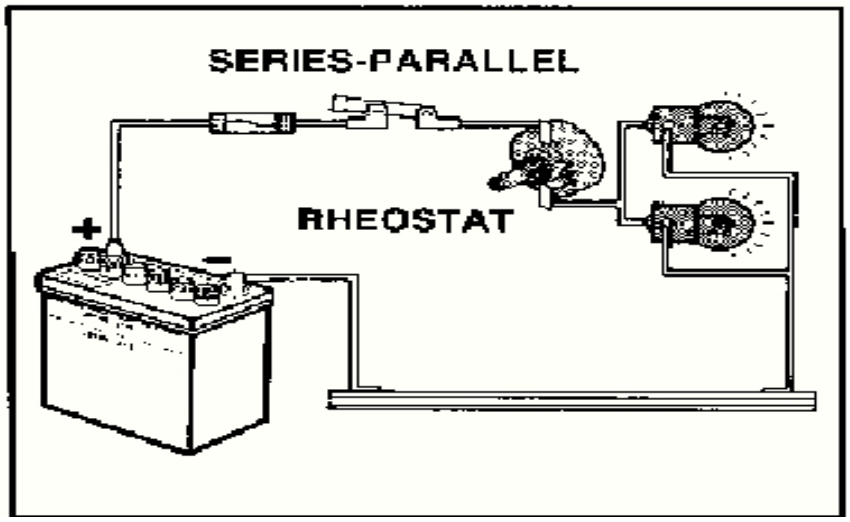
Automotive Electrical-Electronics

Level-I

Based on March 2022, Curriculum Version 1



Module Title: Apply Fundamentals of Automotive Electrical/ electronic System

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Acknowledgment

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Introduction to the Module

This Module covers the knowledge, skills and attitudes required to apply basic knowledge, skills and understanding of Electrical/electronic system as it relates to the automotive electrical/ electronic systems, components and technologies found in modern motor Vehicles. The unit involves the development of skills and knowledge that relate to the fundamental operating Principles of Automotive electrical/electronic systems.

This module is designed to meet the industry requirement under the automotive electrical/ electronic occupational standard, particularly for the unit of competency: apply automotive electrical/ electronic systems,

This module covers the units:

- Identify and locate Electrical /electronic fundamentals
- Determine method of system or component operation
- Carry out Test and measurement s of electrical/electronic systems components

Learning Objective of the Module

- Identifying and locate Electrical /electronic systems
- Determine method of system/ component operation
- Carry out Test and measurements of electrical/electronic systems components

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit, If required
5. Read the identified reference book for Examples and exercise

UNIT ONE: Identify and locate Electrical /electronic fundamentals

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Overviews of Electricity
- Common Electrical Terminology
- Electronic component or system

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Suitable and relevant sources of information are located to assist with electrical/electronic fundamentals.
- Elements of electricity/electronics are identified and located.
- Elements of electricity common terminology are applied to common terminology for automotive electrical circuits, systems and components
- Elements of electricity are applied to common electrical calculations for automotive electrical circuits, systems and components
- Location of electronic component system or component is confirmed in relation to modern vehicle configuration
- Alternative methods of system or component location are identified in relation to possible light vehicle configuration (where applicable)

1. Identify and Locate Electrical /Electronic Fundamentals

1.1. Fundamentals of Electricity

Knowing the basic principles of automotive electricity is essential for the Automotive Electrician to understand the operation of all automotive electrical systems and components. Unless you have a clear understanding of these fundamental principles, you will find it difficult to service the various electrical components and systems encountered in the Vehicle electrical system.

This understanding will enable you to make sound decisions in the troubleshooting process of all electrical systems

1.1.1 ELECTRON THEORY

Electricity is a form of energy and is produced by the movement of small atomic particles known as electrons. It can be easily transmitted or converted to other forms, such as mechanical or heat energy. To transmit electricity, conductors such as copper, steel, carbon or an electrolyte are used. Insulators such as rubber, porcelain or Bakelite are used to prevent electrical leakage from conductors. The three elements of electricity are voltage, current and resistance.

1.1.2. **Atoms and Electricity**

All matter is made up atoms.Atoms have a nucleus with electrons in motion around it.

The **nucleus** is composed of **protons** and **neutrons**.

Electrons have a negative charge (-), Protons have a positive charge (+) and Neutrons are neutral.

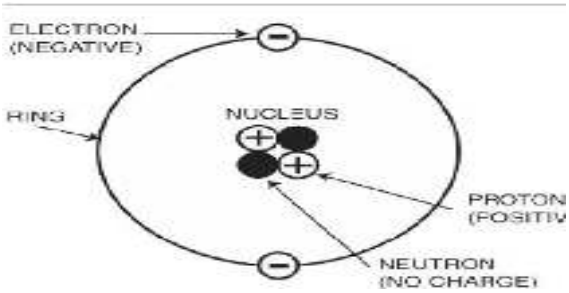


Figure: 1.1 electron flow

1.1.3.Electron Flow

The number of electrons in the outer orbit (valence shell or ring) determines the atom's ability to conduct electricity.Electrons in the inner rings are closer to the core, strongly attracted to the protons, and are called **bound electrons**. Electrons in the outer ring are further away from the core, less strongly attracted to the protons, and are called **free electrons.** Electrons can be freed by forces such as friction, heat, light, pressure,chemical action, or magnetic action.These freed electrons move away from one atom to the next. A stream of free electrons forms an electrical current.

To have a continuous flow of electricity, three things must be present:

- an excess of electrons in one place,
- a lack of electrons in another place &
- a path between the two places.

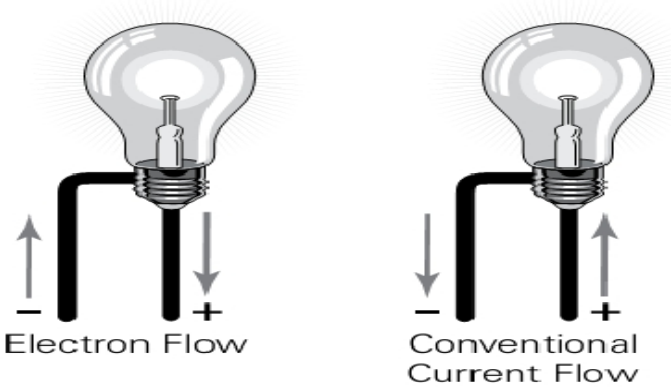


Figure:1.2 flow of electricity

1.1.4.Current Flow Theories

· Two theories describe current flow.

A. The **conventional theory, commonly used for** automotive systems, says current flows from (+) to (-).

B The **electron theory, commonly used for electronics,** says current flows from (-) to (+).

While the direction of current flow makes a difference in the operation of some devices, such as diodes, the direction makes no difference to the three measurable units of electricity: voltage, current,and resistance.

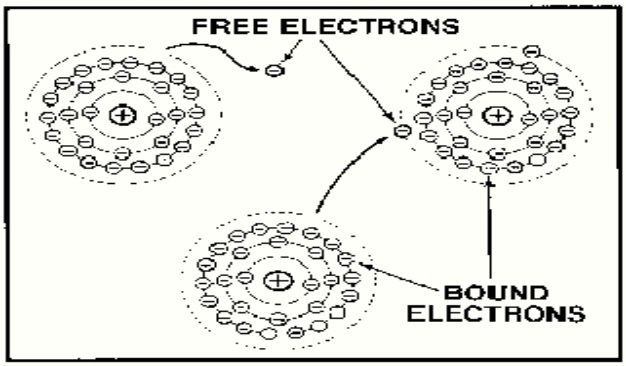


Figure: 1 .3 current flow

1.1.5. Measuring Unit & Devices

The three most commonly used instruments for measuring DC circuit values are the ammeter (a device for measuring current), the voltmeter (a device for measuring voltage) and the ohmmeter (a device for measuring resistance).

a. Ammeter

One of the problems with electricity is that we cannot see it. We have to rely on instruments to detect its presence, and to measure it. To measure current we need a "flow" meter

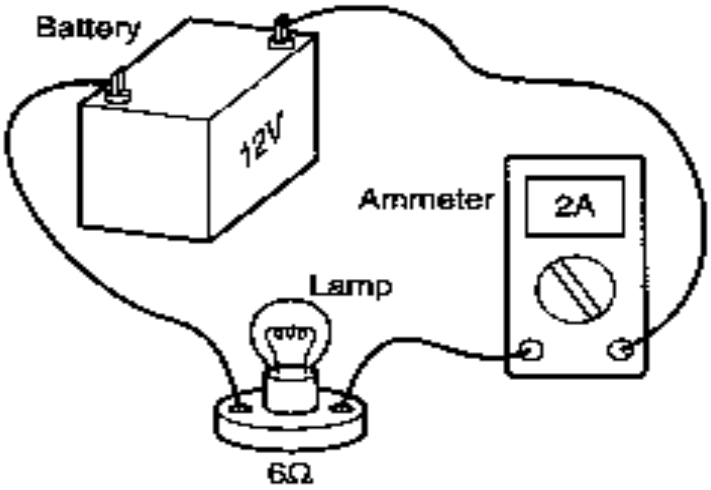


Figure: 1 .4 ammeter connection

Something we can insert so that the current will pass through and it will display the rate of flow. To work, it has to have a very low resistance so that the current can pass through without the meter itself restricting the current flow. This type of meter is called an ammeter. To use it the circuit must be broken and the meter inserted. Notice that the ammeter is connected in series with the rest of the circuit. Any current flowing must pass through the meter on its way around the circuit

b. Voltmeter

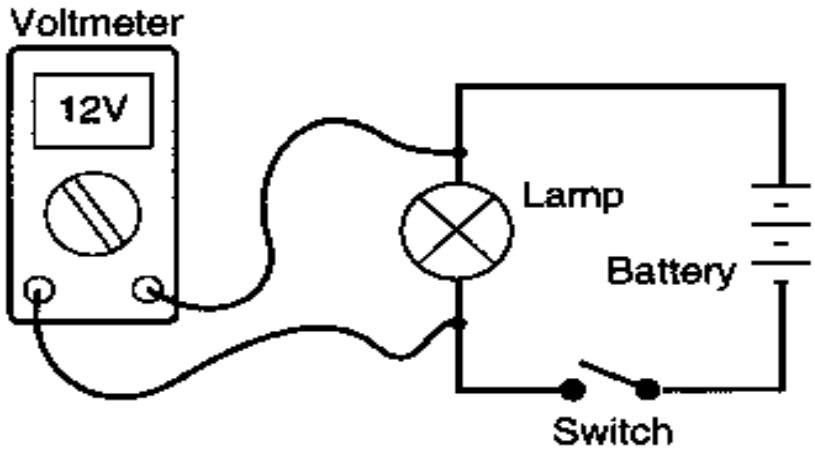


Figure: 1 .5 voltmeter connection

When current flows through a resistance some of the supply pressure (voltage) is lost across that resistance. There is a pressure difference across the resistance. Therefore a voltage difference is found across components. To measure it the voltmeter has to be connected across the component (i.e. in parallel with it).

C. Ohmmeter

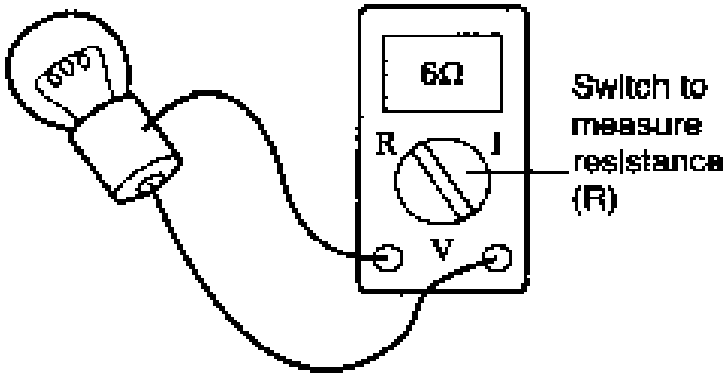


Figure: 1 .6 ohmmeter

When measuring resistance the ohmmeter provides the voltage to pass a current through the components. From the current flowing, the meter works out the resistance. It is therefore important that there are no other currents flowing. The component to be measured must therefore be disconnected from its circuit first.

d. Multi-meter

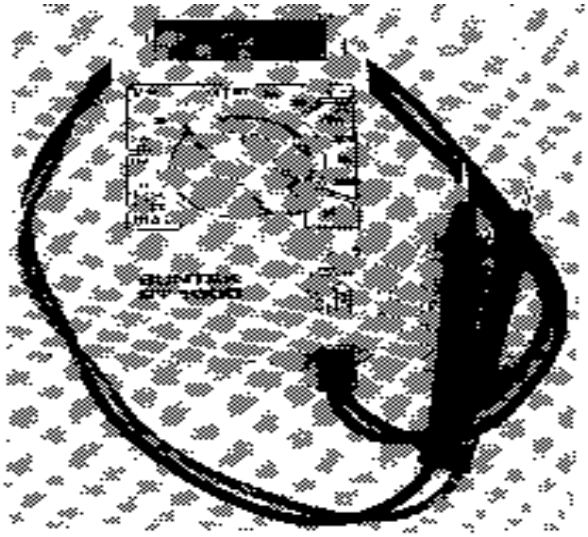


Figure: 1 .7 multi-meter

Most meters used for measuring DC circuit values by technicians are multipurpose meters or multi-meters. They are generally designed to measure voltage, resistance, and current. Therefore, a multi-meter is often called a volt-ohm-milli-ammeter, or VOM, because it can measure volts, ohms, and milli-amperes.

1.2. Common Electrical Terminology

1.2.1. Current

Electric current is a flow of electrons and is measured in amps, (short for amperes). The amp is a measure of flow rate. In other words how much electricity is flowing per second.

1 amp = 6,240,000,000,000,000,000 electrons per second

In electronic circuits a current of one amp is quite large, so often the milli-amp is used instead.

A milli-amp (mA) is a thousandth of an amp (A).

1.2.2. Voltage

Electricity does not flow through a wire unless it is pushed. There has to be an electrical pressure and this pressure is called **voltage** and is measured in volts. The symbol is V. It is also called electrical

pressure, and electromotive force (emf). This pressure can be provided by a battery, or it can be produced by a generator.

1.2.3. Resistance

The rate that the electrons pass around the circuit (i.e. the amount of current) is dependant not only on the force (voltage) but also by how much resistance there is in the circuit. Resistance is measured in ohms (Ω). If the same voltage is used in a low resistance circuit as in a high resistance circuit, more current (amps) will flow in the low resistance circuit. Because in a car the same 12V battery powers all circuits, the only way that current can vary is by varying the resistance.

1.2.4. Ohm's Law

In 1827, George ohm introduced simple mathematical formula, which relates voltage, current, and resistance. This formula is called **ohm's law**. Ohm's law says voltage is equal to current time's resistance. A force of 1V is required to push a current of 1A through a resistance of 1Ω.

$$V = I \times R \qquad (or) \qquad I = \frac{V}{R} \qquad (or) \qquad R = \frac{V}{I}$$

Where, V = Voltage in volts

I = Current in amperes

R = Resistance in ohms

1.2.5. Electrical Power

Power is indication of how much work can be accomplished in a specified amount of time, that is, arate of doing work. Since energy is measured in jou les (J) and time is measured in seconds (S), power is measured in joules per second (J/S) or watt (W).The electrical circuit of measurement for power is the

Power=work/Time, p=w/t

Where, 1watt (W) = 1juole (J)/1second(S)

1.2.6. Sources of electricity

There are several different devices that can supply the voltage necessary to generate an electric curren The two most common sources are generators and electrolytic cells.

a. Generator

Generators use mechanical energy, such as water pouring through a dam or the motion of a turbine driven by steam, to produce electricity.

The electric outlets on the walls of homes and other buildings,from which electricity to operate lights and appliances is drawn are connected to generators located in electric power stations.The voltage between the terminals drives an electric current through the appliance that is plugged into the outlet.

b. Electrolytic cells

Electrolytic cells use chemical energy to produce electricity.Chemical reactions within an electrolytic cell produce a potential difference between the cell's terminals. An electric battery consists of a cell or group of cells connected together.

c. Other sources

There are many sources of electric current other than generators and electrolytic cells.

Fuel cells produce electricity through chemical reactions, fuel cells do not store chemicals and therefore must be constantly refilled.Electricity produced directly by heating is called **thermoelectricity**.Some substances emit electrons when they are struck by light, Electricity produced in this way is called **photo electricity**.When pressure is applied to certain crystals, a potential differenceDevelops acrossthem.Electricitythusproducediscalled **piezoelectricity**. The piezoelectric effect occurs in crystalline

1.3. Electronic component system

1.3.1. Passive electronic components

Passive components do not have gain or directionality. In the perspective of electrical technology, Passive components are known as electrical components or elements.

Passive components are capacitors, inductors, resistors and diodes

1.3.2. Active electronic components

Active components have their own gain or directionality. Semiconductor devices (various Types of transistors) and vacuum tubes come under active components

Self check-1

Test-I Matching

Instruction: select the correct answer for the give choice. You have given 1 Minute for each question. Each question carries 2 Point.

A	B
-------1. Current flow from -to+	A. Electrical pressure
-------2. Voltage	B. Device for measuring voltage
-------3. Generator	C. Conventional theory
-------4. Diode	D. Passive electric components
-------5. Ammeter	E. Comprehension method
	F. Device for measuring current

Test II: Give a short Answer

Instruction: write short answer for the given question. You are provided 3 minute for each question and each point has 5Points.

1. What is the purpose of Voltage?
2. What are the basic requirements of continuous electron flow
3. 3. Explain Current Flow Theories
4. What is ohm's law, proof it?
5. Mention the source of electricity

Operation sheet 1.1. Calculate Voltage and Current circuit connected in series with two lamps and 3-ohms resistance with 12v source.

Operation title: Application of ohms law principle

Purpose: To practice simple circuit calculation

Instruction: Use the given above information, in this operation you have given 25minuts.

Tools and requirement:

1. Flexible wire
2. lamps
3. battery
4. Switches

Precautions: Be carefully to make electric short and burned of circuit

Steps in doing the task

Step-1: Use the given above circuit components

Step-2: connect each lamps in series correctly

Step-3: calculate the above parameters correctly

Step-4: Report the result

Lap Test-1.1

Task-1: Connect three 12v automotive battery in parallel

Task-2: Connect Ammeter with lamp and battery

UNIT TWO: Determine Electric Circuit System

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Electrical test equipment
- Circuit Diagrams
- Most common electrical circuit problems
- Methods of identifying electrical circuit problems

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Appropriate electrical test equipment is identified and applied for the purpose of testing circuit diagram, system or component
- System or component is examined and sub-assembly components are identified
- Operational principles of circuit, component and system functions are determined and interpreted.
- System or component relationship to light vehicle operation is determined
- Potential for unsafe conditions or associated risk factors with system or component operation or testing is identified
- Potential common faults with system or component are identified appropriate electrical test equipment is identified and applied for the purpose of testing circuit, system or component

2. Determine Electric Circuit System

2.1. Electrical test equipment

Various electrical tests and testing devices are used by an automotive technician

a. Jumper Wire

- ✓ Handy for testing switches, relays, solenoids, wires, and other components
- ✓ Jumper can be substituted for a component such as a switch

If the circuit begins to function with the jumper in place, the component being bypassed is defective

b. Test Light

- Used to quickly check a circuit for power
- To use a test light:
  - connect the alligator clip to ground
  - touch the pointed tip to the test point in the circuit
  - if power is present, the light will illuminate

c. Self-Powered Test Light

- Used to check for a complete electrical path
- To use a self-powered test light:
  - disconnect the circuit power source
  - connect the test light leads across the desired part of the circuit
  - if the light illuminates, the circuit or part has continuity

Voltmeter, Ammeter, Ohmmeter and Multi-meter are also electrical tests and testing devices used by an automotive technician

2.2. Types of electrical circuits and ohms laws

Circuit is a complete path that electrons travel from a power source

(such as a battery) through a **load** such as a light bulb and back to the power source.

 The current must start and finish at the same place (power source). Most automotive circuits conta in five basic parts

1. Power source - such as a generator or battery.
2. Conductors - wires that provide a path for current flow and insulators - keep electricity in the conductors and load
3. load - a device that changes the electrical energy to usable form of energy such as mechanical, light, sound, magnetism or heat.
4. Controllers - such as switches or relays, that control or direct the flow of electrons
5. Circuit protection – devices such as fuses and circuit breakers.

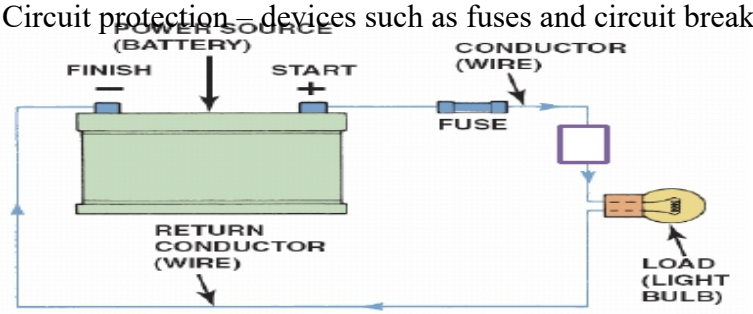


Figure:2.7 Circuit connection with load

2.2.1 Series circuits

In a series circuit, there is only one current path. The same battery current flows through each component. A breakage in the path would cease the function of all the equipments The total resistance in a series circuit is the sum of the individual resistors. This is written as:

$$R_{total} = R_1 + R_2 + R_3$$

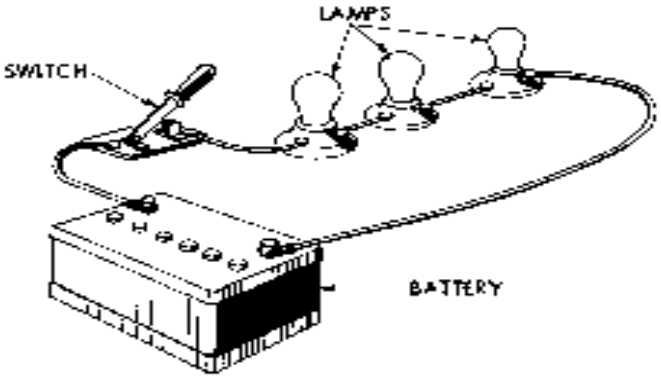


Figure:2.8 series circuit

Example:

- In this series circuit with a 2 ohm resistor and a 4 ohm resistor, current (2 amperes) is the same throughout, even though the voltage drops across each resistor are different
- Electrical loads or resistance connected in series behave following **series circuit laws** .

LAW 1 The total resistance in a series circuit is the sum total of the individual resistances.

LAW 2 The current is the same throughout the entire circuit.

LAW 3 Although the current (in amperes) is constant, thevoltage drops across each resistance in the ci rcuit can vary at each resistor.

All current flows through all resistances (bulbs). The totalresistance of the circuit is the sum of the individualresistances of each bulb, and the bulbs will light dimly because of the increased resistance and the reduction of current flow (amperes) through the circuit.

- In a series circuit, the voltage is dropped or lowered by each resistance in the circuit. The higher the resistance is, the greater the drop in voltage.

2.2.2. Parallel circuits

In a parallel circuit, there is more than one current path. The current splits up, with the greater current flowing through the smallest resistance. A breakage in any one path would not interfere with the operation of the remainder of the units in the circuit.

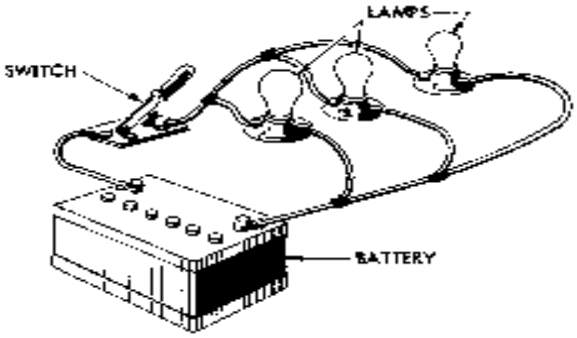
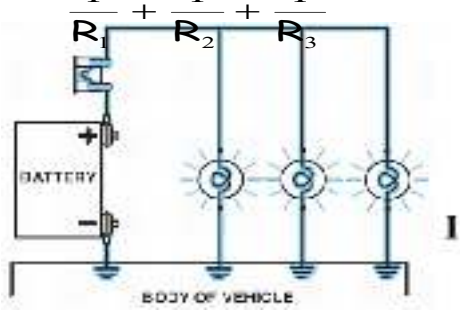


Figure2.9 Parallel circuits

The total resistance in a parallel circuit is found by using the formula:

$$R_{total} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Example:



$$I_T = I_1 + I_2 + I_3 \ldots + I_N$$

A typical parallel circuit used in vehicles includes many of the interior and exterior lights

LAW 1 :The total resistance of a parallel circuit is always less than that of the smallest-resistance leg.

LAW 2 :The voltage is the same for each leg of a parallel circuit.

LAW 3 :The sum of the individual currents in each leg will equal the total current.

The current in a parallel circuit splits (divides) according to the resistance in each branch.Each branch 12v appliad to the resirtors

2.2.3. Series-parallel circuits.

A circuit is an endless path formed by a conductor from a source of electrical supply to the control, through the load, and back to the source. There are various types of electrical circuits used in the modern automobile, among them the series, and parallel circuits

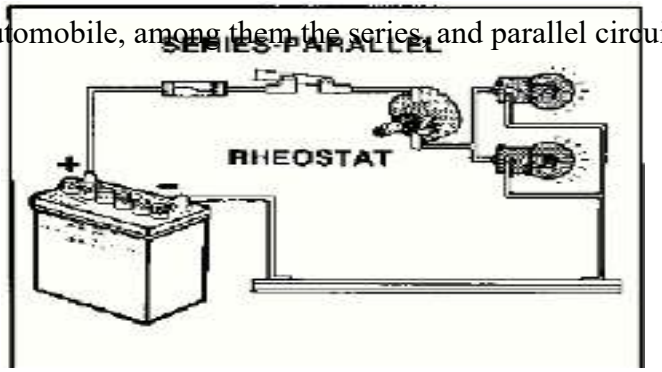
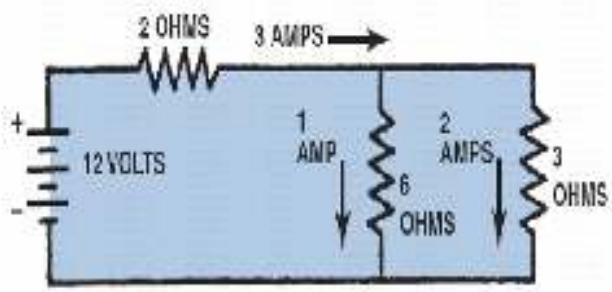


Figure:2.10 Series-parallel circuits

Example



2.3. Most common electrical circuit problems

2.3.1. Open Circuits

An **open circuit** is any circuit that is not complete, orthat lacks continuity, such as a broken wire, therefore no current can flow.

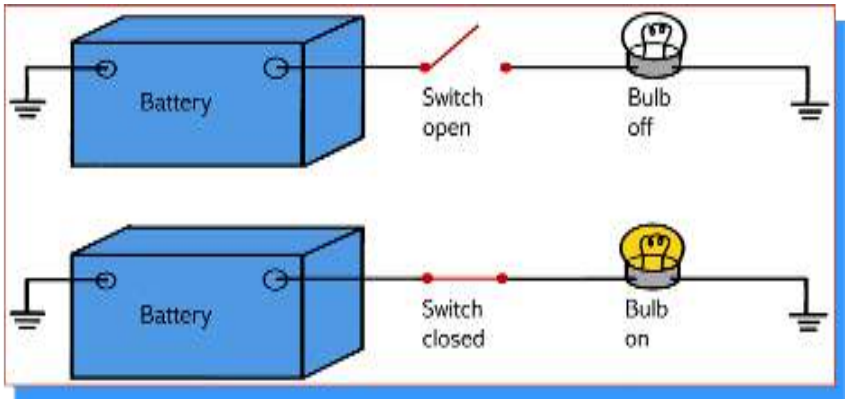
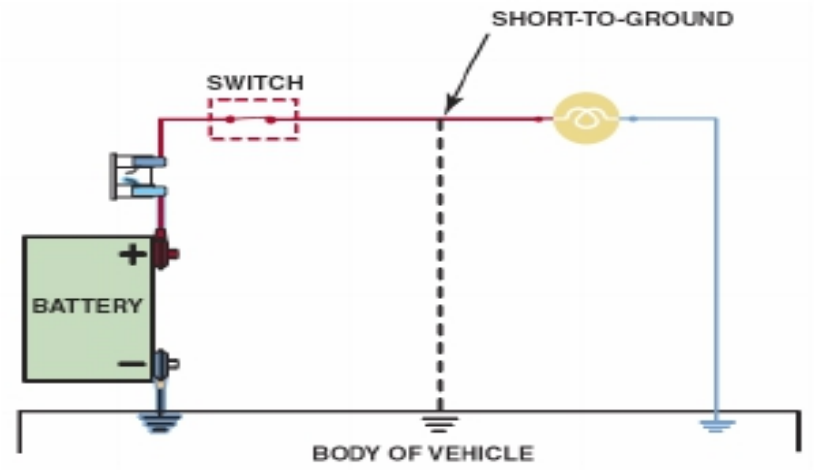


Figure: 2.11 Open Circuits

2.3.2. Short Circuit

A short circuit:Is a complete circuit in which the current bypasses some or all of the resistance in the circuit.

- Involves the power side of the circuit.
- Involves a copper-to-copper connection.
- Is also called a short-to-voltage.
- May or may not blow a fuse.
- **A fuse or circuit breaker** opens the circuit to prevent possible overheating
- damage in the event of a short circuit.



2.3.3.High Resistance circuit

- High resistance can be caused by any of the following:
  - Corroded connections
  - Loose terminals in a connector
  - Loose ground connection

Self check-2

Test-I Matching

Instruction: select the correct answer for the give choice. You have given 1 Minute for each question. Each question carries 2 Point.

A	B
-------1. Test light	A. Corroded connection
-------2. Controllers	B. Only one current path
-------3. Circuit protection	C. Fuse &circuit breaker
-------4. Series circuit	D. Easily check circuit
-------5.Causes of high resistance	E. Switch/relay
	F. Electric load

Test II: Give a short Answer for the following question

Instruction: write short answer for the given question. You are provided 3 minute for each question and each point has 5Points.

1. Draw and explain the d/t b/n series, parallel and series-parallel circuit?
2. Mention the most common electrical circuit problems
3. What is the difference between open circuit and grounded circuit?
4. Which value is constant and varies in parallel and series circuit?
5. Connect Ammeter and Ohmmeter correctly in a circuit

Operation sheet 2.2. Check Electric circuit common faults.

Operation title: Identify electrical circuit problems

Purpose: To practice pin point circuit problems

Instruction: Use the given above information, in this operation you have given 25minuts.

Tools and requirement:

1. Flexible wire
2. Lamps
3. Battery
4. Switches
5. Test lamp
6. Multi-meter

Precautions: Be carefully to make electric short and burned of circuit

Steps in doing the task

Step-1: Use the given above circuit connection

Step-2: Use appropriate safety requirement

Step-3: select and use testing equipment

Step-4: Identify circuit faults

Step-4: Report the result

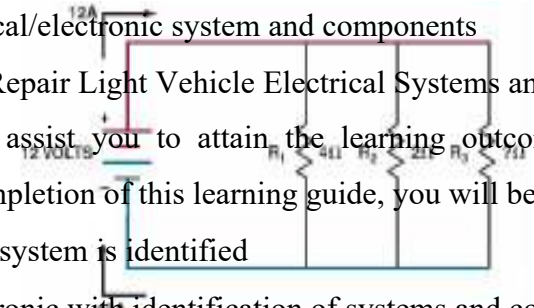
Lap Test-2.

Task-1: Connect one-24vbattery with two -12v battery at the same time on a charger

Task-2: Calculate total voltage using the following circuit

Task-3: Calculate Resistance R3 using the following circuit

UNIT THREE: Carry out Test and measurements of electrical/electronic systems
This unit to provide you the necessary information regarding the following content coverage and topics: • Requirements of Workplace Health and Safety (WHS) Testing electrical/electronic system and components • Testing electrical/electronic system and components • Maintain and Repair Light Vehicle Electrical Systems and Components This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Component or system is identified • electrical/electronic with identification of systems and components are tested • electrical/electronic systems components are measured • Workplace Health and Safety (WHS) requirements are applied



3. Test and measurements of electrical/electronic systems components

3.1. Requirements of Workplace Health and Safety (WHS)

3.1.1. Work shop Safety

- ❖ Floors and work areas should be kept clean and organized.
- ❖ Keep all tools and equipment clean, dressed, and organized.
- ❖ Memorize the location of all safety and first aid equipment
- ❖ Deactivate the high voltage system before any service is performed.
- ❖ Follow all manufacturer's warnings and procedures.

3.1.2. Personal Safety

- Wear appropriate clothes, shoe ...
- Ensure the work shop hazard free
- The vehicle must park on straight surface
- The area must be clean

3.1.3. Precautions:-

- ➢ Ensure work area hazard free.
- ➢ Keep yourself from electric shock
- ➢ Keep yourself from danger & injury workings. may be the safety &hydraulic jack will be slept by it self
- ➢ know and implement the correct procedures
- ➢ apply wearing of protective cloths

3.2 Testing electrical/electronic system and components

3.2.1. Electronic system components

In electronic systems, the components are solid state and do not have moving parts Solid state circuits use semiconductors

a. Semiconductor

- Substance capable of acting as both a conductor and an insulator
- this enables semiconductor devices to control current without mechanical points
- Semiconductor devices include:
  - ✓ diodes
  - ✓ transistors
  - ✓ integrated circuits
- Diode

An "electronic check valve" that allows current to flow in only one direction

- ✓ when a diode is forward biased, it acts as a conductor
- ✓ when a diode is reverse biased, it acts as an insulator

- Transistor

Allows the control of a high current circuit with a low current circuit

- ✓ performs the same basic function as a relay

- Acts as a remote switch or current amplifier
- Operates more quickly than a mechanical device can
- Has no moving parts to wear or deteriorate
- Transistor Operation
- Small base current energizes the semiconductor material, changing it from an insulator to a conductor
- Higher current can pass through the collector and emitter terminals
- Capacitors

✓ Devices used to absorb unwanted electrical pulses, such as voltage fluctuations

✓ Used in various types of electrical and electronic circuits

✓ Connected to the supply wires for the car radio

- ❍ absorbs alternator or ignition system "noise" that may be heard in the speakers

- Integrated Circuit (IC)

Figure: 3.1 Contains microscopic diodes, transistors, resistors, and capacitors in a wafer-like chip

- Printed Circuit

✓ Uses flat conductor strips mounted on an insulating board

✓ Reduces weight and bulk by replacing separate wires

Circuit tester

A. Using Jumper Cable is used to check (diagnose) a circuit by bypassing The switch or to provide a power

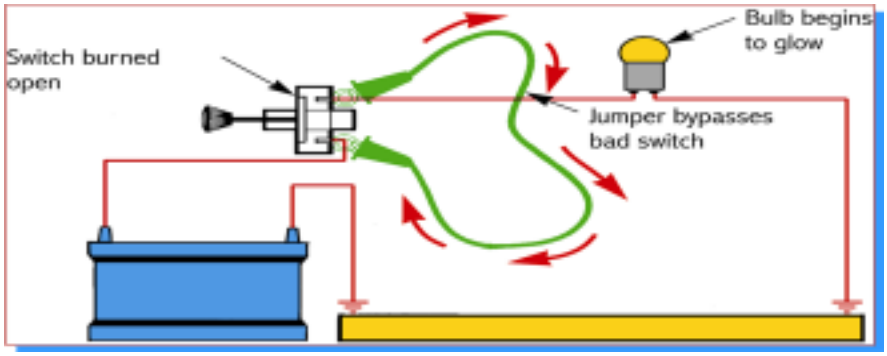


Figure 3.2 diagnosis using jumper cable

B. Using Test lamp checking fuse, Used to quickly check a circuit for power

To use a test light:

- ✓ Connect the alligator clip to ground
- ✓ Touch the pointed tip to the test point in the circuit, if power is present, the light will illuminate

Figure 3.3.fuse check

C. Self-Powered Test Light

Used to check for a complete electrical path

To use a self-powered test light:

- ✓ Disconnect the circuit power source
- ✓ Connect the test light leads across the desired part of the circuit
- ✓ If the light illuminates, the circuit or part has continuity

Self check-3

Test-I Matching

Instruction: Match column B with A. You have given 1 Minute for each question. Each question carries 2 Point.

A	B
---------1. Diode	A Parallel connected
---------2. Semi-conductor	B. Keep yourself from eclectic shock
---------3. Transistor	C. Act as a remote
---------4. Printed circuit	D. Check valve
---------5. Precaution	E. Solid state component
	F. Flat conductor

Operation sheet 3.3 .Identifying categories of semi conductors and their function

Operation title: Identification methods of semi conductors

Purpose: To identify semi conductors from other electrical components

Instruction: Use the correct electrical safety procedure. You have given 15Minut for the task and you are expected to categories and demonstrate function of semi conductors with the given components

Tools and requirement:

1. Multi-meter
2. Voltage regulator/stabilizer

Steps in doing the task

1. Follow the correct safety procedure
2. Identify semi conductors
3. Demonstrate each function

Precautions: Don't touch sensitive parts with dust.

Lap Test-3

Task-1: Test functionality of Printed Circuit/dash board

Task-2: Check diode

Task-3: Check functionality of relay