EE 240 Circuits I

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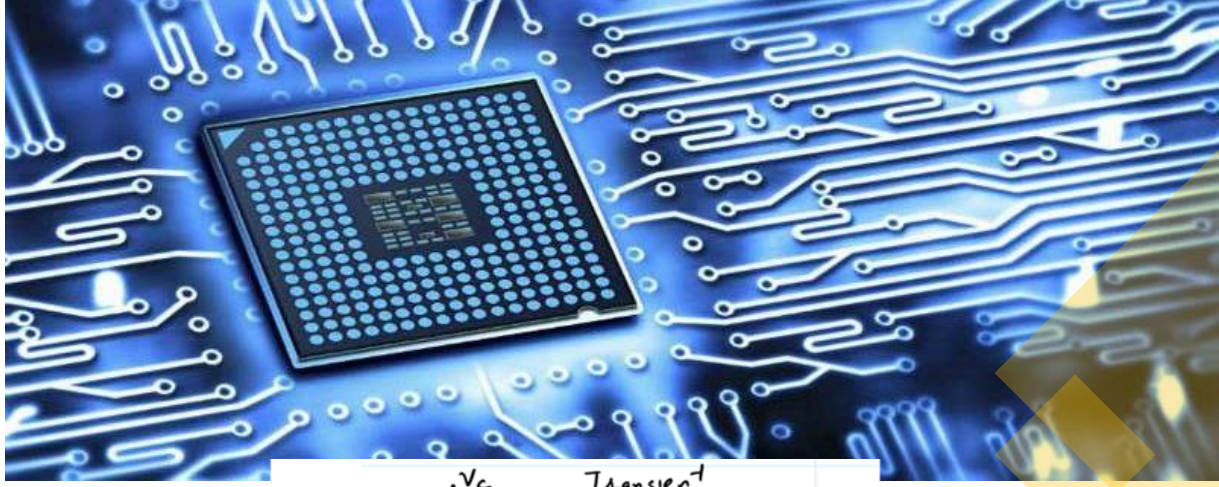
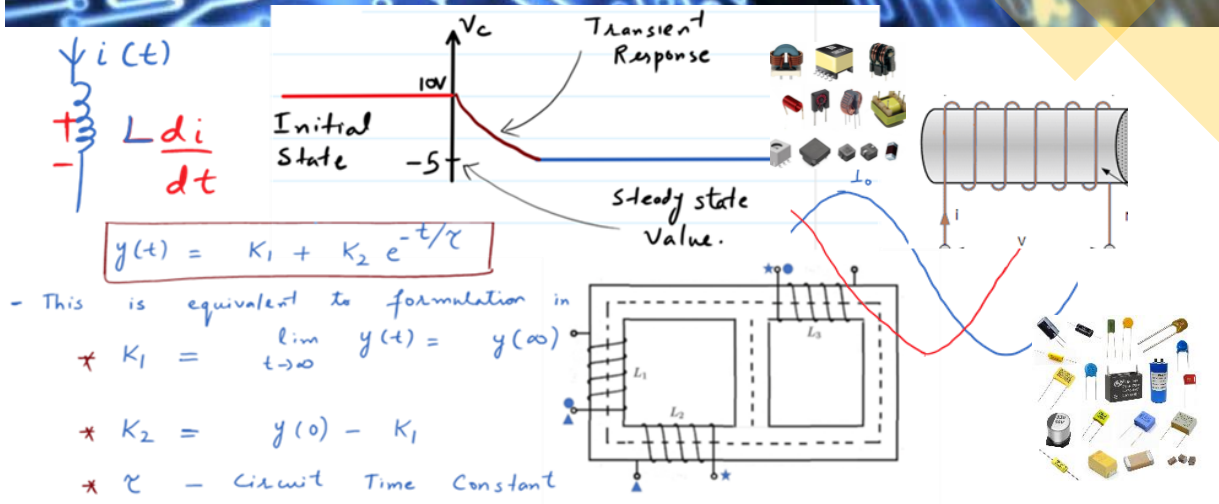


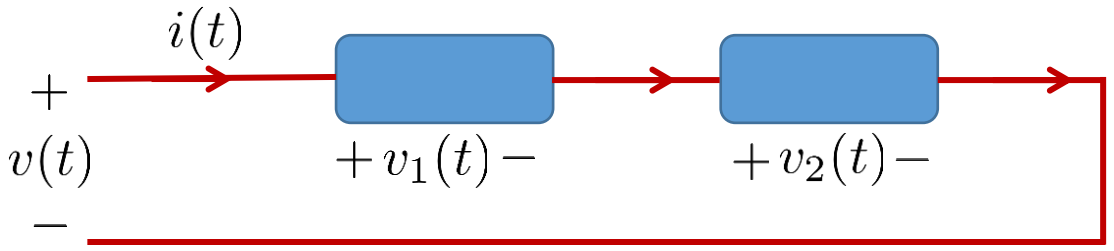


Recap

Elements and Sources in Series/Parallel

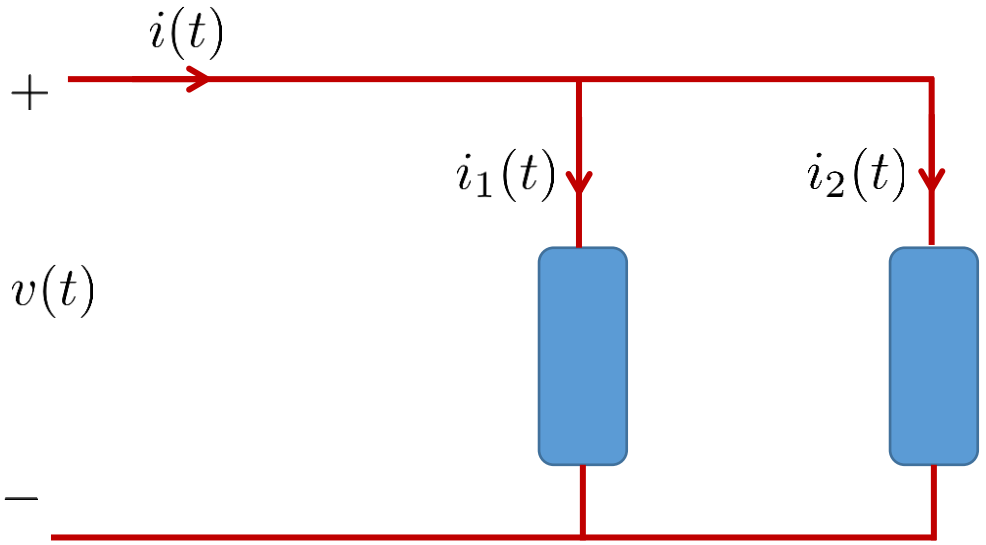
Series Connection:

Idea: same current, voltage is divided



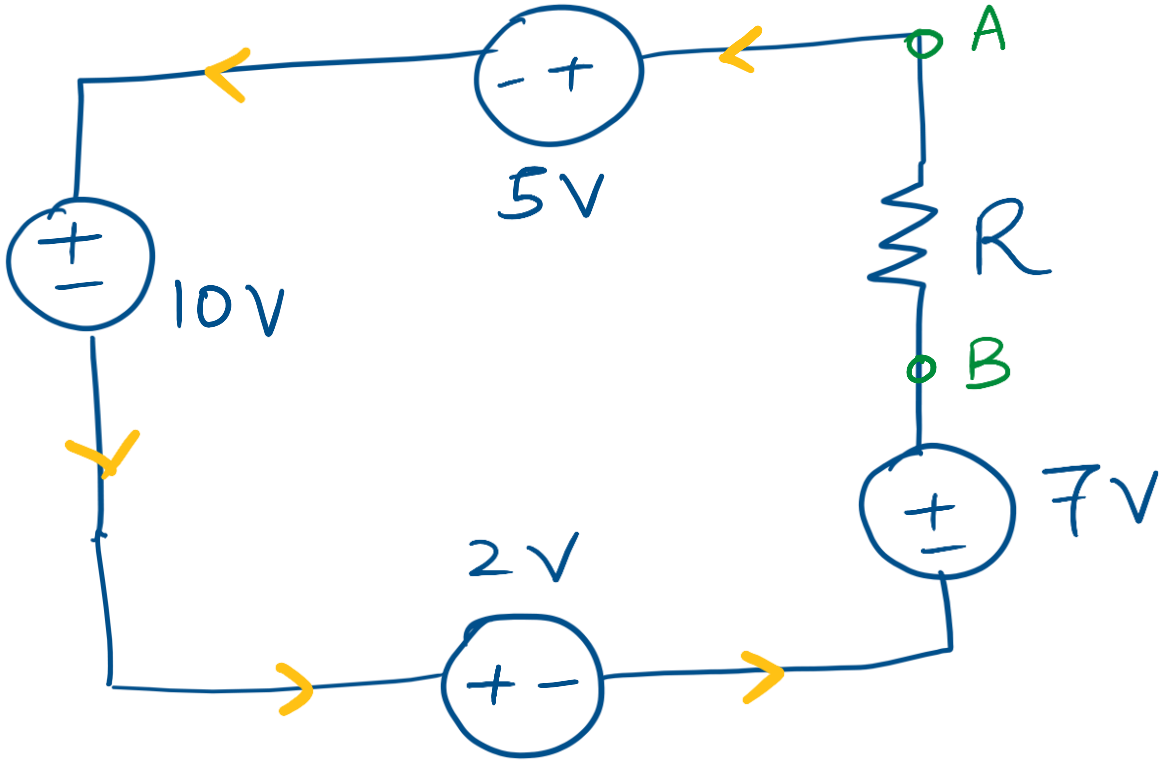
Parallel Connection:

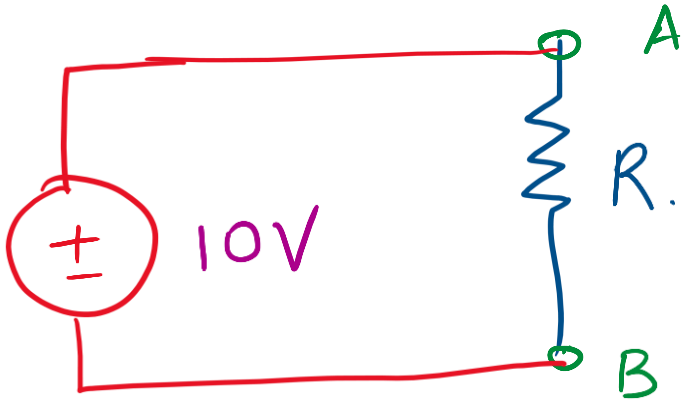
Idea: same voltage, current is divided



Voltage Sources in Series

Voltage sources in series can be represented with an equivalent single voltage source.





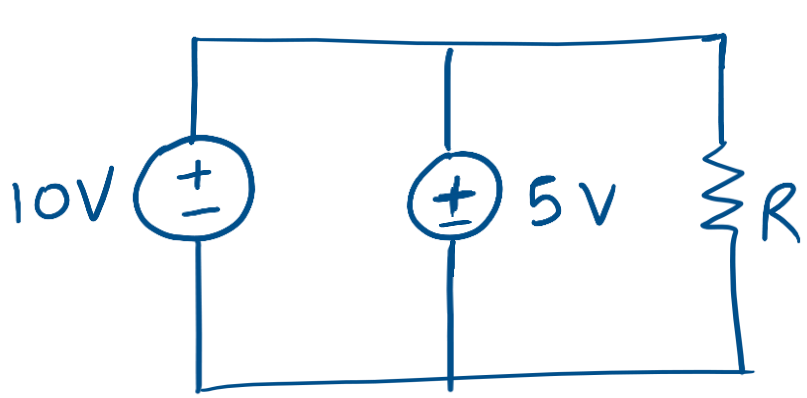
* Let's traverse from A to B.
  * Drop of $5 + 10 + 2 = 17\,V$
  * Gain of $7\,V$ = Drop of $-7\,V$

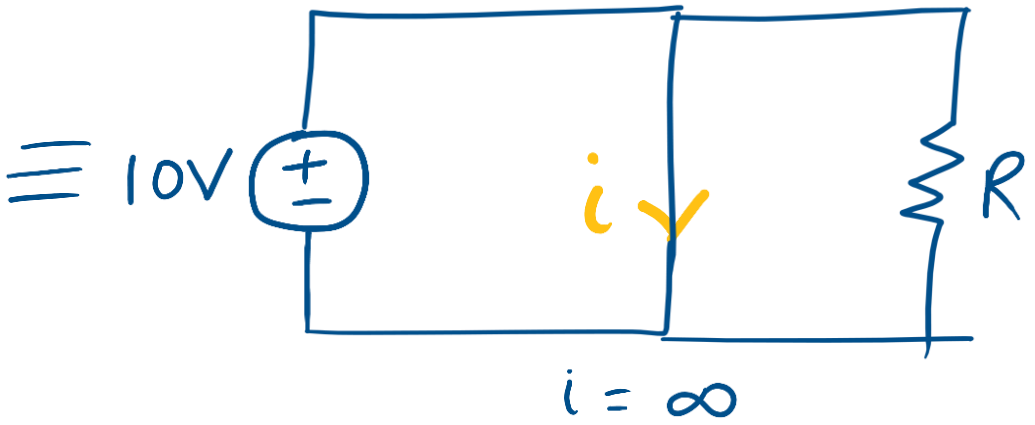
$\Rightarrow$ Net Drop $= 10\,V$

Voltage Sources in Parallel

Q: Determine the internal resistance of the ideal voltage source?

A: Zero resistance (How? Analyze i-v characteristics)



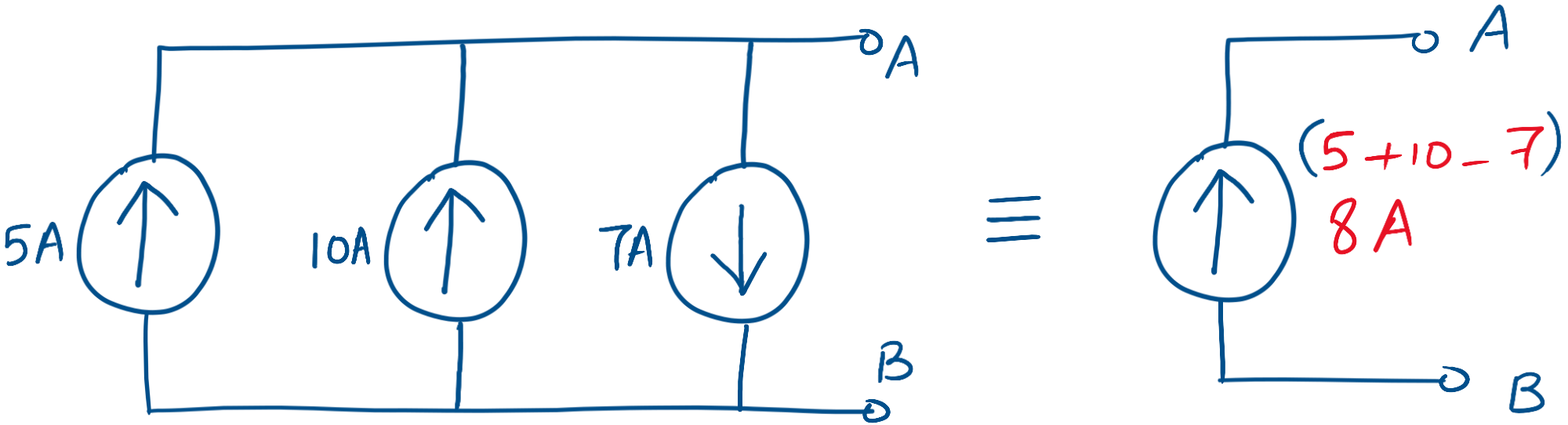


* Infinite current flow due to zero resistance

Voltage sources are NOT connected in parallel except for the case when both sources have the same voltage level. For circuit analysis, voltage sources of same voltage level, connected in parallel, can be replaced with a single voltage source.

Current Sources in Parallel

Current sources in parallel can be represented with an equivalent single current source.



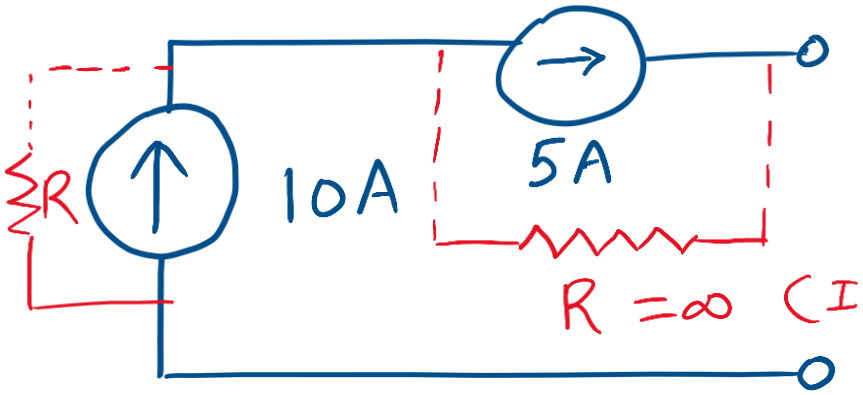
* 5A and 10A is being fed to terminal A
* 7A is being drawn from terminal A.

Current Sources in Series

Q: Determine the internal resistance of the ideal current source?

A: Infinite resistance (How? Analyze i-v characteristics)

In other words,
- Ideal current source with zero current is equivalent to **open circuit.**
- Voltage across the current source depends on the circuit it is connected to.



Virtual Resistance

$R = \infty$ (Infinite Resistance)

* If KCL is to be satisfied; 5A current flow through infinite resistance due to which infinite voltage develops across a source.

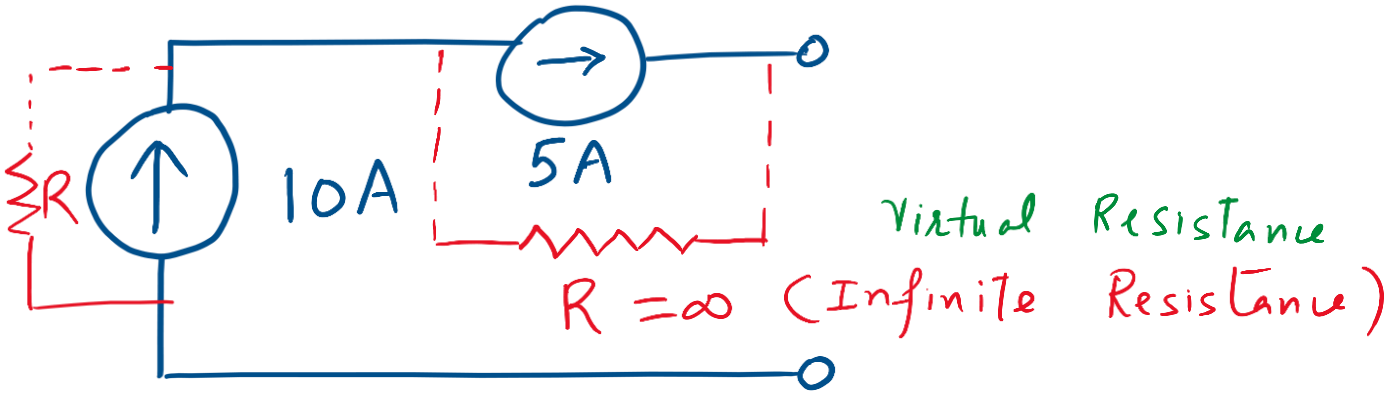
Current sources are NOT connected in series except for the case when both sources have the same current rating (value + direction).
For circuit analysis, current sources of same value, connected in series, can be replaced with a single current source.

Current Sources in Series

Q: Determine the internal resistance of the ideal current source?

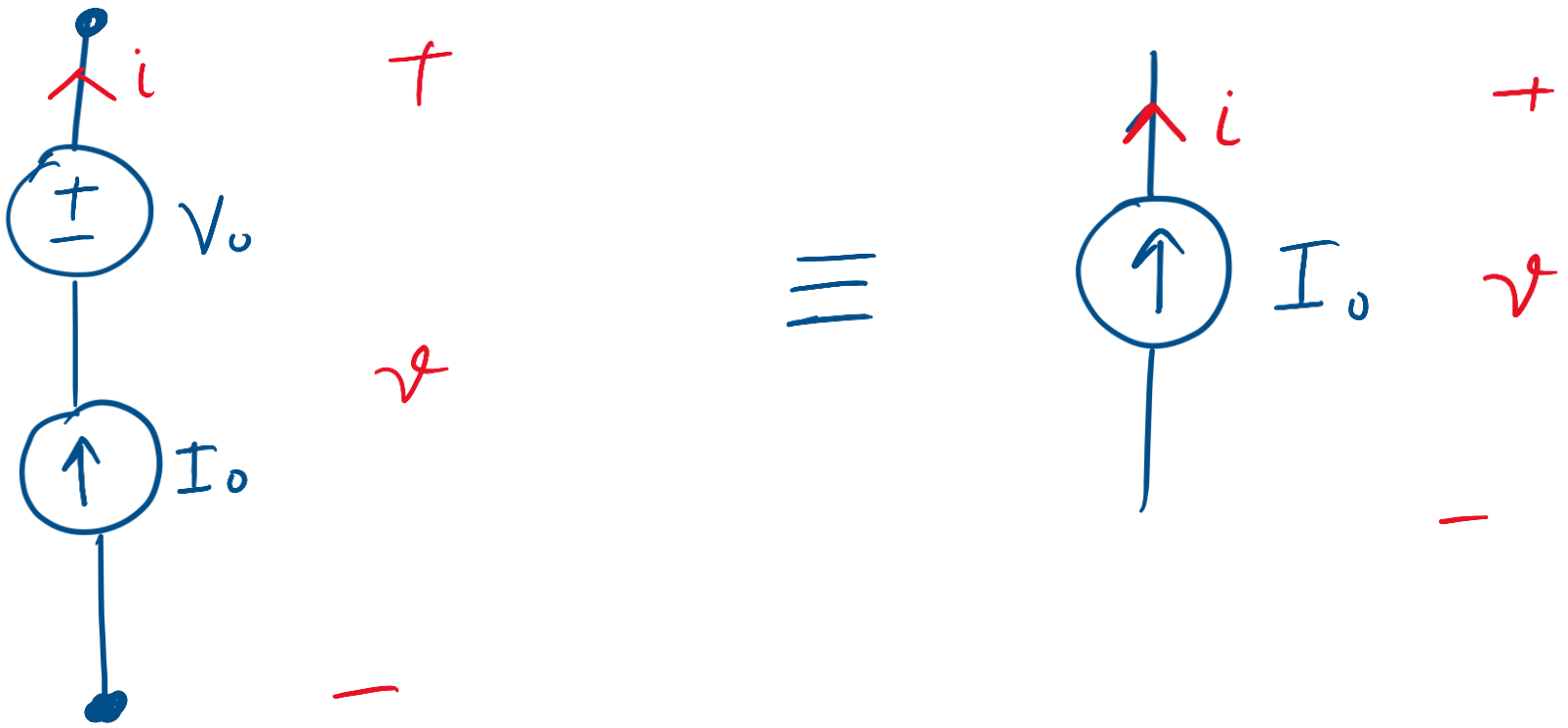
A: Infinite resistance (How? Analyze i-v characteristics)

In other words,
- Ideal current source with zero current is equivalent to **open circuit.**
- Voltage across the current source depends on the circuit it is connected to



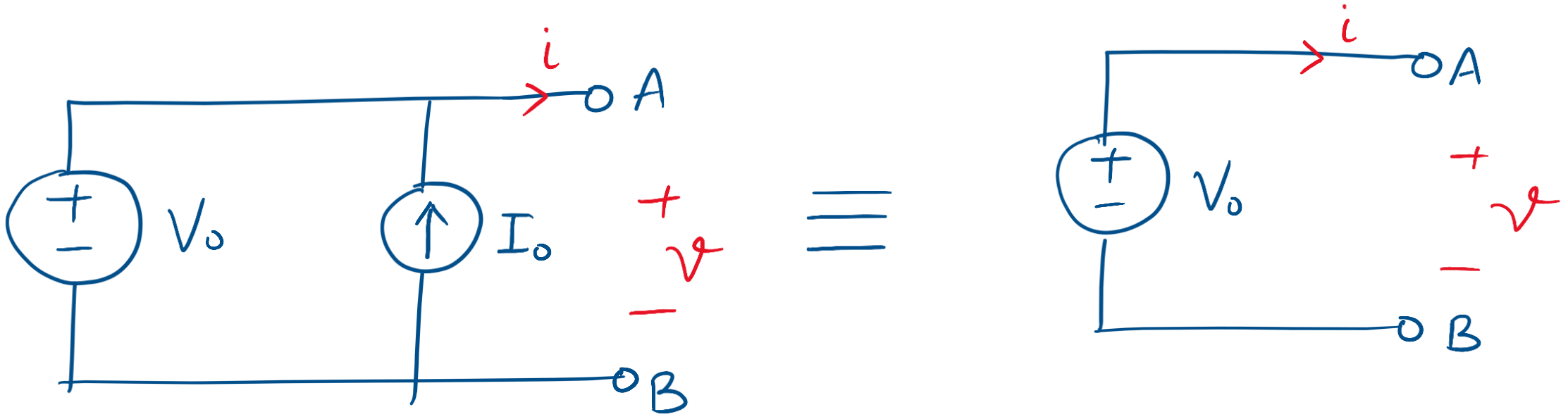
Current sources are NOT connected in series except for the case when both sources have the same current rating (value + direction).
For circuit analysis, current sources of same value, connected in series, can be replaced with a single current source.

Current Source and Voltage Source in Series



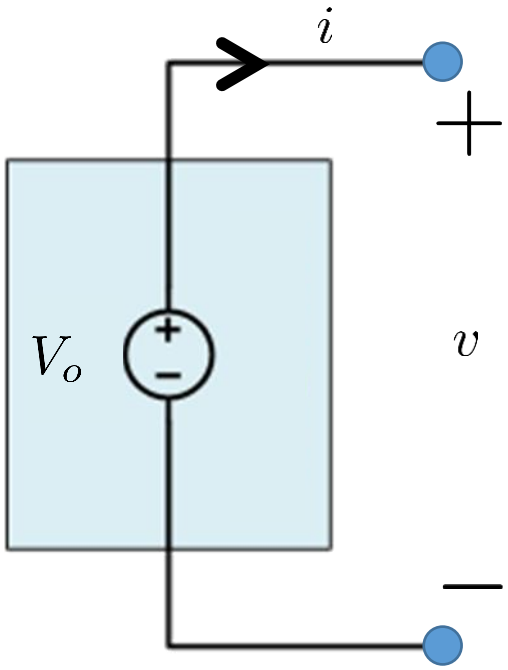
* Note here that $i = I_o$ for any value of v
* But these are the characteristics of a current source.

Current Source and Voltage Source in Parallel

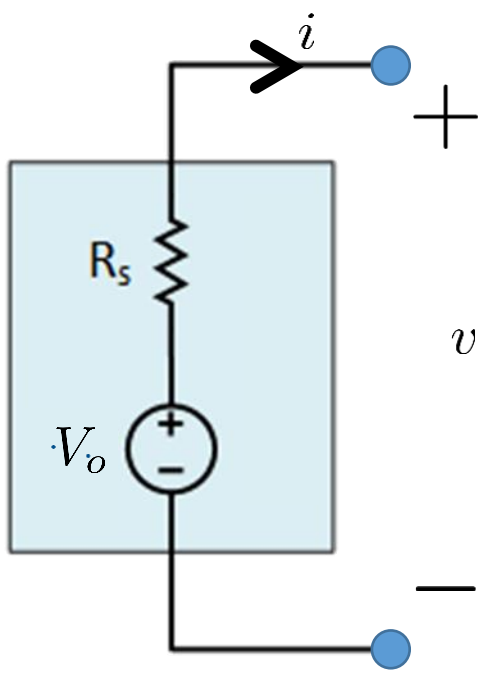


* $v = V_0$ for any value of i

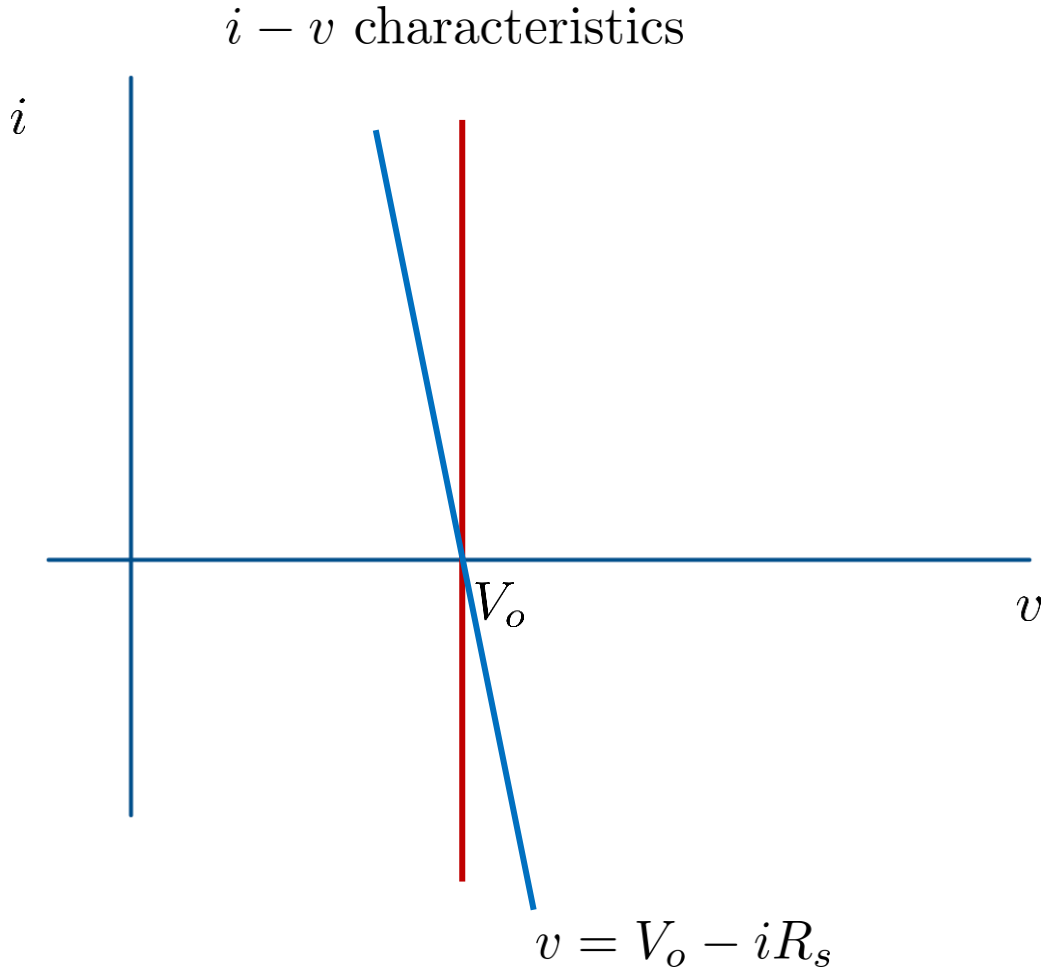
Practical Models – Voltage Source



Ideal Voltage Source



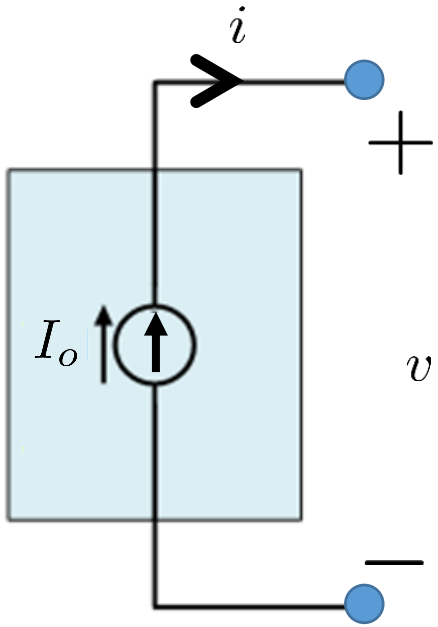
Practical Voltage Source (Model)



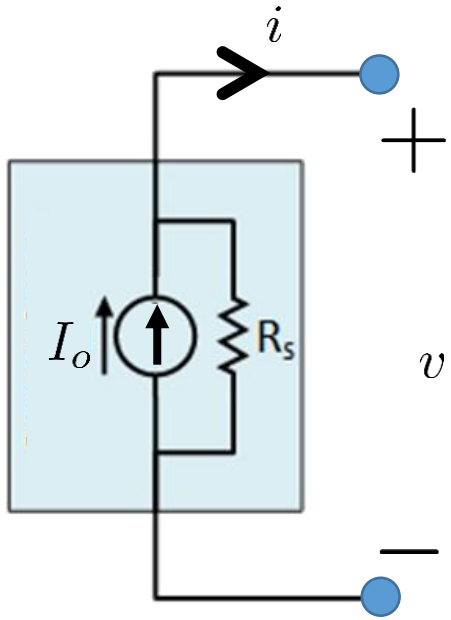
Practical voltage source: ideal voltage source with reistance R_s in series.

Consequence: Voltage drops with the increase in current across the terminals.

Practical Models – Current Source

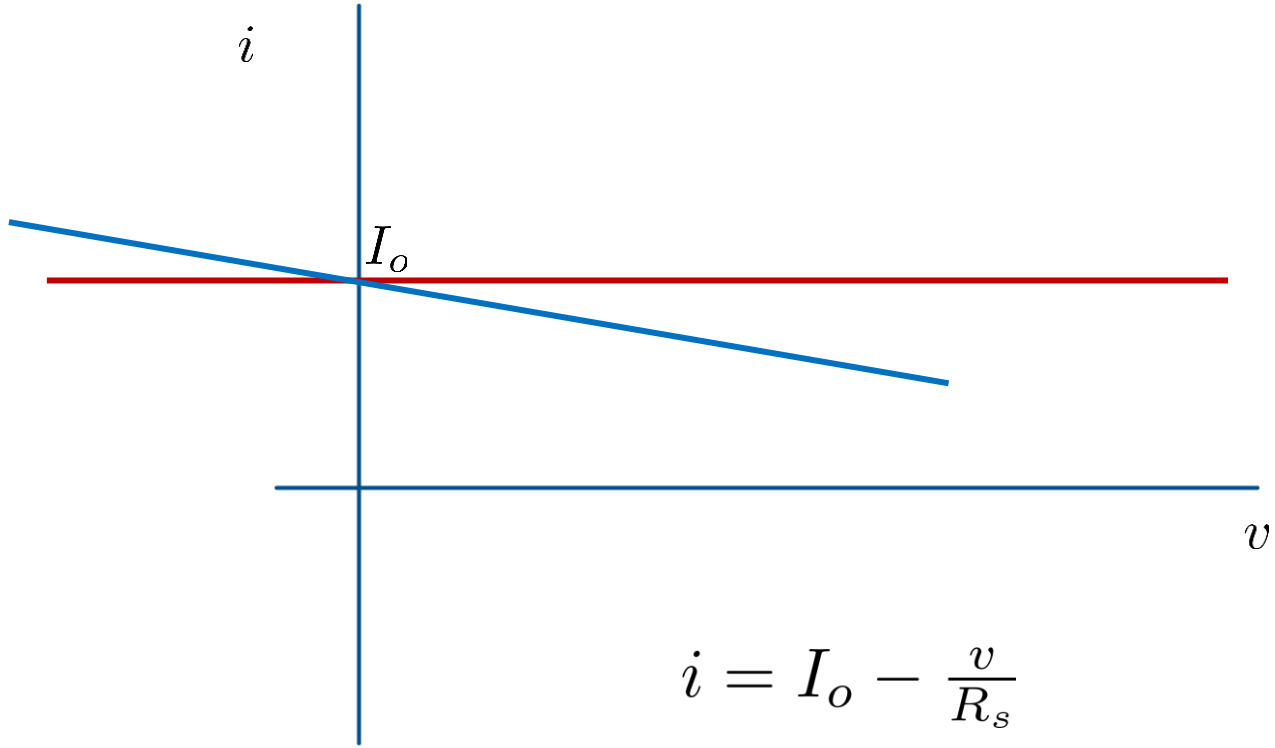


Ideal Current Source



Practical Current Source (Model)

$i - v$ characteristics



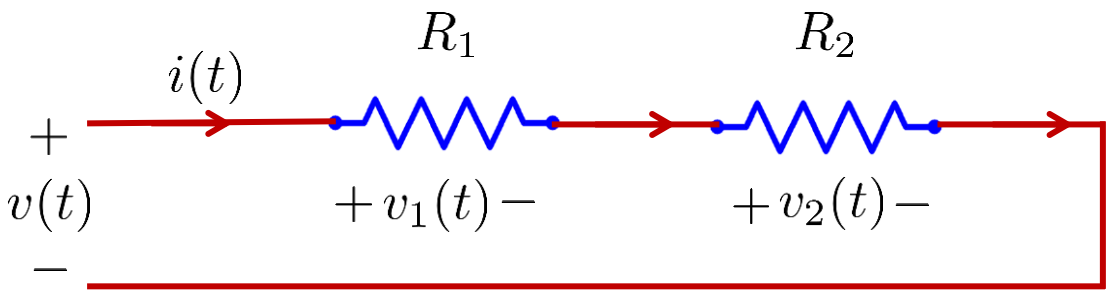
$$i = I_o - \frac{v}{R_s}$$

Practical current source: ideal current source with large reistance R_s in parallel.

Consequence: current drops with the increase in the voltage across the terminals.

Voltage and Current Divider Rules

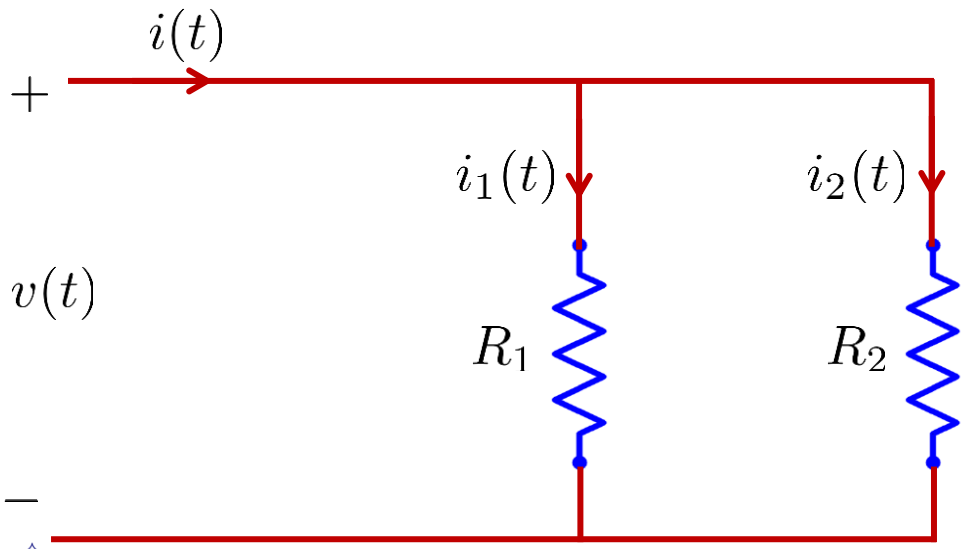
Voltage Divider:



$$v_1(t) = \frac{R_1}{R_1 + R_2} v(t)$$

$$v_2(t) = \frac{R_2}{R_1 + R_2} v(t)$$

Current Divider:

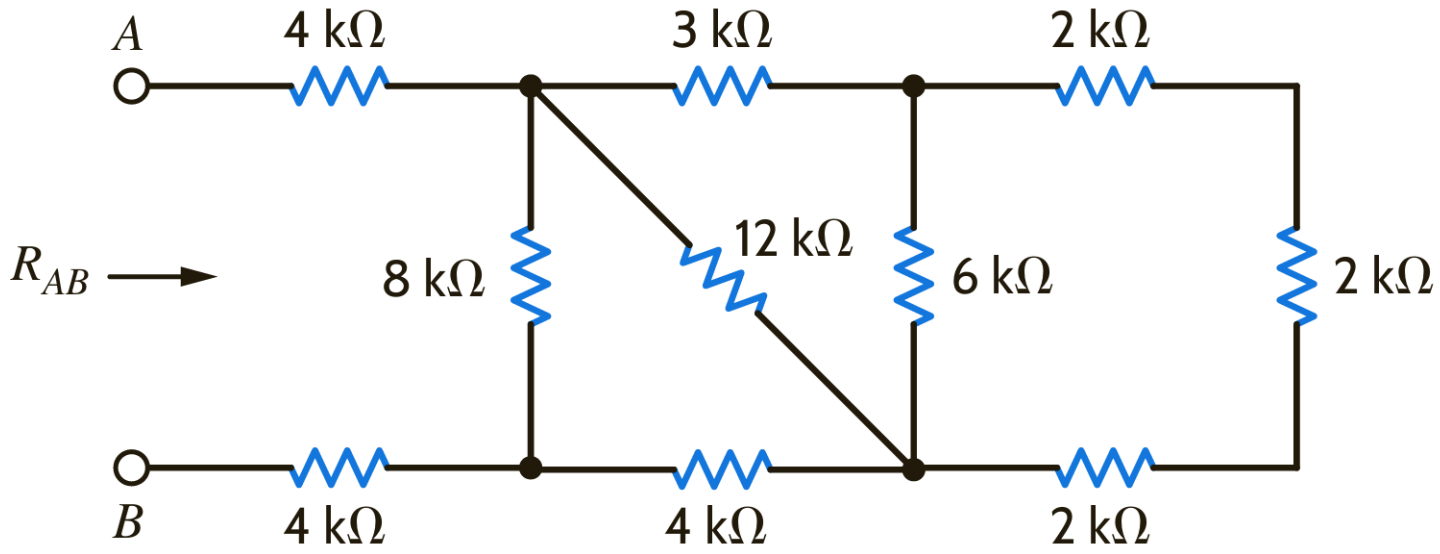


$$i_1(t) = \frac{R_2}{R_1 + R_2} i(t)$$

$$i_2(t) = \frac{R_1}{R_1 + R_2} i(t)$$

Equivalent Resistance

Examples:



$$R_{\text{eq}} = 4\text{k} + 4\text{k} + 8\text{k} || \left(4\text{k} + 12\text{k} || (3\text{k} + 6\text{k} || (2\text{k} + 2\text{k} + 2\text{k})) \right) = 12 \ \ \Omega$$

Equivalent Resistance

Circuit-Analysis Example: