gradeup

GATE 2020

Electronics & Communication Engineering

Mega Mock Challenge (29 Jan -30 Jan)

Questions & Solutions

1. The average marks of each student in a class A is 25% less than the average marks of each students of class B. If the total marks of class A is 30% more than that of class B. Find the number of students in the class B is what percent of the no. of the students of class A?

A. 64.24% B. 57.69%

C. 56.24% D. 73%

Ans. B

Sol. $25\% = \frac{1}{4}$

Let the average marks of the students of the class B = 4x

Then the average marks of the students of the class A = 3x

Let the total no. of students in class B = m

then the total no. of students in class A = n

Total marks of class A $= 3xn$

And total marks of class B $= 4xm$

A.T.Q.

$\frac{\text{Total marks of A}}{\text{Total marks of B}} = \frac{130}{100} = \frac{3xn}{4xm}$

⇒ 520m = 300n

$\Rightarrow \frac{m}{n} = \frac{30}{52}$

Required percentage $= \frac{30}{52} \times 100$

= 57.69%.

2. A shopkeeper had certain number of gold coins in year 2015. In the year 2016, the number of gold coins increased by 35%. In the year 2017, the number of coins declined to 60%. In the year 2018, the number of coins increased by 25%. In the year 2019, he sold 15% of the total coins, then he had only 54726 coins left. Find the percentage decrease of the no. of coins in this duration.

A. 13.7532% B. 13.9375%

C. 14.28% D. 15.74%

Ans. B

Sol. Let the initial no of coins = 1000

Let the final no. of coins = x

A.T.Q.

$x = 1000 \times \frac{135}{100} \times \frac{60}{100} \times \frac{125}{100} \times \frac{85}{100}$

$x = 1000 \times \frac{27}{20} \times \frac{3}{5} \times \frac{5}{4} \times \frac{17}{20}$

⇒ x = 860.625

Total decrease in the no. of coins = 1000 – 860.25

= 139.375

% decrease $= \frac{139.375}{1000} \times 100$

= 13.9375%.

3. There are three inlet pipes A, B and C fitted in a tank. If A can fill the tank in 30 hours, B can fill the tank in 35 hours and C can fill the tank in 42 hours. Starting with A, followed by B and C each pipe opens alternatively for one-hour period till the tank gets filled up completely. Find the total time, the tank will be filled completely.

A. $12\frac{3}{2}$ hour B. $11\frac{2}{3}$ hour

C. $13\frac{1}{3}$ hour D. $14\frac{7}{3}$ hour

Ans. B

Sol. Let the capacity of the tank = LCM (30, 35, 42) = 210 unit

Efficiency of pipe A = $\frac{210}{30}$ = 7

Efficiency of pipe B = $\frac{210}{35}$ = 6

Efficiency of pipe C = $\frac{210}{42}$ = 5

Total work done in 3 hours (7 + 6 + 5) = 18 unit

Time taken

$= \frac{210}{18} = 11\frac{12}{18} = 11\frac{2}{3}$ hours.

4. Showing a man on the stage , Rita said, "He is the brother of the daughter of the wife of my hus-band . How is the man on stage related to Rita ?

A. Son
B. Husband
C. Cousin
D. Nephew

Ans. A

Sol. Hence, Correct option is A.

5. **Direction:** Choose the most appropriate option to change the narration (direct/indirect) of the given sentence.

Manali said, “Kindly come on time, dear Vikas.”

A. Manali requested Vikas affectionately to come on time.
B. Manali requested to Vikas affectionately to come on time.
C. Manali affectionately requested Vikas to come on time.
D. Manali requested Vikas affectionately to kindly come on time.

Ans. C

Sol. This is an imperative sentence of direct narration. We will change it into the indirect narration accordingly. The inverted commas (“ ”) used in Direct Narration will be removed in Indirect Narration. ‘Said’ is changed to ‘requested’ if sentence starts with please, kindly etc. And adverb affectionately is used for ‘dear’. Correct sequence will be ‘affectionately requested’. Hence option C is the correct answer.

6. The formula of density of a gas is defined by $\rho = \frac{m}{V}$, where ρ = density, m = mass, V = Volume. Find the percentage change in density if the mass is increased by 35% and volume is decreased by 20%.

A. 48%
B. 35%
C. 58.25%
D. 68.75%

Ans. D

Sol. $\rho_1 = \frac{m}{V}$

A.T.Q.

$$\rho_2 = \frac{135m}{80V} = \frac{27m}{16V}$$

% increase $= \frac{\rho_2 - \rho_1}{\rho_1} \times 100$

$$= \frac{\frac{27m}{16V} - \frac{m}{V}}{\frac{m}{V}} \times 100$$

$$= \frac{1100}{16}\%$$

= 68.75%

7. A, B and C can complete a work in 20, 25 and 45 days respectively. They started the work together and A left 4 days before the completion of the work and B left 3 days before the completion of work. Find the total no. of days for the work to be completed.

A. $33\frac{77}{101}$
B. $11\frac{77}{101}$
C. $14\frac{81}{101}$
D. $13\frac{81}{101}$

Ans. B

Sol. Let the total work = LCM (20, 25, 45) = 900 unit

A’s efficiency $= \frac{900}{20} = 45$

B’s efficiency $= \frac{900}{25} = 36$

C’s efficiency $= \frac{900}{45} = 20$

If A left 4 days before the completion and B left 3 days before the completion,

Now, Total work = 900 + 45×4 + 36×3 = 1188

Required time to complete the whole work $= \frac{1188}{45+36+20} = \frac{1188}{101}$

$$= 11\frac{77}{101}$$

8. In a family, there are total consumption of 35 kg wheat and 12 kg of sugar every month. If the price of sugar is $33\frac{1}{3}\%$ more than that of wheat. And if he spends total Rs. 765 on the wheat and sugar every month. If the price of sugar in increased by $66\frac{2}{3}\%$. Find the percentage of reduction on the wheat consumption so the expenditure remains the same.

A. 30.47 B. 47.30

C. 30 D. 40

Ans. A

Sol. $33\frac{1}{3}\% = \frac{1}{3}$

Let the price of wheat = 3x

Therefore, the price of sugar = 4x

A.T.Q.

$3x \times 35 + 4x \times 12 = 765$

⇒ 153x = 765

⇒ x = 5

Then price of sugar = 4x = Rs.20

Price of wheat = 3x = Rs.15

When the price of sugar be increased by $66\frac{2}{3}\%$.

$66\frac{2}{3}\% = \frac{2}{3}$

3k = 20 (Given) or $k = \frac{20}{3}$

New price of sugar

$= 3k + 2k = 5k = \frac{100}{3}$

Since the consumption of sugar and price of wheat remain same in both the cases.

Now, $\frac{100}{3} \times 12 + 15 \times y$ (new quantity of wheat) = Rs.765

⇒ 15y = 765 – 400 = 365

$y = \frac{365}{15}$

% change in consumption of

wheat $= \frac{35 - \frac{365}{15}}{35} \times 100$

$= \frac{525 - 365}{35 \times 15} \times 100$

$= \frac{16000}{525} = 30.47\%$

9. The ratio of present ages of Vijay and Prashant is 8 : 9. The ratio of their ages before 6 years was 13 : 15. Find the ratio of their ages of 12 years from now.

A. 12 : 13 B. 11 : 12

C. 10 : 11 D. 13 : 14

Ans. B

Sol. Let the age of Vijay and Prashant be 8x and 9x respectively.

A.T.Q.

Ratio of their ages before 6 years,

$\frac{8x - 6}{9x - 6} = \frac{13}{15}$

120x – 90 = 117x - 78

3x = 12

x = 4

Therefore, the present age of Vijay and Prashant is 32 years and 36 years respectively.

Required, Ratio of their ages after 12 years.

$= \frac{32 + 12}{36 + 12}$

$= \frac{44}{48}$

$= \frac{11}{12}$

= 11 : 12.

10. **Direction:** In the following questions, some of the sentences have errors and some have none. Find out which part of a sentence has an error. If there is no error, corresponding to (d) in the answer.

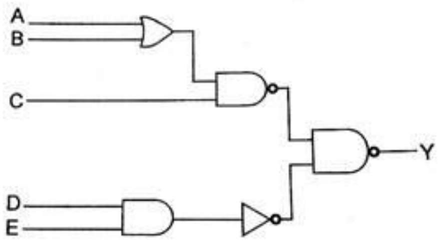
The Party will now seek to stand of its governance record, five years after nearly sweeping the Assembly results in 2015 .

A. The Party will now seek to
B. stand with its governance record,
C. the Assembly results in 2015
D. five years after nearly sweeping

Ans. B

Sol. Option B has the grammatically incorrect part. Here preposition 'of' needs to be replaced with 'on'. **Stand on** means 'to be based on; depend on'.

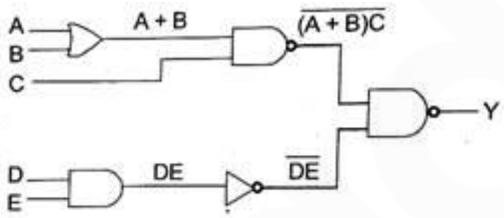
11. Output Y of the circuit shown in the figure is



A. (A+B)C+DE B. AB+C(D+E)
C. (A+B)C+D+E D. (AB+C).DE

Ans. A

Sol.



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

12. The system of equation kx + 2y − z = 1, (K − 1) y − 2z = 2 and (k + 2)z = 3 will have unique solution if K =

A. 0 B. 1
C. -2 D. -1

Ans. D

Sol. The given equations can be written as

$$\underset{A}{\begin{bmatrix} k & 2 & -1 \\ 0 & k-1 & -2 \\ 0 & 0 & k+2 \end{bmatrix}} \underset{X}{\begin{bmatrix} x \\ y \\ z \end{bmatrix}} = \underset{B}{\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}}$$

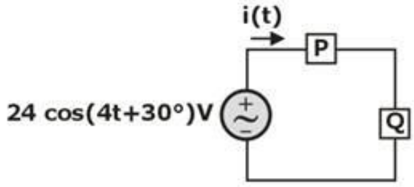
To get unique solution ρ(A)= ρ(AB) = 3

⇒ |A| ≠ 0

i.e. k (k − 1) (k +2) ≠ 0

∴k≠ 0, 1, -2

13. Two elements P and Q are connected in series as shown in figure. If current i(t) in the circuit is i(t) = 0.5 cos (4t − 30°) A, then which of the following set of element values is correct?



A. P - resistor 24 Ω, Q - inductor 10.4 H
B. P - resistor 41.6 Ω, Q - inductor 10.4 F
C. P - resistor 24 Ω, Q - inductor 41.6 H
D. P - resistor 24 Ω, Q - inductor 6 mF

Ans. A

Sol. Impedance of the circuit

$$Z = \frac{V}{I} = \frac{24\angle 30^\circ}{0.5\angle -30^\circ} = 48\angle 60^\circ$$

or Z = 48 (cos 60° + jsin 60°) = 24 + j24$\sqrt{3}$ Ω

Here, R = 24

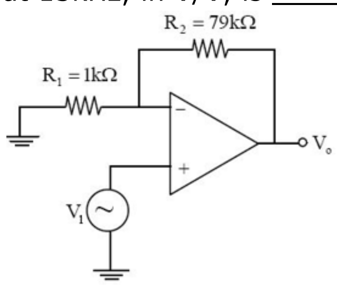
Since Im (Z) > 0, so the other element is an inductor.

$$\omega L = 24\sqrt{3}$$

$$4 \times L = 24\sqrt{3}$$

L = 10.4 H

14. The amplifier circuit shown in the figure is implemented using a compensated operational amplifier (op-amp), and has an open-loop voltage gain, $A_0 = 10^5 V/V$ and an open-loop cut-off frequency, f_c= 8 Hz. The voltage gain of the amplifier at 15kHz, in V/V, is _______.



A. 44.3 B. 45
C. 54 D. 34

Ans. A

Sol. Non-inverting amplifier

Open loop gain $=10^5$

Open loop bandwidth= 8 Hz

Gain-bandwidth product of op-amp = $8 * 10^5 = 0.8$ Mhz

Gain-bandwidth remains constant

Closed loop gain = 1 + (R_f/R_1) = 1 + (79/1) =80

gain bandwith is constant so

at gain of 80 BW =10kHz

Gain at 15KHz = $\dfrac{80}{1+j\dfrac{f}{f_c}}$

$$=\frac{80}{\sqrt{1+\left(\frac{15}{10}\right)^2}}$$

$$=\frac{80}{\sqrt{3.25}}$$

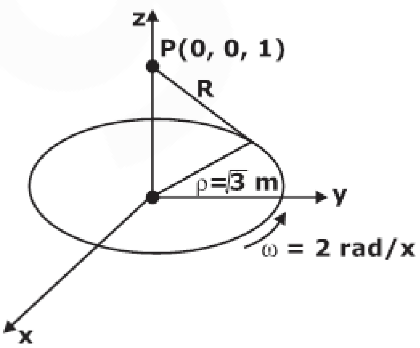
=44.3

15. In the plane z = 0 a disk of radius $\sqrt{3}m$, centered at origin carries a uniform surface charge density ρ_s = 2 C/m³. If the disk rotates about the z – axis at an angular velocity ω = 2 rad/s then the magnetic field intensity at the point P (0, 0, 1) will be

A. a_z A/m B. $2a_z$ A/m
C. a_y A/m D. $2a_y$ A/m

Ans. A

Sol.



Since the uniformly charged disk is rotating with an angular velocity ω = 2 rad/s about the z-axis so we have the current density

K = ρ_s × (angular velocity) = ρ_s (ωρ)

= 2 × 2 × ρ

or K = 4 ρ a_φ

According to Biot-savart law, magnetic field intensity at any point P due to the current sheet element KdS is defined as

$$H = \int_s \frac{KdS \times a_R}{4\pi R^2}$$

Where R is the vector distance of point P from the current element.

Now from the figure we have

R = $a_z - \rho a_\rho$

Or $R = \sqrt{1+\rho^2}$

And $a_R = \dfrac{a_z - \rho a_\rho}{\sqrt{1+\rho^2}}$

So the magnetic field intensity due to a small current element KdS at point P is

$$dH = \frac{KdS \times a_R}{4\pi R^2} = \frac{(4\rho a_\phi)\times(a_z - \rho a_\rho)}{4\pi(\rho^2+1)^{3/2}} = \frac{4\rho(a_\rho + \rho a_z)}{4\pi(\rho^2+1)^{3/2}}$$

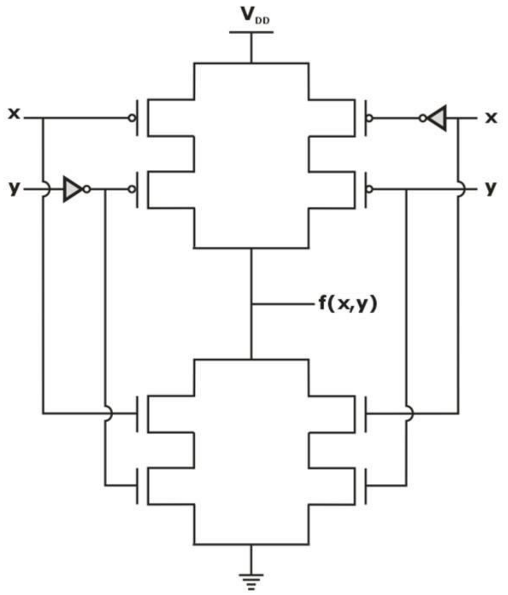
On integrating the above over φ around the complete circle, the ay compounds get cancelled by symmetry, leaving us with

$$H(z) = \int_0^{2\pi}\int_0^{\sqrt{3}} \frac{4\rho^2 a_x}{4\pi(\rho^2+1)^{3/2}}(\rho d\rho d\phi)$$

$$= 2\int_0^{\sqrt{3}} \frac{\rho^3}{(\rho^2+1)^{3/2}} d\rho a_z = 2\left[\sqrt{\rho^2+1} + \frac{1}{\sqrt{\rho^2+1}}\right]_0^{\sqrt{3}} a_z$$

$$= 2\left[\frac{3+2\left(1-\sqrt{1+3}\right)}{\sqrt{1+3}}\right] a_z = a_z A/m$$

16. The logic function f(x,y) realized by the given circuit?



A. NOR B. XOR
C. NAND D. XNOR

Ans. B

Sol. In NMOS,

Series connection = AND operation
Paraller connection = OR operation

f(x, y) = $X\bar{Y} + \bar{X}Y$ = XOR gate

17. A signal x (t) is defined in the range –5 ≤ t ≤ 5 and has energy of 16 units. If a new signal y (t) is formed by transforming x (t) is given as $y(t) = \frac{1}{2}x\left(\frac{t}{2}\right)$, then the energy of the new signal y (t) will be __________ units.

Sol. $\because \quad y(t) = \frac{1}{2}x\left(\frac{t}{2}\right)$

Here two operations are involved
Amplitude scaling → scales the energy by (scaling factor)^2
Time expansion → increase the energy by same factor

$\therefore$ energy of signal $y(t) = \left(\frac{1}{4}\right)\times 16\times 2$

$= 8$ units

18. In a photo diode, the width of the depletion layer W is 1 mm, generation rate of excess carriers is 10^{20} cm^{-3} sec^{-1}. The diffusion length of electrons and holes are 20 mm and 10 mm respectively. Then the steady state photo current density of the photo diode is ______mA/cm^2.

Sol. Given, L_n = 20 mm
L_p = 10 mm
W = 1 mm
G = 10^{20} cm^{-3} sec^{-1}
For photo diode, the steady state photo current density is
$J = q\left[W+L_n+L_p\right]G$
= 1.6 × 10^{-19} [0.1 + 30 × 0.1]
10^{20} A/cm^2
J = 49.60 mA / cm^2

19. Let 6+8j be a zero of a fourth order linear phase FIR filter. Then the complex number which is NOT a zero of this filter is

A. $\frac{1}{6}-\frac{1}{8}j$ B. 6-8j

C. $\frac{3}{50}-\frac{2}{25}j$ D. $\frac{3}{50}+\frac{2}{25}j$

Ans. A

Sol. In case of FIR filter, it has one zero, let it be Z_0
Then the other zeros are

$$\frac{1}{Z_0}, Z_0^*, \left[\frac{1}{Z_0}\right]^*$$

$$\frac{1}{Z_0} = \frac{1}{6+8j} = \frac{6-8j}{100} = \frac{3}{50} - \frac{2}{25}j$$

$$Z_0^* = 6-8j$$

$$\left[\frac{1}{Z_0}\right]^* = \frac{3}{50} + \frac{2}{25}j$$

20. The solution of differential equation

$$\frac{d^2y}{dx^2} + p\frac{dy}{dx} + (q+1)y = 0$$

Where p = 4 and q = 3 is

A. e^{-3x} B. xe^{-x}
C. xe^{-2x} D. x^2e^{-2x}

Ans. C

Sol. Given $\frac{d^2y}{dx^2} + p\frac{dy}{dx} + (q+1)y = 0$

Here P = 4 & q = 3

$\Rightarrow [D^2 + 4D + (3+1)]y = 0$

$\Rightarrow [D^2 + 4D + 4]y = 0$

$\Rightarrow (D+2)^2 = 0$

$\Rightarrow D = -2, -2$ [roots are real & equal]

$\therefore \quad y = (c_1 + c_2x)e^{-2x}$

$= c_1e^{-2x} + c_2xe^{-2x}$

Hence e^{-2x} and xe^{-2x} are independent solution.

21. In a 10 bit Dual slope type voltmeter, an unknown signal voltage is integrated over 25 cycles of clock, if the signal has 100 Hz pickup, then max. clock Freq. can be

A. 2500 Hz B. 4Hz

C. 0.4Hz D. 25 KHz

Ans. A

Sol. $T_{signal} \le 25\ T_{clk}$

$\frac{1}{100} \le \frac{25}{f_{clk}}$

$f_{clk} \le 2500$

$f_{clk(max)} = 2500Hz$

22. If a transistor has common emitter current gain of 200 and base current of 0.125 mA, then the emitter current of the transistor will be ____________ mA

(Assume that the reverse saturation current I_{CO} is negligible).

Sol. Given, β = 200

$I_B = 0.125$ mA

But, $\beta = \frac{I_C}{I_B} \Rightarrow I_C = \beta\ I_B$

$I_C = 200 \times 0.125 \times 10^{-3}$

= 25 mA

$I_E = I_C + I_B$

= (25 + 0.125) mA

= 25.125 mA

23. For TTL circuit

$I_{OH} = 400\ \mu A$, $I_{1H} = 40\mu A$

$I_{OL} = 16mA$, $I_{IL} = 2mA$

Find the fan – out

A. 8 B. 10

C. 9 D. None

Ans. A

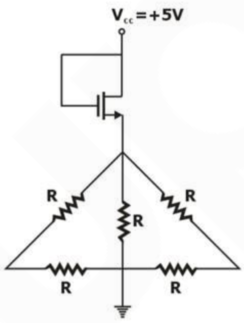
Sol. Fan – out = min $\left(\frac{I_{OH}}{I_{1H}}, \frac{I_{OL}}{I_{IL}}\right)$

$= \min\left(\frac{400}{40}, \frac{16}{2}\right)$

= min (10, 8) = 8

(a) option is correct

24. Consider the circuit shown in figure.



NMOS transistor has V_{TN} = 0.7V and $\mu n Cox\frac{W}{L} = 20\ mA/V$, If value of resistance R = 4KΩ; then region of operation of transistor will be

A. Saturation region

B. Active region

C. Cutoff region

D. Linear region

Ans. A

Sol. For MOS transistor to be saturation region

$V_{DS} > V_{GS} - V_T$

For given circuit, $V_{DS} = V_{GS}$

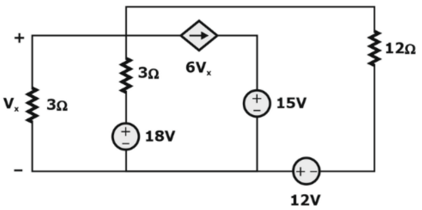
$\therefore V_{DS} - V_{GS} > -V_T$

$0 > -V_T$

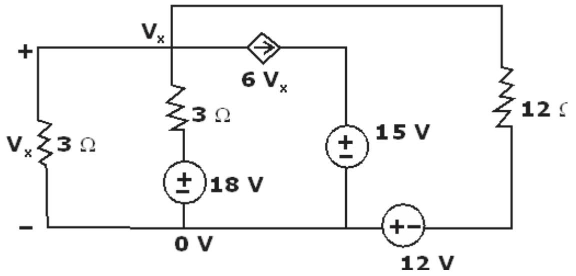
Which is always true.

Hence, transistor will be in saturation region

25. The value 'V_x' in the figure below is _____ (in V). (Rounded up to two decimal places)



Sol.



$$\frac{V_x}{3}+\frac{V_x-18}{3}+6Vx+\frac{V_s+12}{12}=0$$

$$4V_x+4V_x-72+72V_x+V_x+12=0$$

$$V_x=\frac{60}{81}$$

$$V_x=\frac{20}{27}V$$

$$V_x=0.74V$$

26. A single die is rolled six times, the probability that the six outcomes are all different is

A. $\frac{5}{6^6}$ B. $\frac{1}{6^5}$

C. $\frac{5}{324}$ D. $\frac{25}{216}$

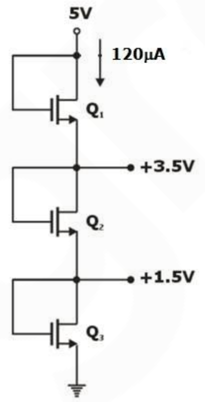
Ans. C

Sol. Number of favourable cases = 6!

Total number of outcomes possible = 6^6

Required probability $=\frac{6!}{6^6}=\frac{5}{324}$

27. Consider the circuit shown below:



All the three NMOS transistors in the circuit have V_T = 1 V, λ = 0, $\mu_n C_{ox}$ = 120 μA/V², $L_1 = L_2 = L_3$ = 1μm , then gate widths of W_1, W_2 and W_3 are

A. 8 μm, 2 μm, 8 μm

B. 2 μm, 8 μm, 2 μm

C. 8 μm, 8 μm, 8 μm

D. 2 μm, 2 μm, 2 μm

Ans. A

Sol. $I_{Q_1}=I_{D_2}=I_{D_3}=120\mu A$

$$\frac{K_{n1}'}{2}(\frac{W_1}{L_1})(1.5-1)^2=120\mu A$$

$$\frac{120\times10^{-6}}{2}(\frac{W_1}{L_1})(0.25)=120\times10^{-6}$$

$$W_1=\frac{2}{0.25}L_1=8\mu A$$

$$\frac{K'_{n2}}{2}(\frac{W_2}{L_2})(2-1)^2=120\mu A$$

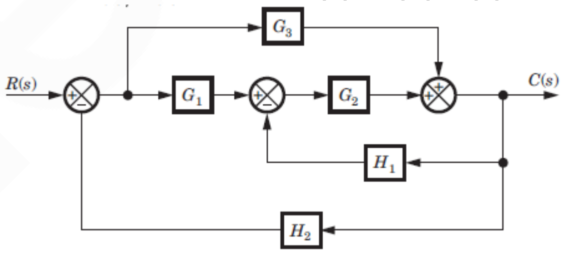
$$W_2=2L_2=2\mu m$$

$$V_{GS1}=V_{GS3}=1.5V$$

So, W_3 = 8μm

∴ W_1, W_2, W_3 = 8 μm, 2 μm, 8 μm

28. For the system shown In figure, Transfer function H(s)=C(S)/R(s) is



A. $\frac{G_3}{1-H_1G_2-H_2G_3-G_1G_2H_2}$

B. $\frac{G_3+G_1G_2}{1+H_1G_2+H_2G_3+G_1G_2H_2}$

C. $\frac{G_3}{1+H_1G_2+H_2G_3+G_1G_2H_2}$

D. None of the above

Ans. B

Sol. Consider the block diagram as a SFG. Two forward Path G_1G_2 and G_3 and three loops -$G_1G_2H_2$, $-H_2G_3$, $-H_1G_2$

There is non-touching loop so B is correct.

29. If is given that the solution of the differential equation $\frac{dy}{dt}=t(1+y)$ passes through origin. The value of y(2) will be______

Sol. $\frac{dy}{dt} = t(1+y)$

$$\frac{dy}{1+y} = tdt$$

By taking integration on both sides, we get

$$\ln(1+y) = \frac{t^2}{2} + c$$

Given, that above equation passes through given

So for t = 0, y = 0.

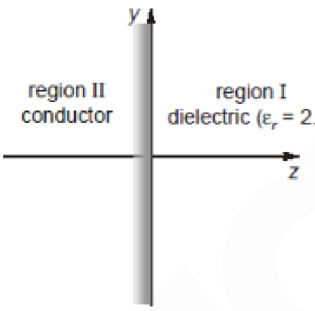
ln(1) = 0 + c

$$\ln(1+y) = \frac{t^2}{2}$$

$$y = -1 + e^{t^2/2}$$

$$y(2) = -1 + e^2 = 6.40$$

30. A homogenous dielectric $(\varepsilon_r = 2.5)$ fills region $I(z>0)$ while region $II(z<0)$ is perfect conductor as shown in the figure



If the surface charge on the conductor is 5nC/m², then electric field intensity $\vec{E}\,at\,(-10,-20,2)$ is

A. $565.5\hat{z}$ (V/m)

B. $226.2\hat{z}$ (V/m)

C. $565.5\hat{y}$ (V/m)

D. $226.2\hat{y}$ (V/m)

Ans. B

Sol. Point (-10, -20, 2) is region I

$\because \quad D_n = \rho_s = 5$ nC/m²

$\Rightarrow \quad \vec{D} = 5\hat{z}$ nC/m²

$$\vec{E} = \frac{\vec{D}}{\varepsilon_0 \varepsilon_r} = 5\times10^{-9} \times \frac{36\pi}{2.5} \times 10^9\,\hat{z} = 226.2\hat{z} \text{ (V/m)}$$

31. An amplifier exhibits distortion in the form of voltage fluctuations of ~ 10%. These fluctuations are to be restricted to ~ 1% by incorporating negative feedback in the amplifier circuit. If ultimate gain is desired to be 120, what should be the open loop gain of the amplifier?

A. 1200 B. 1100

C. 1300 D. 1500

Ans. A

Sol. The distortion D_{FB} in an amplifier with feedback and distortion D without feedback in the amplifier are related as,

$$D_{FB} = \frac{D}{(1+AB)}$$

Where A is open loop gain of amplifier and B is the gain of feedback network.

Now,

D = 10 % = 10/100

$$D_{FB} = 1\% = \frac{1}{100}$$

Therefore, by using above equation

$$\frac{1}{10} = \frac{1}{(1+AB)}$$

Or, (1+AB) = 10

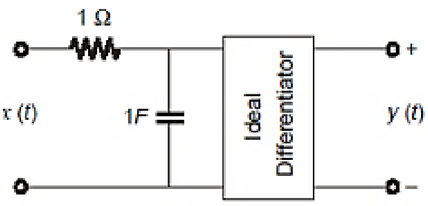
Now, $A_{FB} = \frac{A}{1+AB} = \frac{A}{10}$

Or, A = 10 x A_{FB}= 10x120

Since (A_{FB} = 120)

A =120

32. A low pass circuit, followed by an ideal differentiator is given by



If the input PSD is given by

$$s_x(\omega) = 2\delta(\omega+2) + \delta(\omega+1) + \delta(\omega-1) + 4\delta(\omega+2)$$

The output signal power is given by__________

A. 0.924 B. 1.45

C. 2.24 D. 3.24

Ans. A

Sol. Here $|H(\omega)|^2 = \left|\frac{J\omega}{1+j\omega}\right|^2 = \frac{\omega}{1+\omega^2}$

$$sY(\omega) = |H(\omega)|^2 = \frac{\omega^2}{1+\omega^2}$$

$$\therefore \quad SY(\omega) = \frac{\omega 2}{1+\omega^2}(2\delta(\omega+2)$$
$$+\delta(\omega+1)+\delta(\omega-1)+4\delta(\omega+2))$$

And
$$py = \frac{1}{2\pi}\int_{-\infty}^{\infty} s_Y(\omega)d\omega$$

$$= \frac{1}{2\pi}\int_{-\infty}^{\infty}\frac{\omega^2}{1+\omega^2}(2\delta(\omega+2)+\delta(\omega+1)$$
$$+\delta(\omega-1)+4\delta(\omega+2))d\omega$$

$$= \frac{1}{2\pi}\left[2.\frac{4}{1+4}+\frac{1}{2}+\frac{1}{2}+\frac{4\cdot 4}{1+4}\right]$$

$$= \frac{29}{10\pi} = 0.924W = 0.924W$$

33. Consider a coherent orthogonal MFSK system with M = 8 having the equally likely waveforms defined as
S_1 (t) = A cos 2π f_it, i= 1,……M 0 ≤ t ≤ T
Where T = 0.2 ms. The received carrier amplitude A is 1 mV and the two sided AWGN spectral density is $N_0/2 = 10^{-11}$ W/Hz. What is the bit error probability for the system? (Assume Q(2.236)=0.0127)

Sol. Given, the received carrier amplitude,
A = 1mV = 10^{-3} V
Time duration of the M –ary symbol,
T_s = 0.2 ms = 0.2 × 10^{-3} s
Two sided AWGN spectral density,

$$\frac{N_0}{2} = 10^{-11}W/Hz$$

So, we get symbol energy for the system as

$$E_s = \frac{A^2}{2}T_s$$

$$= \frac{(10^{-3})^2}{2}\times(0.2\times10^{-3})$$

= 10^{-10} Joule/symbol

Therefore, the symbol error probability for the system is obtained as

$$P_E = (M-1)Q\left(\sqrt{\frac{E_S}{N_0}}\right)$$

$$= (8-1)Q\left(\sqrt{\frac{10^{-10}}{2\times10^{-11}}}\right)$$

=7Q(2.236)
=7 × 0.0127 = 8.89× 10^{-2}
Again, we have the coherent orthogonal MFSK system with M = 8, so we get
K = $\log_2$M = $\log_2$ 8 = 3
Thus, the bit error probability for the system is obtained as

$$P_e = \frac{2^{k-1}}{2^k-1}P_E$$

$$= \frac{2^2}{2^3-1}(8.89\times10^{-2})$$

= 5.08× 10^{-2}

34. A single side band signal is generated by modulating signal of 900 kHz carrier by the signal m(t) = cos 2000πt+2sin 2000πt. The amplitude of the carrier is A_c =100.
The Hilbert transform $\hat{m}$(t) of the signal is
A. -sin(2π1000t) -2cos(2000πt)
B. –sin(2π1000t) +2cos(2000πt)
C. sin(2π1000t)+2 cos(1000t)
D. sin(2π1000t)-2cos(2π1000t)

Ans. D

Sol. Given the message signal
M(t) =cos (200πt)+2sin(2000πt)
The Hilbert transform is defined as

$$\hat{m}(t) = \frac{1}{\pi t} * m(t)$$

Where the term $\frac{1}{\pi t}$ is the transfer function which defines the Hilbert transform of signal. In frequency domain the transfer function becomes

$$H(f) = e^{-j\frac{\pi}{2}sgn(f)}$$

Therefore, Hilbert transform is equivalent to $-\frac{\pi}{2}$ phase shift for positive frequencies and $+\frac{\pi}{2}$ phase shift for negative frequencies. Here, the given signal has positive frequencies only. So, the Hilbert transform is given by $-\frac{\pi}{2}$ phase shift as

$$\hat{m}(t) = \cos\left(2000\pi t - \frac{\pi}{2}\right) + 2\sin\left(2000\pi t - \frac{\pi}{2}\right)$$

$= \sin(2000\pi t) - 2\cos(2000\pi t)$

$= \sin(2\pi 1000t) - 2\cos(2\pi 1000)\ t$

35. The lower sideband of the SSB AM signal is

A. $-100\cos[2\pi(f_c-1000)t] + 200\sin[2\pi(f_c-1000)t]$

B. $-100\cos[2\pi(f_c-1000)t] - 200\sin[2\pi(f_c-1000)t]$

C. $100\cos[2\pi(f_c-1000)t] - 200\sin[2\pi(f_c-1000)t]$

D. $100\cos[2\pi(f_c-1000)t] + 200\sin[2\pi(f_c-1000)t]$

Ans. D

Sol. Given, the message signal,

$M(t) = \cos(2000\pi t) + 2\sin(2000\pi t)$

We have just obtained the Hilbert transform of message signal as

$$\hat{m}(t) = \sin(2\pi 1000t) - 2\cos(2\pi 1000t)$$

Also, we have the amplitude of carrier signal, $A_c = 100$

Since, the lower sideband of single sideband (SSB) AM signal is represented as

$x(t) = A_c\, m(t)\cos 2\pi f_c t + A_c\, \hat{m}(t) \sin 2\pi f_c t$

So, substituting the values in the signal, we get

$x(t) = 100[\cos(2000\pi t) + 2\sin(2000\pi t)]\cos 2\pi f_c t + 100[\sin(2\pi 1000t) - 2\cos(2\pi 1000t)]\sin 2\pi f_c t$

$= 100\cos[2\pi(f_c-1000)\ t] - 200\sin[2\pi(f_c-1000)\ t]$

36. An anti-aircraft gun can take a maximum of four shots at an enemy plane moving away from it. The probabilities of hitting the plane destroyed at first, second, third and the fourth shot are 0.4, 0.3, 0.2 and 0.1 respectively. What is the probability that the gum hits the plane?

A. 0.6024 B. 0.0024

C. 0.8976 D. 0.6976

Ans. D

Sol. Let P(ist shot) = 0.4, P(2nd shot) = 0.3

P(3rd shot) = 0.2, P(4th shot) = 0.1

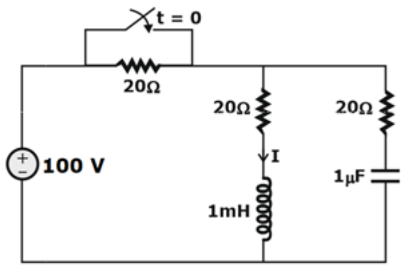
∴ Requires probability

= P(1st) + (1-P(1st)) P(2nd) + (1-P(1st))(1-P(2nd)) P(3rd) + (1-P(1st))(1-P(2nd)(1-P(3rd)(P (4th)

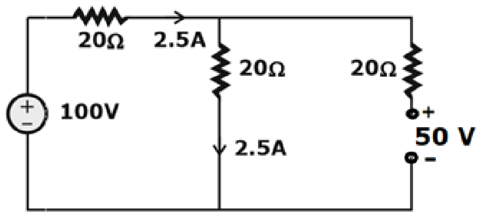
$= 0.4 + 0.6 \times 0.3 + 0.6 \times 0.7 \times 0.2 + 0.6 \times 0.7 \times 0.8 \times 0.1$

$= 0.4 + 0.18 + 0.084 + 0.0336 = 0.6976$

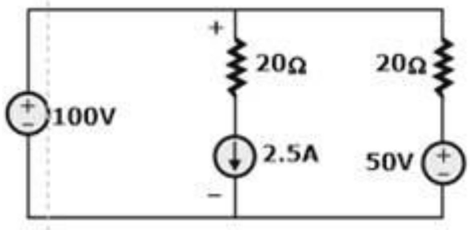
37. In the circuit shown in figure below, switch S is closed at t = Find the rate of change of current through inductor with respect to time at t = 0$^+$. [in KA/sec]



Sol. At t = 0$^-$



At t = 0$^+$



Voltage across inductor branch = 100 V at t = 0^+

$100 = 2.5 \times 20 + V_L$

$V_L(0^+) = 50$ V

$$\frac{L di_L(0^+)}{dt} = 50$$

$$\frac{di_L(0^+)}{dt} = \frac{50}{1\times10^{-3}} = 50\times10^{3}\ A/sec = 50\ KA/sec$$

38. A uniform plane wave in air is normally incident onto a lossless dielectric plate of thickness $\frac{\lambda}{8}$, and of intrinsic impedance $\eta = 260\Omega$. The SWR in front of the

Sol.

$$\beta d = \frac{2\pi}{\lambda}\times\frac{\lambda}{8} = \frac{\pi}{4}, \tan\frac{\pi}{4} = 1$$

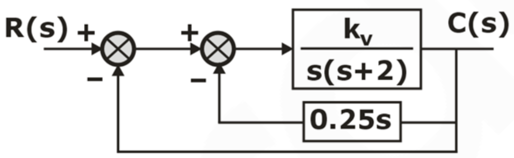
$$\eta_2 = 260, \eta_1 = \eta_3 = \eta_0$$

$$\eta_{in} = \eta_2\left(\frac{\eta_3 + j\eta_2\tan\beta_2 d}{\eta_2 + j\eta_3\tan\beta_2 d}\right) = \frac{260(377 + j260)}{260 + j377} = 243 - j92\ \Omega$$

$$\Gamma = \frac{(\eta_{in} - \eta_0)}{\eta_{in} + \eta_0} = \frac{243 - j92 - 377}{243 - j92 + 377} = 0.26\angle -137^0$$

$$s = \frac{1 + |\Gamma|}{1 - |\Gamma|} = \frac{1.26}{0.74} = 1.70$$

39. A control system is shown in the following fig. For k_v = 10, the percentage of peak over shoot is (in %)



Sol. For K_v = 10,

Total transfer function

$$TF = \frac{C}{R} = \frac{\frac{K_v}{s(s+2)}}{1 - \left[-\frac{K_v \times 0.25s}{s(s+2)} - \frac{K_v}{s(s+2)}\right]}$$

$$TF = \frac{K_v}{s^2 + \left(2 + \frac{K_v}{4}\right)s + K_v}$$

Comparing with second order system

$$TF = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

$$\omega_n^2 = K_v = 10,\ \omega_n = \sqrt{10}$$

$$2\xi\left(\sqrt{10}\right) = 2 + \frac{K_v}{4} = 2 + 2.5 = 4.5$$

$\xi = 0.7115$

% of peak over shoot

$$= e^{\frac{-\pi\xi}{\sqrt{1-\xi^2}}} = e^{-3.18} = 0.0419 = 4.2\%$$

40. Find the Solution of the differential equation y``+4y`+13y=0, y (0) = 0; y`(0) =1

A. y=$\frac{e^{-3x}}{3}$sin(3x)

B. y=$\frac{e^{-2x}}{2}$sin(2x)

C. y=$\frac{e^{-2x}}{3}$sin(3x)

D. y=$\frac{e^{-2x}}{3}$sin(2x)

Ans. C

Sol. y``+4y`+13y=0

(D^2+4D+13) =0

D=$\frac{-4\pm\sqrt{16-52}}{2}$ = $\frac{-4\pm i6}{2}$ = $-2\pm i3$

y= e^{-2x}($c_1$cos3x+$c_2$sin3x)

At x=0, y=0

0=c_1

y=$e^{-2x}C_2$sin3x

y`=C_2[e^{-2x}(3cos3x)+(-2) e^{-2x} sin3x]

At x=0 and y`=1

so C_2=1/3

y=$\frac{e^{-2x}}{3}$sin(3x)

41. Consider a silicon PN junction at T = 300 k with acceptor concentration of N_a = 10^{18} cm^{-3} and donor concentration of N_d = 10^{15} cm^{-3}. If we change the acceptor doping concentration to N_a = 10^{16} cm^{-3} by keeping all other parameters constant, then the percentage decrease in built – in potential of the junction will be equal to __________ %. (Assume n_i = 1.5 × 10^{10} cm^{-3}, kT = 0.026 eV)

Sol. Given,

Acceptor concentration, $N_a = 10^{18}\ cm^{-3}$ and donor concentration of $N_d = 10^{15}\ cm^{-3}$

Intrinsic carrier concentration, $n_i = 1.5 \times 10^{10}\ cm^{-3}$

The built-in voltage,

$$V_{bi} = \frac{kT}{q} \ell n \left[\frac{N_a N_d}{n_i^2}\right]$$

$$= 0.026\ \ell n \left[\frac{10^{18} \times 10^{15}}{(1.5 \times 10^{10})^2}\right]$$

= 0.757 V

Now, new acceptor doping concentration is $N_a = 10^{16}\ cm^{-3}$

The new built in voltage is $V_{bi\ (new)}$

$$V_{bi\ (new)} = 0.026\ \ell n \left[\frac{10^{16} \times 10^{15}}{(1.5 \times 10^{10})^2}\right]$$

= 0.637 V

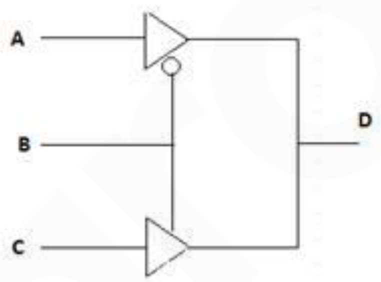
The percentage decrease in built –in potential is

$$= \frac{V_{bi} - V_{bi(new)}}{V_{bi}} \times 100$$

$$= \frac{0.757 - 0.637}{0.757} \times 100$$

= 15.85 %

42. identify the circuit shown below?



A. bidirectional buffer

B. De multiplexer

C. Multiplexer

D. Encoder

Ans. C

Sol. In the circuit given there are two tristate buffers. One with active low enable and second one is with active high enable. As per the operation of these buffers truth table is given below

It equivalent to 2×1 MUX

B is selection line, A & C are the input lines, 'D' is the output

B	D
0	A
1	C

43. Consider an aluminium gate-silicon dioxide p-type silicon MOS structure with tox = 450 Å. For an aluminium-silicon dioxide junction, $\varphi'_m = 3.20$ V and X' = 3.25 V, $E_g = 1.11$ eV. The silicon doping is $N_a = 3.20$ V and X' = 3.25 V, $E_g = 1.11$ eV . The silicon doping is Na = 2 × $10^{16}cm^{-3}$ and the flat-band voltage is VFB = – 1.0 V. The fixed charge, Q'_{ss} (number of electronic charges per unit area) will be ---------× $10^{10}\ cm^{-2}$.

Sol. Difference between E_{Fi} and E_F in p-type substrate is defined as

$$\phi_{fp} = V_f \ln\left(\frac{N_a}{N_i}\right)$$

$$= (0.0259)\ln\left(\frac{2 \times 10^{16}}{1.5 \times 10^{10}}\right) = 0.365\ V$$

So, the metal-semiconductor work function difference is given as

$$\phi_{ms} = \phi'_m - \left(X' + \frac{E_g}{2e} + \phi_{fp}\right)$$

= 3.20 – (3.25 + 0.56 + 0.365) = – 0.975 V

Now, we have the capacitance per unit area as

$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{(3.9)(8.85 \times 10^{-14})}{450 \times 10^{-8}}$$

= 7.67 × 10^{-8} F/cm²

Since, the flat band voltage is given by

$$V_{FB} = \phi_{ms} - \frac{Q'_{ss}}{C_{ox}}$$

So, $Q'_{ss} = (\phi_{ms} - V_{FB})C_{ox}$

$= [-0.975 - (-1)] (7.67 \times 10^{-8})$

$= 1.92 \times 10^{-9}$ C/cm^2

Hence, the fixed oxide charge, Q'_{ss} (number of electronic charges per unit area) is

$$n = \frac{Q'_{ss}}{e}$$

$$= \frac{1.92 \times 10^{-9}}{1.6 \times 10^{-19}} = 1.2 \times 10^{10} cm^{-2}$$

44. The Laplace transform of e^{4t} cos(3t) is:

A. $\frac{S-3}{(S-3)^2+9}$

B. $\frac{S-3}{(S-3)^2+16}$

C. $\frac{S-4}{(S-4)^2+9}$

D. $\frac{S+4}{(S+4)^2+9}$

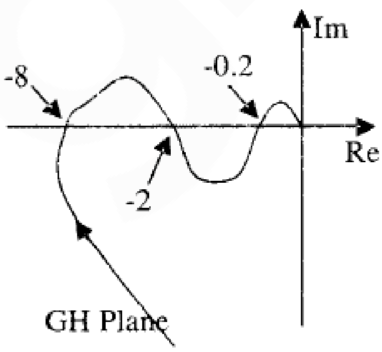
Ans. C

Sol. $L\{\cos(3t)\} = \frac{S}{S^2+9}$

By first shift property,

$$\therefore L\{e^{4t} \cos t(3t)\} = \frac{S-4}{(S-4)^2+9}$$

45. The polar diagram of a conditionally stable system for open loop gain K=1 is shown in figure. The open loop transfer function of the system is known to be stable. The closed-loop system is stable for



A. $K < 5$ and $1/2 < K < 1/8$

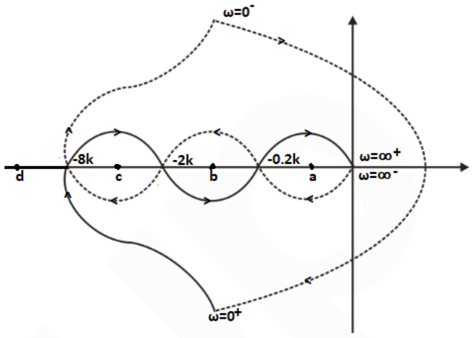
B. $K < \frac{1}{8}$ and $1/2 < K < 5$

C. $K < \frac{1}{8}$ and $5 < K$

D. K>1/8 & K<5

Ans. B

Sol.



Since it is already given that the open loop transfer function is stable. from the Nyquist stability criteria we know that

N = P -Z

where N ⇒ Number of Encirclement of "**-1+j0**" in anticlockwise direction.

P ⇒ Number of right hand pole of open loop transfer function

Z ⇒ Number of right hand pole of closed loop transfer function.

Since the open loop is already stable so we consider that P = 0

Case 1: Considering Point a as "-1+j0"

at that point total encirclement N = -2 (since the encirclement is clockwise)

P = 0

from equartion N = P-Z

-2 = 0-Z

Z = 2 (**Unstable Condition**)

Case 2: Considering Point b as "-1+j0"

at that point total encirclement N = -1+1 =0

P = 0

from equation N = P-Z

-1+1 = 0-Z

Z = 0 (**stable Condition**)

in that condition

1>0.2K which means K <5 & 1<2K which means K>1/2

so the range of K will be 1/2<K<5.

Case 3: Considering Point c as "-1+j0"

again at that point total encirclement N = -2 (since the encirclement is clockwise)

P = 0

from equation N = P-Z

-2 = 0-Z

Z = 2 (Unstable Condition)

Case 4: Considering Point d as "-1+j0"

at that point total encirclement N = 0 (No encirclement)

P = 0

from equation N = P-Z

0 = 0-Z

Z = 0 (stable Condition)

here the range of K is decided as

8K<1 which means K<1/8.

So for the system to be stable K<1/8 & 1/2<K<5.

46. If a root of the equation $3x^3 - 4x^2 - 4x + 7 = 0$ is found out using Newton Raphson's method. If the first assumption for the root is 2.5, then the root after two iterations will be________.

Sol. $f(x) = 3x^3 - 4x^2 - 4x + 7$

$$f'(x) = 9x^2 - 8x - 4$$

$$x_1 = x_0 - \left.\frac{f(x)}{f'(x)}\right|_{x=2.5}$$

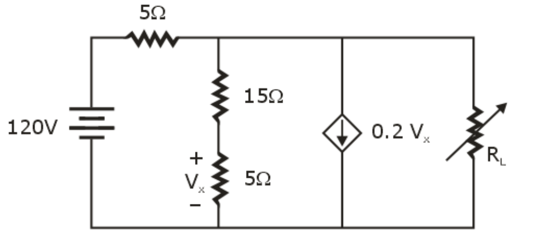
$$= 2.5 - \frac{3x(2.5)^3 - 4x(2.5)^2 - 4 \times 2.5 + 7}{9x(2.5)^2 - 8 \times 2.5 - 4}$$

= 1.9147

Similarly by doing second iteration by taking x_1=1.9147

we get x_2=1.495

47. In the circuit shown in the figure below, find the power (maximum) absorbed by the load resistor R_L is _______ (in watts).

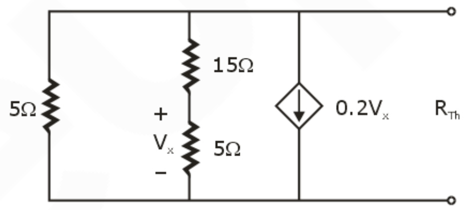


Sol. For maximum power to be transferred to the load resistor (R_L)

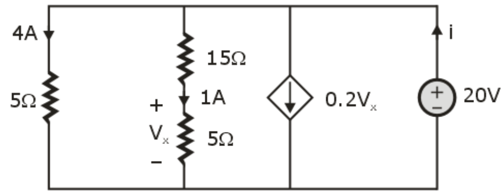
$R_L = R_{Th}$

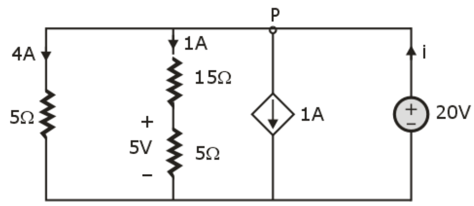
$$\& \ P_{max} = \frac{V_{th}^2}{4R_{Th}}$$

For R_{Th}: Replace the independent source by their internal resistance



Connect 20 V voltage source across load terminals





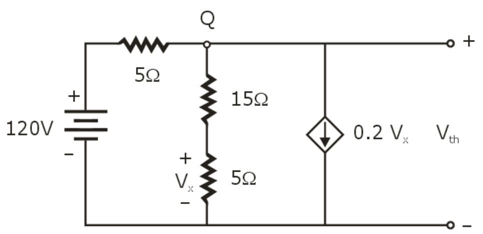
$$R_{Th} = \frac{20}{I}$$

Applying KCL at point P

I = 1 + 1 + 4 = 6 A.

$$R_{Th} = \frac{20}{6}\Omega$$

For V_{th}:



Applying KCL at node Q

$$\frac{V_Q - 120}{5} + \frac{V_Q - 0}{20} + 0.2V_x = 0 \ldots (i)$$

$$V_x = \frac{5}{20} V_Q$$

$$V_x = \frac{V_Q}{4}$$

$V_Q = 4V_x$

$V_Q = V_{Th}$

$$\frac{V_{Th} - 120}{5} + \frac{V_{Th}}{20} + 0.05V_{Th} = 0$$

$0.3\ V_{Th} = 24$

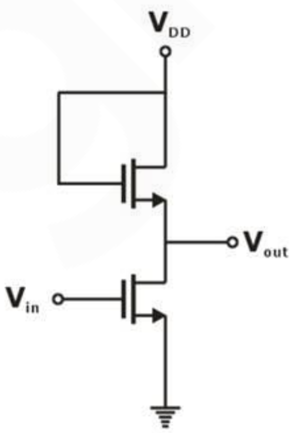
$$V_{Th} = \frac{24}{0.3}$$

$V_{Th} = 80$ volts

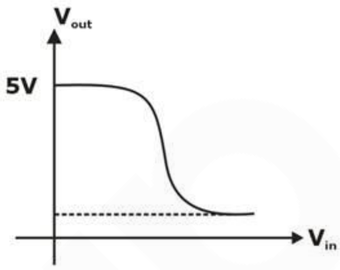
$$P_{max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{(80)^2 \times 6}{4 \times 20}$$

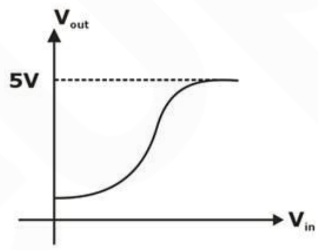
$P_{max} = 480$ watts

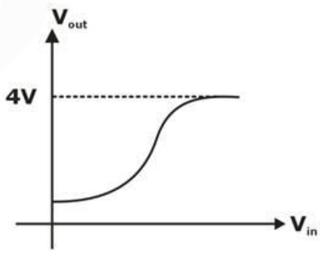
48. An enhancement type NMOS transistor is connected as a load device in the circuit with another MOSFET as shown in figure below:

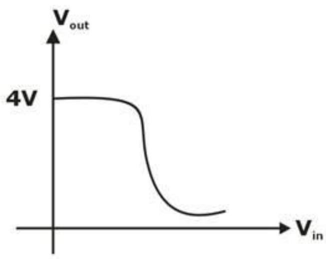


The supply voltage V_{DD} is fixed at 5 V and input voltage V_{in} is varied from 0 to 5 V. If both the transistors have negligible effect of channel length modulation and $V_T = 1$ V, then which one of the following figure represents the transfer characteristics of circuit in a better way?

A.


B.


C.


D.


Ans. D

Sol. Since the configuration represents as investor MOSFET with an active load, the output will be
high for the values of input signal and low for high values of input signal.
Now, since the load transistor T_1 has shorted drain gate.
$V_{DS} > V_{GS} - V_T$
$0 > - V_T$

Which is always true, hence the transistor T_1 will always work in saturation region.

When $V_{in} = 0$ V, $I_D = 0$

Hence, $I_D = K_n(V_{GS_1} - V_T)^2$

$$0 = (V_{GS_1} - V_T)^2$$

$$U_{G_1} - V_{S_1} - V_T = 0$$

For transistor T_1,

$$V_{s1} = V_0 \text{ and } V_{GS1} = V_{DD} = 5V$$

Thus, $V_{G_1} - V_0 - VT = 0$

5 – V_0 – 1 = 0

V_0 = 4V

Hence, Maximum value of output = 4V

49. Let c_n denotes the exponential Fourier series coefficients of a signal x(t) defined as

x(t) = t^2, –π < t < π

x(t + 2π) = x(t)

Match List-I (Fourier series coefficient) with List II(Value of coefficient) and choose the correct answer using the codes given below.

List I	List II
(Fourier series coefficient)	(Value of coefficient)
P. c_0	1. –2
Q. c_1	2. $\pi^2/3$
R. c_2	3. –2/9
S. c_3	4. ½
	5. 0

A. P-1, Q-4, R-2, S-3

B. P-5, Q-1, R-4, S-3

C. P-2, Q-1, R-4, S-3

D. P-5, Q-4, R-1, S-2

Ans. C

Sol.

$$c_n = \frac{1}{T}\int_{-T/2}^{T/2} x(t)e^{-jn\omega_0 t}dt$$

Since $T = 2\pi \text{ and } \omega_0 = \frac{2\pi}{T} = 1$

$$c_n = \frac{1}{2\pi}\int_{-\pi}^{\pi} t^2 e^{-jnt}dt$$

Integrating by parts, we get

$$c_n = \frac{2\cos n\pi}{n^2}, n \neq 0$$

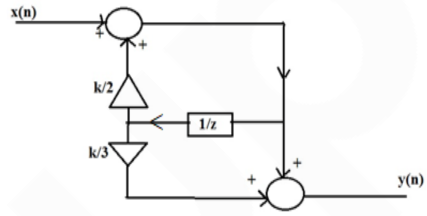
$$c_0 = \frac{1}{2\pi}\int_{-\pi}^{\pi} t^2 dt = \frac{\pi^2}{3}$$

$$c_1 = \frac{2\cos\pi}{1} = -2$$

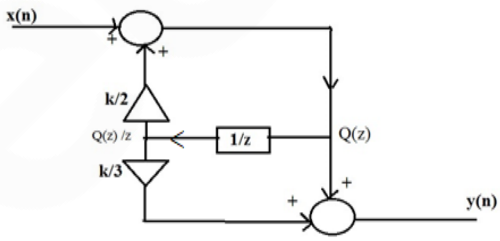
$$c_2 = \frac{2\cos 2\pi}{(2)^2} = \frac{1}{2}$$

$$c_3 = \frac{2\cos 3\pi}{(3)^2} = -\frac{2}{9}$$

50. Consider the causal discrete time system shown below, minimum magnitude of K for which system become unstable is



Sol. As shown in figure



$Y(z)=Q(z)+\frac{K}{3} z^{-1} Q(z)$ and

$Q(z) = X(z) + \frac{k}{2}z^{-1}Q(z)$

So $Q(z)=\frac{x(z)}{[1-Z^{-1}\frac{k}{2}]}$

$Y(z)=Q(z)(1+\frac{k}{3}Z^{-1})$

$\frac{Y(z)}{X(z)} = [\frac{1+\frac{K}{3}z^{-1}}{1-\frac{K}{2}z^{-1}}]$ = H(z)

Has pole at k/2 and for causal and stable pole should be inside unit circle so

$1 - \frac{K}{2} > 0$

$1 > \frac{K}{2}$

$|\frac{k}{2}| < 1$

|k| < 2 (for stable system)

Hence for unstable system |k| ≥ 2

51. For a continuous random variable **X** having the pdf **f(x)** given by

$f(x) = \begin{cases} e^{-x} & x \geq 0 \\ 0 & otherwise \end{cases}$. what will be the median of the random variable **X** .

A. log4 B. $\log_e 2$

C. e^2 D. e^{-2}

Ans. B

Sol. For the continuous random variable x with probability density function f(x), median is that value 'a' for which

$$P(x \leq a) = \frac{1}{2}$$

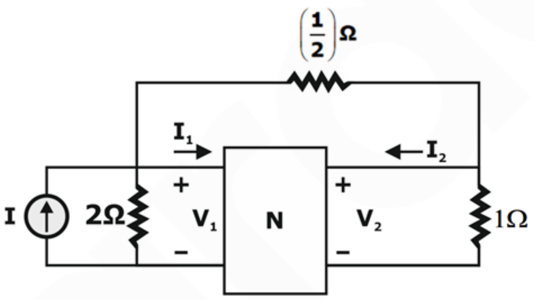
So, $\int_0^a f(x)dx = \frac{1}{2} \Rightarrow \int_0^a e^{-x}dx = \frac{1}{2}$

$\Rightarrow -(e^{-x})_0^a = \frac{1}{2} \Rightarrow (e^{-a} - e^{o}) = \frac{-1}{2} \Rightarrow e^{-a} = \frac{1}{2}$

$\Rightarrow e^a = 2$

So, $a = \log_e 2 = \ln 2$.

52. In the circuit shown below, N is a two-port network. If I = 1 A, then the values of V_1 and V_2 will be



Take the Y-parameter of two port network N, as $\begin{bmatrix} 2℧ & 1℧ \\ 2℧ & 2℧ \end{bmatrix}$

A. $V_1 = 0\ V$ and $V_2 = \frac{2}{9} V$

B. $V_1 = \frac{2}{9} V$ and $V_2 = 0\ V$

C. $V_1 = 0$ V and $V_2 = 2$ V

D. $V_1 = 2$ V and $V_2 = 0$ V

Ans. B

Sol. Applying KCL at input node, we get,

$$\frac{V_1}{2} + \frac{V_1 - V_2}{\left(\frac{1}{2}\right)} = -I_1 + I$$

$$\frac{5}{2}V_1 - 2V_2 = I - I_1 \quad \text{............(1)}$$

Applying KCL at output node, we get,

$$\frac{V_2 - V_1}{\frac{1}{2}} + \frac{V_2}{1} + I_2 = 0$$

$$-2V_1 + 3V_2 + I_2 = 0 \quad \text{.........(2)}$$

As per the question, for network N, the y-parameters are

$$I_1 = y_{11}V_1 + y_{22}V_2 = 2V_1 + V_2$$

$$I_2 = y_{21}V_1 + y_{22}V_2 = 2V_1 + 2V_2$$

By substituting the values of I_1 and I_2 in equation (1) and (2), we get,

$$\frac{5}{2}V_1 - 2V_2 = 1 - (2V_1 + V_2)$$

$$\frac{5}{2}V_1 - 2V_2 = 1 - 2V_1 - V_2$$

$$\frac{9}{2}V_1 - V_2 = 1 \quad \text{...(3)}$$

and, $-2V_1 + 3V_2 + 2V_1 + 2V_2 = 0$

$V_2 = 0$ ...(4)

From equations (3) and (4)

$$V_1 = \frac{2}{9}V \text{ and } V_2 = 0\ V$$

53. Five telemetry signals, each of bandwidth 240 Hz are to the transmitted simultaneously by binary 8 bit PCM. The signals must be sample at least 20% above the Nyquist rate. Framing and synchronization requires an additional 0.5% of extra bits. The bit rate (in kbps) of the multiplexed signal is............

Sol. N = 5

f_m = 240 Hz

f_q = 480 Hz

f_s = 20% higher than $f_s = 1.2\ f_q$

$\therefore f_s = 480 \times 1.2 = 576$ samples/sec

r_b = [Nm+ a] fs

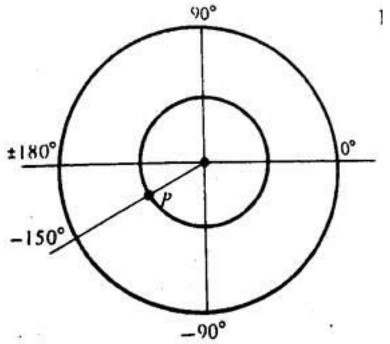
Nm = 5 × 8 = 40 bits

$$a = \frac{0.5}{100} \times 40 = 0.2$$

$\therefore r_b = (40 + 0.2)\ 576$

$= 23155$ bps $= 23.155$ kbps

54. A 500 m lossless transmission line is terminated by a load that is located at P on the smith chart of given figure . If $\lambda = 150m$. How many voltage maxima exist on the line ?



Sol. In the given smith chart , location of P from from the load will be $=360^0 - 150^0 = 210^0$

In smith chart ,

$\frac{\lambda}{2} = 360°$

Therefore , first maxima will occur at

$= \frac{210}{360} \times \frac{\lambda}{2}$, $where\ \lambda = 150$m

=26.25

And distance between two consecutive maxima $= \frac{\lambda}{2}$

So next maxima will occur at 26.25+75=101.25

So third maxima will occur at 26.25+75+75=176.25

.

.

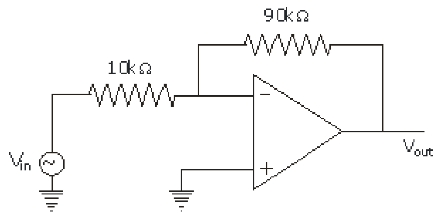
.

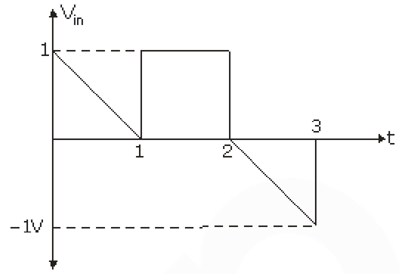
.

i.e 26.25+(75)6=476.25

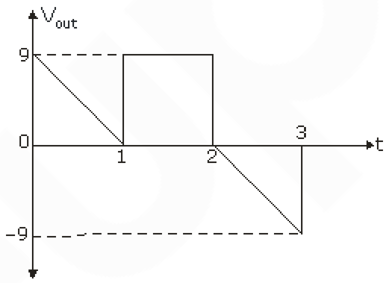
So total number of maxima is 7

55. For the ideal OP-amp based circuit shown below, find the output waveform for the input waveform shown below.

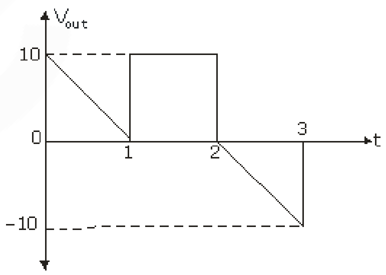




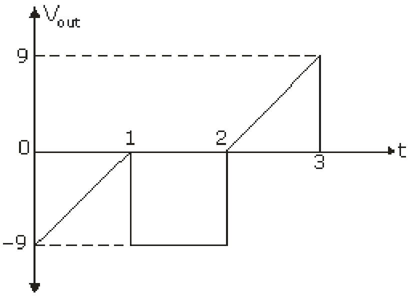
A.



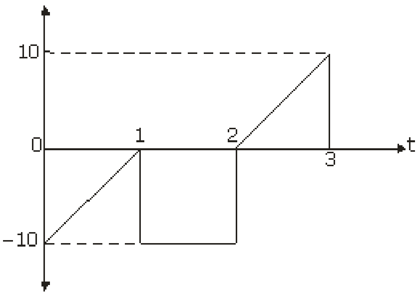
B.



C.



D.



Ans. C

Sol. As we can observe that it is a non-inverting amplifier.

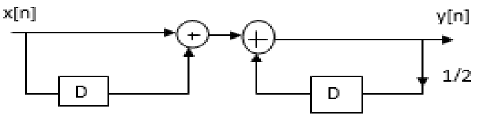
$\therefore V_{out} = -\frac{R_f}{R_1} V_{in}$

$= -\frac{90}{10} V_{in}$

$\therefore V_{out} = -9\ V_{in}$

∴ Option C is correct.

56. Consider the system shown below:



D is a delay block of 1 unit. What is the impulse response of the cascaded system?

A. $\left(\frac{1}{2}\right)^n u[n]$

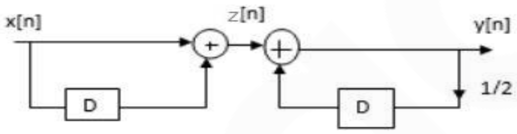
B. $\left(\frac{1}{2}\right)^{n-1} u[n-1]$

C. $\left(\frac{1}{2}\right)^n u[n] + \left(\frac{1}{2}\right)^{n-1} u[n-1]$

D. $\left(\frac{1}{2}\right)^{n-1} u[n] + \left(\frac{1}{2}\right)^{n-1} u[n-1]$

Ans. C

Sol. Let us consider each of the blocks individually.



Considering the 1st block only: z(n)=x(n)+x(n-1)

Considering the 2nd block only, y(n)=z(n)+0.5y(n-1)

so y(n)-0.5y(n-1)z(n)=z(n)

Therefore, the impulse response of the 1st system: $h_1[n] = \delta[n] + \delta[n-1]$

The impulse response of the 2nd system: $h_2[n] = \left(\frac{1}{2}\right)^n u[n]$

The impulse response of the cascaded system is :

$$h[n] = h_1[n] * h_2[n] = (\delta[n] + \delta[n-1]) * \left(\frac{1}{2}\right)^n u[n]$$

$$= \left(\frac{1}{2}\right)^n u[n] + \left(\frac{1}{2}\right)^{n-1} u[n-1]$$

57. An ideal n–channel MOSFET has the following parameters : mobility of electrons μ_n = 500 cm² /V–sec, threshold voltage V_{TN} = 0.6V and oxide thickness t_{ox} = 200Å. The MOSFET is biased in the saturation region at V_{GS} = 5 V to get the saturation drain current ($I_{D\ (sat)}$) of 6 mA, the required aspect ratio is ________________.

(Assume that the permittivity of oxide layer is 34.5 × 10^{-14} F/ cm)

Sol. The saturation drain current equation of a MOSFET is

$$I_{D(sat)} = \frac{1}{2}\mu_n \times C_{ox} \times \frac{W}{L}(V_{GS} - V_T)^2$$

Given, $I_{D\ (sat)}$ = 6mA

Mobility of electron, m_n = 500 cm² /V–sec

Oxide capacitance,

$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{34.5 \times 10^{-14}}{200 \times 10^{-8}} F / cm^2$$

C_{ox} = 172.5 nF/cm²

$$6 \times 10^{-3} = \frac{1}{2} \times 500 \times 172.5 \times 10^{-9} \times \left(\frac{W}{L}\right)(5 - 0.6)^2$$

$$\boxed{\frac{W}{L} = 7.18}$$

58. Consider a continuously operating coherent BPSK receiver with the data rate 5000 bits/s. The input digital waveforms are

$S_1(t)$ = A cosω_0t mV

S_2 (t) = - A cos ω_0t mV

Where A = 1 mV, and the single sided noise power spectral density is $N_0 = 10^{-11}$ W/Hz

Assume that the signal power and energy per bit are normalized relative to a 1Ω resistive load. What is the expected number of bit errors made in one day by the BPSK receiver?

(Assume $Q\sqrt{20} = 4.05 \times 10^{-6}$)

Sol. Given, the data rate

R_b = 5000 bits/sec

The amplitude of input waveform,

A = 1 mV = 10^{-3} V

Single-sided noise power spectral density,

$N_0 = 10^{-11}$ W/Hz

Since, the signal power is normalized relative to 1 Ω resistive load, so we have the average signal power as

$$\frac{A^2}{2} = \frac{\left(10^{-3}\right)^2}{2} = \frac{10^{-6}}{2} W$$

Therefore, the bit energy is given by

$$E_b = \frac{A^2}{2} T_b = \frac{A^2}{2R_b}$$

$$= \frac{10^{-6}}{2 \times 5000} = 10^{-10} \text{ Joule/bit}$$

So, the bit error probability for BPSK receiver is obtained as

$$P_e = Q\left(\sqrt{\frac{2E_b}{N_0}}\right) = Q\left(\sqrt{\frac{2\times10^{-10}}{10^{-11}}}\right)$$

$$= Q\left(\sqrt{20}\right) = Q(4.47)$$

$= 4.05\times 10^{-16}$

Thus, the average number of errors in one day is given by

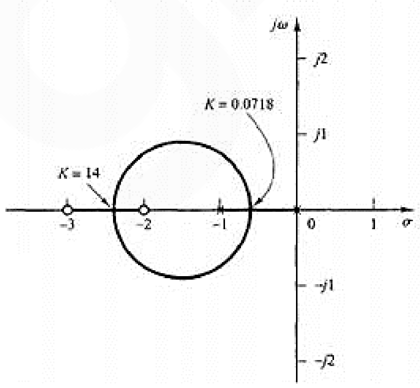
errors/day = $P_e R_b \times$ (86400 sec/day)

= $(4.05 \times 10^{-6}) \times 5000 \times (86400)$

= 1750 bits in error

59. A root locus is the locus of closed loop poles where the roots of denominator are polynomials which gets plotted as open loop gain constant changes. It is found that the Root Locus has many branches which are closed loop poles that came in s-plane since there are open loop poles.

The root locus plot is as shown below:



What will be the actual breakaway point?

A. +0.634 B. -0.634

C. +2.366 D. -2.366

Ans. B

Sol. We see that the characteristic equation for the system is given as:

1 = [K(s+2)(s+3)/s(s+1) = 0

Now K will be:

K = -[s(s+1)/(s+2)(s+3)]

In order to calculate breakaway point, we do:

dK/ds = -[(2s+1)(s+2)(s+3) – s(s+1)(2s+5)]/[(s+2)(s+3)]^2

= -4(s+0.634)(s+2.366)/[(s+2)(s+3)]^2

By equating it to 0 and solving for value of s, we get s = -0.634

So the breakaway point is -0.634

60. The state-space representation for a system is

$$X = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix} x + \begin{bmatrix} 10 \\ 0 \\ 0 \end{bmatrix} u,$$

$$Y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} x$$

The transfer function Y(s)/U(s) is

A. $\frac{10(2s^2+3s+1)}{s^3+3s^2+2s+1}$

B. $\frac{10(2s^2+3s+1)}{s^3+2s^2+3s+1}$

C. $\frac{10(2s^2+3s+2)}{s^3+3s^2+2s+1}$

D. $\frac{10(2s^2+3s+2)}{s^3+2s^2+3s+1}$

Ans. C

Sol. X=A.x+B.u, y=C.x+D.u

So, from given equation

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix} \quad B = \begin{bmatrix} 10 \\ 0 \\ 0 \end{bmatrix} \quad C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \quad D = 0$$

$T(s) = Y(s)/U(s) = C(sI-A)^{-1}B + D$

$(SI - A)^{-1}$ =

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

Substituting these value, we get T(s)

$$= \frac{10(2s^2+3s+2)}{s^3+3s^2+2s+1}$$

61. In a rectangular waveguide for which a= 1.5cm, b=0.8cm, $\sigma = 0$, $\mu = \mu_0$ and $\varepsilon = 4\varepsilon_0$,

$$H_x = 2\sin\left(\frac{\pi x}{a}\right)\cos\left(\frac{3\pi y}{b}\right)\sin\frac{(\pi\times10^{11}t-\beta z)A}{m}.$$

The cut-off frequency and phase constant β are :

A. 28.57GHz ,1718.81 rad/m

B. 30.12GHz,1781 rad/m

C. 29.12GHz, 1829 rad/m

D. 28.32GHz, 1819 rad/m

Ans. A

Sol. From the given expression of H_x,

m=1, n=3

Therefore, $f_{c_{mn}} = \frac{v_p}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$,

Here , $v_p = \frac{c}{\sqrt{\mu_r\varepsilon_r}} = \frac{c}{2}$

$$f_{c_{13}} = \frac{c}{4}\sqrt{\left(\frac{1}{1.5\times10^{-2}}\right)^2 + \left(\frac{3}{0.8\times10^{-2}}\right)^2}$$

$= 28.57\text{GHz}$

$\omega = 2\pi f$,

here, from the given expression, $\omega = \pi\times10^{11}$

therefore , $2\pi f = f$

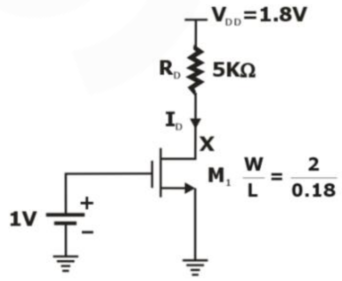
$f = 50\text{GHz}$

Now, $\beta = \omega\sqrt{\mu\epsilon}\sqrt{\left(1-\left(\frac{f_c}{f}\right)^2\right)}$

$= \frac{\pi\times10^{11}\times2}{3\times10^8}\sqrt{\left(1-\left(\frac{28.57}{50}\right)^2\right)}$

=1718.81 rad/m

62. Calculate the bias current of M_1 in the below figure. Assume μ_nC_{ox} = 100 $\mu A/V^2$ and V_{TH} = 0.4V. It gate voltage increases by 10 mV, what is the change in the drain voltage?



A. 200 μA, 34 mV

B. 200 μA, 36mV

C. 300 μA, 34mV

D. 300 μA, 36mV

Ans. A

Sol.

Let's assume M_1 = saturation region

$\because V_{GS}$ = 1V

$$I_D = \frac{\mu_n C_{ox} W}{2L}[V_{GS} - V_T]^2 = \frac{100\times10^{-6}\times2\times[1-0.2]^2}{2\times0.18}$$

I_D = 200 μA

We must check our assumption by calculating V_D

$V_x = V_{DD} - R_DI_D = 1.8 - 5\times10^{-3}\times200\times10^{-6} = 0.8V$

The drain voltage is lower than the gate voltage but less than V_{TH}

$\therefore M_1$ = Saturation Region

Now, it gate voltage increases to 1.01V, then I_D = 206.7 μA

$\therefore V_x = V_{DD} - R_DI_D$

$V_x = 1.8 - 5K \times 206.7\ \mu A = 0.766$ V

Fortunately, M_1 is still in Saturation.

$\therefore$ 34 mV change in V_x reveals that the current can amplify the circuit.

63. A random process given by $x(t) = 10\cos(2\pi t + \theta)$ where θ is the random variable uniformly distributed in the interval (0, 2π). Find

Autocorrelation $R(\tau)|_{\tau=1}$ = ________.

Sol.

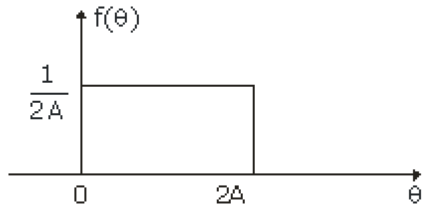
$R(\tau) = E[x(t_1)\times(t_2)]$

$R(\tau) = E\{10\cos(2\pi t_1 + \theta).10\cos(2\pi t_2 + \theta)\}$

$= \frac{100}{2}E\{\cos(2\pi t_1 + \theta + 2\pi t_2 + \theta) + \cos(2\pi t_1 + \theta - 2\pi t_2 - \theta)\}$

$R(\tau) = 50E[\cos(2\pi t_1 + 2\pi t_2 + 2\theta) + \cos2\pi(t_1 - t_2)]$

Now, $E[y(t)] = \int_{-\infty}^{\infty} t.y(t)\,dt$



Here A= π

$e[\cos(2\pi(t_1+t_2)+2\theta)] = \int_0^{2\pi}\frac{1}{2\pi}\cos[2\pi(t_1+t_2)+2\theta]d\theta = 0$

……… area under sine function in one cycle.

Now, $E[\cos2\pi(t_1 - t_2)]$

$= E[\cos2\pi(t_2 - t_1)] = E[\cos2\pi(\tau)]$

$R(\tau) = 50\cos(2\pi\tau)$

$R(\tau = 1) = 50.$

64. Consider an air-filled rectangular waveguide with inside dimensions 5 cm × 2cm. If the wave impedance is 222.24 Ω for TM_{11} mode of propagation. Then the operating frequency (in GHz)is given by

Sol. Given a=5cm, b=2cm, η_{TM11}=222.24Ω

$$\eta_{TM_{11}} = \eta\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}$$

Where $$\lambda_c = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2+\left(\frac{n}{b}\right)^2}}\Bigg|_{m=1, n=1}$$

$$= \frac{2ab}{\sqrt{a^2+b^2}} = \frac{2\times5\times2}{\sqrt{5^2+2^2}}$$

$$\lambda_c = 3.71cm$$

$$\left(\frac{\eta_{TM11}}{\eta}\right)^2 = 1-\left(\frac{\lambda}{\lambda_c}\right)^2$$

$$\Rightarrow \quad \lambda = \lambda_c\sqrt{1-\left(\frac{222.24}{120\pi}\right)^2}$$

$$\Rightarrow \quad \lambda \approx 3cm$$

But $\lambda = \frac{c}{t}$

$$\Rightarrow \quad f = \frac{c}{\lambda} = \frac{3\times10^{10}}{3} = 10\,GHz$$

65. The I/P – O/P voltage for the standard TTL family are given by V_{ohmin}= 2.6 V V_{olman} = 0.6V V_{ihmin} = 2V and V_{ilmax} = 0.4 V. The maximum-amplitude noise that can be tolerated when a low O/P is driving an input is

A. 0.2 V
B. 0.4 V
C. 0.6 V
D. 2 V

Ans. A

Sol. V_{nl} = V_{ilmax} - V_{ihmin}
= 0.6 - 0.4
= 0.2 V

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OUR TOP GRADIANS IN GATE 2019


Anshul Goel
AIR-2
Mechanical Engg.


Nipun Mittal
AIR-3
Computer Science Engg.


Chetan
AIR-4
Electronics Engg.


Pradeep Kumar
AIR-5
Electrical Engg.


Shreyans Mehta
AIR-7
Civil Engg.


Mahesh Singh
AIR-10
Mechanical Engg.


Raja Keshri
AIR-11
Electrical Engg.


Sairam
AIR-13


Raghvendra Sharma
AIR-16
Computer Science Engg.


Ghanendra Singh
AIR-21
Electronic Engg.


Manthan Sharma
AIR-22
Electrical Engg.


Swastik Samantaray
AIR-23
Electronics Engg.


Arghya Kamal Dey
AIR-23
Electronics Engg.


Rohan Kumar Biswal
AIR-27
Mechanical Engg.


Boda Devilal
AIR-29
Civil Engg.


Kartavya Kothari
AIR-45
Computer Science Engg.


Umang Jaggi
AIR-46
Civil Engg.


Guda Sai Rohin
AIR-30
Mechanical Engg.


Sethu Raj R
AIR-33
Civil Engg.


Ajay Kumar Sharma
AIR-37
Civil Engg.


Nishant Pahuja
AIR-48
Electrical Engg.


Mohd Kashif
AIR-60
Computer Science Engg.


Nikhil Kote
AIR-63
Mechanical Engg.


Ankur Agrawal
AIR-65
Mechanical Engg.


Syed Hashim
AIR-70
Mechanical Engg.


Rohit Gaur
AIR-71
Civil Engg.


Abhinav Sridhar
AIR-80
Electronics Engg.


Akhil Sharma
AIR-100
Civil Engg.

And Many More.......