B.Tech.

First Semester Examination

Electrical Technology (EE-101F)

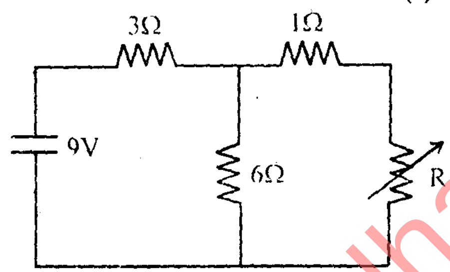
Note : Attempt *ALL* Questions. Questions '1' is compulsory.

Multiple choice questions answers.

Q. 1. (i) The maximum power that can be distributed in the load in the circuit shown is :

(a) 3 watt (b) 6 watt

(c) 6.75 watt (d) 13.6 watt



Ans. (a) 3 watt.

Q. 1. (ii) In delta connected circuit when, one resistor is open. The power will be :

(a) Zero (b) Reduced to 1/3

(c) Reduced by 1/3 (d) Unchanged.

Ans. (c) Reduced by 1/3.

Q. 1. (iii) If $V = (a + jb)$ and $I = (c + jd)$, the power is given by,

(a) $ac - bd$ (b) $ac + bd$

(c) $bc - ad$ (a) $bc + ad$.

Ans. (b) $ac + bd$.

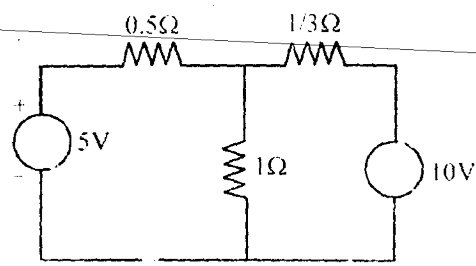
Q. 1. (iv) KCL is consequences of law of conservation of :

(a) Energy (b) Charge

(c) Flux (d) All.

Ans. (b) Charge.

Q. 1. (v) The potential at point 'A' is given network :



(a) 6V (b) 7V

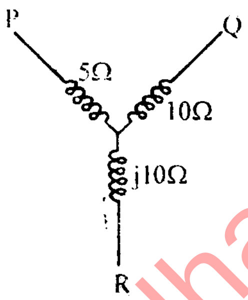
(c) 8V (d) None of these.

Ans. (c) 8V.

Q. 1. (vi) In the delta equivalent of the given star-connected impedance ZOR is equal to :

(a) 40Ω (b) $(20+j10)\Omega$

(c) $\left(5+\frac{10}{3}i\right)\Omega$ (d) $(10+30j)\Omega$.



Ans. (d) $(10+30j)\Omega$.

Q. 1. (vii) The power delivered to a three phase load can be measured by use of 2 wattmeters only when the :

(a) A load is balanced

(b) A load is unbalanced

(c) 3-phase load is connected to the source through three wires

(d) 3-phase load is connected to source through & wire.

Ans. (c) 3-phase load is connected to the source through three wires.

Q. 1. (viii) If permanent brake magnet is moved away from the spindle of the moving disc, energy meter.

(a) Will run fast (b) Will run slow

(c) No effect (d) Will come to stop

Ans. (b) Will run slow.

Q. 1. (ix) The advantage of PMMC type instrument is :

(a) Low power consumption (b) No hysteresis loss

(c) Efficient current damping (d) All of above.

Ans. (d) All of above.

Q. 1 (x) In which instrument the deflecting torque depends upon frequency?

(a) Hot wire (b) Moving coil

(c) Moving iron (d) Induction type.

Ans. (d) Induction type.

Q. 1. (xi) Which of the following does not change in ordinary transformer ?

(a) Voltage (b) Curre

(c) Frequency (d) All of above.

Ans. (c) Frequency.

Q. 1. (xii) A transformer has full load iron loss of 900W and copper loss of 1600W at percent of the load the transformer will have maximum efficency.

(a) 100% (b) 90%

(c) 75% (d) 50%.

Ans. (c) 75%.

Q. 1. (xiii) A transformer operating at constant load current, maximum efficiency will occur at a p.f.

(a) Zero (b) Unity

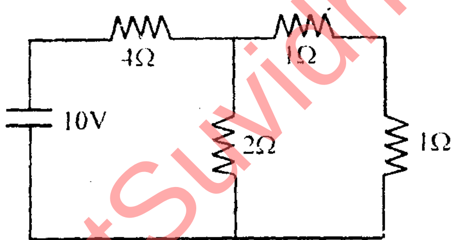
(c) 0.8 lead (d) 0.8 load

Ans. (b) Unity.

Q. 1. (xiv) The Thevenin's equivalent resistance when the current is to be obtained through 2Ω resistance is :

(a) 5Ω (b) 2Ω

(c) 1.33Ω (d) 1.5Ω



Ans. (c) 2Ω.

Q. 1. (xv) The torque-speed characteristics of a d.c. shunt motor is :

(a) A rectangular hyperbola (b) A dropping straight line

(c) A parabola (d) None of the above.

Ans. (b) A dropping straight line.

Q. 1. (xvi) In case of series resonance the supply voltage depends upon the voltage across the :

(a) Inductance (b) Capacitance

(c) Resistance (d) None.

Ans. (c) Resistance.

Q. 1. (xvii) A change of 5% in supply voltage to a $3-\phi$ IM will produce the approx change in the torque of :

(a) 5% (b) 7.5%

(c) 10% (d) 15%.

Ans. (c) 10%.

Q. 1. (xviii) The mechanical load in an induction motor can be represented by :

(a) $\frac{R_{2e}}{5} - R_{2e}$ (b) $R_{2e} - \frac{5}{R_{2e}}$

(c) $\frac{1}{S(R_{2e}-1)}$ (d) $R_{2e}\left(\frac{1}{S}+1\right)$

Ans. (a) $\frac{R_{2e}}{S} - R_{2e}$.

Q. 1. (xix) **In an induction motor the rotor input is 600W and slip is 4%. The rotor copper loss is :**

(a) 700W (b) 600W

(c) 650W (d) 24W.

Ans. (d) 24W

Q. 1. (xx) **If a synchronous motor is under excited it takes lagging vars from the system when it is operated as :**

(a) Synchronous motor (b) Synchronous generator

(c) Synchronous motor as well as (d) None of these.

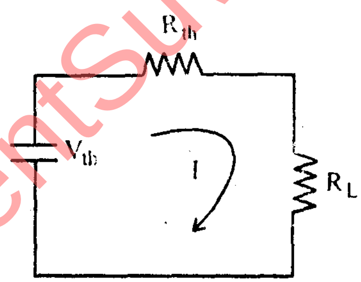
Ans. (c) Synchronous motor as well as.

Section-A

Q. 2. (a) **State and prove maximum power transfer theorem.**

Ans. **Statement :** "Any electrical circuit will deliver maximum power to load when load resistance is equal to the emm equivalent resistance of circuit.

Proof : Let is consider a thevenin equivalent circuit as shown in fig.



Apply KVL is circuit :

$$I = \left(\frac{V_{th}}{R_{th}+R_L}\right) \quad ...(1)$$

Power delivered to load

$$P = I^2 R_L \Rightarrow P = \frac{V_{th}^2}{(R_{th}+R_L)^2}.R_L$$

Now, for maximums value of 'p'

$$\frac{\partial p}{\partial R_L} = 0$$

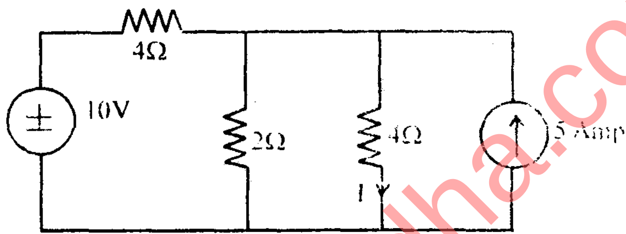
$$\Rightarrow \quad \frac{V_{th}^2\left[(R_{th}+R_L)^2 - 2(R_{th}+R_L)R_L\right]}{(R_{th}+R_L)^2} = 0$$

$$\Rightarrow \quad (R_{th}+R_L)^2 = 2(R_{th}+R_L)R_L$$

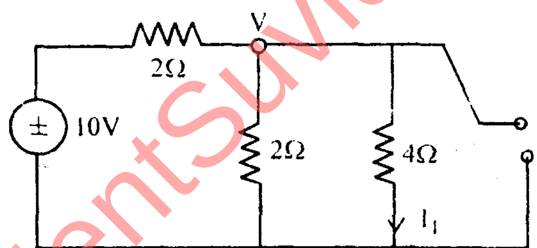
$$\Rightarrow \quad \boxed{R_{th} = R_L} \quad \textbf{Hence prove}$$

For maximum power transfer R_{th} must be equal to R_L.

Q. 1. (b) Calculate I, for given circuit using superposition theorem.



Ans. (i) Consider voltage source and open current source using Nodal method :

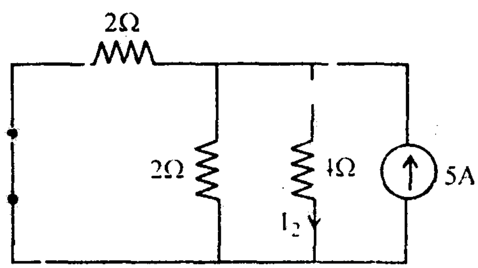


$$\frac{V-10}{2} + \frac{V}{2} + \frac{V}{4} = 0$$

$$\Rightarrow \quad V = 4 \text{ volt}$$

$$\Rightarrow \quad I_1 = \frac{4}{4} = 1 \text{Amp} \ (\downarrow \text{down})$$

(ii) Consider current source and short voltage source :



Again, use Nodal method,

$$\frac{V}{2}+\frac{V}{2}+\frac{V}{4}-5=0$$

$$5V=20$$

$$V=4\text{ volt}$$

$$I_2=1\text{Am } (\downarrow) \text{ down}$$

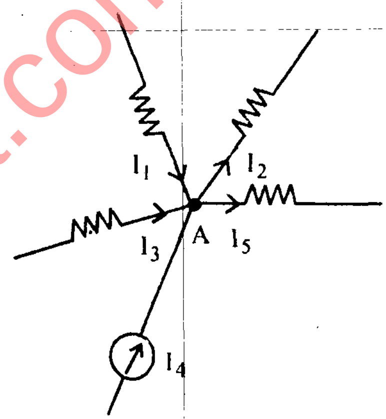
$$I=I_1+I_2$$

$$(I=2\text{ Amp downward}).$$

Q. 2. (a) State and explain KVL and KCL.

Ans. Kirchoff's Current Law (KCL) :

Statement : In any electric circuit the algebric sum of currents at any node is equal to zero. Let, a node as shown in fig.



Sign Conversion : Let incoming current (+ve)

Outgoing current (−ve)

According to KCL :

$$\Sigma I=0$$

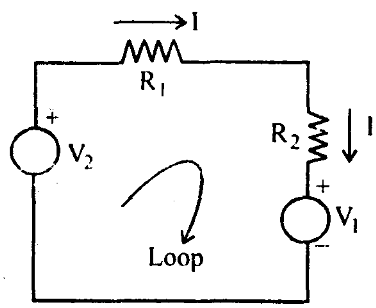
$$\Rightarrow \quad I_1+I_3+I_4-I_2-I_5=0$$

$$\Rightarrow \quad (I_1+I_3+I_4)=I_2+I_5$$

⇒ Some of incoming current = Some of out going current.

KVL (Kirchoff's Voltage Law) :

Statement : In any closed loop the algebric sum of voltage is equal to zero. Let, a loop as shown in figure.



Let voltage gain (+ve)

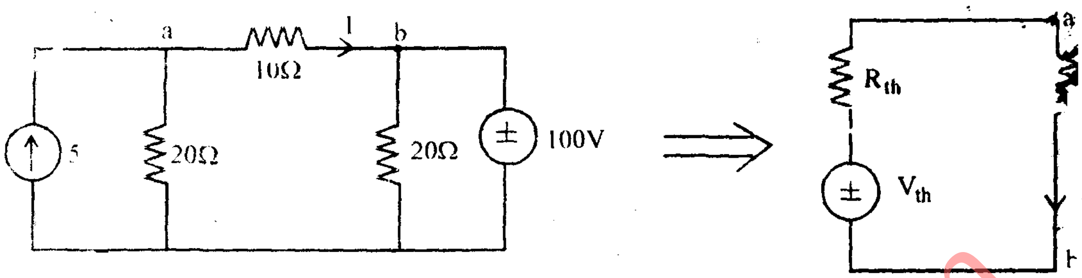
Voltage drops (−ve)

$$V_2-IR_1-IR_2-V_1=0$$

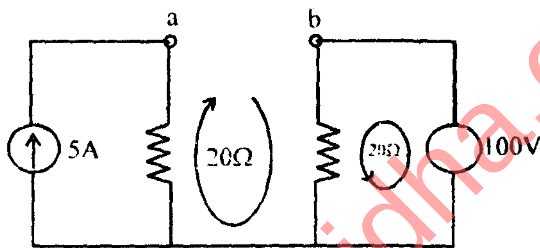
$$\Rightarrow \quad (V_2-V_1)=I(R_1+R_2)$$

Hence, Acco. ding to KVL : "For any closed loop algebric sum of emf applied is equal to voltage drops."

Q. 2. (b) Determine current 'I' using Thevenin's Theorem.



Ans. Circuit for V_{th} :



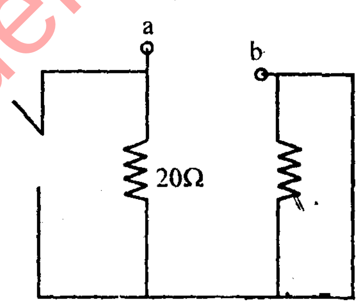
$$V_{th} = V_{ab} = V_a - V_b$$

$$V_a = 100 \text{ volt}$$

$$V_b = 100 \text{ volt}$$

$$V_{th} = 0 \text{ volt}$$

Circuit of R_{th} : (Open current source & short voltage source)



$$R_{th} = 20\Omega$$

Now,

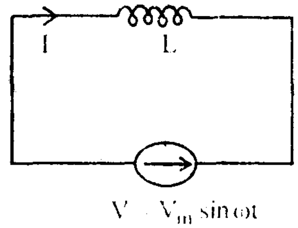
$$I = \left(\frac{V_{th}}{R_{th} + R_L}\right)$$

$$I = 0 \text{ Amp.}$$

Section-B

Q. 3. (a) Explain purely inductive single phase account and draw waveforms and phasor diagram.

Ans. Let. use consider a purely inductive circuit having inductance 'L' and voltage supply $V = V_m \sin \omega t$ given.



$$V = V_m \sin \omega t$$

$$V = V_m < 0 \qquad \text{...(i)}$$

For for inductors,

$$Z = 0 + jX_L \Rightarrow Z = X_L < +1/2 \qquad \text{...(ii)}$$

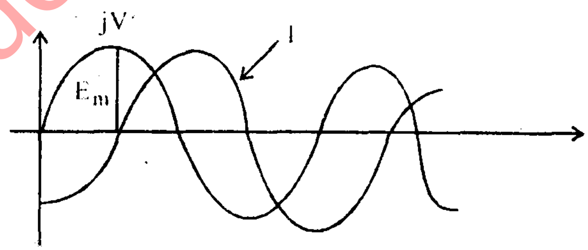
as, up know,

$$I = \frac{V}{Z} \Rightarrow I = \frac{V_m < 0}{X_L < \pi/2}$$

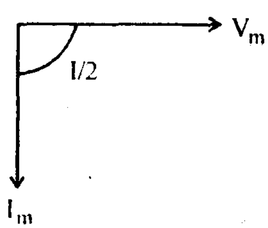
$$I = \frac{V_m}{X_L} < -\frac{\pi}{2} = I_m < -\frac{\pi}{2} \qquad \text{...(iii)}$$

$$\boxed{I = I_m \sin\left(\omega t - \frac{\pi}{2}\right)}$$

Waveforms :



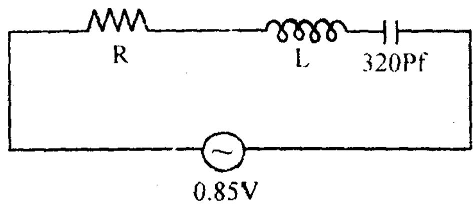
Phasor :



Instantaneous Power :

$$P = VI$$

Q. 3. (b) For the circuit shown determine the value of inductance for resonance if Q = 50 and f_0 = 175 kHz. Also find the circuit current, the voltage across the capacitor and band width of circuit.



Ans.

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$\Rightarrow \quad 175 \times 10^3 = \frac{1}{2\pi\sqrt{L \times 320 \times 10^{-12}}}$$

$$\Rightarrow \quad L = 2.58 \text{ mH}$$

Hence, the reactance of coil at resonance,

$$X_L = 2\pi fL = 2\pi \times 175 \times 10^3 \times 2.58 \times 10^{-3} = 2840\,\Omega$$

Since,
$$Q = \frac{\omega_0 L}{R} \Rightarrow R = \frac{\omega_0 L}{Q}$$

$$\Rightarrow \quad R = \frac{2840}{50} = 56.8\,\Omega$$

The impedance of circuit at resonance is,

$$Z = R = 56.8\,\Omega$$

Therefore current
$$I_0 = \frac{0.85}{56.8} = 14.96 \text{ mA}$$

The voltage across capacitor,

$$V_C = I_C X_C \text{ or } QV$$

$$\Rightarrow \quad V_C = 50 \times 0.85 = 42.5 \text{ volt}$$

The bandwidth of the current is,

$$B = \frac{f_0}{Q} = \frac{175 \times 10^3}{50}$$

$$\Rightarrow \quad B = 3.5 \text{ kHz.}$$

Q. 4. (a) A 4700Ω resistor and 2μF capacitor are connected in parallel across a 240V 60Hz source. Determine the circuit impedance and the line current.

Ans. The current is resistor,

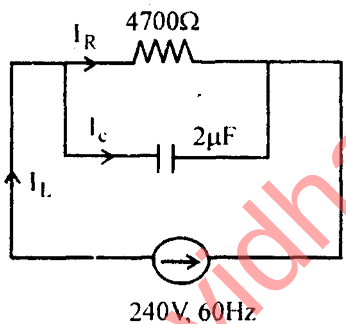
$$I_R = \frac{240}{4700} = 0.0514A$$

In capacitor

$$I_C = (j\omega C)V$$

$$= j\left(2\pi \times 60 \times 2 \times 10^{-6} \times 240\right)$$

$$= 0.1808\, j \text{ Amp}$$



Line current,

$$I_L = I_R + I_C$$

⇒ $$I_L = [0.051 + j(0.1808)]\text{Amp}$$

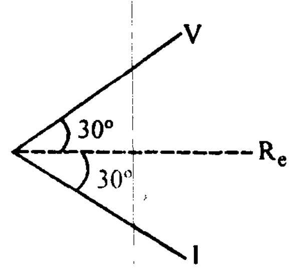
Therefore, impedance :

$$Z = \frac{V}{I_L} = \frac{240 < 0}{0.188 < 74.30}$$

⇒ $$\boxed{Z = 1276 < -74.3\Omega}$$ **Ans.**

Q. 4. (b) In an electric circuit voltage and current are given as $V = 10\sin(\omega t + 30^\circ)$ amd $I = 10\sin(\omega t + 30^\circ)$ determine active and reactive power in circuit.

Ans. Phasor's will be as shown in figure,



$$V_{rms} = \frac{10}{\sqrt{2}}$$

$$I_{rms} = \frac{10}{\sqrt{2}}$$

$$\phi = 60^\circ$$

As; we know : $$P = VI \text{ (Absolute power)}$$

Active Power :

$$P_a = V_{rms} I_{rms} \cos\phi$$

$$= \frac{10}{\sqrt{2}} \cdot \frac{10}{\sqrt{2}} \cos 60^\circ$$

$$= 25 \text{ watt}$$

Reactive Power :

$$P_r = V_{rms} I_{rms} \sin\phi$$

$$= \frac{10}{\sqrt{2}} \cdot \frac{10}{\sqrt{2}} \sin\phi = \frac{100}{2} \sin 60$$

$$= 25\sqrt{3}\ V_{rms}\ kg.$$ **Ans.**

Section-C

Q. 5. (a) Three equal impedances, each (20 + j30)Ω are connected in star across a 3-phase, 400V, 50Hz supply. Determine :

(a) The phase and line currents

(b) The power factor of the load

(c) The reading of the wattmeters

When the 2-wattmeter method is used to measure power input to the load.

Ans.

$$Z_p = 20 + j30 = 36.05\angle 56.31^\circ\ \Omega$$

$$\theta = \angle 56.35^\circ,\ \cos\phi = .5547 \text{ (lagging)}$$

$\Rightarrow$

$$\tan\phi = 1.5$$

Phase current

$$I_p = \frac{V_p}{Z_p} = \frac{(400/\sqrt{3})\angle 0^\circ}{36.05\angle 56.31^\circ} = 6.406\angle -56.31^\circ \text{ A}$$

$$I_L = I_P = 6.406\text{A}$$

Total power consumed,

$$P = 3I_p^2 R_p = 3 \times (6.406)^2 \times 20 = 2462 \text{ W}$$

$$\tan\phi = \sqrt{3}\frac{P_1 - P_2}{P_1 + P_2}$$

$$1.5 = \sqrt{3}\frac{P_1 - P_2}{2462} \Rightarrow P_1 - P_2 = \frac{1.5 \times 2462}{\sqrt{3}} = 2132\text{W} \quad \text{...(o)}$$

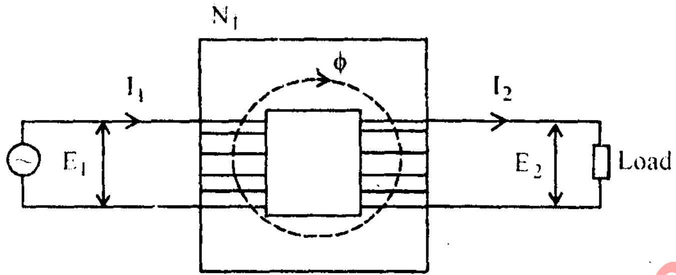
$$P_1 + P_2 = 2462 \quad \text{...(ii)}$$

$$P_1 = 2297 \text{ W}$$

$$P_2 = 165 \text{ W}$$ **Ans.**

Q. 5. (b) Derive expression for e.m.f. of 1-ϕ transformer.

Ans.



The flux at any instant is given by

$$\phi = \phi_m \sin \omega t$$

The instantaneous emf induced is a coil of turn N linked by this flux is given by Faradays' Law as :

$$e = -\frac{d}{dt}(\phi N) = -N\frac{d\phi}{dt}$$

$$e = -N\omega\phi_m \cos\omega t$$

$\Rightarrow$ $$e = N\omega\,\phi_m \sin(\omega t - \pi/2)$$

Hence, we can consists.

$$e = E_m \sin(\omega t - \pi/2) \qquad ...(1)$$

The RMS value

$$E_{rms} = \frac{E_m}{\sqrt{2}}$$

$$= \frac{N\phi_m\omega}{\sqrt{2}} = \frac{N\phi_m(2\pi f)}{\sqrt{2}}$$

$\Rightarrow$ $$\boxed{E_{rms} = 4.44\phi_m fN}$$

Primary $$E_1 = 4.44\,\phi_m f\,N_1$$

$$E_2 = 4.44\,\phi_m fN_2$$

$\Rightarrow$ $$\frac{E_1}{E_2} = \frac{N_1}{N_2}$$ **Hence proved**

Q. 6. (a) A 400V, 3-phase motor has an output of 50 h.p and operates at a power factor of 0.86 with an efficiency of 90%. Calculate the reading on each of two wattmeters connected to measure the input. What is the full-load time current?

Ans. Output of the motor $= 50$ h.p. $= 50 \times 746$

$$P_{out} = 37300\text{W}$$

$$\text{Input} = \frac{P_{out}}{\eta_{(efficiencies)}} = \frac{37300}{0.9} = 41444\text{W}$$

∵ Be we are using two wattmeter. P_1, P_2

⇒ $$P = P_1 + P_2 = 41444\,W \quad \text{...(i)}$$

Since, $$\cos\phi = 0.86 \Rightarrow \tan\phi = 0.5934 \quad \text{...(ii)}$$

Using : $$\tan\phi = \sqrt{3}\frac{P_1 - P_2}{P_1 + P_2}$$

⇒ $$P_1 - P_2 = 18630 \quad \text{...(iii)}$$

Solve by equations (i) & (ii)

⇒ $$P_1 = 30037\,W \;\&\; P_2 = 11407\,W$$

For wattmeters,

$$P = \sqrt{3}V_L I_L \cos\phi$$

⇒ $$I_1 = \frac{P}{\sqrt{3}V_2\cos\phi} = \frac{41444}{\sqrt{3}\times 400\times 0.86}$$

$$I_L = 69.56$$ **Ans.**

Q. 6. (b) A 10kVA, single phase transformer for 2000/400V at no load, has $R_1 = 5.5\Omega$, $X_1 = 12\Omega$, $R_2 = 0.2\Omega$, $X_2 = 0.45\Omega$. Determine the approximate value of the secondary voltage at full load, 0.8 P.F. (lagging), when the primary applied voltage is 2000V.

Ans. For A single phase transform

$$\frac{N_1}{N_2} = \frac{E_1}{E_3} = \frac{2000}{400} = 5$$

$$R_{e_2} = R_2 + R_1\left(\frac{N_2}{N_1}\right)^2 = 0.2 + 5.5\left(\frac{1}{5}\right)^2 = 0.42\,\Omega$$

$$X_{e_2} = X_2 + R_1\left(\frac{N_2}{N_1}\right)^2 = 0.45 + 12\left(\frac{1}{5}\right)^2 = 0.93\Omega$$

$$KVA = \frac{V_2 I_2}{1000}$$

$$I_2 = \frac{1000\times KVA}{V_2} = \frac{1000\times 10}{400} = 25A$$

Since for secondary side.

$$\cos\phi_2 = 0.8,\ \sin\phi_2 = 0.6$$

$$E_2 = E_1.\frac{N_2}{N_1} = V_1.\frac{N_2}{N_1} = 2000\times\frac{1}{5} = 400V$$

By Secondary Equation :

$$E_2 = V_2 + I_2 R_{e_2} \cos\phi_2 + I_2 X_{e_2} \sin\phi_2$$

$$400 = V_2 + 25 \times 0.42 \times 0.8 + 25 \times 0.93 \times 0.6$$

$$V_2 = 400 - 8.4 - 13.95$$

$$V_2 = 377.65\,V \qquad \textbf{Ans.}$$

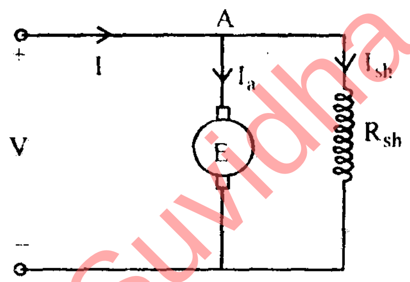
Section-D

Q. 7. (a) Discuss D.C. shunt motor and write its voltage and current equation.

Ans. This is the most common type of d.c. motor the field winding is connected is parallel with the armature as shown.

By KCL at Junction 'A' :

$$I = I_a + I_{sh} \qquad ...(i)$$



Voltage Equations : The voltage equations are written by using Kirchoff's voltage low (KVL). For winding, circuit.

$$V = I_{sh} R_{sh} \qquad ...(ii)$$

For armature-winding circuit,

$$V = E + I_a R_a \qquad ...(iii)$$

Power Equation : Power input = Mechanical power development + losses in armature + loss in the field.

$$VI = P_m + I_a^2 R_a + I_{sh}^2 R_{sh}$$

$$= P_m + I_a^2 R_a + VI_{sh}$$

$$P_m = VI - I_{sh} - I_a^2 R_a = V(I - I_{sh}) - I_a^2 R_a$$

$$= (V - I_a R_a) I_a$$

$$\boxed{P_m = EI_a} \qquad ...(iv)$$

Multiply by I_a in equation (ii)

$$VI_a = EI_a + I_a^2 R_a$$

Electrical power supplied,

$$VI_a = P_m + I_a^2 R_a \qquad \textbf{Hence proved.}$$

Q. 7. (b) A 50A [illegible] meter on full load test makes 61 revolution in 37 seconds. If the normal disc speed is 500 revolution per kwh. Find the percentage error.

Ans. Energy consumed in 37 seconds

$$= \frac{VI\cos\phi}{1000} \times t \text{ kwh}$$

$$= \frac{230 \times 50 \times \cos\phi}{1000} = \frac{37}{60 \times 60} \text{kwh}$$

$$= 0.11819 \cos\phi$$

Let load is purely resistive, $\cos\phi = 1$

So, energy consumed in 37 second

$$= 0.11819 \times 1$$

$$= 0.11819 \text{ kwh}$$

Now, energy consumption registered by motor.

$$= \frac{\text{Number of revolutions made}}{\text{Meter constant}}$$

$$= \frac{61}{500} = 0.122 \text{ kwh}$$

Percentage Error :

$$= 100 \times \frac{(\text{actual registration} - \text{true energy consumption})}{\text{True energy consumption}}$$

$$\% \text{ Error} = \frac{(0.122 - 0.11819)}{0.11819} \times 100$$

$$= 3.22\%$$ **Ans.**

Q. 8. (a) A moving coil instrument gives full-scale deflection of 20mA when a potential difference of 50mV is applied. Calculate the series resistance to measure 500V on full-scale.

Ans.

$$I_m = 20 \times 10^{-3} \text{ A}$$

$$V_m = 50 \times 10^{-3} \text{ V}$$

$$\Rightarrow \quad R_m = \frac{V_m}{I_m} = \frac{50 \times 10^{-3}}{20 \times 10^{-3}} = 2.5\Omega$$

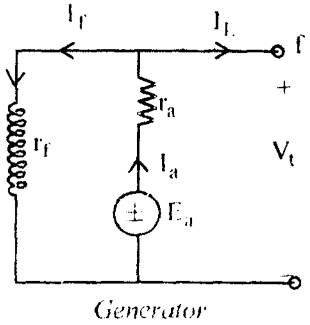
Series resistance of the meter to measure 500V

$$R_s = \frac{V_m}{I_m} - R_m = \frac{500}{20 \times 10^{-3}} - 2.5 = 25000 - 2.5$$

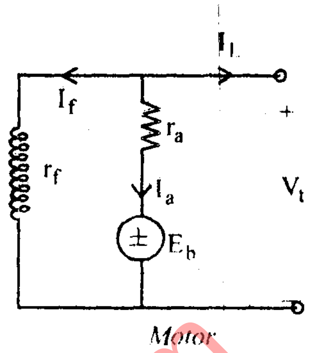
$$R_s = 24997.5\Omega$$ **Ans.**

Q. 8. (b) A 230V DC shunt machine has armature circuit resistance of 0.5Ω and Field circuit resistance of 115Ω. If this machine is connected to 230V supply mains. Find the ratio of speed as a generator to the speed as a motor. The line current is each core is 40a.

Ans.



Generator



Motor

For generator : $I_l = 40\,Amp$

$$I_f = \frac{V_f}{d_f} = 2\,Amp$$

$$I_a = I_L + I_f \qquad \text{...(i)}$$

$$E_a = V_t + I_a r_a$$

$$= 230 + (I_c + I_f) r_a = 230 + (40 + 2)0.5$$

$\Rightarrow$ $E_a = 251\,volt$ ...(ii)

For Motor : $I_l = 40\,Amp$

$$I_f = \frac{V_f}{r_f} = 2\,Amp$$

$$E_b = V_L - r_a I_a$$

$$E_b = 230 - (I_L - I_f) r_a$$

$$= 230 - (40 - 20)0.5$$

$$E_b = 211\,volt \qquad \text{...(iii)}$$

Now, $\frac{E_a}{E_b} = \frac{K_a \phi N_g}{K_a \phi N_m}$ (Flux (i) constant)

$\Rightarrow$ $\frac{2\pi}{211} = \frac{N_g}{N_m}$

$\frac{N_g}{N_m} = 1.1896$ **Ans.**