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ESE- 2018 (Prelims) - Offline Test Series-Test-16
ELECTRICAL ENGINEERING
SUBJECT: ELECTRIC CIRCUITS & FIELDS+ MATERIAL SCIENCE + ELECTRICAL MACHINES-SOLUTIONS

01. Ans: (d)

Sol: The number of independent current equations = n-1.

02. Ans: (d)

Sol: $H(s) = \frac{4(s^2+25)}{s^2+2.5s+100}$,

$$H(j\omega) = \frac{4(25-\omega^2)}{(100-\omega^2)+j2.5\omega}$$

$|H(j\omega)| = 1, \ \omega = 0$

$= 0, \ \omega = 5$ (notch occurs here)

$= 4, \ \omega = \infty$

Gain at high frequencies is more than the gain at low frequencies.

$\therefore$ The given H(s) represents a high pass notch filter.

03. Ans (c)

04. Ans: (c)

Sol: $2\,I_1 + 2\,I_2 = 6$

If $I_1 = 1.5$ A, $I_2 = 1.5$ A

05. Ans: (d)

Sol: $I_1 = 2\,V_1 + V_2$

$I_2 = 2\,V_1 + 3\,V_2$

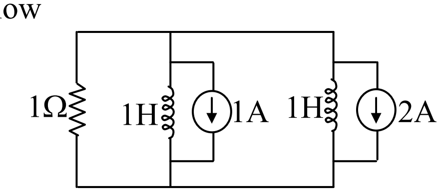
$$Z_{12} = \left.\frac{V_1}{I_2}\right|_{I_1=0}$$

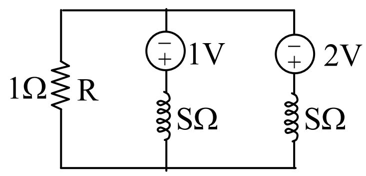
$I_1 = 0$, $V_2 = -2\,V_1$, $I_2 = -4\,V_1$,

$$Z_{12} = -\frac{1}{4}\,\Omega$$

06. Ans: (a)

Sol: The circuit as stated in the question is given below





By nodal analysis,

$$\frac{V(s)+1}{s}+\frac{V(s)+2}{s}+\frac{V(s)}{1}=0$$

$$\Rightarrow V(s)\left(\frac{2}{s}+1\right)=-\frac{1}{s}-\frac{2}{s}$$

$$\Rightarrow V(s)\left(\frac{2+s}{s}\right)=-\frac{3}{s}$$

$$\Rightarrow V(s)=\frac{-3}{s+2}$$

∴ current through 'R' is

$$I_R(s)=\frac{V(s)}{R}=\frac{V(s)}{1}=V(s)$$

$$\Rightarrow I_R(s)=\frac{-3}{s+2}A$$

∴ by ILT, $i_R(t) = -3e^{-2t}A$

$\Rightarrow i_R(\infty) = -3e^{-\infty} = 0A$

∴ $i_R(\infty) = 0A$

07. Ans: (d)

Sol: Keeping c–d open,

$R_{ab} = (30 + 90) \,||\, (60 + 60) = 60\ \Omega$

Keeping a–b open

$R_{cd} = (30 + 60) \,||\, (60 + 90) = 56.25\ \Omega$

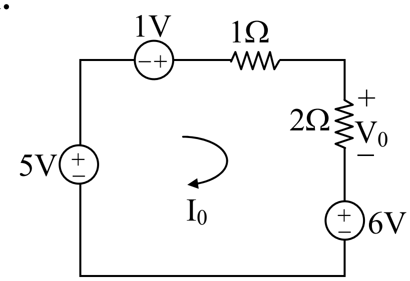
08. Ans: (b)

Sol: $Q=\int i.dt$; $Q = i.t = CV$

$$V=\frac{I}{C}.t=\frac{40\times10^{-3}}{50\times10^{-6}}\times10\times10^{-3}=8V$$

09. Ans: (b)

Sol:

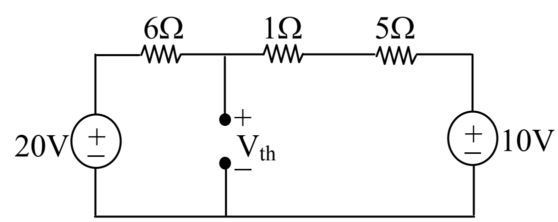


Hence, $I_0=\frac{5+1-6}{32}=\frac{0}{32}=0A$

$V_0 = I_0\times2 = 0V$

10. Ans: (a)

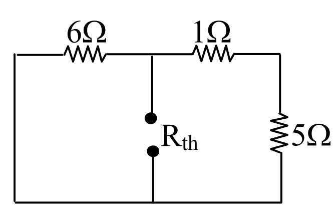
Sol: Calculation for V_{th}



$$\therefore \frac{V_{th}-20}{6}+\frac{V_{th}-10}{6}=0$$

$\Rightarrow V_{th} = 15$ Volts

Calculation for R_{th}



$$\therefore R_{th} = 6 // 6 = \frac{6}{2} = 3\Omega$$

$$\therefore P_{max} = \frac{V_{th}}{4R_{th}} = \frac{15^2}{4\times3} = \frac{15\times15}{4\times3}$$

$$= \frac{15\times5}{4} = \frac{75}{4} = 18.75\text{W}$$

11. Ans: (d)

Sol: For two capacitor C_1 and C_2, connected in parallel and charged to a voltage V.

we have $C_1V = Q_1$ and $C_2V = Q_2$

or $\frac{C_1}{C_2} = \frac{Q_1}{Q_2}$

From the data,

$\frac{50}{100} = \frac{Q_1}{Q_2}$ and $Q_1 + Q_2 = 300\mu C$

Hence, $Q_1 = 100\mu C$ and $Q_2 = 200\mu C$ (transferred to the 100-μF capacitor)

12. Ans: (a)

Sol: At steady state ($t\to\infty$),Input voltage is zero

Therefore, $I = \frac{V(\infty)}{1} = 0\text{A}$

13. Ans: (b)

Sol: $Y(s) = \frac{1}{R} + Cs + \frac{1}{Ls}$,

$Y(\infty) = \infty$, Pole at $s = \infty$,

$Y(0) = \infty$, Pole at $s = 0$

14. Ans: (b)

Sol: $V_A = \left(20 - \frac{V_A}{2}\right)2 + \left(20 - \frac{V_A}{2} - 10\right)1$

$$= 40 - V_A + 10 - \frac{V_A}{2}$$

$2.5\ V_A = 50$, $V_A = 20$ Volts.

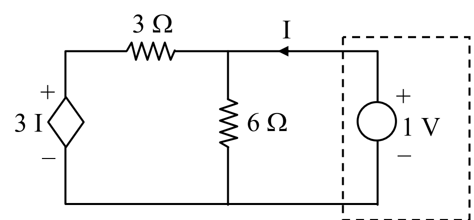
15. Ans: (c)

Sol: Area under the graph

Charge $= \left[\frac{1}{2}\times2\times5 - 1\times1\right]\mu C = 5 - 1 = 4\mu C$

16. Ans: (b)

Sol:



Apply KCL,

$$I = \frac{1}{6} + \frac{1-3I}{3}$$

$$I = \frac{1}{4}\text{A}$$

$$R_{th} = \frac{1}{I} = \frac{1}{0.25} = 4\ \Omega$$

17. Ans: (b)

Sol: When voltage source is in parallel with current source then we can neglect the current source.

18. Ans: (c)

Sol: KVL is applicable to only planar circuits only

KCL is applicable to both planar and non planar circuits.

19. Ans: (d)

Sol: Magnetic field due to a square loop of side 'L' at the center is given by

$$\left|\overline{H}\right| = \frac{2\sqrt{2}I}{\pi L}$$

Loop A : L = d

Loop B : L = 4d

$$\left|\overline{H}\right|_A : \left|\overline{H}\right|_B = \frac{2\sqrt{2}I}{\pi d} : \frac{2\sqrt{2}I}{\pi(4d)}$$

$$= 1 : \frac{1}{4}$$

$$= 4 : 1$$

'I' is the current carried by loop.

20. Ans: (a)

Sol:

$$\overline{D} = \hat{a}_y - 2\sqrt{3}\hat{a}_z \qquad \overline{D} = \left|\overline{D}\right|\overline{a}_n$$

$$\left|\overline{D}\right| = \sqrt{4} = 2 \qquad = \rho_s \hat{a}_n$$

$$\therefore \rho_s = 2\,{}^{C}\!/_{m^2}$$

21. Ans: (a)

Sol: The method of images concept is used.

The value of image charge and the distance from q should be such that the sum of the potentials of two charges on the spherical surface is zero.

The image charge must be negative and its value is equals to -(R/d)q. The image charge is on the radial line joining the point charge and the center of the sphere. The image charge will be located at a distance R^2/d from the center of the sphere.

22. Ans: (d)

Sol: $\oint H.dl = 3I + 2I + I = 6\,I$

Circulation of loop carrying current 3I and 2I in the same direction

The loop carrying I is in the same direction.

23. Ans: (b)

Sol: $\nabla^2 V = 0$

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = 0$$

$$\text{Sinhx}.\cos(ky).e^{pz}\left[1 - k^2 + p^2\right] = 0$$

$$\therefore\ k = \sqrt{1 + p^2}$$

24. Ans (a)

Sol: Yoke is the outer frame of the DC machine and is cylinder of cast steel or rolled steel. Even number of pole cores are bolted on the yoke. The yoke serves the following two purposes.

(i) It supports the pole cores and acts as protecting cover to machine

It forms the part of magnetic circuit.

25. Ans: (c)

26. Ans: (b)

27. Ans: (b)

Sol: $\dfrac{R_A}{R_B} = \dfrac{n_B e}{n_A e} = \dfrac{4\times 10^{21}\times e}{2\times 10^{21}\times e} = \dfrac{2}{1}$

28. Ans: (a)

29. Ans: (c)

Sol: Silver is a monovalent atom with highest conductivity of $7 \times 10^7(\Omega\text{–m})^{-1}$, but aluminium is a trivalent atom with $4\times10^7(\Omega\text{–m})$ so 1^{st} statement is wrong.

With increasing temperature in conducting metals, lattice vibration takes place and hence conductivity decrease.

$\sigma = \dfrac{ne^2 t}{m}$ $\qquad \sigma \propto t$

t = average collusion time.

30. Ans: (a)

Sol: Self-assembly is a bottom-up manufactory technique, all the other options are correct. In self-assembly, weak interaction play very important role, self assembling molecules adopt a organised structure which thermodynamically more stable that the single, unassembled components.

31. Ans: (a)

Sol: Silicon carbide material is a high melting point material with good semiconductivity character.

32. Ans: (c)

Sol: PVC material is a thermoplastic materials. They are formed by addition polymerization and in PVC each polymer chain is connected linearly.

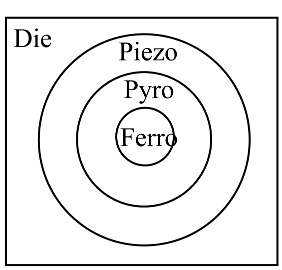
33. Ans: (b)

34. Ans: (b)

35. Ans: (b)

36. Ans: (a)

Sol:



All ferroelectric materials are piezoelectric material; some of piezoelectric materials are pyroelectric materials.

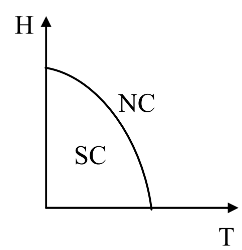
37. Ans: (a)

Sol: Ionic polarisability $\alpha_I = \dfrac{e^2}{\omega^2 m}$

Ionic polarisability is inversely proportional to the square of natural frequency.

38. Ans: (a)

Sol: 1: Super conductors exhibits normal conductivity when the applied field is more than critical field.



2 & 3: Ceramic materials are becoming super conductor at much higher temperature than metals.

39. Ans: (a)

Sol: The magnetic bubbles used in computer memories to store the data which made up of Yttrium-iron garnet.

40. Ans: (b)

41. Ans: (d)

Sol: The monoclinic system:

$a \neq b \neq c$

$\alpha = \beta = \gamma = 90°$

The number of independent parameters required to represents monoclinic is 4.

42. Ans: (b)

Sol: The velocity of an electron

$$\frac{1}{2}mV^2 = 5eV$$

$$= 5 \times 1.6 \times 10^{-19}$$

$$mV^2 = 2 \times 5 \times 1.6 \times 10^{-19}$$

$$V^2 = \frac{2\times5\times1.6\times10^{-19}}{9.1\times10^{-31}} = 1.758 \times 10^{12}$$

$$\Rightarrow V = 1.3 \times 10^6 \text{ m/s}$$

43. Ans: (c)

Sol: For ideal transformer the various assumptions are

1. Winding resistances are negligible
2. All the flux setup by the primary links the secondary
3. The core losses are negligible
4. The core has constant permeability

44. Ans: (c)

Sol: $r\% = \dfrac{\text{ohmic loss at rated current}}{\text{Rated VA}} \times 100$

$(r\%) = \dfrac{4000}{200000} \times 100 = 2\%$

Regulation $5 = (r_{pu}\cos\theta_2 + x_{pu}\sin\theta_2)$

$5 = 2 \times 0.8 + x_{pu} \times 0.6$

$X_{pu} = 5.66\%$.

45. Ans: (b)

Sol: Transformation ratio of auto transformer

$k = \dfrac{2500}{2750} = \dfrac{10}{11}$

Rating of auto transformer $= \dfrac{10\,\text{kVA}}{1-k}$

$= \dfrac{10\,\text{kVA}}{\frac{1}{11}} = 110$ kVA

Conducted kVA = k × input VA

$= \dfrac{10}{11} \times 110$

= 100 kVA

46. Ans: (c)

Sol: The symbol Yd represents HV in star and LV in delta. The time-phase displacement can be expressed either in degrees or by clock method. In this the HV line phase is considered as the minutes hand and always set at 12 'o' clock positive. The corresponding LV line phasor is represented by hour hand. And "Yd11" represents HV in star and LV winding in delta and LV phasor at 11 'o' clock i.e., 30^o ahead of the zero hour position (12 'o' clock) i.e., HV lags the LV phasor by 30^o.

47. Ans: (c)

Sol: VA rating of the open-delta connection

$= \sqrt{3}\, V_L I_L = \sqrt{3}\, V_{ph} I_{ph}$

Utilization factor

=

$\dfrac{\text{Actual available kVA rating}}{\text{sum of the kVA rating of transformer installed}}$

$= \dfrac{\sqrt{3} V_{ph} I_{ph}}{2 V_{ph} I_{ph}} = 0.866.$

48. Ans: (a)

Sol: Capacitor split induction motor:

A capacitor is connected in auxiliary field winding as stator field winding is divided into two such that the angle between the field currents is made to nearly 90^o such that maximum torque is obtained.

Resistor split induction machine:

In resistor split a resistor is connected in auxiliary winding as stator field winding is divided into two such that the angle between the field is different and the torque induced is less than the torque produced in capacitor split.

Shaded pole:

The torque produced in shaded poles less than the above two slip-phase techniques.

49. Ans: (d)

Sol: At reduced voltage and frequency,

$$\left(\frac{V}{f}\right) = \text{constant}$$

(i) Starting current is decreased

(ii) Power factor at starting is improved and therefore more power input to rotor

(iii) Starting torque is increased.

50. Ans: (a)

Sol: If rotor slots are skewed than the parasitic torques can be reduced.

Becausing of skewing leakage reactance increases, so low starting torque and maximum torque.

Because of skewing there will be quiter operation.

51. Ans: (b)

Sol: In squirrel cage induction motor rotor winding is in accessible while running so we cannot use rotor resistance control technique.

52. Ans: (c)

Sol: By increasing the frequency,

(1) The increasing frequency N_s increases but $T_{st} \propto \frac{1}{N_s}$ So T_{st} decreases.

(2) Deep bar rotor increases starting torque

(3) By increasing number of poles N_s decreases, as N_s decreases $T_{st} \propto \frac{1}{N_s}$ So T_{st} increases.

(4) By using double cage rotor, resistance of the rotor can be increased, So starting torque increases.

53. Ans: (c)

Sol: $$\frac{T_e}{T_m} = \frac{2}{\frac{S_m}{S} + \frac{S}{S_m}}$$

$$\frac{T_e}{100} = \frac{2}{2+0.5} = \frac{2}{2.5}$$

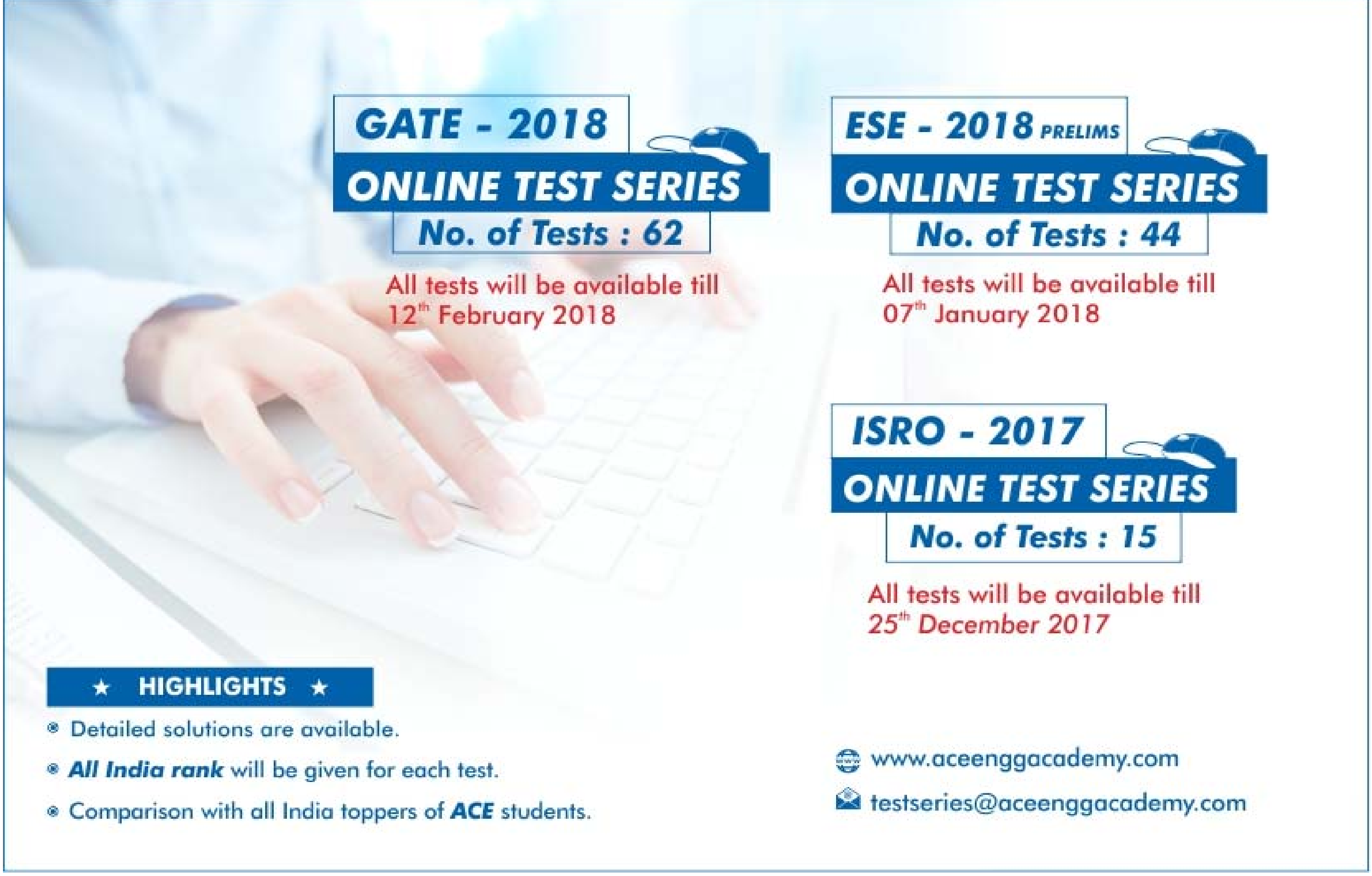
$$T_e = 100 \times \frac{4}{5} = 80 \text{ Nm}$$

54. Ans: (c)

Sol: Slip at maximum torque does not depends on supply voltage so $S_{MT} = 0.2$ and $T_{em} \propto V^2$

$$\frac{T_{em1}}{T_{em2}} = \left(\frac{V_1}{V_2}\right)^2 = \left(\frac{400}{360}\right)^2$$

$$T_{em2} = \frac{81}{100} \times 200 = 162 \text{ Nm}$$



55. Ans: (d)

Sol: The direction of rotation of 1-ϕ induction motor can be reversed by either reversing the leads of main winding or auxiliary winding but not both.

56. Ans: (d)

Sol: $\omega_i = 40.5$ kW; $\omega_{cu} = 50$ kW

$$\eta_{max} = \sqrt{\frac{\omega_i}{\omega_{cu}}} = = \sqrt{\frac{40.5}{50}} = 0.9$$

57. Ans: (d)

Sol: As driving torque increases for constant flux the output of machine increases. So generator can be loaded.

In another way with increase in flux then back emf generated increases as $E_b \propto \phi$. So $E_b > V_t$ then the generator can be loaded.

58. Ans: (c)

Sol: If two over-compounded generators are connected in parallel without equalizer ring then if emf of one generator goes up then due to cumulative action of compound connection the load shared by one generator increases where as other generator load gets relived accordingly. Finally a state comes where one machine acts as an generator and other motor.

This can be avoided by use of equilizer bar. Equilizer is a a very low-resistance copper wire, which connects identical terminals having same polarity.

59. Ans: (c)

60. Ans: (a)

Sol: Shunt field current = $\frac{250}{125}$ = 2 A

Armature current = $\frac{10,500}{250}$ –2 = 40 A

At starting, $E_b = 0$

External resistance required $=R = \frac{V_t}{2\times 40} - 0.5$

$= \frac{250}{2\times 40} - 0.5 = 2.62\ \Omega$

61. Ans: (d)

62. Ans: (d)

Sol: Interpoles are narrow poles placed exactly midway between main poles.

For generator polarity of interpole must be same as that of main pole ahead of it in direction of rotation. For motor polarity is same as that of main pole behind it.

They are connected in series with armature.

63. Ans: (b)

Sol: A synchronous machine is given to be initially floating. It implies that the machine is operating on an infinite bus, neither delivering nor receiving any current the corresponding equivalent circuit is given in figure1 (for simplicity, resistance/ phase is neglected)

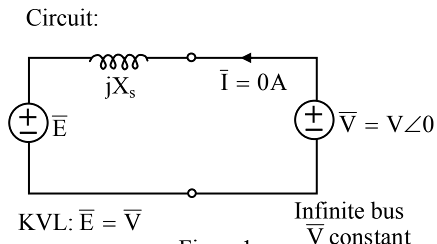


Figure1

Generation operation: Now the machine is loaded as a generator. This is achieved by increasing its prime mover input. Its excitation is, however, assumed constant, but the generator delivers a current $\bar{I}$. Corresponding circuit and phasor diagram are shown in fig.

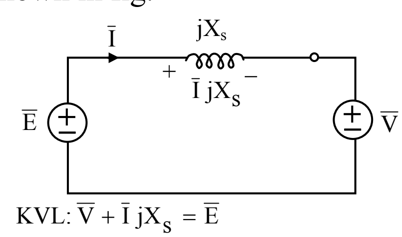
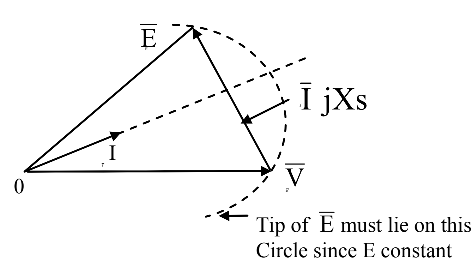


Figure 2



If we assume $\bar{I}$ to be lagging, trip of $\bar{E}$ can never lie on the circle. An example is shown in fig.3

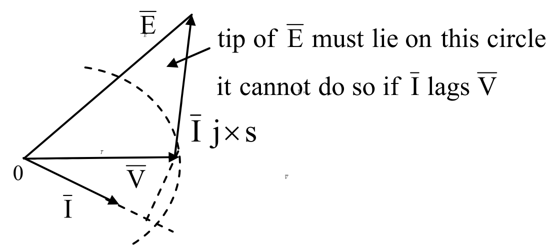


Fig.3

Thus, the generator delivers a leading current to the bus. By a very similarly analysis, if the machine is loaded as a motor by placing a machines load on the shaft, the current drawn by the motor cannot be leading. It can only be lagging.

64. Ans: (b)

Sol: For an isolated alternator, if speed increases, its output frequencies increases.

$\therefore$ reactance $x \propto f$ also increases.

For an alternator connected to infinite bus operating frequency is constant.

65. Ans: (b)

Sol: To eliminate n^{th} harmonic, coils should be short pitched by $\frac{\pi}{n}$ degrees

$\therefore$ To eliminate 5^{th} harmonic

66. Ans: (b)

Sol: Step angle = $\frac{360}{mN_r}$

m = number of phases & N_r = number of rotor tooth.

$= \frac{360}{3\times10}$

= 12

67. Ans: (c)

68. Ans: (d)

Sol: The conductivity is in descending order as follows. Hard drawn copper, cadmium copper, Aluminium & galvanised steel.

69. Ans: (b)

Sol: For an LTI network:

$y(t) = h(t) * x(t)$, $Y(s) = H(s)\,X(s)$

A is True.

$\delta(t) \xrightarrow{LT} 1$

R is True and is not the correct explanation of A.

70. Ans: (a)

Sol: In resonance the current in series RLC circuit is maximum and the voltage across the capacitor is quality factor times the input voltage.

71. Ans: (a)

Sol: Voltage Regulation $\propto \frac{1}{SCR}$ and Power output $\propto$ SCR. High value of SCR indicates, alternator said to be more stable

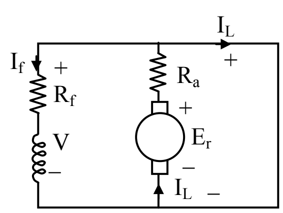
72. Ans: (d)

'Statement I' is false, but 'Statement II' is true.

Sol: In figure, because of the short-circuit, V = 0.

Since V = 0, $I_fR_f = 0$ and I_f is zero.

But residual magnetism will induce a voltage E_r in the armature, which circulates a current I_L in the armature and the short-circuit $\left(I_L = \frac{E_r}{R_a}\right)$



73. Ans: (d)

Sol: Airgap does substantially increase the reluctance of the flux path in an induction motor. 'Statement II' is correct.

But because of this a large mmf is needed to establish the flux as demanded by the voltage applied. Large mmf means, for a given number of turns per phase, a large magnetizing current.

Induction motor has a relatively small magnetizing reactance and large magnetizing current. 'Statement I' is wrong.

74. Ans: (c)

Sol: At 0°K, neighbouring atomic magnetic moments are frozen with magnetic dipoles pointing in opposite directions.

75. Ans: (c)

Sol: Critical field exists only below the transition temperature.