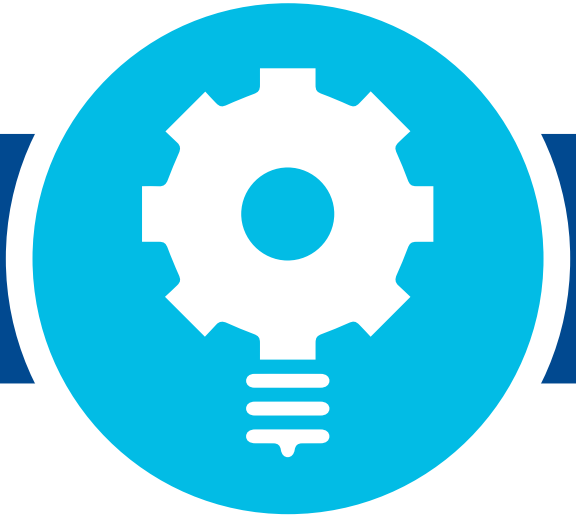

COMPUTER & NETWORKING CABLES
TECH TERMS GUIDE

FROM CABLENET

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www.cablenet.co.uk

Network Patch Leads | Copper Networking | Fibre Networking | Power Leads & PDUs | Computer Cables
AV & Security | Intelligent Power & Active Communications | DataCentre products

CABLENET

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This has been enhanced to support all the products we sell and feature in our Product Guide. We offer over 3000 premium quality, affordable products for all your Computer & Network cabling needs.

Our proven business delivery model helps you to quickly solve your connectivity demands with our reliable and competitive range of networking, cabling and power products with both copper and fibre optic cabling solutions. Most of our products are available for next day delivery from our large stock held in our 24,000ft warehouse in Surrey.

If you have any technical questions on anything in this Tech Terms Guide, please contact your personal account manager. We strive to continue to offer the very best customer service and retain our repeat business year after year and hope you find this Guide useful.

Peter Pearson
Managing Director

COMPUTER & NETWORKING CABLES TECH TERMS GUIDE

What's Inside...

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Network Patch Leads Facts

Ethernet cables, Network cables, Category cables and Patch cables are generally all the same thing. Also the terms "patch cable" and "patch cord" are generally synonymous. We refer to them as Patch Leads. All are used on LANs design around the Category 5, 5e, 6 or 6a patch cable international specifications with varying network speeds. The selection of the appropriate patch cable for the intended network application and environment is very important to the performance of the entire network.

Patch Leads are critical to the operation of Networks and allow system performance to operate at the intended high speeds and bandwidth. A patch cable connects two electronic or optical devices to each other for signal routing. This is usually for network applications, to "patch" a signal from one hub, switch, or router to another hub, switch, or router are used to connect equipment in computer bays or racks, or to connect peripheral devices to the computer. As network cables are used for connecting a variety of network elements from Ethernet switches and Ethernet routers to computers, servers and other network items - if there is an Ethernet interface, they can be connected using Ethernet cables.

Patch leads have twisted wire pairs within an overall patch lead. Twisting the wires together enables the currents to balance, i.e. in one wire the current is moving in one direction, and in the other wire of the pair the current is going in the other, enabling the overall fields around the twisted pair to cancel. In this way, data can be transmitted over considerable lengths without the need for undue precautions. The number of twisted per unit length is arranged to be different for each pair - the rate being based on prime numbers so that no two twists ever align and all four twisted pairs are layer up with difference Twisted lengths .This reduces crosstalk within the cable. The terminations can then be made to the required connector using a crimp tool.

Early network cables were unshielded, but as data speeds increased shielded versions were introduced to improve performance. For example, an unshielded twisted pair (UTP) cable may be satisfactory but a shielded cable is needed for Category 6a performance and is also more suitable for longer runs or where the cable passes through areas of high electrical noise. There are different methods that can be used for shielding Ethernet cables. The most common is to place a shield around each twisted pair. This not only provides shielding for the cable externally, but also reduces crosstalk between the internal twisted pairs as well.

Categories & Classes

Component		Link/Channel		Frequency	Application
TIA	ISO/EN	TIA	ISO/EN		
Cat 5e	Cat 5e	Cat 5e	Class D	100 MHz	1G Base-T
Cat 6	Cat 6	Cat 6	Class E	250 MHz	1G Base-T
Cat 6A	Cat 6_A	Cat 6A	Class E_A	500 MHz	10G Base-T
	Cat 7		Class F	600 MHz	10G Base-T
	Cat 7_A		Class F_A	1000 MHz	10G Base-T
	Cat8		Class F_A	2000 MHz	up to 40G Base-T

Cat-5e: This cable is defined in TIA/EIA-568 and has a slightly higher frequency specification than Cat-5 and can be used for 100Base-T and 1000Base-t (Gigabit Ethernet).

Cat-6: This cable is defined in TIA/EIA-568-B and provides a significant improvement in performance over Cat5 and Cat 5e. During manufacture Cat 6 cables are more tightly wound than either Cat 5 or Cat 5e and can support speeds up to 10Gbps.
The Cat 6 Ethernet cables generally have 2+ twists per cm and some may include a nylon spline to reduce crosstalk, although this is not actually required by the standard.

Cat-6a: The "a" in Cat 6a stands for "Augmented". The Cat 6a cables are able to support twice the maximum bandwidth, and are capable of maintaining higher transmission speeds over longer network cable lengths. Cat 6a cables utilise shielded to eliminate crosstalk for today's network applications and higher speed protocols such as 10GBASE-T.

Cat-7: This is defined by ISO/IEC 11801 Class F cabling. It comprises four individually shielded pairs inside an overall shield. It is aimed at applications where transmission of frequencies up to 600 Mbps is required.

Cat-8: These cables are designed for use in High performance 25 /40 GBASE-T Ethernet Networking applications up to a maximum length of 30M.

Cable Constructions

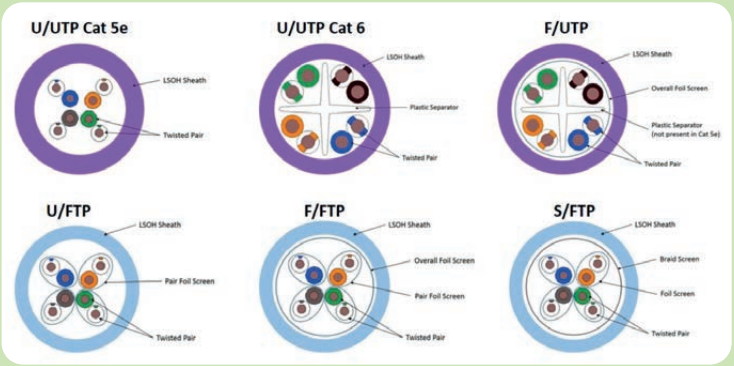
Copper cables used for structured cabling have 4 twisted pairs of wires but there are a number of different types of construction:

The ISO/IEC 11801 standard defines the different types of cable screen constructions as *X/YTP*, where *X* is the type of overall screen, *Y* is the type of screen around the twisted pairs and *TP* stands for *Twisted Pair*.

Some examples of typical cable constructions can be seen in the diagram to the right.

X can be:
- U for Unscreened
- F for Foil Screened
- S for Braid Screen

Y can be:
- U for Unscreened
- F for Foil Screened



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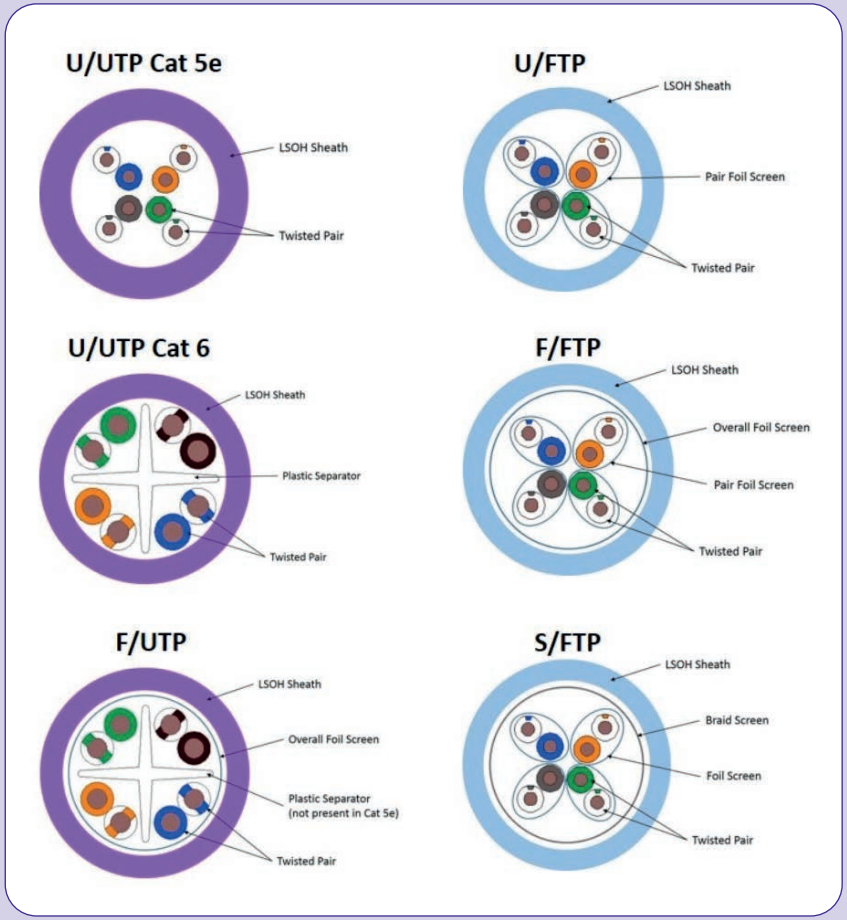

Categories & Classes

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Cat 6	Cat 6	Cat 6	Class E	250 MHz	1G Base-T
Cat 6A	Cat 6_A	Cat 6A	Class E_A	500 MHz	10G Base-T
	Cat 7		Class F	600 MHz	10G Base-T
	Cat 7_A		Class F_A	1000 MHz	10G Base-T
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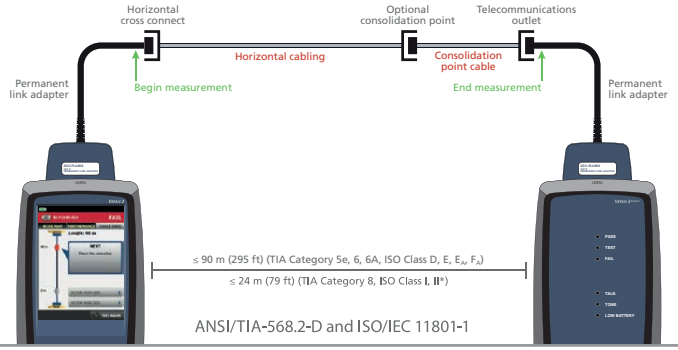
Twisted Pair Certification Methods

Permanent Link Certification

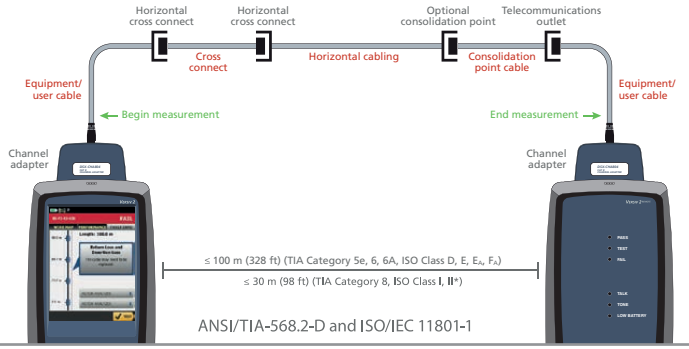
The permanent link test is used to certify the permanent cabling infrastructure and is typically conducted during the installation phase of the network.



ANSI/TIA-568.2-D and ISO/IEC 11801-1

Channel Certification

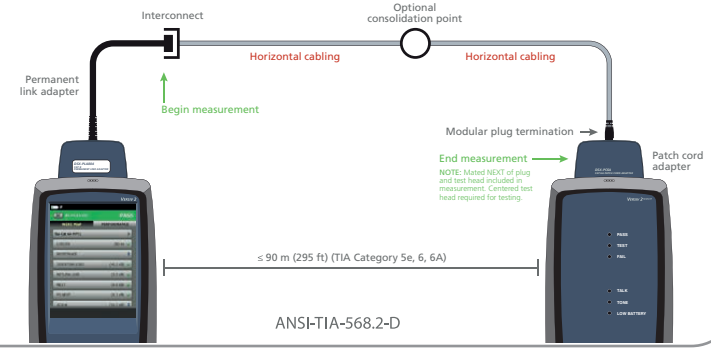
The channel test involves everything in the permanent link test, plus the patch cords in the work area, and those used for interconnection and/or cross connection. Channel tests are commonly performed after initial installation when the patch cords are available.



ANSI/TIA-568.2-D and ISO/IEC 11801-1

Modular Plug Terminated Link Certification

The modular plug terminated link has an interconnect (modular jack) on one end and a modular plug on the other, and is tested on one end with a permanent link adapter and the other with a patch cord adapter. The MPTL is used in applications where a patch cord is unnecessary or inconvenient such as LED lighting, security, and wireless access points.



ANSI-TIA-568.2-D

*Cross connects and consolidation points are not allowed for Cat 8 or Class I/II

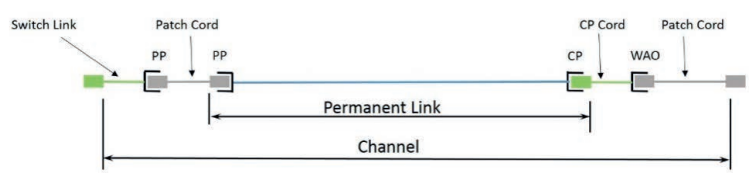
Ethernet Cabling Guidelines

	TWISTED PAIR	Multimode Fibre OM3	Multimode Fibre OM4	Singlemode Fibre OS2 1310mm	Singlemode Fibre OS2 1550mm
10BASE-T (10Mb/s)	✓	2000m	2000m	N/S	N/S
100BASE-T (100Mb/s)	✓	2000m	2000m	N/S	N/S
1000BASE-T (GbE)	✓	550m	1000m	5000m	N/S
10GBASE-T (10GbE)	✓	300m	550m	10000m	40000m
40GBASE-T (40GbE)	✓	100m	100m	10000m	40000m
100GBASE-T (100GbE)		100m	150m	10000m	40000m

N/S = Not Specified

Maximum Copper Cabling Lengths

The TIA 568-C standard defines the maximum length of the Permanent Link to be 90m and the maximum length of the Channel to be 100m, typically made up of 90m of solid conductor cable and 10m of stranded conductor cable.



Wi-Fi & PoE

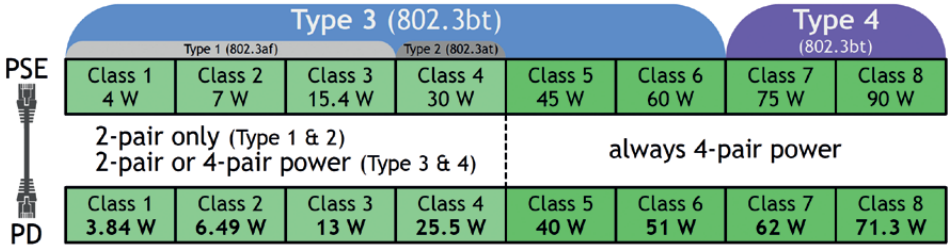
The latest design standard for Wired and Wireless building combine conventional cabling requirements with the demands of the latest Wi-Fi standards and ever-increasing use of PoE equipment, requires an intelligent approach to cabling in order to derive full benefits.

With the implementation of a Wi-Fi 6 network these technological changes must be understood with the implications for the wired cabling uplink infrastructure. The potential of Wi-Fi 6 can only be fully unlocked if the wired infrastructure is properly specified, designed, and deployed.

Wi-Fi 6 &6E (802.11ax) differ from previous generations of wireless technology as It will deliver four times faster average throughput, with data rates in excess of 5 Gb/s expected. It will benefit from the provision of two wired high bandwidth IT cabling uplink connections that will enhance PoE remote powering.

- **Wi-Fi 6 wireless access points (WAPs) need two class EA/category 6A or higher connections.** The ability of Wi-Fi 6 to support greater than 5 Gb/s data speeds for uplink connections. Standards organisations and design experts are recommending deploying two minimum category 6A) to each wireless access point (WAP). Wi-Fi 6 WAPs will need at least one class EA/category 6A connection to support either 2.5GBASE T or 5GBASE-T., 2.5 Gb/s or 5 Gb/s transmission speeds, and to take full advantage of Wi-Fi 6 technology as it matures to support greater than 5 Gb/s, two connections will be required to support link aggregation.
- **Wi-Fi 6 requires a minimum of 25 Gb/s capable backbone.** Installing a 25 Gb/s capable multimode optical fibre backbone will be required to support Wi-Fi 6 uplink capacity. In fact, this is already a key recommendation for Wi-Fi implementations per industry cabling standards.
- **Wi-Fi 6 WAPs will need more power and thermally stable cabling systems.** Wi-Fi 6 radio chips use significantly more complex signal processing and will require 30-watt Type 2 PoE power over Ethernet (PoE). Since the higher power can cause heat build-up in cable bundles, Wi-Fi 6 WAPs are better supported by thermally stable shielded cabling systems and solid conductor cords used in Category 6A shielded cabling.

The Different Options for Using the 4 Pairs



A first option is to use two pairs to power the PD and use the 4 pairs to convey the data.

A second option is to use the 4 pairs to both feed the PD and convey the data.

MPTL (Modular Plug Terminated Link)

In a traditional network infrastructure, IP devices typically connect to the network by patch cords from outlets that are terminated to horizontal cables. For some devices, especially those mounted to a ceiling that tend to be permanently fixed, the traditional method is not always the most efficient. Devices such as PoE lights, security cameras and wireless access points can instead be connected directly via a standards-based modular plug-terminated link (MPTL), eliminating the faceplate, outlet, and patch cord. The MPTL reduces extra connection points and improves security by eliminating patch cords that can be easily disconnected.

MPTL's are built with infrastructure cable directly connecting the end device with the horizontal network infrastructure using an RJ45 plug on one end and an RJ45 jack on the patch panel side. This eliminates the need for an additional outlet and patch cord and speeds up deployment in the field.

The MPTL link method meets TIA 568.2-Dand ISO/IEC TR 11801-9910 ED1, see test on page 29.

CPR Guidelines

EUROCLASS	Reaction to Fire	Smoke Production (S)	Flaming Droplets (D)	Acidity (A)
A_{ca}	Gross heat of combustion BS EN ISO 1716			
$B1_{ca}$	Flame Spread BS EN 50399	S1, s2 and s3	Optional additional during the fire test to monitor flaming droplets	Optional separate test to measure the acidity of gasses given off. Measured as pH and conductivity
$B2_{ca}$	BS EN 60332-1-2 Heat release.	Mandatory test for smoke production monitored during s1, s2 and s3	d0 d1 d2	a1 a2 a3
C_{ca}	BS EN 50399	BS EN 61034-2	BS EN 50399	BS EN 60754-2
D_{ca}	Heat release BS EN 50399 Flame Spread BS EN 60332-1-2			
E_{ca}	Flame Spread BS EN 60332-1-2	Basic test by independent authorised laboratory (notified body)		
F_{ca}	Factory or laboratory test (not necessarily notified body) but does not meet the requirements of class Eca			

Classes A to E have to be tested by an independent authorised laboratory. With F, E & D classes this is a one-off certification. For C Class & above these must be regularly tested and subject to the AVCP system which controls the consistency of assessment results.

What Does OM1 to OM5 Mean?

Multi-mode cables can be found in OM1, OM2, OM3 and OM4 types. Each type has different properties.

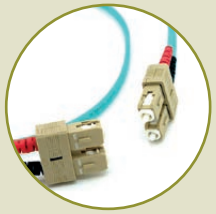
OM5

OM5 New Standard developed when you are using Shortwave Wavelength Division Multiplexing (SWDM) applications. For 10 Gigabit and 100 Gigabit Ethernet it only transmits at the same distance as the low cost OM3 and OM4 Fibre. It has a suggested jacket colour of Lime Green. OM5 fibre, also known as WBMMF (wideband multimode fibre) at a minimum speed of 28Gbps per channel through the 850-953 nm window.

OM4

It is a further improvement to OM3, uses a 50µm core and was developed specifically for VSCEL laser transmission and allows 10 Gigabit Ethernet up to 550m compared to 300M with OM3 and 100 Gigabit Ethernet at lengths up to 150 meters. Often supplied in a jacket colour of Erika Violet to differentiate it from OM3 . It is completely backwards compatible with OM3 fibre.

OM3



Its core size is 50µm, but the cable is optimized for laser based equipment that uses fewer modes of light. As a result of this optimization, it is capable of running 10 Gigabit Ethernet at lengths up to 300 meters. Since its inception, production techniques have improved the overall capabilities of OM3 to enable its use with 40 Gigabit and 100 Gigabit Ethernet up to 100 meters. It has a suggested jacket colour of aqua .

OM2

Its core size is 50µm and was the original fibre to support 10 Gigabit Ethernet but only up to 82 meters and has been superseded by OM3 and OM4.

OM1

The original multimode fibre with a core size of 62.5 micrometres (µm). It can only support 10 Gigabit Ethernet at lengths up 33 meters. No longer a recognised LAN standard in data transmission.

Ethernet Cabling Guidelines

	Multimode Fibre OM3	Multimode Fibre OM4	Multimode Fibre OM5	Singlemode Fibre OS2 1310mm	Singlemode Fibre OS2 1550mm
10BASE-T (10Mb/s)	2000m	2000m		N/S	N/S
100BASE-T (100Mb/s)	2000m	2000m		N/S	N/S
1000BASE-T (GbE)	550m	1000m		5000m	N/S
10GBASE-T (10GbE)	300m	550m	400m	10000m	40000m
40GBASE-T (40GbE)	100m	100m	150m	10000m	40000m
100GBASE-T (100GbE)	100m	150m	150m	10000m	40000m

N/S = Not Specified

Advantages of Fibre Optic Cables

Design and installation

Fibre is lightweight and thin, with a strong pulling strength. Its small size makes it easier to handle, and it takes up much less space in cabling ducts. Fibre networks also enable you to put all your electronics and hardware in one central location, instead of having wiring closets with equipment throughout the building.

Greater bandwidth

Fibre provides greater bandwidth than copper and has standardized performance up to 10 Gbps along with futureproofing with speeds from 40 Gbps up to 400 Gbps.

Immunity and reliability

Fibre provides extremely reliable data transmission. It is completely immune to many environmental factors and because the core is made of glass, which is an insulator, no electric current can flow through. It is immune to electromagnetic interference and radio-frequency interference (EMI/RFI), crosstalk and impedance problems.

Low attenuation and greater distance

very little signal loss occurs during transmission, and data can move at higher speeds and greater distances. Fibre does not have the 100-metre distance limitation of copper and Fibre distances can range from 300 meters to 100s kilometres, depending on the cable type used, cable, wavelength, and network.

Security Your data is safe with fibre cable. It does not radiate signals and is extremely difficult to tap. If the cable is tapped, it is very easy to monitor because the cable leaks light, causing the entire system to fail. If an attempt is made to break the physical security of your fibre system, you will know it.

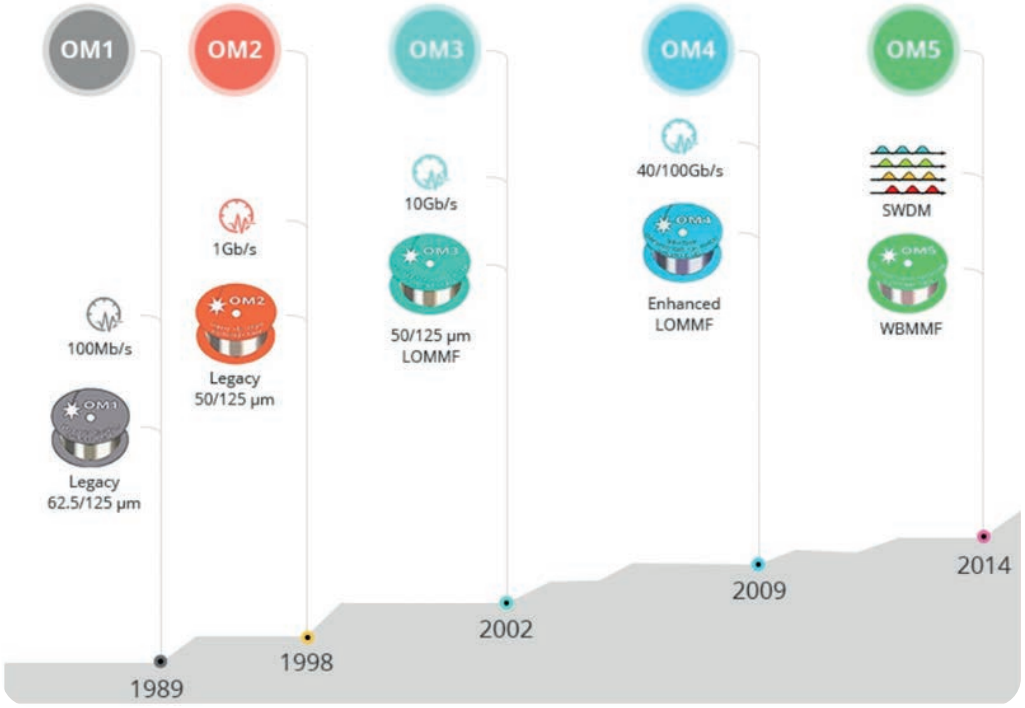
What is the difference between Single mode UPC and APC?

Most of our customers are simply looking to minimize Insertion Loss and maximize Return Loss. This means they want as much light as possible to pass through the fibre to its destination and as little light as possible to bounce back to its source. For most applications, UPC will provide this for you. However, in some circumstances, you need more Return Loss than UPC can offer. That is when you use APC. If you have green connectors on your fibre or devices, you may need APC. APC is designed specifically to maximize return loss. APC ends are actually polished to have an ~8° angle on the end of the fibre. An APC end will almost always have a green connector to make it clear that the fibre is APC. The part that is actually polished to an angle is so small that you won't be able to tell it is angled from looking at it.

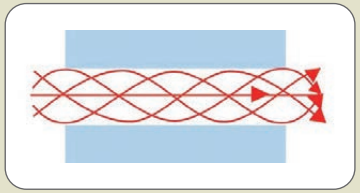
If you mix APC and UPC, the result can be tremendous insertion loss (meaning a lot of light will be lost at the point where you connect the APC to the UPC). So, if you have a port on your device that specifies it needs APC, you will need to use a cable with an APC end on it. If you have a cable with a green connector and you want to attach an adapter cable to the end, you will need to make sure an APC end connects to it.

How many types of Multimode Fibre?

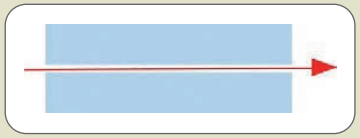
Identified by ISO 11801 standard, multimode fibre optic cables can be classified into OM1 fibre, OM2 fibre, OM3 fibre, OM4 fibre and newly released OM5 fibre. The next part will compare these fibres from the side of core size, bandwidth, data rate, distance, colour and optical source in details.



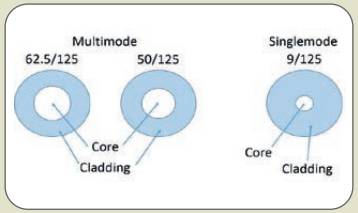
Singlemode vs. Multimode



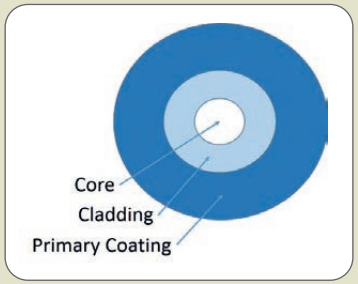
There are two types of Optical fibres, multimode and singlemode. In multimode fibres the light travels in multiple paths (modes) down the fibre, in a singlemode fibre the light travels as a single beam down the core of the fibre.



Single mode fibre is suitable for long distance applications, while multimode optical fibre is designed for short distance runs.



Fibres are defined by the ratio between the diameter of the core and the diameter of the cladding, expressed in microns (thousandths of a millimetre). There are two constructions of multimode fibre (50/125 and 62.5/125) and one construction of singlemode fibre (9/125).



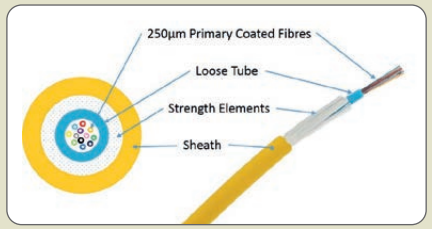
The glass fibres then have a coloured plastic primary coating that takes the overall diameter up to 250 microns. This provides protection and strength to the glass fibres and enables individual fibres to be identified at each end of a fibre optic cable.

Multi-mode fibre is typically cost effective for inside buildings or corporate campuses while single-mode is better suited for longer distance runs. Single-mode fibre can transmit over greater distances but typically requires more expensive equipment. Multi-mode is cost effective for installations where the lengths don't exceed a few hundred meters.

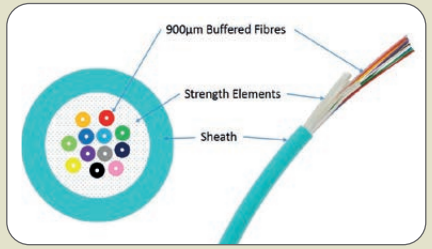
Loose Tube vs. Tight Buffered

Loose Tube Cables

Loose Tube fibre optic cables are the type that has traditionally been used in telecommunications networks where they are predominantly installed in external environments. The 250 micron primary coated fibres are contained within a plastic tube which may or may not contain a water blocking gel. One or more tubes are then surrounded by some form of strength member before an outer sheath is applied. The outer sheath may be PVC, LSZH or PE, depending on the environment in to which the cable will be installed. The construction of a typical single loose tube cable is shown below.



Each loose tube will typically contain 12 fibres, although some constructions have up to 24 fibres in each tube. The use of multiple tubes in a single cable sheath mean that cables with several hundred fibres can be produced.



Tight Buffered Cables

A limitation of the loose tube fibre optic cable construction is its deployment in vertical cable runs. The 250 micron primary coated fibres are not supported in the loose tube which means that there can be significant stress on the fibres when installed vertically. One answer to this is to install loops of cable every 10m or so but the more common modern solution is to use a tight buffered construction.

The 250 micron primary coated fibres have an additional secondary coating (buffer) that has an overall diameter of 900 micron (0.9mm). The 900 micron buffered fibres are surrounded with a strength element and an overall sheath is then applied.

The strength elements may be Aramid Yarn or E-glass yarn and the sheath is typically a Universal Low Smoke Zero Halogen (ULSZH) material, making it suitable for use in both internal and external (when installed in a dry duct) environments. Tight buffered cables tend to have a maximum of 24 fibres but are suitable for both horizontal and vertical cable runs.

CPR Cable

For Bulk Fibre Cables that are covered by CPR please see pages 115-116 in the DataCentre section. Please be aware that Fibre Patch Cords are NOT covered by CPR regulations.

Connectors & Adaptors

Fibre Optic Connectors

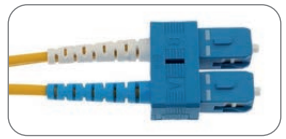
Unlike with copper cabling where one style of connector, the RJ45, dominates, with fibre there are a number of different connectors that can be used.

LC Connectors

The LC connector is sometimes referred to as a Small Form Factor (SFF) connector as it has much smaller dimensions than the SC connector. In fact it is possible to get twice as many fibres terminated on LC connectors in the space used by SC connectors. LC connectors have a simple latch, similar to that used on a RJ45 plug, making it familiar in use for network technicians. This has become the connector of choice in most new network fibre installations.

SC Connectors

The SC connector has a square format and has a push/pull latching mechanism. The image shows two SC connectors that have been joined using a special clip to create a SC Duplex connector with the A and B legs identified in the moulding of the clip.



ST Connectors

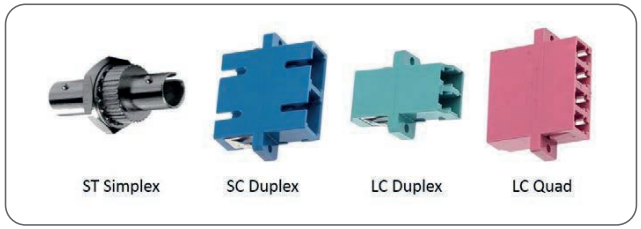
The ST connector has a round barrel and uses a bayonet fixing mechanism to secure it to the mating connector. It is not recommended for new installations and is only seen in legacy fibre deployments.

MPO/MTP® Connectors

The MPO or MTP® connector has larger dimensions than the LC Duplex connector but can accommodate up to 24 fibres in a single ferrule, making it ideal for high density installation. This style of connector is also finding favour in multi-channel fibre applications such as 40G and 100G Ethernet. However, the high precision nature of the connector means that it is not suitable for field termination.

Fibre Optic Adaptors

The standard way of joining two fibres together at a patch interface is through the use of adaptors, sometimes also referred to as couplers. These devices consist of a plastic housing with precision alignment sleeves that are designed to ensure that the two fibre end faces are perfectly aligned when a fibre connector is inserted in to both sides of the adaptor. The adaptors are specific to the type of connector(s) to be mated. Some typical fibre adapters are shown below.



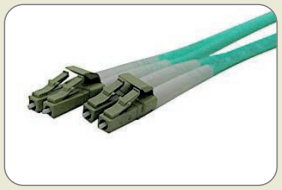
Patch Cable Types Explained...

Single Mode OS2 Patch Cable

OS2 Patch Cables are made to provide bandwidth used in long distance transmission. They are 2.8mm Duplex Design with white strain relief boots and our standard LSOH jacket colour is Yellow. Each fibre cable is tested for insertion loss. Individual test results are provided.

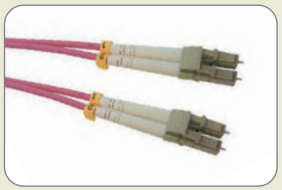
10 Gigabit 50µm OM3 Patch Cable

OM3 Patch Cables are made to provide bandwidth that will support transmission above 10 Gigabits and can be used for applications up to 300 metres. They are 2.8mm Duplex Design with white strain relief boots and our standard LSOH jacket colour is Aqua Blue. Each fibre cable is tested for insertion loss. Individual test results are provided.



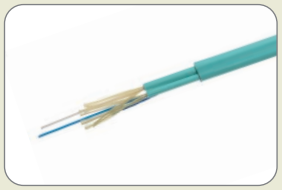
10 Gigabit 50µm OM4 Patch Cable

OM4 Patch Cables are made to provide bandwidth that will support transmission above 10 Gigabits and can be used for applications up to 550 metres. They are 2.8mm Duplex Design with white strain relief boots and our standard LSOH jacket colour is Aqua Blue or Erika Violet. Each fibre cable is tested for insertion loss. Individual test results are provided.



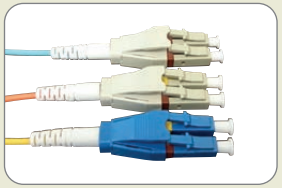
Ruggedised Patch Cable

All our Ruggedised are manufactured with individual fibre cable in a Flat Twin design with an additional overall LSOH jacket for added protection. Single mode OS2 has a Yellow LSOH jacket and Multimode OM3 and OM4 fibre with an Aqua Blue Jacket. Each fibre cable is tested for insertion loss. Individual test results are provided.



Uniboot LC Reverse Polarity Patch Cable

We can offer Uniboot LC Single and Multimode fibre patch cords offer a compact design and with a few simple steps the connector polarity can be reversed without any connector re-termination. Single mode OS2 has a Yellow LSOH jacket and Multimode OM3 and OM4 fibre with an Aqua Blue Jacket. Each fibre cable is tested for insertion loss. Individual test results are provided.



What is Return Loss?

When light hits the end of a fibre optic cable, a portion of it can bounce back towards the source. This is known as Back Reflection and it can cause a few different problems. Return Loss is the term for how much the end of a cable cuts down on Back Reflection.

You want as much Return Loss as possible.

What is Insertion Loss?

When light travels out of the port on your hardware into the fibre optic cable, some of it is lost in the transition. The amount that is lost is referred to as Insertion Loss.

You want as little Insertion Loss as possible

Testing and Certifying Fibre Optic Cable

It is relatively easy to certify fibre optic cable because it is immune to electrical interference. You only need to check a few measurements.

Attenuation. Measured in decibels/kilometre (dB/km), this is the decrease of signal strength as it travels through the fibre cable. Generally, attenuation problems are more common on multimode fibre optic cables.

Return loss. This is the amount of light reflected from the far end of the cable back to the source. The lower the number, the better. For example, a reading of -60 decibels is better than -20 decibels. Like attenuation, return loss is usually greater with multimode cable.

Graded refractive index. This measure how the light is sent down the fibre. This is commonly measured at wavelengths of 850 and 1300 nanometres. Compared to other operating frequencies, these two ranges yield the lowest intrinsic power loss. (NOTE: This is valid for multimode fibre only.)

Propagation delay. This is the time it takes a signal to travel from one point to another over a transmission channel.

Test Equipment

Optical time-domain reflectometry (OTDR). This enables you to isolate cable faults by transmitting high-frequency pulses onto a cable and examining their reflections along the cable. With OTDR, you can also determine the length of a fibre optic cable because the OTDR value includes the distance the optic signal travels.

Fibre Optic Light Sources and Meters. These fibre optic testers function by shining a light down one end of the cable and at the other end, there is a receiver calibrated to the strength of the light source. With this test, you can measure how much light is going to the other end of the cable. Generally, these testers give you the results in dB lost, which you then compare to the loss budget. If the measured loss is less than the number calculated by your loss budget, your installation is good.

Newer fibre optic testers have an even broader range of capabilities. They can test both 850- and 1300-nanometer signals at the same time and can even check your cable for compliance with specific standards.

MPO

MPO or MTP (multi-fibre termination push-on) terminated cables are widely used in high-density data centres. The terms MPO and MTP are often used however MPO is the recognised a fibre connector type, while MTP is a registered trademark of an MPO connector manufactured by US Conec. All MTPs are MPOs but not all MPOs are MTPs. To the naked eye, there is little difference between the two connectors, and in cabling and transceiver interfaces, they are compatible with each other.

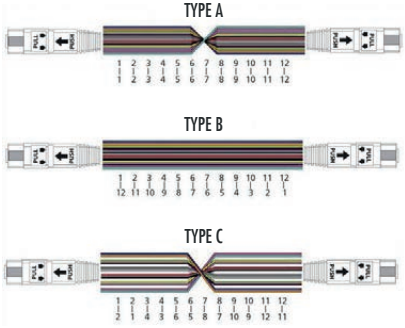
MPO Design

MPO connectors are typically available with 8, 12, or 24 fibres with 32, 48, 60, or 72 fibres fibre counts available, but these are typically used for specialty super high-density multi-fibre arrays in large scale optical switches.

MPO connectors are either male (with alignment pins) or female (without alignment pins). In order to mate two MPO connectors together through an adapter, one connector must have pins and the other must be without pins. The role of the alignment pins is to ensure that fibres are facing each other perfectly, ensuring successful mating.

MPO connectors are often color-coded to help contractors distinguish between the different fibre types and polish specifications for single mode. MPO connectors are made for both single-mode and multimode multifibre cables. In single-mode OS2 applications, per Telecommunications Industry Association's (TIA) specification, the cable jacket is yellow. The connector colour will vary depending on the connector type. Ultra-Physical Contact (UPC) connectors will also be yellow, while Angled Physical Contact (APC) connectors are green. With multimode OM3/OM4, both MPO connectors and cable jacket will be aqua, per TIA specifications.

MPO Polarity



Achieving polarity is another challenge with MPOs. Polarity defines the direction of the light path or flow and is called the A-B-Cs of fibre polarity. This is more complex with multi-fibre MPO cables and connectors. Industry standard TIA-568.3-D names three different polarity methods for MPOs: Method A, Method B, and Method C. Each method uses different types of MPO cables.

When examining a typical 12 fibre configurations, Method A uses a key up connector on one end and a key down connector on the other end so that the fibre located in Position 1 arrives at Position 1 at the other end. Method B uses key up connectors on both ends to achieve the transceiver-receiver flip so that the fibre located in Position 1 arrives at Position 12 at the opposite end, the fibre located in Position 2 arrives at Position 11 at the opposite end, and so on. Method C uses a key up connector on one end and a key down on the other end like Method A, but the flip happens within the cable itself where each pair of fibres is flipped so that the fibre in Position 1 arrives at Position 2 at the opposite end, and the fibre in Position 2 arrives at Position 1.

Whichever Method is chosen, Polarity needs to be consistent.

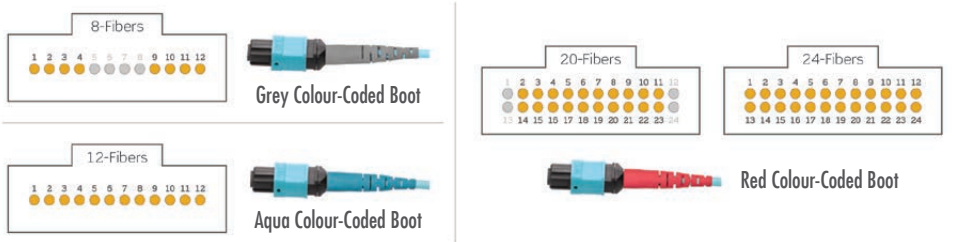
MPO 8 Fibre, 12 Fibre and 24 Fibre

For density, 24-fibre cabling has an advantage over 12-fibre since the higher density in the enclosure leaves more rack space for active equipment, reducing the total amount of rack space required for patching. With 24-fibre, enclosures can have twice as many connections with the same number of ports compared to 12-fibre.

Also, 24-fibre cabling only needs half the number of cables with less pace needed and improved airflow and reduced cooling costs.

Ina 8-fibre, parallel optic applications. A Base8 or 8-fibre cabling infrastructure actually uses 12-fibre MPO connectors to achieve 40, 100, 200, or 400 Gb/s channels. In these cases, only 8 of the 12 fibres are used, so a third of the connector capacity is dark or unused. Using a 24-fibre cabling infrastructure, you can run three 8-fibre channels in one connector.

MPO CONNECTORS IN THE CHANNEL



New VSFF Fibre Connectors for next-gen 200/400G transceiver QSFP-DD and OSFP

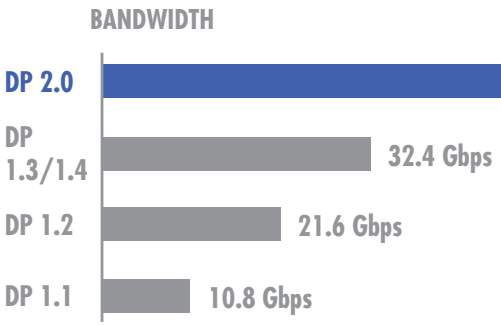
These new connectors will offer a 40% size reduction compared to LC Duplex, with performance exceeds LC and Double the density in patch panel compared to LC. For example, it will be possible to have 256F in a 1U Fibre panel.

Power Connection Guide

IEC 60320-1 Appliance Couplers

Connector (Female)	Appliance Inlet (Male)	Diagram	Earth Contact	Rewirable Connector Allowed?	Max. Current (A)	Remarks and Example Uses
BS1363	BS1363		✓	✓	13	Commonly known as UK Main Lead.
C5	C6		✓	✗	2.5	This coupler is sometimes colloquially called a cloverleaf coupler or "Mickey Mouse". Commonly used on laptop power supplies and portable projectors, as well as on some desktop computers and recent LCD televisions from LG.
C7	C8		✗	✗	2.5	The C7 coupler is commonly reffered to as a "Figure of Eight".
C13	C14		✓	✓	10	Very common on personal computers and peripherals. Commonly but incorrectly referred to as a "kettle cord" or "kettle lead", but kettles actually require the C15/C16.
C15	C16		✓	✓	10	For use in high temperature settings, for example, electric kettle, computer networking closets. The official designation in Europe for the C15/C16 coupler is a 'hot condition' coupler.
C19	C20		✓	✓	16	This coupler is used for some IT applications where higher currents are required, as for instance, on high-power workstations and servers, uninterruptible power supplies, power distribution units, large network routers, and switches.
C21	C22		✓	✓	16	High-temperature variant of C19/C20.

What is DisplayPort?



The DisplayPort connector and cable is most commonly found in its full-size form, where it has 20 pins fitted into an L shape connector. That helps it stand out from more uniform ports like HDMI, USB-A, and USB-C. Also commonplace is its smaller variant, known as Mini DisplayPort, which originally debuted on Apple devices in 2008, before becoming a more commonplace addition to standalone monitors.

When it was introduced in 2010, DisplayPort 1.2 heralded in a new era of high-end data transmission,but it also improved the standard's resolution and refresh rate support, opening up the option of 5K resolution at up to 30Hz, 4K at up to 75Hz, and 1080p at up to 240Hz.

DisplayPort 1.4, however, takes things a much greater step further. It supports 1440p resolution at up to 240Hz, and even 4K at up to 120Hz.it also supports 5K resolution at up to 60Hz, and even 8K resolution at 30Hz. It also supports DSC 1.2. and with DSC enabled it can handle 4K at 60Hz with 30bit/px colour and HDR, and even 8K at up to 60Hz.

DisplayPort 1.4 cables are entirely backward compatible with older DisplayPort devices too, whether you're using a full size or Mini DisplayPort connection.

The DisplayPort 2.0 standard was only announced by its governing body, VESA, in mid-2019, but when supporting monitors, laptops, and graphics cards start to appear, they will offer higher refresh rates and resolutions than anything else out there. It will add support for two 4K monitors running at up to 144Hz at the same time, or a single 16K display with HDR enabled (with DSC compression)and in the near future, it will be DisplayPort 2.0 vs HDMI 2.1.

DisplayPort is Different from HDMI?

DisplayPort and HDMI are very different technically, and each began with a different product focus. For over ten years, HDMI has been the de-facto connection for home entertainment systems and is used widely on HDTVs as an AV interface. Some PCs and monitors include HDMI to enable connectivity with HDTVs and other consumer electronics gear. DisplayPort, a newer standard originally developed to support the higher performance requirements of personal computers, is based on updated signal and protocol technology similar to that already used in today's computer systems, enabling an increase in performance and integration. Because DisplayPort uses common signaling technology in use for data communications and a packetized data structure, through a common connector, it can be combined with standards such as USB and Thunderbolt. With link training/link quality monitoring as in data communications, DisplayPort provides a more robust and stable AV link.

DisplayPort 2.0 Performance to USB4™ and New USB Type-C® Devices

DisplayPort Alt Mode version 2.0 enables all of the latest capabilities of DisplayPort through the USB Type-C connector, including beyond-8K resolution and higher refresh rates, along with USB data delivery

DisplayPort Alt Mode 2.0 provides seamless interoperability with the new USB4™ specification published by the USB Implementers Forum (USB-IF), and fully enables all of the features in the latest version of the DisplayPort standard (version 2.0) through the USB Type-C® (USB-C) connector. With DisplayPort Alt Mode, the USB-C connector can transmit up to 80 Gigabits per second (Gbps) of DisplayPort video data utilizing all four high-speed lanes in the cable, or up to 40 Gbps with simultaneous SuperSpeed USB data delivery. VESA anticipates first products incorporating DisplayPort Alt Mode 2.0 to appear on the market in 2021.

DisplayPort and Thunderbolt

Thunderbolt takes advantage of DisplayPort technology, and Thunderbolt Hosts (such as notebooks and personal computers) are backward-compatible with DisplayPort cables and DisplayPort monitors. This means you can plug a DisplayPort monitor into a Thunderbolt computer output, using a standard DisplayPort cable. The adoption of DisplayPort technology by Thunderbolt has helped to accelerate the adoption of DisplayPort in high-end computing and video post-production.

DVI Monitor Port

Newer computer use DVI instead of VGA. The new breed of "thin" laptops use the smaller variants of DVI like the Mini-DVI and Micro-DVI.

A DVI cable has 29 pins, though some connectors may have less pins depending on their configuration.

DVI's video signal is compatible with HDMI, so a simple converter can allow a DVI monitor to receive input from an HDMI cable.

Additionally, DVI to VGA converters are also available to connect your new graphics card to an old monitor that supports only VGA mode.

DVI-D cables are used for direct digital connections between source video and LCD monitors.

DVI-I cables are integrated cables which are capable of transmitting either a digital-to-digital signal or an analogue-to-analogue signal. This makes it a more versatile cable, being usable in either digital or analogue situations.

HDMI Cables

The HDMI Advantage

HDMI technology is the global standard for connecting high-definition equipment. HDMI is the intelligent, all-digital interface used by most of the world's largest consumer electronics, PC and mobile device manufacturers incorporate HDMI connectivity into their products. HDMI is backwards compatible with DVI so you can use a converter to watch video on a DVI device.

There are several HDMI cable types plus a special cable certification designation to choose from; each designed to meet a particular performance standard. Here is an overview of the HDMI cable types, their capabilities, and how to tell them apart.

Active Optical HDMI Cables (AOC)

For longer length installations you will want to use a cable that supports 1.4 and 2.1 speeds, some are available with detachable heads for ways of installation through walls.

Finding the Right Cable...

The Ultra High Speed HDMI 2.1 Cable

This latest HDMI cable is the only cable that complies with stringent specifications designed to ensure support for all HDMI 2.1 features including uncompressed 8k@60 and 4K@120. The cable's bandwidth supports up to 48Gbps, it is backwards compatible with existing HDMI devices, and features exceptionally low EMI which reduces interference with nearby wireless devices. For verification and authentication the cable packaging is required to display the Ultra High Speed HDMI Certification Label which includes the Cable Name Logo printed on it.

Premium High Speed HDMI 1.4a Cable and Premium High Speed HDMI 1.4a Cable with Ethernet

are special certification designations for High Speed HDMI Cables that have been designed and certified for ultra-reliable performance for 4K/UltraHD including advanced features such as 4K60, HDR, expanded color spaces including BT.2020, and 4:4:4 chroma sampling. They have low EMI and are identified by HDMI Licensing Administrator's Premium HDMI Cable Certification Label for authentication verification.

"Trust the cable with the label" - *Only Premium HDMI Cables are allowed to display and promote the official Premium HDMI Cable Authentication Label.*

High Speed HDMI 1.4a Cable with Ethernet

This cable type offers the same baseline performance as the High Speed HDMI Cable shown above (1080p video resolution and beyond), plus an additional, dedicated data channel, known as the HDMI Ethernet Channel, for device networking. HDMI Ethernet Channel functionality is only available if both linked devices are HDMI Ethernet Channel-enabled.

High Speed HDMI 1.4a Cable

The High Speed HDMI cable is designed and tested to handle video resolutions of 1080p and beyond, including advanced display technologies such as 4K, 3D, and Deep Color. If you are using any of these technologies, or if you are connecting your 1080p display to a 1080p content source, such as a Blu-ray Disc player, this is the recommended cable.

Standard HDMI Cable with Ethernet

This cable type offers the same baseline performance as the Standard HDMI Cable shown above (720p or 1080i video resolution), plus an additional, dedicated data channel, known as the HDMI Ethernet Channel, for device networking. HDMI Ethernet Channel functionality is only available if both linked devices are HDMI Ethernet Channel-enabled.

Standard HDMI Cable

The Standard HDMI cable is designed to handle most home applications, and is tested to reliably transmit 1080i or 720p video – the HD resolutions that are commonly associated with cable and satellite television, digital broadcast HD, and upscaling DVD players.

Thunderbolt 3

Thunderbolt is developed by Intel and Thunderbolt 3 is an incredibly powerful technology and makes connecting devices that little bit easier. supports a much wider range of data transfer. It supports data up to 40Gbps and also supports high-resolution displays and allows you to daisy-chain devices so that you only have to connect those devices to one port on your computer.

Thunderbolt 3 is essentially a hardware interface that is designed to combine a number of different transfer protocols into a single physical connector.

Thunderbolt 3 combines a number of different standards, including PCI Express 3.0, DisplayPort 1.2 and Thunderbolt at 20GBps and 40Gbps, all in one cable.

That physical connector happens to be the USB-C connector. There are some major differences between Thunderbolt 3 and USB-C. While Thunderbolt 3 is an actual data transfer protocol, USB-C is simply the type of connector that it uses. When you talk about USB-C ports, it could use a number of different protocols, including Thunderbolt 3 or USB 3.1. Put simply, Thunderbolt 3 is backwards compatible with USB-C devices, but a USB-C computer will not work with a Thunderbolt 3 device.

Thunderbolt 3's massive bandwidth, you can drive up to two 4K displays with a 60Hz refresh rate and a single Thunderbolt 3 port can transfer speeds at up to 40Gbps. To put that in perspective, an entire 4K movie can be transferred in about 30 seconds at those speeds.

Thunderbolt 3 also supports the DisplayPort 1.2 protocol, and you can connect Thunderbolt 3 ports to external displays. While it uses the DisplayPort protocol, it can easily be converted into other video ports such as HDMI, DVI, or VGA through a simple adapter. On displays that support daisy-chaining, you can even connect up to two 4K displays with a refresh rate of 60Hz through a single Thunderbolt 3 cable.

Thunderbolt 3 can transfer power too, just like USB.

Thunderbolt 4

Thunderbolt 4 is more of a consolidation and evolution but real-world performance as Intel has mandated the minimum data rate and features that OEMs need to implement. Manufacturers using Thunderbolt 4 must hit higher performance minimums, guaranteeing that all supported devices support twin 4K displays or a single 8K display. Thunderbolt 4 enhancements will make it possible to wake all hub-connected devices on touch,

Thunderbolt 4 is designed to be fully compliant with the upcoming USB4 protocol. That means that Thunderbolt 4 devices will work seamlessly with USB4 computers.

Thunderbolt 4 ports will show the small lightning bolt logo, which will help differentiate it from USB4 Type-C ports, and older USB 3.2 Type-C ports. Thunderbolt 4 cables, however, will have that same logo, but will also have a small number 4 written underneath it.

USB-C vs Thunderbolt 3

USB-C (formally known as USB Type-C) and Thunderbolt 3 describe different things. USB-C is, by itself, just a form-factor for a connection. USB-C is an evolution of the design of older boxy USB connectors (known as Type-A). USB-C is a reversible connector, which means no more fiddling when plugging it in. It also has more pins than USB-A, allowing for increased power delivery, data transfer speeds, and video bandwidth to travel across the cable.

The term "USB-C" is used in the product description, it should be seen as shorthand for "a USB port that uses the Type-C form factor."

Thunderbolt 3, by contrast, refers to specifications detailing transfer speeds, data bandwidth, and more. The take-home message is to remember that TB3 uses a USB-C connector but offers additional features over the USB protocol.

When discussing USB-C vs. Thunderbolt 3, it is important to note that both connections share quite a bit in common. Both use the Type-C form factor for the connection. Both USB-C and TB3 can be used to power devices, transfer data at high speeds, and connect a variety of peripherals including displays. Both can be used to connect a computer to a compatible docking station, which you may want to use.

There are noticeable differences between the two standards. The key differences between USB-C and TB3 can be boiled down to three main points: data transfer rates, display connections, and connecting external devices.

1. Data transfer: Thunderbolt 3 is significantly faster than USB-C. USB-C supports transfer speeds ranging from 480 Mbps (USB 2.0) to 20 Gbps (USB 3.2 Gen 2x2); 10 Gbps is the most common speed. Thunderbolt 3 supports transfer rates up to 40 Gbps.

2. Display connections: One of the big draws of Thunderbolt 3 is its versatility. In addition to offering blazingly fast transfer speeds, Thunderbolt 3 has the bandwidth to drive up to two 4K monitors at 60 Hz. USB-C can also support external displays with the optional "DisplayPort Alternate Mode" feature. Without this feature, displays will not work when connected via USB-C. Verify that your computer supports this feature if you intend to use an external display over USB-C.

3. Device support: Both be used to connect a variety of peripherals such as printers and hard drives. Thunderbolt 3 supports PCIe devices like external GPUs and fast external hard drives. USB-C cannot connect to these kinds of devices.

4. Daisy-chaining: Thunderbolt 3 supports daisy-chaining. Up to 6 compatible devices can be connected in a chain using their own ports instead of connecting to the host device. With USB-C, these devices would all need to connect to individual host USB-C ports.

5. Backward compatibility: Thunderbolt 3 B3 is compatible with USB-C. If a USB-C device is plugged into a Thunderbolt port, the port reverts to USB-C mode to support the device. Compatibility is not reciprocal, however. A USB-C only port will not work with a Thunderbolt 3 device.

USB-C will meet the needs of most people. However, there are specific use cases where Thunderbolt 3 is advantageous (or even necessary). Faster data transfer speeds (40 Gbps vs. 10-20 Gbps), support for two high-resolution displays, and the ability to connect devices like external GPUs are only available via Thunderbolt 3.

Keep in mind that Thunderbolt 3 is a proprietary connection, the copyright of which is owned by Intel. As such, Thunderbolt 3 often comes at a price over USB-C. If work does not demand data-hungry peripherals, USB-C is a flexible and cost-effective option for most users.

USB4 vs Thunderbolt 4

USB 4 and Thunderbolt 4 are functionally almost identical support.

Thunderbolt 4 and USB4 cables will be entirely interchangeable, and will be backward compatible. Thunderbolt 3 cables will also work with Thunderbolt 4 and USB4 connections. Older USB-C 3.2 connections will work with USB4 connections, but won't be able to offer the fastest 40 Gbps transfer speeds.

USB4 and Thunderbolt 4 both support power delivery up to 100W, making it possible to charge almost any supporting device using the connection. More importantly, though, where older USB-C 3.2 devices did not have to support the higher wattage options of USB Power Delivery, USB4 certified devices must to qualify. That means that any USB4 or Thunderbolt 4 port will be able to charge any USB4 compatible device at full power delivery for the fastest charging.

A Brief History of USB

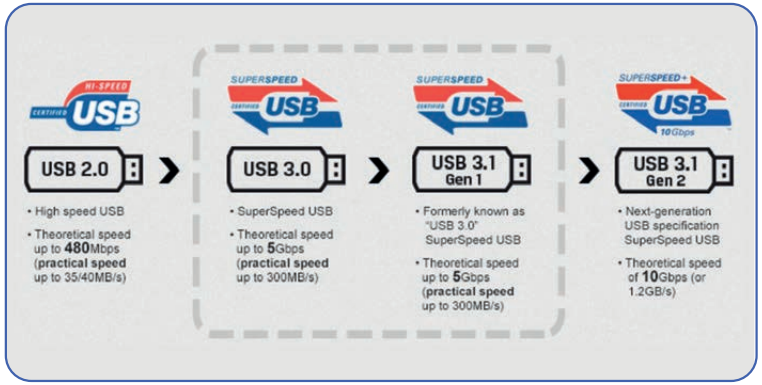
At the time of USB-IF's formation in the late 1990s, modern computing was beginning to blossom but interface technologies were lagging behind. USB-IF stepped in to create a standard connector type to replace the many serial or parallel ports.

Throughout the years, various protocol upgrades were released, increasing data rates and power capabilities, as well as new shapes and sizes of connectors. At the point that USB-C was developed in 2014, there were 11 different USB connector types but being largely physically incompatible with one another.

USB-C is the latest connector type developed by the USB Implementer's Forum (USB-IF) and is designed to replace all previous USB connectors versions. USB-C connectors are truly reversible, meaning you can plug it in either orientation, and end the struggle to connect a USB cable. No more flipping the cable around multiple times to find the proper orientation . All USB-C cables can interconnect using another connector on one end of the cable but in the future USB-C to USB-C cables will become the standard.

USB-C is slim, reversible, with a connector with 24 pins compared to 9 pins on the previous generation of USB 3.0. These extra pins allow for increased power, data, and video. While USB 3.0 ports and their 9 pins were capped at a 5Gbps transfer rate, USB-C can support up to 80Gbps depending on the protocol. and eventually carry up to 240W of Power.

The USB-IF are now introducing a new brand commonly referred to as SuperSpeed. See chart below.



Old Technical Name	USB 3.0	USB 3.1	USB 3.2
New Technical Name	USB 3.2 Gen 1	USB 3.2 Gen 2	USB 3.2 Gen 2x2
Marketing Name	SuperSpeed USB	SuperSpeed USB 10Gbps	SuperSpeed USB 20Gbps
Bandwidth	5Gbps	10Gbps	20Gbps
Connector	USB-A and USB-C	USB-A and USB-C	USB-C only

USB-IF Compliance Program

The Universal Serial Bus (USB) specification defines the product design targets at the level of interfaces and mechanisms. To complement the specification and enable measurement of compliance in real products, the USB-IF has instituted a Compliance Program that provides reasonable measures of acceptability. The Compliance Program uses multiple test specifications along with a Test ID (TID) to track and define the test criteria used to evaluate a product. Products that pass this level of acceptability are considered USB-IF certified and are added to the Integrator's List and have the right to license the USB-IF Logos.

About the USB-IF The non-profit USB Implementers Forum, Inc. was formed to provide a support organization and forum for the advancement and adoption of USB technology as defined in the USB specifications. The USB-IF facilitates the development of high-quality compatible USB devices through its logo and compliance program, and promotes the benefits of USB and the quality of products that have passed compliance testing. Further information, including postings of the most recent product and technology announcements, is available by visiting the USB-IF website at **www.usb.org**

USB4

The USB4 specification has three new benefits:

- Two-lane operation with up to 40 Gbps operation (over certified cables), using the USB Type-C connection; Currently, the fastest USB specification, USB 3.2 Gen 2x2, only offers transfer speeds up to 20 Gbps, though its 10 Gbps counterpart is far more common on devices. USB 3.2 Gen 2 transfers data at up to 10 Gbps, USB 3.2 Gen 1 (and all previous USB 3.0 and 3.1 specifications) operate at up to 5 Gbps. USB4 will be able to move data at up to
- Backward compatibility with USB 3.2, USB 3.1, USB 3.0, USB 2.0, and even Thunderbolt 3.
- USB4 will use the USB Type-C connection.

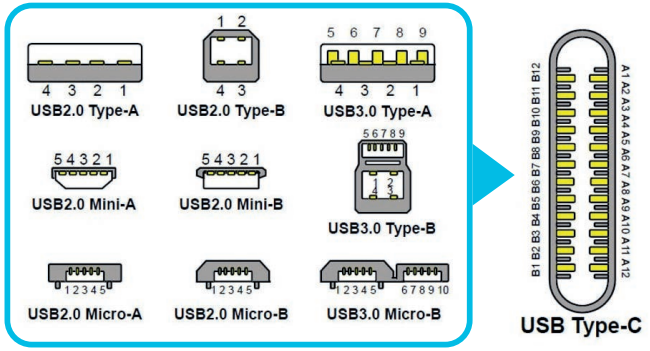
USB-C Enables Exciting New Possibilities

Higher quality displays
- Experience resolutions beyond 4K with DisplayPort over USB-C
- Connect a computer to dual 4K Ultra HD displays
- Enable multiple monitors with a single connector, using MST

Docking with ease
- Increase productivity with true single-cable docking
- Enable display, charging, power, networking, data and audio with one connection

Universal charging & power
- USB-C enabled laptops can be charged via the USB-C port, eliminating the need for proprietary power cords
- Power & charge any USB-C enabled device with the same cable

Designed for the future
- USB-C currently supports data speeds up to USB 3.1 (10 Gbps)
- Designed to scale as faster data speeds evolve



USB3.1c Cable

A new connector has arrived for computers, peripherals, and mobile devices, the USB-C connector. Also known as USB Type-C, it's much more than just USB. Unlike its predecessors, the USB-C connector offers an array of benefits:

- **Supports multiple technologies** to accommodate Alternate Modes. The Alt Mode spec allows for DisplayPort, HDMI, and Thunderbolt 3 protocols to be transferred over a USB connection.
- **Powers and charges your laptop.** USB-C can deliver up to 100W of power making it perfect for tablets and laptops. Bandwidths of 10Gbps using USB 3.1 and 40Gbps using Thunderbolt 3

The USB-C cable head is smaller than before, and looks a bit like a Micro-USB connector.

Eventually this is the USB connector you'll use with your devices instead of using your existing USB-A, Micro-B, USB-Mini or Lightning cable. Many popular laptops and phones have already switched to, or added USB-C ports.

Use an Existing Port

If you have a spare video or USB 3.0 port, it's easy and inexpensive to connect your computer to another monitor.

MY COMPUTER HAS THIS PORT ↓ / I WANT TO CONNECT TO →	VGA	DVI	HDMI	DisplayPort
Mini DisplayPort	WAV-003	WAV-001	WAV-002	–
DisplayPort	24-0204	24-0205	24-0208	32-2422A
HDMI	24-0209	32-3750	32-3632	–
Micro HDMI	–	–	32-3646	–
Mini HDMI	–	–	32-3640	–
USB 3.0	24-0304	24-0303	24-0306	24-0307

USB Cables and Connectors

You can use USB cables to:

- connect most new devices to your computer
- connect computer accessories like mice, keyboards, etc
- charge a variety of gadgets including mobile phones
- transfer data

How to recognize USB Cables

- The standard USB connector, USB-A, is a rectangular connector.
  - The USB-A end is present on every USB cable as it is the end that connects to your computer.
- The other end of the USB cable may have different connectors including:
  - USB-B; commonly used with printers, external hard drives, and larger devices
  - Mini-USB and Micro-USB; commonly used with portable devices
  - USB Male to Female connectors for extending the length of a USB cable.

VGA

One of the most common video connectors for computer monitors and high-definition TVs is the VGA cable. You may also use a VGA cable to connect your laptop to a TV screen or a projector.

Converter cables are available to let VGA monitors connect to newer computers that only output HDMI or DVI signals.

Coaxial Cable

Coaxial cable is an electrical cable which transmits radio frequency (RF) signals and are often referred to as RG Cable, which vary by gauge and impedance. The data is carried in the centre conductor called the dielectric, while the surrounding layers of shielding stop any signal loss (also called attenuation loss) and help reduce EMI. There are two main types of coaxial cables with an impedance of 50 Ohm (Ω) 75 50 Ohm. Cables with 75 Ohm are mostly used for video signals, while 50 Ohm cables tend to be used for data and wireless communications. There are also URM & LMR versions available.

Popular types are:

Coaxial Cable Type	Outside Diameter
RG-58	4.95mm
RG-59	6.15mm
RG-6	6.90mm
RG-62	6.15mm
RG-11	10.30mm
RG-12	14.10mm
RG-213	10.30mm

Coaxial Cable Connector Types

Coaxial cable connectors have two distinct connector styles male and female. Male connectors have metals pin which protrude from the centre and female connectors have a recessed hole to receive the pin. The most popular type is BNC, Bayonet Neil-Concelman, BNC are used for quick connection or disconnection in RF equipment, test instruments, radio, television, and video signal.

HDBaseT

HDBaseT is a connectivity standard for distribution of uncompressed HD multimedia content. HDBaseT technology converges full HD digital video, audio, 100BaseT Ethernet, power over cable, and various control signals through a single LAN cable. This is referred to as 5Play™, a feature set that sets HDBaseT technology above the current standard.

HDBaseT Architecture

HDBaseT sends video, audio, Ethernet, and control from the source to the display, but only transfers 100Mb of data from display to source (Ethernet and control data). The asymmetric nature of HDBaseT is based on a digital signal processing (DSP) engine and an application front end (AFE) architecture.

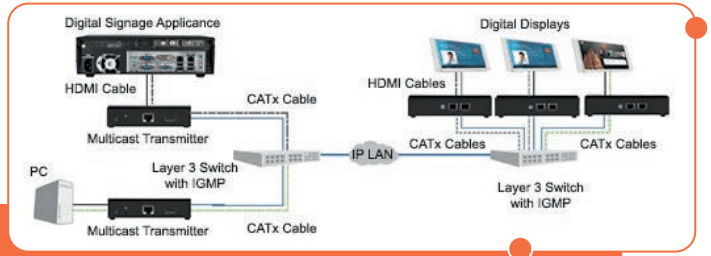
HDBaseT uses a proprietary version of Pulse Amplitude Modulation (PAM) technology, where digital data is represented as a coding scheme using different levels of DC voltage at high rates. This special coding provides a better transfer quality to some kinds of data without the need to "pay" the protecting overhead for the video content, which consumes most of the bandwidth. HDBaseT PAM technology enables the 5Play feature-set to be maintained over a single 330-foot (100 m) CAT cable without the electrical characteristics of the wire affecting performance.

HDMI Connector Standards

High-Definition Multimedia Interface (HDMI) was the first digital interface to combine uncompressed high-definition video, up to eight channels of uncompressed digital audio, and intelligent format and command data in a single cable. HDMI is the de facto standard for consumer electronics. HDMI is backward compatible with DVI. Buy only tested cables with the HDMI logo. This guarantees the cable will perform to specification especially because there is no maximum length specified in the HDMI standard. And because longer lengths require a larger cable, HDMI cables usually have 24–28 AWG copper conductors. For 1080p, Deep Color, or 3D content, choose High-Speed HDMI cables.

HDMI Connector

The HDMI connector is compact and is somewhat similar to a USB connector. Use this serial interface to connect audio/video equipment, such as DVD players, a set-top box and A/V receivers with an audio and/or video monitor, such as digital TV over a single cable. HDMI works with standard, enhanced, and high-definition video. It has a bandwidth from 10.2 Gigabytes so it supports all HDTV standards and has bandwidth to spare for future applications. What's more, HDMI is backward compatible with DVI equipment, such as PC's, TV's and other electronic devices using the DVI standard. The DVI device simply ignores the extra data.



AV over IP Distribution

IP-based distribution technologies use transmitters and receivers to extend signals over a TCP/IP network (a LAN or even a WAN, for instance). Oftentimes, they're called IP streamers when used with codecs. But, when choosing one, be sure you're not looking at the consumer-grade devices for streaming video in small office applications; be sure it's a professional-grade multicasting product.

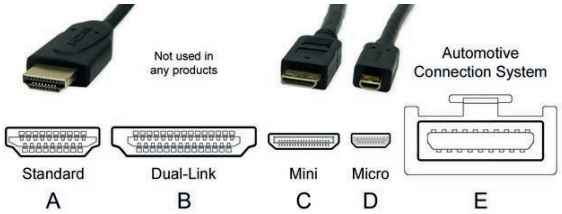
These sophisticated extenders use CATx cabling infrastructure, but in comparison to standard non-networked CATx extenders, they multicast data over an active Ethernet network. They do this by packetizing media streams for delivery over an IP-based network, so source content can be delivered anywhere you have Ethernet wiring.

What is HDMI Distribution?

HDMI distribution is achieved by AV devices, such as extenders, switches or matrices, that accept a single input signal and distribute the same signal to multiple isolated outputs and/or destinations without ground loops or signal degradation. They are used for a number of common engineering tasks, including multiple amplification, cable television, splitting monitor and front of house mixes, and "tapping" a signal prior to sending it through effects units to preserve a "dry" signal for later experimentation.

HDMI Connector Types

There are multiple different types of HDMI cable connectors sold on today's market. Although they all essentially do the same thing, they're not usually interchangeable in any specific application or device. In other words, you'll need to know which connector type you're going to be using before making a purchase.



There are currently five standard connector types available for HDMI cables, namely:

- Type A (standard)
- Type B (dual link - not currently used in any mainstream consumer products)
- Type C (mini)
- Type D (micro)
- Type E (the Automotive Connection System, chiefly developed for in-vehicle use)

These various HDMI cable connector types are easy enough to identify physically, due to their noticeably different sizes. However, if you're not familiar with the naming schemes for HDMI subtypes, then the range of available options can look a little confusing at first glance. Rest assured that, for the vast majority of home and workplace applications, HDMI connector types A, C and D (standard, mini and micro) will be the only versions you'll generally need.

9 PDU "Must Haves"

1. kWh metering accuracy of 1%

ISO/IEC +/- 1% billing-grade accuracy for reporting and billing. Accurate kWh metering allows you to measure actual energy usage for accurate customer or department charge-back billing or reporting. The data can be used to encourage energy efficient behaviour among users, establish power consumption baselines and analyse the effect of efficiency initiatives.

2. Latching relays which consume 7W or less

Latching (bistable) relays only require power to switch from one state to another, i.e. on or off. This means the PDUs consume 67% less energy and thus produce less heat. Also, they can be configured to return to the pre-outage state instantly or sequence outlets on. Instantly on may be appropriate for operations where even moments of downtime can be costly, e.g. high-speed financial trading. Power sequencing may be important to minimize inrush current or where the operation requires certain devices to come on line before other devices, e.g. a data base used for processes.

3. Removable "hot swap" intelligent controller

A flush-mount controller with industrial-grade reliability, configurable firmware, disaster recovery support and hot swap capability.

4. High resolution colour display

The highest on-board resolution in the industry at 220 x 176, and easy to navigate menus. The colours are a useful indication such as turning the screen red for critical alarms. A built-in accelerometer enables the LCD display to change orientation automatically facilitating different installations.

5. Maximum operating temperature rating as possible

Many data centres monitor cold aisle temperatures to provide optimal cooling but, most rack PDUs are located in the hot aisle where IT equipment exhaust temperatures are much higher. A maximum operating temperature of up to 140F (60C) is recommended for reliable performance in high-heat environments.

6. Low-profile, flush-mount circuit breakers

Circuit breakers eliminate the need to stock fuses, don't require licensed electricians to change fuses, and eliminate the possibility of installing the wrong fuse. Low-profile circuit breakers improve rack accessibility by the elimination of circuit breaker doghouses (large housings) which can block inserting or removing devices in a rack. For rack PDUs rated 16A, the upstream facility circuit breaker provides sufficient overcurrent protection for the rack PDU so there are not circuit breakers on the PDU itself.

7. Residual current monitoring option

Current monitoring reduces the risk of electric shock by measuring current leaking to ground. It automatically checks the residual current circuitry and generates alerts if there is an unsafe condition.

8. User-configurable Power-On sequencing

Sophisticated outlet sequencing can power on equipment plugged into a single outlet or a group of outlets, e.g. devices with multiple power supplies. Power sequencing can minimize inrush currents and provide consistent powering up processes. User configurable means you can set which outlets to delay and how much to delay individual outlets, not just global settings to the entire PDU.

9. Rapid USB configuration

Configuring a PDU can include firmware updates, location and device naming conventions, setting critical and non-critical thresholds for power and environmental sensors, etc. USB configuration is a reliable, quick and easy method of configuring PDUs. Once a sample configuration has been created purchase as many USB flash drives as you have power strips in a row of cabinets. Copy the desired settings/sample configuration onto the USB drives and insert them into each PDU. By the time you return to the first cabinet, the configuration will have automatically finished by itself. The process takes about 20 seconds. You can now remove the USB drives and move on to the next row. With minimal effort, a single person can configure hundreds of power strips in a few hours. This method of configuration ensures error-free deployments, something that is unlikely if each PDU must be configured manually.

Need Help Finding the Right PDU? You Need to Know...

Global Region:
Asia Pacific • Americas • Australia/New Zealand • Europe

Metering Type:
None • Input • Outlet

Switched Outlets:
Yes • No

Outlet Count:
0 • 1-50

Plug Type:
C20 • CS8265C • IEC 60309 316P6 • IEC 60309 332P6
IEC 60309 460P9 • IEC 60309 532P6 • NEMA 5-15P • NEMA L5-20P
NEMA L5-30P • NEMA L6-30P • NEMA L21-30P

Form Factor:
0U • 1U • 2U

Common Questions

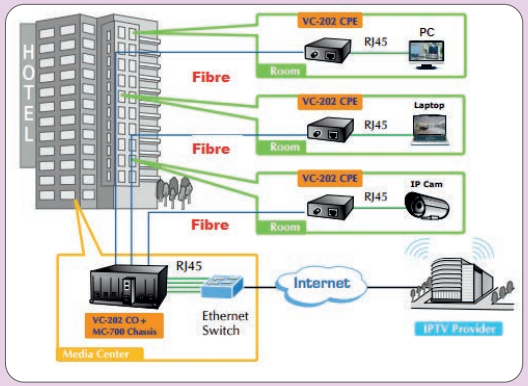
Will restarting my Rack PDU affect power to the outlets?
What is the default user name and password?
What is the default IP address?
Is it ok to change a fuse while the Rack PDU is still plugged in?
Where can I find the MIB?
Where can I find firmware updates?
Where can I find the product manual for my Rack PDU?
Where can I find a list of available data cables and power cords?
Will restarting the Sentry Power Manager (SPM) affect power on my Rack PDUs?
What do the 3 LED displays on my Rack PDU represent?
My LED says "FE" or "bE". What does this mean?
MY LED says "OL". What does this mean?
How do I manually reset my Rack PDU back to factory defaults?
Can I connect to "master" PDUs together?
Where can I find more technical documents including trouble-shooting steps?

We have the answers!

Media Converters

Media conversion is a cost-effective solution to extend fiber networking rapidly rather than adopting optical fiber only. It also efficiently helps to solve the distance limit between the Ethernet and Local Area Network. With the feature-rich chassis provided by PLANET, at least 16 converters can easily expand the fiber optic networks by simply plug and play. The wiring distance of PLANET media converter chassis is extendable from 2 up to 120 kilometers and available upon request.

Building a network solution of FTTH (Fiber to the Home) or FTTC (Fiber to the Curb) for ISPs, PLANET Manageable family of media converter chassis and FST/GST converters offer the multiple selections for FTTx deployment. The Managed family is a series of managed Media Conversion Center that provides hot plug and play slots for various types of converters. Through the management interface, the entire status of the converters can be remotely controlled within the chassis from on/off and status/statistics of ports, as well as the advanced features like redundant links.



Switches

What is a Network Switch?

Most business networks today use switches to connect computers, printers and servers within a building or campus. A switch serves as a controller, enabling networked devices to talk to each other efficiently. Through information sharing and resource allocation, switches save businesses money and increase employee productivity.

What is a Unmanaged Network Switch?

An unmanaged switch works right out of the box. It's not designed to be configured, so you don't have to worry about installing or setting it up correctly. Unmanaged switches have less network capacity than managed switches. You'll usually find unmanaged switches in home networking equipment.

What is a Managed Network Switch?

A managed network switch is configurable, offering greater flexibility and capacity than an unmanaged switch. You can monitor and adjust a managed switch locally or remotely, to give you greater network control.

Ethernet Cabling Guidelines

	TWISTED PAIR	Multimode Fibre OM3	Multimode Fibre OM4	Singlemode Fibre OS2 1310mm	Singlemode Fibre OS2 1550mm
10BASE-T (10Mb/s)	✓	2000m	2000m	N/S	N/S
100BASE-T (100Mb/s)	✓	2000m	2000m	N/S	N/S
1000BASE-T (GbE)	✓	550m	1000m	5000m	N/S
10GBASE-T (10GbE)	✓	300m	550m	10000m	40000m
40GBASE-T (40GbE)	✓	100m	100m	10000m	40000m
100GBASE-T (100GbE)		100m	150m	10000m	40000m

N/S = Not Specified

Powered by PoE

The first generation of PoE, IEEE 802.3af Type 1 (15W), was used for powering lower-power devices like IP clocks, VoIP phones and simple security cameras. With the development of IEEE 802.3at Type 2 (30W), higher level IEEE 802.3bt Type 3 (60W) and Type 4 (90W), and POH (100W) for AV applications, remote powering technology now powers everything from wireless access points, advanced pan-tilt-zoom cameras, access control devices and LED lights, to video displays, point of sale machines and even computers and laptops.

Need to Know...

While PoE is simple to install and support, there are still a few important aspects to consider:

PoE budget – calculate how many devices will be connected and how many watts are needed for each of them. This will help determine the best type of switch, number of ports required, or number of switches needed. The good news is that the math is simple.

Avoid vendor lock-in – by choosing products that are standards-based and so can be blended in the same network.

Stick to standards-based products – without going into lots of technical detail, there have been various versions of PoE and equipment over the years, not all standards-based. Mixing-and-matching incompatible or products not compliant with current standards can affect performance or even cause system failure.

Upgrades and flexibility – plan for the future as much as possible, but also choose PoE solutions that can be easily extended or upgraded at a later date. Look for plug-and-play PoE product ranges that fit a wide variety of situations, from simple solutions for SMBs through to supporting the complex demands of mission-critical utilities.

Make the most of extra features – what will make the PoE network even better? For instance, will auto-sense for adjusting power requirements be useful? What about how the PoE switches are managed - can that be done remotely?

PoE Tech Standards

The principle of PoE power supply is based on the use of twisted copper pairs of the Ethernet cable to power from the source called PSE (Power Sourcing Equipment), the remote equipment called PD (Power Device).

The IEEE 802.3 standard sets the maximum distance of the Ethernet cable at 100 meters to take into account losses caused by the resistivity of the cable.

An Ethernet cable is made up of four pairs of wires. When the connection is 10 or 100 Mbits, the data travels on only two pairs, namely wires 1, 2, 3 and 6; the other two spare parts, namely the wires 4, 5, 7 and 8, can be used to convey the electric current (type A). It is however possible to use the wires 1, 2, 3 and 6 to convey the data and the power (type B), leaving the free pairs unused. When the connection is above 100 Mbits, the four pairs are used to carry the data. In this case, the power can be transmitted on the wires 1, 2, 3 and 6 or 4, 5, 7 and 8. The IEEE 802.3af (15 W) and 802.3at (30 W) PoE standards describe these two scenarios.

According to the standard, PDs must support power transmission capabilities in both types A and B.

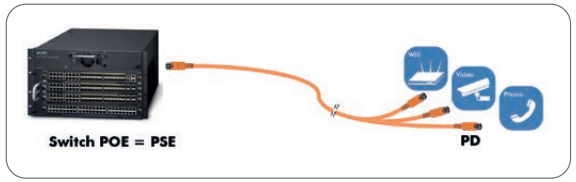
On power-up, the PSE needs to determine how much power it needs to supply the PD to avoid damaging it. For this there are two methods: either by a HW protocol (Physical Layer Classification) or by using the LLDP protocol (Link Layer Discovery Protocol) for data exchange between the two devices PSE and PD.

The data and the power supply pass in the same Ethernet cable, so there is only one cable to be pulled per connected device. Therefore, compared to an external power supply, the amount of connectors and adapters is reduced.

Source (PSE) Configurations

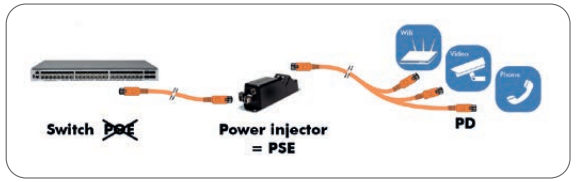
"PSE End Point" Configuration

The "End Point" configuration is used to connect a PoE power supply, usually a switch, to a PoE compatible PD remote dev.



"PSE Midspan" Configuration

The "Midspan" configuration is used to connect PoE-incompatible power equipment to PoE-compatible PD equipment via a PoE-compatible adapter.



IEEE 802.3BT Version

The work of the IEEE 802.3bt version (also called "4PPOE" or "POE++") takes into account this need to increase the supplied electrical power, as well as increasing the bandwidth to reach 10 Gbit/s. It incorporates advances in technology during this period (cf. the work on PoH).

Main evolutions of the IEEE 802.3bt version of the standard:

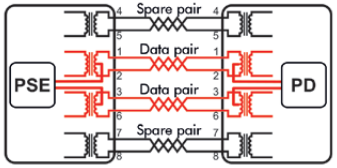
- Introduction of Type 3 and Type 4 for the PSE/PD duo to reach respectively 60 W and 90 W at the source (PSE)
- Using the 4 twisted pairs available in an Ethernet cable
- Addition of new power classes: classes 5 to 8 and improvement of the process of mutual identification between the PSE and PD
- Addition of the "Automatic class" function
- Increase of power supply (Extended power capability) if the length of the cable used is known
- Improvement of consumption in idle mode
- Increase of bandwidth up to 10 Gbits/s (10G-BASE-T cables)

The table below summarizes the different types of IEEE 802.3 standards:

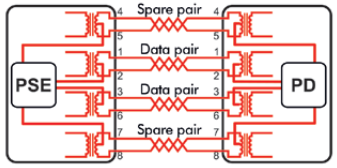
Type	Standard	PSE min. input power	PD guaranteed min. power	Cable category	Max. cable length	Number of pairs
Type 1	IEEE 802.3af	15.4 W	12.95 W	Cat 5e	100m	2 pairs
Type 2	IEEE 802.3at	30 W	25.5 W	Cat 5e	100m	2 pairs
Type 3	IEEE 802.3bt	60 W	51 W – 60 W*	Cat 5e and above	100m	2 pairs class 0-4 4 pairs class 0-4 4 pairs class 5-6
Type 4	IEEE 802.3bt	90 W	71 W – 90 W*	Cat 5e and above	100m	4 pairs class 7-8

** Provides power at the destination of 60 W for Type 3 and 90 W for Type 4, if the cable length is known (<100m)*

The Different Options for Using the 4 Pairs



A first option is to use two pairs to power the PD and use the 4 pairs to convey the data.



A second option is to use the 4 pairs to both feed the PD and convey the data.

Specifying the Correct Cabinet...

Choosing a cabinet

What to consider:

- **A.** The height
- **B.** The U Space
- **C.** The width
- **D.** The depth

With the above in mind you need to consider the internal versus external measurements. For instance, the internal height of a 42U height cabinet is 1867mm and the external height is 1999mm.

All standard cabinets have industry standard 19" mounting angles. This internal measurement is 483mm. The external dimensions can be either 600mm or 800mm. In most instances 600mm is the most common for server racks and 800mm for cabling racks allowing for cable management each side of the rack.

U height is 1.76" imperial and 44.45mm metric.

Plinths & Castors

The Cabinet comes with "traveling" castors only to be used when the cabinet is EMPTY. Castors are only really needed if the cabinet needs to be moved often. In this instance you would need heavy duty castors to be added to the bill of materials. Plinths are available in two options. As either a "skirt" for the bottom of the cabinet to help optimise airflow, or as an extendable plinth. Extendable plinths are recommended for use in cabinets that have an uneven weight distribution, as they aid the stabilisation of a cabinet with the use of an extending arm that pulls out of the plinth like a draw.

Do you need a PDU (Power Distribution Unit)?

How many servers/switches you need to attach to the PDU and what type of outlets i.e. C13/C19 or BS1363 (UK socket) and quantity of each. This will determine how many sockets are required on your PDU. Depending on the position and the number of connectors required in your cabinet will also determine if your PDU needs to be mounted horizontally or vertically.

Shelves

Shelves come in two options, fixed or cantilever. Fixed shelves are mounted at the front and rear of the cabinet for heavy equipment, 30kg+. Cantilever are mounted on the front mounting angles only and have a maximum weight capacity of 20kg. Depending on depth and weight of equipment being mounted will determine the type of shelf you require.

Mounting Angles & Support Rails

Mounting Angles are fixed at a standard width size of 19", these mounting angles are attached to the front and rear of the cabinet and are adjustable to accommodate the equipment being housed.

Cabling

Think about cable management - to make sure your cables don't get mixed up. Jumper rings and panels stop harmful strain (stretch) on your cabling - essential for a tidy solution.

Options & Extras

- Earth bonding kits aids earth continuity between the frame, doors and the top cover of the cabinet to help prevent risk of electrocution.
- Earth bonding kits provide enough leads for all the panels on a cabinet to be bonded to the main frame.
- Don't worry about fans unless the cabinet is going to be very full.
- A baying kit is used to join 2 adjacent server cabinets for better stability.
- A document wallet will keep all your important documents close to hand.
- "U" measuring strip will help you level up and space your equipment when bolting it into the cabinet. There is nothing worse than struggling to bolt something in, only to find that it's not level and you need to start again.

Fibre Types

Singlemode cables can be found in OS2 type. Multimode cables can be found in OM1, OM2, OM3, OM4 and OM5 types. Each type has different properties.

OS2 Singlemode Fibre

Unless requested otherwise all singlemode fibre cables they will conform to ITU-T G652.D. This standard describes the geometrical, mechanical and transmission attributes of the cable and ensures that the cable can be used in the operating wavelengths around 1310nm and 1550nm.

Also, in higher fibre density environments fibre with tighter cable routing and reduced bend radius there is another standard G.657.A1 and or G.657.A2. Cables meeting either of these standards are often referred to as Bend Insensitive (BI) or Reduce Bend Sensitive (RBS) fibre cable. All G.652.D, G.657.A1 and G.657.A2 all have the same physical size with internal and external core diameters of 9µm and 125µm, respectively, are completely compatible with each other and G.652 and G.657 are compatible with all standard connectors such as LC, SC, MU, and E2000 in UPC or APC polishes.

OM5 Multimode Fibre

OM5 New Standard developed when you are using Shortwave Wavelength Division Multiplexing (SWDM) applications. For 10 Gigabit and 100 Gigabit Ethernet it only transmits at the same distance as the low cost OM3 and OM4 Fibre. It has a suggested jacket colour of Lime Green. OM5 fibre, also known as WBMMF (wideband multimode fibre) at a minimum speed of 28Gbps per channel through the 850-953 nm window.

OM4 Multimode Fibre

It is a further improvement to OM3, uses a 50µm core and was developed specifically for VSCEL laser transmission and allows 10 Gigabit Ethernet up to 550m compared to 300M with OM3 and 100 Gigabit Ethernet at lengths up to 150 meters. Often supplied in a jacket colour of Erika Violet to differentiate it from OM3 . It is completely backwards compatible with OM3 fibre.

OM3 Multimode Fibre

Its core size is 50µm, but the cable is optimized for laser based equipment that uses fewer modes of light. As a result of this optimization, it is capable of running 10 Gigabit Ethernet at lengths up to 300 meters. Since its inception, production techniques have improved the overall capabilities of OM3 to enable its use with 40 Gigabit and 100 Gigabit Ethernet up to 100 meters. It has a suggested jacket colour of aqua.

Ethernet Cabling Guidelines

	Multimode Fibre OM3	Multimode Fibre OM4	Multimode Fibre OM5	Singlemode Fibre OS2 1310mm	Singlemode Fibre OS2 1550mm
10BASE-T (10Mb/s)	2000m	2000m		N/S	N/S
100BASE-T (100Mb/s)	2000m	2000m		N/S	N/S
1000BASE-T (GbE)	550m	1000m		5000m	N/S
10GBASE-T (10GbE)	300m	550m	400m	10000m	40000m
40GBASE-T (40GbE)	100m	100m	150m	10000m	40000m
100GBASE-T (100GbE)	100m	150m	150m	10000m	40000m

N/S = Not Specified

IEEE Standard	Application	Fibre Type	Baud Rate (GBd)	Transmission Type	# of λ's	# of Fibres	Distance (metres)	Connector
802.3cm	400GBASE-SR8	Multimode	50	Parallel	NA	16	70 (OM3) 100 (OM4)	MPO-16/MPO-24
802.3cm	400GBASE-SR4.2	Multimode	50	Parallel/SWDM	2	8	70 (OM3) 100 (OM4) 150 (OM5)	MPO-8/MPO-12
802.3bs	400GBASE-DR4	Singlemode	100	Parallel	NA	8	500	MPO-8/MPO-12
802.3bs	400GBASE-FR8	Singlemode	50	WDM	8	2	2,000	Duplex
802.3cu	400GBASE-FR4	Singlemode	100	WDM	4	2	2,000	Duplex
802.3cu	400GBASE-LR4-6	Singlemode	100	WDM	4	2	6,000	Duplex
802.3bs	400GBASE-LR8	Singlemode	50	WDM	8	2	10,000	Duplex

Current IEEE 400 Gb/s Ethernet standards for the data center using QSFP-DD transceivers.

Connectors

Fibre Optic Connectors

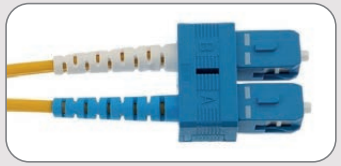
Unlike with copper cabling where one style of connector, the RJ45, dominates, with fibre there are a number of different connectors that can be used.

LC Connectors

The LC connector is sometimes referred to as a Small Form Factor (SFF) connector as it has much smaller dimensions than the SC connector. In fact it is possible to get twice as many fibres terminated on LC connectors in the space used by SC connectors. LC connectors have a simple latch, similar to that used on a RJ45 plug, making it familiar in use for network technicians. This has become the connector of choice in most new network fibre installations.

SC Connectors

The SC connector has a square format and has a push/pull latching mechanism. The image shows two SC connectors that have been joined using a special clip to create a SC Duplex connector with the A and B legs identified in the moulding of the clip.



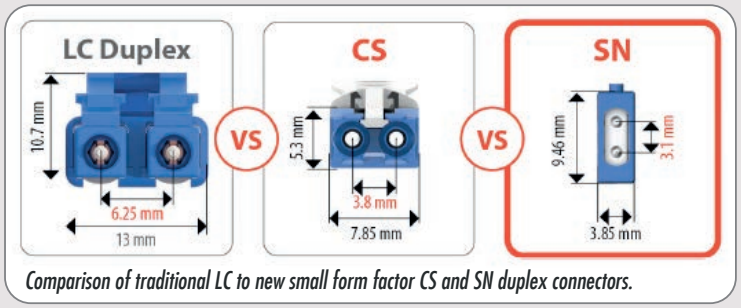
ST Connectors

The ST connector has a round barrel and uses a bayonet fixing mechanism to secure it to the mating connector. It is not recommended for new installations and is only seen in legacy fibre deployments.

MPO/MTP® Connectors

The MPO/MTP® connector has larger dimensions than the LC Duplex connector but can accommodate up to 24 fibres in a single ferrule, making it ideal for high density installation. This style of connector is also finding favour in multi-channel fibre applications such as 40G and 100G Ethernet. However, the high precision nature of the connector means that it is not suitable for field termination.

LC Duplex, CS, SN, Comparison



Comparison of traditional LC to new small form factor CS and SN duplex connectors.

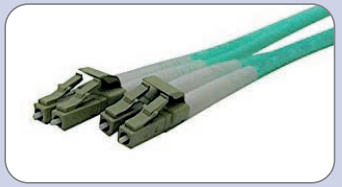
Patch Cable Types Explained

Single Mode OS2 Patch Cable

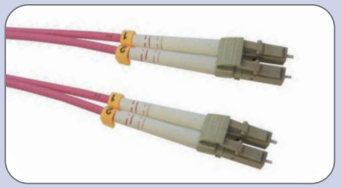
OS2 Patch Cables are made to provide bandwidth used in long distance transmission. They are 2.8mm Duplex Design with white strain relief boots and our standard LSOH jacket colour is Yellow. Each fibre cable is tested for insertion loss. Individual test results are provided.

10 Gigabit 50µm OM3 and OM4 Patch Cable

OM3 Patch Cables are made to provide bandwidth that will support transmission above 10 Gigabits and can be used for applications up to 300 metres. They are 2.8mm Duplex Design with white strain relief boots and our standard LSOH jacket colour is Aqua Blue. Each fibre cable is tested for insertion loss. Individual test results are provided.

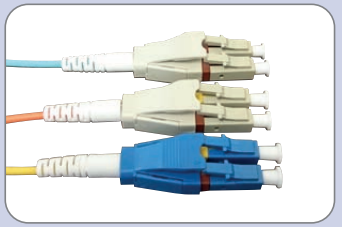


OM4 Patch Cables are made to provide bandwidth that will support transmission above 10 Gigabits and can be used for applications up to 550 metres. They are 2.8mm Duplex Design with white strain relief boots and our standard LSOH jacket colour is Aqua Blue or Erika Violet. Each fibre cable is tested for insertion loss. Individual test results are provided.



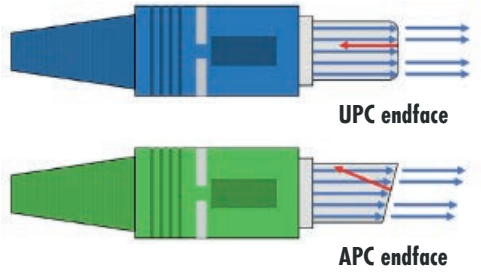
Uniboot LC Reverse Polarity Patch Cable

We can offer Uniboot LC Single and Multimode fibre patch cords offer a compact design and with a few simple steps the connector polarity can be reversed without any connector re-termination. Single mode OS2 has a Yellow LSOH jacket and Multimode OM3 and OM4 fibre with an Aqua Blue Jacket. Each fibre cable is tested for insertion loss. Individual test results are provided.



What's the Difference Between UPC Endface & APC Endface?

An APC connector endface features an 8-degree angle to direct reflected light into the cladding where it does not propagate back to the transmitter, improving system performance for 400 Gb/s PAM4 applications.



MPO/MTP

MPO/MTP (multi-fibre termination push-on) terminated cables are widely used in high-density data centres. The terms MPO and MTP are often used; however, MPO is the recognised fibre connector type, while MTP is a registered trademark of an MPO connector manufactured by US Conec. All MTPs are MPOs, but not all MPOs are MTPs. To the naked eye, there is little difference between the two connectors, and in cabling and transceiver interfaces, they are compatible with each other.

Note: MTP® is a registered trademark of US Conec Ltd. This is the term US Conec uses to describe their connectors. American Conec MTP products are fully compliant with MPO standards. Therefore, the MTP connector is a type of MPO connector.

MPO/MTP Design

MPO/MTP connectors are typically available with 8, 12, or 24 fibres, with 32, 48, 60, or 72 fibres available. However, these higher fibre counts are generally reserved for speciality super high-density multi-fibre arrays in large-scale optical switches.

MPO/MTP connectors are either male (with alignment pins) or female (without alignment pins). To join two MPO/MTP connectors together through an adapter, one connector must have alignment pins, and the other must not. The role of the alignment pins is to ensure that the fibres align perfectly, ensuring successful mating.

MPO/MTP connectors are often colour-coded to help contractors distinguish between the different fibre types and polish specifications for single mode. MPO/MTP connectors are made for both single-mode and multi-mode multi-fibre cables. The cable jacket is yellow in single-mode (OS2 applications), per Telecommunications Industry Association's (TIA) specification. The connector colour will vary depending on the connector type. Ultra-Physical Contact (UPC) connectors will also be yellow, while Angled Physical Contact (APC) connectors are green. With multi-mode OM3/OM4, both MPO/MTP connectors and cable jackets will be aqua, per TIA specifications.

MPO/MTP Connectors

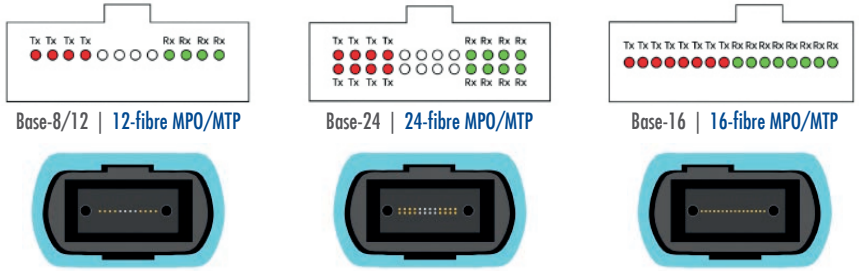
Until recently, the primary method of connecting switches and servers within the data centre involved cabling organised around 12 or 24 fibres, typically using MPO/MTP connectors. The introduction of octal technology (eight switch lanes per switch port) enables data centres to match the increased number of ASIC I/Os (currently 256 per switch ASIC) with optical ports. Fibre cable manufacturers quickly reacted to this new dilemma and started to develop "Base-8" solutions. These new systems migrated the base unit of fibre bundles from 12 fibres to 8 fibres, and MPO/MTP cabling systems started to emerge based on 8 fibre MPO/MTP and trunk cables in multiples of 8 fibres.

New Base-8 and 16-fibre configurations support eight server connections using eight fibres to transmit and eight fibres to receive. MPO/MTP 16-fibre connectors are keyed differently to prevent connection with the 12-fibre MPO/MTP connectors.

The next speeds have now emerged as 400G. There will likely be minimal adoption of multi-mode fibre cabling, which will utilise an SR8 solution – 8 lanes of 50Gb/s and require a 16 fibre MPO/MTP connector. Base-8 infrastructure can support this 16-fibre solution by combining two Base-8 MPO/MTP connectors per link.

From a connectivity perspective, existing 8-fiber and 12-fiber MPO/MTP (Base-8/12) connectors will support 400 Gb/s 8-fibre applications, including 400GBASE-SR4.2 and 400GBASE-DR4. However, 16-fibre applications like 400GBASE-SR8 are now driving the need for 16-fiber MPO/MTP (Base-16) connectors, which have a different form factor from the Base-8/12 with an offset key.

MPO/MTP CONNECTORS IN THE CHANNEL



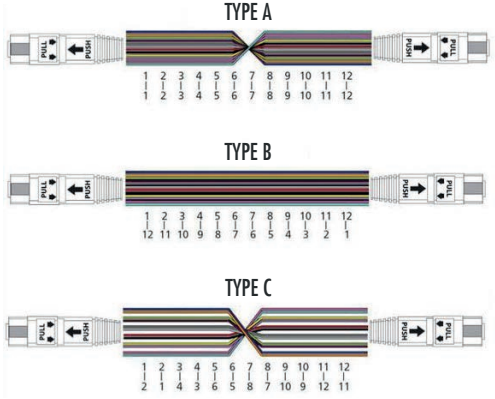
MPO/MTP Polarity

Achieving polarity is another challenge with MPO/MTPs. Polarity defines the direction of the light path or flow and is called the A-B-Cs of fibre polarity. This is more complex with multi-fibre MPO/MTP cables and connectors. Industry-standard TIA-568.3-D names three different polarity methods for MPO/MTPs: Method A, Method B, and Method C. Each method uses different types of MPO/MTP cables.

When examining a typical 12 fibre configuration, Method A uses a key-up connector on one end and a key-down connector on the other end so that the fibre located in Position 1 arrives at Position 1 at the other end. Method B uses key-up connectors on both ends to achieve the transceiver-receiver flip so that the fibre located in Position 1 arrives at Position 12 at the opposite end, the fibre located in Position 2 arrives at Position 11 at the opposite end, and so on.

Method C uses a key up connector on one end and a key down on the other end like Method A, but the flip happens within the cable itself where each pair of fibres is flipped so that the fibre in Position 1 arrives at Position 2 at the opposite end, and the fibre in Position 2 arrives at Position 1.

Whichever method is chosen, polarity needs to be consistent.



What Is Base-8 and 16 MPO/MTP Cabling?

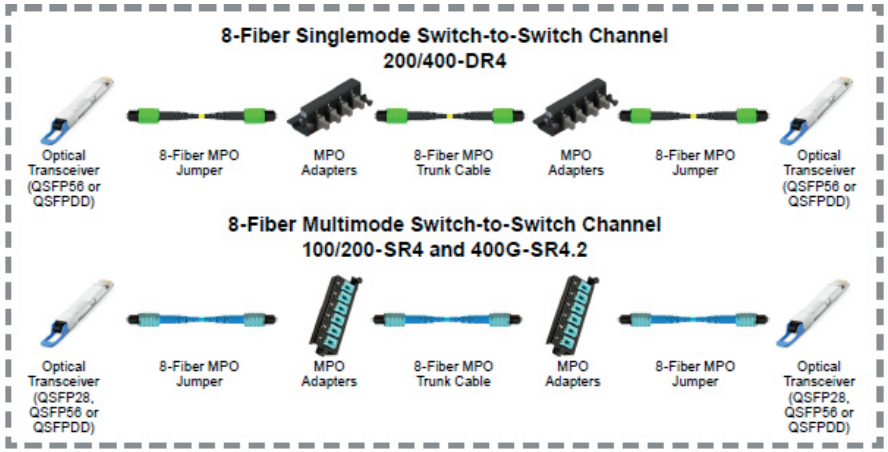
As we forward through the evolution of Ethernet speeds for enterprise applications, with the migration of Ethernet speeds from 10Gb/s to 40Gb/, the IEEE802.3 standard launched the next Ethernet speed of 40Gb/s as a parallel transmission of four lanes of 10Gb/s (40GBASE-SR4), meaning that a single 40Gb/s fibre port on a switch would transmit and receive four separate lanes of 10Gb/s across 4 pairs of fibres. The standard transmission protocol had shifted from a legacy 2-fibre duplex system (one transmit and one receive) to an 8-fibre system (four transmits and four receives), and Base-8 was born.

These new 40Gb/s transceivers, called QSFP+ (Quad Small Form-factor Pluggable), had an MPO/MTP as the connector interface, utilising a standard Base-12 fibre connector but leaving the four middle connectors dark. Fibre cable manufacturers quickly reacted to this new dilemma and developed "Base-8" solutions. These new systems migrated the base unit of fibre bundles from 12 fibres to 8 fibres, and MPO/MTP cabling systems started to emerge based on 8-fibre MPO/MTP and trunk cables in multiples of 8 fibres.

The 100GBASE-SR4 standard utilised 4 lanes of 25Gb/s across 4 pairs of fibres, a further migration to 100Gb/s using Base-8 fibre cables and further strengthening the case for Base-8 connections.

The next speeds have now emerged as 400G. There will likely be minimal adoption on multi-mode fibre cabling, utilising an SR8 solution – 8 lanes of 50Gb/s and requiring a 16 fibre MPO/MTP connector. Base-8 infrastructure can support this 16-fibre solution by combining two Base-8 MPO/MTP connectors per link. The vast majority of 400G systems will run over single-mode fibre with either multiple wavelengths across a duplex fibre connection or four lanes of 100G transmitted across four pairs of fibres – again utilising Base-8 cabling.

From a connectivity perspective, existing 8-fiber and 12-fiber MPO/MTP (Base-8/12) connectors will support 400 Gb/s 8-fibre applications, including 400GBASE-SR4.2 and 400GBASE-DR4. However, 16-fibre applications like 400GBASESR8 are now driving the need for 16-fiber MPO/MTP (Base-16) connectors, which have a different form factor from the Base-8/12 with an offset key. While 24-fibre MPO/MTP connectors can be used for 16-fibre applications, their larger form factor and eight unused fibres make the Base-16 a more cost-effective solution.



While 100 GBd rate will enable 400 Gb/s over eight fibres supported via Base-8/12 connectors, future 800 Gb/s applications will sustain the need for Base-16 connectors. The IEC is currently working on specifications for Base-16 connectivity, and the IEEE Beyond 400 Gb/s Ethernet Study Group is looking to standardise on the Base-16 for future 800GBASE-SR8 and 800GBASE-DR8 applications.

The variety of connector technology options provides more ways to break out and distribute the additional capacity that octal modules offer. Connectors include parallel 8-, 12-, 16- and 24-fiber multi-push on (MPO/MTP) and duplex fibre LC, SN, MDC and CS connectors.

What Is Base-12 and 24 MPO/MTP Cabling?

Since manufacturers first produced fibre-optic cables, they came in multiples of twelve fibres. Cable fibre counts were commonly 12, 24, 48, 96, and 144, leading to systems around fibre optic cables also based on 12 fibres. For example, patch panels are typically based on multiples of 12, 24, 48, and 144, and network switches are generally based on multiples of 24.

The first MPO/MTP connector was with 12 fibres, and when in 1996, IBM introduced the first fibre cabling system based on 36, 72 and 144 fibre trunks terminated with 12 fibre MPO/MTP connectors. This system allowed the flexibility of being able to connect different "harness" types of assemblies to an MPO/MTP connector which fanned out to the duplex connection required by the equipment at the end of the cable, securely set on the magic number of 12!

As we forward through the evolution of Ethernet speeds for enterprise applications, with the migration of Ethernet speeds from 10Gb/s to 40Gb/s, there is a fundamental shift in transmission modes and the basis of fibre systems. The IEEE802.3 standard launched the next Ethernet speed of 40Gb/s as a parallel transmission of four lanes of 10Gb/s (40GBASE-SR4), meaning that a single 40Gb/s fibre port on a switch would transmit and receive four distinct lanes of 10Gb/s across 4 pairs of fibres. The standard transmission protocol had shifted from a legacy 2 fibre duplex system (one transmit and one receive) to an 8-fibre system (four transmit and four receive), and Base-8 was born.

A Base-12 MPO/MTP cabling uses fibre optical links based on increments of 12 fibres and 12-fibre MPO/MTP fibre optic connectors. Base-12 and or Base-24 are mainstream in MPO/MTP cabling systems.

A Base-24 MPO/MTP trunk can be used in a channel with both parallel transceivers at the uplink and duplex transceivers at the downlink. This configuration could be used to breakout 100 Gb/s to 25 Gb/s or 400 Gb/s to 100Gb/s in the future, without making any changes to the cabling system. The graphic below shows one channel breakout, three times the number of links that can be supported with the same cassettes and Base-24 trunk when fully populated. Alternate configurations are possible with other cabling schemes. Alternate configurations are possible with Base-8 or Base-12, using additional trunk cables to support an equivalent number of connections.

Fibre Utilisation

Base-12 is more advantageous in high-density network cabling because it has more cores and higher density. However, Base-8 MPO/MTP cabling has better fibre utilisation than Base-12 MPO/MTP cabling. Although the Base-12 MPO/MTP cabling is still the most common choice for most data centre operators, there are still no standardised transceivers using all 12 fibres. Many popular transceivers (SR4 transceivers, for example), only use an 8-fibre interface. Base-8 MPO/MTP links allow customers to directly connect fibres to those transceivers without any fibre waste. If we use a 12-fibre connector into a transceiver which only requires eight fibres, which means that four fibres are unused. You may consider using a conversion cable to convert the Base-12 cabling to Base-8 cabling (two Base-12 to three Base-8, for example) to make use of all fibres. However, it will cause additional insertion loss, reducing the cable performance.

In addition, when using MPO/MTP to LC duplex breakout harnesses to connect to switch line cards, the Base-8 harnesses easily route to all common port count line cards, as all common line cards contain a number of ports wholly divisible by the number four (since a Base-8 harness provides four LC duplex connections). If you use Base-12 MPO/MTP to LC duplex breakout harnesses, you will get 6 LC duplex connections. But these harness cables can't fully connect to line cards with 16 or 32 ports since 16 and 32 are not wholly divisible by 6.

Therefore, for the sake of fibre utilisation, Base-8 MPO/MTP cabling is a better choice. Of course, if you don't mind the fibre wasting, Base-12 MPO/MTP cabling could also be selected.

For Future Cabling System

Base-12 and Base-8 MPO/MTP cabling can be seamlessly converted to Base-2 cabling in relatively smaller networks like 10G connections. Under such circumstances, either is feasible. However, for more extensive networks like 40G, 100G or even 400G connection, a Base-8 solution will gain more widespread market acceptance since a more significant number of 40G, and 100G circuits are deployed utilising eight-fibre transceivers. So do 400G direct connections, which use 400G QSFP-DD transceivers and MPO/MTP-16 trunk cables. In addition, the 8-fibre cabling could work with the 24-fibre cabling seamlessly since a single 24-fibre MPO/MTP could break out to three 8-fibre MPO/MTPs. Customers deploying 10G data rates today, can still deploy the Base-8 system since upgrading to a 40G or 100G circuit will be much simpler and more cost-effective. Base-12 connectivity is not optimal for 8- fibre transceiver systems.

Current and Upcoming IEEE Ethernet Standards for 25 to 400 GB/s Targeted for the Enterprise Data Centre Environment

IEEE Standard	Transceiver	Signaling	Lane Rate	# of Lanes	# of Fibres	Fibre Type	Technology	Distance in metres
802.3bm	100G-SR4	NRZ	25 GB/s	4	8	Multimode	Parallel Optics	70 (OM3) 100 (OM4)
802.3cd	100G-SR2	PAM4	50 GB/s	2	4	Multimode	Parallel Optics	70 (OM3) 100 (OM4)
802.3cd	100G-DR	PAM4	100 GB/s	1	2	Singlemode	Short-Reach Duplex	500
802.3db*	100G-SR	PAM4	100 GB/s	1	2	Multimode	Duplex	70 (OM3) 100 (OM4)
802.3db*	100G-VR	PAM4	100 GB/s	1	2	Multimode	Short-Reach Duplex	30 (OM3) 50 (OM4)
802.3cd	200G-SR4	PAM4	50 GB/s	4	8	Multimode	Parallel Optics	70 (OM3) 100 (OM4)
802.3bs	200G-DR4	PAM4	50 GB/s	4	8	Singlemode	Short-Reach Parallel Optics	500
802.3db*	200G-SR2	PAM4	100 GB/s	2	4	Multimode	Parallel Optics	70 (OM3) 100 (OM4)
802.3db*	200G-VR2	PAM4	100 GB/s	2	4	Multimode	Short-Reach Parallel Optics	30 (OM3) 50 (OM4)
802.3cm	400G-SR8	PAM4	50 GB/s	8	16	Multimode	Parallel Optics	70 (OM3) 100 (OM4)
802.3cm	400G-SR4.2	PAM4	50 GB/s	8	8	Multimode	SWDM & Parallel Optics	70 (OM3) 100 (OM4) 150 (OM5)**
802.3bs	400G-DR4	PAM4	100 GB/s	4	8	Singlemode	Short-Reach Parallel Optics	500
802.3db*	400G-SR4	PAM4	100 GB/s	4	8	Multimode	Parallel Optics	60 (OM3) 100 (OM4)
802.3db*	400G-VR4	PAM4	100 GB/s	4	8	Multimode	Short-Reach Parallel Optics	30 (OM3) 50 (OM4)

** Currently in development.*
*** OM5 multimode fibre offers specified bandwidth at the 953-nanometer wavelength for SWDM applications. OM4 and OM5 multimode fibre offers the same bandwidth at the 850-nanometer wavelength and therefore support the same distances for all applications except for the SWDM 400G-SR4.2 application.*

QSFP Form Factor Transceivers

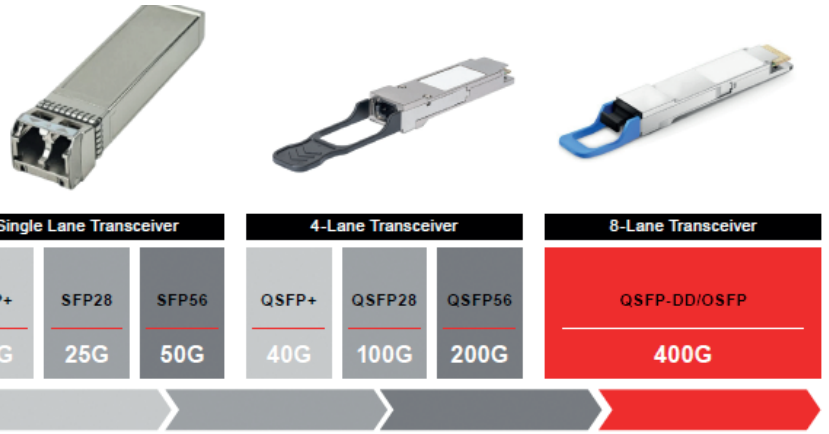
To support higher signalling rates, pluggable optical transceivers have also evolved. Iterations of QSFP transceiver modules have advanced from QSFP+ at a 10 GBd rate, to QSFP28 at a 25 GBd rate, and to QSFP56 at a 50 GBd rate. Equipped with a four-lane electrical interface, these transceivers enable 40, 100, and 200 Gb/s transmission respectively. The latest QSFP-DD form factor features an eight-lane interface, hence the DD designation for double density over existing four-lane QSFP form factors.

With the ability to support a 50 GBd rate, QSFP-DD transceivers support up to 400 Gb/s transmission, while enabling backwards compatibility with previous QSFP transceiver modules to avoid full active equipment replacement. Another eight-lane pluggable transceiver is the OSFP that also supports a 50 GBd rate but is not compatible with the QSFP form factor. The development of 100 GBd PAM4 is underway within the IEEE industry standards association to support higher speeds, but a 100 GBd rate has already been achieved by leveraging QSFP-DD transceivers and converting eight lanes of 50 Gb/s to four lanes of 100 Gb/s.

Just as the adoption of the QSFP28 form factor drove the adoption of 100G by offering high density and lower power consumption, the jump to 400G and 800G is being enabled by new transceiver form factors. The current SFP, SFP+ or QSFP+ optics are sufficient to enable 200G link speeds. However, making the jump to 400G will require doubling the density of the transceivers.

QSFP-Double Density (QSFP-DD7) and octal (2 times a quad) small form factor pluggable (OSFP8) Multi Source Agreements (MSAs) enable networks to double the number of electrical I/O connections to the ASIC. This not only allows summing more I/ Os to reach higher aggregate speeds, it also allows the total number of ASIC I/O connections to reach the network. The 1U switch form factor with 32 QSFP-DD ports matches 256 (32x8) ASIC I/Os. In this way, we can build high-speed links between switches (8*100 or 800G) but also have the ability to maintain the maximum number of connections.

The optical market for 400G is being driven by cost and performance as OEMs try to dial into the sweet spot of hyperscale and cloud scale data centers. In 2017, CFP8 became the first-generation 400G module form factor to be used in core routers and DWDM transport client interfaces. The CFP8 transceiver was the 400G form factor type specified by the CFP MSA. The module dimensions are slightly smaller than CFP2, while the optics support either CDAUI-16 (16x25G NRZ) or CDAUI-8 (8x50G PAM4) electrical I/O. As for bandwidth density, it respectively supports eight times and four times the bandwidth density of CFP and CFP2 transceiver.



Transceiver technology has advanced to support 50 Gb/s over a single lane, 200 Gb/s over four lanes, and 400 Gb/s over eight lanes.

Current Versus Future Network Configurations

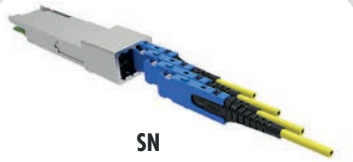
	Enterprise Data Centers		Cloud Data Centers	
	SERVER	UPLINKS	SERVER	UPLINKS
Current Network Speeds	1G	10G	10G	40G
Future Network Speed Options	10G OR 25G	40G OR 100G	25G OR 50G OR 100G	100G OR 200G OR 400G

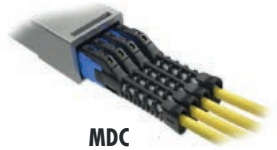
Predictions – OSFP vs QSFP-DD

With regards to OSFP versus QSFP-DD, it's too early to tell which way the industry will go right now, both form factors are supported by leading data center Ethernet switch vendors and both have large customer support. Perhaps the enterprise will prefer QSFP-DD as an enhancement to current QSFP based optics. OSFP seems to be pushing the horizon with the introduction of OSFP-XD, extending the number of lanes to 16 with an eye toward 200G lane rates in the future. For speeds up to 100G, QSFP has become a go-to solution because of its size, power and cost advantage compared to duplex transceivers. QSFP-DD builds on this success and provides backwards compatibility which allows the use of QSFP transceivers in a switch with the new DD interface. Looking to the future, many believe that the 100G QSFP-DD footprint will be popular for years to come. OSFP technology may be favoured for DCI optical links or those specifically requiring higher power and more optical I/Os.

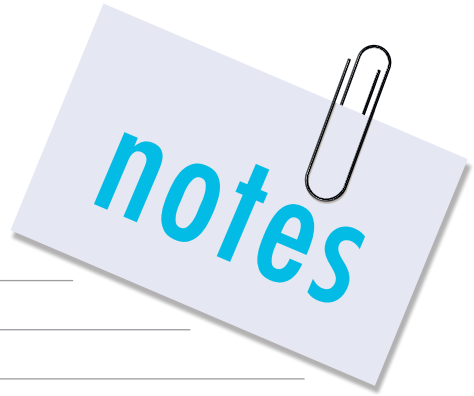
SN & MDC Connectors

Four SN and MDC small form factor duplex connectors fit into a single QSFP-DD transceiver to support 4X100 Gb/s breakout application in leaf-spine switch-to-switch links.


SN


MDC

Note: MDC® is designed and manufactured by US Conec Ltd. The SN is designed and manufactured by Senko Advance Co Ltd (Japan).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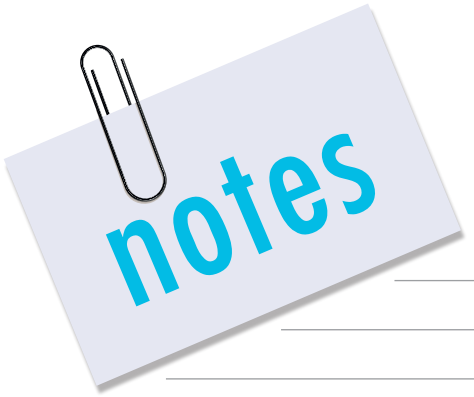
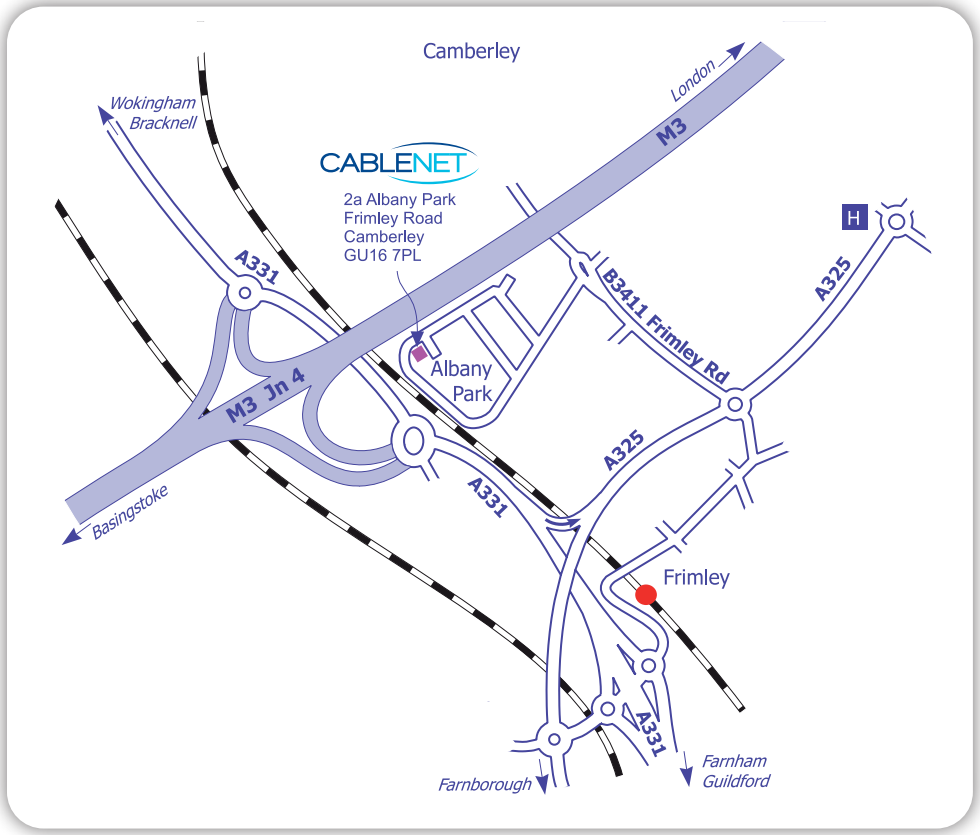

notes

How to find us



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