# High Performance Testing of Wireless Handset Front-end Modules

## White Paper


## Abstract

Multiport, multifunction wireless front-end modules require high performance and high-speed test. A test system and process has been developed which provides a state-of the-art combination of accurate measurements and high throughput at high speeds. This system allows individualized frequency spacing, data taking, and calibration on measurement paths, at speeds up to 10 times faster then previously available.



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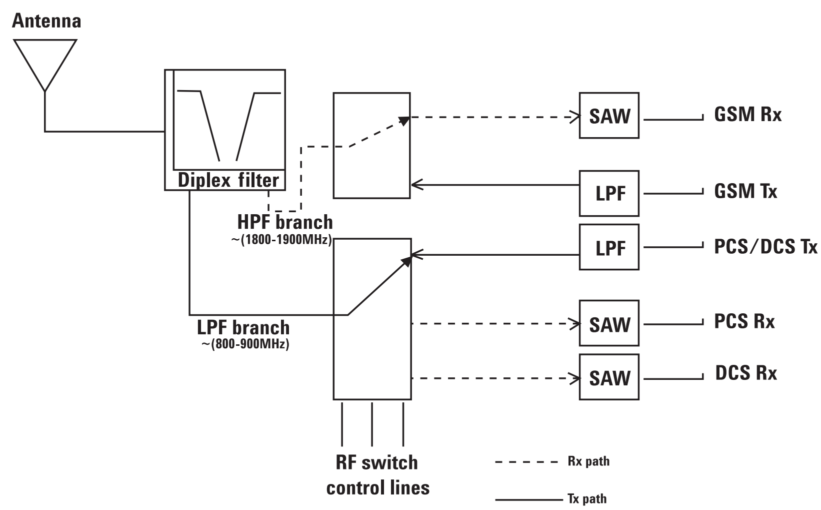
## High performance wireless handset front-end modules

Today's integrated circuit technology has provided engineers the ability to decrease the size of RF modules as well as reduce the cost of production. An example of this would be using low temperature cofired ceramics (LTCC) technology for the design and development of front-end modules for wireless handsets. A block diagram of such a module is shown here.




Typically these modules are placed between the transmit/receive section and the antenna of a wireless device. This particular module is a tri-band wireless module consisting of a total of six ports of which three are differential. Each path/port corresponds to a specific cellular band and mode. The receive ports of the first generation LTCC wireless handset modules consist of single-ended connections (unbalanced) but future modules will have integrated SAW filters with differential (balanced) receive ports. Using a differential topology on the receive ports significantly reduces the system noise performance which is desirable in the receiver section of a wireless handset. Typically LTCC devices do not require tuning in the final stages of integration and therefore it is desirable to have very high speed testing procedures. Generally a final pass/fail result of all measurement specifications for all paths is all that is required in production.

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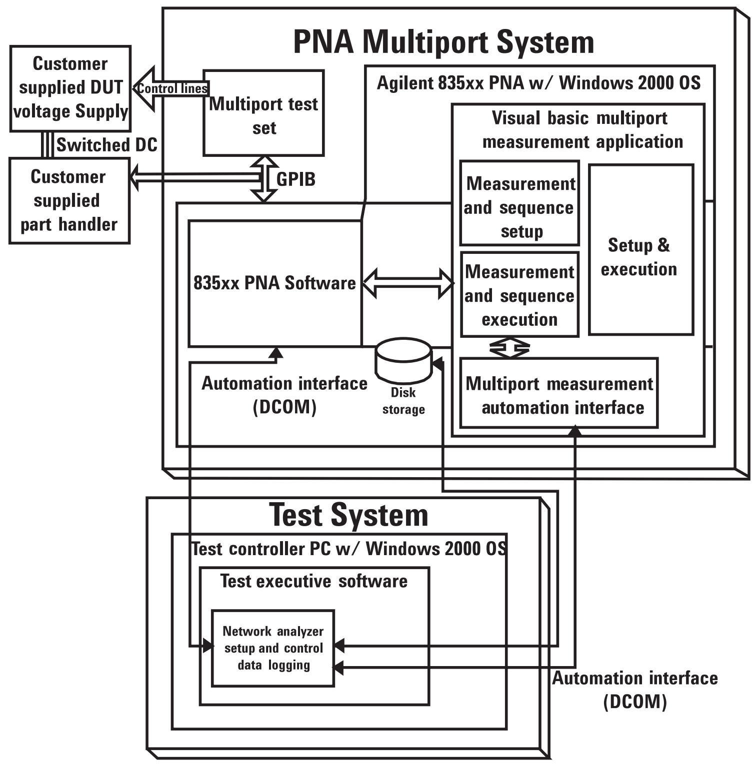
## Multiport test system

The high-speed multiport test system that is used consists of an E8357A, 6 GHz PNA Series vector network analyzer with a 128 MB memory upgrade and a 16 channel firmware upgrade. The system's multiport application interface and multiport automation interface provide device measurement path setup, manage the calibration process, and operate the device switch control during testing.

This multiport test system is suitable for manual and automated testing and is ideal in high volume manufacturing. Multiple RF ports are provided by external test sets controlled by the PNA through GPIB. Calibration consists of multiple two port calibrations.

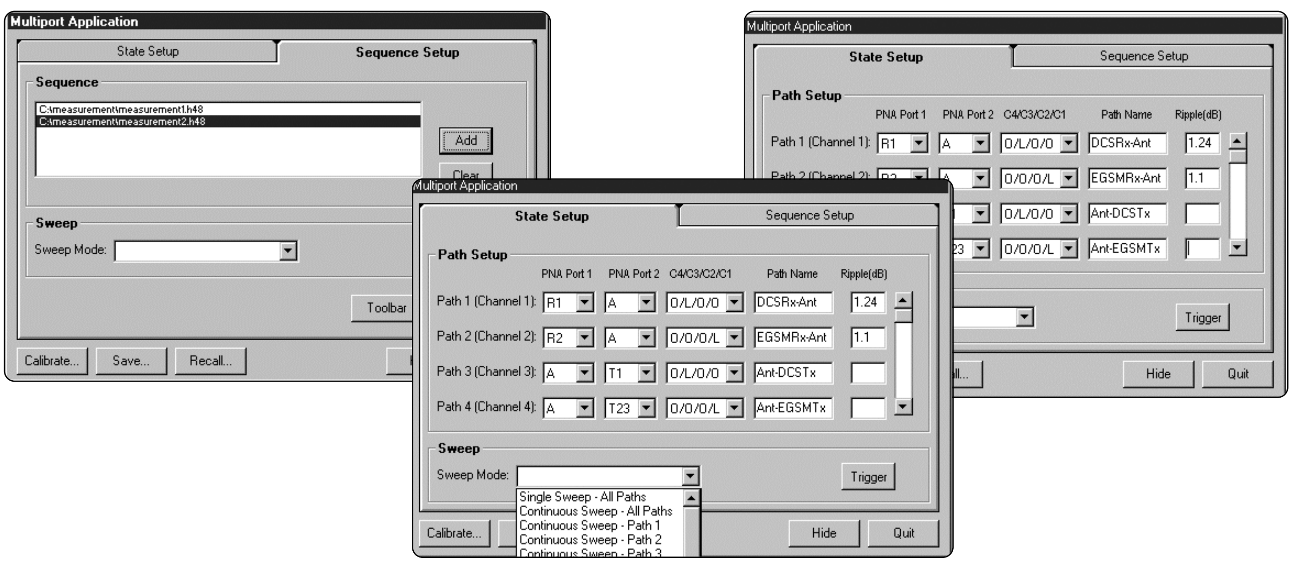


## Multiport control application

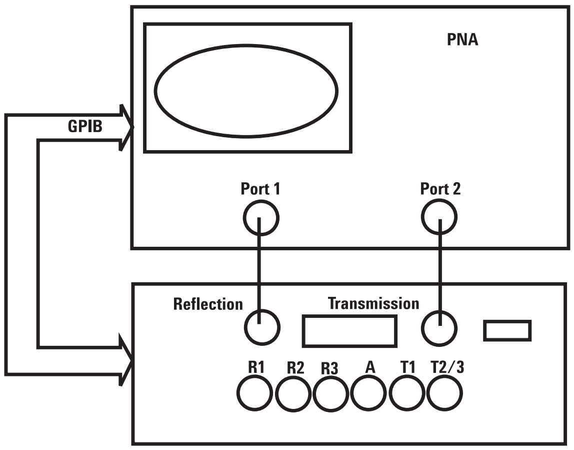
The automation capabilities of the PNA provide the application development framework for a high-speed test system. The multiport application runs inside the PNA as an application and allows the user to configure a set of device path measurements using the external test set and PNA application. Each RF measurement path requires a separate calibration for increased accuracy. A special version of the PNA application allows the configurability of up to 16 channels per instrument state. This means that one instrument state can have up to 16 concurrent calibrations corresponding to 16 measurement paths. If more than 16 measurement paths are required the user can use the sequencing function in the multiport application to sequence through multiple instrument states. The multiport application handles all the triggering for the measurement on the PNA. The user uses the PNA application for all measurement formatting such as what S-parameters to measure and what format to display the trace data.

The Multiport Application Interface has three main sections as shown in the figure below. The first window is split into two tabs. The first tab, "State Setup", is used to define what path/port combination is associated with a channel on the PNA. The path can also have an associated control line output. The control lines can be used to switch the modes of an LTCC module for example. The path can also have an associated name and ripple limit check. Up to 16 paths can be configured using the state setup tab. Once setup is completed the user can perform various triggering modes such as continuously sweep all paths or continuously sweep a single path. The sequence of triggering operations is as follows:

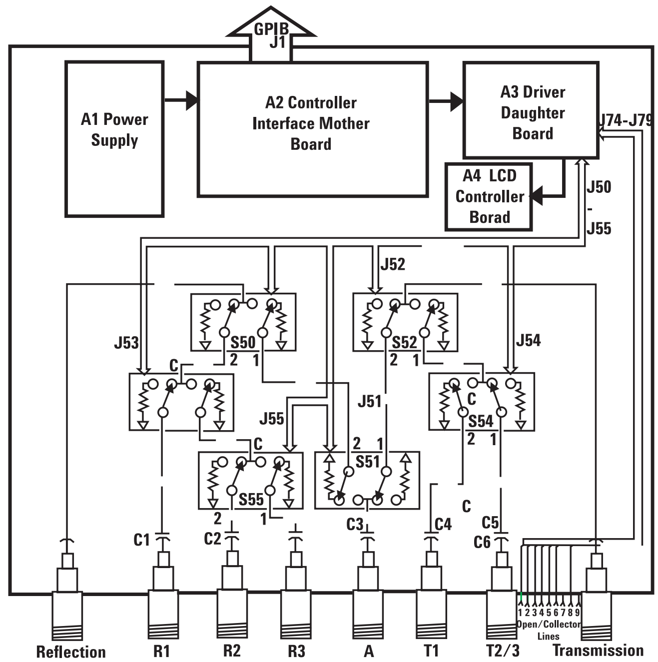
1. Set control line output
2. Set external RF path
3. Sweep PNA application associated channel
4. Perform limit check




The second tab, "Sequence Setup", is used to configure a measurement sequence to be used by the Multiport Toolbar. The user would add states that were created using the state setup tab to the sequence. If more than 16 paths are needed in the measurement, then the user would add two or more states to the sequencer. Once this is complete the toolbar can be activated and used for triggering the created multiport measurement sequence. Pass/Fail indicators provide the user with the final test result for the multiport DUT. The PNA can also be made invisible which will increase the overall measurement speed because the operating system no longer needs to update the display with trace data. The multiport data can also be saved into one file consisting of multiple 'S2P' data formats corresponding to individual DUT paths.




Z5623A Option H46




(Type-N)
Z5623A Option H46

## Multiport test set

The Agilent Z5623A Option H46 external test set is used in this system to measure the 6-port LTCC antenna switch modules (ASM). This solid state test set provides 6 RF output ports and 4 external control lines. The external control lines are configured as open collector and may be used to control external peripheral devices. In the case of the LTCC wireless handset modules these control lines are used to control the modes of the DUT. The multiport application allows the user to configure a specific RF path and control line output setting per PNA channel. This test set is configured for module testing and is limited in some of the path measurements. Other test set configurations are available on request.

## Measurement speed

High speed measurements are performed on multiport ASMs using the Agilent Z5623S S46 multiport test system. The following sections provide test scenarios with resultant total measurement speed. These sections provide information useful in determining measurement speed from a specific customer's multiport test requirement.

1. See PNA user's guide for more information.

## General measurement performance

The following table illustrates the resulting speed of a number of generic measurement setups. General system parameters were as follows:

- IFBW = 35 kHz
- No instrument state recall
- Start = 600 MHz, Stop = 3 GHz
- 1 trace per channel
- Z5623A H46 solid state external test set
- Swept mode

| Measurement Speed (typical) | 4 paths / 201 points (per path) | 8 paths / 201 points (per path) | 8 paths / 401 points (per path) | 16 paths / 201 points (per path) | 16 paths/ 401 points |
|---|---|---|---|---|---|
| Two port calibration / PNA visible | 450ms | 850ms | 1s | 1.65s | 1.95s |
| Two port calibration / PNA invisible | 300ms | 600ms | 650ms | 1.2s | 1.3s |
| Response calibration / PNA visible | 300ms | 575ms | 650ms | 1.1s | 1.25s |
| Two port calibration / PNA invisible (stepped mode ) | 650ms | 1.35s | 2s | 2.7s | 4s |

## Specific LTCC measurement performance

The following table on page six outlines a specific example of a measurement on an LTCC module. The module consisted of a total of 6 ports. General system parameters were as follows:

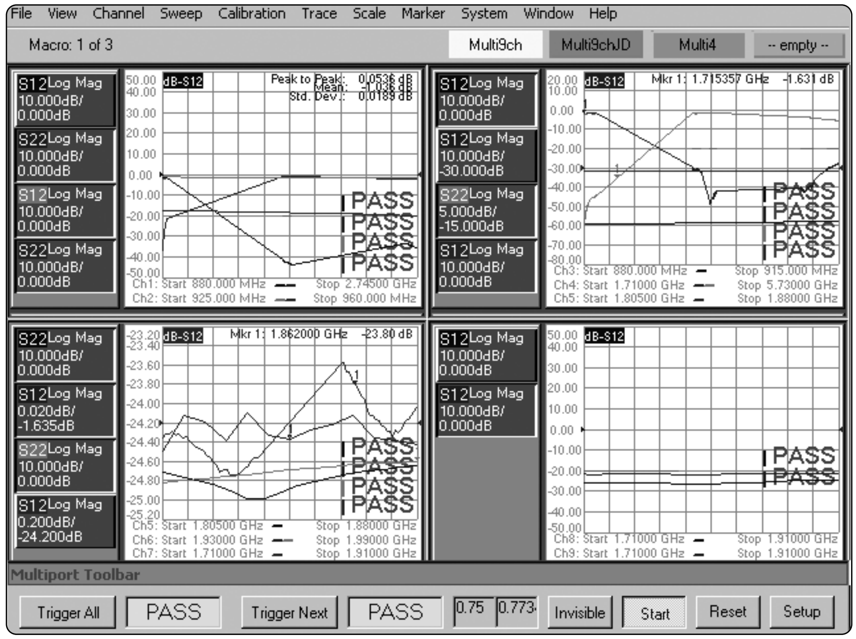
- IFBW = 35 kHz
- No instrument state recall
- Segment sweep
- Z5623A H46 solid state external test set
- Stepped mode
- Total of 14 traces in 9 channels
- Two port calibration on all channels

Total test time with PNA visible = 700ms
Total test time with PNA invisible = 500ms

1. Other test sets are available on request.
2. Some applications may require 'stepped mode' sweep due to device/system electrical length, contact Agilent for more information.

| Trace | Channel | Path | Mode | Meas | Typ | Start | Stop | Points Chan | Points | Limit Value | Limit Type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | TX1-Ant | GSM TX | S12 | Insert Loss | 880 | 915 | 8 | 8 | +-2 | Min |
| 1 | 1 | TX1-Ant | GSM TX | S12 | Attenuation | 1760 | 1830 | 15 | 15 | -35 | Max |
| 1 | 1 | TX1-Ant | GSM TX | S12 | Attenuation | 2640 | 2745 | 22 | 22 | -30 | Max |
| 2 | 1 | TX1-Ant | GSM TX | S22 | VSWR | 880 | 915 | 8 | * | -11 | Max |
| 3 | 2 | Ant-RX1 | GSM RX | S12 | Insert Loss | 925 | 960 | 8 | 8 | -2 | Min |
| 4 | 2 | Anat-RX1 | GSM RX | S22 | VSWR | 925 | 960 | 8 | * | -11 | Max |
| 5 | 3 | TX1-RX1 | GSM TX | S12 | Isolation | 880 | 915 | 8 | 8 | -20 | Max |
| 6 | 4 | TX2=Ant | D/PCS-TX | S12 | Insert Loss | 1710 | 1785 | 29 | 29 | -2 | Min |
| 6 | 4 | TX2=Ant | D/PCS-TX | S12 | Insert Loss | 1850 | 1910 | 29 | 29 | -2 | Min |
| 6 | 4 | TX2=Ant | D/PCS-TX | S12 | Attenuation | 3420 | 3570 | 56 | 56 | -20 | Max |
| 6 | 4 | TX2=Ant | D/PCS-TX | S12 | Attenuation | 3700 | 3820 | 56 | 56 | -20 | Max |
| 6 | 4 | TX2=Ant | D/PCS-TX | S12 | Attenuation | 5130 | 5355 | 83 | 83 | -20 | Max |
| 6 | 4 | TX2=Ant | D/PCS-TX | S12 | Attenuation | 5500 | 5730 | 83 | 83 | -20 | Max |
| 7 | 4 | TX2=Ant | D/PCS-TX | S22 | VSWR | 1710 | 1785 | 29 | * | -20 | Max |
| 7 | 4 | TX2=Ant | D/PCS-TX | S22 | VSWR | 1850 | 1910 | 29 | * | -20 | Max |
| 8 | 5 | Ant-RX2 | DCS-RX | S12 | Insert Loss | 1805 | 1880 | 16 | 16 | -2 | Min |
| 9 | 5 | Ant-RX2 | DCS-RX | S22 | VSWR | 1805 | 1880 | 16 | * | -11 | Max |
| 10 | 6 | Ant-RX3 | PCS-RX | S12 | Insert Loss | 1930 | 1990 | 13 | 13 | -2 | Min |
| 11 | 6 | Ant-RX3 | PCS-RX | S22 | VSWR | 1930 | 1990 | 13 | * | -11 | Max |
| 12 | 7 | TX2-RX2 | D/PCS-TX | S12 | Isolation | 1710 | 1785 | 29 | 29 | -20 | Max |
| 12 | 7 | TX2-RX2 | D/PCS-TX | S12 | Isolation | 1850 | 1910 | 29 | 29 | -20 | Max |
| 13 | 8 | TX2-RX3 | D/PCS-TX | S12 | Isolation | 1710 | 1785 | 29 | 29 | -20 | Max |
| 13 | 8 | TX2-RX3 | D/PCS-TX | S12 | Isolation | 1850 | 1910 | 29 | 29 | -20 | Max |
| 14 | 9 | TX2-RX3 | D/PCS-RX2 | S12 | Isolation | 1710 | 1785 | 29 | 29 | -20 | Max |
| 14 | 9 | TX2-RX3 | D/PCS-RX2 | S12 | Isolation | 1850 | 1910 | 29 | 29 | -20 | Max |

*Points measured as part of Insertion Loss Measurement  Total Points 600




## Conclusion

This white paper presents a high performance system for measuring multifunction, multi-port modules. Many specialized considerations for high speed testing are accommodated, such as device control and sweep synchronization, complete data testing, and both a manual test interface and a remote programming interface. This system provides a complete solution, with throughput up to 10 times faster than previously available.

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