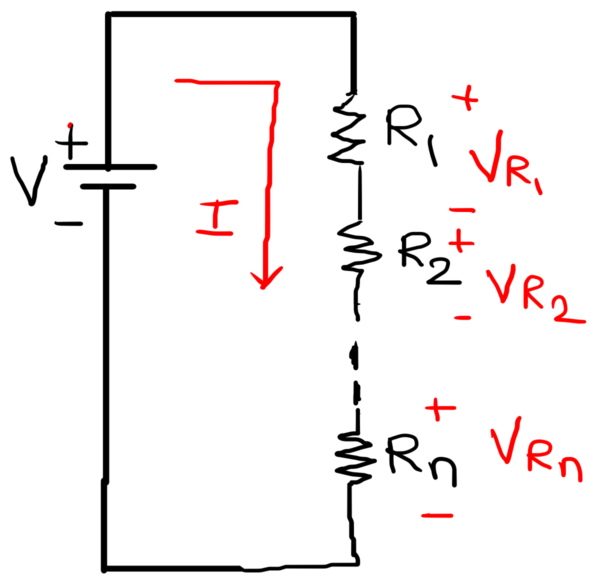
Series Combination of Resistors (Current is same in all resistor)



Applying KVL

$$V - V_{R_1} - V_{R_2} - \cdots - V_{R_n} = 0$$

$$V = V_{R_1} + V_{R_2} + \cdots + V_{R_n}$$

$$V = IR_1 + IR_2 + \cdots + IR_n$$

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

$$\frac{V}{I} = R_1 + R_2 + \cdots + R_n \quad \text{also } I = \frac{V}{R_1 + R_2 + \cdots + R_n}$$

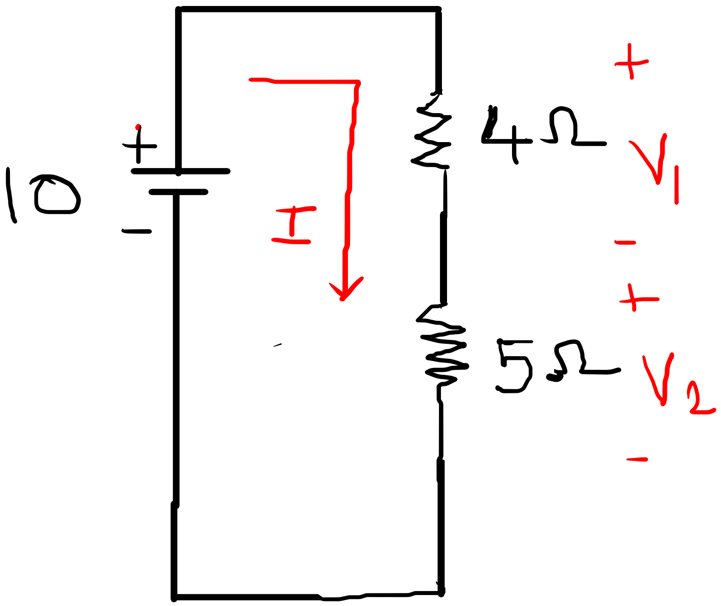
$$\boxed{R_{eq} = R_1 + R_2 + \cdots + R_n} \qquad R_{eq} = \sum_{i=1}^{n} R_i$$

Voltage Division Formula

$$V_{R_1} = IR_1 = \frac{R_1 \times V}{R_1 + R_2 + \cdots + R_n}, \quad V_{R_2} = I \cdot R_2 = \frac{R_2 \times V}{R_1 + R_2 + \cdots + R_n} \;\&\; V_{R_n} = IR_n = \frac{R_n \times V}{R_1 + R_2 + \cdots + R_n}$$

[Voltage across any resistor in a Series Combination] = applied Voltage × (Resistance of the same branch / Sum of all Resistances)

Series Combination of Resistors (Current is same in all resistor)



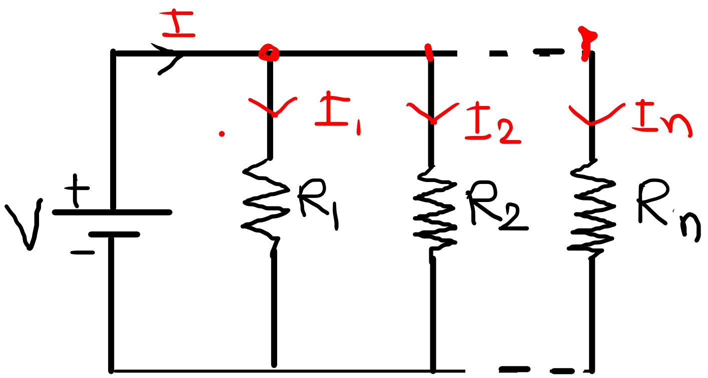
$$V_1 = \frac{4}{4+5} \times 10 = \frac{40}{9}$$

$$V_2 = \frac{5}{5+4} \times 10 = \frac{50}{9}$$

Voltage Division Formula

$$\left[\text{Voltage across any resistor in a Series Combination}\right] = \text{applied Voltage} \times \left(\frac{\text{Resistance of Same branch}}{\text{Sum of resistances in Series}}\right)$$

Parallel Combination of Resistors (Voltage Across all resistors is Same)



Applying KCL

$$I = I_1 + I_2 + \cdots + I_n$$

$$I = \left[\frac{V}{R_1} + \frac{V}{R_2} + \cdots + \frac{V}{R_n}\right] = V\left[\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}\right]$$

$$\frac{I}{V} = \left[\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}\right] = \frac{1}{R_{eq}}$$

$$\boxed{V = \frac{I}{\left[\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}\right]}}$$

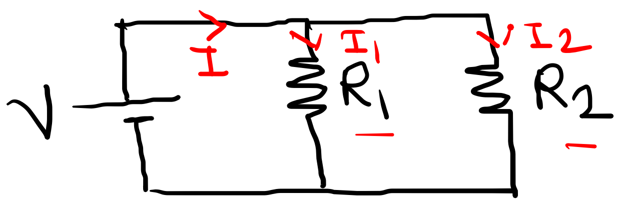
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$$

Current Division formula

$$I_n = \frac{I \times \frac{1}{R_n}}{\frac{1}{R_{eq}}}$$

$$I_1 = \frac{V}{R_1} = \frac{1}{R_1}\left[\frac{I}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}}\right] = \left(\frac{\frac{1}{R_1} \times I}{1/R_{eq}}\right) = \left(\frac{\frac{1}{R_1} \times I}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}}\right)$$

For two Resistors in parallel



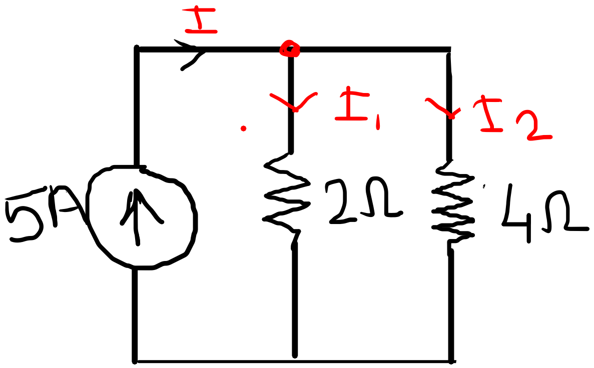
$$I_1 = \frac{\frac{1}{R_1} \times I}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{\frac{1}{\cancel{R_1}} \times I}{\frac{R_1 + R_2}{\cancel{R_1} R_2}} = \frac{R_2 \times I}{R_1 + R_2}$$

$$I_2 = \frac{R_1 \times I}{R_1 + R_2}$$

Current Through a resistor(in parallel = combination of two) resistors)

Total Current X (Resistance of other branch / Sum of Resistances

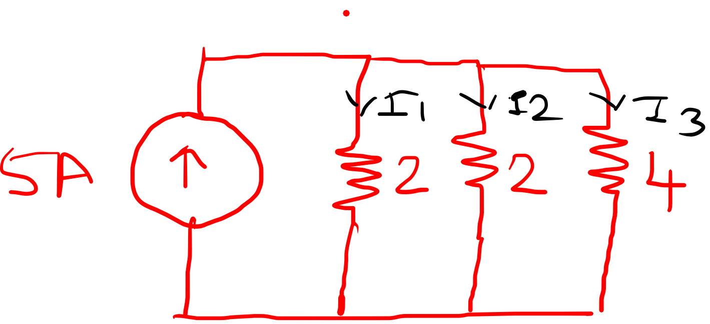
Parallel Combination of Resistors (Voltage Across all resistors is Same)



Current Division formula

$$I_1 = \frac{5\times 4}{4+2} = \frac{20}{6}$$

$$I_2 = \frac{5\times 2}{2+4} = \frac{10}{6}$$



$$I_1 = \frac{\frac{1}{2}\times 5}{\frac{1}{2}+\frac{1}{2}+\frac{1}{4}}$$

$$I_3 = \frac{5\times\frac{1}{4}}{\frac{1}{2}+\frac{1}{2}+\frac{1}{4}}$$

$$I_2 = \frac{\frac{1}{2}\times 5}{\frac{1}{2}+\frac{1}{2}+\frac{1}{4}}$$

Current Through a resistor(in parallel = combination of two) resistors)

Total Current X (Resistance of other branch / Sum of Resistances

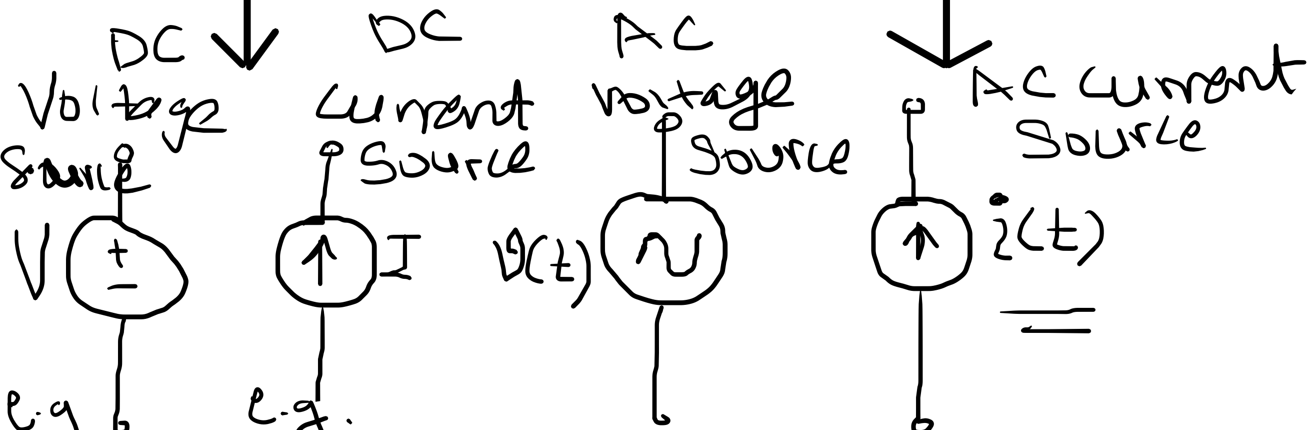
Energy Sources

Voltage & Current Sources

Direct Current (DC) Sources Vs Alternating Current (AC) Sources

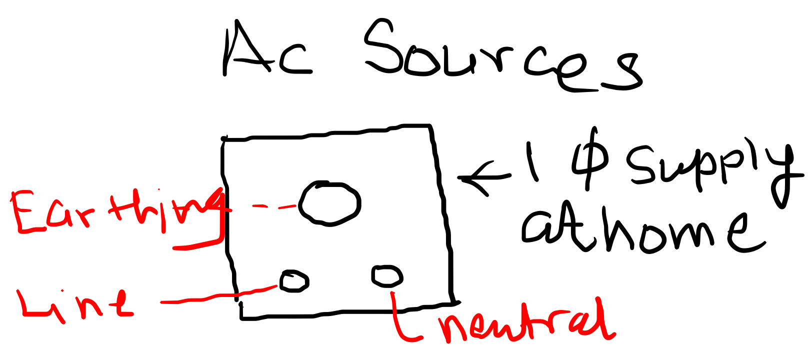
Ideal Vs Practical

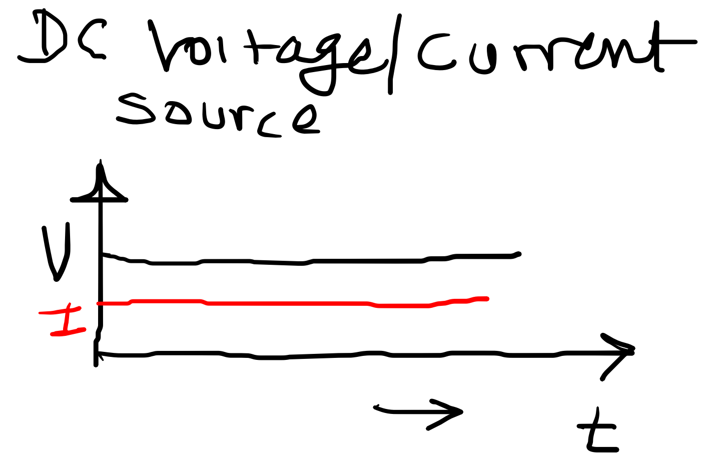
Dependent Vs Independent

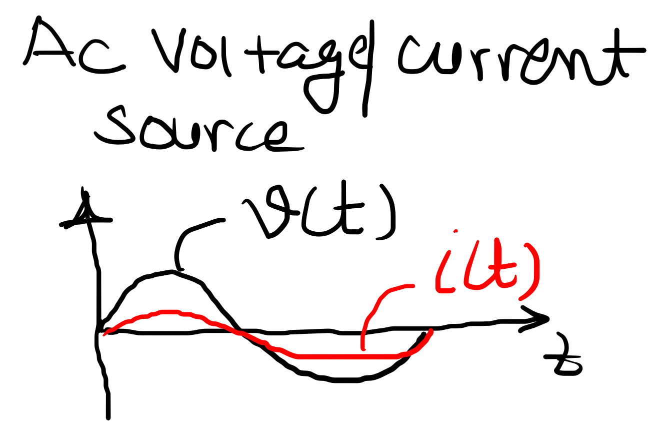


e.g Battery 3V 9V mobile Battery

e.g. Solar cell







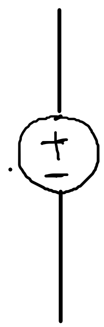
Energy Sources

Voltage
or
Current
Source

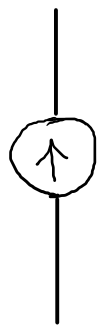
Direct Current (DC) Sources
Vs
Alternating Current (AC) Sources

Ideal
Vs
Practical

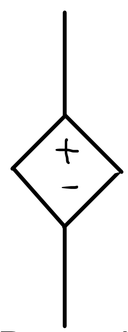
Dependent
Vs
Independent



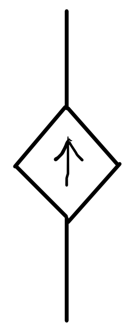
Independent
Voltage
Source



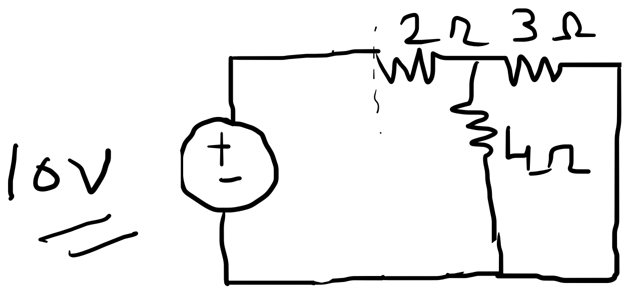
Independent
Current
Source

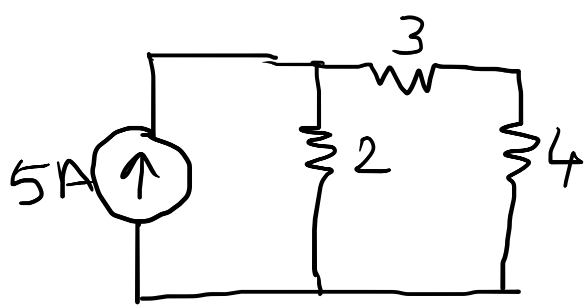


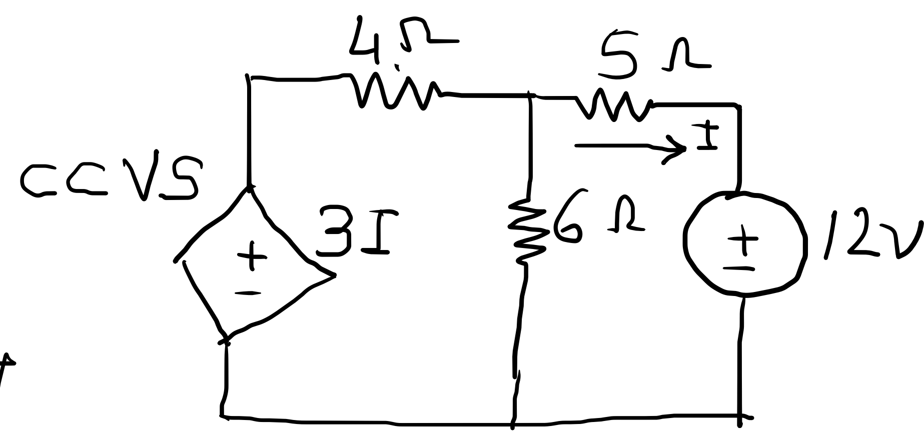
Dependent
Voltage
Source



Dependent
Current
Source







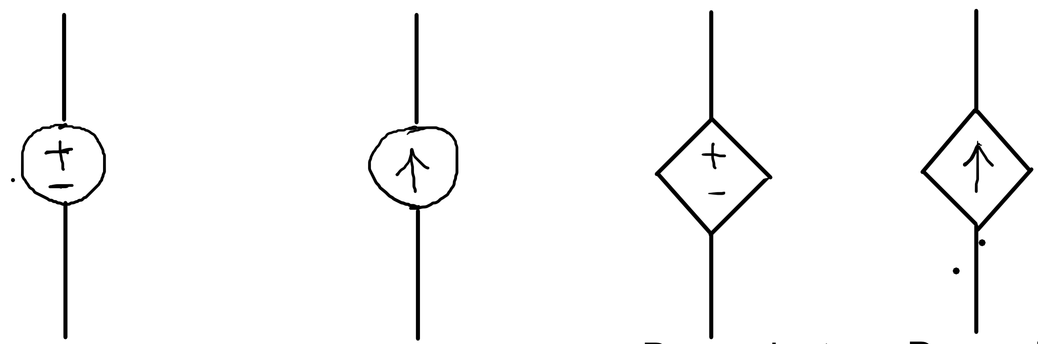
Energy Sources

Voltage or Current Source

Direct Current (DC) Sources Vs Alternating Current (AC) Sources

Ideal Vs Practical

Controlled Dependent Vs Independent Uncontrolled

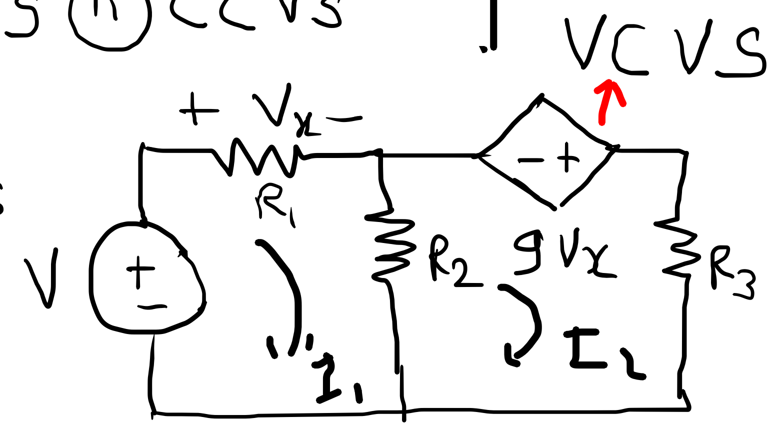


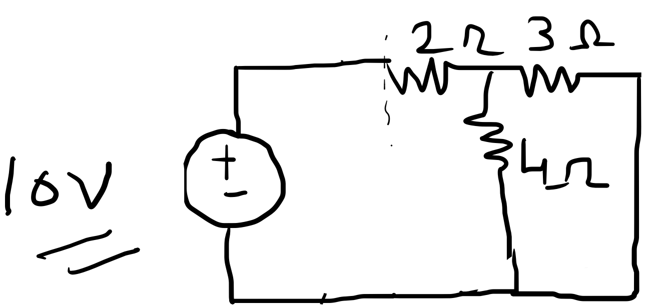
Independent Voltage Source | Independent Current Source | Dependent Voltage Source | Dependent Current Source

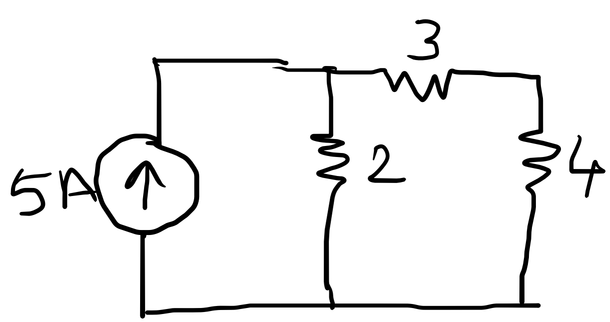
(I) VCVS (II) CCVS

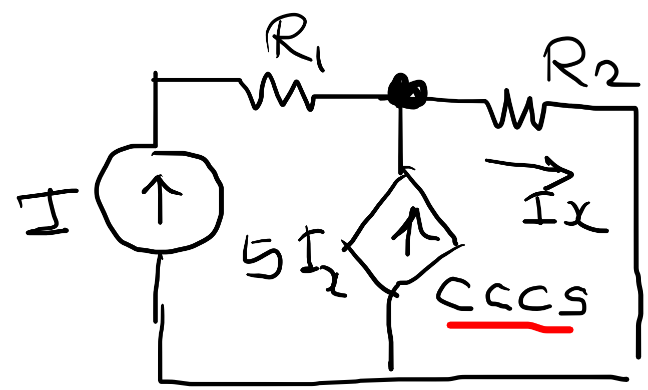
(III) CCCS

(IV) VCCS









Energy Sources

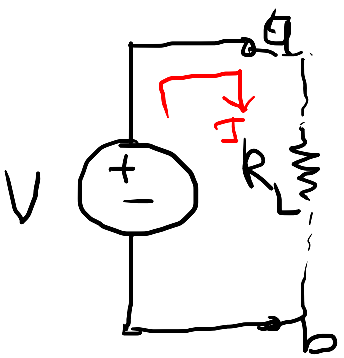
Voltage or Current Source

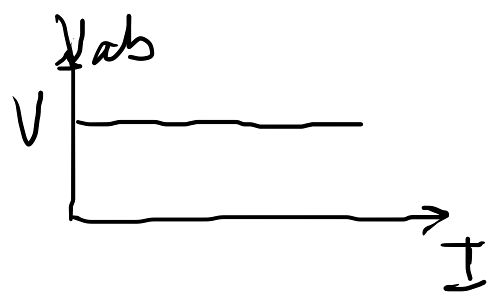
Direct Current (DC) Sources Vs Alternating Current (AC) Sources

Ideal Vs Practical

Dependent Vs Independent

Ideal Voltage Source





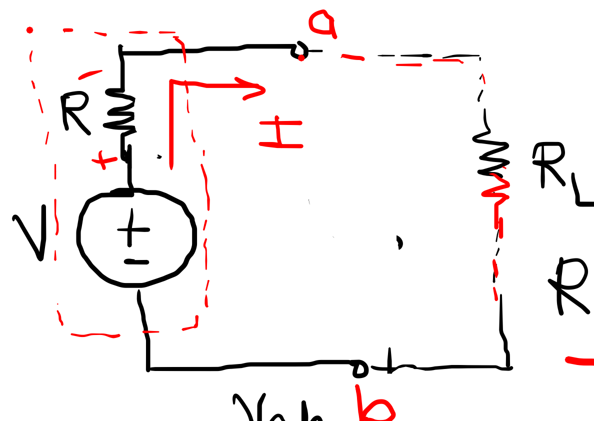
$$V_{ab} = V$$

terminal voltage remains constant for all values of current

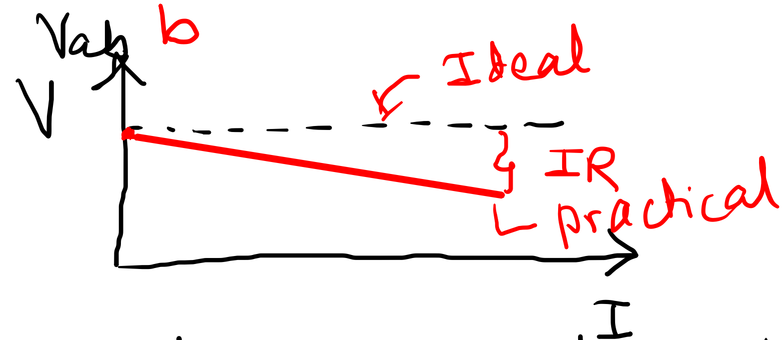
Practical Voltage Source

$$I = \frac{V}{R + R_L}$$

$$V_{ab} = V - IR$$



R is internal resistance



Terminal voltage reduces by I·R drop.

Energy Sources

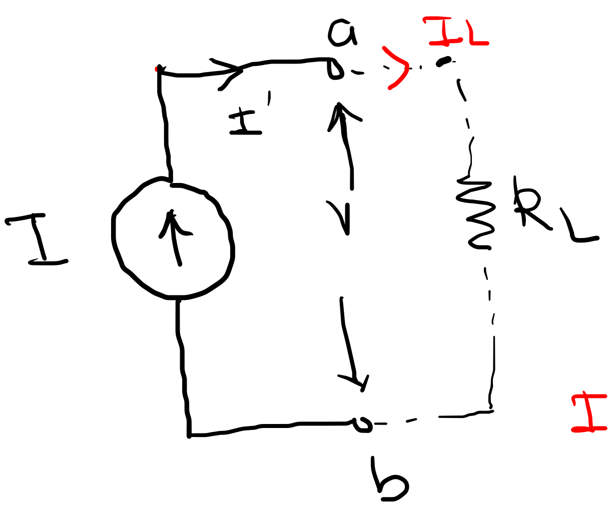
Voltage or Current Source

Direct Current (DC) Sources Vs Alternating Current (AC) Sources

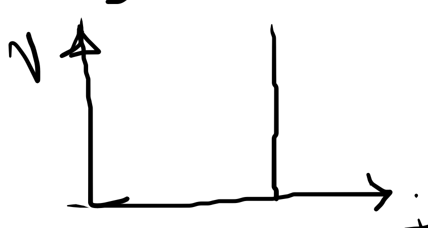
Ideal Vs Practical

Dependent Vs Independent

Ideal Current Source

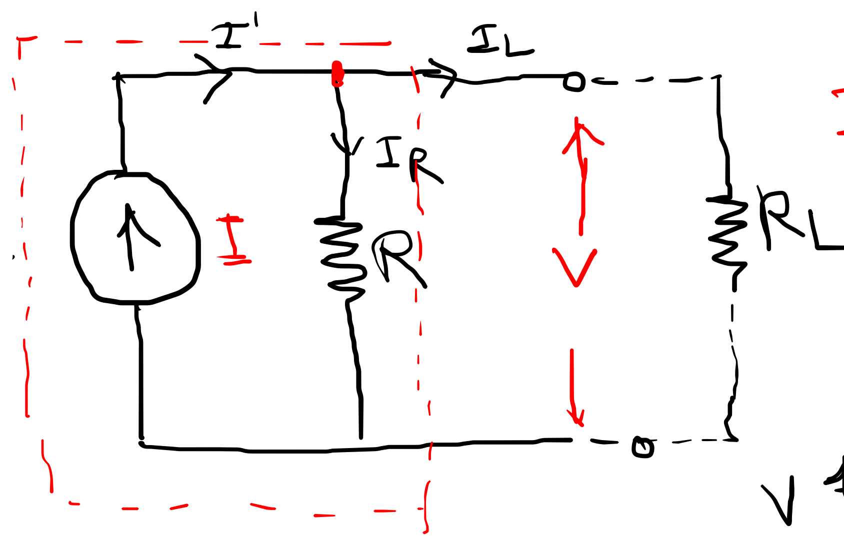


$I_L = I$



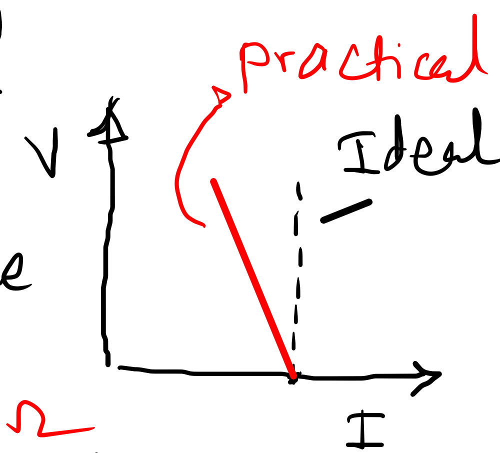
Current flowing is constant for all voltages

Practical Current Source



$I_L = I - I_R$

$I_L = I - \frac{V}{R}$

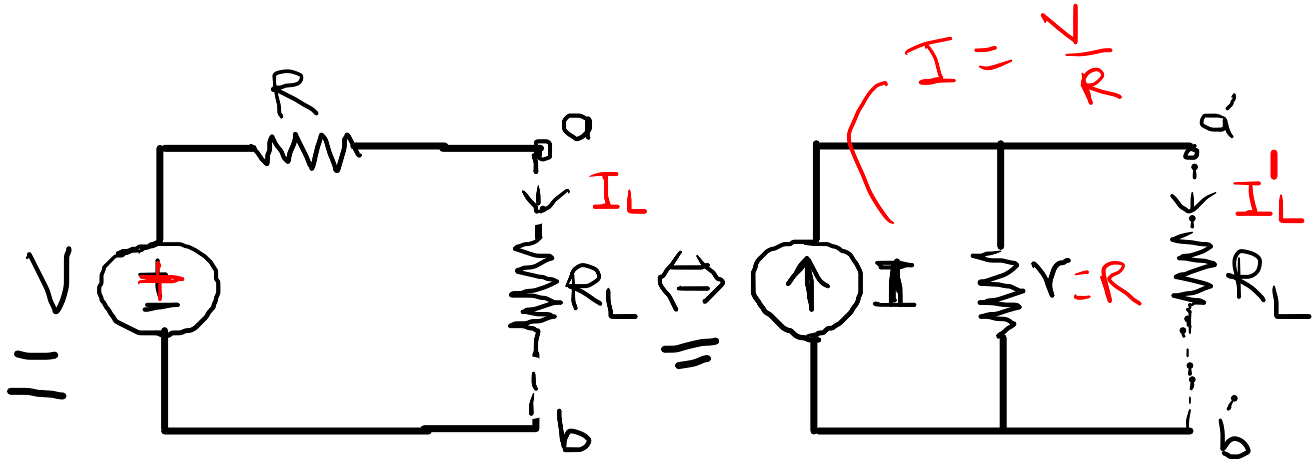


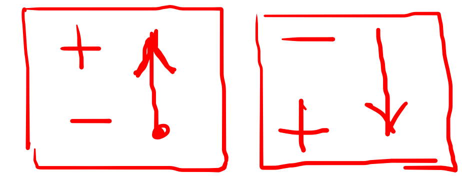
R → internal resistance of current source.

$R \to \infty$ few MΩ

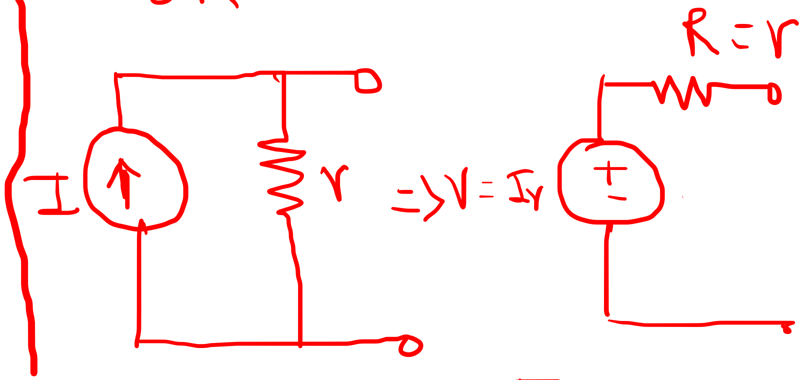
Current reduces by $\frac{V}{R}$

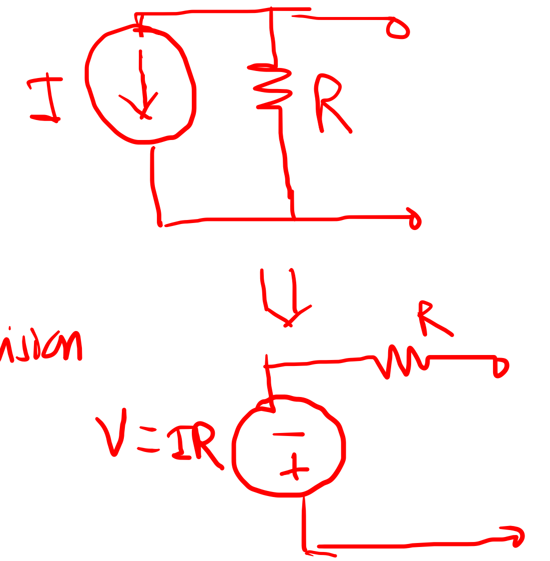
Source Transformation





OR





$I_L = I_L'$ & $V_{ab} = V_{a'b'}$

$$I_L = \frac{V}{R+R_L} \qquad I_L' = \frac{r}{r+R_L} \times I$$

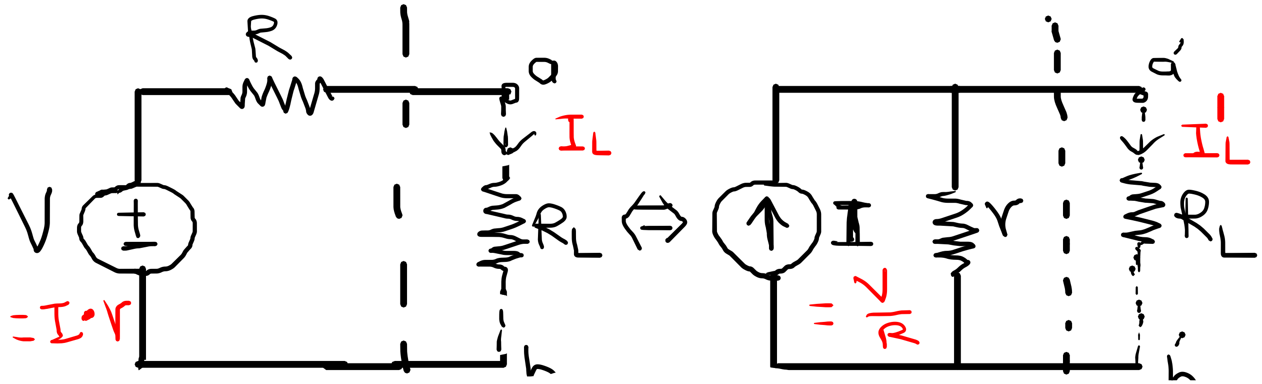
$$\frac{V}{R+R_L} = \frac{I \cdot r}{r+R_L}$$

Using current division formula

when R_L is removed $V_{ab} = V$ & $V_{a'b'} = V = Ir$

$$R + \cancel{R_L} = r + \cancel{R_L} \qquad \boxed{R = r}$$

Source Transformation



For maintaining Electrical Equivalence of above networks

$$I_L = I_L' \quad \& \quad V_{ab} = V_{a'b'} \quad \text{— (1)}$$

$$\frac{V}{R+R_L} = \frac{I \times r}{r+R_L} \quad \text{— (2)}$$

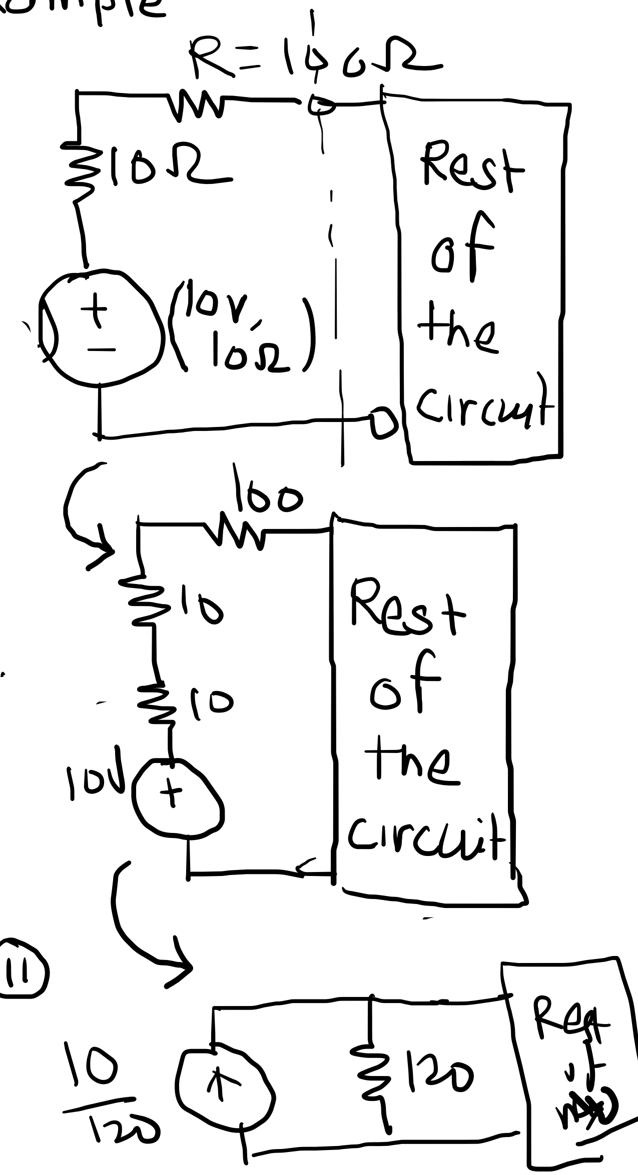
if R_L is removed from above networks

$V_{ab} = V$ & $V_{a'b'} = I \times r$ substitute in (2)

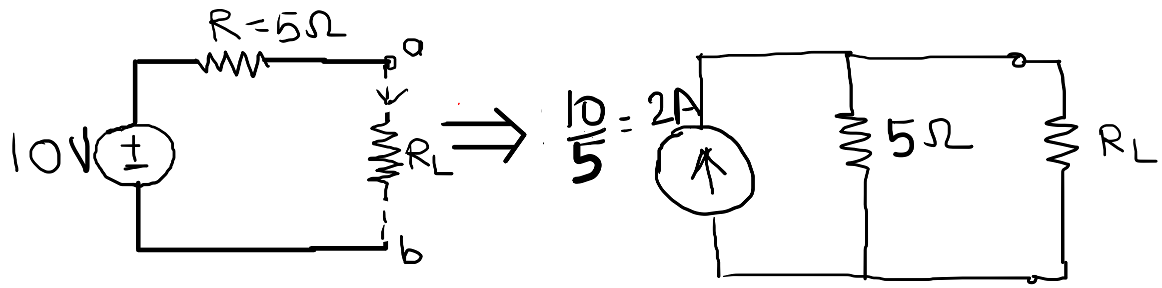
so $R + \cancel{R_L} = r + \cancel{R_L}$

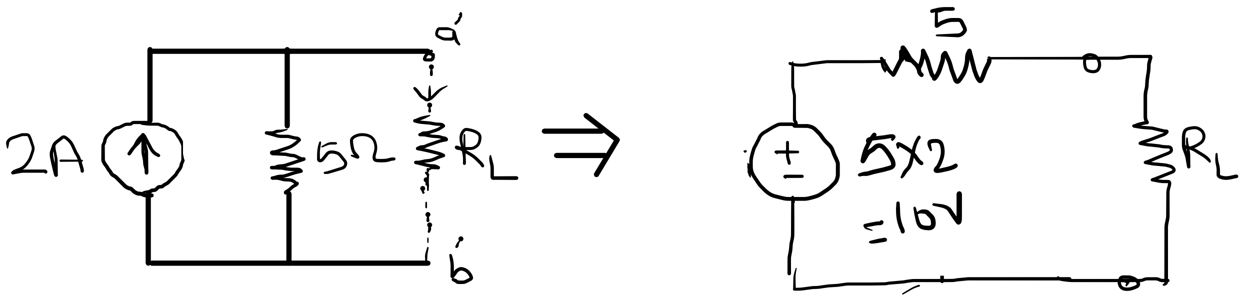
$\therefore$ $R = r$

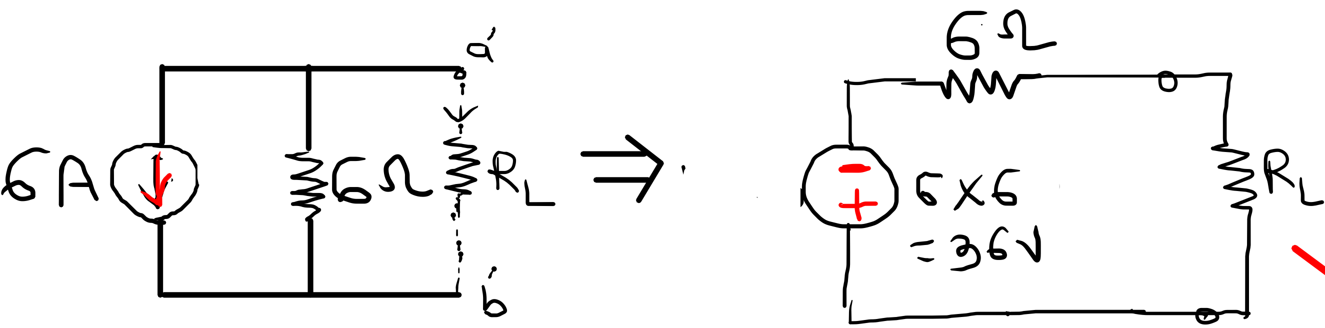
Exomple



Source Transformation Examples







Note the direction of current source & polarity of Voltage Source