MADE EASY

PRACTICE QUESTIONS

for SSC-JE : CBT-2

Induction + Synchronous Machines

Electrical Engineering

04 Induction + Synchronous Machines

Q.1 The laws of electromagnetic induction are summarized in the following equation:

(a) $e = L\frac{di}{dt}$ (b) $e = iR$

(c) $e = -\frac{d\psi}{dt}$ (d) None of these

Q.2 A coil of 1000 turns is wound on a core. A current of 1 A flowing through the coil creates a core flux of 1 mWb. What is the energy stored in the magnetic field?

(a) 1 J (b) $\frac{1}{4}$ J

(c) 2 J (d) $\frac{1}{2}$ J

Q.3 Hydrogen is preferred to air for synchronous generator cooling because

(a) the heat transfer capability of hydrogen is less than that of air but its specific heat is several times that of air.

(b) the heat transfer capability of hydrogen is more than that of air but its specific heat is less than that of air.

(c) the heat transfer capability of hydrogen is more than that of air and its specific heat is several times more than that of air.

(d) the heat transfer capability and specific heat of hydrogen is almost equal to that of air.

Q.4 The synchronous reactance of a 500 V, 50 kVA alternator having an effective resistance of 0.2 Ω, if an excitation current of 10 A produces 200 A armature current on short circuit and an emf of 450 volts on open circuit, is

(a) 2.6 Ω (b) 5.2 Ω

(c) 2.25 Ω (d) 4.5 Ω

Q.5 Short-circuit ratio of a synchronous machine is defined as the ratio of

(a) field current required to produce rated voltage on full-load and field current required to produce rated current on short-circuit.

(b) field current required to produce rated voltage on open-circuit and field current required to produce rated armature current on short-circuit.

(c) field current required to produce rated voltage on short-circuit and field current required to produce rated current on short-circuit.

(d) field current required to produce rated voltage on full-load and field current required to produce rated voltage on short-circuit.

Q.6 An underexcited motor is operating at no load on infinite bus of voltage 1.0 p.u. and drawing a current of 0.8 pu. Its synchronous reactance is 0.5 p.u. What is the pu value of its excitation emf?

(a) 1.4 (b) 1.0

(c) 0.6 (d) 0.4

Q.7 Synchronous reactance, X_s (unsaturated) is obtained as:

V_{OC} = open-circuit voltage (line)

I_{SC} = short-circuit current (line)

I_f = field current

(a) $\left.\dfrac{V_{OC}}{I_{SC}}\right|_{I_f \text{ (rated)}}$

(b) $\left.\dfrac{V_{OC}}{I_{SC}}\right|_{\text{any } I_f}$

(c) $\left.\dfrac{V_{OC}/\sqrt{3}}{I_{SC}}\right|_{I_f \text{ constant; in linear region of OCC}}$

(d) $\left.\dfrac{V_{OC}/\sqrt{3}}{I_{SC}}\right|_{I_f \text{ constant; in non-linear region of OCC}}$

Q.8 A synchronous motor is operating at 0.8 leading power factor. Now excitation is increased keeping the prime mover input constant, power factor angle will

(a) Decrease
(b) Increase
(c) remains same
(d) cannot be determined

Q.9 The synchronizing coefficient of a synchronous machine is

(a) $\left(\dfrac{d\delta}{dP_e}\right)$ at operating point; it decreases as δ increases

(b) $\left(\dfrac{d\delta}{dP_e}\right)$ at operating point; it increases as δ increases

(c) $\left(\dfrac{dP_e}{d\delta}\right)$ at operating point; it increase as δ increases

(d) $\left(\dfrac{dP_e}{d\delta}\right)$ at operating point; it decreases as δ increases

Q.10 A three-phase synchronous motor draws 200 A from the line at unity power factor at rated load. Considering the same line voltage and load, the line current at a power factor of 0.5 leading is

(a) 200 A (b) 100 A
(c) 400 A (d) 300 A

Q.11 The steam input to a turbogenerator connected to infinite busbars is increased. Which of the following events will take place?

(a) The generator will feed more real power to busbars and its power angle will increase.
(b) The generator will feed more leading kVAR to busbars but its power angle will not change.
(c) The generator will feed more real power to busbars and its power angle will decrease.
(d) The generator will feed more lagging kVAR to busbars but its power angle will not change.

Q.12 Damper windings of a synchronous machine are:

(a) Short-circuited copper bars placed on the rotor in interpolar regions, which prevent the rotor from running at subsynchronous speed.
(b) Short-circuited copper bars placed in pole shoes, which prevent the rotor from running at supersynchronous speed.
(c) Short-circuited copper bars placed in pole shoes, which help to reduce rotor oscillation about the operating point.
(d) Short-circuited copper bars placed on the rotor in the interpolar regions, which help reduce rotor oscillation about the operating point.

Q.13 A synchronous motor operates at unity power factor. The points to the right of the unity power factor locus of V-curves corresponds to

(a) over excitation and lagging current input.
(b) under excitation and leading current input.
(c) under excitation and lagging current input.
(d) over excitation and leading current input.

Q.14 An alternator with higher value of SCR has
(a) poor voltage regulation and higher stability limit.
(b) better voltage regulation and lower stability limit.
(c) poor voltage regulation and lower stability limit.
(d) better voltage regulation and higher stability limit.

Q.15 The power-angle characteristic of a salient machine contains a second harmonic term, because
(a) of the slot harmonics.
(b) the frequency has a second harmonic component.
(c) of the difference in reluctance of air gap in the direct and quadrature axis.
(d) the air-gap flux density has a second harmonic component.

Q.16 Consider the following methods to prevent hunting phenomenon in synchronous machines:
1. By using a flywheel.
2. By designing the synchronous machine with suitable synchronizing power coefficient or stiffness factor.
3. By employment of damper windings.

Which of the above are correct?
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Q.17 An alternator is operating on infinite bus. It will develop maximum synchronizing power when it is operating on
(a) no load
(b) full load
(c) in steady-state stability limit
(d) any load

Q.18 The nature of armature mmf for a zero power factor lagging load in a 3-phase alternator is
(a) magnetizing (b) de-magnetizing
(c) neutral (d) cross-magnetizing

Q.19 Compounding curve for an alternator is:
(a) plot of I_a v/s I_f at constant load
(b) plot of power factor v/s I_f
(c) plot E_f (excitation emf) v/s I_f at constant load
(d) None

Q.20 A cage induction motor has a full load slip of 0.05. The motor starting current at rated voltage is 5.5 times its full load current. Find the tapping on auto transformer starter which should give full load torque at starting
(a) 81.3% (b) 85%
(c) 84% (d) 82.7%

Q.21 For maximum starting torque in an induction motor
(a) $r_2 = 0.5x_2$ (b) $r_2 = x_2$
(c) $r_2 = 2x_2$ (d) $r_2 = 0$

Q.22 Which one of the following is the correct statement?
In a 3-phase induction motor, the resultant flux is of a constant nature and is
(a) equal to ϕ_m, where ϕ_m is maximum flux due to any phase
(b) 1.5 time maximum value of flux due to any phase
(c) $\sqrt{3}/2$ times maximum value of flux due to any phase
(d) 3 ϕ_m

Q.23 The crawling in the induction motor is caused by
(a) Improper design of stator laminations
(b) Low voltage supply
(c) High loads
(d) Harmonics developed in motor

Q.24 A 6-pole 50 Hz induction motor runs at a speed of 950 rpm. The frequency of rotor currents is
(a) 47.5 Hz (b) 50 Hz
(c) 5 Hz (d) 2.5 Hz

Q.25 The starting current of an induction motor is five times the full-load current while the full-load slip is 4%. The ratio of starting torque to full-load torque is
(a) 0.6 (b) 0.8
(c) 1.0 (d) 1.2

Q.26 As resistance is added in the rotor circuit of a slip ring motor
(a) its maximum torque increase but occurs at the same slip.
(b) its maximum torque decreases but occurs at the same slip.
(c) its maximum torque remains the same and also occurs at lower slip.
(d) its maximum torque remains the same but occurs at higher slip.

Q.27 The advantage of the double squirrel-cage induction motor over single cage rotor is that its
(a) efficiency is higher
(b) power factor is higher
(c) slip is larger
(d) starting current is lower

Q.28 The injected e.m.f in the rotor of induction motor must have
(a) The same frequency as the slip frequency
(b) The same phase as the rotor e.m.f
(c) A high value for satisfactory speed control
(d) The same phase as the rotor e.m.f and a high value for satisfactory speed control

Q.29 Which one of the following statements is correct? A smaller air gap in a polyphase induction motor helps to
(a) reduce the chances of crawling
(b) increase the starting torque
(c) reduce the chance of cogging
(d) reduce the magnetizing current

Q.30 In a 3-phase induction motor the rotor impedance angle at stand still is θ. The load angle δ will be
(a) $\pi + \theta$ (b) $\pi - \theta$
(c) $\frac{\pi}{2} + \theta$ (d) $\frac{\pi}{2}$

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Answer Keys

1.	(c)	**2.**	(d)	**3.**	(c)	**4.**	(c)	**5.**	(b)	**6.**	(b)	**7.**	(c)
8.	(b)	**9.**	(d)	**10.**	(c)	**11.**	(a)	**12.**	(c)	**13.**	(d)	**14.**	(d)
15.	(c)	**16.**	(d)	**17.**	(a)	**18.**	(b)	**19.**	(d)	**20.**	(a)	**21.**	(b)
22.	**(b)**	**23.**	(d)	**24.**	(d)	**25.**	(c)	**26.**	(d)	**27.**	(d)	**28.**	(a)
29.	(d)	**30.**	(c)										

Detailed Solutionsutions

1. (c)

From Faraday's law of electromagnetic induction,

$$e = -\frac{d\psi}{dt}$$

(minus sign is due to Lenz's law).

2. (d)

$$L = \frac{N\phi}{I} = \frac{1000 \times 10^{-3}}{1} = 1\ H$$

$$\therefore \quad \text{Energy stored} = \frac{1}{2}LI^2 = \frac{1}{2} \times 1 \times 1^2 = \frac{1}{2}\ \text{Joule}$$

3. (c)

Hydrogen is preferred to air for synchronous generator cooling because:

(i) Hydrogen has specific heat 14 times that of air.

(ii) Hydrogen has heat transfer coefficient 1.5 times of that of air.

(iii) Hydrogen has thermal conductivity 7 times that of air.

So, hydrogen takes away heat more effectively.

4. (c)

Given, $V_{oc} = 450$ V; $I_{sc} = 200$ A

Let X_s be synchronous reactance

$$\because \quad X_s = \frac{V_{oc}}{I_{sc}} = \frac{450}{200} = 2.25\ \Omega$$

5. (b)

$$\text{Short-circuit ratio (SCR)} = \frac{I_{SC}}{I_{\text{rated}}}$$

$$= \frac{\text{Field currents required to produce rated voltage on OC}}{\text{Field currents required to produce rated voltage on SC}}$$

$$= \frac{V_{\text{rated}} / X_{s(\text{sat})}}{I_{\text{rated}}} = \frac{Z_{\text{Base}}}{X_{s(\text{sat})}}$$

$$= \frac{1}{X_{s(\text{sat})} / Z_{\text{Base}}} = \frac{1}{X_{s(\text{sat})\,\text{p.u.}}}$$

6. (b)

At no load drawing a current of 0.8 p.u.

$$\vec{E}_f = \vec{V} - \vec{I}_a (jX_s) = 1\angle 0° - 0.8\angle 0° \, (j0.5) = 1.077\angle{-21.8°}$$

$$|E_f|_{\text{p.u.}} = 1.077 \text{ p.u.} \approx 1.0 \text{ p.u.}$$

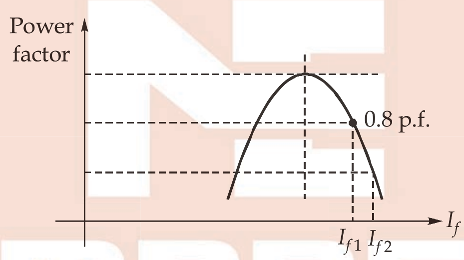
7. (c)

$$X_{s(\text{unsaturated})} = \left.\frac{V_{OC/\sqrt{3}}}{I_{sC}}\right|_{\text{At } I_f \text{ corresponding to linear part of OCC}}$$

$X_{s(\text{unsaturated})}$ value would be much higher and would give voltage regulation value far larger than the actual value.

8. (b)

Inverted V curve is the curve between power factor and field current.



Power factor reduces. Thus it is obvious power factor angle will increase.

9. (d)

Power develope, $$P_e = \frac{E_f V_t}{X_s} \sin\delta$$

Synchronizing coefficient, $$\frac{dP_e}{d\delta} = \frac{E_f V_t}{X_s} \cos\delta$$

$$S_p = \left.\frac{dP_e}{d\delta}\right|_{\substack{\delta=\delta_0 \\ \text{at operating point}}} = \frac{E_f V_t}{X_s} \cos\delta_0$$

It is decreases as δ increases.

10. (c)

$$P = VI \cos\phi$$

For same voltage and load, $$I\cos\phi = \text{constant}$$

$$I_1 \cos\phi_1 = I_2 \cos\phi_2$$

at unity power factor, $$I_1 = 200 \text{ A}$$

$$200 \times 1 = I_2 \times 0.5$$

$$I_2 = 400 \text{ A}$$

11. (a)

The steam input to a turbo-generator connected to infinite busbar is increased means the generator will feed more real power to busbars and its power angle will increase but not change in reactive power.

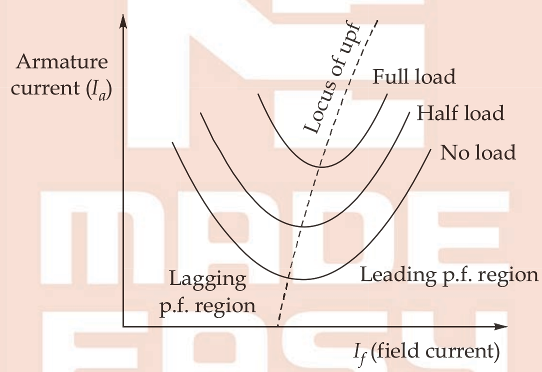
Change in real power $\Delta P \propto$ Steam input power

Change in reactive power $\Delta Q \propto \Delta V$.

12. (c)

Damper windings consists of short-circuited copper bars embedded in the face of the field poles of synchronous machine when the speed of the machine deviates from the synchronous speed or hunting takes place, there is a relative motion between the rotor (or damper winding) and the air gap flux and therefore eddy currents are set-up in this winding in such a way as a suppress the oscillations. The effectiveness of the damping winding in suppressing the rotor oscillation however depends upon the resistance of this winding; the lower the resistance, the stronger is the damping action.

13. (d)



$\therefore$ As we go right of the unity power factor locus of V-curve we obtain over excitation and leading current input.

14. (d)

$$\text{SCR} = \frac{1}{X_{S(\text{sat})}} \propto \frac{\text{Air gap}}{N_{\text{ph}}}$$

SCR $\uparrow$, $X_{S(\text{sat})} \downarrow$, voltage regulation improves, air gap $\uparrow$, stability $\uparrow$ due to increase in moment of inertia of machine.

15. (c)

$$P = \underbrace{\frac{VE_f}{X_d}\sin\delta}_{\text{Excitation Power}} + \underbrace{\frac{V^2}{2}\left(\frac{1}{X_q} - \frac{1}{X_d}\right)\sin 2\delta}_{\text{Reluctance Power}}$$

16. (d)

All statements are correct.

The prime mover is provided with a large and heavy fly wheel. This increases the inertia of the prime mover and helps in maintaining the rotor speed constant and hence hunting is reduced.

17. (a)

$$\therefore \quad P = \frac{E_f V_t}{X_s}\sin\delta$$

Synchronous power, $$P_{sy} = \frac{dP}{d\delta} = \frac{V_t E_f}{X_s}\cos\delta$$

P_{syn} is maximum for $\delta = 0°$

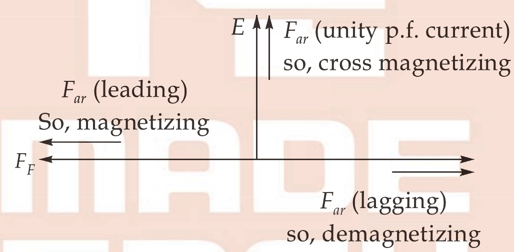
At $\delta = 0$, $P = 0$

But, $$P_{syn} = \frac{V_t E_f}{X_s}$$

i.e. P_{syn} is maximum at no load.

18. (b)

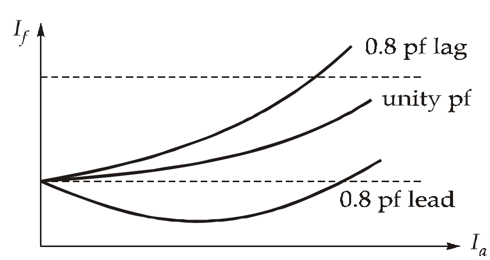
The given phasor below is best way to remember the effect of armature reaction. In generator,



and, reverse effect for motor as in generator.

19. (d)

Compounding curve is a plot of I_f against armature current required to maintain constant terminal voltage while a constant pf load is varied



20. (a)

Full load slip, $$S_{fl} = 0.05$$

$$I_{st} = (5.5)\ I_{fl}$$

For auto-transformer starter, $$\frac{T_{st}}{T_{fl}} = x^2 \times S_{fl} \times \left(\frac{I_{sC}}{I_{fl}}\right)^2$$

and
$$T_{fl} = T_{st} \text{ (given)}$$
$$1 = x^2 \times 0.05 \times (5.5)^2$$
$$x = 0.8131 \text{ or } 81.31\%$$

21. (b)

- Maximum torque in an induction motor occurs at $s = \dfrac{r_2}{x_2}$
- For maximum starting torque occurs when $s = 1$

i.e. when, $\dfrac{r_2}{x_2} = 1$

i.e. $r_2 = x_2$

22. (b)

Resultant field rotate in space at synchronous speed and is given by,
$$f_r = \frac{3}{2} f_m \cos(\omega t - \theta)$$
i.e. peak of the resultant mmf is
$$f_r = \frac{3}{2} f_m = 1.5 f_m$$
Where $f_m \rightarrow$ peak of any phase's mmf

23. (d)

Induction motor running stably at very low speed (1/7th of the normal speed) is known as crawling due to asynchronous torque generated due to slot harmonics.

24. (d)

Synchronous speed of motor,
$$N_s = \frac{120 f}{P} = \frac{120 \times 50}{6} = 1000 \text{ rpm}$$
Rotor speed,
$$N_r = 950 \text{ rpm}$$
and slip,
$$s = \frac{1000 - 950}{1000} = 0.05$$
Rotor frequency,
$$f_r = sf = 0.05 \times 50 = 2.5 \text{ Hz}$$

25. (c)

We know that,
$$\frac{T_{st}}{T_{fl}} = s_{fl} \times \left(\frac{I_{st}}{I_{fl}}\right)^2 = 0.04 \times \left(\frac{5 I_{fl}}{I_{fl}}\right)^2 = 1$$

26. (d)

Maximum torque of induction motor is independent of rotor circuit resistance

$$T_{max} = \frac{1}{2\omega_{sm}} \frac{V_1^2}{x_2'}$$

and $$S_{T_{max}} = \frac{r_2'}{x_2'}$$

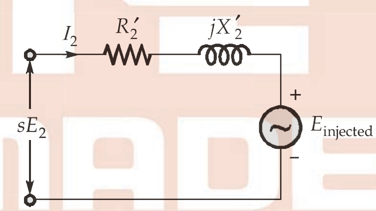
i.e. as the resistance is added in the rotor circuit of a slip ring motor its maximum torque remains the same but occurs at higher slip.

27. (d)

Double squirrel cage induction motor is designed to provide a high starting torque with a low starting current. The rotor is so designed that the motor operates with the advantages of a high resistance rotor circuit during starting and a low-resistance rotor circuit under running conditions.

28. (a)

EMF injection method is a speed control method of SR_1M (slip ring induction motor) in which injected emf have same frequency as the slip frequency. The injection of voltage in rotor is called doubly effect:



29. (d)

Small air gap ⇒ lower reluctance ⇒ higher inductance ⇒ smaller magnetising current as $I \propto \frac{1}{L}$ from the eqn. $N\phi = LI$.

30. (c)

- Torque angle of induction motor

$$= \frac{\pi}{2} + \theta = \delta$$

$$\frac{\pi}{2} < \delta < \pi$$

- When rotor leakage inductance << rotor resistance

$$\theta = 0° \text{ and } \delta = \frac{\pi}{2}$$

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