VXI-Based Test Station Reduces Development Cost and Cycle Time

by Paul A. DeStefano, Lockheed Martin

Figure 1. Hellfire II Common Core Test Station With Temperature Forcing Unit

In an increasingly competitive defense electronics market, lean production initiatives are paramount to remaining competitive. And, the limited defense budget has forced the aerospace/defense industry to drive process improvements well beyond the low hanging fruit.

The need for faster cycle time has created a huge challenge for test-development organizations to deliver production-ready equipment for first-article testing. And commercial manufacturers face the same challenges.

The design of automatic production test equipment represents a significant portion of the nonrecurring cost of developing state-of-the-art production lines, especially when each system is one-of-a kind and custom-built. In addition, the recurring support cost of a large number of unique systems throughout numerous production and depot facilities is cost-prohibitive.

The need to lower test-system development and support costs and shorten development times has driven Lockheed Martin Electronics and Missiles (LM E&M) to implement a formal hardware and software design reuse strategy resulting in a standardized, reconfigurable Common Core Test Station (**Figure 1**).

The evolutionary test-development process was too inefficient—until one company used a VXIbus-based system to aggressively reduce cost and cycle time.

Central to the Common Core test platform is the VXIbus, an industry-standard test-equipment architecture widely supported by many leading test and measurement manufacturers. Standard plug-and-play instrument software provides universal support with commercially available test-development software and maximizes portability from one generation to the next.

This enables faster development times and seamless upgrades when newer instruments replace the older hardware. Software rewrites and system redesigns are minimized. In addition, LM developed a standard test-executive software package to use with every Common Core platform, resulting in more than 50% software reuse. This new test strategy has resulted in documented reductions in development costs of more than 50% along with development-cycle time reductions in excess of 40%.

Previous Methodology

Until recently, test stations were customized for the technology, signal characteristics, and assembly level of the unit under test (UUT). Not only would customization occur at each subassembly test level, but also among programs using various technologies. Specialized test platforms, some developed in-house and others available commercially, provided particular advantages for each type of test to be performed at the circuit-card, subsystem, and system level.

The result was unaffordable test-development costs that reached millions of dollars for a full complement of production test equipment on a major program. The problem was compounded by the lack of formal reuse of test hardware and software.

Rapid technology advancements and lack of standardization in the test-instrument industry encouraged new designs that used instruments with increased capability and accuracy. Unfortunately for the test engineer, these newer instruments were not software or interface compatible with previous instruments and required significant design modifications to integrate them into a test-station design.

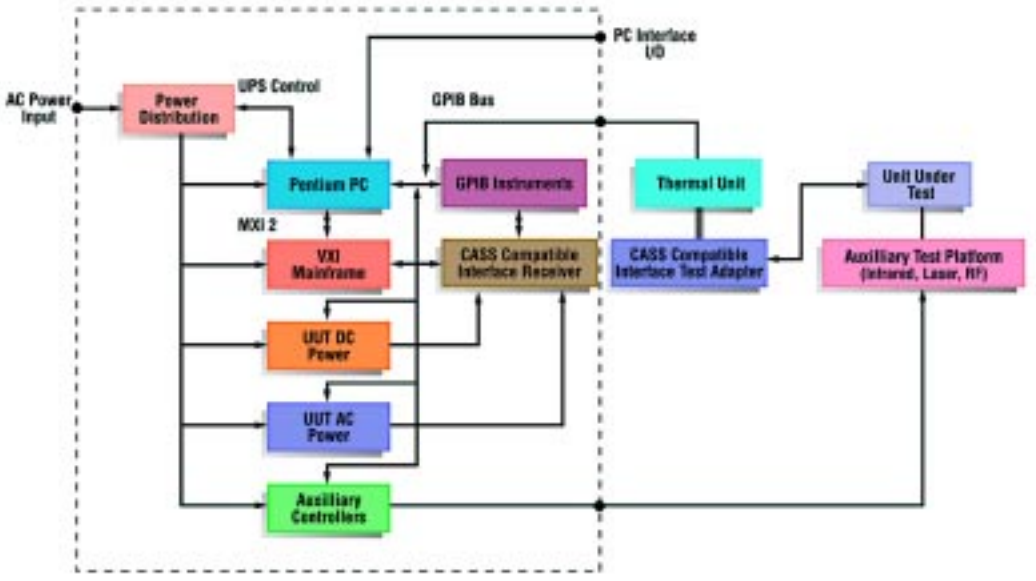

Figure 2. System Diagram of Common Core Test Station

In addition, custom test equipment resulted in extremely high life-cycle operating and support costs. Each test station contained a variety of system architectures, software languages, computer platforms, instrument types, and bus protocols.

To provide adequate maintenance and support, an excessive staff of support engineers with the technical skills to cover the full range of hardware and software technologies was required. To achieve minimum station downtime, a substantial assortment of spare hardware was required since lack of commonality prevented shared spares.

Supplier obsolescence continues as another significant factor that has driven the need for common-platform test equipment. Test-system companies have long since taken for granted that the average market availability of a test instrument was about three years. Any equipment that required replacement or duplication after that period of time would require a costly redesign effort.

With production rates on successful programs increasing, the need for duplicate test stations to keep up with production throughput resulted in redesigned test-equipment hardware and software. This, again, required additional unique test stations and spares inventory and new support training programs.

Test-Development Strategy

In late 1997, the LM E&M Test Engineering Department formed a team to revolutionize the test-equipment development process. The previous evolutionary methodology of making improvements from one program to the next was too inefficient to implement the far-reaching improvements that were needed. The team, consisting of various engineering disciplines along with representatives supporting other LM sites, set aggressive goals to reduce test-development costs by 50% while reducing cycle time by 40% by the end of 1999.

The Test Station

The result is the Common Core Test Station consisting of high-performance commercial off-the-shelf components based on VXIbus technology (**Figure 2**). The system is PC-based with a Windows™ NT Operating System.

LabWindows/CVI from National Instruments is the application software of choice because of its flexibility in creating C source code and the existence of the vast majority of instrument drivers. Test-applications software is written in C, an industry-standard programming language.

The core of the system software is the LM E&M-copyrighted Test Executive Software containing all common functions needed to operate the station, such as test sequencing, error handling, SPC test data collection, system initialization, data-sheet generation, and graphical user interfaces.

The PC connects to the VXI mainframe through a MXI-2 high-speed interface to a Slot-0 controller. The 13-slot, C-size VXI mainframe contains all general-purpose VXI instrument modules such as switching, a digital multimeter, a waveform generator, a digital-to-analog converter, a 1553 interface, an RF multiplexer, and 25-MHz digital I/O. The remainder of the Common Core Test Station includes power conditioning and distribution, GPIB instrumentation, UUT power sources, and a computer-controlled uninterruptable power source.

The VXI receiver panel is mounted directly in front of the VXI mainframe to minimize signal wire length from the instrument modules to the Interface Test Adapter (ITA). This is especially important for tests using Teradyne's Logic Automated Stimulation and Response (LASAR) high-speed pattern generation from the digital I/O modules. The ITA is a reusable design supporting simultaneous testing of two circuit cards while providing signal conditioning, loading, and air-temperature control. Built-in air channels that

provide uniform air distribution and rapid temperature transition allow full MIL-Spec temperature range testing.

The Common Core Test Station provides a single test platform across all assembly levels from mixed-signal circuit cards and subassemblies through full system-level testing on missile, fire control, and launch-vehicle programs. This includes functional, thermal, and diagnostic test capabilities using test vectors, boundary scan (JTAG), and guided- probe diagnostics.

The use of industry-standard, commercial VXI hardware components available from many suppliers minimizes rapid obsolescence and sole sourcing by providing competing sources for system components. The result is a low-cost system with an open architecture for easy expansion and performance upgrades.

The goal of reducing the cost of a turnkey test station by 50% has been met and continues to be exceeded.

The standard software drivers that come with VXI products contribute to the portability of application software from one test system to another. Spares inventory also is reduced to a common set of hardware that can be used across multiple test stations and production programs.

Affordable Multi-Missile Manufacturing Initiative

The Defense Advanced Research Projects Agency (DARPA), in cooperation with the U.S. Army, Navy, and Air Force, awarded a five-year program to LM for Affordable Multi-Missile Manufacturing (AM3). The purpose of the program is to develop and demonstrate advanced manufacturing concepts and enterprise systems that substantially reduce the cost of producing tactical weapon systems.

In 1998, LM initiated an upgrade and enhancement of the Common Core Test System to further reduce engineering-development, operating, and support costs. The result is a multiuse test station with a Universal Selftest Adapter, an Automatic Calibration Interface, a Real-Time SPC Operator Alert System, and Consolidated Automated Support System (CASS) compatibility. This universal approach to all system components further reduces the nonrecurring engineering effort and recurring support costs associated with the test station.

Pinout and adapter compatibility with the CASS currently used by the U.S. Navy presents new business opportunities. It provides a DoD NAVAIR standard interface that will allow Test Program Set (TPS) Adapters developed for the Common Core System to be connected directly to other CASS-compatible systems. Depending on the software environment and VXI instrument complement of these other systems, much of the same TPS application software can be ported. Test commonality between the production factories and field-support depots can be readily achieved.

Program and Depot Deployment

Since the deployment of the Common Core Test Station in late 1997, significant accomplishments have been realized. The goal of reducing the cost of a turnkey test station by 50% has been met and continues to be exceeded. Additional strategies are planned to further reduce the total cost by 65%. This will be accomplished by increasing hardware and software reuse and implementing supplier cost-reduction strategies related to various system components.

Through a team effort between LM and Hewlett-Packard, a lower-level circuit-card thermal test was developed to better replicate the operational environment of a guidance section. This was accomplished using the Temperature Forcing Unit and VXI arbitrary waveform generator modules to better simulate electrically noisy environments by modulating random noise onto signal lines. The more robust test has allowed manufacturing defect detection to be driven down to the circuit-card level where rework costs are much lower than at the guidance-section level.

Conclusion

As a result of the continuing success of the program, the VXI-based Common Core Test Station has been established as the test-equipment standard for all new programs at LM E&M. Over the past two years, 12 systems have been deployed across eight programs in the Missile, Fire Control, and Launch Vehicle program areas.

Present test applications include circuit-card assemblies, seeker assemblies, avionics sections, guidance electronics, all-up missiles, targeting pods, safe and arm units, fire-control circuit cards, and satellite launch-vehicle electronics. Over the next two years, 21 additional Common Core Systems are planned for five additional Missile, Fire Control, and Strike Weapon Programs.

About the Author

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