Paper 1, TDC Part-1
Chapter– 4, Circuit Theorems
Lecture - 2

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Circuit Theorem

- In previous lecture we have discussed "Superposition Theorem" and did one example. Today we will solve few more problems on superposition theorem.

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Eg→ 2 Obtain the current in the branch containing 10Ω resistor of the network shown in fig B using superposition theorem.

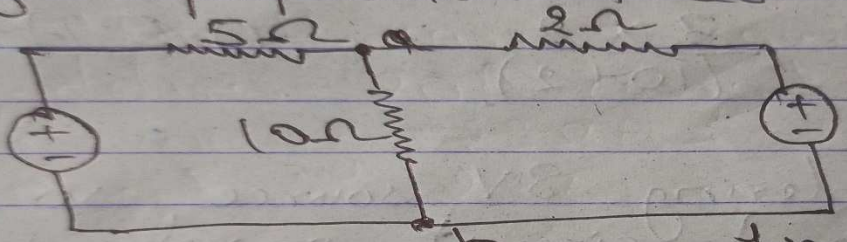

fig. (B)

Soln.

The network consist of two active voltage sources of 20V and 8V. As per superposition theorem we will take one source first then take the other source, so here we take 20V source first.

Circuit Theorem

So the 8V source will be short circuited as it is a voltage source. The fig of the new is drawn in fig. ~~2 (A)~~ B(2).

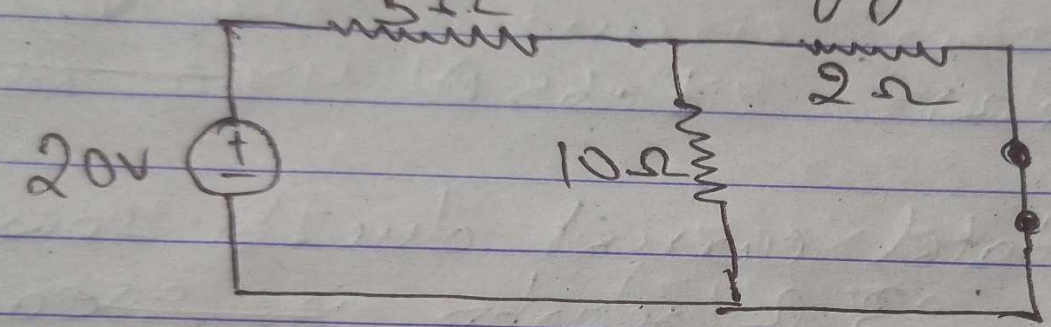

fig B(2)

Here 10Ω & 2Ω are in IInd now so

$$R'_{eq} = \frac{5 \times 2}{3} \Omega = \frac{5}{3} \Omega =$$

Now 5Ω is in series with $\frac{5}{3}$ Ω so

$$R_{eq} = \left(5 + \frac{5}{3}\right) \Omega = \frac{20}{3} \Omega$$

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Circuit Theorem

$$I_7' = \frac{20}{20} \times 3\ A = 3A$$

$$I'_{10\Omega} = \frac{3 \times 2}{(10+2)} = 0.5\ A \quad \text{—— (i)}$$

Now considering 8V source so 20V source will be short circuit, so redrawing n/w. as shown in figure B(3)

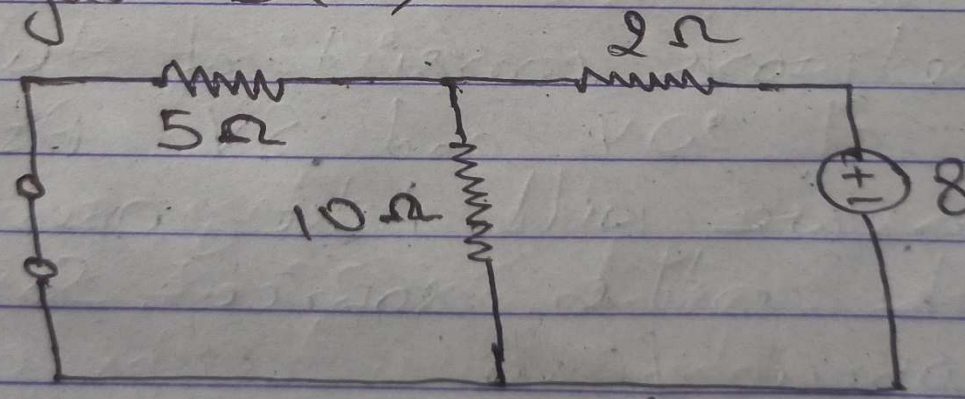

fig B(3)

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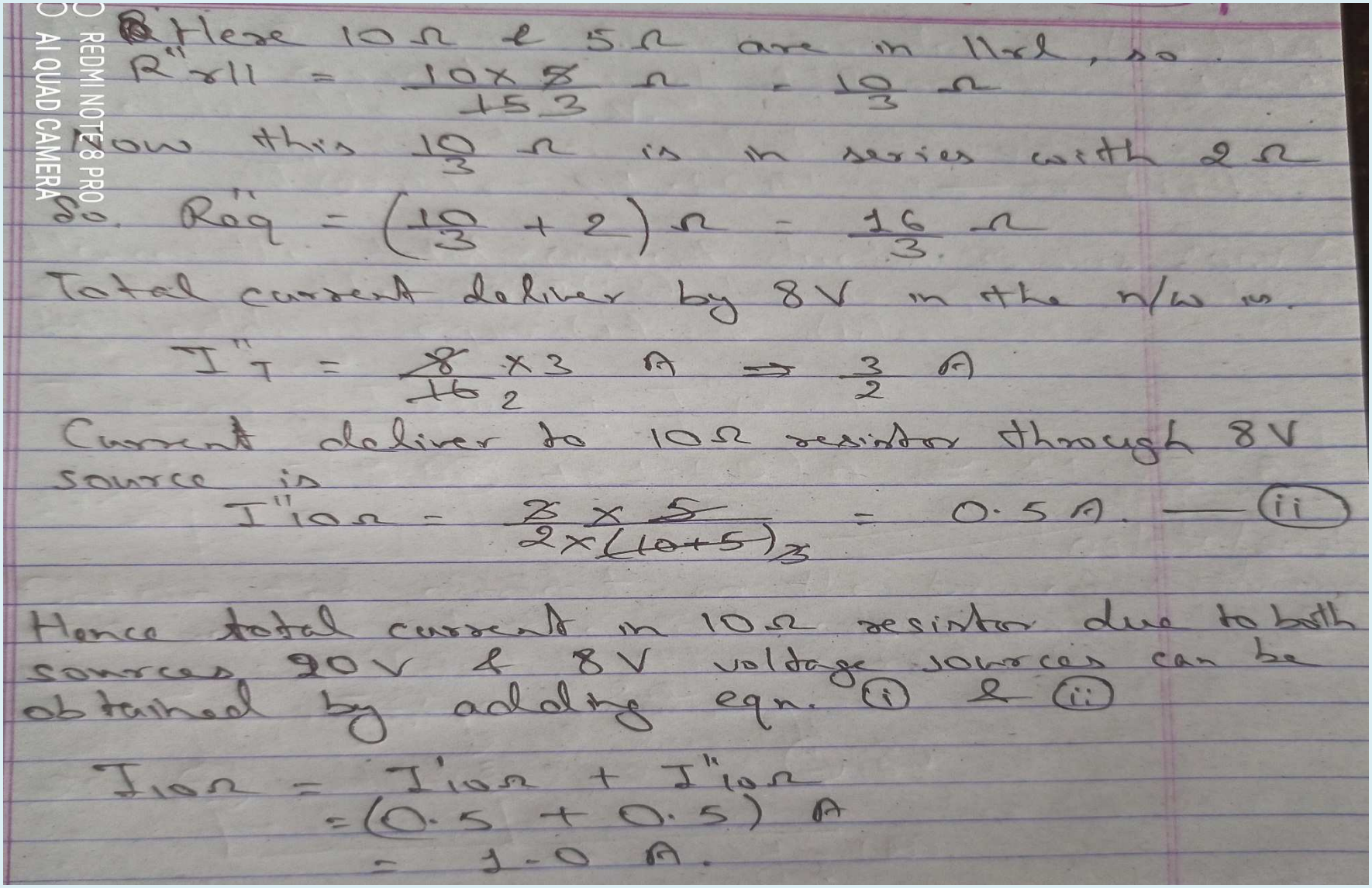
Circuit Theorem



Here 10Ω & 5Ω are in ||rl, so.

$R''_{||} = \frac{10 \times 5}{15}\ \Omega = \frac{10}{3}\ \Omega$

Now this $\frac{10}{3}\ \Omega$ is in series with $2\ \Omega$

So. $R''_{eq} = \left(\frac{10}{3} + 2\right)\Omega = \frac{16}{3}\ \Omega$

Total current deliver by 8V in the n/w is.

$I''_T = \frac{8}{16/3} \times 3\ A \Rightarrow \frac{3}{2}\ A$

Current deliver to 10Ω resistor through 8V source is

$I''_{10\Omega} = \frac{3 \times 5}{2 \times (10+5)_3} = 0.5\ A.$ — (ii)

Hence total current in 10Ω resistor due to both sources 20V & 8V voltage sources can be obtained by adding eqn. (i) & (ii)

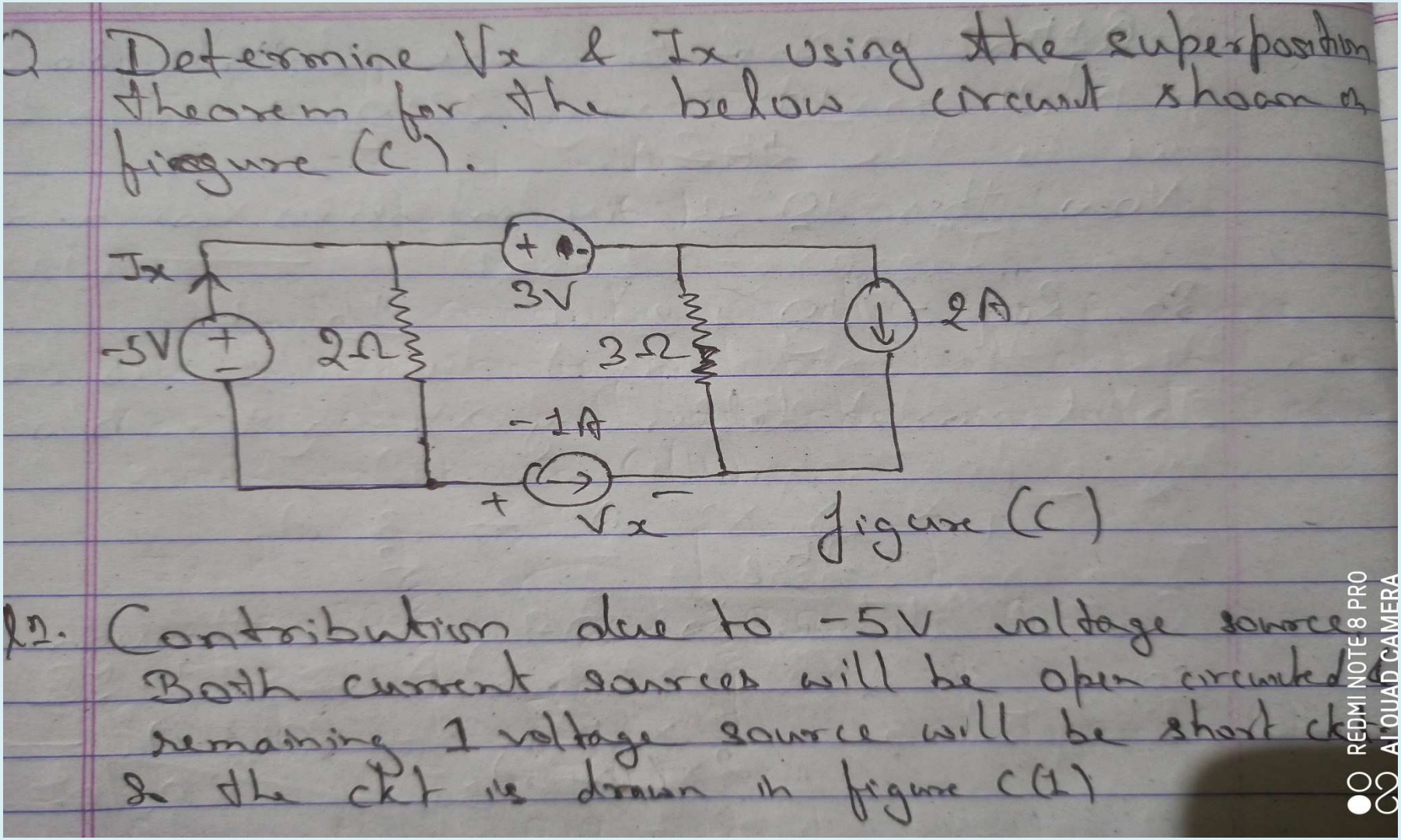
$I_{10\Omega} = I'_{10\Omega} + I''_{10\Omega}$

$= (0.5 + 0.5)\ A$

$= 1.0\ A.$

Circuit Theorem

- Now let us see third example.



Circuit Theorem

remaining 1 voltage source will be short ckt. & the ckt is drawn in figure c(1)

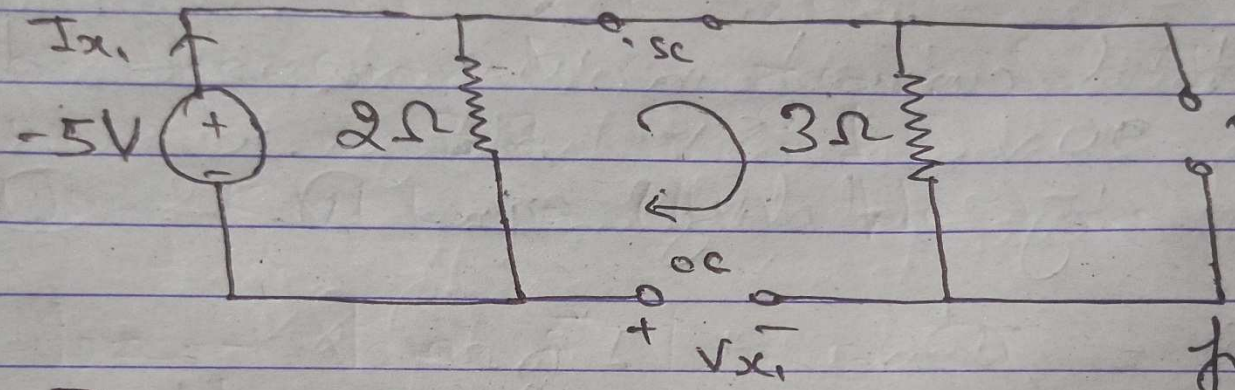


fig c (1)

$$I_{x_1} = \frac{-5\,V}{2\,\Omega} = -2.5\,A.$$

Current through 3Ω resistor is zero.

Now using KVL in second loop we have

$$-(2\Omega \times -2.5A) + (3\Omega \times 0A) - V_{x_1} = 0$$

$$5V + 0V - V_{x_1} = 0$$

$$V_{x_1} = 5V$$

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Circuit Theorem

Now contribution due to 3 V voltage source. Again both current is open circuited & 1 voltage source is ~~short~~ short circuited. as shown in fingure (2)

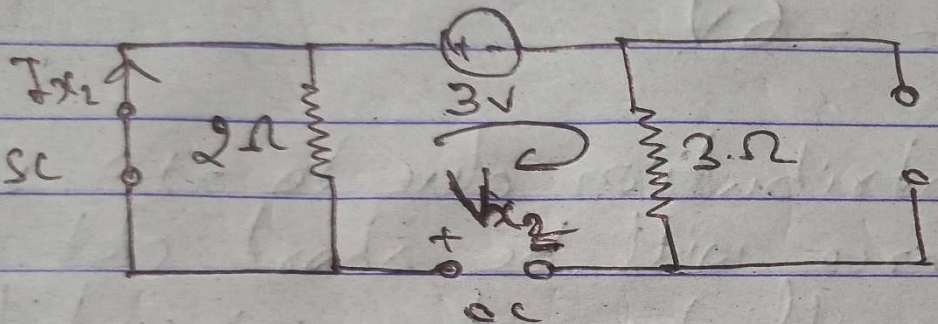

figure (2).

The current through 2Ω resistor is zero, ~~so the current at it is~~ as there is short circuit ~~so I_{x_2}~~

So $I_{x_2} = 0$ A.

Current through 3Ω is also zero.

Now applying KVL in loop of fig. (2)

$$-3V + V_{3\Omega} + V_{x_2} + V_{2\Omega} = 0$$

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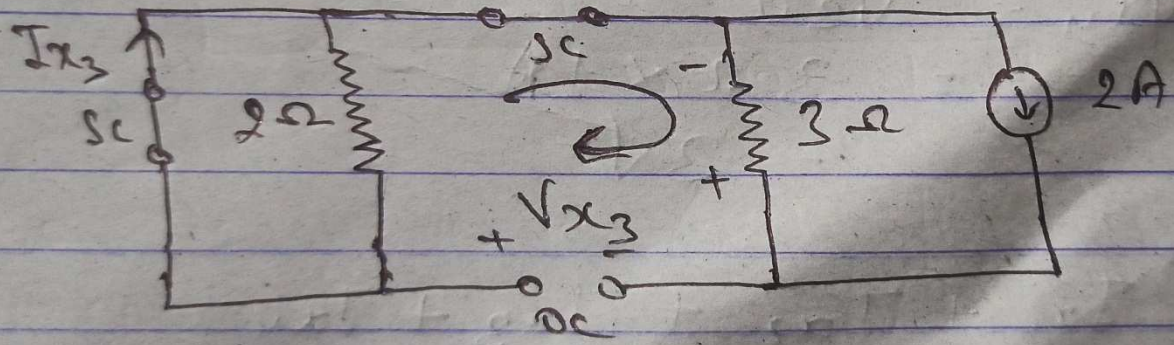
Circuit Theorem

$$-3V + V_{3\Omega} + V_{x_2} + V_{2\Omega} = 0$$
$$-3V + 0V + V_{x_2} + 0V = 0$$
$$V_{x_2} = 3V$$

Now contribution due to 2A current source, both voltage source will be short ckt. and I current source open ckt. as shown in figure c(3).



Again, the 2Ω resistor is short circuited so current through it is zero, So $I_{x_3} = 0$ A.

$$I_{3\Omega} = 2\text{ A}.$$

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Circuit Theorem

Using KVL

$V_{2\Omega} - V_{3\Omega} - V_{x_3} = 0$

$0 - 3 \times 2\ V - V_{x_3} = 0$

$V_{x_3} = -6V$

Now lastly contribution due to -1A source. The voltage source will be short ckt and one current source will be open circuited, as shown in figure C(4).

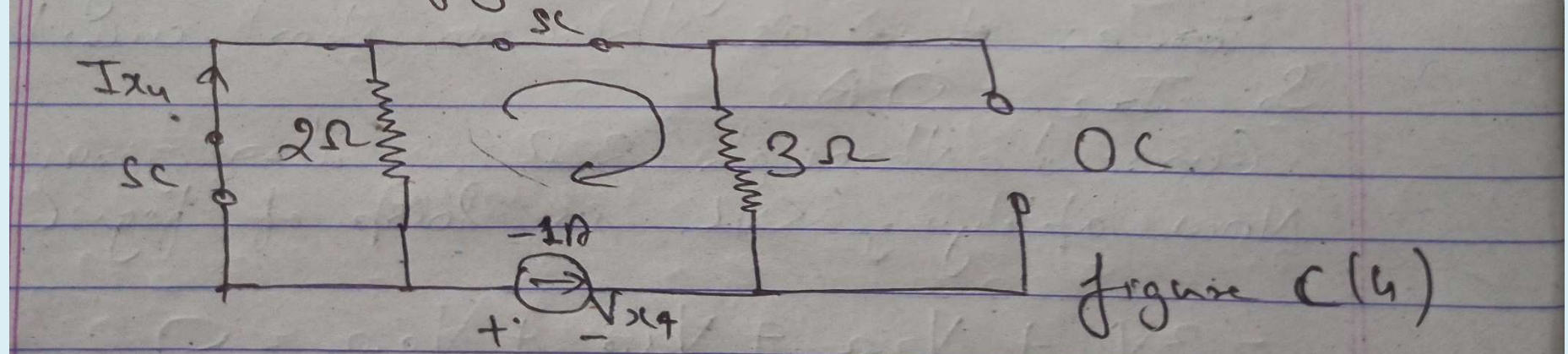

figure C(4)

Again the 2Ω resistor is short circuited.

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Circuit Theorem

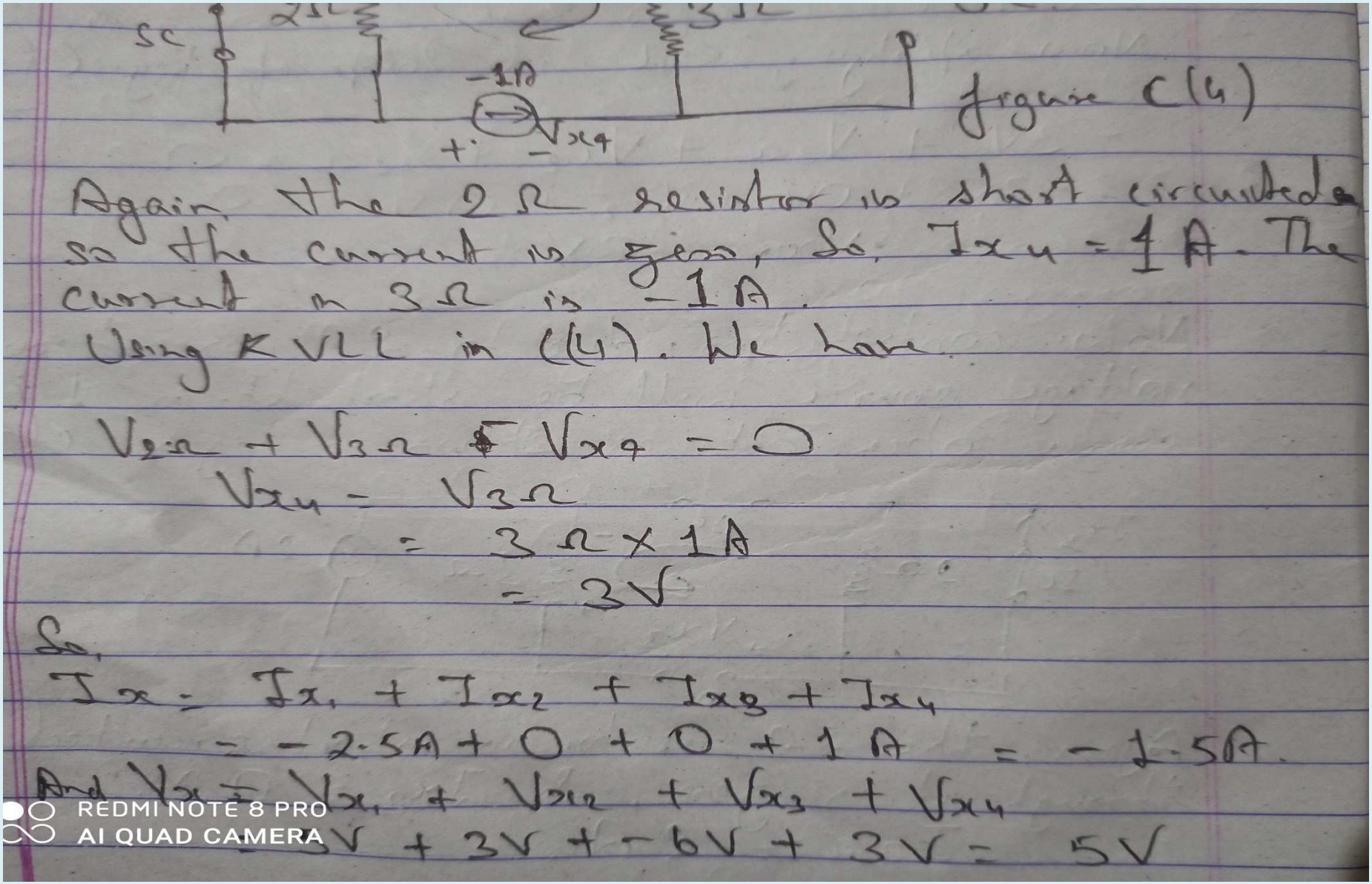

figure c(4)

Again the 2Ω resistor is short circuited so the current is zero, So, $I_{x4} = 1A$. The current in 3Ω is $-1A$.

Using KVL in (4). We have

$$V_{2\Omega} + V_{3\Omega} + V_{x4} = 0$$

$$V_{x4} = V_{3\Omega}$$

$$= 3\Omega \times 1A$$

$$= 3V$$

So,

$$I_x = I_{x1} + I_{x2} + I_{x3} + I_{x4}$$

$$= -2.5A + 0 + 0 + 1A = -1.5A.$$

And $V_x = V_{x1} + V_{x2} + V_{x3} + V_{x4}$

$$= -2V + 3V + -6V + 3V = 5V$$

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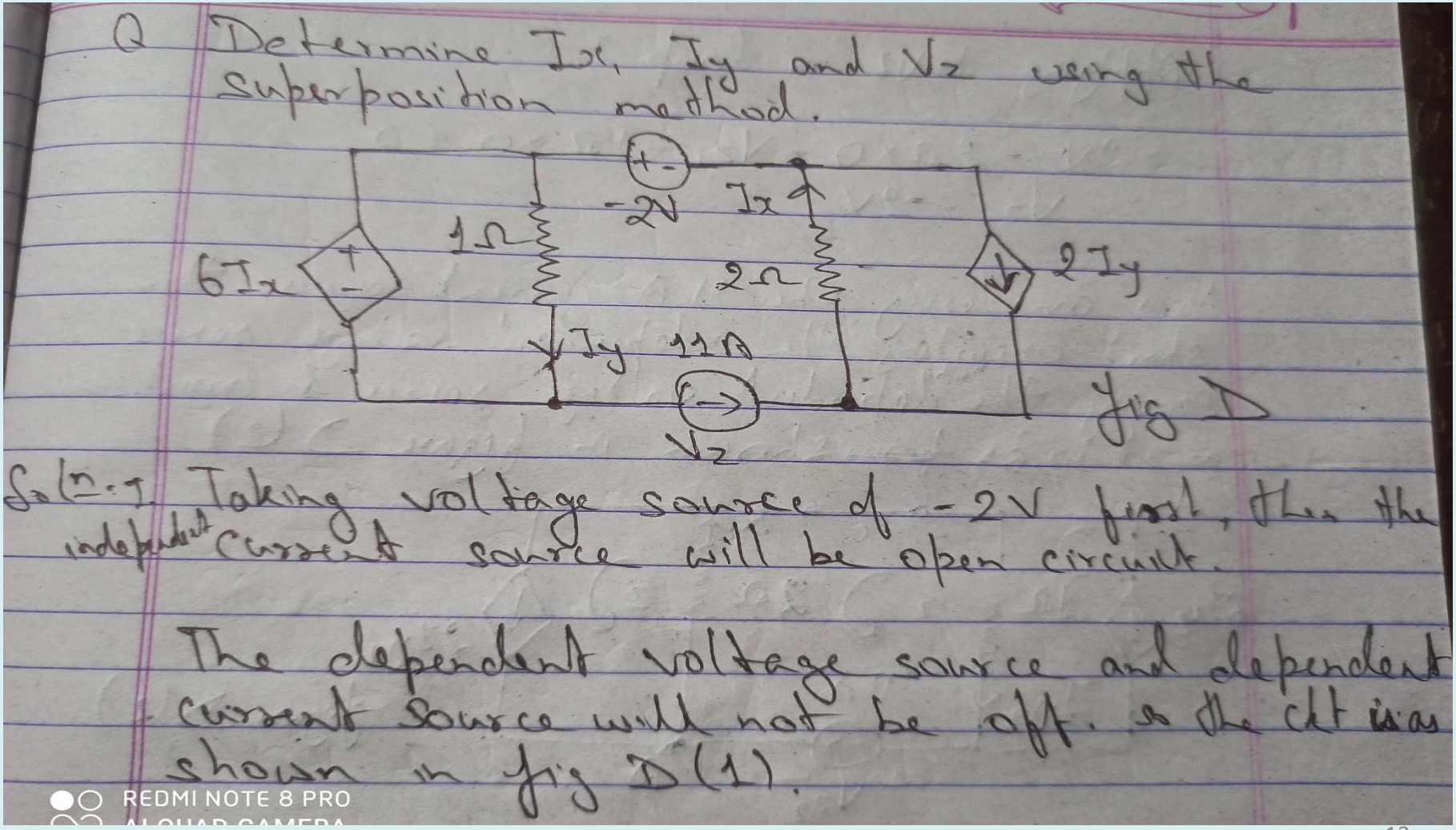
Circuit Theorem

- Now let us see fourth example with dependent source.
- In circuit with dependent source, we will never short circuit the dependent voltage source.
- Similarly we will never open circuit the dependent current source.

Circuit Theorem

- Fourth example with dependent source.



Circuit Theorem

shown in fig D(1).

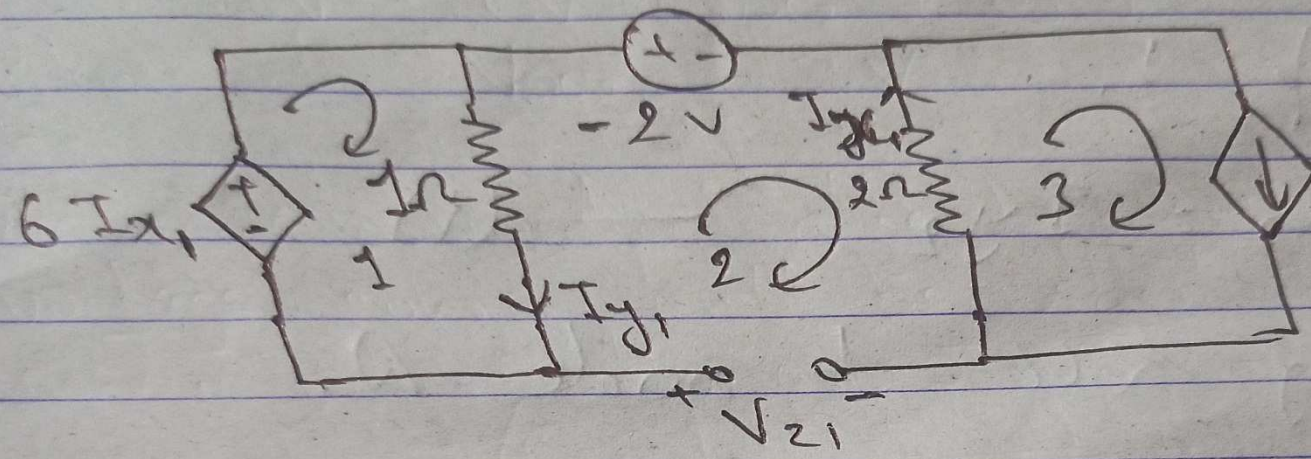


fig D(1)

In loop 1,

$$-6I_{x_1} + 1\Omega \times I_{y_1} = 0$$

$$I_{y_1} = 6I_{x_1}$$

In loop 3,

$$2I_{y_1} = I_{x_1}$$

Therefore $I_{x_1} = I_{y_1} = 0$

Circuit Theorem

Applying KVL in loop 2.

$-2V - 2\Omega \times 0 - V_{2_1} - 1\Omega \times 0 = 0$

$V_{2_1} = -2V$

Now considering the 11 A current source then short circuiting the independent voltage source, while leaving the dependent voltage source & current source as it is as shown in figure 5 (2)

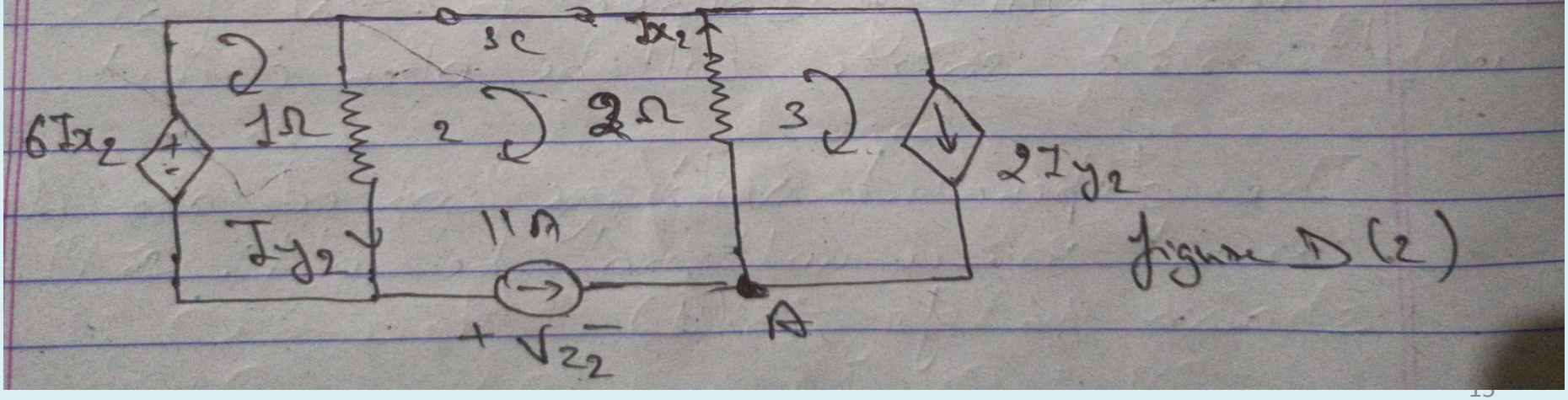


figure 5 (2)

Circuit Theorem

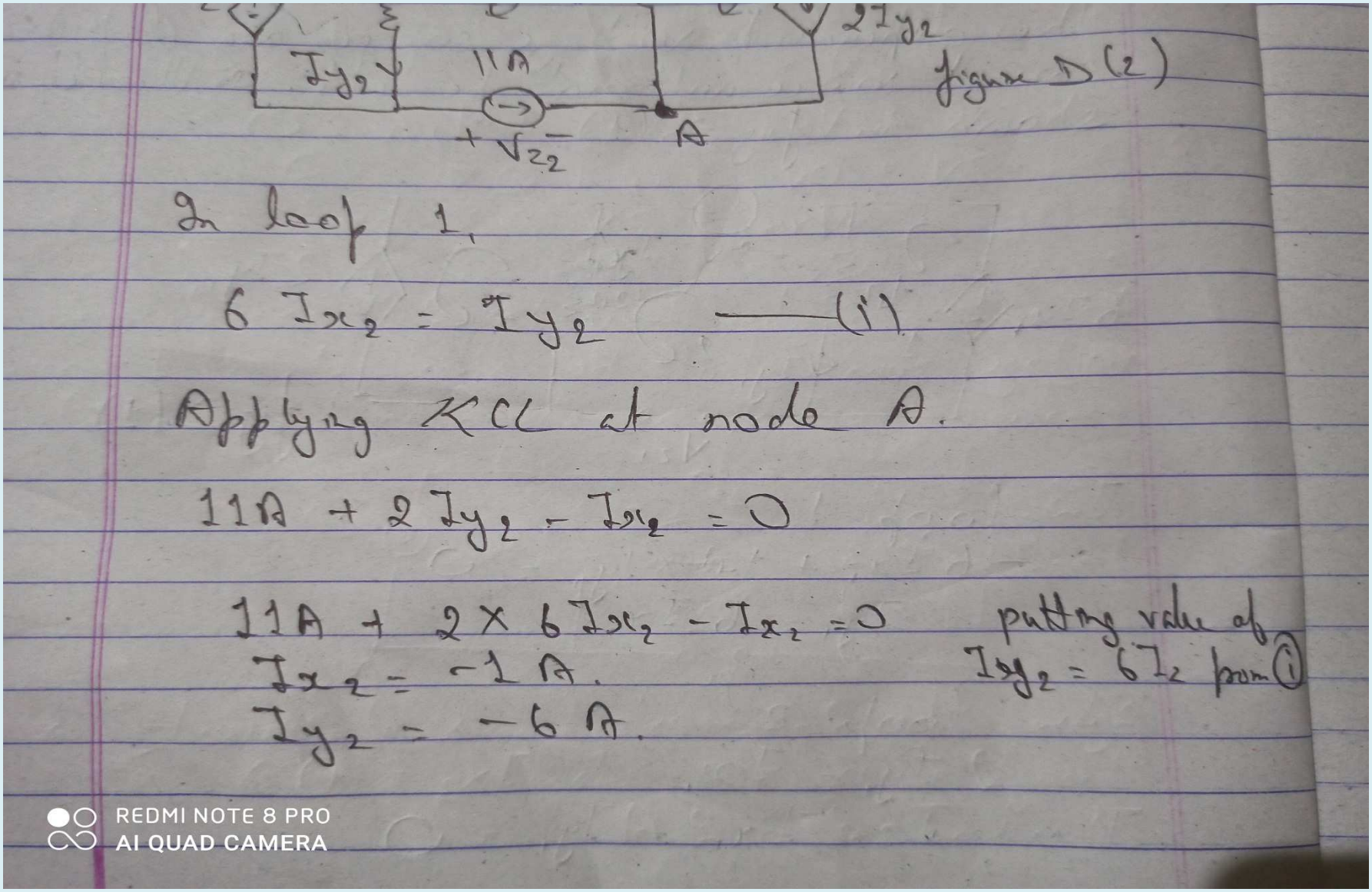


figure 5 (2)

In loop 1,

$$6 I_{x_2} = I_{y_2} \quad \text{——(i)}$$

Applying KCL at node A.

$$11A + 2 I_{y_2} - I_{x_2} = 0$$

$$11A + 2 \times 6 I_{x_2} - I_{x_2} = 0$$

putting value of $I_{y_2} = 6 I_2$ from (i)

$$I_{x_2} = -1 A.$$

$$I_{y_2} = -6 A.$$

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Circuit Theorem