

Lecture 2

Basics – 2 of 7

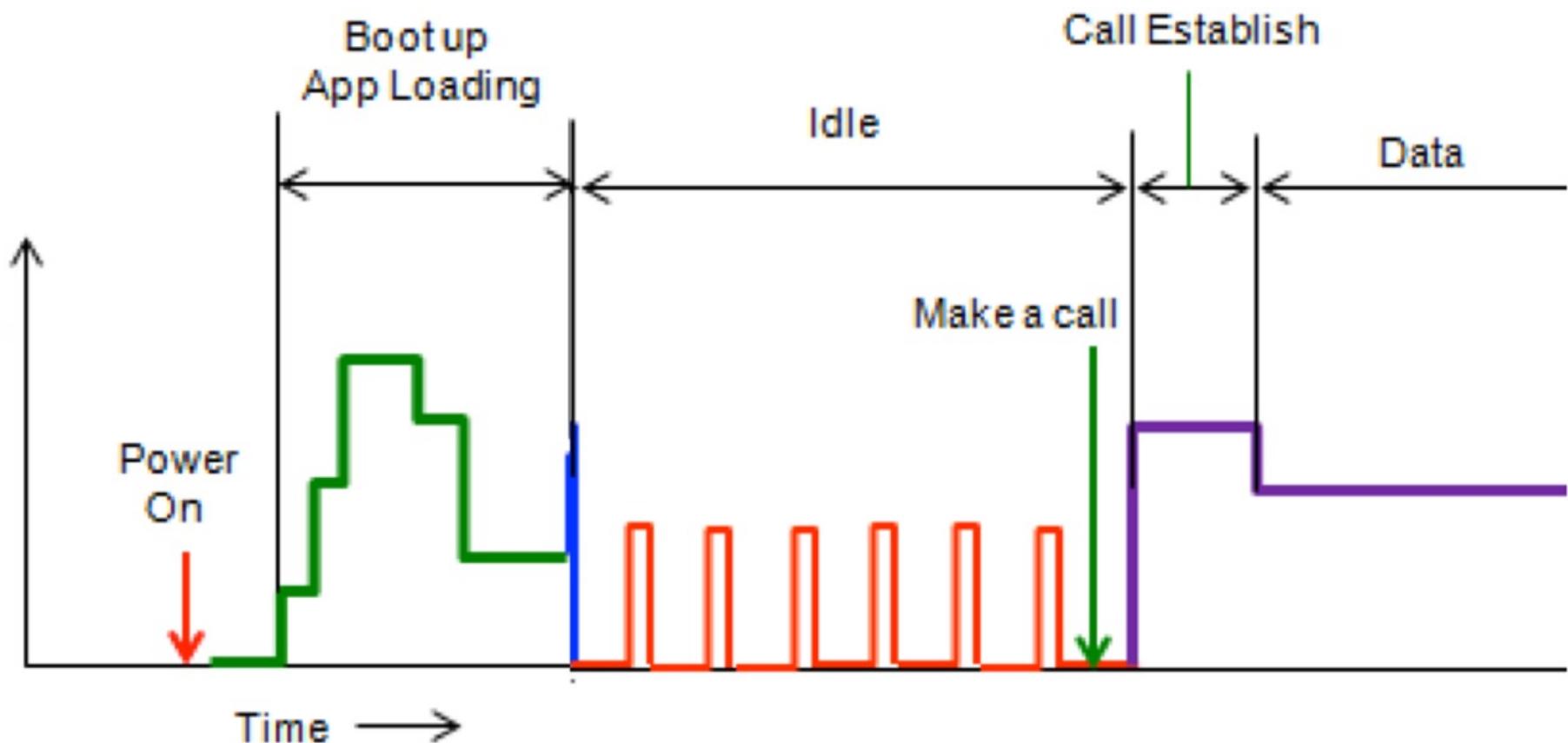
time variation; sources; resistors

Circuit Variables

Current	$i(t)$	amperes	directional
Voltage	$v(t)$	volts	directional
Power	$p(t) = v(t)i(t)$	watts	
Energy	$E(t)$	joules	

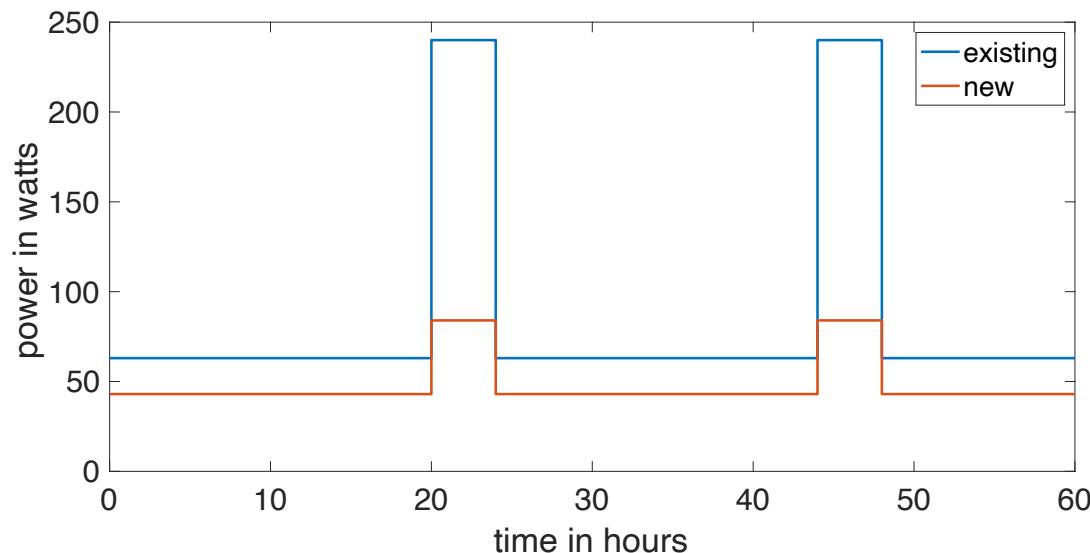
- Typically, these are time varying

- As an example – smart phone power usage

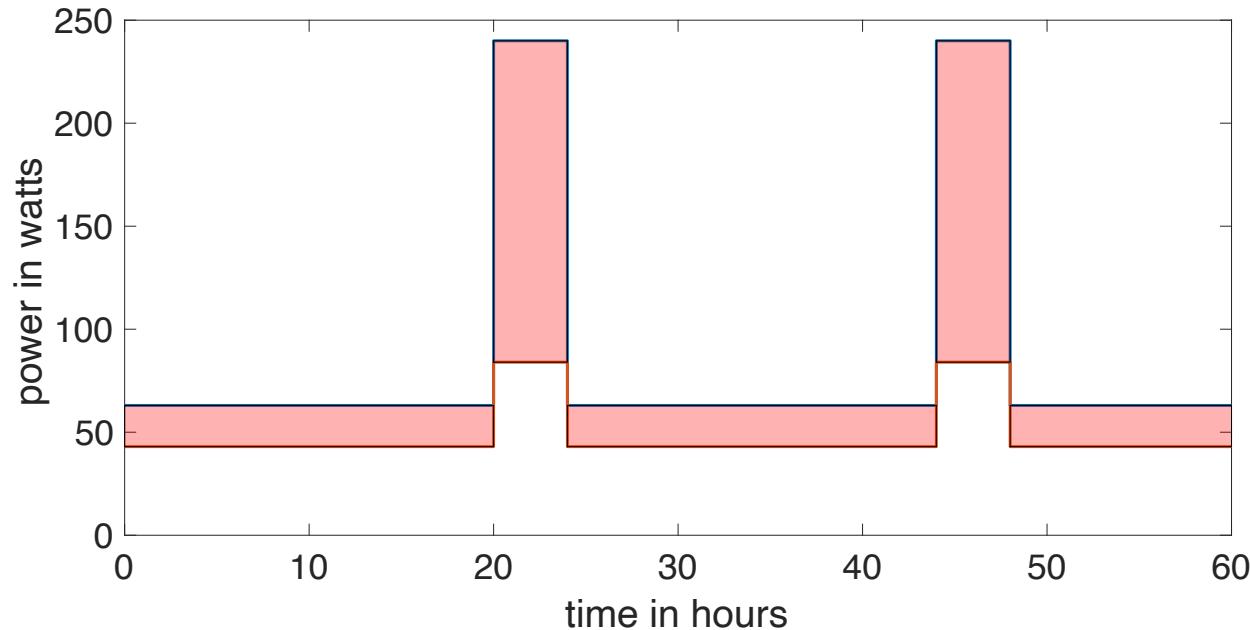


Example: I currently have a 3-year-old iMac on my desk with power consumption of 63 watts (idle) to 240 watts (active computing). A new iMac is better vis-à-vis power with levels of 43-84 Watts, respectively. Can I argue the \$1,600 price tag based upon the obvious energy savings?

- Assumptions:
 - Low/high power usage for a typical day is 20/4
 - Electricity rate of 18 cents/kWh



- Answer: Consider the extra power over a year

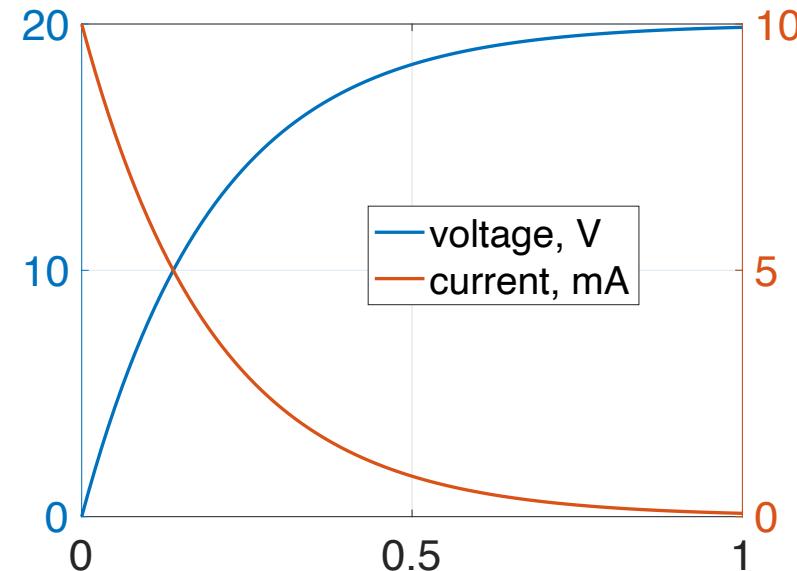


- High power: $365 * 4 * (240 - 84) = 228 \text{ kWh}$
- Low power: $365 * 20 * (63 - 43) = 146 \text{ kWh}$
- Savings per year = $(228 + 146) * 0.18 = \$67$

Example: The voltage and current at the terminals of a two-terminal circuit device for $t > 0$ seconds are

$$v(t) = 20 (1 - e^{-5t}) \text{ V}$$

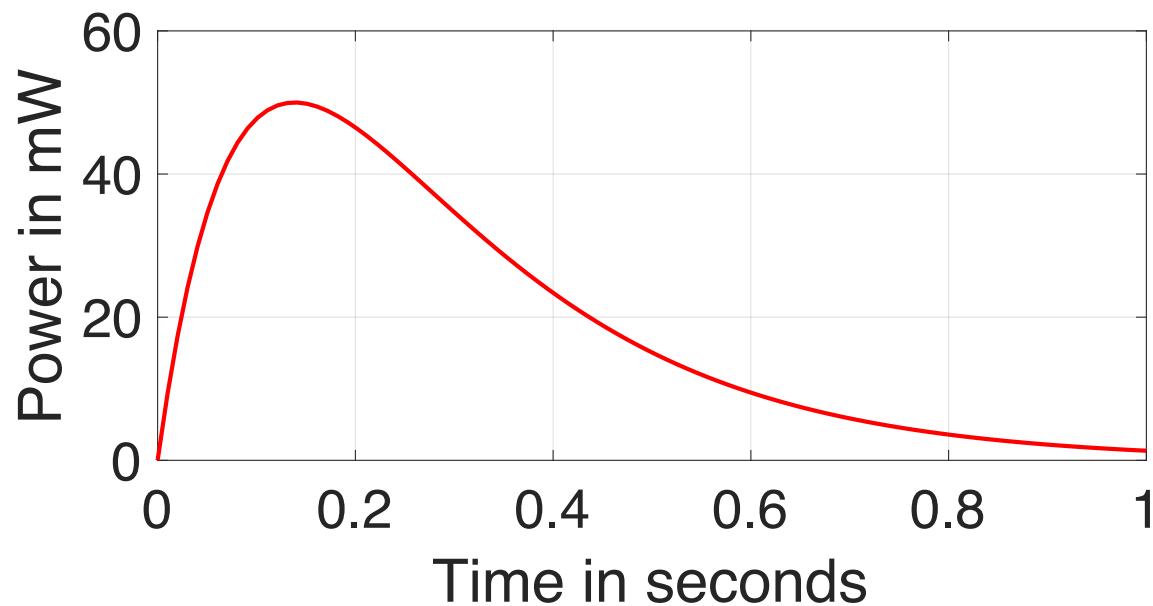
$$i(t) = 10 e^{-5t} \text{ mA}$$



- At what time is the power being delivered to the device a maximum?
- What is that maximum?

- Answer:
 - First, use the fact that power is the product of voltage and current

$$\begin{aligned}
 p(t) &= v(t) * i(t) \\
 &= 200 (e^{-5t} - e^{-10t}) \text{ mW}
 \end{aligned}$$



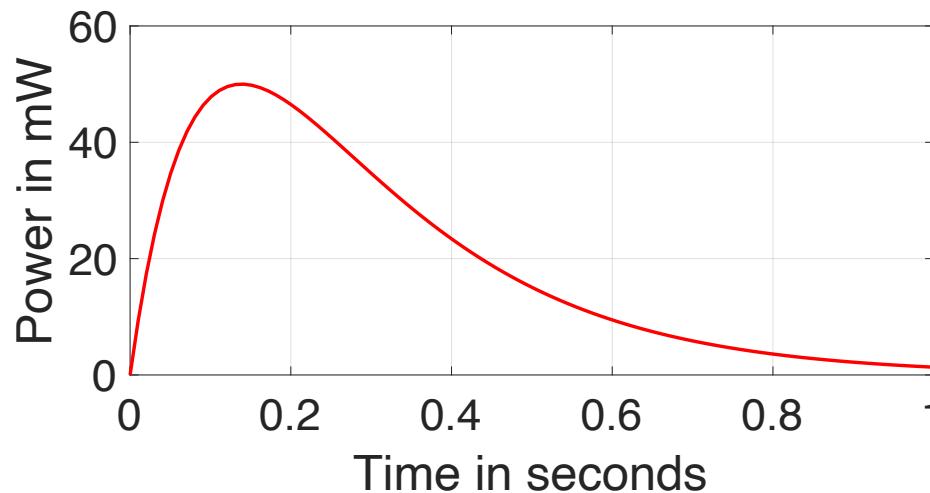
- Calculus gets us the extreme point:

$$\frac{dp(t)}{dt} = 200 (-5e^{-5t} + 10 e^{-10t})$$

- This derivative is zero when

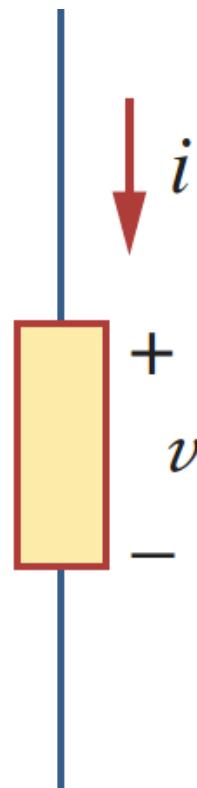
$$t = \frac{\ln 2}{5} = 0.139 \text{ sec.}$$

- The peak is $p\left(\frac{\ln 2}{5}\right) = 50 \text{ mW}$



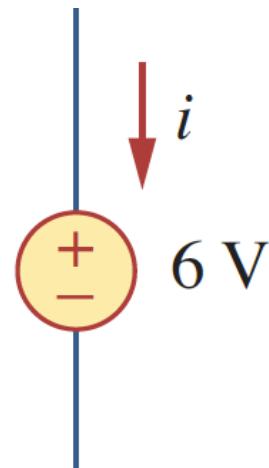
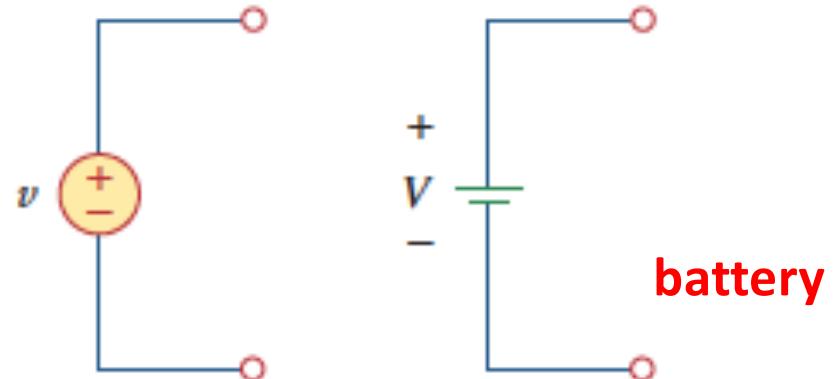
2 Terminal Devices

- Typical components for ELE 212/215:
 - Voltage and current sources
 - Resistors, inductors, capacitors
- Each has its own v, i characteristic
- Passive sign convention
 - Power $p = v i$
 - $p > 0$ “absorbed”
 - $p < 0$ “delivered”



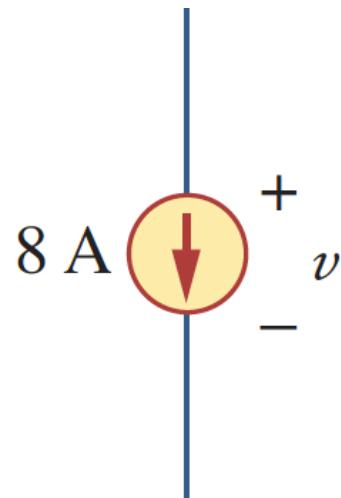
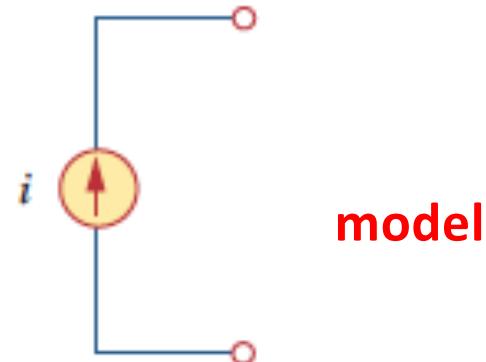
Sources

- Voltage source:
 - Fixed voltage
 - Any current necessary
 - Example:



Power $p = v i$ can be positive or negative

- Current source:
 - Fixed current
 - Any voltage necessary
 - Example:



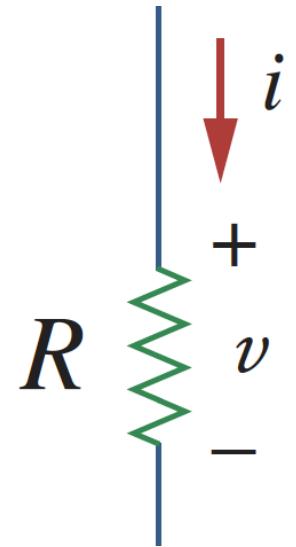
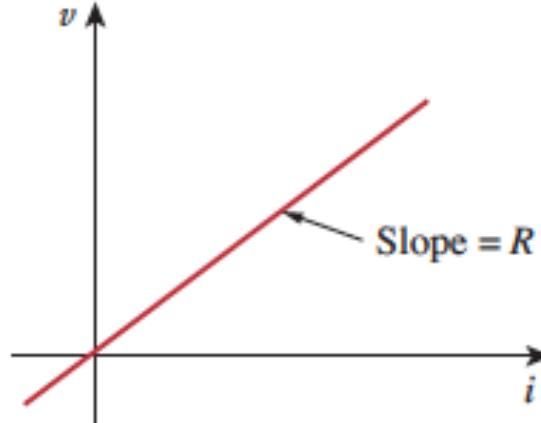
Power $p = v i$ can be positive or negative



Resistors

- Ohm's Law

$$v = R i$$



- Unit is ohms (Ω , $k\Omega$, $M\Omega$)
 - Also written as $i = \frac{v}{R} = v G$
 - G = conductance (mhos, Siemens, \mathcal{S})

- Power is $p = v i = R i^2 = \frac{v^2}{R} = v^2 G$
 - Always positive; power is always absorbed

Example: If the current through a $60\ \Omega$ resistor is $0.3\ A$, what is the voltage across it? How much power is it absorbing?

\$895

Practice problem: I'm thinking of buying an electric car. How much would I save by having a home charger versus using the publicly available charging stations?

- Assumptions:
 - Average 330 miles from 82 kWh (Tesla model 3)
 - Drive 15,000 miles per year
 - Electricity rate of 18 cents/kWh at home vs 42 cents/kWh at the chargers

0.424 mA

Practice problem: If the voltage across a $33\text{ k}\Omega$ resistor is 14 volts, what is the current through the resistor?

137 volts

Practice problem: If a $150\text{ k}\Omega$ resistor has a power rating (i.e. maximum power allowed) of $1/8$ watt, what is the maximum voltage that can be applied across the resistor?

3.57 mA

Practice problem: If the voltage across a $56\ \Omega$ resistor is 200 mV, what is the current through the resistor?

34.6 mA

Practice problem: If a $100\ \Omega$ resistor is absorbing 120 mW, what is the current through the resistor?