



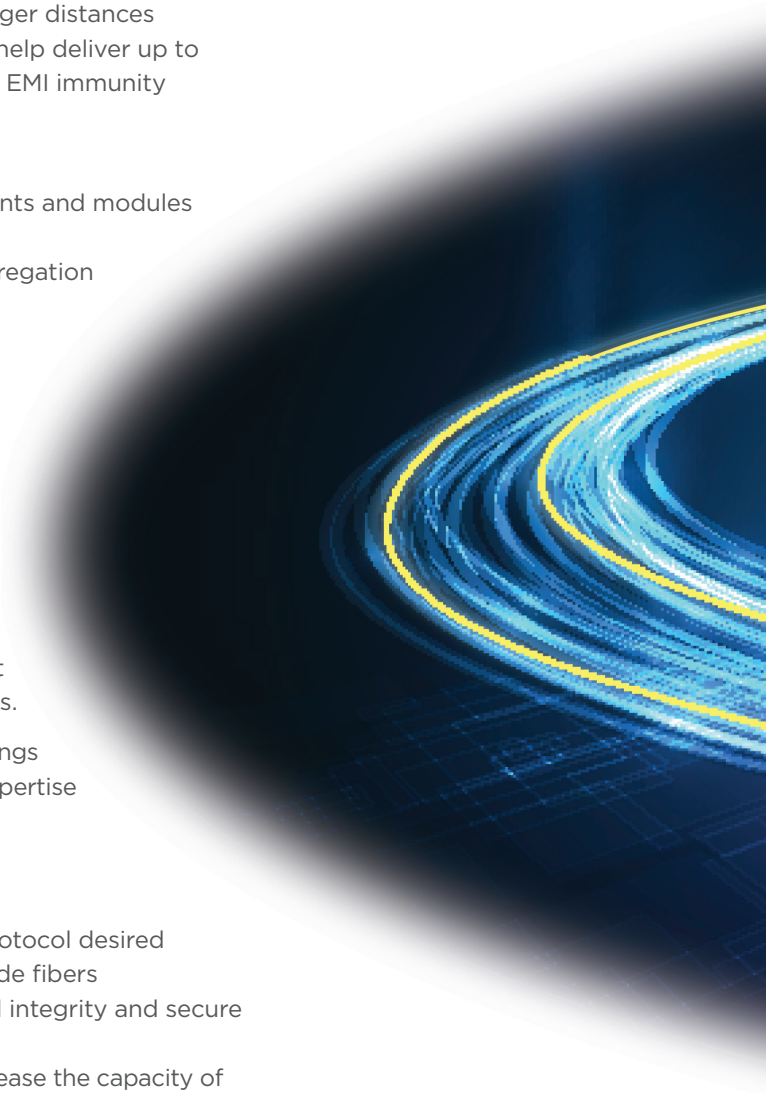
# RUGGED FIBER OPTICS
## FOR HARSH ENVIRONMENTS

**Solutions Built to Survive** . . . From Systems to Components . . . Higher Speeds, Longer Reaches . . . Delivering End-to-End Reliability

# COMPONENTS AND SYSTEMS DESIGNED FOR SURVIVABILITY IN HARSH ENVIRONMENTS

TE Connectivity's (TE) portfolio of RFO (Ruggedized Fiber Optics) products allows us to deliver end-to-end solutions with the benefits of optical technology to challenging harsh environment applications. Fiber optics enables data and video delivery at higher speeds over longer distances not possible with traditional copper cable. RFO products help deliver up to 10 Gb/s communication protocols over fiber with inherent EMI immunity and significant size, weight, and power (SWaP) benefits.

- Gigabit Ethernet data transmission components
- HD and 3D video uncompressed transmission components and modules
- Serial and analog data transmission solutions
- Chassis-based systems for maximum flexibility and aggregation of all data protocols over fiber



## End to End, ASIC to ASIC

Count on TE for comprehensive answers that can help give you complete connectivity in virtually any harsh environment you encounter, from the bottom of the sea to the edge of space and beyond. From electro-optic conversion products to connectors and harnesses, we have solution sets tailored to your application. RFO's range of connectivity and harnessing capabilities incorporates both single and multi-fiber Physical Contact (PC) and Expanded Beam (EB) interface style connectors.

To develop ideal solutions for rugged applications, RFO brings subject matter experts (SMEs) with considerable design expertise to partner and work with your team quickly and efficiently.

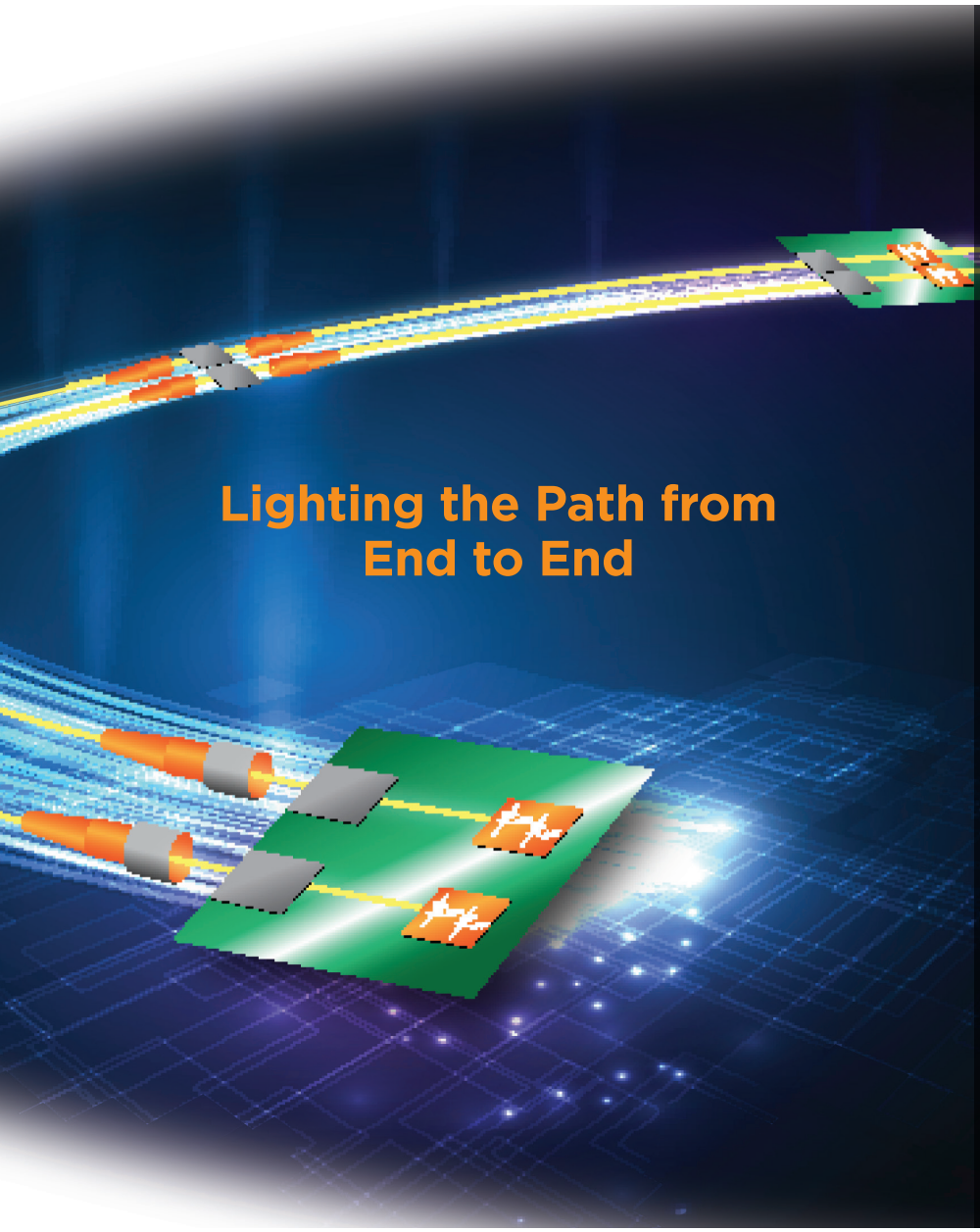
## Do More with Light

- Higher speeds to support 10 Gb/s and beyond in any protocol desired
- Longer distances for multi-kilometer links via single mode fibers
- Electromagnetic immunity to achieve exceptional signal integrity and secure data transmission in some of the noisiest environments
- Coarse wavelength-division multiplexing (CWDM) to increase the capacity of a fiber and greatly simplify networks, thus helping to reduce installation and operation costs
- Hermetic protection from vacuum to 10,000+ psi, extreme temperatures from -55°C to over +173°C, and high shock/vibration with RFO and hybrid seals
- Achieve SWaP goals with smaller size, lower weight, and low power consumption
- Maximize reliability with full qualification and high-reliability technologies

**TE Components . . . TE Technology . . . TE Know-how . . .**

AMP | Agastat | CII | Hartman | Kilovac | Microdot | Nanonics | Polamco | Raychem | Rochester | DEUTSCH
SEACON Phoenix | L.L. Rowe | Phoenix Optix | AFP | SEACON

Get your product to market faster with a smarter, better solution.



# Lighting the Path from End to End

## APPLICATIONS

### Commercial Aerospace

- Avionics
- In-Flight Entertainment and Cabin Systems
- Computing Modules
- Wireless Communication
- Optical Sensors

### Military

- C5ISR Electronic Systems
- Missile Defense
- Ground Defense
- Aerospace
- Space

### Military Marine

- Naval On-Ship, Shipyard, and Submarine Systems
- Submarine Telecommunication Cable Networks

### Marine Oil and Gas

- Offshore and Subsea Data, Sensor and Communication Systems
- Commercial Marine
- Remotely Operated Vehicle (ROV) Video and Control
- Sensors

## TE's RUGGED SOLUTIONS

### Rugged Interconnects

- Circular and Rectangular Connectors
- Backplane/Daughtercard Connectors
- Cable and Harnessing
- Optical Flex Circuits
- Hermetic Feedthroughs

### Rugged Media Conversion

- Transceivers
- Media Converters
- Video Transmission
- Electronic and Passive Switches
- Rugged Active Optical Cables





# BEFORE YOU CONNECT YOUR SIGNAL, WE'LL HELP YOU . . .

## Convert It, Protect It, Aggregate It, Multiplex It, Switch It, Network It . . . With Maximum Signal Integrity and Reliability

Our expanded portfolio of rugged system-level solutions enhances communications by allowing you to leverage the advantages of optical fiber in tactical and field deployments. With sophisticated media conversion and CWDM multiplexing, you can extend your reach while supporting a full range of video and Ethernet protocols over simple cost-efficient systems.

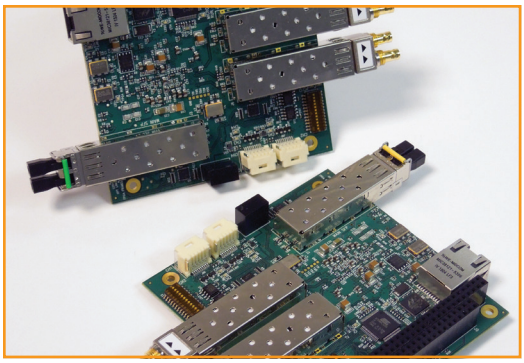
## Built Tough

Our media converters and link extenders are built for rugged "throw down" field use, with extended temperature ranges and suitability for use in harsh environments.

## Packaging Expertise to Make It Your Way

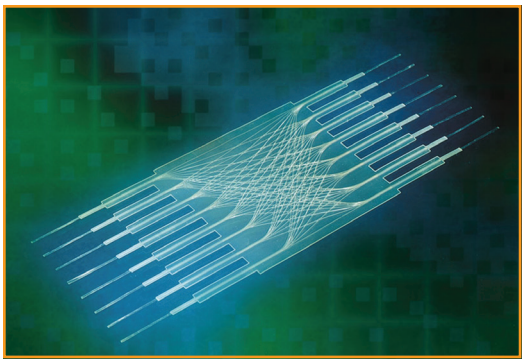
We will work closely with you to help you build a custom system to meet your precise needs fast and efficiently.

- Field-protected rugged enclosures for tactical deployments
- Expanded beam connectivity technologies to help eliminate signal degradation and simplify use
- Ruggedized cabling links, including nuclear hardened
- Compact, weight-saving systems
- Hermetically sealed feedthroughs and penetrators
- Optical flex circuits to manage and route high fiber counts in small spaces



## Collaboration for Elegant Solutions

Combine our design, engineering, and testing expertise with a commitment to collaboration. This results in solutions that boost performance, simplify deployment, and lighten the load on your engineering department.

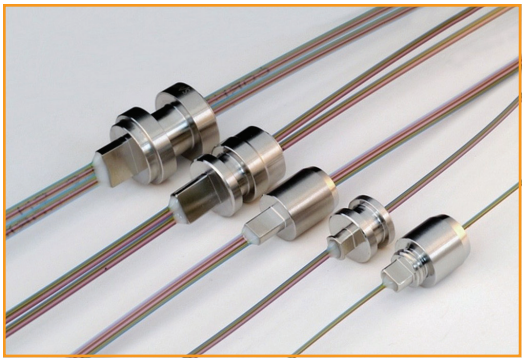


## Complex Routing Made Simple

We can design and build optical flex circuits to help solve your demanding routing issues. With up to 6 levels of fiber crossings in a single layer and up to 12 layers, our circuits support tight bend radii and both single-mode and multimode applications.

## Rugged Harnesses Ready to Connect

Get the convenience of fiber optic harnesses built to high standards to meet your requirements for ruggedness and optical performance. We test and characterize the optical performance of each harness to help ensure link budgets are met.



## Hermetic Feedthroughs and Penetrators

We excel at creating high-reliability hermetic small glass-sealed multifiber and hybrid feedthroughs and penetrators for applications ranging from aerospace, subsea/submarine to extreme-pressure, high-temperature downhole.

# CONNECT WITH CONFIDENCE

## Standard or Custom, We've Got You Covered

With a global presence, strong research and engineering, and world-class manufacturing, we can support you with a large catalog of standard products that is constantly expanding to embrace the latest technologies and application needs.

These same capabilities allow us to work with you to devise a custom solution in a quick and cost effective way. Whether you need a media converter with nonstandard packaging, a hermetic feedthrough, complex harnesses, or specially configured connectors, you'll find us to be an innovative collaborator.

## Linking to Performance

Better fiber-optic systems and links begin with a holistic perspective and products designed to work as a complete system. Here are some examples of how we are adding value and simplifying deployment of fiber optics:

- SuperDrum integrated reels, which integrate cables, connectors, and media conversion
- HDLT (High Density Lensed Termini) connectors, which enable 24 fibers in a Size 9 38999 connector shell
- HYDRALIGHT connectors, which allow subsea wet-mate connections of up to 48 fibers at depths of 7000 m

As a trusted leader in optical technology, TE offers high-performance connector solutions that are also easy to maintain in the field. Our products are designed to operate reliably in harsh and challenging environments, and the company's technical specialists have an in-depth understanding of application requirements.

## Ease of Use

- Rear-removable optical termini
- Removable alignment sleeves that help support simple, effective cleaning and maintenance of termini
- Lens protected inserts and termini protect the fiber core behind the lens and assure the performance of the optical link

## Precision Connections

- Dowel pin alignment
- Standard and tight-tolerance keying

## Ruggedness

- Environmental sealing
- Anti-vibration coupling mechanisms
- Pressure-balanced subsea connectors

## Wide Range

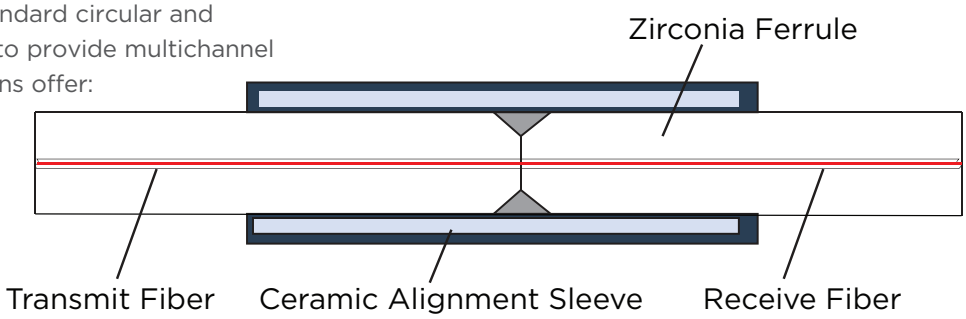
- Physical contact (PC) and expanded beam (EB) interface styles
- Versions for land, sea, and air

## Physical Contact (PC) Connectors

A PC connection uses ferrules that are mated within a precision sleeve to assure radial alignment to minimize optical misalignment losses. The termini and mating sleeves can be incorporated into standard circular and rectangular connectors to provide multichannel operation. PC connections offer:

- Lowest insertion loss
- Lower reflection
- Compact format

While most PC connectors use a ceramic ferrule for a single fiber, the MT ferrule is a multifiber variation typically holding 12 or 24 fibers.




## Expanded Beam (EB) Connectors

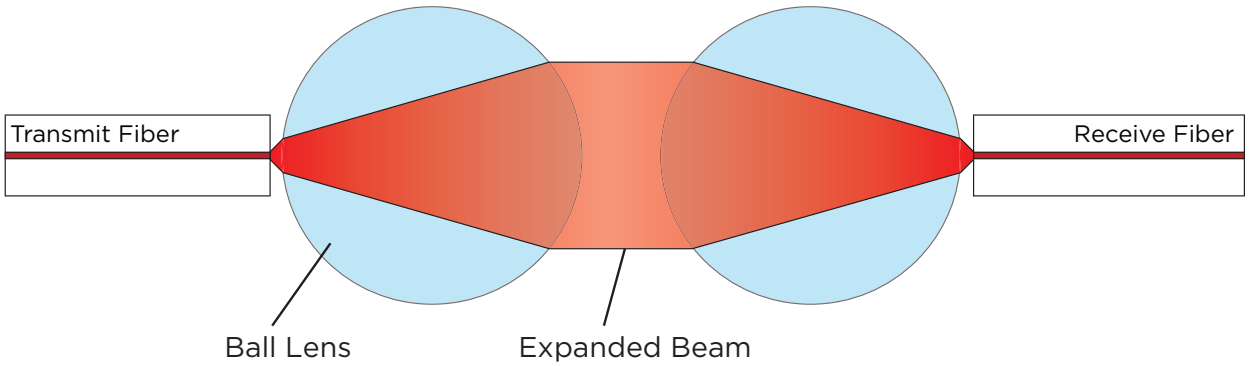
EB connectors expand and re-focus light at the fiber end faces and allow an air gap in the optical pathway. The EB concept uses optical lenses (typically a 3-mm ball lens for dedicated inserts or 1.25-mm lens for EB16 termini) to expand and collimate the beam emitted from the launch fiber. The expanded beam remains collimated across the mechanical interface until the receiving lens focuses the beam onto the receiving fiber.

Standard channel counts for EB-specific connectors are 1, 2, 4 and 8. Since these connectors are used in rugged and tactical environments, they are usually terminated on robust ruggedized, metal-tubed, and avionics/flight-grade cable.

The innovative EB16 optical termini employs the same technology from the well-established dedicated inserts into a termini that can be used in 38999 Series III and EN4165 size 16 cavities to allow for flexibility and higher fiber counts.

The absence of physical fiber contact makes EB connectors very useful in demanding environments. They offer:

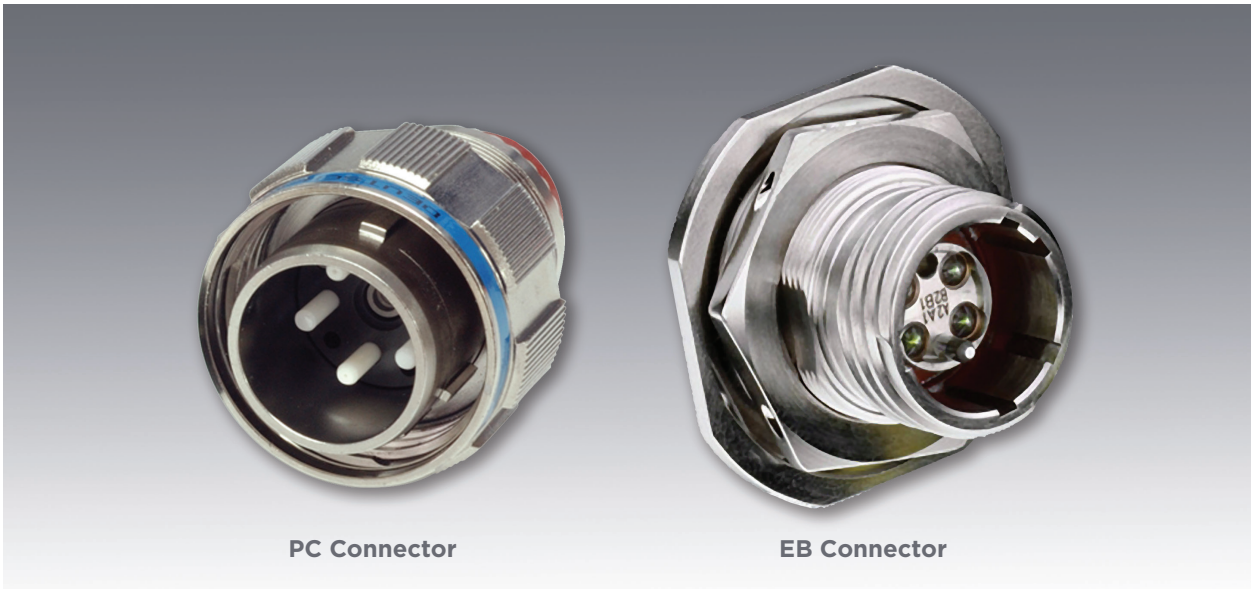
- Sealed optical interface
- High vibration and shock resistance
- High mating-cycle durability
- Tolerance to dirt and debris
- Easy cleaning



## COMPARISON OF PC AND EB CONNECTOR TECHNOLOGIES

| Performance Criteria | PC | EB |
|---|---|---|
| Insertion Loss | ★★★★ | ★★ |
| Return Loss (SM) | ★★★★ | ★★ |
| Return Loss (SM) – Unmated | ★ | ★★ |
| Lateral Connector Misalignment | ★ | ★★★★ |
| Connector Angular Tilt | ★★★★ | ★ |
| Mating Durability | ★★ | ★★★★ |
| Water Exposure | ★★★ | ★★ |

| Performance Criteria | PC | EB |
|---|---|---|
| Dust Exposure | ★ | ★★★ |
| Vibration Susceptibility | ★★ | ★★★ |
| Repair | ★★ | ★★ |
| Cleanability | ★★ | ★★★★ |
| Wear | ★ | ★★★★ |
| Wavelength Range | ★★★★ | ★★ |



PC Connector

EB Connector

## SYSTEMS AND SUBSYSTEMS

### AFP SuperChassis Platform

**Modular**
- 2U chassis with 20 powered slots
- 5 and 10-slot options available

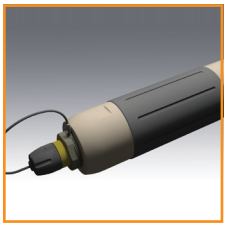
**Flexible Choice of Modules**
- 3G, HD-SDI, and HDMI video
- Gigabit Ethernet
- CWDM multiplexing
- Single mode-to-multimode wavelength conversion

**Reliable**
- Redundant hot-swappable power supplies

### AFP SuperDrum Integrated Reel

**Capable**
- Integrated cable, connectors, and active electronics
- Modular: uses SuperChassis active modules

**Convenient**
- Quick deployment
- Expanded beam connectors standard



### AFP SuperBullet Media Converter

**Convenient**
- Expanded beam connector interface
- RJ45 port
- Locally powered over Ethernet
- Up to 5 km standard transmission distance

**Rugged and Compact**
- Lightweight, heavy gauge aluminum housing
- IP67 rated

### AFP SuperCase Multi-Signal Field Cases

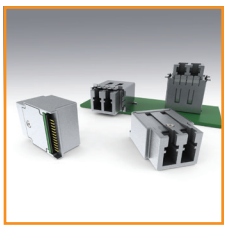
**Powerful**
- Aggregator and distance extender over fiber
- 3G/HD/SD digital video, intercom, audio, VOIP, Ethernet and other protocols
- Discrete 1 signal per fiber or multiplexed up to 18 channels per fiber

**Convenient**
- Portable case with battery mount
- Rack-mount tray option

### AFP 10 GbE Dual Media Converter

**Capable**
- Expanded beam, duplex LC, and RJ45 connectors
- SFP transceiver slots for flexibility in transceiver choice

**Low Profile**
- 1U rack-mount unit
- Expanded beam connectors standard



### AFP MCUBE Transceiver

**High Performance**
- Performance to 3 Gb/s

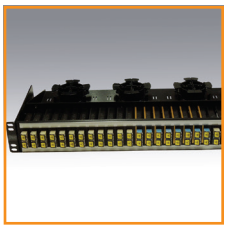
**Space-Saving Size**
- Miniature cube
- Horizontal or vertical mount

**Versatile Options**
- Fabry-Perot lasers for discrete single channel per fiber
- Distributed feedback CWDM lasers for multiplexing up to 18 channels per fiber

### AFP RunGear Multi-Signal Portable Gear

**Powerful**
- Aggregator and distance extender over fiber
- 3G/HD/SD digital video, intercom, audio, VOIP, Ethernet and other protocols
- Discrete 1 signal per fiber or multiplexed up to 18 channels per fiber

**Convenient**
- Portable case with battery mount
- Rack-mount tray option



### AFP Normal Through Optical Switch (NTOS)

**Modular**
- Ultra-high-density LC or SC channels
- Signal agnostic, rated to 10 Gb/s
- Single mode and multimode modules

**Reliable**
- Low insertion loss
- Completely passive for high reliability
- 1, 1.5, and 2U rack-mount chassis options

## SYSTEMS AND SUBSYSTEMS

### AFP Coax-to-Fiber Media Converters

**Powerful**
- SMPTE* 3G/HD/SD-SDI up to 2.97 Gb/s
- Extend distance to 10 km at 3G-SDI

**Flexible**
- CWDM transmitters available
- Up to 18 channels multiplexed onto single-mode fiber

### AFP TELEMUX Platform

**Multi-Protocol**
- Time-domain multiplexing combines Ethernet, video, control, and data signals
- High-quality digitized analog video or SD-SDI digital video
- 10/100/1000 Mb/s Ethernet, low latency

**Numerous Applications**
- ROV, security robots, and remote monitoring applications

### AFP CWDM Passives for Multiplexing

**Convenient**
- Up to 18 wavelengths
- Modular and tray mounted passives
- Signal agnostic
- Variety of packaging options

## OPTICAL TERMINI

### Expanded Beam Termini
- Lens insert assemblies for military and ARINC connectors
- EB16 termini for Size 16 cavities
- HDLT termini for up to 24 fibers in a Size 8 cavity


### Physical Contact Termini

**Single-Fiber Ceramic Ferrules**
- ARINC 801
- MIL-PRF-29504/4 pin and /5 socket
- DEUTSCH 1.25 and 2.5 mm

**Multifiber Arrays**
- MT multifiber ferrules


## CIRCULAR CONNECTORS

### MC801 Connectors

**Rugged**
- Resists shock and vibration, moisture, and corrosion
- 100% scoop proof
- Self-locking threaded coupling for anti-vibration integrity

**Lightweight**
- High-strength aluminum shells
- 38999 Series III style
- ARINC 801 termini

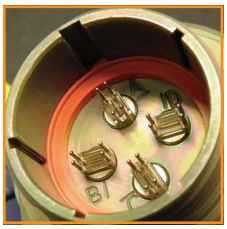

### M83526/20, /21 and PRO BEAM Connectors

**Expanded Beam Interface**
- Performs consistently and reliably
- 3000-mating-cycle durability
- Vibration tolerant

**Flexible**
- 1, 2, 4 or 8 fibers in a single connector interface
- Available in Sr., Jr. and Mini sizes


* Society of Motion Picture & Television Engineers

## CIRCULAR CONNECTORS



MT
EB

### HDLT Connectors

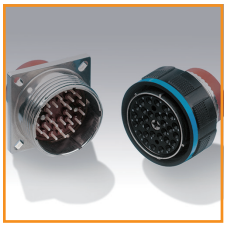
**High-Density Lensed Termini**
- Uses standard Quadrax contact geometry and shell inserts
- 12 or 24 fibers in a size 8 cavity
- Lens protection for each fiber
- Up to 8 termini or 192 fibers per connector
- TE ribbonized discrete cable for full degrees of freedom
- Flexibility for easier routing

PC

### DEUTSCH MC3 MKII Connectors

**Harsh Environments**
- High-performance, maintainable optical connectivity
- Insert-to-insert keying assists precision alignment

**Convenient**
- Individually rear insertable/removable optical contacts enable easy assembly
- Backshells and adapters available for most single and multifiber cable types



PC

### DEUTSCH MC5 Connectors

**High Density**
- Compact 1.25 mm precision zirconia ceramic ferrules
- Extensive range including 1, 2, 4, 6, 8, 10, and 30 positions

**Robust**
- Sustained performance over a wide range of environmental conditions
- Simple termination process and tooling

MT

### DEUTSCH MC6 Connectors

**High Density**
- MT ferrules for 12 and 24 channels

**Convenient**
- Rear release contact using size 8 extraction tools
- Retrofit triple rear seal available
- MIL-DTL-38999 Series III anti-vibration coupling with tri-start thread

PC

### MIL-DTL-38999 Qualified

**Rugged**
- Resists shock and vibration, moisture, and corrosion
- 100% scoop proof
- Self-locking threaded coupling for anti-vibration

**Lightweight**
- High-strength aluminum shells
- MIL-PRF-29504 style termini

PC
EB

### DEUTSCH RSC Connectors

**Rugged**
- Single-channel connectors
- Manufactured from ARCAP alloy for corrosion resistance
- Anti-vibration coupling mechanism

**Versatile**
- RSC: M29504/4 and /5 termini
- RSC EB: EB16 termini
- RSC-v: APC or tunable interface

## RECTANGULAR CONNECTORS

PC
EB
MT

### DEUTSCH DMC-M Connectors

**Flexible**
- Interchangeable modular inserts
- MC5, MT, and ARINC 801 interfaces
- Hybrid electrical/ ARINC 801 inserts

**Lightweight**
- Composite housing

**EN4165 Qualified**
- Single-module and multicavity styles

PC
EB
MT

### GPR Connectors

**Versatile**
- Shell accepts inserts for signal, power, coax, data bus, and fiber optic contacts
- GPRB version for fiber optics
- F12 insert for up to 12 ARINC 801 termini
- M2 insert holds two 4-channel mini-EB inserts

PC
EB
MT

### ARINC Connectors

**Flexible**
- Inserts for ARINC 404 and 600 connectors
- Up to 4 Mini EB termini per insert or 128 per connector
- Up to 36 standard 1.25 mm MC5 termini per insert

**Convenient**
- Easily removable front insert allows cleaning or replacing damaged alignment sleeves

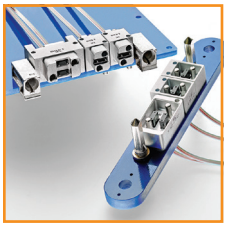
MT

### DEUTSCH 369 Connectors

**Compact**
- 24-fiber MT ferrule
- Single mode or multimode ribbon or discrete fibers
- Integrated plug-side coupling bushing

**Versatile**
- In-line or flange mount

## BOARD-LEVEL PRODUCTS

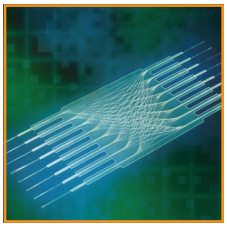


MT

### VITA 66 Optical Modules

**Industry Standard**
- Compatible with VITA 46 VPX systems

**Versatile**
- MT: extreme density with up to 48 fibers/module
- VITA 66.1 full size modules
- VITA 66.4 half-size modules (Contact TE for VITA 66 EB and ARINC 801 modules)

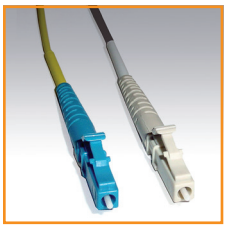


### Optical Flex Circuits

**Versatile**
- Symmetrical and asymmetrical designs
- Tight bend radii
- Very low insertion loss over a broad temperature range

**Highly Customizable**
- Up to 6 levels of fiber crossings in a single layer
- Up to 12 layers
- Range of packaging options for environmental conditions

## DISCRETE CONNECTORS



### Tight-Jacketed LC, SC, ST Connectors

**High Performance**
- Low insertion loss
- High reflection loss in single-mode versions

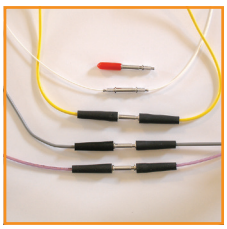
**Standard Interfaces**
- SC, ST and LC styles

### Sealed LC Connectors

**Robust**
- ODVA style
- IP67 sealing
- Aluminum or composite shells

### U.S Navy Commercial Item Description Approved

**NAVSEA Approved**
- Approved for shipboard use
- LightCrimp Plus ST multimode connectors
- Tight construction single-mode and multimode SC and LC connectors



### Mechanical Optical Splice

**High Performance**
- NAVSEA approved for shipboard use
- Manufactured to single-mode tolerances
- Capable of jacketed and buffered fiber
- High-reliability optical terminations

## ACCESSORIES AND CABLE

### Tactical Optical Cable Repair Kit

**Convenient**
- Fusion splice for repairing up to four fibers at once
- Cable repair protection sleeves
- Solutions for rodent-resistant cables and standard tactical cable

### AFP EB Test Set

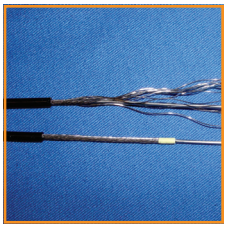
**Versatile**
- Integrated PRO BEAM Jr. EB harsh environment connectors
- Multimode and single-mode ports
- Simultaneous testing of up to four fibers
- Up to 4 wavelength combinations

**Easy to Use**
- Large internal memory for measurement storage
- Clear LED display in dB or dBm units
- High dynamic range
- Go/No Go parameters

### Reels

**Heavy-Duty, Lightweight**
- Cable reel to organize and protect connectors
- Up to 500 meters

**Flexible**
- Options include special backpack harnesses, separate reel stand or combo reel/ reel stand



### Rochester Armored Fiber Optic Cable

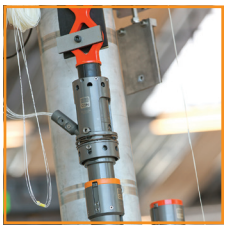
**Rugged, Tactical, Field Deployable**
- 2 and 4 fiber constructions with color-coded fibers
- Stainless-steel, gel-filled rodent-resistant tube
- Steel-wire strength members
- Hybrid copper/fiber options available

## OFFSHORE AND SUBSEA CONNECTORS AND CABLES

### Subsea Terminations

**SEACON SUTA (Subsea Umbilical Termination Assembly)**
- Integral fiber management system
- High-pressure feed-through penetrations

**SEACON MUX Cable Terminations**
- Field installable and testable assembly (FITA)
- Pressure balanced oil filled (PBOF) termination chamber



### Wet-Mate Connectors

**SEACON HYDRALIGHT Connectors**
- 6 to 48 optical channels
- Rated to 10,000 psi (7000 m)

**DEUTSCH OFS Series Connectors**
- Permanent connection for downhole sensors and data acquisition
- Rated to 22,500 psi

### Dry-Mate Submersible Connectors

**SEACON OPTI-CON Hybrid Connectors**
- Up to 20 optical or electrical contacts in any combination
- Rated 7500 psi (5200 m)

**SEACON MINI-CON/MSS Connectors**
- 1 to 48 contacts
- Rated to 20,000 psi (13,700 m)

**SEACON Military Connectors**
- MIL-DTL-24231 and MIL-DTL-24217 styles
- Rated up to 10,000 psi (7000 m)

**DEUTSCH MOD Series Splash-Zone Connectors**
- Explosion-proof quick connect/ disconnect in hazardous areas

### Downhole HP/HT Connectors

**SEACON HP/HT Downhole Connectors**
- Rated to 10,000 psi (7000 m)
- 2-channel optical, 2-channel electrical or 4-channel hybrid versions
- Up to +125°C

**DEUTSCH O1-DH Series Connectors**
- Single-fiber connector to fit tight shell casings
- Rated to 30,000 psi
- Up to 177°C

### Rochester Umbilical Cables

**Size and Weight Savings**
- Thin wall insulation technology for reduced diameters
- Longer cables

**STEEL-LIGHT Optical Fibers**
- Strands of plow steel concentrically arranged around the fiber buffer for excellent protection
- Excellent flexibility
- Helps protect fiber from attenuation-inducing hydrostatic pressures

**Versatile**
- Wide range of standard and custom configurations for signals, optical, and power

## LET'S CONNECT

We make it easy to connect with our experts and are ready to provide all the support you need. Just call your local support number or visit www.te.com/industrial to chat with a Product Information Specialist.

## Technical Support

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**9-1773456-9 09/16**