ELEG 205
Fall 2017

Lecture #2

Mark Mirotznik, Ph.D.
Professor
The University of Delaware
Tel: (302)831-4221
Email: mirotzni@ece.udel.edu
Let’s begin with some definitions

1. Electrical Charge
   - What is it?
   - What are its units?
   - What is the symbol
Let’s begin with some definitions

1. Electrical Charge
   - What is it?
   - What are its units?
   - What is the symbol

- Charge is the phenomenon giving rise to forces observed between electrical charged bodies. There are 2 kinds of charges: positive & negative
- Defined in terms of the charge on 1 electron \(\sim=1.6\times10^{-19}\) Coulombs
  - or stated as Charge on \(6.2\times10^{18}\) electrons is 1 Coulomb
- Symbol Q (constant) or \(q(t)\) (time varying)
Let’s begin with some definitions

1. Electrical Current
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Let’s begin with some definitions

1. Electrical Current
   - What is it?
   - What are its units?
   - What is the symbol?

   - Motion or flow of charge constitutes an electric current
   - Conventional current is the flow of positive charges
   - Electron current is negative charges
   - Measure of rate of flow of charge through a surface
     \[ I(t) = \frac{dQ}{dt} \]
   - 1 Ampere = 1 Coulomb/sec
   - Charge is the sum or ‘accumulation’ of current
   - Symbol for non-time varying I and i(t) for time varying current
Let’s begin with some definitions

1. Electrical Current
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Is 1.0 Amp of current a lot of current? Would it kill you if that much current went through your heart?
Let’s begin with some definitions

1. Electrical Current
   - What is it?
   - What are its units?
   - What is the symbol

   - When describing current please use terms like:
     - The current through ....
     - The current flow through ...

   - When describing current please DO NOT use terms like:
     - The current across ....
     - The current between ...
Let’s begin with some definitions

1. Electrical Voltage
   - What is it?
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Let’s begin with some definitions

1. Electrical Voltage
   - What is it?
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• Fix one Coulomb of charge in space … energy input (work) is required to bring another Coulomb of charge from a point A to a new point B closer to the fixed charge ….... the potential energy difference between points B & A is known as voltage:

• 1 Volt = 1 Joule / Coulomb
• Symbol for non-time varying V and V(t) for time varying voltage
Let’s begin with some definitions

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   - Symbol for non-time varying V and V(t) for time varying voltage

   Technically true but kind of a boring and non-intuitive definition for voltage
Good Analogy to Electrical Circuit

Think of voltage as the pressure between two points and electric current as the flow of water.
Good Analogy to Electrical Circuit

Some Questions

1. Which is bigger $I_A$ or $I_C$?
Good Analogy to Electrical Circuit

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Good Analogy to Electrical Circuit

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5. Which is bigger \( P_{BG} \) or \( P_{CG} \)?
Good Analogy to Electrical Circuit

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Some Questions

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4. Which is bigger $I_D$ or $I_E$?
5. Which is bigger $P_{BG}$ or $P_{CG}$?
6. Which is bigger $I_A$ or $I_G$?
7. Could you write an equation for $P_{BC}$ in terms of the other variables in the diagram?
Good Analogy to Electrical Circuit

Think of voltage as the pressure between two points and electric current as the flow of water.
Where the analogy breaks down!

This is called an open circuit.
No current flows in an open circuit.
(electrons do not shoot out the end of the wire)
Some things to keep in mind about voltage

1. Voltage is always measured between two points in a circuit. Saying the voltage at point A is 100 Volts is meaningless unless you tell me what it is measured with respect to.

2. We normally identify a point in the circuit as the reference. This is typically given the symbol of “ground”

3. Voltage has a polarity (+ and -) that tells us which side has the higher voltage with respect to the other side. The + is the high side and the – is the low side.

• When describing voltage please use terms like:
  • The voltage across ....
  • The voltage between ...

• When describing voltage please DO NOT use terms like:
  • The voltage through ....
  • The voltage flowing ...
Power and Energy

Power = Rate of change of energy

\[ P(t) = \frac{dE}{dt} \] Watts

In an electrical circuit power is defined as the product of voltage times current

\[ P(t) = V(t) \cdot I(t) \] Watts

Energy would then be the integral of power over time and equal to

\[ E(t_o) = \int_{0}^{t_o} V(t) \cdot I(t) \, dt \] Joules
Power and Energy

\[ P(t) = V(t) \cdot I(t) \text{ Watts} \]

Power can be either positive or negative. Positive power means a circuit or circuit element is supplying power and negative power means that circuit or circuit element is absorbing power.

In the figure above how would we know if “circuit A” is supplying power to “circuit B” or if it is the other way around?
To determine if power is positive or negative we have defined a convention called passive sign convention. It is **REALLY IMPORTANT** that you learn and follow passive sign convention!!!

**Passive Sign Convention:**

- If positive current flows OUT of the positive voltage terminal of a circuit or circuit element that circuit or circuit element is supplying power (power is positive).

- If positive current flows IN to the positive voltage terminal of a circuit or circuit element that circuit or circuit element is absorbing power.
Passive Sign Convention

Example

Circuit A

V = 10 Volts and I = 3 Amps

Is circuit A supplying power to circuit B or absorbing power from circuit B?
How much power?

Passive Sign Convention:

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- If positive current flows IN to the positive voltage terminal of a circuit or circuit element that circuit or circuit element is absorbing power.
Passive Sign Convention

Example

V = -10 Volts and I = -2 Amps

Is circuit A supplying power to circuit B or absorbing power from circuit B?
How much power?
Passive Sign Convention

Example

V = -10 Volts and I = -2 Amps

Is circuit A supplying power to circuit B or absorbing power from circuit B?
How much power?
Passive Sign Convention

Example

V = 5 Volts and I = 3 Amps

Is circuit A supplying power to circuit B or absorbing power from circuit B?
How much power?
An electric source is capable of supplying power/energy. The other parts of the circuits we will study are called passive components (e.g. resistors, capacitors and inductors). The passive components can never supply power, they can only absorb it (i.e. convert the energy into heat) or store it.

<table>
<thead>
<tr>
<th>Type of Sources We Will Use in This Course</th>
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1. Independent Voltage Source

The voltage, $V$, across the terminals of an independent voltage source is always the same independent of what you attach to it (i.e. independent of the rest of the circuit)

*Note: The current, $I$, flowing out of the independent voltage source will depend on the specific circuit*
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1. Independent Voltage Source

What is an example of an independent voltage source?

- 9 Volt battery
- 24 Volt car battery

Is this an example of an independent voltage source?
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2. Independent Current Source

The current, $I$, flowing out of the terminals of an independent current source is always the same independent of what you attach to it (i.e. independent of the rest of the circuit)

**Note:** The voltage, $V$, across an independent current source will depend on the specific circuit.
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1. Dependent Voltage Source

The voltage, $V$, across the terminals of a dependent voltage source will depend on some other property within the circuit (i.e. it is dependent of the rest of the circuit).

**Note:** The current, $I$, flowing out of the dependent voltage source will also depend on the specific circuit.

What is an example of a dependent voltage source?
1. Dependent Voltage Source Example (Amplifier)

What is an example of a dependent voltage source?
Type of Sources We Will Use in This Course

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1. Dependent Current Source

The current, I, flowing out of the terminals of a dependent current source depends on what you attach to it (i.e. dependent of the rest of the circuit)

*Note: The voltage, V, across an independent current source will also depend on the specific circuit*
Type of Sources We Will Use in This Course

An electric source is capable of supplying power/energy. The other parts of the circuits we will study are called passive components (e.g. resistors, capacitors and inductors). The passive components can never supply power, they can only absorb it (i.e. convert the energy into heat) or store it.

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Our first passive circuit component

**Resistor** - A resistor “resists” the flow of current. The higher the resistor value the more it resists current.

![Resistor Symbol](image)

**Resistor Units** - \( \Omega \) (ohm)

**Actual Resistors** -

Is 1 ohm a large amount of resistance or a small amount?
Some Commonly Encountered Resistance Values

1 kΩ = 1,000 Ω

Wire (short circuit) → R = 0 Ω

1 MΩ = 1,000,000 Ω

Open circuit → R = ∞ Ω
The Law of the Resistor

Ohm’s Law

\[ V(t) = R \cdot I(t) \]

Notice the polarity of the voltage and direction of the current
Does it have to be this way?
The Law of the Resistor

Ohm’s Law

\[ V(t) = R \cdot I(t) \]

Notice the polarity of the voltage and direction of the current
Does it have to be this way?

A resistor can ONLY absorb power (turns it into heat).

It does NOT store power or supply power

Passive sign convention would require that the current must always flow into the positive voltage terminal of a resistor!!
The Law of the Resistor

Ohm’s Law

\[ V(t) = R \cdot I(t) \]

What is the current flowing through the resistor?
What direction does it flow?
The Law of the Resistor

Ohm’s Law

\[ V(t) = R \cdot I(t) \]

What is the current flowing through the resistor?
What direction does it flow?
The Law of the Resistor

Ohm’s Law

\[ V(t) = R \cdot I(t) \]

What is the voltage across the terminals of the resistor?
The Law of the Resistor

Ohm’s Law

\[ V(t) = R \cdot I(t) \]

What is the voltage across the terminals of the resistor?
The Law of the Resistor

Ohm’s Law

\[ V(t) = R \cdot I(t) \]

What is the voltage across the terminals of the resistor?
Power Absorption in a Resistor

Ohm’s Law \[ V = R \cdot I \]

Power Law \[ P = V \cdot I \]
Power Absorption in a Resistor

Ohm’s Law \[ V = R \cdot I \]

Power Law \[ P = V \cdot I \] (true always)

Combine the Two:

\[ P = V \cdot I = (R \cdot I) \cdot I = I^2 R \]

or

\[ P = V \cdot I = V \cdot \left( \frac{V}{R} \right) = \frac{V^2}{R} \]
Summary of Resistor Laws

Ohm’s Law \[ V = R \cdot I \]

Power Law \[ P = V \cdot I \] (always true)

Resistor Power Law: \[ P = I^2 R = \frac{V^2}{R} \] (true for resistor)