SSC JE CONVENTIONAL 2017

GENERAL ENGINEERING (ELECTRICAL)

1. (a) The resistance of copper winding of a motor at room temperature of 25°C is 3.0 Ω . After an extended operation of the motor at full load, the winding resistance increases to 4. 0 Ω. Find the temperature rise. Given that the temperature coefficient of copper at 0°C is 0.00426 °C

[15 Marks]

Solution : Given, $T_1 = 25°C$
$R_1 = 3\ \Omega$
$R_2 = 4\ \Omega$
$\alpha_0 = 0.00426\ °C$
$T_2 - T_1 = ?$

$R_1 = R_0(1+\alpha_0 T_1)$, $R_2 = R_0(1+\alpha_0 T_2)$

$$\frac{R_1}{R_2} = \frac{R_0\ (1+\alpha_0\ T_1)}{R_0\ (1+\alpha_0\ T_2)}$$

$$\frac{3}{4} = \frac{1+0.00426\times 25}{1+0.00426\times T_2}$$

$3 + 3\times0.00426\times T_2 = 4 + 4\times0.00426\times25$

$$T_2 = \frac{4+0.426-3}{0.00426\times 3} = \frac{1.426}{0.01278}$$

$T_2 = 111.58°C$

Now, $T_2 - T_1 = 111.58 - 25 = 86.58°C$

$\boxed{\text{Temperature rise} = 86.58°C}$

(b) A toaster rated at 2000 W, 240 V is connected to a 230 V supply. Will the toaster be damaged ? Will its rating be affected ?

[15 Marks]

Solution : Given, Rating of toaster = 2000W, 240V

So, Resistance of toaster $= \frac{240\times 240}{2000} = 28.8\Omega$

Maximum allowed current through toaster $(I_{max}) = \frac{2000}{240} = 8.33$ Amp

So, if current through toaster is $(I) > I_{max}$.
Then, Toaster will get damage otherwise not.
Now,

$$I = \frac{230}{28.8} = 7.98 \text{ Amp}$$

i.e $I < I_{max}$
Therefore, toaster will not get damage.

(c) Define the following terms :
(i) Drift velocity
(ii) Current density
(iii) Power
(iv) Electromotive force

[20 Marks]

Solution: (i) Drift velocity (V_d) : It is the average velocity of that particle, such as an electron, attains in a material due to an electric field.

(or)

It is the product of mobility of particle to the electric field applied.
I.e $V_d = \mu.E$

(ii) Current density (J_d): It is the electric current per unit area of cross section. It is vector quantity

$$J_d = \sigma.E \text{ or } J = \frac{I}{A}$$

(iii) Power : Electrical power is the rate at which electrical energy is converted into another form. Such as motion, heat or EM field.

(iv) Electro motive force: It is the electrical intensity or pressure developed by a source of electrical energy such as a battery or generator.

(d) The domestic power load in a house comprises the following :
(i) 10 lamps of 100 W each
(ii) 5 fans of 80 W each
(iii) 1 refrigerator of 0-5 hp
(iv) 1 heater of 1 kW
Calculate the total current taken from the supply of 230 V.

[10 Marks]

Solution: Concept used

Total power (P_T) = $P_1+P_2+P_3+P_4$ &

(I_T) total current = $\frac{P_T}{V}$

So $P_1 = 10\times100 = 1000W$

$P_2 = 5\times80 = 400W$

$P_3 = 1\times\frac{1}{2}\times746 = 373\ W$

$P_4 = 1 \times 1000 = 1000W.$

So $P_T = 2773$ watt

$\therefore\ I_T = \frac{2773}{230} = 12.057\ A$

2. (a) Using Kirchhoff's law, determine the current I_A and I_B in network shown in Figure1

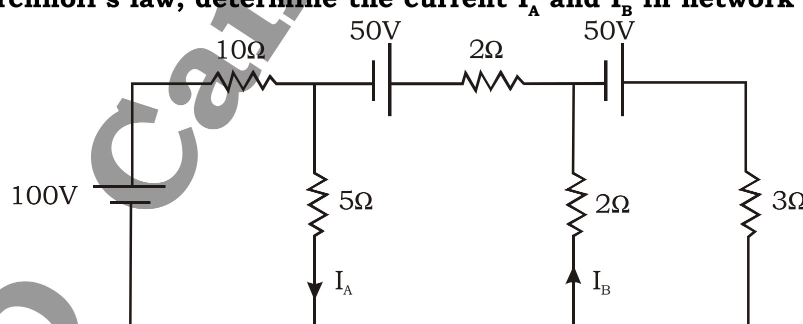
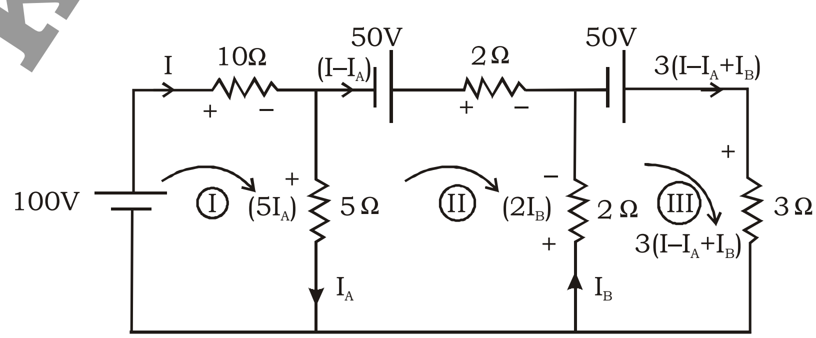


Figure 1

[15 Marks]

Solution:



KVL in loop (I), $-100+10I + 5I_A = 0$

$10I + 5I_A = 100$

$\boxed{I=10 - 0.5I_A}$ ....(i)

KVL in loop (II), $- 5I_A - 50 + 2 (I - I_A) - 2I_B = 0$

$- 5I_A - 50 + 2I - 2I_A - 2I_B = 0$

$2I - 7I_A - 2I_B - 50 = 0$

Put $I = 10 - 0.5I_A$

$2(10 - 0.5I_A) - 7I_A - 2I_B - 50 = 0$

$20 - I_A - 7I_A - 2I_B - 50 = 0$

$- 8 I_A - 2I_B = 30$

$- 4 I_A - I_B = 15$

$\boxed{I_B = 4I_A - 15}$ ....(ii)

KVL in loop (III), $3(10 - 0.5I_A) - 3I_A + 5(4I_A - 15) - 50 = 0$

$30 - 1.5I_A - 3I_A - 20I_A - 75 - 50 = 0$

$- 24.5I_A = 95$

$\boxed{I_A = \frac{95}{24.5}}$

$I_B = 4I_A - 15 = 4 \times \frac{95}{24.5} - 15$

$I_B = 0.51$ Amp

So, $\boxed{\begin{array}{l} I_A = -3.8775\text{Amp} \\ I_B = 0.51 \text{ Amp} \end{array}}$

(b) For the circuit shown in Figure 2 find I such that current in the 100 Ω resistor is zero.

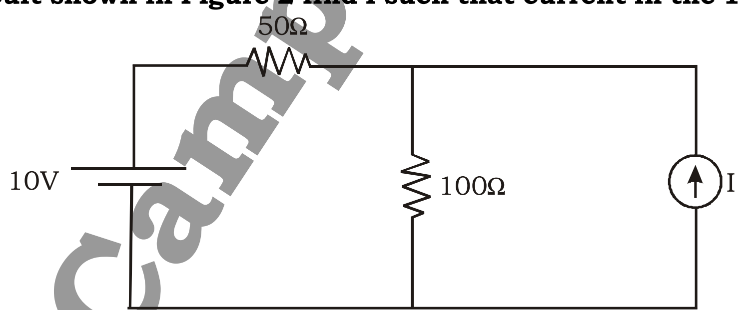
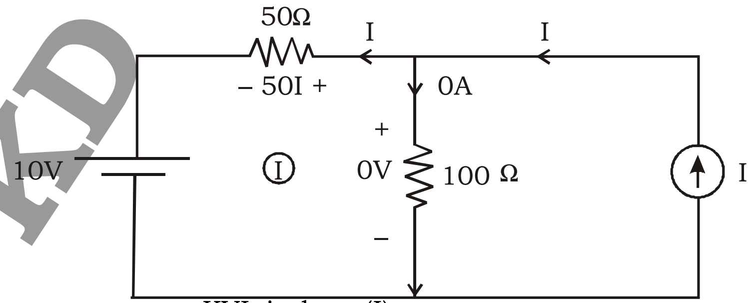


Figure 2

[15 Marks]

Solution :



KVL in loop (I)

$- 10 - 50I + 0 = 0$

$- 50I = 10$

$I = -\frac{1}{5}$

$\boxed{I = - 0.2 \text{ Amp}}$

(c) A series combination of two capacitances $C_1 = 5\ \mu F$ and $C_2 = 10\ \mu F$ is connected across a dc supply of 300 V. Determine the

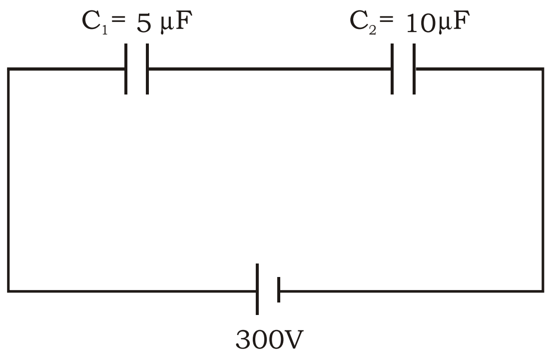
(i) charge

(ii) voltage

(iii) energy stored in each capacitor

[15 Marks]

Solution:



(i) Charge: In series connection charge in same.

$$Q_1 = Q_2 = Q_T$$
$$Q_T = C_T.V$$

$$C_T = \frac{C_1C_2}{C_1+C_2} = \frac{5\mu \times 10\mu}{5\mu + 10\mu}F$$

$$C_T = \frac{10}{3}\mu F$$

$$Q_T = \frac{10}{3}\mu \times 300 = 100\mu C$$

(ii) Voltage

$$V_1 = V\times\frac{C_1}{C_{1+}C_2} \qquad V_2 = V\times\frac{C_1}{C_{1+}C_2}$$

$$= 300 \times \frac{5\mu}{15\mu} \qquad =300\times\frac{5\mu}{15\mu}$$

$$V_1 = 200V \qquad V_2 = 100V$$

(iii) Energy stored in each capacitor,

$$E_1=\frac{1}{2}C_1V_1^2 \qquad E_2=\frac{1}{2}C_2V_2^2$$

$$=\frac{1}{2}\times 5\mu \times 200^2 \qquad =\frac{1}{2}\times 10\mu \times 100^2$$

$$= 100000\mu\ J \qquad = 50000\mu\ J$$

$$\boxed{E_1=0.1J} \qquad \boxed{E_2=0.05J}$$

(d) Define the following terms :

(i) Self-inductance

(ii) Flux

(iii) RMS value of alternating waves

[15 Marks]

Solution : (i) Self Inductance : Inductance or in other words inductance of the coil is defined as the property of the coil due to which it opposes the change of current flowing through it. Inductance is attained by a coil due to the self-induced emf produced in the coil itself by changing the current flowing through it.

(ii) Flux : It is defined as the amount of electric field or magnetic field passing through a surface. The total flux depends on the strength of the field. the size of the surface it passes through and their orientation.

(iii) RMS value of Alternating wave:-

RMS value is based on the heating effect of the wave { current or voltage}. It is defined as the amount of heat produced across a resistor. When an a.c is applied produced heat is equal to the heat produced by dc across the same value of resistor. and operated for the same time.

$$H_{ac} = H_{dc}$$

3. (a) A circular coil of area 300 cm² and 25 turns rotates about its vertical diameter with an angular speed of 40 rad/sec in a uniform horizontal magnetic field of magnitude 0.05 T. Find the maximum voltage induced in the coil.

[10 Marks]

Solution : Given

Area (A) = 300cm²

$= 300 \times 10^{-4}$ m²

Number of turns = 25

Angular velocity (ω) = 40 rad/sec

Maximum induced (e_m) = $N\omega AB$

$= 25 \times 40 \times 300 \times 10^{-4} \times 0.05$

= 1.50 Volt

(b) Define the following terms :

(i) Reluctance

(ii) Permeance

(iii) Magnetic Field Strength

[15 Marks]

Solution : **Reluctance :** It is analogous to the resistance of an electric circuit. It depends on the geometrical and. material properties of the circuit. It offers opposition to the magnetic field in the magnetic circuit.

$$S = \frac{\text{Magnetomotive Force}}{\text{Magnetic flux.}} = \frac{\text{mmf}}{\phi} = \frac{l}{\mu A}$$

(ii) Permeance: It is the inverse of Reluctance and it is analogous to the conductance in electric circuit.

$$\text{Permeance} = \frac{\phi}{MMF} = \frac{\mu A}{l}$$

(iii) Magnetic field strength:

It is defined as the magnetic flux density per unit perneability of the material used.

i.e $H = B/\mu = NI/l$

(c) A coil has 1000 turns enclosing a magnetic circuit of 20 cm² in cross-section, with 4 A current in the coil, the flux density is 1.5 Wb/m², and with 8 A current, it is 1.9 Wb/m². Find the mean value of inductance between these current limits and the induced emf if the current decreases from 8 A to 4 A in 0.06 sec.

[15 Marks]

Solution: Given,

Number of turns (N) = 1000

Area (A) = 20cm² or 20×10^{-4}m²

magnetic flux (ϕ_1) = $1.5 \times 20 \times 10^{-4} = 30 \times 10^{-4}$ Wb.

(ϕ_2) = $1.9 \times 20 \times 10^{-4} = 38 \times 10^{-4}$ Wb

Current (I_1) = 4A

Current (I_2) = 8A

So, Inducdance (L_1) = $\frac{N\phi_1}{I_1} = \frac{1000 \times 30 \times 10^{-4}}{4} = 0.75$ H

$$L_2 = \frac{N\phi_2}{I_2} = 0.475 \text{ Henry}$$

$L_{eq} = \sqrt{L_1 . L_2} = 0.597$ Henry.

and induced emf = $L_{eq} \frac{di}{dt} = \frac{0.597 \times (4-8)}{0.06}$

$= -39.72$ volt

(d) A coil A of 1200 turns and another coil B of 800 turns lie near each other so that 60 percent of the flux produced in one links with the other. It is found that a current of 5 A in coil A produces a flux of 0.25 mWb, while the same current in coil B produces a flux of 0.15 mWb. Determine the mutual inductance and coefficient of coupling between the coils.

[20 Marks]

Solution: Given:-

Flux (ϕ_A) = 0.25×10^{-3}wb

Flux (ϕ_B) = 0.15×10^{-3}wb

Number of turns (N_A) = 1200

Number of turns (N_B) = 800

Current in coils = 5A

So,

$$L_A = \frac{N\phi_A}{I_A} = \frac{1200\times0.25\times10^{-3}}{5} = 0.06 \text{ Henry.}$$

and $$L_B = \frac{800\times0.15\times10^{-3}}{5} = 0.024 \text{ Henry.}$$

Therefore.

$$M = K\sqrt{L_2L_2}$$

$$= 0.6\sqrt{0.06\times0.024}$$

$$= 0.0228 \text{ Henry}$$

4. (a) Determine the average and rms value of the resultant current in a wire carrying simultaneously a dc current of 10 A and sinusoidal current of peak value of 1.414 A. [10 Marks]

Solution: The given current are

dc current, I_O = 10A

sinusoidal currect, $I_{(t)}$ = 1.414 sinωt A.

Then the resultant current is I = (10+1.414 sinωt)A.

As the average of sinusoidal current is zero and dc current always has average value.

Hence,

I_{avg} = 10+0 = 10A.

And we know that rms value of

$i = I_0 + I_1\sin\omega t + I_2\sin 2\omega t + \ldots\ldots\ldots$ is

$$I_{rms} = \sqrt{I_0^2 + \frac{1}{2}\left(I_1^2 + I_2^2 + \ldots\ldots\right)}$$

$$\therefore \quad I_{rms} = \sqrt{10^2 + \left(\frac{1}{2}\times1.414^2\right)} = 10.05A$$

(b) The resistance of a coil is 3 Ω and its time constant is 1.8 sec. At t = 0 sec, a 10 V source is connected to it. Determine the

(i) current at t = 1 sec

(ii) time at which the current attains half of its final value

(iii) initial rate of growth of current [15 Marks]

Solution : Resistance of coil (R). = 3Ω

Time constant (τ) = $\frac{L}{R}$ = 1.8sec.

∴ L = 5.4 Henry

Using :-

$$I_{L(t-t0)} = I_{L(\infty)} - [I_{L(\infty)} - I_{L(0+)}]\, e^{-\frac{(t-t_0)}{\tau}}$$

$$= \frac{10}{3}\left(1 - e^{-0.56(t-t_0)}\right)A$$

Here t_o = 0 sec

$$\therefore \quad I_{L(t)} = \frac{10}{3}\left(1 - e^{-0.56t}\right)A$$

(i) at t = 1sec.

$$I_L(t=1\text{sec}) = \frac{10}{3}(1-e^{-0.56})$$

$$= \frac{4.28}{3}A = 1.43\text{ A}$$

(ii) at t = T

$$I_L(t=T) = \frac{I_L(\infty)}{2}$$

$$= \frac{5}{3}$$

$$\therefore \quad \frac{5}{3} = \frac{10}{3}(1-e^{-0.56T})$$

$e^{-0.56T} = 0.5$

T = 1.237 sec.

(iii) Rate of growth of currect = $\frac{dI_{(t)}}{dt}$

$= 1.867e^{-0.56t}$

(c) Explain in brief the following :

(i) Energy meter

(ii) CRO

(iii) 2 wattmeter method

(iv) Multimeter

[20 Marks]

Solution:

(i) Energy meter:

Energy Meter

- Energy = Power × time $= \int_0^t Pdt = \int_0^t v(t)\,.\,i(t)dt = v.i.t.$

  If v is expressed in volt (v), current (i) in A and time in second (s) then,

  unit of energy = Joule or Watt second

  If v is expressed in volt (v), current (i) in A and time in hour then,

  unit of energy = Watt hour
- For a.c. circuits, energy is measured in terms of kWh (killowatt hour).
- For d.c. circuits, energy is measured in terms of Ah (Ampere hour).
- Energy meter is used to measure energy in ac circuit which is an integrating instrument and works on the principle of induction motor.

$$T_{d1} \propto \phi_c I_p \cos\angle\phi_c - I_p$$

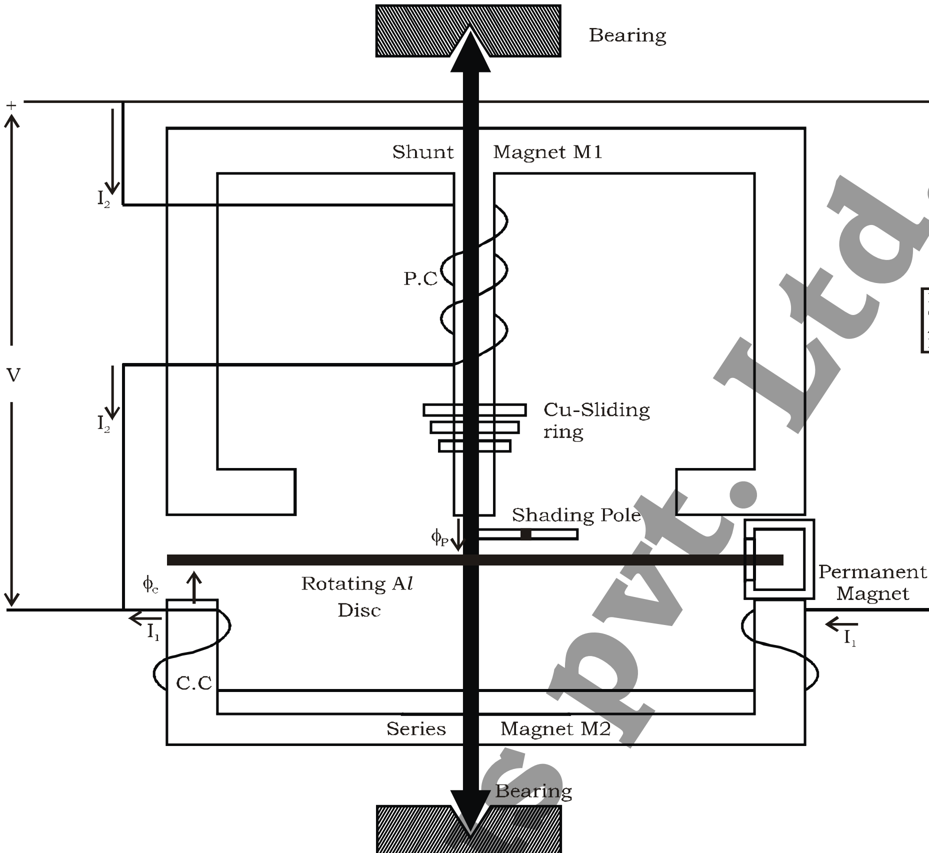
$$T_{d2} \propto \phi_p I_c \cos\angle\phi_p - I_c$$

$$\boxed{T_d \propto T_{d1} - T_{d2}}$$

- **Requirement**

  1. Driving Mechanism : A shunt magnet M_1 is wound with a coil called P.C which measures the voltage of load. The series magnet M_2 carries the load current to the current coil. This current I_1 lags the voltage by an angle ϕ.

$$\boxed{T_d \propto VL_1 \cos\phi}$$



2. Braking Mechanism : A percent magnet is use which producing a constant hun in the rotating disc & this flux is induced an eddy voltage which is directly proportional to the speed of disc & this eddy voltage produces a current & interaction of this current with the flow produces a braking torque which is directly proportional to the speed of the disc. This braking torque in opposition to the driving torque which keeps the rotation of disc constant.

N.dt = P.dt = Energy

3. Recording Mechanism : Reduced gears mechanism are used to record the number of revolutions made by the disc. The pointers in the gear wheel changes the number in dials.

Note : shading rings made of copper is kept in the P.C to adjust the ϕ angle between I_2 & V so that the energy meter record correctly.

$$t = \frac{t}{3600} hr.$$

4. Moving Mechanism : This consists at an Al disc unwanted an a light alloy shaft. The disc is positioned in air gap between series & shund magnets. The rotor turns on a steel pivot, screwed to the foot at the shaft. The pivot is supported by a jewell bearng. A pinion engages the shaft with counting or recording mechanism.

- **Errors in energy meter & correction**

1. **Lag compensation :** lag coil or shading ring.
2. **Over voltage :** saturate shunt magnet or keeping hales in side limbs.
3. **Light load or friction :** shading loop.
4. **Creeping :** Due to over compensation, corrected by making two holes in disc in opposite to the axis of rotation.
5. **Over load compensation :** storable shunt magnet in series mag.
6. **Speed adjustment :**
   - By adjusting p.magnet position near to shaft - speed high
   - By adjusting P.M. away from shaft - speed slow
7. **Temperature compensation :** Mutemp material used.

Note : It the C.C or P.C coil terminal are reversed the disc will rotate in opposite direction.

(ii) CRO :

➢ **Basics of CRO (Cathod Ray Oscilloscope)**

- It is a very useful and versatile laboratory instrument used for display, measurement and analysis of waveforms.
- Normal from of a CRO uses a horizontal input voltage, which is an internally generated ramp voltage, called *'time base.* This move the luminous spot periodically in a horizontal direction from left to right over screen.
- Vertical input to the CRO is the voltage under investigation. This moves luminous spot up and down with current value of the voltage.
- CRO operates on voltage. But is is possible to convert current, strain, acceleration, and pressure into voltage with the help of transducers.
- Used to investigate waveforms, transient phenomena, for very low frequency range to the radio frequencies.
- CRO mainly consist of **CRT (Cathode Ray Tube)**, which is heart of CRO.

➢ **Advantage of CRO**

(i) Frequency and time period can be measured.
(ii) It has x-y scale waveform pattern.
(iii) It can display two or more input waveforms simultaneously.
(iv) It can measure the voltages like V_m, V_{pp}, V_{rms} and V_{avg}.
(v) Phase angle can be measured with the help of CRO.
(vi) Sensitivity is high.
(vii) It can study the quantities from a low frequency (20 Hz) to a very high frequency (upto GHz).
(viii) It can be used for high applications (i.e. sampling oscilloscope).
(ix) It has high precision.

(iii) 2 wattmeter method :

- For measurement of power in n^{th} wire system the minimum no. of watt meter required is (n-1).
- For 3-ϕ, 3-wire system the minimum wattmeter required is 3-1 = 2.
- Measurement of power by two wattmeter method is given below,

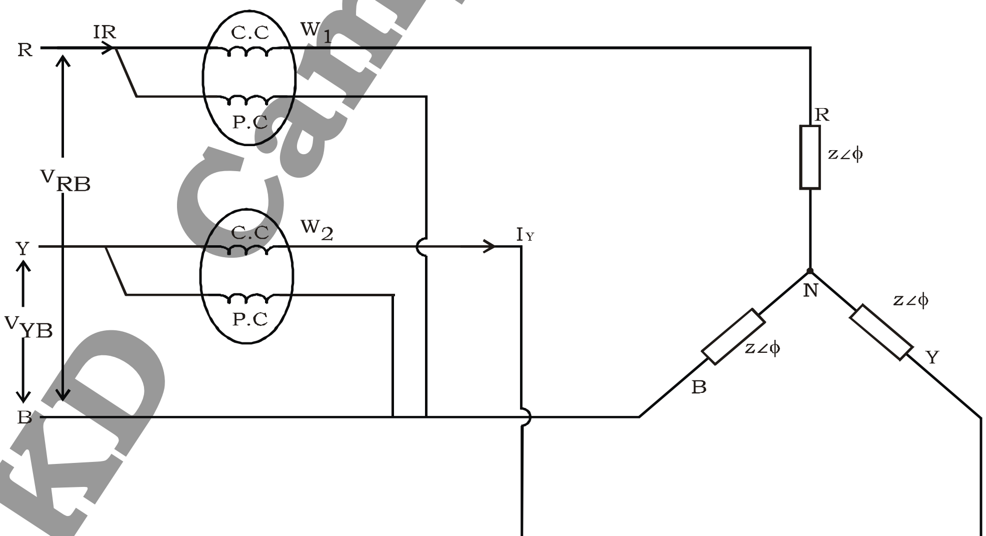


Fig. : *Phasor for a star load*

- Reading of wattmeter 1

$$W_1 = V_{RB} I_R \cos\angle(V_{RB} - I_R)$$

$$W_1 = V_L I_L \cos(30 - \phi) \qquad \text{............. (1)}$$

- Reading of wattmeter 2

$$W_2 = V_{YB} I_Y \cos\angle(V_{YB} - I_Y)$$

$$W_2 = V_L I_L \cos(30 + \phi) \qquad \text{............. (2)}$$

- Now on adding equations (1) & (2), we get

$$W = W_1 + W_2$$
$$= V_L I_L \cos(30-\phi) + V_L I_L \cos(30-\phi)$$
$$= V_L I_L [\cos(30-\phi) + \cos(30-\phi)]$$
$$= V_L I_L 2\cos 30 \cos\phi$$

$$\boxed{W = \sqrt{3} V_L I_L \cos\phi} \quad \text{............. (3)}$$

This result shows that it is the power for 3 - ϕ system.

- Now on subtracting equations (1) & (2), we get

$$W_1 - W_2 = V_L I_L \cos(30-\phi) - V_L I_L \cos(30+\phi)$$
$$= V_L I_L [\cos(30-\phi) - \cos(30+\phi)]$$
$$= V_L I_L \,.\, 2 \sin 30 .\ \sin\phi$$

$$\boxed{W_1 - W_2 = V_L I_L \sin\phi} \quad \text{............. (4)}$$

- On Dividing equation (4) by equation (3), we get

$$\frac{W_1 - W_2}{W_1 + W_2} = \frac{V_L I_L \sin\phi}{\sqrt{3} V_L I_L \cos\phi}$$

$$\tan\phi = \sqrt{3}\frac{(W_1 - W_2)}{(W_1 + W_2)}$$

Power factor angle, $\boxed{\phi = \tan^{-1}\left\{\sqrt{3}\frac{(W_1 - W_2)}{(W_1 + W_2)}\right\}}$

Power factor, $\boxed{\cos\phi = \cos\left[\tan^{-1}\left\{\sqrt{3}\frac{(W_1 - W_2)}{(W_1 + W_2)}\right\}\right]}$

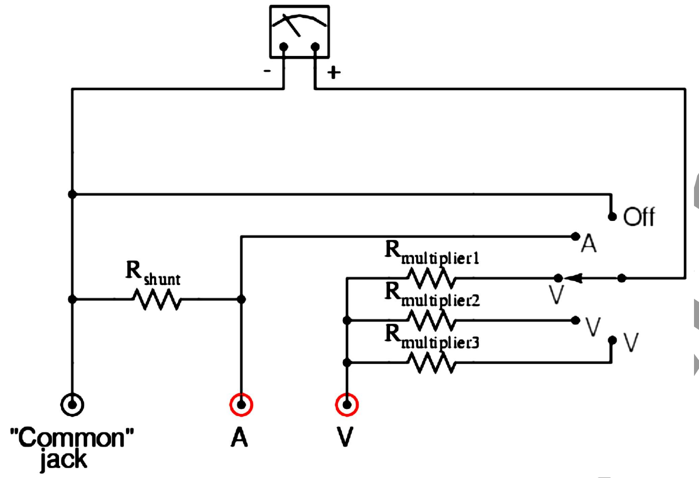
Variation in Wattmeter Readings

p.f. angle (ϕ)	p.f. ($\cos\phi$)	W_1 [$V_L I_L \cos(30+\phi)$]	W_2 [$V_L I_L \cos(30-\phi)$]	$W = W_1 + W_2$ [$W = \sqrt{3} V_L I_L \cos\phi$]	Observations
0°	1	$\frac{\sqrt{3}}{2} V_L I_L$	$\frac{\sqrt{3}}{2} V_L I_L$	$\sqrt{3} V_L I_L$	$W_1 = W_2$
30°	0.866	$\frac{V_L I_L}{2}$	$V_L I_L$	$1.5\ V_L I_L$	$W_2 = 2W_1$
60°	0.5	0	$\frac{\sqrt{3}}{2} V_L I_L$	$\frac{\sqrt{3}}{2} V_L I_L$	$W_1 = 0$
90°	0	$\frac{-V_L I_L}{2}$	$\frac{V_L I_L}{2}$	0	$W_1 = -W_2$

(iv) Multimeter : The ammeter, the voltage and the ohmmeter all use a basic D's Arsonval movement. the difference between these instruments is the circuit in which the basic movement is used. It is therefore obvious that an instrument can be ddsigned to perform these three measurment function. This instrument which contains a function switch to connect the appropriate circuits to the d'Arsonval movement, is called a "Multimeter" or Volt-ohm-milli-ammeter" (V.O.M).

A representative example of a commercial multimeter is the simpson model 260 whose complete combination of a d.c milli-ammeter, a d.c voltemter, an a.c. voltmeter, a multirange ohmmeter and an output meter.

This multimeter uses a d' Arsonval movement that has a resistance of 200Ω and a full scale current of 50Ω



This instrument is provided with a selector switch which can be set for different modes of operation like measurement of voltage, current, resistance etc., and also for various ranges of these quantities.

(d) In a moving coil instrument, the coil has a length of 5 cm, a width of 4 cm and 100 turns. The magnetic flux density in the air gap is 0.2 Wb/m². The hair spring provides a controlling torque of 0.5 × 10^{-7} Nm/degree deflection of the coil. What current will be required to give a deflection of 60° ?

[15 Marks]

Solution: Given that,

Length of the coil, l = 5cm = 5×10^{-2} m.

Width of the coil, d = 4×10^{-2}m

number to turns = 100

Magnetic flux density in air - gap, B = 0.2 Wb/m²

Controlling torque/degree deflection of the coil = spring constant = K = 0.5×10^{-7}Nm/degree

deflection of the coil, θ = 60°.

At equilibrium, $T_c = T_d$

$\Rightarrow$ K θ = BINA=BIN (l×d)

$\therefore$ [A = l×d]

then, $I = \dfrac{K\theta}{BIld} = \dfrac{0.5\times10^{-7}\times60}{0.2\times100\times5\times10^{-2}\times4\times10^{-2}}$

= 7.5×10^{-5}A = 75×10^{-6}A

= 75 μA.

5. (a) A shunt generator gives full load output of 30 kW at a terminal voltage of 200 V. The armature and shunt field resistances are 0.01 Ω and 100 Ω respectively. The iron and friction losses are 1000 W. Calculate the

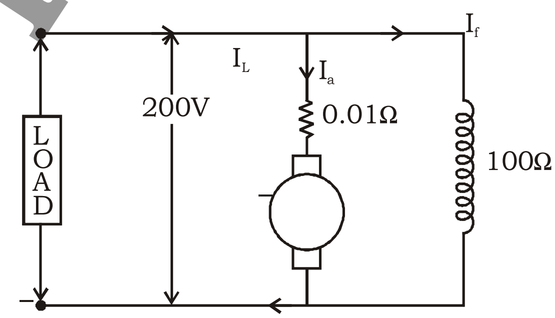
(i) emf generated

(ii) copper losses

(iii) efficiency

[15 Marks]

Solution:



$P_{iron} + P_{friction} = 1000$ watt

$P_{out} = 30$ KW.

$= VI_L = 30$ KW.

$\Rightarrow 200 \times I_L = 30 \times 1000$

$$\Rightarrow 200 \times I_L = \frac{30 \times 1000}{200}$$

$= 150$ Amp.

$I_a = I_1 + I_f$

$= 150 + 2 = 152$ Amp

(i) $E = V_t + I_a R_a$

$= 200 + (152 \times 0.01)$

$= 201.52$ Volt

(ii) Copper Loss $= P_{winding} + P_{field}$.

$= I_a^2 R_a + I_f^2 R_f$.

$= 152^2 \times 0.01 + 2^2 \times 100$

$= 231.04 + 400$

$= 631.04$ Watt

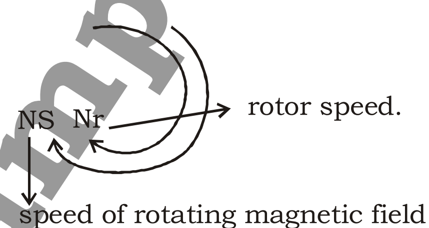
(iii) $$\eta = \frac{P_{out}}{P_{out} + P_{loss}}$$

$$= \frac{30\,kW}{30kW + P_i + P_c + P_{friction}} \times 100 = \frac{30 \times 1000}{30 \times 1000 + 1000 + 631.04} \times 100 = 94.84\%$$

(b) Explain dynamic breaking of 3-phase induction motor.

[15 Marks]

Solution: Dynamic breaking of induction motor.



In case of dynamic breaking three phase supply is cut so rotating magnatic field is getting vanished Now we apply the d.c supply.

* This DC supply will produce constant magnatic field and this will be cut by the rotating magnetic field.
* According to Faraday's law an emf will be Induced and it will oppose the motion by lenz's law.
* Due to opposite force machine will stop.

(c) Explain in brief the following :

(i) Fractional kilowatt motors

(ii) Auto transformers

(iii) S.C. test of 3-phase transformer

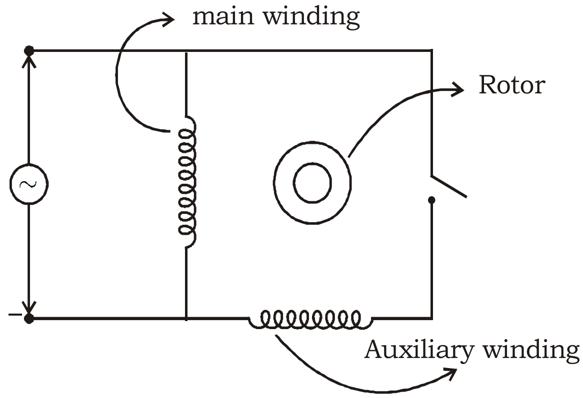
[15 Marks]

Solution : (i) Fractional kilowatt motors

* Small motors which has power rating less than 1 kW is fractional kilowatt.
* This type of motors are normally used for domestic application
* **Type of fractional kilowatt motors**

(A) 1 ϕ induction motor

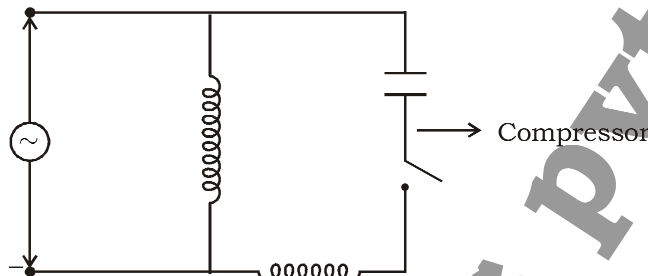
(1) Split phase induction motor



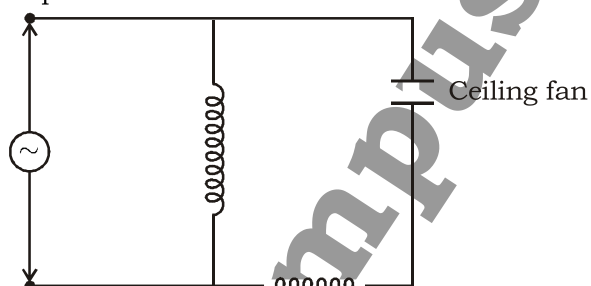
Application $\longrightarrow$ washing machine

(ii) Capacitor Type

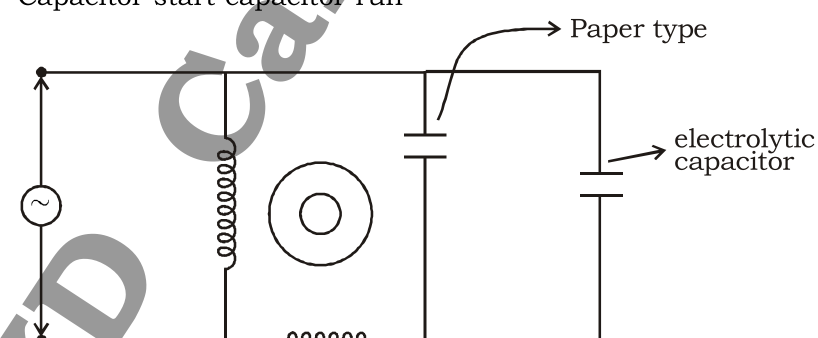
(a) Capacitor start Induction motor



(b) Capacitor run induction motor



(c) Capacitor start capacitor run



Example $\rightarrow$ refrigerator

(iii) Shaded pole induction motor

Example $\rightarrow$ toys.

(2) 1-Q synchronous motor

(a) Reluctance motor

Example timing and signaline.

(b) hysterisis motor

example $\rightarrow$ Sound $\rightarrow$ Tap recoder.

(3) Universal motor $\rightarrow$ This is a series type of motor which can work with both A.C as well as d.c

* it can run up to a speed of 20000 rpm.
* it has high starting torquee and high speed
* Smaller in size.

Application $\rightarrow$ (i) vaccum cleaner
(ii) vaccum cleaner
(iii) mixer
(iv) seveing machine.

(4) Repulsion motor.

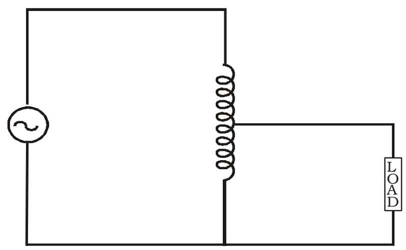
* this type of motor is operatied by brush shifting.
* The direction of rotation is along the shifting of brush.

Types
(i) Repulsion motor.
(ii) compensatied type ropulsion motor.
(iii) Repulsion start induction run.
(iv) Repulion - Induction motor.

(ii) Autotransformer : Special type of transformer which transfers power through both conduction as wiell as Induction.

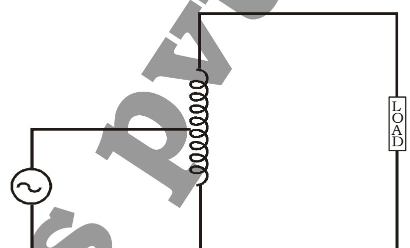
* In such tyhpe of transformer there is a common winding between primary and secondry.

Advantage of outo transformer



Step down

or



Step up

Advantage
(i) Iron saving
(ii) Copper saving.
(iii) less iron and copper loss
(iv) high efficiency.
(v) less leakage flux.
(vi) better voltage regulation

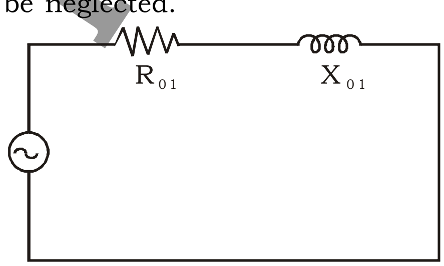
Disadvantage
(i) economical for transformation (K) near about unity.
(ii) Physical connection between primary and secondary.
(iii) Impact of short ckt is more.

(iii) Short circuit test of 3-ϕ transformer : These test is conducted to find.
(i) Copper loss.
(ii) series parameter like winding resistance leakage reactance.
(iii) voltage regulation.

Conditions
(i) It is operated at rated current and from high voltage side.
(ii) Low voltage is short circuited in order to ensure that the power is not dragged by any load and the power consumed is only due to copper loss.

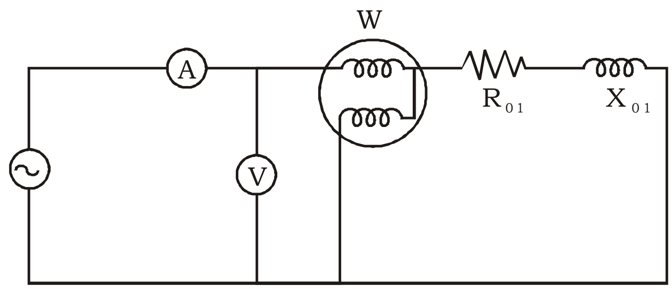
* During this test the current flowing through shunt parametre is even lower so the core loss can be neglected.

*



Equivalent circuit

Testing arrangement



Result of testing

Wattmetre reading (w) $\rightarrow$ copper loss

Impedance = $\dfrac{\text{Voltmetre reading}}{\text{ammetre reading.}}$

Wattmeter reading = (ammetre reading)^2×R.

X = $\sqrt{Z^2 - R^2}$

(d) Explain parallel operation of two alternators.

[15 Marks]

Solution : Parallal operation of alternator

Advantage of parallal operation

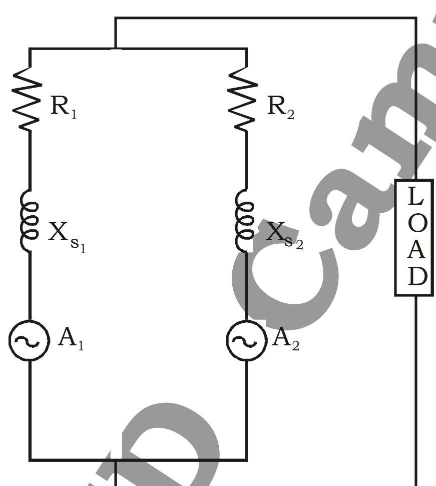
(i) Better reliability

(ii) Supply for increased load demand.

(iii) better maintenance.

(iv) economical operation.

(v) less amount of energy wastage.



A_1 $\rightarrow$ Alternator 1

A_2 $\rightarrow$ Alternator 2.

R_1 $\rightarrow$ Resistance alternator

R_2 $\rightarrow$ Resistance alternator 2

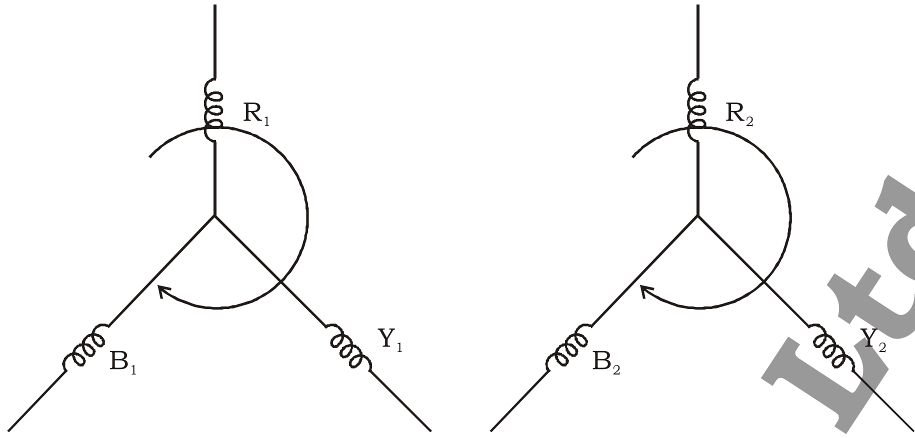
Xs_1,Xs_2 $\rightarrow$ Synchronous reactance

Condition of parrallal operation

(i) Voltage rating of the alternators should be same otherwise one will act as source and another will act as load and a circulating current will flow in the circuit.

(ii) frequency should be same $\rightarrow$ for the same frequency there will not be any droop and system will remain more stable.

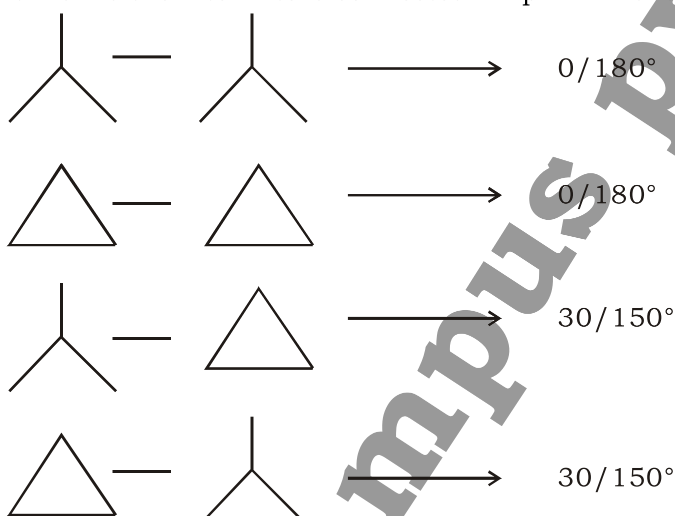
(iii) Phase sequance should remain same



If the phase sequence is not same than due to phase angle diflerance between corresponding phase a circulating current will flow.

(iv) Same phase shift :
The alterators used for parallal operation should have same phase shift.

* It means the alternators connected in parallal should be of same phase shift family.



6. (a) Explain in brief of the following,

(i) Merz-price system of protection

(ii) Short-circuit current for symmetrical faults

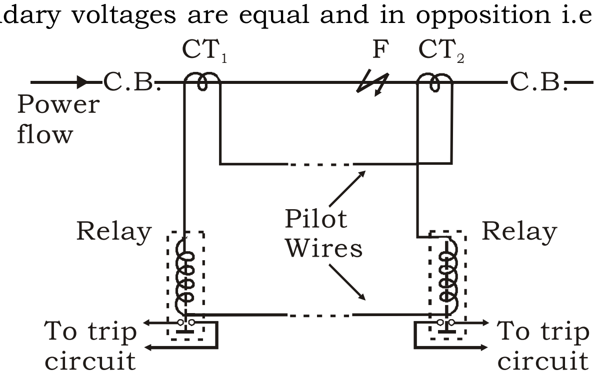
(iii) Electric welding

[30 Marks]

Solution :

(i) Merz-price system of protection :

Figure shows the single line diagram of Merzprice voltage balance system for the protection of a 3 phase ling. Identical current transformer are placed in each phase at both ends of the line. The pair of CTs in each line is connected in series with a relay in such a way that under normal condition, their secondary voltages are equal and in opposition i.e they balance each other.



Under healthy conditions, current entering the line at one-end is equal to the leacing it at the other end. Therefor, equal and opposite voltages are induced in the secondries of the CTs at the two ends of the line. The result is theat no current folws through the relays. Suppose a fault occurs at point F on the line as shown in Figure. This will cause a greater current to flow through CT_1 than through CT2. Consequently, their secondary voltages become unequal and circulating current flows through the pilot wires and relays. The circuti breakers at both ends of the line will trip out and the faulty line will be isolated.

Figure shows the connections of Merz-Price voltage balance for all the three phase of the line.

Advantages

(i) This system can used for ring mains as well as parallel feeders.

(ii) This system provides instantaneous protection ofr ground faults. This decreases the possibility of these faults involving other phases.

(iii) This sysytem provides instantaneous relaying which reduces the amount of damage to overhead conductors resulting from arcing faults.

Disadvantages

(i) Accurate matching of current transformers is very essential.

(ii) If there is a break in the pilot-wire circuit, the system will not operate.

(iii) This system is very expensive owing to the greater length of pilot wires required.

(iv) In case of long lines, charingcurrent due to pilot - wire capacitance* effects may be sufficient to cause relay operation even under normal conditions.

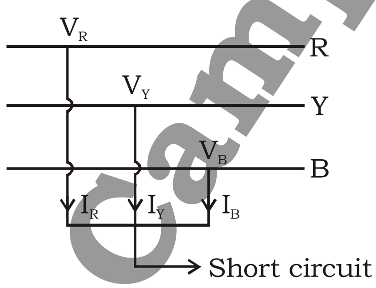
(v) This system cannot be used for line voltages beyond 33 KV because of constructional difficulties in matching the current transformers.

(ii) Short-circuit current for symmetrical faults :

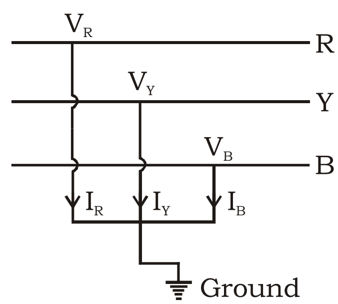
A fault in which all the three phases is involving known as symmetrical fault.

(i) All the three phase to earth (L.L.L.G.)
(ii) All the three short circuited (LLL)

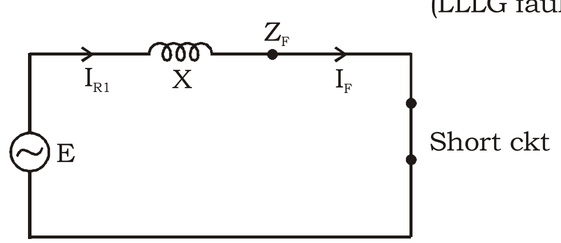
} 3% Chances of occurrence



(LLL fault)



(LLLG fault)



E = Thevenin equivalent of prefault voltage

X = Thevenin equivalent reactance

$$I_F\,(3\phi) = \frac{E}{X}$$

Let E = 1 P.U.

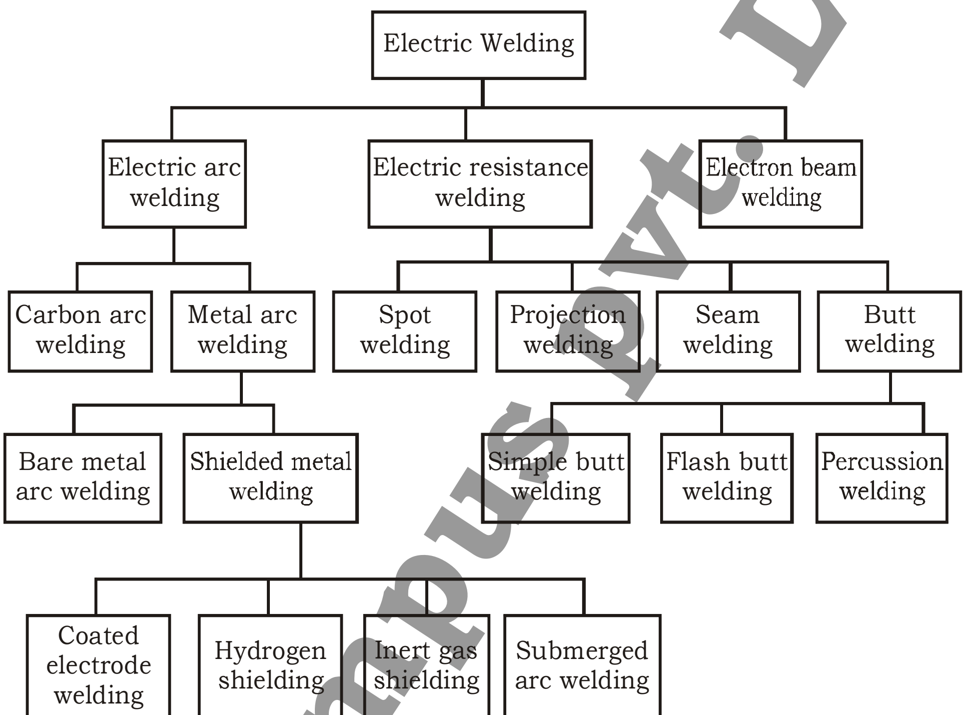
then $\Rightarrow$ $I_F\,(3\phi) = I_{SC} = \dfrac{1}{X}$

(iii) Electric welding :

It is metallurgical union of metals brought about by the application of heat and pressure so that welded joint should have, as far as possible, same properties as the parent metal in adjacent parts of weld. Depending upon how the heat applied is created, we get different types of welding such as thermal welding, gas welding and electric welding. We will, in this chapter, not deal with thermal and gas welding. Electric welding will be gone through in details with some introduction to other modern welding techniques.

➢ **Classification of Electrical Welding**

Electric welding is classified as electric arc welding and electric resistance welding and electron beam welding. These are further sub-classified as :



(b) How is the rating of a cable determined ?

[10 Marks]

Solution :

The current carrying capacity of an insulated conductor or cable is the maximum current that it can continuously carry without exceeding its temperature rating. It is also known as ampacity.

Whilst the cables are in operation they suffer electrical losses which manifest as heat in the conductor, insulation and any other matallic components in the construction. The current rating will depend on how this heat is dissipated through the cable surface and into the surrounding areas. The temperature rating of the cables is a determing factor in the current carrying capacity of the cables. The maximum temperature rating for the cables is essentially determined by the insulation material.

By choosing an ambient temperature as a base for the surroundings, a permissible temperature rise is available from which a maximum cable rating can be calculated for a particular enviroment. If the thermal resistivity values are known for the layers of materials in the cable construction then the current ratings can be calculated.

The formula for calculating current carrying capacity is:

$$I = \left\{ \frac{\Delta\theta - W_d\left[\frac{1}{2}T_1 + n\left(T_2 + T_3 + T_4\right)\right]}{RT_1 + nR\left(1+\lambda_1\right)T_2 + nR\left(1+\lambda_1+\lambda_2\right)\left(T_3+T_4\right)} \right\}^{1/2}$$

I = permissible current rating

$\Delta\theta$ = Conductor temperature rise in (K)

R = Alternating current resistance per unit length of the conductor at maximum operating temperature (Ω/m)

W_d = dielectric loss per unit length for the insulation surrounding the conductor (W/m)

T_1 = thermal resistance per unit length between one conductor and the sheath (Km/W)

T_2 = thermal resistance per unit length of the bedding between sheath and the armour (Km/W)

T_3 = thermal resistance per unit length of the external sheath of the cable (Km/W)

T_4 = thermal resistance per unit length between the cable surface and the surrounding medium (Km/W)

n = number of load-carrying conductors in the cable (conductors of equal size and carrying the same load)

λ_1 = Ratio of losses in the metal sheath to total losses in all conductors in that cable

λ_2 = ratio of losses in the armouring to total losses in all conductors in that cable.

Cable Capacity

- **For Cu Wire Current Capacity (Up to 30 Sq.mm)** = 6 × Size of Wire in Sq.mm
  Ex. For 2.5 Sq.mm = 6×2.5 = 15 Amp, For 1 Sq.mm = 6×1 = 6 Amp, For 1.5 Sq.mm = 6×1.5 = 9 Amp
- **For cable Current Capacity =** 4 × Size of cable in Sq.mm, Ex. For 2.5 Sq.mm = 4 × 2.5 = 9 Amp.
- Nomenclature for cable Rating = Uo/U
- where Uo = Phase-Ground Voltage, U = Phase-Phase Voltage, Um = Highest Permissible Voltage.

Minimum Bending Radius

- Minimum Bending Radius for LT Power Cable = 12 × Dia of cable.
- Minimum Bending Radius for HT Power Cable = 20 × Dia of cable.

(c) What are the different configurations of BJT ? Explain each with suitable circuit diagram.

[10 Marks]

Solution :

(i) Common-Base Configuration : Base is common to both the input and output sides of the configuration.

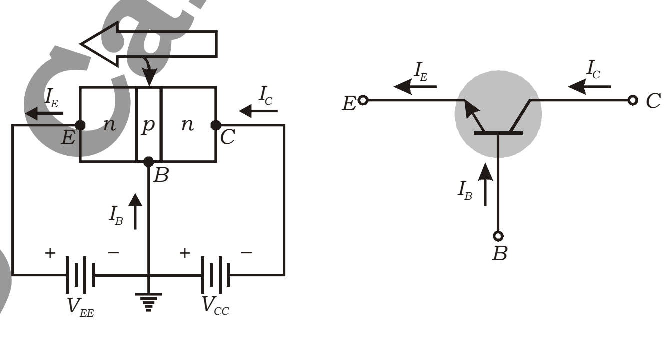


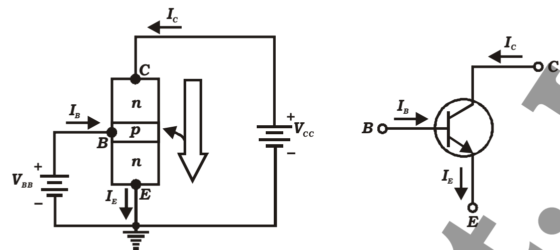
Fig. : *npn transistor*

To describe the behavior of a three-terminal device such as the common-base amplifiers of Fig. requires two sets of characteristics—one for the driving point or input parameters and the other for the output side. The input set for the common-base amplifier as shown in Fig. relates an input current (I_E) to an input voltage (V_{BE}) for various levels of output voltage (V_{CB}).

Alpha (α) : In the dc mode the levels of I_C and I_E due to the majority carriers are related by a quantity called alpha and defined by the following equation:

$$\boxed{\alpha_{dc} = \frac{I_C}{I_E}}$$

(ii) Common Emitter Configuration : The most frequently encountered transistor configuration appears in Fig. for the pnp and npn transistors. It is called the common-emitter configuration because the emitter is common or reference to both the input and output terminals (in this case common to both the base and collector terminals). Two sets of characteristics are again necessary to describe fully the behavior of the common-emitter configuration: one for the input or base-emitter circuit and one for the output or collector-emitter circuit.



Beta (β) : In the dc mode the levels of I_C and I_B are related by a quantity called beta and defined by the following equation:

$$\boxed{\beta_{dc} = \frac{I_C}{I_E}}$$

Relation between α and β

$$I_E = I_C + I_B$$

we have $$\frac{I_C}{\alpha} = I_C + \frac{I_C}{\beta}$$

and dividing both sides of the equation by I_C results in

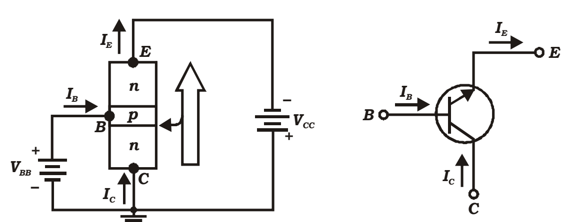
$$\frac{I}{\alpha} = 1 + \frac{1}{\beta}$$

or $$\beta = \alpha\beta + \alpha = (\beta + 1)\alpha$$

so that $$\boxed{\alpha = \frac{\beta}{\beta + 1}}$$

or $$\boxed{\beta = \frac{\alpha}{1 - \alpha}}$$

(iii) Common-Collector Configuration : The third and final transistor configuration is the common-collector configuration, shown in Fig. with the proper current directions and voltage notation. The common-collector configuration is used primarily for impedance-matching purposes since it has a high input impedance and low output impedance, opposite to that of the common-base and common- emitter configuration.



(d) Explain electric installation of machines and relevant IE rules in brief.

[15 Marks]

Solution : Machine installation and commissioning is a key part of putting the machine into service. If installation and commissioning is carried out carefully using the correct procedures, it is an investment in the machine´s serviceability and reliability for its entire service life.

All tasks carried out on the machines are recorded, delivered to the user and also filed for further reference if needed.

Installation procedures

A suitable rigid and safe cradle must be provided for proper machine seating, as well as a clutch ensuring the safe transmission of torque from the driving to the driven equipment. Our engineers check whether the clutch allows the required axial and radial clearances to compensate for the thermal dilation of the machines and the bearing lift in sliding bearings.

Main tasks carried out:

Visual inspection of the cradle

Inspection of the clutch

Proper machine axial alignment checking and correction

Checking the main and auxiliary electric circuit connection

Checking the cooling circuit connection

Checking the lubricating circuit connection

Commissioning

Mechanical and electrical installations are inspected first to check whether the required parameters are kept. Subsequently, all auxiliary and supervisory circuits required for machine starting and operation are checked.

Main tasks carried out:

Visual inspection of the main cable terminals

Check of the cooling and lubricating systems

Electrical measurement and check of all the machine´s wiring

Testing and calibrating setup parameters

Protection testing

Excitation system and Automatic Voltage Regulation (AVR) setting

Checking the idle running, load running and connecting the generator phases to the grid

Checking the operating parameters – load sharing, checking operating temperatures and vibrations

As soon as the parameters are set and the correct operation tested and confirmed the commissioning work is considered completed and the equipment is handed over to the customer with a record (description of the work, set values, summary, recommendations for the future use of the machines).