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GATE - 2021

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SUBJECTWISE WEIGHTAGE

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01	Electric Circuits	7
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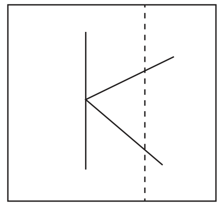
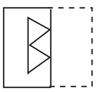
General Aptitude

01.

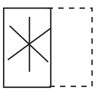


A transparent square sheet shown above is folded along the dotted line. The folded sheet will look like ______.

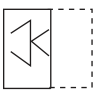
(a)



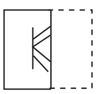
(b)



(c)



(d)



01. Ans: (a)

02. Oasis is to sand as island is to ______

Which one of the following options maintains a similar logical relation in the above sentence?

(a) Land (b) Water

(c) Mountain (d) Stone

02. Ans: (b)

Sol: Oasis is a water pool amidst sand just as island is a piece of land amidst water.

03. Seven cars P.Q,R,S,T,U and V are parked in a row not necessarily in that order. The cars T and U should be parked next to each other. The cars S and V also should be parked next to each other, whereas P and Q cannot be parked next to each other. Q and S must be parked next to each other. R is parked to the immediate right of V. T is parked to the left of U.

Based on the above statements, the only INCORRECT option given below is:

(a) Q and R are not parked together

(b) There are two cars parked in between Q and V.

(c) V is the only car parked in between S and R

(d) Car P is parked at the extreme end.

03. Ans: (b)

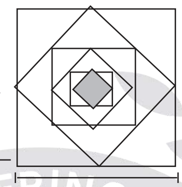
Sol: As per the conditions given, we get two possibilities

1. PTUQSVR
2. TUQSVRP

Going by any of the above two possibilities there can't be two cause between Q and V.

$\therefore$ Option (b) is suitable answer.

04.



In the figure shown above, each insided square is formed by joining the midpoints of the sides of the next larger square. The area of the smallest square(shaded) as shown, in cm^2 is :

(a) 6.25 (b) 12.50

(c) 1.5625 (d) 3.125

04. Ans: (d)

Sol: When a square is formed by joining the midpoints of the next larger square, the area of inner square is exactly of the area of the larger square.

Area of 1st square = $10 \times 10 = 100$ Sq.cm

Area of 2nd square = $\frac{1}{2} \times 100 = 50$ Sq.cm

Area of 3rd square = $\frac{1}{2} \times 50 = 25$ Sq.cm

Area of 4th square = $\frac{1}{2} \times 25 = 12.5$ Sq.cm

Area of 5th square = $\frac{1}{2} \times 12.5 = 6.25$ Sq.cm

Area of the smallest square is 6th square = $\frac{1}{2} \times 6.25 = 3.125$ Sq.cm

Option (d) is the correct answer.

05. For a regular polygon having 10 sides, the interior angle between the sides of the polygon, in degrees, is:

(a) 216 (b) 396

(c) 324 (d) 144

05. Ans: (d)

Sol: Each interior angle in a regular polygon = $\frac{(2n-4)90^\circ}{n}$

Where n is the number sides.

$\therefore$ Each interior angle = $\frac{[(2\times10)-4]90^\circ}{10}$ = 144 °

06. The poeple____ were at the demonstration were from all sections of society.

(a) whom (b) whose

(c) which (d) who

06. Ans: (d)

Sol: The subject of the verb is 'who'.

07. Let X be a continuous random variable denoting the termperature measured. The range of temperature is [0, 100] degree Celsius and let the probability density function of X be f(x) = 0.01 for $0 \le X \le 100$. The mean of X is _____

(a) 5.0 (b) 25.0

(c) 50.0 (d) 2.5

07. Ans: (c)

Sol: $f(x) = 0.01,\ 0 \le x \le 100$

$$E(x) = \int_0^{100} x\, f(x)\,dx = \int_0^{100} 0.01x\,dx$$

$$= 0.01\left(\frac{x^2}{2}\right)_0^{100} = 0.01\left\{\frac{(100)^2}{2}\right\} = 50$$

08. Which one of the following numbers is exactly divisible by $(11^{13}+1)$?

(a) $11^{33}+1$ (b) $11^{39}-1$

(c) $11^{52}-1$ (d) $11^{26}+1$

08. Ans: (c)

Sol: $a^n - b^n$ is divisible by (a + b), only when n is even.

Take the 3rd option put $11^{13} = a$, $1^{13} = b$

Now $\frac{11^{52}-1^{52}}{11^{13}+1^{13}} = \frac{(11^{13})^4-(1^{13})^4}{11^{13}+1^{13}}$

$\Rightarrow \frac{a^4-b^4}{a+b}$

$\therefore$ Option (c) is correct.

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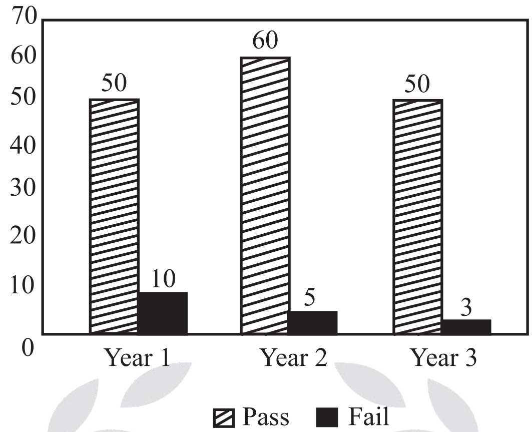


The number of students passing or failing in an exam for a particular subject is presented in the bar chart above. Students who pass the exam cannot appear for the exam again. Students who fail the exam in the first attempt must appear for the exam in the following year. Students always pass the exam in their second attempt.

The number of students who took the exam for the first time in the year 2 and the year 3 respectively, are _____.

(a) 60 and 50 (b) 65 and 53

(c) 55 and 48 (d) 55 and 53

09. Ans: (c)

Sol: Out of 65 students appeard in year-2, 10 are from year-1

Therefore 55 students appeared for the 1st time in year-2.

Out of 53 students appeared in year-3, 5 are from year-2 (who failed in year-2)

Therefore 48 students appeared for the first time in year-3.

Option (c) is correct.

10. The importance of sleep is often overlooked by students when they are preparing for exams. Research has consistently shown that sleep deprivation greatly reduces the ability to recall the material learnt. Hence, cutting down on sleep to study longer hours can be counterproductive.

Which one of the folloiwng statements is the CORRECT inference from the above passage?

(a) Students are efficient and are not wrong in thinking that sleep is a waste of time.

(b) To do well in an exam, adequate sleep must be part of the preparation.

(c) If a student is extremely well prepared for an exam, he needs little or no sleep.

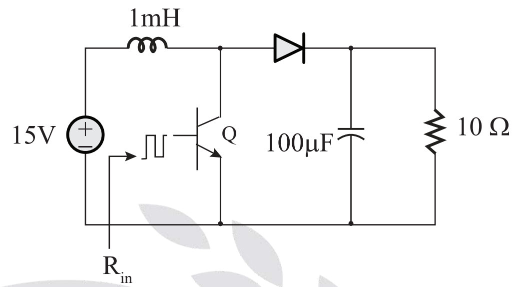
(d) Sleeping well alone is enough to prepare for an exam. Studying has lesser benefit.

10. Ans: (b)

Sol: Deprivation of sleep during exams will have negative effect on exams. So, considerable sleep is necessary to do well in exams.

Electrical Engineering

01. Consider the boost converter shown. Swithch Q is operating at 25 kHz with a duty cycle of 0.6. Assume the diode and switch to be ideal. Under steady-state condition, the average resistance R_{in} as seen by the source is ______ Ω.
(Round off to 2 decimal places)



01. Ans: 1.6

Sol: f = 25 kHz

D = 0.6

Find R_{in} = ? (in Ω)

To check continuous conduction or discontinuous conduction

$$K = K = \frac{2fL}{R} \text{ and } k_{cr} = D(1-D)^2$$

$$\text{Now } k = \frac{2fL}{R} = \frac{2\times 25k \times 0.001}{10} = 5$$

$$k_{cr} = D(1-D)^2 = 0.6 \times (1-0.6)^2 = 0.096$$

As $[k > k_{cr}]$ means continuous conduction case

$$\text{In C.C.C. } V_0 = \frac{V_S}{(1-D)}$$

According to Power balance equation

$$\frac{P_i}{P} = \frac{P_o}{P}$$

$$V_S i_{s\,avg} = V_0 I_0$$

$$V_S\, i_{S\,avg} = \frac{V_0^2}{R} = \frac{V_S^2}{R(1-D)^2}$$

$$i_{s\,avg} = \frac{15}{10(1-0.6)^2}$$

$i_{s\,avg}$ = 9.375 amp

Now average resistance (R_{in})

$$R_{in} = \frac{V_s}{i_{s\,avg}} = \frac{15}{9.375}$$

R_{in} = 1.6 Ω.

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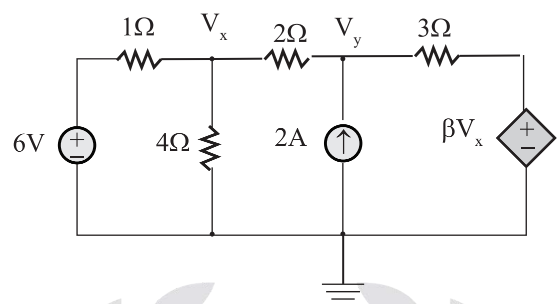
02. In the given circuit, for voltage V_y to be zero, the value of β should be __________.
(Round off to 2 decimal places).



02. Ans: –3.25

Sol: By KCL at V_x:

$$\frac{V_x - 6}{1} + \frac{V_x}{4} + \frac{V_x - V_y}{2} = 0$$

$$4V_x - 24 + V_x + 2V_x - 2V_y = 0$$

If $V_y = 0$, $\quad 7V_x = 24 \Rightarrow V_x = \frac{24}{7}$

By KCL at V_y:

$$2 = \frac{V_y - V_x}{2} + \frac{V_y - \beta V_x}{3}$$

If $V_y = 0$

$$2 = \frac{-V_x}{2} + \frac{-\beta V_x}{3}$$

$$2 = -V_x\left[\frac{1}{2} + \frac{\beta}{3}\right]$$

$$2 = \frac{-24}{7}\left[\frac{1}{2} + \frac{\beta}{3}\right]$$

$$\frac{-7}{12} = \frac{1}{2} + \frac{\beta}{3} \Rightarrow \frac{\beta}{3} = \frac{-7}{12} - \frac{1}{2} = \frac{-7-6}{12}$$

$$\frac{13}{3} = \frac{-13}{2} \Rightarrow \beta = \frac{-13}{4} \Rightarrow \beta = -3.25$$

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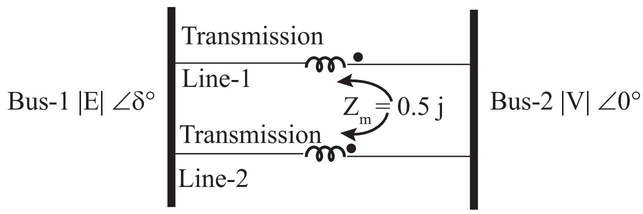
03. In the figure shown, self-impedances of the two transmission lines are 1.5j p.u each, and $Z_m = 0.5\ j$ p.u is the mutual impedance. Bus voltages shown in the figure are in p.u. Given that $\delta > 0$, the maximum steady-state real power that can be transferred in p.u from Bus-1 to Bus-2 is



(a) $\frac{|E||V|}{2}$

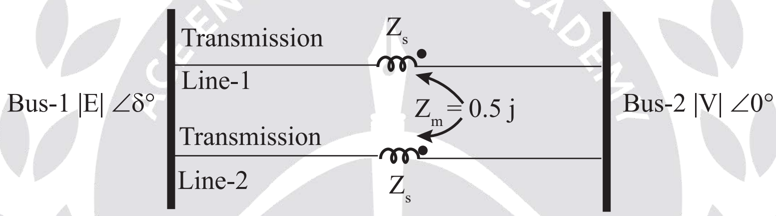
(b) $|E||V|$

(c) $2|E||V|$

(d) $\frac{3|E||V|}{2}$

03. Ans: (b)

Sol: Given figure of a 2 bus power system network



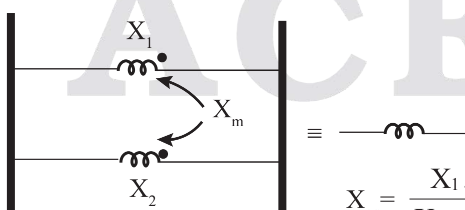
The self impedance of each line $Z_5 = j1.5$ p.u.

Mutual impedance between lines, $Z_m = j0.5$ p.u.

As the network is lossless, the expression for maximum power transfer capacity will be $P_{max} = \frac{|E|.|V|}{|B|}$

Where 'B' is the short circuit transfer impedance of the network.

If two reactors of self reactance X_1 and X_2 connected in parallel with a mutual reactance of X_m then the equivalent reactance will be



$$X_{eq} = \frac{X_1.X_2 - X_m^2}{X_1 + X_2 - 2X_m}$$

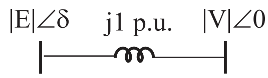
So, the equivalent transfer reactance between the buses will be

$$X_{eq} = \frac{X_S.X_S - X_m^2}{X_S + X_S - 2X_m}$$

$$= \frac{1.5 \times 1.5 - (0.5)^2}{1.5 + 1.5 - 1}$$

$$= 1 \text{ p.u.}$$

So, the given two bus system can be redrawn as,

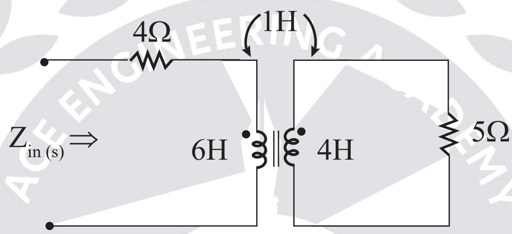


In this model, B = j 1 p.u.

So, $P_{max} = \dfrac{|E|.|V|}{1} = |E|.|V|$

Correct option is (b)

04. The input impedance, $Z_{in}(s)$, for the network shown is



(a) $\dfrac{25s^2+46s+20}{4s+5}$

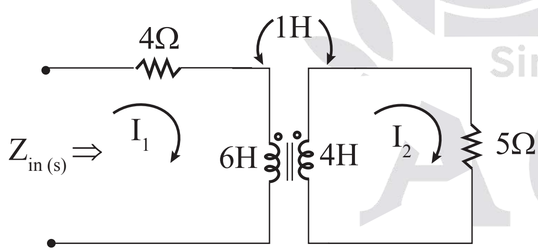
(b) 6s + 4

(c) 7s+4

(d) $\dfrac{23s^2+46s+20}{4s+5}$

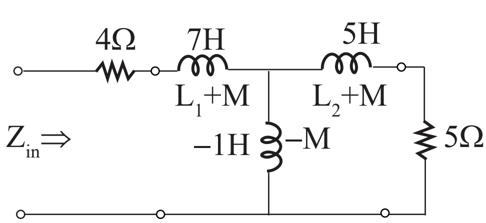
04. Ans: (d)

Sol:

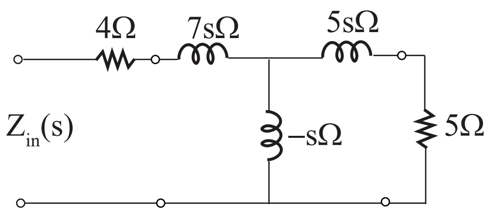


The above coupled circuit is magnetic opposing

The equivalent circuit is



Convert into s-domain circuit



$Z_{in}(s) = ((5s+5) // -s) + (7s+4)$

$$= \frac{(5s+5)(-s)}{(7s+5)} + 7s + 4$$

$$= \frac{-5s^2 - 5s + 28s^2 + 16s + 35s + 20}{(4s+5)}$$

$$Z_{in}(s) = \frac{23s^2 + 46s + 20}{(7s+5)}$$

05. Two single-core power cables have total conductor resistances of 0.7Ω and 0.5Ω, respectively, and their insulation resistances (between core and sheath) are $600\ M\Omega$ and $900\ M\Omega$, respectively. When the two cables are joined in series, the ratio of insulation resistance to conductor resistance is ________ $\times 10^6$.

05. Ans: 300

Sol: Details of the two single core power cables given,

Cable-1: $R_{C1} = 0.7\ \Omega$, $R_{i1} = 600\ M\Omega$

Cable 2: $R_{C2} = 0.5\ \Omega$, $R_{i2} = 900\ M\Omega$

If these two cables are connected in series, the conductor resistance will be in series and insulation resistances will be in parallel.

Equivalent conductor resistance, $R_{C\,eq} = R_{C1} + R_{C2} = 1.2\ \Omega$

Equivalent insulation resistance, $R_{i\,eq} = R_{i1} \,||\, R_{i2} = \dfrac{600 \times 900}{600 + 900}$

$= 360\ M\Omega$

The ratio of equivalent insulation resistance to conductor resistance,

$$\frac{R_{i\,eq}}{R_{C\,eq}} = \frac{360 \times 10^6}{1.2} = 300 \times 10^6$$

06. Consider a continuous-time signal x(t) defined by x(t) = 0 for |t|>1, and x(t) = 1– |t| for |t|≤1. Let the Fourier transform of x(t) be defined as $X(\omega) = \int_{-\infty}^{\infty} x(t) e^{-j\omega t} dt$. The maximum magnitude of X(ω) is ______________.

06. Ans: 1

Sol: Given $x(t) = 1-|t| \quad |t| \le 1$

$\qquad 0 \quad |t| > 1$

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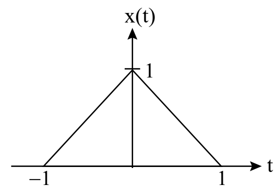


So, given signal is a triangular function

$x(t) = \text{Tri}(t)$

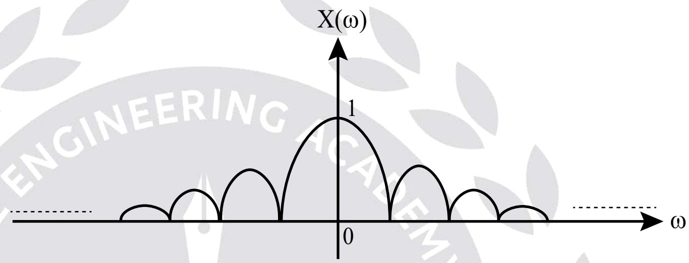
from standard F.T pair

If $x(t) = A\text{Tri}\left(\frac{t}{T}\right)$, then

$X(\omega) = ATsa^2\left(\frac{\omega T}{2}\right)$

Here $x(t) = \text{Tri}(t)$ [A = 1, T = 1]

$X(\omega) = Sa^2\left(\frac{\omega}{2}\right)$



Maximum magnitude of X(ω) is '1'

07. The power input to a 500 V, 50 Hz, 6-pole, 3-phase induction motor running at 975 RPM is 40 kW. The total stator losses are 1 kW. If the total friction and windage losses are 2.025 kW, then the efficiency is ______ %.

07. Ans: 90

Sol: Stator input (P_{si}) = 40 kW

Stator losses (P_{sl}) = 1 kW

Stator output power/Rotor input power $P_{ri} = P_{si} - P_{sl}$

$= 40 - 1$

$= 39$ kW

Rotor speed, $N_r = 975$ rpm

P = 6; f = 50 Hz,

Synchronous speed,

$$N_s = \frac{120f}{P} = \frac{120\times 50}{6} = 1000 \text{ rpm}$$

$$\text{Slip, } s = \frac{1000-975}{1000} = 0.025$$

We have $P_{ri} : P_{rl} : P_{ro} = 1 : s : (1 - s)$

P_{r0} = Rotor output power

$$\therefore \quad \frac{P_{ro}}{P_{ri}} = (1 - s) \Rightarrow P_{r0} = P_{ri}(1 - s)$$

P_{ro} or Gross mechanical power (P_{gm})

$= 39(1 - 0.025)$ kW

$= 38.025$ kW

P_{ml} (Mech loss) = 2.025 kW

(friction and windage loss)

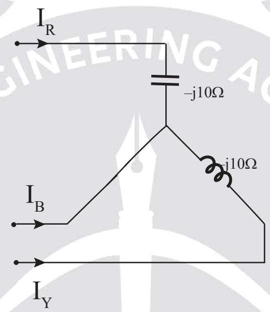
$\therefore$ Net power $= P_{ro} - P_{mc}$

$= 38.025 - 2.025$

$= 36$ kW

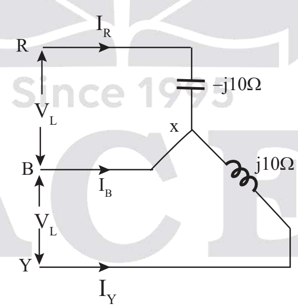
$$\eta = \frac{36}{40} \times 100 = 90\%$$

08. A three-phase balanced voltage is applied to the load shown. The phase sequence is RYB. The ratio $\frac{|I_B|}{|I_R|}$ is ______.



08. Ans: 1

Sol: A 3-ϕ balanced supply



The phase sequence is RYB

$V_{RY} = V_L \angle 0°$, $V_{YB} = V_L \angle -120°$, $V_{BR} = V_L \angle 120°$,

$$I_R = \frac{V_{RB}}{-j10} = \frac{-V_{BR}}{-j10} = \frac{-V_L \angle +120}{-j10}$$

$$I_Y = \frac{V_{YB}}{j10} = \frac{V_L \angle -120}{j10}$$

By KCL at (X)

$$I_B = -(I_R + I_Y)$$

$$\frac{I_B}{I_R} = -\left(1+\frac{I_Y}{I_R}\right)$$

$$= -\left(1+\frac{V_L\angle -120}{j10}\bigg/\frac{V_L\angle +120}{j10}\right)$$

$$= -\left(1+\frac{(-0.5-j0.866)}{-0.5+j0.866}\right)$$

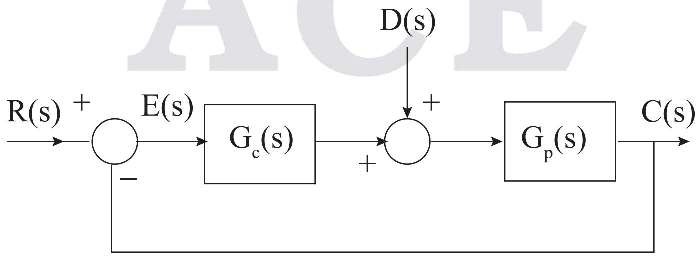
$$\frac{I_B}{I_R} = -\left(1+\frac{(-1-j\sqrt{3})}{(-1+j\sqrt{3})}\right)$$

$$= -\frac{(-1+j\sqrt{3}+(-1-j\sqrt{3})}{(-1+j\sqrt{3})}$$

$$= \frac{2}{(-1+j\sqrt{3})} = \frac{2(-1-j\sqrt{3})}{4}$$

$$\left|\frac{I_B}{I_R}\right| = \frac{2}{2} = 1$$

09. In the given figure, plant $G_p(s) = \dfrac{2.2}{(1+0.1s)(1+0.4s)(1+1.2s)}$ and compensator $G_c(s) = K\left[\dfrac{1+T_1 s}{1+T_2 s}\right]$. The external disturbance input is D(s). It is desired that when the disturbance is a unit step, the steady-state error should not exceed 0.1 unit. The minimum value of K is ____.
(Round off to 2 decimal places.)



09. Ans: –10.45

Sol: With R(s) = 0, $\dfrac{E(s)}{D(s)} = \dfrac{-G_p(s)}{1+G_p(s)G_c(s)}$

UPCOMING BATCHES @ HYDERABAD

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Batch Type	Timings	Batch Date	Duration	Venue & Streams
Regular	Daily 4 to 6 Hours	**2^{nd} & 17^{th} April 2021**	5 to 6 Months	Abids (CS&IT) Dilsukhnagar (EC, EE, IN) Kothapet (CE, ME, PI)
		1^{st} & 17^{th} May 2021		
		1^{st} & 17^{th} June 2021		

GATE + PSUs - 2022 (FLEXIBLE BATCHES)

Batch Type	Timings	Batch Date	Duration	Venue & Streams
Flexible Batches	Daily 6 to 8 Hours	**5^{th}, 20^{th} July 2021**	3 to 4 Months	Abids (CS&IT) Dilsukhnagar (EC, EE, IN) Kothapet (CE, ME, PI)
		4^{th}, 18^{th} August 2021		

GATE + PSUs – 2022 (SPARK BATCHES)

Batch Type	Timings	Batch Date	Duration	Venue & Streams
Spark	Daily 5 to 8 Hours	**17^{th} May 2021**	5 to 6 Months	Abids (CE, ME, CS) Kukatpally (EC, EE)
		1^{st} & 17^{th} June 2021		

ESE + GATE + PSUs – 2022 (REGULAR BATCHES)

Batch Type	Timings	Batch Date	Duration	Venue & Streams
Regular	Daily 6 to 8 Hours	**2^{nd} & 17^{th} April 2021**	9 to 10 Months	Kukatpally (EC, EE) Abids (CE, ME)
		1^{st} & 17^{th} May 2021		
		1^{st} & 17^{th} June 2021		

ESE + GATE + PSUs – 2022 (SPARK BATCHES)

Batch Type	Timings	Batch Date	Duration	Venue & Streams
Spark	Daily 6 to 8 Hours	**17^{th} May 2021**	9 to 10 Months	Kukatpally (EC, EE) Abids (CE, ME)
		1^{st} & 17^{th} June 2021		

$$= \frac{\dfrac{-2.2}{(1+0.1s)(1+0.4s)(1+1.2s)}}{1+\dfrac{2.2}{(1+0.1s)(1+0.4s)(1+1.2s)}\times\dfrac{K(1+T_1 s)}{(1+T_2 s)}}$$

$$= \frac{E(s)}{D(s)} = \frac{-2.2(1+T_2 s)}{(1+0.1s)(1+0.4s)(1+1.2s)(1+T_2 s)+2.2K(1+T_1 s)}$$

$D(s) = \frac{1}{s}(\text{unit step})$

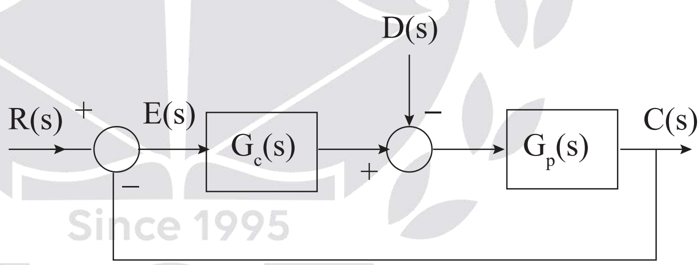
Steadt state error = $\underset{s\to 0}{Lt}\, sE(s)$

$$= \underset{s\to 0}{Lt}\ s\left[\frac{-2.2(1+T_2 s)}{(1+0.1s)(1+0.4s)(1+1.2s)(1+T_2 s)+2.2K(1+T_1 s)}\right]\frac{1}{s}$$

$$\frac{-2.2}{1+2.2K} = 0.1$$

$$\Rightarrow K = \frac{-23}{2.2} = -10.45 \quad \textbf{(Ans)}$$

In case Block diagram given with negative polarity at disturbance,



With R(s) = 0, $\frac{E(s)}{D(s)} = \frac{G_p(s)}{1+G_p(s)G_c(s)}$, Input $D(s) = \frac{1}{s}$

Given steady state error = 0.1

$\underset{s\to 0}{Lt}\ s\,E(s) = 0.1$

$\underset{s\to 0}{Lt}\ s\left[\frac{G_p(s)}{1+G_p(s)G_c(s)}\right]\frac{1}{s} = 0.1$ ...... (1)

$\underset{s\to 0}{Lt}\ G_P(s) = \frac{2.2}{1\times 1\times 1} = 2.2$

$\underset{s\to 0}{Lt}\ G_c(s) = k\left[\frac{1}{1}\right] = k$

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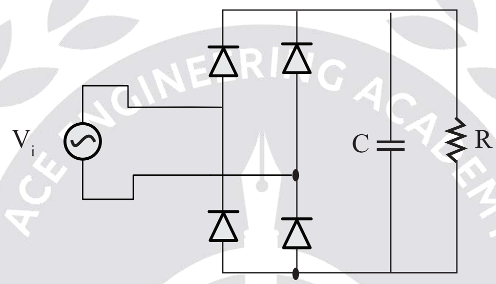
$$\Rightarrow \frac{2.2}{1+2.2\times k} = 0.1$$

$22 = 1+2.2k$

$\Rightarrow 21 = 2.2\ k$

$k = 9.54$

10. In the circuit shown, the input V_i is a sinusoidal AC voltage having an RMS value of 230 V ± 20%. The worst-case peak-inverse voltage seen across any diode is ____ V. (Round off to 2 decimal places.)



10. Ans: 390.32

Sol: The given circuit is bridge full wave rectifier with RC filter.

In bridge FWR, peak inverse voltage of each diode is V_m.

Then $(PIV)_{diode} = \sqrt{2}\ [230 \pm 20\%]$

$$= \sqrt{2}\left[230 + \frac{20}{100}\times 230\right]$$

$$= \sqrt{2}\ (230 + 46)$$

$= 390.32$ Volts

11. Two discrete-time linear time-invariant systems with impulse responses $h_1[n] = \delta[n-1]+\delta[n+1]$ and $h_2[n] = \delta[n]+\delta[n-1]$ are connected in cascade,where $\delta[n]$ is the Kronecker delta. The impulse response of the cascaded system is

(a) $\delta[n-1]\ \delta[n]+\delta[n+1]\ \delta[n-1]$

(b) $\delta[n-2]+\delta[n-1]+\delta[n]+\delta[n+1]$

(c) $\delta[n-2]+\delta[n+1]$

(d) $\delta[n]\ \delta[n-1]+\delta[n-2]\delta[n+1]$

11. Ans: (b)

Sol: Given $h_1(n) = \delta\ (n-1) +\delta\ (n+1)$

$h_2(n) = \delta\ (n) +\delta\ (n-1)$

When two LTI systems are connected in cascade , the resultant impulse response is convolution of individual impulse responses. i.e $h(n) = h_1(n)*h_2(n)$

$h(n) = [\delta(n-1) + \delta(n+1)] * [\delta(n) + \delta(n-1)]$

$h(n) = \delta(n-1) * \delta(n) + \delta(n-1) * \delta(n-1) + \delta(n+1) * \delta(n) + \delta(n+1) * \delta(n-1)$

$\delta(n-n_1) * \delta(n-n_2) = \delta(n-n_1-n_2)$

$h(n) = \delta(n-1) + \delta(n-2) + \delta(n+1) + \delta(n)$

$h(n) = \delta(n-2) + \delta(n-1) + \delta(n) + \delta(n+1)$

12. Let f(t) be an even function, i.e. f(–t) = f(t) for all t. Let the Fourier transform of f(t) be defined as $F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-j\omega t} dt$. Suppose $\frac{dF(\omega)}{d\omega} = -\omega F(\omega)$ for all ω, and F(0) = 1. Then

(a) f(0) = 0 (b) f(0) > 1

(c) f(0) < 1 (d) f(0) = 1

12. Ans: (c)

Sol: Given f(–t) = f(t). [f(t) is even]

Given $\frac{dF(\omega)}{d\omega} = -\omega F(\omega)$....... (1)

From differentiation in time domain property

$$\frac{df(t)}{dt} \longleftrightarrow j\omega F(\omega)$$

From differentiation in freuqency domain property

$$tf(t) \longleftrightarrow \frac{jdF(\omega)}{d\omega}$$

Apply IFT to equation (1)

$$-jt\, f(t) = \frac{jdf(t)}{dt}$$

$$\frac{df(t)}{dt} = -\, tf(t) \text{..... (2)}$$

From equation (1) & (2)

f(t) is a chance of gaussian function

$$f(t) = \frac{1}{\sqrt{2\pi}} e^{-t^2/2}$$

$$\left[e^{-at^2} \longleftrightarrow \sqrt{\frac{\pi}{a}} . e^{-\omega^2/4a}\right]$$

$$\left[e^{-t^2/2} \longleftrightarrow \sqrt{2\pi} . e^{-\omega^2/2}\right]$$

$$\frac{1}{\sqrt{2\pi}} e^{-t^2/2} \longleftrightarrow e^{-\omega^2/2}$$

$$f(t) = \frac{1}{\sqrt{2\pi}} e^{-t^2/2}$$

$$f(0) = \frac{1}{\sqrt{2\pi}} \quad = <1$$

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Morning, Evening Batches	**6am to 8am** & **6pm to 8:30pm**	20th March 2021	8 to 10 Months	Abids, Dilsukhnagar, Kukatpally.

GATE + PSUs – 2022 & ESE + GATE + PSUs – 2022 — @ DELHI

Batch Type	Timings	Batch Date	Duration	Venue
Regular Batches	Daily 5 to 6 Hours	5th March 2021	6 to 7 Months	ACE campus Saket
		7th April 2021		
		15th May 2021		
		5th June 2021		

GATE + PSUs – 2022 & ESE + GATE + PSUs – 2022 — @ PUNE

Batch Type	Timings	Batch Date	Duration	Venue
Regular / Weekend Batches	Daily 5 to 6 Hours	20th March 2021	6 to 7 Months	Pune Classroom

GATE + PSUs – 2022 & 2023 — @ VIZAG

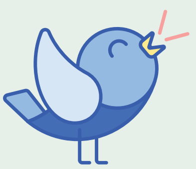
Batch Type	Timings	Batch Date	Duration	Venue
Weekend Batch	Saturday **2 pm to 8 pm** Sunday **9am to 6pm**	3rd April 2021	6 to 7 Months	Vizag Classroom

GATE + PSUs – 2022 & 2023 — @ VIJAYAWADA

Batch Type	Timings	Batch Date	Duration	Venue
Weekend Batch	Saturday **2 pm to 8 pm** Sunday **9am to 6pm**	3rd April 2021	6 to 7 Months	Vijayawada Classroom

GATE + PSUs – 2022 — @ TIRUPATI

Batch Type	Timings	Batch Date	Duration	Venue
Weekend Batch	Saturday **2 pm to 8 pm** Sunday **9am to 6pm**	20th March 2021	6 to 7 Months	Tirupati Classroom



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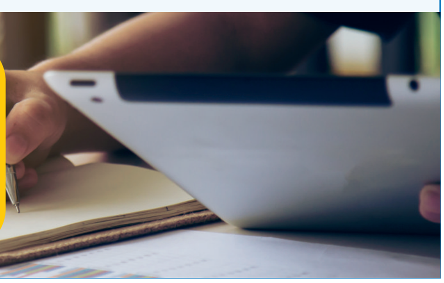


13. Suppose the probability that a coin toss shows 'head' is p, where $0 < p < 1$. The coin is tossed repeatedly until the first "head" appears. The expected number of tosses required is

(a) $1/p$ (b) $(1-p)/p$

(c) $p/(1-p)$ (d) $1/p^2$

13. Ans: (a)

Sol: Let x = number of tosses required

x	1	2	3	......
p(x)	p	qp	q^2p	......

$$E(x) = p + 2qp + 3q^2p + ...$$

$$= p(1+2q + 3q^2 + ...)$$

$$= p(1-q)^{-2} \quad [\because (1-x)^{-2} = 1+2x+3x^2+...]$$

$$= pp^{-2}$$

$$= p^{-1}$$

$$= \frac{1}{p}$$

14. Consider a large parallel plate capacitor. The gap d between the two plates is filled entirely with a dielectric slab of relative permittivity 5. The plates are initially charged to a potential difference of V volts and then disconnected from the source. If the dielectric slab is pulled out completely, then the ratio of the new electric field E_2 in the gap to the original electric field E_1 is ________.

14. Ans: 5

Sol: Method-1:

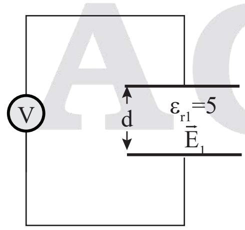


Fig (i)

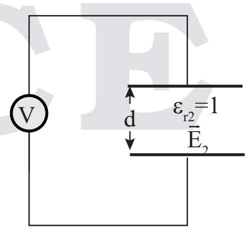


Fig (ii)

For the given medium, Electric field intensity, $E \propto \frac{1}{\varepsilon}$

$$\frac{E_2}{E_1} = \frac{\varepsilon_{r1}}{\varepsilon_{r2}} = \frac{5}{1} = \mathbf{5}$$

$\therefore$ The ratio $\frac{E_2}{E_1} = 5$

Method-2:

From the concept of capacitance

$$C = \frac{Q}{V} = \frac{Q}{Ed}$$

$$C_1 = \frac{Q}{E_1 d} \ \& \ C_2 = \frac{Q}{E_2 d} \quad (\because \text{maintaining same charge in both the cases})$$

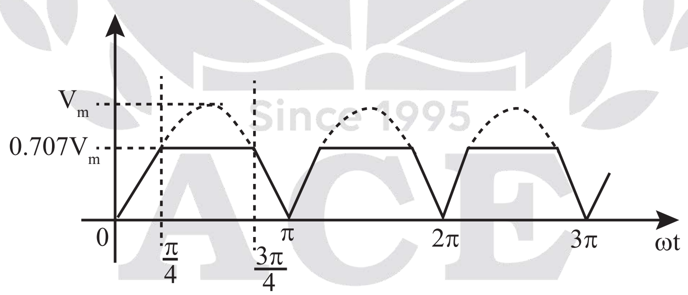
$$\frac{C_1}{C_2} = \frac{E_2}{E_1}$$

$$\frac{E_2}{E_1} = \frac{\left(\frac{\varepsilon_0 \varepsilon_{r1} A}{d}\right)}{\left(\frac{\varepsilon_0 \varepsilon_{r2} A}{d}\right)}$$

$$= \frac{\varepsilon_{r1}}{\varepsilon_{r2}} = \frac{5}{1}$$

$$\therefore \text{Ratio } \frac{E_2}{E_1} = 5$$

15. The waveform shown in solid line is obtained by clipping a full-wave rectified sinusoid (shown dashed). The ratio of the RMS value of the full-wave rectified waveform to the RMS value of the clipped waveform is __________. (Round off to 2 decimal places.)



15. Ans: 1.21

Sol: The rms value of the full wave rectified waveform

$$(V_R)_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} V_m^2 \sin^2 \omega t . d\omega t}$$

$$= \frac{V_m}{\sqrt{2\pi}}\left[\int_0^{\pi}(1-\cos 2\omega t)\, d\omega t\right]^{\frac{1}{2}}$$

$$= \frac{V_m}{\sqrt{2\pi}}\left[(\pi-0)-\frac{1}{2}\sin 2\omega t\Big|_0^{\pi}\right]^{\frac{1}{2}}$$

$$= \frac{V_m}{\sqrt{2\pi}}\left[(\pi-0)-\frac{1}{2}(\sin 2\pi-\sin 0)\right]^{\frac{1}{2}}$$

$$(V_R)_{rms} = \frac{V_m}{\sqrt{2}}$$

The rms value of clipped waveform is

$$(V_C)_{rms} = \sqrt{\frac{1}{\pi}\left[\int_0^{\frac{\pi}{4}} V_m^2\sin^2\omega t d\omega t + \int_{\frac{\pi}{4}}^{\frac{3\pi}{4}}\left(\frac{V_m}{\sqrt{2}}\right)^2 d\omega t + \int_{\frac{3\pi}{4}}^{\pi} V_m^2\sin^2\omega t d\omega t\right]}$$

$$= \sqrt{\frac{1}{\pi}\left[2\times\int_0^{\frac{\pi}{4}} V_m^2\sin^2\omega t d\omega t + \int_{\frac{\pi}{4}}^{\frac{3\pi}{4}}\left(\frac{V_m}{\sqrt{2}}\right)^2 d\omega t\right]}$$

$$= \sqrt{\frac{1}{\pi}\left[\frac{2V_m^2}{2}\int_0^{\frac{\pi}{4}}(1-\cos 2\omega t)\, d\omega t + \frac{V_m^2}{2}\int_{\frac{\pi}{4}}^{\frac{3\pi}{4}} 1.d\omega t\right]}$$

$$= \sqrt{\frac{1}{\pi}\left[V_m^2\left\{\frac{\pi}{4}-\frac{1}{2}\sin 2\omega t\Big|_0^{\frac{\pi}{4}}\right\}+\left\{\frac{V_m^2}{2}\left(\frac{3\pi}{4}-\frac{\pi}{4}\right)\right\}\right]}$$

$$= \sqrt{\frac{1}{\pi}\left[V_m^2\left\{\frac{\pi}{4}-\frac{1}{2}\left(\sin\frac{\pi}{2}-\sin 0\right)\right\}+\frac{V_m^2}{2}\left(\frac{2\pi}{4}\right)\right]}$$

$$= \frac{V_m}{\sqrt{\pi}}\sqrt{\frac{\pi}{4}-\frac{1}{2}+\frac{\pi}{4}}$$

$$(V_C)_{rms} = 0.584V_m$$

Now, $\dfrac{(V_R)_{rms}}{(V_C)_{rms}} = \dfrac{0.707V_m}{0.584V_m}$

$= 1.21$

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16. In the open interval (0,1), the polynomial $p(x) = x^4 - 4x^3 + 2$ has
   (a) no real roots
   (b) two real roots
   (c) one real root
   (d) three real roots

16. Ans: (c)

Sol: $p(0) = 2$ and $p(1) = -1$

According to intermediate mean value theorem, there exists atleast one real root (or) odd number of real roots lie between 0 and 1.

So, option (c) is correct.

17. An 8-pole, 50 Hz, three-phase, slip-ring induction motor has an effective rotor resistance of 0.08Ω per phase. Its speed at maximum torque is 650 RPM. The additional resistance per phase that must be inserted in the rotor to achieve maximum torque at start is _______ Ω. (Round off to 2 decimal places.) Neglect magnetizing current and stator leakage impedance. Consider equivalent circuit parmaeters referred to stator.

17. Ans: 0.52

Sol: $P = 8$; $f = 50$ Hz; $N_S = \dfrac{120 \times 50}{8} = 750$ rpm

Effective Rotor resistance $R_2 = 0.08$

Rotor speed at Max torque = 650 rpm

We have s_{Tmax} (slip at max torque)

$$= \frac{750 - 650}{750} = 0.1333$$

$$s_{Tmax} = \frac{R_2}{X_{20}}$$

Where X_{20} is the standstill rotor leakage reactance

$$0.1333 = \frac{0.08}{X_{20}}$$

$X_{20} = 0.600\ \Omega$

$\therefore$ Additional Resistance required to obtain Max torque at starting

$$R_{add} = X_{20} - R_2$$

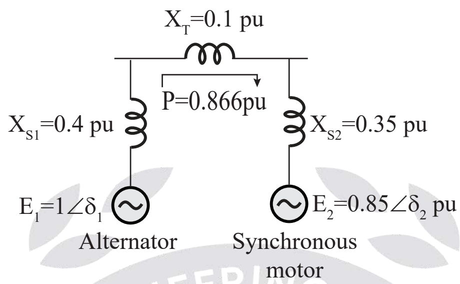
$$= 0.6 - 0.08$$

$$= 0.52\ \Omega$$

18. An alternator with internal voltage of $1\angle\delta_1$ p.u and synchronous reactance of 0.4 p.u is connected by a transmission line of reactance 0.1 p.u to a synchronous motor having synchronous reactance 0.35 p.u and internal voltage of $0.85\angle\delta_2$ p.u. If the real power supplied by the alternator is 0.866 p.u, then $(\delta_1-\delta_2)$ is ____________ degrees. (Round off to 2 decimal places.)
(Machines are of non-salient type. Neglect resistances.)

18. Ans: 60

Sol:



Alternator internal voltage, $E_1 = 1\angle\delta_1$ pu

Alternator synchronous reactance $X_{S1} = 0.4$ pu

Reactance of transmission line $X_T = 0.1$ pu

Synchronous motor reactance, $X_{S2} = 0.35$ pu

Synchronous motor internal voltage, $E_2 = 0.85\angle\delta_2$ pu

Real power supplied by alternator is 0.866 pu

Then $\delta_1 - \delta_2 = ?$

$$P = \frac{E_1 E_2}{X_{S1}+X_T+X_{S2}}\sin(\delta_1-\delta_2)$$

$$0.866 = \frac{1\times 0.85}{0.4+0.1+0.35}\sin(\delta_1-\delta_2)$$

$$= \frac{0.85}{0.85}\sin(\delta_1-\delta_2)$$

$0.866 = \sin(\delta_1-\delta_2)$

$(\delta_1-\delta_2) = \sin^{-1}(0.866) = 60°$

19. Which one of the following vector functions represents a magnetic field $\vec{B}$?

(a) $10x\hat{x} - 30z\hat{y} + 20\,y\hat{z}$

(b) $10x\hat{x} + 20y\hat{y} - 30\,z\hat{z}$

(c) $10z\hat{x} + 20y\hat{y} - 30\,x\hat{z}$

(d) $10y\hat{x} + 20x\hat{y} - 10\,z\hat{z}$

19. Ans: (b)

Sol: The vector field which represents the magnetic field (or) flux density $(\vec{B})$, should satisfy the following condition.
i.e. $\nabla.\vec{B} = 0$

Option (a): Let $\vec{B} = 10x\hat{x} - 30z\hat{y} + 20y\hat{z}$

$\nabla.\vec{B} = 10 - 0 \neq 0$, hence this does not represents magnetic field.

Option (b):Let $\vec{B} = 10x\hat{x} + 20y\hat{y} - 30z\hat{z}$

$\nabla.\vec{B} = 10 + 20 - 30 = 0$ and hence this represents magnetic field

Option (c): Let $\vec{B} = 10z\,\hat{x} + 20y\,\hat{y} - 30x\,\hat{z}$

$\nabla.\vec{B} = 0 + 20 - 0 \neq 0$ and hence this does not represent magnetic field

Option (d): Let $\vec{B} = 10y\hat{x} + 20x\hat{y} - 10z\hat{z}$

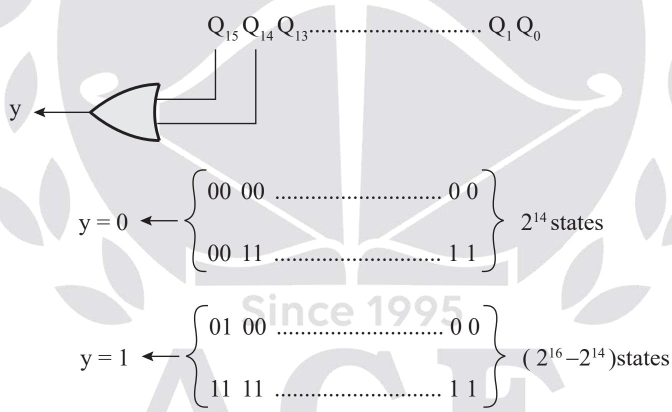
$\nabla.\vec{B} = 0 + 0 - 10 \neq 0$ and hence this does not represent a magnetic field

Therefore option (b) is correct.

20. A 16-bit synchronous binary up-counter is clocked with a frequency f_{clk}. The two most significant bits are OR-ed together to form an output Y. Measurements show that Y is periodic, and the duration for whcih Y remains high in each period is 24ms. The clock frequency f_{clk} is _________ MHz. (Round off to 2 decimal places.)

20. Ans: 2.05

Sol:



Y = 1, for 24 ms

$\therefore\ (2^{16} - 2^{14})T = 24$ ms

$$f_{clk} = \frac{1}{T} = \frac{2^{16} - 2^{-14}}{24\text{ms}}$$

$$= \frac{2^{16} - 2^{-14}}{24 \times 10^{-3}}$$

$$\simeq 2.05 \text{ MHz}$$

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21. Let f(x) be a real-valued function such that $f'(x_0)=0$ for some $x_0 \in (0,1)$, and $f''(x) > 0$ for all $x \in (0,1)$. Then f(x) has

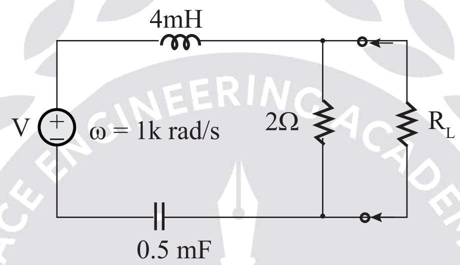
(a) exactly one local minimum in (0,1)
(b) one local maximum in (0,1)
(c) no local minimum in (0,1)
(d) two distinct local minima in (0,1)

21. Ans: (a)

Sol: $f'(x_0) = 0$ and $f''(x_0) > 0 \quad$ for all $x \in (0, 1)$

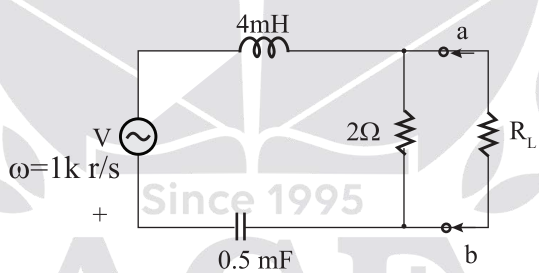
f(x) has exactly one local minimum in (0, 1)

22. In the given circuit, for maximum power to be delivered to R_L its value should be ______ Ω. (Round off to 2 decimal places.)



22. Ans: 1.414

Sol:

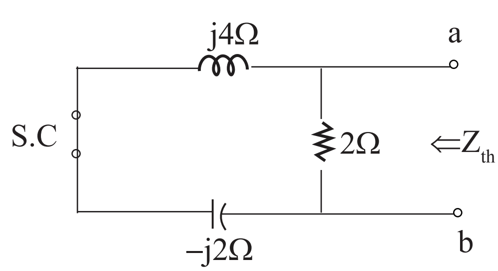


For maximum power transfer across R_L, the Thevenens equivalent impedance

For Z_{th} ($V \rightarrow$S.C)

$Z_L = j\omega L = j10^3 \times 4m = j4\Omega$

$$Z_c = \frac{1}{j\omega c} = \frac{1}{j10^3 \times 0.5 \times 10^{-3}} = -j2\Omega$$

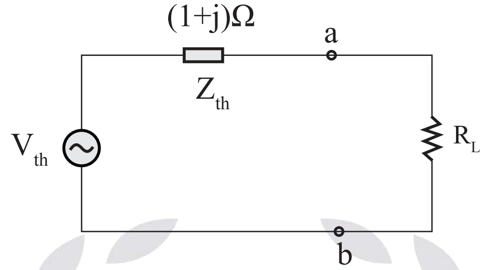


$$Z_{th} = 2 \,||\, (j4 - j2) = 2 \,||\, j2 = \frac{2\,(j2)}{(2+j2)}$$

$$Z_{th} = \frac{4j(2-j2)}{8} = \frac{(2j+2)}{2} = (1+j)\Omega$$

$Z_{th} = (1+j)\Omega$

Thevenin equivalent



For maximum power transfer

$$R_{ll} = \sqrt{R_{th}^2 + X_{th}^2} = \sqrt{1^2+1^2} = \sqrt{2}$$

$R_L = 1.414\ \Omega$

23. One coulomb of point charge moving with a uniform velocity $10\,\hat{x}$ m/s enters the region $x \geq 0$ having a magnetic flux density $\vec{B} = (10y\hat{x} + 10x\hat{y} + 10\hat{z})$T. The magnitude of force on the charge at $x = 0^+$ is _____ N.
($\hat{x}$, $\hat{y}$, and $\hat{z}$ are unit vectors along x-axis, y-axis, and z-axis, respectively.)

23. Ans: 100

Sol: $Q = 1$ C

Velocity, $\vec{v} = 10\hat{x}$ m/sec

Magnetic field, $\vec{B} = 10y\,\hat{x} + 10x\,\hat{y} + 10\,\hat{z}$ T

Magnetic force on moving charge is given by

$\vec{F} = Q\vec{v} \times \vec{B}$

$= 1 \times 10\,\hat{x} \times (10y\,\hat{x} + 10x\,\hat{y} + 10\,\hat{z})$

$= 100(0) + 10x\,\hat{z} - 100\,\hat{y}$

$\vec{F} = 100x\,\hat{z} - 100\,\hat{y}$ N

The force at $x = 0^+$ is

$\vec{F} = -100\,\hat{y}$ N

Magnitude of force F = 100 N

24. A counter is constructed with three D flip-flops. The input-output pairs are named (D_0, Q_0), (D_1, Q_1) and (D_2, Q_2), where the subscript 0 denotes the least significant bit. The output sequence is desired to be the Gray-code sequence 000,001,011,010,110,111,101, and 100, repeating periodically. Note that the bits are listed in the Q_2Q_1
Q_0 format. The combinational logic expression for D_1 is

(a) $\overline{Q}_2 Q_0 + Q_1 \overline{Q}_0$ (b) $Q_2Q_1 + \overline{Q}_2\overline{Q}_1$

(c) $Q_2Q_1Q_0$ (d) $Q_2 Q_0 + Q_1 \overline{Q}_0$

24. Ans: (a)

Sol:

$$000 \rightarrow 001 \rightarrow 011 \rightarrow 010 \rightarrow 110 \rightarrow 111 \rightarrow 101 \rightarrow 100$$

	PS	NS	FF(i/p)
	$Q_2\,Q_1Q_0$	$Q_2\,Q_1\,Q_0$	$D_2\,D_1\,D_0$
0	0 0 0	0 0 1	0 0 1
1	0 0 1	0 1 1	0 1 1
3	0 1 1	0 1 0	0 1 0
2	0 1 0	1 1 0	1 1 0
6	1 1 0	1 1 1	1 1 1
7	1 1 1	1 0 1	1 0 1
5	1 0 1	1 0 0	1 0 0
4	1 0 0	0 0 0	0 0 0

$D_1 = \sum m(1,3,2,6)$

$Q_2 \backslash Q_1Q_0$	00	01	11	10
0		1	1	1
1				1

$D_1 = \overline{Q}_2 Q_0 + Q_1 \overline{Q}_0$

25. Inductance is measured by

(a) Wein bridge (b) Maxwell bridge

(c) Kelvin bridge (d) Schering bridge

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25. Ans: (b)

Sol: Wein's bridge is used for measurement of frequency.

Maxwell's bridge is used for measurement of inductance.

Kelvin's bridge is used for measurement of low value of resistance

Schering bridge is used for measurement of capacitance, dilectric loss and permittivity etc.

26. Suppose I_A, I_B and I_C are a set of unbalanced current phasors in a three-phase system. The phase-B zero sequence current $I_{B0} = 0.1\angle 0°$ p.u. If phase-A current $I_A = 1.1\angle 0°$ p.u and phase-C current $I_C = (1\angle 120° + 0.1)$ p.u, then I_B in p.u is

(a) $1.1\angle 240° - 0.1\angle 0°$
(b) $1\angle -120° + 0.1\angle 0°$
(c) $1.1\angle -120° + 0.1\angle 0°$
(d) $1\angle 240° - 0.1\angle 0°$

26. Ans: (b)

Sol: The phase-B zero sequence current, $I_{B0} = 0.1\angle 0°$ p.u.

Phase-A and phase-C currents,

$I_A = 1.1\angle 0°$ p.u., $I_C = 1\angle 120° + 0.1$ p.u.

As $I_A + I_B + I_C = 3.I_{B0}$

$1.1 + I_B + 1\angle 120° + 0.1 = 0.3$

$I_B = 0.3 - 1.2 - 1\angle 120°$

$= -0.9 - 1\angle 120°$

It can be rewritten as,

$I_B = 0.1 + [-1 - 1\angle 120°]$

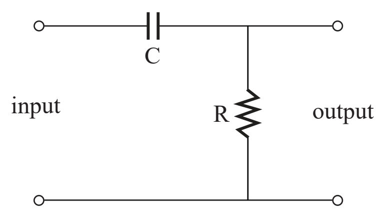
$= 0.1 - (1 + 1\angle 120°)$

$= 0.1 - [-(1\angle -120°)]$

$= 0.1 + 1\angle -120°$ p.u.

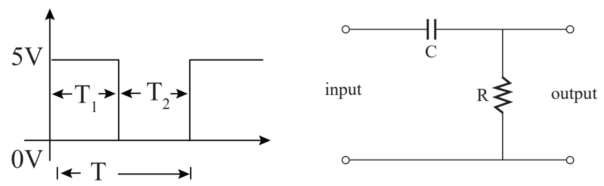
Correct answer is (b).

27. A 100 Hz square wave, switching between 0 V and 5 V, is applied to a CR high-pass filter circuit as shown. The output voltage waveform across the resistor is 6.2 V peak-to-peak. If the resistance R is 820 Ω, then the value C is ___________ μF. (Round off to 2 decimal places.)



27. Ans: 12.46

Sol:

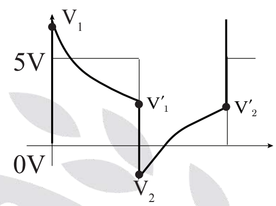


Given f = 100 Hz, T = 10msec

Consider the input is symmetrical square wave.

$T_1 = T_2 = 5$ msec then

steady state output wave form is



$V_1' = V_1 e^{-T/2RC}$ .... (1)

$V_2' = V_2 e^{-T/2RC}$ .... (2)

$V_1' - V_2 = 5$ .... (3)

$V_1 - V_2' = 5$ .... (4)

voltage across resistor is output voltage = $V_1 - V_2$

(peak to peak)

$\therefore \quad V_1 - V_2 = 6.2$ V

$V_1' = V_1 e^{-T/2RC} \Rightarrow V_1 = V_1' e^{T/2RC}$ .... (5)

$V_2' = V_2 e^{-T/2RC} \Rightarrow V_2 = V_2' e^{T/2RC}$ ......(6)

By adding (3) & (4) equations

$(V_1' - V_2) + (V_1 - V_2') = 10$

$(V_1' - V_2') + (V_1 - V_2) = 10$

Now subtracting (5) & (6)

$V_1 - V_2 = e^{T/2RC}(V_1' - V_2')$

$$e^{T/2RC} = \frac{(V_1 - V_2)}{(V_1' - V_2')} = \frac{6.2}{3.8}$$

apply natural logarithm on both sides

$$\frac{T}{2RC} = \ln\left(\frac{6.2}{3.8}\right)$$

$$C = \frac{T}{2R\ell n\left(\frac{6.2}{3.8}\right)}$$

$$= \frac{10 \times 10^{-3}}{2 \times 820 \times \ell n\left(\frac{6.2}{3.8}\right)}$$

$C = 12.46\mu F$

28. If the input x(t) and output y(t) of a system are related as y(t) = max(0, x(t)). then the system is
(a) linear and time-variant
(b) non-linear and time-variant
(c) linear and time-invariant
(d) non-linear and time-invariant

28. Ans: (d)

Sol: $y(t) = \max(0, x(t))$

$y(t) = 0 ;\quad x(t) < 0$

$\quad\quad x(t) ;\; x(t) > 0$

$y(t) = x(t)\, u[x(t)]$

(1) $y_1(t) = x_1(t)\, u[x_1(t)]$

$y_2(t) = x_2(t)\, u[x_2(t)]$

$y_3(t) = [ax_1(t)+bx_2(t)]u[ax_1(t)+bx_2(t)]$

$y_3(t) \neq a\, y_1(t) + b\, y_2(t)$

So, Nonlinear system

(2) $y(t) = x(t)\, u[x(t)]$

$y_1(t) = x(t-t_0)\, u[x(t-t_0)]$

$y(t-t_0) = x(t-t_0)\, u[x(t-t_0)]$

$y_1(t) = y(t-t_0)$

So, it is time invariant system

29. Consider the table given:

Constructional feature	Machine type	Mitigation
(P) Damper bars	(S) Induction motor	(X) Hunting
(Q) Skewed rotor slots	(T) Transformer	(Y) Magnetic locking
(R) Compensating winding	(U) Synchronous machine	(Z) Armature reaction
	(V) DC machine	

The correct combination that relates the constructional feature, machine type and mitigation is
(a) P-T-Y, Q-V-Z, R-S-X
(b) P-U-X, Q-V-Y, R-T-Z
(c) P-U-X, Q-S-Y, R-V-Z
(d) P-V-X, Q-U-Z, R-T-Y

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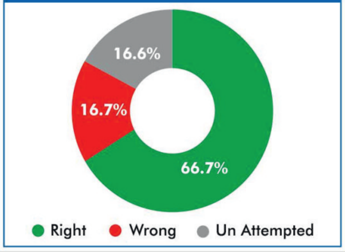

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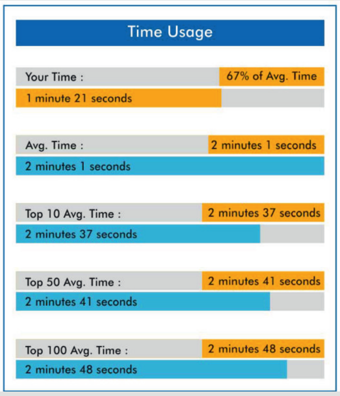

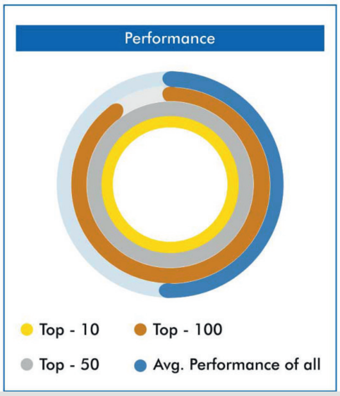

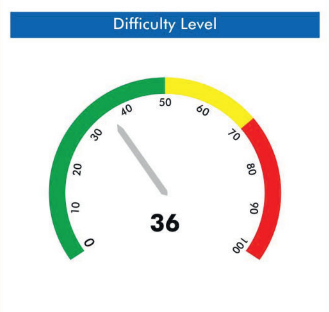

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29. Ans: (c)

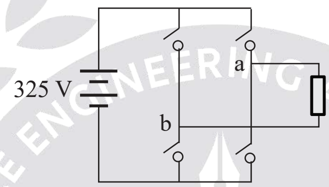
Sol: P: Damper bars used in synchronous machine (U) to prevent hunting (X)

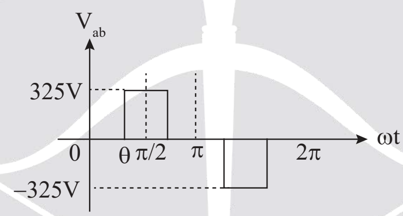
Q: Skewed rotor slots used in induction motor (S) to avoid magnetic locking (Y)

R: Compensating winding used in DC machine (V) to neutralize cross magnetizing effectr of armature reaction (Z) under main poles (polar zone).

30. A single phase full bridge inverter fed by a 325 V DC produces a symmetric quasi-square waveform across 'ab' as shown. To achieve a modulation index of 0.8, the angle θ expressed in degrees should be _________ . (Round off to 2 decimal places.)

(Modulation index is defined as the ratio of the peak of the fundamental component of V_{ab} to the applied DC value.)





30. Ans: 51.07

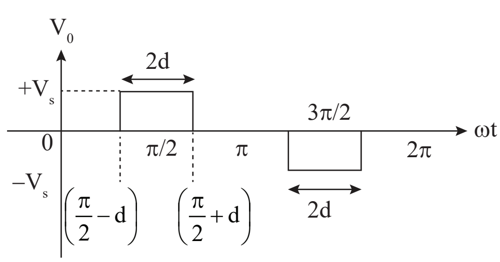
Sol: V_S = 325 volt (DC)

M.I. = 0.8

$$\text{M.I.} = \frac{(V_{ab1})_{peak}}{V_s}$$

$(V_{ab1})_{peak} = \text{M.I.} \times V_s = 0.8 \times 325 = 260$ volts

Now according to FSA



$$V_0 = \frac{a_0}{2} + \sum_{n=1}^{\infty}[a_n \cos n\omega t + b_n \sin n\omega t]$$

Here, $\frac{a_0}{2} = 0$, $a_n = 0$

$$b_n = \frac{2}{\pi}\int_{\frac{\pi}{2}-d}^{\frac{\pi}{2}+d} V_s \sin(n\omega t)\, d\omega t = \frac{4V_s}{n\pi}\sin\left(\frac{n\pi}{2}\right).\sin(nd)$$

$$V_0 = \sum_{n=1,3,5...}^{\infty} \frac{4V_s}{n\pi}\sin\left(\frac{n\pi}{2}\right).\sin(nd)\sin(n\omega t)$$

$$(V_{ab1})_{peak} = (V_{01})_{peak} = \frac{4V_s}{\pi}\sin(d)$$

Now, as $(V_{01})_{peak} = 260$

$$\frac{4V_s}{\pi}\sin(d) = 260$$

$$\frac{4\times 325}{\pi}\sin(d) = 260$$

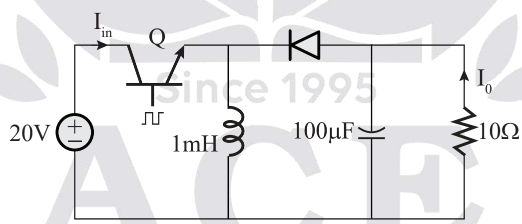
$d = 38.93°$

According to given waveform, $2\theta = \pi - 2d$

$$\theta = \frac{\pi - 2d}{2} \text{ or } \frac{180° - 2d}{2}$$

$\theta = 51.07°$

31. Consider the buck-boost converter shwon. Switch Q is operating at 25 kHz and 0.75 duty-cycle. Assume diode and switch to be ideal. Under steady-state condition, the average current flowing through the inductor is ___________ A.



31. Ans: 24

Sol: Given: f = 25 kHz

D = 0.75

Find $(i_L)_{avg} = ?$

To check continuous conduction or discontinuous conduction

$K = \frac{2fL}{R}$ and $k_{cr} = (1-D)^2$

Now $k = \frac{2fL}{R} = \frac{2\times 25k \times 1m}{10} = 5$

$k_{cr} = (1-D)^2 = (1-0.75)^2 = 0.0625$

As $[k > k_{cr}]$ means continuous conduction case

Mode (1) from [t = 0] to [t = DT] [when switch is ON]

$$C\frac{dV_0}{dt}+\frac{V_0}{R}=0 \quad .... (1)$$

Mode (2) from [t = DT] to [t = DT] [when switch is ON]

$$C\frac{dV_0}{dt}+\frac{V_0}{R}=0 \quad .... (2)$$

Now applying Amp. sec balance equation then it results

$$I_L=\frac{I_o}{(1-D)}=\frac{V_0}{R(1-D)}=\frac{DV_s}{R(1-D)^2}=\frac{0.75\times 20}{10(1-0.75)^2}=24 \text{ Amp}$$

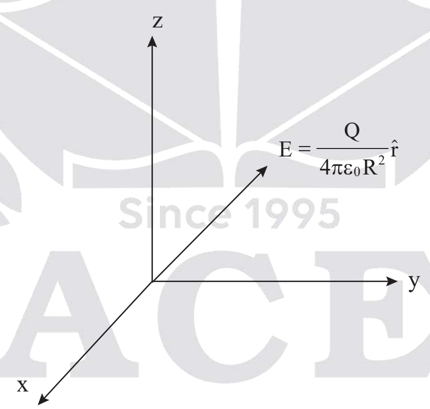
32. A 1 μC point charge is held at the origin of a cartesian coordinate system. If a second point charge of 10 μC is moved from (0, 10, 0) to (5, 5, 5) and subsequently to (5, 0, 0), then the total work done is ________ mJ. (Round off to 2 decimal places.)

Take $\frac{1}{4\pi\varepsilon_0}=9\times 10^9$ in SI units. All coordinates are in meters.

32. Ans: 9

Sol: 1 μC at (0, 0, 0)

10 μC: (0, 10, 0) →(5, 5, 5) → (5, 0, 0)



⇒ Path independent

⇒ Conservative field

$$W=-q\int_{\text{initial}}^{\text{final}}\vec{E}.d\vec{\ell}=-q\int_{\text{initial}}^{\text{final}}\frac{Q}{4\pi\varepsilon_0 R^2}\hat{r}dr$$

$$=\frac{-1\times 10^{-6}\times 10\times 10^{-6}}{4\pi\varepsilon_0}\left[\frac{-1}{R}\right]_{\text{in}}^{\text{fin}}$$

$$=10\times 10^{-12}\times 9\times 10^9\left[\frac{1}{R}\right]_{\text{in}}^{\text{fin}}$$

$$= 90 \times 10^{-3}\left[\frac{1}{R}\right]_{in}^{fin}$$

Initial point: $\sqrt{0^2+10^2+0^2} = 10$

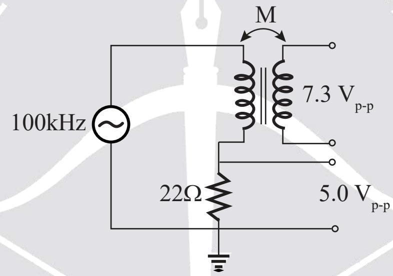
Final point: $\sqrt{5^2+0^2+0^2} = 5$

$$= 90 \times 10^{-3}\left[\frac{1}{R}\right]_{10}^{5}$$

$$= 90 \times 10^{-3}\left[\frac{1}{5}-\frac{1}{10}\right]$$

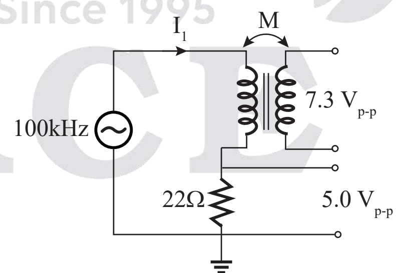
$= 9$ mJ

33. An air-core radio frequency transformer as shown has a primary winding and a secondary winding. The mutual inductance M between the winding of the transformer is _________ μH. (Round off to 2 decimal places.)



33. Ans: 50.95

Sol:



$$I_1 = \frac{2.5\sin\omega t}{22}$$

$I_1 = 0.114\sin\omega t$

$$\therefore \quad e_2 = M.\frac{dI_1}{dt}$$

$$\frac{7.3}{2} = M[0.114\,\omega\cos\omega t]_{max}$$

$$\frac{7.3}{2} = M \times 0.114 \times 2\pi \times 10^5$$

$M = 50.95$ μH

34. Consider a power system consisting of N number of buses. Buses in this power system are categorized into slack bus, PV buses and PQ buses for load flow study. The number of PQ buses is N_L. The balanced Newton-Raphson method is used to carry out load flow study in polar form. H, S, M, and R are sub-matrices of the Jacobian matrix J as shown below:

$$\begin{bmatrix}\Delta P\\ \Delta Q\end{bmatrix} = J\begin{bmatrix}\Delta\delta\\ \Delta V\end{bmatrix}, \text{ where } J = \begin{bmatrix}H & S\\ M & R\end{bmatrix}$$

The dimension of the sub-matrix M is

(a) $N_L \times (N - 1 + N_L)$
(b) $(N - 1) \times (N - 1 + N_L)$
(c) $N_L \times (N \times 1)$
(d) $(N - 1) \times (N - 1 - N_L)$

34. Ans: (c)

Sol: Number of buses in the system = N

Number of PQ buses = N_L

Number of slack busses = 1

Number of PV buses = $N - 1 - N_L$

The NR (polar) load flow formulation,

$$\begin{bmatrix}\Delta P\\ \Delta Q\end{bmatrix} = \begin{bmatrix}H & S\\ M & R\end{bmatrix}\begin{bmatrix}\Delta\delta\\ \Delta V\end{bmatrix}$$

M is the submatrix that relates $[\Delta Q]$ and $[\Delta\delta]$

Number of elements in ΔQ vector = number of Q's known
= number of PQ buses
= N_L

Number of elements in $\Delta\delta$ vector = number of unknown δ's
= $N - 1$

So, size of matrix 'M' will be = $N_L \times (N - 1)$

Correct answer is (c)

35. Let A be a 10×10 matrix such that A^5 is a null matrix, and let I be the 10×10 identity matrix. The determinant of A + I is _______

35. Ans: 1

Sol: A^5 is a null matrix i.e., $A^5 = 0$

$\Rightarrow$ A is a nilpotent matrix of index 5

$\Rightarrow$ All eigen values of nilpotent matrix are zeros

for $\lambda = 0$, the eigen value of A + I is

$\lambda + 1 \Rightarrow 0 + 1 = 1$

det $(A + \lambda I)$ = product of eigen values

$= 1\times1\times1\times1\times1\times1\times1\times1\times1\times1$

$= 1$

36. The causal signal with z-transform $z^2(z-a)^{-2}$ is (u[n] is the unit step signal)

(a) $a^{2n}u[n]$ (b) $(n+1)a^n u[n]$

(c) $n^{-1}a^n u[n]$ (d) $n^2 a^n u[n]$

36. Ans: (b)

Sol: Assume $X(z) = z^2 (z-a)^{-2}$

$$X(z) = \frac{z^2}{(z-a)^2}$$

From standard Z.T pair

$$n(a)^n u(n) \longleftrightarrow \frac{az}{(z-a)^2}$$

$$n(a)^{n-1} u(n) \longleftrightarrow \frac{z}{(z-a)^2}$$

From time shifting property

$$x(n-n_0) \leftrightarrow z^{-n0}\ X(z)$$

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

$$(n+1)(a)^n u(n+1) \longleftrightarrow \frac{z^2}{(z-a)^2}$$

So, $x(n) = (n+1)(a)^n u(n+1)$

Given causal signal

So, $x(n) = (n+1)(a)^n u(n)$

(or)

Assume $X(z) = z^2(z-a)^{-2}$

$$X(z) = \frac{z^2}{(z-a)^2}$$

$$X(z) = \frac{z}{z-a} \cdot \frac{z}{z-a}$$

Given causal so, $(a)^n u(n) \longleftrightarrow \frac{z}{z-a}$,

$X(z) = X_1(z).\ X_2(z)$ .... (1)

$x_1(n) * x_2(n) \leftrightarrow X_1(z)\, X_2(z)$

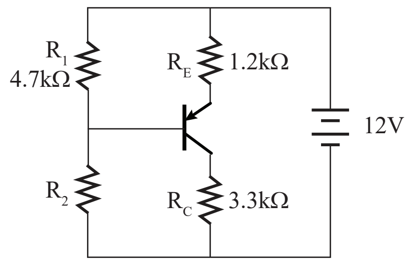
Apply IZT to equation (1)

$x(n) = x_1(n) * x_2(n)$

$x(n) = (a)^n u(n) * (a)^n u(n)$

$x(n) = (n+1)(a)^n u(n)$

37. In the BJT circuit shown, beta of the PNP transistor is 100. Assume $V_{BE} = -0.7$ V. The voltage across R_C will be 5 V when R_2 is ____________ kΩ. (Round off to 2 decimal places.)



37. Ans: 17.06

Sol: The thevenins equivalent circuit is

$$R_{th} = \frac{4.7R_2}{4.7+R_2},\ V_{th} = \frac{12R_2}{4.7+R_2}$$

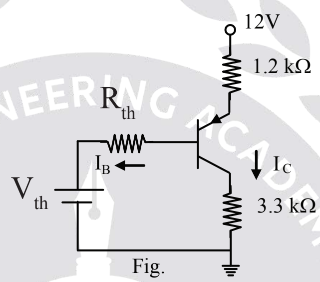


Fig.

Given that $V_{Rc} = 5V$

$I_c(3.3k) = 5$

$I_c = 1.515$ mA

then $I_B = \frac{I_c}{\beta} = 15.15\ \mu A$

$I_E = I_c + I_B = 1.5303$ mA

$V_E = 12 - 1.2 \times 10^3 I_E$

$= 10.1636$ V

$V_{BE} = -0.7 \Rightarrow V_B - V_E = -0.7$

$V_B = V_E - 0.7 = 9.4636$ V

Apply KVL from base to ground of transistor circuit.

$V_B - I_B R_{th} - V_{th} = 0$

$$9.4636 - 15.15 \times 10^{-6}\left(\frac{4.7 \times 10^3 R_2}{4.7+R_2}\right) - \frac{12R_2}{4.7+R_2} = 0$$

$$9.4636 - \frac{0.0712R_2}{4.7+R_2} - \frac{12R_2}{4.7+R_2} = 0$$

$9.4636\ (4.7 + R_2) - 12.0712R_2 = 0$

$44.4789 - 2.6076R_2 = 0$

$$R_2 = \frac{44.4789}{2.6076} = 17.057$$

$\therefore R_2 \approx 17.06$ kΩ

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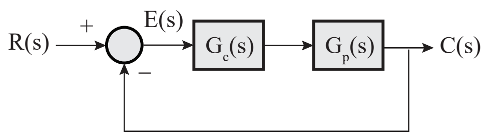
Total Selections in Top 10 33

EE : 9	E&T : 8	ME : 9	CE : 7

38. Consider a closed-loop system as shown. $G_p(s) = \dfrac{14.4}{s(1+0.1s)}$ is the plant transfer function and $G_C(s) = 1$ is the compensator. For a unit step input, the output response has damped oscillations. The damped natural frequency is ________ rad/s. (Round off to 2 decimal places.)



38. Ans: 10.91

Sol: Characteristic equation $1 + G_c(s)G_p(s) = 0$

$$1+\frac{14.4}{s(1+0.1s)} = 0$$

$0.1s^2 + s + 14.4 = 0$

$s^2 + 10s + 144 = 0$

$\omega_n = \sqrt{144} = 12$

$2\zeta\omega_n = 10$

$\zeta = \dfrac{10}{2(12)} = \dfrac{10}{24}$

$\omega_d = \omega_n\sqrt{1-\zeta^2} = 12\sqrt{1-\left(\dfrac{10}{24}\right)^2} = 10.91$ rad/s

39. Suppose the circle $x^2 + y^2 = 1$ and $(x-1)^2 + (y-1)^2 = r^2$ intersect each other orthogonally at the point (u, v). Then $u + v =$ ________.

39. Ans: 1

Sol: Given: $x^2 + y^2 = 1$

Differentiating with respect to x

$2x + 2y\dfrac{dy}{dx} = 0$

$2x = -2y\dfrac{dy}{dx}$

$\dfrac{dy}{dx} = \dfrac{2x}{-2y} = \dfrac{-x}{y}$

$m_1 = \dfrac{-x}{y}$

and $(x-1)^2 + (y-1)^2 = r^2$

Differentiating with respect to x.

$2(x-1) + 2(y-1)\dfrac{dy}{dx} = 0$

$2(x-1) = -2(y-1)\dfrac{dy}{dx}$

$$\frac{dy}{dx} = -\frac{(x-1)}{(y-1)} = m_2 \quad \text{(say)}$$

Two circles cut each other othogonally

$m_1 m_2 = -1$ at (u, v)

$$\left(\frac{-x}{y}\right)\left[-\frac{(x-1)}{(y-1)}\right] = -1$$

$$\frac{-x}{y}\frac{(x-1)}{(y-1)} = 1$$

$-x^2 + x = y^2 - y$

$-x^2 - y^2 + x + y = 0$

$x^2 + y^2 - x - y = 0$

At (u, v) $u^2 + v^2 - u - v = 0$

$u^2 + v^2 = u + v$

$u + v = 1 \; (\because u^2 + v^2 = 1)$

40. The state space representation of a first-order system is given as

$\dot{x} = -x + u$

$y = x$

where, x is the state variable, u is the control input and y is the controlled output. Let $u = -Kx$ be the control law, where K is the controller gain. To place a closed loop pole at -2, the value of K is ___________.

40. Ans: 1

Sol: $\dot{x} = -x + u \;\; ; u = -kx$

$\dot{x} = -x - Kx$

$\dot{x} = -(K+1)x$

$A = -(K + 1)$

Characteristic equation $|sI - A| = 0$

$s - [-(K+1)] = 0$

$s + K + 1 = 0$

$s = -(K+1)$ pole

$s = -2$ given pole

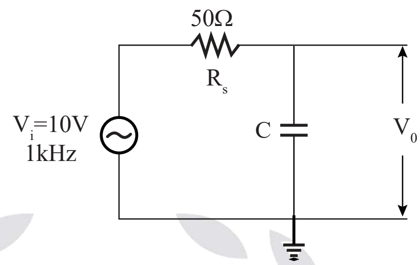
$\therefore -(K + 1) = -2$

$\Rightarrow K = 1$

41. A signal generator having a source resistance of 50 Ω is set to generate a 1 kHz sinewave. Open circuit terminal voltage is 10 V peak-to-peak. Connecting a capacitor across the terminals reduces the voltage to 8 V peak-to-peak. The value of this capacitor is _______ μF. (Round off to 2 decimal places.)

41. Ans: 2.39

Sol:



$$V_0 = \frac{\frac{1}{j\omega C}V_i}{R_S + \frac{1}{j\omega C}}$$

$$= \frac{V_i}{1 + j\omega R_S C}$$

$$\Rightarrow \frac{V_0}{V_i} = \frac{1}{1 + j\omega R_S C}$$

$$\Rightarrow \left|\frac{V_0}{V_i}\right| = \frac{1}{\sqrt{1 + \omega^2 R_S^2 C^2}}$$

$$\Rightarrow \left|\frac{8}{10}\right| = \frac{1}{\sqrt{1 + (\omega R_S C)^2}}$$

$$\Rightarrow \sqrt{1 + (\omega R_S C)^2} = 1.25$$

$$\Rightarrow (\omega R_S C)^2 = 0.5625$$

$$\Rightarrow \omega R_S C = 0.75$$

$$\Rightarrow C = \frac{0.75}{50 \times 2\pi \times 1 \times 10^3 \text{Hz}} = 2.38851$$

$$\therefore C = 2.39\ \mu F$$

42. Two generators have cost function F_1 and F_2. Their incremental-cost characteristics are

$$\frac{dF_1}{dP_1} = 40 + 0.2P_1$$

$$\frac{dF_2}{dP_2} = 32 + 0.4P_2$$

They need to deliver a combined load of 260 MW. Ignoring the network losses, for economic operation, the generations P_1 and P_2 (in MW) are

(a) $P_1 = 140$, $P_2 = 120$
(b) $P_1 = 120$, $P_2 = 140$
(c) $P_1 = P_2 = 130$
(d) $P_1 = 160$, $P_2 = 100$

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42. Ans: (d)

Sol: The incremental fuel cost of two generators,

$$\frac{dF_1}{dP_1} = 40 + 0.2P_1$$

$$\frac{dF_2}{dP_2} = 32 + 0.4P_2$$

Where P_1 and P_2 are real power generation by units

Total load, $P_L = 260$ MW

$P_1 + P_2 = 260$ MW .... (1)

For economic operation (by neglecting losses)

$$\frac{dF_1}{dP_1} = \frac{dF_2}{dP_2} \Rightarrow 40 + 0.2P_1 = 32 + 0.4P_2$$

$0.2P_1 - 0.4P_2 = -8$ .... (2)

Eqn. (1) × 0.4 + Eqn (2)

$0.4P_1 + 0.4P_2 + 0.2P_1 - 0.4P_2 = 104 - 8$

$0.6P_1 = 96$

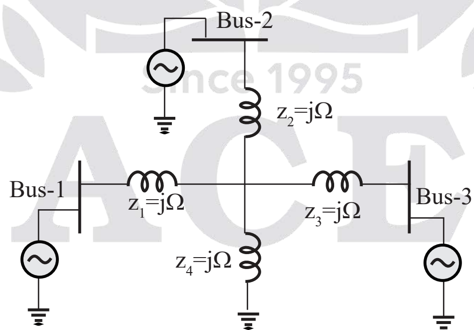
$P_1 = 160$ MW

Now, $P_2 = 260 - 160$

$= 100$ MW

Correct answer is (d)

43. A 3-Bus network is shown. Consider generator as ideal voltage sources. If rows 1, 2 and 3 of the Y_{Bus} matrix correspond to Bus 1, 2 and 3, respectively, then Y_{Bus} of the network is



(a) $\begin{bmatrix} -4j & 2j & 2j \\ 2j & -4j & 2j \\ 2j & 2j & -4j \end{bmatrix}$

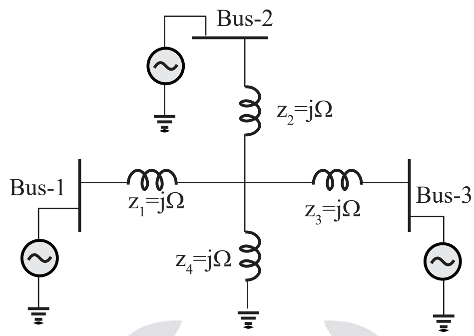
(b) $\begin{bmatrix} -4j & j & j \\ j & -4j & j \\ j & j & -4j \end{bmatrix}$

(c) $\begin{bmatrix} -\frac{3}{4}j & \frac{1}{4}j & \frac{1}{4}j \\ \frac{1}{4}j & -\frac{3}{4}j & \frac{1}{4}j \\ \frac{1}{4}j & \frac{1}{4}j & -\frac{3}{4}j \end{bmatrix}$

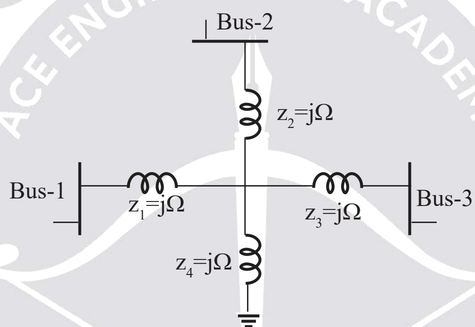
(d) $\begin{bmatrix} -\frac{1}{2}j & \frac{1}{4}j & \frac{1}{4}j \\ \frac{1}{4}j & -\frac{1}{2}j & \frac{1}{4}j \\ \frac{1}{4}j & \frac{1}{4}j & -\frac{1}{2}j \end{bmatrix}$

43. Ans: (c)

Sol: Given three buse power system



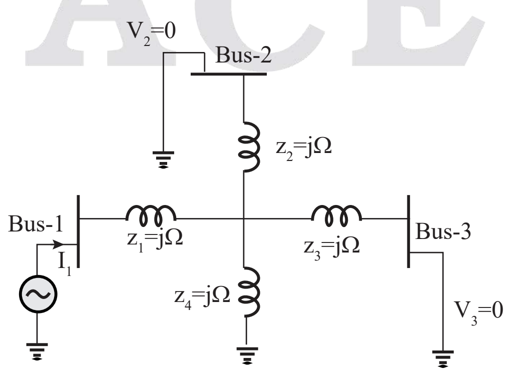
Voltage sources at buses –1, 2, 3 are said as ideal which has internal impedance.
The network of impedances can be drawn as



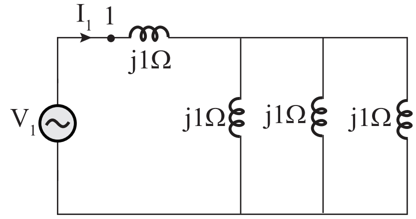
Method-1: Let us keep a voltage source at Bus-1 and keep short circuit at other buses.

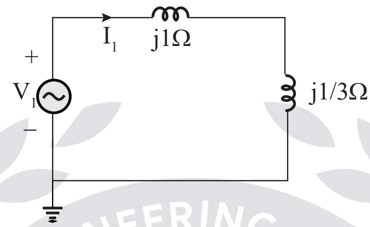
Let I_1 will be the current injected by source V_1

Now, $\quad Y_{11} = \left.\dfrac{I_1}{V_1}\right|_{\substack{V_2 = V_3 = 0 \\ V_1 \neq 0}}$



By basic network reduction technique





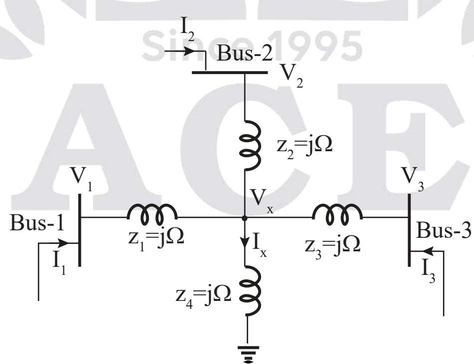
Now $Y_{\_Bus}$ element, $Y_{11} = \dfrac{I_1}{V_1} = \dfrac{1}{j1 + j\dfrac{1}{3}}$

$= -j\dfrac{3}{4}$

In the four options given only option (c) has $Y_{11} = -j\dfrac{3}{4}$.

So correct answer will be option (c)

Method-2: (By KCL application on at each node)



Let node voltages are V_1, V_2 , V_3

node current injections are I_1, I_2 I_3.

There is an extra node which is not identified as bus.

Let that node voltage is V_x.

Where $V_x = I_x Z_4$

$= (I_1 + I_2 + I_3)(j1)$

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and many more...

Total Selections in Top 10 58

EE : 9	EC : 9	ME:7	CE : 7	CS : 7	IN : 6	PI : 9	XE : 4

Where $I_1 = \frac{V_1 - V_x}{j1}$ $\quad I_2 = \frac{V_2 - V_x}{j1}, I_3 = \frac{V_3 - V_x}{j1}$

$$V_x = \left(\frac{V_1 - V_x}{j1} + \frac{V_2 - V_x}{j1} + \frac{V_3 - V_x}{j1}\right)(j1)$$

$$V_x = V_1 + V_2 + V_3 - 3V_x$$

$$4V_x = V_1 + V_2 + V_3$$

$$V_x = \frac{1}{4}(V_1 + V_2 + V_3)$$

Now, currents

$$I_1 = \frac{V_1 - V_x}{j1}$$

$$= -j\left[V_1 - \frac{1}{4}(V_1 + V_2 + V_3)\right]$$

$$= -jV_1 + j\frac{V_1}{4} + j\frac{V_2}{4} + j\frac{V_3}{4}$$

$$I_1 = V_1\left(\frac{-j1}{4}\right) + V_2\left(\frac{j1}{4}\right) + V_3\left(\frac{j1}{4}\right) \text{ .... (1)}$$

$$I_2 = \frac{V_2 - V_x}{j1}$$

$$= -j1\left[V_2 - \frac{1}{4}(V_1 + V_2 + V_3)\right]$$

$$I_2 = V_1\left(\frac{j1}{4}\right) + V_2\left(\frac{-j3}{4}\right) + V_3\left(\frac{j1}{4}\right) \text{ .... (2)}$$

$$I_3 = \frac{V_3 - V_x}{j1}$$

$$= -j1\left[V_3 - \frac{1}{4}(V_1 + V_2 + V_3)\right]$$

$$I_3 = V_1\left(\frac{j1}{4}\right) + V_2\left(\frac{j1}{4}\right) + V_3\left(\frac{-j3}{4}\right) \text{ .... (3)}$$

From equations (1), (2), (3)

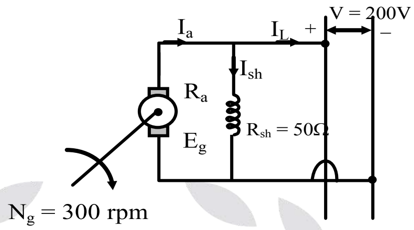
$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \underbrace{\begin{bmatrix} \frac{-j3}{4} & \frac{j1}{4} & \frac{j1}{4} \\ \frac{j1}{4} & \frac{-j3}{4} & \frac{j1}{4} \\ \frac{j1}{4} & \frac{j1}{4} & \frac{-j3}{4} \end{bmatrix}}_{Y_{Bus} \text{ matrix}} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$

Correct answer is (c)

44. A belt-driven DC shunt generator running at 300 RPM delivers 100 kW to a 200 V DC grid. It continues to run as a motor when the belt breaks, taking 10 kW from the DC grid. The armature resistance is 0.025 Ω, field resistance is 50 Ω, and brush drop is 2 V. Ignoring armature reaction, the speed of the motor is _______ RPM. (Round off to 2 decimal places.)

44. Ans: 275.19

Sol: DC shunt generator



$P_L = V\,I_L$

$100 \times 10^3 = 200 \times I_L$

$I_L = \dfrac{100\times10^3}{200} = 500\text{A}$

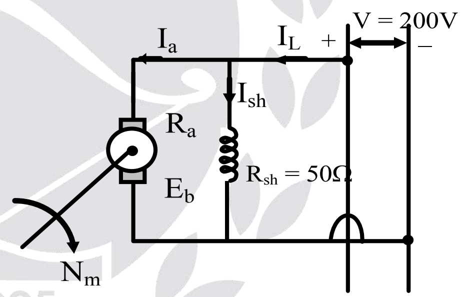
$I_{sh} = \dfrac{V}{R_{sh}} = \dfrac{200}{50} = 4\text{A}$

$\therefore I_a = I_L + I_{sh} = 504$ A

$E_g = V + I_a R_a + BD = 200 + (504\times0.025) + 2$

$= 214.6$ V

If belt breaks, generator continues to run as a motor (shunt motor) taking $P_{in} = 10\text{kW}$



$P_{in} = V\times I_L$

$10\times10^3 = 200\times I_L$

$I_L = \dfrac{10\times10^3}{200} = 50\text{A}$

$I_{sh} = 4\text{A}$

$I_a = I_L - I_{sh}$

$= 50 - 4 = 46$ A

$E_b = V - I_a R_a - BD = 200 - (46\times0.025) - 2 = 196.85$ V

$E_g = \dfrac{\phi_g Z N_g}{60}\times\dfrac{P}{A}$ $\qquad$ $E_b = \dfrac{\phi_m Z N_m}{60}\times\dfrac{P}{A}$

$E_g = kN_g\phi_g$ $\qquad$ $E_b = kN_m\phi_m\,\phi_g \propto I_{sh} = 4\text{A}$ $\qquad$ $\phi_m \propto I_{sh} = 4\text{A}$

$E_g = kN_g I_{sh}$ $\qquad$ $E_b = kN_m I_{sh}$

$\dfrac{E_b}{E_g} = \dfrac{kN_m I_{sh}}{kN_g I_{sh}} \Rightarrow \dfrac{196.85}{214.6} = \dfrac{N_m}{300}$

motor spee $(N_m) = \dfrac{196.85}{214.6}\times 300$

$= 275.19$ rpm

45. Let p and q be real numbers such that $p^2 + q^2 = 1$. The eigen values of the matrix $\begin{bmatrix} p & q \\ q & -p \end{bmatrix}$ are

(a) j and –j
(b) pq and –pq
(c) 1 and –1
(d) 1 and 1

45. Ans: (c)

Sol: Let $A = \begin{bmatrix} p & q \\ q & -p \end{bmatrix}$

the characteristic equation is

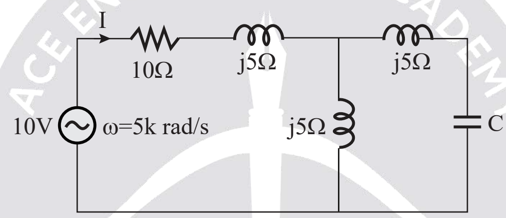
$\lambda^2 - \lambda(-p + p) + (-p^2 - q^2) = 0$

$\lambda^2 - (p^2 + q^2) = 0$

$\lambda^2 - 1 = 0 \qquad [\because p^2 + q^2 = 1]$

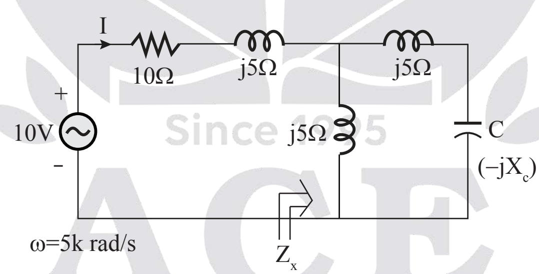
$\therefore \lambda = 1, -1$

46. In the given circuit, the value of capacitor C that makes current I = 0 is ________ μF.



46. Ans: 20

Sol: In the given circuit, the value 'C' for I = 0



For current I = 0 ⇒ $I = \frac{V}{Z}$

i.e $Z_T = \frac{V}{I} = \infty$ (infinity)

$Z_T = \infty \Rightarrow Z_x = \infty \quad (\because 10 + j5 + \infty = \infty)$

$Z_x = j5 \| j(5 - X_c)$

$Z_x = \frac{j5(j(5 - X_c))}{j(10 - X_c)} = \frac{j5(5 - X_c)}{(10 - X_c)}$

If I = 0 ⇒ $Z_x = \infty$

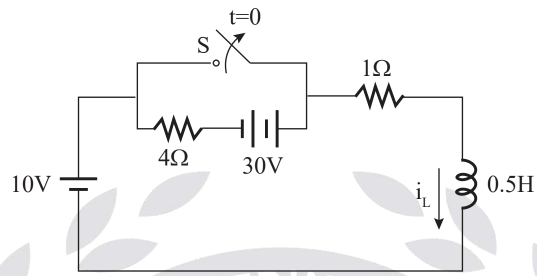
$\frac{1}{0} = \infty = \frac{j5(5 - X_c)}{(10 - X_c)}$

$10 - X_c = 0 \Rightarrow X_c = 10 \Rightarrow \frac{1}{\omega c} = 10$

$$C = \frac{1}{10\omega} = \frac{1}{10 \times 5 \times 10^{3}} = 20 \times 10^{-6}F = 20\mu F$$

$C = 20\mu F$

47. In the circuit, switch 'S' is in the closed position for a very long time. If the switch is opened at time $t = 0$, then $i_L(t)$ in amperes, for $t \geq 0$ is

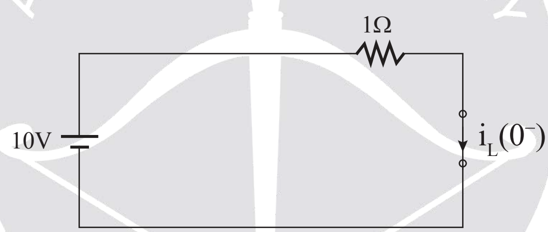


(a) $8 + 2e^{-10t}$
(b) $8e^{-10t}$
(c) $10(1 - e^{-2t})$
(d) 10

47. Ans: (a)

Sol: For $t < 0$ 'S' is closed

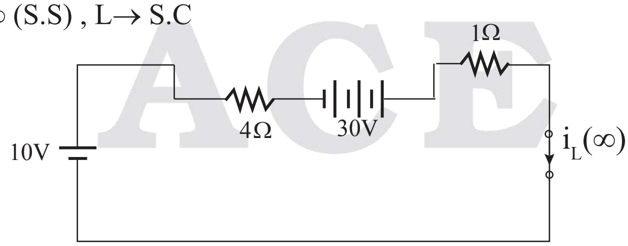
$t = 0^-$ (S.S) L →S.C



$$i_L(0^-) = \frac{10}{1} = 10A = i_L(0^+) = I_0$$

For $t > 0$, 'S' is opened

For find vlaue take $t = \infty$ (S.S) , L→ S.C



$$i_L(\infty) = \frac{10+30}{4+1} = \frac{40}{5} = 8 \text{ Amps}$$

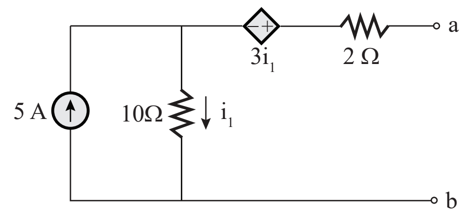
$$\text{Time constant } \tau = \frac{L}{R_{eq}} = \frac{0.5}{4+1} = \frac{1}{10}\text{sec}$$

$$i_L(+) = i_L(\infty) + (i_L(0) - i_L(\infty))\, e^{-t/\tau}$$

$$= 8 + (10 - 8)\, e^{-10t}$$

$i_L(+) = (8+2e^{-10t})$ Amps $t \geq 0$

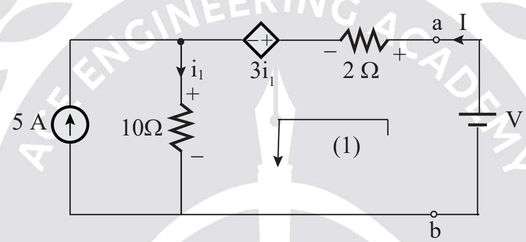
48. For the network shown, the equivalent Thevenin voltage and Thevenin impedance as seen across terminals 'ab' is



(a) 10 V in series with 12 Ω.
(b) 50 V in series with 2 Ω.
(c) 65 V in series with 15 Ω.
(d) 35 V in series with 2 Ω.

48. Ans: (c)

Sol: For Thevenins equivalent circuit use the V-I method for V_{th} & R_{th}



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

By KCL at (X)

$5 + I = i_1 \quad \Rightarrow i_1 = (5 + I)$ .... (1)

By KVL for (1)

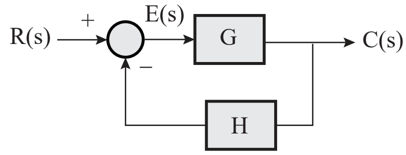
$-V + 2I + 3i_1 + 10i_1 = 0$

$V = 2I + 13i_1 = 2I + 13(5+I)$

$V = 15\, I + 65 \Rightarrow V = R_{th}\, I + V_{th}$

$R_{th} = 15\Omega\, ,\ V_{th} = 65\Omega$

49. For the closed-loop system shown, the transfer function $\dfrac{E(s)}{R(s)}$ is



(a) $\dfrac{1}{1+GH}$
(b) $\dfrac{GH}{1+GH}$
(c) $\dfrac{1}{1+G}$
(d) $\dfrac{G}{1+GH}$

49. Ans: (a)

Sol: From Massion's Gain formula

Number of loops $L_1 = -GH$

Forward path M = 1

$$\frac{E(s)}{R(s)} = \frac{1}{1+GH}$$

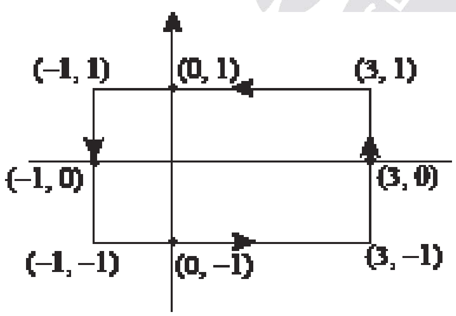
50. Let $(-1-j)$, $(3-j)$, $(3+j)$ and $(-1+j)$ be the vertices of a rectangle C in the complex plane. Assuming that C is traversed in counter-clockwise direction, the value of the counter integral $\oint_C \frac{dz}{z^2(z-4)}$ is

(a) $\frac{j\pi}{16}$ (b) $\frac{-j\pi}{8}$

(c) 0 (d) $\frac{j\pi}{2}$

50. Ans: (b)

Sol:



Let $f(z) = \frac{1}{z^2(z-4)}$

z = 0, 4 are singular points

z = 0 lies inside the rectangle

z = 4 lies outside the rectangle

$$\int_c \frac{dz}{z^2(z-4)} = \int_c \frac{\left(\frac{1}{z-4}\right)}{(z-0)^{1+1}} dz$$

$$= 2\pi j \frac{F'(0)}{1!} \qquad \{ F(z) = \frac{1}{(z-4)}$$

$$= 2\pi j F'(0) \qquad F'(z) = \frac{-1}{(z-4)^2}$$

$$= 2\pi j\left(\frac{-1}{16}\right) \qquad F'(0) = \frac{-1}{(0-4)^2} = \frac{-1}{16}$$

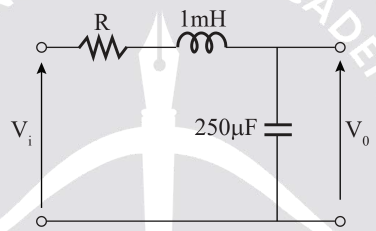
$$= \frac{-\pi j}{8}$$

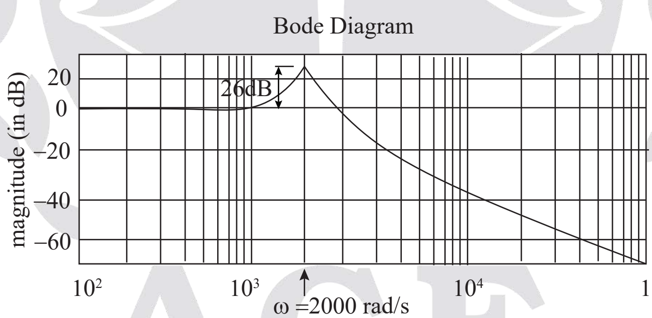
51. Let $p(z) = z^3 + (1 + j)z^2 + (2 + j)z + 3$, where z is a complex number.
Which one of the following is true?
(a) The complex roots of the equation $p(z) = 0$ come in conjugate pairs
(b) All the roots cannot be real
(c) conjugate $\{p(z)\} = p(\text{conjugate}\{z\})$ for all z
(d) The sum of the roots of $p(z) = 0$ is a real number

51 Ans: (b)

Sol: $p(z) = z^3 + (1 + j)z^2 + (2 + j)z + 3$
Every non zero constant polynomial with complex coefficents has atleast one complex root.
So, option (b) is correct.

52. The Bode magnitude plot for the transfer functon $\frac{V_0(s)}{V_i(s)}$ of the circuit is as shown.
The value of R is __________ Ω. (Round off to 2 decimal places.)





52. Ans: 0.1

Sol: $$\frac{V_o(s)}{V_i(s)} = \frac{1}{1 + RCs + LCs^2}$$

$$= \frac{1}{1 + RCj\omega + LC(j\omega)^2}$$

$$= \frac{1}{1 - \omega^2 LC + j\omega RC}$$

$$= \left|\frac{V_0(j\omega)}{V_i(j\omega)}\right| = \frac{1}{\sqrt{(1 - \omega^2 LC)^2 + \omega^2 R^2 C^2}} = 20 \text{ (i.e., 26 dB)}$$

$$\frac{1}{(1-\omega^2LC)^2+\omega^2R^2C^2} = 400$$

$$1 + \omega^4L^2C^2 - 2\omega^2LC + \omega^2R^2C^2 = \frac{1}{400}$$

$$1 + \omega^2C[\omega^2L^2C - 2L + R^2C] = \frac{1}{400}$$

Given

$\omega = 2000$, $L = 10^{-3}$, $C = 250 \times 10^{-6}$

$$1 + 2000^2\,(250 \times 10^{-6})\,[2000^2\,(10^{-3})^2\,250\times10^{-6} - (2 \times 10^{-3}) + R^2\,250 \times 10^{-6}] = \frac{1}{400}$$

$1 + 1 - 2 + R^2\,(250 \times 10^{-6}) = 0.25 \times 10^{-2}$

After simplification, $R = 0.1$

Method-2:

$$\frac{V_o(s)}{V_i(s)} = \frac{1}{1+RCs+LCs^2}$$

$$\zeta = \frac{R}{2}\sqrt{\frac{C}{L}} \text{ and } M_r = \frac{1}{2\zeta\sqrt{1-\zeta^2}}$$

$$\zeta = \frac{R}{2}\sqrt{\frac{250\times10^{-6}}{10^{-3}}} = \frac{R}{4}$$

Given that magnitude = 26 dB

$26 = 20\log M_r$

$\Rightarrow M_r = 20$

$$20 = \frac{1}{2\left(\frac{R}{4}\right)\sqrt{1-\left(\frac{R}{4}\right)^2}}$$

$$\frac{8}{R\sqrt{16-R^2}} = 20$$

$\Rightarrow 16 = 100R^2\,(16 - R^2)$

$\Rightarrow 0.16 = 16R^2 - R^4$

$\Rightarrow R^4 - 16R^2 + 0.16 = 0$

Let $R^2 = x$

$\Rightarrow x^2 - 16x + 0.16 = 0$

After solving $x = 0.01$ and $15.98 \simeq 16$

$\therefore\ R = \sqrt{x} = 0.1$ and 4

M_r is valid for $0 < \zeta < \frac{1}{\sqrt{2}}$

$\therefore$ Suitable value of $R = 0.1\ \Omega$.

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53. In a single-phase transformer, the total iron loss is 2500 W at nominal voltage of 440 V and frequency 50 Hz. The total iron loss is 850 W at 220 V and 25 Hz. Then, at nominal voltage and frequency, the hysteresis loss and eddy current loss respectively are

(a) 900 W and 1600 W (b) 1600 W and 900 W

(c) 250 W and 600 W (d) 600 W and 250 W

53. Ans: (a)

Sol: Iron loss at 440 V, 50 Hz = 2500W

Iron loss at 220 V, 25 Hz = 850W

$$\frac{440}{50} = \frac{220}{25}$$

$$\frac{v_1}{f} = \text{constant}$$

$W_i = Af + Bf^2$

At 50 Hz, $2500 = A(50) + B(50)^2$

At 25 Hz $850 = A(25) + B(25)^2$

By solving A = 18, B = 0.64

W_h at f = 50 Hz = Af

= 18 × 50

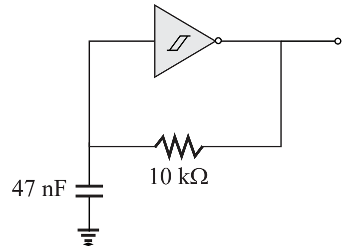
= 900 W

W_e at f = 50 Hz = Bf^2

= $0.64 \times (50)^2$

= 1600 W

54. A CMOS Schmitt-trigger inverter has a low output level of 0 V and a high output level of 5 V. It has input thresholds of 1.6 V and 2.4 V. The input capacitance and output resistance of the Schmitt-trigger are negligible. Thge frequency of the oscillator shown in ___________ Hz. (Round off to 2 decimal places.)



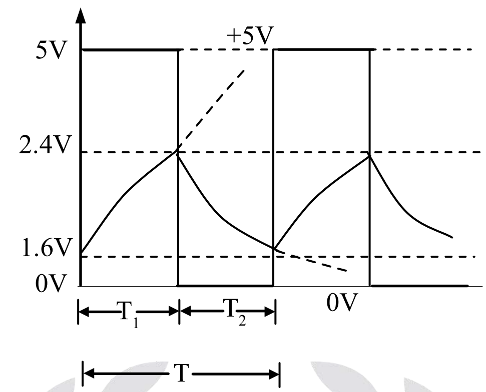
54. Ans: 3158

Sol: Given that $(V_0)_{Low} = 0V$

$(V_0)_{High} = 5V$, $V_{LTP} = 1.6V$, $V_{UTP} = 2.4V$

$\tau = RC = 10^4 \times 47 \times 10^{-9} = 0.47$ msec

The output wave form is



Voltage across cap is $V_c = V_f + (V_i - V_f)e^{-t/\tau}$

$$V_c - V_f = (V_i - V_f)e^{-t/\tau}$$

$$e^{t/\tau} = \left(\frac{V_f - V_i}{V_f - V_c}\right)$$

$$\Rightarrow t = \tau \ell n\left(\frac{V_f - V_i}{V_f - V_c}\right)$$

T_1 calculation:

$V_i = 1.6V$, $V_f = 5V$, $\tau = RC$, at $t = T_1$, $V_c = 2.4$ V

$$T_1 = \tau\ \ell n\left(\frac{5-1.6}{5-2.4}\right)$$

$$= 0.47 \times 10^{-3} \ell n\left(\frac{3.4}{2.6}\right)$$

$= 0.12608$ msec

T_2 calculation:

$V_i = 2.4V$, $V_f = 0$, $\tau = RC$, at $t = T_2$, $V_c = 1.6V$

$$T_2 = \tau \ell n\left(\frac{0-2.4}{0-1.6}\right)$$

$$= 0.47 \times 10^{-3} \ell n\left(\frac{2.4}{1.6}\right)$$

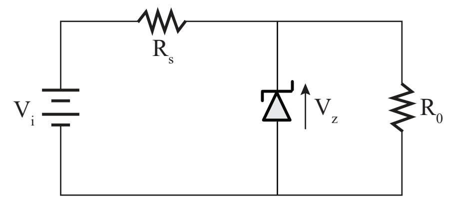
$= 0.190568$ msec

Then $T = T_1 + T_2 = 0.316648$ msec

frequency of oscillations $f = \frac{1}{T}$

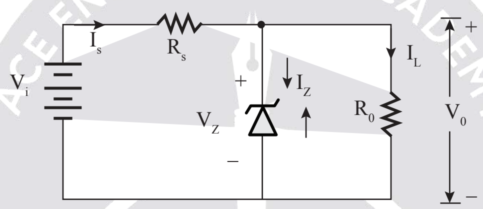
$= 3158.08$ Hz

55. In the circuit shown, a 5 V Zener diode is used to regulate the voltage across load R_0. The input is an unregulated DC voltage with a minimum value of 6 V and a maximum value of 8 V. the value of R_s is 6 Ω. The Zener diode has a maximum rated power dissipation of 2.5 W. Assuming the Zener diode to be ideal, the minimum value of R_0 is __________ Ω.



55. Ans: 30

Sol:



Given that $V_0 = V_z = 5V$

$V_i min = 6V$, $V_i max = 8V$, $R_s = 6\ \Omega$

$P_z max = 2.5\ W \Rightarrow V_z I_z max = 2.5$

$\Rightarrow I_z max = \frac{2.5}{5} = 500mA$

$$I_s = \left(\frac{V_i - V_z}{R_s}\right)$$

$$I_s max = \left(\frac{V_i max - V_z}{R_s}\right) = \left(\frac{8-5}{6}\right) = 500\ mA$$

$$I_s min = \left(\frac{V_i min - V_z}{6}\right) = 166.67\ mA$$

To get minimum value of R_0, current through R_0 must be maximum for this

$I_s min = I_z min + I_L max$

As zener is ideal consider $I_z min = 0$

$I_L max = I_s min = 166.67 \times 10^{-3}$

$$\frac{5}{(R_0)_{min}} = 166.67 \times 10^{-3} \Rightarrow (R_0)_{min} = \frac{5}{166.67 \times 10^{-3}}$$

$$= 29.9994\Omega$$

$(R_0)min \approx 30\Omega$