GENERAL APTITUDE

Q. 1 – Q. 5 carry one mark each.

01. **Fill in the blank with an appropriate phrase**

Jobs are hard to _____ these days

(A) Come by (B) Come down

(C) Come of (D) Come from

01. Ans: (A)

Sol: 'Come by' means to manage to get something.

02. ***The question below consists of a pair of related words followed by four pairs of words. Select the pair that best expresses the relation in the original pair.***

MONKEY : TROOP :

(A) sheep : hard

(B) elephant : Parliament

(C) bacteria : Colony

(D) wolves : School

02. Ans: (C)

Sol: Troop consists of monkeys just as a colony consists of bacteria.

03. ***Choose the most appropriate word from the options given below to complete the following sentence:***

If you had gone to see him, he _______ delighted.

(A) Would have been

(B) Will have been

(C) Had been

(D) Would be

03. Ans: (A)

Ans: 'A" conditional tense type 3 grammatical code is

If +had+V3, would +have+V3

04. Which of the following options is closest in meaning to the underlined word?

European intellectuals have long debated the consequences of the **hegemony** of American popular culture around the world.

(A) regimen (B) vastness

(C) dominance (D) popularity

04. Ans: (C)

Sol: Dominance means influence or control over another country, a group of people etc.

05. How many one-rupee coins, 50 paise coins, 25 paise coins in total of which the numbers are proportional to 5, 7 and 12 are together work ₹115?

(A) 50, 70, 120 (B) 60, 70, 11
(C) 70, 80, 90 (D) None of these

05. Ans: (A)

Sol: $(5\times1 + 7\times0.5 + 12\times0.25)x = 115$

$(5 + 3.5 + 3)x = 115$

$11.5x = 115$

$x = 10$

$\therefore$ Number of one rupee coin = 5x

$= 5\times10 = 50$

Number of 5-paise coin = 7x = 7×10 = 70

Number of 25-paise coin = 12x

$= 12\times10 = 120$

Q. 6 – Q. 10 carry Two marks each.

06. Critical reading is a demanding process. To read critically, you must slow down your reading and, with pencil in hand, perform specific operations on the text mark up the text with your reactions, conclusions, and questions, then you read, become an active participant.

This passage best supports the statement that

(A) Critical reading is a slow, dull but essential process.

(B) The best critical reading happens at critical times in a person's life.

(C) Readers should get in the habit of questioning the truth of what they read.

(D) Critical reading requires thoughtful and careful attention.

06. Ans: (D)

Sol: Choice (A) is incorrect because the author never says that reading is dull.

Choice (B) and (C) are not support by the paragraph.

Choice (D) is correct as it is implied in the entire passage.

07. Anil's house faces east from the back-side of the house, he walks straight 50 metres, then turns to the right and walks 50m again finally, he turns towards left and stops after walking 25 m. Now Anil is in which direction from the starting point?

(A) South-east

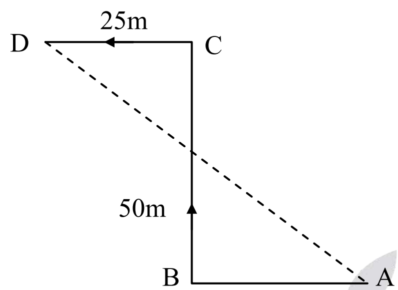
(B) South-west

(C) North-east

(D) North- west

07. Ans: (D)

Sol: The movement of Anil are shown in the adjoining figure



He starts walking from back of his house (i.e) towards west now, the final position is D, which is to the north west of his starting point A.

08. A and B enter into a partnership, A puts in ₹50 and B puts in ₹45. At the end of 4 months, A withdraws half his capital and at the end of 5 months B withdraws $\frac{1}{2}$ of his, C then enters with a capital of ₹70 at the end of 12 months, the profit of concern is ₹254, how can the profit be divided among A, B and C ?

(A) ₹76, ₹80 and ₹98

(B) ₹80, ₹76 and ₹98

(C) ₹76, ₹98 and ₹80

(D) ₹80, ₹98 and ₹76

08. Ans: (B)

Sol:

A's share : B's share : C's share

(50×4+25×8) : (45×5+22.5×7) : (70×7)

400 : 382.5 : 490

800 : 765 : 980

160 : 153 : 196

Total profit = ₹254

$$\text{Profit of A} = \frac{160}{160+153+196}\times 254$$

$$= \frac{160}{509}\times 254$$

$$= ₹79.8 \approx ₹80$$

$$\text{Profit of B} = \frac{153}{509}\times 254$$

$$= ₹76.34$$

$$\approx ₹76$$

$$\text{Profit of C} = \frac{196}{509}\times 254$$

$$= ₹97.8$$

$$\approx ₹98$$

∵ Hence option 'B' is correct.

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09. A sum of ₹25400 was lent out in two parts, one of 12% and the other at $12\frac{1}{2}$%. If the total annual income is ₹3124.2, the money lent at 12% is _____.

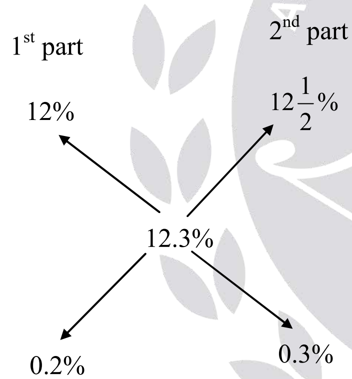
(A) ₹15240 (B) ₹25400

(C) ₹10160 (D) ₹31242

09. Ans: (C)

Sol: Overall rate of interest

$$\frac{3124.2}{25400}\times 100 = 12.3\%$$



∴ The sum will be divided in the ratio 0.2:0.3 (or) 2:3

∴ The sum lent at 12% = $25400\times\frac{2}{5}$

= ₹10160.

10. The following question is to be answered on the basis of the table given below.

Category of personnel	Number of staff in the year-1990	Number of staff in the year-1995
Data preparation	18	25
Data control	5	8
Operators	18	32
Programmers	21	26
Analysts	15	31
Managers	3	3
Total	80	135

What is the increase in the sector angle for operators in the year 1995 over the sector angle for operators in the year 1990?

(A) 4° (B) 3°

(C) 2° (D) 1°

10. Ans: (A)

Sol: Sector angle for operators in the year 1990

$$= \frac{18}{80}\times 360° = 81°$$

Sector angle for operators in the year 1995

$$= \frac{32}{135}\times 360°$$

= 85.33

≃ 85%

∴ Required difference = 85°– 81° = 4°

ELECTRONICS & COMMUNICATION ENGINEERING

Q. 11 – Q. 35 carry one mark each.

11. Assume that excess carriers have been generated uniformly in a semiconductor to a concentration of $10^{16}/cm^3$ at t = 0. The forcing function generating the excess carriers turns off at t = 0. Assuming the excess carrier life time $\tau_p = 10^{-9}s$ .The excess carrier concentration at t = 3ns is ________$\times 10^{14}\,cm^{-3}$.

11. Ans: 4.978 [Range: 4.5 to 5.5]

Sol: Excess carrier concentration with respect to time is given by

$$\delta_p(t) = \delta_p(0)\ e^{-t/\tau_p}$$

$$= 10^{16} \times e^{-3\times10^{-9}/10^{-9}}$$

$$= 4.978\times10^{14}/cm^3$$

12. A uniform and constant magnetic field of $10 mWb/m^2$ is directed along the z-axis of a rectangular co-ordinate system. A circular contour in the xy plane centered at the origin has a radius that is decreasing at 100 m/s. Given the initial radius of 100mm, the induced emf (in volt) in the path as a function of time is ________

12. Ans: 0.628 [Range: 0.58 to 0.65]

Sol: The flux through the contour

is $\phi = \psi_{max} = \oint_C \overline{B}.\overline{dS}$

$$\psi_m = B_z(\pi r^2) Wb$$

$$v = -\frac{d\psi_m}{dt} = -2\pi B_z r\frac{dr}{dt}$$

$$= -2\pi(0.01)(0.1)(-100)$$

$$= 0.628 volt$$

13. If directional derivative of $\phi = 2xz - y^2$, at the point (1, 3, 2) becomes maximum in the direction of $\bar{a}$, then magnitude of $\bar{a}$ is ________

13. Ans: 7.48 [Range: 7.4 to 7.5]

Sol: Given $\phi = 2xz - y^2$

$$\nabla\phi = \frac{\partial\phi}{\partial x}\bar{i} + \frac{\partial\phi}{\partial y}\bar{j} + \frac{\partial\phi}{\partial z}\bar{k}$$

$$= 2z\,\bar{i} - 2y\bar{j} + 2x\,\bar{k}$$

$\therefore$ Required direction vector = $\bar{a} = (\nabla\phi)$ at (1, 3, 2) = $(4\bar{i} - 6\bar{j} + 2\bar{k})$

Magnitude of $\bar{a} = \sqrt{16+36+4}$

$= \sqrt{56}$

$= 7.48$

14. A sinusoidal carrier is frequency modulated by a sinusoidal signal with the frequency deviation of 10 kHz. If the message signal frequency is 5 kHz, then the fraction of carrier power P_{f_c} to the total power P_t is _______

(Given that $J_0(2) = 0.224$, $J_0(5) = -0.178$ & $J_0(8) = 0.172$)

14. Ans: 0.0501 [Range: 0.0490 to 0.0510]

Sol: Given $\Delta f = 10\text{kHz}$ and $f_m = 5\text{kHz}$

$$\beta = \frac{\Delta f}{f_m} = \frac{10k}{5k} = 2$$

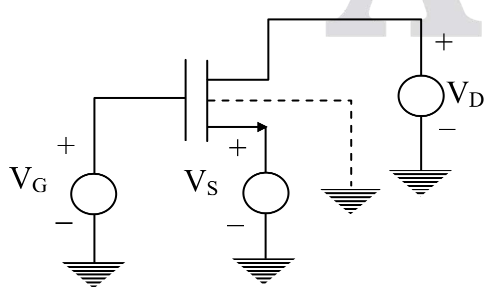
$$\beta = 2$$

$$P_{f_c} = \frac{A_C^2}{2} J_0^2(2)$$

$$P_t = \frac{A_C^2}{2}$$

$$\frac{P_{f_c}}{P_t} = J_0^2(2) = 0.0501$$

15. Consider the following circuit.



$V_S = 1V$, $V_G = V_D = 2.5V$, $\mu_n C_{ox} = 1\ \text{mA/V}^2$, $\frac{W}{L} = 100, V_{THO} = 0.5V$.

The drain current (in mA) with $\lambda = 0$ is _____(Assume $\gamma = 0.5\sqrt{V}$ and $\phi_F = 0.5V$)

15. Ans: 31.44 [Range: 31 to 32]

Sol: $V_{TH} = V_{THO} + \gamma\left(\sqrt{2\phi_F + V_{SB}} - \sqrt{2\phi_F}\right)$

$$= 0.5 + 0.5\left[\sqrt{(2\times0.5)+1} - \sqrt{(2\times0.5)}\right]$$

$$= 0.707V$$

Since $V_G = V_D$, the device is in saturation

$$I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{GS} - V_{TH})^2$$

$$= \frac{1}{2}\times(1m)\times100\times(1.5-0.707)^2$$

$$= 31.44\text{Ma}$$

16. A numerical solution of the equation $f(x) = x + \sqrt{x} - 3 = 0$ can be obtained using Newton - Raphson method. If the starting value is $x = 2$ for the iteration then the value of x that is to be used in the next step is _____

16. Ans: 1.69 [Range: 1.4 to 1.8]

Sol: Given $f(x) = x + \sqrt{x} - 3 = 0$ and $x_0 = 2$

$$f^1(x) = 1 + \frac{1}{2\sqrt{x}}$$

Newton - Raphson formula is

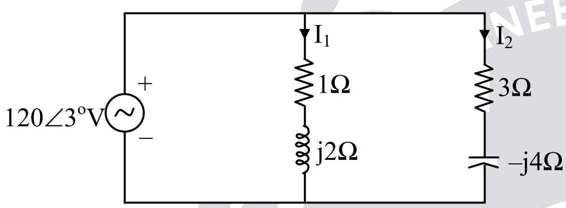
$$x_{n+1} = x_n - \frac{f(x_n)}{f^1(x_n)}$$

$$\Rightarrow x_1 = x_0 - \frac{f(x_0)}{f^1(x_0)}$$

$$= 2 - \frac{\left(2+\sqrt{2}-3\right)}{\left(1+\frac{1}{2\sqrt{2}}\right)}$$

$= 1.6939$

17. Consider the following circuit. The behaviour of parallel circuit with the power factor of _____ lagging



17. Ans: 0.8 [Range: 0.77 to 0.83]

Sol: Total admittance

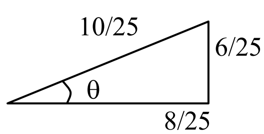
$$Y = Y_1 + Y_2 = \frac{1}{Z_1} + \frac{1}{Z_2}$$

$$= \frac{1}{1+j2} + \frac{1}{3-j4} = \frac{1-j2}{5} + \frac{3+j4}{25}$$

$$Y = \frac{5-j10+35+j4}{25} = \frac{(8-j6)}{25} \mho$$

$$Y = \left(\frac{8}{25}\right) - j\left(\frac{6}{25}\right)$$

$Y = G - jB$



$\cos\theta = 0.8$

0.8 lagging power factor.

18. Given $X(z) = \frac{z^2+z}{z^3-3z^2+3z-1}; |z|>1$, then x(n) value at n = 2 is _______

18. Ans: 4

Sol: $X(z) = \frac{z^{-1}+z^{-2}}{1-3z^{-1}+3z^{-2}-z^{-3}}$

$1 - 3z^{-1} + 3z^{-2} - z^{-3})z^{-1} + z^{-2}(z^{-1}+4z^{-2}+$-----

$z^{-1}-3z^{-2}+3z^{-3}-z^{-4}$

$4z^{-2}-3z^{-3}+z^{-4}$

$4z^{-2}-12z^{-3}+12z^{-4}-4z^{-5}$

$X(z) = z^{-1} + 4z^{-2} +$ ------

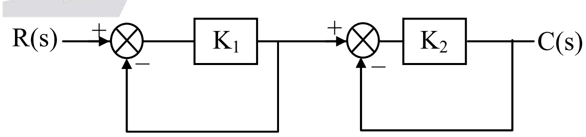
Apply inverse z-transform

$\delta(n-n_0) \leftrightarrow z^{-n_0}$

$x(n) = \delta(n-1) + 4\delta(n-2) +$ ------

$x(2) = 4$

19. A control system is represented by the block diagram shown in figure. The nominal values of the parameters are K_1 = 1 and K_2 = 10. Then Sensitivity of the transfer function with respect to K_1 is _____



19. Ans: 0.5

Sol: Transfer function,

$$\frac{C(s)}{R(s)} = \left(\frac{K_1}{1+K_1}\right)\left(\frac{K_2}{1+K_2}\right) = \left(\frac{10K_1}{11+11K_1}\right)$$

$$S_{K_1}^{T}=\left(\frac{\partial T/T}{\partial K_1/K_1}\right)=\left(\frac{K_1}{T}\right)\left(\frac{\partial T}{\partial K_1}\right)$$

$$=\frac{K_1}{\left(\frac{10K_1}{11+11K_1}\right)}\times\left[\frac{10(11+11K_1)-10K_1(11)}{(11+11K_1)^2}\right]$$

$$=\left(\frac{11}{11+11K_1}\right)\Rightarrow\left(S_{K_1}^{T}\right)_{K_1=1}=\frac{11}{22}=0.5$$

20. A butter worth LPF is to meet the following specifications pass band ripple = 1dB for $\Omega \le$ 4rad/sec and stop band attenuation $\ge$ 20 dB for $\Omega \ge$ 8 rad/sec.
The minimum order required for butterworth filter is ______

20. Ans: 5

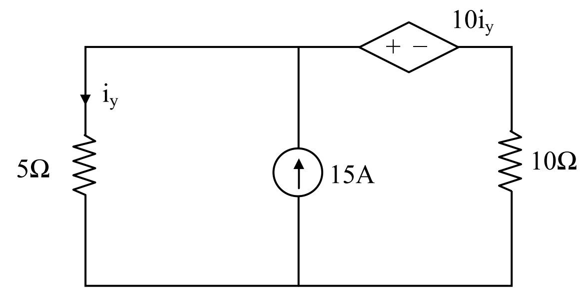
Sol: Given δ_p = 1dB, Ω_p = 4rad/sec, δ_s = 20dB and Ω_s = 8 rad/sec

$$n=\frac{1}{2}\frac{\log\left[\frac{10^{0.1\delta_s dB}-1}{10^{0.1\delta_p dB}-1}\right]}{\log\left(\frac{\Omega_s}{\Omega_p}\right)}$$

$$=\frac{1}{2}\frac{\log\left[\frac{10^{0.1(20)}-1}{10^{0.1(1)}-1}\right]}{\log\left(\frac{8}{4}\right)}$$

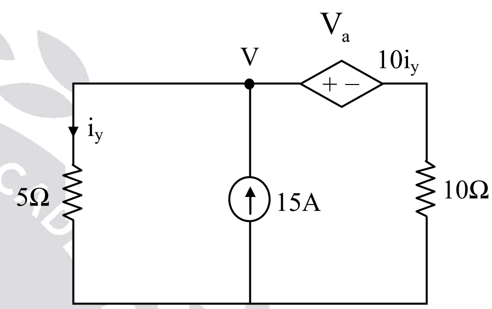
$$=4.289\approx 5$$

21. In the given circuit, the power (in kiloWatts) delivered by the dependent source is________



21. Ans: 4.5

Sol:



By KCL at node 'V'

$$\frac{V}{5}+\frac{V-10i_y}{10}=15\Rightarrow 2V+V-10i_y=150$$

$3V - 10i_y = 150$

$$3V-10\left(\frac{V}{5}\right)=150\Rightarrow V=150\,\text{Volts}$$

and $i_y=\frac{V}{5}=30\,A$

Power delivered by the dependent source

$$P_d=V_aI_d=(10i_y)\left(\frac{10i_y-V}{10}\right)$$

$$=10\times 30\left(\frac{10(30)-150}{10}\right)$$

= 300(15) = 4500 Watts

= 4.5kW

22. Simplify the following Boolean expression $F = \overline{\overline{X\overline{Y} + XYZ} + X\left(Y + X\overline{Y}\right)}$ and the number of literals in the simplified expression are______

22. Ans: 0

Sol: $F = \overline{\overline{X\overline{Y} + XYZ} + X\left(Y + X\overline{Y}\right)}$

$= \overline{\overline{X\left(\overline{Y} + YZ\right)} + X\left(Y + X\right)\left(Y + \overline{Y}\right)}$

[∵ distributive law A + BC = (A + B)(A + C)]

$= \overline{\overline{X\left(\overline{Y} + Z\right)} + X\left(X + Y\right)}$

$= X\left(\overline{Y} + Z\right).\overline{X\left(1 + Y\right)}$ [$\because A + \overline{A} = 1$]

$= X\left(\overline{Y} + Z\right).\overline{X\left(1 + Y\right)}$ [$\because \overline{\overline{A}} = A$]

$= X\left(\overline{Y} + Z\right).\overline{X} = 0$

[$\because$ A(1+B) = A, $A.\overline{A} = 0$]

23. A base band signal band limited to 5 MHz is to be transmitted using VSB modulation. The percentage of vestige bandwidth allowed is 20% of USB bandwidth. The bandwidth saving (in MHz) due to VSB modulation when compared to DSB-SC modulation is _______

23. Ans: 4

Sol: Given W = 5 MHz

BW of USB is 5 MHz

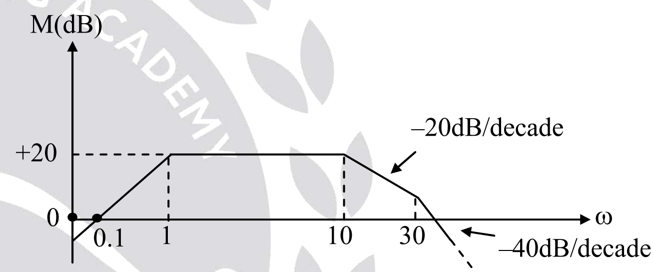
BW of vestige is 20% of 5 MHz = 1 MHz

BW of VSB signal = 5MHz + 1MHz = 6 MHz

BW of the DSB-SC signal = 2W = 10 MHz

So, the BW saving is 4 MHz.

24. The asymptotic magnitude plot of a minimum phase system is shown in figure. The transfer function of a given system is



(A) $\frac{10s}{(s+1)(s+10)(s+30)}$

(B) $\frac{3000s}{(s+1)(s+10)(s+30)}$

(C) $\frac{3000s^2}{(s+1)^2(s+10)(s+30)}$

(D) $\frac{300s}{(s+1)(s+10)(s+30)}$

24. Ans: (B)

Sol: Calculations for initial slope

$\Rightarrow S = \frac{M_2 - M_1}{\log \omega_2 - \log \omega_1} \Rightarrow S = \frac{20 - 0}{\log 1 - \log 0.1}$

$\Rightarrow S = \frac{20}{0 + 1} = +20\ dB/dec$

Transfer function,

$$G(s)H(s) = \frac{K\ s}{(1+s)(1+s/10)(1+s/30)}$$

Calculations for K:

$$M|_{\omega=0.1} = 20\log K + 20\log\omega$$

$0 = 20\log K - 20\log 0.1$

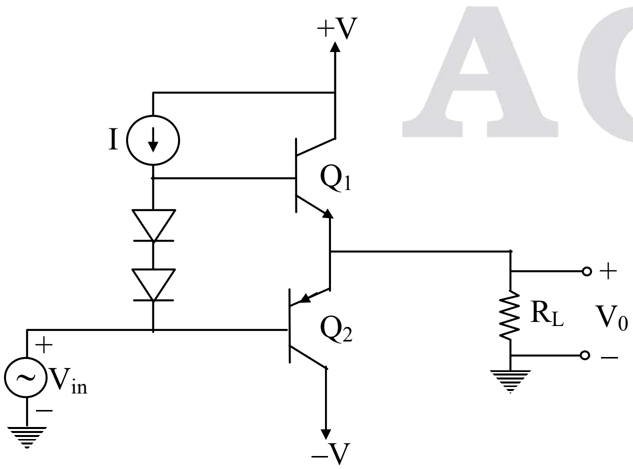
$0 = 20\log K - 20$

$20 = 20\log K \Rightarrow K = 10$

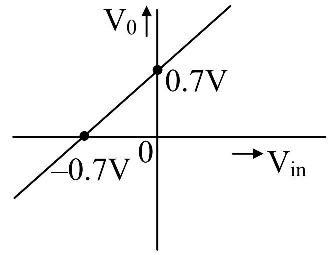
$$G(s)H(s) = \frac{10s}{(1+s)(1+s/10)(1+s/30)}$$

$$= \frac{3000s}{(s+1)(s+10)(s+30)}$$

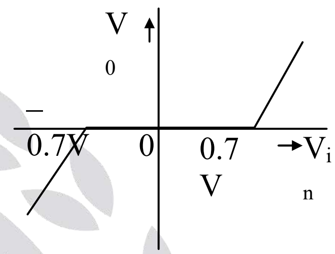
25. Consider the following circuit. The diode forward drop and base-to-emitter forward drop is considered to be 0.7V. $[V_{BE\,(ON)} = V_{D\,(ON)} = 0.7V]$. Sketch the transfer characteristics?



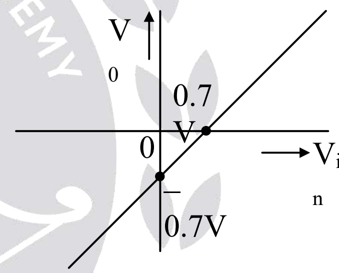
(A)



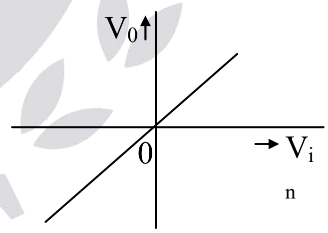
(B)



(C)



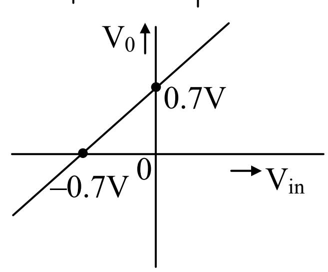
(D)



25. **Ans: (A)**

Sol:

V_{in}	V_{B1}	V_0
0V	1.4V	0.7V
–0.7V	0.7V	0V



26. For the function $f(x, y) = x^2 - y^2$, the point (0, 0) is

(A) a local minimum
(B) a saddle point
(C) a local maximum
(D) not a stationary point

26. Ans: (B)

Sol: Given $f(x,y) = x^2 - y^2$

$\Rightarrow f_x = 2x,\ f_y = -2y$ and

$f_{xx} = 2,\ f_{xy} = 0,\ f_{yy} = -2$

Consider $f_x = 0$ and $f_y = 0$

$\Rightarrow 2x = 0$ and $-2y = 0$

$\Rightarrow (0,0)$ is a stationary point

At (0, 0), $f_{xx} f_{yy} - (f_{xy})^2 = -4 < 0$

$\therefore$ f(x, y) has neither a maximum nor minimum at (0, 0).

27. A synchronous counter built using T flip-flops, the flip-flop inputs are $T_2 = Q_2 \oplus Q_1$; $T_1 = Q_1 \oplus Q_0$; $T_0 = Q_2 \odot Q_0$. Determine the counter state after 2 pulses if the present state is 110.

(Assume Q_2 as MSB, Q_0 as LSB)

(A) 000 (B) 110
(C) 100 (D) None

27. Ans: (A)

Sol: $T_2 = Q_2 \oplus Q_1$; $T_1 = Q_1 \oplus Q_0$;

$T_0 = Q_2 \odot Q_0$

CLK	P.S	FF Inputs	N.S
	$Q_2\ Q_1\ Q_0$	$T_2\ T_1\ T_0$	$Q_2\ Q_1\ Q_0$
1	1 1 0	0 1 0	1 0 0
2	1 0 0	1 0 0	0 0 0

28. A system is described by the impulse response $h(n) = (-1)^n u(n)$. The difference equation of the inverse of this system is

(A) y(n) + y(n–1) = x(n)
(B) y(n) – y(n–1) = x(n)
(C) y(n) = x(n) + x(n–1)
(D) y(n) = x(n) – x(n–1)

28. Ans: (C)

Sol: Given $h(n) = (-1)^n u(n)$

$$(a)^n u(n) \xleftrightarrow{Z.T} \frac{1}{1-az^{-1}} \quad H(z) = \frac{1}{1+z^{-1}}$$

$$H_{inv}(z) = \frac{1}{H(z)} = 1 + z^{-1} = \frac{Y(z)}{X(z)}$$

$Y(z) = X(z) + z^{-1}X(z)$

Apply inverse z-transform

$y(n) = x(n) + x(n-1)$

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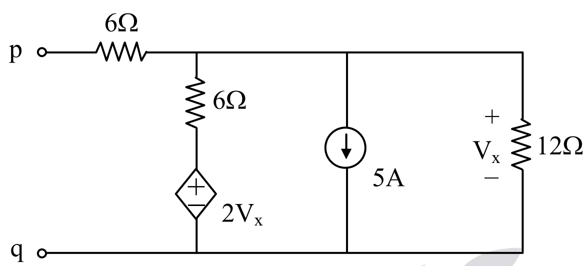
29. In the following circuit, the thevenin's voltage and resistance looking into terminals p & q respectively are.

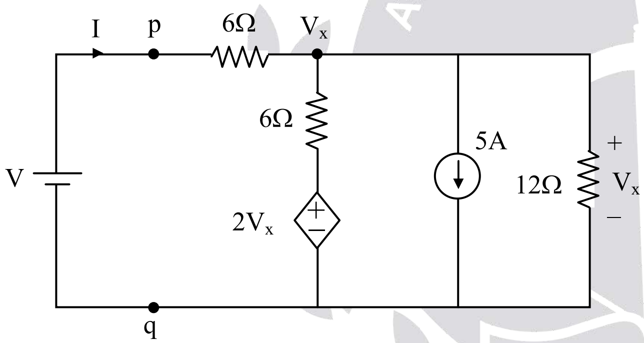


(A) 40V, 6Ω (B) 60V, 12Ω

(C) 40V, –12Ω (D) 60V, –6Ω

29. Ans: (D)

Sol: V-I method



By KCL at V_x

$$I = \frac{V_x - 2V_x}{6} + 5 + \frac{V_x}{12}$$

$$I = \frac{-V_x}{6} + 5 + \frac{V_x}{12} = \frac{-2V_x + 60 + V_x}{12}$$

$12I = 60 - V_x$

$12I = 60 - (V - 6I)$ $\left(I = \frac{V - V_x}{6} \right)$

$12I = 60 - V + 6I$ $\quad V_x = V - 6I$

$V = -6I + 60$

$V = R_{th}I + V_{th}$

$V_{th} = 60$ Volts

$R_{th} = -6\Omega$

30. Consider a CMOS inverter with C = 5fF, V_{DD} = 2V and propagation delay t_p = 10ps. Find the energy-delay product when the inverter is operated at its theoretical maximum possible operating frequency.

(A) 10×10^{-26} J-s (B) 20×10^{-26} J-s

(C) 10×10^{-15} J-s (D) 20×10^{-15} J-s

30. Ans: (A)

Sol: $EDP = \frac{1}{2} C V_{DD}^2 t_p$

$$= \frac{1}{2} \times 5 \times 10^{-15} \times (2)^2 \times 10 \times 10^{-12}$$

$= 100 \times 10^{-27} = 10 \times 10^{-26}$ J-S

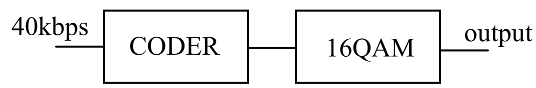
31. The bit rate of a system is 40 kbps. To correct the errors in transmitted bits, a (7, 4) block code is used. The output of the coder again passed through the 16-QAM modulator. If the raised cosine pulse with 100% excess bandwidth is used, then the bandwidth of the QAM signal is

(A) 35 kHz (B) 17.5 kHz

(C) 20 kHz (D) 10 kHz

31. Ans: (A)

Sol: Bit rate = 40kbps



In a coder bit rate increases by a factor of n/k. Where k = 4, n = 7.

The bit rate at the output of the coder is $40\text{ kbps}\times\frac{7}{4}$.

The bit rate at the input of the modulator $= 70$kbps.

Raised cosine pulse with $\alpha = 1$ is used & $M = 16$

$$\text{Bandwidth} = \frac{R_b[1+\alpha]}{\log_2 M}$$

$$= \frac{70\times10^3[1+1]}{\log_2 16} = \frac{70\times10^3\times2}{4}$$

$= 35$ kHz.

32. A continuous random variable X has a probability density function $f(x) = e^{-x}$, $0 < x < \infty$. Then $P(X > 2)$ is

(A) 0.1353 (B) 0.2354

(C) 0.2343 (D) 1.1353

32. Ans: (A)

Sol: $P(X > 2) = \int_2^{\infty} f(x)\cdot dx$

$$= \int_2^{\infty} e^{-x}dx = \left.\frac{e^{-x}}{-1}\right|_2^{\infty}$$

$$= e^{-2} = 0.1353$$

33. A material has $\sigma = 10^{-2}$S/m and $\varepsilon = 3\varepsilon_o$. At what frequency will the conduction current equal the displacement current?

(A) 180MHz (B) 60 MHz

(C) 0.6 MHz (D) 6 GHz

33. Ans: (B)

Sol: For the two current to be equal

$|J_c| = |J_d|$

$\sigma E = j\omega\varepsilon E$

$\sigma = \omega\varepsilon = 2\pi f\varepsilon$

$$\Rightarrow f = \frac{\sigma}{2\pi\varepsilon} = \frac{10^{-2}}{2\pi\times3\times\frac{10^{-9}}{36\pi}} = 60\text{MHz}$$

34. In a counter type ADC the clock frequency is 1 MHz and threshold voltage is 10 mV. The DAC has full scale output of 20.46V and resolution of 10 bits. Find the conversion time for analog input of 3.728V.

(A) 1023μs (B) 511.5μs

(C) 190μs (D) 187μs

34. Ans: (D)

Sol: Step size $= \frac{20.46}{2^{10}-1} = \frac{20.46}{1023} = 20$mV.

Given $V_{in} = 3.728$V, then V_d has to be $= 3.728 + 10$mV

$V_d = 3.728 + 0.01 = 3.738$V

$$= \frac{3.738}{20\times10^{-3}} = 186.9 = 187_{10}$$

$= 010111011_2$

Conversion time is $\Rightarrow 187\times1\mu s = 187\mu s$.

35. The solution to $x^2y^{11} + xy^1 - y = 0$ is

(A) $y = C_1x^2 + C_2 x^{-3}$

(B) $y = C_1 + C_2x^{-2}$

(C) $y = C_1 x + \frac{C_2}{x}$

(D) $y = C_1 x + C_2 x^4$

35. Ans: (C)

Sol: Put $ln\, x = t$ so that $x = e^t$ and

let $x\frac{dy}{dx} = Dy$, $x^2\frac{d^2y}{dx^2} = D(D-1)\,y$

where $D = \frac{d}{dt}$

Given differential equation is

$x^2y^{11} + xy^1 - y = 0$

$\Rightarrow$ $D(D-1)y + Dy - y = 0$

$\Rightarrow$ $(D^2 - 1)\, y = 0$

Consider Auxiliary equation $f(D) = 0$

$\Rightarrow D^2 - 1 = 0$

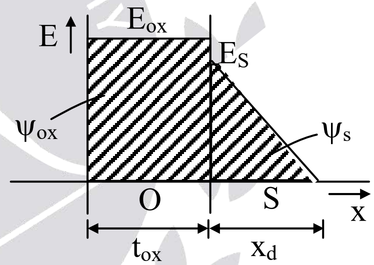
$\Rightarrow D = 1, -1$ are different real roots

$\therefore$ The general solution of given equation is

$y = C_1e^t + C_2e^{-t} = C_1 x + \frac{C_2}{x}$

Q. 36 – Q. 65 carry Two marks each.

36. An ideal MOS capacitor has boron doping concentration of $10^{16}/cm^3$ in the substrate. When a gate voltage is applied a depletion region width of 0.3μm is formed with a surface potential of 0.1V. Given that $\varepsilon_0 = 8.854 \times 10^{-14}$ F/cm and the relative permitivities of silicon and SiO_2 are 12 and 4 respectively. The voltage drop(in mV) in the oxide layer, if the thickness of oxide layer is $100\,\overset{0}{A}$ is _______



36. Ans: 20 **[Range: 19.8 to 20.1]**

Sol: $\psi_s = \frac{1}{2}x_dE_s$

$E_s = \frac{2\psi_s}{x_d} = \frac{2\times 0.1}{0.3\mu m} = \frac{2}{3}\,V/\mu m$

$\varepsilon_{ox} E_{ox} = \varepsilon_s E_s$

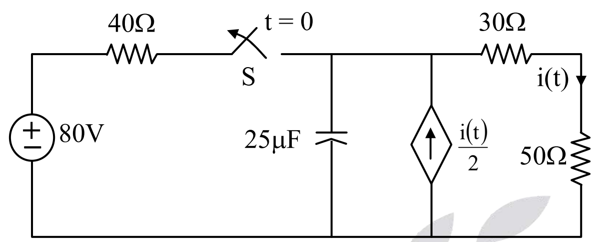
$E_{ox} = \frac{\varepsilon_s}{\varepsilon_{ox}}E_s = \frac{12}{4}\times\frac{2}{3}V/\mu m = 2V/\mu m$

$\psi_{ox} = E_{ox}\, t_{ox} = 2V/\mu m \times 100\,\overset{0}{A}$

$= 2V\frac{1}{10^{-6}m}\times 100\times 10^{-10}m$

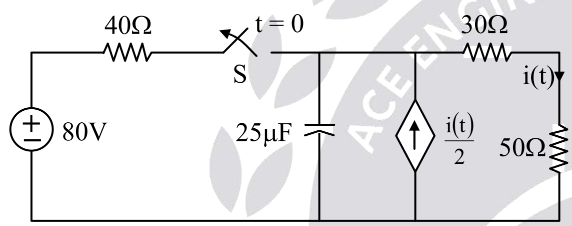
$= 20mV$

37. The circuit is under steady state for $t < 0$, the switch is opened at $t = 0$. The value of $i(t)$ (in milliamperes) at $t = 4$msec is ________.



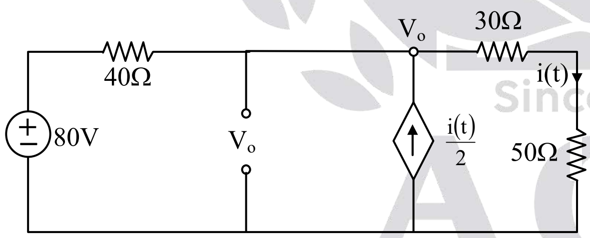
37. Ans: 294.303 [Range: 292 to 296]

Sol:



For $t < 0$, S is closed at $t = 0^-$

Circuit is in steady state condition and capacitor acts as open circuit



By KCL at V_0,

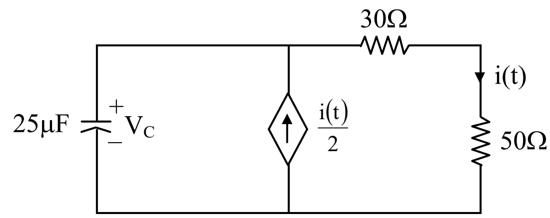
$$\frac{V_0 - 80}{40} + i(t) = \frac{i(t)}{2} \Rightarrow \frac{V_0 - 80}{40} + \frac{i(t)}{2} = 0$$

$$\Rightarrow \frac{V_0 - 80}{40} + \frac{1}{2}\left(\frac{V_0}{80}\right) = 0$$

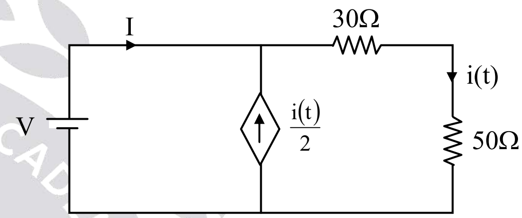
$4V_0 - 320 + V_0 = 0 \Rightarrow 5V_0 = 320$ V

$V_0 = 64$ Volts

For $t > 0$, S is opened, R-C source free circuit



For Req



$\tau = R_{eq}C$

$$I + \frac{i(t)}{2} = i(t)$$

$$\Rightarrow \frac{i(t)}{2} = I$$

$$\Rightarrow \frac{V}{80 \times 2} = I$$

$$\Rightarrow R_{eq} = \frac{V}{I} = 160\Omega$$

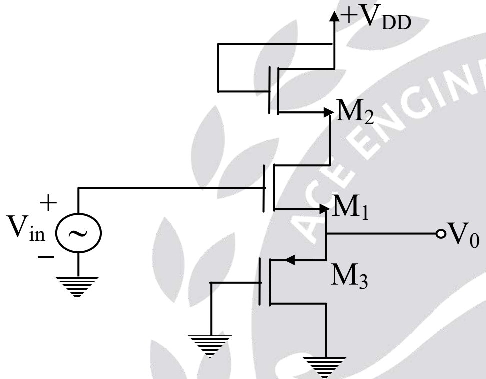
Voltage across capacitor is given by,

$$V_C(t) = V_0 e^{\frac{-t}{\tau}} = 64e^{-250t}$$

$$i(t) = \frac{V_C(t)}{80} = \frac{64e^{-250t}}{80}$$

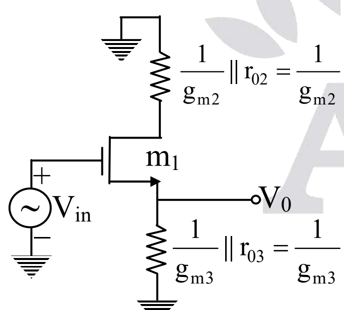
$$\Rightarrow i(t)\big|_{t=4\,m\,sec} = 0.8e^{-1} = 294.303\,mA$$

38. In the following circuit, the MOSFETs used are of enhancement mode and operating in saturation region. If all the MOSFETs are identical and by neglecting the channel length modulation, the low frequency small signal gain $\left(\frac{V_0}{V_{in}}\right)$ is ______



38. Ans: 0.5 [Range: 0.49 to 0.51]

Sol:



$$\frac{1}{g_{m2}} \| r_{02} = \frac{1}{g_{m2}}$$

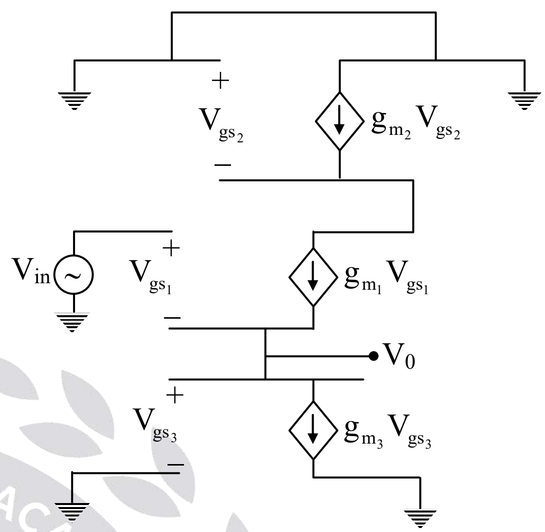
$$\frac{1}{g_{m3}} \| r_{03} = \frac{1}{g_{m3}}$$

$$\frac{V_0}{V_{in}} = \frac{i_{d_1}(1/g_{m3})}{V_{gs1} + i_{d1}(1/g_{m3})}$$

$$= \frac{i_{d_1}(1/g_m)}{i_{d_1}(1/g_m) + i_{d_1}(1/g_m)} = \frac{1}{2}$$

$$= 0.5$$

(OR)



From the above diagram

$g_{m_1} V_{gs_1} = g_{m_3} V_{gs_3}$

$\Rightarrow V_{gs_1} = V_{gs_3} \left(\because g_{m_1} = g_{m_2} = g_{m_3} = g_m\right)$ ______(1)

By KVL, $V_{gs_1} = V_{in} - V_0$ ________(2)

$V_0 = V_{gs_3}$ ______(3)

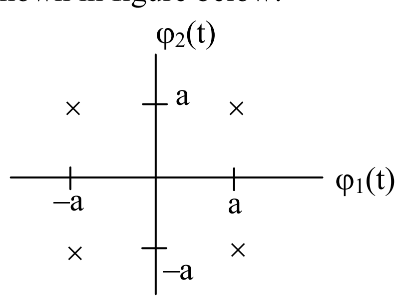
Apply Equation (2) and (3) in equation (1)

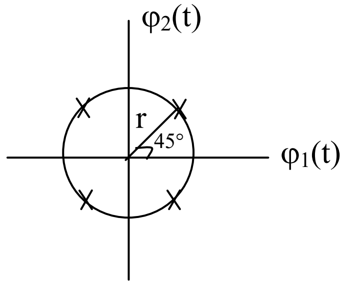
$V_{in} - V_0 = V_0$

$\Rightarrow V_{in} = 2V_0$

$\Rightarrow \frac{V_0}{V_{in}} = \frac{1}{2} = 0.5$

39. Consider two 4-ary constellation plots as shown in figure below:



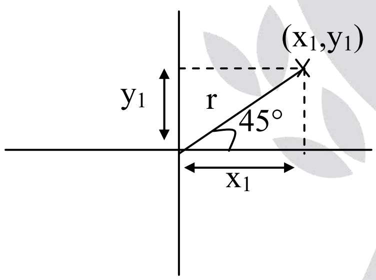


$\varphi_1(t)$ and $\varphi_2(t)$ form ortho normal basis functions. It is known that the average energy taken by both the constellation plots is same. If a = Kr, then the value of K is _____ [where K is a positive constant]

39. Ans: 0.707 [Range: 0.7 to 0.71]

Sol: Average energy of the first constellation plot $= \frac{1}{4} \times 4[a^2 + a^2] = 2a^2$

Considering the circular constellation plot



$$\cos 45° = \frac{x_1}{r}$$

$$\therefore\ r = \sqrt{2}x_1 \Rightarrow x_1 = r/\sqrt{2}$$

$$\sin 45° = \frac{y_1}{r}$$

$$\therefore\ r = \sqrt{2}y_1 \Rightarrow y_1 = r/\sqrt{2}$$

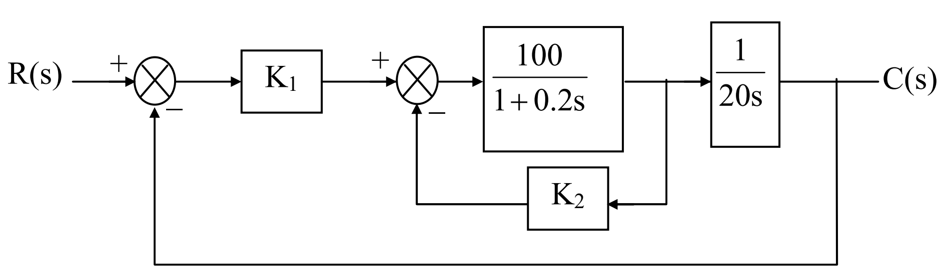
Average energy of the second constellation plot $= \frac{1}{4} \times 4\left[\frac{r^2}{2} + \frac{r^2}{2}\right] = r^2$

Since average energy of both the constellation plots are same

$$\Rightarrow 2a^2 = r^2$$

$$\therefore\ a = \frac{1}{\sqrt{2}} r \Rightarrow a = 0.707r$$

40. The system shown below has second order response with a damping ratio of 0.5 and a settling time with ± 2% tolerance is 0.5 sec. Then the value of K_1 is _____



40. Ans: 10.24 [Range: 10 to 11]

Sol: $$\frac{C(s)}{R(s)} = \frac{100K_1/(20s(1+0.2s))}{1+\frac{100K_2}{(1+0.2s)}+\frac{100K_1}{20s(1+0.2s)}} = \frac{100K_1}{20s(1+0.2s)+100K_2(20s)+100K_1}$$

$$\frac{C(s)}{R(s)} = \frac{100K_1}{20s+4s^2+2000K_2 s+100K_1} = \frac{100K_1}{4s^2+s(2000K_1+20)+100K_1}$$

$\underrightarrow{CE}$ $4s^2+s(2000K_1+20)+100K_1=0$

$\underrightarrow{CE}$ $s^2+S(500K_1+5)+25K_1=0$

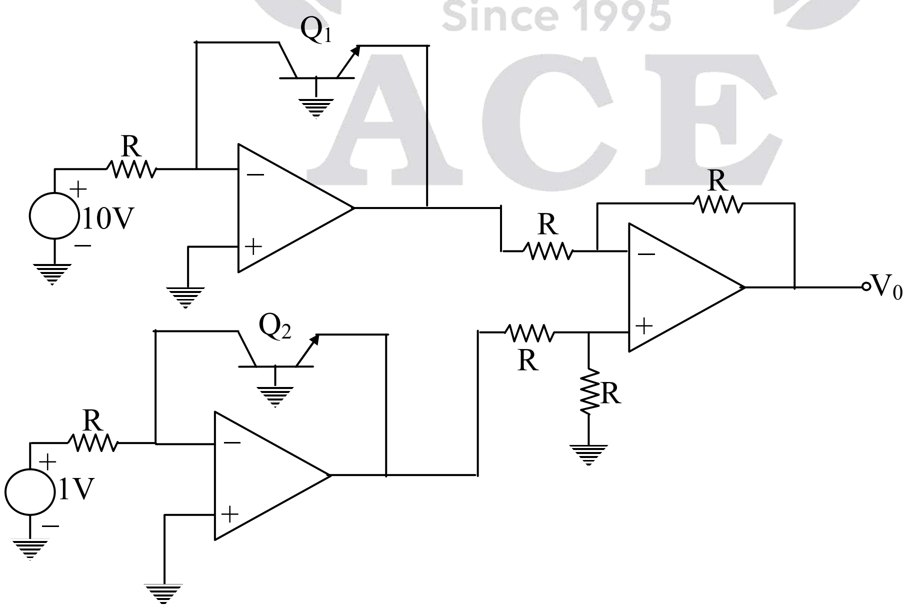
Given Data: $\xi = 0.5$, $t_s = 0.5$ sec

$\pm 2\%$ $t_s = \frac{4}{\xi\omega_n} \Rightarrow 0.5 = \frac{4}{0.5\times\omega_n}$

$\Rightarrow \omega_n = 16$ rad/sec

$\omega_n^2 = 25K_1 \Rightarrow K_1 = \frac{256}{25} = 10.24$

41. The transistors shown obey a non linear relation $I_C = I_S\, e^{\frac{V_{be}}{V_T}}$ where V_T is the thermal voltage equal to 25mV and I_S is the reverse saturation current. If β is large, then the value of output voltage V_0 (in milli volt) is ______



41. Ans: 57.56 **[Range: 57 to 58]**

Sol: Here $V_{e2} = -V_{BE2}$, $V_{e1} = -V_{BE1}$

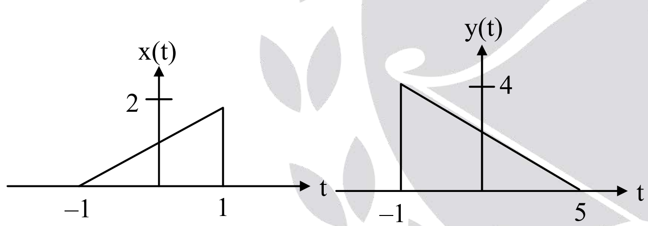
$V_0 = V_{e2} - V_{e1} = V_{be1} - V_{be2}$

$$= V_T \ln\left[\frac{I_{C1}}{I_{C2}}\right]$$

$$= V_T \ln\left[\frac{10/R}{1/R}\right] = 25m \ln[10]$$

$V_0 = 57.56$ mV

42. Consider the signals x(t) & y(t) as shown below. Then y(t) expression interms of x(t) as $y(t) = Ax\left(\frac{t}{B} + C\right)$. Then the value of A + B + C is _____



42. Ans: –0.333 **[Range: – 0.30 to –0.35]**

Sol: y(t) is amplitude scaled by 2 it is also folded, expanded & shifted version of x(t)

y(t) can be expressed as $y(t) = Ax(\alpha t + \beta)$

t = –1 of x(t) corresponds to t = 5 of y(t)

t = 1 of x(t) corresponds to t = –1 of y(t)

$$\left.\begin{aligned} 5\alpha + \beta &= -1 \\ -\alpha + \beta &= 1 \end{aligned}\right\} \alpha = -\frac{1}{3} \ \& \ \beta = \frac{2}{3}$$

$$\therefore y(t) = 2x\left(\frac{-t}{3} + \frac{2}{3}\right)$$

But, given $y(t) = Ax\left(\frac{t}{B} + C\right)$

Then A = 2

B = –3

$C = \frac{2}{3}$

$A + B + C = \frac{-1}{3} = -0.333$

43. Consider a CMOS inverter for which $V_{DD} = 2V$, $V_{tn} = |V_{tp}| = 0.6V$, $\mu_n = 2\mu_p$ and $\mu_n C_{ox} = 100\mu A/V^2$, L = 0.15μm and $\left(\frac{W}{L}\right)_n = 2$. The transistors are matched.

The output resistance (in kΩ) of the inverter in the high output state is _____

43. Ans: 3.571 **[Range: 3 to 4]**

Sol: Since PMOS and NMOS devices are matched, the output resistance in the high output state will be same as output resistance in the low output state i.e. $r_{DSp} = r_{DSn}$

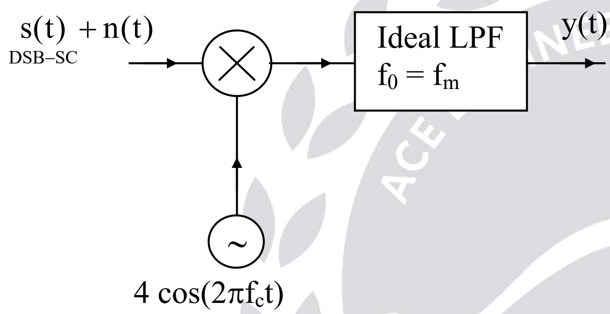
The output resistance of the inverter in the low output state is

$$r_{DSn} = \frac{1}{\mu_n C_{ox}\left(\frac{W}{L}\right)_n (V_{DD} - V_{tn})}$$

$$= \frac{1}{100\times10^{-6}\times2\times(2-0.6)} = 3.571k\Omega$$

$r_{DSn} = r_{DSp} = 3.571k\Omega$

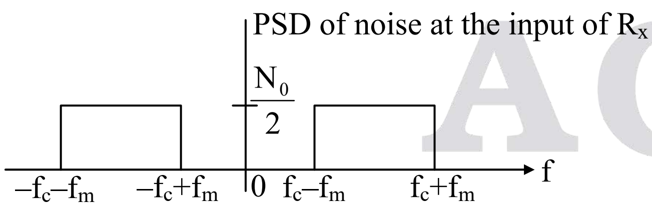
44. Consider a base band signal band limited to 5 kHz. The modulation scheme is DSB-SC. The modulated signal s(t) is transmitted through a channel, which is modelled using AWGN having two sided PSD of 10^{-10} W/Hz. The Coherent receiver is used to demodulate the message signal from the modulated signal, as shown in the figure below.

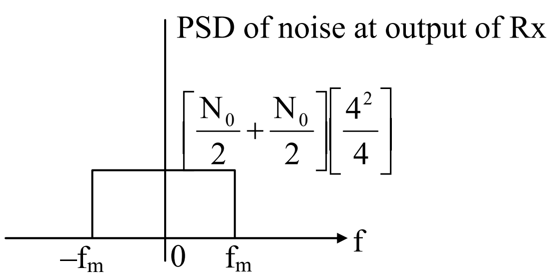


The power of the noise component (in μW) at the output of receiver is _____

44. Ans: 8 [Range: 7.95 to 8.05]

Sol:





∴ Power of noise at output of R_x is

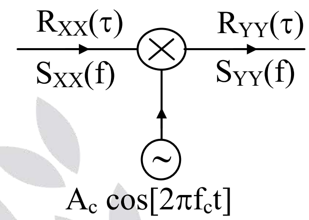
$$2f_m \times \frac{16}{4}[N_0] = 4N_0 \times 2f_m$$

$$= 4 \times 2 \times 10^{-10} \times 2 \times 5 \times 10^3$$

$$= 8\ \mu W$$

NOTE: $Z(t) = A_c \cos(2\pi f_c t)$

$$R_{ZZ}(\tau) = \frac{A_c^2}{2}\cos(2\pi f_c \tau)$$



$$R_{YY}(\tau) = R_{XX}(\tau)R_{ZZ}(\tau) = R_{XX}(\tau)\frac{A_c^2}{2}\cos(2\pi f_c \tau)$$

$$\Rightarrow S_{YY}(f) = \frac{A_c^2}{4}\left[S_{XX}(f - f_c) + S_{XX}(f + f_c)\right]$$

45. Consider the differential equation $\frac{dy}{dx} + 2xy = e^{-x^2}$ with initial condition $y(0) = 1$. The value of $y(1)$ is _____.

45. Ans: 0.7357 [Range 0.73 to 0.74]

Sol: Given $\frac{dy}{dx} + 2xy = e^{-x^2}$ …….. (1)

with $y(0) = 1$ …….. (2)

$\therefore$ I. F. $= e^{\int 2x\,dx} = e^{x^2}$

Now, the general solution of (1) is

$\Rightarrow y.\ e^{x^2} = \int e^{x^2} .\ e^{-x^2} dx + c$

$\Rightarrow y.\ e^{x^2} = x + c$ …….. (3)

Using (2), (3) becomes

$\Rightarrow 1 = 0 + c \Rightarrow c = 1$

$y = x\, e^{-x^2} + e^{-x^2}$

$y = (x + 1)\, e^{-x^2}$

$\therefore y(1) = 2 \times e^{-1} = 0.7357$

46. The surface integral $\iint_s (\bar{F}.\bar{n})\, dS$ over the surface S of the sphere $x^2 + y^2 + z^2 = 9$, where $F = (x+y)\bar{i} + (x+z)\bar{j} + (y+z)\bar{k}$ and $\bar{n}$ is the unit outward surface normal, yields ________.

46. Ans: 226.08 [Range: 226 to 227]

Sol: $\vec{F} = (x+y)\vec{i} + (x+z)\vec{j} + (y+z)\vec{k}$

div $\vec{F} = 1 + 1 = 2$

$\iint_S \vec{F}.\vec{n}\, dS = \iiint_V \text{div}\,\vec{F}\, dx\, dy\, dz$ (By Gauss divergence theorem)

$= \iiint 2\, dx\, dy\, dz$

$= 2 \times$ volume of the sphere

$= 2 \times \frac{4}{3}\pi(3)^3 = 72\pi = 226.08$

47. Consider a control system with $G(s) = \frac{K(s+40)}{s(s+10)}$, $H(s) = \frac{1}{(s+20)}$. The value of 'k' for which the system will oscillate is ______

47. Ans: 600

Sol: $\underrightarrow{CE}\ 1 + G(s)H(s) = 0$

$\underrightarrow{CE}\ 1 + \frac{K(s+40)}{s(s+10)} \cdot \frac{1}{(s+20)} = 0$

$\underrightarrow{CE}\ s(s+10)(s+20) + K(s+40) = 0$

$\underrightarrow{CE}\ s^3 + 30s^2 + s(K+200) + 40K = 0$

CE:- $s^3 + 30s^2 + s(K + 200) + 40K = 0$

s^3	1	K+200
s^2	30	40K
s^1	$\left(\frac{30(K+200) - 40K}{30}\right)$	
s^0	40K	

For marginal stable

$\Rightarrow (30K + 6000 - 40K) = 0$

$10K = 6000$

$K = 600$

48. The value of the double integral $\int_0^8 \left(\int_{y/2}^{(y/2)+1} \left(\frac{2x - y}{2}\right) dx \right) dy$, using the substitution $u = \left(\frac{2x - y}{2}\right)$ and $v = \frac{y}{2}$ is ______.

48. Ans: 4

Sol: Given $u = \frac{2x - y}{2}$ and $v = \frac{y}{2}$

$\Rightarrow du = dx,\ dv = \frac{dy}{2}$ and $dy = 2\, dv$

If $x = \frac{y}{2}$ then $u = 0$

If $x = \frac{y}{2}+1$ then $u = 1$

If $y = 0$ then $v = 0$

If $y = 8$ then $v = 4$

$$\int_0^8 \left[\int_{\frac{y}{2}}^{\frac{y}{2}+1} \left(\frac{2x-y}{2}\right)dx\right]dy = \int_{v=0}^{4}\int_{u=0}^{1} 2u\ du\,dv = 4$$

49. Given F.T of x(t) is X(f) = 8Sinc(2f)Sinc(4f). Then the value of x(t) at t = 0 is _____

49. Ans: 2

Sol: Using plancheral's theorem

$$\int_{-\infty}^{\infty} x_1(t)x_2(t)dt = \int_{-\infty}^{\infty} X_1(f)X_2(f)df$$

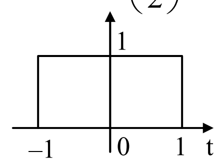
$$A\,\text{rect}\left(\frac{t}{T}\right) \leftrightarrow AT\ \text{Sinc}(fT)$$

8Sinc(2f)Sinc(4f)= [2 Sinc(2f)][4Sinc(4f)]

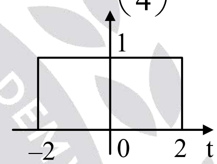
$$\int_{-\infty}^{\infty} (2\text{Sinc}(2f))(4\text{Sinc}(4f))df$$

$$= \int_{-\infty}^{\infty} \text{rect}\left(\frac{t}{2}\right)\text{rect}\left(\frac{t}{4}\right)dt$$

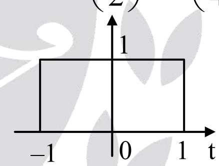
$\text{rect}\left(\frac{t}{2}\right)$



$\text{rect}\left(\frac{t}{4}\right)$

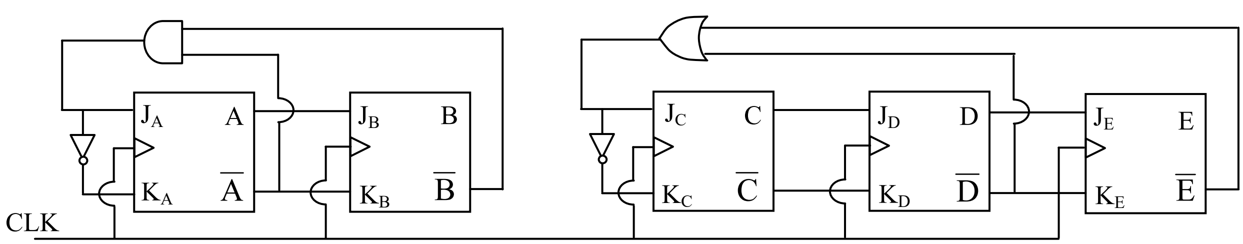


$\text{rect}\left(\frac{t}{2}\right)\text{rect}\left(\frac{t}{4}\right)$



$$\int_{-\infty}^{\infty} \text{rect}\left(\frac{t}{2}\right)\text{rect}\left(\frac{t}{4}\right)dt = \int_{-1}^{1}(1)dt = 2$$

50. Two Johnson counters of 2-bit and 3-bit are connected parallely as shown in the following figure. The initial value of the counter is ABCDE = 00001. The modulus of the counter is _____



50. Ans: 15

Sol: In the given figure

$J_A = \overline{A}.\overline{B} = \overline{A+B}$ $\quad J_B = A$ $\quad J_C = \overline{D}+\overline{E} = \overline{DE}$ $\quad J_D = C$ $\quad J_E = D$

$K_A = A+B$ $\quad K_B = \overline{A}$ $\quad K_C = DE$ $\quad K_D = \overline{C}$ $\quad K_E = \overline{D}$

CLK	J_A K_A	J_B K_B	J_C K_C	J_D K_D	J_E K_E	A B C D E
0						0 0 0 0 1
1	1 0	0 1	1 0	0 1	0 1	1 0 1 0 0
2	0 1	1 0	1 0	1 0	0 1	0 1 1 1 0
3	0 1	0 1	1 0	1 0	1 0	0 0 1 1 1
4	1 0	0 1	0 1	1 0	1 0	1 0 0 1 1
5	0 1	1 0	0 1	0 1	1 0	0 1 0 0 1
6	0 1	0 1	1 0	0 1	0 1	0 0 1 0 0
7	1 0	0 1	1 0	1 0	0 1	1 0 1 1 0
8	0 1	1 0	1 0	1 0	1 0	0 1 1 1 1
9	0 1	0 1	0 1	1 0	1 0	0 0 0 1 1
10	1 0	0 1	0 1	0 1	1 0	1 0 0 0 1
11	0 1	1 0	1 0	0 1	0 1	0 1 1 0 0
12	0 1	0 1	1 0	1 0	0 1	0 0 1 1 0
13	1 0	0 1	1 0	1 0	1 0	1 0 1 1 1
14	0 1	1 0	0 1	1 0	1 0	0 1 0 1 1
15	0 1	0 1	0 1	0 1	1 0	0 0 0 0 1

So, the modulus of the counter is 15

51. A hollow rectangular wave guide with dimensions satisfying the condition a > b > a/2, is to be used to transmit a signal at carrier frequency of 6 GHz. The cut off frequency of the dominant TE mode is lower than the carrier by 25% and that of the next mode is at least 25% higher than the carrier. Then the narrow dimension (in cm) is ____.

51. Ans: 2

Sol: For m = 1 and n = 0 (TE_{10} mode) and v = c (hollow guide)

$$f_{c_{TE10}} = \frac{c}{2a}$$

Denote carrier frequency as f_o = 6 GHz

$f_{c_{TE10}}$ = $0.75f_o = 0.75\times6$ GHz = 4.5 GHz.

We have

$$a = \frac{c}{2\times f_{c_{TE10}}} = \frac{3\times10^8}{2\times4.5\times10^9} = 3.33\,\text{cm}.$$

If b is chosen such that

a > b > a/2 the second mode will be

TE_{01}, followed by TE_{20}

$f_{c_{TE20}}$ = 9 GHz [As the carrier frequency is less than cut-off frequency. So, TE_{20} mode will not propagate]

for $f_{c_{TE01}} = \frac{c}{2b}$

$f_{c_{TE01}} = 1.25f_o$ = 7.5 GHz

we get

$$b = \frac{c}{2f_{c_{TE01}}} = \frac{3\times10^8}{2\times7.5\times10^9} = 2\,\text{cm}$$

52. Consider a p-type semiconductor at T = 300K, with carrier concentrations of $p_0 = 10^{15}/cm^3$, $n_0 = 10^5/cm^3$ and $n_i = 10^{10}/cm^3$. In non-equilibrium assume that the excess carrier concentrations are $\delta_n = \delta_p = 10^{13}/cm^3$. Determine quasi-Fermi energy levels

(A) Quasi Fermi level for holes (E_{Fp}) remains the same as equilibrium Fermi level (E_F) but quasi Fermi level for electrons (E_{Fn}) will be below intrinsic level (E_i) by 0.1796eV.

(B) Quasi Fermi level for holes (E_{Fp}) remains the same as equilibrium Fermi level (E_F) but quasi Fermi level for electrons (E_{Fn}) will be above intrinsic level (E_i) by 0.1796eV.

(C) Quasi Fermi level for holes (E_{Fp}) remains the same as equilibrium Fermi level (E_F) but quasi Fermi level for electrons (E_{Fn}) will be below intrinsic level (E_i) by 0.2993eV.

(D) Quasi Fermi level for holes (E_{Fp}) remains the same as equilibrium Fermi level (E_F) but quasi Fermi level for electrons (E_{Fn}) will be above intrinsic level (E_i) by 0.2993eV.

52. Ans: (B)

Sol: $n = n_0 + \delta_n \approx \delta_n$

$p = p_0 + \delta_p \approx p_0$

Since $p \approx p_0$, E_{Fp} is same as E_F

$$E_{Fn} - E_i = KT\ell n\left(\frac{n}{n_i}\right) = KT\ell n\left(\frac{n_0+\delta_n}{n_i}\right) \approx KT\left(\frac{\delta_n}{n_i}\right)$$

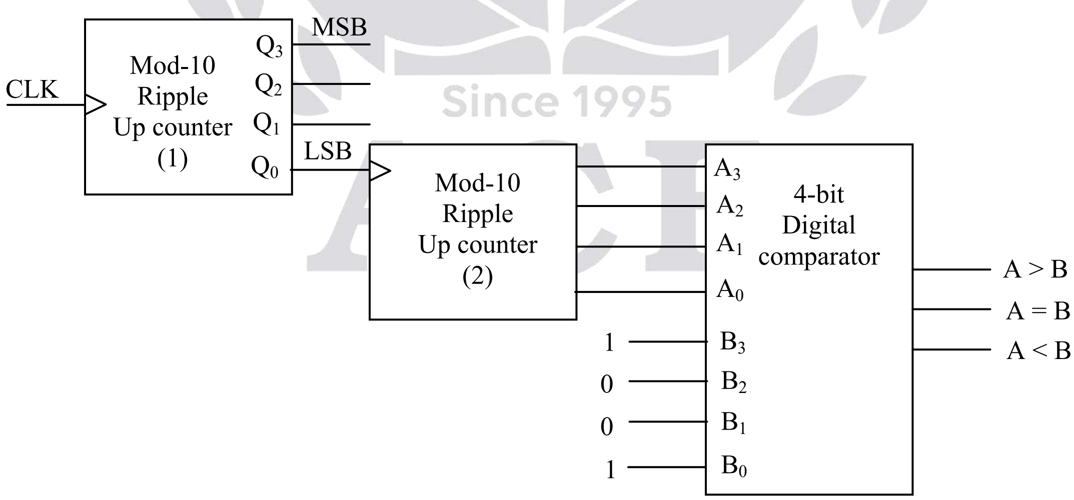
$$= 0.026 \times \ell n\left(\frac{10^{13}}{10^{10}}\right)$$

$$= 0.1796 eV$$

Since $E_{Fn} - E_i > 0 \Rightarrow E_{Fn}$ lies above E_i by 0.1796eV

53. In the following logic circuit, find the minimum number of clock pulses required to obtain the A = B output HIGH of digital comparator.

Initially both counters are cleared and A < B output is high.



(A) 9 (B) 17

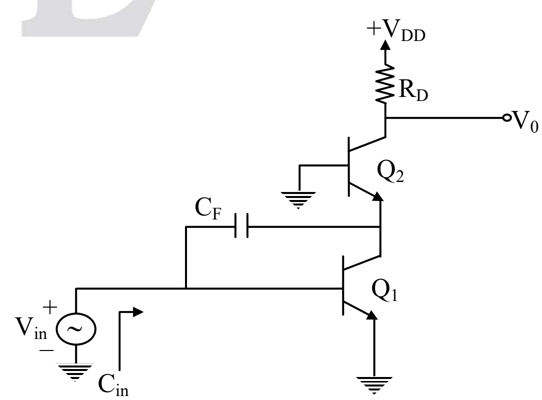
(C) 18 (D) 88

53. Ans: (B)

Sol: Here CLK of up counter (2) is Q_0 of up counter(1).

CLK	Q_3 Q_2 Q_1 Q_0	A_3 A_2 A_1 A_0	B_3 B_2 B_1 B_0	A = B
0	0 0 0 0	0 0 0 0	1 0 0 1	0
1	0 0 0 1 →	0 0 0 1	1 0 0 1	0
2	0 0 1 0	0 0 0 1	1 0 0 1	0
3	0 0 1 1 →	0 0 1 0	1 0 0 1	0
4	0 1 0 0	0 0 1 0	1 0 0 1	0
5	0 1 0 1 →	0 0 1 1	1 0 0 1	0
6	0 1 1 0	0 0 1 1	1 0 0 1	0
7	0 1 1 1 →	0 1 0 0	1 0 0 1	0
8	1 0 0 0	0 1 0 0	1 0 0 1	0
9	1 0 0 1 →	0 1 0 1	1 0 0 1	0
10	0 0 0 0	0 1 0 1	1 0 0 1	0
11	0 0 0 1 →	0 1 1 0	1 0 0 1	0
12	0 0 1 0	0 1 1 0	1 0 0 1	0
13	0 0 1 1 →	0 1 1 1	1 0 0 1	0
14	0 1 0 0	0 1 1 1	1 0 0 1	0
15	0 1 0 1 →	1 0 0 0	1 0 0 1	0
16	0 1 1 0	1 0 0 0	1 0 0 1	0
(17)	0 1 1 1 →	1 0 0 1	1 0 0 1	1
18	1 0 0 0			

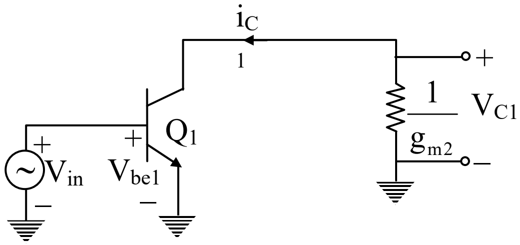
54. The transistors Q_1 and Q_2 are similar and neglect early effect. The small signal voltage gain $\left(\frac{V_0}{V_{in}}\right)$ is –100. Using miller's approximation, find the input capacitance C_{in} (Neglect all other capacitances). Assume the transistors operate with the same bias current.

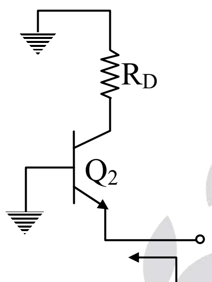


(A) C_F (B) $2C_F$ (C) $11C_F$ (D) $101C_F$

54. Ans: (B)

Sol: $C_{in} = C_F(1 + A)$





$R_{in2} = \frac{1}{g_{m2}}$

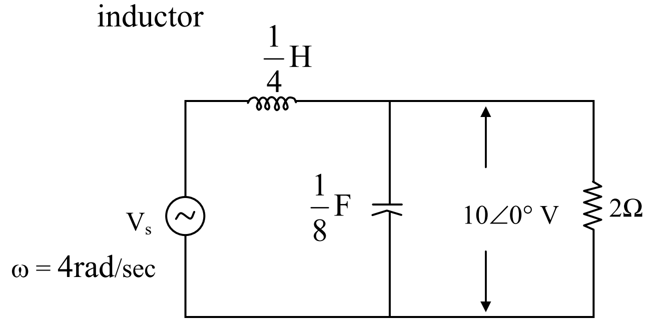
$$\frac{V_{C1}}{V_{in}} = -A = \frac{i_{C1}[1/g_{m2}]}{i_{C1}[1/g_{m1}]} = \frac{-1/g_m}{1/g_m} = -1$$

$-A = -1$

$\therefore A = 1$

$C_{in} = C_F(1 + A) = C_F(1 + 1) = 2C_F$

55. For an AC circuit as shown in figure, what is the phase angle of voltage across capacitor lags the voltage across the inductor

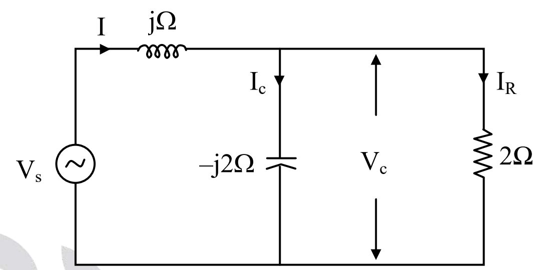


(A) 45° (B) –45°

(C) 135° (D) –135°

55. Ans: (C)

Sol:



$I_R = 5A$

$I_C = j\omega CV_C = 5\angle 90^o$

$I_L = I = I_R + I_C = 5 + j5 = 5\sqrt{2}\angle 45^o$

$V_L = j\omega L I_L = j5\sqrt{2}\angle 45^o = 5\sqrt{2}\angle 135^o$

$V_C = 10\angle 0^o$

$\Rightarrow$ Voltage across capacitor lags the voltage across inductor by 135°.

56. Given matrix $[A] = \begin{bmatrix} 4 & 2 & 1 & 3 \\ 6 & 3 & 4 & 7 \\ 2 & 1 & 0 & 1 \end{bmatrix}$, then the system AX = O, where $X = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix}$ has

(A) no solution

(B) a unique solution

(C) only one independent solution

(D) two linearly independent solutions

56. Ans: (D)

Sol: Given $A = \begin{bmatrix} 4 & 2 & 1 & 3 \\ 6 & 3 & 4 & 7 \\ 2 & 1 & 0 & 1 \end{bmatrix}$

$R_2 \to 4R_2 - 6R_1$;

$R_3 \to 2R_3 - R_1$

$$\sim \begin{bmatrix} 4 & 2 & 1 & 3 \\ 0 & 0 & 10 & 10 \\ 0 & 0 & -1 & -1 \end{bmatrix}$$

$R_3 \to (10)R_3 + R_2$

$$\sim \begin{bmatrix} 4 & 2 & 1 & 3 \\ 0 & 0 & 10 & 10 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$\therefore \rho(A) = 2$

$\therefore$ Number of linearly independent solutions

= Number of variables – Rank of A

= 4 – 2 = 2

57. Consider the random process $X(t) = (A + 1)\cos(\omega t) + B\sin(\omega t)$. Where A and B are independent random variables both having zero mean and unit variance. The auto correlation function $R_{XX}(t_1, t_2)$ is

(A) $\cos\omega(t_2 - t_1)$

(B) $\sin\omega(t_1 - t_2)$

(C) $2\cos(\omega t_1)\cos(\omega t_2) + \sin(\omega t_1)\sin(\omega t_2)$

(D) $\cos(\omega t_1)\sin(\omega t_2) + \sin(\omega t_1)\cos(\omega t_2)$

57. Ans: (C)

Sol: Given that E(A) = 0, E(B) = 0,

$\sigma_A^2 = \sigma_B^2 = 1$

$R_{XX}(t_1,t_2) = E[X(t_1)X(t_2)]$

$= E[[(A + 1)\cos(\omega t_1) + B\sin(\omega t_1)][(A+1)\cos(\omega t_2) + B\sin(\omega t_2)]]$

$R_{XX}(t_1,t_2) = E[(A+1)^2]\cos(\omega t_1)\cos(\omega t_2) + E[B^2]\sin(\omega t_1)\sin(\omega t_2) + E[(A+1)]B\cos(\omega t_1)\sin(\omega t_2) + E[B(A+1)]\sin(\omega t_1)\cos(\omega t_2)$

$E[A+1]^2 = E[A^2 + 2A + 1]$

$= E[A^2] + 2E[A] + E[1] = 2$

$E[(A+1)B] = E[AB] + E[B]$

$= E[A]E[B] + E[B] = 0$

$E[B^2] = 1.$

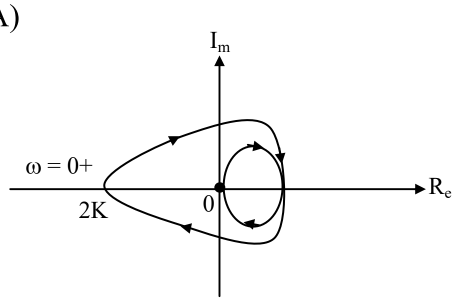
Substituting all the values in $R_{XX}(t_1,t_2)$

$R_{XX}(t_1,t_2) = 2\cos(\omega t_1)\cos(\omega t_2) + \sin(\omega t_1)\sin(\omega t_2)$

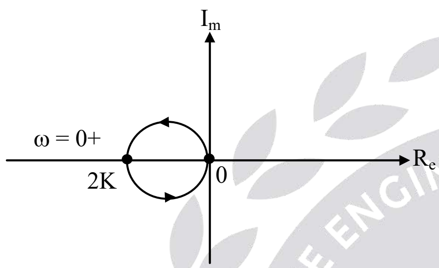
58. The open loop transfer function of a system is $G(s)H(s) = \dfrac{K(s-2)}{(s+1)^2}$

The Nyquist plot for this system is

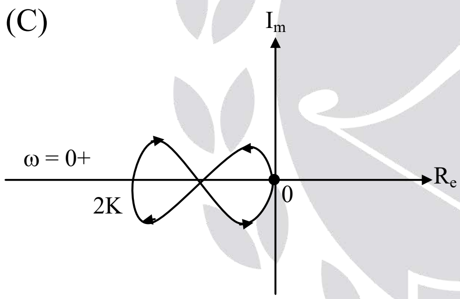
(A)



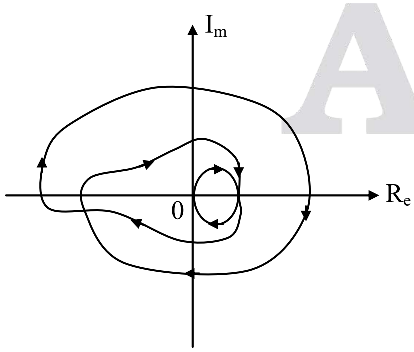
(B)



(C)



(D)



58. Ans: (A)

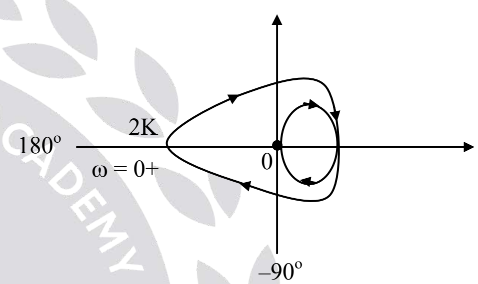
Sol: $G(j\omega)H(j\omega) = \dfrac{K(j\omega - 2)}{(j\omega + 1)^2}$

$$M = \frac{K\sqrt{\omega^2 + 4}}{(\omega^2 + 1)} \angle\phi$$

$$= -2\tan^{-1}(\omega) + \left(180° - \tan^{-1}\left(\frac{\omega}{2}\right)\right)$$

$$\angle\phi = 180° - \tan^{-1}\left(\frac{\omega}{2}\right) - 2\tan^{-1}(\omega)$$

$$\left.\begin{array}{l}\omega = 0\ ;\ 2K\angle 180° \\ \omega = \infty\ ;\ 0\angle -90°\end{array}\right\}\text{Direction is clockwise}$$



59. Let $x(n) = \{3,4,\underset{\uparrow}{5},6\}$. The step interpolated signal $h(n) = x(0.5n–1)$ is ______

(A) $\{3,0,\underset{\uparrow}{4},0,5,0,6,0\}$

(B) $\{3,3,\underset{\uparrow}{4},4,5,5,6,6\}$

(C) $\{3,3,4,4,\underset{\uparrow}{5},5,6,6\}$

(D) $\{3,4,5,\underset{\uparrow}{6},3,4,5,6\}$

59. Ans: (B)

Sol: $x(n-1) = \{3,\underset{\uparrow}{4},5,6\} = y(n)$

$$h(n) = y\left(\frac{n}{2}\right) = \{3,3,\underset{\uparrow}{4},4,5,5,6,6\}$$

if we apply step interpolation

Hearty Congratulations to our GATE-2019 Top Rankers

and many more...

	TOP 10	TOP 100
CE	5	44
ME	6	60
EE	7	71
EC	9	74
CS	5	28
IN	10	74
PI	10	49

60. A lossless transmission line is operating at a frequency of 1 GHz connected to an unmatched load producing a voltage reflection coefficient of $0.5\angle 30^0$. If a short circuited stub is connected in parallel to this line for providing impedance matching, then the optimum length and nearest location of the stub from the load respectively are

(A) 3.41cm & 12.5 cm
(B) 1.70 cm & 6.25 cm
(C) 3.41 cm & 6.25 cm
(D) 1.70 cm & 12.5 cm

60. Ans: (C)

Sol: Given: frequency, f = 1 GHz

$$\lambda = \frac{c}{f} = \frac{3\times 10^{10}}{1\times 10^{9}} = 30\text{cm}$$

Reflection coefficient, $K = 0.5\angle 30^0$

$|K| = 0.5$

$$\phi = 30^0 \text{ (or) } \frac{\pi^c}{6}$$

Optimum length of the stub:

$$\ell_t = \frac{\lambda}{2\pi}\tan^{-1}\left(\frac{\sqrt{1-|K|^2}}{2|K|}\right)$$

$$= \frac{\lambda}{2\pi}\tan^{-1}\left[\frac{\sqrt{1-(0.5)^2}}{2\times 0.5}\right] = \frac{\lambda}{2\pi}(0.713)$$

$$\therefore \ell_t \approx 3.41\text{cm}$$

Nearest location of the stub from the load is

$$\ell_s = \frac{\lambda}{4\pi}\left[\phi + \pi - \cos^{-1}(|K|)\right]$$

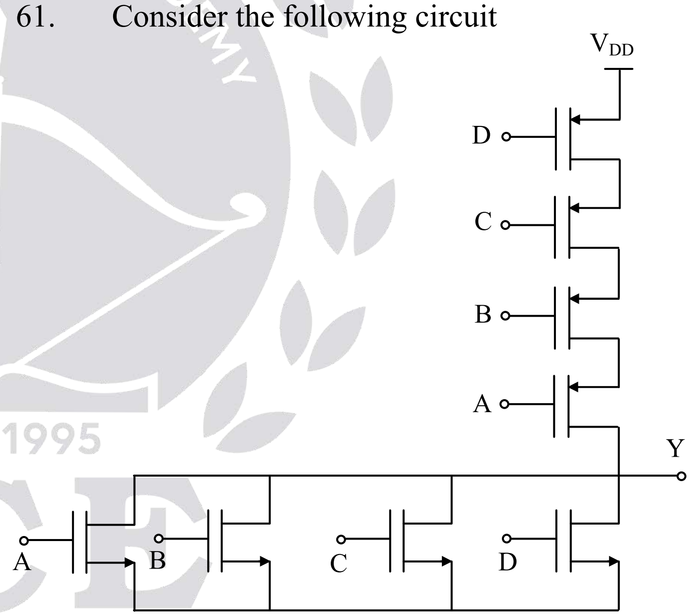
$$= \frac{\lambda}{4\pi}\left[\frac{\pi}{6} + \pi - \cos^{-1}(0.5)\right]$$

$$= \frac{\lambda}{4\pi}\left[\frac{\pi}{6} + \pi - \frac{\pi}{3}\right]$$

$$= \frac{\lambda}{4\pi}\frac{5\pi}{6} = \frac{5\lambda}{24}$$

$$\therefore \ell_s = 6.25\,\text{cm}$$

61. Consider the following circuit



In the given 4-input NOR gate, if the width of NMOS transistors are W, then the widths of PMOS transistors to obtain equal rise and fall times with $\mu_n \approx 2\mu_p$ is

(A) 4W
(B) $\frac{1}{4}$W
(C) 8W
(D) $\frac{1}{8}$W

61. Ans: (C)

Sol: Since $\mu_n \approx 2\mu_p$, the series combination of 4 PMOS devices must present resistance equal to that of an NMOS transistor, then

$$\frac{W_n}{W_p} = \frac{\mu_p}{\mu_n} \Rightarrow W_p = \frac{\mu_n}{\mu_p} W_n = 2W$$

⇒ Width of PMOS transistor

= 4(2W)

= 8W

62. The annual precipitation data of a city is normally distributed with mean and standard deviation as 1000 mm and 200 mm, respectively. The probability that the annual precipitation will be more than 1200 mm is

(A) 0.1587 (B) 0.3174

(C) 0.3456 (D) 0.2345

62. Ans: (A)

Sol: Let X = annual precipitation

We know area under normal curve in the interval $(\mu - \sigma, \mu + \sigma) = 0.6826$

where μ is mean and σ is standard deviation

$\Rightarrow P(800 < X < 1200) = 0.6826$

Required probability = $P(X > 1200)$

$$= \frac{1 - 0.6826}{2}$$

$= 0.1587$

63. In the following 2-bit synchronous up/down counter using T-flip flops

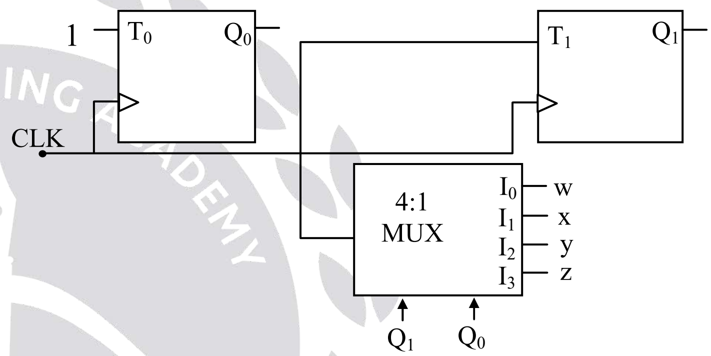
if m = 1

⇒ It should act as an 'up counter"

if m = 0

⇒ it should act as a "down counter"

w, x, y, z are functions of m ,which of the following is correct.



(A) $w = y = m$, $x = z = \overline{m}$

(B) $w = y = \overline{m}$, $x = z = m$

(C) $w = y = 0$, $x = z = m$

(D) $w = y = m$, $x = z = 1$

63. Ans: (B)

Sol:

P.S		Input	N.S		FF Inputs	
Q_1	Q_0	m	Q_1	Q_0	T_1	T_0
0	0	0	1	1	1	1
0	0	1	0	1	0	1
0	1	0	0	0	0	1
0	1	1	1	0	1	1
1	0	0	0	1	1	1
1	0	1	1	1	0	1
1	1	0	1	0	0	1
1	1	1	0	0	1	1

$\Rightarrow T_0 = 1$

$T_1 = Q_0 \odot m$

i.e if $Q_0 = 0 \Rightarrow T_1 = \overline{m}$

if $Q_0 = 1 \Rightarrow T_1 = m$.

Then $I_o = I_2 = \overline{m}$ i.e $w = y = \overline{m}$

$I_1 = I_3 = m$ i.e $x = z = m$

64. We wish to sample a signal of 1 sec duration, band-limited to 50Hz & compute the DFT of the sampled signal with spectral spacing Δf. The number of zeros needed to be Padded to reduce the spacing to 0.5Δf, using the minimum sampling rate to avoid aliasing if we use radix-2 FFT are

(A) 100 (B) 156

(C) 28 (D) 256

64. Ans: (B)

Sol: Given signal duration = 1 sec

$f_m = 50$ Hz & $f_s = 2f_m = 100$ Hz

and N = (f_s) (signal duration) = 100 × 1

= 100

and $\Delta f = \frac{f_s}{N} = 1$ Hz

To reduce spectral spacing to $\frac{\Delta f}{2} = 0.5\text{Hz}$, we require 200 samples.

So, N = 256 (for FFT)

Available number of samples = 100

∴ Number of Padding zeros = 256 – 100 = 156

65. The far field of a certain antenna is given by $|\overline{E}| = \frac{150}{r}\sin^2\theta \, V/m$, then the total average power (in Watt) radiated is

(A) 100 (B) 200

(C) 400 (D) 375

65. Ans: (B)

Sol: $$P_{rad} = \int_{\phi=0}^{2\pi}\int_{\theta=0}^{\pi}\frac{|\overline{E}|^2}{2\eta_o}r^2\sin\theta d\theta d\phi$$

$$= \left(\frac{150}{r}\right)^2\frac{r^2}{2\eta_o}2\pi\int_{\theta=0}^{\pi}\sin^5\theta d\theta \text{ ------ (1)}$$

Finding integration part

$$\int_{\theta=0}^{\pi}\sin^5\theta d\theta = \int_{\theta=0}^{\pi}\left(1-\cos^2\theta\right)^2\sin\theta d\theta$$

Let cosθ = t

$\Rightarrow \sin\theta d\theta = -dt$

For θ = 0 ⇒ t = 1 and for θ = π ⇒ t= –1

So, now

$$\int_{t=1}^{-1}\left(1-t^2\right)^2\times(-dt) = \int_{t=1}^{-1}\left(2t^2-t^4-1\right)dt$$

$$= 2\left[\frac{t^3}{3}\right]_1^{-1} - \left[\frac{t^5}{5}\right]_1^{-1} - [t]_1^{-1} = \frac{16}{15}$$

Now equation (1) becomes,

$$P_{rad} = \frac{2\pi}{2\times120\pi}\times(150)^2\times\frac{16}{15} = 200\text{W}$$


Hearty Congratulations
to our ESE-2019 Top Rankers
AIR 1 KARTIKEYA SINGH EE
AIR 1 RAJAT SONI E&T
AIR 1 HARSHAL BHOSALE ME
AIR 1 ABUZAR GAFFARI CE
AIR 2 SHAMBHAVI T EE
AIR 2 ANKUSH MANGLA E&T
AIR 2 SAHIL GOYAL ME
AIR 3 ABHISHEK ANAND EE
AIR 3 ROHIT KUMAR E&T
AIR 3 KUMAR CHANDAN ME
AIR 3 AMARJEET CE
AIR 4 ANKIT TAYAL EE
AIR 4 AMIR KHAN E&T
AIR 4 SAURAV ME
AIR 4 AMAN GULIA CE
AIR 5 KUMAR MAYANK EE
AIR 5 AYUSH CHANDRA CE
AIR 6 RITESH LALWANI EE
AIR 6 PUSHPAK ME
AIR 6 KABIL BHARGAVA CE
AIR 7 KARTIKEY SINGH EE
AIR 7 RAHUL JAIN E&T
AIR 7 MANISH RAJPUT ME
AIR 8 KULDEEP KUMAR E&T
AIR 8 HEMANT KUMAR SINGH ME
AIR 8 YOGESH KUMAR CE
AIR 9 DEEPITA ROY EE
AIR 9 SHUBHAM KARNANI E&T
AIR 9 DWEEP SABAPARA ME
AIR 9 ANKIT KUMAR CE
AIR 10 ANKITA SHARMA EE
AIR 10 GAURAV SRIVASTAVA E&T
AIR 10 SUMIT BHAMBOO ME
and many more...
Total Selections in Top 10: 33 | EE : 9 | E&T : 8 | ME : 9 | CE : 7