White Paper

WIRING THE FASTEST: CABLES IN MOTORSPORTS

Abstract

In Motorsports, every component of the vehicle must be optimized for performance, including the cables used in its electrical and communication systems. Cables should be **lightweight to minimize the overall weight of the vehicle**, which directly impacts speed and fuel efficiency. A lighter vehicle accelerates faster, handles better, and achieves higher top speeds, giving it a competitive edge on the track. Flexibility in cables is essential to accommodate the intricate and dynamic design of a vehicle. The cables must be able to **bend and twist around tight spaces and complex geometries** without compromising their integrity or performance. Flexible cables ensure reliable connections and reduce the risk of damage due to vibrations and constant movements during a race. Additionally, **small cables are crucial for efficient space management** within the vehicle. Motorsport vehicles have limited space, and every millimetre counts. Smaller cables allow for more efficient routing through the vehicle's chassis and bodywork, reducing clutter and improving airflow. This contributes to better aerodynamics, which is critical for maintaining high speeds and stability on the track. In summary, using lightweight, flexible, and small cables in Motorsport vehicle is vital for enhancing performance, reliability, and aerodynamic efficiency, all of which are essential for achieving success in the highly competitive world of Motorsports.

GORE® Shielded Twisted Pair Cables

Thanks to the use of **unique materials and innovative manufacturing techniques**, the cables from W. L. Gore & Associates exhibit a smaller diameter than conventional alternatives. Our cables demonstrate unparalleled mechanical and electrical performance. This superiority is attributed to the meticulous attention to detail and **advanced engineering processes** employed in the production of our cables. The reduction in diameter not only enhances the aesthetics but also offers practical advantages in installations where space is limited. Figure 1b shows the difference between a conventional Shielded Twisted Pair and **GORE® Shielded Twisted Pair**. Moreover, the insulation and dielectric materials used in our cables are specifically engineered to excel in harsh environments.

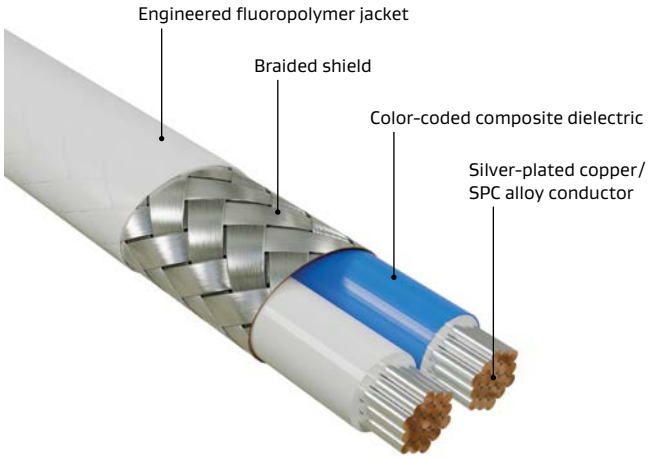
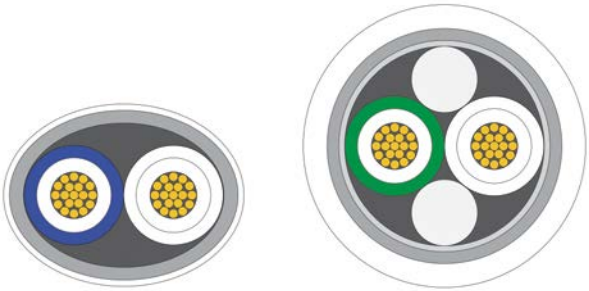


Figure 1a: Design of a Shielded Twisted pair

This strategic design consideration ensures that our cables maintain optimal performance and reliability even in the **most demanding conditions**, making them ideal for a wide range of applications across the motorsports sector. Our cables outperform their counterparts in terms of mechanical and electrical robustness, diameter reduction, and suitability for challenging environments. These findings underscore the undeniable quality and innovation embedded in our cable offerings, affirming our position as the preferred choice for customers seeking reliability and performance excellence.



GORE® Shielded Twisted Pair Cables | Alternative Round Cables

Figure 1b: Dimensional difference between W. L. Gore & Associates' Shielded Twisted Pair and another vendor's product.

GORE® USB Cables (2.0/3.1 Versions)

USB cables that can survive in flex applications and harsh environments ensure reliable data transfer and power delivery even under demanding conditions, **reducing downtime and maintenance costs**. In the Motorsports sector, the importance of small and lightweight USB cables cannot be overstated. This **high data transfer rate** (10 Gbps) facilitates rapid and reliable communication between various vehicle components, such as sensors, onboard computers, and telemetry systems. The speed and consistency of data transmission at 10 Gbps ensure that **real-time data monitoring** and analysis are precise and instantaneous, allowing teams to **make informed decisions swiftly during races**. The combination of small, lightweight USB cables and their ability to handle 10 Gbps data rates is paramount in the motorsport sector. These attributes (Figure 2b) not only enhance vehicle performance but also enable teams to leverage advanced data technologies effectively for competitive advantage on the track.

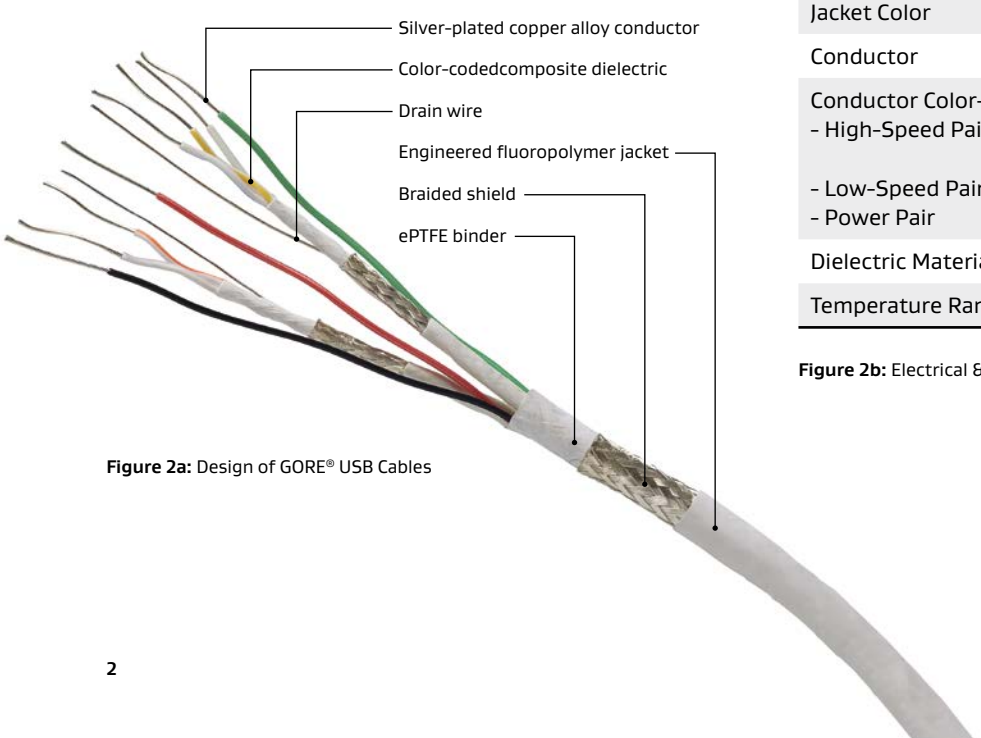


Figure 2a: Design of GORE® USB Cables

Electrical

Property	Value
Standard Impedance [Ohms] - High-Speed Pairs - Low-Speed Pairs	 90 ± 5 90 ± 10
Typical Operating Voltage [V]	<15
Nominal Velocity of Propagation [%]	80
Nominal Time Delay [ns/m (ns/ft)]	4.07 (1.24)
Capacitance [pF/m (pF/ft)]	50.0 (15.2)
Maximum Skew Within Pair [ps/m (ps/ft)]	15.0 (4.6)
Dielectric Withstanding Voltage [Vrms] - Conductor-to-Conductor - Conductor-to-Shield	 1500 1000

Mechanical / Environmental

Property	Value
Jacket Material	Engineered Fluoropolymer
Jacket Color	White (Laser Markable)
Conductor	Silver-Plated Copper Alloy
Conductor Color-Coding - High-Speed Pairs - Low-Speed Pairs - Power Pair	 Blue/White, Yellow/White, Orange/White, Violet/White Green/White Black/Red
Dielectric Material	ePTFE/PTFE
Temperature Range [°C]	–65 to +200

Figure 2b: Electrical & Mechanical properties of GORE® USB Cables

GORE® Power Feeder

In motorsports, it is critical to have **low-weight and small-sized power cables** for several key reasons. GORE® Power Feeder are very lightweight, and reducing the weight of power cables directly contributes to the overall performance and speed of the vehicle, as lighter components improve acceleration and handling. Additionally, GORE® Power Feeder **take up less space**, which is at a premium in motorsport vehicles where efficient use of every inch is necessary for optimal design and function. GORE® Power Feeder Designs are also **easier to route** and manage, reducing the risk of damage and ensuring more reliable electrical connections. However, beyond the impressive electrical properties, the mechanical characteristics (Figure 3b) of the cables are particularly noteworthy, as they do not form creases even at the smallest bending radii. Most strikingly, the **minimum bending radius** is as small as **three times the outer diameter**.

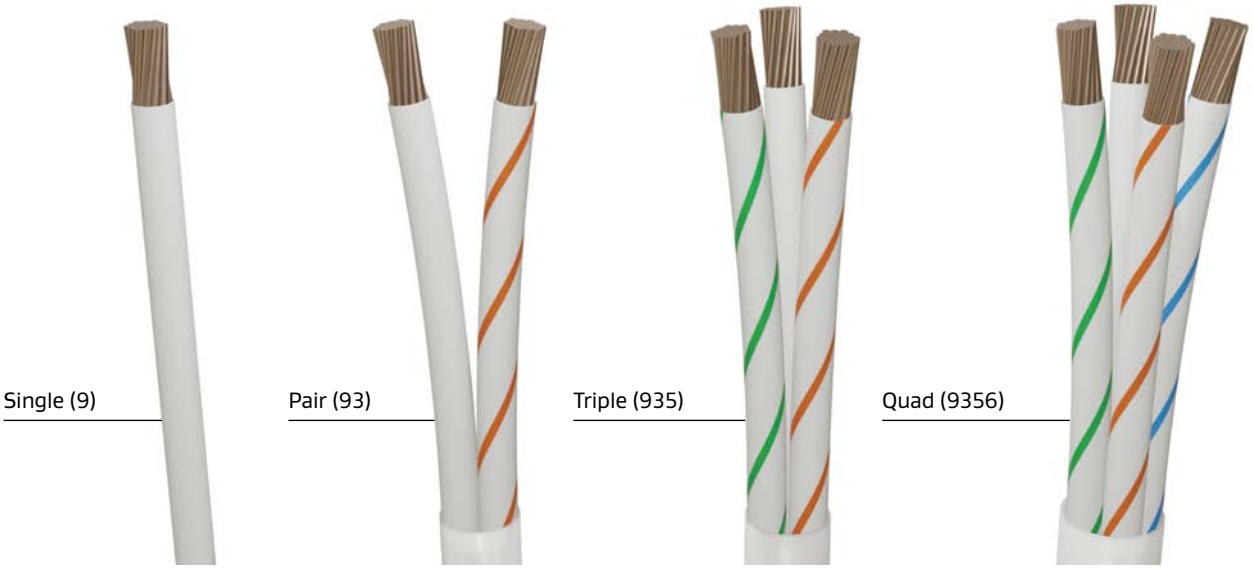


Figure 3a: Design of GORE® Power Feeder

Electrical & Mechanical properties

Characteristics	
Minimum CMA	26284
Conductor DC Resistance	1.41 Ω/km max. @ 23 °C, IAW AS29606
Conductor	Nickel plate copper strands, plated IAW ASTM-B355 and meeting EU directive 2011/65/EU RoHS
Voltage Breakdown	15 kV AC min. per ASTM D3032 Section 5
Dynamic Cut Through	125 lbs. min at 23 °C & 90 lbs. min. at 260 °C AS4373 Method 703
Operation Voltage	1000 Vrms max. @ 260 °C and 25000 ft altitude
Operation Temperature Range	–65 °C to +260°C
Weight nom.	92.7 lbs/1000 ft (nom.)/145 g/m (nom.)
Minimum Bend Radius	x3 Outer Diameter "D" or greater

Figure 3b: Electrical & Mechanical properties of GORE® Power Feeder

GORE® Magnet Wires

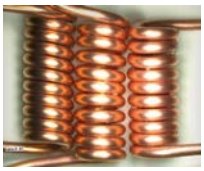
Ensuring that motor windings are resistant to water and oil infiltration is crucial for the longevity and reliability of electric motors in diverse operational environments. Water and oil can penetrate the windings, causing **insulation degradation, short circuits, and corrosion** of metallic components. Such deterioration significantly undermines motor functionality, leading to potential failures and necessitating costly repairs. Water resistance is particularly critical in applications where motors are exposed to high moisture levels, such as in marine environments, wastewater treatment facilities, and outdoor installations. Similarly, oil resistance is vital in industrial settings where motors may come into contact with lubricants or hydraulic fluids. These resistances **prevent the degradation of insulation materials**, ensuring the continuous and efficient operation of the motor without disruptions.

The results of the **High-pressure high-temperature (HPHT)** testing shows that **Polyimide (PI) enamelled wire** suffers significant insulation resistance loss and voltage breakdown performance degradation after **90 hours**, becoming brittle and cracking immediately under mechanical stress (Figure 4a, left). In contrast, **GORE® Magnet Wires** exhibit continuous superior performance, remaining **fully functional after 48 days** of exposure to HPHT conditions (Figure 4a, center). Enamelled wires typically fail under similar conditions after approximately 90 hours of runtime, highlighting the enhanced durability and reliability of GORE® Magnet Wires in demanding environments. GORE® Magnet Wires are designed for **maximum reliability** and their **voltage endurance** are crucial for high-performance applications. GORE® Magnet Wires exhibit **exceptional continuous use voltage** capabilities and can withstand **high temperatures up to 260 °C**, ensuring optimal performance in extreme conditions. Additionally, GORE® Magnet Wires are **hydrolysis & coolant resistant**, maintaining integrity and functionality in the presence of moisture.

The **high breakdown voltage** (Figure 4b) characteristic further enhances their durability, preventing electrical failures and extending the lifespan of the motor. These attributes collectively contribute to the superior performance and reliability of motor windings in demanding environments.

Polyimide enameled wire

(l) original (reference)
(c) oil resistance
(r) hydrolytic stability



Gore engineered fluoro-polymer wrapped wire

(l) original (reference)
(c) oil resistance
(r) hydrolytic stability

(l) Polyimide enameled wire
(r) Gore engineered fluoropolymer wrapped wire

Figure 4a: High pressure high temperature exposure at 280 °C with H_2O in synthetic oil

GORE® Magnet Wires outperforms PI enamelled wire.

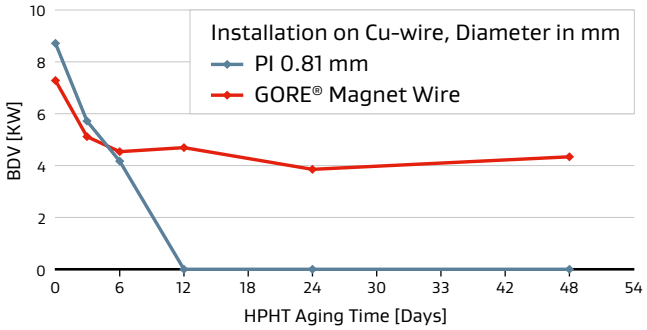


Figure 4b: Insulation resistance and voltage breakdown performance for PI enamelled wire & GORE® Magnet Wire

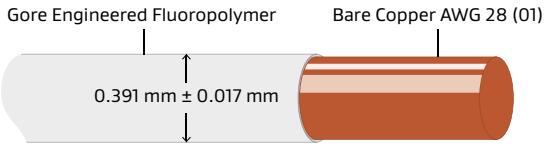


Figure 4c: GORE® Magnet Wires Design for AWG 28 solid copper wire

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