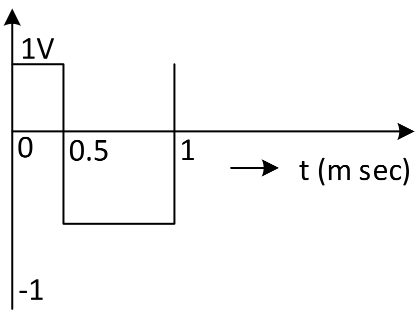
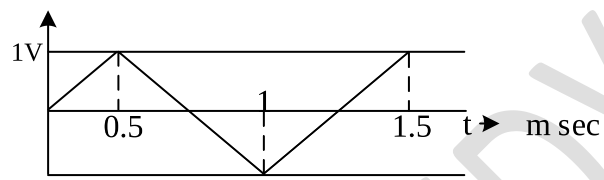
Basics of Network Theory (Part-I)

1. A square waveform as shown in figure is applied across 1 mH ideal inductor. The current through the inductor is a ……. wave of …… peak amplitude.



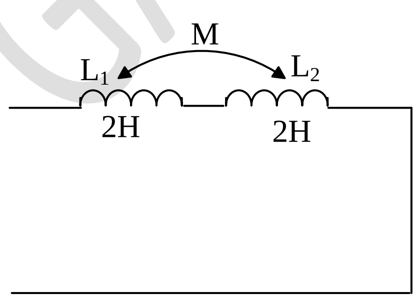
[Gate 1987: 2 Marks]



Ans. **The current through the inductor is $i_L = \frac{1}{L}\int_0^t v dt$. The integration of a square wave is a triangular wave so the current through the inductor is a triangular wave of 1 volt peak amplitude. Slope of triangular wave is ±2**

2. Two 2H inductance coils are connected in series and are also magnetically coupled to each other the coefficient of coupling being 0.1. The total inductance of the combination can be

(a) 0.4 H
(b) 3.2 H
(c) 4.0 H
(d) 4.4 H



Ans. **(d)**

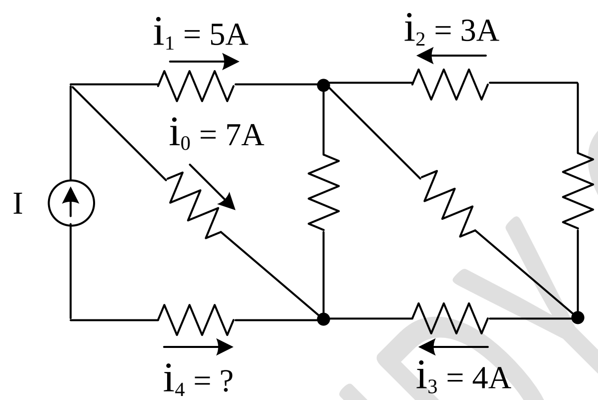
The equivalent inductance $\boldsymbol{Leq = L_1 + L_2 \pm 2M}$

$$= 2 + 2 \pm 2 \times 0.1\sqrt{2 \times 2}$$

$\boldsymbol{M = K\sqrt{L_1 L_2}}$ $\quad\quad = 4 \pm 0.4$

$$= 4.4, 3.6$$

3. The current i_4 in the circuit of Figure is equal to



(a) 12 A
(b) -12 A
(c) 4 A
(d) None of these

[Gate 1997: 1 Mark]

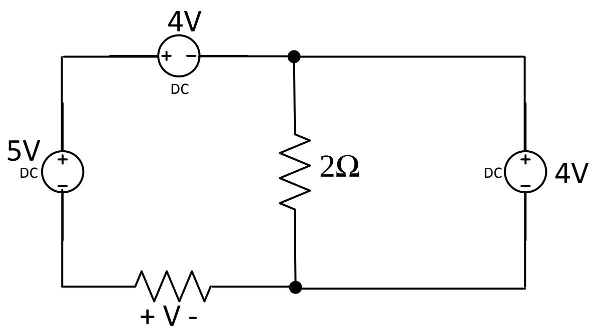
Ans. **(b)**

$\boldsymbol{I = i_0 + i_1}$

$\boldsymbol{= 12A}$

$\boldsymbol{i_4 = -12A}$

4. The Voltage V in Figure is equal to



(a) 3 V
(b) -3 V
(c) 5 V
(d) None of these

[Gate 1997: 1 Mark]

Ans. **(a)**

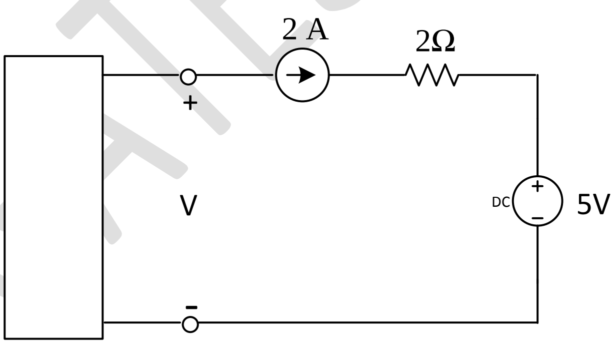
Apply KVL

$$V + 5 - 4 = 4$$

$$V = 4 + 4 - 5$$

$$= 3V$$

5. The voltage V in Figure is always equal to



(a) 9 V
(b) 5 V
(c) 1 V
(d) None of these

[Gate 1997: 1 Mark]

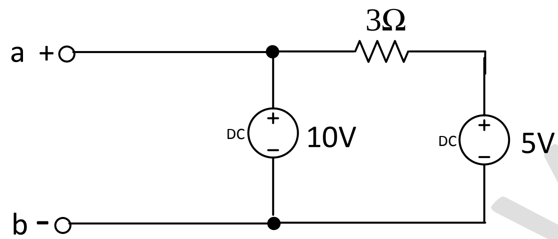
Ans. **(d)**

$$V = V_{2A} + 2 \times 2 + 5$$

$$= V_{2A} + 9$$

Since the voltage of 2A current source is not known, it is not possible to find the value of voltage V.

6. The voltage V in Figure is

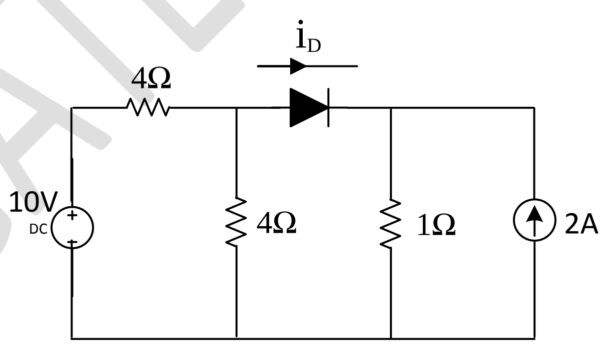


(a) 10 V
(b) 15 V
(c) 5 V
(d) None of the these

[Gate 1997: 1 Mark]

Ans. **(a)**

7. In the circuit shown in the figure the current i_D through the ideal diode (zero cut in voltage and zero forward resistance) equals

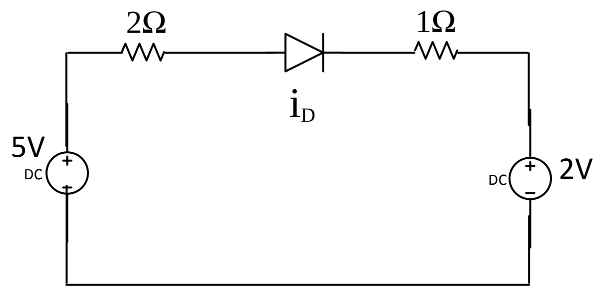


(a) 0 A
(b) 4 A
(c) 1 A
(d) None of these

[Gate 1997: 3 Marks]

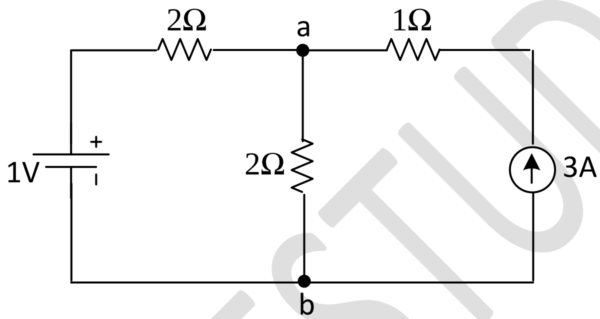
Ans. **(c)**

Applying the source conversion



$$i_D = \frac{5-2}{3} = 1Amp$$

8. The voltage across the terminals a and b in Figure is



(a) 0.5 V
(b) 3.0 V
(c) 3.5 V
(d) 4.0 V

[Gate 1998: 1 Mark]

Ans. **(c)**

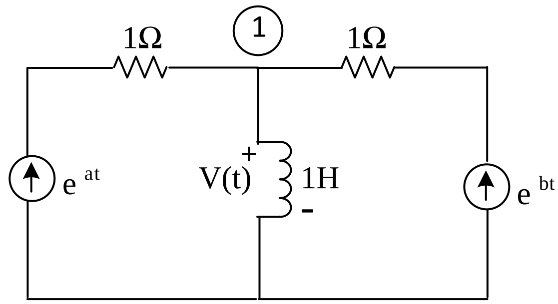
Taking b as reference node and applying KCL at a

$$\frac{V_{ab}-1}{2} + \frac{V_{ab}}{2} = 3$$

$$V_{ab} - 1 + V_{ab} = 6$$

$$V_{ab} = \frac{6+1}{2} = 3.5V$$

9. In the circuit of the figure, the voltage V(t) is



(a) $e^{at} - e^{bt}$
(b) $e^{at} + e^{bt}$
(c) $ae^{at} - be^{bt}$
(d) $ae^{at} + be^{bt}$

[Gate 2000: 1 Mark]

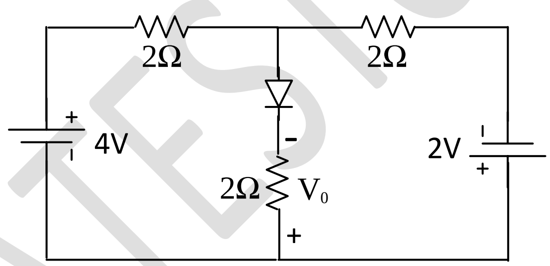
Ans. **(d)**

The voltage v(t) is

$$\boldsymbol{v(t) = L\frac{d}{dt}\left(e^{at} + e^{bt}\right)}$$

$$\boldsymbol{= ae^{at} + be^{bt}}$$

10. For the circuit in the figure, the voltage V_0 is



(a) 2 V
(b) 1 V
(c) -1 V
(d) None of these

[Gate 2000: 2 Marks]

Ans. (d)

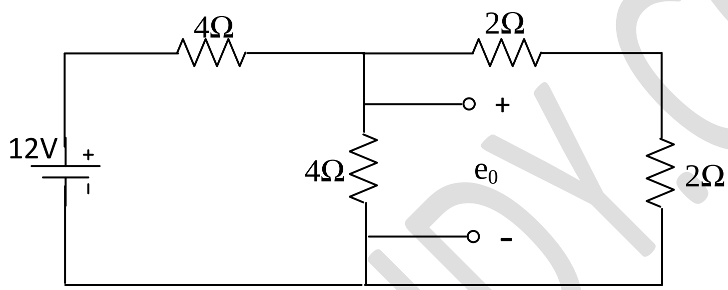
Since the diode is forward biased, it is taken as short circuit. Writing KCL

$$\frac{-V_0-4}{2}+\left(\frac{-V_0}{2}\right)+\left(\frac{-V_0+2}{2}\right)=0$$

$$-3V_0-2=0$$

$$V_0=-\frac{2}{3}$$

11. The voltage e_0 in the figure is



(a) 2 V
(b) 4/3 V
(c) 4 V
(d) 8 V

[Gate 2001: 2 Marks]

Ans. (c)

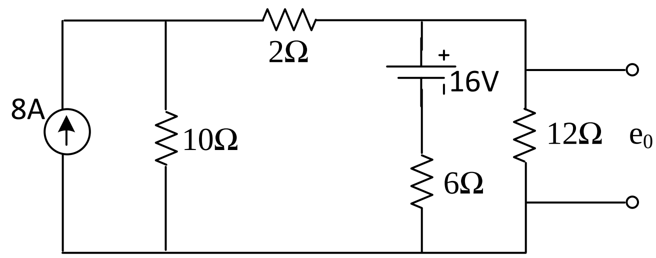
Writing KCL

$$\frac{e_0-12}{4}+\frac{e_0}{4}+\frac{e_0}{4}=0$$

$$3e_0=12$$

$$e_0=4V$$

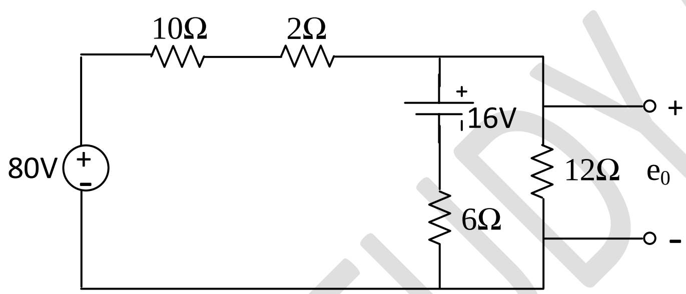
12. The voltage e_0 in the figure is



(a) 48 V
(b) 24 V
(c) 36 V
(d) 28 V **[Gate 2001: 2 Mark]**

Ans. **(d)**

Applying the source conversion, the circuit is as shown

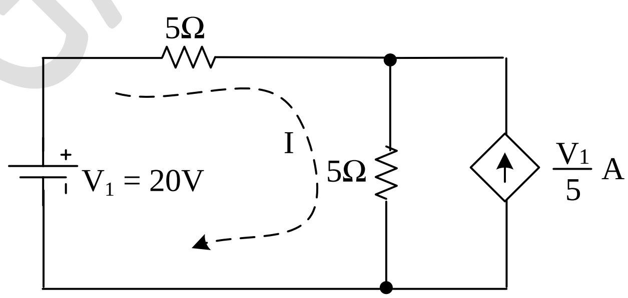


Writing KCL $\frac{e_0-80}{12}+\frac{e_0-16}{6}+\frac{e_0}{12}=0$

$$4e_0 = 112$$

$$e_0 = \frac{112}{4} = 28V$$

13. The dependent current source shown in the figure



(a) Delivers 80W
(b) absorbs 80 W
(c) delivers 40 W
(d) absorbs 40 W

[Gate 2002: 1 Mark]

Ans. **(a)**

Writing KVL

$$V_1 - 5I - 5\left(I + \frac{V_1}{5}\right) = 0$$

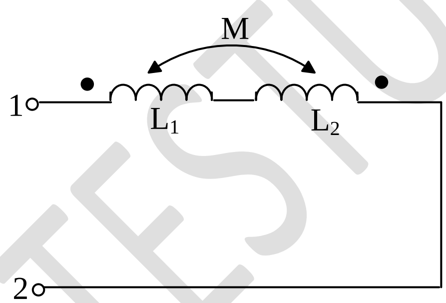
$$V_1 - 10I - V_1 = 0$$

$$I = 0$$

Voltage across dependent source =20V

Thus power delivered by it is $= 20 \times \frac{20}{5} = 80W$

14. The equivalent inductance measured between the terminals 1 and 2 for the circuit shown in the figure



(a) $L_1 + L_2 + M$
(b) $L_1 + L_2 - M$
(c) $L_1 + L_2 + 2M$
(d) $L_1 + L_2 - 2M$

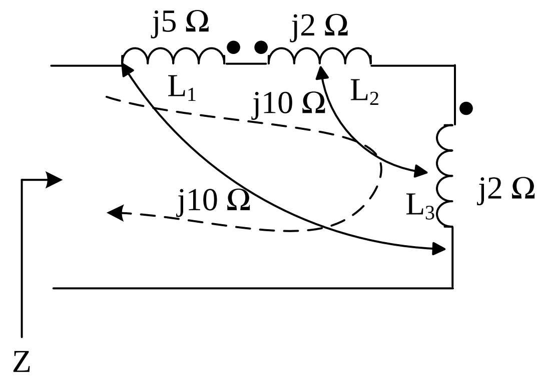
[Gate 2004: 1 Mark]

Ans. **(d)**

The coils are wound in opposite directions, they are series opposing

$$Leq = L_1 + L_2 - 2M$$

15. Impedance Z as shown in the figure is



(a) j 29 Ω
(b) j 9 Ω
(c) j 19 Ω
(d) j 39 Ω

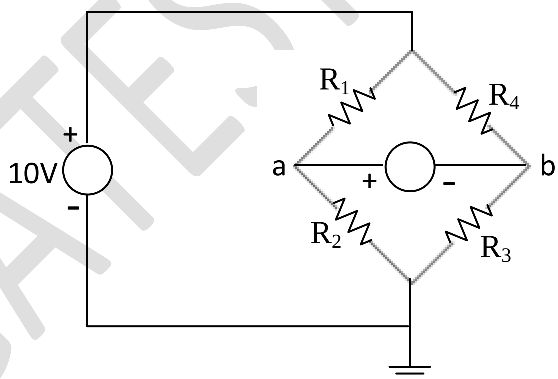
[Gate 2005: 2 Marks]

Ans. **(b)**

Current leaves the dotted terminal of L_1 and enters the dotted terminal of L_3 so mutual induction M_{13} is negative, M_{23} is positive.

$$jwLeq = j5 + j2 + j2 + j10 - j10 = j9$$

16. If $R_1 = R_2 = R_4 = R$ and $R_3 = 1.1R$ in the bridge circuit shown in the figure, then the reading in the ideal voltmeter connected between a and b is



(a) 0.238 V
(b) 0.138 V
(c) -0.238 V
(d) 1 V

[Gate 2005: 2 Marks]

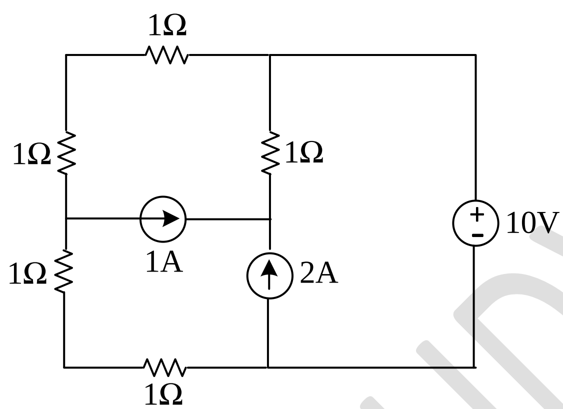
Ans. (c)

$$V_a = \frac{10.R_2}{R_1+R_2} = 5V$$

$$V_b = \frac{10.R_3}{R_4+R_3} = \frac{10\times1.1}{2.1} = 5.238$$

$$V_a - V_b = -0.238V$$

17. In the circuit shown, the power supply by the voltage source is

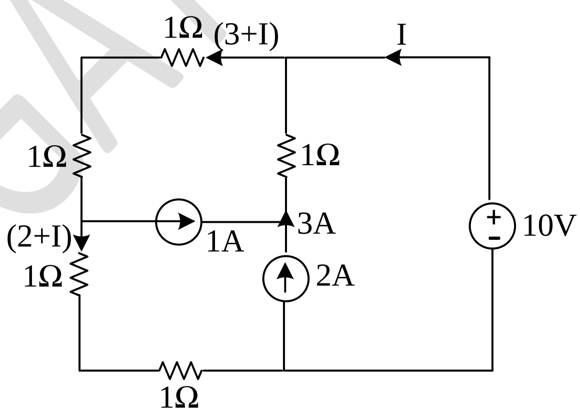


(a) 0 W
(b) 5 W
(c) 10 W
(d) 100 W

[Gate 2010: 2 Marks]

Ans. (a)

Applying KVL in the outer loop



$\mathbf{(3 + \mathit{I})2 + (2 + \mathit{I})2 = 10}$

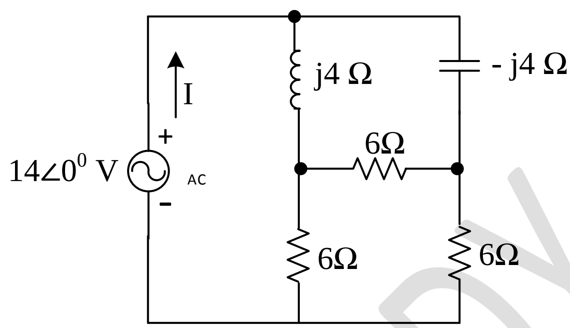
$\mathbf{6 + 2\mathit{I} + 4 + 2\mathit{I} = 10}$

$\mathbf{10 + 4\mathit{I} = 10}$

$\mathbf{\mathit{I} = 0}$

Power supplied by the voltage source $\mathbf{\mathit{P} = \mathit{VI} = 0}$

18. In the circuit shown below, the current I is equal to

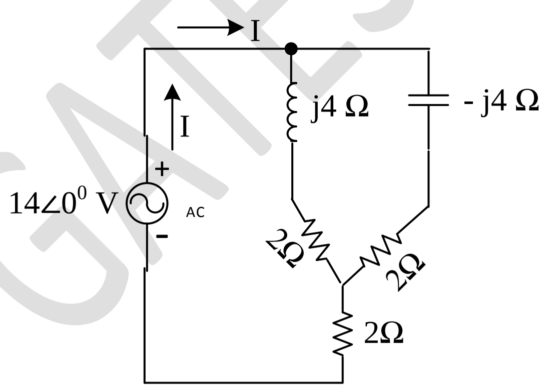


(a) $1.4\angle 0^0$ A
(b) $2.0\angle 0^0$ A
(c) $2.8\angle 0^0$ A
(d) $3.2\angle 0^0$ A

[Gate 2011: 2 Marks]

Ans. (b)

Converting delta into star the circuit is redrawn as impedance of the circuit is



$\mathbf{(2 + \mathit{j}4)||(2 - \mathit{j}4) + 2 = 7}\Omega$

Current $\mathbf{\mathit{I} = \frac{14\angle 0^0}{7} = 2\angle 0^0 \mathit{A}}$

19. The average power delivered to an impedance (4 – j3)Ω by a current 5 cos (100πt + 100) A is

(a) 44.2 W
(b) 50 W
(c) 62.5 W
(d) 125 W

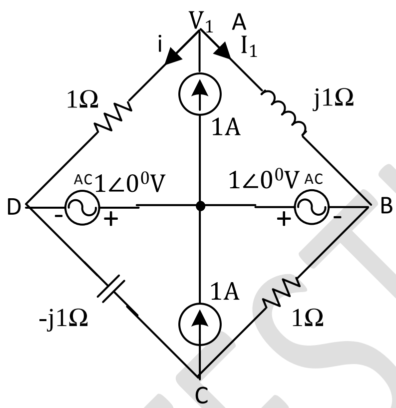
[Gate 2012: 1 Mark]

Ans. (b)

Average power is same as rms power

$$\boldsymbol{P = I_{rms}^2\, R = \left(\frac{5}{\sqrt{2}}\right)^2 \times 4 = 50W}$$

20. In the circuit shown below, the current through the inductor is



(a) $\frac{2}{1+j}A$
(b) $\frac{-1}{1+j}A$
(c) $\frac{1}{1+j}A$
(d) 0 A

[Gate 2012: 1 Mark]

Ans. (C)

In the balanced bridge, the product of opposite arms are equal.

$$\boldsymbol{j1 \times -j1 = 1 \times 1 = 1}$$

In the balanced bridge, current flowing through the diagonal element is zero.

Applying nodal analysis at top node

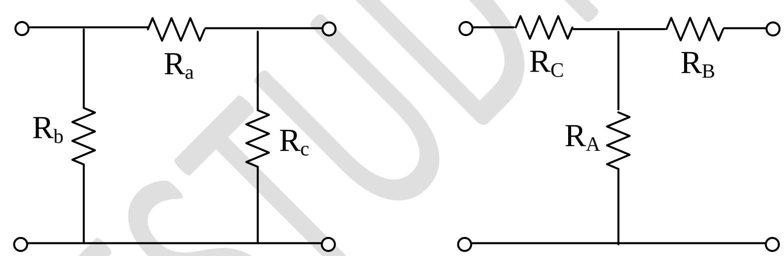
$$\frac{V_1+1\angle 0^0}{1}+\frac{V_1+1\angle 0^0}{j1}=1$$

$$V_1 j1+j1+V_1+1\angle 0^0=j1$$

$$V_1=\frac{-1}{1+j1}$$

$$I_1=\frac{V_1+1\angle 0^0}{j1}=\frac{\frac{-1}{1+j}+1}{j1}=\frac{j}{(1+j)j}=\frac{1}{1+j}$$

21. Consider a delta connection of resistors and its equivalent star connection as shown below. If all elements of the delta connection are scaled by a factor k, k> 0, the elements of the corresponding star equivalent will be scaled by a factor of



(a) K^2
(b) K
(c) 1/K
(d) $\sqrt{K}$

[Gate 2013: 1 Mark]

Ans. **(b)**

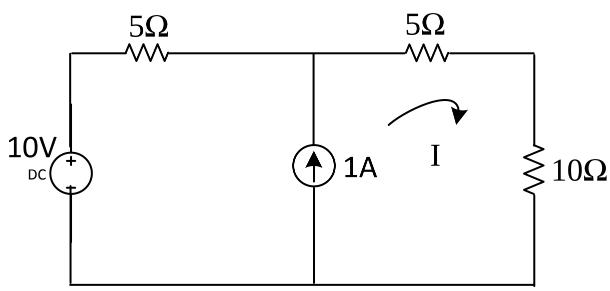
In the star connection,

$$R_c=\frac{R_bR_a}{R_a+R_b+R_c}\ ,\quad R_B=\frac{R_aR_c}{R_a+R_b+R_c}$$

$$R_A=\frac{R_b.R_c}{R_a+R_b+R_c}$$

If the delta connection components are scaled by a factor K, then the star equivalent will also be scaled by a factor K

22. Find the current I in the following branch



[Gate:2014]

Ans. **Using superposition taking 10V source and replacing the current source by its internal resistance (∞)**

$$\boldsymbol{I = \frac{10}{20} = 0.5A}$$

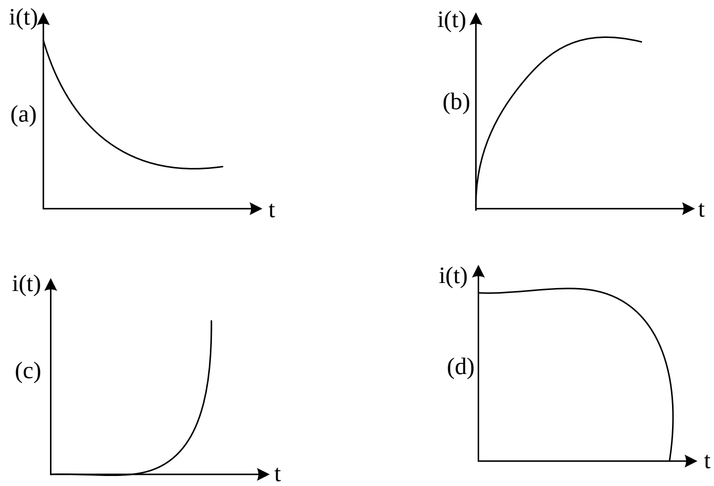
Taking current source and replacing voltage source by its internal resistance zero

$$\boldsymbol{I = \frac{5}{20} \times 1 = \frac{1}{4}A}$$

Total current $\boldsymbol{I = \frac{1}{2} + \frac{1}{4} = 0.75A}$

23. A series RC circuit is connected to DC voltage source at time t_0=0. The relation between the source voltage V_s, the resistance R, the capacitance C, the current i(t) is below:

$$V_s = Ri(t) + \frac{1}{C}\int_0^t i(t)dt$$



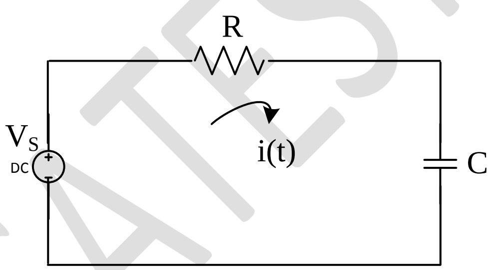
Which one of the following i(t) represents

[Gate:2014]

Ans. **(a)**

Given

$$V_s = Ri(t) + \frac{1}{C}\int_0^t i(t)dt$$



At t = 0 DC source V_s is connected to the RC series network.

Since there is no charge on capacitor initially so, at t = 0 it acts like a short circuit and the current through the network is

$$i(t) = \frac{V_s}{R}$$

then as the capacitor starts charging current starts decreasing at the rate the capacitor starts charging