Guide to earthing structured cabling systems and related hardware

1 Standards & related documents

The best known structured cabling design standards are the EN 50173 series, ISO 11801 series and TIA 568. Whist these standards are similar documents there are differences in terminology and some minor variations between them. Overviews of these documents would normally be covered during training from most reputable cabling solutions manufacturers.

Much important detail is, however, buried in related unseen documents. For example, ISO 11801 refers to 49 other specifications and the average cabling installer is unlikely to read them – so, which of these referenced documents can be identified as important to the reader in a short guide?

Two important referenced documents with respect to Earthing are EN 50174-2:2018 (Information technology - Cabling installation - Part 2: Installation planning and practices inside buildings) and EN 50310:2016 (Telecommunications bonding networks for buildings and other structures). These documents contain a large amount of technical data necessary for compliance of an installation and should obtained and be referred to as a matter of course.

We will discuss some aspects of these two documents here.

The protective bonding network of a building or other structure is defined as a set of interconnected conductive elements to ensure electrical safety (EN 50310:2016).

The installation guidelines for electrical isolation components for the protection of information technology cabling from electrical surges developed by a rise of earth potential are covered within EN 50174-3. These discussions are outside the scope of this document.

2 Protective Earthing versus Functional Earthing

Protective Earthing concerns safety i.e. low frequency currents with a high level of magnitude which present a safety hazard to personnel.

Functional Earthing concerns other effects such as EMC i.e. high frequency currents with low levels of magnitude, which may not constitute a hazard to personnel but can degrade data signalling. Functional Earthing also relates to the provision of reference signalling voltages or return paths.

2.1 Why the need for earthing?

Protective Earthing is a requirement to divert unwanted, potentially hazardous currents from all exposed metallic parts such as equipment chassis, racks, cabinets, cable trays, conduit, and patch panels for personnel safety reasons and to avoid potential damage to equipment.

Because low frequency currents will always use the path with the lowest impedance a single wire which has low impedance at low frequencies, can be used to connect items to the protective earth.

As such, Protective Earthing is required for both unscreened (U/UTP) and screened (Foiled or shielded TP) cabling systems.

Functional Earthing in a screened or shielded cabling system is a method of draining or dissipating unwanted noise currents from the cable screen so as not to impair the EMC performance of the cabling system.

Unlike single wires, large conductive surfaces with a low inductance at high frequencies are required to drain these currents. Aluminium foils, braided copper shields, connector shields and equipment chassis can all form part of the bonding network.

2.2 What are those unwanted currents and where do they originate from?

Protective Earthing: Commonly known as fault currents these are low frequency currents e.g. 50Hz or 60Hz with a high level of magnitude and are associated with the power used to supply equipment such as computers, servers, data switches etc. These currents manifest when an electrical fault exists with the equipment.

Functional Earthing: These are high frequency currents with low levels of magnitude and in most cases present no hazard to personnel safety. This noise is radiated in the form of electromagnetic fields from devices such as neighbouring computer type equipment, adjacent cables (UTP), radio broadcasts, wireless devices etc.

2.3 What methods are used to earth the screen or shield and why?

Because low frequency currents will always use the path with the lowest impedance a single wire such as a drain wire which has low impedance at low frequencies can be used to connect the screen to the protective bonding network.

Unlike single wires, large conductive surfaces with a low inductance at high frequencies are required to drain these H.F. currents. Aluminium foils, braided copper shields, connector shields and equipment chassis can all form part of the bonding network.

2.4 Does it mean that two different methods need to be applied together?

Yes, a suitable means of eliminating high frequency noise with low level of magnitude is needed. At high frequencies the current will choose the path with the lowest inductance as opposed to the shortest path and because a single wire has both a high impedance and high inductance at high frequencies it will not drain these currents to earth.

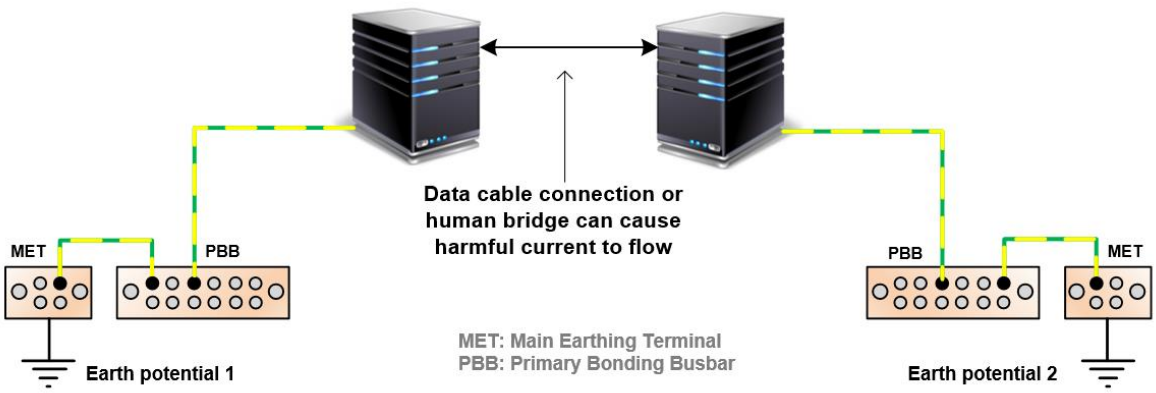
Shield terminations for EMC are not suitable for earthing low frequency currents with a high level of magnitude because these currents present a hazard to personnel and therefore the shield must never be used as a means of Protective Earthing.

3 Building Safety Requirements

3.1 Earthing & Equipotential Bonding

A common misconception is that all reference points for earth are at the same potential since they are all connected to the ground at some point. Because our planet has differing earth potentials which can occur over a short space this needs to be considered when designing and installing bonding networks.

The potential difference between two separate earthing points can give rise to harmful currents occurring if these two points are bridged (See diagram 1).

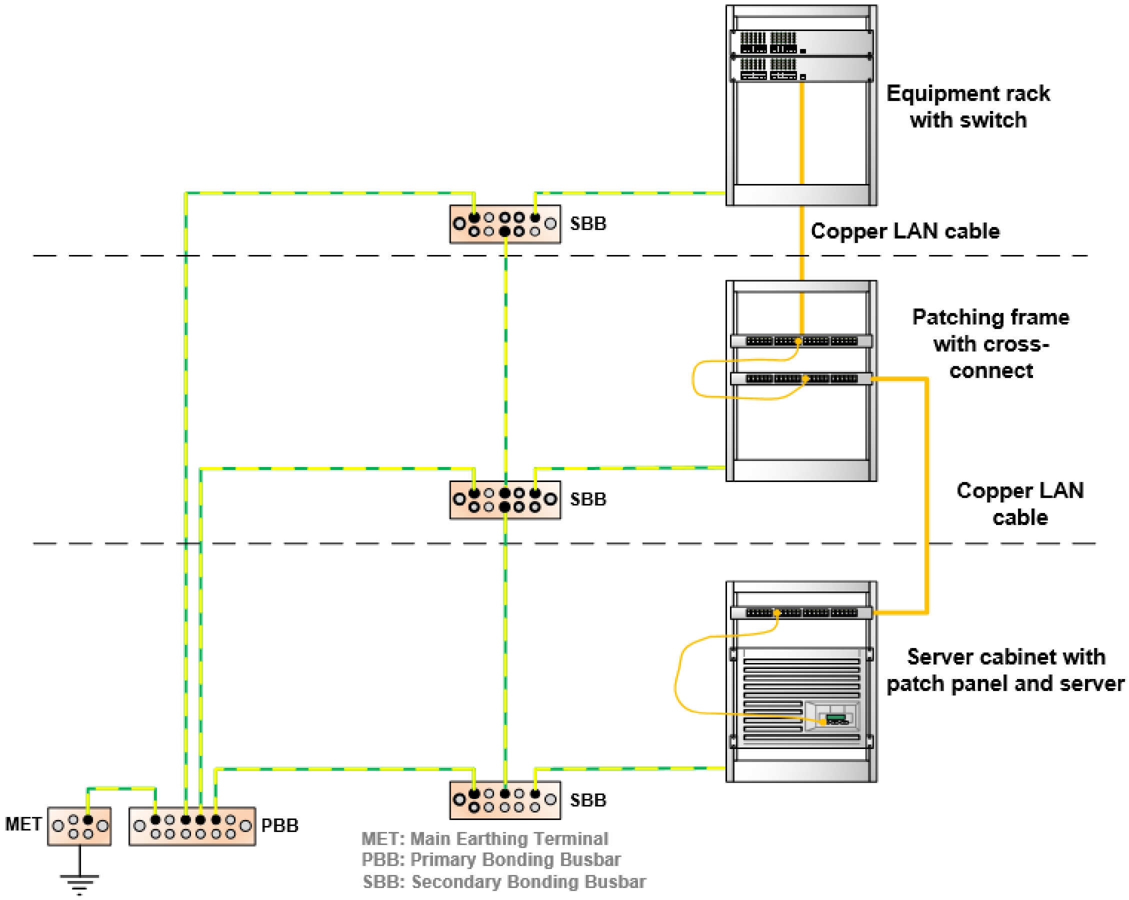


Graphic 1

The method of achieving all earth connections at the same safe potential is to bond them together and physically connect them in the soil or ground at the same point i.e. the MET (See diagram 2).

This is known as equipotential bonding. The MET (Main Earthing Terminal) is normally provided by the local electricity supplier as a drilled copper bus-bar and sized in accordance with local wiring regulations, existing building requirements and future growth expectations.

According to EN50310:2016: "The d.c. resistance of any two points of the bonding network shall have a maximum value of 1.67mΩ/m."



The metallic bodies of the switch, patch panels and server are grounded through the rack and cabinet frames to the Secondary Bonding Busbar (SBB)

Graphic 2

This procedure applies to unshielded, shielded and fibre optic cabling systems alike. All metal parts regardless of the type of cabling must be bonded for personnel safety reasons and to avoid potential damage to equipment.

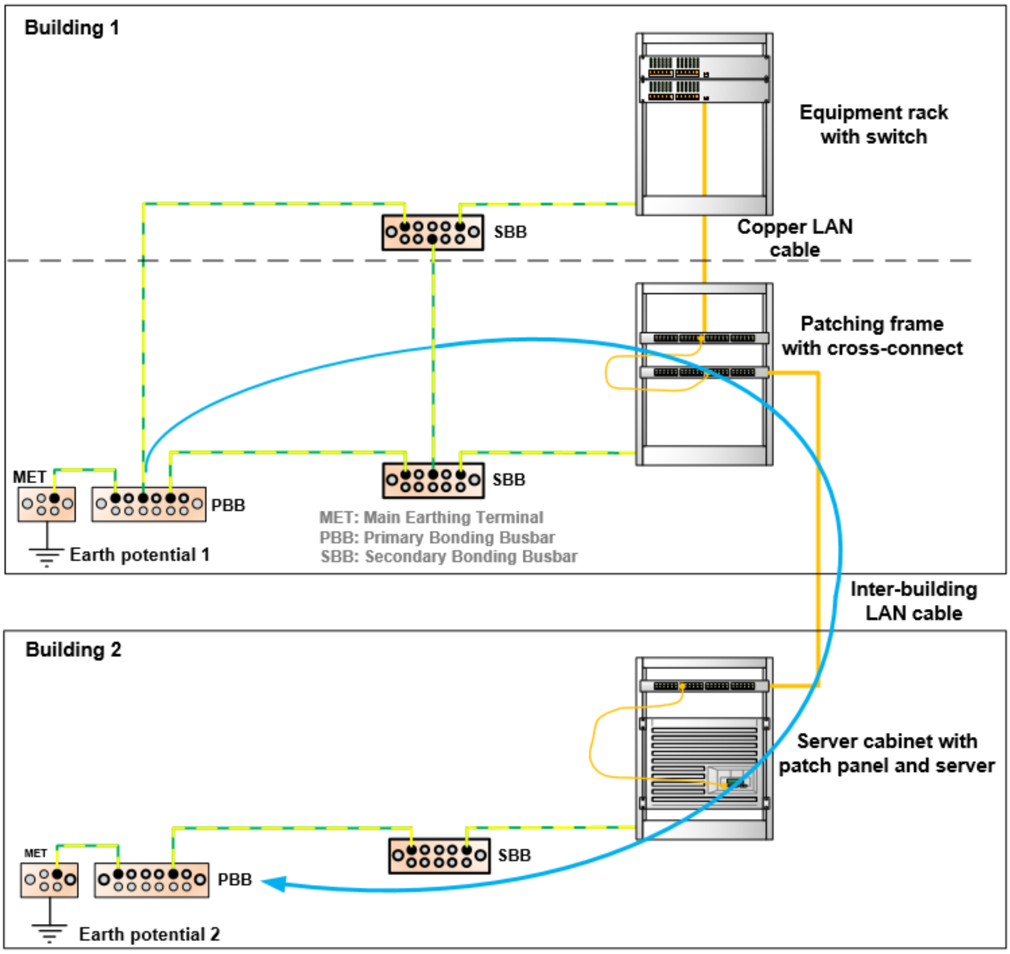
Aginode's cabling hardware is specially designed to accommodate easy installation and to automatically achieve optimum bonding conditions without the use of extra straps.

3.2 Ground Loops

Ground loops are another potential hazard that can occur in certain situations and need to be eliminated.

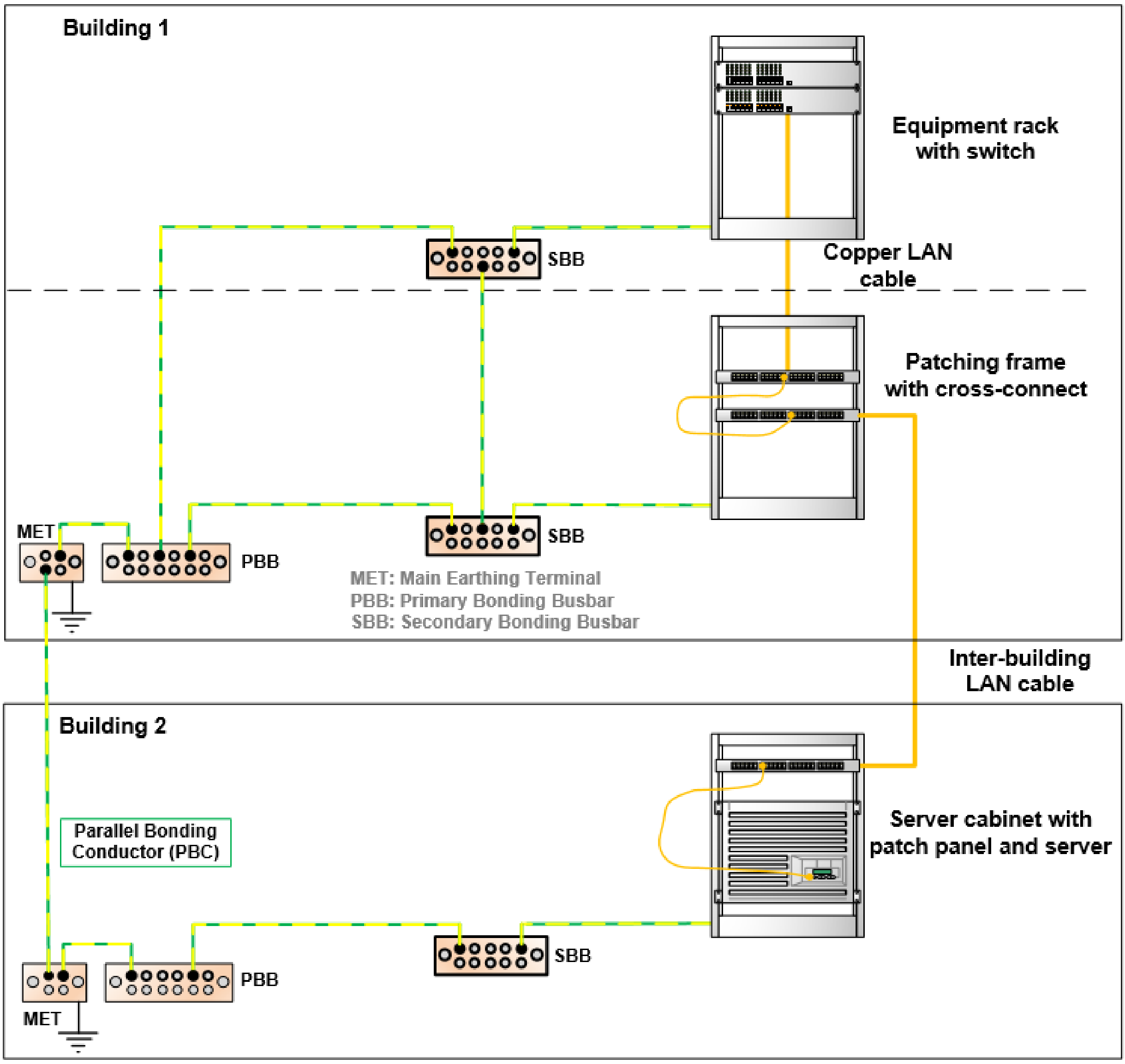
3.2.1 Inter-building cable links

If a cable link (with metallic armour that needs to be grounded on both sides) is connecting two separate buildings each having their own MET, which could be at different earth potentials, a ground loop can be propagated (See graphic 3).



Graphic 3

One method to overcome this is to install a low impedance connection (parallel earth/bonding conductor or PEC / PBC) between MET 1 & MET 2 which will help to equalise differing earth potentials between buildings (See diagram 4).



Graphic 4

Specifying and installing a parallel bonding conductor can be a complicated task and it is recommended that such a project is undertaken by experienced qualified contractors.

Installing copper LAN cables between buildings also requires surge suppressors in case of lightning strikes, which is also complex. It should be noted that the cable screen shall not be used as a parallel bonding conductor.

Aginode strongly advise against installing copper LAN cabling and recommends fibre optic cabling as a safer alternative between buildings. OF cable structure including a dielectric armour (such as the LANmark-OF UD cable) will not propagate unwanted currents since there are no metallic conductors.

If there is a requirement to run a conductive cable between two buildings standards such as EN 50174-3 and local electrical codes should be consulted.

3.3 Single and double ended earthing

To comply with the requirements on EN 50174-2: 2018 which requires the screen to be continuous from transmitter to receiver, the cable channel needs to be earthed at both ends (Through the equipment at the user side).

However the standard also consider screen bonded at one end only as the local earthing configuration of equipment needs to be considered.

3.3.1 Local variations in earthing configuration

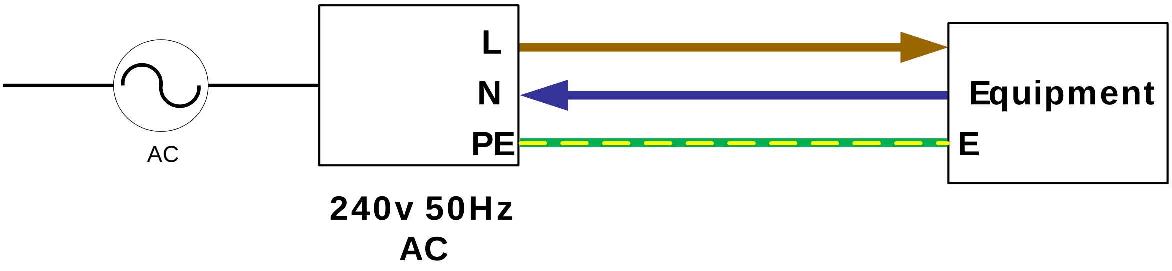
Having established proper earthing methods through the protective earth for panels, racks, cabinets and equipment chassis for all types of cabling, consideration needs to be given for local variations in earthing configurations where shielded cabling is concerned.

There are two considerations that need to be considered:

- The configuration for the protective earth in the power distribution system used locally
- How modern the building earthing system is

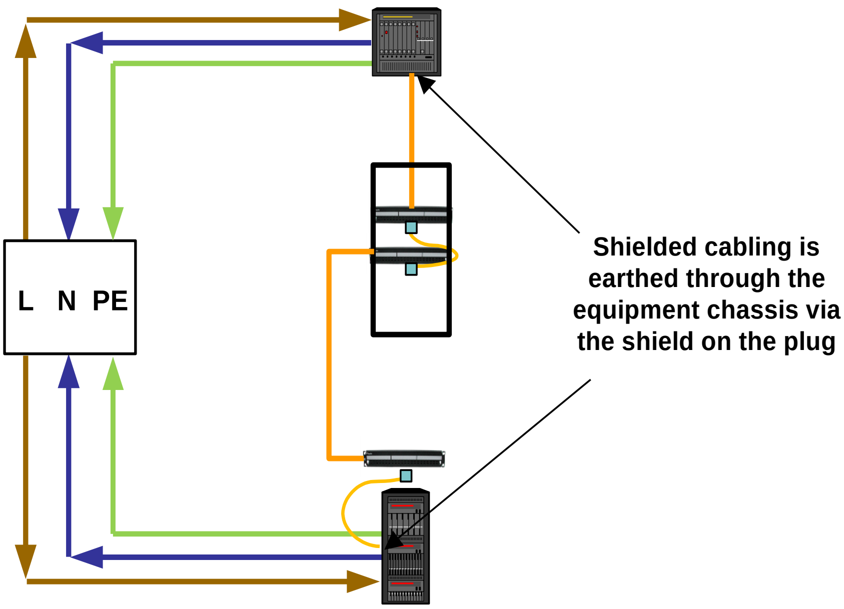
The supply of mains power and protective earth to equipment comes in two configurations depending upon the local regulations.

One uses 3 conductors, one which carries the current to the appliance (live), one which returns the current from the appliance (neutral) and the third is a protective earth which is separate from the neutral: TN-S system (See graphic 8).



Graphic 8

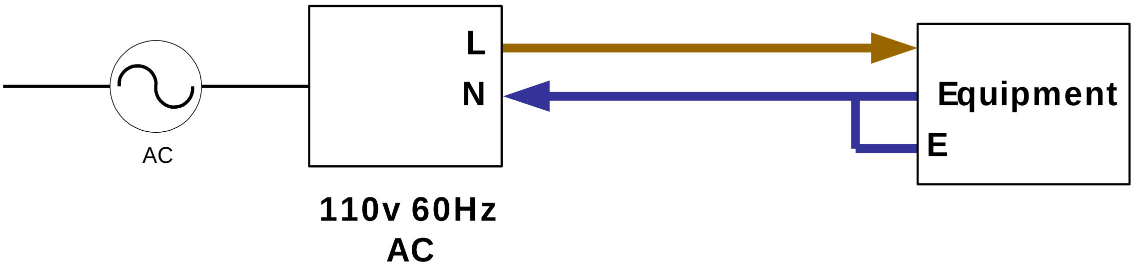
In the TN-S system configuration using double sided earthing, the fault current will always propagate along the protective earth conductor and not along the screen since the protective earth conductor has a lower impedance and all earth potentials are the same (see diagram 9).



Graphic 9

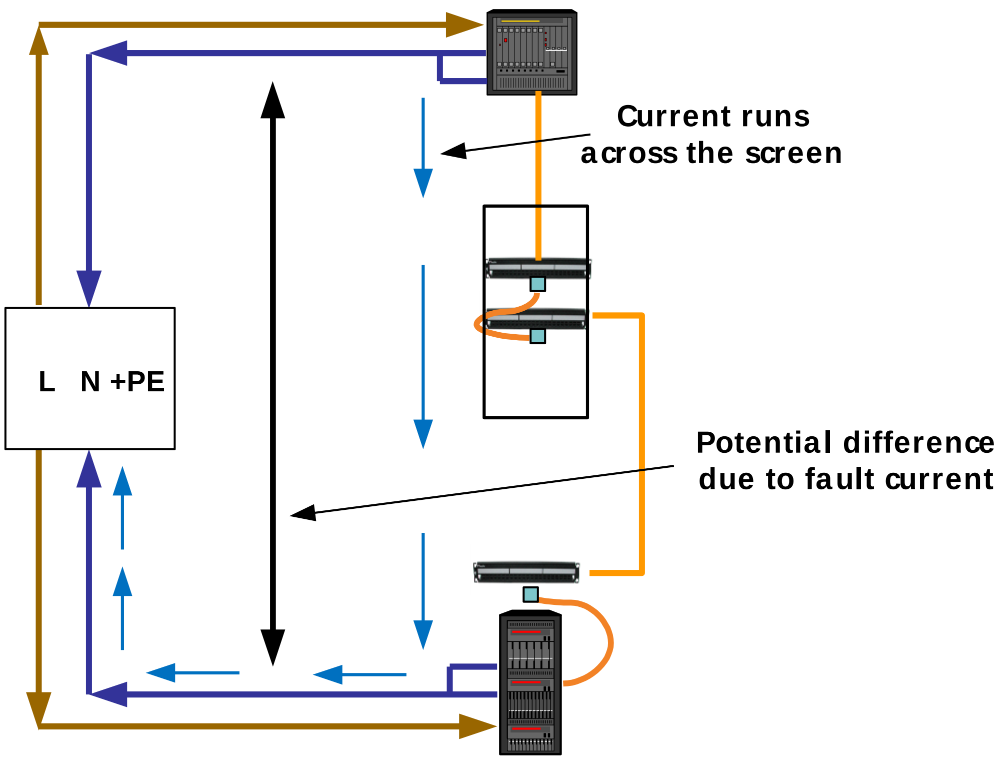
The other earthing configuration uses two conductors only, one to supply the current to the appliance (live) and the second to return the current (neutral).

The protective earth which is connected to a ground point inside the equipment is also connected to the return conductor (TN-C system) (See graphic 10).



Graphic 10

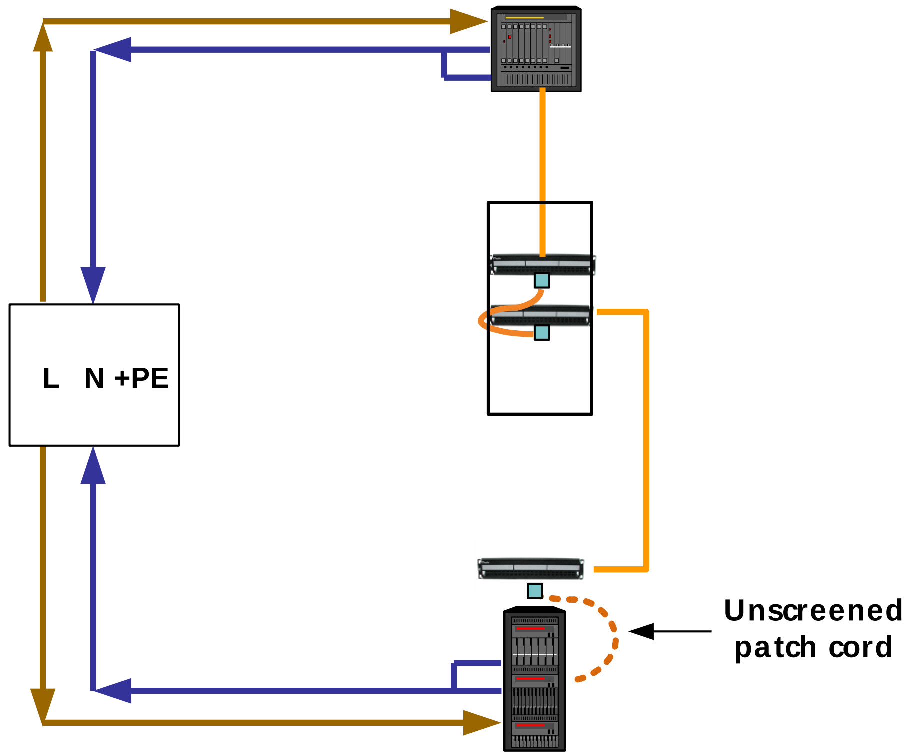
In this example with double sided earthing, in the event of a fault current occurring in one of the equipments a potential difference can exist between the neutral + earth for both equipments, which can result in current flowing across the shield (See graphic 11).



Graphic 11

To prevent this ground loop an unscreened (UTP) patch cord is required at one end, which blocks dc/low frequency current to flow (See graphic 12).

It should be noted that this configuration would not comply with the requirements on EN 50174-2: 2018 which requires the screen to be continuous from transmitter to receiver. However the standard also consider screen bonded at one end only.



Graphic 12

3.4 Building earthing system

Modern buildings are designed with equipotential bonding systems throughout their entire structure, which makes the design of the protective earth network simple and easy. However, it is important that all metallic parts such as cable trays etc are bonded together and to the protective earth otherwise potential differences between the two can give rise to harmful currents. International standards cover this in greater detail and should be followed accordingly.

Older buildings on the other hand need greater attention when designing the protective earth network. Equipotential bonded systems may not exist therefore different potentials may exist between floors. Safety should always prevail over EMC performance and where cabling is installed over two protective earth networks it should be earthed at both sides.

4 Electromagnetic Compatibility (EMC)

The EMC performance of a cabling system can be defined as its susceptibility to external RF noise and its ability to radiate RF noise. The characteristics, which make up a cabling system's EMC performance, are electrical balancing of the twisted pairs and its shielding effectiveness.

UTP systems show good immunity to RF noise up to 30MHz due to the balancing of the pairs. Beyond this frequency the immunity can decline.

Shielded systems however, have an even greater immunity to RF noise and over a greater frequency spectrum because of the aluminium foil screen, which protects the data being transmitted on the conductors by draining the noise to ground.

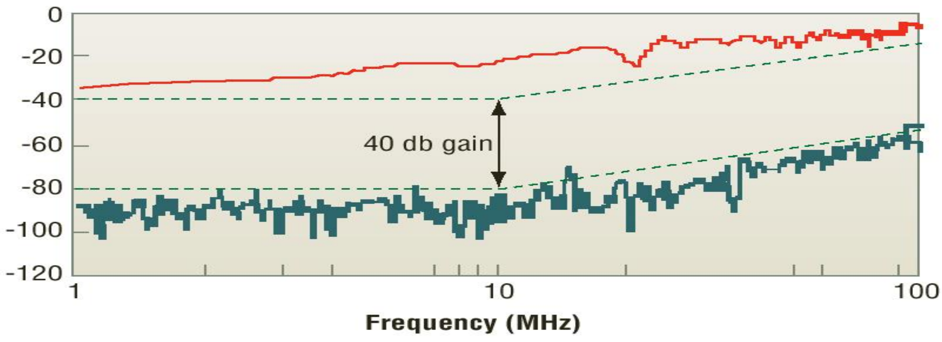
Shielding effectiveness of shielded cables will also vary according to their design. For instance F/UTP cables have an aluminium foil surrounding all four pairs and provide a high degree of noise protection with STP cables having greater shield effectiveness with an individual foil over each pair in addition to an overall braid.

Shielding effectiveness is of particular importance where 10G Ethernet is concerned. Screened and shielded cabling is immune to alien crosstalk transmitted from adjacent cables with the result that the installed system is able to meet the A-XT requirement by design.

4.1 Antenna effects

In certain circumstances cables can behave like an antenna by picking up RF signals or radiating signals being transmitted on the twisted pairs. This phenomenon is dependent on the signal wavelength, which gets worse as the frequency increases.

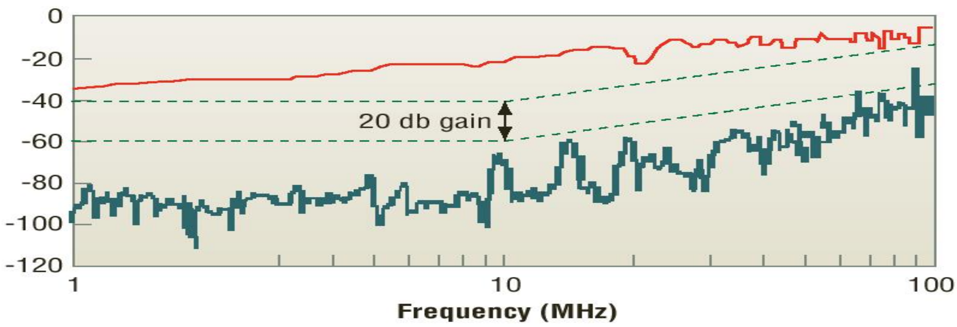
Both unshielded and shielded twisted pairs are susceptible to this effect and by varying degrees. Tests between unshielded and shielded cabling show that shielded cabling, when grounded at both ends, is a minimum 40dB of magnitude better i.e. less susceptible to picking up RFI from external sources than unshielded cabling (See graphic 13).



Graphic 13

This is due to the shield providing a constant reference point to ground thus having controlled and stable common mode impedance to ground. With unshielded cabling the common mode impedance varies according to its ground plane reference i.e. its proximity to metal surfaces.

Further tests have demonstrated that shielded cabling when left ungrounded at both ends still performs better by a minimum of 20dB of magnitude over unshielded cabling (See graphic 14).



Graphic 14

Although the common mode impedance is less stable because the shield is not grounded it is still better controlled than with unshielded cabling due to the proximity of the metal shield around the twisted pairs. In this instance the cable acts like a low pass filter and attenuates the RF noise along the screen.

Best practices however are to ensure the cable is bonded at both ends for the best results which will be achieved in the complete cabling installation using screened patch cords.

These levels of noise associated with shielded cabling systems are of no consequence and will not interfere with data being transmitted on the twisted pairs nor will it interfere with neighbouring equipment.

As transmission frequencies increase it can be seen that this noise can be a problem with unshielded cabling systems. This is of particular concern with full-duplex high data rate systems such as 10G Ethernet where alien crosstalk from adjacent cables can result in catastrophic distortion to the data signalling. Shielded systems are effectively immune to alien crosstalk as any noise picked up on the shield is returned to ground.

5 Earthing implementation on site

5.1 Responsibilities

It is the responsibility of the customer to liaise with the Electricity Company or local authority to ensure the integrity & functionality of the MET. Once this is assured, it is the responsibility of the Nexans partner to ensure adequate connectivity to the MET as detailed within this document.

5.2 Cabling systems earthing

Earthing/bonding is required for all unscreened and screened / Shielded cabling system.

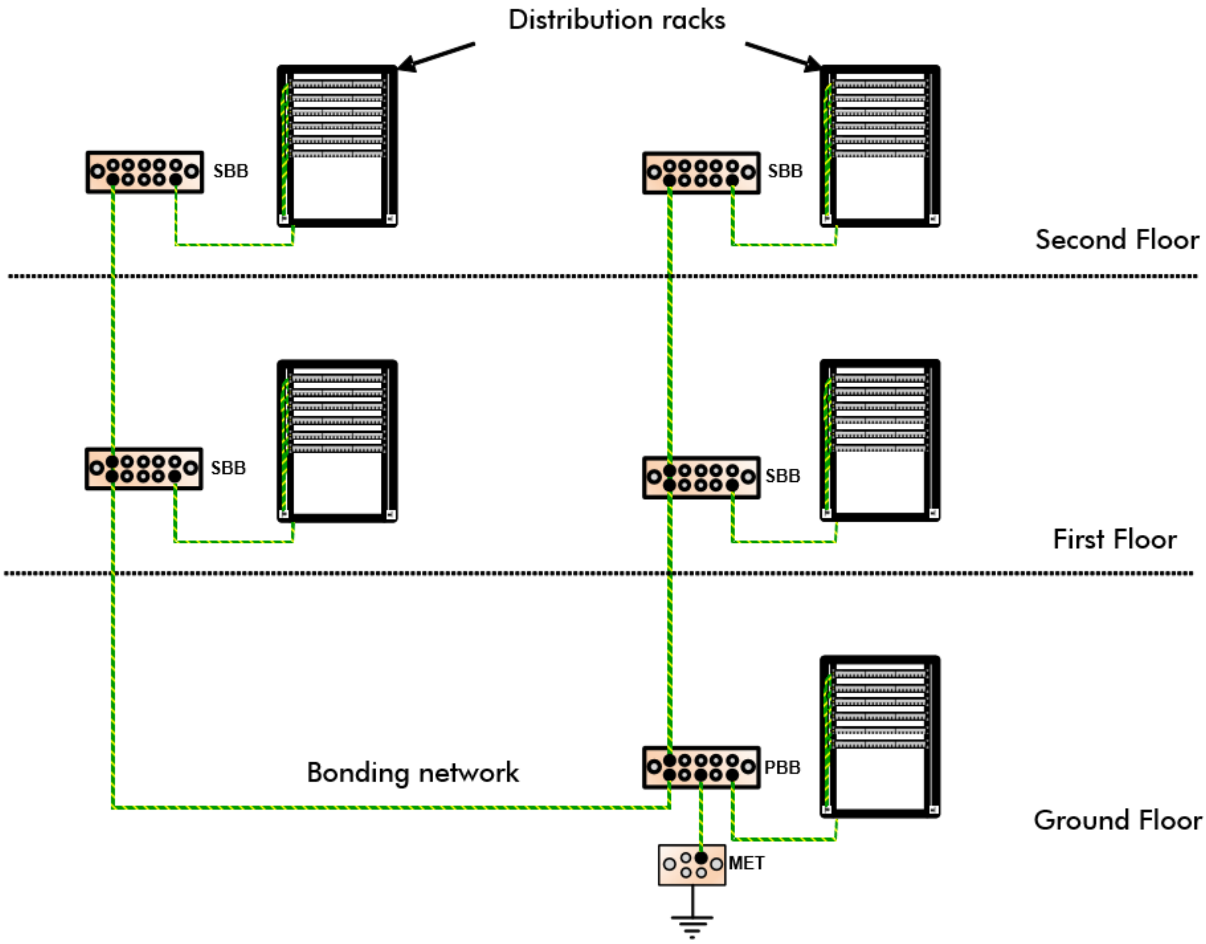
All metallic parts of the system (mainly cabinets and patch panels) shall be bonded throughout back to a Secondary Bonding Busbar usually located in the cabling distributors rooms / computer room (See diagram 2). All those bonding bars are linked back to the MET (Main Earthing Terminal) bonding point. The bonding network will normally be provided by the local Electricity supplier in accordance with country-specific wiring regulations.

EN 50174-2:2018 & EN 50310: 2016 Refer

Where possible a bonding backbone can be installed which will remove the need for multiple bonding home runs and connections to the MET. This should be installed using earthing wire and localised drilled bus-bars and clearly marked: "DATA EARTH DO NOT REMOVE", at all interconnection points.

Localised bus-bars provided within telecommunications closets shall be provided following the same guidelines required for the MET bus-bar.

Localised bus-bars should be located as near as possible to the backbone cabling with bonding connections to them kept as short as possible (See graphic 15).



Graphic 15

The d.c. resistance of any two points of the bonding network shall have a maximum value of 1.67mΩ/m.

Large buildings (*) are sometimes pre-wired with a functional earth to all floors and this can be used with customer agreement, provided that there are no doubts as to its earthing integrity. All connections to this shall be clearly marked: "DATA EARTH DO NOT REMOVE".

(*): For large buildings EN 50310 addresses requirements and provides recommendations for spaces where there is a high density of telecoms equipment or frames. Larger conductors are specified.

5.3 Bonding connection at the MET

The connection of the bonding network at the MET is to be:
"Soundly made and electrically & mechanically satisfactory".
This connection shall be clearly marked "DATA EARTH DO NOT REMOVE", with a permanent label.
Care must be taken when connecting new cables to the MET not to loosen or disconnect any existing wiring.

WARNING: Under no circumstances must the bonding network be connected to any equipment owned by the Electricity Company as an alternative to the MET. If no MET is available then the customer must arrange with the local Electricity Company to have one provided.

5.4 Bonding Cabinets and panels

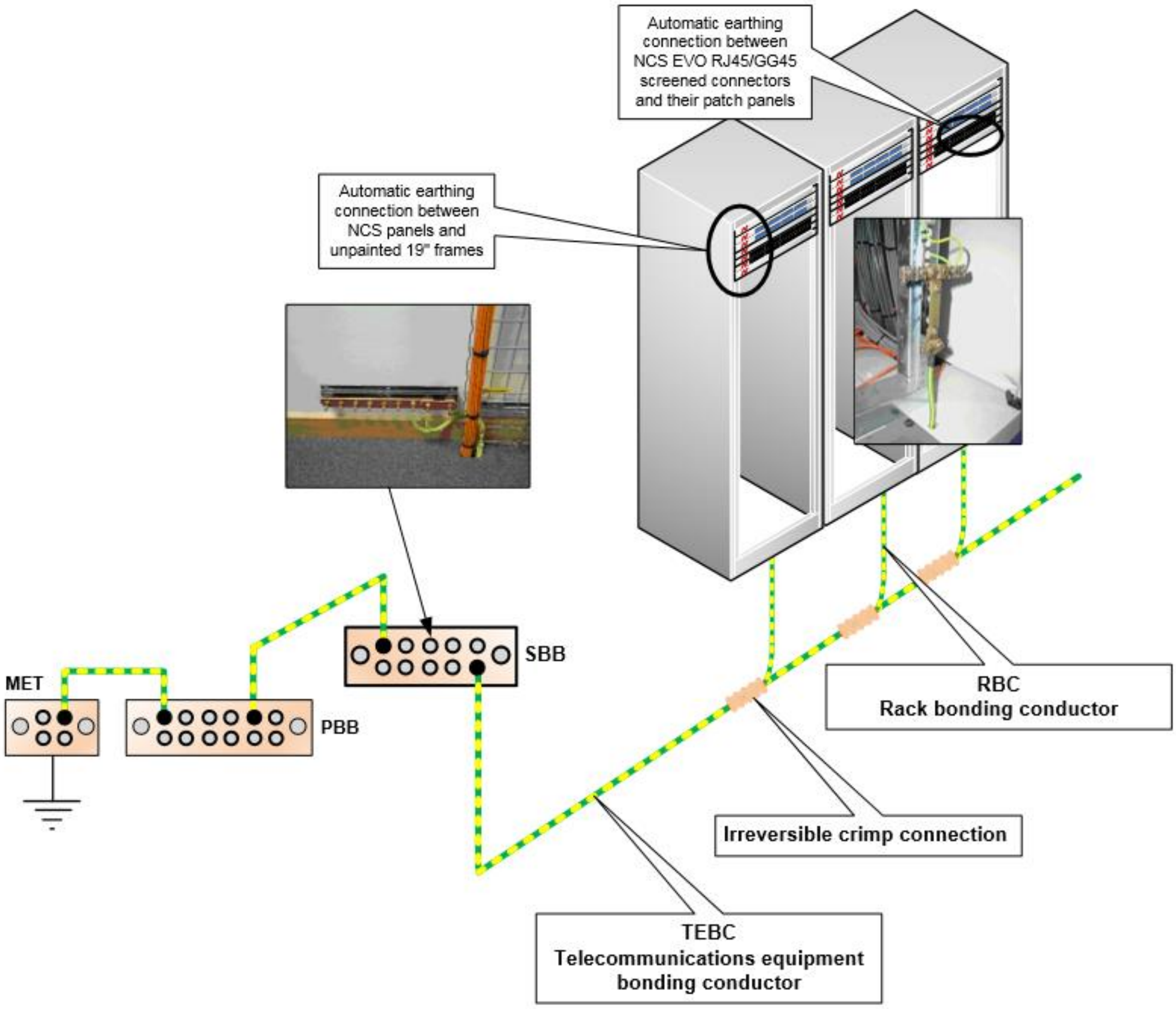
If racks are adjacent to each other they shall not be bonded together using a daisy chaining structure.

Every rack bonding conductor has to be directly connected to the closest SBB or to the Telecommunications equipment bonding conductors (TEBC) circulating in the room.

The TEBC shall be a continuous conductor with a bonding conductor of a minimum cross-sectional area of 16 mm^2 (See clause 10.2 of EN 50310:2016)

Earth runs should be kept as short as practically possible, with the wire as straight as is practically possible.
Please refer to local earthing regulation documents in order to ensure that the bonding wires are sized accordingly.

Note: The minimum recommended following EN 50310 is 4 mm² for a rack of 21U or under and 16 mm² for racks of >21U).



Graphic 16

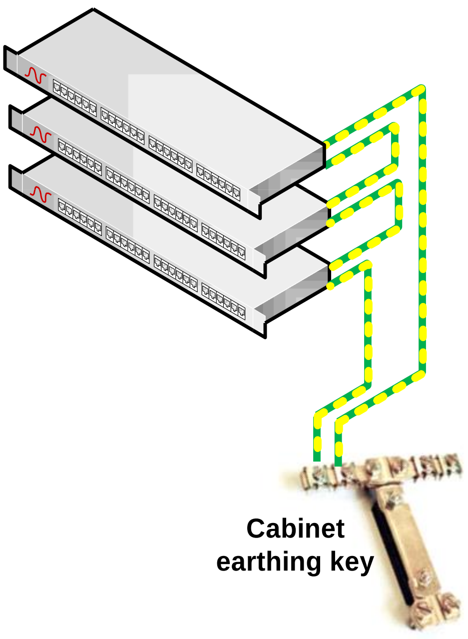
Aginode's LANmark patch panels are designed to automatically provide a bonding contact with Aginode frames; patch panels in other Aginode ranges have other bonding arrangements.

If the cabinet is not designed to provide the panels with an automatic contact with the earth, then the patch panels earthing screw must be connected with separate earth straps to the cabinet Earth Key (Daisy chaining or Star wiring).

The patch panels are then bonded together using appropriately sized earthing wire terminated with ring connectors or spade terminals and then bonded to the main rack earthing key (See graphic 17).

The Aginode recommended size of conductor for this purpose is 2.5 mm². Some proprietary copper strips that run the vertical length of the rack are available in the industry. This allows for a push on blade terminals and short length of earthing wire premade with a ring terminal to connect to the panel grounding screw.

The first and last panels shall have individual links back to cabinet earthing key. This ensures that should any one panel be disconnected the remaining panels remain bonded.



Not required when using Aginode LANmark panels and Aginode cabinets

Note: Always verify panel earthing facilities prior to installation as some panels may differ

Graphic 17

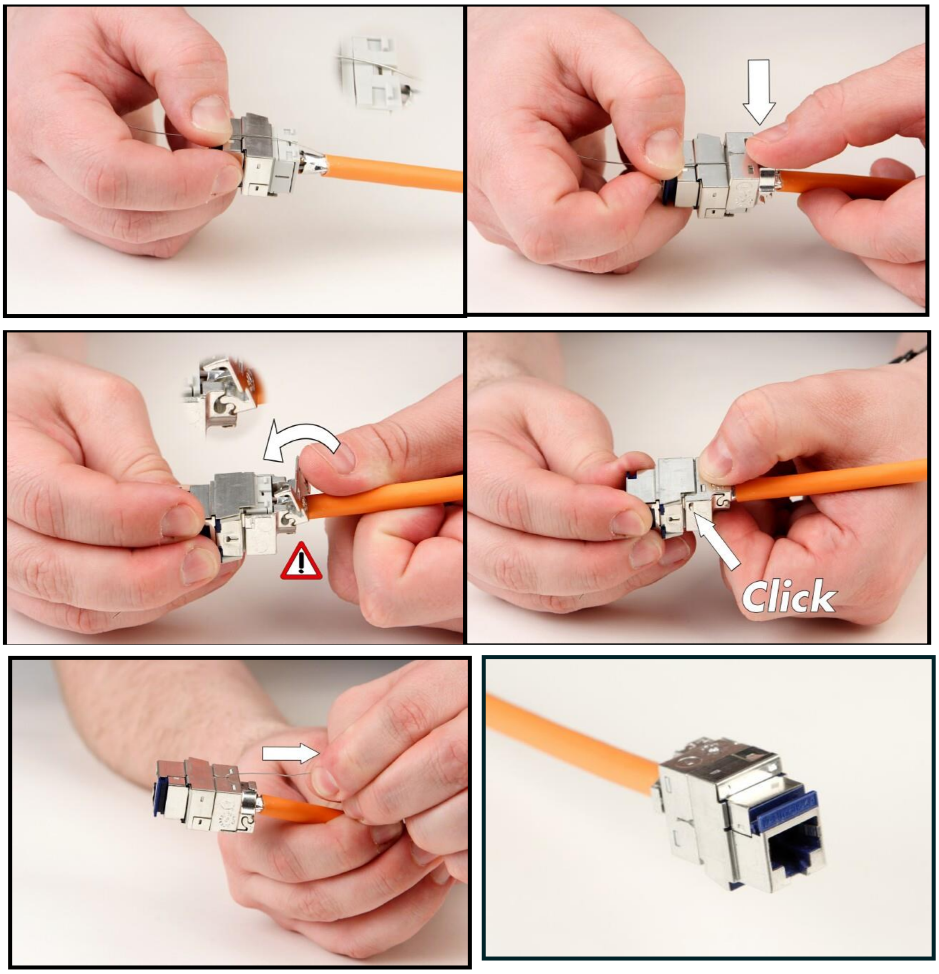
5.5 Additional requirements for screened / shielded cabling systems

Aginode screened / shielded cables are differentiated from U/UTP cables by the provision of an overall foil screen around the core of 4 twisted pairs (F/UTP). In some cable variants this is supplemented by the provision of an additional overall braid (SF/UTP series cables) or even individually screened pairs (S/FTP – PIMF - series cables).

Connectors also have to be screened.

Here lies the only additional requirement for earthing of Aginode LANmark screened cabling systems:

The screen of the cable has to be connected to the screen of the connector during the termination process.



Bonding (Safety) is ensured by the connection of the drain wire and grounding (EMC performance) is realised by the rear cover ensuring a true 360° EMI protection around the cable.

The rear cover of our LANmark EVO series connector (Cat.5e, Cat.6 & Cat.6A) is easily installed in just a few seconds.

The bonding of the connector screen within the Aginode LANmark copper patch panels is also automatically performed when inserting the snap-in EVO connector into the patch panel.

The screened cabling system is now safely bonded to the main earth through the patch panel, the cabinet frame and its earthing key.

Automatic earthing system (Clip-on)

The "screen" or "shield" gives increased immunity from external EMI & RFI and reduces emissions from the system.

The most important factors when installing a shielded system are the maintenance of screen integrity throughout the system and the correct bonding of the screen to allow effective discharge of any induced voltages to earth.

- The maintenance of screen integrity is a function of good system design and is therefore primarily the responsibility of the manufacturer. However, adherence to correct installation practices will avoid compromising screen integrity and effecting system performance with regard to emissions and immunity.
- Bonding of the screen in the correct manner is the responsibility of the installation contractor and must be carried out in accordance with the installation guidelines.

6 Conclusion

Protective Earthing requirement applies to unshielded, shielded and fibre optic cabling systems alike. All metal parts regardless of the type of cabling must be earthed for personnel safety reasons and to avoid potential damage to equipment.

Functional earthing requirement applies to shielded system only. But the only additional operation to be performed is to connect the screen of the connector to the screen of the cable during the termination process on site.

Bonding of the connector screen with the patch panel and of the patch panel with the cabinet are automatically performed when using Aginode cabling systems.

The additional cost linked to the implementation of a screened Aginode LANmark cabling system is negligible

- Low project price variation for the screened cable and connectors
- Just a few additional seconds to terminate the screened connector on site

Screened cabling brings valuable EMC performance improvement against unscreened systems:

Shielding effectiveness is of particular importance where 10G Ethernet is concerned. Screened or shielded cabling is immune to alien crosstalk transmitted from adjacent cables with the result that the installed system is able to meet the A-XT requirement by design.

Screened cabling, when grounded at both ends, is a minimum 40dB of magnitude better i.e. less susceptible to picking up RFI from external sources than unshielded cabling.

It is also interesting to note that screened cabling when left ungrounded at both ends still performs better by a minimum of 20dB of magnitude over unscreened cabling.

Disclaimer

This document is a guideline only. International and local procedures and safety standards for earthing and grounding must be observed and followed at all times.

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