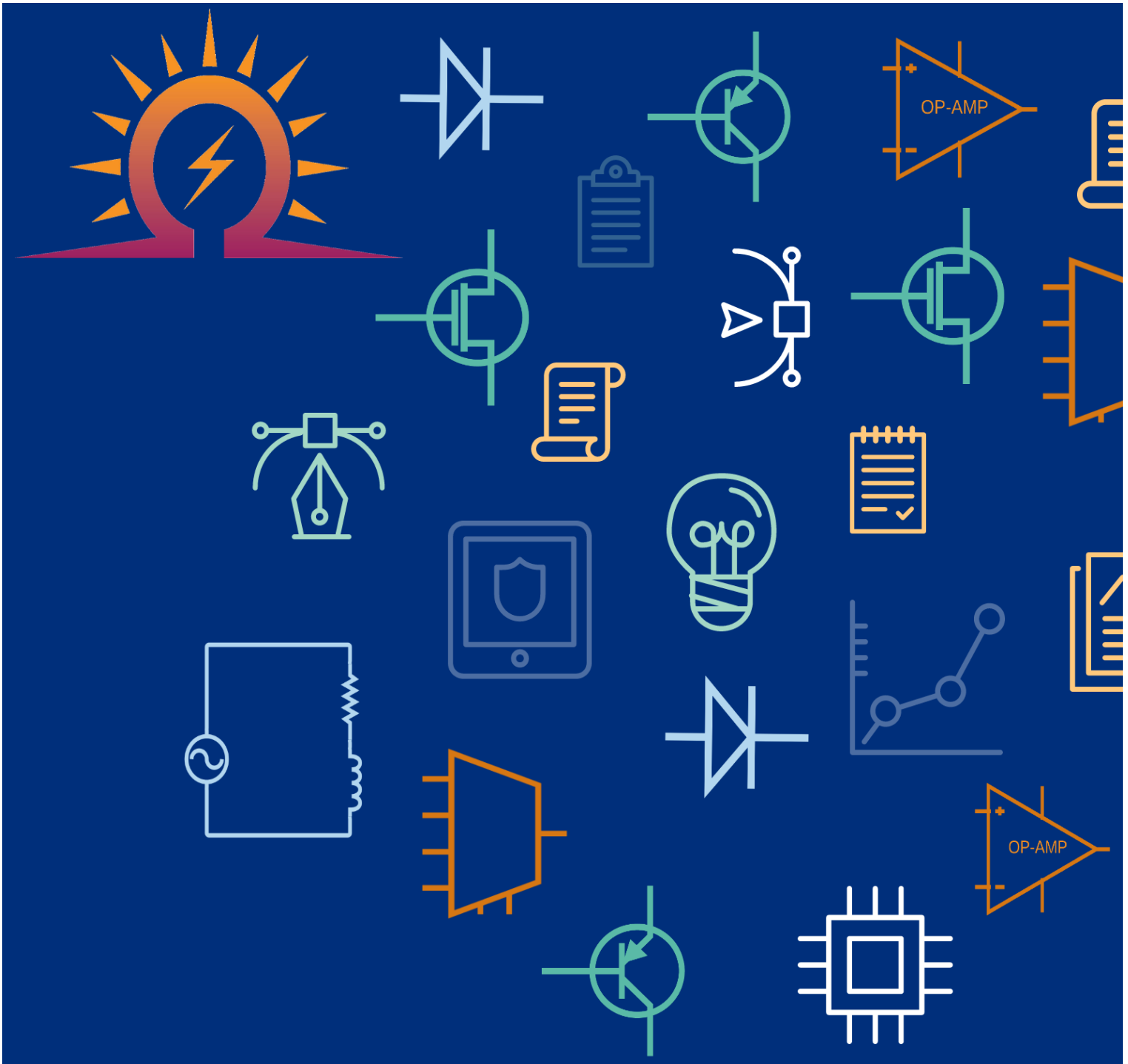

GATE 2020
QUESTION PAPER & DETAILED SOLUTIONS

ELECTRONICS AND COMMUNICATION (EC) ENGINEERING

OHM INSTITUTE FOR ELECTRICAL AND ELECTRONICS ENGINEERING

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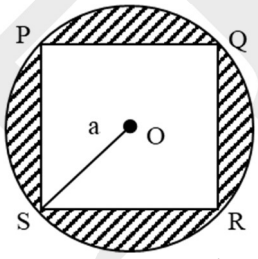
General Ability

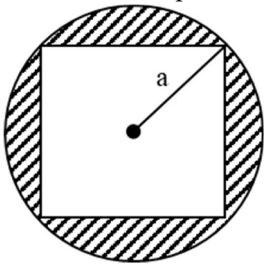
1. It is quarter past three in your watch. The angle between the hour hand and minute hand is
(a) 00 (b) 7.50 (c) 150 (d) 22.50
Answer: (b)
Solution:
AT 3:15,
Minutes hand is exactly on 3, hours hand rotates from 3 by an angle of $\frac{360°}{12}\times\frac{15}{60}=7.5°$.

2. a, b, c are real numbers. The quadratic equation $ax^2-bx+c=0$ has equal roots, which is β, then
(a) $\beta^2=ac$ (b) $\beta=b/a$ (c) $\beta^3=bc/(2a)^2$ (d) $b^2\neq 4ac$
Answer: (No options match with the answer)
Solution:
$\beta+\beta=2\beta=\frac{b}{a}\Rightarrow\beta=\frac{b}{2a}$ (Option b is wrong)
$\beta\times\beta=\beta^2=\frac{c}{a}$ (Option c is wrong)
$\beta^2.\beta=\frac{b}{2a}.\frac{c}{a}=\frac{bc}{2a^2}\Rightarrow\beta^3=\frac{bc}{2a^2}$ (Options c is wrong)
When roots are equal, $b^2=4ac$ (Option D is wrong).
Hence none of the options match the answer.

3. A circle with center 'O' is shown in the figure. A rectangle PQRS of maximum possible area is inserted in the circle. If the radius of the circle is a, then the area of the shaded portion is

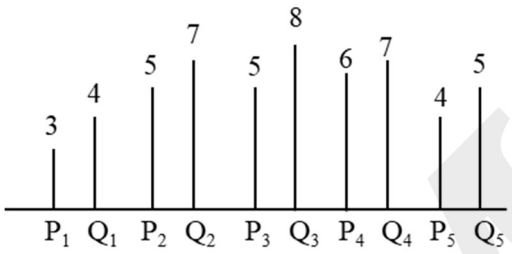


(a) πa^2-a^2 (b) πa^2-3a^2 (c) $\pi a^2-\sqrt{2}a^2$ (d) πa^2-2a^2
Answer: (d)
Solution:
The rectangle of maximum possible area would be a square



Shaded area $=\pi a^2-\frac{(2a)^2}{2}=\pi a^2-2a^2$

4. The following figure shows the data of students enrolled in 5 years (2014 to 2018) for 2 schools P and Q. During this period, the ratio of the average number of students enrolled in school P to the average of the difference of the number of students enrolled in school P and Q is _____



(a) 31:23 (b) 8:23 (c) 23:31 (d) 23:8

Answer: (d)

Solution:

$$\frac{|\text{Avg.P}|}{|\text{Avg.(P}-\text{Q)}|}=\frac{\left(\frac{3+5+5+6+4}{5}\right)}{\left(\frac{1+2+3+1+1}{5}\right)}=\frac{23}{8}$$

5. He is not only accused of theft _____ of conspiracy.

(a) rather (b) rather than

(c) but even (d) but also

Answer: (d)

6. Global financial crisis is considered to be the most serious world-wide financial crisis, which started with subprime lending crisis in USA in 2007. The subprime lending crisis led to the banking crisis in 2008 will the collapse of Lehmann Brothers in 2008. The subprime lending refers to the provision of loans to those borrowers who may have difficulties in repaying loans, and it rises because of excess liquidity following the east Asian crisis.

Which of the following sequences shows the correct precedence as per the given passage?

(a) banking crisis → subprime lending crisis → global financial crisis → east Asian crisis

(b) global financial crisis → east Asian crisis → banking crisis → subprime lending crisis

(c) subprime lending crisis → global financial crisis → banking crisis → east Asian crisis

(d) east Asian crisis → subprime lending crisis → banking crisis → global financial crisis

Answer: (d)

7. The untimely loss of life is a cause of serious global concern as thousands of people get killed ___ accidents and other die ___ diseases like cancer

(a) during, from (b) in, of (c) from, of (d) from, from

Answer: (b)

8. Given a super additive function $f(x_1 + x_2) > f(x_1) + f(x_2)$ for $x > 1$, which of the following satisfies the given function?

(a) e^x (b) $\frac{1}{\sqrt{x}}$ (c) e^{-x} (d) $\frac{1}{x}$

Answer: (a)

Solution:

Let $f(x) = e^x$

$f(x_1 + x_2) = e^{x_1+x_2} = \left(e^{x_1}\right)\left(e^{x_2}\right)$

$f(x_1) = e^{x_1}$

$f(x_2) = e^{x_2}$

Since $x > 1$, e^x is an increasing function.

$\Downarrow$

$e^{x_1+x_2} = \left(e^{x_1}\right)\left(e^{x_2}\right)$ $f(x_1), f(x_2),$ $f(x_1 + x_2) > 1$

$f(x_1 + x_2) = f(x_1)\, f(x_2) > f(x_1) + f(x_2)$

9. Explicit : Implicit then Express : ?

(a) Impress (b) Supress (c) Repress (d) Compress

Answer: (b)

Solution:

Explicit : Implicit $\Rightarrow$ Opposites

Opposite of Express would be Suppress

10. The Canadian constitution requires equal importance to English and French. Last year air Canada lost a lawsuit and had to pay a six figure fine to French speaking couple after they filed a complaint about formal in-flight announcements in English last in 15 sec as opposed to informal 5 sec message in French.

The French speaking couples were upset at _____.

(a) The English announcements being long than French once

(b) The English announcements being clear than French

(c) Equal importance given to English and French

(d) The in-flight announcement being made in English

Answer: (a)

Electronics and Communication Engineering

1. Consider the following equations,

$x_1 + 2x_2 = b_1$,

$2x_1 + 4x_2 = b_2$,

$3x_1 + 7x_2 = b_3$,

$3x_1 + 9x_2 = b_4$

For the above system of equations to have consistent solution, then

(a) $b_2 = 2b_1$ and $6b_1 - 3b_3 + b_4 = 0$

(b) $b_2 = 2b_1$ and $3b_1 - 6b_3 + b_4 = 0$

(c) $b_3 = 2b_1$ and $3b_1 - 6b_3 + b_4 = 0$

(d) $b_3 = 2b_1$ and $6b_1 - 3b_2 + b_4 = 0$

Answer: (a)

Solution:

$x_1 + 2x_2 = b_1$ … (1)

$2x_1 + 4x_2 = b_2$ … (2)

$3x_1 + 7x_2 = b_3$ … (3)

$3x_1 + 9x_2 = b_4$ … (4)

$$(1)\times 2 = \underbrace{2x_1 + 4x_2}_{\downarrow (2)} = 2b_1$$

$$\boxed{b_2 = 2b_1}$$

$6b_1 - 3b_3 + b_4 = 6(x_1 + 2x_2) - 3(3x_1 + 7x_2) + (3x_1 + 9x_2)$

$= 9x_1 + 21x_2 - 9x_1 - 21x_2$

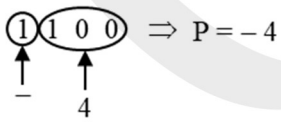
$= 0$

$$\therefore \boxed{\begin{aligned} b_2 &= 2b_1 \\ 6b_1 - 3b_3 + b_4 &= 0 \end{aligned}}$$

2. 1100 represented in sign-magnitude, 1's complement and 2's complement form is P, Q, R respectively then P + Q + R in 2's complement form in 6bits = _____

Answer: 110101

Solution:



$\Rightarrow P = -4$

$$1100 \xrightarrow{1^s \text{ complement}} 0011 \Rightarrow \boxed{Q = -3}$$

$$1100 \xrightarrow{1^s} 0011 \xrightarrow[+1]{2^s} 0100 \Rightarrow \boxed{R = -4}$$

$P + Q + R = -4 - 3 - 4 = -11$

$$11 \xrightarrow{\text{binary}} 01011 \xrightarrow[\text{complement}]{1^s} 10100 \xrightarrow[\text{complement}]{2^s} \boxed{10101} \xrightarrow{\text{Sign-bit extension}} \boxed{110101}$$

3. X is a random variable which is uniformly distributed in [–2, 10]. If Y = 2X – 6 is another random variable. Then P (Y ≤ 7 | X ≥ 5) = _____.

Answer: 0.3

Solution-1:

$X \in [-2, 10]$

$Y = 2X - 6 \in [-10, 14]$ $\quad 2(-2) - 6 = -10$

$\quad 2(10) - 6 = 14$

$X = 5 \Rightarrow Y = 2(5) - 6 = 4$

$\therefore P(Y \le 7 \mid X \ge 5) = P(Y \le 7 \mid Y \ge 4)$

$$= \frac{P(Y \le y \text{ n } Y \ge 4)}{P(Y \ge 4)}$$

$$= \frac{\left(\frac{3}{24}\right)}{\left(\frac{10}{24}\right)}$$

$$= \boxed{0.3}$$

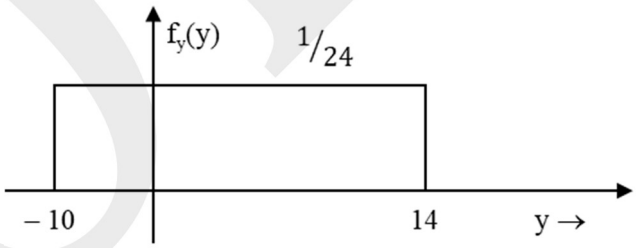
Solution-2:

$Y = 2X - 6$

$X \ge 5$ would imply $Y \ge 4$

$\therefore$ Y = 2X-6 is a uniform RV

In the interval – 10 to 14



$$\therefore P\left(\frac{Y \le 7}{X \ge 5}\right) = P\left(\frac{Y \le 7}{Y \ge 4}\right)$$

$$= \frac{P(4 \le Y \le 7)}{P(Y \ge 4)}$$

$$= \frac{3}{10} = 0.3$$

4. In 8085 microprocessor, the number of address lines required to map 16 k byte memory are _____.

Answer: 14

Solution:

$$16\text{ k byte} = 2^4 \times 2^{10} = 2^{\boxed{14}}$$

$\downarrow \quad \downarrow$

16 1k byte

$\Rightarrow$ 14 address lines are required to map 16 k byte memory.

5. If V_1 to V_6 are 6 vectors in R^4 space then which of the following statements is false?

(a) any 4 vectors can form R^4 basis

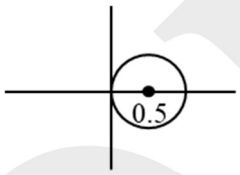
(b) any 4 vectors can span R^4 space

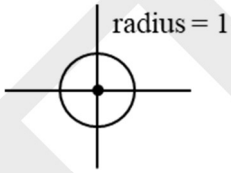
(c) V_1, V_3, V_5, V_6 vectors if they span R^4 then they are basis vectors

(d) V_1 to V_6 vectors are not linearly independent

Answer: (a)

6. A transmission line is terminated by a load of impedance Z = jX where X = [–∞, ∞], the smith chart for the given load is

(a) 

(b) 

(c) a stright line (d) a point at origin

Answer: (b)

Solution:

Radius of constant r-circles = $\frac{1}{1+r}$

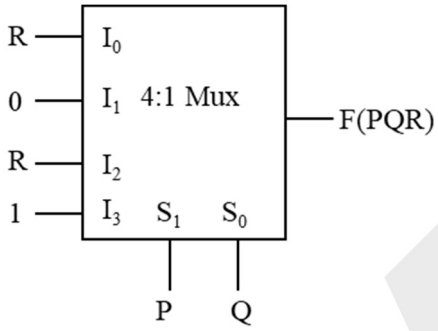
Centre of constant r-circles = $\left(\frac{r}{1+r}, 0\right)$

Here load impedance is $z = r + jx = \frac{jX}{z_0}$

$\Rightarrow$ r = 0 (constant)

Hence its locus is a circle of radius $\frac{1}{1+0} = \boxed{1}$ with centre at $\left(\frac{0}{1+0}, 0\right) = (0,0)$.

7. For the digital circuit shown below



F(PQR) = _____

(a) $PQ + \overline{Q}R$ (b) $\overline{Q} + PR$ (c) $P\overline{Q}R + \overline{P}Q$ (d) $P + Q\overline{R}$

Answer: (a)

Solution:

From the circuit,

$$F = (\overline{P}\overline{Q})R + (\overline{P}Q)(0) + (P\overline{Q})R + PQ(1)$$

$$F = \overline{P}\overline{Q}R + P\overline{Q}R + PQ$$

$$F = \overline{Q}R + PQ$$

8. Magnetic field of a uniform plane wave in vaccum is $H = (\hat{a}_x + 2\hat{a}_y + ba_z)\cos(\omega t + 3x - y - z)$ then b _____.

Answer: 1

Solution:

$$\hat{H} = \frac{\left(\hat{a}_x + 2\hat{a}_y + b\hat{a}_z\right)}{|H|}$$

$$\hat{k} = \frac{\left(-3\hat{a}_x + \hat{a}_y + \hat{a}_z\right)}{|k|}$$

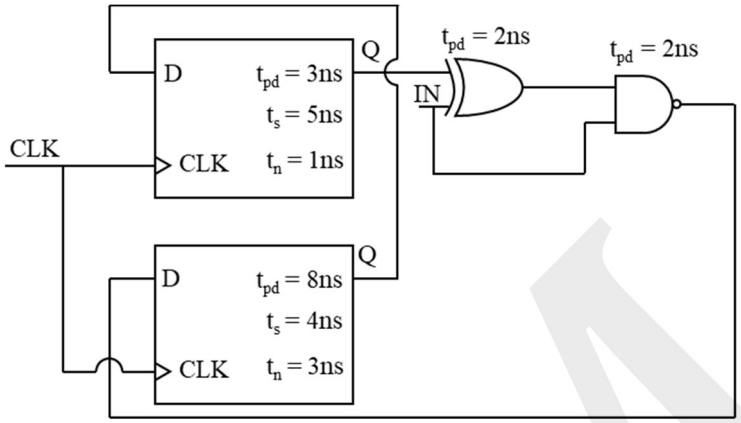
In a TEM wave

$$\hat{H} \cdot \hat{k} = 0$$

$\Rightarrow$ $-3(1) + 2(1) + b(1) = 0$

$\Rightarrow$ $-3 + 2 + b = 0 \Rightarrow \boxed{b = 1}$

9. Consider the digital circuit shown below



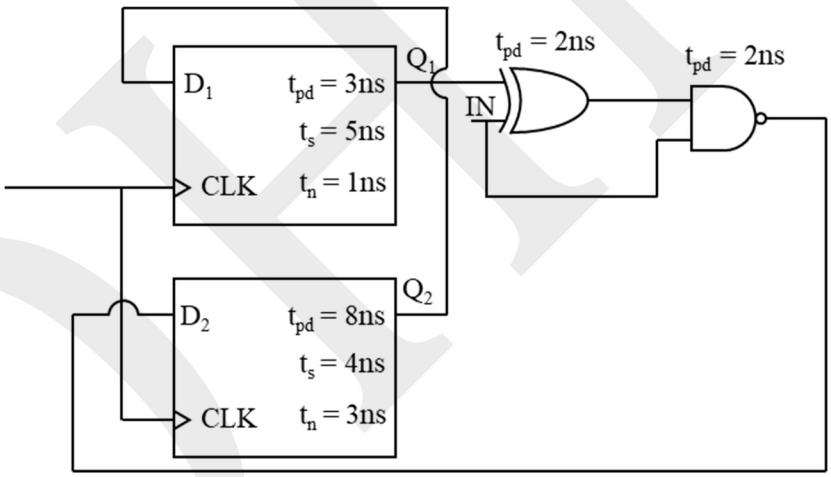
t_{pd} = propagation delay

t_s = setup time t_h = hold time

The maximum frequency at which the above counter is operated is _____ MHz. [rounded off to nearest integer]

Answer: 76

Solution:



The logic in this question is "the data at the input of one of the FF should arrive at the next FF t_s(setuptime) (of second FF) before next active edge of clock"

So, data at D_1 arrives at D_2

t_{pd} + t_{pd} + t_{pd} < $T - t_{12}$

(FF1) (XOR) (NAND) ↑

Clock

Time Period

$3 + 2 + 2 < T - 4$

$\boxed{T > 11 \text{ ns}}$

Data at D_2 arrives at D_1

$t_{pd_{FF2}} < T - t_{s1} \Rightarrow 8 < T - 5 \Rightarrow \boxed{T > 13 \text{ ns}}$

So, where T > 13 (largest of 13, 11)

There exists no-setup time violation for both FFs.

Hence max frequency = $\frac{1}{T_{min}} = \frac{1}{13 \text{ ns}}$

= 76.9 MHz $\Rightarrow$ f < 76.9

Hence f can take integers value of [1, 2, …… 76] MHz

Hence the nearest VALID operating frequency is 76 MHz.

Note: 77 MHz is the nearest INVALID frequency.

10. A 50 Ω transmission line of length 3 λ/4 is terminated by a load of 400 Ω, Z_{in} (input impedance) of the transmission line is _____ Ω.

Answer: 6.25

Solution:

$$Z_{in} = Z_o\left[\frac{Z_L + jZ_o \tan\beta l}{Z_o + jZ_L \tan\beta l}\right]$$

$$\beta l = \frac{3}{4}(2\pi) = \frac{3\pi}{2}$$

$$\therefore Z_{in} = \frac{Z_o^2}{Z_L} = \frac{(50)^2}{400} = 6.25\ \Omega$$

11. Characteristic equation for a differential equation is $\frac{d^2y}{dx^2} - 6\frac{dy}{dx} + 9y = 0$, the solution for the differential equation is _____.

(a) $(C_1 + C_2x)\, e^{3x}$ (b) $(C_1 + C_2x)e^{-3x}$ (c) $C_1e^{3x} + C_2e^{-3x}$ (b) C_1e^{3x}

Answer: (a)

Solution:

$D^2 - 6D + 9 = 0$

$\Rightarrow (D - 3)^2 = 0 \Rightarrow D = 3$ (repeated root)

$\Rightarrow$ Solution is $\boxed{y(x) = (C_1 + C_2x)e^{3x}}$

12. A function $f(x, y, z) = e^{1-x\cos y} + xze^{-\frac{1}{1+y^2}}$ then $\frac{\partial f}{\partial x}(1, 0, e) =$ _____.

(a) 1/e (b) 1 (c) 0 (d) – 1

Answer: (c)

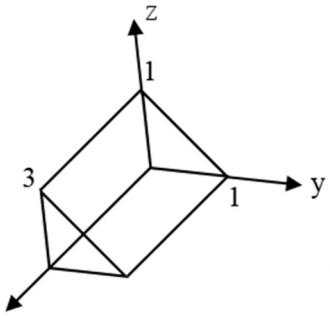
Solution:

$$\frac{\partial f}{\partial x} = (e^{1-x\cos y})(-\cos y) + ze^{\frac{-1}{1+y^2}}$$

$$\frac{\partial f}{\partial x}(1, 0, e) = \left(e^{1-1\cos 0}\right)\left(-\cos 0\right) + ee^{\frac{-1}{1+0}}$$

$$= (e^0)(-1) + 1 = 0$$

13. $\iiint x\,dxdydz =$ _____; where υ is the volume enclosed by the following region



Answer: 2.25

Solution:

$$\iiint xdxdydz = \int_0^1 \left[\int_0^{1-y} \left[\int_0^3 [xdx] dz \right] \right] dy$$

$$= \int_0^1 \left[\int_0^{1-y} \left[\frac{x^2}{2} \right]_0^3 dz \right] dy$$

$$= \int_0^1 \left[\int_0^{1-y} \frac{9}{2} dz \right] dy$$

$$= \int_0^1 \left[\frac{9}{2} z \right]_0^{1-y} dy$$

$$= \int_0^1 \frac{9}{2}(1-y)dy = \frac{9}{2}\left[y - \frac{y^2}{2} \right]_0^1 = \frac{9}{4} = 2.25$$

14. A 10-bit DAC has range of 0 to 10 V. If input is 13A H then output = _____V.

Answer: 3.0694

Solution:

$$\text{Resolution} = \frac{10}{(2^{10}-1)} = \frac{10}{1023} \text{V}$$

$13A\ H = (01\ 0011\ 1010)_2 = 1(2)^1 + 1(2)^3 + 1(2)^4 + 1(2)^5 + 1(2)^8 = 314$

$$\therefore \text{Output} = 314 \times \frac{10}{1023} = 3.0694$$

15. Which of the following statements is false?

(a) If $\bar{A}$ is irrotational, $\nabla^2 A = 0$

(b) If $\bar{A}$ is solenoidal, $\bar{\nabla}.\bar{A} = 0$

(c) $\nabla \times (\nabla \times A) = \nabla(\nabla.A) - \nabla^2 A$

(d) $\bar{\nabla} \times \bar{A}$ is vector field

Answer: (a)

Solution:

For an irrotational field,

$$\nabla \times A = 0$$

But it is given as $\nabla^2 A = 0$ which cannot be conclusively said. Hence Option A is the wrong statement.

16. The outcome of a fair coin being tossed is 0 or 1. M and N are first and second outcomes of the coin tossed twice and X = min (M, N) then expectation of X is E(X) = _____.

Answer: 0.25

Solution-1:

M	N	$X = \min(M, N)$	
0	0	0	$P(X=0)=\frac{3}{4}$
0	1	0	
1	0	0	$P(X=1)=\frac{1}{4}$
1	1	1	

$$E(X) = 0\times\frac{3}{4}+1\times\frac{1}{4}=0.25$$

Solution-2:

Sample space = {00, 01, 10, 11}

Every outcome is labelled as M, N

Outcome	M	N	X = min(M, N)	P(X)
00	0	0	0	$\frac{1}{4}$
01	0	1	0	$\frac{1}{4}$
10	1	0	0	$\frac{1}{4}$
11	1	1	1	$\frac{1}{4}$

$$\therefore\ E[x]=\sum_{i-0}^{3}X_i P(X=X_L)$$

$$=\frac{1}{4}(0)+\frac{1}{4}(0)+\frac{1}{4}(0)+\frac{1}{4}(01)=0.25$$

E[X] = 0.25

17. The open-loop transfer function of a feedback system is G(s) H(s) = $\frac{k(s+11)}{s(s+2)(s+8)}$. The value of 'k' for marginally stable is _____.

Answer: 160

Solution:

Characteristic equation is $s[s^2 + 10s + 16] + k[s + 11] = 0$

(or) $s^3 + 10s^2 + 16s + ks + 11k = 0$

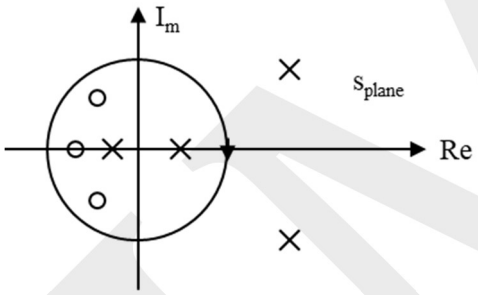
(or) $s^3 + 10s^2 + (16 + k)s + 11k = 0$

Routh Array:

s^3	1	$16+k$
s^2	10	11k
s^1	$\frac{160-k}{10}$	0
s^0	11k	

For marginal stability, 160 – k = 0 or k = 160.

18. Pole-zero plot of G(s) is shown in the figure. Closed contour Γ is mapped into G(s) plane, mapping in circles



(a) point (–1 + j0) of G(s) once in CW (b) point (–1 + j0) of G(s) once in CCW
(c) origin of G(s) once in CW (d) origin of G(s) once in CCW

Answer: (c)

Solution:

[P – Z] times encircles the origin in CCW.
(or) – 1 time encircles the origin in CCW
Or once in CW.

19. Characteristic equation of a control system is given by $s^3 + 3s^2 + (k + 2)s + 3k = 0$. In the Root locus plot, as K varies from 0 to ∞, breakaway/break in point lies within

(a) (–2, –1) (b) $-\infty, -3$ (c) (–1, 0) (d) (–3, – 2)

Answer: (c)

Solution:

$s^3 + 3s^2 + k(s + 3) + 2s = 0$ or $k = -\left[\frac{s^3+3s^2+2s}{s+3}\right]$

BA/BI point can be calculated by $\frac{dk}{dy}=0$

$$\Rightarrow \frac{(s+3)(3s^2+6s+2)-(s^3+3s^2+2s).1}{(s+3)^2}=0$$

(or) $3s^3 + 6s^2 + 2s + 9s^2 + 18s + 6 – s^3\ \ 3s^2 – 2s = 0$
(or) $2s^3 + 12s^2 + 18s + 6 = 0$
By solving the equation, we can get s = – 0.468, – 3.88, – 1.653.
Hence, – 0.468 is valid point hence option (c).

OUR CORE TEAM

B SURENDRA REDDY

Education

M.Tech in Power Electronics from IIT-BOMBAY

Experience/Achievements

- 8 years of experience in GATE|ESE|PSUs coaching
- AIR 82 in GATE-2010
- Worked as faculty in ACE Engineering academy, TIME and VEDA
- Worked as Asst Professor in GITAM Univ, Hyd
- Worked as Field Engineer in GE Industries ltd

Subjects taught

- **Electrical Machines**

GOUTHAM

Education

- **B.Tech (ECE) from IIIT, Hyd**
- **M.Tech (Microelectronics & VLSI) from IIT-Madras**

Experience/Achievements

- 5 years of experience in GATE|ESE|PSUs coaching
- Worked as faculty in ACE Engineering academy
- Rank 18 in GATE 2012
- Worked as RFIC Design engineer in QUALCOMM, Hyderabad
- Worked as Analog Design Engineer at TEXAS Instruments, Bangalore

Subjects taught

- **Analog Electronics, EDC, VLSI, Network theory (Circuit Theory)**

KNS HEMANTH

Education

- **Integrated Masters from BITS PILANI**

Experience/Achievements

- 4 years of experience in GATE|ESE|PSUs coaching
- All India 4th ranker in UPSC ESE 2015(IES)
- AP Transco-2017 5th Ranker
- All India 4th (Airforce) ranker in UPSC CDS(I) 2013
- All India 6th (Army) ranker in UPSC CDS(I) 2013
- Worked as faculty in ACE Engineering Academy for GATE|ESE|PSUs
- Worked as Management Trainee in Steel Authority of India Ltd (SAIL)
- Worked in ST-Ericson in DFT (Design for Testability)

Subjects taught

- **Digital Electronics, EMFT**

MY

Education

- **B.E (Hons) from BITS-Pilani**

Experience/Achievements

- 4 years of experience in GATE|ESE|PSUs coaching
- Worked as faculty in leading GATE institutes across India
- AIR1 in ESE
- AIR26 in GATE
- Industry experience in commissioning large scale Instrumentation projects
- Expert in latest Telecommunication technologies

Subjects taught

- **Signals and Systems, Communication Systems and Measurements**

BNSS SHANKAR

Education

M.Tech in Electrical Engineering from IIT-Kanpur

Experience/Achievements

- 11 years of experience in GATE|ESE|PSUs coaching
- Worked as Technologist in General Electric, Hyd
- Six-sigma certified on quality control in GE
- Worked as faculty in ACE Engineering academy, Gate forum, TIME, Saimedha across India.

Subjects taught

- **Power Electronics**
- **Control Systems**

J Y GIRI

Education

M.Tech in Electrical Engineering from IIT-Kanpur

Experience/Achievements

- 10 years of experience in GATE|ESE|PSUs coaching
- Worked as faculty in ACE Engineering academy, Gate forum
- Rank 1 in APCPDCL 2010
- GATE AIR 110
- Worked as Asst professor in Kalinga university
- WOrked as AE in APCPDCL
- WOrked as R & D Engg in ABB

Subjects taught

- **Power Systems**

20. If $G(s) = \frac{1}{(s+1)(s+a)}$; $a > 0$. The given input is $5\cos 3t$ and output is $\frac{1}{\sqrt{10}}\cos[3t - 1.892]$. Then the value of 'a' is _____.

Answer: 4

Solution:

Magnitude is $\frac{5}{\sqrt{1^2+\omega^2}\sqrt{a^2+\omega^2}} = \frac{1}{\sqrt{10}}$

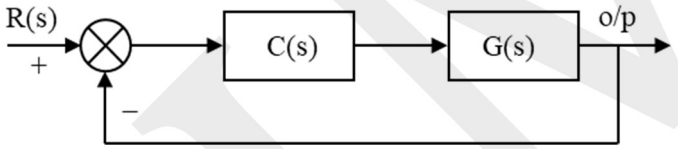
By substituting, $\omega = 3$, $\frac{5}{\sqrt{10}\times\sqrt{a^2+9}} = \frac{1}{\sqrt{10}}$

(or) $a^2 + 9 = 25$

$a^2 = 16$ (or) $a = \pm 4$

as $a > 0$, $a = 4$

21. Consider the control system shown in figure.



$G(s) = \frac{1}{s(s+1)}; C(s) = \frac{K(s+1)}{s+3}$ and steady-state error (e_{ss}) for ramp input is 0.1. The value of K is _____.

Answer: 30

Solution:

e_{ss} for ramp input is $e_{ss} = \frac{1}{k_v} = 0.1$ (or) $k_v = 10$.

But $k_v = \underset{s\to 0}{Lt}\, s.G(s)$

$= \underset{s\to 0}{Lt}\, s.\frac{1}{s(s+1)}.\frac{k(s+1)}{s+3}$

$= \frac{k}{3}$

$\therefore e_{ss} = \frac{1}{k_v} = \frac{3}{k} = 0.1$ (or) $k = 30$

22. If $\frac{dy}{dx} = (y-1)x$ has 2 solutions, then the solutions are

(a) $\ln|y-1| = 2x^2 + c$, $y = 1$

(b) $\ln|y-1| = \frac{1}{2}x^2 + c$, $y = -1$

(c) $\ln|y-1| = 2x^2 + c$, $y = -1$

(d) $\ln|y-1| = \frac{1}{2}x^2 + c$, $y = 1$

Answer: (d)

Solution:

Integration by Parts:

$$\frac{dy}{(y-1)} = xdx$$

$$|x|y+1|| = \frac{1}{2}x^2 + C$$

Integration by Integrating Factor Method:

$$\frac{dy}{dx} = yx - x$$

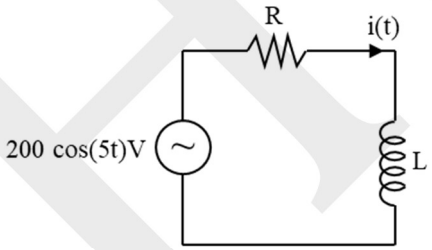
$$\frac{dy}{dx} + (-x)y = -x$$

$$\text{If} = e^{\int Pdx} = e^{\int -xdx} = e^{\frac{-x^2}{2}}$$

$$ye^{-x^2/2} = \int \left(e^{-x^2/2}\right)(-x)dx = e^{-x^2/2}$$

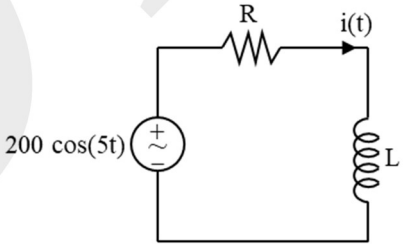
$$\boxed{y = 1}$$

23. The current in the R-L series circuit is i(t) = 10 cos(5t – $\frac{\pi}{4}$) A value of L is _____H.



Answer: 2.83

Solution:



$$i(t) = 10\cos\left(5t - \frac{\pi}{4}\right)A$$

$$I = 10\angle -45°A$$

$$= \frac{200\angle 0°}{R + j5L} = \frac{200}{\sqrt{R^2 + 25L^2}}\angle -\tan^{-1}\left(\frac{5L}{R}\right)$$

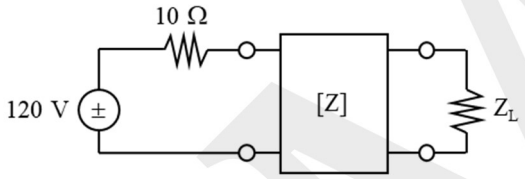
$$\tan^{-1}\left(\frac{5L}{R}\right)=45^\circ \Rightarrow R=5L$$

$$\frac{200}{\sqrt{R^2+25L^2}}=10$$

$$\frac{200}{5\sqrt{2}L}=10$$

$$L=\frac{4}{\sqrt{2}}=2\sqrt{2}=2.83\ \text{H}$$

24.

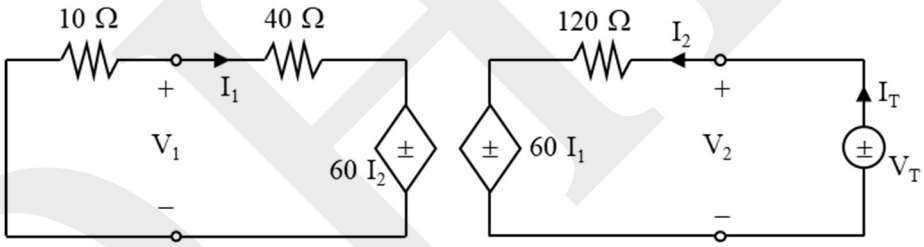


$$[Z]=\begin{bmatrix}40 & 60\\ 60 & 120\end{bmatrix}$$

Value of Z_L for which maximum power is delivered to load is_____Ω

Answer: 48

Solution:



$V_2 = V_T$; $I_2 = I_T$

$50\ I_1 + 60\ I_2 = 0$

$60\ I_2 = -50\ I_1$

$I_1 = -1.2\ I_2$ … (1)

$V_T = 120\ I_2 + 60\ I_1$

$= 120\ I_2 - 72\ I_2$

$= 48\ I_2 = 48\ I_T$

$$Z_{TH}=\frac{V_T}{I_T}=48\ \Omega$$

For $Z_L = 48\ \Omega$, max power is delivered to the load.

25. A single crystal intrinsic semiconductor is ck R.T with effective density of states for holes twice of states for holes twice that of electrons $V_T = 26$ mV. Intrinsic fermi level is shifted from mid gap energy level by

(a) 9.01 meV (b) 26.90 meV (c) 18.02 meV (d) 13.45 meV

Answer: (a)

Solution:

$N_v = 2\,N_C$

$$E_I = \frac{E_C + E_V}{2} - \frac{KT}{2}\ln\left(\frac{N_C}{N_V}\right)$$

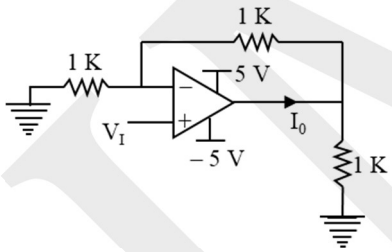
$$= \frac{E_C + E_V}{2} - \frac{26}{2}\ln\left(\frac{N_C}{2N_C}\right)$$

$$= \frac{E_C + E_V}{2} - 13\ln\left(\frac{1}{2}\right)$$

$$= \frac{E_C + E_V}{2} - 9.01\text{ meV}$$

E_I lies 9.01 meV below the middle of the bandgap.

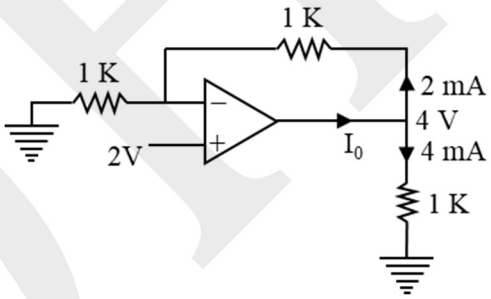
26.



$V_I = 2V$, I_0 = _____mA.

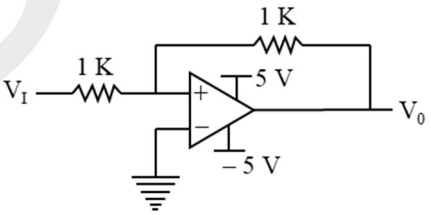
Answer: 6

Solution:



$I_0 = 2 + 4 = 6$ mA

27.



If $V_I = 1$ V sin (ωt), then V_0 is ____

(a) a constant of either +5V or – 5V
(b) 2V sin (ωt)
(c) – 1V sin (ωt)
(d) square wave of 5V amplifier

Answer: (a)

Solution:

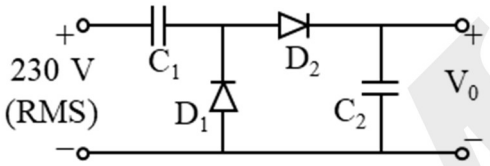
UTP = + 5V

LTP = – 5V

Since the given input always lies between the 2 trip points,

the output is a constant of either +5V or – 5V.

28.



Magnitude of steady state output V_0 is _____V

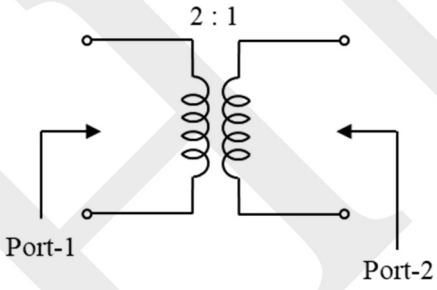
Answer: 650.44 V

Solution:

The given circuit is a voltage doubler.

$V_0 = 2V_p = 2 \times 230 \times \sqrt{2} = 650.44$ V

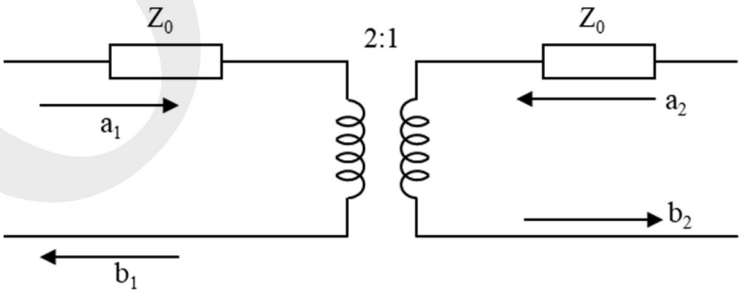
29.



For the above 2-port network consisting of an ideal lossless transformer, parameter S_{21} for a reference impedance of 10 Ω is_____ (2 decimals).

Answer: (0.8)

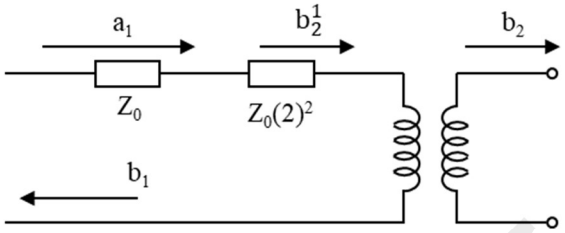
Solution:



$$s_{21} = \left.\frac{b_2}{a_1}\right|_{a_2=0}$$

Hence, we consider $a_2 = 0 \Rightarrow$ No source on port-z side.

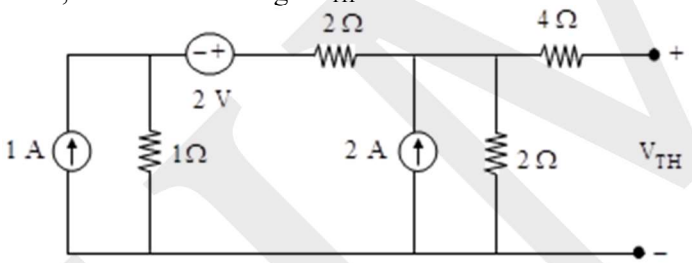
By impedance T/f



$$\frac{b_2^1}{a_1}=\frac{2z_2}{z_2+z_1}=\frac{2(4z_0)}{4z_0+z_0}=\frac{8}{5}$$

$$\frac{b_2^1}{b_2}=\frac{2}{1}=\frac{\left(\frac{8}{5}\right)}{b_2}=2=\boxed{b_2=\frac{4}{5}=0.8}$$

30. In the circuit shown below, Thevenin's voltage V_{TH} is

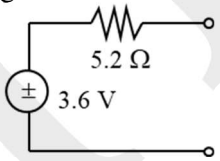


(a) 2.8 V (b) 2.4 V (c) 4.5 V (d) 3.6 V

Answer: (d)

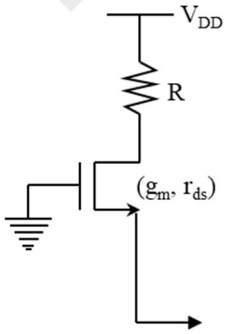
Solution:

After repeated source transformation, the given circuit can be reduced to



V_{TH} = 3.6 V

31.

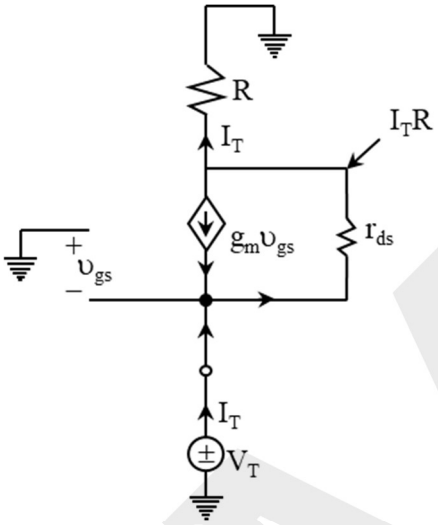


Find Norton equivalent resistance of the circuit looking into source.

(a) $\frac{r_{ds}+R}{1+g_m r_{ds}}$ (b) $r_{ds}+R$ (c) $r_{ds}+R+\frac{1}{g_m}$ (d) $r_{ds}+R+g_m r_{ds}R$

Answer: (a)

Solution:



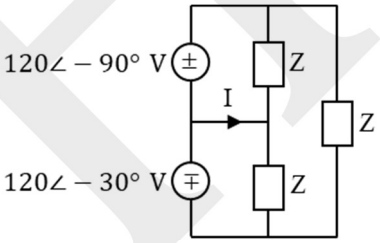
$\upsilon_{gs} = -V_T$

$$g_m\upsilon_{gs} + I_T = \frac{V_T - I_TR}{r_{ds}} - g_mV_T + I_T = \frac{V_T - I_TR}{r_{ds}}$$

$V_T(1 + g_mr_{ds}) = I_T(R + r_{ds})$

$$Req = \frac{V_T}{I_T} = \frac{R + r_{ds}}{1 + g_mr_{dss}}$$

32.



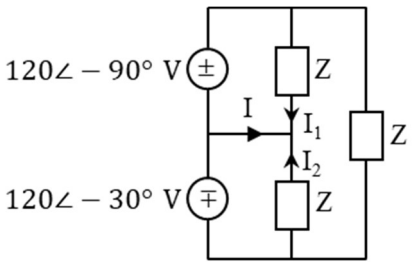
Z = 80 – j 35 Ω, Find I

(a) 2.38∠143.63°A (b) 2.38∠–23.63°A

(c) 0 A (d) 2.38∠–96.37°A

Answer: (a)

Solution:



Z = 80 – j 35 Ω = 87.32 $\angle -23.63°$ Ω

$$I_1 = \frac{120\angle -90^\circ}{Z}$$

$$= \frac{120\angle -90^\circ}{87.32\angle -23.63^\circ} = 1.37\angle -66.37^\circ \text{A}$$

$$I_2 = \frac{120\angle -30^\circ}{Z}$$

$$= \frac{120\angle -30^\circ}{87.32\angle -23.63^\circ} = 1.37\angle -6.37^\circ \text{ A}$$

$$I = -(I_1 + I_2)$$

$$= 2.38 \angle 143.63^\circ \text{ A}$$

33. A PN junction solar cell area 1 cm^2 illuminated uniformly with 100mWcm^{-2} has the following parameters : efficiency = 15%, open circuit voltage = 0.7V, fill factor =0.8 and thickness = 200 μm average optical generation rate (in cm^{-3} s^{-1}) is

(a) 83.60×10^{19} (b) 5.57×10^{19} (c) 0.84×10^{19} (d) 1.04×10^{19}

Answer: (c)

Solution:

$$P_{IN} = 100\frac{mW}{cm^2} \times \text{Area}$$

$$= 100\frac{mW}{cm^2} \times 1\ cm^2$$

$$= 100\ mW$$

$$\eta = \frac{P_{o,\,max}}{P_{IN}}$$

$$0.15 = \frac{P_{o,\,max}}{100\ mW}$$

$$P_{o,\,max} = 15\ mW$$

$$F.F = \frac{P_{o,\,max}}{V_{oc}.I_{sc}}$$

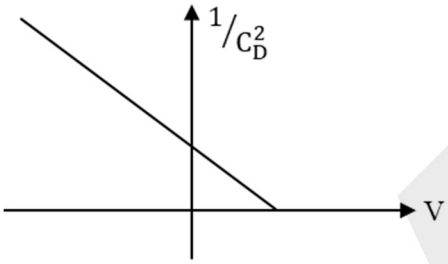
$$0.8 = \frac{15\times10^{-3}}{0.7\times I_{sc}}$$

$$I_{sc} = 0.027\ A = I_L$$

$$G_{avg} = \frac{I_L}{q.(volume)} = \frac{I_L}{q.A.t}$$

$$= \frac{0.027}{1.6\times10^{-19}\times1\times200\times10^{-4}} = 0.84 \times 10^{19}\ cm^{-3}s^{-1}.$$

34. For a one-sided abrupt PN junction depletion capacitance C_D is 50 PF at a reverse bias of 0.2 V. Slope of the plot between $\frac{1}{C_D^2}$ and applied voltage V is _____$\times 10^{20}\,F^{-2}v^{-1}$.



(a) – 5.7 (b) – 1.2 (c) – 3.8 (d) – 0.4

Answer: Data Insufficient

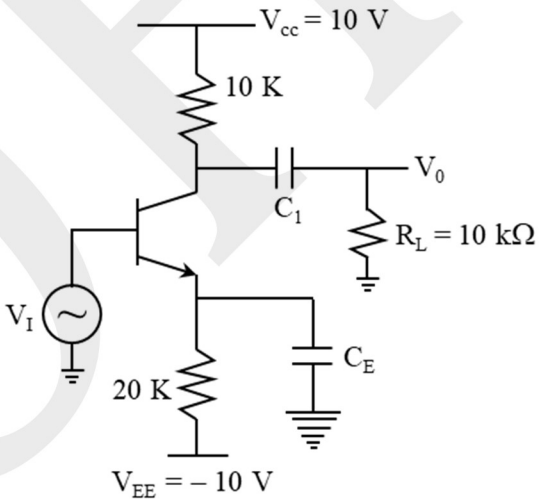
Solution:

$$\frac{1}{C_D^2} \propto (V_{BI} - V)$$

$$\frac{1}{C_D^2} = k(V_{BI} - V)$$

"–k" is the slope of the plot between $\frac{1}{C_D^2}$ and V. Here, k and V_{BI} are unknown. To solve for k_1 we require 2 pieces of data.

35.



$V_{on} = 0.7$ V, $\beta \to \infty$, $r_0 \to \infty$

Capacitors behave as S.C at the signal frequency. Find V_O/V_I.

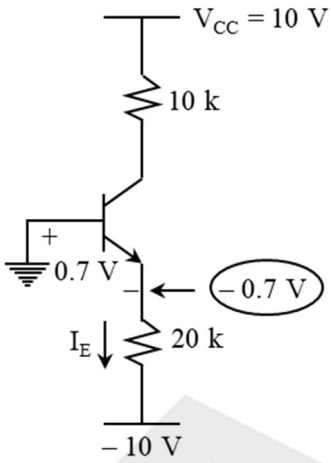
(a) – 128.21 (b) – 178.85

(c) – 256.42 (d) – 89.42

Answer: (d)

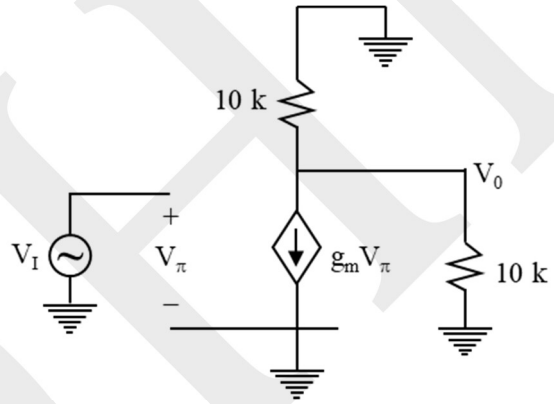
Solution:

DC-Analysis:



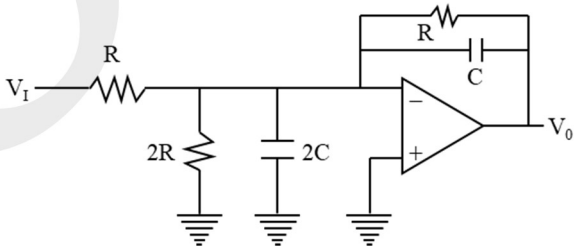
$$I_E = \frac{10 - 0.7}{20K} = 0.465 \text{ mA} = I_C$$

AC – Analysis:



$$\frac{V_O}{V_I} = -g_m.5k = -89.42$$

36.



$R = 2k\Omega$; $C = 1\ \mu F$

3dB frequency of the circuit is _____ Hz.

(a) 59.68 (b) 79.58 (c) 34.46 (d) 17.92

Answer: (b)

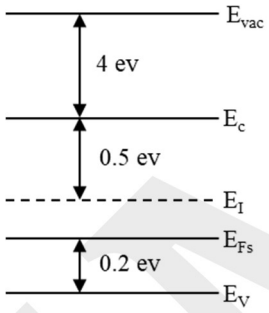
Solution:

The given circuit is a 1st order LPF.

$$\omega_c = \frac{1}{RC}$$

$$f_c = \frac{1}{2\pi RC} = \frac{1}{2\times 3.17\times 2\times 10^{3}\times 10^{-6}} = 79.58 \text{ Hz.}$$

37. A MOS capacitor is fabricated on a p-type substrate and its band diagram is shown below.



E_g = 1 ev; V_{TH} = – 0.16 V

Co_x = 100 nF/cm^2

ϕ_m = 3.87 eV

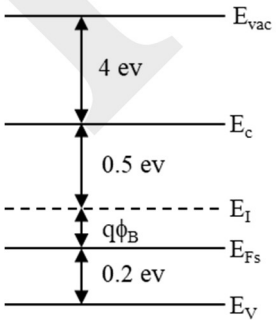
No charge within the oxide. If voltage across the capacitor is V_{TH}, magnitude of depletion charge per unit area (in C/cm^2) is

(a) 1.7×10^{-8} (b) 1.41×10^{-8}

(c) 0.93×10^{-8} (d) 0.52×10^{-8}

Answer: (a)

Solution:



E_g = 1 ev

$0.5 + q\phi_B + 0.2 = 1$

$q\phi_B$ = 0.3 ev

ϕ_B = 0.3 v

$V_{GB} = V_{TH} \Rightarrow \psi_s = 2\phi_B$ = 0.6 v

ρ_s = Magnitude of depletion charge per unit area.

$= qN_A w = qN_A\sqrt{\dfrac{2 \in_s \psi_s}{qN_A}}$

$= \sqrt{2 \in_s qN_A \psi_s}$

$V_{FB} = \phi_{ms} = \phi_m - \phi_s$

$= 3.87 - 4.8$

$= -0.93$ v

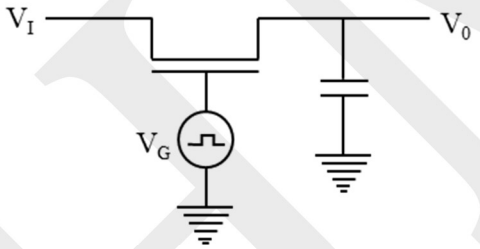
$V_{TH} = V_{FB} + \dfrac{\sqrt{2 \in_s qN_A (2\phi_B)}}{C_{ox}} + 2\phi_B$

$= 0.16 = -0.93 + \dfrac{\rho_s}{100 \times 10^{-9}} + 0.6$

$\rho_s = 0.17 \times 10^{-7}$

$= 1.7 \times 10^{-8}$ C/cm^2.

38.



V_{TH} = 3 V, V_{SUB} = – 10 V, V_I : (–10 V, + 10 V) minimum and maximum values of V_G for proper sampling and holding respectively are

(a) 10 V and – 10 V (b) 3 V and – 3 V

(c) – 3 V and – 3 V (d) 13 V and – 7 V

Answer: (d)

Solution:

During sampling, switch must be closed.

$V_{GS} > V_{TH}$

$V_G > V_S + V_{TH}$

$V_G > V_{I,\,max} + V_{TH}$

$V_G > 10 + 3$

$\boxed{V_G > 13 \text{ V}}$

During hold mode, switch must be OPEN.

$V_{GS} < V_{TH}$

$V_G < V_S + V_{TH}$

$V_G < V_{I,\,min} + V_{TH}$

$V_G < -10 + 3$

$\boxed{V_G < -7 \text{ V}}$

UPCOMING BATCHES

Date of Commencement	Batch Name	Branch	Duration	Fee
27-Mar-2020	LTGEC-1	ECE	6 Months	~~45,999/-~~ 36,999/-
25-Apr-2020	LTGEC-2	ECE	6 Months	45,999/-
10-May-2020	LTGEC-3	ECE	6 Months	45,999/-
24-May-2020	LTGEC-4	ECE	6 Months	45,999/-
7-Jun-2020	LTGEC-5	ECE	6 Months	45,999/-

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39. If the input-output relation for a system with input x(n) and output y(n) is given by $y[n] = \max\left|x[k]\right|$, where $-\infty \le k \le n$

The unit impulse response of the system is _____

(a) u(n) (b) δ(n)

(c) 1 for all n (d) 0 for all n

Answer: (a)

Solution:

For impulse response of a system

x(n) = δ(n) ; y(n) = Max [δ(k)]

$\therefore$ y(n) = 0 $-\alpha \le k \le n$

1 $n \ge 0$

$\therefore$ y(n) = u(n)

40. A digital communication system is used to transmit a block of N bits, the probability of a signal bit error is given by α. The block of N bits is received as error if at least 1-bit error occurs. The probability of error in transmission is _____

(a) $1-(1-\alpha)^N$ (b) $1-\alpha^N$ (c) α^N (d) $N(1-\alpha)$

Answer: (a)

Solution:

P_e = 1 – (P(no error for all the N bits)

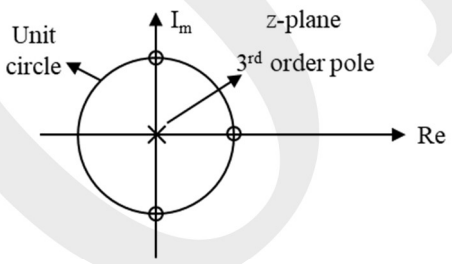
P(no error for all N bits) = $(1-\alpha)^N$

$P_e = 1-(1-\alpha)^N$

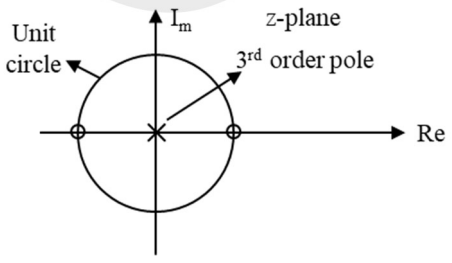
41. Pole zero plot of the transfer function of a system with input x[n] and output y[n] related by the input-output equation

$y[n] = \sum_{k=0}^{3}(-1)^k x[n-k]$ Will be

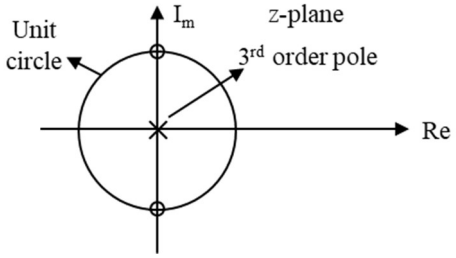
(a)



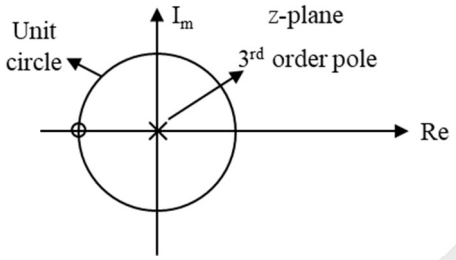
(b)



(c)



(d)



Answer:(a)

Solution:

$y(n) = x(n) - x(n-1) + x(n-2) - x(n-3)$

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

$$H(z) = \left(1 - z^{-1}\right)\left(1 + z^{-2}\right)$$

$$H(z) = \frac{(z-1)(z^2+1)}{z^3}$$

3 zeros @ $z = 1, \pm j$

3 poles @ origin (z=0) (pole of order 3)

42. Let a random variable Y be defined as

$$Y = \int_{-\infty}^{+\infty} w(t)\phi(t)dt$$

Where $\phi(t) = 1 \quad 5 \le t \le 7$

$\phi(t) = 0$ otherwise

Where w(t) is a real white gaussian noise process with 2-sided power spectral density $S_w(f) = 3$ Watts/Hz. The variance of random variable Y is __

Answer: 6

Solution:

$$y = \int_{5}^{7} w(t)dt$$

$$E[y^2] = E\left[\int_{5}^{7} w(t_1)dt_1 \int_{5}^{7} w(t_2)dt_2\right]$$

$$= \int_5^7 \int_5^7 E\left[w(t_1)w(t_2)\right]dt_1dt_2$$

$$= \int_5^7 \int_5^7 R_w(t_2 - t_1)dt_1dt_2$$

$S_w(f) = 3$

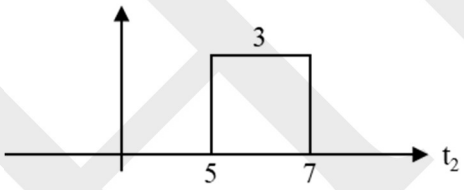
$$= \int_5^7 \int_5^7 3\delta(t_2 - t_1)dt_1dt_2$$

$$= \int_5^7 \int_5^7 3\delta(t_1 - t_2)dt_1dt_2$$

$$= 3\int_5^7 u(t_1 - t_2)\Big|_{t_1=5}^{t_1=7} dt_2$$

$$= 3\int_5^7 \left[u(7 - t_2) - u(5 - t_2)\right]dt_2$$

= Area under



= (3) (2) = 6.

43. Consider a binary random variable X which can take values +2 or -2. If probability P(X= +2) = α. The value of α for which entropy of X is maximum is ____

Answer: 0.5

Solution:

Entropy is maximum when the binary random variable is equiprobable.

$\therefore$ P(X +2) = P(X = – 2) = 0.5

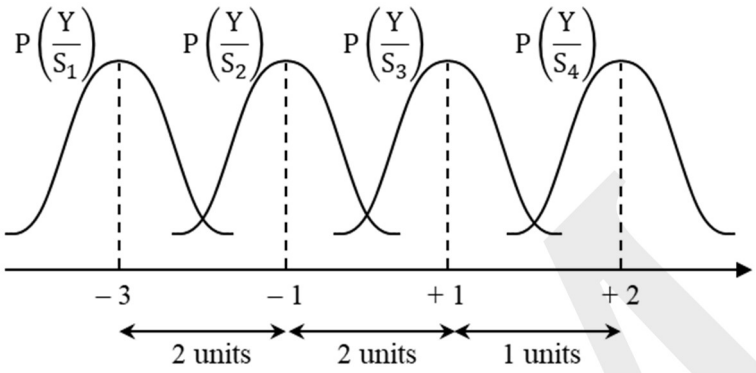
$\therefore$ $\alpha = 0.5$

44. In a digital communication system, four symbols S_1, S_2, S_3, S_4 are transmitted. The symbol values are S_1=-3, S_2=-1, S_3=+1 and S_4=+2. If the receiver receives Y=S+W where W is zero mean, unit variance, gaussian random variable. If P_i is the conditional probability of symbol error for ML decoding when S=S_i, then the value of 'i' for which conditional symbol probability if error is highest is __

Answer: 3

Solution:

Conditional pdfs for the transmitted symbols.



Symbols S_1 and S_4 have only one decision boundary hence P_e will be less compared to S_2 and S_3.

S_2 and S_3 are bounded by error due to 2 decision boundaries.

Since S_2 is comparatively distant from adjacent symbols S_1 and S_3 (2 units each respectively) it will have lower probability of error compared to S_3 which is 2 units and only 1 unit far from its adjacent symbols S_2 and S_4.

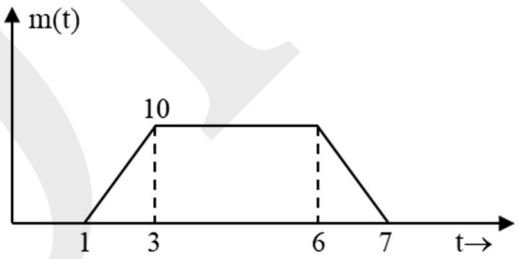
$\therefore$ S_3 has the highest probability of error.

45. For a message signal m(t), phase and frequency modulated waveforms are given by,

$S_{PM}(t) = \cos(1000\pi t + k_p m(t))$

$S_{FM}(t) = \cos\left(1000\pi t + k_f \int_{-\infty}^{+\infty} m(\tau)d\tau\right)$

If the highest instantaneous frequency of S_{PM} and S_{FM} are same, then $\frac{k_p}{k_f} =$ _____



Answer: 2

Solution:

For FM,

$$f_i = f_c + \frac{k_f}{2\pi} m(t)$$

For PM

$$f_i = f_c + \frac{k_p}{2\pi} \frac{dm}{dt}$$

For FM

$$f_{i\,max} = f_c + \frac{k_f}{2\pi} m(t)|_{max}$$

$$f_{i\,max} = f_c + \frac{k_f}{2\pi}(10)$$

For PM,

$$f_{i\,max} = f_c + \frac{k_p}{2\pi}\frac{dm}{dt}|_{max}$$

$f_{i\,max}$ is contributed by positive slope.

$$\therefore\ f_{i\,max} = f_c + \frac{k_p}{2\pi}\left(\frac{10}{2}\right)$$

$$f_{i\,max\ FM} = f_{i\,max\,PM}$$

$$f_c + \frac{k_f}{2\pi}(10) + f_c + \frac{k_p}{2\pi}(5)$$

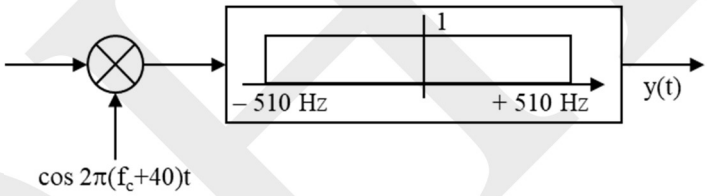
$$\therefore \frac{k_p}{k_f} = 2$$

46. Consider

$$x(t) = m(t)\cos(2\pi f_c t)$$

Where, $m(t) = 4\cos 1000\pi t$ and $f_c = 1$ MHz

The output y(t) of the block given below is _____



(a) $\cos(1000\pi t)$ (b) $\cos(920\pi t)$ (c) $\cos(460\pi t)$ (d) $\cos(540\pi t)$

Answer: (b)

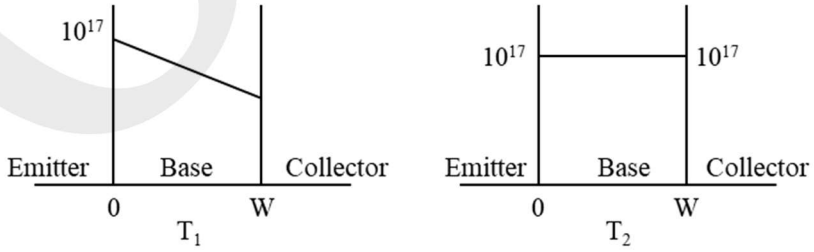
Solution:

Output of multiplier = $x(t)\cos 2\pi(f_c + 40)t$

$= 2\cos 1000\,\pi t \cos 2\pi(2f_c + 40)t + 2\cos 1000\,\pi t \cos 2\pi(40t)$

Output of filter = $\cos 920\,\pi t$

47. Concentration profile for two NPN transistors is shown below.



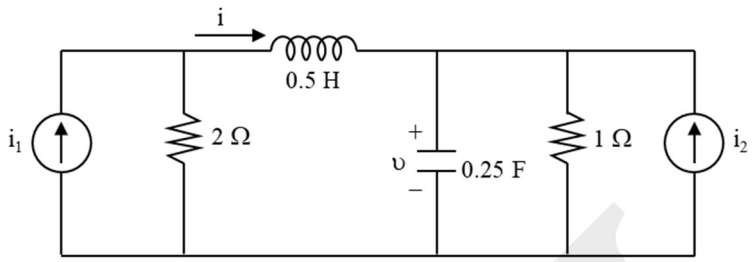
Common emitter current gain of T_2 is _____

(a) Approximately 0.7 time of T_1 (b) Approximately 2.0 time of T_1

(c) Approximately 0.3 time of T_1 (d) Approximately 2.5 time of T_1

Answer: (either a or c) (will update)

48.



Which is the correct state equation for the above circuit?

(a) $\frac{d}{dt}\begin{bmatrix}\upsilon\\ i\end{bmatrix}=\begin{bmatrix}4 & -4\\ -2 & -4\end{bmatrix}\begin{bmatrix}\upsilon\\ i\end{bmatrix}+\begin{bmatrix}0 & 4\\ 4 & 4\end{bmatrix}\begin{bmatrix}i_1\\ i_2\end{bmatrix}$

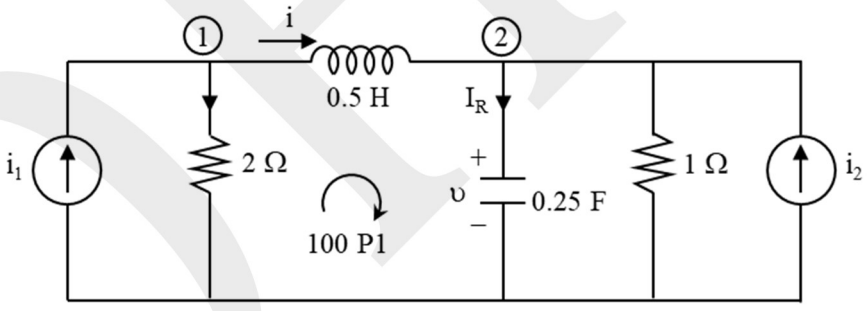
(b) $\frac{d}{dt}\begin{bmatrix}\upsilon\\ i\end{bmatrix}=\begin{bmatrix}-4 & 4\\ -2 & -4\end{bmatrix}\begin{bmatrix}\upsilon\\ i\end{bmatrix}+\begin{bmatrix}0 & 4\\ 4 & 0\end{bmatrix}\begin{bmatrix}i_1\\ i_2\end{bmatrix}$

(c) $\frac{d}{dt}\begin{bmatrix}\upsilon\\ i\end{bmatrix}=\begin{bmatrix}-4 & -4\\ -2 & 4\end{bmatrix}\begin{bmatrix}\upsilon\\ i\end{bmatrix}+\begin{bmatrix}4 & 4\\ 4 & 0\end{bmatrix}\begin{bmatrix}i_1\\ i_2\end{bmatrix}$

(d) $\frac{d}{dt}\begin{bmatrix}\upsilon\\ i\end{bmatrix}=\begin{bmatrix}-4 & -4\\ -2 & -4\end{bmatrix}\begin{bmatrix}\upsilon\\ i\end{bmatrix}+\begin{bmatrix}4 & 0\\ 0 & 4\end{bmatrix}\begin{bmatrix}i_1\\ i_2\end{bmatrix}$

Answer: (b)

Solution:



Applying KCL @ node (2)

$$i = c\frac{d\upsilon}{dt} + I_R + (-i_2)$$

$$i = 0.25\frac{d\upsilon}{dt} + I_R + (-i_2)$$

$$\frac{1}{4}\frac{d\upsilon}{dt} = i + i_2 - \frac{\upsilon}{1}$$

$$\boxed{\frac{d\upsilon}{dt}} = -4\upsilon + 4i + (0)i_1 + (4)i_2$$

Applying KCL @ pole 1

$$-2(i_1 - i) + 0.5\frac{di}{dt} + \upsilon = 0$$

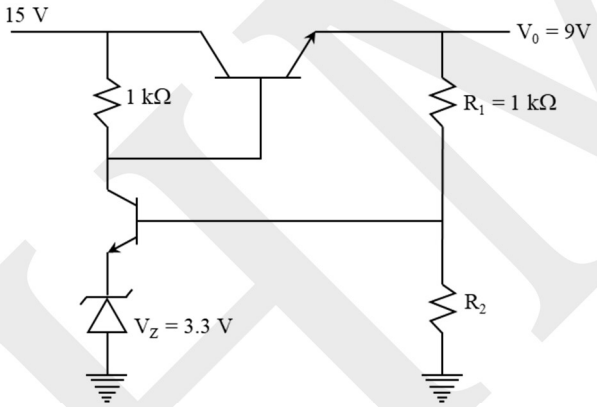
$$0.5\frac{di}{dt} = -\upsilon + 2(i_1 - i)$$

$$\frac{di}{dt} = -2\upsilon + 4(i_1 - i)$$

$$\boxed{\frac{di}{dt} = -2\upsilon - 4i + 4i_1 + 0i_2}$$

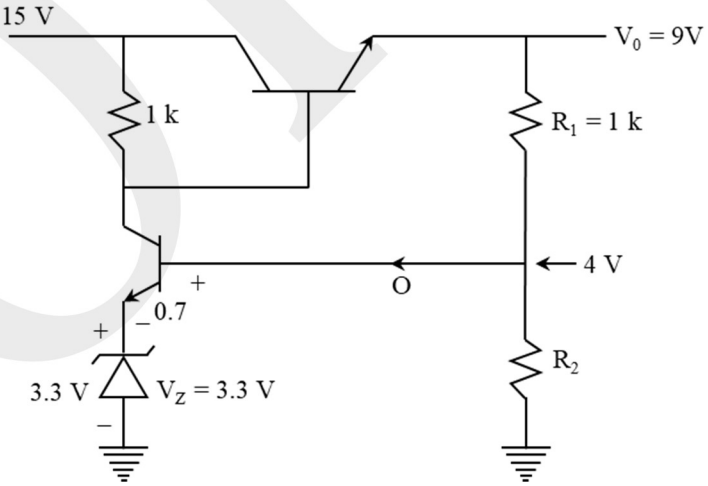
Hence, $\frac{d}{dt}\begin{bmatrix}\upsilon \\ i\end{bmatrix} = \begin{bmatrix}-4 & 4 \\ -2 & -4\end{bmatrix}\begin{bmatrix}\upsilon \\ i\end{bmatrix} + \begin{bmatrix}0 & 4 \\ 4 & 0\end{bmatrix}\begin{bmatrix}i_1 \\ i_2\end{bmatrix}$

49. For the voltage regulator shown below, if β of each transistor is large and V_{on} = 0.7 V, then R_2 = __ Ω



Answer: 800

Solution:



$$\frac{G \times R_2}{R_1 + R_2} = 4V$$

Since, R_1 = 1k, R_2 = 800 Ω

50. X(t) = cos(200πt) is sampled for t = $\frac{n}{400}$ where n = 0,1,2 3,4,5,6,7

Consider the DFT X(k) where

$$X(k)=\sum_{n=0}^{7}x(n)e^{-j\frac{\pi}{2}nk}$$

Then which of the following statements is true?

(a) X(k) is non-zero for all k
(b) X(4) is non-zero
(c) X(2) and X(6) are non-zero
(d) X(3) and X(5) are non-zero

Answer: (c)

Solution1:

$$x(n)=\cos 200\pi\left(\frac{n}{400}\right)$$

$$x(n)=\cos\frac{n\pi}{2}$$

$$x(n)=\frac{e^{j\frac{n\pi}{2}}(1)+e^{-j\frac{n\pi}{2}}(1)}{2}$$

Let y(n) = 1 $0 \le n \le 7$

Y(k) is non zero only for k = 0 where Y(k) is the DFT of y(n)

$$\therefore \quad x(n)=\frac{e^{j\frac{n\pi}{2}}(1)+e^{-j\frac{n\pi}{2}}}{2}$$

$$x(n)=\frac{e^{j\frac{2\pi}{8}(2n)}(1)+e^{-j\frac{2\pi}{8}(-2n)}}{2}$$

$$\therefore \quad X(k)=\frac{Y(k-2)+Y(k+2)}{2}$$

$$X(2)=\frac{Y(0)}{2}$$

$$X(-2)=\frac{Y(0)}{2}=X(6)$$

$\therefore$ X(2) and X(6) are none zero, all other are 0.

Solution2:

$$x(n)=\cos\frac{n\pi}{2} \quad 0 \le n \le 7$$

$f(n)=\cos\frac{n\pi}{2}$ is periodic with $\frac{2\pi}{\omega_0}=\frac{2\pi}{\pi/2}=4$

$$\underset{\text{8-point}}{x(n)} = [\ \underset{\text{4-point}}{f(n)}\ ,\ \underset{\text{4-point}}{f(n)}\ ]$$

Let, $x(n) \Leftrightarrow X(k)$

And $f(n) \Leftrightarrow F(k)$

$$\therefore X(k) = 2F\left(\frac{k}{2}\right)$$

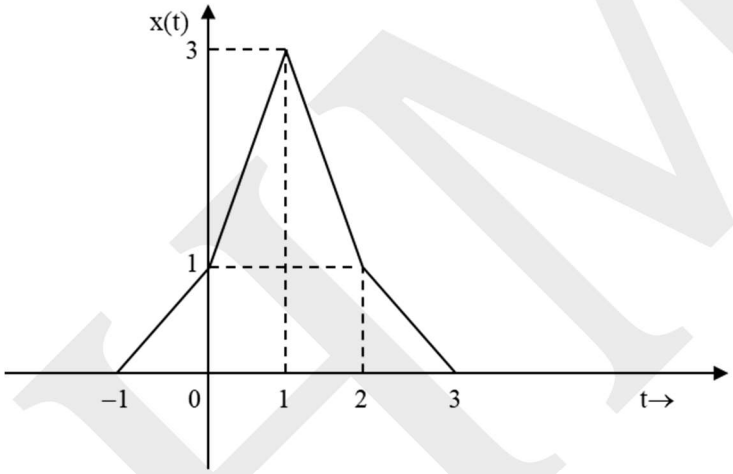
$f(n) = \cos\frac{n\pi}{2} = [1,0,-1,0]$

$F(k) = [0,2,0,2]$

$X(k) = 2F\left(\frac{k}{2}\right) = [0,0,4,0,0,0,4,0,0]$

$\therefore X(2)$ and $X(6)$ are non – zero

51. Consider $X(\omega)$ to be the Fourier transform of x(t) given by



Then $\int_{-\infty}^{+\infty} |X(\omega)|^2 d\omega$ is ____

Answer: 58.64

Solution:

$$\int_{-\infty}^{\infty} |X(\omega)|^2 \, d\omega = 2\pi \int_{-\infty}^{\infty} |x(t)|^2 \, dt$$

$= 2\pi \times$ Energy of x(t)

Due to symmetry

$E_1 = E_4$; $E_2 = E_3$

$$E_1 = E_4 = \frac{1}{3}$$

$$E_2 = E_3 = \int_0^1 (2t+1)^2 dt = \frac{13}{3}$$

$$\int_{-\infty}^{\infty} |X(\omega)|^2 \, d\omega = 2\pi\left[E_1 + E_2 + E_3 + E_4\right] = 2\pi[(2)(E_1 + E_2)]$$

$$= 4\pi\left[\frac{1}{3} + \frac{13}{3}\right] = \frac{56\pi}{3} = 58.64$$

52. The transfer function of a stable discrete time LTI system is

$$H(z) = \frac{K(z-\alpha)}{z+0.5}$$, where K and α are real numbers.

The value of α with $|\alpha| > 1$ for which magnitude of system is constant for all frequencies is _____

Answer: – 2

Solution:

$$H(z) = \frac{K(z-\alpha)}{z+0.5}$$

For magnitude to be constant for all frequencies, the filter should act as an all pars filter

For APF,

$$\text{Zero} = \frac{1}{(\text{Pole})^*}$$

Here, pole $\Rightarrow z_p = -0.5$

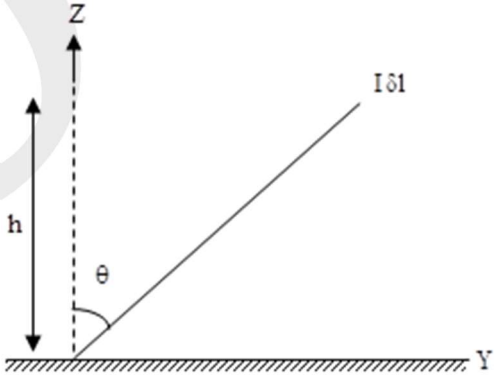
$\therefore$ Also, zero $\Rightarrow z_0 = \alpha$

$$\text{Zero} = \frac{1}{\text{pole}^*} = \frac{1}{(-0.5)^*}$$

$$\text{Zero} = \alpha = \frac{1}{-0.5} = -2$$

$\therefore \alpha = -2.$

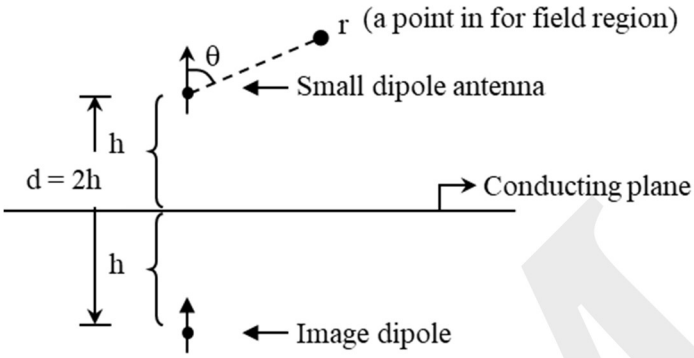
53. For an infinitely small dipole in free space the electric field in the far field is proportional to $\left(\frac{e^{-jkr}}{r}\right)\sin\theta$, where $k = \frac{2\pi}{\lambda}$. A vertical infinitesimally small electric dipole ($\delta l << \lambda$) is placed at a distance h ($h > 0$) above an infinite ideal conduction plane as shown in figure. The minimum value of h for which one of the maxima in the far field radiation pattern occurs at $\theta = 60°$ is __



(a) λ (b) 2λ (c) $\lambda/4$ (d) $\lambda/2$

Answer: (d)

Solution:



Normalized resultant pattern is,

$$E(\theta) = \left| (\sin\theta) \quad \frac{(\beta d\cos\theta + \alpha)}{2} \right|$$

↑ Unit factor ↑ Array factor

$\beta = \frac{2\pi}{\lambda}$; $d = 2h$; $\alpha = 180°$ ($\because$ Phase shift between the real and image dipoles is ± 180°)

$$E\cos = \left|\sin\theta\cos\left(\frac{2\pi}{\lambda}\right)\frac{2h.\cos\theta}{2} + \frac{180°}{2}\right|$$

$$E\cos = \left|\sin\theta\sin\left(\frac{2\pi b}{\lambda}\right)\cos\theta\right| \qquad \text{let } h = k\lambda$$

$$E\cos = \left|\sin\theta\sin\left(2\pi k\cos\theta\right)\right|$$

Given maximum should occur @ $\theta = 60°$.

$$\Rightarrow E_{max}^{(\theta)}\big|_{\theta=60°} = \left|\frac{\sqrt{3}}{2}\sin\left(2\pi k.\frac{1}{2}\right)\right|$$

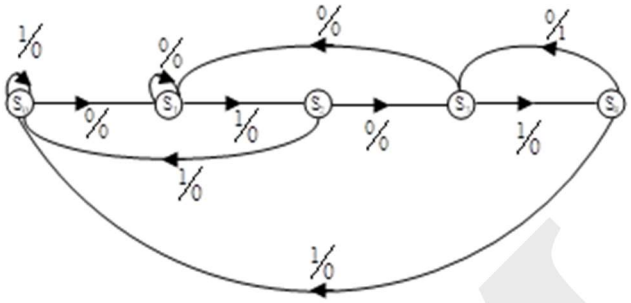
$$= \frac{\sqrt{3}}{2}\sin(\pi k) \leftarrow \text{ has maxima for } k = 1/2, 3/2, ...$$

$\therefore$ Smallest value of k is $1/2$.

$\therefore n = k\lambda$

$$\boxed{n = \frac{\lambda}{2}}$$

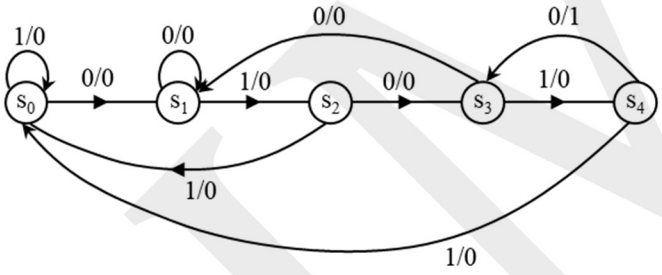
54. For the FSM shown below, the input pattern for which output is 1 is _____.



(a) 01010 (b) 0101 (c) 10101 (d) 1010

Answer: (a)

Solution:



For the above FSM, the sequence that is being detected is input bit pattern until output is 1 [on arrows the format is input/output].

$\therefore$ Sequence being detected is 01010.

55. Consider the recombination process via bulk traps in a forward biased PN homojunction diode. The maximum recombination rate is U_{max}. If the e^- and hole capture cross-sections are equal, which one of the following is false

(a) U_{max} occurs at the edges of the depletion region

(b) with all parameters unchanged U_{max} increases if the thermal velocity of the carrier increases.

(c) U_{max} decreases if the intrinsic carrier density is reduced

(d) U_{max} depends exponentially on applier bias

Answer: (c)

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