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Advancements in Ecu Board-to-board Connectivity for Higher Levels of Autonomous Driving

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

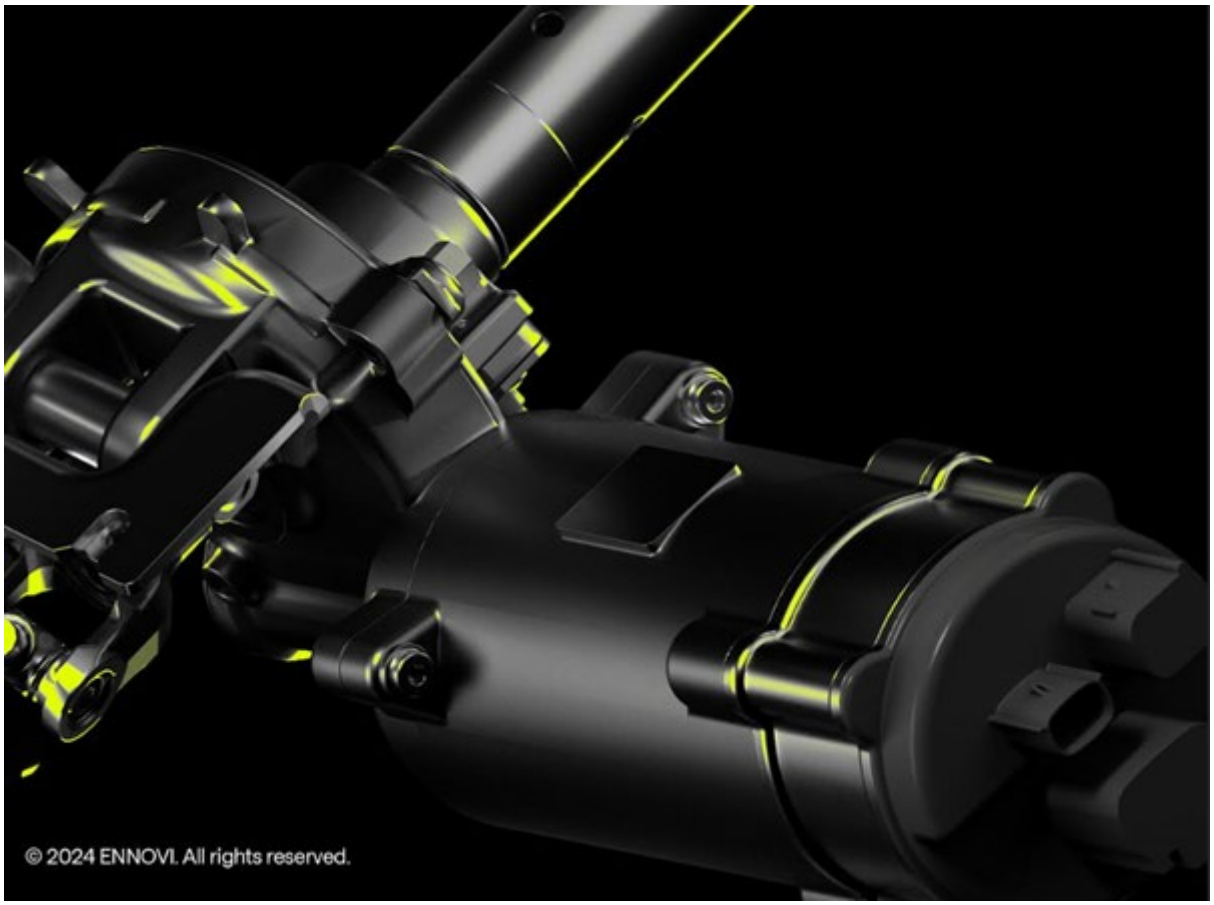

Image: Sensors, actuators, electronic control units (ECUs), steering system, infotainment systems, on-board chargers, charging systems

The progression towards fully autonomous driving has led to an increase in the number and variety of sensors needed to get a complete and actionable picture of the vehicle's dynamically changing environment. The exponential increase in the volume of data generated by these advanced sensors required 10Gbps connectivity to the electronic control unit (ECU) and paved the way for the adoption of Automotive Ethernet.

Current ECUs typically are based on having one single board. To handle more data and with the outside dimensions of the ECU somehow fixed in the X and Y direction, the only room for manoeuvre is to explore using the z-axis. For that reason, developers are considering using multiple boards – two to three – within the ECU. However, you will need a high-speed board-to-board connector if you want to communicate between these boards. Any latency or failure to act correctly can literally be a life-or-death situation.

Today, we are at Level 2 with some models achieving Level 2+ and, even, Level 2++. At Level 3, the responsibility for any accident is transferred from the driver to the OEM. With Level 2, if the car crashes, the onus is on the driver who perhaps didn't hit the brake in time or manoeuvre the car to avoid an obstacle. With Level 3, on the other hand, it is the autonomous driving system that has control and, if it doesn't brake or manoeuvre in time, the car has an ECU issue.

Of course, you can take an off-the-shelf solder-based solution, of which there are many on the market. With a solder-based structure, though, if it is under load, the solder joint could crack, which would lead to signal connectivity issues.

With a press-fit structure, it has the advantage of being more robust than a solder-based board-to-board connector **(Figure 1)**. As we move to higher levels of autonomous driving, this robustness in connectivity is becoming a critical design consideration.

Figure 1. The press-fit technology eliminates the risk of breakage and failures inherent to solder joints.

Observing trends in the datacom industry reveals a significant preference for press-fit technology, especially in backplane connectors operating at 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.

With high-speed data transmission, precision becomes increasingly important – even minor deviations in shape can affect their electrical performance. The shape and length of the press-fit pins are precise, which is achieved by adhering to strict manufacturing tolerances. When these pins are matched with a PCB of the 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.

In addition, the shortness and lower capacitance of press-fit pins, compared to through-board solder pins, means resonance is reduced. For both above reasons, greater signal integrity can be achieved. Additionally, a press-fit strategy supports manufacturing operations in a socially responsible way, with minimal impact on the environment compared to soldering processes creating solder fumes during assembly.

OEMs and their Tier 1 partners must ensure that their connectivity solutions within the ECU are robust to ensure that they do not have liabilities with the move to Level 3 autonomous driving. For this reason, the dominance of solder-based interconnect structures, especially in the ECU, is quickly fading and the trend within the market is moving towards press-fit structures, like the ENNOVI multi-row board-to-board connector platform (**Figure 2**).

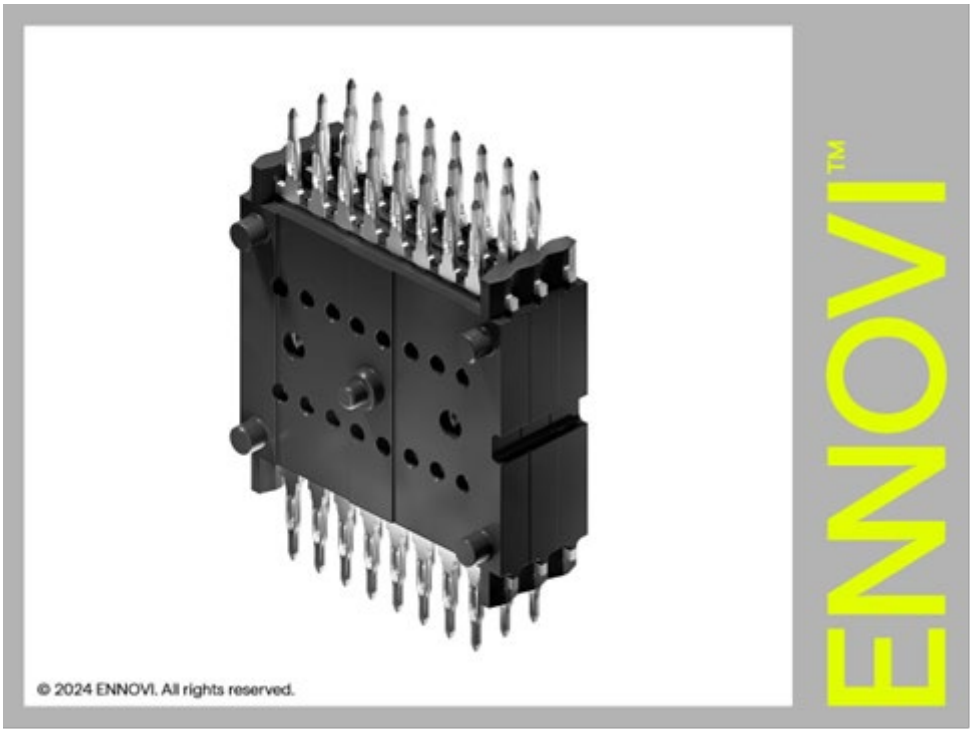

Figure 2. The multi-row board-to-board connector platform features a press-fit structure with highly reliable interfaces with high normal forces and is IEC 60352-5 and IPC9797 certified.

This robust off-the-shelf platform, with board stacking heights ranging from 7mm to 30mm, with between 1 and 6 rows, each of which can have from 4 up to 30 contact terminals which comply with IEC60352-5 and IPC-9797 standards, provides engineers with the inherent flexibility they need while following a custom-based design strategy. An optional plating technology helps

mitigate tin whisker build-up, thus preventing the risk of short circuits and extending the operational lifespan of the platform.

Being able to fit enough high-speed interconnect terminals into a small space while not having excess is a priority and minimizes the total cost of ownership. The current platform is based on the 0.4mm press-fit pin, capable of data rates up to 10Gbps (5GHz) and in compliance with automotive specifications, including resistance to humidity, temperature cycling, vibration, and mechanical shock.

The product roadmap is to move the platform to 0.2mm, which will be smaller in size and capable of handling more data. With even higher levels of autonomous driving, OEMs and Tier 1 suppliers want higher data rates. Having the same ECU space constraints or less can only be achieved by reducing the size of the pins, which enables more pins per square millimeter and increases the data rate capability.

Conclusion

The relentless march towards higher levels of autonomous driving necessitates robust and reliable ECU board-to-board connectivity solutions. The traditional solder-based interconnect structures are giving way to press-fit technology, which offers superior durability and signal integrity.

ENNOVI's multi-row board-to-board connector platform exemplifies this shift, providing a versatile and resilient solution that meets the stringent requirements of the automotive industry. With the ability to handle high data rates and ensure consistent electrical performance, press-fit connectors are set to become the cornerstone of ECU design as we move into Level 3 autonomy and beyond. The future of automotive interconnects is clearly steering towards smaller, more efficient designs that can accommodate the increasing data demands without compromising on reliability or safety, ensuring that the vehicles of tomorrow are not only smarter but also safer.

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 Electromechanical Industry. Ralph has great command in fine mechanical product designs and holds 12 patents.

He has a Bachelor of Applied Science (B.A. Sc.) in Mechanical Master of Science (M.Sc.) degree in Mechanical Engineering with specialization in Mechatronics from Technical University Twente, The Netherlands.