PART B

Unit-5

Electricity Bill:

Power rating of house hold appliances

I	Appliances	Wattage (min)	Wattage (max)
1.	ceiling Fan	60W	80W
2.	Dish washer	1200W	1500W
3.	Electric iron	800W	1500W
4.	Electric stove	2000W	2000W
5.	Refrigerator	100W	200W
6.	LED light bulb	7W	10W
7.	Tube light	22W	22W
8.	Washing m/c	500W	500W
9.	Air conditioner	800W	1000W
10.	PCs	100W	450W
11.	Laptop	40W	120W
12.	Printers	10W	50W
13.	ceiling Fan	60W	80W
14.	DVD Player	26W	60W
15.	24 inch LED TV	40W	60W

Definition of Unit

Unit of electrical energy consumed is 1kwh. one 1kwh is the electrical energy consumed by an electrical appliance of power 1kw when it is used for one hour.

Tariff:

The rate at which electrical energy is supplied to a consumer is known as tariff.

Two Part Tariff:

When the rate of electrical energy is charged on the basis of maximum demand of the consumer and the units consumed it is called a two part tariff.

In two part tariff, the total charge to be made from the consumer is split into 2 components.

1. Fixed charges 2. running charges.

Fixed charges depend upon the maximum demand of the consumer.

Running charges depend upon the number of units consumed by the consumer.

Total charges = Rs (b x kw + c x kwh)

b = charge/kw of maximum demand

c = charge/kw of energy consumed.

Advantages:

i) It is easily understood by the consumers

ii) It recovers the fixed charges which depend upon the maximum demand of the consumers but are independent of the units consumed.

Disadvantages:

i) The consumer has to pay the fixed charges irrespective of the fact whether he has consumed or not consumed the electrical energy.

ii) There is always error in assessing the maximum demand of the consumer.

Problems.

1. The domestic power in a hour comprises of load as given in table. calculate i) the total load & current taken from the supply of 230V. ii) the total energy consumption per month 1HP = 746W

Sl.No	item	load	Hours used / day
1.	8 lamps	100W	10
2	3 Fans	80W	8
3	1 refrigerator	½ HP	24
	1 Heater	1000W	1

Soln

	Load	Hour	Energy / day
8 lamps	8 x 100 = 800W	10	8000
3 Fans	3 x 80 = 240W	8	1920
1 refrigerator	½ x 746 = 373	24	8952
1 heater	1000W	1	1000
	P = 2413W		E = 19872 Whr

$$I = P/V = \frac{2413}{230} = 10.5A$$

Energy consumption / month = 19,872 x 30 = 5,96,160 Wh
= 596.16 kWh

Energy consumption = 596.16 units / month.

2. A supply is offered on the basis of fixed charges of Rs 30 per annum plus 3 paise per unit or alternatively, at the rate of 6 paise per unit for the first 400 units per annum and 5 paise per unit for all additional units. Find the number of units taken per annum for which the cost under the two tariffs becomes the same.

Soln Let x (>400) be the number of units taken per annum for which the annual charges due to

both tariffs become equal.

Annual charge due to first tariff

$= Rs(30 + 0.03x)$

Annual charges due to second tariff

$= Rs[(0.06 \times 400) + (x - 400) \times 0.05]$

$= Rs[4 + 0.05x]$

As the charges in both cases are equal

$30 + 0.03x = 4 + 0.05x$

$x = \frac{30 - 4}{0.05 - 0.03} = 1300$ kwh.

3) A consumer has a maximum demand of 200kw at 40% of load factor. If the tariff is Rs 100 per kw of maximum demand plus 10 paise per kwh. find the overall cost per kwh.

Soln

Unit consumed / year

= max. demand x L.F x Hours in a year

$200 \times 0.4 \times 8760 = 7,00,800$ kwh

Annual charges = Annual M.D. charges + Annual energy charges

$= Rs(100 \times 200 + 0.1 \times 7,00,800)$

$= Rs\ 90,080$

Overall cost / kwh $Rs = \frac{90,080}{7,00,800}$ $Rs\ 0.125 = 12.85$ Paise

4) The maximum demand of a consumer is 20A at 220V and total energy consumption is 8760 kwh. If the energy is charged at the rate of 20 paise per unit for 500 hours use of the maximum demand per annum plus 10 paise per unit for additional units calculate i) annual bill ii) equivalent flat rate.

soln

Assume load factor and power factor to be unity.

Max. demand = $\frac{220 \times 20 \times 1}{1000}$ = 4.4 kw

i) Units consumed in 500 hrs

= 4.4 × 500 = 2200 kwh

Charges for 2200 kwh = 0.2 × 2200 = Rs 440

Remaining units = 8760 − 2200 = 6560 kwh

Charges for 6560 kwh = Rs 0.1 × 6560 = Rs 656

Total annual bill = Rs (440 + 656) = Rs 1096

ii) Equivalent Flat rate = $\frac{\text{Rs } 1096}{8760}$ = Rs 0.125 = 12.5 paise.

Desirable characteristics of a Tariff:

1) Proper return:

The total receipts from the consumers must be equal to the cost of producing and supplying electrical energy plus reasonable profit. This will enable the electric supply company to ensure continuous and rediable service to the consumers.

2) Fairness:

The tariff must be fair so that different types of consumers are satisfied with the rate of change of electrical energy.

3) Simplicity:

The tariff should be simple so that an ordinary consumer can easily understand it.

4) Reasonable profit:

The profit element in the tariff should be reasonable.

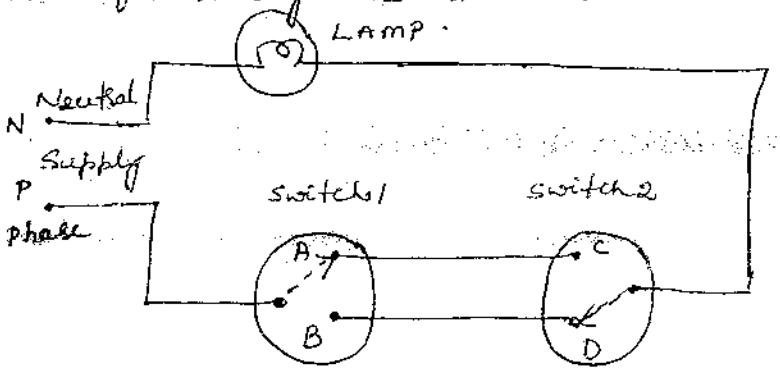
5) Attractive: The tariff should be attractive so that a large number of consumers are encouraged to use electrical energy.

Lamp control:

① Control from 2 points or 2-way control:

Fig below shows the way in which the connections are made to control a lamp from 2 points. Here 2, two-way switches are used.

In big halls, corridors, bedrooms & staircase it is necessary to control the lamp from 2 points. In such cases a two-way lamp circuit is used for wiring as shown below.

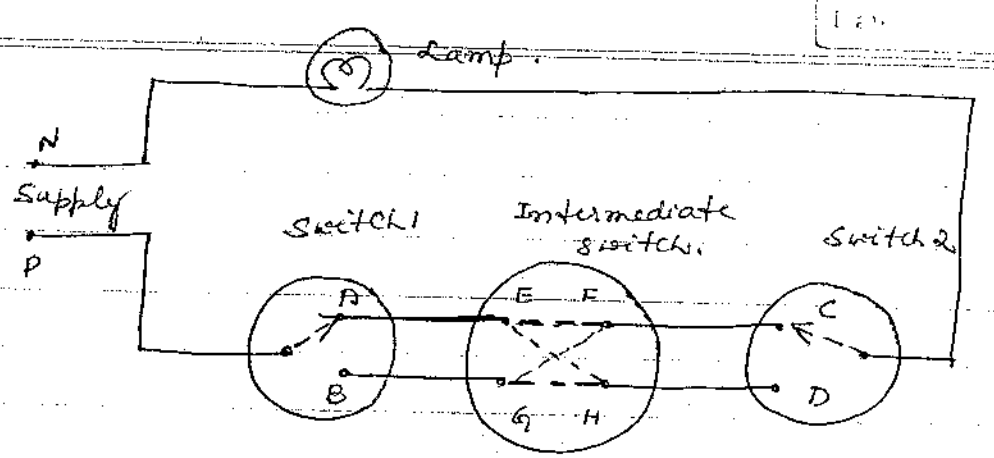


For the position of the switches as shown above, the lamp ckt is not closed & hence the lamp is dark. Table below gives the positions of switches & the lamp conditions.

switch 1	Swich 2	lamp condition
A	D	OFF
A	C	ON
B	C	OFF
B	D	ON

② Control from 3-points or 3-way control:

In very big corridors, godowns or workshops, it may be necessary to control a lamp from 3 points. In such cases, the circuit connection requires two, two-way switches & an intermediate switch as shown in fig below.



Intermediate switch is a combination of 2, Two way switches coupled together. It has four terminals EFGH. For one position, it connects points EF & GH, which is called straight connection. For another position, it connects points EH & GF which is called Cross connection.

Table below gives the positions of various switches & the lamp conditions.

Switch 1	Intermediate switch	switch 2	lamp condition.
A	EF - GH	C	ON
A	EF - GH	D	OFF
B	EF - GH	C	OFF
B	EF - GH	D	ON
A	EH - GF	C	OFF
A	EH - GF	D	ON
B	EH - GF	C	ON
B	EH - GF	D	OFF

Specification of wires:

The conductors wires may be specified according to either type of conductor or type of insulation. Since copper is costly, Aluminium is used as conductor material. The current carrying capacity of a wire depends on its size. The current flowing

through the wire must be always under safer limits. Conductors of largeer area of c/s are required to carry larger currents & wires of smaller sizes to carry smaller currents. Types of wires generally in use are

(a) Vulcanised India Rubber (VIR) insulated
(b) Poly-vinyle Chloride (PVC) insulated
(c) Weather proof Wire
(d) Flexible Wires.

The sizes of wire generally used for house wiring are

(a) 1.0 mm² – copper (Cu) } for point wiring to
or light or fan points.
1.5 mm² – Aluminium (Al) }

(b) 2.5 mm² – Cu } for 5A sockets of
or medium load
4.0 mm² – Al }

Protective Devices used in Domestic Wiring

(1) Fuse (2) Miniature Circuit Breaker
(3) Residual current circuit Breaker (RCCB)
(4) Earthing

Earthing:

Earthing or grounding means connecting the body of an electrical equipment to the earth by a wire of negligible resistance. The earth is considered to be at zero potential. Hence Earthing brings the body of the equipment to zero potential & thus avoids shocks to the person, in the event of any leakage & faults etc. Hence, by providing such earthing, risk to human life & the risk of fire are eliminated.

objectives of Earthing: (1) To maintain the line voltage constant
(2) To ensure safety of life & property from electric shock & fires
(3) To protect Tall buildings & structures from lightening strikes
(4) To protect buildings & appliances under fault conditions.

Methods of Earthing

① Pipe Earthing:

In this system, a galvanised iron (GI) pipe of approved length & diameter is vertically embedded into the ground to work as an earth electrode. The depth to which the pipe must be buried depends on the condition of the moisture in the ground. The pipe at the bottom should be surrounded by alternate layers of salt & coal to improve the soil condition & efficiency of the earthing system. A funnel with a mesh is provided at the top of the pipe to pour water into the pit & to keep soil wet during summer.

for fig's of pipe & plate earthing refer next page.

→

② Plate Earthing:

In this system of earthing, a pit is dug in the ground until sufficient moisture is available in the soil. The earth continuity conductor is connected to the GI or copper plate with nuts & bolts. This plate is kept at the bottom of the pit & is covered with alternate layers of salt & charcoal for improving the soil condition & η of the earthing system. A c/s view of the earthing arrangement using plate earthing is given below. A funnel is provided at the top to pour water into the pit during summer to ensure better earthing.

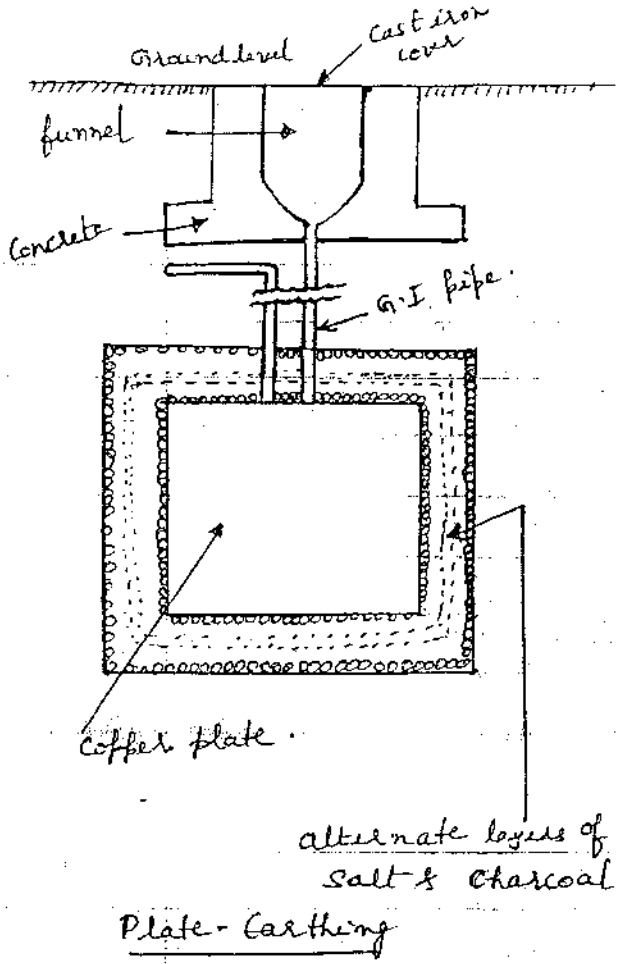
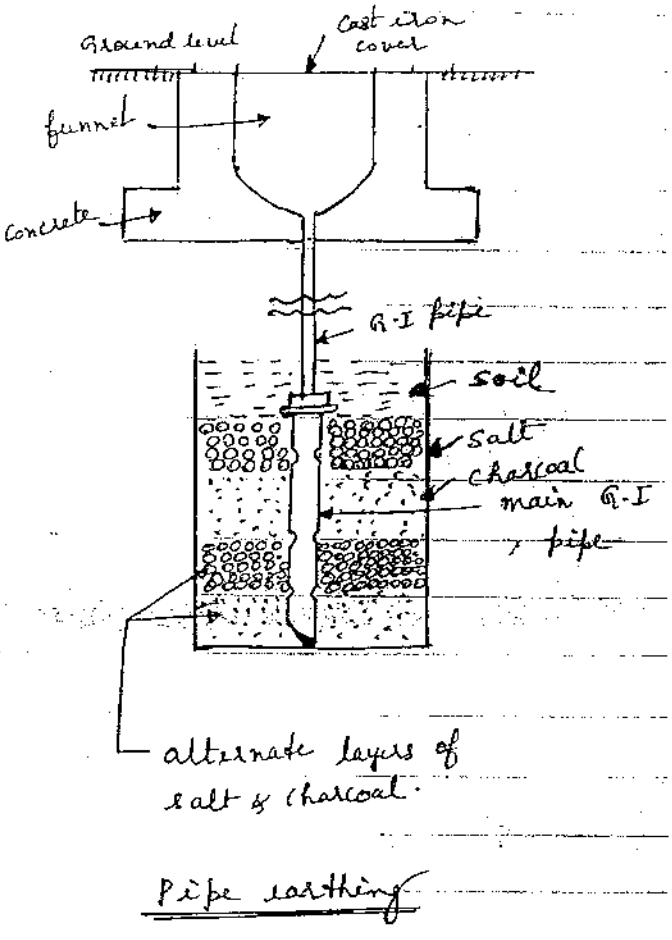


Plate - Earthing



Pipe earthing

Fuses:

It is a safety device, which protects the circuit from overloads & short circuits.

The fuse wire is connected to the phase wire of the supply. When the current taken by the load exceeds the rated current of the fuse wire, the fuse wire melts & disconnects the supply from the load circuit & thus protects the circuit & the apparatus connected to the supply.

The current rating of a fuse is based on the current which the fuse can carry continuously without melting.

For low currents (upto 15A) it is made of tin & lead (37% lead & 63% of tin) & for high currents fuse wire is made of tinned copper.

Characteristics of fuse element

1. Low cost
2. Low melting point
3. High resistance.
4. High conductivity
5. free from deterioration due to oxidation.

Advantages of fuse.

1. It is the simplest & cheapest form of protecting device.
2. It requires no maintenance
3. The minimum operating time & the minimum operating current can be easily adjusted by choosing appropriate cross-sectional area of fusing element.
4. Operation of fuse is simple & no complexity is involved.

Disadvantages of fuse.

1. They should be replaced after its operation.
2. The replacement of fuse takes a lot of time

Circuit Breaker (CB)

** A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overcurrent or overload or short circuit. Its basic function is to interrupt current flow after protective relays detect a fault.

** The circuit Breaker must detect a fault condition & low voltage circuit breaker, this is usually done within the breaker itself. Circuit Breaker for larger currents or high voltages are usually arranged with a protective relay circuit.

Miniature Circuit Breaker (MCB)

** MCB is used to break small currents
** Rated current not more than 100A
** Trip characteristics of current normally not adjustable
** Thermal or thermal-magnetic operation

Advantages of MCB compared to fuse

1. It automatically switches off the electrical circuit during abnormal condition of the network
2. Quick restoration of supply is possible by switching on MCB
3. MCB's are more reliable & more sensitive compared to fuses.
4. Handling MCB is more electrically safer than fuse.

Disadvantages

more costlier than fuse

Residual current Circuit Breaker (RCCB)

** The MCB & fuse cannot provide protection against earth leakage currents
** Hence there is need of a device which can directly detect the earth leakage currents & cut the supply if such currents exceed a preset value. Such a device is called Earth leakage Circuit Breaker (ELCB)
** There are two types of ELCB. They are:
(1) Voltage operated ELCB generally called ELCB.
(2) Current operated ELCB generally called Residual Current Circuit Breaker (RCCB)
** RCCB work by comparing the current entering the live wire with current leaving the neutral wire

Electric Shock

Electric shock is the physiological reaction or injury caused by electric current passing through the human body.

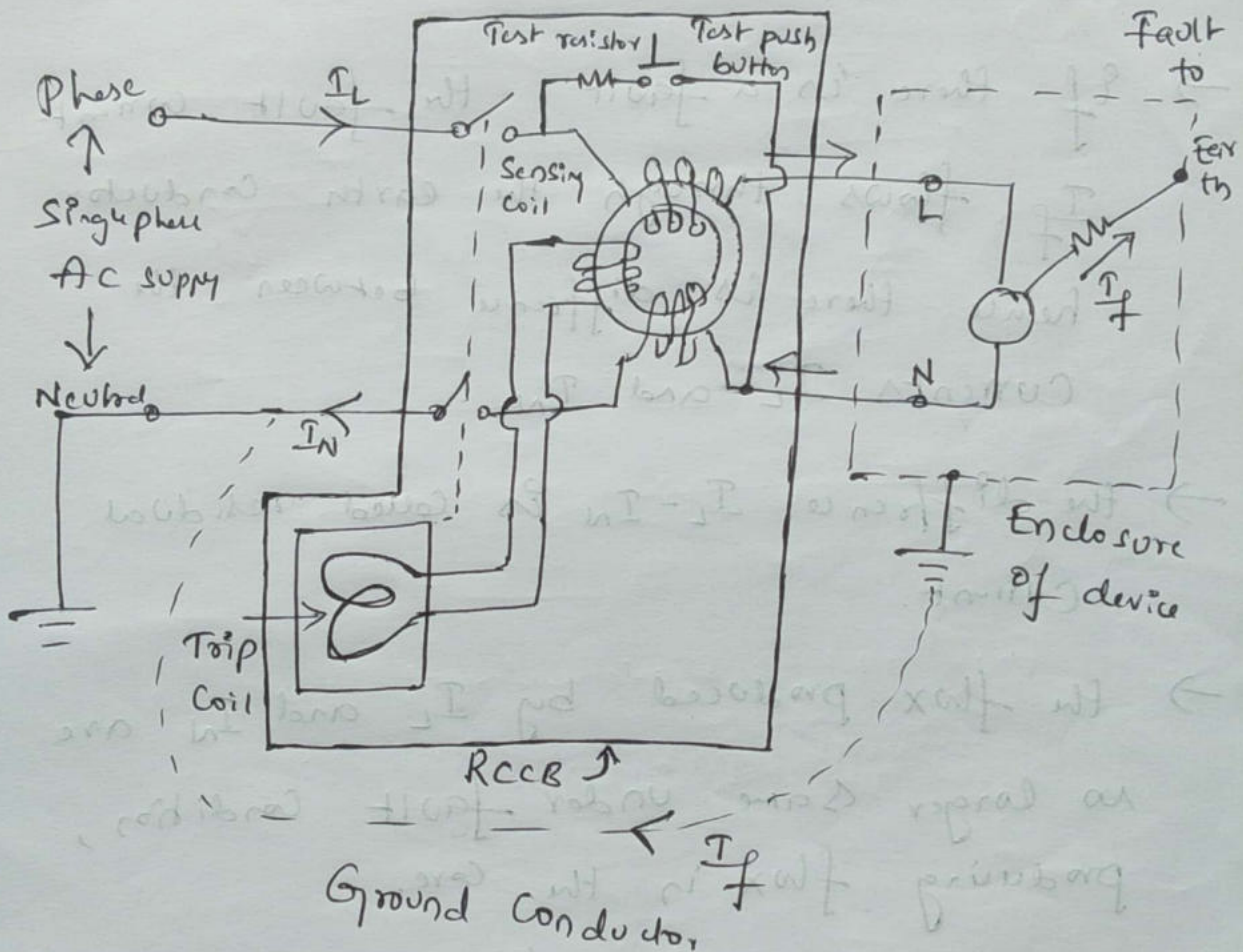
Safety precautions against Electric Shock

1. Always keep the earth connection in good condition.
2. All electrical equipments are connected with good quality wires.
3. Before replacing a blown out fuse always put the main switch off.
4. Line wires should always be connected through the switch.
5. Insulation of the conductors used must be proper & in good condition. Otherwise the person coming in contact with such faulty insulated conductors may receive a shock.
6. Use rubber shoes & rubber gloves while doing any electrical work.
7. The sockets should be fixed at a height beyond the reach of the children.

* Residual current circuit breaker (RCCB)

→ Residual current circuit breaker is nothing but the current operated earth leakage circuit breaker.

→ The schematic of RCCB is shown in fig.



→ RCCB consist of small current transformer surrounding live and neutral wire. the sensing coil or current transformer is connected to a tripping coil of circuit breaker.

→ under normal conditions, the current in line conductor I_L is same as the current in neutral conductor I_N.

→ hence $(I_L - I_N)$ is zero hence two fluxes produce by I_L and I_N cancel each other and sensing coil does not sense any imbalance.

→ if there is a fault, the fault current I_f flows through the earth conductor hence there is difference between the currents I_L and I_N.

→ the difference $I_L - I_N$ is called residual current.

→ the flux produced by I_L and I_N are no longer same under fault conditions, producing flux in the core.

→ Due to the residual flux, EMF gets induced in the sensing coil which circulates current through the tripping coil of the circuit breaker.

→ this operates circuit breaker and disconnects the supply from the device.

→ As the action of trip coil depends on the residual current, the device is called residual current, circuit breaker.

→ The properly connected RCCB can detect small currents in miliampers and operates in arround 25msec