Getting to Know Fiber Optics

Fiber Optical Cables & Connectors

Why should I use fiber optic cable in my installation

1. A fiber cable can be run over a longer distance without adding special equipment.

2. Immunity to EMI/RFI noise. This is especially useful in factory environments where heavy machinery tends to generate high levels of EMI/RFI.

3. Low data errors. Optical fiber tends to have a much lower bit error rate in comparison to copper cabling. This reduces the occurrences of retransmissions thereby increasing network efficiency.

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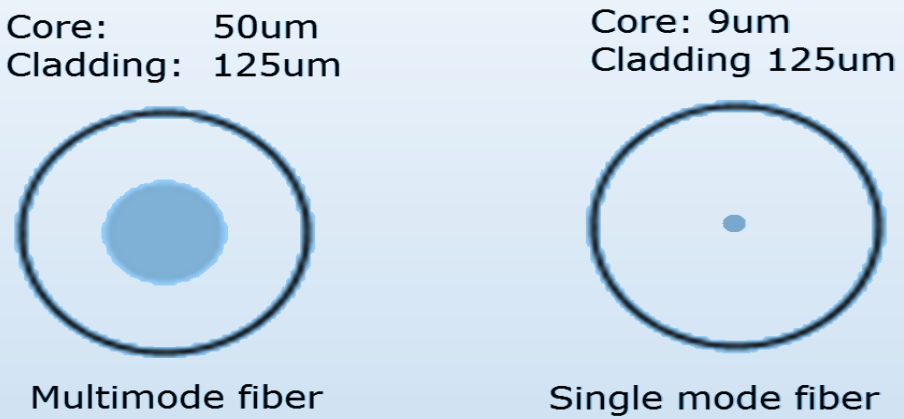
Multi-Mode vs Single-Mode Fiber Cables



MultiMode (OM1/OM2/OM3/OM4/OM5)	SingleMode (OS1/OS2)
Use: Suitable for short length interconnects up to a few hundred meters. Widely deployed in data centers and local area networks (LANs).	**Use:** Used for long length data applications. Widely deployed in carrier networks, metropolitan area networks, metropolitan area networks, and passive optical networks (PONs).
Core: has larger core 50um and operates at wavelength around 850nm.	**Core:** smaller core 9um and operates at wavelength between 1260nm-1650nm.
Transmitter required: Multimode which has a VCSEL laser is cheaper to manufacturer and matches good with fiber with a core diameter of 50um.	**Transmitter required:** SingleMode which uses a more expensive Edge emitting laser source which requires a hermetic package to achieve higher emission power. Less tolerance to fiber core misalignment.
Cost: Nearly two to three times lower than single mode	**Cost:** two to three time more than multimode because it costs more to manufacture and are more fragile.

Note: µm = micron. 50µm = 0,05mm. 9µm = 0,009mm. 125µm = 0,125mm
Wavelength NM: electromagnetic radiation of different wavelengths. Wavelength and frequency are related. www.thefoa.org/tech/wavelength.htm

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What is difference between Multi-Mode OM1, OM2, OM3, OM4, OM5 Cables

	Core/Jacket Diameter	Cable Color	Bandwidth/Wavelength			Link distance				
			850nm	953nm	1300nm	100mbps	1Gbps	10Gbps	40Gbps	100Gbps
OM1	62.5/125um	Orange	200m	NA	500m	2000m	275m	33m	NA	NA
OM2	50/125um	Orange	500m	NA	500m	2000m	550m	82m	NA	NA
OM3	laser optimized 50/125um	Aqua	2000m	NA	500m	2000m	550m	300m	100m	70m
OM4	laser optimized 50/125um	Aqua	4700m	NA	500m	2000m	550m	400m	150m	100m
OM5	laser optimized 50/125um	Lime Green	4700m	2470m	500m	NA	NA	400m	150m	100m

What is difference between Single-Mode OS1, OS2 Fiber Cables

	OS1	OS2
Use	Indoor Use	Outdoor or loose tube use (street, underground)
Core/Cladding Diameter	9/125um	9/125um
Wavelength	1300nm, 1550nm	1300nm, 1383nm, 1550nm
Manufactured	Tightly buffered manufactured into solid medium	Held in medium but blown or inserted into carrier
Strength	More tolerent of bending	Bend Sensative
Signal loss	Greater loss per km than OS2	Low loss
Attenuation	Cable loss: 1.0db/km	Cable loss: 0.4db/km
Bandwidth 100mbps	2000m	2000m
Bandwidth 1Gbps	5 km at 1310 nm	5 km at 1310 nm
Bandwidth 10Gbps	10 km at 1310 nm	10 km at 1310 nm

Note: µm = micron. 50µm = 0,05mm. 9µm = 0,009mm. 125µm = 0,125mm. 62,5 µm = 0,0625mm

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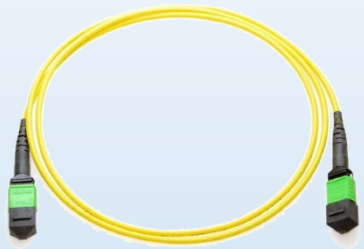
What is the Difference between Duplex vs Simplex vs WDM Fiber Cable



Simplex	Duplex	WDM (Wavelength Division Multiplexing)
Consists of a single strand of glass of plastic fiber.	Consists of two strands of glass or plastic fiber.	Multiplexes a number of optical carrier signals onto a single optical fiber by using different wavelengths (i.e., colors) of laser light. This technique enables bidirectional communications over one strand of fiber, as well as multiplication of capacity. Uses a multiplexer at the transmitter to join the several signals together, and a demultiplexer at the receiver to split them apart.
Simplex fiber is most often used where only a single transmit and/or receive line is required between devices	This cable is most often used for duplex communication between devices where a separate transmit and receive are required.	WDM systems are popular with telecommunications companies because they allow them to expand the capacity of the network without laying more fiber.
For example, an interstate trucking scale that sends the weight of the truck to a monitoring station or an oil line monitor that sends data about oil flow to a central location.	Workstations, fibre switches and servers, Ethernet switches, backbone ports, and similar hardware require duplex cable.	Most WDM systems operate on single-mode fiber optical cables, which have a core diameter of 9 µm. WDM works in a pair (A-B). One converter frequency is WDM TX:1550nm, WDM RX 1310 and second converter is WDM TX: 1310, WDM RX 1550nm.

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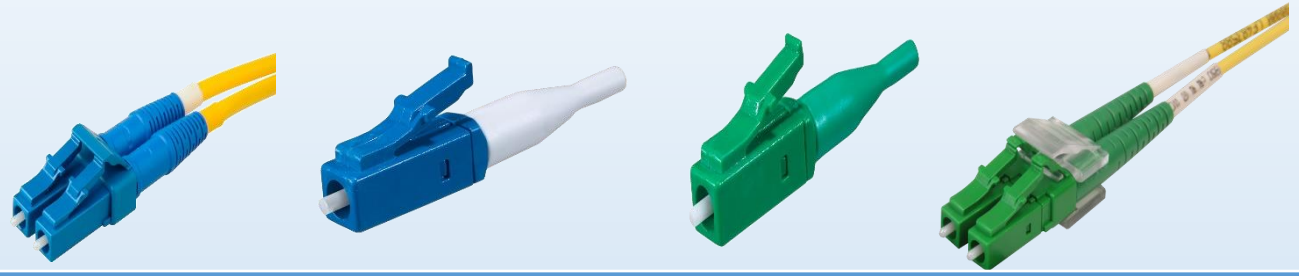
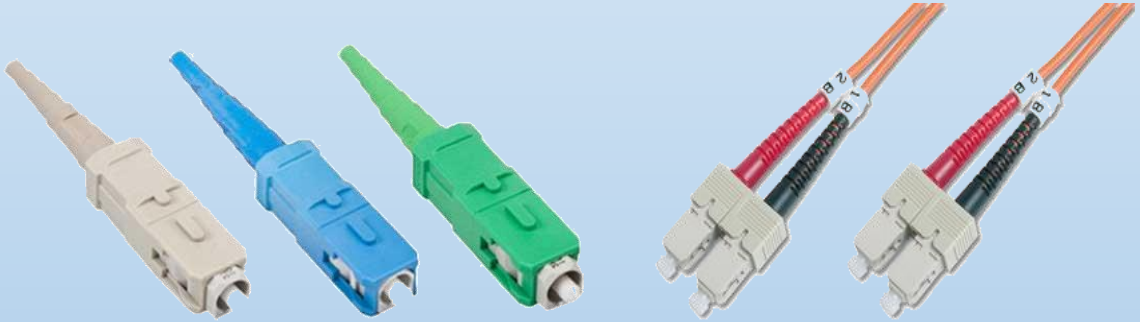
Optical Connectors Types

Connector type must match the Optical Media converter or Module port type



LC Connectors

LC uses a 1.25 mm ferrule, half the size of the ST. A standard ceramic ferrule connector. Snap-on RJ45 style.
Good performance, highly favored for single-mode and the connector of choice for multimode transceivers for gigabit speeds and above, including multimode Ethernet and Fibre Channel.



SC Connectors

It's a snap-in connector that latches with a simple push-pull motion. The SC style connector is suitable for both single mode and multimode cable and will support an APC polish.

ST Connectors

It has a bayonet mount and a long cylindrical ferrule to hold the fiber. Most ferrules are ceramic, but some are metal or plastic. And because they are spring-loaded, you have to make sure they are seated properly. used primarily with multimode fiber. An ST style connector will not support an APC polish.

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Standards of Fiber Optical Connectors

different polish of the fiber optic connector

PC (Physical Contact)	UPC (Ultra Physical Contact)	APC (Angled Physical Contact)
Connectors color: Usually the PC single-mode fiber connector is blue, but the PC multimode fiber connector is beige.	**Connectors color:** Usually the UPC single-mode fiber connector is blue, but the UPC multimode fiber connector is beige. (Note: 10G UPC multimode fiber connector is aqua.)	**Connectors color:** APC fiber connector can only be used with single-mode fiber and it is green.
Polished angle: slight spherical design to reduce the overall size of the end-face	**Polished angle:** no angle	**Polished angle:** 8°
Return loss: -40db or greater. Nominal Reflectance 0,01%	**Return loss:** -50db or greater. Nominal Reflectance 0,001%	**Return loss:** -60db or greater. Nominal Reflectance 0,0001%
Use: implemented on ethernet equipment such as media converters, fiber based switches	**Use:** implemented on ethernet equipment such as media converters, fiber based switches	**Use:** Commonly used in passive optical applications
		(GPONS & passive optical lans) due to fact many ISP providers, cable companies use RF signals to deliver video „triple play" to customers. Higher optical wavelength ranges (above 1500 nanometers) which are used for RF video signals should use APC connectors. Reflected light can adversely impact signal.

Return loss: measurment of reflected light expressed as a negative DB value (higher the return loss the better the performance). -20dB loss equates to 1% of the light being reflected back, -50dB leads to nominal reflectance of 0.001%, and -60dB (typical of an APC ferrule) equates to just 0.0001% being reflected back.
Insertion loss: refers to the fiber optic light loss caused when a fiber optic component insert into another one to form the fiber optic link. Insertion loss can result from absorption, misalignment or air gap between the fiber optic components. We want the insertion loss to be as less as possible. Typical insertion loss is less than 0.2dB.
Note: APC & UPC connectors cannot and should not be mated. Not only does it cause poor performance since the fiber cores will not touch but it can also destroy both connectors.

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Choosing Optical Patch Cables

Choices	Options
Connector1	LC, ST, SC
Connector2	LC, ST, SC
Fiber Class	Multimode OM1, OM2, OM3, OM4, OM5, Singlemode OS2
Mode	Multimode Singlemode
Color Cable	Aqua, violet, green, orange, yellow
Fiber diameter	Singlemode 9/125um, Multimode 50/125um, 62,5/125um
Polishing	PC, UPC, APC
Cable type	Simplex, Duplex, WDM
Length	0,5m, 1m, 2m, 3m, 5m, 7m, 10m, 15m, 20m

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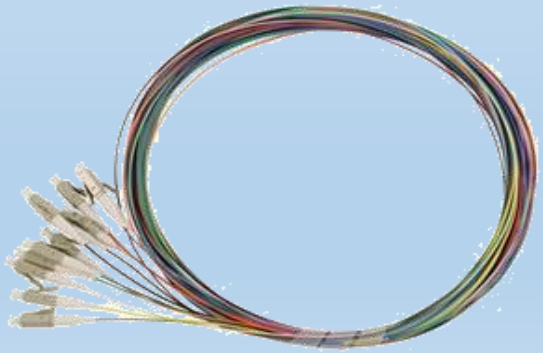
Simplex Pigtails

(end 1 has a connector, end 2 is bare fiber)

Choices	Options
Modes Available	Singlemode OS2 9/125um, Multimode OM2, OM3, OM4 50/125um
Connector Types Available	LC, SC, ST
Polishing	PC, UPC, APC
# of pigtails	1, 12
Lengths	1m, 1,5m, 2m, 3m

12pc colored pigtail



LC Multimode pigtail

SC Singlemode pigtail

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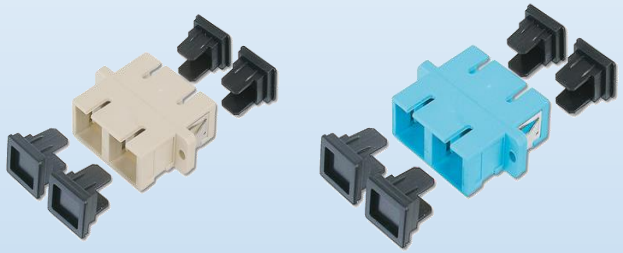
Fiber Optic Couplers/Adapters

Standard colors: Singlemode: Blue Multimode : Grey/Aqua

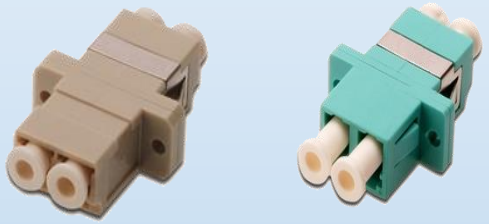
SC-SC Singlemode

SC-SC Multimode



LC-LC Singlemode

LC-LC Multimode



SC-SC Simplex Singlemode

SC-SC Simplex Multimode

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Fiber Installation Cable

Choices	Options
Application	Indoor, Universal (Indoor/Outdoor)
Color Cable	Black, Yellow, Beige, Blue
Fiber Diameter	Singlemode 9/125um Multimode 50/125um
Number of fibers	4, 8, 12, 24
Cable Jacket	LSOH
Fiber Class	Multimode OM2, OM3, OM4, Singlemode OS2
Mode	Multimode, Singlemode

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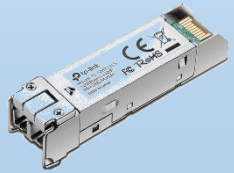
SFP Media Converters / SFP Transceiver Modules

Media Converters: Convert 100mbps or gigabit RJ45 copper cable to fiber.

Choices	Options
Speeds Available	10/100mbps, 10/100/1000Mbps
Fiber Types Available:	Multimode, Singlemode
Interfaces	1x RJ45 Interface. 1x SC/UPC Fiber Interface of duplex mode type, including two interfaces, namely TX and RX. When the two sets of optical transceiver are interfaced or connected to switch with fiber interface, the fiber is in cross connection, namely "TX-RX", "RX-TX" (direct butting for single optical fiber).
Wavelengths	Multi-Mode 850nm, Single-Mode 1310nm, WDM 1310nm:1550nm
Max Distances Available	up to 550m, up to 2km, 10km, 20km, 40km, 60km

Optical SFP Module (Small Form-factor Pluggable). Plugs into SFP slot of a network switch

Choices	Options
Speeds Available	100mbps, 1Gbps, 10Gbps
Fiber Type Available	Multimode, Singlemode
Connector Types	LC, SC
Wavelength	850nm, 1310nm, 1550nm
Max Distance	up to 550m, up to 2km, 10km, 20km, 40km, 60km, 70km, 120km



Note: Different types of transcievers are not interchangeable. Speed , Fiber type, Wavelength must match in pair. Connector types can be different.
Although they have similar form factors and optical connector interfaces, mainly due to differences in laser wavelength and fiber core size and more importantly the speed and reach specifications.

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PLC Splice/Splitters

PLC: Planar Lightwave Circuit Splitters:

- A simple passive component which plays an important role during the applications of technologies like GPON, EPON and BPON.
- Allows a strand of fiber optic signal being equivalently split into several strands of optical signal, which can support a single network interface to be shared by many subscribers.
- During the selection of a PLC splitter, split ratios should always be considered.
- Multiple form factors are available for PLC splitters.

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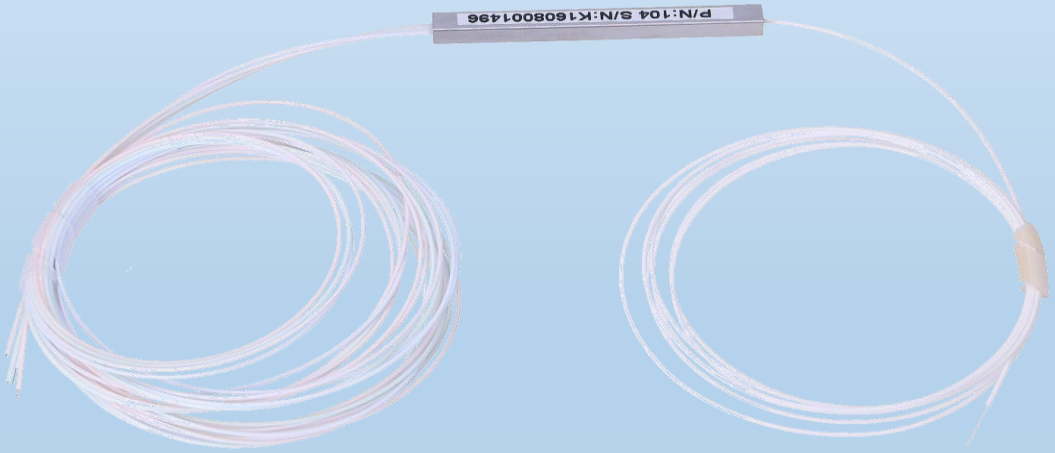
Bare Fiber PLC Splitter

- the simplest and commonly used PLC splitter in FTTx projects. This type of PLC splitter leaves bare fiber on all its ends. Thus, they can be spliced by network engineer freely according to the applications.



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Blockless PLC Splitter

- Looks like a bare fiber PLC splitter. The main differences are that the blockless PLC splitter is usually terminated with fiber optic connectors and it uses a compact stainless tube package. It is also common that many bare fiber PLC splitters also use stainless tube package for the split chip.

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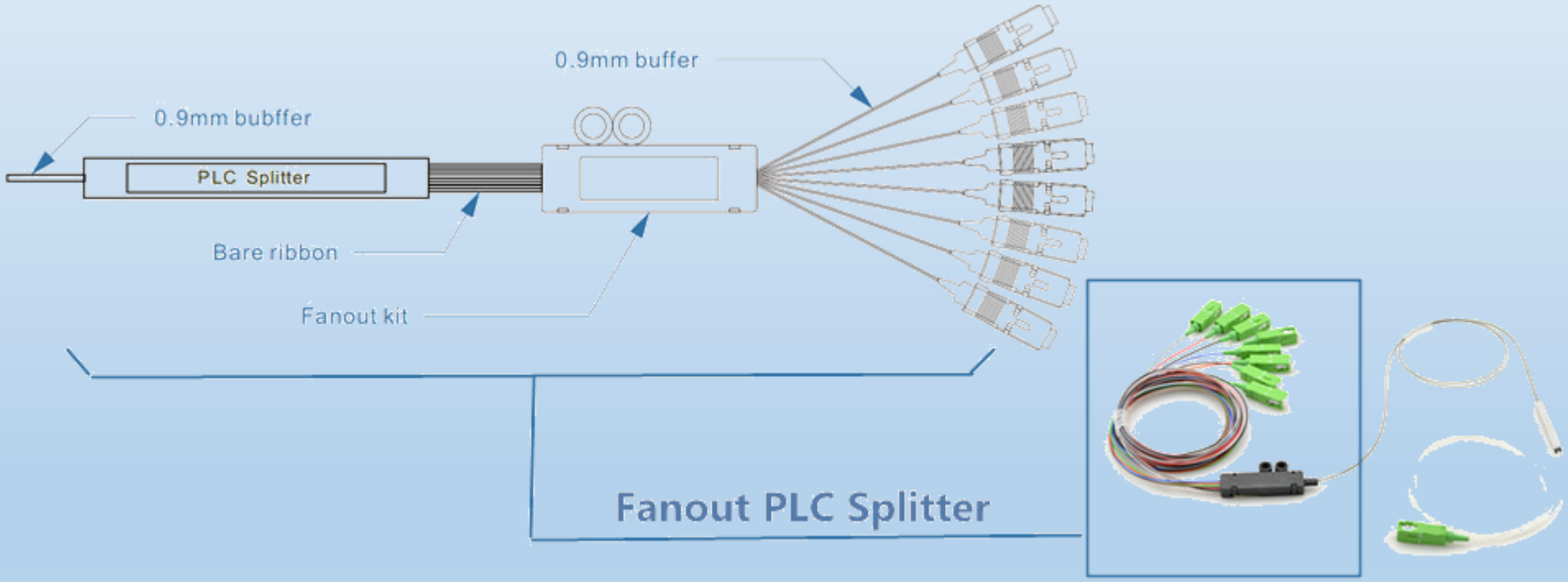
Fanout PLC Splitter

- generally uses 0.9mm buffer fiber, added with a length of ribbon fiber terminated with fanout kit behind the PLC split chip. The splitter ratios of fanout PLC splitters also come in various types.



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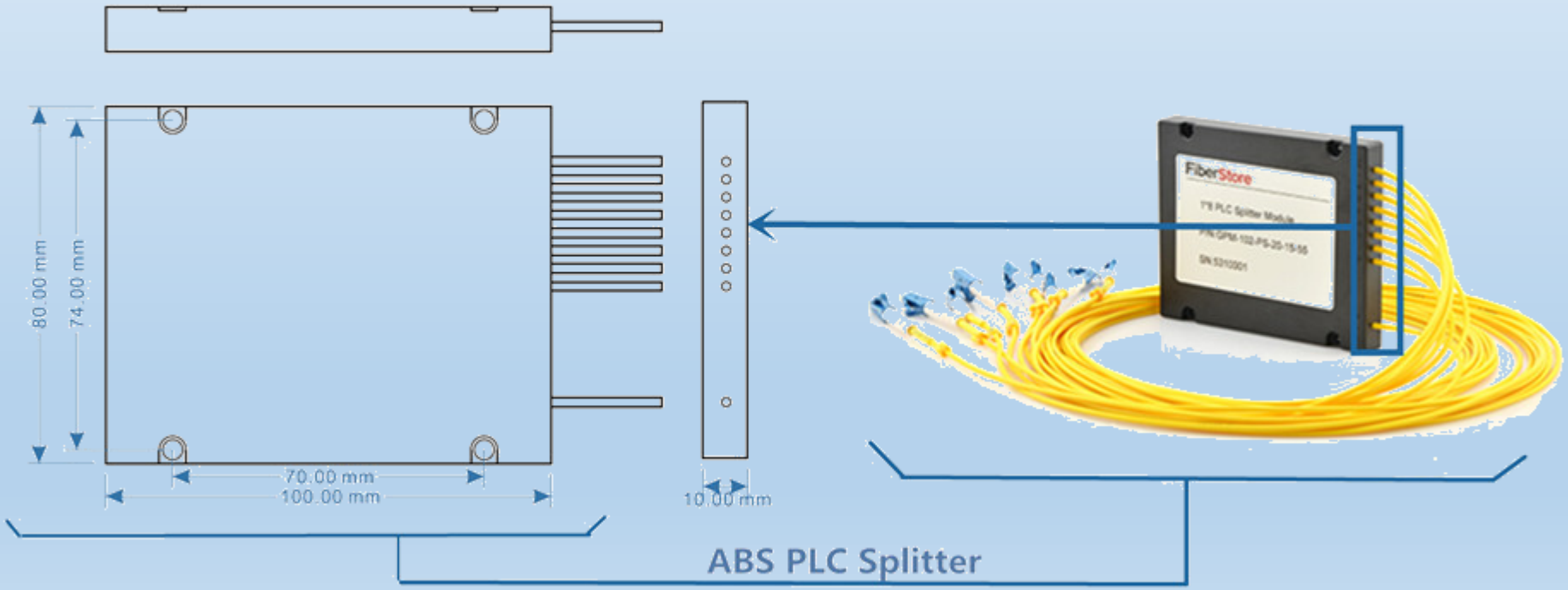
ABS Module PLC Splitters

- Uses ABS plastic box to holding the splitter chip. The inbound fibers and distribution fibers are arranged on the same plate of this ABS box, which can provide easier and more flexible cabling. Except providing reliable protection, ABS PLC splitter can also be installed in a variety of boxes or enclosures. It is very commonly to install a ABS PLC splitter in a standard 19-inch rack unit.



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LGX Box PLC Splitters

- It houses the whole PLC splitter inside a metal box and leave fiber optic adapters for both inbound fibers and distribution fibers on its front panel. The LGX PLC splitter can be used stand alone or be installed in the standard rack unit or fiber enclosures for better cabling.

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Tray Type PLC Splitters

- Uses a space saving package form factor for better cable management. However, it uses a international 19-inch design which can be deployed in ODF for compact cable management and signal distribution. With this design, the ports on tray type PLC splitter are clearly marked, which can reduce the faults caused by wrong connections.

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Rackmount PLC Splitters

- Designed to meet the requirement of high cabling density for data centers or server room. It can be firmly installed on the data center or server racks. More ports can be added on the PLC splitters. It is an ideal solution for high density cabling environment.

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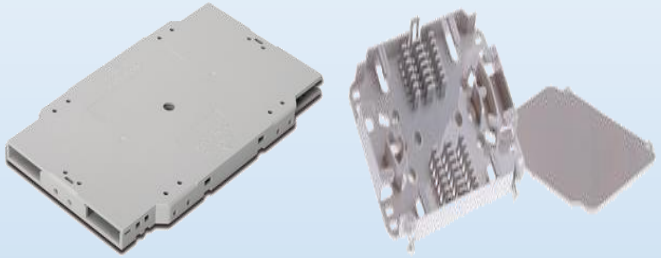
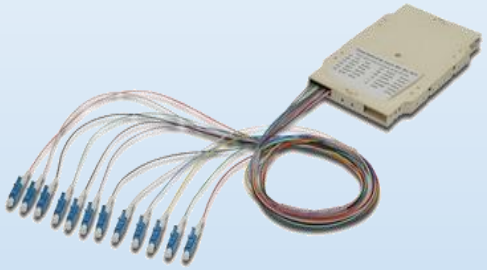
Parts of Rackmount Splice/Splitter Boxes

Splice cassette for 12 or 24splices



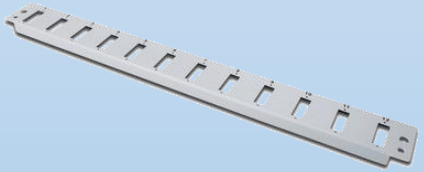
Splice cassette with 12 pigtails



Empty splice box

1U, Equipped 12x LC duplex splice box

Front panel



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Fiber to the Home – GPON

(Gigabit Passive Optical Network)

Internet and Telecom providers can offer high speed fiber optic delivery system for Triple Play services, (Data, Voice, IPTV).
A PON allows for longer distances between central offices and customer premises. **Digital Subscriber Line (DSL) the maximum distance between the central office and the customer is approximately 5,5 km**, a **Fiber PON local loop can operate at distances of over 20 km.**
The clear advantage of PON networks generally is that a single shared optical fiber can support multiple users through the use of inexpensive passive optical splitters. In GPON networks, up to 128 ONUs can share one fiber connection to the OLT. This makes GPON an attractive option for service providers wanting to replace copper networks with fiber, particularly in high-density urban areas.

- **PON (passive optical networks)** are point-to-multipoint optical networks with no active elements in the signals path from source to destination. The only interior elements used in such networks are passive combiners, couplers, and splitters. A PON consists of OLT (optical line terminal) at the service provider's central office and many number of ONU (optical network units) at the customer's home. The goal of PON is to reduce the amount of fiber.

- **PON (Passive Fiber Optical Network) consists of two parts.**
  - **OLT** (Optical Line Terminal) deployed at provider premises

ONU (Optical Network Unit) Consumer premises equipment

Up to 128 ONU devices can connect to 1 GPON OLT port using a passive optical splitter.

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Two types of standards of Passive Optical Networks (GEPON, GPON)

- **GEPON (Gigabit Ethernet PON)** is a fast Ethernet over passive optical networks which are point to multipoint to the premises (FTTP) or fiber to the home (FTTH) architecture in which single optical fiber is used to serve multiple premises or users. **Generally delivers 1 Gbit/s upstream/downstream bandwidth.** Employs a single Layer 2 network that uses Internet Protocol (IP) to carry data, voice, and video,. Costs of EPON equipment are approximately 10 percent of the costs of GPON equipment because it does not require multi-protocol conversions, and the result is a lower cost of silicon. In GPON, there are three management systems for the three Layer protocols. EPON equipment is cost competitive with VDSL.

- **GPON (Gigabit Ethernet PON)** provides three Layer 2 networks: ATM for voice, Ethernet for data and proprietary encapsulation for voice.
- **Advantages**
  - **Operates at 2.488 Gbps downstream and 1.244 Gbps upstream**.
  - Distance between OLT and ONT/ONU can be up to 20 km.
  - The downstream channel is broadcast to all ONTs. The upstream channel uses time division multiplexing with a dynamic bandwidth allocation mechanism.
  - GPON specifies QoS and management protocols required for triple-play services over the network.
  - Downstream security guaranteed with 128-bit AES encryption
  - No active equipment in the access network, preventing problems from electromagnetic interference or lightning.
- **Flexibility**
  - Not only does GPON offer twice the bandwidth of EPON/GEPON at its downstream speed of 2.5 Gbps, but it also supports twice the split ratio. This means that with a 64-way split, each GPON subscriber still receives an impressive connection bandwidth of about 35 Mbps. If a service provider chooses to implement lower split ratios, such as 16 or 32, then even more bandwidth can be delivered to subscribers. This greater bandwidth delivered by GPON is fully available to subscribers due to the improved bandwidth efficiency of the GPON standard. What's more, GPON is designed to provide triple-play services (data, video, and voice), not just high-speed Internet access. GPON's higher line speed, greater split ratios, and support for triple-play services combine to offer maximum flexibility and cost advantages for service provider deployments.

- **Interoperabilty**
  - GPON was developed by the ITU-T to be an industry-wide interoperable standard. Full interoperability means that devices such as ONTs can operate reliably with OLT equipment from different vendors.

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