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Prelims Through Questions

for

ESE 2021

Electrical Engineering

Day 7 of 11

Q.271 - Q.320

(Out of 500 Questions)

Control Systems + Power Electronics + Digital Electronics

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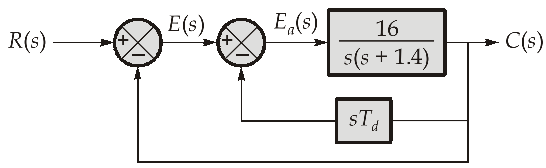
Q.271 For the derivative feedback control system shown in figure below, the damping ratio is equal to 0.7.



The value of derivative gain constant T_d is,

(a) 0.275 (b) 0.250
(c) 0.262 (d) 0.225

271. (c)

For the given system, characteristic equation is

$$\left(1+\frac{16}{s(s+1.4)+16sT_d}\right) = 0$$

or, $s^2 + 1.4s + 16s\,T_d + 16 = 0$

or, $s^2 + (1.4 + 16T_d)\,s + 16 = 0$

Comparing with $s^2 + 2\,\xi\omega_n s + \omega_n^2 = 0$, we have:

$$\omega_n = \sqrt{16}\text{ rad/s} = 4\text{ rad/sec}$$

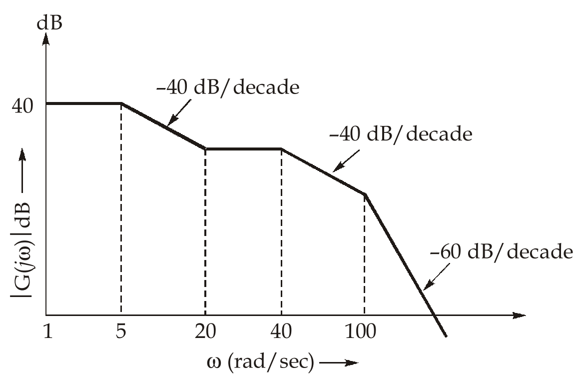
and $2\,\xi\omega_n = (1.4 + 16T_d)$

or, $2 \times 0.7 \times 4 = 1.4 + 16T_d$ $\quad(\because \xi = 0.7\text{, given})$

or, $5.6 - 1.4 = 16T_d$

or, $T_d = \dfrac{4.2}{16} = 0.2625$

Q.272 The Bode magnitude plot of the open loop transfer function $G(s)$ of a certain system is shown below.



If the system is of minimum phase type, then the open-loop transfer function $G(s)$ will be given by:

(a) $\dfrac{5\times10^4(s+5)^2(s+40)^2}{(s+20)^2(s+100)}$

(b) $\dfrac{5\times10^4(s+20)^2}{(s+5)^2(s+40)^2(s+100)}$

(c) $\dfrac{10^6(s+20)^2}{(s+5)^2(s+40)^2(s+100)}$

(d) $\dfrac{10^5(s+20)^2}{(s+5)^2(s+40)^2(s+100)}$

272. (c)

Since, the system is of minimum phase system, it has no poles or zeros in the right hand side of s-plane.

There are four corner frequencies for the transfer function $G(s)$.

(i) Two poles at ω_1 = 5 rad/sec as slope changes by –40 dB/dec.

(ii) Two zeros at ω_2 = 20 rad/sec as slope changes by +40 dB/dec.

(iii) Two poles at ω_3 = 40 rad/sec as slope changes by –40 dB/dec.

(iv) A pole at ω_4 = 100 rad/sec as slope changes here by –20 dB/dec.

Therefore open loop transfer function in time constant form;

$$G(s) = \frac{K\left(1+\frac{s}{20}\right)^2}{\left(1+\frac{s}{5}\right)^2\left(1+\frac{s}{40}\right)^2\left(1+\frac{s}{100}\right)}$$

$\because$ Initial slope = 0 dB

then, $20\log K = 40$ dB

or $K = 100$

Now open loop transfer function,

$$G(s) = \frac{100\times25\times40^2\times100(s+20)^2}{20^2(s+5)^2(s+40)^2(s+100)} = \frac{10^6(s+20)^2}{(s+5)^2(s+40)^2(s+100)}$$

Q.273 A second order system has a closed loop transfer function $\dfrac{C(s)}{R(s)} = \dfrac{16}{s^2+4.8s+16}$. If the system is initially at rest and subjected to a unit step input at t = 0, the third peak (third overshoot) in the response will occur at

(a) 0.67 π sec
(b) π sec
(c) 1.56 π sec
(d) 1.23 π sec

273. (c)

Given, $\dfrac{C(s)}{R(s)} = \dfrac{16}{s^2+4.8s+16} = \dfrac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$

Here, ω_n = 4 rad/s, $2\xi\omega_n$ = 4.8

or, $\xi = \dfrac{4.8}{2\times4} = 0.6$

Peak time, $t_p = \frac{n\pi}{\omega_d} = \frac{n\pi}{\omega_n\sqrt{1-\xi^2}}$

For overshoots, $n = 1, 3, 5, ...$

For undershoots, $n = 2, 6, 8, ...$

For 3rd peak, $n = 5$ (3rd overshoot is the third peak)

So, $t_p = \frac{5\pi}{4\sqrt{1-0.6^2}} = \frac{5\pi}{4\times 4/5} = \frac{25\pi}{16} = 1.56\,\pi$

Q.274 The response of a system to a unit step input is $t\,u(t) - \frac{1}{4}u(t) + \frac{1}{8}e^{-2t}u(t)$. Which one of the following is the unit impulse response of the system?

(a) $u(t) - \frac{1}{4}e^{-2t}u(t)$

(b) $-\frac{1}{8}\delta(t) + u(t) - \frac{1}{4}e^{-2t}u(t)$

(c) $u(t) - \frac{1}{8}e^{-2t}u(t)$

(d) $-\frac{1}{4}\delta(t) + u(t) - \frac{1}{8}e^{-2t}u(t)$

274. (b)

Response due to unit step input,

$$c(t) = tu(t) - \frac{1}{4}u(t) + \frac{1}{8}e^{-2t}u(t)$$

$$C(s) = \frac{1}{s^2} - \frac{1}{4s} + \frac{1}{8(s+2)}$$

$$\text{Impulse response} = \frac{C(s)}{1/s} = \frac{\frac{1}{s^2} - \frac{1}{4s} + \frac{1}{8(s+2)}}{1/s}$$

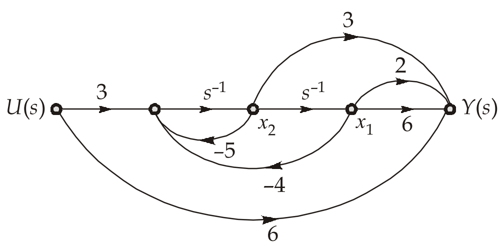
$$= \frac{1}{s} - \frac{1}{4} + \frac{s}{8(s+2)} = \frac{1}{s} - \frac{1}{4} + \frac{1}{8}\left[1 - \frac{2}{s+2}\right]$$

$$\text{Impulse response} = \frac{1}{s} - \frac{1}{8} - \frac{1}{4(s+2)}$$

Taking Laplace inverse, we get,

$$\text{Impulse response} = -\frac{1}{8}\delta(t) + u(t) - \frac{1}{4}e^{-2t}u(t)$$

Q.275 The state space representation of the system represented by the signal flow graph shown below is



(a) $\dot{x} = \begin{bmatrix} 1 & 0 \\ -4 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 3 \end{bmatrix} u(t)\ ;\ y(t) = \begin{bmatrix} 6 & 1 \end{bmatrix} x + 6u(t)$

(b) $\dot{x} = \begin{bmatrix} 0 & 1 \\ -4 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 3 \end{bmatrix} u(t)\ ;\ y(t) = \begin{bmatrix} 8 & 3 \end{bmatrix} x + 6u(t)$

(c) $\dot{x} = \begin{bmatrix} 1 & 0 \\ -4 & -5 \end{bmatrix} x + \begin{bmatrix} 1 \\ 3 \end{bmatrix} u(t)\ ;\ y(t) = \begin{bmatrix} 1 & 6 \end{bmatrix} x + 6u(t)$

(d) $\dot{x} = \begin{bmatrix} 0 & 1 \\ -5 & -4 \end{bmatrix} x + \begin{bmatrix} 1 \\ 3 \end{bmatrix} u(t)\ ;\ y(t) = \begin{bmatrix} 8 & 3 \end{bmatrix} x + 6u(t)$

275. (b)

The state equations from the given signal flow graph can be written as:

$$\dot{x}_1 = x_2 \quad \text{... (i)}$$

and

$$\dot{x}_2 = -4x_1 - 5x_2 + 3u(t) \quad \text{... (ii)}$$

In matrix form,

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -4 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 3 \end{bmatrix} u(t)$$

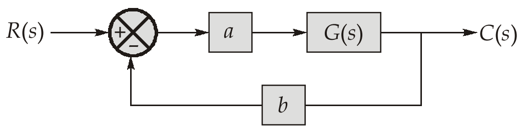
Also, output is

$$y(t) = 8x_1 + 3x_2 + 6u(t) \quad \text{... (iii)}$$

In matrix form

$$y(t) = \begin{bmatrix} 8 & 3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + 6u(t)$$

Q.276 For the system shown in the figure below, the sensitivity of the closed loop transfer function w.r.t. parameter 'a' is



(a) $\dfrac{1}{1 + aG(s)}$

(b) $\dfrac{1}{1 + abG(s)}$

(c) $\dfrac{-1}{1 + abG(s)}$

(d) 1

276. (b)

The closed loop transfer function is given by

$$\frac{C(s)}{R(s)} = M(s) = \frac{aG(s)}{1 + abG(s)}$$

Sensitivity w.r.t. to 'a': $$S_a^{M(s)} = \frac{a}{M(s)} \cdot \frac{\partial M(s)}{\partial a}$$

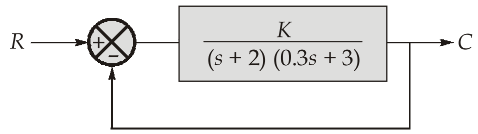
Now, $$\frac{a}{M(s)} = \frac{[1+abG(s)]}{G(s)}$$

and $$\frac{\partial M(s)}{\partial a} = \frac{\partial}{\partial a}\left[\frac{aG(s)}{1+abG(s)}\right]$$

$$= \frac{G(s)[1+abG(s)] - aG(s)[bG(s)]}{[1+abG(s)]^2} = \frac{G(s)}{[1+abG(s)]^2}$$

$$S_a^{M(s)} = \left[\frac{1+abG(s)}{G(s)}\right] \times \frac{G(s)}{[1+abG(s)]^2} = \left[\frac{1}{1+abG(s)}\right]$$

Q.277 The system shown in the figure below has unit step input.



The steady state error is 0.2, the value of K required should be

(a) 24 (b) 30
(c) 0.2 (d) 22

277. (a)

$$G(s) = \frac{K}{(s+2)(0.3s+3)}$$

Since input is unit step, therefore steady state error is

$$e_{ss} = \lim_{s\to 0}\left(\frac{1}{1+K_p}\right) = 0.2 \quad \text{(Given)}$$

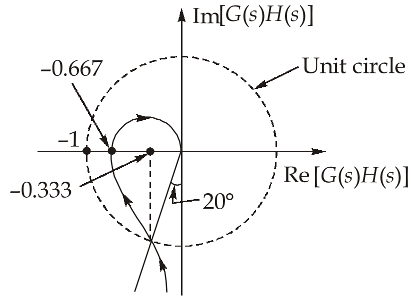
Here, $$K_p = \lim_{s\to 0}[G(s)] = \lim_{s\to 0}\frac{K}{(s+2)(0.3s+3)} = \frac{K}{6}$$

$\therefore$ $$0.2 = \frac{1}{1+K/6}$$

or, $$1+\frac{K}{6} = 5$$

or, $$K = 24$$

Q.278 A portion of the polar plot of an open-loop transfer function is shown in the figure below.



The phase margin and gain margin will be respectively

(a) 20° and 0.667 (b) 20° and 1.5
(c) 70° and 0.667 (d) 70° and 1.5

278. (d)

From the polar plot, we can observe;

$$\text{Gain margin} = \frac{1}{0.667} = 1.5$$

$$\text{Phase margin} = 90° - 20° = 70°$$

Q.279 Consider the following loop transfer function:

$$G(s)H(s) = \frac{K(s+2)}{s(s^2+4)}$$

The angle of departure at $s = j2$ for $K > 0$ is

(a) 90° (b) 75°
(c) 45° (d) 135°

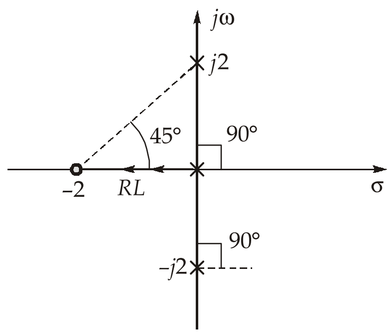
279. (c)

Given, $$G(s)H(s) = \frac{K(s+2)}{s(s^2+4)}$$

Here, $P = 3$, $Z = 1$, $P - Z = 2$

No. of branches of RL terminating at zero = 1.

No. of branches of RL terminating at infinity = 2.



Here, two branches of RL has to terminate at infinity.

Thus, the two imaginary poles will terminate at infinity.

Hence, we need to find angle of departure for which we join all poles and zeros with the imaginary pole at $s = j2$.

Now, $\phi = \Sigma(\phi_z - \phi_P)$

Here, $\Sigma\phi_z = 45°$

and $\Sigma\phi_P = 90° + 90° = 180°$

Thus, $\phi = 45° - 180° = -135°$

∴ Angle of departure is,

$$\phi_D = 180° + \phi$$
$$= 180° - 135° = 45°$$

Q.280 The loop transfer function of a negative feedback system is given as,

$$G(s)H(s)=\frac{K}{s(s+2)(s^2+2s+2)}\ ;\ 0 < K < \infty$$

Consider the following statements regarding the Root locus plot of the system:

S_1 : centroid exists at s = –1

S_2 : one break away point exists at s = –1

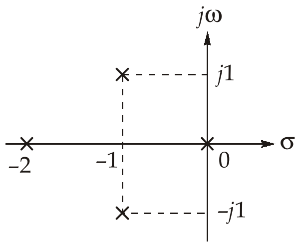
S_3 : total three break away points exists.

Select the correct statements using the codes given below.

(a) S_1 and S_3 only
(b) S_1 and S_2 only
(c) S_2 and S_3 only
(d) S_1, S_2 and S_3

280. (b)

Pole-zero plot at K = 0



- all the open loop poles are symmetric about s = –1.
- so, only one breakaway point exists, that itself at centroid.
- centroid, BA point exists at s = –1
- so, S_1 and S_2 are correct.

Q.281 A control system is represented by following state space representation

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}-5 & 1\\ 0 & -4\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}0\\ 1\end{bmatrix}u(t)$$

$$y = \begin{bmatrix}1 & 4\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

If two such systems are connected in parallel then overall transfer function of the combined system is

(a) $\dfrac{4s+21}{(s+4)(s+5)}$
(b) $\dfrac{4s+36}{(s+4)(s+5)}$
(c) $\dfrac{2(s+9)}{(s+4)(s+5)}$
(d) $\dfrac{2(4s+21)}{(s+4)(s+5)}$

281. (d)

The transfer function from steady state model can be written as

$$T(s) = C[sI - A]^{-1} B$$

$$[sI - A]^{-1} = \frac{\text{adj}[sI-A]}{|sI-A|}$$

$$[sI - A] = \begin{bmatrix} s+5 & -1 \\ 0 & s+4 \end{bmatrix}$$

$$[sI - A]^{-1} = \frac{1}{(s+5)(s+4)}\begin{bmatrix} s+4 & 1 \\ 0 & s+5 \end{bmatrix}$$

$$T(s) = \frac{1}{(s+5)(s+4)}\begin{bmatrix} 1 & 4 \end{bmatrix}\begin{bmatrix} s+4 & 1 \\ 0 & s+5 \end{bmatrix}\begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

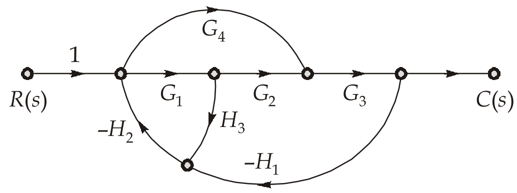
$$T(s) = \frac{1}{(s+5)(s+4)}\begin{bmatrix} 1 & 4 \end{bmatrix}\begin{bmatrix} 1 \\ s+5 \end{bmatrix}$$

$$T(s) = \frac{1+4(s+5)}{(s+4)(s+5)} = \frac{4s+21}{(s+4)(s+5)}$$

If two systems are connected in parallel

$$T'(s) = T(s) + T(s) = \frac{2(4s+21)}{(s+4)(s+5)}$$

Q.282 A control system is defined by the signal flow graph given below:



The number of forward paths and number of individual loops for the signal flow will be respectively

(a) 1, 2 (b) 2, 4

(c) 1, 3 (d) 2, 3

282. (d)

For the given signal flow graph

Forward paths:

$$P_1 = G_1G_2G_3$$

gains $P_2 = G_3G_4$

Number of possible forward paths: 2

Individual loop gain:

$$L_1 = H_1H_2G_3G_4$$
$$L_2 = -G_1H_2H_3$$
$$L_3 = G_1G_2G_3H_1H_2$$

Number of individaul loops for given signal flow graph is equal to 3.

Q.283 The open loop transfer function of the unity feedback system is given by

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

The Nyquist plot of above system will intersect the real axis at a point given by

(a) $\left(-\frac{1}{3},0\right)$
(b) $\left(-\frac{4}{3},0\right)$
(c) $\left(-\frac{2}{3},0\right)$
(d) $\left(-\frac{5}{3},0\right)$

283. (c)

Given open loop transfer function,

$$G(s) = \frac{1}{s(2s+1)(s+1)} \quad , \quad H(s) = 1$$

So,
$$G(s)H(s) = \frac{1}{s(2s+1)(s+1)}$$

By putting,
$$s = j\omega$$

$$G(j\omega)\, H(j\omega) = \frac{1}{(j\omega)(2j\omega+1)(j\omega+1)}$$

The intersection with real axis occurs in negative half of the $j\omega$ plane when $\text{Im}\{G(j\omega)H(j\omega)\} = 0$

$$\therefore \text{Im}\left\{\frac{(+1-2j\omega)(+1-j\omega)(-j\omega)}{\omega^2(4\omega^2+1)(1+\omega^2)}\right\} = 0$$

$$\text{Im}\{(\omega - 2\omega^3)j - (\omega^2 + 2\omega^2)\} = 0$$

So,
$$\omega(1 - 2\omega^2) = 0$$

$$\omega = 0, \text{ and } \omega = \frac{1}{\sqrt{2}}$$

$$\therefore \text{ Value } G(j\omega)H(j\omega)\Big|_{\omega=\frac{1}{\sqrt{2}}} = \frac{1}{\left(j\frac{1}{\sqrt{2}}\right)\left(2j\frac{1}{\sqrt{2}}+1\right)\left(j\frac{1}{\sqrt{2}}+1\right)} = \frac{1}{\frac{j^2}{2}-1} = \frac{1}{-\frac{3}{2}} = -\frac{2}{3}$$

Q.284 The open loop transfer function of a system is

$$G(s)H(s) = \frac{K}{s(1+4s)(1+3s)}$$

The value of phase crossover frequency for the given system will be

(a) $\frac{1}{\sqrt{2}}$ rad/sec
(b) $\frac{1}{\sqrt{3}}$ rad/sec
(c) $\frac{1}{2\sqrt{2}}$ rad/sec
(d) $\frac{1}{2\sqrt{3}}$ rad/sec

284. (d)

Given, $$G(s)H(s) = \frac{K}{s(1+4s)(1+3s)}$$

Putting, $s = j\omega$

$$G(j\omega)H(j\omega) = \frac{K}{(j\omega)(1+4j\omega)(1+3j\omega)}$$

At phase crossover frequency, ω_{pc}

$$\angle G(j\omega_{pc})H(j\omega_{pc}) = -180° \quad \text{...(i)}$$

$$\angle G(j\omega_{pc})H(j\omega_{pc}) = -90° - \tan^{-1} 4\,\omega_{pc} - \tan^{-1} 3\,\omega_{pc} = -180°$$

$$\tan^{-1} 4\,\omega_{pc} + \tan^{-1} 3\,\omega_{pc} = 90° \quad \text{...Using equation (i),}$$

$$\tan^{-1}\left[\frac{4\omega_{pc} + 3\omega_{pc}}{1 - 12\omega_{pc}^2}\right] = 90°$$

$$\frac{4\omega_{pc} + 3\omega_{pc}}{1 - 12\omega_{pc}^2} = \tan 90°$$

So, $$1 - 12\omega_{pc}^2 = 0$$

$$\omega_{pc}^2 = \frac{1}{12}$$

$$\omega_{pc} = \frac{1}{2\sqrt{3}} \text{rad/sec}$$

Q.285 The transfer function of phase lead compensator is given by $G(s) = \frac{1+0.25s}{1+0.025s}$. The value of frequency at which maximum phase is obtained from the compensator will be

(a) $\sqrt{10}$ rad/sec
(b) 10 rad/sec
(c) 4 rad/sec
(d) $4\sqrt{10}$ rad/sec

285. (d)

The standard transfer function for phase lead compensator,

$$G(s) = \frac{\alpha(1+Ts)}{1+\alpha Ts}$$

By comparing $\alpha T = 0.025$

and $T = 0.25$

Frequency at which maximum phase is obtained,

$$\omega_m = \sqrt{\frac{1}{\alpha T}\cdot\frac{1}{T}} = \sqrt{\frac{1}{0.025}\times\frac{1}{0.25}} = \sqrt{40\times 4} = 4\sqrt{10} \text{ rad/sec}$$

Q.286 The number of poles which lie on right half of s-plane for closed loop transfer function given below will be

$$T(s) = \frac{s^3 + 2s^2 + 6s + 18}{s^5 - 2s^4 + 3s^3 - 6s^2 + 2s - 4}$$

(a) 1
(b) 2
(c) 3
(d) None

286. (a)

For given transfer function,

The characteristic equation:

$$1 + G(s)H(s) = s^5 - 2s^4 + 3s^3 - 6s^2 + 2s - 4$$

Forming the Routh table for above characteristic equation

s^5	1	3	2
s^4	–2	–6	–4
s^3	0	0	

The row corresponding s^3 has all terms as zero.

$\therefore$ We have to form auxiliary equation using row corresponding to s^4

$$P(s) = -2s^4 - 6s^2 - 4$$

So, $$\frac{dP(s)}{ds} = -8s^3 - 12s \text{ or } -2s^3 - 3s$$

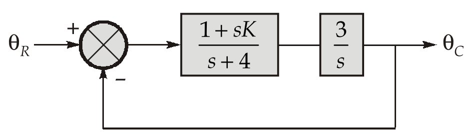
Now using the coefficient of $\frac{dP}{ds}$ corresponding to s^3 row

s^5	1	3	2
s^4	–2	–6	–4
s^3	–2	–3	
s^2	–3	–4	
s^1	$\frac{9-8}{-3} = \frac{-1}{3}$	0	
s^0	–4		

$\therefore$ there is one sign change in s^4 row and hence one root lies on right half of s-plane.

Hence option (a) is correct.

Q.287 A control system with damping ratio $\xi = \sqrt{3}$ is represented by the block diagram which employs proportional plus error rate control. The value of error rate constant K when unit step is given as input to system will be



(a) $\frac{1}{3}$ (b) $\frac{1}{2}$
(c) $\frac{1}{4}$ (d) $\frac{2}{3}$

287. (d)

The closed loop transfer function for given system,

$$\frac{G(s)}{1+G(s)} = \frac{\frac{3(1+sK)}{s(s+4)}}{1+\frac{3(1+sK)}{s(s+4)}} = \frac{3(1+sK)}{s(s+4)+3(1+sK)}$$

$$= \frac{3(1+sK)}{s^2+4s+3(1+sK)} = \frac{3+3sK}{s^2+(4+3K)s+3}$$

Comparing the transfer function with standard second order transfer function.

$$\omega_n^2 = 3$$

$$\Rightarrow \quad \omega_n = \sqrt{3}\,\text{rad/sec}$$

$$2\xi\omega_n = 4 + 3K$$

$$2\sqrt{3}\xi = 3K + 4$$

$$\frac{2\sqrt{3}\xi - 4}{3} = K$$

given, $\xi = \sqrt{3}$, $\quad K = \frac{6-4}{3} = \frac{2}{3}$

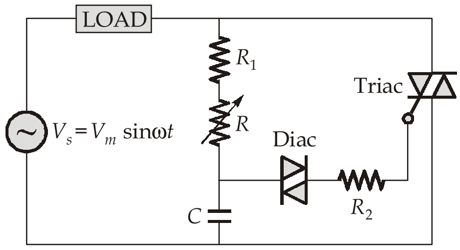
Q.288 Which of the following firing schemes can be used for feedback control system?
1. *R* Firing scheme
2. *RC* firing scheme
3. UJT firing scheme
4. Cosine firing scheme

(a) 3 and 4 only (b) 2, 3 and 4
(c) 3 only (d) 1, 2, 3 and 4

288. (a)

R and *RC* firing scheme can not be used for feedback control systems.

Q.289 In the circuit shown in figure, variable resistor *R* is used to



(a) control the current through diac.
(b) control the current through triac.
(c) control the charging time of capacitor *C*.
(d) control the discharging time of capacitor *C*.

289. (c)

Value of capacitor, *C* and the variable resistor *R* are so selected to give a firing angle range of nearly 0° and 180°. Variable resistor *R* controls the charging time of capacitor *C* and therefore the firing angle of triac.

Q.290 Latching current for a SCR, inserted between a dc voltage source of 200 V and the load is 100 mA. What is the minimum width of gate-pulse current required to turn-on this SCR in case load consists of an inductance $L = 0.2$ H?

(a) 100 μsec
(b) 50 μsec
(c) 200 μsec
(d) 10 μsec

290. (a)

$$E = L\frac{di}{dt};$$

$$i = \frac{E}{L}t$$

$$0.100 = \frac{200}{0.2}t$$

$$\Rightarrow \quad t = 100 \text{ μsec}$$

Q.291 A 200 V, 100 rpm, 10 A separately excited dc motor is fed from a single-phase full converter supplied by an ac source voltage of 230 V, 50 Hz. Armature circuit resistance is 1 Ω. What is the motor constant in V-s/rad?

(a) $\frac{114}{\pi}$
(b) $\frac{57}{2\pi}$
(c) $\frac{63}{\pi}$
(d) $\frac{57}{\pi}$

291. (d)

For motor action:

$$V_t = E_a + I_a r_a$$

$$V_t = K_m \omega_m + I_a r_a$$

$$200 = K_m \times 2\pi \times \frac{100}{60} + 10 \times 1$$

$$K_m = \frac{190 \times 60}{200\pi} = \frac{57}{\pi} \text{ V-s/rad}$$

Q.292 If V_s is the input dc voltage in single PWM inverter, then the pulse width required for eliminating third harmonic and corresponding rms value of fundamental component of output voltage are

(a) $120°, \frac{2\sqrt{2}}{\pi}V_s$ (b) $60°, \frac{\sqrt{6}}{\pi}V_s$

(c) $60°, \frac{2\sqrt{2}}{\pi}V_s$ (d) $120°, \frac{\sqrt{6}}{\pi}V_s$

292. (d)

$$V_{0n,\,rms} = \frac{4V_s}{n\pi\sqrt{2}}\sin nd \cdot \sin\frac{n\pi}{2}$$

For eliminating third harmonic

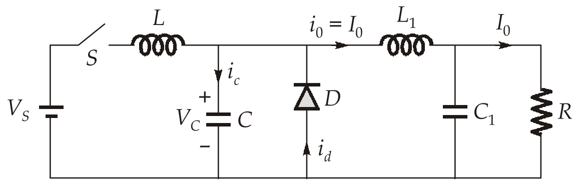
$$nd = \pi$$

$$d = \frac{\pi}{3} = 60°$$

∴ pulse width $2d = 120°$

$$V_{01,\,rms} = \frac{2\sqrt{2}V_s}{\pi} \times \sin 60° = \frac{\sqrt{6}V_s}{\pi}\text{ V}$$

Q.293 A ZCS resonant converter is shown in figure has peak current of $I_0 + V_s\sqrt{\frac{C}{L}}$ in the switch S. For natural turn off which of the following is true?



(a) $V_s\sqrt{\frac{C}{L}} > 0$ (b) $V_s\sqrt{\frac{C}{L}} > I_0$

(c) $V_s\sqrt{\frac{C}{L}} < I_0$ (d) $V_s\sqrt{\frac{C}{L}} \le I_0$

293. (b)

For natural turn-off, peak resonant current $\left(\frac{V_s}{Z_0}\text{ or } V_s\sqrt{\frac{C}{L}}\right)$ must be greater than load current I_0.

Q.294 For a type A chopper, duty ratio is 1/3. The ripple factor is

(a) $\sqrt{3}$ (b) $\sqrt{2}$

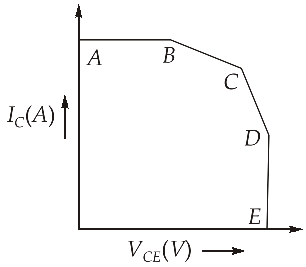
(c) $\sqrt{5}$ (d) 1.5

294. (b)

Here, $$\alpha = \frac{1}{3}$$

$$\text{R.F.} = \sqrt{\frac{1}{\alpha} - 1} = \sqrt{\frac{1}{(1/3)} - 1} = \sqrt{2}$$

Q.295 A forward biased safe operating area (FBSOA) curve for BJT is shown in figure. Which of the boundary in the curve decides the secondary breakdown limit?



(a) *AB* (b) *BC*
(c) *CD* (d) *DE*

295. (c)

- Boundary *AB* is the maximum limit for dc and continous current.
- Boundary *BC* is as to limit the junction temperature to safe value.
- Boundary *CD* is secondary breakdown limit.
- Boundary *DE* is is maximum voltage capability.

Q.296 In a step down chopper, duty ratio is 1/3 and the input voltage is V_s. What is the maximum value of fundamental output voltage?

(a) $\frac{2\sqrt{3}V_s}{\pi}$ V (b) $\frac{2V_s}{\pi}$ V
(c) $\frac{\sqrt{3}V_s}{\pi}$ V (d) 0

296. (c)

$$V_{0n} = \frac{2V_s}{n\pi}\sin n\pi\alpha$$

$$V_{01} = \frac{2V_s}{\pi}\sin\frac{\pi}{3} = \frac{\sqrt{3}V_s}{\pi}\text{ V}$$

Q.297 The full bridge inverter is used to produce a 60-Hz voltage across a series RL load using bipolar PWM. The dc input is 100 V, amplitude modulation ratio m_a is 0.8 and the frequency modulation ratio m_f is 21. What is the amplitude of the 60 Hz component of the output voltage?

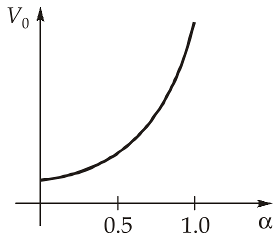
(a) 1680 V (b) $1680\sqrt{2}$ V
(c) $80\sqrt{2}$ V (d) 80 V

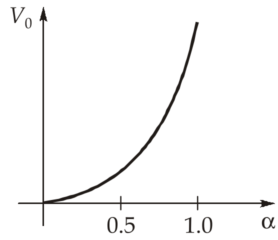
297. (d)

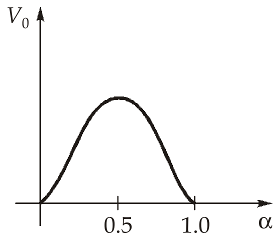
Amplitude of the 60 Hz fundamental frequency is

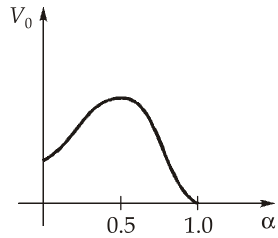
$$V_1 = m_a V_{dc} = 0.8 \times 100 = 80 \text{ V}$$

Q.298 For a buck-boost converter, the output voltage versus duty ratio waveforms is

(a)


(b)


(c)


(d)


298. (b)

In buck-boost converter,

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

At $\alpha = 0, V_0 = 0$

At $\alpha = 1, V_0 = \infty$

Q.299 A three phase full bridge inverter having a load impedance of $(5 - j10)$ Ω for the fundamental frequency. What is the impedance for the lowest order harmonic present in load current?

(a) $(1 - j2)$ Ω
(b) $(5 - j2)$ Ω
(c) $(25 - j50)$ Ω
(d) $(5 - j50)$ Ω

299. (b)

For n^{th} harmonic

$$Z_n = R - jX_n$$

$$X_n = \frac{1}{n\omega C}$$

Lowest order harmonic present is 5^{th}

$$Z_n = 5 - j\left(\frac{10}{5}\right) = (5 - j2)\ \Omega$$

Q.300 Number of thyristors, each with a rating of 1000 V and 200 A, required in each branch of a series-parallel combination for a circuit with a total voltage and current ratings of 6 kV and 1 kA respectively. If the device derating factor is 10%, then what is the number of thyristors in series and parallel branch required respectively are?

	No. of thyristors in series branch	No. of thyristors in parallel branch
(a)	7	6
(b)	6	7
(c)	7	7
(d)	6	6

300. (a)

$$\text{D.R.F} = 1 - \text{string efficiency}$$

$$0.1 = 1 - \frac{6000}{n_s \times 1000} = 1 - \frac{1000}{n_p \times 200}$$

No. of series connected SCRs,

$$n_s = \frac{6000}{1000 \times 0.9} = 6.6 \simeq 7$$

No. of parallel - connected SCRs,

$$n_p = \frac{1000}{200 \times 0.9} = 5.5 \simeq 6$$

Q.301 Consider the following statements:

1. GTO has fast switching speed compared to SCR.
2. When compared with SCR, magnitude of latching and holding currents are less in a GTO.
3. GTO circuit configuration has lower size and weight as compared to thyristor circuit unit.
4. Gate drive circuit losses are more in GTO when compared with SCR.

Which of the above statement(s) is/are **not** correct?

(a) 1 and 3 only (b) 2 only
(c) 4 only (d) 2 and 4 only

301. (b)

When compared with SCR, magnitude of latching and holding currents are more in a GTO.

Q.302 Consider the statements given below,

Use of freewheeling diode

1. Reduce the reactive power demand of the converter
2. Improves the fundamental power factor
3. Decreases the Current Distortion Factor (CDF)
4. Increases Total Harmonic Distortion (THD)

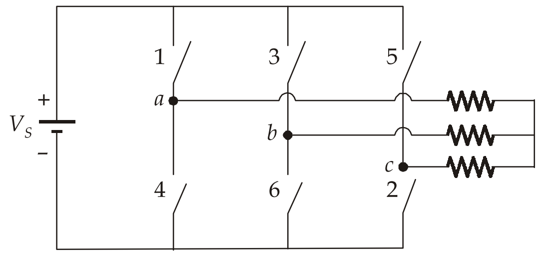
Which of the above statement(s) is/are **not** correct?

(a) 1, 2 and 4 only (b) 1 and 3 only
(c) 2 only (d) 3 and 4 only

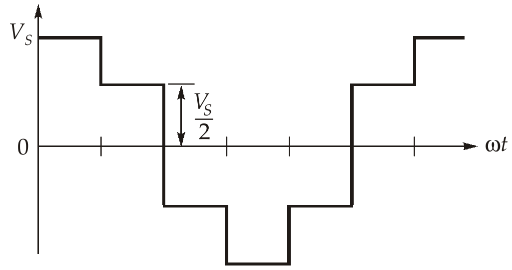
302. (d)

Free wheeling diode improves the current distortion factor (CDF) and reduces the Total Harmonic Distortion (THD).

Q.303 Figure (a) shows a 3-ϕ inverter fed by a constant voltage source V_s and connected to a balanced resistive load at the output. Each switching device may conduct for 120° or for 180°. The waveform shown in figure (b) is,



(a)



(b)

(a) output line voltage in 120° mode of operation.
(b) load phase voltage in 120° mode of operation.
(c) output line voltage in 180° mode of operation.
(d) load phase voltage in 180° mode of operation.

303. (a)

Q.304 Commutation overlap in the phase controlled ac to dc converter is due to
(a) load inductance
(b) harmonic content of load current
(c) source inductance
(d) switching operation in the converter

304. (c)

The commutation overlap occurs in the phase controlled ac to dc converter is due to source inductance.

Q.305 Consider the following statements regarding switching characteristics of thyristor.
1. The spread time is the time taken by the anode current to rise from 0.9 I_{anode} to I_{anode}.
2. The dynamic process of the SCR from conduction state to forward blocking state is called commutation process or turn off process.
3. The turn off time t_q of a thyristor is defined as the time between the instant anode current becomes zero and the instant SCR regains forward blocking capability.

Which of the above statement(s) is/are **not** correct?
(a) 1 only
(b) 2 only
(c) 1 and 3 only
(d) None of the above

305. (d)

All the given statements are correct.

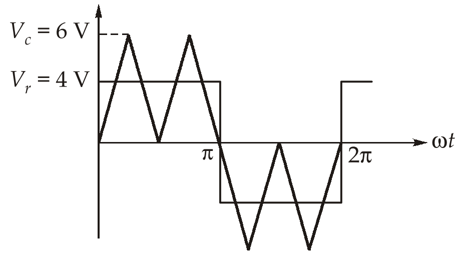
Q.306 Which of the following pair of devices possess bi-directional current capability?

(a) Triac and GTO
(b) Triac and RCT
(c) RCT and IGBT
(d) GTO and RCT

306. (b)

Triac and RCT possess bi-directional current capability. IGBT and GTO are unidirectional current devices.

Q.307 Output voltage of an inverter is controlled by multiple pulse modulation technique. If the peak value of reference voltage is 4 V and peak value of carrier voltage is 6 V. Then the total pulse width in each half cycle is



(a) 30°
(b) 40°
(c) 50°
(d) 60°

307. (d)

$$V_r = 4 \text{ V}$$
$$V_c = 6 \text{ V}$$
$$\text{Total pulse width} = 2d$$
$$\frac{2d}{N} = \left(1 - \frac{V_r}{V_c}\right)\frac{\pi}{N} \text{ (Where } N \text{ is number of pulses per half cycle)}$$
$$2d = \left(1 - \frac{V_r}{V_C}\right)\pi$$
$$2d = \left(1 - \frac{4}{6}\right)180° = 60°$$

Q.308 If A, B, C are 3 input variables, then the following Boolean functions

$y_1 = A \oplus B \oplus C$; $y_2 = AB + (A \oplus B)C$

1. y_1 is sum of full adder.
2. y_2 is borrow of full subtracter.
3. y_1 is difference of full subtracter.
4. y_2 is carry of full adder.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2 and 4 only
(c) 1, 2, 3 and 4
(d) 1, 3 and 4 only

308. (d)

Q.309 Consider the following circuits:

1. BCD to Gray code converter
2. Counters
3. Shift registers
4. Full subtracter

Which of the above circuits are classified as combinational logic circuits?

(a) 1 and 2 only (b) 1, 3 and 4 only
(c) 2 and 3 only (d) 1 and 4 only

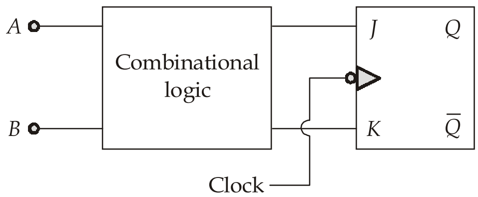
309. (d)

BCD to gray code converter and full subtractor are combinational circuits.

Counter and shift registers are sequential circuits.

Q.310 The following truth table has to be realized with the circuit shown in figure,

A	B	Q_{n+1}
0	0	Q_n
0	1	1
1	0	$\bar{Q}_n$
1	1	0



What is the output of the combinational logic circuit to the J-input ?

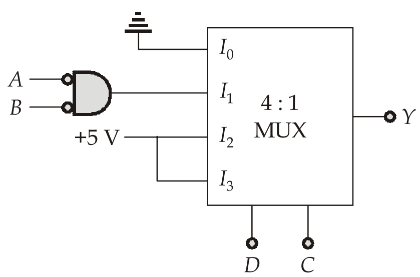
(a) $A \odot B$ (b) AB
(c) $\bar{A}B$ (d) $A \oplus B$

310. (d)

A	B	Q_{n+1}	J	K
0	0	Q_n	0	0
0	1	1	1	0
1	0	$\bar{Q}_n$	1	1
1	1	0	0	1

$$J = A \oplus B$$

Q.311 Consider the following circuit:



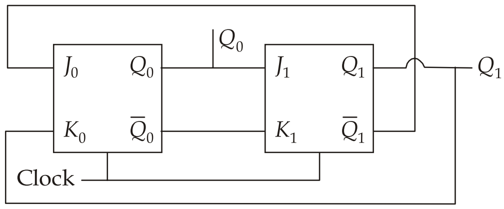
Which one of the following gives the function implemented by the MUX-based digital circuit?

(a) $Y = \bar{A}\bar{B}C\bar{D} + D\bar{C}$
(b) $Y = \bar{A}\bar{B}\bar{D} + C$
(c) $Y = \bar{A}\bar{B} + D\bar{C} + CD$
(d) $Y = \bar{A}\bar{B}C + D$

311. (d)

$$Y = \bar{A}\bar{B}\bar{D}C + D\bar{C} + DC$$
$$= \bar{A}\bar{B}C\bar{D} + D(C + \bar{C})$$
$$= (\bar{A}\bar{B}C + D)(\bar{D} + D)$$
$$Y = \bar{A}\bar{B}C + D$$

Q.312 In the figure shown assume initially $Q_0 = Q_1 = 0$. Then the state of Q_0 and Q_1 immediately after 777^{th} clock pulse are



(a) 01
(b) 00
(c) 11
(d) 10

312. (d)

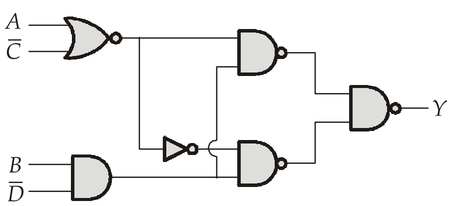
This is a Johnson counter and the no. of states is $2N$, where N is the no. of flip flops.

$$N = 2 \text{ i..e MOD 4 counter}$$
$$Q_0Q_1 = 00 \rightarrow 10 \rightarrow 11 \rightarrow 01 \rightarrow 00$$
$$\text{Number of states completed} = \frac{777}{4} = 194$$
$$\text{Remainder} = 1$$

The logic state after 777^{th} clock pulse is

$$Q_0Q_1 = 10$$

Q.313 In the following circuit, the output Y equals which one of the following?



(a) $B\bar{D} + A\bar{C} + AD$
(b) $C\bar{D} + AB$
(c) $B\bar{D}$
(d) $A\bar{B} + AC$

313. (c)

$$Y = \overline{\overline{\overline{\overline{A+\overline{\overline{C}}}\ B\overline{D}}}\ \overline{(A+\overline{C})B\overline{D}}}$$

$$= \overline{\left((A+\overline{C})+\overline{B\overline{\overline{D}}}\right)\left(\overline{A+\overline{\overline{C}}+\overline{B\overline{\overline{D}}}}\right)}$$

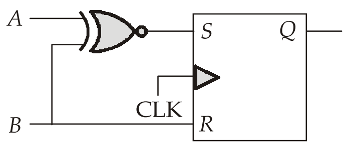
$$= \overline{\left(A+\overline{C}\right)\left(\overline{A+\overline{C}}\right)+\left(\left(A+\overline{C}\right)\overline{B\overline{D}}\right)+\left(\overline{B\overline{D}}\left(\overline{A+\overline{C}}\right)\right)+\left(\overline{B\overline{D}}\,\overline{B\overline{D}}\right)}$$

$$= \overline{\overline{B\overline{\overline{D}}}+\overline{B\overline{\overline{D}}}}$$

$$Y = \overline{\overline{B\overline{\overline{D}}}}$$

$$Y = B\overline{D}$$

Q.314 An AB flip-flop is constructed from an SR flip-flop as shown below. The expression for next state Q^+ is



(a) $\overline{A}\overline{B}+AQ$

(b) $\overline{A}\overline{B}+\overline{B}Q$

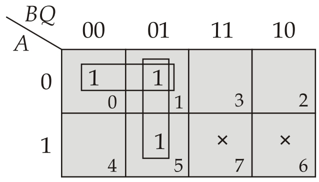
(c) Both (a) and (b)

(d) None of these

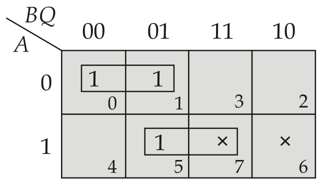
314. (c)

Truth Table:

A	B	Q	S	R	Q^+
0	0	0	1	0	1
0	0	1	1	0	1
0	1	0	0	1	0
0	1	1	0	1	0
1	0	0	0	0	0
1	0	1	0	0	1
1	1	0	1	1	×
1	1	1	1	1	×



$$Q^+ = \overline{A}\overline{B}+\overline{B}Q$$



$$Q^+ = \overline{A}\overline{B}+AQ$$

Q.315 If $t_p \rightarrow$ duration of the clock pulse
$\Delta t \rightarrow$ propagation delay
$T \rightarrow$ clock period
then to avoid the race-around condition occurring with the J-K flip-flop.
(a) $t_p = \Delta t = T$
(b) $t_p > \Delta t = T$
(c) $t_p < \Delta t < T$
(d) $t_p < \Delta t = T$

315. (c)

To avoid race around condition

$$t_p < \Delta t < T$$

Q.316 Which of the following statements is/are true about the Asynchronous counter?
1. The design implementation is simple.
2. The speed becomes slow as the number of states increases.
3. All the flip-flops are triggered same clock signal simultaneously.

(a) 1 only
(b) 1 and 2 only
(c) 2 and 3 only
(d) 1, 2 and 3

316. (b)

In asynchronous counter all flip-flops are not triggered with the clock signal simultaneously.

Q.317 For an edge-triggered D flip-flop
1. Change in the state of the flip-flop can occur only at a clock pulse edge.
2. The state of the flip-flop depends on the D-input.
3. The output follows the input at each clock pulse.

(a) 1 and 2 only
(b) 1 and 3 only
(c) 2 and 3 only
(d) 1, 2 and 3

317. (d)

Direction (Q.318 to Q.320): The following items consists of two statements, one labelled as **Statement (I)** and the other labelled as **Statement (II)**. You have to examine these two statements carefully and select your answers to these items using the codes given below:

Codes:
(a) Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are true but Statement (II) is **not** a correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

Q.318 Statement (I): In phase lead compensation settling time is reduced and thus speed of the time response is improved.
Statement (II): In phase lead compensation the bandwidth is increased.

318. (a)

The bandwidth in phase lead compensation is increased, thus improving the speed of response.

Q.319 Statement (I): The phase angle for a minimum phase transfer function at $\omega = \infty$ is $[-90(m - n)]°$, where n and m are the orders of the numerator and denominator polynomials of the transfer function respectively.

Statement (II): The phase angle for non minimum phase transfer function is not $[-90(m - n)]°$.

319. (b)

Both statements are independently correct but has no relationship together.

Q.320 Statement (I): Polarities of output voltage and the direction of output current in a chopper are restricted.

Statement (II): Power semiconductor devices used in a chopper circuit are bidirectional.

320. (c)

Power semiconductor devices used in chopper circuits are unidirectional devices.

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