QwikConnect

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Special Report

Glenair

Design Trends in High-Performance Interconnect Systems

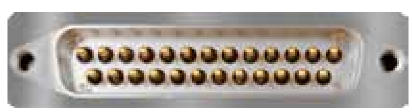
Design Trends in Interconnect Systems

This issue of *QwikConnect* is about change. It's about technology trends in commercial and military markets—everything from the increased use of miniaturized, unmanned systems in aerospace to the growth of high speed and high-bandwidth applications in the IT industry. Specifically it is about technology trends in the connectors, cables and other components used to interconnect cutting-edge electronic technologies in high-reliability industries.

We're all familiar with emerging "future soldier" systems such as Land Warrior. We all know what a Predator drone is and what it is used for. Satellites? Medical robots? The Mars Rover? Check, check and check. But how conversant are we with the important trends and latest inventions in the connector technologies that serve these systems? Could you, for example, describe the evolution in connector packaging to meet the changing needs of the down-hole drilling and well-logging industry? If you answered no, then you'll want to read on as *QwikConnect* discusses the most important trends in connector design for defense, aerospace and other high-reliability applications.

Five Key Trends, Plus a Few Surprises

Change is inevitable, except, as comedian Gallagher once observed, from a vending machine. The evolution of ever more sophisticated electronic equipment, especially in military applications, has led inevitably to changes in connector design and packaging. The ongoing pursuit of miniaturization, our first category, has led to numerous evolutions and inventions. A common application type, such as high-reliability wire-to-board connectors, illustrates the ongoing evolution in connector size and density to meet the demands for space-saving interconnections in OEM systems. Interestingly, these smaller, higher density interconnects still have to meet extremely high requirements for vibration, shock, temperature tolerance, corrosion resistance and so on. As Victor Hugo once said, *"many great actions are committed in small struggles"*. In our industry, it's apt to say some of the greatest design work and innovation has been accomplished in the pursuit of small results.

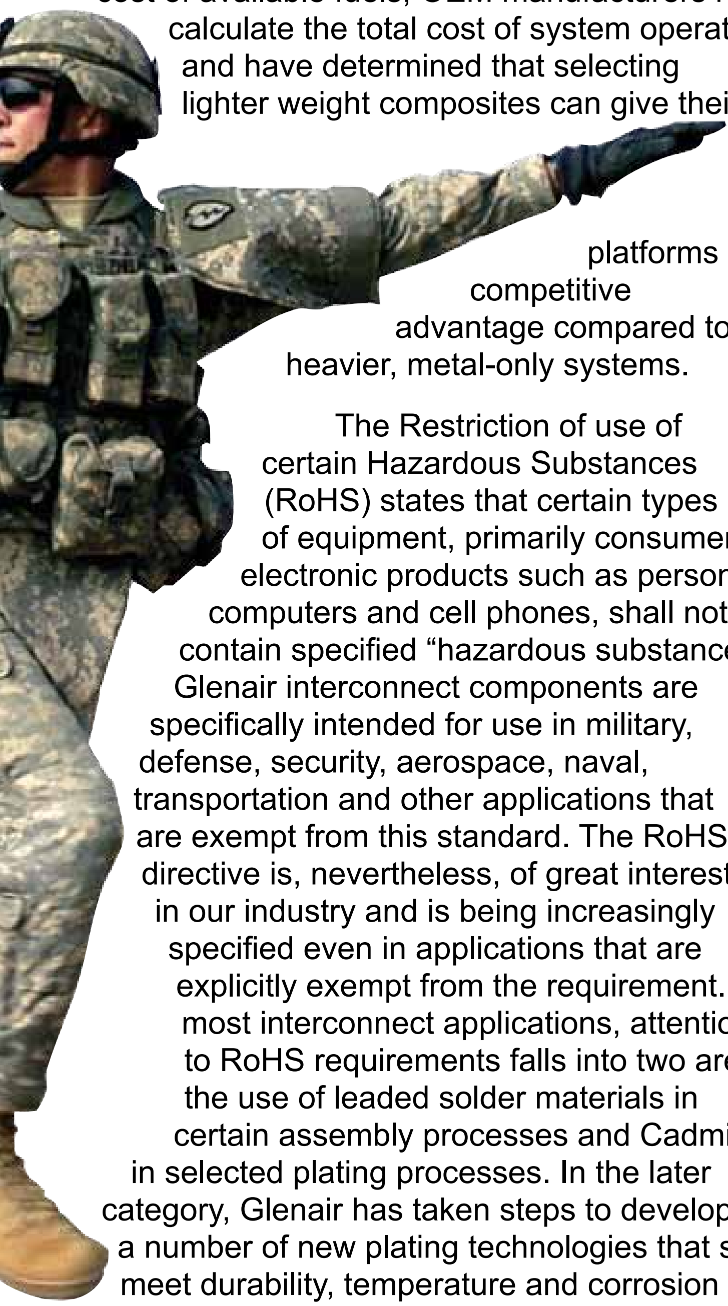


D-Subminiature Connector
Contacts on 0.109 Inch Spacing

Micro-D Connector
Contacts on 0.050 Inch Spacing

Nano Connector
Contacts on 0.025 Inch Spacing

The second interconnect design trend we will explore is the accelerated use of composite thermoplastics in high-reliability systems. No better example can be found than in systems, such as the Boeing 787 *Dreamliner*, that have made across-the-board commitments to replace heavy metal materials with lightweight composite plastics. Once used only in isolated and non-structural roles, composites now enjoy full-scale use throughout the most innovative commercial and military airframe applications. The principal reason, of course, is weight savings. Given the cost of available fuels, OEM manufacturers now calculate the total cost of system operation and have determined that selecting lighter weight composites can give their platforms a competitive advantage compared to heavier, metal-only systems.



The Restriction of use of certain Hazardous Substances (RoHS) states that certain types of equipment, primarily consumer electronic products such as personal computers and cell phones, shall not contain specified “hazardous substances.” Glenair interconnect components are specifically intended for use in military, defense, security, aerospace, naval, transportation and other applications that are exempt from this standard. The RoHS directive is, nevertheless, of great interest in our industry and is being increasingly specified even in applications that are explicitly exempt from the requirement. For most interconnect applications, attention to RoHS requirements falls into two areas, the use of leaded solder materials in certain assembly processes and Cadmium in selected plating processes. In the later category, Glenair has taken steps to develope a number of new plating technologies that still meet durability, temperature and corrosion resistance benchmarks while satisfying the RoHS directive. Cadmium reduction or elimination is another important trend. We’ll look at these important developments in the third section of our “trends” issue.

Electromagnetic interference is the bane of a cable engineer’s existence. In fact, the pursuit of sensible approaches to resolve EMI and EMP challenges in interconnection systems is the number one challenge faced in many high-reliability interconnect systems. Electromagnetic Interference (EMI) is conducted, radiated or magnetically induced voltage that degrades, obstructs, or repeatedly interrupts the performance of electronic equipment. Interconnect technology innovations, such as improved shielding materials, advanced EMI filter connectors and new conductive surface finish technologies are all employed in cutting-edge EMC (Electromagnetic Compatibility) interconnect cable designs. We’ll explore the full range of these technologies in the fourth section of our article.

Avionic and other civilian/military vehicle data transfer systems are growing increasingly complicated—the number of data paths, data rates and the quantity and sophistication of subsystems continue to escalate. In addition to transmission speed, accuracy and reliability are tremendously important. Ethernet communication technology, with its huge installed base and history of reliability, is ideally suited for vehicles and other field applications. Although there are many MIL-STD-1553 bus architecture and data link systems in use, applications such as tactical radar require faster data rates than older architectures can deliver. As high-speed data systems become more prevalent in defense, aersospace, transportation and other high-reliability applications, the need for connector technology that can deliver the required performance in harsh, ruggedized settings becomes paramount. We explore this trend last (but not least!) in this special report.

Connector Trends: Miniaturization

Circular Mil-Spec Type Connectors

Circular MS type connectors are typically grouped into standard, miniature and subminiature families. These groupings reflect the packaging density and contact size, and also represent the evolution of connector roles over the past 70 years. The standard group includes the venerable 5015's (Glenair Series IT and ITS) and the 28840 shipboard connector. Miniature circulars include the 26482 (Glenair Series IPT), while the MIL-DTL-38999 is the only significant subminiature circular. Until recently, the evolution of MS type circulars, at least in terms of package size and layout density, had halted at the sub-miniature or "high density" 38999. But the Glenair Series 80 Mighty Mouse connector has effectively advanced miniaturization into the true "ultraminiature" category. The Series 80 Mighty Mouse Connector is designed for high-reliability commercial and aerospace/defense interconnect applications that require both robust environmental/EMI performance and reduced size and weight. The Series 80 Mighty Mouse Connector offers comparable performance to MIL-DTL-38999 Series interconnects with up to 71% weight and 52% size savings for similar contact counts. The major breakthrough trend to miniaturization was facilitated by placing smaller #23 contacts (to accept #22 to #28 wire) on contact spacing of .076 inch.

Standard

MIL-DTL-5015
MIL-DTL-22992
MIL-DTL-28840

Miniature

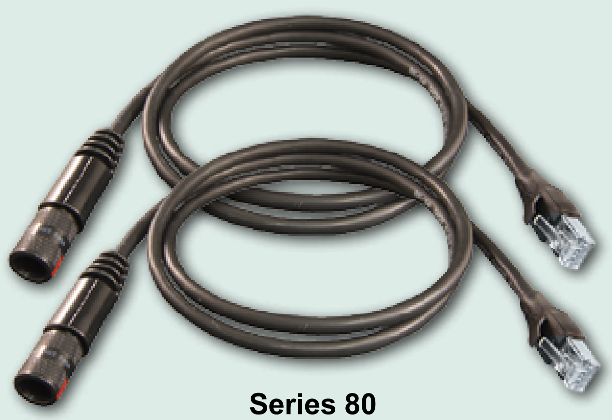
MIL-DTL-26482
MIL-DTL-26500
MIL-DTL-83723

Subminiature

MIL-DTL-38999
(Series III Shown)

Ultraminiature

Series 80
Mighty Mouse



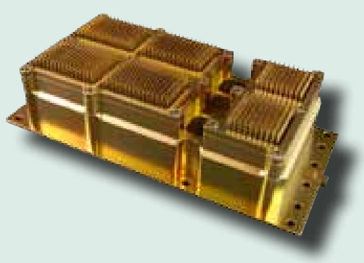
Series 80
Mighty Mouse

The smaller and lighter Mighty Mouse maintains the same approximate electrical and mechanical performance as larger and heavier military standard environmental connectors. Insert arrangements are available for as few as 1 and as many as 130 contacts. The product series includes cable sets and backshells, all available with accelerated lead-times—many are packaged for immediate same-day shipment. #16 and #20 layouts are also available for higher current requirements and for coaxial contact accommodation. Custom layouts, such as might be required to accommodate a different gage or type of contact may be readily incorporated into existing shell/coupling designs. Glenair also offers the complete Mighty Mouse package in a rectangular version called the "Micro-Crimp."

Rectangular I/O and Board-to-Wire Connectors

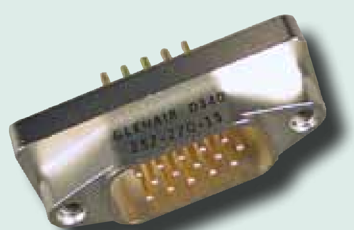
Industry-Standard rectangular I/O and board-to-wire connectors include ARINC type rack and panel connector at one end of the size and density spectrum extending to nanominiature connectors on the other. The D-subminiature and the Micro-D complete the standard range from low to high density. The trend to miniaturization has been more rapid in rectangular connector packaging due to their more frequent application in Board-to-Wire and Board-to-Board level interconnections. The MIL-DTL-32139 Nanominaiture connector with its 0.025 inch contact spacing is the latest evolution in rectangular shaped connectors for board-level I/O applications. Featuring solid gold TwistPin contacts and aluminum, titanium or stainless steel shells, the Nanominiature is the smallest, yet remarkably robust, connector in the high-reliability industry. Glenair was one of the first interconnect manufacturers to qualify to the new MIL-DTL-32139 Nanominiature Mil-Spec for these precision-machined connectors that deliver both ultra high density and maximum weight and space savings. These high reliability ultra miniature interconnects are ideal for critical applications where size and weight restrictions preclude the use of larger connectors such as M24308 D-Subminiatures. Ideal for military and civilian applications of all types, the rugged contact system allows the nano connector to be used in the most demanding miniaturized applications. The Glenair Nano contact system consists of a TwistPin (a miniaturized version of the Glenair Micro-D TwistPin) and a tubular socket providing excellent durability and superior resistance to shock and vibration. Accommodating #30 or #32 AWG wire, Nano TwistPin contacts handle 1 AMP current rating and 70 Volts AC RMS operating voltage.

Standard



ARINC (800)

Subminiature



MIL-DTL-24308

Micro

MIL-DTL-83513

Nano

MIL-DTL-32139

Nanominiature connectors are high reliability ultraminiature interconnects intended for critical applications where size and weight restrictions will not allow the use of larger connectors. Typical applications include miniaturized electronics boxes used in UAV’s, satellites, missile systems, and geophysical instruments. Contact spacing of 0.025 inches combined with a rugged contact system allow these nano connectors to be used in demanding environments where commercial-grade connectors should not be used. These high reliability ultra miniature interconnects are well suited for applications requiring both ultra high density as well as maximum weight and space savings.

Series 79
Nanominiature

Connector Trends: Composite Materials

For many people, "plastic" means "cheap and breakable." But when engineers search for new ways to enhance weight savings, corrosion resistance, shock and vibration dampening and stealth they immediately turn to plastic—the only alternative material capable of meeting, and beating, the established performance levels of aluminum, brass, titanium and steel.

The name "plastic" refers to the ability to form or shape a material, or to the moldability a material adopts under forces such as pressure or heat. Engineers often use the term "polymer" when referring to plastic materials, because it more clearly describes how many (poly) chemical units (mers) combine in complex chains to create modern plastic resins. "Thermoplastics" are polymer materials that melt to a liquid when heated and form into a hard, dimensionally stable shape when cooled.

Thermoplastic polymers are created by subjecting various chemical and petroleum-based ingredients to heat and pressure in sealed vessels. Specific chemical additives control how the polymer is formed and contribute to its performance in such areas as surface hardness and flame resistance. The process of mixing base materials with chemical additives to create specific types of plastic resins is called "polymerization." The resulting plastic materials can be classified in various ways—by chemical or physical structure, by strength or thermal performance and by optical or electrical properties.

Resin Morphology

When polymer resins are combined with glass fibers, or other structural materials, the resultant "composite" material can deliver truly amazing levels of performance. Since over sixty thermoplastic base-resins can be used to produce composites, it is helpful to understand a little about resin chemistry and morphology as a baseline for understanding the properties of the different grades of composite plastics. Although "morphology" sounds complicated, it can simply be viewed as the orientation the molecules take when they go from the liquid to solid state during processing, such as injection molding. A thermoplastic resin is either amorphous, having a random molecular orientation, or semi-crystalline, having ordered or crystalline regions of molecules dispersed within the random amorphous molecules. Morphology choice depends on application, as there are advantages for each material type. The most significant structural classification for polymers has to do with their shape at the molecular level. Polymers whose long, linear shaped molecules fold tightly together into packed and ordered areas are classified as semi-crystalline. Polymers with bulkier molecular shapes not inclined to fold up into spaghetti-like crystals are classified as amorphous.

Thermoplastic connector components, such as this Band-in-a-Can Backshell, may be selectively plated with conductive material. This strategy enables users to enjoy the weight saving and durability properties of composites while addressing EMC grounding requirements.

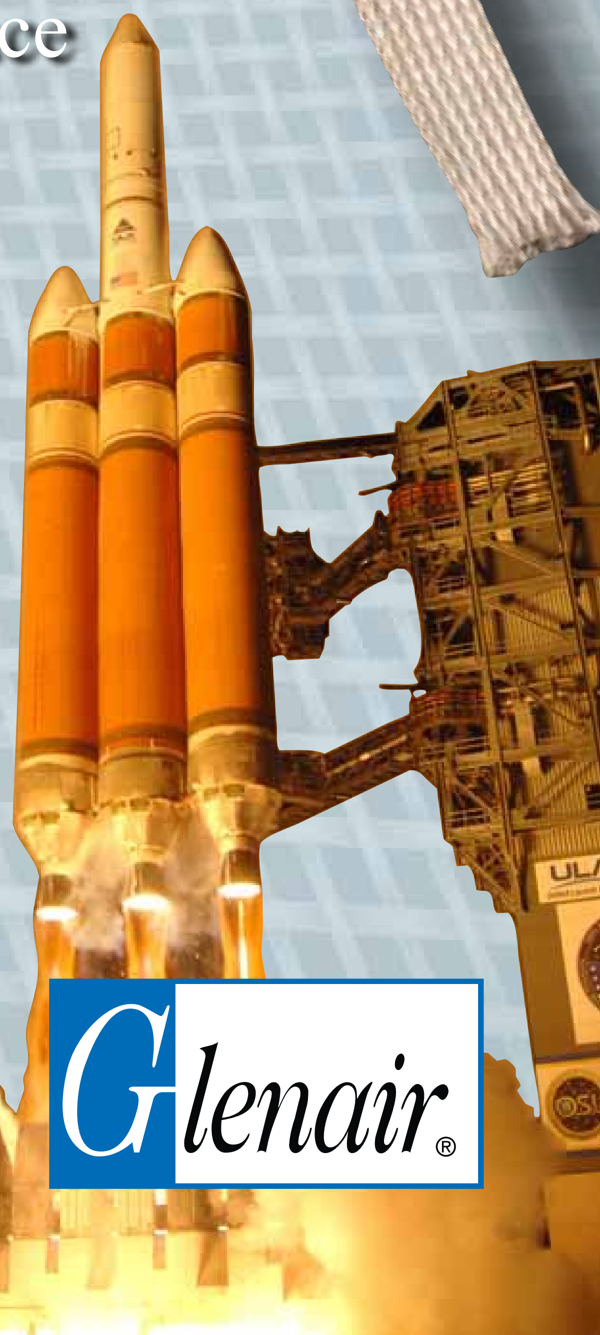
SERIES 103

AmberStrand®

Conductive Composite Braid

The Smart Way to Reduce Launch and Flight Weights in Aerospace Systems

For many applications, the cable shield is the most important element in controlling EMI.Unfortunately, metal shielding—especially when applied in multiple layers—can be extremely heavy. The opportunity to provide robust EMI shielding at a fraction of the weight is the principal advantage of composite thermoplastic EMI/RFI braid made from AmberStrand® Fiber. In both atmospheric and exoatmospheric applications, any reduction in the static weight of the system leads to measurable cost savings at take-off and launch. And transfer impedance test reports demonstrate the effectiveness of the material compared to conventional metal solutions. So get smart! Reduce weight and save money with AmberStrand® EMI/RFI Braiding.



Glenair®

Application Benefits of Composite Thermoplastics

The benefits of modern plastic materials have not yet led to the wholesale elimination of metal from high-performance air, sea and space applications. Aluminum, for example, is still a popular choice for most high-density connectors and accessories. But the significant advantages offered by composites, —especially reduced weight—are so beneficial that most new OEM development programs now include significant composite content.

Corrosion Resistance: One of the most appealing attributes of composites is their unlimited corrosion resistance as compared to conventional materials. Aluminum interconnect components, for example, are subject to galvanic coupling which causes the metal material to be "sacrificed" to its cadmium/nickel plating. Since high-temperature plastic is not sacrificial to plating, finished products last longer, require less maintenance and directly reduce the overall cost of ownership of the system.

Composite Thermoplastic Versus Common Metal Materials

Weight Savings		
Material	**Specific Gravity**	**Density (lbs./Inch^3)**
Composite	**1.27 - 1.51**	**.055**
Aluminum	**2.55 - 2.80**	**.098**
Titanium	**4.51 - 4.62**	**.162**
Stainless Steel	**7.70 - 7.73**	**.284**
Brass	**8.40 - 8.70**	**.305**
Corrosion Protection		
Material	**Plating**	**Salt Spray**
Composite	**Nickel**	**2000+ Hrs**
Aluminum	**Nickel**	**48-96 Hrs**
Aluminum	**Zinc Colbalt**	**350-500 Hrs**
Aluminum	**Cadmium Nickel**	**500-1000 Hrs**
Aluminum	**Zinc Nickel**	**500-1000 Hrs**
Titanium	**Nickel**	**500-1000 Hrs**
Stainless Steel	**Nickel**	**500-1000 Hrs**
Brass	**Nickel**	**500-1000 Hrs**

Vibration Dampening: Another major benefit of composite thermoplastics is vibration dampening. Unlike metals, polymer plastics are less subject to harmonic resonance due to their lighter weight and inherent attenuating properties. Threaded components made from these materials are far less likely to vibrate loose when subjected to prolonged periods of vibration and shock. Again, reduced maintenance and reduced cost of ownership are the major benefits realized by systems built from vibration dampening thermoplastics.

Weight Reduction: Next to their anti-corrosive capabilities, the characteristic of composites that makes them most attractive is their ability to provide increased strength and stiffness at lighter weights than metal materials. The typical weight savings for composites over aluminum is approximately 40% (depending on component design).

Weight savings versus metals such as steel and brass are even more pronounced, as their specific gravities are several times that of plastic. Composite materials directly reduce aircraft empty weights and increase fuel fractions. For the aerospace engineer, this improvement leads directly to smaller, lower-cost aircraft that use less fuel to perform a given mission.

Stealth: Reduction of magnetic signatures, corrosion related magnetic signatures and acoustic signatures is critical to the development of stealth applications. Signatures are those characteristics by which systems may be detected, recognized, and engaged. The reduction of these signatures can improve survivability of military systems, leading to improved effectiveness and fewer casualties. Composite thermoplastics are at the heart of a number of advanced stealth application development projects. Forty percent of the structural weight of the F-22 is polymer composites, and other systems such as the B-2 and F-117A expanded their use of stealth technologies beyond basic shaping and material coating techniques to include the use of structural and component composite thermoplastics.

Cost Comparison and Temperature Resistance

Thermal properties are extremely important when selecting plastic materials for use in high-performance applications. Composite glass transition temperature (the point at which the heated material softens) will dictate whether or not the plastic is suitable for use in high-heat applications such as adjacent to an engine or other heat source. But other properties, such as its specific gravity, hardness, refractive index, dielectric strength, conductivity, chemical resistance, UV and flame resistance are also critical in deciding which recipe of resins, fibers and additives will be selected for a particular project.

Temperature resistance can be measured in a variety of ways: melt temperature, heat deflection temperature, glass transition temperature, and continuous use temperature. The resins that offer the highest capabilities in each of these categories are often the most expensive, but typically offer the lowest lifetime cost because of enhanced durability and strength. Two of the top thermal performers, Polyetheretherketone (PEEK) and high-temperature ETFE, are high cost materials, but exceptional performers over the long run.

The glass transition temperature, or the point at which the heated resin will soften, varies from material to material. Extremely high-heat applications, such as the interconnect cabling serving jet engine sensors, are generally considered to be ill-suited for composites.

Additives can be used to increase flame retardency, to improve lubricity or, in the case of pigments, simply to change the color of the final product. Again, material costs can rise with the addition of chemical compounds that contribute to improved performance. In terms of cost, thermoplastic resins can be arranged into three basic categories:

- Low cost/commodity resins with large volume market costs of less than $1.50/lb
- Medium cost/engineering resins that fall between $1.50-$3.00/lb
- High cost/high temperature resistant resins that typically run above $3.00/lb.

Re-Designing for Composites

Interconnect products made of composite materials offer significant advantages over steel or aluminum. They're lighter. They don't rust. They don't loosen under vibration. They can hide from radar. Yet the ability to design composite components that take advantage of these properties while still meeting form, fit and function requirements is no simple task.

Connector accessories, no matter the material, must thread onto the back of connectors. Intermatability with other components, whether composite or metal, is critical. Composite component design is further complicated due to the unique strengths and weakness of the material. Abrupt changes in wall thicknesses, for example, can lead to stress problems in both manufacture and use. Sharp, un-radiused angles can create stress and cause cracking. The length, shape, orientation and distribution of reinforcing fibers is also a critical concern, as is the impact of other additives, such as colorizers and flame retardants, on the behavior of the material during manufacture and use.

But interconnect systems designers continue to specify composites, despite the complications of the design and manufacturing process. The weight savings, corrosion resistance and other significant advantages of composites represent real, out-of pocket savings in fuel consumption and lifetime system maintenance for a broad range of air, sea and space applications. Call our factory for the latest information on composite interconnect solutions.

Connector Trends: RoHS Compliance

Cadmium, a chemical element with the symbol Cd and atomic number 48, is a silver-white metal with a melting temperature of 321°C. When heated above this temperature, for example in an accidental fire, cadmium oxide fumes may be emitted. These fumes are considered to be dangerous to the environment and human health; which is why Glenair component parts plated with cadmium are specifically rated to only 175°C.

While cadmium oxide exposure risks in humans are still relatively unknown, it has nevertheless become a goal of many industries to proactively eliminate cadmium from manufactured products and systems. This movement is a significant challenge in our industry, particularly since military specifications still require the use of cadmium. In fact, military parts are currently exempt from cadmium and other substance reduction initiatives.

Because of its desirable functional qualities, electroplated cadmium has long been applied to components on commercial and military land, sea and air systems as well as NASA space systems. Cadmium provides up to 1,000 hours of sacrificial corrosion protection and excellent lubricity and resistance to galling for threaded applications. While the reduction and eventual elimination of cadmium from military systems is a laudable goal, replacement materials must deliver the same levels of performance.

The Department of Defense and the National Aeronautics and Space Administration (NASA) recently formed the Joint Cadmium Alternatives Team (JCAT) to identify and validate alternatives to cadmium for DoD systems and NASA applications. Working with a variety of DoD organizations and OEMs, JCAT defined the functional properties of electroplated cadmium, the substrates and components to which it is currently applied, and the desired properties for potential alternative/replacement materials.

Along with these military and space pollution prevention initiatives, a number of governmental controls have emerged recently. In the United States, the EPA and several states have issued regulations restricting the use of certain heavy metals. The European Union introduced the sweeping Restrictions of Hazardous Substances (RoHS) directive. China has established its own version of RoHS.

The Joint Strike Fighter (JSF) program is the first major program to fall subject to JCAT's efforts and is planned to be cadmium free. Additionally, JSF program managers intend to eliminate the use of hexavalent chromium, another useful but reportedly toxic substance integral to a number of finish treatment options. On the commercial front, the Boeing 787 "Dreamliner," we are told, will be fabricated exclusively from cad-free materials. So the hunt for a cadmium replacement is on, and in this section of our special report on interconnect system trends we offer you a number of alternative material and plating solutions to RoHS compliance.

New Mil-Spec Alternatives to Cadmium

MIL-DTL-38999L, published in May 2008, and MIL-DTL-83513, published in October 2008, call for new plating options for connectors and accessories. These are among the most important mil-specs controlling circular and rectangular military interconnects. Additionally, MIL-DTL-28840, the controlling mil-spec for shipboard, high density circular interconnects, is in the revision process. All three of these new or prospective mil-specs call out new plating options that are free of both cadmium and hexavalent Chromium.

It is expected that when other military and related industry specs are revised, they will also adopt these changes. For instance, the "grand-daddy" of specifications for backshells and accessories, AS85049, controlled by the Society of Automotive Engineers (SAE), will likely incorporate the plating additions established by these revised mil-specs:

Code P: Pure electrodeposited aluminum, conductive, temperature rated -65˚C to 175˚C, in accordance with MIL-DTL-83488, Type II, to withstand 500 hours of dynamic salt spray testing. (Glenair offers AlumiPlate electrodeposited aluminum plating that matches these requirements).

Code T: Nickel fluorocarbon polymer over a suitable underplate, conductive, temperature rated -65˚C to 175˚C, to withstand 500 hours of dynamic salt spray testing. (Glenair offers 1000 Hour Grey Nickel-PTFE plating that matches these requirements).

Code Z: Zinc nickel in accordance with ASTM B841 over a suitable underplate, conductive, temperature rated -65˚C to 175˚C, to withstand 500 hours of dynamic salt spray testing. Glenair offers zinc-nickel (code ZR) plating that matches these requirements.

New Non-Toxic Plating Choices Available Now @ Glenair

At present, Glenair's customers specify cadmium plating on parts more often than any other finish treatment. Although cadmium plating is exempted under the Restrictions of Hazardous Substances (RoHS), there continues to be considerable impetus in the military and industrial sectors to reduce use of cadmium and other common plating substances, such as hexavalent chromium.

The Joint Group on Pollution Prevention (JG-PP), a partnership between the Military Services, NASA, DLA, and DCMA, appointed a Joint Cadmium Alternatives Team (JCAT) and sponsored a Hexavalent Chromium Coating Alternatives Technology Survey to find replacements for these two substances. Thus far, efforts to identify cadmium substitutes have proven more successful than hexavalent chromium replacements. Not surprisingly, any material active enough to provide corrosion control has high potential to also be a health and environmental hazard.

Cadmium plating offers interconnect designers excellent corrosion resistance, lubricity, solderability, adhesion and ductility. The main drawback of cadmium is its purported toxicity. The search for cadmium alternatives has been challenging, as replacements need to provide simultaneously 1) lubrication and consistent friction control, 2) protection to substrate aluminum or alloy steel from corrosion, 3) a barrier coating base, and 4) galvanic protection for compatibility between dissimilar metals such as aluminum and steel.

Glenair has offered low cadmium zinc nickel for some time, and now offers a nickel-PTFE plating, called 1000Hour Gray, which is superior to standard nickel-fluorocarbon polymer finish treatments. 1000 Hour Gray is also virtually free of cadmium and hexavalent chromium and is suitable for use in RoHS applications.

A Guide to RoHS and Non-RoHS Compliant Materials and Platings

Electroless Nickel

Cost: 1 of 5
Conductivity: 5 of 5
Corrosion Resistance: 2 of 5

-65 to +200°C

Glenair Code M

RoHS Compliant

Aluminum plated with electroless nickel offers excellent conductivity, wear resistance, and adequate corrosion resistance. Typically specified on electrical connectors and accessories used in avionics boxes, exoatmospheric equipment, and missiles, electroless nickel is a good choice when exposure to marine or corrosive atmospheres is not a primary concern. The plating process is purely chemical, and once started, is autocatalytic (it runs by itself).

Zinc-Nickel

Cost: 2 of 5
Conductivity: 3 of 5
Corrosion Resistance: 4 of 5

-65 to +175°C

Glenair Code ZR

RoHS Compliant

Recently added to MIL-DTL-38999 and MIL-DTL-83513, this "Class Z" zinc-nickel plated aluminum has become a cost-effective alternative to cadmium. Available with a black RoHS-compliant chromate conversion coating, zinc-nickel plated aluminum is commonly found on soldier systems and military airframe applications.

Black Zinc-Cobalt

Cost: 2 of 5
Conductivity: 3 of 5
Corrosion Resistance: 3 of 5

-65 to +175°C

Glenair Code UCR, F7

RoHS Compliant

Zinc-cobalt with black trivalent chromate topcoat fills the need for a RoHS compliant conductive black finish for soldier systems, unmanned vehicles, robots and other tactical gear. This new addition to the Glenair lineup is likely to replace black zinc-nickel for new Future Combat System applications. Black zinc-cobalt plating is a standard finish on Glenair's ITS 5015 reverse bayonet power connectors.

Black Anodize

Cost: 1 of 5
Conductivity: 0 of 5
Corrosion Resistance: 2 of 5

-65 to +175°C

Glenair Code C

RoHS Compliant

Black anodized aluminum is a popular finish for electrical connectors and accessories. Typically employed when conductivity is not required, black anodized aluminum offers a modicum of corrosion protection and is relatively inexpensive. Anodizing is an electrolytic process that creates aluminum oxide films by oxidizing the base metal. The resulting coating is much harder and denser than natural oxidation. The parts are immersed in a sulfuric acid solution at room temperature. After anodizing, the parts are dyed black.

Cadmium

Cost: 2 of 5
Conductivity: 4 of 5
Corrosion Resistance: 4 of 5

-65 to +175°C

Glenair Code NF, LF, JF

RoHS Not Compliant

Cadmium plated aluminum has been the unchallenged workhorse of the defense/aerospace industry. Offering up to 1000 hours of salt spray protection when deposited over a preliminary coating of electroless nickel, cadmium is highly conductive, provides good lubricity and resistance to galling. As plated, cadmium has a silvery appearance. A subsequent chromic acid passivation bath creates a chromate topcoat over the cadmium, enhancing corrosion protection. Olive drab chromate is widely used, followed by gold chromate and clear chromate.

Stainless Steel

Cost: 5 of 5
Conductivity: 3 of 5
Corrosion Resistance: 5 of 5

-65 to +200°C

Glenair Code Z1, ZL, ZW

RoHS Compliant

Stainless steel offers unbeatable strength and protection from environmental stress if durability and corrosion resistance are more important than cost and weight. Typically found on aircraft engines, landing gear, geophysical equipment, armored vehicles and marine applications, passivated stainless steel is widely specified in throughout the interconnect industry. Also offered with nickel and cadmium plating for improved conductivity, stainless steel is an obvious alternative to cadmium if cost and weight are not an issue.

Marine Bronze

Cost $ $ $ $
Conductivity + + + +
Corrosion Resistance ⌛ ⌛ ⌛ ⌛ ⌛

-65 to +200°C

Glenair Code AB

RoHS Compliant

Marine bronze, an alloy of bronze, aluminum and nickel, is more resistant to the corrosive effects of seawater than ferrous alloys. Used on Glenair's GeoMarine connector coupling nuts, marine bronze is unplated and develops an aluminum oxide protective layer when exposed to air. Marine bronze connectors and accessories are found in shipboard and offshore drilling applications.

Plated Composite

Cost $ $
Conductivity + + + + +
Corrosion Resistance ⌛ ⌛ ⌛ ⌛ ⌛

-65 to +200°C

Glenair Code XM, XMT

RoHS Compliant

Plated composite connectors and accessories provide unsurpassed corrosion protection and excellent conductivity. Glass-reinforced thermoplastic is metallized and plated with electroless nickel (Glenair Nickel-PTFE is also now available). Plated composite connectors and accessories have become the first choice for aerospace programs seeking to eliminate cadmium and reduce weight.

Unplated Composite

Cost $
Conductivity —
Corrosion Resistance ⌛ ⌛ ⌛ ⌛ ⌛

-65 to +175°C

Glenair Code XB, XO

RoHS Compliant

If conductivity and EMI shielding are not required, unplated composites provide the best solution to corrosion protection. Glenair's composite connector accessories are ideally suited for use in harsh environments where even stainless steel parts can be attacked by corrosive fluids. Available in black (code XB) and brown (code XO).

AlumiPlate℠

Cost $ $ $ $ $
Conductivity + + + + +
Corrosion Resistance ⌛ ⌛ ⌛ ⌛

-65 to +175°C

Glenair Code AL, XAL

RoHS Compliant

AlumiPlate provides excellent conductivity and corrosion resistance. 99.99% pure aluminum is electrolytically deposited onto aluminum in a specialized water-free process, followed by a trivalent chromate conversion coating. AlumiPlate has been approved by Boeing and Lockheed as a replacement for cadmium. AlumiPlate has been added to MIL-DTL-38999 and MIL-DTL-83513. Threaded parts require dry lube to prevent galling. AlumiPlate is a service mark of AlumiPlate Incorporated, Minneapolis, Minnesota.

Nickel-PTFE

Cost $ $ $ $
Conductivity + + + + +
Corrosion Resistance ⌛ ⌛ ⌛ ⌛

-65 to +175°C

Glenair Code MT, XMT, ZMT

RoHS Compliant

Now approved for MIL-DTL-38999 and MIL-DTL-83513, Glenair's ***1000 Hour Grey***™ meets the need for a cadmium replacement with excellent conductivity, wear resistance and corrosion protection. This extremely durable finish is gun-metal gray. A proprietary preliminary undercoat is followed with a composite coating of electroless nickel phosphorus and polytetra-fluoroethylene (PTFE). An organic topcoat provides sealing and added resistance to SO_2 salt fog. Ni-PTFE is approved for the Joint Strike Fighter and offers extremely good lubricity.

Hardcoat Anodize

Cost $ $ $
Conductivity —
Corrosion Resistance ⌛ ⌛ ⌛

-65 to +200°C

Glenair Code G2

RoHS Compliant

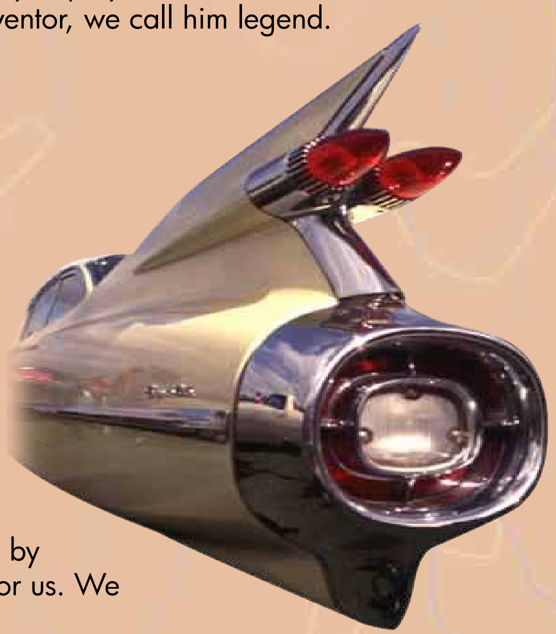
Hardcoat anodized aluminum offers greater wear resistance and better corrosion resistance compared to conventional anodizing. Typically employed when conductivity is not required, hardcoat aluminum offers good corrosion protection for marine and tactical applications. The resulting finish is a matte greenish-gray color. Hardcoat anodizing is an electrolytic process that creates aluminum oxide films by oxidizing the base metal in a sulfuric acid solution. The parts are immersed in a sulfuric acid solution at cold temperature. After anodizing, the parts can be dyed black (code GB).

THE TEN MOST IMPORTANT Technology Innovations … Of All Time

When our publisher challenged us to produce a centerfold on technology that changed the world, he no doubt was thinking about such things as the printing press, the telephone, personal computers, solid-state electronics and other signature breakthroughs in science and technology. But those types of lists are, frankly, a dime-a-dozen. So we have instead endeavored to present our readers with a more refined list; one we are confident will be greeted with broad recognition as truly representing **The Ten Most Important Technology Innovations of All Time**, *counting down from...*

#10 Pinball

Yes, we agree it is hard to accept that pinball is way down at the bottom of the list at #10. But that's where the sophisticated database and computer ranking system we employed in this project placed it, so let's just accept that sometimes life can be unjust. In 1869, British inventor and American immigrant Montague Redgrave was granted US Patent #115,357 for what would ultimately become the beloved, hypnotic mix of flashing lights, ringing bells, extra balls, and replays known as pinball. Redgrave's machine is universally recognized as the precursor to all games that feature the goal of *scoring more points than the last time you played.* Talk about impact! Some may call Redgrave an inventor, we call him legend.



#9 Automobile Tailfins

General Motors design chief Harley Earl is famously credited with introducing tailfins on the 1948 Cadillac. Taking his inspiration from fighter jets such as the P-38 Lightning, Earl turned the common automobile tail light into a monument of design innovation. For those who may claim the automotive tailfin served no practical purpose we need only point to 50's era product documentation published by Plymouth stating categorically that Tailfins are not merely stylish, but in fact serve as "stabilizers that reduce by 20% the need for steering correction in a cross wind." That's good enough for us. We say bring 'em back.

#8 Super Glue

Super Glue is a marvel of chemical science. Its practical uses are endless, from repairing cracks in vintage guitars, to stopping runs in nylons and even closing flesh wounds. Cyanoacrylate is the abbreviated chemical name for fast-acting adhesives sold under trade names like Super Glue and Krazy Glue. You may not be able to pronounce it, but you'll have to agree that Cyanoacrylate belongs in our top ten list. Try it on blisters on your next hiking trip! You'll want to lift your camp mug to Dr. Harry Coover and Fred Joyner of Kodak Laboratories who invented the substance during experiments to invent a plastic gun-sight during WW II.

#7 The Television Remote Control

Now we are hitting our stride. Some call it the clicker, the flipper, even the wangerdanger. But whatever the name, it is universally recognized that the Television Remote Control is the greatest innovation since the creation of indoor plumbing (see #6, below). The first TV remote was invented by Zenith Radio Corporation in 1950, and was nicknamed the "Lazy Bones" by its makers—a curious name for this sublime gift of design and innovation.

#6 The Flush Toilet

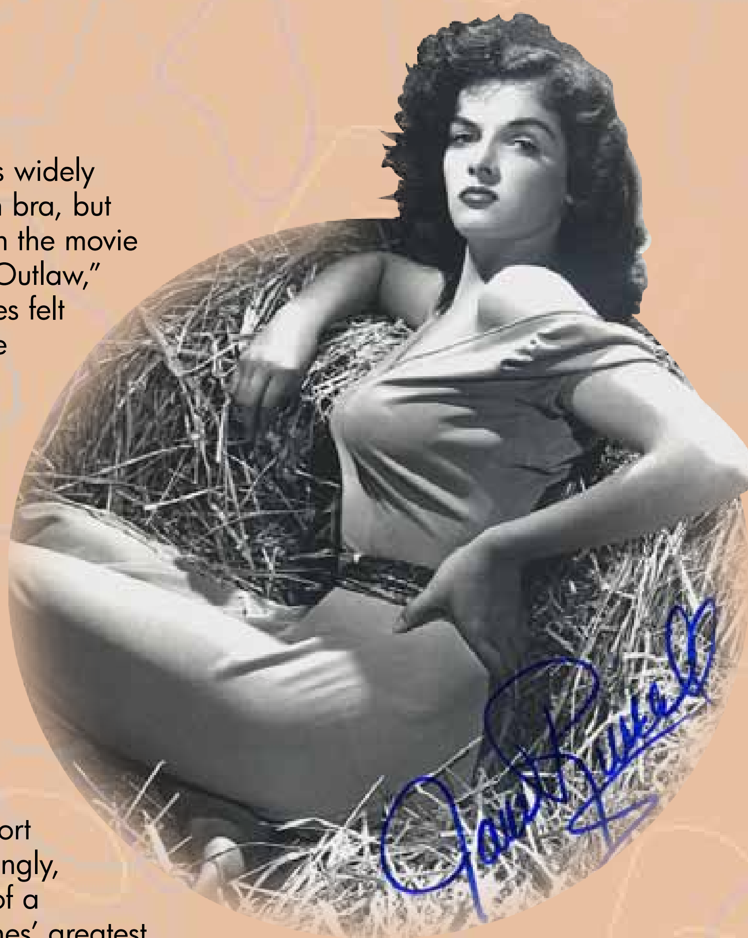
How many men does it take to change a roll of toilet paper? We don't know. It has never happened. But seriously, in London during the Industrial Revolution countless people looking for work migrated to urban areas ill-prepared to handle crowded conditions and volumes of human waste. In the 1854 outbreak of cholera in Soho, John Snow, a British physician and champion of medical hygiene, determined that the polluted Broad Street pump was the geographical center of the outbreak. His singular discovery ultimately led to widespread improvements in sanitation and to #6 on our list, the flush toilet.

#5 The Microwave Oven

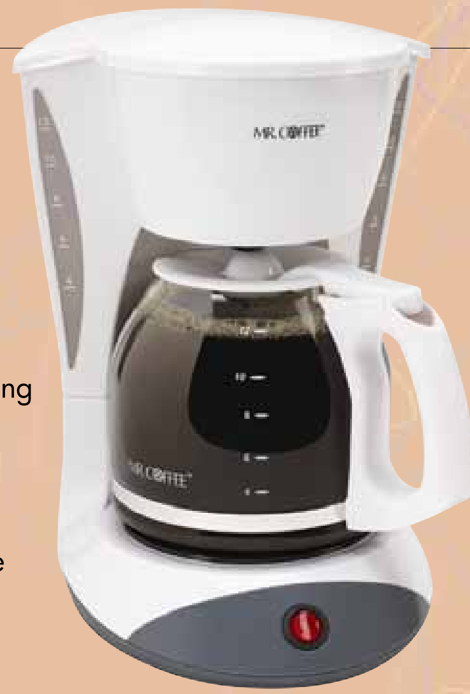
The microwave oven was discovered accidentally in 1945 by Percy Spencer, a self-taught engineer from Howland, Maine. Percy was working on an active radar set at Raytheon when he noticed a chocolate bar in his pocket had started to melt. Percy surmised the radar had melted his chocolate bar with microwaves. To verify his finding, he created a high density electromagnetic field by feeding microwave power into a sealed metal box. When food was placed in the box the temperature of the food rose rapidly, and the microwave oven was born. Capitalizing on his discovery, Spencer went on to invent the hot-pocket after-school snack.

#4 The Conical Push-Up Bra

New York socialite Mary Phelps Jacob is widely considered to be the inventor of the modern bra, but brazier technology came of age in 1941 on the movie set of Howard Hughes' production of "The Outlaw," starring Jane Russell and Jack Buetel. Hughes felt that the camera and lights did not do justice to Russell's rather prodigious bosom. So he employed his engineering skills to jury-rig a cantilevered underwire contraption to better emphasize her assets. And so, necessity being the mother of invention, the conically-shaped push-up bra was born. The new technology was all in good fun for Russell, who joked years later in an interview that she hadn't really needed the help and had secretly removed the new bra before filming (you be the judge). Hughes, for his part, was simultaneously engaged in the design and production of the H-4 Hercules troop transport plane dubbed the "Spruce Goose." Interestingly, there are those who contend that, in terms of a lasting legacy, the Spruce Goose was Hughes' greatest accomplishment. Go figure!



#3 Mr. Coffee



We are told the Turks invented coffee makers in 575 A.D. But for folks in the know, real coffee satisfaction began in 1972 thanks to Mr. Coffee and his automatic drip process machine with disposable filter. Yes, we know that there are many more sophisticated ways to make coffee, but if they're so great why is Mr. Coffee the largest selling coffee maker in the world? Hmmm? Perhaps it's because Mr. Coffee (circa 1979) was the first to add a timer so coffee lovers could wake up to a freshly brewed morning breakfast beverage without so much as lifting a finger. Now that's the kind of technology breakthrough that deserves recognition and respect! By the way, can you name the original Mr. Coffee celebrity spokesman?

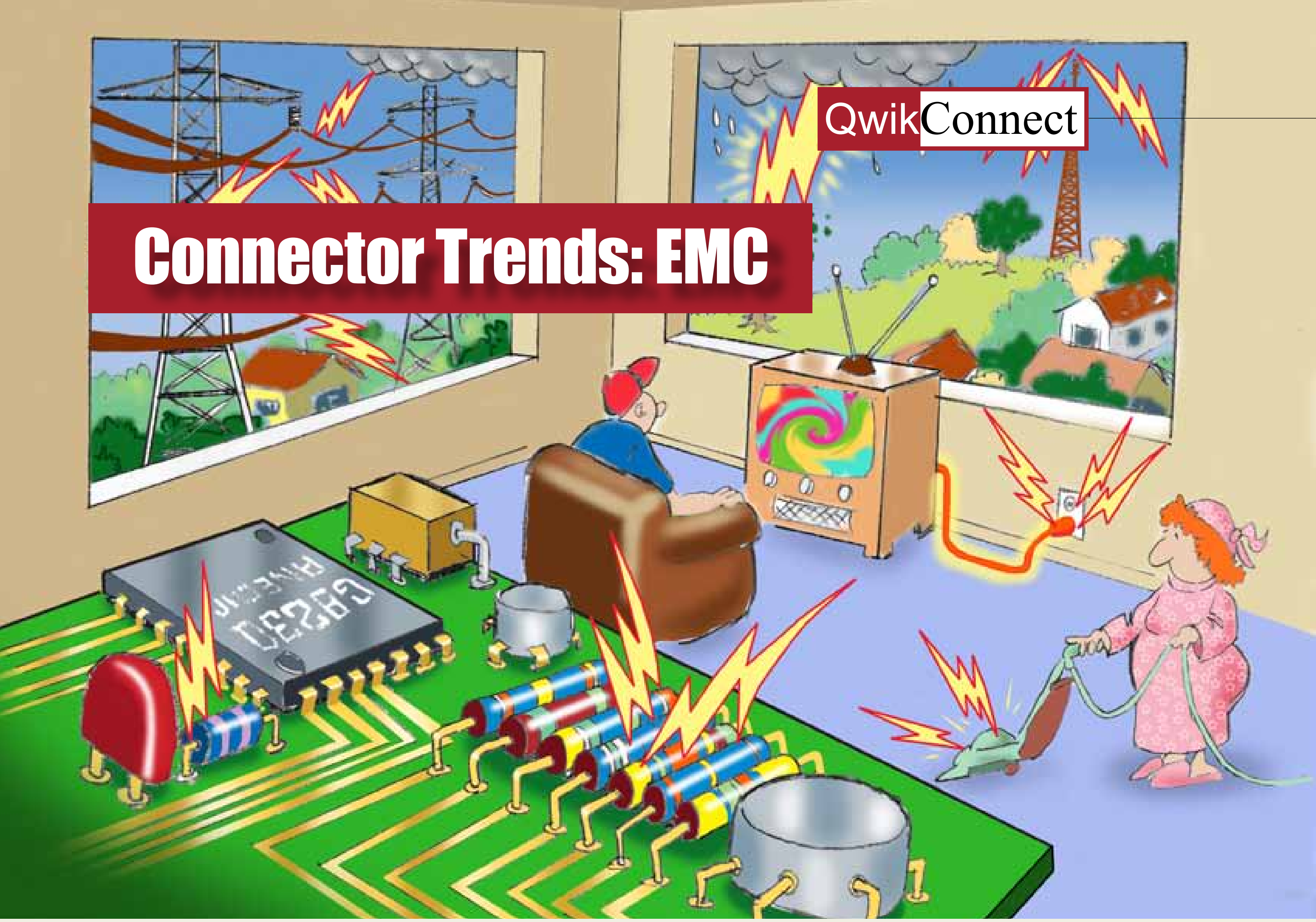
#2 Duct Tape

The practical uses of duct tape are endless. But what are the origins of this venerable product? During World War II, the American armed forces utilized a strong, waterproof tape to keep moisture out of ammunition cases. Soldiers nicknamed the waterproof material "duck" tape. Following the war, housing in the United States boomed, and the strong military tape was used for binding and repairing duct work in suburban air-conditioning units. When Johnson and Johnson changed the tape's color from Army green to sheet metal gray, "duct" tape was born. Nowadays duct tape is used in hundreds of practical ways, such as do-it-yourself shoe repair. But seriously, duct tape is so cool that we are reluctant to stoop to lame jokes at its expense. We'll save that for...

#1 The Weber BBQ

Native Americans used a wooden structure to roast meat, which was dubbed barbacoa by the Spanish—a term that was eventually applied to the pit style cooking techniques used in the Southeastern United States. As originally applied, BBQ meant the indirect, slow roasting of meats. But this art was lost on many backyard chefs who turned outdoor charcoal-based cooking into a direct grilling affair suitable only for hot dogs and burgers. It was not until the invention of the moderately-priced hemispherical BBQ, known far and wide simply as a "Weber" that the opportunity to smoke, or slow-cook, meats returned to America's backyards. So, with appropriate ceremony and due recognition for his contribution to good-taste and family fun, we convey upon Mr. George Stephen, a humble welder at the Weber Brothers Metal Works the honor of having fathered the single most important technology innovation of all time. Pass the BBQ sauce!

Connector Trends: EMC



Conventional (and New) Approaches to EMC

This section of our special report outlines both current and emerging technology trends for resolving EMI and EMP in interconnection systems. But first, some important definitions:

What is EMI?

Electromagnetic interference (EMI) is conducted, radiated or magnetically induced voltage that degrades, obstructs, or repeatedly interrupts performance of electronic equipment. A simple example is the static you hear on your AM radio when you run a vacuum cleaner nearby or drive your car adjacent to high-power lines.

What is EMC?

Electromagnetic compatibility is the extent to which a piece of hardware tolerates electrical interference from other equipment, and/or is likely to produce EMI that will impact other equipment.

Emmissions, Susceptibility and Immunity

Emission is the unwanted generation of electromagnetic energy by a source.

Susceptibility is the degree to which a piece of equipment is affected by the unwanted generation of electromagnetic energy from another source.

Immunity is the state whereby a piece of electrical equipment is entirely protected from electromagnetic disturbances.

Sources of EMI

EMI sources are man-made and naturally occurring. The purpose of EMC technology is to resolve EMI problems that originate in input/output

Four Typical Sources of EMI

Conducted Electric Current
Radiated Electromagnetic Field
Parasitic Capacitance
Inductive Coupling

connectors and cables or between subsystems and circuit boards that utilize interconnect devices.

There are four typical sources of EMI: *Conducted Electric Current* such as from an AC power circuit or motor; *Radiated Electromagnetic Field* often from a radio or TV broadcast tower; *Parasitic Capacitance,* typically caused by leakage from a resistor, inductor or other PCB-level electronic device; and *Inductive Coupling* via crosstalk from adjacent wires in a cable.

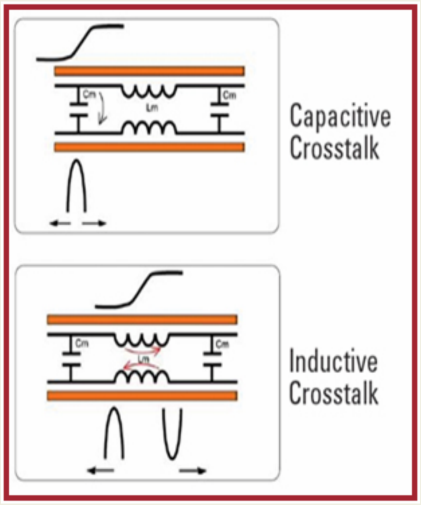
High speed electronic components and sub-systems are increasingly susceptible to EMI. Lower supply voltages and higher operating frequencies also increase potential for EMI noise. The resolution of these problems requires a broad-based approach that utilizes many different types of EMC materials and technologies, some of which are established industry standards, others of which represent new trends and techniques in managing EMI.

EMC Design Strategies

Here are five conventional strategies for combating EMI and EMP in electronic systems.

EMC Design Strategy #1: Point-to-Point Grounding of Electrical Lines

In a cable, "ground" is the return path for current and not necessarily a ground to "earth." It simply closes the current loop. Power line coupling occurs when radiated EMI is picked up by power lines or ground loops, or when power line transients couple to the victim's power cable and circuits. Digital circuits are particularly susceptible to power transients (or "spikes"), power supply oscillations and ground wire coupling. To resolve ground for power lines, employ primary transient protection on input power lines by using drain wires and ground conductors/pins, or TVS filtering of power circuits at the receptacle connector.



Man-Made vs. Natural EMI

Man-Made:	**Naturally Occurring :**
High frequency devices	Electrostatic discharge (ESD)
Electronics/computers	Lightning (LEMP)
Cell phones/radios	
Wireless/RF energy	
Microwave equipment	
Power lines	
Electric motors	
AC Power Circuits	
Nuclear event (HEMP)	

The illustration shows Kirchhoff's current law (KCL) which states that the sum of currents flowing toward a point is equal to the sum of currents flowing away from that point. In theory, all current present at the beginning of a loop must reach the end.

EMC Design Strategy #2: Absorption or Deflection of Radiated EMI

Wires and cables act as antennas intercepting radiated electromagnetic energy and conducting EMI into electronic systems. The higher the frequency of the EMI (10 MHz +) the greater the necessity for high-coverage EMC cable shielding technologies.

Wire shields, foils, braided screens, EMI backshells, conductive gaskets and other technologies absorb radiated EMI as heat or deflect it outright. Shielding effectiveness (also called transfer impedance) is ratio of current on the inside of the shield to current on outside. The quality or amount of shielding required to effect adequate absorption or deflection is directly related to the operating frequencies and susceptibilities of the electronic system. This measure is typically expressed in decibels (dBs) of shielding at a defined frequency. Here are four points to bear in mind:

- Wires and cables act as antennas
- Higher frequency EMI requires high-coverage shielding
- Wire shields, foils, braided screens, EMI backshells, conductive gaskets absorb and reflect EMI
- Shielding effectiveness, as determined in a transfer impedance test, is *the* bottom line.

EMC Design Strategy #3: Elimination of Cable Shielding Apertures

Radio frequency immunity depends on effective shielding. Radiated EMI/RFI can penetrate signal and control cables to develop interfering voltages carried to the victim. Cable, connector and electronic box (module) conductive plating and shielding, as well as filtering, are key techniques to resolve radiated EMI that couples to wire conductors and/or shielding.

Elimination of apertures or gaps in shields and enclosures is critical, especially for high frequency (short wavelength) EMI. Resolution of low frequency EMI requires thicker shielding material while high frequency EMI is best managed with thin layers of highly conductive material. Use of EMI gaskets, nut-plates, connector ground springs and appropriate types of cable shielding is also critical. AmberStrand® Braid is especially effective since it does not introduce unwanted gaps or apertures.

EMC Design Strategy #4: Capacitive or Inductive Filtering

Filter connectors use internal capacitors to "strip off" unwanted noise from the signal as it enters the electronic module. They may also employ inductors and diodes for EMP applications to shunt transient voltages to ground. These capacitors act as low-pass filters to attenuate high-frequency noise and allow low-frequency signals to pass. Each application environment dictates different capacitance values and cut-off frequencies to affect the desired performance. Virtually any standard connector type can be outfitted with filtering technology. Filtered receptacles should be mounted with conductive gaskets and nut rings to eliminate potential gaps, apertures or weaknesses in the ground path. Here is a summary of key filter connector facts:

- Filter connectors "strip off" noise or transient voltages
- "Low-pass" filters attenuate high-frequency noise
- The application environment (operating frequencies of the protected equipment) dictates capacitance
- Filtering can be incorporated into a wide range of connector packaging

EMC Design Strategy #5: Conversion to Fiber Optics

Optical fiber is ideally suited to EMI environments due to its total immunity. Optical media uses light to transmit signals, so it's not susceptible to electric or magnetic field interference or transient voltage spikes. Unlike copper or other conductive materials subject to interference coupling, fiber media is a dielectric that cannot emit EMI. Conversion of critical circuits, such as high-speed data buses, to fiber optics is increasingly common even in lower-cost commercial systems. here are the key facts:

- Optical fiber is immune to EMI
- Optical media uses light to transmit signals
- No electric or magnetic field interference or transient voltage spikes
- The fiber media dielectric cannot emit EMI
- Conversion to fiber optics is increasingly common, especially in high-speed datalink applications.

5 EMI Design Strategies

1. Isolate and segregate problem circuits to reduce or eliminate cross-talk
2. Absorb or conduct magnetic field radiation to ground
3. Eliminate apertures in shielding
4. Filter high-frequency interference at connector
5. Convert to fiber optics

Design Techniques Summary

To Reduce EMI Problems in Connectors and Cables

To summarize the key design strategies to reduce EMI problems in connectors and cables: (1) Use effective point-to-point grounding of electrical power lines to isolate and segregate problem circuits, and reduce cross-talk. (2) Absorb or drain conducted magnetic field radiation to ground. (3) Eliminate apertures in cable shielding for effective reflection of EMI. (4) Employ capacitive or inductive filtering of high-frequency interference at the connector, and (5) Convert to optical data transmission

Overview of TEN Current and new EMC Technologies for Interconnect Cabling

1 Cable and Wire Shielding

"Shielding reduces crosstalk, prevents transient emissions, reflects and absorbs EMI, and prevents the antenna effect".

Cable and wire shielding is one of the most effective and simple EMC choices. Shielding reduces crosstalk, prevents transient emissions, reflects and absorbs EMI, and prevents the wire antenna effect. Shielding materials can be applied to individual wires and overall cables. Shielding reduces both emissions and susceptibility. In many applications, the material type is less important than total percent of coverage. For example, a high-coverage percent is required for high frequency EMI applications. And since metal-braid and foil can be prone to gaps after handling, most high-reliability applications rely overbraided metal or composite braiding. Whatever the material, an uninterrupted ground path is essential: from the cable shield, to the backshell, to the connector, and finally to enclosure and/or equipment chassis. Here are a few tips for the application of shielding:

- Apply to individual wires and overall cables
- Material type often less important than total % coverage
- Increase coverage % in high frequency EMI
- Metal-braid and foil prone to gaps with handling
- Glenair AmberStrand® metal-clad composite braid is the latest tool in the battle for EMC. The materials provides better coverage than equivalent metal solutions while significantly reducing weight.

2 *Connector Ground Springs*

"Ground springs improve overall shielding effectiveness by reducing shell-to-shell resistance"

Connector ground springs reduce shell-to-shell resistance, and improve the ground path to eliminate surface conducted EMI. An EMI spring can be located on the plug or receptacle. Many types of spring are used, from simple dimples on shell to recessed beryllium copper springs. On the Series 79 Micro-Crimp product, the spring improves shielding effectiveness to a 60 dB attenuation minimum in the 100 MHz to 1000 MHz frequency range. Key facts include:

- Applicable to both plug or receptacle
- Range of available technologies, from simple shell dimples to integrated springs.

3 *Connector Shrouds*

"The shroud reduces apertures and gaps"

Connector shrouds minimize apertures and gaps to reduce EMI emissions and susceptibility. A connector shroud performs the role sometimes played by a backshell to fully enclose backend terminations and PCB leads within a shielded space. Key facts:

- Extension of the connector shell that fully enclosing the backend, typically for use in connector to PCB terminations.
- Eliminates EMI leaks by eliminating aperatures.

4 *Drain Wires*

"Drain wires provide a ground path for foil shielded cables"

Drain wires serve as a ground path for conducted emissions that are coupled to wrapped foil shielding. Typically, a drain wire is terminated to backshell or a dedicated connector ground pin. Key facts:

- Drain wires provide a ground path for conducted emissions coupled to wrapped foil shielding
- Drain wires are typically terminated to the backshell or a dedicated connector ground pin

5 *Shielded Boxes and Enclosures*

"Box design and plating eliminates both emmissions and susceptibility in the enclosure"

In boxes and enclosures, the key is to eliminate all unshielded apertures. Electronic enclosures are typically made of magnetically conductive materials. In high-frequency applications even small gaps at a seam, door, window or connector cutout can reduce EMC. All apertures, for instance, where connectors are mounted, must be equipped with conductive gaskets or other suitable materials. A broad range of specialty magnetically conductive materials are used in shielding box apertures. Key facts:

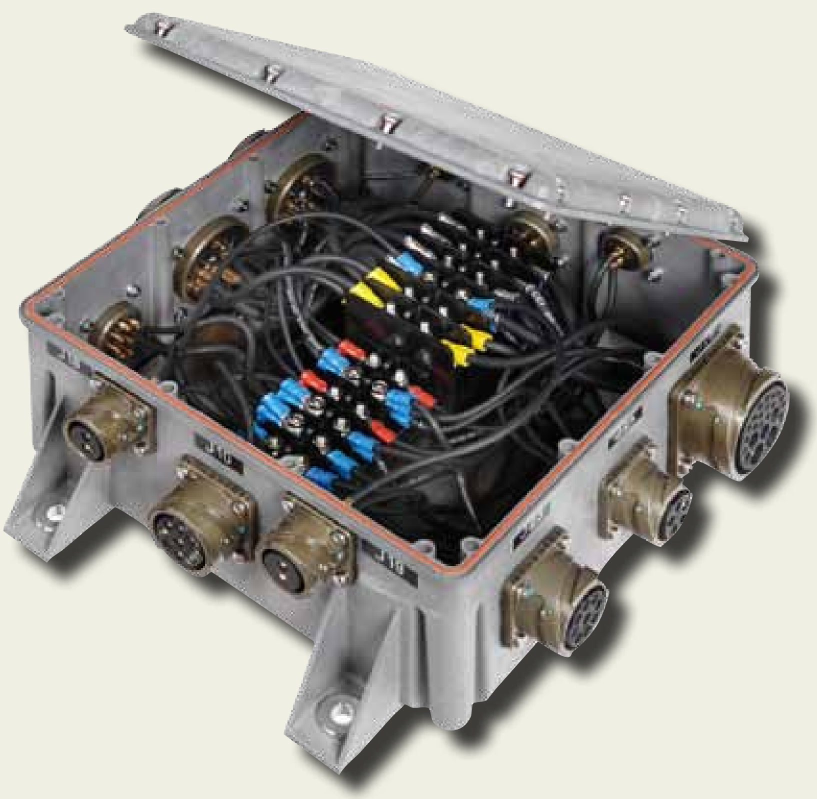
- In high-frequency applications, even very small gaps are problematic
- Always use conductive gaskets for all potential EMI windows, including connectors and all other penetrations.
- Consider internally plating boxes to insure reliable grounding and shielding of all components.

6 *Conductive Plating*

"Plating is the heart interconnect system EMC"

The selection of magnetically conductive base materials and/or surface plating is critical to EMC. The conductive layer on the outside of all EMC technologies must be optimized for low resistance and low potential drop to insure effective grounding of EMI. Surface platings must be compatible within the same galvanic range to prevent galvanic corrosion that decreases shielding performance. The appropriate galvanic range is 0.3 Volts for environmental applications and 0.5 Volts for benign environments. Key facts:

- Effective plating choices will deliver systems optimized for low resistance and low potential drop
- Plating choices in multi-component systems must always be galvanically compatible

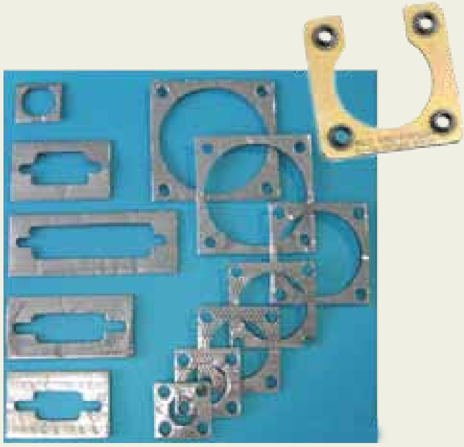


7 *Conductive Gaskets and Nut-Plates*

"Use one on every connector or feed-through"

Every connector or feed-through penetration in a shielded electronic equipment enclosure must be equipped with a conductive gasket and/or nut-plate. Die-cut conductive gaskets eliminate potential gaps between connector and box and reduce shell-to-box resistance. Connector mounting should be augmented with a nut-plate device to insure reliable connector shell attachment to box; again eliminating potential gaps. Filter connectors also perform optimally when mounted with conductive gasket and nut-plate. Key facts:

- Conductive gaskets eliminate potential gaps
- Nut-plates insure reliable, gap-free connector shell attachment to box



8 *Glenair Shield Termination Backshells*

"EMI backshells are required for every EMI shield termination application, unles shielding is to be termintated directly to the connector"

EMI Backshell provide a 360° termination platform for individual wire and overall cable shields. As we mentioned before, all EMI backshells and connectors should have common surface platings to prevent galvanic corrosion. There are dozens of different types, all of which provide the following functions:

- Insure low-resistance ground path to the connector for any conducted EMI.
- Enclose the wire-to-contact termination area to prevent EMI emission.

9 *Flexible Metal-Core Conduit*

"The ultimate in EMI Protection"

Flexible metal core conduit is the ultimate in EMI protection. With superior crush resistance, environmental protection and abrasion resistance, metal core is widely used for above-deck shipboard applications as well as in tanks, heavy machinery, air frames and submarines. You might say metal core is "versatile." Metal core conduit offers optimum EMI protection by eliminating any apertures or gaps that could allow line of sight EMI. Materials include helically wound brass, nickel iron and stainless steel. Metal core conduit has but one weakness—tensile or pull strength, which is why these products are almost always equipped with braided shielding. Key facts:

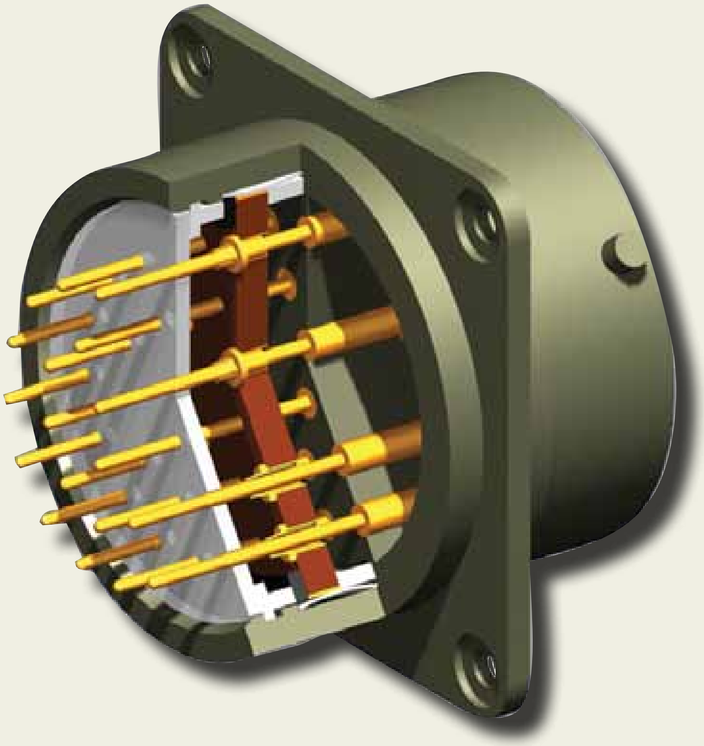
- Eliminates all potential EMI apertures
- Needs overbraiding for additional tensile strength
- Materials include helically wound brass, nickel iron, and stainless steel

10 *Filter Connectors*

"Resolves EMI problems when nothing else can".

Filtered connectors resolve EMI problems either before or after problems are discovered. They are the easiest permanent EMI/EMP solution, stripping off conducted EMI before it can pass through the connection device and harm sensitive electronics. With only a small change in connector package size, filtered connectors don't consume PCB real estate, and they easily replace an existing non-filtered connector. By using connectors, filtering is moved away from sensitive board electronics when a signal "barrier" is needed in a system. Plus, they shunts unwanted electrical surge fast {$1X10^{-9}$ seconds}. Filter packaging can mate with any standard connector – 5015, 26482, 38999, 24308, 83723, 26500, 83513, Mighty Mouse, ARINC, and more. Key facts:

- Easiest permanent solution
- Capacitance 500 pf to 50,000 pf
- Small package size
- Easily replaces existing non-filtered connector
- Mates with standard connectors
- Keeps filtering away from sensitive board electronics
- Shunts electrical surge fast {$1X10^{-9}$}



Connector Trends: High Speed

Side by side comparison of two approaches to high-speed Ethernet connectivity for military systems: The Glenair "Mighty Mouse" Cordset (left) provides superior shielding and environmental protection, as well as superior mating performance, reduced size, weight and ease of use).

In response to requests for ruggedized, shielded connectors and cables to replace unshielded systems for high-speed serial data, Glenair developed its “Mighty Mouse” high speed serial data cordsets. Available for 100BASE-T, 1000BASE-T Gigabit Ethernet, IEE 1394, USB 2.0 and CAN Bus applications, these cordsets combine aerospace-grade data cables with Series 80 “Mighty Mouse” harsh environment connectors for maximum performance and minimum size.

Until now, high-speed serial data system designers have had to settle for RJ45 connectors incorporated into large circular connector housings. Glenair understands the advantages and disadvantages of this design as we make a complete range of these devices ourselves in our 5015 type (Series ITS) and 26482 type (Series IPT) configurations (please consult the factory for information on these solutions).

But this article is about the latest trends; about solutions to interconnect challanges that use the most innovative design approaches and disciplines. And that is why we are dedicating our entire discussion on this important trend—high-speed and mixed signal datalink communications—to solutions designed around our Series 80 Mighty Mouse line.

“Mighty Mouse” ASAP cordsets offer space and weight savings with superior performance that far outmatches other attempts to bring high speed and matched impedance capabilities into the MS type circular connector packaging. These miniaturized connectors and cordsets are ideal for Ethernet data switches requiring high density packaging. “Mighty Mouse” high speed serial data cordsets are already used on numerous commercial avionics programs for sensors and other remote devices. Additionally, Glenair is proud to have these cordsets in operation on Air Force One.

ASAP “Mighty Mouse” cordsets offer many advantages over quadrax contacts. Quadrax contacts require significant termination labor and are housed in large connectors that lack the environmental sealing of “Mighty Mouse” connectors. Further, quadrax solutions are rarely robust enough for long runs in airframes, and they cannot support Gigabit Ethernet. With a large range of layout configurations, “Mighty Mouse” cordsets can easily accommodate data and power applications, and are available in all five “Mighty Mouse” connector series styles. Cabling options include 100BASE-T Ethernet 4 conductor UTP OAL shielded, 100BASE-T Ethernet Quad shielded, 1000BASE-T Gigabit Ethernet with 8 shielded conductors, IEEE 1394 Hi-Speed Quad 110 Ohm, USB 2.0 with two #22 power conductors and one STP #26, Two STP 100 Ohm shielded conductors, or Four STP 100 Ohm shielded conductors.

High density data switching in military applications: Glenair ASAP "Mighty Mouse" Cordsets are available now for 1000BASE-T Ethernet and other high-speed data protocols.

Cable jacketing comes in translucent blue FEP fluorocarbon that meets FAA flammability requirements, or black low-smoke/zero halogen polyurethane for mass transit or shipboard applications. Three strain relief options are available–polyamide overmolding, threaded aluminum backshells or low smoke/zero halogen heat-shrink boots. Specify any length of cable. Ordering is simple—there are no minimums and cable and connector components are in stock.

High-Speed Data Protocols

Ethernet

Avionic and other military vehicle data transfer systems are growing increasingly complicated—the number of data paths, data rates and the quantity and sophistication of subsystems continue to escalate. In addition to transmission speed, accuracy and reliability are tremendously important. Ethernet communication technology, with its huge installed base and history of reliability, is ideally suited for military vehicles and other field applications. Although there are many MIL-STD-1553 bus architecture and data link systems in use, applications such as tactical radar require faster data rates than older architectures can deliver.

Basic Ethernet protocol is referred to as "CSMA/DC" (Carrier Sense, Multiple Access and Collision Detection). To define some terms: "Carrier Sense," the hosts can detect whether the medium is idle or busy; "Multiple Access," multiple hosts are connected to the common medium; and "Collision Detection," when a host transmits, the protocols can determine whether its transmission has collided with the transmission of another host. If two or more information packets are sent simultaneously, a collision occurs and neither transmission is successful—collision detection instructs the system to retransmit the colliding packets. Legacy Ethernet is half-duplex, meaning information can move in only one direction at a time, and is less-than-ideal for many avionic applications, as fastest-possible communication is not guaranteed. The collision problem occurs in any bus-oriented architecture, such as MIL-STD-1553.

Full-duplex, switched Ethernet eliminates the collision problem by employing links that are point-to-point (not a bus) with a separate twisted pair for transmission and reception. Full-duplex also has the ability to send and receive data at the same time by employing a network of Ethernet switches able to forward incoming packets to their appropriate destinations. Gigabit Ethernet transfers data on four pairs of wires instead of only two pairs under legacy Ethernet forms. Further, transmission coding is enhanced for Gigabit Ethernet so that the standard clock rate of 125 MHz that produces 100 mbps data transfer rates in so-called "Fast Ethernet" is supercharged to 1,000 mbps. Gigabit Ethernet can fit an order of magnitude more data into the same cable than can Fast Ethernet, but employs the same transmission schemes and frame format as the earlier Ethernet versions.

IEEE 1394

In the early 1990s, Apple Computer and Texas Instruments worked with the Institute of Electrical and Electronics Engineers (IEEE) to establish a very fast serial bus interface standard that supports data transfer rates of up to 400 mbps (in 1394a) and 800 mbps (in 1394b). Products supporting the 1394 standard go under different names, depending on the company. Apple uses the name FireWire, Texas Instrument uses Lynx and Sony uses i.link to describe their 1394 products. A single 1394 port can be used to connect up 63 external devices. In addition to its high speed, 1394 also supports isochronous data, delivering data at a guaranteed rate. This isochronous feature makes it ideal for devices that need to transfer high levels of data in real-time, such as video and audio applications. 1394 makes full use of all SCSI (Small Computer System Interface, a parallel interface standard used for attaching peripheral devices to computers) capabilities and, compared to USB 2.0 High Speed, has higher sustained data transfer rates. Like USB, 1394 supports both Plug-and-Play and hot plugging, and also provides power to peripheral devices. A typical 1394 commercial connector is shown above.

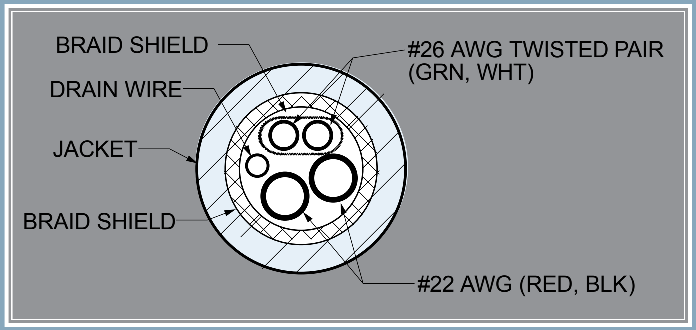
MIL-STD-1533

MIL-STD-1533 defines all aspects of the serial digital multiplex data bus for military vehicles. Multiplexing combines two or more information channels on to a common transmission medium. When compared to older analog point-to-point wire bundles, multiplexing allows for weight reduction, simplicity of system design, standardization and flexibility. The 1553 data bus provides integrated, centralized system control and a standard interface for all interconnected equipment. Devices connect using twisted, shielded pairs of wires to maintain message integrity. All devices in the system are connected to a redundant pair of buses to provide a second path of traffic should one of the buses become damaged. Data rates of 1 megabit per second (mbps) are standard under MIL-STD-1553. MIL-STD-1773 contains the requirements for fiber optic cabling systems as a 1553 bus transmission medium.

USB 2.0

USB 3.0 (Universal Serial Bus High Speed) is the most recent revision of USB specifications. Introduced by a consortium of seven computer and telecommunications industry leaders in 1995 (Compaq, DEC, IBM, Intel, Microsoft, NEC and Northern Telecom), USB ports began to appear on personal computers in 1997. Within a few years, USB became popular for connecting nearly every external peripheral device. Along with other desirable features, USB devices are "hot swappable"—they can be connected without turning the computer off, enabling removable devices to be plugged and unplugged as needed.

USB has evolved into a standard technology for personal computers and other consumer electronics. At its introduction, USB 1.0, now called "Low Speed USB," ran at just 1.5 mbps. USB 1.1, introduced in 1998 and often referred to as "Full Speed USB," runs at 12 mbps. Released in 2009, USB 3.0 or "Superspeed USB," is the most advanced with a data transfer rate of 4.8 Gbps. and is backward compatible with previous versions of USB.



The speeds associated with USB are theoretical maximums; the actual speed a USB-compliant device achieves is not necessarily the speed of the USB specification. Unlike parallel, serial, PS/2 and game port interfaces, USB features a single set of "universal" connections for all USB peripherals to the personal computer. This single set replaces the need for multiple external ports and allows up to 127 peripherals to be connected sequentially into a single external USB port using multiple USB hubs.

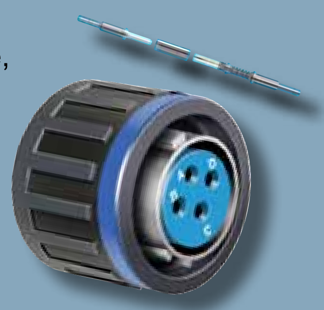
Integration

We mentioned Glenair integrates commercial connection devices that traditionaly deliver datalinks for these protocols into standard MS type connector shells. We offer rugged field-ready circular connectors that enclose single and double RJ-45 or USB connectors. Users of these standard products need not worry about damaging delicate high bandwidth connections in harsh conditions when these connectors are deployed in place of standard, non-protected solutions.The MIL-DTL-5015 or MIL-DTL-26482 type connector shells provide impact resistance, ingress protection and positive coupling.

The Ulitimate in High-Speed, High-Bandwidth Interconnect Technology: Fiber Optics

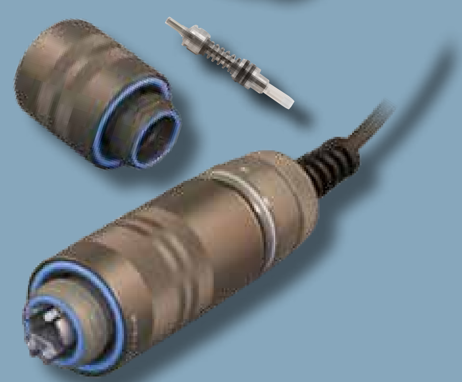
From our MIL-PRF-28876 type fiber optic connectors to our MIL-DTL-38999 type solutions, Glenair produces advanced performance fiber optic interconnection systems for every military and commercial standard. Fiber optic connectors, termini and cabling offer reduced weight, reduced size, huge bandwidth and EMI immunity— and Glenair manufactures a solution for every branch of the military and every mission-critical commercial application.

MIL-DTL-38999 Type Fiber Optic Connectors



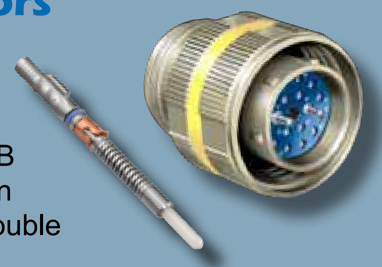
Glenair's unique alignment techniques maximize optical performance and provide reliable, repeatable interconnection of optical fibers. Ferrule design—critical to performance—has traditionally relied upon a machined stainless steel terminus incorporating a precision micro drilled hole. Glenair's unique precision ceramic ferrules, with concentricity and diametric tolerances controlled within one micron (.00004 of an inch), meet the needs of high bandwidth and low allowable insertion loss applications. In fact, Glenair's ferrules are approximately 10 times more accurate than alternative designs, and have reduced insertion loss values from 1.5dB to less than .5dB (typical loss for Glenair termini is .3 dB).

GFOCA Hermaphroditic Fiber Optic Connectors



Most commonly used by the army for long-run battlefield communications, the GFOCA Connection System is also well suited to dockside naval communications, down-hole drilling and other harsh environment applications. The hermaphroditic system uses low insertion loss butt-joint termini and a ruggedized coupling mechanism for reliable, repeatable mating. The genderless mating system is rated to 2000 cycles, depending on fiber media selection.

Glenair High Density (GHD) Fiber Optic Connectors



The Glenair High Density Fiber Optic Connector System is designed for applications that require reduced size and weight as well as outstanding optical and environmental performance. The System accomodates a broad range of single- and multi-mode fiber media, and offers insertion loss values less than .5dB (typical loss for Glenair termini is .3 dB). Dense cavity spacing is achieved with an innovative #18 genderless Front Release terminus design that provides nearly double the density of standard M28876 and D38999 fiber optic connector series.

Outlook

To Swap or Not to Swap?

All of life, and business too, is a series of trade-offs. Sometimes we may believe it wise to give up one thing to gain another. We might, for example, forego career advancement in favor of spending more time with our families. Trade-offs of that caliber are to be saluted. As the saying goes, nobody goes to their maker wishing they had spent more time at work.

But other trade-offs are not so wise. Especially when they put us in a worse position to achieve the things that really matter in life, like one's health and happiness. Simply put, many people (and organizations) will trade-away one set of conditions to achieve what they believe to be a more desirable set of conditions—often driven solely by short-term considerations.

Let's look at some specifics. What kind of a swap is it to sacrifice customer satisfaction by cutting back on customer service resources in an attempt to achieve a better short term financial metric? What kind of a swap is it to reduce maintenance, training, safety, and quality programs to show a few better quarters of financial results? What kind of a swap is it to scrimp on decent facilities, again just to shift the short-term financial metric?

We are faced with this challenge every day at Glenair. The decisions we make regarding staffing, building maintenance, safety, training, product quality—you name it—always require a trade-off. Let's face it, delivering top-notch customer service, high levels of product quality and a world-class work environment is expensive. But we will tell you honestly that faced with the choice, we will not trade-away the key operational and service strengths of our business for the sake of short-term financial "advantage."

The bottom line (as the MBA's like to say) is that companies need shock absorbers—necessary cushions to fall back on when the going gets unexpectedly tough. They need agreeable, comfortable facilities. They need adequate capacity for even the busiest months. And they need to be staffed in an ample manner to sustain high levels of productivity and service. Sure, it makes sense to watch costs. But it makes more sense to pay foremost attention to long-term health and sustainability.

To swap or not to swap. That is the question. At Glenair we believe the highest "net present value" results when we don't swap out good business practices for the sake of short-term financial "advantage."

Chris Toomey

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