Department of Electrical Engineering

Summer Training

1. Electrical Supply

Figure 1 shows the local electricity supply from the sub-station to the consumer end. The voltage is stepped down from 11kV to 400V at the transformer in the sub-station. The 400V line-to-line is supplied to the consumer as a 3-phase supply or as a 230V 1-phase supply.

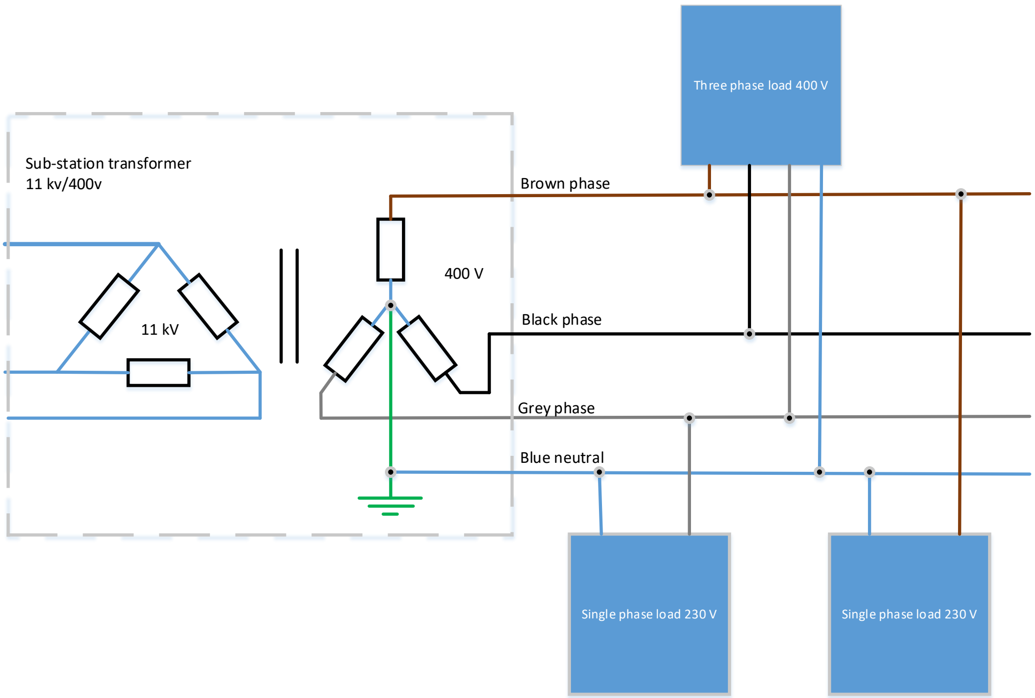

Figure 1: Electrical Supply - From Sub-Station to Consumer End

2. The TT System

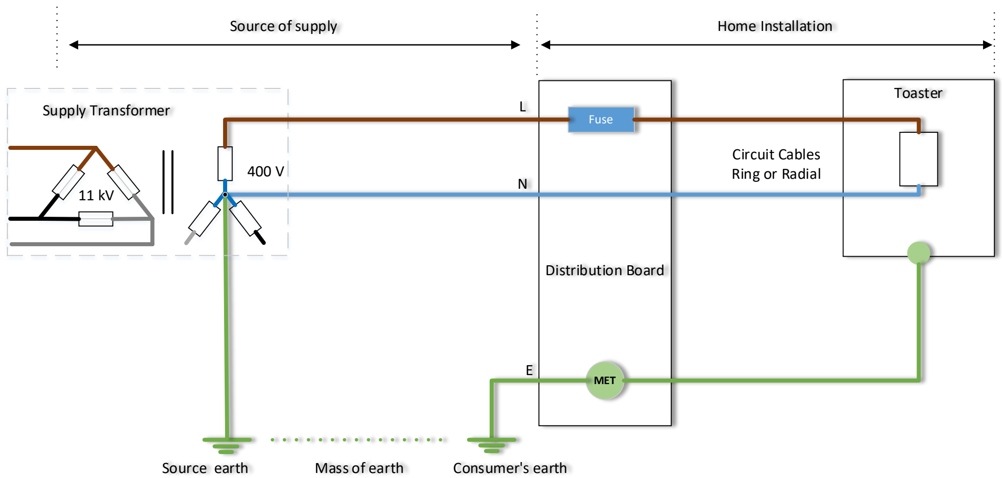

Figure 2: TT Supply System

Figure 2 shows the TT (Tera-Tera) supply system. The first letter indicates the type of supply earthing, with T indicating that one or more points of the supply system is/are directly earthed, like an earthed neutral at the transformer. The second letter indicates the earthing arrangement in the installation, with T indicating that all exposed conductive metal is connected to earth.

The TT supply system is the supply system used locally. In the TT system the earth terminal is not provided by the electricity supply company. The neutral and earth (protective) conductors are kept separate throughout the installation, with the final earth terminal connected to an earth electrode by means of an earthing conductor. The whole installation must be protected by a residual current device (RCD) with an operating current of 30mA and tripping time of not more than 200ms. The neutral conductor is then connected to earth at the transformer at the sub-station.

Figure 3 shows the path of the earth fault current in case of a fault to earth. Connecting the metal housing or metal work that is not intended to carry current to earth will provide a path to earth for the current in case of a fault, caused by an extraneous or exposed conductive part. In this way the fault current can be detected by an RCD situated in the consumer unit which will cut the supply and thus remove the electrocution danger.

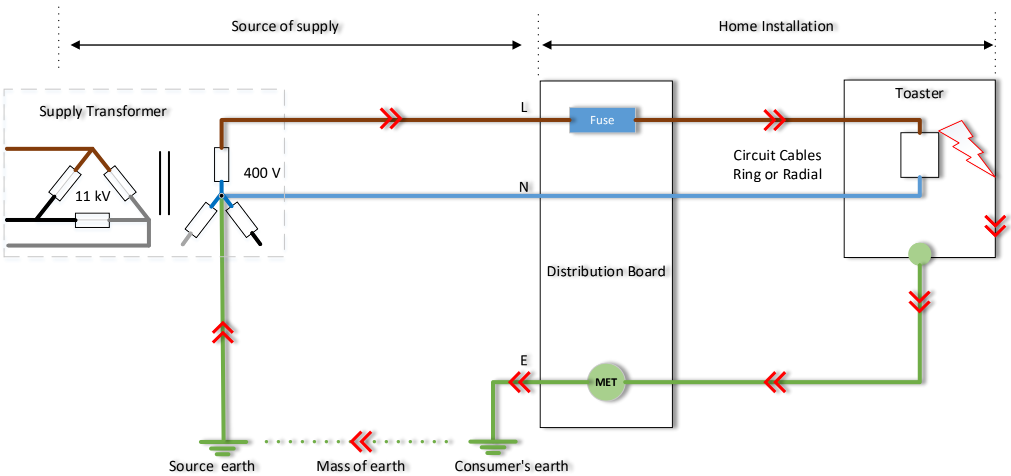

Figure 3: Earth Fault Current Path

3. Distribution Board Wiring

Electrical installations must follow the IET wiring regulations. These regulation are published as the British Standard BS7671:2018 Requirements for Electrical Installations - IET Wiring Regulations 18th Edition.
Figure 4 shows a line representation of the wiring diagram of a typical domestic distribution board (DB). Electrical supply is provided by the service provider through a service fuse and the electricity meter. This is followed by the main circuit breaker, surge protection, over/under voltage protection, and the residual current device (RCD). From there supply is provided to the various circuits for power and lighting, through miniature circuit breakers (MCBs). The wiring between the main circuit breaker, surge protection, over/under voltage protection, RCD, and MCBs should be at least $10mm^2$. In cases the individual MCBs are linked together using an appropriate bus bar which supplies the live to each MCB. Each circuit should be protected by an MCB, connected on the live wire. The MCBs should be sized according to the wire within each circuit. For protection, the wire should be sized to withstand higher current than the size of the MCB. If current higher than the MCB rating flows through the MCB, the MCB trips protecting the circuit wires, preventing a potential fire, caused be heating up of the wires.

As can be observed from figure 4, the neutral wire after the RCD is connected to the neutral bar. The neutral wire for each individual circuit will be connected to this bar. Another bar in the DB is the earth bar, called the main earthing terminal (MET), connecting all earth wires from the individual circuits with the earth electrode. The earth wire between the MET and the electrode should be sized as $16mm^2$ when the wire is protected against corrosion and $25mm^2$ if not protected.

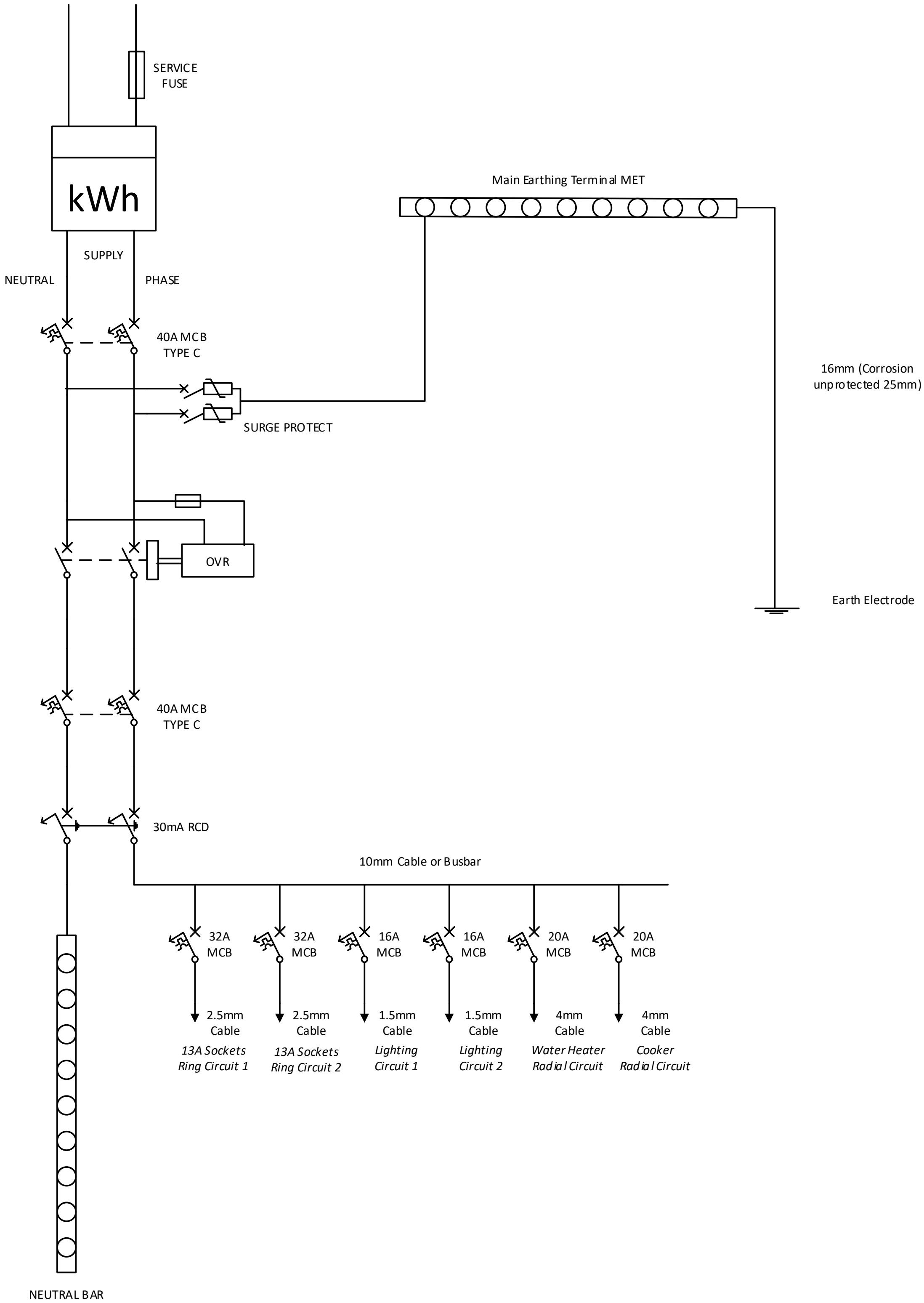

Figure 4: Line Diagram of a Typical Domestic Distribution Board

4. Power Circuits - Ring and Radial Circuits

Figure 5 shows a ring power circuit. A ring final circuit starts and finishes at the distribution board, where it is connected to a 30 A or 32 A overcurrent protective device. For domestic installations the floor area served by each ring circuit must not exceed 100 m². Ring circuits in commercial or industrial environment must take into consideration the maximum current demand so that the rating of the protective device is not exceeded. The cable size for standard ring power circuits is 2.5 mm² when using PVC insulated cable.

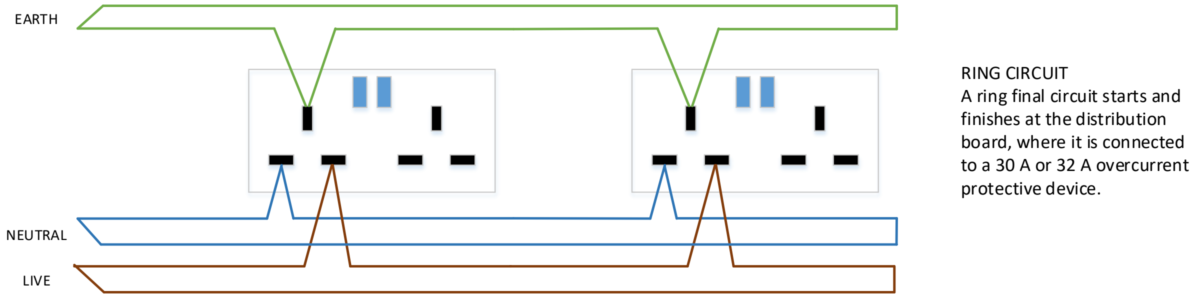

Figure 5: Ring Power Circuit

Figure 6 shows a radial power circuit. A radial final circuit starts at the distribution board, where it is connected to an overcurrent protective device. The amount of sockets on a radial circuit is not specified in the installation regulations, however this will be constrained by load and diversity. Radial power circuits can be installed using a 32 A MCB (or cartridge fuse to BS88 in rare cases) when using 4mm² sized cables, to supply a floor area no greater than 75m². Radial power circuits can also be installed using a 20 A MCB (or BS88 fuse in rare cases) when using 2.5 mm² sized cables, to supply a floor area of not more than 50m².

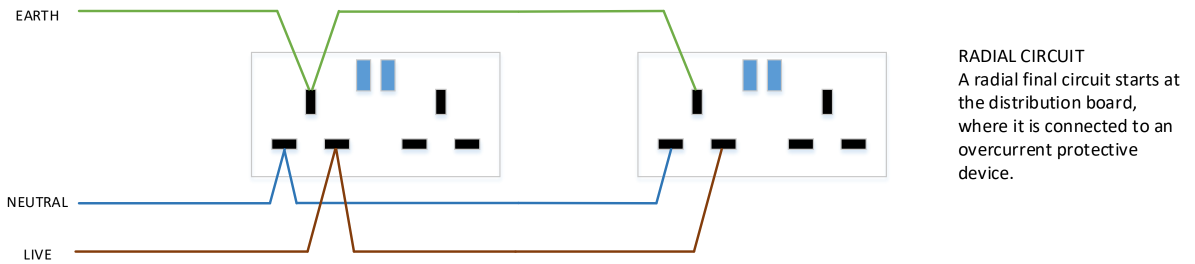

Figure 6: Radial Power Circuit

Figure 7 shows another ring power circuit, however it includes a Spur, which is a branch from a ring or radial final. A spur can be unfused or fused. An unfused spur should feed one single or one twin socket-outlet only. An unfused spur may be connected to the origin of the circuit in the distribution board. On the other hand, a fused spur, which is supplied using a Fused Switch Unit (FCU) can feed a number of socket-outlets, depending upon the load characteristics, taking into consideration load and diversity into account.

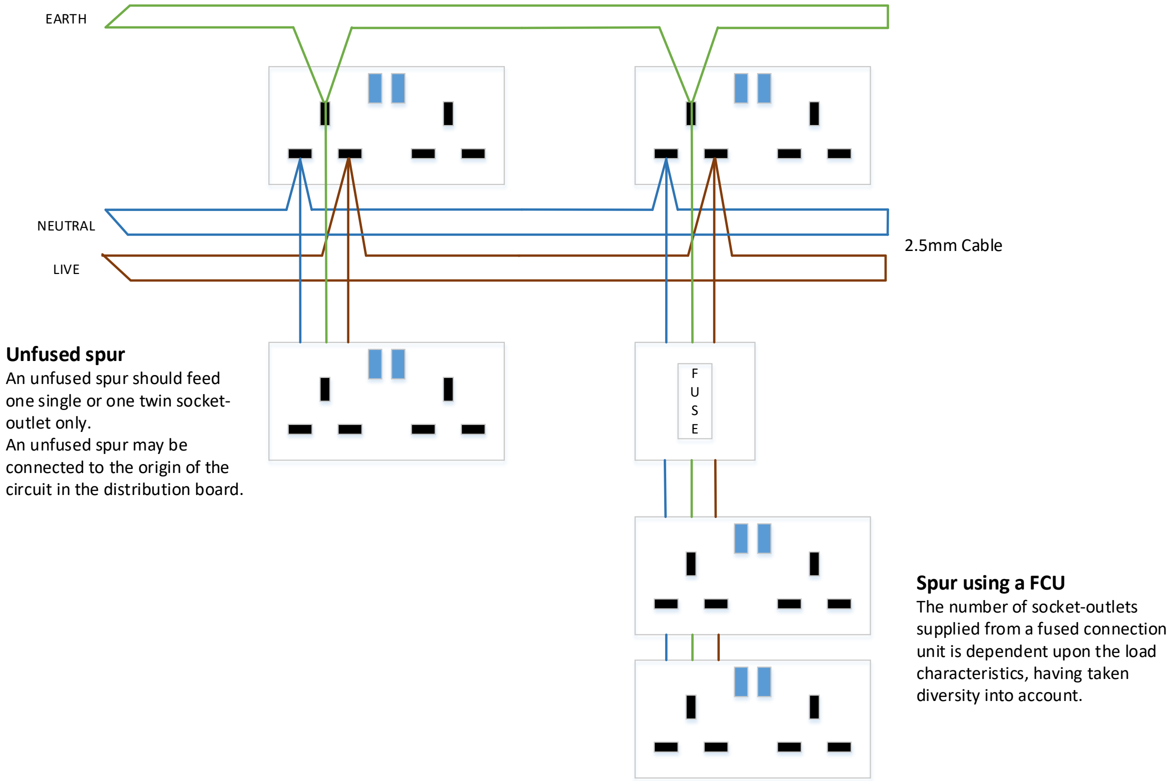

Figure 7: Ring Power Circuit with Spur

5. Lighting Circuits

Lighting circuits are used to control lamps, tubes, and any kind of luminaire. Lighting circuits starts at the distribution board with an overcurrent protection device, generally a MCB rated at 10A or 16A, and using a 1.5mm^s cable. Figure 8 shows a basic lighting circuit containing only a switch and a bulb. Figure 9 shows multiple bulbs or luminaires connected to the same lighting circuit.

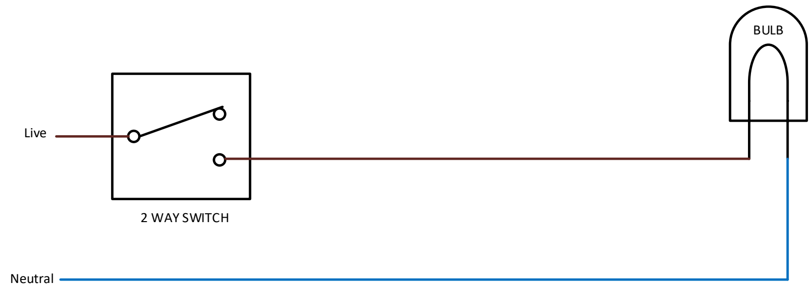

Figure 8: Basic Lighting Circuit

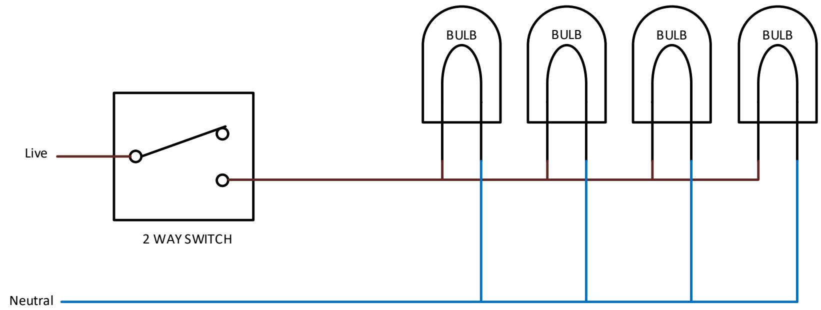

Figure 9: Lighting Circuit with Multiple Bulbs

Figure 10 shows a two way switching lighting circuit. With this circuit the luminaire can be switch on/off using two switches. This circuit is used in corridors, stairs, and in rooms where it is convenient to switch on/off from the opposite ends.

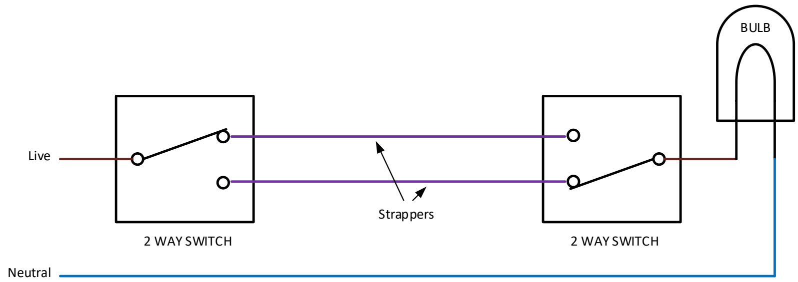

Figure 10: Two Way Switching Lighting Circuit

Figure 11 shows a two way switching lighting circuit with an intermediate switch. This circuit is used when switching from more than two positions is needed.

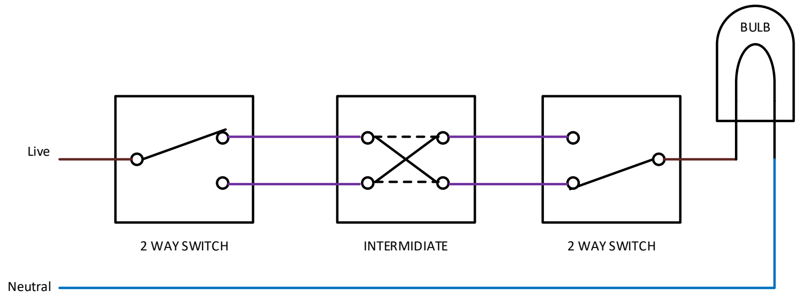

Figure 11: Two Way Switching Lighting Circuit with Intermediate Switch

6. Distribution Board Devices

Figures 12 to 16 show the various common types of devices found in a domestic distribution board.

Figures 12 and 13 show Double and Single Pole Miniature Circuit Breakers (MCB). The double pole version cuts both live and neutral, while the single pole only cuts the live wire. An MCB protects against overcurrent. There are several different types of MCBs – types A, B, C, D, K, and Z. However, the most common and widely used versions are the types B, C, and D. Each type of MCB has a different response to overcurrent, according to different trip curves. The variations are generally known as the tripping characteristics or overcurrent characteristics.
Type B MCBs are the most sensitive, used for domestic applications and low voltage commercial installations where any current surges are likely to be small. Type B MCBs are designed to trip if the current flowing through them goes up to between three and five times the recommended maximum or rated value.
Type C MCBs are used where higher current surges are likely to occur, like with small electric motors and fluorescent lighting. Type C MCBs are designed to trip at currents between five and ten times their rated value.
Type D MCBs are used where very strong current surges occasionally occur, like with commercial and industrial devices, such as welding equipment, large motors, uninterruptible power supply units, and X-ray machines. D-type MCBs are the least sensitive type, tripping when current goes up to between ten and twenty times the rated value.

Figure 14 shows a Residual Current Device (RCD) or a Residual Current Circuit Breaker (RCCB). The RCD offers protection against current leakage to earth, faults to earth, and electrical shock. Figure 15 shows a Residual Current Circuit Breaker with integral overcurrent protection (RCBO) is a device that incorporates both an RCD and an MCB, thus offering both protection against current leakage to earth and overcurrent.

Figure 16 shows an over/under voltage protection device (OVR). The OVR monitors the supply voltage and switches off the supply to the circuits if the supply voltage goes over or under s specific value. This protects the equipment and appliances connected to the circuits. The OVR works in conjunction with a contactor to switch off/on the supply to the circuits. Figure 17 shows a typical contactor used or this application. The OVR and the contactor can be found as separate devices or combined as a single device.

Figure 18 shows a Surge protective device. This device is intended to limit transient overvoltages and divert surge currents. Surges can originate from the electrical utility company during switching of switchgear, and also from lightning. Surges can also occur during switching of large loads, like electrical motors.

Figure 12: Double Pole MCB

Figure 13: Single Pole MCB

Figure 14: RCD

Figure 15: RCBO


Figure 16: Over/Under Voltage Trip OVR

Figure 17: Contactor

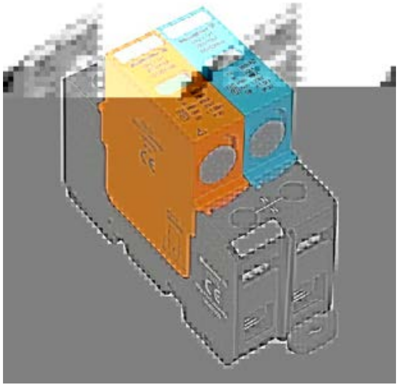

Figure 18: Surge Protection Device

7. Earth Electrode

Figure 19 shows a representation of an earth electrode installation. A hole of diameter not less than 30mm and depth 2m is drilled into the ground where the soil is likely to be most compacted. A copper earth rod of diameter 10mm and length 2m is placed in the hole which is filled with bentonite. Water is added so that it can expand and thus ensure a better contact with the general mass of earth. An earth clamp if fitted on to the earth rod for the connection to the earthing conductor. This connection must be labelled "safety electrical connection do not remove." The connection is housed in an inspection box.

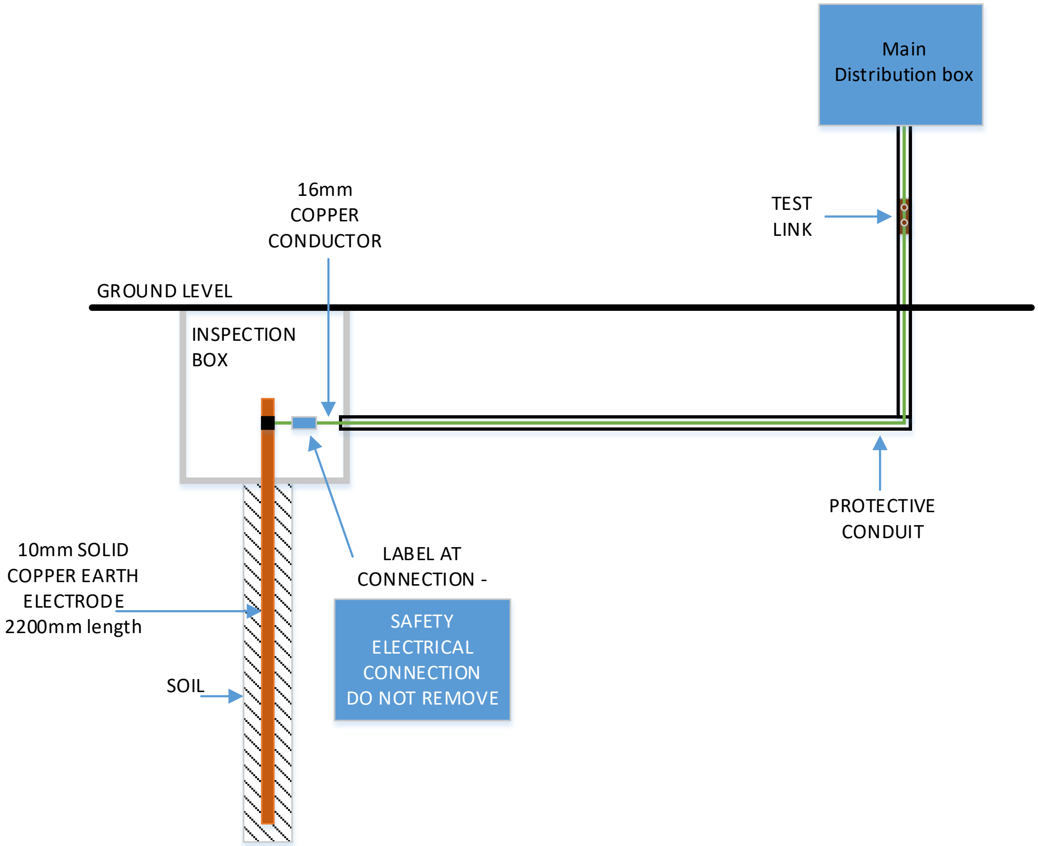

Figure 19: Earth Electrode Installation