

# Qwik Connect

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**G**lenair®

Multi-Gigabit  
**Optoelectronic  
Datalinks** for  
Mission-Critical  
Applications

An EADS Astrium engineer routes a test cable on one of the James Webb Space Telescope's scientific instruments at the NASA Goddard Space Flight Center cleanroom  
Photo Credit: NASA / Chris Gun

# The ABCs of **Optoelectronic Datalinks** for Mission-Critical Applications

## An Introductory Primer for “The Rest of Us”

Glenair is in the business of making the interconnect components and wiring systems used to carry power and data from one point to another in applications such as aircraft avionics. The overwhelming majority of the technologies we produce are electrical and use copper cabling and contacts as a transmission “medium” to move electrons throughout systems comprised of sensors, controls, and other electronic devices. By contrast, fiber optic interconnect systems utilize photons (light energy) and glass fiber cable as their transmission medium. Fiber optic interconnect technologies are used when data rates, distance, or other considerations such as size, weight or EMI immunity are key requirements. But regardless of the medium (electrical or optical), the system devices that produce and consume the signals and power are always electronic. In other words, they require that the transmitted signal be delivered in a form that can be read and processed electronically. This is where “Optoelectronics” comes in. Optoelectronics (also known as Photonics) are board-level devices that convert received electromagnetic energy into optical energy (and vice versa). The big event takes place on a printed circuit board, via devices called “transceivers” that receive, convert and transmit optical and electrical signals.

This special issue of *QwikConnect* is geared for systems engineers, PCB designers and others who would like to gain a complete understanding of Glenair’s optoelectronic capabilities, especially when it comes to the many devices we produce designed for rugged high-temperature, high-vibration and space (radiation belt) environments. This short introduction is geared for “the rest of us” that need a basic understanding of optoelectronics and the applications they serve.



The conversion of electrical energy to visible optical energy is really not so grand of a thing. Folks have been doing it for years. A common light bulb, for example, performs this conversion with the simple flip of a switch. Incandescent light bulbs, such as the one shown here, use a thin filament of tungsten wire to manage the conversion. The current flowing through the wire generates heat, some of which is emitted in the form of visible light.

The use of light energy (photons) for communication is also not particularly new. Signal lamps (above) have been used in naval vessels for generations. Modern signal lamps deliver a focused pulse of light in direct line-of-sight or via reflection on clouds. The light pulse is achieved by opening and closing shutters enclosing the high-intensity light source. Signal operators use Morse code (essentially an on/off pattern of dits and dashes) to spell out the message. Despite the old-school feel of this technology, it is the grandparent of modern fiber optic communications. The principal difference is that modern high-datarate systems use modulated light (a narrow band or linewidth of light) to propagate digital pulses of light (ones and zeros) down an optical fiber instead of through the open air.

As mentioned before, conversion is a two way street. Photonic transceivers must convert electrical energy to optical energy but also optical to electrical. Photovoltaic (PV) cells, used in solar panels are commercial implementations of this technology and are able to convert sunlight directly into electricity



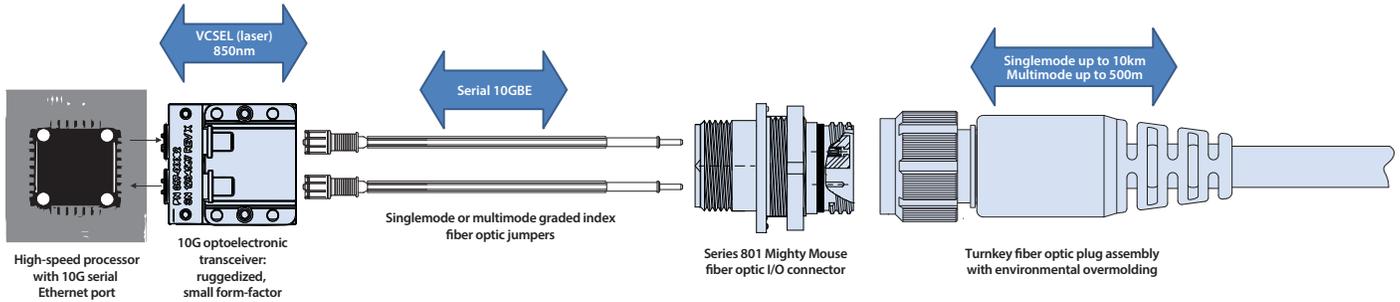
for use as power. When sunlight strikes the PV cell, it is absorbed within specially formulated “semiconductor” material. In the process, the absorbed energy knocks electrons loose, allowing them to flow freely as electrical current. In fiber optic interconnect datalinks, the role of the photovoltaic cell is performed by a miniature photodiode, an optical detector that converts photons into electrons by a process called “quantum absorption,” originally documented by Albert Einstein.

In optoelectronic interconnect systems, optical transmitters and receivers (or transceivers when the two functions are combined) are integrated circuit assemblies built from radiation-resistant and heat / vibration tolerant lasers, controllers, amplifiers and other components. The function of

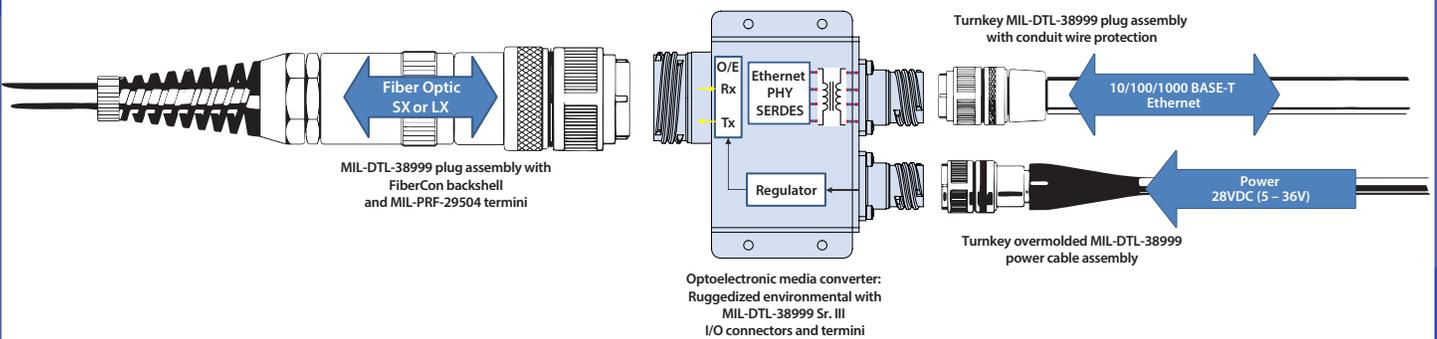
these key technologies are discussed in depth in the following pages. For now it’s enough to note that these units are the “optical engines” that convert electrical data to optical pulses—and vice versa—and are incorporated into a wide range of COTS and custom optoelectronic solutions.

Here are three real-world examples illustrating the interplay of these high-performance Glenair photonic technologies in systems such as avionic platforms, satellite communications, flight displays, data servers and other harsh application environments. Note that from the fiber optic data links to the optoelectronic components, these are all 100% manufactured, tested and qualified by Glenair. In fact we believe we are the only supplier in our industry with such a broad range of both catalog and custom capabilities.

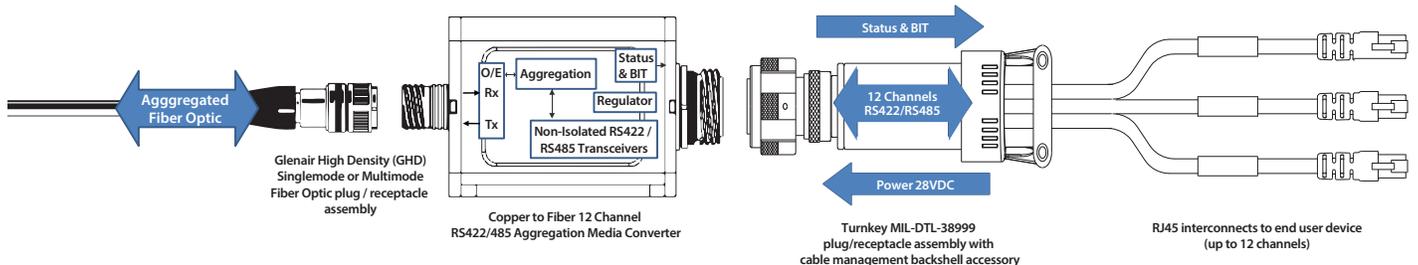
## MIGHTY MOUSE INTEGRATED OPTOELECTRONIC / FIBER OPTIC SYSTEM



## MIL-DTL-38999 INTEGRATED OPTOELECTRONIC / FIBER OPTIC SYSTEM



## GLENAIR HIGH DENSITY (GHD) INTEGRATED OPTOELECTRONIC / FIBER OPTIC AGGREGATION SYSTEM



# Multi-Gigabit Optoelectronic Datalinks for Ruggedized Applications



## AS9100D traceability

Now let's take a look at some of the application environments where these ruggedized PCB-mounted transceivers and other of our optoelectronic technologies are used to convert high-speed data from electrical bits to optical fiber and back again at rates up to 10 Gbps and beyond. Again, all of these technologies offer the same functionality and mating interfaces as legacy commercial-grade transceivers, but are ruggedized and qualified for military/aerospace environments and built in an AS9100D environment with full traceability. The expanding list of applications for Glenair Optoelectronic solutions includes phased-array radar, electronic warfare systems, video transport and switching, Ethernet switching, box-to-box and board-to-board 10 Gbps high-speed communications between processors, and network storage devices.

## Data-intensive airframe applications

Hundreds of feet of copper wire media are typically used in a commercial aircraft. Legacy airframe databus protocols such as MIL-STD-1553 put very little stress on copper media in terms of data rate and bandwidth. But new applications, including Gb Ethernet and high-definition In-Flight Entertainment (IFE), have led to commercial aircraft databus requirements better met by fiber optic media and Optoelectronic technology—particularly transmitter and receiver solutions that are reduced in size and weight. These small form-factor copper-to-fiber media converters must meet the rugged shock, vibration, and fiber-link distance requirements of this complex commercial airframe environment.



▲ Optoelectronics are ideally suited for protocol-specific airframe applications up to 10 Gbps (10 billion bits per second) such as IEEE 802.3-2015 1–100 Gb Ethernet



## High-definition video surveillance

The growing requirement for high resolution, high color fidelity, and high-speed frame rates has become a major development direction in video surveillance. The need for high-resolution video in preventive surveillance applications (like municipal policing or facility security) has led to the development of camera and recording technologies with extremely high bandwidth and high-speed requirements. Optoelectronic technologies are in high demand for their ability to affect digital-to-optical conversion as well as high-speed and high-bandwidth data transport.



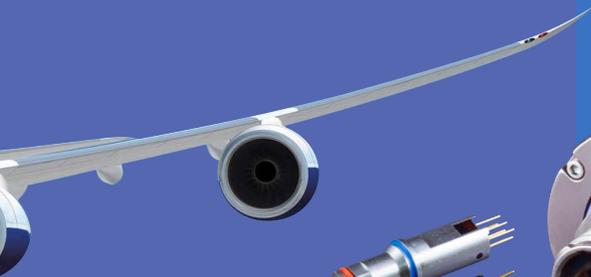
## Ultra high-bandwidth electronics

The proliferation of radar technology, combined with higher-resolution data requirements, has led to the incorporation of fiber optic and optoelectronic media conversion—particularly small-footprint PCB mount transceivers. Next-generation military radar offers longer standoff range and the ability to simultaneously detect, identify and track multiple air and surface targets. These compact and lightweight radar modules increasingly rely on interference-free small form-factor Optoelectronic componentry.

▲ In addition to aerospace applications of high-bandwidth radar technology, numerous ground-to-air radar systems have been developed to support ground soldiers with more robust air traffic control capabilities.



Photo: Balticservers.com



▲ Glenair optoelectronics remove much of the complexity of incorporating fiber optics into high-speed Ethernet data server applications. By moving transmitter and receiver functions into active cables or to the I/O interface of equipment housings, large data farm installations may be upgraded to high-speed fiber optic datalink capabilities without major redesign of the network configuration.

## Aerospace avionics/displays

Glenair Optoelectronic technologies are designed specifically for military/ aerospace environments—including space vehicles and satellites—where commercial transceivers can't go. They are fully self-contained and require no soldering to the host board. FPGAs with 10 Gbps I/O are being widely deployed in mil/aero equipment (processor boards employing Xilinx, Altera, etc.) for 100-ohm differential CML 10 Gbps data. Glenair Harsh-Environment Fiber Optic Transceivers are perfectly applied in these applications to increase signal integrity, reduce system complexity and optimize size and weight requirements.



# Multi-Gigabit Optoelectronic Datalinks for Space Avionics

## Technical Overview for PCB Designers and Space System Engineers

No other application environment is as weight conscious as space. The use of non-metallic fiber optic components in multi-gigabit datalinks onboard spacecraft can save significant weight and deliver other benefits compared to traditional copper-based cabling including complete electrical isolation between modules, immunity from radio frequency (RF) interference, and elimination of "ground loops". The Glenair line of rugged COTS photonic transceiver components is particularly well-suited for space applications and has been purpose-designed to for use in harsh-environment multi-gigabit fiber optic datalinks. Fiber optic interconnect engineers as well as PCB designers and system engineers will appreciate this deep dive into the design, construction and reliability testing of Glenair ruggedized photonic technologies.

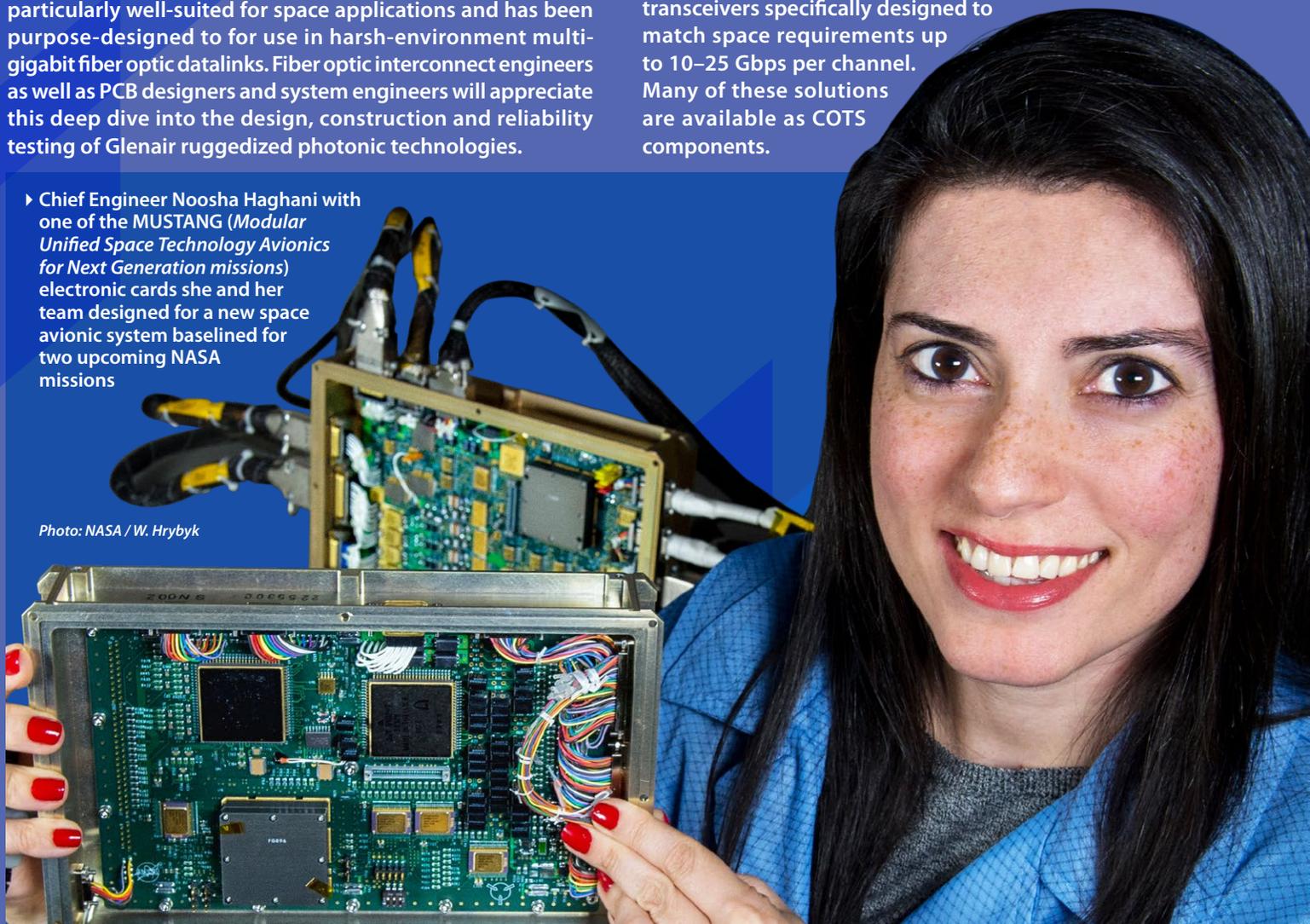
- ▶ Chief Engineer Noosha Haghani with one of the MUSTANG (*Modular Unified Space Technology Avionics for Next Generation missions*) electronic cards she and her team designed for a new space avionic system baselined for two upcoming NASA missions

Photo: NASA / W. Hrybyk

## Data Transmission in Space

Data transmission rates between avionics modules onboard spacecraft continue to increase, driven by the use of processors with multi-gigabit-per-second high-speed serial data I/O's. These complex systems support the growing data requirements of onboard sensors and increased bandwidth requirements between communications switches and satellite communication terminals. Optical fiber is an ideal medium for space-based signal transmission platforms, since it supports data rates up to many 10s of Gbps, is far lighter and smaller than copper wiring of equivalent bandwidth, and is immune to radio-frequency (RF) interference from adjacent cables (and therefore does not require heavy RF shielding). Ground-loop issues are also reduced due to the complete electrical isolation provided by non-metallic fiber-optic assemblies.

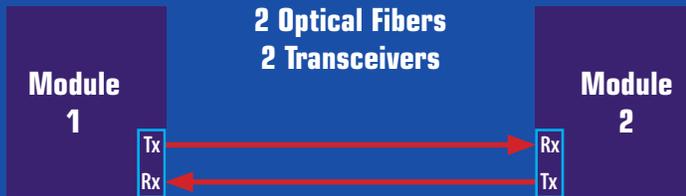
The emerging SpaceFibre standard for spacecraft networking anticipates the use of both high-speed serial copper and fiber optic transmission between avionics modules and subsystems at serial data rates up to 10 Gbps. However today, the availability of suitable photonic transceivers for space applications is not widespread. Glenair has undertaken a comprehensive development program for photonic transceivers specifically designed to match space requirements up to 10–25 Gbps per channel. Many of these solutions are available as COTS components.



### 100-Ohm Differential Data 4 Coax Cables



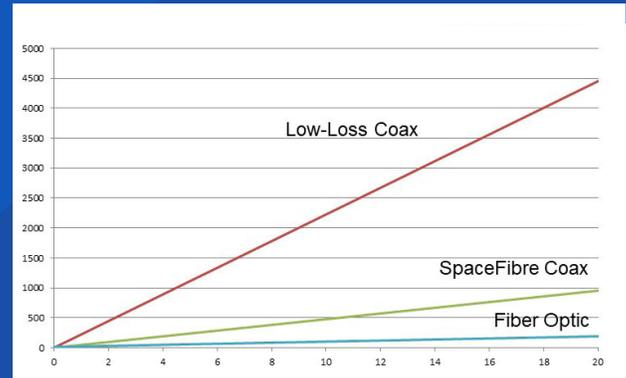
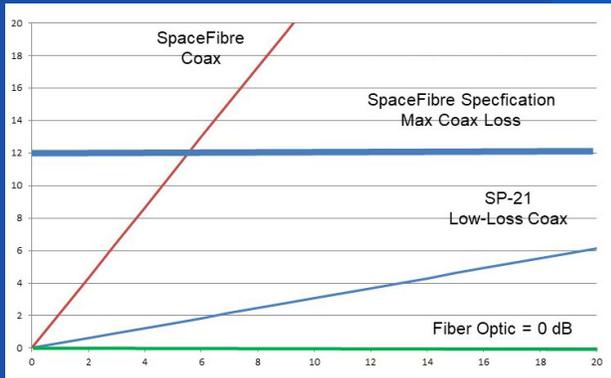
### 2 Optical Fibers 2 Transceivers



**Table 1: Summary of cable loss and mass at 10GHz for a 3m link**

	Low-Loss Coax (Gore Type 21 Space-grade)	SpaceFibre Coax (Axon AW2.2)	Fiber Optic (2mm jacketed with 2 XCVR)
Cables required	4	4	2
Loss	1.5 dB + 2 conn	10.7 dB + 2 conn	0 dB
Cable mass (no connectors)	223 g/m	48 g/m	9.6 g/m
Optical XCVRs	0	0	9.4g
3-meter total mass	<b>669g</b>	<b>144g</b>	<b>38.2g</b>
Power consumption	<b>0</b>	<b>0</b>	<b>0.8W</b>

**Figure 1. Comparison of interconnect solutions for SpaceFibre.**



**Figure 2. Left: comparison of dB loss vs. cable length for coax and fiber optic links  
Right: mass vs. length for various cables.**

As mentioned, fiber optics can contribute to substantial reduction in the size and weight of datalink cabling on spacecraft. But the promise of fiber optic weight reduction can only be achieved when transmitters, receivers and transceivers can be supplied with mission-critical levels of reliability—including hardening against severe space stress factors, such as vibration, shock, temperature and multiple forms of radiation.

Here is a practical example illustrating some of the advantages of fiber optic cabling compared to copper-based coax cables on a spacecraft (see Figure 1 above): in the example, a digital serial datalink is operating at 1 to 10 Gbps between two modules using the SpaceFibre data networking protocol standard. Serial differential digital current-mode-logic (CML) signals are sent in both directions between Module 1 and Module 2. According to the SpaceFibre draft standard, this can be accomplished in two ways:

1. Using four high-speed copper coax cables (two coaxes for each of the 100-ohm differential signal pairs), or
2. Using two fiber-optic links (one fiber for each signal path).

The mass of the four copper cables is 48 g/m, the diameter of each cable is 2.4mm, and the loss at 10 GHz is 3 dB/m. By comparison, the mass for each of the two optical links is 10 g/m with a diameter of 2 mm per jacketed simplex fiber (note: the loss of the link is fully compensated in the electronics to generate a full-amplitude CML signal at the end of the link). The photonic transceivers at each end of the link each have a mass of 5 g, and a circuit board footprint of approximately 2 cm X 2 cm. Completing the math, the total mass of the SpaceFibre copper cabling is 144g vs. 38g for the 3-meter optical link, a 3.8X reduction in mass. If low-loss Gore Type 21 coax is used instead, the reduction in weight is even greater: 17X (670g vs 38g) for a 3-meter link. See Figure 2 and Table 1 for the full details.

## Designing Photonic Transceivers for Space

So having established the benefits of using fiber optic datalinks in SpaceFibre applications, let's turn now to the design of the various optoelectronic devices, which as we stated have been specifically ruggedized for use in space. The Glenair transceiver has two main components: a laser transmitter and a photodiode receiver. The function of the transmitter is to convert electrical serial data bits to optical pulses. The photodiode receiver converts optical pulses to electrical serial data bits. These two functions are performed in conjunction with semiconductor and integrated circuit (IC) devices such as laser diodes, electronic amplifiers, and control-loop components.

To achieve bit rates up to 10 Gbps, commercially-sourced laser diodes, photodiodes and IC components were selected by Glenair that operate from -40°C to +85°C without the need for external thermal controls. While manufacturers of these commercial grade components do not typically have test data for the performance of their devices in radiation environments, Glenair was able to select solutions that, due to material type, were intrinsically radiation-resistant. As radiation-hardened performance is one of the central challenges in fielding photonic transceivers in space applications, the selection of intrinsically radiation-resistant componentry was critical to the design process (more on radiation exposure levels and testing below).



**Figure 3.**  
Top: Optoelectronic Size #8 Contact, Center: D-sub connector version, Bottom: D38999 connector version



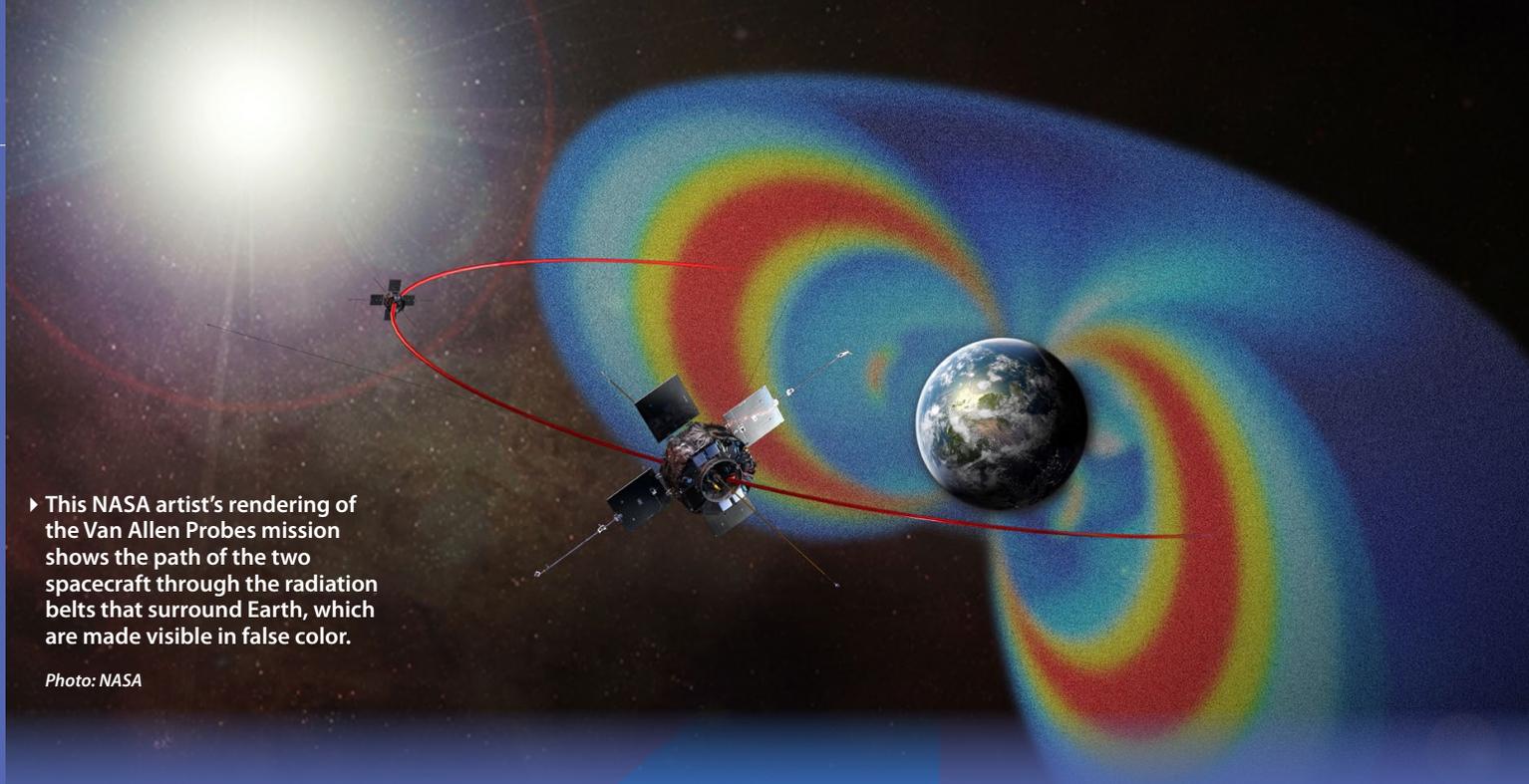
**Figure 4.**  
PCB-mountable quad-output transmitter unit: Top view (left) and bottom view (right).

Many if not most commercial-grade Datacom transceivers and IC chipsets contain CMOS circuitry and memory to support bias control lookup and other functions. Such memory-dependent components are notoriously prone to radiation damage. So in addition to our focus on material makeup, we specifically prohibited the use of CMOS circuitry in our ruggedized transceiver technologies.

Turning to packaging, our goal was for the absolute smallest size, but always with the ability to interface reliably with aerospace-grade fiber optic datalink connectors as well as the many standard I/O connectors commonly used in aerospace avionics. Commercially available transceiver devices incorporate serial I/O monitor and control ports that conform to datacom industry networking interface standards and are built primarily for commercial-grade optical connectors. As such they are not suitable for use in space. Our approach was to design optical engines and other of our photonic solutions for drop-in accommodation in aerospace-grade connectors that, as stated above, are built to withstand the radiation exposure, temperature, and vibration/shock levels encountered in space.

These two key design principles were applied by Glenair to a pair of unique package designs: a size #8 cavity optoelectronic contact that fits directly into the wide range of aerospace-grade I/O connectors, and a family of printed circuit board (PCB) mountable transceivers. Let's take a look at these two solutions beginning with the ultra-small size #8 optoelectronic contact (see figure 3).

The ultimate in small form-factor packaging, Glenair size #8 transmitter and receiver contacts provide optoelectric conversion of high-speed data signals at the I/O interface to the avionics box or module. The contacts transmit and receive differential CML electrical signals over multimode fiber optic cable. Transmitters consist of a laser driver with a temperature compensation circuit to maintain optical power over the entire operating temperature range, and an 850nm VCSEL laser. The transmitter has a Tx Disable Pin to turn off/reset transmitter output and a Tx Fault Pin to signal a fault condition. Receivers consist of an 850nm PIN Photo Detector, a Transimpedance Amplifier with automatic gain control circuit, and a Limiting Amplifier. The receiver also includes a CMOS-compatible loss of output signal (LOS) indicator. Tx-fault and LOS signals are used by the system to enable built-in-test (BIT) functionality.



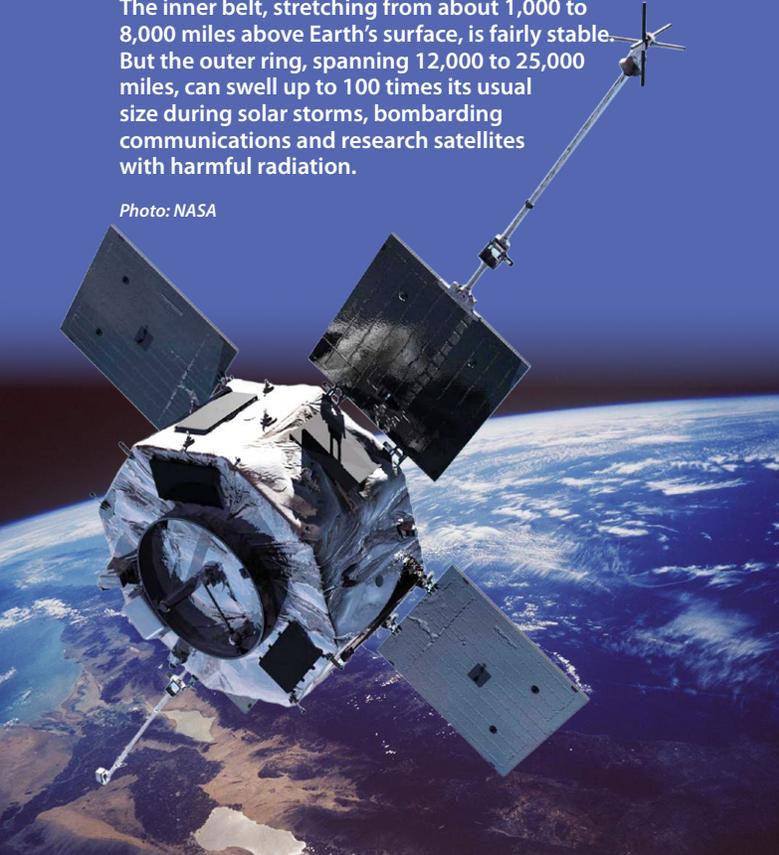
▶ This NASA artist's rendering of the Van Allen Probes mission shows the path of the two spacecraft through the radiation belts that surround Earth, which are made visible in false color.

Photo: NASA

Again, the focus of the development was on fitting into the allotted form-factor, strictly complying with ARINC 801 optical contact float requirements, and surviving harsh aerospace environments. The result is a family of transmitter and receiver contacts that may be inserted directly into ARINC 404 or 600 avionic-bay connectors, or into special front-insert D38999 or D-sub connectors (see Figure 3). The optical fiber interface of the ARINC 801 fiber optic contact used supports repeated blind-mating due to the incorporation of a unique patented

- ▼ One of the Van Allen Probes orbiting the earth. Its namesake radiation belts were discovered in 1958 with instruments aboard the Explorer 1 spacecraft. The inner belt, stretching from about 1,000 to 8,000 miles above Earth's surface, is fairly stable. But the outer ring, spanning 12,000 to 25,000 miles, can swell up to 100 times its usual size during solar storms, bombarding communications and research satellites with harmful radiation.

Photo: NASA

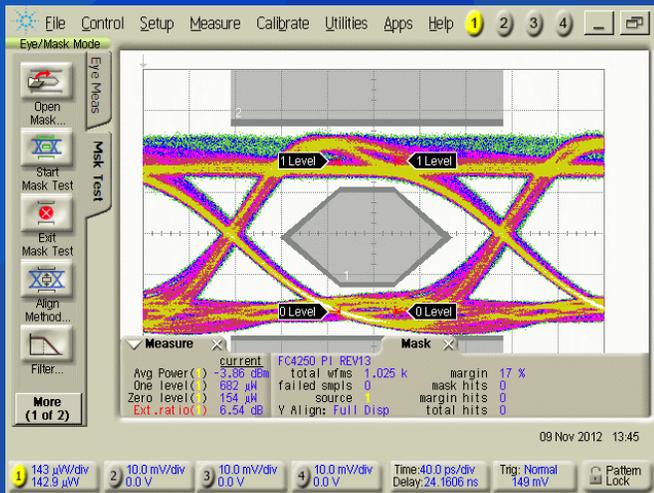


design featuring a floating optical ferrule, mated to a flexible circuit board assembly internal to the unit.

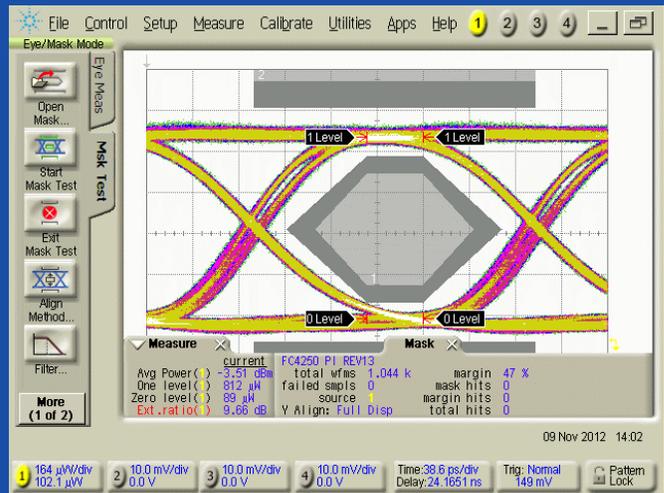
The optical interface to the cable is accomplished using a mating adapter in the plug that accepts a standard ARINC 801 optical contact supporting data rates from 50 Mbps to 5 Gbps. Contacts operate from 3.3 V input power, consume ~60 mA of current, and have a transmitter enable input, as well as transmitter fault and Loss of Signal (LOS) output status discrete signals. The optical interface specifications conform to the output power levels, eye-mask-margins, extinction ratios, and receiver sensitivity typical of industry-standard Fiber Channel and Gigabit Ethernet specifications. Optical ports will interface via standard 50/125 micron or 62.5/125 micron multimode optical fiber and with other commercial datacom optical transceivers as might be encountered in ground test equipment.

As mentioned above, one benefit of this simplified circuit approach is that there are no microprocessor or memory devices in the units, which are typically more susceptible to single-event effects (SEE), latch-up, and so on.

In addition to the Size #8 contacts, the same optical and electrical device circuits have been incorporated into printed-circuit-board (PCB) mountable transceivers as shown in Figure 4. Glenair PCB mount transceivers are ruggedized harsh-environment equivalents to SFP transceivers but with mechanical design suited to the harsh temperature and vibration environments found in Military and Aerospace applications. Glenair PCB-mount optical transceivers for non-radiation environments support optional Digital Monitoring Interface (DMI) features in accordance with SFF 8472. The Transceiver is comprised of a transmitter section and a receiver section that reside on a common package and interface with a host board through a high-speed electrical connector. A broad



-40°C



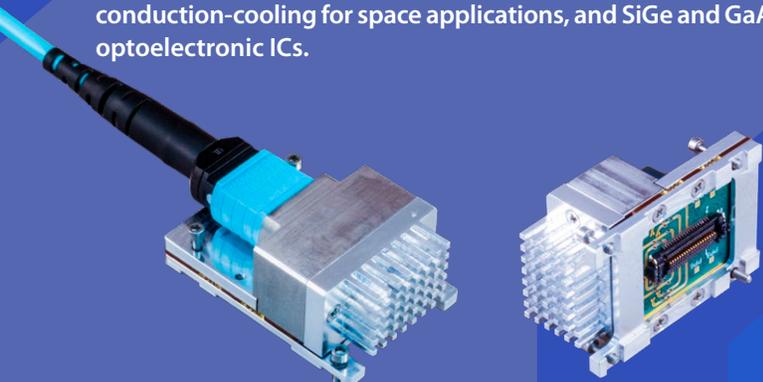
+90°C

Figure 5. Size #8 contact filtered eye diagrams at 4.25Gbps.

range of Ethernet application types are supported including High-Speed Digital balanced signals (including 4B/5B, 8B/10B, and 64B/66B) Fast Ethernet, Gigabit Ethernet, 10G Ethernet Fiber Channel (1X, 2X, 4X, 8X), ARINC 818, AFDX, SFPDP, and Serial Rapid I/O (sRIO). Video application support includes DVI, ARINC 818, and SMPTE (SDI, HD-SDI, 3G-SDI).

These devices utilize a high-speed surface-mounted PCB connector on the bottom of the unit to provide the connectivity to the host PCB via 100-ohm differential CML data streams, and are affixed using captive screws to threaded inserts soldered into the host PCB. This mechanical structure eliminates any stress on the high-speed electrical connector, and provides for heat sinking of the unit to the PCB.

The transceivers are supplied in a wide range of form factors, data rates, wavelengths, laser and receiver types. Special 50 Gbps multi-channel (Parallel) photonic transceivers have also been developed and deliver Up to 12.5 Gbps per fiber, with conduction-cooling for space applications, and SiGe and GaAs optoelectronic ICs.



▲ 050-346 Parallel optical 40Gbps PCB-mount photonic transceiver

In addition to discrete transceiver devices for surface-mount PCB application, Glenair supplies the optical engines pre-packaged in environmental media converters with a wide range of I/O interconnects and optical / electrical performance.

## Test results

Various reliability and qualification tests were conducted on both the Size #8 Optoelectronic contacts as well as the ruggedized space-grade transceivers.

The filtered transmitter eye diagram at 4.25 Gbps for the Size #8 contacts at various temperatures is shown in Figure 5. Test data demonstrates stable optical power, acceptable eye-mask margins and extinction ratios over the -40°C to +90°C range of ambient operating temperature. The performance of the board-mount transceivers is similar; understandable since they use the same circuit schematic and components. The eye-mask testing was performed at 4.25 Gbps due to the availability of test equipment with this data rate filter. The links tested using these devices also run error-free at 5 Gbps.

The receiver sensitivity typical for the Size #8 optoelectronic contact measured at 4.25 Gbps is approximately -19 dBm, which is 5 dB of margin beyond the Fiber Channel standard specification for 4.25 Gbps of -14 dBm. Given the transmitter output power of approximately -3.5 dBm, this yields an optical link budget of greater than 16 dB at 4.25 Gbps.

2000-hour accelerated aging tests were performed on 20 transmitter and receiver devices while operating at +85°C, and no failures were observed. Temperature cycle testing was also performed for 1000 cycles from -55°C to +125°C, non-



operating on the PCB-mount transceivers as well as the Size #8 contacts. The units were removed at intervals and subjected to additional temperature cycling from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  to ensure operating temperature performance within specifications.

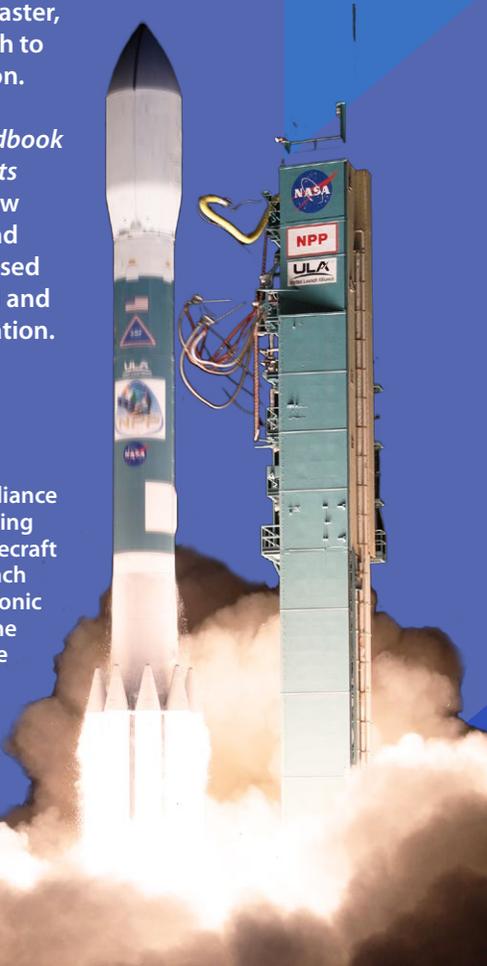
Transceivers were subjected to operational vibration and shock testing. This was followed by 650 G, 0.9 ms shock pulses, 10 shocks per direction in all three axes. The units were exposed to these levels while operating and errors were monitored at 5 Gbps. No errors were detected during any of these exposures.

Finally, the Size #8 contacts were tested for resistance to radiation exposure to 165 krad of gamma radiation from a cobalt-60 source, and  $2.5 \times 10^{12}$  neutrons/cm<sup>2</sup>, while operating under continuous error monitoring—with no errors detected. Test results of for proton and heavy ion irradiation are complete and available from the factory on request. The radiation levels these parts have survived are in-line with the most severe requirements for earth-orbiting spacecraft.

Our scientists incorporate the latest research and best practices on the measurement of radiation effects in optoelectronic systems, providing consumers of these solutions with a faster, more reliable path to space qualification. Throughout the process, the *Handbook of Radiation Effects* (above) by Andrew Holmes-Siedle and Len Adams was used for both practical and theoretical validation.

▶ A United Launch Alliance Delta II rocket carrying the NASA NPP spacecraft lifts off. Rocket launch subjects optoelectronic components to some of the most extreme vibration forces imaginable

Photo: NASA/ULA



## Optoelectronics By Location

### INSIDE-THE-BOX: PCB-MOUNTED RUGGEDIZED TRANSCEIVERS



### AT-THE-BOX INTERFACE: PHOTONIC CONTACTS AND CONNECTORS



### OUTSIDE-THE-BOX: ENVIRONMENTAL MEDIA CONVERTERS AND ACTIVE CABLES



# Integrated Optoelectronic and Fiber Optic Datalinks

Glenair signature Fiber Optic interconnect solutions for GB Ethernet and other high-speed/high-bandwidth applications

## TURNKEY FIBER OPTIC CABLE AND CONDUIT ASSEMBLIES



Catalog point-to-point solutions as well as bespoke multibranch assemblies

## GLENAIR BUTT-JOINT FIBER OPTIC CONNECTION SYSTEMS



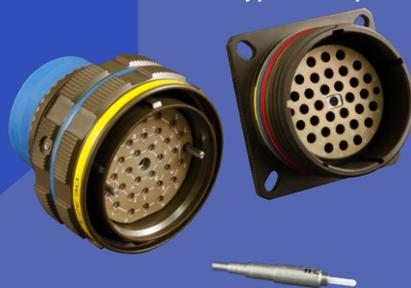
MIL-DTL-38999 type fiber optic



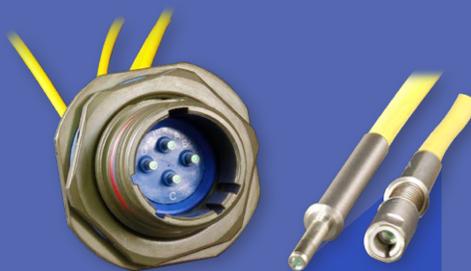
Glenair High Density (GHD) fiber optic



Mighty Mouse fiber optic



ARINC 801 type fiber optic



Eye-Beam® GLT grin-lens expanded beam



NGCON MIL-PRF-64266 fiber optics



MIL-PRF-28876 fiber optic

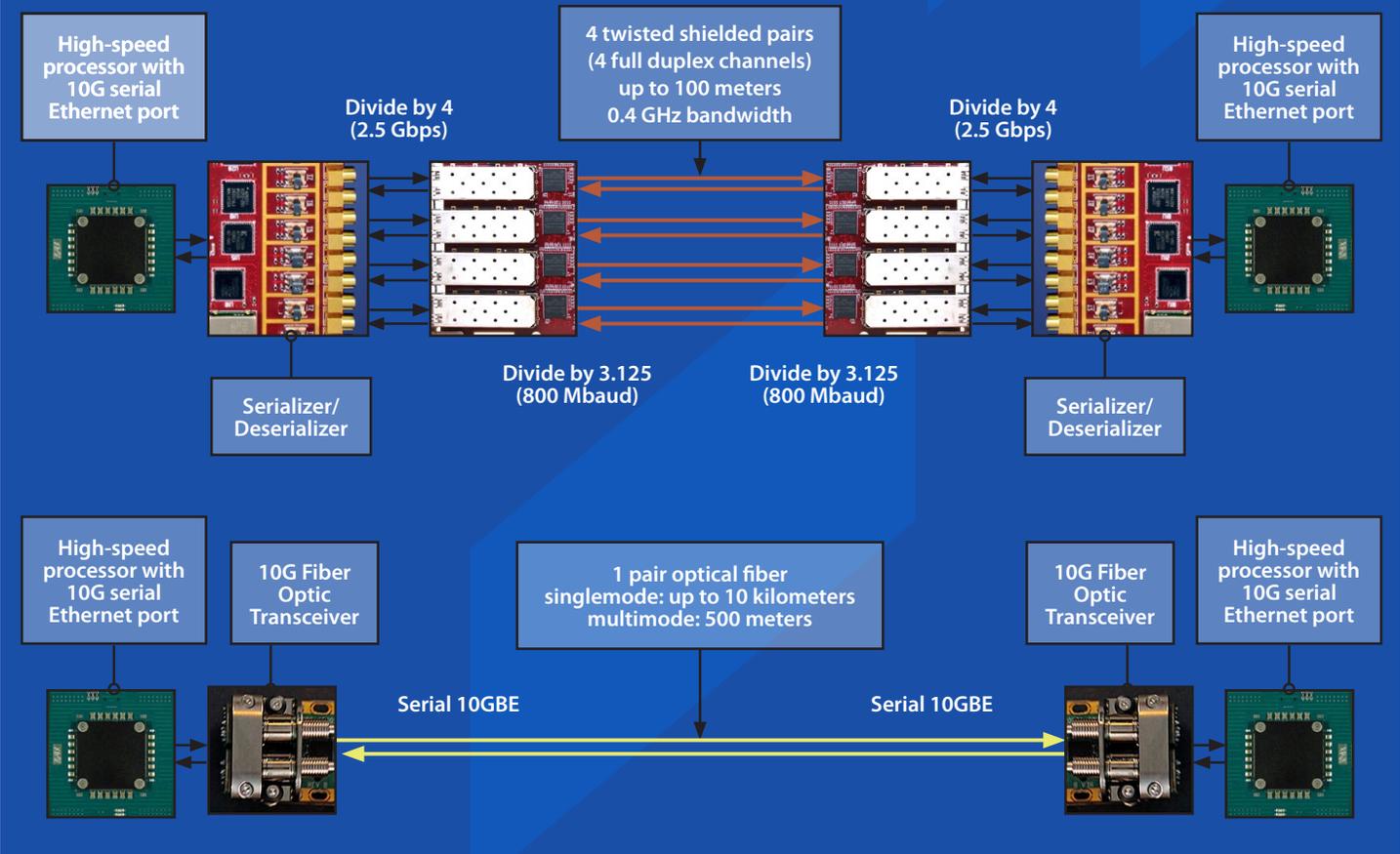


GFOCA M83526 Compliant fiber optic



Glenair Front Release (GFR) fiber optic

## HOW ETHERNET WORKS IN COPPER VS. FIBER OPTIC SYSTEMS



## 10G Serial data vs. 10G Ethernet

10/100/1000BASE-T interfaces are ubiquitous on all types of equipment. In electrical-only systems, Ethernet Physical-Layer (or PHY) and serializer/de-serializer (SERDES) electronics transform a high-speed serial BASEband digital signal into a series of parallel signals. Each parallel signal uses highly-bandwidth-efficient modulation/demodulation techniques at each end of the cable. This allows for dramatic reduction of cable bandwidth requirements, but adds the cost of sophisticated Ethernet signal processing electronics at each end. For example, since transmission is bi-directional (on 4 twisted pairs of wires for GB Ethernet and 10GB Ethernet) it requires echo-cancellation and other processing. This is why a shielded twisted pair can support 10GBASE-T Ethernet, but could never support 10 Gigabit serial transmission.

Ethernet signal processing breaks up a high-speed data stream up to 10 Gbps into 4 lower-data-rate streams, reducing the required bandwidth by more than 10X. This allows straight-pin connectors and twisted pair wiring to be used. Significantly,

all of the Ethernet signal processing can be avoided by incorporating fiber-optics into the system. Using 10G fiber-optic transceivers between chips, for example, eliminates the need to convert 10G serial Ethernet signals to 10G Ethernet and back again. Fiber optics easily supports 10G serial data rates over long distances, simplifying system design and maximizing signal integrity.

In fact all high-speed signal formats benefit from incorporation of fiber optics, including 10/100/1000 BASE-T and 10 GB Ethernet; DVI and HDMI Video; High Speed Digital Data (1-10 Gbps or higher).

As fiber-optic technology has advanced, particularly in the ability to utilize field-programmable gate arrays (FPGA) as high-performance optical interconnections at the logic (board) level in high-speed 10G+ systems, the value of photonic technology has become much more tangible. As a result, the point or level at which optical technology offers a demonstrable advantage compared to purely electrical systems has moved lower—out of stand-alone transceivers and interconnect cabling to board and logic layer solutions and integration components.

# AS9100 Rev. D Certified Optoelectronics Assembly and Test Laboratory

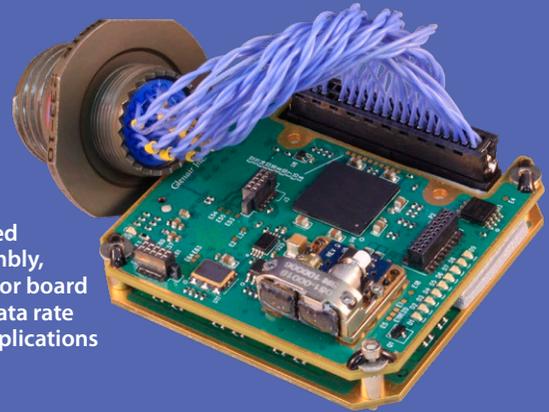
Turnkey in-house optical and electrical PCBA design, development, assembly, and test



▲ Final assembly, PCB-mount optoelectronic transceiver



▲ Assembly lines, 11,000 sq. ft. optoelectronic assembly and test facility, Glendale CA



▶ Embedded subassembly, aggregator board for low data rate signal applications



▲ Conformal coating of optoelectronic subassembly



▲ Assembly of ruggedized Ethernet copper-to-fiber media converter subassembly



▲ Small form-factor ruggedized media converter subassembly

▶ Fiber optic datalink OTDR inspection/qualification



◀ Thermal shock and cycling: 100% production part environmental inspection and test, with simultaneous signal integrity qualification

▼ Eye pattern / signal integrity testing: 100% inspection and test of all production parts



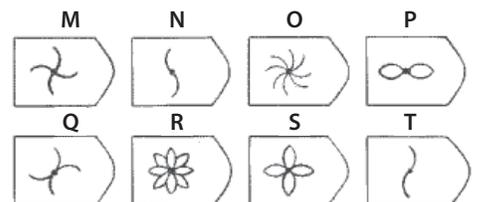
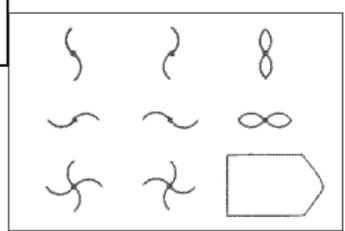
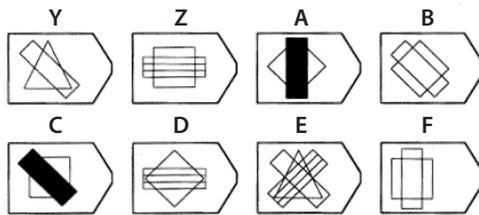
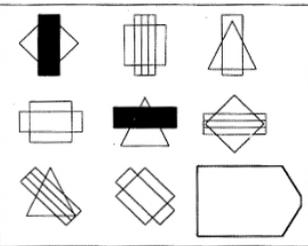
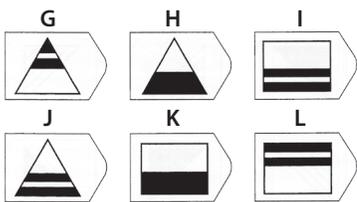
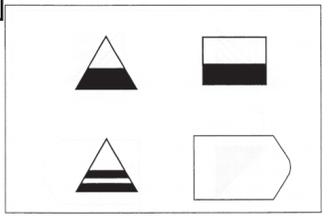
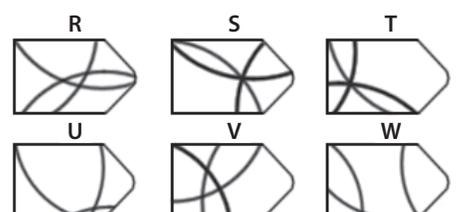
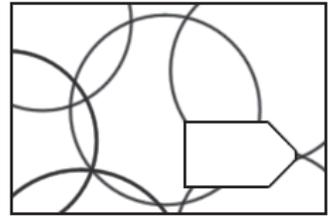
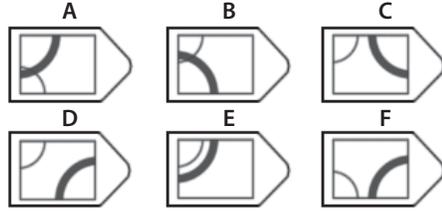
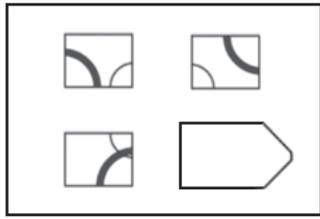
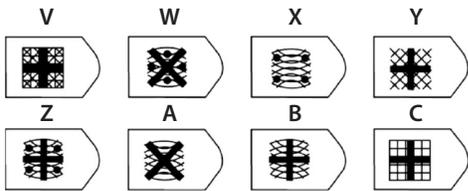
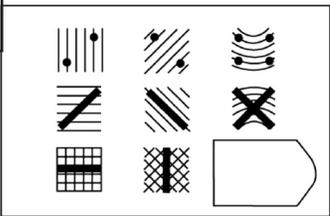
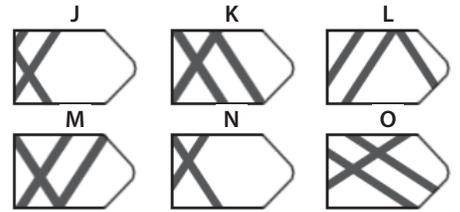
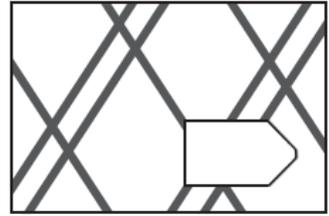
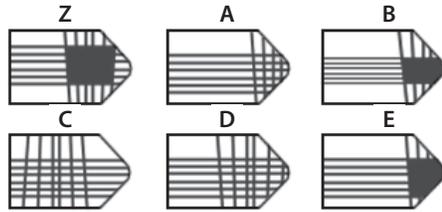
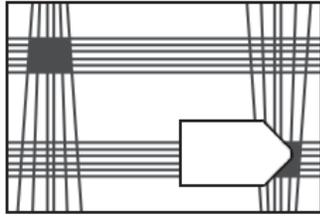
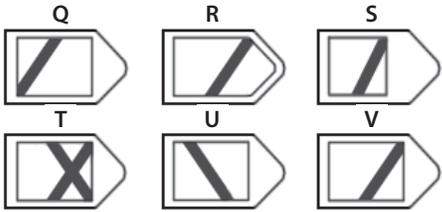
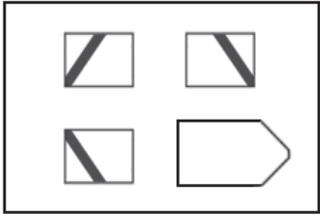
▶ PCB-mount transceiver evaluation and test board

# Hey, is this some kind of IQ test?

**I**

The image displays a 3x3 grid of IQ test puzzles. Each puzzle is contained within a rectangular frame. The top-left corner of each puzzle frame contains a 2x2 grid of shapes. The bottom-right cell of this 2x2 grid is an empty pentagonal shape with a pointed right side, intended for the correct answer. Below each puzzle frame is a set of five possible answers, each within a pentagonal frame and labeled with a letter.

- Puzzle 1 (Top-Left):** The 2x2 grid contains two identical octagons with a diagonal line and a shaded triangle, and one empty pentagonal shape. Options H-M show variations of the octagon and a shaded circle.
- Puzzle 2 (Top-Middle):** The 2x2 grid contains two identical squares with a vertical line and a horizontal line, and one empty pentagonal shape. Options K-M show variations of the square and the pentagonal shape.
- Puzzle 3 (Top-Right):** The 2x2 grid contains a 5x5 grid of dots with diagonal lines, and one empty pentagonal shape. Options J-O show variations of the grid and the pentagonal shape.
- Puzzle 4 (Middle-Left):** The 2x2 grid contains a square with a small square in the bottom-right, two overlapping circles, and a triangle. The bottom-right cell is an empty pentagonal shape. Options Y-F show variations of these shapes.
- Puzzle 5 (Middle-Middle):** The 2x2 grid contains a circle with vertical lines, a square with vertical lines, and one empty pentagonal shape. Options C-H show variations of the circle and square patterns.
- Puzzle 6 (Middle-Right):** The 2x2 grid contains a circle with a dot inside, a circle with a dot inside, and one empty pentagonal shape. Options I-N show variations of the circle and dot.
- Puzzle 7 (Bottom-Left):** The 2x2 grid contains a square with a small black square in the bottom-left, a square with a small black square in the bottom-left, and one empty pentagonal shape. Options K-R show variations of the square and black square.
- Puzzle 8 (Bottom-Middle):** The 2x2 grid contains a square with an 'X', a square with a 'Z', and a square with a diagonal line. The bottom-right cell is an empty pentagonal shape. Options I-P show variations of these shapes.
- Puzzle 9 (Bottom-Right):** The 2x2 grid contains a diamond with a dot inside, a diamond with a dot inside, and one empty pentagonal shape. Options O-T show variations of the diamond and dot.



Answers in Chris Toomey's *Outlook* column (last page)



# INSIDE-THE-BOX

## PCB-Mount Optoelectronics: connectorized, high-density, board-mount transceivers built for rugged vibration and shock applications up to 10Gbps



050-404/405 RF-over-fiber for SATCOM, IFE and other RF distribution systems

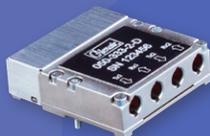
Glenair PCB mount transceivers are ruggedized harsh-environment equivalents to SFP transceivers but with mechanical design suited to the harsh temperature and vibration environments found in Military and Aerospace applications. PCB mount optical transceivers support optional Digital Monitoring Interface (DMI) features in accordance with SFF 8472. The Transceiver is comprised of a transmitter section and a receiver section that reside on a common package and interface with a host board through a high-speed electrical connector.

- Smallest footprint available
- Passed jet fighter and space launch shock and vibration testing
- No soldering required
- CML 100 Ohm differential input and output
- -40°C to +85°C operating temperature range

### RUGGEDIZED 10 GBPS PCB-MOUNT MODULES FOR ETHERNET, HIGH-SPEED VIDEO, AND STORAGE



EMI shielded and radiation-tolerant transceivers



Dual transceivers, quad transmitters, quad receivers



Bi-directional transceivers

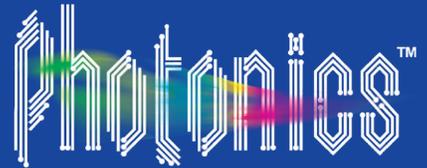


Parallel optical transceivers



Small form-factor, high-vibration, high-temperature tolerant

# PCB-Mount Transceivers, Transmitters and Receivers



**General Purpose / Ethernet Applications:** High-Speed Digital balanced signals (i.e. 4B/5B, 8B/10B, 62B/64B etc.) Fast Ethernet, Gigabit Ethernet, 10G Ethernet Fiber Channel (1X, 2X, 4X, 8X), ARINC 818, AFDX, SFPDP, Serial Rapid I/O (sRIO)

**Video Applications:** DVI, ARINC 818, SMPTE (SDI, HD-SDI, 3G-SDI)

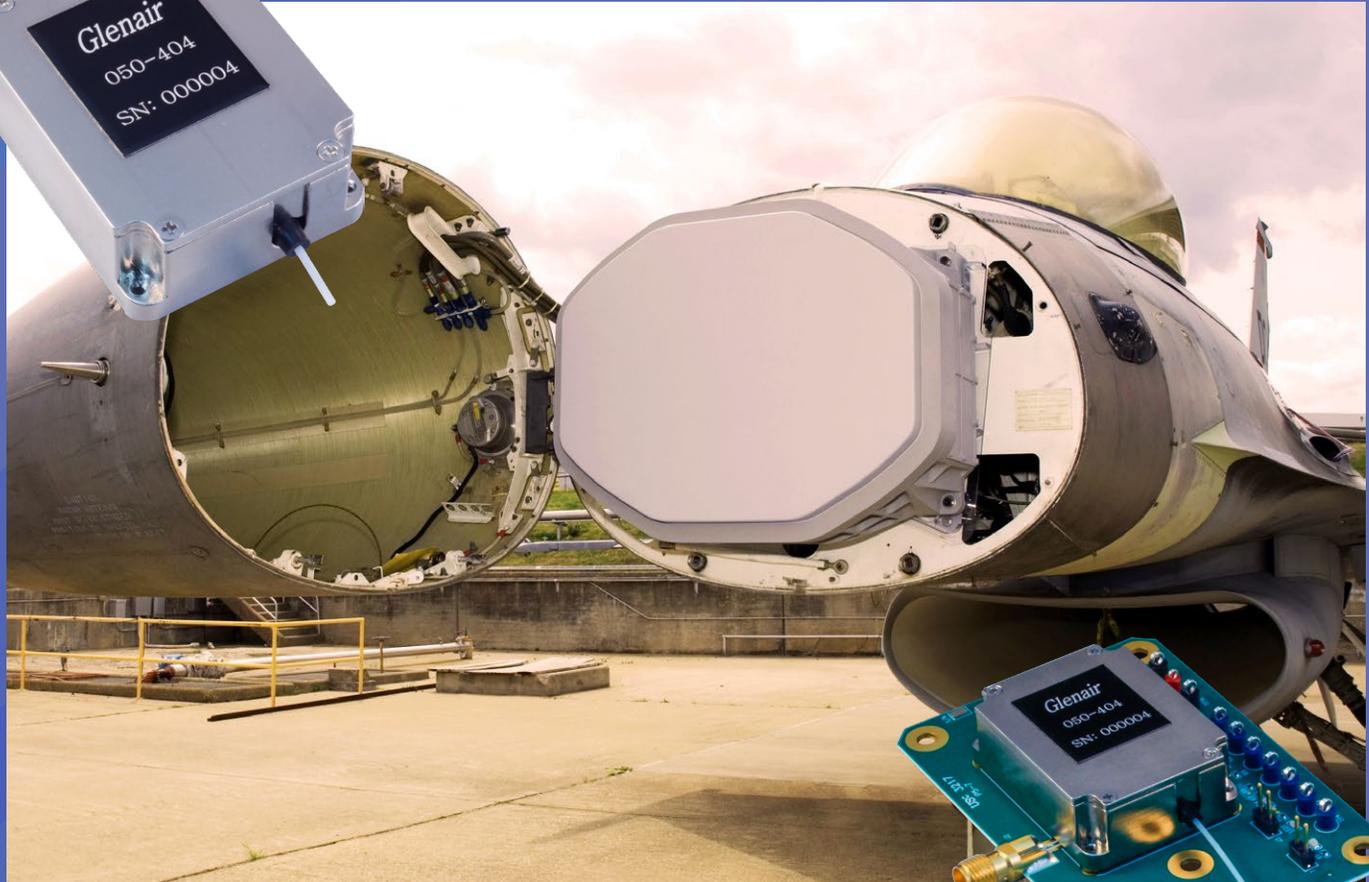


Part Number	DESCRIPTION	DATARATE (Gbps)	WAVE LENGTH (nm)	LASER TYPE	RECEIVER TYPE	MAX. DISTANCE (km)	PACKAGE TYPE
050-315	Transceiver	0.1 - 5	850	VCSEL	PIN TIA	0.5	1
050-316	Dual Transmitter	0.1 - 5	850	VCSEL	N/A	0.5	1
050-317	Dual Receiver	0.1 - 5	850	N/A	PIN TIA	0.5	1
050-318	Transceiver	0.1 - 1.25	1310	FP	PIN TIA	10	1
050-319	Dual Transmitter	0.1 - 2.5	1310	FP	N/A	10	1
050-320	Dual Receiver	0.1 - 4.25	1310	N/A	PIN TIA	10	1
050-321	Transceiver	0.05 - 0.2	1300	LED	PIN TIA	20	1
050-324	Transceiver	0.1 - 2.5	1310	DFB	PIN TIA	40	1
050-325	Dual Transmitter	0.1 - 2.5	1310	DFB	N/A	40	1
050-327	Transceiver	1 - 10.5	850	VCSEL	PIN TIA	0.4	1
050-328	Transceiver	1 - 10.5	1310	DFB	PIN TIA	10	1
050-331	SMPTE Dual Transmitter	1.5 - 2.97	850	VCSEL	N/A	1	1
050-332	SMPTE Dual Receiver	1.5 - 2.97	850	N/A	PIN TIA	1	1
050-333	Dual Transceiver	0.1 - 5	850	VCSEL	PIN TIA	0.5	2
050-336	Quad Transmitter	0.1 - 5	850	VCSEL	N/A	0.5	2
050-337	Quad Receiver	0.1 - 5	850	N/A	PIN TIA	0.5	2
050-340	BIDI Transceiver	0.1 - 1.25	1310/1550	FP/FP	PIN TIA	4	1
050-341	BIDI Transceiver	1 - 10	1270/1330	DFB/DFB	PIN TIA	10	1
050-342	CWDM Transceiver	0.1 - 2.5	CWDM	DFB	PIN TIA	20	1
050-343	CWDM Transceiver	1 - 10.5	CWDM	DFB	PIN TIA	10	1
050-346	Parallel Optical Transceiver	4 X 10 - 14	850	VCSEL	PIN TIA	0.5	3
050-348	EMI Shielded Transceiver	0.1 - 5	850	VCSEL	PIN TIA	0.5	1
050-352	Transceiver	0.05 - 0.2	1310	FP	PIN TIA	10	1
050-354	Transceiver	2.5 - 5	1310	FP	PIN TIA	10	1
050-356	CWDM Dual Transmitter	0.1 - 2.5	CWDM	DFB	N/A	10	1
050-357	SMPTE Dual Receiver	1.5 - 2.97	1250-1600	VCSEL	PIN TIA	10	1
050-358	SMPTE CWDM Dual Transmitter	1.5	CWDM	DFB	N/A	10	1
050-360	Radiation-Tolerant Dual Transmitter	0.1 - 5	850	VCSEL	N/A	0.5	1
050-361	Radiation-Tolerant Dual Receiver	0.1 - 5	850	VCSEL	PIN TIA	0.5	1
050-362	Radiation-Tolerant Transceiver	0.1 - 5	850	VCSEL	PIN TIA	0.5	1
050-363	Radiation-Tolerant Quad Transmitter	0.1 - 5	850	VCSEL	N/A	0.5	2
050-364	Radiation-Tolerant Quad Receiver	0.1 - 5	850	VCSEL	PIN TIA	0.5	2
050-369	Transceiver MMF TX · SMF RX	1 - 10	850 TX 1310 RX	VCSEL	PIN TIA	10	1
050-373	Dual-Transceiver (4 mounting screws)	0.1 - 5	850	VCSEL	PIN TIA	0.5	2
050-374	Quad Transmitter (4 mounting screws)	0.1 - 5	850	VCSEL	N/A	0.5	2
050-375	Quad Receiver (4 mounting screws)	0.1 - 5	850	N/A	PIN TIA	0.5	2
050-376	CWDM Dual Transmitter	1 - 10	CWDM	DFB	N/A	10	1
050-379	SMPTE CWDM Transceiver	1.5	CWDM	DFB	PIN TIA	10	1
050-385	Radiation-Tolerant Dual Transceiver	0.1 - 5	850	VCSEL	PIN TIA	0.5	2
050-386	Dual Transmitter	1 - 10.5	850	VCSEL	PIN TIA	0.4	1
050-389	SMPTE Transceiver	1.5 - 2.97	850	VCSEL	PIN TIA	1	1
050-394	BIDI Transceiver	0.1 - 2.5	1310/1490	DFB/DFB	PIN TIA	10	1
050-397	BIDI Transceiver	0.1 - 1.25	1310/1550	DFB/DFB	PIN TIA	10	1



## INSIDE-THE-BOX

# RF over Fiber low-noise PCB-mounted transmitters, receivers, and transceivers

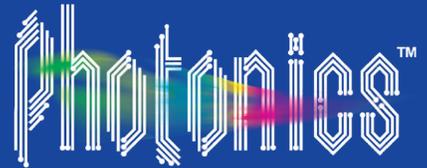


Radio Frequency over Fiber (RFoF) communication systems integrate wireless radio frequency (RF) transmissions and fiber optic datalinks into a single system. The technology allows designers to far exceed the distance and data-rate capabilities of conventional copper coax wire media used in legacy RF data-link applications. RF over Fiber is an analog conversion process that modulates the laser-generated light within the conversion unit with the RF signal for transmission over optical fiber. RF over fiber is an antenna signal distribution technology ideally suited for mobile and fixed-earth installations such as secure command centers, reduced-footprint airframe applications, naval vessels, phased-array antenna installations and more.

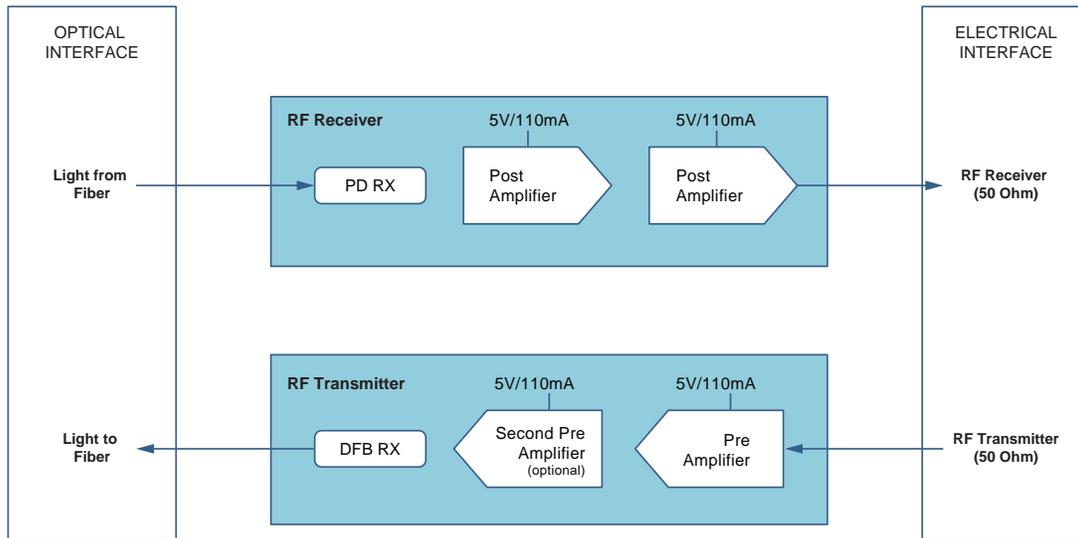
The benefits of RF over Fiber include lower transmission loss (attenuation) as well as reduced sensitivity to electromagnetic noise. The usual range of fiber optic benefits, including immunity to EMI/EMP, unlimited transmission distances, lighter weight, and improved security also apply. Glenair low-noise, shielded RF over Fiber solutions have a useful RF bandwidth from 2 MHz to 3.5 GHz can be embedded inside-the-box, such as with the PCB-mount transceivers highlighted on this spread, or incorporated into stand-alone copper-to-fiber media converters for outside-the-box environmental applications. Higher-frequency units, up to 40 GHz, are currently under development.

Glenair RF over fiber transmitters, receivers, and transceivers are ruggedized for military and aerospace applications that demand high temperature as well as vibration and shock tolerance.

- 2MHz – 3.5 GHz antenna signal distribution
- New high-frequency 20 and 40 GHz units in development
- High-vibration PCB mount solution
- -40°C to +85°C operating case temperature
- High Spurious Free Dynamic Range (SFDR) link
- APC fiber optic contact standard
- Integrated high-speed PIN photo diode and low-noise RF amplifiers



## EXAMPLE FUNCTIONAL BLOCK DIAGRAM FOR GLENAIR 050-400 RF OVER FIBER TRANSCEIVER



### RF over Fiber PCB-Mount Component Selection Guide

	<b>050-400</b>	PCB Mount RF-over-Fiber Transceiver 20MHz to 3.5 GHz
	<b>050-404</b>	PCB Mount RF-over-Fiber Transmitter 2 MHz – 3.5 GHz
	<b>050-405</b>	PCB Mount RF-over-Fiber Receiver 2 MHz – 3.5 GHz
	<b>050-406</b>	PCB Mount RF-over-Fiber Transmitter 2 MHz – 3.5 GHz Low-Noise configuration
	<b>050-407</b>	PCB Mount RF-over-Fiber Receiver 2 MHz – 3.5 GHz Low-Noise configuration

### APPLICATIONS

- Ground terminal and intra-facility links for secure shelters
- Electronic Warfare (EW) systems
- Phased-Array antenna systems
- Naval vessels
- Reduced-footprint airframe applications
- Satellite communications (SATCOM)
- Mobile command, control, and communications vehicles





## AT THE I/O INTERFACE

# Size #8 Optoelectronic transmitter and receiver contacts for Ethernet, video and high-speed data



Size 8 Optoelectronic contacts transmit and receive differential CML or LVPECL electrical signals over Multimode fiber optic cable. Transmitters consist of a laser driver or LED driver with a temperature compensation circuit to maintain optical power over the entire operating temperature range, and a 850nm VCSEL laser or a 1300nm LED. Receivers consist of a PIN Photo Detector, a Transimpedance Amplifier with automatic gain control circuit, and a Limiting Amplifier. Differential output data signals are LVPECL or CML compatible. The transmitter has a Tx Disable pin to turn off transmitter output.



▲ Patented Optoelectronic contacts integrate into Glenair connectors including SuperNine® (D38999 Series III), ARINC 801, ARINC 404, and others



Optoelectronic contact evaluation boards are available for all size #8 transmitters or receivers

- Fast and Gigabit Ethernet, DVI, HDMI video capable transmitter and receiver-equipped contacts
- ARINC 664, 801, 803, 804 and 818 standard compliant
- Link distances up to 550 meters, multimode
- Single, 3.3 V power supply
- Wave-solderable termination with RoHS-compliant solders
- For use in ARINC 600 and other size #8 cavity-equipped connectors
- Current offerings include 1.25mm ARINC 801 and 2.5mm ELIO® solutions

# Optoelectronic Contacts for Ethernet, Video and High-Speed Data



## 050-301 SIZE 8 CAVITY OPTO-ELECTRONIC CONTACTS, 100MBPS TO 5GBPS, MMF, 3.3V



050-301  
(patented)

- Front-release, front-insert, front-removable Size #8 OE converter designed for ARINC 600
- ARINC 664, 801, 803, 804, and 818 Standard Compliant
- Data rates from 100Mbps to 5.00Gbps
- Supports Fast and Gigabit Ethernet, AFDX, 1x/2x Fibre Channel, DVI, DHMI, SFPDP, Serial Rapid I/O (sRIO)
- 100 ohms differential CML inputs with Tx Fault and Tx Disable
- Link distances up to 550 meters with multimode 50/125µm or 62.5/125 µm fiber
- Single 3.3V power supply
- ARINC 801 1.25mm ceramic fiber ferrule
- Solutions available in 38999 style connectors
- -40°C to +85°C Operating Case Temperature
- Evaluation fixtures available

## 050-307 SIZE 8 CAVITY OPTO-ELECTRONIC CONTACTS, 100MBPS TO 5GBPS, MMF, 3.3V



050-307  
(patented)

- Front-release, front-insert, front-removable Size #8 OE converter designed for ARINC 600
- ARINC 664, 801, 803, 804, and 818 Standard Compliant
- Data rates from 100Mbps to 5 Gbps
- Supports Fast and Gigabit Ethernet, AFDX, 1x/2x Fibre Channel, DVI, DHMI, SFPDP, Serial Rapid I/O (sRIO)
- 100 ohms differential CML inputs with Tx Fault and Tx Disable
- Link distances up to 550 meters with multimode 50/125µm or 62.5/125 µm fiber
- Single 3.3V power supply
- ELIO 2.5mm ceramic fiber ferrule
- Solutions available in 38999 style connectors
- Mates with ELIO 2.5mm Termini
- -40°C to +85°C Operating Case Temperature
- Evaluation fixtures available
- Compatible with Souriau ELIO AQ6S Quadrax Adapter

## 050-367 SIZE 8 CAVITY OPTO-ELECTRONIC CONTACTS, 3G-SDI AND HD-SDI, MMF, 3.3V



050-367  
(patented)

- SMPTE EG 34:2004 Compliant to Pathological Conditions CASE 1, CASE 2 and CASE 3.
- SMPTE ST 297:2015 (3G-SDI & HD-SDI)
- SMPTE 424 Compliant (3G-SDI)
- SMPTE 292 Compliant (HD-SDI)
- SFP Compatible Electrical Input signal levels
- 850nm VCSEL support 3G-SDI & HD-SDI
- Industry standard CML input and outputs that make for simple integration on customer host PCB
- Front-release, front-insert, front-removable
- Fits size 8 quadrax cavity for ARINC 600
- Solutions available in 38999 style connectors
- -40°C to +85°C Operating Case Temperature
- Evaluation fixtures available

## 050-399 SIZE 8 CAVITY OPTO-ELECTRONIC CONTACTS, DC TO 1 MBPS, MMF, 3.3V



050-399  
(patented)

- Front-release, front-insert, front-removable Size #8 OE converter designed for ARINC 600
- ARINC 664, 801, 803, 804, and 818 Standard Compliant
- Data rates from DC to 1 Mbps
- Supports RS232, RS422, and RS485 data rates
- DC coupled transmitter and receiver
- Link distances up to 2Km
- Single 3.3V power supply
- ARINC 801 1.25mm ceramic fiber ferrule
- Solutions available in 38999 style connectors
- -40°C to +85°C Operating Case Temperature
- Evaluation fixtures available



## AT THE I/O INTERFACE

Environmentally sealed Optoelectronic connectors housing turnkey copper-to-fiber transceiver technology



Glenair is able to offer our Optoelectronic solutions customers turnkey multichannel receptacle connectors housing integrated transceiver technology for fast/gigabit Ethernet, DVI and HDMI video, as well as various high-speed data transfer protocols. Available connector designs incorporate Glenair small form-factor opto-electronic contacts (050-301) or an ELIO® equipped configuration that intermates with the standard ELIO® 2.5mm fiber optic terminus (050-307). Receptacles are populated with factory-tested size #8 contacts, and are ready for immediate use as fiber-optic-to-electrical circuit board I/O connectors. Special size #8 cavity adapters are also available to enable construction of compatible plug connectors on the cable side. Hybrid insert arrangements for mixed power, signal, high-speed electrical, and optoelectronic conversion available.

- 2.5mm ELIO® solution for multimode Ethernet, video, and high-speed data applications
- 1.25mm ARINC 801 multimode fiber optic termini for Ethernet, video, and high-speed data
- Made-to-order configurations with a wide range of connector packages including Series 80 Mighty Mouse



◀ Special size #8 cavity adapters facilitate construction of standard fiber optic plug connectors that intermate with the size #8 opto-electronic transceiver contacts (shown here: Glenair HiPer-D high-performance M24308 D-Sub)



◀ Opto-electronic receptacle connectors are populated with size #8 contacts, and ready for immediate assembly in I/O to circuit board applications



## OPTOELECTRONIC CONNECTOR SELECTION GUIDE

	<p><b>050-304</b> <b>050-335</b> <b>050-355</b></p>	<p><b>MIL-DTL-38999 Series III Type Receptacle Connectors with Size 8 Optoelectronic Contacts</b></p> <p>Convert from electrical to fiber optic signals within a D38999 connector to support high speed fiber optic transmission in harsh environments. The 050-304 incorporates size 8 active contacts in one of three standard configurations to enable optical Transmitters, optical Receivers or Optical Transceivers, or custom configurations. 050-335 adds environmental sealing. 050-355 is designed for thicker bulkhead panel mounting.</p>
	<p><b>059-0001</b></p>	<p><b>Size 8 cavity adapter kits for 1.25mm ARINC 801 and ELIO® 2.5mm terminus</b></p> <p>Size 8 cavity adapters convert D38999 size 8 cavities (Twinax, Coax, Quadrax or power) into ARINC 801 fiber optic cavities or ELIO® fiber optic cavities per EN4531. Kit includes the adapter and an ARINC 801 terminus.</p>
	<p><b>050-313</b></p>	<p><b>Optoelectronic Transceiver, MIL-DTL-38999 Type 2.5mm ELIO® Compatible, 100Mbps – 4.25Gbps</b></p> <p>D38999 Type 11-02 receptacle connector incorporating an opto-electronic transceiver operating from 100Mbps to convert electrical signals to multimode fiber. Ideal for harsh-environment, extreme shock, vibration and temperature avionics and military applications where copper cable link distance, bandwidth, weight or bulk make the use of twisted pair, Twinax or Quadrax copper conductors unacceptable.</p>
	<p><b>050-3001</b> <b>050-3006</b></p>	<p><b>D-Sub Active Receptacle Connector with two Glenair Size 8 Optoelectronic Contacts (050-3006) or with four contacts (050-3001)</b></p> <p>Convert from electrical to fiber optic signals within a D-Sub receptacle connector to support high speed fiber optic transmissions in harsh environments. The connector is fitted with ARINC 801 termini adapters for proper housing and retaining of contacts at the required optical interface to achieve repeatable low-loss optical transmission characteristics.</p>
	<p><b>050-392</b> <b>050-3005</b></p>	<p><b>Optoelectronic D38999 Series III Type Receptacle Connector with Hybrid Electrical Power and Signal Contacts</b></p> <p>Convert from electrical to fiber optic signals within a D38999 connector using Arr. 25-26 IAW prEN 3645-001 to support high-speed fiber optic transmissions in harsh environments. The connector is environmentally sealed using a potting compound that protects customer electronics in the unmated condition. Hybrid contact layouts support optoelectronic, signal, and power contacts from size #20 to size #8. 050-3005 accommodates El Ochito® 10G Ethernet octaxial contacts.</p>



## OUTSIDE-THE-BOX / ENVIRONMENTAL

### Reduced form-factor, harsh environment copper-to-fiber Ethernet media converters



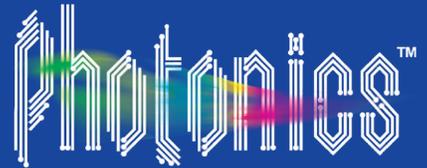
Glenair offers turnkey harsh-environment media converters for in-line and panel mount applications. The devices facilitate conversion of 10/100/1000BASE-SX/LX fiber optic gigabit Ethernet data streams to electrical signals servicing switches, routers, and other peripherals. Designed for use in ruggedized applications such as geophysical, naval, commercial and military aerospace, these reduced form-factor electrical-to-optical transceivers deliver proven performance with significant size and weight savings compared to conventional transceiver equipment. Available for a wide range of fiber optic formats, including 1.25mm, 1.57mm, 2.0mm, and 2.5mm ferrules, in both singlemode and multimode, Glenair's complete range of media converters meets virtually every fiber-optic-to-copper application requirement. Consult factory for custom configurations including expanded beam fiber optics, and other mil-aero connector families not shown on this spread including M28876 and others.



◀ Glenair media converters incorporated into turnkey active cable assemblies remove the complexity of leveraging fiber optics for long distance datalinks.

- Reduced form-factor devices for in-line conversion of electrical and optical signals
- Active cable versions that reduce the risk of damage to fiber optic interfaces
- Weight-saving technology incorporating power and signal conversion functions
- Auto-negotiation 10/100/1000BASE-T to 100BASE-FX, 1000BASE-SX and 1000BASE-LX
- Advanced monitor & control functions via serial interface for network management and BIT

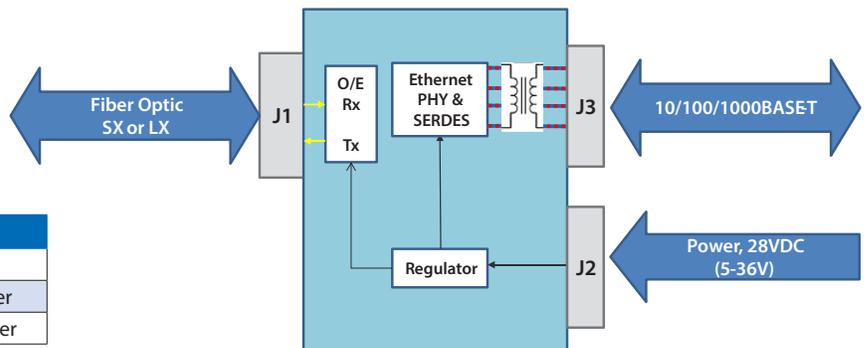
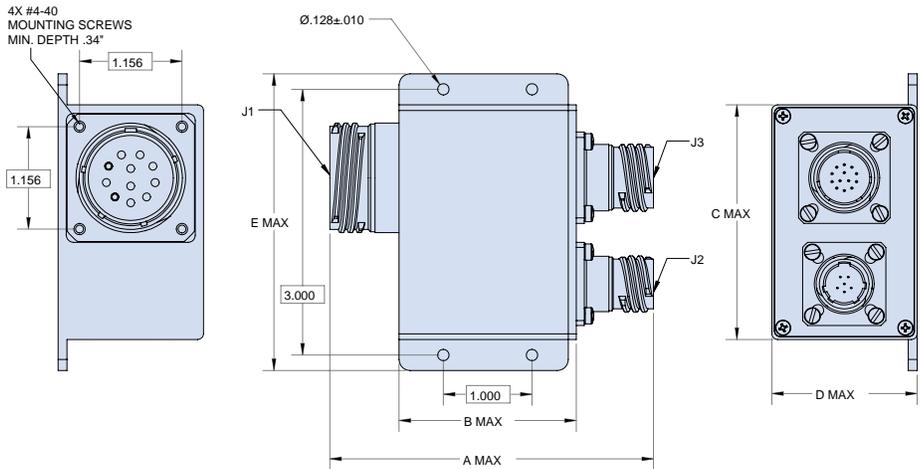
# OUTSIDE-THE-BOX / ENVIRONMENTAL Copper-to-Fiber Media Converters for Ethernet Applications



## EXAMPLE FUNCTIONAL BLOCK DIAGRAM FOR GLENAIR 050-105 ETHERNET MEDIA CONVERTER



**050-105**  
10/100/1000BASE-T to  
1000BASE-SX/LX Media  
Converter



**Table I: Signal Protocol**

Code	Name	Medium
-SX	1000BASE-SX	Multimode Fiber
-LX10	1000BASE-LX10	Singlemode Fiber

Part No.	Description	Part No.	Description
<b>050-105</b>	10/100/1000BASE-T to Fiber Optic Ethernet (SX, LX10, EX, FX) with D38999 Series III signal, power, and fiber optic interfaces	<b>050-113</b>	10/100/1000BASE-T to SX, LX10, or FX Fiber Optic Ethernet, MIL-DTL-1560 interface
<b>050-103</b>	10/100/1000BASE-T to 1000BASE-SX/LX Media Converter with Mighty Mouse Connectors	<b>050-115</b>	10/100/1000BASE-T to 1000BASE CWDM Media Converter
<b>050-110</b>	10/100/1000BASE-T to 1000BASE-SX/LX, GFOCA, 38999 Quadrax (signal and BIT), 38999 (Power)	<b>050-117</b>	LRU Media Converter, Single or Dual Channel, 10/100/1000BASE-T to SX/LX Lightning Strike Protection DO160 level 3
<b>050-112</b>	10/100/1000BASE-T to SX, LX10, or FX Fiber Optic Ethernet, GFOCA Fiber Optic interface	<b>050-130</b>	LRU Media Converter, Single or Dual Channel, Flange Mount. 10/100/1000BASE-T to Fiber Optic Ethernet



OUTSIDE-THE-BOX / ENVIRONMENTAL

## Reduced form-factor media converters for harsh-environment video applications



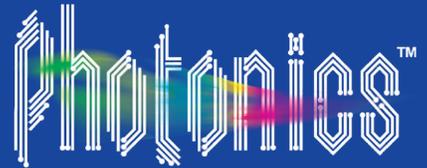
Glenair Copper-to-Fiber-Optic Video Media Converters enable extended link distances, improved EMI and security in harsh environments and provide solutions for both MMF and SMF applications. These media converters support ruggedized military systems applications and are tailored to support a variety of Video protocols including DVI, HDMI, SMPTE (SDI, HD-SDI and 3G-SDI), ARINC 818 and more.

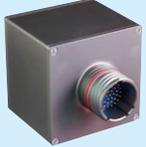
Many options for mil-spec and military-grade electrical and fiber optic connectors are available including Mighty Mouse, D38999, M28876, GHD, NGCON (M64266), HMA (M83526), and GFOCA. Contact Glenair for custom configurations, application-specific designs and engineering services.



- Supports video protocols including DVI, HDMI, SMPTE, and ARINC 818
- Fiber Link up 500m multimode, 10km with singlemode
- Standard MIL-STD-1560 plus custom contact arrangements—including quadrax coaxial
- Power supply functions with wide input-voltage ranges
- Advanced monitor & control functions via serial interface for network management and BIT

# OUTSIDE-THE-BOX / ENVIRONMENTAL Copper-to-Fiber Media Converters for Video Applications



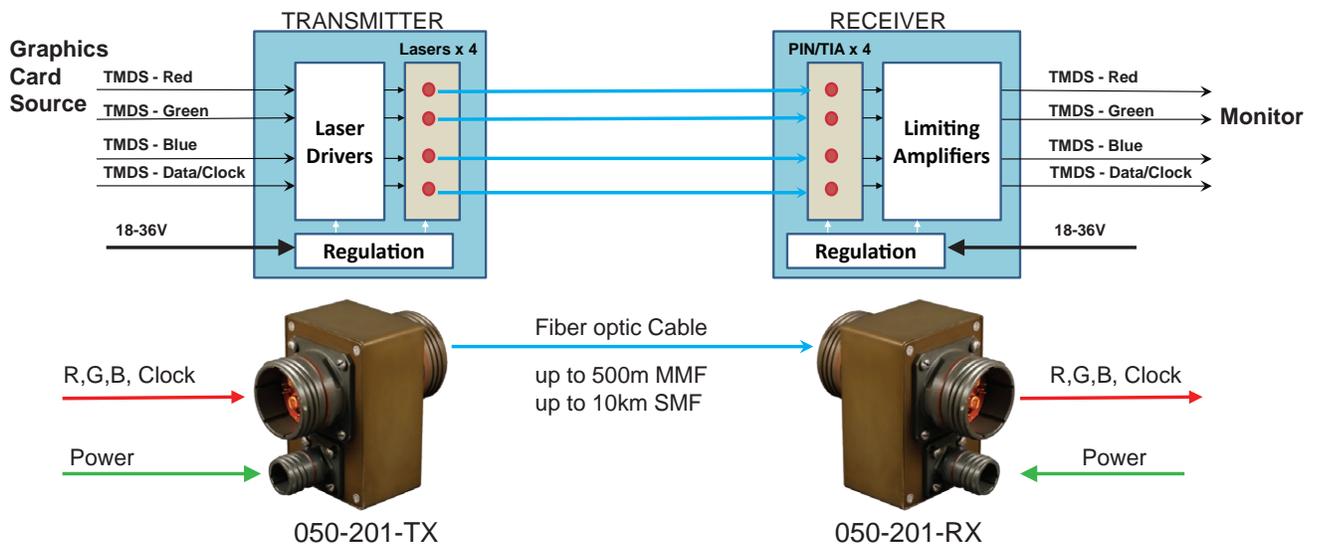
Video Media Converter Selection Guide		
	<b>050-201</b>	DVI Copper to Fiber Media Converter with MIL-DTL-38999 power, signal, and fiber optic connectors
	<b>050-205</b>	Copper to Fiber DVI Media Converter, 28VDC D38999 (ARINC801 for Fiber Optic), D38999 (Quadax and Pin contacts for Signal, Power and Service Port)
	<b>050-206 050-210</b>	Dual-DVI Copper-to-Fiber Media Converter, 28VDC Fiber Optics: D38999 with ARINC 801 contacts (050-206) or D38999 with Glenair Eye-Beam (050-210) Signal and Service Port: D38999 with hybrid Quadrax and discrete 39029 Pin contacts Power: D38999 with size #22D contacts
	<b>050-207</b>	4-Channel SMPTE Copper to Fiber Media Converter HD-SDI and 3G-SDI with MIL-DTL-38999 and Glenair High Density (GHD) power, signal, and fiber optic connectors

## ENVIRONMENTAL PERFORMANCE



- -40°C to +85°C operating temperature range
- Meets MIL-STD-810 Mechanical Shock and Vibration
- Meets MIL-STD-1344 immersion resistance

## EXAMPLE FUNCTIONAL BLOCK DIAGRAM FOR GLENAIR 050-201 VIDEO MEDIA CONVERTER



PROVEN FLIGHT HERITAGE

# SPACE-GRADE SOLUTIONS

NASA · ESA · JAXA · Commercial



Complex space-grade cable assemblies (shown: Glenair-made "Golden Umbilical")

## SPACE-GRADE WIRE HARNESS ASSEMBLIES



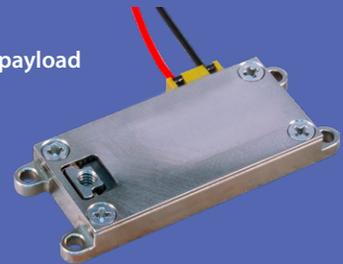
EMI/RFI shielded multibranch Micro-D connector assembly with Glenair Series 23 SuperNine<sup>®</sup> panel mount I/O connector



Multibranch Micro-D / Mighty Mouse cable assembly with ArmorLite<sup>™</sup> lightweight EMI shield overbraiding

## HOLD-DOWN RELEASE MECHANISMS (HDRMS)

Light Duty  
Up to 75 lb release payload



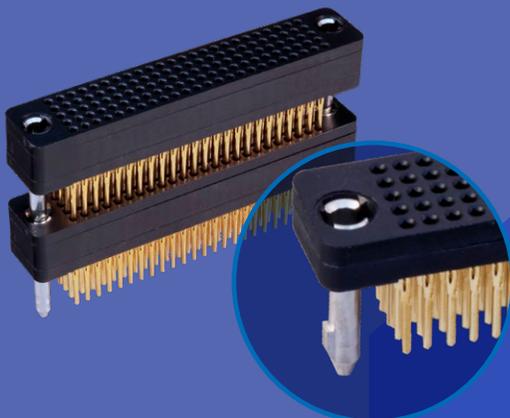
Medium Duty  
Up to 1,000 lb release payload



Heavy Duty  
Up to 20,000 lb release payload



## HD STACKER<sup>™</sup>



High-density (.0625" pitch) board-to-board stacking connector with solder-free press-fit (compliant pin) board mounting

## LATCHING MICROSTRIPS<sup>™</sup>



Latching MicroStrips<sup>™</sup>: cable-to-cable and cable-to-board reduced size- and weight Micro-D TwistPin connectors

## CERTIFIED ECSS-E-ST-50-12C SPACEWIRE CABLES



ESA, NASA, JAXA, and RKA approved SpaceWire cables for both laboratory test and space flight applications

## FIBER OPTIC CONNECTORS, CABLES, AND PHOTONIC MEDIA CONVERSION



High-speed, high-bandwidth space-grade solutions

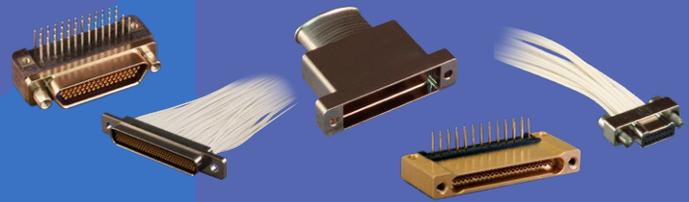
## EMI/RFI FILTER CONNECTORS



MIL-DTL-38999 type, Series 80 Mighty Mouse, and other circulars

HiPer-D and Micro-Crimp filtered rectangulars

## SPACE-GRADE 83513 MICRO-D AND 32139 NANO



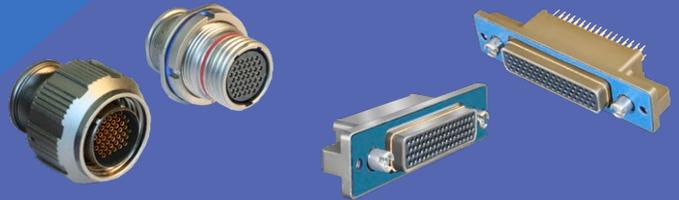
ESA and NASA screened connectors and backshells available as discrete components or wired pigtail assemblies

## SERIES 28 HIPER-D M24308 INTERMATEABLE



Qualified MIL-DTL-24308 Class K Space-Grade Hermetic, environmental, filter, Sav-Con's and cordsets

## LIGHTWEIGHT MIGHTY MOUSE AND MICRO-CRIMP



Small, lightweight, high-density ideally suited for space programs

A proven product, ideal for guidepin and rack-and-panel applications

## SAV-CON® CONNECTOR SAVERS



Available for every military and commercial circular and rectangular connector series

## ULTRA-LIGHTWEIGHT CONDUIT AND BRAID



Factory-terminated and user-installable conduit systems

Weight-saving microfilament EMI braided shielding solutions

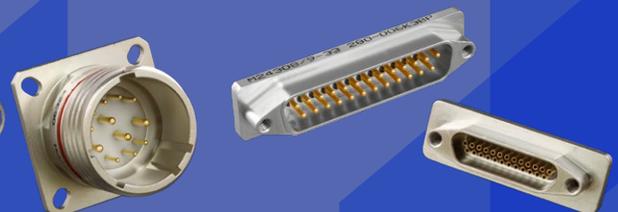
## ASSISTED-RELEASE, AND LANYARD QUICK-DISCONNECTS



Blind mate D38999 type feedthrough with kick-off assist

Lanyard-release quick-disconnects

## SPACE-QUALIFIED HERMETIC RECEPTACLES



Glass-to-metal and CODE RED encapsulant hermetic solutions for high-pressure / low-leakage space applications

## Availability Plus

Long-time members of the Glenair community have deep fluency when it comes to our most important business practice. I'm talking of course about our commitment to a unique "high-availability" business model that:

- puts tens of thousands of part numbers in stock for immediate shipment,
- fuels an ever growing factory footprint bringing new capacity and new capabilities on-line virtually every day,
- fields a massive technical support and sales team ready at a moment's notice to respond to customer requirements, and
- promotes a "first with the most" attitude that drives our organization to excel in a highly technical and dynamic industry.

But there is an additional, powerful force at Glenair that is also putting strong wind in our sails: technology innovation. Marv Borden, one of Glenair's original founders, constantly talked about products that "do a job for the customer; that solve real problems; that make the *customer's* systems and solutions more valuable and competitive." So, while this is not exactly a new practice at Glenair (designing clever products that meet a real need in the marketplace), it is absolutely the case that we have gotten better and better at this side of the work as the years have gone by.

The fact that so many of our most complicated and technical solutions have taken off as quickly as they have testifies to the appetite, the need, for ongoing innovation in our industry. I am constantly pleased, and even a bit amazed, at how well our newest product offerings are doing. And as I look at the orders and listen to the customers that place them, the same story appears again and again: Yes, they love the innovative technical features that make so many of our products "super" (hi-per, better than QPL, pick your term), but they never lose sight of the "high-availability" practices that brought them to Glenair in the first place. And when we put the two things together—as we do in so many of our new interconnect products and solutions—well then folks, the fun just never stops.

Our fiber optic and optoelectronic solutions are powerful examples of this technical innovation *plus* availability model. The highly sophisticated electrical-to-optical conversion technologies and fiber optic datalink solutions presented in this issue would make Marv Borden proud. Boy, do they "do a job" for a customer. Oh, and by the way, the solution to this issue's centerfold puzzle, spelled out by the answers to each individual problem, is "I love my fiber optics." Which couldn't be more true for both myself and the fabulous team of scientists, engineers, marketers, and production folks who bring these solutions to life for our customers.

*Chris Toomey*

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