Roll No. ☐☐☐☐☐☐☐☐☐☐☐☐ **Total No. of Pages : 02**

Total No. of Questions : 09

B.Tech. (AI & DS)/(AI & ML)/ (Block Chain) / (CE)/(CSE)/ (CSE) (AI&ML) /(CSE) (Cyber Security) /(Computer Science and Design)/(EE)/(ECE)/(EEE)/(ETE)/(FT)/(IT)/(ME)/(Robotics & Artificial Intelligence)/CSE (Internet of Things and Cyber Security including Block Chain Technology) (Sem.–1,2)

BASIC ELECTRICAL ENGINEERING

Subject Code :BTEE-101-18

M.Code :93797

Date of Examination : 11-05-2024

Time : 3 Hrs. **Max. Marks : 60**

INSTRUCTIONS TO CANDIDATES :

1. **SECTION-A is COMPULSORY consisting of TEN questions carrying TWO marks each.**
2. **SECTION-B &C have FOUR questions each.**
3. **Attempt any FIVE questions from SECTION B & C carrying EIGHT marks each.**
4. **Select atleast TWO questions from SECTION - B & C Each.**

SECTION-A

1. Write briefly:

a) Explain the types of cables.

b) What is the difference between active and passive elements?

c) Draw a construction schematic for a salient-pole type of synchronous machine.

d) Draw Norton's equivalent circuit.

e) Why do we perform earthing in electric systems? Enlist its types.

f) What are polyphase systems?

g) Write voltage and current relations in star and delta connections.

h) Draw a sine voltage waveform, hence indicate peak, rms and instantaneous values on it.

i) What is the relation between rotor copper loss, slip and rotor input?

j) Enlist various types of magnetic materials.

SECTION-B

2. Draw and explain the electric schematic of a miniature circuit breaker.

3. A resistance of 15 ohms and capacitor of 150 μF capacitance are connected in series across a 230 V, 50 Hz supply. Estimate

   a) Impedance of the circuit

   b) Current

   c) Power factor and phase angle

   d) Power consumed in the circuit.

4. Power to an induction motor is supplied by a 12-pole, 3-phase, 500 rpm alternator. The full load speed of the motor is 1440 rpm. Find the percentage slip, and number of poles in the motor.

5. State and prove the Thevenin's theorem. Give an example.

SECTION-C

6. Derive the voltage and current equations in time domain for a first order RL circuit.

7. What is parallel resonance? Derive the voltage and current equations at resonance. Draw its waveforms.

8. In a 25 kVA, 2000/200 V power transformer the iron and full load copper losses are 350W and 400 W respectively. Calculate the efficiency at unity power factor at full load.

9. Write a short note on :

   a) Important characteristics of batteries

   b) Power factor improvement.

NOTE : Disclosure of Identity by writing Mobile No. or Making of passing request on any page of Answer Sheet will lead to UMC against the Student.

Section-A

(1) Write briefly:

(a) Explain the types of cables.

Ans: Cables are mainly classified into three types:

(i) Coaxial cable: A guided media cable that transmits high frequency signals and is made up of a solid conductor, three layers of insulation and a grounding conductor.

(ii) Twisted pair cable: Also known as LAN cables, these are common Ethernet cables that consist of two insulated copper wires twisted together to reduce electromagnetic interference and crosstalk.

(iii) Fiber optic cable: They contain thin glass fiber strands within an insulated covering instead of electrical wires.

Other types are patched cables, data cables, power cables, etc..

(b) What is the difference between active and passive elements?

Ans:

Active elements	Passive elements
(i) They behave as source of power in the circuit.	(i) They act as load in the circuit.
(ii) The slope of V-I characteristics curve is negative.	(ii) The slope of V-I characterics curve is positive at all the points.
(iii) They are able to do the amplification of signal.	(iii) They can not amplify the signal.
(iv) Example; Solar cell, SCR, etc.	(iv) Example; resistor, capacitor, etc

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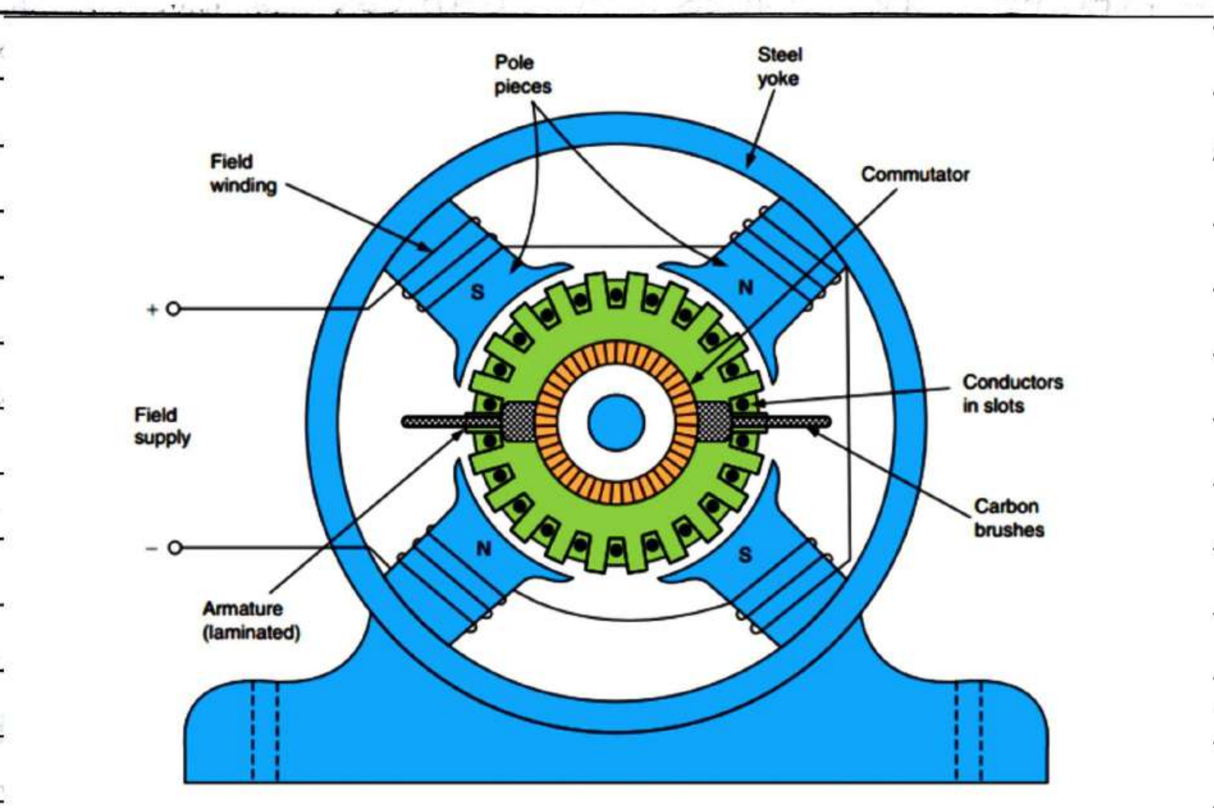
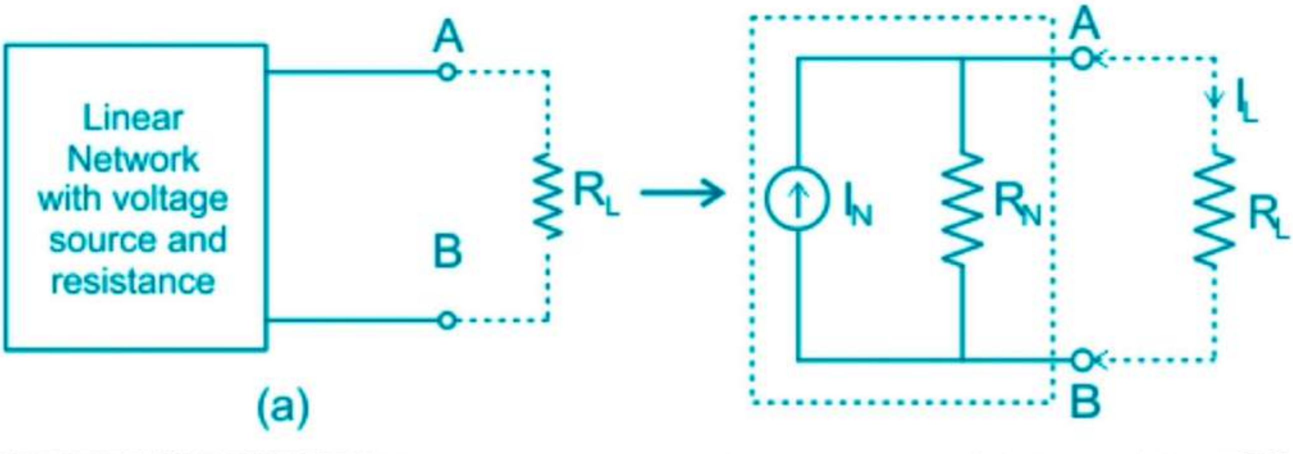
(c) Draw a construction schematic for a salient-pole type of synchronous machine.

Ans:



(d) Draw Norton's equivalent circuit.

Ans:

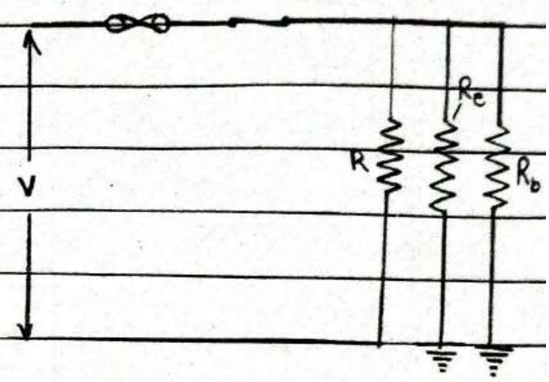


Simple cirtuit

Norton's equivalent Circuit

(e) Why do we perform earthing in electric systems? Enlist its types.

Ans: Under faulty conditions, If metallic body of the appliance is properly earthed as shown, the earth resistance R_e is in parallel with appliance resistance and body resistance R_b.



Earth resistance is very small as compared to human body resistance. Whole of the current flows through earth resistance and no current through human body. Thus operator is protected from electric shock. That's why, we perform earthing in electric systems.

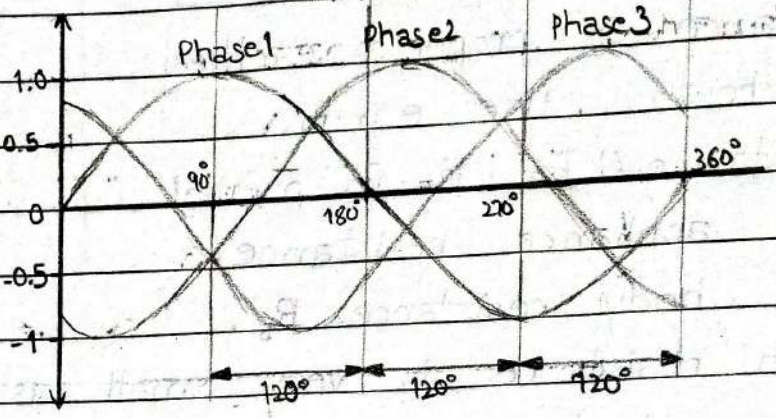
⇒ Various types of earthing is :

(i) Strip earthing
(ii) Earthing through water mains.
(iii) Pipe earthing
(iv) Rod earthing
(v) Plate earthing

(f) What are polyphase systems?

Ans: Polyphase system is a combination of two or more than two voltages having same magnitude and frequency but displaced from each other by an equal electrical angle. The angular displacement between the adjacent voltages is called a phase difference and depends upon no. of phases.

Phase difference = $\frac{360^\circ \text{ electrical degree}}{\text{Number of phases}}$



(g) Write voltage and current relation in star and delta connections.

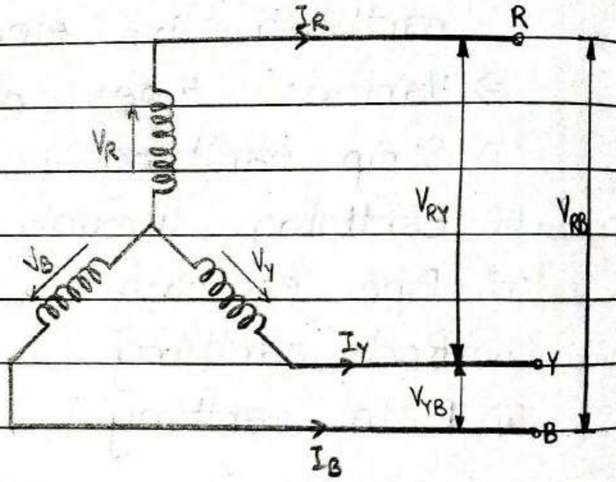
Ansr In star connection :

Line voltage = $\sqrt{3}$ X Phase voltage

i.e., $V_L = \sqrt{3}\, V_{Ph}$

and Line current = Phase current

i.e., $I_L = I_{Ph}$



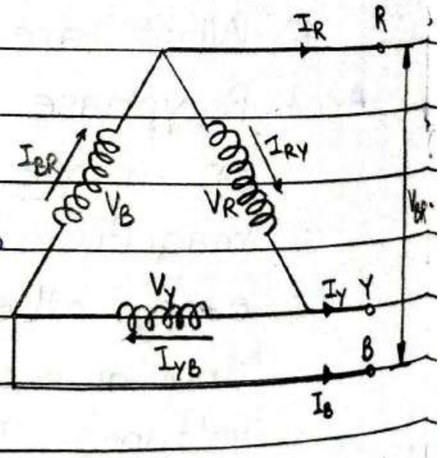
In delta connection :

Line voltage = Phase voltage

i.e., $V_L = V_{Ph}$

and Line current = Phase current X $\sqrt{3}$

i.e., $I_L = \sqrt{3}\, I_{Ph}$



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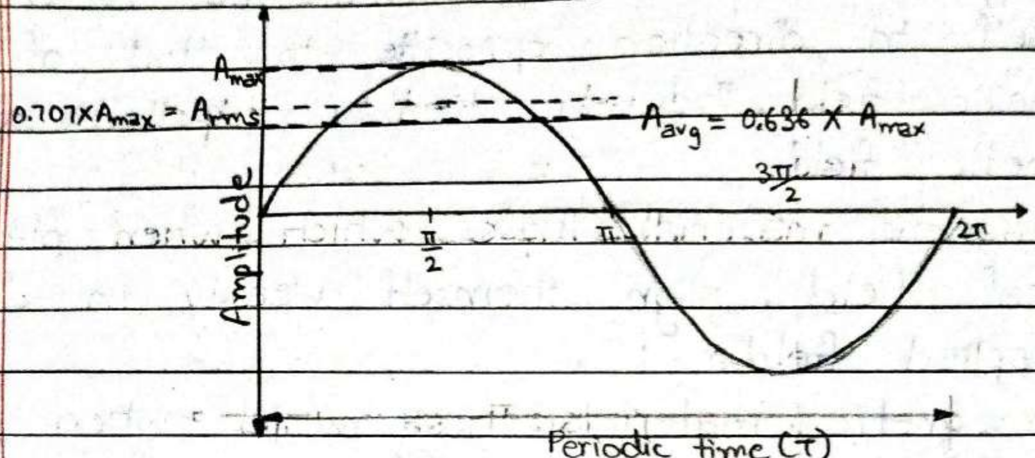
(h) Draw a sine voltage waveform, hence indicate peak, rms and instantaneous values on it.

Ans:



Sinusoidal waveform

(i) What is the relation between rotor copper loss, slip and rotor input?

Ans: Let P_g = gross output, P_{rcu} = Rotor copper loss

P_2 = Rotor input

Then Power transferred from stator to rotor,

$$P_2 = \frac{2\pi N_s T}{60}$$

Also, Power developed by rotor, $P_g = 2\pi NT / 60$

Rotor copper loss, $P_{rcu} = P_2 - P_g = SP_2$

$$\boxed{P_{rcu} = SP_2}$$

Rotor input (P_2) = Rotor coppr loss (P_{rcu}) + Gross output (P_g)

From, $P_{rcu} = sP_2$ & $P_g = (1-s)P_2$

$$\boxed{P_{rcu} = \left(\frac{s}{1-s}\right) P_g}$$ [here, s = slip]

The above is the required relation between rotor copper loss, slip and rotor input.

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Magnetic materials.

(j) Enlist various types of magnetic materials are:

Ans: Various types of magnetic materials are:

(i) Diamagnetic materials: Those materials which allign themself in direction opposite to that of applied magnetic field. They are weakly repelled by magnetic field.

(ii) Paramagnetic materials: Those which when placed in external field, align themself weakly in direction of applied field.

(iii) Ferromagnetic materials: Those which when placed in external magnetic field, are strongly attracted in the direct of applied field.

(iv) Antiferromagnetic materials: Those which are having magnetic moments on different sublattices of crystals that compensate each other, resulting in ~~small~~ zero net magnetisation.

(v) Ferrimagnetic materials: Those in which the magnetic dipole of the atoms on different sublattices are opposed as in antiferromagnetism but opposing moments are unequal and a net magnetization remains.

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Section-B

(2) Draw and explain the electric schematic of a miniature circuit breaker.

Ans: MCB (miniature circuit breaker) is a device that ensure definite protection of wiring system & electrical equipment against over current & short circuit.

Construction of MCB:

The construction of MCB can be explained by considering the following parts:

(i) **Outer body**: The outer body is made from special glass fibre reinfored polyster with the help of injection moulding technique.

- The outer body & other polyster parts are fire resistant, and is water resistant.
- Polyster parts have ability to withstand high temperature & mechanical impacts.

(ii) **Contacts**: The contacts of an MCB are made of pure silver. This provide definite advantage: long contact life, low contact resistance, ensures quick arc removal & low heat generation.

(iii) **Operation mechanism**: All the components of the operating mechanism are made of special plastic, that they are self lubricating & eliminates wear and tear, rust and corrosion. They are very light in weight and tough.

(iv) **Arc extinguishing contact**: The arc produced during breaking & making of contact is extinguished in this chamber.

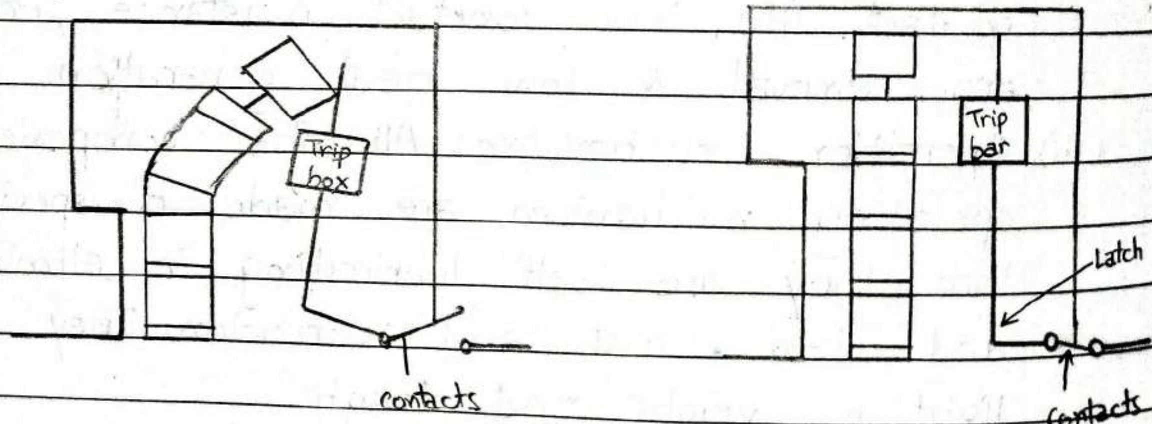
(v) **Fixing arrangement**: There are chip type construction at the back of MCB to easily attaches it to Nin-Bar & can be easily removed by screw drivers.

(vi) Mechanical interlocking of multiple MCBs : The levers of all MCBs are interlocked so that all the MCBs trip off simultaneously even if fault occur in any one of the phase.

⇒ Working of MCBs :

- Under normal condition, MCB operates as switch to make the circuit 'ON' or 'OFF'.
- Under overload or short circuit condition, it automatically operates or trips so that current interruption takes place in a load circuit. The automatic operation of MCB can be obtained in two ways - because there are magnetic tripping or thermal tripping in MCBs.

⇒ Working of MCB under over load condition:



- Under overload condition, as the current through bimetallic strip increases, it causes more heat & it causes bending of bimetallic strip due to different thermal expansion of both metals.

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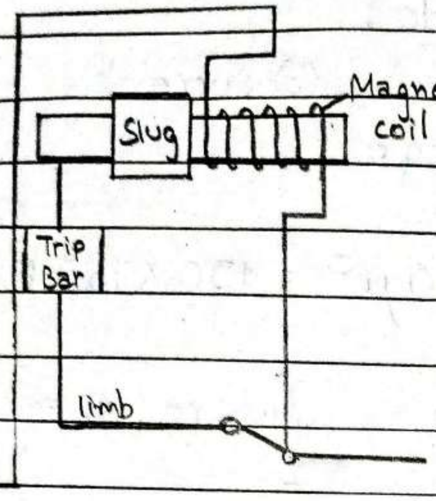
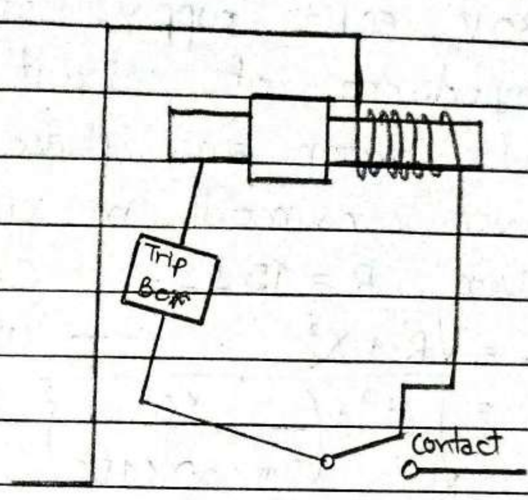
- This deflection futher releases the trip latch & hence the contact gets separated.





In some MCBs, magnetic field generated by coil causes / develops pull on trip bar so that the contact get open.
When fault current flows, the large magnetic field is generated by coil. It is sufficient to over come the spring force. Hence slug moves and activate the tripping mechanism.

- A combination of both magnetic & thermal expansion mechanisms are found in all MCBs.
- When the contacts starts separating, arc is produced which is forced into arc slitter plates. Her arc is splitted into series of arcs, thus energy is taken out of arc & it extinguished.

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(3) A resistance of 15 ohms and capacitor of 150 μF capacitance are connected in series across a 230 V, 50 Hz supply. Estimate:
(a) Impedance of circuit (b) current
(c) Power factor and phase angle
(d) Power consumed in circuit

Ans: Given, $R = 15\,\Omega$, $C = 150\,\mu F = 150 \times 10^{-6}$ F

(a) $Z = \sqrt{R^2 + X_c^2}$ — (1)

$= \sqrt{15^2 + \left(\frac{10^6}{2\pi \times 50 \times 150}\right)^2}\ \Omega$ $\left[\text{where, } X_c = \frac{1}{2\pi f C}\right]$

$Z = 25.99\,\Omega$

(b) Current $= I = \frac{V}{Z} = \frac{230}{25.99}$ A

$I_{rms} = 8.85$ A

(c) Power factor, $\cos\phi = \frac{R}{Z} = \frac{15}{25.99}$

$\cos\phi = 0.577$

Also, Phase angle, $\phi = \cos^{-1}(0.577)$

$\phi = 54.75°$

(d) Power consumed; $P_{avg} = VI\cos\phi$

$= 230 \times 8.85 \times 0.577$

$P_{avg} = 1174.48$ W

(4) Power to an induction motor is supplied by a 12-pole, 3-phase, 500 rpm alternator. The full load speed of motor is 1440 rpm. Find the percentage slip and number of poles in motor.

Ans: Frequency of supply to induction motor, $f = \frac{pn}{120}$

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where, p = poles of alternator = 12
n = speed of alternator = 500

$\therefore$, $f = \frac{12 \times 500}{120} = 50 Hz$

Speed of induction motor = 1440 rpm = n_1

No. of poles of induction motor = $p_1 = \frac{120 \times f}{n_1} = \frac{120 \times 50}{1440}$

$p_1 = 4.16$

The no. of poles are to be even, selecting the nearest even no. as the no. of poles, $p_1 = 4$

$\Rightarrow$ synchronous speed of induction motor, $N_s = \frac{120 f}{p_1}$

$N_s = \frac{120 \times 50}{4} = 1500$ rpm

$\therefore$, slip = $\frac{N_s - N}{N_s} = \frac{1500 - 1440}{1500} = 0.04$

Percentage slip = $0.04 \times 100 = 4\%$

Thus, motor has 4 poles and percentage slip of 4%

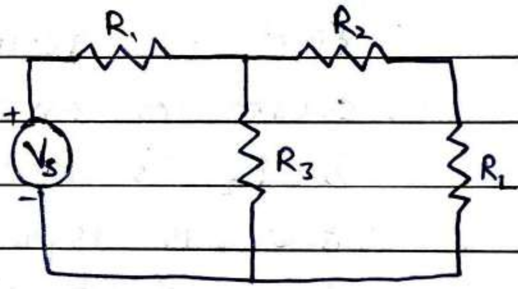
⑤ State and prove the Thevenin's theorem. Give an example.

⇒ Thevenin's theorem:

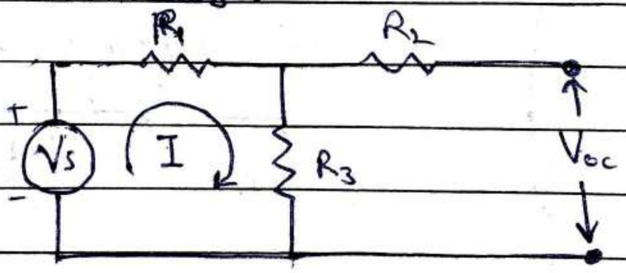
Statement: Any 2 terminal bilateral linear D.C. circuit can be replaced by an equivalent circuit consisting of a voltage source & a series resistor.

- It is applicable where it is desired to determine current through or voltage across any one element in a network without going through the regorous method of solving of a network equations.

Explaination: Simple D.C. circuit as shown.
We have to find the current in load resistance (R_L).

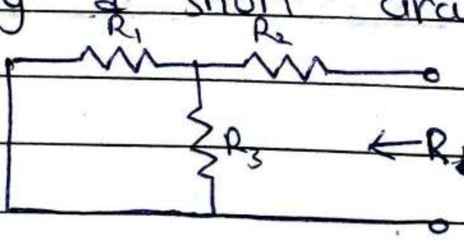


- Remove the load resistance & find open circuit voltage V_{oc} across the open circuited load terminals.

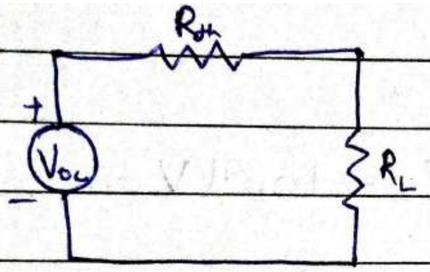


$$V_{oc} = \frac{R_3 V_s}{R_1 + R_3}$$

- To find the thevenin resistance (Voltage source is removed by a short circuit.



$$R_{th} = R_2 + \frac{R_1 R_3}{R_1 + R_3}$$



Thevenin's Equivalent circuit

$$I_L = \frac{V_{oc}}{R_{th} + R_L}$$

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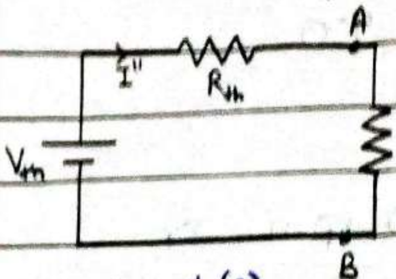
⇒ Proof of Thevenin's theorem:

Consider the network as shown below



circuit (2)

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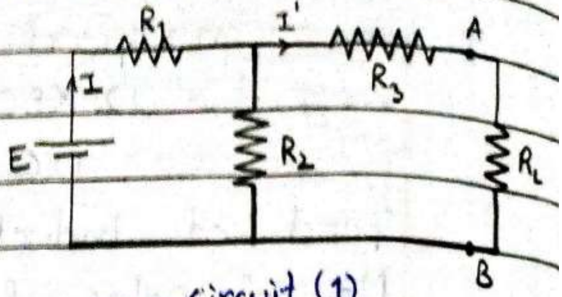

circuit (1)

The effective resistance of the network in (1) is:

$$R_{eff} = R_1 + \frac{R_2(R_3+R_L)}{R_2+R_3+R_L} \quad \text{—— (i)}$$

Current I in circuit is $= \frac{E}{R_{eff}} = \frac{E}{R_1 + \frac{R_2(R_3+R_L)}{R_2+R_3+R_L}}$

$$\text{or, } I = \frac{E(R_2+R_3+R_L)}{R_1R_2 + R_1R_3 + R_1R_L + R_2R_3 + R_2R_L} \quad \text{—— (ii)}$$

The current through load (I') is found using branch current method.

$$I' = \frac{IR_2}{R_2+R_3+R_L} \quad \text{—— (iii)}$$

Substituting for I from (ii) ~~and~~ in (iii),

$$I' = \frac{E(R_2+R_3+R_L)R_2}{(R_2+R_3+R_L)(R_1R_2+R_1R_3+R_1R_L+R_2R_3+R_2R_L)}$$

$$\text{or } I' = \frac{ER_2}{R_1R_2 + R_1R_3 + R_1R_L + R_2R_3 + R_2R_L} \quad \text{—— (iv)}$$

⇒ Now, Thevenin's voltage, $V_{th} = ER_2 / R_1 + R_2$ —— (v)

Thevenin's resistance, $R_{th} = R_3 + \frac{R_1R_2}{R_1+R_2}$ —— (vi)

Consider equivalent circuit (2)

The current I'' is $= \frac{V_{th}}{R_{th} + R_L}$

Substitution for V_{th} and R_{th} from (v) and (vi)

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$$I'' = \frac{ER_2}{(R_1+R_2)\left(R_3 + \frac{R_1 R_2}{R_1+R_2}\right) + R_L}$$

or $$I'' = \frac{ER_2}{R_1R_2 + R_1R_3 + R_2R_3 + R_1R_L + R_2R_L} \quad \text{—— (vii)}$$

From equation (iv) and (vii).

$$I' = I''$$

Hence Thevenin's theorem is verified.

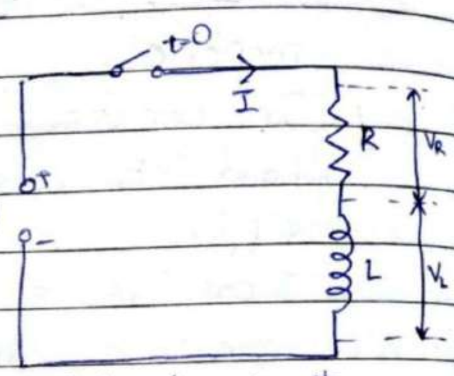
(6) Derive the voltage and current equation in time domain for a first order RL circuit.

Ans: The short timed electrical phenomenon that occurs in a system due to sudden change in voltage, current of load is called transient response.

⇒ Consider circuit containing resistance R (ohm) & inductor of inductance L (Henry) with a switch as shown.

The switch has been kept open for a long time, & is closed at $t=0$.

Applying KVL to circuit after switching



R-L series circuit

$$V = IR + L\frac{dI}{dt}$$

$$L\frac{dI}{dt} = V - IR$$

$$dI/dt = V/L - IR/L$$

$$\frac{dI}{dt} + \frac{IR}{L} = \frac{V}{L} \longrightarrow \text{(i)}$$

[We know that, $\left(\frac{dy}{dx} + Py = Q\right)$ is a linear diff. eq. $\longrightarrow$ (ii)

where P & Q are functions of x only,

$I.F = e^{\int P dx}$

Solution of this eq. is, $y \times I.F. = \int Q \times I.F.\, dx + C$]

∴, comparing (i) with (ii), we get

$P = R/L$, $Q = V/L$

$I.F. = e^{\int \frac{R}{L} dt} = e^{\frac{Rt}{L}}$

Sol. ⇒ $I \times e^{Rt/L} = \int \frac{V}{L} \times e^{\frac{Rt}{L}}\, dt + C$

$$= \frac{V}{L}\frac{e^{Rt/L}}{\frac{R}{L}} + C = \frac{V}{R}e^{Rt/L} + C$$

$$I = \frac{V}{R} + \frac{C}{e^{Rt/L}} = \frac{V}{R} + Ce^{-Rt/L} \longrightarrow \text{(iii)}$$

where C is constant of integration & it must satisfy the initial condition on inductance current thus, At $t=0$, $I=0$

$$0 = \frac{V}{R} + Ce^{0} \Rightarrow C = -\frac{V}{R} \longrightarrow \text{(iv)}$$

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Using (iv) in (iii), we get

$$\boxed{I} = \frac{V}{R} - \frac{V}{R}e^{-Rt/L} = \boxed{\frac{V}{R}(1-e^{-Rt/L})}$$

In above expression, first term

V/R → corresponds to steady state condition force responce

$-V/R \times e^{-R/L\,t}$ → corresponds to transient state (natural resistance) which approaches to zero as $t \to \infty$.

- Ratio L/R is called time constant denoted by τ.
- The reciprocal of time constant (i.e. R/L) is called damping co-efficient of circuit.
- Voltage across resistor is,

$$\boxed{V_R} = IR = \frac{V}{R}(1-e^{-Rt/L}) \times R = \boxed{V(1-e^{-Rt/L})}$$

- Voltage across inductor is,

$$V = V_R + V_L$$

$$V_L = V - V_R = V - V(1-e^{-Rt/L}) = Ve^{-Rt/L}$$

$$\boxed{V_L = Ve^{-t/\tau}}$$

Now = $I = \frac{V}{R}(1-e^{-Rt/L})$ | $V_R = V(1-e^{-Rt/L})$ | $V_L = Ve^{-t/\tau}$

At $t=0$,

$\Rightarrow I = 0$ | $V_R = 0$ | $V_L = V$

At $t = L/R = \tau$

$\Rightarrow I = \frac{V}{R}(1-e^{-1})$ | $V_R = V(1-e^{-1})$ | $V_L = Ve^{-1}$

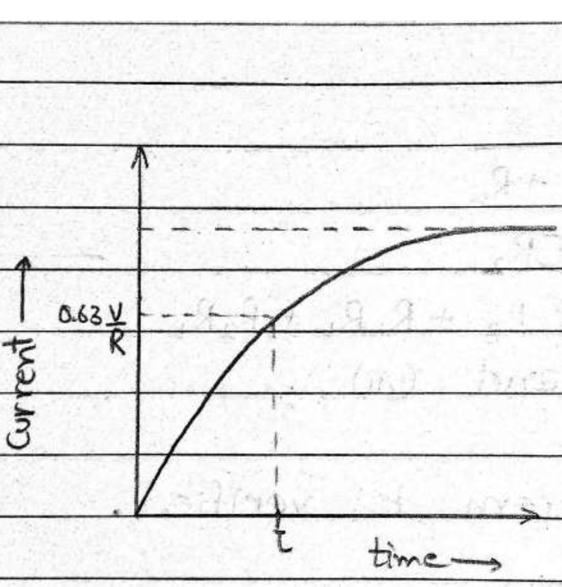
$= \frac{V}{R}(1-0.37)$ | $= V(1-0.37)$ | $= 0.37V$

$= 0.63\,V/R$ | $= 0.63V$

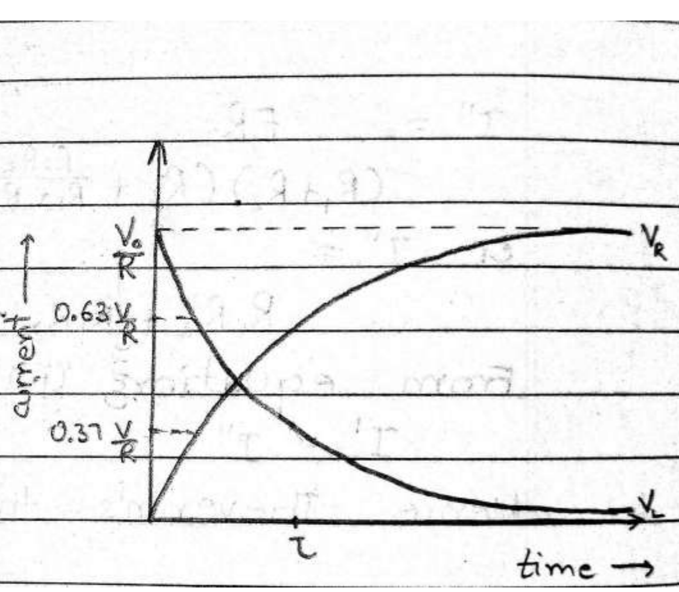
At $t = \infty$

$\Rightarrow I = \frac{V}{R}(1-e^{-\infty})$ | $V_R = V(1-e^{-\infty})$ | $V_L = Ve^{-\infty}$

$= \frac{V}{R}$ | $= V$ | $= 0$



Current
0.63 V/R
τ
time



current
V₀/R
0.63 V/R
0.37 V/R
V_R
V_L
τ
time

(8) In a 25 kVA, 2000/200 V power transformer the iron and full load copper losses are 350 W and 400 W respectively. Calculate the efficiency at unity power factor at full load.

Ans- Given: Apparent Power, $P = 25\ kVA$

Iron loss, $P_i = 350\ V$

Copper loss, $P_c = 400\ V$

Power factor, $P.F. = 1$

Now, at full load, $x = 1$

$$\text{Effeciency} = \eta = \frac{x . P \times 10^3 \times P.F.}{x . P \times 10^3 \times P.F. + x^2 P_c + P_i} \times 100$$

$$= \frac{25 \times 10^3 \times 1 \times 100}{25 \times 10^3 \times 1 + 400 + 350}$$

$$= 97.08\ \%$$

9Q: Write a short note on:(a) Important characteristics of batteries. (b)Power factor improvement.

Ans:- (a) Battery Characteristics:

The suitability of any battery for particular application is based on certain characteristic properties. Some of the important characteristics of battery are

1. **Voltage**:

In general, high voltage is desired from any battery. The voltage of any battery depends on the emf of the cells which constitute the battery system. The emf of the cell depends on the free energy in the overall cell reactions as given by Nernst equation. Ecell = E0 cell -2.303 RT/ nF log Q Where Ecell = Ecathode -Eanode and Q is the ratio of the molar concentrations of product and reactants. From the above equation, emf of the cell and the voltage available from the battery is dependent on the standard electrode potential difference between the cathode and anode, temperature and the extent of the cell reaction. To get required high voltage, the difference in the standard electrode potential should be more; temperature of the reaction and q value should be low. The conductivity of the electrolyte should be high.

2. **Current**:

It is a measure of the rate at which the battery discharging. The ability to deliver a high voltage with is dependent on rapid electron transfer reaction and correct design of active material.

3. **Capacity**:

The total number of ampere hour (Ah) or watt hour (Wh) that can be withdrawn from a fully charged battery under specific conditions of discharge is termed as capacity of the battery. The capacity depends on the size of the battery and is given by Faraday's equation C= WnF/M Where

W= weight of the active material

C= capacity

M= molar mass of the active material

F= Faraday constant

4. **Energy density**:

The ratio energy available from a battery to its volume or mass is called as energy density and is represented as Energy density = i xtx Ecell / W Where t is the time at fixed current i to reach Ecell. The energy density is measured by determining the capacity and recording Ecell during the discharge and total weight (W) of a battery.

5. **Energy efficiency**:

The energy efficiency in % is given by the equation % of energy efficiency = Energy released during discharge / Energy required during charge Energy efficiency depends on the a. current efficiency of the electrode process, b. the potential encountered in both discharge and the charge reactions c. the battery resistance and d. rate of recharging and discharging.

6. **Electricity storage density:**

Electrical storage density is measure of the charge per unit weight stored in the battery i.e. its capacity per unit weight. Weight of the battery includes the weight of electrolyte, current collectors, terminals, the controllers etc. A high storage density depends on a good battery design and also the appropriate selection of electrode reaction.

7. **Power density:**

The ratio of the power available from a battery to its weight (W/ Kg) or its volume (W/V) is called power density. The power density will decrease during discharge and while recharge it will increase.

8. **Cycle life:**

The number of recharge per discharge cycles that are possible before the failure ofa secondary battery is called cycle life. In secondary battery it is essential for the discharge per recharge cycles to perform the active material in a suitable state for further discharge reaction. The discharge per recharge cycles depends on the correct chemical composition, morphology and proper distribution of active material in the battery.

9. **Shelf life:**

The duration of storage under specific condition at the end of which battery still retaining the ability to give specific performance is called shelf life. Shelf life for most of the storage must be good. Good shelf life for a battery is possible when there is no shelf discharge or corrosion on corrent collectors.

(b) Power factor improvement refers to the optimization of electrical systems to enhance their effectiveness and decrease energy consumption. It's essentially a measure of how efficiently the real power (performing work) is utilized compared to the apparent power flowing through the circuit. A value of 1 signifies ideal effectiveness, while lower values indicate inefficiency and potential issues.

There are some list of Power Factor Improvement Methods given below :

1. Static Capacitor

2. Synchronous Condenser

3. Phase Advancer

1.) Static capacitor: the majority of power system loads and industries are inductive, which results in a lower system power factor due to lagging current. Static capacitors are connected in parallel to these low-power factor devices to raise the power factor. These static capacitors supply driving current, which adjust the lagging inductive part of the load current. This successfully wipes out or kills the lagging part of the load current and corrects the power component of the load circuit to improve the overall efficiency. To enhance system or device efficiency, these capacitors are introduced close to enormous inductive loads, similar to inductance motors and transformers, to further develop the load circuit power factor.

2.) Synchronous condenser: A synchronous condenser draws leading current and partially eliminates the reactive component when connected across the supply voltage (in parallel). Along these lines, the power factor is gotten to the next level. In most large industries, synchronous condensers are used to raise the power factor.

3.) Phaser advancer: The Phase Advancer is a simple AC exciter that connects with the primary shaft of an motor and works with the motor's rotor circuit to further improve power factor. It is usually utilized in industries to further develop the power factor of induction motors. Since the stator windings of an induction motor remove lagging current 90° from phase with voltage, the power element of the motor is low. The induction motor's power factor rises as a result of the external AC source providing exciting ampere-turns. The Phase Advancer is responsible for this procedure.