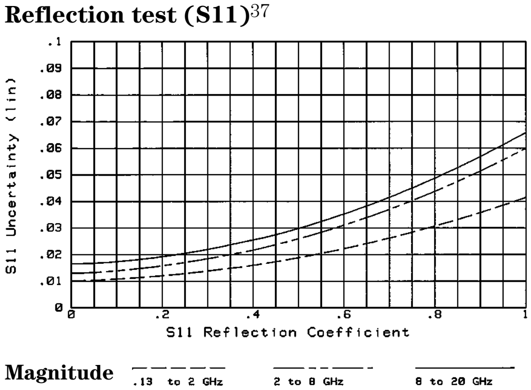


Magnitude

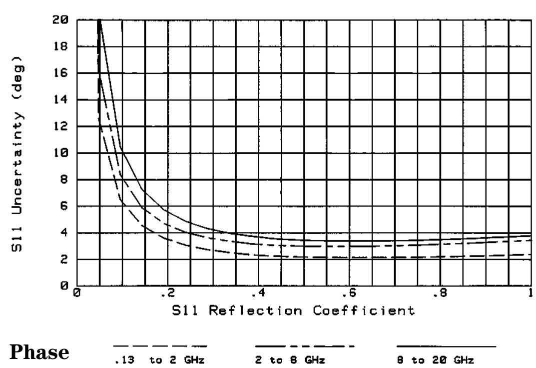


Phase

Reflection test (S11)[37]



Magnitude



Phase

33 Additional technical information about microwave measurement error analysis and calibration is available upon request from an Agilent Technologies representative.
34 Crosstalk effects are included in dynamic range and dynamic accuracy specification.
35 Cable stability and system drift are not included.
36 The graphs for transmission measurements assume a well-matched device (S11 = S22 = 0).
37 The graphs shown for reflection measurement uncertainty apply to a one-port device.
38 Before calibration accuracy enhancement the source match is 10 dB return loss and the receiver is 12 dB return loss.
39 Tracking includes switch repeatability, temperature stability and frequency response.
40 Reverse transmission tracking (S12) is ±0.25 dB from 0.13 to 0.5 GHz, and ±0.15 dB from 0.5 to 2.0 GHz.

Distance-time domain performance summary

Introduction

Analog and digital device design, testing and trouble shooting are made easier by using both the distance-time domain and frequency domain capabilities of the 8703A. This combination lets the user:

1) Discover if a problem exists.
2) Locate and quantify potential causes of the problem (i.e. unexpected reflections, attenuations, etc.)
3) Simulate frequency domain and distance-time domain results with unwanted responses mathematically removed using the Gating function.

Method

A step or impulse response is simulated by processing frequency domain data through an inverse Fast Fourier Transform (FFT). This produces a linear distance-time response. This is similar to a time domain reflectometer (TDR) response done with a broadband oscilloscope and a small signal step or impulse stimulus. Data is displayed in a parameter-versus-time format for transmission and reflection parameters.

Features

Measurement range is the maximum distance or time span that can be displayed given that the test signal stays within the dynamic range of the 8703A. Range (Ta), also called "alias free range", is defined below:

Ta = (N-1) / Freq. Span

where "N" = number of CRT data points[42]. If N = 201 points and Freq. Span = 20 GHz then Ta = 10 nano- seconds (or approximately 2 meters in fiber cable with a 1.4 index of refraction). Longer ranges are achieved by changing the key parameters.

Measurement range-resolution is a measure of the 8703A's ability to locate a single response and is defined as:

Tr = (Time Span) / (N-1)

where the "Time Span" is the span of time displayed on the 8703A's CRT. "N" is the number of display data points[41]. For example, range-resolution is 0.5 pico- seconds for a time span of 0.4 nanoseconds and N = 801 in the bandpass mode. This is approximately 0.1 mm in single-mode fiber.

Response resolution is the smallest distance or time between two responses, where each response can be identified. Response resolution is estimated for the three stimulus types available in the 8703A:

Lowpass step response[42]:

Tr = (0.45 / Fspan) x 1.0 (min.) window factor
2.2 (normal)
3.3 (max.)

Lowpass impulse response[43]:

Tr = (0.6 / Fspan) x 1.0 (min.) window factor
1.6 (normal)
2.4 (max.)

Bandpass impulse response[43]:

Tr = 2 X (0.6 / Fspan) x 1.0 (min.) window factor
1.6 (normal)
2.4 (max.)

Where the "Fspan" is the frequency span of the frequency domain measurement. For example, if the Fspan is 20 GHz and a normal window factor is used for the lowpass impulse mode, then the response-resolution is 48.5 picoseconds (approximately 5 mm of separation between reflection responses in fiber cable)[44].

Window factors control the pulse width or step rise time used in the inverse Fourier transform. Minimum, normal and maximum windows are user selected to make trade offs between time resolution versus overshoot and ringing in the response.

Distance-time markers can be used to automatically calculate and display length and location of optical and electrical responses. The relative velocity factor or refractive index value used in the marker calculations can and should be set to match the medium being used.

Gating enables some frequency domain and distance-time domain test conditions to be isolated and simulated. For example, unwanted reflection and transmission paths within a device can affect a device's response. Gating enables the effect of these unwanted paths to be marked and mathematically removed in the distance-time domain. This new simulated response can also be viewed in the frequency domain while the gating function is active. In this way the simulated effect of a design change can be evaluated.

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41 Lowpass impulse and step modes have a 201 CRT data point maximum limit. This does not apply to the bandpass mode.
42 Effective rise time of the 8703A's step signal is equal to the response resolution "Tr".
43 Effective pulse width (full-width-half-maximum) of the 8703A's impulse signal is equal to the response resolution "Tr".
44 Calculated time is for the actual distance traveled. Reflection paths must be considered to estimate physical locations. The 8703A automatically calculates the distance traveled for a reflection measurement and displays the "one way" path length. Multiple reflections in transmission paths are not automatically accounted for.

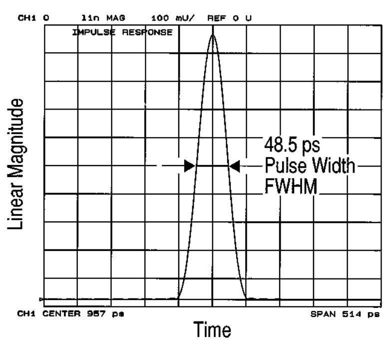
Distance-time domain performance summary cont'd

Table 8. Single response system dynamic range[45] (for distance-time lowpass impulse and step response modes, typical).

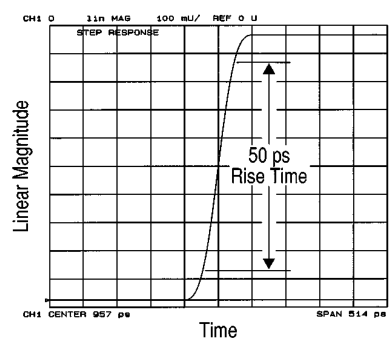
	Frequency bandwidth (GHz)	
Measurement description	**0.13 to 12.0**	**0.13 to 20**
Lightwave forward transmission measurement		
Optical-to-optical	51 dBo	51 dBo
Optical-to-electrical	110 dBe	110 dBe
Electrical-to-optical	95 dBe	95 dBe
Lightwave reflection measurement		
Optical (Impulse mode only)	44 dBo	44 dBo
Microwave forward transmission measurement		
Electrical-to-electrical	110 dBe	110 dBe
Microwave reflection measurement		
Electrical (Impulse mode only)	56 dBe	56 dBe

Signal shape examples

The following are graphs of impulse and step signals generated by the inverse FFT of the 8703A using a 20 GHz Fspan. Electrical (dBe) and electro-optical (dBe) cases are not presented since the signal shape is similar to the lightwave examples shown.



Lightwave impulse response transmission test (DUT = 21 cm single mode fiber)



Lightwave step response transmission test (DUT = 21 cm single mode fiber)

45 Limited by maximum lightwave receiver input power, maximum microwave power and system noise floor. Specified for a 20 GHz frequency bandwidth, a normal window factor, a 10 Hz IF bandwidth, a 16 averaging factor and after an appropriate calibration has been performed (i.e., response & isolation calibration for optical tests, response & match and isolation calibration for electrical-to-optical and optical-to-electrical tests, or full 2-port and isolation calibration for electrical test).

Group delay measurements

Group delay is computed by measuring the phase change within a specified frequency aperture (determined by the frequency span and the number of points per sweep). The phase change, in degrees, is then divided by the frequency aperture, in Hz (times –360).

Aperture

Determined by the frequency span, the number of steps per sweep, and the amount of smoothing applied. (Minimum aperture limited by source frequency resolution of 1 Hz.)
Minimum aperture = (frequency span) / (number of points–1)
Maximum aperture = 20 % of the frequency span

Range

The maximum delay is limited to measuring no more than ±180 degrees of phase change within the minimum aperture. For example, with a minimum aperture of 1 Hz, the maximum delay that can be measured is 500 milliseconds.

Accuracy

Accuracy is a function of the uncertainty in determining the phase change. The following is a general formula for calculating typical accuracy, in seconds, for a specific group delay measurement.

$$\frac{\pm 0.003 \text{ x Phase Uncertainty (deg)}}{\text{Aperture (Hz)}}$$

Data accuracy enhancement

Lightwave measurement calibration types

Response: Simultaneously accounts for magnitude and phase errors due to a system's modulation frequency response. This applies for either transmission or reflection tests.

Response and match: Accounts for magnitude and phase responses as well as microwave source and receiver return loss errors. The isolation part of this calibration can be included to compensate for directivity (reflection) and crosstalk (transmission).

Response and isolation: Compensates for modulation frequency responses plus directivity (reflection) or crosstalk (transmission).

Microwave measurement calibration types

Frequency response: Simultaneously corrects for magnitude and phase frequency response errors for either reflection or transmission measurements.

Response/isolation cal: Compensates for frequency response plus directivity (reflection) or crosstalk (transmission).

1-port cal: Correction of test set port 1 or port 2 directivity, frequency response and source match errors.

2-port cal: Compensates for directivity, source match, reflection frequency response, load match, transmission frequency response, and crosstalk.

Reference plane extension

Applies to lightwave and microwave. Redefines the plane of the measurement reference (zero phase) to other than the source or receiver ports of the lightwave and microwave test sets. Is defined in seconds of delay from the test set port and ranges between ±10 seconds.

Calibration kits

Select from standard lightwave and microwave calibration kits. Lightwave calibration kits are internally defined for an optical “thru” and “Fresnel”. Microwave calibration kits for 3.5mm, 7mm, or type-N 50 ohm connectors are also defined for electrical “open”, “shorts” and loads (sliding or fixed broadband loads). Customized calibration kits, called “User Kits”, can be be defined or modified, and saved and recalled internally or from disc, for use with other calibration kits.

Data averaging

IF bandwidth: Selectable from 10 Hz, 30 Hz, 100 Hz, 300 Hz, 1 kHz, and 3 kHz bandwidths.
Sweep-to-sweep averaging: Averages vector data on each successive sweep. Averaging factors range from 1 to 999.

Segmented cal

Perform a single calibration in frequency list sweep mode for all segments. Afterwards, calibration remains valid for any one segment selected from the list.

Frequency subset cal

Perform a calibration in linear sweep mode, up to 1601 points over entire frequency range. Afterwards, calibration remains valid for any frequency subset (smaller frequency range within endpoints used during calibration). Analyzer measures over nearest arbitrary number of cardinal calibration points.

Environmental characteristics

Operating temperature

0 to 55°C

Warranted temperature

23 ±3°C

Non-operating storage temperature

–40° to +70°C

8703A Lightwave Component Analyzer

Power: 47.5 to 66 Hz: 90 to 132 volts, 198 to 264 volts, 350 VA (for top plug) +95 VA (for bottom plug) = 445 VA total maximum
Weight: Net, 50 kg (110 lb.); shipping, 57 kg (125 lb.)
Dimensions: 370 H x 425 W x 502 mm D (14.57 H x 16.73 W x 19.76 in. D) Allow 50 mm (2.0 in.) additional depth for front panel connectors.

83424A and 83425A Lightwave CW Sources

Power: 90 to 132 volts, 198 to 264 volts, 95 VA maximum
Weight: Net, 7.5 kg. (16.5 lb.); shipping, 9.0 kg (19.8 lb.)
Dimensions: 88.9 H x 425 W x 502 mm D (3.5 H x 16.75 W x 19.75 in. D)

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

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