QwikConnect

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HIGH-SPEED INTERCONNECT SOLUTIONS

HIGH-SPEED INTERCONNECT SOLUTIONS

Glenair continues to make significant inroads into the ruggedized high speed interconnect market. This evolution began the late 1980s with pioneering fiber-optic solutions for the Mil-Aero segment. We have since dramatically enhanced our position both in fiber-optic and high-speed over copper wire through consistent investment, the addition of industry leading engineering talent and strong technical support of our field sales teams. But as with all product development initiatives at Glenair, the main driver is our ability to listen and respond to our customers' needs.

This introduction provides an overview of high speed data transmission—a primer or reminder for the interconnect user. We divide data transmission (protocols and hardware) in to four families delineated by function, distance and topology. A separate section of this edition of *QwikConnect* presents the dominant protocols, with a short description of their key features. The interconnection hardware associated with each of the protocols will be discussed, focusing on tests and validations required to insure hardware performance meets the requirements of a given protocol. Often ruggedized applications have more stringent requirements than the standards, so proposed solutions must be validated by specific tests.

Overview of Data Transmission

The first category, labeled "peripherals," covers primarily protocols developed for user and storage interfaces connected to a computer. These peripherals are characterized by short connection distances, a few yards at the most, and cover a broad range of bandwidths from capturing keystrokes to interfacing with a high-definition display or a hard drive. The demand of bandwidth and the component costs further dictates if the transmission is bit-by-bit (serial) or in multiple streams of data (parallel).

Transmission style is an important distinction for cabling and interconnects because performance requirements typically differ. Serial links tend to be optimized for highest bandwidth, whereas parallel links are more sensitive to electromagnetic interference (EMI or "cross-talk") and timing considerations. Either way, connected peripheral devices normally do not communicate directly with each other, but are set up in a star configuration, with a single bi-directional link between the computer and each device. The connections in this category are typically fixed, and users rarely reconfigure the setup once it's running.

The second category, "Sensing and Control," covers the links used to tie a computer or a logic circuit to devices to be monitored or controlled. These devices can range from a data logging application in a laboratory to controlling the flap position on an aircraft. The connection distances for these applications can be significantly longer than in the previous category, typically up to a hundred yards. In some Sensing and Control protocols, there are provisions for a repeater device to be used for even longer distances. Bandwidth requirements can be fairly low for command and control feedback loops (industrial and aeronautic applications), but for instrumentation, data logging and image processing, bandwidth demands increase significantly. The links are typically configured as daisy chains that may include loops and branches. Often, there is a hierarchical structure amongst the nodes since data does not always flow from a central point to a peripheral instrument. The protocols in this category must be very flexible to accommodate a vast range of devices at each node. As with peripherals, the configuration is usually fixed and users don't typically modify the system once it's up and running. The majority of signal contacts carried through Glenair connectors serve Sensing and Control functions.

The third and most wide-spread commercial data transmission category is the computer network. The Ethernet protocols dominate this category, with an ever increasing range of bandwidths. High bandwidth requirements are driven by peak demand during usage bursts, but even the fastest links are frequently at idle. The network is organized by switches and routers with a tree-like structure. The configuration of the network is likely to change very frequently, new users are created and others removed. Connections and cables must be robust and flexible.

The last data transmission category covers trunk lines that typically aggregate traffic from millions of users and transmit the data over long distances.

Unlike the previous categories, this one does not have roots with the computer industry, but instead derives from telephony standards developed much longer ago. Today's trunk lines are fiber optic-based, typically spanning 560 kilometers between repeaters and about 80 kilometers between amplifiers. End points can be located thousands of miles apart. Most networks use a technology called Dense Wavelength Division Multiplexing (DWDM), where multiple optical wavelengths are transmitted simultaneously over a single mode fiber. Each wavelength carries up to 10 Gigabits of data every second, and modern trunk lines can have as many as 160 channels in a single fiber. Losses from an 80 kilometer link can be compensated with a single optical amplifier, making this technology extremely cost effective. The combination of optical amplification and wavelength multiplexing is at the core of our data-centric existence. As high bandwidth demand has edged closer to the individual user, this technology has been adapted for the mass-market and optical componentry has evolved from a niche into the mainstream electronic market. This trend will continue, and general acceptance of optical transmission technology in our markets will accelerate. In the ruggedized interconnection markets, now more than ever, the rate limiting factor in this evolution is at the interconnect level, no longer at the transmission technology. Raising these rate limits presents Glenair with opportunities reaching far into the future.

Data Transmission Application Families

Peripherals: User and storage interfaces connected to a computer

- Short connection distances (a few yards maximum)
- Cover a broad range of bandwidths
- Serial (bit-by-bit) or Parallel (multiple data streams)
- "Star" configuration
- Stable installation, not usually user-modified

Sensing and Control: Links between a computer/logic circuit and monitored or controlled devices

- Longer connection distances (100 yards, longer with repeater devices)
- Broad range of bandwidths
- "Daisy chain" configuration
- Stable installation, not usually user-modified

Computer Networks: Mainframe, server and desktop system-to-system networks

- Most widespread category
- Dominated by Ethernet protocols
- Ever-increasing range of bandwidths, driven by peak bandwidth demand
- "Tree" structure with switches and routers
- Flexible configuration, user-modified as nodes are added or removed

Trunk Lines: Long-distance point-to-point data transport media

- Aggregate traffic from millions of users
- Long distance transmission (end points can be thousands of miles apart)
- 10 GB/second per wavelength

HIGH-SPEED DATA TRANSMISSION SCIENCE

High speed proliferation:

High-speed technology is being simultaneously "pushed" and "pulled" into high reliability military/aerospace applications: Pushed from the availability of high speed technologies in consumer-grade electronics, and pulled by the constant demand for more data (imagery, positioning, video) by every level of operational forces.

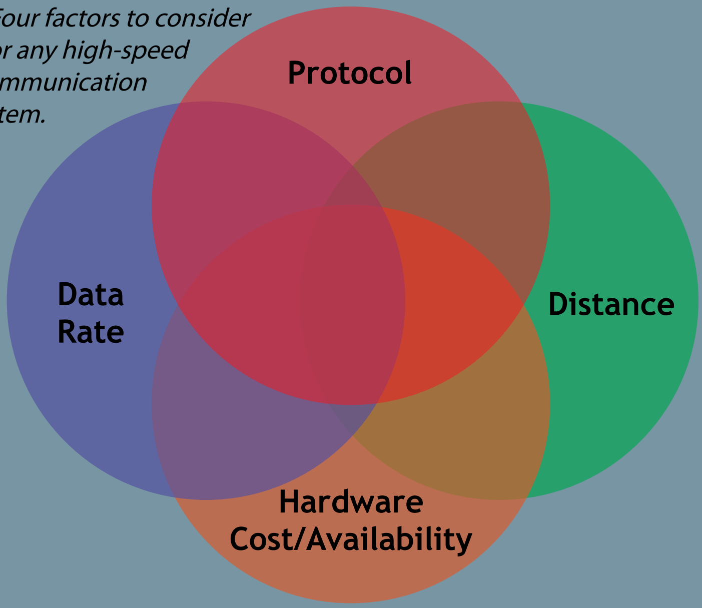
The "Push": Even inexpensive consumer-grade laptop computers now boast multiple USB, SATA, RJ45, HDMI, and DVI ports. This widespread—and increasing—availability of high speed protocols in consumer products has led to a "trickle-up" effect into Mil-Aero systems. 20 years ago, the 100kb RS 232 standard was optimal. Today's USB 3.0 offers *50,000 times* greater speed, and this increased capability is being designed into aerospace and military systems.

The "Pull": Today's Mil-Aero systems are exponentially more data-intensive than in the past. The Predator UAV has two onboard imaging systems and a laser designator that allows the pilot to identify targets and provide the laser-guidance for manned aircraft. Even a small diameter bomb now has an imaging system and integrated communications to the launch vehicle and ground station. Today's military demands that intelligence information be made available to everyone constantly—from the infantryman up to the chairman of the Joint Chiefs of Staff. This increasing demand for data "pulls" high-speed technology into the high-reliability Mil-Aero market.

Goal of communication system:

The goal of any high-speed data communication network or system is simple: Move the maximum amount of data, while minimizing bandwidth. Bandwidth is expensive, so optimizing the transfer of data is important. There are four overlapping and inter-related factors to consider:

Four factors to consider for any high-speed communication system.



Protocol: A high-speed protocol is used to optimize the amount of data per bandwidth transferred. Which high speed protocol will the system use? Examples could be 100BASE-T for computer networking, or a Military/Aerospace protocol like MIL-STD-1553.

Distance: How far does the data have to travel? A data system to connect a monitor to a computer might only have to travel one or two feet, but a fiber optic trunk line could have end points thousands of miles apart.

Hardware Cost/Availability: What cabling, routing, and devices are cost-effective for the system? Should the

The MC-12 ISR aircraft provides intelligence, surveillance, and reconnaissance support to ground forces with sensors, satellite communications datalinks and a robust voice communications suite system be flexible to allow for modifications (like when users are added to computer networks) or is it a more stable, permanent system? Will the system be expected to function in harsh environments?

Data Rate: Systems characterized as "high-speed" range from CAN bus/ARINC 825 data protocols that transmit at less than 1 MHz bandwidth, to DisplayPort protocols that can transmit in a range of 5-17 Gigabits per second. The speed of data is another important consideration.

High speed interconnect engineers make decisions about designing systems based on which of these interrelated factors they know. For example, if you know that you are designing a networking system that uses the 100BASE-T protocol, you know that your data rate can go up to 20 MHz, and you can make decisions about available hardware as you consider costs and distance limitations.

Changes occur at high speed

The behavior of electrical systems changes at high speeds. These changes must be taken into consideration as high speed systems are designed:

High Frequency Skin Effect In the DC domain, current traveling through a wire is evenly distributed throughout the conductive medium. At higher frequencies, the wavelengths get shorter, and the bulk of the current is carried at the *surface* of the conductor. This phenomenon is known as the *skin effect*. As a result, the wire begins to act more like an antenna, so interconnect designers must be more sensitive to the choice of insulating material, and to mechanical tolerances—the distance between pairs of wires, the dimensions and construction of the cable.

Wavelengths Get Shorter at high frequencies. Mechanical tolerances become more critical, and devices must be built to a smaller scale. Materials must be selected carefully because they may not exhibit the same behavior at higher frequencies. The actual physical dimensions of connectors get smaller—smaller than the wavelength of operation, so that the wave doesn't "see" the connector.

The Ideal Connector in a high speed system should be perfectly matched to the cable impedance. Glenair engineers match the transmitting wire's physical aspects (materials, spacing) as closely as possible for the best high speed connector performance.

The High-Frequency Skin Effect

Cross section of a low-frequency (60 Hz AC) conductor: The skin effect is already apparent with a biased distribution of current to the exterior of the conductor.

At 1 kHz, the skin depth is as small as 1mm in a copper conductor.

At 1MHz, the skin depth goes to as little as 100 microns.

Basic Characterization of High Speed Systems

Bandwidth, data rate, insertion loss, impedance, VSWR, jitter and skew are basic terms we can use to characterize and define aspects of high speed interconnect systems. Some basic definitions and explanations for these terms follow:

Bandwidth vs. data rate

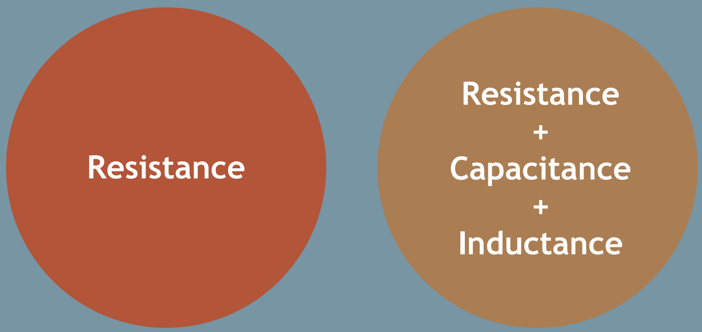
Bandwidth is the frequency range of the carrier wave. Data rate is the number of "bits" of data transferred per a given unit of time. Think of the difference between sending a fax of a document, and trying to describe and read that same document to the recipient over the phone. Both use the same *bandwidth* (the frequency of the telephone line), but the data rate of the fax is much faster—a facsimile of the document can be sent and received more quickly than a person can describe and read all of the words on the document.

Insertion loss

Insertion loss refers to the difference between the amount of data received versus what has been sent—how much data is "lost" in transmission. In high speed data systems, contributors to insertion loss include material absorption and radiation.

Impedance

Electrical impedance, or simply "impedance," describes a measure of opposition to alternating current (AC). Electrical impedance extends the concept of resistance to AC circuits, describing not only the relative amplitudes of the voltage and current, but also the relative phases. When the circuit is driven with direct current (DC), there is no distinction between impedance and resistance; the latter can be thought of as impedance with zero phase angle.



Direct Current (DC) *Alternating Current (AC)*

How Impedance is Measured: A Time Domain Reflectometer (TDR) transmits a short rise time pulse along the conductor. If the conductor is of a uniform impedance and is properly terminated, the entire transmitted pulse will be absorbed in the far-end termination and no signal will be reflected toward the TDR. Any impedance discontinuities will cause some of the incident signal to be sent back towards the source. Increases in the impedance create a reflection that reinforces the original pulse, while decreases in the impedance create a reflection that opposes the original pulse. The resulting reflected pulse is displayed or plotted as a function of time, and because the speed of signal propagation is almost constant for a given transmission medium, can be read as a function of cable length.

Impedance matching is the practice of designing the input impedance of an electrical load or the output impedance of its corresponding signal source in order to get maximum power transfer from source to load.

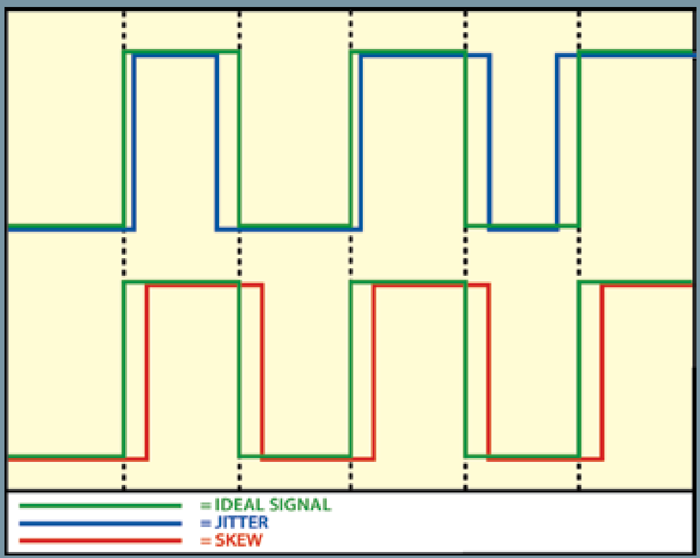
VSWR/return loss

VSWR (pronounced viz-war) stands for Voltage Standing Wave Ratio. This is a measure of how well a load is impedance-matched to a source. VSWR is used as an efficiency measure for transmission lines. Impedance mismatches in a cable tend to reflect the transmitted waves back toward the source end of the cable, preventing all the power from reaching the destination end. VSWR measures the relative size of these reflections. The value of VSWR is always expressed as a ratio with 1 in the denominator (2:1, 3:1, 10:1, etc.) It is a scalar measurement only (no angle), so although they reflect waves oppositely, a short circuit and an open circuit have the same VSWR value (infinity:1). An ideal transmission line would have an SWR of 1:1, with all the power reaching the destination and no reflected power. This perfect impedance match corresponds to a VSWR 1:1, but could never be achieved in practice.

VSWR	Reflection coefficient	Return loss	Notes
1:1	0.00	infinity	A perfect match
1.5:1	0.20	13.98	A good rule of thumb: 1.5:1 = 14 dB
1.9:1	0.31	10.16	A good rule of thumb: 1.9:1 = 10 dB
3.0:1	0.50	6.02	A good rule of thumb: 3:1 = 6 dB
infinity:1	1.000	0.00	short or open circuit

Jitter and skew

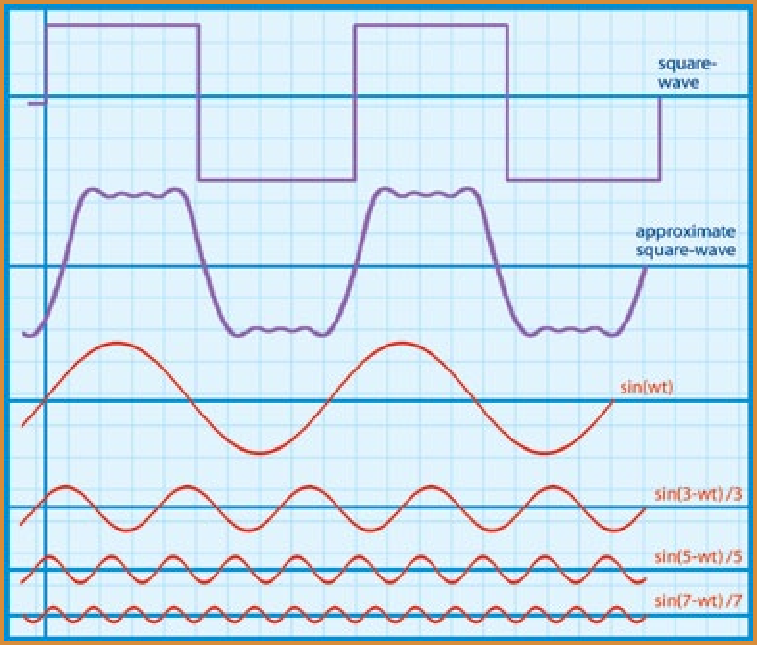
Jitter is defined as the undesired deviation from true periodicity of an assumed periodic signal in electronics and telecommunications, often in relation to a reference clock source. Skew is the difference in arrival time of simultaneously transmitted bits.



Jitter shows as 'flexing' of the square waveform, skew shows as the waveform 'offset' from the clock signal.

~MAKING WAVES~

Data transmitted as a signal can be thought of as a square wave. However, nature creates sinusoid waves. In electrical systems, multiple sine waves in harmonics create an approximation of square waves. If your carrier wave is at frequency "X," the wave actually has components at 3X, 5X, and 7X frequency for harmonics. This is an important consideration when rating cables or connectors to a certain frequency—the higher harmonic frequencies must be considered as well as the primary frequency of the carrier wave.



The Twisted Pair

High speed systems use twisted pair cabling—a type of wiring in which two conductors (the forward and return conductors of a single circuit) are twisted together to cancel electromagnetic interference (EMI) from external sources. While the high-speed technologies we are discussing are at the leading edge of today's technology, the twisted pair was invented in 1881 by Alexander Graham Bell.

The earliest telephones transmitted over telegraph lines, which were open single-wire earth return circuits. In the 1880s, electric trams were installed in many cities, which introduced noise into these circuits. The growing use of electricity in homes—with power lines strung on the same utility poles with the telephone lines—again increased interference. Lawsuits were filed, to no avail, so engineers implemented Bell's invention to cancel out the interference.

The two wires in the twisted pair carry equal and opposite signals. The destination detects the difference between the two. This is known as differential mode transmission. Wires placed side-by-side without twisting would always expose one wire to more interference than the other, but in a twisted pair, noise sources (like the electric trolley and power lines in Bell's day) tend to affect both wires equally. The noise affecting a twisted pair produces a common-mode signal which is cancelled at the receiver when the difference signal is taken.

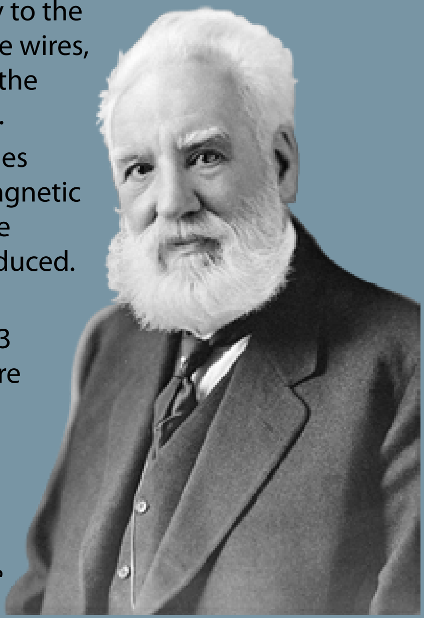
Differential Transmission Advantages

Resistance to electromagnetic interference

Transmission of a signal over a balanced line reduces the influence of noise or interference due to external stray electric fields. Twisted conductors are equally exposed to any external magnetic fields that could induce unwanted noise. A balanced line utilizes a differential receiver, and since the wires in the pair have the same impedance to ground, the interfering fields or currents induce the same voltage in both wires. The receiver responds only to the difference between the wires, it is not influenced by the induced noise voltage.

Some balanced lines also include electromagnetic shielding to reduce the amount of noise introduced.

Twisted pairs are utilized in today's Cat-3 Ethernet cables, and are still used in telephone wires.



Alexander Graham Bell, inventor of the telephone …and the twisted pair!

Double the resistance

Break out your algebra and consider a single-ended digital system with supply voltage V_S: The high logic level is V_S and the low logic level is $0V$. The difference between the two levels is therefore $V_S - 0V = V_S$.

Now consider a differential system with the same supply voltage. The voltage difference in the high state, where one wire is at V_S and the other at $0V$, is $V_S - 0V = V_S$. The voltage difference in the low state, where the voltages on the wires are exchanged, is $0V - V_S = -V_S$. The difference between high and low logic levels is therefore $V_S - (-V_S) = 2V_S$ —twice the difference of the single-ended system. If the voltage noise on one wire is uncorrelated to the noise on the other, the result is that it takes twice as much noise to cause an error with the differential system as with the single-ended system. In other words, in a differential transmission system, the noise immunity is doubled.

Suitability for use with low-voltage electronics

There is a continuing trend in the portable and mobile electronics industries to lower the supply voltage, in order to save power and reduce unwanted emitted radiation. However, a low supply voltage can cause problems with signaling because it reduces the noise immunity. Differential signaling helps to reduce these problems because, for a given supply voltage, it gives twice the noise immunity of a single-ended system.

Modern applications of low-voltage electronics include everything from closed circuit monitoring security systems, to home theater systems, and personal electronic devices like tablet PCs and cell phones.

Longer cable runs

Another advantage of balanced differential transmission is the ability to run longer cables. The aforementioned noise reduction inherent in balanced pairs reduces the amount of noise per distance, allowing a longer cable run to be practical.

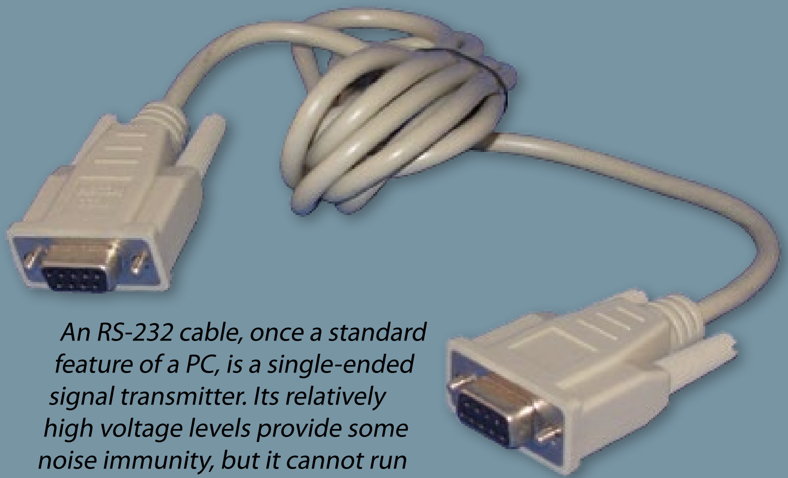
Tolerance of ground offsets

In a twisted pair differential transmission circuit, the receiving device reads the difference between the two signals. Since the receiver ignores the wires' voltages with respect to ground, small changes in ground potential between transmitter and receiver do not affect signal detection at the receiving end.

Comparison with single-ended signaling

In single-ended signaling, the transmitter generates a single voltage that the receiver compares with a fixed reference voltage, both relative to a common ground connection shared by both ends.

The widely used RS-232 system is an example of single-ended signaling. RS-232 was once a standard feature of personal computers, used for connecting modems, printers, and other peripherals. The standard uses ±12 V to represent a signal, and anything less than ±3 V to represent the lack of a signal. These high voltage levels give the signals some immunity from noise, since few naturally occurring signals create that sort of voltage. The RS-232 standard also had the advantage of requiring only one wire per signal. However, there was a serious disadvantage: it could not run at high speeds. The effects of capacitance and inductance, which filter out high-frequency signals, limit the speed. Large voltage swings driving long cables also require significant power from the transmitting end. This problem can be reduced by using smaller voltages, but then the chance of mistaking random environmental noise for a signal becomes much more of a problem. In many instances single-ended designs are not feasible. Another difficulty is the electromagnetic interference that can be generated by a single-ended signaling system which attempts to operate at high speed. These disadvantages led to the development of the low voltage, smaller-size, and high speed Universal Serial Bus (USB) standard which has displaced RS-232 for most peripheral interconnections.



An RS-232 cable, once a standard feature of a PC, is a single-ended signal transmitter. Its relatively high voltage levels provide some noise immunity, but it cannot run at high speed. It has been largely replaced by USB.

HIGH-SPEED CABLING PROTOCOLS

1. Mil-Aero Protocols				
Protocol	**# of Pairs**	**Cabling Spec**	**Bandwidth**	**Cable Construction**
CAN bus\ ARINC-825	1 Pair Per Channel	120 Ohm	< 1 MHz	Twisted Pair
1553 (ARINC-429)	1 Pair Per Channel	70-85 Ohm	1 MHz	Twinax
ARINC-664 (AFDX)	2 Pairs	100 Ohm	5-10 MHz	2 Twisted Pairs

2. Ethernet/Networking Protocols					
Protocol	**# of Pairs**	**Simplex/Duplex**	**Cabling Spec**	**Bandwidth**	**Cable Construction**
10BASE-T	2	Simplex	Cat3/4	5-MHz	2 UTP
100BASE-T	2	Simplex	CAT5	100-MHz	2 UTP
1000BASE-T	4	Duplex	CAT5E	100-MHz	4 STP
10GBASE-T	4	Duplex	CAT6/6A	500-MHz	4 STP

3. High Speed Peripheral and Display Protocols					
Protocol	**Pin Count**	**Cabling Spec**	**Bandwidth**	**Data Rate**	**Cable Construction**
USB 2.0	4	90-Ohm	400 MHz	480 MB/s	1 Data Pair 1 Power Pair
eSATA	7	100-Ohm	Up to 4.5 GHz	3 GB/s	2 Data Pairs
USB 3.0	9	90-Ohm	Up to 7.5 GHz	5 GB/s	3 Data Pairs 1 Power Pair
DisplayPort	20	100-Ohm	Up to 540 MHz	5 GB/s - 17 GB/s	4 Data Pairs
HDMI	19	100-Ohm	340 MHz	10 GB/s	4 Data Pairs

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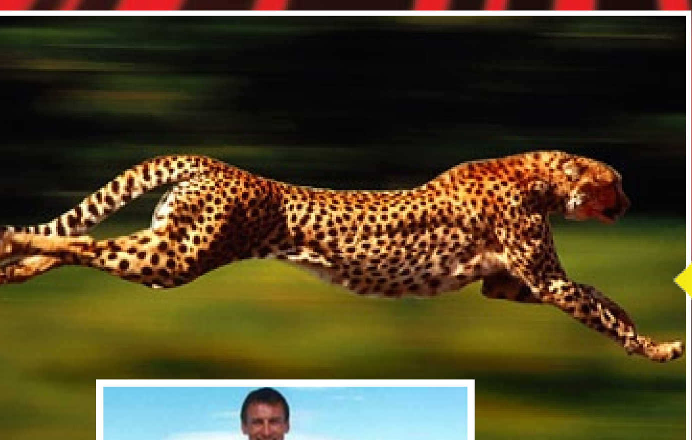
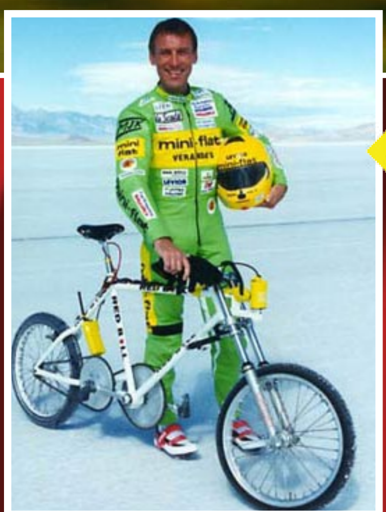
The Fastest Superhero *is The Flash. While some may argue that Superman, The Silver Surfer or Green Lantern are all equally capable of hyperspace speeds, the tie-breaker is that The Flash depends solely on his amazing speed for all his heroic feats as well as the fact that he has a much cooler name.*



The Cheetah (*Acinonyx jubatus*) ***boasts the fastest land speed of any living animal—between 70 and 75 mph—and can accelerate from 0 to over 62 mph in three seconds.***



Fastest Pedal Pusher
On October 3rd, 1995 Fred Rompelberg, cycling in the slipstream of a dragster on the Bonneville Salt Flats, attained a speed of 167.044 mph (268.831 kph). The Dutchman, at age 50, was the oldest professional cyclist in the world at the time. His record still stands.

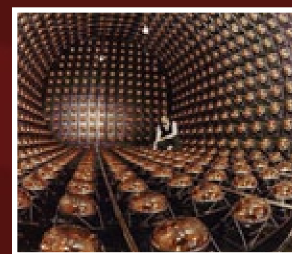
The Fastest Man in the World?
Jamaican speedster, Usain Bolt, posts an average speed of 23.72 mph or 38.18 km/h. His 2008 world record-breaking run in New York City was preceded by a lightning storm, making it way too easy for the media to nickname him, "Lightning Bolt."

HINGS RLD!

l Blackbird SR-71 has held ord for the fastest air- nned aircraft since 1976. ckbird's most interesting e features were its "chines," l powerful vortices around elves, generating much ional lift near the front f the aircraft. This lead to surprising improvements in aerodynamic performance.

The Falcon (Falco peregrinus), has been called "Nature's Finest Flying Machine." Falcons begin flying at around forty days after birth when their parents begin encouraging flight through "baiting" with food. They are famed for their aerial prowess and speed, having been clocked diving, or stooping, at speeds of up to 220 mph!

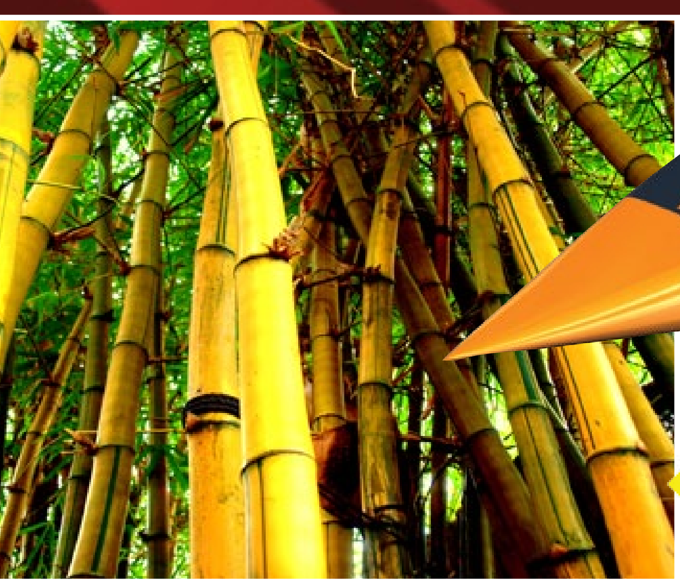
Fastest Rail-Car Rocket was successfully demonstrated by Professor Fate in 1908 to break the then world record. Fate covered the measured mile in just 12 seconds.



The Fastest thing in the Universe may be the Neutrino As of October, 2011, the value of neutrino velocity is the subject of theoretical and experimental studies. Meaning "Small Neutral One," the Neutrino is an electrically neutral, weakly interacting elementary subatomic particle. Try saying that five times fast!

The Fastest Train is France's V150. The V150 is a specially-designed TGV train code-named in reference to 150 meters per second (or more!) With a world land speed record, for conventional railed trains, of 357.2 mph (574.8 kilometers per hour), the V150 is made up of three double-decker cars with two powerful engines totalling 25,000 horsepower. Larger wheels than found on a typical TVG keep the V150's engines from overheating at higher speed.

The Fastest Car? The Bloodhound SSC is a project aiming to break the land speed record. Powered by a jet engine and rocket, it is being designed to reach approximately 1,000 mph. With full funding, construction should be complete by the end of 2012, and record attempts will be made in 2013.



The Fastest Plant With reported growth rates of 39 inches (100 cm) in 24 hours, Bamboo are some of the fastest growing plants in the world. Growth rate depends on soil and climatic conditions, however, and 1-4 inches (3-10 cm) per day is more typical.

HIGH-SPEED CABLING PROTOCOLS

Ethernet

Ethernet is a family of computer networking technologies for local area networks (LANs) commercially introduced in 1980. Standardized in IEEE 802.3, Ethernet has largely replaced competing wired LAN technologies.

Systems communicating over Ethernet divide a stream of data into individual packets called frames. Each frame contains source and destination addresses and error-checking data so that damaged data can be detected and re-transmitted.

Ethernet standards define several wiring and signaling variants that have evolved over time. The original 10BASE5 Ethernet used coaxial cable as a shared medium. Later, coaxial cables were replaced by twisted pair and fiber optic links in conjunction with hubs or switches. Data rates have periodically increased, from the original 10 megabits per second to 100 gigabits per second.

Since its commercial release, Ethernet has retained a good degree of compatibility. Features such as the 48-bit MAC address and Ethernet frame format have influenced other networking protocols.

Ethernet initially competed with two largely proprietary systems, Token Ring and Token Bus. Ethernet was able to adapt to market realities and shift to inexpensive and ubiquitous twisted pair wiring, and these proprietary protocols soon found themselves competing in a market inundated with Ethernet products. By the end of the 1980s, Ethernet was clearly the dominant network technology.

Ethernet technology has evolved to meet new bandwidth and market requirements. Growing beyond computer networking, Ethernet is now used to interconnect appliances, personal electronic devices, and in industrial applications. Ethernet is quickly replacing legacy data transmission systems in the world's telecommunications networks.

USB 2.0

USB (Universal Serial Bus) is an industry standard developed in the mid-1990s that defines the cables, connectors and protocols used for connection, communication and power supply between computers and electronic devices.

USB was designed to standardize the connection of computer peripherals (keyboards, mice, digital cameras, printers, disk drives and network adapters) to personal computers, both to communicate and to supply electric power. It has become common on other devices, such as smartphones, PDAs and video game consoles. USB has effectively replaced a variety of earlier interfaces, such as serial and parallel ports, as well as separate power chargers for portable devices.

USB 3.0

USB 3.0 is the third major revision of the Universal Serial Bus standard for computer connectivity. It has transmission speeds of up to 5 Gigabytes per second, which is 10 times faster than USB 2.0. USB 3.0 significantly reduces the time required for data transmission, reduces power consumption, and is backwards compatible with USB 2.0.

SUPERSPEED CERTIFIED USB

DisplayPort

DisplayPort is a digital display interface standard produced by the Video Electronics Standards Association (VESA). The specification defines a digital interconnect for audio and video. The interface is primarily used to connect a video source to a display device such as a computer monitor or television set.

DisplayPort is the first display interface to rely on packetized data transmission similar to other data communication protocols such as Ethernet and USB. It supports both external (box-to-box) and internal (laptop LCD panel) display connections. Unlike DVI/HDMI and LVDS standards where differential pairs are fixed to transmitting RGB pixels and a clock signal, the DisplayPort protocol transmits small data packets with the clock signal embedded. The use of data packets also allows for DisplayPort to be extensible, so that additional features can be added over time without significant changes to the interface itself.

The DisplayPort connector supports 1, 2, or 4 differential data pairs (lanes) in a Main Link, each with a raw bit rate of 1.62, 2.7, or 5.4 Gbit/s per lane with self-clock running at 162, 270, or 540 MHz.

HDMI

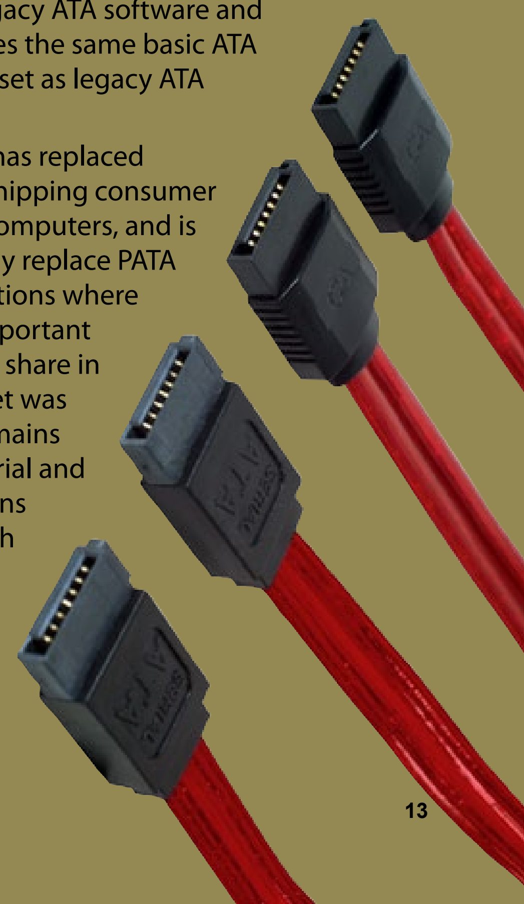
HDMI (High-Definition Multimedia Interface) is a compact audio/video interface for transmitting uncompressed digital data. It is a digital alternative to consumer analog standards, such as radio frequency (RF) coaxial cable, composite video, S-Video, SCART, component video, D-Terminal, or VGA. HDMI connects digital audio/video sources (such as DVD or Blu-ray Disc players, camcorders, PCs, video game consoles such as the PlayStation 3 and Xbox 360, and AV receivers) to compatible digital audio devices, computer monitors, video projectors, tablet computers, and digital televisions.

SATA

Serial ATA (SATA or Serial Advanced Technology Attachment, or eSATA for external SATA) is a computer bus interface for connecting host bus adapters to mass storage devices such as hard disk drives and optical drives. Serial ATA was designed to replace the older ATA (AT Attachment) standard (also known as EIDE), offering several advantages over the older parallel ATA (PATA) interface: reduced cable-bulk and cost (7 conductors versus 40), native hot swapping, faster data transfer through higher signaling rates, and more efficient transfer through an (optional) I/O queuing protocol.

SATA host-adapters and devices communicate via a high-speed serial cable over two pairs of conductors. In contrast, parallel ATA (the redesignation for the legacy ATA specifications) used a 16-bit wide data bus with many additional support and control signals, all operating at much lower frequency. To ensure backward compatibility with legacy ATA software and applications, SATA uses the same basic ATA and ATAPI command-set as legacy ATA devices.

As of 2009, SATA has replaced parallel ATA in most shipping consumer desktop and laptop computers, and is expected to eventually replace PATA in embedded applications where space and cost are important factors. SATA's market share in the desktop PC market was 99% in 2008. PATA remains widely used in industrial and embedded applications that use CompactFlash storage, though even in these applications, the next CFast storage standard will be based on SATA.

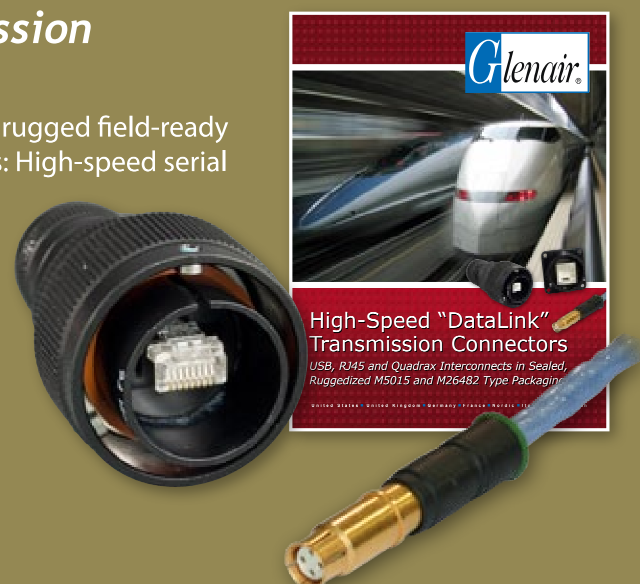


HIGH-SPEED INTERCONNECT SOLUTIONS

High-speed data transmission protocols may be organized into three broad categories: 1) Mil-Aero data bus protocols such as ARINC 1553 and CAN bus, 2) Networking protocols such as 10, 100, and 1000BASE-T Ethernet, and 3) Peripheral and display protocols such as USB 3.0 and SATA. Generally speaking, larger connector packages and contact layout densities are appropriately applied for category 1) Mil-Aero protocols. Higher density contact layouts with or without shielded contacts are appropriately applied for the Ethernet/networking category of protocols. Finally, ultraminiature and nanominiature interconnects are best applied for the highest data rate peripheral and display protocols. The following Glenair high-speed connector products are organized from largest to smallest in terms of packaging size and lowest to highest in terms of contact density per the three referenced categories of high speed protocols.

ITS Series High-Speed Datalink Transmission Connectors

Bridge the gap between high performance data transmission and rugged field-ready circular connectors with Glenair Datalink Transmission Connectors: High-speed serial data connectors and standard duty Ethernet connectors suited to 10BASE-T-1000BASE-T networking protocols are protected with military-grade connector shell packaging. USB, RJ-45 and Quadrax interconnects are integrated inside sealed, ruggedized M5015 and M26482 type connector shells. By integrating the two into a single, refined package, users will no longer have to worry about damaging delicate high bandwidth connections in harsh conditions. The MIL-DTL-5015 or MIL-DTL-26482 type connector shells provide impact resistance, ingress protection and positive coupling in a wide array of finishes and shell styles.



IPT and IPT-ST Series Bayonet-Lock Connectors

Recommended for Mil-Aero data bus protocols (CAN bus, 1553), Glenair IPT and IPT SE series connectors offer rugged, high vibration performance and rapid mating for both high-performance and general duty signal connector applications. The products are environmentally sealed and can be equipped with EMI/RFI shield termination backshell accessories. IPT SE is qualified to VG 95328. Both product series are in accordance with MIL-C-26482.

MIL-DTL-38999 Type Cylindrical Connectors

MIL-DTL-38999 is a high-performance connector family designed for cable-to-panel I/O applications in military, aerospace and other demanding situations. Environmental class plugs and receptacles—with high-density insert arrangements (up to 128 contacts)—are available with crimp removable contacts, PC tails, and solder cups. Glenair manufactures both Military Standard MIL-DTL-38999 as well as commercial Hermetic connectors plus EMI/EMP filter versions, standard environmentals, bulkhead feedthroughs, Sav-Con® connector savers and more. All of our D38999 type solutions are available with high-speed contacts and insulators optimized for CAN bus and 1553 Mil-Aero data bus protocols, as well as 10BASE-T to 1000BASE-T Ethernet/networking protocols.

Series 28 HiPer-D M24308 Intermateable Connectors

Meet the Series 28 HiPer-D. Suited for Mil-Aero Databus protocols and intermateable/intermountable with standard M24308 type D-Subs, the HiPer-D meets the need for improved performance in hostile environments. Unlike standard M24308 connectors with stamped steel shells, the HiPer-D is machined from aluminum or stainless steel. The dielectric inserts are made with thermoset epoxy for unbeatable resistance to chemicals and are capable of 200°C continuous operating temperature. Aerospace grade fluorosilicone grommets and face seals provide watertight sealing. Integrated grounding fingers provide advanced electromagnetic compatibility. Best of all, the HiPer-D is available in every standard and high-density M24308 layout and is stocked for immediate same-day shipment.

Series 79 Micro-Crimp High-Performance Rectangular Connectors

For today's high-bandwidth 1000BASE-T Ethernet networking protocols that require advanced levels of environmental protection, electromagnetic shielding and size/weight reduction, Glenair offers the Series 79 Micro-Crimp. The Micro-Crimp connector features crimp, rear-release size #23 contacts on .075 inch (1.9 mm) spacing, as well as size #12 and #16 power and coaxial crimp contacts in a range of hybrid layouts. Panel mounted connectors feature conductive sealing gaskets. Right angle printed circuit board connectors have an EMI shroud to prevent electromagnetic interference. Wire sealing grommets and interfacial seals protect circuits from moisture and contamination. Available in 31 insert arrangements, the Micro-Crimp provides a wide selection of arrangements for high-speed data as well as general-duty signal and power transmission.

Series 80 "Mighty Mouse" Ultraminiature Connectors and Cables

Glenair's revolutionary connector series reduces interconnect system size and weight by 50% compared to MIL-DTL-38999 connectors. The Mighty Mouse is used on hundreds of mission-critical defense, medical, industrial and geophysical applications. Equipped with controlled impedance or standard signal contacts, the Mighty Mouse is ideal for Mil-Aero data bus protocols like CAN bus and 1553, as well as Ethernet and networking protocols (10BASE-T to 1000BASE-T). The Mighty Mouse product line includes filtered connectors, hermetics, power and coaxial layouts, board mount connectors, overmolded cordsets, plus fiber optic and high-speed versions.

Series 80 "Mighty Mouse" High Speed PFA Teflon® Insert Connectors

Originally developed as a smaller and lighter alternative to D38999 connectors for aerospace applications, the Mighty Mouse product line now includes a broad range of insert arrangements all equipped with special PFA insulators for 100 Ohm high speed peripheral and display protocols such as eSATA, USB 3.0, and HDMI. High-speed cordsets, terminated to a broad range of commercial USB and Ethernet interconnects are also available as standard catalog offerings.

Series 811 "Mighty Mouse" High Density Connectors

Glenair Series 811 Mighty Mouse High Density (HD) is the connector series of choice for weight-saving, high-reliability performance in eSATA, USB 3.0, and HDMI protocol applications. The Series 811 High Density (HD) utilizes the same ultraminiature form factor connector shells as our standard 801 Mighty Mouse, but adds high performance micro TwistPin contacts set on .050 inch centers for optimal contact layout density. Five insert arrangements are available from 7 to 42 contacts, with additional insert arrangements in the works.

MIL-DTL-83513 Micro-D Connectors and Cables

Glenair offers qualified Military Standard 83513 Micro-D connectors as well as COTS selections, backshells, mounting hardware and more. Our TwistPin contact provides superior performance—especially in vibration and shock applications. Glenair Micro-D connectors are suited for Ethernet and networking as well as eSATA, USB 3.0 and HDMI peripheral and display protocols. Where interconnect failure is simply not an option, the Glenair high-reliability Micro-D offers performance benefits far outweighing any potential cost savings realized by specifying a lesser caliber connector.

Series 89 M32139 Nanominiature Connectors

Nanominiature connectors are high reliability-ultraminiature interconnects intended for critical peripheral and display protocol applications where size and weight restrictions will not allow the use of larger connectors. Typical applications include miniaturized electronics boxes used in UAVs, 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. Glenair nanominiature connectors, both commercial and MS QPL versions, are available with accelerated lead-times; many part numbers are stock items available for immediate shipment.

Fiber Optic Interconnect Solutions

Today, the use of fiber optic systems to carry digitized voice, video, and data is universal. For the high bandwidth demands of display and peripheral protocols such as HDMI, USB 3.0 and eSATA, fiber optic interconnect systems offer exponentially larger bandwidth compared to standard electrical cabling. Glenair manufactures a solution for every branch of the military and every mission-critical commercial application. Glenair's fiber optic offerings include Series #16 AWG Mighty Mouse, QPL MIL-PRF-28876 fiber optic connectors and MIL-DTL-38999 type solutions, Mil-qualified fiber optic termini, the innovative high-density GHD connector system, and the revolutionary Eye-Beam™ expanded-beam lens terminus.

AS39029 Qualified High Performance Contacts

Glenair brings a new perspective to the supply of high-performance crimp, shielded and fiber optic contacts: High Availability! Whether you need a standard duty socket for a MIL-DTL-28840 connector or an extended duty pin for MIL-DTL-38999 Series III, we have you covered with products that are always in stock—with no dollar or quantity minimums. The AS39029 product series supplied by Glenair includes all the most popular standard and extended duty pin and socket contacts for use in high-performance circular and rectangular multi-pin connectors. We are particularly well positioned to supply special-purpose shielded Coaxial, Twinax and Quadrax contacts demanded for today's high-speed applications.

VISIT US AT WWW.GLENAIR.COM AND USE THE LITERATURE ORDER FORM FOR IMMEDIATE CATALOG FULFILLMENT

APPLICATION CHECKLIST FOR HIGH-SPEED INTERCONNECTS

Use this checklist as a starting point for designing your high-speed interconnect system.

Analog (RF/microwave) or **High Speed Digital**

Analog (RF/microwave)

Loss budget ______________

Distance ______________

Number of RF channels

____

Bandwidth ______________

Hybrid (Yes/No) ______________

Size constraints

____

Level of interconnect/ configuration of assembly

____

High Speed Digital

(Check all applicable protocols)

Mil-Aero

- ☐ CAN bus/Arinc 825
- ☐ 1553/Arinc 429
- ☐ Arinc 664/AFDX

Ethernet/Networking

- ☐ 10BASE-T
- ☐ 100BASE-T
- ☐ 1000BASE-T
- ☐ 10GBASE-T

Peripherals and Displays

- ☐ USB 2.0
- ☐ eSATA
- ☐ USB 3.0
- ☐ DisplayPort
- ☐ HDMI

Connector package density/size requirements

- ☐ Standard (MIL-DTL-5015)
- ☐ Miniature (MIL-DTL-26482)
- ☐ Subminiature (MIL-DTL-38999)
- ☐ Ultraminiature (Series 79, Series 80 Mighty Mouse)
- ☐ Microminiature (MIL-DTL-83513 Micro-D)
- ☐ Nanominiature (MIL-DTL-32139 Nanominiature)

General dimensional details (size/shape/length)

____

____

____

____

Level of Interconnection

- ☐ Level 2: board-to-board interconnects
- ☐ Level 3: interconnects between sub-assemblies within the equipment
- ☐ Level 4: interconnects between sub-assemblies and system input/output
- ☐ Level 5: external I/O, system-to-system or cable-to-cable

Anticipated contact configurations (if known)

____

____

For hybrid cables: list other media types (additional signals, power, fiber, etc.)

____

____

Customer-supplied cable: list part number and manufacturer

____

____

Glenair supplied cable: describe cable attributes

Number of conductors ______________________

Dielectric materials ______________________

Jacketing ______________________

Reinforcing members ______________________

Additional shielding ______________________

Conduit ______________________

Electrical properties (impedance, insertion loss, wire gauge)

____

Temperature ______________________

Connector-to-connector interface

- Standard multi-pin signal contacts ☐
- Commercial RJ45 ☐
- Commercial SATA ☐
- Commercial USB ☐
- Commercial Micro USB ☐

Glenair Guiding Principles

Periodically we like to re-publish our company "Guiding Principles"—especially useful for new members of the Glenair team. These principles constitute Glenair's own unique approach to customer service.

Protect the reputation of the organization: It is your primary responsibility to behave in a manner which reflects well on Glenair. Our "zero tolerance" employee conduct policy prohibits all forms of unethical behavior in the workplace.

Be reality oriented and intellectually honest: Base decisions on an objective view of the facts obtained through your own research and "homework," rather than on optimistic opinions, guesses, assumptions, wishful thinking or outright lies.

Bow to the customer's convenience: Every customer has unique requirements, and should be allowed to choose their preferred way of doing business with us at each and every point in the sales cycle.

Build "win-win" business relationships: Build successful, long-term business relationships through mutually beneficial business practices. Avoid cumbersome rules, complex sales agreements, "one-sided" contracts, and other restrictive business arrangements.

Keep today's customer satisfied: It is cheaper to hold what you have than to retake what you have lost. Listen carefully to each existing Glenair customer to learn exactly what they value most, and then deliver that flavor of value and service in every business dealing. If we don't satisfy our current customers, someone else will.

Be the first with the most: Speed ranks with quality as the surest path to customer satisfaction, and our standard is nothing less than the fastest "turn-around" in the industry. But don't confuse speed with haste. Always balance speed with proper preparation and execution.

Follow the Glenair "game-plan": We compete on quality, flexibility, speed, availability, customer service, and complete market coverage; not on discount pricing, strong-arm sales agreements, exclusive distribution contracts, or other "conventional" marketing schemes.

Pursue each task through to completion: Make persistence and determination your approach to tackling difficult tasks. If an idea is worth pursuing in the first place, it is clearly worth more than one try.

Practice follow-up and follow-through: Visit daily every area under your supervision which has a bearing on customer satisfaction. Base decision-making on personal, first-hand knowledge and follow-through. Don't just trust that everything is working "according to plan."

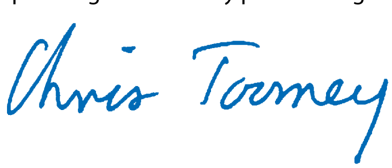
Delegate the right part of the job: Communicate the ultimate goal of a task (the "what") and empower individual employees to formulate their own execution plan (the "how").

Trust your judgement: There is no comprehensive "book of rules" for every situation affecting customer satisfaction. In the absence of an applicable guiding principle, use your best judgement to solve problems and meet customer needs. If in doubt, ask yourself how you would like to be treated if you were in the customer's shoes.

Grow the Glenair family with quality people: We employ the best and brightest in the industry. Keep your eyes open for "superstars" and work to bring them on board. Likewise, provide existing employees with training opportunities, care and respect to further their progress as members of the Glenair team.

Take Action: It is not enough to subscribe to these principles on an intellectual level. Each guiding principle requires daily attention and action. Knowledge of an effective approach only has value if the knowledge is put to use. Master these principles and act accordingly.

Reserve the right to change your mind: We have a good grip on the right way to do things. But sometimes new information becomes available--or better thinking is employed--which leads us to change the old for the new. At such times we should put our egos aside, and accept change as a healthy part of our growing business.



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