ENG2200
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 (4)	15%
• Midterm	25%
• Final	40%

LAB

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

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

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

Voltage and Current

- Find the total charge delivered

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

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

- 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

Alessandro Volta (1745-1827)

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

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

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

Power

James Watt

(1736-1819)

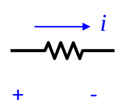
- transfer (rate of change) of energy per unit time
- P in watts = Joules per second $p = dw/dt = (dw/dq)(dq/dt) = vi$

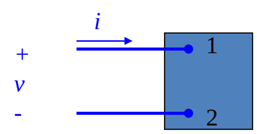
$$P = \frac{dw}{dt} = \frac{dw}{dq} \times \frac{dq}{dt}$$

$$P = vi$$

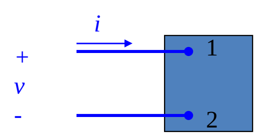
Reference Polarity

- 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





Reference Polarity

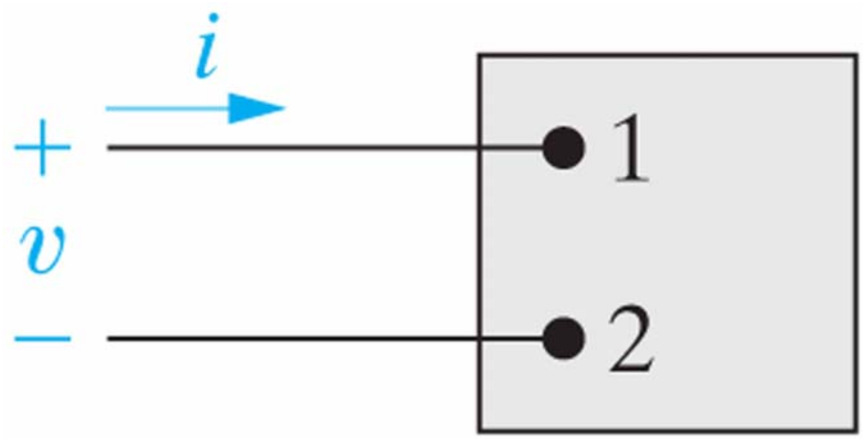


- Positive voltage drop from 1 to 2
- Positive charge flow from 1 to 2
- Voltage rise from 2 to 1
- For example $v_{12} = v_1 - v_2 = 5\ V$
- Positive charge are moving 1 $\rightarrow$ 2
- Negative value positive charge 2 $\rightarrow$ 1

TABLE 1.4 Interpretation of Reference Directions in Fig. 1.5

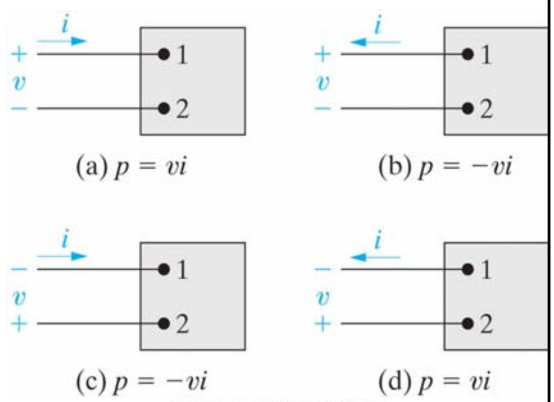
	Positive Value	Negative Value
v	voltage drop from terminal 1 to terminal 2 *or* voltage rise from terminal 2 to terminal 1	voltage rise from terminal 1 to terminal 2 *or* voltage drop from terminal 2 to terminal 1
i	positive charge flowing from terminal 1 to terminal 2 *or* negative charge flowing from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

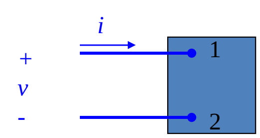


Power.

- 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

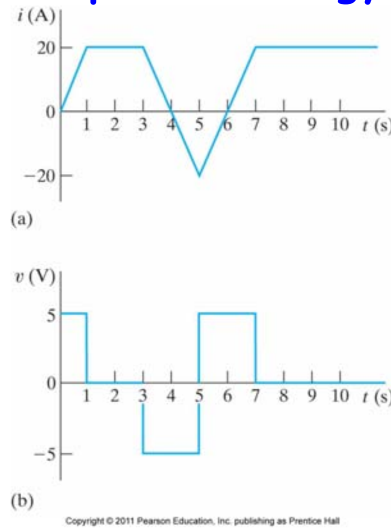


- Assume the current and voltage are gives as

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

- 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)