The VXI Bus: Well-Conceived for Demanding Test Applications

Charles Greenberg
EADS North American Defense
Charles.greenberg@eads-nadefense.com

The VXI platform is ideal for demanding test applications. But what exactly do “demanding electronic test problems” consist of and how well has the VXI platform been used to solve them? To answer this question, I will focus on three specific categories of electronics test where my organization, EADS North America Defense Test & Services along with others have taken advantage of the attributes of the VXI bus to solve demanding test applications:

1. Re-hosting a legacy military test system
2. Building a test system with Synthetic Instruments (SI)
3. A synthetic replacement for an obsolete instrument

Re-Hosting a Legacy Military Test System

There are numerous examples of aging military test systems that need modernization. System designers switched from rack mounted standalone boxes to modular VXI instrumentation as part of a solution, usually combined with non-modular instruments such as oscilloscopes. VXI instruments were chosen for many reasons, but usually these reasons included the following:

- **Maintainability:** VXI is at its best when a low Mean Time to Repair (MTTR) is a must, as it is for mission-critical military testing. All VXI modules are plug-ins with front access for easy module and cable removal and replacement. Even VXI chassis power supplies, fans and system monitors are frequently designed to be pluggable and spare-able for low MTTR.
- **Compact Rack Footprint:** VXI allows up to twelve C-sized instruments to fit into 7-9U (1U = 1.75” vertical space) of rack space, more if mezzanine modules are used with VXI carriers. VXI modules have a space advantage over racked, standalone boxes because the backplane eliminates redundant power supplies, cabling, connectors, and cooling systems while doing away with front panel controls.
- **Well-Defined Hardware/Software Integration:** With the VXI bus hardware platform with its well-defined power and cooling specs along with commonly available VXI*plug&play*, IVI and VISA software tools, the integration task becomes straightforward and predictable.
- **Inherent Scalability:** VXI modules tend to use backplane mechanisms that allow automatic setup of master/slave modes which allow channels of functionality to be added or subtracted at will with minimal re-configuration required.
- **Availability of Top-Notch Instruments**: A wide selection of high-performance instruments, mainframes and switching is available:
    - From analog to digital to microwave plus a vast selection of switching
    - From an estimated 80 different hardware manufacturers

These are some of the reasons given for using VXI instrumentation and switching in the Joint Services’ Agile Rapid Global Combat Support (ARGCS) demonstration system. This system is designed to run Test Program Sets (TPS) from CASS, TETS (Viper/T), IFTE, ESTS and potentially other test systems.

The ARGCS system designers couldn’t just procure all of the legacy instruments and assemble them into one gigantic tester that ran all legacy TPS. They needed a single core set of instruments and switching that was flexible enough to run legacy TPS from all supported legacy systems.

ARGCS Core Instruments

Digital and analog instruments for the ARGCS system needed to fit in a minimal footprint yet run TPS written for legacy systems that used different instruments. This means that all pre-existing measurement, stimulus, and signal switching capability had to be duplicated in the core instrument set.

The solution required state of the art technology to produce measurements that could duplicate the functionality, accuracy, resolution and bandwidth of the legacy systems. To achieve this, two principles were used:

- **Extra Dynamic Range:** There are too many legacy measurement ranges in existence to duplicate them all on a single instrument. This necessitates using different ranges, but ranges that had more resolution than the preceding systems had. Some examples of this are in the table below:

Table 1: Comparison of ARGCS Dynamic Ranges to Those of Previous Test Systems

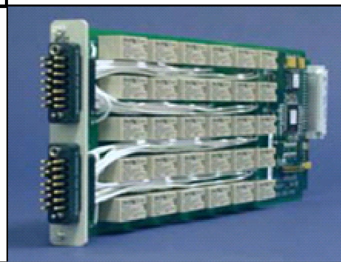
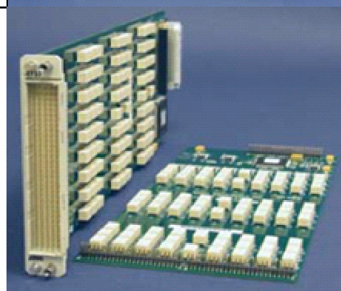
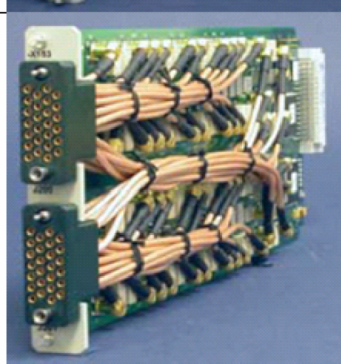
Instrument Type	Legacy Specs	ARGCS Specs
Waveform Generator	12-bit 125 MS/s	16-bit 200 MS/s
Digitizer	8-bit 1 GS/s	10-bit 2GS/s
Digital Multimeter	+/- 1.2 Million counts	+/- 24 Million counts

- **Extensions to Commercial-Off-the- Shelf (COTS) Hardware:** The 340 mm (13.386”) depth of the VXI module gave ARGCS hardware designers room to extend the performance of COTS hardware (Digital Multimeters, Digitizers, Waveform Generators, etc.) by adding missing functionality.

ARGCS Switching

The key to solving the ARGCS switching riddle was flexibility. In this case, the depth of the VXI modules proved extremely helpful in building a group of switches that could reconfigure themselves into different legacy configurations. The implementation of reconfigurable switching configurations requires extra switches and traces on the switch card, which is only possible when you have room for them. So much room is available that a triple 8x24 expandable 60 MHz matrix could be built (over 900 relays) and fit in a single VXI slot. No other fixed-depth modular system in existence would have the board depth, area, or volume required to implement this. Table 2 lists the examples of the extreme density and configurability offered by the ARGCS switching and made possible by the dimensions of the VXI bus:

Table 2: Density and Configurability of ARGCS Switching from EADS North America Defense Test & Services

ARGCS Switch	Photo	Density	Software Configurability
Power Switch 1260-X153 20 Channel, 10 Amps		Effectively 1/3 VXI slot Up to 720 channels/VXI chassis	Twenty SPST Ten DPST Ten (1x2)
Multiplexer 1260-X133 26 (1x4), 2 Amps		Effectively 1/3 VXI slot Up to 936 channels per VXI chassis	Twenty (1x4) and Twelve (1x2) Twenty Three (1x4) and Six (1x2) Five (2x8) and Twelve (1x2)
2-wire Multiplexer 1260-X138 8 (1x8), 2 Amps		Effectively 1/3 VXI slot Up to a (1x2304) channel multiplexer per VXI chassis	One (1x64) two-wire Two (1x32) two-wire Four (1x16) two-wire One (1x16) two-wire plus One (1x48) two-wire
Coaxial Switch 1260-X153 10 (1x4), 1 GHz, 2 Amps		Effectively 1/3 VXI slot Up to 360 coaxial (1x4) per VXI chassis	Ten (1x4) Eight (1x4) and Four (1x2) Nine (1x4) and Two (1x2) Four (1x8) and Two (1x4)
Matrix Switch 1260-43 3 (8x24), 60 MHz, 2Amps		1 VXI slot Up to two (96x216) matrices per VXI chassis	Three (8x24) Two (16x48) & One (8x24) One (24x72) Expandable up to six cards

Building a Test System with SI

At a March, 2006 Synthetic Instruments Working Group (SIWG) meeting, BAE Systems gave a presentation about an SI system that they built using the VXI bus. This synthetic system consists of signal measurement devices including:

- Analog to Digital Converters (ADCs): Both high-speed and narrowband types
- RF Down-converters with Local Oscillator
- An RF Power Meter
- An LF Signal Conditioner

and signal generation devices as follows:

- Arbitrary Waveform Generator (3)
- RF Synthesizer

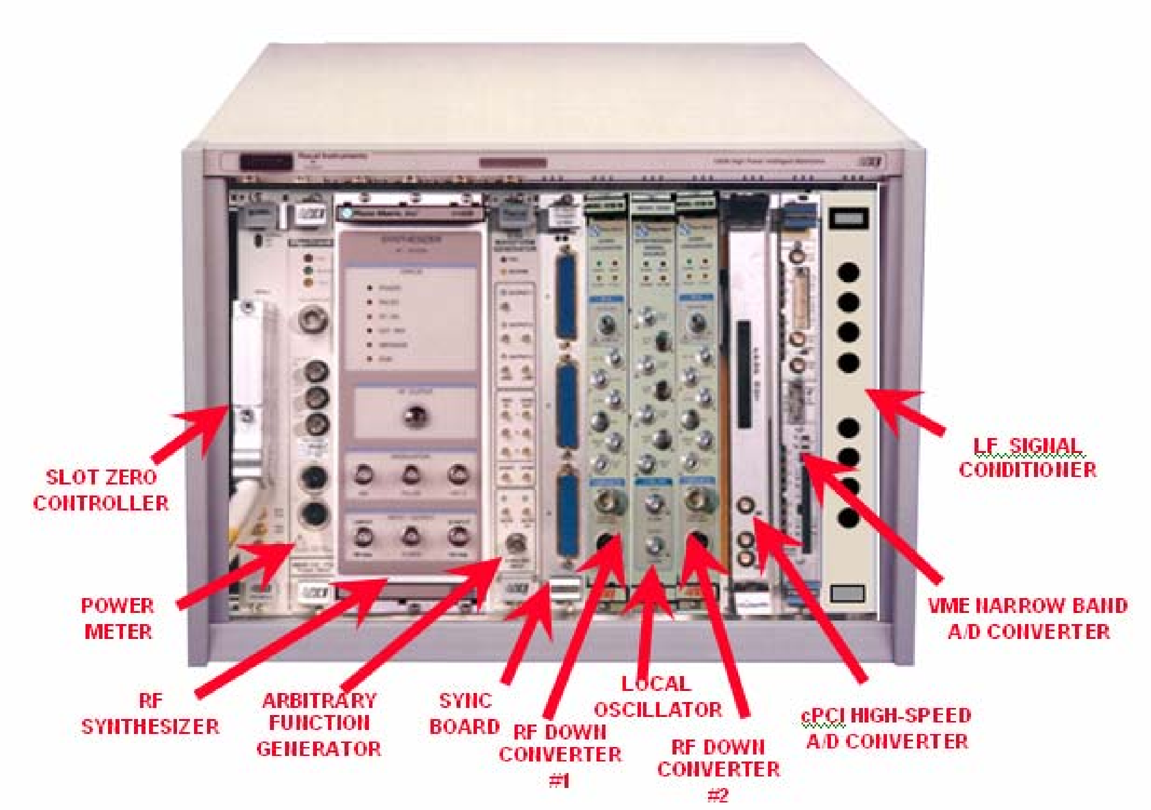


Figure 1: BAE Systems Synthetic Instrument Measurement and Stimulus System (SIMSS)

The system also includes a synchronization card to synchronize the various components and a switching "hood" which routes signals between the instruments and the system's front panel interface.

Figure 2: Front Panel Interface to the BAE Systems SIMSS

System designers recently replaced an older digitizer with a digitizer from Acqiris, a division of Agilent Technologies, to improve the system performance of their SI. Although the digitizer was a 6U Compact PCI card, they were able to accommodate it in their VXI system using a carrier from C&H Technologies. Carriers such as this make technology that is currently unavailable in a native VXI instrument available. This is exactly the way the performance of SI was supposed to be improved by those that envisioned it. The data converters need the ability to be updated as the technology comes into existence, and the VXI platform is accommodating this need.

A "Synthetic" Replacement for an Obsolete Instrument

While it may be self-evident that VXI modules and software of different types and from different vendors coexist and operate seamlessly, it has also been shown that other device types can operate in a VXI chassis alongside native VXI devices. Some examples are PXI modules, M-Modules (mezzanine cards) and VME modules in carriers that adapt these modules to VXI.

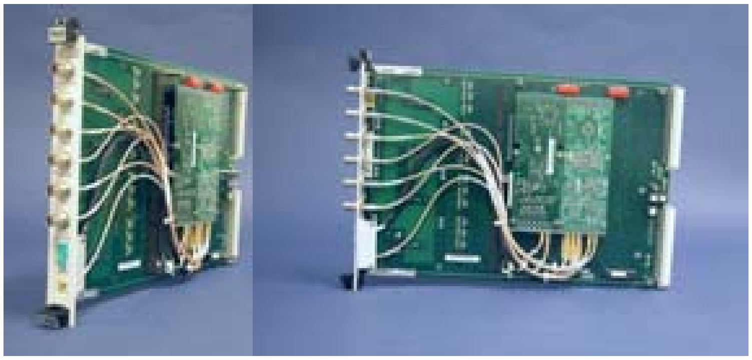


Figure 3: M-Module Mezzanine Instruments Used to Replace a Wavetek 1396 Arb

In Figure 3 an example is shown of a legacy instrument replacement. Fluke recently discontinued one of their older VXI waveform generators which happened to have been used in the USAF's ESTS system and the US Army's IFTE system. A replacement was built using a COTS waveform generator M-Module (Model MA1801A) along with a COTS amplifier/attenuator M-Module (Model M1709), both instruments from EADS North America Defense Test & Services, that duplicated the legacy functionality. An M-Module carrier (Model VX405C from C&H Technologies) was used to adapt the M-Modules to the VXI bus. A special command parser was also created to map native 1396 commands of the legacy unit to the VXI*plug&play* drivers of the M-Modules. The result was replacement of > 85% of legacy functionality and command compatibility at the VISA-SCPI level.

The Well-Conceived VXI Bus

The examples above show that the VXI bus is being used today to solve demanding electronics test applications. This would be impossible without the use of a well-conceived instrumentation standard. The VXI Consortium founders, which included HP (now Agilent Technologies), Tektronix, Racal Instruments (now EADS North America Defense Test & Services) and others applied their combined knowledge as an industry and defined what is still the go-to architecture for the most demanding test applications twenty years later, where density, time-to-repair, reliability, configurability, scalability and maintainability are key.