

NxTest and the development of synthetic instrumentation

This article explores the state-of-the-art of COTS synthetic instrumentation for meeting NxTest requirements with an analysis of the rationale, limitations and alternatives for specifying both new and upgrade class NxTest instantiations based upon traditional instrument specifications.

By Marvin Rozner

You may have been hearing the term “synthetic instrumentation” used lately to describe a new test system architecture that promises to revolutionize the way we test products. So just what is synthetic instrumentation (SI), and where did it come from?

The term synthetic instrumentation was coined by the U.S. Department of Defense (DoD) Next Generation Automatic Test Systems (NxTest) Integrated Product Team (IPT) to describe a new test architecture that would support the charter of its group. In April of 2002, the DoD Automatic Test Systems (ATS) Executive Agent Office (EAO) formally chartered the NxTest IPT—made up of representatives from the Air Force, Army, Marine Corps and Navy—with two main goals: to reduce the total acquisition and support costs of DoD ATS and to improve the inter- and intra-operability of the armed services’ ATS functions.” Certainly, no budget-minded citizen can quarrel with the key goals of the initiative, which were outlined by Bill Ross, assistant director of the ATS EAO, last year, and refined by the Synthetic Instrument Working Group (SIWG).

- reduce the total cost of ownership of ATS;
- reduce time to develop and field new or upgraded ATS;
- provide greater flexibility to the warfighter through U.S. and coalition partner interoperable ATS;
- reduce test system logistics footprint;
- reduce the physical footprint; and
- improve quality of test.

They proposed two main thrusts to drive the NxTest activities. First, define what elements in a test system significantly impact these costs and interoperability, and second to develop a generic test system architecture that would assist in achieving these goals. They wanted an open system architecture that would support new test needs and permit flexible insertion of updates and new technology with minimum impact on existing ATS components while also supporting broad commercial application to garner test industry support. The second purpose of the NxTest team was to define, develop,

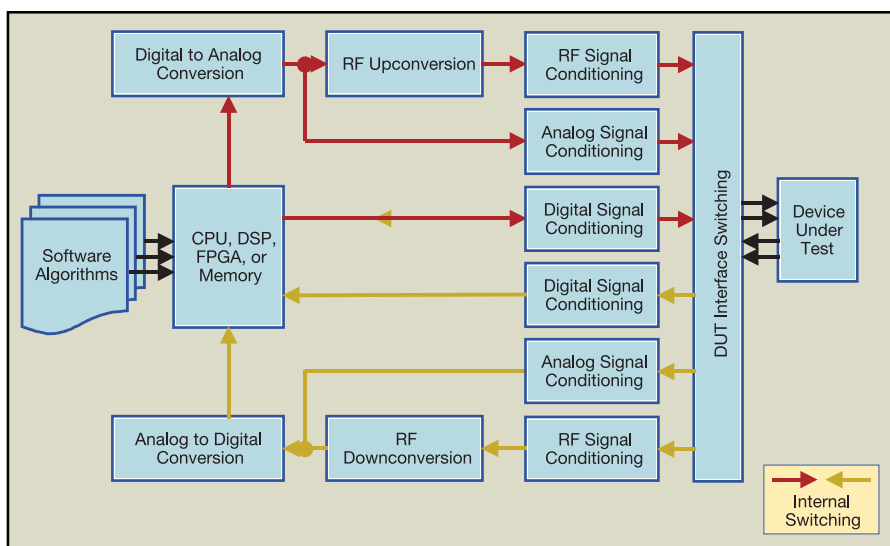


Figure 1. SIWG generic synthetic instrument block diagram.

demonstrate and plan the implementation of these new and emerging test technologies into the DoD maintenance test environment.

To achieve these goals and address the challenges, emphasis is placed upon the use of commercial-off-the-shelf (COTS)

equipment, wherever possible, within a common and shared technical framework. Perhaps the most important technology required to meet the goals is the use of synthetic instrumentation, and even the most steadfast vendors of traditional instruments

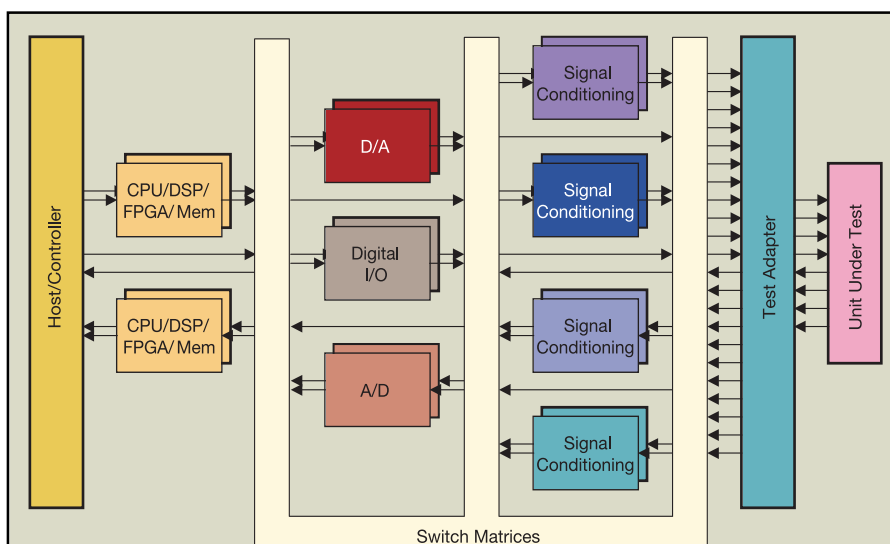


Figure 2. Multidimensional synthetic instrument block diagram.

that populate systems of the old “rack-and-stack” genre are “going synthetic.”

With these goals and challenges in mind the NxTest IPT began working in earnest with participants from the test industry as well as the Ministries of Defense from the United Kingdom, Spain and other countries. While their goals seemed lofty, there was enough work going on throughout the industry that suggested that they might be achievable if the DoD and industry could work together in an organized fashion. They had

seen the major impact that “virtual instrumentation” had made in the 1980s and 1990s and they were now seeing a more evolved architecture under development by several test suppliers that held the promise of further achieving their goals. In an effort to bring some common terminology between industry participants they proposed that this new architecture be called “synthetic instrumentation.” According to the definition under development by the SIWG, synthetic systems are defined as: “A reconfigurable system that



Figure 3. Current third-generation RF synthetic instruments.

links a series of elemental hardware and software components, with standardized interfaces, to generate signals or make measurements using numeric processing techniques.”

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Synthetic instruments

Basically, synthetic instruments “synthesize” the stimulus or measurement capabilities found in traditional test instruments through a combination of software algorithms and hardware modules that are based on core instrumentation circuit building blocks. The concept of synthetic instrumentation finds its roots in the well-accepted technologies and techniques behind software-defined radios, mobile phones and other communications systems designed and fielded today. The block diagram of a synthetic instrument is shown in Figure 1 as defined by the SIWG.

Figure 2 illustrates some of the real power behind the synthetic architecture. The modular nature of synthetic instruments allows system integrators to tailor solutions tightly to each individual application. By integrating the appropriate modules the architecture supports many diverse applications such as:

- multichannel stimulus or measurement path configurations;
- mix-n-match performance, size and price levels for each channel, including routing individual channels through multiple signal conditioning blocks to provide test-specific functionality;
- easily upgrade the system to add or remove functionality at any time, or completely reconfigure it for an entirely new application;
- add processing power or new test algorithms as required; and
- provide sophisticated “system-level” calibration and diagnostics capabilities.

NxTest activities

The NxTest team has spearheaded many of the key SI-related industry initiatives. Some of the most significant are the automated test markup language (ATML), common test interface (CTI) and SIWGs.



Figure 4. Pre-production prototype of a fourth-generation synthetic test system.

You have already been exposed to some of the definitions developed by the SIWG. The NxTest IPT sponsored the creation of this working group to:

“Define synthetic instrumentation and its attributes. Develop a framework that balances user and supplier objectives, facilitates rapid technology advancements and adaptation throughout the test life cycle, and complements/supports other relevant test and measurement industry activities.”

Although the SIWG is the newest of the working groups it boasts almost 100 members representing more than 40 companies and organizations within the test industry and the DoD including representation from most of the major test equipment suppliers. After sponsoring the first meeting, control of the SIWG was turned over to the industry and the DoD became a standard member.

The NxTest IPT sponsored the creation of the ATML and CTI Working Groups almost two years ago. The ATML Working Group was chartered with developing a common XML schema for critical software interfaces in the test environment. This group has transitioned to the formal IEEE SCC20 committee and will be releasing the first ATML schema standards in the coming months. The CTI Working Group was chartered with developing a common, general purpose and scalable test interface that could provide for interoperability between test systems used by the various DoD services. This group is in the process of finalizing its interface definition and may publish it by the time you read this.

The DoD has also started several major NxTest-related programs. Possibly the most significant of these is the Agile Reconfigurable Global Combat Support (ARGCS) program. The creation of this challenging Advanced Concept Technology Demonstration (ACTD) program was sponsored by the NxTest IPT, and authorized by the Office of the Secretary of Defense (OSD). ARGCS is the first major joint services test system program in the United States. This program will result in a common and scalable test platform that can be used by the Air Force, Army, Marine Corps and Navy.

The ARGCS test platform will demonstrate the most scalable and reconfigurable test system architecture ever fielded. The platform will support factory, depot, intermediate and operational level tests. At the

same time it also supports simple and complex system configurations. For the first time, this industry-leading flexibility will allow the U.S. Air Force, Army, Marine Corps and Navy as well as NATO and coalition partners to individually procure systems configured for their specific operational scenarios while sharing the same core hardware and software modules for unprecedented cross-service interoperability.

Real world example

In 1996, Aeroflex’s Systems Division was awarded a contract to provide the industry’s first synthetic RF and microwave test system for the world’s leading provider of communications satellites. The first of nine systems was shipped in 1998. The system was called the STI1000. A third-generation STI1000 system is shown in Figure 3 along with a system configured for high-speed production testing of radar transmit/receive modules called the TRM1000.

These two systems represent the current state-of-the-art of RF synthetic instrumentation including capabilities like output power calibrated to within 10ths of a dB, from 0.2 GHz to 32 GHz, through 25 feet of cable, with a remote switch matrix that can reside within a thermal vacuum chamber. These systems emulate all the standard measurements that can be made with traditional instruments like power meters, spectrum analyzers, network analyzers, oscilloscopes, noise figure meters and more. They also provide the functionality of single or multichannel CW and even complex signal generators.

The two smaller synthetic systems shown in Figure 3 display the state of the art for baseband synthetic systems. These configurations can support up to 600 MHz instantaneous bandwidths for stimulus and response. While they too emulate the functionality of many traditional instruments they also display many advanced measurement and complex modulation capabilities that are either difficult or impossible to perform with a rack of traditional instruments. Finally, Figure 3 highlights the scalability of synthetic instrumentation with hardware modules as small as those in a 3U PXI form factor.

While there are many hardware and software elements from several suppliers that support the SI architecture there are even more exciting products on the horizon. The next generation of synthetic solutions will be powered by hardware and software designed from the ground up for use in the synthetic test environment. These new elements will allow for advanced capabilities such as automated system configuration, automated diagnostics, ultrahigh-speed processing, and even more complex waveform generation and analysis. For example, Aeroflex will soon introduce its fourth-generation synthetic

instrument platform that will include many of these capabilities and more. The pre-production prototype shown in Figure 4 includes a complete dc-26.5 GHz synthetic test system with stimulus and measurement paths, device interface switching, built-in NIST traceable calibration capabilities, and up to 400 MHz of instantaneous bandwidth among a host of features. Advanced systems like these will replace entire racks of traditional test equipment and they will likely surpass the “lofty” goals and objectives of the NxTest IPT.

To protect investments in systems and, more important, in the test program sets (TPSS), the requirements for many new or upgraded test systems are often written in terms of the traditional instrument-level specifications that they replace. Certainly, such an approach to requirements specification development is easier than attempting to research and integrate various specific test requirements associated with the various DUT’s to be addressed by the testing initiative in question.

However, when it comes to the objective of a synthetic test implementation, there is a conflict in requirements based upon traditional instrument components vs. the specific and real requirements of the DUT’s to be

addressed. In most cases, traditional instruments are not used at all of the boundary conditions of their capabilities. By simply aggregating the worst-case specifications of all the traditional instruments it makes the job of providing a synthetic test solution difficult at best. It results in a synthetic solution that, if built, would be the “super instrument,” which, in many cases, translates to higher cost. Although it is true that this aggregation approach can work in many lower performance or lower-frequency applications it is extremely difficult to manage when high-performance instruments enter the mix. This can lead to the notion that synthetic system components must be constructed from instruments without front panels rather than software-defined multifunctional stimulus-response channels. Such an approach might work but it would severely weaken the opportunity for synthetic test systems to contribute to achievement of many of the NxTest goals.

Furthermore, synthetic instruments allow you to insert a software translation layer into your system that, in most cases, will allow you to use legacy TPSS without modification. This software can translate “traditional instrument programming statements” to

equivalent test and measurement functions of the synthetic system. However, just as stated previously, if you base the system specifications on mimicking “all” the functionality of the legacy instruments you may end up with costly “software overkill.” In reality, most test applications only use a fractional subset of the available instrument functions.

The best way to specify test systems for synthetic implementations, or even rack-n-stack implementations for that matter, entails listing the “actual” stimulus and measurement functions needed along with their performance requirements and margin. This allows the synthetic system integrator to select only the hardware and software modules they need, and it dramatically reduces the size, complexity and cost of the solution. When properly specified, synthetic test system solutions actually tend to be less expensive and much smaller than systems based on traditional instruments. If you are interested in using synthetic instrumentation, work with one or more of your equipment suppliers early on in the specification development process to maximize your overall success.

Summary

All in all it is an exciting time for the test industry. The realization of synthetic instrumentation promises to take the test industry to the next level of performance and value. And for this we owe a special thanks to the NxTest IPT and their early industry partners for laying the foundation that we will build upon. **DE**

ABOUT THE AUTHOR

Marvin Rozner is vice president of business development at Aeroflex Systems Division. He has more than 20 years of experience in electro-optic and test systems. His work includes positions with Hughes Aircraft, Hughes Space and Communications, Boeing Satellite Systems and, currently, Aeroflex. At Aeroflex, he has business development responsibility for Aeroflex Synthetic Test Solutions. Rozner’s specific experience encompasses the development of advanced test system architectures, managing test system and process development programs, and general management as well as analog, digital, electro-mechanical and software design. His work spans missile, space, biotechnology, radar and general-purpose test industries with emphasis on the application of advanced synthetic technologies to test solutions.