Electeng101

Alexander Bailey

E-mail: alexkingstonbailey@gmail.com

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1 Fundamentals of Electrical and Digital Systems

1.1 Electricity as Energy

The fundamental concept that underpins the modern electrical 'cycle' is:

> Energy is used to separate charges i.e the chemical reaction in a cell. This becomes the electric potential energy of the circuit

Separation of charge causes a difference in electric potential energy. When this difference is applied to a closed circuit, charge will move around the circuit. The movement of charge through is called a current.

Charge

> Electric charge is the physical property of matter that causes it to experience a force when placed in an electromagnetic field. (q or Q)

We typically describe charge as having two states: postive (like a proton) and negative (like an electron). These are not inherent to the universe but are just what we have defined. Of course, the classic line is: 'Like charges repel, opposite charges attract'. Modelling the wire as a pipe carrying water, charge would be the amount of water.

We model the strength of the electrostatic force as proportional to the charge of both particles and inversely proportional to the radius squared i.e.

$$F \propto \frac{q_1 q_2}{r^2}$$

Current

> Current is the rate of flow of charge represented by i or I.

$I = \frac{q}{t}$
or
$I = \frac{dq}{dt}$

Current is defined numerically as the number of charges flowing through a particular point in one second. Mathematically, it is the derivative of the total number of charges q passing through a given section over time t (written as $\frac{dq}{dt}$). Current thusly has units of Coulombs per second (Cs^{-1}) but Electrical Engineers have given this another name, the *Ampere* (A).

Current gives Electrical Engineers an idea of how *fast* energy is being used instead of how *much* energy it has received[1]. In the water analogy, current would be the speed of the water in the pipe.

[1] *Note that most electrical devices require a continuous supply of energy to function so speed is generally much more useful than amount*

Voltage

> Voltage is the difference in electrical potential energy of each unit of charge between two points represented by v or V.

Because a voltage is a difference, we must know what point in the circuit that the difference is measured relative to for it to make sense. Voltage is commonly called a potentiial difference (PD) and has units Joules per Coulomb (JC^{-1}). Using our water analogy, voltage would be the pressure of the water in the pipe.

1.2 Circuit Definitions

Here are some conventions used to describe all circuits:

load	'destination' of the electricity i.e. a lightbulb
topology	the nature of the connections between components
nodes	the point where two or more components meet

When we are discussing values in a circuit, voltage is 'across' a component, current is 'through'. This means the voltage through a branch but we could also talk about the voltage 'at' a component. 'at' means the PD is measured from the point to ground.

> **Circuit Topologies**
>
> **Closed**
>
> The circuit has both flow of charge and energy transfer
>
> **Open**
>
> No electric potential means no flow of charge and no energy transfer. The circuit could be disrupted, i.e there is an air gap with (theoretically) infinite resistance.
>
> **Short**
>
> The circuit (or circuit section) has a 0v potential difference. This could mean a path of lower resistance meant no voltage 'went' down that path or that voltages cancelled etc.

1.3 Models

In Electrical Engineering (EE), a model is a description that communicates

- Physical Characteristics
- Electrical Function

- Magnitude

Models allow you to more easily handle complex systems. They compartmentalise systems into smaller sub-systems. In circuit diagrams, component symbols are models of the actual components. We can then focus on our actual engineering instead of *why* we are doing what we are doing (leave that to the physicists).

Mathematical Models, such as Ohm's Law, are still models. They simplify our calculations by making an approximation.

Some EE models include:

- Component Symbols
- Schematics
- Block Diagrams
- PCB Layouts

2 SMART Engineering

> Systems of Monitoring, Analysis, and Response Technologies

3 Electricity Supply