
GATE - 2009

Answer Keys

| | | | | | | | | | | | | | |
|-----------|---|-----------|---|-----------|---|-----------|---|-----------|---|-----------|---|-----------|---|
| 1 | B | 2 | C | 3 | A | 4 | D | 5 | B | 6 | D | 7 | A |
| 8 | A | 9 | B | 10 | D | 11 | D | 12 | B | 13 | A | 14 | C |
| 15 | B | 16 | C | 17 | C | 18 | D | 19 | B | 20 | C | 21 | D |
| 22 | C | 23 | A | 24 | A | 25 | D | 26 | C | 27 | D | 28 | D |
| 29 | B | 30 | C | 31 | C | 32 | A | 33 | A | 34 | B | 35 | B |
| 36 | A | 37 | A | 38 | C | 39 | A | 40 | D | 41 | D | 42 | C |
| 43 | A | 44 | C | 45 | A | 46 | C | 47 | B | 48 | C | 49 | A |
| 50 | A | 51 | B | 52 | C | 53 | D | 54 | A | 55 | C | 56 | B |
| 57 | A | 58 | A | 59 | B | 60 | D | | | | | | |

Q.1 (B)

Since all the applied voltage appears across it.

Q.2 (C)

Let $y = \frac{u}{v}$, % error in y = % error in u - % error in v

Here $u = G_1 + G_2$, $v = G_3$

Q.3 (A)

When diode is ON, $i = 1\text{mA}$. When diode is OFF, i is zero after small reverse recovery time.

Q.6 (D)

Internal resistance = $\frac{2000\text{V}}{400\text{A}} = 5\Omega$

Internal voltage drop = $200\text{A} \times 5\Omega = 1000\text{V}$

Q.7 (A)

It is a balanced Wheatstone bridge.

Q.9 (B)

$P = \frac{EV}{X} \sin \delta \approx \frac{V^2}{X} \sin \delta$

Q.12 (B)

Q.13 (A)

All other XNOR, NOR, NAND gates can be derived from NOT, OR, AND gates.

Q.14 (C)

$$M = \sqrt{L_1 L_2}; L_1 = \frac{N_1 \phi_1}{i_1}, \phi_1 = B_1 A_1$$

$$\therefore \boxed{M \propto \sqrt{A_1 A_2}} \quad \frac{M_1}{M_2} = \sqrt{\frac{20 \times 20}{10 \times 10}} = \sqrt{4} = 2$$

$$M_2 = \frac{M_1}{2}$$

Q.15 (B)

B is stable as slip ≈ 1

A is unstable as slip ≈ 0

Q.17 (C)

$$a = 1.42; GM = -20 \log a$$

Since $a > 1$, GM will be negative and unstable

$$\text{Now, } G(j\omega)H(j\omega) = \frac{1 - j\omega T_1}{j\omega C(1 + j\omega T_2)}$$

(Assuming one pole in RHS plane)

$$\boxed{|G(j\omega)H(j\omega)| = -90 - \tan^{-1} \omega T_1 - \tan^{-1} \omega T_2}$$

$$\text{At } \omega=0, \boxed{|G(j\omega)H(j\omega)| = -90}$$

$$\text{At } \omega=\infty, \boxed{|G(j\omega)H(j\omega)| = -270}$$

Q.18 (D)

From Routh table,

The equation is

$$2s^3 + 4s^2 + 2s + 4 = 0$$

$$s^2 [4 + 2s] + [2s + 4] = 0$$

$$(s^2 + 1)(2s + 4) = 0$$

$$\boxed{s = \pm j = -0.5} \quad \text{LHS}$$

Q.19 (B)

Since at $\omega=2$ and $\omega=25$, slope changes from 40dB/dec to -60dB/dec at both the value. So there are poles at $\omega=2$ and $\omega = 25$.

Also at $\omega=0.1$ slope is -40dB/dec.

\therefore It means there are two poles at origin.

Hence the transfer function of the form,

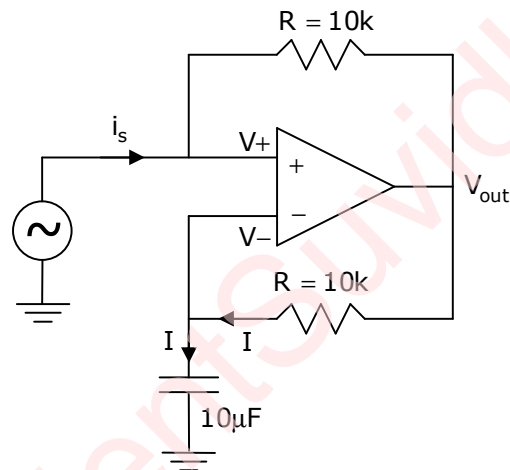
$$T(s) = \frac{K(s+5)}{s^2(s+2)(s+25)}$$

$$80 = 20 \log \frac{5k}{(0.1)^2 \times 50} \Rightarrow K = 1000$$

Q.20 (C)

Trace = Sum of principal diagonal elements

Q.21 (D)



$$X_c = \frac{1}{j\omega C} = \frac{1}{j2\pi \times 50 \times 10 \times 10^{-6}} = \frac{-j100}{\pi}$$

$$I = \frac{V_- - V_+}{X_c} = \frac{10 - 10}{X_c} = \frac{j\pi}{100}$$

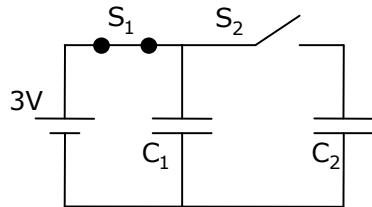
$$V_{out} = 10 + \frac{(10,000)j\pi}{100} = 10 + j100\pi$$

$$i_s = \frac{V_+ - V_{out}}{R} = \frac{10 - 10 - j100\pi}{10000} = -j10\pi \text{mA} = 10\pi \text{mA} \angle -90^\circ \text{s}$$

Q.22 (C)

When S_1 is closed, S_2 is open

C_1 is full charged to 3V

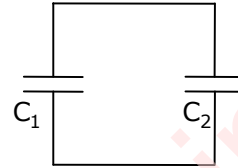


When S_1 is open

S_2 is closed

$$Q = C_1 V_1 = C_2 V_2$$

$$1F \times 3V = 2F \times V_2; V_2 = 1.5V$$



Q.24 (A)

Apply KVL for input loop

$$V_{in} = (2k\Omega)I_1 + (49I_1 + I_1) / (100\mu F) s$$

$$= (2kI_1) + \frac{50I_1}{5 \times 100\mu F} = 2kI_1 + \frac{I_1}{(2\mu F) s}$$

$$C_{off} = 2\mu F$$

Q.25 (D)

XRA A \rightarrow Accumulator is cleared, $A \leftarrow 00H$

MVI B \xleftarrow{FOH} B $\leftarrow FOH$

SUB B $\leftarrow (A) \leftarrow (A) - (B)$

(A) $\leftarrow FFFFFFF10H$

Q.26 (C)

$$Y_{Bus} = \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} & Y_{14} \\ Y_{21} & Y_{22} & Y_{23} & Y_{24} \\ Y_{31} & Y_{32} & Y_{33} & Y_{34} \\ Y_{41} & Y_{42} & Y_{43} & Y_{44} \end{bmatrix}$$

here

$$Y_{11} = Y_{10} + Y_{12} + Y_{13} + Y_{14} = -5j \quad \text{----- [1]}$$

$$Y_{22} = Y_{20} + Y_{22} + Y_{23} + Y_{24} = -10j \quad \text{----- [2]}$$

$$Y_{33} = Y_{30} + Y_{32} + Y_{33} + Y_{34} = -9j \quad \text{----- [3]}$$

$$Y_{44} = Y_{40} + Y_{42} + Y_{43} + Y_{44} = -8j \quad \text{----- [4]}$$

$$Y_{12} = Y_{21} = -Y_{12} = 2j$$

$$Y_{13} = Y_{31} = -Y_{13} = 2.5j$$

$$Y_{14} = Y_{41} = -Y_{14} = 0j$$

$$Y_{23} = Y_{32} = -Y_{23} = 2.5j$$

$$Y_{24} = Y_{42} = -Y_{24} = 4j$$

From equation 1,

$$Y_{10} = Y_{11} - Y_{12} - Y_{13} - Y_{14}$$

$$Y_{10} = -5j + 2j + 2.5j + 0j = -5j + 4.5j = -0.5j$$

From Eqn. 2

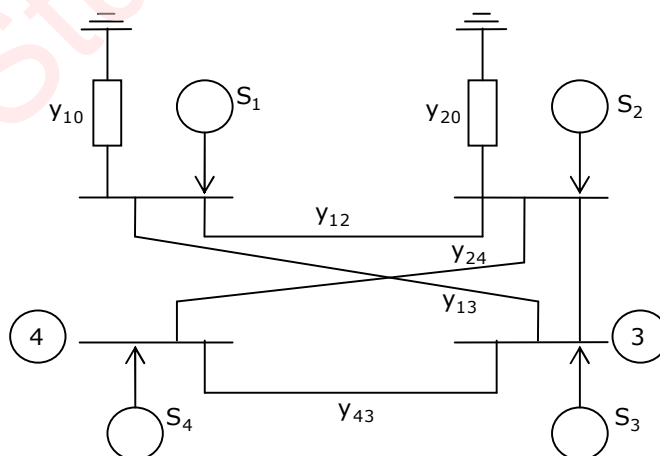
$$Y_{20} = Y_{22} - Y_{12} - Y_{23} - Y_{24} = -10j + 2j + 2.5j + 4j = -1.5j$$

From Eqn. 3

$$Y_{30} = Y_{33} - Y_{31} - Y_{32} - Y_{34} = -9j + 2.5j + 2.5j + j4 = 0$$

From Eqn. 4,

$$Y_{40} = Y_{44} - Y_{41} - Y_{42} - Y_{43} = -8j - 0 + 4j + j4 = 0$$



Q.28 (D) ✓
Phase crossover frequency

$$-90 - 0.1\omega \times \frac{180}{\pi} = -180$$

$$\therefore \omega = 15.7$$

$$a = |G(j\omega)|_{\omega=15.7}; \text{GM} = 20 \log a = 23.9\text{dB}$$

Q.32 (A)

$$G = \frac{P}{\cos \phi} = \frac{500\text{MW}}{0.9} = 555.56\text{MVA}$$

$$\text{KE stored} = \frac{1}{2} \times M \times \left(\frac{2\pi N}{60} \right)^2 = \frac{1}{2} \times 27.5 \times 10^3 \left[\frac{2\pi \times 3000}{60} \right]^2$$

$$= 1357.07\text{MJ}$$

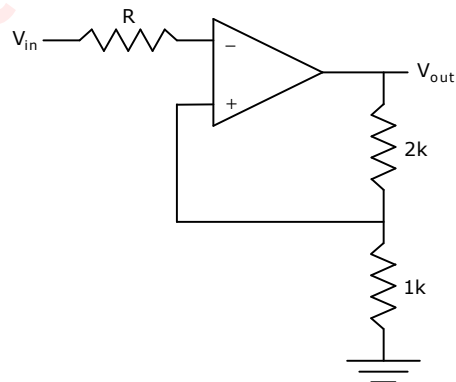
$$N = \frac{120f}{P} = 3000\text{rpm}$$

$$H = \frac{\text{KE}}{\text{MVA}} = \frac{1357.07}{555.56} = 2.44\text{MJ/MVA}$$

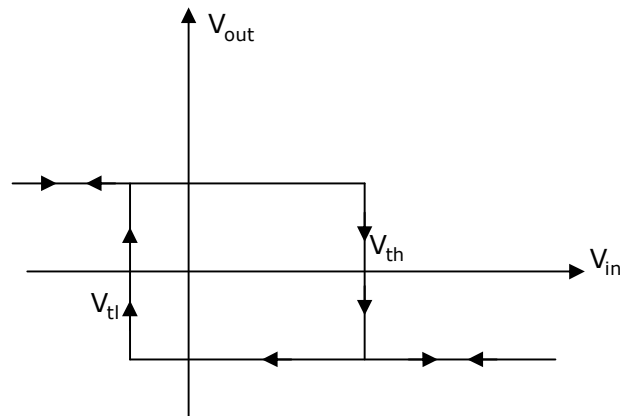
Q.40

| | |
|--|---|
| $(0, 2) \rightarrow (2, 0)$ $m = \frac{0-2}{2-0} = -1$ $y - 2 = -1[x - 0] = -x$ $\boxed{x + y = 2}$ | $\int_{(x,y)} F(x, y) dx dy$ $= \int_0^2 x^2 + x(2-x) dx + \int_2^0 y^2 + y(2-y) dy = 0$ |
|--|---|

Q.41 (D) For



Hysteresis Diagram is



$$\left. \begin{aligned} V_{th} &= \left(\frac{1k}{3k} \right) V_H = 2V = t_2 \\ V_{tl} &= \left(\frac{1k}{3k} \right) (-3) = -1V = t_4 \end{aligned} \right\} \begin{aligned} &\text{After } t_2, V_{out} = -3VA \\ &\text{After } t_4, V_{out} = 6VA \end{aligned}$$

Q.42 (C)

$$Z_{\text{auxiliary}} = r_a + j\omega L_a = 1 + j \times 2\pi \times 50 \times \frac{10}{\pi} = 1 + j1000$$

$$Z_{\text{main}} = r_m + j\omega L_m = 0.1 + j2\pi \times 50 \times \frac{0.1}{\pi} = 0.1 + j10 \approx 10 \angle 90^\circ$$

$$\text{starting torque} = KI_a I_m \sin(I_a, I_m) \rightarrow \sin(0) = 0$$

Q.43 (A)

$$V_L = L \frac{di}{dt}; \quad i = \frac{1}{L} \int v dt$$

$$i = \left[\frac{\pi}{0.1} \right] \int 10 \sin 100\pi t = (100\pi) \frac{\cos 100\pi t}{100\pi}$$

$$i(t) = \cos 100\pi t$$

$$i(t) = 0 \text{ when } \cos 100\pi t = 0 \Rightarrow 100\pi t = n\frac{\pi}{2}$$

$$t = \frac{n}{200}$$

When $n=1$, $t=5\text{msec}$; $n=2$, $t=10\text{msec}$; $n=3$, $t=15\text{msec}$

\therefore Answer is (A)

Q.47 (B)

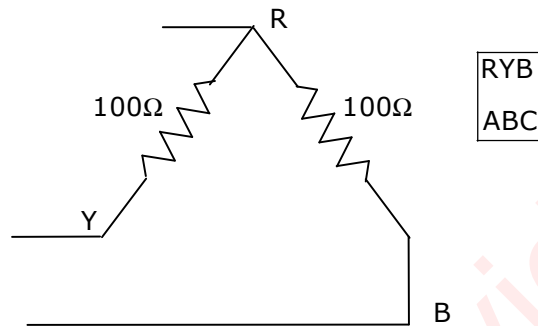
By Superposition theorem,

When 4V is shorted, $i^1=0$, as all the current will flow through short. When 5A is open, $i^{11}=2A$

Therefore $i_{2\Omega}=2A$

Q.48 (C)

Wattmeter reading = Current through the coil (I) \times Voltage across Pressure coil (V) \times Cos(phase angle between V & I)



$$I_{BR} = I_{CC} = \frac{400\sqrt{120}}{100} = 4\sqrt{120}$$

$$V_{YB} = V_{PC} = 400\sqrt{120}$$

$$W = 4\sqrt{120} \times 400\sqrt{120} \times \cos(240) = -800W$$

Q.49 (A)

For triangular wave,

$$\text{Avg value} \rightarrow \frac{V_m}{3}$$

$$\text{rms value} \rightarrow \frac{V_m}{\sqrt{3}}$$

$$\therefore \frac{V_m}{3} = 10V, V_m = 30V$$

$$\text{rms value} = \frac{30}{\sqrt{3}} = 10\sqrt{3}$$

Q.53 (D)

Q.54 (A)

$$V = L \frac{di'}{dt'} = \left(\frac{400}{\pi} \text{ m} \right) \frac{dt}{dt}$$

$$\frac{dt}{dt} \text{ is max } \rightarrow 0 \rightarrow 5 \text{ msec}$$

$$V = \left(\frac{400}{\pi} \text{ m} \right) \frac{10}{5 \text{ msec}} \left[\frac{800}{\pi} \right] V$$

$$\text{If } i(t) = 10 \sin(100\pi t)$$

$$V = \left(\frac{400}{\pi} \right)^{\text{mH}} \frac{di(t)}{dt} = \left[\frac{400}{\pi} \right] \pi \times 10 \times \cos(100\pi t)$$

$$= 400 \cos(100\pi t)$$

$$V_{\text{max}} = 400 \text{ V}$$

Q.55 (C)

$$\frac{dx_1(t)}{dt} = -3x_1(t) + x_2(t) + 2\mu(t)$$

$$\Rightarrow s x_1(s) = -3x_1(s) + x_2(s) + 2 \text{ ----- [1]}$$

$$\frac{dx_2(t)}{dt} = -2x_2(t) + \mu(t)$$

$$\Rightarrow s x_2(s) = -2x_2(s) + 1$$

$$(s+2)x_2 = 1$$

$$x_2 = \frac{1}{(s+2)}; \text{ From [1], } (s+3)x_1 = 2 + \frac{1}{s(s+2)}$$

$$x_1 = \frac{2s+5}{(s+2)(s+3)}$$

$$y(t) = x_1(t) \Rightarrow H(s) = \frac{y(s)}{X(s)} = \frac{2s+5}{(s+2)(s+3)} = \frac{2s+5}{s^2+5s+6}$$

Q.56 (B)

$$e^{At} = L^{-1}[\phi(s)]; \phi(s) = [sI - A]^{-1}$$

From given state equations

$$\dot{x}_1(t) = -3x_1(t) + x_2(t) + 2\mu(t)$$

$$\dot{x}_2(t) = -2x_2(t) + \mu(t)$$

$$\phi(s) = \left[\begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} -3 & 1 \\ 0 & -2 \end{bmatrix} \right]^{-1} = \begin{bmatrix} s+3 & -1 \\ 0 & s+2 \end{bmatrix}^{-1}$$

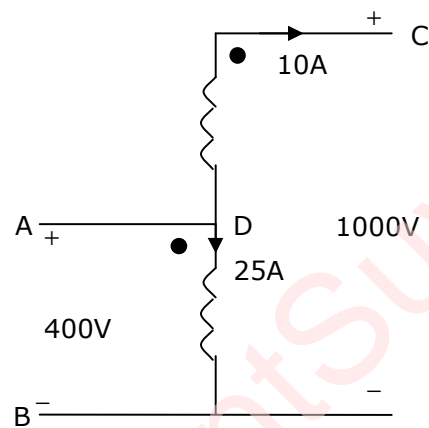
$$= \frac{1}{(s+2)(s+3)} \begin{bmatrix} s+2 & 1 \\ 0 & s+3 \end{bmatrix}$$

$$\phi(s) = \begin{bmatrix} \frac{1}{s+3} & \frac{1}{(s+2)(s+3)} \\ 0 & \frac{1}{(s+2)} \end{bmatrix}$$

$$e^{At} = L^{-1}[\phi(s)] = \begin{bmatrix} e^{-3t} & e^{-2t} - e^{-3t} \\ 0 & e^{-2t} \end{bmatrix}$$

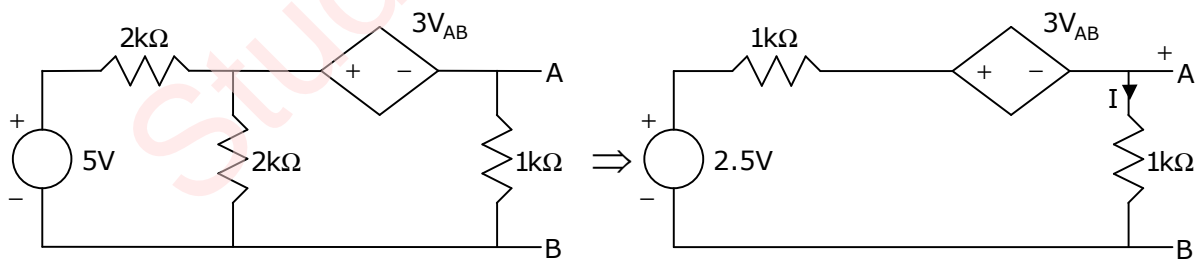
Q.57 (A)

Q.58 (A)



$$1000 = 25A + 400V = 10A \times 1000V$$

Q.59 (B)



$$V_{OC} = V_{AB}$$

$$2.5 = (1k\Omega)I + 3V_{AB} + V_{AB}$$

$$V_{AB} = (1k\Omega)I$$

$$\therefore 2.5 = V_{AB} + 3V_{AB} + V_{AB} = 5V_{AB}$$

$$V_{AB} = 0.5V$$

Apply short across AB: $V_{AB} = 0$, $3V_{AB} = 0$,

$$I_{sc} = \frac{2.5V}{1k\Omega} = 2.5mA$$

Q.60 (D)

$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{0.5V}{2.5mA} = \frac{1000}{5} = 200\Omega = 0.2k\Omega$$