TTE Training Ltd.

Phase 2
Electrical Course Notes

E2-CN-005

Cable Termination Techniques

Cable Termination

Methods:

There are a variety of termination methods for cable. The termination method utilised depends basically on the system installed, type of cable used and type of connector. Using the proper termination method allows for good mechanical and electrical integrity. No matter what type of termination you will be performing, the most important thing is to use the proper tools and materials for the type of termination. For example, a crimp using pliers will work, but using a crimp tool and the proper die designed for your type of cable and connector is better. This is just to provide some general guidelines. The termination method may vary somewhat based on system requirements and connector manufacture design methods.

Preparation:

Making careful preparations before cable termination takes place will ensure that the job is done properly and will save you time and money from the onset.
Begin by determining where the termination point is located. If unknown, make sure each cable will reach the farthest point in the wiring panel equipment room. Next, route the cables to this area making sure the cable length is correct as well as labeling each cable as you go so you can identify it later. Then form and dress the cable by ensuring that all cables are parallel to each other, shaping them into neat bundles using hand tightened cable ties or hook & loop wraps. If a cable is too long, make sure to remark the newly created end the same as before. Once the termination area is set up, use the proper cable management hardware to act as the support and relief. This is important since some cables have specific minimum bend radius requirements. Knowing this will protect the integrity of the cable being installed.

Cable Definition:

One or more conductors provided with insulation. The insulated conductor(s) may be provided with an overall covering to give mechanical protection.

Construction: A cable consists of three parts. See Figure 1:

Conductor
Insulation
Sheath (Mechanical Protection)

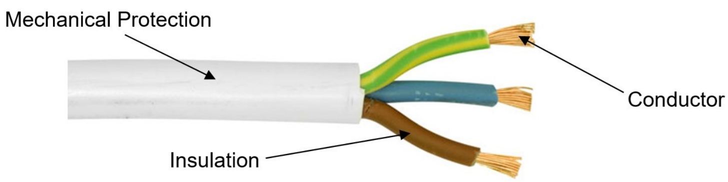


Figure 1

The most common conductor material used is Copper. Aluminum is used for larger cables and its use is not normally used in domestic installations.

The most common insulation used is PVC. Other materials are used as insulation depending on what the cable is being used for and where it is being installed.

The most common mechanical protection used is PVC. Further protection is provided by installing cables in locations where they are unlikely to be damaged. Where this is not possible, cables must be installed in conduit, trunking or ducting. Otherwise a suitably armoured cable must be used. When cables are installed in conduit or trunking they need not have any other form of mechanical protection. The conduit or trunking is deemed to be its mechanical protection.

Cables are manufactured in a range of common sizes. These are decided by the Cross-Sectional-Area (CSA) of the conductor, which is specified in square millimeters (mm^2).

The following page shows a list of the standard sizes used in domestic installations.

Cross Sectional Area:

The cross-sectional-area is the surface area of a section of conductor.

1.5 mm^2 – 2.5 mm^2 – 4 mm^2 – 6 mm^2 – 10 mm^2 – 16 mm^2

A single-phase cable insulation is colour coded as follows:

Phase (Live) – Brown

Neutral – Blue

Earth – Green / Yellow

In the cable most commonly used for domestic installations, there is a bare earth conductor, and this must be terminated using Green / Yellow sleeving.

Cables are manufactured with solid, stranded or flexible cores.

Solid cores are used for the small cable sizes where the wiring is fixed.

Stranded cores are used for the larger cable sizes and where more flexibility is required, e.g. where cables are installed in conduit or trunking systems.
The number of strands is normally 7, 19 or 27 per core.

Flexible cords are used where extra flexibility is required,
e.g. pendants, immersion heaters and leads for portable and hand-held equipment. The number of strands is normally 16, 24, 32, 36, 40 or 50 per core.

These flexible cords when used as leads for portable and hand-held equipment must be provided with an overall covering for mechanical protection.

Flexible Cord Definition

“A flexible cable in which the CSA of the conductors does not exceed 4 mm^2.”

Flexible cords are manufactured in standard sizes as follows:

0.5 mm^2 – 0.75 mm^2 – 1.0 mm^2 – 1.25 mm^2 – 1.5 mm^2 – 2.5 mm^2 – 4 mm^2

Larger flexible conductors are known as flexible cables.

Single Core Circular Cables:

PVC Insulated – Unsheathed solid or stranded copper conductor with PVC insulation.

e.g. 1.5 mm2 PVC Brown. See Figure 2.

Applications: Installations where drawn into conduit or trunking.

Sizes: 1.5, 2.5, 4, 6, 10, 16 mm^2

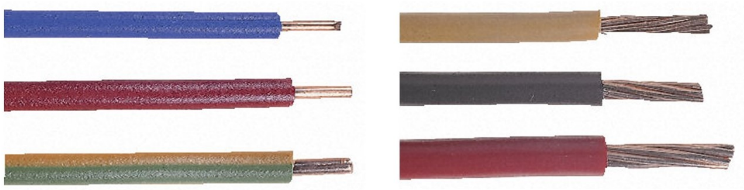


Figure 2.

Multicore Flat Cables:

Twin-Core with Circuit Protective Conductor PVC Insulated PVC Sheathed
Two copper conductors, PVC insulated, laid parallel and surrounded by PVC sheath to give a flat finish. An uninsulated protective conductor is laid in the centre.

e.g. 1.5 mm^2 Twin Brown / Blue and Earth. See Figure 3.

Applications: As for single core PVC / PVC, especially suited to three-plate ceiling rose method of wiring. Also used for wiring socket outlets etc.

Sizes: 1.5 2.5 4 6 10 16 mm^2.

Figure 3.

Round Flexible Cords:

PVC Insulated PVC Sheathed
PVC insulated flexible copper conductor with PVC sheath forming a round cord. Available in two, three, four and five cores.

e.g. 3 x 1. 5 mm^2, PVC circular flex. See Figure 4.

Applications: General-purpose flexible cord for pendants, portable tools and appliances. Should not be used where sheath can meet hot surfaces.

Sizes: 0.5 0.75 1.0 1.25 1.5 2.5 4 mm^2.

Figure 4.

SY, YY Power and Control Cables:

PVC Insulated PVC Sheathed Screened (SY) or Unscreened (YY)
PVC insulated flexible copper conductor with inner PVC sheath and or outer screening and or clear PVC sheath forming a round cable.
Available in a variety of cores.

e.g. 5 x 1. 0 mm^2 SY, and 25 x 0.5 mm^2 YY See Figure 5.

Applications: Power and control cables used mainly in industrial automation.

Sizes: 0.5 0.75 1.0 1.25 1.5 2.5mm^2.

Figure 5.

Steel Wire Armoured (SWA) Power Cables:

PVC Insulated PVC Sheathed Steel Wire Armoured
XLPE insulated flexible copper conductor with inner PVC bedding and outer steel wire armour with PVC sheath forming a round cable.
Available in two, three, four and five cores.

e.g. 5 x 1. 5 mm^2 See Figure 6.

Applications: Power and sub mains cables used mainly in industrial power installations.

Sizes: 1.5 to 400mm^2.

Figure 6.

Compression Glands:

Cable glands come in a variety of types and designs, but we will look at the most common types used.

PVC:

These fit directly onto the cables outer sheath by the tightening of the back nut which comprises a compression seal to grip the cable sheath.
Manufactured in different entry sizes of M12, M16, M20, M25, M32, M40, M50, M63 see Figure 7.

Figure 7.

SY YY:

These fit directly onto the cables outer sheath by the tightening of the back nut which comprises a compression seal to grip the cable sheath, they may also have a slotted entry to accommodate and terminate the braided screen. Manufactured in different entry sizes of M20, M25, M32, M40, M50 see Figure 8.

Figure 8.

SWA:

The BW gland is an (indoor only) general purpose gland that fits directly onto the cables steel wire by the tightening of the back nut on to the gland body where the steel terminates between the nut chamfer and body cone, completed by covering with an outer shroud to protect it. The CW is an indoor/outdoor gland that incorporates a waterproof seal in the back nut to prevent water ingress plus a cone and ring assembly to terminate the steel wire. The EX gland is a specialist gasproof gland for use in flammable atmospheres and again terminates the steel wire internally between a cone and ring. Manufactured in different entry sizes of M20, M25, M32, M40, M50, M63 see Figure 9.

BW CW EX

Figure 9.

Terminals, Clamps and Lugs:

There are a wide variety of conductor terminals. Typical types are as shown in Figure 10.

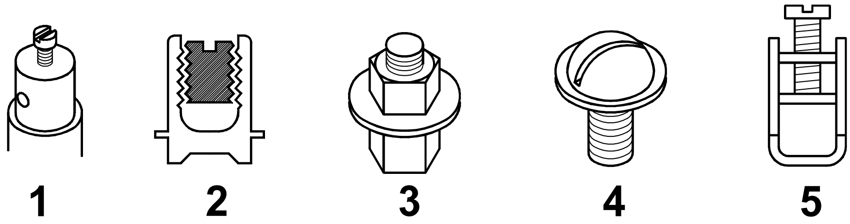


Figure 10.

The screw terminal (**1**) will be found in various accessories such as, lamp holders, batten holders and plug tops used in domestic premises. A shrouded version of this terminal is probably the most commonly used type. It will be found in switches, sockets, ceiling roses and consumer units.

The split terminal (**2**) will be used in joint boxes to enable joints to be made without having to cut conductors.

The post terminal (**3**) will be used mainly to make connections to earth and in such places as the mains connection to an electric cooker or an electric motor.

The screwhead terminal (**4**) will also be mainly used to make connections to earth and is also very popular in older fuse boards.

The clamp terminal (**5**) is now in common use in main switches, MCB's, RCD's and RCBO's and even DIN terminals Figure 11.

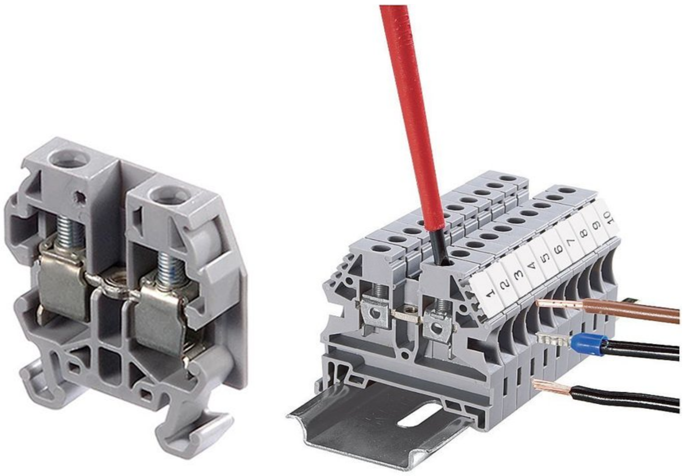


Figure 11.

Use of Hand Tools:

An engineer can often be judged by their appearance and by the tool kit with which they carry out their work. Clothing should be neat and tidy and kept in this manner by using an overall when necessary. Tool kits should contain all the necessary equipment to do the work correctly and efficiently.

Combination Pliers:

These have serrated jaws and are used for gripping, twisting and bending conductors. They also have a curved section, serrated for gripping round metal items. A wire cutter is also provided. See Figure 12.

Figure 12.

Long Nose Pliers:

These are used for fine work where the electrician’s pliers are too large and for guiding conductors into terminals etc. They are available with additional features such as small lug crimpers. See Figure 13.

Figure 13.

Side Cutters:

Commonly referred to as “snips”, these are used to cut small cables and conductors, and to trim insulation. See Figure 14.

Figure 14.

Wire Strippers:

These are used to strip insulation from conductors. The adjusting screw should be used to prevent damage to the inner conductor. See Figure 15.

Figure 15

Automatic Wire Strippers:

Another form of wire stripper is the automatic wire stripper. See Figure 16. This tool is designed to remove insulation from a range of conductor sizes.

Figure 16.

Jokari Knives:

These are a type of safety knife See Figure 17. Designed to remove the outer sheath of the cable by utilizing a small blade which can be rotated thru 90^0 to score down the cable sheath making it easier to remove, the blade depth is fully adjustable.

Figure 17.

Junior Hacksaw:

This is used to cut the larger size cables where the side cutters cannot, also used to cut mini trunking and openings in surface boxes for cable entry and to score the SWA strands during cable preparation.

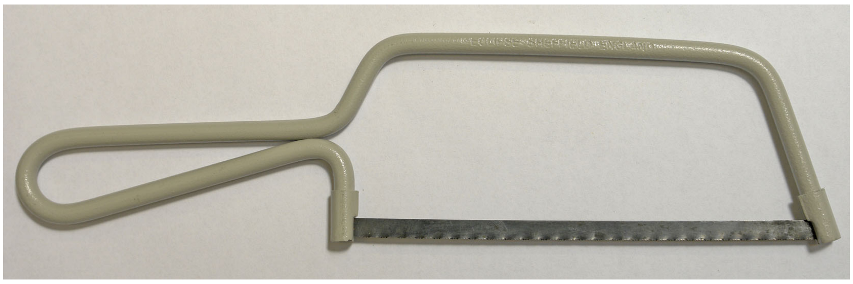


Figure 18.

Crimping:

The lug terminal comes in an extremely wide variety of shapes and sizes. They may be bare or insulated. Methods of connecting to the cable vary as follows:
Ferrules, which are used on flexible cables to prevent the strands from spreading out and are then connected using a screw or clamp terminal.
Large power cables where the lug is compressed onto the cable using a hydraulic type crimp tool. The lug is then connected to a post or screwhead terminal.

A crimp type connection allows for quick and simple installation while still maintaining a mechanical and electrical connection close to a solder type termination. Solid or stranded wire can be used in this type of termination.
Some of the key points to remember for a good clean connection are as follows:

1. Make sure you use the proper size connector for the type of cable you are using.
2. Make sure all your cuts and stripping are clean.
3. Avoid nicks as much as possible.
4. Use the proper crimp tool; don't try to improvise with pliers, etc.

The most common crimp method involves two compressions, one on the insulation for a strong mechanical connection and one on the conductor or shielding for a good electrical connection. A crimp tool is designed specifically for this type of termination for the type of connector you are using. This allows for good connections both mechanical and electrical. Using pliers will allow connection. However, it may not be a solid mechanical or electrical connection and can cause the connector to eventually come loose and intermittent problems with the electrical signal can occur.

Note: Use a ratcheting crimper for all terminations, this will help ensure consistency and eliminate over and under crimping and reduce hand stress.

Types of crimp terminations:

The crimp terminals shown are three most common sizes used for panel wiring and small motor connections the Ferrule colour indicates the conductor size.

Red $0.25mm^2$ - $1.5mm^2$

Blue $1.1mm^2$ - $2.5mm^2$

Yellow $2.7mm^2$ - $6.0mm^2$

Female spade

piggyback

fully insulated

pin

Blade

Fork

Ring

Crimps are available in a vast array of shapes and sizes and so too are the crimping tools for each crimp type, from hand crimps, which can accommodate the smallest cables and up to 35mm, to hydraulic crimpers, which are needed for heavy power cables.

Un-insulated crimps

Bootlace ferrules

Hydraulic crimp
(range 35mm to 400mm)

A typical crimp kit containing a selection of the most used crimps

Cable preparation:

Strip the insulation off the end of the wire, making the exposed portion just a little longer than the metal portion of your crimp connector. If you are crimping stranded wire, twist the strands together with your fingers or pliers to make them easier to insert into the connector. Insert the bare wire end into the connector, making sure that it is contacting the metal portion, and only insulated wire is showing outside the connector.

Matching the colour on the crimping tool to the colour of the connector, place the connector in the tool, and squeeze hard. Depending on the length of the connector, you may be able to do this in several places to ensure that you have made a good connection. With larger uninsulated lugs you can wrap the end of the cable and the crimped area of connection with electrical tape for added security.

Soldering:

A procedure in which two or more metal products are fixed as one by melting and running a space filler metal (Solder) in the joint. The space filler metal has a lower melting temperature than the work piece. Soldering is applied in electrics, electronics, plumbing and metalwork from flashing to ornaments. The Solder itself is an alloy (combination of two or more metals) each selected to provide a low melting point and mechanical strength. Early common Solder alloys were made from a ratio 60% - 40% Tin to Lead as Lead has a sufficiently low melting point (typical 190^{0}C) with the Tin providing the tensile strength required to secure a joint mechanically. In recent times a Lead-free solder has been introduced (alloy of Tin, Silver and Copper) to dispense with the toxic elements contained within Leaded solder but the melting point increases (220^{0}C typical). Solders containing Lead are still available and often preferred where there is a controlled exposure time.

Leaded Solder

Lead Free Solder

Flux:

The centre cores of these wire forms of solder, contain a de-oxidising or cleaning agent known as Flux. This helps the solder to adhere to the surface of the metals being joined, by removing any surface impurities caused by moisture in the air. In a common wire type solder the Flux is a resin-based product called Rosin. When the solder is heated to its molten state the Flux turns to a liquid and cleans the two surfaces to be joined, giving off a whitish grey smoke which is not toxic but can cause eye irritation and headaches if Soldering for a prolonged length of time. Therefore, it is always desirable to carry out Soldering tasks in a well vented area or open space, if this is not possible then some sort of fume extraction system should be made available.

Iron

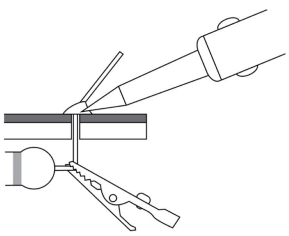
Gun

Soldering Tools:

The most common electrical/electronic Soldering tool is the Soldering Iron or Gun, and these are available in a wide range of types, operating voltages and power ratings. Some come with interchangeable tips designed for the type of Soldering work being performed, and there are even gas versions available.

Soldered Joints:

When making a soldered joint it is important to use the correct methods and to limit the contact time the soldering iron has on the materials involved. For instance, small electronic components can be damaged by the heat produced by the iron and you made need to make use of freezer sprays, heat sinks or thermal shunts.



Crocodile clip as Heat Sinking Tool

Tinning and Joining:

Tinning is the process of pre-coating the terminal or wire and component with a thin film of solder to help both items being joined adhere together a lot easier.

Tinned Wire

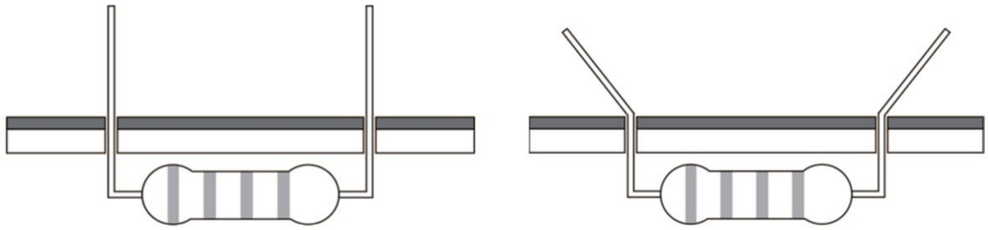
The types of joint made will differ according to the component type, wire type, tooling, even terminal type. Simple discrete components such as Transistors, Resistors, Capacitors, Diodes etc. can be PCB mounted and may need to be replaced easily, therefore a simple push through printed circuit board connection will suffice, but ideally should be attached in a way that they are strong enough and of good quality to prevent a dry joint (joint moving while solder is still solidifying or dirty soldering iron tips) identifiable as a dull flakey metallic look as opposed to a good joint which tends to be a little brighter in appearance.

Dry Joint Good Joint

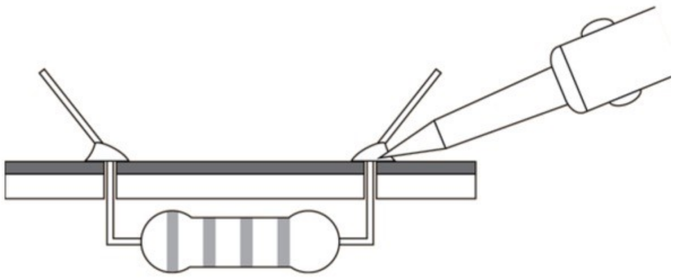
The dry joint will cause a high resistance and can prevent the circuit from performing correctly, keep iron tips clean by frequently wiping the tip on a damp sponge, normally part of the soldering iron stand.

Mounting Components:

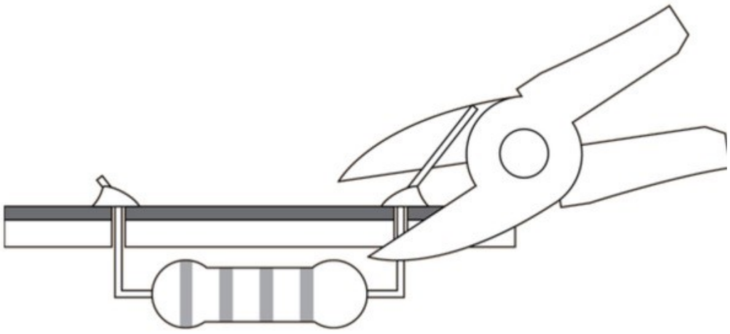
Depending on the terminal type, if using a PCB then the best way to join is as follows: -



Place the component centrally between the required holes in the printed circuit board and bend to a slight angle to hold in place, too acute an angle makes it too difficult to replace.



Apply just enough solder to secure the component in place. Then cut off the excess wire using a pair of side cutters.



De-soldering:

As well as joining wires and components there may be a need to replace soldered connections and there are a variety of tools available to do this and examples of some are shown below.

Typical Solder sucker or de-soldering tool

Also available are braided copper tapes that act like a sponge to the molten solder, soaking up excess solder as required.

As with all tools they will last longer and perform better if they are looked after, kept clean and put back where they belong when finished with. Always carry out an inspection before use to check the condition of your tools and equipment this is vitally important for electrical tools to ensure they always remain safe to use.