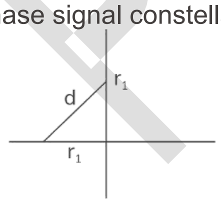
1. The input x(t) and output y(t) relationships of a continuous time system are given below:
(i) $y(t) = x(t-2) + x(t+4)$
(ii) $y(t) = (t-4)\,x(t+1)$
(iii) $y(t) = (t+4)\,x(t-1)$
(iv) $y(t) = (t+5)\,x(t+5)$
The systems are either causal or non-causal. Choose the correct option.
(A) Non-causal, causal, causal, non-causal
(B) Causal, non-causal, causal, non-causal
(C) Non-causal, causal, non-causal, causal
(D) Non-causal, non-causal, causal, non-causal

Sol. The correct option is (D).
A causal system is that system which depends on present and past input only. It does not depend on future value of inputs.
(i) $y(t) = x(t-2) + x(t+4)$
For $t = 0$
$y(0) = x(-2) + x(4)$
Here, output depends on past and future values of input. Hence, it is not causal system or non-causal system.
(ii) $y(t) = (t-4)\,x(t+1)$
For $t = 0$
$y(0) = (-4)\,x(1)$
Again output depends on future values of inputs. Hence, it is non-causal system.
(iii) $y(t) = (t+4)\,x(t-1)$
For $t = 0$
$y(0) = 4x(-1)$
For $y = 1$
$y(1) = 5x(0)$
Here output depends upon past values of input, not future. Thus, it is a causal system.

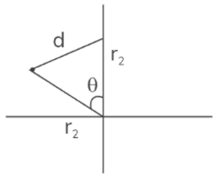
(iv) $y(t) = (t+5)\,x(t+5)$
For $t = 0$
$y(0) = 5x(5)$
Again output depends upon future values of input.
Hence, it is non-causal system.
Hence, the correct option is (D).

2.. What is the additional average transmitted signal energy required by an 8-bit PSK signal to obtain the same value of error probability as in the 4-bit PSK signal?___dB.

Sol. Answer is 5.33
4-bit phase signal constellation :



$$d^2 = r_1^2 + r_1^2$$
$$d^2 = 2r_1^2$$
$$r_1 = \frac{d}{\sqrt{2}} = 0.707d$$
8-bit phase signal constellation



$\theta = \frac{\pi}{4}$

$d^2 = r_2^2 + r_2^2 - 2r_2^2 \cos\frac{\pi}{4}$

$\quad = \left(2-\sqrt{2}\right) r_2^2$

$r_2 = \frac{d}{\sqrt{2-\sqrt{2}}} = 1.3065\,d$

Additional power required

$= 10\log\left(\frac{E_8}{N_0}\right) - 10\log\left(\frac{E_4}{N_0}\right)$

$= 10\log\left(\frac{r_2}{r_1}\right)^2 = 20\log\left(\frac{r_2}{r_1}\right) = 20\log\left(\frac{1.3065}{0.707}\right)$

$= 5.33\text{dB}.$

3. The net magnetic flux crossing the cylindrical surface described by $2 \le \rho \le 4$ and $0 \le Z \le h$ is 6.4 m Wb. If the magnetic flux density over the surface is $\vec{B} = \left(\frac{2}{\pi\rho}\right)\hat{a}_\rho$. Then the height 'h' of the cylindrical surface is (in m).

(A) 0.5

(B) 1.2

(C) 1.6

(D) 2

Sol. The correct option is (C).

Given, magnetic flux density $\vec{B} = \left(\frac{2}{\rho\pi}\right)\hat{a}_\rho \text{mT}$

$2 \le \rho \le 4$ and $0 \le Z \le h$

$0 \le \varphi \le 2\pi$

Then, flux $\Psi = \iint \vec{B}\cdot d\vec{s}$

$\because \beta \longrightarrow \hat{a}_\rho$

$\Downarrow$

$d\vec{s} \longrightarrow \hat{a}_\rho$

Should be taken

$\Rightarrow d\vec{s} = \rho\, d\phi\, dz$

$\Rightarrow \Psi = \iint \frac{1}{\pi}\left(\frac{2}{\rho}\right)\hat{a}_\rho \cdot (\rho\, d\phi\, dz)\hat{a}_\rho\,(\text{mW}_b)$

$= \int_{z=0}^{h}\int_{\phi=0}^{2\pi} \frac{2}{\pi}\, d\phi\, dz = \frac{2}{\pi}\int_0^{2\pi} d\phi \int_0^h dz$

$= \frac{2}{\pi}(2\pi)(h) = 4h(\text{mW}_b)$

$\because \Psi = 6.4\ \text{mW}_b$

$\Rightarrow 6.4\ \text{mW}_b = 4h(\text{mW}_b)$

$\Rightarrow h = \frac{6.4}{4} = 1.6m$

Hence, the correct option is (C).

4. If the magnetic field component in the lossy dielectric is given as $\vec{H} = 20e^{-\alpha x}\cos(\omega t - x)\hat{a}_x\ A/m$ the intrinsic impedance of the medium at a particular frequency is 100 ∠30° Ω. Then α = ____?

(A) $\sqrt{3}$

(B) $\frac{1}{\sqrt{3}}$

(C) $\frac{2}{\sqrt{3}}$

(D) $\frac{\sqrt{3}}{2}$

Sol. The correct option is (B).

Given, α ≠ 0 ⇒ lossy dielectric

$\eta = 100\angle 30^\circ = |\eta| e^{j\theta_n}$ ↗ $|\eta| = 100$ ↘ $\theta_n = 30^\circ$

$\vec{H}(x,t) = 20e^{-\alpha x}\cos(\omega t - x)\hat{a}_y A/m$

Standard $\vec{H}(x,t) = H_0 e^{-\alpha x}\cos(\omega t - \beta x)\hat{a}_y A/m$

⇒ H_0 = 20, α = ?, ω = ?, β = 1 rad/m.

We know that,

$$\alpha = \omega\sqrt{\frac{\mu\varepsilon}{2}(\sec\theta - 1)} \quad \ldots\ldots(1)$$

$$\beta = \omega\sqrt{\frac{\mu\varepsilon}{2}(\sec\theta + 1)} \quad \ldots\ldots\ldots(2)$$

Where, $\tan\theta = \frac{\sigma}{\omega\varepsilon}, \sec\theta = \sqrt{1 + \left(\frac{\sigma}{\varepsilon\omega}\right)^2}$

From (1) and (2),

$$\frac{\alpha}{\beta} = \sqrt{\frac{\sec\theta - 1}{\sec\theta + 1}} = \sqrt{\frac{1 - \cos\theta}{1 + \cos\theta}}$$

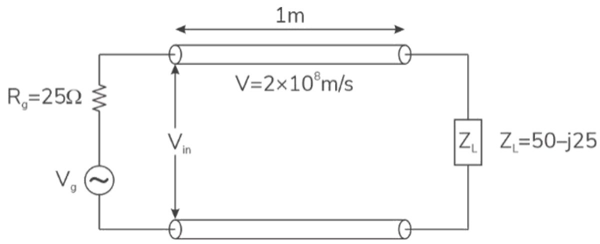
On solving $\frac{\alpha}{\beta} = \tan\left(\frac{\theta}{2}\right) = \tan\theta_n$

$\Rightarrow \alpha = \beta\tan\theta_n = 1\tan(30^\circ)$

$$\left(\alpha = \frac{1}{\sqrt{3}}\right)$$

Hence, the correct option is (B).

5. consider the transmission line circuit shown below.



If V_{in} = 40 cos(2π × 10^8t – 49°)V is input voltage to the transmission line.

For $V_g = V_{g_0}\cos(2\pi\times10^8 t - \theta_g)V$.

Which of the following is/are correct.

(A) $V_{g_0} = 20$

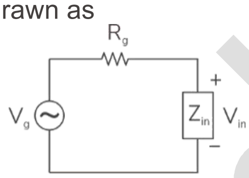
(B) $V_{g_0} = 80$

(C) θ_g = 57.13°

(D) θ_g = 40.86°

Sol. The correct options are (B) and (C).

The input side of the circuit can be drawn as



$$\Rightarrow V_{in} = \frac{Z_{in}}{R_g + Z_{in}} V_S$$

$$\therefore V_S = \left(\frac{R_g + Z_{in}}{Z_{in}}\right) V_{in}$$

Now, $$Z_{in} = Z_0\left[\frac{Z_L + jZ_0\tan\beta l}{Z_0 + jZ_L\tan\beta l}\right]$$

Now, $$\beta = \frac{2\pi}{\lambda} = \frac{2\pi f}{v} = \frac{\omega}{v} = \frac{2\pi\times10^8}{2\times10^8} = \pi$$

∴ βl = π

$$\therefore Z_{in} = Z_0\left[\frac{Z_L + 0}{Z_0 + 0}\right] = Z_L$$

$$V_S = \left[\frac{25 + (50 - j25)}{(50 - j25)}\right] V_{in}$$

$$= \left[\frac{75 - j25}{50 - j25}\right] V_{in}$$

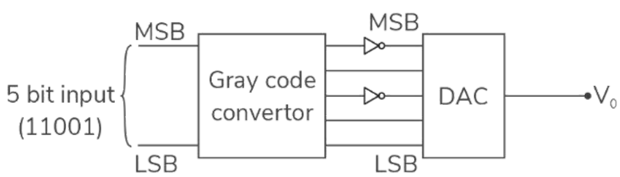
= [2 ∠–8.13]V_{in}

V_s = 80 cos(2π × 10^8t – 57.13)V

$V_{g_0} = 80$ $\qquad$ $\theta_g = 57.13°$

Hence, the correct options are (B) and (C).

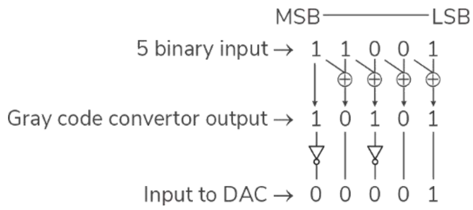
. 6. Consider a 5 bit DAC circuit as shown below :



Find output voltage V_0, if full scale voltage of DAC is 6.2 V.

Sol. The correct answer is 0.2.

Given,



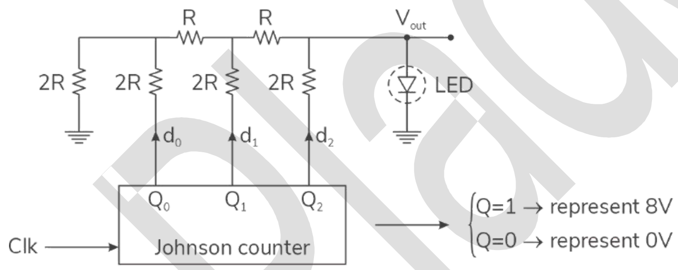
∵ Output of DAC, $V_0 = \left(\frac{V_{FS}}{2^n - 1}\right)$ [Decimal equivalent of input]

$$V_0 = \frac{(6.2)}{31}[1] = 0.2\,V$$

$V_0 = 0.2$ V

Hence, the correct answer is 0.2.

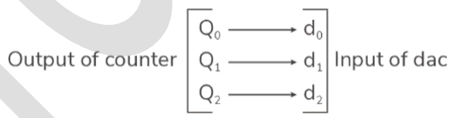
7. Consider a counter based DAC circuit as shown below.



The LED will glow when $V_{out} \geq 3.5$. Assume, initial state of Johnson counter is 000. How many times does the LED glow after 6 clock pulses?

Sol. The correct answer is 3.

Here output of 3 bit Johnson counter is fed to a 3 bit DAC, as



Output voltage of DAC can be written as

$$V_{out} = \left(\frac{V_{ref}}{2^n}\right)(D_{eq})$$

n ⟶ number of bits (= 3)

D_{eq} ⟶ decimal equivalent of binary input.

V_{ref} ⟶ Voltage when output state of counters is high (Q = 1)

⇒ $V_{ref} = 8$ V

$$V_{out} = \left(\frac{8}{2^3}\right)D_{eq} = (D_{eq})$$

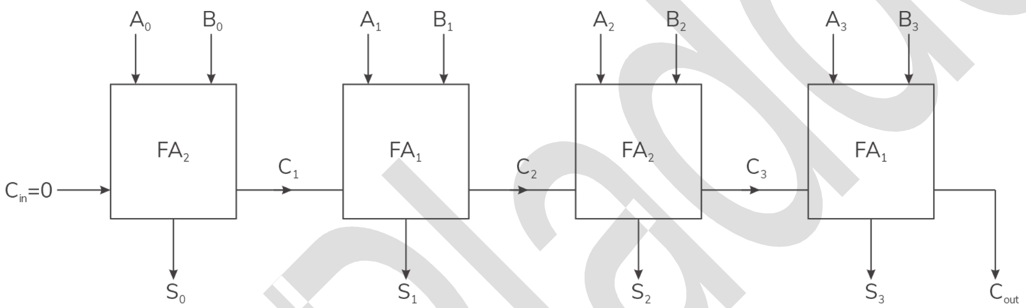
	$Q_2 = d_2$	$Q_1 = d_1$	$Q_0 = d_0$	$V_0 = D_{eq} = (2^2 d_2 + 2^1 d_1 + 2^0 d_0)$	States of LED
Initial	0	0	0		
1st clk	1	0	0	4 V	ON
2nd clk	1	1	0	6 V	ON

3rd clk	1	1	1	7 V	ON
4th clk	0	1	1	3 V	OFF
5th clk	0	0	1	1 V	OFF
6th clk	0	0	0	0 V	OFF

$\therefore$ LED to glow = ($V_{out} \geq 3.5$)
or (D_{eq}) $\geq$ 3.5
From the table, it is clear that LED will glow 3 times.
Hence, the correct answer is 3.

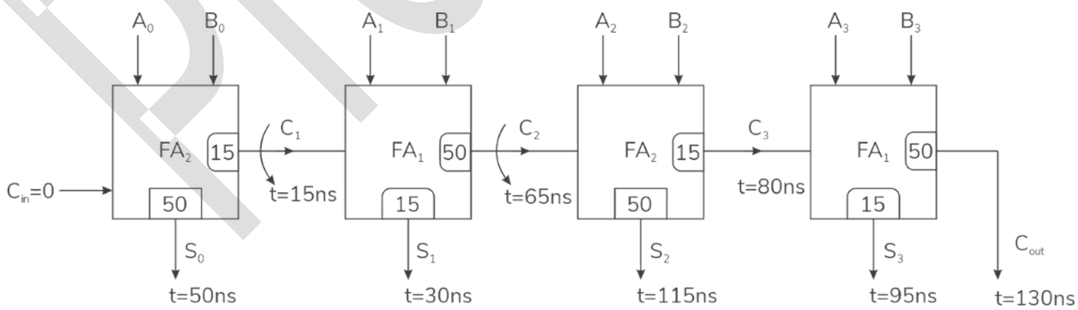
8. Consider the 4 bit full adder circuit shown below. The characteristic of each full adder in terms of delay is shown.

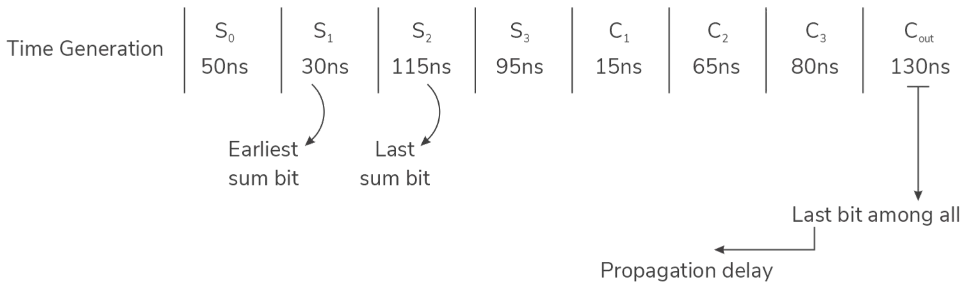
	t_{sum}	t_{carry}
FA_1	15 ns	50 ns
FA_2	50 ns	15 ns



Let all the inputs are available to t = 0 ns, the corresponding sum bit and carry bit will be generated at.
(a) Among sum bits, S_1 is generated at the earliest.
(b) Among sum bits, S_2 is generated at the last.
(c) Carry bit, C_3 is generated at t = 80 ns.
(d) Total propagation delay of 4 bit adder is 130 ns.

Sol. The correct options are (A), (C) and (D).

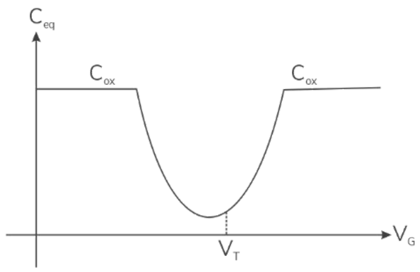




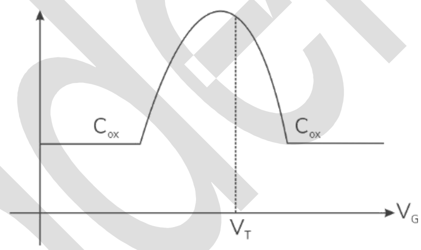
Hence, the correct options are (A), (C) and (D).

9. Which of the following represent a MOS-CV plot in P-type substrate at low frequency.

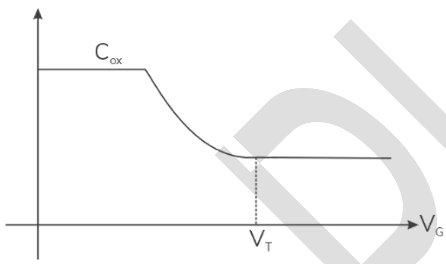
(A)



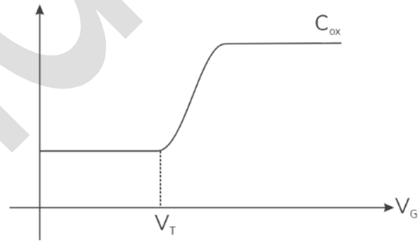
(B)



(C)

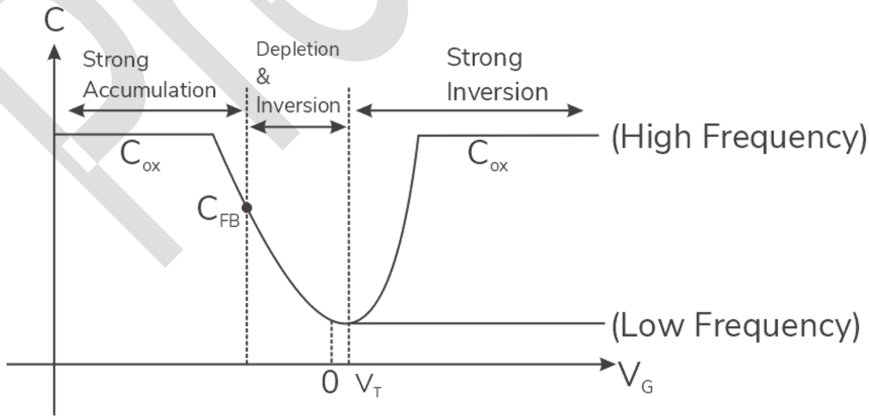


(D)

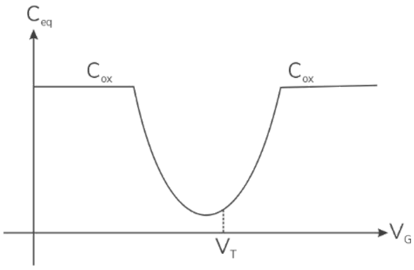


Sol. (A) is the correct answer.

MOS capacitance vs Gate Voltage Plot for P-substrate (N-MOS) is given as



At low frequency,



Hence, (A) is the correct answer.

10. Consider the following statements is/are correct regarding threshold voltage of a MOS capacitor.

(A) The threshold voltage (V_T) increases with increase in gate oxide thickness.
(B) The threshold voltage (V_T) decreases with increase in gate oxide thickness.
(C) The threshold voltage (V_T) increases with increase in substrate doping.
(D) The threshold voltage (V_T) decreases with increase in substrate doping.

Sol. Threshold voltage of mos capacitor is given by

$$V_T = \phi_S + \frac{Q_d}{C_{ox}}$$

(Ideal)

Here, $Q_d = qN_AW_d \rightarrow$ Doping $\uparrow \Rightarrow N_a\uparrow \Rightarrow Q_d\uparrow \Rightarrow V_T\uparrow$

$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} \rightarrow \text{thickness} \uparrow \Rightarrow t_{ox} \uparrow \Rightarrow C_{ox} \downarrow \Rightarrow V_T \uparrow$$

Hence, option A and C are correct.