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Detailed Solutions

SSC-JE 2018 Mains Test Series (PAPER-II)

Electrical Engineering Test No : 6

Q.1 (a) Solution:

Given,

$$R_3 = 60\ \Omega,$$
$$R_2 = 740\ \Omega,$$
$$C_2 = 0.156\ \mu F,$$
$$C_4 = 0.2\ \mu F$$

At balance $(R_1 + j\omega L_1)\left(\frac{1}{j\omega C_4}\right) = (R_3)\left(R_2 + \frac{1}{j\omega C_2}\right)$

Comparing the real and imaginary part seperately

$$L_1 = R_2 R_3 C_4$$

and $$R_1 = R_3 \frac{C_4}{C_2}$$

$$L_1 = 60 \times 740 \times 0.2 \times 10^{-6} = 8.88 \times 10^{-3}\ H$$
$$= 8.88\ mH$$

$$R_1 = 60 \times \frac{0.2 \times 10^{-6}}{0.156 \times 10^{-6}} = 76.92\,\Omega$$

$\therefore$ Reactance of arm ab = $2\pi f L_1 = 2\pi \times 4 \times 10^3 \times 8.88 \times 10^{-3}$
$= 223.18\ \Omega$

$\therefore$ Effective impedance of specimen

$$Z_1 = \sqrt{R_1^2 + X_1^2} = \sqrt{(223.18)^2 + (76.92)^2}$$
$$= 236.06\ \Omega$$

Q.1 (b) Solution:

Given,

$$\text{Line to line voltage} = 400 \text{ V}$$

$$\text{Phase to neutral voltage} = \frac{400}{\sqrt{3}} \text{ V}$$

Taking V_R as reference R-phase to neutral voltage,

Similarly,
$$V_{RN} = \frac{400}{\sqrt{3}}\angle 0° \text{ V}$$

$$V_{YN} = \frac{400}{\sqrt{3}}\angle -120° \text{ V}$$

$$V_{BN} = \frac{400}{\sqrt{3}}\angle -240° \text{ V}$$

As load connected between Y and B phase.

$$V_{YB} = \frac{400}{\sqrt{3}}\angle -120° - \frac{400}{\sqrt{3}}\angle -240°$$

$$= 400\angle -90° \text{ V}$$

$$\text{Power factor of load } \cos\phi = 0.85; \quad \phi = \cos^{-1} 0.85$$

$$= 31.78°$$

$$\text{Load current, } I_L = \frac{\text{Voltage across load}}{Z} = \frac{400\angle -90°}{200\angle 31.78°}$$

$$= 2\angle -121.78° \text{ A}$$

$$\text{Voltage across pressure coil, } V_{RN} = \frac{400}{\sqrt{3}}\angle 0°$$

$$\text{Phase angle between } V_{RN} \text{ and } I_L = 121.78°$$

$$\text{Wattmeter reading} = |V_{RN}||I_L|\cos\phi$$

$$= \frac{400}{\sqrt{3}} \times 2\cos(121.78°)$$

$$= \frac{400}{\sqrt{3}} \times 2(-0.527) = -243.41 \text{ W}$$

Q.1 (c) Solution:

The resonant frequency,

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R_L^2}{L^2}}$$

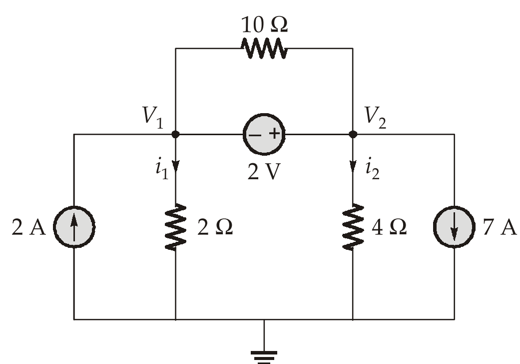
$$= \frac{1}{2\pi}\sqrt{\frac{1}{0.1\times 10\times 10^{-6}} - \frac{(10)^2}{(0.1)^2}}$$

$$= \frac{1}{2\pi}\sqrt{10^6 - 10^4} = \frac{1}{2\pi}(994.98)$$

$$= 158.35 \text{ Hz}$$

Q.1 (d) Solution:

Applying KCL to supernode



$$2 = i_1 + i_2 + 7$$

$$2 = \frac{V_1}{2} + \frac{V_2}{4} + 7$$

$$8 = 2V_1 + V_2 + 28$$

$\Rightarrow$ $$2V_1 + V_2 = -20 \quad \text{...(i)}$$

$$V_2 - V_1 = 2 \quad \text{...(ii)}$$

After solving (i) and (ii),

$$V_1 = -7.33 \text{ V}$$

$$V_2 = -5.33 \text{ V}$$

Power delivered by 7 A current source

$$= 5.33 \times 7$$

$$= 37.31 \text{ W}$$

Q.1 (e) Solution:

We apply KVL in the loop,

$$-12 + 4i + 2V_0 - 4 + 6i = 0$$

Put, $$V_0 = -6i$$

$$-12 + 4i - 12i - 4 + 6i = 0$$

$$-2i = 16$$

$$i = -8 \text{ A}$$

$$V_0 = -6 \times -8 = 48 \text{ V}$$

Q.2 (a) Solution:

Given,

$$R_{e\,(\text{p.u.})} = 0.015 \text{ p.u.}$$

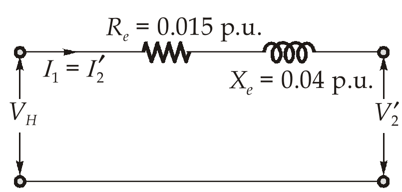
and $$X_{e(\text{ p.u.})} = 0.04 \text{ p.u.}$$

Let us take base voltage = 3300 V

then, $$V_H = 1 \text{ p.u.}$$

Full load current = $1.0\angle -36.86°$ p.u.

The equivalent circuit diagram on h.v. side can be drawn as below (neglecting shunt parameters)



∴ From circuit diagram,

$$V_H = V_2' + I_2'(R_e \cos\theta + X_e \sin\theta)$$

$$V_2' = 1 - 1(0.015 \times 0.8 + 0.04 \times 0.6)$$

$$V_2' = 0.964 \text{ p.u.}$$

Secondary voltage on secondary side;

$$V_2 = 230 \times 0.964 = 221.72 \text{ V}$$

Q.2 (b) Solution:

Operating Forces in Electro mechanical indicating instrument

- Three types of forces are needed for the satisfactory operation of any indicating instrument. These are:

(i) Deflecting force,

(ii) Controlling force,

(iii) Damping force

Deflecting Force:

The deflecting or operating force is required for moving the pointer from its zero position. The system producing the deflecting force is called *'Deflecting system'* or *'Moving System'* The deflecting force can be produced by utilizing any of the effects mentioned earlier. Thus the deflecting system of an instrument converts the electric current or potential into a mechanical force called deflecting force. The deflecting system thus acts as the prime mover responsible for deflection of the pointer.

Controlling Force:

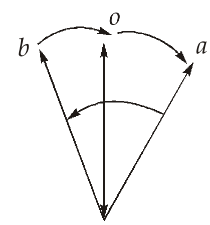
This force is required in an indicating instrument in order that the current produces deflection of the pointer proportional to its magnitude. The system producing a controlling force is called a ''Controlling System''. The functions of the controlling system are:

To produce a force equal and opposite to the deflecting force at the final steady position of pointer in order to make the deflection of the pointer definite for a particular magnitude of current. In the absence of a controlling system, the pointer will shoot (swing) beyond the final steady position for any magnitude of current and thus the deflection will be indefinite.

To bring the moving system back to zero when the force causing the instrument moving system to deflect is removed. In the absence of a controlling system the pointer will not come back to zero when current is removed. Controlling force is usually provided by springs.

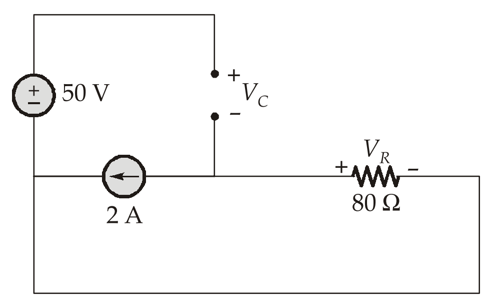
Damping Force

When a deflecting force is applied to the moving system, it deflects and it should come to rest at a position where the deflecting force is balanced by the controlling force. The deflecting and controlling forces are produced by systems which have inertia and, therefore, the moving system cannot immediately settle at its final position but overshoots or swings ahead of it. Consider Fig. Suppose O is the equilibrium or final steady position. Because of inertia the moving system moves to position 'a'. Now for any position 'a' beyond the equilibrium position the controlling force is more than the deflecting force and hence the moving system swings back. Due to inertia it cannot settle at 'O' but swings to a position say 'b' behind the equilibrium position. At 'b', the deflecting force is more than the controlling force and hence the moving system again swings ahead. The pointer thus oscillates about its final steady (equilibrium) position with decreasing amplitude till its kinetic energy (on account of inertia) is dissipated in friction and therefore, it will settle down at its final steady position. If extra forces are not provided to ''damp'' these oscillations, the moving system will take a considerable time to settle to the final position and hence time consumed in taking readings will be very large. Therefore, damping forces are necessary so that the moving system comes to its equilibrium position rapidly and smoothly without any oscillations.



Q.2 (c) Solution:

For $t < 0$;



$$V_R(0^-) = -160 \text{ V}$$
$$V_{2A} = 160 \text{ V}$$
$$V_C(0^+) = 210 \text{ V}$$

and $$V_C(0^-) = V_C(0^+) = 210 \text{ V}$$

Q.2 (d) Solution:

For moving iron ammeter

Given,

$$\text{Full scale deflection, } \theta = 135°$$
$$\text{Current, } I = 8 \text{ A}$$
$$\text{Torque, } T = 280\,\mu \text{ N-m}$$

Torque produced in moving iron instruments

$$T_d = \frac{1}{2} I^2 \frac{dL}{d\theta}$$

$$280 \times 10^{-6} = \frac{1}{2}(8^2)\frac{dL}{d\theta} \times 10^{-6}$$

$$\frac{dL}{d\theta} = \frac{280 \times 10^{-6} \times 2}{64} = 8.75\ \mu\text{H/radian}$$

Q.3 (a) Solution:

$$\text{Fault MVA/Fault level} = (\text{Rated MVA}) \times \frac{100}{\% X}$$

$$= 100 \times \frac{100}{20} = 500 \text{ MVA}$$

Q.3 (b) Solution:

Various Types of Electric Braking: Following are the various types of electric braking:

1. Plugging
2. Rheostatic braking
3. Regenerative braking

1. Plugging

This is the simple method of braking. In this method, the armature connections of motor are reversed. Due to this motor starts to move in the reverse direction. When it is done, the motor tends to rotate in the reverse direction and it will stop by applying mechanical brakes. At the end of braking period the supply to the motor automatically cut-off.

Plugging is possible on the following types of electric motors:

- DC series motor
- DC shunt motor
- Three-phase induction motor
- Synchronous motors

2. Rheostatic Method of Braking

In the rheostatic braking, the motor is disconnected from the supply lines and is connected to an external resistance *R* during braking period. Motor runs as generator and energy produced is wasted in resistance *R*. In this method of braking no energy is drawn from the supply by the electric motor during the braking period. The magnetic field remains connected to the supply. If supply fails there will be no braking.

The following drives can be braked by rheostatic method of braking:

- DC motors both shunt and series.
- Induction motor (with a separate source of DC excitation during braking).
- Synchronous motor.

3. Regenerative Braking

- In this type of braking, kinetic energy of the motor is converted into electrical energy, which is feedback to the supply lines and is not wasted in a rheostat. During braking period, the field excitation is increased much so that the induced voltage becomes more than the supply voltage. At this stage the motor acting as generator will pump electrical energy back into the lines.

- Let us take the case of DC series motor. Regenerative braking cannot be used in series motor without modification. It is due to the fact that when DC machine starts working as a generator, the direction of the armature current will be reversed, therefore, the field connections must also be reversed at the same moment. If it is not done, the field flux will be neutralized and the machine will fail to build up.
- Hence some modification should be provided, either auxiliary winding is provided in the motor as separate excitation is given to the field.

Q.3 (c) Solution:

Electroplating:

This is the process of covering the articles made up of cheap metals by a thin layer of superior metal by means of electrolysis. The article to be coated may be metallic or non-metallic (plastics). The base metal and coated metal may be same or different. Some common metals and alloys of which coating can be provided on metallic and non-metallic surfaces, include zinc, chromium, tin, nickel, copper, silver, gold and platinum etc.

Operations Involved in Electroplating

The following operations are involved while electroplating is done:

1. Cleaning process
2. Deposition of metal

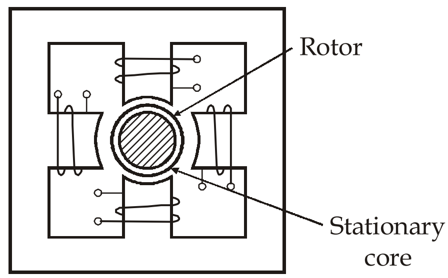
1. **Cleaning process:** The object to be electroplated is thoroughly cleaned degreased. If the electroplating is done on an unclean and greased surface, the metal deposited will not be well adherent to the base metal and is likely to peel off.
2. **Deposition of metal:** The article to be electroplated is made cathode, solution is made up of salt of the metal to be deposited and anode is of the same metal which is to be deposited.

Precautions in Electroplating Process

1. The object to be electroplated must be cleaned thoroughly.
2. It should not be handled with bare hands. Use a piece of paper or clean rubber gloves.
3. All connections must be clean, tight and free from corrosion.
4. The experiment plate (or the object to be electroplated) must be connected to the negative terminal of the battery.
5. The plates (electrodes) should not touch each other.
6. Keep the current constant during the electroplating process.
7. The plate must be rinse in dilute H_2SO_4 after removing from electrolyte, otherwise the deposit will turn black.

Q.3 (d) Solution:

Induction Cup Relay



Induction cup relay

- It possesses high sensitivity, high speed and produces a steady non-vibrating torque.
- Its operating time is to the order of 0.01 second. Thus with its high torque/inertia ratio, it is quite suitable for higher speeds of operating.
- It is less sensitive to dc transients.
- Induction cup type relays were widely used for distance and directional relays.
- The theory given below is true for both disc type and cup type induction relays.
- Above figure shows how force is produced in a rotor which is cut by ϕ_1 and ϕ_2. These fluxes are alternating quantities and can be expressed as follows:

$$\phi_1 = \phi_{1m} \sin \omega t, \quad \phi_2 = \phi_{2m} \sin(\omega t + \theta)$$

Where θ is the phase difference between ϕ_1 and ϕ_2. The flux ϕ_2 leads ϕ_1 by θ.

- Voltages induced in the rotor,

$$e_1 \propto \frac{d\phi_1}{dt} \propto \phi_{1m} \cos \omega t$$

$$e_2 \propto \frac{d\phi_2}{dt} \propto \phi_{2m} \cos(\omega t + \theta)$$

- The induced eddy currents in the rotor are in phase with their voltages.

$$i_1 \propto \phi_{1m} \cos \omega t$$

$$i_2 \propto \phi_{2m} \cos(\omega t + \theta)$$

- The forces produced,

$$F_1 \propto \phi_1 i_2$$

or $$F_1 \propto \phi_{1m} \phi_{2m} \cos(\omega t + \theta) \cdot \sin \omega t$$

$$F_2 \propto \phi_2 i_1$$

or $$F_2 \propto \phi_{1m} \phi_{2m} \sin(\omega t + \theta) \cdot \cos \omega t$$

$$F = (F_2 - F_1)$$

or $$F \propto \phi_{1m} \phi_{2m} \sin \theta$$

$F = K\phi_1 \phi_2 \sin\theta$. In this expression, ϕ_1 and ϕ_2 are rms values.

- If the same current produces ϕ_1 and ϕ_2 the force produced is given by

$$F = KI^2 \sin\theta$$

- A stationary iron core is placed inside the rotating cup to decrease the air gap without increasing.
- The spindle of the cup carries an arm which closes contacts.
- A spring is employed to provide a resetting torque.
- When two actuating quantities are applied, one may produce an operating torque while the other may produce restraining torque.

Q.4 (a) Solution:

As we can write:

Voltage regulation; $V.R = Z_{pu} \cdot \cos(\theta_{eq} - \phi)$

For leading power factor angle $= -30°$

$V.R. = 0.1 \cos(90° + 30°)$

If resistance is negligible;

then $\theta_{eq} = 90°$

therefore; $V.R. = 0.1\{-\sin 30°\}$

$= -0.1 \times 0.5 = -0.05$

$\%\ V.R. = -5\%$

Q.4 (b) Solution:

As we know that external characteristic is the graph between terminal voltage and load current,

$\because \quad V_t = 300 - 0.5\, I_L$

Power delivered to load $= 6$ kW

$\Rightarrow \quad V_t \times I_L = 6000$

$\Rightarrow \quad (300 - 0.5\, I_L) \times I_L = 6000$

$\Rightarrow \quad I_L^2 - 600 I_L + 12000 = 0$

On solving we get;

$I_L = 20.71$ A or 579.28 A

Where, $I_L = 20.71$ A is the possible value

Therefore,

Terminal voltage, $V_t = 300 - (0.5 \times 20.71)$

$V_t = 289.645$ Volts

Load resistance $= \dfrac{V_t}{I_L} = \dfrac{289.645}{20.71}$

$R_L = 13.98\ \Omega$

Q.4 (c) Solution:

Applying KVL we get,

$$V_{CC} - I_C R_C - V_{CE} = 0$$

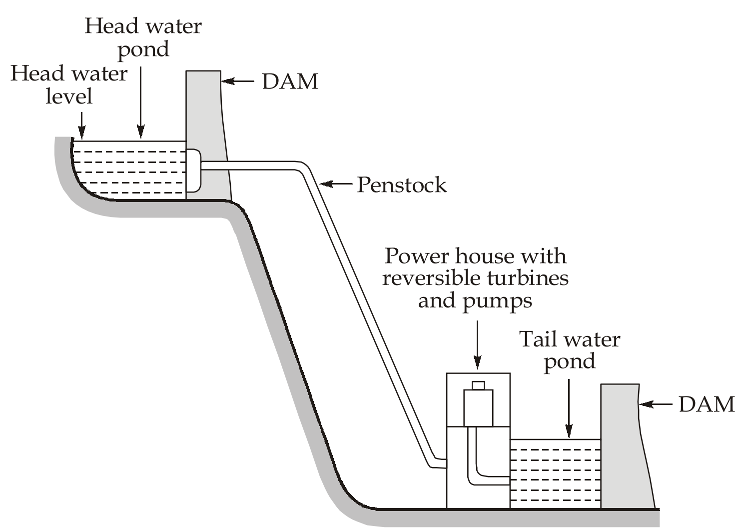
$$I_C = \frac{V_{CC} - V_{CE}}{R_C} = \frac{3 - 0.2}{1\text{k}} = 2.8 \text{ mA}$$

$$I_B = \frac{I_C}{\beta} = \frac{2.8\text{mA}}{50} = 56\ \mu\text{A}$$

Q.4 (d) Solution:

Pumped Storage Plant:

- A pumped storage plant is a special type of plant mean to supply peak load.
- During peak load period, water is drawn from the head water pond through the penstock and generates power for supplying the peak load.
- During off-peak period, the water is pumped back from tail water pond to the head water pond. So that this water may be used to generate energy during next peak load period.
- They can be used for load frequency control.
- When load demand in the system is suddenly increased then, they can be immediately switched on to meet the extra demand.



Q.5 (a) Solution:

Given;

$$T_{max} = 4 \times T_{fl}$$

and $$T_{st} = 1.6\ T_{fl}$$

as we know,

$$\frac{T_{st}}{T_{\max}} = \frac{2}{\dfrac{s_{\max,T}}{1} + \dfrac{1}{s_{\max,T}}}$$

or
$$\frac{1.6}{4} = \frac{2}{\dfrac{s_{\max,T}}{1} + \dfrac{1}{s_{\max,T}}}$$

$$0.4 = \frac{2\,s_{\max,T}}{s_{\max.T}^2 + 1}$$

or
$$s_{\max.T}^2 - 5s_{\max,T} + 1 = 0$$

This yields,
$$s_{\max,\,T} = \frac{5 \pm \sqrt{21}}{2}$$

Neglecting the higher values;

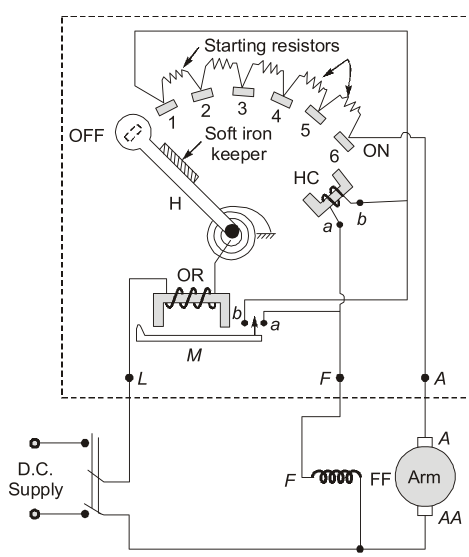
We get,
$$s_{\max,\,T} = 0.21$$

Q.5 (b) Solution:

Three Point Starter

- A three point starter with its electrical connection and protective features is shown below.
- Here three terminals (L, A, F) are available from the starter therefore it is called a ***three-point starter***.

  where L(line), A(Armature) and field(F) must be connected to supply terminal, motor armature terminal and shunt field terminal respectively.



Operation

- When the motor is at rest starter handle H is kept in the off position by strong spiral spring.
- For starting the motor, the handle is rotated to connect with stud 1, as soon as handle H touches stud 1, the shunt field and holding coil HC get connected in series across the supply, whereas the armature gets connected in series with the entire starting resistance.
- Since the current begins to flow in both the field and armature windings, the motor starts rotating.
- After the armature has picked up sufficient speed, the handle H is moved to stud 2, thereby cutting out the resistance between stud 1 to stud 2.

Disadvantage

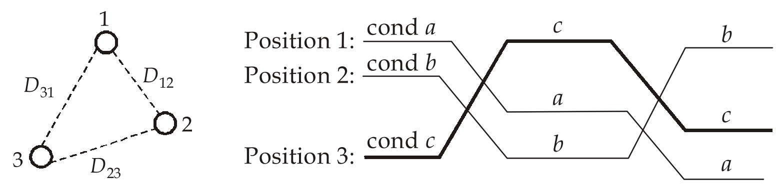
- Three-point starter can not be used where wide range of speed control by shunt field control (or field weakening method) is required.
- In case of a three-point starter, the field circuit and the hold coil are in series. If speeds above the normal are to be obtained, the field current must be reduced. At a certain value of reduced field current (therefore, increased motor speed), the electromagnetic pull of the holding coil may become less than the spring force. In such a case, the starter handle returns to the OFF position and the motor stops. Thus a three-point starter can not be used where wide range of speed control by shunt field control (or field weakening method) is required. This undesirable feature can be overcome in four-point starters.
  - **Here two important magnetic coils are used:**
    - Holding magnet coil or HC which is connected with field winding. The coil HC is also called no-voltage release or low voltage release is acting as protective device.
    - Protective device OR, known as the overload release is provided in series with the armature circuit.
  - The disadvantage of three-point starter can be overcome in four-point starter.

Q.5 (c) Solution:

(i) Transposition of Conductor:

- When conductors of a three phase line are unsymmetrically spaced, the flux linkages and the inductance of each phase are not the same. The different inductance in each phase results in an unbalanced circuit.
- In a transposed line, the phase conductors have their position interchanged and

therefore the conductor of each phase occupies all the three positions about the one third of its length.



An unsymmetrically spaced 3-phase conductors with it's transposition-cycle

- Transposition makes it possible for each phase conductor to have the same average inductance.

(ii) Skin Effect:

- In AC system, there is non-uniform distribution of current in a conductor i.e. most of the current is distributed on the outer surface because of non-uniform distribution of flux linkage.
- Flux linking the outer strand decreases as we move outwards.
- Due to skin effect, $R_{ac} > R_{dc}$ i.e. effective conductor resistance is more for AC than for DC.
- Skin depth of conductor is given as,

$$\delta = \sqrt{\frac{2}{\omega\mu\sigma}}$$

where, δ = skin depth; ω = frequency (in radius)

μ = permeability; σ = conductivity

- With increase in frequency, skin depth reduces and skin effect is more.

(iii) Bundled Conductor:

- A bundled conductor made up of two or more subconductors, per phase in close proximity compared with spacing between phases.
- It's preferable for lines of 400 kV or higher voltages.

Advantages of Bundled Conductor

- With use of bundle conductors, self GMD/GMR is increased and hence reactance of the line is reduced. This results in greater transmission capacity of the line.
- Reduces corona losses
- Increased efficiency of transmission
- Reduces surge impedance

Q.5 (d) Solution:

Given,

$$\text{terminal voltage} = 250 \text{ V}$$
$$\text{flux per pole; } \phi = 3 \times 10^{-3} \text{ Wb}$$
$$\text{No. of conductor, } Z = 600$$
$$P = 4$$

No. of parallel paths, $A = 2$
(For wave winding)

Back emf, $$E_b = \frac{\phi NZP}{60A} \quad \text{...(i)}$$

Since, motor output; $P_{out} = 10 \times 10^3$ W

Power developed $= E_b \times I_a$

$$\because \quad E_b = \frac{10 \times 10^3}{I_a} = \frac{10000}{50}$$
$$E_b = 200 \text{ V}$$

From equation (i), we get

$$N = \frac{200 \times 60 \times 2}{3 \times 10^{-3} \times 600 \times 4}$$
$$= \frac{10000}{3} \text{ rpm} = \frac{10000}{3 \times 60} \text{ rps}$$

We know that;

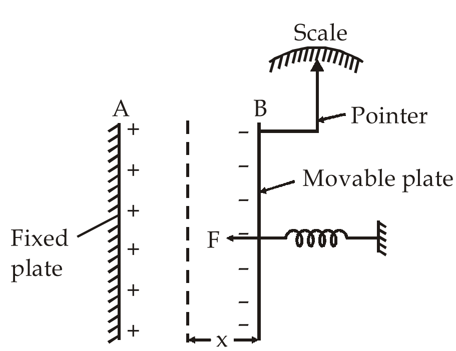
$$\text{Developed torque} \times \text{Speed} = \text{Power}$$
$$\text{Developed torque} = \frac{10000 \times 3 \times 60}{2\pi \times 10000} = 28.65 \text{ N-m}$$

Q.6 (a) Solution:

(i) Electrostatic Instrument

The principle is force of attraction between static charges.

Force and Torque equation: Linear Motion:



Controlling force – spring

Force between plates

$$F = \frac{1}{2}V^2\frac{dC}{dx}$$

C = capacitance between plates.

$$\text{Deflection, } x = \frac{V^2}{2K}\frac{dC}{dx}$$

- Motion of pointer is linear (line).
- $x \propto V^2$. Scale is non-linear.

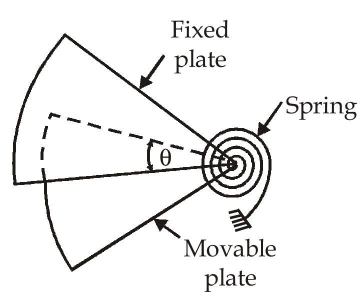
  $\because$ the motion of pointer is proportional to voltage and not to the current.

  Therefore electrostatic type instruments are used for measurement of voltages only (H. V) around 20 kV.

Circular Motion

$$T = \frac{1}{2}V^2\frac{dC}{d\theta}$$

$$\theta = \frac{1}{2}\frac{V^2}{K}\frac{dC}{d\theta}$$



$$\theta \propto V^2$$

Scale is non linear.

(ii) Hall Transducer

- Hall effect transducers works on the principle of hall effect.
- **Hall effect:** If a metal or a semiconductor carries a current (I) placed in a transverse magnetic field (B), an electric field (E) is developed which is perpendicular to both the directions of B and I.
- A voltage is developed due to this electric field which is known as "Hall Voltage".

- Hall voltage

$$V_H = \frac{R_H \cdot BI}{t}$$

$$B = \text{Magnetic flux density (Wb/m}^2)$$
$$t = \text{Thickness of strip (m)}$$
$$I = \text{Current through the strip (A)}$$
$$R_H = \text{Hall coefficient} = \frac{1}{\rho} = \frac{1}{ne}$$

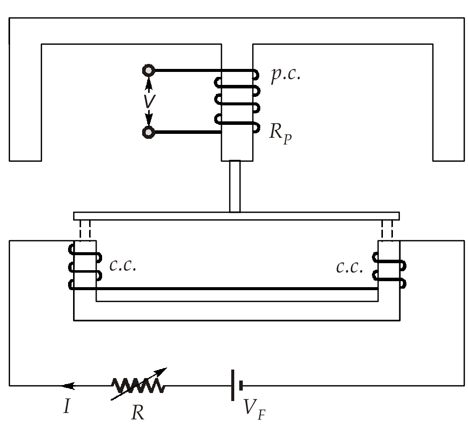
- V_H is positive for p-type semiconductors and negative for n-type semiconductors.

Applications of Hall Effect Transducers

- Measurement of magnetic flux density.
- Measurement of conductivity and mobility of charge carriers.
- Multiplication of two input signals.
- To find the type of semiconductor, i.e. either p-type or n-type.
- Designing of gauss meter.

(iii) Phantom Loading of Energy Meter

- When the energy meter is tested under high current rating, there is a lot of waste of power. To reduce this unwanted power loss, "Phantom" or "Fictitious" loading is done.
- In "Phantom" loading, the pressure coil of the energy meter is supplied with the normal voltage and the current coil from a separate low voltage supply of dc battery with a variable resistance R. The total power supplied for the test is that due to the small pressure coil current, plus that due to the current circuit supplied at low voltage. The arrangement is shown in figure.
- Figure shows the arrangement for "*Fictitious*" or "Phantom" loading.



Fictitious or Phantom Loading

- Total power consumed in phantom loading = $\dfrac{V^2}{R_p} + V_F.I$

  (where, R_p = resistance of pressure coil circuit)

Q.6 (b) Solution:

$$\text{Input resistance of voltmeter} = 1000 \times 10 = 10\text{ k}\Omega$$
$$\text{output resistance of circuit} = 5\text{ k}\Omega$$
$$\text{Open circuit voltage} = 6\text{ V}$$

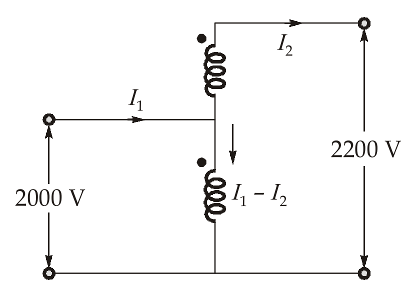
Due to loading effect the voltage measured,

$$V_m = \frac{V_t}{1+\frac{Z_0}{Z_L}} = \frac{6}{1+\frac{5}{10}} = \frac{6}{1+0.5} = 4\text{ V}$$

Percentage error in voltage reading,

$$= \frac{4-6}{6} = \frac{-2}{6} = -0.333 \text{ i.e. } -33.33\%$$

Q.6 (c) Solution:



From the diagram shown;
We can write;
Transformation ratio,

$$a_{\text{auto}} = \frac{2200}{2000} = \frac{11}{10}$$

Also we know that; rating of auto transformer;

$$S_{\text{auto}} = \frac{S_{T.W.}}{\left(1-\frac{1}{a}\right)} = \frac{20\text{ kVA}}{\left(1-\frac{10}{11}\right)} = 220\text{ KVA}$$

Efficiency of two winding transformer;

$$\eta_{T.W.} = \frac{20\times10^3\times0.7}{20\times10^3\times0.7+P_L}$$

Where, P_L = total losses

$$0.97 = \frac{14 \times 1000}{14000 + P_L}$$

⇒ Solving we get; $P_L = 433 \text{ W}$

Now efficiency for auto transformer;

$$\eta_{auto} = \frac{220 \times 0.7}{220 \times 0.7 + 0.433} = \frac{154}{154 + 0.433}$$

$$\eta_{auto} = 99.72\%$$

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