Test Equipment Solutions Ltd specialise in the second user sale, rental and distribution of quality test & measurement (T&M) equipment. We stock all major equipment types such as spectrum analyzers, signal generators, oscilloscopes, power meters, logic analysers etc from all the major suppliers such as Agilent, Tektronix, Anritsu and Rohde & Schwarz.

We are focused at the professional end of the marketplace, primarily working with customers for whom high performance, quality and service are key, whilst realising the cost savings that second user equipment offers. As such, we fully test & refurbish equipment in our in-house, traceable Lab. Items are supplied with manuals, accessories and typically a full no-quibble 2 year warranty. Our staff have extensive backgrounds in T&M, totalling over 150 years of combined experience, which enables us to deliver industry-leading service and support. We endeavour to be customer focused in every way right down to the detail, such as offering free delivery on sales, covering the cost of warranty returns BOTH ways (plus supplying a loan unit, if available) and supplying a free business tool with every order.

As well as the headline benefit of cost saving, second user offers shorter lead times, higher reliability and multivendor solutions. Rental, of course, is ideal for shorter-term needs and offers fast delivery, flexibility, try-before-you-buy, zero capital expenditure, lower risk and off balance sheet accounting. Both second user and rental improve the key business measure of Return On Capital Employed.

We are based near Heathrow Airport in the UK from where we supply test equipment worldwide. Our facility incorporates Sales, Support, Admin, Logistics and our own in-house Lab.

All products supplied by Test Equipment Solutions include:
- No-quibble parts & labour warranty (we provide transport for UK mainland addresses).
- Free loan equipment during warranty repair, if available.
- Full electrical, mechanical and safety refurbishment in our in-house Lab.
- Certificate of Conformance (calibration available on request).
- Manuals and accessories required for normal operation.
- Free insured delivery to your UK mainland address (sales).
- Support from our team of seasoned Test & Measurement engineers.
- ISO9001 quality assurance.

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Network Analyzers

HP 8719D, 8720D, 8722D Microwave Network Analyzers, 50 MHz to 40 GHz

- 50 MHz to 12.5, 20, or 40 GHz frequency coverage
- Fast-sweeping, built-in synthesized source
- Integrated solid-state switching S-parameter test set
- Vector receiver, error correction, time domain
- Direct save/recall from built-in 3.5-inch floppy disk drive
- Up to 105 dB dynamic range

HP 8720D provides flexibility, performance, and ease of use to solve your toughest device measurement problems.

HP 8720D Series Microwave Network Analyzers

The HP 8719D, 8720D and 8722D vector network analyzers (VNAs) offer built-in source, receiver, and S-parameter test set covering frequencies from 50 MHz to 13.5, 20 or 40 GHz. With their built-in 3.5-inch disk drive and serial/parallel ports, you’ll benefit from improved data handling, in addition to higher accuracy, faster sweep speed, and built-in test sequencing automation. Compact, economical, and easy to use, the 8720D family provides accurate, fast tests of microwave filters, amplifiers, mixers, multiport devices and cables in coaxial and waveguide environments, as well as waveguide, in fixture and on-wafer. The HP 8720 family is an ideal choice for cost- and space-conscious engineers in research and development, manufacturing, incoming inspection, or quality assurance.

Affordable Analyzers with Outstanding Performance

Despite their affordable price, the HP 8720 series network analyzers offer remarkable performance. The integrated source is fully synthesized, even while sweeping, and provides stability and accuracy within 10 ppm (typical). Yet the sweep rate is extremely fast: measurement update times are typically about 1 ms per point. Frequency resolution is 1 Hz standard for accurate measurements of narrowband or long-delay devices.

The tuned receivers with variable bandwidth IF filters provide up to 105 dB of dynamic range. A built-in, solid-state switching test set measures both forward and reverse parameters with a single connection, and provides continuous updating of all four S-parameters as required for two-port error correction.

Two independent channels can simultaneously display two measurements, such as reflection and transmission responses. The receiver detects both magnitude and phase, and displays results in a variety of useful formats, including group delay, deviation from linear phase, complex impedance or admittance, and SWR or rectangular, polar or Smith charts. Built-in vector accuracy enhancement provides excellent error-corrected accuracy in all common coaxial connectors. A user kit supports user-defined standards, and allows calibration in waveguide (including effects of dispersion).

Powerful Features for Active Devices

With +5 dBm at their test ports, the HP 8719D and 8720D have plenty of power for testing amplifiers. Option 007 provides 5 dB more output power by replacing the solid-state transfer switch with a mechanical switch (although Option 007 does not provide continuous updating of all four S-parameters). For sensitive small-signal devices, the built-in step attenuator can cut power back to –70 dBm. Absolute power levels can be set accurately anywhere in the system, using the power meter calibration feature. Power-sweep capability and power resolution of 0.01 dB make it easy to test the gain-compression characteristics of active components. A new sweep mode controls power during retrace for safe testing of AGC amplifiers.

In-Fixture and On-Wafer Device Characterization

Use TRL*/LRM* calibration to minimize fixture errors for measuring noncoaxial devices (such as microstrip). Combine the network analyzer with a wafer probing station in order to measure devices while still on the wafer. For even better accuracy, Option 400 adds a fourth sampler and TRL/LRM calibration. Electronic port extensions and gating are also available to enhance accuracy.

Time Domain and Fault Location

Time domain capability (Option 010) computes and displays the response versus time or distance (instead of frequency) of the device under test. Use the domain to locate and quantity individual faults or discontinuities in a network. Apply the gating feature to remove the effects of unwanted reflections (separated in time), then view the device under test’s true response versus frequency.

Productivity Features

Limit-test capability makes pass/fail decisions quantitative and decisive, allowing faster tuning and more consistent testing. Fast two-port tuning mode speeds up 12-term error correction by allowing the user to specify a number of forward sweeps to take before updating the reverse sweep.

To document results without a computer, the copy feature sends the measured display to a compatible plotter or printer using the HP-IB, serial, or parallel interface. A built-in buffer controls the peripheral while you continue with the next measurement. Up to five markers per channel can be used to annotate trace features or search and track values with marker functions.

With save/recall capability, you can define and save test configurations, then recall identical conditions later, and align or test each device under test consistently. Use up to 31 internal nonvolatile memory registers, or save/recall directly to an internal 3.5-inch floppy disk drive.

Automate repeated tasks with test sequencing. Create test sequences with automatic keystroke recording, then repeat the measurements with a single keystroke. No programming expertise is needed. You can also use test sequencing to control external devices such as part handlers through the parallel port.

Adapter Removal Calibration

This feature, adopted from the 8510, provides greater accuracy for measuring non-insertable devices, such as devices with the same sex connectors on both ports or different connector types on ports 1 and 2. Adapter-removal calibration effectively removes the errors from the adapter that must be used during a non-insertable calibration to make a “thru” connection between the test ports. For customers with older versions of the HP 8719D, 8720D, or 8722D, this capability can be obtained with a firmware upgrade (p/n 08720-60168). Other key features included in the new firmware are S2P format data output files and a wider IF bandwidth. S2P format is convenient, easy-to-read, and compatible with CAD programs, including HP EEsol Libra, Touchstone, and jOmega. A wider 3.7 kHz IF bandwidth has been added to provide 15 to 20 percent faster measurements than the previous 3 kHz bandwidth, with only minor increases in trace noise and noise floor.

Key Literature

HP 8719D, 8720D, 8722D Microwave Vector Network Analyzers

Brochure, p/n 5964-6419E
HP 8719D, 8720D, 8722D Network Analyzers

Technical Specifications, p/n 5964-9133E
HP 8719D, 8720D, 8722D Network Analyzers

Configuration Guide, p/n 5964-9138E
Flexible Configuration for Applications

Option 007 replaces the standard solid-state transfer switch with a mechanical switch to provide 5 dB more power at the test port, and 5 dB more dynamic range. The mechanical transfer switch does not provide continuous updating of all 4 parameters for full two-port calibration.

Option 010 adds time-domain capability, which allows fault location and gating of fixture responses.

Option 012 provides direct sampler access, enabling the user to eliminate coupling loss and increase sensitivity by 16 dB. Option 012 allows filter rejection measurements to greater than –120 dB and allows insertion of attenuation between coupler and sampler. By using separate transmit and receive antennae, Option 012 can improve signal-to-noise in free-space measurements.

Option 085 is a high-power S-parameter test set modification allowing device test up to +43 dBm (20 watts) input and output. It deletes the bias tees, replaces the solid-state switch with a mechanical switch, and adds internal attenuators.

Software Enhances Measurement Capability

Software options enhance the HP 8720 family of network analyzers. They combine a standard network analyzer with Options 400, 010, 012, and 1D5 at a value price.

Upgrades and Retrofit Kits

The following options are available for all three models:

- Add Four-Sampler Test Set
- Add Frequency Offset Mode
- Add High-Power Test Capability
- Add Direct Sampler Access
- Add Time Domain Capability
- Add Rackmount Kit
- Add High-Stability Frequency Reference
- Add Rackmount and Handle Kit
- Add 1 yr. on-site to 3-yr. return to HP warranty

Ordering Information

The following options apply to all three network analyzers:

- Opt 007 Mechanical Transfer Switch
- Opt 010 Time Domain Capability
- Opt 012 Direct Sampler Access
- Opt 085 High-Power Test Set
- Opt 085 Frequency Offset Mode
- Opt 1D5 High-Stability Frequency Reference
- Opt 1CM Rackmount Kit
- Opt 1CP Rackmount and Handle Kit
- Opt W08 Conver 1-yr. on-site to 3-yr. return to HP warranty

The DX models are pre-configured systems for noncoaxial applications that include Options 400, 010, 012, and 1D5 at a value price.

Network Analyzers, 50 MHz to 40 GHz

HP 8719D
HP 8720D
HP 8722D

Minimum Frequency
50 MHz
50 MHz
50 MHz

Maximum Frequency
13.5 GHz
20 GHz
40 GHz

Frequency Resolution
1 Hz
1 Hz
1 Hz

Frequency Accuracy
10 ppm
10 ppm
10 ppm

Max. Source Power (std)
+5 dBm
+5 dBm
+5 dBm, < 20 GHz

With Option 007
+10 dBm
+10 dBm
0 dBm, < 20 GHz

With Option 007
–70 dBm
–70 dBm
–75 dBm

Power Flattness
± 1.5 dB
± 1.5 dB
± 2 dB

Power Sweep Range
20 dB
20 dB
15 dB

System Dynamic Range (>2 GHz)
100 dB
100 dB
82 to 93 dB

With Option 007
105 dB
105 dB
86 to 98 dB

Test Port Connector
3.5 mm
3.5 mm
2.4 mm

Measurement Rate (typical, 201-point sweep): < 2 ms/point (1-port cal)
to < 5 ms/point (full 2-port cal)

HP-IB Functions: SH1, A1H, T6, TEO, L4, LE0, SR1, RL1, PP0, DC1, D70, C0, C1, C3, C2, E2

Size: 222 mm H x 425 mm W x 457 mm D (8.75 in x 16.750 in x 18.00 in)

Weight: Net, 25 kg (54 lb); shipping, 28 kg (61 lb)

Internet URL www.hp.com/go/tmc98

Product & Order Info See inside back cover
Agilent 8719D, 8720D, and 8722D Network Analyzers
Data Sheet

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2 Definitions and test conditions
3 System performance
3.4.5 Instruments with multiple options
   Standard (no options)
   Standard Instrument Performance
   Option 400 (four samplers for TRL)
   Also includes these configurations combined with
   Options 089 and/or 012
6, 7, 8 Option 007 (mechanical switch)
   Option 007/085 Performance
   Option 085 (high power)
   Also includes these configurations combined with
   Options 089 and/or 012
9 Option 012
10 Option 089
11 Specifications and characteristics
12 Measurement throughput summary
13 Analyzer options
15 Capabilities
22 Software
24 Accessories

Agilent Technologies
Innovating the HP Way
Definitions and Test Conditions

This data sheet provides two types of performance information:

- System Specifications
- Supplemental Characteristics

**System specifications** describe the instrument’s warranted performance over the temperature range of 23 °C ± 3 °C (except where noted).

**Supplemental characteristics** describe the instrument’s non-warranted performance parameters.

**System dynamic range**
These specifications apply to transmission measurements in the full frequency range at 10 Hz IF BW with response and isolation correction or full two-port calibration. Dynamic range is limited by maximum receiver input level and the receiver’s noise floor.

**Measurement uncertainty**
Curves show the worst-case magnitude and phase uncertainty for reflection and transmission measurements, after calibration. Calibration is the process of measuring known standards from a calibration kit to characterize a network analyzer’s systematic (repeatable) errors.

Reflection measurement uncertainty is plotted as a function of S11 (reflection coefficient). Based on a one-port calibration, using specified calibration kit, with 10 Hz IF bandwidth and no averaging. Assumes a one-port device (S22=S12=0).

Transmission measurement uncertainty is plotted as a function of S21 (transmission gain/loss, in dB from reference level). Assumes a well-matched device (S11=S22=0). Based on a full two-port Short-Open-Load-Thru calibration (including isolation with averaging factor of 8), using specified calibration kit, with 10 Hz IF bandwidth and no averaging.

**Measurement port characteristics**
The characteristics indicate performance after error correction (full two-port calibration). The performance accuracy is determined by the quality of calibration standards and how well “known” they are, plus system repeatability, stability, and noise. Crosstalk is not shown, since isolation calibration will reduce crosstalk to the noise floor.
**System performance**

**Agilent 8719D, 8720D with 3.5 mm test ports**

*Standard, Options 400, 012, 089, or any combination of these options*

*Calibration kit: Agilent 85052B, 3.5 mm with sliding loads*

*Cables: Agilent 85131F 3.5 mm flexible cable set*

*IF bandwidth: 10 Hz*

*Averaging: None (8 during isolation calibration)*

**System dynamic range**

<table>
<thead>
<tr>
<th>Frequency Range (GHz)</th>
<th>0.05 to 0.5</th>
<th>0.5 to 2</th>
<th>2 to 8</th>
<th>8 to 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directivity</td>
<td>48 dB</td>
<td>48 dB</td>
<td>44 dB</td>
<td>44 dB</td>
</tr>
<tr>
<td>Source Match</td>
<td>40 dB</td>
<td>40 dB</td>
<td>33 dB</td>
<td>31 dB</td>
</tr>
<tr>
<td>Load Match</td>
<td>48 dB</td>
<td>48 dB</td>
<td>44 dB</td>
<td>44 dB</td>
</tr>
<tr>
<td>Reflection Tracking</td>
<td>±0.006 dB</td>
<td>±0.006 dB</td>
<td>±0.006 dB</td>
<td>±0.006 dB</td>
</tr>
<tr>
<td>Transmission Tracking</td>
<td>±0.017 dB</td>
<td>±0.018 dB</td>
<td>±0.066 dB</td>
<td>±0.099 dB</td>
</tr>
</tbody>
</table>

1. Rolls off below 840 MHz to 77 dB at 50 MHz

**Measurement uncertainty**

*Reflection measurements*

<table>
<thead>
<tr>
<th>Frequency Range (GHz)</th>
<th>0.05 to 0.5</th>
<th>0.5 to 2</th>
<th>2 to 8</th>
<th>8 to 20</th>
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<td>±0.066 dB</td>
<td>±0.099 dB</td>
</tr>
</tbody>
</table>

**Maximum output power**

+5 dBm

*Transmission measurements*
System performance (continued)

Agilent 8722D with 2.4 mm test ports
Standard, Options 400, 012, 089, or any combination of these options.

Calibration kit: Agilent 85056A, 2.4 mm with sliding loads
Cables: Agilent 85133F 2.4 mm flexible cable set
IF bandwidth: 10 Hz
Averaging: None (8 during isolation calibration)

System dynamic range

<table>
<thead>
<tr>
<th>Frequency Range (GHz)</th>
<th>Dynamic Range (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 to 2</td>
<td>93 dB1</td>
</tr>
<tr>
<td>2 to 8</td>
<td>93 dB</td>
</tr>
<tr>
<td>8 to 20</td>
<td>91 dB</td>
</tr>
<tr>
<td>20 to 40</td>
<td>80 dB</td>
</tr>
</tbody>
</table>

1. Rolls off below 840 MHz to 72 dB at 50 MHz

Corrected measurement port characteristics

<table>
<thead>
<tr>
<th>Frequency Range (GHz)</th>
<th>Directivity</th>
<th>Source Match</th>
<th>Load Match</th>
<th>Reflection Tracking</th>
<th>Transmission Tracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 to 2</td>
<td>42 dB</td>
<td>42 dB</td>
<td>42 dB</td>
<td>±0.005 dB</td>
<td>±0.020 dB</td>
</tr>
<tr>
<td>2 to 8</td>
<td>42 dB</td>
<td>42 dB</td>
<td>42 dB</td>
<td>±0.010 dB</td>
<td>±0.038 dB</td>
</tr>
<tr>
<td>8 to 20</td>
<td>42 dB</td>
<td>42 dB</td>
<td>42 dB</td>
<td>±0.010 dB</td>
<td>±0.048 dB</td>
</tr>
<tr>
<td>20 to 40</td>
<td>38 dB</td>
<td>38 dB</td>
<td>38 dB</td>
<td>±0.021 dB</td>
<td>±0.110 dB</td>
</tr>
</tbody>
</table>

Maximum output power
0.05 to 20 GHz: -5 dBm
20 to 40 GHz: -10 dBm

Measurement uncertainty

Reflection measurements

<table>
<thead>
<tr>
<th>Frequency Range (GHz)</th>
<th>Directivity</th>
<th>Source Match</th>
<th>Load Match</th>
<th>Reflection Tracking</th>
<th>Transmission Tracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 to 2</td>
<td>42 dB</td>
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<td>±0.020 dB</td>
</tr>
<tr>
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<td>42 dB</td>
<td>42 dB</td>
<td>±0.010 dB</td>
<td>±0.038 dB</td>
</tr>
<tr>
<td>8 to 20</td>
<td>42 dB</td>
<td>42 dB</td>
<td>42 dB</td>
<td>±0.010 dB</td>
<td>±0.048 dB</td>
</tr>
<tr>
<td>20 to 40</td>
<td>38 dB</td>
<td>38 dB</td>
<td>38 dB</td>
<td>±0.021 dB</td>
<td>±0.110 dB</td>
</tr>
</tbody>
</table>

Transmission measurements

<table>
<thead>
<tr>
<th>Frequency Range (GHz)</th>
<th>Directivity</th>
<th>Source Match</th>
<th>Load Match</th>
<th>Reflection Tracking</th>
<th>Transmission Tracking</th>
</tr>
</thead>
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<td>42 dB</td>
<td>42 dB</td>
<td>42 dB</td>
<td>±0.005 dB</td>
<td>±0.020 dB</td>
</tr>
<tr>
<td>2 to 8</td>
<td>42 dB</td>
<td>42 dB</td>
<td>42 dB</td>
<td>±0.010 dB</td>
<td>±0.038 dB</td>
</tr>
<tr>
<td>8 to 20</td>
<td>42 dB</td>
<td>42 dB</td>
<td>42 dB</td>
<td>±0.010 dB</td>
<td>±0.048 dB</td>
</tr>
<tr>
<td>20 to 40</td>
<td>38 dB</td>
<td>38 dB</td>
<td>38 dB</td>
<td>±0.021 dB</td>
<td>±0.110 dB</td>
</tr>
</tbody>
</table>
Agilent 8719D Option 400
Agilent 8720D Option 400
Agilent 8722D Option 400
(with 3.5 mm test ports using TRL)
Includes instruments with Options 012 and/or 089

Calibration kit: Agilent 85052C, 3.5 mm for TRL
Cables: Agilent 85131F 3.5 mm flexible cable set
IF bandwidth: 10 Hz
Averaging: None (8 during isolation calibration)

System dynamic range

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>8719D/8720D</th>
<th>8722D</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 to 2 GHz</td>
<td>100 dB(^1)</td>
<td>93 dB(^2)</td>
</tr>
<tr>
<td>2 to 8 GHz</td>
<td>100 dB</td>
<td>93 dB</td>
</tr>
<tr>
<td>8 to 20 GHz</td>
<td>100 dB</td>
<td>91 dB</td>
</tr>
<tr>
<td>20 to 40 GHz</td>
<td>—</td>
<td>80 dB</td>
</tr>
</tbody>
</table>

1. Rolls off below 840 MHz to 77 dB at 50 MHz
2. Rolls off below 840 MHz to 67 dB at 50 MHz

Corrected measurement port characteristics

<table>
<thead>
<tr>
<th>Frequency Range (GHz)</th>
<th>8719D/8720D</th>
<th>8722D</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 to 0.5</td>
<td>48 dB</td>
<td>50 dB</td>
</tr>
<tr>
<td>0.5 to 2</td>
<td>48 dB</td>
<td>50 dB</td>
</tr>
<tr>
<td>2 to 8</td>
<td>48 dB</td>
<td>50 dB</td>
</tr>
<tr>
<td>8 to 20</td>
<td>48 dB</td>
<td>50 dB</td>
</tr>
<tr>
<td>20 to 40</td>
<td>—</td>
<td>80 dB</td>
</tr>
</tbody>
</table>

| Directivity       | 48 dB       | 50 dB |
| Source Match      | 40 dB       | 50 dB |
| Load Match        | 48 dB       | 50 dB |
| Reflection Tracking| ±0.006 dB | ±0.006 dB |
| Transmission Tracking| ±0.020 dB | ±0.026 dB |

Measurement uncertainty

Reflection measurements

Transmission measurements

Maximum output power

Agilent 8719D/8720D: +5 dBm
8722D (0.05 to 20 GHz): –5 dBm
(20 to 40 GHz): –10 dBm
System performance (continued)

Agilent 8719D, 8720D, 8722D Option 007

Includes instruments with Options 012 and/or 089

Option 007 replaces the standard solid-state transfer switch with a mechanical switch to provide higher output power.

Option 085 adds internally controlled 0 to 55 dB step attenuators (5 dB steps) in the receiver path of both ports, an RF loop that allows the addition of an amplifier before the transfer switch, and RF loops after the switch that allow insertion of isolators, required for measurements above 1 watt. An internal reference channel switch is added and internal bias tees are deleted. This system is capable of full two-port calibrated measurements to 20 watts. Measurements up to 100 watts may be possible using specific configurations. Option 085 is not compatible with Option 400.

System dynamic range

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Option 007 8719D/20D</th>
<th>8722D</th>
<th>Option 085 8719D/20D</th>
<th>8722D</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 GHz</td>
<td>82 dB</td>
<td>72 dB</td>
<td>77 dB</td>
<td>67 dB</td>
</tr>
<tr>
<td>0.05 to 2 GHz</td>
<td>105 dB</td>
<td>98 dB</td>
<td>100 dB</td>
<td>93 dB</td>
</tr>
<tr>
<td>2 to 8 GHz</td>
<td>105 dB</td>
<td>98 dB</td>
<td>100 dB</td>
<td>93 dB</td>
</tr>
<tr>
<td>8 to 20 GHz</td>
<td>105 dB</td>
<td>96 dB</td>
<td>100 dB</td>
<td>91 dB</td>
</tr>
<tr>
<td>20 to 40 GHz</td>
<td>—</td>
<td>85 dB</td>
<td>—</td>
<td>77 dB</td>
</tr>
</tbody>
</table>

1. Rolls off below 840 MHz to specified value at 50 MHz

Maximum output power

<table>
<thead>
<tr>
<th></th>
<th>Option 007</th>
<th>Option 085</th>
</tr>
</thead>
<tbody>
<tr>
<td>8719D/8720D</td>
<td>+10 dBm</td>
<td>+5 dBm</td>
</tr>
<tr>
<td>8722D (0.05 to 20 GHz)</td>
<td>0 dBm</td>
<td>–5 dBm</td>
</tr>
<tr>
<td>8722D (20 to 40 GHz)</td>
<td>–5 dBm</td>
<td>–10 dBm</td>
</tr>
</tbody>
</table>

2. With jumper cable installed between RF out and RF in ports, i.e. no external amplification.

Supplemental characteristics (Option 085)

Maximum R-channel input level: 0 dBm
Minimum R-channel input level: –34 dBm
Maximum RF port input: +43 dBm
Attenuators: 55 dB maximum, 5 dB steps
Maximum test port power (no isolators): +30 dBm
Maximum test port power (with high power isolators): +43 dBm

Option 085 block diagram and example high power measurement setup
Agilent 8719D or 8720D with Option 007 or 085

Calibration kit: Agilent 85052B 3.5 mm with sliding loads
Cables: Agilent 85131F 3.5 mm flexible cable set
IF bandwidth: 10 Hz
Averaging: None (8 during isolation calibration)

Corrected measurement port characteristics

<table>
<thead>
<tr>
<th>Frequency Range (GHz)</th>
<th>0.05 to 0.5</th>
<th>0.5 to 2</th>
<th>2 to 8</th>
<th>8 to 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directivity</td>
<td>48 dB</td>
<td>48 dB</td>
<td>44 dB</td>
<td>44 dB</td>
</tr>
<tr>
<td>Source Match</td>
<td>40 dB</td>
<td>39 dB</td>
<td>32 dB</td>
<td>30 dB</td>
</tr>
<tr>
<td>Load Match</td>
<td>48 dB</td>
<td>45 dB</td>
<td>38 dB</td>
<td>37 dB</td>
</tr>
<tr>
<td>Reflection Tracking</td>
<td>±0.006 dB</td>
<td>±0.010 dB</td>
<td>±0.030 dB</td>
<td>±0.031 dB</td>
</tr>
<tr>
<td>Transmission Tracking</td>
<td>±0.011 dB</td>
<td>±0.016 dB</td>
<td>±0.070 dB</td>
<td>±0.122 dB</td>
</tr>
</tbody>
</table>

Measurement uncertainty

Reflection measurements

8720D OPT 007/085 with 85052B Calibration Kit

Transmission measurements

8720D OPT 007/085 with 85052B Calibration Kit
System performance (continued)

Agilent 8722D with Option 007 or 085

Calibration kit: Agilent 85052A 2.4 mm with sliding loads
Cables: Agilent 85131F 2.4 mm flexible cable set
IF bandwidth: 10 Hz
Averaging: None (8 during isolation calibration)

Corrected measurement port characteristics

<table>
<thead>
<tr>
<th>Frequency Range (GHz)</th>
<th>0.05 to 2</th>
<th>2 to 8</th>
<th>8 to 20</th>
<th>20 to 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directivity</td>
<td>42 dB</td>
<td>42 dB</td>
<td>42 dB</td>
<td>38 dB</td>
</tr>
<tr>
<td>Source Match</td>
<td>40 dB</td>
<td>35 dB</td>
<td>34 dB</td>
<td>31 dB</td>
</tr>
<tr>
<td>Load Match</td>
<td>41 dB</td>
<td>48 dB</td>
<td>37 dB</td>
<td>35 dB</td>
</tr>
<tr>
<td>Reflection Tracking</td>
<td>±0.011 dB</td>
<td>±0.037 dB</td>
<td>±0.039 dB</td>
<td>±0.047 dB</td>
</tr>
<tr>
<td>Transmission Tracking</td>
<td>±0.019 dB</td>
<td>±0.054 dB</td>
<td>±0.082 dB</td>
<td>±0.145 dB</td>
</tr>
</tbody>
</table>

Measurement uncertainty

Reflection measurements

8722D OPT 007/085 with 85056A Calibration Kit

8722D OPT 007/085 with 85056A Calibration Kit

Transmission measurements

8722D OPT 007/085 with 85056A Calibration Kit

8722D OPT 007/085 with 85056A Calibration Kit
Option 012

Option 012 adds RF loops that provide direct access to the A and B samplers in the port 1 and port 2 receivers. This allows transmission measurements that bypass the receiver coupler for improved signal-to-noise and sensitivity. The system is capable of antenna measurements to –110 dBm at 40 GHz, and filter rejection measurements to 120 dB. Use of multiple antennae provides improved signal-to-noise for free space transmission and reflection measurements. The RF loops can also be used to integrate components into the test set. Adding a 20 dB attenuator increases the test port 0.1 dB compression level to +30 dBm. With front panel jumpers installed, the system operates as a standard system and meets standard instrument specifications.

Supplemental characteristics (Option 012)

<table>
<thead>
<tr>
<th>Frequency Range (GHz)</th>
<th>0.05 to 0.5</th>
<th>0.5 to 2</th>
<th>2 to 8</th>
<th>8 to 20</th>
<th>20 to 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression1 Test Port</td>
<td>20 dB</td>
<td>16 dB</td>
<td>15 dB</td>
<td>8 dB</td>
<td>3 dB</td>
</tr>
<tr>
<td>Direct</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampler Input</td>
<td>2 dBm</td>
<td>1 dBm</td>
<td>0 dBm</td>
<td>-7 dBm</td>
<td>-12 dBm</td>
</tr>
<tr>
<td>Average Noise Floor2</td>
<td>-125 dBm</td>
<td>-125 dBm</td>
<td>-125 dBm</td>
<td>-123 dBm</td>
<td>-120 dBm</td>
</tr>
<tr>
<td>Receiver Dynamic Range</td>
<td>127 dB</td>
<td>126 dB</td>
<td>125 dB</td>
<td>116 dB</td>
<td>108 dB</td>
</tr>
</tbody>
</table>

1. Input power level that causes 0.1 dB compression in the receiver
2. 10 Hz IF BW

Option 012 test set block diagram

Option 400 and 012 test set block diagram

Measure filter rejection to –120 dB

Measure amplifier output to +43 dBm

16 dB more sensitivity for antenna test. Improved signal to noise for free space materials test.
System performance (continued)

**Option 089**
Option 089 adds frequency offset mode, allowing the receiver to be offset from the source frequency. This allows direct conversion loss measurement of mixers without need for a reference mixer. RF and IF frequencies must be within the specified operating range of the instrument. This test set modification adds an internal reference channel switch and deletes the reference channel output. Firmware guides the user through test setup. When not in frequency offset mode, the system operates as a standard system and meets standard instrument specifications.

### Supplemental characteristics (Option 089)

<table>
<thead>
<tr>
<th></th>
<th>8719D/8720D</th>
<th>8722D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference (R) Input Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>-34 dBm</td>
<td>-34 dBm</td>
</tr>
<tr>
<td>Maximum (for 0.1 dB compression)</td>
<td>-7 dBm</td>
<td>-12 dBm</td>
</tr>
<tr>
<td>Maximum (damage level)</td>
<td>0 dBm</td>
<td>0 dBm</td>
</tr>
</tbody>
</table>

*Note: To utilize full instrument receiver dynamic range, measure test signal at port 2. This configuration requires a power splitter and reference mixer to provide a phase lock signal to the R channel input.*

**Option 089 test set block diagram**

---

**Analyzer’s guided test setup display**

![Analyzer’s guided test setup display diagram](image)
## Specifications and Characteristics

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>0.05 to 13.51 GHz</td>
<td>S-1</td>
</tr>
<tr>
<td>8719D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8720D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8722D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy (at 23 °C ± 3 °C)</td>
<td>±10 ppm</td>
<td>S-1</td>
</tr>
<tr>
<td>Stability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 °C to 55 °C</td>
<td>±7.5 ppm</td>
<td>C</td>
</tr>
<tr>
<td>Option 1D5</td>
<td>±0.05 ppm</td>
<td>C</td>
</tr>
<tr>
<td>Per year (aging)</td>
<td>±3 ppm</td>
<td>C</td>
</tr>
<tr>
<td>Option 1D5</td>
<td>±0.5 ppm</td>
<td>C</td>
</tr>
<tr>
<td>Resolution</td>
<td>1 Hz</td>
<td>S-3</td>
</tr>
<tr>
<td>System Characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Input Level</td>
<td>30 dBm</td>
<td>C</td>
</tr>
<tr>
<td>Reference (F) Input Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>8719D/8720D</td>
<td>–7 dBm</td>
</tr>
<tr>
<td>8722D</td>
<td>–12 dBm</td>
<td>C</td>
</tr>
<tr>
<td>Minimum</td>
<td>8719D/8720D/8722D</td>
<td>–34 dBm</td>
</tr>
<tr>
<td>High Level Trace Noise2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnitude (zero-peak)</td>
<td>0.05 to 13.5 GHz</td>
<td>0.03 dB</td>
</tr>
<tr>
<td>13.5 to 20 GHz</td>
<td>0.04 dB</td>
<td>C</td>
</tr>
<tr>
<td>20 to 40 GHz</td>
<td>0.15 dB</td>
<td>C</td>
</tr>
<tr>
<td>Phase (zero-peak)</td>
<td>0.05 to 13.5 GHz</td>
<td>0.3°</td>
</tr>
<tr>
<td>13.5 to 20 GHz</td>
<td>0.4°</td>
<td>C</td>
</tr>
<tr>
<td>20 to 40 GHz</td>
<td>1.5°</td>
<td>C</td>
</tr>
<tr>
<td>Spectral Purity Characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harmonics at maximum output level</td>
<td>&lt;–15 dBc</td>
<td>C</td>
</tr>
<tr>
<td>Phase Noise</td>
<td>to 60 kHz from carrier at 2 GHz</td>
<td>&lt;–55 dBc</td>
</tr>
<tr>
<td>to 60 kHz from carrier at 20 GHz</td>
<td>&lt;–35 dBc</td>
<td>C</td>
</tr>
<tr>
<td>Nonharmonic Spurious Signals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 100 kHz offset</td>
<td>&lt;–40 dBc</td>
<td>C</td>
</tr>
<tr>
<td>at 200 kHz offset</td>
<td>&lt;–45 dBc</td>
<td>C</td>
</tr>
<tr>
<td>at &gt;200 kHz offset</td>
<td>&lt;–65 dBc</td>
<td>C</td>
</tr>
</tbody>
</table>

## Power Characteristics

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Range</td>
<td>75 dB</td>
<td>C</td>
</tr>
<tr>
<td>8719D/8720D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8722D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Output Power</td>
<td>5 dBm</td>
<td>C</td>
</tr>
<tr>
<td>8719D/8720D (Standard, Options. 085, 400)</td>
<td>+5 dBm</td>
<td>C</td>
</tr>
<tr>
<td>8719D/8720D (Option 007)</td>
<td>+10 dBm</td>
<td>C</td>
</tr>
<tr>
<td>8722D (Standard, Options 085, 400)</td>
<td>–5 dBm</td>
<td>C</td>
</tr>
<tr>
<td>8722D (Option 007)</td>
<td>–10 dBm</td>
<td>C</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.01 dB</td>
<td>S-3</td>
</tr>
<tr>
<td>Flatness (at 5 dB below maximum output power)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8719D/8720D</td>
<td>±2 dB</td>
<td>S-1</td>
</tr>
<tr>
<td>8722D</td>
<td>±3 dB</td>
<td>S-1</td>
</tr>
<tr>
<td>Power Sweep Range</td>
<td>20 dB</td>
<td>S-3</td>
</tr>
<tr>
<td>8719D</td>
<td>20 dB</td>
<td>S-3</td>
</tr>
<tr>
<td>8722D</td>
<td>15 dB</td>
<td>S-3</td>
</tr>
<tr>
<td>Power Linearity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>±5 dB from reference</td>
<td>±0.35 dB</td>
<td>S-1</td>
</tr>
<tr>
<td>–10 dB from reference</td>
<td>±0.6 dB</td>
<td>S-1</td>
</tr>
<tr>
<td>+10 dB from reference</td>
<td>±1 dB</td>
<td>S-1</td>
</tr>
<tr>
<td>Test Reference Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8719D/8720D (Standard, Options 085, 400)</td>
<td>–5 dBm</td>
<td>S-3</td>
</tr>
<tr>
<td>8719D/8720D (Option 007)</td>
<td>0 dBm</td>
<td>S-3</td>
</tr>
<tr>
<td>8722D (Standard, Options 085, 400)</td>
<td>–10 dBm</td>
<td>S-3</td>
</tr>
<tr>
<td>8722D (Option 007)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Frequency Range (GHz)

<table>
<thead>
<tr>
<th>Description</th>
<th>0.05</th>
<th>0.05 to 2</th>
<th>2 to 8</th>
<th>8 to 20</th>
<th>20 to 40</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Range</td>
<td>77 dB</td>
<td>100 dB</td>
<td>100 dB</td>
<td>100 dB</td>
<td>S-1</td>
<td></td>
</tr>
<tr>
<td>8719D/8720D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Standard, Options 085, 400)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8719D/8720D (Option 007)</td>
<td>82 dB</td>
<td>105 dB</td>
<td>105 dB</td>
<td>105 dB</td>
<td>S-1</td>
<td></td>
</tr>
<tr>
<td>8722D (Standard, Options 085, 400)</td>
<td>67 dB</td>
<td>93 dB</td>
<td>93 dB</td>
<td>91 dB</td>
<td>89 dB</td>
<td>S-1</td>
</tr>
<tr>
<td>8722D (Option 007)</td>
<td>72 dB</td>
<td>98 dB</td>
<td>98 dB</td>
<td>96 dB</td>
<td>85 dB</td>
<td>S-1</td>
</tr>
</tbody>
</table>

1. Does not apply to 8722D.
2. Trace noise is defined as variation of a high signal level trace due to noise. The value given represents a noise variation that is three standard deviations away from the trace’s mean value as measured in a 3 kHz IF bandwidth in the fast sweep mode (STEP SWP OFF).
3. The dynamic range specifications apply to transmission measurements using 10 Hz IF BW and response and isolation correction or full two-port correction. Dynamic range is limited by the maximum test port power and the receiver’s noise floor.
4. With 85133E flexible cable on test port.
5. Rolls off below 840 MHz to specified value at 50 MHz.
6. 77 dB for Option 085.
7. For Option 012 direct sampler input compression levels, refer to page 9.

S-1: This performance parameter is verifiable using performance tests documented in the service manual.
S-2: Due to limitations on available industry standards, the guaranteed performance of the instrument cannot be verified outside the factory. Field procedures can verify performance with a confidence prescribed by available standards.
S-3: These specifications are generally digital functions or are mathematically derived from tested specifications, and can therefore be verified by functional pass/fail testing.

C: Non-warranted performance characteristics are intended to provide information useful in applying the instrument. Performance characteristics are representative of most instruments, though not necessarily tested in each unit. Not field tested.
# Measurement throughput summary

## Full frequency band sweep time (ms)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>51</th>
<th>201</th>
<th>401</th>
<th>1601</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single Band Sweep (10 to 12 GHz)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncorrected</td>
<td>170/56</td>
<td>523/93</td>
<td>999/143</td>
<td>3866/443</td>
</tr>
<tr>
<td>One-port calibration²</td>
<td>170/56</td>
<td>523/93</td>
<td>999/143</td>
<td>3866/443</td>
</tr>
<tr>
<td>Two-port calibration³</td>
<td>331/100</td>
<td>1053/173</td>
<td>2024/272</td>
<td>7880/872</td>
</tr>
<tr>
<td><strong>Agilent 8719D Full Sweep (0.05 to 13.5 GHz)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncorrected</td>
<td>612/496</td>
<td>1905/589</td>
<td>1539/651</td>
<td>4371/951</td>
</tr>
<tr>
<td>One-port calibration²</td>
<td>612/496</td>
<td>1905/589</td>
<td>1539/651</td>
<td>4371/951</td>
</tr>
<tr>
<td>Two-port calibration³</td>
<td>1217/977</td>
<td>2118/1166</td>
<td>3100/1287</td>
<td>8911/1892</td>
</tr>
<tr>
<td><strong>Agilent 8720D Full Sweep (0.05 to 20 GHz)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncorrected</td>
<td>585/447</td>
<td>1068/580</td>
<td>1548/637</td>
<td>4386/939</td>
</tr>
<tr>
<td>One-port calibration²</td>
<td>585/447</td>
<td>1068/580</td>
<td>1548/637</td>
<td>4386/939</td>
</tr>
<tr>
<td>Two-port calibration³</td>
<td>1162/880</td>
<td>2144/1147</td>
<td>3123/1263</td>
<td>8942/1885</td>
</tr>
<tr>
<td><strong>Agilent 8722D Full Sweep (0.05 to 40 GHz)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncorrected</td>
<td>760/581</td>
<td>1281/696</td>
<td>1733/713</td>
<td>4649/955</td>
</tr>
<tr>
<td>One-port calibration²</td>
<td>760/581</td>
<td>1281/696</td>
<td>1733/713</td>
<td>4649/955</td>
</tr>
<tr>
<td>Two-port calibration³</td>
<td>1510/1144</td>
<td>2572/1376</td>
<td>3497/1414</td>
<td>8478/1976</td>
</tr>
<tr>
<td><strong>Time Domain Conversion⁴</strong></td>
<td>13</td>
<td>44</td>
<td>90</td>
<td>387</td>
</tr>
<tr>
<td><strong>GPIB Data Transfer⁵</strong></td>
<td>13</td>
<td>18</td>
<td>25</td>
<td>61</td>
</tr>
<tr>
<td>Binary (Internal)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IEEE754 floating point format</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 bit</td>
<td>14</td>
<td>21</td>
<td>31</td>
<td>89</td>
</tr>
<tr>
<td>64 bit</td>
<td>16</td>
<td>30</td>
<td>48</td>
<td>153</td>
</tr>
<tr>
<td>ASCII</td>
<td>52</td>
<td>181</td>
<td>355</td>
<td>1391</td>
</tr>
</tbody>
</table>

1. All values are typical.
2. S11 one-port calibration, with a 6 kHz IF bandwidth. Includes system retrace time.
3. Time domain gating is assumed off.
4. Option 010 only, gating and error-correction are off. Does not include sweep time.
5. Measured with an HP Omnibook 5500 133 Pentium computer.
Analyzer options

Option 010 time domain
With the time domain option, data from transmission or reflection measurements in the frequency domain are converted to the time domain using a Fourier transformation technique (chirp Z) and presented on the display. The time domain response shows the measured parameter value versus time. Markers may also be displayed in electrical length (or physical length if the relative propagation velocity is entered).

Time stimulus modes
Standard stimulus
Two types of time excitation stimulus waveforms can be simulated during the transformations, a step and an impulse.

External stimulus
Other time excitation stimulus waveforms can be accomplished using an external controller.

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

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

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

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

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

Range resolution
Time resolution of a time domain response (for example, 0.3 nanoseconds versus 0.307 nanoseconds).

\[ \text{Range resolution} = \frac{\text{time span}}{\text{number of points} - 1} \]

Distance
Related to time by speed of light and relative velocity, in space, \( V_{\text{rel}} = 1 \); for distance to response in reflection measurement, multiply by \( \frac{1}{2} \).

\[ \text{Distance} = 3 \times 10^8 \text{ m/sec} \times V_{\text{rel}} \times \text{Time} \]

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

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

Option 085, high power system
This option is designed to permit the measurement of high power amplifiers at RF levels up to 20 Watts (+43 dBm), with full two-port calibration. A switch is added to the reference path so that booster amplifier response can be ratioed out. To protect the analyzer from high power levels, this option allows the addition of isolators at both test ports and includes internally controlled step attenuators between couplers and samplers. Bias tees, isolators and booster amplifiers are not included. Network analyzers with option 085 can also be configured to operate as standard instruments with degraded power accuracy or as instruments capable of making single connection multiple measurements.

Option 007, mechanical transfer switch
This option replaces the solid state transfer switch with a mechanical switch in the test set, increasing the test port power and dynamic range.

Option 089, frequency offset mode
This option adds the ability to offset the source and receiver frequencies for frequency translated measurements. This provides the instrument with mixer measurement capability. It also provides a graphical setup that allows easy configuration of your measurement.

Option ID5, high stability frequency reference
This option provides the analyzer with ±0.05 ppm temperature stability from 0 °C to 60 °C (referenced to 25 °C).

Option 012, direct access receiver configuration
This option provides front panel access to the A and B samplers for improved receiver sensitivity. Option 012 improves signal-to-noise in free space materials measurements with the use of multiple antennas. Direct connection of the reflection antennas to the A and B samplers eliminates internal reflections of the transmitted signal in the reflection path, improving the signal to noise ratio. Option 012 also allows you to add attenuators between the couplers and samplers, increasing the power handling capability of the instrument.

Option 400, fourth sampler and TRL calibration firmware
This option converts the built-in test set to a four-sampler configuration, allowing TRL calibration. This provides the highest accuracy for non-coaxial environments, such as on-wafer probing, in-fixture or waveguide measurements.
Capabilities

Measurement capabilities
Number of measurement channels
2; each fully independent

Parameters
S\textsubscript{11}: Forward reflection (input match)
S\textsubscript{21}: Forward transmission (insertion loss/gain/phase)
S\textsubscript{12}: Reverse transmission (reverse isolation)
S\textsubscript{22}: Reverse reflection (output match)
A, B, R: Receiver signal level
A/R, B/R, A/B: Ratioed receiver signals

Auxiliary Input: DC voltage on AUX INPUT

Parameter conversion
Z – Reflection: equivalent parallel impedance
Y – Reflection: equivalent parallel admittance
Z – Transmission: equivalent series impedance
Y – Transmission: equivalent series admittance
1/S: complex inverse of S-parameters

Display formats
Cartesian
Log/linear magnitude, phase, group delay, SWR, real and imaginary

Smith chart
Log/linear magnitude and phase, R+jX, G+jB, or real/imaginary markers

Polar
Linear/log magnitude, phase, or real and imaginary markers

Markers
Number of markers
5 per channel; 1 “active” per channel; can be coupled (same stimulus in both channels) or uncoupled (independent stimulus in each channel).

Displayed marker values
All activated markers with both stimulus and response values are displayed; with dual-channel uncoupled, can display up to 10 markers; all but active marker replaced by bandwidths or statistics, when enabled.

Stimulus resolution
Discrete (actual measurement points) or continuous (linearly interpolated between points, with 1 Hz resolution).

Delta markers
Displays difference in both stimulus (e.g. frequency) and response (e.g. dB) between active marker and reference marker; reference marker may be any of five markers, or a sixth fixed marker given any arbitrary position on display.

Polar format markers
Linear magnitude and phase; log magnitude (dB) and phase; real and imaginary.

Smith chart format markers
Linear magnitude and phase; log magnitude (dB) and phase; real and imaginary (R+jD); complex impedance (R+jX); complex admittance (G+jB).

Search
Finds maximum, minimum, or target value.

Bandwidth
Finds and displays center frequency, bandwidth at a user-defined level (for example, –3 dB), Q factor, and shape factor (ratio of 60 dB and 6 dB bandwidths); updates while tuning with tracking enabled; valid for band-pass or band-reject (notch) filters.

Statistics
Calculates and displays mean, standard deviation, and peak-to-peak deviation of trace; active between two markers or over entire trace.

Tracking
Performs new search (min/max/target) at end of each sweep; if disabled, occurs once on demand.

Marker-to functions
Set start, stop or center to active marker stimulus values; set span to active and delta marker stimulus values; set reference to active marker response value; set electrical delay to active marker phase response value.

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

Aperture
Selectable. Maximum aperture: 20% of frequency span. Minimum aperture: (frequency span)/(number of points–1).

Range
The maximum delay is limited to measuring no more than 180° of phase change within the minimum aperture. Range= 1/(2 x minimum aperture).

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

\[ \pm (0.003 \times \text{Phase accuracy (deg)}) / \text{Aperture (Hz)}. \]
Capabilities (continued)

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

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

Fast swept list
Define up to 30 different subsweep frequency ranges in any combination of CW, CW-delta F, or start-stop sweep modes. Set test-port power levels and IF bandwidth independently for each segment.

Measured number of points per sweep
Linear frequency: choose 3, 11, 21, 51, 101, 201, 401, 801, 1601 points.

Source coupling
Set a coupled channel sweep (same stimulus conditions on both channels) or an uncoupled channel sweep (independent stimulus conditions).

Chop/alternate sweeps
Select whether to alternately or simultaneously (chop) measure channels when measuring with two-port calibration. Chop mode is faster, while alternate mode optimizes dynamic range. The default is chop mode.

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

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

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

Power
Control the test port signal by setting the internal attenuator over a 70 dB range. Power trip automatically reduces source power to its minimum value when excessive signal levels are incident on the receiver test port. A caution message is also displayed. Source power range differs depending on the selected options. Power slope can be set in dBm/GHz.

Continuous switching
Continuously switches the RF output between port 1 and port 2; enables simultaneous active display of forward and reverse parameters.

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

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

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

Data accuracy enhancement
Description
Measurement calibration is the process that significantly reduces measurement uncertainty due to system directivity, source and load match, tracking and crosstalk. A wide range of calibrations are available for the Agilent 8719D/20D/22D. Full two-port calibration removes all the systematic errors, resulting in the most accurate measurements.

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

Response and isolation
Compensates for frequency response and directivity (reflection) or frequency response and crosstalk errors. Requires an open, short, and load circuit termination (reflection) and a through connection and load termination (transmission).
**One-port calibration**
Uses test set port 1, or port 2, or both to correct for directivity, frequency response, and source match errors. Requires open, short, and load.

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

**TRL*/LRM* calibration**
Compensates for directivity, reflection and transmission frequency response, and crosstalk in both the forward and reverse directions. Especially suitable for calibrating non-coaxial environments, such as in test fixtures. Requires through, reflect, and line or match standards. TRL*/LRM* is a special implementation of TRL/LRM calibration modified for the three-sampler receiver in the standard Agilent 8719D/20D/22D.

**TRL/LRM calibration**
With Option 400 (four-sampler receiver). TRL/LRM provides the highest accuracy for non-coaxial test environments such as fixture, on-wafer or in waveguide. Compensates for directivity, reflection and transmission frequency response, and crosstalk in both forward and reverse directions.

**One-path, two-port calibration**
Provides a full two-port error corrected measurement when the device under test is turned around and measured in both directions.

**Calibration Features**

**Fast two-port**
Compensates for 12-terms, similar to full two-port, except that 2 of 4 raw parameters (forward or reverse) are continuously re-measured while the remaining 2 are periodically updated at a user-selectable rate. Improves update rate for tuning, and reduces unnecessary wear on transfer switch in Option 007. [Meas] key or contact closure at rear panel foot switch connector causes full two-port update.

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

**Set Z_o**
Redefine the characteristic impedance of a measurement to a value other than 50 or 75 ohms.

**Velocity factor**
Enter the velocity factor of your propagation medium to convert equivalent electrical length to physical length.

**Electrical delay**
Add or subtract delay (linear phase slope), up to +10 µs, similar to “line stretchers,” both coax or wave-guide (dispersive) modes. Secondary readout in distance computed from velocity factor.

**Reference plane extension**
Redefine the reference plane after calibration. A new reference plane is defined in seconds of delay from the test port and ranges between ±1 seconds. Similar to electrical delay, but applied appropriately to each of four parameters.

**Select default calibration kit**
Select from a list of standard calibration kits: 7 mm, 3.5 mm, Type-N 50 ohm, Type-N 75 ohm, 2.4 mm, 2.92 mm, and 3.5 mm TRL. You can also define the standards (for example, open circuit capacitance coefficients, offset short length, or fixed loads) of a user-defined kit.

**Segmented calibration**
Calibration remains valid for any frequency segment (in frequency list mode), after calibrating all segments with a single calibration.

**Receiver power calibration**
Adjusts nonratioed receiver inputs to absolute (non-ratioed) power level. Displays absolute power in dBm. Requires reference sweep of known source power.

**Data averaging**

**IF bandwidth**
The IF bandwidth is selectable from 6 kHz to 10 Hz bandwidth to reduce the effective displayed noise floor of the instrument.

**Weighted sweep-to-sweep averaging**
Averages vector data on each successive sweep.

\[ A(n) = S(n)/F + (1-1/F) x A(N-1) \]

where \( A(n) \) is the current average, \( S(n) \) is the current input signal and \( F \) is the averaging factor. Averaging factors range from 1 to 999.

**Trace smoothing**
Similar to video filtering, this function computes the moving average of adjacent data points.

Smoothing aperture defines the trace width (number of points) to be averaged, and ranges from 0.25% to 20% of the trace width. This function also sets the aperture for group delay measurements.
Capabilities (continued)

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

Trace functions
Display data
Display current measurement data, memory data, or current measurement and memory data simultaneously.

Trace math
Vector division or subtraction of current linear measurement values and memory data.

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

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

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

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

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

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

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

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

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

Disk drive
Data, instrument states (including calibration data), user graphics, data plots (HP-GL commands), and test sequences can be stored on disk, using the analyzer’s built-in disk drive or any external disk drive with command subset CS/80. Data files can be stored in MS-DOS format or Hewlett-Packard’s standard LIF format in binary or ASCII formats (compatible with the Agilent 85150A microwave design system). A disk to be used for data storage can be initialized directly by the analyzer.

Data hardcopy
Data plotting
Hard copy plots are automatically produced with HP-GL compatible graphics printers such as the HP DeskJet or LaserJet (in single color or multi-color format). The analyzer provides Centronics, RS-232C, and GPIB interfaces.

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

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

Quadrants
Plot entire display fullpage sized or in one of four different quadrants of the plotter paper.

Data listings
Printouts of instrument data are directly produced with a printer such as the HP DeskJet 520, LaserJet, or 560C or PaintJet 3630A. Select a standard (single color) or color print. Printouts can include either the graphical display image (excluding soft-key label), or lists of numeric data; one line per stimulus point, with up to five columns defined by currently active parameters.
System Capabilities

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

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

Transform
When time domain (Option 010) is present, selects the time domain transform menu.

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

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

Auto
The input signal frequency is counted and displayed.

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

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

Frequency offset on/off
Sets the RF source to be swept at a frequency that is offset from the receiver as required in a swept RF/IF, fixed LO, mixer test. The maximum delay between the RF source and the R channel input is 0.3 microseconds. Frequency offset mode requires RF and IF frequencies to be in the specific range of the instrument.

Offset value
Set the offset frequency value.

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

Test sequences

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

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

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

Other GPIB instruments
Send simple commands to GPIB instruments via the title string.

Test sequence BNC output
Set TTL high or low on the analyzer rear panel output.

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

Other functions
Pause/continue, wait, title sequence, print sequence, duplicate sequence, pause, and select.
Capabilities (continued)

GPIB (remote) programming

Interface

Addressing
The GPIB address of the analyzer can be verified or set from the front panel via the local menu and can range from 0 to 30 decimal (factory set at 16).

Pass control
Allows the analyzer to request control of the GPIB (when an active controller is present) whenever it needs to output to a plotter or printer.

System controller
Allows the analyzer to become a controller on the GPIB to directly control a plotter or a printer.

Talker/listener
Allows the analyzer to become a GPIB talker/listener when an external controller is present.

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

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

Interface function codes
SHI, AHI, T6, L4, SRI, RLI, PPO, DC1, DT1, CI, C2, C3, CIO, E2

Upgrades
Refer to Configuration Guide.

Security

Frequency blank
Blanks all frequency information from display, including markers; requires FACTORY RESET to re-enable.

Reset memory
Writes binary zeros to all non-volatile memory registers, erasing all instrument state and calibration data; used with PRESET.

General characteristics

Front panel connectors
Connector type
Agilent 8719D/8720D: 3.5 mm precision
Agilent 8722D: 2.4 mm precision

Impedance
50 ohms (nominal)

Rear panel connectors
External reference frequency input (EXT REF INPUT)
Frequency: 1, 2, 5, and 10 MHz (±200 Hz at 10 MHz)
Level: –10 dBm to +20 dBm, characteristically
Impedance: 50 ohms

High-stability frequency reference output (Option 1D5)
Frequency: 10.0000 MHz
Frequency stability (0 °C to 55 °C): ±0.05 ppm
Daily aging rate (after 30 days): <3 x 10⁻⁶/day
Yearly aging rate: 0.5 ppm/year
Output: 0 dBm minimum
Nominal output impedance: 50 ohms

External auxiliary input (AUX INPUT)
Input voltage limits: ±10 V to ±10 V

External AM input (EXT AM)
±1 volt into a 5 kΩ resistor, 1 kHz maximum, resulting in approximately 8 dB/volt amplitude modulation.

External trigger (EXT TRIGGER)
Triggers on a negative TTL transition or contact closure to ground.

Test sequence output (TEST SEQ)
This connector outputs a TTL signal which can be programmed by the user in a test sequence to be high or low. By default, this output provides an end-of-sweep TTL signal. (For use with part handlers.)

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

Test port bias input (except Option 085)
Maximum voltage: +30 Vdc
Maximum current (no degradation in RF specifications): ±200 mA
Maximum current: ±1A

External monitor: VGA video output
This connector drives external VGA monitors.

GPIB
This connector allows communication with compatible devices including external controllers, printers, plotters, disk drives, and power meters.
Parallel port
This connector is used with parallel (or Centronics interface) peripherals such as printers and plotters. It can also be used as a general purpose I/O port, with control provided by test sequencing functions.

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

DIN keyboard
This connector is used for the optional AT compatible keyboard for titles and remote front-panel operation.

Internal memory
Typical data retention time with 3 V, 1.2 Ah battery:
At 25 °C: 11,904 days (32.6 years)
At 40 °C: 1244 days (3.4 years)
At 70 °C: 250 days (0.68 year)

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

Weight
Net: 25 kg (54 lb)
Shipping: 28 kg (61 lb)

Cabinet dimensions
222 mm (H) x 425 mm (W) x 457 mm (D) (8.75 x 16.75 x 18 in)
(These dimensions exclude front and rear panel protrusions.)

Environmental Characteristics
General Conditions
RFI and EMI susceptibility
Defined by VADE 0730, CISPR Publication 11, and FCC Class B Standards.

ESD (electrostatic discharge)
Must be eliminated by use of static-safe work procedures and an anti-static bench mat (such as Agilent 92175T).

Dust
The environment should be as dust-free as possible.

Operating conditions
Operating temperature: 0 °C to 55 °C
Error-corrected temperature Range: ±1 °C of calibration temperature
Humidity: 5% to 95% at 40 °C (noncondensing)
Altitude: 0 to 4500 meters (15,000 feet)

Non-operating storage conditions
Temperature: −40 °C to +70 °C
Humidity: 0 to 90% relative at +65 IC (noncondensing)
Altitude: 0 to 15,240 meters (50,000 feet)

Ventilation
Allow 100 mm (4 in.) around rear and sides.
Software

Agilent 85071B Materials Measurement Software
Description
The 85071B software uses broadband S-parameter measurements to determine the electromagnetic properties of dielectric and magnetic materials. The software calculates both the complex permittivity \( e_r \) (or dielectric constant) and permeability \( \mu_r \), including loss factors. Depending on the network analyzer and fixtures used, measurements can extend from 100 MHz to 110 GHz. The software offers the choice of four algorithms, each designed to address specific measurement needs.

Operating requirements
Standard: Requires MS-DOS on an HP Vectra (or any 100%-compatible PC-AT computer) compatible with Microsoft Windows 3.0 or higher with mouse. Requires >20 Mbyte hard disk and >640 Kbytes RAM.

Option 300: Substitutes HP BASIC Software for the standard version for operation with HP 9000 series 300 controllers. Requires BASIC 5.0 or higher and 2 Mbytes of RAM.

Performance summary
Frequency range: 100 MHz to 110 GHz (characteristically, depending on network analyzer, fixture, and material).
Format: \( e_r' \), \( e_r'' \), \( \mu_r' \), \( \mu_r'' \), \( \tan \delta \), \( \tan \delta_m \), or Cole-Cole plots; tabular listings of data.
Stimulus control: Frequency range, number-of-points, and linear or log sweep.
Calibration: The software can use any calibration including a calibrated response gated in the time domain.
Accuracy: 1 to 2%
Fixture: The software works with simple transmission lines: coaxial airlines, or rectangular waveguide containing a cross-sectional sample of the material-under-test.
Data display: Displays current measurement data, and can save/display 3 memory traces for comparison.
Data storage: Save/recall/export data via disk in MS-DOS® ASCII format or HP BASIC BDAT format (HP LIF binary).

Agilent 85070B Dielectric Probe Kit
Description
The 85070B dielectric probe kit allows convenient non-destructive testing of materials using the open-ended coaxial probe method. The probe, together with its own dedicated software, determines the complex permittivity of a wide variety of liquids, semi-solids, and solids. Since the probe kit measures only permittivity, only non-magnetic materials should be measured. Measurements are efficient and cost-effective because the testing is non-destructive and there is no need for sample preparation or special fixtures.

Operating requirements
Standard: Requires MS-DOS on an HP Vectra (or any 100%-compatible PC-AT computer) compatible with Microsoft Windows 3.0 or higher with mouse. Requires >20 Mbyte hard disk and >640 Kbytes RAM.

Option 300: Substitutes HP BASIC Software for the standard version for operation with HP 9000 series 300 controllers. Requires BASIC 5.0 or higher and 2 Mbytes of RAM.

Performance summary
Frequency range: 200 MHz to 20 GHz (typical, depending on network analyzer, fixture, and material).
Probe Temperature
Range: –40 °C to +200 °C
Rate: <10°C per minute
Format: \( e_r' \), \( e_r'' \), \( \tan \delta \), or Cole-Cole diagram in linear format.
Stimulus control: Frequency range, number-of-points, and linear or log sweep.
Calibration: Guided, using open, short (included), and deionized water. Supports user-defined standards.
Accuracy
Dielectric constant, \( e_r' \): ±5%
Loss tangent, \( \tan \delta \), \( e_r''/e_r' \): ±0.05
Data display: Displays current measurement data, and can save/display up to three memory traces for comparison.
Data storage: Save/recall/export data via disk in MS-DOS® ASCII format or HP BASIC BDAT format (HP LIF binary).
Accessories

A wide range of accessories support the Agilent 8720 family of network analyzers, including calibration kits, verification kits, cables and adapters in both 7 mm, 3.5 mm, Type-N, and 2.4 mm coax and in the standard waveguide bands. The standards used in the 3.5 mm, Type-N, and 2.4 mm calibration and verification kits use precision slotless connectors (PSC-3.5, PSC-N, and PSC-2.4).

Calibration kits
Vector accuracy enhancement procedures require that the systematic errors of the measurement system be characterized by measuring known devices (standards) on the system over the frequency range of interest. Agilent Technologies offers the following types of calibration kits:

### Calibration kits

#### Standard calibration kits
Contain open circuits, short circuits, and both fixed and sliding terminations in both sexes for all connector types (except 7 mm, a sexless connector). Connector gauges are included in these kits for maintaining each standard’s connector interface. Standard calibration kits that include RTL adapters and devices are also available in 7 mm and 3.5 mm connectors.

#### Precision calibration kits
Have precision 50Ω airline(s) for performing the Thru-Reflect-Line (TRL) calibration. These kits also contain the open circuit, short circuit, and fixed terminations used for traditional open-short-load calibration techniques.

<table>
<thead>
<tr>
<th>Calibration Kit and Name</th>
<th>Frequency Range (GHz)</th>
<th>Connector Type</th>
<th>Return Loss, Fixed Load</th>
<th>Return Loss, Sliding Load</th>
<th>Return Loss, Airline at fmax</th>
<th>Residual Directivity at fmax</th>
<th>Residual Source Match at fmax</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Precision</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>85052C</td>
<td>0.045 to 26.5</td>
<td>3.5 mm</td>
<td>≥46 dB, DC to 2 GHz</td>
<td>—</td>
<td>50 dB</td>
<td>50 dB</td>
<td>50 dB</td>
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<tr>
<td><strong>Standard</strong></td>
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</tr>
<tr>
<td>85050B</td>
<td>0.045 to 18</td>
<td>7 mm</td>
<td>≥52 dB, DC to 2 GHz</td>
<td>≥52 dB, 2 to 18 GHz</td>
<td>—</td>
<td>45 dB</td>
<td>30 dB</td>
</tr>
<tr>
<td>85052B</td>
<td>0.045 to 26.5</td>
<td>3.5 mm</td>
<td>≥44 dB, DC to 3 GHz</td>
<td>≥44 dB, 3 to 26.5 GHz</td>
<td>—</td>
<td>44 dB</td>
<td>30 dB</td>
</tr>
<tr>
<td>85054B</td>
<td>0.045 to 18</td>
<td>Type-N</td>
<td>≥48 dB, DC to 2 GHz</td>
<td>≥42 dB, 2 to 18 GHz</td>
<td>—</td>
<td>42 dB</td>
<td>30 dB</td>
</tr>
<tr>
<td>85056A</td>
<td>0.045 to 50</td>
<td>2.4 mm</td>
<td>≥42 dB, DC to 4 GHz</td>
<td>≥36 dB at 50 GHz</td>
<td>—</td>
<td>38 dB</td>
<td>31 dB</td>
</tr>
<tr>
<td><strong>Economy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85050D</td>
<td>0.045 to 18</td>
<td>7 mm</td>
<td>≥38 dB, DC to 18 GHz</td>
<td>—</td>
<td>—</td>
<td>36 dB</td>
<td>30 dB</td>
</tr>
<tr>
<td>85052D</td>
<td>0.045 to 26.5</td>
<td>3.5 mm</td>
<td>≥30 dB at 26.5 GHz</td>
<td>—</td>
<td>—</td>
<td>36 dB</td>
<td>29 dB</td>
</tr>
<tr>
<td>85054D</td>
<td>0.045 to 18</td>
<td>Type-N</td>
<td>≥34 dB at 18 GHz</td>
<td>—</td>
<td>—</td>
<td>34 dB</td>
<td>28 dB</td>
</tr>
<tr>
<td>85056D</td>
<td>0.045 to 50</td>
<td>2.4 mm</td>
<td>≥26 dB at 50 GHz</td>
<td>—</td>
<td>—</td>
<td>26 dB</td>
<td>23 dB</td>
</tr>
<tr>
<td>85056K</td>
<td>0.045 to 40</td>
<td>2.92 mm</td>
<td>≥26 dB at 40 GHz</td>
<td>—</td>
<td>—</td>
<td>25 dB</td>
<td>22 dB</td>
</tr>
<tr>
<td><strong>Waveguide</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X11644A1</td>
<td>8.2 to 12.4</td>
<td>WR-90</td>
<td>≥42 dB, 8.2 to 12.4 GHz</td>
<td>50 dB</td>
<td>40 dB</td>
<td>30 dB</td>
<td></td>
</tr>
<tr>
<td>P11644A1</td>
<td>12.4 to 18</td>
<td>WR-62</td>
<td>≥42 dB, 12.4 to 18 GHz</td>
<td>50 dB</td>
<td>40 dB</td>
<td>30 dB</td>
<td></td>
</tr>
<tr>
<td>K11644A1</td>
<td>18 to 26.5</td>
<td>WR-42</td>
<td>≥42 dB, 18 to 26.5 GHz</td>
<td>50 dB</td>
<td>40 dB</td>
<td>30 dB</td>
<td></td>
</tr>
<tr>
<td>R11644A1</td>
<td>26.5 to 40</td>
<td>WR-28</td>
<td>—</td>
<td>46 dB</td>
<td>50 dB</td>
<td>40 dB</td>
<td>30 dB</td>
</tr>
<tr>
<td><strong>Electronic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85060A1</td>
<td>1 to 18</td>
<td>7 mm</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>44.5 dB</td>
<td>39.5 dB</td>
</tr>
<tr>
<td>Option 001</td>
<td>0.45 to 2</td>
<td>7 mm</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>51 dB</td>
<td>44.5 dB</td>
</tr>
<tr>
<td>85062A1</td>
<td>1 to 26.5</td>
<td>3.5 mm</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>41.5 dB</td>
<td>35.5 dB</td>
</tr>
<tr>
<td>Option 001</td>
<td>0.45 to 2</td>
<td>3.5 mm</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>50.5 dB</td>
<td>43.5 dB</td>
</tr>
<tr>
<td>85064A1</td>
<td>1 to 18</td>
<td>Type-N</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>44.5 dB</td>
<td>39.5 dB</td>
</tr>
<tr>
<td>Option 001</td>
<td>0.45 to 2</td>
<td>Type-N</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>50 dB</td>
<td>43.5 dB</td>
</tr>
</tbody>
</table>

1. Airline return loss, directivity, and source match are typical values for these calibration kits.
2. Residuals based on Agilent 8720D at fmax=20 GHz for 3.5 mm kits or on Agilent 8722D at fmax=40 GHz for 2.4 mm kits.
3. Requires an Agilent 85060C control unit.
Economy calibration kits
Include the open circuit, short circuit, and fixed termination standards but not sliding terminations or gauges. Gauges can be ordered separately.

Waveguide calibration kits
Contain two coax-to-waveguide adapters with precision flanges, a flush short circuit, a precision waveguide line section, and either sliding or fixed terminations. They support calibration based on TRL*, offset load, or short/offset-short/load/thru methods.

Electronic calibration kits
Require an Agilent 85060C control unit for operation and Agilent 85060 series calibration modules of the appropriate connector type. The calibration modules are programmed by a control unit to present many different impedances to the test ports. A full two-port calibration can be done with a single connection. Each standard calibration kit contains the two-port calibration module and a torque wrench for proper connection. Options are available to add a lowband module to the kit, and to change the sex of the connectors of the module.

Verification kits
Measuring known devices, other than the standards used in calibration, is an easy way to verify the correct operation of an Agilent 8719D/20D/22D network analyzer system. Agilent offers the following verification kits which contain precision devices, with data traceable to NIST used to verify the analyzer’s error-corrected measurement performance.

- 85051B 7 mm verification kit; 0.045 to 18 GHz
- 85055A Type-N verification kit; 0.045 to 18 GHz
- 85053B 3.5 mm verification kit; 0.045 to 26.5 GHz
- 85057B 2.4 mm verification kit; 0.045 to 50 GHz

Test port return cables
Test port cables are available in the 7 mm, 3.5 mm, Type-N, and 2.4 mm connectors types. All cables connect directly to the special ruggedized test port of the network analyzer test port (NMD connector). Agilent offers the following cable choices:

- Single cables in semi-rigid and flexible
- Cable set in semi-rigid and flexible

A single long cable with an appropriate test port adapter is best for applications where the test device requires a connection next to the test port for mechanical rigidity. A set of cables offers the flexibility required to position the test devices away from the test set.

Semi-rigid cables offer excellent performance and are suitable for applications where the connectors of the test device are in-line or parallel. Flexible cables are ideal for manufacturing environments since they are more rugged and have a tighter bending radius than semi-rigid cables. Semi-rigid cables are warranted for 90 days; flexible cables are warranted for 1 year.
## Accessories (continued)

### Test port return cable specifications

<table>
<thead>
<tr>
<th>Connector Type</th>
<th>Frequency</th>
<th>Length</th>
<th>Return Loss</th>
<th>Insertion Loss</th>
<th>Stability</th>
<th>±Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single cables for 8719D and 8720D (3.6 mm)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85131C Semi-rigid Cable</td>
<td>DC to 26.5</td>
<td>81 (32)</td>
<td>≥17 dB</td>
<td>0.43 /f + 0.3</td>
<td>&lt;0.06 dB</td>
<td>0.16 (f) +0.5</td>
</tr>
<tr>
<td>85131E Flexible Cable</td>
<td>DC to 26.5</td>
<td>96.5 (38)</td>
<td>≥16 dB</td>
<td>0.35 /f + 0.3</td>
<td>&lt;0.22 dB</td>
<td>0.16 (f) +0.8</td>
</tr>
<tr>
<td>85132C Semi-rigid Cable</td>
<td>DC to 18</td>
<td>81 (32)</td>
<td>≥17 dB</td>
<td>0.35 /f + 0.3</td>
<td>&lt;0.06 dB</td>
<td>0.16 (f) +0.5</td>
</tr>
<tr>
<td>85132E Flexible Cable</td>
<td>DC to 18</td>
<td>97.2 (38.25)</td>
<td>≥17 dB</td>
<td>0.35 /f + 0.3</td>
<td>&lt;0.22 dB</td>
<td>0.16 (f) +0.8</td>
</tr>
</tbody>
</table>

| **Cable set for 8719D and 8720D (3.6 mm)** | | | | | | |
| 85131D Semi-rigid Cable Set | DC to 26.5 | 53 (21) | ≥16 dB | 0.30 /f + 0.2 | <0.06 dB | 0.16 (f) +0.5 |
| 85131F Flexible Cable Set | DC to 26.5 | 62.2 (24.5) | ≥16 dB | 0.25 /f + 0.2 | <0.12 dB | 0.13 (f) +0.5 |
| 85132D Semi-rigid Cable Set | DC to 18 | 53 (21) | ≥17 dB | 0.25 /f + 0.2 | <0.06 dB | 0.16 (f) +0.5 |
| 85132F Flexible Cable Set | DC to 18 | 62.9 (24.75) | ≥17 dB | 0.25 /f + 0.2 | <0.12 dB | 0.13 (f) +0.5 |

### Single cables for 8722D (2.4 mm)

<table>
<thead>
<tr>
<th>Connector Type</th>
<th>Frequency</th>
<th>Length</th>
<th>Return Loss</th>
<th>Insertion Loss</th>
<th>Stability</th>
<th>±Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>85133C Semi-rigid Cable</td>
<td>DC to 50</td>
<td>81 (32)</td>
<td>≥16 dB</td>
<td>0.84 /f + 0.3</td>
<td>&lt;0.06 dB</td>
<td>0.18 (f)</td>
</tr>
<tr>
<td>85133E Flexible Cable</td>
<td>DC to 50</td>
<td>113 (44)</td>
<td>≥12.5 dB</td>
<td>0.58 /f +0.35</td>
<td>&lt;0.25 dB</td>
<td>0.8 +0.16 (f)</td>
</tr>
<tr>
<td>85134C Semi-rigid Cable</td>
<td>DC to 26.5</td>
<td>81 (32)</td>
<td>≥16 dB</td>
<td>0.46 /f + 0.3</td>
<td>&lt;0.06 dB</td>
<td>0.18 (f)</td>
</tr>
<tr>
<td>85134E Flexible Cable</td>
<td>DC to 26.5</td>
<td>97.2 (38.25)</td>
<td>≥16 dB</td>
<td>0.46 /f + 0.3</td>
<td>&lt;0.22 dB</td>
<td>0.16 (f) +0.8</td>
</tr>
<tr>
<td>85135C Semi-rigid Cable</td>
<td>DC to 18</td>
<td>81 (32)</td>
<td>≥17 dB</td>
<td>0.46 /f + 0.3</td>
<td>&lt;0.06 dB</td>
<td>0.18 (f)</td>
</tr>
<tr>
<td>85135E Flexible Cable</td>
<td>DC to 18</td>
<td>97.2 (38.25)</td>
<td>≥17 dB</td>
<td>0.46 /f + 0.3</td>
<td>&lt;0.22 dB</td>
<td>0.16 (f) +0.8</td>
</tr>
</tbody>
</table>

### Cable set for 8722D (2.4 mm)

<table>
<thead>
<tr>
<th>Connector Type</th>
<th>Frequency</th>
<th>Length</th>
<th>Return Loss</th>
<th>Insertion Loss</th>
<th>Stability</th>
<th>±Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>85133D Semi-rigid Cable Set</td>
<td>DC to 50</td>
<td>53 (21)</td>
<td>≥15 dB</td>
<td>0.55 /f + 0.2</td>
<td>&lt;0.06 dB</td>
<td>0.16 (f)</td>
</tr>
<tr>
<td>85133F Flexible Cable Set</td>
<td>DC to 50</td>
<td>72 (28)</td>
<td>≥12.5 dB</td>
<td>0.48 /f +0.25</td>
<td>&lt;0.17 dB</td>
<td>0.8 +0.16 (f)</td>
</tr>
<tr>
<td>85134D Semi-rigid Cable Set</td>
<td>DC to 26.5</td>
<td>53 (21)</td>
<td>≥16 dB</td>
<td>0.31 /f + 0.2</td>
<td>&lt;0.06 dB</td>
<td>0.18 (f)</td>
</tr>
<tr>
<td>85134F Flexible Cable Set</td>
<td>DC to 26.5</td>
<td>62.9 (24.75)</td>
<td>≥16 dB</td>
<td>0.31 /f + 0.2</td>
<td>&lt;0.12 dB</td>
<td>0.13 (f) +0.5</td>
</tr>
<tr>
<td>85135D Semi-rigid Cable Set</td>
<td>DC to 18</td>
<td>53 (21)</td>
<td>≥17 dB</td>
<td>0.31 /f + 0.2</td>
<td>&lt;0.06 dB</td>
<td>0.18 (f)</td>
</tr>
<tr>
<td>85135F Flexible Cable Set</td>
<td>DC to 18</td>
<td>62.9 (24.75)</td>
<td>≥17 dB</td>
<td>0.31 /f + 0.2</td>
<td>&lt;0.12 dB</td>
<td>0.13 (f) +0.5</td>
</tr>
</tbody>
</table>

1. Phase stability of semi-rigid/flexible cables is specified with a 90 degree bend and a 4”/3” radius.
2. Cable length and stability are supplemental characteristics.
3. Special rugged female connector specifically for connecting to the network analyzer test port, but does not mate with a standard male connector.
Test port adapter sets
The Agilent 85130 series test port adapter sets protect the test set port when connecting devices to the test port. These adapters, listed below with the single cables, convert the ruggedized test set port to a connection mateable with the device under test. Each set contains a male and a female adapter.

**Adapter sets**

<table>
<thead>
<tr>
<th>Adapter Set</th>
<th>Connector Type (Test Port to Device)</th>
<th>Frequency (DC–f&lt;sub&gt;max&lt;/sub&gt;)</th>
<th>Return Loss at f&lt;sub&gt;max&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>85130C</td>
<td>3.5 mm&lt;sup&gt;1&lt;/sup&gt; to Type–N</td>
<td>DC to 18 GHz</td>
<td>≥28 dB</td>
</tr>
<tr>
<td>85130D</td>
<td>3.5 mm&lt;sup&gt;1&lt;/sup&gt; to PSC-3.5 mm (f) or 3.5 mm&lt;sup&gt;1&lt;/sup&gt; (m)</td>
<td>DC to 26.5 GHz</td>
<td>≥28 dB</td>
</tr>
<tr>
<td>85130E</td>
<td>2.4 mm&lt;sup&gt;1&lt;/sup&gt; to 7 mm</td>
<td>DC to 18 GHz</td>
<td>≥26 dB</td>
</tr>
<tr>
<td>85130F</td>
<td>2.4 mm&lt;sup&gt;1&lt;/sup&gt; to PSC-3.5 mm (f) or 3.5 mm&lt;sup&gt;1&lt;/sup&gt; (m)</td>
<td>DC to 26.5 GHz</td>
<td>≥26 dB</td>
</tr>
<tr>
<td>85130G</td>
<td>2.4 mm&lt;sup&gt;1&lt;/sup&gt; to PSC-2.4 mm (f) or 2.4 mm&lt;sup&gt;1&lt;/sup&gt; (m)</td>
<td>DC to 50 GHz</td>
<td>≥23 dB</td>
</tr>
</tbody>
</table>

1. Special rugged female connector specifically for connecting to the network analyzer test port, but does not mate with a standard male connector.

Equipment rack systems
**Agilent 85043D Racked System Kit**
The 85043D racked system kit is a rack standing 128 cm (50.5 in) high, with a width of 60 cm (24 in) and a depth of 80 cm (32 in). Complete with support rails and AC power distribution (suitable for 50 to 60 Hz, 100 to 240 VAC), the kit includes rack mounting hardware for all instruments. Thermal design is such that no rack fan is needed.

**Agilent 1181A System Testmobile**
The 1181A system testmobile is a unit that provides mobility for instruments, test systems, and workstations. It holds units up to 610 mm (24 in) deep. The load capacity is up to 90 kg (200 lbs) on the tilt tray and 227 kg (500 lb) total. The following accessories are available for the test mobile:

- 35181A top mounted printer/plotter stand
- 35181B keyboard holder
- 35181C 3.5 inch high storage drawer
- 35181D work surface
- 35181E anti-static work mat
- 35181G 5.25 inch high storage drawer
- 92199B power strip for US and Canada
- 92199E international power strip (IEC-320)

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