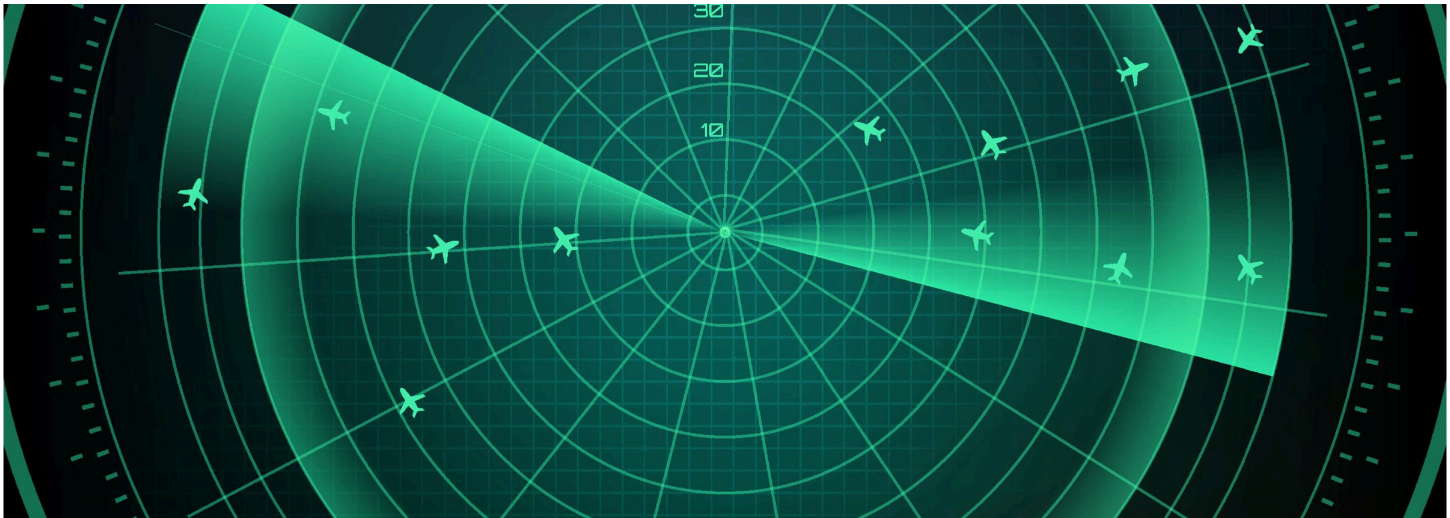
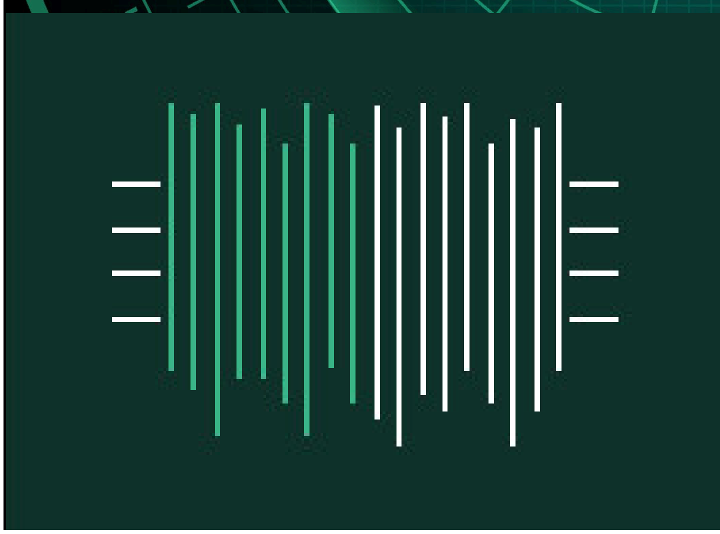
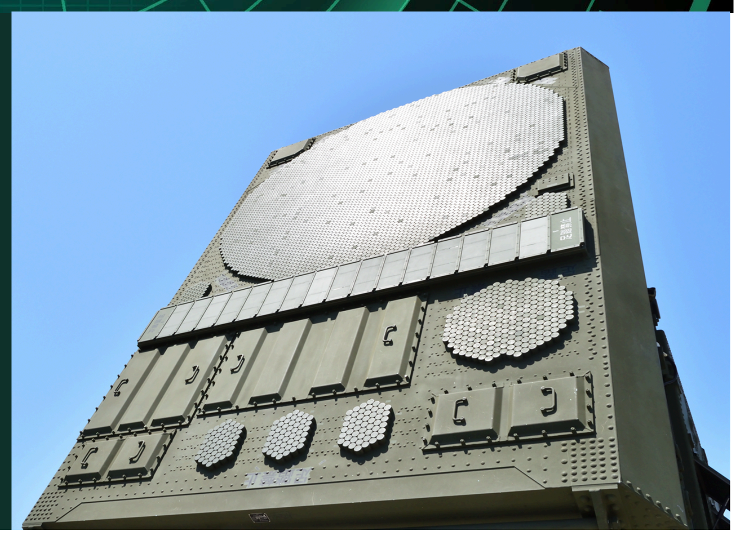
NI is now part of Emerson.







Solution Brochure

Radar System Test Solutions

Explore NI's Radar System Test Solutions

Contents

The Importance of Radar Test

Radar technology is critical for air surveillance, defense systems, precision navigation, space applications, and more. To meet future electromagnetic spectral operation requirements, modern radars are increasingly designed to be frequency agile, cognitive, and multi-modal, utilizing ultra-broadband active electronically scanned arrays (AESA) to adapt to the ever-changing electromagnetic spectrum environment. Due to the increased complexity and cost of designs, identifying issues before the open-air range test has never been more important. Today, radar engineers leverage powerful modeling and simulation tools to digitally test designs prior to implementation. However, hardware testing from components to sub-systems to integrated system-level tests is of critical importance to ensure Radar sensors deliver performance once deployed.

Modern Radar System Test Requirements

- Wide-Band RF Parametric Test
- Digital System Functional Testing
- Multi-Channel and Multi-Function Ready
- Closed-Loop Real-Time System Level Radar Target Geneartion

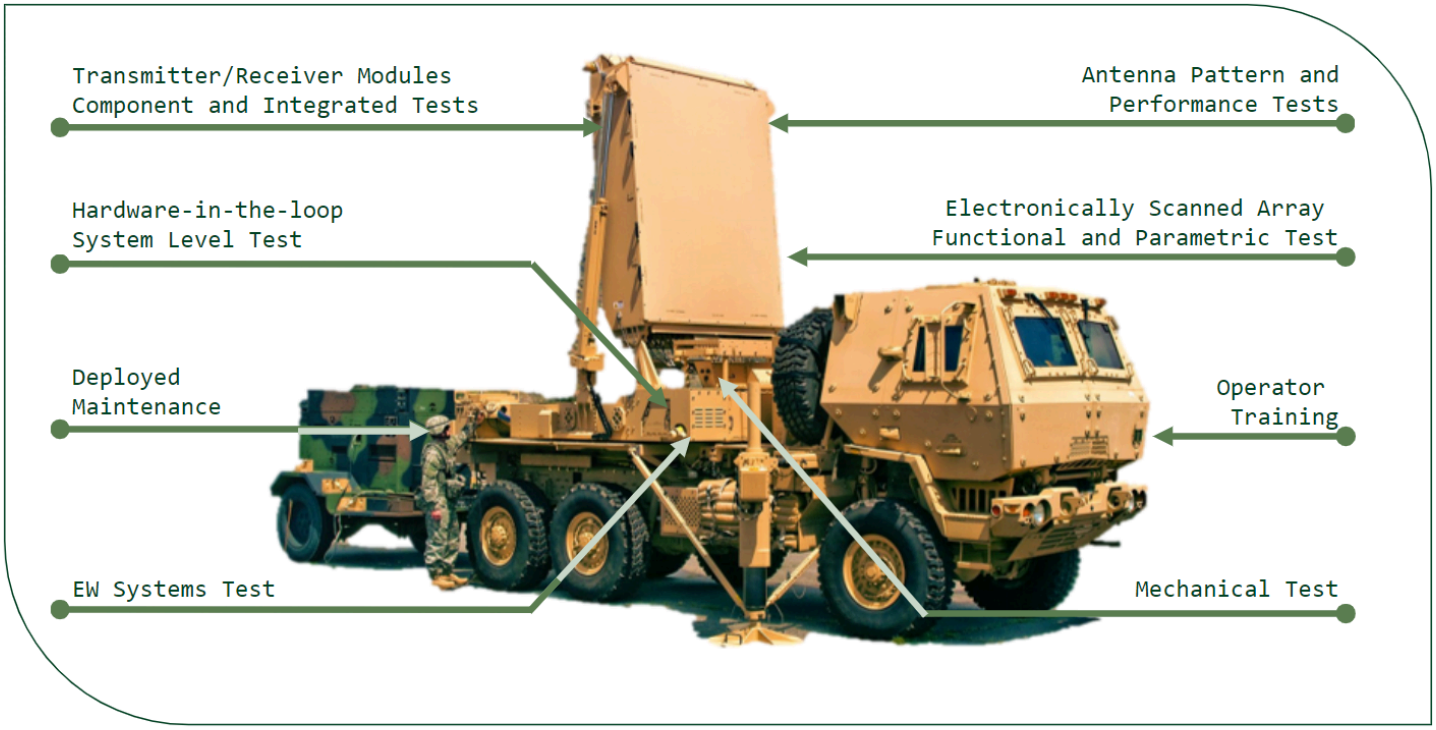


FIGURE 01

Critical Systems to Test on Modern Radar Systems

Overview of NI Solutions for Radar Test

The NI approach to Radar System Test combines COTS modular hardware and flexible software tools to address all components of the radar system, from digital sub-systems to RF parametric test to end-to-end system level functional test. NI solutions are built on the PXIe modular platform that can be customized to meet your specific IO performance requirements.

The NI Vector Signal Transceiver (VST) is the central RF technology for Radar RF Systems test. On its own, the VST can transmit and receive any RF signals performing key signal fidelity measurements such as transmit power, modulation accuracy, TOI, Radar pulse stability, and more. The VST can be paired PXIe Source Measure Units (SMUs), RF Switches, and external couplers to perform parametric measurements such as power added efficiency and S-parameters. Engineers can perform full end-to-end system level test with the NI Radar Target Generation driver for the VST, unlocking the ability to inject multiple independent precision test targets for system level performance evaluation.

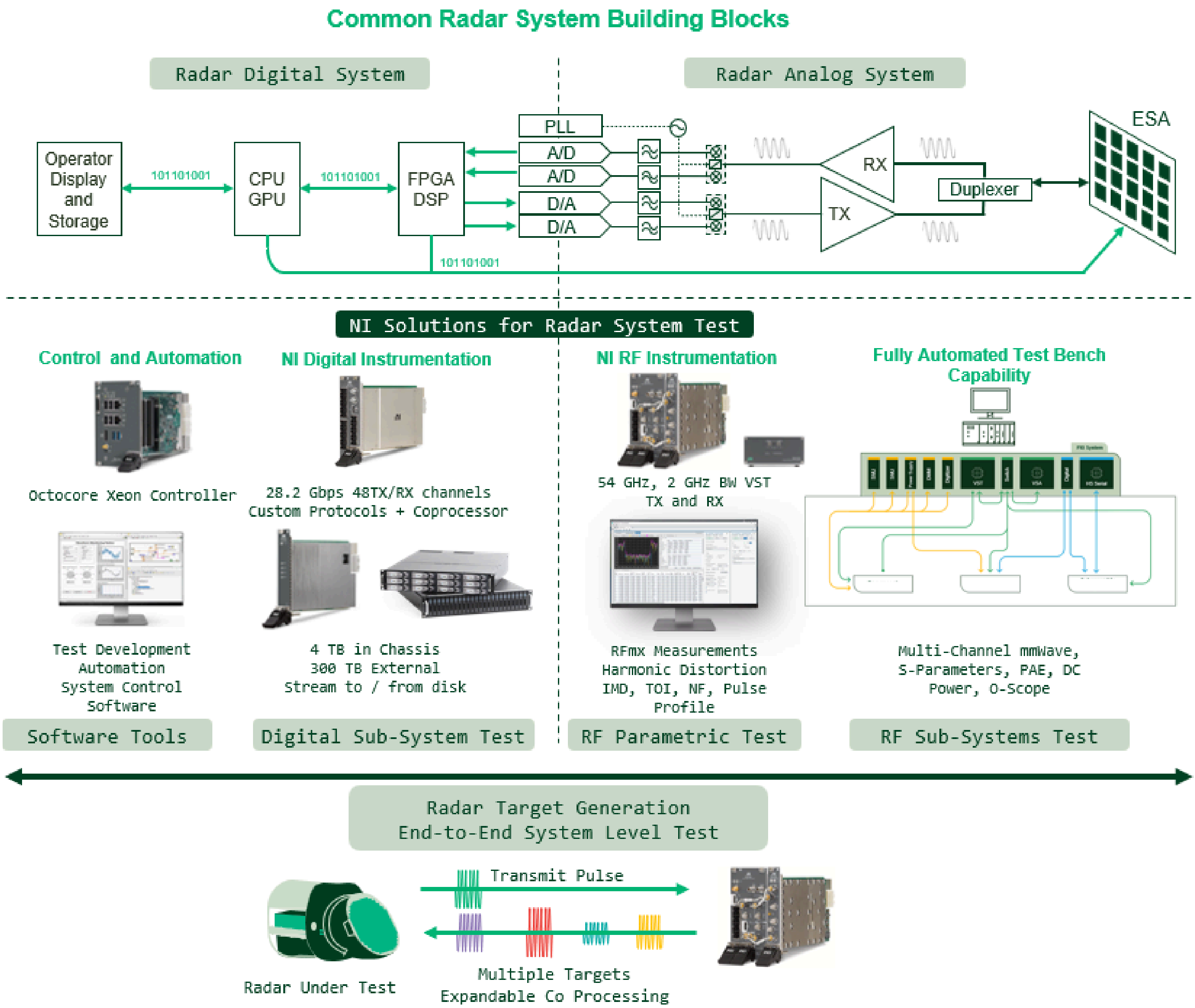


FIGURE 02

Common Radar System Building Blocks and NI Test Solutions

Radar RF Parametric Test Hardware and Software

Vector Signal Transceiver

The PXI Vector Signal Transceiver (VST) product line combines a vector signal analyzer and vector signal generator with a common FPGA and high-speed digital interfaces for real-time signal processing and control. With up to 4 GHz of instantaneous RF bandwidth, and frequency coverage from 9KHz to 54GHz its fully capable of covering the most common Radar operational frequencies. The NI VST is ideally suited for pulsed signal generation and spectral analysis. The VST provides the high-performance measurements and the fast speed for automation in a small form factor. You can use VST instruments throughout the development cycle from design to validation to production test—minimizing measurement correlation errors and improving efficiency with test software reuse. The modular PXI platform allows users to configure systems with multiple VSTs to support multiple input, multiple output (MIMO) applications, and simplifies synchronization between instruments thanks to shared timing and synchronization resources in the PXI chassis.

FIGURE 03

PXIe-5842 Vector Signal Transceiver

FIGURE 04

PXIe-5668 Vector Signal Analyzer

Vector Signal Analyzer

PXI Vector Signal Analyzers (VSAs) feature a wide frequency range, real-time signal analysis, and advanced signal processing. These instruments can perform measurements for a broad range of wireless technologies with select models featuring a LabVIEW-programmable FPGA that you can customize for advanced measurement applications. PXI VSAs are ideal for Radar parametric test due to their flexibility and excellent RF specifications. NI's VSA portfolio is highlighted by the PXIe-5668, which offers up to 765 MHz of instantaneous bandwidth up to 26.5 GHz with industry-leading dynamic range, and best-in-class measurement performance and speed.

RFmx Measurement Software

RFmx is a set of interoperable software applications that optimize NI RF instrumentation for general-purpose, cellular, connectivity, and aerospace/defense test applications. RFmx streamlines test system development by accelerating setup, measurement, and performance. Soft front panels provide an intuitive interface for connecting to hardware, enabling users to efficiently perform measurements and debug automated tests. Composite measurement functionality and parallelized execution ensure maximum instrument utilization for test time reduction. You also can perform and debug measurements with interactive software front panels, create and playback open, unlocked waveforms with the included RFmx Waveform Creator, and speed up automated testing with the performance-optimized API. And with dedicated personalities for conventional spectrum analysis, modulated signals, and standard defined signals, RFmx is tailored to your application.

FIGURE 05

Use RFmx soft front panels for interactive measurement of complex RF signals

RFmx SpecAn

RFmx SpecAn enhances NI RF instruments for spectrum analysis and device characterization. It allows signal analysis in time, frequency, and power domains, including TXP, ACP, and CCDF measurements. You can correct AM-AM/PM distortion with built-in DPD models or validate beamformer performance by capturing PAvT.

RFmx Phase Noise

RFmx Phase Noise, running within RFmx SpecAn, enhances NI RF instruments for phase noise analysis. It measures log plot, spot, and integrated phase noise with automatic or manual range settings. Advanced techniques like trace smoothing, spur removal, and instrument phase noise cancellation improve measurement performance.

RFmx Noise Figure

RFmx Noise Figure, running within RFmx SpecAn, enhances NI RF instruments for noise figure, gain, and effective temperature measurements using Y-factor and Cold Source methods. It improves accuracy with built-in calibration and reduces test time with integrated noise source control and multifrequency optimization.

RFmx Demod

RFmx Demod enhances NI RF instruments for analog and digital modulated signal analysis. It supports various modulation schemes (AM, FM, PM, ASK, FSK, MSK, PSK, QAM) and measurements like analog distortion, frequency error, EVM, and demodulated bits. Advanced signal processing includes pulse shape filtering, equalization, synchronization, and impairment compensation.

"With the increased emphasis on digital active electronically scanned arrays, systems are becoming more capable and multi-functional than ever before. For test engineers, this creates the technical challenge of validating fundamental component and system level RF parameters over a wide variety of test cases and applications. The Electronically Scanned Array Characterization Reference Architecture allows test engineers to validate high mix test plans more efficiently than traditional single function test equipment by combining modular, software connected RF instrumentation with trusted measurement science with a validated system configuration."

Abhay Samant - Director of Systems Research & Development: Aerospace, Defense, & Government

Pulsed RF Measurements Library

A unified software experience across the design cycle

With easy-to-use, interactive interface panels for developing and debugging systems, to automatable APIs for deploying both characterization as well as production test systems, the Pulsed RF Measurements Library provides a unified software experience for testing ESA components and modules across the design cycle. In addition to easy-to-use panels, the library also includes support for several development environments including LabVIEW, C, C#, and .NET, as well as for FPGA programming.

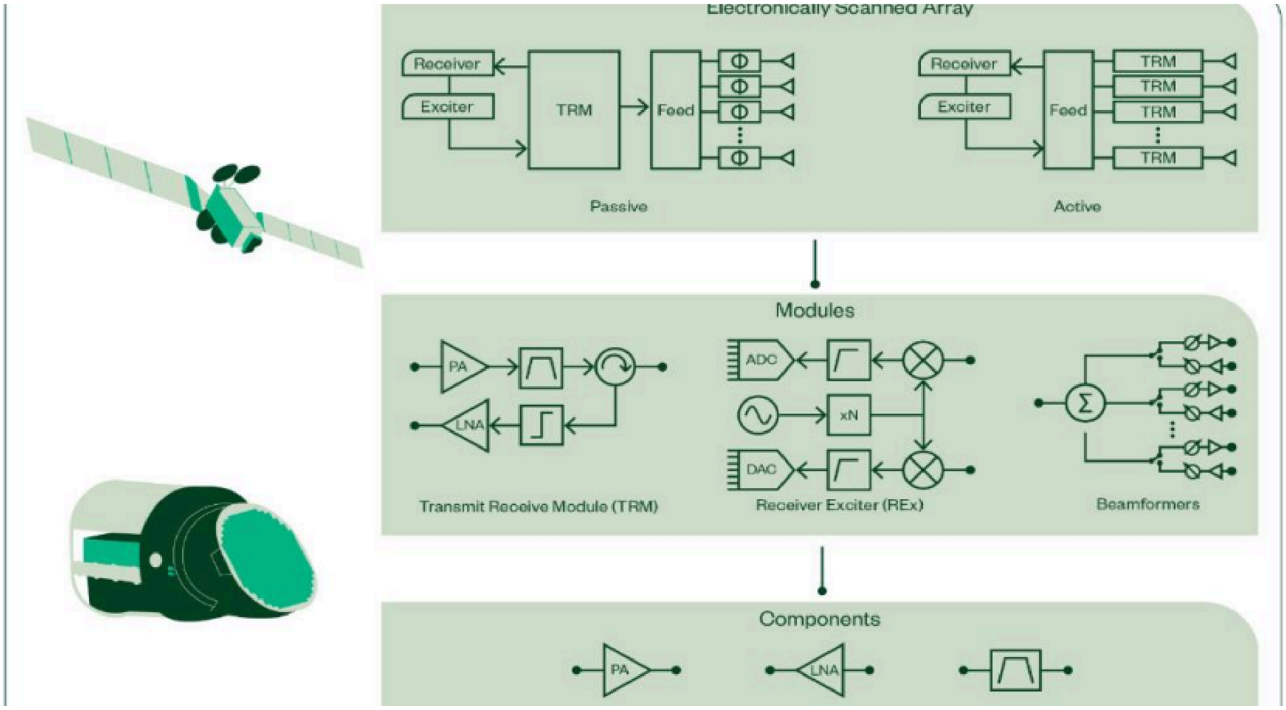


FIGURE 06

Components and Modules Used in the Latest Electronically Scanned Arrays for Radar and Satellite Communication Applications

Key Measurement Capabilities

- Power and phase stability
- Power added efficiency
- Network analysis and S-Parameters
- Spectral analysis
- Pulse profile and stability
- Phase noise

"Teams developing the next generation of phased array technology are under significant market pressure. Rapid technological advancements introduce new testing scenarios that must be addressed more quickly than before. Traditional methods lack the scalability needed to meet these challenges and add risk. The Electronically Scanned Array Reference Architecture enables teams to confidently validate and test new phased arrays and their components in a more scalable manner than traditional market solutions."

Reggie Rector - Senior Director and General Manager: Aerospace, Defense, & Government

Pulse Profile and Pulse Stability Measurements

The designs of active components in an ESA are significantly affected by heating effects and nonlinear distortions due to increasing complexity, denser architectures, and GaN technology. These designs also face trapping and memory effects with pulsed signals and gate pulsing circuitry.

Under these conditions, components may become unstable, causing output pulse variations in phase and amplitude, leading to transient distortions like overshooting, undershooting, drooping, and variations in pulse repetition interval (PRI). For Radar systems, this results in reduced signal-to-noise ratio (SNR), incorrect parameter estimation, false target detection, and limitations in detecting small cross sections, among other performance degradations.

FIGURE 07

Measurement Panel for Taking Pulse Profile and Stability Measurements Included with the Pulsed RF Measurements Library

Common Test Challenges

- Synchronizing RF pulsed stimulus with DUT control to accurately characterize component stability
- Instrumentation phase noise negatively affects measurement accuracy
- Limited RF instrumentation bandwidth reduce test coverage

The NI Advantage:

- Wide frequency coverage from sub-L to Ka band and flexible bandwidth configuration up to 1 GHz to tailor the test system to the design.
- Tight sub-nanosecond synchronization between PXI modules for synchronous RF pulsing and flexible trigger routing for DUT control.
- Phase stability up to -90 dB with low phase noise impact due to shareable LO between transmit and receive

S- Parameter Measurements

Accurately predicting and controlling the interaction between front-end components (power amplifiers, duplexers, and phase shifters) requires focusing on input/output port impedance mismatch and antenna mutual coupling. This is achieved by characterizing reflections and transmissions, known as scattering parameters (S-parameters). S-parameter measurements can be used for calibration or application-specific processing, such as radar cross section and spectrum flatness.

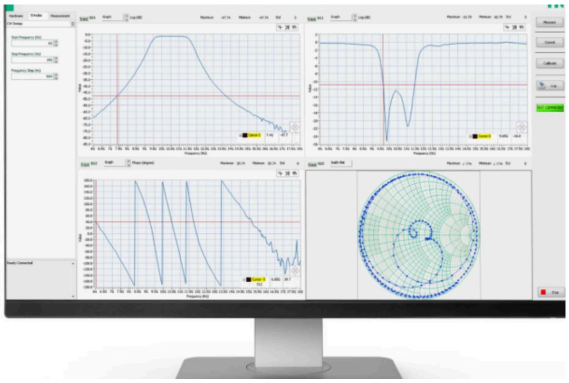


FIGURE 08

S-Parameter measurement soft front panel

Common Test Challenges

- Correlation of small signal and large signal analysis due to multiple instruments
- Complexity of DUT interfaces distorts built-in reflectometry of VNA
- Performing fundamental RF measurements under unique application-specific stimuli

The NI Advantage:

- Perform flexible S-parameter measurements using CW and pulsed waveforms on the same HW as large signal analysis.
- Combine S-parameters with other parametric tests and simplified integration using a single reconfigurable and modular system.
- Reduce overall test time and cost with unified software experience and increased hardware reuse.

Power Added Efficiency Measurements

Monolithic microwave-integrated circuit (MMIC) designs are demanding more efficiency and higher performance while reducing the component's footprint, maintaining reliability, and lowering test cost. With the move toward integrated antenna arrays and the introduction of 5G in radar systems, satellites, and wireless connectivity applications, new MMIC designs and solid-state devices are expected to deliver higher RF power and wider operational bandwidth while lowering power consumption and limiting heat dissipation.

Power added efficiency (PAE) is one of the most common figures of merit to characterize and validate power amplifiers and integrated circuits. The newest MMIC designs impose a real challenge to the component's characterization and validation process, due to the need for higher signal integrity and lower cost modular test systems capable of measuring all component-specific performance indicators.

Common Test Challenges

- Synchronization of RF and DC instrument for accurate measurement results
- Traditional measurement setups are challenging and difficult to use
- Automating sweep measurements

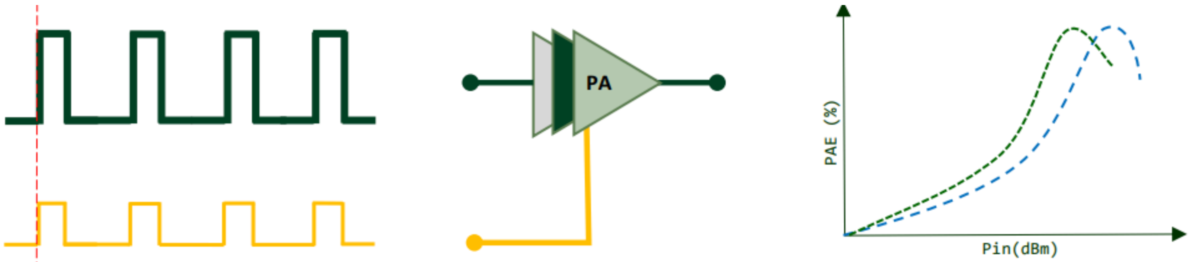


FIGURE 09

Combine a Source Measurement Unit with a Vector Signal Transceiver in a Synchronous PXI System to Accurately Measure PAE

The same data set that is used for PAE can also be used to calculate the compression points of your DUT. The Pulsed RF Measurements Library includes the calculations for the P1dB, P2dB, and P3dB compression points.

The NI Advantage:

Easy-to-use integration of DC and RF measurements in both interactive examples and programmatic APIs

Tight sub-nanosecond synchronization between PXI modules for synchronous RF pulsing, DC triggering, and DUT control

High-precision DC and RF instrumentation and scalable measurement capabilities with reduced test time for performing frequency

FIGURE 10

Measurement Panel for Taking Power Added Efficiency and Compression Point Measurements Included with the Pulsed RF Measurements Library

Radar Digital System Test Hardware and Software

Modern Radars are built on advanced digital sub-systems to perform radar system signal processing for target tracking, identification, and cognitive/adaptive functions. Testing digital systems independently from RF systems gives engineers the ability to validate algorithms and system functionality prior to RF systems integration. Common functions performed with NI digital instrument technology include digital Radar target generation, adaptive threat testing, and custom digital protocol validation.

High-Speed Serial Instrument

PXIe High-Speed Serial Instruments are designed for engineers who need to test digital interfaces and perform digital system level validation through high-speed serial protocols. These are built on AMD Ultrascale+ FPGA technology and are programmable through the high-level programming environment of LabVIEW FPGA for maximum application specific customization and reuse. These instruments take advantage of FPGA multigigabit transceivers (MGTs) to support line rates up to 28.2 Gbps and up to 48 RX/TX connectors. As part of the PXI platform, they benefit from PXI clocking, triggering, and high-speed data movement capabilities, including streaming to and from disk, as well as peer-to-peer (P2P) streaming.

FIGURE 11

PXIe-7903 High Speed Serial Instrument

FIGURE 12

PXIe-8267 High Performance RAID

High Capacity in System Storage

Radar digital systems test often relies on streaming test data to and from storage to record test data or playback digital patterns. NI's high capacity system storage consists of either in chassis RAIDs with up to 4 TB per PXIe slot, or third-party options with up to 64 TB per module. All storage solutions are based on the PXIe Gen 3 x8 backplane and can stream up to 7.1 GB/s sustained read and write.

PXI FlexRIO Coprocessor Modules

XI FlexRIO Coprocessor Modules feature high-performance FPGAs that add signal processing capability to PXI systems. These modules leverage the latest FPGAs from AMD Xilinx, streaming technologies such as PCI Express, and NI Peer-to-Peer Streaming for high-bandwidth data communication with other modules over the backplane. When paired with another PXI device, such as a PXI Vector Signal Transceiver, PXI FlexRIO Coprocessor Modules provide the additional FPGA resources required to run complex algorithms in real time. Import your VHDL or Verilog channel model algorithms easily with LabVIEW FPGA Component-Level IP (CLIP) integration capabilities.

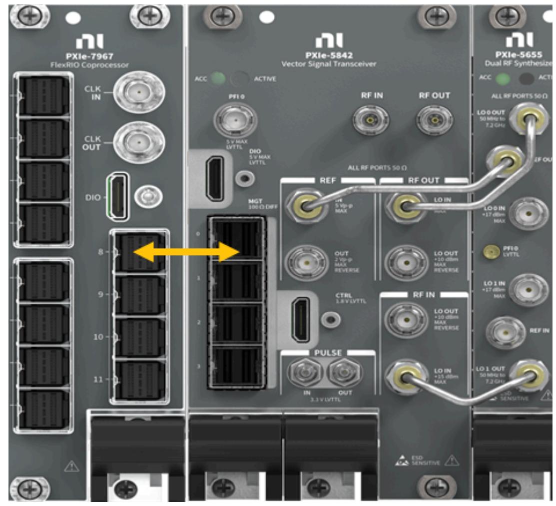


FIGURE 13

PXIe FlexRIO Coprocessor Modules

LabVIEW FPGA

LabVIEW FPGA is a software add-on for LabVIEW that you can use to more efficiently and effectively design FPGA-based systems through a highly integrated development environment, IP libraries, a high-fidelity simulator, and debugging features. You can create FPGA VIs that combine direct access to I/O with user-defined LabVIEW logic to define custom hardware for applications such as digital protocol communication, hardware-in-the-loop simulation, and rapid control prototyping. Though the LabVIEW FPGA Module contains many built-in signal processing routines, you can also integrate existing hardware description language (HDL) code as well as third-party IP.

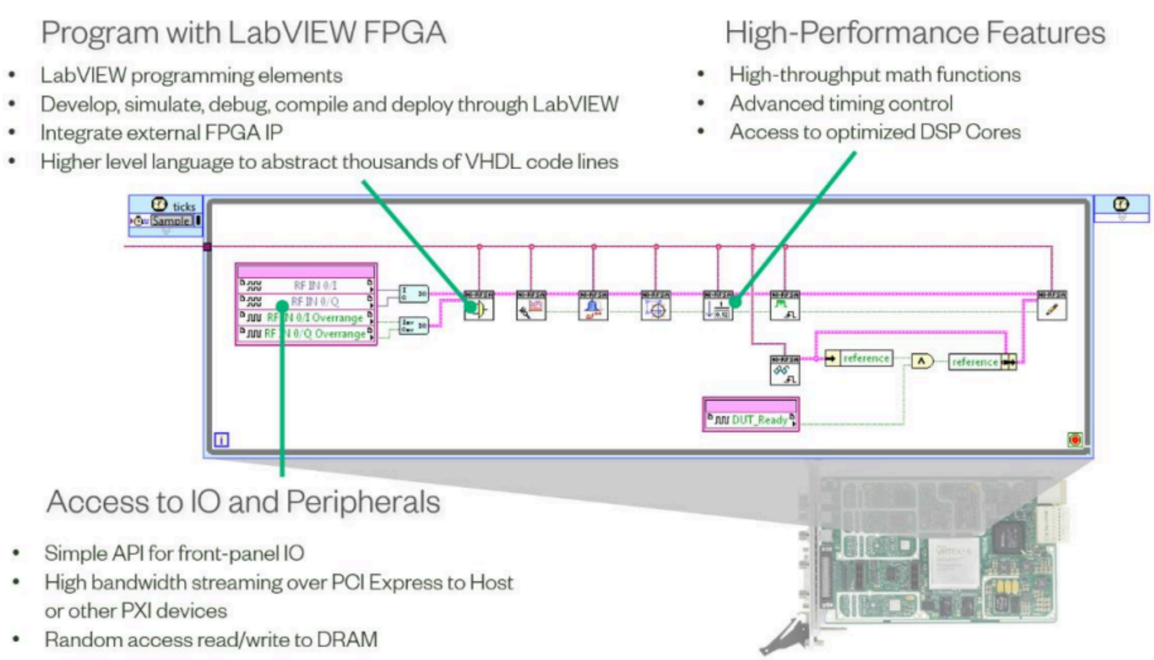


FIGURE 14

LabVIEW FPGA Block Diagram

System Level Test with Radar Target Generation

The NI Radar Target Generation (RTG) Driver enhances the PXIe Vector Signal Transceiver (VST) for Radar system-level testing. The VST combines an RF vector signal analyzer and generator with a programmable FPGA and digital interfaces for real-time signal processing and control. The RTG driver, built on top of the VST, is a closed-source, license-restricted, and pre-compiled FPGA personality that enables the VST to function as a closed-loop, real-time Radar target generator.

With this driver, engineers can inject up to four independent targets with configurable range (time delay), velocity (Doppler frequency offset), and path loss (attenuation) into a radar for testing. In its default personality, the VST serves as a calibrated RF generator and analyzer. Beyond the standard VST calibration, the RTG driver includes a loopback calibration, allowing users to apply accurate time delay and attenuation by de-embedding residual and external cabling and fixture effects. The RTG Driver is an excellent solution for engineers needing to perform basic functional validation of radars, production testing, or MRO (Maintenance, Repair, and Overhaul).

Applications

- Closed-loop real time target generation or channel emulation
- Open-loop spectral and datalink systems test
- Programmable signal generation and analysis

Key Characteristics

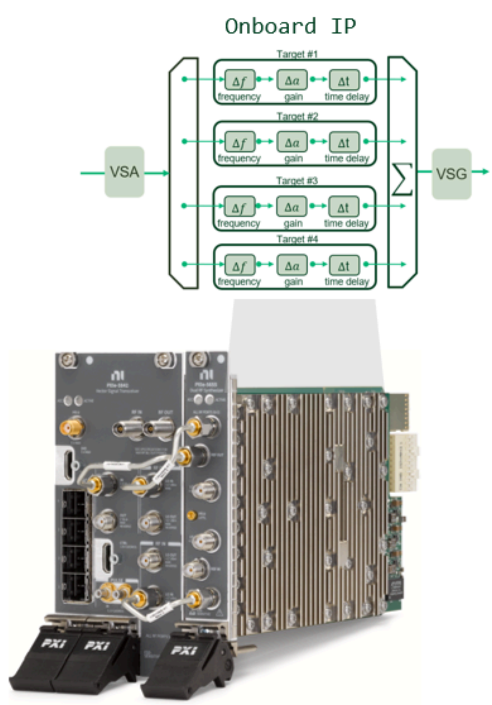
Frequency Range:	9 kHz up to 54 GHz *
Signal IBW:	Up to 2 GHz
Number Of Targets:	4 per Channel
Channels per Chassis:	Up to 8
Signal Parameters:	Range, Doppler, Gain
Maximum Range:	32,000 km
Minimum Range:	125 m (PXIe-5841,30,31, 32) 530m (PXIe-5842) <1m (Low Latency Mode)
Range Step:	0.8 ns (PXIe-5830/31/41) 0.4 ns (PXIe-5842)
Doppler Offset:	+/- 2 MHz
Doppler Resolution:	< 1 Hz
Pulse Width:	Unrestricted
Typical Rx to Tx SFDR:	68 dBc
Overlapping Targets:	Yes

The NI Advantage

- Built on standard off-the-shelf RF test hardware
- Reduce cost with a single instrument for multiple test requirements
- Identify issues before costly open air test range test

Supported NI Modules: PXIe-5830/1/2, PXIe-5841, PXIe-5842

** >26.5 GHz mmWave External Hardware Required*



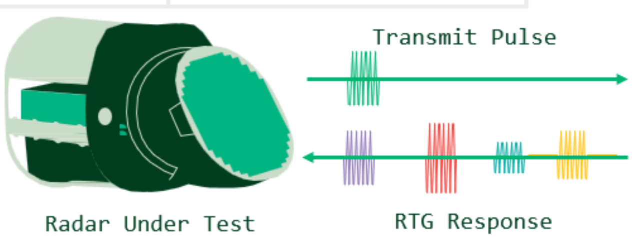


FIGURE 15

Radar Target Generation Driver for VSTs

RF Recording Software

RF Recording Software enables RF data recording in labs, anechoic chambers, or open-air ranges for validating devices under test (DUTs). This stored data is often reused for offline analysis, or ultimately 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

The NI RF Recording Software leverages the Vector Signal Transceiver (VST) to provide the acquisition capability needed for validation of RF systems under test and the High-Speed Serial Instrument as an FPGA coprocessor, for data aggregation and signal processing. This is coupled with either in-chassis data storage and/or Ethernet-based storage servers such as the Dell PowerEdge R7525 Rack Server.

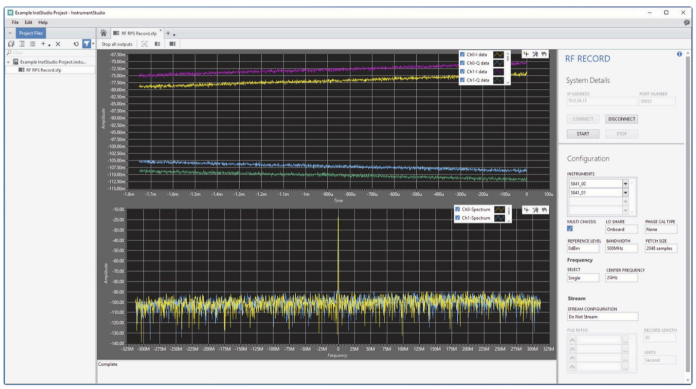


FIGURE 16

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

Solution Overview

- 1 GHz IBW recording on over 8 channels with phase synchronization.
- Independent or shared LO configurations for individual center frequencies or phase alignment across channels.
- Built-in calibration for LO power, multichannel amplitude correction, and phase coherence.
- Up to 300 TB data storage with transfer rates up to 40 GB/s per server.

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.

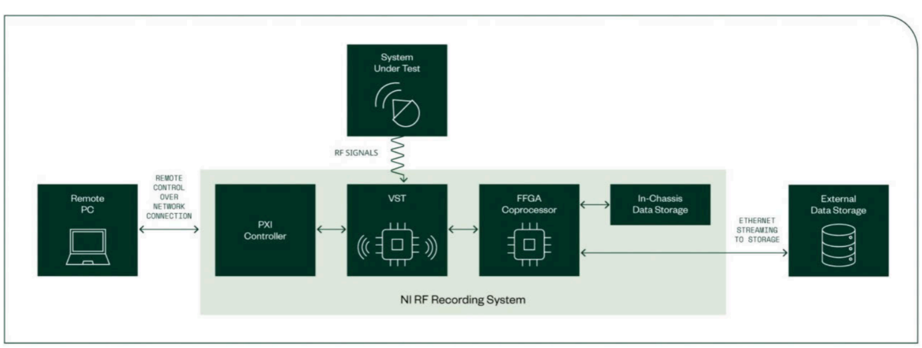


FIGURE 17

The NI RF Recording Solution

Radar Test Partners

Information System Labs

US-based Partner Information System Labs has more than 40 years of RF modeling, simulation, and test experience. ISL's RFView worldwide terrain database when combined with NI RF Transceiver technology can inject realistic EM environments into RF systems for Radar, ELINT, or EW. With ISL RFView HWIL, you can fly and test your radar anywhere on Earth from your lab.

www.islinc.com

ELT Group

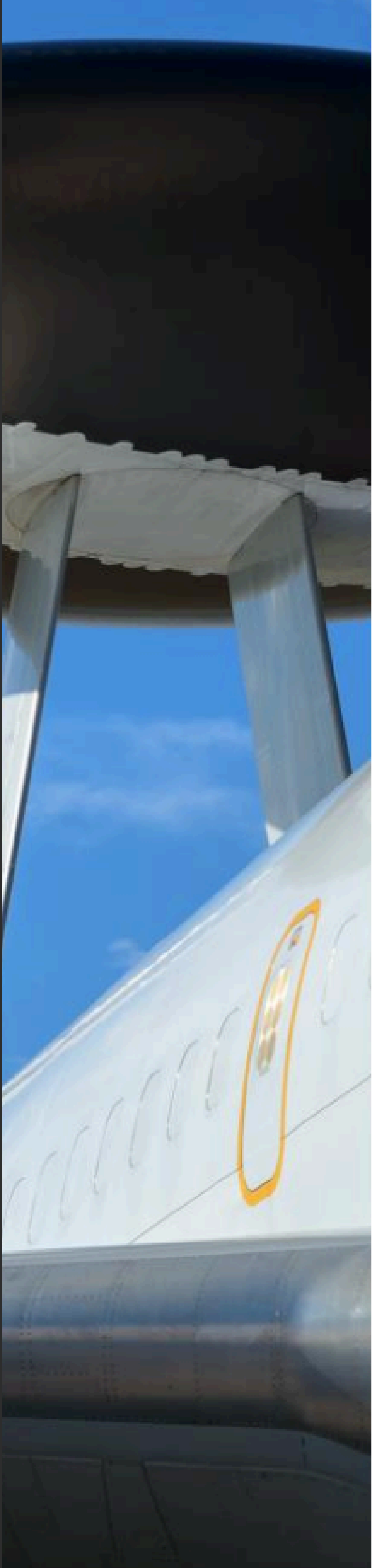
EU-based partner, ELT Gmbh is a Center of Excellence for Design, Development, and Integration of COTS-based solutions for ground-based ELINT, ground-based communication warfare/intelligence, simulation-based EW analysis, and radar testing and training systems.

www.elettronica.de

Constelli

India-based partner Constelli specializes in radar and EW test solutions. An expert in radar and EW threat environment emulation, Constelli provides IP to test and validate radar systems with multiple targets or threats, and comprehensive operational scenario simulation—all based on NI technology.

www.constelli.com



NI Services and Support

NI offers a variety of solution integration options customized to your application-specific requirements. You can use your own internal integration teams for full system control or leverage the expertise of our worldwide network of NI Partners to obtain a turnkey system.

Contact your account manager or call or email us to learn more about how NI can help you increase product quality and accelerate test timelines at +1 (888) 280-7645 or inro@ni.com

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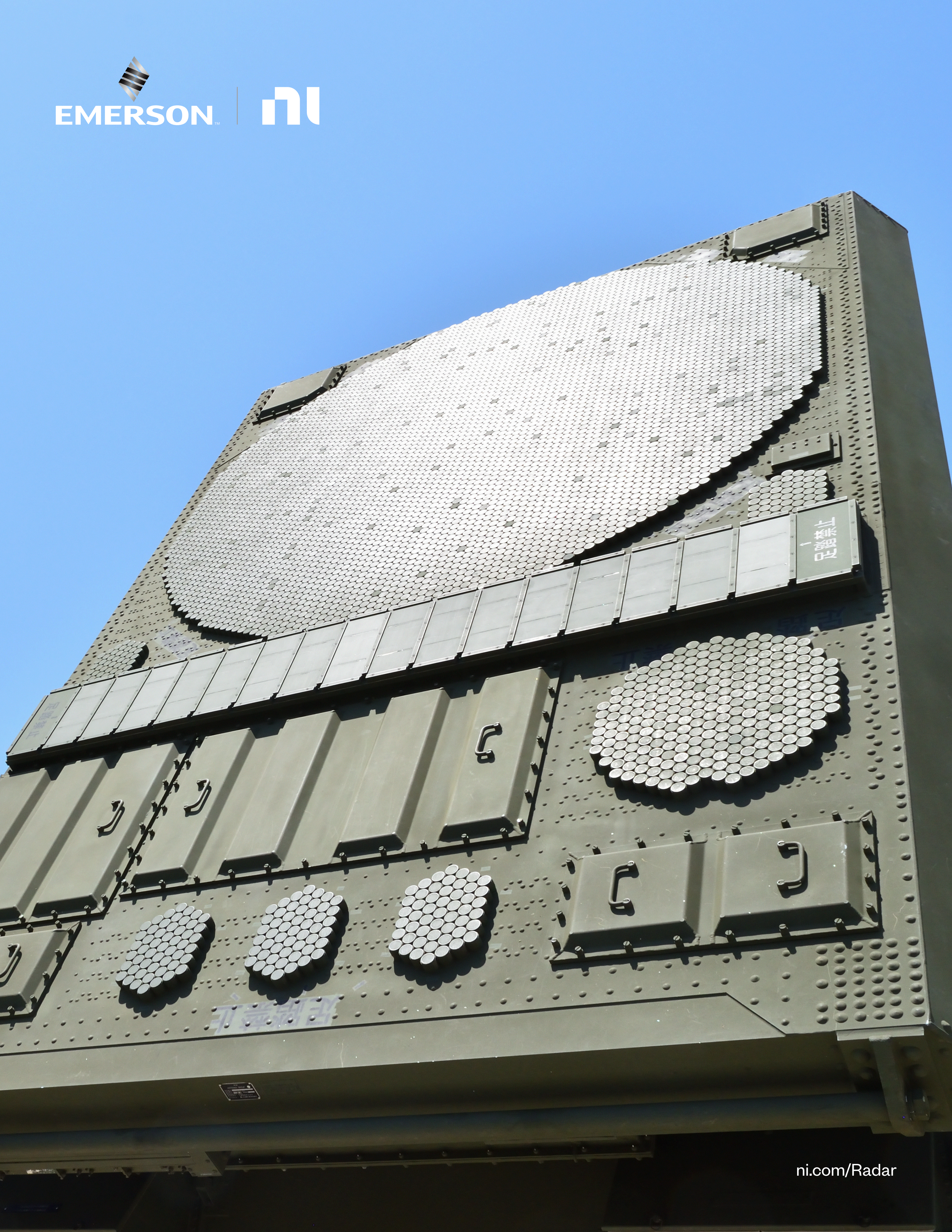

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