

# VPX Backplanes Go Optical

VPX backplanes surpass 40 Gbps in copper Ethernet and also gain a backplane optical interface connector.

By Michael Munroe, Technical Specialist, Elma Bustronic

Optical backplanes are seen by some as the ultimate solution for higher bandwidth interconnections, and hence long anticipated in embedded computing. The practicality of backplane-based optical solutions is closer to becoming a reality with the release of two ANSI-VITA standards addressing backplane optical interfaces.

VPX has become the backplane architecture of choice for new embedded applications in the mil-aero marketplace. Important attributes of VPX include:

- Support of multiple high speed serial protocols
- Flexible point-to-point topologies: both stars and meshes
- Capability to supply up to 276 watts to a 3U card and 384 watts to a 6U card and even more if the 48 volt option were used
- XMC/PMC mezzanine sockets
- Distributed clock signals
- The rugged 3U and 6U Eurocard format
- A high density connector that provides a 3U card with 64 differential pairs and a 6U card with 192 differential pairs in addition to all the standard power and utility signals.

The last point is becoming an increasingly important aspect of the VPX architecture. In addition to both conventional rear transition modules and a very capable rear copper cable interface there are now a series of ANSI-VITA standards that define backplane coaxial cables for RF signals and backplane optical ribbon cables. The VPX optical backplane module accepts a standard optical ribbon assembly terminated with an MT ferrule. (see Figure 1).

## The Need For More Speed

VPX backplanes on the market today regularly support 5 Gbps and 6.2 Gbps channels and several new VPX backplanes are supporting 8, 10 and even 14 Gbps channels. All the VPX specifications such as VITA 65 and the various VITA 46 dot specifications point to VITA 68 for their electrical channel requirements. This document is still in draft version and when released will address the three currently defined backplane bandwidths, 3.125, 5.0 and 6.25 Gbaud. It is also intended to address 10GBASE-KR and 40GBASE-KR4. This document is progressing slowly.

**"VPX IS POISED TO OFFER A GRACEFUL TRANSITION FROM COPPER TO OPTICAL."**



Figure 1: A 12 optical fiber ribbon terminated to an MT ferrule.

PCIe Gen3 and InfiniBand FDR are not currently planned to be included because of the additional engineering work it will require to define card and backplane electrical margins to ensure intermateability. So although it will take some time for the VPX interface channel specification to address these new higher speeds, these backplanes already now exist and card vendors have begun offering VPX cards that utilize PCIe Gen3 and 10GBASE-KR Ethernet signaling.

10GBASE-KR and 40GBASE-KR4 are both backplane Ethernet standards based upon bi-directional 10Gbps differential lanes. These are fully defined within IEEE 802.3-2008. However, in that document individual backplane and daughter card losses are not defined because there is no backplane connector addressed in that document. Each

backplane architecture must undertake apportion losses and define channel requirements individually for the backplane and daughter card. This work has just been completed within PICMG for PICMG 3.1r2. This should make it easier for all subsequent standards to address the same issue for their backplane and daughter card designs.

Although there are VPX backplanes that can support serial communication across the backplane at 8, 10 and 14 Gbps, maintaining these speeds over copper I/O cables is no longer practical. Copper cables supporting PCIe Gen3 are only defined to support distances of two meters or less. For longer distances optical cables must be used.

If I/O is going to be able to keep parity with the backplane, it is going to have to be optical. Copper cabling can carry 1000 Base-T Gigabit



**Figure 2: Top: Hybrid VME/VPX backplane with VITA 66.1 optical connectors and VITA 67.2 coaxial copper connectors and standard VITA 46 MultiGig connectors in positions J0-J4. Bottom: Optical ferrules close up.**

signals for 1,000 meters. At the InfiniBand FDR 14.1 Gbps data rate, the practical distance for copper I/O cabling is less than seven meters.

### VITA's VPX Keeps Pace

Two new standards released in 2011, ANSI-VITA 66.0 (Optical Interconnect on VPX – Base Standard) and ANSI-VITA 66.1 (Optical Interconnect on VPX – MT Variant) are laying the groundwork for migration to optical technologies within the embedded computing industry. These two VITA 66 dot standards are the first in a family of documents that will define a variety of backplane optical interfaces compatible with the existing Eurocard form factor used by the VPX architecture. Because the Eurocard architecture also utilizes CompactPCI, CompactPCI Express, CompactPCI SO as well as PXI and PXI Express these new optical connector interfaces have the potential to rapidly migrate to other platforms if they first become established within the VPX community. In addition, AdvancedTCA utilizes a connector system with the same mating interface as required for the previously mentioned embedded architectures. This means the VPX optical module could potentially be used for Zone 3 implementations in that architecture as well.

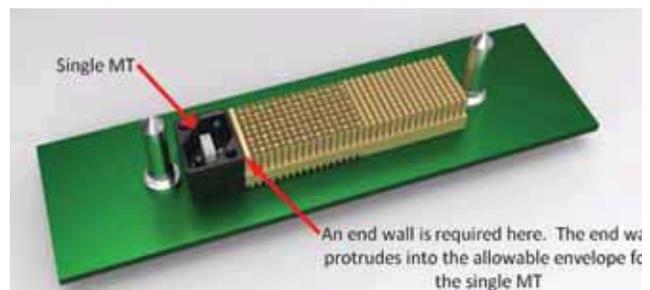
### It's Not All "Just Optics"

There are three basic system implementations that are now possible based upon the VITA 66.1 interconnect: 1) Fiber optic I/O from the chassis to external points such as sensor arrays, 2) Direct slot-to-slot fiber optic links providing high bandwidth paths between pairs of cards within a system, and 3) Switched optical data planes with multiple payload cards connected to an optical switch slot (Figure 2).

Figure 1 shows an optical cable assembly with 12 fibers terminated at each end with an MT ferrule. This assembly would plug into the VITA 66.1 backplane module and could connect from slot to slot or be used to connect the backplane to an external sensor array.

Figure 2 shows a 6U backplane with the VITA 66.1 optical modules implemented in the J5 position of slots 5, 6 and 7. Although the VITA 66.1 optical module is new, it is based upon the existing well-established MT and MPO ferrule technology first introduced as an EIA standard around 1993. VITA 66.1 defines a VPX compatible module that positions the MPO multi-fiber ferrule with sufficient precision to allow it to be used as a backplane interface for conventional VPX plug in cards. The VITA 66.1 standard provides for up to two MT ferrules in a one-inch long module. Each of the two MT ferrules can hold up to 24 optical fibers.

This means that a 6U VPX module could support up to six VITA 66.1 modules for a total of 288 optical fibers, such as the one shown in Figure 1. Of course, this represents a theoretical maximum and it is not expected that any card would implement more than one or two modules for a total of between 24 and 96 optical fibers. The reason for the wide range is that although an individual MT ferrule today can hold more than the two 12-fiber ribbons defined within VITA 66.1 and slots could potentially be populated with up to six modules, there are no defined topologies at this time for card-to-card optical connections. Therefore the most likely implementations within VPX will be to carry signals between systems or between a system and an external sensor field and this will be unlikely to require more than a single optical module on any individual VPX card.



**Figure 3: Proposed alternate optical connector, with a single MT ferrule. This connector will be useful on 3U VPX modules.**

Another important aspect of the VITA 66.1 technology is that it only defines the positioning of MT ferrules. The MT ferrule allows the use of one or more optical fiber ribbons of that can each be comprised of up to 12 fibers. These fibers can be either single mode or multi-mode. The data rate at which these fibers can be driven is independent of the MT ferrule. However, the optical devices that are available today to drive MT ribbon assemblies are readily available that drive each fiber at 10 or 14 Gbps and some are already available that drive each fiber at 28 Gbps. Any such device coupled to a fiber ribbon that is terminated with an MT ferrule will be accepted by the new VITA 66.1 optical modules.

Although the VITA 66.1 connector is ideal for 6U VPX backplanes, it is not a good solution for 3U VPX backplanes because it occupies an

Year	Data Plane Protocol	Channel Gbaud Rate			
		Control Plane	Data Plane	Expansion Plane	Optical Plane
2012	SRIO 1.3	1.25	3.125	5.0	
	PCIe 2.1	1.25	5.0	5.0	
	SRIO 2.2	1.25	6.25	5.0	
2013	10GBase-KR	1.25	10.5	5.0	
	10GBase-KR	1.25	10.5	8.0	
	InfiniBand FDR	1.25	14.0	8.0	14.0
2014	InfiniBand EDR		n/a	n/a	26.0
2015	Fiber Channel 125GFC		n/a	n/a	104.0

Table 1: Notional VITA 65 Channel Gbaud rate implementation timeline

entire connector module. This is acceptable for 6U cards as shown in Figure 2 above. However, pins are precious in 3U. Therefore one connector company is preparing a proposed optical module that provides a single MT ferrule in half the space of a full 16 wafer VPX module. Figure 3 shows an example of a single MT ferrule implemented in a half size connector. This is much the same approach that was taken by the VITA 67.1 committee for their 4-cavity RF module.

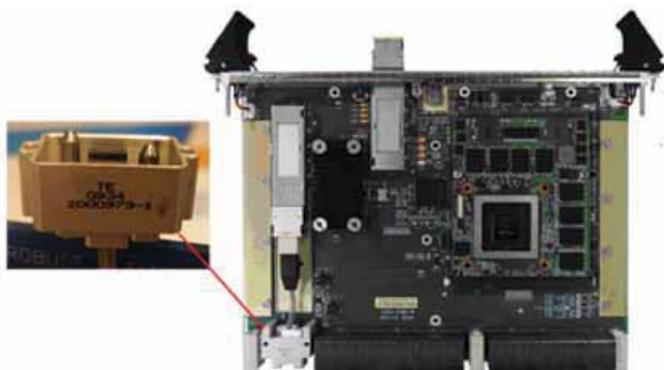


Figure 4: Embedded Server card from CSPI with provisions for VITA 66.1 connectivity. (Courtesy CSPI).

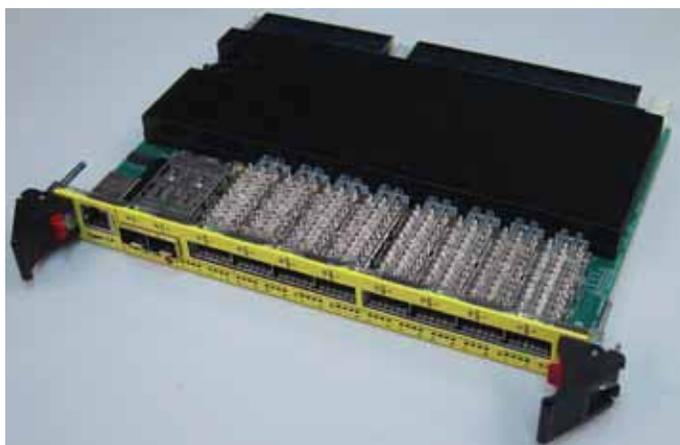


Figure 5: This 6U VPX switch card from Annapolis Microsystems is the first VPX switch capable of switching either 40GBASE-KR4 Ethernet channels or 56Gbps InfiniBand FDR channels. (Courtesy Annapolis Micro Systems.)

**Optical and Copper InfiniBand cross paths in the VPX backplane architecture**

In mid November 2012, the InfiniBand Trade Association made available to the public Release 1.3 of its Architectural Specification. This release includes the InfiniBand FDR electrical interface that supports 14 Gbps lanes as well as the FDR optical interface.

VPX is at an interesting intersection of optical and copper technologies. At the present time, companies within the VITA community have introduced backplanes and cards supporting both copper signaling and optical IO at the InfiniBand data rate:

- Elma has introduced family of 3U and 6U VPX backplanes that offer VPX slots compliant to VITA 66.1 optical modules. Two backplanes are currently available to support these higher data rates - one is a 12-slot dual star and the other is a 4-slot mesh (see Figure 2).
- CSPI introduced an Embedded Server card that incorporates an InfiniBand FDR, 56 Gbit/s Host Channel Adapter with failover capabilities via a 56 Gbp/s QSFP transceiver on the front panel or the VITA 66.1 optical interconnect to the backplane (see Figure 4).
- Annapolis Micro Systems, Inc. introduced a card which supports InfiniBand FDR at 14 Gbps/lane on the data plane and PCIe Gen3 at 8 Gbps/lane on the expansion plane (see Figure 5).

Currently, ANSI-VITA 65 recognizes data rates up to 6.25 Gbaud in three different steps shown for year 2012 in Table 1. As mentioned, there are products on the market already that correspond to the lines shown for year 2013. A big unknown is whether or not the copper data rates will continue to rise. Note, however that the optical data rates will continue to grow. This table represents the author’s opinion and is not sanctioned by VITA.

Embedded computer pundits have been predicting the demise of copper interconnects for some time and those of in the industry have wondered when this would happen and what the future would look like. VPX is poised to offer a graceful transition from copper to optical. It is well designed to provide all the power future cards will require. VPX also has features to support system management and distributed clocks as well as JTAG, and all of these features will be required regardless of how the data plane communicates with other cards and the outside world. Now it is clear that if I/O goes optical, VPX has the necessary features to support that transition as well. Going slot to slot can also make use of the VITA 66.1 optical ribbon module.

Michael Munroe is a Backplane Technical Specialist for Elma Bustronic Corporation. In addition to over 20 years of experience in the packaging and interconnect industry, Michael is an active member of the VITA Standards Organization, a professional member of the IEEE and currently serves as Secretary-Treasurer of PICMG.

