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Automotive Ethernet Connectivity Advancements

By Ralph Semmeling, Product Portfolio Director for Signal Interconnect at ENNOVI (formerly known as Interplex)

The automotive industry is currently undergoing a significant transformation with the adoption of 10Gb/s Automotive Ethernet protocols to accommodate the data-intensive requirements of autonomous driving technologies. Clearly there are technical challenges and solutions associated with implementing high-speed data transmission capabilities within automotive systems, focusing on the transition from traditional bus structures to Automotive Ethernet.

There's also a clear engineering rationale behind the adoption of press-fit connectivity solutions over traditional solder-based methods, emphasising signal integrity, manufacturing efficiency and environmental considerations.

The shift to Automotive Ethernet

The progression towards fully autonomous vehicles has led to an exponential increase in volume of data generated by vehicular sensors. This data is crucial for the autonomous vehicle's decision-making processes, such as braking, accelerating and maneuvering.

Traditional bus systems like CAN and FlexiBus are becoming increasingly inadequate for this data-intensive environment, paving the way for the adoption of Automotive Ethernet, which offers a streamlined, two-wire solution, capable of handling these advanced data requirements of 10Gb/s and beyond.

This protocol is covered by different standard committees, including IEEE and Open Alliance, to allow plug-and play setups within the vehicle.

The standardisation of the Automotive Ethernet interface, spearheaded by The United States Council for Automotive Research (USCAR), marks a significant milestone in automotive connectivity, drawing parallels with the data-centre industry's approach to standardised interfaces. The initiative was brought about by the adoption of the high-speed modular twisted-pair data (H-MTD) interface – a connector system used in automotive networking applications that supports frequencies to 20GHz and data transmission rates to 56Gbps.

The mechanical and electrical aspects of the interface were defined, leaving specifications more open to adaptation and the establishing of the solder-based footprint. Initially, these 10Gbps Ethernet solutions were used between electronic control units (ECUs) and sensors. 1Gbps Ethernet solutions used with sensors were mostly propriety interfaces, which restricts access to

multiple suppliers. With the rise of more advanced sensors requiring 10Gbps connectivity, standardising the interface on both ends not only simplifies cable harness manufacturing but also enables multiple supplier possibilities.

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Sensor connectivity

Typically, these sensor applications come with integrated connectors. For instance, upon examining the interior of a radar sensor housing, you would find six to eight pins, all of which are press-fit and insert-moulded. Tier-1 suppliers receive these radar sensors with pre-integrated terminals, allowing them to easily press-fit their PCB hardware onto the sensor, seal the housing and complete the assembly.

As the automotive industry shifts to more advanced sensors, the integration of Automotive Ethernet within these setups becomes essential. The Automotive Ethernet structure now has a couple of terminals that are press-fit because there are still low-speed signals within the radar housing. These are next to a solder-based Ethernet connector, which means a soldering process must be added into the radar housing assembly – which is not ideal.

Opting for additional soldering not only prolongs the assembly time but also generates unwanted fumes and calls for additional cleaning, complicating the manufacturing process.

The adoption for press-fit pins

By having access to press-fit interconnects, automotive customers are presented with a far simpler and faster assembly process, with a much lower risk of errors occurring. Moreover, press-fit solutions align seamlessly with existing Tier 1 assembly lines, requiring no modifications to current manufacturing practices.

As solder use is eliminated, there are no problems caused by variations in the amount of solder paste applied (and the capacitance associated with this). In addition, the shortness and lower capacitance of press-fit pins, compared to through-board solder pins, means resonance is reduced. For both of these reasons, greater signal integrity can be achieved.

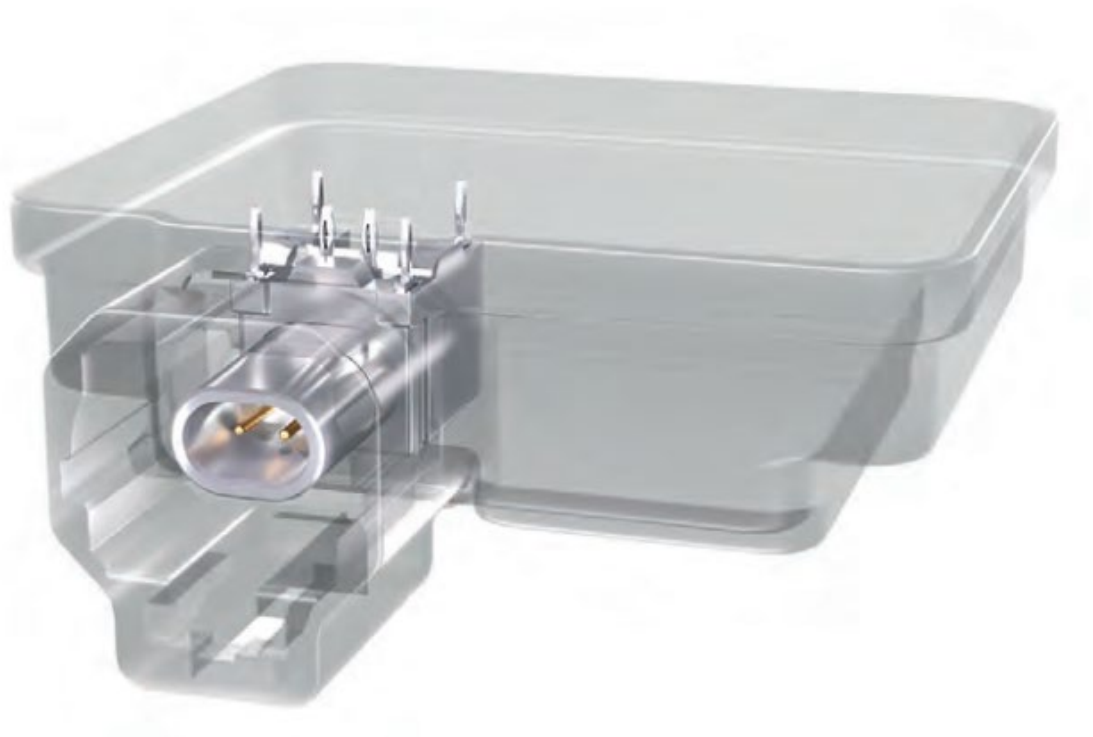

Figure 1. ENNOVI-NET Automotive Ethernet connector technology with press-fit solution incorporated into a radar housing

Additionally, a press-fit strategy supports manufacturing operations to be conducted in a socially responsible way, with minimal impact on the environment, in comparison to soldering processes that create solder fumes during assembly.

More factors are involved

Another critical factor to consider is the tighter manufacturing tolerances required for high-speed interconnects. Accuracy in the design and manufacturing of the signal and ground terminals, plastic housing and shielding are paramount, as even minor deviations in shape can significantly affect their electrical performance. This precision becomes increasingly important in high-speed data transmission, where the tiniest deviances impact functionality.

Comparing high-speed solder-based connectors to their press-fit counterparts illustrates this point. Press-fit connectors are designed with precision, featuring pins of exact shape and length that adhere to strict manufacturing tolerances, ensuring minimal variability. When these pins are matched with a PCB of a corresponding hole size, the result is a highly consistent and reliable connection with little room for error.

In contrast, solder-based connections can introduce variability in the amount of solder used, potentially compromising the connection's integrity and performance. From a manufacturing standpoint, press-fit technology offers a more consistent and reliable solution, especially critical in applications requiring high-speed data transmission.

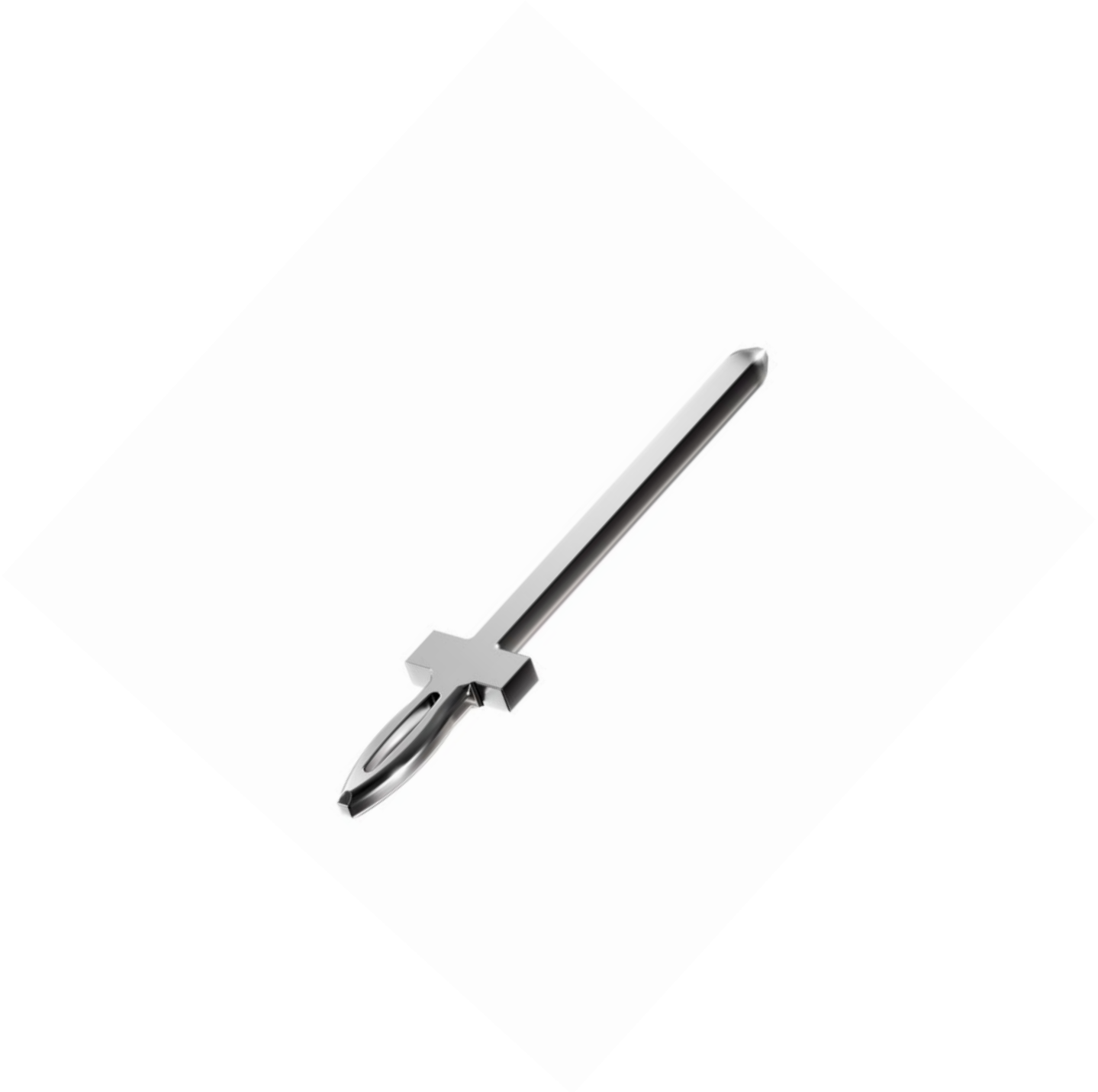

Figure 2. ENNOVI-NET technology offers high repeatability whilst avoiding quality problems associated with solder.

High-speed applications necessitate specific design considerations to mitigate mechanical stress on press-fit pins, ensuring their signal integrity under operational conditions, now adopted by the automotive industry.

Open database?

The debate over whether soldering or press-fit is the superior method for interconnects remains open, yet from environmental and precision standpoint, press-fit clearly takes the lead. Observing trends in the datacom industry reveals a significant preference for press-fit technology, especially in backplane connectors, which operate at speeds of 112Gbps and beyond.

The rarity of solder-based backplane connectors in the market is a testament to the consistency and efficiency of press-fit connectors, which are designed to accommodate ever-thinner and shorter pins, for optimal high-speed electrical performance.

Robustness versus performance

Whilst solder-based solutions might be perceived as more robust, the balance between reliability and performance is delicate. High-speed applications necessitate specific design considerations to mitigate mechanical stress on press-fit pins, ensuring signal integrity under operational conditions. This concept of balancing robustness with performance is now being adopted by the automotive industry, known for its stringent requirements for durability.

Achieving desired data rates and bandwidth for vehicle operation without compromising connector robustness requires innovative approaches. The ENNOVI-NET product exemplifies this, with its completely insert-moulded design which ensures that any mechanical stress on the connector is absorbed by the housing, not the press-fit pins themselves. This design method ensures that the press-fit pins are subjected only to the necessary insertion forces, avoiding additional strain.

In setups where connectors stand alone, the dynamics would differ, with the press-fit pins bearing the brunt of mechanical forces. However, in sensor applications like those addressed by ENNOVI-NET and conforming to standards such as USCAR and LV214, the integrated approach effectively manages these forces. This ensures that the connectors can withstand the operational demands placed upon them, marrying robustness with the high-speed performance essential in modern automotive applications.

Through the patented IndiCoat plating technology that can be applied to press-fit interconnects, ENNOVI is able mitigate the growth of tin whiskers, which can pose a reliability risk or, in worst-case scenarios, induce a short circuit. The quality of the end-product is thereby assured for a long time.

Empowering car makers

The press-fit approach empowers carmakers to leverage their existing manufacturing infrastructure whilst offering superior signal integrity and performance over traditional solder-based solutions. By facilitating 10Gb/s high-speed data transfer, ENNOVI-NET is revolutionising Automotive Ethernet connectivity, introducing a new value proposition for OEMs and Tier-1 suppliers.

By adopting a press-fit variant of the widely used USCAR interface, the automotive sector stands to enhance its production efficiency and reduce operational costs, without sacrificing the quality or dependability of its products.

About the Author

Ralph Semmeling is a Product Portfolio Director at ENNOVI (formerly known as Interplex), a provider of interconnect solutions. He has over 25 years of experience in the automotive industry with extensive knowledge of High-Tech Electro Mechanical Industry. Ralph has great command in fine mechanical product designs and holds 12 patents. www.linkedin.com/in/ralph-semmeling-b4900111

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