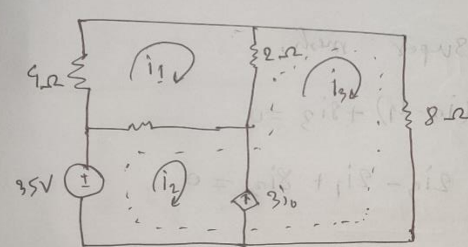
1

Nam: Khan Md Shahedul Islam
Student Id: 2018380130

Ans: 1

Let's get the mesh currents that are labelled as shown bellow:



Now, I'm going to apply kirchhoff's law (Voltage), the algebric ~~value~~ sum of all voltages around a closed path (or loop) is zero.

for mesh 1, we get accordingly,

(2)

$$4i_1 + 2(i_1 - i_3) + 10(i_1 - i_2) = 0$$

$$\Rightarrow 4i_1 + 2i_1 - 2i_3 + 10i_1 - 10i_2 = 0$$

$$\Rightarrow 16i_1 - 10i_2 - 2i_3 = 0$$

$$\Rightarrow 8i_1 - 5i_2 - i_3 = 0 \quad \text{------} \quad (i)$$

Applying kirchhoff's voltage law to mesh 2 and mesh 3 formed super mesh,

$$-35 + 10(i_2 - i_1) + 2(i_3 - i_1) + 8i_3 = 0$$

$$\Rightarrow -35 + 10i_2 - 10i_1 + 2i_3 - 2i_1 + 8i_3 = 0$$

$$\Rightarrow -12i_1 + 10i_2 + 10i_3 = 35 \quad \text{------} \quad (ii)$$

Applying Kirchhoff's current law at Node A:

$3i_0 = i_3 - i_2$

But $i_0 = i_1$

Substituting i_1 for i_0 in ~~question~~ equation

$3i_0 = i_3 - i_2$

$\Rightarrow 3i_1 = i_3 - i_2$

$\Rightarrow 3i + i_2 - i_3 = 0$ —— (iii)

Subtracting (iii) from (i):

$8i_1 - 5i_2 - i_3 = 0$

$3i_1 + i_2 - i_3 = 0$

$5i_1 - 6i_2 = 0$

$\Rightarrow 5i_1 - 6i_2 = 0$ —— (iv)

(i) × 10 + (ii) $\Rightarrow$

$80i_1 - 50i_2 - 10i_3 = 0$

$-12i_1 + 10i_2 + 10i_3 = 35$

$\Rightarrow 68i_1 - 40i_2 = 35$ —— (v)

(4)

Solving (iv) and (v) ⇒

$i_1 = 1.01\ A$

$i_2 = .84\ A$

Finding the value of i_0 -

$i_0 = i_1$

$= 1.01 A$

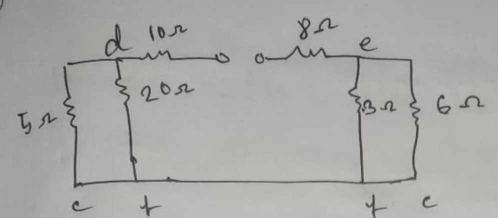
$\therefore$ current $\underline{\underline{i_0 = 1.01\ A}}$

(Ans)

Ans: 2

From fig 3 the nodes c, f are at the same point. Hence, redraw the fig →

(5)



We can see 20Ω, 5Ω and 6Ω, 3Ω are parallel.

Calculating the value of the parallel equivalent resistance, R_{eq_1} for 20Ω, 5Ω.

$$R_{eq_1} = 20\Omega \parallel 5\Omega$$

$$= \frac{20\Omega(5\Omega)}{20\Omega + 5\Omega}$$

$$= \frac{100}{25}\Omega = 4\Omega$$

$\therefore R_{eq_1} = 4\Omega$

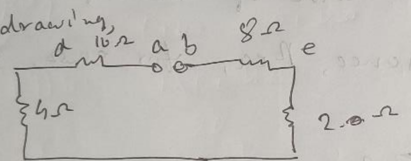
Calculating the value of resistance R_{eq_2} for 6Ω, 3Ω.

$R_{eq_2} = 6\,\Omega \parallel 3\,\Omega$

$$= \frac{6\,\Omega(3\,\Omega)}{6\,\Omega + 3\,\Omega}$$

$$= \frac{18}{9}\,\Omega = 2\,\Omega$$

Redrawing,



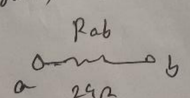
From here, 10 Ω, 8 Ω, 2 Ω, 4 Ω are in series

Calculating R_{ab} for these,

$R_{ab} = 10\,\Omega + 8\,\Omega + 2\,\Omega + 4\,\Omega$

$= 24\,\Omega$

Again Redrawing,



Therefore, the value of equivalent $R_{ab} = 24\,\Omega$

[Ans]

Ans: 4

The circuit is a non-inverting amplifier.

Writing the expression for output voltage:

$$V_{o_1} = \left(1 + \frac{R_F}{R_1}\right) V_1$$

Substituting $50\,k\Omega$ for R_F, $10\,k\Omega$ for R_1 and $4\,mV$ for V_1

$$V_{o_1} = \left(1 + \frac{50\,k\Omega}{10\,k\Omega}\right)(4\,mV)$$

$\Rightarrow (1+5)(4\,mV)$

$\Rightarrow (6)(4\,mV)$

$\Rightarrow 24\,mV$

(8)

Here, a resistor combination is connected as load, to the non-inverting amplifier.

The ~~60~~ 60 kΩ and 30 kΩ resistors are in parallel.

$$R_{eq} = \frac{(60\,k\Omega)(30\,k\Omega)}{60\,k\Omega + 30\,k\Omega}$$

$$= \frac{1800\,k\Omega}{90}$$

$$= 20\,k\Omega$$

It's in series combination with the parallel combination

$\therefore$ ~~Ra~~ Totall R_t is $40\,k\Omega$

The current through 20 kΩ is i_x

$$i_x = \frac{V_{o1}}{R_t}$$

Subbing 24 mV for V_{o1} and 40 kΩ for R_t

9

$$i_x = \frac{24\,mV}{40\,k\Omega}$$

$$= .6 \times 10^{-6} = .6\,\mu A$$

Voltage acrross the $60\,k\Omega$ is v_o

$$P_p = \frac{v_o^2}{60\,k\Omega}$$

Subbing 12 mV for v_o

$$P_\Delta = \frac{(12 \times 10^{-3})^2}{60\,k\Omega}$$

$$= \frac{144 \times 10^{-6}}{60000} = 24 \times 10^{-10} = 2.4\,nW$$

∴ Power dissipitated in $60\,k\Omega$ is $\underline{\underline{2.4\,nW}}$

(Ans)

10

Ans.2

Apply Kirchoff's current law at Node, v_o,

$$\frac{v_o}{10k} + \frac{v_o}{40k} + \frac{v_o - 1}{22k} = 0$$

$$\Rightarrow \frac{v_o}{10} + \frac{v_o}{40} + \frac{v_o - 1}{22} = 0$$

$$\Rightarrow 44v_o + 11v_o + 20v_o - 20 = 0$$

$$\Rightarrow 75v_o = 20$$

$$\Rightarrow v_o = \frac{20}{75} = \frac{4}{15} V$$

~~$44v_o + 11v_o + 20v_o - 20 = 0$~~

~~$75v_o = 20$~~

~~$v_o = 20/75 = 4/15V$~~

11

Same to mod IV.

$$\frac{v_o - 1}{22k} + 0.003v_o + i_o = \frac{1}{30k}$$

$$\Rightarrow \frac{v_o - 1}{22} + 3v_o + 1000 i_o = \frac{1}{30}$$

$$\Rightarrow 30v_o - 30 + 198v_o + 660000 i_o = 22$$

$$\Rightarrow 2010v_o + 660000 i_o = 52$$

Subbing $v_o = \frac{4}{15}$ V in this eq.

$$2010(4/15) + 660000 i_o = 52$$

$$\Rightarrow 536 + 660000 i_o = 52$$

$$\Rightarrow 660000 i_o = -484$$

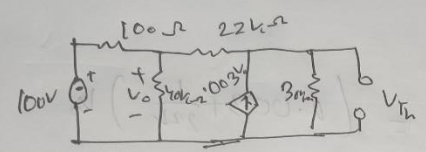
$$\Rightarrow i_o = -733\ \mu A$$

Calculate the Thevenin Resistance.

(12)

$R_{Th} = \frac{1}{I_o} = \frac{1}{-733\times10^{-6}} = -1.3636 k\Omega$

Draw circuit to calculate Thevenin voltage.



At Node v_o Kirchoff's law,

$$\frac{v_o - 100}{10k} + \frac{v_o}{40k} + \frac{v_o - V_{Th}}{22k} = 0$$

$$\Rightarrow \frac{v_o}{10} + \frac{v_o}{40} + \frac{v_o - V_{Th}}{22} = \frac{100}{10}$$

$$\Rightarrow \frac{44v_o + 11v_o + 20v_o - 20V_{Th}}{440} = \frac{4400}{440}$$

$$\Rightarrow 75v_o - 20V_{Th} = 4400$$

$$\Rightarrow 75v_o = 20V_{Th} + 4400$$

$$\Rightarrow v_o = 0.2667V_{Th} + 58.67 \quad --(1)$$

13

Apply Kirchoff's law at V_{Th}.

$$\frac{V_{Th} - V_o}{22k} + \frac{V_{Th}}{30k} = 0.003 V_o$$

$$\Rightarrow \left(\frac{1}{22k} + \frac{1}{30k}\right) V_{Th} = \left(0.003 + \frac{1}{22k}\right) V_o$$

$$\Rightarrow \left(\frac{1}{22} + \frac{1}{30}\right) V_{Th} = \left(3 + \frac{1}{22}\right) V_o$$

$$\Rightarrow \left(\frac{30+22}{660}\right) V_{Th} = \left(\frac{66+1}{22}\right) V_o$$

$$\Rightarrow V_{Th} = \left(\frac{67}{22}\right)\left(\frac{660}{52}\right) V_o$$

$$= 36.65 V_o$$

(Ans)

14

Ans: 10

Resonant frequency:

The resonant frequency ω for a series RLC circuit is

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(40\times10^{-3})(1\times10^{-6})}}$$

$= 5k$ rad/s

Impedance at resonance.

The impedance of a series RLC network is

$$Z = R + j\omega L + \frac{1}{j\omega C}$$

At, $\omega = \omega_0$

Since, the impedance of a series RLC circuit is purely resistive at resonant frequency.

$$Z_{\omega_0} = R$$

$$\Rightarrow Z_{\omega_0} = 1k\Omega$$

(Ans)

16

Ans:7

For $t < 0$, the Inductor acts as a short circuit to dc and the circuit becomes what shown below. Applying KVL to left top of the circuit shown

$$4i_0 = 3i_0 + 24 \Rightarrow i_0 = 24\,A$$

Applying ohm's law to the 2Ω resistors given,

$$i(0) = \frac{4i_0}{2} = \frac{4 \cdot 24}{2} = 48\,A$$

For, $t > 0$, the switch is moved so that the current i_0 becomes equal to zero. Then, the dependent voltage source $(4i_0)$ can be replaced with

(17)

a short circuit and circuit shown below become a source free RL circuit. Time constant.

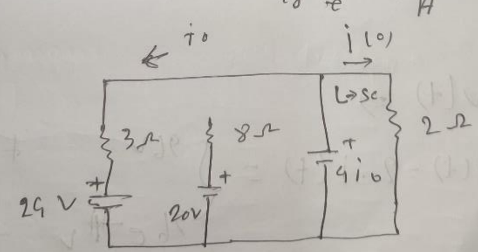
$$\tau = \frac{L}{R} = \frac{.5}{2} = \frac{1}{4}\,s$$

inductor current for $t>0$ is

$$i(t) = i(0)\, e^{-t/\tau} = 48\, e^{-4t}\ A$$

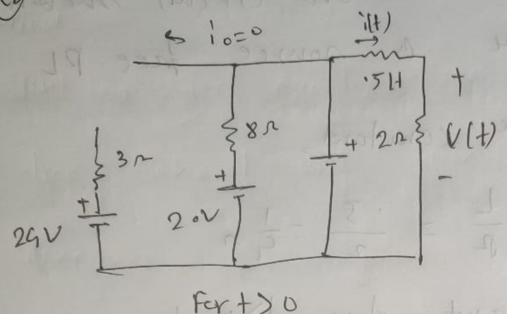
Then the inductor current is

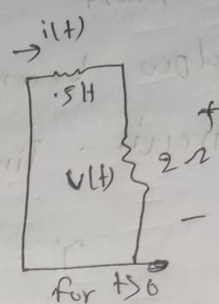
$$i(t) = \begin{cases} 48\,A & t<0 \\ 48\, e^{-4t}\ A & t>0 \end{cases}$$



for $t < 0$

(18)





Applying Ohm's law to the 2Ω resistors gives

$$v(t) = 2 \cdot i(t) = \begin{cases} 96V & t < 0 \\ 96e^{-4t}\,V & t > 0 \end{cases}$$

voltage $v(t) \Rightarrow$

$$v(t) = 2 \cdot i(t) = \begin{cases} 96V & t < 0 \\ 96e^{-4t}\,V & t > 0 \end{cases}$$

(Ans)

(19)

Ans: 9

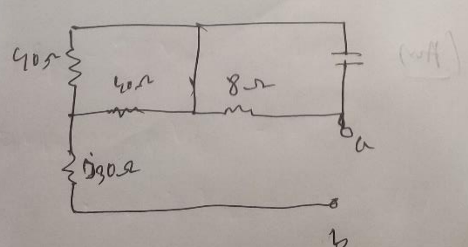
To find Z_{Th} reserence Z_L, and open circuit $5\angle 9A$ (current source) short circuit $6\angle 0°$ (voltage source)

$40\Omega \,||\, 40\Omega$

$$= \frac{40\times 40}{40\times 40} = 20\Omega$$

$$-j\,10 \,||\, 80\,\Omega = \frac{80\times -j10}{80-j10}$$

$$= 1.23 - j9.846\,\Omega$$



(20)

$20\,\Omega$ and $1.23 - j9.846\,\Omega$ are in series with $j30$ given ~~Zab~~ =

$$Z_{ab} = 20 + 1.23 - j\,9.846 + j\,30$$

$$= 21.23 + j\,20.15\,\Omega$$

For maximum power resonant

$$Z_L = \text{conjugette}\,(Z_{ab})$$

$$Z_L = Z_{ab}^{*}$$

$$Z_L = 21.23 - j\,20.15\,\Omega$$

(Ans)

21

Ans: 6

Here, 4 μF is in series with 12 μF

$$\frac{(4 \times 12)}{4 + 12} = 3 \mu F$$

And 3 μF is in parallel with 3 μF

given.

$3 \mu F + 3 \mu F = 6 \mu F$

Now, 6 μF is in series with 6 μF

$$\frac{6 \times 6}{6 + 6} = 3 \mu F$$

And, 3 μF is in parallel with

2 μF given.

$3\,\mu F + 2\,\mu F = 5\,\mu F$

And, $5\,\mu F$ is in series with $5\,\mu F$

given,

$$\frac{5 \times 5}{5+5} = 2.5\,\mu F$$

Hence, $C_{eq} = 2.5\,\mu F$

$\therefore$ equivalent capacitance at terminal a-b is $\underline{\underline{2.5\,\mu F}}$

(Ans)

Ans. to: 5

$V_1 = 6I_1 - j4i_2$

$V_2 = -j4I_1 + 8\dot{I}_2$

$2\angle 30^\circ = 2\dot{I}_1 + V_1$

$V_2 = 0$

Now,

$\dot{I}_1 = 0.2\angle 30^\circ$ A

$\dot{I}_2 = 0.1\angle 120$ A

$\therefore \dot{I}_1 = 0.2$ A

$I_2 = 0.1$ A

(Ans)