ACE *Pre*-GATE 2017 **Branch: EE**

Q.1 – Q.5 Carry One Mark Each

01. Reaching a place of appointment on Friday. I found that I was two days earlier than the scheduled day. If I had reached on the following Wednesday then how many days late would I have been?

(a) one (b) Two

(c) three (d) four

01. Ans: (c)

Sol: Friday → 2 days earlier

Therefore, scheduled day = Friday + 2 = Sunday

Sunday + 3 = Wednesday

Therefore, I would have been late by 3 days

02. Choose the most appropriate phrase from the options given below to complete the following sentence.

The bus stopped to _________ more passengers.

(a) Take in (b) Take on

(c) Take up (d) Take for

02. Ans: (b)

03. Choose the appropriate sentence from the following options.

(a) She has been discharged since.

(b) She has since been discharged.

(c) She has been since discharged.

(d) She since has been discharged.

03. Ans: (b)

04. Fill in the blank with an appropriate phrase.

The jet _________ into the air.

(a) Soared. (b) Soured.

(c) Sourced. (d) Sored.

04. Ans: (a)

05. Choose the most appropriate word from the options given below to complete the following sentence.

If I had known that you were coming, I ____________ you at the airport.

(a) Would meet (b) Would have met

(c) Will have met (d) Had met

05. Ans: (b)

Q.6 – Q.10 Carry two marks each

06. Which of the following can be logically inferred from the given statement.

"No other studied medicine except Helen"

(a) Helen only studied medicine

(b) Only Helen studied medicine

(c) Helen studied only medicine

(d) Helen studied medicine only

06. Ans: (b)

07. The average electricity bill of a household for January to June is ₹ 980, for July to September is ₹ 670, for October to December is ₹ 720. If the family goes on vacation for June and July and no electricity is used, what would be the average electricity bill for that year?

(a) ₹ 500 (b) ₹ 600 (c) ₹ 700 (d) ₹ 800

07. Ans: (c)

Sol: Average electricity bill from January to June = ₹ 980

$\therefore$ Total electricity bill from January to May = 980 × 5 = ₹ 4900

(As no electricity is used in June)

Similarly, total electricity bill from August to September (as no electricity is used in July) = 670 × 2 = ₹ 1340

And total electricity bill from October to December = 720 × 3 = ₹ 2160

Therefore, total electricity bill from January to December = 4900 + 1340 + 2160 = ₹8400

Thus, average electricity bill for the whole year $= \frac{8400}{12} =$ ₹700

08. The following question has four statements of three segments each. Choose the alternative where the third segment in the statement can be deduced using both the preceding two but not just from one of them.

A. Sonia is an actress. Some actresses are pretty. Sonia is pretty.

B. All actors are pretty. Manoj is not an actor. Manoj is not pretty

C. Some men are cops. Some men are brave. Some brave people are cops.

D. All cops are brave. Some men are cops. Some men are brave.

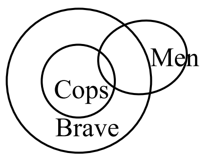
(a) only C (b) only A (c) only D (d) B and C

08. Ans: (c)

Sol: Statements:

All cops are brave

Some men are cops



Conclusion:

Some men are brave (True)

Hence, only D follows.

09. A contractor, who got the contract for building the flyover, failed to construct the flyover in the specified time and was supposed to pay ₹ 50,000 for the first day of extra time. This amount increased by ₹ 4,000 each day. If he completes the flyover after one month of stipulated time, he suffers a loss of 10% in the business. What is the amount he received for making the flyover in crores of rupee? (One month = 30 days)

(a) 3.1 (b)3.24 (c) 3.46 (d) 3.68

09. Ans: (b)

Sol: The sum of money that the contractor was supposed to pay for the period of an month over the stipulated time is

$$= S_n = \frac{n}{2}[2a + (n-1)d]$$

a = 50,000, n = 30, d = 4000

$$S_{30} = \frac{30}{2}[2\times 50,000 + (30-1)\times 4000] = 15[100,000 + 29\times 4000]$$

₹ 3240000 = ₹ 32.4 lakhs

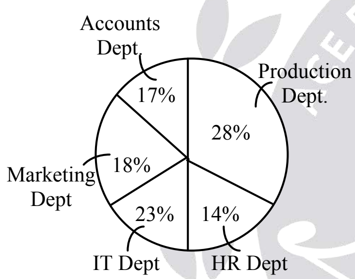
Loss in the business = 10%

∴ Amount he received for making the flyover = $\frac{3240000}{0.1} = 32400,000$ = ₹ 3.24 crores

10. Study the following pie chart and table carefully to answer the following question that follow: Percentage break up of employees working in various departments of an organisation and the ratio of men to women in them.

Total number of employees = 1800

Percentage break up of employees:



Ratio of men to women

Department	**Men**	**Women**
Production	11	1
HR	1	3
IT	5	4
Marketing	7	5
Accounts	2	7

What is the number of men working in the marketing department?

(a) 132 (b) 174

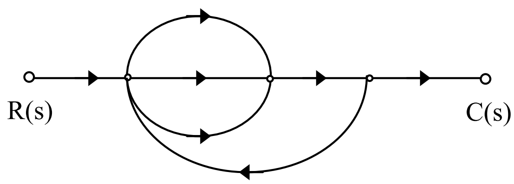
(c) 126 (d) 189

10. Ans: (d)

Sol: Number of men working in the marketing department $= 1800 \times \frac{18}{100} \times \frac{7}{12} = 189$

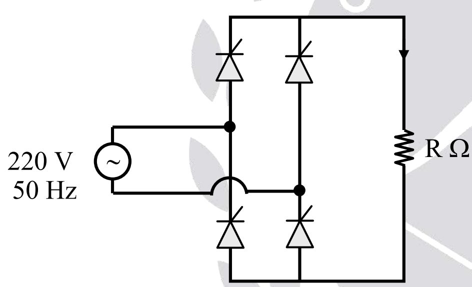
Q.11 – Q.35 Carry one mark each.

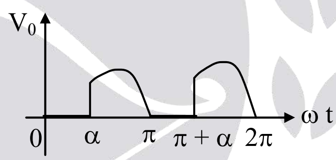
11. The number of loops in the following signal flow graph is/are______



Ans: 3 (Range 3 to 3)

12. Input voltage to the following single phase bridge rectifier is 220 V (RMS), 50 Hz. The load resistance is 7 Ω. The delay angle (in degree) required to deliver 3.61 kW is ____.





Ans:88 (Range 88.0 to 88.3)

Sol: $V_{or}^2 = \frac{1}{\pi}\int_{\alpha}^{\pi} V_m^2 \sin^2 \omega t \, d\omega t$

$$= \frac{V_m^2}{2\pi}\left[\pi - \alpha + \frac{1}{2}\sin 2\alpha\right]$$

$$P_0 = \frac{V_{or}^2}{R} = \frac{V_m^2}{2\pi R}\left[(\pi - \alpha) + \frac{1}{2}\sin 2\alpha\right]$$

$$= \frac{\left(220\sqrt{2}\right)^2}{2\pi \times 7}\left[(\pi - \alpha) + \frac{1}{2}\sin 2\alpha\right] = 3610$$

$$\Rightarrow (\pi - \alpha) + \frac{1}{2}\sin 2\alpha = 1.64 \Rightarrow \alpha = 88°$$

13. $\underset{x\to\infty}{\text{Lt}}\sqrt{\left(x^2+x+1\right)}-x=$ _________

Ans: 0.5

Sol: $\underset{x\to\infty}{\text{Lt}}\sqrt{\left(x^2+x+1\right)}-x = \underset{x\to\infty}{\text{Lt}}\left[\sqrt{x^2+x+1}-x\right]\left[\frac{\sqrt{x^2+x+1}+x}{\sqrt{x^2+x+1}+x}\right]$

$$=\frac{1+0}{\sqrt{1+0+0}+1}=\frac{1}{2}$$

14. The area frequency response characteristics of a 200MW, 50Hz power system is 105 MW/Hz and regulation constant is 0.01Hz/MW. The load frequency constant of power system is __________ MW/Hz

Ans: 5 (no range)

Sol: $B=D+\frac{1}{R}$

$$105=D+\frac{1}{0.01}\Rightarrow D=5\text{MW/Hz}$$

15. The signal x(t) = cos(50πt) + cos(80πt) is sampled at 200Hz. The minimum number of samples required to prevent leakage is _________

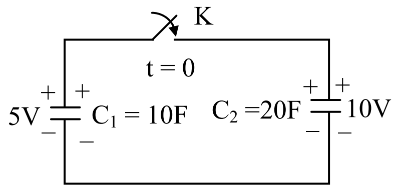
Ans: 40 (No Range)

Sol: $\frac{\omega_1 T_s}{2\pi}=\frac{50\pi/200}{2\pi}=\frac{1}{8}=\frac{5}{40}$

$$\frac{\omega_2 T_s}{2\pi}=\frac{80\pi/200}{2\pi}=\frac{1}{5}=\frac{8}{40}$$

∴ The minimum number of samples required to prevent leakage is 40

16. What is $V_{c_1}(0^+) = ?$



(a) $\frac{25}{3}$ V (b) $\frac{20}{3}$ V (c) 5V (d) None

Ans: (a)

Sol: $V_{c_1}(0^+) = \frac{5\times10}{30} + \frac{10\times20}{30} = \frac{5}{3} + \frac{20}{3} = \frac{25}{3}$

DISTRACTOR LOGIC:

Option: B $V_{c_1}(0^+) = \frac{10\times20}{30} = \frac{20}{3}$

Option: C $V_{c_1}(0^+) = V_{c_1}(0^-) = 5$ V

Option: D At $t=0^+$ KVL is violated

17. A 3-ϕ, 460V, 1740 rpm, 60Hz, 4 pole WRIM has the following parameter per phase

$R_1 = 0.25\ \Omega,\ R_2^1 = 0.2\Omega$

$X_1 = X_2^1 = 0.5\ \Omega, X_m = 30\Omega$

The rotational losses are 1700 W with the rotor terminals short circuited. Find breakdown frequency, when motor is operated from a 3-ϕ, 460V, 60Hz supply.

(A) 0.39 HZ (B) 11.5 HZ (C) 11.75 HZ (D) 26.44 HZ

Ans: (c)

Sol: $S_{T_{max}} = \frac{0.2}{\sqrt{0.25^2 + (0.49+0.5)^2}}$

$= 0.1958$

$f_{2_{T\max}} = 0.1958 \times 60 = 11.752$ Hz

DISTRACTOR LOGIC

Option:A

Sol: $S_{T_{max}} = \dfrac{0.2}{\sqrt{0.25^2 + (30+0.5)^2}}$

$= 0.0065$

$f_{2_{T\,max}} = 0.0065 \times 60 = 0.39$ Hz

Option B:

$S_{T_{max}} = \dfrac{0.2}{0.25^2 + (0.49+0.5)^2}$

$= 0.1918$

$f_{2_{T\,max}} = 0.1918 \times 60 = 11.5$ Hz

Option:D

$S_{T_{max}} = \dfrac{0.45}{\sqrt{0.25^2 + (0.49+0.5)^2}}$

$= 0.4407$

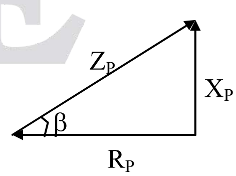
$f_{2_{T\,max}} = 0.4407 \times 60 = 26.44$ Hz

18. An electrodynamometer wattmeter measures a power in single phase,50 Hz AC circuit. The load voltage is 230V and load current is 10A at 0.5 lagging p.f. The wattmeter pressure coil resistance is 10kΩ and inductance is 100mH, then % error will be

(A) zero (B) -1.68% (C) 0.54% (D) 0.156%

Ans: (C)

Sol: $\tan\beta = \dfrac{X_P}{R_P}$



$= \dfrac{2\pi \times 50 \times 100 \times 10^{-3}}{10 \times 10^3} = 0.00312$

$\beta = 0.179$

% error = + $(\tan\phi \tan\beta) \times 100$

$= 1.732 \times 0.00312 \times 100$

$= 0.54$ %

DISTRACTOR LOGIC

Option: (A) There is no effect of pressure coil resistance on wattemeter reading

Option: **(B)** if it is energey meter

$$\% \text{ error} = \frac{\sin(10-30)-0.5}{0.5}\times 100$$

$= -1.68\%$

Option: (D) % error = + (cosϕ Tanβ) ×100

$= 0.5 \times 0.00312 \times 100 = 0.156\%$

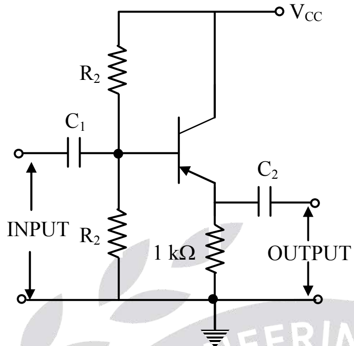
19. If A, B & C are n × n matrices and | A | = 2, | B | = 3 & | C | = 5 then the value of $|A^2 B C^{-1}|$ =?

(A) $\frac{6}{5}$ (B) $\frac{12}{5}$ (C) $\frac{18}{5}$ (D) $\frac{24}{5}$

Ans: (B)

Sol: $|A^2\ B\ C^{-1}| = \frac{|A||A||B|}{|C|} = \frac{2\times 2\times 3}{5} = \frac{12}{5}$

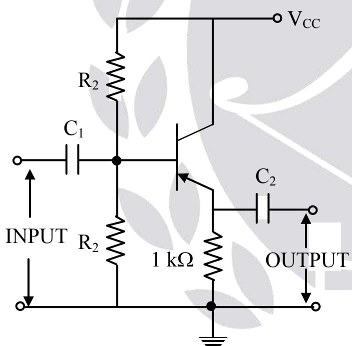
20. In the amplifier circuit shown in figure, the transistor parameters with usual notations are $g_m = 0.015S$, $r^1_{be} = 1K$, $r^1_{bb} = 90\Omega$, $C^1_{be} = 20pF$ and $C^1_{bc} = 3pF$. Neglecting the loading effect of biasing resistors, R_1 & R_2, the mid-frequency voltage gain of the amplifier is



(A) – 13.76 (B) 0 (C) 0.936 (D) 1

Ans: (C)

Sol:



Consider the parameters of BJT

$r^1_{be} = 1K$, $r^1_{bb} = 90\Omega$ & $g_m = 0.015S$,

Step(1) : $h_{ie} = r^1_{be} + r^1_{bb} = 1090\Omega$

$$\text{Consider, } r^1_{be} = \frac{h_{fe}}{g_m} \Rightarrow h_{fe} = r^1_{be} \times g_m = 1k\Omega \times 0.015\,\mho = 15$$

Step(2): The given circuit is emitter follower (CC Amplifier)

$\therefore$ The mid-frequency voltage gain in a CC amplifier,

$$A_V = \frac{(1+h_{fe})R_E}{h_{ie} + (1+h_{fe})R_E} = \frac{16\times 1K}{1.09K + 16\times 1K} = \frac{16K}{17.09K}$$

$A_V = 0.936$

DISTRACTOR LOGIC

Option: A: If the given circuit is assumed as CE Amplifier, with a load resistance of R_L=1k ; then,

Step(1) : $h_{ie} = r_{be}^1 + r_{bb}^1 = 1090\Omega$

Consider, $r_{be}^1 = \frac{h_{fe}}{g_m} \Rightarrow h_{fe} = r_{be}^1 \times g_m = 1k\Omega \times 0.015\,\mho = 15$

Step(2): $A_V = -\frac{h_{fe}R_L}{hie} = -\frac{15\times 1k}{1.09k} = -13.76$

Option: B If the given circuit is assumed as CE Amplifier, with load resistance of R_c;

Step(1) : $h_{ie} = r_{be}^1 + r_{bb}^1 = 1090\Omega$

Consider, $r_{be}^1 = \frac{h_{fe}}{g_m} \Rightarrow h_{fe} = r_{be}^1 \times g_m = 1k\Omega \times 0.015\,\mho = 15$

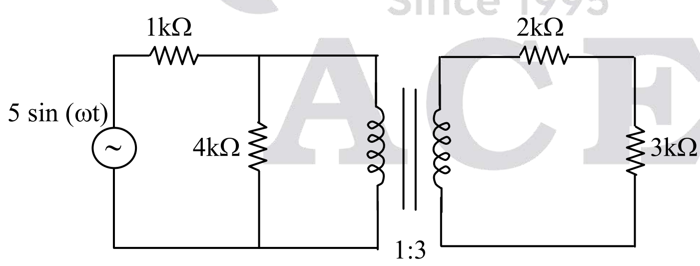
Step(2) : As R_c = 0 given in the circuit.

$A_v = -\frac{h_{fe}R_c}{hie} = -\frac{15\times 0}{1.09k} = 0$

Option : C: CC Amplifier; Av = 0.936

Option : D : The voltage gain in a cc amplifier ideally is '1'

21. The AC source in the circuit shown below has a voltage magnitude of 5 volts, which is divided partly over the 1kΩ resistor and the remainder over the rest of the circuit. Compute the magnitude of the voltage over the 1kΩ.



(A) 0.1 V (B) 0.89 V (D) 1.08 V (D) 3.36 V

Ans: (D)

Sol: First, find the equivalent resistance looking into the primary (left) terminals of the transformer. The resistance on the right side of the transformer is 5 kΩ since the 2 kΩ and 3 kΩ are in series. This is then reflected to the left side by the transformer resistance equation: $R_{eq} = \left(\frac{1}{3}\right)^2 5k\Omega$

$R_{eq} = 0.56\ k\Omega$ Now we have the 4 kΩ and 0.56 kΩ resistors in parallel, which is 0.488 kΩ. The 0.488 kΩ is in series with the 1 kΩ , so we can use a voltage divider equation to find the voltage over the 1kΩ resistor: $V = \left(\frac{1k\Omega}{1k\Omega + 0.488k\Omega}\right)5V$

$V = 3.36\ V$

DISTRACTOR LOGIC

Option A: $R_{eq} = (3)^2 \times 5k\Omega = 45\ k\Omega$

4 kΩ series with 45 kΩ and is equal to 49 kΩ.

$$V = \left(\frac{1k\Omega}{1k\Omega + 49\ k\Omega}\right)5V = 0.1\ V$$

Option B: $R_{eq} = \left(\frac{1}{3}\right)^2 5k\Omega = 0.56\ k\Omega$

4 kΩ in series with 0.56 kΩ and is equal to 4.56 kΩ.

$$V = \left(\frac{1k\Omega}{1k\Omega + 4.56\ k\Omega}\right)5V = 0.89\ V$$

Option C: $R_{eq} = (3)^2 \times 5k\Omega = 45\ k\Omega$

4 kΩ parallel with 45 kΩ and is equal to 3.6 kΩ.

$$V = \left(\frac{1k\Omega}{1k\Omega + 3.6\ k\Omega}\right)5V = 1.08\ V$$

22. A dual slope integrating type DVM is used to measure a voltage signal V(t) = (100+100sin100πt)V, in its (0-200)V range of operation and it has $3\frac{1}{2}$ - digit display. The accuracy specification of this DVM is 0.5% of reading + 1 digit. What is the reading of this DVM and percentage error in reading?

(A) 100 V, 0.6% (B) 100V, 1.5% (C) 70.7 V, 1.5% (D) 200V, 0.6%

Ans: (A)

Sol: DVM measures average value of input voltage signal.

$\therefore$ DVM reading = 100 V

1 digit = 1 count

= 1 step

= r (resolution)

Resolution of DVM in 200V range is $\frac{200}{2\times10^3}$

= 0.1 V

Error $= \frac{0.5}{100}\times100 + 0.1$

= 0.6 V

% error in reading of 100V = $\frac{0.6}{100}\times100\%$

= 0.6%

DISTRACTOR LOGIC

Option: (B) DVM measures average value of input voltage signal.

$\therefore$ DVM reading = 100 V

1 digit = 1 count

= 1% of error

%error $= \frac{0.5}{100}\times100 + 1$ = 1.5%

Option: (C) DVM measures RMS value of input voltage signal.

$\therefore$ DVM reading = 70.7 V

1 digit = 1 count

= 1% of error

%error $= \frac{0.5}{100}\times100 + 1$ = 1.5%

Option: (D) DVM reading $= V_{dc} + Vm_{(ac)}$

=100+100

=200V

1 digit = 1 count = 1 step

= r (resolution)

Resolution of DVM in 200V range

$= \frac{200}{2\times10^3}$

= 0.1 V

$$\text{Error} = \frac{0.5}{100} \times 100 + 0.1$$
$$= 0.6 \text{ V}$$

$$\% \text{ error in reading of 100V} = \frac{0.6}{100} \times 100\%$$
$$= 0.6\%$$

23. The electric field intensity is given inside a sphere of radius R≤bm as $\vec{E} = 4R^2\hat{r}$ (N/C). If the sphere has permittivity 'ε', then the total electric displacement leaving the sphere $R = \frac{b}{2}$ m will be

(A) $4\pi\varepsilon b^4$ Coulomb
(B) $\pi\varepsilon b^4$ Coulomb
(C) πb^4 Coulomb
(D) $\frac{\pi b^4}{4}$ Coulomb

Ans: (B)

Sol: Given: $\vec{E} = 4R^2\hat{r}$ (N/C); $R \le b$

$\vec{D} = \varepsilon\vec{E}$

$= 4\,\varepsilon\, R^2\ \hat{r}\, C/m^2$

From Gauss's Law

$\psi_{net} \equiv Q_{enc} = \oint_s \vec{D}.d\vec{S}$

(or)

$\psi_{net} = D_r \times \text{Area}$

$= 4\varepsilon R^2 \times 4\pi R^2$

$= 16\pi\varepsilon R^4$

The net electric flux leaving the sphere of radius $R = \frac{b}{2}$ is given by

$\psi_{net} = 16\pi\varepsilon\left(\frac{b}{2}\right)^4$

$\therefore\ \psi_{net} = \pi\varepsilon b^4$ C

DISTRACTOR LOGIC

Option A: Simplification mistake

$$\psi_{net} = 16\pi\varepsilon\left(\frac{b}{2}\right)^4$$

$$= 16\pi\varepsilon \times \frac{b^4}{4} == 4\pi\varepsilon b^4$$

Which is wrong answer

Option C: If we take directly $\vec{E}$, while applying Gauss's law, then $\psi_{net} = 4R^2 \times 4\pi R^2$

$$= 16\pi\left(\frac{b}{2}\right)^4 = \pi b^4$$

Which is wrong answer

Option D: $\psi_{net} = D_r \times \text{Area}$

If we take area = πR^2 then which results $\psi_{net} = \frac{\pi b^4}{4}$, which is wrong answer.

24. The general solution of $\frac{dy^4}{dx^4} - 6\frac{dy^3}{dx^3} + 12\frac{dy^2}{dx^2} - 8\frac{dy}{dx} = 0$ is

(A) $y = C_1 + (C_2 + C_3 x + C_4 x^2)\, e^{2x}$
(B) $y = (C_1 + C_2 x + C_3 x^2)\, e^{2x}$
(C) $y = (C_1 + C_2 x + C_3 x^2 + C_4 x^3)\, e^{2x}$
(D) $y = C_1 + C_2 x + C_3 x^2 + C_4 e^{2x}$

Ans: (A)

Sol: The given equation is $(D^4 - 6D^3 + 12D^2 - 8D)\, y = 0$

$$D(D^3 - 6D^2 + 12D - 8)\, y = 0$$

$$D(D-2)^3 = 0$$

$$\therefore D = 0, 2, 2, 2$$

$\therefore$ The required solution is (A)

25. The Decimal equivalent of 2's complement representation of 8 bit integer is most positive when except _________

(A) MSB are zeros
(B) LSB are zeros
(C) MSB are ones
(D) LSB are ones

Ans: (C)

Sol: If MSB of 2's complement representation of integer is zero then it represents the positive number. So option (C) is correct.

DISTRACTOR LOGIC

Option (A): If 'Except' is ignored in the given question, then option (A) is correct option.

Option (B): If LSB is considered as sign bit and 'Except' is ignored in the given question, then option (B) is correct option.

Option (D): If LSB is considered as sign, then option (D) is correct option.

26. $L^{-1}\left\{\frac{e^{-1/s}}{s^{1/2}}\right\} = \frac{\cos 2\sqrt{t}}{\sqrt{t}}$ then $L^{-1}\left\{\frac{e^{-a/s}}{s^{1/2}}\right\} = ?$

(A) $\frac{\cos 2\sqrt{at}}{\sqrt{at}}$ (B) $\frac{\cos 2\sqrt{t}}{\sqrt{at}}$ (C) $\frac{\cos 2\sqrt{at}}{\sqrt{t}}$ (D) $\frac{\cos \sqrt{at}}{\sqrt{t}}$

Ans: (C)

Sol: By using change of scale properly

$$L^{-1}\left\{f\left(\frac{s}{a}\right)\right\} = a\,F(at)$$

$$L^{-1}\left\{\frac{e^{\frac{-1}{(s/a)}}}{\left(\frac{s}{a}\right)^{\frac{1}{2}}}\right\} = \frac{a\cos 2\sqrt{at}}{\sqrt{at}}$$

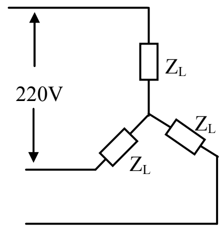
$$\Rightarrow L^{-1}\left\{\frac{e^{-a/s}}{s^{1/2}}\right\} = \frac{\cos 2\sqrt{at}}{\sqrt{t}}$$

27. A 220V, 3-ϕ system supplies 363W to a wye connected balanced load at 0.8 pf lagging. The value of phase current is

(A) $1.2\angle -36.87°$ (B) $1.2\angle 36.87°$ (C) $2\angle -36.87°$ (D) $2\angle +36.87°$

Ans: (A)

Sol:



Phase voltage = $\frac{220}{\sqrt{3}}$

Total real power supplied by source

$P = 3V_{ph}I_{ph}\cos\phi$

$$I_{ph} = \frac{P}{3V_{ph}\cos\phi} = \frac{363}{3\left[\frac{220}{\sqrt{3}}\right][0.8]} = 1.2\text{ A}$$

$\because\ \phi = \cos^{-1}[0.8] = 36.87°$

Lagging so, $I_{ph} = 1.2\angle-36.87°$A

(option A is correct)

DISTRACTOR LOGIC

Option: B Phase voltage = $\frac{220}{\sqrt{3}}$

Total real power supplied by source

$P = 3V_{ph}I_{ph}\cos\phi$

$$I_{ph} = \frac{P}{3V_{ph}\cos\phi} = \frac{363}{3\left[\frac{220}{\sqrt{3}}\right][0.8]} = 1.2\text{ A}$$

$\because\ \phi = \cos^{-1}[0.8] = 36.87°$

Lagging so, $I_{ph} = 1.2\angle36.87°$A

Option: C Phase voltage = 220 V

Total real power supplied by source

$P = 3V_{ph}I_{ph}\cos\phi$

$$I_{ph} = \frac{P}{3V_{ph}\cos\phi} = \frac{363}{220\times0.8} = 2\text{ A}$$

$\because\ \phi = \cos^{-1}[0.8] = 36.87°$

Lagging so, $I_{ph} = 2\angle-36.87°$A

Option: D Phase voltage = 220 V

Total real power supplied by source

$P = 3V_{ph}I_{ph}\cos\phi$

$$I_{ph} = \frac{P}{3V_{ph}\cos\phi} = \frac{363}{220\times 0.8} = 2\ A$$

$\because\ \phi = \cos^{-1}[0.8] = 36.87°$

Lagging so, $I_{ph} = 2\angle 36.87°A$

28. A synchronous motor is operating on bus bar at no-load condition with normal excitation. If the load on the motor is increased by keeping the field excitation same, for this

(A) the motor operates at lagging pf, absorbs reactive power

(B) the motor operates at leading pf, absorbs reactive power

(C) the motor operates at lagging pf, delivers reactive power

(D) the motor operates at leading pf, delivers reactive power

Ans: (A)

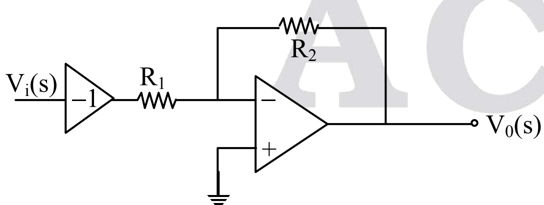
Sol: At normal excitation, no load condition $\delta = 0, E = V$

As load increases 'δ' increases then

$E\cos\delta < V \Rightarrow$ under excitation

$\therefore$ lagging pf, absorbs reactive power.

29. The controller shows in figure below is



(A) proportional controller

(B) PI controller

(C) PD controller

(D) PID controller

Ans: (A)

Sol: $\frac{V_0(s)}{V_i(s)} = TF = G(s) = (-1)\frac{R_2}{R_1}\ ;\ \frac{R_2}{R_1} = \text{constant}$

$\therefore$ It is a proportional controller

30. For a lossless transmission line 50% series compensation and 50% shunt compensation is provided. Then surge impedance loading (SIL) and maximum power transfer capacity (P_{max}) will be

(A) SIL reduced by 1.732 times, P_{max} increased by two times

(B) SIL remains same, P_{max} increased by two times

(C) SIL increased by 1.732 times , P_{max} remains same

(D) Both SIL and P_{max} remain same

Ans: (B)

Sol: $SIL = \frac{V^2}{Z_{Co}}$ Z_{Co} is surge impedance with compensation

$Z_{Co} = Z_C\sqrt{\frac{1-K_{se}}{1-K_{sh}}}$ where Z_C is surge impedance of uncompensated line K_{se} & K_{sh} are degree of series and shunt compensations

From data $K_{se} = 0.5$, $K_{sh} = 0.5$

So, $Z_{Co} = Z_C$ and no change in SIL

$$P_{max} = \frac{|V_S||V_r|}{|B|} = \frac{|V_s|V_r|}{Z_c \sin\beta\ell} = \frac{|V_s|V_r|}{Z_c\beta\ell}$$

$$= \frac{|V_s|V_r}{X_{line}}$$

With 50% series compensation,

$$P_{max\ new} = \frac{|V_s|V_r|}{X_{line} - 0.5X_{line}}$$

$$= 2.\frac{|V_s|V_r|}{X_{line}}$$

P_{max} increased by 2 times

DISTRACTOR LOGIC

Option A: $SIL = \frac{V^2}{Z_{C_0}}, Z_{C_0}$; is surge impedance with compensation

$Z_{C_0} = Z_c\sqrt{\frac{1-K_{se}}{1+K_{sh}}}$; where Z_c is surge impedance, and series and shunt compensations from data

$K_{se} = 0.5$; $K_{sh} = 0.5$

$$Z_{C_0} = Z_c\sqrt{\frac{1-0.5}{1+0.5}}$$

$$= Z_C\sqrt{\frac{0.5}{1.5}}$$

$$= \frac{1}{\sqrt{3}} \times Z_C$$

Reduced by 1.732 times

$$P_{max} = \frac{|V_s||V_r|}{|B|} = \frac{|V_s|V_r|}{Z_C \sin\beta\ell} = \frac{|V_s|V_r|}{Z_C\beta\ell} = \frac{|V_S|V_r|}{X_{line}}$$

With 50% series compensation, $P_{max,new}$

$$= \frac{|V_S||V_r|}{X_{line} - 0.5X_{line}}$$

$$= 2\frac{|V_S||V_r|}{X_{line}}$$

P_{max} increased by 2 times

Option C: $SIL = \frac{V^2}{Z_{C_0}}$, Z_{C_0} is surge impedance with compensations

$Z_{C_0} = Z_c\sqrt{\frac{1+K_{sh}}{1-K_{se}}}$; Where Z_C is surge impedance, and series and shunt compensation

from data $K_{se} = 0.5$; $K_{sh} = 0.5$

$$Z_{C_0} = Z_C\sqrt{\frac{1+0.5}{1-0.5}}$$

$$= Z_C\sqrt{3}$$

Increased by 1.732 times

$$P_{max} = \frac{|V_s||V_r|}{|B|} = \frac{|V_S||V_r|}{Z_C \sin\beta\ell}$$

$$= \frac{|V_S||V_r|}{Z_C\beta\ell}$$

$$= \frac{|V_s||V_r}{X_{line} - K_{se}X_{line} + K_{sh}X_{line}}$$

$$= \frac{|V_S||V_r|}{X_{line} - 0.5X_{line} + 0.5X_{line}}$$

$$= \frac{|V_s||V_r|}{X_{line}}$$

P_{max} remains same

Option D: $SIL = \frac{V^2}{Z_{C_0}}, Z_{C_0}$ is surge impedance with compensation $Z_{c_0} = Z_C\sqrt{\frac{1-K_{se}}{1-K_{sh}}}$; where Z_C is surge impedance of uncompensated line, and K_{se} & K_{sh} are degree of series and shunt compensation from data $K_{se} = 0.5$; $K_{sh} = 0.5$

$$Z_C\sqrt{\frac{1-0.5}{1-0.5}} = Z_C\sqrt{1}$$

So, $Z_{C_0} = Z_C$ no change in SIL

$$P_{max} = \frac{|V_s||V_r|}{|B|} = \frac{|V_S||V_r|}{Z_C \sin\beta\ell}$$

$$= \frac{|V_S||V_r|}{Z_C\beta\ell}$$

$$= \frac{|V_s||V_r}{X_{line} - K_{se}X_{line} + K_{sh}X_{line}}$$

$$= \frac{|V_S||V_r|}{X_{line} - 0.5X_{line} + 0.5X_{line}}$$

$$= \frac{|V_s||V_r|}{X_{line}}$$

P_{max} remains same

31. In a uniform region of free space, if the electric field intensity is given by $\vec{E} = \hat{x}4x + \hat{y}3y$ Volt/m, then the potential at X(0, 2, 2)m with respect to Y(2, 2, 2)m is

(A) 8V (B) −8V (C) −16 V (D) 16 V

Ans: (A)

Sol: Potential at X w.r.t Y is given by

$$V_{XY} = -\int_{Y(2,2,2)}^{X(0,2,2)} \vec{E}.d\vec{\ell}$$

$$= -\left[\int_2^0 4x\,dx + \int_2^2 3y\,dy\right]$$

$$\therefore V_{XY} = -4\frac{x^2}{2}\Big|_2^0 = 8\,V$$

DISTRACTOR LOGIC

Option B: If we take $V_{xy} = -\int_X^Y \vec{E}.d\vec{\ell}$

Then $V_{XY} = -8$ V which is wrong answer .

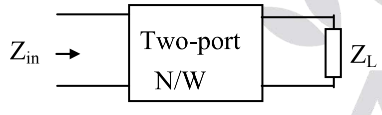
Option C: $V_{XY} = -\left[\int_0^2 4x dx + \int_2^2 3y dy\right]$

$= -4x^2\Big|_0^2 = -16$V, which is incorrect answer .

Option D: $V_{XY} = -\left[\int_2^0 4x dx + \int_2^2 3y dy\right]$

$= -4x^2\Big|_2^0 = 16$V, it is a simplification mistake in integration .

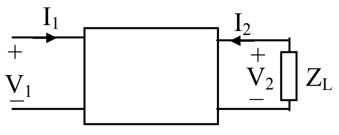
32. A two port network having Z-parameters as $[Z] = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}$ is terminated to a load impedance Z_L as shown. The input impedance Z_{in} of two port network is given by



(A) $Z_{11} - \frac{Z_{12}Z_{21}}{Z_{22}+Z_L}$ (B) $Z_{11} - \frac{Z_{12}(Z_{21}+Z_L)}{Z_{22}}$ (C) $Z_{11} + Z_L$ (D) $Z_{22} + Z_L$

Ans: (A)

Sol: Input impedance, $Z_{in} = \frac{V_1}{I_1}$



Z –parameter equations

$V_1 = Z_{11}I_1 + Z_{12}I_2$

$V_2 = Z_{21}I_1 + Z_{22}I_2$

But, $V_2 = -I_2Z_L$

So,

$-I_2Z_L = Z_{21}I_1 + Z_{22}I_2$

$-I_2(Z_L + Z_{22}) = Z_{21}I_1$

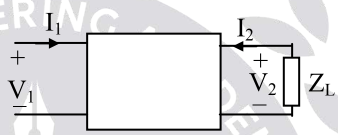
$$I_2 = -\frac{Z_{21}}{Z_L + Z_{22}}.I_1$$

$$\text{So, } V_1 = Z_{11}I_1 - \frac{Z_{21}Z_{12}}{Z_L + Z_{22}}.I_1$$

$$\text{So, } Z_{in} = \frac{V_1}{I_1} = \left[Z_{11} - \frac{Z_{21}.Z_{12}}{Z_L + Z_{22}}\right]$$

DISTRACTOR LOGIC

Option: B Input impedance, $Z_{in} = \frac{V_1}{I_1}$



Z –parameter equations

$V_1 = Z_{11}I_1 + Z_{12}I_2$

$V_2 = Z_{21}I_1 + Z_{22}I_2$

But, $V_2 = -I_1Z_L$

So,

$-I_1Z_L = Z_{21}I_1 + Z_{22}I_2$

$I_1(Z_{21} + Z_L) = Z_{22}I_2$

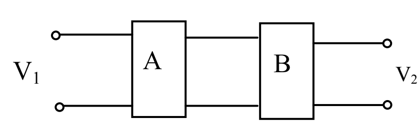
$$I_2 = \frac{Z_{21} + Z_L}{Z_{22}}.I_1$$

$$\text{So, } V_1 = Z_{11}I_1 - \frac{Z_{12} \times (Z_{21} + Z_L)}{Z_{22}}.I_1$$

$$\text{So, } Z_{in} = \frac{V_1}{I_1} = \left[Z_{11} - \frac{Z_{21} \times (Z_{12} + Z_L)}{Z_{22}}\right]$$

Option: C If two networks are in cascade than

$$Z_{eq} = [Z_A] + [Z_B]$$



$$= \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} + \begin{bmatrix} Z_L & Z_L \\ Z_L & Z_L \end{bmatrix} = \begin{bmatrix} Z_{11} + Z_L & Z_{12} + Z_L \\ Z_{21} + Z_L & Z_{22} + Z_L \end{bmatrix}$$

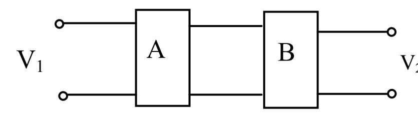
The input impedance is given by

$$\frac{V_1}{I_1} = Z_{11} + Z_L$$

Option: D If two networks are in cascade than

$$Z_{eq} = [Z_A] + [Z_B]$$

$$= \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} + \begin{bmatrix} Z_L & Z_L \\ Z_L & Z_L \end{bmatrix} = \begin{bmatrix} Z_{11}+Z_L & Z_{12}+Z_L \\ Z_{21}+Z_L & Z_{22}+Z_L \end{bmatrix}$$



The input impedance of output port is given by

$$\frac{V_2}{I_2} = Z_{22} + Z_L$$

33. A 4 pole series motor has 944 wave connected armature conductors. At a certain load the flux/pole is 34.6 mWb and the total mechanical torque developed is 209 N-m. With an applied voltage of 500V, the speed of the motor will be (The total motor resistance is 1Ω.)

(A) 422 rpm (B) 440 rpm (C) 477 rpm (D) 496 rpm

Ans: (B)

Sol: $T = \frac{1}{2\pi} \times \frac{\phi Z I_a P}{A}$

$$\Rightarrow 209 = \frac{1}{2\pi} \times \frac{34.6\times10^{-3}\times944\times I_a\times4}{2}$$

$I_a = 20.10$ A

$E_b = V - I_aR_a = 500 - 20.10\times1 = 479.89$ A

$$E_b = \frac{\phi ZNP}{60A} \Rightarrow 479.89$$

$$= \frac{34.6\times10^{-3}\times944\times N\times4}{60\times2}$$

$\Rightarrow N = 440.77$ rpm

DISTRACTOR LOGIC

Distractor logic:

Option: A $T = \frac{1}{2\pi} \times \frac{\phi Z I_a P}{A}$

$$\Rightarrow 209 = \frac{1}{2\pi} \times \frac{34.6\times10^{-3}\times944\times I_a\times4}{4}$$

$I_a = 40.20$ A

$E_b = V + I_aR_a = 500 - 40.20 \times 1 = 459.8$ A

$$E_b = \frac{\phi ZNP}{60A} = 459.8$$

$$459.8 = \frac{34.6 \times 10^{-3} \times 944 \times N \times 4}{60 \times 2}$$

$\Rightarrow N = 422.32$ rpm

Option: C $T = \frac{1}{2\pi} \times \frac{\phi Z I_a P}{A}$

$$\Rightarrow 209 = \frac{1}{2\pi} \times \frac{34.6 \times 10^{-3} \times 944 \times I_a \times 4}{2}$$

$I_a = 20.10$ A

$E_b = V + I_aR_a = 500 + 20.10 \times 1 = 520.1$ A

$$E_b = \frac{\phi ZNP}{60A} = 520$$

$$520 = \frac{34.6 \times 10^{-3} \times 944 \times N \times 4}{60 \times 2}$$

$\Rightarrow N = 477.61$ rpm

Option: D $T = \frac{1}{2\pi} \times \frac{\phi Z I_a P}{A}$

$$\Rightarrow 209 = \frac{1}{2\pi} \times \frac{34.6 \times 10^{-3} \times 944 \times I_a \times 4}{4}$$

$I_a = 40.20$ A

$E_b = V + I_aR_a = 500 + 40.20 \times 1 = 540.2$ A

$$E_b = \frac{\phi ZNP}{60A} = 540.2$$

$$540.2 = \frac{34.6 \times 10^{-3} \times 944 \times N \times 4}{60 \times 2}$$

$\Rightarrow N = 496.16$ rpm

34. The below program is executed by 8085 microprocessor

```
XRA A
MOV L, A
MOV H, L
DCX H
DAD H
MOV M, A
INR M
MOV A, M
```

After execution, what will be the contents of PSW

(A) FFFEH (B) 0101 H (C) 01FFH (D) FE01H

Ans: (B)

Sol: (A) = 00H [$\because$ (A) $\forall$ (A) = 00H]

$\rightarrow$ cy =0, P = 1, AC = 0, Z = 1, S = 0

(L) $\leftarrow$ (A) = 00H

(H) $\leftarrow$ (L) = 00H

DCX H $\Rightarrow$ 0000H – 1 = FFFFH

FFFF = 1111 1111 1111 1111

FFFF = 1111 1111 1111 1111

$\overline{\text{1111 1111 1111 1110}}$ $\rightarrow$ FFFEH

(HL) = FFFEH with cy = 1

Other flags are remains same.

(FFFEH) $\leftarrow$ (A) = 00H

00H+1 = 01H

= (FFFEH)

Cy flag not affected for INR $\Rightarrow$ cy remains 1

Remaining 4 flags are affected based on result

01H = 0000 0001 $\Rightarrow$ P = 0, AC = 0 , Z = 0, S = 0

(A) $\leftarrow$ (FFFEH) = 01H

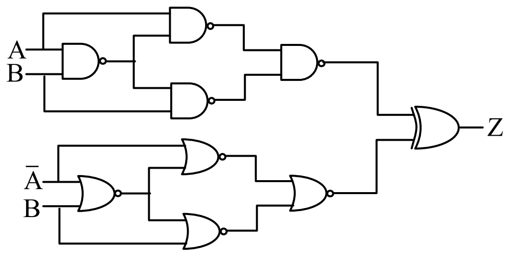
(A) = 01H , (flag reg) = 00 × 0 × 0 × 1

= 0000 0001

= 01H

(PSW) = 0101H

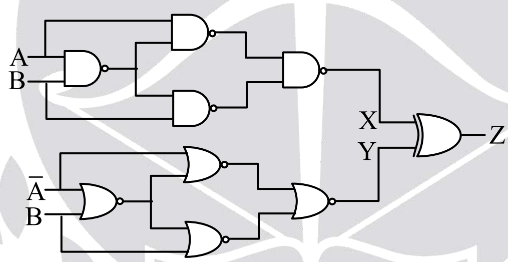
35. The output Z is



(A) $A \oplus B$ (B) $A \odot B$ (C) 1 (D) 0

Ans: (D)

Sol:



$X = A \oplus B$

$Y = A \oplus B$

$Z = A \oplus B \oplus A \oplus B$

$= A \oplus A \oplus B \oplus B$

$= 0 \oplus 0$

$Z = 0$

DISTRACTOR LOGIC

Option (C): If $\overline{A}$ is takn as A

$X = A \oplus B$

$Y = A \odot B$

$Z = A \oplus B \oplus A \odot B$

$= A \oplus A \oplus B \odot B$

$= 0 \oplus 1$

$Z = 1$

Option (A): If XOR gate is taken OR-gate

$Z = [A \oplus B] + [A \oplus B]$

$= A \oplus B$

Optio (B): If $X = A \odot B$

$Y = A \odot B$

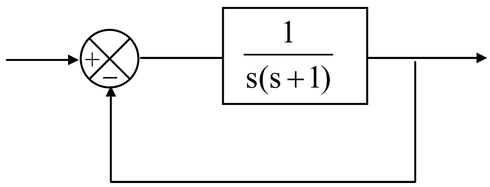
And output gate considers as OR gate then

$Z = A \odot B \oplus A \odot B$

$= A \odot B$

Q.36 – Q.65 carry two marks each

36. Consider the system shown in figure below



The approximate 2% settling time of the response to a unit step input is __________ seconds.

Ans: 8 (Range 7.9 to 8.3)

Sol: $CE = 1 + \frac{1}{s(s+1)} = 0$

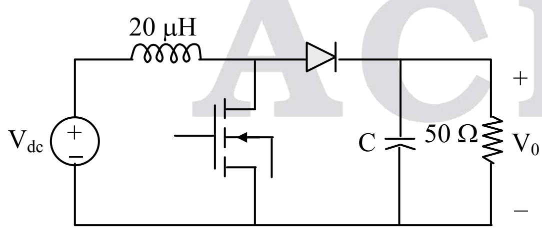
$s^2 + s + 1 = 0$

$\omega_n = 1$ and $2\zeta\omega_n = 1$

$\Rightarrow \zeta\omega_n = 0.5$

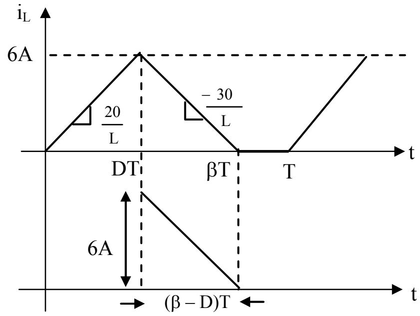
$t_s = \frac{4}{\zeta\omega_n} = 8$ sec for 2% criterion

37. Input voltage to the following DC-DC converter is 20 V and output voltage is 50 V. Duty cycle ratio is 0.5. RMS value of diode current (in ampere) is ____.



Ans: 2 (Range 2 to 2)

Sol:



In continuous conduction mode, $V_0 = \dfrac{V_{dc}}{1-D} = \dfrac{20}{1-0.5} = 40\text{V}$

But given $V_0 > 40$ V, so it is discontinuous mode of operation.

Power balance equation $P_0 = P_{in}$

$$\Rightarrow V_{dc}.I_s = 50 \times \left(\frac{50}{50}\right)$$

$$I_s = \frac{50}{20} = 2.5\,\text{A}$$

$$\frac{V_0}{V_{dc}} = \frac{\beta}{\beta - D} = \frac{50}{20} = 2.5$$

$\Rightarrow \beta = 2.5 \times \beta - (2.5 \times 0.5)$

$\beta = 0.833$

$$I_L = \frac{\frac{1}{2} \times I_{L\,Max} \times \beta T}{T} = 2.5$$

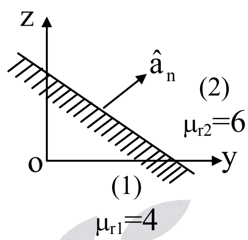
$I_{L\,Max} = 6$ A

$$I_{D,rms} = \left[\frac{6^2}{3} \times \left(\frac{5}{6} - \frac{1}{2}\right) \times \frac{T}{T}\right]^{\frac{1}{2}}$$

$$= \left[\frac{6^2}{3} \times \frac{2}{6}\right]^{\frac{1}{2}}$$

$I_{D,rms} = 2$ A

38. Region 1, where $\mu_{r1} = 4$, is the side of the plane y + z =1 containing the origin (shown in figure). In region 2,μ_{r2} = 6. If the magnetic flux density in region 1 is $\vec{B}_1 = 2\hat{a}_x + \hat{a}_y$ (Tesla), then the magnitude of magnetic flux density (in T) in region 2 is ______.



Ans: 3.2 (Range: 3 to 3.5)

Sol: The unit vector normal to the plane y + z = 1 is given by

$$\hat{a}_n = \frac{\hat{a}_y + \hat{a}_z}{\sqrt{2}}$$

$$B_{n_1} = \vec{B}_1.\hat{a}_n = (2\hat{a}_x + \hat{a}_y).\left(\frac{\hat{a}_y + \hat{a}_z}{\sqrt{2}}\right)$$

$$B_{n1} = \frac{1}{\sqrt{2}}$$

$$\vec{B}_{n_1} = B_{n_1}\hat{a}_n = \frac{1}{\sqrt{2}}\left(\frac{\hat{a}_y + \hat{a}_z}{\sqrt{2}}\right)$$

$$\vec{B}_{n_1} = 0.5\hat{a}_y + 0.5\hat{a}_z$$

$$\vec{B}_{n2} = \hat{B}_{n_1} = 0.5\hat{a}_y + 0.5\hat{a}_z$$

$$\vec{B}_{t_1} = \vec{B}_1 - \vec{B}_{n_1}$$

$$= (2\hat{a}_x + \hat{a}_y) - (0.5\hat{a}_y + 0.5\hat{a}_z)$$

$$\vec{B}_{t_1} = 2\hat{a}_x + 0.5\hat{a}_y - 0.5\hat{a}_z$$

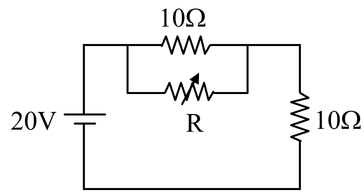
$$\frac{B_{t1}}{\mu_1} = \frac{B_{t2}}{\mu_2} \Rightarrow \vec{B}_{t2} = \left(\frac{\mu_2}{\mu_1}\right)\vec{B}_{t1} = \left(\frac{3}{2}\right)\left[2\hat{a}_x + 0.5\hat{a}_y - 0.5\hat{a}_z\right]$$

$$\vec{B}_{t2} = 3\hat{a}_x + 0.75\hat{a}_y - 0.75\hat{a}_z$$

$$\vec{B}_2 = 3\hat{a}_x + 1.25\hat{a}_y - 0.25\hat{a}_z \quad \left[\because \vec{B}_2 = \vec{B}_{t2} + \vec{B}_{n2}\right]$$

$$\therefore \left|\vec{B}_2\right| = \sqrt{(3)^2 + (1.25)^2 + (-0.25)^2} = 3.259 \text{ Tesla}$$

39. The maximum power transferred to R is _____(in watts).



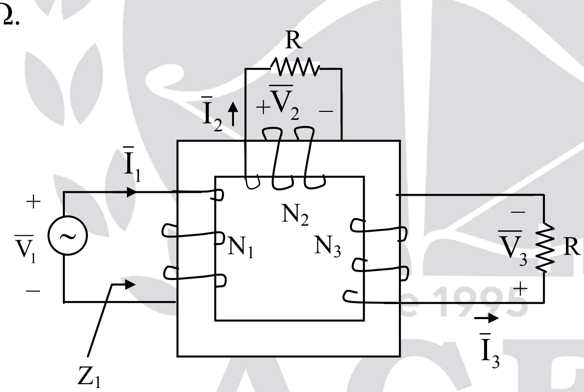
Ans: 5

Sol: $R_{th} = 10||10 = 5\Omega$

$V_{th} = 10V$

$$P_{max} = \frac{V_s^2}{4.R_L} = \frac{10^2}{4\times 5} = \frac{100}{20} = 5W$$

40. The three-winding ideal transformer in the following figure has $N_1 = N_2 = 2N_3$ and identical load resistors (R) connected across coils 2 and 3. The input impedance $\boldsymbol{Z}_1$ as indicated in the figure is ________×R Ω.



Ans: 0.8 (Range 0.8 to 0.8)

Sol: MMF balance requires that

$$N_1\bar{I}_1 = N_2\bar{I}_2 + N_3\bar{I}_3$$

$$N_1\bar{I}_1 = N_1\bar{I}_2 + \frac{1}{2}N_1\bar{I}_3$$

Or

$$\bar{I}_1 = \bar{I}_2 + \frac{1}{2}\bar{I}_3 \text{ .... (1)}$$

Since the value of flux through all three coils is identical, $\bar{V}_1 = \bar{V}_2 = 2\bar{V}_3$.

By Ohm's law, $\bar{I}_2 = \frac{\overline{V}_2}{R} = \frac{\overline{V}_1}{R}$ ……….. (2)

$\bar{I}_3 = \frac{\overline{V}_3}{R} = \frac{\overline{V}_1}{2R}$ …………… (3)

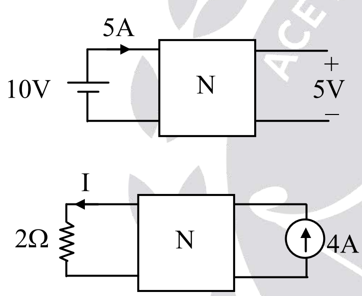
Use (2) and (3) in (1) to find

$\overline{I}_1 = \frac{\overline{V}_1}{R} + \frac{\overline{V}_1}{4R} = \frac{5\overline{V}_1}{4R}$

Hence,

$\boldsymbol{Z}_1 = \frac{\overline{V}_1}{\overline{I}_1} = \frac{4}{5}R$

41. The current I (in Amp) is _____.



Ans: 1

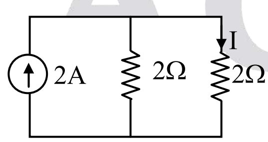
Sol: $\frac{V_2^1}{V_1} = \frac{I_2^1}{I_1}$

$\frac{5}{10} = \frac{I_2^1}{4}$

$I_2^1 = \frac{20}{10} = 2A$

$R_{th} = \frac{10}{5} = 2\Omega$

I = 1Amp



42. Synchronous generator is connected to an infinite bus by a transformer and lossless network. Infinite bus voltage is 1.0 pu and a voltage of generator is 1.2 pu. The transfer admittance is 2.0 pu. The power transfer by the generator is 1.0 pu. A 3-phase fault is taking place in the lossless network so that the power transfer is zero. The fault is cleared by circuit breaker and the original network is restored. The critical clearing angle made by the rotor at the time fault gets cleared by circuit breaker is _____ (in degrees)

Ans: 87.6 (Range: 86 to 88)

Sol: $P_s = P_e = 1.0$

$$P_{M_1} = \frac{EV}{X_{1_{eq}}} = (EV)y_{eq} = 2.0\,(1.2\times1.0) = 2.4$$

$$\delta_0 = \sin^{-1}\left(\frac{P_S}{P_{M_1}}\right)$$

$$= \sin^{-1}\left(\frac{1.0}{2.4}\right)\text{ele. degree} = 24.62°$$

$$\delta_{0(rad)} = \delta_0 \times \frac{\pi}{180} = 0.429$$

Fault: $P_{e_2} = 0, P_{m_2} = 0$

$$\delta_m = 180° - \sin^{-1}\left(\frac{P_S}{P_{m_3}}\right)$$

$$P_{m_3} = P_{m_1}$$

$$\delta_m = 180° - \sin^{-1}\left(\frac{1.0}{2.4}\right) = 180° - 24.62° = 155.38°$$

$$\delta_{m(rad)} = \delta_m \times \frac{\pi}{180} = 2.711$$

$$\delta_c = \cos^{-1}\left[\frac{P_S(\delta_m - \delta_e) + P_{m_3}\cos\delta_m}{P_{m_3}}\right]$$

$$\delta_C = \cos^{-1}\left[\frac{1.0(\delta_m - \delta_o) + 2.4\cos\delta_m}{2.4}\right]\text{ele. degree}$$

$$\delta_c = \cos^{-1}\left[\frac{1.0(2.711 - 0.429) + 2.4\cos(155.38)}{2.4}\right] = 87.6°$$

43. A 3-phase synchronous motor has a reactance of 0.8 pu with negligible resistance. When connected to busbar at rated voltage and the excitation adjusted to an emf of 1.2 pu, the machine draws rated input kVA. The mechanical power developed by the motor is ______ pu.

Ans: 0.992 (Range: 0.8 to 1)

Sol: $X_s = 0.8$ pu, E = 1.2 pu, V = 1.0 pu, $I_a = 1$pu

$$|I_a z_s| = \sqrt{E^2 + V^2 - 2VE\cos\delta}$$

$$\Rightarrow 1\times 0.8 = \sqrt{1.2^2 + 1^2 - 2\times 1\times 1.2\cos\delta}$$

$$\Rightarrow \delta = 41.4°$$

$$P = \frac{EV}{X_s}\sin\delta \Rightarrow \frac{1.2\times 1}{0.8}\sin 41.4^o$$

$$= 0.992 \text{ pu}$$

44. A 250 V shunt motor has an armature resistance of 0.5 Ω and field resistance of 250Ω. When driving a load at 600 rpm, the torque of which is constant, the armature takes 20 A current. If it is desired to raise the speed from 600 to 800 rpm, then the resistance to be inserted in the shunt field circuit is ________Ω.

Ans: 88.0 to 88.5Ω

Sol: Torque constant $T_2 = T_1$

$$\phi_2 I_{a_2} = \phi_1 I_{a_1}$$

$$\Rightarrow I_{sh_2} I_{a_2} = I_{sh_1} I_{a_1}$$

$$I_{sh_1} = \frac{V}{R_{sh}} = \frac{250}{250} = 1A$$

$$I_{sh_2} I_{a_2} = 1\times 20$$

$$I_{a_2} = \frac{20}{I_{sh_2}}$$

$$E_{b_1} = V - I_{a_1}R_a = 250 - 20\times 0.5 = 240 \text{ A}$$

$$E_{b_2} = V - I_{a_2}R_a = 250 - \frac{20}{I_{sh2}}\times 0.5 = 250 - \frac{10}{I_{sh_2}}$$

$$\frac{E_{b_2}}{E_{b_1}} = \frac{I_{sh_2} \times N_2}{I_{sh_1} \times N_1} \Rightarrow \frac{250 - \frac{10}{I_{sh_2}}}{240} = \frac{I_{sh_2} \times 800}{1 \times 600}$$

$$= 250 - \frac{10}{I_{sh_2}} = 320\, I_{sh_2}$$

$$\Rightarrow 32\, I_{sh_2}^2 - 25\, I_{sh_2} + 1 = 0$$

$$I_{sh_2} = \frac{25 \pm \sqrt{25^2 - 4 \times 32 \times 1}}{2 \times 32}$$

I_{sh_2} = 0.739 A or (0.0422 A is too low)

$$I_{sh_2} = 0.739\text{A} = \frac{V}{R_{sh_2}} = \frac{250}{R_{sh_2}}$$

$$R_{sh_2} = \frac{250}{0.739} = 338.29\ \Omega$$

Resistance to be added

= 338.29–250 = 88.29 Ω

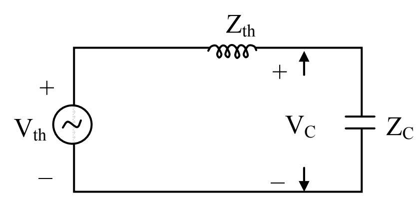
45. In a power system network Thevenin's impedance and voltage with respect to a bus are given as 0.9 pu and j0.2 pu respectively. The load kept at that bus consumes constant complex power of 1 + j1 pu. A shunt capacitor bank is connected at that bus to increase voltage magnitude to 1 pu. The power factor of load capacitor combination is ____________ (lag)

Ans: 0.894 (Range: 0.85 to 0.92)

Sol: From given data V_{th} = 0.9 pu; Z_{th} = j0.2 pu. To increase voltage magnitude to 1 pu, a shunt capacitor bank was connected.

V_c = 1pu

$$V_C = V_{th}\ \frac{Z_C}{Z_C + Z_{th}}$$

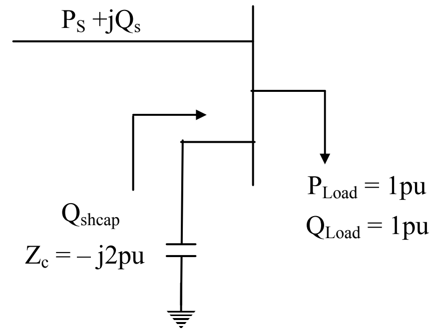


$$1 = 0.9 \frac{Z_C}{j0.2 + Z_C}$$

So, Z_C = –j2 pu

Load at that bus is 1 + j1 pu

From this, $Q_{sh\,cap} = \frac{|V|^2}{X_c} = \frac{1}{2} = 0.5$ pu



So, $P_S = P_{load} = 1$ pu

$Q_S = Q_{load} - Q_{sh\,cap} = 0.5$ pu

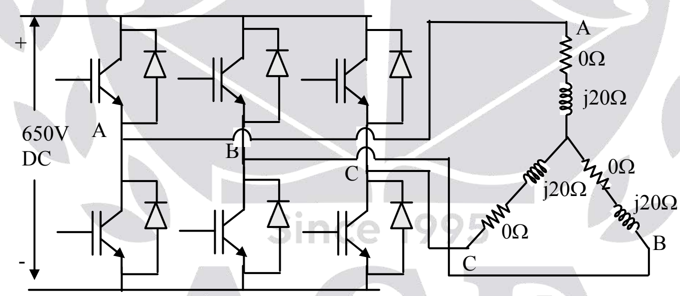
Overall power factor

$$\cos\phi_s = \frac{P_s}{\sqrt{P_s^2 + Q_s^2}}$$

$$= \frac{1}{\sqrt{1+(0.5)^2}} \text{ lag}$$

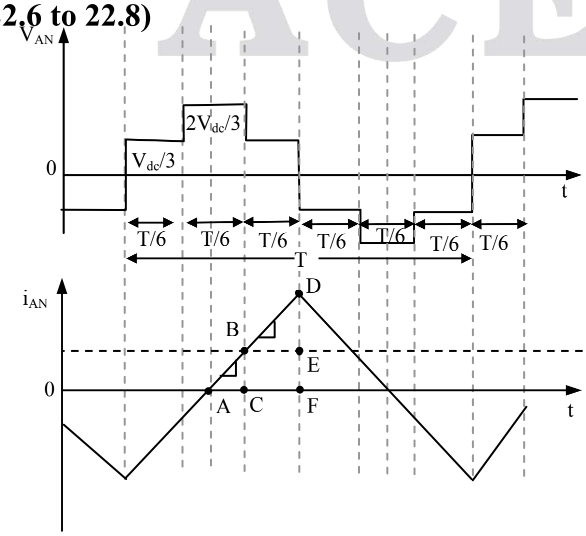
$$= 0.894 \text{ lag}$$

46. A three phase voltage source inverter (VSI) as shown in figure is feeding a star connected inductive load of (0 + j20) Ω/ph. If it is fed from a 650 V battery and operates with 180° conduction mode with fundamental frequency of output as 50 Hz, the peak value of per phase load current in ampere is ____________.



Ans: 22.69 (Range 22.6 to 22.8)

Sol:



$\Delta ABC, \frac{2V_{dc}}{3L} = \frac{BC}{AC} \Rightarrow BC = \frac{2V_{dc}}{3L} \times \frac{T}{12} = \frac{V_{dc}}{18Lf}$

Is ΔBDE, $\frac{V_{dc}}{3L} = \frac{DE}{BE} \Rightarrow DE = \frac{V_{dc}}{3L} \times \frac{T}{6} = \frac{V_{dc}}{18Lf}$

$i_{0\,(peak)} = BC + DE = \frac{V_{dc}}{18Lf} + \frac{V_{dc}}{18Lf}$

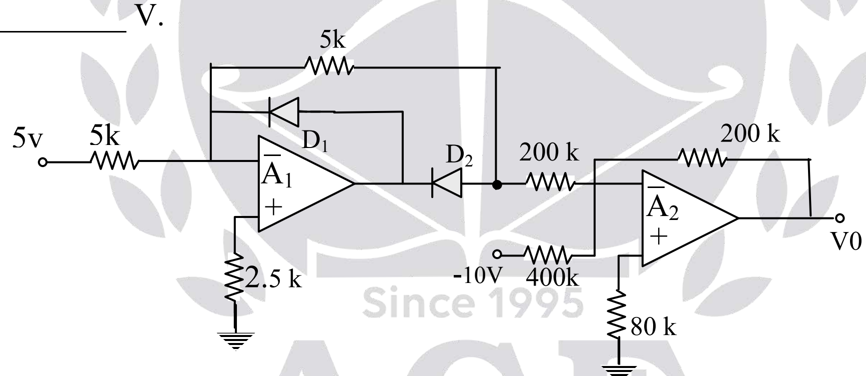
$= \frac{V_{dc}}{9Lf}$

But $2\pi\, Lf = 20$

so $Lf = \left(\frac{20}{2\pi}\right)$

$i_{0,\,peak} = \frac{650 \times 2\pi}{9 \times 20} = 22.69$ A

47. The output voltage V_0 of op-amp circuit shown in figure assuming op-amp & diodes as ideal, is ________________ V.



Ans: $V_0 = 10$ (Range: 10 to 10)

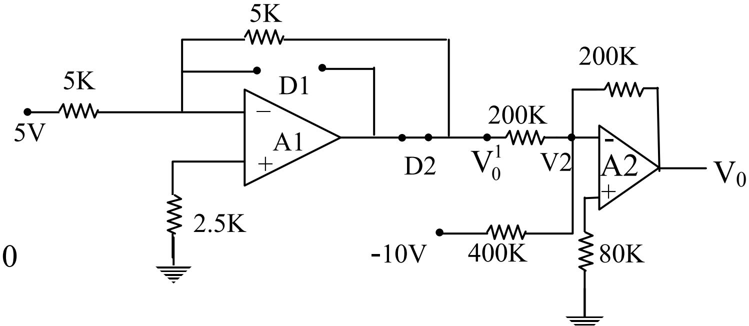
Sol: Step (1): For the given input of 5v, D1 is off & D2 is ON

$V_0^1 = \frac{-5k}{5k} \times 5v = -5v$

Step (2): KCL at the inverting input, V_2 of op-amp2(A_2)

Op-amp 2 (A2)

$\frac{V_0^1}{200k} - \frac{10v}{400k} + \frac{V_0}{200k} = 0$



$$V_0 = 200k\left[\frac{5V}{200k}+\frac{10V}{400k}\right] = 5\text{ V} + 5\text{ V}$$

$\therefore V_0 = 10$ V

48. By changing the order of interaction $\int_1^4 \int_{\sqrt{y}}^2 \left(x^2+y^2\right) dxdy$ becomes

(A) $\int_1^2 \int_1^{x^2} \left(x^2+y^2\right) dydx$

(B) $\int_1^4 \int_1^{x^2} \left(x^2+y^2\right) dydx$

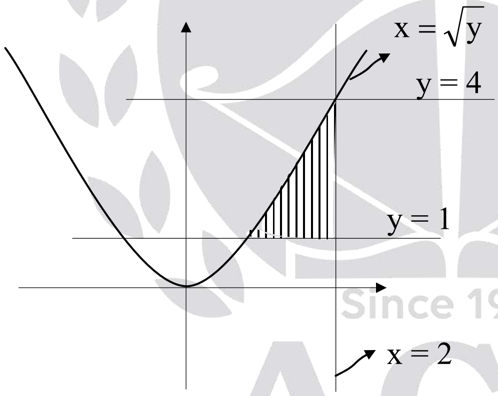
(C) $\int_1^2 \int_{x^2}^1 \left(x^2+y^2\right) dydx$

(D) $\int_1^4 \int_{x^2}^1 \left(x^2+y^2\right) dydx$

Ans: (A)

Sol: In the given double integral the limits of $x : \sqrt{y} \to 2$ and $y : 1 \to 4$

$\therefore$ The required area is shaded below



$$\therefore \int_1^4 \int_{\sqrt{y}}^2 \left(x^2+y^2\right) dxdy \text{ becomes } \int_1^2 \int_1^{x^2} \left(x^2+y^2\right) dydx$$

49. In the circuit shown in figure , a silicon transistor with V_{BE} = 0.7V, β = 100 is used. The transistor is biased at _____ ?

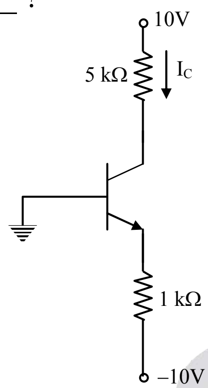
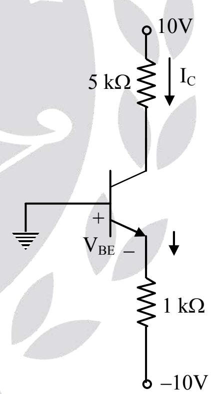


Fig.

(A) 9.2 mA (B) 2.1 mA (C) 1.86 mA (D) 0

Ans: (B)

Sol: Step (1): KVL for BE loop of BJT



$0 - 0.7V - I_E\, 1K + 10V = 0$ …….. (1)

$\Rightarrow I_E = \dfrac{9.3V}{1K} = 9.3mA$ …….. (2) [i.e J_E is FB]

$\Rightarrow I_C = \left(\dfrac{\beta}{1+\beta}\right) I_E = 9.2mA$ ….. (3)

Step (2): KVL for C-loop

$10V - I_C \times 5K - V_C = 0$ …… (4)

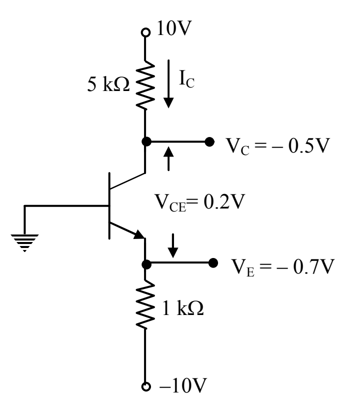
$V_C = 10V - 9.2mf \times 5K = -36V$ ……. (5)

$\Rightarrow V_{CB} = V_C - V_B = -36V - 0 = -36V$ …… (6)

NOTE: ∵ V_{CB} is –Ve, collector junctions is F.B

∴ BJT is operated in saturation region

Step (3): ∵ BJT is in saturation, $V_{CE_{sat}} = 0.2V$



$\Rightarrow V_C = V_{CE_{sat}} + V_E = -0.5V$ ……. (1)

KVL for collector –loop:

$I_C = \dfrac{10V - (-0.5V)}{5K} = 2.1mA$ …. (2)

DISTRACTOR LOGIC

Option: A: If the device(BJT) is in forward active region, KVL for BE loop of BJT

$0 - 0.7V - I_E\ 1K + 10V = 0$

$$I_E = \frac{9.3V}{1K} = 9.3mA$$

$$\therefore I_c = \left(\frac{\beta}{1+\beta}\right) I_E = \frac{100}{101} \times 9.3mA$$

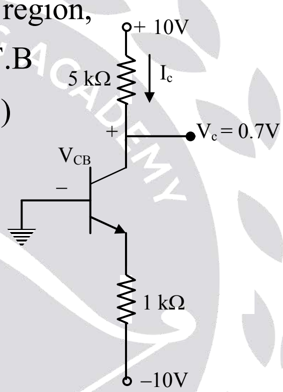
$I_c = 9.2mA$

Option: B: $I_c = 2.1mA$ …… (1) ($\because$ Device is actually biased in saturation region)

Option:C: If the device is in inverse (or reverse) active region,

(i.e) E-B junction is R.B & C.B junction is F.B

Assuming $V_{CB} = 0.7V \Rightarrow V_c = 0.7V$ …… (1)



[$\because V_{CB} = V_C - V_B = V_C$]

KVL for collector loop of BJT

$10V - I_c\ 5K - 0.7V = 0$ …… (1)

$$I_c = \frac{9.3V}{5K} = 1.86mA \text{ …… (2)}$$

Option: D If the device is in cutoff region

$I_B = 0 \Rightarrow I_C = 0$ …… (1)

50. The incidence matrix of a graph is given below

$$A = \begin{bmatrix} -1 & 0 & 1 & 1 & -1 & 0 \\ 1 & -1 & 0 & 0 & 0 & -1 \\ 0 & 1 & -1 & -1 & 1 & 0 \end{bmatrix}$$

The number of possible Trees are

(a) 3 (b) 7 (c) 11 (d) 14

Ans: (b)

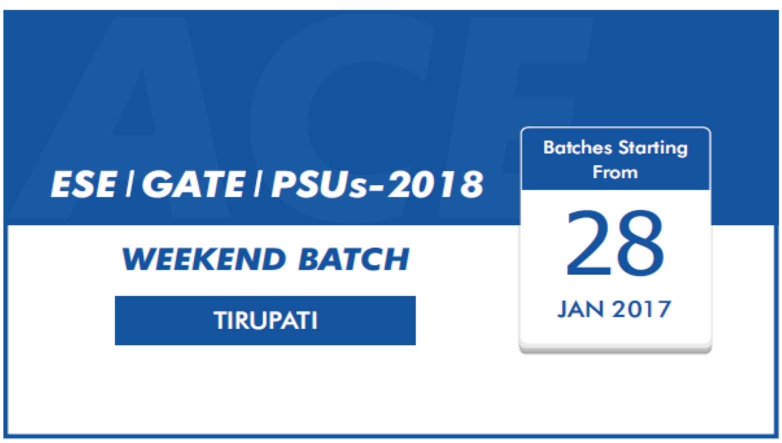
Sol: Given is reduced incidence matrix, so, Number of trees = $\det|[A_r][A_r]^T|$

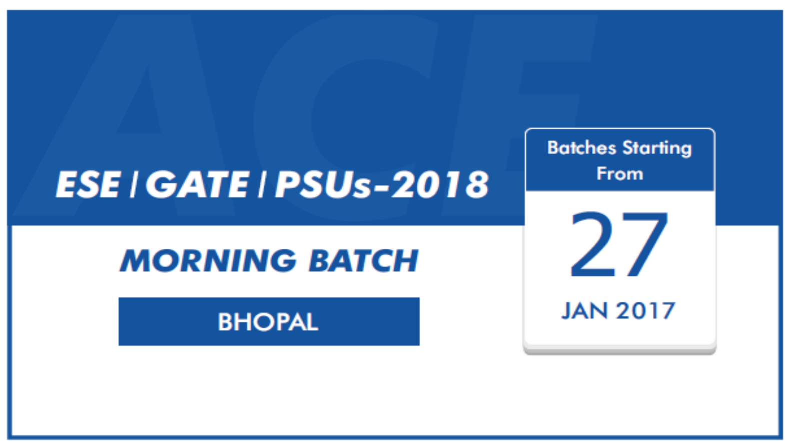
$$[A_r][A_r]^T = \begin{bmatrix} -1 & 0 & 1 & 1 & -1 & 0 \\ 1 & -1 & 0 & 0 & 0 & -1 \\ 0 & 1 & -1 & -1 & 1 & 0 \end{bmatrix} \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \\ -1 & 0 & 1 \\ 0 & -1 & 0 \end{bmatrix}$$

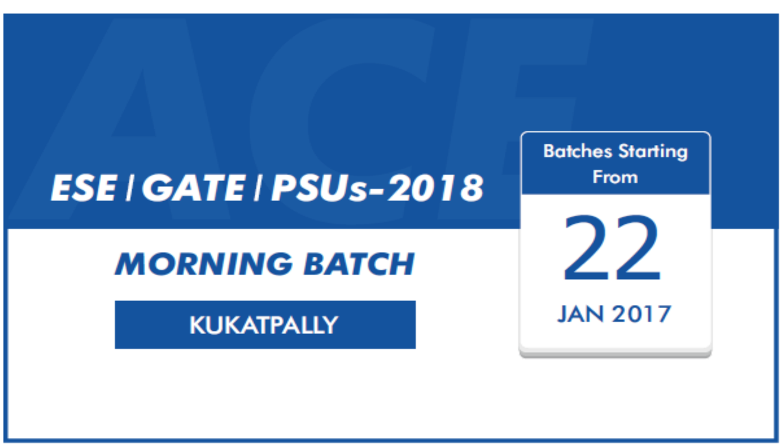
$$[A_r][A_r]^T = \begin{bmatrix} 4 & -1 & -3 \\ -1 & 3 & -1 \\ -3 & -1 & 4 \end{bmatrix}$$

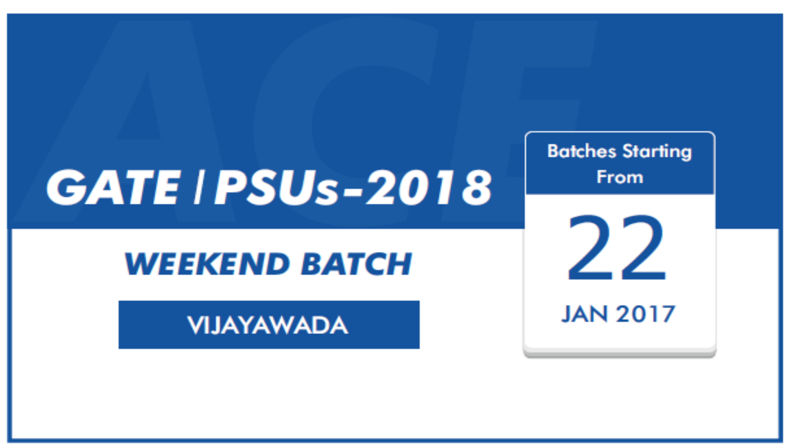
$$\det\left|[A_r][A_r]^T\right| = 4[12-1]+1[-4-3]-3[1+9]$$

$$= 44–7 – 30 = 7 \text{ trees only}$$

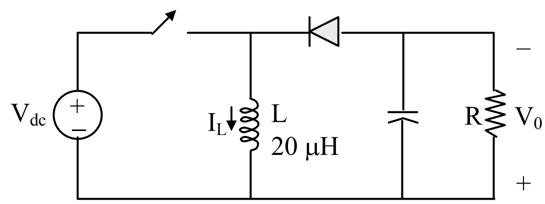








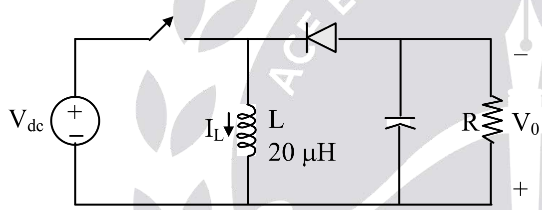
51. Input voltage to the following Buck-Boost converter is 20 V. Assume that the capacitor is large to treat output voltage is constant of 60 V. The switch is operating at 50 kHz with a duty ratio of 0.6. Average value of inductor current is _____.



(A) 12 A (B) 7.2 A (C) 4.8 A (D) insufficient data

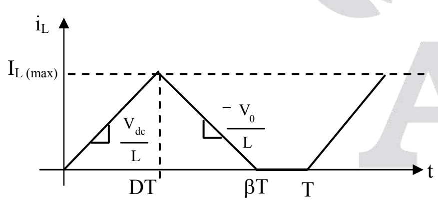
Ans: (C)

Sol:



In CCM Buck Boost, $V_0 = V_{dc}\left[\frac{D}{1-D}\right] = 20 \times \frac{0.6}{0.4} = 30\,\text{V}$

But given $V_0 > 30$ V, so it is discontinuous mode of operation.



From i_L waveform

$$\frac{20}{L}DT = \frac{60}{L}(\beta T - DT)$$

$$\Rightarrow 4DT = 3\beta T \Rightarrow \beta = \frac{4}{3} \times D = 0.8$$

$$\therefore I_{L\max} = \frac{V_{dc}}{L} \times DT = \frac{20}{20\mu} \times 0.6 \times 20\mu = 12\,\text{A}$$

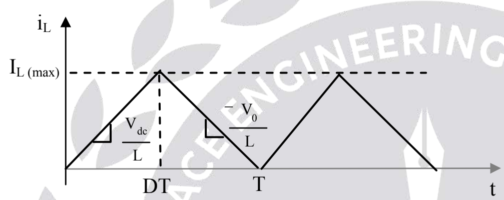
$$I_{L\ (avg)} = \frac{\frac{1}{2}\times 12\times 0.8\times 20\mu}{20\mu} = 4.8\,\text{A}$$

DISTRACTOR LOGIC

Opton (A) : $V_0 = V_{dc}\left[\frac{D}{1-D}\right] = 20\times\frac{0.6}{0.4} = 30\,\text{V}$

$$\frac{20}{L}DT = \frac{30}{L}(\beta T - DT)$$

β =1 so it is continuous conduction mode



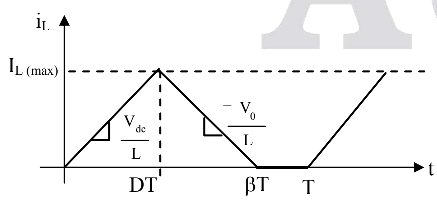
$$i_{L\ peak} = \frac{V_{dc}}{L}\times DT$$

$$= \frac{20}{20\mu}\times 0.6\times 20\mu$$

$$= 12\ \text{A}$$

$\therefore\ i_{L\,(avg)} = 12\ \text{A}$

Option B: $V_0 = V_{dc}\left[\frac{D}{1-D}\right] = 20\times\frac{0.6}{0.4} = 30\,\text{V}$



From wave form

$$\frac{20}{L}DT = \frac{60}{L}(\beta T - DT)$$

$$\Rightarrow 4DT = 3\beta T \Rightarrow \beta = \frac{4}{3}\times D = 0.8$$

$$\therefore I_{L\max} = \frac{V_o}{L} \times DT = \frac{30}{20\mu} \times 0.6 \times 20\mu = 18\text{ A}$$

$$I_{L\ (avg)} = \frac{\frac{1}{2} \times 18 \times 0.8 \times 20\mu}{20\mu} = 7.2\text{ A}$$

Option D: To check whether it is continuous or discontinuous condition, R value is required. But it is not given in the problem, so it is insufficient data.

52. The solution of $\frac{d^2y}{dx^2} = y$ which passes through the origin and $\left(\ell n2, \frac{3}{4}\right)$ is ______

(A) $y = \frac{e^x}{2} - e^{-x}$ (B) $\frac{3}{8}\left(e^x + e^{-x}\right)$ (C) $y = \frac{1}{2}\left(e^x - e^{-x}\right)$ (D) $\frac{e^x}{2} + e^{-x}$

Ans: (C)

Sol: The given equation is $(D^2 - 1)\,y = 0$

i.e., $D = \pm 1$ are the roots of A. E

$\therefore\ y = (C_1e^x + C_2e^{-x})$

If it passes through the origin i.e. x = 0, y = 0

then $C_1 + C_2 = 0$ ………… (1)

Similarly if passes through $\left(\ell n2, \frac{3}{4}\right)$

then $\frac{3}{4} = \left(2C_1 + 0.5C_2\right)$ ………. (2)

By solving (1) & (2) for C_1 ; C_2

We get $C_1 = \frac{1}{2}$ & $C_2 = \frac{-1}{2}$

$\therefore\ y = \frac{1\left(e^x - e^{-x}\right)}{2}$ is the required solution.

53. The four arms of a wheatstone bridge are as follows: Arm AB =100 Ω, BC = 10Ω, CD = 4Ω and DA = 50Ω.The galvanometer has a resistance of 20Ω and is connected across BD. A source of 10V DC is connected across AC, then the current through the galvanometer is

(A) zero (B)13.3mA (C)5.18mA (D)39mA

Ans: (C)

Sol: $V_{th} = V_B - V_D$

$$= \left(10\times\frac{10}{10+100} - 10\times\frac{4}{4+50}\right)$$

$= 0.9091 - 0.7407$

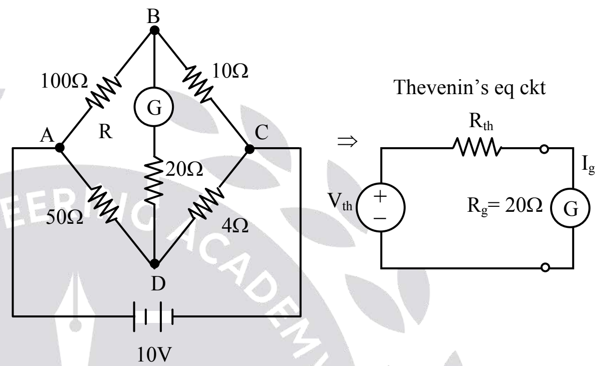
$= 0.17V$

$$R_{th} = \frac{100\times10}{100+10} + \frac{50\times4}{50+4}$$

$= 9.09091+3.7037$

$= 12.7946\Omega$

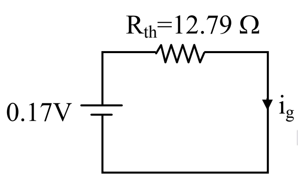
$$I_g = \frac{V_{th}}{R_{th}+20} = \frac{0.17}{12.7946+20} = 5.18\text{mA}$$



DISTRACTOR LOGIC

Option: (A) if bridge is balanced, $i_g = 0$

Option: **(B)** if galvanometer resistance is neglected



$$i_g = \frac{0.17}{12.179} = 0.01329 \text{ A} = 13.3 \text{ mA}$$

Option: (D) if AB & AD branches are interchanged

$$V_{th} = \frac{10\times10}{10+50} - \frac{10\times4}{4+100}$$

$= 1.28$ Volts

$$R_{th} = \frac{10\times50}{10+50} + \frac{4\times100}{104}$$

$= 12.18\ \Omega$

$i_g = \dfrac{1.28}{20+12.18}$

$= 0.03977$ A

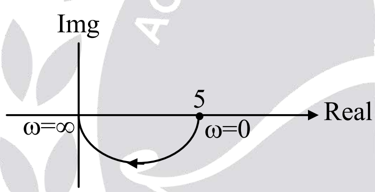
$= 39$ mA

54. The Loop transfer function of the unity feedback system is $\dfrac{10}{(s+2)}$ then gain margin of the system is

(A) 0 (B) 0.2 (C) 5 (D) ∞

Ans: (D)

Sol: The Nyquist plot (from $\omega = 0$ to $\omega = \infty$) is shown in figure below



Nyquist plot does not intersection the negative real axis

$\therefore$ Gain margin is infinite

DISTRACTOR LOGIC:

Option A: Point of intersection is '∞', then GM = $\dfrac{1}{\infty} = 0$

Option B: $\angle\left(\dfrac{10}{j\omega+2}\right) = -\tan^{-1}\dfrac{\omega}{2} = -180\,\Big|_{\omega=\omega_p} \Rightarrow \omega_{pc} = 0$

$\left|\dfrac{10}{j\omega_{pc}+2}\right| = \dfrac{10}{2} = 5$

$GM = \dfrac{1}{5} = 0.2$

Option C: $\left|\dfrac{10}{j\omega_{pc}+2}\right|_{\omega_{pc}} = 5$

$\therefore$ GM = 5

55. The synchronous speed of an induction motor is 900 rpm. Under a blocked rotor condition, the input power to the motor is 45 kW at 193.6A. The stator resistance per phase is 0.2 Ω and the transformation ratio is a = 2. The ohmic value of the rotor resistance per phase is

(A) 0.05Ω (B) 0.1Ω (C) 0.25 Ω (D) 0.8 Ω

Ans: (A)

Sol: $P_{BR} = 3I_{BR}^2\left(R_1 + R_2^1\right)$

$$= 3I_{BR}^2\left(R_1 + a^2R_2\right)$$

$$0.2 + 4\times R_2 = \frac{45\times10^3}{3\times193.6^2}$$

$$R_2 = 0.05\Omega$$

DISTRACTOR LOGIC

Option:B $P_{BR} = 3I_{BR}^2\left(R_1 + R_2^1\right)$

$$= 3I_{BR}^2\left(R_1 + aR_2\right)$$

$$0.2 + 2\times R_2 = \frac{45\times10^3}{3\times193.6^2}$$

$$R_2 = 0.1\Omega$$

Option:C $P_{BR} = I_{BR}^2\left(R_1 + R_2^1\right)$

$$= I_{BR}^2\left(R_1 + a^2R_2\right)$$

$$0.2 + 4\times R_2 = \frac{45\times10^3}{193.6^2}$$

$$R_2 = 0.25\ \Omega$$

Option:D $P_{BR} = 3I_{BR}^2\left(R_1 + R_2^1\right)$

$$= 3I_{BR}^2\left(R_1 + \frac{R_2}{a^2}\right)$$

$$0.2 + \frac{R_2}{4} = \frac{45\times10^3}{3\times193.6^2}$$

$$R_2 = 0.8\ \Omega$$

56. A protection system is installed with $1\frac{1}{2}$ cycle circuit breaker. If the relay issued TRIP signal to breaker at voltage zero instant, the breaker operating time is

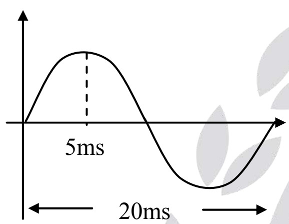
(A) 30ms (B) 35ms (C) 25 ms (D) 40ms

Ans (B)

Sol: Voltage zero means current is peak

For 50Hz,

Time period (T) $= \frac{1}{50}\text{m sec} = 20\text{m sec}$



$1\frac{1}{2}$ cycle circuit breaker $\Rightarrow$circuit breaker opening time = 20 +10 =30ms

Arcing time = 5ms

Circuit breaker operating time

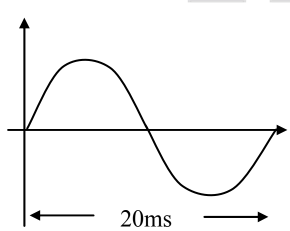
= opening time + arcing time

= 30+5 = 35ms

DISTRACTOR LOGIC

Option-A: Voltage zero means current is peak for 50Hz,

Time period (T) $= \frac{1}{50}\text{m sec} = 20\text{m sec}$

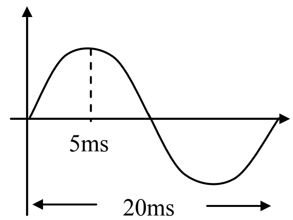


$1\frac{1}{2}$ cycle circuit breaker $\Rightarrow$circuit breaker opening time = 20+10 =30ms

Option-C: Voltage zero means current is peak

For 50Hz,

Time period (T) $= \frac{1}{50}$ msec = 20msec



$1\frac{1}{2}$ cycle circuit breaker ⇒circuit breaker opening time = 20 +10 =30ms

Arcing time = 5ms

Circuit breaker operating time

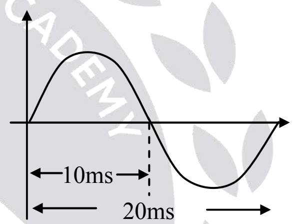
= opening time – arcing time

= 30 – 5 = 25ms

Option-D: Voltage zero means current is peak

For 50Hz,

Time period (T) $= \frac{1}{50}$ msec = 20msec



$1\frac{1}{2}$ Cycle circuit breaker ⇒circuit breaker opening time = 20 +10 =30ms

Arcing time = 10 ms

Circuit breaker operating time

= opening time – arcing time

= 30 + 10 = 40ms

57. The input signal x(t) = 4+cos(4πt) – sin(8πt) is passed though a filter with impulse response h(t) = Sinc^2(t) cos(16πt). Then the output is_________

(A) $\frac{1}{4}$cos(4πt) (B) –0.5sin(8πt) (C) 0 (D) 4+cos(4πt)–sin(8πt)

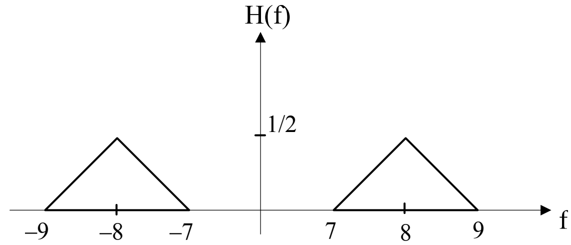
Ans: (C)

Sol: The input frequencies are $f_1 = 0$, $f_2 = 2Hz$, $f_3 = 4Hz$

$Sinc^2(t) \leftrightarrow Tri(f)$

$$H(f) = \frac{Tri(f-8) + Tri(f+8)}{2}$$

So no input frequencies are passed through the filter



Distractor Logic:

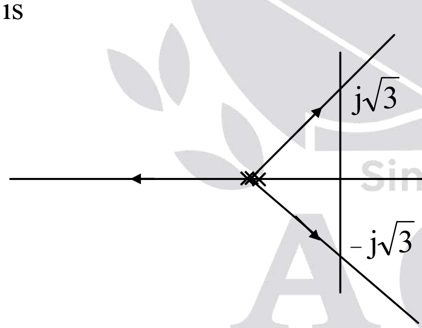
Option A: If you feel filter spectrum covers the frequency range from 1 – 3Hz misinterpretation of Ans(A)

Option B: If you feel filter spectrum covers the frequency range from 3 – 5Hz misinterpretation of Ans(B)

Option C: Correct option

Option D: If you feel that h(t) is ideal all pass filter with pass band gain of 1, that passes all frequencies. misinterpretation of Ans(D)

58. The root loci diagram of a unity feedback system is given below. The closed loop transfer function for K = 2, is

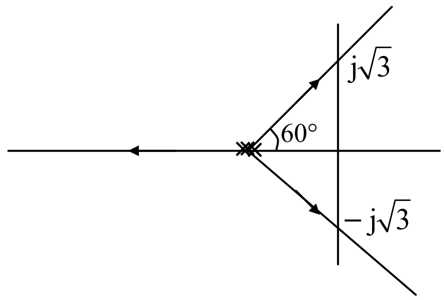


(A) $\frac{2}{s^3 + 3s^2 + 3s + 1}$ (B) $\frac{1}{s^3 + 3s^2 + 3s + 1}$

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

Ans: (D)

Sol: $\tan 60° = \dfrac{\sqrt{3}}{x} \Rightarrow x = 1$



Pole is at s = –1

Open loop TF $G(s) = \dfrac{K}{(s+1)^3}$

Closed loop TF $= \dfrac{G(s)}{1+G(s)H(s)}$

H(s) = 1, K = 2

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

DISTRACTOR LOGIC:

Option A: Three poles are at s = –1

$$\therefore\ TF = \frac{K}{(s+1)^3} = \frac{2}{(s+1)^3} = \frac{2}{s^3+3s^2+3s+1}$$

Option B: Three poles are at s = –1

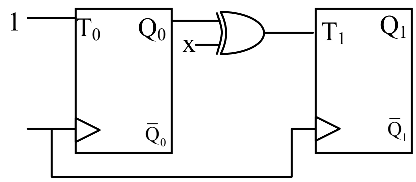
$$TF = \frac{1}{(s+1)^3} = \frac{1}{s^3+3s^2+3s+1}$$

Option C: Three poles at s = –1

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

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

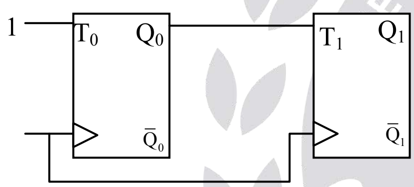
59. The following counter is a



(A) up counter when x = 0
(B) down counter when x = 0
(C) up counter when x = 1
(D) always up counter

Ans: (A)

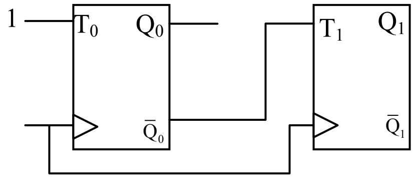
Sol: If x = 0 ⇒ $T_1 = Q_0$



Present state Q_1	Q_0	T_1	T_0	Next state Q_1	Q_0
0	0	0	1	0	1
0	1	1	1	1	0
1	0	0	1	1	1
1	1	1	1	0	0

∴ If x = 0 given counter is up counter

If x = 1 ⇒ $T_1 = \bar{Q}_0$



Present state Q_1	Q_0	T_1	T_0	Next state Q_1	Q_0
0	0	1	1	1	1
0	1	0	1	0	0
1	0	1	1	0	1
1	1	0	1	1	0

∴ If x = 1 given counter is down counter.

60. Two identical generators are connected in parallel to a common bus. Sequence reactances of each generator are $X_1 = X_2 = j0.2$ pu and $X_0 = j0.05$ pu. The neutral of one of the generator is connected to ground by reactance of j0.05 pu and other generator neutral is isolated from ground. A most common short circuit fault is taking place at the common busbar with a fault reactance of j0.05 pu. If the operating voltage of busbar is 13.2 kV, then the voltage of zero sequence network in kV is

(A) 2.77 (B) 3.54 (C) 6.66 (D) 4.42

Ans: (A)

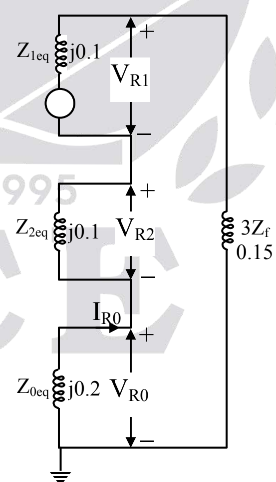
Sol: $X_{1eq} = \dfrac{j0.2}{2} = j0.1$

$X_{2eq} = \dfrac{j0.2}{2} = j0.1$

$X_{0eq} = X_0 + 3X_n + 3X_F$

$= 0.05 + 3\times0.05 + 3\times0.05$

$= 0.35$



$$I_{R_0} = I_{R_1} = \frac{E_{R_1}}{Z_{1_{eq}} + Z_{2_{eq}} + Z_{0_{eq}}}$$

$$= \frac{1.0}{j0.1 + j0.1 + j0.35}$$

$$I_{R_0} = I_{R_1} = \frac{1.0}{j\,0.55} = 1.82\angle -90^\circ$$

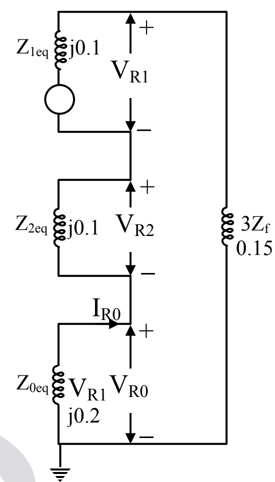
$$V_{R_0} = -I_{R_0} X_{0eq} = -1.82\angle -90^\circ \times 0.2\angle 90^\circ$$

$$V_{R_0} = -0.364 = 0.364\text{pu}$$

$$V_{R_0} = 0.364 \times \frac{13.2}{\sqrt{3}} = 2.77\text{kV}$$

DISTRACTOR LOGIC

Option B: $X_{1eq} = j0.2$



$X_{2eq} = j0.2$

$X_{0eq} = X_0 + 3X_n + 3X_F$

$= 0.05 + 3\times0.05 + 3\times0.05$

$= 0.35$

$$I_{R_0} = I_{R_1} = \frac{E_{R_1}}{Z_{1_{eq}} + Z_{2_{eq}} + Z_{0_{eq}}} = \frac{1.0}{j0.2 + j0.2 + j0.35}$$

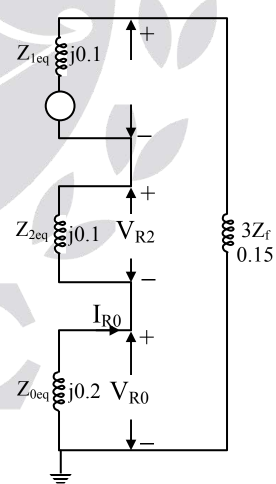
$$I_{R_0} = I_{R_1} = \frac{1.0}{j\,0.75} = 1.33\angle-90^\circ$$

$$V_{R_0} = -I_{R_0} X_{0eq} = -1.33\angle-90^\circ \times 0.35\angle 90^\circ$$

$$V_{R_0} = -0.465 = 0.465\,\text{pu}$$

$$V_{R_0} = 0.465 \times \frac{13.2}{\sqrt{3}} = 3.54\,\text{kV}$$

Option C: $X_{1eq} = \frac{j0.2}{2} = j0.1$



$X_{2eq} = \frac{j0.2}{2} = j0.1$

$X_{0eq} = X_0 + 3X_n + 3X_f$

$= 0.05 + 3\times0.05 + 3(0.05)$

$= 0.35$

$$I_{R_0} = I_{R_1} = \frac{E_{R_1}}{Z_{1_{eq}} + Z_{2_{eq}} + Z_{0_{eq}}} = \frac{1.0}{j0.1 + j0.1 + j0.2}$$

$$I_{R_0} = I_{R_1} = \frac{1.0}{j\,0.4} = 2.5\angle-90^\circ$$

$$V_{R_0} = -I_{R_0} X_{0eq} = -2.5\angle-90^\circ \times 0.35\angle 90^\circ$$

$$V_{R_0} = -0.875 = 0.875\,\text{pu}$$

$$V_{R_0} = 0.875 \times \frac{13.2}{\sqrt{3}} = 6.66\,\text{kV}$$

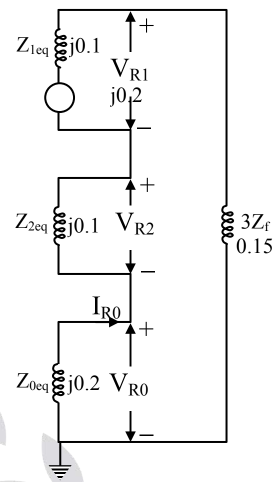
Option D: $X_{1eq} = j0.2$

$X_{2eq} = j0.2$

$X_{0eq} = X_0 + 3X_n + 3X_f$

$= 0.05 + 3\times 0.05 + 3\times 0.05$

$= 0.35$



$$I_{R_0} = I_{R_1} = \frac{E_{R_1}}{Z_{1_{eq}} + Z_{2_{eq}} + Z_{0_{eq}}} = \frac{1.0}{j0.2 + j0.2 + j0.2}$$

$$I_{R_0} = I_{R_1} = \frac{1.0}{j\,0.6} = 1.66\angle -90^\circ$$

$$V_{R_0} = -I_{R_0} X_{0eq} = -1.66\angle -90^\circ \times 0.35\angle 90^\circ$$

$$V_{R_0} = -0.581 = 0.581\,\text{pu}$$

$$V_{R_0} = 0.581 \times \frac{13.2}{\sqrt{3}} = 4.42\,\text{kV}$$

61. $\displaystyle\int_C \frac{z\cos z}{\left(z-\frac{\pi}{2}\right)^2}dz = ?$ where 'C' is $|z-1| = 1$

(A) $i\pi$ (B) $-i\pi$ (C) $i\pi^2$ (D) $-i\pi^2$

Ans: (D)

Sol: $z = \frac{\pi}{2} = \frac{3.14}{2} = 1.57$ is a pole of order '2' lies inside 'C'

$$\therefore \int_C \frac{z\cos z}{\left(z-\frac{\pi}{z}\right)^2}dz = 2\pi i\, f^1\left(\frac{\pi}{2}\right) \text{ (where } f(z) = z\cos z)$$

$$= 2\pi i\left(\frac{-\pi}{2}\right)$$

$$= -\pi^2 i$$

62. $f(x, y) = (x^2 + y^2 + 6x + 12)$ has

(A) maximum value at (–3, 0) (B) minimum value at (–3, 0)

(C) maximum value at (0, –3) (D) minimum value at (0, –3)

Ans: (B)

Sol: $\frac{\partial f}{\partial x} = (2x + 6) = 0$ ………. (1)

$\frac{\partial f}{dy} = 2y = 0$ ……………. (2)

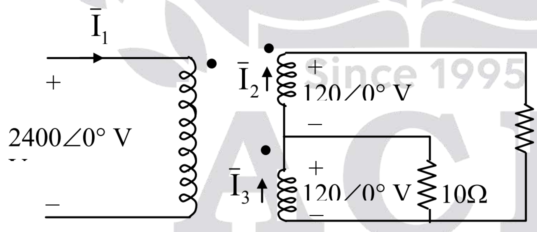
By solving (1) & (2) for (x, y) = (–3, 0) is the stationary point

$r = \frac{\partial^2 f}{\partial x^2} = 2$, $s = \frac{\partial^2 f}{\partial x \partial y} = 0$, $t = \frac{\partial^2 f}{\partial y^2} = 2$

$\therefore$ At (–3, 0); $(rt - s^2) = 4$ & $r = 2$

$\therefore$ we get minimum value of f(x ,y)

63. An ideal residential distribution transformer is connected as shown in the Fig. Assume that the two series-connected secondary windings are identical. Determine the primary current and minimum kVA rating of a 2400:240/120V transformer required to sustain this load without risk of winding over-temperature.



(A)1.8 A, 5.76 kVA (B) 1.03 A, 4.07 kVA

(C) 1.8 A, 2.88 kVA (D) 1.03 A, 2.03 kVA

Ans: (A)

Sol: $\bar{I}_2 = \frac{240\angle 0^\circ}{20} = 12\angle 0^\circ$ A

$\bar{I}_3 = \frac{120\angle 0^\circ}{10} + \bar{I}_2 = 12\angle 0^\circ + 12\angle 0^\circ = 24\angle 0^\circ$ A

$\bar{I}_1 = \frac{120}{2400}\bar{I}_2 + \frac{120}{2400}\bar{I}_3 = \frac{120}{2400}(36\angle 0^\circ) = 1.8\angle 0^\circ$ A

Since $\bar{I}_3$ is the larger secondary current, the rating is dictated by the lower secondary winding; thus,

$$S_R = 2V_3I_3 = 2(120)(24) = 5.76 \text{ kVA}$$

DISTRACTOR LOGIC

Option B: $\overline{I}_2 = \dfrac{240\angle 0^\circ}{20} = 12\angle 0^\circ \text{ A}$

$$\bar{I}_3 = \frac{120\angle 0^\circ}{10} + \bar{I}_2 = 12\angle 0^\circ + 12\angle 0^\circ = 16.97\angle 0^\circ \text{ A}$$

$$\bar{I}_1 = \frac{120}{2400}\bar{I}_2 + \frac{120}{2400}\bar{I}_3 = \frac{120}{2400}(36\angle 0^\circ) = 1.03\angle 0^\circ \text{ A}$$

$$S_R = 2V_3I_3 = 2(120)(16.97) = 4.072 \text{ kVA}$$

Option C: $\overline{I}_2 = \dfrac{240\angle 0^\circ}{20} = 12\angle 0^\circ \text{ A}$

$$\bar{I}_3 = \frac{120\angle 0^\circ}{10} + \bar{I}_2 = 12\angle 0^\circ + 12\angle 0^\circ = 24\angle 0^\circ \text{ A}$$

$$\bar{I}_1 = \frac{120}{2400}\bar{I}_2 + \frac{120}{2400}\bar{I}_3 = \frac{120}{2400}(36\angle 0^\circ) = 1.8\angle 0^\circ \text{ A}$$

$$S_R = 2V_3I_3 = (120)(24) = 2.88 \text{ kVA}$$

Option D: $\overline{I}_2 = \dfrac{240\angle 0^\circ}{20} = 12\angle 0^\circ \text{ A}$

$$\bar{I}_3 = \frac{120\angle 0^\circ}{10} + \bar{I}_2 = 12\angle 0^\circ + 12\angle 0^\circ = 16.97\angle 0^\circ \text{ A}$$

$$\bar{I}_1 = \frac{120}{2400}\bar{I}_2 + \frac{120}{2400}\bar{I}_3 = \frac{120}{2400}(36\angle 0^\circ) = 1.03\angle 0^\circ \text{ A}$$

$$S_R = 2V_3I_3 = (120)(16.97) = 2.036 \text{ kVA}$$

64. If the probability that a man aged ‘X’ years will die within a year be ‘P’ then the chance that out of 5 men A, B, C, D and E each aged ‘X’ years, ‘A’ will die during the year and be the first person to die is ____________

(A) $\dfrac{P(1-P)^4}{5}$ (B) $\dfrac{1-(1-P)^5}{5}$ (C) $1 - (1 - P)^5$ (D) $P(1 - P)^4$

Ans: (B)

Sol: The probability that a man aged 'X' year will not die within a year is $(1 - P)$

$\therefore$ The chance that none of the five persons die within a year is $(1 - P)^5$

$\therefore$ $1 - (1 - P)^5$ gives atleast one of the five dies within a year

$\therefore$ Anyone has the same chance of being dead first, hence the required probability $= \frac{1-(1-P)^5}{5}$.

NO-DISTRACTOR LOGIC

65. An RC low pass filter has the impulse response $h(t) = e^{-t}\, u(t)$. The response of the system due to the input $x(t) = e^{2t}\, u(-t)$ is________

(A) $\frac{1}{3}e^{2t}u(-t)+\frac{1}{3}e^{-t}u(t)$

(B) $\frac{-1}{3}e^{2t}u(t)-\frac{1}{3}e^{-t}u(-t)$

(C) $-\frac{1}{3}e^{2t}u(-t)-\frac{1}{3}e^{-t}u(t)$

(D) $e^{2t}u(-t)+e^{-t}u(t)$

Ans: (A)

Sol: $H(s)=\frac{1}{s+1}$; $\sigma > -1$

$X(s)=\frac{-1}{s-2}$; $\sigma < 2$

Output ROC = $(\sigma > -1) \cap (\sigma < 2) = -1 < \sigma < 2$

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

Based on the output ROC, take inverse Laplace transform

$$y(t)=\frac{1}{3}e^{2t}u(-t)+\frac{1}{3}e^{-t}u(t)$$

Distractor Logic:

Option A: Correct Answer

Option B: In the partial fraction if we feel pole '2' is right sided & pole '–1' is left sided

Option C: In the partial fraction expansion if we take negative sign of Y(s) as it is

Option D: In the partial fraction expansion if we miss $\frac{1}{3}$ multipliers