وَمَا أُوتِيتُمْ مِنَ الْعِلْمِ إِلَّا قَلِيلًا

Introduction to Electronics

Lecture 02
Review on Circuits Basics

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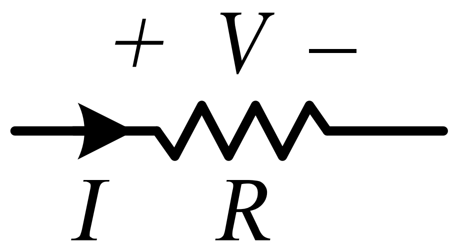
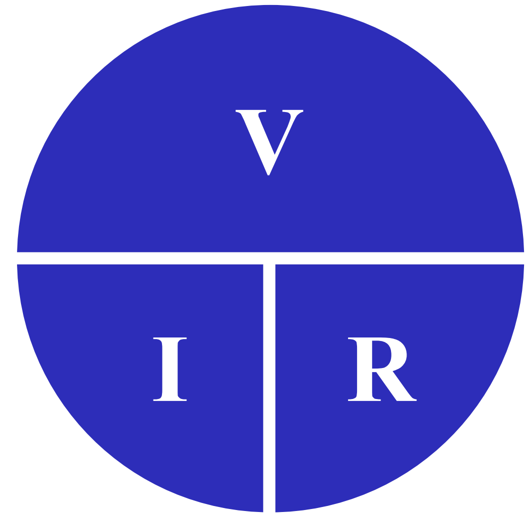
Ohm's Law





$$V = IR$$

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

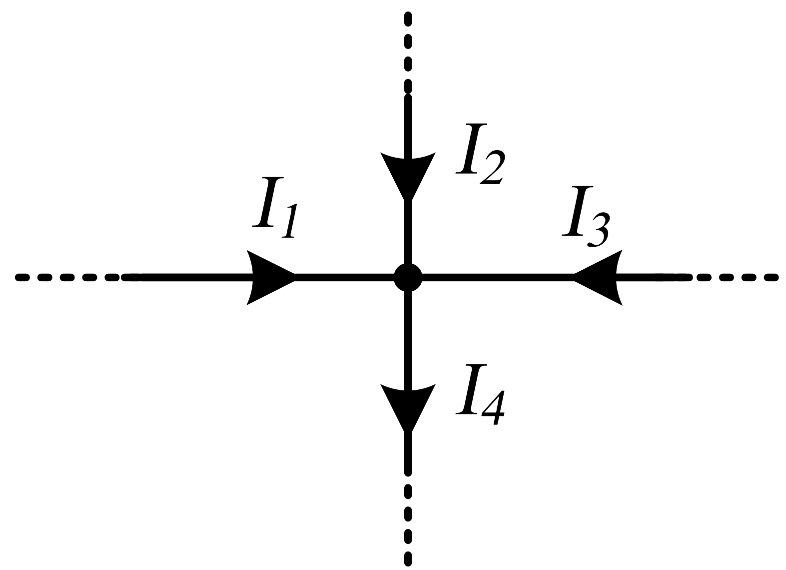
$$R = \frac{V}{I}$$

Kirchhoff’s Current Law (KCL)

- The sum of all currents flowing into a node is zero.

$$\Sigma I = 0$$

$$I_1 + I_2 + I_3 - I_4 = 0$$



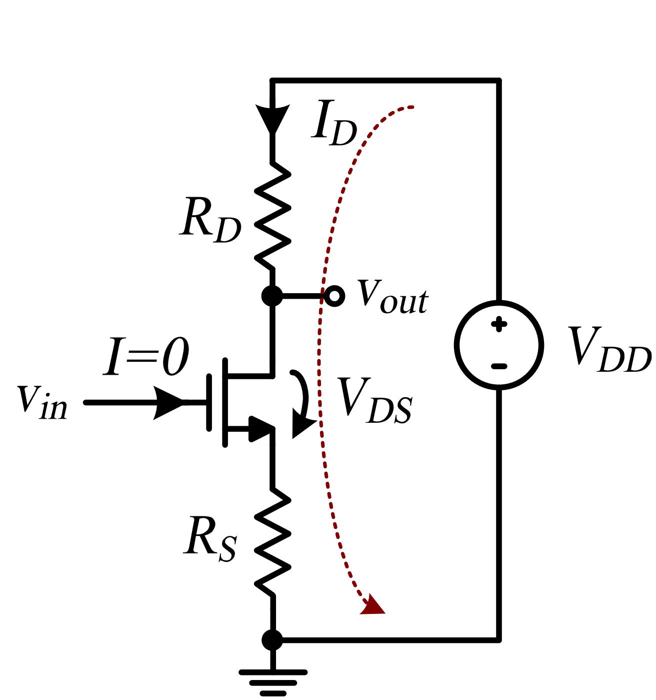
Kirchhoff's Voltage Law (KVL)

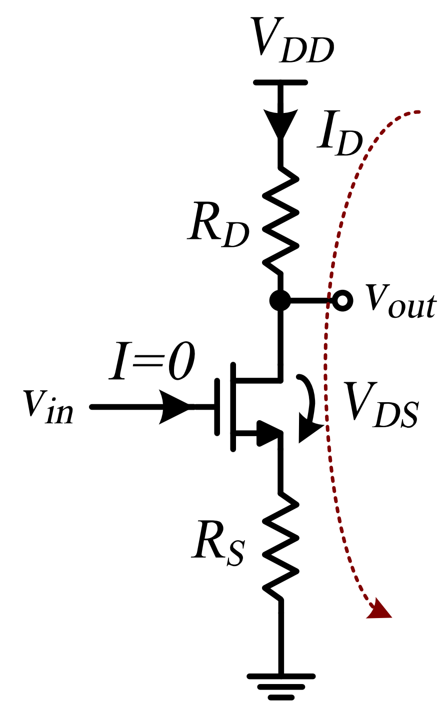
- The sum of all voltage drops around any closed loop is zero

$$\Sigma V = 0$$

$$-V_{DD} + I_D R_D + V_{DS} + I_D R_S = 0$$

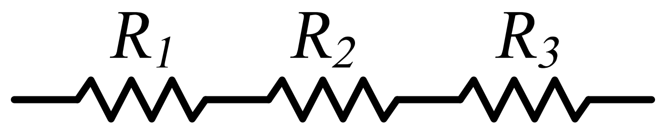
$$V_{DD} = I_D R_D + V_{DS} + I_D R_S = I_D(R_D + R_S) + V_{DS}$$





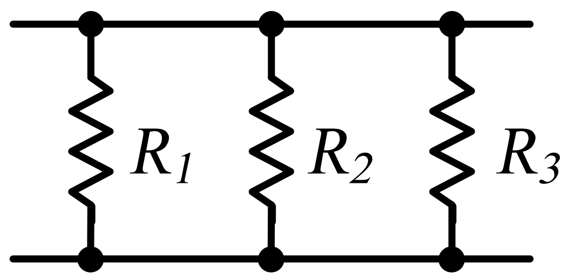
Resistor Combinations

- Resistors in series: Largest resistor dominates



$$R_{eq} = R_1 + R_2 + R_3$$

- Resistors in parallel: Smallest resistor dominates



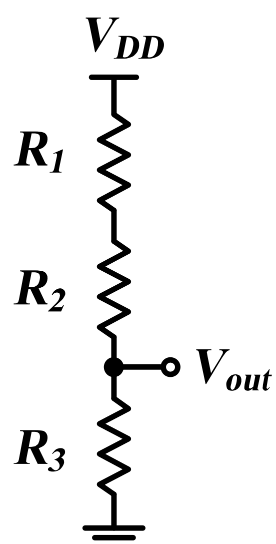
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

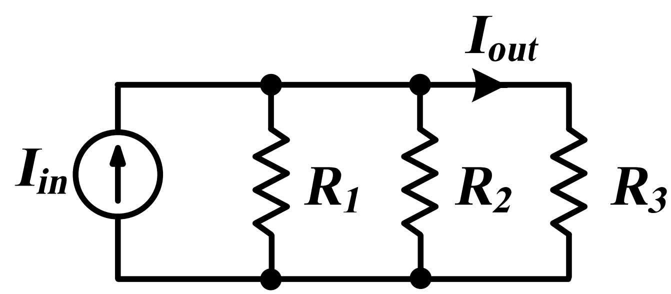
Voltage and Current Dividers

- Voltage divider → the largest resistor takes most of the voltage
- Current divider → the smallest resistor (largest conductance) takes most of t
  - Remember that current flows in the least resistance path

$$V_{out} = V_{DD} \cdot \frac{R_3}{R_1 + R_2 + R_3}$$

$$I_{out} = I_{in} \cdot \frac{G_3}{G_1 + G_2 + G_3}$$



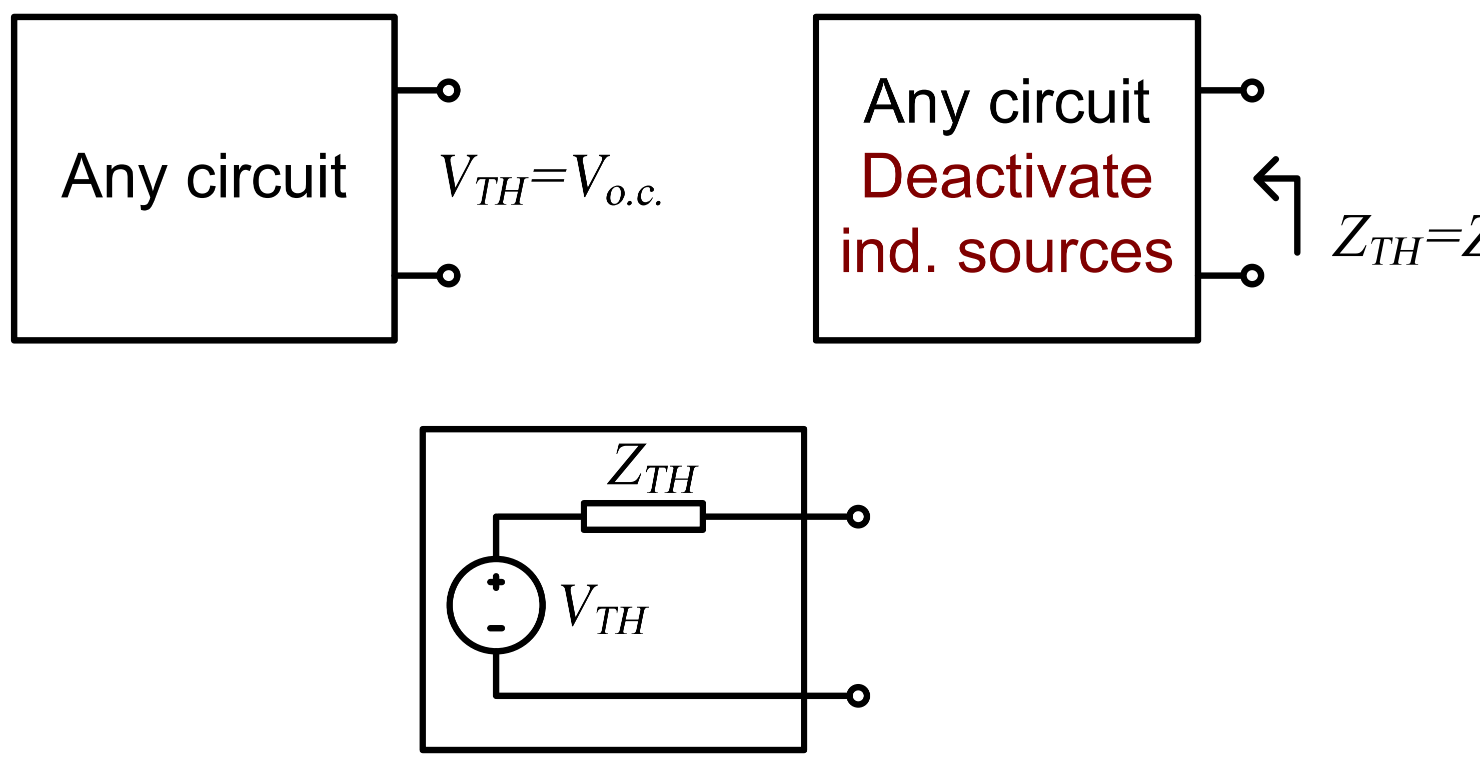


Thevenin Equivalent Circuit

- Any one port circuit can be replaced by a voltage source and a series impeda

$$V_{TH} = V_{o.c.}$$

$$Z_{TH} = Z_{eq} \text{ (turn OFF all independent sources)}$$



Norton Equivalent Circuit

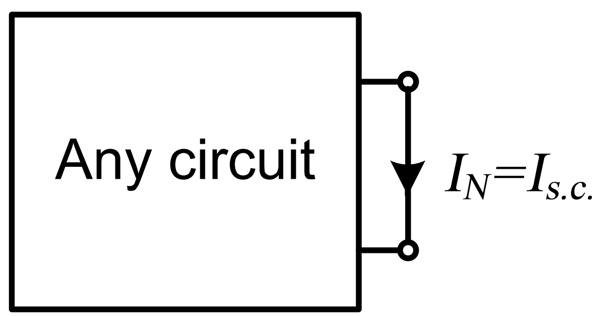
- Any one port circuit can be replaced by a current source and a parallel impe

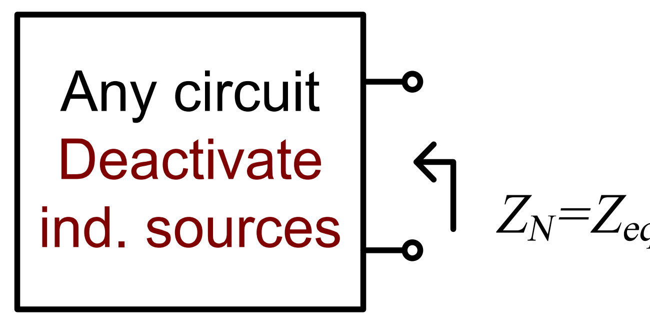
$$I_N = I_{s.c.}$$

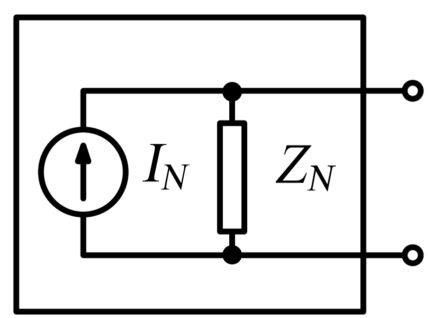
$Z_N = Z_{eq}$ (turn OFF all independent sources)

$$\boldsymbol{Z_N = Z_{TH}}$$

$$\boldsymbol{V_{TH} = V_{o.c.} = I_N \times Z_N}$$







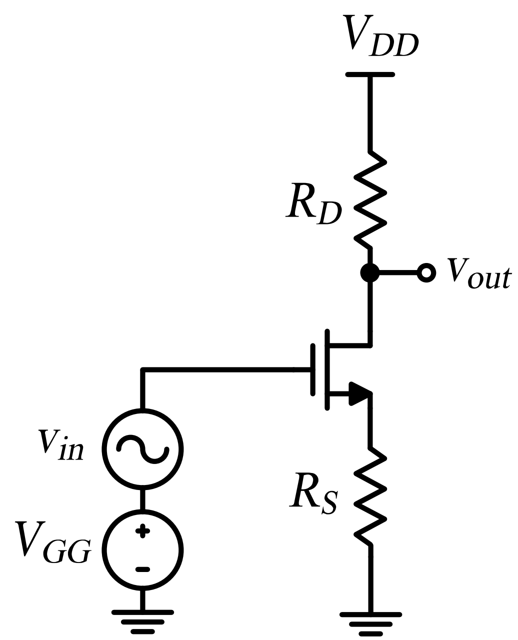
Superposition Theorem

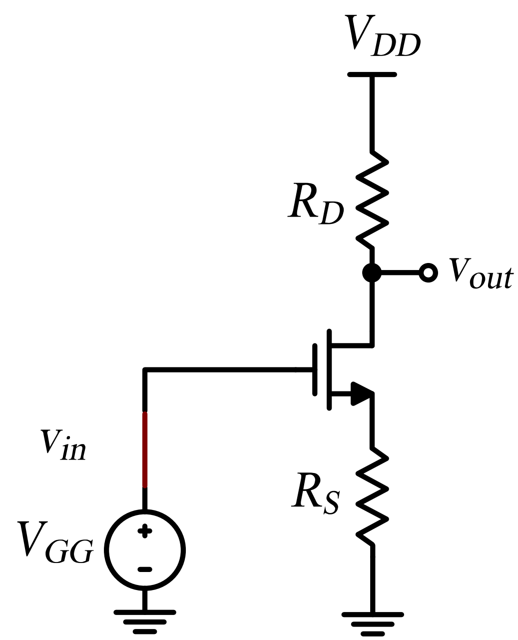
- Deactivate all independent sources except one
  - Independent voltage source → short circuit (s.c.)
  - Independent current source → open circuit (o.c.)
  - Do NOT deactivate dependent sources
- Solve the circuit
- Repeat the previous two steps for every source
- Algebraically add all the results

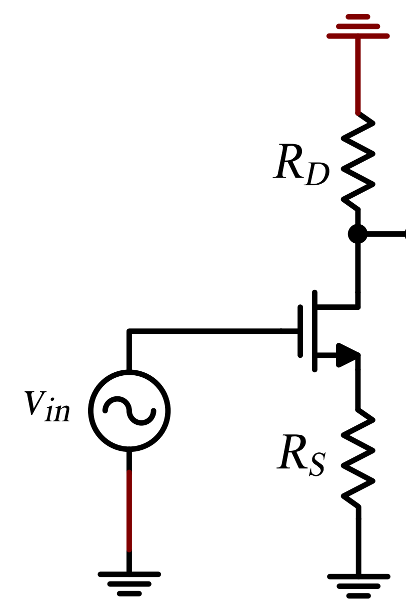
We use this frequently to separate AC and DC solutions

Superposition Theorem

DC + AC = DC + AC







Capacitance

$$Q = CV \quad \Rightarrow \quad i = \frac{dQ}{dt} = C\frac{dV}{dt}$$

$$V = V_o \cos(\omega t + \theta) = V_o \cdot Re\{e^{j(\omega t + \theta)}\}$$

$$V = V_o e^{j(\omega t + \theta)} = V_o \angle \theta$$

$$i = C\frac{dV}{dt} = j\omega C\left(V_o e^{j\omega t}\right) = j\omega C \cdot V$$

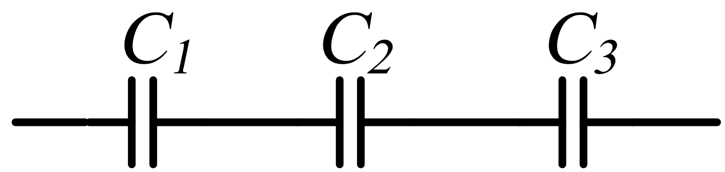
$$Z_C = \frac{V}{i} = \frac{1}{j\omega C} = \frac{1}{sC} \quad \Rightarrow \quad X_C = |Z_C| = \frac{1}{\omega C}$$

$$\omega \uparrow\uparrow \Rightarrow X_C \to 0 \Rightarrow s.c.$$

$$\omega \downarrow\downarrow \Rightarrow X_C \to \infty \Rightarrow o.c.$$

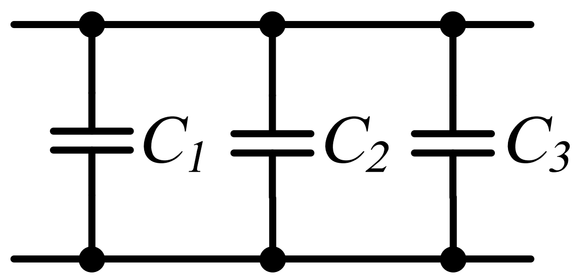
Capacitance Combinations

- Capacitors in series: Smallest capacitor dominates



$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

- Capacitors in parallel: Largest capacitor dominates



$$C_{eq} = C_1 + C_2 + C_3$$

Thank you!