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Solution Brochure

Radar Target Generation Software

RADAR Target Generation Software

The RADAR Target Generation (RTG) Software includes applications and APIs to help you operate certain models of the PXI Vector Signal Transceiver (VST) as a closed-loop real-time RADAR target generator. The RTG software works with scenarios calculated in real-time, provided from a file, or generated from a linear motion calculation. With this software, 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 test. In its default personality, the VST is a calibrated RF generator and analyzer. Beyond the standard VST calibration, the RTG software includes a loopback calibration that enables users to apply accurate time delay and attenuation by de-embedding residual and external cabling and fixture effects. The RTG Software is well suited to basic functional validation of RADARs, production test, or MRO (maintenance, repair and overhaul).

Contents

Trends in Radar Design and Test

Radar technology has been a critical capability for flight safety, precision navigation, space applications, and more. To meet future electromagnetic spectral operation requirements, modern radars are being increasingly designed to be frequency agile with cognitive modes while utilizing ultra-broadband active electronically scanned arrays to dynamically adapt to electronic warfare and the ever-changing electromagnetic spectrum. Additionally, modern radars are increasingly designed with the goal of improved EW resilience and low probability of intercept (LPI) with multifunction and cognitive capability, radar, EW, and comms. Due to the increased complexity of designs, finding issues before an open-air range test has never been more important. Today, radar engineers are leveraging powerful modeling and simulation tools to digitally test systems prior to integration. Most leading radar manufacturers leverage hardware-in-the-loop (HIL) integration testing to mitigate risk and find issues in the early stages of the design cycle. Radar target generation technology is a powerful tool to inject realistic targets into radar systems in the lab or during production test to validate system performance or provide that final functional check before deployment.

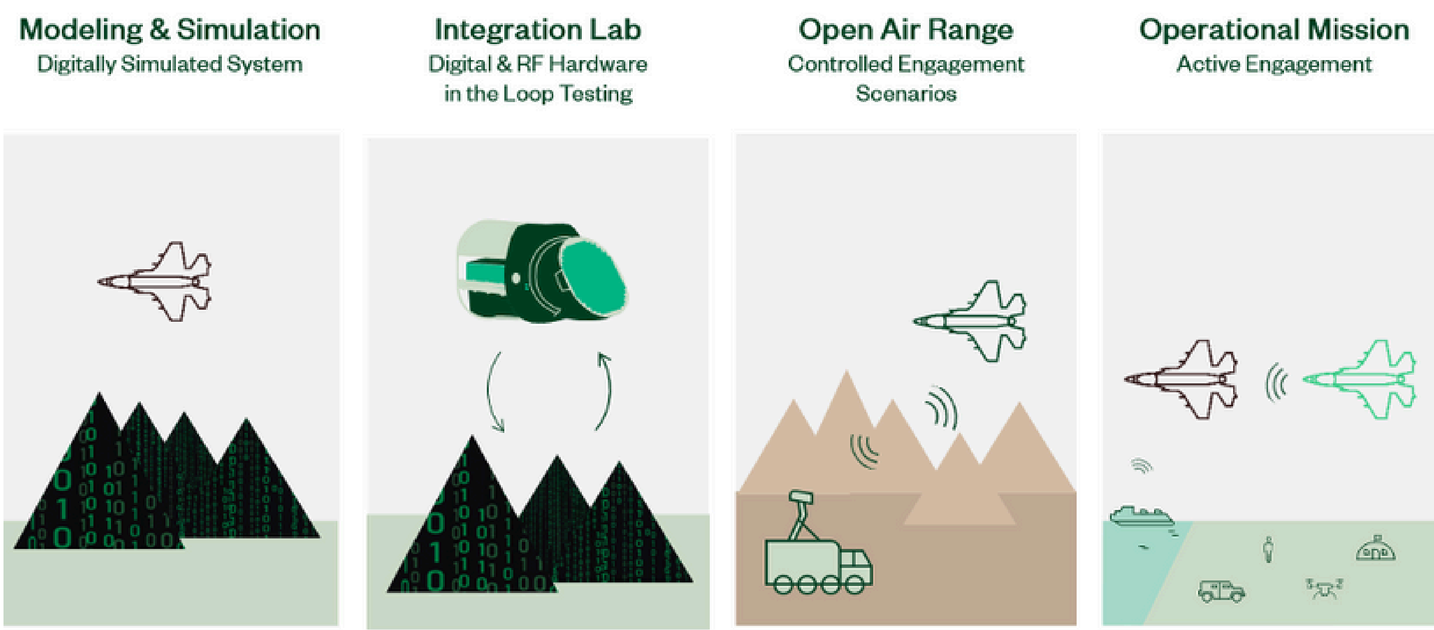
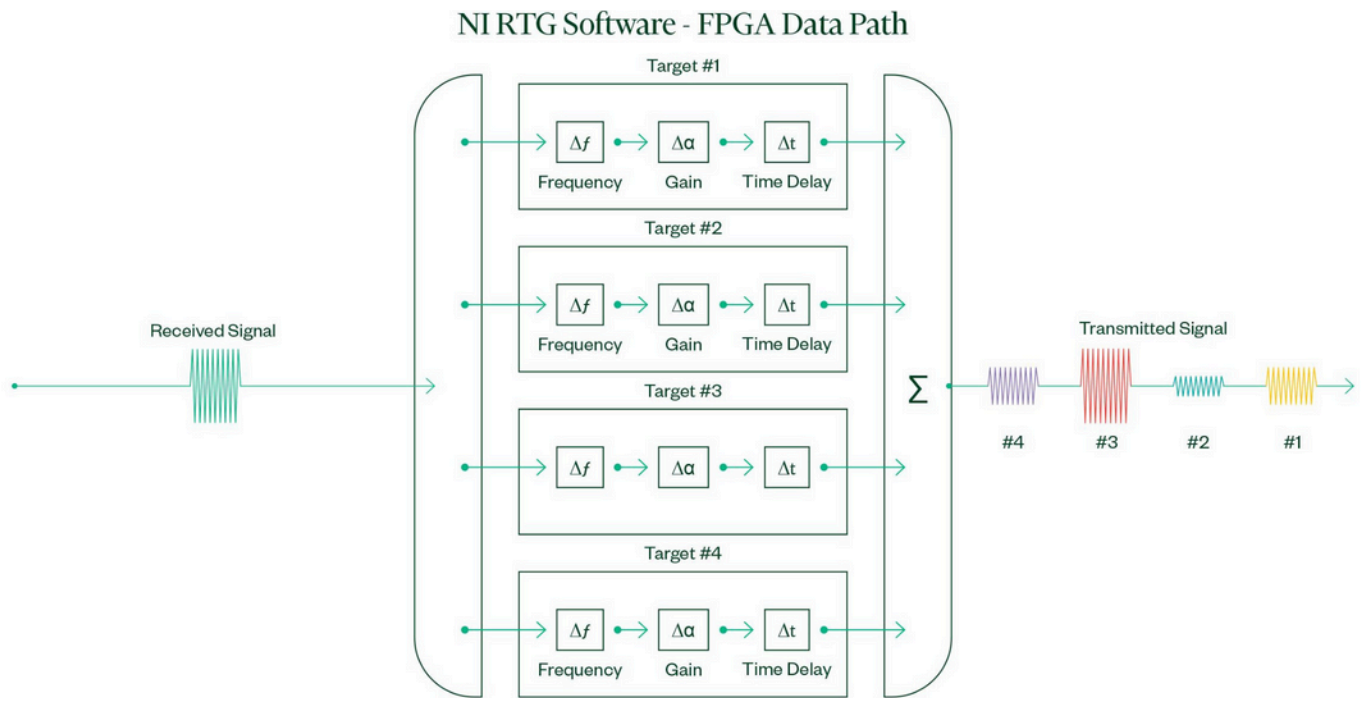


FIGURE 1

Phases of Radar Design Test and Evaluation

Radar Target Generation Software Overview



- Generates up to four simultaneous, in-beam targets per vector signal transceiver, with configurable time delay, frequency offset, and attenuation.
- Sets targets ranging from <1 m in a low-latency, predictive mode, to a maximum of 64,000 km.
- Consequis velit fugia que qui sum volorum nobitatem duciatia etur simaximent lantiae volupta
- Target configurations may be streamed from scenario generators, provided in a list of beyond 10 million entries or derived from a defined motion path.
- Self-calibration allows the RTG Software to measure losses in the system, to provide accurate delays and attenuations and optimal spectral performance.
- Coprocessor harness allows custom IP to be executed, adding inline parametric measurements or augmented signal processing.

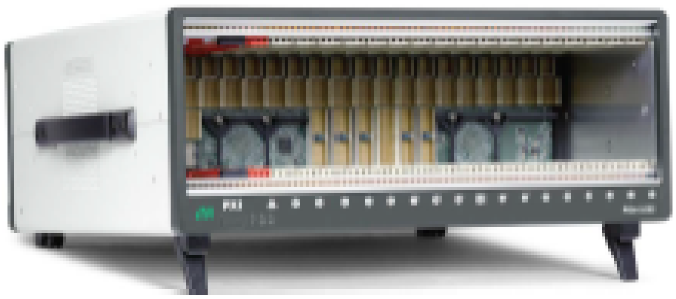
RTG Software Key Characteristics

Characteristic	Value
Frequency Range	10 MHz to 26.5 GHz (22.5 GHz to 44 GHz with frequency extender, PXIe-5831/2 only)
Signal IBW	2 GHz
Number of Targets	4 in-beam, simultaneous targets per channel
Multiple Channel Support	Up to four channels (Vector Signal Transceivers), time synchronized with common start/stop
Channels per PXI Chassis	Up to 4
Signal Parameters	Delay, Doppler, Attenuation
Maximum Range	64 ,000km
Minimum Range	<1 m in low-latency mode 125 m PXIe-5830/31/41 550 m PXIe-5842
Update Rate	15 kHz (List Mode) 1 kHz (Live Mode)
Range Step	0.8 ns (0.12 m)
Doppler Offset	+/-2 MHz
Frequency Corrected Doppler	Supported (50 ns more on minimum target)
Doppler Resolution	<5 Hz
Pulse Width	Unrestricted
Typical Rx to Tx SFDR	68dBc
Overlapping Targets	Yes
Supported Vector Signal Transceivers	PXIe-5830, PXIe-5831, PXIe-5832, PXIe-5841, PXIe-5842

Table 1: Key characteristics of Ni's RTG Software - for full specifications, please refer to the RTG System Benchmarks.

Compatible Hardware

The Radar Target Generation 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 ovencontrolled 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 RTG system.

Vector Signal Transceivers

PXI Vector Signal Transceivers

FIGURE 4

Vector Signal Transceivers provide the RF generation and acquisition capability needed for testing radar systems with radar target generation.

The RTG Software supports the following models: PXIe-5830, PXIe-5831, PXIe-5832, PXIe-5841, PXIe-5842

- Combines RF generation and acquisition into a single PXI module
- Up to 26.5 GHz frequency coverage module only, extendable to 44 GHz with frequency extender
- Up to 2 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

High-Speed Serial Coprocessor

PXIe-7903, 28.2 Gbit/s, 48-Channel High-Speed Serial Instrument

FIGURE 5

The RTG Software supports the use of the PXIe-7903 High-Speed Serial Instrument as an FPGA coprocessor, for augmented signal processing and inline measurements.

- Supported as a Radar Target Generation coprocessor , PXIe-6594 supported as an alternative with some VSTs
- Designed for engineers who must validate, interface through, and test serial protocols.
- Includes a Xilinx Kintex 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 forty-eight TX and RX lanes.
- 20GB onboard DRAM

Timing and Synchronization

PXIe-6674T, OCXO Synchronization Module

FIGURE 6

The PXIe-667 4T OCXO PXI Synchronization Module may be optionally added to the RTG Software for additional triggering connectivity.

- Generates and routes clocks and triggers between devices in a PXI Express chassis
- Can generate two types of clock signal:
    - Highly stable 10 MHz clock based on an onboard precision oven-controlled crystal oscillator (OCXO) reference.
    - Clock from the direct digital synthesis (DDS) clock generation circuit.

Target Configuration Modes

Up to four simultaneous, in-beam targets may be generated, in three configuration modes.

Live Mode

Sends a stream of target configurations to the RTG.

- Can be used to stream target configurations a from scenario generator and central test computer to the RTG system.
- Supports sending configurations at a 1 kHz update rate.
- Supports multiple triggering modes: software; hardware; pulse; and time triggers.
- Useful when using the soft front panels for performing manual verification.

List Mode

Provides configurations to the RTG through CSV file(s). The RTG reads the files and loads them into the system.

- Useful when a large group of configurations is known ahead of time.
- Configurations can be broken into multiple files to keep file size manageable.
- Verified to support at least 10 million configurations with an update rate of at least 15 kHz.
- Supports multiple triggering modes: software; hardware; pulse; and time triggers.

Target Motion Mode

Configures the RTG to create a linear ramp for any delay, attenuation, or frequency shift though a configurable scenario length.

- Configurations are sent to the RTG system at a user-configurable fixed update rate (up to 15 kHz).
- Provides a simple way to create dynamic scenarios.

Analog Gain Ranging

There is an option to add a fast step attenuator prototype to the RTG system, to apply attentuation and to improve the system's dynamic range.

You can find the bill of materials and installation process for this prototype in Adding the Fast Step Attenuator Prototype. Creating a custom solution that matches the fast step attenuator prototype provides the ability to add analog attenuation in RTG. With this analog attenuation solution in place, the RTG calibrates loss during its normal system self-calibration. It can then evaluate each configuration and apply as much of the attenuation as possible to the fast step attenuator, thus optimizing the RTG's dynamic range.

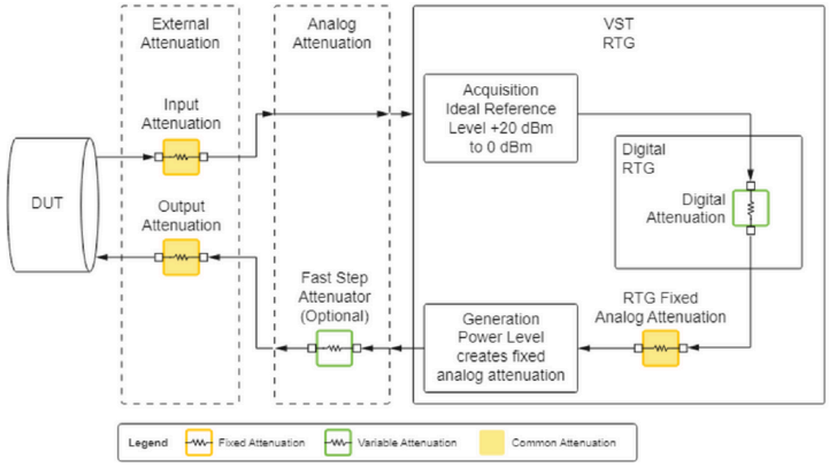


FIGURE 7

In addition to digital attenuation applied within the vector signal transceiver, the fast step attenuator prototype allows optimization of the RTG system's dynamic range.

Low Latency Predictive Mode

Some radars, such as altimeters, fuzes, and seekers for example, need to detect close-in targets in their fielded operation. To test radars with nearby targets, it may be necessary to set a total target delay less than the RTG system's minimum delay. While it is impossible to create a delay less than the minimum, under certain circumstances it is possible to simulate this with a predictive mode of operation. The RTG software can store a radar pulse and use it to create a target for the next arriving radar pulse. For this to function correctly, Predictive Mode requires the following:

- Fixed and known pulse repetition interval (PRI), which must be provided to the RTG through an API method.
- The pulse must not change frequency or any other pulse characteristic.

For Predictive Mode to work, the RTG must make configuration changes relative to a radar pulse using either the Relative to Pulse Rising Edge or Relative to Pulse Falling Edge. This is because changes need to be made at precise times in the PRI.

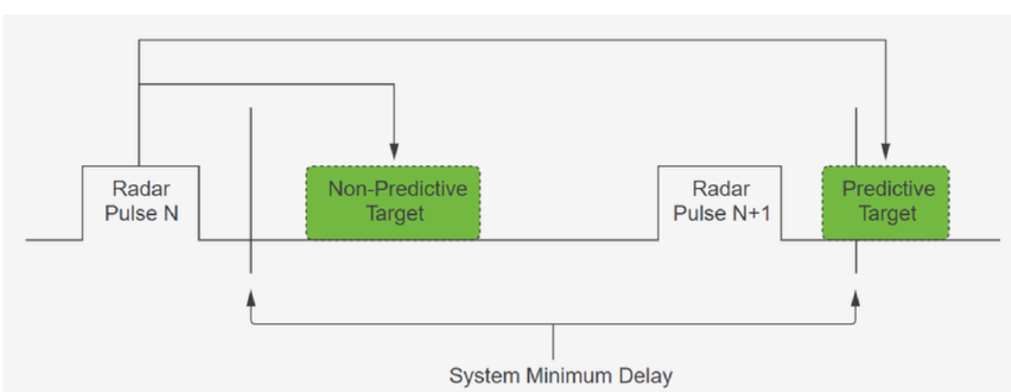


FIGURE 8

For repeatable pulses, Predictive Mode allows the RTG Software to generate low-latency targets at less than the typical minimum range.

Coprocessor Harness

The RTG Software provides a way to add custom processing capabilities. These additional custom capabilities reside on an FPGA coprocessor, the NI PXIe-7903 or PXIe-6594 depending on the VST model used. To support a coprocessor, the RTG Software configures a VST to stream baseband data over a multigigabit transceiver (MGT) link, to the coprocessor. This baseband data is the same IQ data that acts as the input to the RTG target processing algorithm. The coprocessor performs any additional processing on this data then streams it back to the VST.

The signal path for the coprocessor is independent of the RTG signal path. These two signal paths can be selected independently or together.

The RTG Software does not impose any limitations on the algorithms that can be included on the coprocessor. While it is dependent on how the coprocessor algorithm is implemented, the minimum latency, and thus minimum target delays, for targets will be approximately 3 μs, not counting any delays that are external to the RTG.

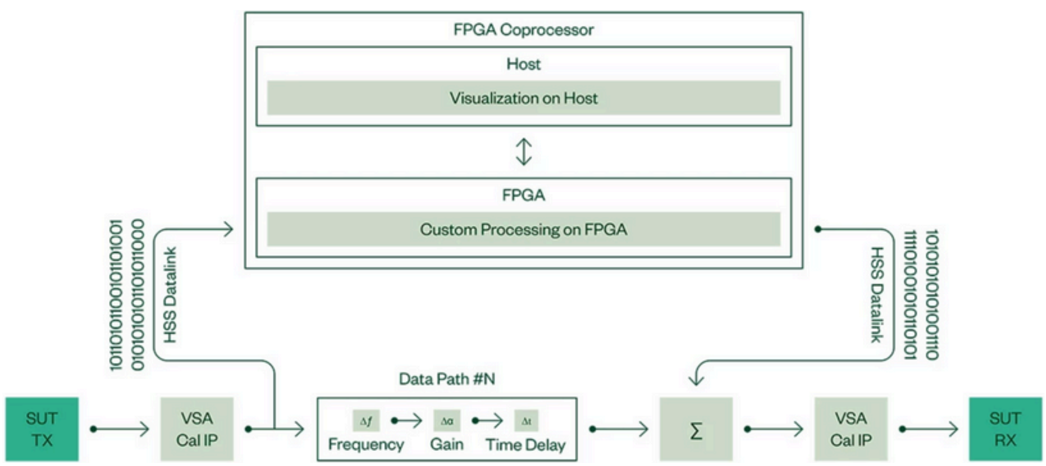


FIGURE 9

Custom FPGA-based processing may be added alongside the RTG signal path, for tasks like inline measurements or waveform replay.

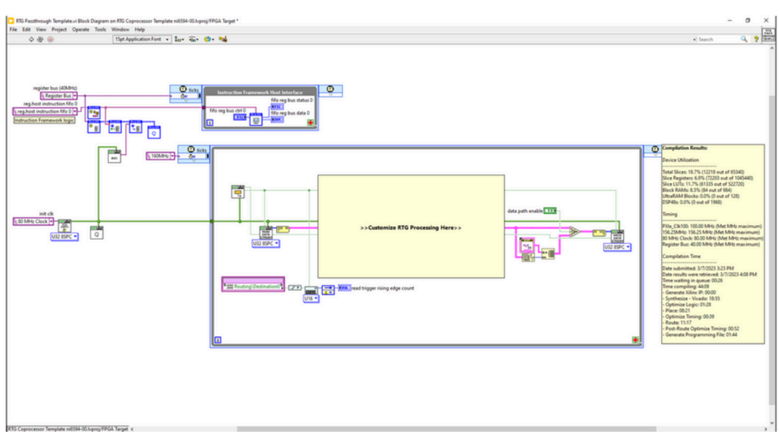


FIGURE 10

The Coprocessor Harness allows custom processing to be incorporated into the RTG Software via Lab VIEW FPGA.

Soft Front Panel and Control API

The RTG Software may be controlled either manually through its soft front panel, or programmatically through APIs for Lab VIEW and gRPO.

The Lab VIEW API may be used for both local and remote RTG systems. The local version makes direct calls to the VST and RTG drivers, and hence only works when running on the PXI controller of the system containing the RTG hardware. The remote version allows remote access to the RTG via a Lab VIEW class. The Lab VIEW API includes the provision to switch between local and remote operation without code changes.

A gRPO protocol buffer file is provided, and can be used to generate classes in any gRPO-supported programming language, including Python and 0# among others.

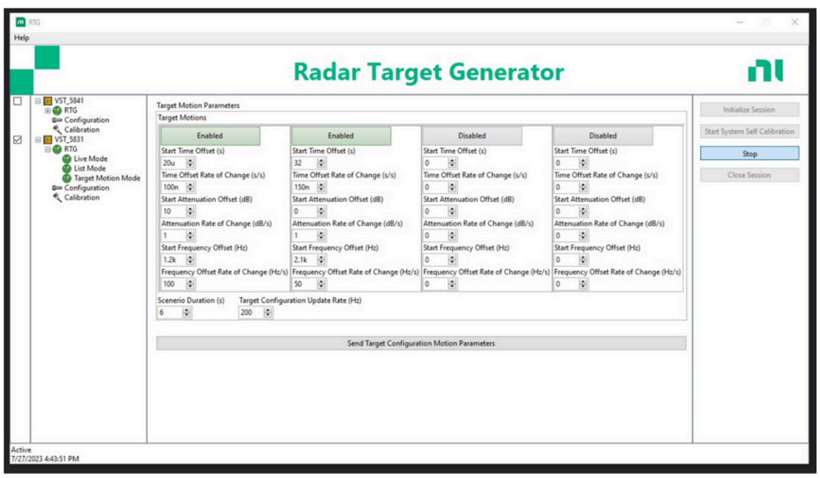


FIGURE 11

The RTG Software soft front panel allows manual control of the RTG, through Live, List, and Target Motion Modes.

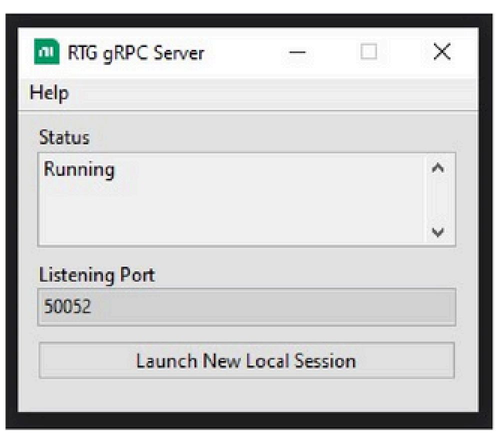
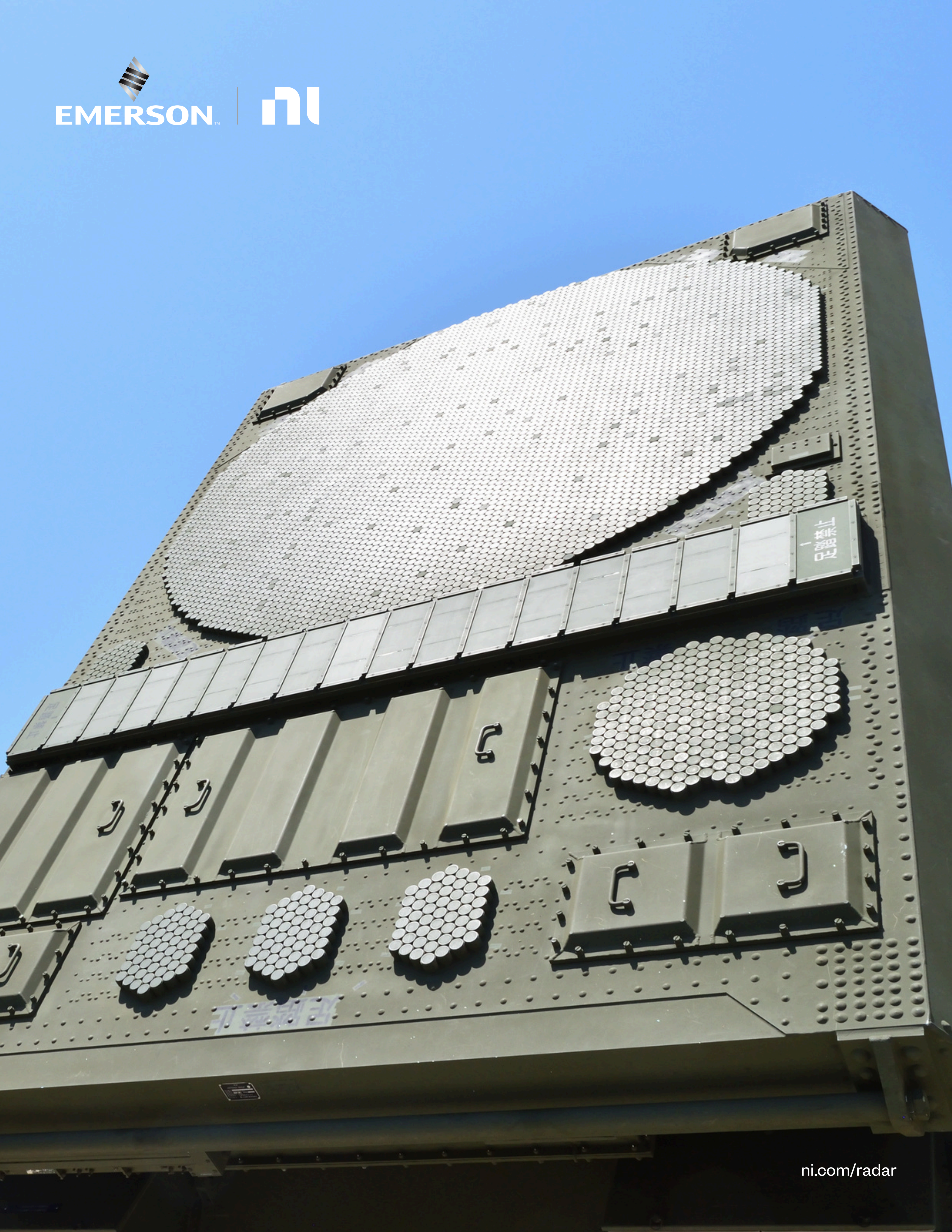


FIGURE 12

The RTG Software API allows programmatic control of the system, either directly on the PXI controller or remotely over a network.



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