Ch. 1: Circuit Variables

1.1 Electrical Engineering Overview.

- It is an integral part of engineering system: building, airplane
- Major classifications of electrical systems:
  - Communication systems to transmit and receive signals
  - Computer systems to process information
  - control systems to regulate processes
  - power systems to generate and distribute electricity
  - Signal processing systems: To process signals and information into suitable form (
- Circuit Theory is a special case of electromagnetic field theory to study static and moving charges from a macro-view point.
- Problem Solving.

1.2 International System of Units

defined quantities

length	(m)	electric current	(A)
mass	(kg)	Thermodynamic Temp.	(K)
time	(s)	Amount of substance	(mol)
		luminous intensity	(cd)

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Derived Quantities:

Frequency	hertz (Hz)	s^{-1}
Force	newton (N)	$kg\,m/s^2$
Energy or Work	joule (J)	$N \cdot m$
Power	watt (W)	J/s
Electric Charge	coulomb (C)	$A \cdot s$
Electric Potential	volt (V)	J/C
Electric Resistance	ohms (Ω)	V/A
Electric conductance	siemens (S)	A/V
Electric Capacitance	farad (F)	C/V
Magnetic flux	weber (Wb)	$V \cdot s$
Inductance	henry (H)	Wb/A

1.3 Circuit Analysis

- Circuit Model
- Ideal circuit components
- Describe behavior using physics and equations
- Solve equations to obtain required variable
- Build Prototype

1.4 Voltage and Current

- Important characteristics of electric charge:

- charge is bipolar meaning that electrical effects are described in terms of positive or negative charges.

- electric charges are discrete multiples of the electronic charge 1.6022×10^{-19} C.

- electrical effects are due to charges in motion and seperation of charges.

Definition of Voltage:

- $v = \frac{dw}{dq}$ energy per unit charge

v voltage in V
w energy in J
q charge in C

- $i = \frac{dq}{dt}$ rate of charge flow

i current in A
t time in s.

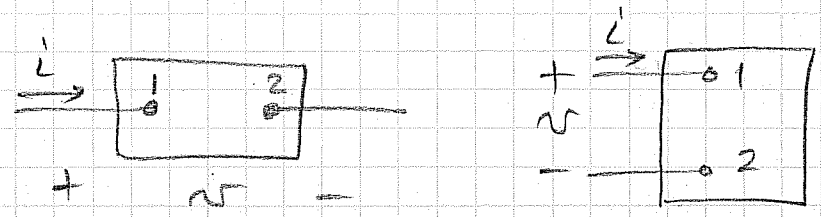
1.5 The Ideal Basic Circuit Element:

It has three attributes:

i) Two terminals to connect to other components.

ii) Described mathematically in terms of current and voltage.

iii) Cannot be subdivided further



Graphical representation of an ideal circuit element.

Passive sign convention: Current entering positive pole (1)

Example 1.3:

$i = 0 \qquad t < 0$

$i = 20e^{-5000t}\ A \qquad t \geq 0$

calculate total charge in coulombs (C) entering the element.

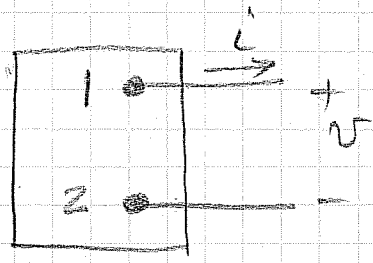
$$i = \frac{dq}{dt} \Rightarrow q(t) = \int_0^t 20e^{-5000t}\,dt + q(0)$$

if $v = 5V$ and $i = 2A$, then

$$P = 5 \times 2 = 10\ W$$

The device is said to consume 10 W.!

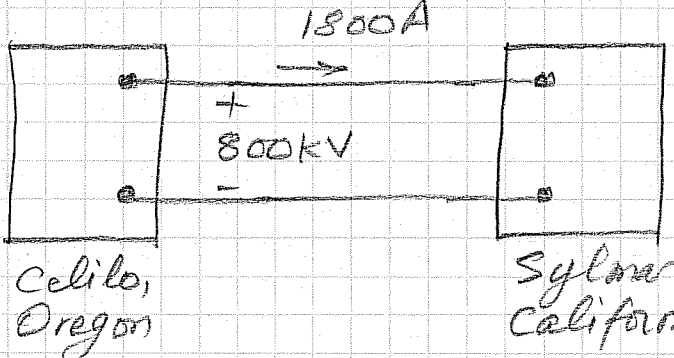
Active Sign Convention: <u>used for generators:</u>



$$p = vi$$

Then p is the power delivered by device

Example 1.7: dc transmission line.



Celio acts as a generator it delivers

$$P_1 = 800 \times 1.8 = 1440\ MW$$

Sylmar acts as a load, it receives or consumes 1440 MW.

Charge entering:

$$\Delta Q = q(\infty) - q(0) = \frac{20}{5000} = 4000 \times 10^{-6}\ C$$

Example 1.4: Maximum current is when

$$\frac{di}{dt} = 0!$$

1.6 Power and Energy

$$p = \frac{dw}{dt}$$ power (p) is energy per unit time.

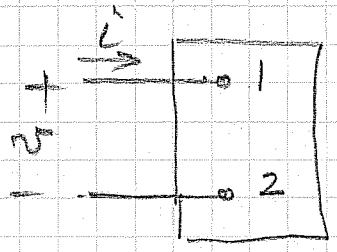
p power in W

w energy in J.

But $$p = \frac{dw}{dt} = \frac{dw}{dq}\frac{dq}{dt} \Rightarrow$$

$$\boxed{p = vi}$$

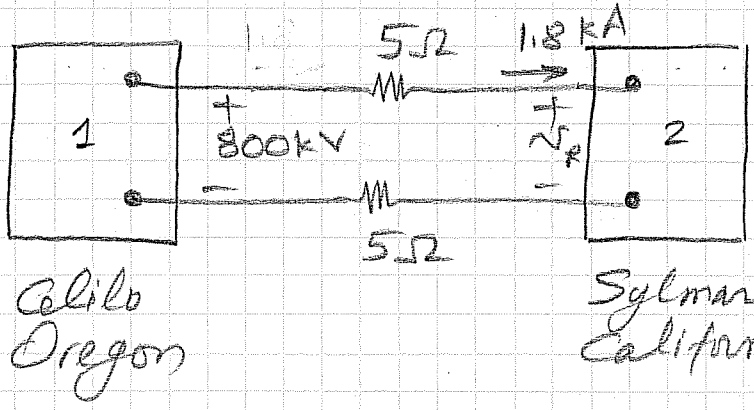
Given the ideal circuit element using a passive sign convention.



Then power consumed by device is:

$$p = vi$$

Suppose we have a resistance $R = 2 \times 5\,\Omega$



$$800 = 1.8 \times 5 + v_R + 1.8 \times 5 \Rightarrow \quad \text{(KVL)}$$

$$v_R = 782\ \text{KV}.$$

Power Supplied from Calilo:

$$P_1 = 800 \times 1.8 = 1440\ \text{mw}.$$

Power consumed received at Sylmar:

$$P_2 = 782 \times 1.8 = 1408\ \text{mw}.$$

Power Consumed in TL (Power loss):

$$P_{TL} = 1440 - 1408 = 32\ \text{mw}$$

$$\eta_{TL} = \frac{P_2}{P_1} = \frac{1408}{1440} = 97.8\ \%.$$

Recommended Problems: 1.18, 1.19, 1.20, 1.21, 1.24,

Conservation of energy: $\sum v_k i_k = 0$!