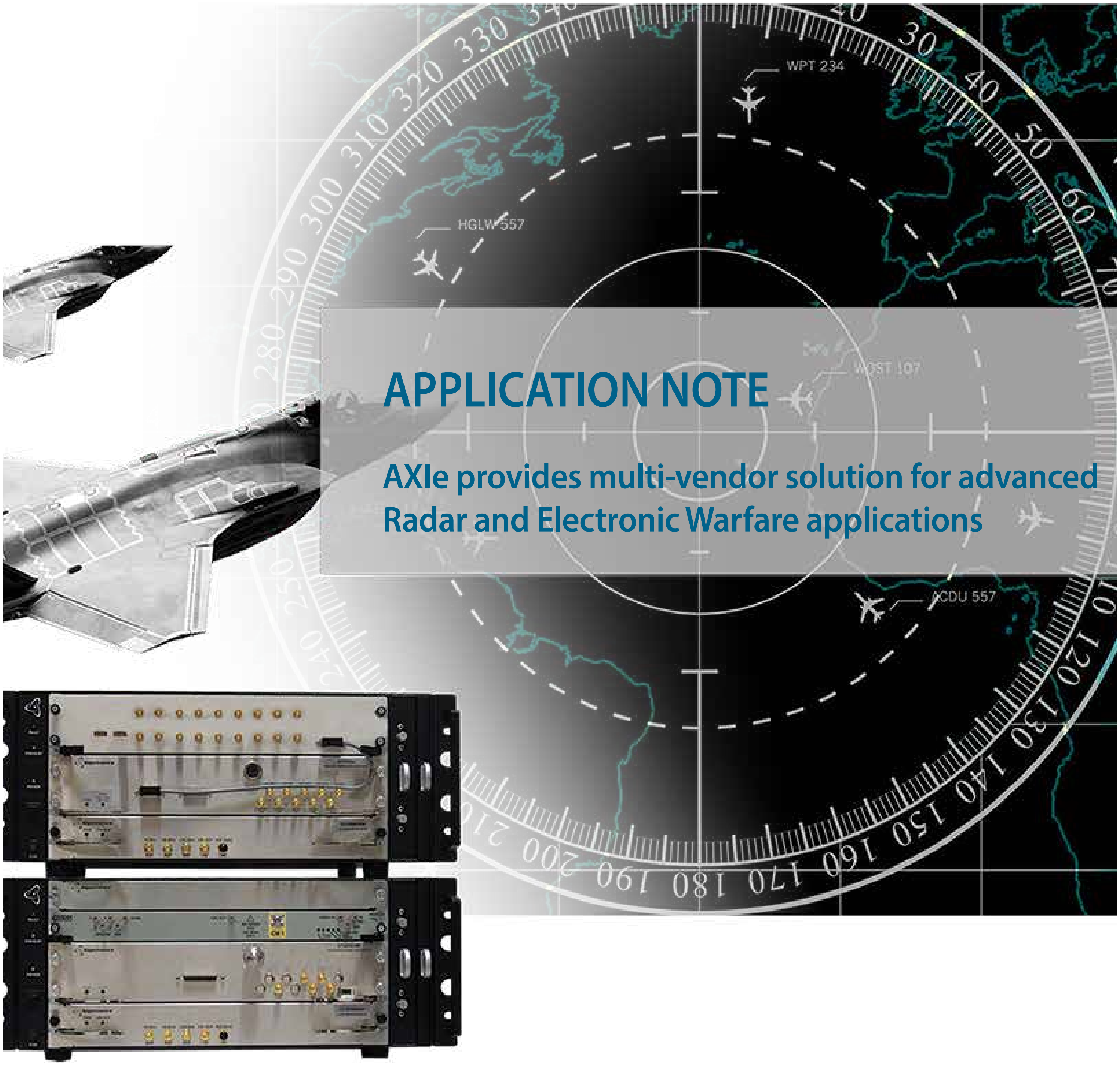
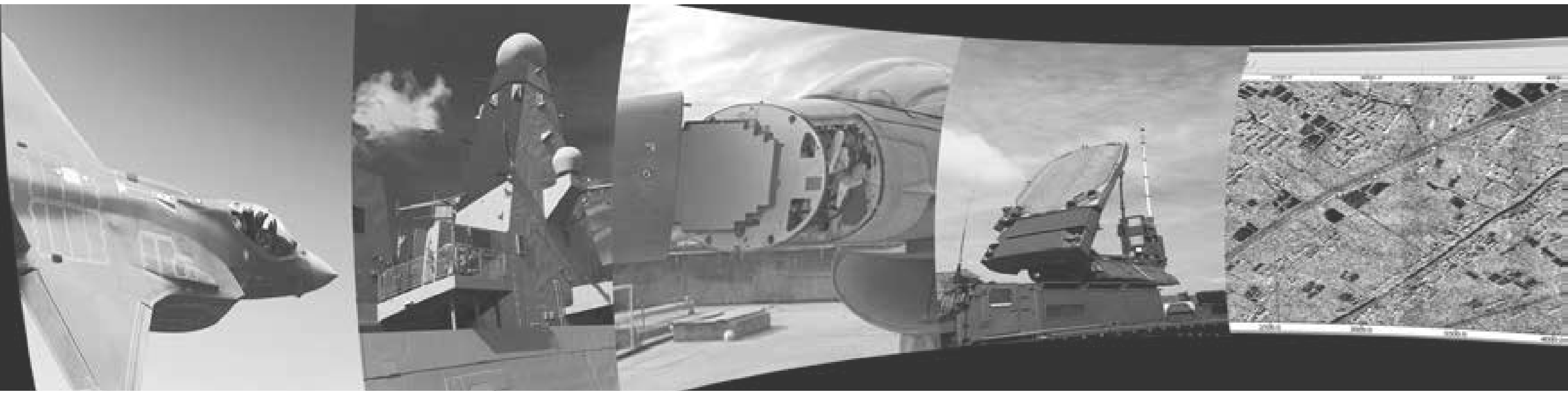


APPLICATION NOTE

AXIe provides multi-vendor solution for advanced Radar and Electronic Warfare applications

Author: Mark Elo, VP of Marketing
Published: Aug 21, 2014
Revision: A

Giga-tronics
Advanced Microwave Signal Generation and Acquisition



When designing operational radar systems for technology proving, range measurements, environment generation, theater threat simulations, HIL (Hardware in the Loop), and test systems for highly integrated LRU's (Line Replaceable Units), you are often challenged to accomplish the task by using COTS (Commercial Off The Shelf) equipment and in some cases ensure a portion of the program is assigned to small businesses. This is compounded by the fact that cost and time constraints make it increasingly difficult to design a new test system for every program or mission. A platform approach often makes the most sense. Until recently the advanced nature of the signals required made it an almost impossible goal.

AXIe is a high-performance modular system that is based on a high speed PCIe backplane. With many operational similarities to PXIe, but with the added advantage of 200W of power dissipation per measurement blade, AXIe allows instrument manufacturers to create extremely high performance capability with the ability to easily leverage existing commercial hardware control and connectivity solutions and an array of industry standard software solutions from suppliers such as Microsoft, The MathWorks and National Instruments.

When configuring an AXIe system for radar test or for operational use, it is important to define the difference between off-line tools and real time tools. This key differentiation determines what tools are applicable for each application.

For test and measurement applications used specifically in ATE (Automated Test Equipment) applications, most measurements are performed in an off-line manner. For example, a receiver test would use an arbitrary waveform generator and/or a microwave signal generator that would be programmed to play individual waveforms or lists of waveforms triggered in a pre-determined order.

To test a transmitter, an instrument such as a spectrum analyzer would give you spectral information regarding the quality of the signal, such as its power, intermodulation and spurious performance. Spectrum Analyzers and Signal Generators or Network Analyzers can also be used to perform stimulus response measurements of simple LRU's that perform filtering, up-conversation or amplification.

There is a broad array of tools available to create and analyze radar waveforms for test and measurement applications. Tools such as MATLAB or NI LabVIEW can create complex waveform files, or you may prefer to use specific pieces of radar signal creation software designed to complement Arbitrary Waveform Generators from Keysight Technologies or Tektronix.

The example in Figure 1 shows how a chirp function can be easily created using National Instruments Graphical programing language LabVIEW.

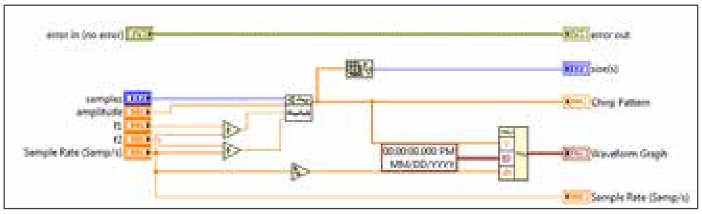
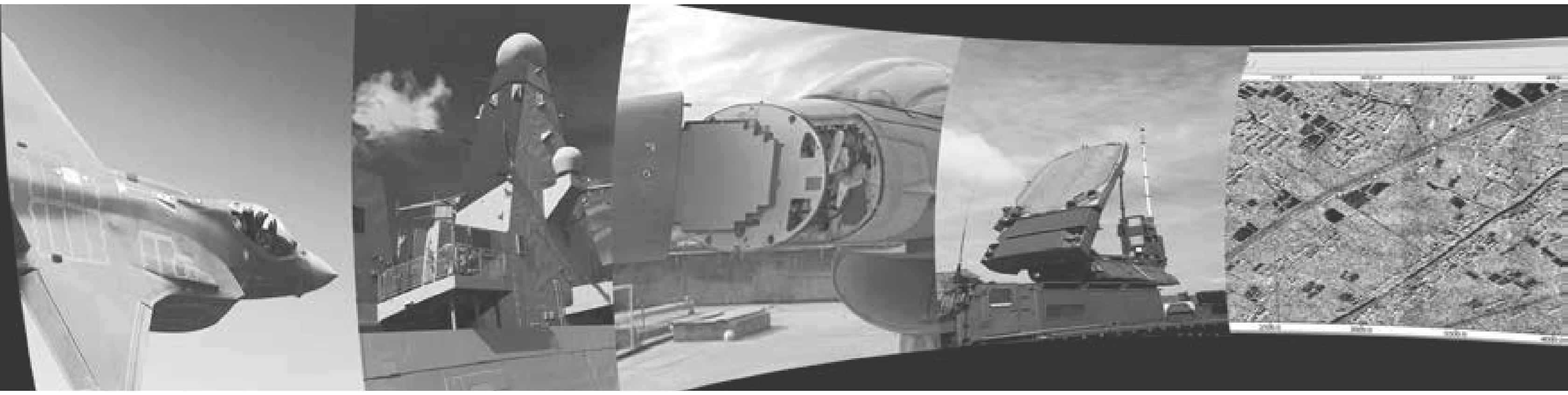


Figure 1, A simple LabVIEW VI (Virtual Instrument) generating a Chirp waveform.

The resultant output of a LabVIEW VI or a MATLAB Script can be down loaded as a waveform file into AXIe instrumentation such as the Keysight M8190A Arbitrary Waveform Generator (AWG). With 2 Gs of memory many thousands of waveforms can be stored in the instrument's memory. This is especially useful not only for Modulation on Pulse waveforms, but if you are required to emulate



specific rise and fall times of specific radars creating a pulse mathematically in an off-line software tool in this way allows you to build a very accurate representation of a potential threat radar.

The state of the art today in AWG's will still not provide enough frequency range, or fidelity for higher frequencies due to limitations in Digital to Analog converters. For example the M8190A can create a maximum RF frequency of 6 GHz. For S-Band Applications this is fine, but for X-band and above an up-converter is required. Two methods of up-conversion are available in AXIe. The Synopsys AWGUP series of up converters offer banded up-conversions (either 2 GHz or 4 GHz of Bandwidth) up to 39 GHz. Fast frequency switching times within these bandwidths make it ideal for testing a specific radar within a known operating band, however when ultra-broadband up-conversion is required the Giga-tronics GT-ASG18A offers wide instantaneous bandwidth up-conversion from 10 MHz to 18 GHz making an ideal platform for multiple types of radars or electronic warfare applications.

The combination of an AXIe AWG and Up-converters allows you to create almost any type of radar waveform at a broad range of microwave frequencies.

For radar signal analysis the Guzik ADC6131 can acquire 13 GHz of instantaneous bandwidth. It has a powerful FPGA processing engine that allows high speed analysis of radar signals within its acquisition bandwidth. Figure 2 shows how the output of a broadband acquisition performed by the ADC6131 using the W2650A Oscilloscope Signal Analyzer (OSA) Software form Keysight Technologies to display the results of the acquisition of a series of pulses in the X-band.

26-Jan-2011 05:31:36.203	Start Time	Pulse Width (PW)	Pulse Rep Intvl (PRI)	Frequency Average
1	-11.790 ns	1.0160 µs	-11.790 ns	10.008 GHz
2	49.992 µs	1.0160 µs	50.004 µs	10.008 GHz
3	99.996 µs	1.0160 µs	50.004 µs	10.008 GHz
4	150.00 µs	1.0155 µs	50.004 µs	10.006 GHz
5	200.00 µs	1.0160 µs	50.004 µs	10.008 GHz
6	250.01 µs	1.0160 µs	50.004 µs	10.007 GHz
7	300.01 µs	1.0155 µs	50.004 µs	10.007 GHz
8	350.01 µs	1.0155 µs	50.004 µs	10.005 GHz
9	400.02 µs	1.0160 µs	50.004 µs	10.007 GHz
10	450.02 µs	1.0160 µs	50.004 µs	10.007 GHz
11	500.03 µs	1.0160 µs	50.004 µs	10.007 GHz
12	550.03 µs	1.0160 µs	50.004 µs	10.007 GHz
13	600.03 µs	1.0160 µs	50.004 µs	10.007 GHz
14	650.04 µs	1.0160 µs	50.004 µs	10.008 GHz
15	700.04 µs	1.0160 µs	50.004 µs	10.007 GHz
16	750.05 µs	1.0160 µs	50.004 µs	10.008 GHz
17	800.05 µs	1.0160 µs	50.004 µs	10.008 GHz
18	850.05 µs	1.0160 µs	50.004 µs	10.008 GHz

Figure 2 – W2650A Oscilloscope Signal Analyzer (OSA) Software from Keysight Technologies showing the output of an acquisition from the Guzik ADC6131.

The upper frequency limit is again driven by the state of the art in ADC technology sampling at 40 Gs/s allows for an instantaneous BW of 13 GHz, for higher frequency. The up-conversions accompanying down-converters will soon become available on the market.

The Keysight Technologies 89601 VSA Software allows deeper analysis of signal quality. Figure 3 shows an AXIe generated 1 GHz chirp centered at 10 GHz simultaneously analyzed in three different domains, amplitude over frequency, frequency shift over a time period, and group delay over time.

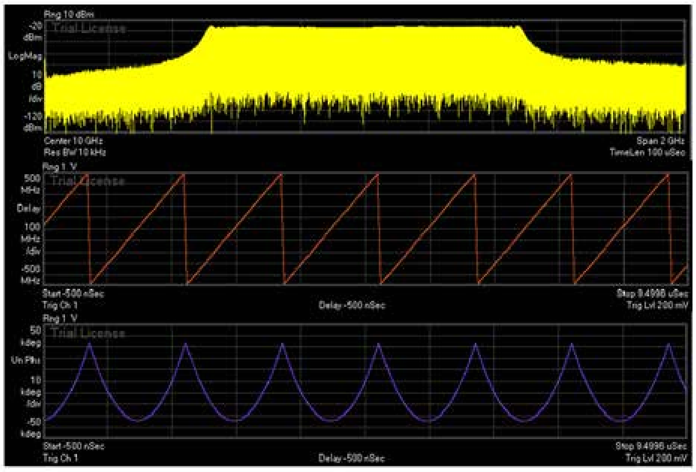
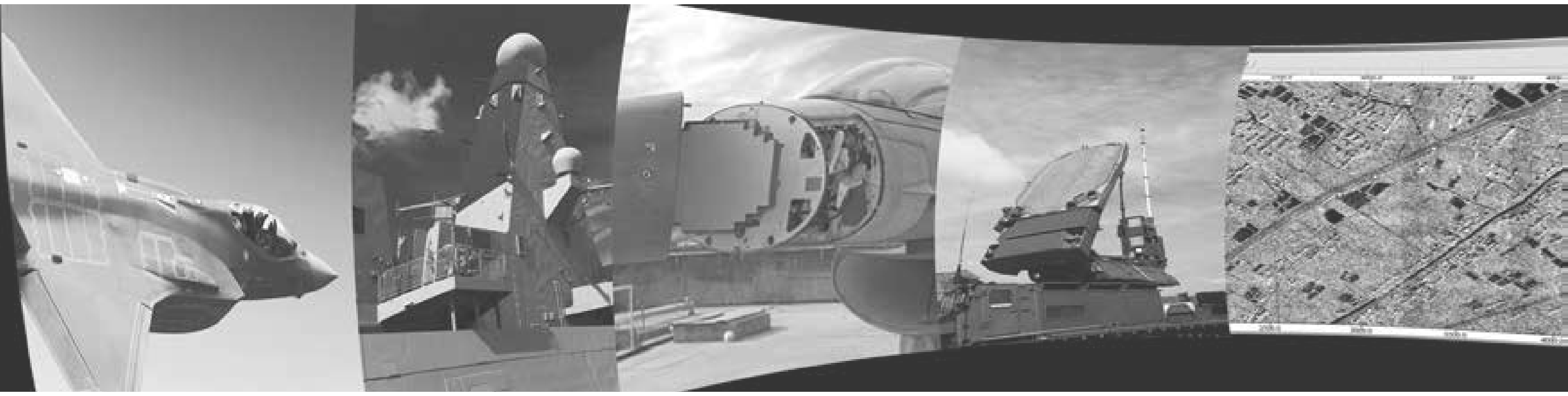


Figure 3 The analysis of a wide instantaneous AXIe generated chirp using the Guzik ADC6131 Digitizer and the Keysight 89601 VSA Software.



For test and measurement and advanced ATE applications AXIe offers a compact generation and analysis tool set. Its capability is similar and in some cases better to that of traditional instrumentation such as wide band Oscilloscopes, Spectrum Analyzers and Microwave Signal generators. The high speed PCIe bus allows waveform up-loads and measurement to run much faster than traditional instruments and its compact design reduces the amount of rack or bench space required to perform measurements. AXIe allows you to take from the pool of pre-developed radar intellectual property designed for the test and measurement applications and use it for more advanced applications such as environment generation, theater threat simulations and Hardware in the Loop applications.

For example, refer to the block diagram in figure 4A. A specialized set of waveforms may have been designed or created form Radar Intel data off-line using the MATLAB Radar tools, this waveform can be down loaded to the AXIe AWG, (Keysight M8190A) that in turn provides an IF to the Gigatronics GT-ASG18A up-converter. Then using the powerful Vertex based FPGA in Giga-tronics GT-FPGA6A it can be configured as a scheduler to play out the waveforms in real time. A response from the system under test can be measured using the Guzik AXIe ADC6131 digitizer for Broadband Signal Acquisition and off-line analysis can be performed using the Keysight W2650A Oscilloscope Signal Analyzer (OSA) Software or the 89601A VSA Software.

Alternatively using the Guzik FPGA developer's tool kit real-time feedback of the waveforms parameters and responses can be feedback to the GT-FPGA6A and a new set of waveforms can be scheduled based on the system under test response.

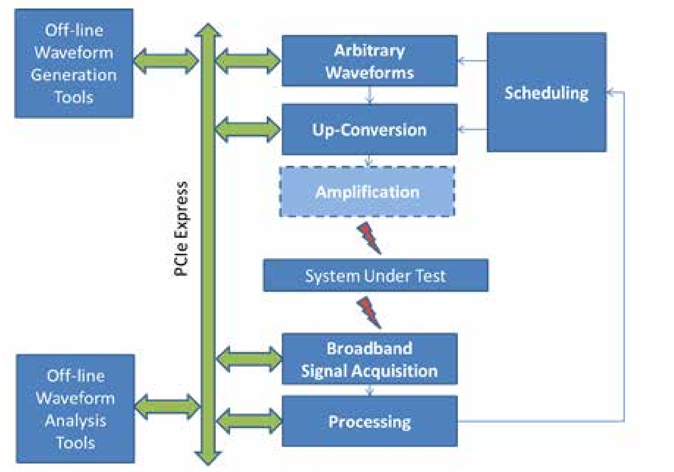


Figure 4A - A closed loop AXIe real time based radar test system

Figure 4A is realized in hardware in figure 4B. In the two AXIe chassis we have the following hardware: The M8190A provides up to 2 Gs of waveform storage and playout. The GT-ASG18A up-converts the baseband signals to anywhere between 10 MHz and 18 GHz. The GT-FPGA6A schedules waveform playout of the M8190A and the GT-ASG18A to the device under test. The Guzik ADC6131 acquires 13 GHz of instantaneous bandwidth; utilizing its SDK waveforms can be analyzed allowing for rescheduling of new waveforms based on the response of the system under test. Each Chassis also contains a GT-SRM100A frequency reference locking all the instrumentation coherently.

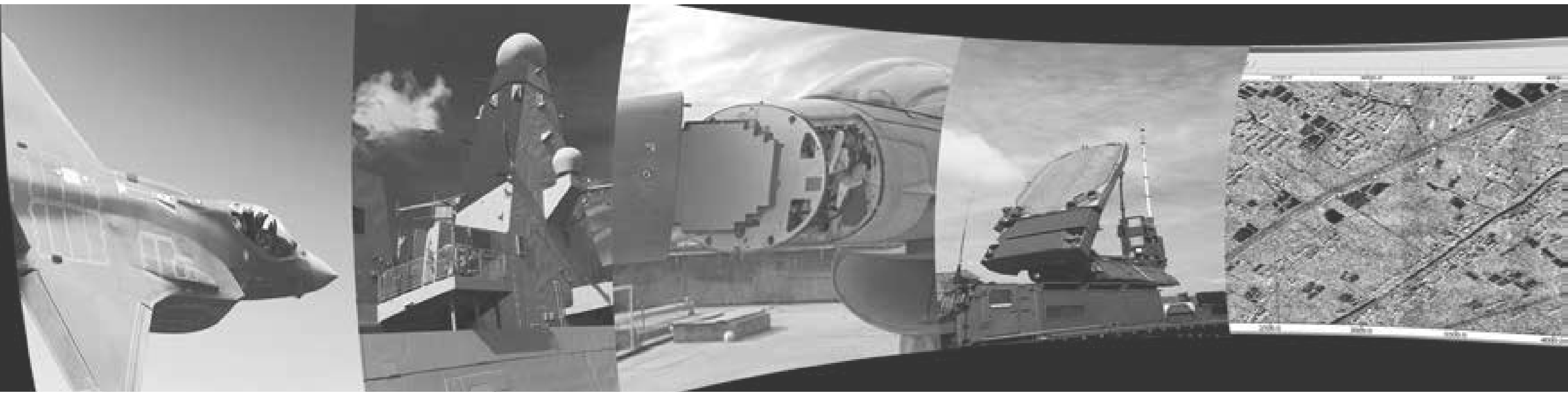


Figure 4B Hardware realization of a closed loop radar test system

Utilizing the M8190A, GT-ASG18A, GT-FPGA6A and the ADC6131 Figure 5 show an off air analysis of two signals rapidly switching between 4 GHz and 10 GHz. The upper display shows 8 GHz of instantaneous Bandwidth in the frequency domain, the lower display shows a Spectrogram of frequency switching over time.

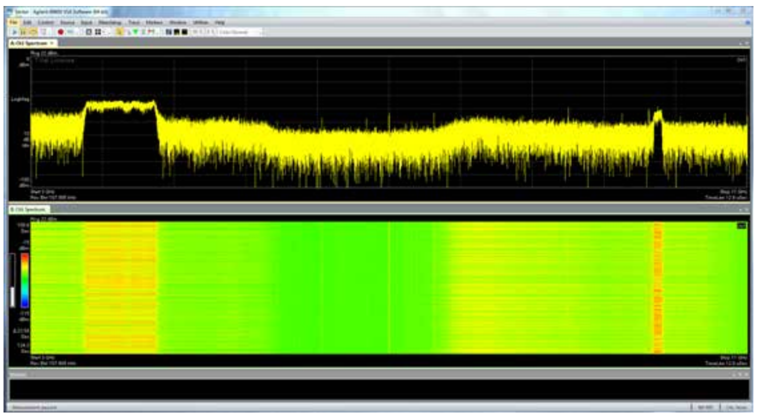


Figure 5 Off-air analysis of broadband spectrum

If you consider the dynamic waveform refresh rate of the M8190A AWG is specified at 1 MHz, this gives you the ability to change the waveform every microsecond. Extrapolating this to threat creation and environment generation, a correctly configured AXIe system utilizing the M8190A and an associated up-converter form Giga-tronics or Synopsis can produce both platform motion events and emitter events with pulse densities in the region of one million pulses per second, and due to the scalable nature of AXIe higher densities are easily achievable.

There are multiple chassis available to host AXIe instrument blades. Ranging from a small two slot chassis that can house one or two instrument blades, to the Keysight M9514A AXIe 14-Slot Chassis (Figure 6) that within 14 rack units offering extremely high densities for multi-emitter configurations (estimated pulse density 3 million pulses per second).
As AXIe is based on the high Reliability, Availability and Serviceability (RAS). ATCA (Advanced Telecommunications Computing Architecture) standard, designed for the minimal down time telecom industry, chassis contain an array of support and diagnostic features. There are swappable components such as fan trays, filters and in some models power supplies combined with diagnostic features, allowing access to functions such as chassis configuration information, instrument module inventory, and chassis health parametric information - such as temperature, fan status and key power supply status indicators.

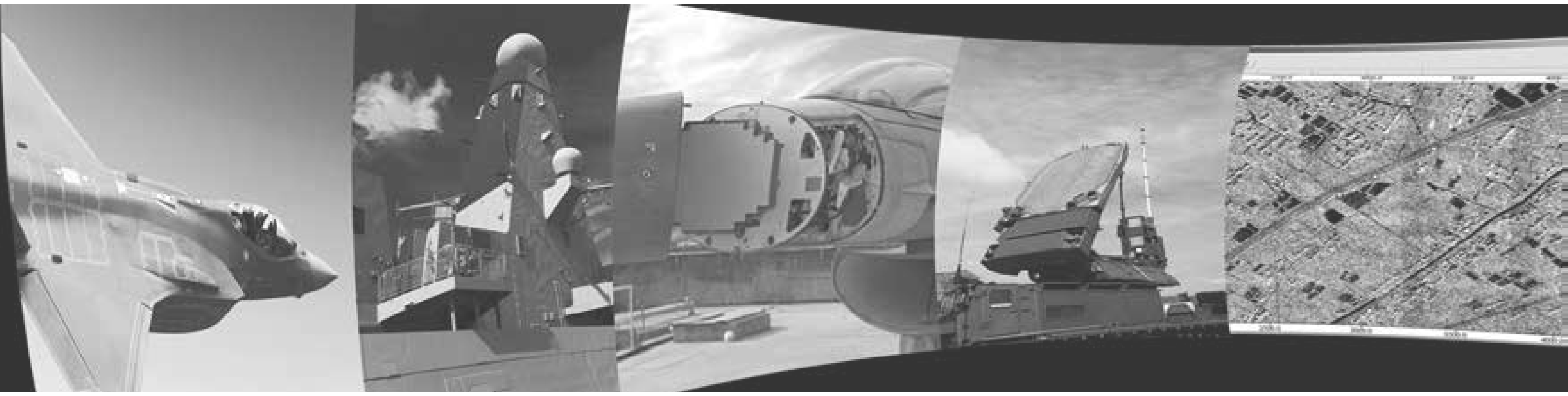


Figure 6 Keysight M9514A AXIe 14-Slot Chassis

An added feature of the AXIe standard is the low latency local bus. This allows instrument blades to communicate directly with each other without involving an external computer or a PCIe endpoint. For example, the ADC 6000 series AXIe-based digitizer blades from Guzik utilize the real-time 40 GByte/s link through AXIe 62-pair Local Bus on the backplane, this allows you to cascade multiple modules for increased high speed processing memory capability, faster data streaming across the multiple PCIe links to an external computer and the ability to interleave modules to increase the sample rate. Also, interleaving two ADC6131 digitizers will increase the maximum sample rate to 80 Gs/s improving the fidelity of the acquisition.

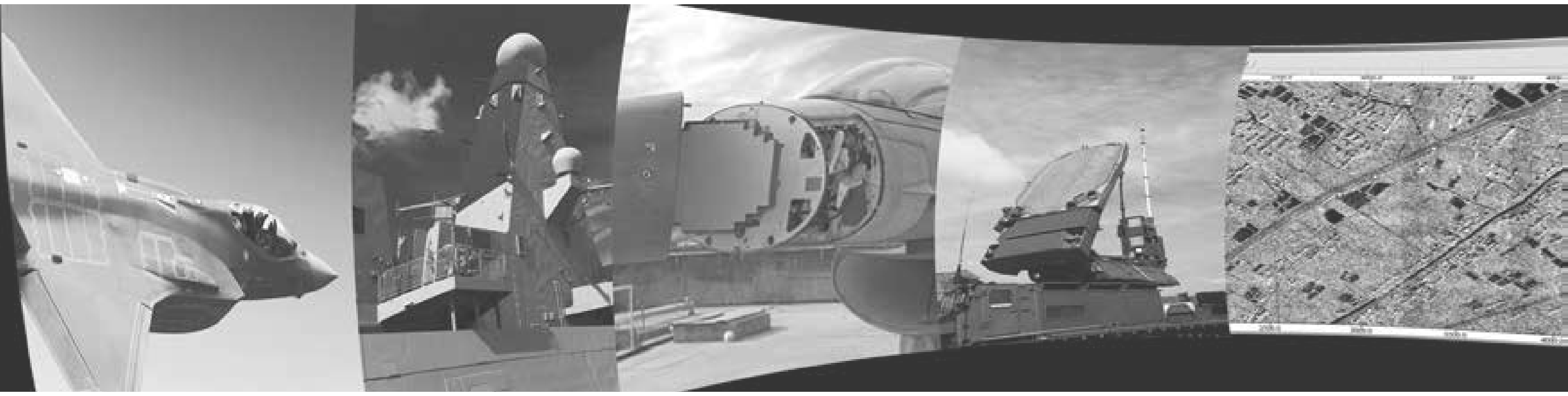
Conclusion

As AXIe builds on industry standards connectivity and interoperability with commercial computing platforms through PCIe, it opens the system to a large array of software tools. Combine this with a selection of high performance COTS hardware components gives you the ability to generate almost any type of signal you or your adversary care to dream up from 10 MHz all the way up to 39 GHz.

With 200W of power dissipation per blade slot, AXIe provides a high performance platform for instrument manufacturers producing broadband microwave up-converters, waveform generators and digitizers. The speed of the PCIe bus can keep up with most radar frame rates and with the addition of high speed waveform scheduling can produce and analyze almost any type of radar or threat.

The compact form factor of AXIe, combined with its high reliability make it an ideal choice for use in complex radar signal generating and analysis systems, with the addition real-time or deterministic triggering AXIe systems can be used for rapid prototyping or proof of concept of next generation systems.

AXIe also provides a balanced mix of manufacturers from the very large to a group of companies creating innovative leading edge technology that meet the requirements of any small business provisions that a specific contract may have.



go-asg.gigatronics.com
Phone / Email
Toll free: 800.726.4442 (USA)
+1 925.328.4650 (International)
Email: asg-info@gigatronics.com