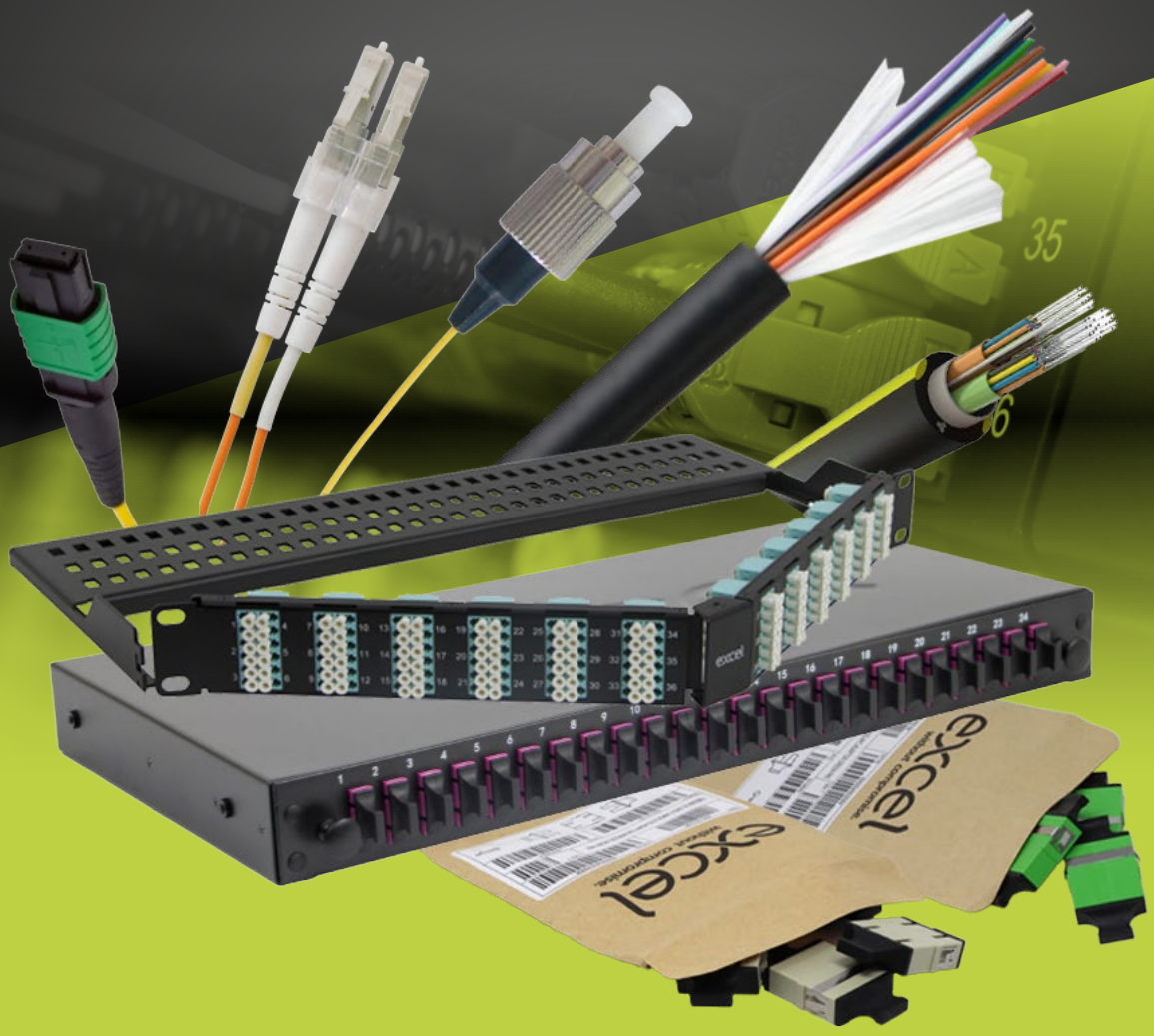
Excel Enbeam Fibre Solutions

www.excel-networking.com/fibre

Section 10



Overview of Fibre Optics

Fibre optic refers to the medium that utilises light for the transmission of signals. Within the infrastructure data cabling environment this is predominately all-silica optical fibre cables. The other constructions include plastic optical fibre and plastic clad optical fibre. This section refers to all-silica optical fibre systems only.

In the simplest terms, optical fibre transmission is a series of pulses of light representing the 1s & 0s of binary encoding. The optical fibre guides and contains the light ensuring it travels from the transmitter to the receiver. As with copper infrastructure cabling systems, the portfolio consists of cable and connecting hardware of different categories and classes.

Fibre optic systems have the benefit over copper with respect to the maximum achievable distance. For a standards compliant installation, copper is generally limited to a maximum of a 100m channel, whereas fibre may support some applications for many kilometres. For this reason fibre optics have traditionally been used in the backbone - typically linking telecommunications rooms - and copper is traditionally used for the horizontal. The backbone encompasses links between buildings. Cables that link buildings have additional challenges. If there is any metallic component, either the conductor medium or any part of the construction, then earth bonding has to be considered. Fibre optic cables are offered with an all dielectric construction, meaning total non-conductivity. This mitigates the need for earth bonding and any over-volt protection requirement. Additionally, as the physical size of the fibre cores are so small (the constructions are discussed later) the resulting strength members, yarns, water blockers etc are reduced in size compared with the equivalent copper cable.

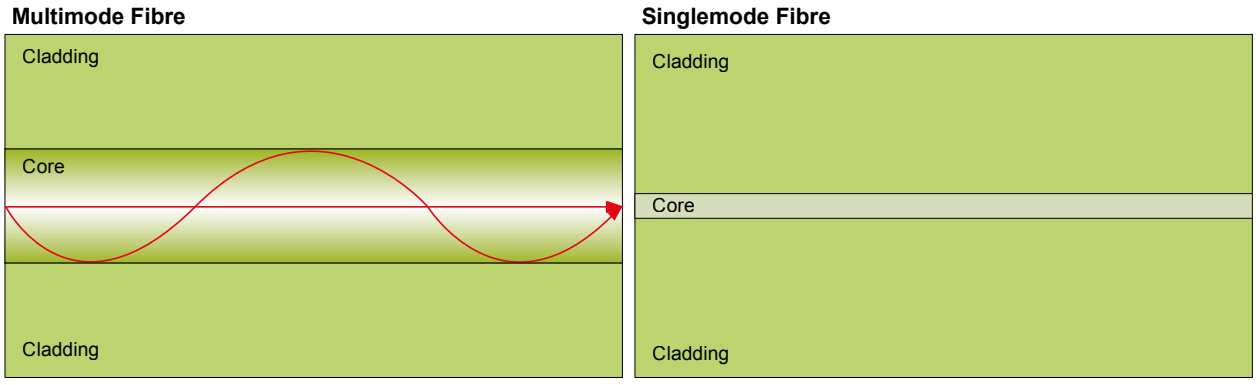
The backbone is not the exclusive use of fibre optic cabling. Customers are deploying fibre in the horizontal element of the infrastructure; sometimes referred to as Fibre To The Desk (FTTd).

Multimode & Singlemode

Fibre optic cabling can be split into two families – Multimode and Singlemode. 'Mode' means path, so the light travels down multi and single paths respectively.

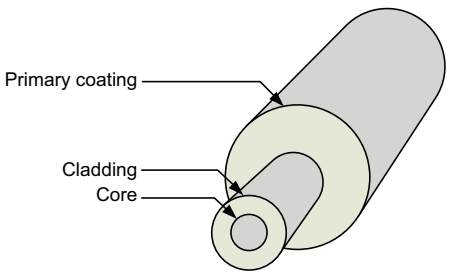
Multimode can use the less expensive LED and VCSEL light sources to transmit the signal.This is referred to as 'overfilled' as the source is broad and floods the modes (and some of the cladding, hence overfilled). The core is manufactured with a graded index. This means that the central light path is 'slower' than the outer paths, which drastically reduces modal dispersion which is one of the limiting factors for the performance of multimode.

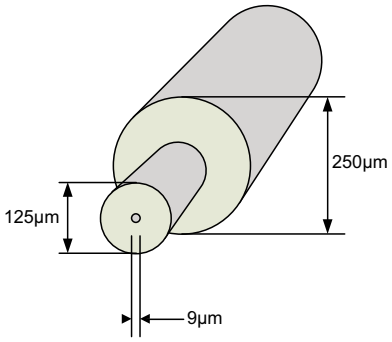
Singlemode requires a laser to transmit the signal along a single path. Lasers offer a high powered signal that can be transmitted for greater distances. However, the active equipment is a higher price than that of multimode.



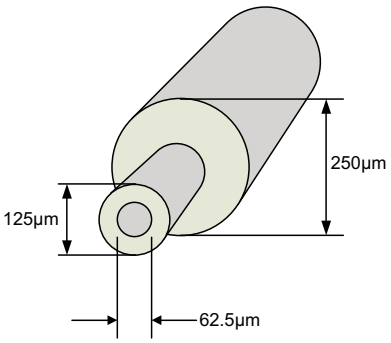
The fibre core comprises of a core and a cladding. This cladding is then covered by a primary coating.

The core is the medium that the light is transmitted along. The cladding is part of the manufacture of the glass. Typically, the cladding is of a consistent size for multimode and singlemode; namely 125µm. Likewise, the primary coating is usually 250µm for both multimode and singlemode. The primary coating can be coloured to differentiate between the cores within a cable.

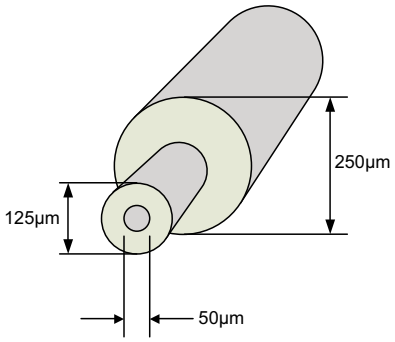




Singlemode
OS1 & OS2



Multimode
OM1



Multimode
OM2, OM3, OM4 & OM5

Cabled Optical Fibre

The term Cabled Optical Fibre refers to the constructed cable product. Once the fibre core is coated (primary, secondary coating, etc) and is encased with the strength members, wraps and sheaths, the product becomes the Cabled Optical Fibre. The performance of fibre optic is affected by the construction, hence the same core manufactured into different Cabled Optical Fibres will have different performances.

The grades of optical fibres, that are detailed by the ITU (International Telecommunications Union), are used to construct the Cabled Optical Fibre categories of cable. The same grade of fibre cabled with a different construction may be a different category of cabled optical fibre.

Singlemode

Singlemode fibre is typically 9/125µm and currently readily available in two categories – OS1 & OS2. OS1 is available in both loose tube and tight buffer constructions. The newer OS2 cabled optical fibre is a low water peak grade of fibre (ITU G.652D). Developments of the product over the years has improved the performance and Excel tight buffed singlemode fibre supports OS2. The low water peak refers to the improved performance around the 1383 nm window. The nature of singlemode having one path for the light, and the transmitting source being a laser, results in a high power and therefore greater distances being achieved. The smaller core size used in singlemode necessitates tighter tolerances being employed for the production of the connector components and couplers.

Cabled Optical Fibre

Cabled Optical Fibre refers to the complete cable including the glass, jacket, strength member, and any other component. This term is required because all of these elements, whether the construction is tight buffer or loose tube, affect the performance.

We have endeavoured to keep our OM2 product set in circulation for as long as possible to assist our customers with the changes in technology to OM3 and OM4. However as of June 2021, we feel it is time to withdraw the OM2 product set from our product portfolio. As stock is depleted it will not be replenished and we would ask our clients to look at our extensive range of OM3 and OM4 products as direct replacements. All OM3 and OM4 products are backward compatible with OM2.

Multimode

Two common dimensions exist for multimode, 62.5/125µm and 50/125µm. For new installations the recommendation is to standardise on OM3, OM4 or OM5. Consideration should be given to OM4 and OM5 for support of the emerging 40 & 100 Gigabit Ethernet standards. These will be accomplished with parallel optics which will influence the connector selection. With the release of Enbeam OM5 now allowing 40 & 100 Gigabit to be transmitted over 2 Multimode fibres by transmitting over 4 wavelengths (850, 880, 910 and 940nm) by short wave division multiplexing (SWDM). All Enbeam OM5 is backward compatible with all Enbeam OM3 and OM4 installations.

NEW for V5

µm

1µm (or 1 micrometres) is 0.000001m or 1x10-6m. Although the correct name is micrometres it is often referred as microns which is the 'slang' term.

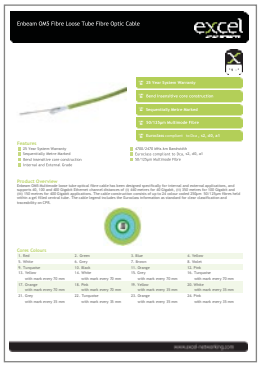
History of OM5

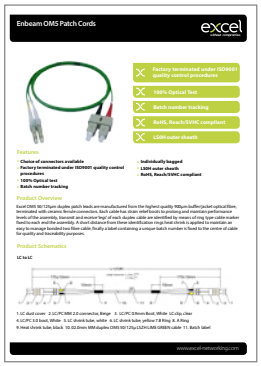
Over the past thirty years, multimode fibre has evolved from OM1 to OM5 fibre. With OM1 and OM2 fibre being released at the end of 20th century, which have now become the legacy 125µm multimode fibre, continues to work well in 10Mb/s, 100Mb/s and 1000Mb/s cabling solution. With the increasing demand for high speed data rate like 10Gb/s, 40Gb/s, 100Gb/s, OM1 and OM2 cannot meet the requirements, so OM3 and OM4 was developed. OM4 fibre cable, with its internal construction, gives higher modal bandwidth than OM3 fibre, which is commonly used as a medium for 40G/100G connection. This causes issues in 40G applications, fibre optic installations had to use one MTP fibre and 4 OM4 duplex fibres (a total of 8 fibres), which causes cable congestion in high-density networks.

The TIA initiated a working group in 2014 to develop guidance for Wideband Multimode fibre (WBMMF) to support Short Wavelength Division Multiplexing (SWDM) transmission, As OM3 and OM4 fibre bandwidth is typically only specified at 850 nm these were not up to the levels needed.

The TIA-492AAAE standard for WBMMF was published in June 2016 and as a result specification for a WBMMF was called for, WBMMF is effectively a type of OM4 fibre, as the WBMMF still has to meet the OM4 bandwidth criteria of EMB ≥4700 MHz•km at 850 nm and with the additional EMB specification at 953 nm of ≥2470 MHz•km.

An international vote in October 2016 gave WBMMF a three-digit designation, and OM5 fibre was born.





Loose Tube & Tight Buffer Cable Construction

The traditional use of fibre was in external environments. The cable is made up of a central strength member around which the primary coated optical fibre is housed in a number of tubes. The various components of the construction have different rates of expansion and contraction due to temperature changes. This is accommodated by housing a number of loose primary coated fibres (typically up to 24) within a series of tubes that spiral around the central strength member. By having the tubes spiral and the primary coated fibre loose within the tube, it allows for the difference in expansion due to temperature of the strength member, tube, fibre, yarn, sheath etc. The tubes containing the fibre may be gel filled to block the ingress of water when installed in external situations. Alternatives to having a central strength member is to have steel wire armour or corrugated steel armour that is around the tubes and under the outer sheath. Aramid yarns are used in the construction for strength and their dielectric properties allow the option of having an all dielectric cable to be installed.

Aramid Yarn

Aramid Yarn is a heat resistant, very strong synthetic yarn. This offers many properties that make it attractive in cabled optical fibre construction, the exceptional strength to weight ratio being one. Kevlar™ is a brand of aramid fibre that is popularly recognised for strength and use in body armour.

The concern with loose tube arises when the cable is required to be mounted vertically. As the primary coated fibre is only typically 250µm in diameter (0.25mm), and is loose within the tube, there is a limit to the vertical rise that is achievable. One solution is to introduce a loop (sympathetic to the bend radius) at regular intervals, say every 10m vertically.

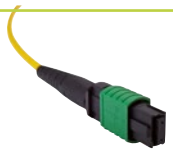
For this reason, tight buffered fibre is more commonly used in internal installations where the ability to route the cable in different planes is required and the temperature change variation is less. The primary coated fibre is surrounded by a secondary coating, usually consisting of two layers, that typically has an overall diameter of 900µm. Secondary coated fibre is suitable where it is housed in trays or within patch panels where it is not subject to repeated handling. For cable construction the secondary coated fibres are surrounded with aramid yarn and an overall jacket sheath. The jacket is offered in various materials depending upon the environment.

A ruggedised cord consisting of the secondary coated fibre with the aramid yarn and outer jacket is typically 2-3mm diameter. This gives very good protection in a compact form with flexibility. These cabled optical fibre units are popular for patch cords often with two single ruggedised units bonded together in a 'shotgun' formation for duplex cords.

Connectors – ST, SC, LC, MTP

A more compact version of the patch cord uses 2 fibres within a single jacket of 2-3mm diameter. These are referred to uniboot patch cords and are particularly useful for LC connections in high density applications.

A variety of connectors are available for use with optical fibre. The following is a selection of the commonly used ones:

	**LC** – the LC connector is one of the new small form factor connectors. Out of the available small form factor connectors the LC appears to be the one being adopted. As with the SC it is available in a simplex or, with the addition of a clip, a duplex version. The physical size of a duplex LC adapter is the same as a simplex SC adapter. Also a quad LC adapter can fit in the aperture required to mount a duplex SC adapter. This has ensured the popularity of the LC over other small form factor connectors as it has the ability to use existing SC mounting hardware.
	**SC** – the SC connector is stated in the infrastructure cabling standards as the connector to be used in new installations (along with small form factor connectors). The SC connector can be used on its own as a simplex connector or joined with a clip with a second to form a duplex connector.
	**ST** – the ST connector uses a bayonet to secure the connector in place. Within the infrastructure cabling standards the ST is recognised for legacy installs but is not to be used for new installations.
	**MTP** – also referred to as MPO a Multiple fibre Push On, Pull Off connector which presents 8, 12, 16 or 24 fibre cores within a single connector. Excel uses the connector manufactured by US Conec branded MTP® Elite as it is a connector with superior quality and performance. The MTP® Elite connector is used in pre-terminated installations and has become popular as a way to support the parallel optics applications being developed (40 & 100 Gigabit Ethernet).

Terminating connectors

The termination of the connectors on the end of the fibre can be achieved by either splicing a pigtail to the end or by directly installing a connector. Direct installing of the connector involves preparing the fibre to bare the cladding. This is then fixed into the ferrule with adhesive. The adhesive used takes many forms, including hot melt, cold cure and hot cure to name a few. The end face is then polished and inspected until the desired standard is achieved. This is a very labour intensive method relying on the skill of the installer. It also puts a larger demand on the installer to maintain consistency.

Fusion splicing a factory manufactured pigtail onto the fibre is the alternative method. The pigtail is a 1-2m length of fibre with the desired connector pre-attached by Excel. As these are factory made, the quality of the termination and consistency can be assured and maintained. The fusion splicer then joins the end of the pigtail and the fibre cable together using an electrical spark. The splice is covered with a heat shrink splice protector. The modern fusion splicer aligns the fibre cores and splices automatically. This ensures consistency and a high quality through the whole installation. A proficient operator can perform in excess of 100 fusion splices in a day, including preparation of the cable and final mounting in the patch panel.

Diverse routing

The fibre optic network is often used in the backbone and data centres. In both these instances the network plays a critical part of the business. It is for this reason that a level of redundancy should be designed into the network design. Effectively, a risk assessment needs to be carried out before designing the network. This risk assessment should include what the risk is to the business if the network fails (this will highlight the level of importance and investment that is prepared to be committed to the network). Complementing this, the physical risks need to be assessed. Whether it is a single fibre core breakage, connecting equipment failure or the proverbial JCB digging up a buried cable, these are all physical risks. The risks can then be mitigated to some extent with Diversity, Redundancy and Capacity. Physical diversity is achieved by connecting the hardware with two or more different connections. The routing of these diverse links needs to be planned so that they do not follow the same route or share the same containment. That way, if there is a breakage in one link the other may be used. Networking equipment is often supplied that has two or more connections and can be configured to automatically switch routing. Although the active equipment may use all of the diverse routing in normal operation, the network is designed such that this offers the levels of redundancy should sections of the physical networks be compromised. The level of redundancy required should be identified in the risk assessment. As the traffic levels and demands increase on the network, a good design will allow capacity to accommodate this. In short, "Design for Tomorrow not Today".

Cable containment

Over the years and ever-expanding networks of today, cable containment is a key part to the performance of all Data cabling regardless of whether it is fibre optics or a Copper based solutions.

Incorrect selection of containment can result in loss of signal, damage to cables, overcrowding which in copper based installations where POE (Power over Ethernet) is in use could result in excessive heat generation.

Types of containment available:

Type	Primary Use	Secondary use	Environment
Galvanized Metal Box Trunking	Electrical	Copper/Fibre	Industrial
Cable Tray	Electrical	Copper/Fibre	Industrial, Data Center and Co-Location
Basket Tray	Electrical	Copper/Fibre	Industrial, Data Center and Co-Location
Ladder Rack Raceway	Copper	Fibre	Industrial, Data Center and Co-Location
Plastic Duct System	Fibre Optics		Data Center and Co-Location

Galvanized Trunking

Galvanized Trunking is often used for Electrical cabling within the industrial environment and you will find copper and fibre based installations using the same containment, however it is important to note any copper / fibre based product should be kept separated from any power often achieved by using three compartment trunking this stops any electrical magnetic interference (EMI) being transferred across to the data cabling. Fibre is not affected by EMI but it is best practice to keep all three separated at all times for clear demarcation & serviceability and also reducing any chance of the fibre cables being Crushed under the weight of copper cables.

Cable Tray

Cable Tray is common in many installations. The down-side of cable tray is the inability to separate cabling types as with the galvanized trunking. Each cable type should have its own containment path.

The down-side to cable tray is the need to use cable ties to first secure the cables into bundles and then to secure each bundle to the tray, this can also have an effect on cable performance due to cable ties being pulled too tight altering the construction within copper cable or causing macro bends and losses in fibre.

Basket Tray

Basket Tray is very similar to the above, designed to be more cost effective and quicker to install but with the same limitations as cable tray in separating cable types and the use of cable ties.

An additional issue is cable sag were the weight of the cable installed fall down between the bars of the tray causing macro bends that again cause signal loss of construction changes within the cable. A solution to the macro bend issue is to lay cable matting along the basket to allow a flatter surface to mount cable on.

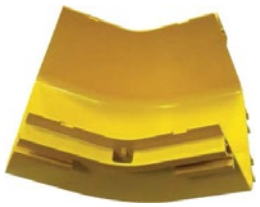
Ladder Rack Raceway

Ladder Rack Raceway is similar to the cable tray and basket tray in having limitations in the separation of cable types and the macro bend issue. Having the same solution in having to lay extra matting to eliminate macro bends, all three also have limitations on the amount of cable that can be stored due to the depth of the solution being used.

Dedicated Plastic Duct System

With the above systems offering partial solutions for cabling pathways, dedicated systems come into play. As the amount of fibre optic cabling being used in the networks of today has increased, the need to have dedicated containment is apparent, the yellow duct systems seen today in some of the largest datacentres and co-location sites offer a well-controlled bend radius for fibre, along with the depth needed to install multiple fibre optic cables without the need to install restrictive and sometimes damaging tie wraps to secure cables. For example - the Enbeam 240mm x 100mm deep ducting system at 75% capacity can hold above 2866 x 2mm cables. This system can also be installed with covers to eliminate contamination, keeping the network free from dust.

This also offers a good visual identification for fibre optic pathways. Whilst all of the above carry electrical and copper based solutions keeping the fibre optics away from heavy cables eliminating the possibility of damage.



Testing

Testing of the installed fibre optic network is vital as it assures compliance with the design. Please refer to Section 12 – Excel Installation Guidelines for detailed information on how to carry out fibre testing to meet the requirements of the Excel Warranty program. It is important that within the specification, and before the installation is undertaken, the required fibre optic testing is detailed.

Fibre optic testing can be broadly split into two levels.

Tier 1 – Loss Testing

Loss testing measures the overall attenuation and is compared with the loss budget calculated for the designed link to determine whether it passes or fails. The loss budget, depending on the test being carried out, is calculated from the length and number of connections and splices. Some tests do not require a loss budget to be calculated but state a maximum length and loss permitted. The loss test is carried out using a light source and power meter.

Tier 2 – Characterisation

Characterisation of the fibre optic link comprises the requirements of Tier 1 testing with the addition of an Optical Time Domain Reflectometer (OTDR) trace to be taken. The Tier 1 test measures the overall loss.

The OTDR offers a loss trace in the time domain. As the speed of light is a known constant and fibre cable has stated Refractive Index (stated on the specification sheet of the cabled optical fibre), the OTDR translates this into a distance measurement. With the OTDR, individual events (splices or connections) can be evaluated. Some applications not only dictate the maximum overall loss, but they also state the maximum individual loss per connector. The OTDR is able to provide this information either automatically or by manual interpretation. The OTDR trace may also be used in the future for assessment of suitability for new applications.

Encircled Flux

Within the two tiers mentioned above, loss testing is a necessity. It is important when testing, that this is carried out correctly to ensure the validity of the results. Loss Testing is carried out with a light source at one end of the link or channel and a power meter at the other. The mode is the path or paths that the light signal takes down the core. In the case of singlemode, this is with a laser and is one path. Therefore singlemode testing is with an appropriate laser based light source, and as it is one path, the path that is used by all equipment when in service will be the same.

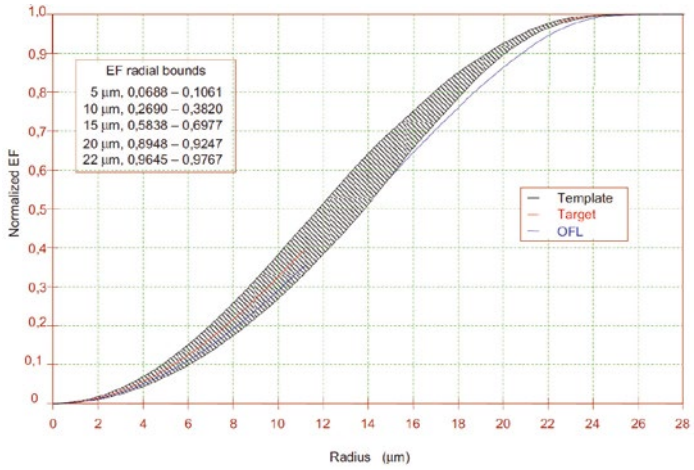
Multimode, on the other hand, has many paths. Modern fibre optic equipment uses a VCSEL (Vertical Cavity Surface-Emitting Laser), which is a low power device designed for use with multimode fibre. As the device is a form of laser it does not use all of the modes for the transmission of the signal. Therefore, when testing it is important that all of the modes are tested to ensure that it will support the selected application. This is referred to as flooding the core. Historically this was achieved by using a mandrel wrap on the lead from the light source. The mandrel wrap is of a specific size, and a certain number of turns around it are made depending on the core size and category. With the aforementioned new applications, it has become necessary to define the fill of the core more precisely. This is by specifying that the launch leads are Encircled Flux (EF)compliant.

Encircled Flux is defined in the standards as “fraction of cumulative near-field power to the total output power as a function of radial distance from the optical centre of the core”. This means that the proportion of the light power is defined based on the position from

the middle of the core. These power levels, as they are defined from the centre of the core are around the centre, hence the term Encircled. This forms a template of the upper and lower limits. An example of a template, as shown in IEC 61280-4(2009) can be seen below.

This graph shows how the Overfilled Light (OFL) condition falls outside the template at the higher radius.

The templates are specified for the different fibres and light wave length used. The graph is an example of 50µ core fibre at a wavelength of 850 nm.



EF requirements

50µ Core – OM2, OM3, OM4 & OM5

850 nm			
Radius µm	EF lower bound	Target	EF upper bound
10	0.2785	0.3350	0.3915
15	0.5980	0.6550	0.7119
20	0.9105	0.9193	0.9295
22	0.9690	0.9751	0.9812

1300 nm			
Radius µm	EF lower bound	Target	EF upper bound
10	0.2792	0.3366	0.3940
15	0.5996	0.6567	0.7138
20	0.9072	0.9186	0.9300
22	0.9663	0.9728	0.9793

62.5µ Core – OM1

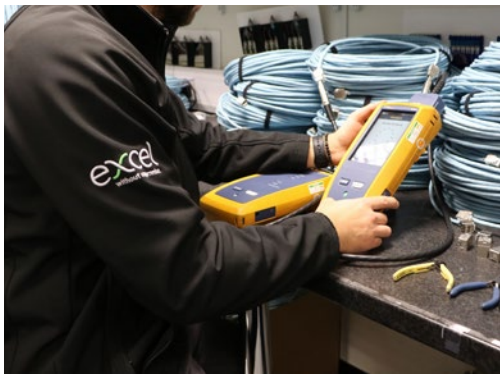
850 nm			
Radius µm	EF lower bound	Target	EF upper bound
10	0.1683	0.2109	0.2535
15	0.3695	0.4390	0.5085
20	0.6337	0.6923	0.7509
26	0.9245	0.9350	0.9455
28	0.9710	0.9783	0.9856

1300 nm			
Radius µm	EF lower bound	Target	EF upper bound
10	0.1680	0.2119	0.2558
15	0.3699	0.4409	0.5119
20	0.6369	0.6945	0.7521
26	0.9254	0.9357	0.9460
28	0.9708	0.9782	0.9856

As the above are defined more stringently than previous methods of multimode testing, this reduces the level of uncertainty. This is important as the demands on the fibre, due to multi-connector designs and higher applications means that the margins are tighter than previously experienced. By reducing the uncertainty, it means that the testing accuracy is improved and links and channels can truly be measured to assure support for the application.

EN50346 – Information technology – Cabling installation – Testing of installed cabling and ISO 11801 – Information technology – Generic cabling for premises state that fibre testing shall be carried out in accordance of ISO/IEC 14763-3 & Amendment 1 – Information technology – Implementation and operation of customer premises cabling – Part 3: Testing of optical fibre cabling. ISO/IEC 14763-3 calls for Multimode fibre to be tested with EF compliant devices.

Example of EF Test Reference Cord attached to a Fluke DSX-8000



Fibre Cabling Standards - Overview

Fibre optic cable and connecting hardware is available in many different types and specifications. The ISO and CENELEC standards bodies have created categories that define these components. Categories include OM1, OM2, OS1, etc. As new applications are developed they are designed to fit within the existing categories. The benefit to the end user client is that a system designed and installed to a specified category will support all current and future applications designed for it.

With the publication of ISO/IEC 11801-1:2017 and BS EN 50173-1:2018 They removed the optical fibre classes OF-100, OF-300, OF-500 & OF-2000 which weren't really referenced as the industry used Categories OM3, OM4 and so forth.

Furthermore, they have announced the intention to remove OM1 and OM2 at the next revision of the standard.

Attenuation limits for optical fibre cabling channels

Type of optical fibres	Maximum channel attenuation dB			
	Multimode		Singlemode	
	850 nm	1300 nm	1310 nm	1550 nm
OM1, OM2, OM3, OM4, OM5, OS1, OS2	2.55	1.95	1.80	1.80
OM1, OM2, OM3, OM4, OM5, OS1, OS2	3.25	2.25	2.00	2.00
OM1, OM2, OM3, OM4, OM5, OS1, OS2	8.5	4.5	3.50	3.50
OS1, OS2			4.00	4.00
OS1, OS2			6.00	6.00

There are currently three basic material combinations used in the manufacture of fibre cables. These are all-silica optical fibre, plastic optical fibre and plastic clad silica optical fibre. The majority of infrastructure cabling used in LAN and Data Centre applications carried out uses the first, all-silica optical fibre.

All-silica optical fibre

All-silica optical fibre is available in two versions which are multimode (OM) and singlemode (OS). Multimode and singlemode are further divided into Categories.

Multimode (MM)

Multimode cabled optical fibre is currently constructed using two glass sizes. These are 62.5/125µm and 50/125µm. For a given category they have minimum bandwidths.

Category	Size	Bandwidth			
		Overfilled launch		Effective laser launch	
		850 nm	1300 nm	850 nm	953 nm
OM1	62.5/125µm	200 MHz.km	500 MHz.km		-
OM2	62.5/125µm and 50/125µm	500 MHz.km	500 MHz.km		
OM3	50/125µm	1500 MHz.km	500 MHz.km	2000 MHz.km	-
OM4	50/125µm	3500 MHz.km	500 MHz.km	4700 MHz.km	-
OM5	50/125µm	3500 MHz.km	500 MHz.km	4700 MHz.km	2470 MHz.km

Singlemode (SM)

The Excel OS2 singlemode is manufactured from a G.652.D (low water peak) grade of glass core. Excel can offer OS2 in both Loose Tube and Tight Buffer construction due to the superior construction methods.

Wavelength	Maximum attenuation	
	OS1	OS2
1310 nm	1.0 dB/km	0.4 dB/km
1383 nm		0.4 dB/km
1550 nm	1.0 dB/km	0.4 dB/km

Supported applications

The following are Ethernet applications supported by different classes and categories of fibre optics and their maximum channel lengths. Other applications are supported, refer to the latest edition of BS EN 50173-1.

Multimode				
Ethernet Application	OM1	OM3	OM4	OM5
1000BASE-SX (Gigabit)	275 m	550 m	1100 m*	
10GBASE-SR/SW (10 Gigabit)	32 m	300 m	550 m	
40GBASE-SR4 (40 Gigabit)		100 m	150 m	440m (40 Gigabit)
100GBASE-SR10 (100 Gigabit)		100 m	150 m	350m (100 Gigabit)
100GBASE-SR4 (100 Gigabit)			100 m**	150m (400 Gigabit)

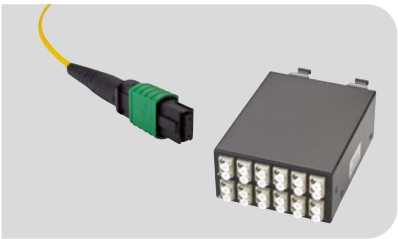
* distance specific to Excel fibre
** under development, correct at time of publication

Singlemode		
Ethernet Application	OS1	OS2
1000BASE-LX (Gigabit)	2,000 m	5,000 m
10GBASE-LX4 & LR/LW (10 Gigabit)	2,000 m	10,000 m
10GBASE-ER/EW (10 Gigabit)	2,000 m	22,250 m
100GBASE-LR4 (100 Gigabit)	10,000 m	10,000 m
100GBASE-ER4 (100 Gigabit)	40,000 m	40,000 m

Excel Enbeam Fibre Optic Cabling Systems

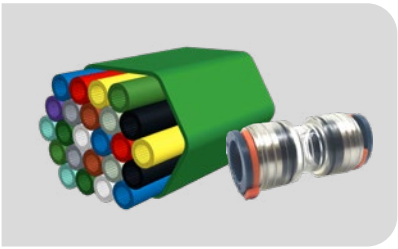
When installed by an accredited Excel Partner the Enbeam fibre range is covered by a 25-year system and application warranty.

The Excel Enbeam Fibre Optic Cabling Systems range includes:



Enbeam Excelerator MTP System

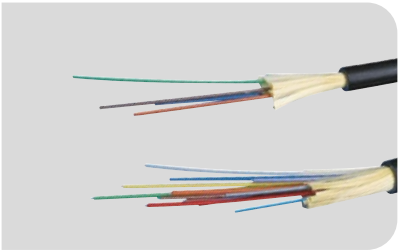
- Provides a reliable, rapidly deployed solution to high density fibre cabling
- Choice of OM3, OM4 and OS2 systems
- Unloaded HD panel accepts up to 12 fibre optic cassettes
- Various panel & cassette options available
- MTP® Trunk cables offer pre-terminated factory tested optical fibre
- Uses the US Conec MTP® Elite connector



Blown Fibre System

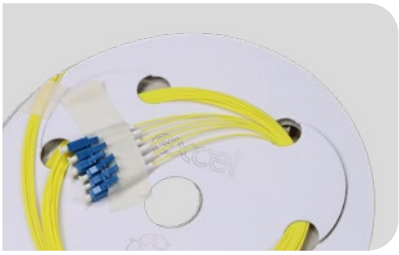
- Provides a flexible, low total life cost and 'peace of mind' solution
- The flexibility offered by blown fibre solutions can substantially minimise network build costs
- Increase network design flexibility
- Reduce initial expenditure/control on-going expenditure

Find out more in the Blown Fibre Section (Section 12)



Excel Enbeam Internal/External Grade Fibre Cables

- Available in a choice of loose tube or tight buffer
- Available in OM1/OM3/OM4/OM5/OS2
- CST Fibre cable available
- SWA Fibre cable available
- Core counts from 4 to 96



Excel Enbeam Fibre Optic Patch Cords

We have all heard the term 'it's only a patch cord', however money spent installing multi millions worth of infrastructure in data centres, and even smaller installations running high dependency equipment can fail quite quickly buy cutting costs on these areas.

Enbeam patch cords are manufactured from high quality materials and are 100% factory tested.

- Available in OM1/OM3/OM4/OM5/OS2
- Connector types include ST, SC, LC and FC
- All connectors are polished to UPC/APC quality
- All patch cords come with an LS0H outer sheath
- Supplied with a test report detailing insertion loss
- Packaged in individual 100% recycled and recyclable paper pouches - zero single use plastic

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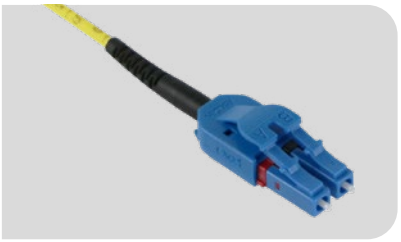


Enbeam Uni-boot Patch Cord

As industries change to High density patching, some changes to the patch cord industry also has to change. The use of uni-boot housings on the connector. This allows the use of a single cable with 2 fibre cores removing the need for the traditional dual zip cord cable. This reduces the overall cabling volume by 50% and is key to a reducing congestion within frames and racks.

Other key features also used within uni-boot patch cords are the ability to reverse the polarity, often needed within fibre installations, depending on which polarity technique is used "A-to-B" patch cord for "straight-through" wiring and "A-to-A" patch cord for "crossover" wiring.

Excel Enbeam Pigtails

- Available in OM1/OM3/OM4/OM5/OS2
- Pigtail types include ST, SC, LC, FC – all UPC and APC
- Choice of 1m or 2m lengths
- Available as tight or loose construction
- Supplied with a short strain relief boot
- Supplied with a test report detailing insertion loss

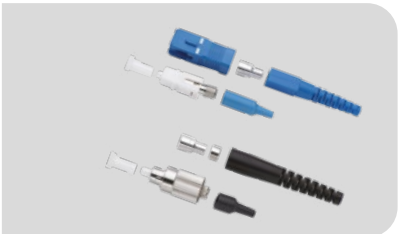
Unlike fibre optic patchcords (cable terminated with fibre connectors on both ends), fibre optic pigtails are single fibres terminated with connectors at one end, while leaving the other side with no connector, so that the connector side can be linked to the equipment and the other side can be spliced with the live incoming fibre cables by fusion splicing or via a mechanical type of splice. High quality pigtails with correct fusion splicing practices offer the best performance for cable terminations. They are usually used within a fibre optic patch panel or Optical Distribution Frame (ODF) and most applications requiring connectors to be installed to multiple fibres in one area.

LC Fibre Optic Pigtail: LC connector features a low loss, high precision 1.25mm ceramic ferrule. LC fibre optic pigtails are suitable for high-density installations.

SC Fibre Optic Pigtail: SC connector is a pull/push connector with a 2.5mm ceramic ferrule. It is light weight, robust and economical to use in different applications such as CATV, LAN, WAN, test and measurement.

FC Fibre Optic Pigtail: the pigtail uses the metallic body FC optic connectors. FC connectors have a screw type structure and high precision ceramic ferrules. FC fibre pigtails are not so widely used in networks due to the changes in infrastructure.

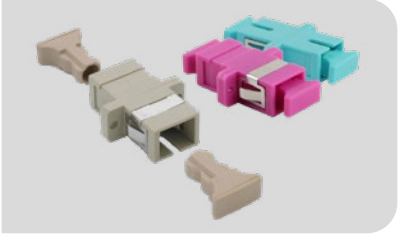
ST Fibre Optic Pigtail: ST fibre optic connectors have a 2.5mm diameter ceramic ferrule, with alloy or plastic bodies. ST fibre pigtails are not so widely used in networks due to the changes in infrastructure.



Excel Enbeam Fibre Optic Connectors

- Available in singlemode and multimode
- Simplex options in ST, SC, LC and FC
- Duplex options in SC and LC
- Highest quality ceramic ferrules
- Both 900µm pigtail and 2 or 3mm cable boots included

Single mode OS1 & OS2 = Blue
Single mode Angle polished (APC) = Green
Multi-mode OM1 = Beige
Multi-mode OM3 = Aqua
Multi-mode OM4 =Heather Violet
Multi-mode OM5 = Lime Green/ Beige



Excel Enbeam Fibre Optic Adaptors

- Available in ST, SC, LC, FC and MTP
- Choice of singlemode or multimode on SC, SC/APC, LC, LC Quad and FC Adaptors
- Choice of aligned-key or key-up/key-down on MTP adaptors

As development in data speeds increase we have seen several changes especially in Multi-Mode, as these changes occur the industry needs a way to clearly identify different types of cabling visually rather than performance, this is why you now see multiple colours of adapters on the market, these colours have been designated by the TIA standards body to enable clear visual identification of all connection types.

Single mode OS1 & OS2 = Blue
Single mode Angle polished (APC) = Green
Multi-mode OM1 = Beige
Multi-mode OM3 = Aqua
Multi-mode OM4 = Heather Violet
Multi-mode OM5 = Lime Green/ Beige

Excel Enbeam Shuttered Adaptors

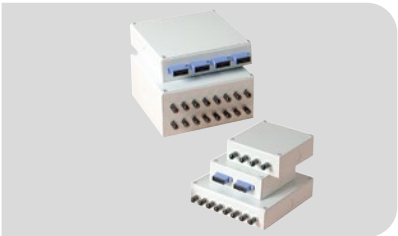
Within the Industry you will hear a lot of people talking about shuttered adaptors and the way in which they protect the connector from dust, this is in fact a secondary result of having a shutter. The main reason for a shutter is the power of the laser used in single mode applications can seriously damage your eye sight if looked at directly; shuttered adaptors use a sprung loaded cover that falls in front of the adaptor blocking the laser signal when unplugging the patch cords. With the increasing need to install Fibre to the home, within datacentres and co-location it removes the change of injury and protects the engineer when preforming maintenance tasks such as cleaning.

This forms a very important solution to today's ever-growing health and safety policies as it removes the need to replace dust caps in adaptors when patching and un-patching and protects the public from injury.

The secondary benefit is it limits dust ingress.

Excel Enbeam Cold Cure Termination System

- Designed to provide a fast curing, no heat termination method on site
- Consists of an anaerobic adhesive and alcohol base activator



Excel Enbeam Fibre Optic Patch Boxes

- Available in ST, SC (Duplex) and LC adaptor styles
- One-piece body construction eliminates fibre snagging
- Ideal for conduit or cable gland entry

Patch boxes come in various sizes and adaptor types but offer a lower cost solution to installations requiring small fibre counts to be distributed into remote areas or floors of a building.

Excel Enbeam Fibre Optic Wall Mounted Enclosures

- Designed for high-density, secure terminations
- Available in ST, SC Duplex, FC and LC in-line adaptor plates

Wall mounted fibre optic boxes have a wide range of applications from small office environment to medical and industrial applications, the double door versions are normally used to segregate splicing areas from the patching fields allowing restricted access to the splice area normally controlled by the service suppliers.

Excel Enbeam FTTx Solutions

Fibre optic cabling is becoming the leader in the access network FTTx. Fibre optic cabling is becoming the leader in the access network FTTx. This Encyclopaedia contains a dedicated section about FTTx systems.

Find out more about Excel's Enbeam FTTx Solutions on the Excel website: https://excel-networking.com/fttx-solution

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Excel Enbeam FTTh Customer Outlets

Enbeam have a range of FTTh customer outlets aimed to feed the FTTh market offering dedicated internal fibre management to protect the incoming fibre. Shuttered adapters can be installed to requirements for customer safety.

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Excel Enbeam MDU Boxes

Whist Multi Dwelling Units (MDU) are used to distribute fibres into dwellings and individual properties, it is not the sole application. These types of boxes are suitable for any application requiring multiple connections distributed within a particular area. These units are normally manufactured to be installed internally and externally with wall and pole mounting options. The box allows easy access for connectivity or disconnect and are normally lockable for security. The Enbeam MDU can be installed in all applications, giving a flexible solution to numerous installations.

- LC Duplex
- SC Simplex
- ABS Material ensures a strong lightweight enclosure
- Water resistant for outdoor and internal use
- Designated splitter area

Excel Enbeam Splice Enclosure

Fibre Optic Splice Closures (FOSC) - also known as Dome Enclosures, are used in the network to distribute network feeder cables in different directions to enable coverage of a wider area. This is achieved by breaking into the feeder cable and splicing to another cable going in a different direction to the main feeder cable (Branching). Key features to these enclosures should include:

- Ability to re-enter multiple times
- High IP Rating against dust and water (IP68)
- Pole or wall mounting
- Multiple cable entry points

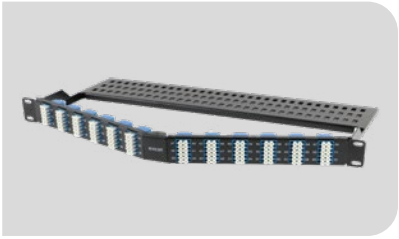
Enbeam Enclosures now offer mechanical sealing methods rather than the old heatshrink method to seal the unit. This allows the enclosure to be reworked multiple times without the need to cut heatshrink or the use of a flame against fibre optical cables.

Most other enclosures in the market will only include the enclosure - then all other installation parts will need to be purchased separately increasing the overall cost of these types of enclosure. The Enbeam Enclosure includes all materials needed to fix the unit to a pole or wall and all termination material to splice to a cable, making the Enbeam Enclosure cost affective and easy to order.

Excel Enbeam High Density Patching Solutions

Expanding network and the volume of connections needed in the industry, and the need to utilizes all existing space to save costs throughout all installations has pushed the terminology know as High Density or Ultra High-Density patching to the top of the list in datacentre and telecommunication designs. The use of high density patching has pushed the design of panels toward MTP and LC connectivity, which in turn creates its own problems to overcome.

The main issue in high density patching is finger access for engineers to be able to patch and un-patch connections. As connections become closer, space is limited not only for the engineers but also the ability to label the panels adequately to identify the connections.



Excel Enbeam 1U 144 Fibre Angled Panel

Excel has designed the Enbeam 1U 144 fibre LC angled panel. In conjunction to the angled panel a new 12 fibre LC adaptor has been developed to enable good finger access and labelling to be applied.

The panel has been designed for pre-terminated connection to the rear of the panel with rear cable management included. The angled design of the panel reduces the bend radius of the patchcords at the front of the panel and allows the fibre to enter cable management at the side of the installed panel with no stress being applied to the patch cord. No separate patchcord managers are needed, further saving U space within the cabinet.

Excel Enbeam 1U 144 High Density Cassette Panel

Excel has designed the Enbeam 1U 144 high density cassette panel to enable horizontal LC patching in groups of 12 fibres per cassette. The panel holds 12 cassettes which gives it 144 fibre capacity. These cassettes have several options available to give total flexibility in any situation, splice, pre-termination and MTP pre-configured cassettes are available.

The use of magnets within the design of the cassettes and cable management offer a unique flexible solution to installations and management of fibre.

The modular design allows the installation to grow as the network grows by adding cassettes when required. Each cassette can be installed from the front or rear of the panel giving greater flexibility.

Each panel is supplied with magnetic covers front and rear to protect fibre from damage, along with hinged cable management allowing access to the panels below or above.

There are several areas where 1U high density panels are used, Top of Rack (TOR), End of Row (EOR).

Top of Rack: The term has been adopted for the way in which switches are installed into Racks. Although switches can be installed anywhere in this application - middle or even bottom of the rack, top of rack is the most common method. In this configuration, the rack cable management is easier to manage and more accessible. This is adopted to enable each rack to be modular in its construction, reducing copper connections to short lengths, giving better cable management and allowing servers and switches to be changed or upgraded, with limited disruption to the network. Each rack is then connected to the core via fibre, reducing the high congestion and routing problems caused by copper infrastructure. It reduces the number of racks and patch panels needed for patching.

Top of Rack advantages:

- Copper stays "In Rack" and no large copper cabling infrastructure required
- Lower cabling costs and less infrastructure dedicated to cabling and patching
- Cleaner cable management
- Modular and flexible
- Future proofed fibre infrastructure
- Short copper cabling to servers

Top of Rack disadvantages:

- More switches to manage
- More ports required in the aggregation
- Potential scalability concerns
- Unique control plane per 48-ports (per switch)
- Higher skill set needed for switch replacement.

End Of Row: The term "End of Row" describes a rack or cabinet placed at either end of the "server row" for the purpose of providing network connectivity to the servers within that row Each server cabinet's design has a bundle of copper cabling (typically Category 6 or 6A) containing as many as 48 (or more) individual cables routed to the "End of Row". For a redundant design there might be two bundles of copper to each rack, each running to opposite "End of Row" network racks. Theses bundle of copper cables are typically terminated on one or more patch panels fixed to the top of the cabinet and connected to the server by short patch cords. Copper bundles are routed underneath a raised floor or overhead on basket or ladder racking. Depending on how much copper is required, it is common to have a rack dedicated to patching all the copper cable next to the rack that contains the "End of Row" network switch. RJ45 patch cables are used to link a port on the network switch to a corresponding patch panel port that establishes the link to the server. With this design the large amount of Copper patching can become un-manageable. Another variation of this design can be referred to as "Middle of Row" which involves routing the copper cable from each server rack to a pair of racks positioned next to each other in the middle of the row. This approach reduces the extreme cable lengths from the far end server cabinets, however potentially exposes the entire row to a localised disaster at the "Middle of Row" (such as leaking water from the ceiling) that might disrupt both server access switches at the same time.

End of Row advantages:

- Fewer switches to manage
- Potentially lower switch costs
- Lower maintenance costs
- Fewer ports required in the aggregation
- Longer life
- High availability
- Modular platform for server access
- Unique control plane per hundreds of ports (per modular switch)
- Lower skill set required to replace a 48-port line card, versus replacing a 48-port switch

End of Row disadvantages:

- Requires an expensive, bulky, rigid, copper cabling infrastructure
- Cable management challenges
- More infrastructure required for patching and cable management
- Long copper cabling limits the adoption of lower power higher speed server I/O
- More future challenged than future proof
- Less flexible "per row" architecture
- Platform upgrades/changes affect entire row

Learn more about what we're doing to help save the environment in the Plastic Free Packaging Section (Section 2)

Excel Enbeam Fibre Optic Patch Panels

- Choice of port density
- Range includes ST, SC, LC, FC and MTP
- Available in multimode and singlemode
- Multiple pre- stamped cable entry positions on rear
- Supplied with a cable management kit and cage nuts

Sliding fibre trays are one of the main components in most fibre optical installations, used to distribute fibre across the network. Any fibre tray should be designed in such a way to allow high quality protection of incoming fibre.

Most industry standard panels will be manufactured from steel, giving a strong housing to protect the fibre. It is important that these panels provide adequate room for fibre to be routed around the panel and respect the bend radius of the fibre optic cable being installed. Smooth operation when opening and closing the panel is key as poor operation can cause fibres to become trapped and broken if the panel does not function correctly. Provisions for splicing should be made and give adequate positions for splice protectors to be held securely, ether by the way of a splice bridge or dedicated splice tray.

Another feature sometimes overlooked is a clear area for labelling as this has an effect on the running of any network. Without clear labelling, re-patching and maintenance carried out over time will cause network issues.

The Enbeam panel has been designed to take all the above issues into account plus more. It
offers one of the best designed panels in the market

- Ball-bearing sliding drawer for smooth operation
- Recessed adaptors provide larger labelling field and better bend radius for patch cords
- Optional patch cord management bar with additional labelling options
- Greater range – OS2, OM3 and OM4
- Blue (OS2), Aqua (OM3) and Heather Violet (OM4) adaptors
- High quality zirconia ceramic alignment sleeves
- Options for pre-loaded splice cassettes
- Options for pre-loaded 12-colour pigtails
- Full installation kit included
- 24-way splice holders included
- Ideal for both splicing and pre-terminated cables

The Enbeam Fibre Optic patch panels come in a range of configurations. This includes different adaptor types and quantities. Each patch panel is supplied with an accessory kit.

Special panel configurations can also be supplied, such as hybrid panels with a mix of adaptors etc.

Excel Enbeam Fibre Optic Patch Panels

The Excel Fibre Optic patch panels come in a range of configurations. This includes different adapter types and quantities. Each patch panel is supplied with an accessory kit.

Key	
Singlemode	Multimode
OS2 OS2-APC	OM1 OM3 OM4

Excel Fibre Optic Patch Panel Configurations

	ST - Simplex			SC - Simplex			SC - Duplex		
									
Adaptors	Fibres	Multimode	Singlemode	Fibres	Multimode	Singlemode	Fibres	Multimode	Singlemode
4	4	200-377	200-427				8	200-401	200-480
6							12	200-405	200-481
8	8	200-378	200-428				16	200-406	200-482
12	12	200-379	200-429	12	200-486	200-484	24	200-407 203-530 204-530	200-483
16	16	200-382	200-430						
24	24	200-384	200-431	24	200-487	200-485	48	200-408 203-532 204-532	200-411
Empty	-	200-950		-	200-952		-	200-951	

	LC - Duplex			Quad - Duplex			LC - Duplex shuttered		
									
Adaptors	Fibres	Multimode	Singlemode	Fibres	Multimode	Singlemode	Fibres	Multimode	Singlemode
4	8	200-460	200-470	8			8		
8	16	200-462	200-472	16			16		
12	24	200-464 203-540 204-540	200-474	24			24	203-550 204-550	
24	48	200-466 201-626 203-542 201-627 204-542	200-476 201-624 201-621 201-625	48			48	203-552 204-552	
24	96			96	200-489	200-488	96		
Loaded with pigtails and cassette		201-622 201-623	201-620 100-621						
Empty	-	200-952		-	200-951				

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UPDATED for V5

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Excel ExpressNet Patch Panel Frames

The Excel ExpressNet Panel provides the ability to have fibre and copper presented in one panel, offering complete flexibility in the installation. The Excel ExpressNet Panel accepts 6 port copper or fibre modules. The modules are available in a choice of Category 6_A Screened, Category 6 Screened and Unscreened, LC fibre with traditional termination or to MTP connector. Pre terminated options are also available.

Watch our Video

The Excel ExpressNet is suitable for installations from data centres, where the panel may aid separation of the routes of cabling, to a remote wall box that has a small number of fibre and copper links. Its design provides a versatile and flexible solution that will suit many applications.

The construction of the panel has a chrome finish and comes in a choice of a 4 or 8 module panels using only 1U of rack space.

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Features

- 4 & 8 Module Patch Panels
- Accepts Copper & Fibre 6 Port Cassettes
- 25 Year system warranty available

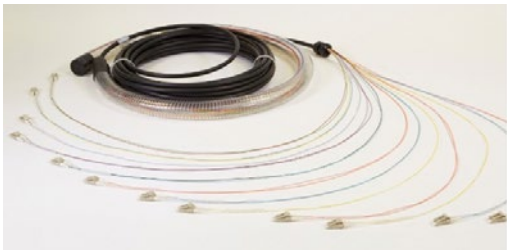
Part Number	Description
100-230	Excel 1U ExpressNet Patch Panel Frames - 4 Module - Unloaded
100-231	Excel 1U ExpressNet Patch Panel Frames - 8 Module - Unloaded
201-600	Excel 6 Port Duplex (12 Fibre) OM3 LC Module
201-601	Excel 6 Port Duplex (12 Fibre) OM4 LC Module
201-602	Excel 6 Port Duplex (12 Fibre) OS2 LC Module
201-610	Excel 6 Port Duplex (12 Fibre) OM3 LC to MTP Module
201-611	Excel 6 Port Duplex (12 Fibre) OM4 LC to MTP Module
201-612	Excel 6 Port Duplex (12 Fibre) OS2 LC to MTP Module
100-235	Excel 6 Port Category 6 Unscreened Module
100-236	Excel 6 Port Category 6 Screened Module
100-237	Excel 6 Port Category 6_A Screened Module
100-232	Excel ExpressNet Blank - Pack of 5

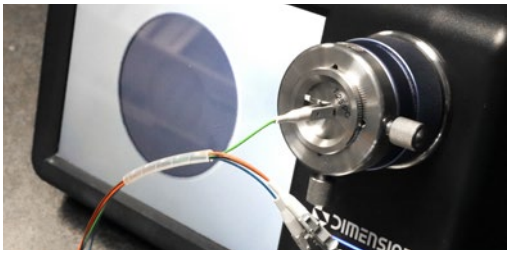
NEW for V5

Pre-Terminated Solutions

Pre-terminated solutions help to reduce installation costs and times, equipment and specialist labour costs. Our team operate with a fast turnaround - typically three working days with all items 100% inspected, fully tested and traceable. Our pre-terminated fibre solutions are also covered by the 25-year Excel system warranty when installed by an accredited partner.

- Available in OM1, OM3, OM4, OM5 and OS2
- Available in all core counts from 2 to 24
- Bespoke breakout lengths to suit application
- Machine polished
- Pre-labelled
- Ferrule geometry checked on interferometer to ensure best performance in all conditions
- Fitted with protection both ends
- One end fitted with a pulling eye
- Glands pre-fitted both ends
- Available on a drum or coiled in a bag
- Plug and Play





Excelerator Configurator

Excel's Excelerator is a range of pre-terminated fibre systems including distribution, break-out and mini break-out cables and MTP solutions. You can use the Excelerator configurator to help you design the cable that you want to use, producing drawings of your solution and requesting a quotation – all within minutes.

View and configure bespoke fibre optic cables using the Excelerator Configurator.

Find out more about
Excel's Pre-Terminated Fibre Solutions and additional Specialist Support Services
in **Section 13** of this Encyclopaedia