Electrical Engineering

Electronics and Communication Engineering

Network Theory

Lecture No. 04

Basics of Network Theory

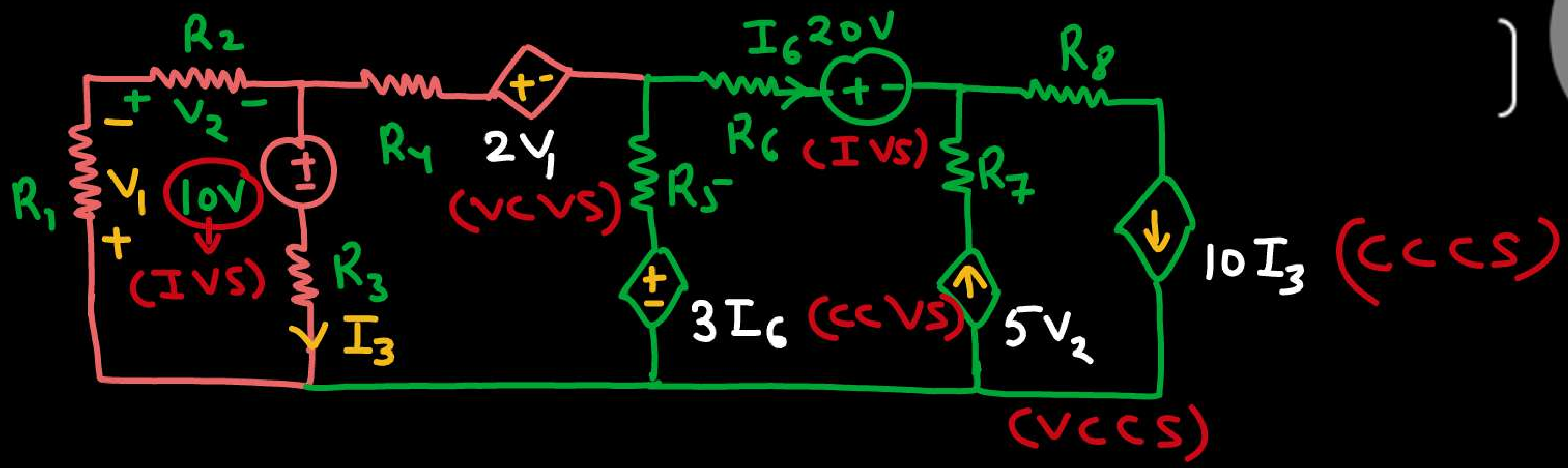
By- Pankaj Shukla sir

Topics to be Covered

1. Series & Parallel operation
2. Question Discussion.
3.
4.
5.
6.

Dependent Sources: (Depending variable → other branch voltage or current)

- **Voltage Source**
  - **VCVS** (Voltage controlled Voltage Source) → kV_x or kV_x
  - **CCVS** (Current controlled Voltage Source) → kI_x or kI_x
- **Current Source**
  - **VCCS** → Voltage controlled Current Source → kV_x. or kV_x
  - **CCCS** → Current controlled current Source. → kI_x. or kI_x



R2
V2
R1
V1
10V
(IVS)
R3
I3
R4
2V1
(VCVS)
I6
20V
R6
(IVS)
R5
3I6
(CCVS)
R7
R8
5V2
(VCCS)
10I3
(CCCS)

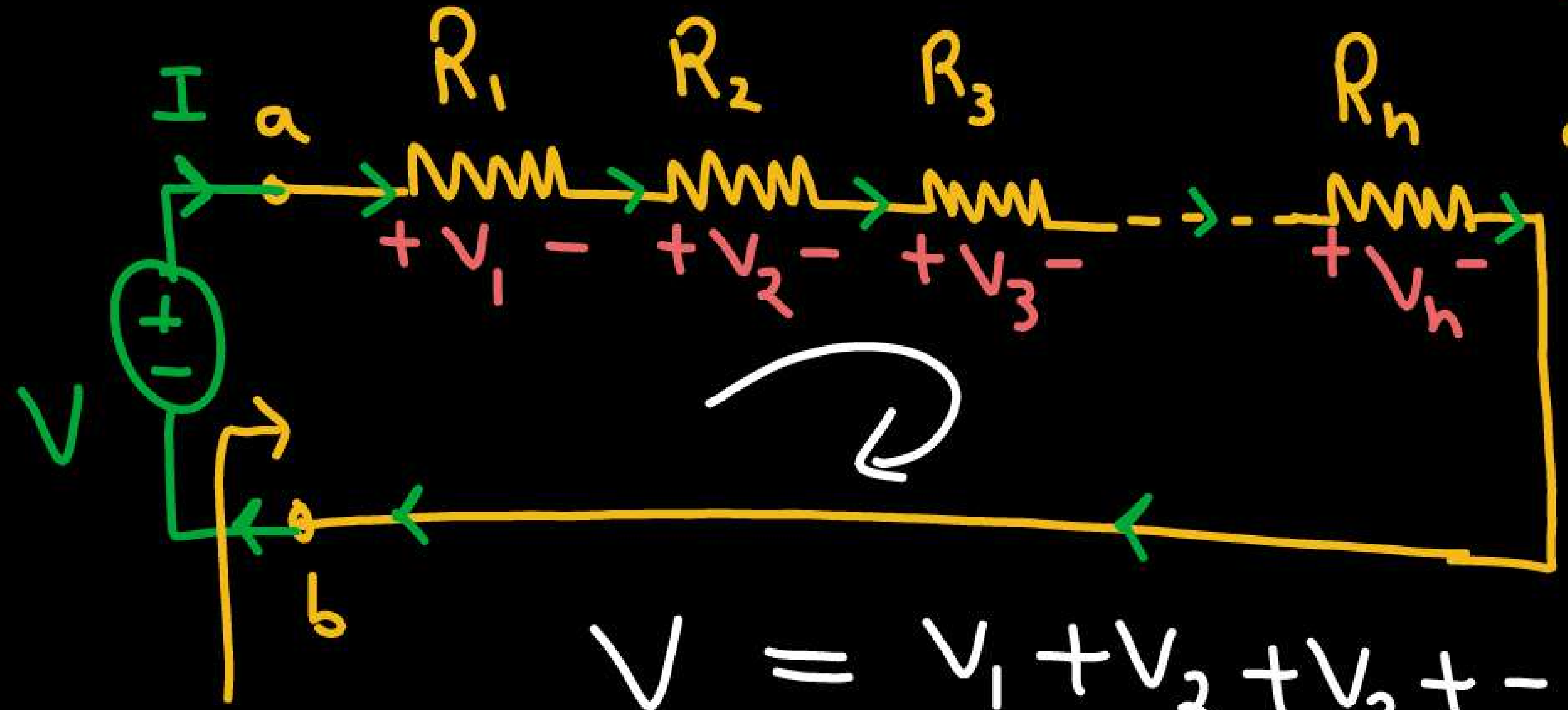
Topic- (Series & Parallel operation)

- R → Series & Parallel operation.
- current Sources → Series & Parallel operation
- Voltage Sources → Series & Parallel operation.

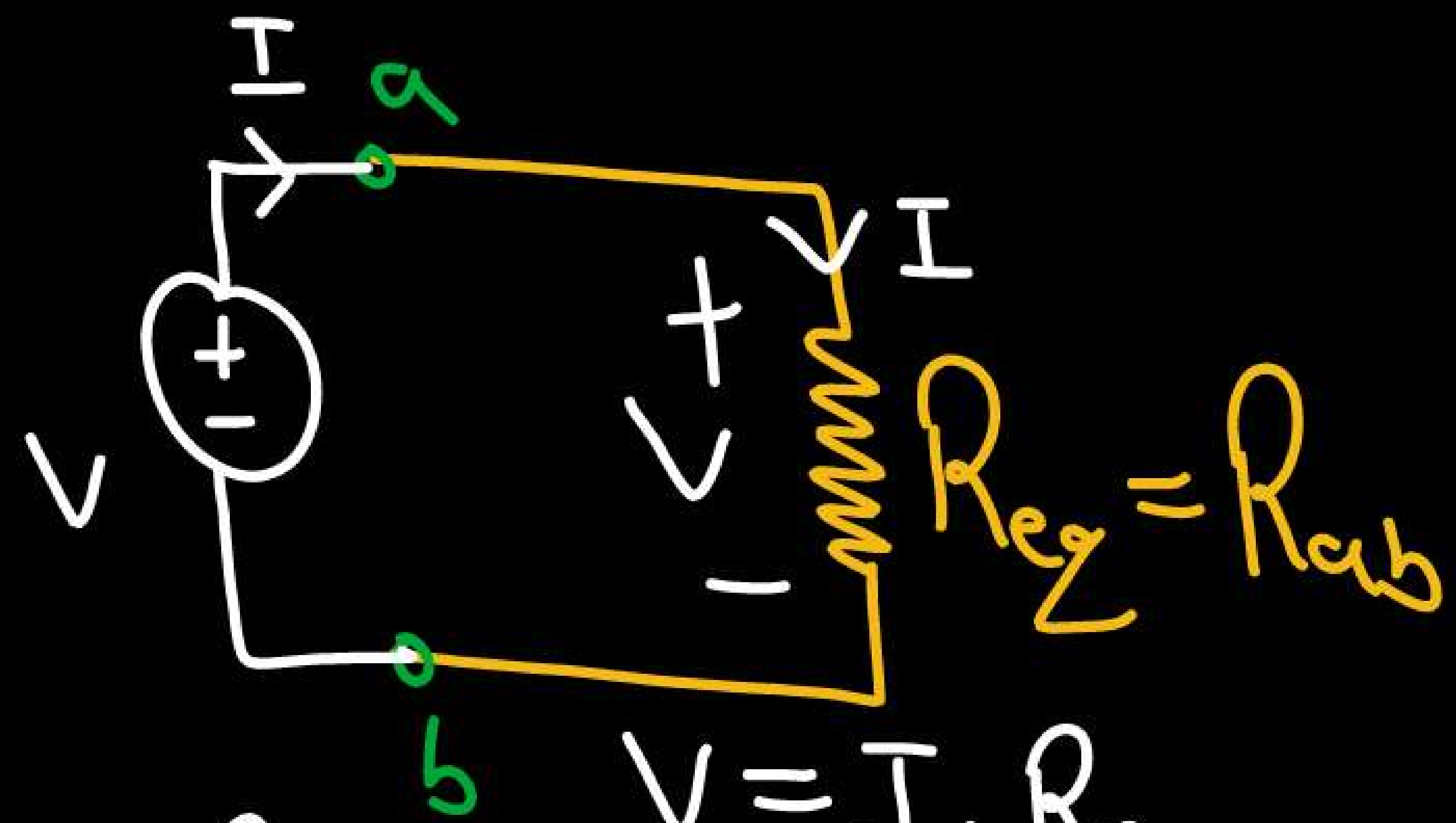
Series Operation:

- current will remain SAME (Always)
- Voltage across each resistor will be different or same.

(1) Resistances:



⇒



$$V = V_1 + V_2 + V_3 + \cdots + V_n$$

$$V = IR_1 + IR_2 + IR_3 + \cdots + I \cdot R_n$$

$$V = I \cdot R_{eq}$$

$$V = I(R_1 + R_2 + R_3 + \cdots + R_n).$$

$$\boxed{\frac{V}{I} = R_1 + R_2 + R_3 + \cdots + R_n = R_{eq} = R_{ab}}$$

- $V_1 = I \cdot R_1 = \left(\frac{V}{R_{eq}}\right) \times R_1$

  $V_2 = I \cdot R_2 = \left(\frac{V}{R_{eq}}\right) \times R_2$

  $V_3 = I \cdot R_3 = \left(\frac{V}{R_{eq}}\right) \times R_3$

  $\vdots$

  $V_n = I \cdot R_n = \left(\frac{V}{R_{eq}}\right) \times R_n$

- Hence, the General expression to find the voltage across any Resistor connected in series.

$$\boxed{V_x = V \times \left(\frac{R_x}{R_{eq}}\right) \quad x = 1, 2, 3, \ldots n} \rightarrow (VDR)$$

- Now lets have Similar Resistance,

$$\left[R_1 = R_2 = R_3 = \dots = R_n = R\right]$$

(1) $$\left[R_{eq} = R + R + R + R + \dots + R = n \cdot R\right]$$

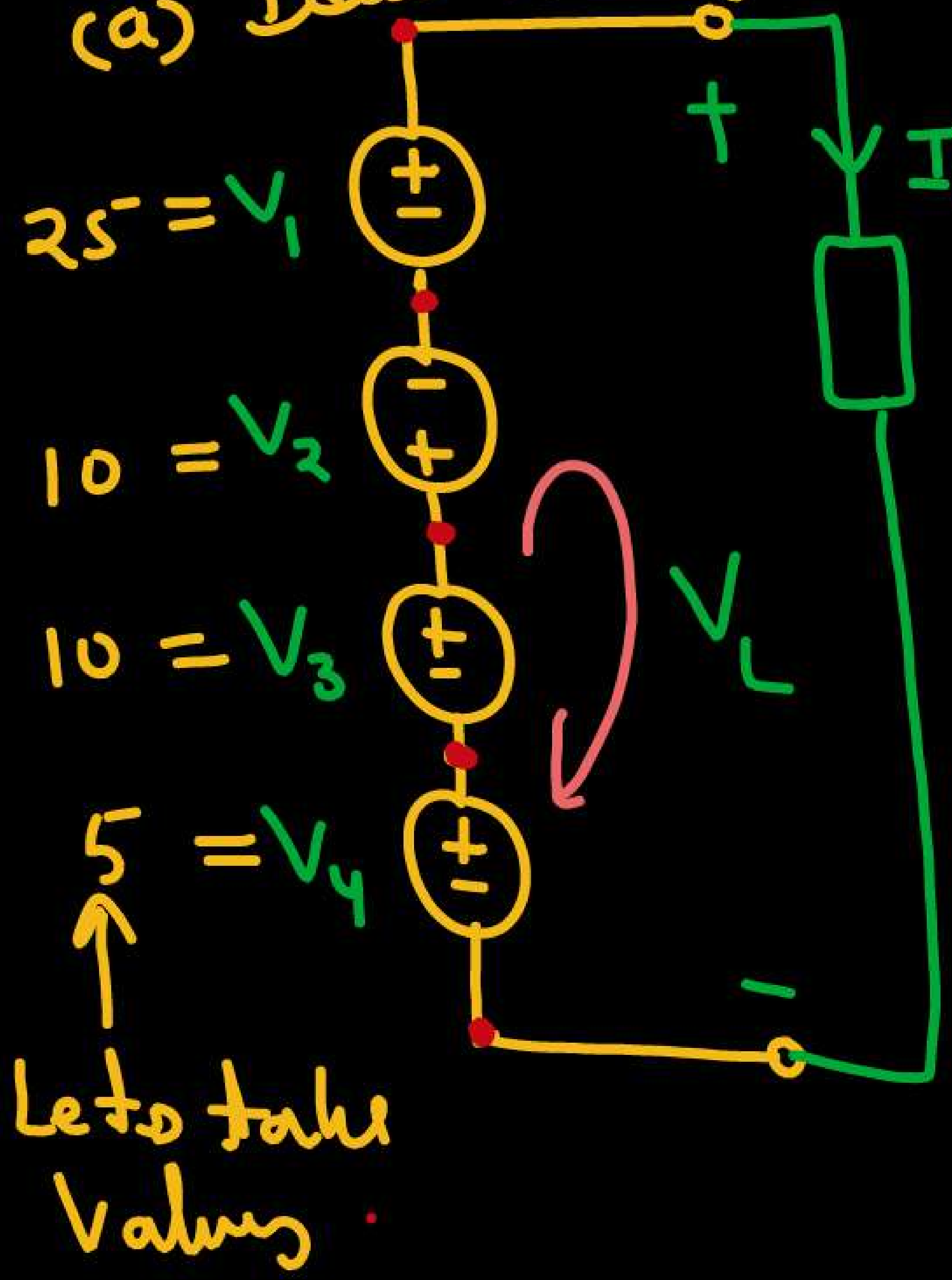
(2) $$V_x = V \cdot \frac{R_x}{R_{eq}} = V \cdot \frac{R}{n \cdot R} = \frac{V}{n}$$

$$\left[V_R = \frac{V}{n}\right] \longrightarrow \left[V_1 = V_2 = V_3 = \dots = V_n = \frac{V}{n}\right]$$

(2) Voltage Sources:

(a) Ideal voltage Source.

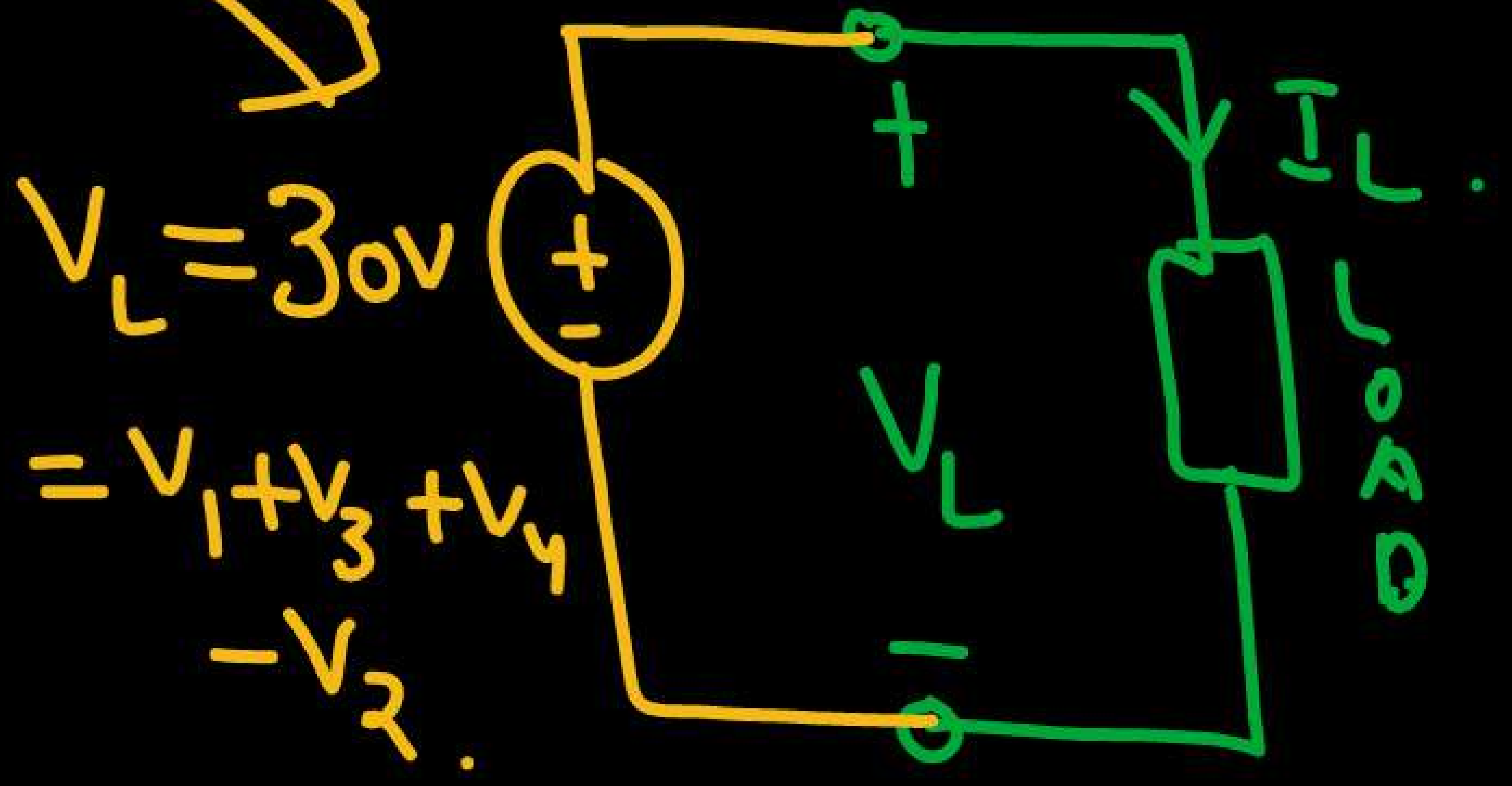
- whenever voltage Sources are connected in Series, then just apply the KVL.



$$V_1 + V_3 + V_4 = V_2 + V_L$$

$$\boxed{V_L = V_1 + V_3 + V_4 - V_2}$$

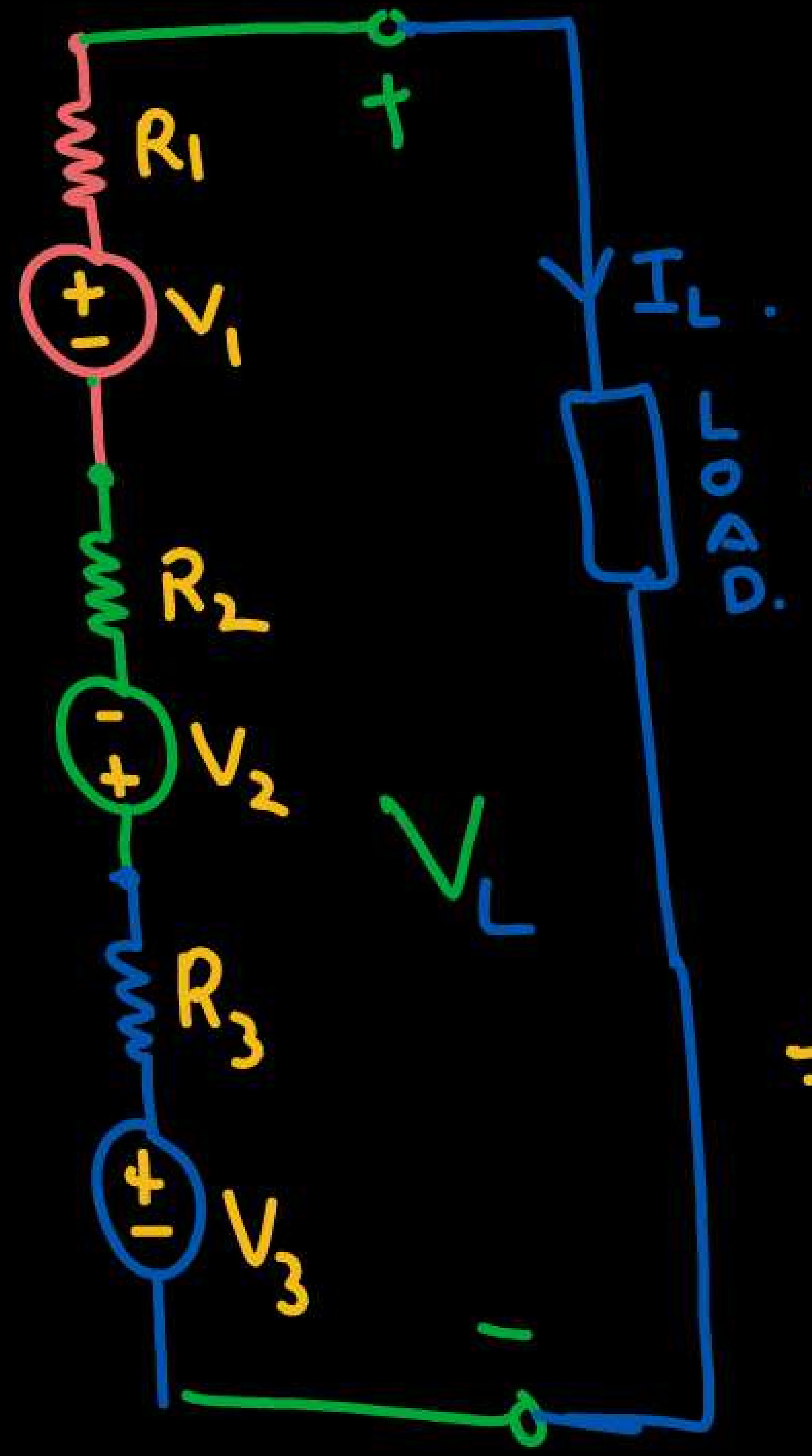
$$V_L = 25 + 10 + 5 - 10 = 30V$$



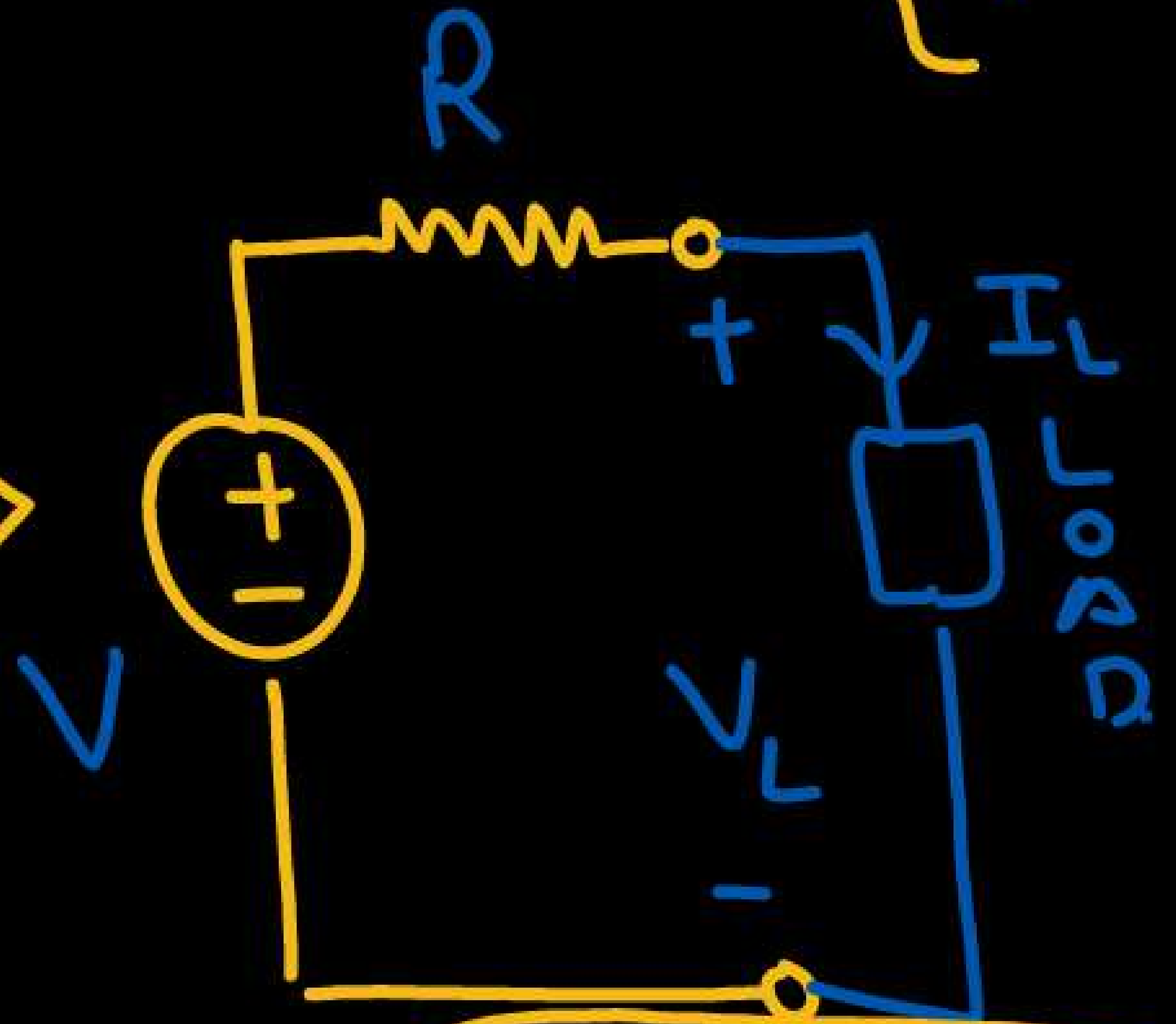
(b) Practical Voltage Sources.

- $V + V_2 = V_1 + V_3$

$$\left[V = V_1 + V_3 - V_2\right]$$

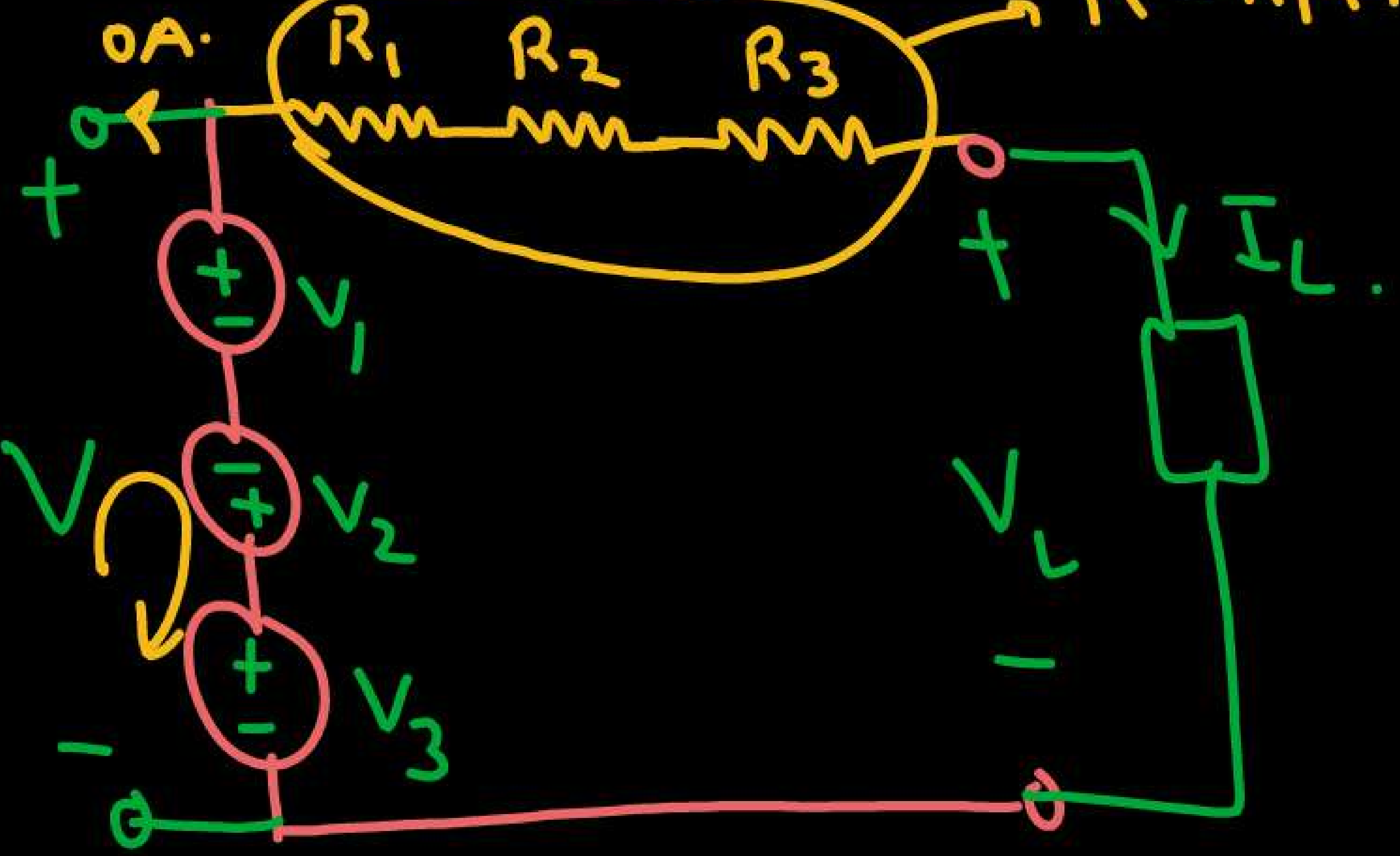


$\Rightarrow$



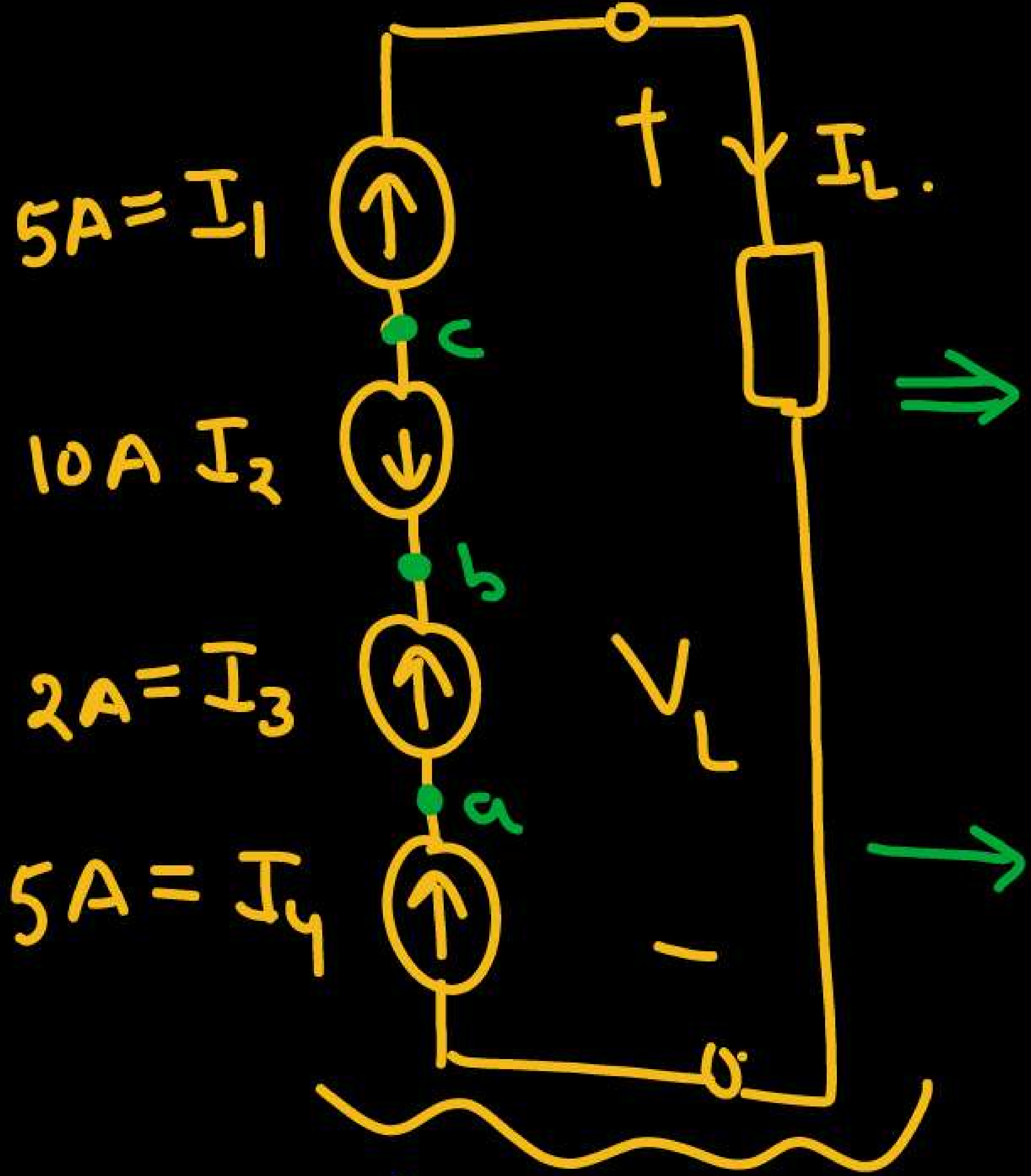
$\longrightarrow$ Here $\left\{\begin{aligned} V &= V_1 + V_3 - V_2 \\ R &= R_1 + R_2 + R_3 \end{aligned}\right\}$

$\Rightarrow$

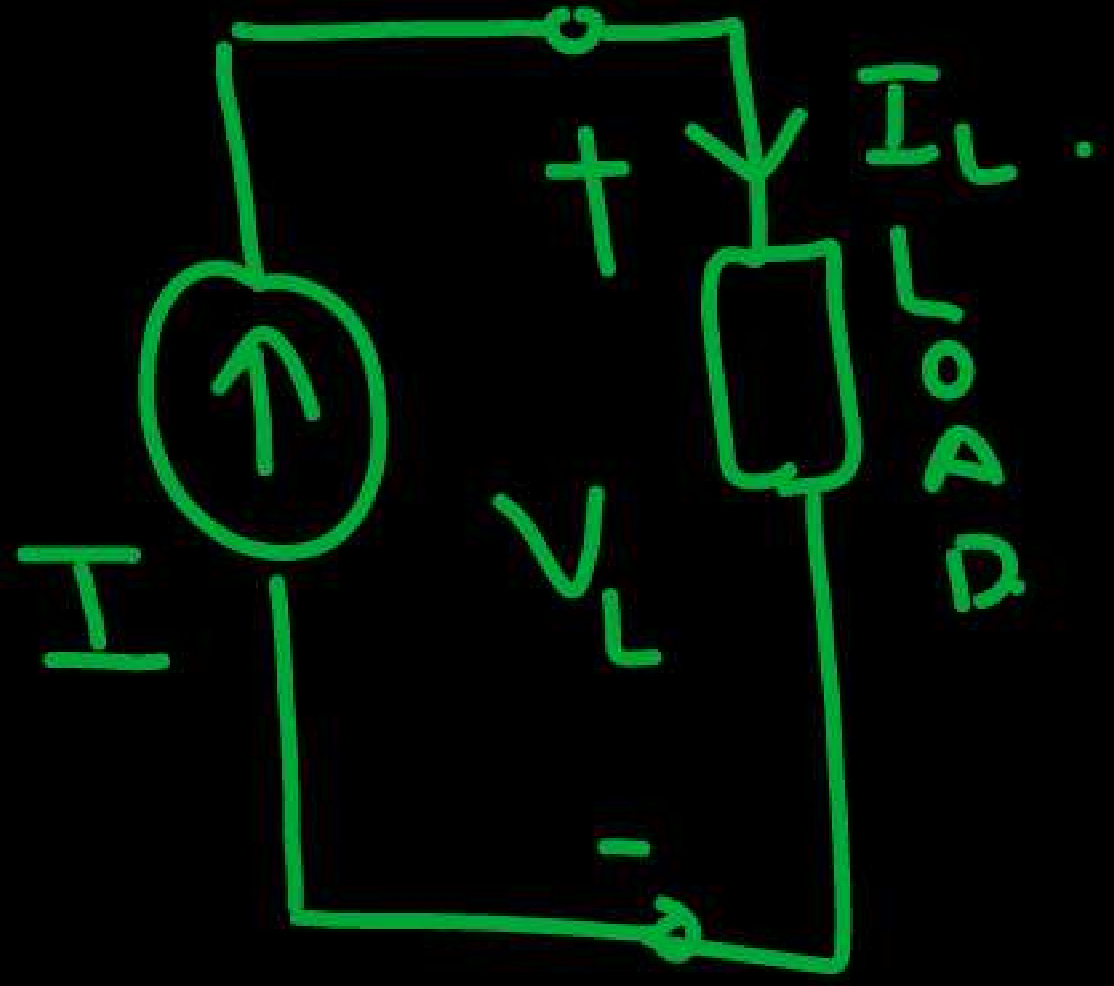


$R = R_1 + R_2 + R_3$

③ Current Sources: (Always apply KCL & it must satisfy)

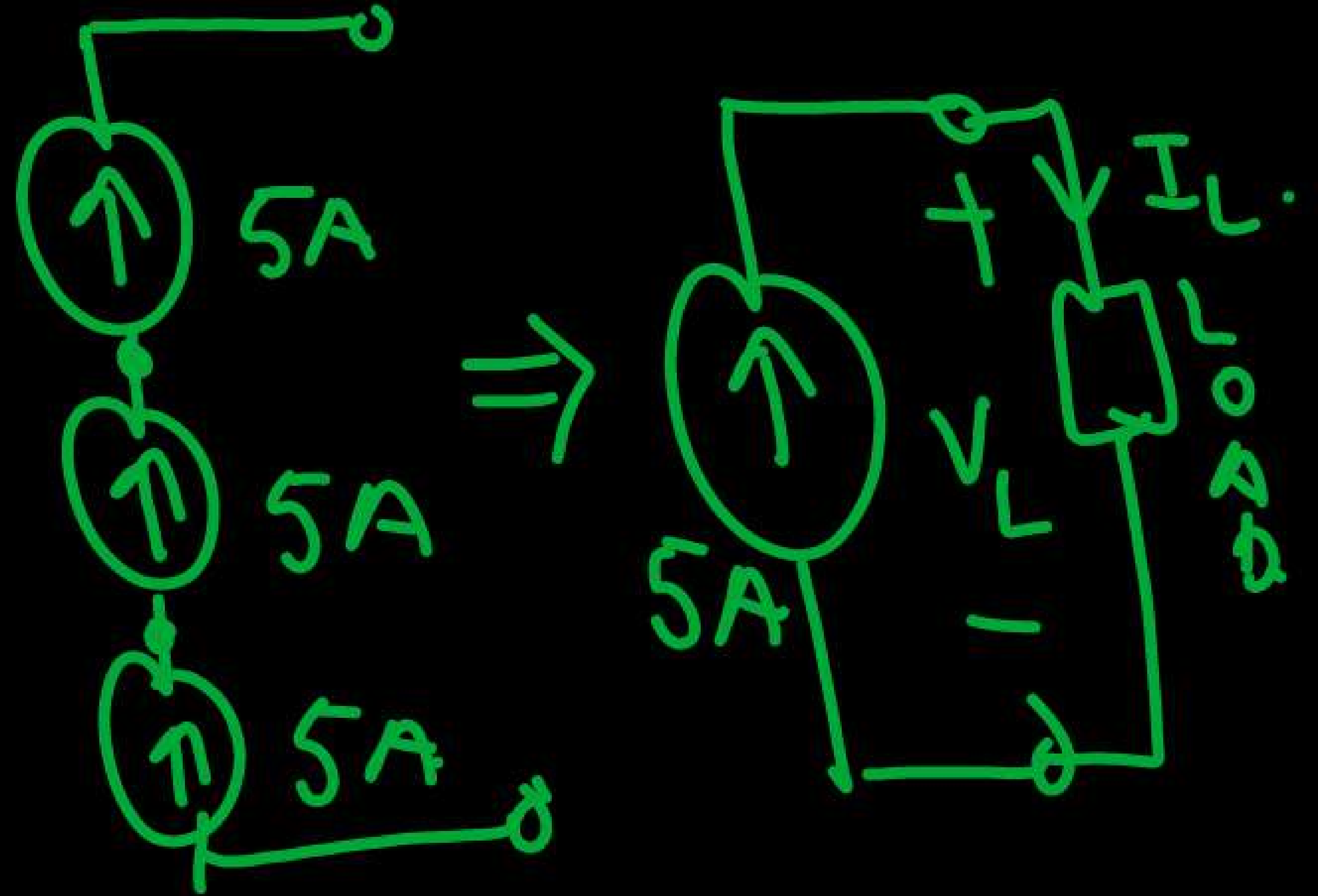


(Invalid ckt)



→ operation is not possible as KCL → fail.

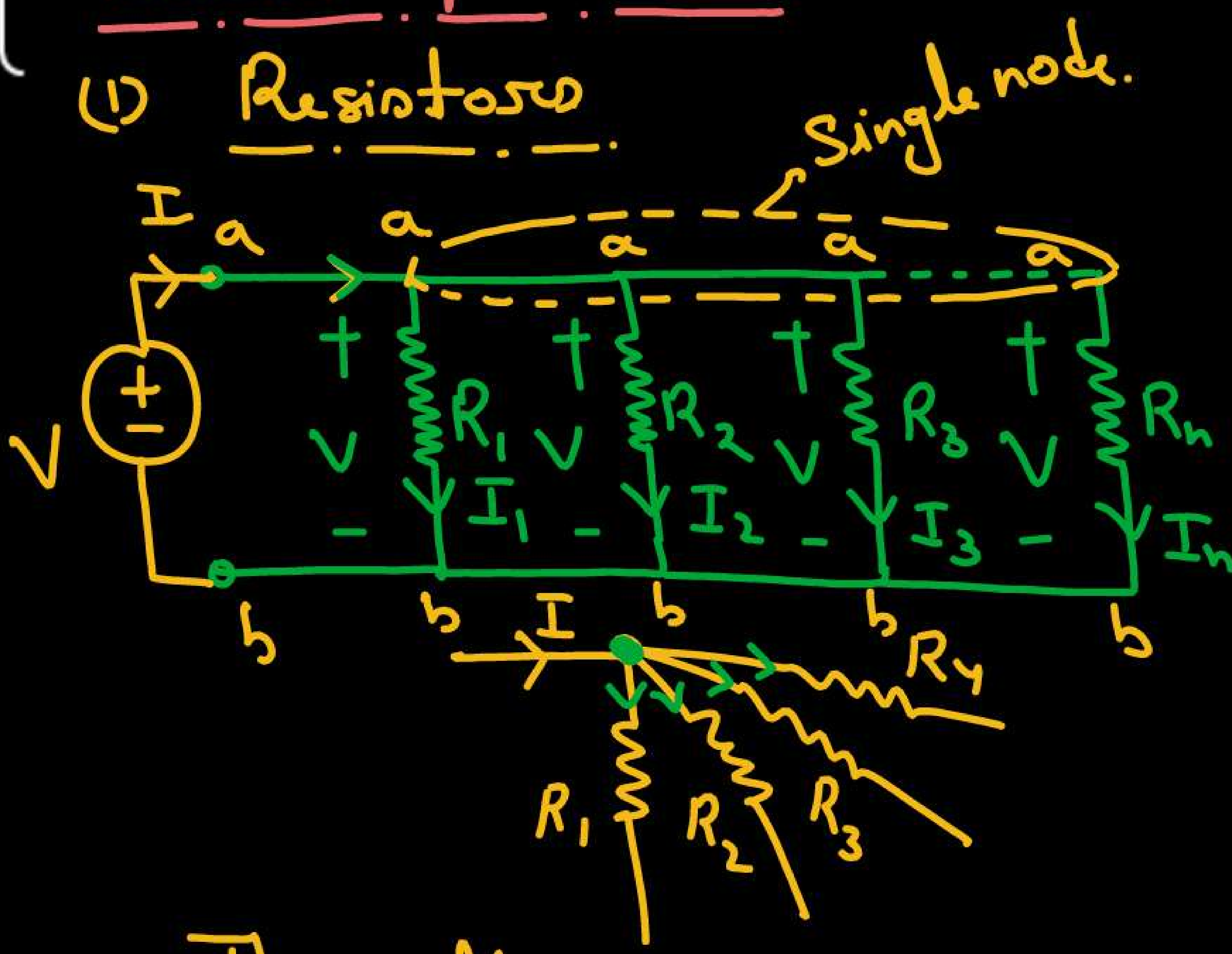
- Now the Series operation of current Sources is only Possible if All the currents are same value & Same direction.



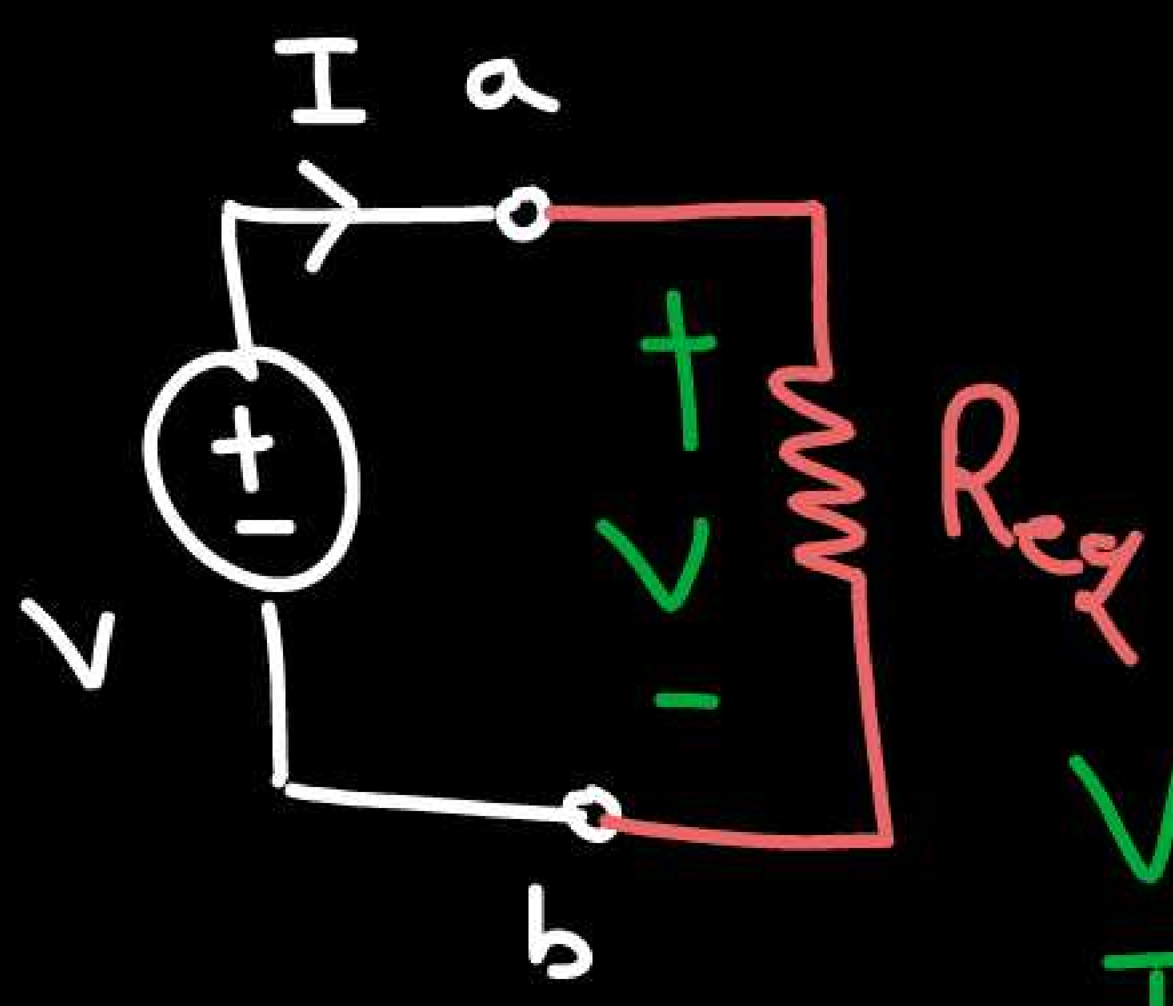
[**Note:** if Practical current Sources are connected in series then how to Proceed $\longrightarrow$ we will see later.]

Parallel operation :

(1) Resistors



$\Rightarrow$



$V = I \cdot R_{eq}$.

$\frac{I}{V} = \frac{1}{R_{eq}}$

- The voltage will remain Same (Always)
- The current in each Resistor will be different or Same.

$$I = I_1 + I_2 + I_3 + \dots + I_n$$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} + \dots + \frac{V}{R_n}$$

$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}\right)$$

$$\boxed{\frac{I}{V} = \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}}$$

Equivalent conductance $\rightarrow G_{eq} = G_1 + G_2 + G_3 + \dots + G_n$

- Now current in each Resistor.

$$I_1 = \frac{V}{R_1} = I \cdot \frac{R_{eq}}{R_1} = \frac{I}{G_{eq}} \cdot G_1$$

$$I_2 = \frac{V}{R_2} = \frac{I}{G_{eq}} \cdot G_2.$$

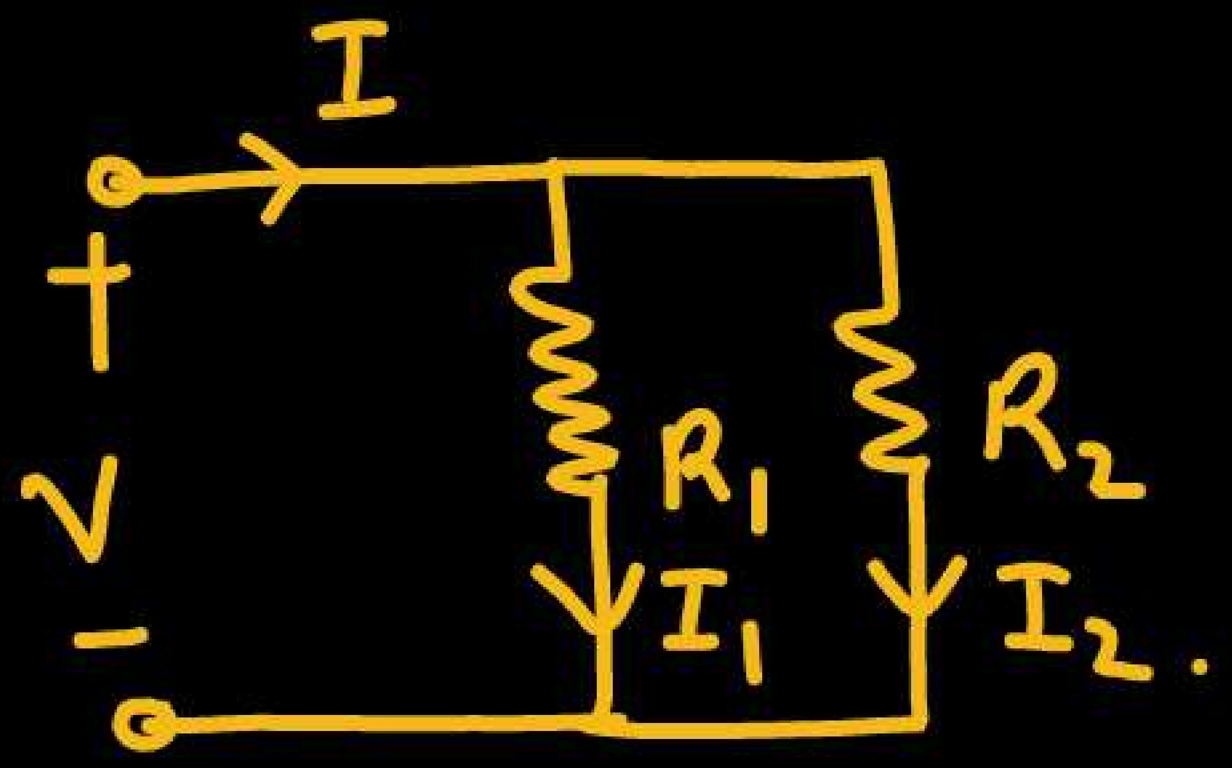
$$I_3 = \frac{V}{R_3} = \frac{I}{G_{eq}} \cdot G_3.$$

$$\vdots$$

$$I_n = \frac{V}{R_n} = \frac{I}{G_{eq}} \times G_n.$$

- Hence current in each Resistor can be easily calculated by using CDR.

$$\boxed{I_x = I \cdot \left(\frac{G_x}{G_{eq}}\right) \quad x = 1, 2, 3, \ldots n.} \rightarrow \text{CDR}$$



$$\boxed{I_x = I \times \frac{G_x}{G_{eq}}}$$

$$I_1 = I \times \frac{G_1}{G_{eq}} = \frac{I \times \frac{1}{R_1}}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{I/R_1}{\left(\frac{R_1 + R_2}{R_1 R_2}\right)}$$

$$G_{eq} = G_1 + G_2.$$

$$\frac{1}{R_{eq}} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$I_1 = I \times \left(\frac{R_2}{R_1 + R_2}\right)$$

$$I_2 = I \times \frac{G_2}{G_{eq}} = \frac{I \times \frac{1}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2}}.$$

$$I_2 = I \times \left(\frac{R_1}{R_1 + R_2}\right)$$

- Now if all Resistors are same.

$$R_1 = R_2 = R_3 = R_4 = \cdots = R_n = R.$$

$$G_1 = G_2 = G_3 = G_4 = \cdots = G_n = \frac{1}{R} = G$$

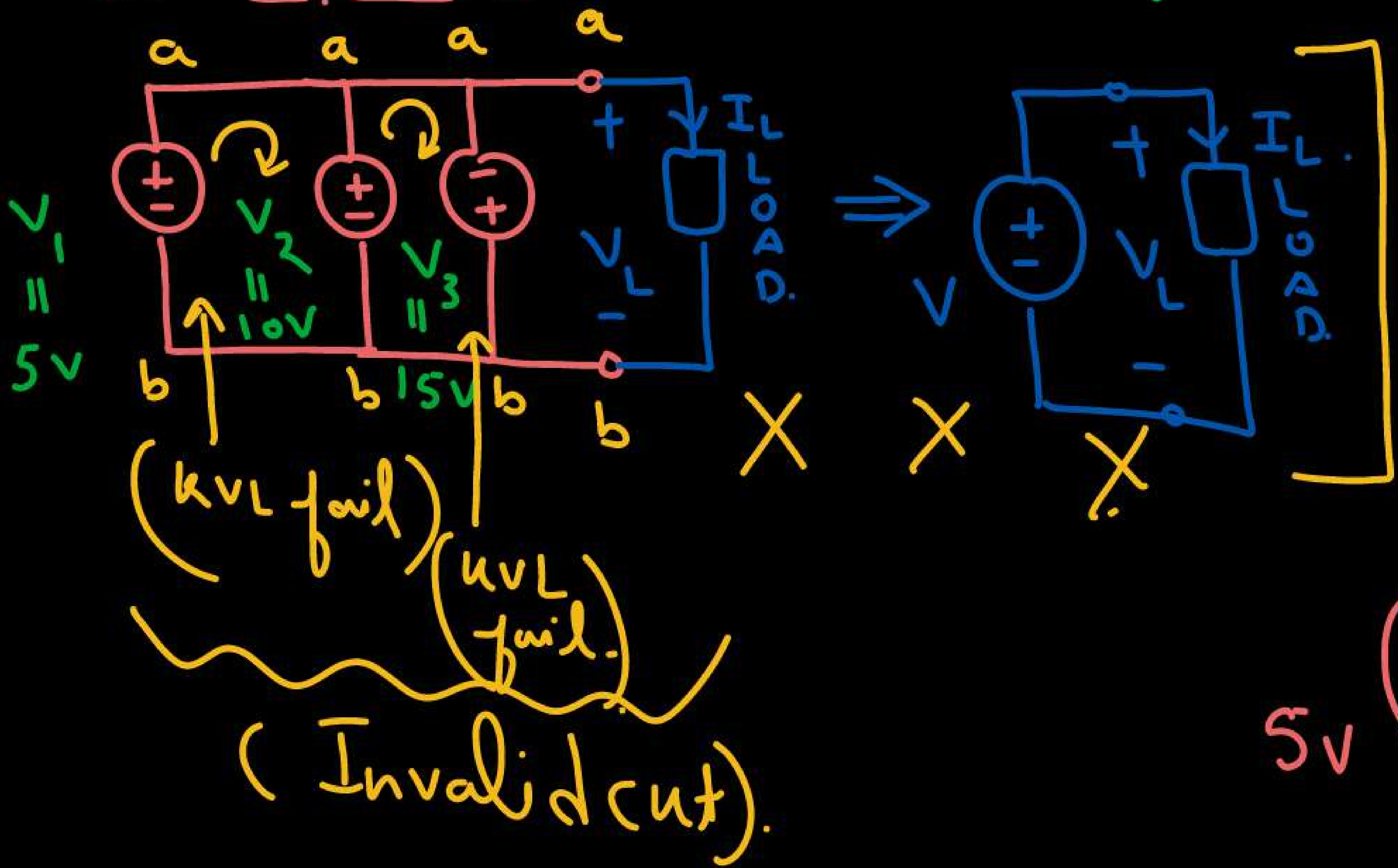
$$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} + \cdots + \frac{1}{R} = \frac{n}{R}. \longrightarrow G_{eq} = G + G + G + \cdots + G. = n \cdot G$$

$$\boxed{G_{eq} = \frac{1}{R_{eq}} = \frac{n}{R}} \text{ or } \boxed{R_{eq} = \frac{R}{n}}$$

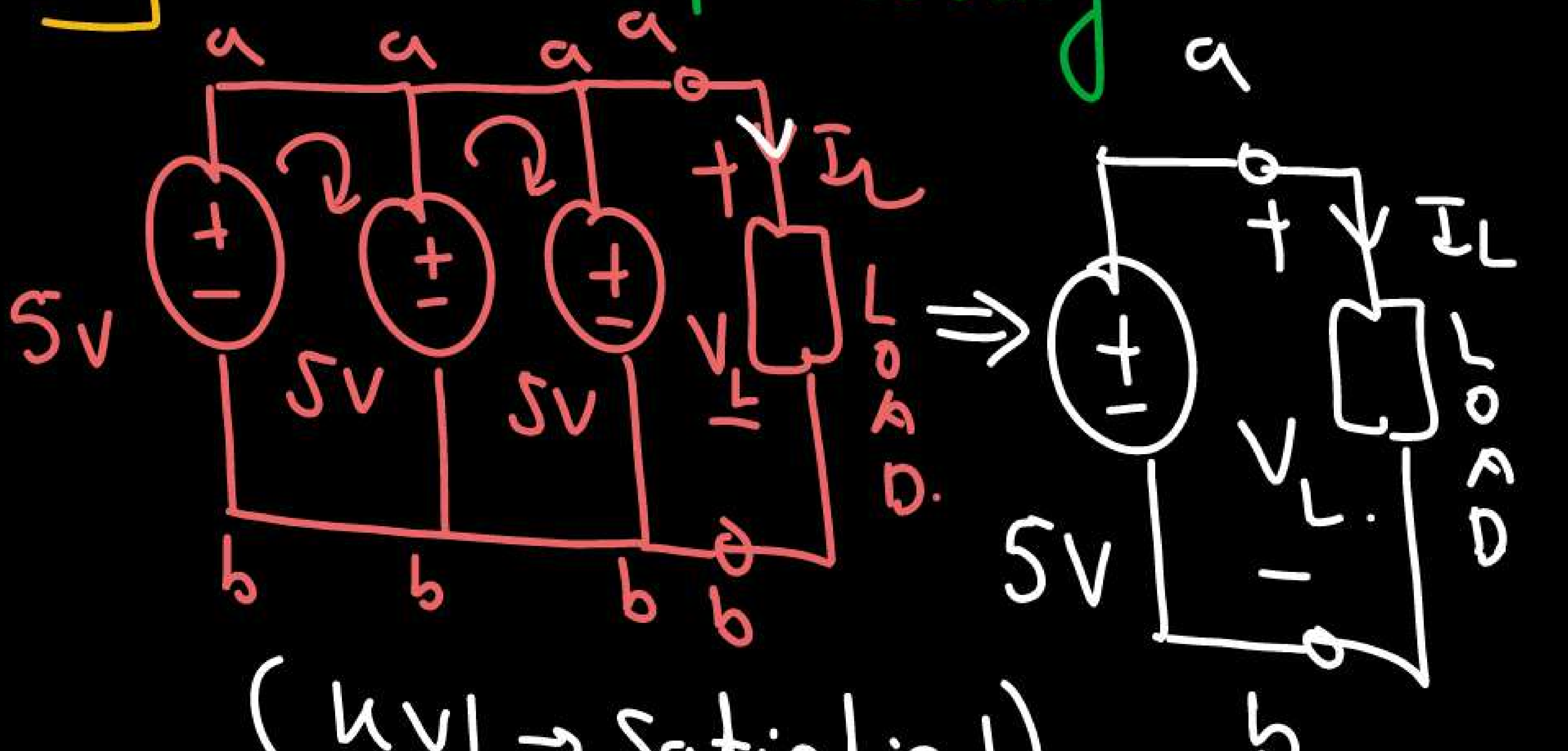
- $$\boxed{I_x = I \cdot \frac{G_x}{G_{eq}} = I \times \frac{G}{G_{eq}} = I \times \frac{\cancel{G}}{n \cdot \cancel{G}} = \frac{I}{n}}$$

② Voltage Sources:

(a) Ideal (KVL Must be Satisfied)

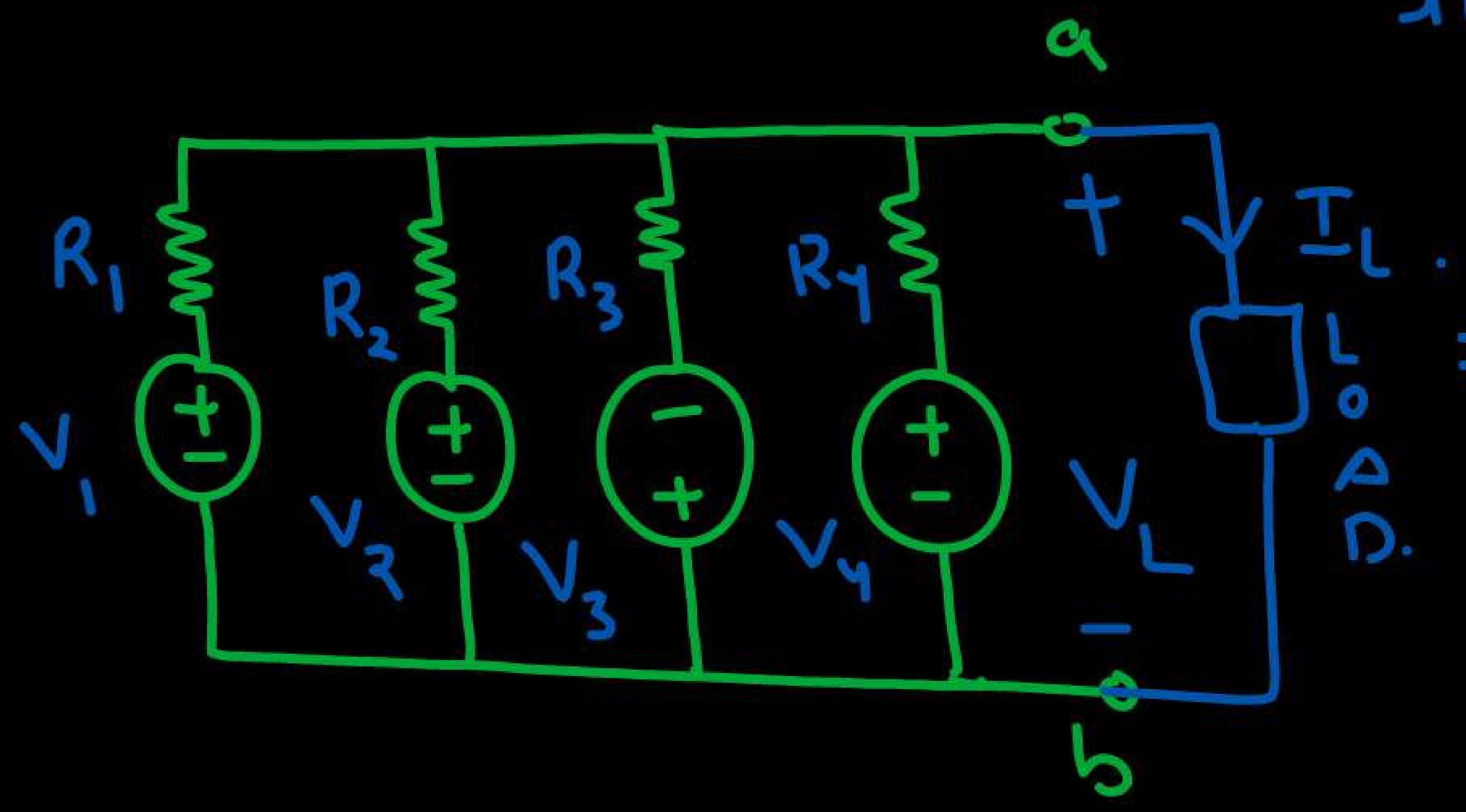


Note: From the Discussion The ideal voltage Sources can be connected in Parallel if they have Same Magnitude & Same polarity.

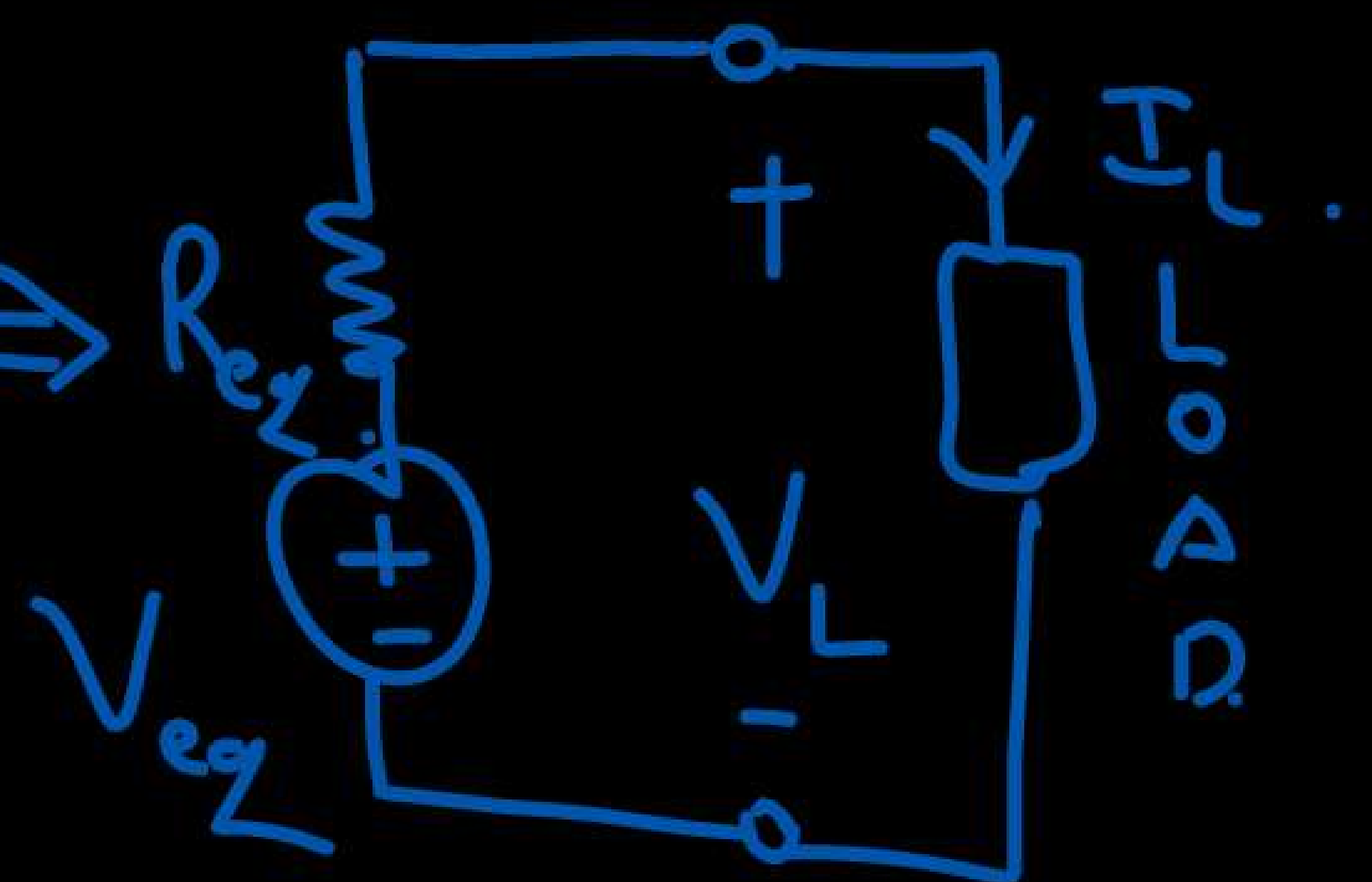


(KVL → Satisfied).

[(b) Practical voltage Source. (We will see this operation in later classes).]

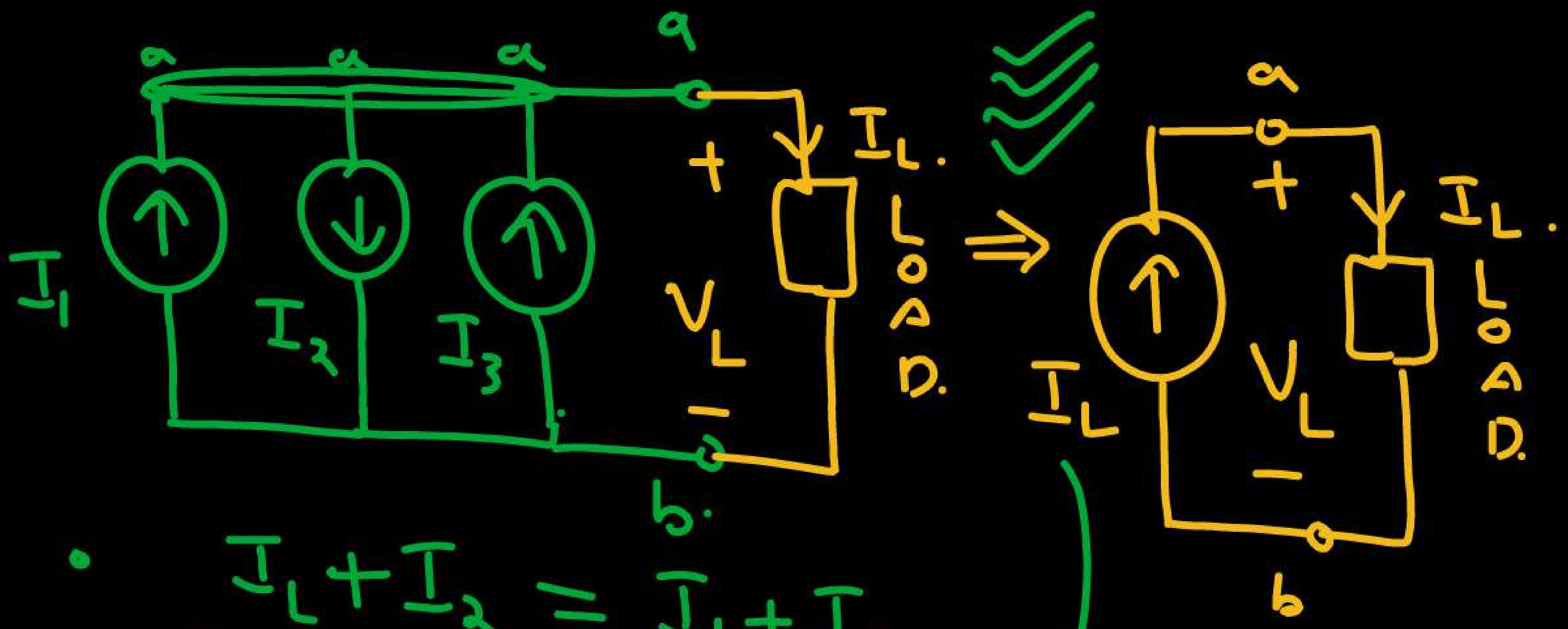


$\Longrightarrow$



③ Current Sources.

(a) Ideal (Just Apply KCL).



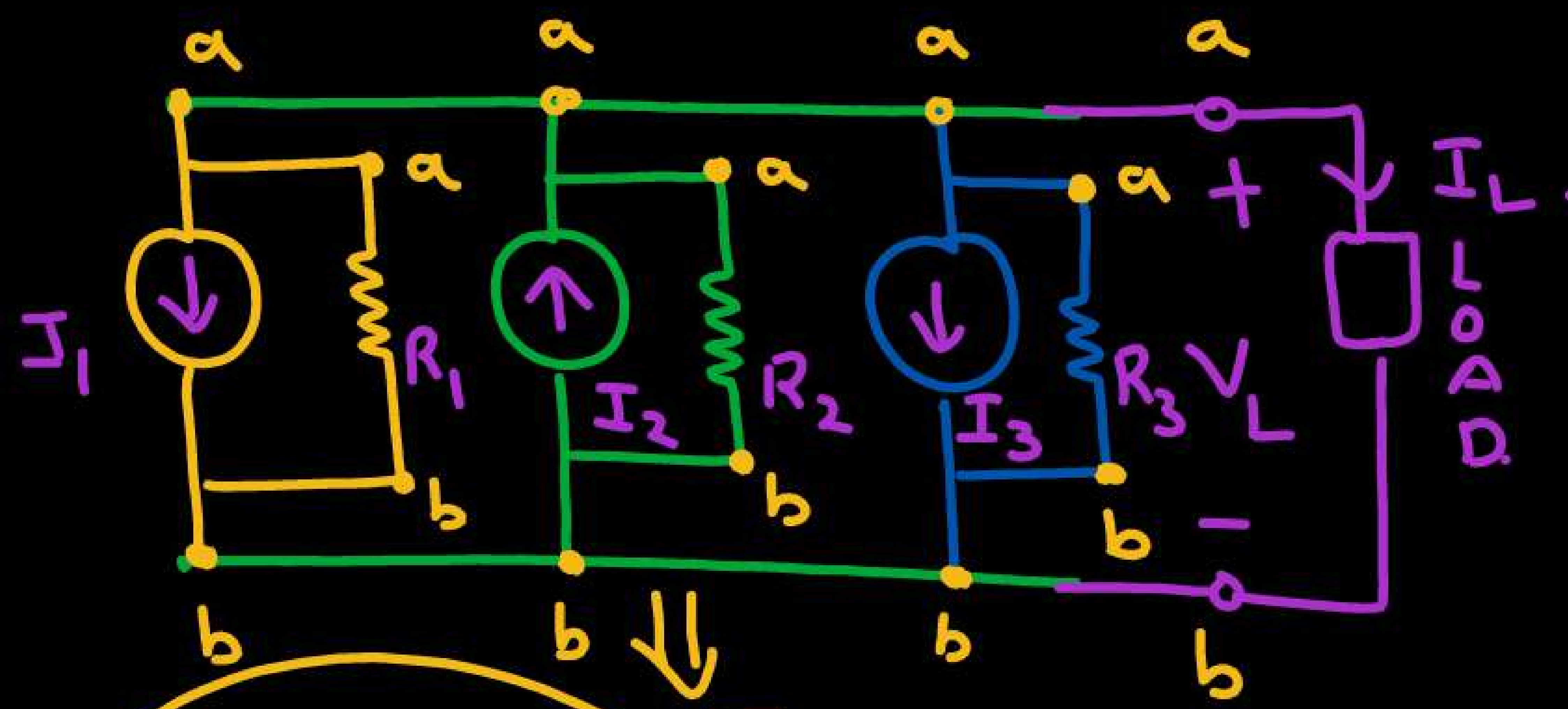
$$I_L + I_2 = I_1 + I_3$$

$$\boxed{I_L = I_1 + I_3 - I_2}$$

(b) Practical current Sources.

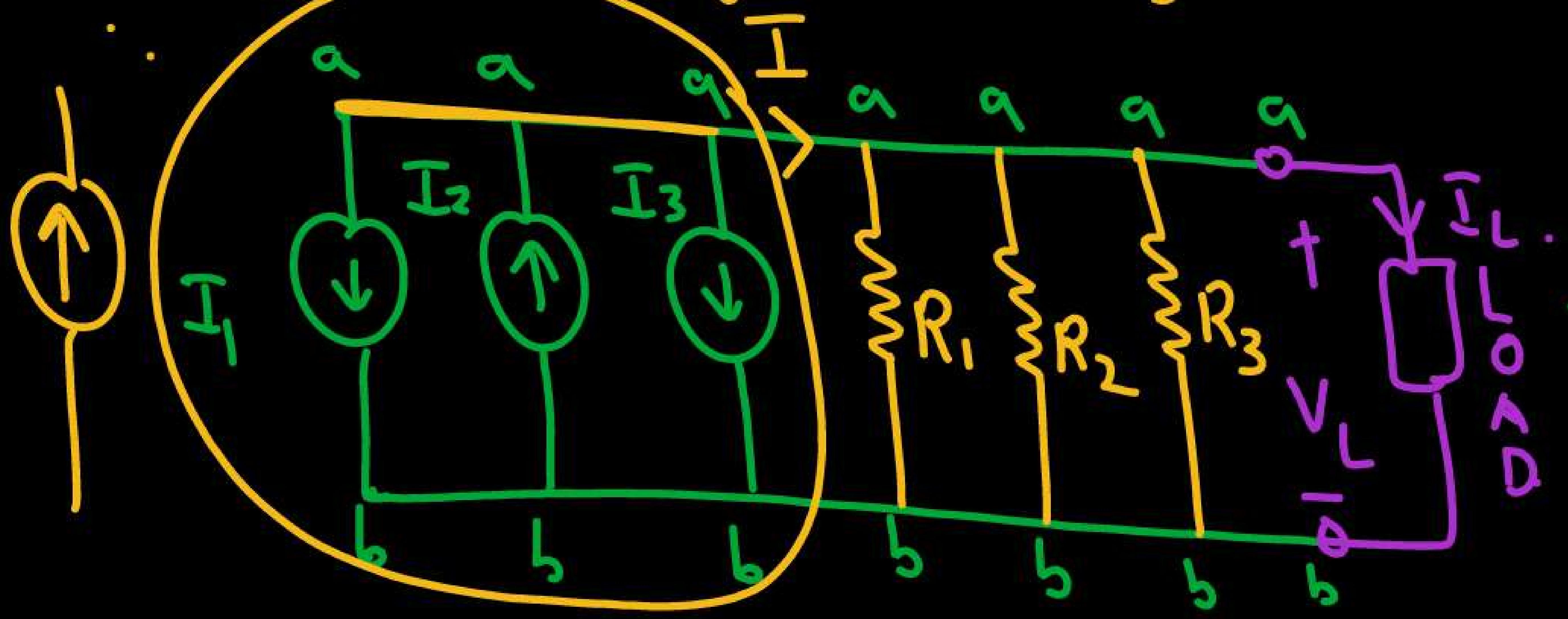
$$I_1 + I_3 + I = I_2$$

$$I = I_2 - I_1 - I_3$$

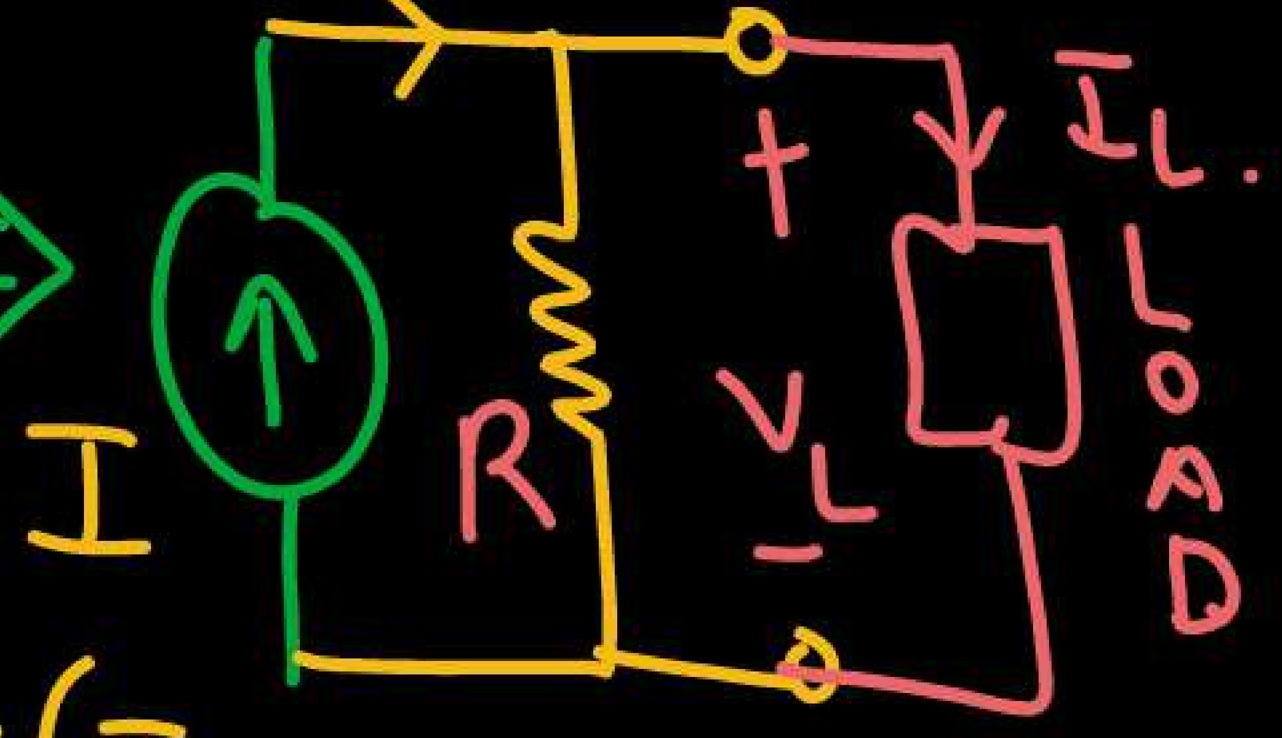


$$\boxed{R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$



$\Rightarrow$



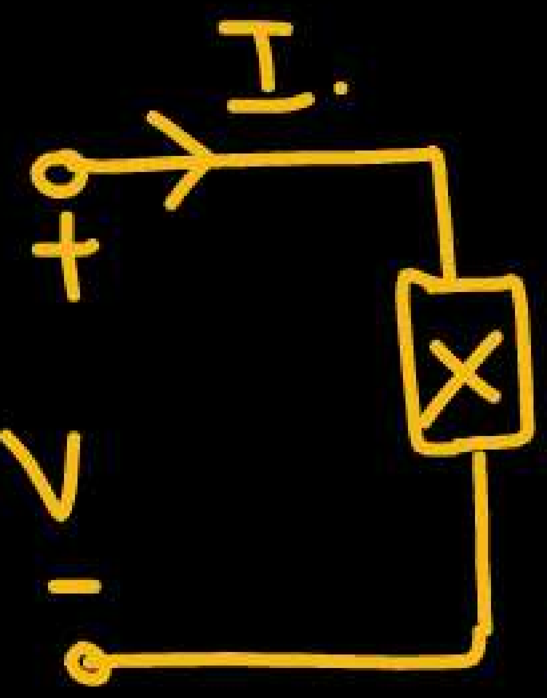
$$= (I_2 - I_3 - I_1)$$

[**Note**: Imp All the concepts of Series & Parallel operation of Independent voltage & current Source are equally Applicable for Dependent voltage & current Sources.]

Note: In electric Circuit.

- R → Always absorbs & Dissipate Power
- L → By default absorbs Power → Store energy
- C → By default absorbs Power → Store energy.

Topic – (Nature of Element).



Nature

Any element.

- → Linear or Non-linear.
- → Active or Passive.
- → Bilateral or Unilateral.
- → Time Variant or Time Invariant.
  (TV) or (TIV).

→ These nature of element will depend upon the connection of element in ckt & also the other conditions of circuit.

Thank you

GW Soldiers !