Abstract – This paper discusses Modular Integration Packaging for Scalable System (MIPSS) being developed under a preliminary standard IEEE-P1693 and describes a benchtop application of the new architecture design. The building block approach segments a test system into core and augmented elements as illustrated in Figure 1. MIPSS defines the electrical and mechanical specifications of a modular interconnect packaging system design for Automatic Test System (ATS) that can be applied in portable/benchtop and rack mounted versions. It specifically, describes a building block approach based upon the integration of four elements: (1) the mechanical chassis that forms the mechanical structure of the building block with alignment features to mate with other enclosures [building blocks], optional test interface choice emulating DOD Interface Standards [1] [2]; (2) merging of VXI/PXI/M-Module [3] [4] [5] multi-standard instrumentation under a single plug&play platform along; (3) mechanical/electrical extension that couples the instrumentation directly to a pluggable test interface panel of choice that connects to the Unit-Under-Test (UUT); and (4) a new pluggable virtual power source. These elements serve to significantly downsize footprint, reduce costs, reuse existing VXI inventory and integrate multi-standard instruments in a common platform, improve maintainability, support organic plug&play integration and enhance current VXI-based DOD ATS (Fig. 1), or commercial ATS applications.

1. Introduction

Automatic Test System (ATS) integration continues to suffer from a lack of standards or the continuous evolution of standards that do not support backward compatibility. The MIPSS architecture attempts to solve these issues through an integration approach that merges many open standards used in Automatic Test Systems (Fig. 2). It is based upon VXIbus Standard (supports current and advanced serial control-Rev 4.0 modules), and a VXIbus carrier module. The carrier serves as an integration bridge to facilitate the use of multiple plug-on mezzanine M-Modules (6-8/carrier) and PXIbus Modules (4-A size/2-B size per carrier) in a common platform. This functionally provides 3-5 times more instruments in a single platform, dramatically reducing footprint, integration costs, and failure risks thru redundancy. Under the plug&play design, Users can also quickly assemble, (re)configure, upgrade, or replace the module within the ATS. A VXI based plug-in power module is also specified that serves as a instrument or UUT source, further integrating power with instrumentation in a compact footprint. The most dramatic benefit of the MIPSS architecture is the transparent plug-on interconnectivity with optional IEEE 1505 RFI [6], MAC Panel (MPC) [7], or Virginia Panel (VPC) [8] test interfaces (Fig. 3), to support migration of the respective Test Program Sets (TPS) from other ATS test interface applications on to a single platform.
2. IEEE-P1693 MIPSS Current Status
The IEEE-P1693 Standard has been under development over the 2005-2010 period through the auspices of the IEEE Instrumentation and Measurement (I&M) Society, Automated Instruments (AI) Committee, TC-8, Michael Stora, Chairman, and the IEEE-P1693 Working Group, Chairman Steve Mann. Due to delays in the adoption of the VXIbus Revision 4.0 (Approved June, 2010), and numerous changes to the supporting standards of IEEE 1149.4, PXIbus-PCI Express Revision, and working group changes in the scope of the original IEEE-P1693 Project Authorization Request (PAR), it was decided by working group to withdraw original PAR and apply for a new PAR under same P1693 number. Because a large number of the MIPSS working group membership is resident in both I&M TC-8 and the IEEE Standards Coordinating Committee (SCC20) for Test and Diagnosis for Electronic Systems, Hardware Interface Work-

Embracing new VXIbus Revision 4.0/PCI-Express serial bus control technology while maintaining backward VXI compatibility, is a fundamental case for extended life. Employing the VXI carrier module mezzanine design, that bridge the physical incompatibility of M-Modules/PXI standards within the MIPSS platform architecture. This further reduces proliferation and provides Integrators and Users with a common platform with access to a broad availability of VXI/PXI/M-Module instrument choices. Power supply sources are a fundamental requirement for all ATS, that are typically proprietary in nature and physically incompatible.

The MIPSS specification has integrated the fundamental requirements of these sources into a VXI plug-in module that can serve platform instrument and UUT needs, through scaled/modular/programmable/switched output elements. The MIPSS archi-
tecture also addressed the physical incompatibilities of the ATS test interfaces used to interconnect with the UUT and related Test Program Set (TPS) applications. By standardizing on the instrument interface, the MIPSS specification creates a transparent interconnect to any UUT test interface applied, enhancing TPS migration. This is particularly valuable to DOD-Aerospace Users, who have a significant TPS investment on platforms that are becoming obsolete.

The concern for ATS health monitoring and test result assessment requirements has also demanded that the MIPSS specification include Mixed Signal Test Bus under IEEE-1149.4 [9] capability to monitor the ATS operational health. Although software standards are not directly applied under the MIPSS Standard, the group recommends, that all related test hardware descriptions and test data results be formatted to meet IEEE 1671 [10], an automatic test markup language (ATML) family of standards, that describes the ATS in a common format adhering to the extensible markup language (XML) standard, and and IEEE 1636 [11] Software Interface for Maintenance Information Collection and Analysis (SIMICA). In summary the MIPSS platform specification serves as an adaptable architecture, that integrates a broad range of standards to meet the needs of its stakeholders.

**ATS vertical-horizontal scalability**

Product test support begins at component design verification and proceeds to board, subassembly and finally system. Under vertical test integration (Fig. 4), test programs and test fixtures are migrated upward to the next level assembly. The scalable building block could mate horizontally or vertically to other blocks. For greater flexibility two building blocks are being specified: (1) basic 10 slot building block for portable use (Fig. 5); and (2) an expanded 19 inch chassis [12], 14 slot building block for use in benchtop and rack mount (Fig. 6) applications. These scalable building blocks provide packaging of ATS into via mechanical mounting points and blind mate connectors on their respective sides, top and bottom.

Through iteration of core elements and the addition of more specific type of assets, each building block can be applied as both a stand-alone test capability for board test and a supple-
mental scalable asset to a larger ATS configuration capable of testing a larger number of UUTs. Similar to configuring plug&play VXI modules into a building block, integrators can form test systems by configuring multi-building blocks. This is the fundamental principle behind the MIPSS architecture which permits Users to develop ATS and TPS assets with minimum effort, applying simple plug&play assembly. The assets can also be reconfigured as test applications change and evolve as new test resources are introduced to the market. Agencies can procure assets and migrate them with the UUT as it moves from development to organic support. The MIPSS elements (VXI Modules and MIPSS Mainframe Building Blocks) can be purchased on a mass scale and distributed as needed in various configurations. Through standardization, Users also gain from large quantity buys from multi-vendors, assuring maximum competitiveness and lowest cost.

**Building block architecture**

The MIPSS building block architecture supports portable, benchtop, and rack mount applications. The MIPSS Building Block illustration (Fig. 5 and 6), describes a ruggedized 10 slot VXI C-Size Mainframe, that supports the VXI Rev 4.0 backplane (Fig. 7) with a plug-able C-size power supply (slot 10), controller supporting parallel and 2eSST serial bus requirements (slot 1), and PCI-e Switch Card (slot2) and power module (slot 14). It also defines a 250 watts per slot pressurized cooling system employing high pressure push-pull blower fans. Secondary conductive cooling via the card guides and side walls are being recommended to extract the extreme content of high heat generating modules.
The VITA 41.4 (VXS - PCI-Express)
In 2001, Motorola proposed VMEbus Switched Serial (VXS) extensions to the VMEbus and produced a draft spec (VITA 41.0) in 2002 [13]. The VXS extensions offer a new high-density, differential P0 connector between the traditional VME P1/P2, (Fig. 7). The new connector interfaces the module to a multi-gigabit serial bus network via up to two x4 bi-directional serial links. This includes backplane revision by the VXI Consortium, to add VME VXS 41.4 PCI Express serial bus control, with protocol enhancement under 2eSST.

Instrument to Interface Direct Coupling
Implementation of MIPSS standard extends the instrument front panel to support direct plug-in to rear of a selected test interface plug-on (Fig. 8). MIPSS Specification is to define a common instrument connector family, that I/O would electrically migrate via a transition panel unique to the interface being applied (i.e. RFI, MPC, VPC, or Personality Interfaces). Where legacy VXI instruments are reutilized, MIPSS designed funnel cards are to be used. Distance between the VXI chassis front panel mounting bar and rear mount of the RFI receiver connector is being assessed to be 3-4 inches in distance. The direct coupling real estate area (Fig. 8 and 9), serves to augment a revised instrument footprint, add switching or external signal I/O through the top and bottom connector interfaces. These features support instrument signal I/O under built-in VXI carrier rerouting/accessing to multiple points from single instrument sources, and across carriers via ribbon cable jumpers, directly to rear of the Transition Panel connector. It standardizes the connector quick disconnect plug-in to minimize differences and assurances consistencies to the mechanical and electrical interconnectivity.

The MIPSS approach piggybacks on the extensive use of mezzanine instrument cards (PXI and M-Module), populated on a VXI Carrier, that has been extended physically (similar to funnel card application) to direct couple signal I/O to the interface choices (Fig. 9). The added real estate of the extended VXI carrier module permits doubling of of mezzanine PXI A & B Size cards on a single carrier, as well as the potential application of switching for the respective PXI/M-Module/Personality Card I/O. This feature expands instrument access to multi-port UUT points, eliminates the need for a secondary VXI switch module/associated cabling, while creating, a virtual test capability with each VXI instrument carrier.

Figure 8. MIPSS Instrument to Transition Panel (Interface Rear Connector) Direct Coupling
Figure 9. MIPSS Building Block Integration of VXI Virtual Instrument/Power/Personality Plug-in Carriers Into A UUT Plug-in Personality Adapter Subassembly.
Virtual power plug-in module

The IEEE-P1693 MIPSS standard also addresses a virtual power module (Fig. 10), that plugs into the chassis like a VXI instrument, to serve the both building block instrumentation needs and those externally required by the UUT. In serving both needs using industry available multi-programmable (0.5-48DCV) power sub-modules (i.e. Vicor VIPAC Modules [14] shown in Fig. 10) under a N+1 and switchable output configuration, greater utility of the power distribution sub-system can occur resulting in smaller footprints and cost savings.

Virtual instrument multi-mezzanine M-card plug-in carrier

Two mezzanine designs are supported: (1) M-Module instrument cards mounted to VXI Carrier (Fig. 11); and (2) PXI A & B Size modules mounted to VXI Extended Carrier (Fig. 12). These carriers serve as the bridge between VXI, PXI, and M-Module standards, allowing integrators and users the ability to maximize test instrumentation availability, while reducing costs, multiplying instrument sources in a common smaller footprint. Under the mezzanine carrier design, each respective carrier could support either: (1) 6-8 M-Modules; or (2) 4 A-Size PXI modules or 2 B-Size PXI modules, or mix of the two. This provides as much as 5x increase in a standard VXI platform with simple plug&play User configurability of VXI/PXI/M-Module instrumentation.

UUT personalty adapter flexibility

Another unique design flexibility sought by the MIPSS specification was to permit developers to integrate the traditional ATE with its respective test interface and UUT Fixtures, into a Personalty ATE dedicated to specific UUT family, (Fig. 9). This concept builds upon the US Army’s DSESTS [15] field deployable test system (Fig. 13), employing only interface cables to connect M1 Tank and M2 Bradley vetronics UUTs. This dramatically reduced footprint and costs by eliminating the traditional use of a Receiver and Fixtures and related cabling. The flexibility provided by the MIPSS specification permits developers and users the ability to configure test with each application in either a traditional or personalty test interface approach. This virtual UUT interface capability, combined with the VXI Carrier Plug-in Modules and related mezzanine cards and switching makes plug&play reconfiguration a reality.

4. Benchtop Application of MIPSS Specification

The greater appeal of MIPSS is the scaling building block multi-platform integration with further flexibility to address portable, benchtop and rack mount applications. Another significant ability is the merger of four incompatible physical standards involving VXI, PXI, M-Module, and CASS/TETS/VDATS/RFI test interfaces, in a single platform. This paper describes a benchtop approach utilizing the MIPSS architecture. This is being illustrated utilizing a 14 slot building block, in a 19 inch, MIPSS benchtop building block application (Fig. 14), augmented with an external server and display.

The MIPSS benchtop building block integrates a 14 slot VXI ruggedized chassis with pressurized cooling system, VXI Rev 4.0 backplane, control/switch/power modules and 11 slots of instruments configured with current VXI instruments, VXI carriers for M-Modules (Fig. 11) and PXI A and B size modules (Fig. 12), provides choice of over 200 for either standard.
Figure 13. Comparison of Traditional ATE to the MIPSS Personality ATE (DSESTS Style Approach)

With the extended VXI Carrier it is possible to support two B-size or four A-size PXI modules on a single VXI Carrier. Although the current carriers utilize the current VXI protocol to manage the standard PXI modules, the MIPSS spec is expected to also provide alternative PCI-Express control via the P0 connector to support advanced PXI instruments employing PCI-e.

Also applied in the MIPSS benchtop building block spec is the plug-on optional test interface latching receiver framework, which is shown with a CASS test interface plugged-in. Applying mating adapters (Fig. 15), optional test receivers can directly mate with the instrument modules/carriers.

To assess potential instrumentation possibilities in the MIPSS benchtop solution the following list of assets could be applied:
1. External Server (1)
2. VXS 41.3 PCI-e Switch Module (1)
3. Virtual Power Module - 1,000 watts w/8 outputs (1)
4. VXI current/advanced 4.0 modules (2)
5. VXI Carrier - 6/8 M-modules/carrier (3) = 18/24 modules
6. VXI Carrier - 4 PXI module/A-size (3) = 12 modules
7. VXI Carrier - 2 PXI module/B-size (3) = 6 modules

The total density of 38 instrument modules can be accommodated within a single platform. Switching is supported in multielements, either as embedded features of the carrier, or switching implemented as a M-module/PXI-A-size/or B-size cards. Under today’s smaller footprint technology advancements in instruments are now performing equal capabilities that serve to make the platform not only a virtual instrument platform, but one that can meet the performance needs as well.

The potential to add a second power supply exists using adjacent slot 13. This would augment the existing capability that services the instrument and control modules, as well as the UUT. Alternatively, the building block could be supplemented with an external power bay controlled via the server and cabled via the external ports of the building block.

Display and external server is a choice by the Integrator and/or User, but should ideally support PCI-express to interface with the switch. Alternatively, ethernet could serve as a second in-
CASS/80 SERIES
CASS RECEIVER

310 115 101 1899AS265-01 CASS Receiver Interface, Single Tier, accepts 19 Modules

The Receiver weighs 21 pounds and has an integrated Microswitch that is activated by engaging the ID. When the ID is lowered 90 degrees to the open position, the ID moves slightly forward, positioning it for connector engagement. The engagement force of 35 lbs. (max.) is designed to ensure reliable and repeatable interfacing.

The CASS Receiver is a single tier engaging mechanism with 19 modular positions that accepts a single tier Interface Device (ID). It features an integration force of 35 lbs. (max.) to ensure secure and reliable connection.

The CASS Receiver is designed to be compatible with various test systems and applications. It is recommended for use in test environments requiring high-performance and reliable interfacing solutions.

5. SUMMARY

The MIPSS specification serves as an electrical/mechanical guidance for ATS integration, which offers complete plug&play interchangeability and reconfigurability for VXI, M-Module and PXI implementation without redesign. Benefits from high density packaging, small footprint, lower costs, organic support provide users with test solutions they can implement without significant expertise or engineering support. The use of plug-in modules, mezzanine cards and carriers support through multi-vendor product availability with broad product offerings, and transparent plug-on test interface or direct UUT interfacing increase user flexibility. Inventory reuse/reiteration of instrument modules further reduces costs and provides ROI value to the user. Standardized application of the ATS integration, lessons learned, tooling reuse and support is the most significant justification for the MIPSS Standard.

Software is not imposed under the MIPSS specification, although integrators and users will be provided under the standard a recommended implementation of user friendly operating system/test system application software, available instrument plug&play drivers, and applicable data interface standards defined under IEEE 1671 ATML, and IEEE 1636 SIMCA Standards.

As described, MIPSS answers the concerns of legacy interfaces by provisioning plug-on features employing optional the test interface of choice, thereby preserving any existing Test Program Set (TPS) investment. The ability to support legacy interfaces would likely require a 19 inch benchtop or rack mount version of MIPSS or multi-building blocks to accommodate the larger receiver footprints and instrumentation needs. In effect the transition panel and receiver serve as the bridging element between building blocks, where it is needed. Typical legacy ID’s and Fixtures are then easily aligned and mated through its respective self-alignment and independent receiver engagement.

Figure 15. MIPSS Transparent Test Interface Adaptation for CASS Applications
6. AUTHORS

Michael J. Stora is General Manager of System Interconnect Technologies, Boonton NJ, (973)299-8321/ E-Mail: mjs@sysintech.com. A member of the IEEE, past member of VXIplug&play, VXIbus Consortium, current Chairman of the I&M TC-8 Automated Instrumentation Committee, Co-Chairman of the IEEE P1505, Receiver Fixture Interface and IEEE P1552, Structured Architecture for Test Systems Standards effort, past chairman of the IEEE 1149 Test Bus Standard, and past chairman functions of the AUTOTESTCON efforts. A Business Manager by education and past positions with Emerson Electric, Raytheon, Harris, GenRad, and MAC Panel, Mike has been directly involved with test technology for 30 years, a holder of four test system patents, developer of several industry test products, and author of numerous published articles.

Byron James is the Managing Partner of IE Test, Fairfield, NJ 07004 800-370-9833 X100, E-Mail: byronjames@ietestllc.com. His direct responsibilities include business development, strategic planning, marketing and national sales. Byron also serves as the program management interface to the customers of IE Test. Byron has over 15 years of experience in the Automatic Test Equipment (ATE) industry performing various functions. During his work career by has worked directly with the US Government, Prime Contractors and commercial accounts.

Rick Freeman is the Business Development/Advanced Programs Manager with the Enterprise Logistics Solutions Business Development team for Lockheed Martin Global Training and Logistics, Orlando, FL 32825, E-mail: rick.freeman@lmco.com. Rick received his BSEE in 1977 from the University of Arkansas and now has 33 years of test related experience. Throughout his career he has developed Automated Test Equipment and associated test programs across multi-disciplined domains.

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