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CALIBRATION PROCEDURE

PXIe-5654

250 kHz to 20 GHz RF Analog Signal Generator

This document contains the verification and adjustment procedures for the PXIe-5654 RF Analog Signal Generator.

Refer to *ni.com/calibration* for more information about calibration solutions.

Contents

NATIONAL INSTRUMENTS

Required Software

Calibrating the PXIe-5654 requires you to install the following package on the calibration system:

- NI-RFSG 14.5 or later

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

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

Related Documentation

For additional information, refer to the following documents as you perform the calibration procedure:

- *NI PXIe-5654 Getting Started Guide*
- *NI RF Signal Generators Help*
- *NI PXIe-5654 Specifications*

Visit *ni.com/manuals* for the latest versions of these documents.

Test Equipment

NI recommends that you use particular equipment for the performance verification and adjustment procedures.

If the recommended equipment is not available, select a substitute using the minimum requirements listed in the following table.

Table 1. Recommended Equipment for PXIe-5654 Calibration

Equipment	Recommended Model	Where Used	Minimum Requirements
Signal source analyzer	Rohde & Schwarz (R&S) FSUP26 Signal Source Analyzer	Verifications: • 10 MHz reference frequency accuracy • 100 MHz reference frequency accuracy • RF OUT frequency accuracy • RF OUT phase noise • PULSE IN operation Adjustments: • Frequency reference accuracy	Frequency range: 0.25 MHz to 20 GHz Frequency counter resolution: 0.1 Hz Phase noise measurement using cross-correlation Frequency counter marker feature Spectrum analysis capabilities
Frequency reference	Symmetricom 8040C Rubidium Frequency Standard	Verifications: • 10 MHz reference frequency accuracy • 100 MHz reference frequency accuracy • RF OUT frequency accuracy Adjustments: • Frequency reference accuracy	Frequency: 10 MHz Frequency accuracy: $\pm 1 \times 10^{-9}$

Table 1. Recommended Equipment for PXIe-5654 Calibration (Continued)

Equipment	Recommended Model	Where Used	Minimum Requirements
Power meter	Anritsu ML2438A with a SC7413A Power Sensor	Verifications: • 10 MHz reference amplitude accuracy • 100 MHz reference amplitude accuracy • RF OUT amplitude accuracy • RF OUT maximum power • RF OUT minimum power Adjustments: • RF OUT power	Range: -15 dBm to 20 dBm Frequency range: 250 kHz to 20 GHz Accuracy: <±4.0%

Table 1. Recommended Equipment for PXIe-5654 Calibration (Continued)

Equipment	Recommended Model	Where Used	Minimum Requirements
K(m)-to-K(m) cable, 36 in.	Florida RF Labs KMS-160-36.0-KMS	Verifications: • 10 MHz reference frequency accuracy • 100 MHz reference frequency accuracy • RF OUT frequency accuracy • RF OUT phase noise • PULSE IN operation Adjustments: • Frequency reference accuracy	Length: 36 in. Loss: <0.7 dB/ft (typical) at 20 GHz Impedance: 50 Ω
K(m)-to-K(f) adapter[1]	Anritsu K224B	Verifications: • 10 MHz reference amplitude accuracy • 100 MHz reference amplitude accuracy • RF OUT amplitude accuracy • RF OUT maximum power • RF OUT minimum power Adjustments: • RF OUT power	Frequency range: DC to 20 GHz VSWR: ≤1.12 Impedance: 50 Ω

The following table lists the equipment NI recommends for optional performance verification procedures for non-warranted specifications. If the recommended equipment is not available, select a substitute using the minimum requirements listed in the table.

[1] The connector on the power sensor listed above may be difficult to access with a torque wrench when there is adjacent connected hardware. Use this adapter if you need to extend the capabilities of the power sensor to make it accessible by a torque wrench.

Table 2. Recommended Equipment for Optional PXIe-5654 Calibration

Equipment	Recommended Model	Where Used	Minimum Requirements
USB digital output	USB-6501 Digital I/O Device	Verifications: • PULSE IN operation	Active drive capability Voltage: <3.3 V CMOS
BNC(m)-to-SMB(f) cable	Radiall R284C0351028	Verifications: • PULSE IN operation	Impedance: 50 Ω
BNC(m)-to-screw terminal block adapter	Clever Little Box CLB-JL73	Verifications: • PULSE IN operation	Impedance: 50 Ω
BNC(m)-to-BNC(m) cable	Pasternack PE3087	Verifications: • PULSE IN operation	Impedance: 50 Ω
BNC Tee adapter (f-f-f)	Pasternack PE9003	Verifications: • PULSE IN operation	Impedance: 50 Ω

Test Conditions

The following setup and environmental conditions are required to ensure the PXIe-5654 meets published specifications.

- Keep cabling as short as possible. Long cables act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections to the PXIe-5654, including front panel connections and screws, are secure.
- Maintain an ambient temperature of 23 °C ± 5 °C.
- Keep relative humidity between 10% and 90%, noncondensing.
- Allow a warm-up time of at least 30 minutes after the chassis is powered on. The warm-up time ensures that the PXIe-5654 is at a stable operating temperature.
- In each verification procedure, insert a delay between configuring all instruments 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, 1,000 ms when the power level changes, and 100 ms for each other iteration.

- Plug the chassis and the calibration instrument(s) into the same power strip to avoid ground loops.
- Use an appropriate torque wrench to tighten all module RF connectors (SMA, 3.5 mm, or K). NI recommends a 0.565 N · m (5 lb · in.) wrench for SMA connectors and a 0.90 N · m (8 lb · in.) wrench for 3.5 mm or K connectors.
- Connect the frequency reference source to the signal source analyzer REF IN back panel connector using a BNC(m)-to-BNC(m) cable, and connect the signal source analyzer REF OUT connector to the PXIe-5654 REF IN connector using a BNC(m)-to-SMA(m) cable.
- Ensure that the PXI chassis fan speed is set to HIGH, that the fan filters, if present, are clean, and that the empty slots contain filler panels. For more information about cooling, refer to the *Maintain Forced-Air Cooling Note to Users* document available at *ni.com/manuals*.
- Frequencies less than and equal to 10 GHz apply to the 10 GHz and 20 GHz PXIe-5654; frequencies above 10 GHz apply only to the 20 GHz PXIe-5654.

Initial Setup

Refer to the *PXIe-5654 Getting Started Guide* for information about how to install the software and the hardware and how to configure the device in Measurement & Automation Explorer (MAX).

Test System Characterization

The following procedure characterizes the test equipment used during verification.

Zeroing and Calibrating the Power Sensor

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

As-Found and As-Left Limits

The as-found limits are the published specifications for the PXIe-5654. NI uses these limits to determine whether the PXIe-5654 meets the specifications when it is received for calibration. Use the as-found limits during initial verification.

The as-left calibration limits are equal to the published NI specifications for the PXIe-5654, less guard bands for measurement uncertainty, temperature drift, and drift over time. NI uses these limits to reduce the probability that the instrument will be outside the published specification limits at the end of the calibration cycle. Use the as-left limits when performing verification after adjustment.

Verification

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

Before starting verification, make the following reference connections.

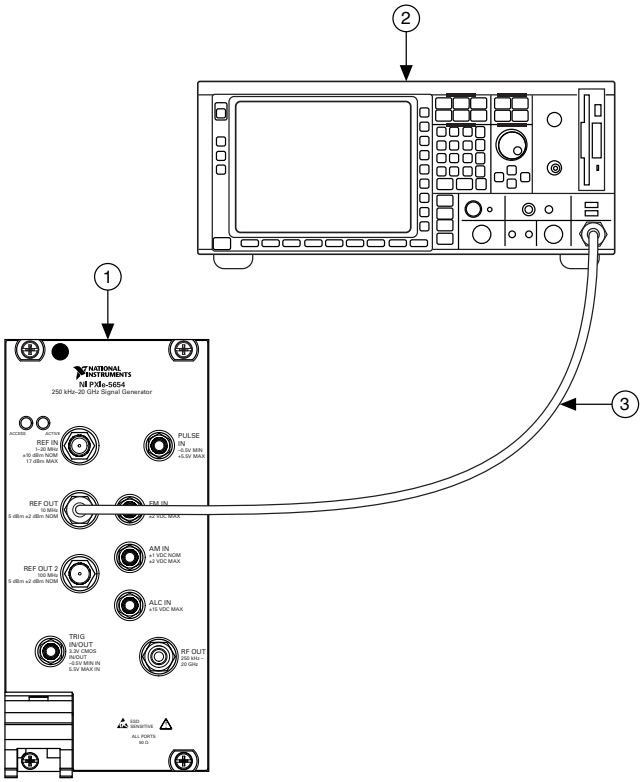
1. Connect the frequency reference source to the signal source analyzer REF IN back panel connector using a BNC(m)-to-BNC(m) cable.
2. Connect the signal source analyzer REF OUT connector to the PXIe-5654 REF IN connector using a BNC(m)-to-SMA(m) cable.

Verifying 10 MHz Reference Frequency Accuracy

This procedure verifies that the internal oven-controlled crystal oscillator (OCXO) is adjusted for correct frequency accuracy.

1. Connect the PXIe-5654 REF OUT 10 MHz front panel connector to the signal source analyzer RF input connector using the K(m)-to-K(m) cable as shown in the following figure.

Figure 1. Reference Frequency Verification (10 MHz) Equipment Setup (Reference Connections Not Shown)



1. PXIe-5654 RF Analog Signal Generator
2. Signal Source Analyzer
3. K(m)-to-K(m) Cable

2. Create a new device session for the PXIe-5654.
3. Configure the PXIe-5654 using the following settings:
   - Frequency: 4 GHz
   - Power Level: 0 dBm
   - Reference Clock Export Output Terminal: RefOut
4. Initiate signal generation.
5. Disable the RF output.
6. Check the signal generation status and verify that there are no reported errors or warnings.
7. Configure the signal source analyzer using the following settings:
   - Center frequency: 110 MHz
   - Reference level: -50 dBm

- Frequency span: 1 kHz
- Reference Clock source: External
- Frequency counter resolution: 0.1 Hz
- Sweep: Manual
- Number of sweeps: 1
- Auto Sweep Time

8. Use the signal source analyzer frequency counter to measure the frequency of the peak at approximately 110 MHz.
9. Calculate the deviation using the following formula:

$$\Delta f = \left| \frac{f_{\text{Measured}}(\text{MHz}) - 110\ \text{MHz}}{110\ \text{MHz}} \right| \text{ ppm}$$

10. Ensure that the deviation found in the previous step is less than the result of the following equation:

    As Left Calculation: *Initial Accuracy* + *Temperature Stability*

    As Found Calculation: *Initial Accuracy* + *Aging* + *Temperature Stability*

    where

    Initial Accuracy = ±0.1 ppm
    Temperature Stability (15 °C to 35 °C) = ±0.2 ppm
    Ten year aging = 1.25 ppm

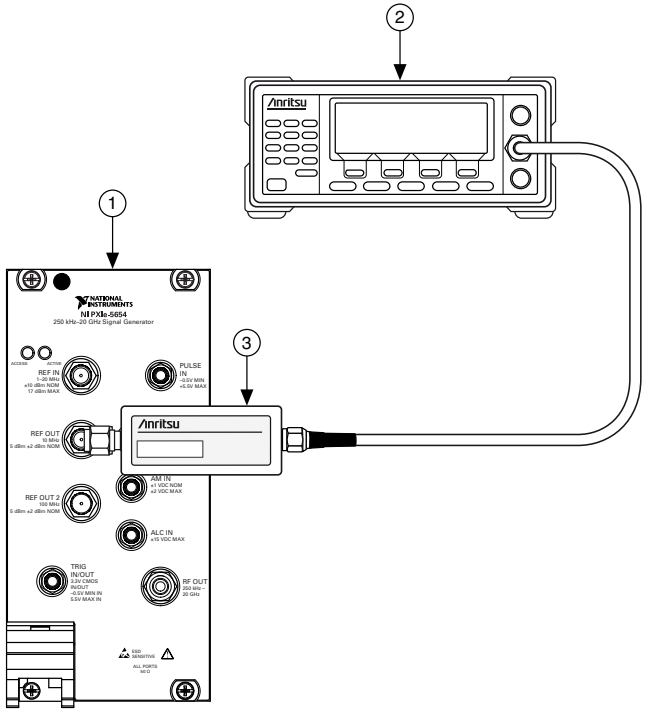
11. Close the device session.

Verifying 10 MHz Reference Amplitude Accuracy

This procedure verifies that the internal 10 MHz reference circuitry is adjusted for correct amplitude accuracy.

1. Connect the power sensor to the PXIe-5654 REF OUT 10 MHz front panel connector as shown in the following figure.

Figure 2. Reference Amplitude Accuracy Verification (10 MHz) Equipment Setup



1. PXIe-5654 RF Analog Signal Generator
2. Power Meter
3. Power Sensor

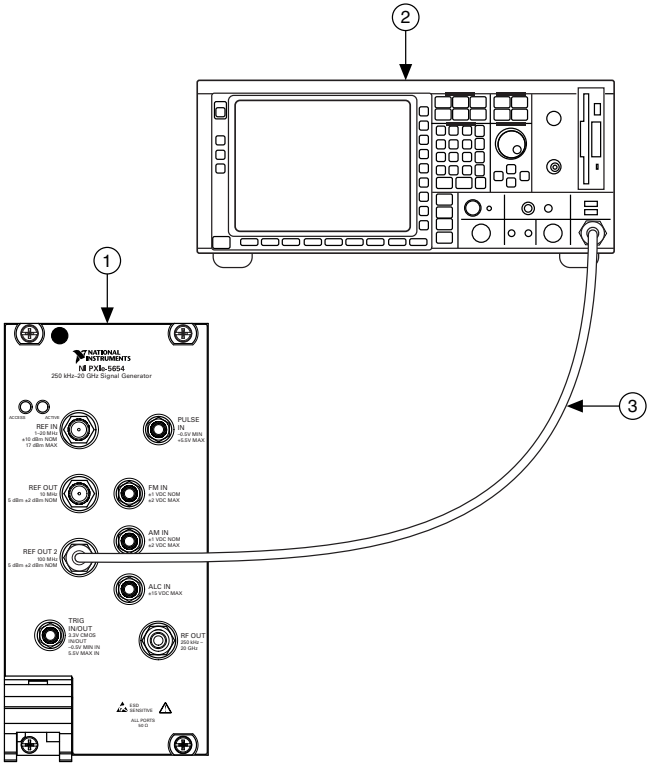
2. Create a new device session for the PXIe-5654.
3. Configure the PXIe-5654 using the following settings:
   - Frequency: 4 GHz
   - Power Level: 0 dBm
   - Reference Clock Export Output Terminal: RefOut
4. Initiate signal generation.
5. Disable the RF output.
6. Check the signal generation status and verify that there are no reported errors or warnings.
7. Measure the PXIe-5654 REF OUT 10 MHz front panel connector power using the power meter.
8. Correct the power meter reading for the 10 MHz measurement frequency and ensure that the corrected power is between 3 dBm and 7 dBm.
9. Close the device session.

Verifying 100 MHz Reference Frequency Accuracy

This procedure verifies that the internal 100 MHz reference circuitry is adjusted for correct frequency accuracy.

1. Connect the PXIe-5654 REF OUT 2 100 MHz front panel connector to the signal source analyzer RF input connector using the K(m)-to-K(m) cable as shown in the following figure.

Figure 3. Reference Frequency Accuracy Verification (100 MHz) Equipment Setup (Reference Connections Not Shown)



1. PXIe-5654 RF Analog Signal Generator
2. Signal Source Analyzer
3. K(m)-to-K(m) Cable

2. Create a new device session for the PXIe-5654.
3. Configure the PXIe-5654 using the following settings:
   - Frequency: 4 GHz
   - Power Level: 0 dBm
   - Reference Clock Export Output Terminal: RefOut2

4. Initiate signal generation.
5. Disable the RF output.
6. Check the signal generation status and verify that there are no reported errors or warnings.
7. Configure the signal source analyzer using the following settings:
   - Center frequency: 100 MHz
   - Reference level: 10 dBm
   - Frequency span: 250 kHz
   - Reference Clock source: External
   - Frequency counter resolution: 0.1 Hz
   - Sweep: Manual
   - Number of sweeps: 1
   - Auto Sweep Time
8. Use the signal source analyzer frequency counter to measure the frequency of the peak at approximately 100 MHz.
9. Calculate the deviation using the following formula:

$$\Delta f = \left| \frac{f_{\text{Measured}}(\text{MHz}) - 100\ \text{MHz}}{100\ \text{MHz}} \right| \text{ ppm}$$

10. Ensure that the deviation found in the previous step is less than the result of the following equation:

    As Left Calculation: *Initial Accuracy* + *Temperature Stability*

    As Found Calculation: *Initial Accuracy* + *Aging* + *Temperature Stability*

    where

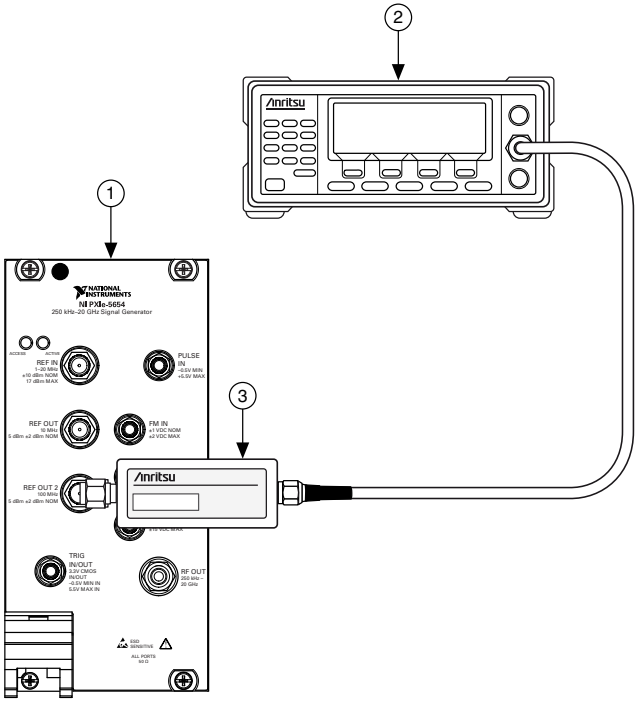
    Initial Accuracy = ±0.1 ppm
    Temperature Stability (15 °C to 35 °C) = ±0.2 ppm
    Ten year aging = 1.25 ppm
11. Close the device session.

Verifying 100 MHz Reference Amplitude Accuracy

This procedure verifies that the internal 100 MHz reference circuitry is adjusted for correct amplitude accuracy.

1. Connect the power sensor to the PXIe-5654 REF OUT 2 100 MHz front panel connector as shown in the following figure.

Figure 4. Reference Amplitude Accuracy Verification (100 MHz) Equipment Setup



1. PXIe-5654 RF Analog Signal Generator
2. Power Meter
3. Power Sensor

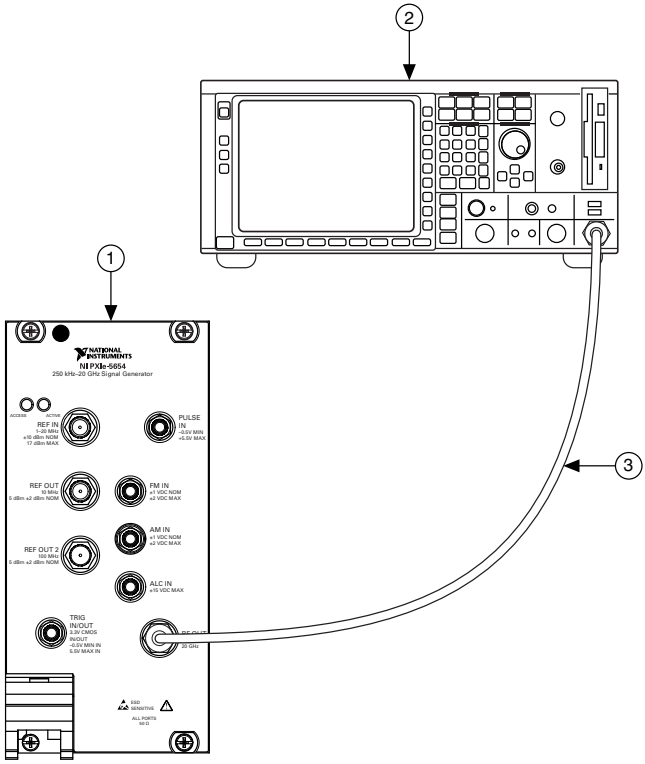
2. Create a new device session for the PXIe-5654.
3. Configure the PXIe-5654 using the following settings:
   - Frequency: 4 GHz
   - Power Level: 0 dBm
   - Reference Clock Export Output Terminal: RefOut2
4. Initiate signal generation.
5. Disable the RF output.
6. Check the signal generation status and verify that there are no reported errors or warnings.
7. Use the power meter to measure the PXIe-5654 REF OUT 2 100 MHz front panel connector power.
8. Correct the power meter reading for the 100 MHz measurement frequency. Ensure that the corrected power is between 3 dBm and 7 dBm.
9. Close the device session.

Verifying RF OUT Frequency Accuracy

This procedure verifies that the internal signal generation circuitry is adjusted for correct frequency accuracy.

1. Connect the PXIe-5654 RF OUT front panel connector to the signal source analyzer RF input connector using the K(m)-to-K(m) cable as shown in the following figure.

Figure 5. RF OUT Frequency Accuracy Verification Equipment Setup (Reference Connections Not Shown)



1. PXIe-5654 RF Analog Signal Generator
2. Signal Source Analyzer
3. K(m)-to-K(m) Cable

2. Create a new device session for the PXIe-5654.
3. Create a list of test frequencies, including endpoints, containing 100 MHz and 1 GHz, according to the frequency range of your PXIe-5654 model, with 1 GHz increments.

4. Configure the PXIe-5654 using the following settings:
   - Frequency: Frequency from the list in step 3
   - Power Level: 0 dBm
   - Reference Clock Source: Onboard Clock
5. Commit the settings to hardware if this is the first iteration of running this procedure; otherwise skip to step 8.
6. Initiate signal generation.
7. Enable the RF output.
8. Check the signal generation status and verify that there are no reported errors or warnings.
9. Configure the signal source analyzer using the following settings:
   - Center frequency: Frequency from the list in step 3
   - Reference level: 20 dBm
   - Frequency span: 1 MHz
   - Reference Clock source: External
   - Frequency counter resolution: 0.1 Hz
   - Sweep: Manual
   - Number of sweeps: 1
   - Auto Sweep Time
10. Measure the frequency of the peak that is returned by the signal source analyzer at approximately the corresponding point in the frequency list you created in step 3.
11. Calculate the deviation using the following formula:

$$\Delta f = \left| \frac{f_{\text{Measured}}(\text{MHz}) - f_{\text{Expected}}(\text{MHz})}{f_{\text{Expected}}(\text{MHz})} \right| \text{ ppm}$$

12. Ensure that the deviation found in the previous step is less than the result of the following equation:

    As Left Calculation: *Initial Accuracy* + *Temperature Stability*

    As Found Calculation: *Initial Accuracy* + *Aging* + *Temperature Stability*

    where

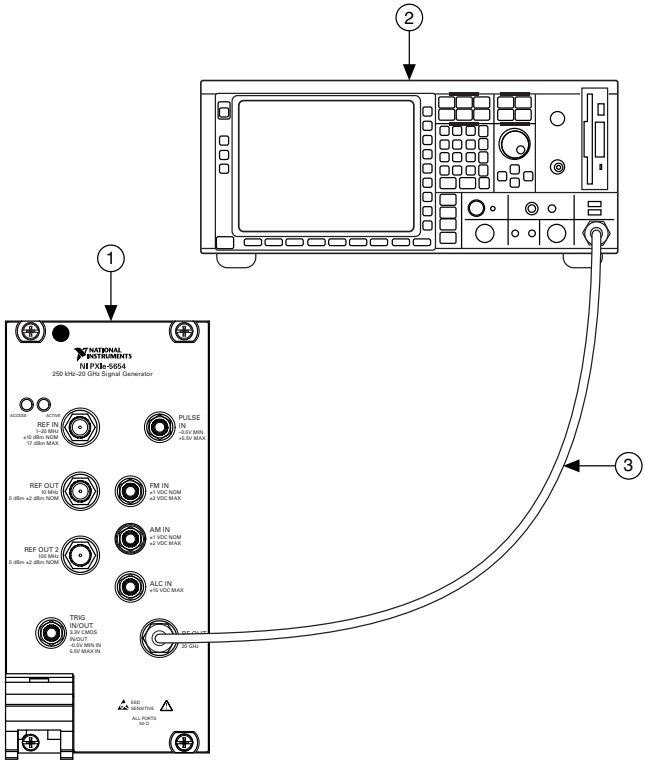
    Initial Accuracy = ±0.1 ppm
    Temperature Stability (15 °C to 35 °C) = ±0.2 ppm
    Ten year aging = 1.25 ppm
13. Repeat steps 4 through 12 for the remaining frequencies in the list created in step 3.
14. Close the device session.

Verifying RF OUT Phase Noise

This procedure verifies that the internal frequency generation circuitry is adjusted for correct phase noise accuracy.

1. Connect the PXIe-5654 RF OUT front panel connector to the signal source analyzer RF input connector using the K(m)-to-K(m) cable as shown in the following figure.

Figure 6. RF OUT Phase Noise Verification Equipment Setup (Reference Connections Not Shown)



1. PXIe-5654 RF Analog Signal Generator
2. Signal Source Analyzer
3. K(m)-to-K(m) Cable

2. Create a new device session for the PXIe-5654.
3. Configure the signal source analyzer using the following settings:
   - Phase noise measurement using cross-correlation phase-locked loops (PLLs) and internal generators
   - Automatic device under test (DUT) detection
   - Spur suppression enabled

- Fast Fourier transform (FFT) mode with Blackman-Harris window
- Measurement span from 100 Hz to 1 MHz (offset frequencies)

4. Use the signal source analyzer to perform a manual frequency sweep at the settings listed in the following table.

Table 3. RF OUT Manual Sweep Settings

Carrier Frequency Offset	Resolution Bandwidth	Cross Correlation
100 Hz to 300 Hz	10 Hz	100
300 Hz to 1 kHz	30 Hz	1,000
1 kHz to 3 kHz	100 Hz	10,000
3 kHz to 10 kHz	300 Hz	10,000
10 kHz to 30 kHz	1 kHz	10,000
30 kHz to 100 kHz	1 kHz	5,000
100 kHz to 300 kHz	3 kHz	1,000
300 kHz to 1 MHz	10 kHz	1,000

5. Configure the PXIe-5654 using the following settings:
   - Frequency: 500 MHz
   - Power Level: +8 dBm
6. Commit the settings to hardware if this is the first iteration of running this procedure; otherwise skip to step 9.
7. Initiate signal generation.
8. Enable the RF output.
9. Set the signal source analyzer center frequency to 500 MHz if the signal source analyzer does not automatically center for phase noise measurements.
10. Check the signal generation status and verify that there are no reported errors or warnings.
11. Measure the phase noise using the signal source analyzer for every offset value in the following table. Record the measurements.
12. Ensure that the recorded measurements are within the limits set in the following tables.

Table 4. RF OUT Phase Noise (dBc/Hz) As-Found Limits

Offset	Carrier Frequency				
	500 MHz	1 GHz	5 GHz	10 GHz	20 GHz
100 Hz	≤-107	≤-101	≤-87	≤-81	≤-75
1 kHz	≤-127	≤-121	≤-109	≤-103	≤-97
10 kHz	≤-135	≤-130	≤-120	≤-114	≤-108

Table 4. RF OUT Phase Noise (dBc/Hz) As-Found Limits (Continued)

Offset	Carrier Frequency				
	500 MHz	1 GHz	5 GHz	10 GHz	20 GHz
100 kHz	≤-137	≤-131	≤-122	≤-117	≤-111
1 MHz	≤-138	≤-132	≤-125	≤-119	≤-113

Table 5. RF OUT Phase Noise (dBc/Hz) As-Left Limits

Offset	Carrier Frequency				
	500 MHz	1 GHz	5 GHz	10 GHz	20 GHz
100 Hz	≤-108.5	≤-102.5	≤-88.5	≤-82.5	≤-76.5
1 kHz	≤-128.5	≤-122.5	≤-110.5	≤-104.5	≤-98.5
10 kHz	≤-135.5	≤-130.5	≤-120.5	≤-114.5	≤-108.5
100 kHz	≤-138	≤-132	≤-123	≤-118	≤-112
1 MHz	≤-138.5	≤-132.5	≤-125.5	≤-119.5	≤-113.5

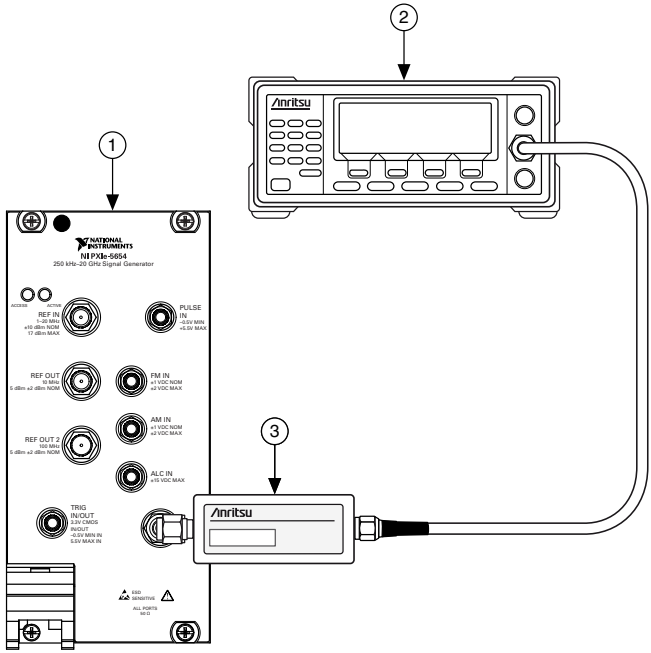
13. Repeat steps 5 through 12 for 1 GHz, 5 GHz, 10 GHz, and 20 GHz carrier frequencies.
14. Close the device session.

Verifying RF OUT Maximum Power

This procedure verifies that the internal signal generation circuitry produces the correct maximum output power.

1. Connect the power sensor to the PXIe-5654 RF OUT front panel connector as shown in the following figure.

Figure 7. RF OUT Maximum Power Verification Equipment Setup



1. PXIe-5654 RF Analog Signal Generator
2. Power Meter
3. Power Sensor

2. Initialize a new external calibration session for the PXIe-5654.
3. Create a list of test frequencies using the following table.

Table 6. RF OUT Maximum Power Test Frequencies

Start Frequency (MHz)	Stop Frequency (MHz)	Frequency Step (MHz)
0.25	0.25	—
250	20,000	250

4. Configure the PXIe-5654 using the following settings:
   - Frequency: *Start Frequency* from the list created in step 3.
   - Automatic Thermal Correction: 0 (Disable)
   - Coarse Amplitude DAC[2]: 65535
5. Initiate signal generation if this is the first iteration of running this procedure; otherwise skip to step 6.

[2] This property is not publicly available. For more information about how to access this property, contact NI technical support.

6. Measure the PXIe-5654 RF OUT front panel connector power using the power meter. Correct the power meter reading for the RF frequency.
7. Verify that the output power measured in step 6 meets the limits in the following table.

Table 7. RF OUT Maximum Power Limits

Frequency (MHz)	As-Found Limit (dBm)	As-Left Limit (dBm)
0.25 to ≤250	>10	>12
>250 to ≤2,800	>13	>14.5
>2,800 to ≤4,370	>13	>15.2
>4,370 to ≤12,100	>13	>14
>12,100 to ≤18,000	>13	>15
>18,000 to 20,000	>12	>15.5

8. Repeat steps 4 through 7 for all test frequencies you created in step 3.
9. Close the external calibration session.

Optional Verification

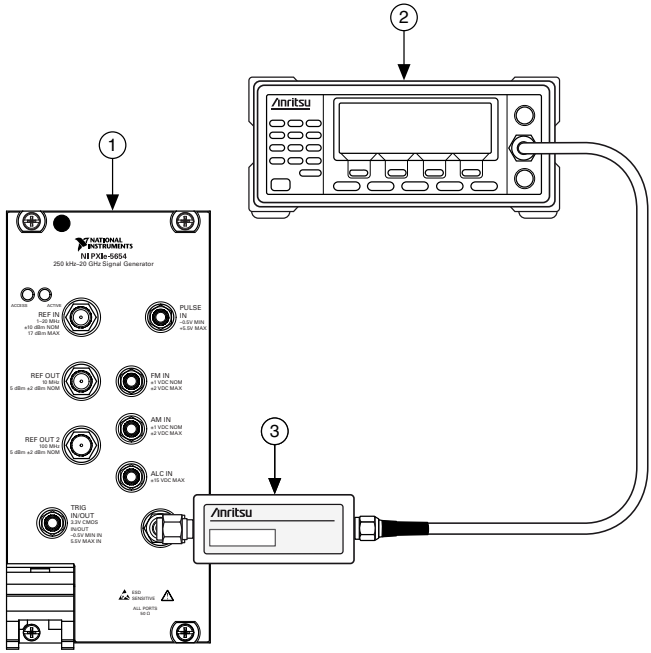
Use the following procedures to verify nonwarranted specifications for the PXIe-5654.

Verifying RF OUT Amplitude Accuracy

This procedure verifies that the internal signal generation circuitry is adjusted for correct amplitude accuracy.

1. Connect the power sensor to the PXIe-5654 RF OUT front panel connector as shown in the following figure.

Figure 8. RF OUT Amplitude Accuracy Verification Equipment Setup



1. PXIe-5654 RF Analog Signal Generator
2. Power Meter
3. Power Sensor

2. Create a new device session for the PXIe-5654.
3. Create a list of test frequencies using the settings in the following table.

Table 8. RF OUT Amplitude Accuracy Test Settings

Power Level (dBm)	Start Frequency (MHz)	Stop Frequency (MHz)	Frequency Step (MHz)
10	0.25	0.25	—
	250	20,000	250
0	0.25	0.25	—
	250	20,000	250
-7	0.25	0.25	—
	250	20,000	250

Table 8. RF OUT Amplitude Accuracy Test Settings (Continued)

Power Level (dBm)	Start Frequency (MHz)	Stop Frequency (MHz)	Frequency Step (MHz)
-10	0.25	0.25	—
	250	20,000	250

4. Configure the PXIe-5654 using the following settings:
   - Frequency: Frequency from the list in step 3
   - Power Level: 10 dBm, which is the *Expected Power (dBm)*
5. Commit the settings to hardware if this is the first iteration of running this procedure; otherwise skip to step 8.
6. Initiate signal generation.
7. Enable the RF output.
8. Check the signal generation status and verify that there are no reported errors or warnings.
9. Measure the PXIe-5654 RF OUT front panel connector power using the power meter. Correct the power meter reading for the RF frequency.

   This measurement is the *Measured Power (dBm)*.
10. Calculate the *Power Deviation (dB)* using the following formula:

    Power Deviation (dB) = Measured Power (dBm) - Expected Power (dBm)
11. Verify that the *Power Deviation (dB)* results in the previous step are within the limits listed in the following table.

Table 9. RF OUT Amplitude Accuracy Limits

Frequency	As-Found Limit	As-Left Limit
250 kHz to 250 MHz	±2.0 dB	±2.0 dB
>250 MHz to 20 GHz	±1.5 dB	±1.5 dB

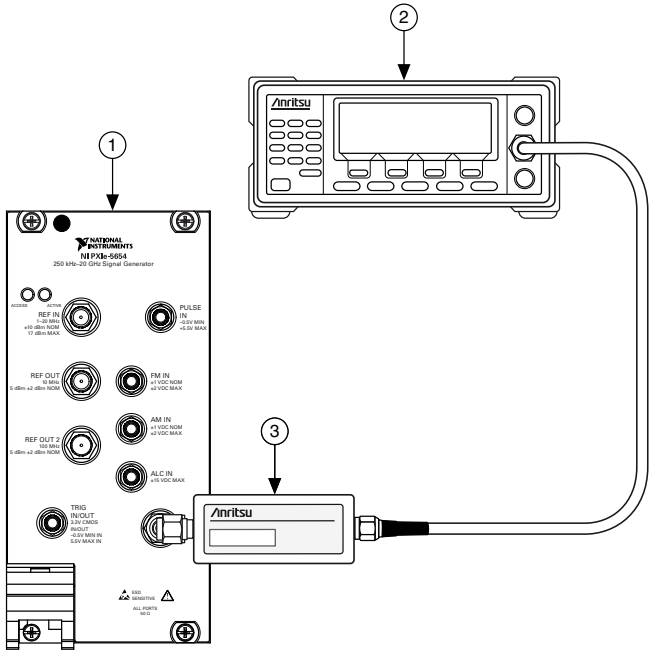
12. Repeat steps 4 through 11 for each test frequency, in the current output power level, in the list created in step 3.
13. Repeat steps 4 through 12 for the remaining output power levels for each test point in the list created in step 3.
14. Close the device session.

Verifying RF OUT Minimum Power

This procedure verifies that the internal signal generation circuitry can produce the correct minimum output power.

1. Connect the power sensor to the PXIe-5654 RF OUT front panel connector as shown in the following figure.

Figure 9. RF OUT Minimum Power Verification Equipment Setup



1. PXIe-5654 RF Analog Signal Generator
2. Power Meter
3. Power Sensor

2. Initialize a new external calibration session for the PXIe-5654.
3. Create a list of test frequencies using the following table.

Table 10. RF OUT Minimum Power Test Frequencies

Start Frequency (MHz)	Stop Frequency (MHz)	Frequency Step (MHz)
0.25	0.25	—
250	20,000	250

4. Configure the PXIe-5654 using the following settings:
   - Frequency: *Start Frequency* from the list created in step 3.
   - Automatic Thermal Correction: 0 (Disable)
   - Coarse Amplitude DAC[3]: 0
5. Initiate signal generation if this is the first iteration of running this procedure; otherwise skip to step 6.

[3] This property is not publicly available. For more information about how to access this property, contact NI technical support.

6. Measure the PXIe-5654 RF OUT front panel connector power using the power meter. Correct the power meter reading for the RF frequency.
7. Verify that the power output measured in step 6 meets the requirements in the following table.

Table 11. RF OUT Minimum Power Limits

Frequency (MHz)	As-Found Limit (dBm)	As-Left Limit (dBm)
0.25 to ≤250	<-13	<-13
>250 to ≤2,800	<-10	<-10
>2,800 to ≤4,000	<-9	<-9
>4,000 to ≤10,400	<-10	<-10
>10,400 to ≤19,000	<-7	<-7
>19,000 to 20,000	<-10	<-10

8. Repeat steps 4 through 7 for each test frequency in the list you created in step 3.
9. Close the external calibration session.

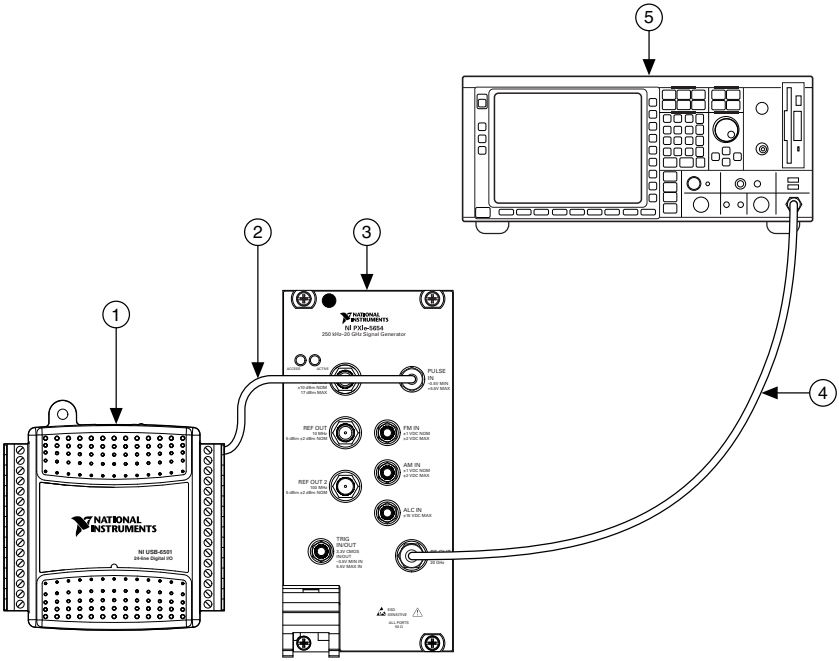
Verifying PULSE IN Operation

This procedure verifies that the PXIe-5654 PULSE IN connection is functioning.

1. Connect the signal source analyzer RF input to the PXIe-5654 RF OUT front panel connector using the K(m)-to-K(m) cable.
2. Connect the Port 0, Line 0 (P0.0) output of the USB digital output device to two separate connectors using a BNC Tee connector and a BNC(m)-to-terminal block adapter.
   a) Connect the P0.0 output of the USB digital output device to the signal source analyzer EXT TRIG/GATE IN back panel connector using a BNC(m)-to-BNC(m) cable. (Not pictured.)
   b) Connect the P0.0 output of the USB digital output device to the PXIe-5654 front panel PULSE IN connector using BNC(m)-to-SMB(f) cable.

   The hardware setup is shown in the following figure.

Figure 10. PULSE IN Operation Verification Equipment Setup



1. USB-6501 Digital I/O Device
2. BNC(m)-to-SMB(f) Cable
3. PXIe-5654 RF Analog Signal Generator
4. K(m)-to-K(m) Cable
5. Signal Source Analyzer

3. Create a new device session for the PXIe-5654.
4. Configure the signal source analyzer using the following settings:
   - Reference level: 5 dBm
   - Start frequency: 0.25 MHz
   - Stop frequency: 10,000 MHz
   - Span (kHz): 2 KHz
   - Resolution bandwidth: 30 Hz
   - Video bandwidth: 100 Hz
   - RF attenuation: 30 dB
5. Configure the PXIe-5654 using the following settings:
   - Pulse Modulation Enabled: TRUE
   - Frequency: 5 GHz
   - Power Level: 10 dBm
6. Commit the settings to hardware.
7. Initiate signal generation.
8. Enable the RF output.

9. Create a USB digital output channel for the Port 0, Line 0 of the USB digital output device.
10. Configure the channel to be Active Drive.
11. Enable the output on the channel created in step 9.
12. Start the USB digital output task for the channel.
13. Sweep the signal source analyzer and read the marker. This value is the *OnPower*.
14. Stop the USB digital output task.
15. Clear the USB digital output task.
16. Repeat steps 9 and 10, disabling the output of the USB digital output channel.
17. Sweep the signal source analyzer and read the marker. This value is the *OffPower*.
18. Verify that the following equation is true.

    OnPower - *OffPower* ≥ 80 dB
19. Close the device sessions.

Adjustment

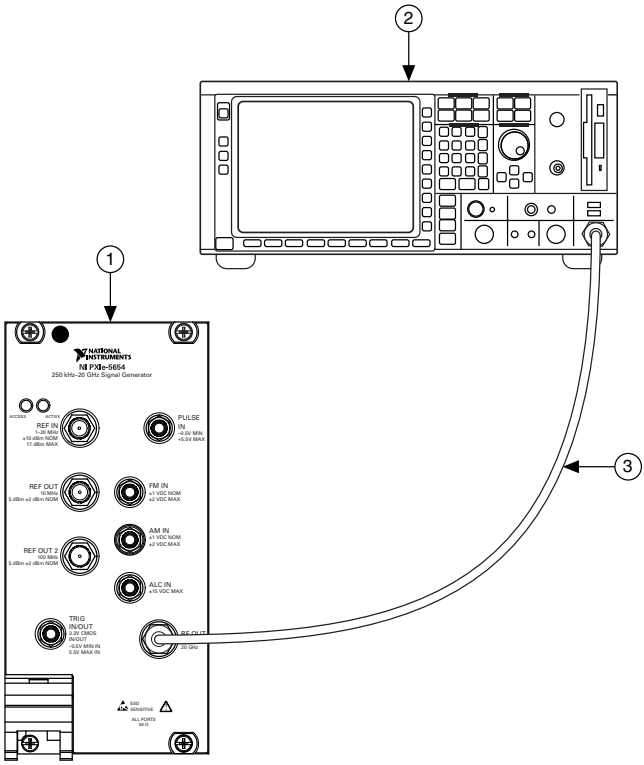
This section describes the steps needed to adjust the PXIe-5654 to meet published specifications.

Adjusting Frequency Reference Accuracy

This procedure adjusts the PXIe-5654 frequency accuracy performance using a signal source analyzer. This adjustment yields a more accurately tuned voltage-controlled oscillator (VCO) frequency.

1. Connect the PXIe-5654 RF OUT front panel connector to the signal source analyzer RF input connector using the K(m)-to-K(m) cable as shown in the following figure.

Figure 11. Frequency Reference Accuracy Adjustment Equipment Setup (Reference Connections Not Shown)



1. PXIe-5654 RF Analog Signal Generator
2. Signal Source Analyzer
3. K(m)-to-K(m) Cable

2. Configure the signal source analyzer using the following settings:
   - Center frequency: 10 GHz
   - Reference level: 10 dBm
   - Frequency counter resolution: 0.1 Hz
   - Reference Clock source: External
3. Call the niRFSG Initialize External Calibration VI using the appropriate password.

   Note The default password for password-protected operations is `NI`.

4. Call the niRFSG 5654 OCXO Cal Initialize VI.
5. Call the niRFSG 5654 OCXO Cal Configure VI.
6. Use the signal source analyzer to measure the frequency at the peak of the signal.
7. Use the frequency measured in step 6 as the value of the **measured frequency** input of the niRFSG 5654 OCXO Cal Adjust VI.

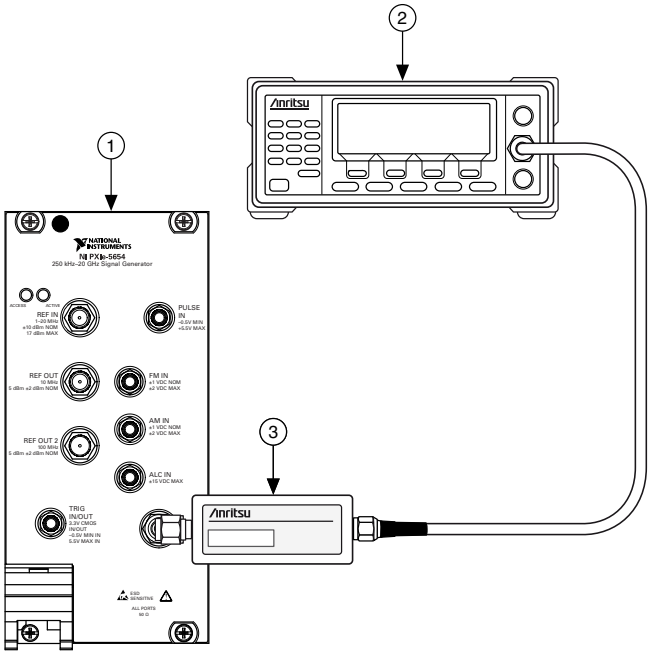
8. Repeat steps 5 through 7 until the **OCXO calibration complete** output of the niRFSG 5654 OCXO Cal Adjust VI returns a value of TRUE.
9. Call the niRFSG Close External Calibration VI to close the session. Set the **write calibration to hardware?** parameter to TRUE to store the results to the EEPROM on the PXIe-5654.

Adjusting RF OUT Power

This procedure adjusts the PXIe-5654 RF OUT power using a power meter. This adjustment yields a more accurate output power for the PXIe-5654 RF OUT front panel connectors.

1. Connect the power sensor to the PXIe-5654 RF OUT front panel connector as shown in the following figure.

Figure 12. RF OUT Power Adjustment Equipment Setup



1. PXIe-5654 RF Analog Signal Generator
2. Power Meter
3. Power Sensor

2. Call the niRFSG Initialize External Calibration VI using the appropriate password.

Note The default password for password-protected operations is `NI`.

3. Call the niRFSG 5654 Power Cal Initialize VI.
4. Call the niRFSG 5654 Power Cal Configure VI.

5. Measure the PXIe-5654 output power with the power meter. Correct the measurement for the frequency output in step 4.
6. Use the power measured in step 5 as input of the niRFSG 5654 Power Cal Adjust VI.
7. Repeat steps 4 through 6 until the **power calibration complete** output of the niRFSG 5654 Power Cal Adjust VI returns a value of TRUE.
8. Call the niRFSG Close External Calibration VI to close the session. Set the **write calibration to hardware?** parameter to TRUE to store the results to the EEPROM on the PXIe-5654.

Reverification

Repeat the *Verification* section to determine the as-left status of the PXIe-5654.

Note If any test fails reverification after performing an adjustment, verify that you have met the test conditions before returning your PXIe-5654 to NI. Refer to the *Worldwide Support and Services* section for information about support resources or service requests.

Related Information

Test Conditions on page 6

Updating Calibration Date and Time

This procedure updates the date and time of the last calibration of the PXIe-5654.

1. Call the niRFSG Initialize External Calibration VI.
2. Call the niRFSG Update External Calibration Date and Time VI.
3. Call the niRFSG Close External Calibration VI to close the session. Set the **write calibration to hardware?** parameter to TRUE to store the results to the EEPROM on the PXIe-5654.

Worldwide Support and Services

The NI 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.

Visit *ni.com/services* for information about the services NI offers.

Visit *ni.com/register* to register your NI product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

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support outside the United States, visit the *Worldwide Offices* section of *ni.com/niglobal* to access the branch office websites, which provide up-to-date contact information.

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