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GATE 2016

Detailed Solutions For Electrical Engineering

Date: 06-02-2016

Afternoon Session

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Q. 1 – Q. 5 carry One mark each.

01. The man who is now Municipal Commissioner worked as ___________
(A) the security guard at a university
(B) a security guard at the university
(C) a security guard at university
(D) the security guard at the university

Ans: (B)

Sol: Option (A) and (D) cannot be the answers because of the word 'the security'

02. Nobody knows how the Indian cricket team is going to cope with the difficult and seamer-friendly wickets in Australia.
Choose the option which is closest in meaning to the underlined phrase in the above sentence.
(A) put up with (B) put in with (C) put down to (D) put up against

Ans: (A)

Sol: 'cope with' means put up with

03. Find the odd one in the following group of words.
mock, deride , praise, jeer
(A) mock (B) deride (C) praise (D) jeer

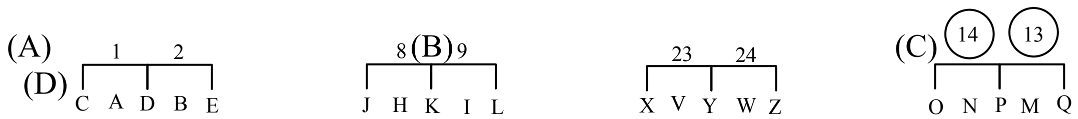
Ans: (C)

Sol: 'mock, deride and jeer' are synonyms which means mockery. Therefore, the odd one is 'praise'

04. Pick the odd one from the following options.
(A) CADBE (B) JHKIL (C) XVYWZ (D) ONPMQ

Ans: (D)

Sol:



In options A, B and C, the letters skipped between consecutive pair of letters in the English alphabet is in increasing order (i,e) A and B, H and I and V and W but in option 'D' N and M are present instead of M and N so, option 'D' is odd one from the group.

05. In a quadratic function, the value of the product of the roots (α, β) is 4. Find the value of $\dfrac{\alpha^n+\beta^n}{\alpha^{-n}+\beta^{-n}}$
(A) n^4 (B) 4^n (C) 2^{2n-1} (D) 4^{n-1}

Ans: (B)

Sol: $$\frac{\alpha^n+\beta^n}{\alpha^{-n}+\beta^{-n}}=\frac{\alpha^n+\beta^n}{\frac{1}{\alpha^n}+\frac{1}{\beta^n}}=\frac{\alpha^n+\beta^n}{\frac{\beta^n+\alpha^n}{\alpha^n+\beta^n}}=\alpha^n\times\beta^n$$

$\alpha^n \times \beta^n = (\alpha\times\beta)^n = (4)^n$

Q. 06 – Q. 10 carry two marks each.

06. Among 150 faculty members in an institute, 55 are connected with each other through Facebook® and 85 are connected through WhatsApp®. 30 faculty members do not have Facebook® or WhatsApp® accounts. The number of faculty members connected only through Facebook® accounts is __________

(A) 35 (B) 45 (C) 65 (D) 90

Ans: (A)

Sol: Total faculty members = 150

The faculty members having facebook account = FB = 55

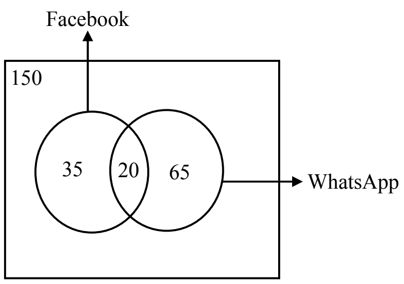
The faculty members having whatsapp = W = 85

The faculty members do not have face book (or) Whats App accounts = 30

The faculty members having any account = 150 – 30 = 120

The faculty members having both the accounts = (FB + W) – 120 = (55 + 85) – 120 = 20

∴ The number of faculty members connected only through Facebook accounts = 55 – 20 = 35



07. Computers were invented for performing only high-end useful computations. However, it is no understatement that they have taken over our world today. The internet, for example, is ubiquitous. Many believe that the internet itself is an unintended consequence of the original invention. With the advent of mobile computing on our phones, a whole new dimension is now enabled. One is left wondering if all these developments are good or, more importantly, required.

Which of the statement(s) below is/are logically valid and can be inferred from the above paragraph?

(i) The author believes that computers are not good for us.

(ii) Mobile computers and the internet are both intended inventions.

(A) (i) only (B) (ii) only (C) both (i) and (ii) (D) neither (i) nor (ii)

Ans: (B)

Sol: The first and second sentences tell us that computers are invented for computation and internet for intended invention. These sentences lead to option ii so option (B) is the right inference

08. All hill-stations have a lake. Ooty has two lakes.

Which of the statement(s) below is/are logically valid and can be inferred from the above sentences?

(i) Ooty in not a hill-station.

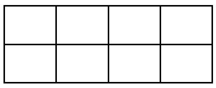
(ii) No hill-station can have more than one lake.

(A) (i) only (B) (ii) only (C) both (i) and (ii) (D) neither (i) nor (ii)

Ans: (D)

Sol: Statement (i) is not true because Ooty is a hill station due Ooty has two lakes statement(ii) is also not true, because in given statements, for hill station one lake is compulsory but not mentioned about number of lakes.

09. In a 2 × 4 rectangle grid shown below, each cell is a rectangle. How many rectangles can be observed in the grid?

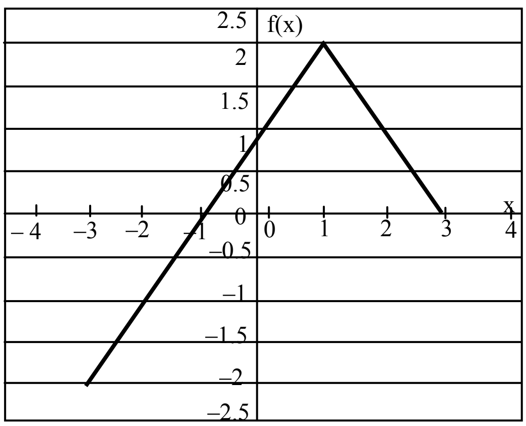


(A) 21 (B) 27 (C) 30 (D) 36

Ans: (C)

Sol: In given 2 × 4 rectangle grid, the following type of rectangles are present.
One figured rectangles = 8
Two figured rectangles = 10
Three figured rectangles = 4
Four figured rectangles = 5
Six figured rectangles = 2
Eight figured rectangles = 1
Total No. of rectangles = 30
∴ The No. of rectangles observed in the given grid = 30.

10.



Choose the correct expression for $f(x)$ given in the graph.

(A) $f(x) = 1 - |x-1|$ (B) $f(x) = 1 + |x-1|$

(C) $f(x) = 2 - |x-1|$ (D) $f(x) = 2 + |x-1|$

Ans: (C)

Sol: @ x = 3 from given graph f(x) must be equals to zero

Option A

$f(x) = 1 - |x - 1|$

@ $x = 3$

$f(x) = 1 - |3 - 1|$

$= 1 - 2 = - 1$

So, it is not

Option B

$f(x) = 1 + |x - 1|$

@ $x = 3$

$f(x) = 1 + |3 - 1|$

$= 1 + 2 = 3$

So, it is not

Option C

$f(x) = 2 - |x - 1|$

@ $x = 3$

$f(x) = 2 - |3 - 1|$

$= 2 - 2 = 0$

So, it is true

Option D

$f(x) = 2 + |x - 1|$

@ $x = 3$

$f(x) = 2 - |3 - 1|$

$= 2 + 2 = 4$

So, it is not

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Q. 1 – Q. 25 carry One mark each.

01. The maximum value attained by the function f(x) = x(x –1) (x –2) in the interval [1, 2] is _______

Ans: 0

Sol: f(x) = x(x–1)(x–2) in [1, 2]

$$f'(x) = 3x^2 - 6x + 2 = 0 \Rightarrow x = \frac{3 \pm \sqrt{3}}{3}$$

$$f''(x) = 6x - 6$$

$$f''\left(\frac{3+\sqrt{3}}{3}\right) = 3.4 > 0 \Rightarrow \text{minimum}$$

$$f''\left(\frac{3-\sqrt{3}}{3}\right) = -3.4 < 0 \Rightarrow \text{maximum}$$

f(1) = 0, f(2) = 0

Max value = 0

02. Consider 3 ×3 matrix with every element being equal to 1. Its only non-zero eigenvalue is _______

Ans: 3

Sol: $A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$

Char equation is $|A - \lambda I| = 0 \Rightarrow -\lambda^3 + 3\lambda^2 = 0$

$\Rightarrow \lambda = 3, 0, 0$

03. The Laplace Transform of $f(t) = e^{2t} \sin(5t)\, u(t)$ is

(A) $\frac{5}{s^2 - 4s + 29}$ (B) $\frac{5}{s^2 + 5}$ (C) $\frac{s-2}{s^2 - 4s + 29}$ (D) $\frac{5}{s+5}$

Ans: (A)

Sol: $\sin 5t\, U(t) \overset{LT}{\leftrightarrow} \frac{5}{s^2 + 5^2}$

$e^{2t} \sin 2t U(t) \overset{LT}{\leftrightarrow} \frac{5}{(s-2)^2 + 25}$ $\left(\because e^{at} f(t) \overset{LT}{\leftrightarrow} F(s-a)\right)$

$$= \frac{5}{s^2 + 4 - 2 \times 2(s) + 25}$$

$$= \frac{5}{s^2 + 4 - 4s + 25}$$

$$= \frac{5}{s^2 - 4s + 29}$$

$\therefore\ e^{2t}\sin 2tU(t) \overset{LT}{\leftrightarrow} \dfrac{5}{s^2-4s+29}$

04. A function y(t), such that y(0) = 1 and $y(1) = 3e^{-1}$, is a solution of the differential equation $\dfrac{d^2y}{dt^2}+2\dfrac{dy}{dt}+y=0$. Then y(2) is

(A) $5e^{-1}$ (B) $5e^{-2}$ (C) $7e^{-1}$ (D) $7e^{-2}$

Ans: (B)

Sol: Given equation $m^2+2m+1 = 0$

$(m+1)^2 = 0$

$y(t) = (c_1+c_2t)e^{-t}$

given y(0) = 1

$1 = c_1$

Given $y(1) = 3e^{-1}$

$3e^{-1} = (1+c_2)e^{-1}$

$3 = 1 + c_2$

$c_2 = 2$

$\therefore\ y(t) = (1+2t)e^{-t}$

$y(2) = 5e^{-2}$

05. The value of the integral $\oint_C \dfrac{2z+5}{\left(z-\frac{1}{2}\right)\left(z^2-4z+5\right)}dz$ over the contour |z| = 1, taken in the anti-clockwise direction, would be

(A) $\dfrac{24\pi i}{13}$ (B) $\dfrac{48\pi i}{13}$ (C) $\dfrac{24}{13}$ (D) $\dfrac{12}{13}$

Ans: (B)

Sol: $f(z) = \dfrac{2(1/2)+5}{(1/2)^2-4(1/2)+5} = \dfrac{6}{13/4} = \dfrac{24}{13}$

Ans = $2\pi i$ [sum of residues]

$= 2\pi i\times\dfrac{24}{13} = \dfrac{48\pi i}{13}$

06. The transfer function of a system is $\dfrac{Y(s)}{R(s)} = \dfrac{s}{s+2}$. The steady state output y(t) is $A\cos(2t+\phi)$ for the input cos(2t). The values of A and ϕ, respectively are

(A) $\dfrac{1}{\sqrt{2}}, -45^\circ$ (B) $\dfrac{1}{\sqrt{2}}, +45^\circ$ (C) $\sqrt{2}, -45^\circ$ (D) $\sqrt{2}, +45^\circ$

Ans: (B)

Sol: $A = \left|\dfrac{j\omega}{j\omega+2}\right|_{\omega=2} = \dfrac{2}{\sqrt{2^2+2^2}} = \dfrac{2}{2\sqrt{2}} = \dfrac{1}{\sqrt{2}}$

$$\phi = \angle \frac{j\omega}{j\omega+2}\bigg|_{\omega=2} = 90^\circ - \tan^{-1}\frac{2}{2} = 45^0$$

07. The phase cross-over frequency of the transfer function $G(s)\ \dfrac{100}{(s+1)^3}$ in rad/s is

(A) $\sqrt{3}$ (B) $\dfrac{1}{\sqrt{3}}$ (C) 3 (D) $3\sqrt{3}$

Ans: (A)

Sol: $\angle \dfrac{100}{(j\omega+1)^3} = -180^\circ\Big|_{\omega=\omega_{pc}}$

$-3\tan^{-1}\omega_{Pc} = -180$

$\omega_{PC} = \sqrt{3}$

08. Consider a continuous-time system with input x(t) and output y(t) given by y(t) = x(t) cos(t)
This system is
(A) linear and time-invariant
(B) non-linear and time-invariant
(C) linear and time-varying
(D) non-linear and time-varying

Ans: (C)

Sol: given y(t) = x(t) cos(t)
It satisfies both additivity and Homogentity principles, so it is linear
If the input is delayed by t_0
$y_1(t) = x\,(t - t_0)\cos(t)$
If the output is delayed by t_0
$y(t - t_0) = x(t - t_0) = x(t - t_0)\cos(t - t_0)$
here, $y_1(t) \neq y(t - t_0)$, So, it is time varying.

09. The value of $\int_{-\infty}^{+\infty} e^{-t}\delta(2t-2)dt$, where $\delta(t)$ is the Dirac delta function is

(A) $\dfrac{1}{2e}$ (B) $\dfrac{2}{e}$ (C) $\dfrac{1}{e^2}$ (D) $\dfrac{1}{2e^2}$

Ans: (A)

Sol: $\int_{-\infty}^{\infty} e^{-t}\delta(2t-2)dt = \int_{-\infty}^{\infty} e^{-t}\delta(2(t-1))dt$

$$= \int_{-\infty}^{\infty} e^{-t}\frac{1}{|2|}\delta(t-1)dt$$

$$= \frac{1}{2}\int_{-\infty}^{\infty} e^{-t}\delta(t-1)dt$$

$$= \frac{1}{2}e^{-1} = \frac{1}{2e}$$

10. A temperature in the range of –40° C to 55° C is to be measured with a resolution of 0.1°C. The minimum number of ADC bits required to get a matching dynamic range of the temperature sensor is

(A) 8 (B) 10 (C) 12 (D) 14

Ans: (B)

Sol: $\frac{55-(-40)}{2^n} \le 0.1$

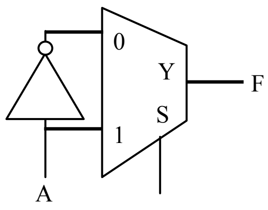
$\frac{95}{2^n} \le 0.1$

$950 \le 2^n$

The minimum 'n' value which can satisfy the above equation is 10

$\therefore$ The minimum number of bits are 10

11. Consider the following circuit which uses a 2-to-1 multiplexer as shown in the figure below. The Boolean expression for output F in terms of A and B is



(A) $A \oplus B$ (B) $\overline{A+B}$ (C) $A+B$ (D) $\overline{A \oplus B}$

Ans: (D)

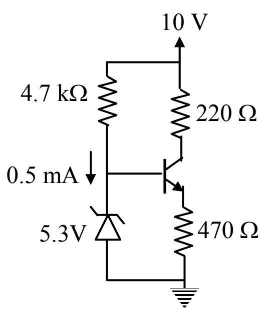
Sol: $F = \bar{S} I_0 + S I_1$

$= \bar{B}\bar{A} + BA$

$= A \odot B$

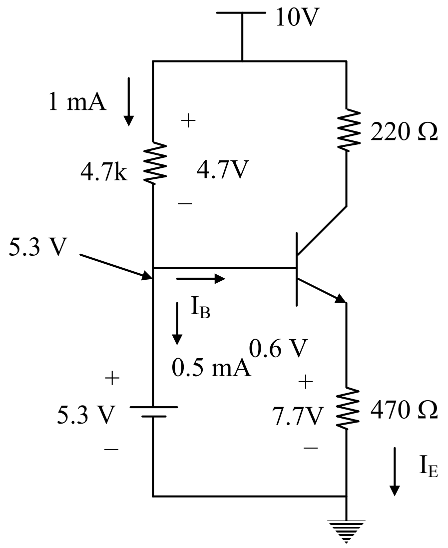
$= \overline{A \oplus B}$

12. A transistor circuit is given below. The Zener diode breakdown voltage is 5.3 V as shown. Take base to emitter voltage drop to be 0.6 V. The value of the current gain β is __________.



Ans: 19

Sol: Zener diode is in breakdown, replace it with a voltage source of value $V_2 = 5.3$ V & $V_{BE} = 0.6$ V



Applying KCL at Base, we get

$I_B = 1 - 0.5 = 0.5$ mA

$$I_E = \frac{4.7}{470} = 10 \text{ mA}$$

$I_E = (\beta + 1)\, I_B$

$$\beta + 1 = \frac{I_E}{I_B} = \frac{10}{0.5}$$

$= 20$

$\Rightarrow \beta = 19$

13. In cylindrical coordinate system, the potential produced by a uniform ring charge is given by $\phi = f(r, z)$, where f is a continuous function of r and z. Let $\vec{E}$ be the resulting electric field. Then the magnitude of $\nabla \times \vec{E}$

(A) increase with r . (B) is 0. (C) is 3. (D) decrease with z.

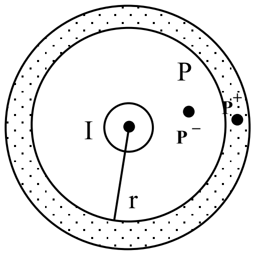
Ans: (B)

Sol: A uniformly charged ring is specified. It can be considered as static. A static electric charge produces an electric field for which $\nabla \times \overline{E} = 0$.

14. A soft-iron toroid is concentric with a long straight conductor carrying a direct current I. If the relative permeability μ_r of soft-iron is 100, the ratio of the magnetic flux densities at two adjacent points located just inside and just outside the toroid is ___________.

Ans: 100

Sol: A 2-dimensional view of a toroidal core is shown. Problem does not give any coil wound around the toroid.

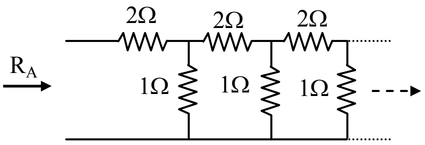


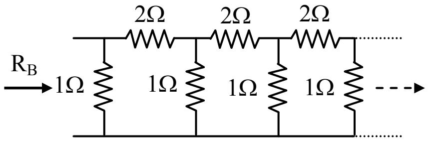
$\overline{B}(P^-)$ due to straight conductor $= \dfrac{\mu_0 I}{2\pi r}$ T

$\overline{B}(P^+)$ due to straight conductor $= \dfrac{100\,\mu_0 I}{2\pi r}$ T

$\overline{B}(P^+)/\overline{B}(P^-) = 100$

15. R_A and R_B are the input resistances of circuits as shown below. The circuits extend infinitely in the direction shown. Which one of the statements is TRUE?

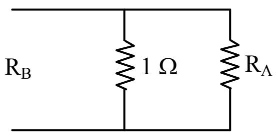




(A) $R_A = R_B$ (B) $R_A = R_B = 0$ (C) $R_A < R_B$ (D) $R_B = R_A/(1+R_A)$

Ans: (D)

Sol:



$$R_B = \frac{1 \times R_A}{1 + R_A}$$

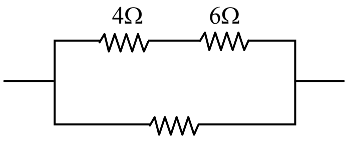
16. In a constant V/f induction motor drive, the slip at the maximum torque
(A) is directly proportional to the synchronous speed.
(B) remains constant with respect to the synchronous speed.
(C) has an inverse relation with the synchronous speed.
(D) has no relation with the synchronous speed.

Ans: (C)

Sol: In an induction motor operating at any voltage V_r, frequency f, slip for max torque = r_2 / x_2 where $x_2 = 2\pi\, L_2$ f.

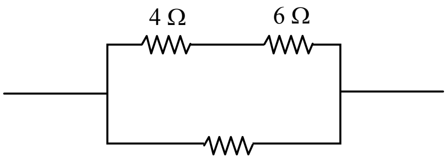
Now; if frequency is changed (irrespective of whether v/f is constant or not) x_2 changes proportionally. So slip for maximum torque is inversely proportional to frequency. Synchronous speed is directly proportional to frequency. Hence slip of maximum torque has an inverse relation with synchronous speed.

17. In the portion of a circuit shown, if the heat generated in 5 Ω resistance is 10 calories per second then heat generated by the 4 Ω resistance, in calories per second, is _________ .



Ans: 2

Sol:

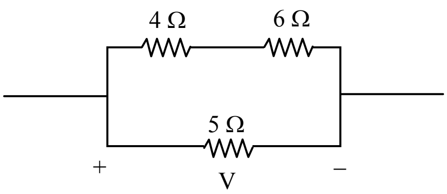


Heat generated by 5 Ω is 10 calories per sec

⇒ 1 calorie per second = 4.184 W

So, power dissipated in 5 Ω is 4.184 × 10

= 41.84 W



So, $\frac{V^2}{5} = 41.84 \Rightarrow V = \sqrt{5(41.84)}$

V = 14.4637

So, Voltage across 4 Ω is

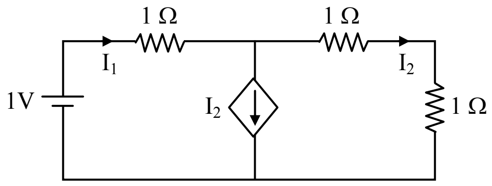
$= 14.4637\left[\frac{4}{10}\right]$

= 5.78548 V

$P_{4\Omega} = \frac{(5.78548)^2}{4} = 8.3679\ \text{Watt}$

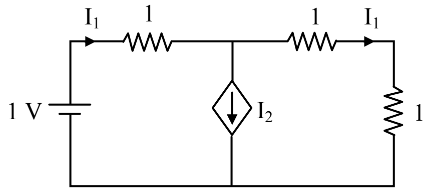
= 2 calories per second

18. In the given circuit, the current supplied by the battery, in ampere, is ________.



Ans: 0.5

Sol:



KVL

$-1 + I_1 + 2I_2 = 0$

$I_1 + 2I_2 = 1$ ……..(1)

also

$I_1 = 2I_2$ ……….(2)

So, current through battery means

$I_1 = \frac{1}{2}$ A

19. In a 100 bus power system, there are 10 generators. In a particular iteration of Newton Raphson load flow technique (in polar coordinates), two of the PV buses are converted to PQ type. In this iteration.

(A) the number of unknown voltage angles increases by two and the number of unknown voltage magnitudes increases by two

(B) the number of unknown voltage angles remains unchanged and the number of unknown voltage magnitudes increases by two

(C) the number of unknown voltage angles increases by two and the number of unknown voltage magnitudes decreases by two

(D) the number of unknown voltage angles remains unchanged and the number of unknown voltage magnitudes decreases by two

Ans: (B)

Sol: Total No. of buses = 100

Generator bus = 10 –1 = 9

Load busses = 90

Slack bus = 1

If 2 buses are converted to PQ from PV it will add 2 unknown voltages to iteration but unknown angles remains constant.

20. The magnitude of three-phase fault currents at buses A and B power system are 10 pu and 8 pu, respectively. Neglect all resistances in the system and consider the pre-fault system to be unloaded. The pre-fault voltage at all buses in the system is 1.0 pu. The voltage magnitude at bus B during a three-phase fault at bus A is 0.8 pu. The voltage magnitude at bus A during a three-phase fault at bus B in pu, is ________.

Ans: 0.84

Sol: Post fault voltage at bus B for fault at bus A is

$V_{BAF} = V_{BBF} - Z_{AB}I_{FA} = 0.8$

$1 - Z_{AB}.\ 10 = 0.8$

$Z_{AB} = 0.02$

Post fault voltage at bus A for fault at Bus 'B'

$V_{AAF} = V_{ABF} - Z_{AB}\ I_{FB}$

$= 1 - 0.02 \times 8 = 1 - 0.16 = 0.84$ pu

21. Consider a system consisting of a synchronous generator working at a lagging power factor, a synchronous motor working at an overexcited condition and a directly grid-connected induction generator. Consider capacitive VAr to be a source and inductive VAr to be a sink of reactive power.

Which one of the following statements is TRUE?

(A) Synchronous motor and synchronous generator are sources and induction generator is a sink of reactive power.

(B) Synchronous motor and induction generator are sources and synchronous generator is a sink of reactive power.

(C) Synchronous motor is a source and induction generator and synchronous generator are sinks of reactive power.

(D) All the sources of reactive power.

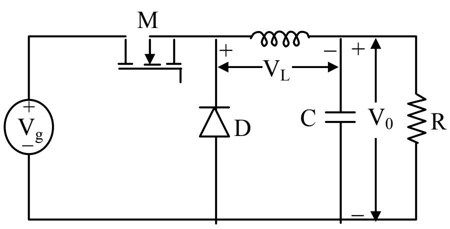
Ans: (A)

Sol: Sync. Generator with lagging PF ⇒ supply P & Q

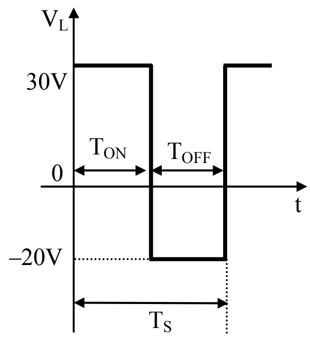
Sync. Motor with over excitation ⇒ supply Q

Induction motor ⇒ Absorbs Q

22. A buck converter, as shown in Figure (a) below, is working in steady state. The output voltage and the inductor current can be assumed to be ripple free. Figure (b) shows the inductor voltage V_L during a complete switching interval. Assuming all devices are ideal, the duty cycle of the buck converter is _________.



(a)



(b)

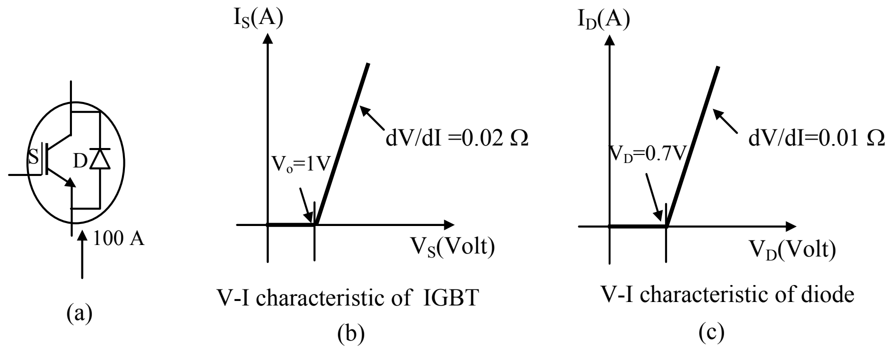
Ans: 0.4

Sol: In steady state, area of inductor voltage for one switching cycle is zero

$$30\times T_{ON} - 20\times T_{OFF} = 0 \Rightarrow \frac{T_{ON}}{T_{OFF}} = \frac{2}{3}$$

Duty cycle $D = \frac{T_{ON}}{T_{ON}+T_{OFF}} = \frac{T_{ON}}{T_{ON}+\frac{3}{2}T_{ON}} = \frac{2}{5} = 0.4$

23. A steady dc current of 100 A is flowing through a power module (S, D) as shown in Figure (a). The V-I characteristics of the IGBT (S) and the diode (D) are shown in Figure (b) and (c), respectively. The conduction power loss in the power module (S, D) in watts, is ________.

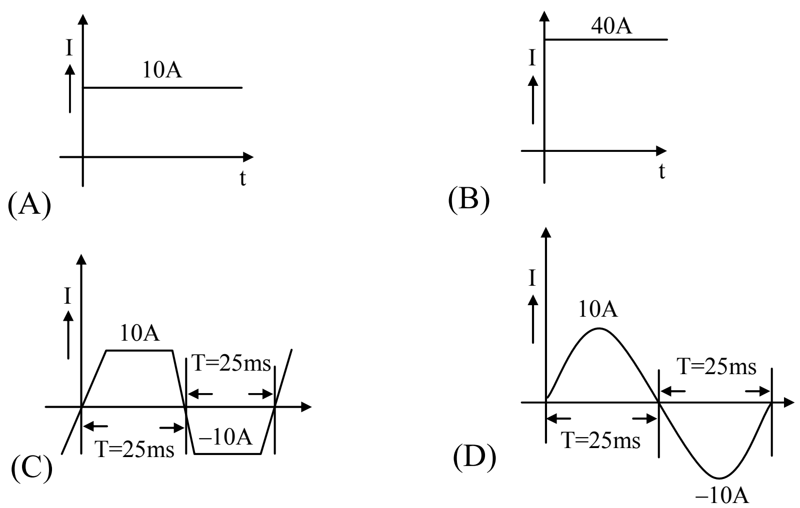


Ans: 170

Sol: No current flows through the IGBT. So current flows only in Diode

Conduction loss = $V_t I_{av} + I_{rms}^2 R_{on} = 0.7\times 100 + 100^2 \times 0.01 = 170\text{ W}$

24. A 4-pole, lap-connected separately excited dc motor is drawing a steady current of 40 A while running at 600 rpm. A good approximation for the waveshape of the current in an armature conductor of the motor is given by

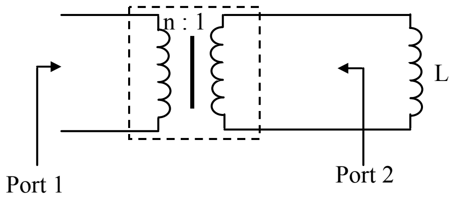


Ans: (C)

Sol: With lap winding, and 4 poles, number of parallel paths = 4, with a total armature current of 40 A; current in each path and hence current in each armature conductor is 10 A. It remains constant at 10 A as long as the conductor is in one path. When it goes into the next path (due to commutator action) the current in it reverses and becomes – 10 A. Assuming straight line commutation, the change from (+ 10 A) to (–10 A) is linear.

With 600 RPM; time for 1 revolution = 0.1 sec. Time of a conductor to cover 1 pole-pitch= 0.1/4 = 25 ms. This is the width of one half cycle of conductor current.

25. If an ideal transformer has an inductive load element at port 2 as shown in the figure below, the equivalent inductance at port 1 is



(A) nL (B) n^2L (C) $\frac{n}{L}$ (D) $\frac{n^2}{L}$

Ans: (B)

Sol: An inductance of L H in the low voltage side becomes n^2L H referred to the high voltage side (hv turns/ lv turns = n).

Q. 26 – Q. 55 carry Two marks each.

26. Candidates were asked to come to an interview with 3 pens each. Black, blue, green and red were the permitted pen colours that the candidate could bring. The probability that a candidate comes with all 3 pens having the same colour is ________.

Ans: 0.01818

Sol: Probability(3 pens) $= \dfrac{3_{C_3} + 3_{C_3} + 3_{C_3}}{12_{C_3}} = \dfrac{4}{12_{C_3}} = 0.01818$

27. Let $S = \sum_{n=0}^{\infty} n\alpha^n$ where $|\alpha| < 1$. The value of α in the range 0 < α < 1, such that S = 2α is ____________.

Ans: 0.2928

Sol: given $s = \sum_{n=0}^{\infty} n\alpha^n$

$s = 0 + 1\alpha + 2\alpha^2 + 3\alpha^3 + \ldots\ldots\infty$

$s = \alpha + 2\alpha^2 + 3\alpha^3 + \ldots\ldots\infty$

$s = \dfrac{\alpha}{(1-\alpha)^2} \qquad (\because\ 0 < \alpha < 1)$

but given, s = 2α

$\dfrac{\alpha}{(1-\alpha)^2} = 2\alpha$

$\dfrac{1}{2} = (1-\alpha)^2$

$(1-\alpha) = \pm\dfrac{1}{\sqrt{2}}$

$1 - \alpha = \dfrac{1}{\sqrt{2}}$ (or) $1 - \alpha = -\dfrac{1}{\sqrt{2}}$

$1 - \dfrac{1}{\sqrt{2}} = \alpha \qquad 1 + \dfrac{1}{\sqrt{2}} = \alpha$

$\alpha = 1 - 0.707 \qquad \alpha = 1.707$

$\alpha = 0.2928$

but given that $0 < \alpha < 1$,

So, $\alpha = 0.2928$

28. Let the eigenvalues of a 2 × 2 matrix A be 1, –2 with eigenvectors x_1 and x_2 repsectively. Then the eigenvalues and eigenvectors of the matrix $A^2 - 3A + 4I$ would respectively, be

(A) 2, 14; x_1, x_2 (B) 2, 14; x_1+x_2: x_1-x_2

(C) 2, 0; x_1, x_2 (D) 2, 0; x_1+x_2, x_1-x_2

Ans: (A)

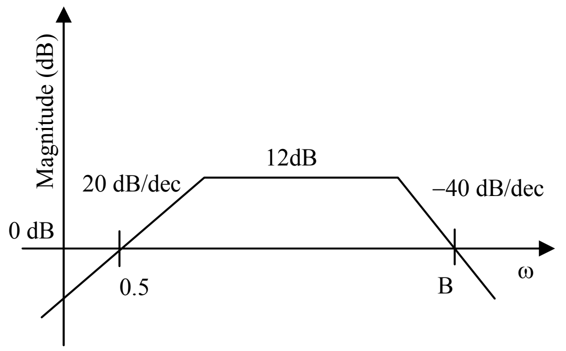
Sol:
$A \rightarrow 1, -2$
$A^2 \rightarrow 1, 4$
$-3A \rightarrow -3, 6$
$4I \rightarrow 4, 4$
$A^2-3A+4I \rightarrow 2, 14$
$\therefore$ eigen values 2, 14
Eigen vectors do not change.

29. Let A be a 4×3 real matrix which rank2. Which one of the following statement is TRUE?
(A) Rank of A^T is less than 2
(B) Rank of A^TA is equal to 2
(C) Rank of A^TA is greater than 2
(D) Rank of A^TA can be any number between 1 and 3

Ans: (B)

Sol: $\rho(A_{4\times3}) = 2;\quad \rho\left(A^T_{3\times4}\right) = 2$
$\rho(A\times B) \le \min[\rho(A), \rho(B)]$
AA^T of order 4×4 whose rank ≤ 2
A^TA is of order 3×3 whose rank ≤ 2

30. Consider the following asymptotic Bode magnitude plot (ω is in rad/s)



Which one of the following transfer functions is best represented by the above Bode magnitude plot?

(A) $\dfrac{2s}{(1+0.5s)(1+0.25s)^2}$ (B) $\dfrac{4(1+0.5s)}{s(1+0.25s)}$

(C) $\dfrac{2s}{(1+2s)(1+4s)}$ (D) $\dfrac{4s}{(1+2s)(1+4s)^2}$

Ans: (A)

Sol: From the given Bode plot the corner frequencies are 2 rad/sec and 4 rad/sec

$$TF = \frac{Ks}{\left(1+\frac{s}{2}\right)\left(1+\frac{s}{4}\right)^2}$$

$20\log K + 20\log\omega = 0$ dB at $\omega = 0.5$

$K = 2$

$$\therefore\ TF = \frac{2s}{(1+0.55)(1+0.25s)^2}$$

31. Consider the following state - space representation of a linear time-invariant system.

$$\dot{x}(t) = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix} x(t),\ \ y(t) = c^T x(t),\ c = \begin{bmatrix} 1 \\ 1 \end{bmatrix} \text{ and } x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

The value of y(t) for $t = \log_e 2$ is ___________.

Ans: 6

Sol: $Y(t) = C^T X(t)$

$X(t) = e^{At} X(0)$

$e^{At} = L^{-1}[(SI-A)^{-1}]$

$$SI - A = \begin{bmatrix} s-1 & 0 \\ 0 & s-2 \end{bmatrix}$$

$$(SI-A)^{-1} = \begin{bmatrix} \frac{1}{s-1} & 0 \\ 0 & \frac{1}{s-2} \end{bmatrix}$$

$$e^{At} = \begin{bmatrix} e^t & 0 \\ 0 & e^{2t} \end{bmatrix}$$

$$X(t) = \begin{bmatrix} e^t & 0 \\ 0 & e^{2t} \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix} = \begin{bmatrix} e^t \\ e^{2t} \end{bmatrix}$$

$$Y(t) = \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} e^t \\ e^{2t} \end{bmatrix}$$

$= [e^t + e^{2t}]_{t=0.693}$ $\qquad t = \ln_e(2) = 0.693$

$= [2+4] = 6$

$Y(t) = 6$

32. Loop transfer function of a feedback system is $G(s)H(s) = \frac{s+3}{s^2(s-3)}$. Take the Nyquist contour in the clockwise direction. Then the Nyquist plot of G(s) encircles $-1 + j0$

(A) once in clockwise direction
(B) twice in clockwise direction
(C) once in anti clockwise direction
(D) twice in anti clockwise direction

Ans: (A)

Sol: $CE = 1 + \frac{s+3}{s^3 - 3s^2} = 0$

$s^3 - 3s^2 + s + 3 = 0$

S^3	1	1
S^2	−3	3
S^1	2	
S^0	3	

Unstable with two right half of s-plane poles

$\therefore$ Z = 2, P = 1

N = P – Z

N = 1 – 2 = –1 once in the cw direction

33. Given the following polynomial equation

$s^3 + 5.5s^2 + 8.5s + 3 = 0$

the number of roots of the polynomial which have real parts strictly less than −1 is ___________.

Ans: 2

Sol: $(Z-1)^3 + (5.5)(Z-1)^2 + 8.5(Z-1) + 3 = 0$

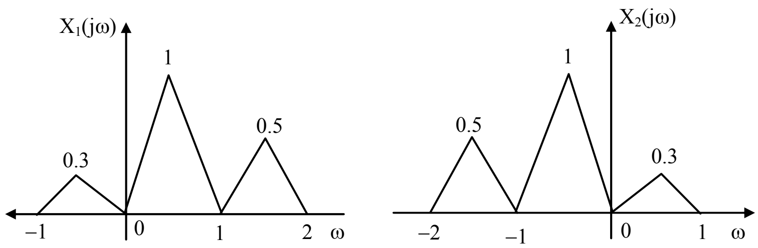
$Z^3 - 3Z^2 + 3Z - 1 + 5.5Z^2 - 11Z + 5.5 + 8.5Z - 8.5 + 3 = 0$

$Z^3 + 2.5Z^2 + 0.5Z - 1 = 0$

$+Z^3$	1	0.5
$+Z^2$	2.5	−1
$+Z^1$	$\frac{2.25}{2.5}$	
$-Z^0$	−1	

Two roots real parts are less than −1

34. Suppose $x_1(t)$ and $x_2(t)$ have the Fourier transforms as shown below



Which one of the following statements is TRUE?

(A) $x_1(t)$ and $x_2(t)$ are complex and $x_1(t)x_2(t)$ is also complex with nonzero imaginary part

(B) $x_1(t)$ and $x_2(t)$ are real and $x_1(t)x_2(t)$ is also real

(C) $x_1(t)$ and $x_2(t)$ are complex but $x_1(t)x_2(t)$ is real

(D) $x_1(t)$ and $x_2(t)$ are imaginary but $x_1(t)x_2(t)$ is real

Ans: (C)

Sol: $A\,tri(t/T) \leftrightarrow AT sa^2\left(\frac{\omega T}{2}\right)$

From duality properly

$$AT s_a^2\left(\frac{tT}{2}\right) \leftrightarrow 2\pi\left[A tri\left(\frac{-\omega}{T}\right)\right]$$

$$T Sa^2\left(\frac{tT}{2}\right) \leftrightarrow 2\pi tri\left(\frac{\omega}{T}\right)$$

$$T = \frac{1}{2}$$

$$\frac{1}{2} Sa^2\left(\frac{tT}{2}\right) \leftrightarrow 2\pi tri(2\omega)$$

$$\frac{1}{4\pi} sa^2\left(\frac{tT}{2}\right) \leftrightarrow tri(2\omega)$$

Assume $x(t) = \frac{1}{4\pi} sa^2\left(\frac{tT}{2}\right)$,

$X(\omega) = tri(2\omega)$

x(t) is real function

$$X_1(\omega) = X\left(\omega - \frac{1}{2}\right) + \frac{1}{2} X\left(\omega - \frac{3}{2}\right) + 0.3X\left(\omega + \frac{1}{2}\right)$$

$$x_1(t) = e^{j\frac{1}{2}t} x(t) + \frac{1}{2} e^{j\frac{3}{2}t} x(t) + 0.3e^{-j\frac{1}{2}t} x(t)$$

$x_1(t)$ is complex function

$X_2(\omega) = x_1(-\omega)$

$x_1(t) = x_1(-t)$

$$x_2(t) = e^{-j\frac{1}{2}t} x(-t) + \frac{1}{2} e^{-j\frac{3}{2}t} x(-t) + 0.3e^{j\frac{1}{2}t} x(-t)\ \ x(-t) = x(t)$$

$$x_2(t) = e^{-j\frac{1}{2}t} x(t) + \frac{1}{2} e^{-j\frac{3}{2}t} x(t) + 0.3e^{j\frac{1}{2}t} x(t)$$

$x_2(t)$ is complex function

$$x_1(t)x_2(t) = x^2(t) + \frac{1}{2}e^{-jt}x^2(t) + 0.3e^{jt}x^2(t) + \frac{1}{2}e^{jt}x^2(t) + \frac{1}{4}x^2(t) + 0.15e^{+j2t}x^2(t)$$
$$+\ 0.3e^{-jt}x^2(t) + 0.15e^{-j2t}x^2(t) + 0.09x^2(t)$$

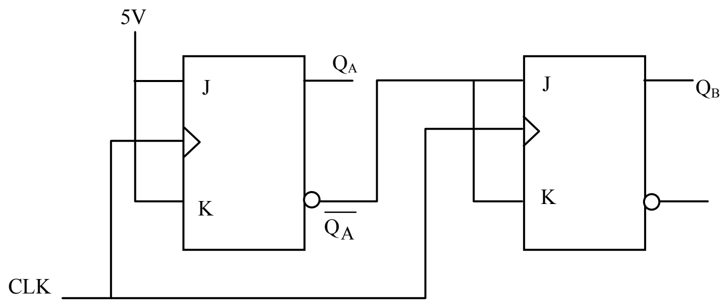
$x_1(t)x_2(t) = x^2(t)[1.34+\cos t+0.6\cos t+0.3\cos 2t]x_1(t)x_2(t)$ is real function

35. The output of a continuous-time linear time-invariant system is denoted by T{x(t)} where x(t) is the input signal A signal z(t) is called eigen-signal of the system T, when T{z(t)} = yz(t), where γ is a complex number, in general and is called an eigenvalue of T. Suppose the impulse response of the system T is real and even. Which of the following statements is TRUE?

(A) cos(t) is an eigen-signal but sin(t) is not
(B) cos(t) and sin(t) are both eigen-signals but with different eigenvalues
(C) sin(t) is an eigen-signal but cos(t) is not
(D) cos(t) and sin(t) are both eigen-signals with identical eigenvalues

Ans: (D)

36. The current state Q_AQ_B of a two JK flip-flop system is 00. Assume that the clock rise-time is much smaller than the delay of the JK flip-flop. The next state of the system is



(A) 00 (B) 01 (C) 11 (D) 10

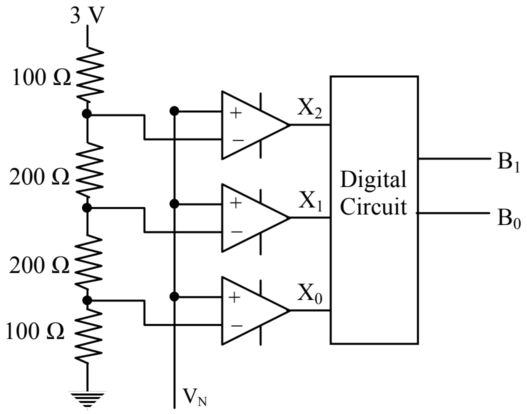
Ans: (C)

Sol:

PS		PI				NS	
Q_A	Q_B	J_A	k_A	$J_B(\overline{Q}_A)$	$k_B(\overline{Q}_A)$	Q_A^+	Q_B^+
		1	1				
0	0	1	1	1	1	1	1

The next state of the system $Q_A\ Q_B = 11$

37. A 2-bit flash Analog to Digital Converter (ADC) is given below. The input is $0 \le V_N \le 3$ Volts. The expression for the LSB of the output B_o as a Boolean function of X_2, X_1 and X_0 is



(A) $X_0\left[\overline{X_2 \oplus X_1}\right]$ (B) $\overline{X}_0\left[\overline{X_2 \oplus X_1}\right]$ (C) $X_0\left[X_2 \oplus X_1\right]$ (D) $\overline{X}_0\left[X_2 \oplus X_1\right]$

Ans: (A)

Sol:

X_2	X_1	X_0	B_1	B_0
0	0	0	0	0
0	0	1	0	1
0	1	1	1	0
1	1	1	1	1

$B_0 = \overline{X}_2\,\overline{X}_1\,X_0 + X_2\,X_1\,X_0$

$= [\overline{X}_2\,\overline{X}_1 + X_2X_1]X_0$

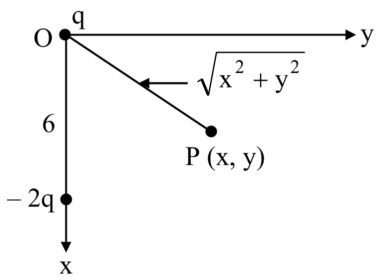
$(X_2 \odot X_1)\,X_0 = X_0\left[\overline{X_2 \oplus X_1}\right]$

38. Two electric charges q and −2q are placed at (0, 0) and (6, 0) on the x−y plane. The equation of the zero equipotential curve in the x−y plane is

(A) x = −2 (B) y = 2 (C) $x^2 + y^2 = 2$ (D) $(x+2)^2+y^2 = 16$

Ans: (D)

Sol:



Potential at P due to q, at origin $= \dfrac{q}{4\pi\varepsilon_0\sqrt{x^2+y^2}}$ V (ref : ∞)

Potential at p due to – 2q at (6,0) $\frac{-2q}{4\pi\varepsilon_0\sqrt{(x-6)^2+y^2}}$ V

Net potential at (given)

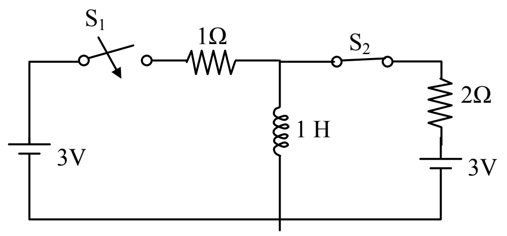
$$P=\frac{q}{4\pi\varepsilon_0}\left[\frac{1}{\sqrt{x^2+y^2}}-\frac{2}{\sqrt{(x-6)^2+y^2}}\right]=0 \therefore \therefore 4(x^2+y^2)=(x-6)^2+y^2=x^2+36-12x+y^2$$

$3x^2 + 3y^2 = 36 - 12x \qquad x^2 + y^2 = 12 - 4x$

$(x + 2)^2 + y^2 = 16$

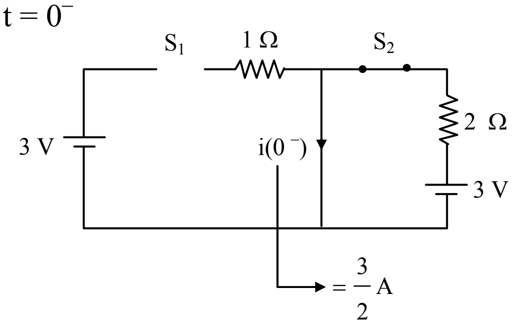
(Equation of zero equipotential curve).

39. In the circuit shown, switch S_2 has been closed for a long time. At time t = 0 switch S_1 is closed. At t = 0^+, the rate of change of current through the inductor, in amperes per second, is ___________.

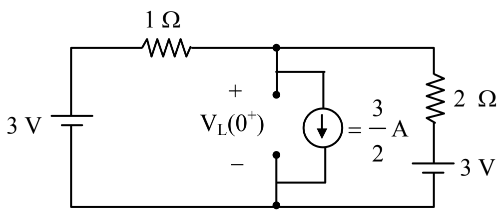


Ans: 2

Sol: $t = 0^-$



at $t = 0^+$



Nodal

$$\frac{(V_L(0^+)-3)}{1}+\frac{3}{2}\frac{(V_L(0^+)-3)}{2}=0$$

$$\frac{2V_L(0^+)-6+3+V_L(0^+)-3}{2}=0$$

$3V_L(0^+) = 6$

$V_L(0^+) = 2$

So, $\frac{di(0^+)}{dt} = \frac{V_L(0^+)}{L} = \frac{2}{1} = 2\,A/sec$

40. A three-phase cable is supplying 800 kW and 600 kVAr to an inductive load. It is intended to supply an additional resistive load of 100 kW through the same cable without increasing the heat dissipation in the cable, by providing a three-phase bank of capacitors connected in star across the load. Given the line voltage is 3.3 kV, 50 Hz the capacitance per phase of the bank expressed in microfarads, is _______________.

Ans: 48

Sol: Initial load = (800 + j600)

load after modification = (900 + j600) to maintain same heat dissipation magnitude of power should be same

Load with compensation

= (900 + j 600 + Compensation)

= 900 + jx)

Equating magnitude of power

$800^2 + 600^2 = 900^2 + x^2$

$8^2 + 6^2 = 9^2 + x^2$

$100 = 81 + x^2$

$x = \sqrt{19} = 4.3588$

Require reactive power = 435.8 kVAr

After compensation

Reactive power to be compensated by capacitor to achieve this is 164.11 kVAr

$$\frac{V_{ph}^2}{X_c / \text{Phase}} = Q_C / \text{Phase}$$

$$\left(3.3k/\sqrt{3}\right)^2 \times \omega C_{ph} = \frac{164.11k}{3}$$

$C_{ph} = 48\ \mu F$

41. A 30 MVA 3-phase, 50Hz, 13.8 kV, star-connected synchronous generator has positive, negative and zero sequence reactances, 15%, 15% and 5% respectively. A reactance (X_n) is connected between the neutral of the generator and ground. A double line to ground fault takes place involving phases ‘b’ and ‘c’, with a fault impedance of j0.1 p.u. The value of X_n (in p.u) that will limit the positive sequence current to 4270 A is _____________.

Ans: 1.1

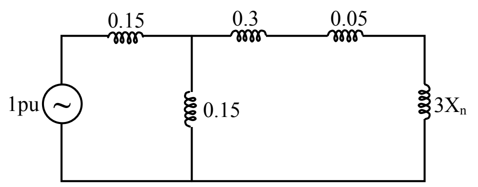
Sol: Since all quantities are given in ‘pu’

Positive sequence current in pu = $\frac{4270}{I_B}$

$= \frac{4.27 \times \sqrt{3} \times 13.8}{30}$

= 3.4 pu

Equivalent circuit



Positive sequence current = $\frac{1}{X_{eq}} = 3.4$

$X_{eq} = \frac{1}{3.4} = 0.2941 \text{ pu}$

$0.15 + \frac{0.15(0.35+3X_n)}{3X_n+0.5} = 0.2941$

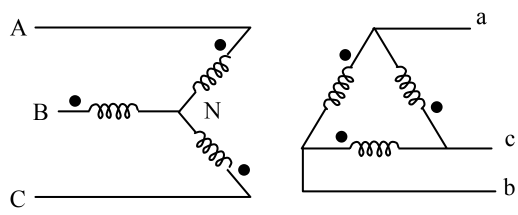
$\frac{0.15(0.35+3X_n)}{3X_n+0.5} = 0.1441$

$0.0525 + 0.45X_n = 0.4323X_n + 0.07205$

$0.0177X_n = 0.01955$

$X_n = 1.104$ pu

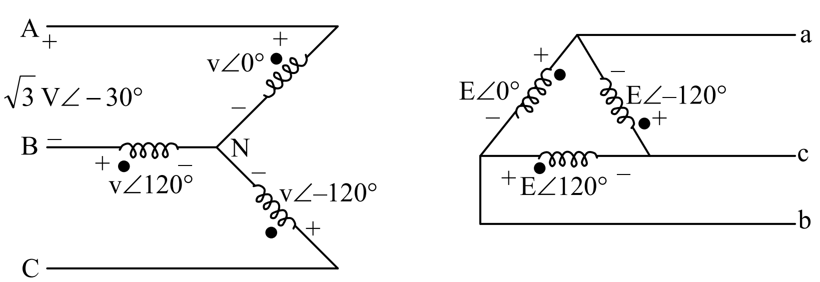
42. If the star side of the star-delta transformer shown in the figure is excited by a negative sequence voltage, then

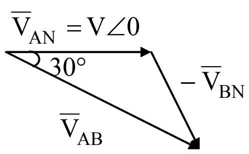


(A) V_{AB} leads V_{ab} by 60°
(B) V_{AB} lags V_{ab} by 60°
(C) V_{AB} leads V_{ab} by 30°
(D) V_{AB} lags V_{ab} by 30°

Ans: (D)

Sol:





With – ve sequence voltages, $\overline{V}_{AN} = V\angle 0°$, $\overline{V}_{BN} = V\angle 120°$ and $\overline{V}_{CN} = V\angle -120°$

$\overline{V}_{AB} = \sqrt{3}V\angle -30°$ from figure $\overline{V}_{ab} = E\angle 0$

$\overline{V}_{AB}$ lags $\overline{V}_{ab}$ by 30°.

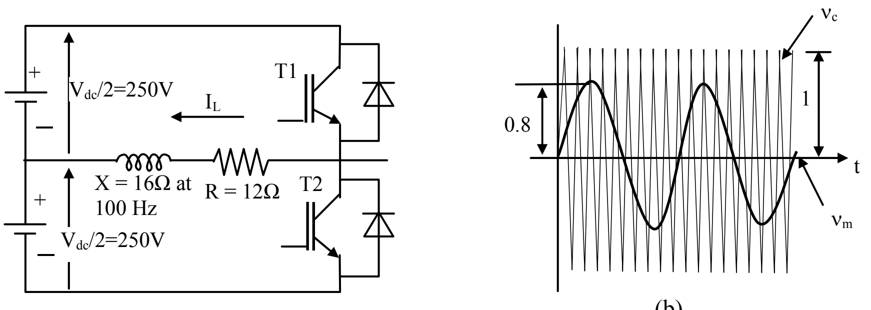
43. A single-phase thyristor-bridge rectifier is fed from a 230 V, 50Hz single-phase AC mains. If it is delivering a constant DC current of 10A, at firing angle of 30°, then value of the power factor at AC mains is

(A) 0.87 (B) 0.9 (C) 0.78 (D) 0.45

Ans: (C)

Sol: Power factor at input mains = $\frac{2\sqrt{2}}{\pi}\cos\alpha = 0.9 \times \cos 30^{\circ} = 0.78$

44. The switches T1 and T2 in Figure are switched in a complementary fashion with sinusoidal pulse width modulation technique. The modulating voltage $v_m(t)$ = 0.8sin(200πt) V and the triangular carrier (V_c), voltage (v_C) are as shown in figure (b). The carrier frequency is 5 kHz. The peak value of the 100 Hz component of the load current (i_L) in Ampere, is ____________.



Ans: 10

Sol: Modulation index, $m_a = \frac{\hat{v}_m}{\hat{v}_{tri}} = \frac{0.8}{1} = 0.8$

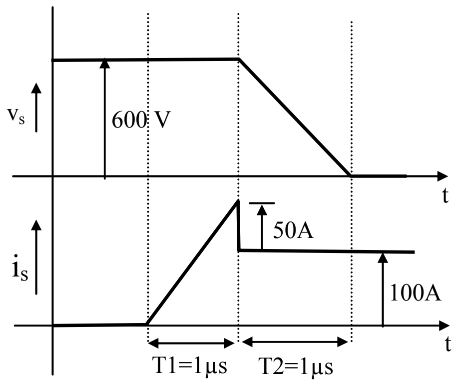
Amplitude of the fundamental output voltage, $\left(\hat{V}_{AO}\right)_1 = m_a \times \frac{V_{dc}}{2} = 0.8 \times 250 = 200\text{ V}$

From the given modulating voltage equation, it can be understood that $\omega_1 = 200\pi$ means, fundamental component frequency = 100 Hz

Load impedance at 100 Hz frequency, $Z_1 = \sqrt{R^2 + X^2} = \sqrt{12^2 + 16^2} = 20\,\Omega$

$\therefore \hat{I}_{L1} = \frac{\hat{V}_{AO1}}{Z_1} = \frac{200}{20} = 10\text{ A}$

45. The voltage (v_s) across the current (i_s) through a semiconductor switch during a turn-ON transition are shown in figure. The energy dissipated during the turn-ON transition, in mJ, is __________.



Ans: 75

Sol: Energy loss during $T_1 = \int_0^{T_1} v.i\,dt = 600 \times \int_0^{T_1} i\,dt$

$= 600 \times$ area under current curve

$$= 600 \times \frac{1}{2} \times 150 \times 1 \times 10^{-6} = 45\,\text{mJ}$$

Energy loss during $T_2 = \int_0^{T_2} v.i\,dt = 100 \times \int_0^{T_{21}} v\,dt$

$= 100 \times$ area under voltage curve

$$= 100 \times \frac{1}{2} \times 600 \times 1 \times 10^{-6} = 30\,\text{mJ}$$

Total energy loss = 45 + 30 = 75 mJ

46. A single-phase 400 V, 50 Hz transformer has an iron loss of 5000 W at the rated condition. When operated at 200 V, 25 Hz, the iron loss is 2000 W. When operated at 416 V, 52 Hz the value of the hysteresis loss divided by the eddy current loss is __________.

Ans: 1.4423

Sol: If v/f is kept constant, maximum core flux density is constant.

In the problem, (400/50) = (200/25) = 8 (416/52). v/f is kept constant. So the maximum core flux density is constant. Let it be B.

Hysterisis loss $W_h = k_h\, f\, B^n$

Eddy current loss $W_w = k_e\, f^2\, B^2$

Total core loss = $W_n + W_e$.

At 400 V & 50 Hz,

$k_h\, 50\, B^n + k_e\, 50^2\, B^2 = 5000$

$\therefore\ k_h B^n + k_e\, 50\, B^2 = 100$ …. (1)

At 200 V, 25 Hz,

$k_h\, 25\, B^n + k_e\, 25\, B^2 = 2000$

$k_h\, B^n + k_e\, 25\, B^2 = 80$ ….. (2)

$k_e\, 25\, B^2 = 20$; $k_h\, B^n = 60$

At 416 V; 52 Hz;

$(k_h B^n)\,52 = 60 \times 52$

$k_e\, 52^2 B^2 = 0.8 \times 52^2$

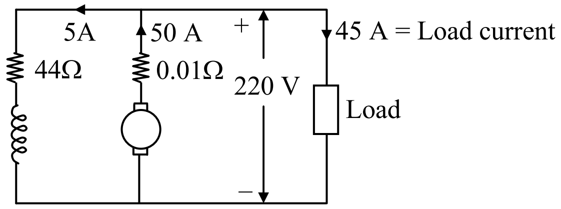
$$\frac{\text{Hysterisis loss}}{\text{Eddy current loss}} = \frac{60\times 52}{0.8\times 52^2} = \frac{75}{52}$$

$= 1.4423.$

47 A DC shunt generator delivers 45 A at a terminal voltage of 220 V. The armature and the shunt field resistances are 0.01 Ω and 44 Ω respectively. The stray losses are 375 W. The percentage efficiency of the DC generator is __________.

Ans: 86.84%

Sol:



Total copper losses = $5^2 \times 44 + 50^2 \times 0.01$
= 1100 + 25
= 1125 W

other losses (given as stray losses) = 375 W

Total losses = 1500 W

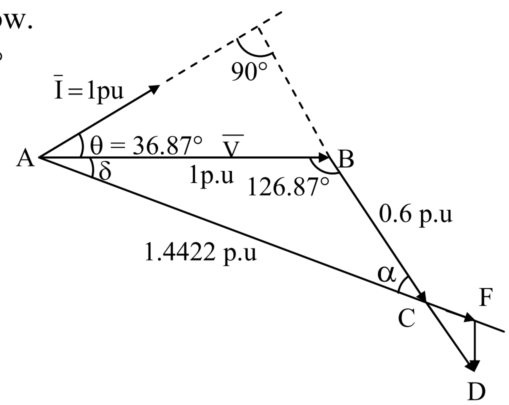
Output = 220 × 45 = 9900 W

Efficiency = 9900/ 11, 400
= 86.84%

48. A three-phase, 50Hz salient-pole synchronous motor has a per-phase direct-axis reactance (X_d) of 0.8 pu and a per phase quadrature-axis reactance (X_q) of 0.6pu. Resistance of the machine is negligible. It is drawing full-load current at 0.8 pf (leading). When the terminal voltage is 1pu, per-phase induced voltage, in pu, is __________.

Ans: 1.6086 p.u

Sol: Phasor diagram for $\bar{E}$ is constructed as below.



$AC^2 = AB^2 + BC^2 - 2(AB)(BC)\cos 126.87°$

$= 1 + 0.36 + 1.2\,(0.6)$

$= 2.08$

$AC = \sqrt{2.08}$

$= 1.4422$

$$\frac{1.4422}{0.8} = \frac{1}{\sin\alpha}$$

$\alpha = 33.7°, \quad \cos\alpha = 0.832$

CF = 0.1664

AF = E = 1.6086 p.u

49. A single-phase 22kVA, 2200 V/220 V, 50 Hz, distribution transformer is to be connected as an auto transformer to get an output voltage of 2420 V. Its maximum kVA rating as an auto-transformer is

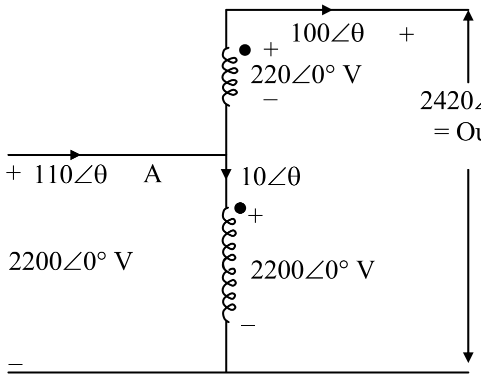
(A) 22 (B) 24.2 (C) 242 (D) 2420

Ans: (C)

Sol:

$$\text{Rated } lv \text{ current } = \frac{22000}{220} = 100 \text{ A}$$

$$\text{Maximum kVA rating } = \frac{2200\times 110}{1000} = \frac{2420\times 100}{1000} = 242 \text{ kVA.}$$



50. A single-phase full-bridge voltage source inverter (VSI) is fed from a 300 V battery. A pulse of 120° duration is used to trigger the appropriate device in each half cycle. The rms value of the fundamental component of the output voltage, in volts, is

(A) 234 (B) 245 (C) 300 (D) 331

Ans: (A)

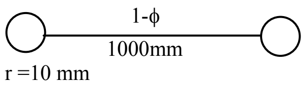
Sol: Pulse width $2d = 120°$

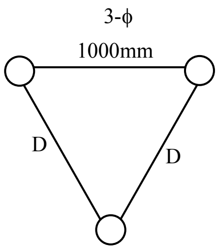
$$V_{o1} = \frac{2\sqrt{2}}{\pi} V_{dc} \sin d = 0.9 \times 300 \times \sin 60^{\circ} = 233.8 \text{ V}$$

51. A single-phase transmission line has two conductors each of 10 mm radius. These are fixed at a center-to-center distance of 1m in a horizontal plane. This is now converted to a three-phase transmission line by introducing a third conductor of the same radius. This conductor is fixed at an equal distance D from the two single-phase conductors. The three-phase line is fully transposed. The positive sequence inductance per phase of the three phase system is to be 5% more than that of the inductance per conductor of the single phase system. The distance D, in meters, is ____________.

Ans: 1.438

Sol:





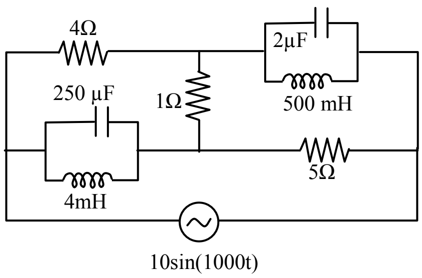
$1.05 \times L_{1-\phi} = L_{3\phi}$

$$1.05\times 0.2 \ln \frac{1000}{0.788\times 10} = 0.2 \ln \frac{\left(1000D^2\right)^{\frac{1}{3}}}{0.788\times 10}$$

$$\left(\frac{1000}{7.88}\right)^{1.05} = \frac{\left(1000D^2\right)^{\frac{1}{3}}}{7.88}$$

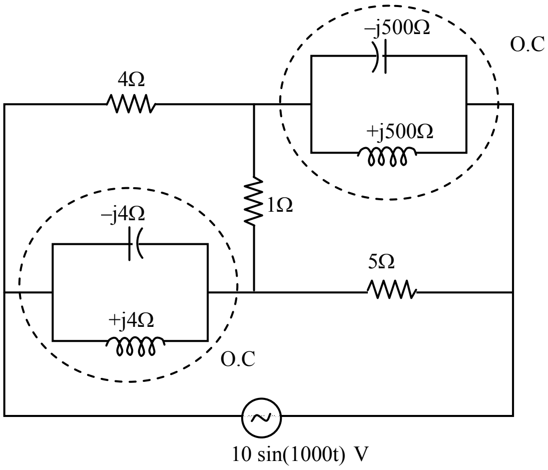
D = 1,438 mm = 1.438 m

52. In the circuit shown below, the supply voltage is 10sin(1000t) volts. The peak value of the steady state current through the 1Ω resistor, in amperes, is _________.



Ans: 1

Sol:



$$I_{1\Omega} = \frac{V}{4+1+5} = \frac{10\sin 1000t}{10}$$

$I_{1\Omega}$ = 1 sin1000t A

The peak value of the steady state current through 1 Ω resister is, 1 A

53. A dc voltage with ripple is given by v(t) = [100+10sin(ωt) – 5sin(3ωt)] volts. Measurements of this voltage v(t), made by moving-coil and moving iron voltmeters, show readings of V_1 and V_2 resplectively. The value of V_2–V_1, in volts, is ___________.

Ans: 0.31 V

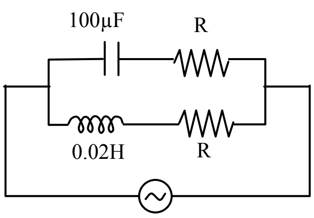
Sol: PMMC; V_1 = 100 V

$$\text{M.I; } V_2 = \sqrt{(100)^2 + \left(\frac{10}{\sqrt{2}}\right)^2 + \left(\frac{5}{\sqrt{2}}\right)^2}$$

$$= \sqrt{10000+50+12.5} = 100.31 \text{ V}$$

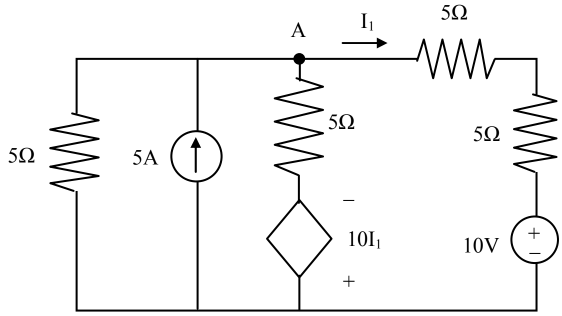
$V_2 - V_1$ = 0.31 V

54. The circuit below is excited by a sinusoidal source. The value of R, in Ω for which the admittance of the circuit becomes a pure conductance at all frequencies is _____________.



Sol: $R = \sqrt{\frac{L}{C}} = \sqrt{\frac{0.02}{100\mu}} = \sqrt{200} = 14.14\ \Omega$

55. In the circuit shown below, the node voltage V_A is ____________ V.



Ans: 11.42

Sol: $\frac{V_A}{5} - 5 + \frac{(V_A + 10I_1)}{5} + \frac{(V_A - 10)}{10} = 0$

$2V_A - 50 + 2V_A + 20\,I_1 + V_A - 10 = 0$

$5V_A + 20I_1 = 60$ …………..(1)

Also,

$I_1 = \frac{(V_A - 10)}{10}$ …………(2)

So, $5V_A + 20\left[\frac{V_A - 10}{10}\right] = 60$

$7V_A = 80 \rightarrow V_A = \frac{80}{7}$

$V_A = 11.42$ Volts