Connecting To First Class – Designing For The Railway Industry

Rail transportation is seen as one of the most attractive, rapidly-growing markets in the electronics industry, particularly interconnect solutions. As environmental concerns come to the fore and with the escalating cost of flying, trains are increasingly seen as the preferred option for journeys up to 500km.

Electronic rail systems provide a unique challenge for component designers. Trains and rail infrastructure inherently require secure and high speed communication over long distances and due to the need to regularly couple and uncouple relatively large scale structures such as wagons and whole carriages, there is a need for robust interconnections that can deal with multiple mating cycles. Harsh environmental conditions mean that both the longevity and safety of equipment is vital.
The demand for rail transport, and consequently connectors, is further enhanced by the train's ability to enter the heart of a city. The Eurostar can reach the centre of Paris from London in less than three hours, whereas a flight requires lengthy check-ins and airports tend to be a distance away from the city, making the train more than a rival for the air industry. Demand is only set to increase further as technologies, such as MagLev, vastly increase speeds.

Away from the traditional European market, emerging economies such as China and India are also in the process of building fast and reliable railway lines as part of an infrastructure to establish an adequate level of competitiveness.

1. System Requirements

The requirements on rail interconnect systems vary depending on whether they are within a wagon, located externally or within the infrastructure and signalling system. Connectors for use both inside and outside the wagon have to be waterproofed to IP68 and supplied in anti-shock shells with a quick locking system. There is also a need for modular components to support signal, power, data bus, coaxial and optical fibre contacts.

The diversity and application-specific nature of railways mean that standard interconnection systems cannot always be used and custom connectors need to be able to cope with the high volume of signal contacts - it is not uncommon to see connectors with up to 280 signal contacts.

EC directives and DIN 43653 and NF F61-030 must also be considered. Shielded versions can be used to protect both the signal paths against electromagnetic disturbances and the system from the electrically noisy environment of a rail system and reducing crowding in the radio spectrum.

2. A New Design

Smiths Connectors completed a project to aid the French railway's (SNCF) implementation of the ERTMS project (European Railway Traffic Management System).

Originated by the European Community, the aim of ERTMS is to create a pan-European, interoperable automatic train control and railways management system. Combining the new ETCS (European Train Control System) control-command system and GSM-R radio for voice and data communication, the project is designed to ensure safe operation of the trains in the network and to deal with the traffic and infrastructure management issues that enable optimisation of both infrastructure capacity and rolling-stock utilisation.

The project and solution itself represented a number of challenges as it needed to be retro-fitted to a wide variety of existing rolling stock and a unique identifier, used in conjunction with GPS tracking, was to be included.

To meet these needs, Smiths Connectors created the Nuloc custom connector. This uses Hyperboloid contact technology to achieve low contact resistance and robust electrical connection.

The device implements the identification function by integrating a recognition code on a printed circuit embedded within the connector receptacle. This code is programmed during the final manufacturing phase. The ERTMS interconnection system

also integrates a coaxial cable assembly to link to the GPS/GSM-R antenna and each cable assembly must be dimensioned to the locomotive type. This is also done during the manufacturing process according to instructions specific to each order.

Like all connectors targeted for rail applications, strict governmental, EC and customer-specified standards exist, all of which much be met if not exceeded. These standards, such as the French NF F 61-030, mean connectors must have the appropriate plating and materials to withstand salt-spray, humidity and industrial gas tests.

3. Further Considerations

The project further highlighted that there are severe environmental stresses within rail electronic/electrical applications and that connectors can be designed to achieve specific electrical insulation and isolation standards by using different materials that can offer resistance to moisture, corrosive atmospheres and industrial gases.

Vibration is another factor that varies according to location and exact application, particularly in traction applications. Naturally, vibration is considerably more troublesome outside the vehicle than within, and will vary with speed of motion. Connectors typically need to withstand a range of test levels including bump (CEI 68-2-29), sine (CEI 68-2-6), random (CEI 68-2-35) and shock (CEI 68-2-27) therefore it is paramount that they all pass a number of critical testing processes. This is not just to demonstrate electrical continuity, but to ensure that the extreme daily wear and tear experienced in rail systems will not affect the contact resistance.

Whilst vibration is in itself a potential problem, it is also a key risk factor in the corrosion performance of a connector. Connectors are particularly susceptible to corrosion or fretting at contact surfaces and interfaces, where repeated relative motion of the mated parts of the connector can initiate damage. Such a possibility needs to be addressed both by the inherent features of the connector system and the manufacturing quality of the finished product.

Enhanced product performance in this area not only reduces the risk of a failure, but can also make a significant contribution to increasing product lifetime, since contact corrosion is a significant cause of long term degradation.

Finally, mating performance is also a key indicator in rail applications. To provide the necessary reliability, minimise maintenance requirements and cope with the number of connections, a component must be able to demonstrably survive tens of thousands cycles, with no impact on contact resistance or insertion/extraction force.

As with many safety-critical applications, connectors must conform to standards on fire and smoke generation. Such specifications tend to be particularly strict in regard to products used within carriages, where they must be flame-retardant, generate no toxic gases when heated or smoke when burned.

The unique nature of rail traction and infrastructure applications provides excellent examples of extreme and developing demands on interconnection technology. In addition to the application and environment-specific requirements, rail designers are also subject to more classical driving forces. The demand for innovative interconnection solutions incorporating power, signal and optical technologies has increased significantly, resulting in the production of much smaller and higher density connections which improve transmission speeds and reduce energy demands and the reduced connector size provides the equipment designer with more space for other electronic components.