TECHNICAL PAPER

Connector Solutions for Automotive and Transportation Applications

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Abstract
Wiring interconnect in the transportation sector continues to evolve at an extremely fast pace. Automotive technologies, largely driven by electric vehicles and self-driving systems, are placing particularly stringent demands on wiring connectors. On one hand, high-speed busses like automotive ethernet are reducing total wire weight and complexity. On the other hand, reliability requirements are becoming more demanding with 200,000-mile lifetime expectations and routine reliance on highly advanced sensor technologies such as radar and video.

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CONNECTOR SOLUTIONS FOR AUTOMOTIVE AND TRANSPORTATION APPLICATIONS

INTRODUCTION

Wiring interconnect in the transportation sector continues to evolve at an extremely fast pace. Automotive technologies, largely driven by electric vehicles and self-driving systems, are placing particularly stringent demands on wiring connectors. On one hand, high-speed busses like automotive ethernet are reducing total wire weight and complexity. On the other hand, reliability requirements are becoming more demanding with 200,000-mile lifetime expectations and routine reliance on highly advanced sensor technologies such as radar and video. Combining these two trends has created a demand for highly configurable connectors that can serve a multitude of purposes in high vibration, extreme temperature conditions without being prohibitively expensive. Interestingly, the basis for solving this demand consists of the two most common connection methods that have faithfully served the electronics industry for decades: the crimp and the insulation displacement contact (IDC).

In both crimp and IDC connections, the joining mechanism of the wire and the contact is cold welding. The principle of cold welding was discovered nearly a century ago, and is conceptually quite simple: in a vacuum, two pieces of similar metals will simply join when placed in close proximity. Assuming a clean surface and no oxidation or corrosion, the two metal pieces simply lose any boundary to define where one ends and the other begins. To achieve this same phenomenon in open air, the gas between the two pieces of metal must be forced out. In a crimp connection, this is accomplished using a crimping tool and die to compress the connector around a bundle of stranded wire.

In an IDC connection, a wedge-shaped slot is forced through the stranded wire insulation in such a way as to guide the metal wire into the slot. The wedge shape exerts a spring force on the wire bundle to create the cold weld. These two techniques are illustrated below.

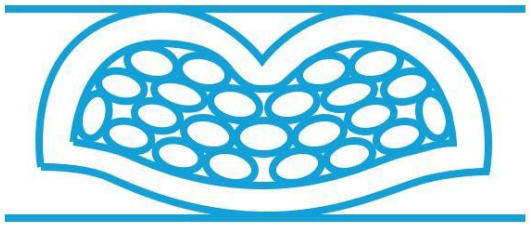

Figure 1
Crimp Cross-Section

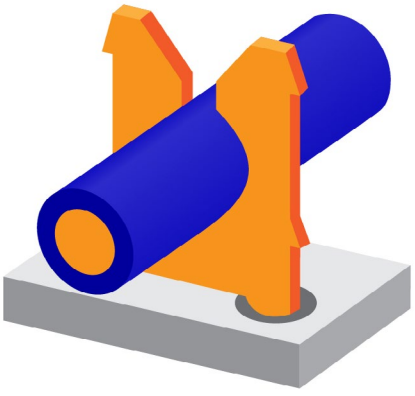

Figure 2
Insulation Displacement Connection [AVX.com]

Crimp based connectors are generally formed by crimping individual wires and then populating a plastic housing, which offers plenty of flexibility. One housing can contain multiple different wire gauges, and the individual crimps can be highly specialized for tight spaces and off-axis connections. This flexibility, however, comes with added cost, both in the required tooling and the time required to build the connector. It is for this reason that IDC connectors have gained such popularity. IDC connectors are commonly formed in place, where all the conductors of a ribbon cable are simultaneously pierced in the process of securing the housing. The tooling is very simple, requiring compression in only one axis, and there is no need to pre-strip the wires. This simplicity yields a high reliability, low-cost connector while sacrificing some of the flexibility seen with crimp contacts. IDC connectors have limits on the range of acceptable wiring gauge and offer fewer choices for unusual or custom form factors.

In the world of transportation, reliability is of utmost importance. Auto manufacturers must not only minimize the cost and inconvenience of breakdowns and recalls, but also abide by the rigorous standards that keep drivers, passengers, and pedestrians safe at all times. To do this, connectors must withstand wide temperature ranges (-40°C up to 125°C) and grueling humidity, salt, vibration, and shock conditions. Crimp and IDC connectors have both performed admirably in this respect, but IDC appears to be gaining an edge as many European auto manufacturers have moved away from crimp connectors altogether. This is largely driven by the industry shift toward LVDS and other high-speed data signaling, and the difficulties associated with validation testing of crimped contacts on the assembly line.

In terms of IDC connectors, AVX has the broadest offering on the market. With over 30 years of experience in connector manufacturing, AVX has IDC connectors that cover a wire gauge range from 12 to 30 AWG across numerous form factors and termination housings. A new development from AVX that is perfectly suited for automotive applications is the low profile IDC connector, shown in the figure below.

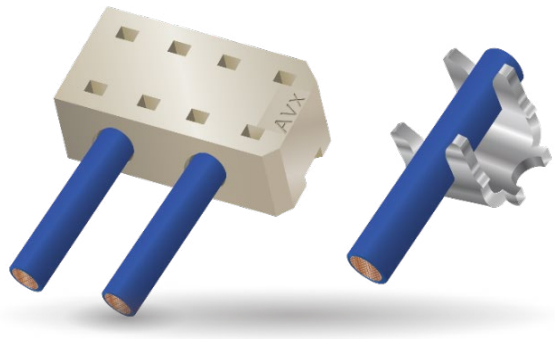

Figure 3
AVX Low Profile IDC Connector

This product has been specifically developed for 22-30 AWG discrete wires in size critical applications. By reducing the Z-axis height by 1mm from previous connectors and overall volume by 50%, this new package size is an ideal choice in space-constrained environments. The low profile IDC has a size range of 1 to 4 positions. The cover on the connector acts as a termination tool for ease of assembly, allowing a flat rock press to terminate up to four wires simultaneously.

Another connector technology worth mentioning in the transportation sector is the solderless press-fit pin. In a manner similar to IDC contacts, a cold weld is created between a PCB and the pin using the spring force of a wedge shape. AVX has combined the press-fit pin with IDC technology to realize a highly reliable wire to PCB connector for critical automotive systems such as airbag, engine, and transmission control units. As shown in the figure on the right, the wire connection is made using IDC technology and the board connection is made using press fit. Dual rows of connections are used for redundancy creating a simple, highly reliable solution.

The cold weld has been the baseline contact method for high-reliability connections for nearly a century. Crimp and IDC based connectors make use of this across a myriad of automotive and other transportation sector applications. IDC connectors, for their manufacturing simplicity and low cost, are taking center stage, especially as power requirements and high-speed data requirements evolve in modern vehicles. AVX has been a leader in this space for over three decades and is well-positioned to offer automotive connectors solutions for the long term.

Visit AVX's website for more information.

Figure 4
AVX Press-Fit IDC 53-8702

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