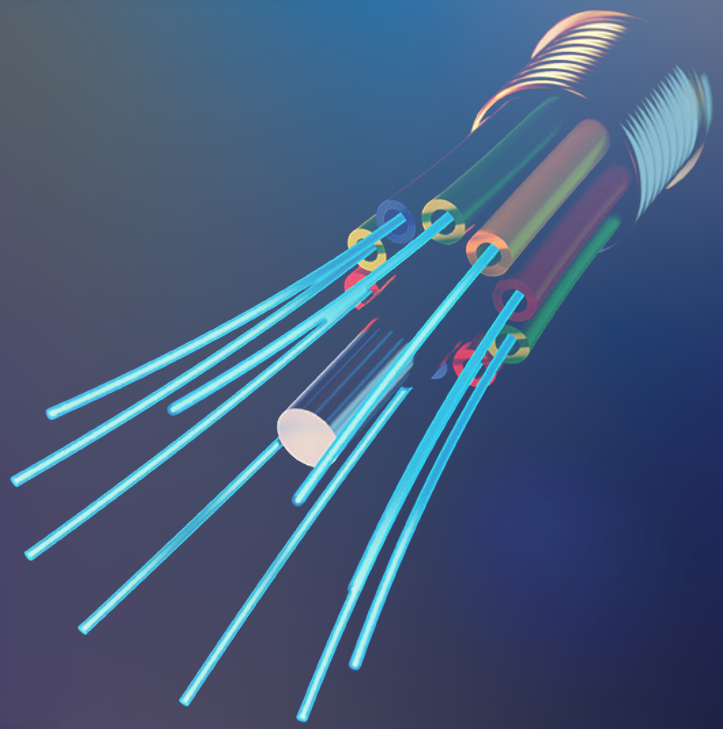
Fiber Optic Connectivity

Powell®

THE FIBER OPTIC ADVANTAGE

Simply stated, fiber optics are the best way to transport data between points. Compared to copper connectivity, fiber optics offer:

- Greater Bandwidth (data transfer capability)
- Faster speeds (31% slower than the speed of light; Copper is ~99% slower)
- Longer Distances (10 Gbps for 40+ km compared to 100 meters)
- Reduced Size and Weight
- Immunity to Electro-Magnetic Interference (EMI)
- Less energy consumption
- Increased security
- Future proof ability
- Lower cost

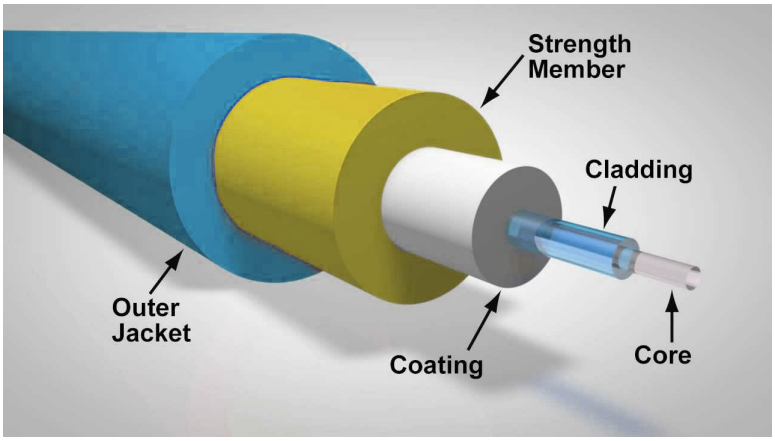


The physics of light do not change. Therefore, although there will continue to be some product improvements in performance; a fiber optic system installed today will still be essentially the same decades for now. It is not affected by any loose electrons, high voltage nearby or other typical copper signal degradations. You cannot steal a fiber optic signal. Fiber optic channels weigh very little and are not subject to commodity price fluctuations like metal conductors.

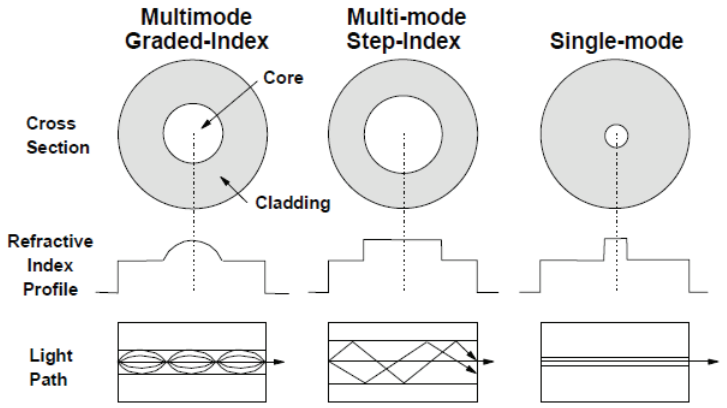
In a world where data demand is forecasted to grow between 23% and 13% CAGR; the demand for fiber optics is expected to also grow 10%+ per annum.

FIBER OPTICS 101

Fiber optics pulse light to transmit digit information. This is done along a translucent medium in the core of a fiber optic channel. Most commonly, this medium is made from a silica-based glass that is optimized for the spectrum of light used as the input and is called the core. That light is propagated by reflecting off the cladding through the glass. A buffer is also over the cladding as protection.



Optical fibers either use a **single mode** (or wave) of light or multiple waves of light (**multimode**).
The single mode fiber is optimized at a size of 9 µm and the most common multimode sizes are 50 µm and 62.5 µm. The cladding for each of these are extruded to the same diameter (125 µm).
The buffer over that is also extruded to a common size (250 µm).



SINGLE MODE FIBERS

In general, single mode fibers are either specified as OS1 or OS2. OS1 is most commonly used in tight-buffered constructions whereas OS2 is for loose tube constructions. Loose tube affords the lowest loss levels and is used in telecom applications where an underground right-of-way is established to transport lots of data. Tight buffer constructions are either used in data centers where lengths are short or in harsh environment applications where the cable can withstand more bends and generally more abuse.

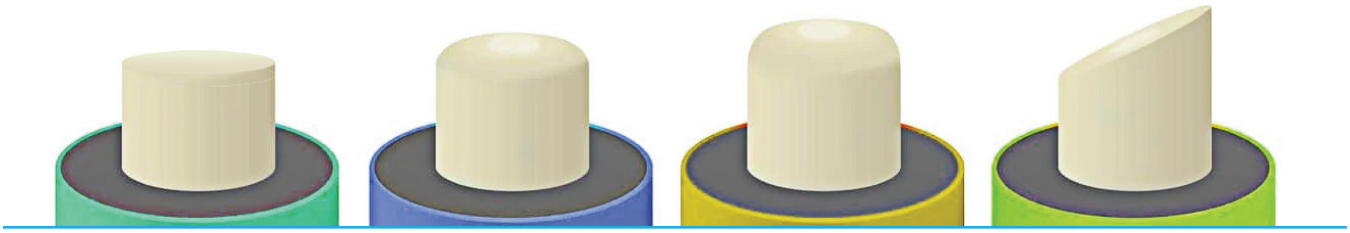
MULTIMODE FIBERS

Multimode fibers are also categorized in a similar fashion. OM1 is the 62.5 µm standard while OM2 is the 50 µm standard. OM3 is a more advanced 50 µm that can support 10 GM/s ethernet up to 300 meters. OM4 can support 10 GB/s up to 550 meters. OM3 is compatible with OM3 and OM4 is also compatible to OM3 & OM2.

MM or SM	Fiber Type	Core/Cladding (µm)	Gigabit Ethernet Length (GbE)	10X Gigabit Ethernet Length (10GbE)	100X Gigabit Ethernet Length (100GbE)
MM	OM1	62.5/125	275 meters	33 meters	-
MM	OM2	50/125	550 meters	82 meters	-
MM	OM3	50/125	800 meters	300 meters	100 meters
MM	OM4	50/125	1100 meters	400 meters	150 meters
SM	OS1	9/125	100 kilometers	40 kilometers	40 kilometers
SM	OS2	9/125	100 kilometers	40 kilometers	40 kilometers

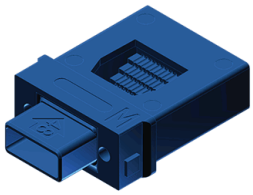
CONNECTING THE FIBERS

The connections to these fibers, once cleaved and polished, can either be done with **Flat**, **Physical Contact (PC)**, **Angled Polished Contact (APC)**, **Ultra Physical Contact (UPC)** within a termini or other fiber connector. This is based on the shape of the glass to be in contact with the other fiber. The more curved a fiber is the better it is a transferring data but is more difficult to terminate. Termini acts as a guide for the fiber-to-fiber connection within harsh environment connectors. PC is the most common method. Not all polishes can be done with all termini.



Flat **PC** **UPC** **APC**

Another popular connection method for high channel counts is the MT Ferrule, which can accommodate 24 fiber channels in the area that otherwise would accommodate three or four termini.



For particularly dirty environments, a lensed solution that projects the light across an air gap called Expanded Beam technology. This method is somewhat easy to mate in the field, very tough and not affected by contaminants at the optical interface. But there are higher losses (lower bandwidth) than contacted connections such as PC or APC.

Most optical fibers used today are Graded Index, meaning the light waves travel in a typical sinusoidal pattern. Some other specialty applications may require Step Index or Polarizing Maintaining fibers, where the light travels in different patterns.

FIBER OPTICS 101

TERMINATION HARDWARE

These act as guiders to ensure the two sides of the connector align perfectly to create the connection.

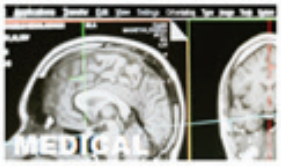
- **M29504 Termini** – commonly used with harsh environment connectors and act similar to contacts for copper connections. One termini fit in each hole of the insert arrangement. The termini are configured to be either pin or socket.
- **MT Ferrules** – High density termination device where each block terminates either 12 or 24 optical fibers. These MT ferrules also work with harsh environment connector bodies.

M29504 Termini

MT Ferrules Termini

FIBER OPTIC INDUSTRIES

The demand and growth for fiber optics is not just in Telecommunications. There is a high demand as well in harsh environment applications, such as:



CONNECTOR TYPES

CIRCULAR

Once it was determined that more protection was required for connection systems for harsh environment applications, circular connectors were created. It is only natural that fiber optics also uses these form factors for the similar environments. The similar terms apply for fiber optics as well where there are plugs, receptacles, backshells, pins, sockets, etc. Some terms are different. Instead of contacts, fiber optic connections use termini or other hardware to guide the fiber-to-fiber connection point. Commonly, the quantity of signals is referred to as the number of channels. Fiber optic specifications for circular connectors include:

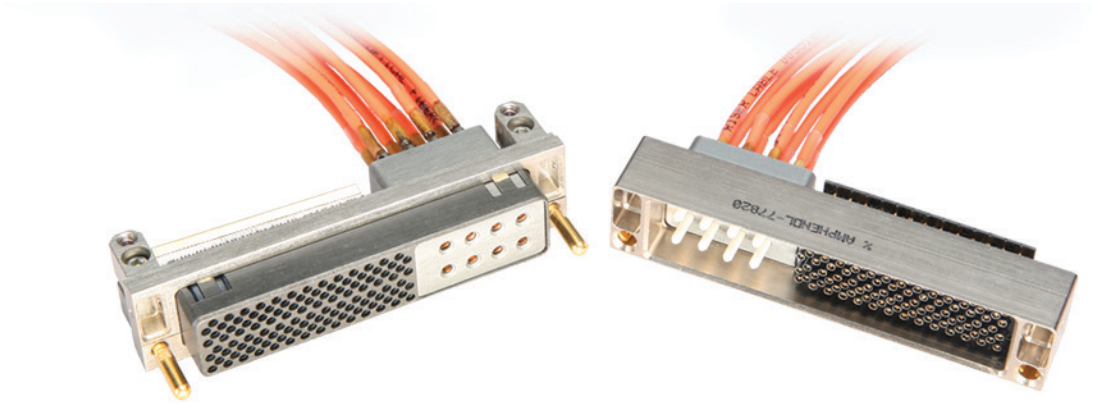
- **M28876** – Designed specifically for fiber optics in US Navy vessels. Uses M29504 termini for connection points. MT Ferrules are also used in commercial-off-the-shelf (COTS) versions as well within the same form factor.
- **D38999** – Use M29504 termini, MT's or Expanded Beam technology instead of contacts. All else is the same as copper specifications. Used in all harsh environment applications.
- **Mighty Mouse** – Smaller form factor than D38999 offered by Glenair. 806 series commonly used with M29504 termini for fiber optic applications.
- **ARINC 801** – Newer design specifically for commercial aerospace applications. Uses ARINC 801 specified termini.
- **Tactical** – Most robust connector system designed for heavy field use with military or broadcast applications. These can be PC or Expanded Beam depending on level of dirtiness in application and loss budgets acceptable for the data. Also referred to as TFOCA, M83526 and other trade names.

CONNECTOR TYPES

RECTANGULAR

These connector systems are generally less protected than circulars and do not mate/un-mate as often as the circular connectors. However, rectangular connectors and connector systems take up much less volume to join the fiber optic channel and commonly make those connections inside protected areas. Most rectangular systems are also modular in concept to tailor the product for what is needed.

- **Micro-D** – common form factor input for computers can also be loaded with termini or MT ferrules for fiber optic use.
- **VITA 66** – essentially a fiber optic version of VITA 46 standards.
  - VITA 66.1 – incorporates MT ferrules
  - VITA 66.2 – incorporates ARINC 801 termini
  - VITA 66.3 – Expanded Beam capability

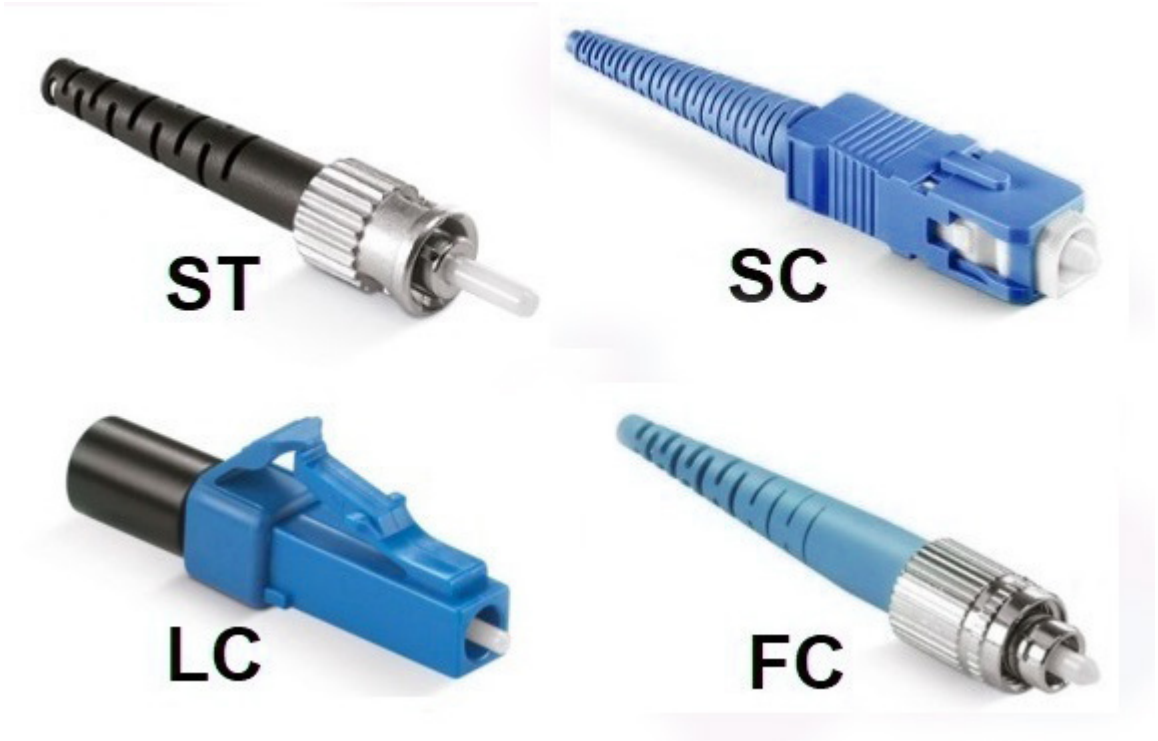


CONNECTOR TYPES

SIMPLEX AND DUPLEX COMMERCIAL GRADE

Not as physically tough as circulars, but in a smaller form factor where space is at a premium, but still protected inside a cabinet or box. Simplex is simply a single fiber channel and Duplex has two channels. These include:

- **ST** – Straight Tip connectors use a bayonet coupling mechanism and are the most robust of these types of connectors that are also used in commercial applications. The U.S. Navy has their own specification for these called M83522.
- **LC** – Lucent Connectors are today the most common connector type for commercial applications. LC's use a push-pull mechanism for easy and quick connect and disconnect while still offering a dependable coupling. With a small form factor as well, these are used in high-density environments and can be incorporated inside circulars instead of termini as well. The D38999 form factor commonly uses LCs as the connection medium.
- **SC** – Standard Connectors are one of the oldest connection methods and they are still used today because of low relative cost and quick patching capability with push-pull as opposed to the latching LC. However, SC connectors are roughly twice the size of LC connectors, so this is not recommended in high density environments.
- **FC** – Ferrule Connectors are being phased out because they are not as reliable as the other simplex & duplex connectors listed above.



FIBER OPTIC COMPONENTS

ACTIVE COMPONENTS

Active fiber optics, also known as Optoelectronics; are the input & output or switching of an optical data transmission that requires electrically powered equipment to operate. The input & output can be done by transmitter, receiver or a combination of the two. This also includes Media Converters, which transform specific data copper data languages into optical digital transmissions. Fiber optics are the best way to transmit data. However, computers and machines use electrons to function, not photons and therefore the digital data must be converted at or near the machine interface.

Transceivers are also typically on the board or inside the connector whereas Media Converters are done outside of the containment area box. Every fiber optic signal must use some sort of active component. These include:

- **Transceivers**
  - Multimode = LED (Light Emitting Diode)
  - Single Mode = Laser
    - Commonly a Vertical-Cavity Surface-Emitting Laser (VCSEL)
  - SFP = Small Form-factor Pluggable is most common board level
  - QSFP = Quad SFP, also common for higher channel densities
  - Firefly® from Samtec allows for placement of transceivers anywhere on the printed circuit board (PCB) and not just on the edge.
- **Active Optical Cables (AOC)** – all in one cable assembly that includes transceivers embedded in the hardware of a plug and play assembly.
- **Size 8 Cavity** – small transmitters or receivers (not transceivers) that fit inside size 8 cavity connectors such as D38999, D-Sub, etc. Often combined with copper connectivity products to provide an all-in-one connector.
- **Media Converters** – Highly customizable to suit applications. Really small boxes that work with various power requirements plus data protocols such as:
  - Ethernet
  - HDMI
  - SMPTE
  - Can Bus
  - ARINC 818
  - & Many others

FIBER OPTIC CABLES

CABLES

There is also a wide variety of cable types available depending on the application. What must first be considered is the type of optical fiber used. Typically, only one type of fiber is used inside a cable (e.g., OM3), but special hybrid cables using more than one type of core are possible. Additionally, composite copper & fiber cables can also be designed on a custom basis.

Fiber optic cables are either:

- **Loose Tube** – the optical fibers freely move inside a tube that can either be gel-filled or dry blocked to take up the additional space inside the tube. This is the best method for long distance communications to maximize data densities.
- **Tight Buffer** – Best for shorter distance communications and smaller channel counts.

The environment the cable is used in will dictate the materials used in the cable construction. Fiber optic cables are typically classified as either:

- **Outdoor** – referred to as Outside Plant to withstand the rigors of the outside elements. It is typically buried but can also survive in the weather.
- **Indoor** – further classified by additional environmental requirements such as:
  - **Riser-Rated** – offers good fire protection. Also called OFNR.
  - **Plenum-Rated** – More stringent fire rating than Riser. Also called OFNP.
  - Low-Smoke, Zero-Halogen (LSZH)
- **Indoor/Outdoor** – used as a transition between indoor and outdoor. Same environmental categories as Indoor but made a little more robustly.
- **Direct Buried** – similar to Outdoor with added protection in the form of armor.
- **Aerial** – for use on Utility poles.
- **Tactical** – Meant to be reeled/unreeled many times during its life as well as withstand significant physical abuse.

Cable types can also be classified as:

- **Simplex** – a single fiber cable used like a hook-up wire or perhaps with breakouts.
- **Duplex** – two channel cable where one fiber is to transmit, and one is used to receive. The cable could be round, flat or zipcord for ease of separating the two fibers.
- **Ribbon** – commonly used in protected areas but can be ruggedized as well. Needed for MT connections.

FIBER OPTIC ACCESSORIES

ACCESSORIES

As with electronics, fiber optics also need a wide variety of complimentary products to ensure a robust sturdy connection is maintained. These include:

- **Backshells** – M28876 has their own backshells available within the specification. D38999 often uses M85049 backshells or manufacturer branded equivalents.
- **Strain Relief** – Boots, Shrink Tubing, Cord Grips and other devices to ensure the cable is not harmfully bent near the connection point. Particularly with single mode fibers, care must be taken to ensure that there are no kinks or microbends in the cable as it will degrade the signal.
- **Splice Enclosures** – can be larger clamshell designs with excess fiber lengths coiled within or smaller protective devices simply to shelter the connection point.

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POWELL ELECTRONICS

The Fiber Optic Connectivity Authority

Powell Electronics is ideally positioned to work with engineers to specify the fiber optic components necessary to suit harsh environment applications. This also includes providing plug and play completed assemblies when needed. Powell is also perfectly situated to ease the burden on purchasing people to source needed materials in a timely and stress-free manner.

Powell's main warehouse is located in Swedesboro, NJ that also provides value added services for connector assembly, kitting, packaging, labeling, supply chain management and other customer centric activities. We are certified to ISO9001, AS9100 and ISO9120 .

Simply put, Powell Electronics is the best channel to market.

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