Common Core ATE for Automated Functional Testing

Summary

The approach to high-end Aerospace/Defense test system development is shifting from application-specific test systems to common core automated test systems in order to reduce overall test cost and increase system flexibility. Common core test sets are also being developed to replace proprietary legacy systems by using commercial-off-the-shelf (COTS) hardware and open software environments. Furthermore, common core test sets allow the customer a seamless transition from product design to product validation and into production.

- *Reduced Test and Development Time*
- *Reduced Cost*
- *Uses Modular Hybrid Design*
- *Provides Flexibility for Hardware Expansion*
- *Reduced Need for Costly Software Upgrades*

G Systems, L.P. (G Systems) recently developed an automated test system (Figure 1) under a subcontract for Lockheed Martin Missiles and Fire Control, Dallas, TX (LMMFC) to test and validate multiple functions of a new missile launcher for the Non-Line-of-Sight – Launch System (NLOS-LS).

The test platform is primarily PXI-based and provides a wide array of instrumentation for complete coverage of test program sets in a single test system. The RF signal generator, signal analyzer, and modular power supply system are from Agilent Technologies. The PXI hardware, including a counter/timer, a DMM, multiplexers and switches, and input/output boards are from National Instruments and other members of the PXI consortium. The system delivered by G Systems also includes multiple

Figure 1: Common Core Test Station

interconnect systems using a Virginia Panel receiver and interchangeable test adapters (ITAs) as well as a full complement of custom cable harnesses.

The test system includes self-contained wrap-around capability for performing automated self-test on the instrumentation and interconnects. A wrap-around test is a cost effective method for testing hardware, cabling, and connections. A signal is generated by one instrument then "wrapped around" the test set, through the ITA, and measured by another instrument, thereby self-testing several instrument functions as well as cabling and connectivity. The range of measurements available includes standard DC measurements, RF spectrum analysis, waveform analysis, Ethernet validation, USB validation, and JTAG. Other instrumentation includes GPS simulation, electronic loads, power supplies, dense switching, and general-purpose data acquisition.

The common core platform is controlled using custom software based on National Instruments' TestStand™, LabWindows™/CVI, and interchangeable virtual instrument (IVI) drivers. All results are archived in a SQL Server™ database.

Overall benefits of this new test platform include reduced test cost and reduced test time. Features of the system include a flexible platform for multiple test programs and a built-in self-test routine for the complete system.

Hardware

The missile launcher test system is based on a hybrid design including PXI-based test hardware as well as box instruments. Hybrid systems take advantage of a five-layer architecture to maximize system life, connectivity, extensibility, and module replaceability (Figure 2). All of the integrated hardware is COTS to reduce cost and increase system flexibility. The primary function of the test set is functional testing of the NLOS missile launch station and related equipment and sub-assemblies.

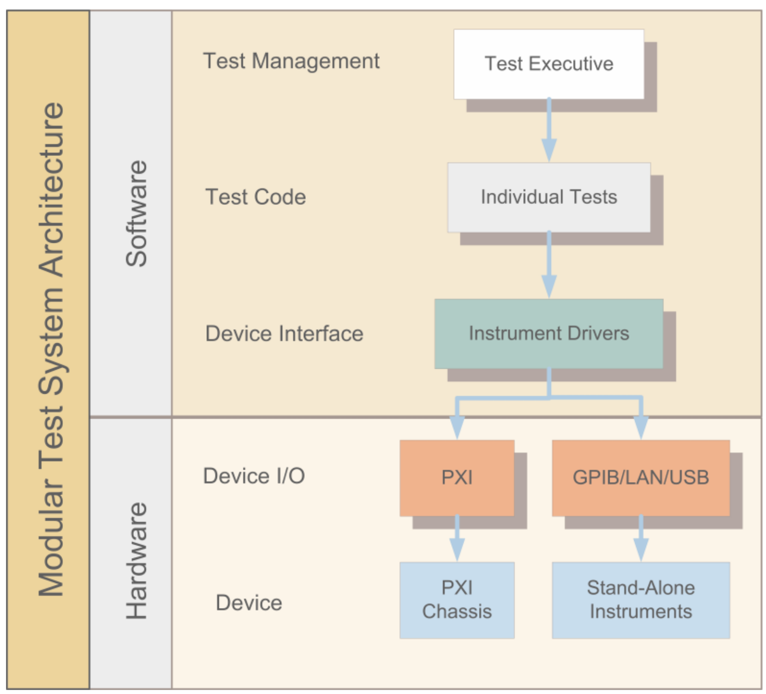

Figure 2: Five-layer Architecture

The NLOS-LS is being developed for the U.S. Army's Future Combat Systems (FCS). The FCS, NLOS-LS spin out one consists of a Precision Attack Missile (PAM) and a highly deployable, platform-independent Container Launch Unit (C/LU) with self-contained tactical fire control electronics and software for remote and unmanned operations. Each Container Launch Unit (C/LU) will consist of a computer and communications system and 15 missiles.

An additional power supply and electronic load are used in testing the launcher under maximum power conditions and are housed in the auxiliary power rack.

An industrial personal computer (PC) serves as the test set executive controller and controls the entire suite of test set hardware. The PXI hardware consists of two (2) PXI instrument chassis and instrument modules including a counter/timer for signal synchronization, a digital multi-meter (DMM) for signal measurement, several multiplexers and switches for signal switching, and multiple Input/Output (I/O) boards for data acquisition.

Also integrated into the test set are an RF signal generator, spectrum analyzer, a global positioning system (GPS) simulator, and a digital storage oscilloscope (DSO). Multiple power supplies and electronic loads provide power to the units under test (UUT) and simulate real-time field test conditions. All instrumentation is connected through a double height Virginia Panel Series 90™ receiver.

With the test executive PC, seamless communication with the peripheral instrumentation via the PCI bus, USB, Ethernet, and/or IEEE 488 is possible. Therefore, the test system can use the best instruments for the required measurements without being constrained to one communication bus.

In order to test multiple launcher systems, while using the same common core test set, various interchangeable test adapters (ITAs) were built to connect to the mass interconnect receiver. The Virginia Panel adapter provides the electrical and mechanical connection to multiple UUTs via unique ITAs thereby maximizing the test set functionality and usage.

Software

The G Systems test set uses a modular test system software architecture consisting of a system management software layer or test executive, application specific software, and an instrument driver layer (Figure 2). This test approach allows for testing multiple products and facilitates adding new tests or additional test hardware. This approach also enables the use of the same test software for design, validation, and production and minimizes start-up time during the transition from design to manufacturing test.

A test executive is a sequencing framework for executing specific test steps. G Systems uses National Instruments TestStand for its test executive software which allows many of the common test requirements to be standardized in the common core test set. Functional tests for features such as the operator interface, UUT tracking, test flow control, and results filing and reporting are the same for all UUTs therefore a common test executive program saves time when multiple system-level tests are required. The common core test set enables engineers to standardize their system tests (self-test, user interface, test reporting….) yet customize specific UUT tests.

IVI Drivers

Another feature of the common core test set is the extensive use of interchangeable virtual instrument (IVI) drivers. Test systems designed with IVI drivers allow the same software code to be used with different instrument platforms. In other words, where IVI drivers are used in the test software, instruments can be exchanged (even between different manufacturers) with no expensive software updates required. This feature is particularly beneficial when an engineer wants to update a test instrument or especially if an instrument requires replacement due to obsolescence. With test sets supporting defense systems which are deployed and supported for ten (10) years or longer, hardware replacement or upgrades are the norm.

Furthermore, IVI drivers permit instrument simulation prior to full system integration which allows developers to test their software prior to buying expensive measurement hardware.

Test System Self-Test

A self-test of the test system ensures that all hardware and instrumentation are functional and performing within specification. Self-testing the hardware is accomplished through a custom self-test ITA interface and self-test software developed in LabWindows/CVI and linked to the TestStand test executive. The self-test ITA has functional stimulus, response, and switching wrap-around for test station hardware verification and confidence checking.

Each instrument manufacturer’s internal built-in-self-test (BIST) verifies the function and operation of the instrument being tested. G Systems’ self-test software calls the available instrument’s internal BIST to verify communication with the instrument and test the necessary function of the instrument to verify the input and output of the instrument as well as the cabling between the ITA and the instrument.

Available IVI drivers, along with built-in TestStand IVI step type, take advantage of the unique IVI architecture. As mentioned previously, IVI provides an abstraction layer so that any IVI compatible instrument can replace the existing instrument in a given class.

The system self-test was designed to use existing hardware and does not require any additional instrumentation which minimizes cost, wiring complexity, and overall system weight. The system self-test was designed such that performing a self-test on one instrument also tests any complementary instrument channels/functionalities, thus minimizing self-test time. An example of this technique is to use the test station's oscilloscope to read the signal generator's signal and thereby test two different instrument functions with one simple test.

All inputs and outputs from each instrument are connected through the Virginia Panel adapter which provides for complete wrap-around verification. Wrapping of I/O modules is accomplished within a given card or between two similar cards thereby minimizing the wiring in the self-test ITA. In general, a test passes if the generated signal is equal to the captured signal within a specified tolerance limit. Some of the tolerance limits are programmatically generated or retrieved while others are configured through sequence file global variables in TestStand.

The self-test sequence was developed in TestStand Sequence Editor with code modules developed in LabWindows/CVI. Test results are displayed on the operator's graphical user interface (GUI) and contain the following data: test number, test step name, test compare type, measured value, lower limit, upper limit, units, pass/fail status, and information regarding possible cause of failure.

Custom GUIs

The common core test set features several levels of graphical user interfaces that are custom designed with the end user's needs and requirements in mind. Three levels of complexity exist with separate GUIs for engineers, technicians, and operators. Engineering views allow complete diagnostics and provide complete parametric test data results. In the operator view, the GUIs provide basic self-test instruction and generic pass/fail status.

Mass Interconnect

In order for a test system to be truly "common core" and support a wide measurement capability for multiple systems, it must have the capability to interconnect to all the integrated hardware and I/O, and be able to uniquely connect to any and all UUTs. Mass interconnect can be defined as "an electromechanical device used in conjunction with automated test equipment (ATE) that reliably connects a multitude of signals simultaneously." A key feature of the G Systems solution is its mass interconnect panel. The interconnect for the test station uses the Virginia Panel double tier Series 90 test panel receiver (Figure 3). The receiver features a double tier frame that aligns with the dual PXI chassis. Large cable bundles are strain relieved at both the receiver and PXI board connections. The receiver panel also hinges down in front of the PXI chassis for easy PXI board access and maintenance.

With this receiver configuration, there is room for all the box instrument connections as well. The existing system has over 2,500 connection points, but moreover, still provides room for expansion should the test engineer require new instrumentation or additional PXI cards. With proper interconnect planning, an ATE configuration can support decades of future production and test engineering by allowing for hardware replacement and re-configuration.

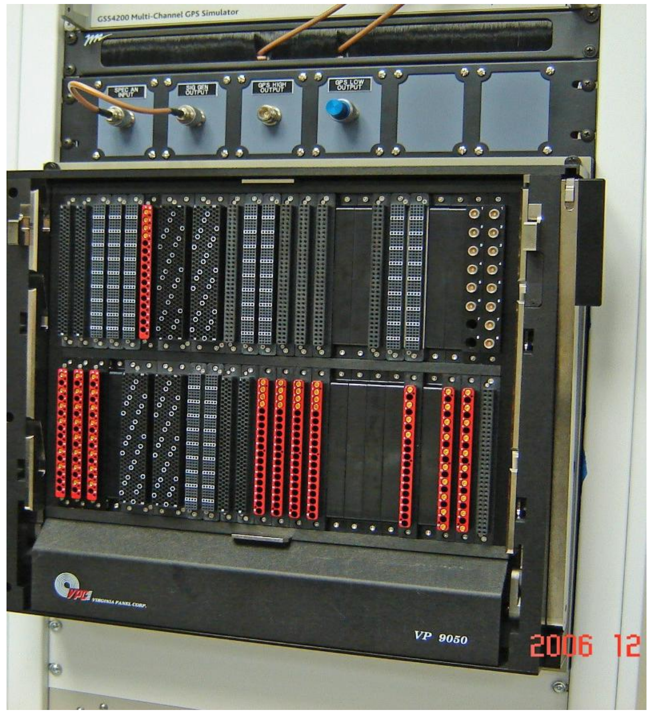

Figure 3: Virginia Panel Series 90 Receiver

Data Storage and Reporting

The magnitude of tests performed with the common core test set requires a database for data storage, data retrieval, and data reporting. By using TestStand Database Options it is very easy to customize one of the default database schemas and enable database results logging with the click of a button. In order to keep the test report size to a minimum, ASCII reporting format was selected in the TestStand Report Options. The ASCII test report consists of approximately 4,000 test results, and these results are also logged to a SQL Server database.

Why G Systems?

Through outsourcing, the defense contractor effectively increases their internal resources. Outsourcing allows the defense contractor's technical staff to focus on major systems-level issues. Moreover, outsourcing can be instrumental in meeting critical deadlines. G Systems completed the common core test station in four and one-half months, whereas the customer had projected 6-8 months for an internal design and build. The time savings kept the program on schedule.

A full-service integrator means "one-stop shopping" for the defense contractor. G Systems' expertise spans from test system design to implementation, including hardware, software, SPC analysis, and results reporting. Assembling all of these skill sets in-house can be challenging. By outsourcing to the experts, the customer pays for exactly the service they need when they need it. This approach minimizes the need to hire additional staff, attend expensive training, and/or license expensive software. Furthermore, embarrassing cost overruns are avoided.

Conclusion

G Systems' new automated missile launcher test station reduces both system test time and overall system test cost for Lockheed Martin Missiles and Fire Control. The test station makes use of a modular hybrid design architecture which allows maximum flexibility for hardware expansion or hardware replacement. The test software makes use of IVI drivers which also facilitates hardware exchange without expensive software upgrades. All the hardware and software are commercial-off-the-shelf products used to replace more expensive proprietary legacy systems. Moreover, G Systems was able to cut test system development time, from design to implementation, nearly in half. The new system also reduces any production start-up delays by using the same system hardware and software for product design through production.

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