INTEGRATED MODULAR AND DISTRIBUTED AVIONICS TAKE FLIGHT

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For embedded computing applications in aerospace, Integrated Modular Avionics (IMA) are an important driver in achieving flexibility. With distributed avionics gaining new popularity as a way of achieving IMA, aircraft designers are taking advantage of recent advances in packaging to make distributed systems simpler and more cost-effective. Commercial aerospace applications are moving beyond traditional protocols like ARINC 429 to higher speed Ethernet-based protocols like ARINC 664 and 629; likewise, the U.S. military is widely adopting Ethernet to take advantage of the high-volume experience in the commercial world. Already, we are seeing the release of 40-Gb/s Ethernet for military applications as application demands move beyond gigabit and 10G capabilities.

Standardizing for Flexibility and Scalability

By creating standardized modules that can be mixed and matched as needed, designers gain a modular system that offers increased design flexibility compared to existing architectures in collecting and distributing throughout the aircraft. At the same time, standardization is a leading trend in the commercial aviation industry, creating more competition and ultimately driving down costs. Standardization can also allow modules to be used across different aircraft.

Figure 1 shows a distributed system for a cabin system in commercial avionics.

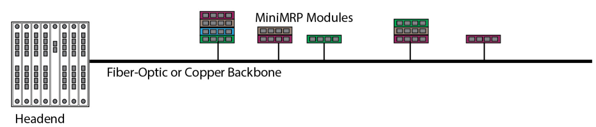

Figure 1. Distributed avionics (Source: TE Connectivity)

Such integrated modular avionics can also reduce weight and save space. One example is the miniature modular rack principle (MiniMRP), which is being developed as an extension to ARINC 836. While similar to the established MRP systems in ARINC 836, MiniMRP modules are 40% smaller, which can also translate into weight savings of up to 60%. Standardized modules can reduce development and qualification cycles. Modules are mounted in frames, with tool-less installation and removal. Designers will ultimately have a choice of customizing a module or selecting a module in a catalog-like fashion from suppliers.

While the ARINC 836 MiniMRP is initially aimed at commercial cabin systems, it will also find use in military aerospace. The concept is applicable to a wide range of commercial and military applications.

Smaller, Lighter Flexibility

In the effort to reduce weight, composite MiniMRP enclosures are a replacement for traditional metal enclosures. Composite enclosures are not only sturdy, they can be easily customized with shielding, circuit traces, embedded antennas, and other features. TE Connectivity (TE) is one of the leaders in creating composite materials with different properties. Composite formulations—including base materials and fillers—are selected according the specific needs of the application. Filler ranges from carbon fibers to microsphere and nanotubes. Composites can be selectively plating to add shielding, circuit elements, and other features. While none of this is necessarily new, what is new is advanced manufacturing techniques that move composite enclosures from expensive boutique devices to cost-effective, high-volume items fully capable of not only replacing metal enclosure, but adding additional features like embedded antennas or connector shells.

Figure 2 shows a MiniMRP enclosure that has integrated connector shells molded into the structure. This cuts down on the number of piece parts for the application and makes assembly easier. The enclosure accepts standard EN4165/ARINC 809 inserts to provide the flexibility obtained from the wide range of modules available. The modules in the figure offers signal, power, RF, and optical connectivity.

Figure 2. Lightweight composite enclosure (Source: TE Connectivity)

System-Level Connectivity

Box-to-box connectivity is also an important issue in distributed avionics. While many links are relatively slow speed and short distances easily accommodated by copper cable, higher-speed interconnects are finding wider use. When high-speed interconnects are required, challenges arise in maintaining signal integrity over longer distances.

As I/O speeds increase, issues of signal integrity and power budgeting create new challenges. Simply put, high-speed signals are harder to manage than low-speed signals. The higher the interconnection speed, the more difficult it is to manage return loss, insertion loss, crosstalk, and similar factors that can degrade signals. While an ideal cabling system would have no intermediate connections between boxes, the real-world need for production breaks and modularity necessitates connectors in the path.

To address this gap in fast copper connectivity, TE Connectivity (TE) has recently introduced three families of CeeLok FAS-T and FAS-X connectors capable of 10 Gb/s performance (an example of which is shown in Figure 3), each of which offers specific advantages to designers in performance and size.

Figure 3. A new generation of circular connectors supports 10 Gb/s Ethernet over copper. (Source: TE Connectivity)

Fiber Optics Coming On Strong

Interconnections present designers with three challenges: weight, distance, speed, and signal integrity. To meet higher speeds over longer distances, fiber optics is gaining greater use in backbone applications. Since copper interconnections are historically the prevalent technology—and continue to make gains in allowing gigabit data rates well within the distances required in aircraft, we will focus here on the reasons designers are turning to fiber optics. As 40G and even 100G links are deployed, fiber will become essential.

Speed and Distance. Simply put, optical fibers carry higher data rates over longer distances than copper cable. Where a twisted pair cable can carry a 1 Gb/s signal over a distance of 100 meter, a multimode fiber can carry the same signal 1000 meters and a single-mode fiber can handle tens of kilometers. With wavelength-division multiplexing allowing multiple wavelengths, the capacity of the fiber is multiplied by the number of wavelengths.

Weight. A fiber-optic cable is significantly lighter than a copper cable. A generic Cat 6 Ethernet cable weights 31 pounds per 1000 feet, while a fiber-optic counterpart offers weight savings of over 66 percent at 10 pounds. For aerospace applications, cable constructions are more complex than this simple example. More complex structures give additional weight advantages to fiber. On one hand, copper cable have benefited from advance weightsaving thin-wall insulations and jackets and better control of electrical parameters such as characteristic impedance. On the other hand, shielded cables are common in aerospace applications for EMI control and achieving signal integrity.

Signal Integrity. Since optical fibers are made of dielectric materials, they neither emit nor receive EMI; compared to copper cables, fiber-optic cables offer ideal noise immunity. This immunity means additional EMI-control methods—in this case, cable shielding—are not required.

The day when fiber's reputation as a fragile and hard-to-use medium are long past. Fiber-optic cables also offer easier use over past versions. Constructions offer crush resistance and resistance to pinching during installation. Fiber preparation during termination is easier, while no-epoxy/no-polish connectors significantly simplify the skill and times required for installation.

Figure 4. Designers have a full range of options for optical connectivity (Source: TE Connectivity)

The range of connectivity options for fiber gives the designer great flexibility. Optical connectors are divided into two main categories:

Physical Contact (PC). The mating termini physical touch. PC termini are further divided in ceramic ferrules for single fibers and MT ferrules of multiple fibers. Ceramic ferrule yield the highest performance—lowest insertion loss and return loss. Multifiber MT ferrules offer the highest fiber density,

Expanded Beam (EB). Of the three termini, the expanded beam is the most tolerant of vibration, shock, and other mechanical hazards. Using a non-contacting interface to avoid any wear and tear on the fiber/ferrule face during vibration, EB connectors expand and re-focus light at the fiber end faces and allow an air gap in the optical pathway. The EB concept uses optical lenses (typically a 3 mm ball lens) to expand and collimate the beam emitted from the launch fiber. The expanded beam remains collimated across the mechanical interface until the receiving lens focuses the beam onto the receiving fiber.

Because the ferrule end-face is enclosed and protected behind the lens, the fiber will never require cleaning. Only the exposed outer lens surface can be contaminated, but is easily cleaned. Because the beam size is substantially expanded across the mechanical interface, the signal will not deteriorate by airborne contamination—for example, a 10-µm dust particle—that can seriously degrade the performance of connecting ferrules. The higher insertion loss of an EB connector is often outweighed by the life-long reliable and consistent EB performance.

Copper and Fiber Coexist

Copper and fiber will coexist in most applications. Each brings specific advantages, from the comfortable familiarity of copper to the high-bandwidth capabilities of fiber over longer distances. As systems are challenged to offer users a seamless experience in handling data, video, infrared imaging and other bandwidth-hungry processes, both optical and copper connectivity must ensure that the end-to-end solution can accommodate production breaks in the path. The good news is that both technologies continue to evolve and give designers new options in meeting ever-increasing data loads.

It's the System That Counts

The drive to reduce weight and increase performance makes it imperative to view connectivity as an end-to-end system. MiniMRP boxes, by integrating the connector shell into the lightweight composite enclosure, are one step. Box-to-box connectivity likewise offers many choices in balancing weight and performance. By treating connectivity as a system, designers can evaluate various tradeoffs—copper versus fiber, types of shielding, cable construction, and so forth—to meet requirements for both signal integrity and the environmental and mechanical needs of the application.

ABOUT THE AUTHOR

With more than 30 years of experience in the electrical interconnect industry; Russell has performed in various roles in product and manufacturing management. His primary focus at TE is to bring newer technologies to market.

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