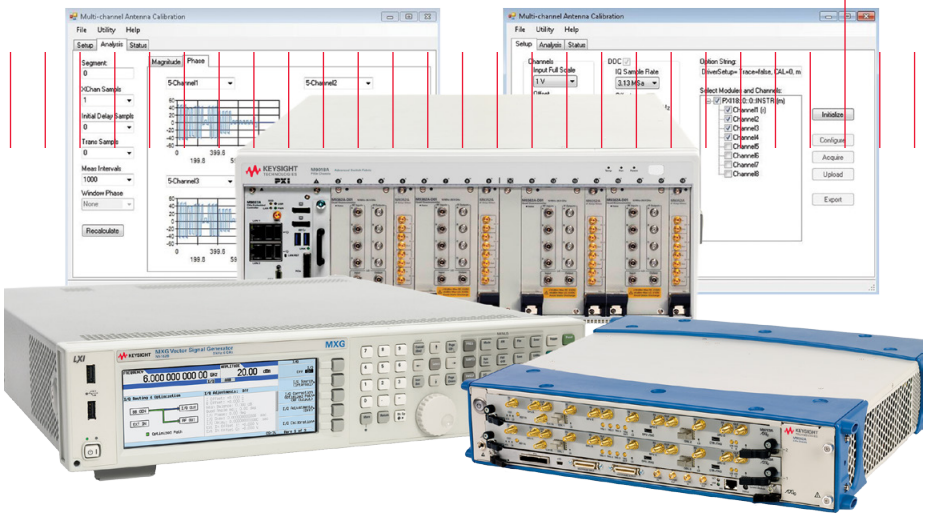
Keysight Technologies, Inc.
Multi-Channel Antenna Calibration, Reference Solution

Solution Brochure



KEYSIGHT TECHNOLOGIES

Multi-channel antenna calibration challenges

As the market for multi-channel, phased-array antenas grow, manufacturers experience increased pressure to reduce cost and increase test capacity. At the same time, manufacturers would like to expand test system flexibility to cover broad use cases and provide options for future upgrades. The calibration and testing of multi-channel antennas brings many challenges and, therefore requires a new testing approach:

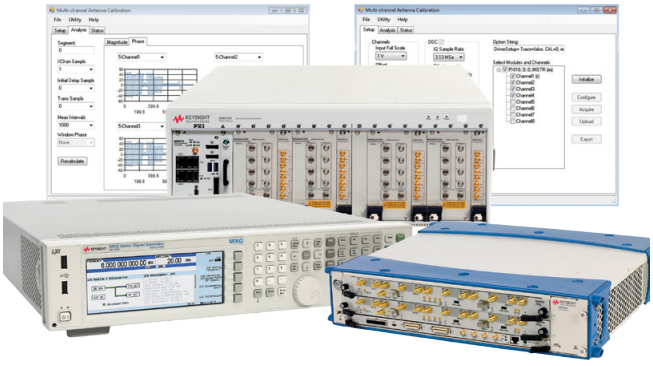
- An increase in the number of array elements results in an increase in test times and test complexity
- For precise beam-forming, it is critical to achieve phase coherent sampling across all input channels, providing relative amplitude and phase measurements
- Advancements in antenna and radar technologies requires a test system that is flexible and upgradeable

Accelerate the calibration of large antenna arrays with precise cross-element phase and magnitude measurements. Get ready for the future with increased measurement bandwidth and system flexibility.

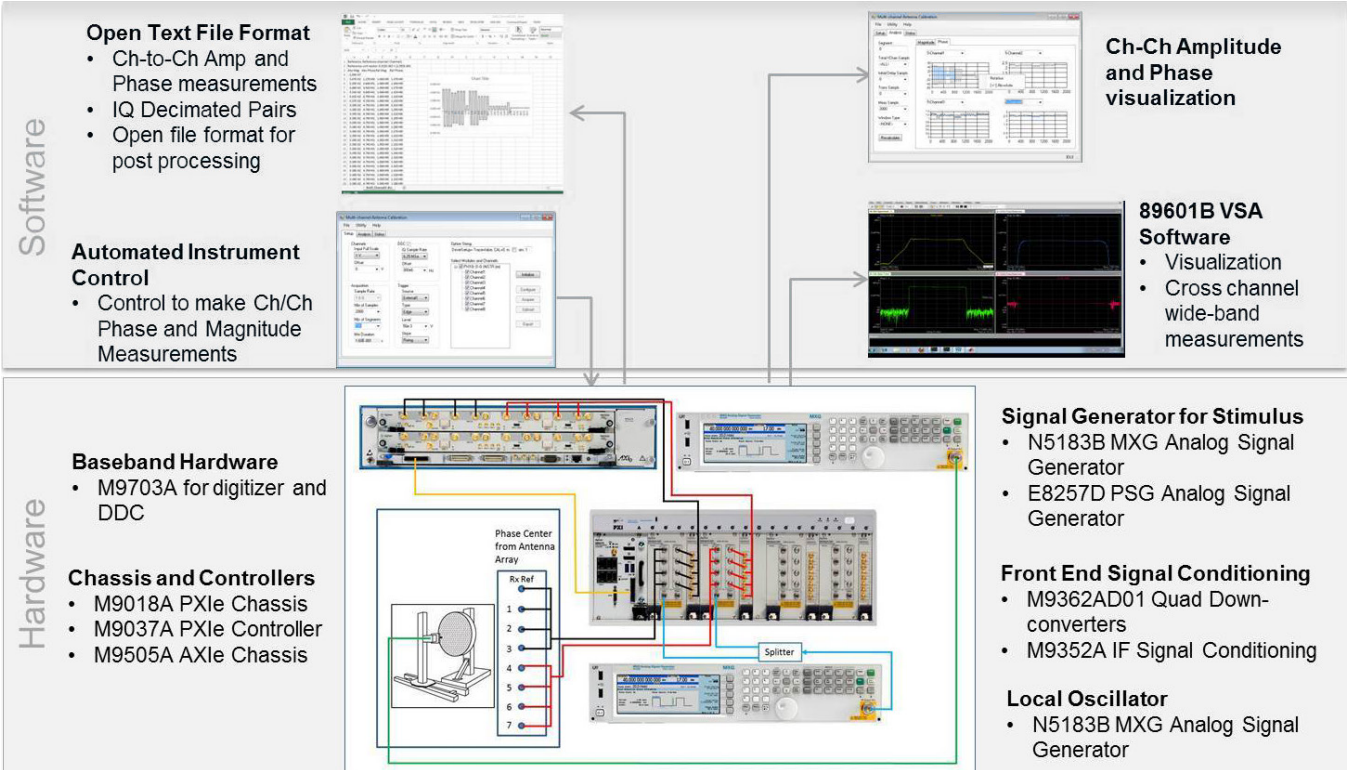
Multi-channel antenna calibration, Reference Solution

The multi-channel antenna test Reference Solution is a combination of hardware, software, and measurement expertise providing the essential components of a narrow-band antenna calibration test system. This enables engineers to use, ehance, or modify the test system as required to meet specific test application needs including scalable channel count, options for downconversion of antenna receive channels, selectable analysis BW, and choice of RF/micro wave sources and LO. It can also be extended to wide-band measurements as needs change.

To facilitate evaluation and integration in your test environment, you can use supplied test code examples to set up receiver channels, including DDC, make phase and magnitude measurements, add channel-channel correction factors, and export measurements for post-processing.



Reference Solution architecture



Hardware

Solution features & benefits	
Features	**Benefits**
Up to 40+ digitizer channels measured in parallel	Provides 8-10x improvement in antenna measurement time
Phase coherent sampling across input channels	Improved calibration and beam-forming
DDC for narrow-band measure-ments	Optimizes signal capture while improving amplitude and phase sensitivity
Typical solution performance	
Measurement throughput	Up to 1M narrow-band measure-ments per second (40 channels)
Frequency range	DC to 40 GHz
Narrow-band analysis BW (with DDC)	300 MHz to < 1 kHz, adjustable
Non-decimated BW	600 MHz
Ch-ch phase coherence	< 1 degree

Product specifications & characteristics	
M9703A AXIe 12-bit digitizer/wide-band receiver	
	8 channels @ 1.6 GSa/s
	2 GHz analog bandwidth
	Real-time digital downconversion (DDC)
M9362A-D01 PXIe microwave quad downconverter	
	4 coherent channels
	26.5 or 40 GHz frequency range
	1.5 GHz analog bandwidth
M9352A PXI hybrid amplifier/attenuator	
	4 channels
	1 GHz analog bandwidth
N5183B MXG microwave analog signal generator	
	13, 20, 31.8 or 40 GHz
	+20 dBm output power at 20 GHz
	Frequency switching time 600 µs, typical
E8257D PSG analog signal generator	
	20, 31.8, 40, 50 or 67 GHz
	+26 dBm output power at 20 GHz
	-143 dBc/Hz phase noise, typical (1 GHz signal)

Hardware configuration

M9703A AXIe 12-bit digitizer/wide-band receiver
www.keysight.com/find/m9703a

Make 8 high-speed, high resolution, and phase-coherent baseband measurements with a single AXIe module. Expand capability by combining multiple modules in a single AXIe chassis. Tune and zoom full-bandwidth ADC measurements with the DDC to a narrower frequency analysis band of interest with improved amplitude/phase sensitivity.

M9362A-D01 and M9352A PXI-based quad downconverter and amplifier
www.keysight.com/find/m9362a-d01
www.keysight.com/find/m9352a

Match the signal output of the antenna to the input of the digitizer by using the PXI-based quad downconverter and amplifier modules. Cover a frequency range of up to 40 GHz with different downconverter options.

N5183B MXG microwave analog signal generator
www.keysight.com/find/n5183b

Provide the downconverters with a local oscillator with low phase noise. The high power output of the MXG allows you to use a splitter to feed the LO to multiple downconverters to ensure phase-coherence. Can also be used to provide a source signal with fast frequency switching.

E8257D PSG analog signal generator
www.keysight.com/find/e8257d

Use the E8257D when you need industry-leading phase noise performance. Provide up to a +26 dBm source/transmit signal for the antenna under test with frequencies up to 67 GHz. Can also be used as an LO source for the downconverters.

AXIe and PXIe chassis and PXIe controller
www.keysight.com/find/pxie-chassis
www.keysight.com/find/axie-chassis

For small systems, the M9502A will support up to 16 digitizer channels (2 modules). For larger systems, the M9505A can support up to 40 digitizer channels (5 modules). Very large systems can be built with the M9514A 14-slot AXIe chassis. The M9018A PXIe chassis has 17 instrument slots available for the PXI-based down-converters and amplifiers. Build a compact test system by utilizing an embedded controller. The Core i7 based M9037A PXIe controller can control both an AXIe and PXIe chassis.

Antenna calibration example software

The Reference Solution is provided with a C# test code example specifically designed to collect data from an antenna under test and compute cross-channel magnitude and phase data. To accelerate test development and facilitate the integration in your test environment, the source code for the example software is provided in the form of a .NET class library. This allows you to build-upon the example (using Microsoft Visual studio or National Instruments LabVIEW) and customize the collection and processing of data to your specific application needs

Test setup and control

The example GUI allows the user to set up the measurements made with the M9703A digitizer, including control over DDC parameters. It includes settings such as initial sample rate, number of samples/segments, trigger control, and decimated IQ sample rate. It also allows the user to select which digitizer channels are used for the test and to select the reference channel for cross-channel measurements. Once the test conditions are set, the hardware is configured, data is acquired, and the decimated I-Q data record is uploaded to the host computer.

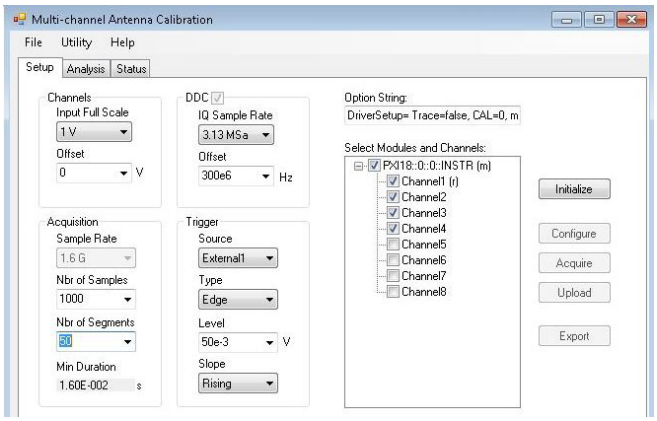


Figure 1. Test setup and control

Computing cross-channel measurements

The analysis tab allows you to quickly visualize absolute or relative phase/magnitude measurements for all measurement intervals in a selected segment.

Isolating measurement intervals

The analysis tab also allows you to isolate each measurement interval by selecting the number of samples you wish to integrate over and setting the interval delay and transition time (samples) between intervals. After recalculating, the software will generate a single I-Q measurement for each interval. Again, you can use the plots to visualize either relative or absolute measurements.

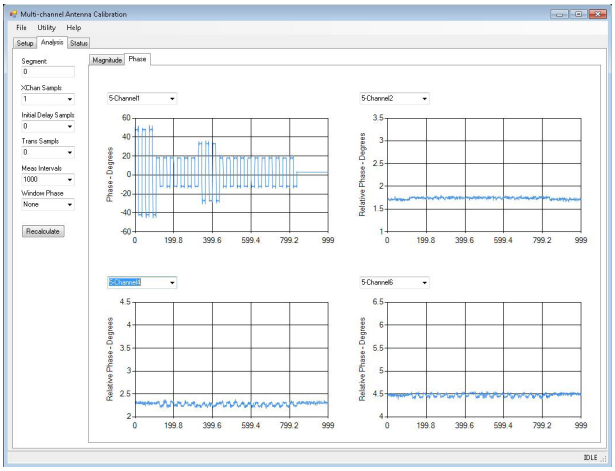


Figure 2. Cross-channel phase measurements for all I-Q samples with absolute (reference channel) and relative (other channels) values

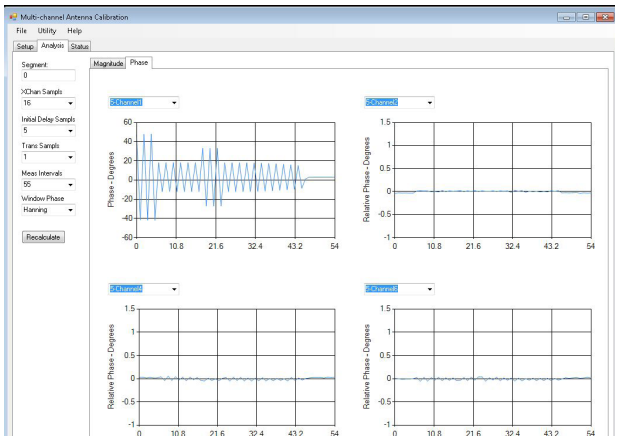


Figure 3. Absolute and relative phase plots, after computing a single I-Q pair for each interval and applying a calibration table

Utility and file functions

The example software also has utility and file functions to help improve and utilize your test results. For example, you can load a cal table containing channel-channel magnitude/phase correction factors to be used when calculating the cross-channel measurements. You can also export your results for post-processing in your test environment.

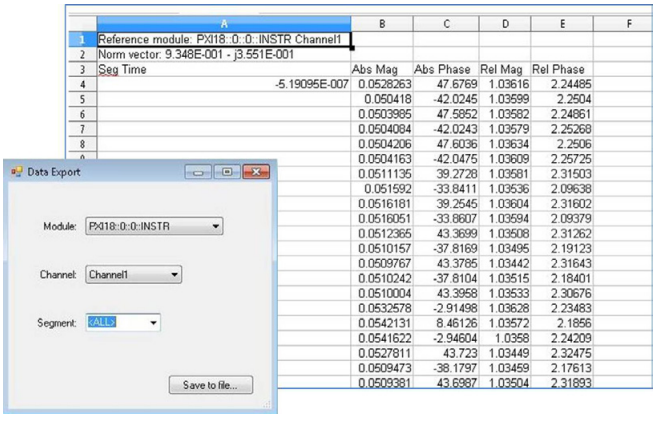


Figure 4. Exporting cross-channel I-Q measurements

Wide-band signal analysis software

89600 VSA software

Using the M9703A and DDC with the Keysight Technologies, Inc. 89600 VSA software for advanced measurement analysis enables cross-channel baseband measurements including phase and amplitude. The VSA software provides seamless control of the M9703A digitizer including DDC and multi-channel support (up to 8-channels). It is particularly useful when more complete visualization is required with wide-band measurements.

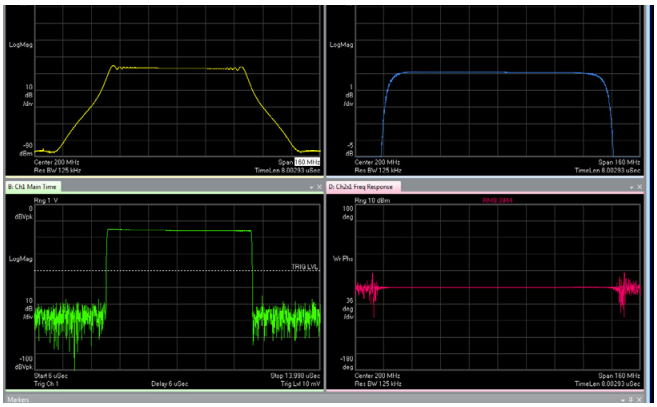


Figure 5. 89600 VSA software plots using a 100 MHz chirp

Integrating the Reference Solution into your test environment

When integrating this Reference Solution into your test environment, keep the following notes in mind:

- This solution can be integrated into existing test ranges by replacing the antenna measurement subsystem currently in use
- Current antenna control hardware and software is reused and interfaced to the Keysight reference solution. Hardware trigger signals are used to synchronize the antenna and the reference solution
- Build upon the Keysight supplied class library to customize the collection and processing of cross-channel measurements
- Existing application software used to automate near-field scan and generate antenna correction factors may need to be modified to use the cross-channel, complex I-Q data from the Keysight reference solution
- Once calculated, antenna correction factors can be downloaded to the DUT using your existing software.

Reference Solution configuration

Model	Description
M9703A	**AXIe 12-bit digitizer**
M9703A-SR2	Maximum sampling rate, 1.6 GS/s
M9703A-DDC	Real-time digital downconversion
M9703A-F10	Bandwidth, 1 GHz path enabled
M9703A-M16	Memory, 16 GB, 1024 MSamples/ch
M9352A	**PXI amplifier/attenuator**
M9362A-D01	**PXIe quad downconverter**
M9362A-D01-F26	10 MHz – 26.5 GHz frequency range
M9362A-D01-F40	10 MHz – 40 GHz frequency range
M9018A	**18-slot PXIe chassis**
M9037A	**PXIe high-performance embedded controller**
M9037A-WE7	Windows embedded standard 7 (64-bit)
M9037A-M08	Adds 8 GB memory
M9037A-M16	Adds 16 GB memory
M9502A	**2-slot AXIe chassis**
M9505A	**5-slot AXIe chassis**
M9514A	**14-slot AXIe chassis**
M9514A-521	Adds AXIe system module
N5183B	**MXG microwave analog signal generator**
N5183B-1E1	Step attenuator, 115 dB
N5183B-1EA	High output power
N5183B-520	Frequency range, 9 kHz to 20 GHz
N5183B-532	Frequency range, 9 kHz to 31.8 GHz
N5183B-540	Frequency range, 9 kHz to 40 GHz
N5183B-UNZ	Fast frequency switching
E8257D	**PSG analog signal generator**
E8257D-1E1	Step attenuator
E8257D-1EA	High output power
E8257D-520	Frequency range, 250 kHz to 20 GHz
E8257D-532	Frequency range, 250 kHz to 31.8 GHz
E8257D-540	Frequency range, 250 kHz to 40 GHz

For a more complete set of configutation options, please refer to the Multi-channel Antenna Calibration, Reference Solution Configuration Guide, literature number 5991-4583EN.

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