Power Systems Test 5

Number of Questions: 25 **Section Marks: 90**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. The self inductance of a long cylindrical conductor due to its internal flux linkages is KH/m. If the diameter of the conductor is double, then self inductance of the conductor due to its internal flux linkages would be **(IAS 2001)**

(A) 0.5 K H/m (B) 1 K H/m
(C) 1.414 K H/m (D) 4 K H/m

2. Which of the following statements are correct for static relays

(P) Power consumption is low
(Q) Large overload capacity
(R) Greater sensitivity
(S) Fast in operation

(A) *P*, *Q* and *R* (B) *P*, *Q* and *S*
(C) *P*, *R* and *S* (D) *P*, *Q*, *R* and *S*

3. A system of 66kV, the line to ground capacitance is 0.02μF and the inductance is 4H. When the magnetizing current of 8A, find the voltage appearing across the pole in a circuit breaker

(A) 113.13kV (B) 1.13kV
(C) 113.13V (D) 56.56kV

4. A 25KVA, 2000V/500V single phase transformer with 20% impedance draws a steady short circuit line current of

(A) 50A (B) 12.5A
(C) 62.5A (D) 250A

5. Match the following:

	List – I		List – II
P	Translay relay	1	Generators
Q	Negative sequence relay	2	Bus bars
R	Differential relay	3	Long transmission lines

	P	*Q*	*R*		*P*	*Q*	*R*
(A)	3	5	1	(B)	3	4	2
(C)	4	5	2	(D)	4	5	1

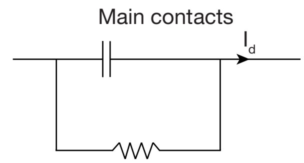
6. A 132 kV, 3-phase system circuit breaker has natural frequency of 20 KHz during fault. Calculate the time taken to reach peak value of restricting voltage.

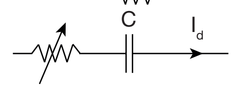
(A) 0.5m sec (B) 0.05m sec
(C) 0.25m sec (D) 0.025m sec

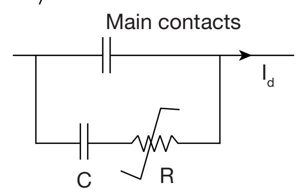
7. A 3-phase, 132kV, oil circuit breaker is rated at 1500A, 5000MVA, 3S. The symmetrical breaking current is

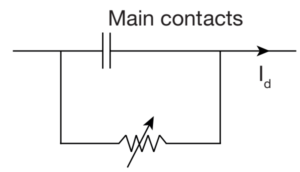
(A) 1.5kA (B) 55.743kA
(C) 25.98kA (D) 21.86kA

8. Which of the following represent the schematic diagram of d. c. switch

(A)


(B)


(C)


(D)


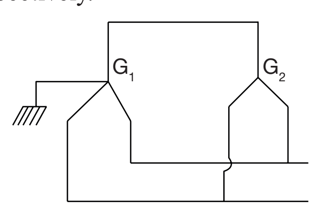
9. If the percentage reactive of the system up to fault point is 40% and the base MVA is 25. Then the short circuit KVA is

(A) 62.5 (B) 62500
(C) 625 (D) 10000

10. A 60Hz overhead line has line to earth capacitance of 2μF. it is decided to use an earth fault neutralizer. Calculate the Inductance value to neutralize the capacitance.

(A) 442.09H (B) 4.42H
(C) 1.40H (D) 1.17H

11. Two 11kV, 40MVA, three phase star connected generators operate in parallel. The positive, negative and zero sequence reactances of each being *j*0.20p.u, *j*0.15p.u, *j*0.08p.u respectively.



Calculate the voltage of the healthy phase for a line to line fault on the terminals of the generators. [Assume fault impedance is equal to zero].

(A) 0.571p.u (B) 0.285p.u
(C) 0.642p.u (D) 0.428p.u

12. A four pole, 50Hz, 100MVA, turbo generator has a moment of inertia of 9×10^3Kg – m^2, then calculate the inertia constant *M* value

(A) 0.11MJ/elect degree
(B) 1.11MJ/elect degree

(C) 0.012MJ/elect degree
(D) 111.03MJ/elect degree

13. A 60 Hz generator supplied 60% of maximum power to an infinite bus through a reactive network. A fault occurs, due to which total reactance increases by 400%. When the fault is cleared, Maximum power that can be delivered is 80% original maximum value. The critical clearing angle for this condition is
(A) 73.74° (B) 61.64°
(C) 38.02° (D) 45.64°

14. The inertia constants of two groups of machine which do not swing together are 4P.u and 6P.u. Then the equivalent inertia constant of the system is
(A) 6P.u (B) 4P.u
(C) 10P.u (D) 2.4P.u

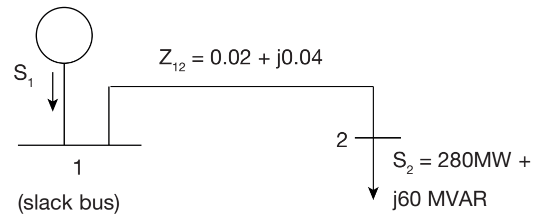
15. A 50Hz, generator is delivering 40% of the power that it is capable of delivering through a transmission line to an infinite bus. A fault occurs that increases the reactance between generator and the infinite bus to 400% of the value before the fault. When the fault is isolated the maximum power that can be delivered is 80% of the original maximum value. The critical clearing angle will be
(A) 23.57° (B) 30°
(C) 53.54° (D) 85.92°

16. An interconnected 50 Hz power system consists of one area with three turbine generator units rated 1000, 750 and 600 MVA respectively. The regulation constant of each unit is $R = 0.05$ pu based on its own rating. Each unit initially operates at ½ of its own rating, when the system load suddenly increases by 200 MW. The steady state drop in frequency is
(A) 0.212 Hz (B) 0.424 Hz
(C) 0.122 Hz (D) 0.425 Hz

17. A 60 Hz four pole turbo generator valid at 500 MVA, 22 kV has the inertia constant, $H = 7.5$MJ/MVA. Find the angular acceleration, if electrical power developed = 400 MW and input – Rotational Losses = 740,000 Hp
(A) 21.89 rpm/s^2
(B) 43.78 rpm/s^2
(C) 437.8 rpm/s^2
(D) 36.5 rpm/s^2

18. In a short circuit test on a 66kV, 3 - phase system, the breaker gave the following results i.e power factor of the fault 0.5 and recovery voltage 0.90 of full line voltage. Then calculate the active recovery voltage.
(A) 48.5kV (B) 42.0kV
(C) 53.8kV (D) 38.0kV

19. For the given system, If $V_2 = 0.9 - j0.1$, What is the $|S_1|$.



(A) 300 MVA (B) 100 MVA
(C) 316 MVA (D) 116 MVA

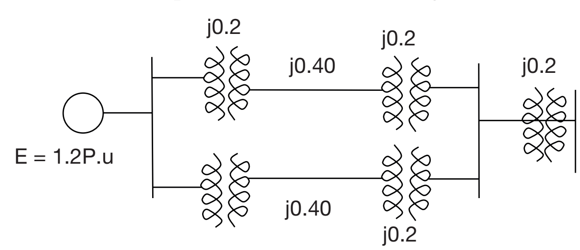
20. A substation supplies an industrial load of 8MW. If an capacitor bank of 5MVAR is installed to maintain the load power factor at 0.95. Then calculate the reactive power supplied by the substation to an industry
(A) 8.6 MVAR (B) 2.6 MVAR
(C) 12.6 MVAR (D) 7.6 MVAR

21. A 132 kV, 200Km transmission line is designed with a line reactance of 0.8Ω/km. Then calculate the transmission capacity of the line
(A) 216MW (B) 325MW
(C) 108MW (D) Insufficient data

22. Two alternators rated for 150MW and 250MW have governor drop characteristics of 4 percent form no load to full load, they are connected in parallel to share a load of 300MW. Calculate the load shared by 250MW alternator.
(A) 214.29MW (B) 85.71MW
(C) 125.34MW (D) 171.42MW

23. A 132kV, 50Hz system has line to ground capacitance of 0.02μF. If the resistance of 12$K\Omega$ is connected across the circuit breaker to eliminate the transient voltage in the system. Then calculate the inductance present in the system
(A) 5.76H (B) 4.8mH
(C) 11.52H (D) 9.6MH

24. For the following single line diagram, If the L-G fault occurs at middle of the one transmission line. Then what is the value of equivalent reactance during the fault



(A) 1.4 (B) 0.4
(C) 0.1 (D) 0.23

25. Two generating units rated for 250 MW and 400 MW respectively have regulations of 6% and 6.4% respectively (from no load to full load). They operate in parallel and share 500 MW load. The power given by second (400 MW) unit is
(A) 200 MW (B) 400 MW
(C) 250 MW (D) 300 MW

Answer Keys

2. C	**3.** A	**4.** C	**5.** B	**6.** D	**7.** D	**8.** C	**9.** B	**10.** D	**11.** D
12. C	**13.** B	**14.** D	**15.** D	**16.** A	**17.** D	**18.** B	**19.** C	**20.** D	**21.** C
22. A	**23.** C	**24.** D	**25.** D						

Hints and Explanations

1. $L_{internal} = \frac{\mu_o \mu_r}{8\pi}$ H/m

Internal inductance is independent on diameter

Choice (B)

2. The static relays have small over load capacity.

Choice (C)

3. Voltage $V = i\sqrt{\frac{L}{C}}$

$= 8\sqrt{\frac{4}{0.02\times10^{-6}}}$ = 113.13kV Choice (A)=

4. Line current = $\frac{25000}{2000}$

I_{base} = 12.5A

Short circuit current = $\frac{\text{Base curent}}{\text{percentage impedance}}$

$I_{SC} = \frac{1.25}{0.2}$ = 62.5A Choice (C)

5. Translay relay is generally used for the protection of long transmission lines. Choice (B)

6. The time taken to reach maximum value = $\frac{1}{2f_n}$

$= \frac{1}{2\times20\times10^3}$ = 0.025m sec Choice (D)

7. The symmetrical breaking current = $\frac{MVA}{\sqrt{3}\times kV}$

$= \frac{5000\times10^6}{\sqrt{3}\times132\times10^3}$ = 21.86kA Choice (D)

8. Choice (C)

9. Base MVA = 25MVA

Short circuit KVA = $\frac{\text{Base KVA}}{\text{Percentage reactace}}$

$= \frac{25,000}{0.4}$ = 62,500KVA Choice (B)

10. $\omega L = \frac{1}{3\omega C}$

$\omega L = \frac{1}{3\times2\pi\times60\times2\times10^{-6}}$

ωL = 442.09

$\Rightarrow$ L = 1.17H Choice (D)

11. $I_{a1} = \frac{E_a}{X_{1eq} + X_{2eq}} = \frac{1}{j0.10 + j0.75}$

$= -j5.714$

$V_{a1} = V_{a2} = E_a - I_{a1}X_{1eq}$

$= 1.0 - j(-5.714)\,(j0.10)$

= 0.4286 P.u Choice (D)

12. Kinetic energy stored = $\frac{1}{2}J\omega^2$

$= \frac{1}{2}J\left(\frac{2\pi N}{60}\right)^2$

$= \frac{1}{2}\times9\times10^3\left(\frac{2\pi\times1500}{60}\right)^2$ = 111.03MJ

$M = \frac{\text{Kinetic energy stored in MJ}}{180\text{f}}$

$= \frac{111.03}{180\times50}$ = 0.012MJ/elect degree Choice (C)

13. $P_{max}\sin\delta_o = 0.6\,P_{max}$

$\Rightarrow$ δ_o = 36.87° (or 0.6435 rad)

$r_1 = 0.25$

$r_2 = 0.8$

$r_2\,P_{max}\sin\delta_{max} = P_m$

$P_m/P_{max} = 0.6$

$\Rightarrow$ $\sin\delta_{max}$ = 0.6/0.8 = 0.75

δ_{max} = 180 – 48.59° = 131.41° = 2.294 rad

$\cos\delta_{cr}$ = {0.6(2.294 – 0.6435) +

0.8 cos(131.4°) – 0.25

cos36.87°} / (0.8 – 0.25) = 0.475

$\delta_{cr} = \cos^{-1}(0.475)$ = 61.64° Choice (B)

14. If the inertia constant of two machines M_1 and M_2 which do not swing together.

The equalent inertia constant $M = \frac{M_1\,M_2}{M_1 + M_2}$

$= \frac{6\times4}{6+4}$ = 2.4P.U Choice (D)

15. $P_m\sin\delta_0 = 0.4P_m$

$\Rightarrow$ δ_0 = 23.57(or) 0.411radians

$r_1 = \frac{100}{400} = 0.25$

$r_2 = 0.8$

$$\delta_C = \cos^{-1}\left[\frac{\left(\frac{P_S}{P_m}\right)(\delta_m - \delta_0) + r_2\cos\delta_m - r_1\cos\delta_0}{r_2 - r_1}\right]$$

$0.4P_m = 0.8\text{Pm} \sin \delta m$

$\Rightarrow$ $\delta_m = 30°$ (or) $\delta_m = 180° - 30° = 150°$

$\delta_m = 2.617$radimns

$\delta_C =$

$$\cos^{-1}\left[\frac{0.4(2.617-0.411)-0.8\times0.866-0.25\times0.9167}{0.55}\right]$$

$= \cos^{-1}(0.071) = 85.92°$ Choice (D)

16. $R_{p.u.\text{new}} = R_{pu\text{ old}} \dfrac{S_{new}}{S_{old}}$

$R_{1\text{ new}} = R_{1\text{ old}} = 0.05$

$R_{2\text{ new}} = 0.05 \times \dfrac{1000}{750} = 0.06667$

$R_{3\text{ new}} = 0.05 \times \dfrac{1000}{600} = 0.08333$

$$\beta = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{0.05} + \frac{1}{0.0667} + \frac{1}{0.0833}$$

$\approx 20 + 15 + 12 = 47$ pu

$$\Delta f = \left(\frac{-1}{\beta}\right)\Delta Pm = \frac{-1}{47}\times 0.2\,\text{p.u}$$

$= -4.25 \times 10^{-3} \times 50$ Hz

$= -0.212$ Hz Choice (A)

17. Input power $= 740000 \times 746 \times 10^{-6} = 552$ MW

$$\frac{7.5}{180\times60}\frac{d^2\delta}{dt^2} = \frac{552-400}{500} \text{ (swing equation)}$$

$$\Rightarrow \frac{d^2\delta}{dt^2} = 437.8 \text{ elec degrees/S}^2$$

Since machine has 4 poles

$$\frac{d^2\delta}{dt^2} = \frac{437.8}{2} = 218.9 \text{ mech degrees/S}^2$$

or $60 \times \dfrac{218.9}{360} = 36.5\,\text{rpm/s}^2$ Choice (D)

18. The peak value of line to neutral voltage

$$= \frac{66}{\sqrt{3}}\times\sqrt{2} = 53.88\text{kV}$$

Recovery voltage = 0.9 × 53.88 = 48.49kV

Active recovery voltage = $V_m \sin\theta$

Power factor cos ϕ = 0.5

$\Rightarrow$ ϕ = 60°

sin60 = 0.866

Active recovery voltage

= 48.49kV × 0.866 = 42kV Choice (B)

19. $Y_{12} = \dfrac{1}{0.02 + j0.04} = 10 - j20$

In $p.u$; $S_2 = \dfrac{-(280 + j60)}{100} = -2.8 - j0.6$ p.u

$I_{12} = y_{12}(V_1 - V_2) = (10 - j20)[1 + j0 - (0.9 - j0.1)]$

$= 3 - j1$

$I_{21} = -I_{12} = -3 + j1$

$S_{12} = V_1 I^*_{12} = (1 + j0)(3 + j1) = 3 + j1$ p.u

$= 300$ MW $+ j100$ MVAR

$|S| = \sqrt{300^2 + 100^2} = \sqrt{100000} = 316.22$ MVA

Choice (C)

20. Load active power = P = 8MW

Load reactive power = Q

Capacitor reactive power = Q_C = 5MVAR

Reactive power supplied by Sub - station after capacitor installation = $Q - Q_C$

Power factor – cosϕ = 0.95

$$\frac{Q - Q_C}{P} = 0.95$$

$Q - 5 = 0.95 \times 8$

$Q = 12.6$MVAR

MVAR supplied by substation after capacitor installation = 7.6MVAR Choice (D)

21. Transmission capacity $= \dfrac{(132\times10^3)^2}{0.8\times200}$

= 108.9MW Choice (C)

22. Power supplied by 150MW unit is x

The percent drop in speed is $\dfrac{4x}{100}$

Percent drop in speed of 250MW is $\dfrac{4}{250}(300 - x)$

$$\frac{4x}{100} = \frac{4}{250}(300 - x)$$

$2.5x = 300 - x$

$3.5x = 300$

$X = 85.71$m

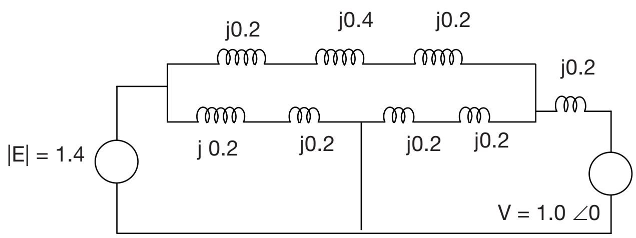
The load shared by 250MW alternator is = 300 – 85.71 = 214.29MW Choice (A)

23. For eliminating the transient voltages in the system when $R = \dfrac{1}{2}\sqrt{\dfrac{L}{C}}$

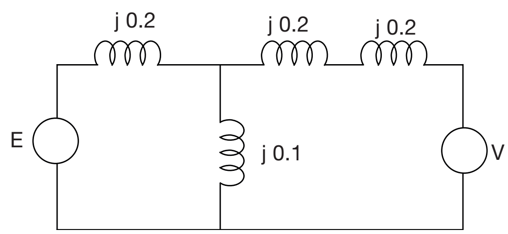
$$12 \times 10^3 = \frac{1}{2}\sqrt{\frac{L}{0.02\times10^{-6}}}$$

$L = 11.52$H Choice (C)

24. The positive sequence reactance diagram during the fault



The reactance diagram simplified



The equivalent reactance during fault $X = 0.23$

Choice (D)

25. For common MVA base of 1000;

$$R_1 = \frac{1000}{250}(0.06) = 0.24$$

$$R_2 = \frac{1000}{400}(0.064) = 0.16$$

$R_1P_1 = R_2P_2$ (since frequency is equal)

$$\Rightarrow \quad P_2 = \frac{R_1 P_1}{R_2}$$

and $P_1 + P_2 = \frac{500}{1000}(in\,\text{p.u})$

$$P_2 = \frac{0.24P_1}{0.16} \Rightarrow P_2 = 1.5P_1$$

$$P_1 + 1.5P_1 = 0.5$$

$$\Rightarrow \quad P_1 = \frac{0.5}{2.5} = 0.2\text{p.u}$$

$P_2 = 1.5 \times 0.2 = 0.3$ p.u $= 0.3 \times 1000$
$= 300$ MW

Choice (D)