Connector Technologies For Data-Driven Military Environments

Klaus Montoya, Senior Cable Design Engineer, Elma Electronic

Smaller form factors combined with an increasing amount of data flowing through military infrastructures has created the need for ruggedized, miniature connectors at home in high-speed, data-driven systems.

Since the start of computing and electronics, connectors have played a solid role in moving data from point A to point B, and in many of today's environments, to C, D, E and on down the line. Performance elements, such as processing speeds and data storage, are the often focal points when designing an electronics system, with not much attention paid to the physical connections that need to be in place for this data to move across.

This has been changing in recent years, and connectors have advanced in their technological abilities, but at a slightly different pace than their higher profile counterparts, such as processor families and onboard storage banks. Yet it is this reliable connection from point A to point whatever within the physical system that is truly what anchors the electronics.

Military environments are becoming especially cognizant of connector technology, due, in part, to the growing amount of data being pushed digitally across modern military infrastructures combined with shrinking form factors. This puts a direct focus on older connector technologies, designed back when connector diameter was measured in inches, and throughputs were RS232 and RS485 signal types, just to name a few. While connectors have begun to shrink in size and weight to keep pace with the reduction in overall system size, adherence to relevant military (MIL-STD) specifications has become problematic. Not only are older connectors not capable of handling the data throughput, but their large size and weight precludes their use in modern military systems, such as unmanned aerial vehicles, on shipboard installations and in rugged ground vehicles.

Figure 1. Modern rugged mini connectors can handle today's data demands.

Replacing the older connectors are smaller connectors aligned to the demands of high-speed, data-driven systems operating in harsh environments. These connectors also meet the industry requirements

put forth in application-specific MIL-STD specifications (Figure 1).

Meeting Today's Data Demands

Connectors that mimic the electrical and mechanical performance of traditional military and aerospace connectors, such as D38999, yet meet the ever-increasing requirements for high-speed interconnect solutions give designers the best of both worlds. Typical high-speed signaling requirements include Ethernet 10GBase-T, USB 3.0, DVI, Display Port, SATA 3.0 and HDMI. Traditional MIL connectors worked so well because they provided solid performance in harsh military applications for the long haul. But the connectors' limitations with regard to handling high-speed, high-bandwidth data in modern communications and control systems inevitably led to technical challenges.

Two main areas of development in these newer ruggedized connectors are the technology within the connectors themselves and two, the cables required to harness the more sophisticated electronic equipment.

More Than Just Mating

A reliable coupling and optimized SWaP in military and aerospace environments aren't the only battle cries. Connectors need to withstand severe shock, vibration and temperature extremes while offering the high performance, reliability and signal integrity necessary for mission-critical applications.
When looking for a connector solution, many factors need to be determined that will help minimize other design challenges that will be encountered down the road. What is the intended temperature range, level of sealing and shielding requirements of the specific application? How many contacts are needed and is there a target number of mating cycles the connector needs to withstand? What about material and locking types?

Figure 2. Space constraints are one of many design considerations.

Where will the connector be placed physically? For example, MIL-STD-1472G for human engineering exists to ensure an actual human can operate the military systems that are designed and developed (Figure 2).

Think about placing connectors onto a PCB or panel. The standard recommends a minimum spacing of one inch between two adjacent connectors to ensure a hand can physically fit within the space. Yet, a designer may have to reduce the gap so everything fits in the amount of space within a given application. Deviations may be required, and sometimes, a compromise needs to be reached.

Such compromises, or striking a balance between theory and practice, drive some of the modernization of rugged connector technologies. Even though connectors designed for high speed and high reliability have been around for a few years, there are times when certain parameters have been tested but not necessarily used in a real world application. Working with the connector manufacturer will allow enhancements and tweaks to the design so it can actually be manufactured, while incorporating feedback into the designs to provide a more optimum solution for the intended use.

Cohesive Connections

With the increased data throughput of more modern rugged connectors comes the concern for the cables used to route the data across the network paths. Just as connector technology was slower to develop, cable manufacturers follow suit with new cable designs that may not quite meet the needs of these newer connectors.

The design challenges with RF cables, in particular, need to take into account several issues: connector types, such as straight or right angle; cable types such as regular coaxial, semi rigid and rigid; requirements for length matching; and (in some cases) phase matching.

Length matching is simply that the longest cable will determine the length of the others in that grouping, when all the cables are routed throughout the chassis.

But phase matching is a much more sophisticated process when considering today's microwave technologies and the inevitable variations in connectors and manufacturing processes. This complicated situation requires experienced designers and state-of-the-art RF instruments as well as a phase spec that calls out the degrees and the specific frequency to match.

The key to incorporating the right RF cables is using suppliers that specialize in this field, as they have the knowledge, the know-how and the latest test equipment to produce a finished product that will meet the needs of a given project.

Rigid cabling has its own design requirements, such as using 3D modeling to determine the actual layout of all the cables needed in a chassis. The cables need to be laid out in a manner that can be converted to a 2D drawing for each cable assembly. Installing these types of cables into a chassis calls for tight tolerances and special manufacturing sequences (Figure 3).

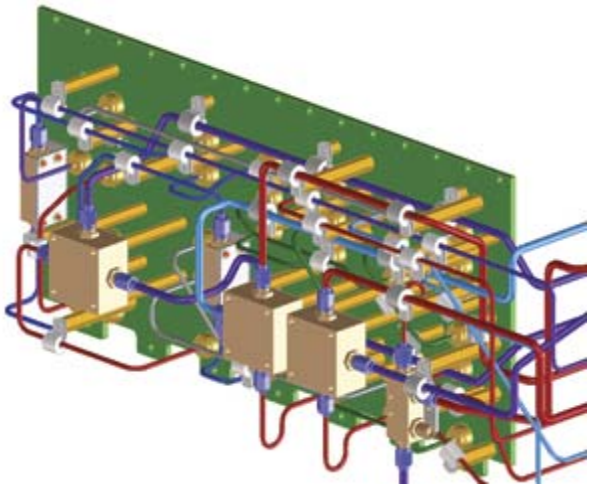

Figure 3. Shown is an example of rigid cabling assembly.

Special tooling is required when fabricating rigid cable assemblies to control the actual bends in specific locations along with the tight tolerances needed. This ensures the accuracies of the finished assembly, so it can be installed as designed.

Connecting in a Modern World

Rugged, reliable, real world…today's military connectors are meeting these requirements in smaller packages, while handling the increased data throughput of high-speed networks.

Design challenges have been met; standards have been maintained. Aircraft, ground vehicles and handheld electronics can no longer be bound by the bulky size of traditional MIL-STD connectors, but are incorporating a new class of miniaturized connectors designed to withstand severe environmental impacts and provide reliable communications in the field and in the air.

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