Installation Guide

Excel is a world-class premium performing end-to-end infrastructure solution - designed, manufactured, supported and delivered - without compromise.

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Introduction

This installation guide has been produced to assist the Excel Partners with the best installation practices for the Excel Structured Cabling System. The Excel Structured Cabling system meets the component performance and configuration requirements of EN50173 for the Class of performance desired. The location is based on a Class 1 environment in terms of M, I, C, E. The design of the cabling system and containment solution into which it is to be installed should be compliant with the requirements of the EN50174 and EN50310 standards.

Refer to Excel Partner Area 'Technical Notes' at www.excel-networking.com for this document and other technical notes.

Generic and Copper

Planning

Before you start, prepare to start.

- Have you got the cabling system design mapped onto the layout of the space?
- Do you have the correct materials ordered against the Bill Of Materials estimated to complete the project?
- Has the fire stop solution been approved?
- Do you need any specialist training or product support from Excel?
- Are the deliveries scheduled to match the installation plan?
- Are there any site inductions required? If so, when are these held?
- Is the area to be handed over to you for your installation? If so, in what condition? Will you be required to run a 'Permit to Work' scheme for you and other trades?
- Is there a clean, dry, secure storage area allocated for your materials?
- Are there any special precautions to observe for site Health and Safety?
- Are the method statements and COSH statements for the installation, termination and testing approved?
- Do you have a change control process and reporting scheme?
- Do you need to notify the site with the names or identification for your staff?
- Is the labelling method, scheme, style, colour agreed and approved by the client?
- Is the test equipment serviceable and to specification?
- Is there a headroom performance requirement from the tested cabling?
- Have you agreed how to deal with a star pass, (ie. marginal results)
- Do you have access to power outlets for testers, laptops etc?

On site

- Is the containment installed in the correct place and to the right specification?
- Are you holding daily briefings for the site operatives?
- Is there any temporary fire stopping required during the installation phase?
- Is there any difference between the reality of the site and the plans?
- Are there any access restrictions or other trades working in the same areas at the same time?
- Is the earthing and electrical system installed?
- Is there restriction on the use of mobile phones or walkie-talkies?

Site Environment Classification

The environments where cabling is to be installed are classified to cover the different conditions under which the cabling is required to operate. Conditions which may affect the cabling performance are used to determine the applicable environmental classification. Use the environmental classification to select the components. The same classification is used to determine the appropriate containment and installation techniques.

The local environment along the channel is classified for each M, I, C, or E group, and the classification of an environment is determined by the most demanding parameter within the M, I, C or E group. With regard to temperature, the local environment is considered to be the operating temperature of the cabling.

The considerations for:

- Mechanical rating include shock/bump, vibration, crush, impact, bending, flexing and torsion
- Ingress rating include particulate ingress, immersion
- Climatic and Chemical rating include humidity, rate of change of temperature, solar radiation, damaging chemical concentration
- Electromagnetic rating include electrostatic discharge, conducted radio frequency, magnetic field

All twisted pair copper cabling supplied by Excel for normal indoor use is designed and classified to perform in a Class 1 environment (M_1, I_1, C_1, E_1). Most indoor office and data centre environments fall within the Class 1 environment (M_1, I_1, C_1, E_1).

If you have a specification requirement which is beyond Class 1 use you must consult with Excel technical support for guidance on containment and product selection.

Excel 'How To' Video Clips

Our series of 'How To' video clips demonstrate the recommended and most efficient methods of installation of various products from across the Excel range. This information can be of particular use for engineers or designers, new to Excel, or to products such as screened Category 6_A. The clips can be viewed via You Tube, or by visiting **www.excel-networking.com**.

We will be adding to the series over time, so please check the Excel website for the latest updates.

Containment and Cable Routing

Power and Data Separation

Local and national safety regulations may require different separation or segregation distances. Separation and segregation for safety must take precedence over all other requirements. To reduce the risk of noise disturbing the data flowing in copper twisted pair cables, Excel recommends following the requirements set out in the latest issue of EN50174; these are summarised below. The more stringent requirement (greater distance) shall take precedence.

Essentially there are two ways of mitigating the effects of noise disturbing the transmission of data in a copper twisted pair cable; one way is to separate by distance the twisted pair cabling from the noise source, using air to attenuate any noise; the other way is to provide a barrier between the noise source and the twisted pair cabling using a grounded barrier to attenuate the noise.

The factors to consider are:

- Environment
- Type of containment
- Performance of cable type
- Application being supported
- Construction of power cable
- Scale of power source
- Proximity to the power cable

When all of this is calculated you get a separation recommendation.

Environment: All twisted pair copper cabling supplied by Excel for normal indoor use is designed and classified to perform in a Class 1 environment M_1, I_1, C_1, E_1.

Containment: No barrier or no metallic barrier (typically wall trunking or open ladder), open metallic (typically basket but not ladder), perforated metallic (typically slotted tray) and solid metallic (typically 1.5mm wall steel conduit).

Cable Style: The performance of the cable and connector set is provided by the manufacturer. The applications to be supported will be the determination factor that provides the Classification for the cabling system chosen.

Power Cable: An assumption is made that power cables will provide a high degree of self cancellation for any noise carried if they are constructed with a live, neutral and earth bound together in a common sheath. If individual tails are used (separate unbound conductors) then power cable is to be treated as a noise hazard.

Power Scale: How many power cables are present or likely to be installed? Classification for power cabling is based on the qualification of a single phase 230 Volt, 20 Amp circuit. Three phase power is to be treated as three times a single phase. For circuits which are more than 20A treat as multiples of 20A. Lower voltage AC or DC power cables must be treated on their current rating, e.g. a 100A 50V DC cable is equivalent to 5 of 20A cables.

$$A = S \times P$$

A (Final Separation Distance) = **S** (Basic Separation Distance) x **P** (Power Cabling Factor)

S - Basic Separation Distance

		Cable Management System			
Segregation Classification	Cable Performance	None (or Non-metallic	Open metallic containment	Perforated metallic containment	Solid metallic containment
d	Class F_A	10 mm	8 mm	5 mm	0 mm
c	Class D or E or E_A F/UTP	50 mm	38 mm	25 mm	0 mm
b	Class D or E or E_A U/UTP	100 mm	75 mm	50 mm	0 mm
a	Coaxial	300 mm	225 mm	150 mm	0 mm

Notes				
	Plastic containment	Equivalent to weld mesh 50 mm x 100 mm and steel tray of less than 1 mm thickness (and trunking without lid)	Equivalent to steel tray of 1 mm thickness (and trunking without lid). Cables to be installed at least 10 mm below top of barrier.	Equivalent to steel conduit 1.5mm wall thickness. Steel conduit less than 1.5mm thickness will require greater separation.

P - Power Cabling Factor

Quantity of Circuits	P – Power cabling factor
1 to 3	0.2
4 to 6	0.4
7 to 9	0.6
10 to 12	0.8
13 to 15	1.0
16 to 30	2.0
31 to 45	3.0
46 to 60	4.0
61 to 75	5.0
> 75	6.0

Zero Segregation - Conditional Relaxation of Requirement

Where the requirements in specific EMI conditions do not apply, no segregation distance is required between power and data where:

Power - Single Phase, Total power ≤ 32A, Power conductors contained in overall sheath or twisted, taped, bundled together

Data Cable - Segregation Classification is "b", "c" or "d" in an E_1 environment classification of EN 50173

Separation requirements for specific EMI sources

Source of disturbance	Minimum separation	Note
Fluorescent lamps	130mm	a
Neon lamps	130mm	a
Mercury vapour lamps	130mm	a
High-intensity discharge lamps	130mm	a
Arc welders	800mm	a
Frequency induction heating	1000mm	a
Hospital equipment		b
Radio transmitter		b
Television transmitter		b
Radar		b

NOTE

a The minimum separations may be reduced provided that appropriate cable management systems are used or product suppliers guarantees are provided

b Where product suppliers guarantees do not exist, analysis shall be performed regarding possible disturbances e.g. frequency range, harmonics, transients, bursts, transmitted power, etc.

Overhead and Under Floor Containment Fill Ratio

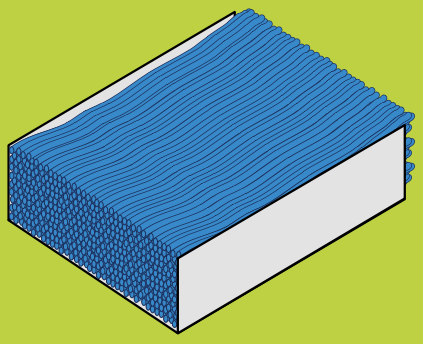
Cable trays, basket, ladder racking and other containment should be filled on day one:

- To accommodate a day one minimum calculated spare fill of 20%
- Up to a maximum of 150mm (6 in) cable depth for solid floor containment.

The spare capacity requirement is to allow room for future expansion, and to facilitate additions and removal of cables once the building becomes operational

NOTE: A calculated fill ratio of 50% will physically fill the entire containment due to spaces between cables, and random placement.

Picture shows a cable tray that is full of cable which equals a 50% fill ratio



Example - What is the minimum width of a 75mm deep cable tray supporting 1000 cables, each with a diameter of 5.5mm?

$$\text{Area of one cable} = \frac{(\text{cable diameter})2 \times \pi}{4}$$

$$\text{Area of one cable} = \frac{(5.5)2 \times 3.14}{4} = 23.75\text{mm}^2$$

$$\text{Area of 1000 cable} = \frac{(5.5)2 \times 3.14) \times 1000}{4} = 23746\text{mm}^2$$

Multiply this occupied area by 1.2 to give 20% over size for day two expansion

$$\text{Usable Area or Area required within cable tray (50\% fill)} = \frac{\text{cable tray width} \times \text{cable tray depth}}{2}$$

$$1000 \text{ cables} = (23746\text{mm2}) \times 1.2 = \frac{\text{cable tray width} \times 75\text{mm}}{2}$$

Minimum width of cable tray = 759.9mm

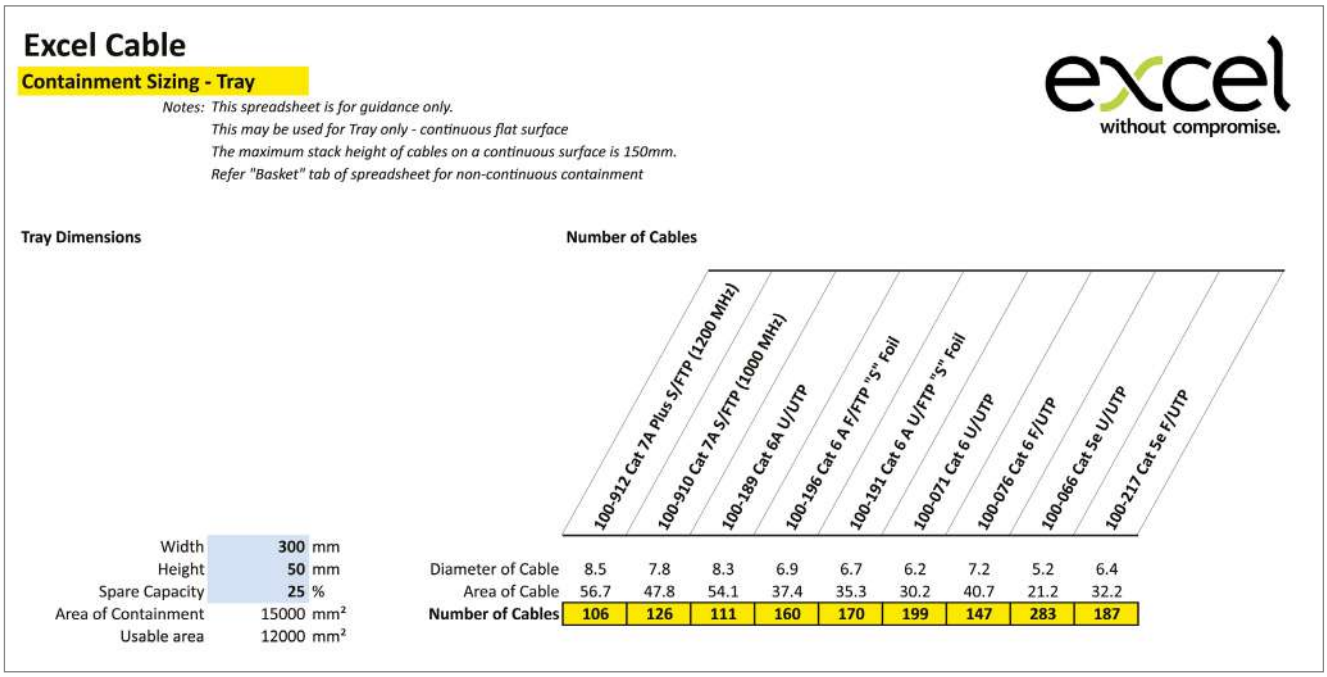
Excel Cable - Containment Size Calculations

Containment sizes may be calculated based on the: dimensions of the containment, diameter of the cable and fill ratios.

Different styles of containment use different formulae to calculate the maximum number of cables that may be housed. These formulae offer an estimate of the quantities. However, the actual quantity of cables that may be contained will be influenced by other factors such as routing, access, etc. Never plan to fill containment to the maximum during the initial installation as quantities are likely to change as additions are required.

Excel offers a spreadsheet that is available for download from the Technical Note section of the Excel website's Partner Area.
excel-containment-sizing.xlsx

(all dimensions in mm)



Excel Cable

Containment Sizing - Tray

Notes: This spreadsheet is for guidance only.
This may be used for Tray only - continuous flat surface
The maximum stack height of cables on a continuous surface is 150mm.
Refer "Basket" tab of spreadsheet for non-continuous containment

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Tray Dimensions

Width	300	mm
Height	50	mm
Spare Capacity	25	%
Area of Containment	15000	mm²
Usable area	12000	mm²

Number of Cables

	100-912 Cat 7A Plus S/FTP (1200 MHz)	100-910 Cat 7A S/FTP (1000 MHz)	100-189 Cat 6A U/UTP	100-196 Cat 6 A F/FTP "S" Foil	100-191 Cat 6 A U/FTP "S" Foil	100-071 Cat 6 U/UTP	100-076 Cat 6 F/UTP	100-066 Cat 5e U/UTP	100-217 Cat 5e F/UTP
Diameter of Cable	8.5	7.8	8.3	6.9	6.7	6.2	7.2	5.2	6.4
Area of Cable	56.7	47.8	54.1	37.4	35.3	30.2	40.7	21.2	32.2
Number of Cables	**106**	**126**	**111**	**160**	**170**	**199**	**147**	**283**	**187**

Cross-sectional area of an individual cable is calculated –

$$Area\ of\ cable = \frac{\pi d^2}{4}$$ (where d = diameter of the cable)

Tray Calculation

This tray calculation is based on the information in EN 50174-2:2009 + A1:2011

$$Maximum\ number\ of\ cables = \frac{wh}{2 \times Area\ of\ cable}$$

(where w = width and h = height of the tray)

(in the above calculation the area of a cable is doubled to allow for the fact that a cable is circular and also will not fit perfectly in containment).

These formulae may be combined into one

$$Maximum\ number\ of\ cables = \frac{2wh}{\pi d^2}$$

Note – the maximum stack height of cables is 150 mm

The number of cables should then be reduced to allow for future installations.

Basket Tray or Ladder

As basket tray and ladder is non-continuous containment the maximum stack height needs to be reduced. This calculation is based on the information in EN 50174-2:2009 + A1:2011

$$Maximum\ stack\ height = \frac{150}{1 + 0.0007\,s}$$

(where "s" is the span distance)

Conduit

The formulae for the maximum number of cables within conduit is based on a calculation that has been modified from the BICSI Telecommunications Distribution Methods Manual (TDMM).

The formula assumes straight runs with no bends and smooth walls.

$$Maximum\ number\ of\ cables = 0.4\,\frac{c^2}{d^2} - 1$$

(where "c" is the inside diameter of the conduit and "d" is the diameter of the cable)

The number of cables should then be reduced to allow for future installations.

Heating Effects

Energy losses from within cabling will be translated into generation of heat. There are many factors which accumulate to create this effect. The installer needs to be aware that the temperature rise in the cabling at these points can be in the order of 10°C or higher when all of these factors come together. The temperature rise created is greatest where:

- the cabling is managed into large bundles
- and/or there are a large number of simultaneous users
- and/or cabling is run into constricted spaces such as at wall penetrations
- and/or the cabling is required to support higher energy applications / PoE applications.
- The energy loss due to heating effects is different for Screened and Unscreened cable.

All the performance criteria for the 100m Channel as outlined in EN 50173-2 is based upon it operating at an ambient temperature of 20˚C and for every degree over this level this distance will be reduced. The following formula provided in the above standard gives the rate of reduction for unscreened cables, in short for temperature increases up to 20˚C above the ambient the Channel should be reduced by 0.4% and for temperatures increased over 40˚C above the ambient there is an additional 0.6% that has to be added.

Unscreened
$L_{t>20^{\circ}C}$=L/(1 + (T-20) *x* 0,004)
$L_{t>40^{\circ}C}$=L/(1 + (T-20) *x* 0,004 + (T-40) *x* 0.006)

This could potentially have a dramatic effect to the performance of installed cabling as recent research shows that the level of heating can be significant in some cases 30-40˚C above the ambient.

Screened Cabling performs much better, as the research has proved it does not heat up as much as an unscreened cable and when it does the de-rating formula is much simpler as it is based upon 0.2%.

Screened
$L_{t>20^{\circ}C}$=L/(1 + (T-20) *0,002)

L = Length T = Temperature

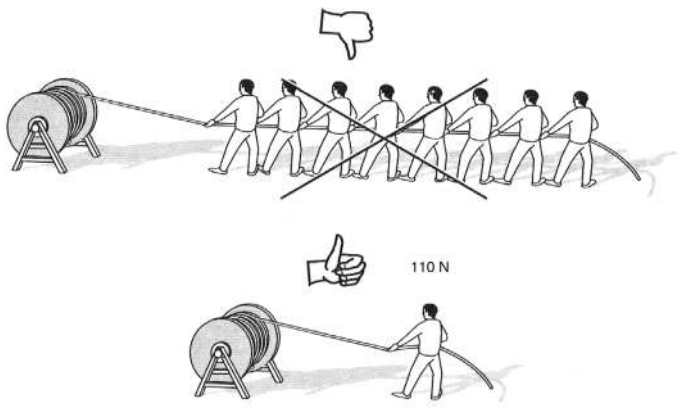
These heating effects can be mitigated by:

- reducing the bundle size
- loosening the bundle ties at points of constriction
- distributing the high energy use across different cable bundles
- It is also possible to Loose Lay the cables on to cable matting or cable tray without bundles entirely, more details of this approach can be found in Tech Note TN08 which is located within the 'Partner Area' of www.excel-networking.com

Cable Installation

From the cabling system design and floor plans, make a cable pulling schedule. Map the pulling schedule onto the floor plans.

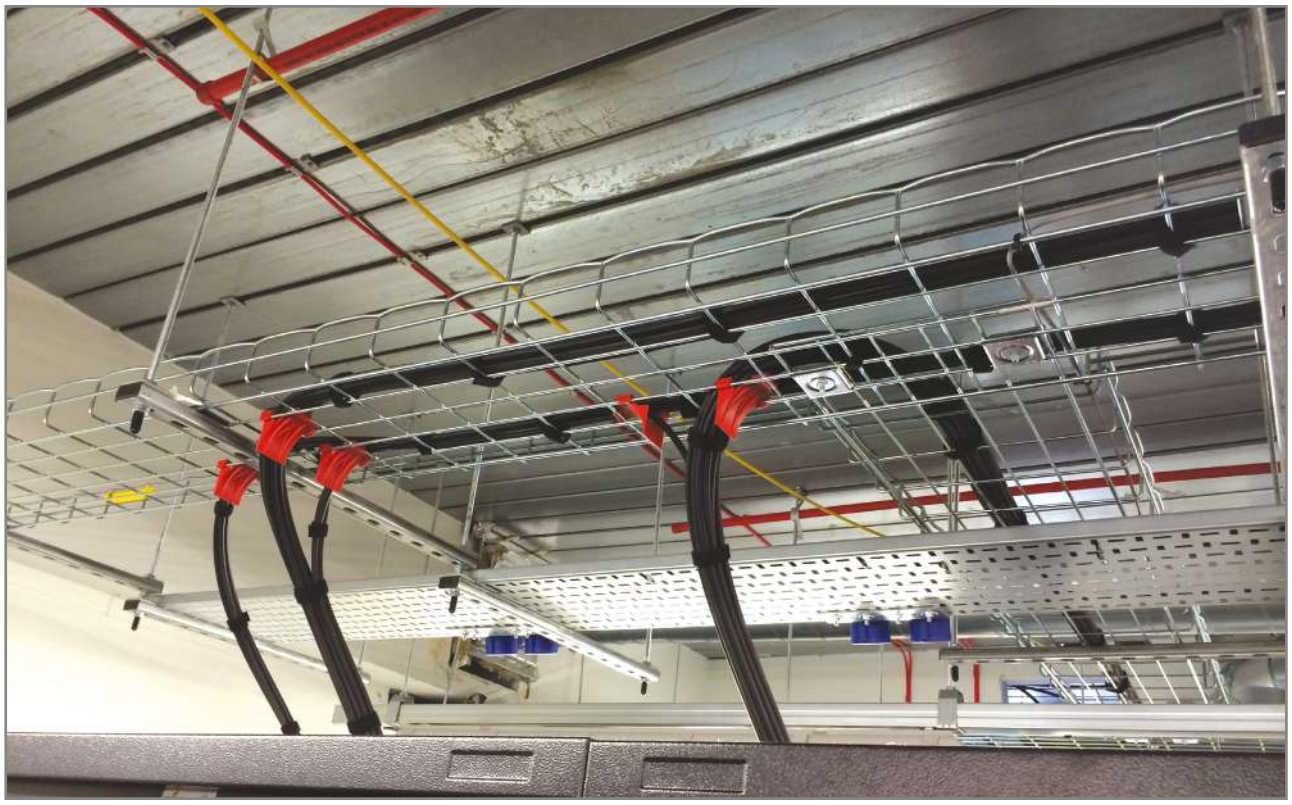
- Identify the labels and cable ID so that temporary labelling can be applied.
- It may be faster, cheaper and more accurate to print two sets of the final cable labels, using one set for installation purposes and then replacing them after testing is completed. This will avoid unsightly 'Pen Marks' on the cable.
- Ensure that for each group of finished labels they are aligned and attached so they are readable from the same direction.
- If the installation is a mixture of copper and fibre optic cabling install the copper cabling first.
- Plan the occupation of cabling in the containment and along the route so that crossovers are eliminated and entry points into and exits from the containment are not congested.
- In any cable run where the cable is to be pulled the run should contain no more than two 90° bends. If more than two 90° bends are required or the sum of all angles is greater than 180° then there must be more pull points along the cable run where the cable is able to be managed in and out of the containment.
- Respect the installation bend radius of the cable. Never exceed the recommended maximum pulling load of the cables.
- Determine the pulling in points which will cause damage to the cable, through sharp edges or bends tighter than the installation bend radius.
- Apply any protection to the containment where damage to the cable sheath may occur. Consider using cable installation aids.
- Bundle size should be kept to a minimum.
- Maximum bundle size is 24 for 4 pair twisted copper cables.
- Smaller bundles make better use of limited containment space.
- With mixed length cables in a cable run always pull in the longest length cables first.
- Secure the stack of cable boxes or reels using a pulling frame or cable stands to hold the packaging in place.
- Pulling force must be respected. Maximum pull force for a single, or bundle of cables, is 110 N (25 lbf).
- Avoid any cable kinks and maintain proper bend radius control during cabling pulling. If any kinks should occur, kinked cable should be removed and replaced.
- For safety, only use cable jacks and pulling frames which are designed for and fit for purpose.
- Always control the rate at which cables are pulled off the drum.
- Take great care over the management of cable drum.



- Hook and eye cable fixings are preferred.
- If nylon type zip ties are used, ensure excess is cut flush, to avoid the creation of sharp and dangerous edges.
- Do not over tighten.
- No deformation, marking or compression of cable jacket is allowed.
- For further clarification on the use of cable ties also see tech Note TN12 in the Partner Area of www.excel-networking.com
- Acclimatise the cables to the location where they are to be installed, minimum 2 hours.
- Refer to the specification sheet for the installation and operating temperature ranges for the cables being installed.
- The recommended installation temperature range is 0° – 60°C (32° – 140° F). Avoid pathways exposed to extreme thermal cycling.
- Remember that for some outdoor cabling there may be a minimum installation temperature.
- Do not install copper cabling or optical fibre cabling with a metallic strength member outdoors when there is a thunder or lightening storm about.
- Only use approved lubricants and pulling gels for the cable type being installed.
- For external installations seal the ends of all cables with a water tight product before installation.

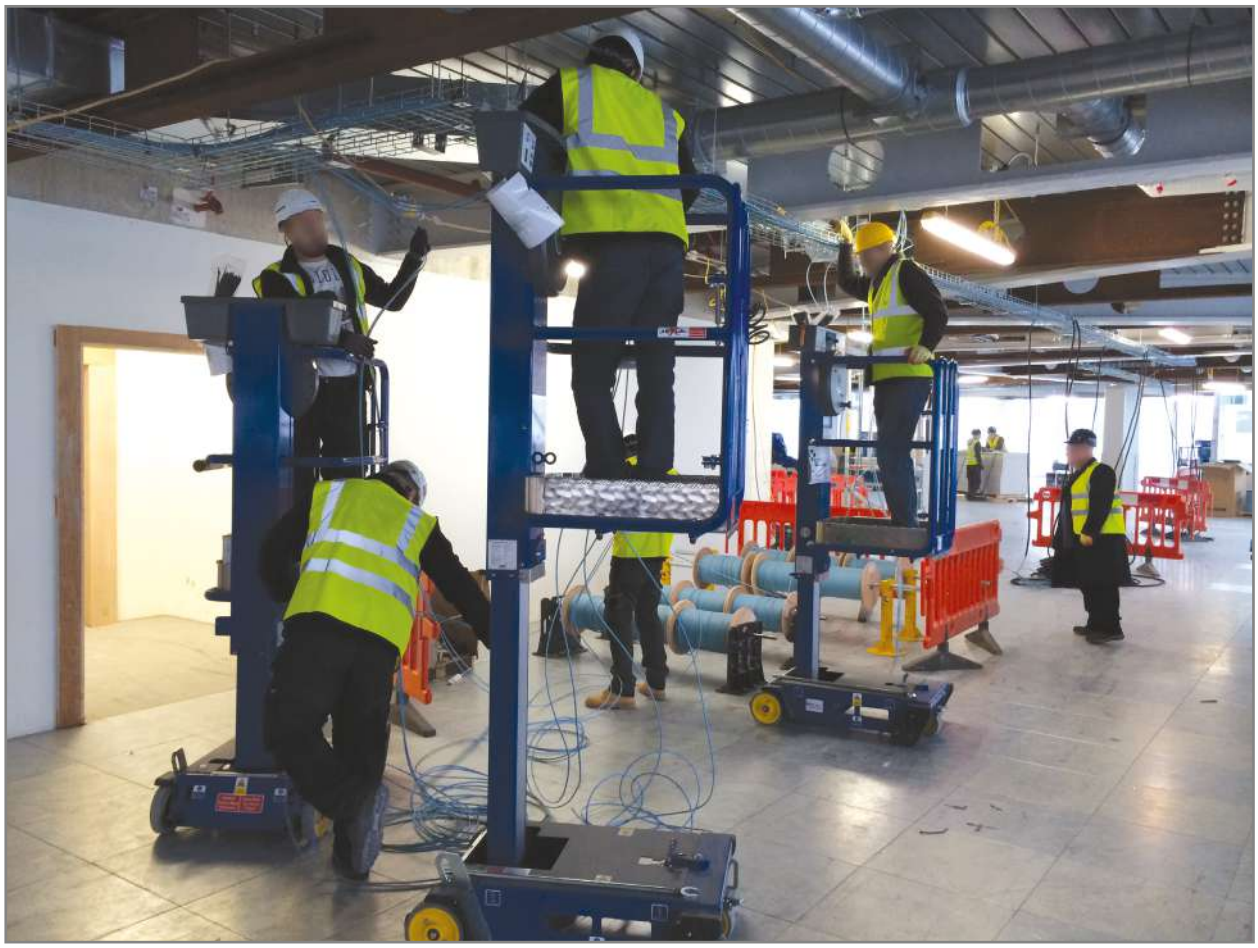
When installing cable at high level the additional requirements are as follows:

- Protect the edges of the basket or tray before starting to install the cable to ensure no damage is caused.
- Ensure that the edges of the tray or basket have a bend radius that exceeds the installation Bend Radius of the cable concerned, this may be achieved by artificially increasing the dimension by the use of temporary packing material
- If bundles of cable are being routed from tray at high level to enter a cabinet from the top, some form of 'waterfall' must be used to ensure the bend radius of the cable is not compromised. This can be simply and cost effectively achieved by the use of a section of split flexible plastic conduit installed along the edge involved. The following image gives an example.



- When installing cable at high level ensure that sufficient engineers are available to carry out the work, it is recommended that cables are 'passed' from one engineer to the next rather than trying to drag them over the tray.

The following image will give an example of this practice.



This table lists the most common part codes for the Excel cable designs. The diameters provided are correct for all part codes to which this design is applied, for example coloured versions of Category 6 U/UTP.

Part Number	Description	Diameter	During Installation – Bend Radius	Installed – Bend Radius
100-065	Excel Category 5e Unscreened Twisted Pair (U/UTP) Cable - PVC	5.2 mm	42mm	21 mm
100-066	Excel Category 5e Unscreened Twisted Pair (U/UTP) Cable - LSOH	5.2 mm	42mm	21 mm
100-216	Excel Category 5e Screened Twisted Pair (F/UTP) Cable - LSOH	6.4 mm	51mm	26 mm
100-070	Excel Category 6 Unscreened Twisted Pair (U/UTP) Cable - PVC	6.2 mm	50 mm	25 mm
100-071	Excel Category 6 Unscreened Twisted Pair (U/UTP) Cable - LSOH	6.2 mm	50 mm	25 mm
100-076	Excel Category 6 Screened Twisted Pair (F/UTP) Cable - LSOH	7.6 mm	61 mm	30 mm
100-189	Excel Category 6_A Unscreened Twisted Pair (U/UTP) Cable – LSOH	8.3 mm	67mm	34mm
100-191	Excel Category 6_A Screened Twisted Pair (U/FTP) ' S-Foil' Cable – LSOH	6.7mm	54mm	27mm
100-196	Excel Category 6_A Screened Twisted Pair (F/FTP) ' S-Foil' Cable – LSOH	6.9mm	56mm	28mm

Earthing, Grounding and Bonding

Unless you are a qualified and competent electrical person leave the connection of the earthing wire onto the electrical system to the electrical trade.

The following information is for guidance purposes, Grounding and bonding of all systems should be carried out in accordance with EN50174-2, EN50310 standards.

The best type of earthing conductor used to provide a signal earth connection is a flat braided strap. Flat is best because it offers a greater surface area and braided straps because impedance is affected by length and braid offers many different routes and therefore lengths of conductor for the unwanted signals to flow along. If you use a solid core conductor to provide an earth strap you can improve this by adding a second, different length, earth conductor to reduce the possibility of an impedance issue resisting the passage of the unwanted signals.

Do not coil an earthing conductor around a screwdriver to make it look neat and tidy, you are forming a coil which can restrict the transmission of signals.

It is best practice to connect the earth stud in a cabinet onto a separate earthing bar located in the cabinet. It is recommended that the bar is provided with four or more attachment points for equipment earths to be connected onto. This is because if all of the equipment earths are run back to the earth stud then for safety reasons the electrical supply must be disconnected every time a new piece of equipment is added or removed from the cabinet.

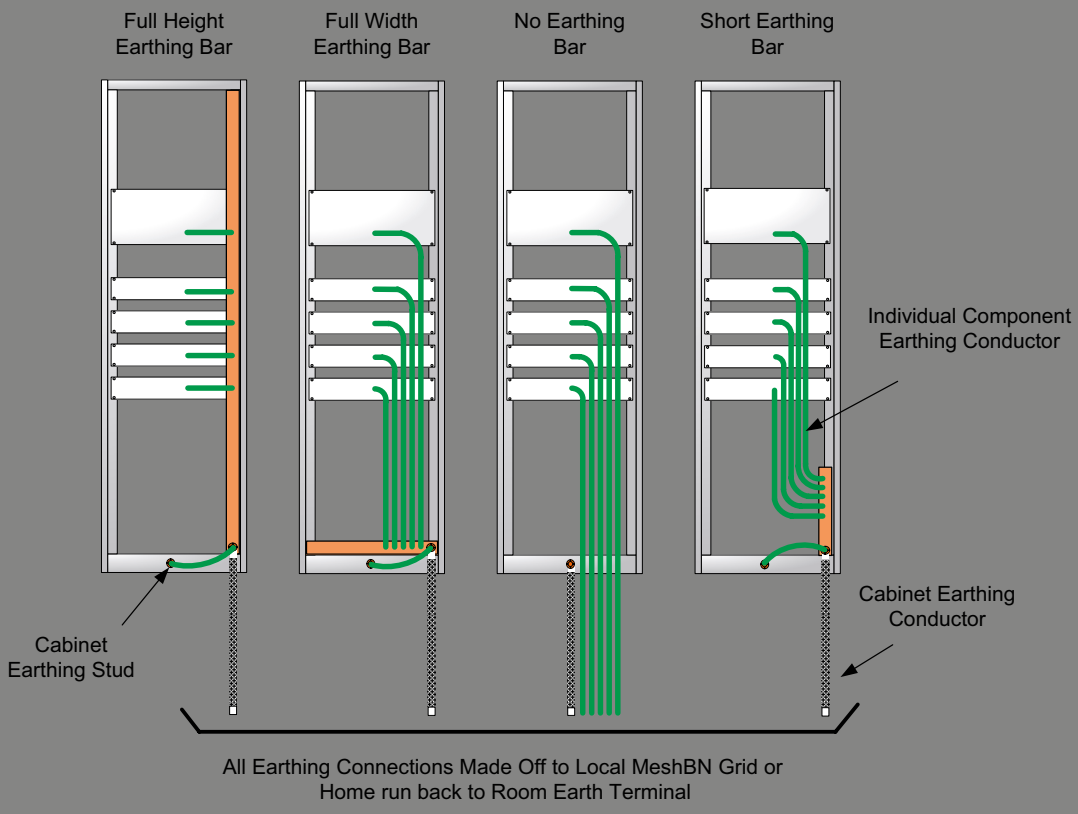
When installing a piece of equipment which requires a signal earth, always install the equipment, then attach the earth connection, then connect up the power.

ESD (Electrostatic Discharge) can kill equipment. When installing equipment into a cabinet or frame always use an ESD strap connected between you and the cabinet.

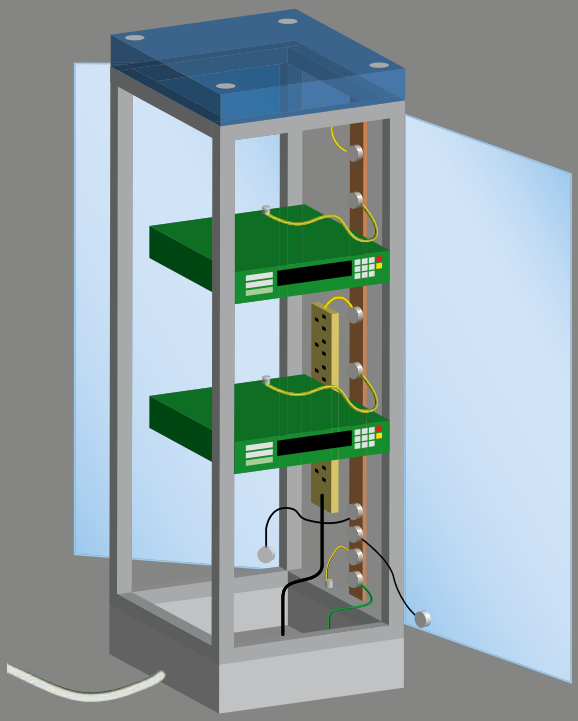
Each earthing conductor must be grounded onto a clean, purposeful earthing point. Use an approved cleaning method and bonding gel to protect the joint from oxidisation.

Do not daisy chain earthing conductors; the only exception to this is where there is a run of metallic cable containment when each length must be grounded onto the next.

Example of Cabinet Earthing



Example of Rack Earthing



The best practices for communications rooms and data centres recommend provision of an equipotential earthing grid or MESH-BN (a bonding network in which all associated equipment frames, racks and cabinets and usually the DC power return conductor, are bonded together as well as at multiple points to the Common Bonding Network).

This grid is used to earth all of the metallic components (frames, racks, floor tiles and pedestals, cable containment, etc) providing:

- a reliable signal reference
- adequate immunity from electromagnetic interference carried by the earthing network

Each rack and frame must be provided with an earthing conductor made back to either the MESH-BN or home run back to the main communications grounding bar within the room. For some installations this may be the electrical earthing bar in the main power distribution board.

Within the UK the specification for the rack earth connection is covered by:

BS6701:2010 Telecommunications equipment and telecommunications cabling specification for installation, operation and maintenance.

5-2.2.4 Earthing of racks, frames and cabinets.

Not less than:

- $4mm^2$ for a rack ≤ 21U
- $16mm^2$ for a rack > 21U

(please refer to the standard for further details)

Racks and Frames

- Install the racks and frames in the pre assigned positions.
- Check alignment of any containment with the cable entrances (for power and data) to the rack.
- Apply temporary labels to identify the location.
- Secure the racks and frames to the solid floor and/or wall to provide stability when loaded with equipment and cabling.
- Install any baying or joining components.
- Attach the earthing kit to all rack and frame components.
- Connect the main earthing conductor.
- Does the site require blanking panels for airflow management in the racks and/or frames?

The layout for the inside of each rack should be determined in the overall site design. As with a lot of new designs there are great pressures on the space available within the racks and frames. As a general rule for laying out a rack, begin at the top with the patch panels starting with optical fibre panels then copper panels. The top most position in a block of patch panels should be reserved for a horizontal wire manager, then there should be no more than two patch panels of 1U height followed by another (or closing) horizontal wire manager. On high density frames the front fingers of the vertical wire manager provide the support for patch cords so there is not the same level of requirements for horizontal wire managers. Horizontal raceways will be required to facilitate shortest routing between patch panel outlets.

- When installing panels and wire managers use all of the securing and fixing holes provided.

NB. It is essential that all cable bundles entering a rack, either from the top or the bottom, are securely attached to cable tray within the rack and under no circumstances should they be solely supported by the rear management of the Patch Panel.

Patch Panels

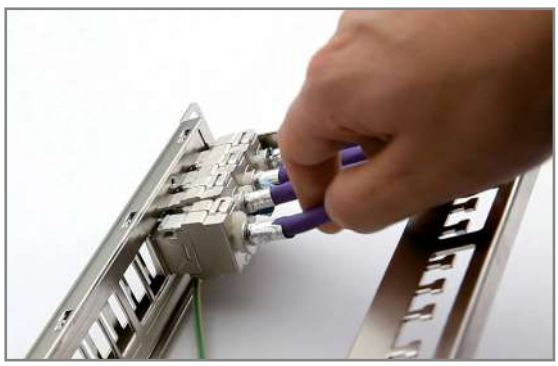
Termination procedures at the patch panel:

- It is acceptable for the cables to be dressed as either, 24 cables from one side or split as 12 from each.
- Maintain acceptable bend radius levels
- Do not kink cables
- Do not overtighten the cable ties to deform the cable in any way.
- Where a rear management bar is provided each cable should be individually secured by way of a cable tie, 'bunching' or grouping of cables is deemed to be a poor installation practice.
- For Category 6 and above, best practice dictates all cables shall be individually terminated and secured to the management bars provided. This has the two benefits of improved performance and ease of re-termination if a wire map error is discovered during testing without the need to disturb any adjacent outlets on the same panel.

To enhance wire management in the back of the panel, it is recommended that a strain relief bar is mounted to the rack. Along the strain relief bar use hook and eye cable ties for additional cable management.

Termination procedures for the punch down patch panel:

- Follow installation instruction sheet
- Outer cable jacket should be trimmed to be as close as possible to point of termination
- Last twist should be no further than 13 mm (0.5 inches) from the point of termination.



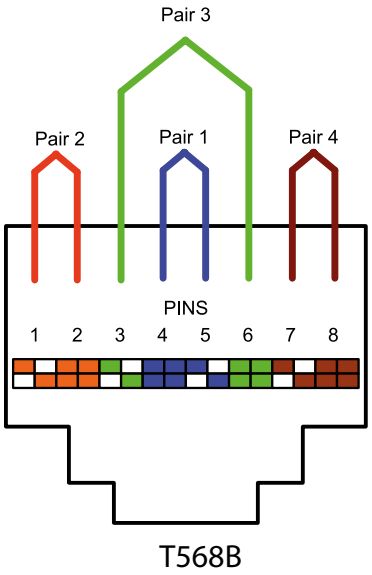
Wall Boxes and Desk Outlets

For a duplex, twin outlet presentation, choose a back box that complies with the minimum bend radius of the cable.

If metal GOP boxes or metal face plates are used, ensure that there is a grounding facility / earthing lug and a suitably sized earth wire connection, with sufficient cable to earth the box and lid.

Colour code

The colour code or punch down followed by Excel for all of their cabling system components is the T568B format.



Suggested Minimum Back Box Depth

Bevelled Euro Faceplate

		Face Plate	100-712 Single & 100-716 Double Gang Bevelled			
		Shutter	100-014	100-020	100-175	Nil
	Jack	Direction of Incoming Cable	Euromod 25 x 50mm Flat Keystone Shutter - White	Category 6_A Angled Shutter for Keystone Jack 50x25mm, White	Euromod 25 x 50mm Angled Keystone Shutter - White	
CAT6_A	100-181 Cat 6_A Low Profile	Top	52 mm	25 mm	30 mm	
		Bottom	52 mm			
		Side	52 mm			
	100-182 Cat 6_A Unscreened	Top	62 mm	30 mm	35 mm	
		Bottom	62 mm			
		Side	62 mm			
CAT6	100-300 Cat 6 Unscreened Module	Top				22 mm
		Bottom				22 mm
		Side				22 mm
	100-366 Cat 6 Unscreened Low Profile	Top				5 mm
		Bottom				15 mm
		Side				5 mm
	100-011 Cat 6 Keystone IDC	Top	30 mm	19 mm	19 mm	
		Bottom	30 mm			
		Side	30 mm			
	100-211 Cat 6 Toolless Jack	Top	33 mm	25 mm	29 mm	
		Bottom	33 mm			
		Side	33 mm			
	100-210 Cat 6 Screened Toolless Jack	Top	63 mm	30 mm	35 mm	
		Bottom	63 mm			
		Side	63 mm			
CAT5e	100-760 Cat 5e Unscreened Low Profile	Top				5 mm
		Bottom				14 mm
		Side				5 mm
	100-010 Cat 5e Keystone IDC	Top	29 mm	19 mm	23 mm	
		Bottom	29 mm			
		Side	29 mm			
	100-203 Cat 5e Toolless Jack	Top	32 mm	25 mm	29 mm	
		Bottom	32 mm			
		Side	32 mm			
	100-906 Cat 5e Screened Toolless Jack	Top	63 mm	30 mm	35 mm	
		Bottom	63 mm			
		Side	63 mm			

Suggested Minimum Back Box Depth

Flat Euro Faceplate

		Face Plate	100-714 Single & 100-718 Double Gang Flat			
		Shutter	100-014	100-020	100-175	Nil
	Jack	Direction of Incoming Cable	Euromod 25 x 50mm Flat Keystone Shutter - White	Category 6_A Angled Shutter for Keystone Jack 50x25mm, White	Euromod 25 x 50mm Angled Keystone Shutter - White	
CAT6A	100-181 Cat 6_A Low Profile	Top	58 mm	31 mm	36 mm	
		Bottom	58 mm			
		Side	58 mm			
	100-182 Cat 6_A Unscreened	Top	68 mm	36 mm	41 mm	
		Bottom	68 mm			
		Side	68 mm			
CAT6	100-300 Cat 6 Unscreened Module	Top				28 mm
		Bottom				28 mm
		Side				28 mm
	100-366 Cat 6 Unscreened Low Profile	Top				11 mm
		Bottom				21 mm
		Side				11 mm
	100-011 Cat 6 Keystone IDC	Top	36 mm	25 mm	25 mm	
		Bottom	36 mm			
		Side	36 mm			
	100-211 Cat 6 Toolless Jack	Top	39 mm	31 mm	35 mm	
		Bottom	39 mm			
		Side	39 mm			
	100-210 Cat 6 Screened Toolless Jack	Top	69 mm	36 mm	41 mm	
		Bottom	69 mm			
		Side	69 mm			
CAT5e	100-760 Cat 5e Unscreened Low Profile	Top				11 mm
		Bottom				20 mm
		Side				11 mm
	100-010 Cat 5e Keystone IDC	Top	35 mm	35 mm	29 mm	
		Bottom	35 mm			
		Side	35 mm			
	100-203 Cat 5e Toolless Jack	Top	38 mm	31 mm	35 mm	
		Bottom	38 mm			
		Side	38 mm			
	100-906 Cat 5e Screened Toolless Jack	Top	69 mm	36 mm	41 mm	
		Bottom	69 mm			
		Side	69 mm			

Suggested Minimum Back Box Depth

6c Faceplates

		Face Plate	100-670 Single & 100-671 Double Gang 6c Faceplate		
		Shutter	100-018	100-022	**Nil**
	Jack	Direction of Incoming Cable	6c Flat Keystone Shutter	6c Angled Keystone Shutter	
CAT6A	100-181 Cat 6A Low Profile	Top	50 mm	30 mm	
		Bottom	50 mm		
		Side	50 mm		
	100-182 Cat 6A Unscreened	Top	60 mm	30 mm	
		Bottom	60 mm		
		Side	60 mm		
CAT6	100-301 Cat 6 Unscreened 6c	Top			21 mm
		Bottom			21 mm
		Side			21 mm
	100-011 Cat 6 Keystone IDC	Top	27 mm	22 mm	
		Bottom	27 mm		
		Side	27 mm		
	100-211 Cat 6 Toolless Jack	Top	60 mm	30 mm	
		Bottom	60 mm		
		Side	60 mm		
	100-210 Cat 6 Screened Toolless Jack	Top	60 mm	30 mm	
		Bottom	60 mm		
		Side	60 mm		
CAT5e	100-758 Cat 5e Unscreened Low Profile	Top			20 mm
		Bottom			20 mm
		Side			20 mm
	100-010 Cat 5e Keystone IDC	Top	26 mm	22 mm	
		Bottom	26 mm		
		Side	26 mm		
	100-203 Cat 5e Toolless Jack	Top	29 mm	22 mm	
		Bottom	29 mm		
		Side	29 mm		
	100-906 Cat 5e Screened Toolless Jack	Top	60 mm	30 mm	
		Bottom	60 mm		
		Side	60 mm		

Suggested Minimum Back Box Depth

Office

		Face Plate	100-270 Single & 100-271 Double Gang Office	Floor Box Plate
		Shutter	100-280	Nil
	Jack	Direction of Incoming Cable	Office Angled Keystone Shutter	
CAT6A	100-181 Cat 6A Low Profile	Top	22 mm	
		Bottom		
		Side		
	100-182 Cat 6A Unscreened	Top	35 mm	
		Bottom		
		Side		
CAT6	100-276 Office Cat 6 Low Profile	Top		10 mm
		Bottom		20 mm
		Side		10 mm
	100-011 Cat 6 Keystone IDC	Top	23 mm	
		Bottom		
		Side		
	100-211 Cat 6 Toolless Jack	Top	32 mm	
		Bottom		
		Side		
	100-210 Cat 6 Screened Toolless Jack	Top	45 mm	
		Bottom		
		Side		
	100-297 Cat 6 Low Profile 6c	Top		18 mm
		Bottom		20 mm
		Side		
CAT5e	100-275 Office Cat 5e Low Profile	Top		10 mm
		Bottom		19 mm
		Side		10 mm
	100-010 Cat 5e Keystone IDC	Top	23 mm	
		Bottom		
		Side		
	100-203 Cat 5e Toolless Jack	Top	32 mm	
		Bottom		
		Side		
	100-906 Cat 5e Screened Toolless Jack	Top	45 mm	
		Bottom		
		Side		
	100-757 Cat 5e Low Profile 6c	Top		18 mm
		Bottom		20 mm
		Side		

Labels and Administration

Excel recommends using the Sharpmark labelling solutions and templates. All Excel panels, outlets and faceplates are supported with predefined label layouts and formats.

An administration system is required by the network owner to organise and control connections and operation of their network and the associated support infrastructure. A full and detailed labelling scheme should be agreed before the start of the installation. As a minimum this will require labels and identifiers being applied to cables, outlets, panels, racks and frames. For larger or more complex installations a more comprehensive administration and labelling scheme is required. Best practices include labelling of items such as:

- Bonds – functional earth
- Cabinets, racks and frames
- Cables - both ends
- Closures
- Pathways
- Spaces
- Termination points including joints
- Cords/jumpers - both ends

Part Number Information	
Description	**Part Number**
Sharpmark Labelling Software	221-000
38 x 12.7mm adhesive wrap-around cable label (10/1050)	221-001
38 x 12.7mm adhesive wrap-around cable label (50/5250)	221-002
38 x 12.7mm adhesive wrap-around cable label (100/10500)	221-003
38 x 25.4mm adhesive wrap-around cable label (21/1029)	221-004
38 x 25.4mm adhesive wrap-around cable label (105/5145)	221-005
38 x 25.4mm adhesive wrap-around cable label (210/10290)	221-006
57 x 25.4mm adhesive wrap-around cable label (30/1050)	221-007
57 x 25.4mm adhesive wrap-around cable label (150/5250)	221-008
8 x 16mm adhesive outlet label (10/3850)	221-010
12 x 20mm adhesive outlet label (10/2070)	221-012
12 x 20mm adhesive outlet label (50/10350)	221-013
10 x 15mm adhesive outlet label (50/9500)	221-017
6 x 21mm adhesive outlet label (10/1890)	221-018
6 x 30 adhesive outlet label (10/1350)	221-019
5 x 15mm adhesive outlet label (10/2080)	221-022

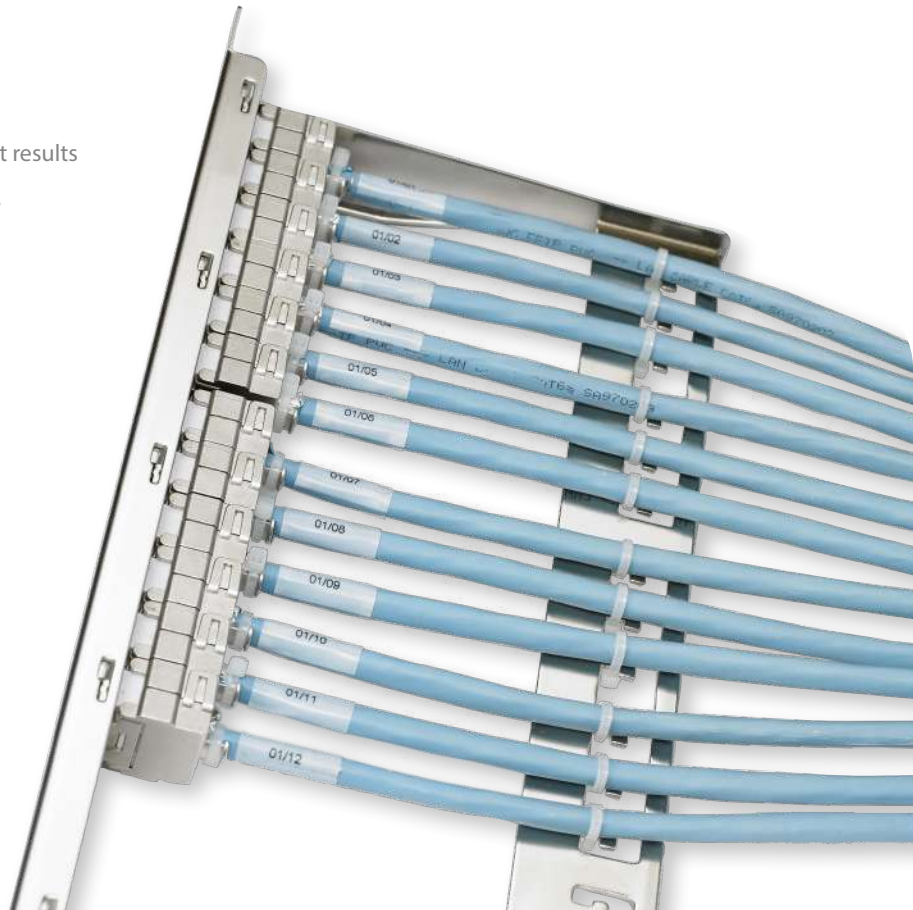
Operation & Maintenance

The Operation and Maintenance manual or documentation handed over to the client at the end of the job is a record of what has been provided with information about the products, how they have been implemented and the testing records.

Please note there may also be local codes and regulations, that outline how this documentation should be compiled.

An O&M package should include:

- As built drawings showing:
  - l date of installation completion
  - l site identity / location identity
  - l location of outlets
  - l identity of outlets
  - l location of cabinet and frames
  - l identity of cabinet and frames
    - l *If required with occupancy and capacity of cabinet and frames*
  - l pathways used
    - l *If required identity of pathways*
    - l *If required with occupancy and capacity of pathways*
  - l fire stopping
    - l *If required identity of fire stop with occupancy and capacity*
  - l Grounding / earthing points
    - l *If required identity of grounding / earthing and connections*
- Details of the product set used throughout the installation including:
  - l product part numbers
  - l product specification sheets. (don't forget to use branded specification sheets - refer to the website section 15 of the Excel Encyclopaedia to see how to add your company logo and details)
  - l label format and typeface
  - l Bill Of Materials
- Summary test result sheets for all outlets and tested components
  - l CD (or other electronic medium) of the detailed test results
  - l Copy of the Fluke Linkware used to view the results
- Details of the test equipment used to certify the performance of the cabling system
- Calibration certificates for the test equipment used
- Details of the test methods used
- Warranty certificates from Excel
- Details of any routine or periodic maintenance requirements including cleaning methods and materials
- Contact details for the installer



Testing

Excel recommends the use of a Level IV tester. This section of the Excel Installation Guidelines is written around the use of the Fluke Networks range of test equipment.

There is a list of acceptable manufacturers in the Warranty Section of the Partner Area at www.excel-networking.com.

Twisted Pair Copper

This section describes and sets out the requirements for Class D (Cat 5e) , Class E (Cat 6) and Class E_A ($Cat6_A$) balanced twisted pair copper Permanent Link testing and Channel testing for the Excel warranty.

Permanent Link Testing

The test set must be fitted with a set of:

- Fluke Permanent Link Adapter PLA004

Channel Testing

The test set must be fitted with a set of Fluke Channel test heads.

IMPORTANT:

- Permanent Link Adapters must be 'serviced' every 5,000 tests.
- Channel Test heads last for a maximum of 2,000 tests, and cannot be serviced, they should be discarded and new ones purchased. N.B. This number is based on the amount of matings, i.e. how often a Patch Lead is plugged into them. When testing a channel you MUST leave that Patch Lead behind or that channel test is no longer valid.
- The test set must be within 12 months of calibration.
- Tests must be run with Graphs Stored enabled and HDTDR / HDTDX recorded for all *PASS/FAIL.
- Calibration of the Permanent Link Adapters shall be carried out in accordance with the recommendations of Fluke using a DTXCAL or DSPCAL as appropriate and on replacement of a Personality Module.
- All Channel Test Heads, Personality Modules or Personality Module tips must be frequently inspected for damage or undue wear.
- At least one set of Fluke calibration tools DSPCAL, DTXCAL must be kept on site at all times during the project installation and testing phases. NOTE: this may give you an improvement in XTALK and RL results.
- Power frequency must be set to 50Hz.
- Limits database and software must be as per the product set under test and Excel warranty requirement.
- The test limits for Excel are CENELEC EN50173 series including all latest amendments, modified by the copper cable type under test (Class D, Class E, etc). If there is any doubt for installed cabling regarding which component performance specification to be used, confirmation should be sought from the client or Project Manager and referred back to Excel for approval under their warranty scheme.
- Installers should budget and schedule for replacement of Channel Test Heads, PLA2 tips and Personality Modules. The replacement rate may be lower than recommended or required depending on wear and condition of the test equipment on site.

Tester Log Sheet

A tester and test set component usage log sheet must be kept with each test set and maintained by the operator of the test set. The tester log must record the components within the test set including:

- test set ID (serial numbers from all major components)
- test cord ID
- test head serial numbers (PLA and Channel Head)
- calibration status (date of calibration for each component)
- component usage (number of tests executed)
- operator ID (name and company)

Replacement of ALL Copper Reference Test Cords is mandatory when they have completed 100 tests or earlier if damage is present on the test cord connectors.

At The Start of Each Day

- Check that the batteries are fully charged
- Check all results from the previous day have been off loaded onto a laptop
- Perform a visual check on the condition of the tester components for wear or damage
- Fill out the tester log sheet and confirm all the tester components and leads are within their usage limits
- Plug the designated main end Channel Head or PLA into the main end of the tester
- Plug the designated remote end Channel Head or PLA into the remote end tester
- Enter operator name site and starting cable ID to be tested

NOTE: Every 6 Months (immediately after calibration and then +6 months) run DSPCAL or DTXCAL set up on the PLA heads

For Each Project

- Enter the NVP for the cable obtained from the product specification sheet
- All Excel Cables are stored under 'Manufacturers' within the DTX setup tab
- Enter the performance level specification for the Channel or Permanent Link to be tested CENELEC EN50173 Class D, Class E, etc.

Recommendations

- Perform a basic wire map test with a Mod Tap (wire map), or similar, before using the Fluke tester to fault find
- Have a laptop computer on site with the latest version of Fluke Linkware installed
- Identify Main and Remote on the Channel adapters and PLA with a permanent ink pen or label ID system

Excel requires a copy of the test results in Fluke software (flw) or the alternative testers native format. Excel will not accept .pdf files under any circumstances.

Each report will be stored by Excel.

The Installer will be provided with a copy of the Channel Warranty documentation Excel will endeavour to process Warranty Application within 5 working days if the process contained in Section 13 of the Excel Encyclopaedia is followed.

Testing Set-up

This element is designed to provide the installer with valuable information on how to set up the Fluke DSX 5000 correctly to provide Excel with the required information to assist us in processing the warranty applications smoothly and without undue delay. (The process differs only very similar across other testers)

It is an easy to follow step-by- step guide for the less experienced whilst providing a useful reminder for those that have been testing for many years.

Copper Testing

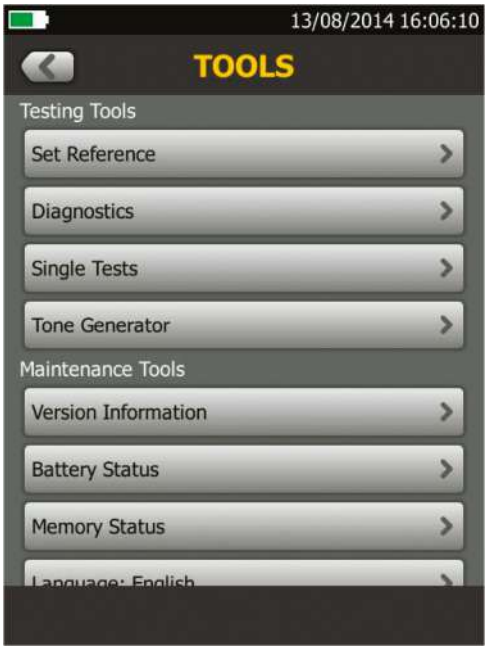
This will be broken down into a number of sub-topics, Permanent Link, Channel, Harness Links/Consolidation Cables and Patch Leads. A full description of what each one of these constitutes can be found in the preceding diagrams.

However the first step is to check that your tester is fit for purpose, it has the right software and test limits loaded and has been calibrated correctly, this is a very simple process with the new Fluke DSX 5000 and shows when the device was last calibrated and the software revision. It is very simple to check on the Fluke Networks website at **Flukenetworks.com** and download the latest version.

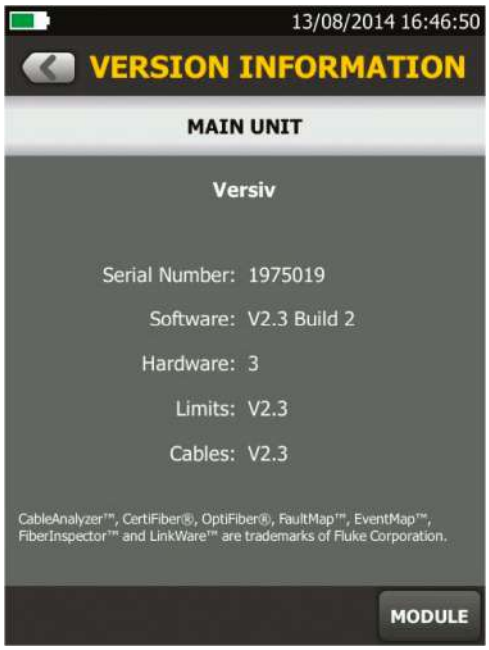
NB. As a Touch Screen interface you select by tapping on the icon involved.

On power up you will get the Home Screen (on the left) which shows how the device was set up for the last test. Tap the Tools icon to bring up that page.

NB. If you ever want to return to the Home Screen at any point you can press the HOME button on the front of the Main Unit.



Go into Tools once there select Version Information, within here you will be able to check both the Main Unit and the module that is fitted, whether that be Copper or Fibre.

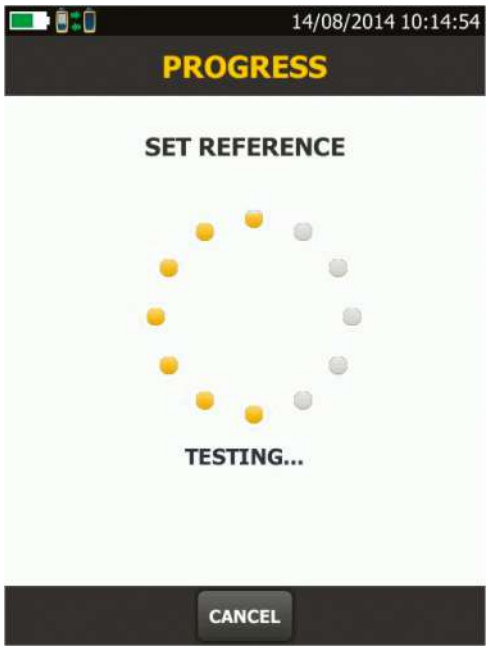


Within Tools you can also set up units of measure, language, date & time etc.

Following this you must reference the Main and Remote Units, again it is a very simple task, attach the PLA004 Permanent Link Adaptor to the Main and the Channel Adaptor to the remote. Plug them together.

Again within the Tools page select Set Reference you will then be guided through the simple process by the on screen instructions.

When ready, select the Test icon the unit will then run through the process, which only takes a few seconds and is recommended prior to starting every days testing.



The next task is to set up the PROJECT INFORMATION. Once more this has been simplified and is even quicker to complete.

From the Home Screen select PROJECT, within this screen you will be able to see each of the topics that require input.

This screen not only allows for projects to be directly set up on the device itself as well as transferring pre-configured projects that have been set up within Fluke Linkware. However for this document we will concentrate setting the project up within the DSX 5000 directly.

From this screen select CHANGE PROJECT, you will then be prompted to either select an existing one or create a new one select CREATE NEW

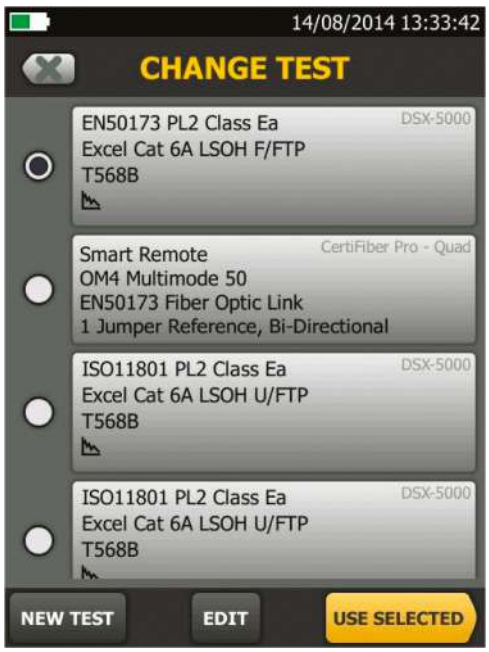
Repeat the process for OPERATOR, which allows for the selection from a list of previous users or the creation of a new one.

Permanent Link

We now have to set up the specific test criteria needed for the project.

Once more this is very simple, as the unit senses whether the module attached is either Copper or Fibre and automatically selects a list of relevant tests. The Home Screen will show the last test carried out.

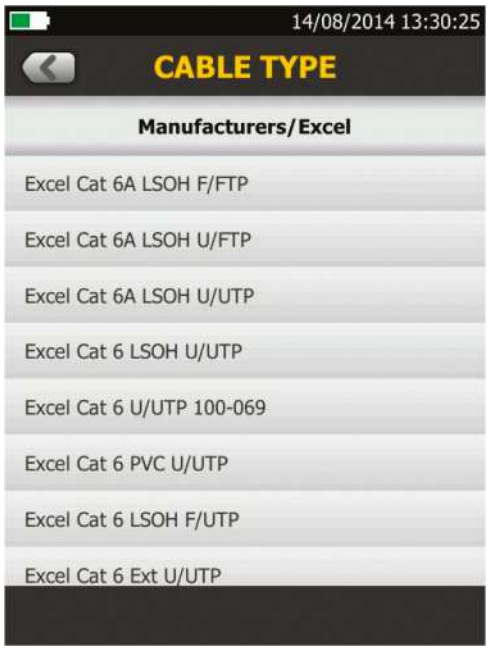
Select TEST which will bring up the details of the test and then you can either, select one from the list displayed, edit one from the list or create a new one. For this exercise select NEW TEST.



This will then bring up a new set of options.

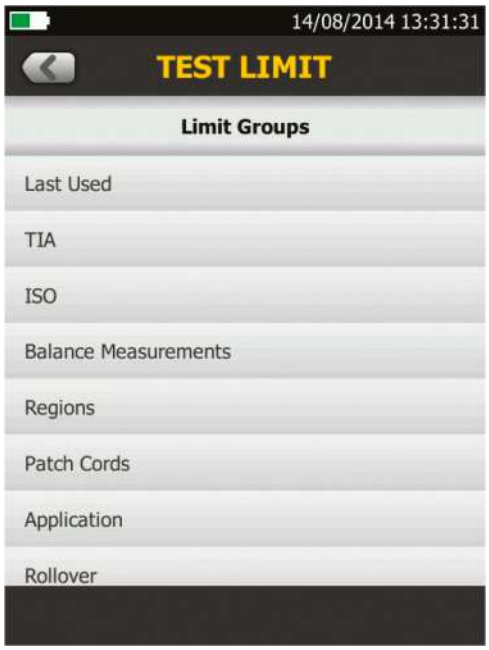
Again this initially brings up the previous test criteria for you to edit and amend

Select CABLE TYPE, This will initially bring up a list of previously used cable types, if the one that you want is not listed select more and then the Manufacturers tab and then scroll down to EXCEL as Fluke Networks and many other equipment manufacturers list the details of Excel cables within their testers.

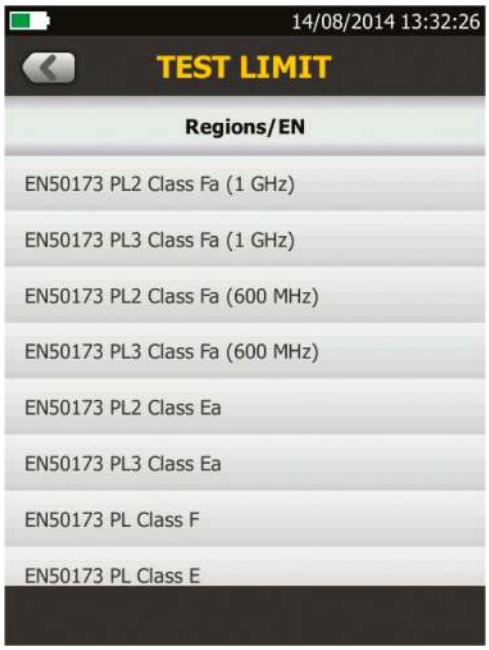


Select the type required, which inserts the relevant NVP etc and automatically takes you back to the previous screen. Follow the same process for selecting the required test limit.

However there is one slight anomaly in this process, by selecting TEST LIMIT it brings up a list of previously used tests, if the one required is not on the list, select MORE, which brings up the following screen, you will notice that it does not include EN (Cenelec).



You must first select REGIONS and then from within that screen EN, this will then bring up all the relevant Cenelec standards to be selected from.



For Warranty Application Purposes, EXCEL prefers that Cenelec test limits are used.

Also note at the higher Classes there is both PL2 and PL3 listed, ensure you select the correct one. PL3 is to be used whenever a Consolidation Point is part of the design.

The TEST SETUP Screen also allows contains two other important items that require selection they are:

STORE PLOT which must be selected as ON and HDTDR/HDTDX which must be set to FAIL/PASS*

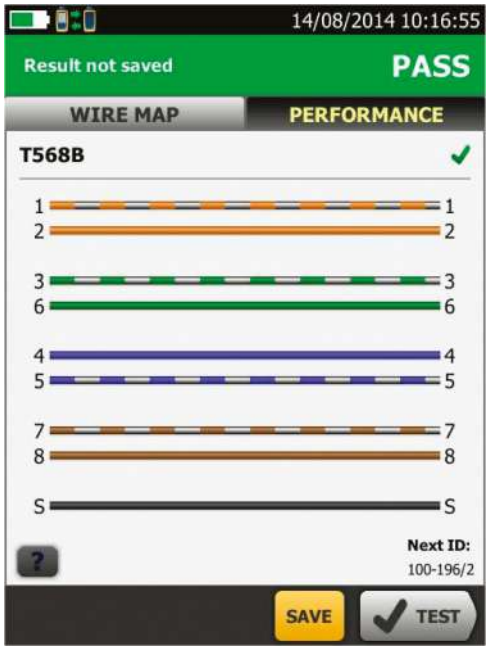
You are now almost ready to start testing but first of all you must select SAVE to store the information you have just created.

One final additional feature of the DSX 5000 is; within the Home Screen, you have the ability to set up the ID field for those links you intend to test, this can be done when setting up the project or at this stage simply by selecting NEXT ID: which brings up the next one in the range that was previously used. Select CHANGE CABLE Ids and then you can either edit the existing range or create a New ID Set within this last item you can even create a start and first point of the range.

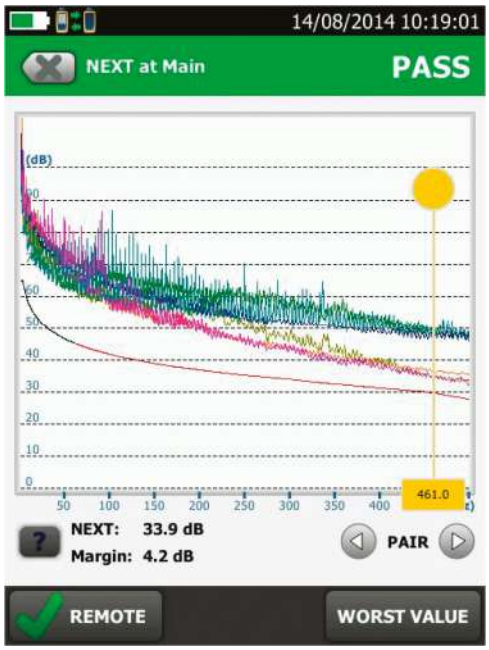
Once you select DONE, it will take you back to the test you have set up

Attach the two PLA004 leads and testing can now commence testing.

Either by pressing the White Button on the front or selecting TEST from the Home screen. It is a remarkably quick process. And the first screen you should see is the PASS screen, which has two tabs the first being WIRE MAP the second being the PERFORMANCE



To see an individual result just select the parameter and it will bring up the next screen.



You then have the option to view either from the Main or Remote end as well as seeing Worst Values, you can scroll each of the Pairs along with being able to drag and drop the cursor to specific frequencies, even zooming in a similar way as you do on any Smartphone.

Channel

Channel Testing is not to be used for Warranty Applications, these guidelines are designed for troubleshooting purposes only.

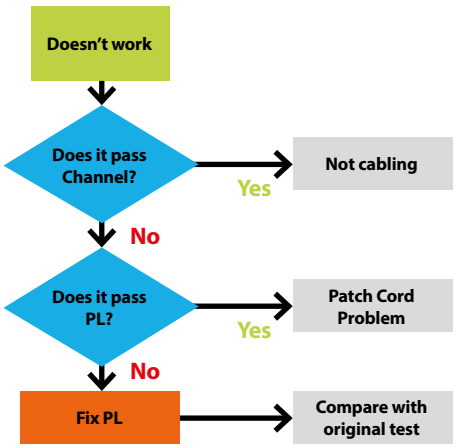
Testing the channel is very simple and straightforward.

Replace the Permanent Link Heads and replace them with the Channel Heads, and following the guidance previously given in this section, select a new set of patch leads to be used as reference cords, they should also be a minimum of 2m in length.

NOTE: these Reference Cord/Patch Leads should be replaced with new ones after every 100 tests.

From the Home Screen select the relevant Channel test in the same manner as described previously and select TEST.

The following is a workflow diagram for troubleshooting.



Harness Links/Consolidation Cables

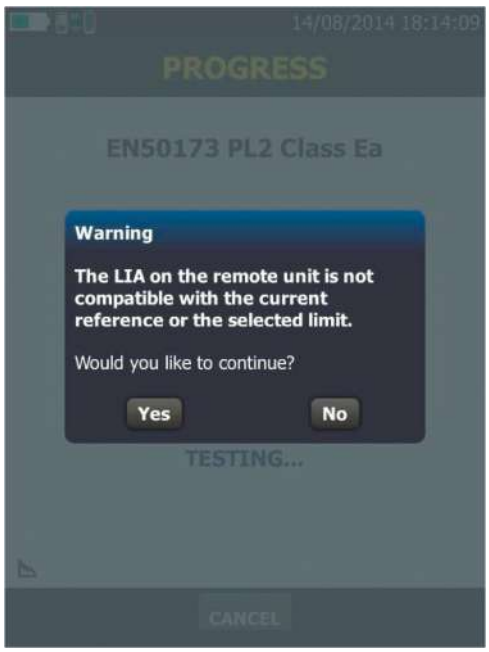
This is also sometimes called a Single Connector Permanent Link test. This is a link with an RJ45 Plug at the outlet.

Cabling standards such as EN50173 defined two definitions for link testing, Channel and Permanent Link. In the case of the above link, it does not fit either model.

** Remote channel adapter & RJ45 plug are excluded from the measurement using Digital Signal Processing*

The above solution is a compromise between what the standards define and the desire to provide accurate test results for both Harness Links and Consolidation Cables In this test scenario, no user patch cords are involved. Therefore it is more closely associated with a permanent link test. This is the process recommended by Fluke Networks.

When you set the DSX 5000 to a Permanent Link standard and then press the Test button you will be greeted by the following screen which correctly warns that the use of the Channel Head is not compatible with a Permanent Link test.



Select YES.

The affect of the remote channel adapter is removed in the above measurement. The channel adapter will normally add a significant amount of NEXT to the measurement unless it is cancelled out. The DSX 5000 uses Digital Signal Processing to cancel out the NEXT in the adapter in accordance with The Standards. Return loss in the mated connection is also minimized, as the adapters contain RL calibration coefficients representing a nominal RJ45 plug.

Therefore it must be noted that the TRUE value of the RJ45 plug is ignored by this test and to ensure optimum performance the Solid Core Patch Cords that are used to construct these Links/Cables are tested as such within the Factory.

Patch Leads

The purpose of certification testing is to ensure that a link, channel, or component meets industry performance standards. Installers certify permanent links and the network owners install patch cords at a later date to complete the channel.

Patch cord certification brings together a compliant permanent link and patch cord to make a standards compliant channel. Patch cord certification can be performed in the factory or the field with the right Test Equipment and Adapters.

As with permanent links and channels, the test equipment used for certification must be set to the correct test limit and the relevant category Patch Cord Test Heads are used.

Image features Category 6 Patch Cord Adapters

The Fluke Networks has a range of Patch Cord Test Head Sets available, Cat5e, Cat6 and Cat6$_A$ They all come in a version that can test both Screened and Unscreened cables. Also note unlike the Permanent Link and Channel Adaptors, they are Specific Main and Remote Heads, check you have them the correct way around as the DSX will warn of an incorrect set up.

From the Home Screen select a new Test Limit as has been described in this document, this time select Patch Cords, this will then bring up all the Categories.

Select the required length and then SAVE, and select from the list and you can start testing.

Permanent Link Description

A Permanent Link is defined as the cabling between two outlets (or three outlets if a Consolidation Point (CP) or Local Distribution Point (LDP) is used) but excludes any patch cords.

A Permanent Link, is the fixed cabling, to which equipment and work area cords are added to complete the channel (see diagram below). Physically the Permanent Link includes cable and outlets (possibly presented in a patch panel). Where a CP or LDP is required in the Permanent Link the CP or LDP to Outlet cord and the outlet are to be included in the Permanent Link measurement and testing. There are limits imposed within the standards for key electrical parameters such as insertion loss, XTALK, RL, ELFEXT, etc. The horizontal PL must take into consideration all elements necessary to configure the operational channel, which has a limit of 100m (305ft).

Channel Description

A channel is defined as the "up to 100m" connection between two active components.

Physically the channel includes horizontal cable outlets (possibly a patch panel), Interconnect (fan out cables) and any cross connect (patch cords), equipment or work area patch cords. There are limits imposed for key electrical parameters such as Attenuation, XTALK, RL, ELFEXT, etc, the channel is not limited to a maximum of 4 connectors or junctions. However should a channel configuration require more than 4 connectors then approval must be given, at design stage, by Excel for their warranty support.

Testing of a channel can take two forms:

- Confidence test where the patch cords are removed or replaced following the test
- Full test where the final configuration is tested and left in place

A channel test serves to validate either conformity with the generic cabling standards or application support.

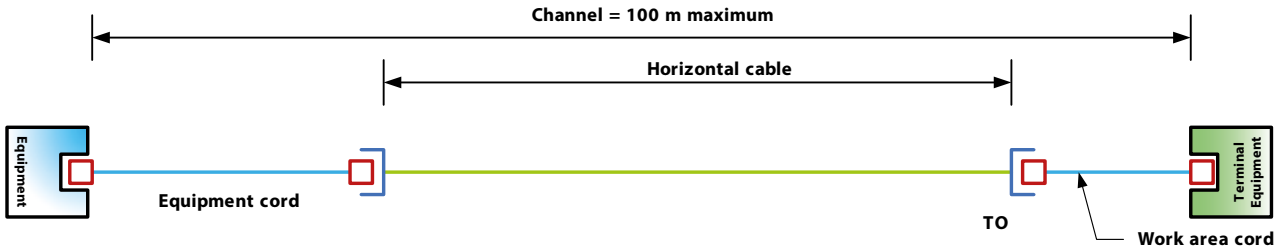
The term "Reference Cord" is defined here as a new Excel patch cord that will only be used for up to 100 tests. After 100 tests the Reference Cord must be destroyed and replaced with another new Excel Reference Cord.

Before a Channel test is performed all components in the Permanent Link must have been configured and validated for component compliance.

Marginal or star passes on all other criteria are to be treated as failures.

Typical Permanent Link & Channel Connectivity Models

a) Interconnect – TO model



Mandatory tests:

Element	Test	
Permanent Link	Permanent Link	

Optional tests:

Channel	Channel	

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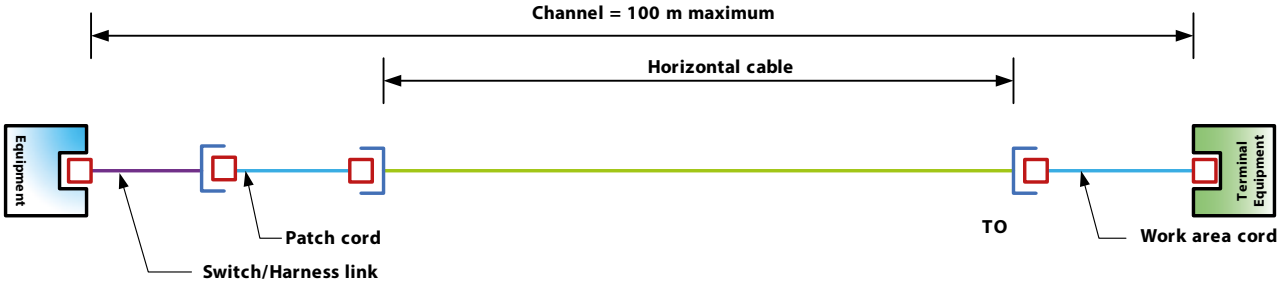
b) Crossconnect – TO model



Mandatory tests:

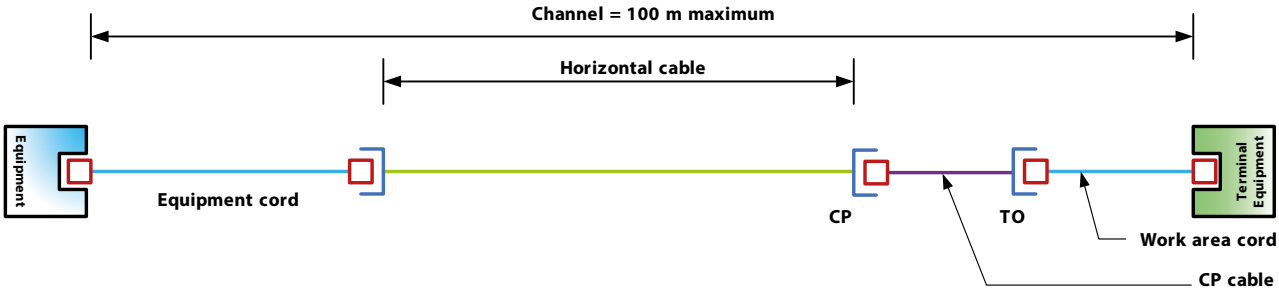
Element	Test	
Permanent Link	Permanent Link	

Switch / Harness Link	Permanent Link (PL head to Ch head)	

Optional tests:

Channel	Channel	

c) Interconnect – CP - TO model



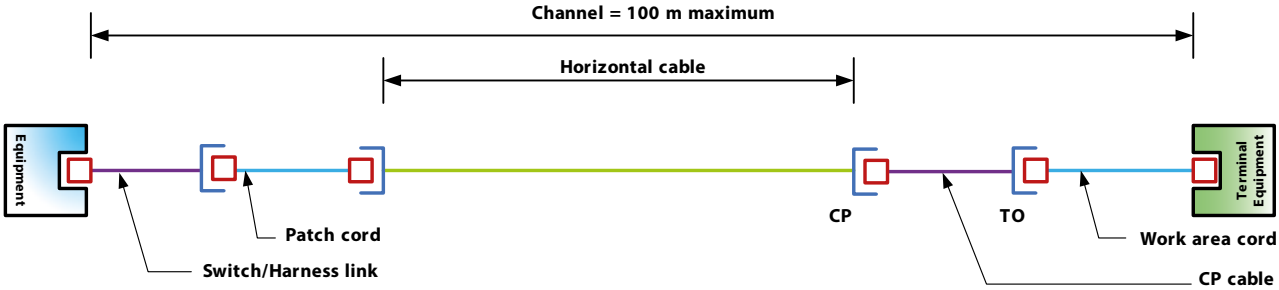
Mandatory tests:

Element	Test	
CP Link	Permanent Link	
CP Cable	Permanent Link (PL head to Ch head)	

Optional tests:

CP Link - TO	Permanent Link	
Channel	Channel	

d) Crossconnect – CP - TO model



Mandatory tests:

Element	Test	
CP Link	Permanent Link	
CP Cable	Permanent Link (PL head to Ch head)	
Switch / Harness Link	Permanent Link (PL head to Ch head)	

Optional tests:

CP Link - TO	Permanent Link	
Channel	Channel	

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