Agilent
ENA RF Network Analyzers
Application Note 1463-8

Improve Measurement Efficiency by Using a New Multiport Test Solution
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Introduction

In recent years, various types of multiband wireless equipment such as 3G mobile phones and wireless LANs have been emerging one after another. With the increasing popularity of these products has come a rapidly increasing demand for highly integrated, sophisticated, RF components.

Mobile phones that support multiple communication services such as the Global System for Mobile communication (GSM) quad band (850 MHz/900 MHz/1.8 GHz/1.9 GHz), and the Universal Mobile Telecommunications System (UMTS), will soon be in production and will enable someone to make a call from anywhere in the world.

Figure 1 shows a switch module that will be used in a multiband mobile phone in the near future. This switch module covers the GSM quad band plus the UMTS triple band, and features fourteen terminal ports. The switch module is one example of the trend toward multiport devices. It’s clear that there is tremendous room for growth in the multiport device market. This is creating strong demand for test solutions for complex multiport devices.

![Figure 1. Switch module for GSM quad plus UMTS triple band.](image)

This application note introduces a test solution for multiport devices as well as complex devices that improve measurement efficiency and productivity in both R&D and manufacturing test.
New multiport test set

To handle measurements of switch modules that cover the GSM quad band and UMTS, Agilent introduces the E5091A-016, a 13/16-port configurable test option (Figure 2) for the E5091A multiport test set. One of the key features of E5091A-016 option is that it has built-in configurable switches. Because these configurable switches are accessible to the user, the test port configuration can be easily modified by using the semi-rigid cables provided with the test set. The E5091A-016 comes in the 13-port test set\(^1\) as the default configuration. If you remove the semi-rigid cables, you can easily configure it to a 16-port test set.

Figure 2. E5091A-016 13/16-port configurable test set.

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1. E5091A-016 is shipped in the 13-port test set configuration from the factory.
Overview of the 13-port configuration

Figure 3 shows the block diagram for the 13-port configuration. The 13-port configuration is the most suitable for switch module testing, especially for the GSM quad band and the UMTS dual band, because it provides an ANT (antenna) port, T1 to T4 (transmission) ports, and R1± to R4± (receiver) ports.

Figure 3. Block diagram of 13-port configuration.
The 13-port configuration realizes the full 7 x 7 matrix switching with the combination of semi-rigid cables and configurable switches (Figure 4). This configuration provides all the isolation measurements in the ANT (antenna) and Tx (transmission) paths that are required for switch module testing.

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Figure 4. Measurement paths of 13-port configuration.
Overview of the 16-port configuration

Figure 5 shows the block diagram of the 16-port configuration. As mentioned previously, you can easily change to the 13-port configuration by removing the semi-rigid cables from the front panel.

The 16-port configuration is most suitable for evaluating filter banks, which are generally adopted in multiband mobile phones. Figure 6 shows an example of a filter bank for the GSM quad band system. The filter bank is constructed by integrating four balanced SAW filters into one package. In this case, a 12-port test set is required for its evaluation.
Responding flexibly to future applications

If you already have the E5091A-009 9-port option test set in your laboratory or on your production line, then the E5091A-016 can be used with it to handle applications such as the GSM quad band plus the UMTS triple band (fourteen terminals), Figure 7.

![Figure 7. Extending the number of test ports with the combination of the E5091A-009.](image)

This will allow you to reduce the investment required for future applications by reusing current assets.

For new users, the E5091A-016 guarantees extendibility. By combining Option 009 with Option 016, you are freed up to move ahead with investments in new equipment.
Realize stable measurement with the temperature control function

Typically, manufacturing test operates eight to 16 hours per day. It is critical that measurements are not affected by changes in the ambient temperature during this time. To maintain a stable yield rate on the production line, periodic calibration is necessary. However, since the multiport calibration procedure takes a lot of time, frequent calibrations would result in a significant drop in manufacturing efficiency. In order to keep calibrations to a minimum, the E5091A is designed to control the temperature of each switch module with a heater. This minimizes the drift of measurement values due to changes in ambient temperature. With this design, the E5091A typically achieves measurement stability of 0.005 dB/°C per switch. This results in a longer calibration interval that increases productivity in manufacturing test.

Enhancement of the ENA

The new firmware supports the complex reference impedance conversion function\(^1\) that enables you to set the test port characteristic as complex impedance (R + jX). In some cases, the port impedance of a subsequent circuit, located after the device under test (DUT), is defined as a complex impedance. Usually, the center of a Smith chart can only be defined as a real part of impedance, hence it is very difficult for engineers to adjust a matching circuit that has complex port impedance.

By using this function, the matching circuit adjustment time is drastically reduced because the center of the Smith chart can be set as complex impedance.

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1. This function is supported by the ENA firmware rev. 6.0 or greater.
Overview of the Measurement Wizard Assistant (MWA)

With multiport devices and balanced circuit evaluations, not only are measurement parameters very complicated but also instrument setup conditions. Because of this complexity, engineers spend a lot of time setting up the measurement system, an expenditure that leads to a loss of efficiency in product development and manufacturing test.

MWA\(^1\) is setup software that enables you to easily set up measurement systems with a simplified interface. By using MWA, you can easily set up measurement parameters and conditions without having knowledge of the ENA architecture.

Figure 8 shows that MWA consists of two kinds of software: one for front-end and one for back-end applications.

![Figure 8. Overview of the Measurement Wizard Assistant (MWA).](image)

The front-end application software has been developed based on Microsoft® Excel VBA, which runs on an external PC. This software enables you to easily set up complex measurement parameters such as a segment sweep and a limit test, as well as control the multiport test set and external instruments by just entering the necessary parameters and programming commands into the spreadsheet. After entering all parameters, MWA automatically generates a setup file for the ENA.

The back-end application software runs on the ENA as a VBA macro. This macro provides the functions of setup-file loading, calibration wizard, and measurement data management. The calibration wizard assists with the operating procedure for multiport calibration by using the electronic calibration (ECal) module or mechanical calibration kits. Consequently, you can drastically reduce the calibration time and eliminate operator errors.

\(^1\) MWA is offered as an ENA option.
Promote measurement efficiency with the MWA

To sort the multiport devices accurately, many kinds of limit tests need to be used. Also, in manufacturing test, an effective method is needed for managing large quantities of measurement results.

To meet these requirements, the back-end application can load up to ten setup files. As mentioned on the previous page, limit test conditions can be set in the setup file, enabling you to register various kinds of limit tests in each setup file. In addition, you can simply change the limit test pattern by changing the setup file. Finally, the back-end application provides a measurement dialog that enables you to manage entire limit test results with a simplified operation.

Figure 9 shows an overview of the measurement dialog. As the figure demonstrates, the measurement dialog can be split into three layers: main, sheet, and mode dialogs.
The main dialog manages the overall limit test results. This dialog box clearly presents the actual conditions of pass/fail results and yield rate of all the limit tests at a glance. The sheet dialog displays limit test results with respect to each setup file. The mode dialog indicates further details of the limit test such as limit values and pass/fail results of each measurement mode that is set by the eight bit control lines of the test set. After performing all of the tests, the final results can be saved with respect to each setup file.

In addition, MWA provides a half mode display function (Figure 10) that is extremely helpful in verifying the test system before the start of automated testing in production. This function displays actual measurement results about the failed measurement paths in a half size display so that you can easily figure out which measurement path has a problem.

Figure 10. Half size display mode.
When attempting to measure a device, one of the greatest challenges is determining how to eliminate unwanted fixture effects. Without removing these effects, you cannot characterize your device accurately. This leads to lower specifications even though your device performs better.

The simplest method for correcting errors is the port extension, which mathematically extends the calibration plane towards the DUT by changing electrical length. However, port extension does not compensate for the insertion loss of the fixture. In most cases, the fixture for a multiport device does not have straight transmission lines in a symmetrical layout due to the complexity of the device. As a result, compensating for only electrical length is insufficient for multiport fixtures. To solve this problem, engineers may try to develop standards for their fixtures. This takes a great deal of engineering time due to the difficulty of making accurate standards.

Agilent Technologies is the first to introduce an automatic port extension (APE) that provides the solution to a complex test environment. APE not only enhances port extension by compensating for both electrical length and insertion loss, it also simplifies the approach. The user no longer needs to provide accurate calibration standards as are required in the case of TRL calibrations. Consequently, you can easily compensate for multiport fixtures.

APE uses the open or short standard for fixture compensation. The open standard is the equivalent of an unused fixture, while the short standard is the equivalent of placing a metal block across all the terminals to short them to the fixture ground. Because you do not need to develop accurate standards for each of your fixtures, you can drastically improve productivity in multiport device development.
Effectiveness of APE

Figure 11 demonstrates the effectiveness of APE. In this example, APE is running on the ENA and measuring a balanced SAW filter.

One trace is with APE off and the other is with APE on. Without APE, measurement results include characteristics of both the fixture and the DUT. This measurement was made with a calibrated network analyzer, but calibration was performed at the connectors of the fixture. The high attenuation shown on this trace is most likely due to the lossy characteristics of the transmission lines in the test fixture.

With APE, the measurement ports are extended from the connectors to the end of the transmission lines, thus removing the effects of the fixture. The result is a measurement of the DUT only and not the fixture and DUT. The trace has less attenuation, which allows you to see the response of the filter itself, without the fixture. As these measurement results indicate, APE is an excellent tool for compensating for fixtures, especially those with a complicated structure like the multiport device fixture.
Conclusion

When it comes to multiport device testing, choosing a test set that can be used not only for current devices but also for future applications is the best use of your capital. In the technical area, more DUT ports mean more complicated measurement parameter setups, and that makes it difficult to evaluate device accuracy in the short term. The solution is not only hardware but also software that enables you to improve measurement efficiency and thereby increase productivity. You also want to state the higher specifications for your devices. For this, the compensation function for test fixtures is necessary for obtaining actual device performance.

In this application note, you were introduced to a new test solution, the E5091A-016, that includes these three key contributions: hardware enhancements, productivity software, and error correction technology. This solution can drastically improve not only measurement efficiency but also productivity of multiport device evaluation in both the laboratory and on the production line.

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Other Asia Pacific
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(fax) (65) 6755 0042

Email: tm_ap@agilent.com

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