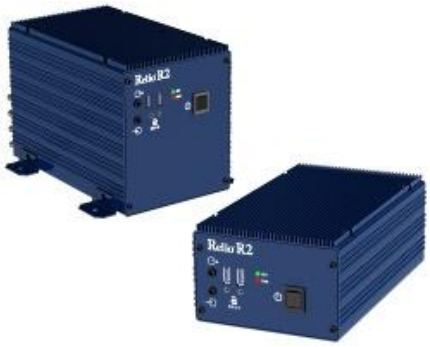
White Paper: Computer System Design for Critical Applications



By: Earle Foster

Careful upfront attention to computer system design will save field failures and headaches later

"Industrial computer" is a widely used term that unfortunately can be quite ambiguous, often applied to computers that have little real advantage over commercial PCs but may outwardly appear "rugged". However, there are many applications that need a computer system that is truly built to a higher standard for reasons that include:

- Uptime is paramount
- High cost of service call or repair
- Harsh operating environment
- Consistency of design
- Long term availability
- Certification Approvals

Building a system that meets all of these criteria requires eliminating the most common causes of failure and obsolescence in the design. Starting with our first Relio solid-state computer design in 2003, Sealevel has progressively raised the bar in providing solutions for mission critical applications through careful design and attention to process.

Important attributes available in Sealevel computer designs include:

Get rid of the fans

All mechanical parts eventually wear out. A sleeved bearing fan's typical life is 30,000 hours at 40°C – less than 3.5 years. At higher temperatures, the lifespan further decreases.

Systems that depend on convention cooling using fans will inevitably overheat and fail once the fan wears out. That may be acceptable for some uses, but could be catastrophic in critical applications. Convectional cooling also assumes there is a path for airflow, but often this is not possible with embedded systems or applications where the computer may be subjected to rain, dust, or sand. Careful consideration of the enclosure type (e.g. extrusion vs. bent metal) and heat removal components is required to achieve the widest temperature range possible given the power dissipation of the components in the enclosure.

To ensure a system will work throughout the entire required operational temperature range, Sealevel uses state of the art thermal modeling tools to guide enclosure design, select subassembly placement within an enclosure, and choose proper heat spreaders and heat sink components.

No rotating media

Just like fans, the moving parts on standard hard drives eventually wear out. But there are other problems with rotating hard drives. Vibration, shock, and unexpected power loss can all cause the read/write heads to crash against the storage media resulting in physical damage and/or corruption of the operating system.

Today, pricing of solid-state hard drives is affordable for capacities suitable for most OEM or industrial applications. These devices vastly outlast traditional rotating hard drives, especially in harsh environments. But it is still important to choose the correct solid-state drive. The drive type (MLC vs. SLC) should be a primary consideration since it greatly impacts lifetime of the hard drive, and

therefore the expected reliability of the industrial computer.

Multi-level cell (MLC) flash drives are the least expensive drives and are commonly found in consumer products like memory sticks and games. However, MLC flash drives wear out at a faster rate (as much as 10 times faster) when compared to single-level cell (SLC) technology. SLC memory is also faster than MLC. As a result of these differences, SLC memory is preferred for industrial applications, especially those utilizing Windows OS, to maximize the mean time before failure (MTBF).

Sealevel's Solid-State R1420

COM Express Architecture

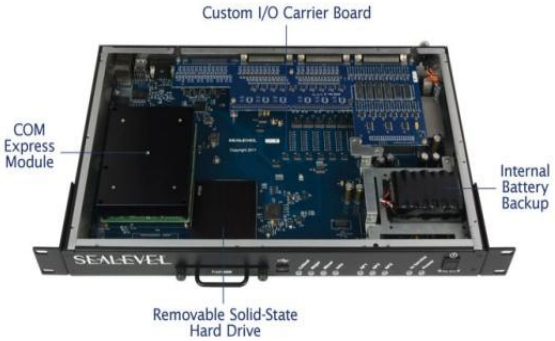
Traditionally, computer systems were designed around a specific computer board form factor (ATX, EBX, etc.) that limited the flexibility to adapt and respond to future application demands. As a result, these systems are not be able to take advantage of processor performance improvements and expanding memory options, thus limiting support for application program requirements or future operating systems. Effectively, the design will be frozen once released to production.

The good news is that the industry standard COM Express architecture now provides the needed flexibility for products requiring long-term availability. COM Express systems combine an off-the-shelf Computer on Module (COM), built according to the PICMG standard, containing the functionality common to most systems (processor, memory, graphics, USB, Ethernet, SATA) with a carrier board that includes system I/O and interface connectors. Using this architecture provides an easy upgrade path for the core processing functions that are most likely to change, thereby extending the useful life cycle of the system.

Internal battery backup

Industrial computers are often used in applications where supplying clean power can be a problem. Examples include applications for vehicles, marine vessels, remote locations with only generator power at times, and less-developed countries with poor power infrastructure. In each of these applications, power can be lost unexpectedly, resulting in an unplanned shutdown of the operating system and possible corruption of the hard drive.

A better solution is to provide for temporary power that allows enough time for the application software to perform an orderly shutdown. In applications that require this feature, Sealevel provides a compact battery pack with power sense and switching circuitry to continue to provide power for more than 5 minutes once a power outage is detected. The power detection circuit provides notification to the application program of the loss of main power, and the application program can then close processes properly and shutdown without damage to the hard drive or operating system.

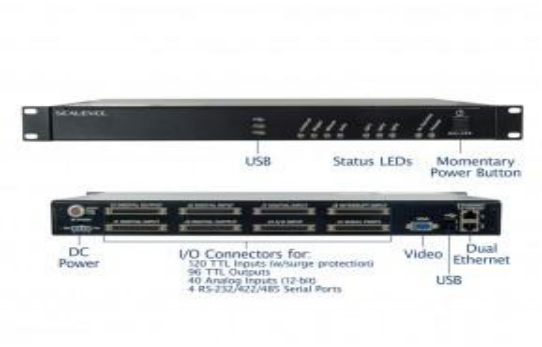


FPGA intelligence on COM Express carrier boards

As described earlier, the COM Express carrier board contains the application specific I/O functionality. Typically, the COM Express CPU module needs to poll the I/O when needed to receive the most current information. For systems with a lot of I/O, this results in processor overhead that can slow down computational tasks or make the graphic user interface less responsive.

To reduce the processor overhead usually associated with retrieving the most current I/O data, Sealevel carrier boards often include a Field Programmable Gate Array (FPGA) that interfaces to the system I/O. The FPGA's firmware continuously polls the I/O and stores the results in a circular memory buffer within the FPGA. To access all of the I/O data, the COM E processor need only read from the FPGA's memory buffer using a driver supplied by Sealevel. This eliminates the normal time required to service each I/O point, initiate A/D readings and wait for data to become available, etc. An example COM E system that implements this FPGA architecture to reduce host overhead is shown below. This 1U, 19" rackmount system contains 256 I/O points including 40 channels of A/D.

Example COM E System Using FPGA



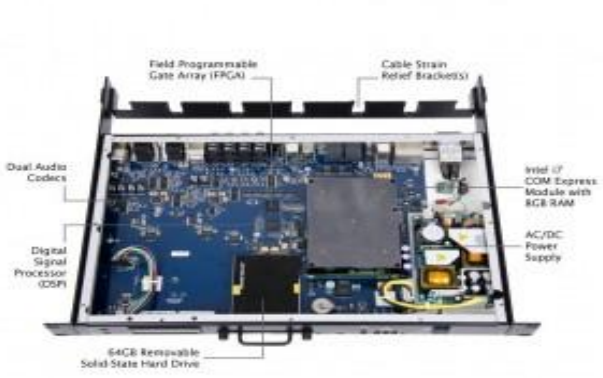
Eliminate internal cabling

Moving parts represent the most common point of failure in an industrial system. Next on the list of trouble spots are cable connections. Many industrial computer designs use a motherboard or an off-the-shelf single board computer (SBC) that supplies standard features including Ethernet, USB, serial, and video. Often the features are accessed via header connectors on the SBC, requiring a cable (usually non-latching) to bring the internal signals to an external connector in the enclosure.

The COM Express architecture allows the custom carrier board to be designed to the exact mechanical dimensions to allow I/O connectors to be soldered directly to the PCB in such a way to allow external access without internal cables. Eliminating cables adds reliability not only in high vibration, high shock design, but in any system design since header connectors can easily become disconnected even during transit.

Typical SBC-based System

Com Express System Eliminates Most Internal Cables



Compliance testing and management

Most computer systems require some form of certification to a standard. For commercial systems to be sold only in the U.S., this may mean only FCC approval to certify the system will not disrupt other nearby electronic equipment. More commonly, FCC and CE approval are desired to allow use in the U.S. and export to Europe and other international locations.

Other optional certifications include:

- UL or ETL safety mark. Safety certification is not compulsory, but may be necessary in order to effectively sell into certain vertical markets, especially in applications where people are in contact with the equipment.
- Hazardous Area. An extension of the basic safety approval, Hazardous Area certification is often pursued for product intended for environments containing explosive gases or dust. The required certification is again defined by the end use or a specific customer requirement and will specify the following criteria:
    - Class: Defines the general nature of hazardous material present (e.g. vapor or dust).
    - Division: Defines the probability that the hazardous material is present (e.g. at all times or under abnormal circumstances).
    - Group: Defines the specific hazardous material present (e.g. gasoline or flour dust).
    - Temperature code: Defines the maximum surface temperature of the equipment.
- MIL-SPEC. For military applications, there are many types of MIL-SPEC requirements. For any system, all applicable MIL-SPEC will be determined by the particular final use and any specific requirements specified by the end customer.
- NEMA. The National Electrical Manufacturers Association (NEMA) publishes standards that are used to describe the types of environments in which a product can be safely used. Many times, the NEMA rating of product is determined to define the products tolerance to liquids impacting the product under various pressure and conditions.

Navigating the maze of certifications can be daunting, and expensive, especially for the inexperienced. Sealevel has a full time compliance staff to bring new designs from prototype through full certifications in the minimum time and lowest cost possible. Prescreening of products for EMI and susceptibility to electrical transient is done prior to going to a certified lab partner to guarantee the best results. Once certification is achieved, strict attention to consistent parts and assembly ensures that the product is always built to the certified standard.

Environmental Stress Screening

For increased reliability, Environmental Stress Screening (ESS) can accelerate defects that may otherwise not be detected until a field failure occurs. This is done by subjecting the unit under test to thermal cycling and vibration testing that can precipitate latent defects such as cold solder joints, loose fasteners, or poor wire crimps. Defects found during ESS can be addressed rapidly to determine root cause and effect a corrective action to eliminate recurrence and improve the overall quality level of the product.
Once a product is released for production, Sealevel's extensive manufacturing capabilities provide a trouble-free pipeline to meet delivery demands. Our in-house test equipment includes modern thermal chambers and vibration stations suitable for large volume production orders requiring ESS.

Summary

Before you select a vendor for your next industrial computer design, carefully consider the factors that affect system performance, reliability, and longevity. A heavy metal enclosure may look the part, but without careful attention to the details described here, a system will not live up to the description “industrial”. Paying special attention to heat management,

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