Lecture 5: Electrical Supply and Distribution

5.1 Single Phase Electric Power

There is only one phase, i.e. the current flows through only one wire and there is one return path called neutral line to complete the circuit. Single-phase comes to the home with two wires: active and neutral. The neutral wire is connected to earth (water pipe, earth stake, etc.) at the switchboard. Single-phase distribution is used when loads are mostly lighting and heating, with few large electric motors.

Single-phase power is:

- Able to supply ample power for smaller customers, including homes and small, non-industrial businesses.
- Adequate for running motors up to about 10kw; a single-phase motor draws significantly more current than the equivalent 3-phase motor, making 3-phase power a more efficient choice for industrial applications.

5.2 Three Phase Electric Power

It is the Polyphase system where three phases are send together from the generator to the load. Each phase are having a phase difference of 120°, i.e. 120° angle electrically. Therefore, from the total of 360°, three phases are equally divided into 120° each. The power in three-phase system is continuous as all the three phases are involved in generating the total power. Three-phase has four wires: three actives (called phases) and one neutral. The neutral wire is earthed at the switchboard.

3-phase power is:

- Common in large businesses, as well as industry and manufacturing. Large domestic installations sometimes have three-phase because it distributes the total load in a way that ensures that the current in each phase is lower.
- Allows for smaller, less expensive wiring and lower voltages, making it safer and less expensive to run.
- Highly efficient for equipment designed to run on 3-phase.

For easy identification, each phase cable has colour coded plastic insulation of brown (red), black (yellow) or grey (blue). The neutral is colour coded blue (black).

5.3 Private Sub-station/transformer

A sub-station is required for the conversion, transformation and control of electrical power. It is used where large buildings or complexes of buildings require greater power than the standard low or medium potential of 230 and 400 volts. A sub-station must be constructed on the customer's premises. It is supplied by high voltage cables from the electricity authority's nearest switching station.

The requirements for a sub-station depend upon the number and size of transformers and switchgear.

A transformer is two electric windings, magnetically interlinked by an iron core. An alternating electromotive force applied to one of the windings produces an electromagnetic induction corresponding to an electromotive force in the other winding.

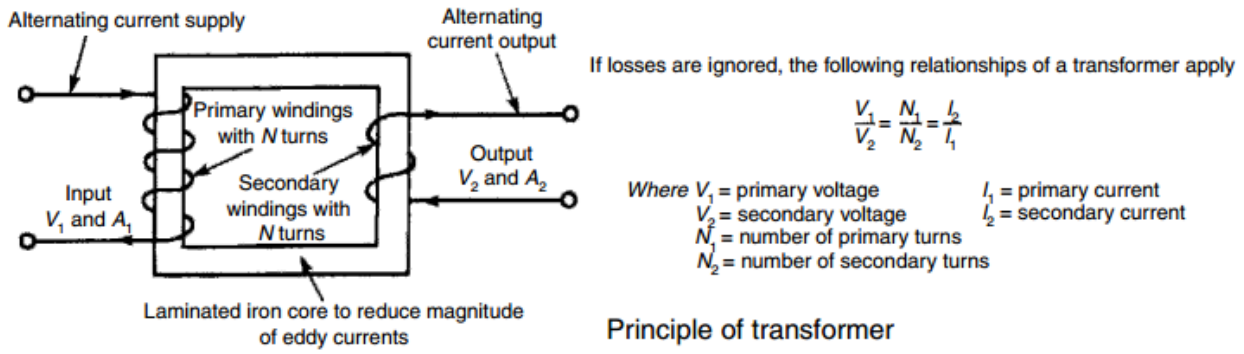

FIGURE 5.1 Principle of transformer.

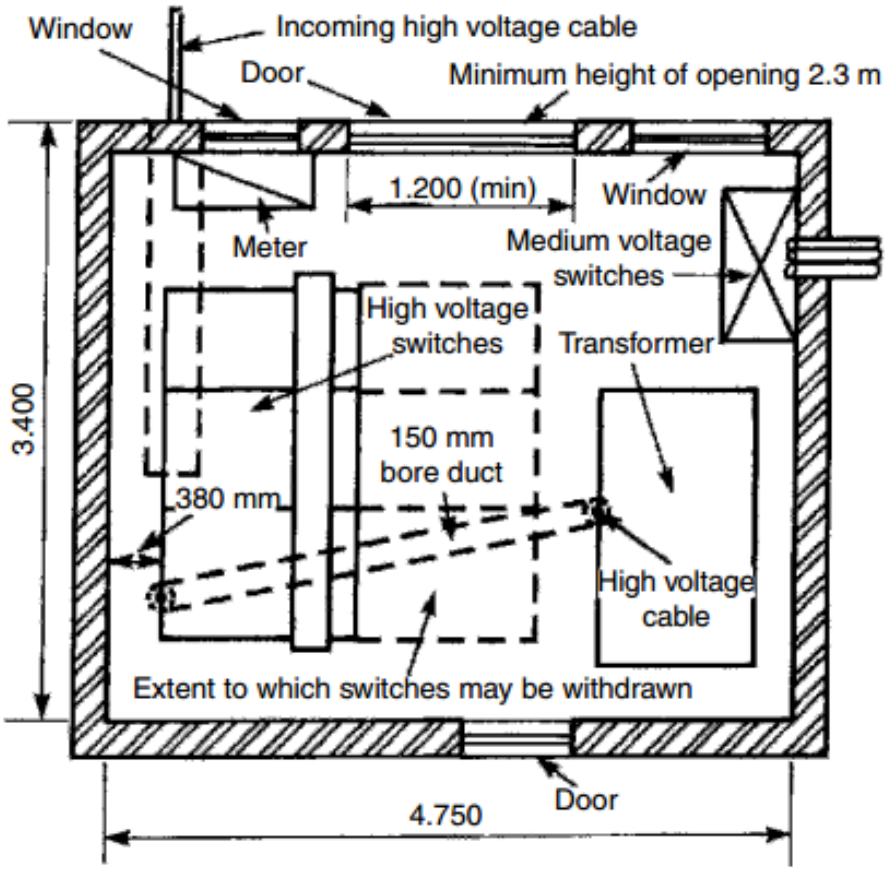

FIGURE 5.2 Construction and layout of sub-station

5.4 Electricity Intake to a Building

The termination and metering of services cables to buildings is determined by the electricity authority's supply arrangements. Most domestic supplies are underground with the service cable terminating at the meter cupboard, as shown in figure 5.3. Depth of cover to underground cables should be at least 750 mm below roads and 450 mm below open ground. In remote areas, the supply may be overhead.

Whatever method is used, it is essential that a safety electrical earthing facility is provided and these are considered on the next page. All equipment up to and including the meter is the property and responsibility of the supplier. This also includes a fusible cut-out, neutral link and in some situations a transformer. Meters are preferably sited in a purpose-made reinforced plastic compartment set in or on the external wall of a building.

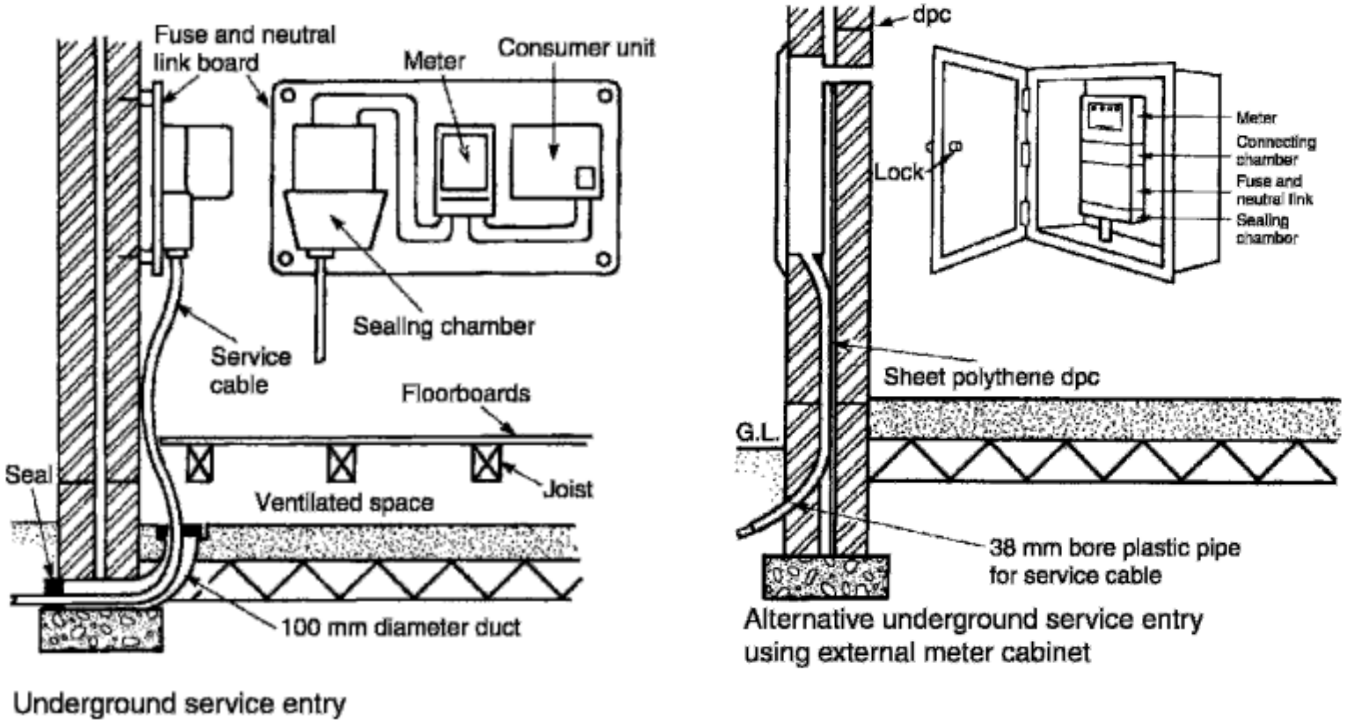

FIGURE 5.3 Electricity Intake to a Building.

Note: All domestic internal distribution systems must be undertaken by a `competent person', i.e. a qualified electrician. Minor work, such as replacing socket outlets, control switches and ceiling fittings can be undertaken without contravention.

5.4 Distribution Board

A distribution board is a component of an electricity supply system that divides an electrical power feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit in a common enclosure. Normally, a main switch, one or more residual-current devices (RCD) or residual current breakers with overcurrent protection (RCBO), are also incorporated.

5.5 Consumer Units

A consumer unit is a type of distribution board.

This unit contains a two-pole switch isolator for the phase/live and neutral supply cables and three bars for the live, neutral and earth terminals. The live bar is provided with several fuse ways or

miniature circuit breakers (up to 16 in number for domestic use) to protect individual circuits from overload.

Each fuse or MCB is selected with a rating in accordance with its circuit function. Traditional fuses are rated at 5, 15, 20, 30 and 45 amps whilst the more modern MCBS are rated in accordance with BS

5.6 Circuits.

The distribution and division of circuits provides comfort, and facilitates rapid location of faults.

Ring Circuit Illustration

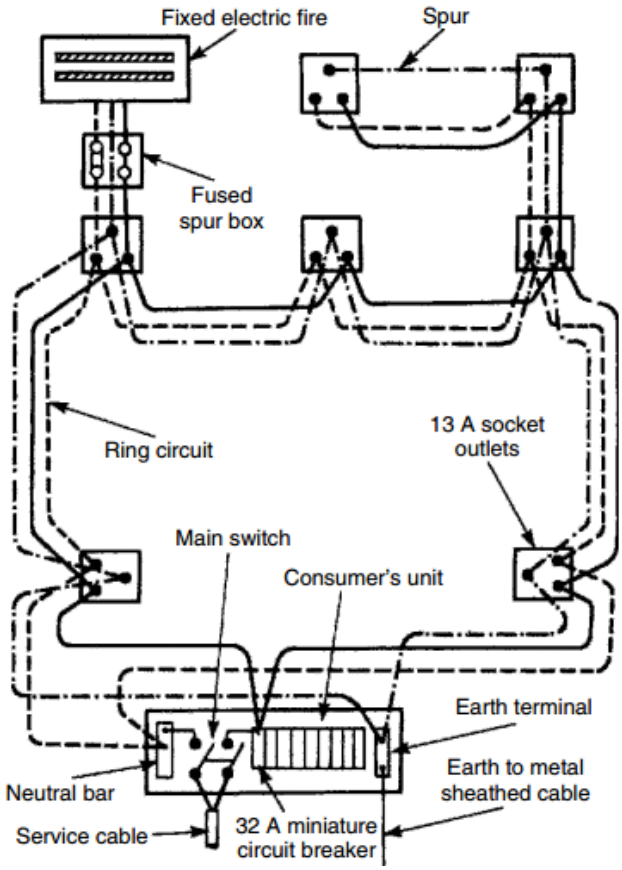

Figure 5.4: Ring Circuit

A ring circuit is used for single-phase power supply to three-pin sockets. It consists of PVC sheathed cable containing live and neutral conductors in PVC insulation and an exposed earth looped into each socket outlet. In a domestic building, a ring circuit may serve an unlimited number

of sockets up to a maximum floor area of 100 m^2. A separate circuit is also provided solely for the kitchen, as this contains relatively high rated appliances. Plug connections to the ring have small cartridge fuses up to 13-amp rating to suit the appliance wired to the plug. The number of socket outlets from a spur should not exceed the number of socket outlets and fixed appliances on the ring

Fixed appliances such as fires, heating controls and low powered water heaters can be connected to a fused spur from a ring socket. Appliances and installations with a load factor above 3 kW, e.g. immersion heater, cooker, extension to an outbuilding, etc. must not be connected to any part of a ring circuit. These are supplied from a separate radial circuit from the consumer unit.

Power sockets should be positioned between **150 mm and 250 mm** above floor levels and work surfaces. An exception is in buildings designed for the elderly or infirm, where socket heights should be between 750 and 900 mm above the floor. **Every socket terminal should be fitted with a double outlet to reduce the need for adaptors.** Disposition of sockets would limit the need for lead lengths to no more than 2 m.

The following provides guidance on the minimum provision for power sockets in domestic accommodation:

Table 5.1 Location Minimum quantity of sockets

Living rooms	8
Kitchen	6
Master bedroom	6
Dining room	4
Study bedroom	4
Utility room	4
Single bedrooms	4
Hall and landing	2
Garage/workshop	2
Bathroom	1 double insulated shaver socket

As both ends of the ring are connected to the same terminals at the consumer unit, the current runs in both directions imposing less of a load on the cables. Electricity loses power over long lengths

of cable and trying to put too much power through a cable, which is not designed for it, is dangerous, so a ring main delivers power from both ends to keep the load as light as possible.

5.7 Radial Circuit

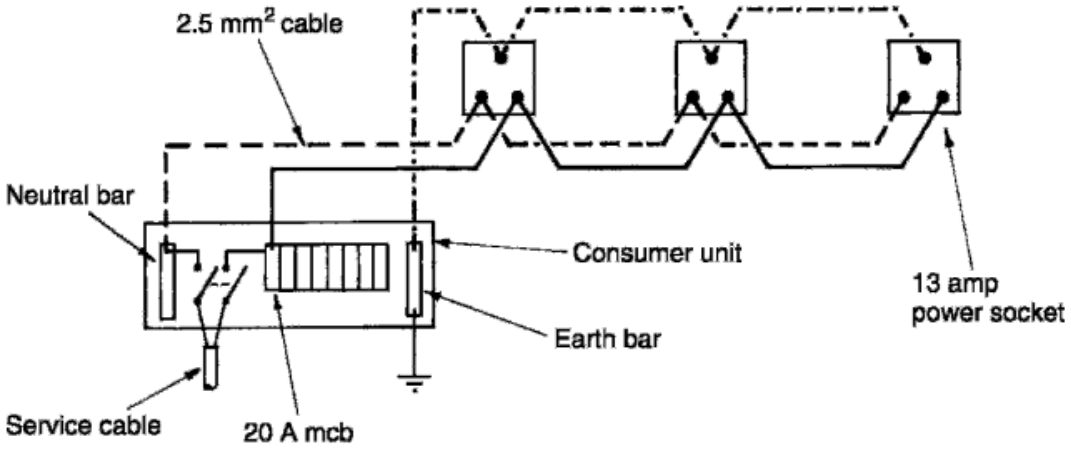

FIGURE 5.5: Radial Circuit

A radial circuit is a mains power circuit found in some homes to feed sockets and lighting points. It is simply a length of appropriately rated cable feeding one power point then going on to the next. The circuit terminates with the last point on it. It does not return to the consumer unit or fuse box as does the more popular circuit, the ring main. A radial circuit may be used as an alternative to a ring circuit to supply any number of power sockets, provided the following limitations are effected:

With 2.5mm^2 cable length limitation of 17m over 20m^2 floor area for a radial supply to sockets, a ring main with a maximum cable length of 54 m over 100 m^2 will usually prove to be more effective.Therefore, radial circuits are more suited to the following:

Table 5.2: Radial circuits

Cable c.s.a(mm2)	Minimum overload protection(amps)	Remarks
2.5	20	Max.20 m^2 floor area,17m cable
4.0	30	Max.50m^2 floor area,21m cable

Type of Circuit (Single Phase)	c.s.a of the conductors	Maximum power	Protective device	Minimum overload protection(amps)
Fixed Lighting	1.5mm^2 (2.5mm^2)	2300W	Circuit Breaker Fuse	16A 10A
10/16 socket outlets	2.5mm^2 (4mm^2)	4600W	Circuit Breaker Fuse	25A 20A
Individual load circuits				
Water Heater	2.5mm^2 (4mm^2)	4600W	Circuit Breaker Fuse	25A 20A
Dish-Washing Machine	2.5mm^2 (4mm^2)	4600W	Circuit Breaker Fuse	25A 20A
Clothes-Washing Machine	2.5mm^2 (4mm^2)	4600W	Circuit Breaker Fuse	25A 20A
Cooker Units	6mm^2 (10mm^2)	7300W	Circuit Breaker Fuse	40A 32A
Electric space heater	1.5mm^2 (2.5mm^2)	2300W	Circuit Breaker Fuse	40A 32A

NB. The **c.s.a** of **aluminium conductors** are shown in brackets.

c.s.a=cross sectional area.

5.8 Service Boxes

Ducts buried in relatively shallow depths terminate in service boxes and are usually located to accommodate secondary mains and the largest number of services without overcrowding the service box and without having too many bends in the service conduits. Usually constructed of precast reinforced concrete, they may be standardized in size, usually about four feet square and four feet deep. The entrance to them is usually quite large and square approximating the

dimensions of the box, providing ample room for the worker to be able to stand erect with the upper part of the body above ground, or to work from the ground level. Steel covers, with inner locked cover, keep out dirt and unauthorized persons.

5.9 Manholes

Larger than service boxes, cable manholes come in many sizes and shapes, some of which may be standardized, but generally shaped to accommodate the number and direction of the cables entering therein.

Headroom of some six feet (2m) or more provides space for the worker to work safely and efficiently. They may accommodate secondary cables as well as primary and transmission cables; the latter proceeding from manhole to manhole bypassing service boxes, the ducts or conduits sometimes referred to as “trunks.”