DETAILED SOLUTIONS

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ESE 2026 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 10

Section A : Power Electronics and Drives [All Topics]
Section B : Power Systems-1 [Part Syllabus]
Section C : Electrical Machines-2 [Part Syllabus]

ANSWER KEY

1.	(b)	16.	(c)	31.	(a)	46.	(c)	61.	(d)
2.	(a)	17.	(b)	32.	(b)	47.	(b)	62.	(d)
3.	(a)	18.	(d)	33.	(c)	48.	(d)	63.	(b)
4.	(d)	19.	(a)	34.	(c)	49.	(b)	64.	(c)
5.	(a)	20.	(b)	35.	(c)	50.	(b)	65.	(a)
6.	(d)	21.	(c)	36.	(d)	51.	(d)	66.	(c)
7.	(b)	22.	(c)	37.	(c)	52.	(d)	67.	(c)
8.	(d)	23.	(c)	38.	(b)	53.	(c)	68.	(b)
9.	(a)	24.	(b)	39.	(a)	54.	(b)	69.	(d)
10.	(a)	25.	(c)	40.	(a)	55.	(d)	70.	(a)
11.	(b)	26.	(c)	41.	(b)	56.	(b)	71.	(b)
12.	(c)	27.	(b)	42.	(c)	57.	(c)	72.	(a)
13.	(b)	28.	(c)	43.	(c)	58.	(b)	73.	(b)
14.	(b)	29.	(c)	44.	(c)	59.	(c)	74.	(b)
15.	(c)	30.	(c)	45.	(c)	60.	(b)	75.	(b)

DETAILED EXPLANATIONS
Section A : Power Electronics and Drives

1. **(b)**

2. **(a)**

3. **(a)**

$$V_L = V_S \Rightarrow L\frac{di}{dt} = V_m \sin\omega t \Rightarrow \frac{di}{dt} = \frac{V_m}{L}\sin\omega t \Rightarrow \frac{di}{dt} \propto \frac{V_m}{L}$$

4. **(d)**

5. **(a)**

For controlled converters:
- Output voltage depends on firing angle but contain ripple. So, output voltage waveform is not smooth.
- Thyristor switching creates non-sinusoidal current. So, harmonic injected into the system.
- Due to phase control (firing delay), current lags. So power factor is less than unity.

6. **(d)**

A large capacitor keeps the output voltage almost constant. Current is drawn from the AC source only when the source voltage becomes higher than the capacitor voltage. So the rectifier draws current in short, sharp pulses.
- Peaky current
- only during positive half cycle
- Zero current during negative half cycle.

7. **(b)**

A single-phase Current Source Inverter (CSI) has capacitor C at the load. The source current is constant.
- Constant current charge or discharge the capacitor linearly.
- So the capacitor voltage becomes a triangular wave.

8. **(d)**
- Output frequency cannot exceed natural resonant frequency.
- In a series inverter, the load is in series with commutating components (L and C). So the same load current flows through them.

9. **(a)**

Let I and I_{sb} be the one-cycle and sub-cycle surge current ratings of the SCR respectively. Then equating the energies involved in them, we get

$$I^2T = I_{sb}^2 \cdot t$$

$$\Rightarrow \quad I^2 \times 0.02 = (3000)^2 \times 0.01 \qquad \left(T = \frac{1}{50} = 0.02 \text{ sec}, t = \frac{T}{2} = 0.01 \text{ sec}\right)$$

$$I = \frac{3000}{\sqrt{2}} = 2121.32 \text{ A}$$

$$I^2t \text{ rating} = I^2 \times T = \left(\frac{3000}{\sqrt{2}}\right)^2 \times 0.01 = 45000 \text{ Amp}^2\text{-sec}$$

Thus, the SCR has one-cycle surge current rating of 2121.32 A and I^2t rating of 45000 Amp^2-sec.

10. (a)

The peak value of circulating current, for firing angle α_1 = 60°, is given by

$$i_{c_p} = \frac{\sqrt{3} \times \sqrt{6} \times V_{ph}}{\omega L}(1 - \sin\alpha_1)$$

$$i_{c_p} = \frac{\sqrt{3} \times \sqrt{6} \times 230}{2\pi \times 50 \times 15 \times 10^{-3}}[1 - \sin 60°] = 27.74 \text{ A}$$

11. (b)

Average load current, $I_0 = \dfrac{I_1 + I_2}{2} = \dfrac{12 + 16}{2} = 14$ A

Average load voltage, $V_0 = I_0 R = 14 \times 10 = 140$ V

But, $V_0 = \alpha \times V_s$

$\therefore$ Duty cycle, $\alpha = \dfrac{T_{on}}{T_{on} + T_{off}} = \dfrac{V_0}{V_s} = \dfrac{140}{200} = 0.7$

12. (c)

Time of one cycle, $T = \dfrac{1}{f} = \dfrac{1}{50}$ sec

$\therefore$ Rate of change of current,

$$\frac{di}{dt} = \frac{0.5\text{A}}{T} = 0.5 \times 50 = 25\text{A/sec}$$

A Short circuit at the load terminals of the inverter puts the most severe conditions on the source. So the value of source inductance must be obtained from these considerations.

$$\therefore \quad V_s = L\frac{di}{dt}$$

$\therefore$ Source inductance, $L = \dfrac{220}{25} = 8.8$ H

13. (b)

Latching and holding currents are more in GTO compared to SCR.

14. (b)

The peak value of current through T_2

$$\left(i_{T_2}\right)_{\text{peak}} = \frac{V_S}{R_2} + \frac{2V_S}{R_1}$$

$$= 400\left(\frac{2}{10} + \frac{1}{100}\right) = 400\left(\frac{21}{100}\right) = 84 \text{ A}$$

15. (c)

Freewheeling diode improves current distortion factor and reduces THD.

16. (c)

$$\theta_{jA} = \frac{T_j - T_A}{P}$$

17. (b)

$$V_{\text{ph rms}} = \frac{V_s\sqrt{2}}{3} = \frac{220 \times \sqrt{2}}{3} = 103.7 \text{ V}$$

$$I_{\text{ph rms}} = \frac{V_{\text{ph rms}}}{R} = 6.91 \text{ A}$$

18. (d)

Peak value of resonant current,

$$I_P = V_S\sqrt{\frac{C}{L}} = 220\sqrt{\frac{20\,\mu\text{F}}{5\,\mu\text{H}}} = 440 \text{ A}$$

Resonant frequency, $\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{20 \times 10^{-6} \times 5 \times 10^{-6}}} = \frac{10^6}{\sqrt{100}} = 10^5 \text{ rad/sec}$

Conduction time of axillary thyristor,

$$\frac{\pi}{\omega_0} = \frac{\pi}{10^5} = 10\,\pi\,\mu\text{sec}$$

Also $\omega_0(t_3 - t_2) = \sin^{-1}\left(\frac{220}{440}\right) = 30°$

$$V_{ab} = V_s \cos \omega_0(t_3 - t_2) = 220 \cos (30°)$$

$$= \frac{220 \times \sqrt{3}}{2} = 110\sqrt{3} \text{ V}$$

19. (a)

$$I_0 = \frac{V_0}{R} = \frac{V_m}{\pi R}(1+\cos\alpha)$$

$$= \frac{220\sqrt{2}}{\pi\times 13.5}\left(1+\cos\frac{\pi}{3}\right) = \frac{110\times 0.9}{13.5}\times 1.5 = 11\text{ A}$$

$$I_{S1} = \frac{2\sqrt{2}}{\pi}I_0\cos\frac{\alpha}{2}$$

$$= 0.9\times 11\times\cos\frac{\pi}{6}$$

$$= 0.9\times 11\times\frac{\sqrt{3}}{2}$$

$$= 8.57\text{ A}$$

20. (b)

Since, $\alpha > 60°$

So, freewheeling period $= \dfrac{3\left[\alpha-\dfrac{\pi}{3}\right]}{2\pi} = \dfrac{3\left[\dfrac{\pi}{2}-\dfrac{\pi}{3}\right]}{2\pi} = \dfrac{1}{4}$

21. (c)

$$g = \frac{I_{s1\text{rms}}}{I_{\text{rms}}} = \frac{\dfrac{10\sqrt{2}}{\sqrt{2}}}{\sqrt{\left(\dfrac{10\sqrt{2}}{\sqrt{2}}\right)^2+\left(\dfrac{5\sqrt{2}}{\sqrt{2}}\right)^2+\left(\dfrac{2\sqrt{2}}{\sqrt{2}}\right)^2}}$$

$$= \frac{10}{\sqrt{100+25+4}} = \frac{10}{11.36} = 0.88$$

$$\text{p.f.} = \cos\phi_1 = g\,.\,FDF$$

$$= 0.88\times\cos\frac{\pi}{3} = 0.88\times 0.5$$

$$= 0.44$$

22. (c)

$$T_{\text{ON min}} = \pi\sqrt{LC} = \pi\sqrt{10\times 10^{-3}\times 100\times 10^{-6}}$$

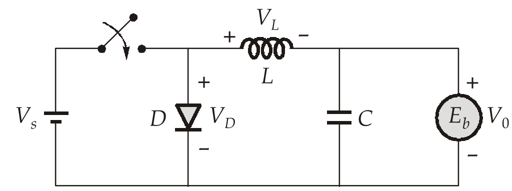
$$= \pi\times 10^{-3}$$

$$= 3.14\text{ ms}$$

$$\alpha_{min} = \frac{T_{ON\,min}}{T} = T_{ON\,min} \times f$$
$$= 3.14 \times 200 \times 10^{-3}$$
$$= 0.628$$

23. (c)

Mode-1:



$t = 0$ to t_r , CH, ON diode reverse biased

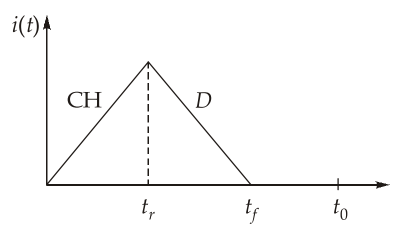
$$V_D = V_S$$

Mode-2:

$t = t_r$ to t_f

Diode forward biased

$$V_D = 0$$



Mode-3:

$t = t_f$ to t_0

Motor terminal rest at E_b

Diode is reverse biased

So, $V_D = E_b$

$$V_{D\,avg} = \frac{1}{T}\left(V_s t_r + 0 \cdot t_f + E_b t_0\right)$$

$$= \frac{V_s t_r + E_b t_0}{t_r + t_f + t_0}$$

24. (b)

Since load is delta connected,

$$Z_Y = \frac{Z_\Delta}{3} = \frac{30}{3} = 10\,\Omega$$

In 120° conduction mode,

$$V_{ph} = \frac{V_{dc}}{\sqrt{6}} = \frac{220}{\sqrt{6}}\text{ V}$$

3-ϕ load power, $$P_0 = \frac{3V_{ph}^2}{R} = 3\left(\frac{220}{\sqrt{6}}\right)^2 \times \frac{1}{10} = 2.42\text{ kW}$$

25. (c)

$$I_{RM} = \sqrt{2Q_R \times \frac{di}{dt}}$$

$$= \sqrt{2 \times 25 \times 10^{-6} \times 50 \times 10^{6}}$$

$$= \sqrt{2500} = 50 \text{ A}$$

26. (c)

$$\text{Power loss} = 1.6 \times 30 = 48 \text{ W}$$

$$= \frac{T_j - T_A}{Q_{jA}}$$

$$48 = \frac{T_j - 61°}{0.5}$$

$$24 = T_j - 61°$$

$$T_j = 85° \text{ C}$$

27. (b)

$$\eta = 1 - \text{derating factor} = 1 - 0.2 = 0.8$$

$$= \frac{\text{Total string voltage}}{n \times \text{Individual voltage rating of each thyristor}}$$

$$\eta = \frac{15000}{n \times 600} = 0.8$$

Number of thyristors in series,

$$n = \frac{15000}{0.8 \times 600} = 32$$

28. (c)

- The amplitude of the fundamental frequency of the PWM output is controlled by value of m_a.
- If the m_a is greater than 1, the amplitude of output increases with m_a, but not linearly.

29. (c)

$$V_{0\,\max} = \frac{3V_m}{2\pi}$$

$$\frac{V_0}{V_{0\max}} = 0.5$$

$$V_0 = V_{0\,\max}\,[1 + \cos(\alpha + 30°)]$$

$$0.5 = 1 + \cos(\alpha + 30°)$$

$$\cos(\alpha + 30°) = -0.5$$

$$\alpha + 30° = 120°$$

$$\alpha = 90°$$

30. (c)

The given circuit is a Boost regulator,

$$V_0 = \frac{V_s}{1-\alpha}$$

$$15 = \frac{5}{1-\alpha}$$

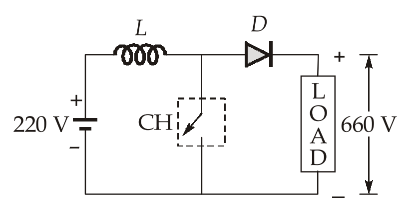
$$\alpha = 0.6667$$

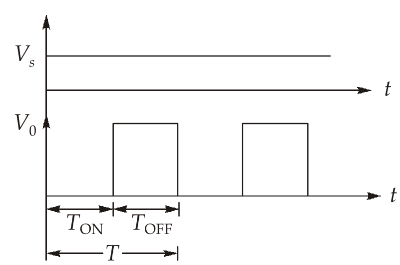
or,
$$\Delta I = \frac{V_s \alpha}{f L}$$

$$\Delta I = \frac{5 \times 0.6667}{25 \times 10^3 \times 150 \times 10^{-6}} = 0.89 \text{ A}$$

31. (a)

32. (b)





Since the give chopper is a step up chopper,

$\therefore$
$$V_0 = \left(\frac{1}{1-\alpha}\right) V_s$$

or,
$$660 = \left(\frac{1}{1-\alpha}\right) 220$$

or,
$$\alpha = \frac{2}{3}$$

The output voltage pulse width is = T_{OFF} .

$\therefore$
$$\frac{T_{ON}}{T_{ON} + T_{OFF}} = \frac{2}{3}$$

$\Rightarrow$
$$3T_{ON} = 2T_{ON} + 2T_{OFF}$$

$$\Rightarrow \qquad T_{OFF} = \frac{T_{ON}}{2} = \frac{100}{2} = 50\ \mu s$$

The pulse width of output voltage is,

$$T_{off} = 50\ \mu s$$

33. (c)

Given :

$$E_{dc} = 35\ V$$

$$E_0 = 24\ V$$

$$f_r = 500\ \text{kHz and } P_0 = 24\ W$$

$$I_0 = \frac{24}{24} = 1\ A$$

Peak voltage rating of resonant capacitor is given by :

$$V_{C_p} = E_{dc} + I_0 \times Z_r = 35 + 1 \times 35 = 70\ V$$

34. (c)

For a dc series motor,

$$V_0 = \alpha V_s = E + I_a R = kI_a\omega + I_a R \qquad (\because \text{ series motor, } \therefore\ \phi\ \alpha\ I_a)$$

$$0.6 \times 600 = (4 \times 10^{-3} \times 300 \times \omega) + 300(0.04 + 0.06)$$

$$\omega = \frac{360 - 30}{1.2} = 275\ \text{rad/sec}$$

35. (c)

For turning ON of SCR, when it is fired it should be in forward bias.

$$\text{At, } \alpha = 15°$$

The magnitude of source voltage

$$V_s = 230\sqrt{2}\sin 15° = 84.18\ V$$

Since at this instant the battery emf is greater than the source voltage. So battery makes thyristor reverse bias. The output voltage of the load at firing angle 15° is 170 V.

36. (d)

$$V_r = 4\ V$$

$$V_c = 6\ V$$

$$\text{Total pulse width} = 2d$$

$$\frac{2d}{N} = \left(1 - \frac{V_r}{V_c}\right)\frac{\pi}{N} \qquad \text{(Where } N \text{ is number of pulses per half cycle)}$$

$$2d = \left(1 - \frac{V_r}{V_c}\right)\pi$$

$$2d = \left(1 - \frac{4}{6}\right)180° = 60°$$

37. (c)

Peak Inverse Voltage across FD = $2\,V_s = 2 \times 230 = 460$ V

Peak Inverse Voltage across main thyristor

$= V_s = 230$ V

38. (b)

For single phase full bridge controlled converter,

Fundamental displacement factor = $\cos\alpha$

$= \cos 45° = 0.707$

39. (a)

For single-phase half controlled converter

Input, $$\text{p.f.} = \frac{\sqrt{2}}{\sqrt{\pi(\pi-\alpha)}}(1+\cos\alpha)$$

For single-phase full controlled converter

Input, $$\text{p.f.} = \frac{2\sqrt{2}}{\pi}\cos\alpha$$

Hence, half-controlled converter has better power factor on the line side.

40. (a)

Statement-II is the correct explanation for the statement-I because chopper drives are used where energy saving is of prime importance.

Section B : Power Systems-1

41. (b)

Surge impedance is calculated as

$$Z_C = \sqrt{\frac{L}{C}} = \sqrt{\frac{0.22\times10^{-3}}{0.202\times10^{-6}}} = 33\ \Omega$$

42. (c)

Inductance of the transmission line

$$L \propto \ln\frac{D}{r}$$

Where D is the spacing between the conductors and r is the radius of the conductor.

43. (c)

The charging current under corona condition increases because corona induces harmonic currents.

44. (c)

The spacing (i.e. effective diameter) in bundled conductors is much greater than conductor's diameter, independent of the number of conductors in the bundle. Thus, bundled conductors are usually used to reduce Corona.

45. (c)

Given, 3-ϕ , 33 kV oil circuit breaker

Rating 1200 A, 2000 MVA, 3 sec

Symmetrical breaking current,

$$I_b = \frac{\text{MVA}}{\sqrt{3}\,\text{kV}}\text{kA}$$

$$= \frac{2000}{\sqrt{3}\times 33} = 34.99 \text{ kA} \approx 35 \text{ kA}$$

46. (c)

Phase relays provide protection to generators and motors against unbalanced loading which causes phase to phase faults.

47. (b)

48. (d)

$$P_1 + P_2 = 200 \quad \text{...(i)}$$

For economical operation,

$$\frac{dF_1}{dP_1} = \frac{dF_2}{dP_2}$$

$$2.0 + 0.01P_1 = 1.6 + 0.02P_2$$

$$P_1 - 2P_2 = -40 \quad \text{...(ii)}$$

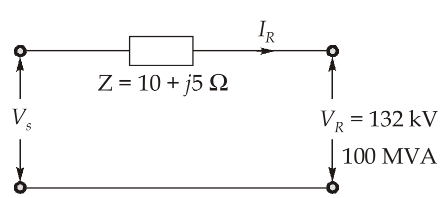
Solving equation (i) and (ii), we get

$$P_1 = 120 \text{ MW},$$

$$P_2 = 80 \text{ MW}$$

49. (b)

For the given transmission line,



$$I_R = \frac{\text{MVA}\times 10^3}{\sqrt{3}\,\text{kV}} = \frac{100\times 10^3}{\sqrt{3}\times 132}\text{A} = 437.38 \text{ A}$$

$$\text{Transmission loss } (P_L) = 3\times I_R^2 R = 3\times(437.38)^2\times 10 = 5.73 \text{ MW}$$

50. (b)

Given that,

$$A = D = 0.9\angle 0°$$
$$B = 200\angle 90°\ \Omega$$
$$C = 0.95 \times 10^{-3}\angle 90°\ \text{S}$$

Receiving end voltage = Sending end voltage

We know that,

$$V_S = AV_R + BI_R$$
$$V_R = AV_R + BI_R \qquad [\because V_S = V_R]$$
$$V_R(1 - A) = BI_R$$
$$L_{sh} = \frac{V_R}{I_R} = \frac{B}{I - A} = \frac{200\angle 90°}{1 - 0.9\angle 0°} = 2000\angle 90°$$

51. (d)

All given statements are correct.

52. (d)

Since, cascaded network,

So, $[T] = [T_1] \times [T_2]$

Line constant C of the combined network is,

$$C = A_2C_1 + C_2D_1$$

53. (c)

$$V = 100 \text{ volts}$$
$$Z = (3 + j4)\ \Omega,\ |Z| = 5$$
$$\because \quad S = \frac{V^2}{|Z|} = \frac{100^2}{5} = 2000 \text{ VA}$$
$$\text{Real power, } P = S\cos\left[\tan^{-1}\left(\frac{4}{3}\right)\right]$$
$$= 2000 \times \frac{3}{5} = 1200 \text{ W}$$
$$\text{Reactive power, } Q = S\sin\left[\tan^{-1}\left(\frac{4}{3}\right)\right]$$
$$= 2000 \times \frac{4}{5} = 1600 \text{ VAR}$$

54. (b)

Capacitance between all three conductors joined and sheath given

$$C_{eq} = 3C_s$$
$$3C_s = 1.8\ \mu F$$
$$C_s = 0.6\ \mu F \quad \text{...(i)}$$

Capacitance between two conductors joined to sheath and the third conductor is,

$$C_{eq} = 2C_c + C_s = 1.5\ \mu F$$
$$C_c = \frac{1.5 - 0.6}{2} = 0.45\ \mu F$$

Capacitance of core to neutral,

$$C_n = 3C_c + C_s = (3 \times 0.45) + 0.6$$
$$C_n = 1.95\ \mu F$$

55. (d)

If the current = I A,

Then, Current through section, $PR = (I - 10)$A

Current through section, $RS = I - 10 - 20 = (I - 30)$A

Current through section, $SQ = I - 30 - 30 = (I - 60)$A

$$V_P - V_Q = 3 \text{ V (given)}$$

By Kirchhoff's voltage law (KVL),

$$V_P - V_Q = (I - 10)\, 0.1 + (I - 30)0.15 + (I - 60) \times 0.2$$
$$3 = 0.45I - 17.5$$
$$I = \frac{20.5}{0.45} = 45.6 \text{ A}$$

Line drop, $V_L = (I - 10)0.1 + (I - 30)0.15 + (I - 60)0.2$

$$V_L = 3.02 \text{ V} \qquad (\because I = 45.6 \text{ A})$$

Hence, $V_P = 220 + V_L$

$$= 220 + 3.02 = 223.02 \text{ V}$$

56. (b)

The string efficiency is given by

$$\frac{\text{Total string voltage}}{n \times \text{voltage across the lowest insulator}}$$

So, $$0.8428 = \frac{\text{Total voltage}}{3 \times 17.5 \text{kV}}$$

Total voltage = 44.25 kV

57. (c)

In short transmission line with upf load only positive voltage regulation is possible.

Section C : Electrical Machines-2

58. (b)

Given,

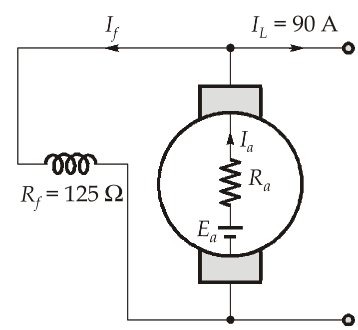
For the given lap wound DC shunt generator,

Number of poles, $P = 4$, $Z = 300$,

$\phi = 0.1$ Wb/pole, $N = 1000$ rpm,

$R_a = 0.2\ \Omega$

and $R_f = 125\ \Omega$



No load emf, $$E = \frac{P\phi NZ}{60A} = \frac{4\times0.1\times1000\times300}{60\times4} = 500\,\text{V}$$

Thus, $$I_f = \frac{500}{125} = 4\,\text{A}$$

Now, $V_t = E - I_aR_a$

We have, $I_a = I_L + I_f = 90 + 4 = 94$ A

So, $V_t = 500 - 94 \times 0.2 = 481.2$ V

59. (c)

An ideal synchronous motor has no starting torque because the relative velocity between stator and rotor mmf's is not zero.

60. (b)

In DC series motor, $\phi \propto I_{se}$

$T \propto \phi\, I_a$

$T \propto I_a^2$ (series motor)

$$\frac{I_{a_2}}{I_{a_1}} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{4}{1}} = 2$$

$E_b \propto I_a\,\omega$

$$\frac{V_{02}}{V_{01}} = \frac{E_{b_2}}{E_{b_1}} = \frac{I_{a_2}\times\omega_2}{I_{a_1}\times\omega_1} = 2 \times 0.25 = 0.5 \text{ p.u.}$$

61. (d)

Given that δ = 20° and if f_1 is the initial supply frequency, then frequency after 10% increase is f_2.

$$f_2 = 1.1\, f_1$$

Also, $$X_{S_2} = 1.1\, X_{S_2}$$

and $$P = \frac{E_0 V_t}{X_{S_1}} \sin\delta_1$$

$$P_2 = \frac{E_0 V_t}{X_{S_2}} \sin\delta_2$$

Therefore, $$\sin\delta_2 = \frac{X_{S_2}}{X_{S_1}} \sin 20° = 1.1 \sin 20°$$

⇒ $$\delta_2 = 1.1 \times 20° = 22° \quad (\sin\delta \approx \delta)$$

$$\delta_2 = 22°$$

62. (d)

- The magnetic axis of the armature flux (the quadrature, or q-axis) is perpendicular to the magnetic axis of the field-winding flux (direct, or d-axis). It is cross magnetizing.
- It is known that the armature reaction flux strengthens each main pole at one end (leading tip) and weakens it at the another end (trailing tip).

63. (b)

The no-load speed of the motor is the speed at which the torque developed by the motor is zero. It is given as

$$\omega_{NL} = \frac{V_t}{K_a \phi_p} \qquad \therefore \quad \omega_{NL} \propto \frac{V_t}{\phi_p}$$

64. (c)

When the induced emf is,

$$E_{a_1} = 110 \text{ V}$$

$$I_{a_1} = \frac{V_t - (E_{a1} + V_{\text{brush}})}{R_a} = \frac{120 - (110 + 2)}{0.25} = 32 \text{ A}$$

Now when induced emf is

$$E_{a_2} = 105 \text{ V}$$

$$I_{a_2} = \frac{120 - (105 + 2)}{0.25} = 52 \text{ A}$$

Percentage change in armature current,

$$= \frac{I_{a1} - I_{a2}}{I_{a1}} = \frac{32 - 52}{32} \times 100 = -62.5\%$$

65. (a)

The maximum allowable current in the armature is equal to 150% of its rated value

$$I_{a\,(max)} = 1.5 \times 28 = 42 \text{ A}$$

Thus, the external resistance in the armature circuit at the instant of plugging must be

$$I_{a(max)} = \frac{V_{a(total)}}{R_a + R_{external}}$$

$$42 = \frac{772}{1 + R_{external}}$$

$$R_{external} = \frac{772}{42} - 1 = 17.38\ \Omega$$

66. (c)

In a cylindrical rotor synchronous machine the stator and rotor mmf both runs at synchronous speed so they are stationary with respect to each other.

67. (c)

$$\text{Rated current, } I_L = \frac{16000}{200 \times 0.8} = 100 \text{ A}$$

$$\text{Field current, } I_f = \frac{200}{100} = 2 \text{ A}$$

$$\text{Armature current, } I_a = 100 - 2 = 98 \text{ A}$$

The back emf is given as;

$$E = V - I_a R_a$$

$$= 200 - 0.102 \times 98 \approx 190 \text{ V}$$

Now for dynamic braking, the value of resistance is;

$$R_d = \frac{190}{100} = 1.9\ \Omega$$

68. (b)

Given, Developed emf, $E_b = 200$ V,

Speed, $N = 1000$ rpm

Poles, $P = 4$,

Average flux density, $B_{av} = 0.8$ T

Length, $l = 0.25$ m

Diameter, $d = 0.2$ m

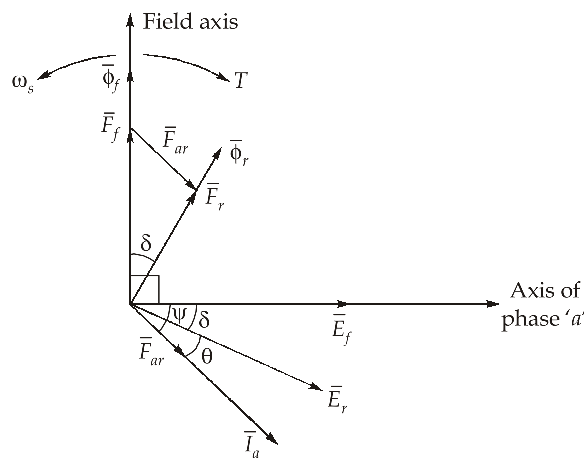
We know that, $B_{av} = \dfrac{P\phi}{2\pi rl}$

or, flux per pole, $\phi = \dfrac{B_{av} \times 2\pi rl}{P}$

$$\phi = \frac{0.8 \times 2 \times 3.14 \times 0.25 \times 0.1}{4}$$

$$\phi = 0.0314 \text{ Wb}$$

69. (d)



From the phasor diagram,

Here, power factor = 0.707 lagging

or, $\theta = 45°$

Power angle, $\delta = 15°$

Then angle between $\bar{E}_f$ and $\bar{F}_{ar}$ $= \delta + \theta$

$= 15° + 45° = 60°$

Angle between main field mmf $\left(\bar{F}_f\right)$ and armature reaction mmf $\left(\bar{F}_{ar}\right)$

$= 90° + \delta + \theta = 90° + 60° = 150°$

70. (a)

The phase voltage, $V_{\text{ph}} = \frac{V_{\text{line}}}{\sqrt{3}} = \frac{1150}{\sqrt{3}} = 663.95 \text{ V}$

Synchronous impedance,

$$Z_{\text{ph}} = \frac{V_{ph}}{I_{ph}}$$

$$\therefore \quad Z_{\text{ph}} = Z_S = \frac{663.95}{200} = 3.3198\,\Omega$$

Synchronous reactance,

$$X_S = \sqrt{Z_S^2 - R_S^2} = \sqrt{(3.3198)^2 - (0.6)^2} = 3.265\ \Omega$$

71. (b)

Though the field winding in a Salient-pole is of concentrated type, the magnetic flux produced by it is nearly sinusoidal because of the shaping of pole-shoes. The air-gap is least at the centre of the pole and increases while moving away from the center.

72. (a)

The input power,
$$P_{in} = \sqrt{3}V_t I_L \cos\theta$$
$$= \sqrt{3} \times 480 \times 50 \times 1$$
$$= 41.6 \text{ kW}$$
$$P_{out} = P_{in} = 41.6 \text{ kW}$$

Rotational speed of the motor,
$$N_m = \frac{120f}{\text{Poles}} = \frac{120 \times 60}{4} = 1800 \text{ rpm}$$

The output torque,
$$\tau = \frac{P_{out}}{\omega_m} = \frac{41.6\,\text{kW}}{1800 \times \frac{2\pi}{60}} = 220.7 \text{ N-m}$$

73. (b)

The synchronous speed is doubly fed so it produces non-zero torque only at one speed which is called synchronous speed.

74. (b)

Field current,
$$I_{sh} = \frac{V_t}{R_{sh}} = \frac{250}{100} = 2.5 \text{ A}$$

Armature voltage,
$$V_a = I_a R_a = 7.2$$

$\Rightarrow$
$$I_a = \frac{7.2}{R_a} = \frac{7.2}{0.04} = 180 \text{ A}$$

Load current,
$$I_L = I_a - I_{sh} = 180 - 2.5 = 177.5 \text{ A}$$

Generated emf,
$$E_g = V_t + I_a R_a$$
$$= 250 + 7.1 = 257.1 \text{ V}$$

We know that,
$$E_g = \frac{\phi NZ}{60} \times \frac{P}{A}$$
$$257.2 = \frac{\phi \times 1000 \times 700}{60}$$
$$\phi = 22 \text{ mWb}$$

75. (b)

Both statements are correct but statement-II is not correct explanation of statement-I.

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