COM Express Benefits Extend Beyond Carrier Boards

Many backplane standards are available that offer varying electrical and mechanical features, but custom systems can also benefit from a backplane architecture. COM Express, a popular implementation of Computer on Module (COM), offers a powerful processing platform with several bus connectivity options perfect for creating versatile backplane systems.

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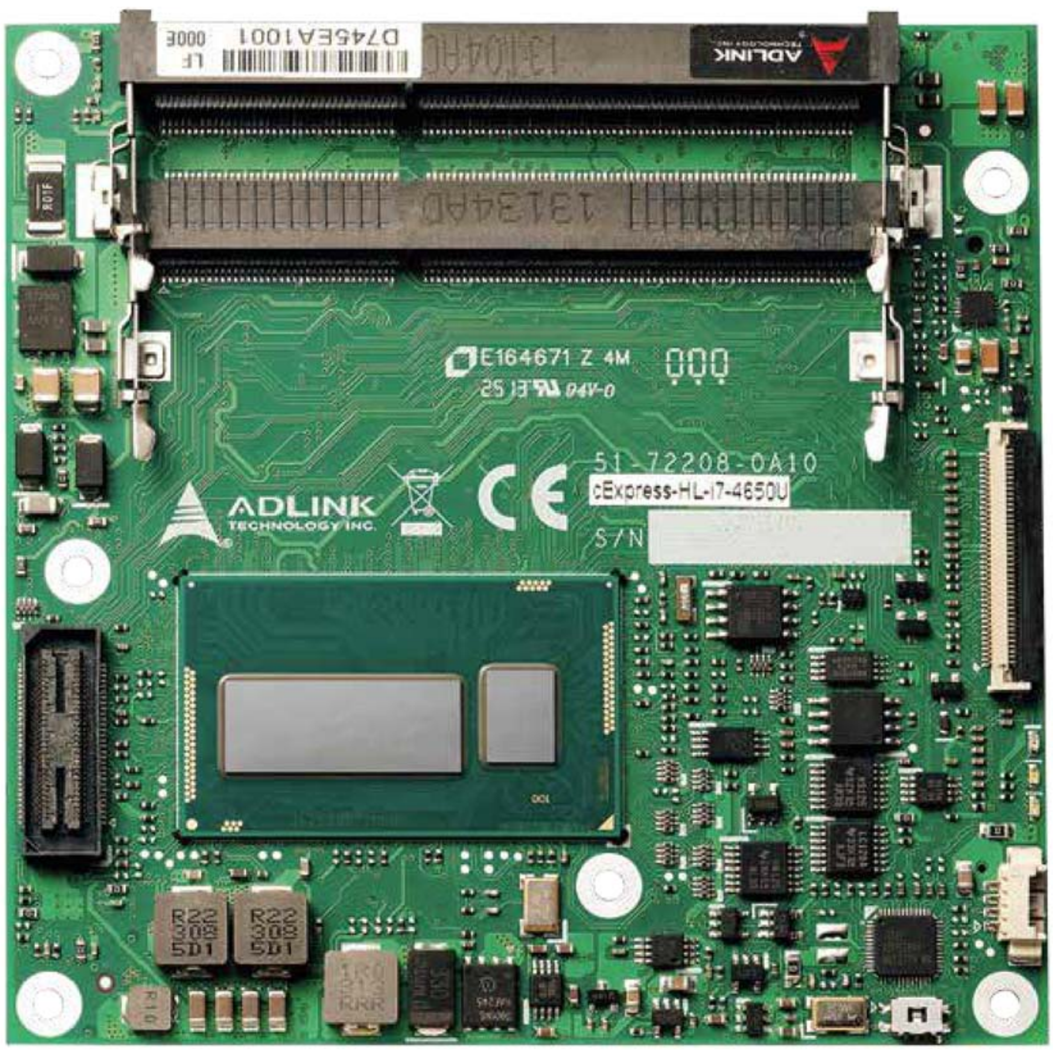

Figure 1
cExpress-HL Compact COM Express Type 6 Module from Adlink offers a 4th generation Intel Core i7/i5/i3 processor. COM Express modules provide core computing functionality and connect to a carrier board that provides connectors and application specific I/O.

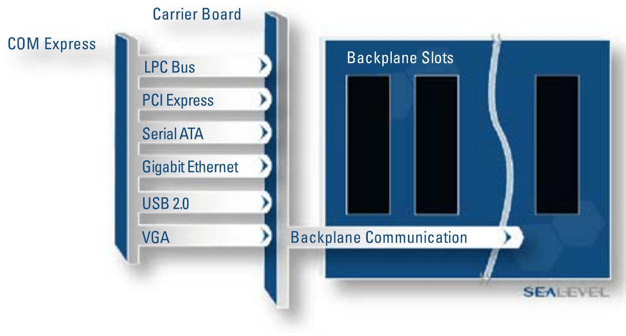

Figure 2
Block diagram shows a COM Express module connected to a carrier board and backplane. COM Express offers a variety of interfaces suitable for backplane communications.

COM Express, a popular solution for creating custom systems, offers designers numerous advantages including fast time-to market, scalable processing, flexible mechanical options and long product life cycle. The COM Express processor module delivers the high-speed functionality germane to all computers such as video, disk interfaces, memory, etc. The module typically connects to an application-specific carrier board that provides the exact configuration of I/O and connectors for a specific purpose. COM Express architecture seems attractive for OEM products with a set functionality (Figure 1), but what about applications that require configuring the I/O set to match various installation locations?

For example, an OEM instrument designed for collecting environmental data at remote sites will usually need to be configured with the I/O types and count specific to each location. Designing a custom carrier board that includes all possible I/O configurations is likely to be size and cost prohibitive. These applications scream for a backplane system to provide the required flexibility. Backplanes also afford room for adding functionality when new application requirements arise.

Developers shouldn't overlook COM Express and the benefits it provides as an option for a backplane solution. The COM Express standard defines multiple connectivity options that are brought out via the module-to-board interconnect, including USB, Ethernet and PCI Express. Alternatively, RS-485 and other familiar serial interfaces can be easily generated from USB or PCIe buses on the carrier board and routed to I/O positions on the backplane.

Depending on the desired system mechanical configuration, the I/O slots and supporting hardware can reside directly on the COM Express carrier board or can be supported on a separate backplane PCB. Each interface choice presents advantages and trade-offs. Designers can choose the best backplane communication configuration by considering the attributes of each interface, the number of slots required, and the throughput/response time required for I/O interface (Figure 2).

Backplane Communication Options

PCI Express, widely implemented as the expansion bus on modern PCs, is the most obvious choice for interfacing backplane I/O with COM Express modules. PCI Express is organized in serial "lanes," each consisting of a low-voltage differential TX/RX pair. COM Express provides up to six PCIe lanes for general purpose use (there is a separate group for graphics). Each single lane has a data rate of 2.5 Gbit/s, and multiple lanes can be grouped together to increase bandwidth, although this is not generally required for accessing general purpose I/O. The high data rate combined with physical-layer flow control capabilities makes PCIe suitable for reliable communications even in high-bandwidth applications.

Still, six lanes can be a limiting factor in backplane design, especially if any lanes are used for creating system functionality, such as serial ports on the carrier board. To expand beyond the six lane limit, a PCI Express packet switch can be implemented on the carrier board or backplane to create the desired number of backplane slots. However, more PCIe lanes results in a bandwidth penalty, so a hybrid approach that implements some number of dedicated PCI Express slots for high-speed backplane I/O while using one of the other serial interface options for the remaining general purpose slots may be more effective.

PCI Express, like all high-speed signals, requires care in layout in order to maintain signal integrity across the backplane. For best performance, signals must be routed as matched-length differential pairs, use controlled impedance, and stay within the electrical length requirements of the standard.

USB can also be a good choice for communicating with I/O cards over a backplane. The COM Express specification requires at least four USB ports, but many modules include the maximum of eight. Some of these ports likely need to be available to the system as general purpose ports, but by implementing USB hubs on the carrier board or backplane, the desired number of ports can be assigned to backplane slots.

USB supports automatic enumeration for detection of USB connected I/O cards and the installation of necessary software drivers. Although USB uses differential signaling, routing USB signals over a backplane requires care since the standard encodes single-ended state information. USB 2.0 offers three speeds for communications: 480 Mbit/s high speed, 12 Mbit/s full speed and 1.5 Mbit/s low speed.

Although the data rates are relatively high, the USB specification requires the host to poll USB devices. This polling architecture, along with other factors including processor performance, operating system, application software and amount of I/O affect latency, makes USB unsuitable for real-time or near real-time

Figure 3
Sealevel Systems' Relio R3 rackmount industrial computer uses a COM Express to backplane architecture. Relio R3s offer 19 expansion slots for application-specific I/O.

requirements. However, for general purpose I/O, USB is a good choice for backplane connectivity.

COM Express modules do not typically include serial port functionality, but implementing RS-485 communications over a backplane is straightforward using the COM Express module's USB or PCIe bus and simple circuitry on the carrier board or backplane. Long a popular standard for industrial communications I/O, RS-485 uses differential signaling that offers noise immunity suitable for electrically noisy environments and is well suited to routing over a backplane.

RS-485 offers relatively low-speed communications, up to 921.6 Kbit/s, and the standard defines an address for each I/O location that simplifies software protocol development. As an alternative to creating a custom software driver to handle communications, industry standard Modbus RTU offers a well-defined, documented option supported by a variety of third-party software packages.

Ethernet is widely used for backplane communications in a wide range of products designed for military and commercial applications. COM Express modules supply a minimum of one Ethernet port, and the specification recommends 10/100/1000BaseT Gigabit for the port. This port can be connected to the backplane slots by adding Ethernet switch circuitry to the carrier board or backplane.

Ethernet implements flow control primarily in software, resulting in possible data loss when there is a large amount of traffic. In that case, adding a managed switch circuit can often improve performance adequately for applications that do not require real-time response. For applications that require deterministic timing, industrial Ethernet protocols like EtherCAT work best.

Rackmount System Example

Sealevel's Relio R3 industrial computer uses a COM Express engine to power a 3U 19" rackmount computer with a total of 19 I/O slots. One PCIe slot is included for high-speed I/O such as video processing, while the other 18 slots connect via RS-485 to Sealevel SeaRAQ I/O boards. As shown in Figure 3, the COM Express processor mounts to a carrier board that brings out all the standard features of the COM Express module including DisplayPort video, Ethernet and USB channels. RS-485 is generated on the carrier board, and a transition board holds the PCIe connector and routes the RS-485 signal to the vertically mounted backplane PCB. This architecture allows configuring the Relio with a choice of Intel i7, i3, or Atom processor simply by changing the COM Express module. As technology evolves and faster processors are available, the system can be upgraded with minimal engineering effort by changing the COM Express module.

For applications that require real-time response, smart I/O backplane cards can offload functionality from the host processor. This approach can eliminate backplane throughput and data integrity concerns for any of the COM Express connectivity choices. Advances in Field Programmable Gate Array (FPGA) technology make designing smart I/O cards easier than ever (Figure 4).

Figure 4
Sealevel SeaRAQ I/O boards connect to the COM Express processor via RS-485. For high-speed applications, FPGAs can be used on I/O boards to reduce throughput requirements.

An FPGA is a good choice for interfacing a PCIe lane from the COM Express module to I/O circuitry on a backplane card. By creating a PCIe endpoint and custom I/O interface logic in the FPGA, the application running on the COM Express module can quickly and easily read and write data using a memory-mapped addressing format. The result is an elegant software interface with fast system I/O response time.

For real-time requirements, it is now possible to run an operating system and execute an application program written in a high-level language directly in an FPGA on an I/O card. A number of CPU cores are available for use in FPGAs. For example, the NIOS II “soft processor” from Altera provides flexibility, tight integration with the FPGA logic, and the ability to easily create custom I/O peripherals. The NIOS II core resides in the FPGA fabric and provides a full 32-bit processing engine capable of running an operating system and allowing application software to be developed in a high level language.

The COM Express backplane architecture provides the freedom to exactly match the application I/O and mechanical requirements while providing an easy upgrade path for the core processing functions that are most likely to change, thereby extending the useful life cycle of the system. OEMs will benefit most from the investment required in the initial design through the product’s configurability, scalability and long life cycle. Additionally, end users will benefit from the ability to upgrade existing hardware with minimal costs compared to a full system replacement.

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