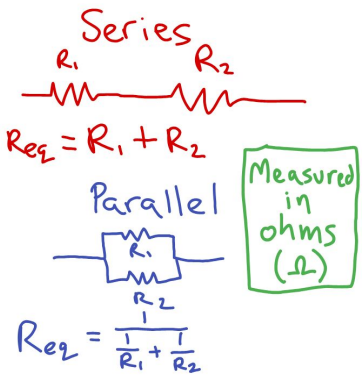
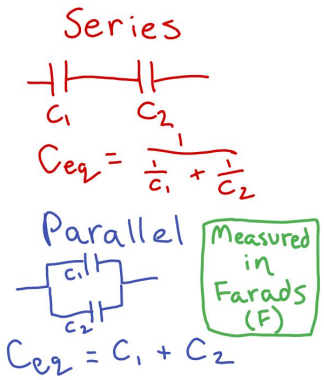
Circuit Components

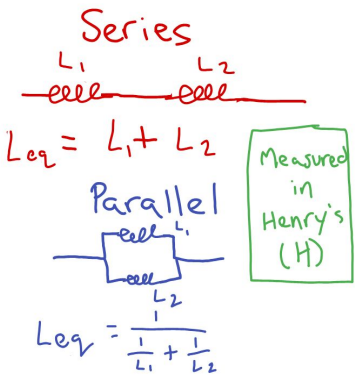
Resistor



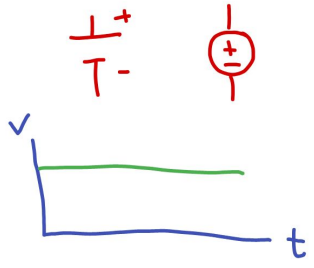
Capacitor



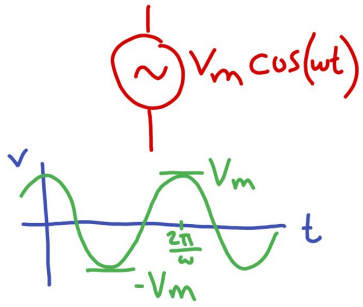
Inductor



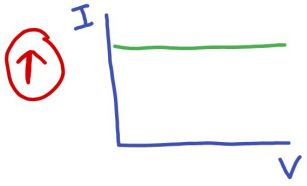
Independent DC Voltage Source



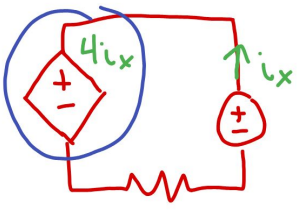
Independent AC Voltage Source



Independent Current Source

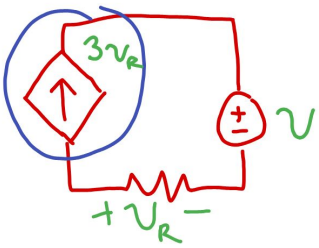


Dependent Voltage Source



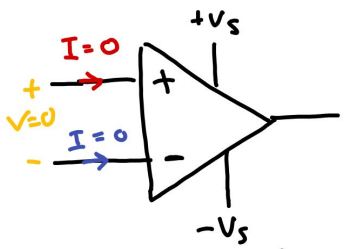
can be voltage or current dependent

Dependent Current Source



can be voltage or current dependent

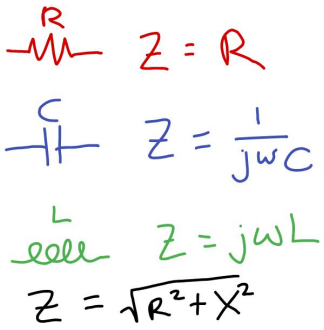
Operational Amplifier



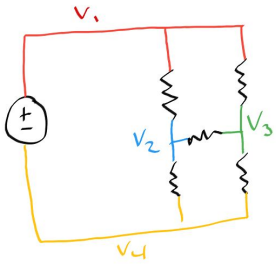
+ = Non-inverting
− = Inverting

Circuit Concepts

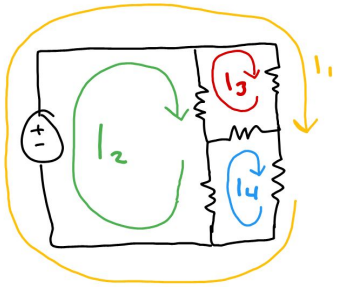
Impedance



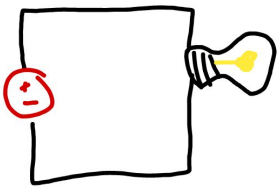
Node



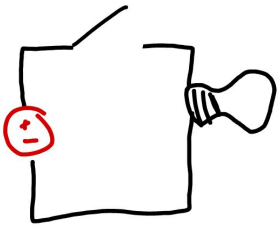
Loop/Mesh



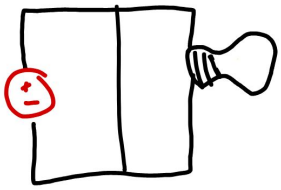
Closed Circuit



Open Circuit

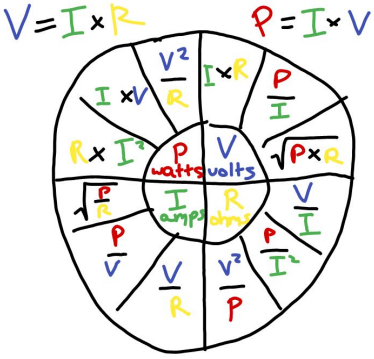


Short Circuit

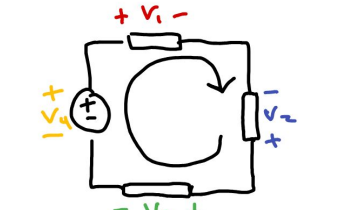


Circuit Laws

Ohm's Law/Power Equation

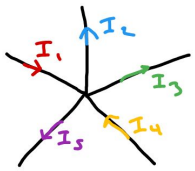


Kirchhoff's Voltage Law



$+V_1 - V_2 + V_3 - V_4 = 0$

Kirchhoff's Current Law



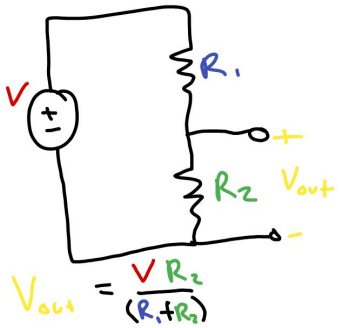
$I_1 + I_4 = I_2 + I_3 + I_5$

OR

$I_1 - I_2 - I_3 + I_4 - I_5 = 0$

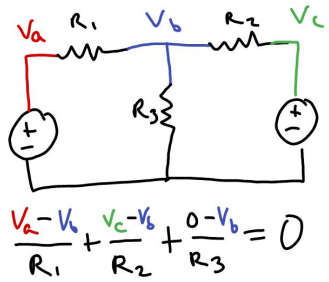
Circuit Solving Strategies

Voltage Division



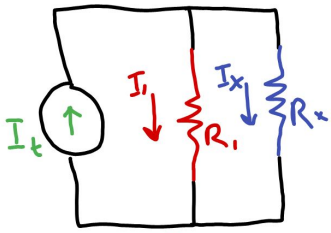
$$V_{out} = \frac{V R_2}{(R_1+R_2)}$$

Node Analysis



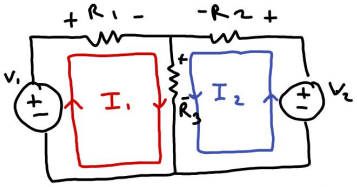
$$\frac{V_a - V_b}{R_1} + \frac{V_c - V_b}{R_2} + \frac{0 - V_b}{R_3} = 0$$

Current Division



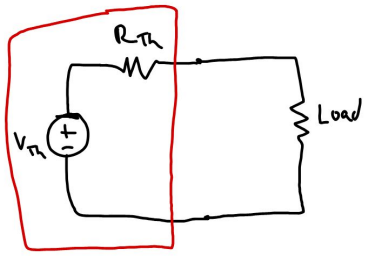
$$I_x = \frac{R_1 /\!/ R_x}{R_x} * I_t$$

Mesh Analysis

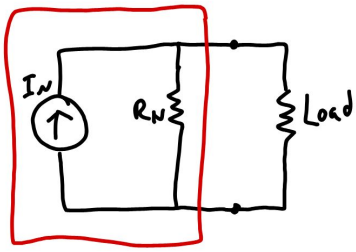


$$V_1 - R_1 I_1 - R_3(I_1 + I_2) = 0$$
$$V_2 - R_2 I_2 - R_3(I_1 + I_2) = 0$$

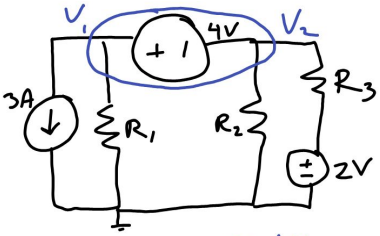
Thevenin Equivalent



Norton Equivalent



Super Node



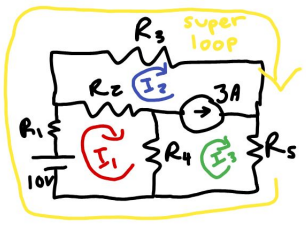
KCL at supernode:

$$3 + \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_2 - 2}{R_3} = 0$$

4V source equation:

$$V_2 - V_1 = 4$$

Super Mesh

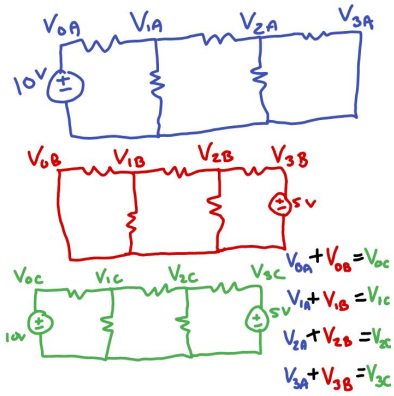


$$I_3 - I_2 = 3A$$

$$I_1 \rightarrow 10 - R_1 I_1 - R_2(I_1 - I_2) - R_4(I_1 - I_3)$$

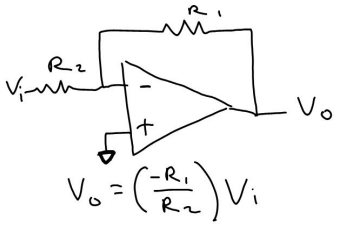
$$SL \rightarrow 10 - R_1 I_1 - R_3 I_2 - R_5 I_3$$

Superposition



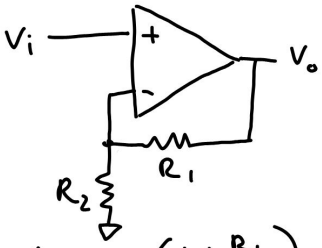
Types of Circuits

Inverting Amplifier



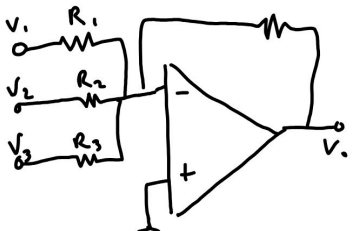
$$V_o = \left(\frac{-R_1}{R_2}\right) V_i$$

Non-Inverting Amplifier



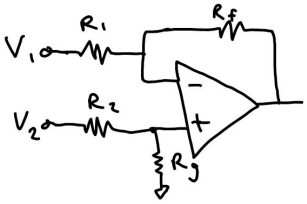
$$V_o = V_i\left(1 + \frac{R_1}{R_2}\right)$$

Summing Amplifier



$$V_o = -\left(\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2 + \frac{R_f}{R_3} V_3\right)$$

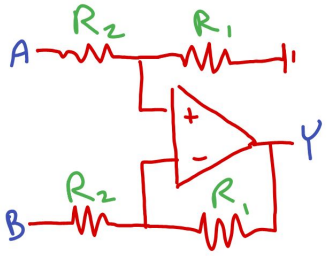
Differential Amplifier



$$V_o = \frac{(R_f + R_1) R_g}{(R_g + R_2) R_1} V_2 - \frac{R_f}{R_1} V_1$$

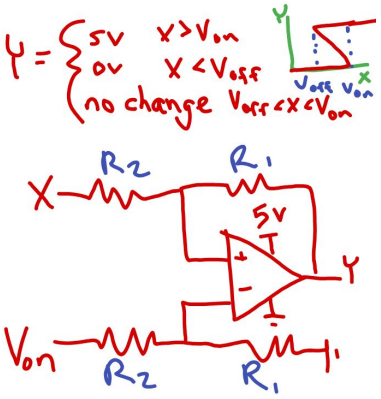
Instrumentation Amplifier

$$Y = \frac{R_1}{R_2}(A - B)$$



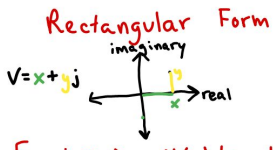
Schmitt Trigger

$$Y = \begin{cases} 5V & X > V_{on} \\ 0V & X < V_{off} \\ \text{no change} & V_{off} < X < V_{on} \end{cases}$$



AC Math

Rectangular Form

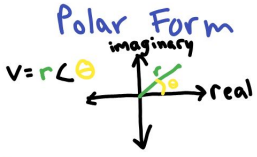


Easier to add/subtract

$$(x_1 + y_1 j) + (x_2 + y_2 j) = (x_1 + x_2) + (y_1 + y_2) j$$

$$(x_1 + y_1 j) - (x_2 + y_2 j) = (x_1 - x_2) + (y_1 - y_2) j$$

Polar Form



Easier to multiply/divide

$$(r_1 \angle \theta_1)(r_2 \angle \theta_2) = r_1 r_2 \angle \theta_1 + \theta_2$$

$$\frac{r_1 \angle \theta_1}{r_2 \angle \theta_2} = \frac{r_1}{r_2} \angle \theta_1 - \theta_2$$

Rectangular vs. Polar

Rectangular → Polar

$$r = \sqrt{x^2 + y^2}$$

$$\theta = \tan^{-1}\left(\frac{y}{x}\right)$$

Polar → Rectangular

$$x = r\cos(\theta)$$

$$y = r\sin(\theta)$$