EECS2200 Electric Circuits

Introduction

ENG2200 Topics to be covered

- Introduction and simple resistive circuits
- Techniques for circuit analysis
- Inductance, capacitance and mutual inductance
- First order circuits RC and RL
- Second order circuits RLC
- AC circuits (analysis and power calculation)
- Balanced 3-phase circuits ?????????
- Introduction to Laplace transform ??????

Marks Distribution

• LAB	20%
• Quiz (3)	15%
• Midterm	25%
• Final	40%

LAB

- Please read the lab manual carefully.
- LAB Policy
- Math requirement

Chapter 1 Overview

- Objective
  - Understanding and be able to use SI units and standard prefixes for power of 10
  - Know and able to use the definition of volts and currents
  - Be able to use the passive sign convention to calculate the power for an ideal basic circuit element given its voltage and current

TABLE 1.1 The International System of Units (SI)

Quantity	Basic Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	degree kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

TABLE 1.2 Derived Units in SI

Quantity	Unit Name (Symbol)	Formula
Frequency	hertz (Hz)	s^{-1}
Force	newton (N)	$kg \cdot m/s^2$
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	ohm (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

TABLE 1.3 Standardized Prefixes to Signify Powers of 10

Prefix	Symbol	Power
atto	a	10^{-18}
femto	f	10^{-15}
pico	p	10^{-12}
nano	n	10^{-9}
micro	μ	10^{-6}
milli	m	10^{-3}
centi	c	10^{-2}
deci	d	10^{-1}
deka	da	10
hecto	h	10^2
kilo	k	10^3
mega	M	10^6
giga	G	10^9
tera	T	10^{12}

Voltage and Current

- The electric charge exists in discrete quantities that are multiple of electron charge 1.6022 $\times 10^{-19}$C
- Current is the rate of charge flow (positive charge)

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

- i=current (amperes)
- q= charge (coulomb)
- t= time (seconds)

André-Marie Ampère
(1775-1836)

Voltage and Current

- Assume that 10 millions electrons are moving from left to right in a wire every microsecond, what is the value of the current flowing in the wire

$$i = \frac{10 \times 10^{6} \times 1.6022 \times 10^{-19}}{10^{-6}} = 1.6022 \times 10^{-7} \text{Ampere}$$

- What about direction?

Voltage and Current

- Find the total charge delivered

$i = 0$ $\quad\quad$ $i = 0$

$i = e^{-5000t}$ $\quad\quad$ $i \geq 0$

- Find the maximum value of the current

$$q = \frac{1}{\alpha^2} - \left(\frac{1}{\alpha} - \frac{1}{\alpha^2}\right)e^{\alpha t}$$

Voltage and Current

- Voltage is the energy per unit charge created by the separation

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

Alessandro Volta (1745-1827)

- v = voltage in volts
- w= energy in joules
- q = charge in coulombs

Power

- transfer (rate of change) of energy per unit time
- P in watts = Joules per second $p = dw/dt = (dw/dq)(dq/dt) = vi$

$$P = \frac{dw}{dt} = \frac{dw}{dq} \times \frac{dq}{dt}$$

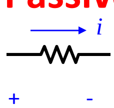
$$P = vi$$

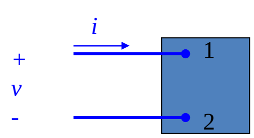
James Watt

(1736-1819)

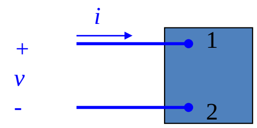
Reference Polarity

- Assignment of reference polarity is arbitrary
- Once you choose a reference, stick to it.
- In this course, The reference direction of a current in an element is the direction of the reference voltage drop across the element – **Passive sign convention**





Reference Polarity

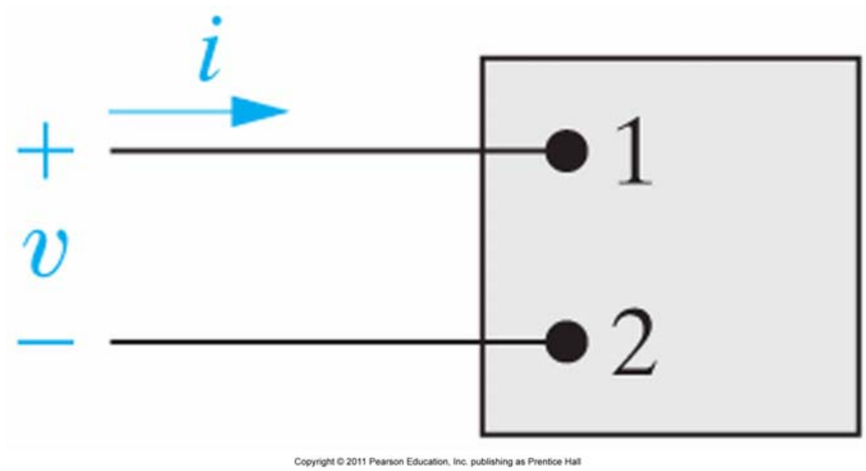


- Positive voltage drop from 1 to 2
- Positive charge flow from 1 to 2
- Voltage rise from 2 to 1
- For example $v_{12} = v_1 - v_2 = 5\ V$
- Positive charge are moving 1 $\rightarrow$ 2
- Negative value positive charge 2 $\rightarrow$ 1

TABLE 1.4 Interpretation of Reference Directions in Fig. 1.5

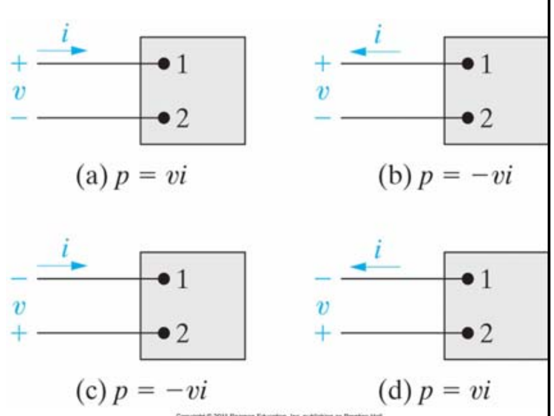
	Positive Value	Negative Value
v	voltage drop from terminal 1 to terminal 2 *or* voltage rise from terminal 2 to terminal 1	voltage rise from terminal 1 to terminal 2 *or* voltage drop from terminal 2 to terminal 1
i	positive charge flowing from terminal 1 to terminal 2 *or* negative charge flowing from terminal 2 to terminal 1	positive charge flowing from terminal 2 to terminal 1 *or* negative charge flowing from terminal 1 to terminal 2

Figure 1.5 An ideal basic circuit element.

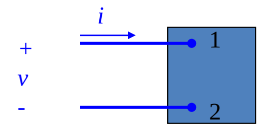


Power.

- If a positive charge moves through a drop in voltage, it loses energy
- If a positive charge moves through a rise in voltage, it gains energy.
- Power is positive in a circuit element it means power is being delivered to the element



Examples

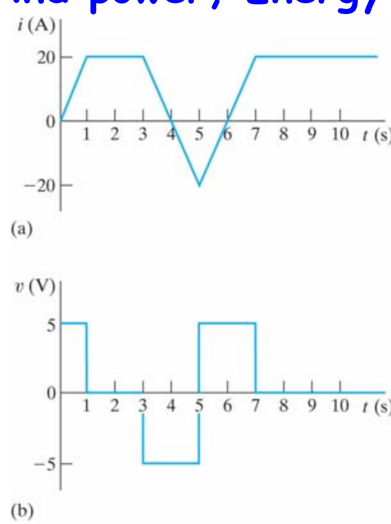


- Assume the current and voltage are gives as

$$i(t)=\begin{cases}0 & t<0\\ 20e^{-5000t} & t\geq 0\end{cases} \qquad v(t)=\begin{cases}0 & t<0\\ 10e^{-5000t}KV & t\geq 0\end{cases}$$

- Find the total charge entering the element
- Max. value of the current entering the element
- Power supplied to the element at 1ms
- Total energy delivered to the circuit

Example; Find power, Energy (10s)



Example; Find power, Energy (20s)