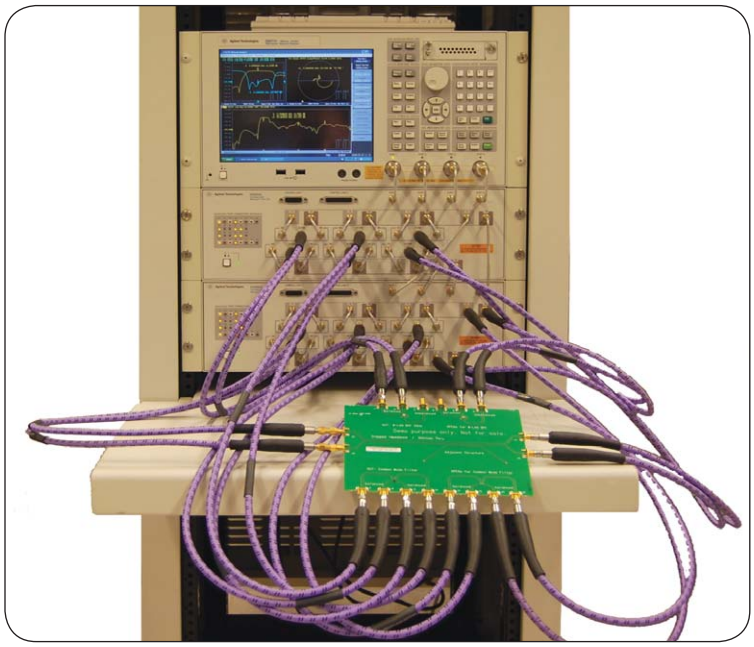
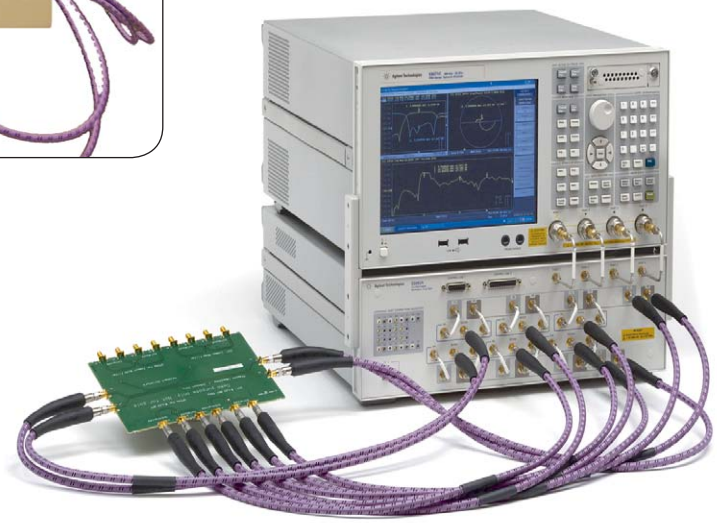
Comprehensive Multiport Solution for the ENA Network Analyzer

Application Note





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Introduction

Many of today's devices have several different functionalities integrated into a single component resulting in multiple RF ports for each device. In the wireless communication industry, multi-band capability is required for devices such as cellular handsets, and supporting additional signals such as WLAN, *Bluetooth*® and GPS will increase the complexity even more. The number of ports of RF Front-End modules installed in networking equipment will expand as multiple input, multiple output (MIMO) is adopted for faster data transfer rates in wireless services. In addition, it's becoming more common to use differential components, such as differential SAW filters, in the receiver paths because they reject unwanted system noise better than single-ended components.

In multiport component test, the time required to connect and disconnect the components can be significantly greater than the actual testing time. Network analyzers with multiport capability are used to reduce measurement times by providing complete characterization of multiport components with a single connection. As measurement requirements of multiport components increase and become more complicated, solutions that provide easy-to-use software for measurement setup are needed to make testing more efficient and improve throughput.

This application note discusses the benefits of using a comprehensive multiport solution such as the Agilent E5071C ENA network analyzer with the E5092A configurable multiport test set. Multiport measurement can be dramatically simplified by using the E5092A configurable multiport test set and ENA software capability. This note also provides information test set setup, software capability and more.

Product Overview

Increasing, changing demands for applications expand the complexity of multiport device measurements. A wide variety of measurements and test configurations are required to meet emerging and existing standards for these devices. The Agilent E5092A configurable multiport test set works with the ENA network analyzer to meet most application needs by providing numerous configurations over a wide frequency range (50 MHz to 20 GHz).

The E5092A is a switching multiport test set that utilizes an architecture based on multiple single-pole-double-throw (SPDT; one input and two outputs) and single-pole-4-throw (SP4T; one input and four outputs) solid state switches. By turning these internal switches on and off the RF signal from the ENA source port can be routed to each port on multiport devices under test (DUTs). The E5092A test set is controlled by the firmware of the ENA via a USB interface. Figure 1 shows a block diagram of the test set.

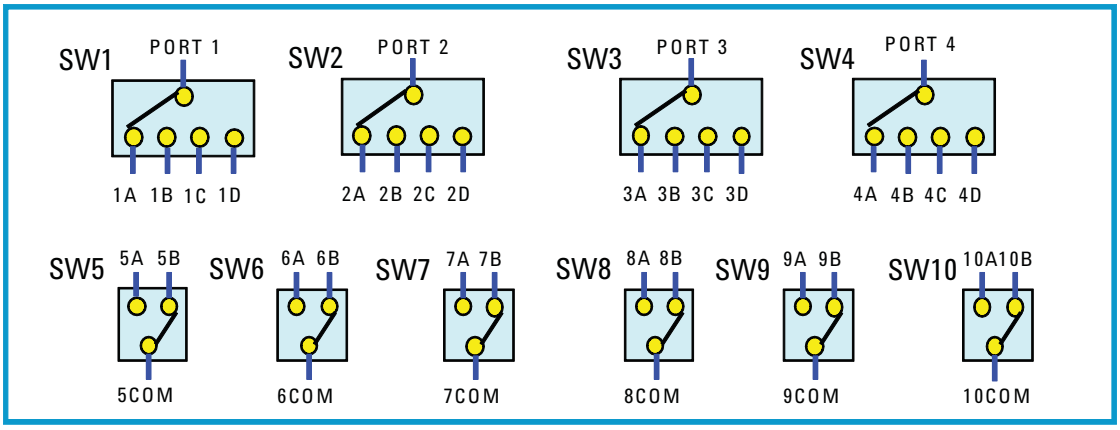

Figure 1. Block diagram of the E5092A

One of the benefits of this test set is that you can access all of the ports of the internal switches from the front panel of the test set; this provides you with flexible multiport test setup (Figure 2). Multiport measurement configurations for your applications can be easily made by connecting external RF cables to the front panel of the E5092A. LED indicators mounted on left side of the front panel indicate the selected output port of each switch enabling you to make the required test set switching configuration for your measurement. For example in Figure 2, the common port of every switch is connected to the output port "nA" (n = 1 to 10).

Figure 2. Front panel the E5092A

Flexible Configuration Setup

Figure 3 shows the block diagram of a 22-port configuration using the E5092A. The 10 internal switches of the test set are connected to each other using external cables on the front panel (Figure 4), and signals from the 4-port ENA are routed for a maximum of 22-port device measurement. Using the multiport test set for switching reduces the time you spend connecting a DUT to the ports of the network analyzer significantly improving your overall test throughput. By minimizing the number of connections, you also lower the possibility of connecting to the wrong ports. This configuration is good to use when you need to make multiple 2-port measurements. You can measure up to 11 different types of measurements on 2-port components using a single testing station without disconnecting the DUTs from the test set.

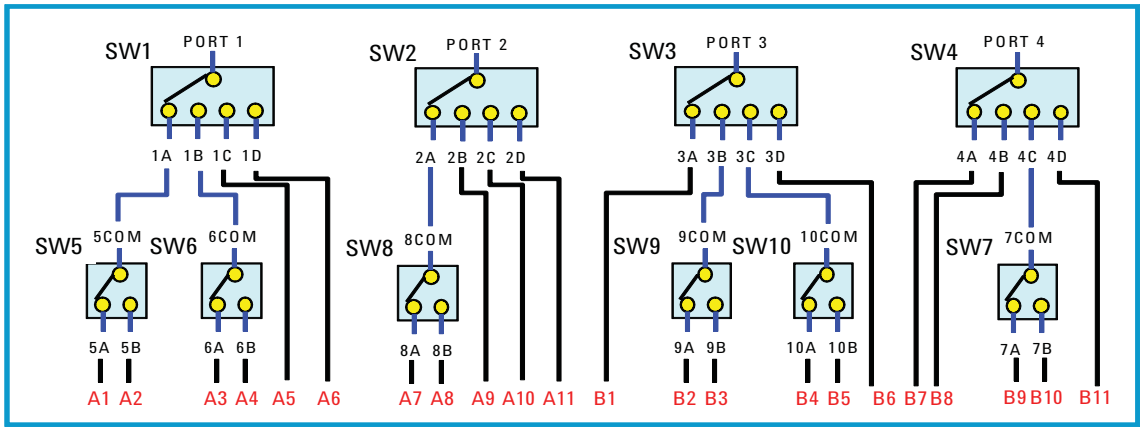

Figure 3. Block diagram of the E5092A 22-port configuration

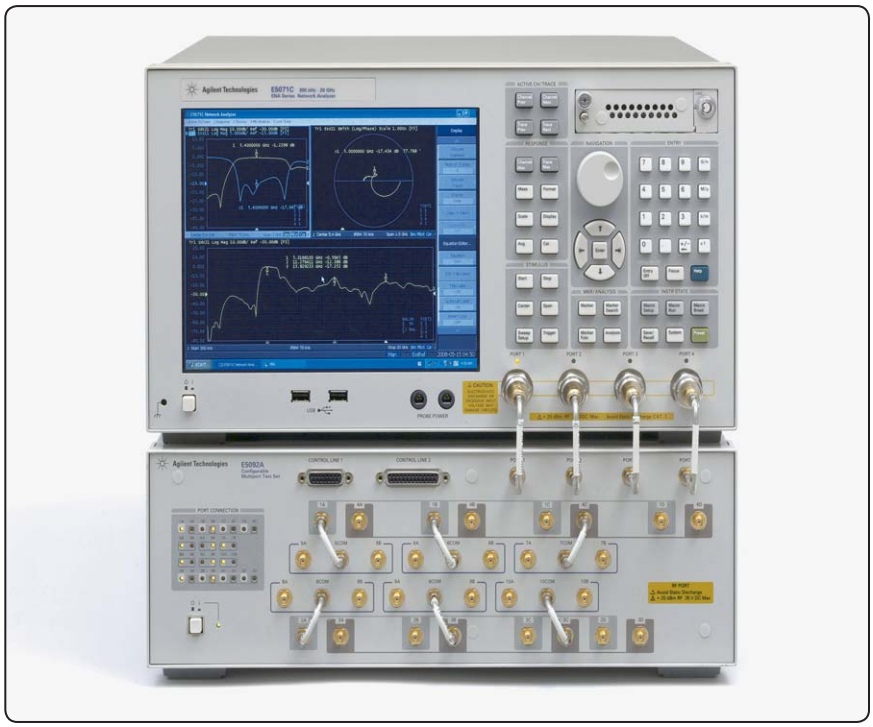

Figure 4. Cable connection for the 22-port configuration[1]

1. The 22-port and 10-port full crossbar configuations can be achieved using the semi-rigid cables (Agilent part number E5092-61636) that are shipped with the E5092A.

Flexible Configuration Setup (cont'd.)

Figure 5 shows a measurement matrix of this configuration. Note that measurements between ports of the test set can not be performed if the ports share the same source or receiver of the ENA. For example, on the 22-port configuration shown in Figures 3 and 5, ports "A1" and "A2" share the same source or receiver port on the ENA (port 1 in this case) so an S21 measurement between the ports cannot be performed.

		Input Port																					
		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
Output Port	A1	0						0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A2		0					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A3			0				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A4				0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A5					0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A6						0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A7	0	0	0	0	0	0	0					0	0	0	0	0	0	0	0	0	0	0
	A8	0	0	0	0	0	0		0				0	0	0	0	0	0	0	0	0	0	0
	A9	0	0	0	0	0	0			0			0	0	0	0	0	0	0	0	0	0	0
	A10	0	0	0	0	0	0				0		0	0	0	0	0	0	0	0	0	0	0
	A11	0	0	0	0	0	0					0	0	0	0	0	0	0	0	0	0	0	0
	B1	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
	B2	0	0	0	0	0	0	0	0	0	0	0		0					0	0	0	0	0
	B3	0	0	0	0	0	0	0	0	0	0	0			0				0	0	0	0	0
	B4	0	0	0	0	0	0	0	0	0	0	0				0			0	0	0	0	0
	B5	0	0	0	0	0	0	0	0	0	0	0					0		0	0	0	0	0
	B6	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0	0
	B7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
	B8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0			
	B9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0		
	B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0	
	B11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					0

O: Measurement possible

Figure 5. Measurement matrix for the 22-port configuration

Another configuration example using the 4-port ENA and the E5092A is shown in Figures 6 and 7. This configuration supports up to a 10-port full crossbar measurement (10x10 port matrix). This means you can perform any 2-port measurement on any of the test set's 10 ports. The measurement matrix is shown in Figure 8. This configuration lets you test all the DUT's transmission paths and reflection characteristics with a single connection to each port of the DUT. This configuration is most suitable for multiport components that require full matrix characterization such as multiport switches, splitters or multiple differential cables.[1]

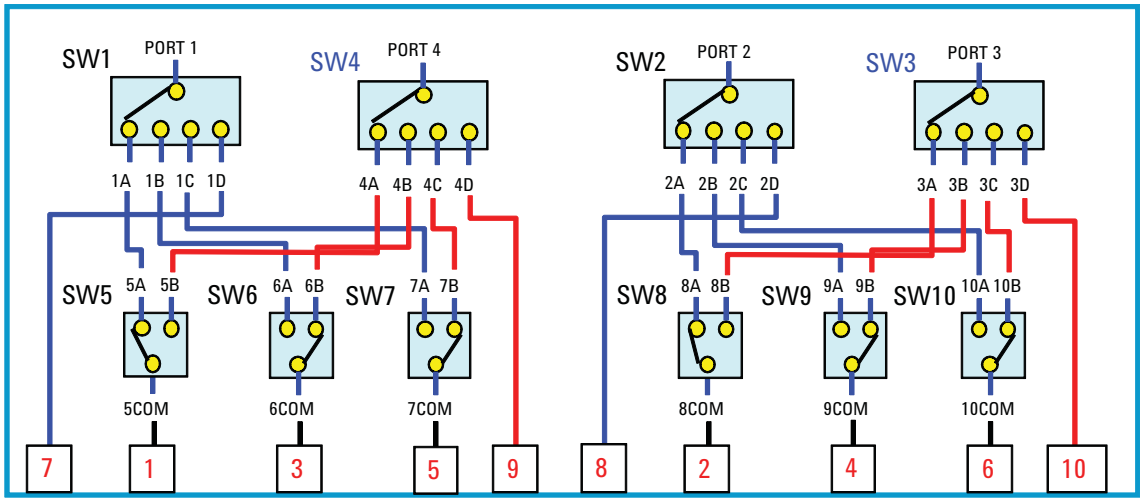

Figure 6. Block diagram of 10-port full crossbar configuration

1. Calibration of the ENA is limited to 4 ports at one time.

Flexible Configuration Setup (cont'd.)

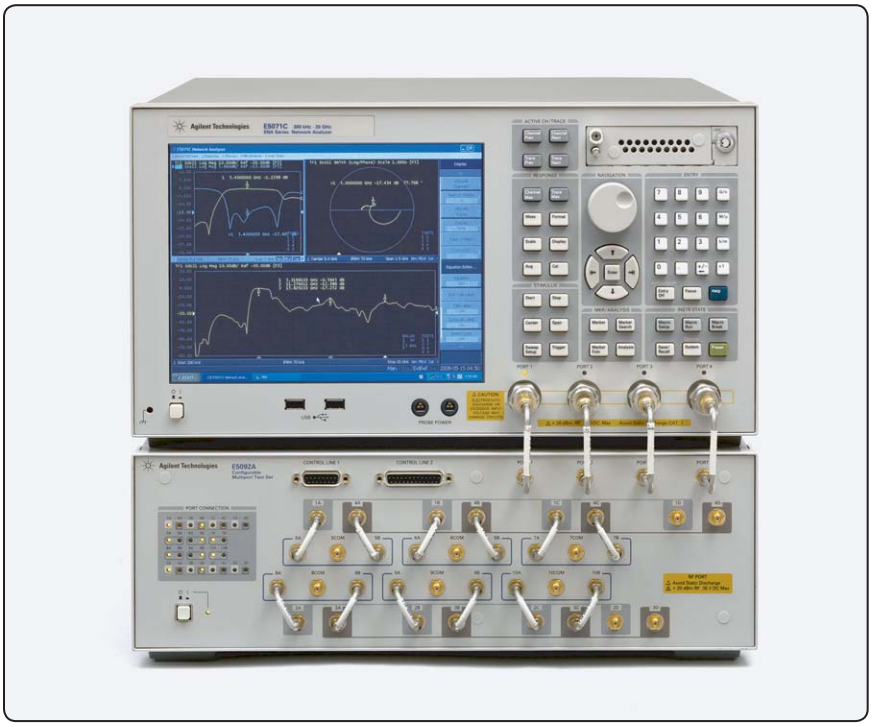

Figure 7. Cable connection for the 10-port full crossbar configuration[1]

		Input Port									
		1	2	3	4	5	6	7	8	9	10
Output Port	1	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0

0: Measurements possible

Figure 8. Measurement matrix for the 10-port full crossbar configuration

As shown in the previous examples, there is a tradeoff between the total number of ports and the number of ports available for a full crossbar measurement. You can select the appropriate configuration for your required application by changing the connection of internal switches with cables on the front panel or by switching the selected configuration using the ENA

1. The 22-port and 10-port full crossbar configurations can be achieved using the semi-rigid cables (Agilent part number E5092-61636) that are shipped with the E5092A.

Flexible Configuration Setup (cont'd.)

Figure 9 shows another configuration example: two E5092A test sets are connected to each other and operated by the firmware of a single ENA. Measurement of devices with up to 40 ports or 16-port full matrix characterization can be performed by combining two test sets. You can use the E5092A to easily expand your current multiport capability to meet future demands.

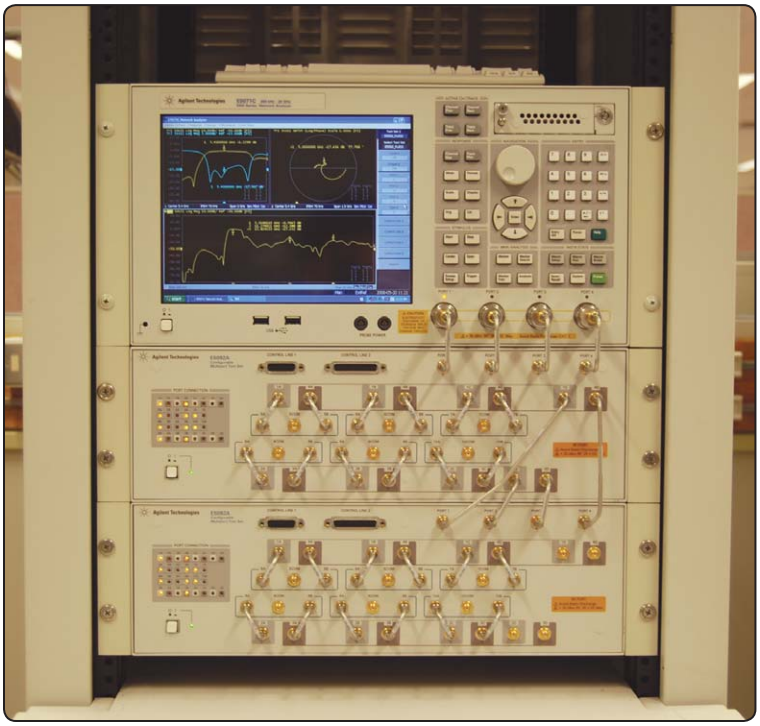

Figure 9. Example of cable connection with two E5092A test sets

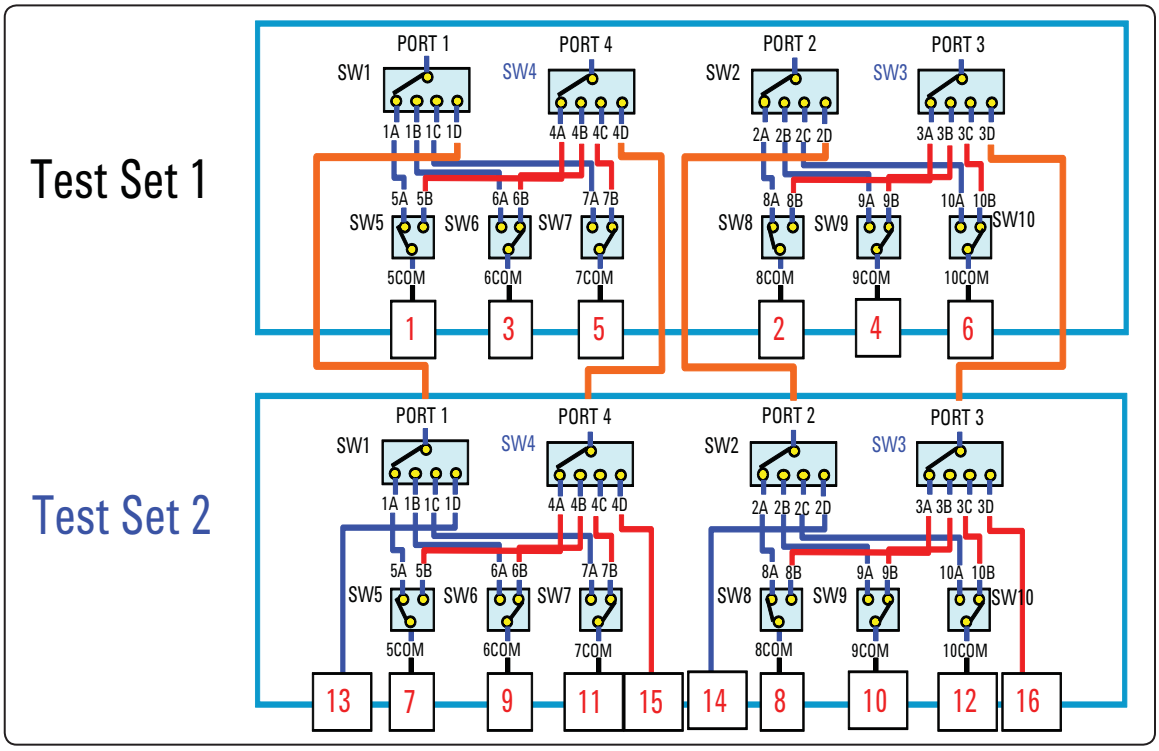

Figure 10. Block diagram of the 16-port full crossbar configuration

Software Capability

In multiport network analysis, the time it takes to set up the measurement is usually much longer than the actual testing time. Measurements become much more complicated with multiport test sets like the E5092A, so easy-to-use software that simplifies test setup and measurements is needed. The ENA offers advanced software capability including Measurement Wizard Assistant (MWA) software.[1,2] MWA software simplifies the setup of complex, time-consuming measurements (See Figure 11).

MWA software consists of two main applications: Front-End and Back-End. The Front-End application is a step-by-step wizard program running on Microsoft® Excel that creates a setup file which includes all the measurement parameters. The Front-End application provides a measurement connectivity matrix which indicates which port combinations of the multiport test set are available for measurements (See Figure 12). When setup parameters are entered for a specific configuration that can not be measured due to the internal switching architecture of the test set, the MWA automatically identifies and eliminates the setup. The Back-End application is a Microsoft VBA program running on the ENA. The Back-End application uses the setup file to automatically set up the necessary parameters on the ENA. The Back-End application also features a calibration wizard that provides step-by-step instructions of calibration procedures for every measurement. This wizard helps you minimize the number of connections between the DUT and the calibration standards during calibration, which helps eliminate the possibility of connecting to the wrong port and saves setup time during calibration (See Figure 13). The whole measurement procedure is controlled by the Back-End application. MWA software saves a lot time and eliminates the possibility of multiport network analysis failure due to operator error.

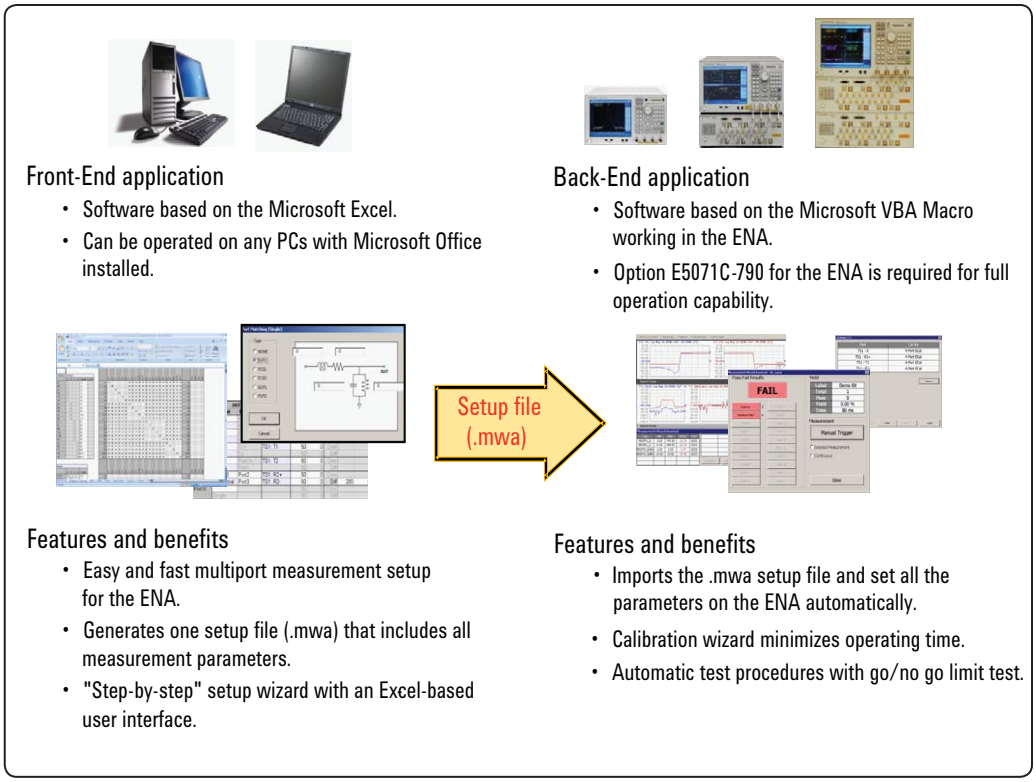

Figure 11. Overview of MWA software

1. The MWA is Option E5071C-790 of the ENA. Upgrade product (E5005A) is also available.

2. For more details, refer to the application note, "Measurement Wizard Assistant Software of the ENA" (5989-4855EN)

Software Capability (cont'd.)

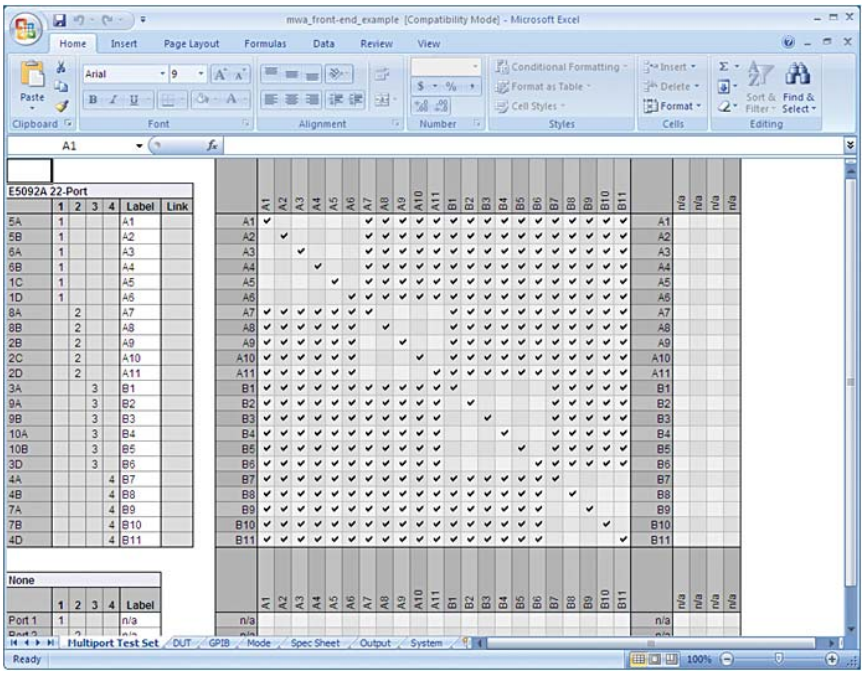

Figure 12. Measurements matrix example using MWA software

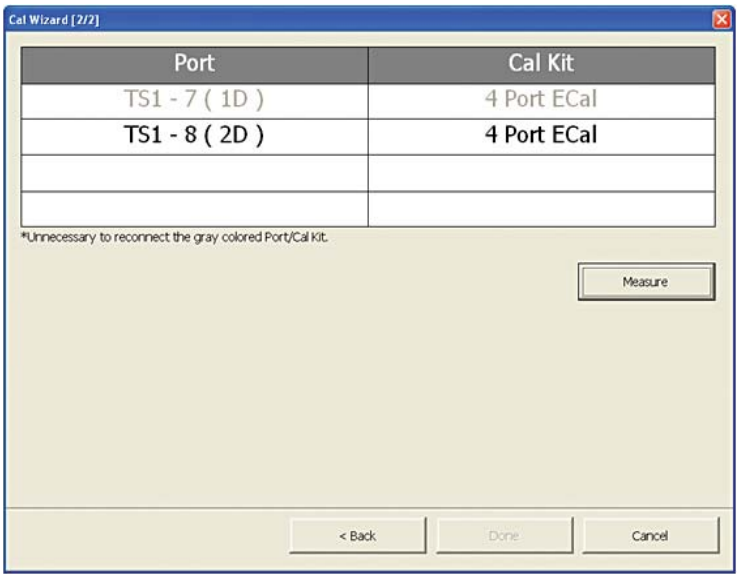

Figure 13. MWA calibration wizard

Other Benefits for Multiport Analysis

Switching optimized for the ENA

The E5092A uses solid state switches to provide fast measurement capability. Solid state switches are much faster than switches that use other technologies such as electro-mechanical (EM) switches. In network analysis, switching should be completed before the network analyzer performs a measurement sweep so that accurate and stable results of the S-parameters are obtained. The E5092A's switches are highly optimized with switch timing synchronized to the wait time of the ENA frequency sweep. As a result, the total time of the measurement sequence is dramatically reduced. The fast measurement speeds benefit high-volume manufacturers using automated test equipment (ATE) systems by increasing measurement throughput. This can have a huge impact on the total cost of test.

Measurement stability

The performance of solid state switches is more easily affected by the temperature variation in the environment than electro-mechanical switches. This can impact the overall performance of a test system using a switching test set, making it necessary to perform frequent calibrations to eliminate drift errors in measurements. The E5092A has a function that controls ambient temperature in the test set which makes it more stable against variations of environment temperature. The stability of the internal switches are specified below 0.003 dB/ degC for the frequency range up to 6 GHz providing superior measurement stability. This helps high-volume manufactures reduce operating time in high-throughput testing.

DC sources for controlling an active DUT

Some multiport components with integrated active devices such as multiport switches or Front-End modules for cellular handsets require bits of DC control voltage to select an active path of operation. The E5092A has control lines, and up to 4 independent DC voltages from the E5092A can be applied to a DUT enabling the operation up to 20 control bits. The output DC voltage ranges from 0 to +5 V for positive signals and -5 V to 0 V for negative signals. The DC voltage output can be set differently for each measurement channel of the ENA, so you can perform S-parameter measurements synchronous to the operation of the DUT. The output pins can be accessed at 15-pin and 25-pin D-sub connectors on the front panel of the E5092A (See Figure 2).

Summary

This application note described some of the benefits of using the ENA network analyzer and the E5092A multiport test set for multiport measurement. The ENA, the E5092A configurable multiport test set and the MWA software form a comprehensive multiport solution that simplifies complicated measurement procedures for multiport characterization.

Required hardware and software for the ENA multiport solution

E5071C	ENA network analyzer
E5092A	Configurable multiport test set
E5071C-790	Measurement Wizard Assistant software
or E5005A	Measurement Wizard Assistant software (upgrade product)

References

ENA series web page: **www.agilent.com/find/ena**

Multiport test sets web page: **www.agilent.com/find/multiport**

MWA web page: **www.agilent.com/find/mwa**

Related literature

ENA Network Analyzers & E5092A Configurable Multiport Test Set Brochure, Literature number 5989-5478EN

ENA Network Analyzers & E5092A Configurable Multiport Test Set Data Sheet, Literature number 5989-5479EN

ENA Network Analyzers & E5092A Configurable Multiport Test Set Configuration Guide, Literature number 5989-5480EN

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