Radio Mechanics
Fourth Year

Module 1
The Starting Point
(Fundamentals of Electronics)

What this module is about

Electronics is one of the most interesting and rewarding fields of study. It offers many opportunities to anyone who gets into it. Do you know somebody who engaged in this field? How about you? Do you want to engage in this endeavor? Engaging in electronics is sometimes frustrating, but knowledge of basic electronics would be of great help. This module will guide you in learning the fundamentals of electronics. Following are some of the interesting topics:

-Ohm's Law
-Power Law
-Sources of Electricity
-Alternating Current (AC) and Direct Current (DC)

What you are expected to learn

After studying this module, you should be able to do these:

1. State the relationship of voltage, current, and resistance.
2. Learn the formulas of Ohm's Law and Power Law.
3. Find the unknown values of voltage, current, resistance and power.
4. Describe the different sources of electricity.
5. Differentiate alternating current (AC) from direct current (DC).

How to learn from this module

In order to gain maximum benefit from this module, you have to follow carefully all the given instructions.

1. Each part of this module will prepare you for the next part, be sure to work on each activity.
2. You must work through this module in sequence as the contents are presented.

3. Following shortly is a pretest. Do the test and check your answers by comparing them with the key to answers given at the last part of this module. Do not look at the key to answer page unless you have completed answering the test.
4. After reading and understanding each lesson, you have to do the given activity and answer the self-check to determine whether you understood what you have read.
5. Posttest is provided at the end. You must answer it and should get a score of at least 80% in order to move on to the next module. If you get lower, you have to go through the module again particularly on the part wherein you have committed an error.

At this momemnt, try to answer the pretest. This will enable you to find out what you already know and what you still need to know about the Fundamentals of Electronics. Good luck!

Reminder:

Be honest in answering and checking the test questions. Remember that you are studying by yourself, your learning totally depends on you.

PRETEST

I. Matching Type
Directions: Column A describes and interprets the meaning of the group of words in Column B. Match Column A with Column B. Write your answer on the blank before each number.

Column A	Column B
____ 1. Voltage, current and resistance are related.	power
____ 2. When one quantity increases, the other one also increases.	inversely proportional
	friction
____ 3. Movement of free electrons is concerted.	Ohm's Law
____ 4. It is invisible force that produces heat, light and motion.	electricity
	electromagnetism
____ 5. It utilizes certain materials that produce voltage when made to vibrate.	alternating current
	chemical action
____ 6. Increase in one quantity decreases the other quantity.	thermionic emission
	directly proportional
____ 7. The changing magnetic field produces current.	piezo-electric
____ 8. Amplitude varies while changing polarity.	direct current
____ 9. This is a type of current that flows in only one direction.	current
	voltage

____ 10. Voltage is produced due to chemical reaction between two different metals immersed in electrolyte.
____ 11. The opposition to the flow of electric current.
____ 12. Production of voltages when certain materials emit their electrons and are exposed to light under certain conditions.
____ 13. Number of times per second a cycle occurs
____ 14. Work is done at a particular rate.
____ 15. What is the basic unit of current.

frequency
resistance
photo-electric
nuclear
volt
ampere

II. Problem Solving

1. Calculate the voltage necessary to drive a current of 0.5 ampere through a resistance of 1,000 ohms.
2. Calculate the power in a circuit where the source of 100 volts produces 4 amperes current in a 25-ohm resistance.
3. What should be the value of a resistor to be connected in a circuit supplied with 24 volts in order to produce current of 0.5 ampere?

Lesson 1

Voltage, Current, and Resistance (Ohm's Law)

Ohm's Law shows the relationship of voltage, current, and resistance . It involves circuit analysis such as finding unknown values of resistance, current and voltage. Ohm's Law states that current flowing in a closed electric circuit is directly proportional to the applied voltage and inversely proportional to the circuit resistance. This law was formulated by George Simon Ohm, a German scientist. Following are terms that relates to Ohm's law:

Directly proportional means when one quantity increases the other quantity also increases.
Example: In a circuit with a high voltage supply, the current flow in the said circuit is large.

Inversely proportional means when one quantity increases the other quantity decreases.
Example: In a high voltage circuit supply producing a large amount of current, circuit resistance is low.

Expressed simply, if the supply of voltage in a circuit is high, it produces a large amount of current and resistance is presumed to be low.

For a better understanding of this lesson, knowledge of the meaning of the three basic electrical quantities, namely voltage, current ,and resistance is necessary.

Voltage - An electrical force that moves electrons or charges to produce current.
- A letter symbol of E or V.
- Volt as its basic unit (v).
- Can be measured by an instrument called voltmeter.

Current - It is the concerted movement of free electrons in conductors.
- Its letter symbol is I.
- Its basic unit is ampere (A).
- It is measured by an instrument, the ammeter.

Resistance - Is the opposition to the flow of electric current.
- Its letter symbol is R.
- Its basic unit is ohm (represented by the Greek letter Omega, **Ω**.
- It can be measured by an instrument called ohmmeter.

Self-check:

1. What is voltage? current? resistance?
2. What letter symbol represents voltage, current and resistance respectively?
3. What is the unit of measuring voltage, current and resistance respectively?
4. What is the relationship between voltage and current? between current and resistance? between voltage and resistance?
5. What is meant by directly proportional? inversely proportional?

Lesson 2

Ohm's Law and Electrical Power Formulas

Ohm's law states the relationship of voltage, current and resistance. It is one of the most essential law governing electronic theories and principles. Knowledge of ohms law is a must for people engaged in the field of electronics. It involves circuit analysis such as finding unknown values of voltage, current and resistance. Ohm's law states that *the higher the voltage, the larger the current and the higher the resistance, the*

lower the current. Their relationship is represented in the following equation:

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

Where:

I - is the current flow (in ampere)
E- is the voltage (in volt)
R- is the resistance (in ohm Ω)

The three basic electrical quantities are defined below:

Voltage = Current x Resistance

E = I X R

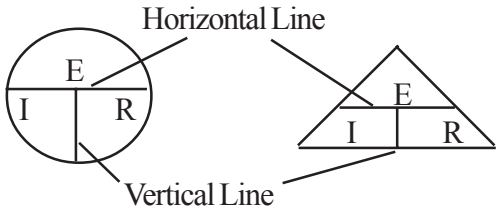
Current = Voltage / Resistance

I = E / R or $\frac{E}{R}$

Resistance = Voltage / Current

R = E/I or $\frac{E}{I}$

To keep the three formulas fresh in your mind, use the magic circle or magic triangle as your memory guide, as follows:



In using the foregoing guide, the horizontal line represents the division process, and the vertical line, the multiplication process. Suppose you want to find out the unknown value of voltage (E), just cover letter E and the remaining letters are I (current) and R (resistance) with a vertical line in between indicating the multiplication process. Thus, E = I / R. Likewise, if you want to find the unknown value of resistance (R) cover letter R. The remaining letters are E and I with a horizontal line in between, indicating the division process. Thus, R = E / I. The same procedure is applied if you want to find the unknown value of current (I).

Power (P) is the rate of doing work. Electric power is the rate at which electrical energy can be delivered to an electrical consuming device. The measuring unit of electric power is the watt. When multiplied by 1,000 is called **kilowatt**. Thus, one thousand (1,000) watts is one (1) kilowatt.

1000 watts = 1 kilowatt

Power = Current x Voltage

$P = I \times E$ This is the basic formula in determining electric power.

Through Ohm's law, one can derive other formulas in determining the extent of electrical power.

$$P = \frac{E^2}{R}$$

P = I x E; by Ohm's law I = E/R
Substituting E/R for I, thus; P = E/R x E; by multiplication, E x E is E^2
Then, $P = E^2 / R$ - this formula is derived from the basic formula.

Another formula which can be used to determine electrical power is,

$P = I^2 \times R$

From the basic formula: P = I x E ; by Ohm's Law, E = I x R
Substituting IR for E, thus P = I x IR; by multiplication, I x I is I^2

Then, $P = I^2 \times R$. This formula was also derived from the basic formula.

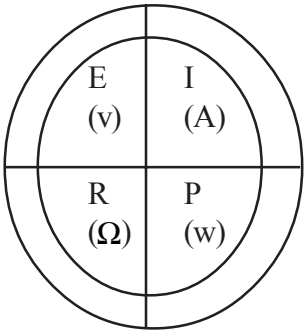
Now that you have gone through the different aspects of Ohm's Law and power formulas, you are now ready for the next lesson which requires their application in solving simple problems. However, before proceeding, try to measure what you have learned by doing the activity and answering the questions in the self-check section.

Self-check

1. What formula are you going to use if you want to determine the unknown value of voltage? current? resistance?
2. What power formula are you going to apply when the resistance and current in a circuit are known?
3. What power formula is used when in a circuit the voltage supply and the resistance are known?

Activity 1

Inside the small circle are the power and the basic electrical quantities. Write the formula for each quantity on the space provided for the purpose.



Lesson 3

Solving Unknown Values of Voltage, Current, Resistance and Power

You have just learned the different formulas used in Ohm's law and electrical power. In the preceding lesson, you learned also that the basic knowledge of Ohm's law and power law is essential to people who want to engage in electronics. Circuit analysis is always associated. It is the first step in a special circuit design and analysis.

In learning the unknown values of voltage, current, resistance and electric power, study the following examples:

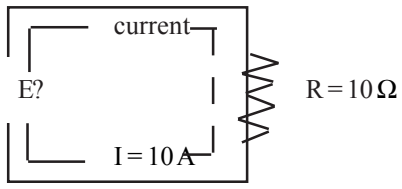
Voltage:

A. Current = 5 amperes
Resistance = 20 ohms
Voltage = ?

Since voltage is unknown, use this formula:

E = I x R; substituting the values of I and R
= 5 A x 20 Ω
E = 100 volts

B.



In the circuit above, voltage (E) is unknown. Thus, the formula is:

E = I x R; substituting the values of I and R
= 10 A x 10 Ω
= 100 volts

C. A source of voltage produces current of 2 amperes through a resistance of 15 ohms. How much is the applied voltage?

The problem asks the value of the applied voltage, hence, the formula for finding the unknown voltage is used.

E = I x R; substituting the given values of I and R
= 2 A x 15 Ω
= 30 volts

Current:

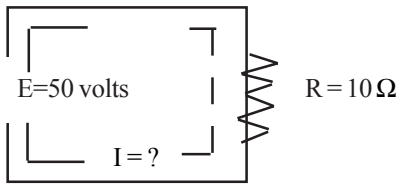
A. Voltage = 120 volts
Resistance = 30 ohms
Current = ?

This time, the current is unknown, hence, use this formula for finding current:

I = E/R, susbstituting the given values of E and R
= 120 v
30 Ω

= 4 amperes

B.



From the above circuit, current (I) is unknown, hence, the formula you are going to use is;
I = E/R; by substituting the values of E and R from the given formula;
= 50 v
10 Ω
= 5 amperes

C. A heater with a resistance of 40 Ω is connected across a 120-volt power source. How much is the current?

The problem asks the amount of current driven by a 120-volt power source, thus, we use this formula for finding unknown current:

I = E ; substituting the values of E and R from the given formula, we have
R

= 120
40 Ω

= 3 A

Resistance:

A. Voltage = 100 volts
Current = 4 amperes
Resistance = ?

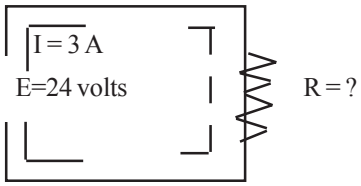
At the moment, resistance is unknown, hence use this formula:

R = E / I ; by substituting the values of E and I from the given formula

= 100 V
4 A

= 25 Ω

B.



In the circuit above, resistance (R) is unknown, so the formula used is

R = E/I; substituting the values of E and I from the given formula

= 24 V
3 A

= 8 Ω

C. How much resistance allows 24 A current driven by a 12-volt source?

The value of resistance (R) is unknown in the problem. The formula we are going to use is as follows:

R = E / I; by substituting the values of E and I from the given formula;

$= \frac{12V}{24\ A}$

$= 0.5\ \Omega$

Electrical Power:

1. A bread toaster takes 5A from the 220-volt power source. How much power is used?

   Given:
   Current (I) = 5 A
   Voltage (E) = 220 V
   Power (P) = ?

   Formula : P = I x E; substituting the values of I and E
   = 5 A x 220 V
   = 1,100 watts

2. Calculate the power in a circuit where a source of voltage produces 3 amperes of current in a 50-ohm resistance.

   Given:
   Current = 3 A
   Resistance = 50 Ω
   Power = ?

   Formula: $P = I^2 \times R$; substituting the values of I and R from the given formula
   $= (3A)^2 \times 50\ \Omega$
   = 3 x 3 x 50
   = 450 watts

3. How much is dissipated by a 2-ohm resistor with 10 volts across it?

   Given:
   Resistance = 2 Ω
   Voltage = 10 V

Power = ?

Formula: $P = E^2 / R$; substituting the values of E and R

$= (10V)^2 = 10 \times 10$

$2\ \Omega \qquad 2$

$= 100$

2

$= 50$ watts

Activity 2

Below are exercises numbered 1-10. Write the values of voltage (E), current (I), resistance (R), and power (P) in the empty squares.

EXERCISES										
	1	2	3	4	5	6	7	8	9	10
Voltage (in volts)		100	24	35	200	100		60	50	12
Current (in ampere)	5		6	5	10		8		20	2
Resistance (in ohm)	10	25		7		40	10	5		6
Power (in watt)	250	400	144		2,000	250	640	720	1,000	

Self-check

1. What power formula are you going to use when the values of current and resistance are given?
2. What should be the power formula if voltage and resistance are given?
3. The voltage of a resistor is 50 volts. The current flowing through it is 2 amperes. What is the value of the resistor?

Lesson 4

Sources of Electricity

Through the ages, man experimented on different methods of producing electricity. He applied his scientific know-how to make electric current work.

Electricity is an invisible force or energy that produces heat as in the flat iron, electric range, and soldering iron; light as in lamps and bulbs; and motion as in motors. This wonderful action of electricity makes almost everything possible.

All materials have changes in their atoms, but to do useful work, these charges must be separated for a potential difference that can make current flow. Some of the most common methods of producing electrical effects are listed below:

1. Friction - In this method, certain materials are rubbed against each other to produce charges. Electricity produced through this method is static electricity, which is usually used in laboratories and in research work.

2. Photoelectric - In this method, certain materials emit their electrons when they are exposed to light under right conditions. Some of these materials are selenium, cesium, and silicon. The electricity produced by this method is utilized in photo diodes, photo transistors, photo cells, and many more.

3. Piezo-electric - This method uses certain materials, which when made to vibrate, produce voltage. Electricity produced by this method is used in crystal microphones and crystal pick-ups, among others.

4. Thermionic emission - This method utilizes materials that release electrons when heated enough. The emitted electrons can be controlled to provide useful applications of electric current. This method is used in operating electron tubes and cathode ray tubes.

5. Chemical action - In this method, two different metals are immersed in electrolyte. Chemical reaction between them occurs thus producing voltage. This method is used in dry cells and batteries.

6. Electromagnetism - Electricity and magnetism are closely related. Any moving charge has an associated magnetic field, and any changing magnetic field can produce current. This is made possible when a conductor, such as coil of wire rotates in a magnetic field. This method is used in operating generators and alternators, the sources of commercial electricity.

7. Nuclear method - In this method, there is a breaking up of atomic structure of some elements, thus releasing a great amount of energy. This method is utilized in nuclear power plants.

Activity 3

1. Visit a battery shop and ask the owner to allow you to observe the processes involved in making batteries (storage batteries in particular). List down all the processes in proper order.
2. List down also all the materials used in making storage batteries.

Self-check:

1. What does electricity produce?
2. What is the source of commercial electricity in our country?
3. Enumerate at least five (5) electronic devices, instruments and appliances , using photoelectricity as power source.

Now that you know the different sources of electricity , you have performed your activity and you have answered the questions given in the self-check properly, you may now proceed to the next lesson.

Lesson 5

Alternating Current and Direct Current

In your study about the different sources of electricity in the preceding lesson, you learned that electromagnetism is one of the most common. Considering the fact that it was produced by generators and alternators, it is also the source of commercial electricity. This important source accounts for most of the electrical power used in homes and industry. Electricity produced is either alternating current (AC) or direct current (DC).

Alternating current (AC) is a type of current that reverses its polarity and direction regularly (at the instant, it is positive and the next instant, it is negative). In other words, it undergoes a cycle. Alternating current can have 60 cycles per second (60 cps), also known as its frequency, which is expressed in hertz. Thus, alternating current (AC) has a frequency of 60 hertz. Alternating current is produced by AC generators.

Features and Characteristics of Alternating Current

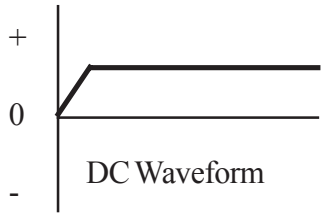
-Varies in amplitude (from minimum to maximum value) while changing polarity.

-Can be stepped up or down by a transformer.

Applications of Alternating Current

1. Alternating current is used in unlimited extent for lighting purposes, both indoor and outdoor.
2. It is used in industries and establishments to operate various machines.
3. It is used at home to operate appliances run by motors.
4. It is also for commercial electrical power distribution.
5. It is likewise used as input signals in amplifier circuits.

Direct Current (DC) is a type of current that flows in only one direction. It is produced from cells on batteries and AC generators. Below is a wave form of direct current.



DC Waveform

Features and Characteristics of Direct Current

-Fixed in polarity (positive or negative)

-Steady or varied in amplitude

Applications of Direct Current

1. DC is employed in transportation to operate engines.
2. DC is used to operate portable appliances such as the radio, TV and karaoke.
3. Used as electrode voltages of active devices in electronic circuits.

Activity 4

List down all your electrical and electronic appliances at home and identify their supply voltage, alternating current voltage (ACV) or direct current voltage (DCV).

Self-check:

Directions: Answer the following questions:

1. What is the difference between alternating current (AC) and direct current (DC)?
2. What are the applications of direct current? the alternating current?
3. What are the features and characteristics of direct current? the alternating current?

LET'S SUMMARIZE

- Ohm's law states the relationship of voltage, current and resistance.
  In an electric circuit, current is directly proportional to the applied voltage and inversely proportional to the circuit resistance.
- The ohm's law formulas are as follows:
  $I = E/R$, for finding unknown current
  $E = I \times R$; for finding unknown voltage
  $R = E/I$; for finding unknown resistance

- The electrical power formulas are as follows:
  $P = I \times E$
  $P = I^2 \times R$
  $P = E^2/R$

- The foregoing formulas are used to determine electric power consumed by electronics / electrical appliances when voltage, current, and resistance are known.
- The sources of electrical energy are friction, photoelectric, piezo-electric, thermionic emission, chemical action, electromagnetism and nuclear.
- Electricity produced by different sources is either alternating current (AC) or direct current (DC). Alternating current periodically changes its polarity and direction while direct current flows in one direction only.

POSTTEST

I. Directions: Write the word or word group that best answers each statement on the blank provided for the purpose.

_____ 1. It is the rate of doing work.
_____ 2. The rate or number of times per second that a cycle occurs.
_____ 3. It states the relationship of voltage, current, and resistance.
_____ 4. It utilizes certain materials which when made to vibrate produces voltage.
_____ 5. It is the concerted movement of free electrons.
_____ 6. It is an invisible force that produces heat, light, and motion.

_____ 7. A type of current that varies in amplitude while changing polarity.
_____ 8. It is the opposition to the flow of electric current.
_____ 9. It is the basic unit for measuring electric current.
_____ 10. It is a type of current that flows only in one direction.

II. Problem Solving

1. What should be the value of a resistor to be connected in a circuit supplied with 12 volts in order to produce a current of 0.2 ampere?
2. What is the power consumed by a bread toaster that is connected to a 220-volt source when a current of 5 amperes flow through it?
3. Determine the current flow in a circuit when a voltage source of 24 volts is applied across a resistance of 8 ohms.

KEY TO ANSWERS

Pretest

I. Multiple Choice
1. Ohm's law
2. directly proportional
3. current
4. electricity
5. piezo-electric
6. inversely proportional
7. electromagnetism
8. alternating current
9. direct current
10. chemical action
11. resistance
12. photo-electric
13. frequency
14. power
15. ampere

II. Problem Solving
1. 500 volts
2. 400 watts
3. 48 ohms

Posttest

I. Identification
1. power
2. frequency
3. Ohm's law
4. piezo-electric
5. current
6. electricity
7. alternating current
8. resistance
9. ampere
10. direct current

II. Problem Solving
1. 60 ohms
2. 1, 100 watts
3. 3 amperes