New VME I/O board features support flexible system architectures

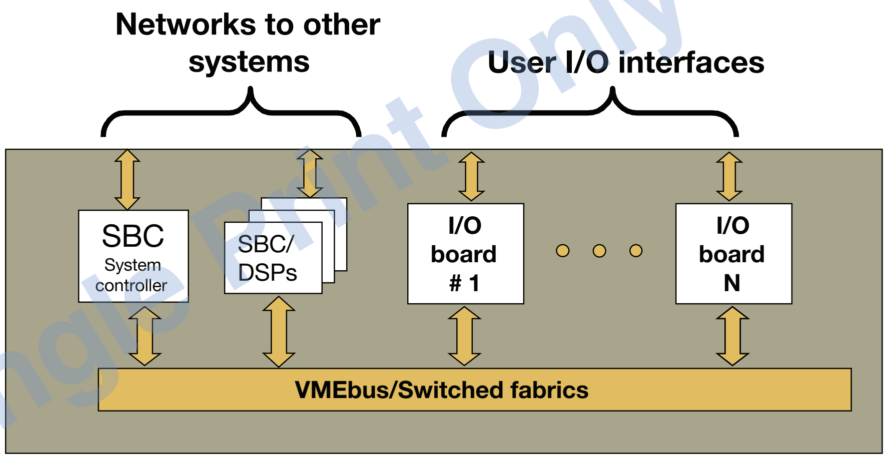
By Steve Larsen

A new generation of I/O boards incorporating multifunction I/O, bus master function, Ethernet, and system processors provides flexibility for implementing new VME system architectures. These new systems feature a reduced number of boards and the choice to go SBC-less, lowering recurring project costs and development labor with quicker time to market.

In a typical modern VME system, there will be some SBC boards with the slot 1 board as system controller, maybe some DSP boards, network I/O boards or network I/O for the SBCs, and I/O boards (see Figure 1). This architectural model fits most military and commercial applications; however, this VME system design paradigm results in undesirable complexity for many low-power CPU, I/O-intensive applications. It imposes the requirement to provide an SBC system controller with an operating system. It also requires the system designer to find I/O from several sources and to integrate the different I/O design protocols via software in the SBC. For general purpose I/O data acquisition systems, these design requirements are burdensome and frequently result in the project being implemented in some platform other than VME.

New approaches to VME I/O board design offer a solution to these issues. Specifically, processor-based, network capable, multifunction I/O boards can:

- Allow systems to be designed with an external PC (or any other computer architecture) interfacing via Ethernet to a network-enabled I/O board with bus master capability. This facilitates communications with additional I/O boards on the VMEbus with no SBC or SBC operating system.
- Allow an extension of this concept by providing a small CPU/FPGA resource system processor module on the bus master I/O board, allowing simple data collection and manipulation algorithms to be performed.



Traditional VME architecture

Figure 1

Multifunction I/O boards

Modern electronic components allow very high I/O channel density. Current 6U VME offerings include up to 144 discrete I/O lines, 60 analog output, or 12 MIL-STD-1553 channels. An issue is that systems tend to require lower numbers of a variety of signal types. This either causes the I/O board count to be high or requires the use of multifunction I/O boards, which provide a mix of functions on a single board. Use of processor-based multifunction I/O boards in data acquisition systems frequently results in up to 50 percent reduction in the total number of boards, yielding significantly lower recurring costs.

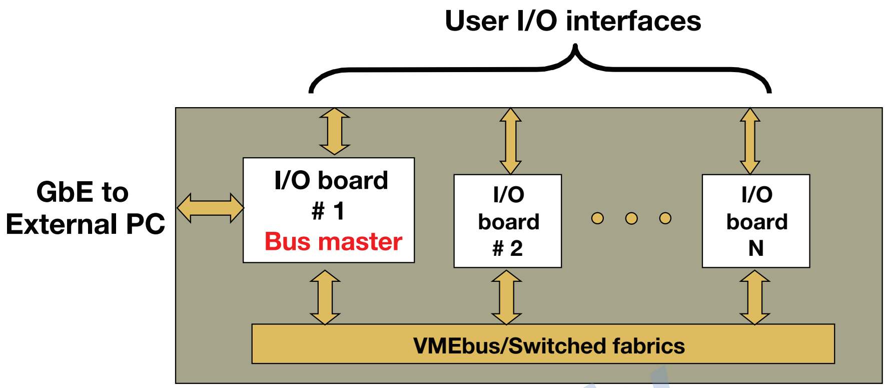
Multifunction boards implement customer-selected function modules on motherboards that provide the interface to the system bus. The configuration of the I/O board is performed at the factory according to the customer's requirements for I/O functions. This approach offers customers the packaging advantages that can be obtained using custom designs while retaining the advantages of COTS to leverage a large user base using common function modules. Other advantages of multifunction boards are that I/O connectorization is optimized for implementation of signal I/O wiring, the inherently rugged board can be offered as either forced air-cooled or as conduction-cooled, and special modules to complete a customer design can easily be added.

Function modules can be designed to be highly programmable at the channel level, allowing the user to tailor the general function of the modules to each signal. This provides the capability for the COTS product to approach the flexibility of a fully custom-designed board. Also, significant fault detection capability including continuous background testing can be designed into the I/O board to support the needs of military programs, including airborne, shipboard, ground mobile, and C4I applications.

Network interface capability

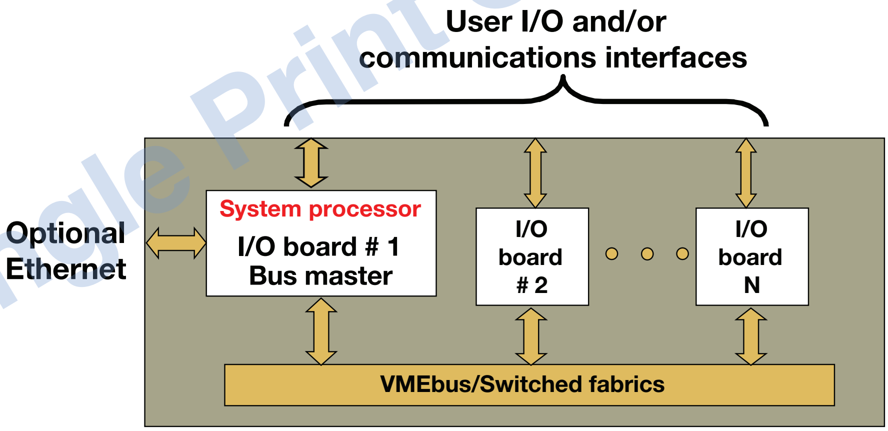
Adding GbE interfacing to I/O boards supports data transfer to and from system processors without having to use the backplane bus. The reduction in backplane traffic can simplify timing and minimize system design effort. This interface also allows the board to be used as a standalone remote sensor interface, with no SBC in the backplane. Multiple boards

> "To fully exploit the features of SBC-less architectures, another feature is required. A compact CPU/FPGA resource can be added as a function module for the bus master board."



I/O subsystem with bus master and Ethernet – No SBC

Figure 2



I/O subsystem with system processor module – No SBC

Figure 3

can be distributed throughout the system and networked to provide complete sensor data acquisition subsystems. The Ethernet can also be used as a system design and debug tool by providing test engineers an independent view of board-level activity.

Providing the capability for the multi-function I/O board to perform as a bus master increases the utility of the Ethernet interface. The I/O board can allow a processing element to communicate with all system I/O via a single Ethernet interface. The bus master feature allows the Ethernet to request bus access and then address any function within the VME memory space, again with no SBC. This configuration is shown in Figure 2.

System processor module

To fully exploit the features of SBC-less architectures, another feature is required. A compact CPU/FPGA resource can be added as a function module for the bus master board. This system processor module now allows the bus master to not only access all I/O functions within the VME memory space, but also allows for coordination of the I/O functions to implement complex system functions. This configuration is presented in Figure 3.

Generically, this architecture can implement the following types of functions:

- Collecting and packing I/O into messages in formats desired by the user instead of the traditional approach of accessing each I/O board using its fixed interface definition to the VMEbus.
- Signal processing/data filtering to remove processing load from the host.
- System health monitoring including digital fault indicators, temperature sensors, fan speeds, and board-level fault indicators.
- Gating functions using data from one sensor to condition the assertion of other interface commands.
- Limit checking so illegal commands via the system interface are rejected.
- Logging error data in the presence of faults to support post-mission failure analysis.
- Simultaneous and shared support for multiple networks requiring access to the same set of I/O signals.

North Atlantic Industries has implemented a system processor module as part of its 64D2 family of multifunction I/O boards that also incorporate bus master and GbE capability. The system processor module is optimized through the use of a DSP from the ADI Blackfin family for system processing, and additional features include a moderate scale FPGA (Altera Cyclone II family), 2 GB flash memory and 500 KB SRAM for real-time program execution.

Sample system projects

These new processor-based, network capable, multifunction boards have been used to implement complex, I/O-intensive systems. Two examples will be cited. The first is a system test capability that uses an external PC for implementing the test software and the VMEbus for hosting the I/O boards that interface with the system under test. The second example is a military navigation system upgrade interface converter that receives navigation data from a military serial bus and distributes this data to existing analog systems. The overall I/O for both projects includes more than 100 channels of different types, including S/D, D/S R/D, D/R, Torque Driver, Discrete, TTL, LVDT, DLV, A/D, D/A, Reference Generator, Inter IC serial bus, and MIL-STD-1553.

In example 1, the test system is implemented without the GbE and bus master capability and uses the multifunction I/O boards to allow a PC to control all the I/O required to support complete testing of a complex system. In this case, the system is implemented in five I/O multifunction boards, an I/O switching relay board, load switching relay board, and three static load boards. Again, using multifunction boards reduced the required number of I/O boards by 50 percent, resulting in a large reduction in projected recurring project cost. The traditional design approach would have required the following boards: SBC, 1553, Discrete, 3 S/Ds (44 channels), LVDT and Reference Generator, DLV, D/S, A/D, and D/A for a total of 10 boards. Further, all test software is exclusively hosted in the test system PC, enabling all test software to be developed using the industry-standard Microsoft PC toolset and minimizing the need for special software development skills to be employed for the project.

In example 2, the military navigation interface system made full use of the embedded SBC-less architecture, implementing the following types of functions:

- Overall system control implementation and serial military bus (MIL-STD-1553) control
- Monitoring I/O system boards for fault detection
- Logging error data in flash memory to support post-mission fault analysis
- Interfacing to PC over Ethernet for system maintenance and troubleshooting functions
- Implementation of gating algorithms, where the state of one signal determines the assertion of another signal
- Monitoring equipment health via system processor module IIC and TTL inputs
- Use of conduction-cooled versions of multifunction boards to support full MIL-STD environmental requirements

This system leveraged multifunction boards, bus master capability, and a system processor module to implement in 6 boards the functions previously requiring up to 12 boards: SBC, 1553 interface, Discrete, A/D and D/A, DLV, LVDT and Reference Generator, S/D, 4 D/S boards (32 channels), and 2 Torque Drivers (6 channels).

The bottom line

New system architecture paradigms using multifunction I/O boards with bus master and Ethernet interface capability and full SBC-less processor-based designs have been used to implement cost-advantaged systems. The COTS hardware to support these new architectures is available for use on similar system projects requiring a large mix of I/O functions and channels with moderate processing requirements. Systems have been completed using both external computing resources and an internal system processor module installed on the bus master I/O board.

Using the new processor-based, network-capable I/O boards, the systems have been implemented with 50 percent fewer general purpose I/O boards and no SBC. The system engineer for these projects credits this new capability with 25 percent system recurring cost reduction. Additional NRE cost reduction results from not having to deal with the learning curve and tool costs associated with using a general purpose SBC. The advantages include reduced-complexity system development and therefore reduced time to market for projects. **CS**

Steve Larsen *has more than 20 years of experience in the development and production of computer-based systems for military applications as system engineer, project engineer, and program manager for the government and major system integrators. He has a BS and MS in Electrical Engineering from the University of Maryland and a Masters of Engineering Administration from George Washington University.*

To learn more, contact Steve at:

North Atlantic Industries
110 Wilbur Place
Bohemia, NY 11716
631-567-1100
slarsen@naii.com
www.naii.com