Conductance

Friday, January 15, 2016
L03

Ohm's Law: $V = iR$

so $i = \left(\frac{1}{R}\right)V$

↑ conductance $G = \left(\frac{1}{R}\right)$

SI-units: Siemens (Ω^{-1})

- once called the mho $\mho$!

Power and energy

Power is the product of voltage and current.

$$p = vi$$

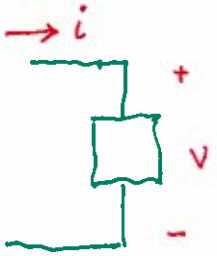
which we may write as

$$p = \underbrace{\frac{dw}{dq}}_{v} \times \underbrace{\frac{dq}{dt}}_{i} = \boxed{\frac{dw}{dt}}$$

POWER IS THE RATE OF ENERGY TRANSFER.

where w = energy in Joules
q = charge in Coulombs
t = time in seconds
p = power in Watts. (W)

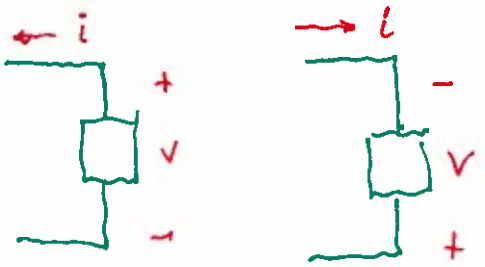
We define power in terms of the passive reference convention



- current reference direction is the same direction as a voltage drop (i.e., from + to -)
- implies that circuit element absorbs power.

For this scenario, $p = vi$

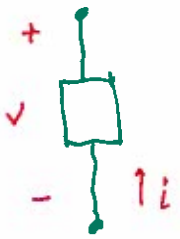
If either current reference direction or voltage reference polarity is reversed ...



must use $p = -vi$
(this is the active reference convention)

[current reference direction is in the direction of a voltage rise: − to +]

Example: Find the power in circuit element at right:



(a) $i = 10\ A$, $V = 12\ V$.

$p = -vi$

$p = -120\ W$

(b) $i = -10\ A$, $V = 60\ V$

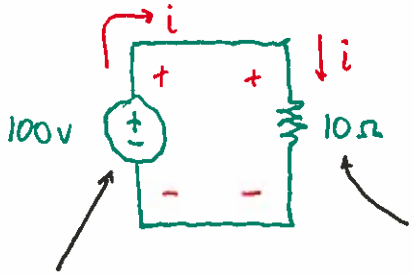
$p = -vi$

$p = 600\ W$

Physical interpretation of the sign of p:

$p > 0$	→ absorbs power
$p < 0$	→ delivers power

Consider the simple circuit:

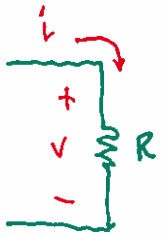


$$i = \frac{100\ V}{10\ \Omega} = 10\ A$$

$p = -vi$
$= -(100 \times 10)$
$= -1000\ W$ (delivering)

$p = vi$
$= 100 \times 10$
$= +1000\ W$ (absorbing)

Power in a resistor:



- By passive reference convention

$$p = vi$$

- By Ohm's Law

$$V = iR$$

Then $p = (iR)i$

$$\boxed{p = i^2 R} \longrightarrow$$ always positive:
- resistor always absorbs power

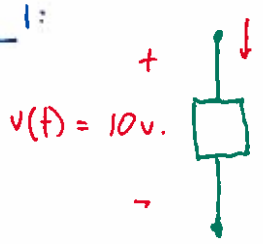
Energy

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

Therefore, $w = \int_{t_1}^{t_2} p(t)\,dt + w(t_1)$

Power companies measure energy to determine monthly bill.
Cost determined by how much power used over time.

Example 1:



(a) Compute power
(b) Compute energy from $t = 0 \to \infty$
(c) Absorbed or delivered?

(a) Passive reference convention observed, so $p = vi$

$$p(t) = 10 \times 2e^{-t} \text{ W}$$
$$= 20e^{-t} \text{ W}$$

(b)
$$w = \int_0^\infty p(t)\,dt = \int_0^\infty 20e^{-t}\,dt$$
$$= -20e^{-t}\Big|_0^\infty$$
$$= 0 - (-20) = 20 \text{ J}$$

(c) w is positive, so circuit element is absorbing energy.