Connector Technology Answers Need for Fast, Rugged, Reliable Solution for Extreme Environments

Greg Powers, Global Aerospace, Defense & Marine, TE Connectivity, www.te.com

The original VITA 42 XMC connectors were not designed to specifically address military applications as a central design goal. The demanding environment of military applications presents several design challenges due to the high levels of vibration and thermal cycling that can stress a connector’s performance and decrease signal integrity. Cracked solder joints from thermal cycling and damaged contacts from stubbing during mating also need to be considered.

As a result of these issues, a new high-reliability XMC connector was needed to meet the demanding requirements of military needs. Goals for the development of such a connector included:

- Uniform solder ball and contact retention features of mated connectors to improve reliability
- High-reliability socket contact design based on MIL-C-55302 Mini-Box contact
- Desirable thermal cycling stability — 2000 or more thermal shock cycles
- Anti-stub design with protected lead-in
- Durability of 500 cycles minimum
- Footprint compatibility with existing XMC board layouts

Mezzanine Boards Provide Flexibility

Mezzanine boards give additional flexibility for systems by providing for expanded functionality and modularity to a pc board. They allow existing boards to be re-configured, upgraded, or customized by the addition of the mezzanine card. Typical applications include application-specific high-speed input/output (I/O) protocols, graphics, memory, and digital-signal processing. Mezzanine boards are widely used in the telecommunications, industrial, and military/aerospace markets.

Solderball: Compliancy Brings Reliability

A new line of header and receptacle connectors attaches to the boards by well-established ball grid array technology. Their solder tail design uses a proven compliant design to provide robust, uniform solder joints. The compliancy is important for two reasons.

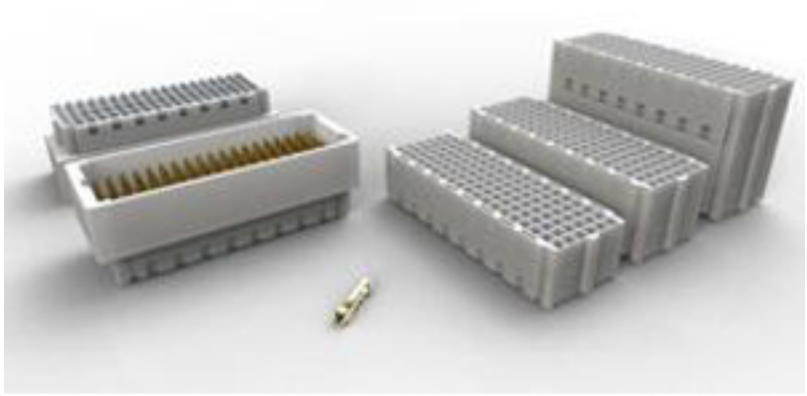

Figure 1. Mezalok XMC connectors and socket contact. First, it accommodates variations in the board-to-connector coplanarity. Ideally, the solder balls would meet the pc board pads along a perfect plane. In reality, small variations exist. With a noncompliant contact design, lack of coplanarity can result in non-uniform solder joints—some stronger or weaker than others. Compliancy helps ensure uniform reliable joints.

Second, compliancy is much more forgiving of thermal cycling, which can lead to cracking of solder joints if some flexibility is not achieved. Since different parts of the connection—pc board, solder joint, and connector housing and contacts—have different coefficients of thermal expansion, a rigid design can lead to failure of the joint. In a military environment, with higher levels of vibration, even small cracks can quickly lead to joint failure.

High-Reliability Contacts for Demanding Environments

The contact design for connectors based on the MIL-C-55302 Mini-Box contact must have years of proven performance in military environments. One such uses four spring members to provide contact on all four sides of the pin, a configuration that works well in high-vibration applications. The redundant four points of contact ensure a low-resistance, reliable connection under trying application circumstances.

The shape of the Mini-Box springs, with their gentle radii, also allows lower insertion forces while maintaining high normal forces when mated. The lower insertion force, in turn, means easier engagements and disengagement of connectors, higher durability, and less chance of damage.

Figure 2. The Mini-Box receptacle design, with redundant spring force on all four sides, has years of proven field use for high-speed application in harsh military environments.

Thermal Stability and Anti-Stub Design

Thermal cycling can be a major failure mechanism in connectors used in military applications. The compliant design of TE Connectivity's Mezalok Connectors' solder balls, for instance, accommodates thermal expansion and contraction. In addition, housings are made of liquid crystal polymer (LCP), which has a low coefficient of thermal expansion and withstands soldering temperatures, including the higher temperatures associated with lead-free solders. Overall, the new design presents a thermally stable connector that withstands thermal extremes well. The connector has been tested to 2000 thermal shock cycles with no failures.

Stubbing occurs when the pin contact does not mate properly with the receptacle. In severe stubbing, the pin can even miss the socket entirely, being pushed into the housing on the outside of the socket. Stubbing can result in damaged contacts, high resistance, and lower cycle life. This connector's design eliminates stubbing through four main features First, the Mini-Box contact is boxed at the end so that there are no exposed spring ends to become deformed or present a stubbing surface.

Second, the receptacle housing provides generous chamfered lead-ins to the Mini-Box contacts. The ends of the contacts are protected by the housing overhanging and protecting the ends of the receptacle.

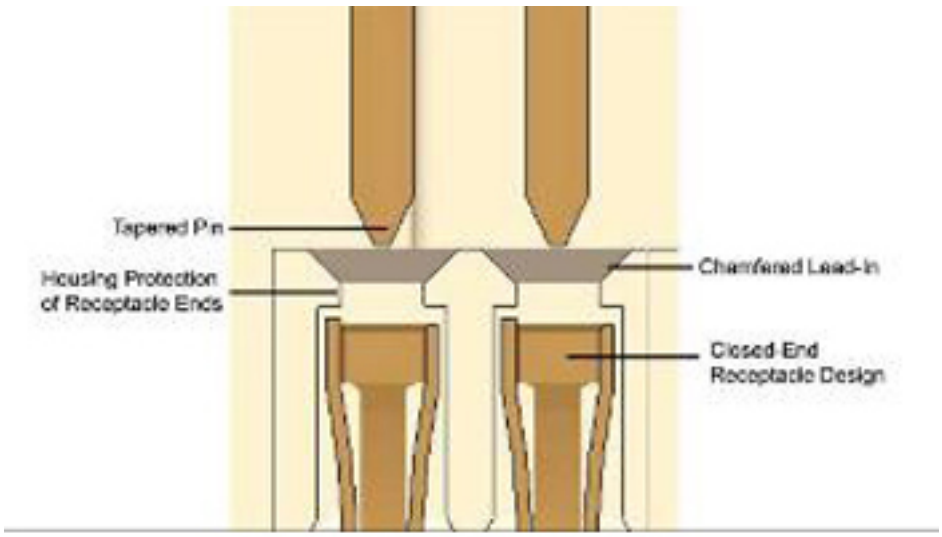

Figure 3. A pin lead-in, closed contact end, and housing overlap all combine to protect the connector system from contact stubbing.

Third, the pin connector is fully shrouded to reduce the possibility of pins being bent.

Fourth, the tip of the pin is tapered to help direct entry into the receptacle.

Improved Durability and XMC Compatibility

The durability target for connectors used in military and aerospace applications is 500 mating cycles. Existing VITA 42 XMC connectors are only specified for 100 mating cycles. The new design meets military durability requirements. Redundant four-sided configuration of the Mini-Box contacts means less wear and tear on the contacts since each spring can have a lower individual normal force.

Mezalok contacts are a high-performance copper alloy selectively plated with 50 micro-inches of gold in the mating areas (with 30 micro-inches as an option). Gold plating, of course, ensures a low-resistance mating without corrosion or films developing over time.

A new rugged connector for XMC aerospace and defense environments must use the same pc board footprint as VITA 42 connectors. As a drop-in replacement without requiring board redesign, the Mezalok connector is configured as a 114-position connector with contacts arranged on 0.050-inch centers in a 6 x 19 grid. A 60-position (6 x 10) connector is also available for special applications. It supports both standard XMC stacking heights 10 and 12 mm and, by customer request, a new height of 18 mm. For the carrier (daughterboard) side, the pin header is a fixed height of 4 mm. Receptacle connectors on the mezzanine side are available in heights of 6, 8, and 14 mm.

Performance

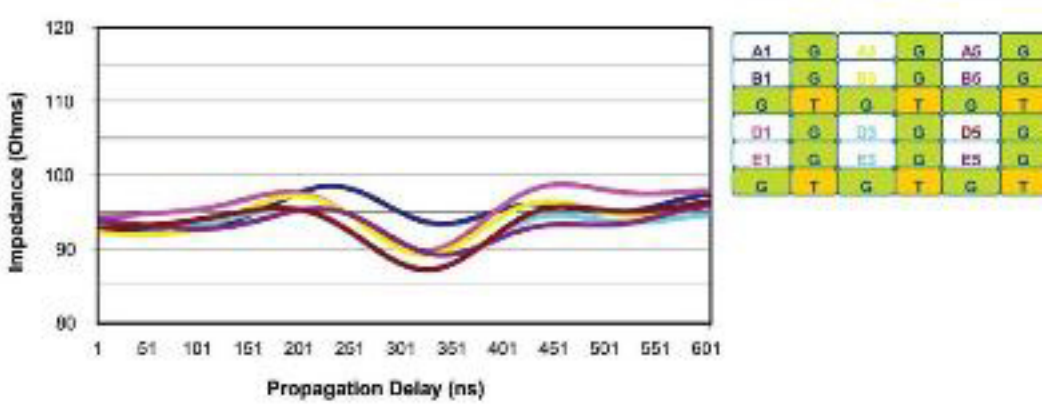

Figure 4. Measured differential impedance for 12 mm connector pair.

Recently a signal integrity analysis was performed to characterize the electrical performance of the connector. The XMC standard uses serial communications, most often with differential pairs to reduce noise. Figure 4 shows the differential impedance for the 12-mm connector pairs measured at a 50 ps rise-time using a standard VITA 42 XMC footprint. The results show a high degree of uniformity between pairs.

Conclusion: Ready to Take Flight

XMC is ready for prime time in military and aerospace applications. One connector combines high data rates and a robust design to withstand vibration, shock, and extreme temperatures to give designers of VXS and VPX systems a high-reliability solution. The connector capitalizes on existing technology that is well understood and field proven. Mini-Box contacts have been in use for decades and today support high-speed backplane and now mezzanine interconnections. Likewise, the BGA solder technology, with its compliant design, has been widely used in connectors and high-pin-count sockets with exceptional reliability.