

SAVING WEIGHT IN INTERCONNECTIONS IN AUTOSPORTS

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In Formula 1 and other autosports, weight reduction is critical to competitive advantage. A few grams saved here and a few more saved there can add up to significant savings overall. We are also seeing a move toward high-density packaging of electronics parts. As the electronic content of cars increases, the natural drive is to miniaturize the package to gain maximum efficiency in the use of space.

The wiring harnesses and interconnection systems offer opportunities for weight and size reduction. The first requirement for connectors and cable is a rugged design that can withstand extreme temperatures, vibration, and exposure to fluids in general and brake cleaner in particular.

The Evolution of Connectors

The evolution of TE Connectivity's (TE) DEUTSCH AS Series connectors demonstrates the miniaturization of connectors. Smaller connectors typically less weight, so attention was paid to higher density connectors. Stainless steels shells gave way to lightweight aluminum, with even lighter composite available. Features like coupling rings became smaller.

As connectors shrank, attention must also be given to usability issues, such as redesigned knurls to make it easy for a gloved technician to quickly and accurately connect and disconnect the connectors.

Composite-shell connectors offer an attractive method for reducing weight. When the industry first looked at composite connectors, they did not live up to expectations for rugged performance in the autosport market. In particular, the composites did not withstand

exposure to brake cleaner. As a result, designers moved away from their use. Composites are evolving. They have improved dramatically, with the next generation soon to meet the needs of auto racing fully. Composites deserve a fresh evaluation of their capabilities to save weight and meet the mechanical and environmental needs of autosports.

Traditionally, composites have reduced connector weight by around 40 percent. By optimizing the reinforcing material and introducing foam into polymer matrices, an additional 10 to 20 percent savings can be reached. Not only the fiber material but also the length of the reinforcing fibers play a significant role in determining the strength of the finished part. Higher strength materials can mean reduced wall thickness and hence lower weight. Introducing foaming agents or microspheres into a polymer composite – although made more difficult as the reinforcing fiber volume increases – is now possible.



Figure 1. New generations of connectors are smaller and lighter.

Cables

High-performance thin-wall cables are already the standard for auto racing. A typical cable, such as TE's SPEC 55 cable, uses a cross-linked ETFE insulation and jacket offering temperature ranges to 150°C or 200°C and excellent resistance to fluids. The thin-wall construction allows weight reduction without compromising performance.

While both the commercial auto industry and the military are starting to use aluminum wire and cable for weight savings, they do not yet find widespread use in autosports. Aluminum wire is seen as hard to work with. Its bend radius is not as tight as copper's and there are concerns over reliably terminating it due to cold creep. Yet contacts that counteract cold creep to form a reliable, gastight connection are available. Aluminum has only 60 percent the conductivity of copper so a larger conductor is needed to achieve the same current-carrying capacity. Even accounting for this, aluminum will be about half the weight.

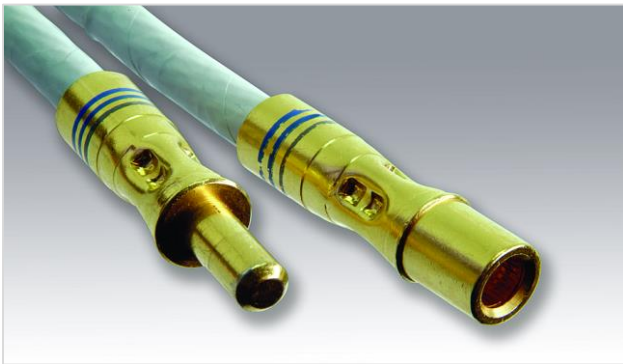


Figure 2. Use of aluminum wire is enhanced with reliable contacts.

Electrical Noise

While shielding has been used sparingly in race cars, newer technology is creating new levels of electrical noise that must be dealt with. High-current energy recovery systems, for example, are a source of electromagnetic interference (EMI). There are three approaches available for combatting EMI. The first is to increase separation between the EMI source and susceptible wires and electronics. With the limited space in a car, this approach is impractical in most cases.

The second approach is shielding. Since shielding adds weight, it is often used on an as-needed basis instead of standardizing on shielded cables. This can be done with a copper overbraid slipped over the cable and terminated to a connector's backshell. The braid forms a low-impedance path to ground to EMI. TE recently introduced a lightweight braid system that offers weight savings of up to 50 percent over traditional braid.

The third approach is fiber optics, which is inherently immune to EMI. In addition, fiber-optic cables are significantly lighter than copper cables. Both glass and plastic optical fibers are candidates

for application in autosports. Glass fibers have the advantages of higher bandwidth and higher operating temperature range—with some specialty fibers as high as 700°C. Disadvantages are that they are harder to work with. While glass-fiber cables are robust and available in ruggedized versions, some care must be taken in routing them and observing bend radii. Cable construction can overcome many of these drawbacks to allow glass-fiber cable to withstand the rigors of building, maintaining, and racing a car.

Plastic optical fibers are less expensive both in the cable itself and in associated electronic transceivers. Widely used today in commercial auto networks, they are also more forgiving of mechanical abuse and tight bending. The main drawback is temperature range, with standard POF cable limited to 85°C and high-temperature versions ranging to 125°C.

Integrated Solutions

If composite connectors deserve a new look, so do composite enclosures as a viable alternative to aluminum for housing electronic control units and other systems. The initial attraction of composite enclosures is weight savings—a carbon-filled polyphenylene sulfide composite enclosure can be 40 percent lighter than an aluminum one.

Composite materials are strong and can be tailored to provide exceptional impact resistance, tensile strength, bending resistance and so forth. They may be sturdier than aluminum counterparts because they are not easily dented or deformed. Replacing metal enclosures with composites gives you all the mechanical and electrical benefits of metal, but with the added bonuses of lower weight, corrosion resistance, and lower costs.

New capabilities and new material formulations give you more options. Fillers, ranging from traditional carbon fiber to microspheres and carbon nanotubes, allow custom tailoring of the enclosure to help achieve the best balance of weight versus electrical, mechanical, and environmental performance. Advanced molding permits standoffs, integrated connector shells, partitions, and other three-dimensional features to be created.

Selective metallization allows circuit traces, shielding, and even embedded antennas to be cost-effectively integrated into the enclosure.



Figure 3. Composite enclosure and selective plating offer a simpler, lighter alternative to aluminum enclosures.

Conclusion

Interconnection technology continues to advance, offering new level of weight savings for autosport applications. More importantly, what's old is new again. Technologies that were though deficient in one respect or another have evolved. Don't rely on yesterday's conventional wisdom. Composite connectors and enclosures, fiber

optics, braid shielding, and aluminum wire all deserves fresh evaluation. Working with a company like TE can also aid by taking a systems-level approach to interconnections. A couple of grams added here can save kilograms elsewhere. It's the final product that wins the race, not the individual components.



ABOUT THE AUTHOR

Paul Webb is the sales and marketing manager for Autosport for TE Connectivity's Global Aerospace, Defense and Marine business unit. With more than 15 years of experience in the global motorsport industry, Paul has developed the TE DEUTSCH products from a small demand from Formula 1 to the market leader in interconnection solutions on all professional racing series. As TE continues to expand its racing presence, the insights and voice of Paul Webb continue to add value to the conversation of this growing focus, as he has been working with and watching these products evolve for many years.

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