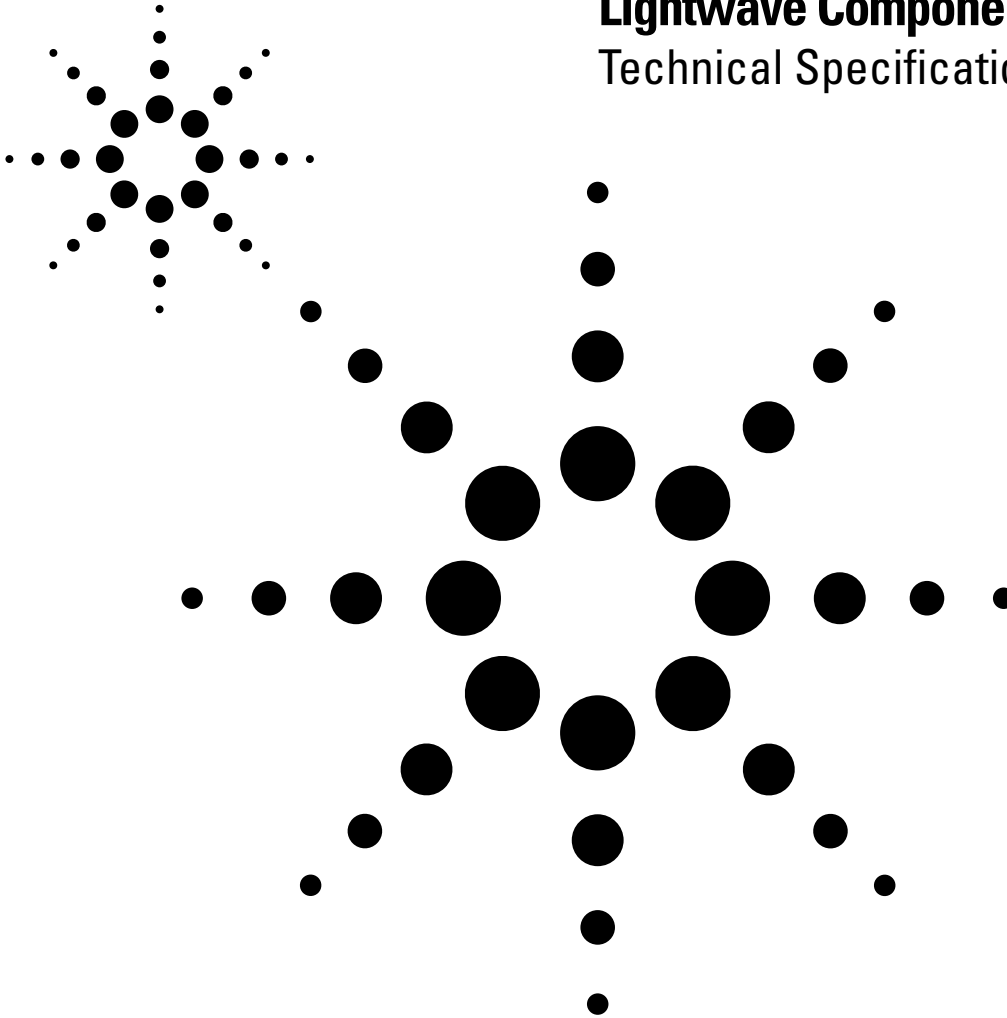
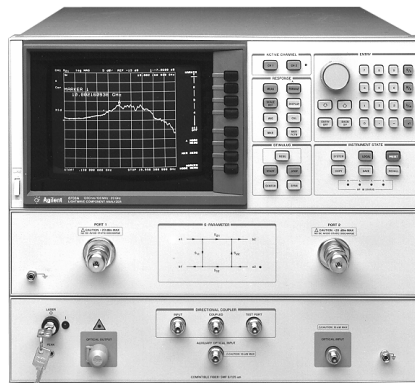


Agilent 8703A Lightwave Component Analyzer Technical Specifications



1300 nm or 1550 nm carrier

**130 MHz to 20 GHz
modulation bandwidth**



Single wavelength configuration



Agilent Technologies
Innovating the HP Way

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 DFB¹ 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

<p>Lightwave source characterization (electrical-in and optical-out)</p> <p>Source slope responsivity tests</p> <ul style="list-style-type: none"> • Modulation bandwidth • Modulated output power flatness • Step response • Modulation signal group delay and differential phase • Reflected signal sensitivity • Distance-time response <p>Optical reflection tests</p> <ul style="list-style-type: none"> • Port return loss • Distance-time response <p>Electrical reflection tests</p> <ul style="list-style-type: none"> • Port impedance or return loss • Distance-time response <p>Lightwave receiver characterization (optical-in and electrical-out)</p> <p>Receiver slope responsivity tests</p> <ul style="list-style-type: none"> • Modulation bandwidth • Modulated output power flatness • Step response • Modulation signal group delay and differential phase • Distance-time response <p>Optical reflection tests</p> <ul style="list-style-type: none"> • Port return loss • Distance-time response 	<p>Electrical reflection tests</p> <ul style="list-style-type: none"> • Port impedance or return loss • Distance-time response <p>Optical device characterization (optical-in and optical-out)</p> <p>Optical transfer function tests</p> <ul style="list-style-type: none"> • Insertion loss or gain • Modulated output power flatness • Step response • Modulation signal group delay and differential phase • Distance-time response • Modal dispersion <p>Optical reflection response tests</p> <ul style="list-style-type: none"> • Port return loss • Distance-time response <p>Microwave device characterization (electrical-in and electrical-out)</p> <p>Electrical transfer function tests</p> <ul style="list-style-type: none"> • Insertion loss or gain • Output power flatness • Step response • Group delay and deviation from linear phase • Distance-time response <p>Electrical reflection response tests</p> <ul style="list-style-type: none"> • Port impedance or return loss • Distance-time response
---	---

Agilent 8703A

Performance overview

Table 2. Agilent 8703A
performance overview²

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 μ W
Modulation bandwidth: 130 MHz to 20 GHz
Modulation frequency resolution: 1 Hz
Modulated optical output power (p-p): 90 to
130 μ W (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

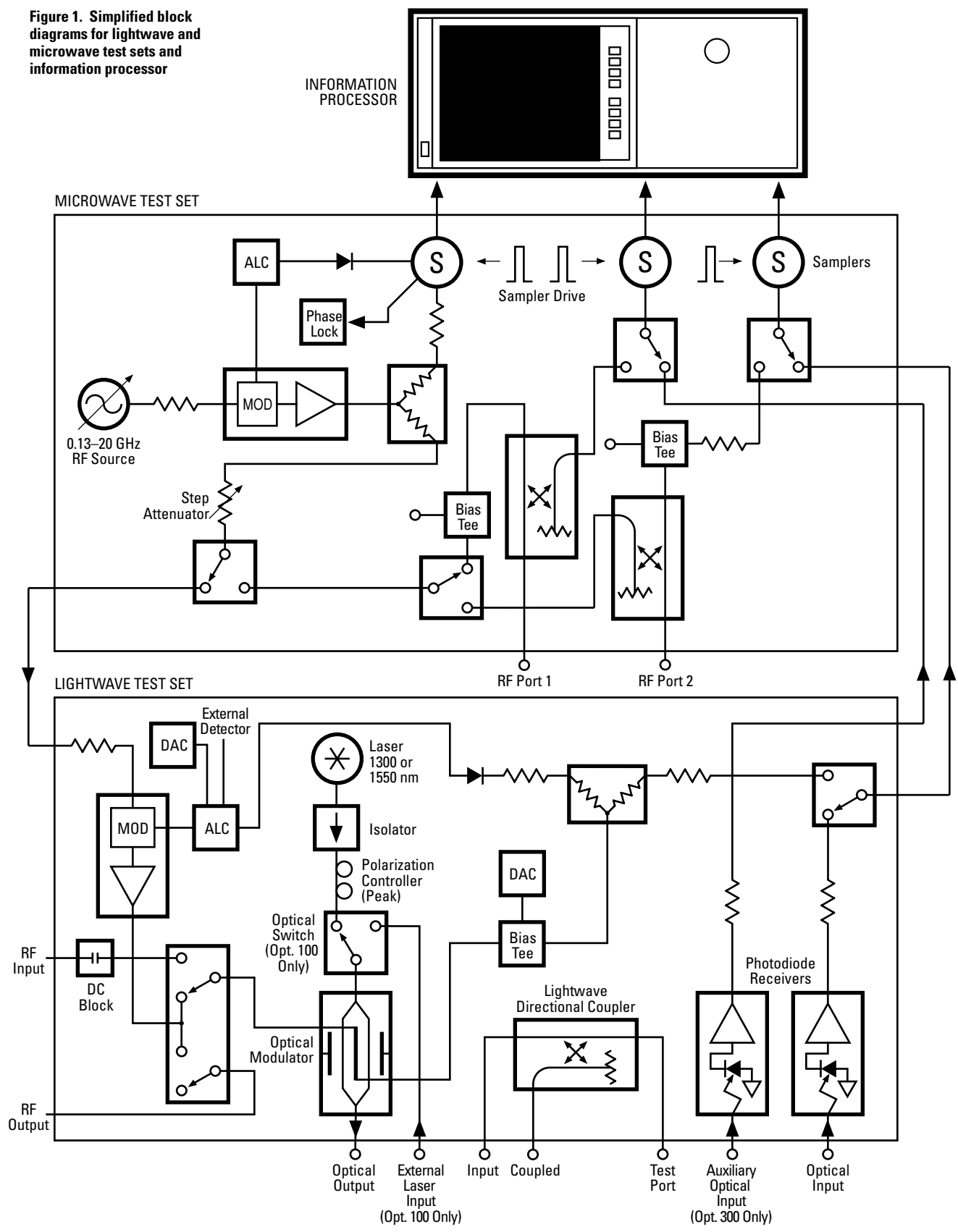
Data averaging:

IF bandwidth control
Sweep-to-sweep averaging

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

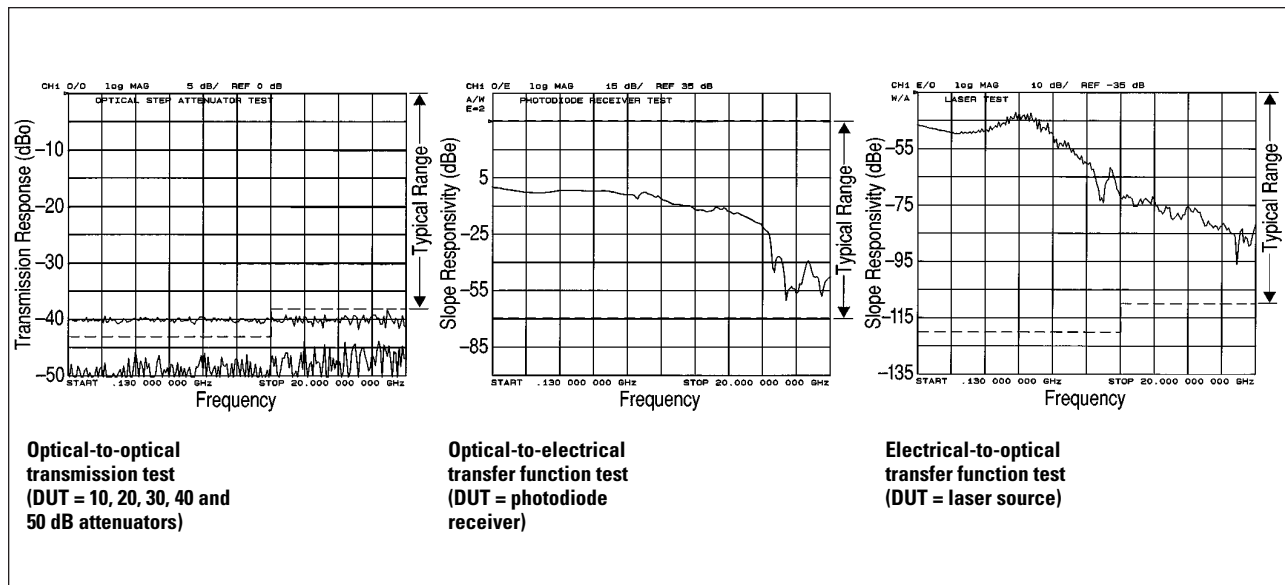
Specifications describe the instrument's warranted performance for the temperature range of $23 \pm 3^\circ\text{C}$ after a three hour warm-up. Supplemental characteristics describe useful, non-warranted performance parameters. These are denoted as "typical" or "nominal".

Measurement examples

The following graphs show device (DUT) measurements compared to typical (---) 8703A measurement ranges⁹.

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 dB ⁵	38 dB ⁵
Optical-to-electrical ⁴	105 dB ⁶	105 dB ⁶
Electrical-to-optical	85 dB ⁷	75 dB ⁷
Lightwave reflection test		
Optical ⁴	36 dB ⁵	31 dB ⁵



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 dB⁵ less dynamic range than is shown for optical transfer function and reflection measurements. Optical-to-electrical transfer function measurements will typically see 2 dB⁵ less.

⁵ For optical-to-optical devices, (dB⁵) = $10 \log (\#2 \text{ optical power (W p-p)} / \#1 \text{ optical power (W p-p)})$

⁶ For optical-to-electrical devices, slope responsivity (dBe) = $20 \log ((\Delta \text{ current (A p-p)} / \Delta \text{ optical power (W p-p)}) / 1 \text{ A/W})$

⁷ For electrical-to-optical devices, slope responsivity (dBe) = $20 \log ((\Delta \text{ optical power (W p-p)} / \Delta \text{ current (A p-p)}) / 1 \text{ W/A})$

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 characteristics⁹

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 power¹¹				
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 isolation¹⁵	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 dB _o	15 dB _o	15 dB _o	15 dB _o
Harmonics (typical)¹⁶	<–9 dB _c	<–9 dB _c	<–9 dB _c	<–9 dB _c
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 dB_o 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. dB_c rating is for dB_e below the fundamental modulation components.

External lightwave sources²²

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.

Wavelengths¹⁷:

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 range¹⁸: 100 μ W to 5 mW (-10 dBm to +7 dBm)

Compatible fiber: 9/125 μ m

Degree of signal polarization: >20:1

Polarization controller: two quarter-wavelength elements required

Lightwave receiver characteristics¹⁹

Input wavelength²⁰: 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: \pm 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)

Directivity²¹: 37 dB (typical)

Isolation (“input” port to “coupled” port): 40 dB (typical)

Return loss, all ports: 37 dBo (typical with HMS-10 connector types)

¹⁷ Caution! Do not input wavelengths below 1200 nm. Damage to the 8703A optical modulator will result.

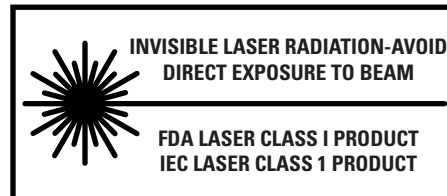
¹⁸ 9 dB optical loss is typical for the external lightwave source path through the optical modulator shown in Figure 1. This will affect system dynamic range. Compare cases to 83424A and 83425A configurations (Table 3 and 4) to calculate dynamic range for systems using different external sources.

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 \pm 10 nm and a normalized calibration can be done. However, complete 8703A performance cannot be warranted outside of 1308 or 1550 \pm 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 errors²³:

- Residual systematic errors (Table 5)
- System dynamic accuracy (dB from reference)²⁴
- 3.5 mm connector repeatability²⁵
- Lightwave source stability
- Lightwave source and receiver factory calibration uncertainty²⁶
- Switch repeatability
- Noise

A 10 Hz IF bandwidth, a 16 averaging factor and a $23 \pm 3^\circ\text{C}$ 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

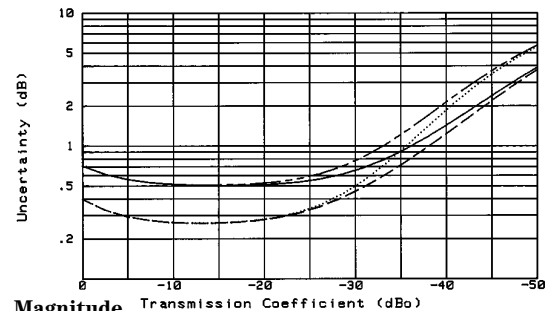
Connectors and cables:

HMS-10 lightwave connectors

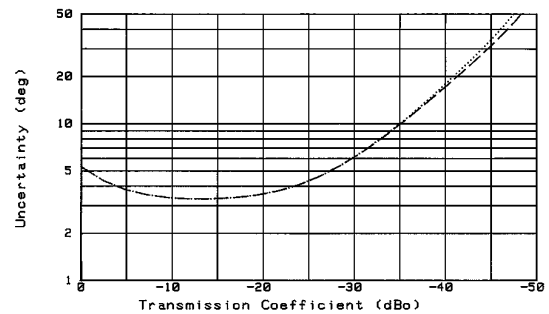
40 cm single mode fiber cables

Measurement uncertainty²⁹

Transmission test

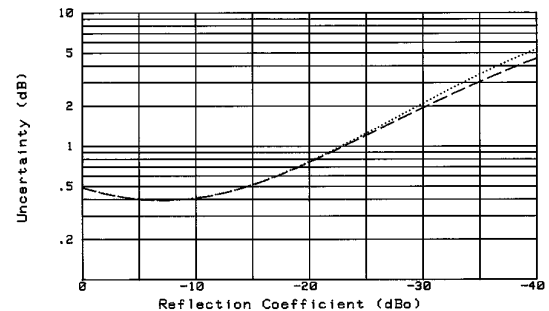


Magnitude
 --- 0.13 to 12 GHz
 - - - 12 to 20 GHz
 0.13 to 12 GHz (typical)
 12 to 20 GHz (typical)



Phase (typical)
 --- 0.13 to 12 GHz
 - - - 12 to 20 GHz

Reflection test



Magnitude (typical)
 --- 0.13 to 12 GHz
 - - - 12 to 20 GHz

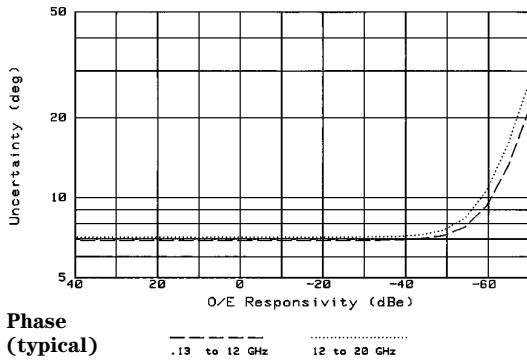
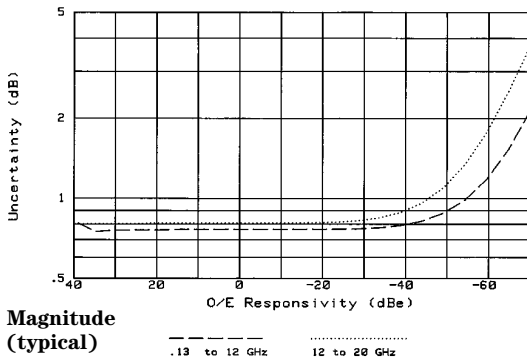
Optical-to-electrical³⁰

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 uncertainty²⁹

Transfer function test



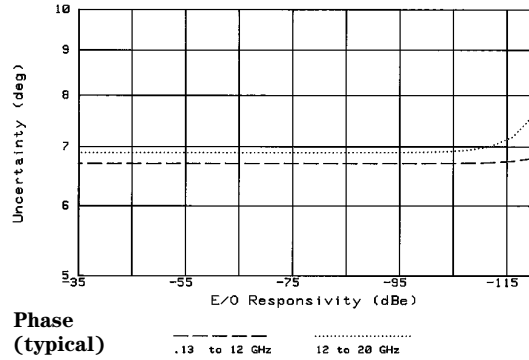
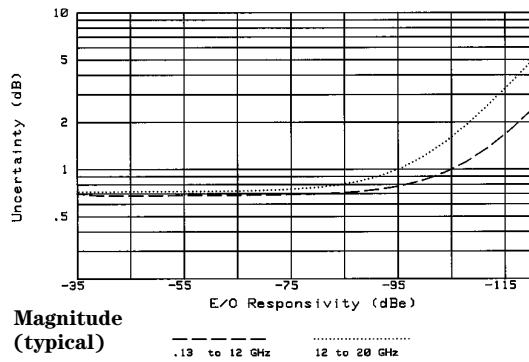
Electrical-to-optical³⁰

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 uncertainty²⁹

Transfer function test



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) = $-20 \log(\rho)$
 Transmission (dBe) = $20 \log(V2/V1) = 20 \log(I2/I1) = 10 \log(P2/P1)$
²⁹ Lightwave measurement uncertainty is defined as:
 Warranted uncertainty = $((\text{system errors})^2 + (\text{random RSS errors})^2)^{0.5}$. 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 dB/e
- RF output port return loss:** 50 dB
- Optical input port return loss:** 50 dB

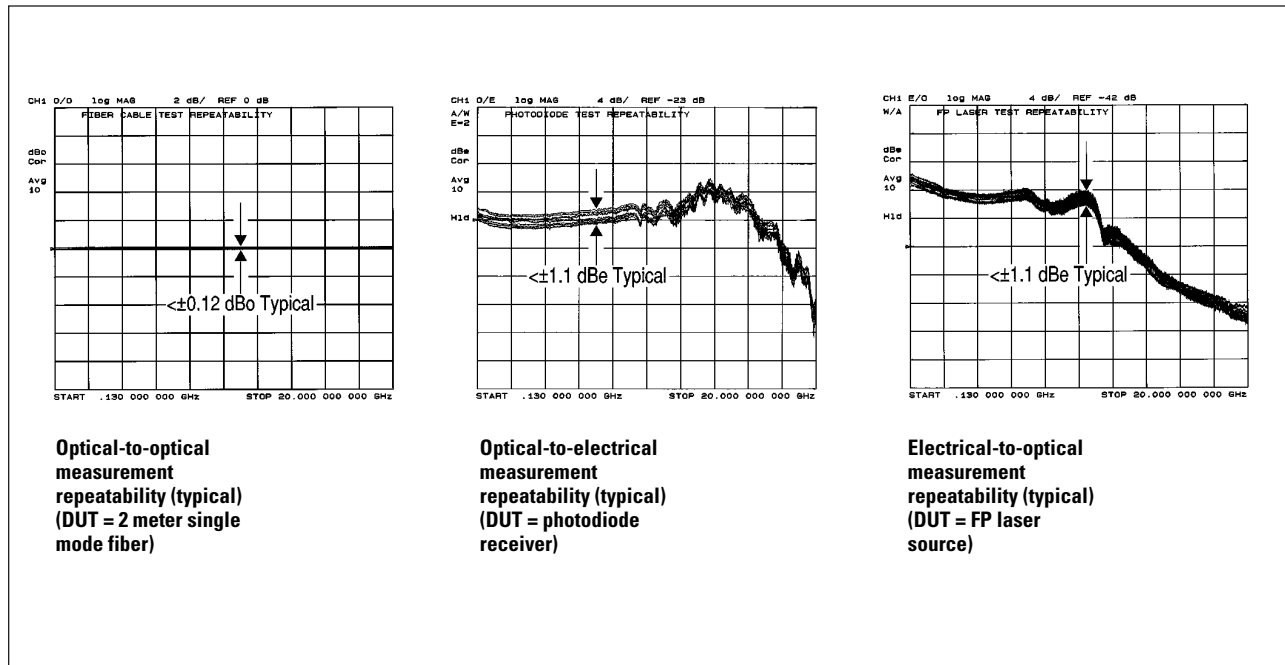
Description of uncertainty term

- 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.



Frequency domain microwave performance summary

Specifications describe the instrument's warranted performance for the temperature range of $23 \pm 3^\circ\text{C}$ 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 range³¹

	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 $23 \pm 3^\circ\text{C}$

± 3.0 ppm/year (typical) at $23 \pm 3^\circ\text{C}$

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)

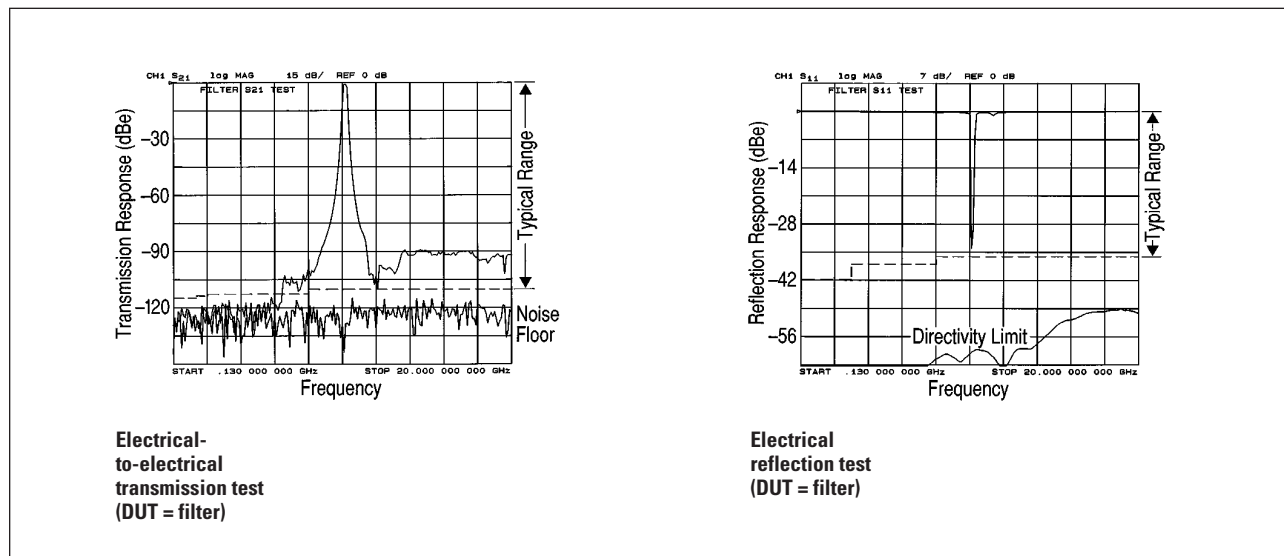
Maximum input power operating level: 0 dBm (1.0 mW)

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 ranges³².



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 errors³³:

- Residual systematic errors (Table 7)
- System dynamic accuracy (dB from reference)³⁴
- 3.5 mm connector repeatability
- Switch repeatability³⁵
- 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

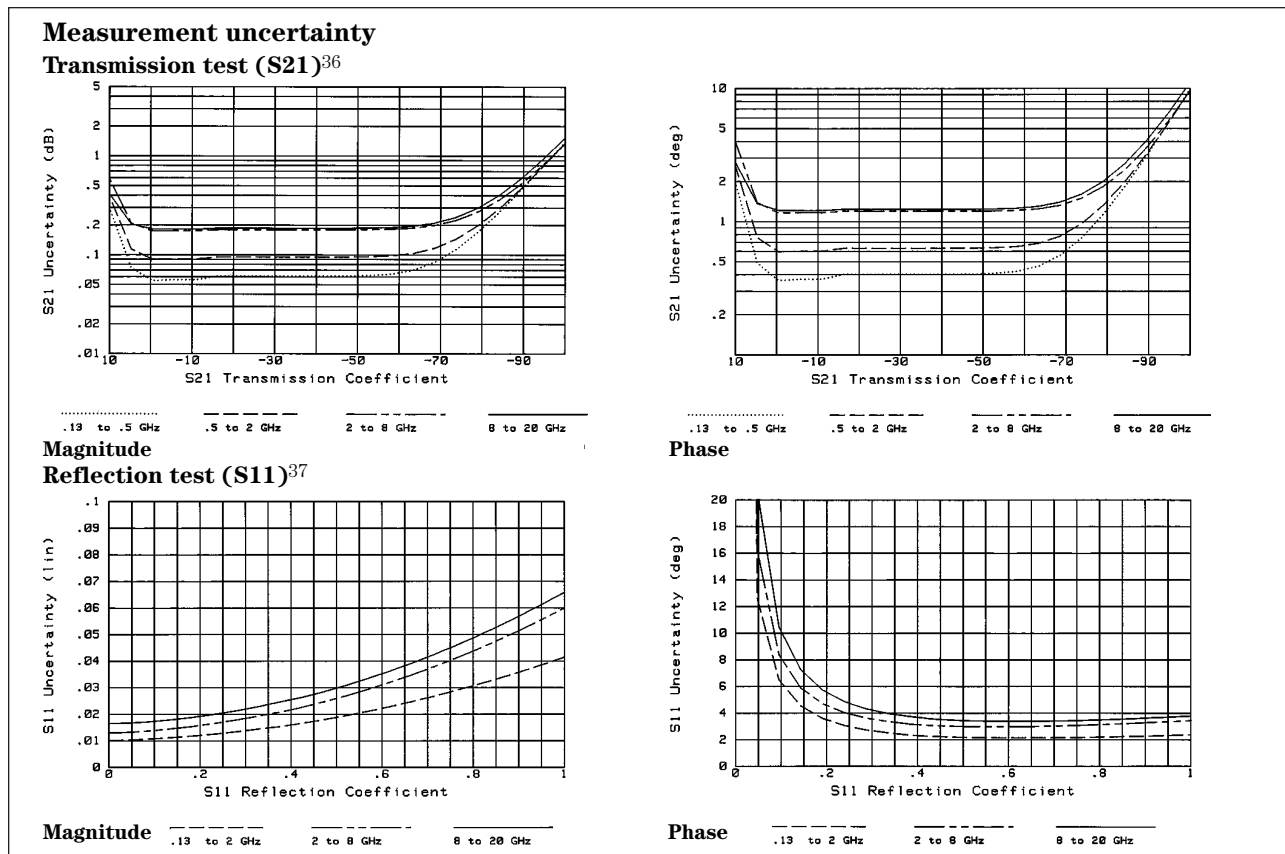
Measurement setup

- 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



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 (T_a), also called "alias free range", is defined below:

$$T_a = (N-1) / \text{Freq. Span}$$

where "N" = number of CRT data points⁴². If N = 201 points and Freq. Span = 20 GHz then $T_a = 10$ 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:

$$Tr = (\text{Time Span}) / (N-1)$$

where the "Time Span" is the span of time displayed on the 8703A's CRT. "N" is the number of display data points⁴¹. 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 response⁴²:

$$Tr = (0.45 / \text{Fspan}) \times 1.0 \text{ (min.) window factor}$$

2.2 (normal)
3.3 (max.)

Lowpass impulse response⁴³:

$$Tr = (0.6 / \text{Fspan}) \times 1.0 \text{ (min.) window factor}$$

1.6 (normal)
2.4 (max.)

Bandpass impulse response⁴³:

$$Tr = 2 \times (0.6 / \text{Fspan}) \times 1.0 \text{ (min.) window factor}$$

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.

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.

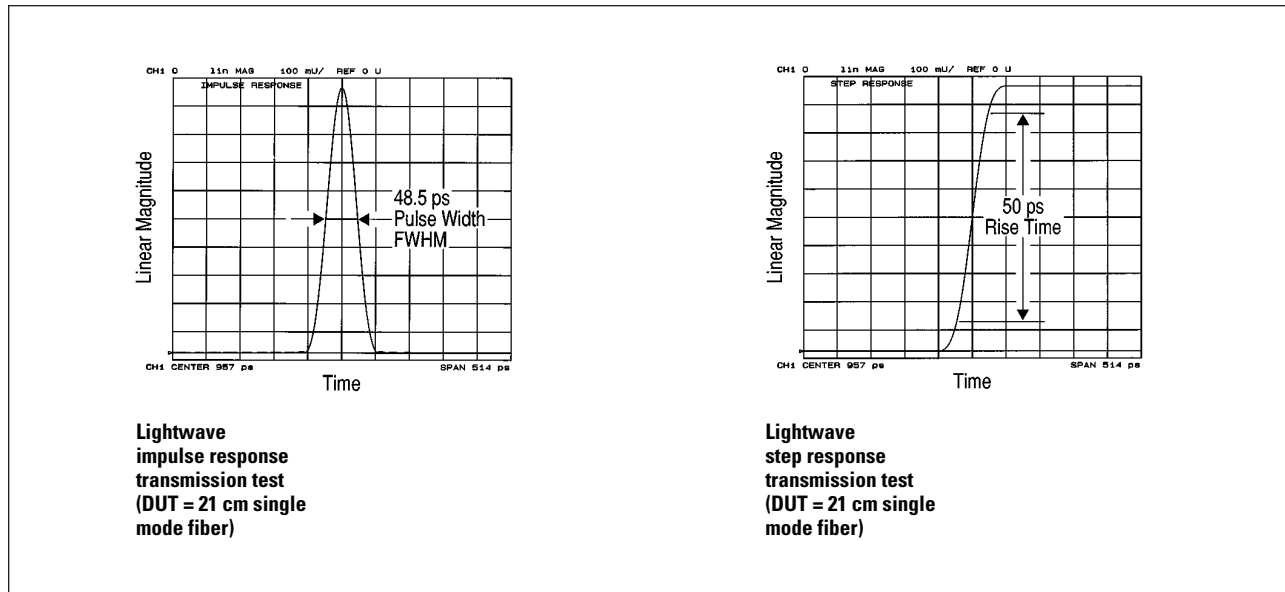
Distance-time domain performance summary cont'd

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

Table 8. Single response system dynamic range⁴⁵ (for distance-time lowpass impulse and step response modes, typical).

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 (dB_e) and electro-optical (dB_e) cases are not presented since the signal shape is similar to the lightwave examples shown.



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).

General information

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.

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

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 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

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:

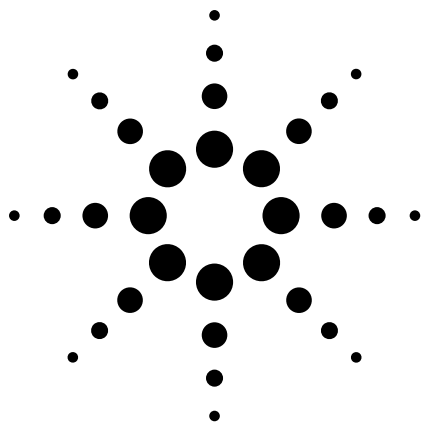
Agilent Technologies
24/F, Cityplaza One, 1111 King's Road,
Taikoo Shing, Hong Kong
(tel) (852) 3197 7777
(fax) (852) 2506 9284

Technical data subject to change
Copyright © 1990, 2000
Agilent Technologies
Printed in U.S.A. 7/00
5952-1754E



Agilent Technologies

Innovating the HP Way



Agilent 8703A Lightwave Component Analyzer Configuration Guide

**1300 nm or 1550 nm
130 MHz to 20 GHz modulation bandwidth**

The Agilent 8703A is part of the Agilent family of lightwave component analyzer solutions. The example configuration will help you consider your important options and record your selections. The Index Numbers in this example refer to appropriate model number descriptions inside this ordering guide.

Additional application information and performance specifications can be found in the technical data sheet (Agilent literature no. 5952-1754E) and Application Note 1550-6 High-speed lightwave component analysis (Agilent literature no. 5091-6478E).

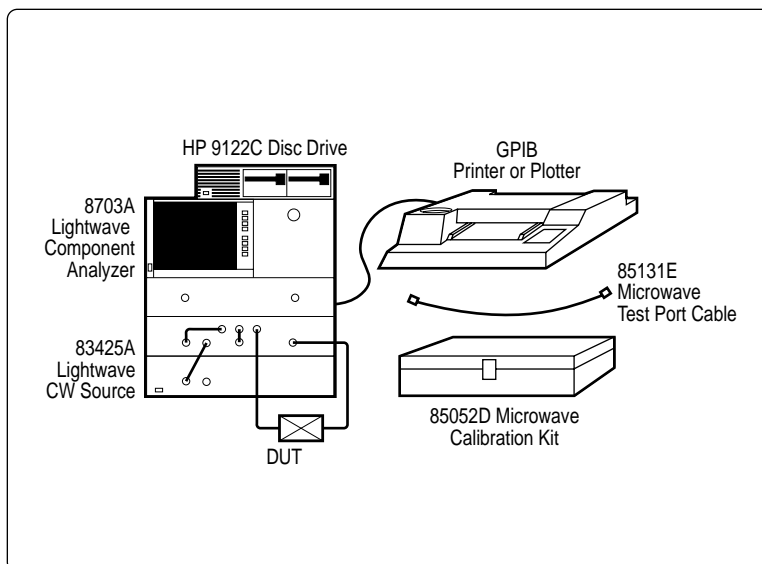
An Agilent 8703A with Option 01X, Option 220, and Option 830 is a complete configuration for a basic 1300 nm DFB system. It provides both lightwave and microwave measurements.

Another configuration is shown in the example and offers 1550 nm distributed feedback (DFB) source capability with an external lightwave source input for DWDM applications.

Modify or delete the following line items as necessary. Your personal configuration will appear on this page when you are finished.

Example Configuration:

Index Number	Model Number and Description	Qty
1.1	Agilent 8703A Lightwave Component Analyzer	1
1.2	Option 01X Connector	1
1.3	Option 100 Adds External Lightwave Source Input	1
1.4	Option 210 1550 nm DFB Laser	1
1.5	Option 300 Adds One Lightwave Receiver	1
1.6	Option 830 Adds Agilent 85052D Microwave Cal Kit and Agilent 85131E Microwave Test Port Cable	1



Agilent Technologies

Lightwave Measurement Instrument and Accessories

1.1

Standard Agilent 8703A configuration

This includes one lightwave receiver (receives both 1300 nm and 1550 nm lightwave signals), one lightwave directional coupler, an HP 9122C disk drive, and three 40 cm fiber optic cables. These cables provide for connections during measurement calibration and attachment to measurement devices. A connector option (section 1.2) must be specified. One laser option (section 1.4) must be specified. Lightwave and microwave test port cables (sections 2.1 and 5.0 to 7.0) with the proper connector type are ordered separately. Also includes Agilent N1031A BenchLink Lightwave software (section 10.5).

- Agilent 8703A** Lightwave Component Analyzer

1.2

Lightwave test port connector options

Must select one option to equip both the Agilent 8703A and the supplied 40 cm fiber optic cables with this connector type.

- Option 011** HMS-10 Connector
- Option 012** FC/PC Connector
- Option 013** DIN 47256 Connector
- Option 014** ST Connector
- Option 015** Biconic Connector
- Option 017** SC Connector

1.3

External lightwave source input option¹

With this option an external lightwave source can be switched in to substitute for the internal lightwave source. Wavelength of external source is restricted to 1530 to 1570 nm for Option 210 configuration and 1290 to 1330 nm for Option 220 configuration.

- Option 100** Adds External Lightwave Source Input

1.4

Distributed feedback laser (DFB) source options

Only one option from this category can be selected.

- Option 210** 1550 nm DFB Laser
- Option 220** 1300 nm DFB Laser

1.5

Lightwave receiver option¹

With two lightwave receivers, simultaneous transmission and reflection tests can be done or two devices can be tested at the same time.

- Option 300** Adds One Lightwave Receiver 1300 nm and 1500 nm

1.6

Accessory and service options

- Option 830** Adds Agilent 85052D Microwave Calibration Kit and Agilent 85131E Microwave Test Port Cables (see section 5.0 to 7.0)
- Option 908** Rackmount Kit
- Option 910** Extra Operating and Service Manual

¹ External lightwave source input or additional lightwave receiver capability can be added later to an existing Agilent 8703A. 8703As may need to be returned to the factory for some of these upgrades. Upgrade cost will be greater than the price of the associated option. Contact the nearest Agilent service center for upgrade price and delivery information.

Fiber Optic Cables

2.1

Fiber optic test port cables

- 81101AC** Diamond HMS-10 Fiber Cable, 9/125 μm , 2 meter
- 11871A** PC Fiber Cable, 9/125 μm , 1 meter
- 11871B** ST Fiber Cable, SMF, 9/125 μm , 1 meter
- 11871C** Biconic Fiber Cable, SMF, 9/125 μm , 1 meter

Lightwave Connector Adapters

4.1

Connector adapters

The lightwave connector options equip the Agilent 8703A with a uniform front panel connector type. However if different connector types are also desired then the following connector adapters can be used. Change a front panel connector type by removing an existing connector type and attaching the desired connector adapter (listed below). Five to seven are required to change the entire front panel depending on the configuration. Fiber optic cables in the new connector type will also be required.

- 81000AI** HMS-10 Connector Adapter
(Agilent part number 08154-61701)
- 81000FI** FC/PC Connector Adapter
(Agilent part number 08154-61702)
- 81000SI** DIN 47256 Connector Adapter
(Agilent part number 08154-61703)
- 81000VI** ST Connector Adapter (Agilent part number 08154-61704)
- 81000WI** Biconic Connector Adapter (Agilent part number 08154-61705)

Microwave Measurement Accessories

For Devices with 3.5 mm Connectors

5.1

Calibration and verification kits

- 85052B** 3.5 mm Calibration Kit
(Contains open and short circuits, fixed lowband and sliding loads, 3.5 mm to 3.5 mm adapters, and 3.5 mm connector tools and gages)
- 85052D** 3.5 mm Economy Calibration Kit
(Contains open and short circuits, fixed precision broadband loads, 3.5 mm to 3.5 mm adapters, and 3.5 mm tools. (Refer to 8703A/Opt. 830, section 1.6.)
- 85053B** 3.5 mm Verification Kit
(Contains precision airline, mismatched airline, 20 dB and 40 dB attenuators with NIST traceable data and uncertainties)

5.2

Test port return cables

The “C” and “E” cables below are for measurements where one end of the device under test is connected directly to the analyzer. These cables have a special 3.5 mm connector on one end for connection to the analyzer and a precision 3.5 mm (female) connector on the other end for connection to the device.

- 85131C** 3.5 mm Test Port Return Cable (Standard)
- 85131E** 3.5 mm Test Port Return Cable (Flexible)
(Refer to 8703A/Option 830, section 1.6)

The “D” and “F” cables below are for measurements where the device under test is connected between the cable ends. Each cable has a special 3.5 mm connector on one end for connection to the analyzer, and a precision 3.5 mm connector on the other end (1 male and 1 female) for connection to the device.

- 85131D** 3.5 mm Test Port Return Cable Set (Standard)
- 85131F** 3.5 mm Test Port Return Cable Set (Flexible)

5.3

Special adapter set

This adapter set functions as a “test port saver” in applications where 3.5 mm devices are measured in high volume. Wear and potential damage to the analyzer’s test ports are minimized.

- 85130D** Special Adapter Set

For Devices with 7 mm Connectors

6.1

Calibration and verification kits

- 85050B** 7 mm Calibration Kit
(Contains open and short circuits, fixed lowband and sliding loads, 7 mm tools and connector gage)
- 85050D** 7 mm Economy Calibration Kit
(Contains an open circuit, short circuit and fixed precision broadband load. 7 mm torque wrench is included)
- 85051B** 7 mm Verification Kit
(Contains beadless airline, mismatched airline, 20 dB and 50 dB attenuators with NIST traceable data and uncertainties)

6.2

Test port return cables

The “C” and “E” cables below are for measurements where one end of the device under test is connected directly to the analyzer’s test ports. (See Agilent 85130B below). These cables have a special 3.5 mm connector on one end for direct connection to the analyzer, and a 7 mm connector on the other end for connection to the device.

- 85132C** 7 mm Test Port Return Cable (Standard)
- 85132E** 7 mm Test Port Return Cable (Flexible)

The “D” and “F” cables below are for measurements where the device under test is connected between the cable ends. Each cable has a special 3.5 mm connector for direct connection to the analyzer, and a 7 mm connector on the other end for connection to the device.

- 85132D** 7 mm Test Port Return Cable Set (Standard)
- 85132F** 7 mm Test Port Return Cable Set (Flexible)

6.3

Special adapter set

This adapter set functions as a 3.5 mm to 7 mm adapter in applications where 7 mm devices are to be connected directly to the analyzer. Recommended when using Agilent 85132C/E single cables.

- 85130B** Special Adapter Set

For Devices with Type-N Connectors

7.1

Calibration and verification kits

- 85054B** Type-N Calibration Kit
(Contains open and short circuits, fixed lowband and sliding loads, 7 mm to type-N adapters, type-N to type-N adapters, and type-N connector tools and gages)
- 85054D** Type-N Economy Calibration Kit
(Contains open and short circuits, fixed precision broadband loads, 7 mm to type-N adaptors, type-N to type-N adaptors, and type-N connector tools)
- 85055A** Type-N Verification Kit
(Contains precision airline, mismatched airline, 20 dB and 50 dB attenuators with NIST traceable data and uncertainties)

7.2

Test port return cables

Use the test port return cables recommended for measurements on devices with 7 mm connectors (Agilent 85132C/D/E/F), with 7 mm to type-N adapters from the Agilent 85054B/D type-N Calibration Kit. If the Agilent 85132C/E single cables are used, the Agilent 85130C adapter set is also recommended.

7.3

Special adapter set

This adapter set functions as a 3.5 mm to type-N adapter in applications where type-N devices are to be connected directly to the analyzer’s test ports.

- 85130C** Special Adapter Set

General System Equipment and Accessories

No external computer is required for copying the analyzer's screen to a plotter or a printer; or storing measurement data, instrument data, and calibration sets to a disk drive (CS80 format drives only).

Peripherals

8.2

Printers

Compatible with most HP Printers configured with GPIB interface. Consult your local Agilent office for more details.

8.3

Disk drives

Measurement data, instrument states, and calibration sets may be stored directly to an external disk without the aid of a computer. Compatible only with the CS80 format drives.

An HP 9122C 3.5 in. Dual Disk Drive is included with the standard Agilent 8703A.

Rack Configuration

9.1

System rack

This system rack is 123.7 cm (48.7 in.) high x 60 cm (23.6 in.) wide x 80 cm (31.5 in.) deep. It is supplied with an anti-static mat, support rails, rack mounting kits, power distribution, and two Agilent 10833A GPIB cables for connecting system peripherals to the analyzer.

- Agilent 85043D** System Rack

Automatic Test Systems

10.1

Computers

An external controller is not necessary for automatic and calibrated Agilent 8703A operation. However, the 8703A can become part of a large automatic test system when a computer is used. Most computers configured with GPIB and software drivers are compatible.

10.2

Mass storage

Compatible with CS80 format drives.

An HP 9122C 3.5 in. Dual Disk Drive is included with the standard Agilent 8703A.

10.4

GPIB cables

Choose one of the following cables for each peripheral:

- 10833A** 1 m (3.3 ft.) GPIB Cable
- 10833B** 2.0 m (6.6 ft.) GPIB Cable
- 10833C** 4.0 m (13.3 ft.) GPIB Cable
- 10833D** 0.5 m (1.6 ft.) GPIB Cable

10.5

Software

The Agilent N1031A BenchLink Lightwave software is included with the standard Agilent 8703A. This software makes possible screen image capture, trace data capture and instrument state save and restore.

BenchLink Lightwave is a 32-bit product that operates and is supported on the following platforms:

- Windows® 95
- Windows® 98
- Windows NT® 4.0
- Windows NT® 5.0

It does not work with Windows® 3.X or prior versions of Windows®. The following PC-to-instrument interfaces are supported by the Agilent N1031A product on the indicated platforms:

Supported Interfaces	95	98	NT 4	NT 5
Agilent				
82335A/B	•	•		
82340A			•	•
82341B			•	•
82341C	•	•	•	•
82341D	•	•		
82350A	•	•	•	•
National Instruments				
National PCI-GPIB	•	•	•	•
National PCI-GPIB+			•	•
National PCMCIA-GPIB	•	•	•	•
National PCMCIA-GPIB+	•	•		
National AT-GPIB/TNT(pnp)	•	•	•	•
National AT-GPIB/TNT+(pnp)	•	•	•	•
National AT-GPIB	•	•	•	•
National AT-GPIB/TNT	•	•		
National EISA-GPIB	•	•		

Windows and Windows NT are U.S. registered trademarks of Microsoft Corporation.

Agilent Technologies' Test and Measurement Support, Services, and Assistance

Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

Our Promise

Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you use Agilent equipment, we can verify that it works properly, help with product operation, and provide basic measurement assistance for the use of specified capabilities, at no extra cost upon request. Many self-help tools are available.

Your Advantage

Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and on-site education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.

By internet, phone, or fax, get assistance with all your test & measurement needs.

**Online assistance:
www.agilent.com/comms/lightwave**

Phone or Fax

United States:

(tel) 1 800 452 4844

Canada:

(tel) 1 877 894 4414

(fax) (905) 282 6495

China:

(tel) 800-810-0189

(fax) 1-0800-650-0121

Europe:

(tel) (31 20) 547 2323

(fax) (31 20) 547 2390

Japan:

(tel) (81) 426 56 7832

(fax) (81) 426 56 7840

Korea:

(tel) (82-2) 2004-5004

(fax)(82-2) 2004-5115

Latin America:

(tel) (305) 269 7500

(fax) (305) 269 7599

Taiwan:

(tel) 080-004-7866

(fax) (886-2) 2545-6723

Other Asia Pacific Countries:

(tel) (65) 375-8100

(fax) (65) 836-0252

Email: tm_asia@agilent.com

Product specifications and descriptions in this document subject to change without notice.

© 1999 Agilent Technologies, Inc.

Printed in USA March 1, 2002

5966-4827E



Agilent Technologies