DC Circuits

An Online Continuing Education Course for Engineers

Course Number: E-2073

Credit: 2 Hours / 2 PDH / 2 CPD

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DC Circuits

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Introduction

All engineers need a "back to the basics" course, and that is exactly what this course provides. The purpose of this course is to utilize the laws associated with basic direct current (DC) theory to find resistances, currents, and voltages at any given point within a circuit. Electric circuits range from very simple circuits containing one or more resistive components and a voltage source (such as a battery and a light bulb contained in a flashlight) to very elaborate, complicated circuits (such as the microprocessor circuit card inside your mobile phone). This course provides a basic introduction to DC resistive circuits and their purpose.

Your mobile phone in your pocket is a complex circuit containing multiple microprocessors, flash and RAM memories, a display, a cellular radio module, as well as WiFi and Bluetooth radio modules, one or more camera modules, a battery, etc. However complex this circuit is, it can still be simplified to a trivial circuit containing a battery and a resistor.

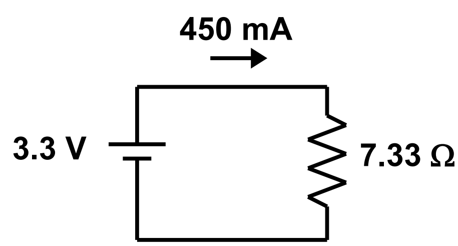

FIGURE 1 – SIMPLIFIED EQUIVALENT CIRCUIT FOR A MOBILE PHONE

There are inductive and capacitive effects that need to be considered, so the load is not purely resistive. Also, the load is not constant, either. The load, or resistance, will fluctuate depending on the current demand on the device (surfing the web, using WiFi or Bluetooth, using GPS, using the camera, display brightness, sound, etc.).

The point is that all circuits can be simplified to fit the model for the parameters that you want to monitor or study. Here, we study DC resistive circuits.

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Ohm’s Law

All electrical or electronic circuits supplied with a driving voltage from a battery or some sort of power supply will generate a current that passes through the circuit.

As an analogy, imagine a river. The water is flowing, and the speed at which the river flows depends on the drop in elevation between two points in the river. This drop in elevation is equivalent to voltage. It is a potential difference (whether regarding gravity or voltage) between two points. If you were standing in the river, and the river was small and shallow, you would probably not be knocked over. However, if the river was deep and wide, you would most likely be swept downstream.

The river that swept you downstream probably contained a lot of moving water, and the river that you were able to stand in had only a little water. The amount of moving water is the current, just like in an electric circuit. The action of the moving electrons in an electric circuit is the current of the circuit. Resistance comes from obstructions to the free flow of the water in the river, like the river bottom, the river edge, fallen trees, rocks, or humans standing in the middle of the river.

Voltage

Voltage is measured in volts. One volt is defined as the electrical pressure required to force an electrical current on one amp through a resistance of one ohm.

$$V = \frac{J}{C}$$

(joule / coulomb)

= kg m^2 / A s^3

Current

Current is measured in amperes (or simply amps). One amp is defined as the current that flows from one coulomb of charge per second.

$$A = \frac{C}{s}$$

(coulomb / second)

Resistance

Resistance is measured in ohms. One ohm is defined as the electrical resistance between two points of a conductor when a constant potential difference of one volt applied between the two points produces a current of one amp.

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V = IR

The fundamental relationship between voltage, current, and resistance in an electric circuit is known as Ohm's Law. It is represented by the equation V = IR (where V is the voltage, I is the current, and R is the resistance in the circuit). Ohm's Law states that the current through a conductor between two points is directly proportional to the voltage across the two points. The constant of proportionality is the resistance.

In an electric circuit, we use Ohm's Law to determine the relationship between voltage, current, and resistance. Three equivalent expressions of Ohm's Law are used interchangeably:

$$V = IR$$

$$I = \frac{V}{R}$$

$$R = \frac{V}{I}$$

Each equation can be used interchangeably to determine either the voltage drop across a component, current through the component, or resistance of the component.

An ohm is defined as the electrical resistance between two points of a conductor when a constant potential difference of 1 volt, applied to these points, produces in the conductor a current of 1 amp. The units of an ohm (Ω) can be broken down as follows:

$$\Omega = \frac{V}{A}$$

$$= \frac{1}{S}$$

$$= \frac{W}{A^2}$$

$$= \frac{V^2}{W}$$

$$= \frac{s}{F}$$

$$= \frac{Js}{C^2}$$

$$= \frac{kg\ m^2}{sC^2}$$

$$= \frac{J}{sA^2}$$

$$= \frac{kg\ m^2}{s^3A^2}$$

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in which the following units apply: volt (V), ampere (A), siemens (S), watt (W), second (s), farad (F), joule (J), kilogram (kg), meter (m), coulomb (C).

The definition of V / A will be sufficient for this course.

The following sample problems will demonstrate how to compute the current through and the voltage across a resistive element using Ohm's Law.

Sample Problem

The voltage drop across a 1 kΩ resistor is 3.3 V. Find the c

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To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

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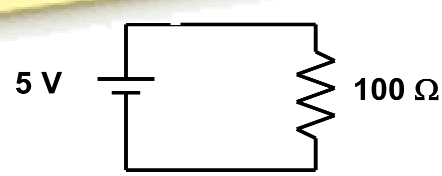

FIGURE 2 – SIMPLE CIRCUIT

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