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17/ENG04/057
ELECTRICAL ELECTRONICS ENGINEERING
CIRCUIT THEORY (EEE322)
SOLUTION:

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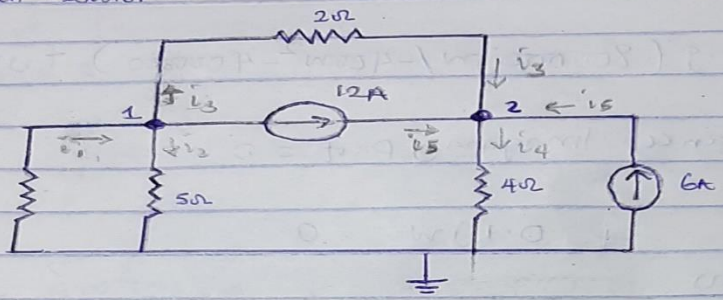
CIRCUIT THEORY II (EEE 322)

Q1

1) Find the Voltage at node 1 and 2 and determine the Current flowing thrugh each resistor.



Solution.

At Node 1, Applying kcl

$i_5 + i_2 + i_3 = i_1$

Where

$i_5 = 12A$, $i_2 = \frac{V_1}{5}$, $i_3 = \frac{V_1 - V_2}{2}$, $i_4 = \frac{-V_1}{10}$

$\therefore 12 + \frac{V_1}{5} + \frac{V_1 - V_2}{2} = -\frac{V_1}{10}$

Multiply thro by 10.

$\therefore 120 + 2V_1 + 5V_1 - 5V_2 = -V_1$

$120 = -7V_1 - V_1 + 5V_2$

$120 = -8V_1 + 5V_2$ ... eq (1).

At Node 2. Applying kcl

$i_4 = i_5 + i_6 + i_3$

$i_4 = \frac{V_2}{4}$, $i_5 = 12A$, $i_6 = 6A$, $i_3 = \frac{V_1 - V_2}{2}$.

$$\Rightarrow \frac{V_2}{4} = 12 + 6 + \frac{V_1 - V_2}{2}$$

Multiply thro by 4

$$\Rightarrow V_2 = (18 \times 4) + 2V_1 - 2V_2$$

$$V_2 = 72 + 2V_1 - 2V_2$$

$$72 = -2V_2 - V_2 + 2V_1$$

$$72 = +3V_2 - 2V_1 \quad \cdots \text{ Eq (2)}$$

Solving Eq (1) and Eq (2) simultaneously:

$$120 = -8V_1 + 5V_2$$

$$72 = +8V_2 - 2V_1 \quad \otimes 4$$

$$\therefore \quad 120 = -8V_1 + 5V_2$$

$$-288 = -8V_1 + 12V_2$$

$$-168 = 0 - 7V_2$$

$$-168 = -7V_2$$

$$V_2 = 168/7$$

$$V_2 = 24\ V$$

$\therefore$ Put $V_2 = 24$ into eq (2).

$$\therefore \quad 72 = 3V_2 - 2V_1$$

$$72 = 3(24) - 2V_1$$

$$72 = 72 - 2V_1$$

$$-2V_1 = 0$$

$$V_1 = 0$$

Current Values:

$$i_5 = 12\ A$$

$$i_2 = V_1/5 \quad \therefore \quad i_2 = 0\ A$$

$$i_3 = (V_1 - V_2)/2$$

$$i_3 = -24/2$$

$$i_3 = -12\ A$$

$$i_1 = -V_1/10 = 0\ A$$

$$i_4 = 24/4 = 6\ A$$

$$i_6 = 6\ A$$

$V_2 = 24\ V$
$V_1 = 0$
$i_1 = 0\ A$
$i_2 = 0\ A$
$i_3 = -12\ A$
$i_4 = 6\ A$
$i_5 = 12\ A$
$i_6 = 6\ A$

Current across resistor (10Ω); $i_1 = 0A$.

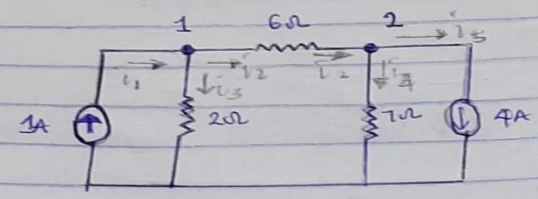
Current across resistor (5Ω); $i_2 = 0A$.

Current across resistor (2Ω); $i_3 = -12A$.

Current across resistor (4Ω); $i_4 = 6A$.

Q2.

2. Obtain V_1 and V_2 and the current through the resistor the circuit in example (ii) if the 2A current source was replaced by a 1A current source.



Solution:

At Node 1: Applying kcl

$i_1 = i_2 + i_3$

Where; $i_1 = 1A$ $\quad i_2 = \frac{V_1 - V_2}{6}$ $\quad i_3 = \frac{V_1}{2}$

$\therefore 1 = \frac{V_1 - V_2}{6} + \frac{V_1}{2}$.

Multiply through by 6.

$6 = V_1 - V_2 + 3V_1$

$6 = 4V_1 - V_2$. ---- eqn(i).

At Node 2; Applying kcl.

$i_2 = i_4 + i_5$

$\therefore$ Where; $i_2 = \frac{V_1 - V_2}{6}$ $\quad i_4 = \frac{V_2}{7}$ $\quad i_5 = 4$.

$\therefore \frac{V_1 - V_2}{6} = \frac{V_2}{7} + 4$

Multiply through by 42.

$\therefore 7V_1 - 7V_2 = 6V_2 + 168$.

$168 = 7V_1 - 13V_2$. ---- (eqn (2)).

From equation (i) Make V_2 Subject.

$V_2 = 6 - 4V_1$ -- (eq 3)

∴ Put eq (3) into eqn (2)

∴ $168 = 7V_1 - 13V_2$

$168 = 7V_1 - 13(-6 + 4V_1)$

$168 = 7V_1 + 78 - 52V_1$

$168 + (-78) = 7V_1 - 52V_1$

$168 - 78 = 7V_1 - 52V_1$

$90 = -45V_1$

$V_1 = -2$

∴ Put $V_1 = -2$ into eqn 3.

$V_2 = -6 + 4V_1$

$V_2 = -6 + 4(-2)$

$V_2 = -6 - 8$

$V_2 = -14$ V.

Current Across each resistor;

At resistor (2Ω); i_3

$i_3 = V_1/2$

$= -2/2$

$= -1$ A.

at resistor (6Ω); i_2

$i_2 = V_1 - V_2/6$

$\Rightarrow -2 - (-14)/6$

$\Rightarrow 12/6$

$= 2$ A

at resistor (7Ω); i_4

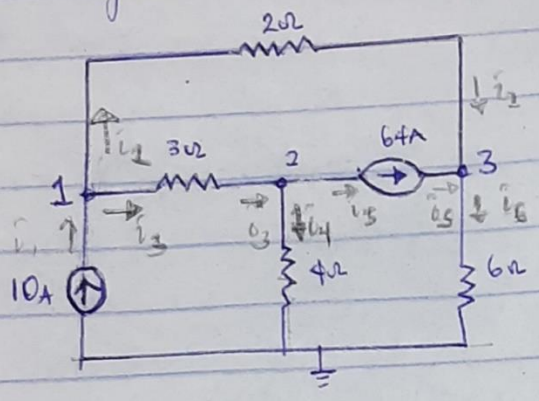
$i_4 = V_2/7$

$= -14/7$

$= -2$ A.

Q3.

Find the Voltages at Nodes 1, 2 and 3 in the Circuit below;



Solution;

At Node 1:

$$i_1 = i_2 + i_3$$

$$i_1 = 10\,A, \quad i_2 = \frac{V_1 - V_3}{2} \quad ; \quad i_3 = \frac{V_1 - V_2}{3}$$

$$\therefore 10 = \frac{V_1 - V_3}{2} + \frac{V_1 - V_2}{3}$$

Multiply thro by 6.

$$60 = 3V_1 - 3V_3 + 2V_1 - 2V_2$$

$$60 = 5V_1 - 3V_3 - 2V_2$$

$$60 = 5V_1 - 2V_2 - 3V_3 \quad \cdots \quad eq(1).$$

At Node 2;

$$i_4 + i_5 = i_3$$

where

$$i_5 = 64A, \quad i_3 = \frac{V_1 - V_2}{3}, \quad i_4 = \frac{V_2}{4}$$

$\therefore 64 + \frac{V_2}{4} = \frac{V_1 - V_2}{3}$

$64 = \frac{V_1 - V_2}{3} - \frac{V_2}{4}$

Multiply through by 12.

$768 = 4(V_1 - V_2) - 3(V_2)$

$768 = 4V_1 - 4V_2 - 3V_2$

$768 = 4V_1 - 7V_2$ ... eqn (2).

At Node B:

$i_5 + i_2 = i_6$.

where $i_5 = 64$, $i_2 = \frac{V_1 - V_3}{2}$ & $i_6 = \frac{V_3}{6}$.

$\therefore 64 + \frac{V_1 - V_3}{2} = \frac{V_3}{6}$.

$64 = \frac{V_3}{6} - \left(\frac{V_1 - V_3}{2}\right)$

Multiply throw by 6.

$384 = V_3 - 3(V_1 - V_3)$

$384 = V_3 - 3V_1 + 3V_3$

$384 = 4V_3 - 3V_1$ ... eqn (3).

From eqn 1 make V_1 Subject.

$\therefore 768 = 4V_1 - 7V_2$.

$768 + 7V_2 = 4V_1$

$V_1 = 192 + 1.75V_2$ ... eq (4)

put eqn (4) into eqn (3)

$384 = 4V_3 - 3V_1$

$384 = 4V_3 - 3(192 + 1.75V_2)$

$384 = 4V_3 - 3(192 + 1.75V_2)$

$384 = 4V_3 - 576 - 5.25V_2$

$960 = 4V_3 - 5.25V_2$

Divide through by (4)

$240 = V_3 - 1.3125V_2$

$\therefore V_3 = 240 + 1.3125V_2$ ... Eq 5.

$\therefore$ Put eqn (4) and eqn (5) into eqn (1).

eqn 4 $\Rightarrow V_1 = 192 + 1.75V_2$

eqn 5 $\Rightarrow V_3 = 240 + 1.3125V_2$

$\therefore$ eqn 1 $\Rightarrow 60 = 5V_1 - 2V_2 - 3V_3$.

$\therefore 60 = 5(192 + 1.75V_2) - 2V_2 - 3(240 + 1.3125V_2)$

$60 = 960 + 8.75V_2 - 2V_2 - 720 - 3.9375V_2$

$\therefore 60 = 240 + 2.8125V_2$

$240 - 60 = 2.8125V_2$

$2.8125V_2 = -180$

$V_2 = -180 \div (2.8125)$

$V_2 = -64.\ V$

$\therefore$ put $V_2 = -64$ into eqn (5) and eqn (4)

$\therefore$ eqn(5)

$V_3 = 240 + 1.3125V_2$

$V_3 = 240 + 1.3125(-64)$

$V_3 = 240 - 84$

$V_3 = 156\ V$

eqn (4) ; $V_1 = 192 + 1.75\ V_2$

$V_1 = 192 + 1.75(-64)$

$V_1 = 192 + (-112)$

$V_1 = 80.\ V$

$\therefore V_1 = 80V$, $V_2 = -64V$, $V_3 = 156V$.