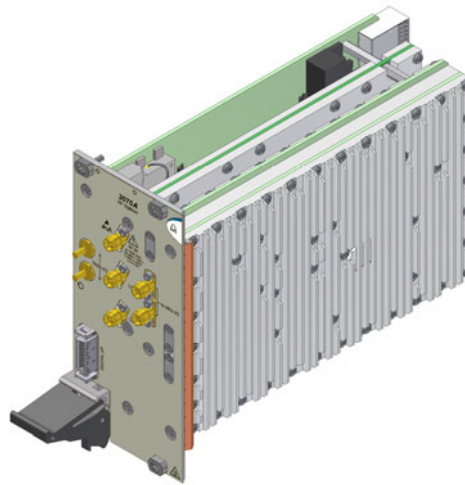# 3070A PXI High Performance Wideband RF Digitizer

User Manual

Document no. 47090/198
Issue 1
27 June 2013

About this manual

This manual explains how to set up and configure an Aeroflex 3070A PXI High Performance Wideband RF Digitizer. Where necessary, it refers you to the appropriate installation documents that are supplied with the module.

Please note: this manual applies only when the instrument is used with the supplied software.

This manual provides information about how to configure the module as a stand-alone device.

3070A is a PXI-based test instrument. You do not need other modules to form an instrument with 3070A. You can use 3070A with other modules/instruments to form a system.

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Intended use

Aeroflex 3000 Series PXI modules are intended for installation in any PXI-compliant chassis, subject to its ability to provide the required air flow for cooling.

The 3070A PXI High Performance Wideband RF Digitizer is designed for users who need to down-convert and digitize RF signals for the purpose of test and measurement.

This manual is intended for first-time users, to provide familiarity with basic operation. The module is controlled using the PXI Studio 2 application software (supplied), which provides an intuitive graphical interface.

Programming is not covered in this document but is documented fully in the help files that accompany the drivers and associated software on the CD-ROM.

Driver version

This PXI module is designed to be used with the driver software supplied with the module on the Aeroflex 3000 Series PXI Modules CD-ROM, part no. 46886/028. You can also download the latest driver from the Aeroflex website.

Aeroflex makes every endeavor to ensure 3070A hardware remains backwards compatible with earlier versions of the module driver. However, operation with earlier versions of driver software may not be supported.

Associated documentation

If you want to…	Refer to…
Find information about drivers, application software, data sheets, getting started and user manuals for this and other modules in the 3000 Series.	**PXI Modules CD-ROM** Part no. 46886/028 Supplied with the module
Install modules into a rack, interconnect them, power up and install drivers.	**3000 Series PXI Modules Common Installation Guide** Part no. 46882/663 On CD-ROM 46886/028 and at www.aeroflex.com/
Set up a populated chassis ready for use.	**3000 Series PXI Modules Installation Guide for Chassis** Part no. 46882/667 On CD-ROM 46886/028 and at www.aeroflex.com/
Set up and use the universal PXI application for system configuration and operation.	**PXI Studio 2 User Guide** Part no: 46892/809 On CD-ROM 46886/028 and at www.aeroflex.com/
Use *IQCreator* ® to create and package arbitrary waveform files	**IQCreator ® Getting Started Guide** Part no: 46892/599 **IQCreator ® User Guide** Part no: 46892/627 On CD-ROM 46886/030

Patent information

This instrument is protected by the following:

UK patent application:

GB2475514A

Granted patents:

GB2294599

US5781600

GB2383205

EP145693

DE60209374.0-08

US7005925

Preface

Hybrid slot compatibility

PXI chassis that provide hybrid slots can accept both PXI Express modules and hybrid-compatible PXI modules. Hybrid-compatible PXI modules have a 'missing' section of connector (see Fig. 1), which allows them to be inserted into both hybrid slots and standard PXI-1 slots.
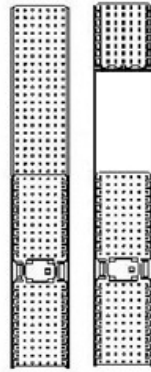

Fig. 1 Standard PXI-1 connector (L) and hybrid-compatible PXI connector (R)

The 3070A fits in both hybrid-compatible and standard slots: but see rack compatibility information for guidance on which slots may be used.

Number of slots

The 3070A occupies three slots in the chassis.

GENERAL INFORMATION

Introduction

This is the user manual for the 3070A PXI High Performance Wideband RF Digitizer module (referred to generically in this document as '3070A').

The 3070A operates over the frequency range 250 MHz to 6.0 GHz.

Applications

The 3070A down-converts and digitizes RF signals. It converts an analog RF waveform presented at the RF port into a series of amplitude- and phase-corrected digital IF or IQ data pairs at the rear-panel PCI interface. Software supplied with the module allows for spectrum analysis of the digitized signals, and optional measurement suites provide signal analysis.

The 3070A can be used in RF test and measurement systems that are used in development or manufacturing. Applications span all areas of radio communications but notably wide-bandwidth communications systems; for example IEEE 802.11ac, where instantaneous signal bandwidths of 160 MHz are possible.

Input range and accuracy

Input level control is provided by electronic switched attenuation, which helps to maximize the usable dynamic range. The module has good level accuracy and repeatability, making the module ideal for high-volume manufacturing.

CAUTION

Refer to the front-panel connector section for maximum allowable input powers, beyond which damage to the module can occur.

Data capture and processing

Data capture can be single shot or repetitive, with the user defining trigger sources, conditions and capture length and sample rate.

Data is captured to internal memory and read out over the PCI bus.

Signal routing

A configurable routing matrix provides flexibility in how to interconnect signals on the PXI backplane, front-panel connections, and the module's internal functions.

10 MHz frequency reference oscillator

The 3070A includes an OCXO frequency reference oscillator for use internally or for output to other modules. The 3070A may also be referenced to an externally-applied 10 MHz reference input.

Triggering

Triggering of data acquisition can be sourced externally from software or hardware. Hardware triggering is supported across the PXI backplane or via front-panel connectors.

PXI backplane sources include PXI star trigger, PXI trigger bus and the PXI local bus.

External triggering is from the PXI backplane or the front-panel TRIG SSMB TTL input. Internal triggering is from the internal timer or level trigger.

Software

The 3070A is supplied with a VXI Plug&Play driver, a C interface DLL, and a *.net* assembly.

PXI Studio 2, also supplied with the module, configures PXI modules as logical instruments using an intuitive and powerful graphical interface. PXI Studio 2 provides comprehensive signal generator, digitizer and spectrum analyzer applications and optional analysis plugins to suit specific communications systems.

Deliverable items

- 3070A PXI High Performance Wideband RF Digitizer

- PXI Modules CD-ROM (part no. 46886/028), containing drivers, application software, data sheets, installation guides, safety instructions and user manuals for this and other modules in the 3000 Series

- Test results data CD-ROM, also contains calibration certificate: part no. 46886/054

- *3000 Series PXI Modules Safety Instructions*: printed item, part no. 46882/882

- SMA semi-rigid link cable assembly 180 mm: part no. 43139/739

Specifications

For the latest specifications, see the data sheet included on the CD-ROM (part no. 46886/028) or go to the Aeroflex website.

All specifications are defined when used in conjunction with the driver software supplied with the module, or a later version.

Warm-up time

Allow thirty minutes for the module to warm up and meet its specifications fully after booting.

INSTALLATION

WARNING

Initial visual inspection

Refer to the *3000 Series Common Installation Guide* (part no. 46892/663) on the PXI Modules CD-ROM (part no. 46886/028).

CAUTION

Handling precautions

Refer to the *3000 Series Common Installation Guide* (part no. 46892/663) on the PXI Modules CD-ROM (part no. 46886/028).

Hardware installation

WARNING

Before installing the module into the chassis, check that:

(a) no foreign conductive bodies are present between pins on the backplane or module connectors

(b) no pins on the backplane or module connectors are bent or damaged.

(c) check that the PXI backplane slot arrangement is compatible.

CAUTION

Airflow

The module's temperature is critically dependent on airflow. The chassis type, module position, fan speed setting, blanking plates, slot blockers and heat from adjoining modules can all affect the cooling performance. In many chassis, the high fan-speed setting is recommended.

When a module is installed in a new chassis or reconfigured in a new slot position in an existing chassis, check the module's temperature using the built-in temperature sensors, as described in *Temperature monitor*.

CAUTION

It is recommended to fit slot blockers (part no. 22361/159)…

…in unused slots. Slot blockers help to maintain the integrity of the airflow in the chassis.

Absolute maximum temperatures

The module includes three internal temperature sensors that can be read via the software. The general location of these sensors is shown in Fig. 2.
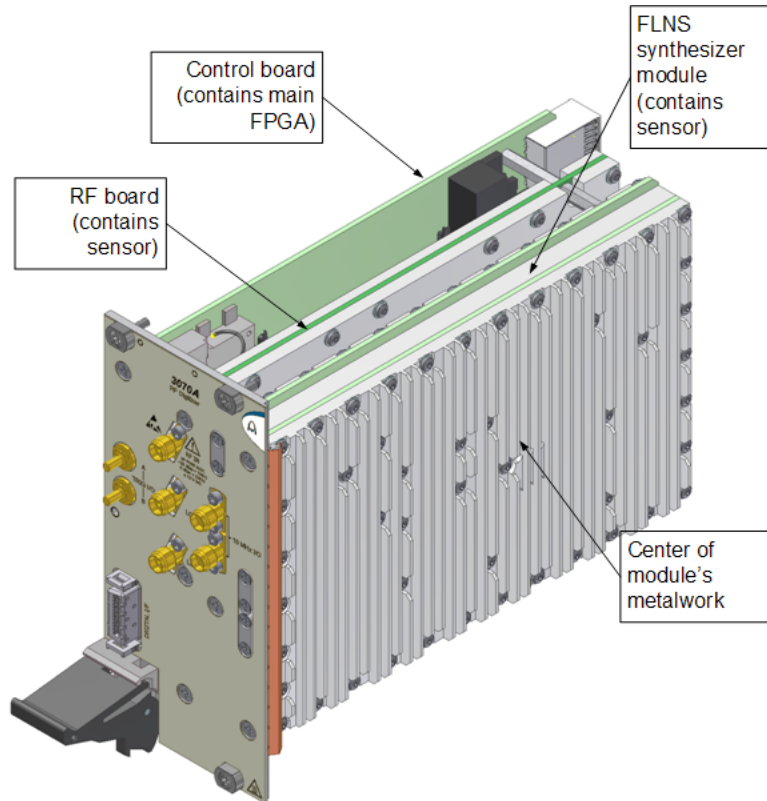

Fig. 2 Location of temperature sensors in 3070A

The absolute maximum temperatures within the 3070A module are listed in Table 1. Operating at or near these limits seriously degrades reliability. The table also shows the typical expected readings.

Table 1 Temperatures within 3070A

Measurement point	Absolute maximum temperature °C	Typical temperature (23°C ambient) °C
Center of module's metalwork	74	46
FPGA temperature sensor	99	68
RF board temperature sensor	73	46
FLNS synthesizer temperature sensor	76	45

It should be sufficient to check the temperature sensors as described in *Temperature monitor*, but a thermocouple may be taped to the 'center of module's metalwork' point if required.

The typical temperature is tested under the following conditions:

- Aeroflex eight-slot PXI chassis model 82531
- Full fan speed
- Dust filters (where fitted) removed
- Slot blockers fitted in all unused slots.

The maximum operating ambient temperature under these conditions is approximately 45°C.

Thermal shutdown

The module contains an over-temperature trip that reduces the power dissipation if high temperatures are detected. To ensure good performance and reliability, operate the module well below this trip point, and check the module's temperature using the built-in temperature sensors, as described in *Temperature monitor*.

Installing the module into the PXI chassis

Refer to the *3000 Series Common Installation Guide* (part no. 46892/663) and *Installation Guide for Chassis* (part no. 46892/697) on the PXI Modules CD-ROM (part no. 46886/028).

Rack compatibility

The 3070A occupies three slots in the PXI chassis. Its rear connectors engage with two backplane slots (Fig. 3).
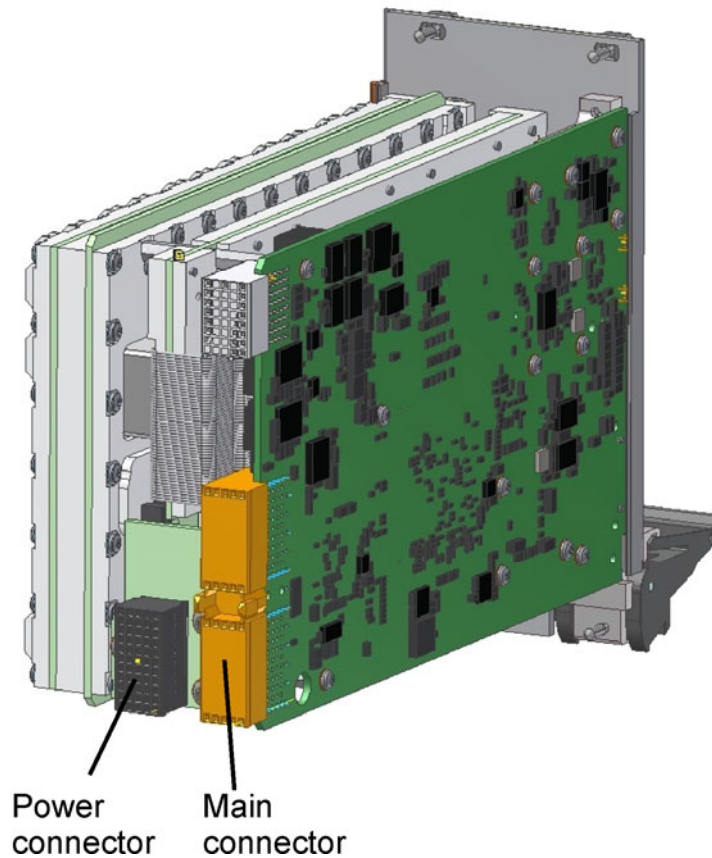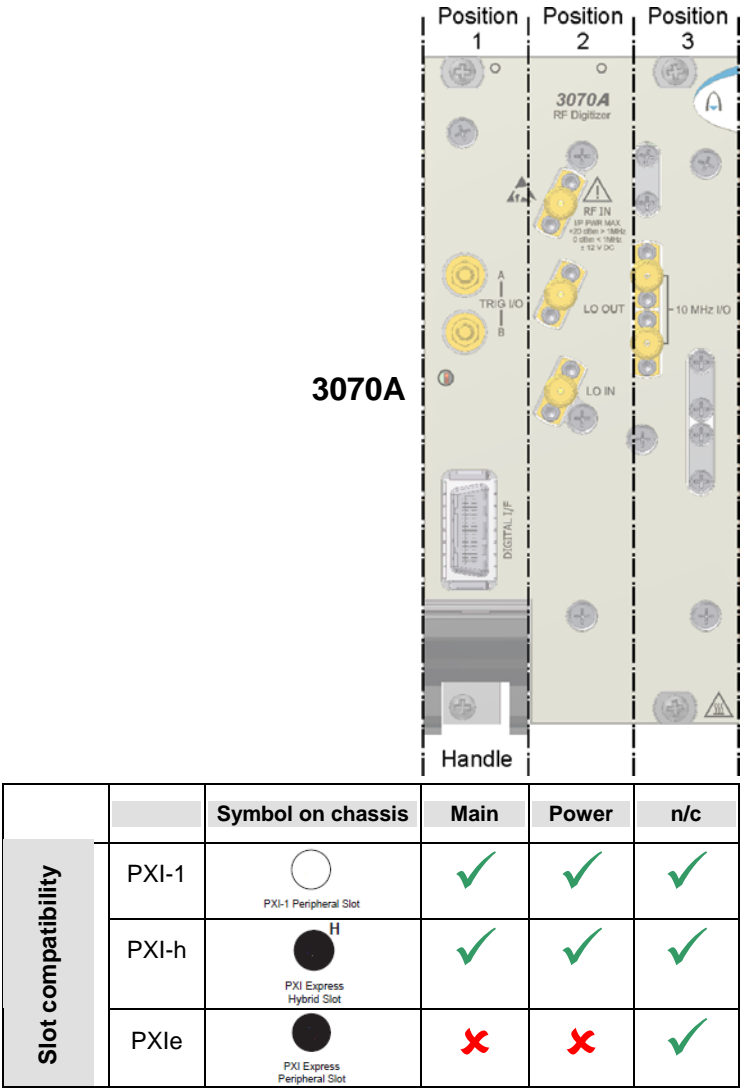

Fig. 3 Backplane connectors on 3070A

The two slots with which the 3070A's connectors engage must contain either PX1-1 (⬤)

PXI-1 Peripheral Slot

or PXI Hybrid (⬤ᴴ) connectors only: slots intended for PXI express (⬤) are not suitable.
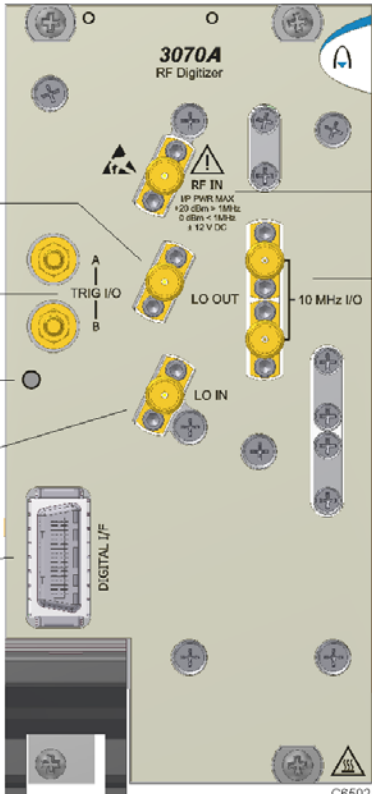
PXI Express
Hybrid Slot

PXI Express
Peripheral Slot

Therefore there may be positions in a chassis where the 3070A should not be fitted, and you need to check the symbols on all three slots to determine that they are suitable for the 3070A.

The following table shows the chassis compatibility for this module.

Compatibility table

3070A

		Symbol on chassis	Main	Power	n/c
Slot compatibility	PXI-1	◯ PXI-1 Peripheral Slot	✓	✓	✓
	PXI-h	● PXI Express Hybrid Slot	✓	✓	✓
	PXIe	● PXI Express Peripheral Slot	✗	✗	✓

OPERATION

Front-panel connectors

Fig. 4 3070A front panel

1	RF IN	SMA socket, 50 Ω. See Cautions below.
2	10 MHz I/O	Two SMA I/O sockets in parallel. Frequency standard input or output.
3	DIGITAL I/F	Not currently used.
4	LO IN	Local oscillator input. +8 to +12 dBm.
5	LED	Shows the status of the module.
6	TRIG A, B	SSMB sockets, 50 Ω.Two inputs, TTL +ve or –ve edge. Also configurable as outputs.
7	LO OUT	Local oscillator output. Typically +10 dBm.

CAUTION   Maximum safe power at the RF input is frequency dependent: see *3070A RF input power handling*.

CAUTION   RF connections may be sensitive to ESD (electrostatic discharge). Avoid ESD to the center pins of RF connectors, even when the module is installed in a chassis.

When the module is not installed in a chassis, always store it in its shipping container to protect it from ESD.

3070A RF input power handling

Input power handling at RF IN depends on the preamp state, and degrades at low frequencies due to the ratings of the switches used in the signal path. This limit applies regardless of the tuned receiver frequency.

	Absolute maximum peak input power (dBm)	
Input frequency	**Preamp off**	**Preamp on**
<1 MHz	0	0
1 MHz–5 MHz	+20	+20
>5 MHz	+30	+24

Front-panel LED

This indicates the status of the module:

yellow, slow flashing	over-temperature shutdown
yellow, steady	FPGA is configured and module has not booted
green, slow flashing	module has booted, clocks are out of lock (10 MHz reference not connected/incorrectly configured)
green, steady	module has booted, clocks are in lock
yellow, fast flashing	FPGA configuration error. This may occur if the power is interrupted during an FPGA update. Try updating the FPGA again.

Software

You can write your own code to run the 3070A module, using the function libraries supplied with the installer. See Programming below.

Or you can run the module from PXI Studio 2, which lets you quickly set the module up to digitize and perform spectrum analysis on a variety of modulation schemes, using a graphical interface.

Programming

Use the *afRfDigitizerDLL.dll* C interface and *afRfDigitizerVXI_32.dll* Plug&Play CVI APIs.

Object-oriented programming is provided by the .net assembly *(afRfDigitizerDotNet.dll).*

Detailed help information

This user manual provides an overview of the facilities that the module provides and summarizes its operation; however, refer to the help files for detailed descriptions of functions, together with their parameter lists and return values.

Program files

Program files are installed onto your computer from the CD-ROM.

You should find registered C and VXI Plug&Play DLLs, *.net* assemblies, libraries, source and associated help files in the program installation folder on your computer. These are typically:

C:\Program Files (x86)\Aeroflex\PXI\DotNET — .net assembly only
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\Bin — everything else.

Driver export functions

On-line help and functional documentation for driver export functions are available on the CD-ROM supplied with your module. They are installed onto your computer at the same time as the drivers.

Driver installation folder

Find help and functional documentation in the driver installation folder on your computer. If you did not change the default location, this is typically the same as for the VISA software.

Help

Within the driver installation folder are help files that provide descriptions, lists of parameters, and return values. Their location is:

C:\Program Files (x86)\IVI Foundation\VISA\WinNT\afRfDigitizer	—	afRfDigitizerVXI_C.chm
	—	afRfDigitizerVXI.chm

These are VXI-compliant help files.

and

accessible from the Start menu link:

*C:\Program Files (x86)\Aeroflex\PXI\Help* — afRf Digitizer.chm

These are general help files for C, VXI, .net programming.

PXI Studio 2

Configuration

To use PXI Studio 2 (supplied on the CD-ROM) with the 3070A and any other modules in the chassis, PXI Studio 2 must be configured to recognize the new modules. Do this by starting PXI Studio 2 and selecting *Config\System Configuration*.

This shows the standard Hardware Configuration screen (full details are in the PXI Studio 2 user guide, part no. 46892/809)
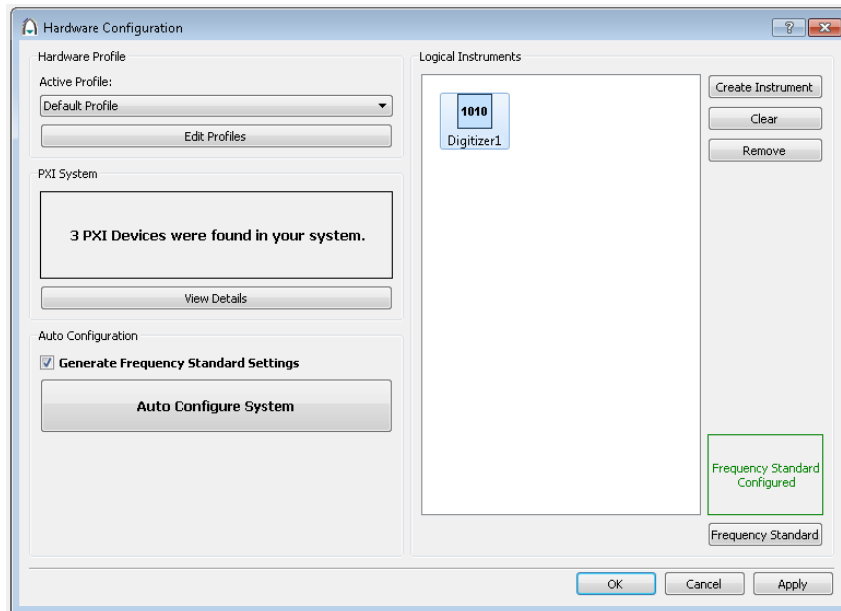

To allow PXI Studio 2 to operate with the new hardware, you can either click **Auto Configure System**, which creates a definition that includes all Aeroflex PXI modules within the system; or you can select **Create Instrument**, which lets you specify which hardware to use. Full details of this operation can be found in the PXI Studio 2 user guide.

Once the hardware configuration has been defined, use the Digitizer Front Panel (under the Instruments menu) to control the 3070A Digitizer (full details in the PXI Studio 2 user guide).

Temperature monitor

You can view the temperature of any module within the system that supports temperature monitoring by opening PXI Studio 2 and selecting *Config\Module Temperature*. Select the appropriate digitizer, for example Digitizer1.
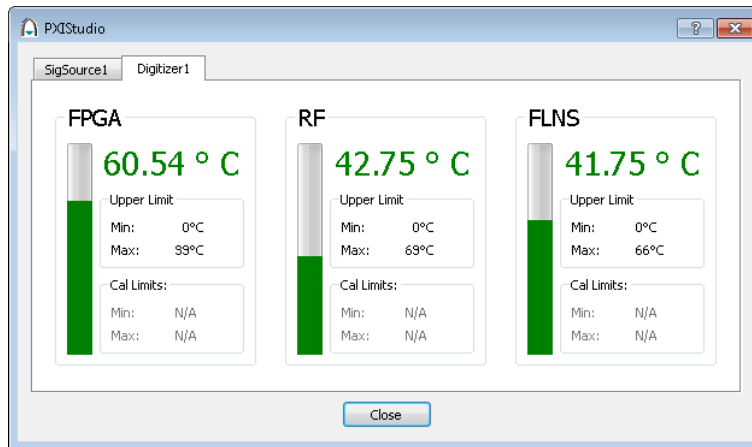
This screen shows the current operating temperature of the different subsystems within the module, as well as the maximum and calibration ranges. If the temperature of a subsystem is currently within the calibration range and maximum range, the readouts show green. If the temperature is out of the calibrated limits, the screen text and graphical temperature display show as orange. If the temperature has gone out of the maximum limits, the graphical temperature display shows red.

Note that calibration temperature limits are not implemented for 3070A.

Example setup

This example shows how to set up a 3050A Signal Generator + 3320 Dual-channel AWG to generate a waveform, and then display the analyzed waveform from the 3070A RF Digitizer. You can explore the capabilities of the 3070A and gain familiarity with this and other modules, using controlled variables, before adding a UUT for practical testing.

Software installation

Refer to the *3000 Series PXI Modules Common Installation Guide* (part no. 46882/663) for installation instructions for:

- 3000 Series drivers

- PXI Studio 2

The Common Installation Guide is supplied with each module as a PDF document on the PXI Modules CD-ROM (part no. 46886/028).

Note: Ensure that you install the module drivers before the PXI Studio 2 application.

# Hardware setup

In its simplest form, the hardware for the example setup is configured as shown in Fig. 5.

Note: *The PXI chassis may have an embedded PXI controller running the application software or be connected via a PCI–PXI, PCIe–PXI, PCI–PXI or PCIe–PXIe interface kit to a computer running the application software.*

Fig. 5 Example of hardware setup — 3320, 3050A, 3070A interconnection

- Ensure that 3000 Series drivers and PXI Studio 2 are installed (on the computer connected to the PXI chassis or on the embedded computer in the PXI chassis).

- Once the modules are installed and powered up, check that their temperatures are in the correct operating range: this is described in *Temperature monitor*. Check temperatures both for the 3070A, and also the SigSource formed by the 3050A and 3320. The 3050A and 3320 are documented in User Manuals 47090/197 and 47090/129 respectively, on CD-ROM 46886/028.

Start PXI Studio 2

After setting up the hardware, start PXI Studio 2 *(Start\All Programs\Aeroflex\PXI Studio 2)*.

Set up hardware configuration

Select *Config\System Configuration* to display the Hardware Configuration screen. This shows that PXI Studio 2 has identified PXI modules in the chassis.
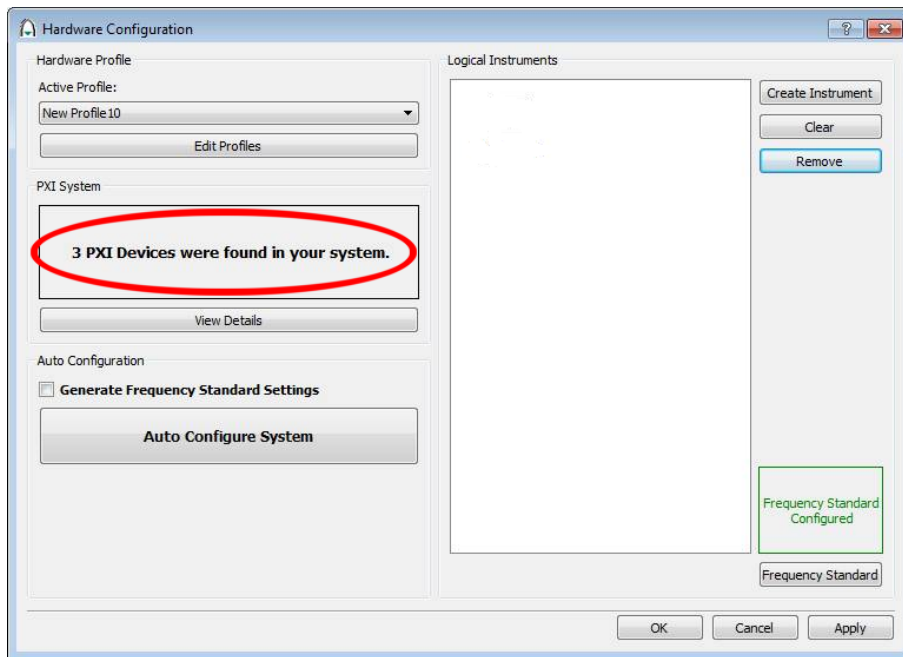
To allow PXI Studio 2 to operate with the new hardware, you can either click **Auto Configure System**, which creates a definition that includes all Aeroflex PXI modules within the system; or you can click **Create Instrument**, which lets you specify which hardware to use.

For now, click **Auto Configure System**. PXI Studio 2 shows the logical instruments it has created. In this example, *SigSource1* consists of the 3050A and 3320; *Digitizer1* is the 3070A Digitizer.
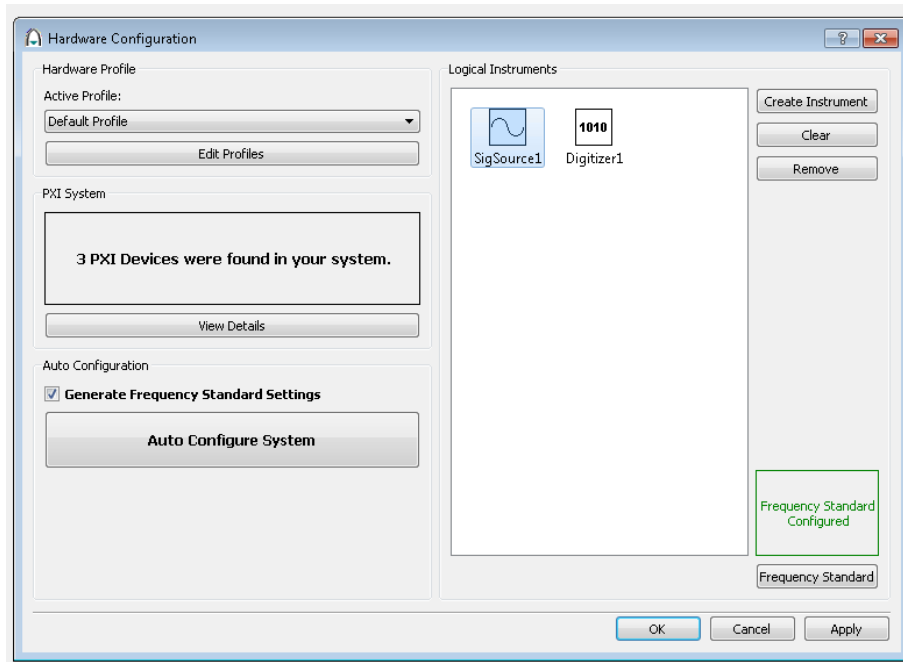
View details of devices

Click View Details to see a summary of devices in the system:
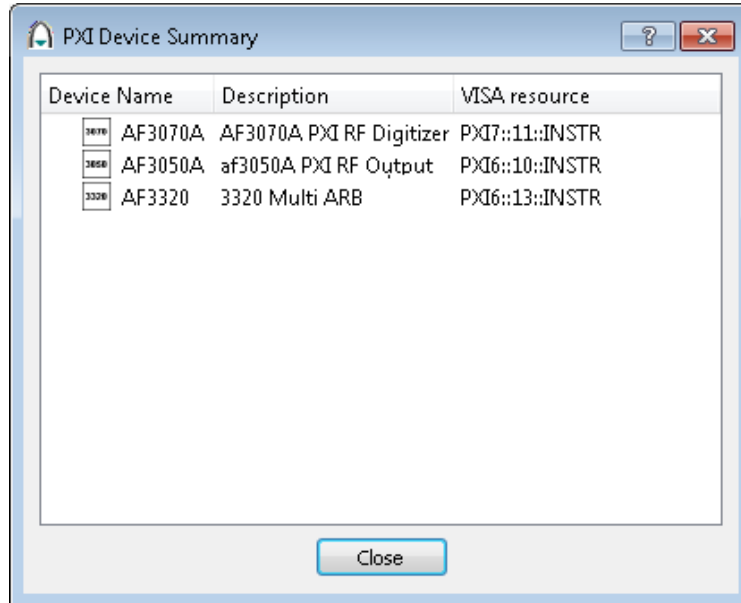
Frequency standard

Set up the frequency standard after configuring the system.

Auto Configure System sets all devices in the system to use the same frequency standard, which is External by default.

To set one of the devices as the frequency standard for the system, click **Frequency Standard** and use the wizard to choose the appropriate device.

Set up the signal source

Select *Instrument Control\Signal Source Front Panel* to display the Signal Source plugin screen.
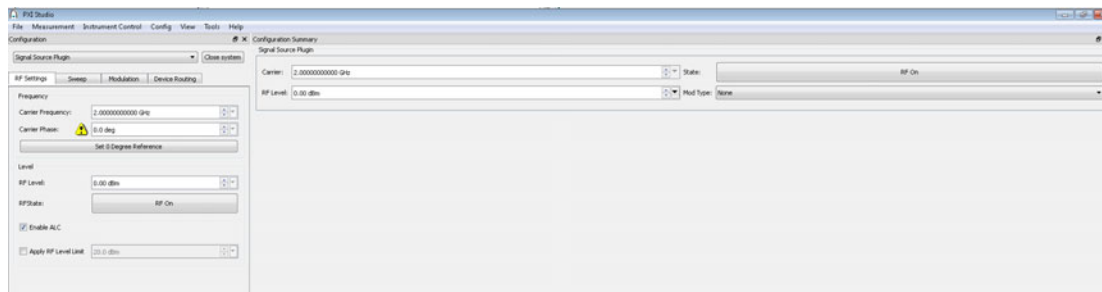
- Set Carrier Frequency to 2 GHz (this is the default value)
- Set RF Level to 0.0 dBm.
- Set RF State to RF On

The Signal Source is now outputting 2 GHz CW at 0 dBm to RF IN on the 3070A Digitizer.

Set up the digitizer

Select *Instrument Control\Digitizer Front Panel* to display the Digitizer plugin screen.
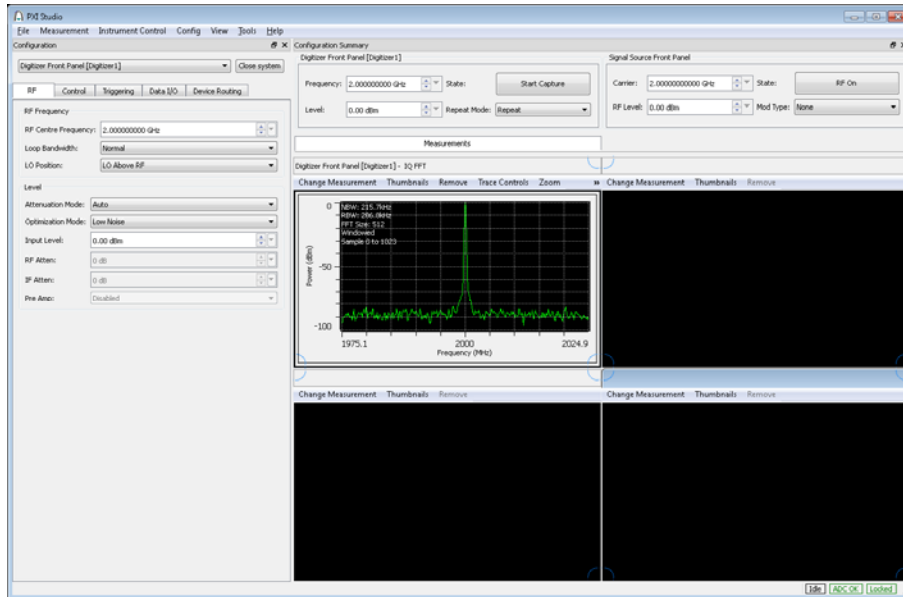
Leave all digitizer settings at the default values for now; these are correct to allow the initial display of the CW supplied by the signal source.

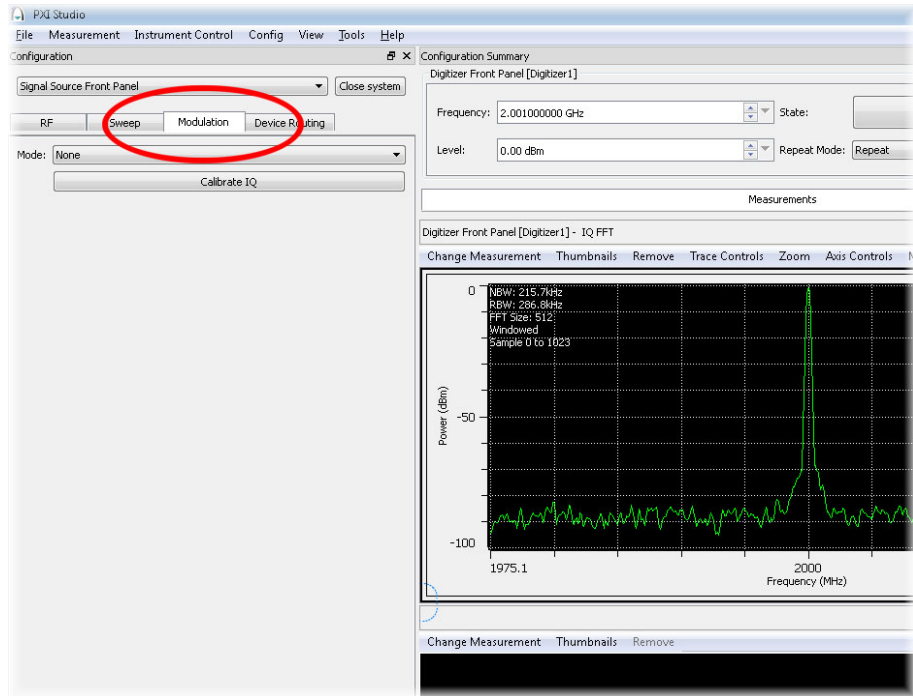Click **Start Capture** to display the 2 GHz carrier, as shown above.

Frequency standard check

Check that the frequency standard is locked. When it is, 'Locked' is displayed in green at the bottom right-hand side of the Signal Source or Digitizer screen:

# Set up the arbitrary waveform generator

Select the Modulation tab on the SigSource screen:

Select **Digital** modulation mode.

Select a file from the Current ARB File box (these are files that are in the arbitrary waveform generator's memory)or look at the Arb catalog (View Arb Catalogue) for all files that are available to be loaded into the arbitrary waveform generator's memory.
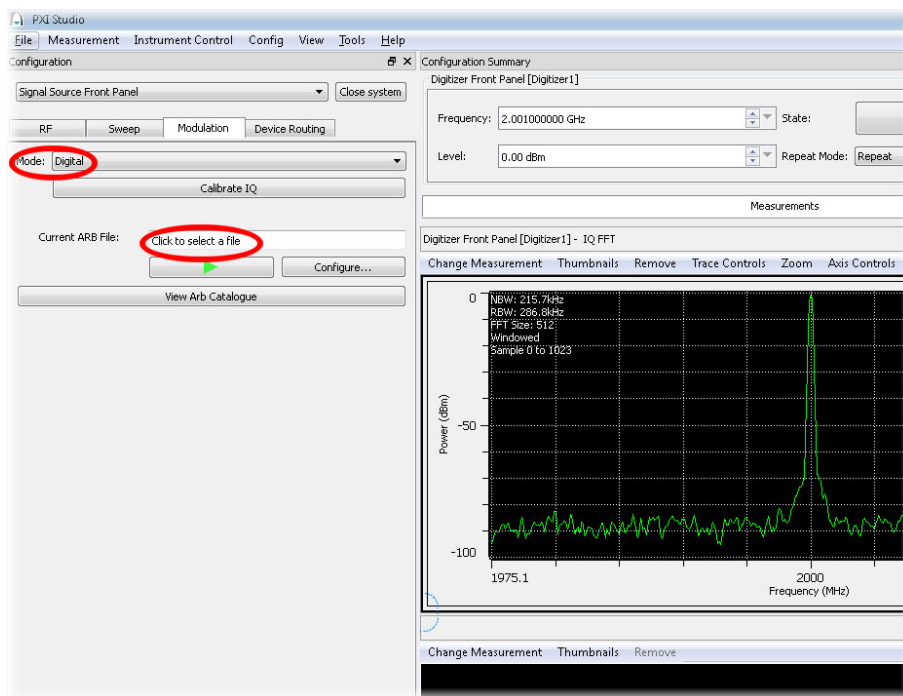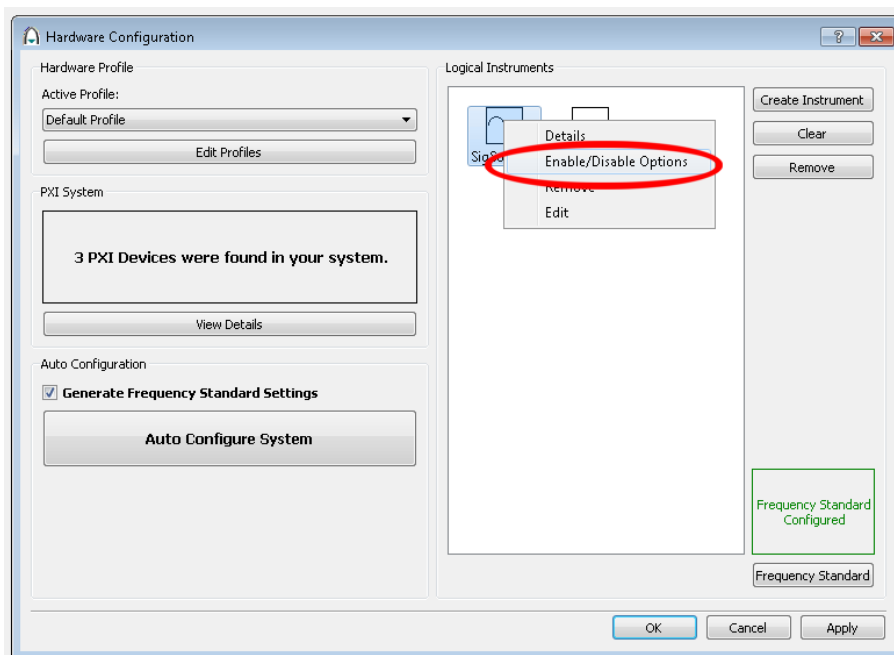
Click the play button [▶] and adjust the span and level (Sweep tab) as appropriate to display the waveform:
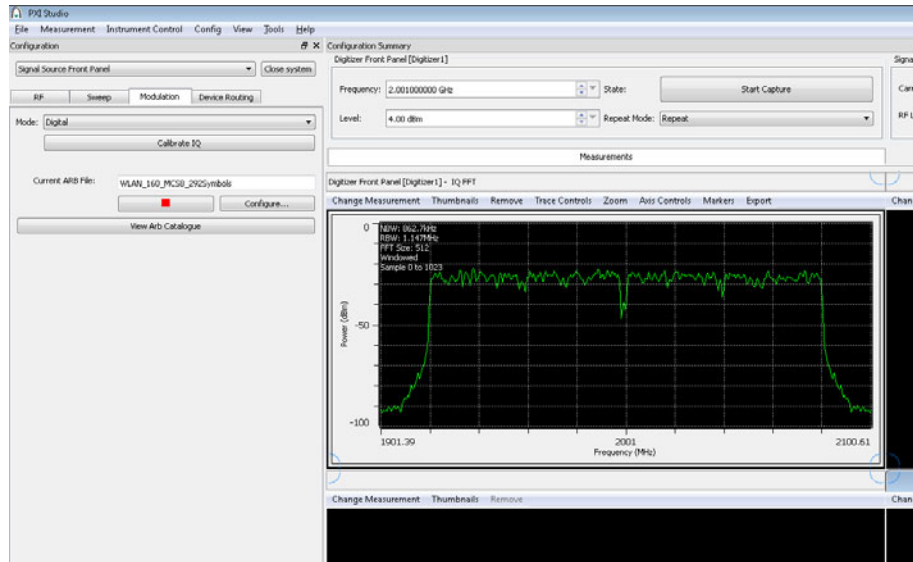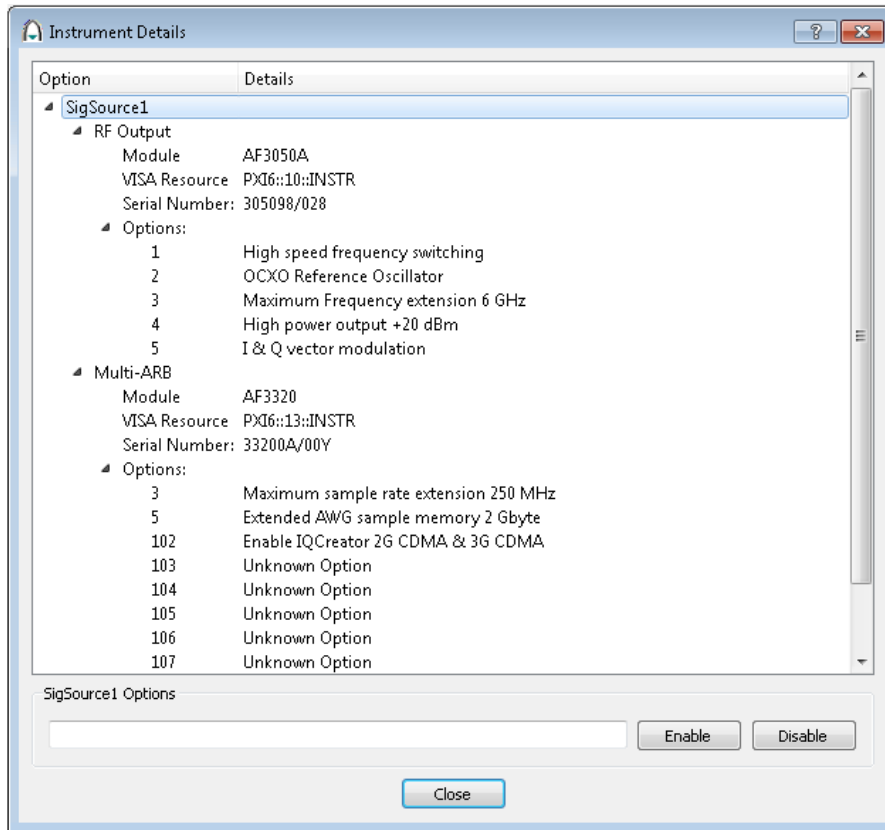
Viewing which options are fitted

You can view which options are currently fitted to the modules within the system.

Right-click on the logical instrument icons in the Hardware Configuration screen. Select Enable/Disable Options from the drop-down list:

The Instrument Details screen is displayed:

This identifies details of individual instruments and shows which options are fitted.

Enabling or disabling options

View the options currently fitted to the module.

- Contact Aeroflex for an option password.

- In the Instrument Details screen, click on the relevant device: the title of the Options box then displays the type of device.

- Enter the option password supplied by Aeroflex in the Options box.

- Click **Enable** or **Disable**. The option appears in, or is removed from, the instrument details.

- Click **Close**.

CAUTION

Do not interrupt power to the module during this operation, which takes approximately 1 s.

BRIEF TECHNICAL DESCRIPTION

Introduction

Fig. 6 shows a highly simplified block diagram of the 3070A.

For center frequencies of 350 to 6000 MHz, the 3070A operates as a single-conversion superheterodyne receiver. For center frequencies of 250 to 350 MHz, the 3070A directly samples the RF signal. Frequencies below 250 MHz are unconverted prior to sampling.

The RF path contains a switchable preamplifier and a RF attenuator control. In automatic attenuation mode, these controls are selected according to the expected peak signal level. The block diagram shows a simplified structure; in reality the RF design is broken into several switched paths, which are presented to the user as a single preamplifier and attenuator control. The broadband switches and attenuators used in the design are capable of extremely fast switching. Note that these devices are susceptible to damage by low frequency signals, as highlighted in *3070A RF input power handling*.

The input signal is converted to an IF frequency in the range 50 to 380 MHz, depending on carrier frequency. The IF frequency is reduced at lower center frequencies to improve spurious rejection at the expense of bandwidth. The IF is sampled in the first or second Nyquist zones of an ADC running at a fixed 400 MHz sample rate. The required user sample rate is generated digitally within a FPGA. The captured data is saved to memory, with a variety of triggering options.

Before the ADC, the signal is filtered with one of two anti-alias filters, depending on the required Nyquist zone. The signal level is adjusted with an IF attenuator, which can be set automatically or manually to optimize for noise or distortion in conjunction with the RF attenuator.

The local oscillator is derived from an internal fast low-noise synthesizer (FLNS). This synthesizer may be locked to its own internal OCXO or to an external reference. The ADC clock is locked to the FLNS.

For coherent LO applications, LO input and output connectors are provided. The local oscillator can be output at the LO OUT connector. A local oscillator can be supplied, via the LO IN connector, from another signal generator or 3070A module. Multiple 3070As can be cascaded to form a multi-channel coherent receiver. A leveling loop is used to maintain a well-controlled level at the mixer and LO OUT connector.
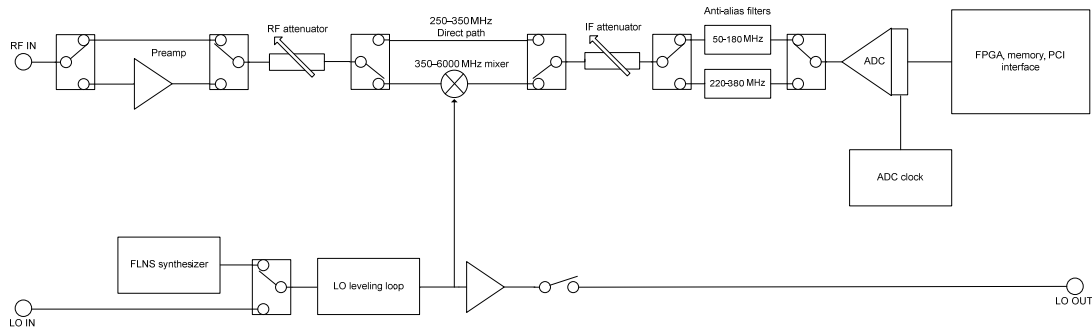

Fig. 6   3070A block diagram