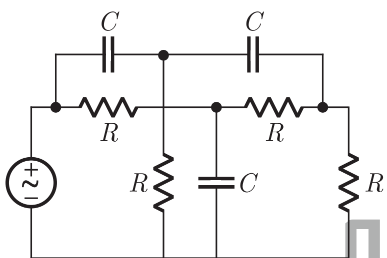
GATE EC 2003

Q. 1-30 Carry One Mark Each

MCQ 1.1 The minimum number of equations required to analyze the circuit shown in the figure is



(A) 3 (B) 4

(C) 6 (D) 7

SOL 1.1 Hence (B) is correct option.

$$\text{Number of loops} = b - n + 1$$
$$= \text{minimum number of equation}$$
$$\text{Number of branches} = b = 8$$
$$\text{Number of nodes} = n = 5$$

Minimum number of equation

$$= 8 - 5 + 1 = 4$$

MCQ 1.2 A source of angular frequency 1 rad/sec has a source impedance consisting of 1 Ω resistance in series with 1 H inductance. The load that will obtain the maximum power transfer is

(A) 1 Ω resistance

(B) 1 Ω resistance in parallel with 1 H inductance

(C) 1 Ω resistance in series with 1 F capacitor

(D) 1 Ω resistance in parallel with 1 F capacitor

SOL 1.2 For maximum power transfer

$$Z_L = Z_S^* = R_s - jX_s$$

Thus $\quad Z_L = 1 - 1j$

Hence (C) is correct option.

MCQ 1.3 A series RLC circuit has a resonance frequency of 1 kHz and a quality factor $Q = 100$. If each of R, L and C is doubled from its original value, the new Q of the circuit is

(A) 25 (B) 50

(C) 100 (D) 200

SOL 1.3 Hence (B) is correct option.

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

When R, L and C are doubled,

$$Q' = \frac{1}{2R}\sqrt{\frac{2L}{2C}} = \frac{1}{2R}\sqrt{\frac{L}{C}} = \frac{Q}{2}$$

Thus $\quad Q' = \frac{100}{2} = 50$

MCQ 1.4 The Laplace transform of $i(t)$ is given by

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

At $t \to \infty$, The value of $i(t)$ tends to

(A) 0 (B) 1

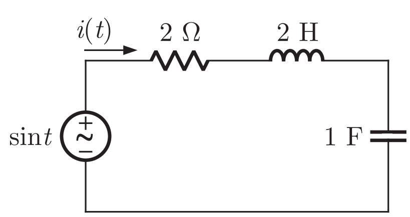
(C) 2 (D) ∞

SOL 1.4 From the Final value theorem we have

$$\lim_{t \to \infty} i(t) = \lim_{s \to 0} sI(s) = \lim_{s \to 0} s\frac{2}{s(1+s)} = \lim_{s \to 0}\frac{2}{(1+s)} = 2$$

Hence (C) is correct answer

MCQ 1.5 The differential equation for the current $i(t)$ in the circuit of the figure is



(A) $2\frac{d^2i}{dt^2} + 2\frac{di}{dt} + i(t) = \sin t$ (B) $\frac{d^2i}{dt^2} + 2\frac{di}{dt} + 2i(t) = \cos t$

(C) $2\frac{d^2i}{dt^2} + 2\frac{di}{dt} + i(t) = \cos t$ (D) $\frac{d^2i}{dt^2} + 2\frac{di}{dt} + 2i(t) = \sin t$

SOL 1.5 Applying KVL we get,

$$\sin t = Ri(t) + L\frac{di(t)}{dt} + \frac{1}{C}\int i(t)\,dt$$

or $$\sin t = 2i(t) + 2\frac{di(t)}{dt} + \int i(t)\,dt$$

Differentiating with respect to t, we get

$$\cos t = \frac{2di(t)}{dt} + \frac{2d^2 i(t)}{dt^2} + i(t)$$

Hence (C) is correct option.

MCQ 1.6 n-type silicon is obtained by doping silicon with

(A) Germanium (B) Aluminium

(C) Boron (D) Phosphorus

SOL 1.6 Pentavalent make $n-$type semiconductor and phosphorous is pentavalent.

Hence option (D) is correct.

MCQ 1.7 The Bandgap of silicon at 300 K is

(A) 1.36 eV (B) 1.10 eV

(C) 0.80 eV (D) 0.67 eV

SOL 1.7 Hence option (B) is correct.

For silicon at 0 K $E_{g0} = 1.21$ eV

At any temperature

$$E_{gT} = E_{g0} - 3.6 \times 10^{-4} T$$

At $T = 300$ K,

$$E_{g300} = 1.21 - 3.6 \times 10^{-4} \times 300 = 1.1 \text{ eV}$$

This is standard value, that must be remembered.

MCQ 1.8 The intrinsic carrier concentration of silicon sample at 300 K is 1.5×10^{16} /m³. If after doping, the number of majority carriers is 5×10^{20}/m³, the minority carrier density is

(A) 4.50×10^{11}/m³ (B) 3.333×10^{4}/m³

(C) 5.00×10^{20}/m³ (D) 3.00×10^{-5}/m³

SOL 1.8 By Mass action law

$$np = n_i^2$$

$$p = \frac{n_i^2}{n} = \frac{1.5 \times 10^{16} \times 1.5 \times 10^{16}}{5 \times 10^{20}} = 4.5 \times 10^{11}$$

Hence option (A) is correct.

MCQ 1.9 Choose proper substitutes for X and Y to make the following statement correct Tunnel diode and Avalanche photo diode are operated in X bias ad Y bias respectively

(A) X: reverse, Y: reverse (B) X: reverse, Y: forward

(C) X: forward, Y: reverse (D) X: forward, Y: forward

SOL 1.9 Tunnel diode shows the negative characteristics in forward bias. It is used in forward

bias.
Avalanche photo diode is used in reverse bias.
Hence option (C) is correct.

MCQ 1.10 For an $n-$ channel enhancement type MOSFET, if the source is connected at a higher potential than that of the bulk (i.e. $V_{SB} > 0$), the threshold voltage V_T of the MOSFET will

(A) remain unchanged
(B) decrease
(C) change polarity
(D) increase

SOL 1.10 Hence option (D) is correct.

MCQ 1.11 Choose the correct match for input resistance of various amplifier configurations shown below :

Configuration	Input resistance
CB : Common Base	LO : Low
CC : Common Collector	MO : Moderate
CE : Common Emitter	HI : High

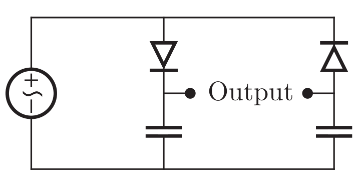
(A) CB – LO, CC – MO, CE – HI
(B) CB – LO, CC – HI, CE – MO
(C) CB – MO, CC – HI, CE – LO
(D) CB – HI, CC – LO, CE – MO

SOL 1.11 For the different combinations the table is as follows

CE	*CE*	*CC*	*CB*
A_i	High	High	Unity
A_v	High	Unity	High
R_i	Medium	High	Low
R_o	Medium	Low	High

Hence (B) is correct option.

MCQ 1.12 The circuit shown in the figure is best described as a

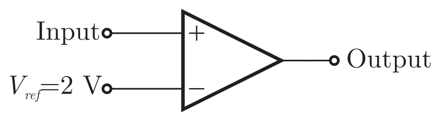


(A) bridge rectifier
(B) ring modulator
(C) frequency discriminator
(D) voltage double

SOL 1.12 This circuit having two diode and capacitor pair in parallel, works as voltage

doubler.
Hence (D) is correct option.

MCQ 1.13 If the input to the ideal comparators shown in the figure is a sinusoidal signal of 8 V (peak to peak) without any DC component, then the output of the comparators has a duty cycle of

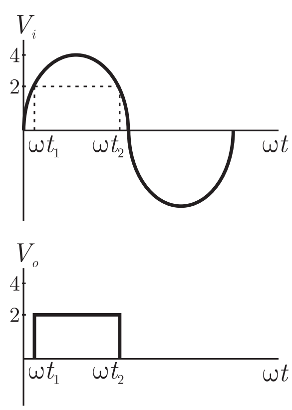


(A) 1/2 (B) 1/3
(C) 1/6 (D) 1/2

SOL 1.13 If the input is sinusoidal signal of 8 V (peak to peak) then

$$V_i = 4\sin\omega t$$

The output of comparator will be high when input is higher than $V_{ref} = 2$ V and will be low when input is lower than $V_{ref} = 2$ V. Thus the waveform for input is shown below



From fig, first crossover is at ωt_1 and second crossover is at ωt_2 where

$$4\sin\omega t_1 = 2\,V$$

Thus $\omega t_1 = \sin^{-1}\frac{1}{2} = \frac{\pi}{6}$

$$\omega t_2 = \pi - \frac{\pi}{6} = \frac{5\pi}{6}$$

$$\text{Duty Cycle} = \frac{\frac{5\pi}{6} - \frac{\pi}{6}}{2\pi} = \frac{1}{3}$$

Thus the output of comparators has a duty cycle of $\frac{1}{3}$.
Hence (B) is correct option.

MCQ 1.14 If the differential voltage gain and the common mode voltage gain of a differential amplifier are 48 dB and 2 dB respectively, then common mode rejection ratio is
(A) 23 dB (B) 25 dB

(C) 46 dB (D) 50 dB

SOL 1.14 Hence (C) is correct option.

$$CMMR = \frac{A_d}{A_c}$$

or $$20\log CMMR = 20\log A_d - 20\log A_c$$
$$= 48 - 2 = 46 \text{ dB}$$

Where $A_d \rightarrow$ Differential Voltage Gain
and $A_C \rightarrow$ Common Mode Voltage Gain

MCQ 1.15 Generally, the gain of a transistor amplifier falls at high frequencies due to the
(A) internal capacitances of the device
(B) coupling capacitor at the input
(C) skin effect
(D) coupling capacitor at the output

SOL 1.15 The gain of amplifier is

$$A_i = \frac{-g_m}{g_b + j\omega C}$$

Thus the gain of a transistor amplifier falls at high frequencies due to the internal capacitance that are diffusion capacitance and transition capacitance.
Hence (B) is correct option.

MCQ 1.16 The number of distinct Boolean expressions of 4 variables is
(A) 16 (B) 256
(C) 1023 (D) 65536

SOL 1.16 The number of distinct boolean expression of n variable is 2^{2^n}. Thus

$$2^{2^4} = 2^{16} = 65536$$

Hence (D) is correct answer.

MCQ 1.17 The minimum number of comparators required to build an 8-bits flash ADC is
(A) 8 (B) 63
(C) 255 (D) 256

SOL 1.17 In the flash analog to digital converter, the no. of comparators is equal to 2^{n-1}, where n is no. of bit.s

So, $$2^{n-1} = 2^8 - 1 = 255$$

Hence (C) is correct answer.

MCQ 1.18 The output of the 74 series of GATE of TTL gates is taken from a BJT in
(A) totem pole and common collector configuration
(B) either totem pole or open collector configuration
(C) common base configuration

(D) common collector configuration

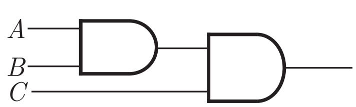
SOL 1.18 When output of the 74 series gate of TTL gates is taken from BJT then the configuration is either totem pole or open collector configuration .
Hence (B) is correct answer.

MCQ 1.19 Without any additional circuitry, an 8:1 MUX can be used to obtain
(A) some but not all Boolean functions of 3 variables
(B) all functions of 3 variables but non of 4 variables
(C) all functions of 3 variables and some but not all of 4 variables
(D) all functions of 4 variables

SOL 1.19 A 2^n:1 MUX can implement all logic functions of $(n+1)$ variable without andy additional circuitry. Here $n = 3$. Thus a 8 : 1 MUX can implement all logic functions of 4 variable.
Here (D) is correct answer.

MCQ 1.20 A 0 to 6 counter consists of 3 flip flops and a combination circuit of 2 input gate (s). The common circuit consists of
(A) one AND gate (B) one OR gate
(C) one AND gate and one OR gate (D) two AND gates

SOL 1.20 Counter must be reset when it count 111. This can be implemented by following circuitry



Hence (D) is correct answer.

MCQ 1.21 The Fourier series expansion of a real periodic signal with fundamental frequency f_0 is given by $g_p(t) = \sum_{n=-\infty} c_n e^{j2\pi f_0 t}$. It is given that $c_3 = 3 + j5$. Then c_{-3} is
(A) $5 + j3$ (B) $-3 - j5$
(C) $-5 + j3$ (D) $3 - j5$

SOL 1.21 Hence (D) is correct answer.
Here$C_3 = 3 + j5$
For real periodic signal

$$C_{-k} = C_k^*$$

Thus $C_{-3} = C_k = 3 - j5$

MCQ 1.22 Let $x(t)$ be the input to a linear, time-invariant system. The required output is $4\pi(t-2)$. The transfer function of the system should be
(A) $4e^{j4\pi f}$ (B) $2e^{-j8\pi f}$
(C) $4e^{-j4\pi f}$ (D) $2e^{j8\pi f}$

SOL 1.22 Hence (C) is correct answer.

$$y(t) = 4x(t-2)$$

Taking Fourier transform we get

$$Y(e^{j2\pi f}) = 4e^{-j2\pi f2} X(e^{j2\pi f}) \qquad \text{Time Shifting property}$$

or $$\frac{Y(e^{j2\pi f})}{X(e^{j2\pi f})} = 4e^{-4j\pi f}$$

Thus $H(e^{j2\pi f}) = 4e^{-4j\pi f}$

MCQ 1.23 A sequence $x(n)$ with the z −transform $X(z) = z^4 + z^2 - 2z + 2 - 3z^{-4}$ is applied as an input to a linear, time-invariant system with the impulse response $h(n) = 2\delta(n-3)$ where

$$\delta(n) = \begin{cases} 1, & n = 0 \\ 0, & \text{otherwise} \end{cases}$$

The output at $n = 4$ is

(A) -6 (B) zero

(C) 2 (D) -4

SOL 1.23 Hence (B) is correct answer.

We have $h(n) = 3\delta(n-3)$

or $H(z) = 2z^{-3}$ Taking z transform

$X(z) = z^4 + z^2 - 2z + 2 - 3z^{-4}$

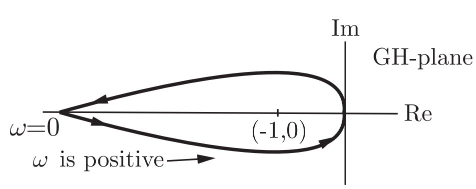
Now
$$\begin{aligned} Y(z) &= H(z)X(z) \\ &= 2z^{-3}(z^4 + z^2 - 2z + 2 - 3z^{-4}) \\ &= 2(z + z^{-1} - 2z^{-2} + 2z^{-3} - 3z^{-7}) \end{aligned}$$

Taking inverse z transform we have

$$y(n) = 2[\delta(n+1) + \delta(n-1) - 2\delta(n-2) + 2\delta(n-3) - 3\delta(n-7)]$$

At $n = 4, y(4) = 0$

MCQ 1.24 Fig. shows the Nyquist plot of the open-loop transfer function $G(s)H(s)$ of a system. If $G(s)H(s)$ has one right-hand pole, the closed-loop system is



(A) always stable

(B) unstable with one closed-loop right hand pole

(C) unstable with two closed-loop right hand poles

(D) unstable with three closed-loop right hand poles

SOL 1.24 Hence (A) is correct option.

$$Z = P - N$$

$N \rightarrow$ Net encirclement of $(-1 + j0)$ by Nyquist plot,
$P \rightarrow$ Number of open loop poles in right hand side of $s-$ plane
$Z \rightarrow$ Number of closed loop poles in right hand side of $s-$ plane
Here $N = 1$ and $P = 1$
Thus $Z = 0$
Hence there are no roots on RH of $s-$plane and system is always stable.

MCQ 1.25 A PD controller is used to compensate a system. Compared to the uncompensated system, the compensated system has
(A) a higher type number
(B) reduced damping
(C) higher noise amplification
(D) larger transient overshoot

SOL 1.25 PD Controller may accentuate noise at higher frequency. It does not effect the type of system and it increases the damping. It also reduce the maximum overshoot.
Hence (C) is correct option.

MCQ 1.26 The input to a coherent detector is DSB-SC signal plus noise. The noise at the detector output is
(A) the in-phase component
(B) the quadrature - component
(C) zero
(D) the envelope

SOL 1.26 The input is a coherent detector is DSB - SC signal plus noise. The noise at the detector output is the in-phase component as the quadrature component $n_q(t)$ of the noise $n(t)$ is completely rejected by the detector.
Hence (A) is correct option.

MCQ 1.27 The noise at the input to an ideal frequency detector is white. The detector is operating above threshold. The power spectral density of the noise at the output is
(A) raised - cosine
(B) flat
(C) parabolic
(D) Gaussian

SOL 1.27 The noise at the input to an ideal frequency detector is white. The PSD of noise at the output is parabolic
Hence (C) is correct option.

MCQ 1.28 At a given probability of error, binary coherent FSK is inferior to binary coherent PSK by.
(A) 6 dB
(B) 3 dB
(C) 2 dB
(D) 0 dB

SOL 1.28 Hence (B) is correct option.

We have $P_e = \frac{1}{2}\mathrm{erfc}\left(\sqrt{\frac{E_d}{2\eta}}\right)$

Since P_e of Binary FSK is 3 dB inferior to binary PSK

MCQ 1.29 The unit of $\nabla\times H$ is

(A) Ampere (B) Ampere/meter

(C) Ampere/meter^2 (D) Ampere-meter

SOL 1.29 By Maxwells equations

$$\nabla\times\vec{H} = \frac{\partial\vec{D}}{\partial t} + J$$

Thus $\nabla\times\vec{H}$ has unit of current density J that is A/m^2

Hence (C) is correct option

MCQ 1.30 The depth of penetration of electromagnetic wave in a medium having conductivity σ at a frequency of 1 MHz is 25 cm. The depth of penetration at a frequency of 4 MHz will be

(A) 6.25 dm (B) 12.50 cm

(C) 50.00 cm (D) 100.00 cm

SOL 1.30 Hence (B) is correct option.

We know that $\delta \propto \frac{1}{\sqrt{f}}$

Thus $\frac{\delta_2}{\delta_1} = \sqrt{\frac{f_1}{f_2}}$

$$\frac{\delta_2}{25} = \sqrt{\frac{1}{4}}$$

or $\delta_2 = \sqrt{\frac{1}{4}}\times 25 = 12.5$ cm

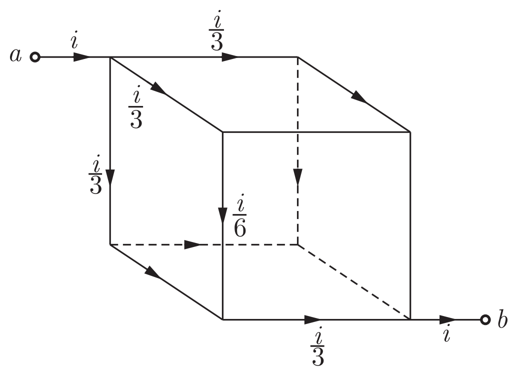
Q.31-90 Carry Two Marks Each

MCQ 1.31 Twelve 1 Ω resistance are used as edges to form a cube. The resistance between two diagonally opposite corners of the cube is

(A) $\frac{5}{6}\,\Omega$ (B) $1\,\Omega$

(C) $\frac{6}{5}\,\Omega$ (D) $\frac{3}{2}\,\Omega$

SOL 1.31 For current i there is 3 similar path. So current will be divide in three path



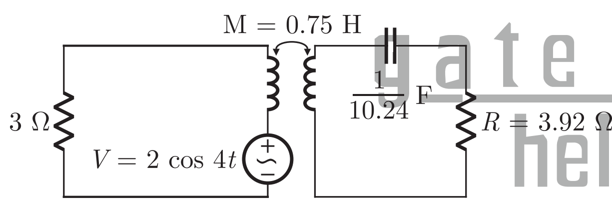
so, we get

$$V_{ab} - \left(\frac{i}{3} \times 1\right) - \left(\frac{i}{6} \times 1\right) - \left(\frac{1}{3} \times 1\right) = 0$$

$$\frac{V_{ab}}{i} = R_{eq} = \frac{1}{3} + \frac{1}{6} + \frac{1}{3} = \frac{5}{6}\Omega$$

Hence (A) is correct option.

MCQ 1.32 The current flowing through the resistance R in the circuit in the figure has the form $P\cos 4t$ where P is



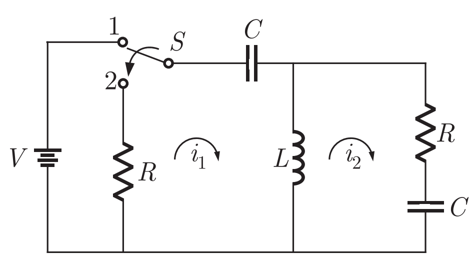
(A) $(0.18 + j0.72)$ (B) $(0.46 + j1.90)$

(C) $-(0.18 + j1.90)$ (D) $-(0.192 + j0.144)$

SOL 1.32 Data are missing in question as $L_1 \& L_2$ are not given

The circuit for Q. 33 & 34 is given below.

Assume that the switch S is in position 1 for a long time and thrown to position 2 at $t = 0$.



MCQ 1.33 At $t = 0^+$, the current i_1 is

(A) $\frac{-V}{2R}$ (B) $\frac{-V}{R}$

(C) $\frac{-V}{4R}$ (D) zero

SOL 1.33 Data are missing in question as $L_1 \& L_2$ are not given

MCQ 1.34 $I_1(s)$ and $I_2(s)$ are the Laplace transforms of $i_1(t)$ and $i_2(t)$ respectively. The equations for the loop currents $I_1(s)$ and $I_2(s)$ for the circuit shown in the figure, after the switch is brought from position 1 to position 2 at $t = 0$, are

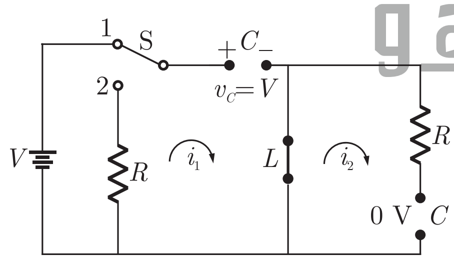
(A) $\begin{bmatrix} R + Ls + \frac{1}{Cs} & -Ls \\ -Ls & R + \frac{1}{Cs} \end{bmatrix} \begin{bmatrix} I_1(s) \\ I_2(s) \end{bmatrix} = \begin{bmatrix} \frac{V}{s} \\ 0 \end{bmatrix}$

(B) $\begin{bmatrix} R + Ls + \frac{1}{Cs} & -Ls \\ -Ls & R + \frac{1}{Cs} \end{bmatrix} \begin{bmatrix} I_1(s) \\ I_2(s) \end{bmatrix} = \begin{bmatrix} -\frac{V}{s} \\ 0 \end{bmatrix}$

(C) $\begin{bmatrix} R + Ls + \frac{1}{Cs} & -Ls \\ -Ls & R + Ls + \frac{1}{Cs} \end{bmatrix} \begin{bmatrix} I_1(s) \\ I_2(s) \end{bmatrix} = \begin{bmatrix} -\frac{V}{s} \\ 0 \end{bmatrix}$

(D) $\begin{bmatrix} R + Ls + \frac{1}{Cs} & -Cs \\ -Ls & R + Ls + \frac{1}{Cs} \end{bmatrix} \begin{bmatrix} I_1(s) \\ I_2(s) \end{bmatrix} = \begin{bmatrix} \frac{V}{s} \\ 0 \end{bmatrix}$

SOL 1.34 At $t = 0^-$ circuit is in steady state. So inductor act as short circuit and capacitor act as open circuit.

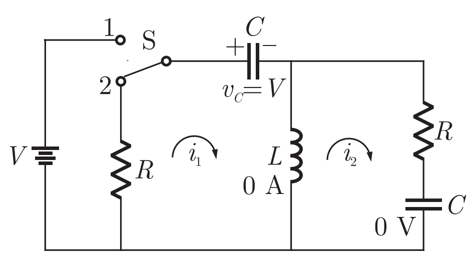


At $t(0^-)$

At $t = 0^-$, $\quad i_1(0^-) = i_2(0^-) = 0$

$v_c(0^-) = V$

At $t = 0^+$ the circuit is as shown in fig. The voltage across capacitor and current in inductor can't be changed instantaneously. Thus



At $t(0^+)$

At $t = 0^+$, $\quad i_1 = i_2 = -\frac{V}{2R}$

Hence (A) is correct option.

MCQ 1.35 An input voltage $v(t) = 10\sqrt{2}\cos(t+10^\circ) + 10\sqrt{5}\cos(2t+10^\circ)$ V is applied to a series combination of resistance $R = 1\,\Omega$ and an inductance $L = 1$ H. The resulting steady-state current $i(t)$ in ampere is

(A) $10\cos(t+55^\circ) + 10\cos(2t+10^\circ+\tan^{-1}2)$

(B) $10\cos(t+55^\circ) + 10\sqrt{\frac{3}{2}}\cos(2t+55^\circ)$

(C) $10\cos(t-35^\circ) + 10\cos(2t+10^\circ-\tan^{-1}2)$

(D) $10\cos(t-35^\circ) + \sqrt{\frac{3}{2}}\cos(2t-35^\circ)$

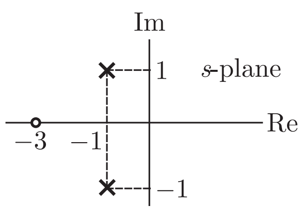
SOL 1.35 Hence (C) is correct option

$$v(t) = \underbrace{10\sqrt{2}\cos(t+10^\circ)}_{v_1} + \underbrace{10\sqrt{5}\cos(2t+10^\circ)}_{v_2}$$

Thus we get $\omega_1 = 1$ and $\omega_2 = 2$

Now
$$Z_1 = R + j\omega_1 L = 1 + j1$$
$$Z_2 = R + j\omega_2 L = 1 + j2$$
$$i(t) = \frac{v_1(t)}{Z_1} + \frac{v_2(t)}{Z_2}$$
$$= \frac{10\sqrt{2}\cos(t+10^\circ)}{1+j} + \frac{10\sqrt{5}\cos(2t+10^\circ)}{1+j2}$$
$$= \frac{10\sqrt{2}\cos(t+10^\circ)}{\sqrt{1^2+2^2}\angle\tan^{-1}1} + \frac{10\sqrt{5}\cos(2t+10^\circ)}{\sqrt{1^2+2^2}\tan^{-1}2}$$
$$= \frac{10\sqrt{2}\cos(t+10^\circ)}{\sqrt{2}\angle\tan^{-1}45^\circ} + \frac{10\sqrt{5}\cos(2t+10^\circ)}{\sqrt{5}\tan^{-1}2}$$
$$i(t) = 10\cos(t-35^\circ) + 10\cos(2t+10^\circ-\tan^{-1}2)$$

MCQ 1.36 The driving point impedance $Z(s)$ of a network has the pole-zero locations as shown in the figure. If $Z(0) = 3$, then $Z(s)$ is



(A) $\frac{3(s+3)}{s^2+2s+3}$

(B) $\frac{2(s+3)}{s^2+2s+2}$

(C) $\frac{3(s+3)}{s^2+2s+2}$

(D) $\frac{2(s-3)}{s^2-2s-3}$

SOL 1.36 Hence (B) is correct option.

$$\text{Zeros} = -3$$
$$\text{Pole}_1 = -1 + j$$
$$\text{Pole}_2 = -1 - j$$

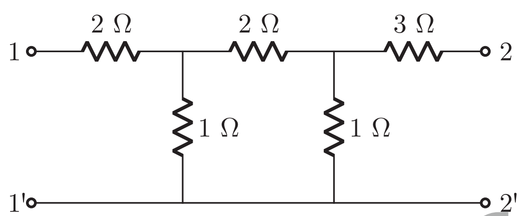
$$Z(s) = \frac{K(s+3)}{(s+1+j)(s+1-j)}$$
$$= \frac{K(s+3)}{(s+1)^2 - j^2} = \frac{K(s+3)}{(s+1)^2+1}$$

From problem statement $Z(0)|_{\omega=0} = 3$

Thus $\frac{3K}{2} = 3$ and we get $K = 2$

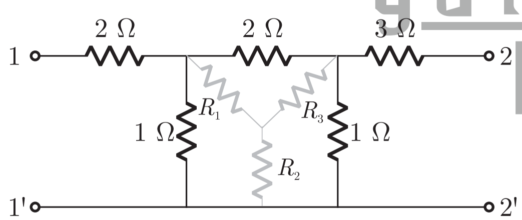
$$Z(s) = \frac{2(s+3)}{s^2+2s+2}$$

MCQ 1.37 The impedance parameters z_{11} and z_{12} of the two-port network in the figure are



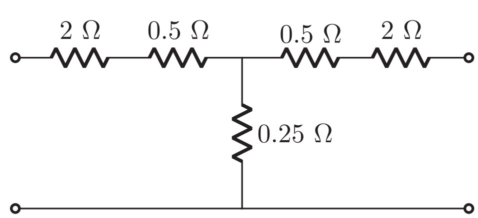
(A) $z_{11} = 2.75\,\Omega$ and $z_{12} = 0.25\,\Omega$
(B) $z_{11} = 3\,\Omega$ and $z_{12} = 0.5\,\Omega$
(C) $z_{11} = 3\,\Omega$ and $z_{12} = 0.25\,\Omega$
(D) $z_{11} = 2.25\,\Omega$ and $z_{12} = 0.5\,\Omega$

SOL 1.37 Using $\Delta -\ Y$ conversion



$$R_1 = \frac{2\times 1}{2+1+1} = \frac{2}{4} = 0.5$$
$$R_2 = \frac{1\times 1}{2+1+1} = \frac{1}{4} = 0.25$$
$$R_3 = \frac{2\times 1}{2+1+1} = 0.5$$

Now the circuit is as shown in figure below.



Now $z_{11} = \frac{V_1}{I_1}\Big|_{I_2=0} = 2 + 0.5 + 0.25 = 2.75$

$$z_{12} = R_3 = 0.25$$

Hence (A) is correct option.

MCQ 1.38 An $n-$type silicon bar 0.1 cm long and 100 μm^2 i cross-sectional area has a majority carrier concentration of 5×10^{20}/m² and the carrier mobility is 0.13 m^2/V-s at 300 K. If the charge of an electron is 1.5×10^{-19} coulomb, then the resistance of the bar is

(A) 10^6 Ohm (B) 10^4 Ohm

(C) 10^{-1} Ohm (D) 10^{-4} Ohm

SOL 1.38 Hence option (A) is correct.

We that $$R = \frac{\rho l}{A},\ \rho = \frac{1}{\sigma} \text{ and } \alpha = nqu_n$$

From above relation we have

$$R = \frac{1}{nq\mu_n A}$$

$$= \frac{0.1\times10^{-2}}{5\times10^{20}\times1.6\times10^{-19}\times0.13\times100\times10^{-12}} = 10^6\Omega$$

MCQ 1.39 The electron concentration in a sample of uniformly doped n-type silicon at 300 K varies linearly from 10^{17}/cm³ at $x=0$ to 6×10^{16}/cm³ at $x=2\mu m$. Assume a situation that electrons are supplied to keep this concentration gradient constant with time. If electronic charge is 1.6×10^{-19} coulomb and the diffusion constant $D_n=35$ cm²/s, the current density in the silicon, if no electric field is present, is

(A) zero (B) -112 A/cm²

(C) +1120 A/cm² (D) -1120 A/cm²

SOL 1.39 Hence option (D) is correct.

$$\frac{dn}{dx} = \frac{6\times10^{16}-10^{17}}{2\times10^{-4}-0}$$

$$=-2\times10^{20}$$

Now $$J_n = nq\mu_e E + D_n q\frac{dn}{dx}$$

Since no electric field is present, $E=0$ and we get

So, $$J_n = qD_n\frac{dn}{dx}$$

$$= 1.6\times10^{-19}\times35\times(-2\times10^{20}) = -1120 \text{ A/cm}^2$$

MCQ 1.40 Match items in Group 1 with items in Group 2, most suitably.

Group 1	Group 2
P. LED	1. Heavy doping
Q. Avalanche photo diode	2. Coherent radiation
R. Tunnel diode	3. Spontaneous emission
S. LASER	4. Current gain

(A) P - 1, Q - 2, R - 4, S - 3

(B) P - 2, Q - 3, R - 1, S - 4

(C) P - 3 Q - 4, R - 1, S - 2

(D) P - 2, Q - 1, R - 4, S - 3

SOL 1.40 LED works on the principal of spontaneous emission.
In the avalanche photo diode due to the avalanche effect there is large current gain.
Tunnel diode has very large doping.
LASER diode are used for coherent radiation.
Hence option (C) is correct.

MCQ 1.41 At 300 K, for a diode current of 1 mA, a certain germanium diode requires a forward bias of 0.1435 V, whereas a certain silicon diode requires a forward bias of 0.718 V. Under the conditions state above, the closest approximation of the ratio of reverse saturation current in germanium diode to that in silicon diode is

(A) 1 (B) 5

(C) 4×10^3 (D) 8×10^3

SOL 1.41 Hence option (C) is correct.

We know that $I = I_{O_{si}}\left(e^{\eta\frac{V_{D1}}{V_T}} - 1\right)$

where $\eta = 1$ for germanium and $\eta = 2$ silicon. As per question

$$I_{O_n}\left(e^{\frac{V_{Dsi}}{e^{\eta VT}}} - 1\right) = I_{O_{Ge}}\left(e^{\frac{V_{DGe}}{\eta V_T}} - 1\right)$$

or $$\frac{I_{O_{si}}}{I_{O_{si}}} = \frac{e^{\frac{V_{Dsi}}{\eta V_T}} - 1}{e^{\frac{V_{DGe}}{\eta V_T}} - 1} = \frac{e^{\frac{0.718}{2\times26\times10^{-3}}} - 1}{e^{\frac{0.1435}{26\times10^{-3}}} - 1} = 4\times10^3$$

MCQ 1.42 A particular green LED emits light of wavelength 5490 A°. The energy bandgap of the semiconductor material used there is
(Plank's constant $= 6.626\times10^{-34}\,J - s$)

(A) 2.26 eV (B) 1.98 eV

(C) 1.17 eV (D) 0.74 eV

SOL 1.42 Hence option (A) is correct

$$E_g = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\times3\times10^8}{54900\times10^{-10}} = 3.62\text{ J}$$

In eV $$E_g(eV) = \frac{E_g(J)}{e} = \frac{3.62\times10^{-19}}{1.6\times10^{-19}} = 2.26\text{ eV}$$

Alternatively

$$E_g = \frac{1.24}{\lambda(\mu\text{m})}\text{ eV} = \frac{1.24}{5490\times10^{-4}\mu\text{m}} = 2.26\text{ eV}$$

MCQ 1.43 When the gate-to-source voltage (V_{Gs}) of a MOSFET with threshold voltage of 400 mV, working in saturation is 900 mV, the drain current is observed to be 1 mA.

Neglecting the channel width modulation effect and assuming that the MOSFET is operating at saturation, the drain current for an applied V_{GS} of 1400 mV is

(A) 0.5 mA (B) 2.0 mA

(C) 3.5 mA (D) 4.0 mA

SOL 1.43 We know that

$$I_D = K(V_{GS} - V_T)^2$$

Thus $$\frac{I_{D2}}{I_{D1}} = \frac{(V_{GS2} - V_T)^2}{(V_{GS1} - V_T)^2}$$

Substituting the values we have

$$\frac{I_{D2}}{I_{D1}} = \frac{(1.4 - 0.4)^2}{(0.9 - 0.4)^2} = 4$$

or $$I_{D2} = 4I_{DI} = 4 \text{ mA}$$

Hence option (D) is correct.

MCQ 1.44 If P is Passivation, Q is n −well implant, R is metallization and S is source/drain diffusion, then the order in which they are carried out in a standard n −well CMOS fabrication process, is

(A) $P - Q - R - S$ (B) $Q - S - R - P$

(C) $R - P - S - Q$ (D) $S - R - Q - P$

SOL 1.44 In n −well CMOS fabrication following are the steps :

(i) $n-$ well implant (Q)

(ii) Source drain diffusion (S)

(iii) Metalization (R)

(iv) Passivation (P)

Hence option (B) is correct.

MCQ 1.45 An amplifier without feedback has a voltage gain of 50, input resistance of 1 k Ω and output resistance of 2.5 kΩ. The input resistance of the current-shunt negative feedback amplifier using the above amplifier with a feedback factor of 0.2, is

(A) $\frac{1}{11}$ kΩ (B) $\frac{1}{5}$ kΩ

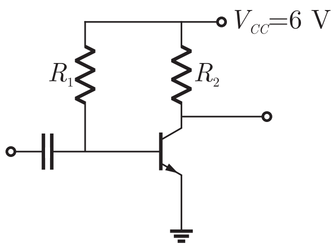
(C) 5 kΩ (D) 11 kΩ

SOL 1.45 Hence (A) is correct option.

We have $R_i = 1\text{k}\Omega, \beta = 0.2, A = 50$

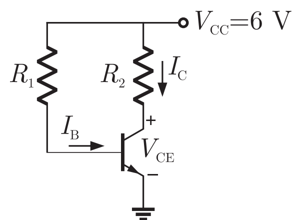
Thus, $$R_{if} = \frac{R_i}{(1 + A\beta)} = \frac{1}{11}\text{k}\Omega$$

MCQ 1.46 In the amplifier circuit shown in the figure, the values of R_1 and R_2 are such that the transistor is operating at $V_{CE} = 3$ V and $I_C = 1.5$ mA when its β is 150. For a transistor with β of 200, the operating point (V_{CE}, I_C) is



(A) (2 V, 2 mA)
(B) (3 V, 2 mA)
(C) (4 V, 2 mA)
(D) (4 V, 1 mA)

SOL 1.46 The DC equivalent circuit is shown as below. This is fixed bias circuit operating in active region.



In first case

$$V_{CC} - I_{C1}R_2 - V_{CE1} = 0$$

or $$6 - 1.5\text{m}R_2 - 3 = 0$$

or $$R_2 = 2k\Omega$$

$$I_{B1} = \frac{I_{C1}}{\beta_1} = \frac{1.5\text{m}}{150} = 0.01 \text{ mA}$$

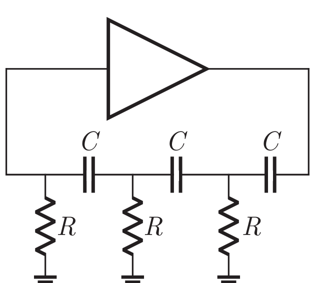
In second case I_{B2} will we equal to I_{B1} as there is no in R_1.

Thus $$I_{C2} = \beta_2 I_{B2} = 200 \times 0.01 = 2 \text{ mA}$$

$$V_{CE2} = V_{CC} - I_{C2}R_2 = 6 - 2\text{m} \times 2\text{ k}\Omega = 2 \text{ V}$$

Hence (A) is correct option.

MCQ 1.47 The oscillator circuit shown in the figure has an ideal inverting amplifier. Its frequency of oscillation (in Hz) is



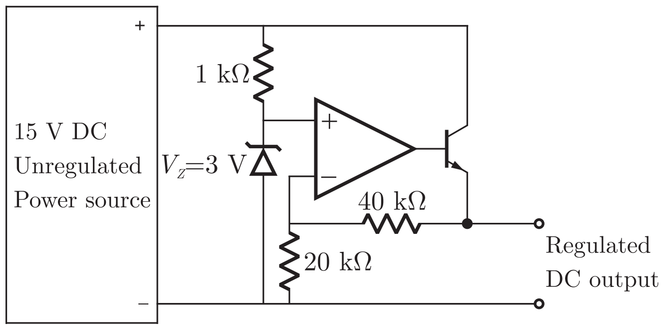
(A) $\frac{1}{(2\pi\sqrt{6}\,RC)}$
(B) $\frac{1}{(2\pi RC)}$
(C) $\frac{1}{(\sqrt{6}\,RC)}$
(D) $\frac{\sqrt{6}}{(2\pi RC)}$

SOL 1.47 The given circuit is a $R-C$ phase shift oscillator and frequency of its oscillation is

$$f = \frac{1}{2\pi\sqrt{6}\,RC}$$

Hence (A) is correct option.

MCQ 1.48 The output voltage of the regulated power supply shown in the figure is



(A) 3 V (B) 6 V

(C) 9 V (D) 12 V

SOL 1.48 If we see th figure we find that the voltage at non-inverting terminal is 3 V by the zener diode and voltage at inverting terminal will be 3 V. Thus V_o can be get by applying voltage division rule, i.e.

$$\frac{20}{20+40}V_o = 3$$

or $$V_0 = 9 \text{ V}$$

Hence (C) is correct option.

MCQ 1.49 The action of JFET in its equivalent circuit can best be represented as a

(A) Current controlled current source

(B) Current controlled voltage source

(C) Voltage controlled voltage source

(D) Voltage controlled current source

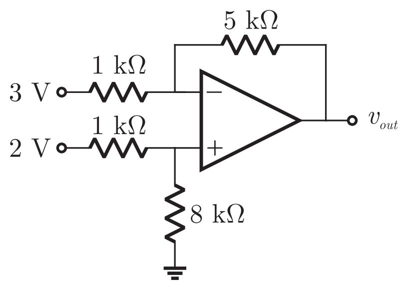
SOL 1.49 For a JFET in active region we have

$$I_{DS} = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

From above equation it is clear that the action of a JFET is voltage controlled current source.

Hence option (D) is correct.

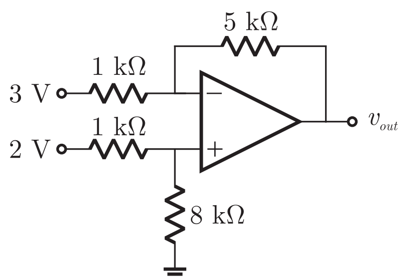
MCQ 1.50 If the op-amp in the figure is ideal, the output voltage V_{out} will be equal to



(A) 1 V (B) 6 V

(C) 14 V (D) 17 V

SOL 1.50 The circuit is as shown below



$$V_+ = \frac{8}{1+8}(3) = \frac{8}{3}\,\text{k}\Omega$$

$$V_+ = V_- = \frac{8}{3}\,V$$

Now applying KCL at inverting terminal we get

$$\frac{V_- - 2}{1} + \frac{V_- - V_o}{5} = 0$$

or
$$V_o = 6V_- - 10$$
$$= 6 \times \frac{8}{3} - 10 = 6 \text{ V}$$

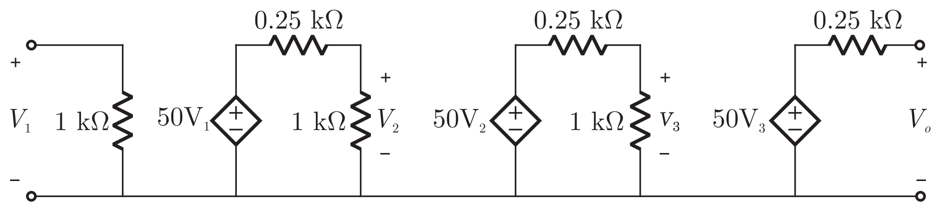
Hence (B) is correct option.

MCQ 1.51 Three identical amplifiers with each one having a voltage gain of 50, input resistance of 1 kΩ and output resistance of 250 Ω are cascaded. The opened circuit voltages gain of the combined amplifier is

(A) 49 dB (B) 51 dB

(C) 98 dB (D) 102 dB

SOL 1.51 The equivalent circuit of 3 cascade stage is as shown in fig.



$$V_2 = \frac{1k}{1k+0.25k} 50\,V_1 = 40\,V_1$$

Similarly $$V_3 = \frac{1k}{1k+0.25k} 50\,V_2 = 40\,V_2$$

or $$V_3 = 40 \times 40\,V_1$$

$$V_o = 50\,V_3 = 50 \times 40 \times 40\,V_1$$

or $$A_V = \frac{V_o}{V_1} = 50 \times 40 \times 40 = 8000$$

or $$20 \log A_V = 20 \log 8000 = 98 \text{ dB}$$

Hence (C) is correct option.

MCQ 1.52 An ideal sawtooth voltages waveform of frequency of 500 Hz and amplitude 3 V is generated by charging a capacitor of 2 μF in every cycle. The charging requires

(A) Constant voltage source of 3 V for 1 ms

(B) Constant voltage source of 3 V for 2 ms

(C) Constant voltage source of 1 mA for 1 ms

(D) Constant voltage source of 3 mA for 2 ms

SOL 1.52 If a constant current is made to flow in a capacitor, the output voltage is integration of input current and that is sawtooth waveform as below :

$$V_C = \frac{1}{C}\int_0^t i dt$$

The time period of wave form is

$$T = \frac{1}{f} = \frac{1}{500} = 2 \text{ m sec}$$

Thus $$3 = \frac{1}{2 \times 10^6}\int_0^{20 \times 10^{-3}} i dt$$

or $$i(2 \times 10^{-3} - 0) = 6 \times 10^{-6}$$

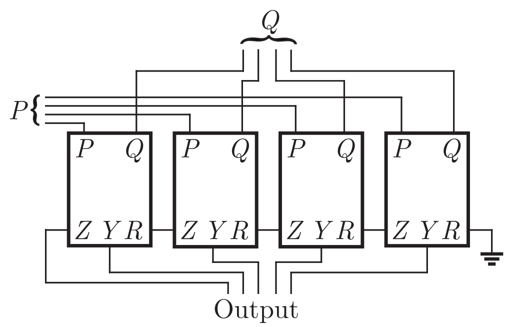
or $$i = 3 \text{ mA}$$

Thus the charging require 3 mA current source for 2 msec.

Hence (D) is correct option

MCQ 1.53 The circuit in the figure has 4 boxes each described by inputs P, Q, R and outputs Y, Z with $Y = P \oplus Q \oplus R$ and $Z = RQ + \overline{P}R + Q\overline{P}$

The circuit acts as a



(A) 4 bit adder giving $P+Q$

(B) 4 bit subtractor giving $P-Q$

(C) 4 bit subtractor giving Q-P

(D) 4 bit adder giving $P+Q+R$

SOL 1.53 Hence (B) is correct answer.

We have
$$Y = P\oplus Q\oplus R$$
$$Z = RQ+\overline{P}R+Q\overline{P}$$

Here every block is a full subtractor giving $P-Q-R$ where R is borrow. Thus circuit acts as a 4 bit subtractor giving $P-Q$.

MCQ 1.54 If the function W, X, Y and Z are as follows

$$W = R+\overline{P}Q+\overline{R}S \qquad X = PQ\overline{RS}+\overline{PQRS}+P\overline{QRS}$$
$$Y = RS+\overline{PR+P\overline{Q}+\overline{P}.\overline{Q}} \qquad Z = R+S+\overline{PQ+\overline{P}.\overline{Q}.\overline{R}+P\overline{Q}.\overline{S}}$$

Then,

(A) $W = Z, X = \overline{Z}$

(B) $W = Z, X = Y$

(C) $W = Y$

(D) $W = Y = \overline{Z}$

SOL 1.54 Hence (A) is correct answer.

$$W = R+\overline{P}Q+\overline{R}S$$
$$X = PQ\overline{RS}+\overline{PQRS}+P\overline{QRS}$$
$$Y = RS+\overline{PR+P\overline{Q}+\overline{\overline{P}Q}}$$
$$= RS+PR\cdot\overline{P\overline{Q}\cdot\overline{PQ}}$$
$$= RS+(\overline{P}+\overline{R})(\overline{P}+Q)(P+Q)$$
$$= RS+(\overline{P}+\overline{P}Q+\overline{PR}+Q\overline{R})(P+Q)$$
$$= RS+\overline{P}Q+Q\overline{R}(P+\overline{P})+Q\overline{R}$$
$$= RS+\overline{P}Q+Q\overline{R}$$
$$Z = R+S+\overline{PQ+\overline{\overline{PQR}}+P\overline{\overline{QS}}}$$
$$= R+S+\overline{PQ}\cdot\overline{\overline{PQR}}\cdot\overline{P\overline{QS}}$$
$$= R+S+(\overline{P}+\overline{Q})(P+Q+R)(\overline{P}+Q+S)$$
$$= R+S+\overline{P}Q+\overline{P}Q+\overline{P}QS+\overline{P}R+\overline{P}QR$$
$$+\overline{P}RS+P\overline{Q}+P\overline{Q}S+\overline{PQ}R+\overline{Q}RS$$
$$= R+S+\overline{P}Q+\overline{P}QS+\overline{P}R+\overline{P}QR+\overline{P}RS$$

$$+ P\overline{Q}S + \overline{PQ}R + \overline{Q}RS$$

$$= R + S + \overline{P}Q(1+S) + \overline{P}R(1+\overline{P}) + \overline{P}RS$$

$$+ P\overline{Q}S + \overline{PQ}R + \overline{\overline{Q}}RS$$

$$= R + S + \overline{P}Q + \overline{P}R + \overline{P}RS + P\overline{Q}S$$

$$+ \overline{PQ}R + \overline{Q}RS$$

$$= R + S + \overline{P}Q + \overline{P}R(1+\overline{Q}) + P\overline{Q}S + \overline{Q}RS$$

$$= R + S + \overline{P}Q + \overline{P}R + P\overline{Q}S + \overline{Q}RS$$

Thus $W = Z$ and $X = \overline{Z}$

MCQ 1.55 A 4 bit ripple counter and a bit synchronous counter are made using flip flops having a propagation delay of 10 ns each. If the worst case delay in the ripple counter and the synchronous counter be R and S respectively, then

(A) $R = 10$ ns, $S = 40$ ns (B) $R = 40$ ns, $S = 10$ ns

(C) $R = 10$ ns $S = 30$ ns (D) $R = 30$ ns, $S = 10$ ns

SOL 1.55 Propagation delay of flip flop is

$$t_{pd} = 10 \text{ nsec}$$

Propagation delay of 4 bit ripple counter

$$R = 4t_{pd} = 40 \text{ ns}$$

and in synchronous counter all flip-flop are given clock simultaneously, so

$$S = t_{pd} = 10 \text{ ns}$$

Hence (B) is correct answer.

MCQ 1.56 The DTL, TTL, ECL and CMOS famil GATE of digital ICs are compared in the following 4 columns

	(P)	(Q)	(R)	(S)
Fanout is minimum	DTL	DTL	TTL	CMOS
Power consumption is minimum	TTL	CMOS	ECL	DTL
Propagation delay is minimum	CMOS	ECL	TTL	TTL

The correct column is

(A) P (B) Q

(C) R (D) S

SOL 1.56 The DTL has minimum fan out and CMOS has minimum power consumption. Propagation delay is minimum in ECL.

Hence (B) is correct answer.

MCQ 1.57 The circuit shown in the figure is a 4 bit DAC

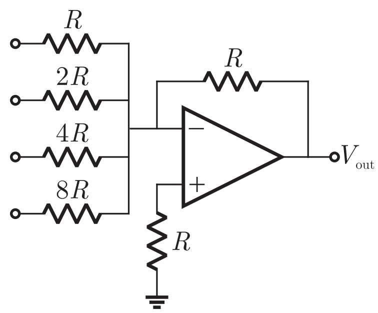


Fig. Q

The input bits 0 and 1 are represented by 0 and 5 V respectively. The OP AMP is ideal, but all the resistance and the 5 v inputs have a tolerance of ±10%. The specification (rounded to nearest multiple of 5%) for the tolerance of the DAC is

(A) ±35%
(B) ±20%
(C) ±10%
(D) ±5%

SOL 1.57 Hence (A) is correct answer.

$$V_o = -V_1\left[\frac{R}{R}b_o + \frac{R}{2R}b_1 + \frac{R}{4R}b_2 + \frac{R}{4R}b_3\right]$$

Exact value when $V_1 = 5$, for maximum output

$$V_{oExact} = -5\left[1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8}\right] = -9.375$$

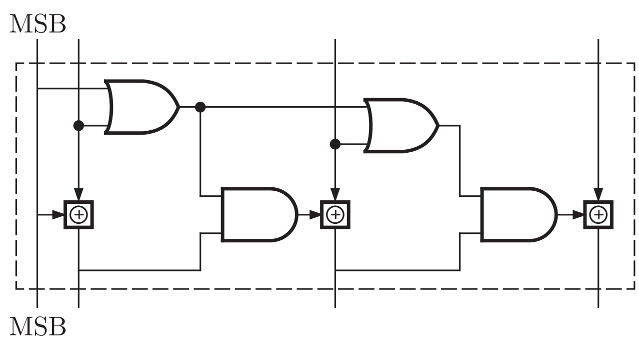
Maximum V_{out} due to tolerance

$$V_{o\max} = -5.5\left[\frac{110}{90} + \frac{110}{2\times 90} + \frac{110}{4\times 90} + \frac{110}{8\times 90}\right]$$

$$= -12.604$$

Tolerance $= 34.44\% = 35\%$

MCQ 1.58 The circuit shown in figure converts



(A) BCD to binary code
(B) Binary to excess - 3 code
(C) Excess -3 to gray code
(D) Gray to Binary code

SOL 1.58 Hence (D) is correct answer.

Let input be 1010; output will be 1101

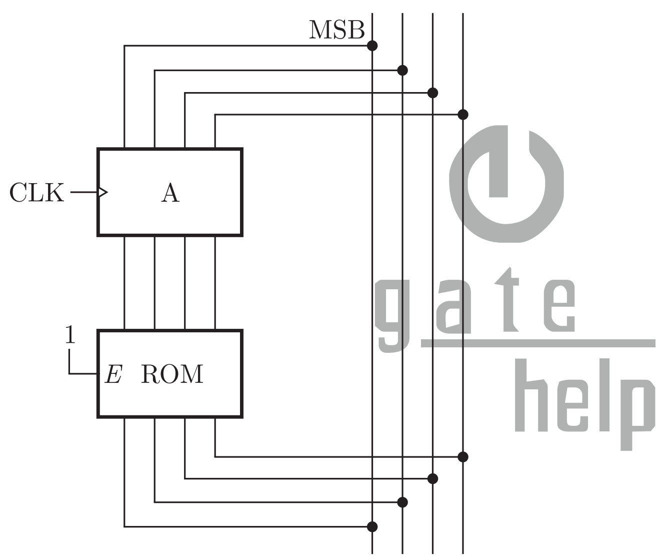
Let input be 0110; output will be 0100

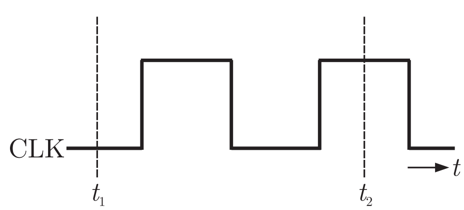
Thus it convert gray to Binary code.

MCQ 1.59 In the circuit shown in the figure, A is parallel-in, parallel-out 4 bit register, which loads at the rising edge of the clock C. The input lines are connected to a 4 bit bus, W. Its output acts at input to a 16×4 ROM whose output is floating when the input to a partial table of the contents of the ROM is as follows

Data	0011	1111	0100	1010	1011	1000	0010	1000
Address	0	2	4	6	8	10	11	14

The clock to the register is shown, and the data on the W bus at time t_1 is 0110. The data on the bus at time t_2 is





(A) 1111 (B) 1011

(C) 1000 (D) 0010

SOL 1.59 After $t = t_1$, at first rising edge of clock, the output of shift register is 0110, which in input to address line of ROM. At 0110 is applied to register. So at this time data stroed in ROM at 1010 (10), 1000 will be on bus.
When W has the data 0110 and it is 6 in decimal, and it's data value at that add is 1010

then 1010 i.e. 10 is acting as odd, at time t_2 and data at that movement is 1000. Hence (C) is correct answer.

MCQ 1.60 In an 8085 microprocessor, the instruction CMP B has been executed while the content of the accumulator is less than that of register B. As a result

(A) Carry flag will be set but Zero flag will be reset

(B) Carry flag will be rest but Zero flag will be set

(C) Both Carry flag and Zero flag will be rest

(D) Both Carry flag and Zero flag will be set

SOL 1.60 CMP B $\Rightarrow$ Compare the accumulator content with context of Register B

If A < R CY is set and zero flag will be reset.

Hence (A) is correct answer.

MCQ 1.61 Let X and Y be two statistically independent random variables uniformly distributed in the ranges $(-1,1)$ and $(-2,1)$ respectively. Let $Z = X + Y$. Then the probability that $(z \leq -1)$ is

(A) zero (B) $\frac{1}{6}$

(C) $\frac{1}{3}$ (D) $\frac{1}{12}$

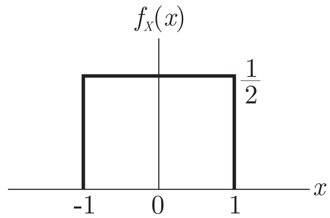
SOL 1.61 The pdf of Z will be convolution of pdf of X and pdf of Y as shown below.

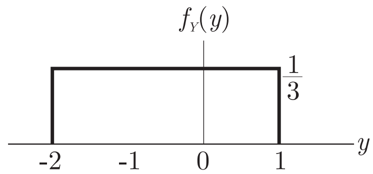
Now $p[Z \leq z] = \int_{-\infty}^{z} f_Z(z)\, dz$

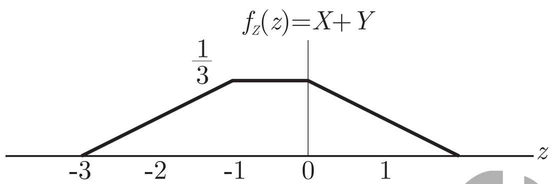
$$p[Z \leq -2] = \int_{-\infty}^{-2} f_Z(z)\, dz$$

$$= \text{Area } [z \leq -2]$$

$$= \frac{1}{2} \times \frac{1}{6} \times 1 = \frac{1}{12}$$







Hence (D) is correct option.

MCQ 1.62 Let P be linearity, Q be time-invariance, R be causality and S be stability. *A* discrete time system has the input-output relationship,

$$y(n) = \begin{cases} x(n) & n \geq 1 \\ 0, & n = 0 \\ x(n+1) & n \leq -1 \end{cases}$$

where $x(n)$ is the input and $y(n)$ is the output. The above system has the properties

(A) P, S but not Q, R

(B) P, Q, S but not R

(C) P, Q, R, S

(D) Q, R, S but not P

SOL 1.62 System is non causal because output depends on future value

For $n \leq 1$ $\quad y(-1) = x(-1+1) = x(0)$

$$y(n-n_0) = x(n-n_0+1) \qquad \text{Time varying}$$

$$y(n) = x(n+1) \qquad \text{Depends on Future}$$

i.e. $\quad y(1) = x(2) \qquad$ None causal

For bounded input, system has bounded output. So it is stable.

$$\begin{aligned} y(n) &= x(n) \text{ for } n \geq 1 \\ &= 0 \text{ for } n = 0 \\ &= x(x+1) \text{ for } n \leq -1 \end{aligned}$$

So system is linear.

Hence (A) is correct answer.

Common data for Q 63 & 64 :

The system under consideration is an RC low-pass filter (RC-LPF) with $R = 1$ kΩ and $C = 1.0$ μF.

MCQ 1.63 Let $H(f)$ denote the frequency response of the RC-LPF. Let f_1 be the highest frequency such that $0 \le |f| \le f_1 \frac{|H(f_1)|}{H(0)} \ge 0.95$. Then f_1 (in Hz) is

(A) 324.8 (B) 163.9

(C) 52.2 (D) 104.4

SOL 1.63 The frequency response of RC-LPF is

$$H(f) = \frac{1}{1 + j2\pi fRC}$$

Now $H(0) = 1$

$$\frac{|H(f_1)|}{H(0)} = \frac{1}{\sqrt{1 + 4\pi^2 f_1^2 R^2 C^2}} \ge 0.95$$

or $1 + 4\pi^2 f_1^2 R^2 C^2 \le 1.108$

or $4\pi^2 f_1^2 R^2 C^2 \le 0.108$

or $2\pi f_1 RC \le 0.329$

or $f_1 \le \frac{0.329}{2\pi RC}$

or $f_1 \le \frac{0.329}{2\pi RC}$

or $f_1 \le \frac{0.329}{2\pi 1k \times 1\mu}$

or $f_1 \le 52.2$ Hz

Thus $f_{1\max} = 52.2$ Hz

Hence (C) is correct answer.

MCQ 1.64 Let $t_g(f)$ be the group delay function of the given RC-LPF and $f_2 = 100$ Hz. Then $t_g(f_2)$ in ms, is

(A) 0.717 (B) 7.17

(C) 71.7 (D) 4.505

SOL 1.64 Hence (A) is correct answer

$$H(\omega) = \frac{1}{1 + j\omega RC}$$

$$\theta(\omega) = -\tan^{-1}\omega RC$$

$$t_g = -\frac{d\theta(\omega)}{d\omega} = \frac{RC}{1 + \omega^2 R^2 C^2}$$

$$= \frac{10^{-3}}{1 + 4\pi^2 \times 10^4 \times 10^{-6}} = 0.717 \text{ ms}$$

Common Data for Questions 65 & 66 :

$X(t)$ is a random process with a constant mean value of 2 and the auto correlation function $R_{xx}(\tau) = 4(e^{-0.2|\tau|} + 1)$.

MCQ 1.65 Let X be the Gaussian random variable obtained by sampling the process at $t = t_i$ and let

$$Q(\alpha) = \int_{\alpha}^{\infty} - \frac{1}{\sqrt{2\pi}} e^{\frac{x^2}{2}} dy$$

The probability that $[x \leq 1]$ is

(A) $1 - Q(0.5)$ (B) $Q(0.5)$

(C) $Q\left(\frac{1}{2\sqrt{2}}\right)$ (D) $1 - Q\left(\frac{1}{2\sqrt{2}}\right)$

SOL 1.65 Hence (D) is correct option.

We have $R_{XX}(\tau) = 4(e^{-0.2|\tau|} + 1)$

$R_{XX}(0) = 4(e^{-0.2|0|} + 1) = 8 = \sigma^2$

or $\sigma = 2\sqrt{2}$ Given

mean $\mu = 0$

Now $P(x \leq 1) = F_x(1)$

$= 1 - Q\left(\frac{X - \mu}{\sigma}\right)$ at $x = 1$

$= 1 - Q\left(\frac{1 - 0}{2\sqrt{2}}\right) = 1 - Q\left(\frac{1}{2\sqrt{2}}\right)$

MCQ 1.66 Let Y and Z be the random variable obtained by sampling $X(t)$ at $t = 2$ and $t = 4$ respectively. Let $W = Y - Z$. The variance of W is

(A) 13.36 (B) 9.36

(C) 2.64 (D) 8.00

SOL 1.66 Hence (C) is correct option.

$W = Y - Z$

$E[W^2] = E[Y - Z]^2$

$= E[Y^2] + E[Z^2] - 2E[YZ]$

$= \sigma_w^2$

We have $E[X^2(t)] = R_x(10)$

$= 4[e^{-0.2|0|} + 1] = 4[1 + 1] = 8$

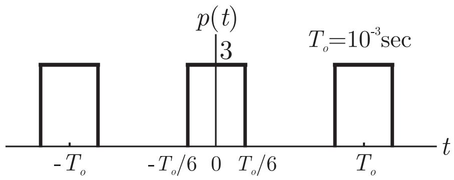
$E[Y^2] = E[X^2(2)] = 8$

$E[Z^2] = E[X^2(4)] = 8$

$E[YZ] = R_{XX}(2) = 4[e^{-0.2(4-2)} + 1] = 6.68$

$E[W^2] = \sigma_w^2 = 8 + 8 - 2 \times 6.68 = 2.64$

MCQ 1.67 Let $x(t) = 2\cos(800\pi) + \cos(1400\pi t)$. $x(t)$ is sampled with the rectangular pulse train shown in the figure. The only spectral components (in kHz) present in the sampled signal in the frequency range 2.5 kHz to 3.5 kHz are



(A) 2.7, 3.4 (B) 3.3, 3.6

(C) 2.6, 2.7, 3.3, 3.4, 3.6 (D) 2.7, 3.3

SOL 1.67 Hence (D) is correct option.

The frequency of pulse train is

$$f\frac{1}{10^{-3}} = 1 \text{ k Hz}$$

The Fourier Series coefficient of given pulse train is

$$C_n = \frac{1}{T_o}\int_{-T_o/2}^{-T_o/2} Ae^{-jn\omega_o t}\,dt$$

$$= \frac{1}{T_o}\int_{-T_o/6}^{-T_o/6} Ae^{-jn\omega_o t}\,dt$$

$$= \frac{A}{T_o(-jn\omega_o)}[e^{-j\omega_o t}]_{-T_o/6}^{-T_o/6}$$

$$= \frac{A}{(-j2\pi n)}(e^{-j\omega_o t} - e^{jn\omega_o T_o/6})$$

$$= \frac{A}{j2\pi n}(e^{jn\pi/3} - e^{-jn\pi/3})$$

or $$C_n = \frac{A}{\pi n}\sin\left(\frac{n\pi}{3}\right)$$

From C_n it may be easily seen that $1,2,4,5,7,$ harmonics are present and $0,3,6,9,..$ are absent. Thus $p(t)$ has 1 kHz, 2 kHz, 4 kHz, 5 kHz, 7 kHz,... frequency component and 3 kHz, 6 kHz.. are absent.

The signal $x(t)$ has the frequency components 0.4 kHz and 0.7 kHz. The sampled signal of $x(t)$ i.e. $x(t)^*\ p(t)$ will have

1 ± 0.4 and 1 ± 0.7 kHz

2 ± 0.4 and 2 ± 0.7 kHz

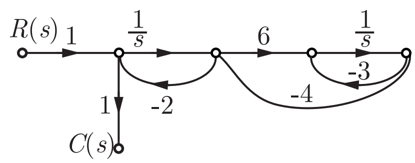
4 ± 0.4 and 4 ± 0.7 kHz

Thus in range of 2.5 kHz to 3.5 kHz the frequency present is

$2 + 0.7 = 2.7$ kHz

$4 - 0.7 = 3.3$ kHz

MCQ 1.68 The signal flow graph of a system is shown in Fig. below. The transfer function $C(s)/R(s)$ of the system is



(A) $\frac{6}{s^2 + 29s + 6}$ (B) $\frac{6s}{s^2 + 29s + 6}$

(C) $\frac{s(s+2)}{s^2 + 29s + 6}$ (D) $\frac{s(s+27)}{s^2 + 29s + 6}$

SOL 1.68 Mason Gain Formula

$$T(s) = \frac{\Sigma p_k \triangle_k}{\triangle}$$

In given SFG there is only forward path and 3 possible loop.

$$p_1 = 1$$

$$\triangle_1 = 1 + \frac{3}{s} + \frac{24}{s} = \frac{s+27}{s}$$

$$L_1 = \frac{-2}{s}, L_2 = \frac{-24}{s} \text{ and } L_3 = \frac{-3}{s}$$

where L_1 and L_3 are non-touching

This $$\frac{C(s)}{R(s)} = \frac{p_1 \triangle_1}{1 - (\text{loop gain}) + \text{pair of non} - \text{touching loops}}$$

$$= \frac{\left(\frac{s+27}{s}\right)}{1 - \left(\frac{-3}{s} - \frac{24}{s} - \frac{2}{s}\right) + \frac{-2}{s} \cdot \frac{-3}{s}} = \frac{\left(\frac{s+27}{s}\right)}{1 + \frac{29}{s} + \frac{6}{s^2}}$$

$$= \frac{s(s+27)}{s^2 + 29s + 6}$$

Hence (D) is correct option.

MCQ 1.69 The root locus of system $G(s)H(s) = \frac{K}{s(s+2)(s+3)}$ has the break-away point located at

(A) $(-0.5, 0)$ (B) $(-2.548, 0)$

(C) $(-4, 0)$ (D) $(-0.784, 0)$

SOL 1.69 We have

$$1 + G(s)H(s) = 0$$

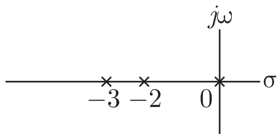
or $$1 + \frac{K}{s(s+2)(s+3)} = 0$$

or $$K = -s(s^2 + 5s^2 + 6s)$$

$$\frac{dK}{ds} = -(3s^2 + 10s + 6) = 0$$

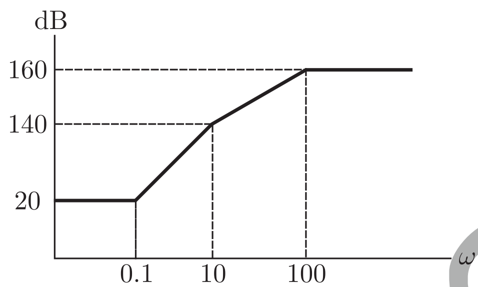
which gives $$s = \frac{-10 \pm \sqrt{100 - 72}}{6} = -0.784, -2.548$$

The location of poles on $s-$ plane is



Since breakpoint must lie on root locus so $s = -0.748$ is possible.
Hence (D) is correct option.

MCQ 1.70 The approximate Bode magnitude plot of a minimum phase system is shown in Fig. below. The transfer function of the system is



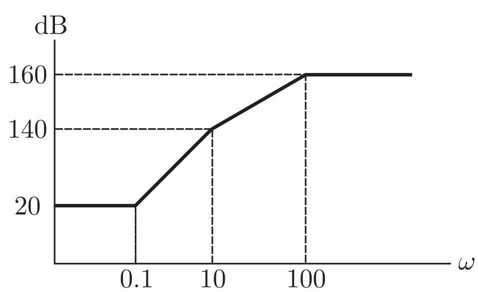
(A) $10^8 \dfrac{(s+0.1)^3}{(s+10)^2(s+100)}$

(B) $10^7 \dfrac{(s+0.1)^3}{(s+10)(s+100)}$

(C) $\dfrac{(s+0.1)^2}{(s+10)^2(s+100)}$

(D) $\dfrac{(s+0.1)^3}{(s+10)(s+100)^2}$

SOL 1.70 The given bode plot is shown below



At $\omega = 0.1$ change in slope is $+60$ dB $\rightarrow$ 3 zeroes at $\omega = 0.1$
At $\omega = 10$ change in slope is -40 dB $\rightarrow$ 2 poles at $\omega = 10$
At $\omega = 100$ change in slope is -20 dB $\rightarrow$ 1 poles at $\omega = 100$

Thus $$T(s) = \frac{K(\frac{s}{0.1}+1)^3}{(\frac{s}{10}+1)^2(\frac{s}{100}+1)}$$

Now $20\log_{10} K = 20$

or $K = 10$

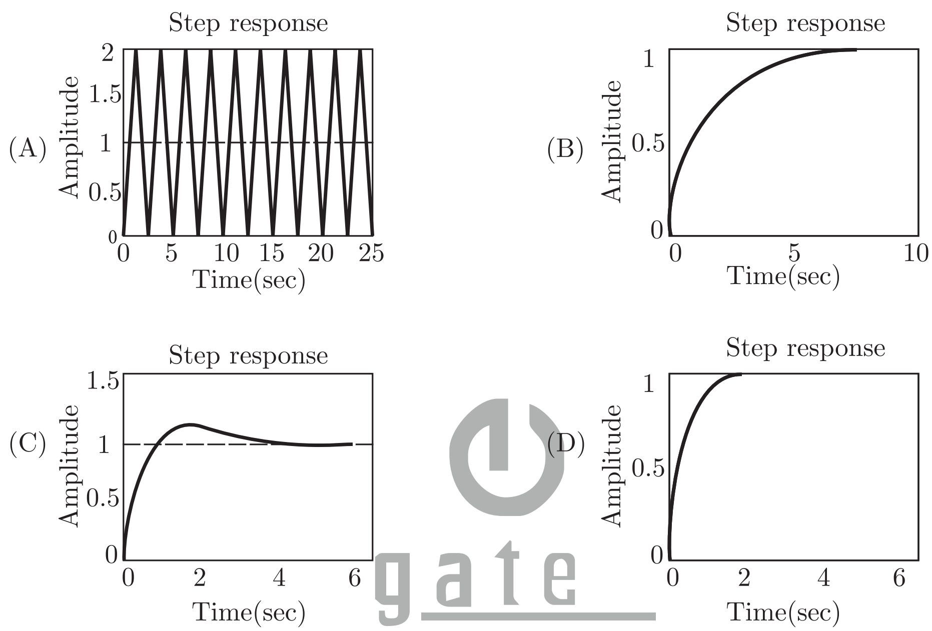
Thus $$T(s) = \frac{10(\frac{s}{0.1}+1)^3}{(\frac{s}{10}+1)^2(\frac{s}{100}+1)} = \frac{10^8(s+0.1)^3}{(s+10)^2(s+100)}$$

Hence (A) is correct option.

MCQ 1.71 A second-order system has the transfer function

$$\frac{C(s)}{R(s)} = \frac{4}{s^2 + 4s + 4}$$

With $r(t)$ as the unit-step function, the response $c(t)$ of the system is represented by



SOL 1.71 The characteristics equation is

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

Comparing with

$$s^2 + 2\xi\omega_n + \omega_n^2 = 0$$

we get $2\xi\omega_n = 4$ and $\omega_n^2 = 4$

Thus $\xi = 1$ Critically damped

$$t_s = \frac{4}{\xi\omega_n} = \frac{4}{1 \times 2} = 2$$

Hence (B) is correct option.

MCQ 1.72 The gain margin and the phase margin of feedback system with

$$G(s)H(s) = \frac{8}{(s+100)^3} \text{ are}$$

(A) dB,0°
(B) ∞,∞
(C) ∞,0°
(D) 88.5 dB, ∞

SOL 1.72 Hence (B) is correct option.

MCQ 1.73 The zero-input response of a system given by the state-space equation

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \text{ and } \begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \text{ is}$$

(A) $\begin{bmatrix} te^t \\ t \end{bmatrix}$ (B) $\begin{bmatrix} e^t \\ t \end{bmatrix}$

(C) $\begin{bmatrix} e^t \\ te^t \end{bmatrix}$ (D) $\begin{bmatrix} t \\ te^t \end{bmatrix}$

SOL 1.73 We have

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \text{ and } \begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$A = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$$

$$(sI - A) = \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} = \begin{bmatrix} s-1 & 0 \\ -1 & s-1 \end{bmatrix}$$

$$(sI - A)^{-1} = \frac{1}{(s-1)^2}\begin{bmatrix} (s-1) & 0 \\ +1 & (s-1) \end{bmatrix} = \begin{bmatrix} \frac{1}{s-1} & 0 \\ \frac{+1}{(s-1)^2} & \frac{1}{s-1} \end{bmatrix}$$

$$L^{-1}[(sI - A)^{-1}] = e^{At} = \begin{bmatrix} e^t & 0 \\ te^t & e^t \end{bmatrix}$$

$$x(t) = e^{At} \times [x(t_0)] = \begin{bmatrix} e^t & 0 \\ te^t & e^t \end{bmatrix}\begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} e^t \\ te^t \end{bmatrix}$$

Hence (C) is correct option.

MCQ 1.74 A DSB-SC signal is to be generated with a carrier frequency $f_c = 1$ MHz using a non-linear device with the input-output characteristic $V_0 = a_0 v_i + a_1 v_i^3$ where a_0 and a_1 are constants. The output of the non-linear device can be filtered by an appropriate band-pass filter.

Let $V_i = A_c^i \cos(2\pi f^i c^t) + m(t)$ is the message signal. Then the value of f_c^i (in MHz) is

(A) 1.0 (B) 0.333

(B) 0.5 (D) 3.0

SOL 1.74 Hence (C) is correct option.

$$v_i = A_c^1 \cos(2\pi f_c t) + m(t)$$

$$v_0 = a_o v_i + a v_i^3$$

$$v_0 = a_0[A_c^{'} \cos(2\pi f_c^{'} t) + m(t)] + a_1[A_c^{'} \cos(2\pi f_c^{'} t) + m(t)]^3$$

$$= a_0 A_c^{'} \cos(2\pi f_c^{'} t) + a_0 m(t) + a_1[(A_c^{'} \cos 2\pi f_c^{'} t)^3$$

$$+ (A_c^{'} \cos(2\pi f_c^{'}) t)^2 m(t) + 3A_c^{'} \cos(2\pi f_c^{'} t) m^2(t) + m^3(t)]$$

$$= a_0 A_c^{'} \cos(2\pi f_c^{'} t) + a_0 m(t) + a_1 (A_c^{'} \cos 2 f_c^{'} t)^3 + 3 a_1 A_c^{'2}\left[\frac{1 + \cos(4\pi f_c t)}{2}\right] m(t)$$

$$= 3 a_1 A_c^{'} \cos(2\pi f_c^{'} t) m^2(t) + m^3(t)$$

The term $3 a_1 A_c^{'} (\frac{\cos 4\pi f_c^{'} t}{2}) m(t)$ is a DSB-SC signal having carrier frequency 1. MHz. Thus $2f_c^{'} = 1$ MHz or $f_c^{'} = 0.5$ MHz

Common Data for Question 75 & 76 :

Let $m(t) = \cos[(4\pi\times10^3)t]$ be the message signal &
$c(t) = 5\cos[(2\pi\times10^6 t)]$ be the carrier.

MCQ 1.75 $c(t)$ and $m(t)$ are used to generate an AM signal. The modulation index of the generated AM signal is 0.5. Then the quantity $\frac{\text{Total sideband power}}{\text{Carrier power}}$ is

(A) $\frac{1}{2}$ (B) $\frac{1}{4}$

(C) $\frac{1}{3}$ (D) $\frac{1}{8}$

SOL 1.75 Hence (D) is correct option.

$$P_T = P_c\left(1+\frac{\alpha^2}{2}\right)$$

$$P_{sb} = \frac{P_c\alpha^2}{2} = \frac{P_c(0.5)^2}{2}$$

or $$\frac{P_{sb}}{P_c} = \frac{1}{8}$$

MCQ 1.76 $c(t)$ and $m(t)$ are used to generated an FM signal. If the peak frequency deviation of the generated FM signal is three times the transmission bandwidth of the AM signal, then the coefficient of the term $\cos[2\pi(1008\times10^3 t)]$ in the FM signal (in terms of the Bessel coefficients) is

(A) $5J_4(3)$ (B) $\frac{5}{2}J_8(3)$

(C) $\frac{5}{2}J_8(4)$ (D) $5J_4(6)$

SOL 1.76 Hence (D) is correct option.

AM Band width $= 2f_m$

Peak frequency deviation $= 3(2f_m) = 6f_m$

Modulation index $\beta = \frac{6f_m}{f_m} = 6$

The FM signal is represented in terms of Bessel function as

$$x_{FM}(t) = A_c\sum_{n=-\infty}^{\infty}J_n(\beta)\cos(\omega_c - n\omega_n)t$$

$$\omega_c + n\omega_m = 2\pi(1008\times10^3)$$

$$2\pi10^6 + n4\pi\times10^3 = 2\pi(1008\times10^3), n = 4$$

Thus coefficient $= 5J_4(6)$

MCQ 1.77 Choose the correct one from among the alternative A, B, C, D after matching an item in Group 1 with most appropriate item in Group 2.

Group 1	**Group 2**
P. Ring modulator	1. Clock recovery

Q. VCO	2. Demodulation of FM
R. Foster-Seely discriminator	3. Frequency conversion
S. Mixer	4. Summing the two inputs
	5. Generation of FM
	6. Generation of DSB-Sc

(A) $P-1; Q-3; R-2; S-4$ (B) $P-6; Q=5; R-2; S-3$

(C) $P-6; Q-1; R-3; S-2$ (D) $P-5; Q-6; R-1; S-3$

SOL 1.77 Hence (B) is correct option.

Ring modulation $\longrightarrow$ Generation of DSB - SC

VCO $\longrightarrow$ Generation of FM

Foster seely discriminator $\longrightarrow$ Demodulation of fm

mixer $\longrightarrow$ frequency conversion

MCQ 1.78 A superheterodyne receiver is to operate in the frequency range 550 kHz - 1650 kHz, with the intermediate frequency of 450 kHz. Let $R = C_{max}/C_{min}$ denote the required capacitance ratio of the local oscillator and I denote the image frequency (in kHz) of the incoming signal. If the receiver is tuned to 700 kHz, then

(A) $R = 4.41, I = 1600$ (B) $R = 2.10, I - 1150$

(C) $R = 3.0, I = 600$ (D) $R = 9.0, I = 1150$

SOL 1.78 Hence (A) is correct option.

$$f_{max} = 1650 + 450 = 2100 \text{ kHz}$$

$$f_{min} = 550 + 450 = 1000 \text{ kHz}$$

or
$$f = \frac{1}{2\pi\sqrt{LC}}$$

frequency is minimum, capacitance will be maximum

$$R = \frac{C_{max}}{C_{min}} = \frac{f_{max}^2}{f_{min}^2} = (2.1)^2$$

or
$$R = 4.41$$

$$f_i = f_c + 2f_{IF} = 700 + 2(455) = 1600 \text{ kHz}$$

MCQ 1.79 A sinusoidal signal with peak-to-peak amplitude of 1.536 V is quantized into 128 levels using a mid-rise uniform quantizer. The quantization-noise power is

(A) 0.768 V (B) $48 \times 10^{-6}\, V^2$

(B) $12 \times 10^{-6}\, V^2$ (D) 3.072 V

SOL 1.79 Hence (C) is correct option.

$$\text{Step size } \delta = \frac{2m_p}{L} = \frac{1.536}{128} = 0.012 \text{ V}$$

$$\text{Quantization Noise power} = \frac{\delta^2}{12} = \frac{(0.012)^2}{12}$$

$$= 12 \times 10^{-6}\ V^2$$

MCQ 1.80 If E_b, the energy per bit of a binary digital signal, is 10^{-5} watt-sec and the one-sided power spectral density of the white noise, $N_0 = 10^{-6}$ W/Hz, then the output SNR of the matched filter is

(A) 26 dB (B) 10 dB

(C) 20 dB (D) 13 dB

SOL 1.80 Hence (D) is correct option.

$$E_b = 10^{-6} \text{ watt-sec}$$
$$N_o = 10^{-5} \text{ W/Hz}$$
$$(\text{SNR}) \text{ matched filler} = \frac{E_o}{\frac{N_o}{2}} = \frac{10^6}{2 \times 10^{-5}} = .05$$
$$(\text{SNR})dB = 10 \log 10 (0.05) = 13 \text{ dB}$$

MCQ 1.81 The input to a linear delta modulator having a step-size $\triangle = 0.628$ is a sine wave with frequency f_m and peak amplitude E_m. If the sampling frequency $f_x = 40$ kHz, the combination of the sine-wave frequency and the peak amplitude, where slope overload will take place is

	E_m	f_m
(A)	0.3 V	8 kHz
(B)	1.5 V	4 kHz
(C)	1.5 V	2 kHz
(D)	3.0 V	1 kHz

SOL 1.81 Hence (B) is correct option.

For slopeoverload to take place $E_m \geq \frac{\triangle f_s}{2\pi f_m}$

This is satisfied with $E_m = 1.5$ V and $f_m = 4$ kHz

MCQ 1.82 If S represents the carrier synchronization at the receiver and ρ represents the bandwidth efficiency, then the correct statement for the coherent binary PSK is

(A) $\rho = 0.5, S$ is required (B) $\rho = 1.0, S$ is required

(C) $\rho = 0.5, S$ is not required (D) $\rho = 1.0, S$ is not required

SOL 1.82 Hence (A) is correct option.

If $s \rightarrow$ carrier synchronization at receiver

$\rho \rightarrow$ represents bandwidth efficiency

then for coherent binary PSK $\rho = 0.5$ and s is required.

MCQ 1.83 A signal is sampled at 8 kHz and is quantized using 8 - bit uniform quantizer. Assuming SNR_q for a sinusoidal signal, the correct statement for PCM signal with a bit rate of R is

(A) $R = 32$ kbps, $SNR_q = 25.8$ dB (B) $R = 64$ kbps, $SNR_q = 49.8$ dB

(C) $R = 64$ kbps, $SNR_q = 55.8$ dB (D) $R = 32$ kbps, $SNR_q = 49.8$ dB

SOL 1.83 Hence (B) is correct option.

$$\text{Bit Rate} = 8k \times 8 = 64 \text{ kbps}$$
$$(\text{SNR})_q = 1.76 + 6.02n \text{ dB}$$
$$= 1.76 + 6.02 \times 8 = 49.8 \text{ dB}$$

MCQ 1.84 Medium 1 has the electrical permittivity $\varepsilon_1 = 1.5\varepsilon_0$ farad/m and occupies the region to the left of $x = 0$ plane. Medium 2 has the electrical permittivity $\varepsilon_2 = 2.5\varepsilon_0$ farad/m and occupies the region to the right of $x = 0$ plane. If E_1 in medium 1 is $E_1 = (2u_x - 3u_y + 1u_z)$ volt/m, then E_2 in medium 2 is

(A) $(2.0u_x - 7.5u_y + 2.5u_z)$ volt/m
(B) $(2.0u_x - 2.0u_y + 0.6u_z)$ volt/m
(C) $(2.0u_x - 3.0u_y + 1.0u_z)$ volt/m
(D) $(2.0u_x - 2.0u_y + 0.6u_z)$ volt/m

SOL 1.84 Hence (C) is correct option.

We have $E_1 = 2u_x - 3u_y + 1u_z$

$$E_{1t} = -3u_y + u_y \text{ and } E_{1n} = 2u_x$$

Since for dielectric material at the boundary, tangential component of electric field are equal

$$E_{1t} = -3u_y + u_y = E_{2t} \qquad (x = 0 \text{ plane})$$
$$E_{1n} = 2u_x$$

At the boundary the for normal component of electric field are

$$D_{1n} = D_{2n}$$

or $$\varepsilon_1 E_{1n} = \varepsilon_2 E_{2n}$$

or $$1.5\varepsilon_o 2u_x = 2.5\varepsilon_o E_{2n}$$

or $$E_{2n} = \frac{3}{2.5}u_x = 1.2u_x$$

Thus $$E_2 = E_{2t} + E_{2n} = -3u_y + u_z + 1.2u_x$$

MCQ 1.85 If the electric field intensity is given by $E = (xu_x + yu_y + zu_z)$ volt/m, the potential difference between $X(2,0,0)$ and $Y(1,2,3)$ is

(A) $+1$ volt
(B) -1 volt
(C) $+5$ volt
(D) $+6$ volt

SOL 1.85 Hence (C) is correct option.

We have $$E = xu_x + yu_y + zu_z$$

$$dl = \hat{u}_x dx + \hat{u}_y dy + \hat{u}_z dz$$

$$V_{XY} = -\int_X^Y E.dl$$

$$= \int_1^2 xdx\hat{u}_x + \int_2^0 ydy\hat{u}_z + \int_3^0 zdz\hat{u}z$$

$$= -\left[\frac{x^2}{2}\Big|_1^2 + \frac{y^2}{2}\Big|_2^0 + \frac{z^2}{2}\Big|_3^0\right]$$

$$= -\frac{1}{2}[2^2 - 1^2 + 0^2 - 2^2 + 0^2 - 3^2] = 5$$

MCQ 1.86 A uniform plane wave traveling in air is incident on the plane boundary between air and another dielectric medium with $\varepsilon_r = 4$. The reflection coefficient for the normal incidence, is

(A) zero (B) $0.5\angle 180°$

(B) $0.333\angle 0°$ (D) $0.333\angle 180°$

SOL 1.86 Hence (D) is correct option.

$$\eta = \sqrt{\frac{\mu}{\varepsilon}}$$

Reflection coefficient

$$\tau = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$$

Substituting values for η_1 and η_2 we have

$$\tau = \frac{\sqrt{\frac{\mu_o}{\varepsilon_o \varepsilon_r}} - \sqrt{\frac{\mu_0}{\varepsilon_o}}}{\sqrt{\frac{\mu_o}{\varepsilon_o \varepsilon_r}} + \sqrt{\frac{\mu_o}{\varepsilon_o}}} = \frac{1 - \sqrt{\varepsilon_r}}{1 + \sqrt{\varepsilon_r}} = \frac{1 - \sqrt{4}}{1 + \sqrt{4}} \qquad \text{since } \varepsilon_r = 4$$

$$= \frac{-1}{3} = 0.333\angle 180°$$

MCQ 1.87 If the electric field intensity associated with a uniform plane electromagnetic wave traveling in a perfect dielectric medium is given by $E(z,t) = 10\cos(2\pi 10^7 t - 0.1\pi z)$ V/m, then the velocity of the traveling wave is

(A) 3.00×10^8 m/sec (B) 2.00×10^8 m/sec

(C) 6.28×10^7 m/sec (D) 2.00×10^7 m/sec

SOL 1.87 Hence (B) is correct option.

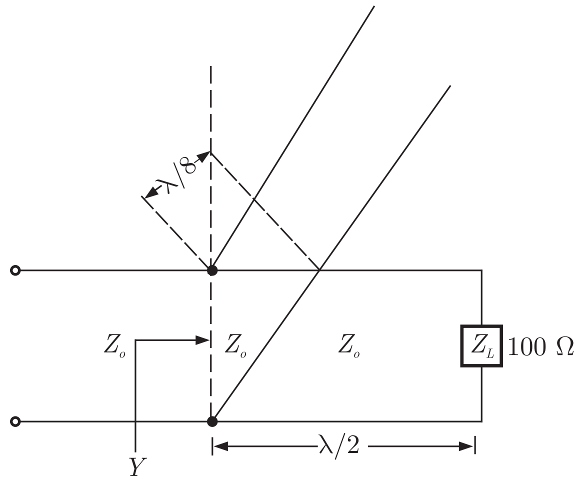
We have $E(z,t) = 10\cos(2\pi \times 10^7 t - 0.1\pi z)$

where $\omega = 2\pi \times 10^7 t$

$\beta = 0.1\pi$

Phase Velocity $u = \frac{\omega}{\beta} = \frac{2\pi \times 10^7}{0.1\pi} = 2 \times 10^8$ m/s

MCQ 1.88 A short - circuited stub is shunt connected to a transmission line as shown in fig. If $Z_0 = 50$ ohm, the admittance Y seen at the junction of the stub and the transmission line is



(A) $(0.01 - j0.02)$ mho
(B) $(0.02 - j0.01)$ mho
(C) $(0.04 - j0.02)$ mho
(D) $(0.02 + j0)$ mho

SOL 1.88 The fig of transmission line is as shown below .

We know that $$Z_{in} = Z_o \frac{[Z_L + jZ_o \tan \beta l]}{[Z_o + jZ_L \tan \beta l]}$$

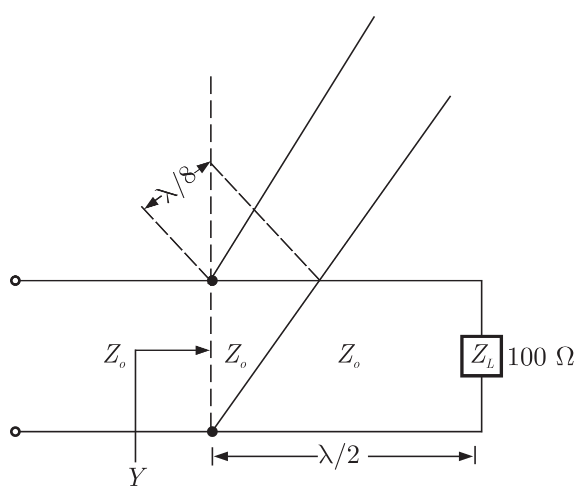
For line 1, $l = \frac{\lambda}{2}$ and $\beta = \frac{2\pi}{\lambda}$, $Z_{L1} = 100\Omega$

Thus $$Z_{in1} = Z_o \frac{[Z_L + jZ_o \tan \pi]}{[Z_o + jZ_L \tan \pi]} = Z_L = 100\Omega$$

For line 2, $l = \frac{\lambda}{8}$ and $\beta = \frac{2\pi}{\lambda}$, $Z_{L2} = 0$ (short circuit)

Thus $$Z_{in2} = Z_o \frac{[0 + jZ_o \tan \frac{\pi}{4}]}{[Z_o + 0]} = jZ_o = j50\Omega$$

$$Y = \frac{1}{Z_{in1}} + \frac{1}{Z_{in2}} = \frac{1}{100} + \frac{1}{j50} = 0.01 - j0.02$$



Hence (A) is correct option.

MCQ 1.89 A rectangular metal wave guide filled with a dielectric material of relative permittivity $\varepsilon_r = 4$ has the inside dimensions 3.0 cm $\times$ 1.2 cm. The cut-off frequency for the dominant mode is

(A) 2.5 GHz (B) 5.0 GHz

(C) 10.0 GHz (D) 12.5 GHz

SOL 1.89 Hence (A) is correct option.

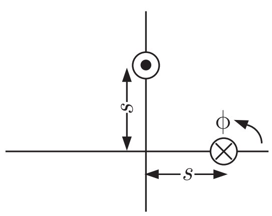
$$u = \frac{c}{\sqrt{\varepsilon_0}} = \frac{3\times10^8}{2} = 1.5\times10^8$$

In rectangular waveguide the dominant mode is TE_{10} and

$$f_C = \frac{v}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

$$= \frac{1.5\times10^8}{2}\sqrt{\left(\frac{1}{0.03}\right)^2 + \left(\frac{0}{b}\right)^2} = \frac{1.5\times10^8}{0.06} = 2.5 \text{ GHz}$$

MCQ 1.90 Two identical antennas are placed in the $\theta = \pi/2$ plane as shown in Fig. The elements have equal amplitude excitation with 180° polarity difference, operating at wavelength λ. The correct value of the magnitude of the far-zone resultant electric field strength normalized with that of a single element, both computed for $\phi = 0$, is



(A) $2\cos\left(\frac{2\pi s}{\lambda}\right)$ (B) $2\sin\left(\frac{2\pi s}{\lambda}\right)$

(C) $2\cos\left(\frac{\pi s}{\lambda}\right)$ (D) $2\sin\left(\frac{\pi s}{\lambda}\right)$

SOL 1.90 Hence (D) is correct option.

Normalized array factor $= 2\left|\cos\frac{\psi}{2}\right|$

$$\psi = \beta d\sin\theta\cos\phi + \delta$$
$$\theta = 90^\circ,$$
$$d = \sqrt{2}\,s,$$
$$\phi = 45^\circ,$$
$$\delta = 180^\circ$$

Now $2\left|\cos\frac{\psi}{2}\right| = 2\cos\left[\frac{\beta d\sin\theta\cos\phi + \delta}{2}\right]$

$$= 2\cos\left[\frac{2\pi}{\lambda.2}\sqrt{2}\,s\cos45^\circ + \frac{180}{2}\right]$$

$$= 2\cos\left[\frac{\pi s}{\lambda} + 90^\circ\right] = 2\sin\left(\frac{\pi s}{\lambda}\right)$$

Answer Sheet

1.	(B)	19.	(D)	37.	(A)	55.	(B)	73.	(C)
2.	(C)	20.	(D)	38.	(A)	56.	(B)	74.	(C)
3.	(B)	21.	(D)	39.	(D)	57.	(A)	75.	(D)
4.	(C)	22.	(C)	40.	(C)	58.	(D)	76.	(D)
5.	(C)	23.	(B)	41.	(C)	59.	(C)	77.	(B)
6.	(D)	24.	(A)	42.	(A)	60.	(A)	78.	(A)
7.	(B)	25.	(C)	43.	(D)	61.	(D)	79.	(C)
8.	(A)	26.	(A)	44.	(B)	62.	(A)	80.	(D)
9.	(C)	27.	(C)	45.	(A)	63.	(C)	81.	(B)
10.	(D)	28.	(B)	46.	(A)	64.	(A)	82.	(A)
11.	(B)	29.	(C)	47.	(A)	65.	(D)	83.	(B)
12.	(D)	30.	(B)	48.	(C)	66.	(C)	84.	(C)
13.	(B)	31.	(A)	49.	(B)	67.	(D)	85.	(C)
14.	(C)	32.	(*)	50.	(B)	68.	(D)	86.	(D)
15.	(B)	33.	(*)	51.	(C)	69.	(D)	87.	(B)
16.	(D)	34.	(A)	52.	(D)	70	(A)	88.	(A)
17.	(C)	35.	(C)	53.	(B)	71	(B)	89.	(A)
18.	(B)	36.	(B)	54.	(A)	72	(B)	90.	(D)

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