Keysight 85070E
Dielectric Probe Kit 200 MHz to 50 GHz

Technical Overview

KEYSIGHT
TECHNOLOGIES

Swept High-Frequency Dielectric Measurements

The Keysight Technologies, Inc. 85070E Dielectric Probe Kit determines the dielectric properties, or complex permittivity, of many materials. Because a materials dielectric properties are determined by its molecular structure, if the molecular structure changes, so will the dielectric properties. Measuring them can indirectly measure other properties that are also correlated to the molecular structure, and can be a valuable alternative when the property of interest is difficult to measure directly.

Measurements are made by simply immersing the probe into liquids or semi-solids — no special fixtures or containers are required. Measurements are non-destructive and can be made in real time. These important features allow the Dielectric Probe Kit to be used in process analytic technologies.

The complete system is based on a network analyzer, which measures the material's response to RF or microwave energy. The probe transmits a signal into the material under test (MUT). Depending on the Keysight network analyzer and probe used, frequencies can extend from 200 MHz to 50 GHz.

The included software controls the network analyzer and guides the user through easy setup and measurement steps. In seconds, it calculates and displays complex permittivity in a variety of formats, including dielectric constant, dielectric loss factor, loss tangent or Cole-Cole.

Features

- Measures complex permittivity
- over a broad frequency range
- Results can be viewed in a variet of formats: er', er", loss tangent, and Cole-Cole
- Data is easily shared with oth-erWindows based programs or through the user programmable Component Object Model (COM) interface

New connection manager works with Keysight Connection Expert to bring ease and flexibility to interface between software and analyzer. GPIB and LAN are both supported with most PNA and ENA network analyzers.
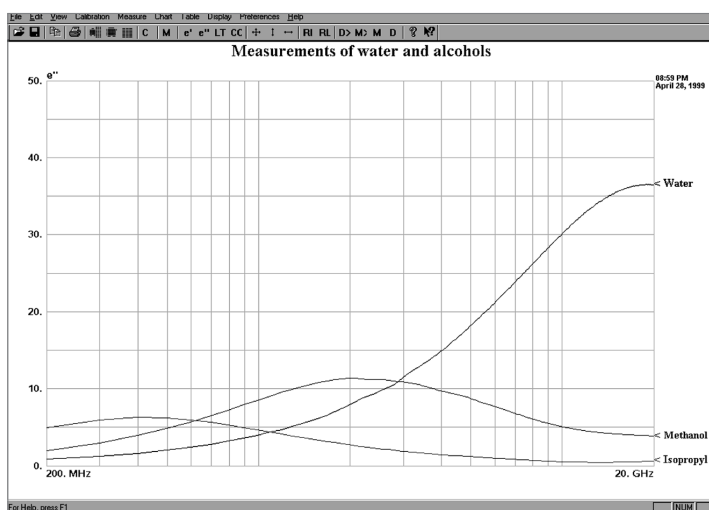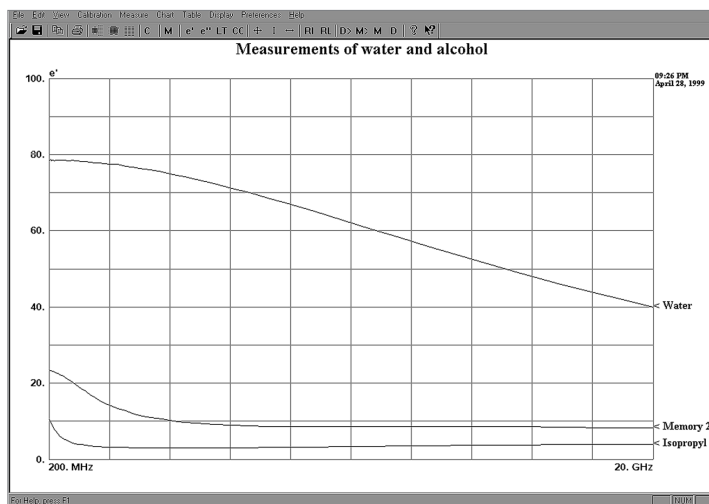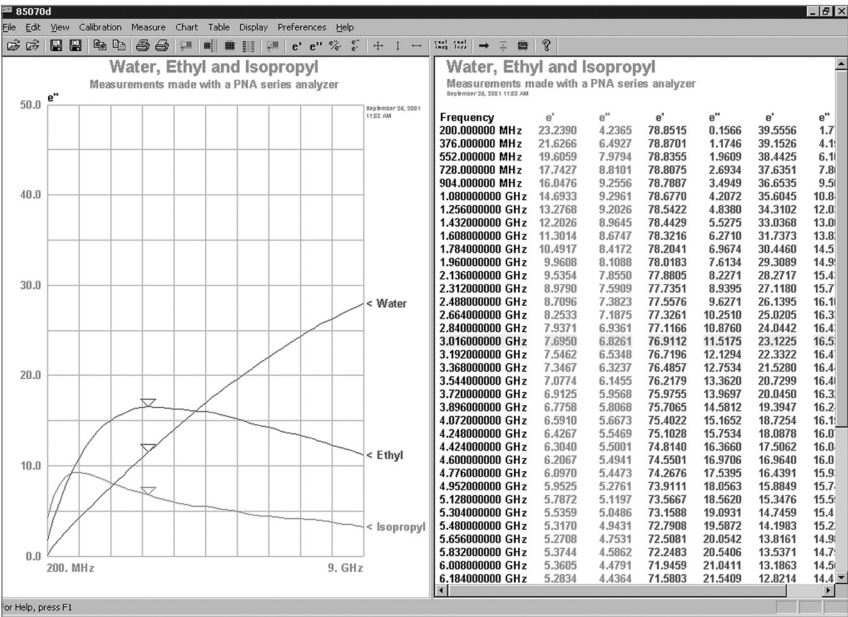

Software displays dielectric constant and loss factor as a function of frequency.

Easy Data Analysis Display

The split screen window and marker aids in data analysis. Simply click on a point on the chart or table to activate and move the marker.

Connect to other programs

Data charts and tables can easily be copied and pasted into any Windows–based application for further analysis or report generation. The component object model (COM) interface allows the measurement to be setup, triggered, and read from a user written program. This is valuable for analyzing material changes over time. Example Visual Basic® and C++ projects are included to aid program development.


Water, Ethyl and Isopropyl
Measurements made with a PNA series analyzer
September 28, 2001 11:22 AM

Frequency	e'	e''	e'	e''	e'	e''
200.000000 MHz	23.2390	4.2365	78.8515	0.1566	39.5556	1.7
376.000000 MHz	21.6266	6.4927	78.8701	1.1746	39.1526	4.1
552.000000 MHz	19.6059	7.9794	78.8355	1.9609	38.4425	6.1
728.000000 MHz	17.7427	8.8101	78.8075	2.6934	37.6351	7.8
904.000000 MHz	16.0476	9.2556	78.7887	3.4949	36.6535	9.5
1.080000000 GHz	14.6933	9.2961	78.6770	4.2072	35.6045	10.8
1.256000000 GHz	13.2768	9.2026	78.5422	4.8380	34.3102	12.0
1.432000000 GHz	12.2026	8.9645	78.4429	5.5275	33.0368	13.0
1.608000000 GHz	11.3014	8.6747	78.3216	6.2710	31.7373	13.8
1.784000000 GHz	10.4917	8.4172	78.2041	6.9674	30.4460	14.5
1.960000000 GHz	9.9608	8.1088	78.0183	7.6134	29.3089	14.9
2.136000000 GHz	9.5354	7.8550	77.8805	8.2271	28.2717	15.4
2.312000000 GHz	8.9790	7.5909	77.7351	8.9395	27.1180	15.7
2.488000000 GHz	8.7096	7.3823	77.5576	9.6271	26.1395	16.1
2.664000000 GHz	8.2533	7.1875	77.3261	10.2510	25.0205	16.3
2.840000000 GHz	7.9371	6.9361	77.1166	10.8760	24.0442	16.4
3.016000000 GHz	7.6950	6.8261	76.9112	11.5175	23.1225	16.5
3.192000000 GHz	7.5462	6.5348	76.7196	12.1294	22.3322	16.4
3.368000000 GHz	7.3467	6.3237	76.4857	12.7534	21.5280	16.4
3.544000000 GHz	7.0774	6.1455	76.2179	13.3620	20.7299	16.4
3.720000000 GHz	6.9125	5.9568	75.9755	13.9697	20.0450	16.3
3.896000000 GHz	6.7758	5.8068	75.7065	14.5812	19.3947	16.2
4.072000000 GHz	6.5910	5.6673	75.4022	15.1652	18.7254	16.1
4.248000000 GHz	6.4267	5.5469	75.1028	15.7534	18.0878	16.0
4.424000000 GHz	6.3040	5.5001	74.8140	16.3660	17.5062	16.0
4.600000000 GHz	6.2067	5.4941	74.5501	16.9706	16.9640	16.0
4.776000000 GHz	6.0970	5.4473	74.2676	17.5395	16.4391	15.9
4.952000000 GHz	5.9525	5.2761	73.9111	18.0563	15.8849	15.7
5.128000000 GHz	5.7872	5.1197	73.5667	18.5620	15.3476	15.5
5.304000000 GHz	5.5359	5.0486	73.1588	19.0931	14.7459	15.4
5.480000000 GHz	5.3170	4.9431	72.7908	19.5872	14.1983	15.2
5.656000000 GHz	5.2708	4.7531	72.5081	20.0542	13.8161	14.9
5.832000000 GHz	5.3744	4.5862	72.2483	20.5406	13.5371	14.7
6.008000000 GHz	5.3605	4.4791	71.9459	21.0411	13.1863	14.5
6.184000000 GHz	5.2834	4.4364	71.5803	21.5409	12.8214	14.4

Display data in chart form, table form, or both.

Calibration Refresh Reduces Drift Errors[1]

The new automated Electronic Calibration Refresh feature recalibrates the system automatically, in seconds, just before each measurement is made. This virtually eliminates cable instability and system drift errors. Processes can now be monitored over long time periods, including tests that vary MUT temperature and pressure over time.

How it works:

The Keysight Electronic Calibration module (ECal) microwave ports are connected in line between the probe and the network analyzer test port cable. The ECal module communication port is connected either to the PC or PNA Series network analyzer running the 85070E software. The software guides the user through a normal "three standard" calibration, (usually open, short, water), performed at the end of the probe. This calibration is then transferred to the ECal module. The ECal module remains in line and a complete ECal calibration is automatically performed before each measurement. Errors due to test port cable movement are removed by the new calibration.

ECal module connected in line
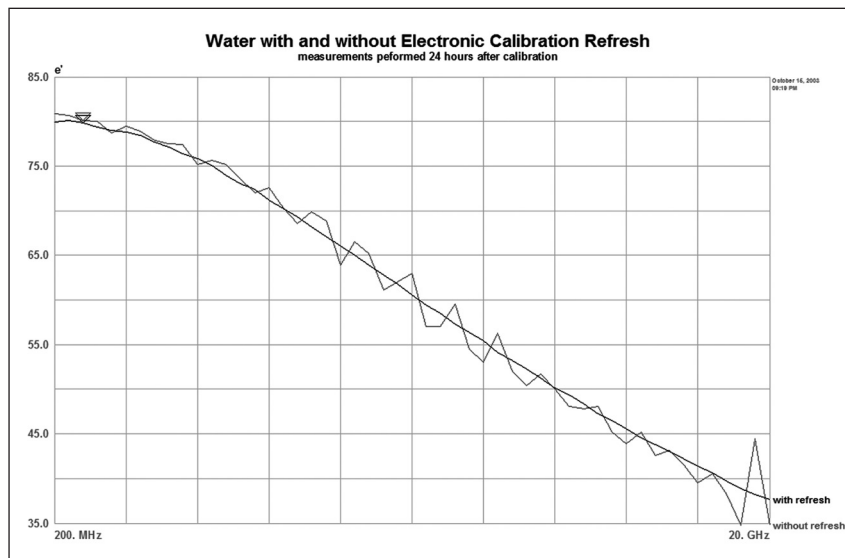
Water with and without Electronic Calibration Refresh

This measurement shows the effects of system drift and cable instability on a dielectric measurement of water and the improvement with Electronic calibration refresh. Both measurements were made 24 hours after the original calibration. The lighter colored, noisier, trace was made before the Electronic Calibration refresh was turned on. The darker, smoother, trace shows the improvement made after the Electronic Calibration refresh was turned on.

For systems without an ECal module, a simpler, "one standard" refresh calibration feature is also available, which can reduce the effects of system drift over time or temperature. After the initial "three standard" probe calibration is performed, the calibration can be refreshed at any time with the connection of a single standard. Any one of the three calibration standards can be defined as the refresh standard.

1. Not compatible with FieldFox RF analyzers

New Options Allow You to Configure Kit to Meet Your Needs

Now three probe designs to choose from

Performance Probe

Combines rugged, high temperature, and frequency performance in a slim design.

This probe features rugged, high temperature and frequency performance in a slim design, perfect for your most demanding applications. The probe is sealed on both the probe tip and the connector end, which make it our most rugged probe. The probe withstands a wide –40 °C to +200 °C temperature range, which allows measurements versus frequency and temperature.

The probe can be autoclaved, so it is perfect for applications in the food, medical, and chemical industries where sterilization is a must. The slim design allows it to fit easily in fermentation tanks, chemical reaction chambers, or other equipment with small apertures.

The small diameter also allows it to be used with smallest sample sizes of all Keysight's probes. It is useful for measuring liquid, semi-solid, as well as flat surfaced solid materials. The Performance Form Probe Kit comes complete with a calibration short.

Frequency range 500 MHz to 50 GHz.
2.4 mm male connector

Performance Probe Kit

150

Borosilicate glass seal

1.6

9.5

2.4 mm male connector

Hermetically sealed on both ends
(all dimensions in mm)

Stainless steel T316L body

Nickel plated tungsten center conductor

Stainless steel T304L tip
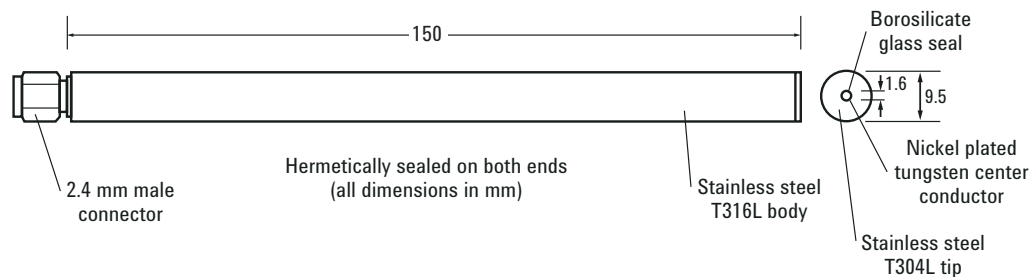
High temperature probe

Survives corrosive chemicals and high temperatures
Frequency range: 200 MHz to 20 GHz. 3.5 mm male connector.

Rugged in design, this probe features a hermetic glass-to-metal seal, which makes it resistant to corrosive or abrasive chemicals. The probe withstands a wide −40 °C to +200 °C temperature range, which allows measurements versus frequency and temperature. The large flange makes it easier to measure flat surfaced solid materials, in addition to liquids and semi-solids. The 3.5 mm aperture has a larger sensing volume than our other probes.
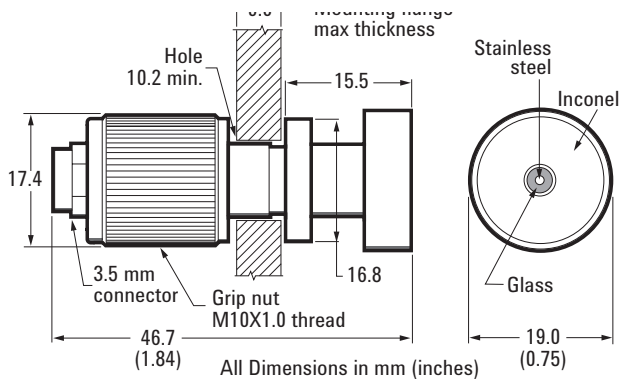
High Temperature Probe Kit

Slim Form Probe

Smaller diameter fits into tight spaces.
Frequency range 500 MHz to 50 GHz. 2.4 mm male connector.

This probe features a slim design, which allows it to fit easily in fermentation tanks, chemical reaction chambers, or other equipment with small apertures. The slim design also allows it to be used with smaller sample sizes. Best used for liquids and soft semi-solids.

For castable solids, the probe is economical enough to be cast into the material and left in place. Because of the consumable nature of this design, these probes are offered in sets of three. The Slim Form probe kit comes with a sealed Slim Form holder that adapts 2.2 mm outer diameter to 10 mm inner diameter bracket included in the kit as well as commercially available "Midi" sized adapters and bushings.
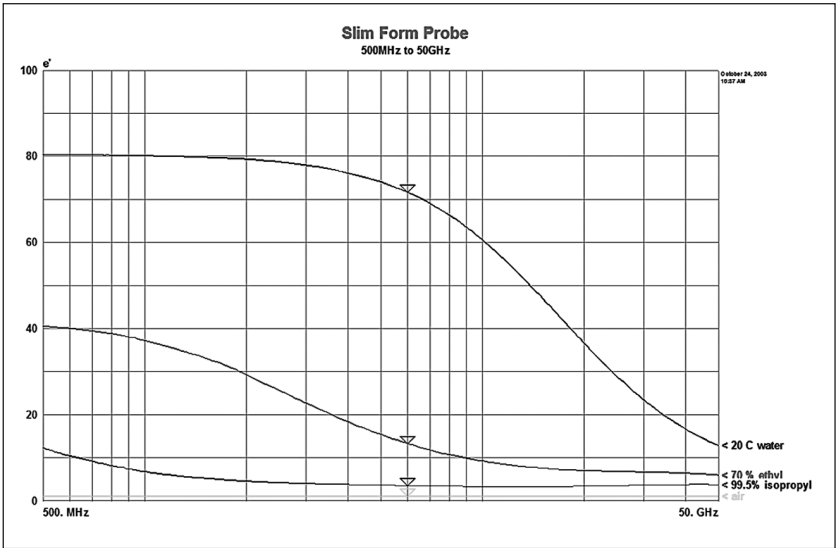
Slim Form Probe measurement to 50 GHz
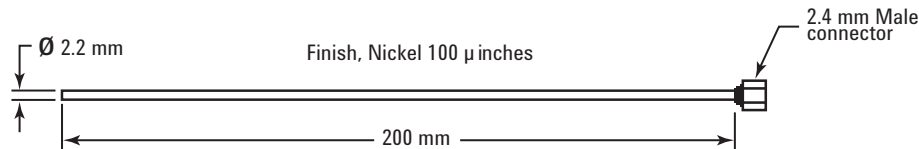
Three Cables to Choose From

20 GHz Flexible Cable

Cable to choose when tempertature performance is not critical. SMA female connectors connect to High Temperature probe. When connecting to Slim Form probe, an additional adapter may be needed (see configuration guide).

50 GHz Flexible Cable

Cable to choose for high frequency applications. 2.4 mm female connectors connect directly to Slim Form Performance probes.

20 GHz High Temperature Cable

Use with High Temperature or Performance probes for high temperature applications from −40 °C to +200 °C. SMA female connectors connect directly to High Temperature probe. Adapter included in kit connects High Temperature Cable to Performance probe.

Accessories

Probe Stand

The probe stand has a 13 x 7 inch porcelain base and 24 inch high by 0.5 inch diameter metal support. This stand works with mounting bracket and ECal holder included in the standard kit. It is highly recommended to stabilize measurement setup.

Software Menu Items

File

Save or recall measurement setups or previous measurement results. Print copies of the measurement results in a tabular or graphical format.

Edit

Copy the measurement results to the clipboard. Either graph or the tabular listing can be copied. This allows your measurement results to be pasted into other applications.

View

Select the section you want to view. Selections include the toolbar, status bar, table of the measurement data, and chart of the measurement data.

Calibration

Select the frequency range, number of points, linear or log sweep. Guided calibration sequence; choice of calibration materials or user-specified; refresh calibration for single standard or ECal; recalibration versus temperature; automatic refresh on or off.

Measure

Trigger a measurement.

Chart

Select the format to be displayed on the chart. Choices include er', er'', loss tangent, and Cole-Cole. Set Graticule scale factors or "autoscale". Select from linear, semi-log, or log-log representations.

Software Menu Items (continued)

Table

Choose between a tabular formatting of real and imaginary or real and loss tangent

Display

Display current measurement data; save/display up to 3 memory traces; compare data to reference trace with trace math. Turn the marker on or off.

Preferences

Select your preference of fonts, colors, and annotations used to plot and list the measurement data.

Help

On-line help including the product manual.

Toolbar

Provides single click access to the most important menu items.

Performance Characteristics

Specifications describe the warranted performance over the temperature range 0 to 55 °C. Supplemental characteristics are intended to provide information useful in applying the instrument, by giving typical but non-warranted performance parameters. These are denoted as "typical," "nominal," or "approximate."

Probe Characteristics Table

	Performance Probe	Slim Form Probe	High Temperature Probe
Frequency Range (nominal)	500 MHz to 50 GHz Maximum limited by MUT properties $< \dfrac{(285-j125)GHz}{\sqrt{\lvert\varepsilon_r^*\rvert}}$	500 MHz to 50 GHz Maximum limited by MUT properties $< \dfrac{(285-j125)GHz}{\sqrt{\lvert\varepsilon_r^*\rvert}}$	200 MHz to 20 GHz with network analyzer 10 MHz to 3 GHz with E4991A Impedance analyzer with option 10. Maximum limited by MUT properties $< \dfrac{100\ GHz}{\sqrt{\lvert\varepsilon_r^*\rvert}}$
Temperature Range	−40 to +200 °C	0 to +125 °C	−40 to +200 °C
Temperature Slew Rate	< 10 degrees/minute	< 10 degrees/minute	< 10 degrees/minute
Immersable Length (approximate)	140 mm	200 mm	35 mm
Connector	2.4 mm male	2.4 mm male	3.5 mm male
Repeatability and Resolution	Two to four times better than accuracy	Two to four times better than accuracy	Two to four times better than accuracy
Material Under Test (assumptions)	Material is "infinite" in size, non-magnetic (μr* = 1), isotropic (uniform orientation), and homogeneous (uniform composition)[2]. Solids have a single, smooth, flat[3] surface with gap-free contact at the probe face.	Liquid or soft semi-solid. Material is "infinite" in size, non-magnetic (μr* = 1), isotropic (uniform orientation), and homogeneous (uniform composition)[2].	Material is "infinite" in size, non-magnetic (μr* = 1), isotropic (uniform orientation), and homogeneous (uniform composition)[2]. Solids have a single, smooth, flat[3] surface with gap-free contact at the probe face.
Sample size (requirements)	Minimum 5 mm insertion and 1 mm around tip of probe	Minimum 5 mm insertion and 5 mm around tip of probe	Diameter: > 20 mm Thickness: $> \dfrac{20}{(\sqrt{\lvert\varepsilon_r^*\rvert})}$ mm Granule size[4]: < 0.3 mm
Expected Value (requirements)	Maximum recommended ε_r': < 100 Minimum recommended loss tangent > 0.05 Not recommended for low loss (loss tangent < 0.5) materials with $\varepsilon' > 5$	Maximum recommended ε_r': < 100 Minimum recommended loss tangent > 0.05 Not recommended for low loss (loss tangent < 0.5) materials with $\varepsilon' > 5$	Maximum recommended ε_r': < 100 Minimum recommended loss tangent > 0.05 Not recommended for low loss (loss tangent < 0.5) materials with $\varepsilon_r' > 5$
Accuracy (typical)[1]	Dielectric constant, $\varepsilon_r' = \varepsilon_r'$ $\pm 0.05\lvert\varepsilon_r^*\rvert$. $\varepsilon_r'' = \varepsilon_r'' \pm 0.05\lvert\varepsilon_r^*\rvert$	Dielectric constant, $\varepsilon_r' = \varepsilon_r'$ $\pm 0.05\lvert\varepsilon_r^*\rvert$. $\varepsilon_r'' = \varepsilon_r'' \pm 0.05\lvert\varepsilon_r^*\rvert$	Dielectric constant, $\varepsilon_r' = \varepsilon_r'$ $\pm 0.05\lvert\varepsilon_r^*\rvert$. $\varepsilon_r'' = \varepsilon_r'' \pm 0.05\lvert\varepsilon_r^*\rvert$

1. Practical frequency range, accuracy and resolution depend on properties of the MUT. Value indicates typical accuracy at 23 ±3 °C, not including effects of probe contact and cable flexure.
2. If the material is not homogeneous, the result is an average value weighted by the intensity of the E-field, which is highest at the center conductor of the probe tip.
3. Sample must be as flat as the probe face, which is lapped to ±100 μ inches.
4. Measurement repeatability for granular materials is dependent on density variation.

Configuration Guide

Choose one of our suggested configurations

High Temperature Configuration

85070E
- – Performance Probe Kit, Option 050, or High-Temperature Probe Kit, Option 020
- – High Temperature Cable, Option 002
- – Probe Stand, Option 001
- – USB Security Key, Option UL8

Rugged High Frequency Configuration

85070E
- – Performance Probe, Option 050
- – Probe Stand, Option 001
- – USB Security Key, Option UL8

Economy Configuration

85070E
- – Slim Form Probe Kit, Option 030
- – 20 GHz Flexible Cable, Option 022
- – USB Security Key, Option UL8

High Temperature Probe Kit (Option 020)

Performance Probe Kit (Option 050)

Slim Form Probe Kit (Option 030)

Configuration Guide (continued)

Or, customize your own

Dielectric Probe Kit, 85070E

Includes:
– Dielectric Probe Software application on CD-Rom
– 1 mounting bracket to connect probes to Option 001 Probe Stand or similar stand
– 1 10 mm holder to connect performance probe or slim form holder to mounting bracket
– 1 3 mm hex key for 10 mm holder and Ecal holder screws
– 1 ECal holder to connect ECal module to mounting bracket
– 1 Type-N male to 3.5 mm male adapter, 1250-1743
– 1 3.5 mm male to 2.4 mm female adapter 11901D
– 1 foam lined walnut box.

Probes – Choose one or all

Performance Dielectric Probe Kit, Option 050

Includes:
– 1 Performance Dielectric Probe
– 1 Calibration Short
– 1 Conductive Elastomer Disk

High-Temperature Dielectric Probe Kit, Option 020

Includes:
– 1 High Temperature Probe
– 1 Calibration Short

Slim Form Probe Kit, Option 030

Includes:
– 3 Slim Form probes
– 1 connector saver
– 1 Calibration short
– 1 10 mm dia sealed probe holder.
– 6 O-rings

Slim Form probe replenishment Kit, Option 033

Contains 3 extra Slim Form Probes

Cables – (Optional, choose any or all)

– High Temperature Cable, Option 002
– 20 GHz Flexible Cable, Option 022
– 50 GHz Flexible Cable, Option 032

Accessory – (Optional, highly recommended)

– Probe Stand, Option 001

Security Key –

– USB Hardware Key, Option UL8

Additional available parts

– 8710-2036 High-Temperature Dielectric Probe
– 85070-60003 Shorting block and clamp for high temperature probe
– 85070-60004 Short for Slim Form Probes
– 85070-60007 Slim Form Probe holder
– 85070-60008 ECal Holder
– 85070-60009 Set of three Slim Form Probes
– 85070-60010 Performance Probe
– 85070-60012 Short for Performance Probe
– 85070-60011 10mm Holder for Performance Probe and Slim Form Probe
– 8120-6286 High Temperature Cable
– 8120-6192 20GHz Flexible Cable
– 8121-1290 50GHz Flexible Cable
– 9301-1298 Probe Stand
– 1250-3449 Connector Saver for Slim Form Probe
– 85070-20036 Conductive Elastomer Disk

85070E Dielectric Probe Kit Upgrades

Software only upgrade to the E version for customers who own the 85070D or earlier version.
– 85070EU Software Upgrade Kit

Probe hardware only upgrade kits are now available to customers who own the 85070E or 85070EU. These kits contain the probe, short and any other small accessories included in the standard probe option.
– 85070E-021 High Temperature Probe Upgrade Kit
– 85070E-031 Slim Form Probe Upgrade Kit
– 85070E-051 Performance Probe Upgrade Kit

Adapter Selection Guide

Some configurations may need extra adapters. The Keysight adapter part numbers are charted below.

Network analzyer port to cable			
Network analyzer port connector	High Temperature 20 GHz Cable	Flexible 20 GHz Cable	Flexible 50 GHz Cable
Type-N female	1250-1743 (included in kit)	1250-1743 (included in kit)	11903A
3.5 mm male	None needed	None needed	11901C
2.4 mm male	11901D (included in kit)	11901D (included in kit)	None needed
Probe to cable			
Probe	High Temperature 20 GHz Cable	Flexible 20 GHz Cable	Flexible 50 GHz Cable
High Temperature Probe	None needed	None needed	11901C
Slim Form Probe	11901D (included in kit)	11901D (included in kit)	None needed
Performance Probe	11901D (included in kit)	11901D (included in kit)	None needed

Adapters needed when using automated Electronic Calibration Refresh

Ecal module to cable			
ECal Module Connector	High Temperature 20 GHz Cable (3.5 mm female)	Flexible 20 GHz Cable (3.5 mm female)	Flexible 50 GHz Cable (2.4 mm female)
Type-N male	1250-1750	1250-1750	11903C
Type-N female	1250-1743 (included in kit)	1250-1743 (included in kit)	11903A
3.5 mm male	None needed	None needed	11901C
3.5 mm female	1250-1748	1250-1748	11901A
2.4 mm male	11901D (included in kit)	11901D (included in kit)	None needed
2.4 mm female	11901C	11901C	11900A
Ecal module to probe			
ECal Module Connector	High Temperature Probe	Performance and Slim Form Probe	
Type-N male	1250-1745	11903B	
Type-N female	1259-1744	11903D	
3.5 mm male	83059B	11901B	
3.5 mm female	None needed	11901D (included in kit)	
2.4 mm male	11901B	11900B	
2.4 mm female	11901C	None needed	

Compatible ECal modules [1]

ECal module requires USB connection to PC or PNA Series network analyzer N469xA series
8509xC series

Free Trial Demo

Evaluate a demo version of 85070E software for up to two weeks. Visit the Keysight web site at www.keysight.com/find/materials to download this demo program.

Compatible network analyzers

A list of compatible network analyzers can be found on the 8507xE Series Support site at: http://na.support.keysight.com/materials/

PC requirements

– Windows XP, Windows 7
– Keysight IO Libraries
– CD drive or internet connection to load software.

PC is optional for PNA and newer ENA series network analyzers where software can be installed directly on the analyzer. All other analyzers require a PC with a GPIB or LAN interface card. LAN is supported with PNA, newer ENA, and FieldFox models. GPIB is supported with newer PNA, ENA and E4991A models. Please see: http://na.support.keysight.com/materials/ for model number and firmware requirements.

1. Optional, needed for Automated Electronic Calibration Refresh

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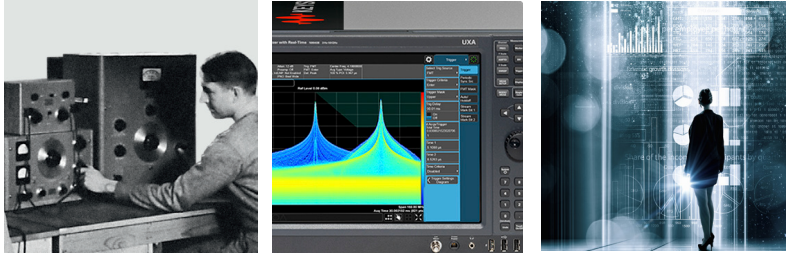
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China	800 810 0189
Hong Kong	800 938 693
India	1 800 11 2626
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 6375 8100

Europe & Middle East
Austria	0800 001122
Belgium	0800 58580
Finland	0800 523252
France	0805 980333
Germany	0800 6270999
Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	800 000154
Sweden	0200 882255
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