Computer-Based Instruments

PXI-5660
RF Signal Analyzer
User Manual

Worldwide Technical Support and Product Information

`ni.com`

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Compliance

FCC/Canada Radio Frequency Interference Compliance*
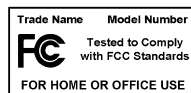
Determining FCC Class

The Federal Communications Commission (FCC) has rules to protect wireless communications from interference. The FCC places digital electronics into two classes. These classes are known as Class A (for use in industrial-commercial locations only) or Class B (for use in residential or commercial locations). Depending on where it is operated, this product could be subject to restrictions in the FCC rules. (In Canada, the Department of Communications (DOC), of Industry Canada, regulates wireless interference in much the same way.)

Digital electronics emit weak signals during normal operation that can affect radio, television, or other wireless products. By examining the product you purchased, you can determine the FCC Class and therefore which of the two FCC/DOC Warnings apply in the following sections. (Some products may not be labeled at all for FCC; if so, the reader should then assume these are Class A devices.)

FCC Class A products only display a simple warning statement of one paragraph in length regarding interference and undesired operation. Most of our products are FCC Class A. The FCC rules have restrictions regarding the locations where FCC Class A products can be operated.

FCC Class B products display either a FCC ID code, starting with the letters **EXN**, or the FCC Class B compliance mark that appears as shown here on the right.

Consult the FCC Web site at `http://www.fcc.gov` for more information.

Trade Name	Model Number
F_C	Tested to Comply with FCC Standards
FOR HOME OR OFFICE USE	

FCC/DOC Warnings

This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual and the CE Mark Declaration of Conformity**, may cause interference to radio and television reception. Classification requirements are the same for the Federal Communications Commission (FCC) and the Canadian Department of Communications (DOC).

Changes or modifications not expressly approved by National Instruments could void the user's authority to operate the equipment under the FCC Rules.

Class A
Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Canadian Department of Communications

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

Class B
Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

• Reorient or relocate the receiving antenna.
• Increase the separation between the equipment and receiver.
• Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
• Consult the dealer or an experienced radio/TV technician for help.

Canadian Department of Communications

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe B respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

Compliance to EU Directives

Readers in the European Union (EU) must refer to the Manufacturer's Declaration of Conformity (DoC) for information** pertaining to the CE Mark compliance scheme. The Manufacturer includes a DoC for most every hardware product except for those bought for OEMs, if also available from an original manufacturer that also markets in the EU, or where compliance is not required as for electrically benign apparatus or cables.

To obtain the DoC for this product, click **Declaration of Conformity** at `ni.com/hardref.nsf/`. This Web site lists the DoCs by product family. Select the appropriate product family, followed by your product, and a link to the DoC appears in Adobe Acrobat format. Click the Acrobat icon to download or read the DoC.

*   Certain exemptions may apply in the USA, see FCC Rules §15.103 **Exempted devices**, and §15.105(c). Also available in sections of CFR 47.

**   The CE Mark Declaration of Conformity will contain important supplementary information and instructions for the user or installer.

Conventions

The following conventions are used in this guide:

< >	Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, DBIO<3..0>.
»	The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.
	This icon denotes a tip, which alerts you to advisory information.
	This icon denotes a note, which alerts you to important information.
ADC	Analog-to-Digital Converter—an electronic device, often an integrated circuit, that converts an analog voltage to digital data
bold	Bold text denotes items that you must select or click on in the software, such as menu items and dialog box options.
coupling	The manner in which a signal is connected from one location to another. AC coupling removes the DC component from a signal.
dBc	Decibels (dB) relative to carrier signal frequency
downconverter	The PXI-5600 RF downconverter module. A downconverter "zooms in" on a narrow frequency component of a signal and shifts it to center around a lower frequency, 15 MHz in the case of the PXI-5600.
IF	Intermediate Frequency—The intermediate signal to which an RF signal is converted in order to be demodulated, displayed, or processed. For instance, the PXI-5600 downconverter will convert RF signals to a 15 MHz IF signal that can be digitized.
italic	Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.

`monospace`	Text in this font denotes text or characters that you should enter from the keyboard, programming examples, and syntax examples. This font is also used for paths, directories, programs, subprograms, subroutines, device names, functions, filenames and extensions.
resolution bandwidth	Resolution bandwidth determines how closely spaced in frequency two signals of equal amplitude can be and still be distinguishable from each other. When measuring a frequency spectrum, decreasing the resolution bandwidth results in finer frequency resolution and increasing the resolution bandwidth results in coarser frequency resolution.
RF	Radio Frequency—Though there is no precise definition, the term is often used for frequencies from tens of megahertz to several gigahertz.
RFSA	RF Signal Analyzer—In this document, RFSA refers to the PXI-5660, which consists of a PXI-5600 RF downconverter module and a PXI-5620 frequency-domain digitizer module.

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Set Up and Configuration

Required Equipment

To set up and use the National Instruments PXI-5660 RF Signal Analyzer (RFSA), you need the following items:

❑ Both PXI-5660 RFSA modules:

– PXI-5600 9 kHz to 2.7 GHz wideband RF downconverter module

– PXI-5620 14-bit, 64 MS/s frequency-domain digitizer module

❑ RF Signal Analyzer CD containing the NI-SCOPE and NI-TUNER drivers

❑ NI Spectral Measurements Toolset (SMT) CD

❑ Cables and accessories:

– Two rigid coaxial cables

– One semi-rigid coaxial cable

– Two "finger-saver" cable wrenches

Related Documentation

In addition to this manual, you may find the following documents helpful:

• The *NI-TUNER Reference Help File* contains function and VI reference information for LabVIEW, LabWindows/CVI, and C programers. The help file is installed at **Start»Programs» National Instruments»RF Signal Analyzer»Documentation» Low Level»NI-TUNER Reference Help**.

• The online *Spectral Measurements Toolset User Guide* contains information on configuring and using the SMT with your PXI-5660 RF Signal Analyzer. It is located at **Start»Programs»National Instruments»RF Signal Analyzer»Documentation»Spectral Measurements Toolset User Guide.pdf**.

• The *NI-SCOPE Function Reference Help* file provides detailed explanations of NI-SCOPE functions, attributes, and parameters for

LabWindows/CVI, C, and Visual Basic programmers. The help file is located at **Start»Programs»National Instruments»RF Signal Analyzer»Documentation»Low Level»NI-SCOPE Function Reference Help**.

- The *NI-SCOPE VI Reference Help* file provides detailed explanations of NI-SCOPE VIs, properties, and parameters for LabVIEW. The help file is located at **Start»Programs»National Instruments»RF Signal Analyzer»Documentation»Low Level»NI-SCOPE VI Reference Help**.

- The printed *PXI-5620 Digitizer User Manual* is packaged with your PXI-5620 digitizer module.

Unpacking

Both modules of the PXI-5660 RF Signal Analyzer ship in antistatic packages to prevent electrostatic damage. Electrostatic discharge can damage several components of the RFSA.

To protect yourself and your device, take *all* of the following precautions when unpacking the two RFSA modules:

- Ground yourself by touching a grounded object.

- Touch the antistatic package to a metal part of the PXI chassis before removing the module from the package.

- Remove each module from the package and inspect it for loose components or any other sign of damage. Notify NI if any component of the RFSA appears damaged in any way. Do *not* install damaged hardware.

- *Never* touch the exposed connector pins.

- Store both RFSA modules in the antistatic envelopes when not in use.

Safety Information

The following section contains important safety information that you must follow when installing and using the product.

Do *not* operate the product in a manner not specified in this document. Misuse of the product can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to National Instruments for repair.

Do *not* substitute parts or modify the product except as described in this document. Use the product only with the chassis, modules, accessories, and cables specified in the installation instructions. You *must* have all covers and filler panels installed during operation of the product.

Do *not* operate the product in an explosive atmosphere or where there may be flammable gases or fumes. Operate the product only at or below the pollution degree stated in the *Specifications for the PXI-5660 RF Signal Analyzer Note to Users*. Pollution is foreign matter in a solid, liquid, or gaseous state that can reduce dielectric strength or surface resistivity. The following is a description of pollution degrees:

• Pollution degree 1 means no pollution or only dry, nonconductive pollution occurs. The pollution has no influence.

• Pollution degree 2 means that only nonconductive pollution occurs in most cases. Occasionally, however, a temporary conductivity caused by condensation must be expected.

• Pollution degree 3 means that conductive pollution occurs, or dry, nonconductive pollution occurs that becomes conductive due to condensation.

Clean the product with a soft nonmetallic brush. Make sure that the product is completely dry and free from contaminants before returning it to service.

You *must* insulate signal connections for the maximum voltage for which the product is rated. Do *not* exceed the maximum ratings for the product. Remove power from signal lines before connecting them to or disconnecting them from the product.

Operate this product only at or below the installation category stated in the *Specifications for the PXI-5660 RF Signal Analyzer Note to Users*.

The following is a description of installation categories:

• Installation category I is for measurements performed on circuits not directly connected to MAINS[1]. This category is a signal level such as voltages on a printed wire board (PWB) on the secondary of an isolation transformer.

    Examples of installation category I are measurements on circuits not derived from MAINS and specially protected (internal) MAINS-derived circuits.

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[1] MAINS is defined as the electricity supply system to which the equipment concerned is designed to be connected either for powering the equipment or for measurement purposes.
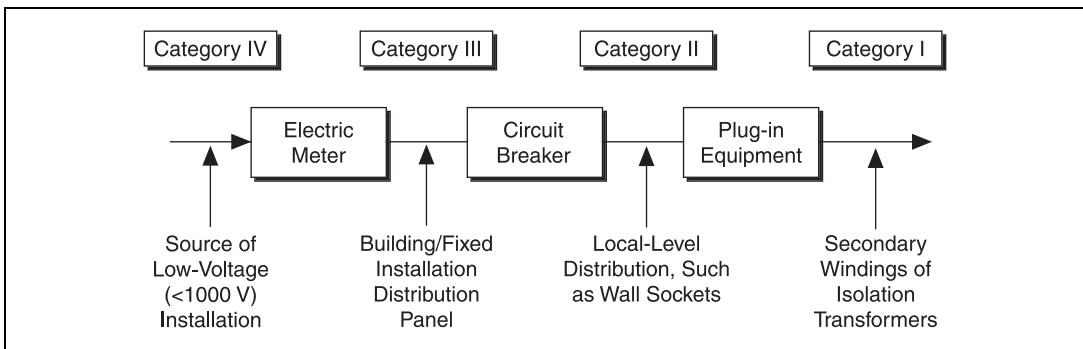
- Installation category II is for measurements performed on circuits directly connected to the low-voltage installation. This category refers to local-level distribution such as that provided by a standard wall outlet.

  Examples of installation category II are measurements on household appliances, portable tools, and similar equipment.

- Installation category III is for measurements performed in the building installation. This category is a distribution level referring to hardwired equipment that does not rely on standard building insulation.

  Examples of installation category III include measurements on distribution circuits and circuit breakers. Other examples of installation category III are wiring including cables, bus-bars, junction boxes, switches, socket outlets in the building/fixed installation, and equipment for industrial use, such as stationary motors with a permanent connection to the building/fixed installation.

- Installation category IV is for measurements performed at the source of the low-voltage (<1,000 V) installation.

Examples of category IV are electric meters and measurements on primary overcurrent protection devices and ripple-control units. Below is a diagram of a sample installation.

```
  Category IV          Category III          Category II          Category I

              ┌──────────┐         ┌──────────┐        ┌──────────┐
       ──────>│ Electric │─────────│ Circuit  │────────│ Plug-in  │─────>
          ▲   │  Meter   │    ▲    │ Breaker  │   ▲    │Equipment │   ▲
          │   └──────────┘    │    └──────────┘   │    └──────────┘   │
          │                   │                   │                   │
     Source of          Building/Fixed       Local-Level         Secondary
     Low-Voltage        Installation         Distribution, Such  Windings of
     (<1000 V)          Distribution         as Wall Sockets     Isolation
     Installation       Panel                                    Transformers
```

Installation

The PXI-5660 RF Signal Analyzer consists of the following hardware modules and software components:

❑ NI-SCOPE and NI-TUNER drivers, contained on the included *RF Signal Analyzer* software CD

❑ NI Spectral Measurements Toolset CD

❑ PXI-5600 wideband RF downconverter module

❑ PXI-5620 RF digitizer module

Note You *must* install the included software before installing your hardware.

The NI-SCOPE and NI-TUNER drivers run the RFSA hardware modules and acquire data. The Spectral Measurements Toolset (SMT) provides versatile spectral measurement and analysis functionality as well as example programs. The relationship between the PXI-5660 RF Signal Analyzer components is illustrated in Figure 1-1.
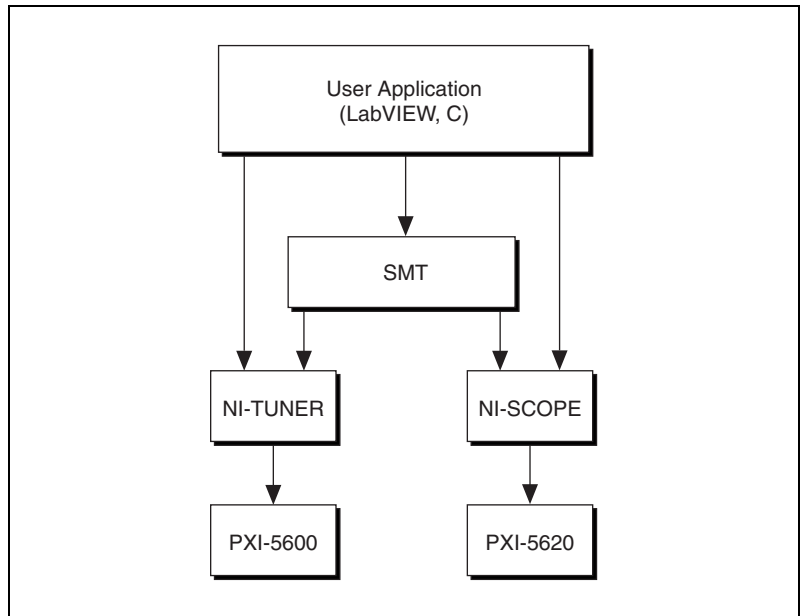

Figure 1-1. Programming Flow

Software Installation

Complete the following steps to install the included RF Signal Analyzer software:

1. Insert the RF Signal Analyzer software CD. The installation program begins automatically. If it does not, navigate to your CD drive and double-click **Setup.exe** to begin installing the RFSA drivers.

2. Select one of the following installation options:

   - Typical—this option installs required software components not present on your system and updates past installations of NI software to work with the PXI-5660 RF Signal Analyzer.

   - Complete—this option installs all RF Signal Analyzer software components and overwrites old installations. Use this option for highest performance or if you are unsure of which software components you need.

   - Custom—this option prompts you before installing each individual software component.

3. When prompted by the installation program, insert the Spectral Measurements Toolset CD and click **Next** to resume installation.

Hardware Installation

Note You *must* install the included software before installing the hardware.

1. Power off the PXI chassis.

2. Install your PXI-5600 RF downconverter module as shown in Figure 1-2.

   a. Remove the black plastic protectors from the six screws in the downconverter module front panel.

   b. Slide the RF downconverter module into an available PXI slot until the ejector handle locks in the upward position.

   c. Tighten the six screws on the RF downconverter module front panel.

Note The PXI-5600 RF downconverter module 10 MHz internal reference clock can drive the PXI backplane clock *only* if installed in slot 2. The RF downconverter module can receive the PXI backplane clock in any slot.
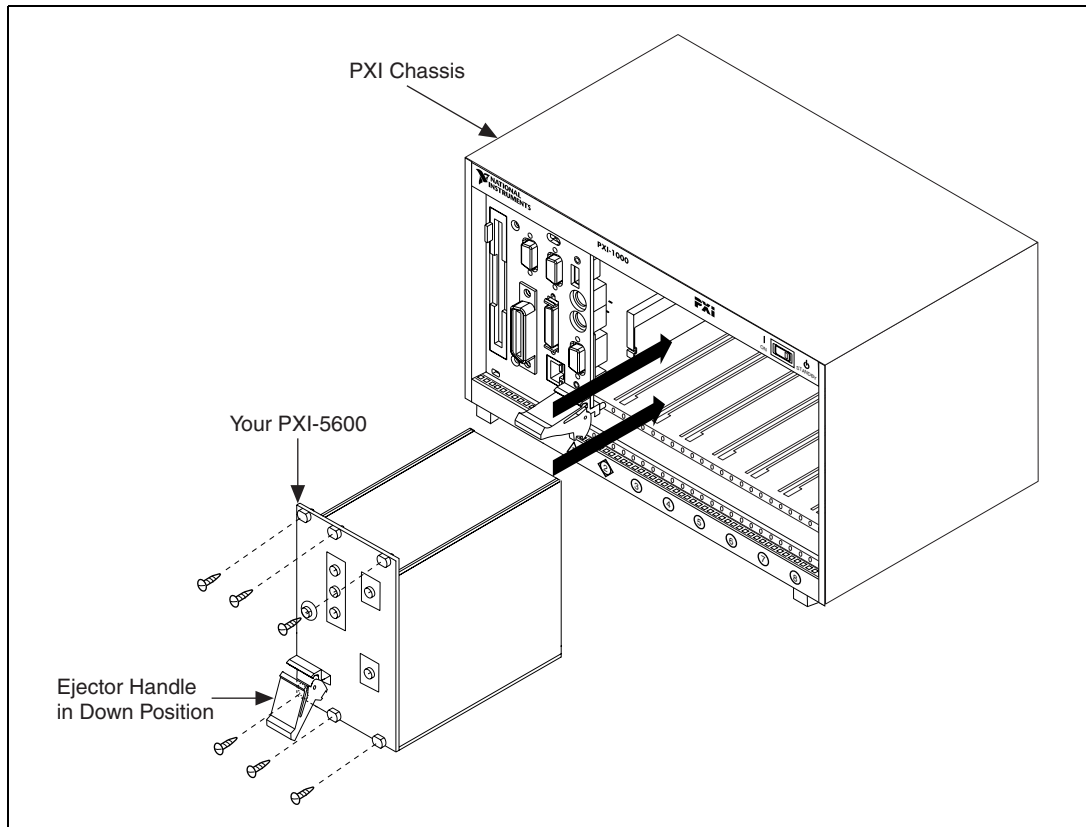
Figure 1-2. PXI-5600 RF Downconverter Module Installation

3. Install the PXI-5620 frequency-domain digitizer module as shown in Figure 1-3.

   a. Remove the black plastic protectors from the two screws in the digitizer module front panel.

   b. Slide the digitizer module into the slot immediately right of the PXI-5600 downconverter. Press firmly until the ejector handle locks in the upward position.

Note   To use the included rigid coaxial cables, you must install the PXI-5620 digitizer module in the PXI slot immediately to the right of the PXI-5600 downconverter module.

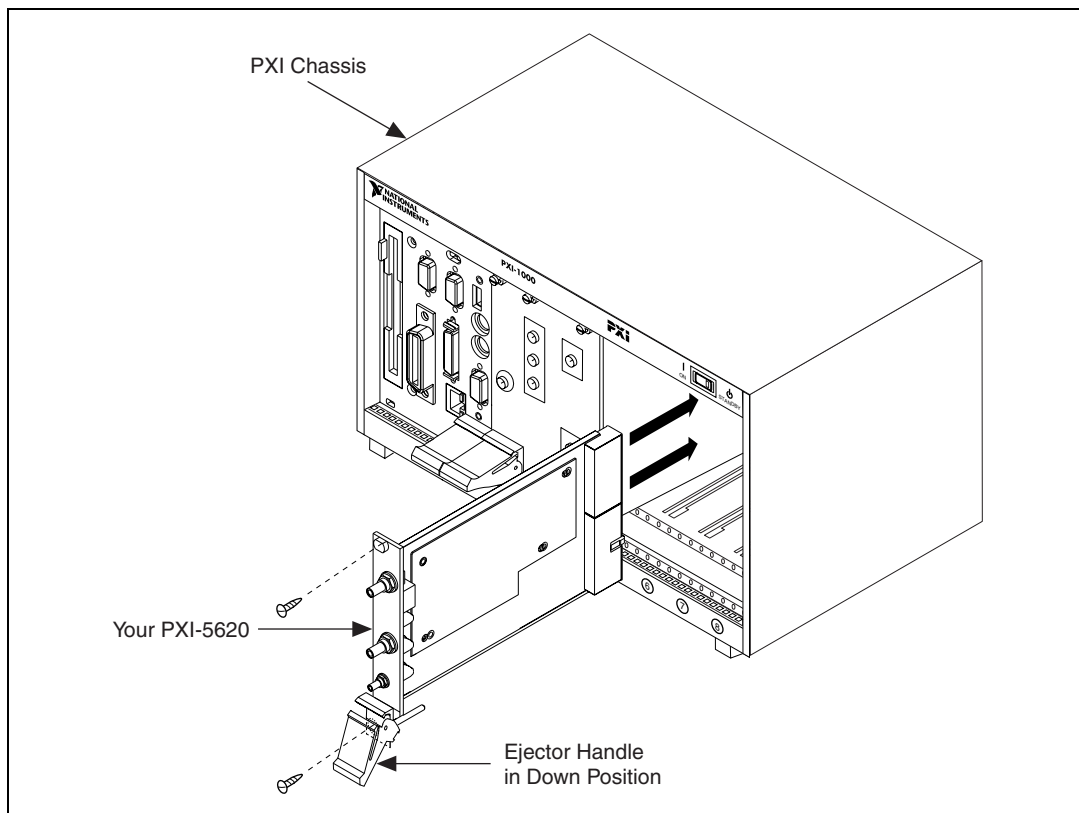c. Tighten the two screws on the frequency-domain digitizer module front panel.

Figure 1-3. PXI-5620 Frequency-Domain Digitizer Module Installation

The RFSA Front Panels

The front panel of the RFSA contains two LEDs and nine connectors. The upper LED is activated when the PXI-5600 downconverter module is powered on. The lower LED indicates when the downconverter module internal oscillators are phase-locked. Refer to Table 1-1 for explanations of the connectors and their uses.

All inputs and outputs are AC coupled.

Table 1-1. PXI-5660 RF Signal Analyzer Front Panel Connectors

Front Panel	Connector	Use
PXI-5600 RF downconverter module	INPUT	Attachment for the analog input signal measured by the RFSA.
	OUTPUT	Output for the frequency-translated signal.
	FREQ REF IN	Input for an external frequency reference signal to which the RFSA can lock.
	10 MHz OUT	Both connectors output identical 180° out-of-phase replications of the downconverter frequency reference signal, useful for driving other devices.
	10 MHz OUT	
	PXI 10 MHz I/O	Bidirectional connection to the PXI 10 MHz backplane clock. (This connector can input to the backplane *only* if the PXI-5600 downconverter module is installed in slot 2.) Refer to Table 1-2 for more information.
PXI-5620 frequency-domain digitizer module	INPUT	Attachment for the frequency-translated signal from the PXI-5600 downconverter module OUTPUT connector.
	REF CLK IN	Input for a 50 Ω, 10 MHz reference clock from the PXI-5600 downconverter module or another source. Normally connected to the PXI-5600 downconverter 10 MHz OUT connector.
	PFI 1	Attachment for external digital triggers.

The PXI-5600 Internal Timebase and the PXI Backplane Clock

The internal 10 MHz timebase of the PXI-5600 downconverter module is the most accurate and stable NI offers, equivalent to standalone frequency reference products. For this reason, you may wish to use the PXI-5600 10 MHz internal reference as a timebase for other devices.

The PXI-5600 reference signal can be passed to other devices via the PXI 10 MHz backplane or through the PXI-5600 10 MHz I/O front panel coaxial connectors. While the PXI backplane offers less than 1 ns skew between slots, connections via the front panel 10 MHz I/O coaxial connections are more precise.

Tip   For best results, drive the PXI-5600 internal reference signal to other devices via the PXI 10 MHz I/O coaxial connections on the downconverter module front panel.

Interconnecting

For maximum versatility, the RFSA modules interconnect through the front panels. Use the included coaxial cables to connect the modules as shown in Figure 1-4.

Complete the following steps to interconnect the RFSA modules:

Note   Install the cables so that they bend upward as in Figure 1-4.

1. Connect the short rigid cable between the PXI-5600 downconverter module OUTPUT connector and the INPUT connector of the PXI-5620 digitizer module.

2. Connect the long rigid cable between either of the PXI-5600 downconverter module reference outputs (10 MHz OUT) and the PXI-5620 digitizer module reference clock input (REF CLK IN).

3. If you wish to drive or lock to the PXI backplane with the highly precise PXI-5600 internal reference (optional), connect the short semi-rigid cable between the other 10 MHz OUT connector and the PXI 10 MHz I/O connector on the PXI-5600 downconverter module front panel. Refer to Table 1-2 for more information about timing configurations and front panel connections.
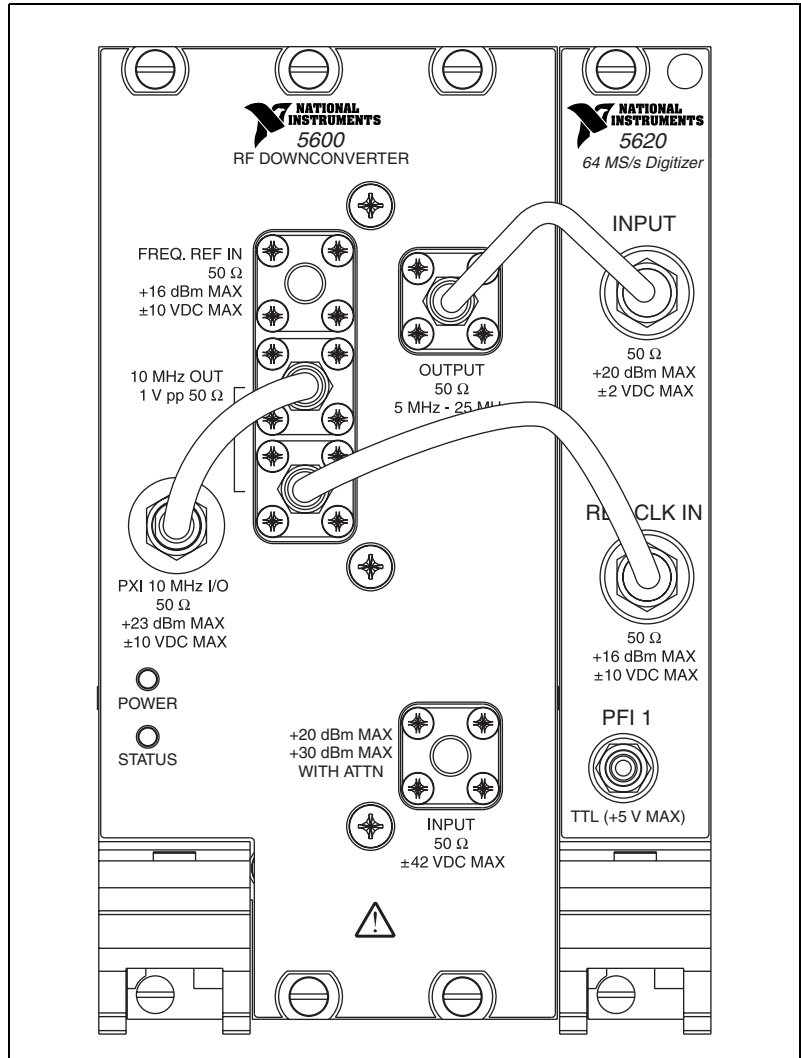
Figure 1-4. Front Panel Connections

4. Connect the bidirectional PXI 10 MHz I/O connector on the PXI-5600 downconverter module front panel according to your desired timing configuration. Refer to Table 1-2 for more information.

Table 1-2. Timing Reference Configurations and the PXI 10 MHz I/O Connector

Timing Configuration	PXI-5600 PXI Installation Slot	Connections
RFSA independent, PXI backplane independent—the default configuration in NI-TUNER software.	any slot	No connections to PXI 10 MHz I/O
RFSA driving PXI backplane (shown in Figure 1-4)	*only* slot 2	10 MHz OUT to PXI 10 MHz I/O**
RFSA locked to PXI backplane*	any slot *except* 2	PXI 10 MHz I/O** to FREQ REF IN
RFSA and PXI backplane locked to external reference	slot 2	External signal to FREQ REF IN; 10 MHz OUT to PXI 10 MHz I/O**
RFSA locked to external reference, PXI backplane independent	any slot	External signal to FREQ REF IN
RFSA independent, PXI backplane driven by external reference	slot 2	External signal to PXI 10 MHz I/O**

* Use this configuration only when driving the PXI backplane with a high-precision reference (such as a PXI-6608 or another PXI-5600 downconverter module) installed in slot 2.

** Because the NI-TUNER default configuration does not use the PXI 10 MHz I/O connector, you must properly configure your software to use this connection. For more information, refer to the *NI-TUNER Reference Help* file, located at **Start»Programs»National Instruments»RF Signal Analyzer»Documentation**.

5. Power on your PXI chassis if you have not done so.

Note To operate the PXI-5620 frequency-domain digitizer module and the PXI-5600 RF downconverter module as separate units, remove the relevant front panel connections. However, you may wish to lock the digitizer module to the downconverter module or other references when acquiring data.

Configuring the Hardware Modules in MAX

Launch Measurement & Automation Explorer (MAX) by double-clicking the desktop icon or by selecting **Start»Programs»National Instruments» Measurement & Automation**.

1. MAX automatically detects new installed devices. Double-click **Devices and Interfaces** to see a list of recognized devices. If the PXI-5620 digitizer module and the PXI-5600 downconverter module do not automatically appear, refresh the list by pressing <F5>.

2. Right-click the PXI-5620 digitizer module and select **Properties** from the drop-down menu to launch the Configuring Devices window. Make note of the device number and system resources assigned to the PXI-5620 digitizer module. You need this number to program your device.

3. In the Configuring Devices window, click **Test Resources**. A dialog box appears and indicates if the digitizer module has passed.

4. Right-click the PXI-5600 downconverter module and select **Properties** from the drop-down menu to launch the Configuring Devices window. Make note of the device number and system resources assigned to the PXI-5600 RF downconverter module. You need this number to program your device.

5. In the Configuring Devices window, click **Test Resources**. A dialog box appears and indicates if the downconverter module has passed.

Note If either module does not pass, power off your PXI chassis, remove both RFSA hardware modules and repeat the installation procedure. If either module still does not pass the test, call NI or visit ni.com/support.

6. Connect a test signal to the INPUT connector on the PXI-5620 digitizer module front panel. Click **Run Test Panels** to run the functional test panel for the PXI-5620. The PXI-5600 downconverter has no test panel.

Note If the PXI-5620 digitizer module cannot run the functional test, call NI or visit ni.com/support.

7. Click **Close** when you finish testing the RFSA modules. Click **OK** from the Configuring Devices window to return to the MAX main window.

8. Select **File»Exit** to exit MAX.

Spectral Measurements Toolset Basics

The NI Spectral Measurements Toolset (SMT) is the measurement and analysis software for your PXI-5660 RF Signal Analyzer. This software package allows easy configuration of spectral measurements and supports a variety of operations, including:

- Configuration functions that abstract hardware settings and return an acquisition size based on your spectrum settings of center frequency, span, and resolution bandwidth

- 3D spectrogram display of joint-time and frequency-domain data and export of filtered time-domain data

- Zoom FFT processing, which computes the FFT only within a frequency range you specify; block zoom, which performs the FFT on a discrete block of data; and continuous zoom, which performs the FFT in real-time on incoming data, are available

- Power in band, adjacent channel power, and occupied bandwidth functions suitable for communications-oriented measurements

- Spectrum averaging, including rms, vector, and peak hold averaging, with linear and exponential weighting

- Unit conversion for typical RF units such as V^2_{rms}, dB, dBm, and dBm/Hz, allowing you to easily convert a raw FFT spectrum to a power spectrum or power spectral density for noise measurements

- Spectrum peak frequency and amplitude measurement

Refer to the *Spectral Measurements Toolset User Guide* for more information on using the SMT by selecting **Start»Programs» National Instruments»RF Signal Analyzer»Documentation**.

2

Making Basic Measurements

This chapter introduces some basic RFSA measurements, including frequency and amplitude, channel power, harmonics, and signal resolution. The interactive RF Signal Analyzer Example VI demonstrates these measurement capabilities of the RFSA. The RF Signal Analyzer Example VI is located at **Start»Programs»National Instruments»RF Signal Analyzer»RF Signal Analyzer Example VI**. When the VI is running, press **<Ctrl-H>** to view information about the controls.

$\bigcirc$ **Tip** The included SMT RBW Tutorial VI can be used to find an appropriate resolution bandwidth (RBW) setting given the frequency and amplitude differences between two tones you are trying to resolve. The SMT RBW Tutorial VI is installed in the SMT Simulated Examples folder located at **Start»Programs»National Instruments» RF Signal Analyzer»LabVIEW Examples»Low Level»Spectral Measurements Toolset**.

$\boxed{\swarrow}$ **Note** Make sure that both modules of the RF Signal Analyzer are interconnected as shown in Figure 1-4, *Front Panel Connections*, before performing the measurements in this chapter.

Measuring Frequency and Amplitude

For this example, use the downconverter module reference from one of the 10 MHz OUT connectors as the source signal. Complete the following steps to perform a frequency and amplitude measurement using the RF Signal Analyzer Example VI:

1. In the PXI-5600 downconverter module front panel, connect one of the 10 MHz OUT reference outputs to the INPUT connector.

2. Open the RF Signal Analyzer Example VI by selecting **Start»Programs»National Instruments»RF Signal Analyzer» RF Signal Analyzer Example VI**.

3. Notice the **Hardware Settings** menu at the right bottom corner of the RF Signal Analyzer Example VI front panel. This menu consists of selectable views containing spectral information such as span and resolution bandwidth, as well as hardware information such as trigger, device numbers, and attenuation.

> 📝 **Note** Use the increment/decrement arrows to select views and change control settings.

    a. Select the **RF Settings** view of the **Hardware Settings** menu. Set the **center frequency** to 10 MHz, the **span** to 10 MHz, and the **resolution bandwidth** to 10 kHz.

    b. Select the **Amplitude** view of the **Hardware Settings** menu. Set **Ref Level (dBm)** to 10 dBm and check the **attenuation auto** box. Refer to Chapter 3, *Guidelines for Making Accurate Measurements*, for more information.

4. Run the RF Signal Analyzer Example VI by clicking the **RUN** icon on the toolbar (white arrow) or by pressing **<Ctrl-R>**. A signal appears at the center of the spectrum graph.

5. Set the averaging controls located below the spectrum graph to the following values:

   - **averaging type—rms averaging**
   - **weighting type—linear**
   - **size**—10 averages
   - **linear weighting mode—moving average**

6. In the **Units** control below the spectrum graph, select **dBm**.

7. Notice the **Measurements** menu in the upper right corner of the RF Signal Analyzer Example VI front panel. This menu consists of several views containing measurement settings and controls.

    a. Select the **Peak Search** view of the **Measurements** menu. A yellow peak threshold line appears on the spectrum graph.

    b. Click the peak threshold line and drag it below the peak value of the 10 MHz signal.

In the **Peak Search** view, the frequency displayed on the graph and its corresponding amplitude are shown in the units selected.

Resolving Two Signals Closely Spaced in Frequency

For a given portion of a displayed spectrum, the frequency resolution is a function of the resolution bandwidth. The displayed spectral shape of a pure sinusoidal waveform input is a function of the filter's spectral response. The larger the resolution bandwidth of the filter, the wider its spectral response. Using a large resolution bandwidth setting, two closely spaced signals of equal amplitude appear as one signal in the displayed spectrum. To resolve these two signals, decrease the RFSA resolution bandwidth setting.

The resolution bandwidth determines how closely spaced in frequency two signals of equal amplitude can be and still be distinguishable from each other. By default, the RFSA resolution bandwidth is the 3 dB point of the filter. If the frequency separation between two input signals is the same as the resolution bandwidth, their spectral responses intersect at 3 dB below their peaks. This intersection appears as a dip in the center of these two peaks.

Perform the following steps to resolve two closely spaced signals:

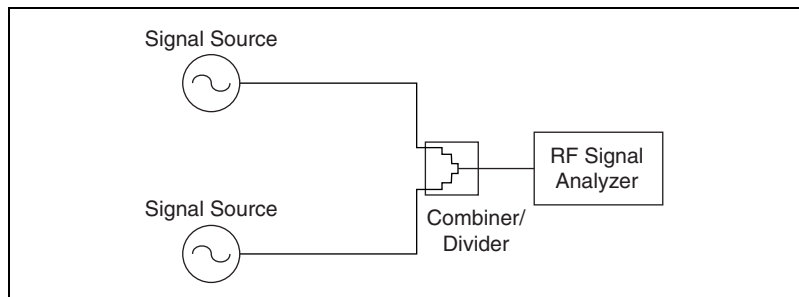1. Connect two signal sources as shown in Figure 2-1.

Figure 2-1. Closely Spaced Signal Measurement Setup

2. Connect the signal to the INPUT connector on the PXI-5600 downconverter module front panel.

3. Set the amplitudes of both sources to –20 dBm. Set their frequencies 10 kHz apart: one to 99.995 MHz and the other to 100.005 MHz.

4. Open the RF Signal Analyzer Example VI by selecting **Start»Programs»National Instruments»RF Signal Analyzer»RF Signal Analyzer Example VI**.

5. Notice the Hardware Settings menu at the right bottom corner of the RF Signal Analyzer Example VI front panel. This menu consists of selectable views containing spectral information such as span and resolution bandwidth, as well as hardware information such as timing and trigger settings, device numbers, and attenuation.

✎ **Note** Use the increment/decrement arrows to select views and change control settings.

    a. Select the **RF Settings** view of the **Hardware Settings** menu. Set the **center frequency** to 100 MHz, the **span** to 1 MHz, and the **resolution bandwidth** to 20 kHz.

    b. In the **Amplitude** view of the **Hardware Settings** menu, set the **Ref Level (dBm)** to –20 dBm and check the **attenuation auto** box. Refer to Chapter 3, *Guidelines for Making Accurate Measurements* for further explanations of these settings and their effects on measurement.

6. Run the RF Signal Analyzer Example VI by clicking the **RUN** icon (white arrow) on the toolbar or by pressing **<Ctrl-R>**. A 100 MHz signal appears on the spectrum graph.

7. Set the averaging controls located below the spectrum graph to the following values:

- **averaging type—rms averaging**
- **weighting type—linear**
- **size**—10 averages
- **linear weighting mode—moving average**

8. In the **Units** control below the spectrum graph, select **dBm**.

9. Return to the **RF Settings** view of the Hardware Settings menu and complete the following steps:

    a. Zoom in on the spectrum by setting the **Span** to 100 kHz. The two signals appear to be one signal in the spectrum.

    b. Decrease the **Resolution Bandwidth** to 10 kHz. A dip appears in the center of the signal spectrum. The depth of this dip relative to the peaks is equal to the defined resolution bandwidth value of the RFSA, which is 3 dB.

    c. Decrease **Resolution Bandwidth** to 1 kHz. Two distinct signals of equal amplitude appear on the spectrum graph.

Resolving signals of unequal amplitudes may require reduction of the resolution bandwidth to much less than the signal separation because the smaller signal may be hidden in the spectral skirt of the larger signal.

Measuring Harmonics

Complete the following steps to perform a harmonic measurement using the RF Signal Analyzer Example VI:

1. On the PXI-5600 downconverter front panel, connect one of the 10 MHz OUT reference outputs to the INPUT connector.

2. Open the RF Signal Analyzer Example VI by selecting **Start» Programs»National Instruments»RF Signal Analyzer»RF Signal Analyzer Example VI**.

3. Notice the **Hardware Settings** menu at the right bottom corner of the RF Signal Analyzer Example VI front panel. This menu consists of selectable views containing spectral information such as span and resolution bandwidth, as well as hardware information such as timing and trigger settings, device numbers, and attenuation.

✏️ **Note** Use the increment/decrement arrows to select views and change control settings.

a. Select the **RF Settings** view of the **Hardware Settings** menu. Set **center frequency** to 25 MHz, **span** to 40 MHz, and **resolution bandwidth** to 100 kHz.

b. In the **Amplitude** view of the Hardware Settings menu, set **Ref Level (dBm) to** 10 dBm and check the **attenuation auto** box. For further explanation of these settings and their effects on measurements, refer to Chapter 3, *Guidelines for Making Accurate Measurements*.

4. Run the RF Signal Analyzer Example VI by clicking the **RUN** icon (white arrow) on the toolbar or by pressing **<Ctrl-R>**. A signal appears at the center of the spectrum graph.

5. Set the averaging controls below the spectrum graph to the following values:

   • **averaging type—rms averaging**

   • **weighting type—linear**

   • **size**—10 averages

   • **linear weighting mode—moving average**

6. In the **Units** control below the spectrum graph, select **dBm**.

7. Notice the **Measurements** menu in the upper right corner of the RF Signal Analyzer Example VI front panel. This menu consists of several views containing measurement settings and controls.

a. Select the **Peak Search** view of the **Measurements** menu. A yellow peak threshold line appears on the spectrum graph.

b. Click on the peak threshold line and drag it below the peak value of the 10 MHz signal and its harmonics.

c. In the **Peak Search Setting** submenu of the **Peak Search** view, select **Multiple Peaks**.

d. Click the **Select Peak** button. Select the harmonic peak to read off its value to the fourth harmonic.

Measuring Adjacent Channel Power

For this example, use the PXI-5600 downconverter module reference from one of the 10 MHz OUT connectors as the source signal. Complete the following steps to measure adjacent channel power leakage using the RF Signal Analyzer Example VI:

1. On the PXI-5600 downconverter front panel, connect one of the 10 MHz OUT reference outputs to the INPUT connector.

2. Open the RF Signal Analyzer Example VI by selecting **Start» Programs»National Instruments»RF Signal Analyzer»RF Signal Analyzer Example VI**.

3. Notice the **Hardware Settings** menu at the right bottom corner of the RF Signal Analyzer Example VI front panel. This menu consists of selectable views containing spectral information such as span and resolution bandwidth, as well as hardware information such as timing and trigger settings, device numbers, and attenuation.

✎ **Note** Use the increment/decrement arrows to select views and change control settings.

  a. Select the **RF Settings** view of the **Hardware Spectrum Settings** menu. Set **center frequency** to 10 MHz, **span** to 100 kHz, and the **resolution bandwidth** to 1 kHz.

  b. In the **Amplitude** view of the **Hardware Settings** menu, set the **Ref Level** to 10 dBm and check the **attenuation auto** box. Refer to Chapter 3, *Guidelines for Making Accurate Measurements*, for further explanation of these settings and their effects on measurements.

4. Run the RF Signal Analyzer Example VI by clicking the **RUN** icon (white arrow) on the toolbar or by pressing **<Ctrl-R>**. A signal appears at the center of the spectrum graph.

5. Set the averaging controls located below the spectrum graph to the following values:

  • **averaging type—rms averaging**
  • **weighting type—linear**
  • **size**—10 averages
  • **linear weighting mode—moving average**

6. In the **Units** control below the spectrum graph, select **dBm**.

7. Notice the **Measurements** menu in the upper right corner of the RF Signal Analyzer Example VI front panel. This menu consists of several views containing measurement settings and controls.

8. Select the adjacent channel power (**ACP**) view of the **Measurements** menu and set the controls to the following values:

    • **channel center**—10 MHz

    • **channel bandwidth**—10 kHz; this is the bandwidth of the channel in which signal power is measured

    • **channel spacing**—20 kHz; this is the frequency spacing between the centers of each channel

   Three graphical histogram bars appear on the spectrum graph. The center bar shows the total power in the 10 kHz bandwidth channel. The two bars on each side show the upper and lower adjacent channel powers.

3

Guidelines for Making Accurate Measurements

This chapter provides guidelines for making accurate measurements with the National Instruments PXI-5660 RF Signal Analyzer.

General Amplitude/Spectrum Measurement

Amplitude dynamic range is the difference between the maximum input level of a device and its minimum detectable signal level. This value estimates the ability of the PXI-5660 RFSA to distinguish and measure the amplitude difference of two signals. The RFSA can make signal measurements over a wide frequency range—from 9 kHz to 2.7 GHz—and a large amplitude dynamic range of greater than 100 dB.

Signals of large amplitude can saturate the system and cause spurious effects. These "spurs" may be large enough to be mistaken for real signals. Avoid this effect by properly adjusting the amplitude of the incoming signal. Achieving proper signal levels may involve attenuating the signal before it gets to the first mixer, either by programming the internal attenuators or by using external attenuation.

The RF Signal Analyzer must be properly configured before making a measurement. A small signal can be buried in noise if the resolution bandwidth setting is too large. To measure a small signal, make sure that the input attenuators are switched off and lower the resolution bandwidth setting to reduce the noise content. For signals below the noise floor of the instrument, use an external low-noise amplifier (LNA) in front of the RFSA to raise the signal level. If the update speed is not fast enough to resolve a signal due to the processing demands imposed by a narrow resolution bandwidth, an LNA helps provided it does not significantly affect system linearity. For example, with a signal level of –100 dBm, set the resolution bandwidth to 1 kHz or less.

Harmonic Distortion

Harmonic distortion is a measure of the amount of power contained in the harmonics of a fundamental signal. Harmonic distortion is inherent to devices and systems that possess nonlinear characteristics—the more nonlinear the device, the greater its harmonic distortion.

Harmonic distortion can be expressed as a power ratio or as a percentage ratio. Use the following formula to express it as a power ratio:

$$P_{HD} = P_{fund} - P_{harm} \text{ (dBc)}$$

where P_{HD} is the power of the harmonic distortion in dBc, P_{fund} is the fundamental signal power in dB or dBm, and P_{harm} is the power of the harmonic of interest in dB or dBm.

Convert the powers to voltages to express harmonic distortion as a percentage ratio:

$$\text{Percentage of Distortion} = \frac{V_{harm}}{V_{fund}} \times 100\%$$

In some applications, the harmonic distortion is measured as a total percentage harmonic distortion (*THD*). This measurement involves the power summation of all the harmonics in the spectrum band, defined in the following equation:

$$THD = \frac{\sqrt{V_{h2}^2 + V_{h3}^2 + V_{h4}^2 + \ldots + V_{hN}^2}}{V_{fund}} \times 100\%$$

A typical setup to perform a harmonic distortion measurement is shown in Figure 3-1. A lowpass or bandpass filter passes the fundamental signal while suppressing its harmonics. This setup injects a very clean sinusoidal signal into the unit under test (UUT). Any harmonic content at the UUT output is assumed to be generated by the UUT instead of the source.
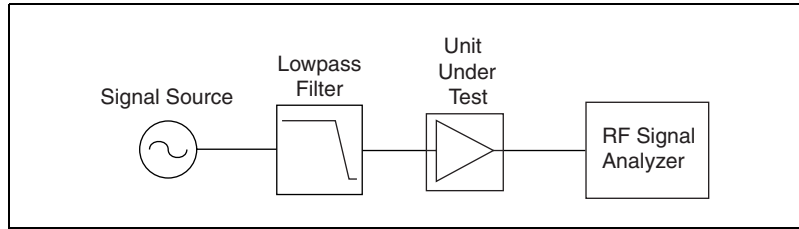
Figure 3-1. Typical Harmonic Distortion Measurement Setup

Tip LabVIEW 6.0 and later provide harmonic distortion analyzer and signal, noise, and distortion analyzer VIs that are useful for this task.

Understanding the RFSA Harmonic Distortion Limits

As with all signal analyzers, there are residual distortions inherent in the PXI-5660 RFSA. It is important that these distortions do not corrupt your measurement.

The level of internal distortion is a function of the linearity of the system, which is primarily determined at the input mixer. Increasing input power at the mixer increases distortion, so if the input signal is too high, the internally generated harmonics overwhelm the harmonics of the original signal.

The specifications for the second- and third-order harmonic intercept points provide sufficient information about the linearity of the system. For example, to measure a second-order harmonic at –70 dBc, the fundamental power at the mixer input has to satisfy the following condition:

$$P_{mixer} \le IIP_2 + Distortion - 3dB \ = \ IIP_2 - 70dBc - 3dB$$

where IIP_2 is the second-order intercept point.

If the input signal power is greater than this value, the signal must be attenuated before the first mixer. There is an upper limit on the amount of attenuation you can switch in because the noise floor rises by the same amount as the attenuation. To lower the noise level decrease the resolution bandwidth, but keep in mind that there is also a practical lower limit on the resolution bandwidth. Decreasing the resolution bandwidth increases measurement time.

The harmonic distortion dynamic range (HDDR) indicates the minimum distortion the RFSA can measure, which is about –96 dBc/Hz for the PXI-5660.

Choosing an Optimal Setting for the RFSA

Because the level of harmonic distortion is often unknown, the optimal attenuation level can be difficult to determine. Complete the following steps to find the proper attenuation setting for the RFSA:

1. Set the attenuation so that the input power at the mixer is about –30 dBm. When using the RF Signal Analyzer Example VI, mixer level is the reference level minus attenuation.

2. Tune to the harmonic frequency of interest and then decrease the resolution bandwidth until the harmonic spur appears.

3. Increase the attenuation level. If the harmonic spur decreases, attenuate more.

4. Repeat step 3 until the harmonic level does not decrease any further. Attenuation does not lower the harmonics of the original signal; it only lowers the internally generated ones.

5. Decrease the resolution bandwidth to lower the noise floor.

This setting is the optimal attenuation setting.

Two-Tone Third-Order Intermodulation Distortion

Two-tone third-order intermodulation distortion (IMD_3) is the measure of the third-order distortion products produced by a nonlinear device when two tones closely spaced in frequency are fed into its input. This distortion product is usually so close to the carrier that it is almost impossible to filter out and can cause interference in multichannel communications equipment.

If F_1 and F_2 are the frequencies of the two tones, then the third-order distortion products occur on both sides of these tones at $2F_2 - F_1$ and $2F_1 - F_2$. Assuming that the power levels of the two tones are equal, IMD_3 is the difference between the power of the fundamental signals and the third-order products, as defined in the following equation:

$$IMD_3 = P_o - P_{o3}$$

where $_o$ refers to the output of the UUT, P_{o3} is the power level of one of the output third-order products, and P_o is the power level of one of the fundamental tones.

The math becomes more involved if the powers of the two tones are different. Once the IMD_3 is measured, calculate the UUT output third-order intercept point (OIP_3) using the following equation:

$$OIP_3 = \frac{IMD_3}{2} + P_o = \frac{1}{2}(3P_o - P_{o3}) \text{ (dB)}$$

The input third-order intercept point (IIP_3) is defined as

$$IIP_3 = (OIP_3 - G),$$

where G is the gain of the device. The IIP_3 number quantifies the third-order linearity of a device.

Use the IIP_3 specification of the PXI-5660 RFSA as a guide to optimize its settings when measuring the IMD_3 of an external device.

The two tones injected into the UUT must be free from any third-order products. These two tones are combined, or summed, at or before the UUT input. If they are not well isolated, they intermodulate with each other and cause distortion. A signal combiner with good input-to-input isolation is recommended to minimize distortion of the input tones.

Measurement Setup

A typical IMD_3 measurement setup is shown in Figure 3-2. Lowpass filters are employed at the source outputs to suppress harmonics.
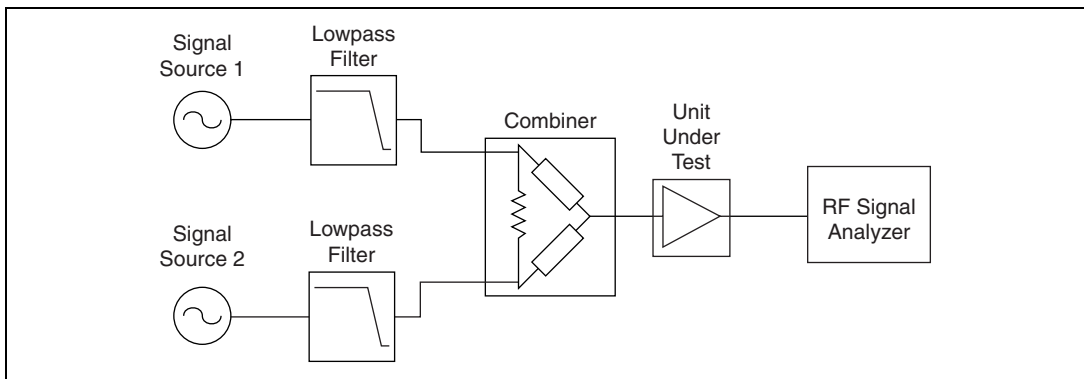

Figure 3-2. Typical IMD_3 Measurement Setup

Understanding Two-Tone Third-Order Intermodulation Distortion Limits of the RFSA

The RFSA generates its own distortion spurs, which are capable of swamping the P_{o3} of the UUT and giving rise to an erroneous measurement. Too much power at the signal input of the RFSA may drive the system into a nonlinear region of operation and produce very large distortion products. Choosing an appropriate attenuation setting for the RFSA minimizes its IMD_3 contribution to the measurement. The IMD_3 improves by 2 dB for every 1 dB of input power decrement.

To measure the IMD_3 of a UUT, input power to the RFSA mixer must satisfy the following condition:

$$P_{mix} \leq IIP_{3rfsa} - \frac{IMD_3 + 3dB}{2} \text{ (dBm)}$$

where IIP_{3rfsa} is the input third-order intercept point of the RFSA (about 10 dBm). For example, to accurately measure an IMD_3 of 80 dBc the input power to the mixer must be less than –31.5 dBm.

If the powers of two-tone signals are larger than this optimal level, they must be attenuated, either with the attenuators internal to the RFSA or with external attenuators. However, as attenuation raises the noise floor of the RFSA, there is a limit to how much attenuation can be used before noise overwhelms the distortion spurs. Its spurious-free dynamic range (SFDR) specification indicates the largest IMD_3 value the RFSA can accurately measure, assuming 0 dB attenuation and input signals whose powers satisfy the above equation.

Choosing an Optimal Setting for the RFSA

Complete the following steps to set optimal attenuation levels for an IMD_3 measurement when the level of the third-order distortion spur (P_{o3}) is unknown:

1. Set the attenuation such that input power at the mixer is about –30 dBm. When using the RF Signal Analyzer Example VI, mixer level is the reference level minus attenuation.

2. Tune to the third-order distortion product frequency of interest, either $2F_2 - F_1$ or $2F_1 - F_2$. Then decrease the resolution bandwidth until a distortion spur appears.

3. Increase the attenuation level.

4. If the harmonic spur decreases, repeat step 3.

5. Repeat step 4 until the harmonic level does not decrease any further. Attenuation does not lower the distortion products of the signal; it only lowers the distortion products generated internally to the RFSA. Decrease the resolution bandwidth to lower the noise floor.

    This setting is the optimal attenuation setting.

1 dB Gain Compression

An amplifier maintains a constant gain for low-level input signals. However, at higher input levels, the amplifier goes into saturation and its gain decreases. The 1 dB compression point (P_{1dB}) indicates the power level that causes the gain to drop by 1 dB from its small signal value.

Measurement Setup

Measuring the 1 dB gain compression point of a device requires driving the UUT into compression without driving the PXI-5660 RFSA into compression. This requires proper attenuation at the RFSA and a signal source of sufficient power to compress the UUT. You may apply attenuation by programming the internal input attenuators or using external attenuation.

The 1 dB compression point is derived from the gain relationship between output power and input power. Using the measurement setup shown in Figure 3-3, source amplitude is slowly increased while the UUT output is monitored. Output power is plotted against input power as shown in Figure 3-4.
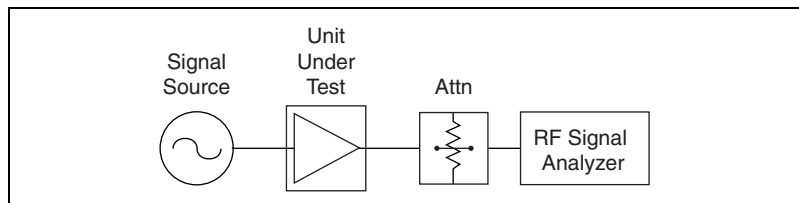

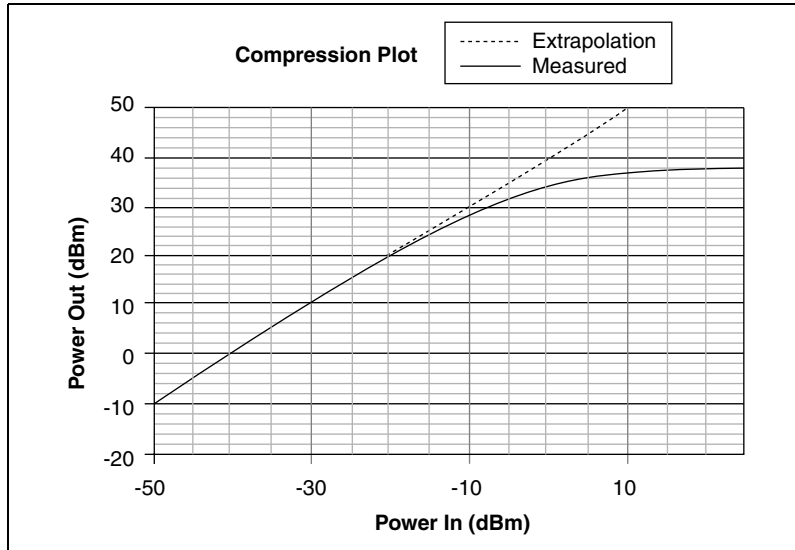**Figure 3-3.** Typical 1 dB Gain Compression Setup

Figure 3-4. Gain Compression Plot

The straight line on this graph is an extrapolation of the small signal gain of the UUT. The input 1 dB compression point is the input power that causes the UUT gain to drop by 1 dB from this small signal value, or approximately –12 dBm in this case.

Understanding RFSA Compression Limits

Like all signal analysis devices, the PXI-5660 RF Signal Analyzer is not completely linear and will eventually reach compression. However, the RF Signal Analyzer architecture possesses a high degree of linearity, and the RFSA compression point is typically 5 dBm or higher.

Ensure accurate UUT compression measurements by limiting the signal at the RFSA input mixer to 20 dB below the RFSA compression point listed in the *Specifications for the PXI-5660 Signal Analyzer Note to Users*.

Choosing the Optimal RFSA Attenuation Setting

Choosing the optimal attenuation settings for a UUT compression measurement requires taking a couple of factors into account:

• The maximum output signal of your UUT must be attenuated to 10–20 dB less than the compression point of the PXI-5660 RFSA.

- The resolution bandwidth setting of the RFSA must be low enough that small signals used to determine the linear gain of the UUT are not overwhelmed with noise from the RFSA.

To set the proper RFSA attenuation level for a compression test on a UUT with known output compression estimate and known approximate gain, complete the following steps:

1. Set the RFSA mixer level to –20 dBm and its reference level to 10 dB above the estimated UUT compression point. When using the RF Signal Analyzer Example VI, mixer level is the reference level minus attenuation.

2. Set the RFSA center frequency to your intended testing frequency, its span to 1 MHz, and its resolution bandwidth to 1 kHz.

3. Inject a signal into the UUT small enough that its output level is at least 20 dB below the estimated UUT compression point. If the UUT output signal level is too close to the noise floor of the RFSA, decrease the RFSA resolution bandwidth.

4. Increase the input signal to the UUT. If the output signal has reached 5 dB below the RFSA reference level and compression of the UUT has not been reached, increase the reference level by 10 dB.

5. Repeat step 4 until compression appears in the UUT.

You have now obtained the optimal attenuation setting for the RFSA.

Noise Figure

All devices have inherent noise. When noise is quantified, it is usually referred to the device input. In other words, all noise power a UUT inherits is assumed to come from its input. The noise figure of a UUT is the ratio in dB of its noise power to the noise power that a matched resistive load would deliver at room temperature. If you terminate a UUT input with a matched resistive load—typically 50 Ω—and measure the noise power density at its output (N_o), the noise figure (NF) is given by the following equation:

$$NF = 10\log\left(\frac{N_o/G}{kT_0}\right)$$

where G is the power gain of the UUT, $k \approx 1.38 \times 10^{-23}$ is Boltzmann's constant, and $T_0 \approx 290\ ^o\mathrm{K}$ is the room temperature.

If you use the PXI-5660 RF Signal Analyzer to measure the output noise of a UUT, the result of the measurement contains not only UUT noise but also noise intrinsic to the PXI-5660. If the UUT gain (*G)* is known, compute the noise figure of the UUT with the following equation:

$$NF \;=\; 10\log\!\left(\frac{N_m - N_{rfsa}}{kT_o} + 1\right) - 10\log G \qquad (3\text{-}1)$$

where N_{rfsa} is the noise measured by the RFSA when its input is terminated with a matched resistive load and N_m is the measured noise with UUT attached. Both N_{rfsa} and N_m are given in watts; G is a linear power gain.

Measurement Setup

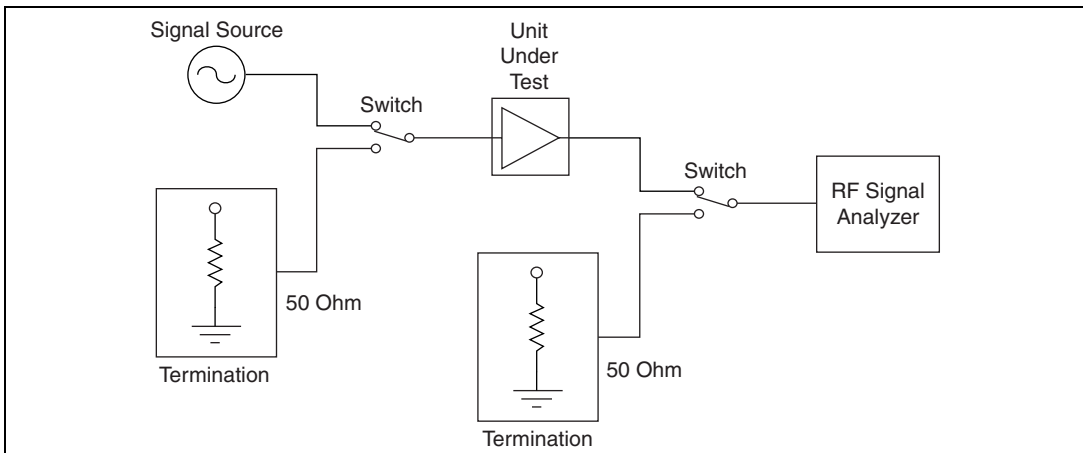Figure 3-5 shows a typical noise figure measurement setup.

Figure 3-5. Typical Noise Figure Measurement Setup

To measure the noise figure, perform the following steps:

1. Turn on the RFSA and let it warm up for 20 minutes.
2. Turn on the UUT if it is active.
3. Set the RFSA to the frequency of interest, and decrease the resolution bandwidth to about 1 kHz.
4. Terminate the RFSA input with a broadband resistive load.
5. Obtain an average reading of the noise level. Make sure to take enough readings to obtain a good average.

6. Convert a reading taken in dBm to watts and normalize it to 1 Hz by dividing by the resolution bandwidth. This value is the noise floor of the RFSA at that frequency, which is N_{rfsa} in this guide.

7. Remove the load termination from the RFSA input.

8. Attach the output of the UUT to the RFSA input.

9. Input a known small signal into the UUT input. This signal level should be less then 10 dB below the 1 dB compression point of the UUT.

10. Measure the output signal level on the RFSA to determine the gain (G) of the UUT.

11. Remove the signal source and terminate the UUT input with a broadband resistive load.

12. Make another averaged reading of the noise with the UUT attached by repeating steps 5 and 6. This average is the noise value for the UUT and RFSA (N_m).

13. Substitute your values into Equation 3-1 according to the following guidelines to determine the UUT noise figure:

    • The value from step 6 equals N_{rfsa}

    • The value from step 10 equals G

    • The value from step 12 equals N_m

4

Troubleshooting

This chapter provides help with common problems associated with installation, hardware, and taking measurements. Refer to Appendix A, *Technical Support and Professional Services*, for further assistance.

Configuration Problems

RFSA Does Not Initialize

Failure to initialize may indicate a problem with MAX. Refer to the *Configuring the Hardware Modules in MAX* section in Chapter 1, *Set Up and Configuration*, for instructions on using MAX.

STATUS LED Does Not Light

If the RFSA is programmed via NI-TUNER to lock to an external reference source or to the PXI backplane, but the STATUS light does not indicate a phase locked status, check for the following errors:

- Make sure a cable is connected from the external source or the PXI 10 MHZ I/O connector to the FREQ REF IN connector

- Ensure that the external source signal is large enough—typically greater than –10 dBm

If you programmed the PXI-5660 RFSA to use the PXI-5600 downconverter module internal timebase, check for the following errors:

- If the RFSA measures the frequency incorrectly or shows no signal when one is supplied, one or more of the local oscillators is not phase-locked. If this happens, contact NI.

- If the RFSA measures the frequency correctly but the LED does not light, there could be a driver software error or the LED is damaged.

The Digitizer Module Does Not Phase Lock to the Downconverter Module

If you programmed the PXI-5620 digitizer module to phase-lock to the PXI-5600 downconverter module internal reference and encounter failure, check that your cable is not faulty and that there is a reference signal coming out of the PXI-5600 10 MHZ OUT front panel connectors. If there is no signal at these outputs, contact NI.

If you programmed the PXI-5620 digitizer module to phase lock to the PXI backplane driven by the PXI-5600 downconverter module internal reference and encounter failure, make sure that the PXI 10 MHZ I/O connector is wired to one of the 10 MHz OUT connectors. Also ensure that the PXI-5600 is in slot 2 of the PXI chassis, immediately adjoining the PXI controller slot.

Measurement Problems

For information about making signal distortion measurements, refer to Chapter 3, *Guidelines for Making Accurate Measurements*.

RFSA Amplitude Reading Does Not Match Source

If the RFSA reports an incorrect amplitude reading, check for the following possible errors:

- Check that the discrepancy between the RFSA and the source is within the error limits of the devices. Verify the absolute amplitude accuracy of the RFSA. Verify the output level accuracy for the source.

- Check for loss in the cables, which can be substantial. For example, RG58 coaxial cable loses about 2.1 dB of signal amplitude per foot at 2 GHz. Unless you are using high-quality cables, expect losses when working with high-frequency signals.

- Ensure that you are using the amplitude calibration functions in the SMT. Failure to apply calibration functions results in large amplitude errors.

RFSA Frequency Reading Does Not Match Source

If the RFSA reports an incorrect frequency reading, check for the following possible errors:

- Check that the RFSA is programmed to lock to the reference of the source.

- Ensure that the RFSA and the source are phase-locked. If the source and the RFSA modules are not phase-locked, then it is normal for a small frequency deviation to exist.

- Make sure the cable used to synchronize the source and RFSA by phase-locking is properly installed and is not faulty.

- Check that the PXI-5620 digitizer module is phase-locked to the PXI-5600 downconverter module, either through the front panel SMA connectors or the PXI backplane.

5

Hardware Overview

This chapter is intended for advanced users and provides an overview of the PXI-5660 RFSA hardware, including brief explanations of hardware features and signal paths, and block diagrams of each module.

Features

The PXI-5660 RF Signal Analyzer consists of the PXI-5600 wideband downconverter module, and the PXI-5620 RF digitizer module.

PXI-5600 Wideband RF Downconverter Module

The PXI-5600 downconverter module, as shown in Figure 5-1, performs two primary functions: frequency shifting, or downconversion, and input signal conditioning. Frequency shifting is performed using a tunable oscillator in the superheterodyne signal chain.

Input signal conditioning is accomplished using three stages of mixer conversion and two sets of gain attenuators whose levels are programmable. The first attenuator can be set to minimize distortion and other spurious signals when input levels are high and to minimize noise when input levels are low. Attenuator levels are set in software.

The second attenuator is in the second intermediate frequency (IF) path before the third mixer and ensures an appropriate output signal level even if the first mixer is intentionally driven into compression. These attenuators are also set when performing linearity measurements. For more information on proper attenuation levels, refer to Chapter 3, *Guidelines for Making Accurate Measurements*.

The PXI-5600 downconverter module translates any 20 MHz-wide band of incoming signal to center at 15 MHz. Thus the downconverter module converts any block of spectrum, up to 20 MHz wide and centered anywhere between 9 kHz and 2.7 GHz, to an IF band between 5–25 MHz. This IF band is then passed to the PXI-5620 digitizer module, as shown in Figure 5-2, for further processing.

PXI-5620 IF Digitizer Module

The PXI-5620 is an IF high-speed digitizer module featuring a 14-bit analog-to-digital converter (ADC) with deep onboard sample memory. Offering sample rates of 1 kS to 64 MS/s and outstanding distortion-free performance, it has been designed to complement the PXI-5600 downconverter module in FFT analysis applications.

Signal Paths

A signal takes the following path through the RFSA to the PXI controller:

1. A signal enters the RFSA through the INPUT front panel connector of the PXI-5600 RF downconverter module.

2. The PXI-5600 RF downconverter module "zooms in" on a 20 MHz block of spectrum and frequency-translates it to center around 15 MHz. The translated IF signal is sent to the downconverter module OUTPUT connector.

3. The IF signal is passed from the downconverter module OUTPUT connector to the PXI-5620 digitizer module front panel connector, INPUT.

4. The PXI-5620 filters and conditions the signal. Gain and dither are applied.

5. The ADC converts the signal from analog to digital.

6. The data is sent to onboard memory (the buffer).

7. The data is transferred to your host computer.
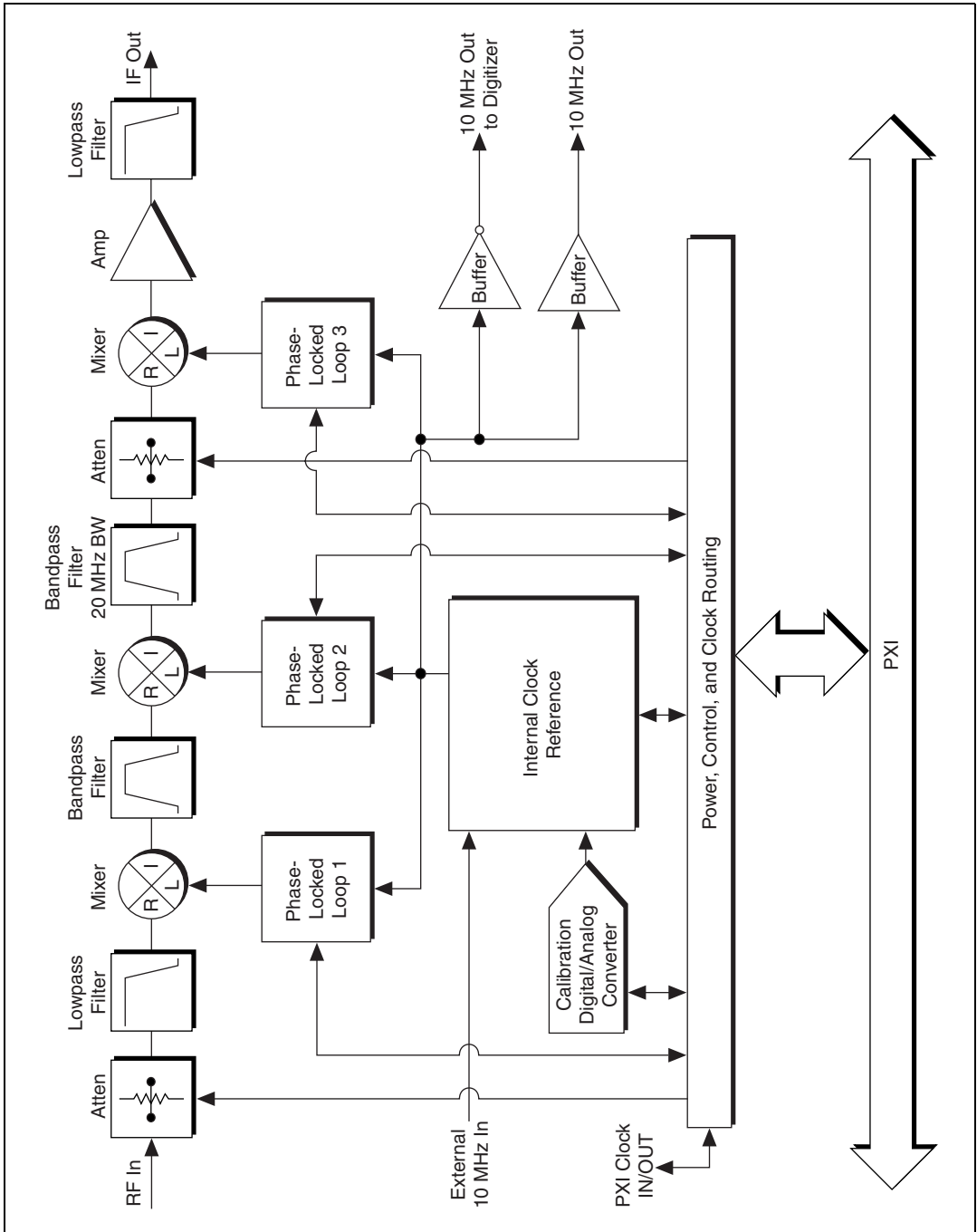
Block Diagrams

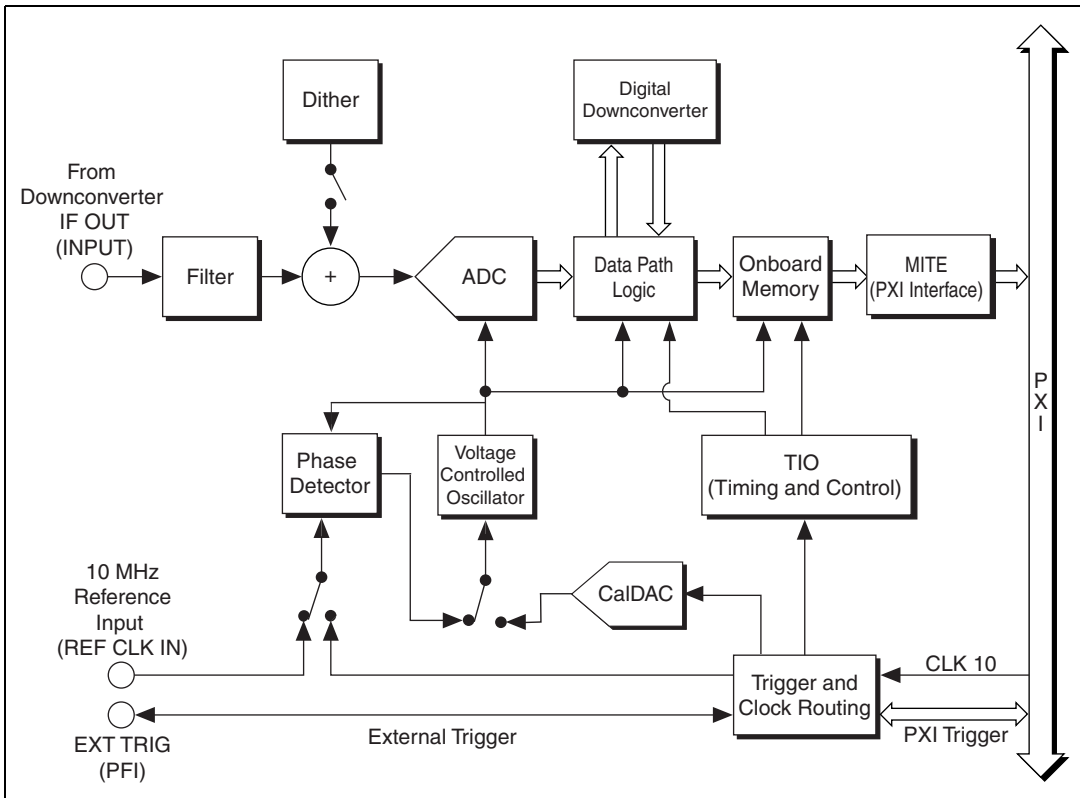**Figure 5-1.** PXI-5600 RF Downconverter Module Block Diagram

Figure 5-2. PXI-5620 Digitizer Module Block Diagram

Calibration

Every National Instruments PXI-5660 RF Signal Analyzer is individually calibrated for frequency response at the factory. During frequency response calibration, the RFSA is used to measure a known high-precision signal. Any error in the returned data is quantified as a set of calibration constants used by software to calculate and apply correction to your analysis based upon the spectrum of interest. For more information on applying calibration correction, see the included example programs.

To guarantee specified accuracy, NI recommends returning both modules of your PXI-5660 RFSA to the factory for annual recalibration. The PXI-5600 and PXI 5620 modules are calibrated independently of one another, not as a combined system. At this time, recalibration of both modules can only be performed at NI. For more information on calibration, contact NI or visit `ni.com/calibration`.

A

Technical Support and Professional Services

Visit the following sections of the National Instruments Web site at ni.com for technical support and professional services:

- **Support**—Online technical support resources include the following:
  - **Self-Help Resources**—For immediate answers and solutions, visit our extensive library of technical support resources available in English, Japanese, and Spanish at ni.com/support. These resources are available for most products at no cost to registered users and include software drivers and updates, a KnowledgeBase, product manuals, step-by-step troubleshooting wizards, hardware schematics and conformity documentation, example code, tutorials and application notes, instrument drivers, discussion forums, a measurement glossary, and so on.
  - **Assisted Support Options**—Contact NI engineers and other measurement and automation professionals by visiting ni.com/ask. Our online system helps you define your question and connects you to the experts by phone, discussion forum, or email.
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