Detailed Solutions

of

Electrical Engg.

GATE-2014

Evening Session

1st March, 2014

MADE EASY

India's Best Institute for IES, GATE & PSUs

Write us at info@madeeasy.in | Phone: 011-45124612, 9958995830

www.madeeasy.in

Expert Opinion

▲ B. Singh (Ex. IES)
CMD, MADE EASY Group

Dear Students,
The Questions of GATE 2014 : EE are based on fundamental and basic concepts of the syllabus. There is no ambiguity and misprint noticed till now, however, it is an observation based on students feedback.

The level and standard of GATE 2014 questions are almost similar to the exam of GATE 2013. There are 3 important observations made by me about GATE 2014 exam.

1. The GATE exam 2014 has been conducted in 4 seatings. The questions were different in each session but difficulty level of questions were almost equal. The standard of the questions were quite average, however it varies on the perception of person to person also.

The average marks on all the papers should be equated and necessary scaling criteria should be adopted for this purpose.

2. The GATE 2014 cut off is expected to be slightly higher than previous year. The cut-off may vary between 27-30 marks (General Category).

$$\text{GATE Cutoff} = \frac{\text{Total Marks obtained by all the candidates}}{\text{Total number of candidates}}$$

GATE cutoff $\nless$ 25 Marks

3. In my opinion the toppers marks of GATE-2014 would be between 85 to 90 marks.

Note

If you have more questions (except from this paper) of GATE 2014 : EE, then kindly mail it to: *madeeeasydelhi@gmail.com*

Note: Please do mention name, mobile no, date & session of exam, while sending the mail.
You may also submit directly (in handwritten format) at MADE EASY Kalu Sarai Office.

If any error or discrepancy is recorded then students are requested to inform us at: ***madeeasydelhi@gmail.com***

Gate 1st March Evening

Q.1 If $\left(z+\frac{1}{z}\right)^2 = 98$ then the value of $\left(z^2+\frac{1}{z^2}\right) = ?$

Solution: (96)

$$\left(z+\frac{1}{z}\right)^2 = 98$$

$$\Rightarrow \quad z^2+\frac{1}{z^2}+2 = 98$$

$$\Rightarrow \quad z^2+\frac{1}{z^2} = 96$$

Q.2 Choose the most appropriate word from the option given below to complete the following sentence:

He could not understand the judges awarding him the first prize, because he thought that his performance was quite

(a) Superb
(b) Medium
(c) Mediocre
(d) Exhilarating

Solution: (c)

Q.3 Choose the closest meaning:

It is fascinating to see life forms COPE WITH varied environmental conditions.

(a) Adopt to
(b) Adapt to
(c) Adept to
(d) Accept with

Solution: (b)

Q.4 The Palaghat in southern parts are low lying areas with hilly terrain due to which parts of Tamil Nadu suffer rainfall and of Kerala suffer summer what it is conclude.

Being covered by upper and lower hilly regions

(a) The Palaghat is formed due the upper hilly acts of Southern and Western India
(b) The parts of Tamil Nadue and Kerala suffer season charges due to it
(c) Monsoon are caused due to Southern disturbance
(d) Tamil Nadu receives maximum rainfall due to it

Solution: (b)

Q.5 Scientists are now able to found the main root cause of depression and other Physiatric diseases with genetics main root cause.

In near future they will be able to provide cure for such diseases. What does it infer.

(a) Depression and other diseases are caused due to genes
(b) There is a cure for such diseases
(c) Genes are main cause of all illnesses
(d) Gene therapy will provide cure of all diseases

Solution: (a)

Q.6 There is discount of 10% on total fare for a round trip and for group of 4 and more, there is 5% discount on total fare. If one way single person fare is Rs.100. Find the group of 5 tourist round trip fare?

Solution: (Rs.850)

Total round trip fare for group of 5 tourist without discount

$$= 5 \times 200 = \text{Rs. } 1000$$

(i) Discount for round trip $= \frac{10}{100} \times 1000 = \text{Rs. } 100$

(ii) Discount for having of group of 5 tourist $= \frac{5}{100} \times 1000 = \text{Rs. } 50$

$\therefore$ Total discount = Rs. 150

$\Rightarrow$ Total round trip fare for group of 5 tourist after discount

$$= \text{Rs. } 1000 - \text{Rs. } 150$$
$$= \text{Rs. } 850$$

Q.7 The Minister speaks in a press conference after scam, minister said "The buck stops here", what he convey by this?

Choose the appropriate meaning of the given phrase.

(a) He wants all the money
(b) He will return the money
(c) He will assume final responsibility
(d) He will resist all enquries

Solution: (c)

Q.8 In a survey 300 respondents were asked wheter they own a vehicle or not. If yes, they were further asked to mention whether they own a car or scooter or both. Their responses are tabulated below. What percent of respondents do not own a scooter.

		Men	Women
Owns	Car	40	34
	Scooter	30	20
	Both	60	46
Do not Owns		20	50

Solution: (48%)

Percent of respondents who do not own a scooter

$$= \frac{74+70}{300} \times 100 = \frac{144}{300} \times 100 = 48\%$$

Q.9 Find the logic circuit for the given K-map.

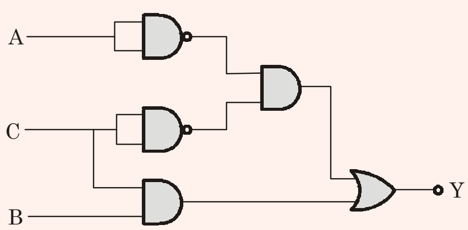
C \ AB	00	01	11	10
0	1	1		
1		1	1	

[Note: Options are not available]

Solution:

C \ AB	00	01	11	10
0	1	1		
1		1	1	

$$Y = \bar{C}\,\bar{A} + CB + \bar{A}B$$



Q.10 If $X(s) = \dfrac{3s+5}{s^2+10s+21}$ is Laplace transform of x(t), then $x(0^+)$ is

(a) 0
(b) 3
(c) 5
(d) 21

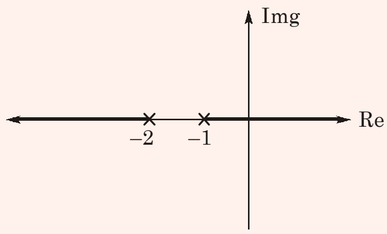
Solution: (b)

$$X(s) = \frac{3s+5}{s^2+10s+21}$$

$$\therefore \quad x(0^+) = \lim_{s\to\infty} s\left(\frac{3s+5}{s^2+10s+21}\right)$$

$$= \lim_{s\to\infty}\left(\frac{3+\frac{5}{s}}{1+\frac{10}{s}+\frac{21}{s^2}}\right) = 3$$

Q.11 Root locus of unity feedback system is shown in figure.



Find closed loop transfer function.

(a) $\dfrac{K}{(s+1)(s+2)}$

(b) $\dfrac{-K}{(s+1)(s+2)+K}$

(c) $\dfrac{-K}{(s+1)(s+2)-K}$

(d) $\dfrac{K}{(s+1)(s+2)+K}$

Solution: (c)

This is converse root locus of

$$G(s)\,H(s) = \frac{-K}{(s+1)(s+2)}$$

From given transfer function

From option (c)

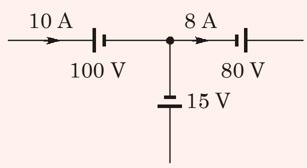
$$\frac{C(s)}{R(s)} = \frac{-K}{(s+1)(s+2)-K}$$

$$G(s)\,H(s) = \frac{-K}{(s+1)(s+2)-K-(-K)}$$

$$= \frac{-K}{(s+1)(s+2)-K+K}$$

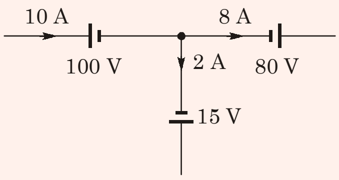
$$G(s)\,H(s) = \frac{-K}{(s+1)(s+2)}$$

Q.12 Total power absorbed by the given circuit is



Solution: (330 W)

Using KCL,



$$\therefore \quad \text{Total power absorbed} = 10 \times 1000 - [(80 \times 8) + (15 \times 2)]$$
$$= 1000 - 640 - 30$$
$$= 330 \text{ W}$$

Q.13 In a balance 3-phase system, 2 wattmeter method is used to measure the power. If reading of one wattmeter is twice of other, the load impedance angle (in radian) is

(a) $\frac{\pi}{12}$

(b) $\frac{\pi}{8}$

(c) $\frac{\pi}{6}$

(d) $\frac{\pi}{3}$

Solution: (c)

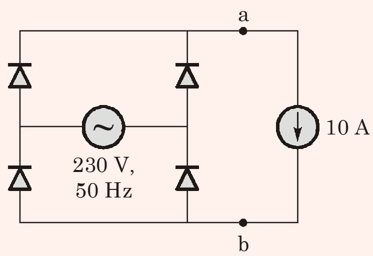
$$\tan\phi = \sqrt{3}\left[\frac{W_1 - W_2}{W_1 + W_2}\right] \quad \text{[By two wattmeter method]}$$

As $W_1 = 2W_2$ [Given]

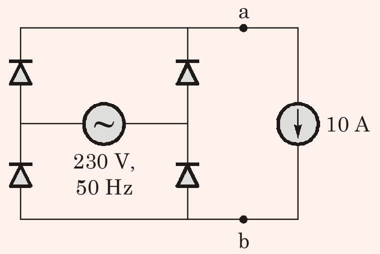
$$\therefore \quad \tan\phi = \sqrt{3}\left[\frac{2W_2 - W_2}{2W_2 + W_2}\right] = \frac{\sqrt{3}}{3} = \frac{1}{\sqrt{3}}$$

$$\therefore \quad \phi = \frac{\pi}{6} \text{ rad.}$$

Q.14 If current source is replaced by resistance R then find the value of R, to maintain same current through branch ab.



Solution: (23 Ω)



$$V_{ab} = 230\text{ V}$$

$$I_{ab} = 10\text{ A}$$

So, $$R_{ab} = \frac{V_{ab}}{I_{ab}} = \frac{230}{10} = 23\ \Omega$$

Q.15 Cascade of three modulus-5 counters results in overall modulus of

(a) 5
(b) 25
(c) 125
(d) 625

Solution: (c)

Overall modulus of cascade of three modulus-5 counters = 5 × 5 × 5 = 125.

Q.16 For a 400 V, 50 Hz, 4 pole, Y-connected alternator.

OCC : V_{OC} = 400 V(rms, line to line), at I_f = 2.5 A.

SCC : I_{SC} = 10 A (rms, phase), at I_f = 1.5 A.

Find per phase synchronous impedance in ohm at rated voltage.

Solution: (13.85 Ω)

$$V_{OC_{L\text{-}L}} = 400\text{ V}$$

$$\therefore \quad V_{OC_{ph}} = \frac{400}{\sqrt{3}}\text{ V}\Big|_{I_f = 2.5\text{ A}}$$

$$I_{SC\,ph} = 10\text{ A}\Big|_{I_f = 1.5\text{ A}}$$

$$\therefore \quad I'_{SC\,ph} = \frac{10}{1.5} \times 2.5 = \frac{50}{3}\text{ A}\Big|_{I_f = 2.5\text{ A}}$$

[∵ of linear relationship between I_{sc} and I_f]

Per phase synchronous impedance

$$= \frac{V_{OC_{ph}}}{I'_{SC\,ph}}\Bigg|_{I_f = 2.5\text{ A}}$$

$$= \frac{400/\sqrt{3}}{50/3} = 13.85\ \Omega$$

Q.17 C_o is capacitance of parallel plate capacitor with air as dielectric. When half of gap is filled with dielectric of permittivity $\in_r$ then modified capacitance is

Fig. (a)

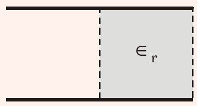


Fig. (b)

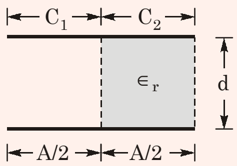
(a) $\frac{C_o}{2}(1+\in_r)$

(b) $C_o \in_r$

(c) $\frac{C_o}{2}\in_r$

(d) $C_o(1+\in_r)$

Solution: (a)



As $$C_o = \frac{A\in_o}{d}$$

where, A = Area of the parallel plate capacitor

d = Distance between the plates

$\therefore$ $$C_1 = \frac{\frac{A}{2}\in_o}{d} \text{ and } C_2 = \frac{\frac{A}{2}\in_o\in_r}{d}$$

As both C_1 and C_2 are in parallel

$\therefore$ $$C_{net} = C_1 + C_2$$

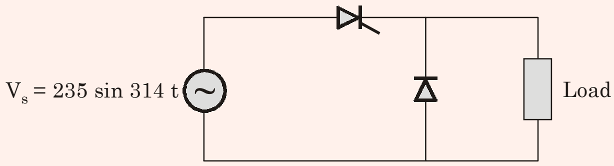
$$= \frac{A\in_o}{2d} + \frac{A\in_o\in_r}{2d}$$

$$= \frac{A\in_o}{2d} + \frac{A\in_o\in_r}{2d}$$

$$= \frac{A\in_o}{2d}(1+\in_r)$$

$\Rightarrow$ $$C_{net} = \frac{C_o}{2}(1+\in_r)$$

Q.18 A rectifier is shown below. The diode and thyristor are ideal switches. The load contains R = 10 Ω and L = 0.05 H. The firing angle α in degrees to obtain a load voltage of 70 V is



Solution: (29.42°)

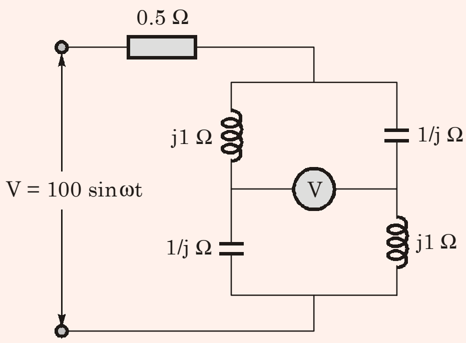
$$V_o = \frac{V_m}{2\pi}(1 + \cos\alpha)$$

$$70 = \frac{235}{2\pi}(1 + \cos\alpha)$$

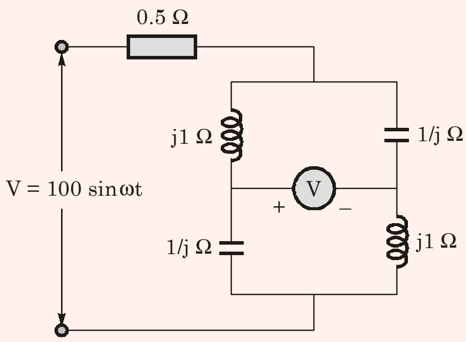
$$\frac{70 \times 2\pi}{235} = (1 + \cos\alpha)$$

$$\Rightarrow \quad \alpha = 29.42°$$

Q.19 What is the value of V in given figure.



Solution: (236 V)



It is a balanced Wheatstone bridge with

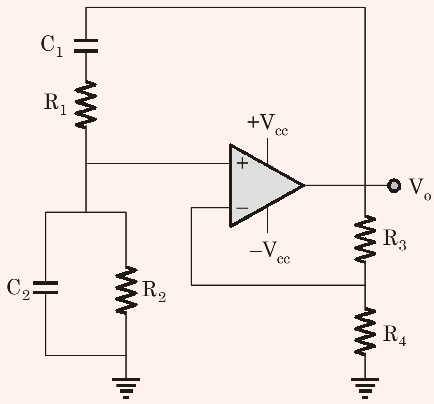
$$Z_1 Z_4 = Z_2 Z_3$$

$$\Rightarrow \quad j \times j = \frac{1}{j} \times \frac{1}{j}$$

$$\Rightarrow \quad -1 = -1$$

$\therefore$ Reading of voltmeter = 0 V

Q.20 Find the condition to balance the Wein's bridge.



(a) $\frac{R_3}{R_4} = \frac{R_1}{R_2}, \omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}$

(b) $\frac{R_2}{R_1} = \frac{C_2}{C_1}, \omega = \frac{1}{R_1 C_1 R_2 C_2}$

(c) $\frac{R_3}{R_4} = \frac{R_1}{R_2} + \frac{C_2}{C_1}, \omega = \frac{1}{\sqrt{R_1 C_1 R_2 C_2}}$

(d) $\frac{R_2}{R_4} + \frac{R_1}{R_2} = \frac{C_2}{C_1}, \omega = \frac{1}{R_1 C_1 R_2 C_2}$

Solution: (c)

Q.21 Given figure shows a circuit diagram of a chopper. The switch 'S' in the circuit in Fig. (a) is switched ON such that the voltage across diode has the wave shape shown in Fig. (b). The capacitor C is large, so that the voltage across it is constant. If switch S and the diode are ideal, the peak to peak ripple (in A) in the inductor current is ______.

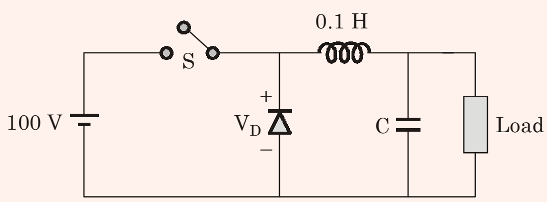


Fig. (a)

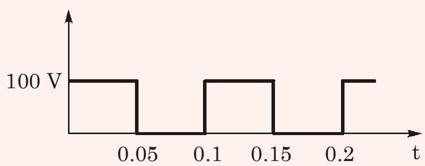


Fig. (b)

Solution:(25 A)

The given circuit is a buck regulator,

$$V_o = V_s \times \frac{t_1}{T}$$

$$V_o = 100 \times \frac{0.05}{0.1}$$

$$\therefore \quad V_o = 50\text{ V}$$

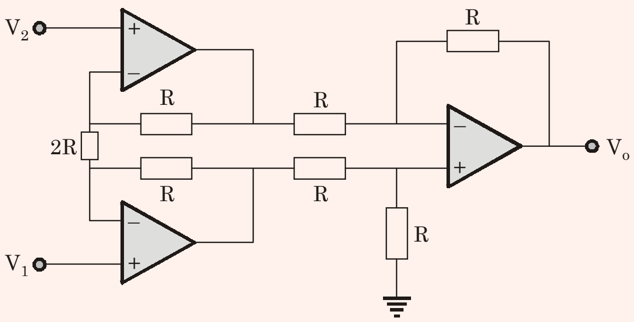
The peak-to-peak inductor ripple current,

$$\Delta I = \frac{V_o \times t_2}{L}$$

$$= \frac{50 \times 0.05}{0.1}$$

$$\Delta I = 25\text{ A}$$

Q.22 Find value of V_o.



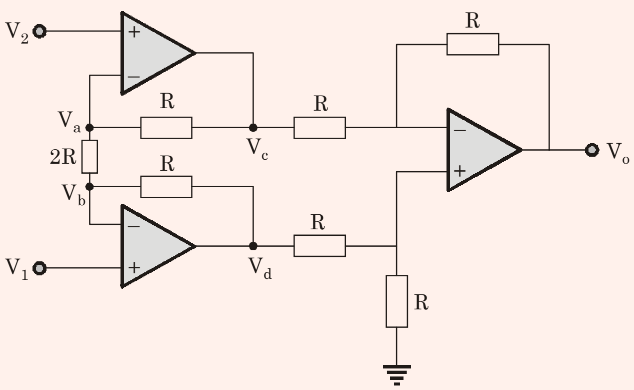
(a) $\frac{1}{2}(V_1 - V_2)$

(b) $V_1 + V_2$

(c) $2(V_1 - V_2)$

(d) $V_1 - V_2$

Solution: (c)



$$V_o = -V_c \times \left(\frac{R}{R}\right) + V_d \times \frac{R}{2R}\left(1 + \frac{R}{R}\right)$$

$$= -V_c + \frac{V_d}{2} \times 2 = V_d - V_c$$

and, $-V_c + IR + I(2R) + IR + V_d = 0$

$\Rightarrow$ $V_d - V_c = -4\,IR$

and, $-V_a + 2\,IR + V_b = 0$

$\Rightarrow$ $2\,IR = V_a - V_b$

$\therefore$ $V_o = -4\,IR$

$= -2(V_a - V_b)$

$= 2(V_b - V_a)$

Here, $V_1 = V_b$

$V_2 = V_a$

$\therefore$ $V_o = 2(V_1 - V_2)$

Q.23 $A = \begin{bmatrix} 0 & 1 & -1 \\ -6 & -11 & 6 \\ -6 & -11 & 5 \end{bmatrix}$, absolute value of the ratio of maximum eigen value to minimum eigen value is

Solution: (1/3)

$$0 = |A - \lambda I|$$

$$0 = \left| \begin{bmatrix} 0 & 1 & -1 \\ -6 & -11 & 6 \\ -6 & -11 & 5 \end{bmatrix} - \begin{bmatrix} \lambda & 0 & 0 \\ 0 & \lambda & 0 \\ 0 & 0 & \lambda \end{bmatrix} \right|$$

$$0 = \begin{bmatrix} -\lambda & 1 & -1 \\ -6 & -11-\lambda & 6 \\ -6 & -11 & 5-\lambda \end{bmatrix}$$

$$\left[-\lambda(-55 - 5\lambda + 11\lambda + \lambda^2 + 66) + 1(-36 + 30 - 6\lambda) - 1(66 - 66 - 6\lambda)\right] = 0$$

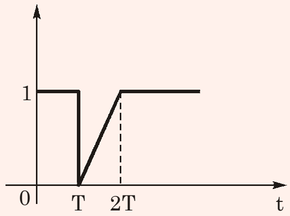
$(-\lambda^3 - 6\lambda^2 - 11\lambda) - 6 - 6\lambda + 6\lambda = 0$

$\lambda^3 + 6\lambda^2 + 11\lambda + 6 = 0$

$\lambda = -1, -2, -3$

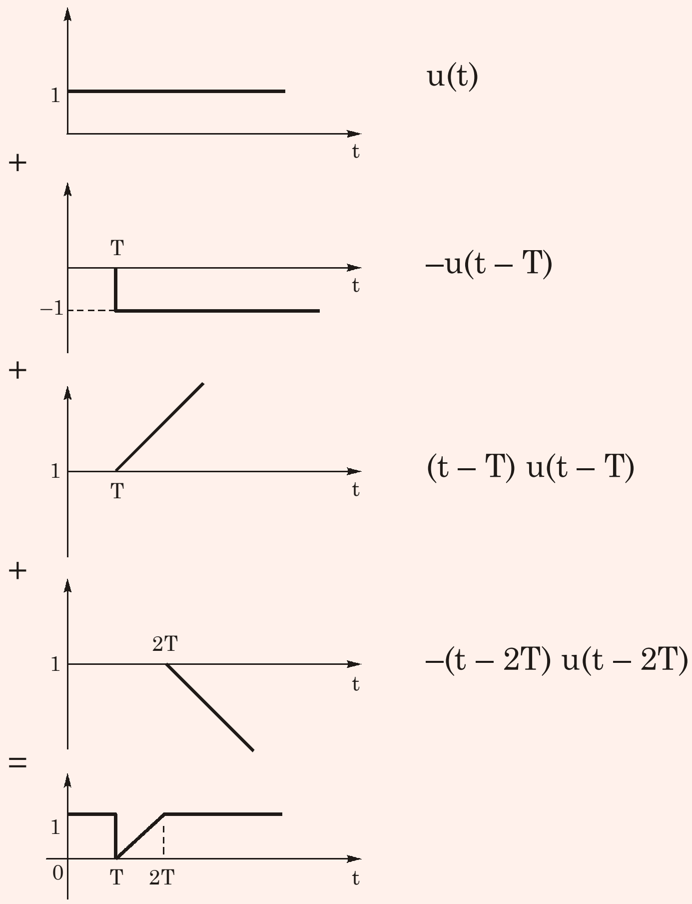
$$\left|\frac{\lambda_{max}}{\lambda_{min}}\right| = \frac{1}{3}$$

Q.24 Select the suitable representation of the below signal.



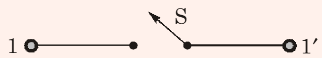
[Note: Options are not available]

Solution: $f(t) = u(t) - u(t - T) + (t - T)\, u(t - T) - (t - 2T)\, u(t - 2T)$

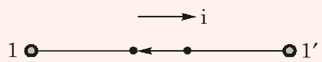


$\therefore \qquad f(t) = u(t) - u(t-T) + (t-T)\, u(t-T) - (t-2T)\, u(t-2T)$

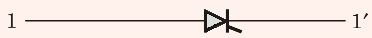
Q.25 An electronics switch S is required to block voltage of either polrity during its OFF state as shown in the figure (a). This swich is required to conduct in only one direction in its ON state as shown in the figure (b).

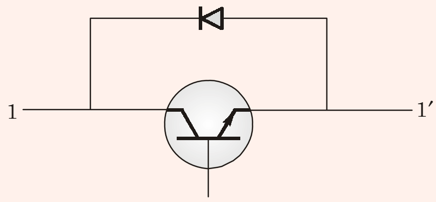


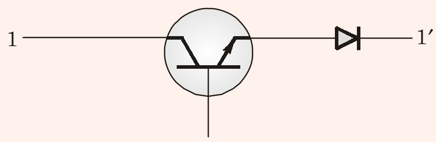
(a)

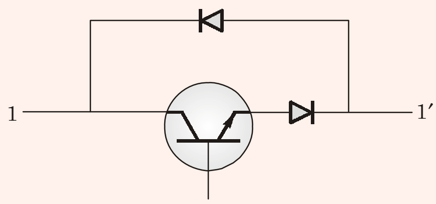


(b)

1. 

2. 

3. 

4. 

Which of the following are valid realizations of the switch S?

(a) Only 1
(b) 1 and 2
(c) 1 and 3
(d) 3 and 4

Solution: (c)

Q.26 In formation of Routh Hurwitz array all the row elements are zero. The premature termination shows

(a) One root at origin
(b) Only one positive real root
(c) Only one negative real root
(d) Imaginary roots

Solution: (d)

Q.27 A 8 pole, 3 phase, 50 Hz induction machine is operating at 700 rpm, frequency of rotor current is ______ Hz.

Solution: (3.33)

As $$n_s = \frac{120f}{P}$$

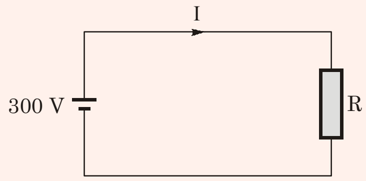
$$= \frac{120 \times 50}{8} = 750 \text{ rpm}$$

$$s = \frac{n_s - n_r}{n_s} = \frac{750 - 700}{750} = \frac{50}{750} = \frac{1}{15}$$

$\therefore$ Frequency of rotor current $= sf$

$$= \frac{1}{15} \times 50 = 3.33 \text{ Hz}$$

Q.28 For circuit shown below, R = 25 + I/2. Find the value of I.



Solution: (10 A)

$$V = IR$$

$$\Rightarrow \quad 300 = I\left(25 + \frac{I}{2}\right)$$

$$\Rightarrow \quad 300 = 25I + \frac{I^2}{2}$$

$$\Rightarrow \quad I^2 + 50I - 600 = 0$$

$$\Rightarrow \quad I = 10 \text{ A} \quad \text{or} \quad -60 \text{ A}$$

$$\Rightarrow \quad R = \left(25 + \frac{10}{2}\right) = 30$$

or $$R = \left(25 - \frac{60}{2}\right) = -5$$

As resistance cannot be negative.

$\therefore$ Value of I = 10 A

Q.29 x(t) is non-zero only for $T_x < t < T'_x$ and similarly, y(t) is non zero only for $T_y < t < T'_y$. Let z(t) be convolution of x(t) and y(t). Which one of the following statement is true?

(a) z(t) can be non zero over an unbounded interval

(b) z(t) is non zero for $t < T_x + T_y$

(c) z(t) is zero outside of $T_x + T_y < t < T'_x + T'_y$

(d) z(t) in non zero for $t > T'_x + T'_y$

Solution: (c)

Q.30 The vector field are given in Cartesian co-ordinate system. The vector field which does not satisfy the property of magnetic flux density is

(a) $y^2\hat{a}_x + z^2\hat{a}_y + x^2\hat{a}_z$

(b) $z^2\hat{a}_x + x^2\hat{a}_y + y^2\hat{a}_z$

(c) $x^2\hat{a}_x + y^2\hat{a}_y + z^2\hat{a}_z$

(d) $y^2z^2a_x + x^2z^2a_y + x^2y^2a_z$

Solution: (c)

According to Maxwell fourth equation,

$$\nabla \cdot B = 0$$

Among the given options, only option (c) is not satisfying above criteria.

Q.31 The solution for differential equation, $\frac{d^2x}{dt^2} = -9x$ with initial condition, $x(0^-) = 1$ and $\left.\frac{dx}{dt}\right|_{t=0} = 1$ is

(a) $t^2 + t + 1$

(b) $\sin 3t + \frac{1}{2}\cos 3t + \frac{2}{3}$

(c) $\frac{1}{3}\sin 3t + \cos 3t$

(d) $\cos 3t + t$

Solution: (c)

$$\frac{d^2x}{dt^2} = -9x$$

Using Laplace transform,

$$s^2 X(s) - sx(0^-) - x'(0^-) = -9X(s)$$

$$s^2 X(s) - s(1) - (1) = -9 X(s)$$

$$X(s)(s^2 + 9) = s + 1$$

$$X(s) = \frac{s+1}{s^2+9}$$

$$= \frac{s}{s^2+9} + \frac{1}{s^2+9} = \frac{s}{s^2+9} + \frac{1}{3}\left(\frac{3}{s^2+9}\right)$$

$$= \cos 3t + \frac{1}{3}\sin 3t$$

Alternative Solution:

$$\frac{d^2x}{dt^2} + 9x = 0$$

$$D^2 + 9 = 0$$

$\Rightarrow$ $$D = \pm 3i$$

$\therefore$ $$x = A\cos 3t + iB\sin 3t$$

As $$x(0) = 1 = A$$

and $$\left.\frac{dx}{dt}\right|_{t=0} = 1 = i3B$$

$\therefore$ $$B = \frac{1}{3i}$$

$\Rightarrow$ $$x = \cos 3t + \frac{1}{3}\sin 3t$$

Q.32 If $f(x) = xe^{-x}$, the maximum value of the function in the interval $(0, \infty)$ is,

(a) e^{-1}
(b) e
(c) $1 - e^{-1}$
(d) $1 + e^{-1}$

Solution: (a)

$$f(x) = xe^{-x}$$

$$f'(x) = e^{-x} + x(-e^{-x})$$

$$= e^{-x} - xe^{-x}$$

$\Rightarrow$ $$f'(x) = 0$$

$\Rightarrow$ $$e^{-x}(1-x) = 0$$

$\Rightarrow$ $$x = 1, \infty$$

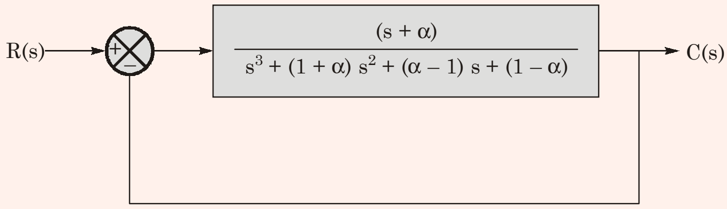
$$f''(x) = -e^{-x} + xe^{-x} - e^{-x}$$

at $x = 1$, $$= -2e^{-1} + (1)\,e^{-(1)}$$

$$= -e^{-1} < 0$$

at $x = 1$, $$f(1) = (1)e^{-1} = e^{-1}$$

Q.33 For what minimum value of α, the system will be stable



Solution: (α = 0.618)

Characteristic equation,

$$1 + G(s)H(s) = 0$$

$$s^3 + (1+\alpha)s^2 + (\alpha - 1)\,s + (1-\alpha) + (s+\alpha) = 0$$

$$\Rightarrow \quad s^3 + (1+\alpha)s^2 + s(\alpha - 1 + 1) + (1 - \alpha + \alpha) = 0$$

$$\Rightarrow \quad s^3 + (1+\alpha)s^2 + \alpha s + 1 = 0$$

By Routh array analysis,

$$\begin{array}{c|cc} s^3 & 1 & \alpha \\ s^2 & 1+\alpha & 1 \\ s^1 & \dfrac{\alpha(1+\alpha)-1}{1+\alpha} & 0 \\ s^0 & 1 & \end{array}$$

For stable system,

$$1 + \alpha > 0$$

i.e. $\alpha > -1$ ...(i)

$$\frac{\alpha(1+\alpha)-1}{1+\alpha} > 0$$

$$\alpha(1+\alpha) - 1 > 0$$

$$\alpha = \frac{-1-\sqrt{5}}{2}, \frac{-1+\sqrt{5}}{2}$$

∴ $\alpha > 0.618$ and $\alpha < -1.62$ ...(ii)

From equations (i) and (ii)

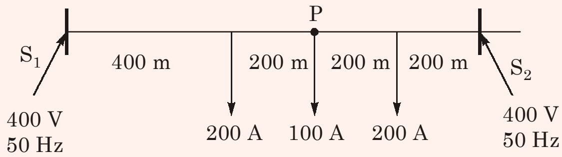
Minimum value of $\alpha = 0.618$.

Q.34 The undesirable property of electrical insulating material is

(a) high dielectric strength
(b) high relative permittivity
(c) high thermal conductivity
(d) high insulation resistivity

Solution: (c)

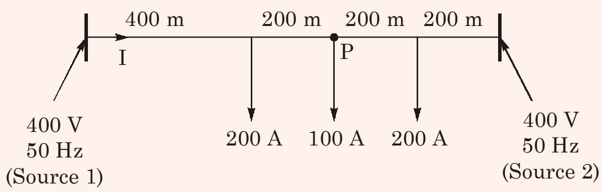
Q.35 The transmission line is fed from both end with source S_1 and S_2 of 400 V, 50 Hz each. The transmission line is 1 km long and has some resistance (m/Ω) and negligible reactance.



What is the contribution of each source S_1 and S_2 from the both end to supply 100 A at point P respectively?

(a) 20 A, 80 A
(b) 100 A, 0 A
(c) 0 A, 100 A
(d) 80 A, 20 A

Solution: (c)



Let current I is supplied by source 1, r be the resistance per unit length

∴ By KVL law

$\Rightarrow -400 + (r \times 400)I + (200r)(I - 200) + 200r(I - 300) + 200r(I - 500) + 400 = 0$

$\Rightarrow 400\,Ir + 200\,Ir - 40000r + 200\,Ir - 60000r + 200\,Ir - 100000r = 0$

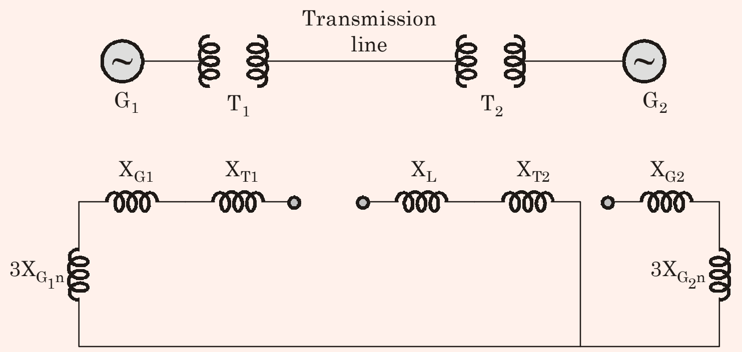
$\Rightarrow \quad 1000\,Ir = 200000r$

$\therefore \quad I = 200\text{ A}$

∴ Contribution of source 1 to 100 A load at point P = 0 A.

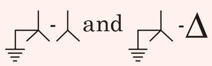
and contribution of source 2 to 100 A load at point P = 100 A.

Q.36 The below diagram shown the zero sequence impedance diagram. Find the connection of both transformers T_1 and T_2.



(a) 

(b) 

(c) 

(d) 

Solution: (c)

Q.37 In a 1-ϕ ac voltage regulator, the rms source voltage is 220 V ac, 50 Hz. Inductance of the coil is 16 mH and resistance is given as 5 Ω. Find the rms thyristor current and angle ϕ?

(a) 45°, 23 A
(b) 45°, 32 A
(c) 32°, 19 A
(d) 29°, 17 A

Solution:

The rms thyristor current $= I_{Tr} = \dfrac{V_s}{\sqrt{R^2 + (\omega L)^2}}$

$$= \frac{220}{\sqrt{5^2 + (2 \times \pi \times 50 \times 16 \times 10^{-3})^2}}$$

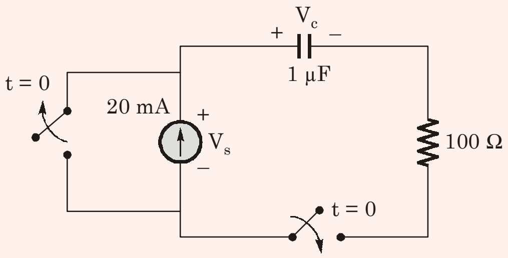
$$I_{Tr} = 32 \text{ A}$$

The load angle $\phi = \tan^{-1}\left(\dfrac{\omega L}{R}\right)$

$$= \tan^{-1}\left(\frac{2\pi \times 50 \times 16 \times 10^{-3}}{5}\right)$$

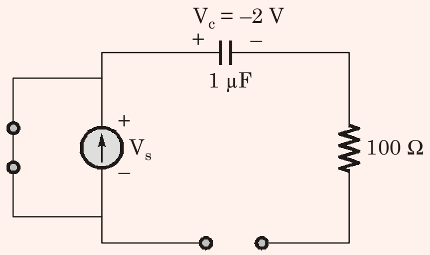
$$\phi = 45°$$

Q.38 Consider the circuit shown below. Given $V_c(0) = -2$ V. The value of voltage (V_s) across the current source in the circuit is



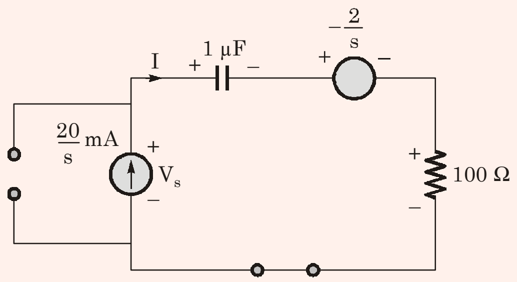
Solution:

At $t = 0^-$



$\therefore$ $$V_s = 0\text{ V}\Big|_{t=0^-}$$

At $t = 0^+$



By KVL,

$$\left(\frac{-2}{s}\right) + \frac{I}{sC} + 100I = V_s$$

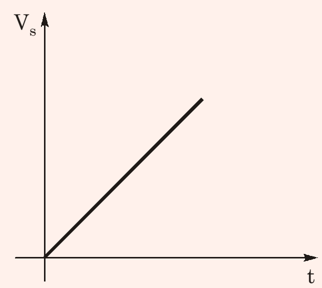
$$\Rightarrow \quad \frac{-2}{s} + \frac{20\times10^{-3}}{s} \times \frac{1}{s\times10^{-6}} + 100\times\frac{20\times10^{-3}}{s} = V_s$$

$$\Rightarrow \quad V_s = -\frac{2}{s} + \frac{20\times10^{3}}{s^2} + \frac{2}{s}$$

$$V_s(s) = \frac{2}{s^2}\times10^4$$

$\therefore$ $V_s(t) = 2 \times 10^4 t$

$\therefore$



Q.39 For a specified input voltage and frequency, if the equivalent radius of the core of a transformer is reduced by half, the factor by which the number of turns in the primary should change to maintain the same no load current.

(a) $\frac{1}{4}$
(b) $\frac{1}{2}$
(c) 2
(d) 4

Solution: (d)

As $E = \sqrt{2}\pi f \phi N$

where, $\phi = B \times A$

$\because$ Radius is reduced by half

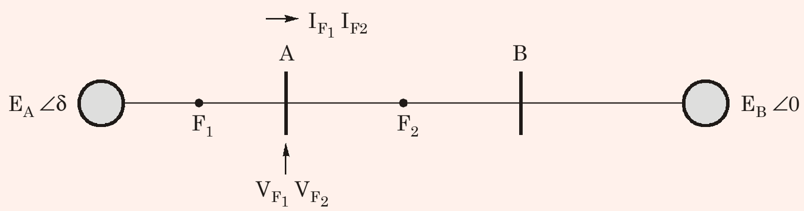
$\therefore$ Area get reduced to $\frac{1}{4}$.

To maintain no load current constant,

we have to maintain E constant.

$\Rightarrow$ Number of turns in the primary should be increased by 4 times.

Q.40 If the fault takes place of F_1 then the voltage and the current at bus A are V_{F1} and I_{F1} respectively. If the fault occurs at F_2, the Bus A voltage and current are V_{F_2} and I_{F_2} respectively. The correct statement about the voltage and current during fault F_1 and F_2 is



(a) V_{F_1} leads I_{F_1} and V_{F_2} leads I_{F_2}
(b) V_{F_2} leads I_{F_1} and V_{F_2} lags I_{F_2}
(c) V_{F_2} lags I_{F_1} and V_{F_2} leads I_{F_2}
(d) V_{F_2} lags I_{F_1} and V_{F_2} lags I_{F_2}

Solution: (a)

In case of fault at F_1,

V_{F_1} lead I_{F_1}

Similarly, in case of fault at F_2 also, V_{F_2} leads I_{F_2} as fault always demands reactive power.

Q.41 In an unbalanced 3-ϕ system, phase current $I_a = 1\angle-90°$ p.u., negative sequence current $I_{b_2} = 4\angle-150°$ p.u., zero sequence current, $I_{C_0} = 3\angle 90°$ p.u. Then, magnitude of phase current I_b in p.u. is

(a) 1.00
(b) 7.81
(c) 11.53
(d) 13.00

Solution: (c)

$$I_a = 1\angle-90° \text{ p.u.}$$

$$I_{b_2} = 4\angle-150° \text{ p.u.}$$

$$I_{c_0} = 3\angle 90° \text{ p.u.}$$

$$I_a = I_{a_1} + I_{a_2} + I_{a_0}$$

As $$I_{b_2} = \alpha I_{a_2}$$

∴ $$4\angle-150° = 1\angle 120° I_{a_2}$$

∴ $$I_{a_2} = \frac{4\angle-150°}{1\angle 120°} = 4\angle-270°$$

$$I_{a_0} = I_{b_0} = I_{c_0} = 3\angle 90°$$

∴ $$I_a = 1\angle-90° = I_{a_1} + 4\angle-270° + 3\angle 90°$$

⇒ $$I_{a_1} = 1\angle-90° - 4\angle-270° - 3\angle 90° = +8\angle-90°$$

⇒ $$I_{b_1} = \alpha^2 I_{a_1} = 1\angle 240° \times 8\angle-90° = 8\angle 150°$$

⇒ $$I_b = I_{b_1} + I_{b_2} + I_{b_0} = 8\angle 150° + 4\angle-150° + 3\angle 90° = 11.53\angle 154.3° \text{ p.u.}$$

Q.42 The core loss of a 1-ϕ 230/115 V, 50 Hz power transformer is measured from 230 V side by feeding the primary 230 V side from a variable voltage variable frequency source with keeping the secondary open circuit, the core loss is measured to be 1050 W for 230 V, 50 Hz input. The core loss again measured to be 500 W for 138 V, 30 Hz input. The hysteresis and eddy current loss of transformer for 230 V, 50 Hz input are respectively.

(a) 508 W and 542 W
(b) 468 W and 582 W
(c) 498 W and 552 W
(d) 488 W and 562 W

Solution: (a)

When $V = 230\text{ V}$

$f = 50\text{ Hz}$

Core losses = 1050 W

Iron loss + Hysteresis loss = 1050 W

Iron loss $= P_i = K_i V^2$

Hysteresis loss $= P_H = K_H V^{1.6} f^{-0.6}$

$$\Rightarrow \quad K_i(230)^2 + K_H \frac{(230)^{1.6}}{(50)^{0.6}} = 1050 \quad \text{...(i)}$$

When $V = 138\text{ V}$

$f = 30\text{ Hz}$

core losses = 500 W

$\Rightarrow \quad P_i + P_H = 500$

$$\Rightarrow \quad K_i(138)^2 + K_H \frac{(138)^{1.6}}{(30)^{0.6}} = 500 \quad \text{...(ii)}$$

Equation (i)

$\Rightarrow \quad 52900\, K_i + K_H\, 574.62 = 1050$ ...(iii)

Equation (ii)

$\Rightarrow \quad 19044\, K_i + K_H\, 344.77 = 500$ ...(iv)

Solving equations (iii) and (iv)

$K_i = 0.01024$

$K_H = 0.885$

∴ Hysteresis loss at 230 V and 50 Hz

$= 0.885 \times 574.62$

$= 508.53\text{ W}$

and Eddy loss $= 0.01024 \times 52900$

$= 541.69\text{ W}$

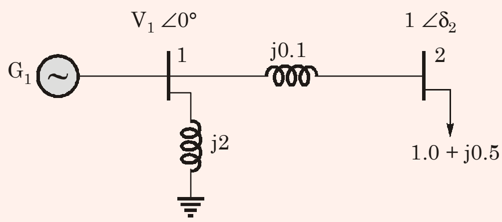
Q.43 An incandescent lamp is marked 40 W, 240 V. If resistance at room temperature (26°C) is 120 Ω and temperature coefficient is 4.5×10^{-3}/°C then "ON" state filament temperature in °C is approximately _______.

Solution: (2470.44°C)

$$P = 40\text{ W}$$
$$V = 240\text{ V}$$
$$\therefore \quad R_\theta = \frac{V^2}{P} = \frac{(240)^2}{40} = 1440\ \Omega$$

At
$$t = 26°$$
$$R = 120\ \Omega$$
$$\alpha = 4.5 \times 10^{-3}/°C$$
$$R_\theta = R[1 + \alpha(\theta_2 - \theta_1)]$$
$$\Rightarrow \quad 1440 = 120\left[1 + 4.5 \times 10^{-3}(\theta_2 - 26)\right]$$
$$2444.44 = \theta_2 - 26°$$
$$\Rightarrow \quad \theta_2 = 2470.44°C$$

Q.44 Find the value of V_1 in p.u. and δ_2 respectively.



(a) 0.95 and ∠6.00°
(b) 1.05 and ∠–5.44°
(c) 1.1 and ∠6.00°
(d) 1.1 and ∠–27.12°

Solution:

$$\frac{V_1\angle 0° - 1\angle\delta_2}{0.1\angle 90°} = I\angle\theta = 1 + j0.5$$
$$\Rightarrow \quad V_1 \angle 0° - 1 \angle\delta_2 = 0.11 \angle 116.56°$$
$$V_1 - (\cos\delta_2 + j\sin\delta_2) = 0.11\left[\cos 116.56° + j\sin 116.56°\right]$$

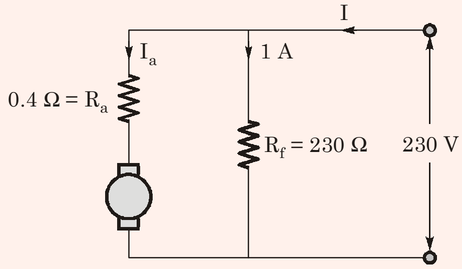
On comparing, real and imaginary terms

We get, $V_1 = 0.95$

and $\delta_2 = \angle 6.00°$

Q.45 A 15 kW, 230 V dc shunt motor has armature circuit resistance 0.4 Ω and field circuit resistance of 230 Ω. At no load and rated voltage, the motor runs at 1400 rpm and the line current drawn by the motor is 5 A. At full load, the motor draws a line current of 70 A. Neglect armature reaction. The full load speed of the motor in rpm is ______.

Solution: (1241.1 rpm)



At no load,

$$n = 1400 \text{ rpm}$$

$$I = 5\text{ A}$$

As $$I = I_f + I_a$$

$\Rightarrow$ $$I_a = 5 - 1 = 4\text{ A}$$

$$230 = E_{f_1} + 4 \times 0.4$$

$$230 - 1.6 = E_{f_1}$$

$\Rightarrow$ $$228.4\text{ V} = E_{f_1}$$

At full load,

$$I = 70\text{ A}$$

$\Rightarrow$ $$I_a = I - I_f$$

$$= 70 - 1 = 69\text{ A}$$

$\therefore$ $$E_{f_2} = 230 - 69 \times 0.4$$

$$= 230 - 27.6$$

$$= 202.4$$

As $$E_f \propto \phi\omega$$

For DC shunt motor, ϕ is constant

$\therefore$ $$E_f \propto \omega$$

$\Rightarrow$ $$\frac{E_{f_1}}{E_{f_2}} = \frac{\omega_1}{\omega_2}$$

$\Rightarrow$ $$\frac{228.4}{202.4} = \frac{1400}{N_2}$$

$\Rightarrow$ $$N_2 = \frac{1400}{1.128} = 1241.1 \text{ rpm}$$

Q.46 A 3-ϕ 50 Hz, 6 pole induction motor has rotor resistance 0.1 Ω and reactance 0.92 Ω. Neglect the voltage drop in stator and assume that the rotor resistance is constant. Given the full load slip 3%. The ratio of maximum torque to full load torque is ___.

Solution: (1.948)

$$r_2 = 0.1\ \Omega \quad \text{and} \quad x_2 = 0.92\ \Omega$$

As
$$T_{fl} = \frac{2T_{em}}{\frac{s_{mT}}{s_{fl}} + \frac{s_{fl}}{s_{mT}}}$$

where,
$$T_{fl} = \text{Full load torque}$$
$$T_{em} = \text{Maximum torque}$$
$$s_{mT} = \text{Slip at maximum torque}$$
$$s_{fl} = \text{Slip at full load}$$

As
$$s_{fl} = 3\% = 0.03$$

and
$$s_{mT} = \frac{r_2}{x_2} = \frac{0.1}{0.92}$$

∴
$$\frac{T_{em}}{T_{fl}} = \frac{\frac{s_{mT}}{s_{fl}} + \frac{s_{fl}}{s_{mT}}}{2}$$

$$= \frac{\left(\frac{\frac{10}{92}}{0.03}\right) + \left(\frac{0.03}{\frac{10}{92}}\right)}{2}$$

$$= \frac{3.62 + 0.276}{2} = 1.948$$

Q.47 The fuel constant of two power plants are

P_1 : $C_1 = 0.05\,P_{g_1}^2 + AP_{g_1} + B.$

P_2 : $C_2 = 0.10P_{g_2}^2 + 3AP_{g_2} + 2B.$

When P_{g_1} and P_{g_2} are generated powers. If two plants optimally share 1000 MW load at incremental fuel constant of 100 Rs/MW, the ratio of load share by power plant 1 and power plant 2 is

(a) 1 : 4
(b) 2 : 3
(c) 3 : 2
(d) 4 : 1

Solution: (d)

Given, $$C_1 = 0.05\,P_{g_1}^2 + AP_{g_1} + B \quad \text{...(i)}$$

$$C_2 = 0.10P_{g_2}^2 + 3AP_{g_2} + 2B \quad \text{...(ii)}$$

and $$P_{g_1} + P_{g_2} = 1000 \quad \text{...(iii)}$$

$$\frac{dC_1}{dP_{g_1}} = \frac{dC_2}{dP_{g_2}} = 100 \quad \text{...(iv)}$$

$$\frac{dC_1}{dP_{g_1}} = 2 \times 0.05\,P_{g1} + A = 100$$

and $$\frac{dC_2}{dP_{g_2}} = 2 \times 0.10\,P_{g_2} + 3\,A = 100$$

$\therefore$ $$0.1\,P_{g_1} + A = 100$$

$$0.2\,P_{g_2} + 3\,A = 100$$

$\Rightarrow$ $$0.3\,P_{g_1} - 0.2P_{g_2} = 200 \quad \text{...(v)}$$

From equations (iv) and (v)

$\therefore$ $$P_{g_1} = 800\text{ MW}$$

and $$P_{g_2} = 200\text{ MW}$$

$\therefore$ $$\frac{P_{g_1}}{P_{g_2}} = \frac{4}{1}$$

■■■■