Calibration Procedure

PXIe-5842 VST3

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PXIe-5842 VST3 Calibration Procedure

This document contains the verification and adjustment procedures for the PXIe-5842 RF PXI Vector Signal Transceiver and associated PXIe-5655 RF Analog Signal Generator. Use the procedures in this document to automate calibration or to perform manual calibration.

Review and become familiar with the entire procedure before beginning the calibration process.

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1. Terms and Definitions

DUT	Refers to the NI product being calibrated, the device under test (DUT). In this procedure, DUT refers to the PXIe-5842 Vector Signal Transceiver.
As-Found Limits	Derived from the published specifications for the DUT. NI uses these limits to determine if the DUT is performing within the recommended calibration interval specifications at the time of calibration and before any adjustment is performed.
As-Left Limits	Derived from the published specifications for the DUT minus guard band to ensure a high probability that the DUT will meet its specifications over the next recommended calibration interval.
Functional Test	Determines whether the DUT is operating correctly. Functional tests are not directly related to performance specifications.
Verification	Evaluates the measured calibration results against the defined As-Found Limits. The result of the evaluation is expressed as a Pass/Fail condition in the calibration certificate using an established evaluation formula.
Adjustment	Performs a set of operations on the DUT to optimize the measurement performance and conform it to the assigned calibrated values.
Reverification	Evaluates the measured calibration results against the As-Left limits after adjustment. The As-Left limits may be tighter than the As-Found limits.
Recommended Calibration Interval	Indicates the recommended period between each round of verification and adjustment of the DUT. There is a high probability that, within this interval, the DUT will remain within the published warranted performance specifications. Some measurement DUTs have warranted specifications for different calibration intervals, for example: 24 hours, 90 days, 1 year, and 2 years. In this case, the specification depends on the calibration cycle chosen by the user.

2. Calibration Overview

Recommended Calibration Interval
1 year

Password
NI

Note
This is the default password for all password-protected operations. This password is site-specific.

PXIe-5842 (Receiver and Transmitter) Estimated Test Time [hours:minutes]

Task	26.5 GHz option	18 GHz option	12 GHz option	8 GHz option
Warm Up	≥ 0:30	≥ 0:30	≥ 0:30	≥ 0:30
Verify Only 500 MHz BW	3:55	3:00	2:20	1:55
Verify Only 1 GHz BW	4:05	3:10	2:30	2:00
Verify Only 2 GHz BW	4:25	3:25	2:40	2:10
Verify, Adjust, Reverify 500 MHz BW	10:15	8:40	7:30	6:40
Verify, Adjust, Reverify 1 GHz BW	10:50	9:10	7:55	7:05
Verify, Adjust, Reverify 2 GHz BW	11:35	9:50	8:30	7:35

PXIe-5842 (Receiver Only) Estimated Test Time [hours:minutes]

Task	26.5 GHz option	18 GHz option	12 GHz option	8 GHz option
Warm Up	≥ 0:30	≥ 0:30	≥ 0:30	≥ 0:30
Verify Only 500 MHz BW	2:30	1:55	1:25	1:05
Verify Only 1 GHz BW	2:40	2:00	1:30	1:10
Verify Only 2 GHz BW	2:50	2:10	1:35	1:15
Verify, Adjust, Reverify 500 MHz BW	6:55	6:05	5:30	5:45
Verify, Adjust, Reverify 1 GHz BW	7:15	6:25	5:50	5:20
Verify, Adjust, Reverify 2 GHz BW	7:50	6:55	6:15	7:35

PXIe-5842 (Transmitter Only) Estimated Test Time [hours:minutes]				
Task	26.5 GHz option	18 GHz option	12 GHz option	8 GHz option
Warm Up	≥ 0:30	≥ 0:30	≥ 0:30	≥ 0:30
Verify Only 500 MHz BW	2:10	1:40	1:15	0:55
Verify Only 1 GHz BW	2:20	1:45	1:15	1:00
Verify Only 2 GHz BW	2:30	1:50	1:20	1:00
Verify, Adjust, Reverify 500 MHz BW	6:15	5:30	4:55	4:30
Verify, Adjust, Reverify 1 GHz BW	6:35	5:45	5:10	4:45
Verify, Adjust, Reverify 2 GHz BW	7:05	6:15	5:35	5:05

Note

Estimated test times assume the user is conducting an automated calibration.

Environmental Conditions	Verification	Adjustment
Ambient temperature	22.5 °C ± 2.5 °C	22.5 °C ± 2 °C
Internal DUT temperature range[1]	Tcal ± 2.5 °C	Tcal ± 2 °C
Relative humidity	Between 10% and 90%, noncondensing	

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[1] The internal temperature of the DUT is greater than the ambient temperature.

2.1. Device Under Test Overview

Figure 1 –PXIe-5842 VST multi-module instrument.

The PXIe-5842 consists of a PXIe-5842 and PXIe-5655 paired as a multi-module, known collectively as the PXIe-5842 VST. The calibration certificate will list both devices.

This instrument must be calibrated as a paired single unit to meet the published specifications. If either of the calibrated, paired PXIe-5842 and PXIe-5655 modules are replaced, the calibration becomes invalid and the “new” instrument must be calibrated.

2.2. Calibration Procedure Overview

Use the calibration sequence described in the flow chart to perform Verification and Adjustment for the PXIe-5842 VST, if needed. When calibrating the PXIe-5655 independently, follow instructions in the *PXIe-5655 Calibration Procedure*.

Note

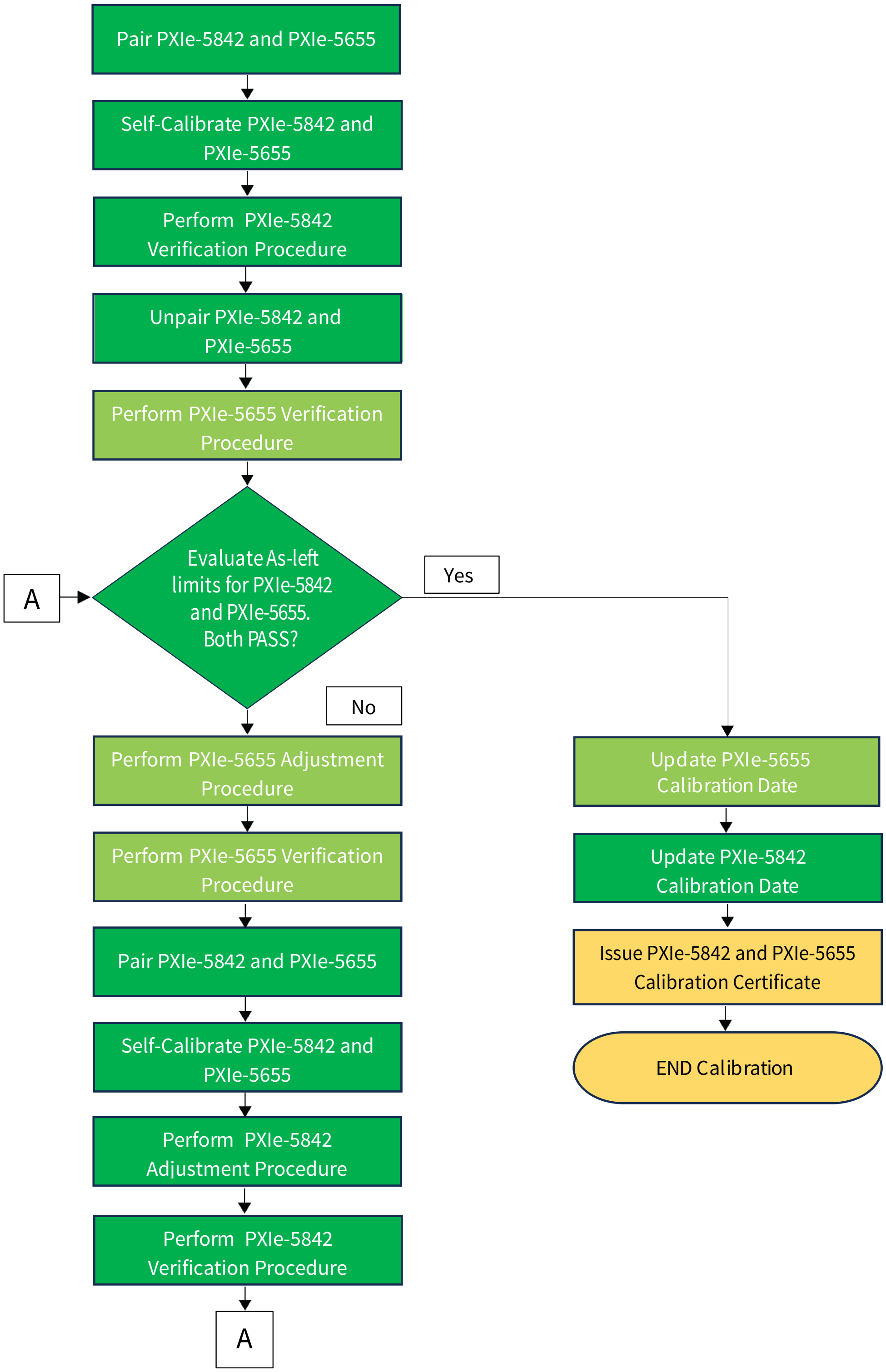
The verification and adjustment procedures for the PXIe-5655 RF Analog Signal Generator are documented in a separate document, *PXIe-5655 Calibration Procedure*. The PXIe-5655 is not required to be adjusted prior to pairing it with the PXIe-5842. If it fails the verification process, it must be adjusted and verified again prior to performing verification when paired with the PXIe-5842.

This calibration procedure includes calibration, verification, and adjustment steps as shown in the following flow chart.

Note

Pair devices by connecting all the semi-rigid cables between the PXIe-5842 and PXIe-5655. Select the associated LO to the PXIe-5842 device in NI MAX.

Unpair devices by disconnecting all the semi-rigid cables between the PXIe-5842 and PXIe-5655. There is no need to unpair in NI MAX.


Pair PXIe-5842 and PXIe-5655
Self-Calibrate PXIe-5842 and PXIe-5655
Perform PXIe-5842 Verification Procedure
Unpair PXIe-5842 and PXIe-5655
Perform PXIe-5655 Verification Procedure
A
Evaluate As-left limits for PXIe-5842 and PXIe-5655. Both PASS?
Yes
No
Perform PXIe-5655 Adjustment Procedure
Perform PXIe-5655 Verification Procedure
Pair PXIe-5842 and PXIe-5655
Self-Calibrate PXIe-5842 and PXIe-5655
Perform PXIe-5842 Adjustment Procedure
Perform PXIe-5842 Verification Procedure
A
Update PXIe-5655 Calibration Date
Update PXIe-5842 Calibration Date
Issue PXIe-5842 and PXIe-5655 Calibration Certificate
END Calibration

Note
Verification and adjustment procedures for the PXIe-5655 RF Analog Signal Generator are documented in a separate document, *PXIe-5655 Calibration Procedure*.

2.3. Calibration Condition Guidelines

- Keep cabling as short as possible. Long cables act as antennas, picking up extra noise that can affect measurements.
- Ensure that all connections to the DUT are secure.
- Allow adequate warm-up time for all components of the calibration system.
- Make all connections as shown in diagrams.
- Ensure that the PXI/PXI Express chassis fan speed is set to Auto, that the fan filters are clean, and that the empty slots contain filler panels. For more information, refer to the Maintain Forced-Air Cooling Note to Users document available at ni.com/manuals.
- If a DUT fails reverification after adjustment, ensure that the Test Conditions have been met before returning the DUT to NI.

3. Calibration Resources

3.1. Required Software

Note
Ensure that the most recent version of the required driver software is installed before conducting the calibration.

Install the following software on the calibration system:

- RFSA 23.5
- RFSG 23.5

3.2. Recommended Documentation

Go to `ni.com/docs` to locate the following documentation for more information when performing this calibration:

- *PXIe-5655 Calibration Procedure*

3.3. Verification Prerequisites

To Verify and Adjust PXIe-5842 you must be able to Verify and Adjust the associated RF Signal Generator PXIe-5655. Refer to the PXIe-5655 Calibration Procedure, available at ni.com/docs for further details.

3.4. Test Equipment

This section details the equipment NI recommends for each test performed as part of this calibration procedure.

NI Calibration Executive Users
Refer to the Calibration Executive Help to find an updated list of test equipment for this calibration procedure.

Standard	Recommended Model	Where Used	Functional Requirement(s)
Chassis	PXIe-1095 PN-785971-01	All	Timing Sync Option
Controller	PXIe-do PN-786636-01	All	16GB RAM/500GB SSD
Phase noise and Spectrum analyzer	R&S FSWP26	6.2 RF Input Third Order Intermodulation Verification 6.8 RF Output Average Noise Density Verification 6.9 RF Output Harmonic Spurs Verification 6.10 RF Output Third Order Intermodulation Verification	Options: B1, B4, B24 and B61
Power Sensor (#1)	R&S NRP33S	5.1 Receiver Fixture Characterization 5.2 Cable loss Characterization 6.5 RF Input Absolute Amplitude Verification 6.6 RF Input Power Linearity Verification 6.7 RF Input Frequency Response Verification	NA
Power Sensor (#2)	R&S NRP33S	5.1 Receiver Fixture Characterization 5.2 Cable loss Characterization 6.3 RF Output Absolute Amplitude Verification	NA

		6.4 RF Output Frequency Response Verification 7.1 Reference Clock Gain Adjustment 7.2 RF Transmission LO Output Adjustment 7.3 RF Receiver LO Output Adjustment	
Signal Generator (x2)	R&S SMA100B 31.8 GHz	5.1 Receiver Fixture Characterization 5.2 Cable loss Characterization 6.2 RF Input Third Order Intermodulation Verification (x2) 6.5 RF Input Absolute Amplitude Verification 6.6 RF Input Power Linearity Verification 6.7 RF Input Frequency Response Verification	Options: B131, B35, K36, and B86.
10 MHz Rb Reference standard	Microchip 8040	All	Reference Clock Routing
GPIB to USB Adapter (x3)	NI 783368-01	All	NA
36” SMA (m) to BNC (m) cable	Fairview Microwave FMC0208315-36	All	Reference Clock Routing
36” BNC (m) to BNC (m) cable (x3)	Fairview Microwave FMC0808058-36	All	Reference Clock Routing
36” 3.5 mm cable (m) to (m) (x5)	Maury SP-35-MM-36-LP	5.1 Receiver Fixture Characterization (cable #1) 5.2 Cable loss Characterization(Cable #A) 6.2 RF Input Third Order Intermodulation Verification (x3) 6.5 RF Input Absolute Amplitude Verification (cable #1) 6.6 RF Input Power Linearity Verification (cable #1)	f≥26.5 GHz VSWR ≤1.25

		6.7 RF Input Frequency Response Verification (cable #1) 6.8 RF Output Average Noise Density Verification (cable #A) 6.9 RF Output Harmonic Spurs Verification (cable #A) 6.10 RF Output Third Order Intermodulation Verification (cable #A)	
3.5 mm Power Splitter (2 resistor)	Keysight 11667B	5.1 Receiver Fixture Characterization #1 6.5 RF Input Absolute Amplitude Verification(#1) 6.6 RF Input Power Linearity Verification (#1) 6.7 RF Input Frequency Response Verification (#1)	VSWR ≤ 1.22
LF Power Combiner	Mini-Circuits ZFRSC-123-S+	6.2 RF Input Third Order Intermodulation Verification	DC to 12 GHz
HF 2.92 mm Power Combiner	Mini-Circuits ZC2PD-K0144+	6.2 RF Input Third Order Intermodulation Verification	1 GHz to 26 GHz
45° SMA (m) to (f) Adapter	Centric C3243	5.1 Receiver Fixture Characterization #1 6.5 RF Input Absolute Amplitude Verification(#1) 6.6 RF Input Power Linearity Verification (#1) 6.7 RF Input Frequency Response Verification (#1)	VSWR ≤ 1.12
3.5 mm (f) to (f) Adapter (x2)	Maury CC-A-35-FF	5.1 Receiver Fixture Characterization 5.2 Cable loss Characterization 6.8 RF Output Average Noise Density Verification (adapter #A) 6.9 RF Output Harmonic Spurs Verification (adapter #A)	VSWR ≤ 1.12

		6.10 RF Output Third Order Intermodulation Verification (adapter #A)	
3.5mm (m) to (m) Adapter	Maury CC-A-35-MM	5.1 Receiver Fixture Characterization (#1) 6.5 RF Input Absolute Amplitude Verification(#1)	VSWR ≤ 1.12
3.5 mm (m) 50 Ω Terminator	Pasternack PE6TR1109	6.11 RF Input Average Noise Density Verification	VSWR ≤ 1.15
Laboratory Mini Scissor Lift Jack	NA	To support Power Sensors	NA

4. Preliminary Actions

4.1. Warm Up the DUT

Warm-up time starts after the installed DUT is powered on in the chassis. Warm-up time resets after the DUT is removed from the chassis. This DUT requires 30 minutes to warm up prior to conducting any tests.

Note
Observe adequate warm-up time for all components of the calibration system.

4.2. Perform Self-Calibration

Self-calibration should be performed after the DUT has warmed up for the recommended time period. This function measures the onboard reference voltage of the DUT and adjusts the self-calibration constants to account for any errors caused by short-term fluctuations in the environment.

Complete the following steps to conduct self-calibration using Measurement & Automation Explorer (MAX).

> **Note**
> Disconnect all external signals before beginning self-calibration.

1. Launch MAX.
2. Select My System»Devices and Interfaces»*[DUT model name]*.
3. Start self-calibration by:
4. Open an RFSA or RFSG session (based on your hardware license) and run AelfCal.vi.

4.3. Zeroing the Power Meter

- Ensure that the power meter is not connected to any signals.
- Zero the power meter using the built-in function, according to the power meter documentation.

5. Perform Characterization

5.1. Receiver Fixture Characterization

This procedure determines the correction factors to apply due to power splitter, cables and connectors that are used to generate a known output power at different frequencies.

The power meter and signal generator are connected to the DUT receiver via a 2-resistor splitter. During external adjust, RF Input Absolute Amplitude Accuracy Verification, and RF Input Frequency Response Verification, a frequency sweep is done with both the power meter and DUT simultaneously.

If you disassemble this fixture, you must recharacterize it before it is used again.

5.1.1. Test Points and Limits

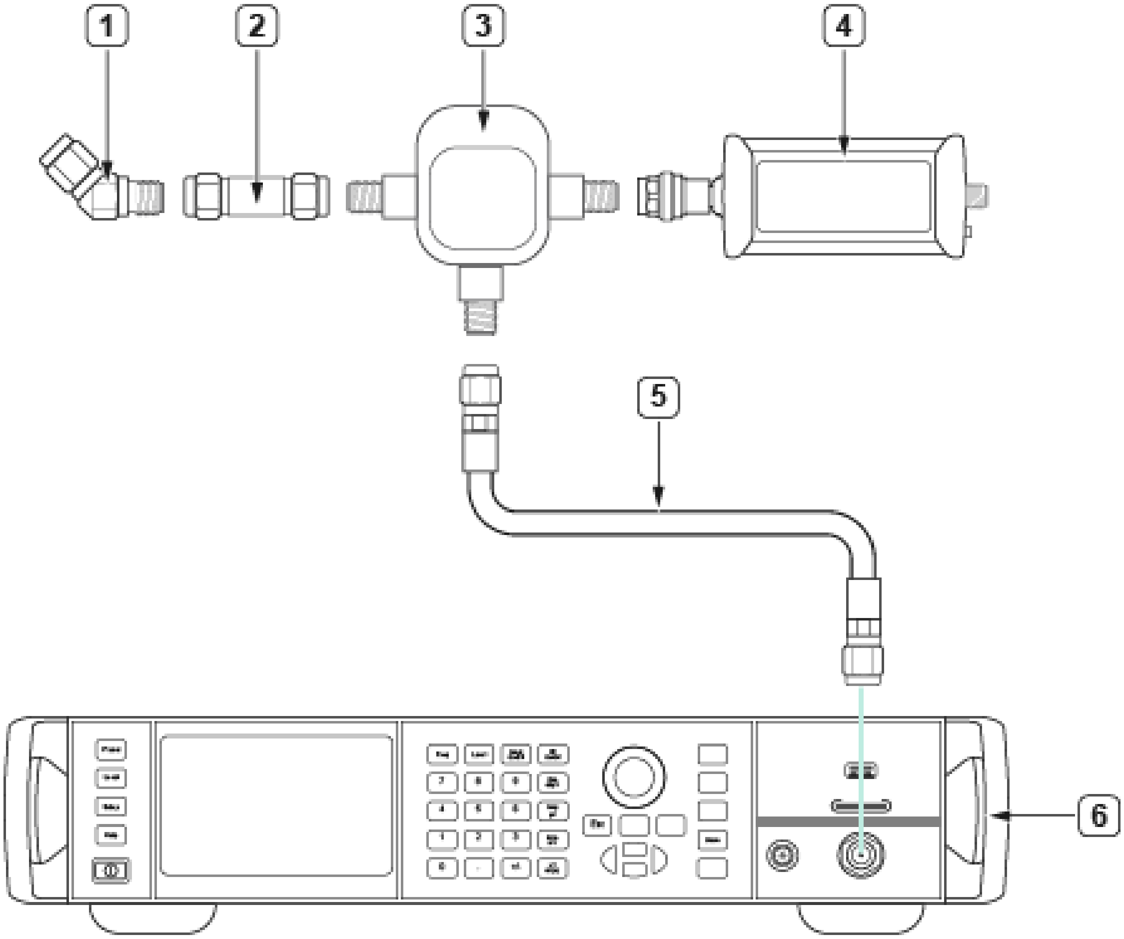
Table 1: Receiver Fixture Characterization Test Points

Range	Frequency step	
	Version	Step
30 MHz to 8.0 GHz	F08	5 MHz
30 MHz to 12.0 GHz	F12	5 MHz
30 MHz to 18 GHz	F18	5 MHz
30 MHz to 26.5 GHz	F26	5 MHz

5.1.2. Initial Test Connections

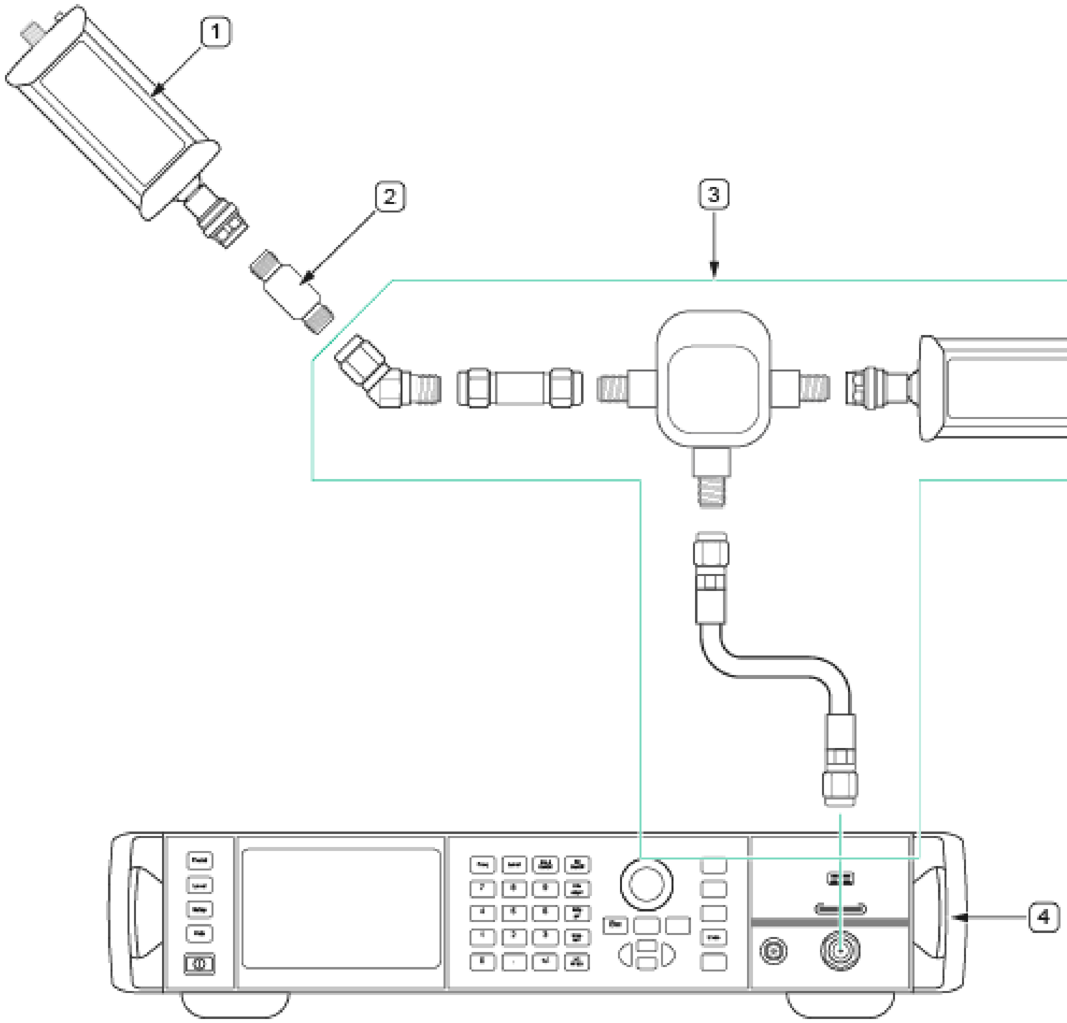
> **Note**
> Make the connections indicated in **Figure 2** and **Figure 3**.

Figure 2. Initial Connection for Receiver Fixture Characterization



1. 45° SMA Male to Female Adapter
2. 3.5 mm Male to Male Adapter
3. 3.5 mm Power Splitter (2 resistor)
4. Power Sensor #1
5. 36” 3.5 mm cable Male to Male #1
6. Signal Generator

Figure 3. Final Measurement Connections for Receiver Fixture Characterization



1. Power Sensor #2
2. 3.5 mm Female to Female Adapter
3. Receiver Fixture from **Figure 2**
4. Signal Generator

5.1.3. Characterization Procedure

1. Assemble the Receiver fixture as per **Figure 2**.
2. Make the final measurement connections as per **Figure 3**.
3. Set the following settings on the Signal Generator:

  - Power: 0 dBm
  - RF Frequency: 30 MHz

For each test point range in **Table 1**, repeat the following steps.

1. Set the initial power level of the signal generator to 0 dBm, record this value as the $\mathtt{Requested\_TX\_Power}_0$.
2. Set the RF Frequency to the next value in the Frequency sweep.
3. Measure the power from the Characterization Power Sensor (#2), record this value as $\mathtt{RX\_Path\_Measurement}_i$ (where $\mathtt{i}$ is the $\mathtt{i}^{th}$ iteration of this measurement), starting at zero.
4. Measure the power from the RX Cal Fixture Power Sensor #1, record this value as $\mathtt{PM\_Path\_Measurement}_i$.
5. Evaluate whether the following is true:

$$\mathtt{Requested\_TX\_Power}_0 - 0.1 \le \mathtt{RX\_Path\_Measurement}_i \le \mathtt{Requested\_TX\_Power}_0 + 0.1$$

6. If the above evaluation is false, set the power level of the signal generator to:

$$\mathtt{Requested\_TX\_Power}_i = \mathtt{Requested\_TX\_Power}_0 + \mathtt{Correction}_i$$

where $\mathtt{Correction}_i = \mathtt{Requested\_TX\_Power}_0 - \mathtt{RX\_Path\_Measurement}_0$

7. Repeat from step 3 until the output of the RX Cal Fixture evaluation is true. If the evaluation is not true after four iterations, check the connections.
8. When the evaluation is true, record the following parameters:

$$\mathtt{RX\_Fixture\_PM\_to\_RX\_Path\_Response} = \mathtt{RX\_Path\_Measurement}_i - \mathtt{PM\_Path\_Measurement}_i$$

(***Equation 1***)

$$\texttt{RX\_Fixture\_TX\_to\_RX\_Path\_Response} = \texttt{Requested\_TX\_Power}_i + \texttt{Correction}_i - \texttt{RX\_Path\_Measurement}_i$$

(***Equation 2***)

Note
Do not disassemble the Receiver Fixture assembly, **Figure 2**, after characterization. If you disassemble this fixture, you must recharacterize it before it is used again.

5.2. Cable loss Characterization

Perform the following steps to characterize the cable loss for the TX Average Noise Density and Harmonic Spurs tests. This characterization should be run right after Receiver Fixture Characterization in section 5.1. The RX Fixture measurements are reused during these measurements.

5.2.1. Test Points

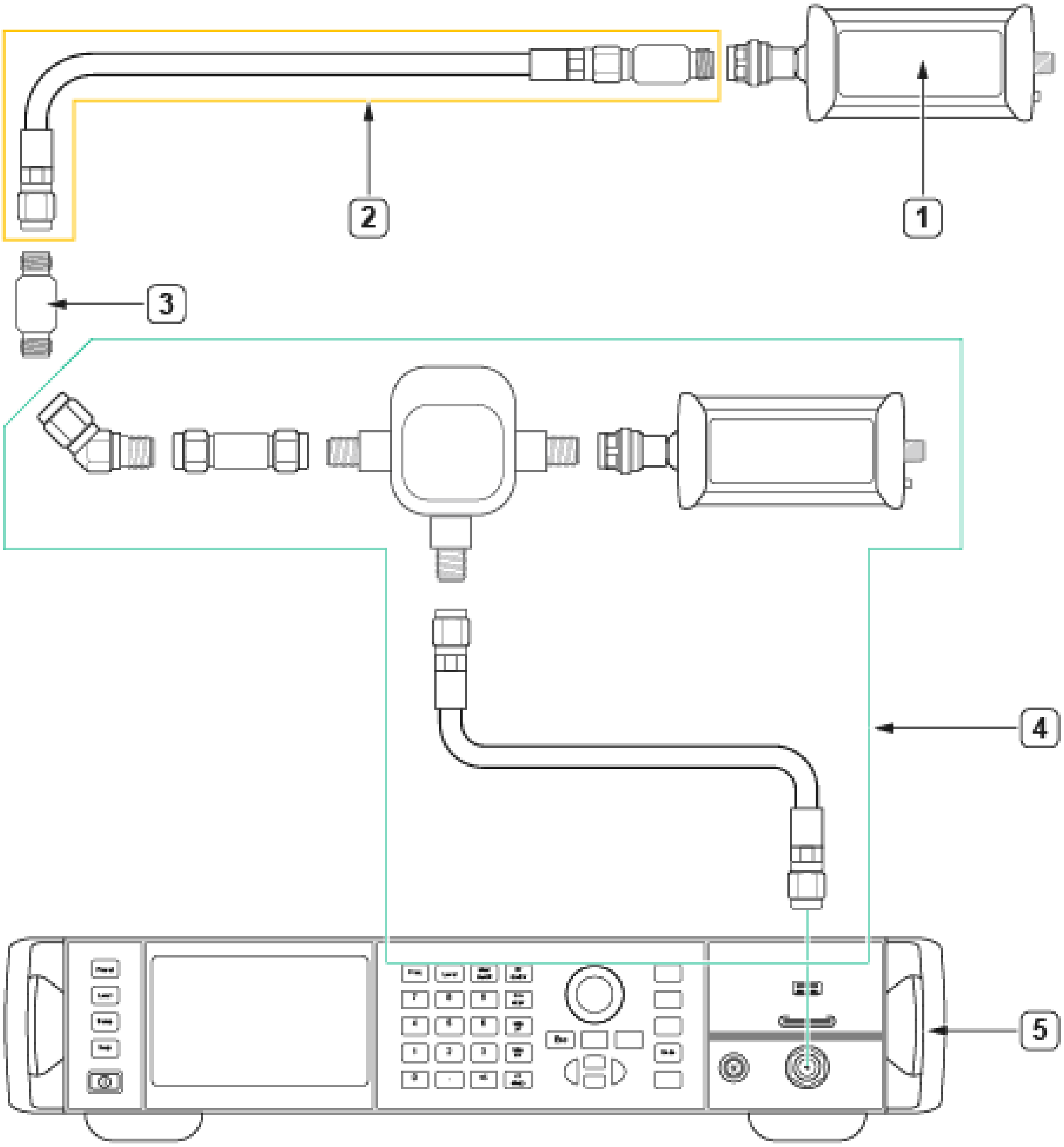
Table 2: Cable Loss Characterization Test Points

Range	Frequency step	
	Version	Step
30 MHz to 8.0 GHz	F08	5 MHz
30 MHz to 12.0 GHz	F12	5 MHz
30 MHz to 18 GHz	F18	5 MHz
30 MHz to 26.5 GHz	F26	5 MHz

5.2.2. Initial Test Connections

Make the connections indicated in **Figure 4.**

Figure 4. Connection for Transmit Cable Loss Characterization



1. Power Sensor #2
2. Cable Characterization Fixture
3. 3.5 mm (f) to (f) Adapter
4. Receiver Fixture
5. Signal Generator

5.2.3. Characterization Procedure

1. Make the cable loss connections as per **Figure 4**.
2. Set the following settings on the Signal Generator:
    - Power: 0 dBm
    - RF Frequency: 30 MHz

For each test point range in **Table 2**, repeat the following steps.

1. Measure the power from the Characterization Power Sensor #2, at the end of the 3.5 mm adapter (see **Figure 4**), and record this value as:
   $$\texttt{RX\_Path\_Cable\_Power}_i.$$
2. Measure the power from the RX Cal Fixture Power Sensor #1, record this value as:
   $$\texttt{PM\_Path\_Power}_i.$$
3. For each frequency range, record the path loss through the cable and adapter, using the following equation:
   $$\mathbf{\texttt{PM\_to\_RX\_Cable\_Path\_Response [dB]}} = \texttt{RX\_Path\_Cable\_Power}_i - \texttt{PM\_Path\_Power}_i - \texttt{RX\_Fixture\_PM\_to\_RX\_Path\_Response}_i$$

(***Equation 3***)

Where $\texttt{RX\_Fixture\_PM\_to\_RX\_Path\_Response}_i$ value was determined at step 5.1 Receiver Fixture Characterization.

Note

Do not disassemble the Receiver Fixture (see **Figure 4**) after characterization. If you disassemble this fixture, you must recharacterize it before it is used again.

Note
The cable and adapter (see **Figure 4**) characterized in this section should be kept together and identified to be used only where *36" 3.5 mm (m) to (f) cable fixture* is required throughout this calibration procedure.

6.Perform Verification

Table 3: DUT hardware options Maximum Frequency

Hardware Option	Maximum Frequency / IQ Center Frequency
F08	8.0 GHz
F12	12 GHz
F18	18 GHz
F26	26.5 GHz

Table 4: DUT hardware options Maximum Signal Bandwidth and IQ Rate

Hardware Option	Maximum Signal Bandwidth	Maximum IQ Rate
B05	500 MHz	625 MS/s
B10	1 GHz	1.25 GS/s
B20	2 GHz	2.5 GS/s

Table 5: Signal Bandwidth for Enabled Mode

IQCF/RF Frequency	Signal Bandwidth
1.70 GHz to < 5.25 GHz	B05: 250 MHz B10: 500 MHz B20: 600 MHz The maximum Signal Bandwidth is also limited by IQ Rate * 0.8
5.25 GHz to 26.5 GHz	B05: 250 MHz B10: 500 MHz B20: 900 MHz The maximum Signal Bandwidth is also limited by IQ Rate * 0.8

Note
Signal Bandwidth is based on the device's upconverter/downconverter value, but **Table 5** indicates required signal bandwidth values in terms of IQCF and RF Frequency because there is no direct control over it in **Enabled** mode.

Table 6: Signal Bandwidth for User Defined Mode

IQCF/RF Frequency	Maximum Settable Signal Bandwidth
30 MHz to < 1.75 GHz	Minimum of the following: ▪ Maximum BW for version: B05: 500 MHz B10: 1 GHz B20: 1.97 GHz ▪ Input: (2 GHz – IQCF) * 2 Output: (2 GHz – RF Frequency) * 2 ▪ Input:(IQCF – 30 MHz) * 2 Output:(RF Frequency – 30 MHz) * 2 ▪ IQ Rate * 0.8
1.75 GHz to 2.0 GHz	Minimum of the following: ▪ B05: 1 GHz – 2 * |XCFO|, capped at 500 MHz ▪ B10: 1 GHz – 2 * |XCFO|, capped at 1000 MHz ▪ B20: 1 GHz – 2 * |XCFO| ▪ IQ Rate * 0.8
>2.0 GHz to 5.8 GHz	Minimum of the following: ▪ B05: 1.4 GHz – 2 * |XCFO|, capped at 500 MHz ▪ B10: 1.4 GHz – 2 * |XCFO|, capped at 1000 MHz

	B20: 1.4 GHz – 2 * |XCFO| IQ Rate * 0.8
>5.8 GHz to 26.5 GHz	Minimum of the following: B05: 2.0 GHz – 2 * |XCFO|, capped at 500 MHz B10: 2.0 GHz – 2 * |XCFO|, capped at 1000 MHz B20: 2.0 GHz – 2 * |XCFO|

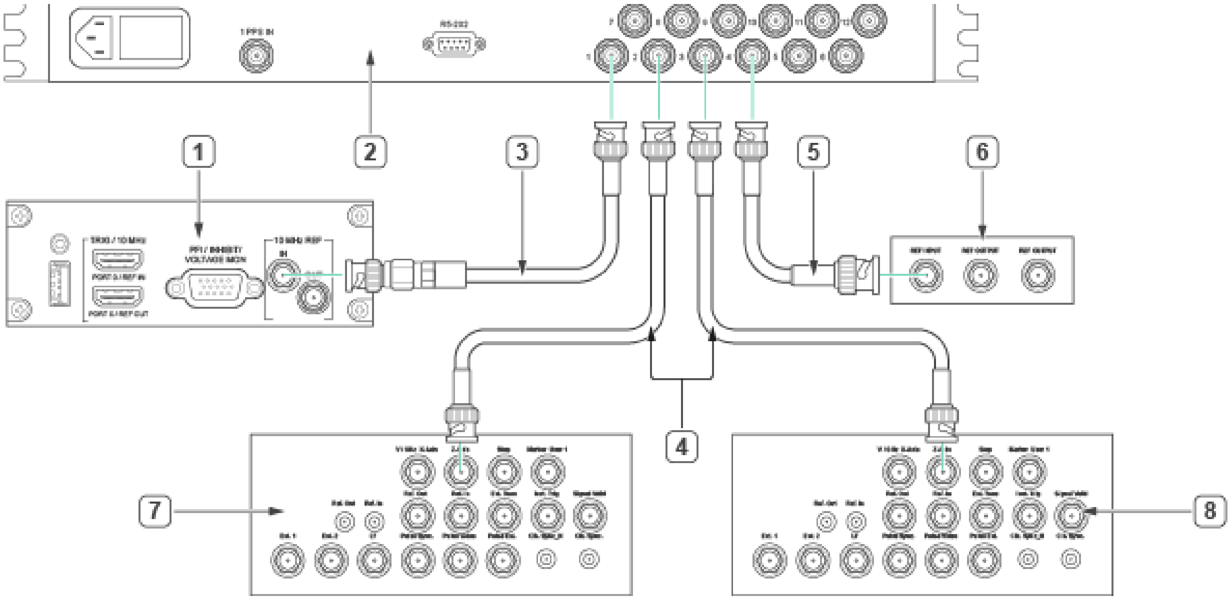
6.1. Initial Reference Clock Connections

The rubidium source must export its 10 MHz signal to the PXIe-1095 chassis PXI_CLK for all verify and adjust procedures. The Signal Generators (SMA 100B) and Spectrum Analyzer (FSWP) must also be connected to the 10 MHz source.

Connect the rubidium reference standard with the timing and sync module of the PXI chassis, the spectrum analyzer, and signal generators as shown in **Figure 5**.

Note
These connections must be made before any Verification or Adjustment procedures are performed.

Figure 5. External Reference Clock Connection



1. Timing and Sync Module of PXI Chassis
2. 10 MHz Rb Reference standard
3. SMA (m)-to-BNC (m) Cable
4. BNC (m)-to-BNC (m) Cable
5. BNC (m)-to-BNC (m) Cable
6. Back of Spectrum Analyzer (FSWP)
7. Back of Signal Generator #1 (SMA100B)
8. Back of Signal Generator #2 (SMA100B)

6.2. RF Input Third Order Intermodulation Verification

6.2.1. Standards Characterization and Test workflow

This characterization/measurement sequence was designed to minimize operator interactions and connections. The RF Input Third Order Intermodulation (TOI) Verification is performed as follows:

1. RF Input TOI Low Frequency Fixture Characterization, which includes Traceability Measurement for Low Frequency Fixture
2. RF Input TOI Low Frequency Test Execution
3. RF Input TOI High Frequency Fixture Characterization, which includes Traceability Measurement for High Frequency Fixture

4. RF Input TOI High Frequency Test Execution

6.2.2. Characterization Validation Minimum requirements

Table 7. Characterization Validation Acceptance Minimum Limits

IQ Center Frequency	Nominal Power Level	Acceptance Limit
30 MHz to 1.0 GHz	-36.0 dBm	0.0 dB
>1.0 GHz to 3.0 GHz		-3.0 dB
>3.0 GHz to 8.0 GHz		-4.0 dB
>8.0 GHz to 26.5 GHz		-2.0 dB
30 MHz to 1.0 GHz	-6.0 dBm	+26.0 dB
>1.0 GHz to 3.0 GHz		+26.0 dB
>3.0 GHz to 8.0 GHz		+25.0 dB
>8.0 GHz to 26.5 GHz		+27.0 dB
30 MHz to 1.0 GHz	+9.0 dBm	+41.0 dB
>1.0 GHz to 3.0 GHz		+41.0 dB
>3.0 GHz to 8.0 GHz		+40.0 dB
>8.0 GHz to 26.5 GHz		+41.0 dB

6.2.3. Input TOI Low Frequency Characterization points

Table 8. Input TOI Low Frequency Fixture Characterization Configurations

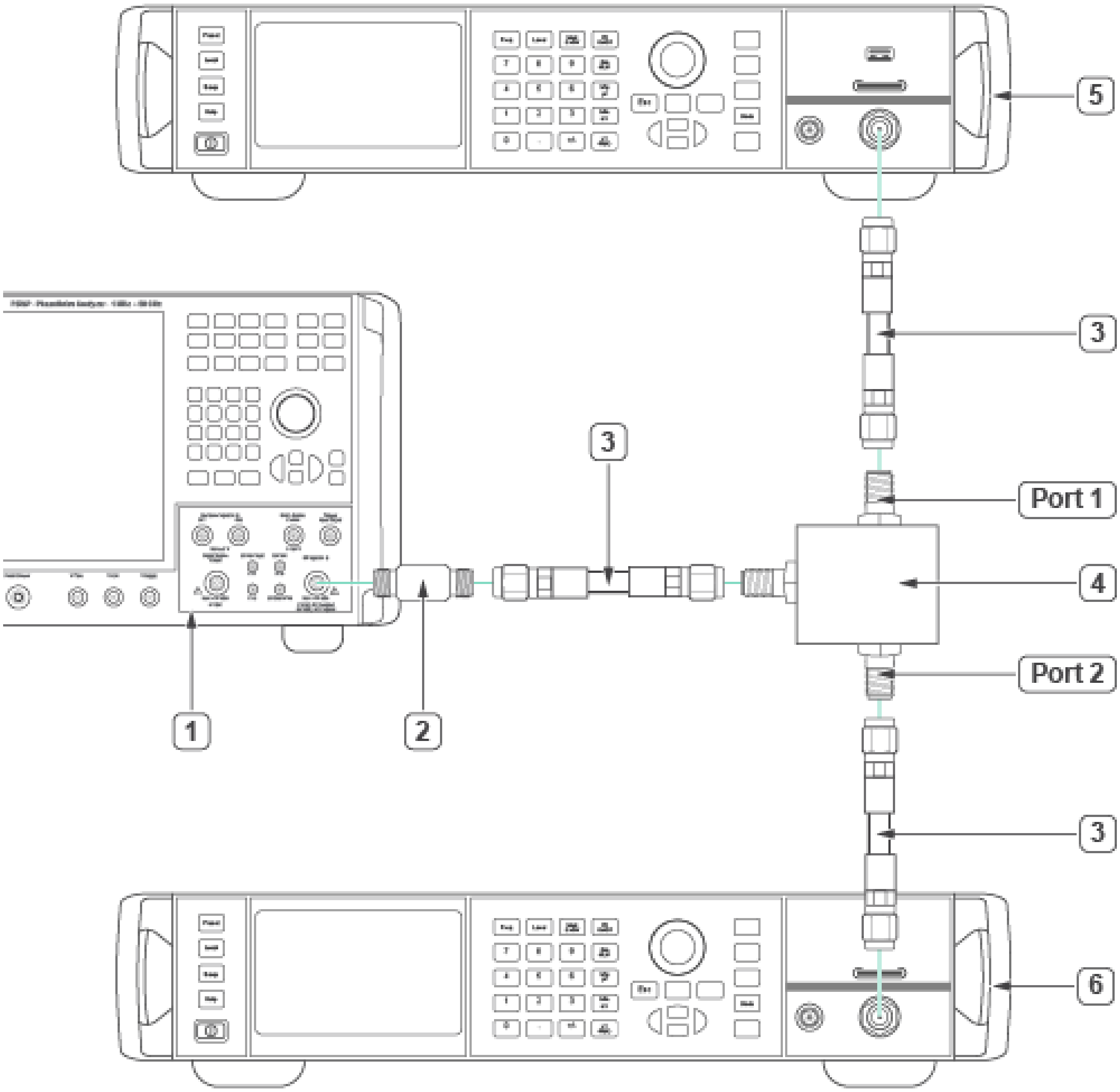
IQ Center Frequency	Nominal Power Level	Spectrum Analyzer Reference Level	Spectrum Analyzer Attenuation
30 MHz to 145 MHz in 5 MHz steps	-36.0 dBm	-30 dBm	0 dB
150 MHz to 190 MHz in 10 MHz steps	-6.0 dBm	0 dBm	20 dB
300 MHz to 1.0 GHz in 20 MHz steps	+9.0 dBm	+15 dBm	35 dB

6.2.4. Input TOI Low Frequency Initial Test Connection

Note

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

Figure 6. RF Input TOI Low Frequency Combiner Characterization Connections



1. Phase noise and Spectrum analyzer
2 3.5mm Male to Female Adapter
3. 36” 3.5 mm cable (m) to (m) (x3)
4. LF Power Combiner
5. Signal Generator #1
6. Signal Generator #2

6.2.5. RF Input TOI LF Power Combiner Characterization

The two tones at the output of the combiner must have the correct amplitude to perform the TOI verification. The combiner response is not linear with frequency and the power delivered by each individual generator also varies.
To ensure that the tones delivered through the combiner to the DUT have the adequate power at each frequency, the system must be characterized prior to performing the verification.

1. Make the connections indicated in Figure 6.
2. Configure the Signal Generator #1 for the following:
    - Power Level: Initial lower Nominal Power Level from **Table 8**.
    - Frequency: Initial IQ Frequency from **Table 8** + 10 MHz.
    - ALC: On.
3. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: Initial IQ Frequency from **Table 8** + 10 MHz.
    - Span: 1 kHz.
    - Reference Level: Initial Reference Level from Table 8.
    - Attenuation: Initial Attenuation from Table 8.
    - RBW: 30 Hz.
    - Sweep Count: 10001.
    - Mode: Auto Peak.
    - Reference Clock: 10 MHz, External.
4. Generate an RF signal on Signal Generator #1 with the specified settings and wait until it settles.
5. Characterize Port1:

> For each Signal Generator #1 Nominal Power Level in **Table 8**, starting with the lower power setting, repeat the following steps.

a. Record this Power Level value as "**Nominal_Power**"

Repeat once for each Signal Generator #1 IQ Center Frequency setting in Table 8.

1. Servo the RF power from the signal generator #1, until the Spectrum Analyzer measurement is equal to (**Nominal_Power** ± 0.075 dB).
2. Record the power setting from the signal generator #1 as:

   Combiner_Port1Low$_i$ [dBm]

   Where "$f(x)_i$" is a linear index number to identify each frequency within the sweep from 1 to n.
3. Configure the Signal Generator #1:
   - Power Level: Current Power iteration Nominal Power Level from **Table 8.**
   - Frequency: (Next IQ Frequency from **Table 8** + 10 MHz).
4. Configure the Spectrum Analyzer for the following settings:
   - Center Frequency: Same Frequency as the Signal Generator #1.
   - Reference Level: Current Power iteration Reference Level from **Table 8.**
   - Attenuation: Current Power iteration Attenuation from **Table 8.**
5. Configure the Signal Generator #1 for the following:
   - ○ Power Level: Next Nominal Power Level from **Table 8**.
   - ○ Frequency: (Initial IQ Frequency from **Table 8** + 10 MHz).

6. Disable the power output of Signal Generator #1.
7. Configure the Signal Generator #2 for the following:
   - Power Level: Initial lower Nominal Power Level from **Table 8**.

- Frequency: (Initial IQ Frequency from **Table 8** + 10.7 MHz).
- ALC: On.

8. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: (Initial Frequency from **Table 8** + 10.7 MHz).
    - Span: 1 kHz.
    - Reference Level: Initial Reference Level from Table 8.
    - Attenuation: Initial Attenuation from Table 8.
    - RBW: 30 Hz.
    - Sweep Count: 10001.
    - Mode: Auto Peak.
    - Reference Clock: 10 MHz, External.

9. Generate an RF signal on Signal Generator #2 with the specified settings, and wait until it settles.

10. Characterize Port2:

For each Signal Generator #2 Nominal Power Level in **Table 8**, starting with the lower power setting, repeat the following steps.

1. Record this Power Level value as “**Nominal_Power**.”

Repeat once for each Signal Generator #2 IQ Center Frequency setting in Table 8.

1. Servo the RF power from the signal generator #2, until the Spectrum Analyzer measurement is equal to (**Nominal_Power** ± 0.075 dB).

2. Record the power setting from the signal generator #2 as:

   $\text{Combiner\_Port2Low}_i$ [dBm]

   Where “$f(x)_i$” is a linear index number to identify each frequency within the sweep from 1 to n.

3. Configure the Signal Generator #2:

        - Power Level: Current Power iteration Nominal Power Level from **Table 8.**
        - Frequency: (Next IQ Frequency from Configurations **Table 8** + 10.7 MHz).
    4. Configure the Spectrum Analyzer for the following settings:
        - Center Frequency: Same Frequency as the Signal Generator #2.
        - Reference Level: Current Power iteration Reference Level from **Table 8.**
        - Attenuation: Current Power iteration Attenuation from **Table 8.**

2. Configure the Signal Generator #2 for the following:
    - Power Level: Next Nominal Power Level from **Table 8**
    - Frequency: (Initial IQ Frequency from Configurations **Table 8** + 10.7 MHz)

11. Disable the power output of Signal Generator #2.

6.2.6. RF Input TOI LF Power Combiner Characterization validation

The characterized tones delivered through the combiner to the DUT must have a significantly lower TOI compared with the DUT specification. Use the following procedure to validate that the TOI of the characterized tones is low enough to minimize the impact in the DUT TOI accuracy determination at each frequency and power level.

1. Configure the Signal Generator #1 for the following:
    - Power Level: Initial lower Nominal Power Level from **Table 8** as determined in the characterization section:

$Combiner\_Port1Low_i$ [dBm]

- Frequency:
  f_1= (Initial IQ Frequency from Configurations **Table 8** + 10 MHz)
- ALC: On

2. Configure the Signal Generator #2 for the following:
   - Power Level: Initial lower Nominal Power Level from Table 8 as determined in the characterization section:

     Combiner_Port2Low$_i$ [dBm]

   - Frequency:
     f_2= (Initial IQ Frequency from Configurations **Table 8** + 10.7 MHz)
   - ALC: On

3. Configure the Spectrum Analyzer for the following settings:
   - Center Frequency: Initial Frequency from Configurations **Table 8.**
   - Span: 1 kHz.
   - Reference Level: Initial Reference Level from **Table 8.**
   - Attenuation: Initial Attenuation from **Table 8.**
   - RBW: 30 Hz.
   - Sweep Count: 10001.
   - Mode: Auto Peak.
   - Reference Clock: 10 MHz, External.

4. Generate RF signals from both Generators simultaneously, with the specified settings. Wait until they settle.

5. Measure the RF signals and validate the TOI

> Repeat, once for each Signal Generator #1 and #2 (simultaneously), using the Nominal Power Level in **Table 8**, starting with the lower power setting.

Repeat, once for each Signal Generator #1 and #2 (simultaneously) IQ Center Frequency setting in Table 8.

1. Set Spectrum Analyzer Center Frequency to (f_1)
2. Measure the power at frequency (f_1) with spectrum analyzer
3. Record the measured power:

$$f_1 = \textbf{fundamental\_tone}_1 \textbf{ [dBm]}$$

4. Set Spectrum Analyzer Center Frequency to (f_2)
5. Measure the power at frequency (f_2) with spectrum analyzer
6. Record the measured power:

$$f_2 = \textbf{fundamental\_tone}_2 \textbf{ [dBm]}$$

7. Set Spectrum Analyzer Center Frequency to:

$$(2f_1 - f_2) = \text{Center Frequency} + 9.3\text{ MHz}$$

8. Measure the power at frequency ($2f_1 - f_2$) with spectrum Analyzer
9. Record the measured power:

$$(2f_1 - f_2) = \textbf{IMD}_3\textbf{\_tone}_1 \textbf{ [dBm]}$$

10. Set Spectrum Analyzer Center Frequency to:

$$(2f_2 - f_1) = \text{Center Frequency} + 11.4\text{ MHz}$$

11. Measure the Power at frequency ($2f_2 - f_1$) with spectrum analyzer
12. Record the measured power:

$$(2f_2 - f_1) = \textbf{IMD}_3\textbf{\_tone}_2 \textbf{ [dBm]}$$

13. Calculate IMD_3 using the following equation:

$$IMD_3 = \text{Min}(\text{fundamental\_tone}_1; \text{fundamental\_tone}_2) - \text{Max}(IMD_3\text{\_tone}_1; IMD_3\text{\_tone}_2)$$

14. Calculate TOI using the following equation:

$$TOI = Min(fundamental\_tone_1; fundamental\_tone_2) + IMD_3/2$$

15. Compare the calculated TOI with limits in **Table 7**

16. If the characterization does not meet the limits in **Table 7**, it must be repeated. Ensure that all equipment and accessories are in good condition and all connections are correctly done before repeating the characterization.

17. Configure the Signal Generator #1 for the following:
    - Power Level: Current Iteration of Nominal Power Level from **Table 8** as determined in the characterization section:

      f_1: Combiner_Port1Low$_i$ [dBm]
    - Frequency:
      f_1= (Next Frequency from Configurations **Table 8** + 10 MHz)
    - ALC: On

18. Configure the Signal Generator #2 for the following:
    - Power Level: Current Iteration of Nominal Power Level from Table 8 as determined in the characterization section:

      Combiner_Port2Low$_i$ [dBm]
    - Frequency:
      f_2= (Next Frequency from Configurations **Table 8** + 10.7 MHz)
    - ALC: On

19. Configure the spectrum analyzer for the following settings:
    - Center Frequency: f_1
    - Reference Level: Reference Level that corresponds to Signal Generator Power Level setting from **Table 8**
    - Attenuation: Attenuation that corresponds to Signal Generator Power Level setting from **Table 8**

1. Configure the Signal Generator #1 for the following:
    - Power Level: Next Iteration of Nominal Power Level from **Table 8** as determined in the characterization section:

Combiner_Port1Low$_i$ [dBm]

  - Frequency:
    f_1= (Initial IQ Frequency from Configurations **Table 8** + 10 MHz)
  - ALC: On

2. Configure the Signal Generator #2 for the following:
   - Power Level: Next Iteration of Nominal Power Level from **Table 8** as determined in the characterization section:

     f_2: Combiner_Port2Low$_i$ [dBm]

   - Frequency:
     f_2= (Initial IQ Frequency from Configurations **Table 8** + 10.7 MHz)
   - ALC: On

3. Configure the Spectrum Analyzer for the following settings:
   - Center Frequency: f_1
   - Reference Level: Reference Level that corresponds to Signal Generator Power Level setting from **Table 8**
   - Attenuation: Attenuation that corresponds to Signal Generator Power Level setting from **Table 8**

6. Disable the power output of Signal Generator #1.

7. Disable the power output of Signal Generator #2.

8. Disconnect the cable connected to the Signal Analyzer without disturbing any of the other connections made according to **Figure 6**

6.2.7. RF Input TOI Low Frequency Verification

Table 9. RF Input TOI Low Frequency Verification Limits

IQ Center Frequency	Nominal Power Reference Level	As-Found Limit	As-Left Limit
30 MHz to 1.0 GHz	-30.0 dBm	-9.0 dB	-7.4 dB
30 MHz to 1.0 GHz	0.0 dBm	+16.0 dB	+17.7 dB
30 MHz to 1.0 GHz	+15.0 dBm	+31.0 dB	+32.5 dB

Table 10. RF Input TOI Low Frequency Verification Test Points

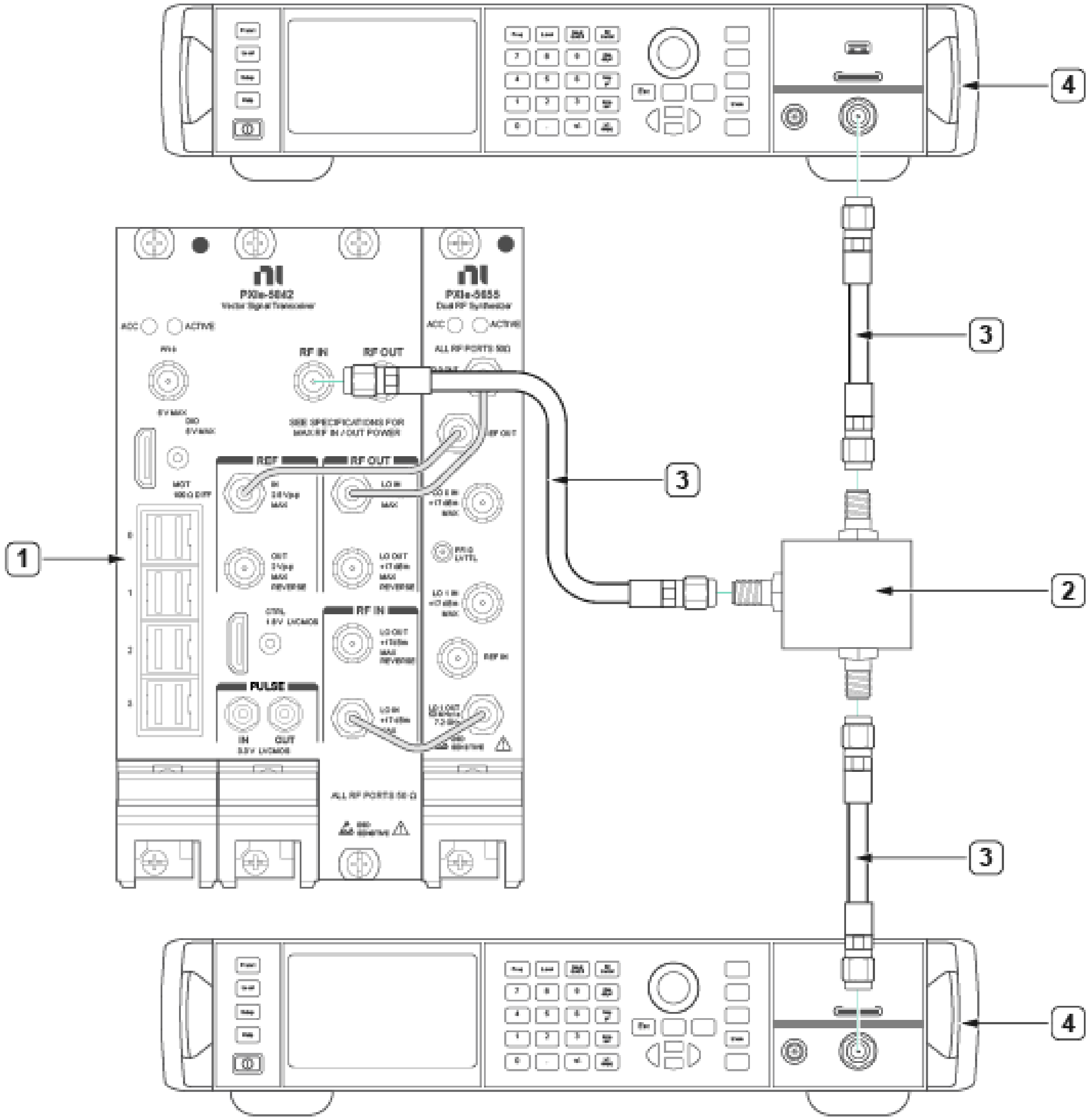
IQ Center Frequency	Nominal Power Level	Spectrum Analyzer Reference Level	Spectrum Analyzer Attenuation
▪ 30 MHz to 145 MHz in 5 MHz steps ▪ 150 MHz to 290 MHz in 10 MHz steps ▪ 300 MHz to 1.0 GHz in 20 MHz steps	-36.0 dBm	-30 dBm	0 dB
	-6.0 dBm	0 dBm	20 dB
	+9.0 dBm	+15 dBm	35 dB

6.2.8. RF Input TOI Low Frequency Verification Initial Test Connection

Note

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

Figure 7. RF Input TOI Verification connections



1. DUT
2 36” 3.5 mm cable (m) to (m) (x3)
3. LF Power Combiner
4. Signal Generator #1
5. Signal Generator #2

6.2.9. RF Input TOI Low Frequency Verification Procedure (Upconverter Mode = User Defined)

This procedure verifies the Third Order Intercept (TOI) Accuracy of the DUT's input channel.

Table 11: RF Input LF TOI Accuracy Test points and Configurations

IQ Center Frequency	Reference Power Level	Downconverter Offset Mode	Downconverter Offset	DUT Bandwidth
▪ 30 MHz to 145 MHz in 5 MHz steps ▪ 150 MHz to 290 MHz in 10 MHz steps ▪ 300 MHz to 1.0 GHz in 20 MHz steps	-30 dBm 0 dBm +15 dBm	User Defined	Driver Default	See **Table 6**

1. Make the connections indicated in **Figure 7**.

2. Configure the DUT for the following settings for "User Defined" mode:

   - IQ Center Frequency: First IQ Center Frequency from **Table 11**
   - Reference Level: First Reference Level from **Table 11**
   - Downconverter Offset Mode: User Defined
   - Downconverter Offset: Driver Default
   - Signal Bandwidth: Signal Bandwidth from **Table 11**
   - Acquisition Type: IQ
   - FFT Window Type: Flat Top
   - IQ Rate: From **Table 4** based on the HW option
   - Number of Samples: 200 kS
   - Number of Records: 10
   - Reference Clock Source: PXI_Clock (Locked to Rubidium)
   - Reference Clock Frequency: 10 MHz

3. Configure the Signal Generator #1 for the following:
   - Power Level:

     (Initial lower Reference Power Level from Table 8 – 6 dB), as determined in the characterization section for that power level and frequency:

     Combiner_Port1Low$_i$ [dBm]
   - Frequency:

     f_1= (Initial IQ Frequency from Configurations **Table 11** + 10 MHz)
   - ALC: On

4. Configure the Signal Generator #2 for the following:
   - Power Level:

     (Initial lower Reference Power Level from **Table 11** – 6 dB), as determined in the characterization section for that power level and frequency:

     Combiner_Port2Low$_i$ [dBm]
   - Frequency:

     f_2= (Initial IQ Frequency from Configurations **Table 11** + 10.7 MHz)
   - ALC: On

5. Generate RF signals from both Generators simultaneously, with the specified settings. Wait until they settle.

6. Taking the Verification measurements

> Repeat, once for each Signal Generator #1 and #2 (simultaneously) Reference Power Level in Table 11, starting with the lower power setting.
>
> > Repeat, once for each Signal Generator #1 and #2 (simultaneously) IQ Center Frequency setting in **Table 11**.
> >
> > 1. Acquire a spectrum of the combined signal using the DUT.
> >
> > 2. Measure the power at the expected distortion frequencies using the following settings:

  - See section 8.2 - Acquiring a Spectrum from IQ Data and Measuring the Peak
    - Frequency Deviation: 15 kHz
    - Search Frequencies: ƒ1, ƒ2, (2ƒ1-ƒ2), (2ƒ2-ƒ1)

3. Record the measured power:

$$f_1 = \textbf{fundamental\_tone}_1\ \textbf{[dBm]}$$

4. Record the measured power:

$$f_2 = \textbf{fundamental\_tone}_2\ \textbf{[dBm]}$$

5. Record the measured power:

$$(2f_1 - f_2) = \textbf{IMD}_3\textbf{\_tone}_1\ \textbf{[dBm]}$$

6. Record the measured power:

$$(2f_2 - f_1) = \textbf{IMD}_3\textbf{\_tone}_2\ \textbf{[dBm]}$$

7. Calculate IMD_3 using the following equation:

$$IMD_3 = \text{Min}(\text{fundamental\_tone}_1; \text{fundamental\_tone}_2) - \text{Max}(IMD_3\text{\_tone}_1; IMD_3\text{\_tone}_2)$$

8. Calculate TOI using the following equation:

$$\textbf{TOI} = \text{Min}(\text{fundamental\_tone}_1; \text{fundamental\_tone}_2) + IMD_3/2$$

9. Compare the calculated TOI with limits in **Table 9**

10. Configure the Signal Generator #1 for the following:
    - Power Level: Current Iteration of Reference Power Level from **Table 11** as determined in the characterization section for that power level and frequency:

      $$\textbf{Combiner\_Port1Low}_i\ \textbf{[dBm]}$$
    - Frequency:
      f_1= (**Next** IQ Frequency from Configurations **Table 11** + 10 MHz)
    - ALC: On

11. Configure the Signal Generator #2 for the following:
    - Power Level: Current Iteration of Reference Power Level from **Table 11** as determined in the characterization section for that power level and frequency:

      Combiner_Port2Low$_i$ [dBm]

    - Frequency:
      f_2= (**Next** IQ Frequency from Configurations **Table 11** + 10.7 MHz)
    - ALC: On

12. Configure the DUT for the following settings:
    - IQ Center Frequency: **Next** IQ Center Frequency from **Table 11**
    - Signal Bandwidth: Signal Bandwidth from **Table 11**
    - IQ Rate: From **Table 4** based on the HW option

1. Configure the Signal Generator #1 for the following:
   - Power Level:
     (Next iteration of Reference Power Level from **Table 8** – 6 dB), as determined in the characterization section for that power level and frequency:

     Combiner_Port1Low$_i$ [dBm]
   - Frequency:
     f_1= (Initial IQ Frequency from Configurations **Table 11** + 10 MHz)
   - ALC: On

2. Configure the Signal Generator #2 for the following:
   - Power Level:
     (Next iteration of Reference Power Level from **Table 8** – 6 dB), as determined in the characterization section for that power level and frequency:

     Combiner_Port2Low$_i$ [dBm]
   - Frequency:
     f_2= (Initial IQ Frequency from Configurations **Table 11** + 10.7 MHz)
   - ALC: On

3. Configure the DUT for the following settings:
    - IQ Center Frequency: Initial IQ Center Frequency from **Table 11**
    - Reference Level: Next Iteration Reference Level from **Table 11**
    - Signal Bandwidth: Signal Bandwidth from **Table 11**
    - IQ Rate: From **Table 4** based on the HW option

6.2.10. Input TOI High Frequency Characterization points

Table 12. Input TOI High Frequency Fixture Characterization Configurations

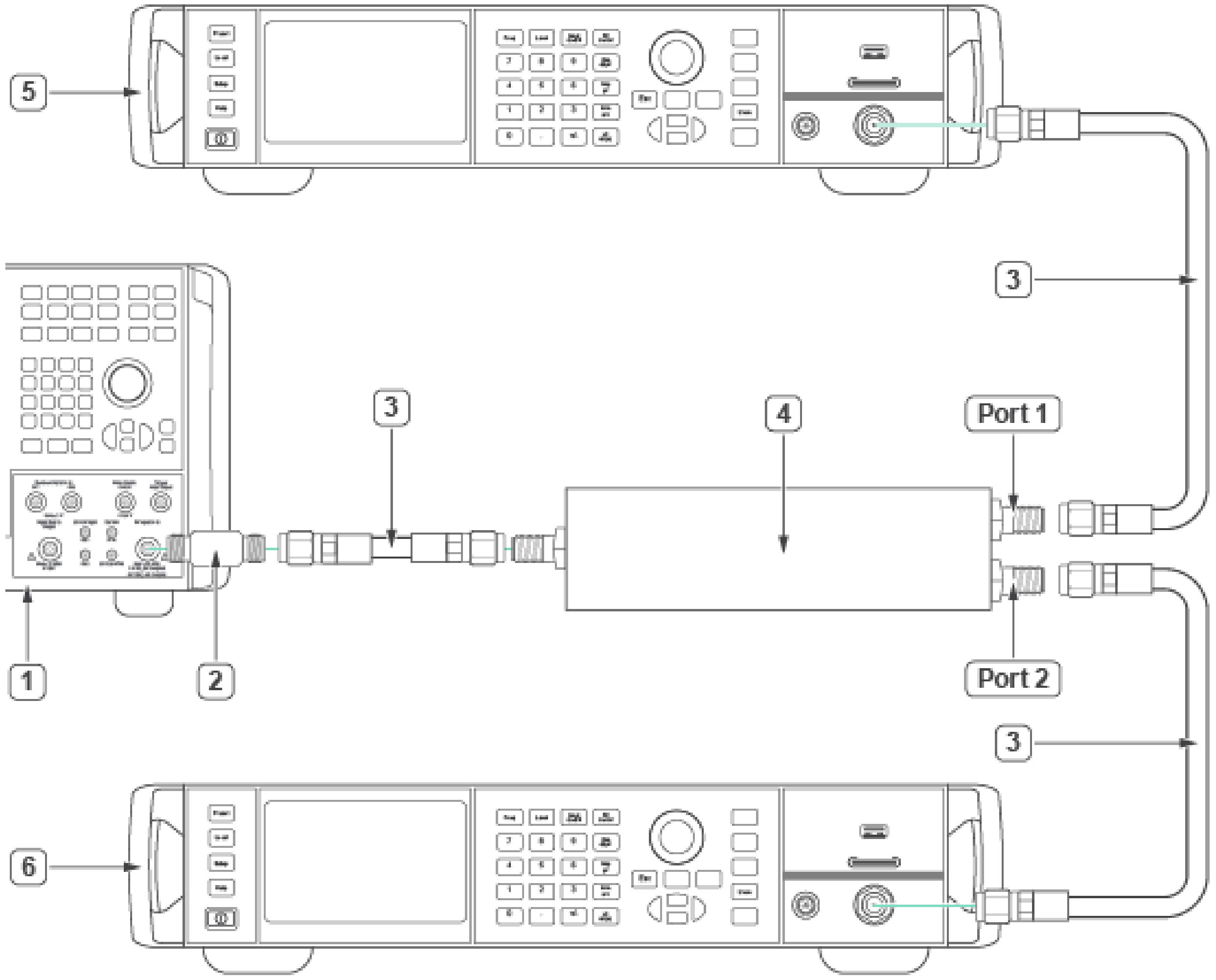
IQ Center Frequency	Nominal Power Level	Spectrum Analyzer Reference Level	Spectrum Analyzer Attenuation
▪ 1.0 GHz to 1.74 MHz in 20 MHz steps ▪ 1.701 GHz; 1.749 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to 26.3 GHz in 100 MHz steps ▪ 26.38 GHz	-36.0 dBm	-30 dBm	0 dB
	-6.0 dBm	0 dBm	20 dB
	+9.0 dBm	+15 dBm	40 dB for 8 GHz ≤ f ≤ 12 GHz, 35 dB otherwise

6.2.11. Input TOI High Frequency Initial Test Connection

Note

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

Figure 8. RF Input TOI High Frequency Combiner characterization Connections



1. Phase noise and Spectrum analyzer
2 3.5mm Female to Female Adapter
3. 36” 3.5 mm cable (m) to (m) (x3)
4. HF Power Combiner
5. Signal Generator #1
6. Signal Generator #2

6.2.12. RF Input TOI High Frequency Power Combiner Characterization

The two tones at the output of the combiner must have the correct amplitude to perform the TOI verification. The combiner response is not linear with frequency and the power delivered by each individual generator also varies.
To ensure that the tones delivered through the combiner to the DUT have the adequate power at each frequency the system must be characterized prior to performing the verification.

1. Make the connections indicated in **Figure 8**
2. Configure the Signal Generator #1 for the following:
   - Power Level: Initial lower Nominal Power Level from **Table 12**
   - Frequency: (Initial IQ Center Frequency from Configurations **Table 12** + 95 MHz)
   - ALC: On
3. Configure the Spectrum Analyzer for the following settings:
   - Center Frequency:
   (Initial IQ Center Frequency from Configurations **Table 12** + 95 MHz)

   - Span: 1 kHz
   - Reference Level: Initial Reference Level from **Table 12**
   - Attenuation: Initial Attenuation from **Table 12**
   - RBW: 30 Hz
   - Sweep Count: 10001
   - Mode: Auto Peak
   - Reference Clock: 10 MHz, External
4. Generate an RF signal on Signal Generator #1, with the specified settings. Wait until it settles.
5. Characterizing Port1:

Repeat, once for each Signal Generator #1 Nominal Power Level in **Table 12**, starting with the lower power setting.

1. Record this Power Level value as "**Nominal_Power**$_p$"

Where "*f(x)*$_p$" is a linear index number to identify each Power level iteration from 1 to n.

> Repeat, once for each Signal Generator #1 IQ Center Frequency setting in **Table 12**.
>
> 1. Servo the RF power from the signal generator #1, until the Spectrum Analyzer measurement is equal to (**Nominal_Power**$_{p,f}$ ± 0.075 dB).
> 2. Record the power setting from the signal generator #1 as:
>
> **Combiner_Port1HF**$_{p,f}$ **[dBm]**
>
> Where "*f(x)*$_f$" is a linear index number to identify each frequency within the sweep from 1 to n and *f(x)*$_p$" is a linear index number to identify each Power level iteration from 1 to n.
>
> 3. Configure the Signal Generator #1:
>   - Power Level: Current Power iteration Nominal Power Level from **Table 12**
>   - Frequency: (Next IQ Frequency from Configurations **Table 12** + 95 MHz)
> 4. Configure the Spectrum Analyzer for the following settings:
>   - Center Frequency: Same Frequency as the Signal Generator #1
>   - Reference Level: Current Power iteration Reference Level from **Table 12**
>   - Attenuation: Current Power iteration Attenuation from **Table 12**

2. Configure the Signal Generator #1 for the following:
    - Power Level: Next Nominal Power Level from **Table 12**
    - Frequency: (Initial IQ Frequency from Configurations **Table 12** + 95 MHz)

3. Disable the power output of Signal Generator #1.

4. Configure the Signal Generator #2 for the following:
   - Power Level: Initial lower Nominal Power Level from **Table 12**
   - Frequency: (Initial IQ Frequency from Configurations **Table 12** + 105 MHz)
   - ALC: On

5. Configure the Spectrum Analyzer for the following settings:
   - Center Frequency:
   (Initial Frequency from Configurations **Table 12** + 105 MHz)
   - Span: 1 kHz
   - Reference Level: Initial Reference Level from Table 8
   - Attenuation: Initial Attenuation from Table 8
   - RBW: 30 Hz
   - Sweep Count: 10001
   - Mode: Auto Peak
   - Reference Clock: 10 MHz, External

6. Generate an RF signal on Signal Generator #2, with the specified settings. Wait until it settles.

7. Characterizing Port2

Repeat, once for each Signal Generator #2 Nominal Power Level in **Table 12**, starting with the lower power setting.

1. Record this Power Level value as "**Nominal_Power_p**"

Where "*f(x)*$_p$" is a linear index number to identify each Power level iteration from 1 to n.

Repeat, once for each Signal Generator #2 IQ Center Frequency setting in **Table 12**.

1. Servo the RF power from the signal generator #1, until the Spectrum Analyzer measurement is equal to (**$\text{Nominal\_Power}_{p,f}$** ± 0.075 dB).

2. Record the power setting from the signal generator #2 as:

$$\textbf{Combiner\_Port2HF}_{p,f}\ \textbf{[dBm]}$$

Where "$f(x)_f$" is a linear index number to identify each frequency within the sweep from 1 to n and $f(x)_p$" is a linear index number to identify each Power level iteration from 1 to n.

3. Configure the Signal Generator #2:
    - Power Level: Current Power iteration Nominal Power Level from **Table 12**
    - Frequency: (Next IQ Frequency from Configurations **Table 12** + 105 MHz)
4. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: Same Frequency as the Signal Generator #2
    - Reference Level: Current Power iteration Reference Level from **Table 12**
    - Attenuation: Current Power iteration Attenuation from **Table 12**

2. Configure the Signal Generator #2 for the following:

    - Power Level: Next Nominal Power Level from **Table 12**
    - Frequency: (Initial IQ Frequency from Configurations **Table 8** + 105 MHz)

8. Disable the power output of Signal Generator #2.

6.2.13. RF Input TOI High Frequency Power Combiner Characterization validation

To ensure that the characterized tones delivered through the combiner to the DUT have a significantly lower TOI compared with the DUT specification in order to minimize the impact in the DUT TOI accuracy determination at each frequency and power level.

1. Configure the Signal Generator #1 for the following:
    - Power Level: Initial lower Nominal Power Level from **Table 12** as determined in the characterization section:

      Combiner_Port1HF$_{p,f}$ **[dBm]**

    - Frequency:
      f_1= (Initial IQ Frequency from Configurations **Table 12** + 95 MHz)
    - ALC: On

2. Configure the Signal Generator #2 for the following:
    - Power Level: Initial lower Nominal Power Level from **Table 12** as determined in the characterization section:

      Combiner_Port2HF$_{p,f}$ **[dBm]**

    - Frequency:
      f_2= (Initial IQ Frequency from Configurations **Table 12** + 105 MHz)
    - ALC: On

3. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: Initial Frequency from Configurations **Table 12**
    - Span: 1 kHz
    - Reference Level: Initial Reference Level from **Table 12**
    - Attenuation: Initial Attenuation from **Table 12**
    - RBW: 30 Hz
    - Sweep Count: 10001
    - Mode: Auto Peak
    - Reference Clock: 10 MHz, External

4. Generate RF signals from both Generators simultaneously, with the specified settings. Wait until they settle.

5. Taking the Validation measurements

> Repeat, once for each Signal Generator #1 and #2 (simultaneously) Nominal Power Level in **Table 12**, starting with the lower power setting.

Repeat, once for each Signal Generator #1 and #2 (simultaneously) IQ Center Frequency setting in **Table 12**.

1. Set Spectrum Analyzer Center Frequency to (f_1)
2. Measure the Power at frequency (f_1) with spectrum Analyzer
3. Record the measured power:

$$\boldsymbol{f_1} = \textbf{fundamental\_tone}_1\ \textbf{[dBm]}$$

4. Set Spectrum Analyzer Center Frequency to (f_2)
5. Measure the Power at frequency (f_2) with spectrum Analyzer
6. Record the measured power:

$$\boldsymbol{f_2} = \textbf{fundamental\_tone}_2\ \textbf{[dBm]}$$

7. Set Spectrum Analyzer Center Frequency to:

$$(2f_1 - f_2) = \text{Center Frequency} + 85\text{ MHz}$$

8. Measure the Power at frequency ($2f_1 - f_2$) with spectrum Analyzer
9. Record the measured power:

$$(2f_1 - f_2) = \textbf{IMD}_3\textbf{\_tone}_1\ \textbf{[dBm]}$$

10. Set Spectrum Analyzer Center Frequency to:

$$(2f_2 - f_1) = \text{Center Frequency} + 115\text{ MHz}$$

11. Measure the Power at frequency ($2f_2 - f_1$) with spectrum Analyzer
12. Record the measured power:

$$(2f_2 - f_1) = \textbf{IMD}_3\textbf{\_tone}_2\ \textbf{[dBm]}$$

13. Calculate IMD_3 using the following equation:

$$IMD_3 = \text{Min}(\text{fundamental\_tone}_1; \text{fundamental\_tone}_2) - \text{Max}(IMD_3\text{\_tone}_1; IMD_3\text{\_tone}_2)$$

14. Calculate TOI using the following equation:

    $$TOI = Min(fundamental\_tone_1; fundamental\_tone_2) + IMD_3/2$$

15. Compare the calculated TOI with limits in **Table 7**

16. If the characterization does not meet the limits in **Table 7**, it must be repeated. Ensure that all equipment and accessories are in good working condition and all connections are correctly done before repeating the characterization.

17. Configure the Signal Generator #1 for the following:
    - Power Level: Current Iteration of Nominal Power Level from **Table 12** as determined in the characterization section:

      f_1: Combiner_Port1HF$_{pf}$ [dBm]
    - Frequency:
      f_1= (Next Frequency from Configurations **Table 12** + 95 MHz)
    - ALC: On

18. Configure the Signal Generator #2 for the following:
    - Power Level: Current Iteration of Nominal Power Level from Table 8 as determined in the characterization section:

      Combiner_Port2HF$_{pf}$ [dBm]
    - Frequency:
      f_2= (Next Frequency from Configurations **Table 12** + 105 MHz)
    - ALC: On

19. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: f_1
    - Reference Level: Reference Level that corresponds to Signal Generator Power Level setting from **Table 12**
    - Attenuation: Attenuation that corresponds to Signal Generator Power Level setting from **Table 12**

1. Configure the Signal Generator #1 for the following:
   - Power Level: Next Iteration of Nominal Power Level from **Table 12** as determined in the characterization section:

Combiner_Port1HF$_{pf}$ [dBm]

- Frequency:
  f$_1$= (Initial IQ Frequency from Configurations **Table 12** + 95 MHz)
- ALC: On

2. Configure the Signal Generator #2 for the following:
   - Power Level: Next Iteration of Nominal Power Level from **Table 12** as determined in the characterization section:

     f$_2$**: Combiner_Port2HF**$_{pf}$ **[dBm]**

   - Frequency:
     f$_2$= (Initial IQ Frequency from Configurations **Table 12** + 105 MHz)
   - ALC: On

3. Configure the Spectrum Analyzer for the following settings:
   - Center Frequency: ***f***$_1$
   - Reference Level: Reference Level that corresponds to Signal Generator Power Level setting from **Table 12**
   - Attenuation: Attenuation that corresponds to Signal Generator Power Level setting from **Table 12**

5. Disable the power output of Signal Generator #1.
6. Disable the power output of Signal Generator #2.
7. Disconnect the cable connected to the Signal Analyzer without disturbing any of the other connections made according to **Figure 8**

6.2.14. RF Input TOI High Frequency Verification

Table 13. RF Input TOI High Frequency Verification Limits

IQ Center Frequency	Nominal Power Reference Level	As-Found Limit [≥]	As-Left Limit [≥]
>1.0 GHz to 3.0 GHz	-30.0 dBm	-10.0 dB	-8.8 dB
>3.0 GHz to 8.0 GHz		-11.0 dB	-9.9 dB
>8.0 GHz to 26.5 GHz		-8.0 dB	-6.8 dB
>1.0 GHz to 3.0 GHz	0.0 dBm	+19.0 dB	+20.4 dB
>3.0 GHz to 8.0 GHz		+18.0 dB	+19.6 dB
>8.0 GHz to 26.5 GHz		+19.0 dB	+21.0 dB
>1.0 GHz to 3.0 GHz	+15.0 dBm	+33.0 dB	+35.0 dB
>3.0 GHz to 8.0 GHz		+33.0 dB	+34.5 dB
>8.0 GHz to 26.5 GHz		+33.0 dB	+35.2 dB

Table 14. RF Input TOI High Frequency Verification Test Points (Downconverter Mode – User Defined)

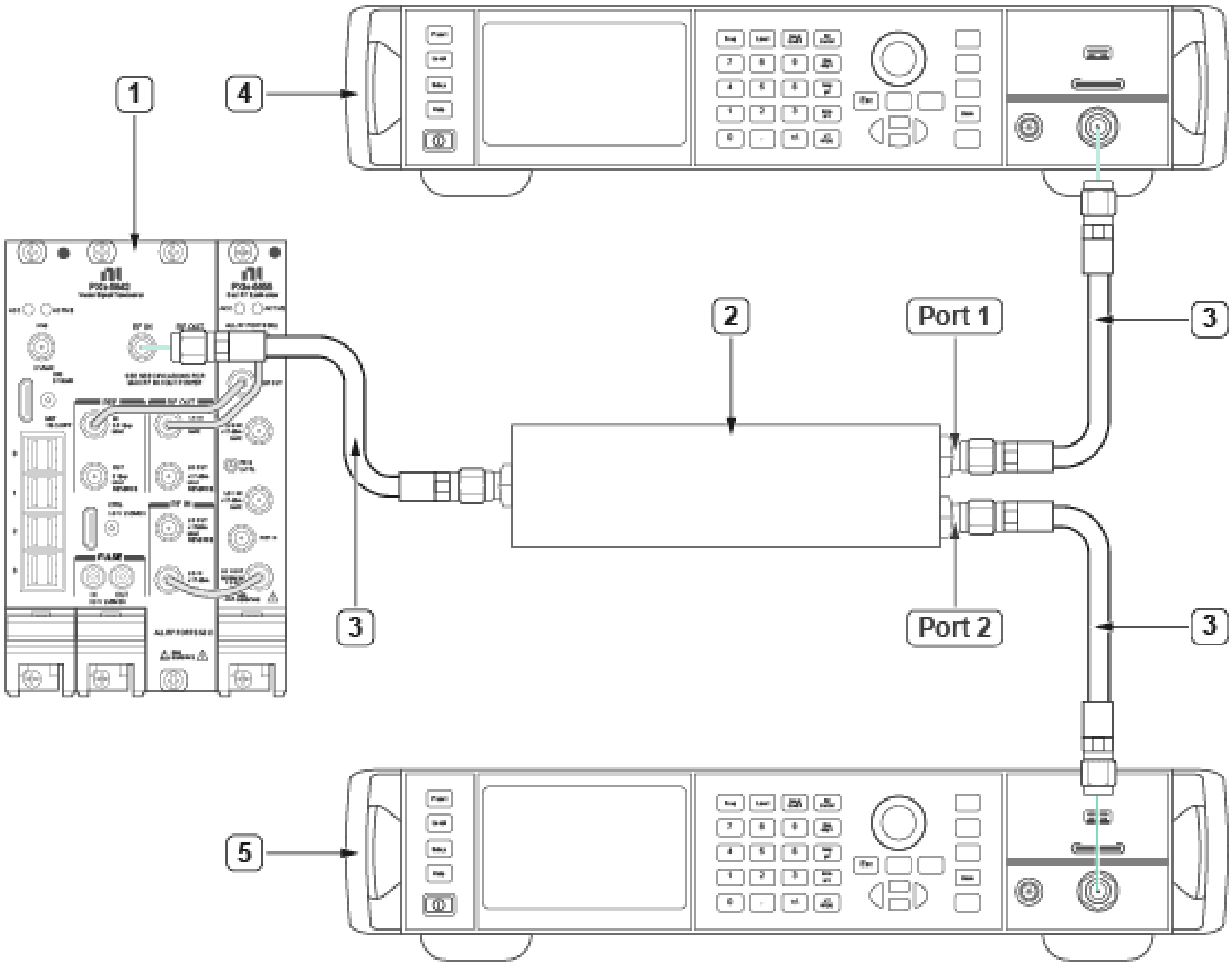
IQ Center Frequency	Nominal Power Level	Spectrum Analyzer Reference Level	Spectrum Analyzer Attenuation
▪ 1.0 GHz to 1.74 MHz in 20 MHz steps ▪ 1.749 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to 26.3 GHz in 100 MHz steps ▪ 26.38 GHz Do not test above (Maximum DUT Frequency – 20 MHz), see **Table 3**	-36.0 dBm	-30 dBm	0 dB
	-6.0 dBm	0 dBm	20 dB
	+9.0 dBm	+15 dBm	40 dB for 8 GHz ≤ f ≤ 12 GHz, 35 dB otherwise

6.2.15. Verification Initial Test Connection

Note

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

Figure 9. RF Input TOI High Frequency Verification connections



1. DUT
2. HF Power Combiner
3. 36” 3.5 mm cable (m) to (m) (x3)
4. Signal Generator #1
5. Signal Generator #2

6.2.16. Verification Procedure

This procedure verifies the Third Order Intercept (TOI) Accuracy of the DUT's input channel.

Table 15: RF Input TOI High Frequency Accuracy Test points and Configurations (Downconverter Mode = **User Defined**)

IQ Center Frequency	Reference Power Level	Downconverter Offset	DUT Bandwidth
▪ 1.0 GHz to 1.74 MHz in 20 MHz steps ▪ 1.749 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to 26.3 GHz in 100 MHz steps ▪ 26.38 GHz Do not test above (Maximum DUT Frequency – 20 MHz), see **Table 3**	-30 dBm, 0 dBm +15 dBm	0	See **Table 6**

6.2.17. RF Input TOI High Frequency Verification Procedure (Downconverter Mode = User Defined)

1. Make the connections indicated in **Figure 9**.
2. Configure the DUT for the following settings:
   - IQ Center Frequency: First IQ Center Frequency from **Table 15**
   - Reference Level: First Reference Power Level from **Table 15**
   - Downconverter Offset Mode: User Defined
   - Downconverter Offset: Downconverter Offset from **Table 15**

- Signal Bandwidth: Signal Bandwidth from **Table 6**
- Acquisition Type: IQ
- FFT Window Type: Flat Top
- IQ Rate: From **Table 4** based on the HW option
- Number of Samples: 200 kS
- Number of Records: 10
- Reference Clock Source: PXI_Clock (Locked to Rubidium)
- Reference Clock Frequency: 10 MHz

3. Configure the Signal Generator #1 for the following:
   - Power Level:

   (Initial lower Reference Power Level from **Table 15** – 6 dB), as determined in the characterization section for that power level and frequency:

   $$\mathbf{Combiner\_Port1HF}_{pf}\ \mathbf{[dBm]}$$

   - Frequency:
     f_1= (Initial IQ Frequency from Configurations **Table 15** + 95 MHz)
   - ALC: On

4. Configure the Signal Generator #2 for the following:
   - Power Level:

   (Initial lower Reference Power Level from **Table 15** – 6 dB), as determined in the characterization section for that power level and frequency:

   $$\mathbf{Combiner\_Port2HF}_{pf}\ \mathbf{[dBm]}$$

   - Frequency:
     f_2= (Initial IQ Frequency from Configurations **Table 15** + 105 MHz)
   - ALC: On

5. Generate RF signals from both Generators simultaneously, with the specified settings. Wait until they settle.

6. Taking the Verification measurements

Repeat, once for each Signal Generator #1 and #2 (simultaneously) Reference Power Level in **Table 15**, starting with the lower power setting.

Repeat, once for each Signal Generator #1 and #2 (simultaneously) IQ Center Frequency setting in **Table 15**.

1. Acquire a spectrum of the combined signal using the DUT.
2. Measure the power at the expected distortion frequencies using the following settings:
   - See section 8.2 - Acquiring a Spectrum from IQ Data and Measuring the Peak
     - Frequency Deviation: 15 kHz
     - Search Frequencies: ƒ1, ƒ2, (2ƒ1-ƒ2), (2ƒ2-ƒ1)
3. Record the measured power:

$$f_1 = \textbf{fundamental\_tone}_\mathbf{1}\ \textbf{[dBm]}$$

4. Record the measured power:

$$f_2 = \textbf{fundamental\_tone}_\mathbf{2}\ \textbf{[dBm]}$$

5. Record the measured power:

$$(2f_1 - f_2) = \textbf{IMD}_\mathbf{3}\textbf{\_tone}_\mathbf{1}\ \textbf{[dBm]}$$

6. Record the measured power:

$$(2f_2 - f_1) = \textbf{IMD}_\mathbf{3}\textbf{\_tone}_\mathbf{2}\ \textbf{[dBm]}$$

7. Calculate IMD_3 using the following equation:

$$IMD_3 = \mathrm{Min}(\mathrm{fundamental\_tone}_1; \mathrm{fundamental\_tone}_2) - \mathrm{Max}(IMD_3\_\mathrm{tone}_1; IMD_3\_\mathrm{tone}_2)$$

8. Calculate TOI using the following equation:

$$\textbf{TOI} = \mathrm{Min}(\mathrm{fundamental\_tone}_1; \mathrm{fundamental\_tone}_2) + IMD_3/2$$

9. Compare the calculated TOI with limits in **Table 13**
10. Configure the Signal Generator #1 for the following:
    - Power Level: Current Iteration of Reference Power Level from **Table 15** as determined in the characterization section for that power level and frequency:

      Combiner_Port1HF$_{pf}$ [dBm]
    - Frequency:
      f_1= (**Next** IQ Frequency from Configurations **Table 15** + 95 MHz)
    - ALC: On
11. Configure the Signal Generator #2 for the following:
    - Power Level: Current Iteration of Reference Power Level from **Table 15** as determined in the characterization section for that power level and frequency:

      Combiner_Port2HF$_{pf}$ [dBm]
    - Frequency:
      f_2= (**Next** IQ Frequency from Configurations **Table 15** + 105 MHz)
    - ALC: On
12. Configure the DUT for the following settings:
    - IQ Center Frequency: **Next** IQ Center Frequency from **Table 15**
    - Signal Bandwidth: Signal Bandwidth from **Table 15**
    - IQ Rate: From **Table 4** based on the HW option

1. Configure the Signal Generator #1 for the following:
   - Power Level:

   (Next iteration of Reference Power Level from **Table 15** – 6 dB), as determined in the characterization section for that power level and frequency:

   Combiner_Port1HF$_{pf}$ [dBm]

- Frequency:
  f_1= (Initial IQ Frequency from Configurations **Table 15** + 95 MHz)
- ALC: On

2. Configure the Signal Generator #2 for the following:
   - Power Level:
     (Next iteration of Reference Power Level from **Table 15** – 6 dB), as determined in the characterization section for that power level and frequency:

     Combiner_Port2HF$_{pf}$ [dBm]
   - Frequency:
     f_2= (Initial IQ Frequency from Configurations **Table 15** + 105 MHz)
   - ALC: On

3. Configure the DUT for the following settings:

   - IQ Center Frequency: Initial IQ Center Frequency from **Table 15**
   - Reference Level: Next Iteration Reference Level from **Table 15**
   - Signal Bandwidth: Signal Bandwidth from **Table 15**
   - IQ Rate: From **Table 4** based on the HW option

6.2.18. Verification Procedure (Downconverter Mode = Enabled)

Table 16: RF Input TOI High Frequency Accuracy Test points and Configurations (Downconverter Mode = **Enabled**)

IQ Center Frequency	Reference Power Level	Downconverter Offset	DUT Bandwidth
▪ 1.701 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to 26.3 GHz in 100 MHz steps ▪ 26.38 GHz Do not test above (Maximum DUT Frequency – 20 MHz), see **Table 3**	-30 dBm, 0 dBm +15 dBm	Driver Default	See **Table 5**

1. Make the connections indicated in **Figure 9**.

2. Configure the DUT for the following settings:

   - IQ Center Frequency: First IQ Center Frequency from **Table 16**
   - Reference Level: First Reference Power Level from **Table 16**
   - Downconverter Offset Mode: Enabled
   - Downconverter Offset: Downconverter Offset from **Table 16**
   - Signal Bandwidth: Signal Bandwidth from **Table 16**
   - Acquisition Type: IQ
   - FFT Window Type: Flat Top
   - IQ Rate: From **Table 4** based on the HW option
   - Number of Samples: 200 kS
   - Number of Records: 10
   - Reference Clock Source: PXI_Clock (Locked to Rubidium)
   - Reference Clock Frequency: 10 MHz

3. Configure the Signal Generator #1 for the following:
   - Power Level:

(Initial lower Reference Power Level from **Table 16** – 6 dB), as determined in the characterization section for that power level and frequency:

Combiner_Port1HF$_{pf}$ [dBm]

- Frequency:
  f_1= (Initial IQ Frequency from Configurations **Table 16** + 95 MHz)
- ALC: On

4. Configure the Signal Generator #2 for the following:
   - Power Level:
     (Initial lower Reference Power Level from **Table 16** – 6 dB), as determined in the characterization section for that power level and frequency:

     Combiner_Port2HF$_{pf}$ [dBm]

   - Frequency:
     f_2= (Initial IQ Frequency from Configurations **Table 16** + 105 MHz)
   - ALC: On
5. Generate RF signals from both Generators simultaneously, with the specified settings. Wait until they settle.
6. Taking the Verification measurements

> Repeat, once for each Signal Generator #1 and #2 (simultaneously) Reference Power Level in Table 16, starting with the lower power setting.
>
> > Repeat, once for each Signal Generator #1 and #2 (simultaneously) IQ Center Frequency setting in **Table 16**.
> >
> > 1. Acquire a spectrum of the combined signal using the DUT.
> > 2. Measure the power at the expected distortion frequencies using the following settings:

- See section 8.2 - Acquiring a Spectrum from IQ Data and Measuring the Peak
    - Frequency Deviation: 15 kHz
    - Search Frequencies: ƒ1, ƒ2, (2ƒ1-ƒ2), (2ƒ2-ƒ1)

3. Record the measured power:

$$f_1 = \mathbf{fundamental\_tone_1\ [dBm]}$$

4. Record the measured power:

$$f_2 = \mathbf{fundamental\_tone_2\ [dBm]}$$

5. Record the measured power:

$$(2f_1 - f_2) = \mathbf{IMD_3\_tone_1\ [dBm]}$$

6. Record the measured power:

$$(2f_2 - f_1) = \mathbf{IMD_3\_tone_2\ [dBm]}$$

7. Calculate IMD_3 using the following equation:

$$IMD_3 = Min(fundamental\_tone_1; fundamental\_tone_2) - Max(IMD_3\_tone_1; IMD_3\_tone_2)$$

8. Calculate TOI using the following equation:

$$\mathbf{TOI} = Min(fundamental\_tone_1; fundamental\_tone_2) + IMD_3/2$$

9. Compare the calculated TOI with limits in **Table 13**

10. Configure the Signal Generator #1 for the following:
    - Power Level: Current Iteration of Reference Power Level from **Table 16** as determined in the characterization section for that power level and frequency:

      $$\mathbf{Combiner\_Port1HF_{pf}\ [dBm]}$$
    - Frequency:
      $\boldsymbol{f_1}$= (**Next** IQ Frequency from Configurations **Table 16** + 95 MHz)
    - ALC: On

11. Configure the Signal Generator #2 for the following:

- Power Level: Current Iteration of Reference Power Level from **Table 16** as determined in the characterization section for that power level and frequency:

  Combiner_Port2HF$_{pf}$ [dBm]

- Frequency:
  f_2= (**Next** IQ Frequency from Configurations **Table 16** + 105 MHz)
- ALC: On

12. Configure the DUT for the following settings:

    - IQ Center Frequency: **Next** IQ Center Frequency from **Table 16**
    - Signal Bandwidth: Signal Bandwidth from **Table 16**
    - IQ Rate: From **Table 4** based on the HW option

1. Configure the Signal Generator #1 for the following:
   - Power Level:
   (Next iteration of Reference Power Level from **Table 16** – 6 dB), as determined in the characterization section for that power level and frequency:

     Combiner_Port1HF$_{pf}$ [dBm]
   - Frequency:
   f_1= (Initial IQ Frequency from Configurations **Table 16** + 95 MHz)
   - ALC: On

2. Configure the Signal Generator #2 for the following:
   - Power Level:
   (Next iteration of Reference Power Level from **Table 16** – 6 dB), as determined in the characterization section for that power level and frequency:

     Combiner_Port2HF$_{pf}$ [dBm]
   - Frequency:
   f_2= (Initial IQ Frequency from Configurations **Table 16** + 105 MHz)
   - ALC: On

3. Configure the DUT for the following settings:
   - IQ Center Frequency: Initial IQ Center Frequency from **Table 16**
   - Reference Level: Next Iteration Reference Level from **Table 16**
   - Signal Bandwidth: Signal Bandwidth from **Table 16**
   - IQ Rate: From **Table 4** based on the HW option

6.3. RF Output Absolute Amplitude Verification

6.3.1. Test Limits

Table 17: RF Output Amplitude Accuracy Verification Test Limits (User Defined Mode)

Frequency Range	As-Found Test Limit		As-Left Test Limit	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
30 MHz to 200 MHz	-0.95 dB	+0.95 dB	-0.61 dB	+0.61 dB
>200 MHz to 1.75 GHz	-0.70 dB	+0.70 dB	-0.33 dB	+0.33dB
>1.75 GHz to 4.0 GHz	-0.70 dB	+0.70 dB	-0.36 dB	+0.36 dB
>4.0 GHz to 6.0 GHz	-0.70 dB	+0.70 dB	-0.34 dB	+0.34 dB
>6.0 GHz to 12.0 GHz	-0.85 dB	+0.85 dB	-0.42 dB	+0.42 dB
>12.0 GHz to 18.0 GHz	-0.95 dB	+0.95 dB	-0.52 dB	+0.52 dB
>18.0 GHz to 22.0 GHz	-0.95 dB	+0.95 dB	-0.56 dB	+0.56 dB
>22.0 GHz to 25.0 GHz	-0.95 dB	+0.95 dB	-0.53 dB	+0.53 dB
>25.0 GHz to 26.5 GHz	-1.1 dB	+1.1 dB	-0.70 dB	+0.70 dB

Table 18: RF Output Amplitude Accuracy Verification Test Limits (Enabled Mode)

Frequency Range	As-Found Test Limit		As-Left Test Limit	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
1.7 GHz to 6.0 GHz	-0.70 dB	+0.70 dB	-0.34 dB	+0.34 dB
>6.0 GHz to 12.0 GHz	-0.85 dB	+0.85 dB	-0.46 dB	+0.46 dB
>12.0 GHz to 18.0 GHz	-0.95 dB	+0.95 dB	-0.56 dB	+0.56 dB
>18.0 GHz to 22.0 GHz	-0.95 dB	+0.95 dB	-0.58 dB	+0.58 dB
>22.0 GHz to 25.0 GHz	-0.95 dB	+0.95 dB	-0.54 dB	+0.54 dB
>25.0 GHz to 26.5 GHz	-1.1 dB	+1.1 dB	-0.42 dB	+0.42 dB

Table 19: RF Output Maximum Power Level (User Defined Mode)

Center Frequency Range	Maximum Power Level
30 MHz to 200 MHz	+15.0 dBm
>200 MHz to 4.0 GHz	+19.0 dBm
>4.0 GHz to 8.0 GHz	+20.0 dBm
>8.0 GHz to 20.0 GHz	+18.0 dBm
>20.0 GHz to 22.0 GHz	+15.0 dBm
>22.0 GHz to 24.0 GHz	+10.0 dBm
>24.0 GHz to 25.0 GHz	+8.0 dBm
>25.0 GHz to 26.5 GHz	0.0 dBm

Table 20: RF Output Maximum Power Level (Enabled Mode)

Center Frequency Range	Maximum Power Level
>1.7 GHz to 4.0 GHz	+19.0 dBm
>4.0 GHz to 8.0 GHz	+20.0 dBm
>8.0 GHz to 12.0 GHz	+17.0 dBm
>12.0 GHz to 20.0 GHz	+16.0 dBm
>20.0 GHz to 22.0 GHz	+13.0 dBm
>22.0 GHz to 24.0 GHz	+6.0 dBm
>24.0 GHz to 25.0 GHz	+4.0 dBm
>25.0 GHz to 26.5 GHz	0.0 dBm

6.3.2. Initial Test Connection

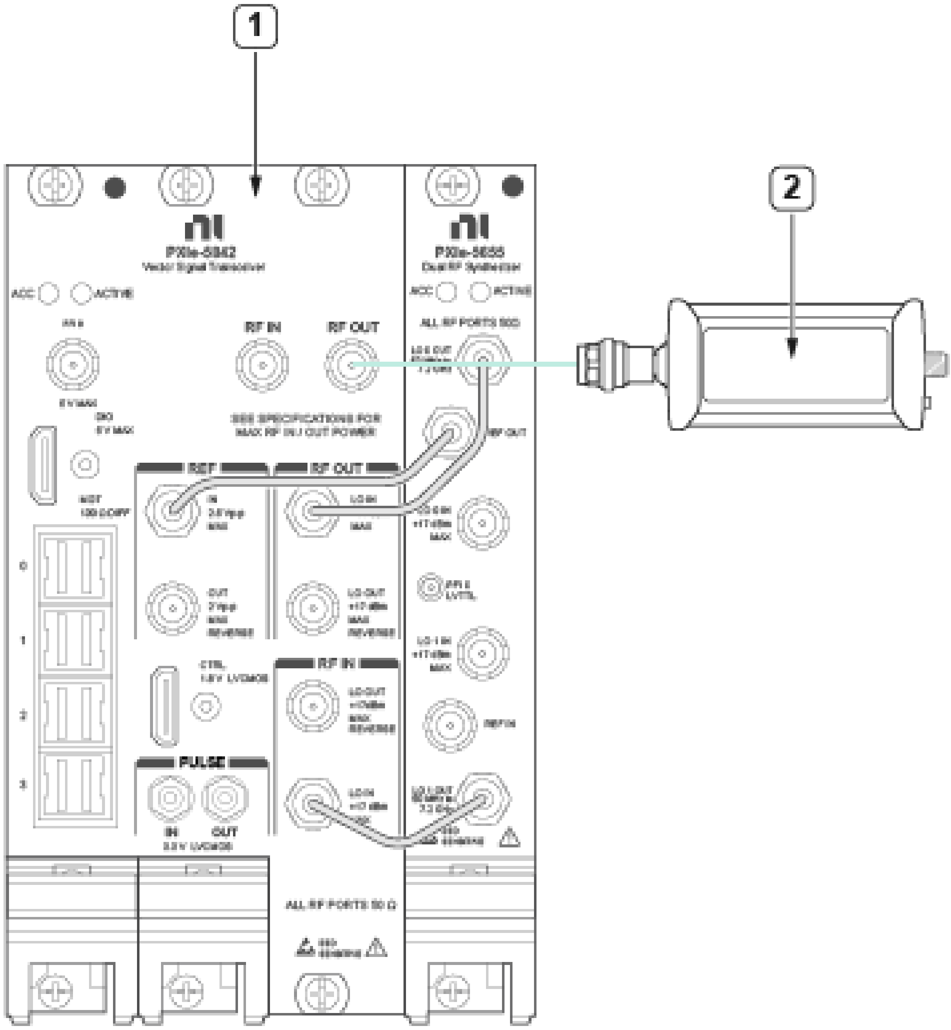
Note

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

CAUTION

The form factor of the power sensor might cause strain to the DUT test port connector due to tight spacing between the chassis and power sensor. Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Figure 10. Connections for RF Output Amplitude Accuracy Verification



1. DUT
2. Power Sensor #2

6.3.3. Verification Procedure

This procedure verifies the power level accuracy of the DUT’s output channel. When the Upconverter Offset Mode is set to User-Defined (DC Coupling) an Upconverter offset is configured. When the Upconverter Offset Mode is set to Enabled (AC-coupled) the Upconverter Frequency is automatically set by the driver

Table 21: Output Absolute Accuracy Test points and Configurations

DUT Frequency Range	DUT Power Level	DUT Upconverter Mode	DUT Bandwidth
▪ 30 MHz to 145 MHz in 5 MHz steps ▪ 150 MHz to 290 MHz in 10 MHz steps ▪ 300 MHz to 1.74 GHz in 20 MHz steps ▪ 1.749 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to (Maximum Frequency) (See Table 3) in 100 MHz Steps	-30 dBm to 5 dBm in 5 dBm steps +10 dBm to Maximum Power endpoint in 1 dBm steps If the +10 dBm point is above the Max Linear Power endpoint for that frequency measure only the Max Linear Power at that frequency See Table 19 and Table 20 for Maximum Power	User Defined	Default
▪ 1.701 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to (Maximum Frequency) (See Table 3) in 100 MHz Steps		Enabled	See **Table 5**

6.3.4. Verification Procedure (Upconverter Mode = User Defined)

1. Ensure that the Power Meter as been zeroed according with section 4.3.

2. Power Meter Aperture configuration

The power meter requires that the frequency is configured to perform internal corrections to achieve its warranted specifications. Always configure the frequency of the power meter before making a measurement.

The power meter's accuracy also depends on the power level it is measuring; set the aperture according to **Table 50:** Power Meter Aperture Configuration

3. Make the connections indicated in **Figure 9**

4. Configure the DUT for the following settings for “User Defined” mode:
    - Mode: CW
    - Upconverter Offset Mode: User Defined
    - Upconverter Frequency Offset:
        - User Defined Mode and Frequency <1.75 GHz: Driver Default
        - User Defined Mode and Frequency ≥1.75 GHz: -20 MHz
    - Power Level: Initial lower Power Level from Configurations **Table 21**
    - Frequency: Initial Frequency from Configurations **Table 21**
    - Bandwidth: Signal Bandwidth from Configurations **Table 21**
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz

5. Configure the Power Sensor for the following settings:
    - Frequency: Initial Frequency from Configurations **Table 21**
    - Power Meter Path Selection: Auto Mode
    - Aperture Time: Select from **Table 50** based on the expected input power
    - Number of Averages: 1

6. Generate an RF signal on the DUT with the specified settings. Wait until it settles.

7. Taking the measurements

> Repeat, once for each DUT Power Level in Table 21, starting with the lower power setting.
>
> 1. Record this Power Level value as “**Requested_TX_Power**”
>
> > Based on your DUT option, repeat once for each DUT Frequency setting in Table 21.
> >
> > 1. Measure the power of the DUT with the Power Meter and record the value as “**PM_measured_power”**.
> > 2. Calculate the absolute power level accuracy using the following equation:
> >
> > **Output Absolute Amplitude (UDM) = PM_measured_power - Requested_TX_Power [dB]**

3. Configure the DUT:
    a. Frequency: Next Frequency from Configurations **Table 21**
4. Configure the Power Sensor:
    a. Frequency: Same frequency as the DUT

2. Configure the DUT for the following settings for “User Defined” mode:

    - Power Level: Next Power Level from Configurations Table 21

6.3.5. Verification Procedure (Upconverter Mode = Enabled)

1. Power Meter Aperture configuration

The power meter requires that the frequency is configured to perform internal corrections to achieve its warranted specifications. Always configure the frequency of the power meter before making a measurement.

The power meter’s accuracy also depends on the power level it is measuring; set the aperture according to **Table 50:** Power Meter Aperture Configuration

2. Make the connections indicated in **Figure 9**.

3. Configure the DUT for the following settings for “User Defined” mode:

    - Mode: CW
    - Upconverter Offset Mode: Enabled
    - Upconverter Frequency Offset: Driver Default
    - Power Level: Initial lower Power Level from Configurations **Table 21**
    - Frequency: Initial Frequency from Configurations **Table 21**
    - Bandwidth: Signal Bandwidth from Configurations **Table 21**
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz

4. Configure the Power Sensor for the following settings:
    - Frequency: Initial Frequency from Configurations **Table 21**
    - Power Meter Path Selection: Auto Mode
    - Aperture Time: Select from **Table 50** based on the expected input power
    - Number of Averages: 1
5. Generate an RF signal on the DUT with the specified settings. Wait until it settles.
6. Taking the measurements

Repeat, once for each DUT Power Level in Table 21, starting with the lower power setting.

1. Record this Power Level value as “**Requested_TX_Power**”

Based on your DUT option, repeat once for each DUT Frequency setting in Table 21.

1. Measure the power of the DUT with the Power Meter and record the value as “**PM_measured_power”**.
2. Calculate the absolute power level accuracy using the following equation:

   Output Absolute Amplitude (ENM) = PM_measured_power - Requested_TX_Power [dB]

3. Configure the DUT:
    a. Frequency: Next Frequency from Configurations **Table 21**
4. Configure the Power Sensor:
    a. Frequency: Same frequency as the DUT

2. Configure the DUT for the following settings for “User Defined” mode:
    - Power Level: Next Power Level from Configurations **Table 21**

6.4. RF Output Frequency Response Verification

6.4.1. Test Limits

Table 22: RF Output Frequency Response Accuracy Verification Test Limits (User Defined Mode)

Frequency Range	As-Found Test Limit		As-Left Test Limit	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
30 MHz to 200 MHz	-1.1 dB	+1.1 dB	-0.81 dB	+0.81 dB
>200 MHz to 1.02 GHz	-0.75 dB	+0.75 dB	-0.36 dB	+0.36 dB
>1.02 GHz to 1.75 GHz	-0.75 dB	+0.75 dB	-0.36 dB	+0.36 dB
>1.75 GHz to 8.0 GHz	-0.65 dB	+0.65 dB	-0.38 dB	+0.38 dB
>8.0 GHz to 12.0 GHz	-0.65 dB	+0.65 dB	-0.40 dB	+0.40 dB
>12.0 GHz to 18.0 GHz	-0.75 dB	+0.75 dB	-0.48 dB	+0.48 dB
>18.0 GHz to 22.0 GHz	-0.80 dB	+0.80 dB	-0.48 dB	+0.48 dB
>22.0 GHz to 25.0 GHz	-0.90 dB	+0.90 dB	-0.59 dB	+0.59 dB
>25.0 GHz to 26.5 GHz	-1.25 dB	+1.25 dB	-0.96 dB	+0.96 dB

Table 23: RF Output Frequency Response Verification Test Limits (Enabled Mode)

Frequency Range	As-Found Test Limit		As-Left Test Limit	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
1.7 GHz to 8.0 GHz	-0.65 dB	+0.65 dB	-0.33 dB	+0.33 dB
>8.0 GHz to 12.0 GHz	-0.65 dB	+0.65 dB	-0.38 dB	+0.38 dB
>12.0 GHz to 18.0 GHz	-0.75 dB	+0.75 dB	-0.44 dB	+0.44 dB

>18.0 GHz to 22.0 GHz	-0.80 dB	+0.80 dB	-0.43 dB	+0.43 dB
>22.0 GHz to 25.0 GHz	-0.90 dB	+0.90 dB	-0.48 dB	+0.48 dB
>25.0 GHz to 26.5 GHz	-1.25 dB	+1.25 dB	-0.42 dB	+0.42 dB

6.4.2. Initial Test Connection

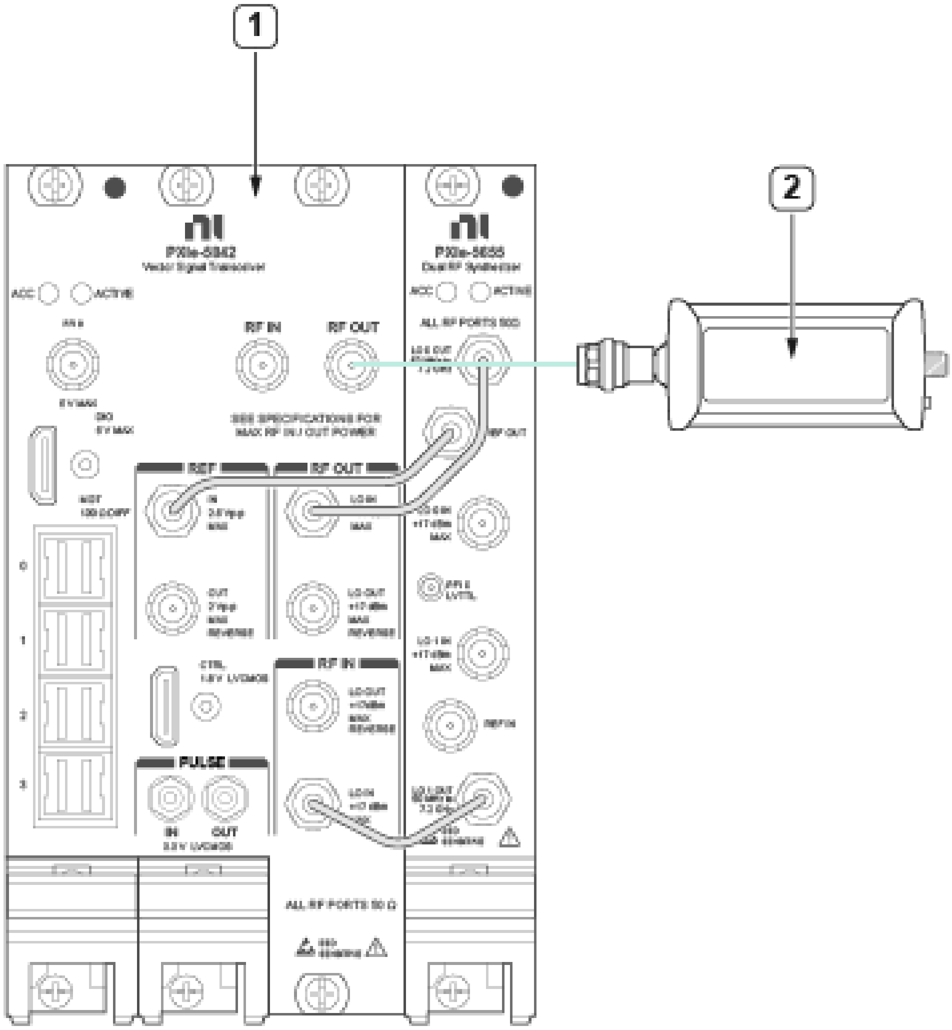
Note

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

CAUTION

The form factor of the power sensor might cause strain to the DUT test port connector. Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Figure 11. Connections for RF Output Frequency Response Accuracy Verification



1.DUT

2. Power Sensor #2

6.4.3. Verification Procedure

This procedure verifies the Frequency Response accuracy of the DUT’s output channel at a specified upconverter center frequency within the bandwidth selected.

Table 24: RF Output Frequency Response Accuracy Test points and Configurations (**User Defined Mode**)

DUT Center Frequency Range	DUT Power Level	Reference Tone Offset	Additional Sweep Info	DUT Bandwidth
▪ 31 MHz ▪ 35 MHz to 65 MHz in 5 MHz steps	▪ -30 dBm ▪ 0 dBm ▪ +10 dBm to Max Linear Power endpoint in 5 dBm steps) ▪ Include Max Linear Power point If the +10 dBm point is above the Max Linear Power endpoint for that frequency, measure only the Max Linear Power at that frequency See Table 19 for Maximum Power	0 Hz	Sweep Step Size: 1 MHz	See **Table 6**
▪ 75 MHz to 275 MHz in 25 MHz steps			Sweep Step Size: 5 MHz Offsets below 200 MHz absolute frequency should be removed	
▪ 280 MHz ▪ 300 MHz to 500 MHz in 100 MHz steps			Sweep Step Size: 10 MHz Must include ±250 MHz Offsets below 200 MHz absolute frequency should be removed	
▪ 530 MHz ▪ 1015 MHz ▪ 750 MHz to 1.5 GHz in 250 MHz steps			Sweep Step Size: 20 MHz Must include ±250 MHz and ±500 MHz Offsets below 200 MHz absolute frequency should be removed	
▪ 1.749 GHz			Sweep Step Size: 20 MHz Must include ±250 MHz	
▪ 1.75 GHz to 11.75 GHz in 250 MHz steps Do not test above Maximum DUT Frequency, see **Table 3**		20 MHz	Sweep Step Size: 20 MHz Must include 100 kHz, ±250 MHz and ±500 MHz	

			Remove 0 Hz offset (start your sweep from +20 MHz up, and -20 MHz down)	
▪ 12 GHz to 26.5 GHz in 250 MHz steps Do not test above Maximum DUT Frequency, see **Table 3**	▪ -30 dBm ▪ 0 dBm ▪ (Max Linear Power – 2 dB) to Maximum Linear Power in 1 dB Steps. (For example, if Maximum Linear power is +4 dBm test: +2 dBm, +3 dBm and +4 dBm) See Table 19 for Maximum Power		Sweep Step Size: 20 MHz Must include 100 kHz, ±250 MHz and ±500 MHz Remove 0 Hz offset (start your sweep from +20 MHz up, and -20 MHz down)	

Table 25: RF Output Frequency Response Accuracy Test points and Configurations (**Enabled Mode**)

DUT Center Frequency Range	DUT Power Level	Reference Tone Offset	Additional Sweep Info	DUT Bandwidth
▪ 1.701 GHz ▪ 1.75 GHz to 11.75 GHz in 250 MHz steps Do not test above Maximum DUT Frequency, see **Table 3**	▪ -30 dBm ▪ 0 dBm ▪ +10 dBm to Max Linear Power endpoint in 5 dBm steps) ▪ Include Max Linear Power point If the +10 dBm point is above the Max Linear Power endpoint for that frequency, measure only the Max Linear Power at that frequency	0 Hz	Sweep Step Size: 20 MHz Must include ±125 MHz and ±250 MHz	See **Table 5**

	See Table 20 for Maximum Power			
▪ 12 GHz to 26.5 GHz in 250 MHz steps Do not test above Maximum DUT Frequency, see **Table 3**	▪ -30 dBm ▪ 0 dBm ▪ Maximum Linear Power to (Max Linear Power – 2 dB) in 1 dB Steps. (For example, if Maximum Linear power is +4 dBm test: +2 dBm, +3 dBm and +4 dBm) See Table 20 for Maximum Power			

6.4.4. Verification Procedure (Upconverter Mode = User Defined)

1. Ensure that the Power Meter has been zeroed according with section 4.3.
2. Power Meter Aperture configuration

The power meter requires that the frequency is configured to perform internal corrections to achieve its warranted specifications. Always configure the frequency of the power meter before making a measurement.

The power meter's accuracy also depends on the power level it is measuring; set the aperture according to **Table 50:** Power Meter Aperture Configuration

3. Make the connections indicated in **Figure 15**.
4. Configure the DUT for the following settings for "User Defined" mode:
   - Mode: Arb Waveform (IQ)
   - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**
   - Number of Samples: 50 kS

- Upconverter Offset Mode: User Defined
- Upconverter Frequency Offset: Driver Default
- MultiTone VI Cluster Input (see section 8.1 for more information):
    - Number of Elements = 1
    - Tone Frequency = Reference Tone Offset from **Table 24**
    - Tone Phase = [0]
    - Tone Power = [0]
- Power Level: Initial lower Power Level from Configurations **Table 24**
- Frequency: Initial Center Frequency from Configurations **Table 24**
- Bandwidth: Signal Bandwidth from Configurations **Table 24**
- Reference Clock Source: PXI_CLK (Locked to Rubidium)
- Reference Clock Frequency: 10 MHz

5. Configure the Power Sensor for the following settings:

    - Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 24**
    - Power Meter Path Selection: Auto Mode
    - Aperture Time: Select from **Table 50** based on the expected input power
    - Number of Averages: 1

6. Generate an RF signal on the DUT with the specified settings. Wait until it settles.

7. Taking the measurements

Repeat, once for each DUT Power Level in Table 24, starting with the lower power setting.

Based on your DUT option, repeat once for each DUT Center Frequency setting in Table 24.

1. Measure the power of the DUT with the Power Meter and record the value as “**PM_measured_power$_{Ref}$**”.

Repeat, sweeping the Tone Offset Frequency of the DUT through all Tone Offsets.
Start from Center Frequency to –Signal Bandwidth/2 and from Center Frequency to +Signal Bandwidth/2, in step sizes indicated on Table 24.

Note

The test points within a BW should start at the center point zero and expand symmetrically from that at the required step size

For Center Frequencies ≥1.75 GHz, test points should start at (Center Frequency + 20 MHz) and expand up, and (Center Frequency -20MHz) and expand down.

1. MultiTone VI Cluster Input:
    a. Tone Frequency = Next Tone Offset based on the step size in **Table 24**.
2. Configure the Power Sensor for the following settings:
    - Frequency: (Current Center Frequency + Reference Tone Offset + Next Sweep Step) from Configurations **Table 24**.
3. Measure the power of the DUT with the Power Meter and record the value as “**PM_measured_power$_i$**”.

Where “x_i” is a linear index number to identify each new tone offset within the sweep from 1 to n.

4. Calculate the normalized frequency response for each baseband tone offset “x_i” using the following equation:

$$\textbf{Normalized\_Frequency\_Response}_i = \textbf{PM\_measured\_power}_i - \textbf{PM\_measured\_power}_{ref}$$

2. Calculate the max frequency response error using the following equation:

$$\textbf{Output Frequency Response (UDM)} = \textbf{Maximum} \left(|\textbf{Normalized\_Frequency\_Response}_i|, \ldots, |\textbf{Normalized\_Frequency\_Response}_n|\right) \textbf{[dB]}$$

3. Configure the DUT:
   - MultiTone VI Cluster Input (see section 8.1 for more information):
     a. Tone Frequency = Reference Tone Offset from **Table 24**
   - Frequency: Next Center Frequency from Configurations **Table 24**
   - Bandwidth: Signal Bandwidth from Configurations **Table 24**
4. Configure the Power Sensor:
   a. Frequency: Same frequency as the DUT

8. Configure the DUT for the following settings:

   - Power Level: Next Power Level from Configurations **Table 24**
   - Frequency: Initial Center Frequency from Configurations **Table 24**
   - Bandwidth: Signal Bandwidth from Configurations **Table 24**
   - MultiTone VI Cluster Input (see section 8.1 for more information):
     - Number of Elements = 1
     - Tone Frequency = Reference Tone Offset from **Table 24**
     - Tone Phase = [0]
     - Tone Power = [0]

9. Configure the Power Sensor for the following settings:

   - Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 24**
   - Aperture Time: Select from **Table 50** based on the expected input power

10. Generate an RF signal on the DUT with the specified settings. Wait until it settles.

6.4.5. Verification Procedure (Upconverter Mode = Enabled)

1. Ensure that the Power Meter has been zeroed according with section 4.3.

2. Power Meter Aperture configuration

The power meter requires that the frequency is configured to perform internal corrections to achieve its warranted specifications. Always configure the frequency of the power meter before making a measurement.

The power meter's accuracy also depends on the power level it is measuring; set the aperture according to **Table 50:** Power Meter Aperture Configuration

3. Make the connections indicated in **Figure 15**.

4. Configure the DUT for the following settings for "Enabled" mode:

    - Mode: Arb Waveform (IQ)
    - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**
    - Number of Samples: 50 kS
    - Upconverter Offset Mode: Enabled
    - Upconverter Frequency Offset: Driver Default
    - MultiTone VI Cluster Input (see section 8.1 for more information):
        - Number of Elements = 1
        - Tone Frequency = Reference Tone Offset from **Table 25**
        - Tone Phase = [0]
        - Tone Power = [0]
    - Power Level: Initial lower Power Level from Configurations **Table 25**
        - Frequency: Initial Center Frequency from Configurations **Table 25**
    - Bandwidth: Signal Bandwidth from Configurations **Table 25**
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz

5. Configure the Power Sensor for the following settings:

    - Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 25**
    - Power Meter Path Selection: Auto Mode
    - Aperture Time: Select from **Table 50** based on the expected input power
    - Number of Averages: 1

6. Generate an RF signal on the DUT with the specified settings. Wait until it settles.
7. Taking the measurements

For each DUT Power Level in Table 25, starting with the lower power setting, repeat the following steps:

Based on your DUT option, repeat once for each DUT Center Frequency setting in Table 25.

1. Measure the power of the DUT with the Power Meter and record the value as “**PM_measured_power$_{Ref}$**”.

Repeat, sweeping the Tone Offset Frequency of the DUT through all Tone Offsets.
Start from Center Frequency to –Signal Bandwidth/2 and from Center Frequency to +Signal Bandwidth/2, in step sizes indicated on Table 25.

Note

The test points within a BW should start at the center point zero and expand symmetrically from that at the required step size.

1. MultiTone VI Cluster Input:
    a. Tone Frequency = Next Tone Offset based on the step size in **Table 25**.
2. Configure the Power Sensor for the following settings:
3. Frequency:
    (Current Center Frequency + Reference Tone Offset + Next Sweep Step) from Configurations **Table 25**.
4. Measure the power of the DUT with the Power Meter and record the value as “**PM_measured_power$_i$**”.

Where "x_i" is a linear index number to identify each new tone offset within the sweep from 1 to n.

5. Calculate the normalized frequency response for each baseband tone offset "x_i" using the following equation:

$$\textbf{Normalized\_Frequency\_Response}_i = \textbf{PM\_measured\_power}_i - \textbf{PM\_measured\_power}_{ref}$$

2. Calculate the max frequency response error using the following equation:

$$\textbf{Output Frequency Response (UDM)} = \textbf{Maximum}\,(|\textbf{Normalized\_Frequency\_Response}_i|,\ldots,|\textbf{Normalized\_Frequency\_Response}_n|)\ [\textbf{dB}]$$

3. Configure the DUT:
   - MultiTone VI Cluster Input (see section 8.1 for more information):
     a. Tone Frequency = Reference Tone Offset from **Table 25**
   - Frequency: Next Center Frequency from Configurations **Table 25**
   - Bandwidth: Signal Bandwidth from Configurations **Table 25**
4. Configure the Power Sensor:
   a. Frequency: Same frequency as the DUT

1. Configure the DUT for the following settings:

   - Power Level: Next Power Level from Configurations **Table 25**
   - Frequency: Initial Center Frequency from Configurations **Table 25**
   - Bandwidth: Signal Bandwidth from Configurations **Table 25**
   - MultiTone VI Cluster Input (see section 8.1 for more information):
     - Number of Elements = 1
     - Tone Frequency = Reference Tone Offset from **Table 25**
     - Tone Phase = [0]
     - Tone Power = [0]

2. Configure the Power Sensor for the following settings:

- Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 25**
- Aperture Time: Select from **Table 50** based on the expected input power

3. Generate an RF signal on the DUT with the specified settings. Wait until it settles.

6.5. RF Input Absolute Amplitude Verification

Table 26: RF Input Absolute Amplitude Accuracy Verification Test Limits (User Defined Mode)

Frequency Range	As-Found Test Limit		As-Left Test Limit	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
30 MHz to 1.75 GHz	-0.75 dB	+0.75 dB	-0.40 dB	+0.40 dB
>1.75 GHz to 6.0 GHz	-0.70 dB	+0.70 dB	-0.36 dB	+0.36 dB
>6.0 GHz to 12.0 GHz	-0.85 dB	+0.85 dB	-0.47 dB	+0.47 dB
>12.0 GHz to 18.0 GHz	-1.05 dB	+1.05 dB	-0.60 dB	+0.60 dB
>18.0 GHz to 22.0 GHz	-1.15 dB	+1.15 dB	-0.60 dB	+0.60 dB
>22.0 GHz to 26.5 GHz	-1.40 dB	+1.40 dB	-0.72 dB	+0.72 dB

Table 27: RF Input Absolute Amplitude Verification Test Limits (Enabled Mode)

Frequency Range	As-Found Test Limit		As-Left Test Limit	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
1.7 GHz to 6.0 GHz	-0.70 dB	+0.70 dB	-0.34 dB	+0.34 dB
>6.0 GHz to 12.0 GHz	-0.85 dB	+0.85 dB	-0.47 dB	+0.47 dB
>12.0 GHz to 18.0 GHz	-1.05 dB	+1.05 dB	-0.62 dB	+0.62 dB
>18.0 GHz to 22.0 GHz	-1.15 dB	+1.15 dB	-0.59 dB	+0.59 dB
>22.0 GHz to 26.5 GHz	-1.40 dB	+1.40 dB	-0.70 dB	+0.70 dB

6.5.1. Initial Test Connection

Note

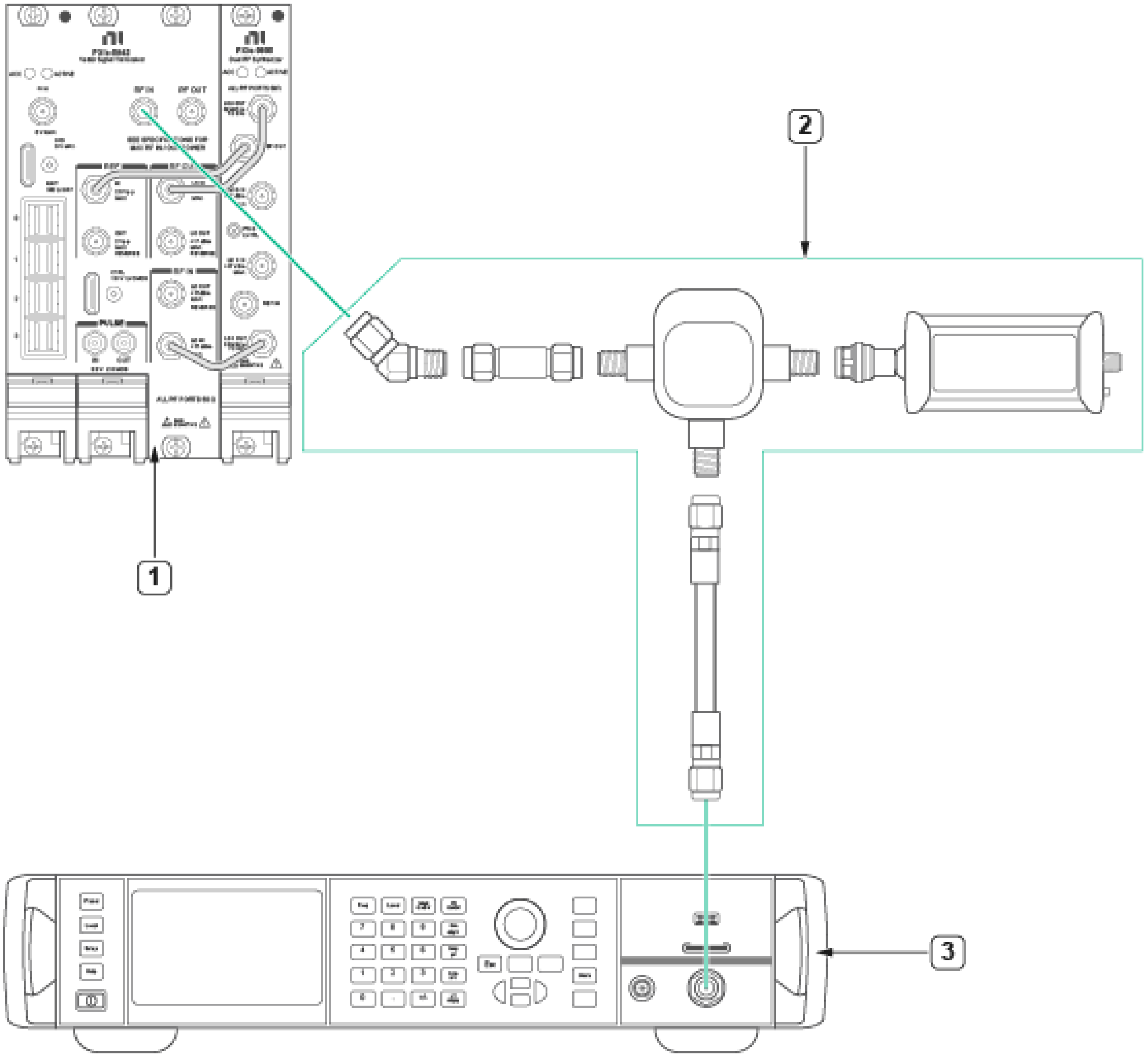
Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

Note

Make sure that you have performed the Input Receiver fixture characterization as per **section 5.1** - Receiver Fixture Characterization before starting this Verification procedure.

CAUTION
Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Figure 12. Connections for RF Input Absolute Amplitude Accuracy Verification



1. DUT	2. Receiver Fixture from Figure 3
3. Signal Generator	

6.5.2. Verification Procedure

This procedure verifies the Absolute Amplitude accuracy of the DUT's Input channel at a specified center frequencies and power levels for the selected Down Converter Offset Modes.

Table 28: RF Input Amplitude Minimum Reference Power Level

DUT IQ Frequency Range	DUT Minimum Reference Power Level	DUT Upconverter Mode
≤ 5.7 GHz	-45 dBm	User Defined
>5.7 GHz to 9.0 GHz	-40 dBm	
>9.0 GHz to Maximum Frequency	-35 dBm	
≤ 3.0 GHz	-35 dBm	Enabled
>3.0 GHz to 9.4 GHz	-40 dBm	
>9.4 GHz to Maximum Frequency	-35 dBm	

Table 29: RF Input Absolute Amplitude Accuracy Test points and Configurations (User Defined Mode)

DUT IQ Center Frequency Range	DUT Reference Power Level	Nominal Power at DUT input	DUT Bandwidth
▪ 30 MHz to 145 MHz in 5 MHz steps ▪ 150 MHz to 290 MHz in 10 MHz steps ▪ 300 MHz to 1.740 GHz in 20 MHz steps ▪ 1.749 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to Maximum Frequency in 100 MHz steps Do not test above Maximum DUT Frequency, see **Table 3**	▪ Minimum Reference Power level from **Table 28** to +25 dBm in 5 dB steps.	▪ DUT Reference Power Level ≤10 dBm: Same as the DUT Reference Power Level ▪ DUT Reference Power Level >10 dBm: +10 dBm	Driver Default

Table 30: RF Input Absolute Amplitude Accuracy Test points and Configurations (Enabled Mode)

DUT IQ Center Frequency Range	DUT Reference Power Level	Nominal Power at DUT input	DUT Bandwidth
▪ 1.701 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to Maximum Frequency in 100 MHz steps Do not test above Maximum DUT Frequency, see **Table 3**	▪ Minimum Reference Power level from **Table 28** to +25 dBm in 5 dB steps.	▪ DUT Reference Power Level ≤10 dBm: Same as the DUT Reference Power Level ▪ DUT Reference Power Level >10 dBm: +10 dBm	See **Table 5**

6.5.3. Verification Procedure (Upconverter Mode = User Defined)

1. Make the connections indicated in **Figure 12**.
2. Configure the DUT for the following settings:
   - Acquisition type: IQ
   - FFT Window Type: Flat Top
   - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**
   - Number of Samples: 50 kS
   - Downconverter Offset Mode: User Defined
   - Downconverter Frequency Offset: Driver Default
   - Reference Power Level: Initial lower Power Level from Configurations **Table 29**
   - IQ Center Frequency: Initial Center Frequency from Configurations **Table 29**
   - Bandwidth: Signal Bandwidth from Configurations **Table 29**
   - Reference Clock Source: PXI_CLK (Locked to Rubidium)

- Reference Clock Frequency: 10 MHz

3. Configure the Signal Generator for the following settings:
   - RF Frequency: Initial Center Frequency from Configurations **Table 29**
   - Power Level: Power Level such that to achieve the minimum Nominal Power at DUT input from **Table 28**

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level (**Table 28**) + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

4. Configure the Power Sensor for the following settings:
   - Frequency: Initial Center Frequency from Configurations **Table 29**
   - Power Meter Path Selection: Auto Mode
   - Aperture Time: Select from **Table 50** based on the expected input power
   - Number of Averages: 1
5. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.
6. Taking the measurements

For each DUT Power Level in Table 29, starting with the lower power setting, repeat the following steps:

Based on your DUT option, repeat once for each DUT Frequency setting in Table 29 starting with the lower frequency.

1. Measure the power deliver to the DUT with the Power Meter and record the value as “**PM_measured_power**”.

2. Measure the power at the DUT and record the value as “**DUT_measured_power**”.
   a) See 8.2 Acquiring a Spectrum from IQ Data and Measuring the Peak
      i) Frequency Deviation: 125 kHz
      ii) Search Frequency: Equal to the CW signal on the Signal Generator
3. Calculate the absolute power level accuracy using the following equation:

Input Absolute Amplitude (UD) = DUT_measured_power - RX_Fixture_PM_to_RX_Path_Response - PM_measured_power [dBm]

Where **“RX_Fixture_PM_to_RX_Path_Response”** is the Receiver Fixture characterized value, at the measurement frequency, calculated by (***Equation 1***) in section **5.1.3 Characterization Procedure**

- Configure the DUT for the following settings:
- IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**
- IQ Center Frequency: Next Center Frequency from Configurations **Table 29**
- Bandwidth: Signal Bandwidth from Configurations **Table 29**
- Downconverter Offset:
  - Frequency <1.75GHz: Driver Default
  - Frequency ≥1.75 GHz: -20 MHz

- Configure the Signal Generator for the following settings:
- RF Frequency: same as the IQ Center Frequency from previous paragraph
- Power Level: Power Level such that to achieve the selected Nominal Power at DUT input at the selected frequency.

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level selected + RX_Fixture_PM_to_RX_Path_Response

(at the selected frequency (***Equation 1***)).

- Configure the Power Sensor:
  - Frequency: Same frequency as the DUT

1. Configure the DUT for the following settings:
   - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**
   - Reference Power Level: Next Power Level from Configurations **Table 29**
   - IQ Center Frequency: Initial Center Frequency from Configurations **Table 29**
   - Bandwidth: Signal Bandwidth from Configurations **Table 29**
   - Downconverter Offset: Driver Default
2. Configure the Signal Generator for the following settings:
   - RF Frequency: Initial Center Frequency from Configurations **Table 29**
   - Power Level: Power Level such that to achieve the selected Nominal Power at DUT input

Note

Nominal Power Level at DUT input should be the:

Selected DUT Reference Power Level + RX_Fixture_PM_to_RX_Path_Response

(Equation 1).

3. Configure the Power Sensor for the following settings:
   - Frequency: Initial Center Frequency from Configurations **Table 29**
   - Aperture Time: Select from **Table 50** based on the expected input power

4. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.

6.5.4. Verification Procedure (Upconverter Mode = Enabled)

1. Make the connections indicated in **Figure 12**.
2. Configure the DUT for the following settings:
    - Acquisition type: IQ
    - FFT Window Type: Flat Top
    - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**
    - Number of Samples: 50 kS
    - Downconverter Offset Mode: Enabled
    - Downconverter Frequency Offset: Driver Default
    - Reference Power Level: Initial lower Power Level from Configurations **Table 30**
    - IQ Center Frequency: Initial Center Frequency from Configurations **Table 30**
    - Bandwidth: Signal Bandwidth from Configurations **Table 30**
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz
3. Configure the Signal Generator for the following settings:
    - RF Frequency: Initial Center Frequency from Configurations **Table 30**
    - Power Level: Power Level such that to achieve the minimum Nominal Power at DUT input from **Table 28**

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level (**Table 28**) + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

4. Configure the Power Sensor for the following settings:
   - Frequency: Initial Center Frequency from Configurations **Table 30**
   - Power Meter Path Selection: Auto Mode
   - Aperture Time: Select from **Table 50** based on the expected input power
   - Number of Averages: 1
5. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.
6. Taking the measurements

For each DUT Power Level in Table 29, starting with the lower power setting, repeat the following steps:

Based on your DUT option, repeat once for each DUT Frequency setting in Table 30 starting with the lower frequency.

1. Measure the power deliver to the DUT with the Power Meter and record the value as “**PM_measured_power”**.
2. Measure the power at the DUT and record the value as “**DUT_measured_power”**.
   - See 8.2 Acquiring a Spectrum from IQ Data and Measuring the Peak

   i) Frequency Deviation: 125 kHz

   ii) Search Frequency: Equal to the CW signal on the Signal Generator
3. Calculate the absolute power level accuracy using the following equation:

Input Absolute Amplitude (EN) = DUT_measured_power - RX_Fixture_PM_to_RX_Path_Response - PM_measured_power [dBm]

Where **“RX_Fixture_PM_to_RX_Path_Response”** is the Receiver Fixture characterized value, at the measurement frequency, calculated by (***Equation 1***) in section **5.1.3 Characterization Procedure**

4. Configure the DUT for the following settings:
    - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**
    - IQ Center Frequency: Next Center Frequency from Configurations **Table 30**
    - Bandwidth: Signal Bandwidth from Configurations **Table 30**
5. Configure the Signal Generator for the following settings:
    - RF Frequency: same as the IQ Center Frequency from previous paragraph
    - Power Level: Power Level such that to achieve the selected Nominal Power at DUT input at the selected frequency

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level selected +
RX_Fixture_PM_to_RX_Path_Response

(at the selected frequency (***Equation 1***)).

6. Configure the Power Sensor:
    - Frequency: Same frequency as the DUT

1. Configure the DUT for the following settings:
    - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**

- Reference Power Level: Next Power Level from Configurations **Table 30**
- IQ Center Frequency: Initial Center Frequency from Configurations **Table 30**
- Bandwidth: Signal Bandwidth from Configurations **Table 30**

2. Configure the Signal Generator for the following settings:
   - RF Frequency: Initial Center Frequency from Configurations **Table 30**
   - Power Level: Power Level such that to achieve the selected Nominal Power at DUT input

Note

Nominal Power Level at DUT input should be the:

Selected DUT Reference Power Level + RX_Fixture_PM_to_RX_Path_Response

(Equation 1).

3. Configure the Power Sensor for the following settings:
   - Frequency: Initial Center Frequency from Configurations **Table 30**
   - Aperture Time: Select from **Table 50** based on the expected input power
4. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.

6.6. RF Input Power Linearity Verification

Table 31: RF Input Linearity Accuracy Verification Test Limits (User Defined and Enabled Modes)

Frequency Range	As-Found Test Limit		As-Left Test Limit	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
30 MHz to 26.5 GHz	-0.50 dB	+0.50 dB	-0.37 dB	+0.37 dB

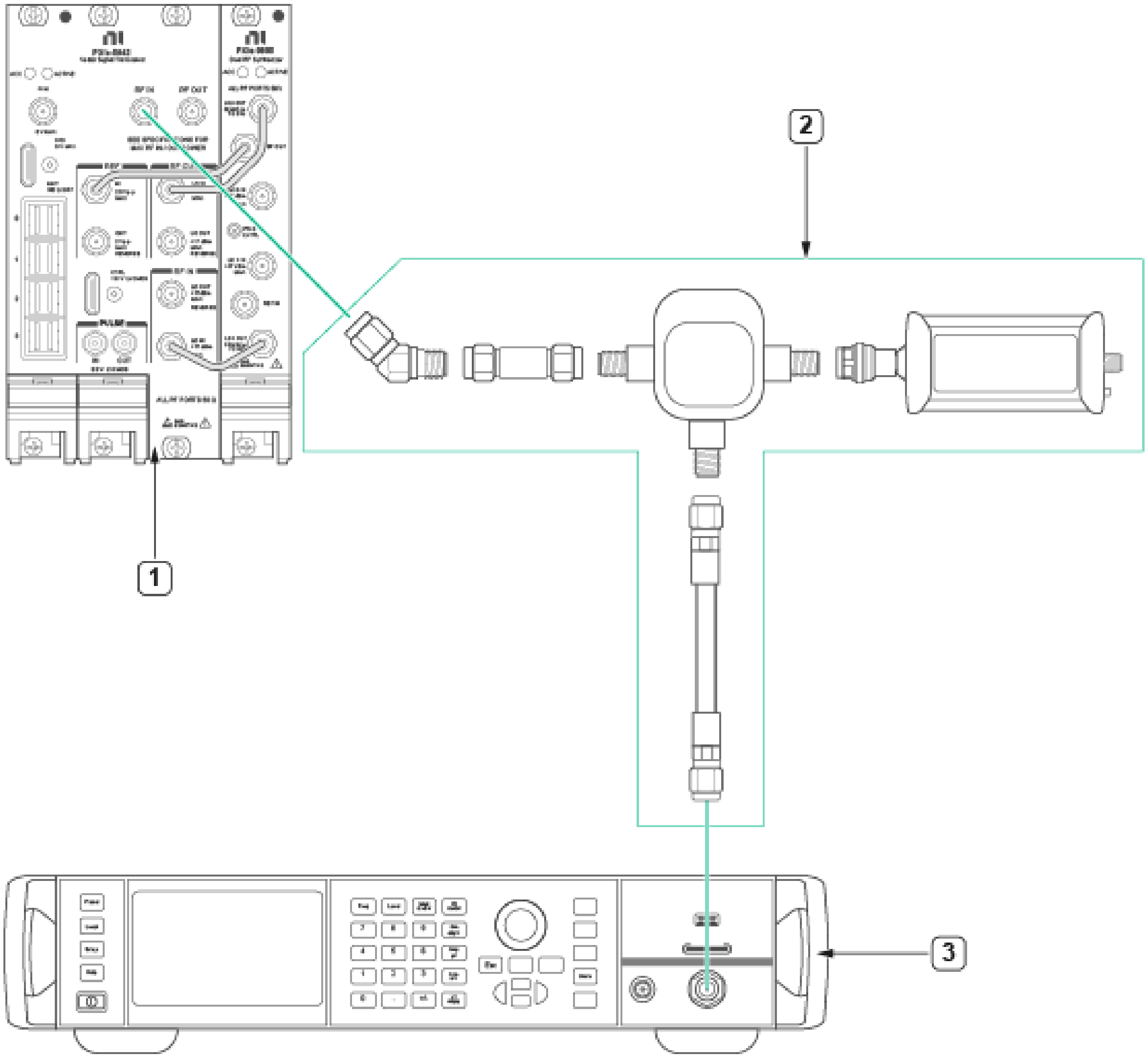
6.6.1. Initial Test Connection

Make sure that you have made the connections described in **Figure 5** External Reference Clock Connection before starting this Verification procedure.

Make sure that you have performed the Input Receiver fixture characterization as per **section 5.1** - Receiver Fixture Characterization before starting this Verification procedure.

CAUTION
Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Figure 13. Connections for RF Input Power Linearity Accuracy Verification



1. DUT
2. Receiver Fixture from Figure 3
3. Signal Generator

6.6.2. Verification Procedure

This procedure verifies the input power linearity accuracy of the DUT’s Analog to Digital Converter (ADC) Input channel at a specified center frequencies and power levels for the selected Down Converter Offset Modes.

Table 32: RF Input Power Linearity Accuracy Test points and Configurations (**User Defined Mode**)

DUT IQ Center Frequency Range	DUT Reference Power Level	Nominal Power at DUT input	DUT Bandwidth
▪ 30 MHz, 45 MHz, 50 MHz, 290 MHz, 530 MHz, 770 MHz ▪ 1.010 GHz, 1.490 GHz, 1.730 GHz, 1.749 GHz ▪ 1.75 GHz to Maximum Frequency in 1 GHz steps ▪ 8 GHz, 12 GHz, 18 GHz and 26.5 GHz Do not test above Maximum DUT Frequency, see **Table 3**	▪ +5 dBm	▪ IQ Center Frequency <10 GHz: -35 dBm to 0 dBm in 1 dB Steps ▪ IQ Center Frequency ≥10 GHz: -40 dBm to 0 dBm in 1 dB steps ▪ Use 0 dBm as the reference power level	Driver Default

Table 33: RF Input Power Linearity Accuracy Test points and Configurations (**Enabled Mode**)

DUT IQ Center Frequency Range	DUT Reference Power Level	Nominal Power at DUT input	DUT Bandwidth
▪ 1.701 GHz ▪ 1.75 GHz to Maximum Frequency in 1 GHz steps ▪ 8 GHz, 12 GHz, 18 GHz and 26.5 GHz Do not test above Maximum DUT Frequency, see **Table 3**	▪ +5 dBm	▪ IQ Center Frequency <10 GHz: -35 dBm to 0 dBm in 1 dB Steps ▪ IQ Center Frequency ≥10 GHz: -40 dBm to 0 dBm in 1 dB steps ▪ Use 0 dBm as the reference power level	See **Table 5**

6.6.3. Verification Procedure (Upconverter Mode = User Defined)

1. Make the connections indicated in Figure 13
2. Configure the DUT for the following settings:

- Acquisition type: IQ
- FFT Window Type: Flat Top
- IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**
- Number of Samples: 50 kS
- Downconverter Offset Mode: User Defined
- Downconverter Frequency Offset: Driver Default
- Reference Power Level: Power Level from Configurations **Table 32**
- IQ Center Frequency: Initial Center Frequency from Configurations **Table 32**
- Bandwidth: Signal Bandwidth from Configurations **Table 32**
- Reference Clock Source: PXI_CLK (Locked to Rubidium)
- Reference Clock Frequency: 10 MHz

3. Configure the Signal Generator for the following settings:

   - RF Frequency: Initial Center Frequency from Configurations **Table 32**
   - Power Level: Power Level such that to achieve 0 dBm Power at DUT input.

> **Note**
>
> Nominal Power Level at DUT input should be the:
>
> DUT Reference Power Level (**0 dBm**) + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

4. Configure the Power Sensor for the following settings:

   - Frequency: Initial Center Frequency from Configurations **Table 32**
   - Power Meter Path Selection: Auto Mode
   - Aperture Time: Select from **Table 50** based on the expected input power
   - Number of Averages: 1

5. Generate a CW signal on the Signal Generator with the specified settings and wait until it settles.

6. Taking the measurements

For each DUT Power Level in Table 32, starting with the 0 dBm Reference power setting down to the minimum power setting, repeat the following steps:

Based on your DUT option, repeat once for each DUT Frequency setting in Table 32 starting with the lower frequency.

1. Measure the power deliver to the DUT with the Power Meter and record the value as “**PM_measured_power**”.
2. Measure the power at the DUT and record the value as “**DUT_measured_power**”.

   a. See 8.2 Acquiring a Spectrum from IQ Data and Measuring the Peak
      i) Frequency Deviation: 125 kHz
      ii) Search Frequency: Equal to the CW signal on the Signal Generator
3. Calculate the Input absolute power level accuracy using the following equation:

Input Absolute Amplitude (UDLin) = DUT_measured_power - RX_Fixture_PM_to_RX_Path_Response - PM_measured_power [dBm]

Where **“RX_Fixture_PM_to_RX_Path_Response”** is the Receiver Fixture characterized value, at the measurement frequency, calculated by (***Equation 1***) in section **5.1.3 Characterization Procedure**

4. If this power iteration to measure the 0 dBm Reference power setting, skip the next step and save the measurement as “**Absolute Amplitude$_{0dBm}$ (UDLin)**” at the set frequency.
5. Calculate the RF Input Power Linearity Accuracy using the following equation:

Input_Power_Linearity (UD)= Input Absolute Amplitude (UDLin) – Input Absolute Amplitude$_{0dBm}$ (UDLin)

Where “**Input Absolute Amplitude$_{0dBm}$ (UDLin)**” is the power measured previously at 0 dBm reference for the set frequency.

6. Configure the DUT for the following settings:
    - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**
    - IQ Center Frequency: Next Center Frequency from Configurations **Table 32**
    - Bandwidth: Signal Bandwidth from Configurations **Table 32**
    - Downconverter Offset:
        - Frequency <1.75 GHz: Driver Default
        - Frequency ≥1.75 GHz: -20 MHz

7. Configure the Signal Generator for the following settings:
    - RF Frequency: same as the IQ Center Frequency from previous paragraph
    - Power Level: Power Level such that to achieve the selected Nominal Power at DUT input at the selected frequency

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level selected +
RX_Fixture_PM_to_RX_Path_Response

(at the selected frequency (***Equation 1***)).

8. Configure the Power Sensor:
    - Frequency: Same frequency as the DUT

1. Configure the DUT for the following settings:

    - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**
    - Reference Power Level: Next Power Level down from Configurations **Table 32**

- IQ Center Frequency: Initial Center Frequency from Configurations **Table 32**
- Bandwidth: Signal Bandwidth from Configurations **Table 32**
- Downconverter Offset: Driver Default

2. Configure the Signal Generator for the following settings:

    - RF Frequency: Initial Center Frequency from Configurations Table 29
    - Power Level: Power Level such that to achieve the selected Nominal Power at DUT input

> **Note**
>
> Nominal Power Level at DUT input should be the:
>
> Selected DUT Reference Power Level + RX_Fixture_PM_to_RX_Path_Response
>
> (Equation 1).

3. Configure the Power Sensor for the following settings:

    - Frequency: Initial Center Frequency from Configurations **Table 32**
    - Aperture Time: Select from **Table 50** based on the expected input power

4. Generate a CW signal on the Signal Generator with the specified settings and wait until it settles.

6.6.4. Verification Procedure (Upconverter Mode = Enabled)

1. Make the connections indicated in **Figure 13**.

2. Configure the DUT for the following settings:

   - Acquisition type: IQ
   - FFT Window Type: Flat Top
   - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**
   - Number of Samples: 50 kS
   - Downconverter Offset Mode: Enabled
   - Downconverter Frequency Offset: Driver Default
   - Reference Power Level: Power Level from Configurations **Table 33**
   - IQ Center Frequency: Initial Center Frequency from Configurations **Table 33**
   - Bandwidth: Signal Bandwidth from Configurations **Table 33**
   - Reference Clock Source: PXI_CLK (Locked to Rubidium)
   - Reference Clock Frequency: 10 MHz

3. Configure the Signal Generator for the following settings:

   - RF Frequency: Initial Center Frequency from Configurations **Table 33**
   - Power Level: Power Level such that to achieve 0 dBm Power at DUT input.

> **Note**
>
> Nominal Power Level at DUT input should be the:
>
> DUT Reference Power Level (**0 dBm**) + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

4. Configure the Power Sensor for the following settings:

   - Frequency: Initial Center Frequency from Configurations **Table 33**
   - Power Meter Path Selection: Auto Mode
   - Aperture Time: Select from **Table 50** based on the expected input power
   - Number of Averages: 1

5. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.
6. Taking the measurements

For each DUT Power Level in Table 33, starting with the 0 dBm Reference power setting down to the minimum power setting, repeat the following steps:

Based on your DUT option, repeat once for each DUT Frequency setting in Table 33 starting with the lower frequency.

1. Measure the power deliver to the DUT with the Power Meter and record the value as “**PM_measured_power**”.
2. Measure the power at the DUT and record the value as “**DUT_measured_power**”.

See 8.2 Acquiring a Spectrum from IQ Data and Measuring the Peak

- Frequency Deviation: 125 kHz
- Search Frequency: Equal to the CW signal on the Signal Generator

3. Calculate the Input absolute power level accuracy using the following equation:

Input Absolute Amplitude (ENLin) = DUT_measured_power - RX_Fixture_PM_to_RX_Path_Response - PM_measured_power [dBm]

Where **“RX_Fixture_PM_to_RX_Path_Response”** is the Receiver Fixture characterized value, at the measurement frequency, calculated by (***Equation 1***) in section **5.1.3 Characterization Procedure**

4. If this power iteration is to measure the 0 dBm Reference power setting, skip the next step and save the measurement as “**Absolute Amplitude_{0dBm} (ENLin)**” at the set frequency.
5. Calculate the RF Input Power Linearity Accuracy using the following equation:

Input_Power_Linearity (EN)= Input Absolute Amplitude (ENLin) – Input Absolute Amplitude_{0dBm} (ENLin)

Where "**Input Absolute Amplitude$_{0dBm}$ (ENLin)**" is the power measured previously at 0 dBm reference for the set frequency.

6. Configure the DUT for the following settings:
    - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**
    - IQ Center Frequency: Next Center Frequency from Configurations **Table 33**
    - Bandwidth: Signal Bandwidth from Configurations **Table 33**
    - Downconverter Offset: Driver Default

7. Configure the Signal Generator for the following settings:
    - RF Frequency: same as the IQ Center Frequency from previous paragraph
    - Power Level: Power Level such that to achieve the selected Nominal Power at DUT input at the selected frequency

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level selected +
RX_Fixture_PM_to_RX_Path_Response

(at the selected frequency (***Equation 1***)).

8. Configure the Power Sensor:
    - Frequency: Same frequency as the DUT

1. Configure the DUT for the following settings:
    - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 4**

- Reference Power Level: Next Power Level down from Configurations **Table 33**
- IQ Center Frequency: Initial Center Frequency from Configurations **Table 33**
- Bandwidth: Signal Bandwidth from Configurations **Table 33**
- Downconverter Offset: Driver Default

2. Configure the Signal Generator for the following settings:

    - RF Frequency: Initial Center Frequency from Configurations **Table 33**
    - Power Level: Power Level such that to achieve the selected Nominal Power at DUT input

Note

Nominal Power Level at DUT input should be the:

Selected DUT Reference Power Level + RX_Fixture_PM_to_RX_Path_Response

(Equation 1).

3. Configure the Power Sensor for the following settings:

    - Frequency: Initial Center Frequency from Configurations **Table 33**
    - Aperture Time: Select from **Table 50** based on the expected input power.

4. Generate a CW signal on the Signal Generator with the specified settings and wait until it settles.

6.7. RF Input Frequency Response Verification

6.7.1. Test Limits

Table 34: RF Input Frequency Response Accuracy Verification Test Limits (**User Defined Mode**)

Frequency Range	As-Found Test Limit		As-Left Test Limit	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
30 MHz to 200 MHz	-0.75 dB	+0.75 dB	-0.46 dB	+0.46 dB
>200 MHz to 1.75 GHz	-0.85 dB	+0.85 dB	-0.52 dB	+0.52 dB
>1.75 GHz to 6.0 GHz	-0.85 dB	+0.85 dB	-0.58 dB	+0.58 dB
>6.0 GHz to 12.0 GHz	-0.95 dB	+0.95 dB	-0.62 dB	+0.62 dB
>12.0 GHz to 18.0 GHz	-1.0 dB	+1.0 dB	-0.64 dB	+0.64 dB
>18.0 GHz to 22.0 GHz	-1.1 dB	+1.1 dB	-0.68 dB	+0.68 dB
>22.0 GHz to 26.5 GHz	-1.15 dB	+1.15 dB	-0.65 dB	+0.65 dB

Table 35: RF Input Frequency Response Verification Test Limits (**Enabled Mode**)

Frequency Range	As-Found Test Limit		As-Left Test Limit	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
1.7 GHz to 6.0 GHz	-0.85 dB	+0.85 dB	-0.51 dB	+0.51 dB
>6.0 GHz to 12.0 GHz	-0.95 dB	+0.95 dB	-0.53 dB	+0.53 dB
>12.0 GHz to 18.0 GHz	-1.00 dB	+1.00 dB	-0.55 dB	+0.55 dB
>18.0 GHz to 22.0 GHz	-1.10 dB	+1.10 dB	-0.59 dB	+0.59 dB
>22.0 GHz to 26.5 GHz	-1.15 dB	+1.15 dB	-0.58 dB	+0.58 dB

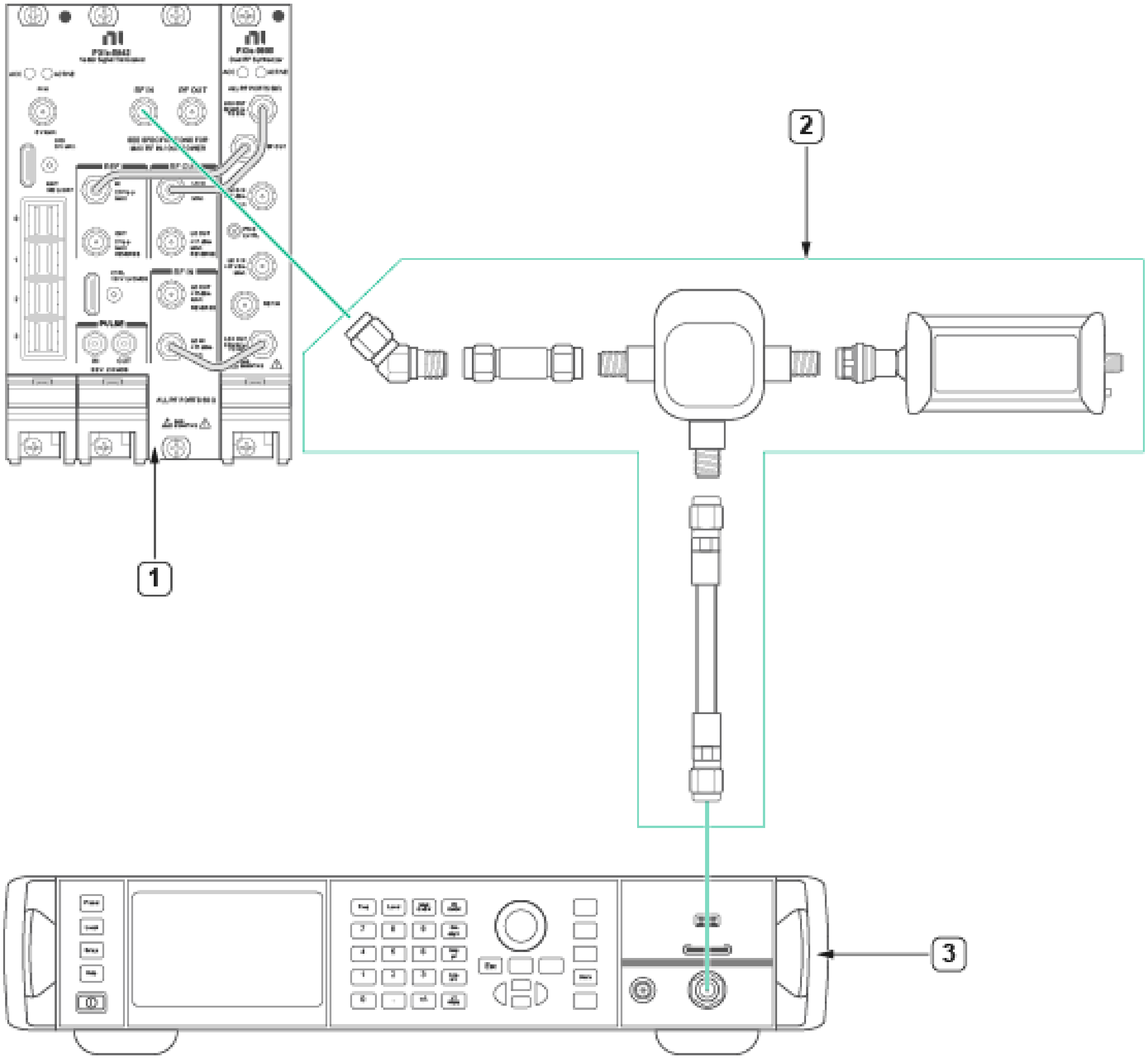
6.7.2. Initial Test Connection

Make sure that you have made the connections described in **Figure 5** External Reference Clock Connection before starting this Verification procedure.

Make sure that you have performed the Input Receiver fixture characterization as per **section 5.1** - Receiver Fixture Characterization before starting this Verification procedure.

> ⚠ **CAUTION**
> Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Figure 14. Connections for RF Input Frequency Response Accuracy Verification



1. DUT
2. Receiver Fixture from Figure 3
3. Signal Generator

6.7.3. Verification Procedure

This procedure verifies the Frequency Response accuracy of the DUT's input channel at a specified downconverter center frequency within the bandwidth selected.

Table 36: RF Input Frequency Response Accuracy Test Points and Configurations (**User Defined Mode**)

DUT IQ Center Frequency Range	DUT Reference Power Level	Power Level at DUT input	Reference Tone Offset	Additional Sweep Info	DUT Bandwidth
▪ 31 MHz ▪ 35 MHz to 65 MHz in 5 MHz steps	▪ -30 dBm ▪ 0 dBm ▪ +25 dBm	▪ -30 dBm ▪ 0 dBm ▪ +10 dBm	0 Hz	Sweep Step Size: 1 MHz	See **Table 6**
▪ 75 MHz to 275 MHz in 25 MHz steps				Sweep Step Size: 5 MHz Must include: ±39 MHz and ±41 MHz	
▪ 280 MHz ▪ 300 MHz to 500 MHz in 100 MHz steps				Sweep Step Size: 10 MHz Must include: ±39 MHz, ±41 MHz and ±250 MHz	
▪ 530 MHz ▪ 1015 MHz ▪ 750 MHz to 1.5 GHz in 250 MHz steps ▪ 750 MHz to 1.5 GHz in 125 MHz steps if Reference Power Level is 0 dBm				Sweep Step Size: 20 MHz Must include: ±39 MHz, ±41 MHz, ±250 MHz and ±500 MHz	
▪ 1.749 GHz				Sweep Step Size: 20 MHz Must include: ±39 MHz, ±41 MHz and ±250 MHz	
▪ 1.75 GHz to 26.5 GHz in 250 MHz steps or ▪ 1.75 GHz to 26.5 GHz in 125 MHz steps if Reference Power Level is 0 dBm			20 MHz	Sweep Step Size: 20 MHz Must include: ±39 MHz, ±41 MHz, ±250 MHz and ±500 MHz Remove 0 Hz offset (start your sweep from +20 MHz up, and -20 MHz down)	

Do not test above Maximum DUT Frequency, see **Table 3**					

Table 37: RF Input Frequency Response Accuracy Test points and Configurations (**Enabled Mode**)

DUT IQ Center Frequency Range	DUT Reference Power Level	Power Level at DUT input	Reference Tone Offset	Additional Sweep Info	DUT Bandwidth
▪ 1.701 GHz ▪ 1.75 GHz to 26.5 GHz in 250 MHz steps ▪ 1.75 GHz to 26.5 GHz in 125 MHz steps if Reference Power Level is 0 dBm Do not test above Maximum DUT Frequency, see **Table 3**	▪ -30 dBm ▪ 0 dBm ▪ +25 dBm	▪ -30 dBm ▪ 0 dBm ▪ +10 dBm	0 Hz	Sweep Step Size: 20 MHz Must include: ±39 MHz, ±41 MHz, ±125 MHz and ±250 MHz	See **Table 5**

6.7.4. Verification Procedure (Upconverter Mode = User Defined)

1. Power Meter Aperture configuration

The power meter requires that the frequency is configured to perform internal corrections to achieve its warranted specifications. Always configure the frequency of the power meter before making a measurement.

The power meter's accuracy also depends on the power level it is measuring; set the aperture according to **Table 50:** Power Meter Aperture Configuration

2. Make the connections indicated in **Figure 14**.

3. Configure the DUT for the following settings for "User Defined" mode:

    - IQ Center Frequency: Initial Center Frequency from Configurations **Table 36**
    - Reference Power Level: Initial lower Power Level from Configurations **Table 36**
    - Downconverter Offset Mode: User Defined
    - Downconverter Frequency Offset: Driver Default
    - Bandwidth: Signal Bandwidth from Configurations **Table 36**
    - Acquisition Type: IQ
    - FFT Window Type: Flat Top
    - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 36**
    - Number of Samples: 50 kS
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz

4. Configure the Signal Generator for the following settings:

    - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 36**.
    - Power Level: Power Level such that to achieve the lowest Power Level at DUT input indicated in Configurations **Table 36**.

Note

The Power Level at DUT input should be the:

Power Level at DUT input + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

5. Configure the Power Sensor for the following settings:

- RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 36**
- Power Meter Path Selection: Auto Mode
- Aperture Time: Select from **Table 50** based on the expected input power.
- Number of Averages: 1

6. Generate an RF signal on the Signal Generator with the specified settings and wait until it settles.

7. Taking the measurements

For each DUT Power Level in Table 36, starting with the lower power setting, repeat the following steps:

Based on your DUT option, repeat once for each DUT Center Frequency setting in Table 36.

> **Note**
>
> **Input Frequency Response**$_{\mathbf{Ref}}$ is always determined at the (Frequency + Reference Tone Offset) test point.
>
> For example, if the IQ Center frequency is 1.75 GHz and the Reference Tone Offset is 0 Hz, then the reference is measured and calculated at (1.75 GHz + 0) =1.75 GHz.
> if the IQ Center frequency is 1.75 GHz and the Reference Tone Offset is 20 MHz, then the reference is measured and calculated at (1.75 GHz + 20 MHz) =1.77 GHz.

1. Measure the power deliver to the DUT with the Power Meter and record the value as "**PM_measured_power**$_{\mathbf{Ref}}$".
2. Measure the power at the DUT and record the value as "**DUT_measured_power**$_{\mathbf{Ref}}$".

See **8.2 Acquiring a Spectrum from IQ Data and Measuring the Peak** Annex for more details on how to make this measurement.

        1. Frequency Deviation: 125 kHz
        2. Search Frequency: Equal to the CW signal on the Signal Generator

3. Calculate the Input absolute power Reference level using the following equation:

$$\textbf{Input Frequency Response}_{\textbf{Ref}} = \textbf{DUT\_measured\_power}_{\textbf{Ref}} - \textbf{RX\_Fixture\_PM\_to\_RX\_Path\_Response} - \textbf{PM\_measured\_power}_{\textbf{Ref}}\ \textbf{[dB]}$$

Where **"RX_Fixture_PM_to_RX_Path_Response"** is the Receiver Fixture characterized value, at the measurement frequency, calculated by (***Equation 1***) in section **5.1.3 Characterization Procedure**

Repeat, sweeping the Tone Offset Frequency of the DUT through all Tone Offsets.
Start from Center Frequency to –Signal Bandwidth/2 and from Center Frequency to +Signal Bandwidth/2, in step sizes indicated on Table 36.

Note

The test points within a BW should start at the center point zero and expand symmetrically from that, at the required step size, to both ±Bandwidth/2 points.

For Center Frequencies where the reference Tone offset is different than zero, test points should start at (Center Frequency + reference Tone offset) and expand up, and (Center Frequency - reference Tone offset) and expand down.

1. MultiTone VI Cluster Input:
    a. Tone Frequency = Next Tone Offset based on the step size in **Table 36**.
2. Configure the Power Sensor for the following settings:
3. Frequency:
    (Current Center Frequency + Reference Tone Offset + Next Sweep Step) from Configurations **Table 36**.

4. Measure the power of the DUT with the Power Meter and record the value as “**$PM\_measured\_power_i$**”.

Where “x_i” is a linear index number to identify each new tone offset within the sweep from 1 to n.

5. Calculate the Frequency Response Input Frequency Response (UD) for each Tone Offset Frequency:

$$\textbf{Input Frequency Response}_i = \textbf{DUT\_measured\_power}_i - \textbf{RX\_Fixture\_PM\_to\_RX\_Path\_Response} - \textbf{PM\_measured\_power}_i \ \textbf{[dB]}$$

6. Calculate the normalized frequency response for each baseband tone offset “x_i” using the following equation:

$$\textbf{Normalized\_Frequency\_Response}_i = \textbf{Input Frequency Response}_i - \textbf{Input Frequency Response}_{Ref} \ \textbf{[dB]}$$

4. Calculate the maximum frequency response error using the following equation:

$$\textbf{Max Input Frequency Response (UD)} = \textbf{Maximum}\ (|\textbf{Normalized\_Frequency\_Response}_i|, \ldots, |\textbf{Normalized\_Frequency\_Response}_n|)\ \textbf{[dB]}$$

5. Configure the DUT for the following settings for “User Defined” mode:

   - IQ Center Frequency: next Center Frequency from Configurations **Table 36**
   - Bandwidth: Signal Bandwidth from Configurations **Table 36**
   - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 36**

6. Configure the Signal Generator for the following settings:

   - RF Frequency: (Next Frequency + Reference Tone Offset) from Configurations **Table 36**.

- Power Level: Power Level such that to achieve the set Power Level at DUT input for this step.

Note

The Power Level at DUT input should be the:

Power Level at DUT input + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

7. Configure the Power Sensor for the following settings:
   - RF Frequency: same frequency as the Signal Generator
   - Aperture Time: Select from **Table 50** based on the expected input power
8. Generate an RF signal on the Signal Generator with the specified settings. Wait until it settles.

1. Configure the DUT for the following settings for “User Defined” mode:
   - IQ Center Frequency: Initial Center Frequency from Configurations **Table 36**
   - Reference Power Level: Next lower Power Level from Configurations **Table 36**
   - Bandwidth: Signal Bandwidth from Configurations **Table 36**
   - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 36**
2. Configure the Signal Generator for the following settings:
   - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 36**.
   - Power Level: Power Level such that to achieve the next Power Level at DUT input indicated in Configurations **Table 36**.

Note

The Power Level at DUT input should be the:

Power Level at DUT input + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

3. Configure the Power Sensor for the following settings:
    - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 36**
    - Aperture Time: Select from **Table 50** based on the expected input power.
4. Generate an RF signal on the Signal Generator with the specified settings and wait until it settles.

6.7.5. Verification Procedure (Upconverter Mode = Enabled)

1. Power Meter Aperture configuration

The power meter requires that the frequency is configured to perform internal corrections to achieve its warranted specifications. Always configure the frequency of the power meter before making a measurement.

The power meter's accuracy also depends on the power level it is measuring; set the aperture according to **Table 50:** Power Meter Aperture Configuration

2. Make the connections indicated in **Figure 14**.
3. Configure the DUT for the following settings for “User Defined” mode:

- IQ Center Frequency: Initial Center Frequency from Configurations **Table 37**
- Reference Power Level: Initial lower Power Level from Configurations **Table 37**
- Downconverter Offset Mode: User Defined
- Downconverter Frequency Offset: Driver Default
- Bandwidth: Signal Bandwidth from Configurations **Table 37**
- Acquisition Type: IQ
- FFT Window Type: Flat Top
- IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 37**
- Number of Samples: 50 kS
- Reference Clock Source: PXI_CLK (Locked to Rubidium)
- Reference Clock Frequency: 10 MHz

4. Configure the Signal Generator for the following settings:
   - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 37**.
   - Power Level: Power Level such that to achieve the lowest Power Level at DUT input indicated in Configurations **Table 37**.

Note

The Power Level at DUT input should be the:

Power Level at DUT input + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

5. Configure the Power Sensor for the following settings:
   - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 36**
   - Power Meter Path Selection: Auto Mode
   - Aperture Time: Select from **Table 50** based on the expected input power.
   - Number of Averages: 1

6. Generate an RF signal on the Signal Generator with the specified settings and wait until it settles.

7. Taking the measurements

For each DUT Power Level in Table 37, starting with the lower power setting, repeat the following steps:

Based on the DUT option, repeat once for each DUT Center Frequency setting in Table 37.

Note

Input Frequency Response$_{Ref}$ is always determined at the (Frequency + Reference Tone Offset) test point.

For example, if the IQ Center frequency is 1.75 GHz and the Reference Tone Offset is 0 Hz, then the reference is measured and calculated at (1.75 GHz + 0) =1.75 GHz.
if the IQ Center frequency is 1.75 GHz and the Reference Tone Offset is 20 MHz, then the reference is measured and calculated at (1.75 GHz + 20 MHz) =1.77 GHz.

1. Measure the power deliver to the DUT with the Power Meter and record the value as "**PM_measured_power$_{Ref}$**".
2. Measure the power at the DUT and record the value as "**DUT_measured_power$_{Ref}$**".

See **8.2 Acquiring a Spectrum from IQ Data and Measuring the Peak** Annex for more details on how to make this measurement.

    1. Frequency Deviation: 125 kHz
    2. Search Frequency: Equal to the CW signal on the Signal Generator

3. Calculate the Input absolute power Reference level using the following equation:

Input Frequency Response$_{Ref}$ = DUT_measured_power$_{Ref}$ - RX_Fixture_PM_to_RX_Path_Response - PM_measured_power$_{Ref}$ [dB]

Where **“RX_Fixture_PM_to_RX_Path_Response”** is the Receiver Fixture characterized value, at the measurement frequency, calculated by (***Equation 1***) in section **5.1.3 Characterization Procedure**

Repeat, sweeping the Tone Offset Frequency of the DUT through all Tone Offsets.
Start from Center Frequency to –Signal Bandwidth/2 and from Center Frequency to +Signal Bandwidth/2, in step sizes indicated on Table 37.

> **Note**
>
> The test points within a BW should start at the center point zero and expand symmetrically from that, at the required step size, to both ±Bandwidth/2 points.
>
> For Center Frequencies where the reference Tone offset is different than zero, test points should start at (Center Frequency + reference Tone offset) and expand up, and (Center Frequency - reference Tone offset) and expand down.

1. MultiTone VI Cluster Input:
    a. Tone Frequency = Next Tone Offset based on the step size in **Table 37**.
2. Configure the Power Sensor for the following settings:
3. Frequency:
    (Current Center Frequency + Reference Tone Offset + Next Sweep Step) from Configurations **Table 37**.
4. Measure the power of the DUT with the Power Meter and record the value as “**PM_measured_power$_i$**”.

Where “x_i” is a linear index number to identify each new tone offset within the sweep from 1 to n.

5. Calculate the Frequency Response Input Frequency Response (UD) for each Tone Offset Frequency:

$\text{Input Frequency Response}_i = \text{DUT\_measured\_power}_i - \text{RX\_Fixture\_PM\_to\_RX\_Path\_Response} - \text{PM\_measured\_power}_i$ [dB]

6. Calculate the normalized frequency response for each baseband tone offset "x_i" using the following equation:

$\text{Normalized\_Frequency\_Response}_i = \text{Input Frequency Response}_i – \text{Input Frequency Response}_{Ref}$ [dB]

4. Calculate the maximum frequency response error using the following equation:

Max Input Frequency Response (EN) = Maximum $(|\text{Normalized\_Frequency\_Response}_i|,\ldots,|\text{Normalized\_Frequency\_Response}_n|)$ [dB]

5. Configure the DUT for the following settings for "User Defined" mode:
    - IQ Center Frequency: next Center Frequency from Configurations **Table 37**
    - Bandwidth: Signal Bandwidth from Configurations **Table 37**
    - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 37**

6. Configure the Signal Generator for the following settings:
    - RF Frequency: (Next Frequency + Reference Tone Offset) from Configurations **Table 37**.
    - Power Level: Power Level such that to achieve the set Power Level at DUT input for this step.

Note

The Power Level at DUT input should be the:

Power Level at DUT input + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

7. Configure the Power Sensor for the following settings:
   - RF Frequency: same frequency as the Signal Generator
   - Aperture Time: Select from **Table 50** based on the expected input power
8. Generate an RF signal on the Signal Generator with the specified settings and wait until it settles.

1. Configure the DUT for the following settings for “User Defined” mode:
   - IQ Center Frequency: Initial Center Frequency from Configurations **Table 37**.
   - Reference Power Level: Next lower Power Level from Configurations **Table 37**.
   - Bandwidth: Signal Bandwidth from Configurations **Table 37**.
   - IQ Rate: Maximum IQ rate for the DUT from DUT hardware options Maximum Signal Bandwidth **Table 37**.
2. Configure the Signal Generator for the following settings:
   - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 37**.
   - Power Level: Power Level such that to achieve the next Power Level at DUT input indicated in Configurations **Table 37**.

Note

The Power Level at DUT input should be the:

Power Level at DUT input + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

3. Configure the Power Sensor for the following settings:
   - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 37**.
   - Aperture Time: Select from **Table 50** based on the expected input power.
4. Generate an RF signal on the Signal Generator with the specified settings and wait until it settles.

6.8. RF Output Average Noise Density Verification

6.8.1. Test Limits

Table 38: Test Points/Limits for Verification Test

Frequency Range	Output Power	As-Found Test Limit	As-Left Test Limit
		High Limit	High Limit
30 MHz to 1.75 GHz	+15 dBm If the +15 dBm point is above the Max Linear Power endpoint for that frequency, measure only the Max Linear Power at that frequency	-129.4 dBm	-130.3 dBm
>1.75 GHz to 3.75 GHz		-132.4 dBm	-133.0 dBm
>3.75 GHz to 6.0 GHz		-135.3 dBm	-135.9 dBm
>6.0 GHz to 8.0 GHz		-131.6 dBm	-132.3 dBm
>8.0 GHz to 12.0 GHz		-131.1 dBm	-132.4 dBm
>12.0 GHz to 18.0 GHz		-130.4 dBm	-131.6 dBm
>18.0 GHz to 22.0 GHz		-128.7 dBm	-129.9 dBm
>22.0 GHz to 24.0 GHz		-132.2 dBm	-133.6 dBm
>24.0 GHz to 25.0 GHz		-131.5 dBm	-132.9 dBm
30 MHz to 1.75 GHz	0 dBm	-144.2 dBm	-145.1 dBm
>1.75 GHz to 3.75 GHz		-143.5 dBm	-144.4 dBm

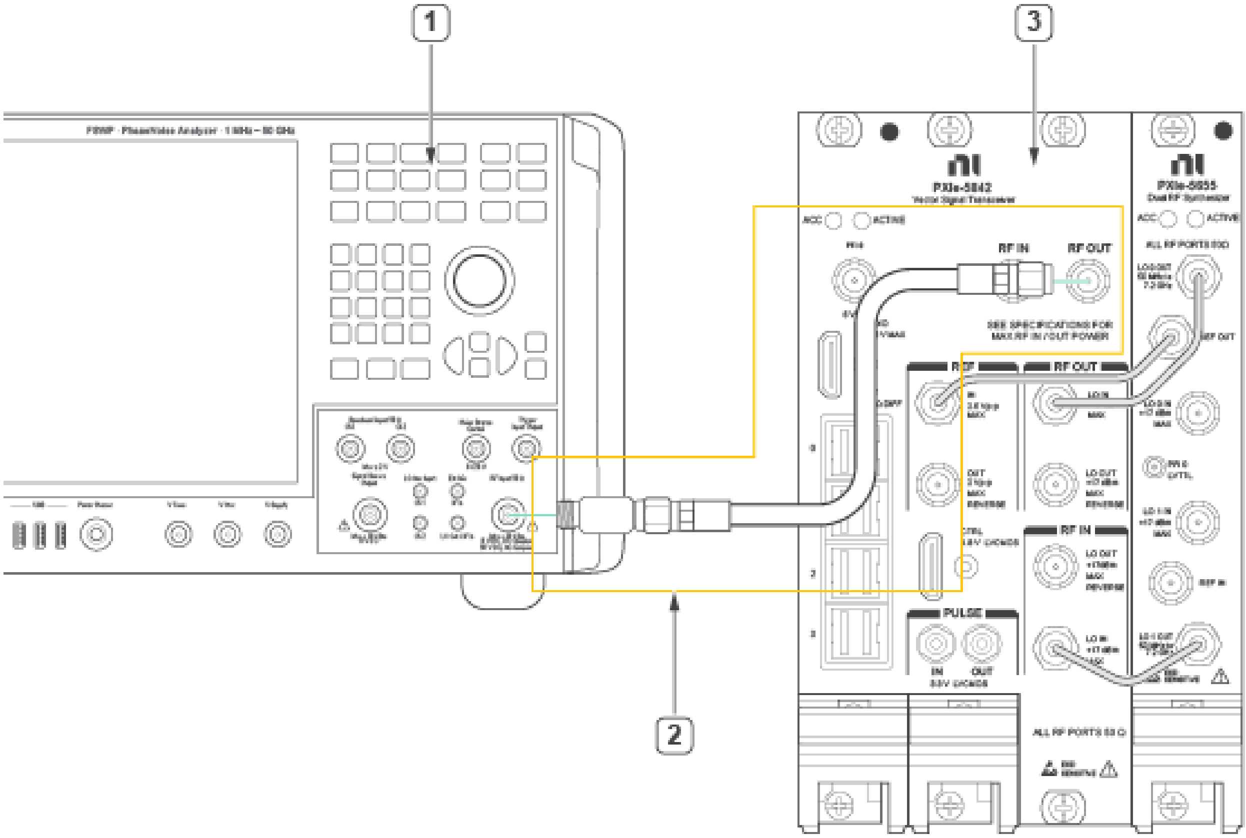
>3.75 GHz to 6.0 GHz		-146.9 dBm	-147.4 dBm
>6.0 GHz to 8.0 GHz		-145.8 dBm	-146.4 dBm
>8.0 GHz to 12.0 GHz		-143.8 dBm	-144.9 dBm
>12.0 GHz to 18.0 GHz		-141.5 dBm	-142.6 dBm
>18.0 GHz to 22.0 GHz		-140.3 dBm	-141.4 dBm
>22.0 GHz to 24.0 GHz		-138.3 dBm	-139.4 dBm
>24.0 GHz to 25.0 GHz		-138.3 dBm	-139.5 dBm
>25.0 GHz to 26.5 GHz		-132.4 dBm	-133.7 dBm
30 MHz to 1.75 GHz	-30 dBm	-167.6 dBm	-168.1 dBm
>1.75 GHz to 3.75 GHz		-167.2 dBm	-167.7 dBm
>3.75 GHz to 6.0 GHz		-166.6 dBm	-167.1 dBm
>6.0 GHz to 8.0 GHz		-166.4 dBm	-166.7 dBm
>8.0 GHz to 12.0 GHz		-165.3 dBm	-166.4 dBm
>12.0 GHz to 18.0 GHz		-162.7 dBm	-163.8 dBm
>18.0 GHz to 22.0 GHz		-161.0 dBm	-162.0 dBm
>22.0 GHz to 24.0 GHz		-158.5 dBm	-159.6 dBm

>24.0 GHz to 25.0 GHz		-158.2 dBm	-159.2 dBm
>25.0 GHz to 26.5 GHz		-156.3 dBm	-157.4 dBm

6.8.2. Initial Test Connection

Make sure that you have made the connections described in **Figure 5** External Reference Clock Connection before starting this Verification procedure.

Figure 15. Connections for RF Output Average Noise Density Verification



1. Phase noise and Spectrum analyzer
2. Cable Characterization Fixture
3. DUT

6.8.3. Verification Procedure

Ensure that the connection fixture between the Spectrum Analyzer and the DUT has been characterized as per section 5.2 Cable loss Characterization.

> **Note**
> Do not disassemble Cable Fixture item #7 from **Figure 4** after characterization. If you disassemble this fixture, you must recharacterize it before it is used again.

Table 39: Output Average Noise Density Configurations

DUT Frequency Range	DUT Power Level	DUT Upconverter Mode	DUT Bandwidth
▪ 30 MHz and 50 MHz ▪ 100 MHz to 550 MHz in 50 MHz steps ▪ 600 MHz to 1.6 GHz in 200 MHz steps ▪ 1.745 GHz	-30 dBm, 0 dBm, +15 dBm or Max Linear Power endpoint for that frequency	**User Defined**	0 Hz
▪ 1.75 GHz ▪ 1.8 GHz to Maximum Frequency (See Table 3) in 200 MHz Steps. For option 26.5 GHz, Maximum Frequency is 26.48 GHz			See **Table 6**
▪ 1.701 GHz		**Enabled**	0 Hz
▪ 1.80 GHz to Maximum Frequency (See Table 3) in 200 MHz Steps. For option 26.5 GHz, Maximum Frequency is 26.48 GHz			See **Table 5**

6.8.4. Verification Procedure (Upconverter Mode = User Defined)

1. Configure the DUT for the following settings for “User Defined” mode:

    - Mode: Arb Waveform (IQ)
    - Power Level Type: Peak
    - Power Level: Initial lower Power Level from Configurations **Table 39.**

    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz
    - Frequency: Initial lowest Frequency from Configurations **Table 39**

    - Upconverter Offset Mode: **User Defined**
    - Upconverter center frequency: Default
    - Bandwidth: Signal Bandwidth from Configurations **Table 39**
    - IQ Rate:
        - Frequency <1.75 GHz: 750 MHz (or maximum for device HW option **Table 4**)
        - Frequency ≥1.75 GHz: 1.25*Signal Bandwidth
    - Number of Samples: 250k
    - Digital Gain: -40 dB
    - MultiTone VI Cluster Input (see section 8.1 Generating an IQ Signal):
        - Number of Elements = 1
        - Tone Frequency = [0]
        - Tone Phase = [0]
        - Tone Power = [0]

2. Configure the Spectrum Analyzer for the following settings:

    - Mode: Spectrum
    - Reference Oscillator Source: External Reference (Locked to Rubidium)
    - Averaging Type: RMS Averaging
    - Number of averages: 10
    - Preamp Level = 30

- Center Frequency: DUT Frequency + 18 MHz
- Noise Marker Frequency: Center Frequency from Configurations (
- **Table 39**) + 2 MHz)
- Reference Level: (+5 of DUT Power Level + DUT Digital Gain)
- Span: 10 MHz
- RBW: 1 MHz
- VBW: 100 kHz
- Sweep Time: 8.94 ms
- Noise Cancellation: Enabled for -30 dBm power level, otherwise Disabled

3. Generate the Signal with the DUT. Wait for Settling.

4. Taking the measurements

For each DUT Power Level in Table 37, starting with the lower power setting, repeat the following steps:

Based on the DUT option, repeat, once for each DUT Frequency in Table 39.

1. Enable the Noise Marker on the Spectrum Analyzer
2. Configure FSWP Noise Marker Frequency.
3. Initiate Spectrum Read.
4. Record the Noise Marker measurement as:
   Noise_Marker_Measurement
5. Calculate the Corrected Average Noise:
   Average Noise Density = Noise_Marker_Measurement + PM_to_RX_Cable_Path_Response [dB] (*Equation 3*)

6. Configure the DUT for the following settings:
   - Frequency: Next Frequency from Configurations **Table 39**
   - Bandwidth: Signal Bandwidth from Configurations **Table 6**
   - IQ Rate:

    - Frequency <1.75 GHz: 750 MHz (or maximum for device HW option **Table 4**)
    - Frequency ≥1.75 GHz: 1.25*Signal Bandwidth

7. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: DUT Frequency + 18 MHz
    - Noise Marker Frequency: Center Frequency from Configurations (**Table 39**) + 2 MHz)
    - Noise Cancellation: Enabled for -30 dBm power level, otherwise Disabled

1. Configure the DUT for the following settings:
    - Power Level: Next Power Level from Configurations **Table 39**

Frequency: Initial lowest Frequency from Configurations **Table 39**

    - Bandwidth: Signal Bandwidth from Configurations **Table 6**
    - IQ Rate: 750 MHz (or maximum for device HW option **Table 4**)

2. Configure the Spectrum Analyzer for the following settings:
    - Reference Level: (+5 of DUT Power Level + DUT Digital Gain)
    - Center Frequency: DUT Frequency + 18 MHz
    - Noise Marker Frequency: (Center Frequency from Configurations (**Table 37**) + 2 MHz)
    - Noise Cancellation: Enabled for -30 dBm power level, otherwise Disabled

6.8.5. Verification Procedure (Upconverter Mode = Enabled)

1. Configure the DUT for the following settings:
    - Mode: Arb Waveform (IQ)
    - Power Level Type: Peak
    - Power Level: Initial lower Power Level from Configurations **Table 39**
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz
    - Frequency: Initial lowest Frequency from Configurations **Table 39**
    - Upconverter Offset Mode: **Enabled**
    - Upconverter center frequency: Default
    - Bandwidth: Signal Bandwidth from Configurations **Table 5**
    - IQ Rate: 1.25 * Signal Bandwidth
    - Number of Samples: 125k
    - Digital Gain: -40 dB
    - MultiTone VI Cluster Input (see section 8.1 Generating an IQ Signal):
        - Number of Elements = 1
        - Tone Frequency = [0]
        - Tone Phase = [0]
        - Tone Power = [0]

2. Configure the Spectrum Analyzer for the following settings:
    - Mode: Spectrum
    - Reference Oscillator Source: External Reference (Locked to Rubidium)
    - Averaging Type: RMS Averaging
    - Number of averages: 10
    - Preamp Level = 30
    - Center Frequency: DUT Frequency + 18 MHz
    - Noise Marker Frequency: (Center Frequency from Configurations (
    - **Table 39**) + 2 MHz)
    - Reference Level: (+5 of DUT Power Level + DUT Digital Gain)
    - Span: 10 MHz
    - RBW: 1 MHz

- VBW: 100 kHz
- Sweep Time: 8.94 ms
- Noise Cancellation: Enabled for -30 dBm power level, otherwise Disabled

3. Generate the Signal with the DUT. Wait for Settling.
4. Taking the measurements

For each DUT Power Level in Table 39, starting with the lower power setting, repeat the following steps:

Based on the DUT option, repeat, once for each DUT Frequency in Table 39.

1. Enable the Noise Marker on the Spectrum Analyzer
2. Configure FSWP Noise Marker Frequency.
3. Initiate Spectrum Read.
4. Record the Noise Marker measurement as:
   Noise_Marker_Measurement
5. Calculate the Corrected Average Noise:
   Average Noise Density = Noise_Marker_Measurement + PM_to_RX_Cable_Path_Response [dB] (*Equation 3*)
6. Configure the DUT for the following settings:
   - Frequency: Next Frequency from Configurations **Table 39**
   - Bandwidth: Signal Bandwidth from Configurations **Table 5**
7. Configure the Spectrum Analyzer for the following settings:
   - Center Frequency: DUT Frequency + 18 MHz
   - Noise Marker Frequency: Center Frequency from Configurations (**Table 39**) + 2 MHz)
   - Noise Cancellation: Enabled for -30 dBm power level, otherwise Disabled

1. Configure the DUT for the following settings:
   - Power Level: Next Power Level from Configurations **Table 39**
   - Frequency: Initial lowest Frequency from Configurations **Table 39**
   - Bandwidth: Signal Bandwidth from Configurations **Table 5**
   - IQ Rate: 750 MHz (or maximum for device HW option **Table 4**)
2. Configure the Spectrum Analyzer for the following settings:
   - Reference Level: (+5 of DUT Power Level + DUT Digital Gain)
   - Center Frequency: DUT Frequency + 18 MHz
   - Noise Marker Frequency: (Center Frequency from Configurations (**Table 39**) + 2 MHz)
   - Noise Cancellation: Enabled for -30 dBm power level, otherwise Disabled

6.9. RF Output Harmonic Spurs Verification

6.9.1. Test Limits

Table 40: Test Points/Limits for Verification Test

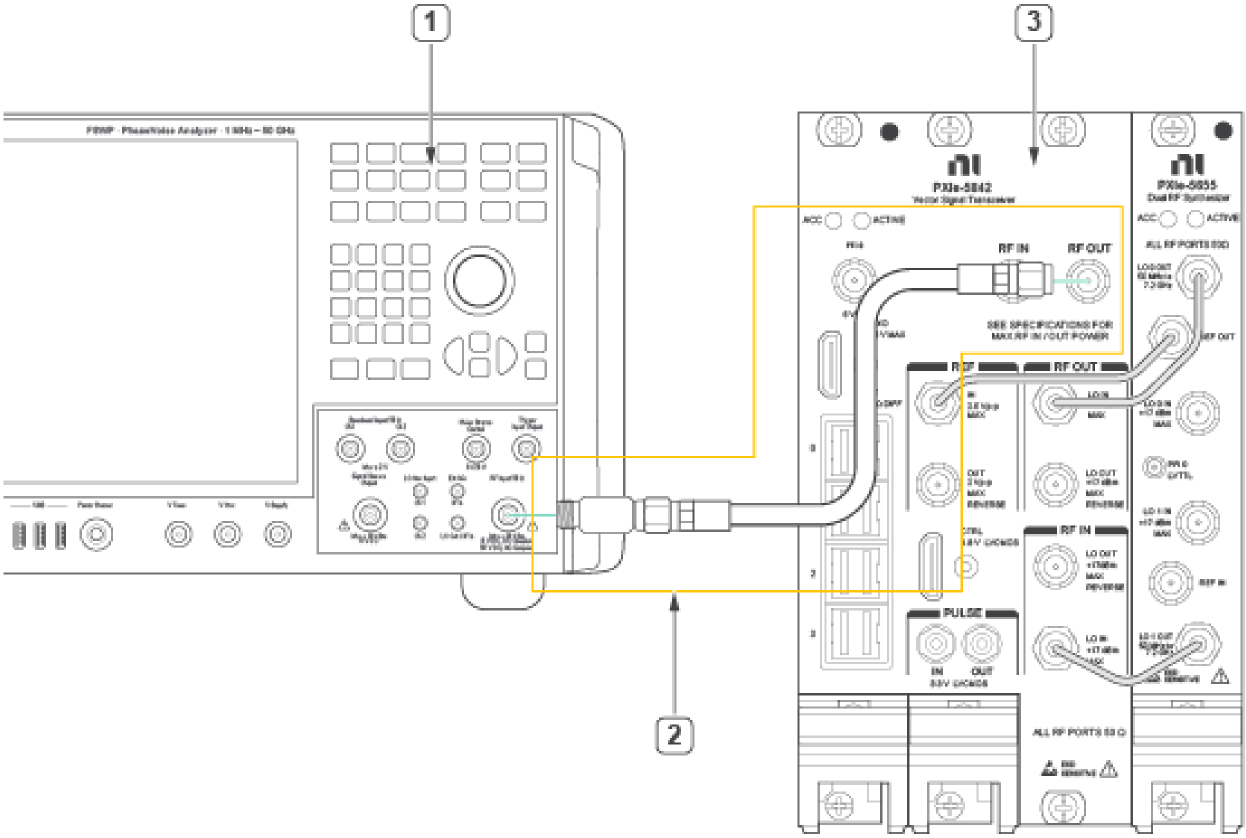
Frequency Range	Digital Gain	**Enabled Mode** Test Limit		**User Defined Mode** Test Limit	
		As-Found Upper Limit	As-Left Upper Limit	As-Found Upper Limit	As-Left Upper Limit
30 MHz to 1.75 GHz	0 dB	-35dBc	-36 dBc	-35 dBc	-36 dBc
>1.75 GHz to 2.3 GHz		-40 dBc	-41 dBc	-40 dBc	-41 dBc
>2.3 GHz to 3.0 GHz		-33 dBc	-34 dBc	-40 dBc	-41 dBc
>3.0 GHz to 6.0 GHz		-39 dBc	-40 dBc	-39 dBc	-40 dBc
>6.0 GHz to 8.0 GHz		-37 dBc	-38 dBc	-37 dBc	-38 dBc
>8.0 GHz to 13.25 GHz		-34 dBc	-35 dBc	-34 dBc	-35 dBc
30 MHz to 1.75 GHz	-12 dB	-45 dBc	-46 dBc	-45 dBc	-46 dBc
>1.75 GHz to 2.3 GHz		-52 dBc	-53 dBc	-52 dBc	-53 dBc
>2.3 GHz to 3.0 GHz		-45 dBc	-46 dBc	-53 dBc	-54 dBc
>3.0 GHz to 6.0 GHz		-52 dBc	-53 dBc	-52 dBc	-53 dBc
>6.0 GHz to 8.0 GHz		-49 dBc	-50 dBc	-49 dBc	-50 dBc
>8.0 GHz to 13.25 GHz		-46 dBc	-47 dBc	-46 dBc	-47 dBc

Note
Test up to 26.5 GHz only; no harmonics above 26.5 GHz will be measured.

6.9.2. Initial Test Connection

Make sure that you have made the connections described in **Figure 5** Initial Reference Clock Connections before starting this Verification procedure.

Figure 16. Connections for RF Output Average Noise Density Verification



1. Phase noise and Spectrum analyzer
2. Cable Characterization Fixture
3. DUT

6.9.3. Verification Procedure

1. Ensure that the connection fixture between the Spectrum Analyzer and the DUT has been characterized as per section 5.2 Cable loss Characterization.

> **Note**
> Do not disassemble Cable Fixture item #7 from **Figure 4** after characterization. If you disassemble this fixture, you must recharacterize it before it is used again.

Table 41: Output Harmonic Spurs Configurations

DUT Frequency	DUT Power Level	DUT Upconverter Mode	Digital Gain	Upconverter Offset
▪ 30 MHz to 45 MHz in 5 MHz steps ▪ 50 MHz to 1.70 GHz in 50 MHz steps ▪ 1.749 MHz	0 dBm	User Defined	0 dB and -12 dB	Driver default
▪ 1.75 GHz to 13.20 GHz (or Maximum Frequency) (See Table 3) in 50 MHz Steps ▪ Include 8.813 GHz and 13.229 GHz unless above maximum frequency				0 MHz
▪ 1.701 GHz ▪ 1.75 GHz to 13.20 GHz (or Maximum Frequency) (See Table 3) in 50 MHz Steps ▪ Include 8.833 GHz and 13.249 GHz unless above maximum frequency	0 dBm	Enabled		Driver default

Table 42: Output Harmonic maximum frequency by Hardware option

Hardware Option	Maximum Frequency	Maximum frequency for 2sd harmonic	Maximum frequency for 3rd harmonic
F08	8.0 GHz	≤4.199 GHz	≤2.799 GHz
F12	12 GHz	≤5.999 GHz	≤2.999 GHz
F18	18 GHz	≤8.999 GHz	≤5.999 GHz
F26	26.5 GHz	≤13.249 GHz	≤8.833 GHz

6.9.4. Verification Procedure (Upconverter Mode = User Defined)

1. Configure the DUT for the following settings:

    - Mode: Arb Waveform (IQ)
    - IQ Rate: 125 MS/s
    - Number of Samples: 50 kS
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz
    - Frequency: First frequency from Configurations **Table 41**
    - Upconverter Offset Mode: User Defined
    - Upconverter Offset from configurations **Table 41**
    - MultiTone VI Cluster Input (see section 8.1 Generating an IQ Signal):
        - Number of Elements = 1
        - Tone Frequency:
            - Frequency < 1.75 GHz: [0]
            - Frequency ≥ 1.75 GHz: [20M]
        - Tone Phase = [0]+
        - Tone Power = [-1]
    - Power Level: First Power Level from configurations **Table 41**
    - Signal Bandwidth:
        - Frequency <1.75 GHz: 0 Hz
        - Frequency ≥1.75 GHz: 100 MHz
    - Digital Gain: First Digital Gain from Configurations **Table 41**

2. Configure the Spectrum Analyzer for the following settings:
   - Mode: Spectrum
   - Reference Oscillator Source: External Reference (Locked to Rubidium)
   - Center Frequency: DUT Frequency + DUT Tone Offset (from Configurations **Table 41**)
   - Reference Level: DUT Power Level +5 dB
   - Span: 10 kHz
   - RBW: 1 kHz
   - Number of averages: 1
   - Attenuation Mode: Auto
3. Enable the DUT to generate the tone and wait until it settles.
4. Taking the measurements

Repeat once for each Digital gain setting.

For each DUT Frequency in **Configurations Table 41,** repeat the following steps:

1. Measure the peak power of the tone and save as:
   Fundamental_Power
2. Save the frequency of the tone as:
   Fundamental_Frequency
3. Calculate the corrected Fundamental measured power:

   Fundamental_Power_Corrected = Fundamental_Power - PM_to_RX_Cable_Path_Response [dB]
4. If the **DUT Frequency + Tone Offset ≤ Maximum frequency for 2nd harmonic** from **Table 42** then reconfigure the Spectrum Analyzer to:
   - Center Frequency: 2 x the measured Fundamental_Frequency
   - Reference level: DUT Power Level - 20.

5. Measure the peak power of the tone and save as:

   2nd HarmPower

6. Calculate the corrected second harmonic measured power:

   2nd HarmPower_Corrected = 2nd HarmPower - PM_to_RX_Cable_Path_Response [dB]

7. If the **DUT Frequency + Tone Offset ≤ Maximum frequency for 3rd harmonic** from **Table 42** then reconfigure the Spectrum Analyzer to:
   - Center Frequency - 3 x the measured Fundamental_Frequency
   - Reference level - DUT Power Level - 30.

8. Measure the peak power of the tone and save as:

   3rd HarmPower

9. Calculate the corrected third harmonic measured power:

   3rd HarmPower_Corrected = 3rd HarmPower - PM_to_RX_Cable_Path_Response [dB]

10. Calculate the output harmonic distortion:

    2nd_HD =
    2nd HarmPower Corrected - Fundamental_Power_Corrected [dBc]

    3rd_HD =
    3rd HarmPower Corrected - Fundamental_Power_Corrected [dBc]

11. Configure the DUT for the following settings:
    - Frequency: Next frequency from Configurations **Table 41**
    - Upconverter Offset for the selected frequency from configurations **Table 41**
    - MultiTone VI Cluster Input (see section 8.1 Generating an IQ Signal):
      - Tone Frequency:
        - Frequency < 1.75 GHz: [0]

      - ❖ Frequency ≥ 1.75 GHz: [20M]

12. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: DUT Frequency + DUT Tone Offset (from Configurations **Table 41**)
    - Reference Level: DUT Power Level +5 dB

1. Configure the DUT for the following settings:
    - Digital Gain: next value from Configurations **Table 41**

6.9.5. Verification Procedure (Upconverter Mode = Enabled)

1. Configure the DUT for the following settings:
    - Mode: Arb Waveform (IQ)
    - IQ Rate: 125 MS/s
    - Number of Samples: 50 kS
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz
    - Frequency: First frequency from Configurations **Table 41**
    - Upconverter Offset Mode: Enabled
    - Upconverter Offset from configurations **Table 41**
    - MultiTone VI Cluster Input (see section 8.1 Generating an IQ Signal):
        - ○ Number of Elements = 1
        - ○ Tone Frequency = [0]
        - ○ Tone Phase = [0]+
        - ○ Tone Power = [-1]
    - Power Level: First Power Level from configurations **Table 41**
    - Signal Bandwidth: 100 MHz
    - Digital Gain: First Digital Gain from Configurations **Table 41**

2. Configure the Spectrum Analyzer for the following settings:
    - Mode: Spectrum

- Reference Oscillator Source: External Reference (Locked to Rubidium)
- Center Frequency: DUT Frequency + DUT Tone Offset (from Configurations **Table 41**)
- Reference Level: DUT Power Level +5 dB
- Span: 10 kHz
- RBW: 1 kHz
- Number of averages: 1
- Attenuation Mode: Auto

3. Enable the DUT to generate the tone and wait until it settles.

4. Taking the measurements

Repeat once for each Digital gain setting.

For each DUT Frequency in **Configurations Table 41,** repeat the following steps:

1. Measure the peak power of the tone and save as:
Fundamental_Power
2. Save the frequency of the tone as:
Fundamental_Frequency

3. Calculate the corrected Fundamental measured power:

Fundamental_Power_Corrected = Fundamental_Power - PM_to_RX_Cable_Path_Response [dB]

4. If the **DUT Frequency + Tone Offset ≤ Maximum frequency for 2nd harmonic** from **Table 42** then reconfigure the Spectrum Analyzer to:
   - Center Frequency: 2 x the measured Fundamental_Frequency
   - Reference level: DUT Power Level - 20.

5. Measure the peak power of the tone and save as:
2nd HarmPower

6. Calculate the corrected second harmonic measured power:

2nd HarmPower_Corrected = 2nd HarmPower - PM_to_RX_Cable_Path_Response [dB]

7. If the **DUT Frequency + Tone Offset ≤ Maximum frequency for 3rd harmonic** from **Table 42** then reconfigure the Spectrum Analyzer to:
   - Center Frequency - 3 x the measured Fundamental_Frequency
   - Reference level - DUT Power Level - 30.
8. Measure the peak power of the tone and save as:

   3rd HarmPower
9. Calculate the corrected third harmonic measured power:

   3rd HarmPower_Corrected = 3rd HarmPower - PM_to_RX_Cable_Path_Response [dB]
10. Calculate the output harmonic distortion:

   2nd_HD =
   2nd HarmPower Corrected - Fundamental_Power_Corrected [dBc]

   3rd_HD =
   3rd HarmPower Corrected - Fundamental_Power_Corrected [dBc]
11. Configure the DUT for the following settings:
   - Frequency: Next frequency from Configurations **Table 41**
   - Upconverter Offset for the selected frequency from configurations **Table 41**
12. Configure the Spectrum Analyzer for the following settings:
   - Center Frequency: DUT Frequency + DUT Tone Offset (from Configurations **Table 41**)
   - Reference Level: DUT Power Level +5 dB

1. Configure the DUT for the following settings:
   - Digital Gain: next value from Configurations **Table 41**

6.10. RF Output Third Order Intermodulation Verification

6.10.1. Test Limits

Table 43: RF Output Third Order Intermodulation Test Points and Limits for Verification Test (**Upconverter Mode – User Defined**)

Frequency Range	Output Power	As-Found Test Limit	As-Left Test Limit
		Upper Limit	Upper Limit
30 MHz to 3.0 GHz	-30 dBm	-51.0 dBm	-51.9 dBm
>3.0 GHz to 6.0 GHz		-49.0 dBm	-50.1 dBm
>6.0 GHz to 12.0 GHz		-53.0 dBm	-54.0 dBm
>12.0 GHz to 26.5 GHz		-46.0 dBm	-47.5 dBm
30 MHz to 3.0 GHz	0 dBm	-47.0 dBm	-48.5 dBm
>3.0 GHz to 6.0 GHz		-48.0 dBm	-49.5 dBm
>6.0 GHz to 12.0 GHz		-53.0 dBm	-54.5 dBm
>12.0 GHz to 26.5 GHz		-47.0 dBm	-48.4 dBm
30 MHz to 200.0 MHz	+15 dBm	-45.0 dBm	-46.6 dBm
200.0 MHz to 3.0 GHz		-48 dBm	-49.6 dBm
>3.0 GHz to 6.0 GHz		-49.0 dBm	-50.4 dBm
>6.0 GHz to 12.0 GHz		-46.0 dBm	-47.3 dBm
>12.0 GHz to 18.0 GHz		-40.0 dBm	-41.3 dBm
>18.0 GHz to 20 GHz		-38.0 dBm	-38.4 dBm
>20.0 GHz to 22 GHz	DUT Maximum Level, see **Table 47**	-36.0 dBm	-36.7 dBm
>22.0 GHz to 25 GHz		-40.0 dBm	-40.6 dBm

Table 44: RF Output Third Order Intermodulation Test Points and Limits for Verification Test (**Upconverter Mode – Enabled**)

Frequency Range	Output Power	As-Found Test Limit	As-Left Test Limit
		Upper Limit	Upper Limit
30 MHz to 3.0 GHz	-30 dBm	-51.0 dBm	-51.8 dBm
>3.0 GHz to 6.0 GHz		-52.0 dBm	-53.6 dBm
>6.0 GHz to 12.0 GHz		-56.0 dBm	-56.7 dBm
>12.0 GHz to 26.5 GHz		-49.0 dBm	-50.2 dBm
30 MHz to 3.0 GHz	0 dBm	-51.0 dBm	-52.0 dBm
>3.0 GHz to 6.0 GHz		-50.0 dBm	-50.7 dBm
>6.0 GHz to 12.0 GHz		-55.0 dBm	-56.0 dBm
>12.0 GHz to 26.5 GHz		-50.0 dBm	-51.6 dBm
30 MHz to 200.0 MHz	+15 dBm	-45.0 dBm	-46.6 dBm
200.0 MHz to 3.0 GHz		-48 dBm	-49.2 dBm
>3.0 GHz to 6.0 GHz		-50.0 dBm	-50.5 dBm
>6.0 GHz to 12.0 GHz		-46.0 dBm	-46.9 dBm
>12.0 GHz to 18.0 GHz		-40.0 dBm	-41.2 dBm
>18.0 GHz to 20 GHz		-38.0 dBm	-38.4 dBm
>20.0 GHz to 22 GHz	DUT Maximum Level, see **Table 47**	-39.0 dBm	-40.2 dBm
>22.0 GHz to 25 GHz		-49.0 dBm	-49.8 dBm

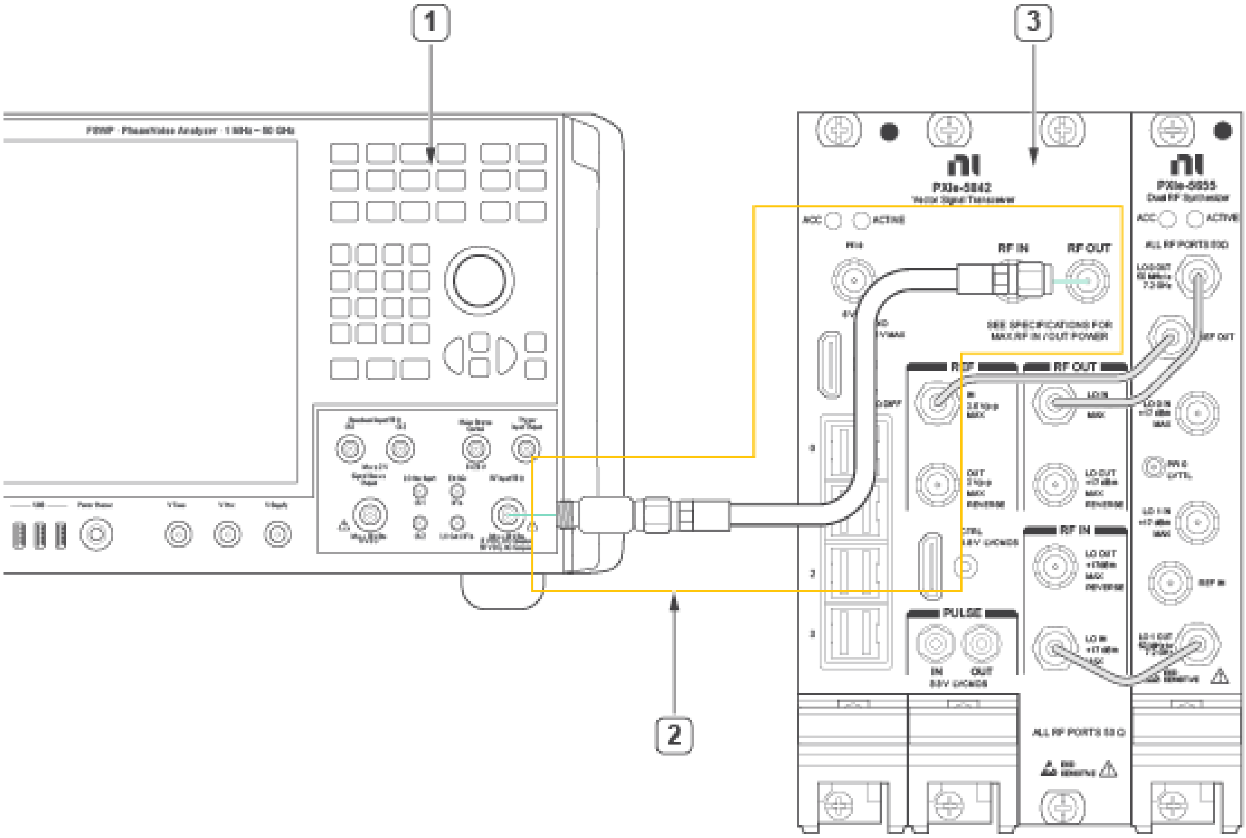
Table 45: DUT Output Maximum Power Level

Frequency Range	User Defined	Enabled
30.0 MHz to 200.0 MHz	+15.0 dBm	NA
>200.0 MHz to 1.7 GHz	19.0 dBm	NA
>1.7 GHz to 4.0 GHz	+19.0 dBm	+19.0 dBm
>4.0 GHz to 8.0 GHz	+20.0 dBm	+20.0 dBm
>8.0 GHz to 12.0 GHz	+18.0 dBm	+17.0 dBm
>12.0 GHz to 20.0 GHz	+18.0 dBm	+16.0 dBm
>20.0 GHz to 22.0 GHz	+15.0 dBm	+13.0 dBm
>22.0 GHz to 24.0 GHz	+10.0 dBm	+6.0 dBm
>24.0 GHz to 25.0 GHz	+8.0 dBm	+4.0 dBm
>25.0 GHz to 26.5 GHz	0.0 dBm	0.0 dBm

6.10.2. Initial Test Connection

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

Figure 17. Connections for RF Output Third Order Intermodulation Verification



1. Phase noise and Spectrum analyzer
2. Cable Characterization Fixture
3. DUT

1. Ensure that the connection fixture between the Spectrum Analyzer and the DUT has been characterized as per section 5.2 Cable loss Characterization.

> **Note**
> Do not disassemble Cable Fixture item #7 from **Figure 4** after characterization. If you disassemble this fixture, you must recharacterize it before it is used again.

6.10.3. Verification Procedure

Table 46: RF Output TOI Configurations (User Defined)

DUT IQ Frequency	DUT Power Level	Signal Analyzer Attenuation	DUT Bandwidth	DUT Tone Offsets
▪ 30 MHz to 90 MHz in 10 MHz steps ▪ 100 MHz to 275 MHz in 25 MHz steps ▪ 300 MHz to 950 MHz in 50 MHz steps	-30 dBm	0 dB	0 Hz	t_1=10 MHz t_2=10.7 MHz
	0 dBm	20 dB		
	Minimum between +15.0 dBm and Maximum DUT Linear Power see **Table 45**	35 dB		
▪ 1.0 GHz to 1.7 GHz in 100 MHz steps ▪ 1.749 GHz	-30 dBm	0 dB	0 Hz	t_1=95 MHz t_2=105 MHz
	0 dBm	20 dB		
	Minimum between +15.0 dBm and Maximum DUT Linear Power see **Table 45**	35 dB		
▪ 1.75 GHz ▪ 1.8 GHz to 26.3 GHz (or Maximum Frequency, (See **Table 3**) in 100 MHz steps ▪ 26.38 GHz (See **Table 3)**	-30 dBm	0 dB	230 MHz	t_1=95 MHz t_2=105 MHz
	0 dBm	20 dB		
	Minimum between +15.0 dBm and Maximum DUT Linear Power see **Table 45**	+40 dB for 8 GHz ≤ f ≤ 12 GHz, otherwise 35 dB		

Table 47: RF Output TOI Configurations (Enabled)

DUT IQ Frequency	DUT Power Level	Signal Analyzer Attenuation	DUT Bandwidth	DUT Tone Offsets
▪ 1.701 GHz ▪ 1.8 GHz to 26.3 GHz (or Maximum Frequency, (See **Table 3**) in 100 MHz steps ▪ 26.38 GHz (See **Table 3)**	-30 dBm	0.0 dB	230 MHz	t_1=95 MHz t_2=105 MHz
	0 dBm	20 dB		
	Minimum between +15.0 dBm and Maximum DUT Linear Power see **Table 45**	+40 dB for 8 GHz ≤ f ≤ 12 GHz, otherwise +35 dB		

6.10.4. Verification Procedure (Upconverter Mode = User Defined)

1. Configure the DUT to generate two single sideband tones simultaneously, offset from the carrier:
   - Mode: Arb Waveform (IQ)
   - Power Level Type: Peak Power
   - Reference Clock Source: PXI_CLK (Locked to Rubidium)
   - Reference Clock Frequency: 10 MHz
   - Frequency: First frequency from Configurations **Table 46** (**f_0**)
   - Upconverter Offset Mode: User Defined
   - Power Level: First Power Level from configurations **Table 46**
   - Signal Bandwidth: Bandwidth Matching the Power Level from configurations **Table 46**
   - Upconverter Offset:
     - Frequency (f_0) < 1.75 GHz: Driver Default
     - Frequency (f_0) ≥ 1.75 GHz: 0 Hz
   - MultiTone VI Cluster Input (see section 8.1 Generating an IQ Signal):
     - Number of Elements = 2

        - Tone Frequency: DUT Tone Offset Frequencies from Configurations **Table 46**
        - Tone Phase = [0, 0]
        - Tone Power = [-7, -7]
    - IQ Rate: Hardware option maximum from **Table 4**
    - Number of Samples: 50 kS
    - Digital Gain: 0 dB

2. Configure the Spectrum Analyzer for the following settings:
    - Mode: Spectrum
    - Reference Oscillator Source: External Reference (Locked to Rubidium)
    - Center Frequency: Same as DUT Frequency (f_0)
        - $f_1 = f_0 + t_1$ (t_1 Matching the DUT Power Level from configurations **Table 46**)
    - Reference Level: DUT Power Level + DUT digital gain
    - Span: 1 kHz
    - RBW: 30 Hz
    - Sweep Count: 10001
    - Mode: Auto Peak
    - Attenuation: Matching the DUT Power Level from configurations **Table 46**
3. Enable the DUT to generate the tones and wait until it settles.
4. Taking the Verification measurements

For each DUT Reference Power Level in **Table 46**, starting with the lower power setting, repeat the following steps:

Repeat, once for IQ Center Frequency setting in **Table 46**.

1. Measure the Power at frequency f_1.
2. Record the corrected measured power with cable characterization at f_1 frequency:

$$Pf_{1C} = Pf_1 - \text{M\_to\_RX\_Cable\_Path\_Response}_{(f1)}\ [\text{dBm}]$$

3. Configure the Spectrum Analyzer for the following settings:

   Center Frequency: Same as DUT Frequency (f_0)

   - $f_2 = f_0 + t_2$ (t_2 Matching the DUT Power Level from configurations **Table 46**)

4. Measure the Power at frequency f_2.

5. Record the corrected measured power with cable characterization at f_2 frequency:

$$Pf_{2C} = Pf_2 - \text{M\_to\_RX\_Cable\_Path\_Response}_{(f2)}\ [\text{dBm}]$$

6. Configure the Spectrum Analyzer for the following settings:

   Center Frequency: Same as DUT Frequency (f_0)

   - $f(IMD3_{T1}) = (2 f_2 - f_1)$

7. Measure the Power at frequency $f(IMD3_{T1})$.

8. Record the corrected measured power with cable characterization at $f(IMD3_{T1C})$ frequency:

$$Pf(IMD3_{T1C}) = Pf(IMD3_{T1}) - \text{M\_to\_RX\_Cable\_Path\_Response}_{(f2(IMD3T1))}\ [\text{dBm}]$$

9. Configure the Spectrum Analyzer for the following settings:

   Center Frequency: Same as DUT Frequency (f_0)

   - $f(IMD3_{T2}) = (2 f_1 - f_2)$

10. Measure the Power at frequency $f(IMD3_{T2})$.

11. Record the corrected measured power with cable characterization at $f(IMD3_{T2C})$ frequency:

$$Pf(IMD3_{T2C}) = Pf(IMD3_{T2}) - \text{M\_to\_RX\_Cable\_Path\_Response}_{(f2(IMD3T2))}\ [\text{dBm}]$$

12. Calculate Output IMD$_3$ using the following equation:

$$\mathbf{Out(IMD_3)} = \mathrm{Min}(Pf_{1C}; Pf_{2C}) - \mathrm{Max}[Pf(IMD3_{T1C}); Pf(IMD3_{T2C})]$$

    - Calculate TOI using the following equation:

$$\mathbf{Out(TOI)} = \mathrm{Min}(Pf_{1C}; Pf_{2C}) + [\mathrm{Min}(Pf_{1C}; Pf_{2C}) - \mathrm{Out}(IMD_3)/2]\ [\mathrm{dB}]$$

    - Compare the calculated Out(TOI) with limits in **Table 43**

13. Configure the DUT to generate two single sideband tones simultaneously, offset from the carrier:
    - Frequency: Next frequency from Configurations **Table 46** (**f_0**)
    - Upconverter Offset:
        - Frequency (f_0) < 1.75 GHz: Driver Default
        - Frequency (f_0) ≥ 1.75 GHz: 0 Hz
    - Power Level: Current Power Level from configurations **Table 46**
    - Signal Bandwidth: Bandwidth Matching the current Power Level from configurations **Table 46**
    - MultiTone VI Cluster Input (see section 8.1 Generating an IQ Signal):
        - Number of Elements = 2
        - Tone Frequency: DUT Tone Offset Frequencies from Configurations **Table 46**
        - Tone Phase = [0, 0]
        - Tone Power = [-7, -7]
    - IQ Rate: Hardware option maximum from **Table 4**

14. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: Same as DUT Frequency **(f_0)**
        - $f_1 = f_0 + t_1$ (**t_1** Matching the DUT Power Level from configurations **Table 46**)
    - Reference Level: DUT Power Level + DUT digital gain
    - Attenuation: Matching the DUT Power Level from configurations **Table 46**

1. Configure the DUT to generate two single sideband tones simultaneously, offset from the carrier:
    - Frequency: First frequency from Configurations **Table 46** (***f_0***)
    - Upconverter Offset:
        - Frequency (f_0) < 1.75 GHz: Driver Default
        - Frequency (f_0) ≥ 1.75 GHz: 0 Hz
    - Power Level: Next Power Level from configurations **Table 46**
    - Signal Bandwidth: Bandwidth Matching the Power Level from configurations **Table 46**
    - MultiTone VI Cluster Input (see section 8.1 Generating an IQ Signal):
        - Number of Elements = 2
        - Tone Frequency: DUT Tone Offset Frequencies from Configurations **Table 46**
        - Tone Phase = [0, 0]
        - Tone Power = [-7, -7]
    - IQ Rate: Hardware option maximum from **Table 4**
2. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: Same as DUT Frequency (f_0)
        - $f_1 = f_0 + t_1$ (t_1 Matching the DUT Power Level from configurations **Table 46**)
    - Reference Level: DUT Power Level + DUT digital gain
    - Attenuation: Matching the DUT Power Level from configurations **Table 46**
3. Enable the DUT to generate the tones and wait until it settles.

6.10.5. Verification Procedure (Upconverter Mode = Enabled)

1. Configure the DUT to generate two single sideband tones simultaneously, offset from the carrier:

- Mode: Arb Waveform (IQ)
- Power Level Type: Peak Power
- Reference Clock Source: PXI_CLK (Locked to Rubidium)
- Reference Clock Frequency: 10 MHz
- Frequency: First frequency from Configurations **Table 47** (*f_0*)
- Upconverter Offset Mode: Enabled
- Power Level: First Power Level from configurations **Table 47**
- Signal Bandwidth: Bandwidth Matching the Power Level from configurations **Table 47**
- Upconverter Offset: Driver Default
- MultiTone VI Cluster Input (see section 8.1 Generating an IQ Signal):
    - Number of Elements = 2
    - Tone Frequency: DUT Tone Offset Frequencies from Configurations **Table 47**
    - Tone Phase = [0, 0]
    - Tone Power = [-7, -7]
- IQ Rate: Hardware option maximum from **Table 4**
- Number of Samples: 50 kS
- Digital Gain: 0 dB

2. Configure the Spectrum Analyzer for the following settings:

- Mode: Spectrum
- Reference Oscillator Source: External Reference (Locked to Rubidium)
- Center Frequency: Same as DUT Frequency (*f_0*)
    - $f_1 = f_0 + t_1$ (t_1 Matching the DUT Power Level from configurations **Table 47**)
- Reference Level: DUT Power Level + DUT digital gain
- Span: 1 kHz
- RBW: 30 Hz
- Sweep Count: 10001
- Mode: Auto Peak
- Attenuation: Matching the DUT Power Level from configurations **Table 47**

3. Enable the DUT to generate the tones and wait until it settles.

4. Taking the Verification measurements

For each DUT Reference Power Level in **Table 47**, starting with the lower power setting, repeat the following steps:

Repeat, once for IQ Center Frequency setting in **Table 47**.

1. Measure the Power at frequency f_1.
2. Record the corrected measured power with cable characterization at f_1 frequency:

   $$Pf_{1c} = Pf_1 - M\_to\_RX\_Cable\_Path\_Response_{(f1)}\ [dBm]$$

3. Configure the Spectrum Analyzer for the following settings:

   Center Frequency: Same as DUT Frequency (f_0)

   - $f_2 = f_0 + t_2$ (t_2 Matching the DUT Power Level from configurations **Table 47**)

4. Measure the Power at frequency f_2.
5. Record the corrected measured power with cable characterization at f_2 frequency:

   $$Pf_{2c} = Pf_2 - M\_to\_RX\_Cable\_Path\_Response_{(f2)}\ [dBm]$$

6. Configure the Spectrum Analyzer for the following settings:

   Center Frequency: Same as DUT Frequency (f_0)

   - $f(IMD3_{T1}) = (2 f_2 - f_1)$

7. Measure the Power at frequency $f(IMD3_{T1})$.
8. Record the corrected measured power with cable characterization at $f(IMD3_{T1c})$ frequency:

   $$Pf(IMD3_{T1c}) = Pf(IMD3_{T1}) - M\_to\_RX\_Cable\_Path\_Response_{(f2(IMD3T1))}\ [dBm]$$

9. Configure the Spectrum Analyzer for the following settings:

Center Frequency: Same as DUT Frequency (f_0)

- $\mathbf{f(IMD3_{T2}) = (}2f_1 - f_2)$

10. Measure the Power at frequency $f(IMD3_{T2})$.

11. Record the corrected measured power with cable characterization at $f(IMD3_{T2C})$ frequency:

$$Pf(IMD3_{T2C}) = Pf(IMD3_{T2}) - M\_to\_RX\_Cable\_Path\_Response_{(f2(IMD3T2))}\ [dBm]$$

12. Calculate Output IMD$_3$ using the following equation:

$$Out(IMD_3) = Min(Pf_{1C}; Pf_{2C}) - Max[Pf(IMD3_{T1C}); Pf(IMD3_{T2C})]$$

- Calculate TOI using the following equation:

$$Out(TOI) = Min(Pf_{1C}; Pf_{2C}) + [Min(Pf_{1C}; Pf_{2C}) - Out(IMD_3)/2]\ [dB]$$

- Compare the calculated Out(TOI) with limits in **Table 43**

13. Configure the DUT to generate two single sideband tones simultaneously, offset from the carrier:

- Frequency: Next frequency from Configurations **Table 47** (**f_0**)
- Upconverter Offset:
  - Frequency (f_0) < 1.75 GHz: Diver Default
  - Frequency (f_0) ≥ 1.75 GHz: 0 Hz
- Power Level: Current Power Level from configurations Table 48
- Signal Bandwidth: Bandwidth Matching the current Power Level from configurations **Table 47**
- MultiTone VI Cluster Input (see section 8.1 Generating an IQ Signal):
  - Number of Elements = 2
  - Tone Frequency: DUT Tone Offset Frequencies from Configurations **Table 47**
  - Tone Phase = [0, 0]
  - Tone Power = [-7, -7]
- IQ Rate: Hardware option maximum from **Table 4**

14. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: Same as DUT Frequency **(f_0)**
        - **$f_1 = f_0 + t_1$** (**t_1** Matching the DUT Power Level from configurations **Table 47**)
    - Reference Level: DUT Power Level + DUT digital gain
    - Attenuation: Matching the DUT Power Level from configurations **Table 47**

1. Configure the DUT to generate two single sideband tones simultaneously, offset from the carrier:
    - Frequency: First frequency from Configurations **Table 47** (**f_0**)
    - Upconverter Offset:
        - Frequency (f_0) < 1.75 GHz: Diver Default
        - Frequency (f_0) ≥ 1.75 GHz: 0 Hz
    - Power Level: Next Power Level from configurations **Table 47**
    - Signal Bandwidth: Bandwidth Matching the Power Level from configurations **Table 47**
    - MultiTone VI Cluster Input (see section 8.1 Generating an IQ Signal):
        - Number of Elements = 2
        - Tone Frequency: DUT Tone Offset Frequencies from Configurations **Table 47**
        - Tone Phase = [0, 0]
        - Tone Power = [-7, -7]
    - IQ Rate: Hardware option maximum from **Table 4**
2. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: Same as DUT Frequency (f_0)
        - **$f_1 = f_0 + t_1$** (**t_1** Matching the DUT Power Level from configurations **Table 47**)
    - Reference Level: DUT Power Level + DUT digital gain
    - Attenuation: Matching the DUT Power Level from configurations **Table 47**
3. Enable the DUT to generate the tones and wait until it settles.

6.11. RF Input Average Noise Density Verification

6.11.1. Verification Test Limits

Table 48: RF Input Average Noise Density Test Points/Limits for Verification Test

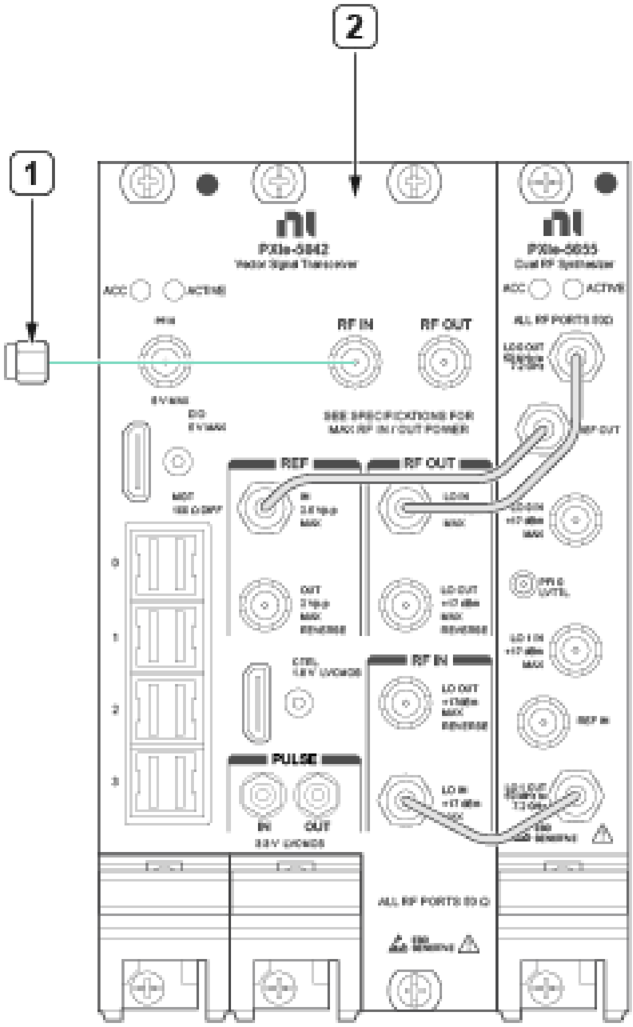
IQ Frequency	Reference Level	As-Found Upper Limit	As-Left Upper Limit
30 MHz to <1.75 GHz	-30 dBm	-163 dBm	-164.8 dBm
1.75 GHz to 3.0 GHz		-162 dBm	-163.3 dBm
>3.0 GHz to 12.0 GHz		-161 dBm	-162.7 dBm
>12.0 GHz to 18.0 GHz		-159 dBm	-160.8 dBm
>18.0 GHz to 22.0 GHz		-157 dBm	-159.3 dBm
>22.0 GHz to 25.0 GHz		-157 dBm	-158.7 dBm
>25.0 GHz to 26.5 GHz		-156 dBm	-157.6 dBm
30 MHz to 1.75 GHz	+0 dBm	-141 dBm	-142.6 dBm
>1.75 GHz to 3.0 GHz		-140 dBm	-141.6 dBm
>3.0 GHz to 22.0 GHz		-140 dBm	-142.1 dBm
>22.0 GHz to 26.5 GHz		-140 dBm	-141.7 dBm

Note

Test up to 26.5 GHz only; no harmonics above 26.5 GHz will be measured.

6.11.2. Initial Test Connection

Figure 18. Connections for Input Average Noise Density Verification



1. 3.5 mm (m) 50 Ω Terminator
2. DUT

6.11.3. Verification Procedure

Table 49: RF Input Average Noise Density Configurations

DUT IQ Frequency	DUT Downconverter Mode	DUT Reference Power Level	Signal Bandwidth
▪ 30 MHz ▪ 50 MHz ▪ 100 MHz to 26.5 GHz (or Maximum Frequency) (See Table 3) in 100 MHz steps	User Defined	▪ -30 dBm ▪ 0 dBm	▪ IQCF <1.75 GHz: Driver Default ▪ If IQCF ≥ 1.75 GHz: 48 MHz
▪ 1.701 GHz ▪ 1.8 GHz to 26.5 GHz (or Maximum Frequency) (See Table 3) in 100 MHz Steps	Enabled	▪ -30 dBm ▪ 0 dBm	48 MHz

6.11.4. Verification Procedure (Downconverter Mode = User Defined)

1. Make the connections indicated in **Figure 18**.
2. Configure the DUT for the following settings:
    - Acquisition Type: IQ Mode
    - FFT Window: Uniform
    - Averaging Mode: RMS
    - Mode: Arb Waveform (IQ)
    - Reference Power Level: First Reference Power Level from configurations **Table 49**
    - IQ Center Frequency: First IQ frequency from Configurations **Table 49**
    - Downconverter Offset Mode: User Defined
    - Downconverter Offset: Driver Default
    - Signal Bandwidth: Signal Bandwidth from Configurations **Table 49**

  - IQ Rate: 60 MS/s
  - Number of Samples: IQ Rate / 1000

3. Taking the measurements

For each DUT Reference Power Level setting from **Configurations Table 49,** repeat the following steps:

For each DUT IQ Frequency in **Configurations Table 49,** repeat the following steps:

1. Initiate a Spectrum read from DUT
2. Measure the Power Spectrum Data with the DUT and name it "**Power_Spectrum_Data**", see 8.2 Acquiring a Spectrum from IQ Data and Measuring the Peak annex for more details.
3. The power Spectrum Data has the following parameters:
   - Spectrum_df: Frequency Spacing of the spectrum
   - Spectrum_f_0: Spectrum Initial Frequency
   - Spectrum_Data: An array of spectrum Y values
4. Create a subset array of **Power_Spectrum_Data**, called **Data_Subset**, including only the points within the noise frequency span of interest that is determined by:
   - Noise Offset: 20 MHz (the offset between the center frequency of Spectrum_Data and Data_Subset)
   - Noise Span: 1 MHz (the span of the Data_Subset)
5. Create array **Data_Subset_No_Spurs** from **Data_Subset** array, by removing all spurs of Data_Subset
   - Take the mean of all remaining points, and remove points (spurs) that are 5 dB above the mean
   - Remove all points below the thermal noise floor (< -174 dBm)
6. Determine the equalization noise bandwidth for the filter used, ENBW. This can be determined by calling the Window Properties VI function with following parameter:
   - BW: 1 Hz BW
   - info.window: Rectangle

7. Calculate the Average Noise Density using formulas:

BW Noise Contribution [dBm/Hz]= 10*log(1/(ENBW * Spectrum_df))
Average_Power_of_Noise_Floor [mW]= Mean($10^{\text{Data\_Subset}[i]/10}$), for all values "*i*"

Average Power of Noise_Floor [dBm] = 10*log(Average_Power_of_Noise_Floor[mW])

Average Noise Density [dBm/Hz] = Average Power of Noise_Floor + BW Noise Contribution

8. Configure the DUT for the following settings:
   - IQ Center Frequency: Next IQ frequency from Configurations **Table 49**
   - Signal Bandwidth: Signal Bandwidth from Configurations **Table 49**

1. Configure the DUT for the following settings:
   - Reference Power Level: Next Reference Power Level from configurations **Table 49**
   - IQ Center Frequency: First IQ frequency from Configurations **Table 49**
   - Signal Bandwidth: Signal Bandwidth from Configurations **Table 49**

6.11.5. Verification Procedure (Downconverter Mode = Enabled)

1. Make the connections indicated in **Figure 18**.

2. Configure the DUT for the following settings:

- Acquisition Type: IQ Mode
- FFT Window: Uniform
- Averaging Mode: RMS
- Mode: Arb Waveform (IQ)
- Reference Power Level: First Reference Power Level from configurations **Table 49**
- IQ Center Frequency: First IQ frequency from Configurations **Table 49**
- Downconverter Offset Mode: Enabled
- Downconverter Offset: Driver Default
- Signal Bandwidth: Signal Bandwidth from Configurations **Table 49**
- IQ Rate: 60 MS/s
- Number of Samples: IQ Rate / 1000

3. Taking the measurements

For each DUT Reference Power Level setting from **Configurations Table 49,** repeat the following steps:

For each DUT IQ Frequency in **Configurations Table 49,** repeat the following steps:

1. Initiate a Spectrum read from DUT
2. Measure the Power Spectrum Data with the DUT and name it "**Power_Spectrum_Data**", see 8.2 Acquiring a Spectrum from IQ Data and Measuring the Peak annex for more details.
3. The power Spectrum Data has the following parameters:
    - Spectrum_df: Frequency Spacing of the spectrum
    - Spectrum_f_0: Spectrum Initial Frequency
    - Spectrum_Data: An array of spectrum Y values
4. Create a subset array of **Power_Spectrum_Data**, called **Data_Subset**, including only the points within the noise frequency span of interest that is determined by:
    - Noise Offset: 20 MHz (the offset between the center frequency of Spectrum_Data and Data_Subset)
    - Noise Span: 1 MHz (the span of the Data_Subset)

5. Create array **Data_Subset_No_Spurs** from **Data_Subset** array, by removing all spurs of Data_Subset
    - Take the mean of all remaining points, and remove points (spurs) that are 5 dB above the mean
    - Remove all points below the thermal noise floor (< -174 dBm)
6. Determine the equalization noise bandwidth for the filter used, ENBW. This can be determined by calling the Window Properties VI function with following parameter:
    - BW: 1 Hz BW
    - info.window: Rectangle

7. Calculate the Average Noise Density using formulas:

BW Noise Contribution [dBm/Hz]= 10*log(1/(ENBW * Spectrum_df))
Average_Power_of_Noise_Floor [mW]= Mean($10^{\text{Data\_Subset}[i]/10}$), for all values “*i*”

Average Power of Noise_Floor [dBm] = 10*log(Average_Power_of_Noise_Floor[mW])

Average Noise Density [dBm/Hz] = Average Power of Noise_Floor + BW Noise Contribution

8. Configure the DUT for the following settings:

    - IQ Center Frequency: Next IQ frequency from Configurations **Table 49**
    - Signal Bandwidth: Signal Bandwidth from Configurations **Table 49**

1. Configure the DUT for the following settings:

    - Reference Power Level: Next Reference Power Level from configurations **Table 49**
    - IQ Center Frequency: First IQ frequency from Configurations **Table 49**
    - Signal Bandwidth: Signal Bandwidth from Configurations **Table 49**

7. Perform Adjustment

Adjustment automatically updates the calibration constants, the date, and the temperature in the DUT EEPROM. If the DUT passes the verification procedures within the As-Left test limits, an adjustment is not required. Proceed to the *Update the Onboard Calibration Information* section.

The adjustments are sensitive to temperature variation. The internal device temperature must be maintained within ± 2.0 °C during the following adjustment sections:

- 7.4. LO and Impairments Self Cal Adjustment
- The transition between 7.5. RF Transmitter Output Gain Adjustment and 7.6. Transmitter Gain Internal Cal Procedure
- The transition between 7.7. RF Receiver External Gain Adjustment and 7.8. Receiver Gain Internal Cal Procedure

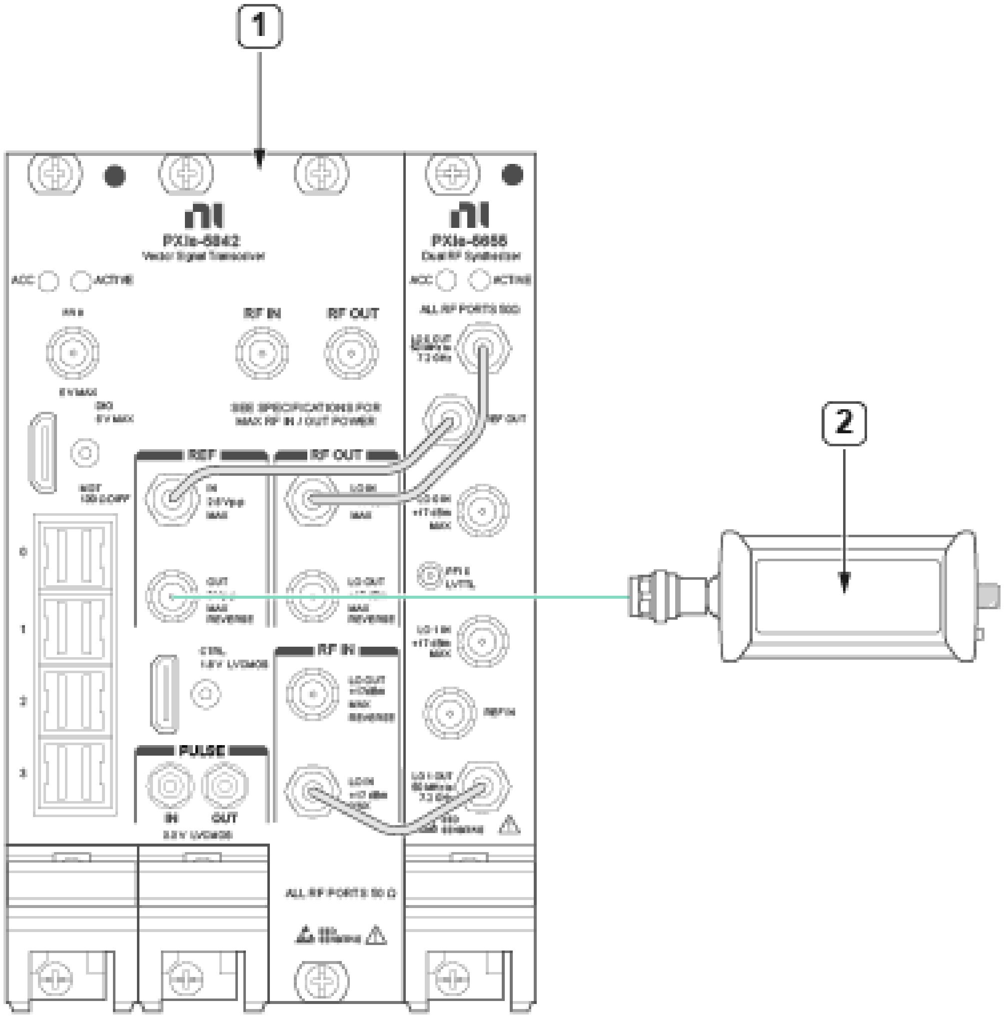
The execution order of the adjust procedure is intentionally setup such that temperature variation is minimized.

7.1. Reference Clock Gain Adjustment

7.1.1. Reference Clock Gain Adjustment Connection

⚠ **CAUTION**
The form factor of the power sensor might cause strain to the DUT test port connector. Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Figure 19. Connection for Reference Clock Gain Adjustment



1. DUT
2. Power Sensor #2

7.1.2. Reference Clock Gain Adjustment Procedure

1. Make the connections according with **Figure 19**
2. Open a calibration session using “***Initialize External Calibration 2.vi***”

3. Call "***Reference Clock Cal Initialize.vi***"

4. Making the Adjustments

> Repeat until the "*Calibration Complete Boolean output*" of the "*Reference Clock Cal Adjust.vi*" or the error wire becomes "TRUE"
>
> 1. Call "*Reference Clock Cal Configure.vi*".
> 2. Call the frequency to measure (Hz) the output from "*Reference Clock Cal Configure.vi*", name it "f_0".
> 3. Configure the Power Sensor to the same frequency "f_0".
> 4. Call "*Reference Clock Cal Configure.vi*" with the following parameters:
>   - Measured Power by the Power Sensor
>   - Frequency "f_0".

5. Call "*Reference Clock Cal Finalize.vi*".

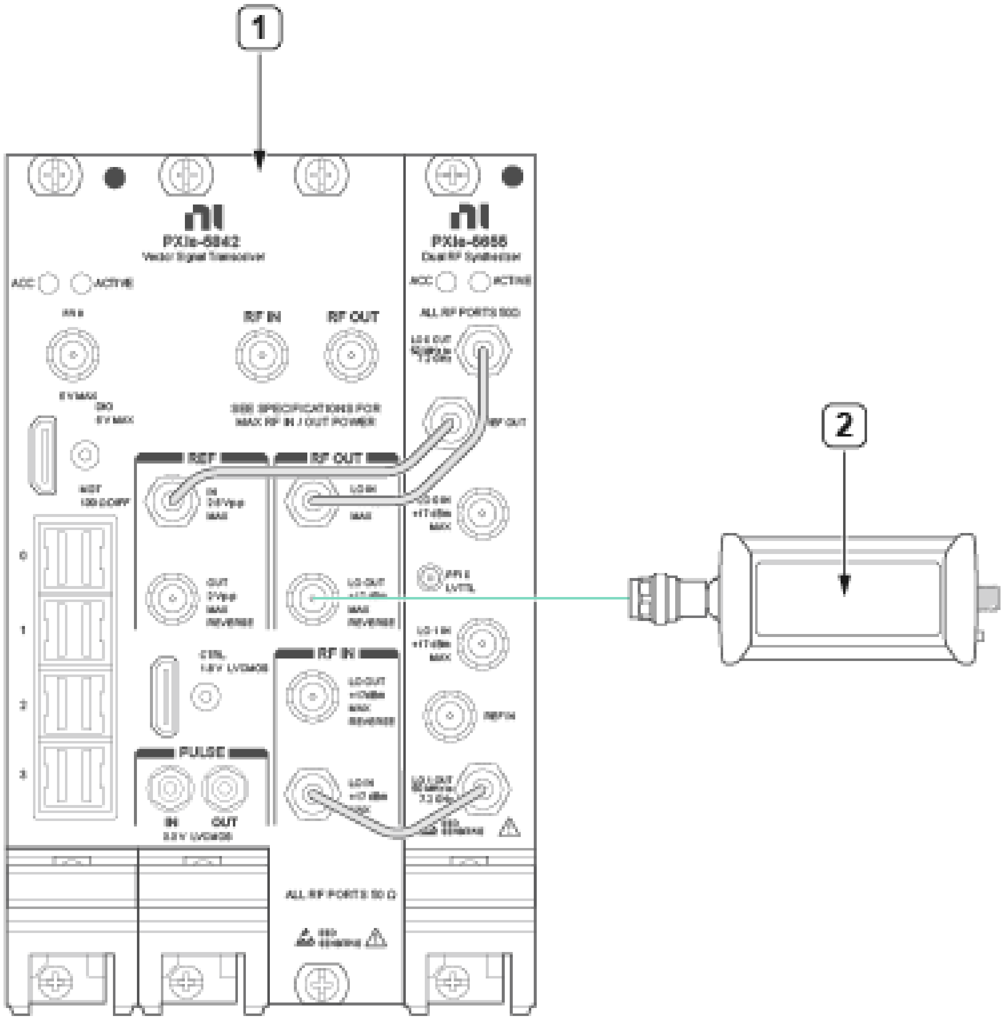
6. Call "***Close External Calibration.vi***" with:
   - Input *"write calibration to hardware?"* - set to True

7.2. RF Transmission LO Output Adjustment

7.2.1. RF Transmission LO Output Adjustment Connection

> **CAUTION**
> The form factor of the power sensor might cause strain to the DUT test port connector. Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Figure 20. Connection for RF Transmission LO Output Adjustment



1. DUT
2. Power Sensor #2

7.2.2. RF Transmission LO Output Adjustment Procedure

1. Make the connections according with **Figure 20**
2. Open a calibration session using “*Initialize External Calibration 2.vi*”
3. Call “*LO Cal Initialize.vi*”.
    - Port Type: “RF out”
4. Making the Adjustments

> Repeat until the “*Calibration Complete Boolean output*“ of the “*LO Cal Adjust.vi*” or the error wire becomes “TRUE”
>
> *1.* Call “*LO Cal Configure 3.vi*”.
>
> 2. Call the frequency to measure (Hz) the output from “*LO Cal Configure 3.vi*”, name it “f_0”.
>
> 3. Configure the Power Sensor to the same frequency “f_0”.
>
> 4. Call “*LO Cal Adjust.vi*” with the following parameter:
>   - Measured Power by the Power Sensor

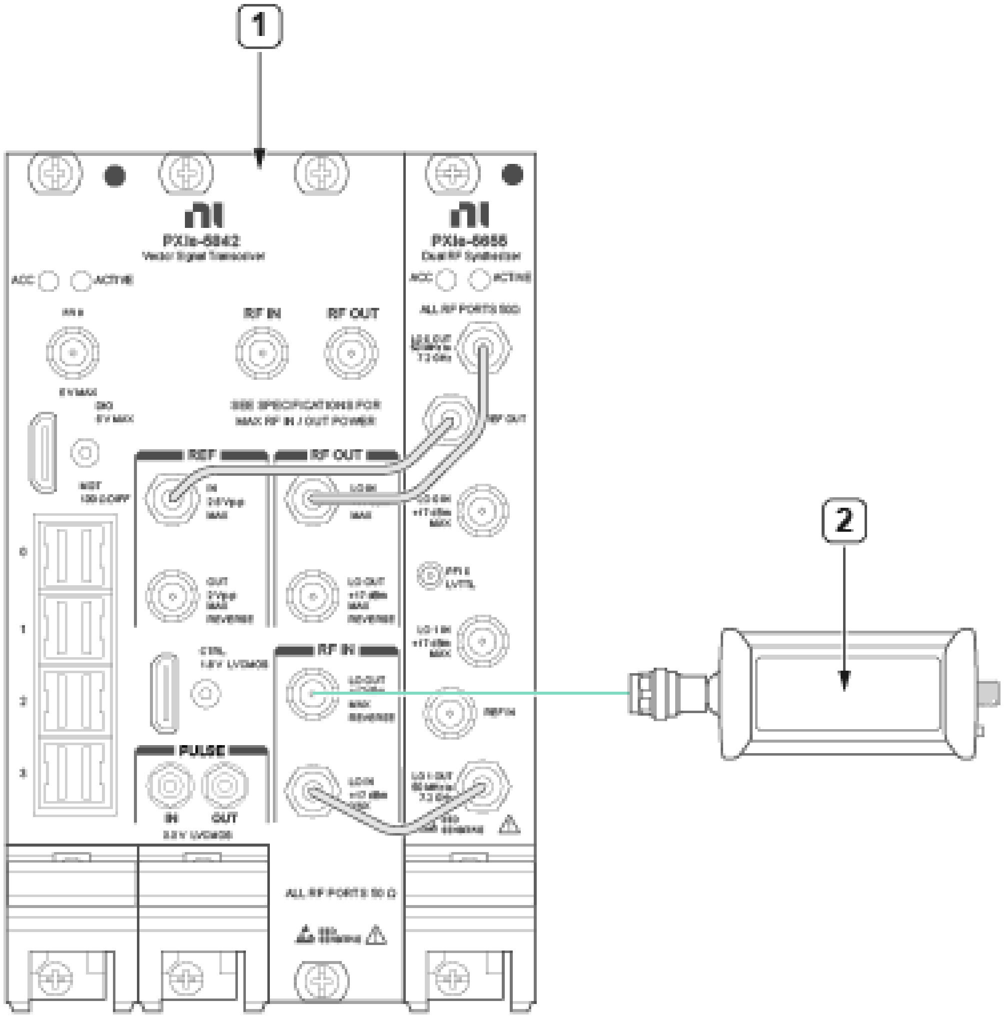
5. Call “*LO Cal Finalize.vi*”.
6. Call “***Close External Calibration.vi***” with:
    - Input “*write calibration to hardware?*” - set to True

7.3. RF Receiver LO Output Adjustment

7.3.1. RF Receiver LO Output Adjustment Connection

> **CAUTION**
> The form factor of the power sensor might cause strain to the DUT test port connector. Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Figure 21. Connection for RF Receiver LO Output Adjustment



1. DUT

2. Power Sensor #2

7.3.2. RF Receiver LO Output Adjustment Procedure

1. Make the connections according with **Figure 21**
2. Open a calibration session using "Initialize External Calibration 2.vi"
3. Call "LO Cal Initialize.vi".
    - Port Type: "RF In"
4. Making the Adjustments

> Repeat until the "*Calibration Complete Boolean output*" of the "*LO Cal Adjust.vi*" or the error wire becomes "TRUE"
>
> 1. Call "*LO Cal Configure 3.vi*".
> 2. Call the frequency to measure (Hz) the output from "*LO Cal Configure 3.vi*", name it "***f*₀**".
> 3. Configure the Power Sensor to the same frequency "***f*₀**".
> 4. Call "*LO Cal Adjust.vi*" with the following parameter:
>   - Measured Power by the Power Sensor

5. Call "*LO Cal Finalize 3.vi*".
6. Call Close "***External Calibration.vi***" with:
    - Input "write calibration to hardware?" - set to True

7.4. LO and Impairments Self Cal Adjustment

No external connections are required for this step; however, the connections for both Transmission and Receiver adjustments should be made during this step.

The environment of the module under adjustment must be maintained at a stable ambient temperature for consistent cooling. There should be no more than ±2 °C temperature variation throughout the sensitive sections of the adjust procedure (< ~1.5 Hours). These sections where temperature variation should be minimized are:

- 7.4 LO and Impairments Self Cal Adjustment
- The transition between 7.5. RF Transmitter Output Gain Adjustment and 7.6. Transmitter Gain Internal Cal Procedure
- The transition between 7.7. RF Receiver External Gain Adjustment and 7.8. Receiver Gain Internal Cal Procedure

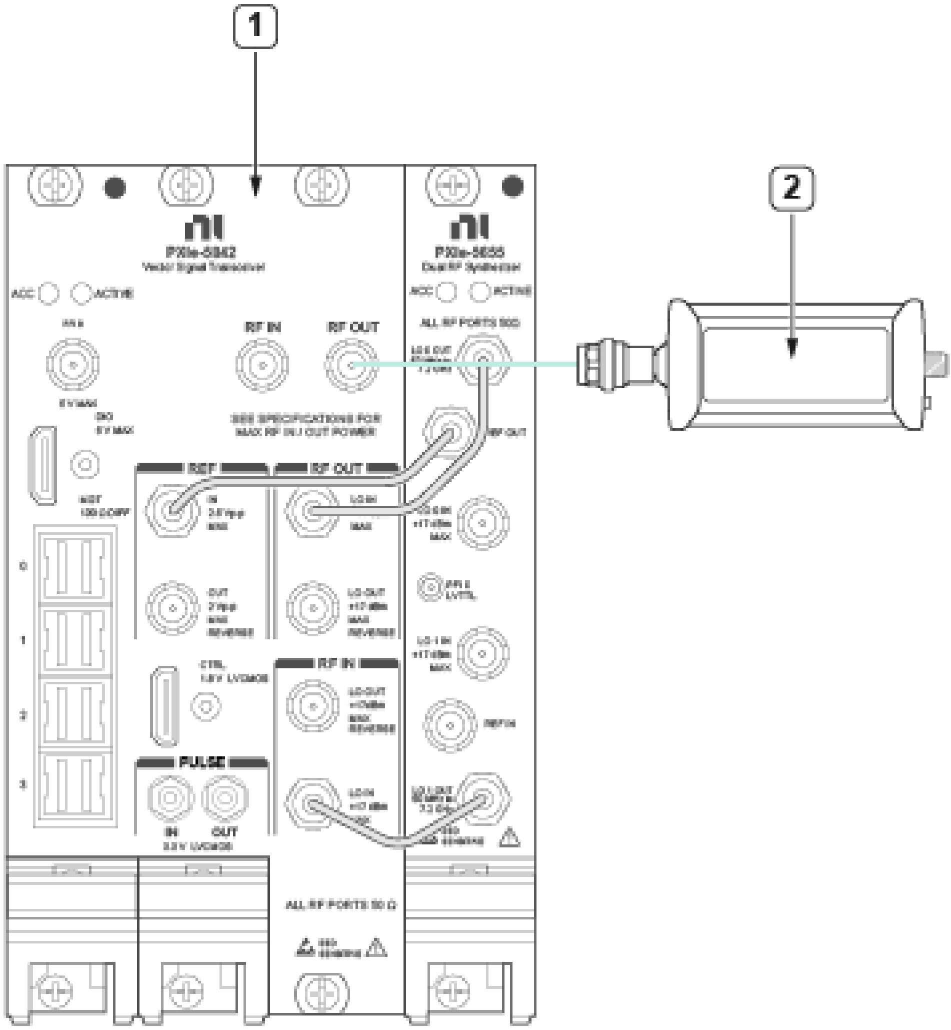
The execution order of the adjust procedure is intentionally setup such that temperature variation is minimized by setting up the hardware connections in advance, running RF Transmitter Output Gain Adjustment and Transmitter Gain Internal Cal Procedure back-to-back, and RF Receiver External Gain Adjustment and Receiver Gain Internal Cal Procedure back-to-back.

7.4.1. RF Receiver Gain Adjustment Connection

CAUTION
The form factor of the power sensor might cause strain to the DUT test port connector. Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

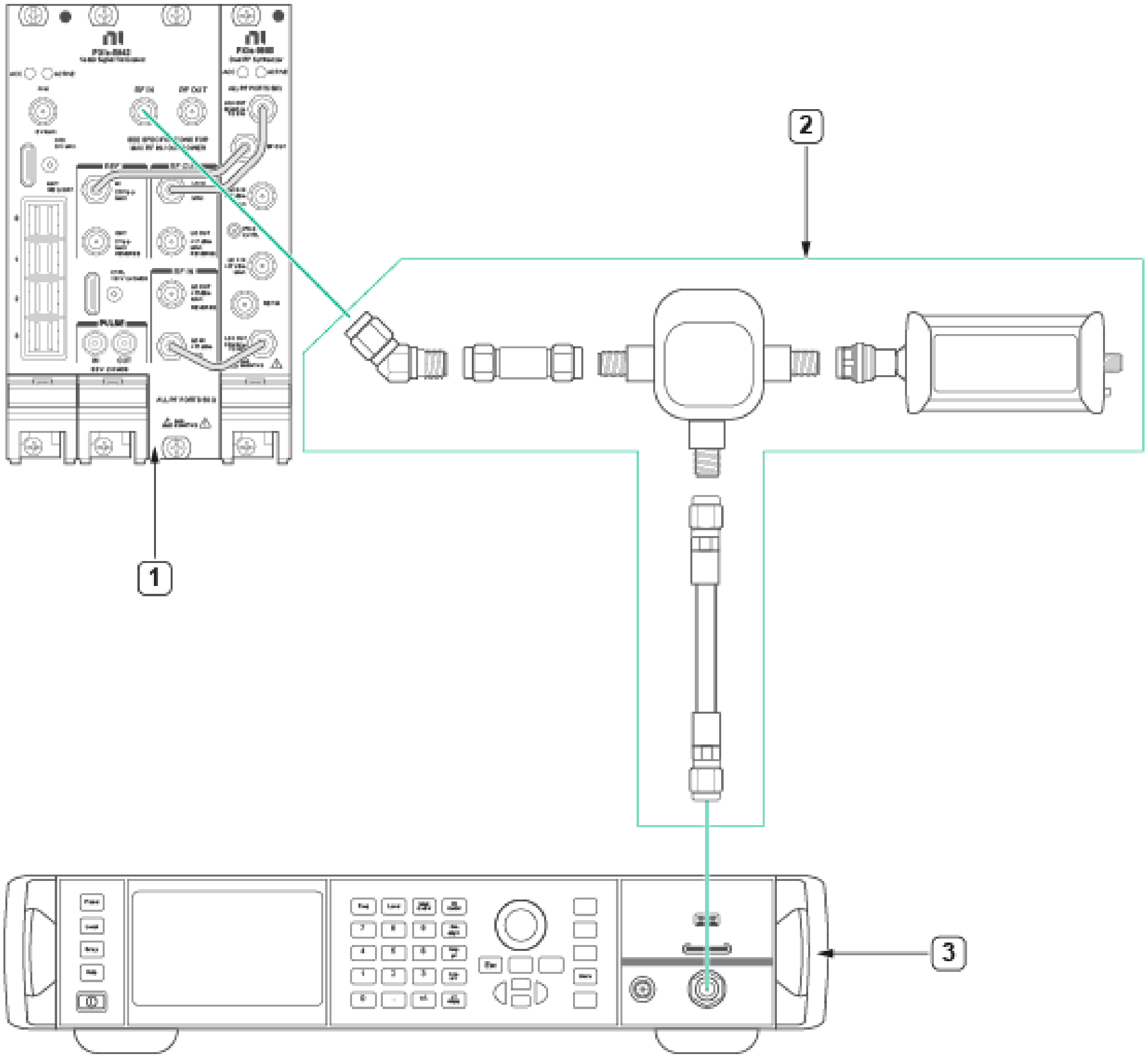
Figure 22. Connection for RF Transmitter LO Output Adjustment



1. DUT

2. Power Sensor #2

Figure 23. Connection for RF Transmitter LO Input Adjustment



1. DUT
2. Receiver Fixture from Figure 3
3. Signal Generator

7.4.2. LO and Impairments Self Cal Adjustment Procedure

Make sure that you have made the connections described in **Figure 5** External Reference Clock Connection before starting this Verification procedure.

1. Make the connections according with **Figure 22**
2. Make the connections according with **Figure 23**
3. Query the “RxSig “and “TxSig” temperature sensors, save the readings respectively as:
    - $tRxSig_{Ref}$
    - $tTxSig_{Ref}$
4. Call “*Procedure X.vi*”, with the string “selfCal1”.
5. If the temperatures changed more than ±2 °C from the reference temperatures, restart the procedure.

7.5. RF Transmitter Output Gain Adjustment

7.5.1. RF Transmission Output Gain Adjustment Procedure

1. Complete the connections according to **Figure 22** and **Figure 23**.
2. Call “*Power Meter Cal Initialize.vi*”.
    - Port: “if.0”
3. Configure the Power Sensor for the following settings:
    - Measurement Mode: Continuous Average Mode (default)
    - Auto Averaging: Enabled (default)

- Aperture Time: 0.001 s
- Auto Averaging Resolution: 3 (default)
- Auto Range Mode: Enabled (default)

4. Making the Adjustments

Repeat, once with each Call "*Power Meter Cal Initialize.vi*", starting with port "if.0" value setting and sequentially increment to "if.6".

> Repeat until the "*Calibration Complete Boolean output*" of the "*Power Meter Cal Adjust.vi*" or the error wire becomes "TRUE".
>
> 1. Call the frequency to measure (Hz) output from "*Power Meter Cal Adjust.vi*", name it "f_0".
> 2. Configure the Power Sensor to the same frequency "f_0".
> 3. Perform a reading with the Power Sensor.
> 4. Return Power Sensor reading to "*Power Meter Cal Adjust.vi*".

1. Call "*Power Meter Cal Finalize.vi*".
2. Call "*Close External Calibration.vi*" with:
    - Input "write calibration to hardware?" - set to True
3. Query the "RxSig "and "TxSig" temperature sensors. Compare the respective readings with $tRxSig_{Ref}$ and $tTxSig_{Ref}$ reference temperatures. If the temperatures changed more than ±2 °C from the reference temperatures, the procedure should be restarted.
4. Open a calibration session using "*Initialize External Calibration 2.vi*" with:
    - "*initialize RFSA*" input Boolean - False

5. Call “*Power Meter Cal Initialize.vi*”.
    - Port: “if.x”, where “x” is the next sequential number up to 6.

7.6. Transmitter Gain Internal Cal Procedure

1. Complete the connections according to **Figure 22**
2. Complete the connections according to **Figure 23**
3. Query the “RxSig “and “TxSig” temperature sensors, save the readings respectively as:
    - $tRxSig_{Ref}$
    - $tTxSig_{Ref}$
4. Call “*Procedure X.vi*”, with the string “if.int2”.
5. During Self Cal query the “RxSig “and “TxSig” temperature sensors. Compare the respective readings with $tRxSig_{Ref}$ and $tTxSig_{Ref}$ reference temperatures.
6. If the temperatures changed more than ±2 °C from the reference temperatures, restart the procedure from section 7.4 LO and Impairments Self Cal Adjustment.

7.7. RF Receiver External Gain Adjustment

7.7.1. RF Receiver External Gain Adjustment Procedure

1. Sections **7.4 LO and Impairments Self Cal Adjustment, 7.5 RF Transmitter Output Gain Adjustment** and **7.6 Transmitter** Gain Internal Cal Procedure must have been completed successfully before proceeding.
2. Complete the connections according to **Figure 22** and **Figure 23**.
3. Open a calibration session using “*Initialize External Calibration 2.vi*” with:
    - “*initialize RFSA*” input Boolean - False
4. Call “*RF Input Gain Cal Initialize.vi*”.
    - Port: “if.0”
5. Configure the Power Sensor for the following settings:
    - Measurement Mode: Continuous Average Mode (default)
    - Auto Averaging: Enabled (default)
    - Aperture Time: 0.001 s
    - Auto Averaging Resolution: 3 (default)
    - Auto Range Mode: Enabled (default)
6. Making the Adjustments

> Repeat, once with each Call “*RF Input Gain Cal.vi*”, starting with port “if.0” value setting and sequentially increment to “if.6”.

Repeat until the "*Calibration Complete Boolean output*" of the "*Input Gain Cal Adjust.vi*" or the error wire becomes "TRUE".

1. Call "*RF Input Gain Cal Configure.vi*"
2. Obtain the "Frequency to measure" output from "*RF Input Gain Cal Configure.vi*", name it "f_0".
3. Obtain the "Power to generate" output from "*RF Input Gain Cal Configure.vi*", name it "P_0".
4. Use the Frequency to measure "f_0" and Power to generate "P_0" to configure the external power sensor and generator.
5. The Power to generate is the desired power at the DUT port, use the values obtained in section **5.1 Receiver Fixture Characterization** to adjust the generator power.
6. Take a measurement with the Power sensor.
7. Adjust the Power Sensor reading based on the values from section **5.1 Receiver Fixture Characterization** to obtained the corrected power measurement at the DUT port.
8. Return corrected Power Sensor reading to "*RF Input Gain Cal Adjust.vi*".

1. Call "*RF Input Gain Cal Finalize.vi*".

2. Call "*Close External Calibration.vi*" with:

    - Input "write calibration to hardware?" - set to "True.6"

3. Query the "RxSig "and "TxSig" temperature sensors. Compare the respective readings with $tRxSig_{Ref}$ and $tTxSig_{Ref}$ reference temperatures. If the temperatures changed more than ±2 °C from the reference temperatures, the procedure should be restarted.

4. Open a calibration session using "*Initialize External Calibration 2.vi*" with:

    - "*initialize RFSA*" input Boolean - False

5. Call “*Input Gain Cal Initialize 2.vi*”.
    - Port: “if.x”, where “x” is the next sequential number up to 6.

7.8. Receiver Gain Internal Cal Procedure

1. Complete the connections according to **Figure 22**
2. Complete the connections according to **Figure 23**
3. Query the “RxSig “and “TxSig” temperature sensors, save the readings respectively as:
    - $tRxSig_{Ref}$
    - $tTxSig_{Ref}$
4. Call “*X.vi*”, with the string “if.int1”.
5. During Self Cal query the “RxSig “and “TxSig” temperature sensors. Compare the respective readings with $tRxSig_{Ref}$ and $tTxSig_{Ref}$ reference temperatures.
6. If the temperatures changed more than ±2 °C from the reference temperatures, restart the procedure from section 7.4 LO and Impairments Self Cal Adjustment.

7.9. External Cal Date update

1. Save the current time as the time at which external adjust was completed. No external connections are required.
2. Call “*X.vi*”, with the string “if.stampExt”.

7.10. Internal Self Cal

1. Final step of adjustment is to run self cal to ensure it can be run successfully. No external connections are required.
2. Call “*X.vi*”, with the string “selfCal2”.

8. Perform Reverification

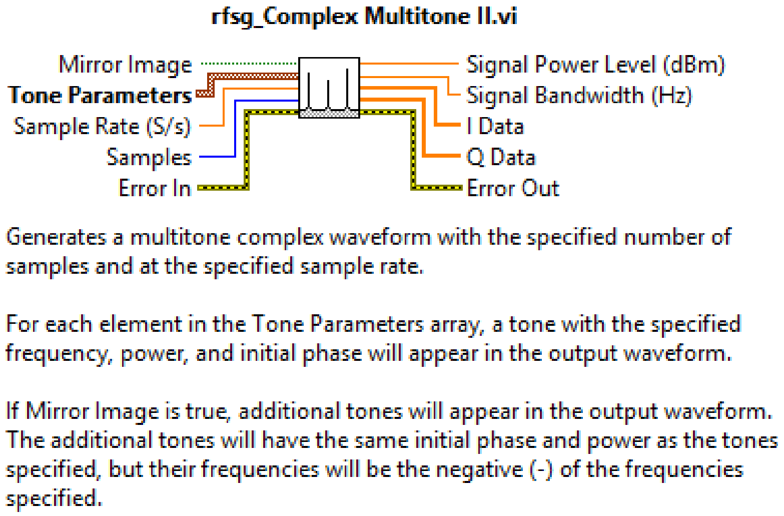
Perform all tests in the Verification section after completing Adjustment. This verification compares the As-Left limits with measurement data collected after the DUT adjustment. The As-Left limits may be tighter than the As-Found limits.

9. Programming Appendix

9.1. Generating an IQ Signal

When generating an RF Signal using the DUT in IQ mode, use the rfsg_Complex Multitone II.vi in conjunction with niRFSG Write Arb Waveform (I-Q).vi.

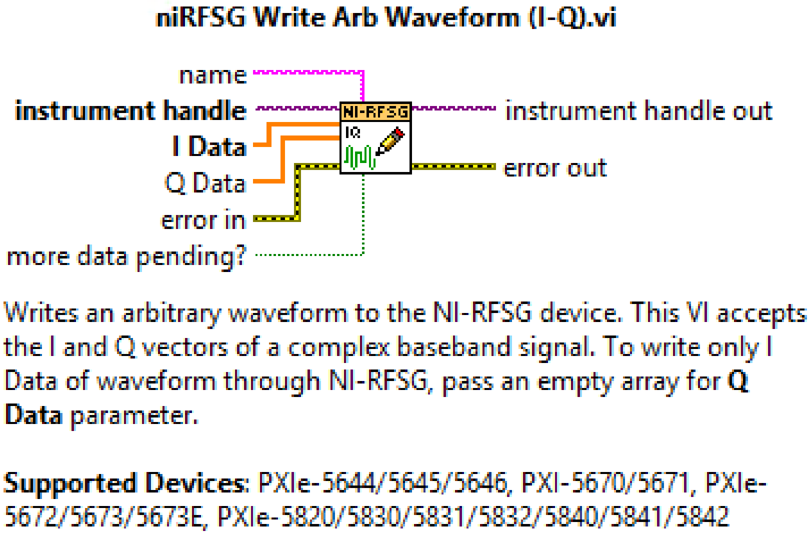
The rfsg_Complex Multitone II.vi can be found here:
…`\<LabVIEW>\instr.lib\niRFSG\niRFSGExamplesSupport.llb\rfsg_Complex Multitone II.vi`



Generates a multitone complex waveform with the specified number of samples and at the specified sample rate.

For each element in the Tone Parameters array, a tone with the specified frequency, power, and initial phase will appear in the output waveform.

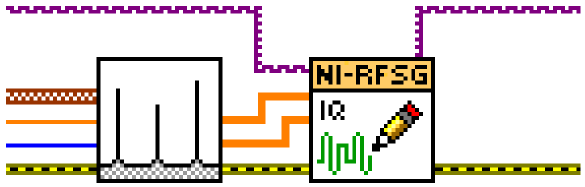
If Mirror Image is true, additional tones will appear in the output waveform. The additional tones will have the same initial phase and power as the tones specified, but their frequencies will be the negative (-) of the frequencies specified.



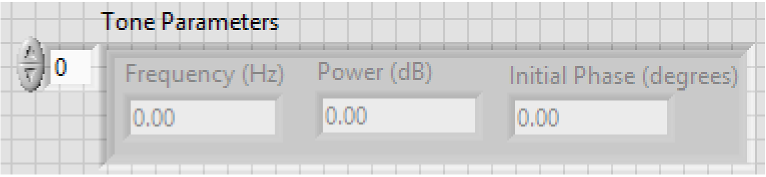
niRFSG Write Arb Waveform (I-Q).vi

Writes an arbitrary waveform to the NI-RFSG device. This VI accepts the I and Q vectors of a complex baseband signal. To write only I Data of waveform through NI-RFSG, pass an empty array for **Q Data** parameter.

Supported Devices: PXIe-5644/5645/5646, PXI-5670/5671, PXIe-5672/5673/5673E, PXIe-5820/5830/5831/5832/5840/5841/5842



The Tone Parameters input to rfsg_Complex Multitone II.vi is an array of clusters. Each element of the array (a cluster) refers to a tone in your waveform. This allows you to generate IQ data that represents multiple tones. You would need to specify the Frequency Offset of the Tone, the Relative Power of the Tone, and the initial phase; throughout the document these may be referred to as “Tone Frequency”, “Tone Power”, and “Tone Phase” respectively. For most test cases, there will only be 1 element for the Tone Parameters input. This represents only a single tone generation. The exception to this is when multiple tones need to be generated in the RF Output Third Order Interpolation verification test.



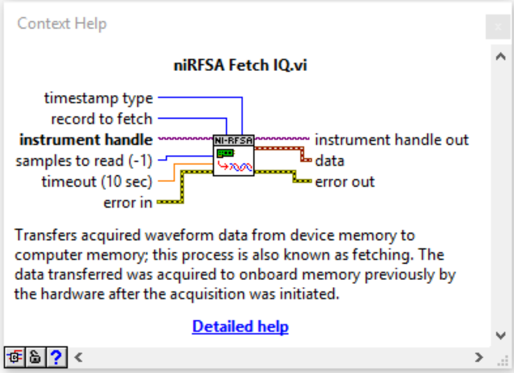
Tone Parameters

0

Frequency (Hz): 0.00
Power (dB): 0.00
Initial Phase (degrees): 0.00

9.2. Acquiring a Spectrum from IQ Data and Measuring the Peak

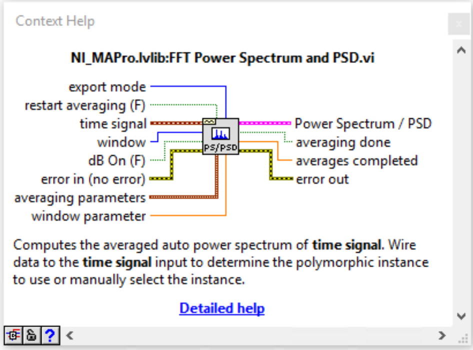
1. When acquiring an RF Signal using the DUT in IQ mode, use the FFT Power Spectrum and PSD.vi in conjunction with niRFSA Fetch IQ.vi



niRFSA Fetch IQ.vi

Transfers acquired waveform data from device memory to computer memory; this process is also known as fetching. The data transferred was acquired to onboard memory previously by the hardware after the acquisition was initiated.

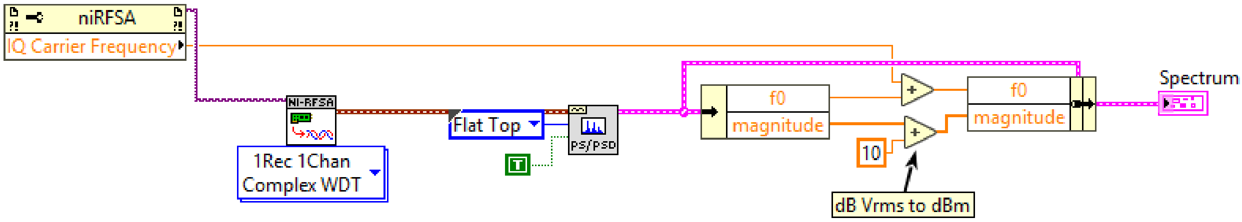
Detailed help



NI_MAPro.lvlib:FFT Power Spectrum and PSD.vi

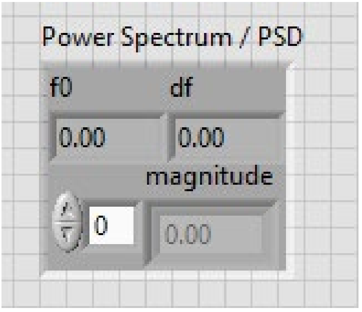
Computes the averaged auto power spectrum of **time signal**. Wire data to the **time signal** input to determine the polymorphic instance to use or manually select the instance.

Detailed help



2. The FFT Power Spectrum and PSD.vi is a part of the NI_MAPro.lvlib which can be found here:

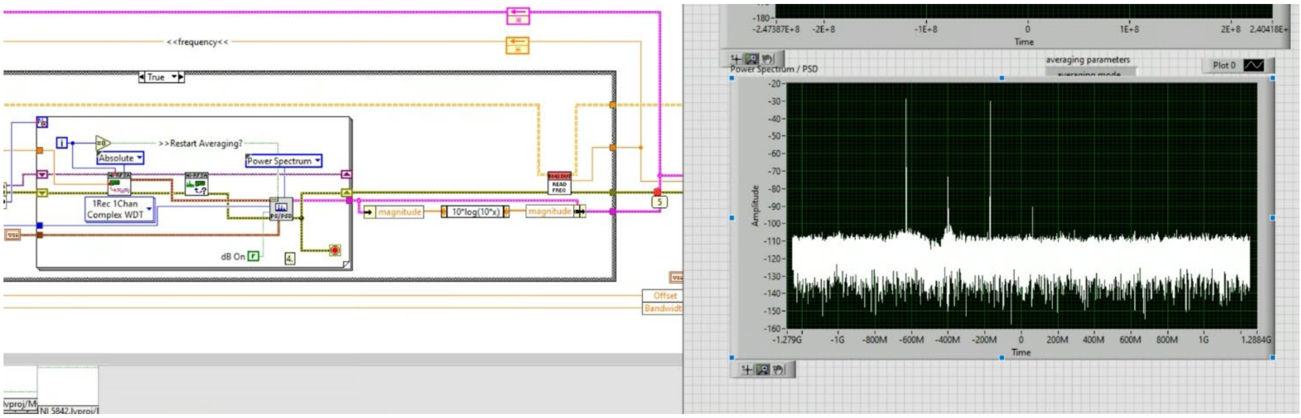
```
C:\Program Files\National Instruments\LabVIEW
2020\vi.lib\measure\NI_MAPro.lvlib
```



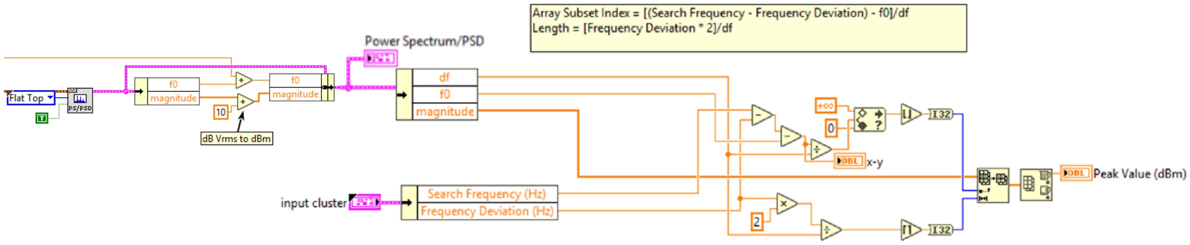
3. Create a subarray of the Magnitude array around the frequency of interest. Adjust the magnitude to convert from dBV to dBm.

   Example

   There are additional considerations for band 1, Setting 400 MHz as the IQCF and generating a tone at 240Mhz gives this result:

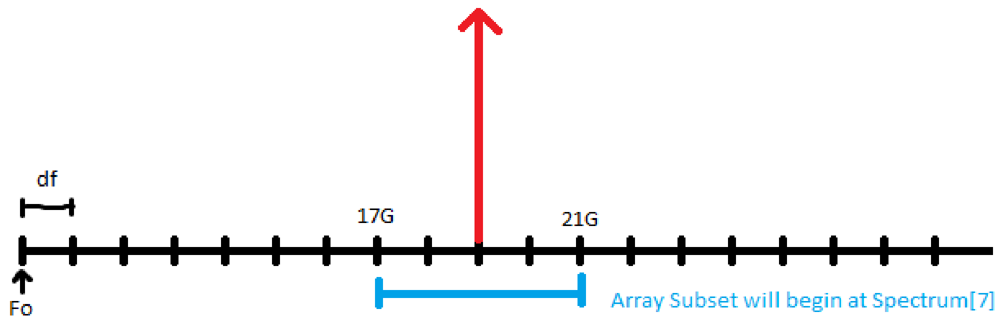


4. 0 offset/Time on the X-axis in this case is 400Mhz. The tone at -400M is baseband and tone below that is an artifact of direct sampling in band 1. Everything below -400 MHz should be ignored. The tone around -160 MHz offset is the 240 MHz signal generator tone and that is the one we should be measuring.
5. Alternatively, you can look at the subset of the array:



Array Subset Index = [(Search Frequency - Frequency Deviation) - f0]/df
Length = [Frequency Deviation * 2]/df

6. Illustrated example:



Array Subset will begin at Spectrum[7] and have length 4

Spectrum[] has the
following properties:
Fo = 10G
df = 1G

With the following search parameters, find Array Subset
Search Frequency = 19G
Frequency Deviation 2G
Array Subset Index = [(Search Frequency - Frequency Deviation) - f0]/df
= [(19G - 2G) - 10G]/1G
= (17G - 10G)/1G
= 7
Length = [Frequency Deviation * 2]/df
= 4G/1G
= 4

10. Power Meter Aperture Configuration

Table 50: Power Meter Aperture Configuration

Power Level [dBm]	Aperture [s]
-45	0.68
-40 to -35	0.013
-30 to -25	132E-6
-20	10E-6
-15 to +5	25E-6
10 to <20	24E-6
≥20	10E-6

11. Revision History

Revision	Section	Changes
37xxxxA-01 November 2023	All	This is the initial release version of the PXIe-5842 Calibration Procedure.

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379017A-01 May 2024