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SSC-JE

Staff Selection Commission

Junior Engineer

Electrical Engineering

Conventional Solved Paper

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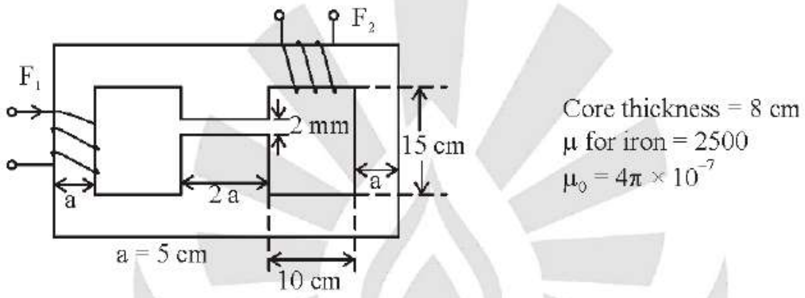
PAPER 1 Exam Held 2007

Staff Selection Commission
Junior Engineer
SSC : JEn Conventional Paper

1. (a) Draw electrical analogue of the given magnetic circuit. [SSC JEn : 15 Marks]

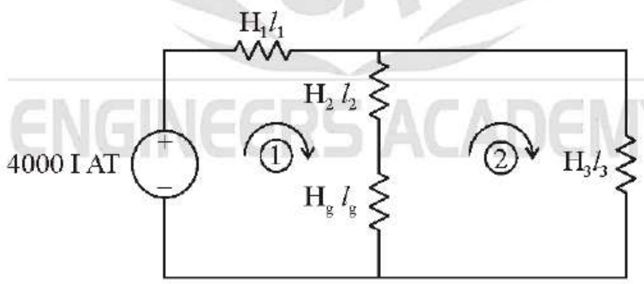
(b) In the magnetic circuit shown, coil F_1 is supplying 4000 AT in the direction indicated. Find the AT of coil F_2 to produce air gap flux of 4 mWb from top to bottom and also current direction.



[SSC JEn : 15 Marks]

Solution :

(a) Electrical analogue of the given magnetic circuit



Important equations

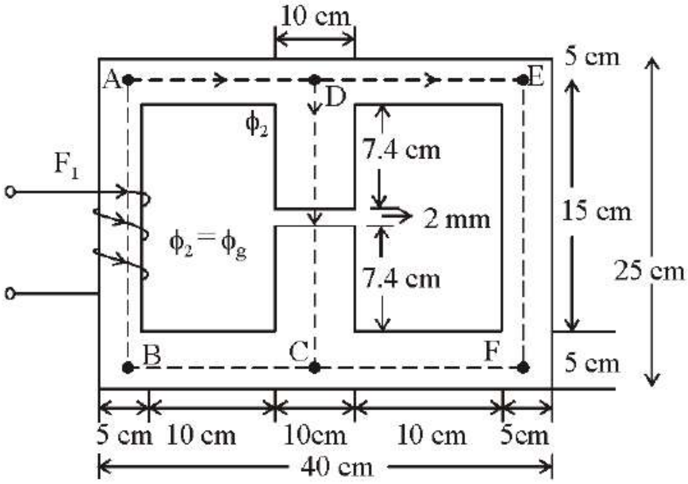
(1) $\phi = \phi_1 + \phi_2$

(2) $NI = H_1l_1 + H_2l_2 + H_gl_g$ (mmf balance in loop) ...(1)

(3) $H_3l_3 = H_gl_g + H_2l_2$ (mmf balance in loop) ...(2)

(4) $NI = H_1l_1 + H_3l_3$ (mmf balance in outer loop)

(b)

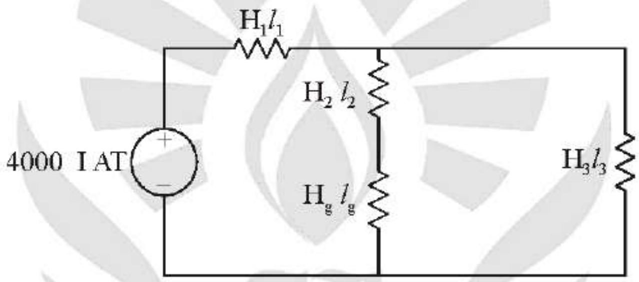


Let number of turn in F_2 winding = N

Current carrying = I

Then MMF produced by winding F_2 = NI

Also l_1 = Length DABC , l_3 = Length DEFC , l_2 = Length DC, i.e. $l_1 = l_3$



Given $\phi_g = \phi_2 = 4 \times 10^{-3}$ Wb

Cross sectional area of central limb

$$A_2 = 8 \times 10^{-2} \times 10^{-2} \times 10$$
$$= 8 \times 10^{-3} m^2$$

$$\text{Flux density, } B_g = B_2 = \frac{4 \times 10^{-3}}{8 \times 10^{-3}} = 0.5T$$

$$H_g = \frac{B_g}{\mu_0} = \frac{0.5}{4\pi \times 10^{-7}} \text{ AT/m} \qquad (\mu_r = 1)$$

$$= 398 \times 10^3 \text{ AT/m}$$

MMF required for Air gap ($H_g l_g$) = $398 \times 10^3 \times 2 \times 10^{-3} = 796$ AT

As $B_2 = B_g$

$$H_2 = \frac{B_2}{\mu_o \mu_r} = \frac{0.5}{4\pi \times 10^{-7} \times 2500} = 159.23 \text{ AT/m}$$

MMF required for iron path ($H_2 l_2$) = 159.23 (effective length of DC iron path)

$= 159.23 \times (20 – 0.2) \times 10^{-2}$

$= 159.23 \times 19.8 \times 10^{-2} = 31.52\text{AT}$

Total MMF required For iron & airgap path

$(796 + 31.52) = 827.52 \text{ AT}$

Mean length of outer limb $(l_3) = l_{DE} + l_{EF} + l_{CF}$

$= 2 \times 17.5 + 20 = 55 \text{ cm}$

As input MMF by winding $F_1 = 4000\text{AT}$

$4000 = H_1 l_1 + (827.52)$ in loop (1)

$H_1 l_1 = 3172.48 \text{ AT}$

$$H_1 = \frac{3172.48}{55 \times 10^{-2}} = 5768.14 \text{ AT/m}$$ (as $l_1 = l_3$, due to same length)

$B_1 = \mu_0 \mu_r H_1$

$B_1 = 18.11 \text{ Wb/m}^2$

$\phi = B_1 A_1$

$= 18.11 \times 8 \times 10^{-2} \times 5 \times 10^{-2}$

$= 72.44 \text{ mWb}$

For magnetic circuit

$\phi = \phi_g + \phi_1$

$72.44 = 4 + \phi_1$

$\phi_1 = 68.44 \text{ mWb}$

$\phi_3 = B_3 A_3$

$$B_3 = \frac{68.44 \times 10^{-3}}{8 \times 10^{-2} \times 5 \times 10^{-2}} = 17.11 \text{ Wb/m}^2$$

$B_3 = \mu_0 \mu_r H_3$

$$H_3 = \frac{17.11}{4\pi \times 10^{-7} \times 2500}$$

$= 5449 \text{ AT/m}$

MMF required $(H_3 l_3) = 5449 \times 55 \times 10^{-2} = 2996.97 \text{ AT}$

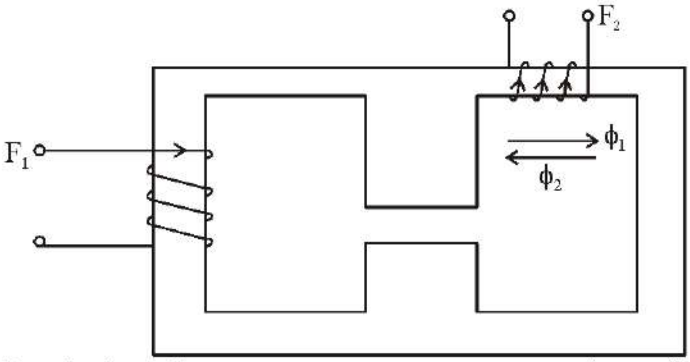
Due to parallel connection, MMF acting across center limb will be same as outer limbs & AT of winding F_2.

Center limb AT = outer limb AT + AT of winding F_2

$827.52 = 2996.97 + \text{AT of winding } F_2$

AT of winding $F_2 = –2169.45 \text{ AT}$

Note : AT can never be negative, basically it represents the direction of current which is flowing in winding F_2. Hence Flux produce due to winding F_2 will oppose the outer limb Flux, then the direction of current in winding F_2 is

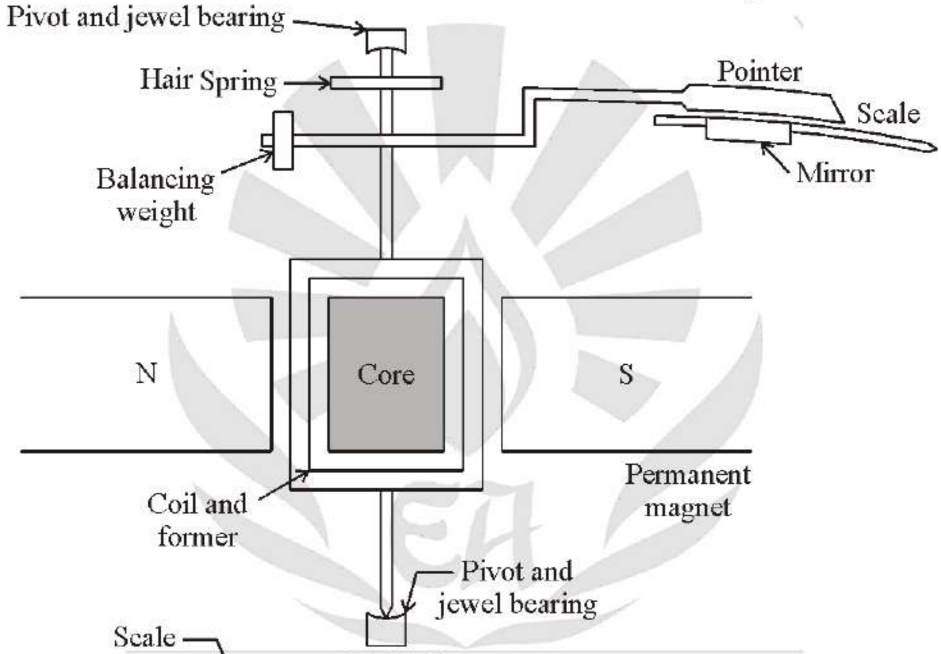


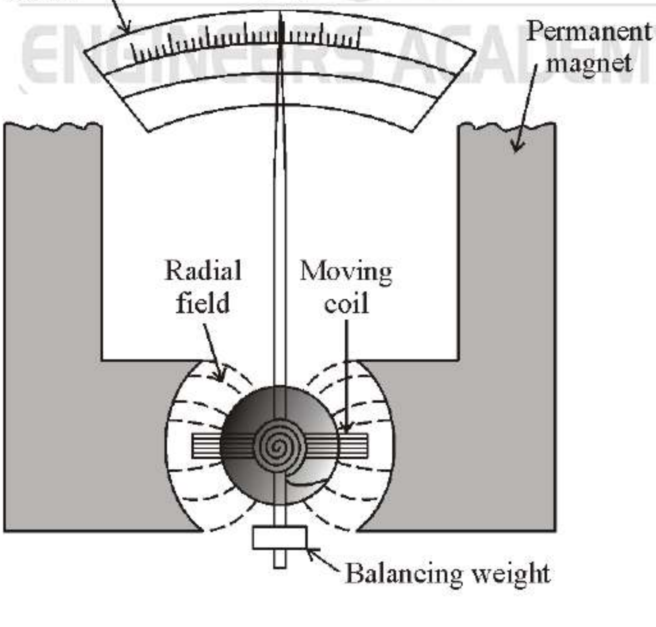
2. (a) Explain the functioning of a permanent magnet type moving-coil instrument with suitable diagram. **[SSC JEn : 15 Marks]**

Solution :

Construction of PMMC Instruments

The general constructional features of this instrument are shown in figure.





Moving coil : The moving coil is wound with many turns of enamelled or silk covered copper wire. The coil is mounted on a rectangular aluminium former which is pivoted on jewelled bearings. The coils move freely in the field of a permanent magnet.

Magnet systems : There has been considerable development in materials for permanent magnets and therefore magnet assemblies have undergone a lot of change in the recent past. Old style magnet system consisted of a relatively long U shaped permanent magnets having soft iron pole pieces. Owing to development of materials like Alcomax and Alnico, which have a high coercive force, it is possible to use smaller magnet lengths and high field intensities. The flux densities used in PMMC instruments vary from 0.1 Wb/m^2 to 1 Wb/m^2.

Control system : When the coil is supported between two jewel bearings the control torque is provided by two phosphor bronze hair springs. These springs also serve to lead current in and out of the coil. The control torque is provided by the ribbon suspension.

Damping system : Damping torque is produced by movement of the aluminium former moving in the magnetic field of the permanent magnet.

Pointer and scale : The pointer is carried by the spindle and moves over a graduated scale. The pointer is of light-weight construction and apart from those used in some inexpensive instrument has the section over the scale twisted to form a fine blade. This helps to reduce parallax errors in the reading of the scale.

Torque equation :

Let,

l, d = length of respectively vertical and horizontal side (width) of coil (meter)

N = number of turns in the coil

B = flux density in the air gap (Wb/m^2)

i = current through moving coil (A)

K = spring constant of suspension (Nm/rad)

θ_F = final steady state deflection of moving coil (rad.)

Force on each side of coil = $NBil \sin \alpha$

Where α = angle between direction of magnetic field and the conductor.

The field is radial and therefore $\alpha = 90°$

Hence, force on each side of coil = $NBil$ ...(1)

Deflecting torque T_d = force × distance

$= NBild$ ...(2)

$= NBAi$ ...(3)

Where $A = ld$ = area of coil (m^2)

N, B, A = constants

$\therefore$ Deflecting torque, $T_d = Gi$ ...(4)

Where $G = NBA = NBld$ [G = constant]

The spring control provides a restoring (controlling) torque

$T_c = K\theta$ ...(5)

Where K = spring constant

For final steady deflection

$T_c = T_d$ or $GI = K\theta$

$\therefore$ Final steady deflection $\theta = (G/K)\ I$ ...(6)

or current $I = (K/G)\theta\ ;\ \theta \propto I$ ...(7)

As the deflection is directly proportional to the current passing through the meter (K and G being constants) we get a uniform (linear) scale for the instrument.

Applications :

(i) To measure voltage, as a voltmeter.

(ii) To measure current, as a ammeter.

Advantages :

(i) Linear scale (or uniform scale)

(ii) High torque weight ratio

(iii) Low power consumption

(iv) Error due to stray magnetic field is lesser

(v) High accuracy

(vi) High sensitivity

(vii) No frequency error

Disadvantages :

(i) Used only for measurement of DC

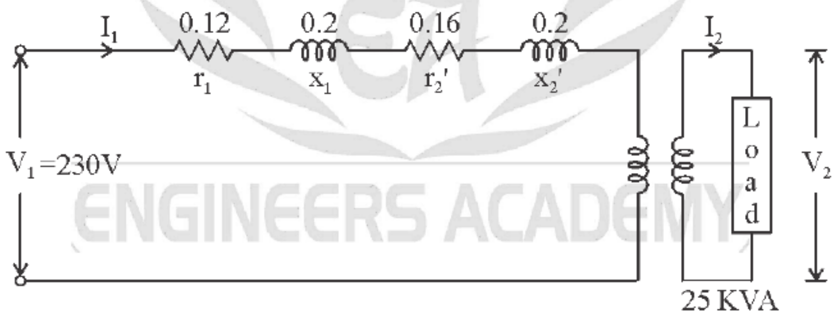
(ii) High cost that of moving iron instruments.

2. (b) A 25 kVA, 230/115V, 50Hz transformer has the following data :

$r_1 = 0.12\Omega$, $r_2 = 0.04\Omega$, $X_1 = 0.2\Omega$, $X_2 = 0.05\Omega$

Find the transformer loading which will make the primary induced e.m.f. equal in magnitude to the primary terminal voltage when the transformer is carrying full load current. Neglect the magnetizing current. [SSC JEn : 15 Marks]

Solution :



$$V_1 I_1 = V_2 I_2 = 25000$$

$$K = \frac{V_{H.V.}}{V_{L.V.}} = \frac{230}{115} = 2$$

Equivalent resistance referred to primary (hv) side,

$$R_{01} = R_1 + R_2 \times K^2$$
$$= 0.12 + 0.04 \times 2^2 = 0.28\ \Omega$$

Equivalent reactance referred to primary (hv) side,

$$X_{01} = X_1 + X_2 \times K^2$$
$$= 0.2 + 0.05 \times 2^2 = 0.4\ \Omega$$

Primary induced emf will be equal to primary terminal voltage i.e. voltage regulation is zero.

When, $I_1 R_{o1} \cos\phi + I_1 X_{o1} \sin\phi = 0$

or $\tan\phi = -\frac{R_{o1}}{X_{o1}} = -\frac{0.28}{0.4} = -0.7$

or $\phi = \tan^{-1} 0.7 = 35°(\text{lead})$ [$\because$ tan ϕ is negative]

And power factor $\cos\phi = \cos 35° = 0.82$ (leading)

Load in kW on full load

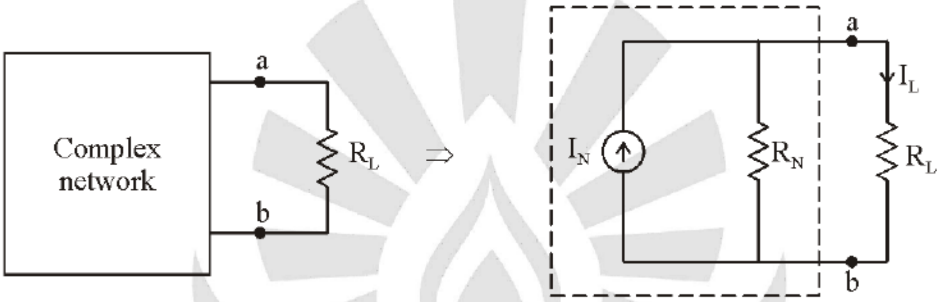
$$\text{kVA} \times \text{pf} = 25 \times 0.82 = 20.5 \text{ kW}$$

So the required answer is transformer loading = 20.5 kW.

3. (a) State and explain Norton's theorem. **[SSC JEn : 15 Marks]**

Solution :

Norton's theorem : This theorem states that for a linear circuit, it is possible to replace every element except the load resistor with an independent current source in parallel with a resistor (Norton Resistance). By using Norton's theorem, we obtain an equivalent circuit composed of an independent current source in parallel with a resistor.



A complex network including a load resistor R_L. Norton equivalent network connected to the load.

I_N = Short circuit current of the network (Norton current)

R_N = Norton resistance (Thevenin's resistance)

$$I_L = I_N\left(\frac{R_N}{R_N + R_L}\right)$$

In other words the Norton equivalent of a linear network is the Norton current source i_{sc} or I_N in parallel with the thevenin resistance R_{Th} or R_N result in a direct relationship between V_{oc} i_{sc} and R_{Th}.

$$V_{oc} = R_{Th}\, i_{sc}$$

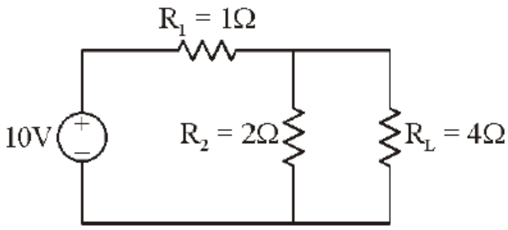
Calculation of R_{th} :

(i) All independent voltage sources are short circuited i.e. replaced by internal resistance.

(ii) All independent current sources are open circuited i.e. replaced by internal resistance.

(iii) All dependent voltage sources and current sources remain as they are.

Let us consider an example



We want to make an equivalent circuit model across load resistance 'R_L'

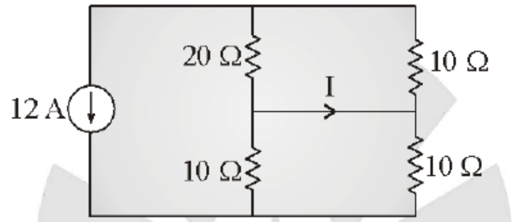
Conventional Practice Paper

Full Mock Test Paper-1

1. **(a)** Define the following terms :
   (i) Mutual Inductance
   (ii) Pinch off voltage
   (iii) Early effect
   (iv) Faraday's law of electromagnetic Induction

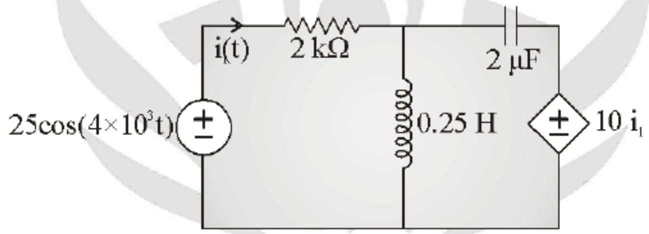
[20 Marks]

1. **(b)** Find the value of current I in the circuit shown in figure.



[20 Marks]

1. **(c)** Find $i_1(t)$ in the circuit shown in figure.



[20 Marks]

2. **(a)** Draw the external characteristics of various types of dc generators in one figure assuming the same no load terminal voltage. Compare these characteristics.

[20 Marks]

(b) A two winding 220 V/110 V, 1.5 kVA transformer is reconnected as a 220/330 V autotransformer. It is re-rated as

[20 Marks]

(c) A 4-pole induction motor (main) & a 6 pole motor (auxiliary) are connected in cummulative cascade. Frequency in the secondary winding of the auxiliary motor is observes to be 1 Hz. For a supply frequency of 50 Hz the speed of the cascade set is

[20 Marks]

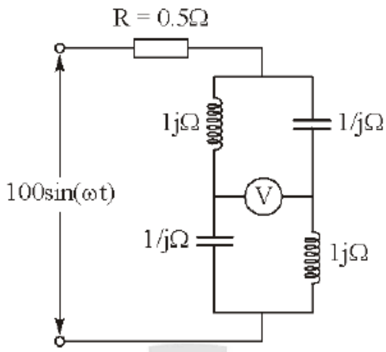
3. **(a)** A 3-phase, 460V, 6-pole, 60 Hz, cylindrical rotor synchronous motor has a synchronous reactance of 2.5 W and negligible armature resistance. The load torque, proportional to the square of the speed, is 398 N.m at 1200 rpm. Unity power factor is maintained by excitation control. Keeping the v/f constant, the frequency is reduced to 36 Hz. The torque angle δ is

[30 Marks]

3. (b) A moving coil of a meter has 100 turns, and a length and depth of 10 mm and 20 mm respectively. It is positioned in a uniform radial flux density of 200 mT. The coil carries a current of 50 mA. The torque on the coil is

[15 Marks]

3. (c) The reading of the voltmeter (rms) in volts, for the circuit shown in the figure is



[15 Marks]

4. (a) Explain travelling waves on a transmission line and define. Standing wave Ratio (SWR). A high frequency lossless transmission line has a characteristic impedance of 600 Ω. Calculate the value of current SWR when the load is (500 + j300) Ω.

[20 Marks]

4. (b) A four arm AC bridge abcd has the following impedances :
Arm ab : $Z_1 = 400 \angle 60° \ \Omega$ (inductive impedance)
Arm ad: $Z_2 = 800 \angle -90° \ \Omega$ (purely capacitive impedance)
Arm bc : $Z_3 = 300 \angle 0° \ \Omega$ (purely resistive)
Arm cd : $Z_4 = 600 \angle 40° \ \Omega$ (inductive impedance)
Determine whether it is possible to balance the bridge under above conditions.

[10 Marks]

4. (c) What are the factors that control the speed of a DC motor?

[20 Marks]

4. (d) In a Wheatstone bridge, for the measurement of resistance, derive the relation for sensitivity of bridge, with detecting galvanometer in operation.
For a bridge, as above the ratio arms are each 100 Ω and bridge is balanced with standard arm adjusted to 230 Ω. If each of the ratio arms have an accuracy of ±0.02% and standard has ±0.01% accuracy guaranteed, what are the limiting values of unknown resistance?

[10 Marks]

5. (a) Explain the importance of fault analysis and types of fault in brief.

[15 Marks]

5. (b) Explain the ARC extinction methods.

[15 Marks]

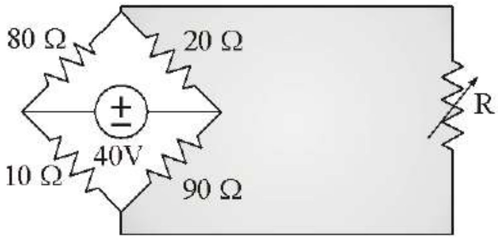
5. (c) Compare the Resistance welding and ARC welding.

[10 Marks]

5. (d) A synchronous motor improves the power factor of a load of 500 kW from 0.707 lagging to 0.95 lagging. Simultaneously the motor carries a load of 100 kW. Find
(i) The leading kVAR supplied by the motor.
(ii) kVA rating of the motor.
(iii) Power factor at which the motor operates.

[20 Marks]

6. (a) Explain Maximum Power Transfer Theorem and find Maximum Power Transfered From Source to Load.

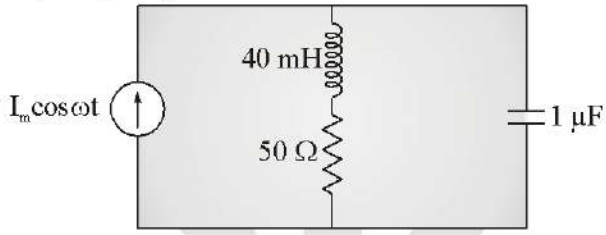


[20 Marks]

6. (b) Explain common base configuration of BJT and make it's input characteristic and output characteristic.

[20 Marks]

6. (c) Find the Resonant frequency of given circuit.



[20 Marks]

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