Circuit Analysis with Ohm's Law and KVL

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Lab procedure

We start the procedure by preparing electronic wire and calculating the resistor color code. Then, we install an electronic component to the breadboard. After that we turn the electronic instruments on and measure voltage across different resistors to make sure that the result is aligned with our simulation in computer and hand calculations. To measure current we reconnect red probe to another port. We also break the circuit up and move the wire to measure Parallel circuit

Brief background knowledge

Ohm's law states that the voltage or potential difference between two points is directly proportional to the current or electricity passing through the resistance, and directly proportional to the resistance of the circuit. The formula for Ohm's law is V=IR.
Ref: https://byjus.com/physics/ohms-law/

KVL, states that "in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop" which is also equal to zero.
Ref: https://www.electronics-tutorials.ws/dccircuits/dcp_4.html

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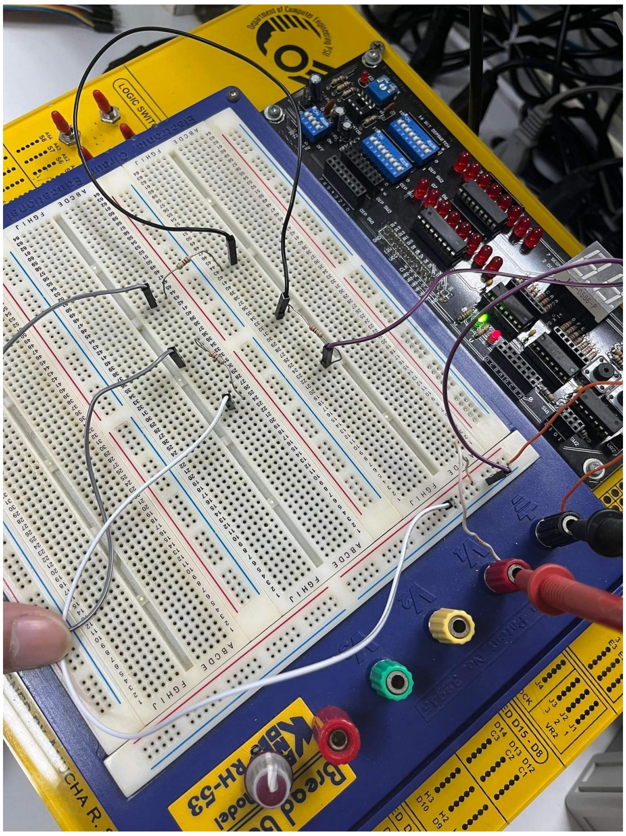
1)



all 3 resistance = 3 Ω

source = 5.09 v

2) Physical circuit

$V_{AB} = 1.7\text{ v}$ $V_{BE} = 1.7\text{ v}$

$V_{FE} = -1.7\text{ v}$ $V_{AF} = 5.09\text{ v}$

$V_{AE} = 3.39\text{ v}$

Calculation

$\underline{V = IR}$

$V_{AB} = IR_{AB}$ $V_{AB} = \frac{5}{9} \times 3 = \frac{5}{3} = \underline{1.67\text{ v}}$

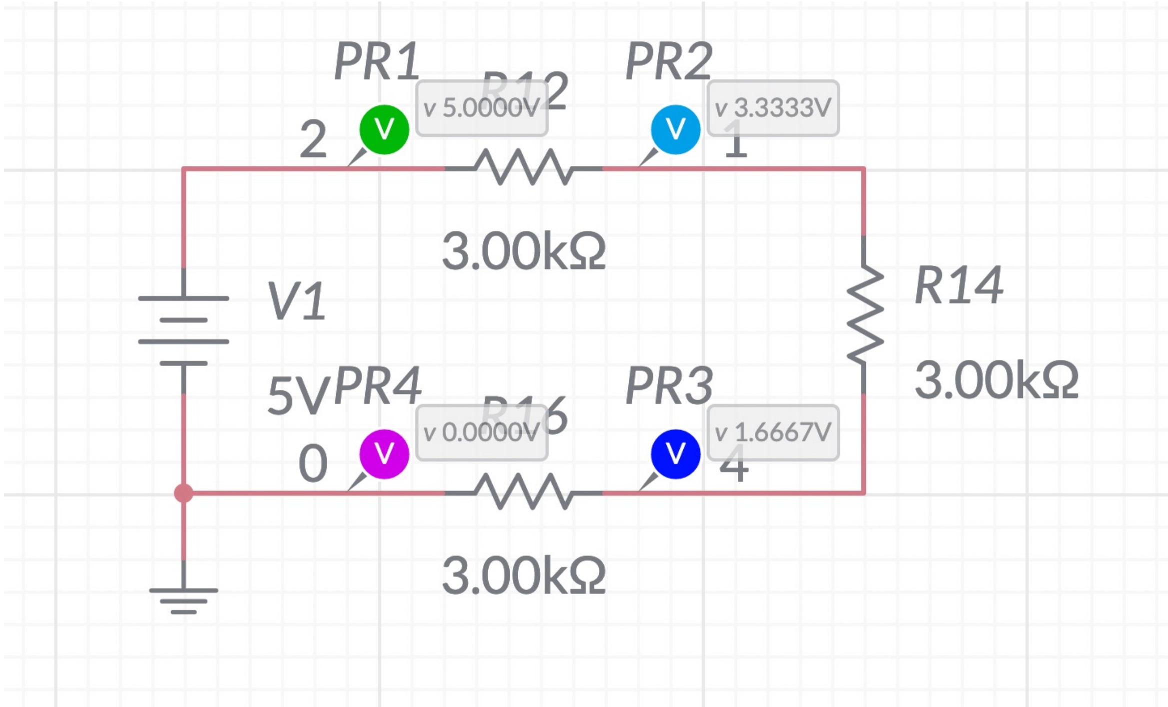
$V_{BE} = IR_{BE}$ $V_{BE} = \frac{5}{9} \times 3 = \frac{5}{3} = \underline{1.67\text{ v}}$

$V_{FE} = IR_{FE}$ $V_{FE} = \frac{5}{9} \times -3 = \underline{-1.67\text{ v}}$

$V_{AF} = I(R_{AB} + R_{BE} + R_{EF}) = IR_T = \frac{5}{9} \times 9 = \underline{5\text{ v}}$

$V_{AE} = I(R_{AB} + R_{BE}) = \frac{5}{9} \times 6 = \frac{30}{9} = \underline{3.33\text{ v}}$

Simulation



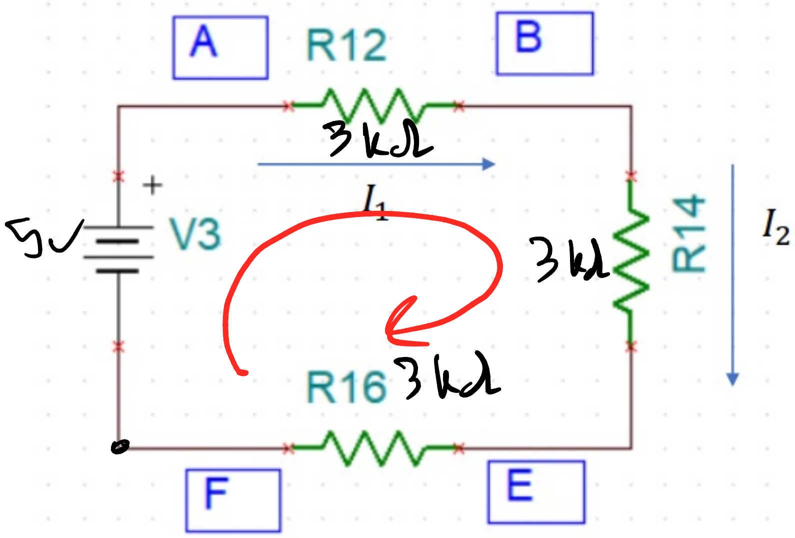
Each resistor is 3 kΩ so each voltage drop is 1.67 v

3) Relationship $V_{AB} = V_{BE} = V_{EF}$ because resistance is the same so voltage will also be the same through all the resistors.

$V_{AB} + V_{BE} + V_{EF} = V_{AF} = V_s$ total voltage is the summation of voltage at each resistor.

$V_{AE} = V_{AB} + V_{BE}$

4) Calculation



$$V_S = V_{AB} + V_{BE} + V_{EF}$$

$$5 = IR_{AB} + IR_{BE} + IR_{EF}$$

$$5 = I(R_{AB} + R_{BE} + R_{EF})$$

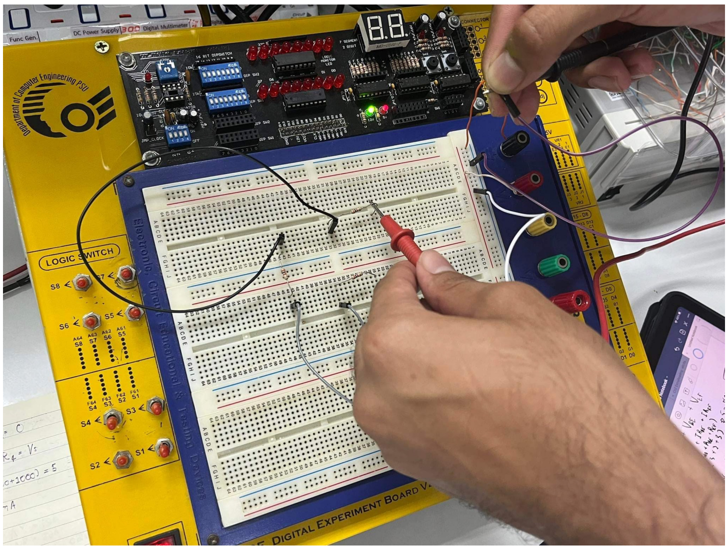
$$5 = I(3+3+3) \Rightarrow 5 = I(9) \Rightarrow \boxed{\frac{5}{9} = I}$$

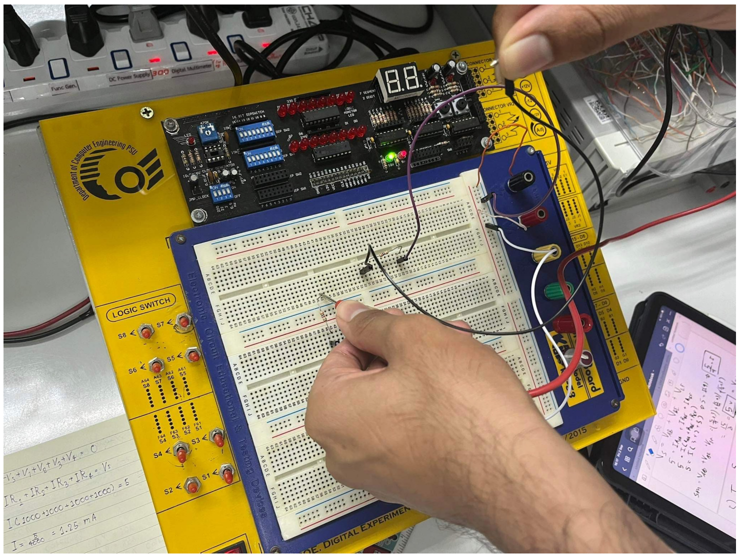
$$\text{Sum} = V_{AB} + V_{BE} + V_{EF} = \left(\frac{5}{9}\times 3\right) + \left(\frac{5}{9}\times 3\right) + \left(\frac{5}{9}\times 3\right)$$

$$= \frac{15}{3} = \boxed{5\text{ V}} = V_{total}$$

5) $I_1 = 0.57$ mA $\quad I_2 = 0.57$ mA

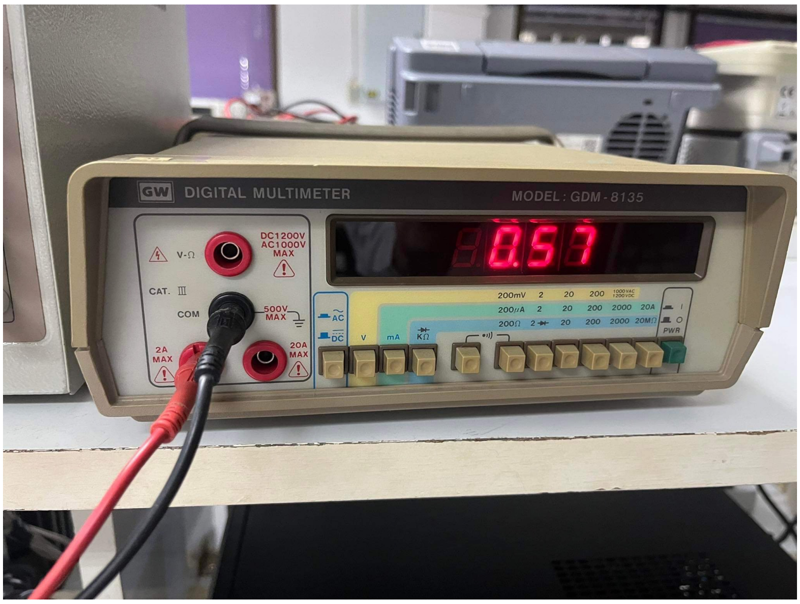
I_1 and I_2 are the same because in series circuit the current remains the same because there is only one path for current to flow through.





I_1 I_2

To measure the current we have to cut the circuit first and then use multimeter to measure in parallel circuit.



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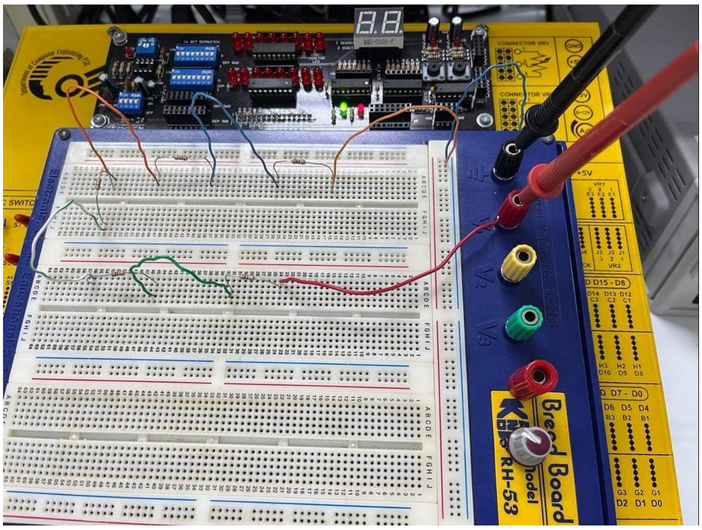
1) 

all 5 resistors $= 3\,k\Omega$

source $= 5.09\,v$

2) Physical circuit

$V_{AB} = 1.01\,v$ $\quad V_{BC} = 1.01\,v$ $\quad V_{AC} = 2.02\,v$

$V_{AD} = 3.05\,v$ $\quad V_{AF} = 5.09\,v$ $\quad V_{BF} = 4.08\,v$

$V_{CF} = 3.05\,v$ $\quad V_{DF} = 2.04\,v$

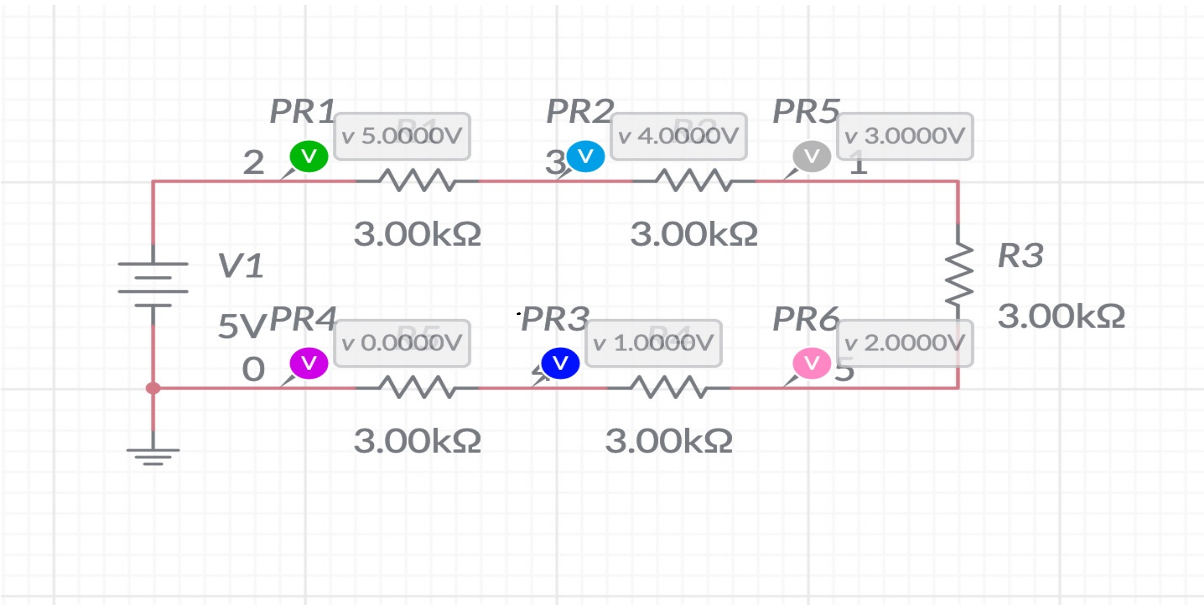
3) Relation of voltage

Each voltage at each resistors are the same 1.01 v because all resistors are $3\,k\Omega$.

$$V_s = V_{AB} + V_{BC} + V_{CD} + V_{DE} + V_{EF} = V_{AF}$$

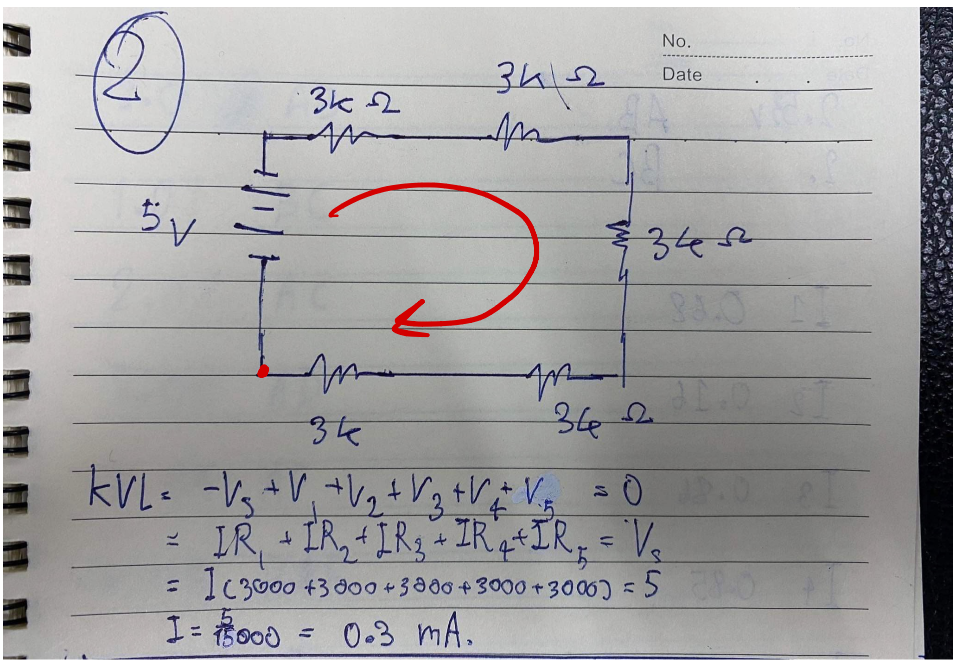
$$1.01 + 1.01 + 1.01 + 1.01 + 1.01 = 5.05\,v$$

Simulation



As you can see in the diagram that after each resistor the voltage drop is 1 v just like the one we measured in LAB.

4) Calculation

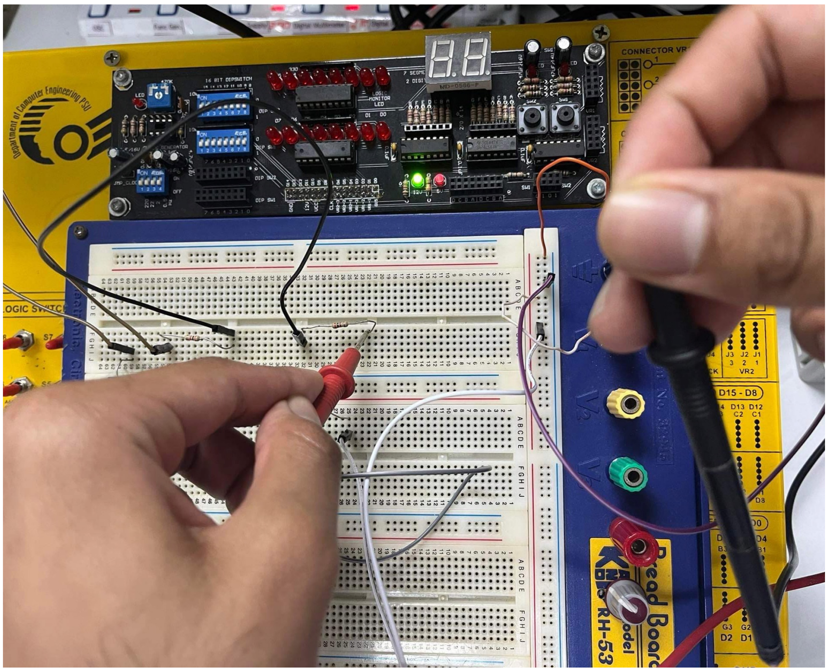


$$\text{sum} = V_{AB} + V_{BC} + V_{CD} + V_{DE} + V_{EF}$$

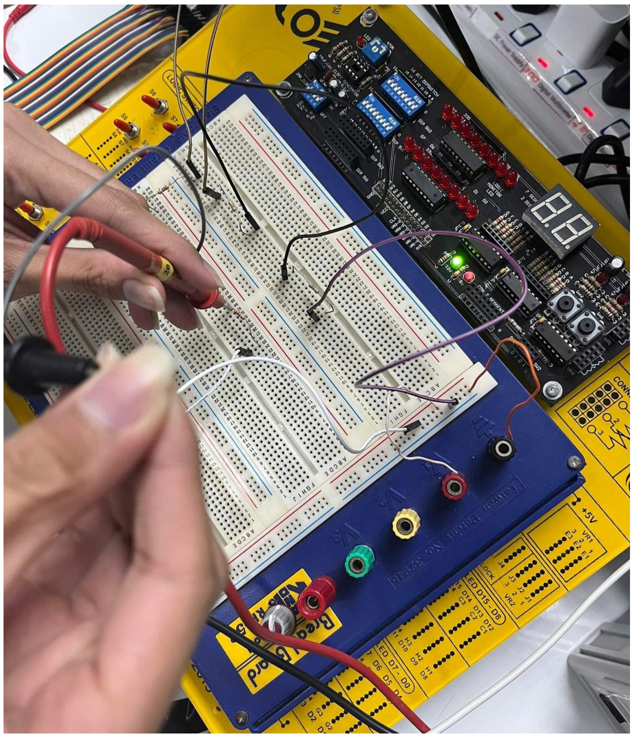
$$\left(\frac{5}{15}\times 3\right) + \left(\frac{5}{15}\times 3\right) + \left(\frac{5}{15}\times 3\right) + \left(\frac{5}{15}\times 3\right) + \left(\frac{5}{15}\times 3\right) = 5\ \text{v}$$

5) $I_1 = 0.33$ mA $I_2 = 0.33$ mA

I_1 and I_2 are the same because in series circuit the current remains the same because there is only one path for current to flow through.



I_1



I_2

To measure it we need to break the circuit and connect 2 probes to the circuit in parallel.

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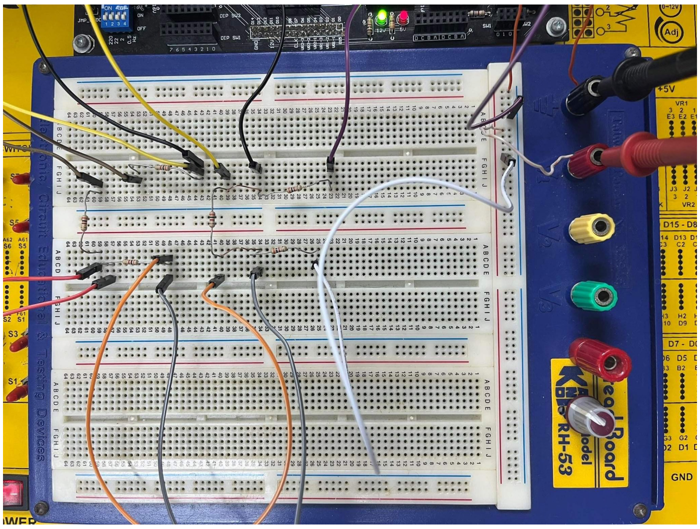


all 6 resistors

= 3kΩ

source = 5.09v

2) Physical circuit

$V_{AB} = 1.86v$ $V_{BC} = 0.46v$ $V_{CD} = 0.45v$

$V_{DE} = 0.45v$ $V_{EF} = 1.83v$ $V_{AC} = 2.31v$

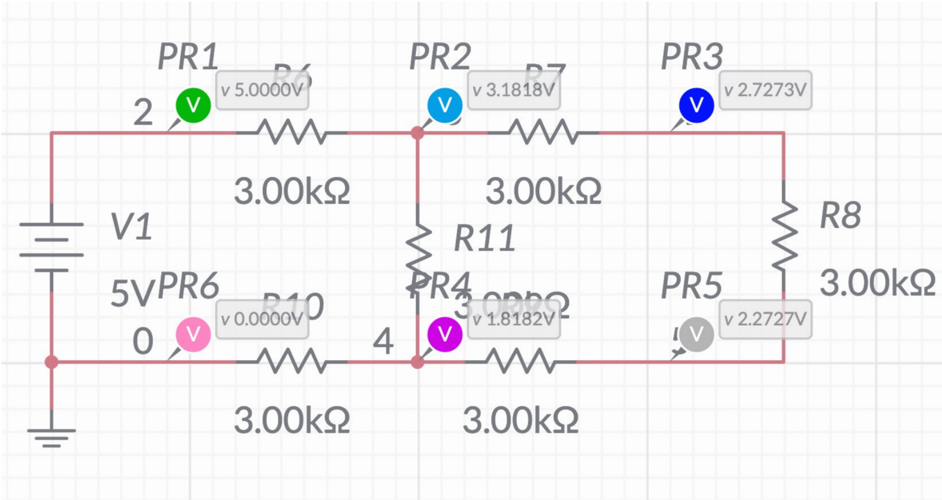
$V_{AD} = 2.77v$ $V_{AF} = 5.08v$ $V_{BF} = 3.22v$

$V_{CF} = 2.76v$ $V_{DF} = 2.3v$

3) Relation of voltage

- Voltage in loop 1 is V_{AB}, V_{EF} is same because in same loop.
- Voltage of V_{BC} and V_{DE} is also same because both in loop 2.

Simulation



To check if the simutation and the real calculation match we can find V_{AB} which is PR1 - PR2 = $5 - 3.18 = 1.82V$

And the real measurement is $1.86V$ so they match and result is correct.

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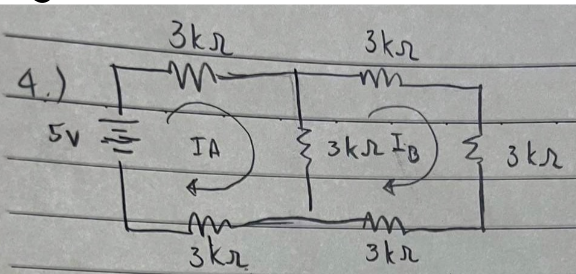
Date

4.)



$-5V + 3(I_A) + 3(I_A - I_B)$
$+ 3(I_A) = 0$

Sol^n $-5 + 3I_A + 3I_A - 3I_B$
$+ 3I_A = 0$
; $9I_A - 3I_B = 5$ — (1)

$3(I_B) + 3(I_B) + 3(I_B) +$
$3(I_B - I_A) = 0$

Sol^n $3I_B + 3I_B + 3I_B + 3I_B -$
$3I_A = 0$
; $12I_B - 3I_A = 0$ — (2)

(1) × 4 ; $36I_A - 12I_B = 20$ — (3)

(3) + (2) ; $33I_A = 20$

$I_A = \frac{20}{33} = 0.6$ mA #

substitude $I_A = 0.6$mA to (2)

$12I_B - 3(0.6) = 0$

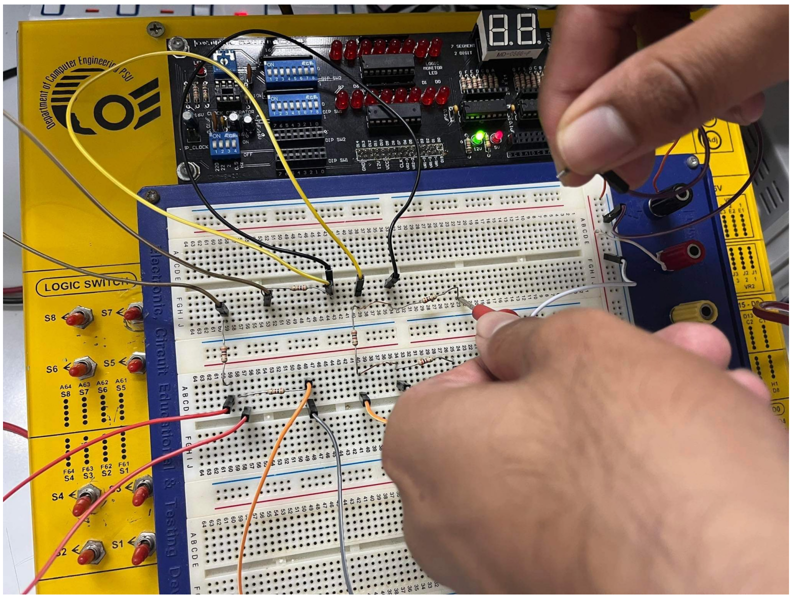
$12I_B = 1.8$

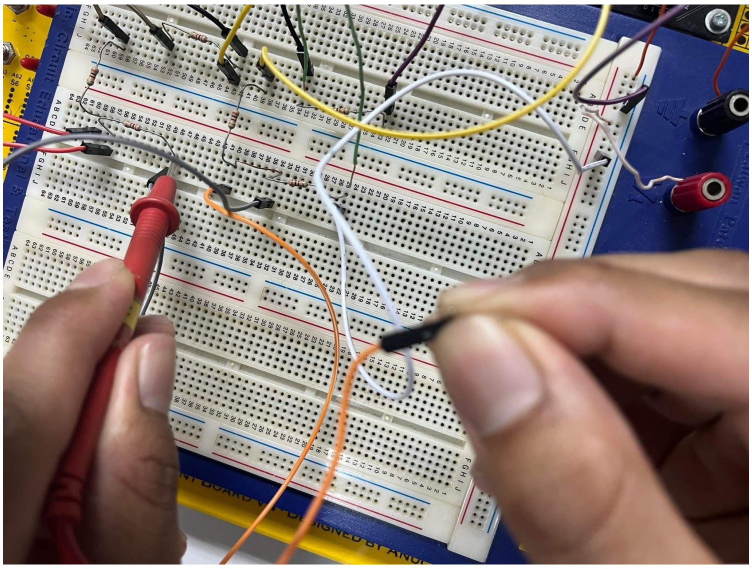
$I_B = \frac{1.8}{12} = 0.15$ mA #

5) $I_1 = 0{,}63$ mA $I_2 = 0.45$ mA

$I_3 = 0.04$ mA $I_4 = 0.05$ mA

$I_5 = 0.02$ mA





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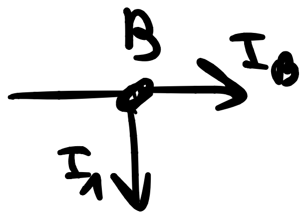
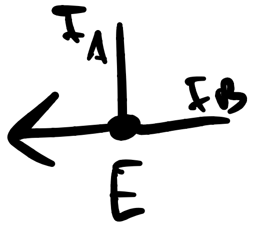


when current reaches point B it splits into 2 path.

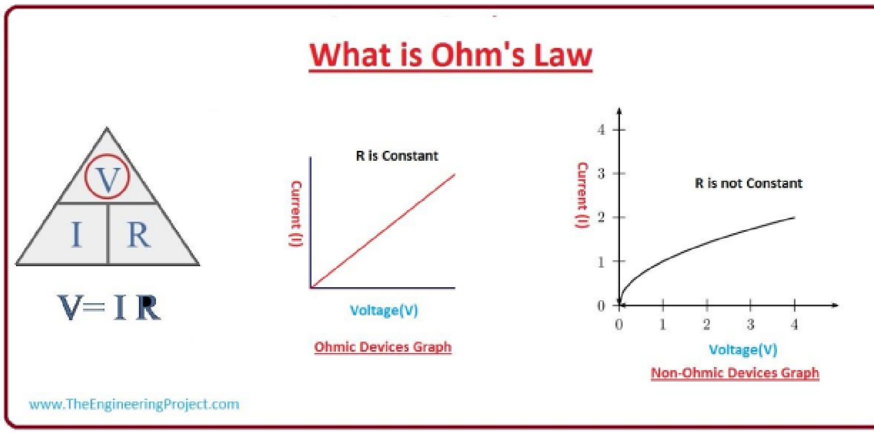
The current before entering B is the unsplit current which is the total current which as calculated above is 0.75 mA. When current reach be the I_A which is current in loop 1 will be 0.6mA and I_B that is in loop 2 will be 0,15 mA.

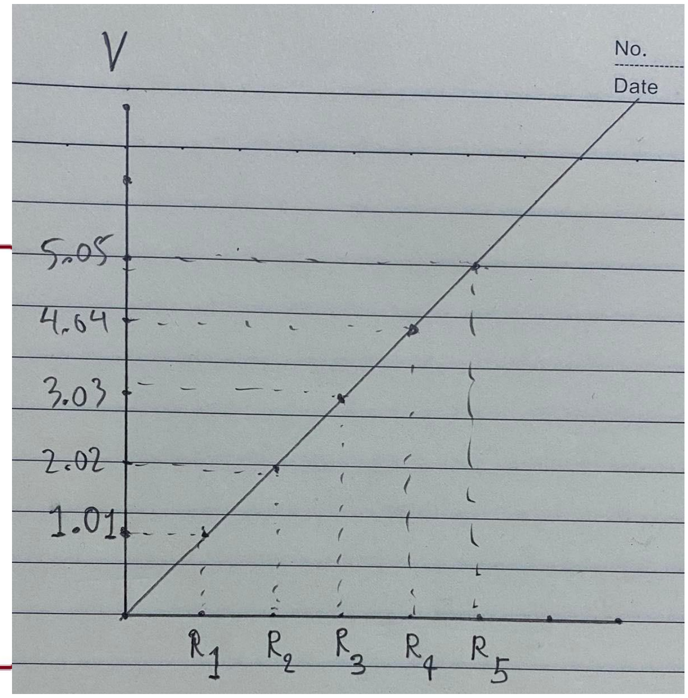


when current reaches point E it rejoin again to be the total current

when reach E I_A will combine I_B to become $0.6 + 0.15 = 0.75$ mA which is the total current.

Graph





The graph indicates that the current flowing in a circuit is directly proportional to the applied voltage. And the voltage against the current graph the slope represents the resistance as voltage increases the resistance also increases, but if the current increases resistance will decrease.

Conclusion

To conclude this experiment, we are trying to analyze the circuit by different resistors and arrange it differently. In the first two experiments, we built a series circuit which is very simple. In a series circuit, current flows in one path and remains constant but voltage will be split according to the value of the resistors. During the experiment my group struggled to measure current because we didn’t understand how. So we did some research and found that we need to break the circuit first and then connect the probe to each end of the broken part. We cannot measure the current in parallel way because the current flows in one path. That's why we need to measure in a series way and read the value. And the last circuit we built was a parallel circuit. This time we observed that when the current reaches a junction it will be split. We can imagine that the current is like a river and when it reaches the intersection, the water in the river will split into multiple parts just like current in a parallel circuit. But the voltage will ramain the same for parallel.