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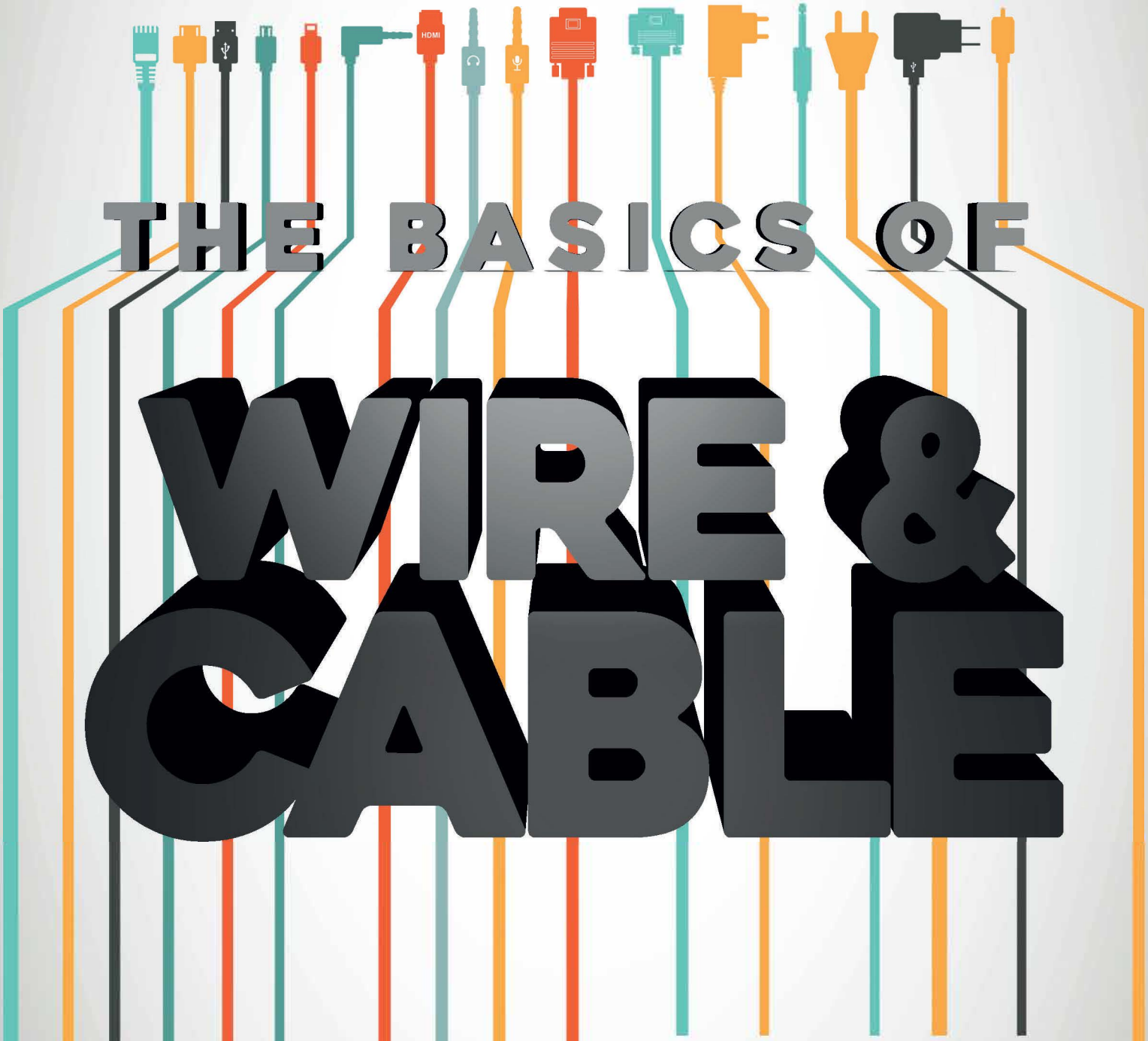

THE BASICS OF WIRE & CABLE

BY
MEMORY PROTECTION DEVICES

Wire and cable products are found everywhere from consumer to industrial applications, demanding application-specific solutions that deliver ideal performance and cost efficiency.

Wire Vs. Cable

A wide range of wire and cable products are available with variable characteristics, including: size or gauge (AWG or KCMIL), physical strength, radiation resistance, weight, electrical properties, chemical/oil/moisture resistance, flexibility, temperature rating, durability, sunlight resistance, flame resistance, cost and availability. Prioritizing these characteristics will help determine the ideal solution, as trade-offs are often required.

A wire is a single conductor (usually copper or aluminum), whereas a cable is defined by two or more insulated wires wrapped in one jacket. Multiple conductors not separated by an insulation layer are typically classified as a single conductor.

There are three types of cable: signal; power; and control.

Signal cables are rated for low power/low current for applications that include TV cable, electronic cable, fiber optic cable, data cable, electromagnetic wire, low voltage power, and communications. Signal cables are usually shielded and carry data modulated power ranging from 4-20 mA DC current.

Analog signal transmission typically consists of two-wire signal leads or three-wire signal leads. Where precision and accuracy are required, the third signal lead, or shield, is necessary. In the three-wire configuration, the shield is grounded at the signal source to reduce common-mode noise. Four (4) types of signal cables are used to carry analog signals: plain pair, twisted pair, co-axial, and shielded-pair. These cables are normally single pair cable with a cross-sectional area ranging from 0.5 mm2 up to 1.5 mm2.

Power/control cables come in larger sizes or gauges and typically deliver 24 VDC or 110/230 VAC unshielded to heavy-duty applications, including mining, energy, transportation, infrastructure, industrial machines, etc. Control cable is usually insulated and sheathed with PVC and paired with some form of circuit protection device.

Electricity is measured in volts, amps and watts. Volts are the amount of electrical force being delivered, with the specific voltage determining insulation thickness requirements. Amps represent the quantity of energy being delivered, with conductor size determined by the required amperage. Watts combine volts and amps to measure total energy using the folloing formula:

Basics of Electricity

WATTS= VOLTS x AMPS (W = V x A)

Different applications are UL-rated for a specific voltage and current:

- Low Voltage or L.T. Cable (up to 1000V)
- High Voltage or H.T. Cable (above 1000V to 11KV)
- Super Tension or S.T. Cable (above 11KV to 33KV)
- Extra High Voltage or E.H.T. Cable (above 33KV to 66KV)
- Extra Super Voltage or E.S.T. Cable (66KV or higher)

Wire and Cable Used in Electronics

Wire and cable are integral to modern high-tech applications such as circuit prototyping, wire harnesses, Ethernet connectivity, and high voltage power transmission, to name a few.

Electronic devices primarily use copper wire, which is considered an excellent conductor and relatively inexpensive. Popularly used for transmitting AC and DC current, copper is far less expensive than gold or silver, which are better conductors. Aluminum is cheaper and lighter than copper but is a less efficient conductor.

Here are some popular wire products used in electronics:

Solid Hook-Up Wire

A single strand of insulated copper wire, while not very flexible, is often used as magnet wire in transformers and motors or for prototyping on a breadboard.

Stranded Hook-Up Wire

A single strand of insulated copper wire, while not very flexible, is often used as magnet wire in transformers and motors or for prototyping on a breadboard.

Coaxial Cable (Coax)

Coax combines a solid copper core with a tubular insulating layer surrounded by a tubular conducting shield and a plastic jacket, commonly used to transmit radio frequency (RF) signals that require protection from electromagnetic interference (EMI).

This includes coaxial,

Network Cable

CAT3, CAT 5, CAT6, CAT 7 and fiber optic cable. Network cable is used to connect devices and for high speed data transmission. Network cable typically comes in twisted pairs to cancel out EMI.

Various types of computer cable are commonly used, in-

Computer Cable

cluding ribbon, socket ribbon, male to female ribbon, USB data sync, ATX, extension cables, power charging cables, and more. A common requirement for these applications is the need for flexible cable.

Codes And Standards

Numerous entities worldwide are responsible for establishing and maintaining wire and cable specifications, safety, and testing standards. Products sold in the US generally carry some form of Underwriters Laboratory (UL) registration, including:

UL1007: Hook-up wire rated for safe operation at up to 80°C (176°F) and 300V.
UL1569: Hook-up wire rated for safe operation at up to 105°C (221°F) and 300V.

UL1423: Wire insulated with extruded PVDF (polyvinylidene fluoride), commonly used in kynar wire, computer back panels, and network stations.

UL94V: Defines the required burn characteristics of plastics, setting flammability standards for plastics used in cable connectors.

ULVW-1: Vertical wire flame test measures the ability to resist fire along a vertically suspended wire, helping reduce the risk of fire spreading across the wire or cable.

Other notable U.S. electrical approvals include:

MIL-C: Applies to military-grade cables and components, defining their electrical and mechanical properties, and setting limits for attenuation and structural return loss.

CL2 / CL3: Applicable to audio cables and speaker wire, determining whether they can be installed in-wall or elsewhere. When wiring a home or building, make sure that all wiring conforms with federal, state, and local building codes.

Power Cords

SVT (Service Vacuum Thermoplastic): Two or three conductors with rubber insulation and plastic jacket. Rated 300V.

SJT (Service Junior Thermoplastic): Two, three or four conductors with plastic insulation and plastic jacket. Rated 300V.

SPT-2 (Service Parallel Thermoplastic) 2/64” Insulation: Two or three conductors with plastic insulation and no jacket. Rated 300V.

Copper is the most popular

Conductive Materials

electrical conductor, combining excellent conductivity and relatively low cost. Designations include: ETP (Electrolytic Tough Pitch); ASTM B-5; FRTP (Fire Refined Tough Pitch); and ASTM B-4 (Lake Copper). Other conductive materials include aluminum, copperweld, alumoweld, tinsel, and thermocouples.

Tinning and Annealing

Tinning and annealing alters the properties of wire. Options include: Bare copper (uncoated); Heavy Tin; Bare Copper Overtinning; Bare Copper Fused; Tin Copper Overtinned; Tin Copper Fused; Prebond; Annealing (heated the wire to 700°F or higher, then allowing it to cool to make the wire more flexible).

Types of wire construction

- Wire Bars
- Rod
- Stranding
- Bunch Strand (ASTM B-174)
- Concentric Strand (ASTM B 8)
- Rope Lay—Bunch Stranded Members (ASTM B-172)
- Rope Lay—Concentric Stranded Members (ASTM B-173)
- Compact Round Conductor (ASTM B-496)
- Compressed Round Conductor (ASTM B-8)
- Sector Conductor
- Segmental Conductor
- Annular Conductor
- Filled Strand

Jackets and Insulation

Application-specific requirements often dictate the need for Jackets and/or Insulation. Key variables include: Size (wall thickness); Electrical (capacitance, insulation resistance, dielectric strength, etc.); Physical (cut-through. abrasion resistance, deformation, etc.); Chemical/environmental resistance; Service Life and long-term reliability; Flexibility; Radiation resistance; Smoke and flame resistance

Insulation

A non-conductive material applied over conductors to provide electrical isolation between conductors, helps prevent shorting

Jacket

Applied over conductor insulation or a cable core to enhance its mechanical, chemical, or electrical properties. Versions include: Thermosetting (rubbers such as neoprene, hypalon, etc.); Thermoplastic (PVC. Polyethylene, TPE, Nylon etc.); Fluoropolymer (Teflon FEP, etc.); Elastomer; and Rubber..

Types of Insulation and Jackets

Options include: Thermosetting (Butyl, Styrene Butadiene (SBR); Ethylene-Propylene (EPR, EPM, EPDM); Crosslink Polyethylene (XLP, XLPE, X-LINK PE); Chlorinated Polyethylene (CPE); Silicone Rubber (150°C and 200°C); Natural Rubber (Rubber Tree Hevea Brasiliensis) (75°C); Polyisoprene Rubber; Polyurethane (121°C); Nitrile-Butadiene (NBR, Nitrile, "BUNA-N" 90°C); Latex (Chlorosulfonated polyethylene (CP, CSM, CSPE) (90°C or 105°C); Polychloroprene (Neoprene) CR (75°C or 90°C)

Thermo Plastic

Polyvinyl Chloride (Vinyl, PVC) (-45°C-105°C); Polyethylene (P.E., Poly); Crystalline Propylene/Ethylene Copolymer (Polypropylene) PP (90°C); Chlorinated Polyethylene (CPE); Polysulfone (-65°C +130°C); Thermoplastic Elastomers (TPE) (90°C); Polyurethane (PU) (75°C); Polyimide (Kapton); Polyamide (Nylons); Type 6 Poly Caprolactan—standard nylon; Type 610 or 612 Zytel 33,37,153, and 157—nylon; Type 66; Copolymer.

Armoring and Shielding

Braid (16 carrier and 24 carrier); Serve (8 carrier & 12 carrier); Braid & Serve Materials
Shielding ____#26, #28, #30, #32, #34 and #36 AWG bare or tinned copper; Armoring ____#26 or #28 AWG Aluminum, Bronze or Steel plus #30 AWG steel; Helical Metal Tape; Helical Metal Tape; Film/Foil Tape; Film/Foil Tape Shielding Materials (copper and aluminum laminated onto polyester film); Longitudinal Corrugated Tape Shield; Longitudinal Corrugated Tape Materials; Strip; Parkway Tape Armor; Parkway Taping Armoring; Interlock Armoring; Round Wire Armoring;

Color Coding

Color codes create a common standard to help identify multiple conductors used in point-to-point wiring and circuit diagrams. Color Codes (ICEA Methods) include: ICEA/NEMA Method 1; ICEA/NEMA Method 2; ICEA/NEMA Method 3; ICEA/NEMA Method 4; ICEA/NEMA Method 5; ICEA/NEMA Method 6; ICEA/NEMA Paired Color Code; Telephone Paired Color Code

UL and NEC regulations restrict the use of green and white as colors and stripes. Special color codes can be used. One method is ICEA Method E-2 (which is similar to Method 1), another is ICEA Method E-4 (which is similar to Method 2).

Wire and cable products used in electronic assemblies need to be properly terminated and tested to ensure that a reliable electrical connection has been achieved.


MPD
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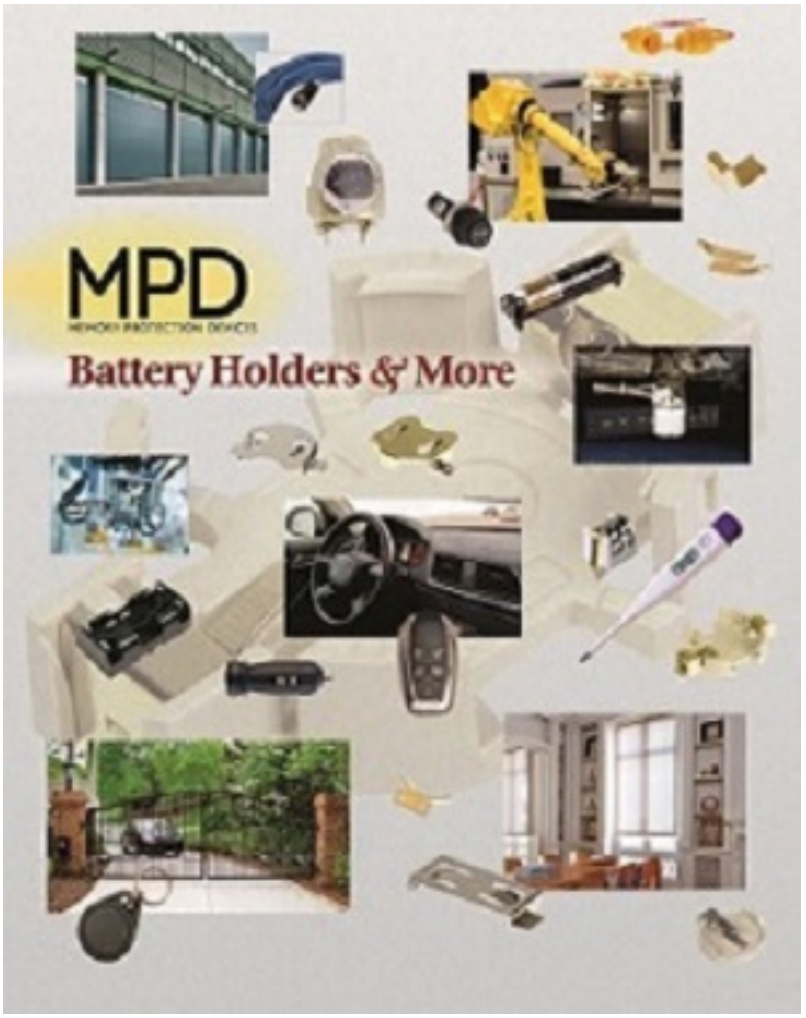
12V Parts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Battery Holders & More


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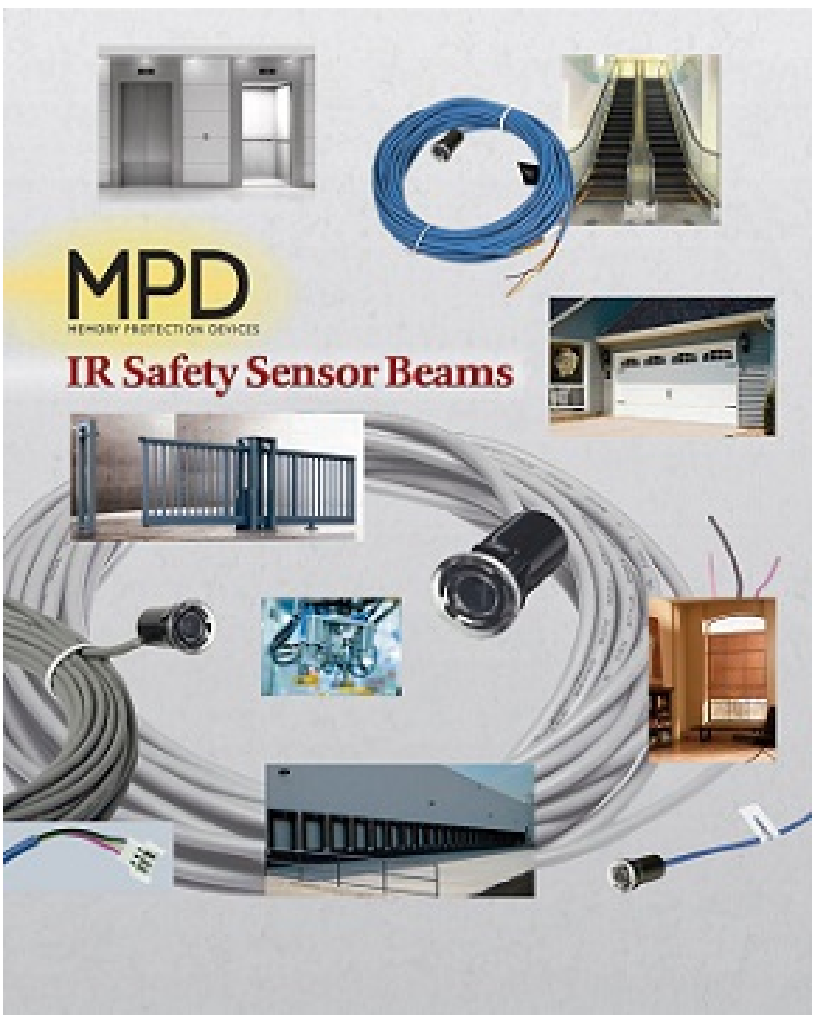
Fuse Holders
FUSE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IR Safety Sensor Beams