Ohmic Devices

$$V = IR$$
$$P_{\text{diss}} = I^2 R = \frac{V^2}{R}$$

Resistors in Series and Parallel
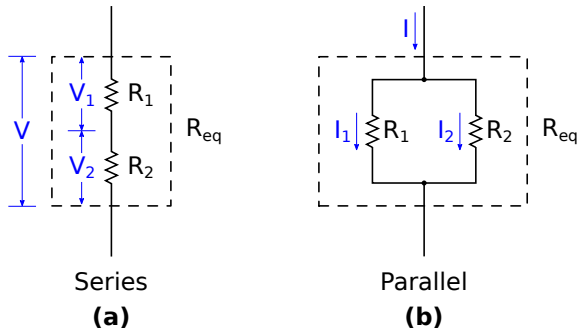
Series **(a)** Parallel **(b)**

Series: $\quad R_{eq} = R_1 + R_2 + R_3 + ...$

$$V_1 = \frac{R_1}{R_1 + R_2} V$$

Parallel: $\quad \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$

$$\Delta I_1 = \frac{R_2}{R_1 + R_2} I$$

Kirchhoff's Rules

Loop Rule: $\quad \sum_{\text{loop}} V_i = 0$

Junction Rule: $\quad \sum_{\text{junction}} I_i = 0$

Phasor Analysis

$$X_L = j\omega L \qquad\qquad X_C = -\frac{j}{\omega C}$$
$$\mathbf{V} = V\, e^{j\phi_v} \qquad\qquad \mathbf{I} = I\, e^{j\phi_i}$$
$$\mathbf{I} = \frac{\mathbf{V}}{Z}$$
$$v(t) = Re(\mathbf{V}\, e^{j\omega t}) \qquad i(t) = Re(\mathbf{I}\, e^{j\omega t})$$
$$\langle P \rangle = \frac{IV}{2} \cos(\phi_v - \phi_i) = \frac{V^2}{2Z} \cos(\phi_v - \phi_i)$$

AC Voltage Divider

$$\frac{V_{out}}{V_{in}} = \frac{|\mathbf{V_{out}}|}{|\mathbf{V_{in}}|} = \left| \frac{Z_2}{Z_1 + Z_2} \right| = \sqrt{\left(\frac{Z_2}{Z_1 + Z_2} \right)^* \left(\frac{Z_2}{Z_1 + Z_2} \right)}$$

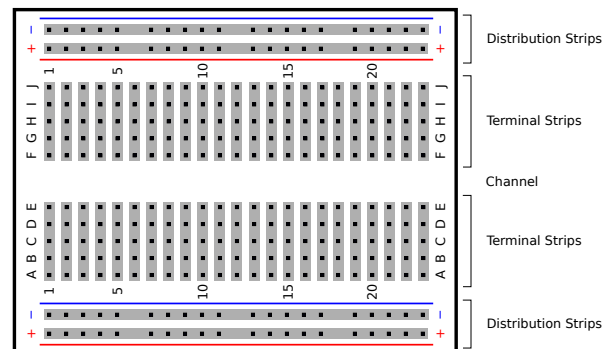$$\tan\phi = \frac{Im\left(\frac{Z_2}{Z_1 + Z_2} \right)}{Re\left(\frac{Z_2}{Z_1 + Z_2} \right)}$$

Resistor Color Codes

color	digit	multiplier
black	0	1
brown	1	10
red	2	100
orange	3	1k
yellow	4	10k
green	5	100k
blue	6	1M
violet	7	10M
gray	8	100M
white	9	1000M

$R = [\text{band1}][\text{band2}] \times 10^{[\text{band3}]} \quad \pm \quad 5\%$ (gold)
$\pm \quad 10\%$ (silver)

Breadboard Layout

Distribution Strips

Terminal Strips

Channel

Terminal Strips

Distribution Strips

Schematic Symbols

DC Voltage Source Resistor Capacitor Inductor

DC Current Source Potentiometer Ground Diode

AC Source NPN Transistor PNP Transistor Op Amp

NPN PNP E B C