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PXIe-8880

mmWave OTA Validation Test Reference Architecture

The mmWave OTA Validation Test Reference Architecture integrates mmWave signal generation and analysis instrumentation, an anechoic chamber, a positioner, and positioner control, providing the ability to measure the complete radiated field of the DUT in all transmitting directions.

This manual contains hardware and software information, including step-by-step procedures and basic information about how to begin using the mmWave OTA Validation Anechoic Chamber and instrumentation with the mmWave OTA Validation Test Software.

 **Notice** The protection provided by this equipment may be impaired if it is used in a manner not described in the documentation.

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Hardware Overview

The mmWave OTA Validation Test Reference Architecture comprises the following hardware:

- mmWave OTA Validation Anechoic Chamber
- mmWave OTA Validation Accessories Kit
- Instrumentation
 - PXIe-5831 Vector Signal Transceiver—IF and mmWave instrument configuration with two mmRH-5582 mmWave Radio Heads (direct TRX ports only)
 - PXIe-6361 Multifunction I/O Module
 - PXIe-1092 or PXIe-1095 PXI Chassis



Note This manual contains only detailed reference information for using the mmWave OTA Validation Anechoic Chamber with the instrumentation. Refer to the documentation for the individual instruments for basic information about installation, configuration, and operation of each instrument.



Note Refer to the documentation included with the mmWave OTA Validation Anechoic Chamber for safety requirements and maintenance information.

Related Information

[mmWave OTA Validation Anechoic Chamber Interior](#) on page 8

[mmWave OTA Validation Anechoic Chamber Exterior](#) on page 4

[What You Need to Get Started](#) on page 9

Software Overview

The mmWave OTA Validation Test Software comprises the following components for interfacing and controlling the mmWave OTA Validation Anechoic Chamber and instrumentation.

mmWave OTA Test Configuration UI

Use the mmWave OTA Test Configuration UI open-source LabVIEW graphical user interface (GUI) to configure connection settings and measurement and sweeping parameters in the test matrix file.

TestStand Template Startup Sequences

Use the installed TestStand template sequences to run the configuration files that you create with the mmWave OTA Test Configuration UI. The template sequences control all aspects of your OTA test and are open-source to enable customization of your test plan.

mmWave OTA Test Visualizer

Use the mmWave OTA Test Visualizer to complete offline analysis of the test data for antenna measurements.

mmWave OTA Test Positioner SFP

Use the mmWave OTA Test Positioner SFP to control the movement of the positioner.

Positioner Modes of Operation

The 3GPP standard for OTA test of 5G NR DUTs requires making power measurements in a spherical grid around the DUT. This process can take a significant amount of time due to the large number of points to test, the movement of the DUT positioner, and coordination with the measurement equipment. NI provides two modes of operation for the positioner: [Step-by-Step Position Sweeping](#) and [Autonomous Position Sweeping](#).

OTA Measurement Interface (OTAMI)

Use the OTAMI LabVIEW interface to store your measurements and compute the most common OTA measurements:

Measurements	<ul style="list-style-type: none">• Effective isotropic radiated power (EIRP)• Total radiated power (TRP)• Error vector magnitude (EVM)• Half power beamwidth (HPBW)• Beam center• Beam direction• First null beamwidth
Visualizations	<ul style="list-style-type: none">• 1D cut analysis• 1D polar plot• 3D antenna pattern• Heat map• Best beam index

Plugin Interfaces

Use the LabVIEW plugin interfaces to customize and adapt the mmWave OTA Validation Test Reference Architecture for your testing environment. To enable the highest degree of customization, NI provides the source code for the plugins. The following plugins are installed with the mmWave OTA Validation Test Software.

- **Antenna Control**—An API framework that allows you to create a plugin to control your specific active antenna module.
- **Positioner Control**—An API that allows you to use a different positioner with the mmWave OTA Validation Anechoic Chamber. If your application requires a different positioner, contact the NI services personnel contracted on your project for more information about using this plugin.

Measurement Software

Use RFmx SpecAn and RFmx NR for compliant 3GPP 5G NR measurements and spectrum measurements. You can also use the RFmx SpecAn SFP or RFmx NR SFP to control the instrumentation.

Related Information

[mmWave OTA Test Positioner SFP](#) on page 25

[RFmx Soft Front Panels](#) on page 26

[OTA Measurement Interface](#) on page 33

[mmWave OTA Test Visualizer](#) on page 27

[Antenna Plugin](#) on page 33

Hardware Components

mmWave OTA Validation Anechoic Chamber Exterior

Top Bulkhead



Notice To avoid damage to chamber connectors, connect only cables that have the correct connector type.

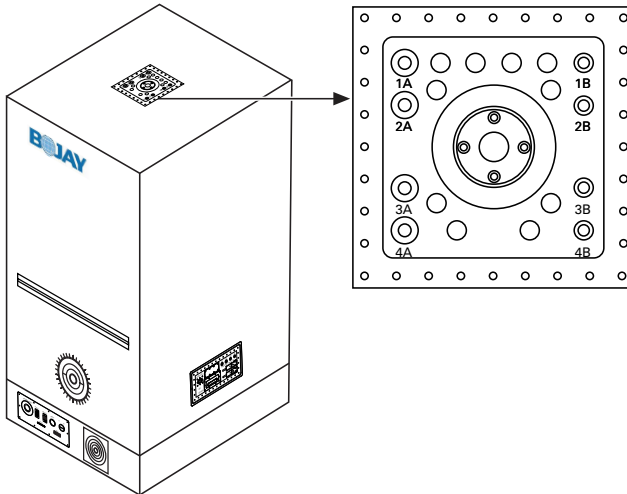


Table 1. Connector Descriptions

Connector	Connector Type	Use
1A through 4A	2.4 mm	Connects to the measurement antenna for horizontal and vertical polarization. Ports 3A and 4A are reserved for applications that use multiple antennas.
1B through 4B	2.92 mm	Reserved for applications ≤ 40 GHz. The mmWave OTA Validation Accessories Kit includes only 2.4 mm cables.

Side Control Panel

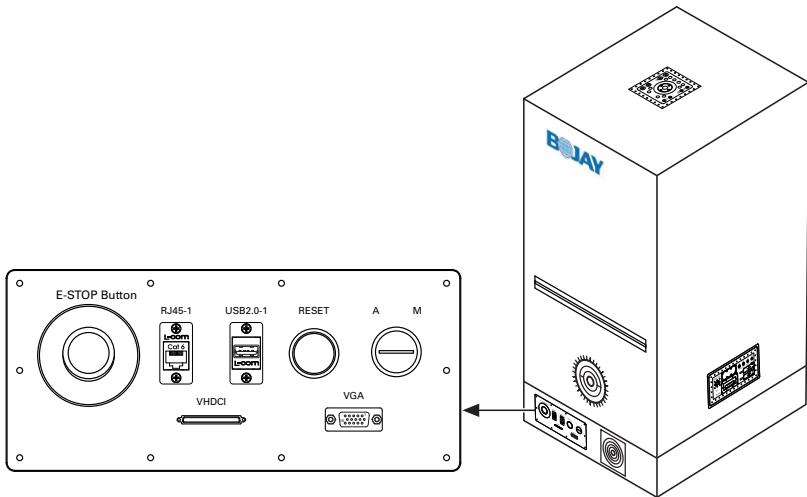


Table 2. Connector Descriptions

Connector	Connector Type	Use
VHDCI	VHDCI	Connects to the PXIe-6361 Multifunction I/O Module VHDCI connector for data acquisition of the state of the positioner. This is required for autonomous operation.
RJ45-1	RJ45	Connects to the Ethernet port 1 on the PXI controller to control the positioner.
USB2.0-1	USB	Reserved for internal use.
VGA	VGA	Reserved for internal use.

Table 2. Connector Descriptions (Continued)

Connector	Connector Type	Use
E-Stop	—	Stops all motion within the chamber immediately.
Reset	—	Resets the chamber to the default operational state.
A — M (Automatic or Manual)	Key Switch	Overrides the automatic lock feature on the exterior of the chamber door when set to Manual. NI does not recommend using the override feature during normal operation.

Rear Bulkhead

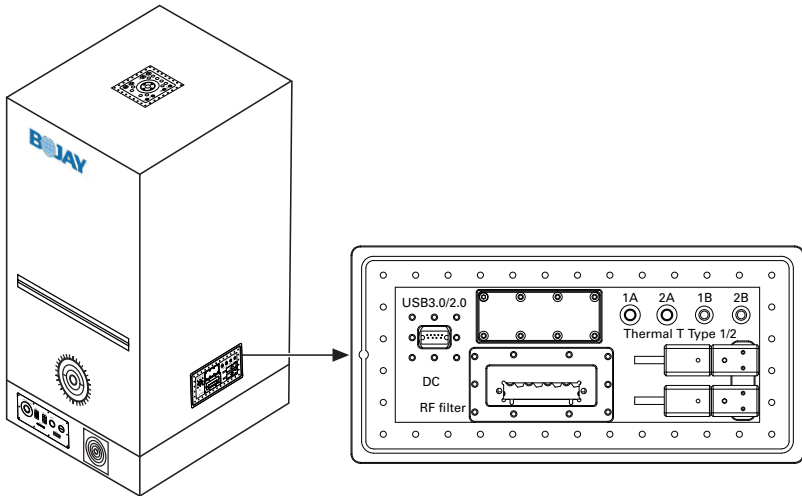


Table 3. Connector Descriptions

Connector	Connector Type	Use
DC RF Filter	Eight 4A 24 V filtered DC connectors, 5.08 mm (8 position)	Supplies power to the DUT or other internal DC needs.
Thermal T Type (x2)	Thermocouple	Monitors two different temperatures inside the chamber.

Table 3. Connector Descriptions (Continued)

Connector	Connector Type	Use
1A through 2A	2.4 mm	Reserved for system calibration and DUTs with >40 GHz inputs.
1B through 2B	2.92 mm	Reserved for DUTs with ≤ 40 GHz inputs.
USB 3.0	USB	Supplies a filtered USB connection into the chamber for any DUT needs. Use the USB 3.0, 1.5 m maximum length cable included in the chamber shipping kit to connect the chamber to your PC.



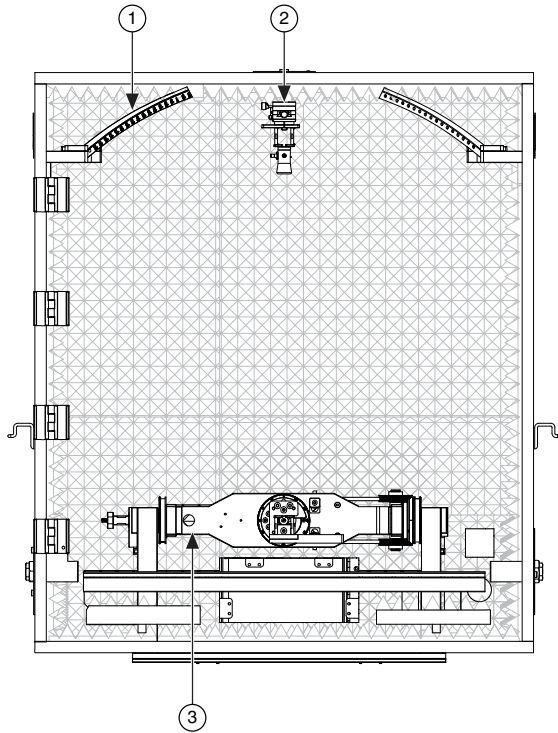
Note Use the AC switch on the rear of the chamber to power on the system.

Related Information

[External Connections](#) on page 11

[Operating the Chamber](#) on page 10

mmWave OTA Validation Anechoic Chamber Interior



1. Arch
2. Measurement Antenna Fixture
3. Positioner



Note Although the arch can hold multiple antennas to support multi-antenna positions at equidistant places from the DUT center of rotation, it holds only one antenna for the mmWave OTA Validation Test Reference Architecture.

Related Information

[Internal Connections](#) on page 13

Getting Started

Refer to the topics in this section to get started using the mmWave OTA Validation Test Reference Architecture. Complete the tasks in the following table in sequential order to ensure your system is ready for use.

Step	Task	Where to Go
1	Verify external chamber and instrument connections.	External Connections on page 11
2	Verify internal chamber cable connections and attach antennas.	Internal Connections on page 13
3	Align the measurement and reference antennas.	Aligning the Antennas on page 16
4	Calibrate the system.	Performing System Calibration on page 18
5	Perform a full antenna pattern test.	Getting Started with Step-by-Step Position Sweeping on page 22
6	Perform a fast full antenna pattern test.	Getting Started With Autonomous Position Sweeping on page 23

What You Need to Get Started

The following items are required to operate the mmWave OTA Validation Test Reference Architecture.

Depending on your application, you may require a different variation of the items listed below. Contact the NI services personnel contracted on your project to help you determine which variation your application requires.

Required Hardware Components

- mmWave OTA Validation Anechoic Chamber
 - Laser Alignment Kit
 - Dual-Polarized Measurement Antenna Fixture
 - DRH50 Dual Ridge Horn Antenna Fixture
- mmWave OTA Validation Accessories Kit
 - PXIe-6361 Multifunction I/O Module
 - SHC68-C68-RDIO2 Digital Cable
 - Dual-Polarized Measurement Antenna
 - DRH50 Dual Ridge Horn Antenna
 - 3 dB 2.4 mm attenuator (x4)
 - 1.85 mm (m)-to-1.85 mm (m) cable, 8 in. (x4)
 - 2.4 mm (m)-to-2.4 mm (m) cable, 48 in. (x2)
 - 2.4 mm (m)-to-2.4 mm (m) flexible cable, 48 in. (x2)
 - Ethernet cable
 - SMA (m)-to-SMA (m) cable, 48 in. (x4)
 - SMA (f)-to-2.4 mm (m) adapter

Required Instrumentation

- PXIe-5831 Vector Signal Transceiver—IF and mmWave instrument configuration with two mmRH-5582 modules (direct TRX ports only)
- PXIe-1092 or PXIe-1095 PXI Chassis
- PXI Express embedded controller or MXI controller system that meets the system requirements specified in the chassis documentation.
- AC power cable

Optional Items

- A 0.9 N · m (8 lb · in.) calibrated torque wrench, 5/16 in. (NI part number 751120-01).

Required Software

You must install the following software to use the mmWave OTA Validation Test Reference Architecture. NI recommends installing application software before installing the mmWave OTA Validation Test Software.

- mmWave OTA Validation Test Software
- TestStand
- LabVIEW
- RFmx SpecAn
- RFmx NR



Note Refer to the *mmWave OTA Validation Test Software Readme* for more information about compatible software versions.

Required Software for Instrumentation

The following instruments require specific drivers that are not installed with the mmWave OTA Validation Test Software. Refer to the instrument documentation available at ni.com/manuals for more information about installing required driver software.

- [PXIe-5831 Vector Signal Transceiver and mmRH-5582 mmWave Radio Head](#)
- [PXIe-6361 Multifunction I/O Module](#)
- [PXIe-1095 Chassis](#) or [PXIe-1092 Chassis](#)

Operating the Chamber

You must complete the following actions when operating the chamber.



Notice The leakage current from the EMI AC filter inside the chamber may cause certain residual current circuit breakers (RCCB) to trip. Use the external isolator provided with the chamber if you are connecting the chamber to an RCCB.

Power On and Reset the Chamber

Complete either of the following actions after you power on the chamber.

- If the key switch is set to Manual, press the Reset button.
- If the key switch is set to Auto, close the chamber door, then press the Reset button.

Opening the Chamber Door During Operation

It is important that the chamber door remain closed when you are performing a test. If the key switch is set to Auto and you open the door during operation, all movement in the chamber stops and you must press Reset to return the chamber to the default state. No action is required if the key switch is set to Manual and you open and close the door during operation.

Related Information

[mmWave OTA Validation Anechoic Chamber Exterior](#) on page 4

Verifying Hardware Connections

Before you begin using the mmWave OTA Validation Anechoic Chamber, refer to the following sections to verify the external and internal connections.

External Connections

Ensure that all required instrumentation is properly configured with the mmWave OTA Validation Anechoic Chamber before use.



Note

- The following figure does not show the PXIe-5831 installed in the chassis or the required connections between the PXIe-5831 and mmRH-5582. Refer to the [PXIe-5831 Getting Started Guide](#) at ni.com/manuals to verify that the PXIe-5831 and all mmRH-5582 modules are properly interconnected.
- Refer to the [PXIe-6361](#) and the [PXIe-1092](#) or [PXIe-1095](#) documentation at ni.com/manuals for detailed installation instructions.

The following figure shows a properly configured mmWave OTA Validation Anechoic Chamber connected to the required instrumentation.

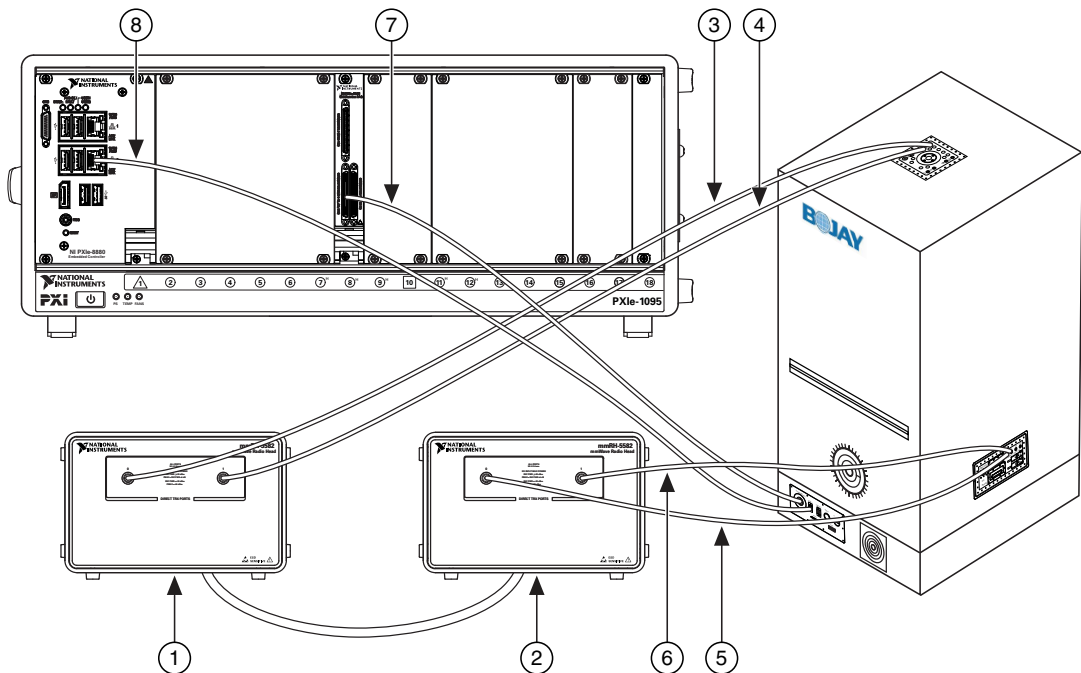


Figure Callout	Connection
1	The first mmRH-5582 module, RF0, connects to the PXIe-5831 (not pictured).
2	The second mmRH-5582 module, RF1, connects to the PXIe-5831 (not pictured).
3	A 3 dB attenuator connects to the first connected mmRH-5582 TRX Port 0, which then connects to the chamber top bulkhead 1A port using an 8 in. 1.85 mm-to-1.85 mm cable.
4	A 3 dB attenuator connects to the first mmRH-5582 module TRX Port 1, which then connects to the chamber top bulkhead 2A port using an 8 in. 1.85 mm-to-1.85 mm cable.
5	A 3 dB attenuator connects to the second mmRH-5582 module TRX Port 0, which then connects to the chamber rear bulkhead 1A port using a 48 in. 2.4 mm-to-2.4 mm cable.
6	A 3 dB attenuator connects to the second mmRH-5582 module TRX Port 1, which then connects to the chamber rear bulkhead 2A port using a 48 in. 2.4 mm-to-2.4 mm cable.

Figure Callout	Connection
7	The PXIe-6361 Connector 0 connects to the chamber control panel VHDCI connection using the SHC68-C68-RDIO2 digital cable.
8	The PXI chassis Ethernet connects to the chamber control panel Ethernet connection.

Related Information

[mmWave OTA Validation Anechoic Chamber Exterior](#) on page 4

Connecting the Chamber to a Client PC

Connect the mmWave OTA Validation Anechoic Chamber to a client PC using a direct connection.



Tip For best results, dedicate one Ethernet port for the communication and connect the Ethernet cable from that port directly to the client PC to avoid slow hubs or switches.



Note The Ethernet port on the client PC must use the same subnet as the host chamber. For example, if you use the default fixed IP address for the chamber (192.168.2.10), use 192.168.2.1 for the client PC. If you are connecting multiple clients to the host chamber through a switch, each client must have a unique IP address on the same subnet as the host.

Verify the Connection

To verify that the chamber is connected to the client PC, open a Command Prompt window and enter "ping 192.168.2.10".

Internal Connections

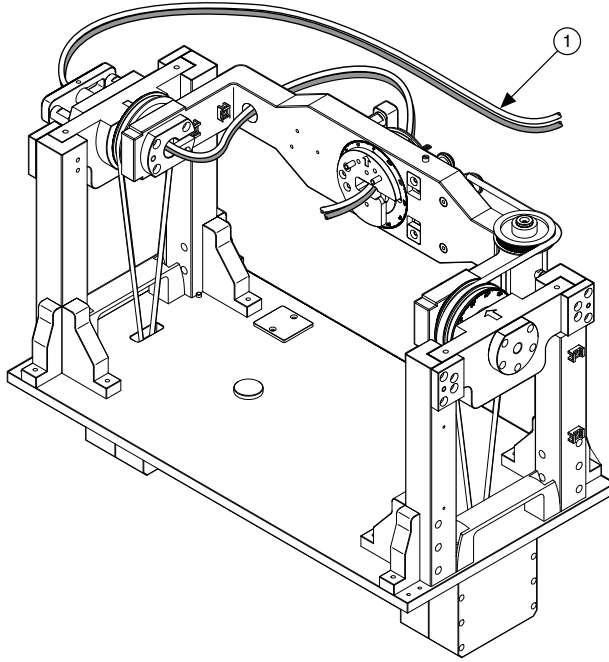
The internal chamber connections may differ depending on your specific application. Refer to the following section to ensure the components within the mmWave OTA Validation Anechoic Chamber are properly configured for system calibration.

Related Information

[mmWave OTA Validation Anechoic Chamber Interior](#) on page 8

Connecting Internal RF Cables

1. Connect one end of two 2.4 mm (m)-to-2.4 mm (m) cables to the interior chamber rear bulkhead 1A and 2A ports.
2. Route the opposite end of the cables through the correct locations on the positioner, as shown in the following figure.



-
1. 2.4 mm (m)-to-2.4 mm (m) Cable (x2)
-

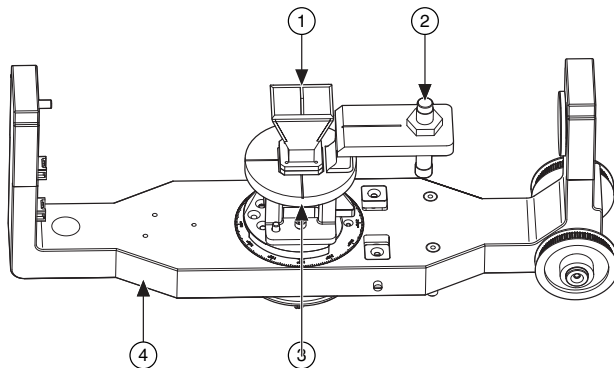


Notice The internal cables are subject to movement and can interfere with testing if not properly managed.

Attaching the Reference Antenna

The reference antenna verifies the functionality and integrity of the system during system calibration and ensures that the system is ready for testing your DUT.

1. Mount the reference antenna to the azimuth axis as shown in the following figure.



- | | |
|----------------------|------------------------------|
| 1. Reference Antenna | 3. Reference Antenna Fixture |
| 2. Calibration Laser | 4. Positioner |

2. Connect the opposite end of the 2.4 mm (m)-to-2.4 mm (m) cable connected to the interior chamber rear bulkhead 1A port to the reference antenna port.



Note The second 2.4 mm (m)-to-2.4 mm (m) cable connected to the interior chamber rear bulkhead 2A port is utilized during system calibration. Use this cable if your DUT has two input ports. Otherwise, leave the cable connected to the 2A port until the system calibration procedure is complete.

3. Close the chamber door.
4. Set the **Elevation** in the mmWave OTA Test Positioner SFP to rotate the positioner so the reference antenna points straight up toward the measurement antenna, as shown in the previous figure.

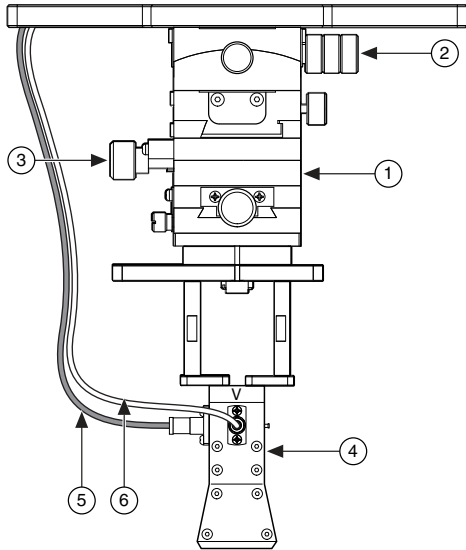
Related Information

[Performing System Calibration](#) on page 18

[mmWave OTA Test Positioner SFP](#) on page 25

Attaching the Measurement Antenna

1. Mount the measurement antenna to the measurement antenna fixture as shown in the following figure.



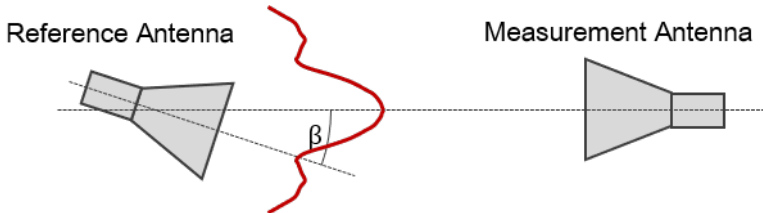
- | | |
|--------------------------------|--|
| 1. Measurement Antenna Fixture | 4. Measurement Antenna |
| 2. Alignment Knob | 5. 1.85 mm (m)-to-1.85 mm (m) Cable, 8 in. |
| 3. Alignment Knob | 6. 1.85 mm (m)-to-1.85 mm (m) Cable, 8 in. |

2. Connect one end of two 1.85 mm (m)-to-1.85 mm (m) cables to the interior chamber top bulkhead 1A and 2A ports.
3. Connect the opposite end of the cable connected to the interior chamber top bulkhead 1A port to port H on the antenna.
4. Connect the opposite end of the cable connected to the interior chamber top bulkhead 2A port to port V on the antenna.

Aligning the Antennas

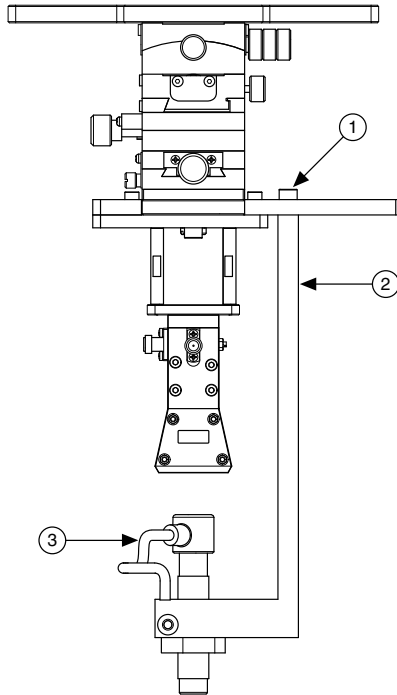
Antenna alignment improves the repeatability and accuracy of your test. The reference antenna data assumes that the antennas are perfectly aligned, so alignment must be performed for each antenna setup.

Figure 1. Reference Antenna Pointing Misalignment



To minimize the measurement uncertainty introduced by improper antenna alignment, complete the following steps before performing system calibration.

1. Secure the laser alignment fixture to the measurement antenna fixture using an Allen wrench to tighten the screws and alignment pins on the fixture.



1. Allen Screw
2. Laser Alignment Fixture
3. Calibration Laser

2. Attach the calibration laser to the laser alignment fixture and plug the laser USB cable into the USB port inside the chamber.
3. Use the alignment knobs on the measurement antenna fixture to move the measurement antenna horizontally and vertically until the laser cross hits the center of the reference antenna.

When the laser cross hits the center of the reference antenna, the measurement antenna is aligned.

4. Attach the reference antenna laser to the reference antenna fixture and plug the reference antenna laser USB cable into the USB port inside the chamber.
5. Use the mmWave OTA Test Positioner SFP to move the laser until it is aligned to the center of the measurement antenna fixture.
6. When the laser cross hits the center of the measurement antenna fixture, add 90° to the current **Elevation** number and click the **Set Absolute Home** button on the **Settings** tab in the mmWave OTA Test Positioner SFP.

The position is saved in the chamber and remains after restarting the system.

7. Unplug the calibration laser USB cable from the USB port.
8. Remove the laser alignment fixture from the measurement antenna fixture.

After antenna alignment is complete, you can perform system calibration and determine all the path losses in the system.

Related Information

[mmWave OTA Test Positioner SFP](#) on page 25

Performing System Calibration

Use the RF System Calibration Assistant to perform a full system calibration on all the mmWave OTA Validation Test Reference Architecture hardware components.

NI recommends performing system calibration in any of the following situations:

- After any module in the chassis is installed, uninstalled, or moved
- After inter-module cabling has been changed, reconnected, or repositioned
- After changing controllers, computers, or reinstalling software
- After self-calibration is performed on the individual instruments

The following equipment is required for the system calibration procedure:

- PXIe-5831 Vector Signal Transceiver and mmRH-5582 mmWave Radio Head
- Rohde & Schwarz NRP50S Power Meter



Note The Rohde & Schwarz NRP50S Power Meter requires software that is not included with the mmWave OTA Validation Test Software. Install the power meter driver software before you complete the following steps.

1. Connect the power meter USB cable to the PXI chassis USB port.
2. Open the RF System Calibration Assistant and click **Start Calibration**.
3. In the **Load Configuration Dialog** dialog box, click the file button and browse to `C:\Users\Public\Public Documents\National Instruments\OTA Test\System Calibration Files`.
4. Select `OTA-Test-Cal-Base.cfg` and click **Open**.



Note The calibration configuration assumes that the name of the PXIe-5831 in Measurement & Automation Explorer (MAX) is `3622`. If you are not using `3622` as the name of the PXIe-5831, either change the name in the configuration file or change it in MAX.

5. Select **Use existing calibration configuration**.

The **NI RF System Calibration Assistant Configurator** window launches.

6. In the **Resources** window, verify that all resources and resource settings are correct for the path loss characterization as shown in the following figure. Ensure the resource name for the power meter matches the name used in MAX.

Figure 2. Resources Window

Resources

Specify the resources and resource settings for the path loss characterization. Supported resources should be listed in each control's drop down menu. Please contact your National Instrument's contact if you'd like to add support for additional resources

Power Meter Resource

Power Meter Type: NRPZ
Power Meter Resource Name: USB::0x0aad:
Enable Power Meter Zero?
Aperture Time (s): 0.02
Average Count: 20

Signal Generator Resource

Signal Generator Type: NIS831 SG
*Signal Generator Alias: 3622
Self Calibrate Generator?

Signal Analyzer Resource

Signal Analyzer Type: NIRFMX
*Signal Analyzer Alias: 3622
Self Calibrate Cal Tone Cal Source Analyzer? Acquired Data

External Path Resources

TX Resource Type: CABLE
*TX External Path Resource Name: CABLE
RX Resource Type: CABLE
*RX External Path Resource Name: CABLE

File Resources

*RF SG System Calibration Data XML File Path: C:\Us...\OTA_System_SG_Calibration.xml
*RF SA System Calibration Data File XML Path: C:\Us...\OTA_System_SA_Calibration.xml

Next >
Cancel Verify Cal Calibrate

By default, **Self Calibrate Analyzer** and **Self Calibrate Generator** are unchecked. NI recommends that you follow the calibration recommendations in the [PXIe-5831 Specifications](#) document and to perform self-calibration when the best accuracy numbers are desired.

7. Click **Next**.
8. In the **De-Embedding Resources** window, verify that the **Resource Name** and **Resource Type** are correct for the reference antenna.

Figure 3. De-Embedding Resources Window

(De-)Embedding Resources

A de-embed resource defines a resource that will not be used post calibration, whereas an embed resource will be inserted into the path, post calibration. Specifying a (de-)embedding resource is equivalent to moving the calibration plane.

Resource Name	Resource Type
CalAnt	NIRFYSICALXML
	N/A
	N/A
	N/A

< Back Next >
Cancel Verify Cal Calibrate

9. In the **Option String** field, verify that the following string appears:
`Interpolate=true,FilePath=<createdpath>\antennadatafile.xml,PathName=VGain`, where `<createdpath>` is the location of the reference antenna values XML file that you created.



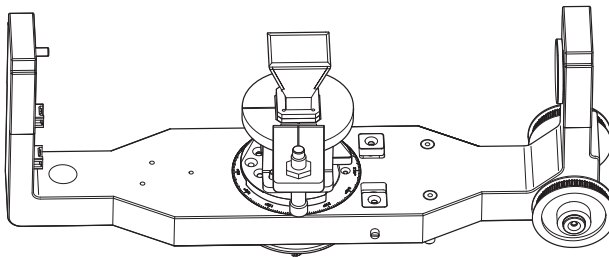
Note If you do not have the XML file, contact the NI services personnel contracted on your project. The calibration values are part of the reference antenna calibration data and are accessible through the embedded QR code on the antenna. The gain values are converted into an XML file that the software can read.

10. To accept all calibration settings, click **Calibrate**.



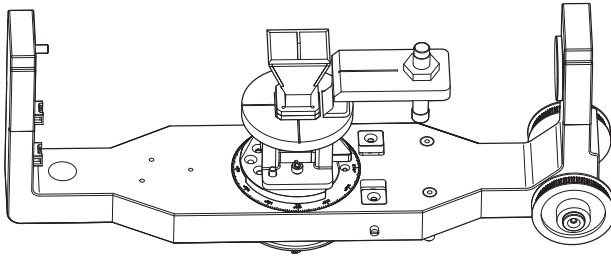
Note Refer to [Advanced System Calibration Settings](#) on page 21 for more information about configuring advanced settings.

11. When the **Connect Power Meter Dialog** box appears, complete the following steps:
- Disconnect the 2.4 mm (m)-to-2.4 mm (m) cable from the reference antenna and connect it to the power meter.
 - Follow the onscreen prompts to connect the correct cables, then click **Continue**.
 - When the calibration is complete, review the graphs and values to ensure the results are as expected. Click **Accept Values** or repeat the calibration if necessary.
 - (Optional) For the second signal generator path, disconnect the 2.4 mm (m)-to-2.4 mm (m) cable from the power meter. Connect the opposite end of the 2.4 mm (m)-to-2.4 mm (m) cable connected to the interior chamber rear bulkhead 2A port to the power meter. Repeat steps 11b-11c.
12. When the **Connect VSA Dialog** box appears, complete the following steps:
- Disconnect the power meter from all cables.
 - Reconnect the opposite end of the 2.4 mm (m)-to-2.4 mm (m) cable connected to the interior chamber rear bulkhead 1A port to the reference antenna.
 - In the mmWave OTA Test Positioner SFP, set the **Azimuth** to 90° and the **Elevation** to -90° to rotate the antenna as shown in the following figure.



The calibration laser fixture should face the chamber door and the laser should point up toward the measurement antenna.

- d) Click **Continue**.
13. When the **MeasAntennaV** dialog box appears, set the **Azimuth** to 0° in the mmWave OTA Test Positioner SFP to rotate the antenna as shown in the following figure, then continue with calibration. This ensures that the correct polarization is measured.



Once the signal analyzer and signal generator paths are complete, the **Calibration Complete** window appears with the file locations of the path loss results.

The default location is expected by the TestStand sequences. If you changed the default location, update the proper configuration. You can set these values using the mmWave OTA Test Configuration UI. Note that if the file is not found, the sequence returns an error.



Tip You can leave the **Calibration Path** field in the mmWave OTA Test Configuration UI empty if you don't want to use a calibration file or if you want to avoid receiving an error.

Advanced System Calibration Settings

Refer to the following section for more information about configuring advanced system calibration settings in the **NI RF System Calibration Assistant Configurator** window.



Note NI recommends that you familiarize yourself with the following settings before making changes to the default settings.

Generator Paths

The power meter measures one signal generator (SG) path. The **Generator Paths** window provides an example of how the SG system calibration works. The SG path is connected to the reference antenna to calibrate the path loss on the system.

You can add as many paths as your application needs for your specific configuration. However, this manual contains information about configuring the SG paths for OTA only.

Generator Calibration Settings

The frequency spacing settings, including levels at which to calibrate, are selected by default. For OTA, it is important to use same level as the level used in the **Analyzer Calibration Settings** window to maintain the same RF state of the instrument.

Analyzer Paths

The analyzer measures two signal analyzer (SA) paths. The reference antenna (RA) values are de-embedded so the SA path loss includes the loss between the end of the RA and the SA instrument.

Analyzer Calibration Settings

The frequency spacing settings, including levels at which to calibrate, are selected by default. For OTA, it is important to set the reference level low enough to get low variation.

Getting Started with Step-by-Step Position Sweeping

With step-by-step position sweeping, sweeping is exclusively controlled by the test execution engine which consumes a list of predefined positions and sequentially performs a measurement at each point.

Step-by-step position sweeping consists of the following typical process flow:

- Move the positioner to the desired position
- Set up your DUT
- Set up the instrument
- Take the measurement
- Repeat the setup and measurement for each position

Complete the following actions before getting started with step-by-step position sweeping.

- Verify that the hardware connections are configured as specified in [Verifying Hardware Connections](#) on page 11.
- Remove the laser alignment fixture.
- Use the mmWave OTA Test Positioner SFP to verify that your DUT can move in all directions without collision.
- Configure TestStand to include the following search paths, including subdirectories, in the search directories:
 - C:\Program Files\National Instruments\LabVIEW 2018\user.lib\OTA Test
 - C:\Program Files\National Instruments\LabVIEW 2018\instr.lib
 - C:\Program Files\National Instruments\LabVIEW 2018\vi.lib\RFmx
- Configure TestStand to call LabVIEW Development System (64-bit).

Complete the following steps to perform a full antenna pattern test step-by-step.

1. Navigate to C:\Users\Public\Public Documents\National Instruments\TestStand 2019 (64-bit)\Examples\OTA Test\Sequences and open the CSV settings file, `Step_by_Step_TRP.csv`.
2. Verify that the individual modules are named correctly in MAX. If the names do not match, either change the name in MAX to match the file or change the file to match your MAX settings.
3. Open the `Step_by_Step_TRP.seq` TestStand sequence, located at C:\Users\Public\Public Documents\National Instruments\TestStand 2019 (64-bit)\Examples\OTA Test\Sequences.

4. Run the sequence.



Notice Verify that nothing interferes with the motion of the positioner. The sequence triggers motion which may cause damage if anything interferes with the positioner.

The sequence runs for about 20 minutes collecting data at 5° intervals in both azimuth and elevation.

Use the mmWave OTA Test Visualizer to visualize the data in the CSV file that is created in the Results folder, located in the same directory as the Sequences folder.

Your system is fully operational if the sequence finishes without error and you can display a 3D antenna pattern from the antenna. To verify the accuracy of the test, refer to [Performing System Calibration](#) on page 18.

Related Information

[mmWave OTA Test Positioner SFP](#) on page 25

[mmWave OTA Test Visualizer](#) on page 27

Getting Started With Autonomous Position Sweeping

With autonomous position sweeping, the measurement initiation is triggered by the positioner instead of the test execution engine. This mode drastically reduces test time.

The motor control sends a digital trigger that causes the instrumentation to execute the measurement at predefined points in the motion path. The measurement results and absolute coordinates of the positioner are stored in a table to link each measurement with its exact position later during results processing. During autonomous position sweeping, motion is supervised by the test execution engine while all the measurements happen in a separate autonomous thread driven by hardware signals.

Use autonomous sweeping when your main task is to get a large number of power measurements around the sphere in a single configuration. This means validating a specific codebook item, frequency, or polarization.

Complete the following actions before getting started with autonomous position sweeping.

- Verify that the hardware connections are configured as specified in [Verifying Hardware Connections](#) on page 11.
- Remove the laser alignment fixture.
- Use the mmWave OTA Test Positioner SFP to verify that your DUT can move in all directions without collision.

- Configure TestStand to include the following search paths, including subdirectories, in the search directories:
 - C:\Program Files\National Instruments\LabVIEW 2018\user.lib\OTA Test
 - C:\Program Files\National Instruments\LabVIEW 2018\instr.lib
 - C:\Program Files\National Instruments\LabVIEW 2018\vi.lib\RFmx
- Configure TestStand to call LabVIEW Development System (64-bit).
- Autonomous mode uses PXI trigger lines between the PXIe-6361 and PXIe-5831. Route the following trigger routes in MAX:



Note The PXIe-6361 appears as **DAQ** in MAX.

- PXI_Trig0 from the PXIe-6361 bus segment to the PXIe-5831 bus segment
- PXI_Trig1 from the PXIe-5831 bus segment to the PXIe-6361 bus segment

Complete the following steps to perform a full antenna pattern test in autonomous mode.

1. Navigate to C:\Users\Public\Public Documents\National Instruments\TestStand 2019 (64-bit)\Examples\OTA Test\Sequences and open the CSV settings file, Autonomous_TRP.csv.
2. Verify that the individual modules are named correctly in MAX. If the names do not match, either change the name in MAX to match the file or change the file to match your MAX settings.
3. Open the Autonomous_TRP.seq TestStand sequence, located at C:\Users\Public\Public Documents\National Instruments\TestStand 2019 (64-bit)\Examples\OTA Test\Sequences.
4. Run the sequence.



Notice Verify that nothing interferes with the motion of the positioner. The sequence triggers motion which may cause damage if anything interferes with the positioner.

The sequence runs for about 30 seconds collecting data at 2° intervals elevation and 5° intervals azimuth.

Use the mmWave OTA Test Visualizer to visualize the data in the CSV file that is created in the Results folder, located in the same directory as the Sequences folder.

Your system is fully operational if the sequence finishes without error and you can display a 3D antenna pattern from the antenna. To verify the accuracy of the test, refer to [Performing System Calibration](#) on page 18.



Tip NI recommends familiarizing yourself with the example sequences. When you save the example sequence as a new file, you must also save the CSV file with the same file name so the sequence file can load it correctly.

Related Information

[mmWave OTA Test Positioner SFP](#) on page 25

[mmWave OTA Test Visualizer](#) on page 27

Software Reference

Soft Front Panels

mmWave OTA Test Positioner SFP

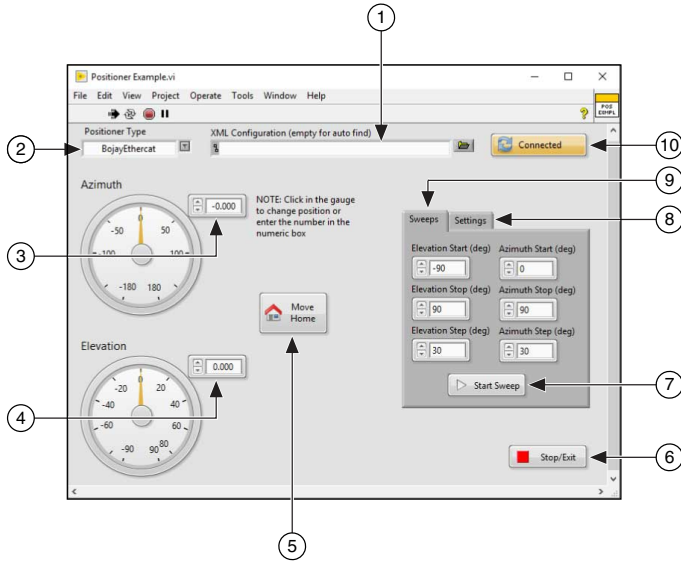
The mmWave OTA Test Positioner SFP allows you to quickly manipulate the positioner.

You can complete the following tasks with the mmWave OTA Test Positioner SFP:

- Move the azimuth or elevation independently
- Configure a sweep in both azimuth and elevation
- Configure the Absolute Zero location of the positioner for antenna alignment

You can access the mmWave OTA Test Positioner SFP at **Start»All Programs»National Instruments»OTA Test»Positioner»mmWave OTA Test Positioner SFP**.

Figure 4. mmWave OTA Test Positioner SFP Environment



1. **XML Configuration**—Browse to the file location of the XML configuration you want to load. Leave the field blank to automatically detect the file location.
2. **Positioner Type**—Select the positioner used with your configuration.
3. **Azimuth**—Select a value to set the desired azimuth of the positioner.
4. **Elevation**—Select a value to set the desired elevation of the positioner.
5. **Move Home**—Move the positioner back to the configured absolute home location.
6. **Stop/Exit**—Stop all motion of the positioner and exit the SFP.
7. **Start Sweep**—Start a sweep.
8. **Settings**—Configure the absolute azimuth and elevation of the positioner. Select the **Set Absolute Home** button to save the current location as the new home position (0, 0).
9. **Sweeps**—Configure a sweep.
10. **Connected**—Reconnect to the positioner if the connection is lost. The SFP attempts to connect to the positioner at startup.

RFmx Soft Front Panels

Use the RFmx SpecAn and RFmx NR Soft Front Panels to make manual uncalibrated measurements for your instrumentation.

The RFmx Soft Front Panels display the state of the measurement while the code is running, which helps you quickly debug issues. Visit ni.com/r/aboutrfmx for more information about getting started with RFmx.

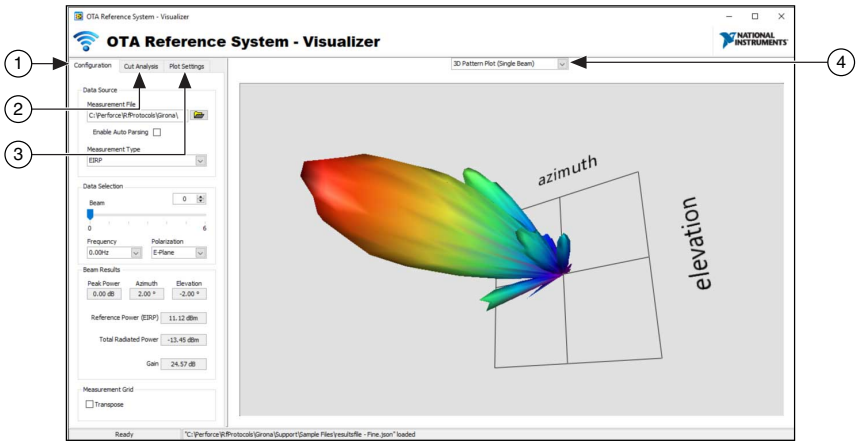
mmWave OTA Test Visualizer

The mmWave OTA Test Visualizer completes offline analysis of your test data for antenna measurements.

Load your measurement results into the mmWave OTA Test Visualizer to view your antenna pattern in different visualizations and analyze your antenna-specific measurements.

The mmWave OTA Test Visualizer is located at **Start»All Programs»National Instruments»OTA Test»Visualizer**.

Figure 5. mmWave OTA Test Visualizer



1. Configuration Tab
2. Cut Analysis Tab
3. Plot Settings Tab
4. Plot Plane Window

Refer to the following sections for more information about the configuration options in the mmWave OTA Test Visualizer.

Related Information

[File Format for Measurement Results](#) on page 32

Configuration Tab

Use this tab to configure basic settings for the file to visualize.

Window	Data Source Settings	Description
Data Source	Measurement File	Selects the CSV file to analyze.
	Enable Auto Parsing	Enables auto update based on the timestamp of the file to help visualize data while running.
	Measurement Type	Selects the type of measurement to visualize.
Data Selection	Beam	Selects the beam.
	Frequency	Selects the frequency.
	Polarization	Selects the polarization.
Measurement Grid	Transpose	Enables transposition if the azimuth or elevation needs to be flipped.

Cut Analysis Tab

Use this tab to configure the cut analysis settings.

Window	Setting	Description
Cut Settings	Plane	Selects the cut plane.
	Desired Angle	Selects the cut angle.
Lobe Detection Settings	Beam Width Power Reduction Level	Selects the beam width definition for the main lobe.
	Minimum Side Lobe Detection Level	Selects the beam width definition for the side lobes.

Plot Settings Tab

Use this tab to configure the plot settings.

Window	Setting	Description
Range and Scale	Display Range	Selects the range of the data to display. For example, a range of 30 dB indicates that the graphs display 30 dB below the maximum number.
	3D Plot Scale	Color code for 3D graphs and heat map.
Manual 3D Plot Controls	Azimuth	Camera view settings.
	Elevation	
	Viewing Distance	

Window	Setting	Description
Cut Analysis Plot	Show Plot Legend	Graph visual settings.
	Invert Y-Axis	Displays the Y data inverted.

Plot Plane Window

The plot plane window displays the preferred visualization for your measurement data.

Refer to the following section for an example of each visualization.



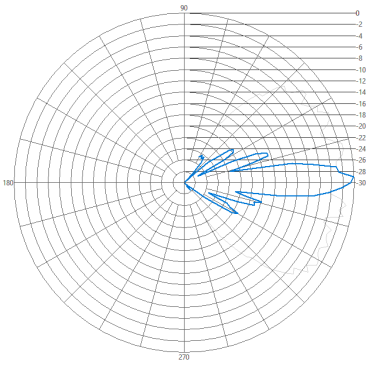
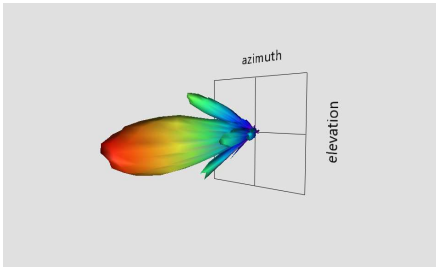
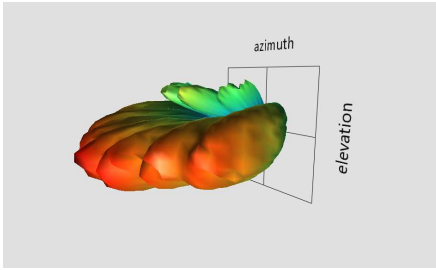
Note The example graphs below use a file that contains multiple beams to show how the beams are displayed on each graph. However, all graphs can also work with only one beam.

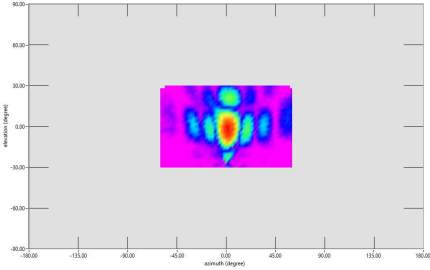
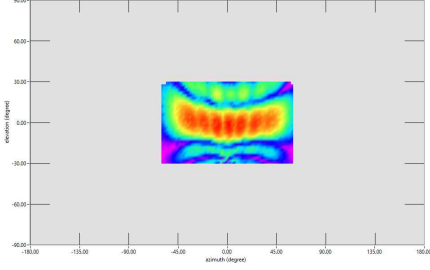
All plot values are references to the maximum EIRP found in the results file. For example, a value of -3 dB on the cut plot and a reference power (EIRP) of 15 dB means that the cut value is 12 dB.

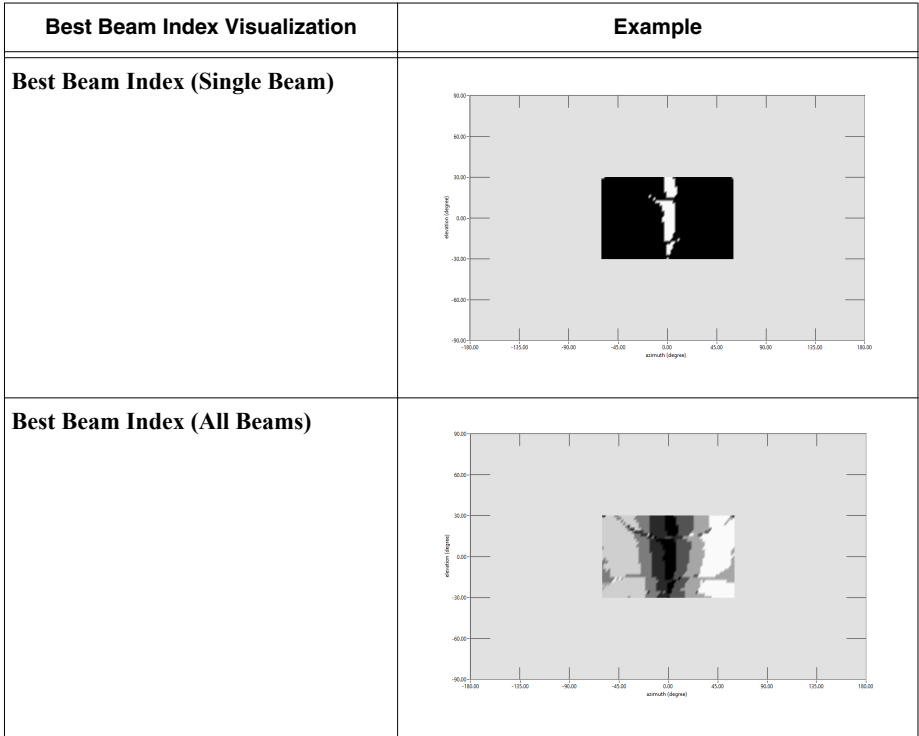


Tip You can right-click on the **Plot Plane** window to display the built-in LabVIEW options, such as exporting the image or the plot data.

1D Cut Analysis Visualization	Example
Cut Analysis (Single Beam)	
Cut Analysis (All Beams)	

Polar Plot Visualization	Example
Polar Plot (Single Beam)	 <p>A polar plot visualization of a single beam. The plot is circular with concentric grid lines representing gain and radial grid lines representing angle. The angle is labeled at 90, 180, and 270 degrees. The gain scale on the right ranges from 0 to -30 dB in increments of 2 dB. A prominent blue lobe is centered at 30 degrees, reaching a gain of approximately -28 dB. Several smaller side lobes are visible, with the largest being at approximately 150 degrees and -10 dB.</p>
3D Pattern Plot (Single Beam)	 <p>A 3D pattern plot of a single beam. The plot shows a main lobe and several side lobes in a 3D space. The axes are labeled 'azimuth' and 'elevation'. The main lobe is colored with a gradient from blue (low gain) to red (high gain). The side lobes are smaller and also show a color gradient.</p>
3D Pattern Plot (All Beams)	 <p>A 3D pattern plot showing multiple beams. The plot shows a main lobe and several side lobes in a 3D space. The axes are labeled 'azimuth' and 'elevation'. The main lobe is colored with a gradient from blue (low gain) to red (high gain). The side lobes are smaller and also show a color gradient.</p>

Heat Map Visualization	Example
<p>Heat Map (Single Beam)</p>	 <p>The figure shows a 2D plot with 'azimuth (degree)' on the x-axis and 'elevation (degree)' on the y-axis. Both axes range from -180.00 to 180.00 with major ticks every 45.00 units. A central rectangular region is highlighted with a color gradient from purple (low intensity) to yellow (high intensity), representing the radiation pattern of a single beam.</p>
<p>Heat Map (All Beams)</p>	 <p>The figure shows a 2D plot with 'azimuth (degree)' on the x-axis and 'elevation (degree)' on the y-axis. Both axes range from -180.00 to 180.00 with major ticks every 45.00 units. A central rectangular region is highlighted with a color gradient from purple to yellow, showing a more complex radiation pattern with multiple lobes, representing the combined effect of all beams.</p>



Note **Best Beam Index (Single Beam)** displays where the selected index best peak is found over all locations. **Best Beam Index (All Beams)** gray codes the indices for the different selected indices. In an ideal scenario, the beam you selected should be the best for the direction that it was intentionally created for, however, in certain cases the index that best suits the direction is not the expected index. The visualization makes it easier to quickly detect a problem with your codebook.

File Format for Measurement Results

You must save your measurement results as a CSV file to load them into the mmWave OTA Test Visualizer.

Figure 6. Example File Format

Elevation	Azimuth	Frequency	BeamNumber	Polarization	PeakPower_dBm	<MeasurementName>
-33.7425	-180.078	2.8E+10	0	1	-21.831706	0
55.82	-180.073	2.8E+10	0	1	-11.87616	0
-63.8175	-180.07	2.8E+10	0	1	-20.97491	0
-53.455	-180.063	2.8E+10	0	1	-21.501376	0
26.19	-180.063	2.8E+10	0	1	-18.577698	0

- **Elevation** and **Azimuth**—Plot the measurement data with the values in these columns.
- **Frequency**—Populate this column with a valid number.
- **BeamNumber**—Customize the value of this column based on the antenna plugin.

- **Polarization**—Use either 0 (H-Plane) or 1 (E-Plane) as the value of this column.
- Each of the remaining columns corresponds to a measurement. The mmWave OTA Validation Test Reference Architecture uses TXPower and EVM measurements in the example, but these can be expanded to any other measurement that your application requires.

OTA Measurement Interface

The OTA Measurement Interface (OTAMI) is the primary interface for your measurement data. Use the OTAMI to store measurements, import and export measurement data, and post-process your measurement results.



Note OTAMI cannot be used to interact with the system components, positioner, or DUT.

OTAMI Features

- Calculates measurement results for the following measurements: TRP, Peak EIRP, Gain, HPBW, FNBW, Pattern Cuts
- Provides measurement data for results visualization
- Adds measurements on-the-fly during sequence execution or import from measurements in a CSV file
- Exports measurement data into a CSV file
- Provides fast data storage and retrieval

Importing Measurement Data

You can either import measurement data into OTAMI from a CSV file or you can add measurement data on-the-fly.

For an example on how to use OTAMI to import measurement data from a CSV file, refer to the Results Example VI, located at `C:\Program Files\National Instruments\LabVIEW 2018\user.lib\OTA Test\Measurement Interface\Examples`.

Antenna Plugin

You can create a custom antenna plugin to add support for a specific antenna module. Before creating a custom antenna plugin, you must implement the antenna plugin interface provided by the antenna base class.

You can access the antenna base class from the following location:

```
C:\Program Files\National Instruments\LabVIEW 2018\user.lib\OTA Test\Plugins\Antennas\Base\Base Antenna Control.lvclass
```

The antenna base class has a beam database to store available beams. Each beam can be accessed with a beam identifier.

The plugin implementation uses the ESF Framework, which enables LabVIEW objects to be instantiated as sessions. The primary benefit of this is to enable LabVIEW objects to be accessed and passed programmatically as named pointers. For more information about the ESF Framework, refer to ni.com/r/esfframework.

Antenna Plugin Class Methods

- **Antenna Initialize**—Reads the antenna configuration from the configuration XML file and adds to the antenna's beam database if the codebook is known. The child class should override this method.
- **Antenna Update**—Reads the current **Antenna Mode** property and the current **Beam** property and executes all the DUT control necessary to control the physical antenna. The child class should override this method.
- **Antenna Close**—Switches the antenna off and releases all potential resource handles. The child class should override this method.
- **DB Add Beam**—Adds a beam to the antenna's beam database. The key is an integer value.
- **DB Clear**—Removes all beams from the antenna's beam database.
- **DB Get All Beams**—Returns an array of all the beams and the respective database indexes that are currently stored in the beam database.
- **Set DB Beam**—Searches the beam database for the beam with the given index and stores it in the Beam class property. This does not change the beam of the actual antenna until the Update method is called.

Antenna Plugin Interface

The following VIs are used as the interface to the antenna plugin.

- niOTA Antenna Initialize
- niOTA Antenna Close
- niOTA Antenna Update
- niOTA DB Get All Beams
- niOTA Set DB Beam

Where to Go Next

Additional Documentation

Find additional documentation for the mmWave OTA Validation Test Reference Architecture including known issues, a datasheet, and readme online at ni.com/r/otahelp.

Contacting NI for Support

Contact the NI services personnel contracted on your project for technical support, including troubleshooting and service requests. To find information about local NI service branches, visit ni.com/contact-us.

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