Overcoming automotive high tech requirements through new interconnection systems

FCI roadmap

The number of features and functions of a modern car is constantly increasing. For years, gasoline consumption, environmental friendliness, comfort and passive safety have been the prime drivers of innovation by automobile manufacturers. This is rapidly changing, and now car manufacturers are also actively focusing on safety systems, hybrid vehicle power train and new bus structures. To rise to these new challenges, manufacturers of connectors have to strike an innovative chord. FCI, a leading manufacturer of connectors, offers a plethora of new technologies and processing methodologies in this area.

New interface standard AK-2

An example of this is the interface technology AK-2, first introduced by FCI in 2004. It was the first airbag connector with 100% scooproof mating contact protection and an optimized interface for assembling pyrotechnic applications like airbags or belt pretensioners. From start, two requirements of the automobile manufacturers had to be met: secure assembly of the interface, and increased ergonomics during assembly.

A typical step in car assembly is mating the connector into the retainer – the component accepting the connector in a one or multi-stage ignition mechanism for the airbag. For this step, the operatives in some assembly situations must be able to insert the connectors into the retainers more or less “blindly”. Because of the previous designs of the interface this often led to broken contact parts in the airbag modules. As, however, this was discovered only in subsequent electrical functional tests, these failures caused great efforts to remove the affected vehicles out of the production line for required repairs.

FCI has now found a way of making the interface failsafe for assembly. The key challenge lay in ensuring that the new development would fit in existing standard components with prescribed dimensions and attributes. FCI solved the problem by using connector elements enclosed by a protective cylinder, which assured the reliability of the connector and its counter part as well as the right positioning of both components.

Leading German automobile manufacturers have now selected this innovation as the future standard, and have published requirements accordingly. US automobile manufacturers, under the aegis of USCAR, have also recently decided to adopt this standard and are working out a USCAR specification to this effect, currently.

Safe mating: The answer to connector mating problems

It is also essential for the automotive industry to reduce the number of unreliable connections. According to studies carried out by automobile manufacturers, there are two main causes of failures. In many cases the connector has not been mated during the final assembly and, therefore, loosens due to vibration while driving. The other cause is an increase in circuit resistance due to defective crimping of the terminal to wire. To address these problems, FCI has already developed several solutions to optimize the reliability and improve ergonomics of the connectors.

The mating of both connector halves of the new APEX 150 connector family now works with a cam device that simplifies the connector mating. The cam allows connector mating with one fluid motion from the assembler . This eliminates the need with typical connectors to actuate a secondary lever or slider. .This innovation is called axial mate assist. Also thanks to the cam, the connector mating force has been reduced by 40% compared to alternatives. This clearly demonstrates the dividends of ergonomics in day-to-day operations on the production line. Assembly is easier and connection reliability increases.

In the case of connectors for high-current highly critical applications for future servo-assisted steering and hybrid drives, FCI has found a highly innovative way for assuring reliable mating. The company uses an RFID chip that has been integrated into the connector. As long as both halves of the connectors have not been joined up, the RFID chip doesn't send signals. As a result of the flange geometry of the connector, the RFID chip is activated as soon as the connector has reached its final snap-in position. This engineering solution was successfully tested with prototypes and can be implemented in varied device types. Comprehensive research with signal connectors and high current interfaces are in progress to prepare for production.

Furthermore, RFID technology has other advantages. An RFID chip read by a stationary terminal or an assembly operator with a mobile terminal can not only inform that a connection has been fully plugged, it also forwards the following data to a database: the part number of the plug connector, the time at which the assembly operation was carried out, and the allocation to the correct cable harness, and/or any other tracing information that is enabled by the read/write characteristics of the memory chip. These represent an important contribution to problem tracking, should any malfunction occur later.

In the case of high pin count connectors, engineers must always find a compromise between two mutually exclusive requirements. On the one hand, the mating force should be as low as possible for obvious ergonomics reasons and on the other, a connector requires high contact pressure for low transfer resistance. To address this challenge, FCI has developed a new kind of contact surface. In a common tin bath, micro particles of Teflon are equally arranged and selectively galvanized onto the contact surface. The micro-particles lower the mating force by more than 40 percent. As a result, this solution also enables simpler connections that lead to enhanced ergonomics and higher reliability of the connections. What's more, measurements show that when the contact is

subject to vibrations, it is much better protected against fretting corrosion when a Tin-Teflon layer is used than when any tin-plated contact is used. This surface is already in production and can be realized for a broad range of contact systems.

Two-step crimping instead of welding

We now address the second main cause of connector failure in automobile production – namely, an increase in contact resistance, which is an *uncontrolled change* along the signal path. This problem is accentuated in the case of the airbag signal path, because there are *short-pulsed, low streams*, which already attain the tolerance limit of electronics at little variability. FCI has resolved this problem at the production stage. The company looked at ways of crimping the strand to the contact to obtain bonds just as stable as those produced by welding. *The standard crimping bond serves well for common applications, but may lead to special problems in airbag applications during the lifetime of a vehicle.* Hence, FCI decided on a two-step crimping process that produces highly compact connections that deliver constant low transition resistance. At the same time, two-step crimping is cheaper and faster than welding as it can be carried out with normal press tools. This specially developed crimping tool has an acceptance ground of a standard applicator.

The manufacturing process of the strand with the contact is also easier. In the first step, the normal crimping operation is carried out at the outer ends of the crimping area. In the next step, the crimping plunger is unburdened again. The crimping area springs back a little bit so that the compressed strands are no longer grouted on such a high degree. The second step of the crimping process developed by FCI eliminates this problem because the cable strands are centrally re-crimped. In the transition area of both crimping ends this leads to an optimal long-term solid grouting under pressure.

Two-step crimping is suitable for all applications in which very low currents and little transition resistance are necessary. Airbag sensors, controllers and in-line connectors to the generator ignition, are examples of such applications.

Press-fit technology: Pressing instead of soldering

As the number of electrical controllers and sensor applications in vehicles rapidly increases, a reliable and cost effective connection between connector and PC board is required. In telecom applications, press-fit technology has been used for some time. This enables connectors to be pressed with one stroke onto a PCB without the need for soldering. In the automobile industry, this solder-free joining technique has only been used in recent years, now with increasing frequency. FCI has constantly enhanced the press-fit technology for the requirements of the automotive industry, including harsh environment. Parts used under hood in the engine compartment have to cope with large temperature variations and strong vibrations. Cost advantage and consistent quality when compared to soldering will drive the use of press-fit technology in vehicles.

The press-in area of the contacts that are pressed onto the PCBs bears significance. With the elastic zone in the area of the tin-plated drill-hole of the PCB, accurate adjustment of the bore tolerance with the press-fit area of the contact is very important for reliable binding. The appropriate processing tools and moulding presses are also essential for the precise adjustment of the components to achieve high assembly quality.. Moreover, this fully automatic process is less expensive than wave soldering and environment friendly ,. FCI provides a broad range of ABS housings, high pin count connectors for engine management/comfort and diverse sensor housings with this technology.

Multimedia applications: Lighter , lower cost shielded connections

FCI also provides new ways to reduce the risk of undesirable electromagnetic interference with multimedia applications, which is caused by the increasing amounts of data transmission in a car. FCI replaces the traditional shielding method (two parts of metal) with plastic metallization , using a simple galvanic process.

The plastic metallization of the connector housing is applied in simple steps. First, it is chemically etched, then activated, and finally, coated. It is galvanised with copper and another metal like tin or nickel as the outer layer. As a result, connectors developed for multimedia applications have achieved better shielding results when compared with costly metal-based shielding.

Cost and weight also play an important part in the wiring for multimedia equipment. FCI has, therefore, chosen the “less is more” approach for the connectors. The company’s development engineers have succeeded in simplifying the connectors for multimedia applications. They have reduced the number of components, by inserting the crimping ferrules in the connector housing, and manufacturing the complete housing from one piece. Instead of three-part housing plus the ferrule and an interior module, the connector now requires only three parts altogether – the interior module, the integrated housing and a locking ring. Fewer parts and a lower proportion of metal means less weight and lower production costs as well. Additionally, the handling of the cable loom is decisively simplified.

Be it AK-2, safe mating, two-step crimping, press-fit technologies or metal shielding of connector housings – these developments illustrate the performance and innovation prowess necessary for components of modern vehicles, even when they fulfil their duty – preferably without problems for the user – in absolute secrecy.