Product Brochure

NI RF Recording Solution

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Recording RF Signals

Engineers and operators need to carry out RF data recording in labs, anechoic chambers, or open-air ranges for validating devices under test (DUTs). This stored data is often reused for RF playback. These applications require full rate, multichannel, phase-coherent systems, including calibration routines, to capture the test environment correctly. These systems typically require:

- Reliable recording of raw I/Q data
- Scalability as channel counts, data rates, and instantaneous bandwidths increase
- Channel-to-channel phase coherence
- Local and remote operation of recording systems

Contents

Solution Overview

- 1 GHz of instantaneous bandwidth recording on more than 8 channels, with phase synchronization across the full instantaneous bandwidth
- Independent or shared LO configurations, for either individual center frequencies per channel or phase alignment across channels
- Built-in calibration procedures for LO power, multichannel amplitude correction, and phase coherence across channels
- Up to 300 TB of data storage at transfer rates up to 40 GB/s per server
- Software features a GUI to simplify set up and utilization of hardware and includes APIs that can be used locally on the controller or remotely over a network connection
- Using calibrated, instrument-grade VST hardware allows parametric test and RF recording to be executed with a single hardware platform

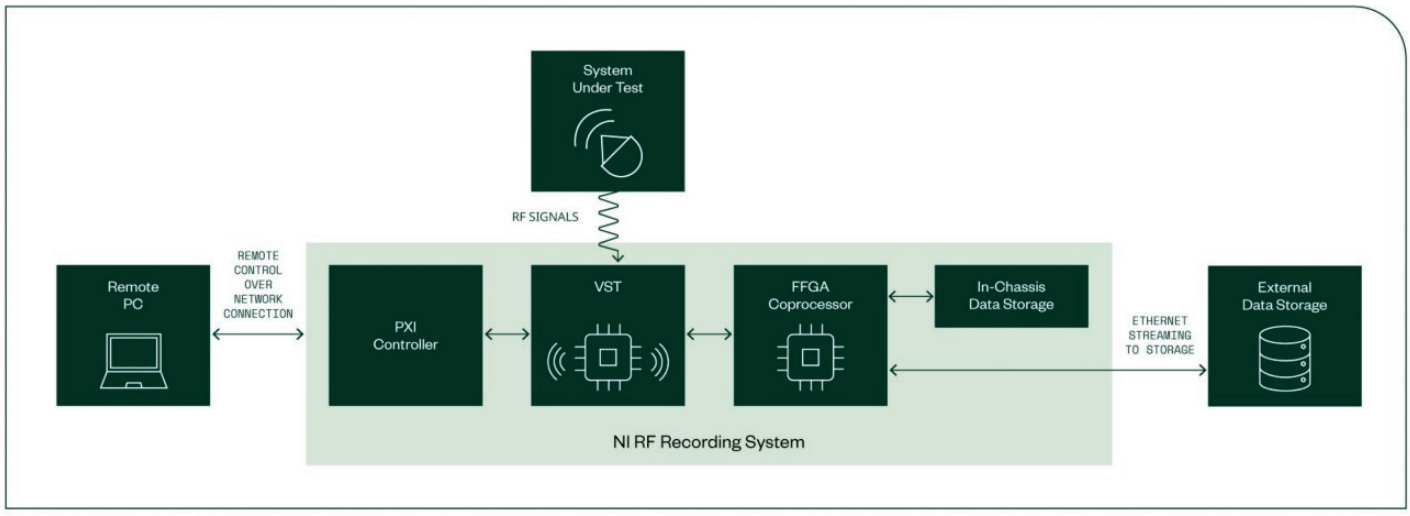


FIGURE 1
The NI RF Recording Solution

RF Recording Solution Specifications

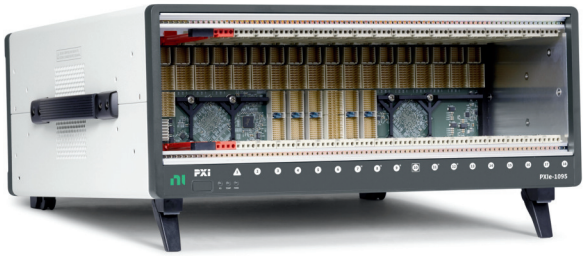
Specification	Value
Frequency Range	9 kHz – 6 GHz
Bandwidth	Up to 1 GHz (Instantaneous)
Operation Mode	Record Only
Number of RF Channels	Up to 32
System Level Calibration	• LO Power calibration • Phase Coherent Calibration • Wideband Phase aligned Calibration
Trigger Modes	Software
Storage Options	Ethernet Based Storage: • Up to 300 TB of system storage • Up to 150 TB of storage per RF channel • 1 GHz of IBW recording up to 32 channels PCIe Based storage: • Up to 24 TB per channel • Recording IBW of 1 GHz BW up to 2 channels (reduced IBW beyond 2 channels)
LO Configuration	•Independent LO setting/ Center frequency per channel •LO sharing option for phase alignment
Graphical User Interface	Ready to use GUI for: • Performing Power LO Calibration • Phase coherency/ phase alignment • Data preview and data recording
Programming Software	gRPC supported API (Remote operation supported)

Table 1: Specifications for NI's RF Recording Solution

Compatible Hardware

- The NI RF Recording Software works with COTS PXI modular instruments, and allows PXI Vector Signal Transceivers to operate as closed-loop, real-time radar target generators. The PXI chassis and controller are integral parts of the system, with the option to add coprocessing and timing & synchronization modules.

PXI Chassis



PXIe-1095, 18-Slot PXI Chassis

- High-bandwidth backplane with up to 24 GB/s of system bandwidth
- Up to 82 W of power and cooling in every slot
- Two hot-swappable power supplies to improve the mean time to repair (MTTR)
- Timing and Synchronization option that includes a built-in oven-controlled crystal oscillator (OCXO) for increased clock accuracy and external clock and trigger routing.
- Accepts PXI Express modules in every slot and supports standard PXI hybrid-compatible modules in up to five slots.

FIGURE 2

The PXI chassis plays an important role in transporting data between modules and the host controller, as well as providing cooling, timing, and synchronization.

PXI Controller

PXIe-8881, Intel Xeon 8-Core x86 Processor

- Ideal for processor-intensive and high-throughput streaming in RF applications.
- 24 GB/s system bandwidth
- Includes two Gigabit Ethernet ports, two USB 3.0 ports, four USB 2.0 ports, and two Thunderbolt 3 ports.
- Removable hard drive
- Available with 16 GB, 32 GB, or 64 GB memory

FIGURE 3

The PXI controller provides embedded computing within the PXI chassis, and runs any host-based processing functions within the RF Recording System.

Vector Signal Transceivers

PXIe-5841 Vector Signal Transceiver

- Combines RF generation and acquisition into a single PXI module
- Up to 21 GHz frequency coverage, extendable to 44 GHz with frequency extender
- Up to 1 GHz instantaneous bandwidth
- Features the flexibility of a software defined radio architecture with RF instrument class performance
- Utilizes NI-TClk timing and synchronization technology to synchronize with more VSTs or other instruments, for multichannel applications

FIGURE 4

Vector Signal Transceivers provide the acquisition capability needed for validation of RF devices under test.

High-Speed Serial Instruments

PXIe-7903, 28.2 Gbps, 48-Channel PXI High-Speed Serial Instrument

- Designed for engineers who need to validate, interface through, and test serial protocols.
- Includes a Xilinx Virtex UltraScale+ FPGA to implement various high-speed serial protocols.
- Programmable in LabVIEW FPGA for maximum application-specific customization and reuse.
- Takes advantage of FPGA multigigabit transceivers for up to 48 TX and RX lanes.
- Industry-standard QSFP28 connectivity (compatible with QSFP+)
- 20 GB onboard DRAM

FIGURE 5

The RF Recording Software supports the use of the PXIe-7903 High-Speed Serial Instrument as an FPGA coprocessor, for data aggregation and signal processing.

Timing and Synchronization

PXIe-6674T, OCXO Synchronization Module

- Generates and routes clocks and triggers between devices in a PXI Express chassis
- In the RF Recording Solution, generates a highly stable 10 MHz clock based on an onboard precision oven-controlled crystal oscillator (OCXO) reference.

FIGURE 6

The PXIe-6674T OCXO PXI Synchronization Module exports and imports reference clocks and triggers in systems with 8 or 16-channel configurations.

CDA-2990, 8-Channel 10 MHz Clock Distribution Device

- Accepts external 10 MHz and pulse-per-second (PPS) input signals and amplifies and distributes them to eight output ports
- Only the version without a GPS-disciplined oven-controlled crystal oscillator (GPSDO) is supported by the RF Recording Solution

FIGURE 6

The CDA-2990 Clock Distribution Device shares the reference clock and triggers in a star configuration for systems with 8 or 16 channels.

Local Oscillator Amplification

Signal Craft Technologies SC2215 Programmable Gain RF Amplifier

- Two-channel programmable gain amplifier that operates from 10 MHz to 26.5 GHz
- Over 31.5 dB of programmable gain, controllable in 0.5 dB increments
- Uses solid-state switches to minimize reliability concerns
- Onboard thermal measurement and in-circuit, high-frequency power detectors minimize outages

FIGURE 6

The Signal Craft Technologies SC2215 shares the LO source in a star configuration for systems with 8 or 16 channels.

Data Storage

The RF Recording Software offers two forms of data storage—local and remote—depending on the channel count in your system.

- Local Storage—Stores raw IQ data to NI TDMS files on RAID drives local to the same PXI controller. Local storage is supported for systems with up to two channels, each recording at 1 GHz instantaneous bandwidth (IBW).
- Remote Storage—Stores raw IQ data to binary files on one or more external data storage computers. Remote storage is extendable for systems with up to 16 channels, each recording at 1 GHz IBW.

PXIe-8267 Data Storage Module

- Large-capacity, high-throughput storage in a single PXI Express slot.
- Features M.2 solid-state drives, ideal for stream-to-disk or stream-from-disk applications requiring sustained, reliable data throughput

FIGURE 7

In-chassis data options provide up to 24 TB of storage per channel, at an instantaneous bandwidth up to 1 GHz for 2 channels or fewer.

Dell PowerEdge R7525 Rack Server

- Built upon a scalable system architecture, providing flexibility to meet open-ended performance demands.
- Up to two 2nd or 3rd Generation AMD EPYCTM Processors with up to 64 cores per processor

FIGURE 8

Ethernet-based storage with servers provides up to 300 TB of system storage, at up to 150 TB per channel. This allows recording of instantaneous bandwidths of 1 GHz on up to 32 channels.

Software Overview

The RF Recording Software includes two entry points to interface with the system:

- InstrumentStudio Panel
- API

The basic installation provides core RF recording functionality which includes the RF recording personality for VSTs, a server to listen for remote commands, and Instrument Studio plugins for user interaction. The software is installed as an executable application on the PXI controller. This setup requires the NI License Manager and the NI Volume License Manager.

In addition to the interface provided by the soft front panel, the RF recording system can be controlled programmatically through the API included in the software installation.

The provided gRPC protocol buffer files expose a programming interface that you can use to communicate with the server, perform an LO power calibration, and phase calibration. You can use any gRPC-supported programming language to write the application.

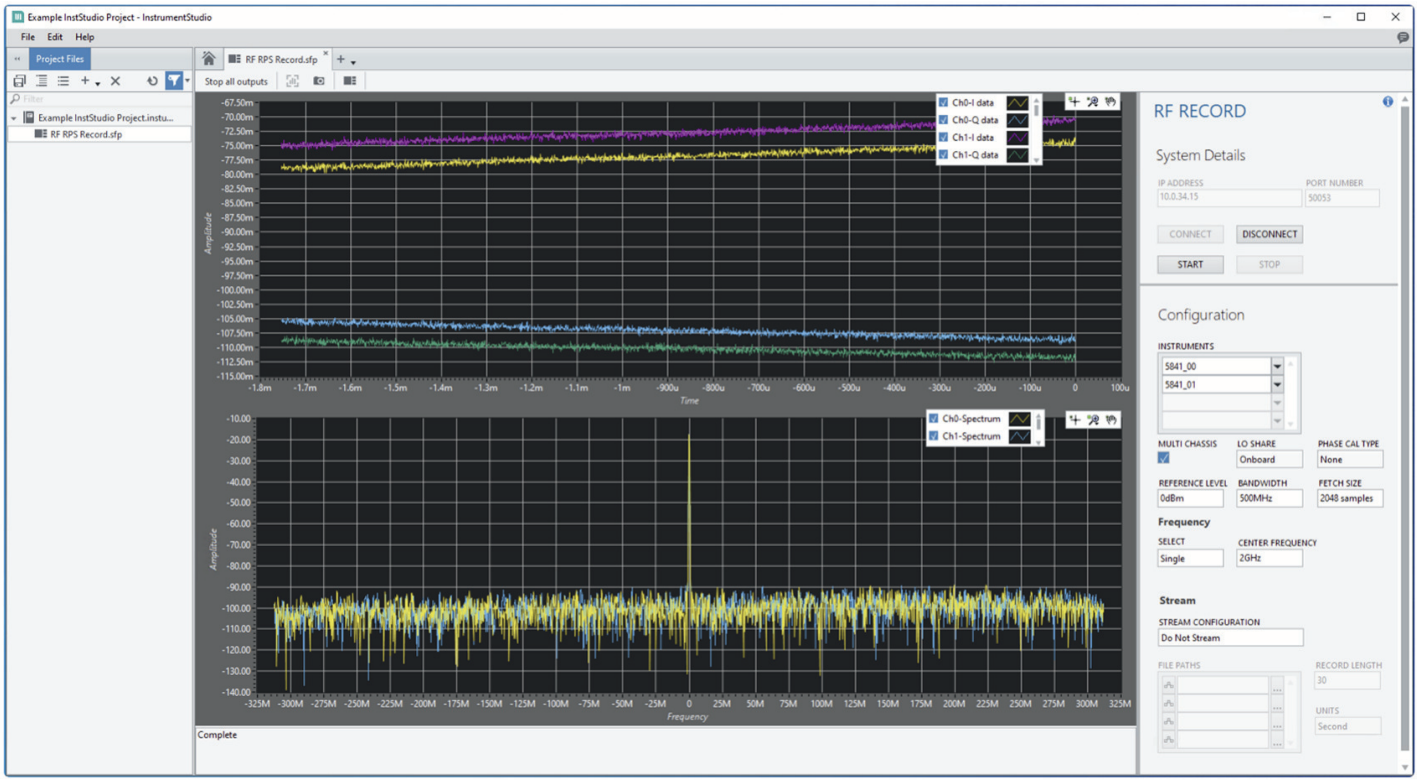


FIGURE 9

The InstrumentStudio plugin allows users to confiigure recordings via a soft front panel.

Calibration

The RF Recording Software system offers up to three phases of calibration, depending on the configuration of your system. The three calibration phases are VST self-calibration, acquisition LO calibration, and acquisition phase calibration. These calibration routines maximise the performance of your system.

LO Power Calibration

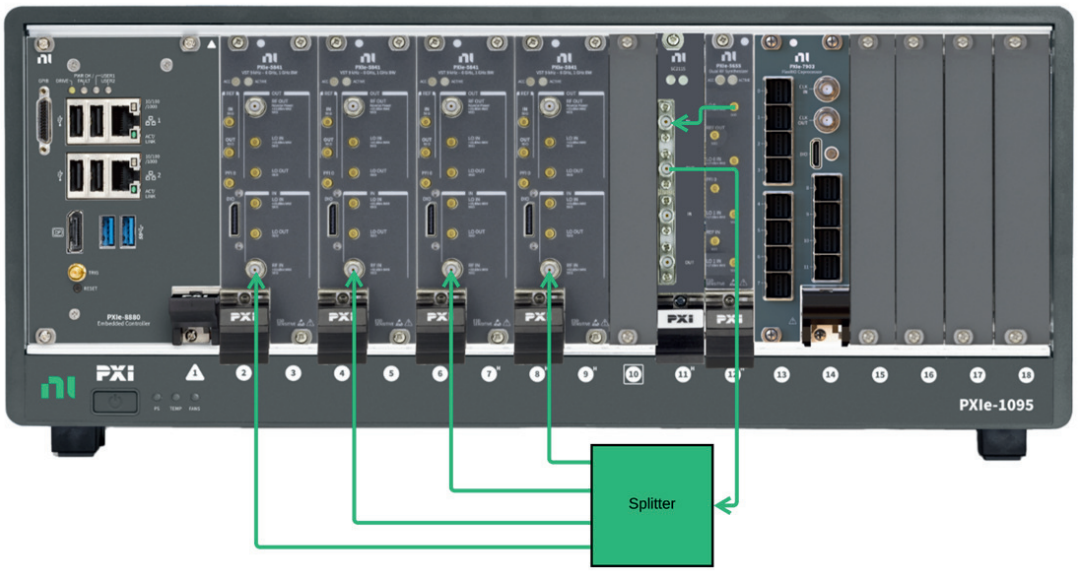


FIGURE 10

Acquisition LO calibration ensures the power level received by every PXIe-5841 RF IN connector is within appropriate/specified limits.

Phase Calibration

The phase calibration step performs relative phase and amplitude adjustments across the full 1 GHz instantaneous bandwidth of the VSTs used in the RF Recording Solution. The stored parameters can be used to apply adjustments during the subsequent recording of RF signals. See the RF Recording Software User Manual for more details.

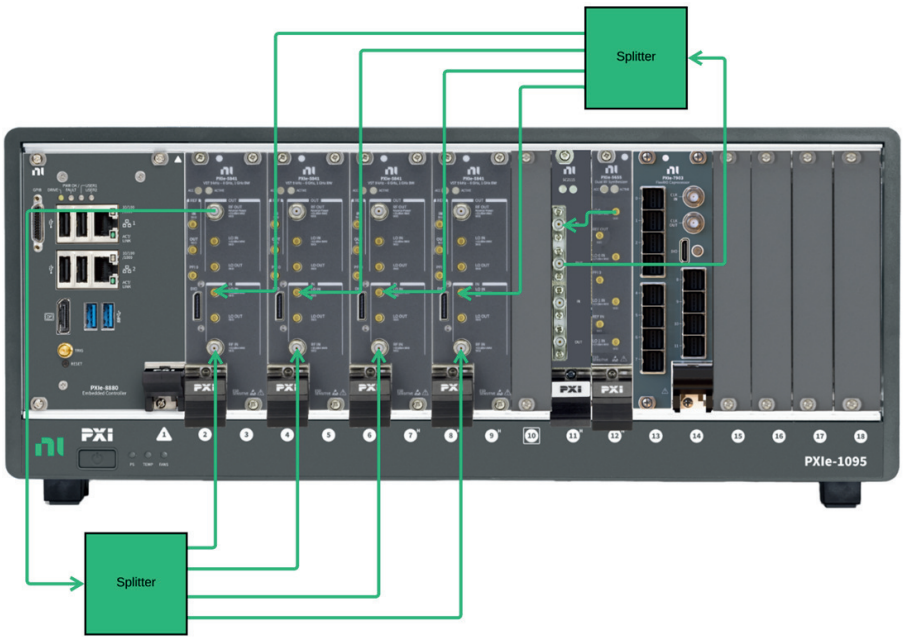


FIGURE 11

Acquisition phase calibration adjusts the relative channel-to-channel phase performance of the VSTs.

Data Movement

The RF Recording System uses up to eight Aurora streams at up to ~5 GB/s from eight VSTs to a PXIe-7903 coprocessor. This can scale up to 40 GB/s total. This streaming speed allows support of up to 2 GHz instantaneous bandwidth.

After aggregation and processing on the PXI-7903, 100 GbE UDP packets are transmitted to two network interface cards (NICs) on the Dell PowerEdge R7525 rack server. This allows 10 GB/s to be transmitted per 100 GbE connection, up to 40 GB/s total.

At maximum capacity, each R7525 server can hold up to 24 15 TB NVMe drives.

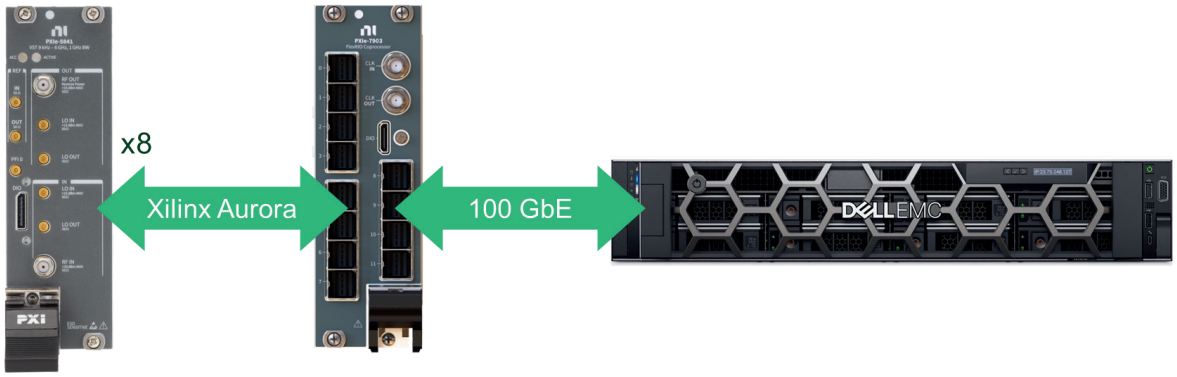


FIGURE 12

Eight VSTs can stream data at around 5 GB/s, up to 40 GB/s total, to a copressor module using the Aurora protocol. Data may then be offloaded to a rack server over 100 GbE connections.

Phase and Amplitude Stability

The RF Recording Solution is designed for multichannel recordings with phase coherence across channels. Figures 13 and 14 show measured performance of phase and amplitude stability across a 1 GHz instantaneous bandwidth, measured for 12 hours across two channels in a single PXI chassis in a controlled temperature environment.

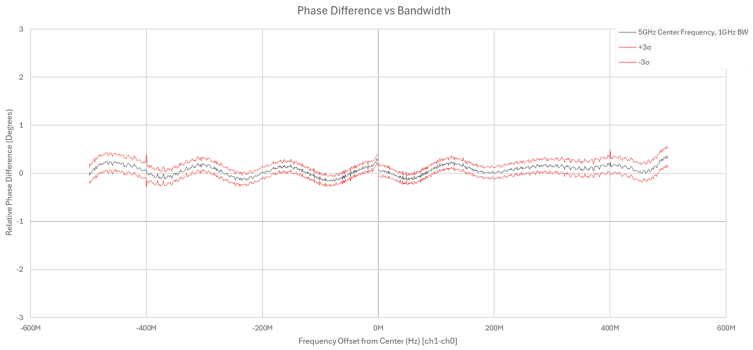


FIGURE 13

Measured phase difference between two channels in a single chassis over a 12-hour time period in a controlled temperature environment.

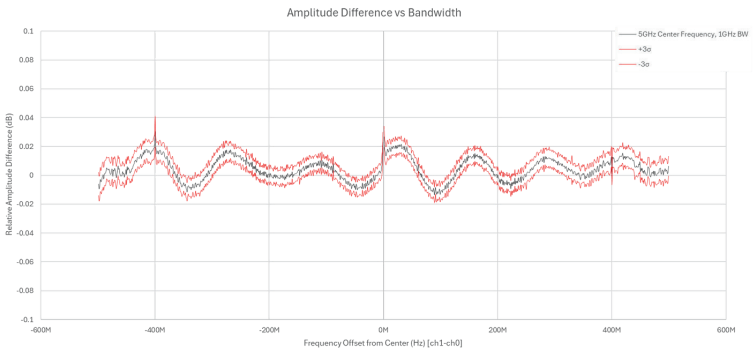


FIGURE 14

Measured amplitude difference between two channels in a single chassis over a 12-hour time period in a controlled temperature environment.

System Integration on Your Terms

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