Circuits Fundamentals

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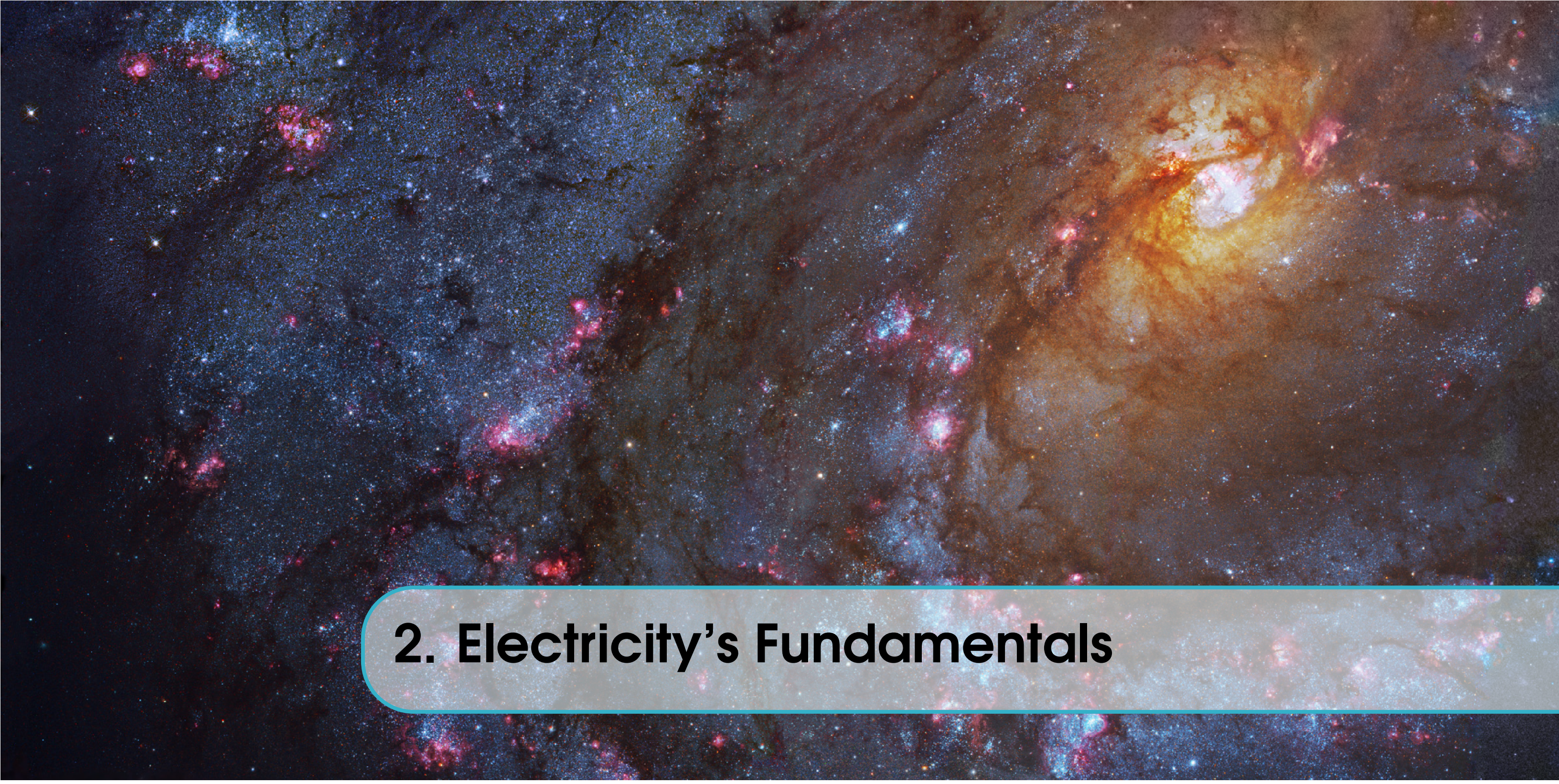
1. Introduction



2. Electricity's Fundamentals

Electricity is, in simple terms, (...)

Positive charges and negative charges are, per charge:

$$Positive: \ 1.6x10^{-19}C \tag{2.1}$$

$$Negative: \ 6.24x10^{18}e \tag{2.2}$$

They're both in the measuring unit of the other.

2.1 Coulomb's Law:

We mathematically define Coulomb's Law as:

$$F = K \cdot (\frac{Q \cdot q}{r^2}) \tag{2.3}$$

a few important constants come from:

$$K = \frac{1}{4\pi \cdot \varepsilon} \tag{2.4}$$

$$\tag{2.5}$$

2.2 Current

When we have a group of charging moving at the same time, we can measure it in amperes, the specific measure can be explained mathematically as:

$$[I] = A = \frac{1C}{1S} \tag{2.6}$$

This is a measure of unit that has a direction, and is inherently vectorial. It is also the main way we'll measure electricity in this course

2.3 Resistivity

It is possible to control Current through resistant materials that can stop partially the flow of electrons. This comes in a sense, as a consequence of Ohm's Law.

We can calculate resistivity as:

$$R = \rho(T^o)x(\frac{L}{A}) \tag{2.7}$$

This 'R' we have in the previous formula is actually an Ohm, and can also be written as Ω.

2.3.1 Ohm's Law

We can use Ohm's Law to describe the way that resistivity can be interpolated from.

We can define it through the following formulas:

$$I_R = \frac{V_R}{R} \tag{2.8}$$

$$R = \frac{V_R}{I_R} \tag{2.9}$$

2.3.2 Effects driven by temperature

Temperature can make it so there are more or fewer free electrons. The higher the temperature, the more free electrons; In a sense this happens because heat physically is a measure of how much (...). The fact there are little to no electrons helps the current technology on superconductivity.

2.3.3 Aislants

An Aislant is meant to make resistivity as large as possible, and even though perfect aislants are, in practice, impossible to achieve, it makes the flow of electrons negligible.

2.4 Conductivity

The opposite of Resistivity is conductivity. This is measured in Siemens, and can be expressed as:

$$[G] = S = \frac{1}{\Omega} \tag{2.10}$$

2.5 Closed and Open Circuits

We can think on circuits being broadly classified in two: An open circuit, which implies (...), or a closed circuit, which implies (...).

2.6 Potential on a Circuit

We can describe the

3. Kirchoff’s Laws

3.1 Kirchhoff’s Current Law (KCL)

We can use the laws established by Kirchhoff to describe the behavior of current. and/or voltage. At it’s most basic, we can describe Kirchhoff’s laws, or KCL, as:

- $$\sum_{node} i_{enter} = 0$$
- $$\sum_{node} i_{out} = 0$$
- $$\sum_{node} i_{enter} = \sum_{node} i_{out}$$

This means that to describe a current we’ll have to assume the current output and the current input of electrical signals will have a zero sum and that they will be equal to each other. Either of these definitions will be interchangeably useable.

For defining a circuit, we should do this for every node in a circuit so we can define a linear equation model. But we probably wouldn’t want to define a whole circuit only through KCL, because even though computationally it can technically be done, if we were to calculate the values of an entire circuit through Kirchhoff alone, it would generally give us linear equation systems that are fairly big and tedious, and can become a differential equation systems in certain scenarios, adding even more complexity. We can see this because when defining currents and voltages, the eventual complexity of the system can be defined as:

$$I_r * V_r = n \tag{3.1}$$

$$KCL = [nxn] \tag{3.2}$$

3.1.1 Gaussian Curves

When we define a Gaussian curve, we can use KCL's laws on them as if every curve acted as a node; Besides this, we can define closed circuits as specific gaussian curves, and to a certain extent, make inputs and outputs dependant on this. This can simplify a circuit system drastically.

3.2 Kirchhoff's Voltage Law (KVL)

There is the possibility to use a version of the previous law where we don't measure Current, but voltage, this works through the following formula:

$$\sum_{c.c} V_i = 0$$

3.3 Node Voltage Analysis

You can analyze the elements of a circuit by the voltages associated to the nodes of a system. given the expression

$$V_{ij} = V_i - V_j$$

we can get a lot of information from a system. To apply this, we:

- Identify the nodes
- Identify/select ground
- Determine what our equations are
- Identify the restrictions of our voltage fonts
- Check for voltage restrictions
  - Dependant
    - To ground
    - Floating
  - Independent
    - To ground
    - Floating
- Solve KCL equations for:
  - Gaussian Curves
  - Nodes

Example

3.4 Examples

3,1

Given two specific nodes, we'll have two serial resistances with .

If we apply Kirchhoff's Voltage and Current law, then:

$$V_{xy} = V_{xc} + V_{cy} < KVL > \tag{3.3}$$

$$x \to I_X = I_{R1}; c \to I_{R1} = I_{R2}; y \to I_{R2} = I_x < KCL > \tag{3.4}$$