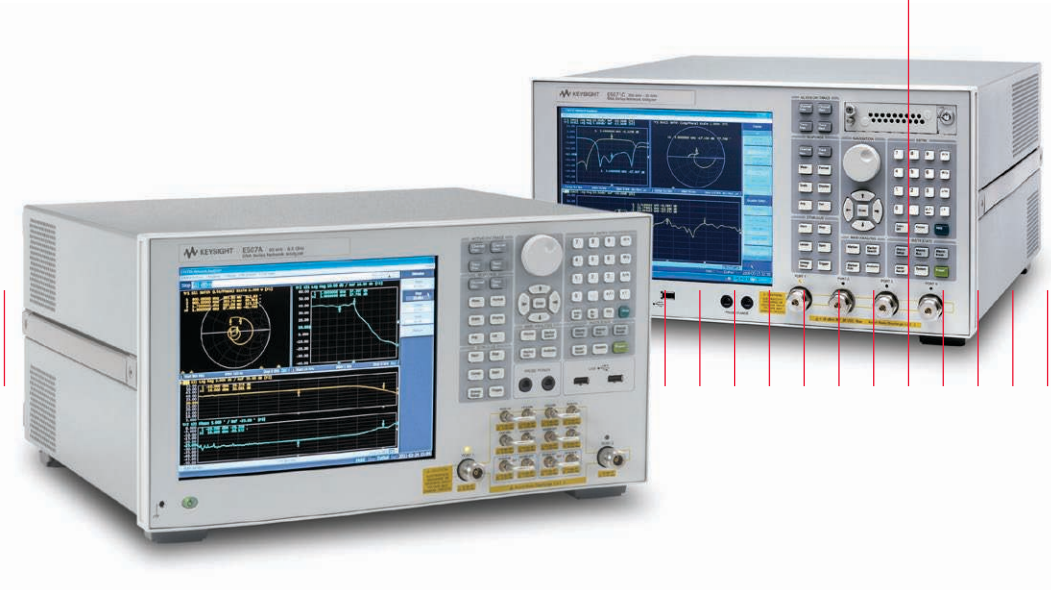# Keysight Technologies
7 Reasons to Upgrade from your 8753 to an ENA Network Analyzer

Application Note

– Superior performance and speed
– 8753-like and enhanced usability
– Enhanced capabilities for passive component measurements
– Better solution for active component measurements
– Advanced measurement functions
– Code migration tool
– Flexible upgradability

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Introduction

Many 8753 users have replaced their analyzers with the ENA Series. Although the reasons for making this change to some extent depend on the customer's particular situation, it is easy to highlight the ENA Series features that are most highly valued by our customers.

This document helps 8753 users understand how the ENA Series can improve their network measurement environment, particularly focusing on the E5071C and E5072A which are the main products for the 8753 migration in 50Ω applications.

E5071C/E5072A overview

The E5071C is the flagship product of the ENA Series network analyzers and plays the central role in the 8753 migration. The E5071C offers the best-in-class RF performance and speed, along with a variety of test frequency (9/100 kHz to 4.5/6.5 /8.5 GHz, 300 k to 14/20 GHz) and test port options (2-port and 4-port).

The E5072A (30 kHz to 4.5 /8.5 GHz) is the enhanced model offering several additional capabilities on top of the 2-port E5071C. The E5072A's unique capabilities include the wider output power range, configurable test set (direct receiver access, and receiver leveling function. The E5072A is suitable for the 8753 migration in power amplifier tests and several other specific applications.

A summary of functional comparison between the ENA Series and the 8753 is available in the comparison table at the end of this document.
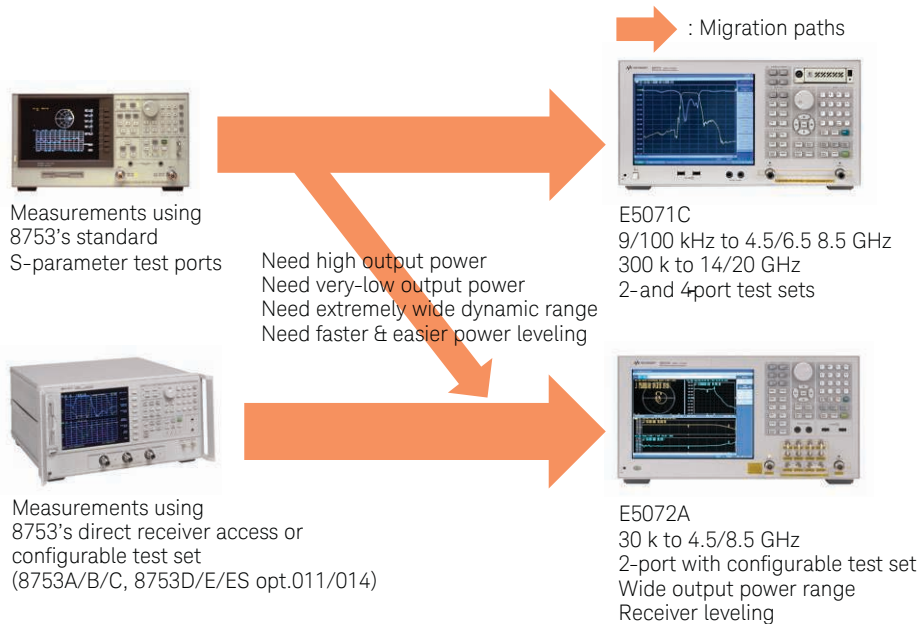

→ : Migration paths

Measurements using 8753's standard S-parameter test ports

Need high output power
Need very-low output power
Need extremely wide dynamic range
Need faster & easier power leveling

E5071C
9/100 kHz to 4.5/6.5 8.5 GHz
300 k to 14/20 GHz
2- and 4-port test sets

Measurements using 8753's direct receiver access or configurable test set (8753A/B/C, 8753D/E/ES opt.011/014)

E5072A
30 k to 4.5/8.5 GHz
2-port with configurable test set
Wide output power range
Receiver leveling

Figure 1. Typical migration paths from 8753 to E5071C/E5072A

7 Reasons to upgrade

1. Superior performance and speed

The trace noise, dynamic range and measurement speed are three key parameters for better network measurements especially in applications related to RF component production tests. Wider dynamic range provides more accurate evaluation of high rejection filters. Lower trace noise helps minimize errors when measuring low-loss devices such as filter pass-bands. The ENA Series provides significantly better measurement performance than the 8753. The comparison charts of dynamic range and trace noise are shown in Figures 2 and 3.

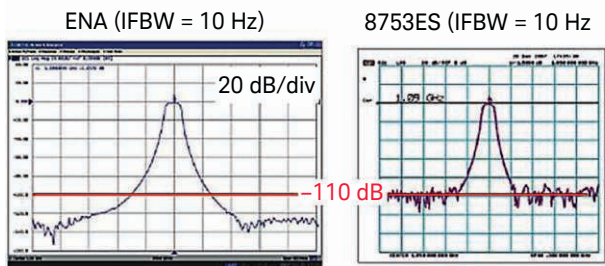| ENA (IFBW = 10 Hz)	8753ES (IFBW = 10 Hz	ENA (IFBW = 1 kHz)	9753ES (IFBW = 1 kHz)

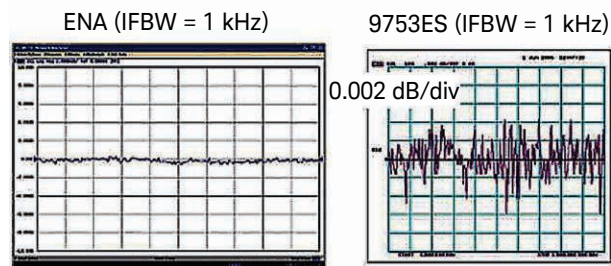Figure 2. Maximum dynamic range comparison   Figure 3. Trace noise comparison

Measurement speed is critically important in production lines, where test throughput is the most significant factor in the cost of test. The ENA Series, with its superior basic measurement performance, sweeps much faster than the 8753 at the same level of dynamic range or trace noise.

Figure 4 shows a comparison of measurement speed for a SAW filter automated production test with equivalent trace noise condition, which requires very low trace noise like 0.01 dB p-p for testing the low insertion loss filter pass band. As shown in this example, the ENA Series provides much faster speed, allowing you to dramatically improve test throughput.

E5071C   19 ms (IFBW = 100 kHz)

8753ES   438 ms (IFBW = 5 kHz)
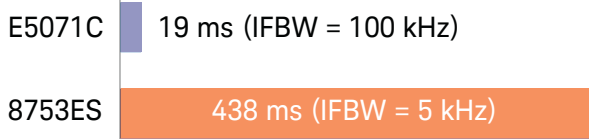
440 MHz to 3 GHz, 366 points, segment sweep, full 2-port cal

Figure 4. Speed comparison in high-volume manufacturing

2. 8753-like and enhanced usability

Similar look and feel to 8753

It is difficult to fully describe the value of the ENA Series' enhanced usability. However, it has been enthusiastically adopted by many 8753 users, who tend to be reluctant to accept a new user interface because they are very familiar with the 8753. Actually, the ENA Series user interface is based on the 8753, with several improvements that mainly allow the Windows-like interface to work much better than the traditional analyzer interface.
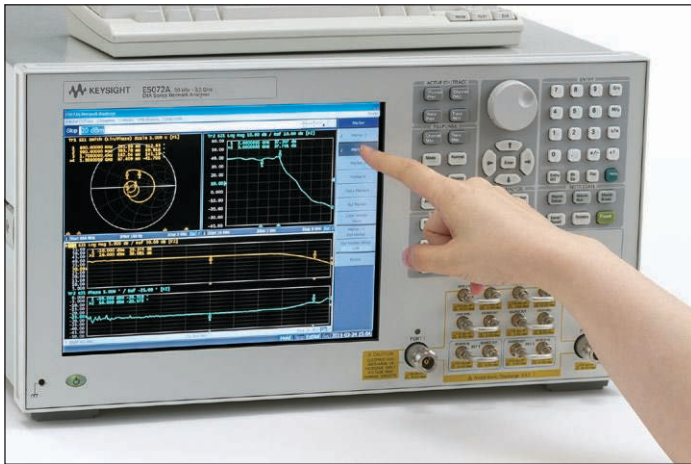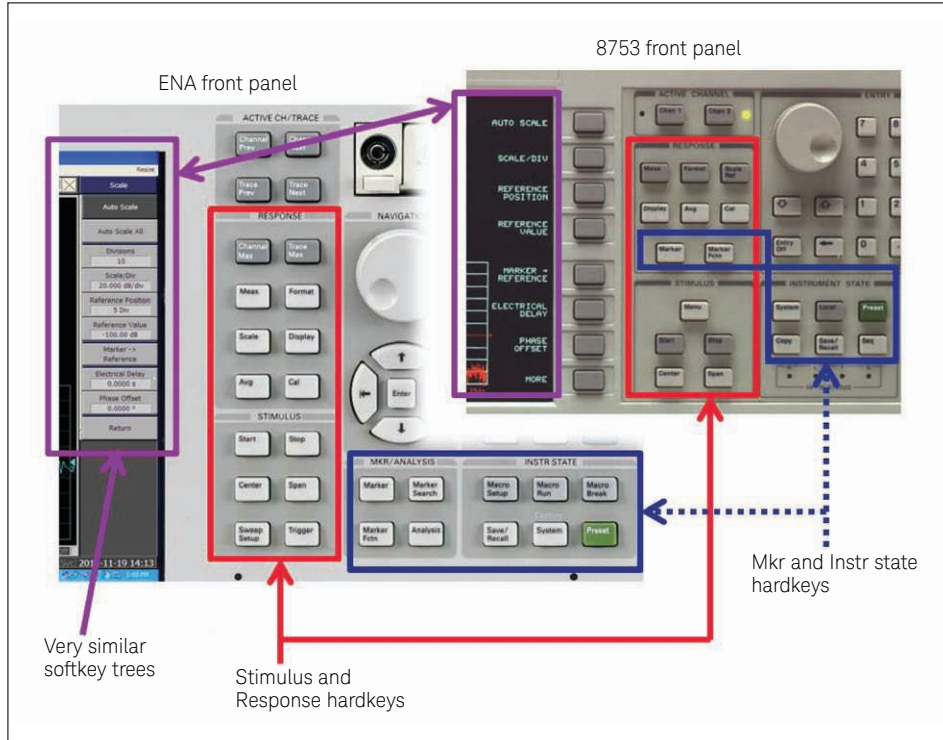

Figure 5. Touch screen

Figure 6. Similar user interface with 8753

Measurement wizards

For complicated measurements using the ENA Series, Keysight Technologies, Inc. offers a variety of measurement wizards with easy-to-use intuitive user interface. The measurement wizards are VBA applications downloadable from Keysight's web site. The measurement wizards guide you through the whole measurement procedures with step-by-step instructions. This enables you to setup all necessary parameters, perform any required calibration, and run your measurements in a short time.
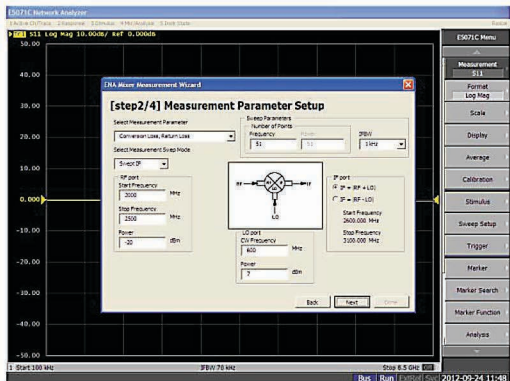
You can customize most of the measurement wizards with the ENA's built-in VBA editor to meet your measurements. For more details about the measurement wizards, visit the following URL: http://www.keysight.com/find/enavba
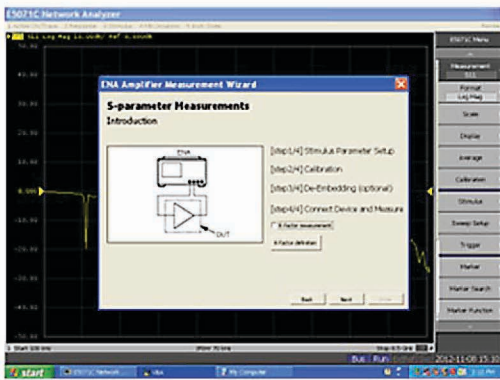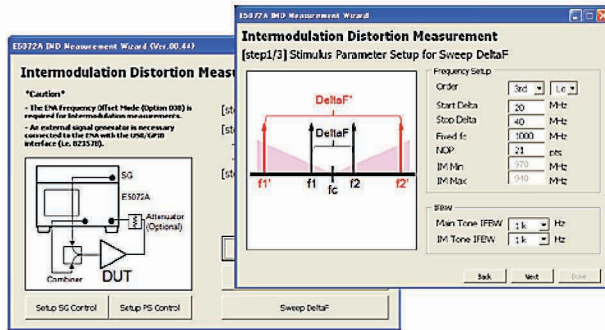
Amplifier Measurement Wizard
(for E5071C and E5072A)
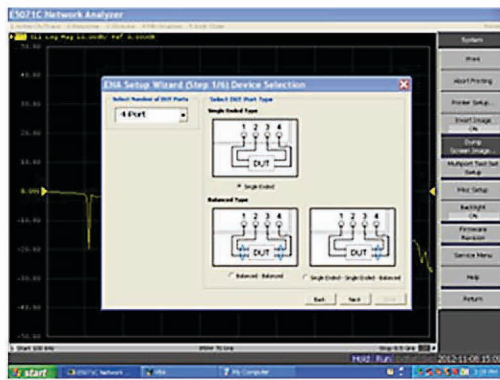
Setup Wizard
(for E5071C)

Mixer Measurement Wizard
(for E5071C)

IMD Measurement Wizard
(for E5072A)

Figure 7. Measurement Wizards for E5071C/E5072A

3. Passive component measurements

The trace noise and dynamic range, are important key parameters for passive component tests. The ENA Series provides significantly better measurement performance than the 8753 in terms of these parameters. Moreover, state-of-the-art calibration techniques and simulator functions are offered by the ENA for easy and fast characterization of devices.

Advanced calibration techniques

The E5071C and E5072A has new calibration techniques such as adapter removal/insertion and unknown thru calibration that are not available with the 8753.

The ENA Series has enhanced adapter removal/insertion capability for accurate mixed connector, multi-port calibration. Traditional adapter removal requires two full two-port calibrations (14 connections). On the other hand, the ENA's enhanced adapter removal/insertion only requires one full two-port calibration and one full one-port calibration (10 connections).

Unknown thru calibration is the preferred through method of calibrating the ENA to measure a non-insertable device. The major benefits of using an unknown thru calibration are:

– Easy to perform
– Provides better accuracy than defined thru and is usually better than adapter removal
– Does not rely on existing standard definitions that may no longer be accurate.
– Causes minimal cable movement if the thru standard has the same footprint as the DUT. In fact, the DUT can often be treated as the thru standard.

Fixture simulator

RF engineers are often required to process the measured S-parameters because of the fact that RF network analyzers only allow measurement at well-defined 50 Ω single-ended coaxial interfaces. The post measurement data processing is time-consuming work including calculation with an external computer and data transfer between the computer and the analyzer.

The Fixture Simulator is a built-in function that uses software in the E5071C and E5072A to simulate various measurement conditions based on the measurement results. It significantly simplifies and speeds up the post measurement data processing. The Fixture simulator includes functions such as:

– Network de-embedding
– Matching circuits embedding
– Balance-unbalance conversion

The fixture simulator contributes to the following four major applications of passive component characterization:

– Removal of unwanted test fixture effects
– Component measurement with non-50 Ω port impedance
– Balanced component measurement
– Evaluation of the total network characteristics when external circuits are attached to the component

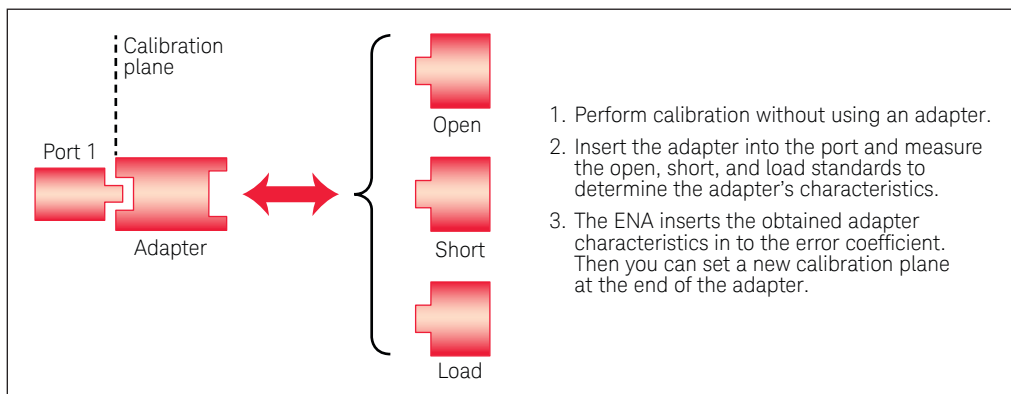More detail about fixture simulator is available at http://cp.literature.keysight.com/litweb/pdf/5988-4923EN.pdf

1. Perform calibration without using an adapter.
2. Insert the adapter into the port and measure the open, short, and load standards to determine the adapter's characteristics.
3. The ENA inserts the obtained adapter characteristics in to the error coefficient. Then you can set a new calibration plane at the end of the adapter.

Figure 8. Enhanced adapter removal and insertion

Widest dynamic range with direct receiver access

The E5071C and E5072A's dynamic range of 123 dB is better than the 8753. For those who require even wider dynamic range for measurements of their high-rejection filters, the E5072A has direct receiver access that enables you to reverse the signal path in the test port couplers and bypass the loss associated with the coupled arm. Using this configuration, you can increase the forward measurement dynamic range more than 150 dB, which is the widest dynamic range in its class.

This configuration is recommended for accurately measuring very low signal levels, such as rejection bands of filters or isolation of RF switch.

Furthermore, the configuration is beneficial for filter-tuning customers. If dynamic range is increased by 20 dB, then 100-times wider IF bandwidth (IFBW) can be selected, thus 100-times faster measurements can be performed to get the same result with trace noise.

This extremely fast speed is a tremendous advantage with the E5072A, if you are doing time-consuming filter-tuning at stop band performance of your DUT.
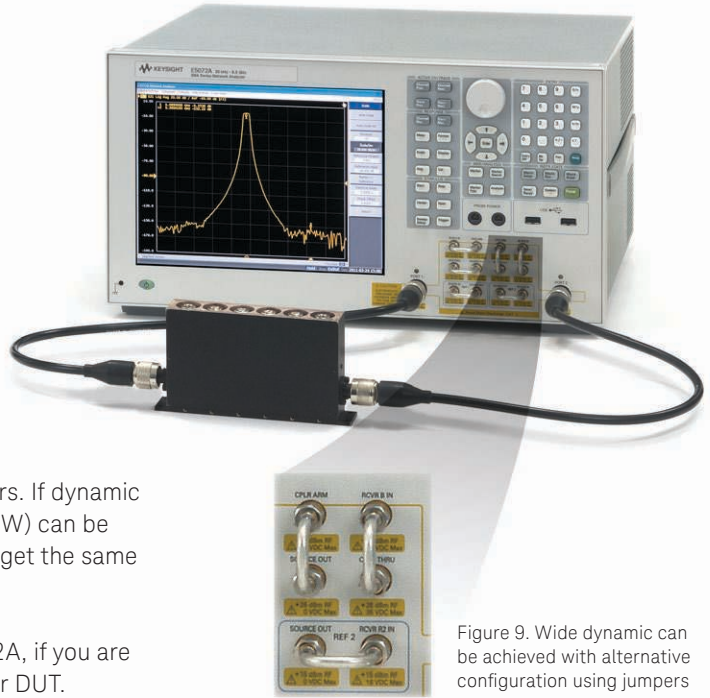

Figure 9. Wide dynamic can be achieved with alternative configuration using jumpers
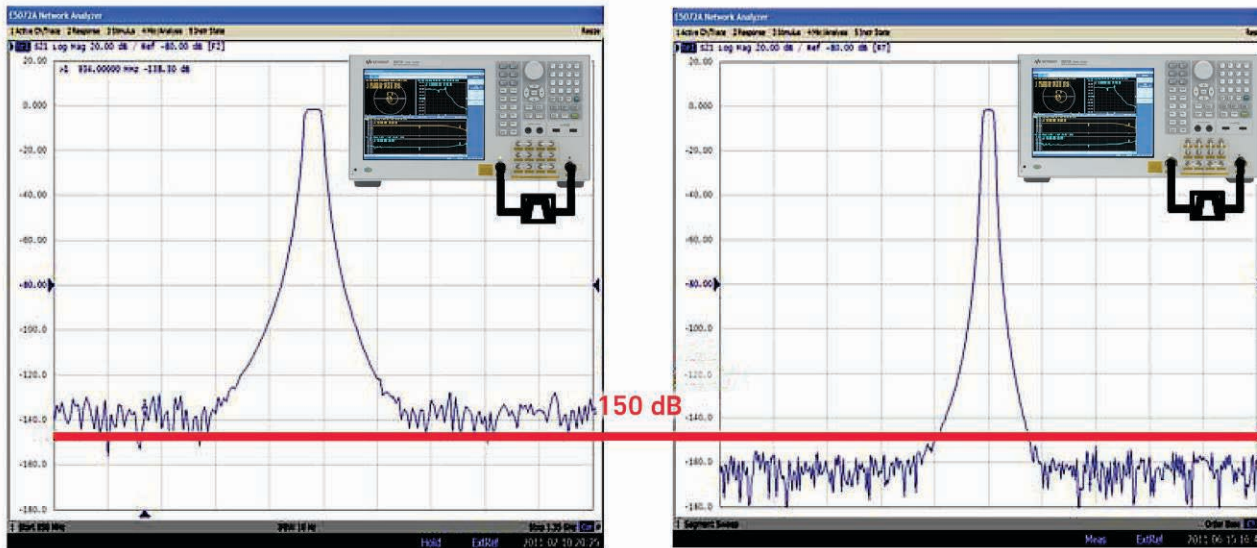

Figure 10. Dynamic range of forward measurement is improved

4. Active component measurements

Among the ENA Series, the E5071C covers basic requirements of RF amplifier measurements. In addition, the E5072A with added enhanced functions is more suitable for full performance characterization of active components.

Wide power range

The E5072A delivers a source power level up to +20dBm from test ports (port 1 and port 2) in the frequency range from 300 kHz to 1 GHz (SPD[1]). The E5072A has a 65 dB power sweep range (i.e. −49 to +16 dBm in 300 kHz to 3 GHz) with specified leveled output power from the test ports that allows measurements of compression characteristics of active devices with a single power sweep.

The E5072A provides high output power from the test ports in a wide frequency range from 30 kHz to 8.5 GHz, thus eliminating additional costs associated with extra hardware such as booster amplifiers. The maximum output power level of E5072A is shown in Figure 11.

High–power measurement with a booster amplifier

For applications that require a specific output power higher than the VNA provides, an external amplifier is necessary in order to boost the power level to the input of the DUT. The problem with using an external booster amplifier is the errors associated with temperature drift from the amplifier which cannot be removed.

In order to overcome the drift effect of a booster amplifier, the E5072A gives you direct access to all source and receiver paths to add external components for a variety of applications such as high-power amplifiers and, directional couplers.

By using external couplers, the incident signal can be measured in the reference receiver (R1) of the E5072A after the booster amplifier rather than before, which cancels the effect of temperature drift and improves measurement uncertainty. All calibration techniques are available with this configuration, and high accuracy and long-term stability of measurements are guaranteed.

The E5072A is an ideal replacement of the 8753 with option 011 (delete test set) and option 014 (configurable test set).

For more details of high-power measurements, refer to Keysight application note, "High-power Measurements Using the E5072A", part number 5990-8005EN.

http://cp.literature.keysight.com/litweb/pdf/5990-8005EN.pdf

1. SPD or Supplemental Performance Data represents the value that is most likely to occur. Not guaranteed by the product warranty.
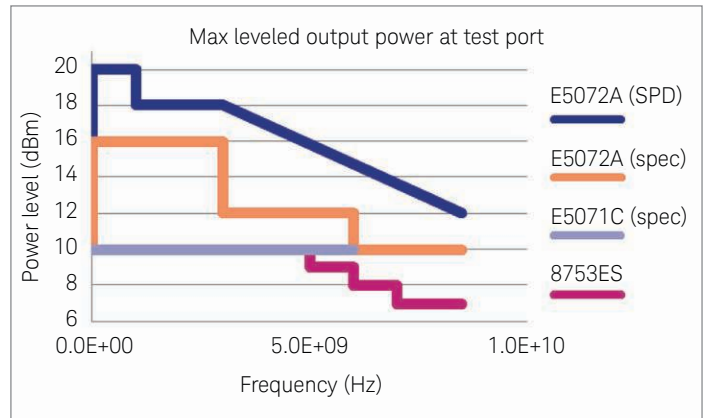

Figure 11. Improved maximum output power level at E5072A's test port

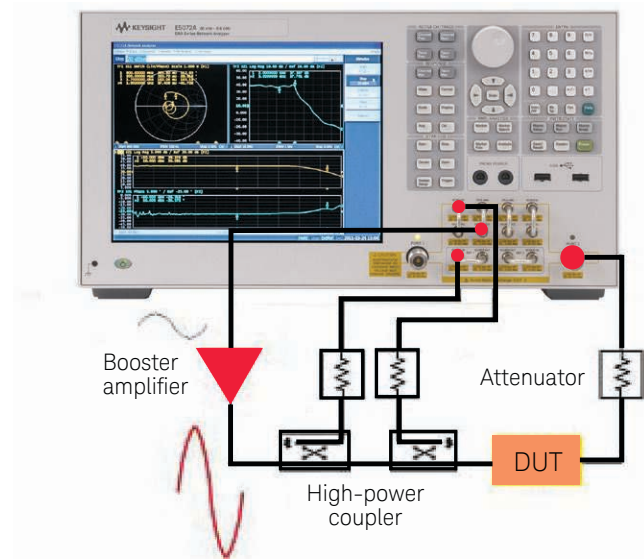Figure 12. Configuration using direct receiver access with a booster amplifier

Standard 2-port configuration   Configuration with direct receiver access
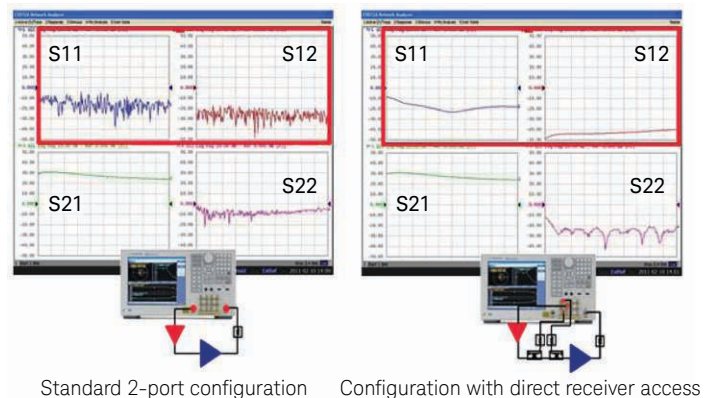
Figure 13. Improved measurement accuracy with the configuration using direct receiver access

Receiver leveling

The E5072A has capabilities of power calibration techniques for accurate measurements which offer the replacement to legacy test systems with multiple instruments. Especially its receiver leveling function using the receiver measurement offers fast leveling of input or output power of the DUT.

The E5072A's receiver leveling adjusts the source power level across a frequency or power sweep using its receiver measurements. Before each measurement sweep, a variable number of background sweeps are performed to repeatedly measure power at the receiver for each stimulus point. Those power measurements are then used to adjust the source power level of the E5072A.
With this receiver leveling function, you can achieve great power level accuracy with much improved throughput compared to conventional leveling methods using an 8753, a power meter and power sensor controlled by a system controller.

For more details of RF amplfier measurements, refer to Keysight application note, "Basics of RF Amplifier Measurements with the E5072A", part number 5990-9974EN.
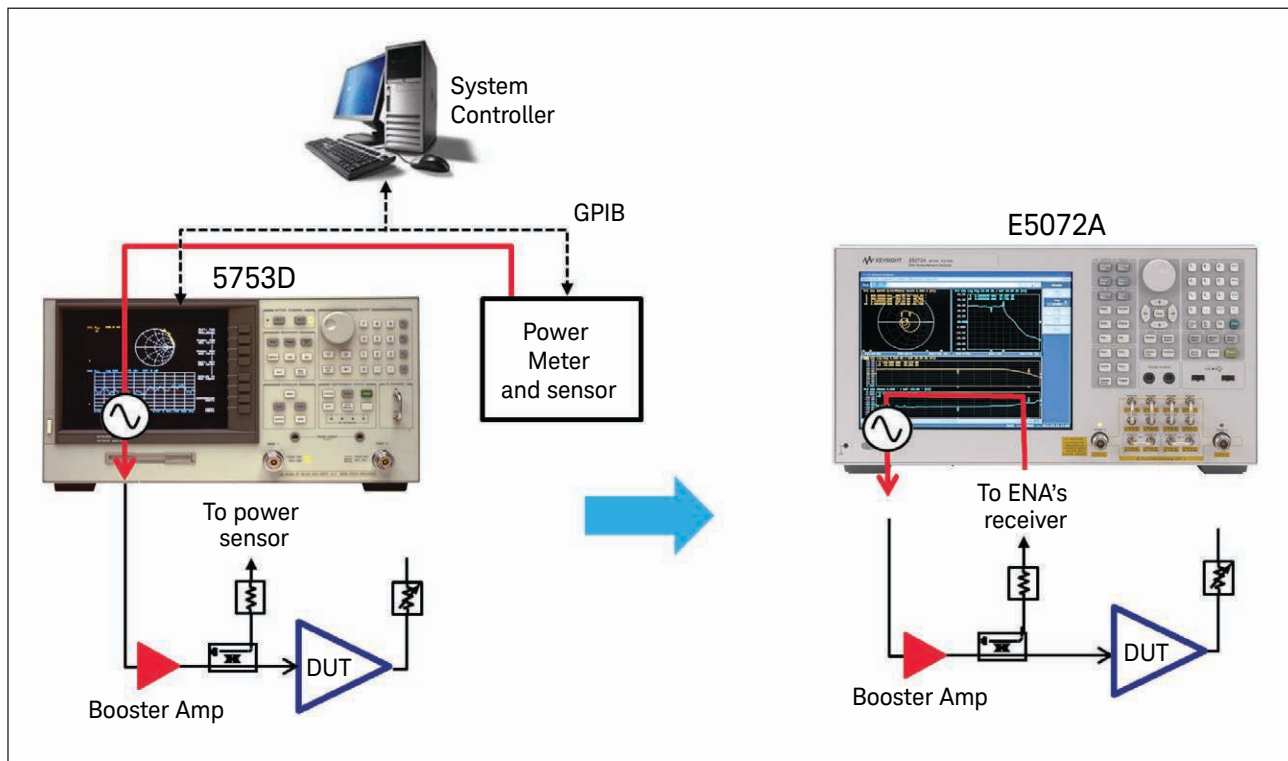
http://cp.literature.keysight.com/litweb/pdf/5990-9974EN.pdf

Figure 14. Receiver leveling with the E5072A replaces conventional power-adjustment method

5. Advanced measurement functions

The E5071C and E5072A have many more unique functions that were not available in the 8753. These capabilities further improve quality and efficiency of your test applications. Here let's see some more examples

Enhanced mixer measurement capabilities

The Option 008 of the E5071C and E5072A offers two kinds of mixer measurement methods. The Frequency Offset Mode (FOM) equivalent to the 8753's and the Vector Mixer Characterization. These two mixer measurement functions provide the following advantages over the 8753:

– Accurate conversion loss measurement
  The E5071C/E5072A offers the Scalar Mixer Calibration capability in the frequency offset mode. The SMC removes mismatch errors in the conversion loss measurements by combining the 1-port and power meter calibrations, and enables more accurate measurements.
– Fixed IF/RF measurement
  The firmware of the E5071C/E5072A-008 can control an external signal generator, and you can measure the mixers while setting the receiver or source to a fixed IF/RF frequency in the frequency offset mode.
– Absolute group delay measurements
  The Vector Mixer Characterization (VMC) supported by the E5071C/E5072A-008 enables absolute group delay measurements of mixers by using a characterized calibration mixer with the de-embedding function

For more details about the mixer measurements using the E5071C/E5072A, refer to the application note "Accurate Mixer Measurements using the Frequency Offset Mode", 5989-1420EN
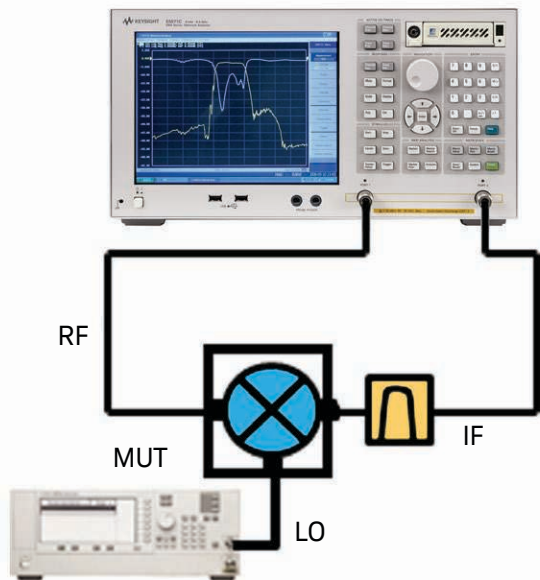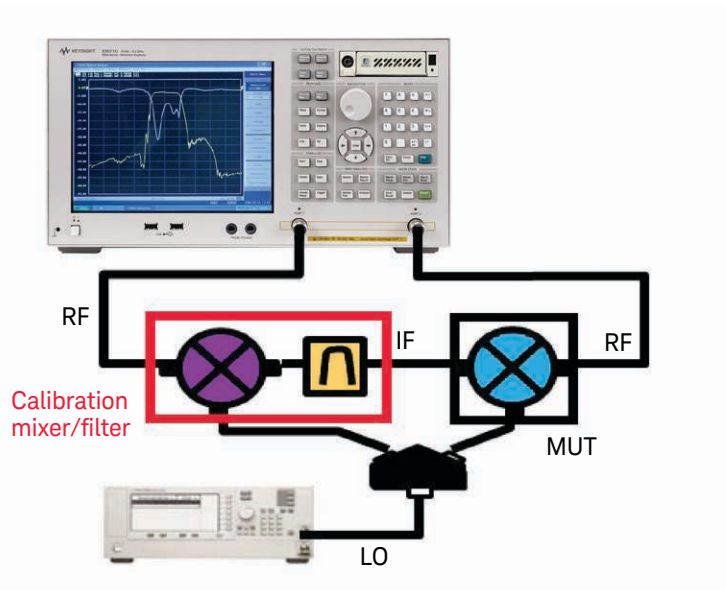

Figure 15. Frequency offset mode

Figure 16. Vector Mixer Characterization

Comprehensive Multiport Solution

– **Easier measurements**
The E5071C has built-in 4-port test set options and enables you to test multiport devices like duplexers and directional couplers with a single connection. This is obviously a significant advantage over the 2-port 8753 for improving the test efficiency.

– **Full 3- and 4-port calibration**
The E5071C 4-port options support the full 3- and 4-port calibration which improves the accuracy of multiport device measurements.

– **E5092A multiport test set**
The combination of the E5071C 4-port options and the E5092A multiport test set offers easy and reliable measurements for multiport devices requiring more than four ports. The E5092A consists of high-performance RF solid state switches and the switch settings are controlled by the firmware of the E5071C 4-port options. The test frequency range is 50 MHz to 20 GHz. By changing the connections of the front-panel semi-rigid cables, you can flexibly make the multiport test configurations suited to your applications, including the 10-port full crossbar configuration.

For more details about the multiport solution with the E5071C and E5092A, refer to the application note "Comprehensive Multiport Solution for the ENA Network Analyzer", 5989-8737EN
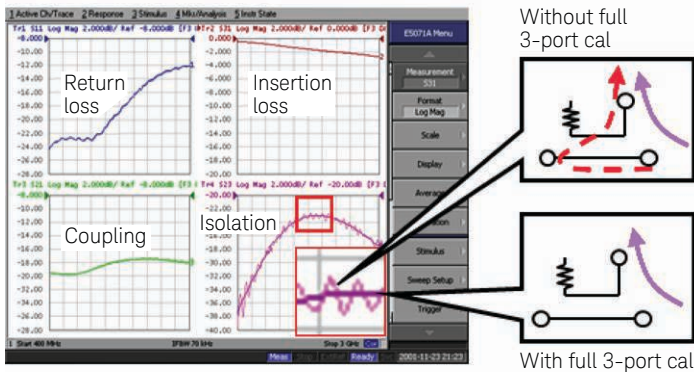

Figure 17. Full 3-port calibration in coupler measurement

Figure 18. E5092A multiport test set

Enhanced time domain analysis

Both the E5071C and E5072A support the option 010 time domain analysis function, which is equivalent to the 8753's. In addition, the E5071C supports the option TDR enhanced time domain analysis function. The E5071C-TDR provides intuitive GUI which is much easier than conventional time domain analysis function.

For more details about the E5071C-TDR, refer to the technical overview "Keysight E5071C ENA Option TDR Enhanced Time Domain Analysis", 5990-5237EN.
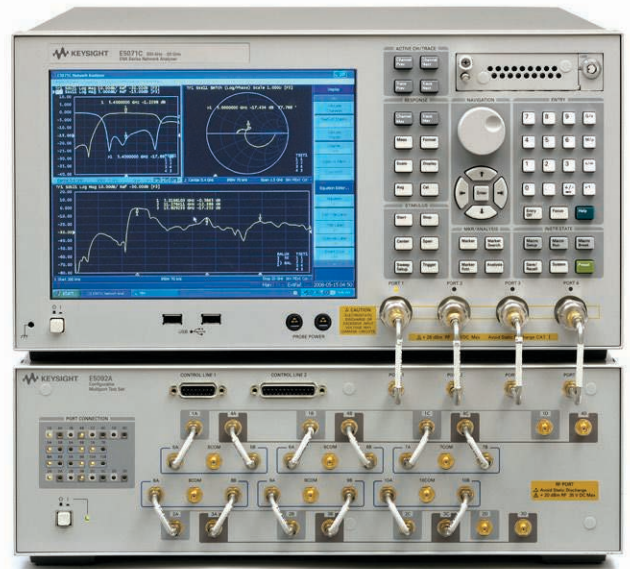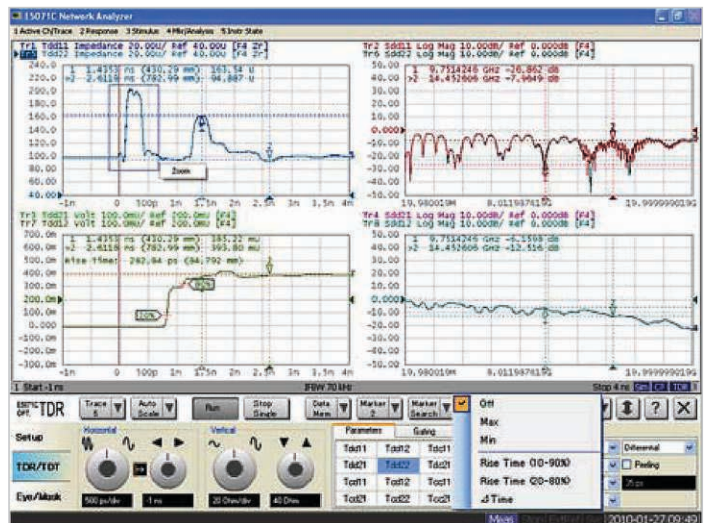

Figure 19. E5071C-TDR enhancement time domain analysis

Figure 20. Replacing the VNA and PIM analyzers with the E5072A based system

Passive Intermodulation (PIM) measurement

Passive intermodulation (PIM) is a form of intermodulation distortion that occurs in passive components such as antennas, cables, connectors, or duplexers with two or more high-power input signals. PIM is becoming a critical parameter in today's wireless communication systems. In the production lines of these RF passive components, dedicated PIM analysers or PIM test systems have been used, along with the network analysers for S-parameter tests. However, the existing PIM test solutions have problems with accuracy, throughput and equipment cost.

The E5072A ENA Series network analyzer offers innovative PIM test solution which solves the problems of the existing PIM test solutions. The E5072A allows you to build a test system for performing both S-parameter and PIM measurements with a single connection, as shown in Figures 20 and 21.

The E5072A's excellent receiver sensitivity and power calibration capability enables more accurate PIM measurements. The option 008 frequency offset mode enables faster swept-frequency PIM measurements. In addition, as the PIM tests in multiple frequency bands and S-parameter tests can be fully covered with the single E5072A-based system, you can reduce the total equipment cost.

For more detail about the PIM measurement solution using the E5072A, visit the Keysight website at www.keysight.com/find/pim
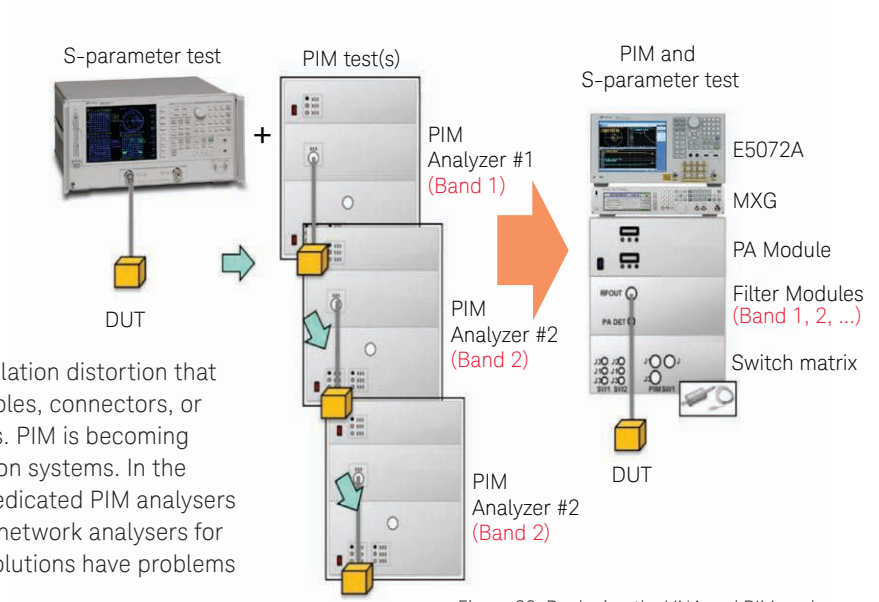

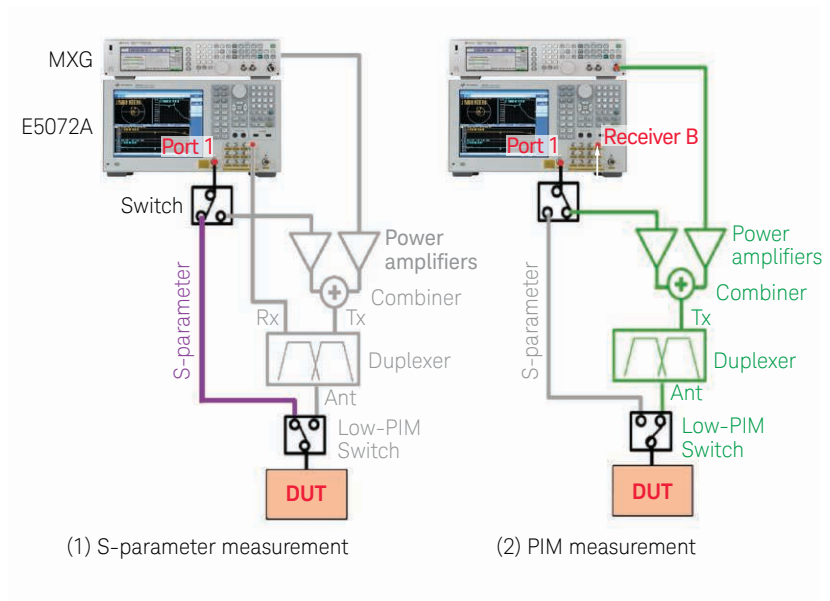(1) S-parameter measurement   (2) PIM measurement

Figure 21. S-parameter and PIM measurement with single connection

6. Code Migration Tool

When you have a test program for the 8753, the code conversion is one of the challenges. Basically it is recommended to rewrite the code for the ENA to fully use the ENA's functionalities. Keysight provides the 8753-to-ENA code conversion assistant editor to support rewriting the code. However, rewriting is difficult in some cases and Keysight also provides an emulator called cXL for such cases.

Code Translator Application (cXL)

Code Translator Application (cXL) is code emulation application which works as background process of ENA Series that allow customer to use the ENA Series with the test program that is written in language for the 8753. It translates incoming 8753 command s via GPIB interface in real time.

Code Conversion Assistant Editor

The 8753-to-ENA code conversion assistant editor helps to convert 8753 GPIB commands. This software consists of a text editor (EmEditor 1) and plug-in software, which works on a PC and makes it easier to edit programs in text file format.

7. Flexile upgradability

Upgrade options protect your hardware investment

The ENA Series is a safe investment because of it is easy to upgrade. It enables to optimize customer investment and extend instrument longevity with upgradeable frequency range and the number of ports. Software options such as time-domain mode, frequency offset mode, and MWA are upgradable as well.

The ENA Series upgrade information is available at website www.keysight.com/find/ena_upgrades

14/20 GHz options

2-port, 6.5/8.5 GHz

4-port, 6.5/8.5 GHz

2-port, 4.5 GHz

4-port, 4.5 GHz
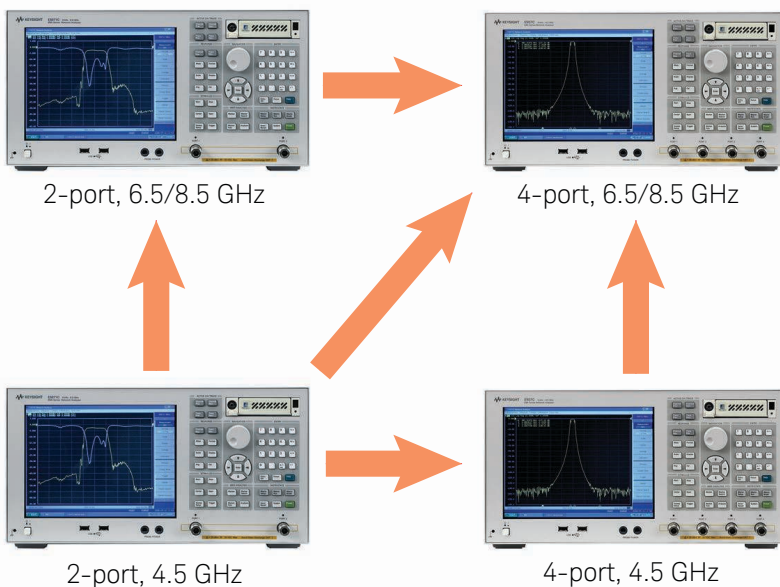
Attractive trade-in offers

Keysight is offering attractive credits to trade in your 8573 and almost all old network analyzers including other vender's network analyzers.

For more details about trade-in offers, visit: www.keysight.com/find/trade-netwrkan

ENA Series/8753ES Comparison Chart

Item	8753ES	E5071C	E5072A	E5061B (RF option)
Test frequency	30 kHz to 3/6 GHz	9/100 kHz to 4.5/6.5/8.5 GHz or 300 kHz to 14/20 GHz	30 kHz to 4.5/8.5 GHz	100 kHz to 1.5/3.0 GHz
Test ports	2- or 3-port	2- or 4-port	2-port	2-port
System impedance	50 Ω	50 Ω	50 Ω	50 or 75 Ω
Source power range (Spec)	–85 to +10 dBm	–55 to +10 dBm (4.5/6.5/8.5 GHz options) –85 to +10 dBm (14/20 GHz options)	–85 to +16 dBm	–45 to +10 dBm
Dynamic range (Spec)	110 dB	123 dB	123 dB	120 dB
Trace noise (Spec)	0.006 dBrms (3 kHz IFBW)	0.004 dBrms (70 kHz IFBW)	0.004 dBrms (70 kHz IFBW)	0.005 dBrms (3 kHz IFBW)
Stability	0.03 dB/°C	0.005 dB/°C	0.005 dB/°C	0.01 dB/°C
Max number of points	1,601	20,001		1,601
Max number of channels	2	160		4
Calibration	SOLT,TRL*, Adapter removal	SOLT, TRL, Adapter removal, Unknown thru, ECal, SMC, VMC	SOLT, TRL, Adapter removal, Unknown thru, ECal, SMC, VMC	SOLT, Adapter removal, ECal
Fixture simulator	No	Yes	Yes	No
Built-in programming environment	No	VBA	VBA	VBA
Frequency and port upgradability	No	Yes	Yes	Yes
Frequency offset mode option	Yes	Yes	Yes	No
Time-domain option	Yes	Yes	Yes	Yes
Enhanced time-domain analysis	No	Yes (option)	No	No
Interface	GPIB	GPIB/LAN/USB	GPIB/LAN/USB	GPIB/LAN/USB
DC measurement	Yes	Yes	Yes	No
Probe power	Yes	Yes	Yes	No
Built-in bias tees	Yes (1A max)	Yes (500mA max)	Yes (1A max)	No
Configurable test set	Yes (option)	No	Yes (standard)	No
Receiver leveling function	No	No	Yes	No
E5092A multiport test set support	No	Yes	No	No

Web Resources

Visit our Web sites for additional production information and literature.

ENA network analyzers: www.keysight.com/find/ena

Electronic calibration (ECal) modules: www.keysight.com/find/ecal

Test and measurement accessories: www.keysight.com/find/accessories

For addition information regarding Maury Microwave waveguide calibration kits visit: www.maurymw.com

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www.lxistandard.org
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This document was previously titled Application Note 1478

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Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	0800 000154
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