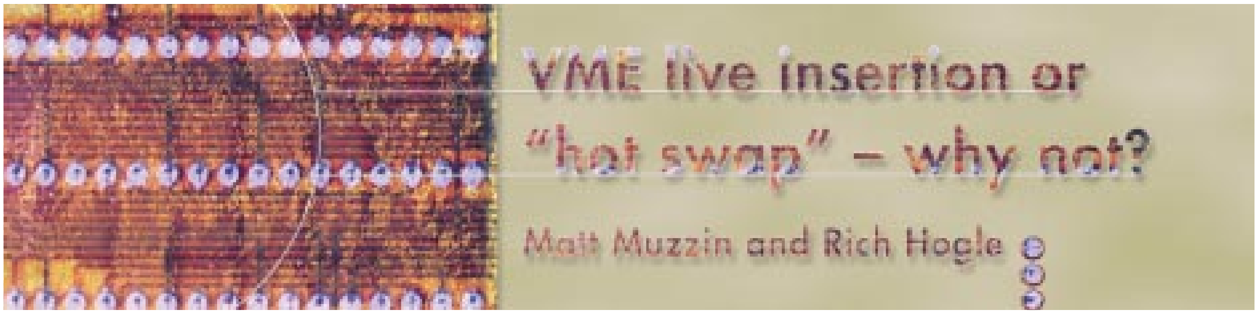

VME live insertion or "hot swap" – why not?

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High reliability is driving the telecom industry. Even the slightest amount of system downtime is becoming unacceptable, so service providers are requiring systems that continue to operate even during component failures or system upgrades. Military, industrial, and process control applications have similar requirements, all of them striving for "Five Nines" or 99.999% uptime.

Key to system designs that provide high-availability is the option to hot swap devices, in other words, perform "live" insertion and removal of hardware without disrupting the host system or application. An example would be pulling out the CPU or I/O board and replacing it with another, with no downtime of either hardware or software anywhere in the system. Not only can you replace failed devices in a hot-swap system, but also online upgrades are possible. For example, you can upgrade an entire single-board computer within the system, or increase the memory on a particular board, simply by swapping out the cards.

When live insertion, or "hot swap," is mentioned, it is usually associated with CompactPCI solutions. The predominant association of hot swap and CompactPCI seems puzzling when you consider that a high percentage of the existing infrastructure is VME-based, and that VME now provides a cost effective migration path to live insertion technology upgrades. Part of the reason for the obscure association between VME and "Hot Swap" is that the CompactPCI Live Insertion specification has already been defined and established, while the VME upgrade is still in draft status. Another contributing factor is that in a VME chassis, critical control signals are daisy-chained to propagate down the backplane starting from slot one. The VITA 1.1-1998 VME64 Extensions draft removed many obstacles with the additional live insertion features made available via the 160-pin, 5-row, DIN-style connectors, which include staggered pins providing proper bus signal pre-bias voltage and geographical addressing at the slot level from the P1 connector in system memory space. The basic framework for providing a live insertion system exists when you combine this draft with the VITA 1.4, VME64x Live Insertion System Requirements Draft Standard (VITA 1.4-200x).

Artela Systems, Inc., in conjunction with DNA Computing Solutions, Inc., has developed a VME Live Insertion System for use in applications where boards, including the system controller, may be extracted or inserted while the chassis is powered. Along with the live insertion enhancements on DNA's VSH750 PowerPC master controller, single-board computer, Artela Systems' VME backplane and chassis include features to support live insertion, such as consideration of electrostatic discharge (ESD), bus grant and interrupt acknowledge daisy-chaining, and the mechanical aspects of inserting and extracting VME64 boards. Artela and DNA have already successfully demonstrated this capability within a major optical network infrastructure, where the application required the system to run with zero downtime, while using a master CPU with several I/O boards as slaves, running under VxWorks.

Insertion process

The insertion process highlights a number of issues that the backplane and chassis design must consider when developing a live insertion solution. This insertion process, as summarized from the VITA Draft Standard for Live Insertion System Requirements (VITA1.4-200x/D0.6), includes the following steps:

1. A live insertion board enters the guide rail and contacts the ESD contact in the guide-rail.
2. Board connector contacts ground and pre-charge voltage pins on backplane.
3. VMEbus signal pins are pre-charged.
4. VMEbus signal pins and remaining power pins contact the backplane.
5. Ejector handles are seated and handle switches close.
6. Blue LED on board front panel is turned ON.
7. Board waits for LI/I signal to go low. (LI/I may be tied low on the backplane or controlled by a centralized device.)
8. Board's power-up sequence continues.
9. Board logic reset signal is generated.

An overview of how DNA Computing Solutions and Artela Systems designed this VME live-insertion solution, along with some design considerations, is provided below.

PowerPC single-board computer

DNA Computing Solutions started with the established VS750 Single-Board Computer, a standard VME 6U form factor PowerPC processor board, and made modifications to create the VSH750 hot-swap version. The specification for the VSH750 was based on the latest draft, March 2000, of VITA –1.4-200x/D0.6, the VME64x Live Insertion System Requirements Draft Standard. Features added to make the hot-swap version were power control, position sensing handles, ESD strips, pre-biased I/O, blue LED, and LI/I and LI/O support to the backplane. VME64x style connectors were already being used. (See Figure 1.)

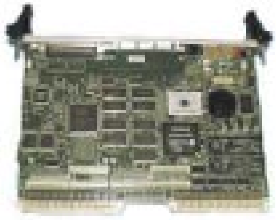


Figure 1: VSH750 750/G4 AltiVec "Hot Swap" Master Controller Single-Board Computer for 6U VME

For Power control, a +5V power-control circuit was added to the board. A Summit Microelectronics Hot-swap Voltage Controller was selected for its suitability for VME applications and its small package size. The voltage controller senses valid supply voltage levels at the backplane for proper card insertion and removal. By selecting external N-channel MOSFETs, the controller appropriately transitions power to the card so VME activity is not disrupted. The VS750 SBC circuit card was produced so that board space can be utilized to provide as many features and options as possible, using every available spot on both sides of the board. This made adding circuitry quite challenging, given the height constraints of a single-slot VME card. Pre-charge voltage distribution to the hot-swap controller, VME I/O signals, and power MOSFETs were implemented in the routing and power planes, and further constrained component location. Finding VITA ETL logic-compliant, pre-biased logic transceivers to use for designing in the ETL components was also difficult, as only one company currently offers ETL compatible logic for VME64x live insertions.

Position–sensing Injector/Extractor handles were used on top and bottom to ease insertion and extraction and to detect any attempt to remove the board. Sensors in the switches detect when extraction motion begins and signal when a board is fully seated, using two separate inputs from the hot-swap voltage controller for power interruption. The VSH750 has selectable options for systems to utilize Life Insertion In (LI/I) and Life Insertion Out (LI/O) support on the backplane. The LI/I and LI/O provide the necessary VME signals to add project-specific control, which increases the level of availability. The hot-swap voltage controller also controls the blue LED, which was added to the front panel to indicate that the board is powered down and ready for removal.

As shown in Figure 2, the injector/extractor handle provides for full front panel I/O usage and is suitable for system (subrack) front and rear (I/O) mounted boards. The handle locking/unlocking device activates in the handle's embedded microswitch.

Figure 2

Features of the handle are:

- Keying of plug-in PCB boards
- ESD protection
- Grounding connection for plug-in boards
- Tying of multiple handles together

The handle is in the unlocked position, with microswitch lever not pushed down. Lifting the handle up locks the handle and pushes the microswitch lever down, which signals the how swap controller that the board is fully inserted, allowing the board to power up. (See Figures 3 and 4.)

VME live insertion boards may build up static while being manipulated outside the system. When a module is inserted into a VME chassis, the potential for an electrostatic discharge (ESD) is always present. Such a discharge may cause a momentary system glitch, fatal system crash, or physical damage that requires field replacement. To eliminate these problems, ESD strips and dissipative resistors were added in accordance with the VITA specification draft. (See Figure 5.)

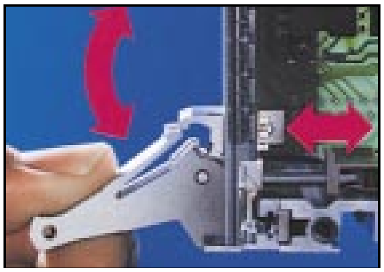


Figure 3

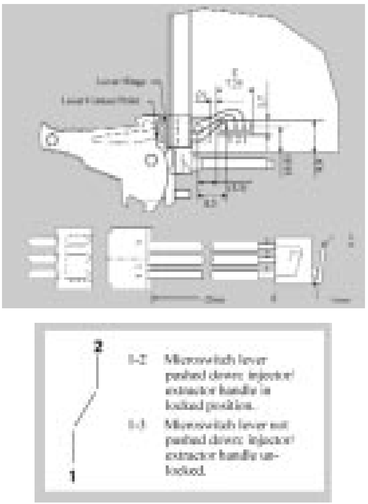


Figure 4

The VME chassis card guides must include an ESD contact clip embedded in the front end of the guide rail that is connected to the chassis ground. A resistor between the ESD discharge strip and the chassis' power return limits the static discharge current. In addition, the front-panel alignment pin provides a path to ground if a static discharge takes place between the front panel and an I/O connector during mating.

SBC portability

The entire board was designed to be hot-swap compliant, depending on component population options chosen. As such, any application using the VS750 can replace them with the VSH750 for hot-swap applications.

Daisy-chain modules

In a VME chassis, Bus Grant and Interrupt Acknowledge signals are daisy-chained to propagate down the backplane starting from slot one, entering the connector on an input pin, and exiting the connector on a separate output pin. A board plugged into a connector slot is responsible for providing continuity between the input pin and the output pin. In the distant past, when a slot was empty, jumpers were manually installed to provide the continuity between input and output. Now Auto Bus Grant (ABG) backplanes provide electronic busing of the daisy-chain signals through empty card slots. Unfortunately, neither these electronic nor mechanical implementations will support live insertion.

One solution Artela provides is a daisy-chain module mounted on the rear side of the backplane between each board slot connector (see Figure 6). This setup requires that the backplane itself provide

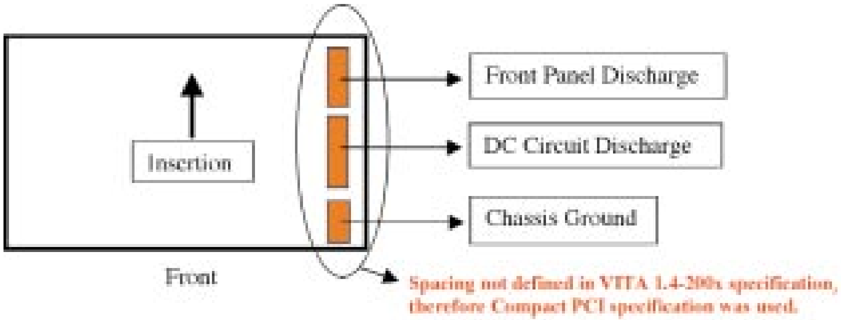
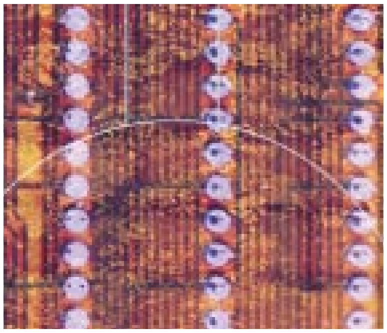


Figure 5



wire-wrap pins for the Bus Grant, IACK, LI/O lines, and power/ground, similar to the older manual-jumper format, but with standard dimensioning.

The LI/O pin is used to control the action of the backplane daisy-chain module. When the LI/O signal for a given VME64X slot is high, the daisy-chain signals are passed through the VME backplane slot by the module. When the LI/O signal is at a low level, the daisy-chain signals do not bypass the slot. VME64X boards that do not support live insertion can tie the LI/O pin to ground, disabling the daisy-chain module.

Front-panel extrusions

Although not specific to VME live insertion, the use of VME64X boards requires some additional consideration for the subrack design. The front-panel extrusions should include protrusions to accommodate the insertion/extraction handles shipped with most VME64x boards. Because of the high insertion force needed when using VME64X 5-row connectors, insertion handles are a necessity. These IEEE-style handles use the front chassis protrusions to provide leverage to the operator as the boards are inserted. Be aware that the insertion/extraction handles are larger than the standard VME front panels, so the boards may not fit into an older standard VME rack.

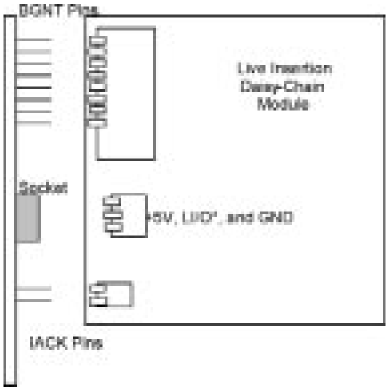


Figure 6

Summary

The VITA 1.1-1998 VME64 Extensions and VITA 1.4-200x VME64x Live Insertion Systems Requirements Draft Standards combine to provide a basic framework for providing live-insertion systems. Artela Systems, Inc. and DNA Computing Solutions Inc. used this framework to develop a complete VME Hot-swap solution using now currently available, standard off-the-shelf products. Hardware alone cannot provide the full solution because higher degrees of fault tolerance require more project-specific software. Companies that specialize in providing high-availability solutions, such as Artela Systems, work with customers to provide the necessary system level software.

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