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PXIe-5667

CALIBRATION PROCEDURE

NI PXIe-5667

3.6 GHz and 7 GHz Spectrum Monitoring Receiver

This document contains the verification procedure for the National Instruments PXIe-5667 (NI 5667) spectrum monitoring receiver. Refer to `ni.com/calibration` for more information about calibration solutions.

When not otherwise specified, the procedures in this document refer to both the NI 5667 3.6 GHz spectrum monitoring receiver and the NI 5667 7 GHz spectrum monitoring receiver products. In places where the procedures differs between the two products, the appropriate device settings are specified.

Note NI 5667 tuned frequencies greater than 3.6 GHz and procedures with the preselector enabled for frequencies greater than 3.6 GHz apply only to the NI 5667 7 GHz spectrum monitoring receiver.

NI warrants the NI 5667 to meet its published specifications if the individual modules are calibrated and operating within specifications. For more information on RF system calibration, visit `ni.com/manuals` and search for `Letter of Conformance`.

Contents

Software

Calibrating the NI 5667 requires you to install the following software on the calibration system.

- NI-RFSA 2.6 or later
- NI Spectral Measurements Toolkit 2.6 or later

You can download all required software from `ni.com/downloads`.

The software supports programming the calibration procedures in the LabVIEW, C, and LabWindows™/CVI™ application development environments (ADEs). When you install the software, you need to install support only for the ADE that you intend to use.

Documentation

You might find the following documentation helpful as you perform the calibration procedure:

- *NI 5667 (3.6 GHz) Spectrum Monitoring Receiver Getting Started Guide*
- *NI 5667 (7 GHz) Spectrum Monitoring Receiver Getting Started Guide*
- *NI RF Vector Signal Analyzers Help*
- *NI PXIe-5667 (3.6 GHz) Specifications*
- *NI PXIe-5667 (7 GHz) Specifications*

The lastest versions of these documents are available on `ni.com/manuals`.

This calibration procedure calibrates the NI 5667 as a single system. To calibrate the NI PXIe-5653, NI PXIe-5622, NI PXIe-5693, or NI PXIe-5694 individually, refer to their calibration procedures available at `ni.com/manuals`. Return the NI PXIe-5603 or NI PXIe-5605 module to NI for calibration and adjustment, if needed.

Test Equipment

Table 1 lists the equipment NI recommends for the performance verification procedures. If the recommended equipment is not available, select a substitute using the minimum requirements listed in the table.

Table 1. Recommended Equipment for NI 5667 Calibration

Equipment	Recommended Models	Minimum Requirements
Power meter	Anritsu ML2438A	Display resolution: ≤0.01 dB Settling: ±0.1% Instrumentation accuracy: <±0.5% Noise, zero set, and drift: ≤±0.5% full-scale (lowest range) Reference power uncertainty: ≤±0.9% Reference output VSWR: <1.04
Power sensor A Power sensor B	Anritsu MA2473D	Power sensor Power range: -60 dBm to 20 dBm Frequency range: 10 MHz to 8 GHz Input VSWR: 10 MHz to 50 MHz .... <1.90 50 MHz to 2 GHz.............. <1.12 2 GHz to 8 GHz .... <1.22 Linearity: -60 dBm to 20 dBm........... <1.8% Calibration factor uncertainty: 10 MHz to 50 MHz .... <1.9% 50 MHz to 500 MHz .... <1.5% 500 MHz to 7 GHz............ <1.5% 7 GHz to 8 GHz .... <1.9%
Signal generator (RF source)	Anritsu MG3692C Options 2A, 3, 4, 15A, and 22	Frequency range: 7 MHz to 8 GHz Frequency accuracy: <0.2 ppm Leveled power: -115 dBm to 18 dBm Power accuracy: ±1.5 dB Harmonics: 0.1 MHz to ≤10 MHz......... <-30 dBc >10 MHz to ≤100 MHz...... <-40 dBc >100 MHz to ≤2.2 GHz ..... <-50 dBc >2.2 GHz to ≤8 GHz.......... <-30 dBc Nonharmonic spurious: 0.1 MHz to ≤10 MHz......... <-30 dBc >10 MHz to ≤2.2 GHz .... <-60 dBc >2.2 GHz to ≤8 GHz.......... <-60 dBc Output VSWR: <2.0

Table 1. Recommended Equipment for NI 5667 Calibration (Continued)

Equipment	Recommended Models	Minimum Requirements
Three SMA (m)-to-SMA (m) semi-rigid cables*	NI 151611A-01	—
SMA (m)-to-SMA (m) semi-rigid cable*	NI 154049A-01 (if using NI 5667 3.6 GHz) NI 154050A-01 (if using NI 5667 7 GHz)	
Two SMA (m)-to-SMA (m) semi-rigid cables*	NI 154048A-01	—
Two SMA (m)-to-SMA (m) semi-flexible cables*	NI 763282-07	—
SMA (m)-to-BNC (m) cable	NI 151890A-1R25	—
SMA (m)-to-SMA (m) cable (36 in.)	MegaPhase G916-SISI-36	Frequency range: DC to 8 GHz Insertion loss: ≤2 dB at 8 GHz Impedance: 50 Ω VSWR: ≤1.35 at 8 GHz
3.5 mm (m)-to-3.5 mm (m) adapter	Huber+Suhner 32_PC35-50-0-2/199_NE	Frequency range: DC to 8 GHz Impedance: 50 Ω Return loss: DC to 1.5 GHz .... ≥35 dB 1.5 GHz to 6 GHz .... ≥30 dB 6 GHz to 8 GHz .... ≥20 dB
3.5 mm (f)-to-3.5 mm (f) adapter	Huber+Suhner 31_PC35-50-0-2/199_N	Frequency range: DC to 8 GHz Impedance: 50 Ω Return loss: DC to 1.5 GHz .... ≥35 dB 1.5 GHz to 6 GHz .... ≥30 dB 6 GHz to 8 GHz .... ≥20 dB

Table 1. Recommended Equipment for NI 5667 Calibration (Continued)

Equipment	Recommended Models	Minimum Requirements
SMA (m)-to-SMA (f) 20 dB attenuator	Huber+Suhner 6620_SMA-50-1/199N	Frequency range: DC to 8 GHz Attenuation: 20 dB (nominal) Power rating: 2 W average Impedance: 50 Ω VSWR: DC to 4 GHz .... ≤1.15 4 GHz to 8 GHz .... ≤1.20
Power splitter (two-resistor type)	Aeroflex/Weinschel 1593	Frequency range: DC to 8 GHz Amplitude tracking: <0.25 dB Phase tracking: <4° Insertion loss: ≤8.5 dB (6 dB, nominal) Power rating: 1 W Impedance: 50 Ω VSWR: DC to 8 GHz .... ≤1.25 Equivalent output VSWR: DC to 8 GHz .... ≤1.25 Connectors: 3.5 mm (f)
Torque wrench	—	Refer to *Test Conditions* for torque wrench specifications.

* Included in the NI PXIe-5667 cable accessory kit.

Test Conditions

The following setup and environmental conditions are required to ensure the NI 5667 meets published specifications.

- Keep cabling as short as possible. Long cables and wires act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections, including front panel connections and screws, are secure.
- Maintain an ambient temperature of 23 °C ± 5 °C.
- Keep the relative humidity between 10% and 90%, noncondensing.
- Ensure that the PXI/PXI Express chassis fan speed is set to HIGH and that the empty slots contain filler panels. For more information about maintaining adequate air circulation in your PXI/PXI Express chassis, refer to the *Maintain Forced-Air Cooling Note to Users* document available at `ni.com/manuals`.
- Allow a warm-up time of at least 30 minutes after NI-RFSA is loaded and recognizes the NI 5667. The warm-up time ensures that the measurement circuitry of the NI 5667 is at a stable operating temperature.
- In each verification procedure, insert a delay between configuring all devices and acquiring the measurement. This delay may need to be adjusted depending on the instruments used but should always be at least 1,000 ms for the first iteration, and 100 ms for each other iteration.
- Use a torque wrench appropriate for the type of RF connector that you are using. NI recommends a 0.565 N · m (5 lb · in.) wrench for SMA connectors and an 0.90 N · m (8 lb · in.) wrench for 3.5 mm connectors.
- Connect the Signal Generator Reference Out to the REF IN connector on the back of the PXI Express chassis with a standard BNC (m)-to-BNC (m) cable.
- Perform self-calibration on the NI 5667.

Initial Setup

Refer to the *NI 5667 (3.6 GHz) Spectrum Monitoring Receiver Getting Started Guide* or the *NI 5667 (7 GHz) Spectrum Monitoring Receiver Getting Started Guide* for information about how to install the software and hardware and how to configure the device in Measurement & Automation Explorer (MAX).

Characterizing the Test System

You use the measured response of the test system during verification tests.

The power splitter and attenuation response is measured at the RF input frequencies used in the verification tests.

Caution The connectors on the device under test (DUT) and test equipment are fragile. Perform the steps in these procedures with great care to prevent damaging any DUTs or test equipment.

Power Splitter Reference Output

Designate one of the two outputs of the power splitter as the reference output. Consistenly use the same output as the reference output throughout the characterization and verification procedures.

Power Sensor Zero/Calibration

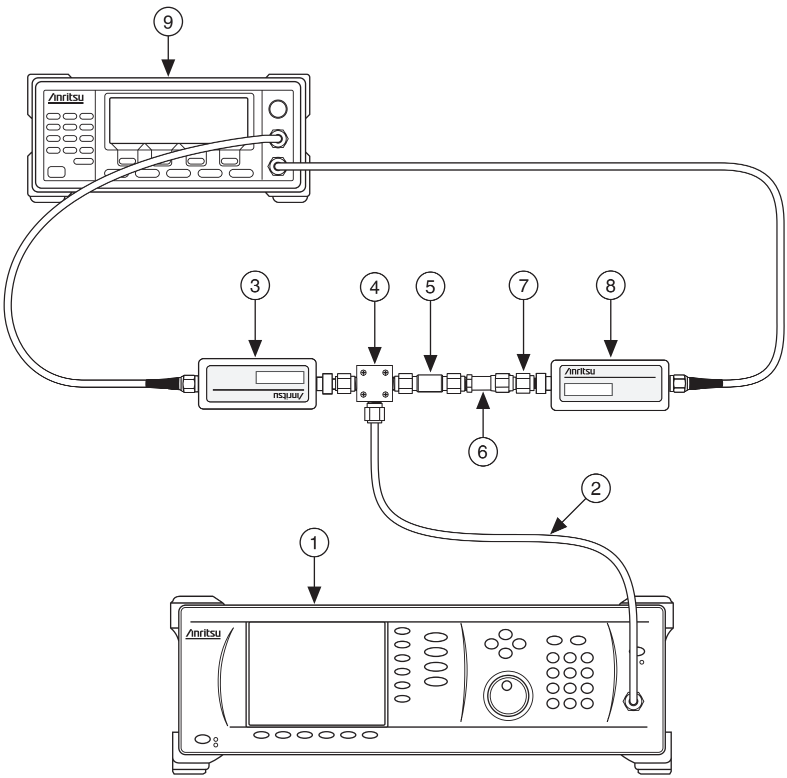
1. Connect channel A of the power meter to power sensor A.
2. Connect channel B of the power meter to power sensor B.
3. Zero and calibrate the power sensors using the built-in functions in the power meter.

RF Source Power (through Splitter and Attenuator)

Note Zero and calibrate the power sensor and define the power splitter reference output using the procedures in the *Power Splitter Reference Output* and *Power Sensor Zero/Calibration* sections of this document prior to starting this procedure.

1. Connect the RF source output to the power splitter input through the SMA (m)-to-SMA (m) cable.
2. Connect power sensor A to the reference output of the power splitter.
3. Connect power sensor B to the other output of the power splitter through the 3.5 mm (m)-to 3.5 mm (m) adapter and the 20 dB attenuator. Figure 1 shows the completed equipment setup.

Figure 1. RF Source Power Characterization (through Splitter and Attenuator) Equipment Setup



1 RF Source	6 20 dB Attenuator
2 SMA (m)-to-SMA (m) Cable	7 3.5 mm (f)-to-3.5 mm (f) Adapter
3 Power Sensor A	8 Power Sensor B
4 Power Splitter	9 Power Meter
5 3.5 mm (m)-to-3.5 mm (m) Adapter	

4. Set the RF source power to 0 dBm.
5. Set the RF source frequency according to the first row in Table 2.

Table 2. RF Source Frequencies

Start Frequency	Stop Frequency	Step Size
20 MHz	55 MHz	5 MHz
60 MHz	100 MHz	20 MHz
150 MHz	550 GHz	50 MHz

Table 2. RF Source Frequencies (Continued)

Start Frequency	Stop Frequency	Step Size
600 MHz	1.5 GHz	100 MHz
1.6 GHz	7 GHz	200 MHz

6. Measure the channel A power and the channel B power using each sensor's appropriate calibration factor for the RF source frequency.
7. Calculate the DUT to power meter through attenuator path loss and RF source to DUT via attenuator path loss for each frequency using the following formulas:

DUT to Power Meter through Attenuator Path Loss = Channel A Power - Channel B Power

RF Source to DUT via Attenuator Path Loss = RF Source Power - Channel B Power

8. Repeat steps 5 to 7 for all remaining frequencies in Table 2.

As-Found and As-Left Limits

The as-found limits are the published specifications for the NI 5667. NI uses these limits to determine whether the NI 5667 meets the device specifications when it is received for calibration.

The as-left limits are equal to the published NI specifications for the NI 5667, less guard bands for manufacturing measurement uncertainty, temperature drift, and drift over time. NI uses these limits to determine whether the NI 5667 meets the device specifications over its calibration interval.

Verification

The performance verification procedures assume that adequate traceable uncertainties are available for the calibration references.

In the event of a failure during the verification of the NI 5667, perform a calibration of the individual modules. Return the NI PXIe-5603 or NI PXIe-5605 module to NI for calibration and adjustment, if needed.

If any individual modules of the NI 5667 device have been adjusted, you must self-calibrate the NI 5667 before performing any verification procedures.

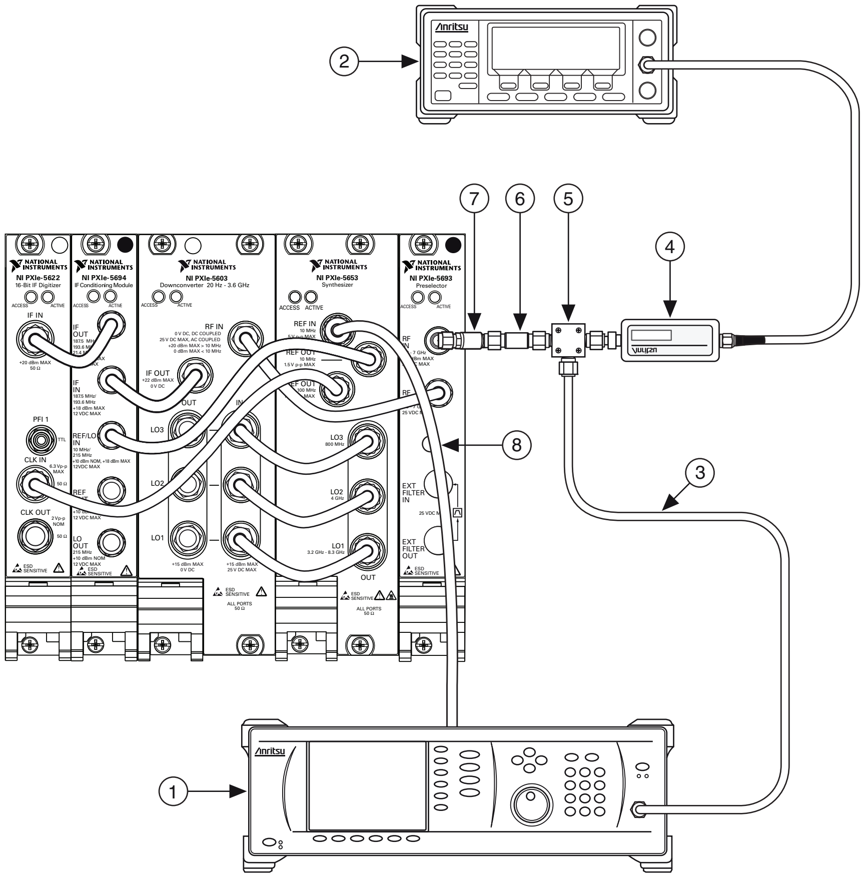
Verifying Absolute Amplitude Accuracy

Note Zero and calibrate the power sensor according to the *Power Sensor Zero/Calibration* section of this document prior to starting this procedure.

1. Connect the RF source to the power splitter input using the SMA (m)-to-SMA (m) cable.

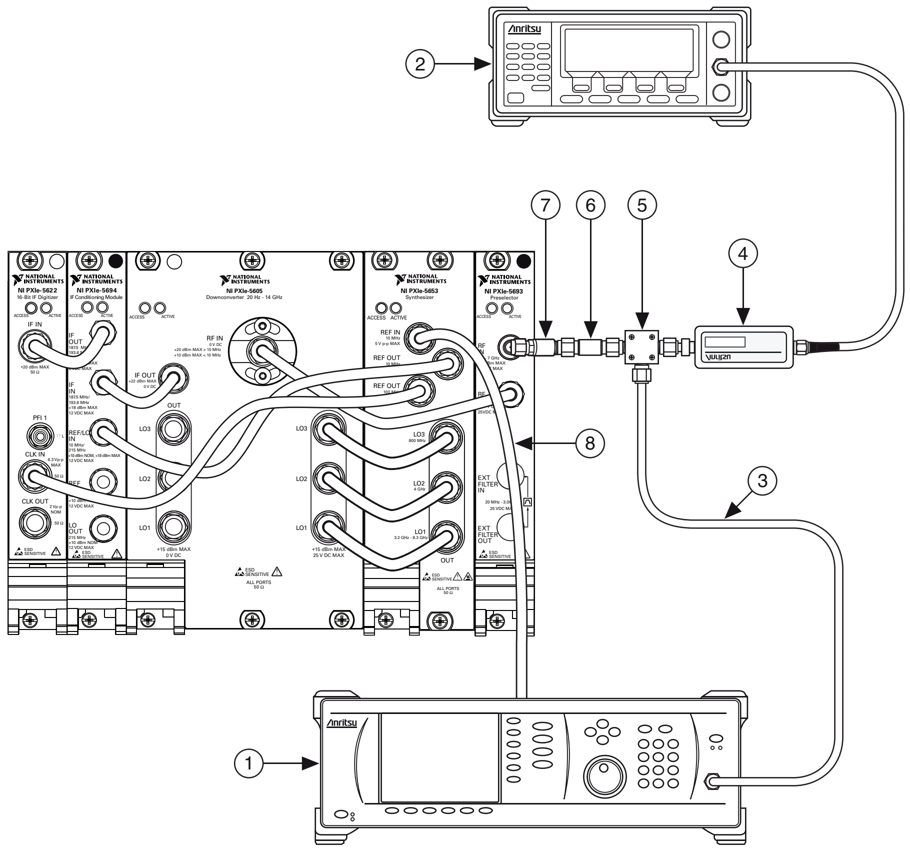
2. Connect the power splitter reference output to power sensor A.
3. Connect the other power splitter output to the NI 5667 RF IN connector using the 3.5 mm (m)-to-3.5 mm (m) adapter and 20 dB attenuator.
4. Connect the RF source 10 MHz REF OUT connector to the NI 5653 10 MHz REF IN connector using the SMA (m)-to-BNC (m) cable. Figure 2 and Figure 3 show the completed equipment setup.

Figure 2. NI 5667 3.6 GHz Spectrum Monitoring Receiver Absolute Amplitude Accuracy Verification (Frequencies > 20 MHz) Equipment Setup



1	RF Source	5	Power Splitter
2	Power Meter	6	3.5 mm (m)-to-3.5 mm (m) Adapter
3	SMA (m)-to-SMA (m) cable	7	20 dB Attenuator
4	Power Sensor A	8	SMA (m)-to-BNC (m) cable

Figure 3. NI 5667 7 GHz Spectrum Monitoring Receiver Absolute Amplitude Accuracy Verification (Frequencies > 20 MHz) Equipment Setup



1	RF Source	5	Power Splitter
2	Power Meter	6	3.5 mm (m)-to-3.5 mm (m) Adapter
3	SMA (m)-to-SMA (m) cable	7	20 dB Attenuator
4	Power Sensor A	8	SMA (m)-to-BNC (m) cable

5. Create a new session for the NI 5667.
6. Configure the NI 5667 according to the following fixed property settings. These settings remain unchanged during the test.
   - Acquisition Type: Spectrum
   - Averaging Mode: RMS Averaging
   - Number of Averages: 10
   - Digital IF Equalization Enabled: TRUE
   - Digitizer Dither Enabled: Enabled
   - Ref Clock Source: RefIn

- Channel Coupling: AC Coupled
- Span: 1 MHz
- Resolution Bandwidth: 30 kHz
- IF Output Power Level: -2 dBm
- Preamp Enabled: Automatic
- IF Filter Bandwidth: 5 MHz
- IF Conditioning Downconversion Enabled: Disabled
- **(NI 5667 7 GHz Spectrum Monitoring Receiver)** Preselector Enabled: Enabled when in signal path

7. Set the power sensor A settling percentage to 0.1% and program the power meter to trigger when settled.
8. Set the NI 5667 reference level using the following values:
   - Start Power: -50 dBm
   - Stop Power: -10 dBm
   - Step Size: 10 dB
9. Set the NI 5667 center frequency and the RF source frequency according to the first row in Table 3.

Table 3. Absolute Amplitude Accuracy Verification (Frequencies > 20 MHz) Test Frequencies

Start Frequency	Stop Frequency	Step Size
20 MHz	55 MHz	5 MHz
60 MHz	100 MHz	20 MHz
150 MHz	550 MHz	50 MHz
600 MHz	1.5 GHz	100 MHz
1.6 GHz	7 GHz	200 MHz

10. Set the RF source amplitude for that RF source frequency using the following equation:

$$\textit{RF Source Amplitude} = \textit{NI 5667 Reference Level} + \textit{RF Source to DUT via Attenuator Path Loss}$$

11. Commit the NI 5667 settings to hardware.
12. Read the channel A power from the power meter. This is the *Measured Input Power.*
13. Calculate the corrected input power using the following formula:

$$\textit{Corrected Input Power} = \textit{Measured Average Power} - \textit{DUT to Power Meter through Attenuator Path Loss}$$

Note The RF source to DUT via attenuator path and DUT to power meter through attenuator path loss values were measured in the *RF Source Power (through Splitter and Attenuator)* equipment characterization procedure. Use the values that corresponds to the frequency range you are testing.

14. Read the NI 5667 power spectrum. The *NI 5667 Power* is the peak value of that spectrum.
15. Calculate the absolute amplitude accuracy at each RF frequency using the following formula:

    Absolute Amplitude Accuracy = NI 5667 Power - Corrected Input Power

16. Repeat steps 8 to 13 for all remaining frequencies in Table 3.
17. Repeat steps 7 to 14 for all reference levels listed in step 8.
18. Compare the absolute amplitude accuracy to the verification test limits in Table 4.

Table 4. NI 5667 Absolute Amplitude Accuracy Test Limits

Frequency	Device	As-Found Limit	As-Left Limit*
20 MHz to 40 MHz	NI 5667 3.6 GHz Spectrum Monitoring Receiver	±2.1 dB	±1.64 dB
	NI 5667 7 GHz Spectrum Monitoring Receiver	±1.5 dB	±1.09 dB
>40 MHz to 2.5 GHz	NI 5667 3.6 GHz Spectrum Monitoring Receiver	±1.3 dB	±0.88 dB
	NI 5667 7 GHz Spectrum Monitoring Receiver	±1.3 dB	±0.87 dB
>2.5 MHz to 3.6 GHz	NI 5667 3.6 GHz Spectrum Monitoring Receiver	±1.6 dB	±1.09 dB
	NI 5667 7 GHz Spectrum Monitoring Receiver	±1.5 dB	±1.05 dB
>3.6 GHz to 7 GHz	NI 5667 7 GHz Spectrum Monitoring Receiver	±4 dB	±2.7 dB

* Refer to the *As-Found and As-Left Limits* section of this document for more information about as-left limits.

19. Close the NI 5667 session.

If the absolute amplitude accuracy verification procedure determines that the NI 5667 is outside of its limits, refer to *Worldwide Support and Services* for information about support resources or service requests.

Worldwide Support and Services

The National Instruments website is your complete resource for technical support. At ni.com/support you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

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