DESIGNING DATA CONNECTIVITY FOR ETHERNET-POWERED APPLICATIONS

In Industrial and Commercial Transportation

The data-driven safety and infotainment applications that populate passenger vehicles are quickly becoming must-haves in industrial and commercial transportation as well.

Soon, drivers of last-mile delivery vans will leave the route up to the vehicle, which will find its way based on a schedule that's input before leaving the depot. Backhoe operators will easily avoid unearthing utility lines, thanks to on-board or cloud-connected devices that limit how deep the equipment can dig. And freight managers will proactively diagnose problems with trucks in their fleet before issues ever occur.

Drivers, operators and other end-users are demanding advanced capabilities for vehicles in every sector of the industrial and commercial transportation market—whether trucks and buses, vans, or heavy equipment for agriculture, construction, and mining. Incorporating these data-intensive applications is vital to help organizations achieve greater efficiency, productivity, and profitability. To remain competitive, OEMs must differentiate their offerings by providing a higher level of value in every vehicle.

But these transformational technologies depend on transmitting more data, faster—driving the need for highspeed data connectivity and infrastructure solutions. Whether you are an OEM, system integrator, or device manufacturer, you must also future-proof solutions for emerging technologies. That calls for the right devices, communication protocols, and cable/connector components, as well as a connectivity partner experienced in industrial and commercial solutions.

Empowering Drivers and Vehicles

Today's applications collect data from an array of devices, including RADAR/LiDAR, cameras, antennas, displays, and telematics. Transmitting the data that devices capture requires high speeds and sufficient bandwidth—with low latency—for processing in electronic control units located throughout the vehicle.

The 500 Kbps speed widely used today with Controller Area Network (CAN) bus connections is no longer sufficient. Certainly, legacy Automation and Advanced Driver Assistance Systems (ADAS)—such as ABS, adaptive cruise control, and lane departure warning—can still use CAN bus. But designers have reached a tipping point, where cutting-edge applications like advanced diagnostics and safety features with automated functionality will require either increasing the number of CAN bus connections or implementing a new network architecture.

ADAS is just one of the three main categories of vehicle applications that use data connectivity. The second is infotainment, such as vehicle dashboards, integrated media and network controllers, and entertainment. These systems offer driver satisfaction and enjoyment as well as information that lets operators monitor and pilot the vehicle.

The critical third category encompasses the in-vehicle networks that form the backbone for communications within the vehicle, between vehicles, with the infrastructure, and even with the manufacturer. This core communication network helps ensure the reliability of information transmission, keeping the driver updated on every aspect of the vehicle.

Integrating Advanced Protocols

As applications evolve, so must the network communication protocols you use. Enabling advanced, data-heavy functionality means integrating Ethernet into a mixed architecture that can meet current and future demands. Ethernet solutions for heavy-duty vehicle applications currently handle up to 1 Gbps of data. But speed is only one criterion.

Standard Ethernet, BASE-TX, uses four or eight wires—half to transmit and half to receive data—and chipsets with four channels. Automotive Ethernet, also known as Single-Pair Ethernet (SPE), uses only two wires. The T1 single twisted pair automotive Ethernet cable can send data out and back over the same wires simultaneously and detect what's coming and going. All processing happens in the chipset. With half the number of cables, SPE uses half the copper wire, takes up less space, provides the ease of terminating on wire, and lowers weight and cost.

SPE protocols comply with IEEE 802.3bp and can transmit at speeds of 100 Mbps (100BASE-T1), 200 times faster than CAN bus. Although these speeds will support near-term applications, in the long term, greater functionality will require a minimum of 1 Gbps (1000BASE-T1). These advanced protocols support more connected devices, greater bandwidth, and increased speeds. For future applications, such as infotainment features and high-resolution cameras for ADAS, speeds will quickly reach 6 Gbps. You need to be ready.

Going Beyond Automotive Performance

You can often follow the lead of automotive engineers to make highspeed bandwidth adoption possible and cost-effective in industrial and commercial vehicle applications. However, bear in mind that automotive Ethernet is designed for a climate-controlled, comfortable interior, not for harsh conditions. It's important to understand the limitations of existing products and ensure the solutions you choose meet both mechanical and electrical demands.

For example, components must provide resistance to severe vibration and mechanical shock, and withstand dust, dirt, and moisture in the chassis and frame. Heavy equipment often operates in temperatures ranging from -40°C to 125°C and gets left in those conditions 24/7 over 20-year lifespans. In addition, serviceability is a requisite for field maintenance of commercial vehicles.

Longer channel lengths are also common in industrial and commercial vehicles. The distance from a camera to the display in a large tractor, excavator, or haul truck may be far more than 15m, the limit for 1000BASE-T1bp Type A. You need connections that work with 1000BASE-T1bp Type B, which extends channel length to 40m. *[see Image 1]*

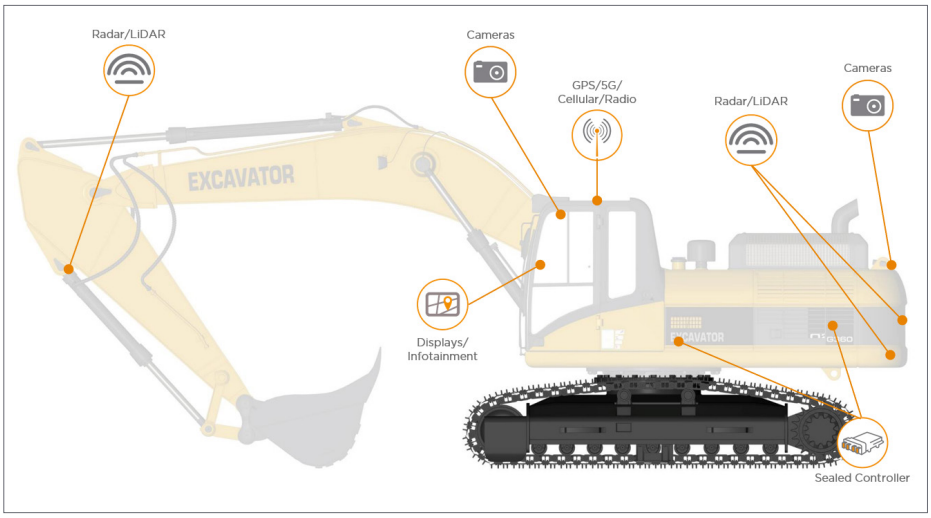


Image 1

During design, these various factors all come into play. Plan ahead for components, placement, environmental conditions, and lifespan—because how you design the cable and connector ultimately impacts performance of the channel, system, and application.

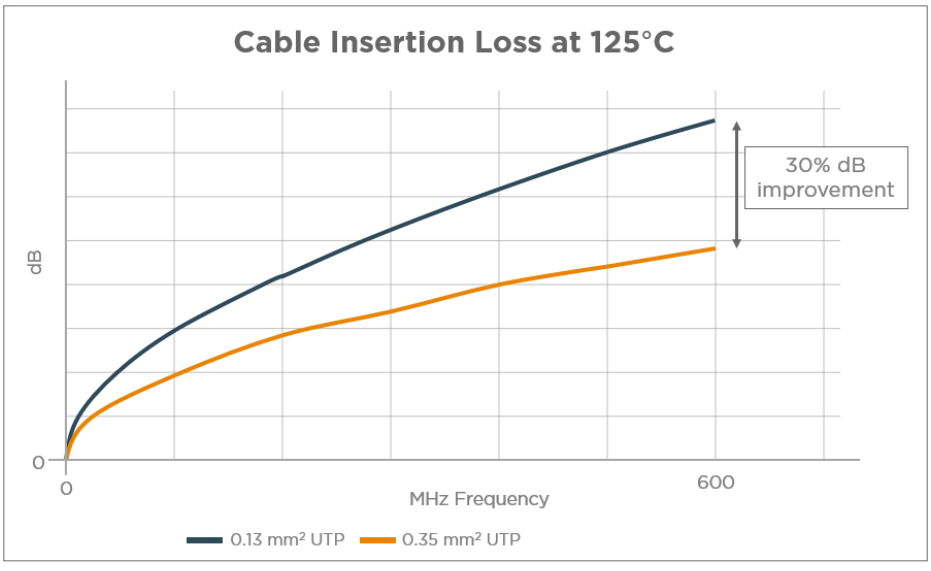


Image 2

Factoring in Electrical Performance

To withstand the vibration and shock inherent in industrial and commercial applications, design engineers select more robust components, which generally means they're larger. The housing should have a proven history in harsh environments. Be aware that some rugged, wear-resistant connectors could negatively impact high-frequency electrical parameters, such as insertion loss, return loss, and common mode conversion, especially if the cable isn't suitable for the application requirements.

Automotive solutions generally use 0.14 mm2 conductor sizes. But by using these very small wire sizes over longer channel lengths and higher temperatures, electrical parameters may deteriorate. Larger conductor sizes can help resolve this issue. In fact, 15 m of 0.35 mm2 cable can improve insertion loss ~30% dB over the same length of 0.13 mm2 cable at 125°C. *[see Image 2]*

Preparing Now

By looking to the future, you can help ensure highspeed network connections meet mechanical and electrical performance, reliability, and resilience requirements for highspeed data

transmission. For essential and emerging applications, solutions should meet the same guidelines that TE Connectivity's (TE) DT highspeed connectors meet:

Support longer channel lengths. Standard automotive data connectivity terminal systems, cables, and physical layers may not work for distances greater than 15m. The connector you choose should support IEEE802.3bp, 1000base-T1 Type B, which extends reach to 40m.

Satisfy current and future speeds. Expect speeds to continue increasing. Provide 1 Gbps speeds for 40m channel lengths with four in-line connections and could enable 2.5/5 Gbps speeds for future applications (cable-dependent).

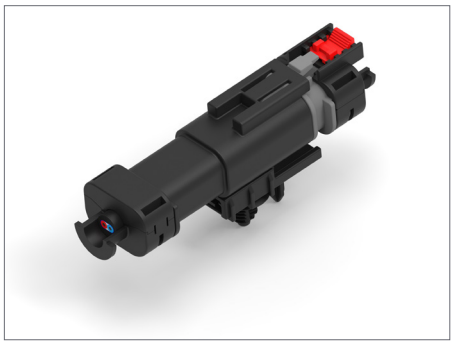
Provide environmental resilience. Temperature, humidity, vibration, and shock can all affect power transmission and signal integrity. Your connector must operate reliably in the harsh conditions.

Prevent dust and water inflow. Cables may pass from one location to another, such as from the engine into the cab, allowing water and grime in as well. Connectors should be sealed and meet the IP67/IP69K ratings for protection against ingress of dust and water.

Use proven technology. DEUTSCH products and the DT/DTM interface have been the market standard for more than 30 years. Consider connectors that leverage the DEUTSCH size 20 contact terminal using existing tools with stamped and formed terminal or solid terminal options.

Enable stable bulkhead mounting. By reducing the number of connectors required and the space they take, you cut costs, streamline installation, and improve serviceability. With a bulkhead mount, half of a connection is attached to a metal vehicle part with screws or a latch. Once mated with another connector, the connection is securely held in place.

Combine power and data. As functionality expands, routing a wiring harness within ever more restricted space poses a challenge. Adding a standalone connector every time you add a device isn't viable. Co-locating power and data transmission in a hybrid connector minimizes space and allows transmission of both electrical current and highspeed data signals.



DT Highspeed Connectors

Simplify assembly. With a product design that allows termination to cable without overly complex process parameters, you can continue using your existing harness supply infrastructure.

WORK WITH A CONNECTIVITY EXPERT.

For years, TE has specialized in the design and manufacture of terminals and connectors for the in-vehicle networks that support industrial and commercial applications. You've come to rely on the robustness of our mechanical package and now we also enable the highspeed data transmission you need.

Our application engineers focus on the entire channel from start to finish, coordinating and integrating physical layer development. We choose and qualify manufacturers whose cables work with our connector systems to make sure everything matches correctly and works optimally. We've designed our products to enable you to create the sophisticated systems that your customers want. But we don't stop there. We also provide support to help you address and overcome the challenges of implementing and launching highspeed channels in your industrial and commercial vehicles. Let us know how we can help you identify the right product for your needs to make sure you're prepared for the future of data connectivity.

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