DC CIRCUITS

Charge - electrons are negatively charged.

The unit of measure of charge is the Coulomb (C) :

$$1\ C = 6.24 \times 10^{18}\ q$$

C = Coulomb
q = charge of a single electron

From the above, q can be expressed in terms of Coulombs:

$$q = 1.602 \times 10^{-19}\ C$$

Current (I) - flow of electric charges.

$$I = \frac{Q}{t}$$

Q = charge in Coulombs (C)
t = time in seconds

The unit of measure of current is the Amp (A) :

$$1\ A = \frac{1\ C}{1\ s}$$

One Amp represents a current flow of one coulomb per second.

current, in terms of rate of change:

$$i = \frac{dq}{dt}$$

Solving for charge, q :

$$dq = i\,dt$$

$$q = \int_{t_0}^{t_f} i\,dt$$

Resistance (R) - opposition to current flow.

Total Resistance for Resistors in series :

$$R_t = R_1 + R_2 + R_3 \,.\,.\, R_n$$

Total Resistance for two Resistors in parallel :

$$R_t = \frac{R_1\ R_2}{R_1 + R_2}$$

Conductance (G) - ability of a conductor to "conduct current flow". reciprocal of resistance.

$$G = \frac{1}{R}$$

G = conductance in Siemens (S)
R = resistance in ohms (Ω)

Voltage (V) - measure of the amount of energy that must be used in order to move electric charges through a circuit.

$$\boxed{V = IR} \qquad \{ \text{Ohm's Law} \}$$

V = voltage in Volts (V)
I = current in Amps (A)
R = resistance in ohms (Ω)

From W = QV, V = W/Q { see Work, Energy, below }
voltage, in terms of rate of change :

$$v = \frac{dw}{dq}$$

Work, Energy (W) - Work must be done in order to move electric charges through a circuit.

$$W = Q\,V$$

W = work required in Joules (J)
Q = charge in Coulombs (C)
V = voltage in Volts (V)

substituting for V, V = I R
substituting for Q, I = Q/t · Q = I t
results in :

$$W = I^2 R\,t$$

Using v = dw/dq and i = dq/dt :
Substituting into p = iv : { see Power, below }
work, energy, in terms of rate of change :

$$p = \frac{dw}{dt}$$

$$dw = p\,dt$$

$$dw = i\,v\,dt$$

$$w = \int_{t_0}^{t_f} i\,v\,dt$$

Power (P) - rate of doing work.

$$P = \frac{W}{t}$$

P = power in Watts (W)
W = Work in Joules (J)
t = time in seconds (s)

substituting for W, $W = I^2 R t$
results in :

$$P = I^2 R$$

The unit of measure of power is the Watt (W) :

$$1 \ W = \frac{1 \ J}{1 \ s}$$

One Watt represents one joule of work per second.

Power can be expressed in other terms :
substituting for I, I = V/R
results in :

$$P = \frac{V^2}{R}$$

or by substituting for R, R = V/ I
results in :

$$P = I V$$

in summary, power can be expressed in three forms :

$$P = I^2 R = \frac{V^2}{R} = I V$$

BASIC CIRCUIT ANALYSIS

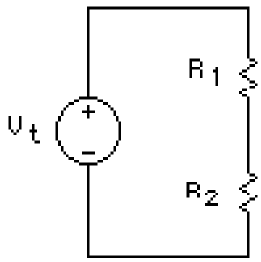
Superpostion Theorem

Each current or voltage in a linear circuit consiting of independent sources equals the algebraic sum of the currents and voltages produced by each source acting alone.

- Choose one source
- Remove all others from the circuit
  - replace voltage sources with short circuits
  - replace current sources with open circuits
- Determine the desired branch currents/voltages, keep track of algebraic sign
- Repeat for all sources
- Sum the individually found branch currents/voltages.

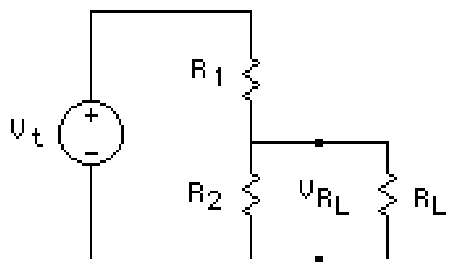
Series Circuits - Voltage Division

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



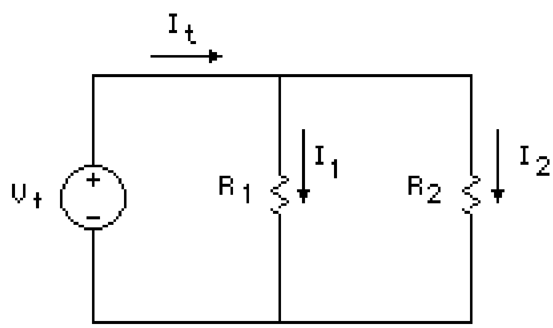
$$V_{R_L} = (V_t)\frac{R_{eq}}{R_1 + R_{eq}}$$

$$R_{eq} = \frac{R_2 R_L}{R_2 + R_L}$$



Parallel Circuits - Current Division

$$I_2 = (I_t)\frac{R_1}{R_1 + R_2}$$



Thevenin's Theorem

Everything in the original circuit, except the load, may be replaced by an equivalent circuit consisting of the series combination of a voltage source and resistance.

To calculate Thevenin Voltage (V_{TH}):
• Remove the load from the circuit
• Calculate the voltage between the terminals where the load was connected. This voltage is called the open-circuit voltage and equals V_{TH}.

To calculate Thevenin Resistance (R_{TH}):
• Remove the load from the circuit
• Reduce all sources to zero.
  • replace voltage sources with short circuits.
  • replace current sources with open circuits.
• Calculate the resistance between the terminals where the load was connected. This resistance equals R_{TH}.

Maximum Power Transfer Theorem

Maximum power is transferred from a source to a load when the resistance of the load equals the resistance of the source.

Reduce the circuit to it's Thevenin equivalent.
Regardless of the size of the load, the load current is stated as :

$$I_L = \frac{V_{TH}}{R_{TH} + R_L}$$

The power delivered to the load is then :

$$P_L = I_L^2 R_L = \frac{V_{TH}^2 R_L}{\left(R_{TH} + R_L\right)^2}$$

For a given circuit, different values of Rl will produce different values of load power. The statement of the Maximum Power Transfer Theorem is that the maximum power is transferred from source to load when the load resistance equals the resistance of the source (R_{TH})

Substituting R_{TH} for R_L results in the formula for maximum possible load power

$$P_{Lmax} = \frac{V_{TH}^2 \left(R_{TH}\right)}{\left(R_{TH} + R_{TH}\right)^2}$$

simplifying results in the final formula :

$$\boxed{P_{Lmax} = \frac{V_{TH}^2}{4 R_{TH}}}$$