Imaginary Numbers

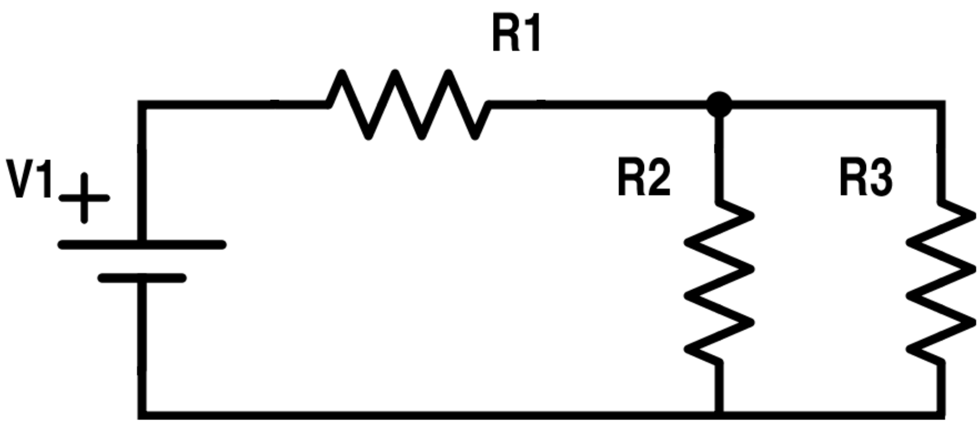
An imaginary number $a + jb$, has magnitude $M = \sqrt{a^2 + b^2}$, and phase $\phi = \tan^{-1}(b/a)$

$$a + jb = Me^{-j\phi} = M\angle\phi$$

Where $j = i = \sqrt{-1}$

KVL/KCL

KVL $\rightarrow$ The sum of all voltages in a loop must be zero.
KCL $\rightarrow$ The sum of currents in and out of a node must be zero.



KVL example, using "positive" as $+ \rightarrow -$:

$$-V_1 + V_{R1} + V_{R2} = 0$$
$$-V_1 + V_{R1} + V_{R3} = 0$$
$$-V_{R2} + V_{R3} = 0$$

KCL example, using the node where the resistors meet:

$$i_{R1} = i_{R2} = i_{R3}$$

Impedance

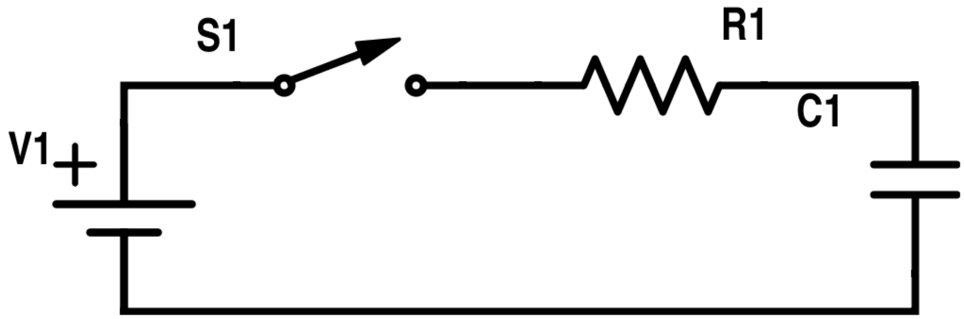
Resistors have real resistance $R = V/I$, measured in Ohms (Ω)
Resistors in series add cumulatively: $R_{ser} = R_1 + R_2$
Resistors in parallel add inversely: $1/R_{par} = 1/R_1 + 1/R_2$, or $R_{par} = \dfrac{R_1 R_2}{R_1 + R_2}$

Capacitors have imaginary reactance $I = C\frac{\partial V}{\partial t}$, or $Z_c = 1/j\omega C$, measure in Farads (F)
Capacitors in series add inversely: $1/C_{ser} = 1/C_1 + 1/C_2$, or $C_{ser} = \frac{C_1 C_2}{C_1 + C_2}$
Capacitors in parallel add cumulatively: $C_{par} = C_1 + C_2$

Inductors have imaginary reactance $V = L\frac{\partial i}{\partial t}$, measured in Henries (H)
Inductors in series add cumulatively: $L_{ser} = L_1 + L_2$
Inductors in parallel add inversely: $1/L_{par} = 1/L_1 + 1/L_2$, or $L_{par} = \frac{L_1 L_2}{L_1 + L_2}$

Note: for capacitors and inductors, you add the impedance's in the above equations, not the individual capacitance/inductance

Time Domain RLC



Fourier/Transfer Function

Frequency Domain RLC

Op Amps

AM Radio/Mixing