ATOMOTIVE MECHANICS

Level – I

Based on March 2022, Curriculum Version 1

Module Title: Apply Automotive Electrical System Fundamentals

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Table of content

Acknowledgment

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Introduction to the Module

In automotive mechanics filed; the Applying Automotive Electrical System Fundamentals helps to know the electrical/electronic fundamentals; to identify automotive electrical/electronic systems component; to locate automotive electrical/electronic systems and components and to determine automotive electrical/electronic method of system or component operation for automotive mechanics filed.

This module covers the knowledge, skill and attitude required to apply basic electricity/electronic as it relates to the electrical systems, components and technologies found in modern motor vehicles. **Applying Automotive Electrical System Fundamentals**

This module covers the units

- Electrical/electronic fundamentals
- Electrical/electronic Systems components and WHS,
- Location of automotive electrical/electronic systems and components and
- Operation of automotive electrical/electronic system or component

Learning Objective of the Module

- Identify and apply electrical/electronic fundamentals
- Identify systems components and apply WHS
- Locate systems and components
- Determine method of system or component operation

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 and
5. Read the identified reference book for examples and exercise

Unit one: Electrical/electronic fundamentals

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

- Basic theory and principles of electricity/electronics
- Common terminology of electricity
- Ohms law
- Types of Electrical circuits

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:

- Know basic theory and principles of electricity/electronics
- Identifying Common terminology of electricity
- Understand Ohms law
- Determine types of electrical circuits

1.1 Basic theory and principles of electricity/electronics

The universe consists of atoms and every atom contains at least one electron. An electron is the smallest particle of an atom and has a negative electric charge. When the movement of electrons is controlled, they are capable of doing work.

The molecule is the smallest part of matter that can be recognized as that particular matter. Sub-division of the molecule results in atoms, which are the smallest part of matter. The atom consists of a central nucleus made up of protons and neutrons. Around this nucleus orbit electrons, like planets around the sun. The neutron is a very small part of the nucleus. It has equal positive and negative charges and is therefore neutral and has no polarity. The proton is another small part of the nucleus, it is positively charged. The neutron is neutral and the proton is positively charged, which means that the nucleus of the atom is positively charged. The electron is an even smaller part of the atom, and is negatively charged. It orbits the nucleus and is held in orbit by the attraction of the positively charged proton. All electrons are similar no matter what type of atom they come from.

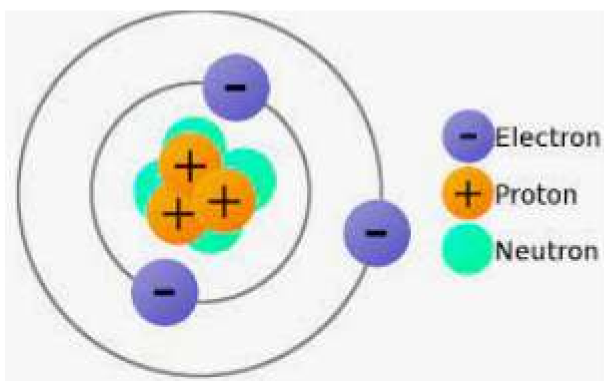


Figure 1-1atoms

When atoms are in a balanced state, the number of electrons orbiting the nucleus equals the number of protons. The atoms of some materials have electrons that are easily detached from the parent atom and can therefore join an adjacent atom. In so doing these atoms move an electron from the parent atom to another atom (like polarities repel) and so on through material. This is a random movement and the electrons involved are called free electrons Materials are called conductors if the electrons can move easily. In some materials it is extremely difficult to move electrons from their parent atoms. These materials are called insulators.

1.1.1 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 is 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.

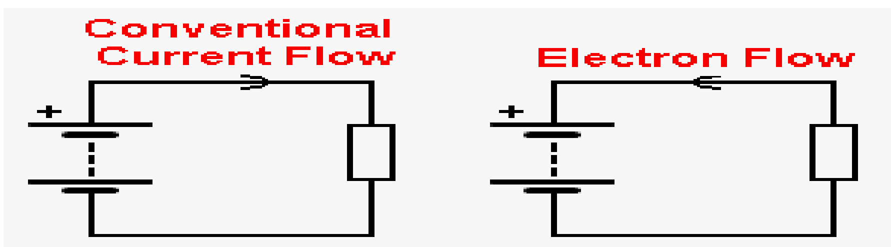


Figure 1-2 flow of electricity

1.1.2 Current Flow Theories

There are two theories describe current flow.

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

.

1.2 Measuring Tools and Equipments

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).

1.2.1 Ammeter

An ammeter (abbreviation of Ampere meter) is a measuring instrument used to measure the current in a circuit. Electric currents are measured in amperes (A), hence the name. The ammeter is usually connected in series with the circuit in which the current is to be measured.

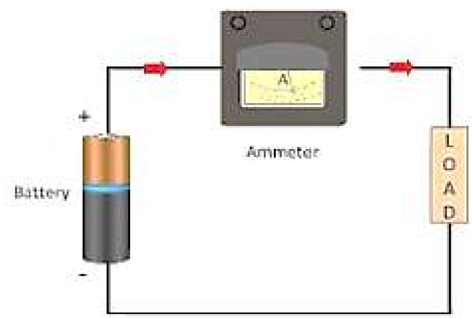


Figure 1-3 Ammeter connection

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.

1.2.2 Voltmeter

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).

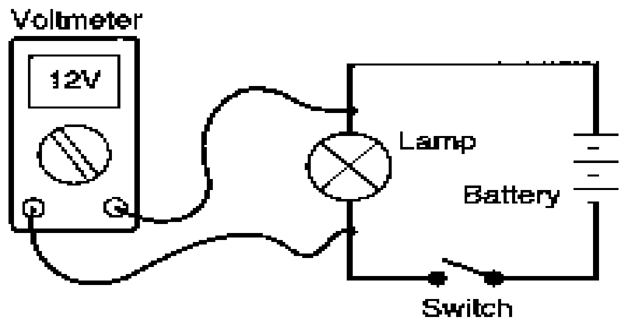


Figure 1-4 Voltmeter connection

1.2.3 Ohmmeter

An ohmmeter is an electrical instrument that measures electrical resistance. Multimeter also functions as ohmmeters when in resistance-measuring mode.

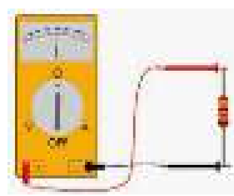


Figure 1-5 Ohmmeter

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.

1.2.4 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-ampere-ammeter, or VOM, because it can measure volts, ohms, and amperes.

Figure 1-6 Multi-meter

1.2.5 Test Light

A test light, test lamp, voltage tester, or mains tester is a piece of electronic test equipment used to determine the presence of electricity in a piece of equipment under test.

Figure 1-7 Test light

1.2.6 Soldering Equipment

A. Soldering iron: A soldering iron is a hand tool used in soldering. It supplies heat to melt solder so that it can flow into the joint between two work pieces. A soldering iron is composed of a heated metal tip and an insulated handle.

Figure 1-8 Soldering iron

B. Soldering Gun: A soldering gun is an approximately pistol-shaped, electrically powered tool for soldering metals using tin-based solder to achieve a strong mechanical bond with good electrical contact.

Figure 1-9 Soldering gun

1.2.7 Diagonal Cutters

Diagonal cutters often used for cutting the end of cable ties flush to cutting wire.

Figure 1-10 Diagonal Cutters

1.2.8 Wire Strippers

A **wire stripper** is a small, hand-held device used to strip the electrical insulation from electric wires.

Figure 1-11 Wire Strippers

1.2.9 Wire Crimpers

A crimping tool is any tool that is designed to “crimp” a connector onto the end of a length of wire.

Figure 1-12 Wire Crimpers

1.3 Common terminology of electricity

1.3.1 Electrical loads

An electrical load is any electrical device or component that consumes electrical energy and converts that energy into another form. As part of any electrical circuit, the component transforms current into something useful, commonly motion, light, or heat. An electric lamp, resistor, or even a motor are simple examples. The term may also refer to the power consumed by a circuit. This is opposed to a power source, such as a battery or generator, which produces power. The following are some of the different types of electrical load are **resistive load**, **inductive load** and **capacitive load**

1.3.2 Voltage

Voltage is the amount of potential energy between two points on a circuit. One point has more charge than another. This difference in charge between the two points is called voltage. It is measured in volts, which, technically, is the potential energy difference between two points that will impart one joule of energy per coulomb of charge that passes through it (don't panic if this makes no sense, all will be explained). The unit "volt" is named after the Italian physicist Alessandro Volta who invented what is considered the first chemical battery. Voltage is represented in equations and schematics by the letter "V".

1.3.3 Amperage

Amperage is the strength of a current of electricity expressed and measured in amperes (called amps for short). Amperage is used to measure the flow of electrical current.

1.3.4 Resistance

Resistance is a measure of the opposition to current flow in an electrical circuit. Resistance is measured in ohms, symbolized by the Greek letter omega (Ω). Ohms are named after Georg Simon Ohm (1784-1854),

All materials resist current flow to some degree. They fall into one of two broad categories:

a). **Conductors:** Materials that offer very little resistance where electrons can move easily. Examples: silver, copper, gold and aluminum.

b). Insulators: Materials that present high resistance and restrict the flow of electrons. Examples: Rubber, paper, glass, wood and plastic.

Resistance can have a wide range. It can be as low as that of a good conductor or as high as some good insulators.

1.3.5 Electrical power

Electric power is the rate, per unit time, at which electrical energy is transferred by an electric circuit. The electrical power can be categorized into two types based on the nature of electrical current flow. The two types of electrical currents are Direct current (DC) & Alternating current (AC). Therefore, the types of electrical power are **DC power & AC power** explained below.

1.4 Ohm's law

In 1827, a German mathematics professor, Georg Ohm, published a book that included his explanation of the behavior of electricity. His thoughts have become the basis for a true understanding of electricity. He found it takes 1 volt of electrical pressure to push 1 ampere of electrical current through 1 ohm of resistance. This statement is the basic law of electricity. It is known as Ohm's law.

For most conductors, the current which will flow through them is directly proportional to the voltage applied to them. The ratio of voltage to current is referred to as resistance. If this ratio remains constant over a wide range of voltages, the material is said to be 'ohmic'. The resistor could be a fog light, the voltage source could be a battery, and the conductor could be a copper wire (Figure 1 13). In any electrical circuit, current (I), resistance (R), and voltage (E) are mathematically related. This relationship is expressed in a mathematical statement of Ohm's law. Ohm's law can be applied to the entire circuit or to any part of a circuit. The voltage (E) in a circuit is equal to the current (I) in amperes multiplied by the resistance (R) in ohms.

$$V = I \times R \rightarrow \text{or} \rightarrow I = \frac{V}{R}$$

Where, I = Current in ampere, V= Voltage in volts and R= Resistance in ohms

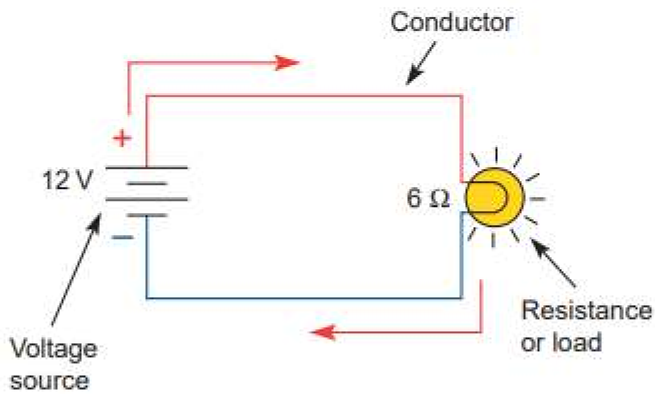


Figure 1-13 A simple circuit consists of a voltage source, conductors, and a resistance or load

1.5 Types of Electrical circuits

An electrical circuit is the combination of different active and passive components such as resistors, capacitors, inductors, diodes, transistors etc. which form an electrical network. In a closed-loop circuit, the electric current flows from the source (such as battery) in the conducting material (e.g. wires and cables) to the load (i.e. light bulb) and hence returns back to the source.

A complete electrical circuit exists when electrons flow along a path between two points. In a complete circuit, resistance must be low enough to allow the available voltage to push electrons between the two points. Most automotive circuits contain five basic parts.

1. **Power sources**, such as a battery or alternator, that provide the energy needed to cause electron flow
2. **Conductors**, such as copper wires, that provide a path for current flow
3. **Loads**, which are devices that use electricity to perform work, such as light bulbs, electric motors, or resistors
4. **Controllers**, such as switches or relays, that control or direct the flow of electrons
5. **Circuit protection devices**, such as fuses, circuit breakers, and fusible links

There are many types of electrical circuits such as:

- ✓ Open Circuit
- ✓ Closed Circuit
- ✓ Short Circuit
- ✓ Series Circuit
- ✓ Parallel Circuit
- ✓ Series-Parallel Circuit
- ✓ D.C. Circuit
- ✓ A.C. Circuit
- ✓ Integrated circuit

1.5.1 Open Circuit

A circuit which has no return path for current to flow in it (i.e. which is not completed) is known as an open circuit. In other words, a circuit where **voltage tends to the EMF (of generating source) and no current is flowing at all** is called an open circuit.

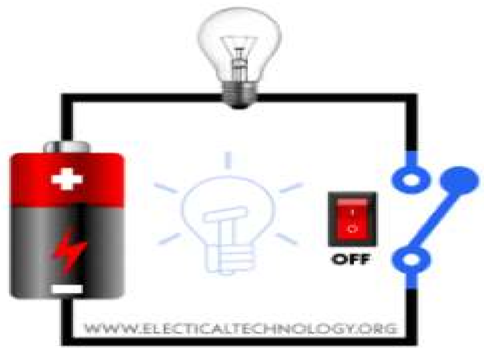


Figure 1-14 Open circuit

1.5.2 Closed Circuit

A circuit which has a return path for current to flow in it (i.e. completed circuit) is known as closed circuit

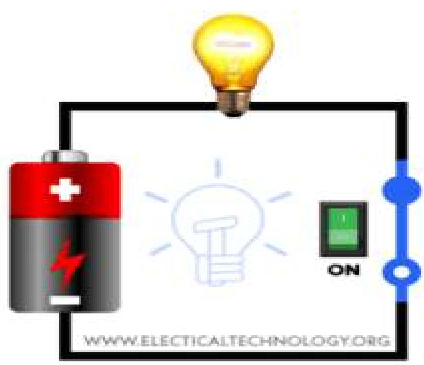


Figure 1-15 Closed Circuit

1.5.3 Short Circuit

A short circuit is a circuit that has a return channel for current to flow in it (i.e. completed circuit). A short circuit is a circuit in which the voltage tends to infinity and the current tends to zero. A short circuit occurs when both points (+ and –) of a voltage source in a circuit become connected for any reason. In this case, the maximum current begins to flow. Short circuits occur when conducting electrical lines become joined or even due to shorting in the load. In other words, a circuit where **voltage tends to zero and current tends to infinity** is called a short circuit.

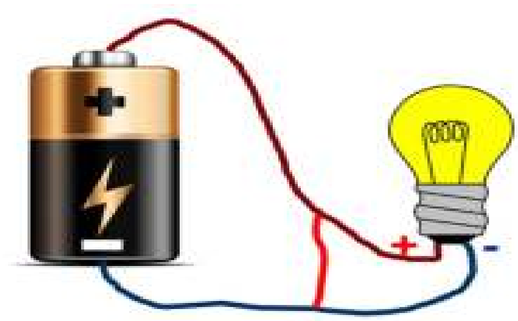
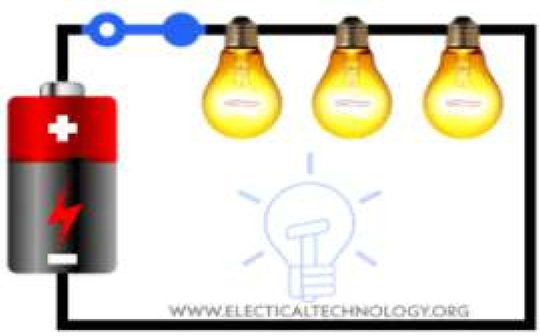


Figure 1-16 Short Circuit

1.5.4 Series Circuit

All of the electrical parts (voltage or current sources, inductors, capacitors, resistors, and so on) are connected in series in this circuit, which means there is only one path for electricity to go and no additional branches. In these circuits, all the electrical elements (Voltage or Current sources, inductors, capacitors, resistors etc) are connected in series i.e. There is only one path for traveling electricity e.g. these are single branch circuits.

a). 

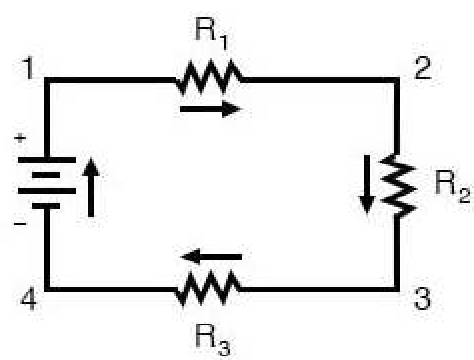
b). 

Figure 1-17 Series Circuit

A). Calculating Resistance, voltage and current for a Series Circuit

The three principles you should understand regarding series circuits:

1. **Current**: The amount of current is the same through any component in a series circuit.

$$I_{Total} = I_1 = I_2 = I_3 = ... = I_n$$

2. **Resistance**: The total resistance of any series circuit is equal to the sum of the individual resistances.

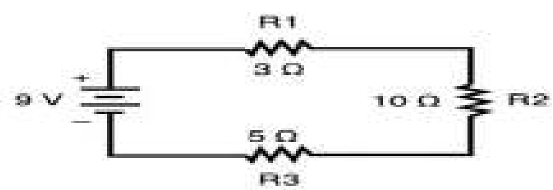
$$R_{Total} = R_1 + R_2 + R_3 + ... + R_n$$

3. **Voltage**: The supply voltage in a series circuit is equal to the sum of the individual voltage drops.

$$V_{Total} = V_1 + V_2 + V_3 + ... + V_n$$

$$V_{Total} = I \times R_1 + I \times R_2 + I \times R_3 + ... + IR_n$$

Example1. Calculate the equivalent resistance for the circuit which is connected to 9V battery and also find the potential difference across 3 Ω, 10Ω and 5 Ω resistors in the circuit shown below.calculate the amount of current passing on the circuite?



<u>Given</u>: V_T=9V, R_1=33 Ω, R_2=10Ω and R_3=5 Ω …. R_T=18 Ω

Required: current (I) =?

Solution: I=V_T/R_T=9V/18 Ω=**<u>0.5 A</u>**

1.5.5 Parallel Circuit

A parallel circuit has branches that divide the current so that just a part of it passes through each branch. On the other hand, the essential concept of a "parallel" connection is that all components are linked across each other's leads. No matter how many components are connected in a purely parallel circuit, there are never more than two sets of electrically common points. There are numerous current flow pathways, but only one voltage exists across all components:

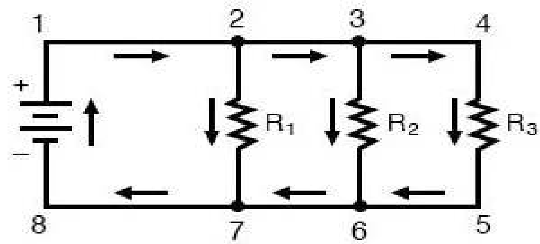


Figure 1-18 Parallel circuite configration

Three Laws of a Parallel Circuit

There are three fundamental relationships concerning voltage, current, and resistance in all parallel circuits.

1. **Voltage**: In a parallel circuit, each load resistor acts as an independent branch circuit and because of this, each branch "sees" the entire voltage of the supply.

Total voltage of a parallel circuit has the same value as the voltage across each branch.

$$V_{Total} = V_1 = V_2 = V_3 .... = V_n$$

2. **Current**: A parallel circuit has more than one path for current flow. The number of current paths is determined by the number of load resistors connected in parallel.

Total current in a parallel circuit is the sum of the individual branch currents.

$$I_{Total} = I_1 + I_2 + I_3 + ... + I_n$$

3. **Resistance**:Whenever more resistances are connected in parallel, they have the effect of reducing the overall circuit resistance.

The net resistance of a parallel circuit is always less than any of the individual resistance values.The overall resistance is commonly determined using the reciprocal equation:

$$\frac{1}{R_{Total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ... + \frac{1}{R_n}$$

Three resistors R_1=1Ω, R_2=2Ω, and R_3=2Ω are connected in parallel. The parallel connection is attached to a V=3V voltage source.

a). What is the equivalent resistance?

b). Find the current supplied by the source to the parallel circuit?

Answer a). $$\frac{1}{R_{Total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{1\Omega} + \frac{1}{2\Omega} + \frac{1}{2\Omega} = \frac{1}{R_{Total}} = \frac{4}{2\Omega} \Rightarrow R_{Total} = 0.5\Omega$$

Answer b). $$I_{Total} = \frac{V_{Total}}{R_{Total}} = \frac{3V}{0.5\Omega} = 6A$$

1.5.6 Series-Parallel Circuits

A series-parallel circuit, or combination circuit, combines both series and parallel connections. Most electronic circuits fall into this category. Series-parallel circuits are typically used when different voltage and current values are required from the same voltage source.

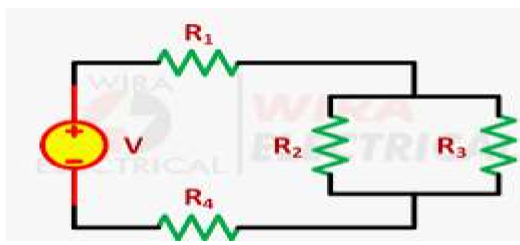
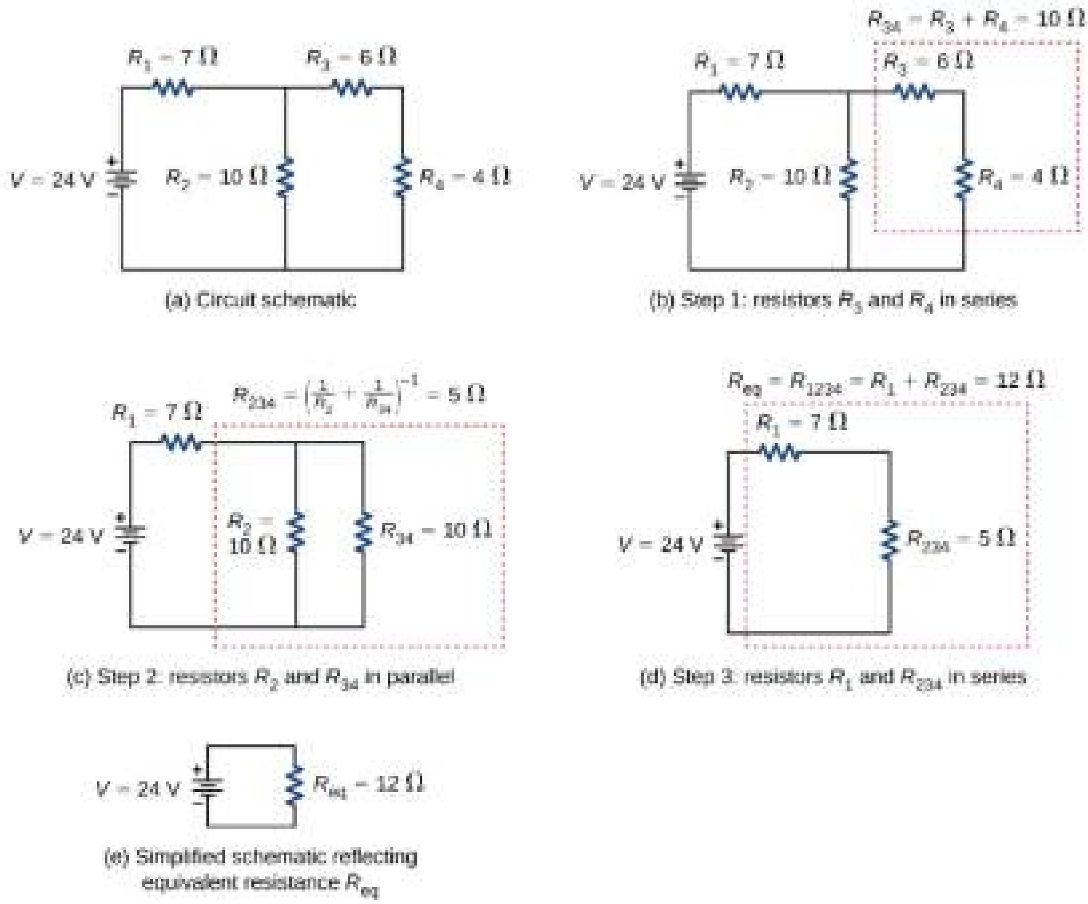


Figure 1-19 Series-parallel circuite

Combinations of series and parallel can be reduced to a single equivalent resistance using the technique illustrated in figure below. Various parts can be identified as either series or parallel connections, reduced to their equivalent resistances, and then further reduced until a single equivalent resistance is left. The process is more time consuming than difficult. Here, we note the equivalent resistance as



a). The original circuit of four resistors.

b). Step 1: The resistors R3 and R_4 are in series and the equivalent resistance is R_{34}=10 Ω.

c). Step 2: The reduced circuit shows resistors R_2 and R_{34} are in parallel, with an equivalent resistance of R_{234}=5 Ω.

d). Step 3: The reduced circuit shows that R_1 and R_{234} are in series with an equivalent resistance of R_{1234}=12 Ω, which is the equivalent resistance R_{eq}.

e). The reduced circuit with a voltage source of V=24V with an equivalent resistance of Req.=12 Ω. This results in a current of I=2A from the voltage sourc

1.5.7 AC Circuit

A circuit containing an AC supply source of voltage is known as AC circuits. The supply sources for example are alternator and synchronous generators.

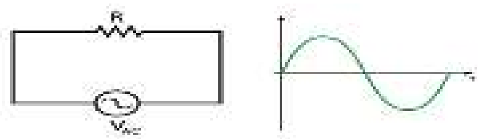


Figure 1-20 **ac circuit**

1.5.8 DC Circuit

A circuit containing a DC supply source of voltage is known as DC circuits. The supply sources for example are batteries and DC generators.

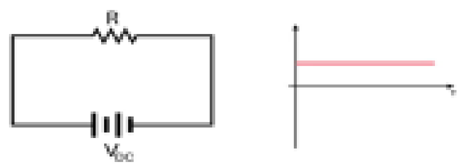


Figure 1-21 DC Circuit

1.5.9 Integrated circuits

An integrated circuit (ICs) is an electronic device comprising numerous functional elements such as transistors, resistors, condensers, etc. on a piece of silicon semiconductor substrate, and is sealed inside a package with multiple terminals.

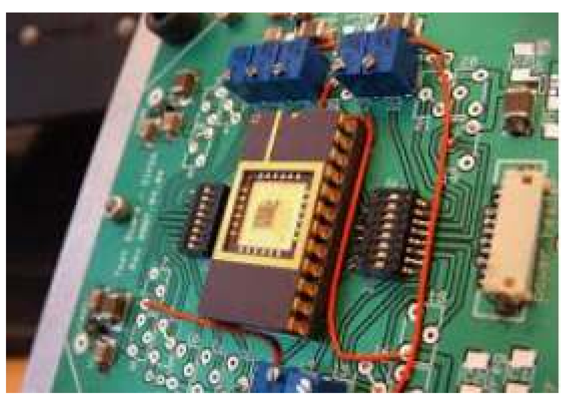


Figure 1-22 Integrated circuits

Self-check-1

Part I. Choose the correct answer

1. If the resistance total in a series circuit doubles, current will:

A. be the same
B. be doubled
C. reduce source voltage
D. be halved

2. _____________ is used to measure the flow of electrical current.

A. voltage
B. Amperage
C. Inductance
D. Resistance

3. Which one of the following is circuit protection devices, such as, , and

A. fuses
B. circuit breakers
C. fusible links
D. All

4. _______________ is an electrical instrument that measures electrical resistance.

A. ohmmeter
B. Ammeter
C. voltmeter
D. All

Part2. All Give short answer

1. What is electron theory?

2. What is series circuit?

3. What is parallel circuit?

Operation sheet 1.1: Apply ohm's law

Operation title: perform ohm's law principle

Purpose: To verify Ohm's Law and experimentally, verify the relationship between current, voltage and resistance in a circuit.

Instruction: Use the given above information, in this operation you have given 50 minutes.

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

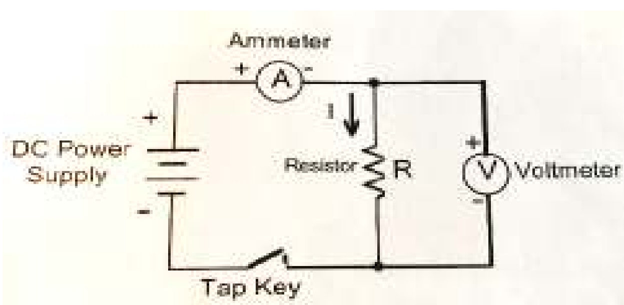
Tools and requirement:

1. Flexible wire
2. Resistor Box(lamps)
3. DC power supply (battery)
4. Voltmeter
5. Ammeter
6. Switches

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

Procedure: Variation of Current with Voltage when the resistance is constant.

1. First, set up the following circuit shown below, using a power supply, an ammeter (A), a voltmeter (V) and one 3-Ω Resistor (R) from resistor box.



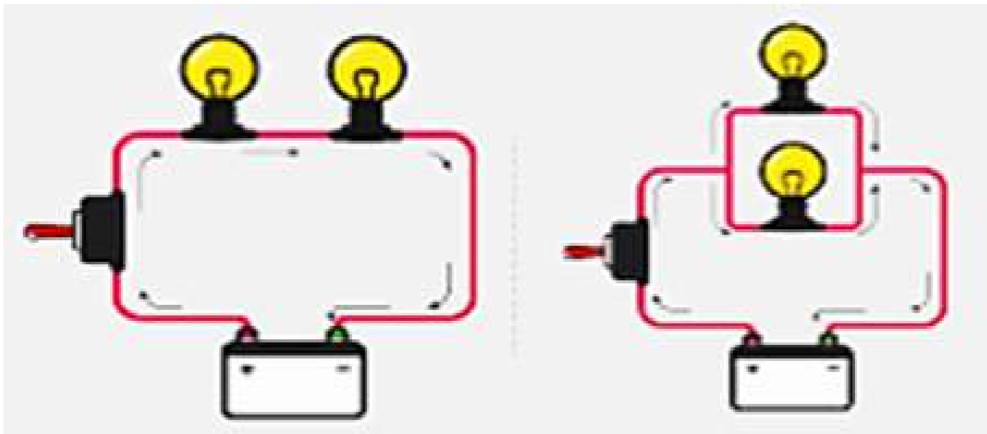
2. Then, let the instructor check the circuit.
3. Later, close the switch and read the voltage and current on the meters.
4. Next, vary the output voltage of the power supply from 0 to 12 V in the increment of 1.5V and record the readings of the voltage V across the resistor and corresponding current I through the resistor in
5. Then, do the graph of the voltage V (vertical axis) versus the electric current I (horizontal axis) for each resistor.

6. Next, calculate the percent error of the actual 3Ω Resistor (R) and the experimental 3Ω Resistor (R).
7. Finally, repeat step 6 and 7.

Quality Criteria: Assured performing of all the activities according to the procedures

Lab Test 1

Task 1. Install circuit of shown on the figure.



Task 2. Apply OHM's low in Series and Parallel connection

Unit Two: Identifying systems components and Applying WHS

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

- WHS requirements
- Automotive electrical/electronic Components or systems

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:

- Applying WHS requirements
- Identifying Components or systems

2.1 Work Health and Safety (WHS) Requirement

Much of your work on an automobile will be around or with the vehicle's electrical system. To prevent personal injury or damage to the vehicle, you should always take the necessary precautions before working. When possible, you should disconnect the vehicle's battery before disconnecting any electrical wire or component. This prevents the possibility of a fire or electrical shock. It also eliminates the possibility of an accidental short, which can ruin the car's electrical system. Disconnect the negative or ground cable first, then disconnect the positive cable because electrical circuits require a ground to be complete, by removing the ground cable you eliminate the possibility of a circuit accidentally becoming completed. When reconnecting the battery, connect the positive cable first, then the negative. Also, remove wristwatches and rings before servicing any part of the electrical system. This helps prevent the possibility of electrical arcing and burns. During disconnecting electrical connectors, do not pull on the wires. When reconnecting the connectors, make sure they are securely connected.

Safe working practices in relation to electrical and electronic systems are essential, for your safety as well as that of others. You only have to follow two rules to be safe.

- ✓ Use your common sense – don't fool about.
- ✓ If in doubt – seek help.

The following section lists some particular risks when working with electricity or electrical systems, together with suggestions for reducing them. This is known as risk assessment.

Electric shock: Ignition high tension is the most likely place to suffer a shock, up to 25 000 V is quite normal. Use insulated tools if it is necessary to work on high tension circuits with the engine running. Note that high voltages are also present on circuits containing windings, due to back EMF as they are switched off – a few hundred volts are common. Mains supplied power tools and their leads should be in good condition and using an earth leakage trip is highly recommended

Battery acid: Sulphuric acid is corrosive so always use good personal protective equipment (PPE). In this case wear the right personal protective equipment, if necessary, rubber gloves. A rubber apron is ideal, as are goggles if working with batteries a lot

Raising or lifting vehicles: Apply brakes and/or chock the wheels when raising a vehicle on a jack or drive-on lift. Only jack under substantial chassis and suspension structures. Use axle stands in case the jack fails

Running engines: Do not wear loose clothing, good overalls are ideal. Keep the keys in your possession when working on an engine to prevent others starting it. Take extra care if working near running drive belts

Exhaust gases: Suitable extraction must be used if the engine is running indoors. Remember, it is not just the carbon monoxide (CO) that might make you ill or even kill you, other exhaust components could cause asthma or even cancer

Moving loads: Only lift what is comfortable for you; ask for help if necessary and/or use lifting equipment. As a general guide, do not lift on your own if it feels too heavy!

Short circuits: Use a jump lead with an in-line fuse to prevent damage due to a short when testing. Disconnect the battery (earth lead off first and back on last) if any danger of a short exists. A very high current can flow from a vehicle battery; it will burn you as well as the vehicle

Fire: Do not smoke when working on a vehicle. Fuel leaks must be attended to immediately. Remember the triangle of fire – Heat/Fuel/Oxygen – don't let the three sides come together
Skin problems: Use a good barrier cream and/or latex gloves. Wash skin and clothes regularly

2.1.1 Electrical Equipment Safety

Precautions Incorrect handling of electrical equipment can cause a short and a fire. Therefore, learn to use it correctly and carefully observe the following precautions: If any irregularity is detected in electrical equipment, immediately turn OFF the switch and contact the controller / foreman. In case of a short or accidental fire in an electrical circuit, turn OFF the switch first before taking fire extinguishing measures. Report any improperly routed wiring or improperly installed electrical equipment to the controller /foreman. Report any blown fuse to your supervisor because a blown fuse indicates some sort of electrical problem.

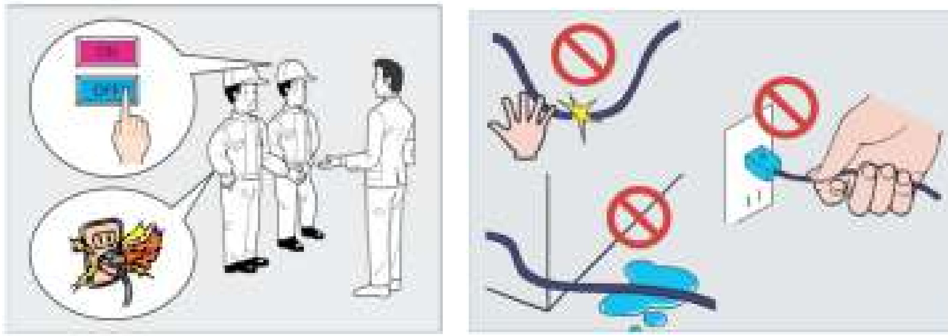


Figure 2-1 Electrical Equipment Safety

Industrial gloves should be used when moving rough or heavy parts. They protect your hands and wrists from cuts, scratches and burns.

Heat-resistant gloves should be worn when working on items such as a hot exhaust or radiator

a).  b). 

Figure 2-2 safety gloves

2.2 Automotive electrical electronic components or systems

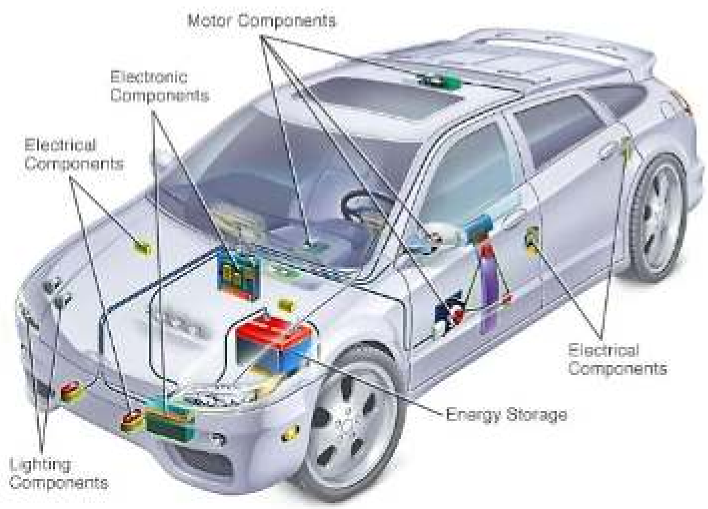


Figure 2-3 Diagram of a vehicle electrical system

2.2.1 Circuit Protective Devices

Fuses: There are three basic types of fuses in use automotive: cartridge, blade, and ceramic. The cartridge fuse is found on older domestic cars and a few imports. Late-model domestic vehicles and many imports use blade or spade fuses. The ceramic fuse was used on many European imports. The core is a ceramic insulator with a conductive metal strip along one side.

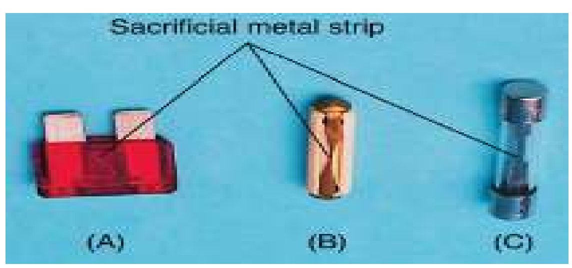


Figure 2-4 (A) Blade fuse, (B) ceramic fuse, and (C) cartridge fuse.

Fuse Links: Fuse or fusible links are used in circuits when limiting the maximum current is not extremely critical. They are often installed in the positive battery lead to the ignition switch and other circuits that have power with the key off. Fusible links are normally found in the engine compartment near the battery. Fusible links are also used when it would be awkward to run wiring from the battery to the fuse panel and back to the load.

Figure 2-5 Typical fuse box or panel

Circuit Breakers: A circuit breaker is an electrical safety device designed to protect an electrical circuit from damage caused by an overcurrent or short circuit.

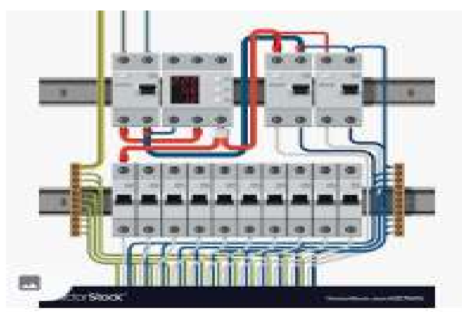
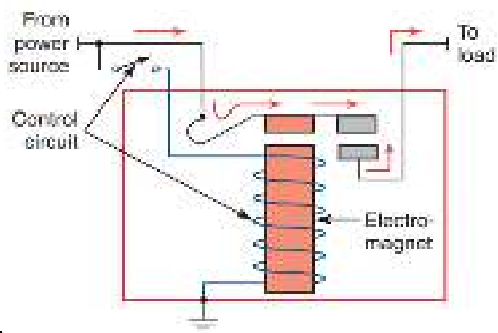
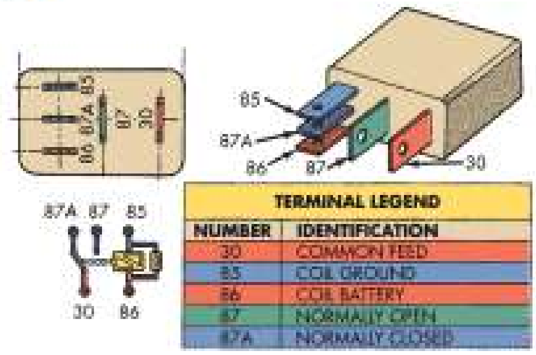


Figure 2-6 Circuit breaker

Relays: A relay is an electric switch that allows a small amount of current to control a high-current circuit. When the control circuit switch is open, no current flows to the coil of the relay, so the windings are de-energized. When the switch is closed, the coil is energized, turning the soft iron core into an electromagnet and drawing the armature down. This closes the power circuit contacts, connecting power to the load circuit.



a).



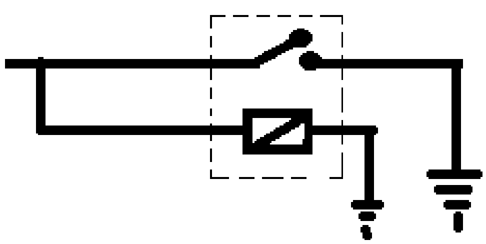
b).

Figure 2-7 a).The basic way a relay works, b). A typical electrical relay inner workings and connections.

Flasher units: The operation of flasher unit is based around an integrated circuit (IC).

The type shown can operate at least four 21 W bulbs (front and rear) and two 5W side repeaters when operating in hazard mode. This will continue for several hours if required.

Flasher units are rated by the number of bulbs they are capable of operating. When towing a trailer or caravan the unit must be able to operate at a higher wattage. Most units use a relay for the actual switching as this is not susceptible to voltage spikes and also provides an audible signal.



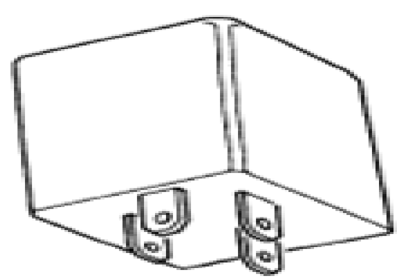


Figure 2-8 a. Flasher circuit b. Flasher units

- ✓ The electronic circuit is constructed together with the relay, on a printed circuit board.
- ✓ Very few components are used as the integrated circuit, is specially designed for use as an indicator timer.
- ✓ The values are normally set to give an on–off ratio of 50% and an operating frequency of 1.5 Hz (90 per minute).

2.2.2 Ignition System:

Mostly used in S.I. systems and based on electricity, the ignition system is used to light mixture of air and fuel. This ignition is generated to start the combustion process in the combustion chamber. Hence we can say that, this system converts chemical energy into heat through the spark generated in the ignition system causing the fuel-air mixture to burn.

A). Function of Ignition System

- ✓ To create high voltage electric spark in the combustion chamber at correct timing in order to burn the air fuel mixture.
- ✓ This creates a potential difference of ~25kV across the spark plugs.
- ✓ It provides high spark voltage to each spark plug in the correct order.
- ✓ It adjusts the spark timing with speed and load of the vehicle.
- ✓ The spark is adjusted so it can be generated when piston is near the top dead Centre.

B). Types of ignition system

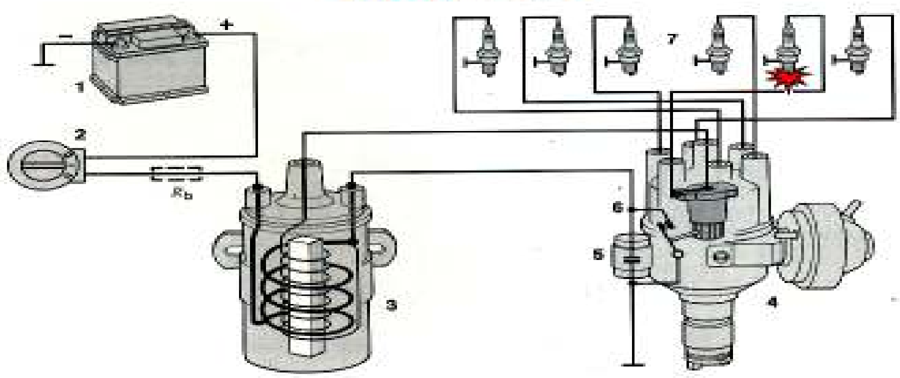
The following are the types of ignition system:

1. Battery ignition system or coil ignition system
2. Magneto ignition system.
3. Electronic Ignition System.

1. Battery ignition system or coil ignition system

a). Battery ignition system or coil ignition system Components

The conventional coil-ignition system is breaker-triggered. The breaker-triggered coil-ignition system is the simplest version of an ignition system in which all functions are implemented.



1. Battery,
2. ignition switch,
3. ignition coil,
4. distributor,
5. condenser,
6. contact breaker,
7. spark plugs,
8. Rb. ballast resistor

Figure 2-9 Conventional ignition system circuit

1. **Battery:** The battery is used to provide current to the ignition system. This in turn energizes the ignition coil. Generally, the voltage of the battery is 6V or 12V.
2. **Ignition Switch:** It is used to turn ON or OFF the engine. One end of the switch is connected with the Primary Winding of Ignition Coil, and another end is connected with the Battery.
3. **Ignition Coil:** It is the main part of Ignition System. The main purpose of it is to step up battery voltage so that it is sufficient for generates the spark. It is working as a step-up transformer, and has two windings, one is primary which have a lesser turn, and the other one is secondary which have a higher number of turn.
4. **Distributor:** It is used in the multi-cylinder engine, and its purpose is to regulate spark in each spark plug at the correct sequence depending on firing order.
5. **Spark Plug:** Spark Plug is another important part of Ignition system. Here the actual Spark is generated for the combustion of Fuel or Charge. If there is more than one spark plug exists then each one is connected separately with the distributor and gives the spark in the sequence.

C. Construction of Battery Ignition System

It consists of two circuits-Primary and secondary circuit or windings

The first circuit comprises of-

- ✓ Battery
- ✓ Primary winding of the ignition coil
- ✓ Condenser
- ✓ Contact breaker from the primary circuit

The second circuit comprises of-

- ✓ Winding of the ignition coil
- ✓ Distributor
- ✓ Spark plugs forms the secondary circuits.

The value of the voltage depends upon the number of turns in each coil. The high voltage 10,000 to 20,000 volts then passes to a distributor.

D. Operation Principles of Ignition System

After turning the switch on in battery ignition system the current flows to-

- ✓ First the primary circuit through ballast register
- ✓ Secondly to primary winding
- ✓ Lastly to contact breaker

The flowing current induces a magnetic field around the primary winding. The contact breaker opens the current flowing through the primary winding and this result in significant current fall, at a particular point. This sudden fall of current generates very high voltage around 300 V in the primary winding section.

This high voltage charges the capacitor completely. The capacitor starts delivering the current towards the battery. This induces reverse flowing of the current. Also there is an already induced magnetic field in the primary winding. It overall results in a very high voltage of 15000 V to 30000 V is generated in the secondary winding.

This high voltage current is then transferred to the distributor. The distributor cap has metallic segments embedded on it. So when it starts rotating then at a certain stage it opens the contact breaker point which allows the high voltage current to transfer to the spark plugs through the metallic segments. So when the high voltage current reaches the spark plug then, its generates a high intensity of spark inside the engine cylinder, which allows the combustion fuel to burn.

2. **Magneto ignition system**

The magneto ignition system has the same principle of working like that of the battery ignition system. In this, no battery is required, as the magneto acts as its own generator. It consists of either rotating magnets in fixed coils or rotating coils in fixed magnets. The current produced by the magneto flows to the induction coil, which works like that of the battery ignition system.

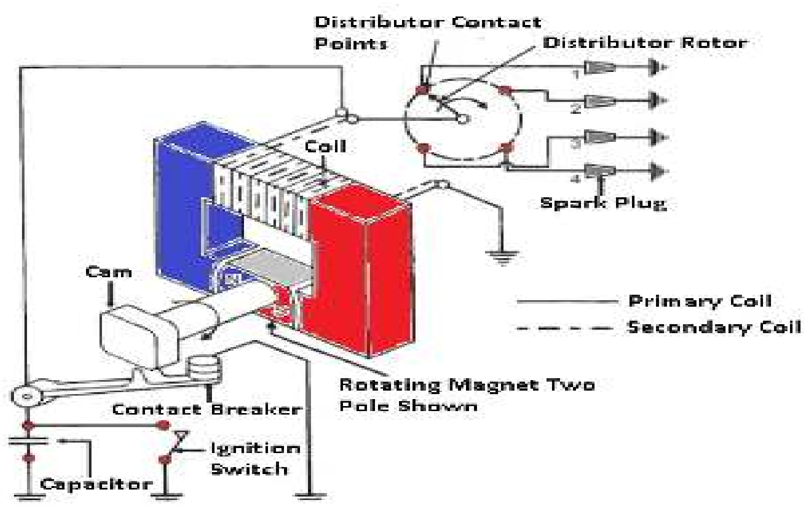


Figure 2-10 Magneto ignition system

2. Electronic ignition system definition

An electronic ignition system is a type of ignition system that works electronic circuits, usually by transistors. The transistors are controlled by sensors to generate electric pulses which then generate a high voltage spark that can burn the lean mixture and provide a better economy and lower emission. The electronic ignition system is fully controlled electronically.

The electronic ignition system is vastly used in aircraft engines, bikes, motorcycles, and cars as it performs the same purpose as other types of ignition systems on

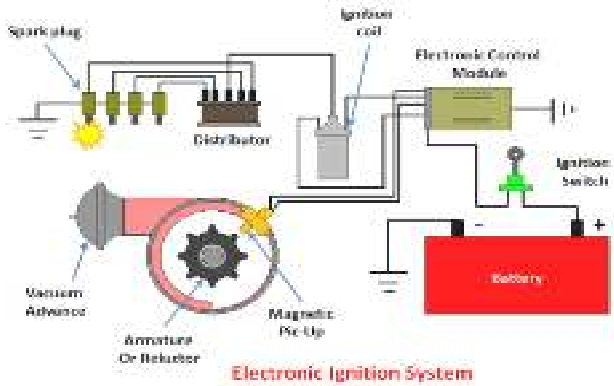


Figure 2-11 Electronic ignition system

2.2.3 The starting system

The starting system includes the battery, starter motor, solenoid, ignition switch and in some cases, a starter relay. An inhibitor or a neutral safety switch is included in the starting system circuit to prevent the vehicle from being started while in gear.

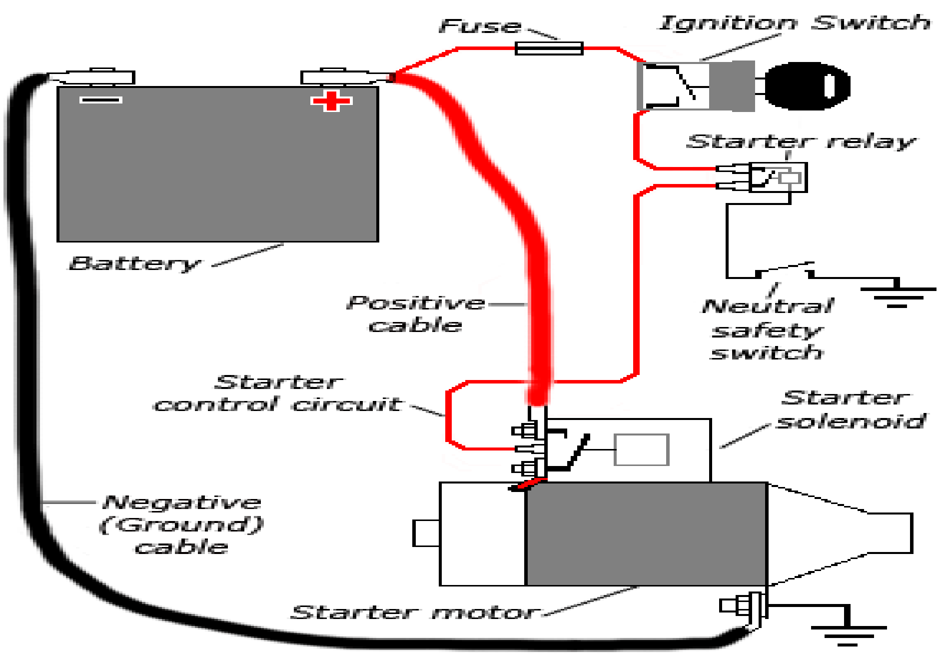


Figure 2-12 Engine starting system

A). Components of starting system

1. **Battery**: The purpose of the battery is to supply current to the starter motor, provide current to the ignition system while cranking, to supply additional current when the demand is higher than the alternator can supply and to act as an electrical reservoir.
2. **Ignition Switch**: The ignition switch allows the driver to distribute electrical current to where it is needed. There are generally 5 key switch positions that are used these are: **Lock, Off, On/Run, Start and Accessory**
3. **Neutral Safety Switch:** This switch opens (denies current to) the starter circuit when the transmission is in any gear but Neutral or Park on automatic transmissions.
4. **Starter Relay:** A relay is a device that allows a small amount of electrical current to control a large amount of current. An automobile starter uses a large amount of current (250+ amps) to start an engine.
5. **Battery Cables:** wire assemblies that provide direct power from the battery to the engine or associated electro-mechanical devices.
6. **Starter Motor:** The starter motor is a powerful electric motor, with a small gear (pinion) attached to the end. When activated, the gear is meshed with a larger gear (ring), which is attached to the engine.

B). Types of Starter Motor

There are four types of starters,

1. **Conventional type** a type of starter in which the armature and pinion gear rotate in an identical manner.
2. **Reduction type** a type of starter that has an idler gear between the drive and driven gears in order to reduce the rotation of the Armature and transmit it to the pinion gear.
3. **Planetary type** a type of starter that has planetary gears to reduce the rotation of the armature. It is more compact and lightweight than the reduction type.
4. **Planetary reduction-Segment conductor motor type** Permanent magnets are used in the field coil. The armature coil has been made more compact, resulting in a shorter overall length.

C). How the starting system works:

When you turn the ignition key to the START position, or press the START button, if the transmission is in Park or Neutral, the battery voltage goes through the starter control circuit and activates the starter solenoid. The starter solenoid powers the starter motor. At the same time, the starter solenoid pushes the starter gear forward to mesh it with the engine flywheel (flex plate in an automatic transmission). The flywheel is attached to the engine crankshaft. The starter motor spins, turning over the engine crankshaft allowing the engine to start. In cars with a push button start, the system disengages the starter as soon as the engine starts running.

2.2.4 Charging System

The charging system produces electricity to supply the electrical components with the amount of electricity required, and to charge the battery while the vehicle's engine is in operation. As soon as the engine starts, the drive belt causes the alternator to operate. Your vehicle's charging system consists of three parts: **the battery, the alternator, and the voltage regulator**. The battery supplies the necessary electrical power to start your engine. The alternator generates the electrical currents to power everything electrical in the car, while the regulator controls the voltage of the currents. The voltage regulator also makes sure the battery stays fully charged. When the battery has lost its charge, the voltage regulator will signal the alternator to recharge the battery.

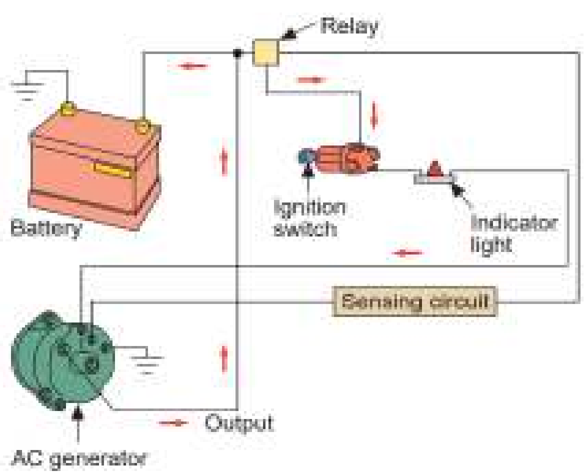


Figure 2-13 Charging system circuit

Types of charging circuits

There are two types of charging system. DC charging circuits, and AC charging circuits

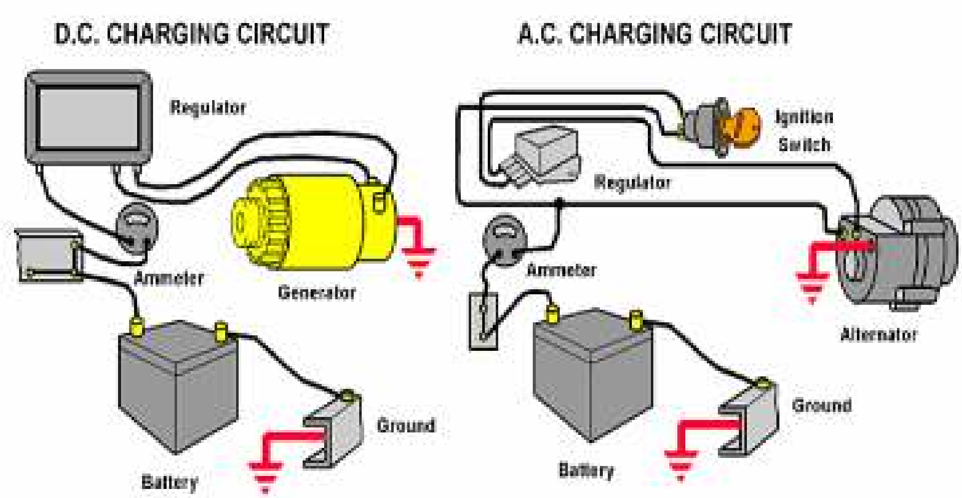


Figure 2-14 DC and AC charging circuits

2.2.5 Engine Management System (EMS):

EMS stands for Engine Management System, consisting of a wide range of electronic and electrical components such as sensors, relays, actuators, and an Engine Control Unit. They work together to provide the Engine Management System with vital data parameters. These are essential for governing various engine functions effectively.

Components of Engine Management System are:

- ✓ Electronic control unit (ECU)
- ✓ Engine immobilizers
- ✓ Crank angle sensors
- ✓ Mass air flow (MAF) sensors
- ✓ Throttle position sensors (TPS)
- ✓ Knock sensors
- ✓ Oxygen sensors
- ✓ Temperature sensors
- ✓ Variable valve timing (VVT) componentry (electrical)

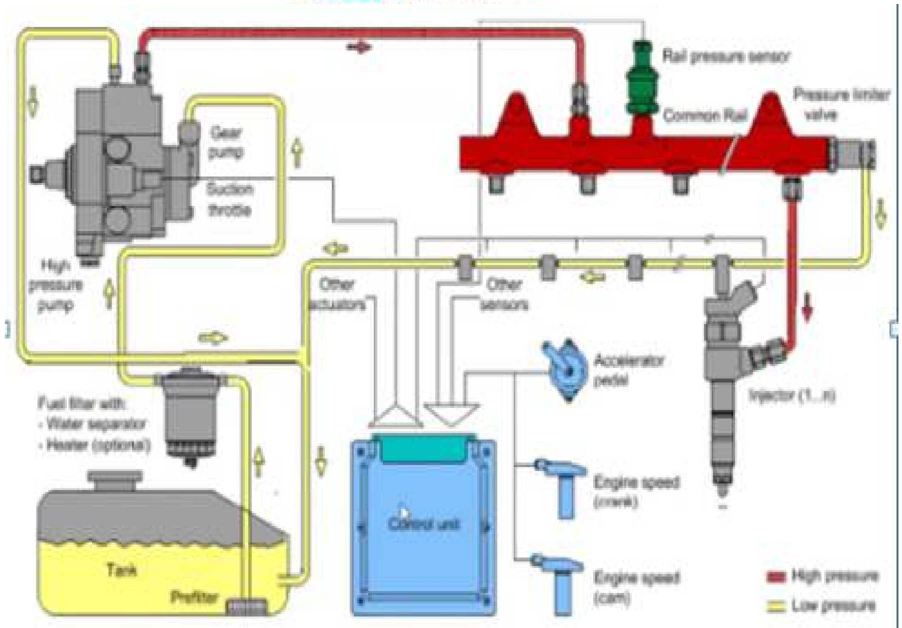


Figure 2-15 Engine management system circuit

2.2.6 Vehicle lighting systems

The lighting system of a motor vehicle consists of lighting and signalling devices mounted or integrated at the front, rear, sides, and in some cases the top of a motor vehicle. They illuminate the roadway ahead for the driver and increase the vehicle's visibility, allowing other drivers and pedestrians to see its presence, position, size, and direction of travel, and its driver's intentions. Emergency vehicles usually have distinctive lighting equipment to warn drivers and indicate priority of movement in traffic.

The lighting systems can categorizes in to two ways

Exterior lights:-lights which are found out of the vehicle. Such as

- ✓ Head light
- ✓ Tail light
- ✓ Parking light
- ✓ Number plate light. Etc

Interior light: - these lights are found the interior part of the vehicle.

- ✓ Instrument panel light
- ✓ Luggage compartment light

✓ Hood panel light, Courtesy light. Etc.

2.2.7 Vehicle Instrumentation Systems

Vehicle instrumentation systems monitor the various vehicle operating systems and provide information to the driver about their correct operation. Warning devices also provide information to the driver; however, they are usually associated with an audible signal. Some vehicles use a voice module to alert the driver to certain conditions.

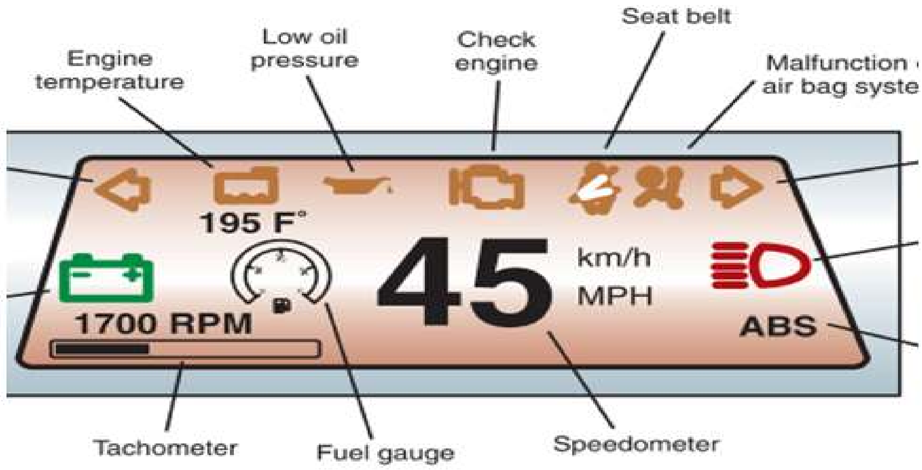


Figure 2-16 Vehicle Instrumentation Systems

2.2.8 Wire Harness Assemblies

A Wire Harness, also known as a cable harness or wiring assembly, is a grouping of wires, cables, or subassemblies designed to transmit signals or electrical power. A basic Wire Harness may include as few as three discreet components, while the more classic harnesses include many more wires and other passive, and potentially active, components.

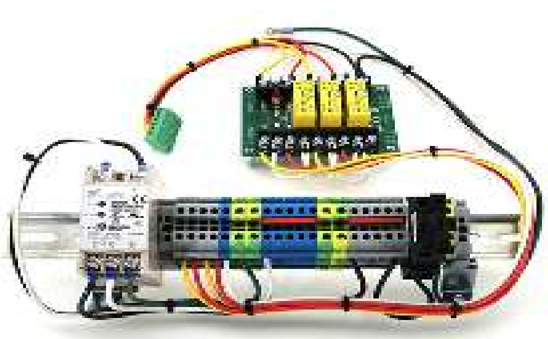


Figure 2-17 Wire harness assembly

Self-check-2

Part II. Choose the correct answer

1. Which one of the following is not the component of ignition system:

   E. Distributer
   F. Ignition coil
   G. Starter solenoid
   H. Ignition switch

2. ______________ is a device used start the engine.

   A. Starter motor
   B. Alternator
   C. Ignition coil
   D. Generator

3. Which one of the following is the function of charging system?

   A. To start the engine
   B. To charge batteries
   C. To provide ignition
   D. All

Part3. All Give short answer

1. What is the function of charging system?
2. What is the function of starting system?
3. What is the function of ignition system?
4. What are the main components of charging system

Unit Three: Locate Electrical/electronic systems and components

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

- Tracing Suitable automotive systems or components
- Identifying Alternative methods of system location

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:

- Tracing Suitable automotive systems or components
- Identifying Alternative methods of system location

3.1 Tracing Suitable automotive systems or components

The locations of vehicle electrical system or component are differing from vehicle design to design and company   to company.

1. Location of battery is commonly under the hood for light duty trucks and for heavy duty trucks it lives under the middle part of vehicle.

Figure 3-1 Location battery

2. Location of starter motor is commonly attached on the engine near to fly wheel

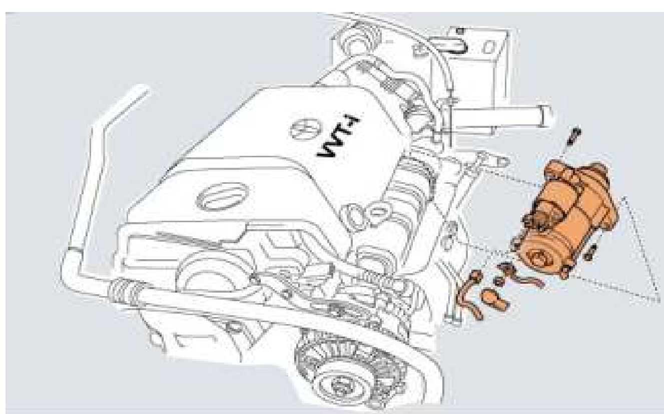
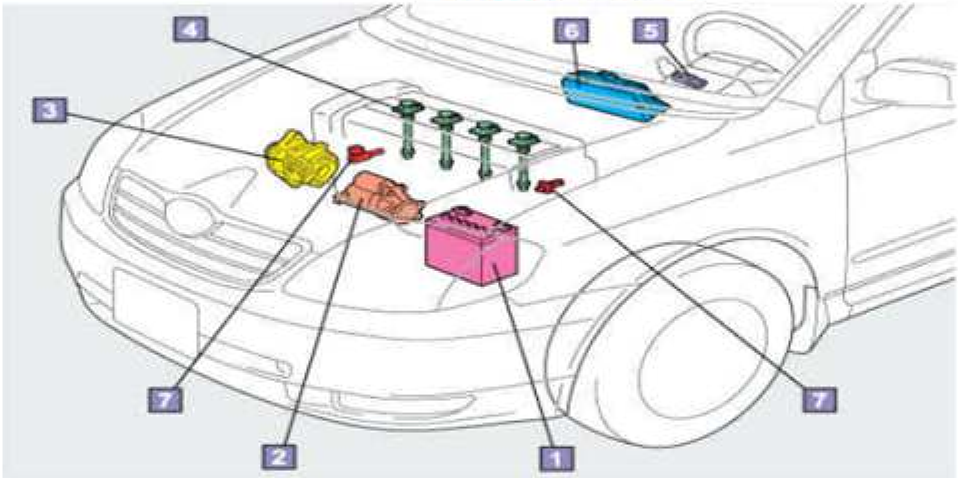


Figure 3-2 Location of starter

3. Location of charging circuit is commonly positioned on the engine attached or connected to crank shaft pulley with belt.



1. Battery
2. Starting System
3. Charging System
4. Ignition System
5. Ignition Switch
6. Combination Meter (Discharge Warning Light)
7. Sensors

Figure 3-3 Location of vehicle electrical system

3.2 Body Electrical

The body electrical components consist of electrical parts that are attached to the vehicle body

1. Wire harness
2. Switches and relays
3. Lighting system
4. Combination meter and gauges
5. Wipers and washers
6. Air conditioning

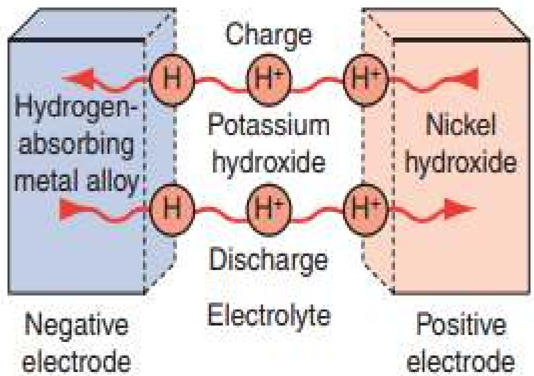
3.3 Alternative methods of system or component

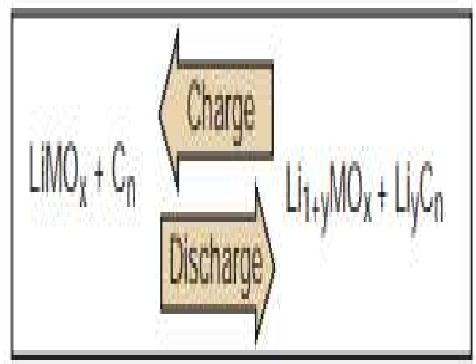
In the quest to improve fuel economy, decrease emission levels, and mak Vehicles more reliable, engineers have applied advanced electronics to starters and generators.

3.3.1 Alternatives of battery

A. Nickel-Based Batteries: Batteries have a positive plate that contains nicke

Two types of nickel-based rechargeable batteries are commonly used: the nickel-metal hydride (NiMH) and nickel-cadmium (NiCad).nickel-metal hydride (NiMH)





B. **Lithium-Polymer Batteries:** The lithium-polymer (Li-Poly or LiPo) battery is not a liquid; rather, the lithium salt is held in a solid polymer composite (such as poly acrylonitrile).

3.3.2 Alternatives of starting systems

There are four types of starters, as shown on the left.

1. **Conventional type:** A type of starter in which the armature and pinion gear rotate in an identicalmanner.
2. **Reduction type**: A type of starter that has an idler gear between the drive and driven gears in order to reduce the rotation of the Armature and transmit it to the pinion gear.
3. **Planetary type**: A type of starter that has planetary gears to reduce the rotation of the armature. It is more compact and lightweight than the reduction type.
4. **Planetary reduction**-Segment conductor motor type Permanent magnets are used in the field coil. The armature coil has been made more compact, resulting in a shorter overall length.

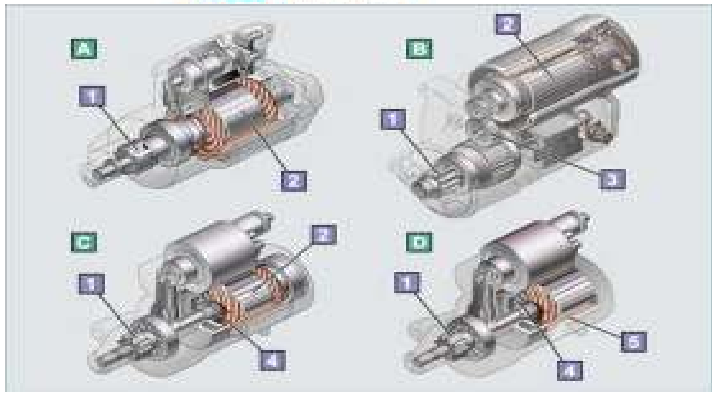
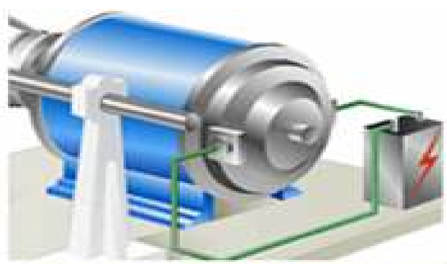


Figure 3-4 types of starters

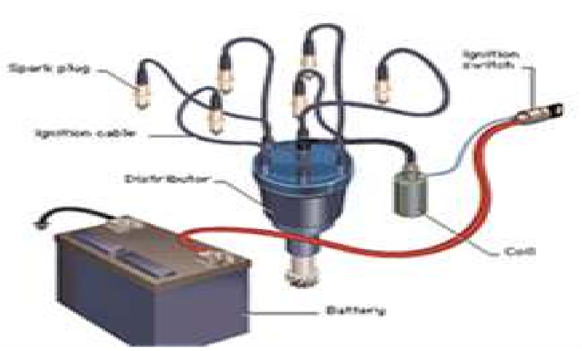
3.3.3 Alternatives of ignition system

1. **Magneto Ignition System:-** is popular on motorcycles because it is lighter than a battery-operated system and requires less maintenance

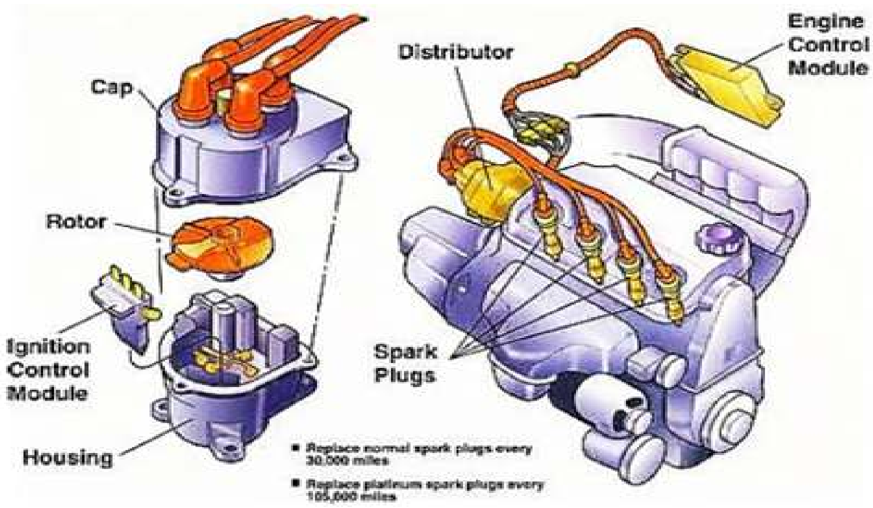


Electric motor using Magneto Ignition

2. **Contact (Breaker) Point Ignition System:** battery-powered ignition systems with mechanical switches



3. **Electronic Ignition Systems** have used sensors, such as a pickup coil and reluctor (trigger wheel), to trigger or signal an electronic module that switches the primary ground circuit of the ignition coil



3.3.4 Alternatives of charging

The charging system has two essential functions:-

1. Generate electrical power to run the vehicle's electrical systems
2. Generate current to recharge the vehicle's battery

3.3.5 Alternatives of lightning system is light emitting diodes

The light emitting diode (LED) is an active light element. If an electrical voltage is applied, current flows through the chip. The electrons of the atoms of the LED chip are highly energized by the voltage. As light is emitted, they return to their initial state of Low energy charge.

Self-check-3

Part I. Give short answer

1. List down alternative of lead acid battery?
2. List down and discuss alternative of ignition system battery?
3. List down body electrical systems

Operation sheet 3.1: Confirm location of system or component

OPERATION TITLE: Identifying location of battery, starter motor and charging circuit

PURPOSE: In order to locate the common location of vehicle battery, starting system and charging system components

CONDITIONS OR SITUATIONS FOR THE OPERATIONS:

- ✓ Safe working area
- ✓ Properly operated tools and equipment's
- ✓ Appropriate working cloths fit with the body

EQUIPMENT TOOLS AND MATERIALS:

- ✓ Multi- meter
- ✓ paper and pen [for recording the data]
- ✓ pliers
- ✓ Lamp
- ✓ Wires and connectors

PROCEDURE:

1. Confirm location of system or component
2. Make ready live vehicle if it is hot let to cool
3. Identifying Location of battery is commonly under the hood for light duty trucks and for heavy duty trucks it lives under the middle part of vehicle.
4. Identifying Location of starter motor is commonly attached on the engine near to fly wheel.
5. Identifying Location of charging circuit is commonly positioned on the engine attached or connected to crank shaft pulley with belt.

QUALITY CRITERIA:

Assured performing of the activities correctly accordance with the given procedure given above.

Unit Four: Operation of Electrical/electronic system or component

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

- Electrical/electronic testing equipment
- Electrical/electronic component sub-assembly
- Electrical/electronic common faults of circuit

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:

- Identifying and applying electrical/electronic testing equipment
- Identifying component sub-assembly
- Identifying common faults of circuit

4.1 Electrical/electronic testing equipment

4.1.1 Test lamp

A circuit tester is a useful and inexpensive tool for making electrical tests.

Checking a simple circuit is straightforward the lighting circuits are among the simpler ones but the electrical wiring in a car contains many interlinking and branching circuits, which bring complications.

All car wiring is colour-coded; unfortunately there are no national or international standards for colours. Colour codes for individual cars can be found in wiring diagrams, in the car handbook or in a service manual. How to use a circuit tester connect the tester clip to the negative terminal of the battery and touch the probe to the positive one. If the tester lamp does not light, the battery is dead (or the bulb in the tester has blown). If it lights, try again with the clip earthed to the car body: if the lamp fails to light, the battery negative terminal is not earthed properly.

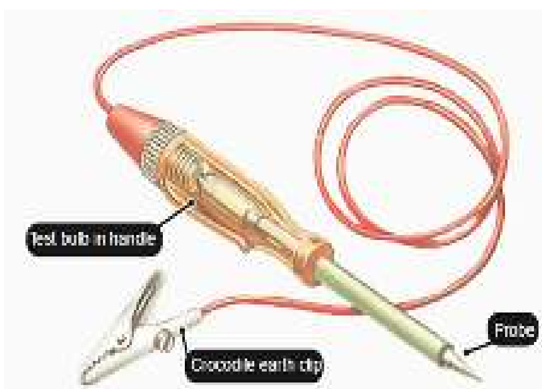


Figure 4-1 Circuit tester

Earth the clip near the switch of the circuit being tested and touch the probe to the 'live' (battery) side of the switch. If the lamp does not light, the wiring between the battery and the switch is faulty, or a fuse has blown.

When checking a component operated by the ignition switch, be sure that the switch is on.

If the lamp lights turn the switch on and probe its other Side: if the lamp does not light, the switch is faulty.

If the switch works, leave it on, earth the clip near the component and probe the live side of the component. If the lamp does not light, the wiring from switch to component is faulty, or a fuse has blown. If all of the checks so far are satisfactory, transfer the clip to the live side of the battery.

Now probe the earthed side of the component (it may be earthed by its metal body being fixed to the car body). If the lamp does not light, the component is badly earthed. If it does light, the component itself is faulty.

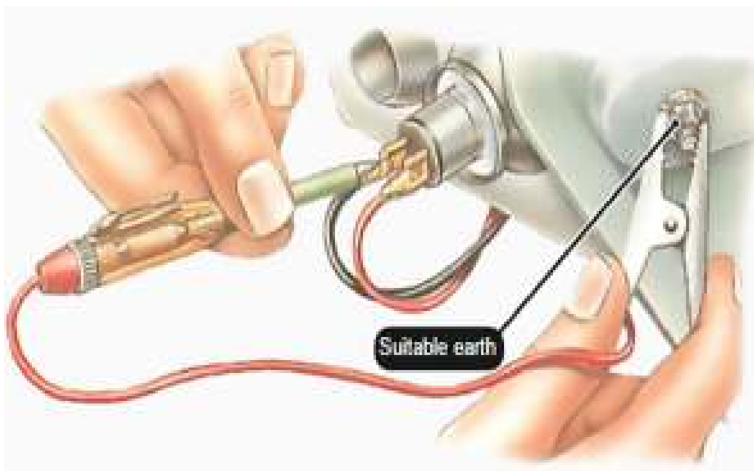


Figure 4-2 Checking circuit with test lamps

4.1.2 Multi meter

A multi-meter is has three parts:

- ✓ Display
- ✓ Selection Knob
- ✓ Ports

The display usually has four digits and the ability to display a negative sign. A few multi-meters have illuminated displays for better viewing in low light situations. The selection knob allows the user to set the multi-meter to read different things such as milliamps (mA) of current, voltage (V) and resistance (Ω).

Two probes are plugged into two of the ports on the front of the unit. COM stands for common and is almost always connected to Ground or '-' of a circuit.

The COM probe is conventionally black but there is no difference between the red probe and black probe other than colour. 10A is the special port used when measuring large currents (greater than 200mA).

Figure 4-3Multimeter

4.1.3 Oscilloscope

An oscilloscope, previously called oscillograph, is a type of electronic test instrument that allows observation of constantly varying signal voltage, usually as a two-dimensional graph of one or more electrical potential difference using the vertical or Y-axis, plotted as a function of time (horizontal X-axis).

- ✓ Oscilloscopes are used to observe the change of an electrical signal over time.
- ✓ An oscilloscope displays voltage waveforms
- ✓ Oscilloscopes display the waveform of a signal and allow quantities such as phase to be measured.

Figure 4-4 Oscilloscope

4.1.4 Clamp Meter

In electrical and electronics engineering a current clamp or current probe is an electrical device having two jaws which open to allow clamping around an electrical conductor.

This allows properties of the electric current in the conductor to be measured, without having to make physical contact with the wire.

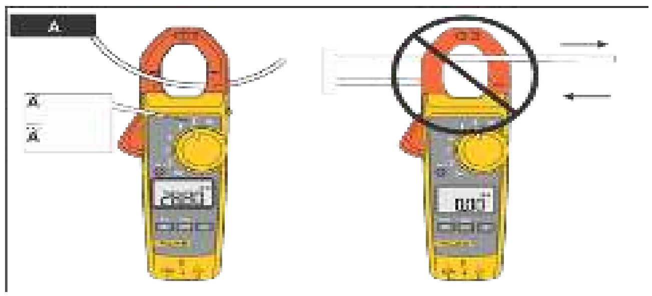


Figure 4-5 Clamp Meter

4.1.5 Electrical and electronic circuits

A. Lighting system circuit: Includes the battery, vehicle frame, all the lights, and various switches that control their use. The lighting circuit is known as a single-wire system since it uses the vehicle frame for the return.

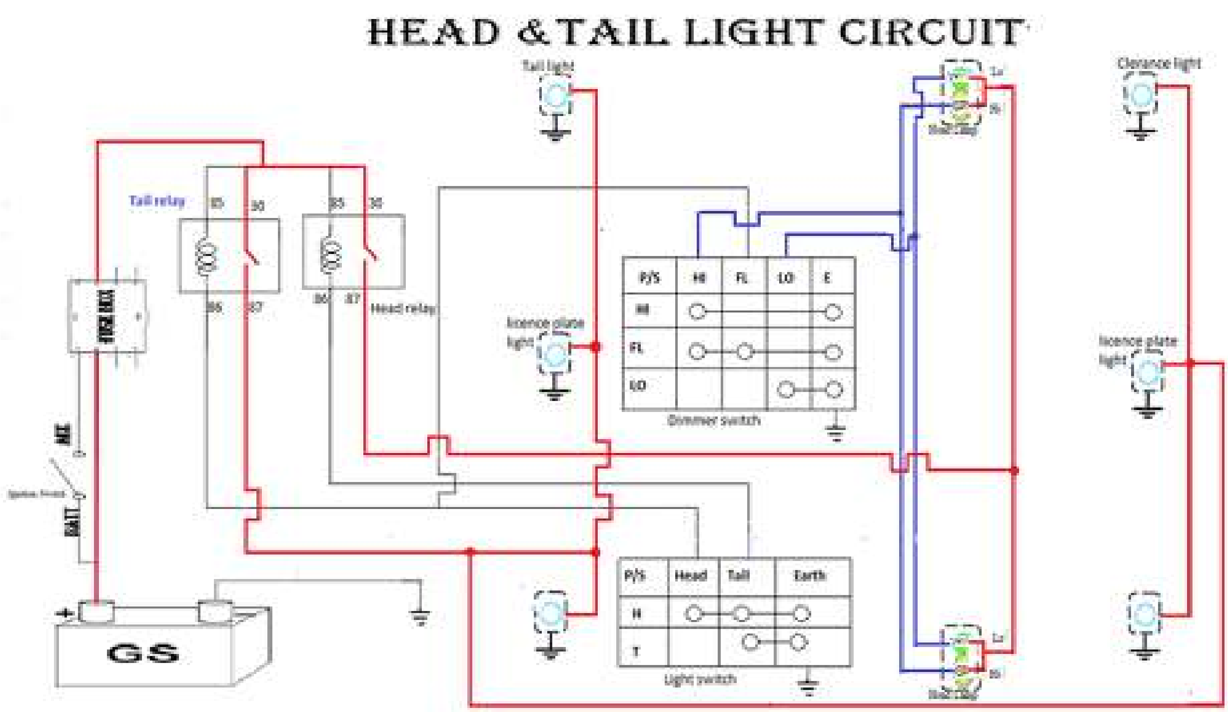


Figure 4-6 head and tail light circuit

4.2 Common faults of circuit

Most car electrical problems are caused by loose, corroded, or damaged wires and terminals. But there are other possible causes, too, such as faulty switches, relays, or sensors. However, the most common symptom among all is a dead battery.

Three common electrical faults mainly can occur are:

- ✓ Short circuit electrical faults,
- ✓ Open circuit faults
- ✓ Overload circuit faults

4.2.1 Electrical Problems in Cars

1. Dead battery

1. Battery will not charge
2. Bad alternator
3. Fatigued starter or solenoid
4. Burning plastic smell
5. Bad battery cables
6. Headlights and other lights malfunctioning
7. Blown electrical fuses
8. Loose wires & faulty fuse boxes
9. Failed spark plugs
10. Engine doesn't start correctly

4.2.2 How to Diagnose Electrical Problems in a Car?

If you're having electrical problems in your car, there are a few things you can do to diagnose the issue:

4.2.3 Safety First

First, **check all fuses and ensure** they are not blown. If they are, replace them with new ones. Next, **check your battery terminals** to ensure they are **clean and corrosion-free**. If they are not, clean them with a wire brush.

Finally, **check your wiring harness** for any loose or damaged wires; if you find any, repair or replace them. If you still can't figure out the problem, it's time to move to the next step for further diagnosis.

4.2.4 Wiring Gauge Sizes And Amp Loads

There are a few different ways to check the wiring gauge size and amp load:

Using Multimeter

If you're using a multimeter, you'll want to set it to the "DC volts" setting. Then, touching one leads to the battery's positive terminal, and the other leads to the negative terminal. The gauge size is too small if the reading is less than 12 volts. The gauge size is too large if the reading is more than 12 volts.

Using Wire Diagram

If you're using a wiring diagram, you'll want to find the section corresponding to the car's part where you're having electrical problems. Then, look at the gauge size and amp load. If the gauge size is too small, the amp load is too high. If the gauge size is too large, the amp load is too low.

Once you've determined the correct wiring gauge size and amp load, you can fix the electrical problem.

How to Inspect a Wiring Circuit?

There are a few things that you will need to inspect your car's wiring circuits properly:

1. First, you will need a voltmeter. This will allow you to measure the voltage of each circuit in your car.
2. Next, you will need a wiring diagram. This will show you which circuits are which and where they are located in your car.
3. Finally, you will need a good set of electrical pliers. These will allow you to properly disconnect and reconnect any wires that you may need to complete your inspection.

Testing For an Open Circuit

If you're having electrical problems with your car, one of the first things you'll want to do is test for an open circuit. An open circuit is a break in the continuity of the course, which means that current cannot flow through it. This can be caused by some things, including a blown fuse, a broken wire, or a faulty connection.

To test for an open circuit, you'll need **a voltmeter or a test light** to test for an open circuit. If you're using a voltmeter, set it to the ohms setting and touch one lead to each end of the circuit. If the meter shows a reading of infinity, then you have an open circuit. If you're using a test light, touch one lead to each end of the circuit if the light doesn't come on.

Continuity Test

A continuity test is another great way to diagnose electrical problems in your car. By testing the continuity of the circuits, you can determine if there is a break in the circuit or if the wiring is faulty. This can help you pinpoint the problem and make the necessary repairs.

To test the continuity of a circuit, you will need a continuity tester. This simple tool can be purchased at most auto parts stores. Once you have your continuity tester, follow these steps:

4.3 Testing circuit diagram, system or component

4.3.1 Type of Circuit Diagram

1. **Block Diagram:** This type of diagram uses rectangular or triangle to represent a component, a group of components or a group of units and arrows to show the connection and flow of a certain device.

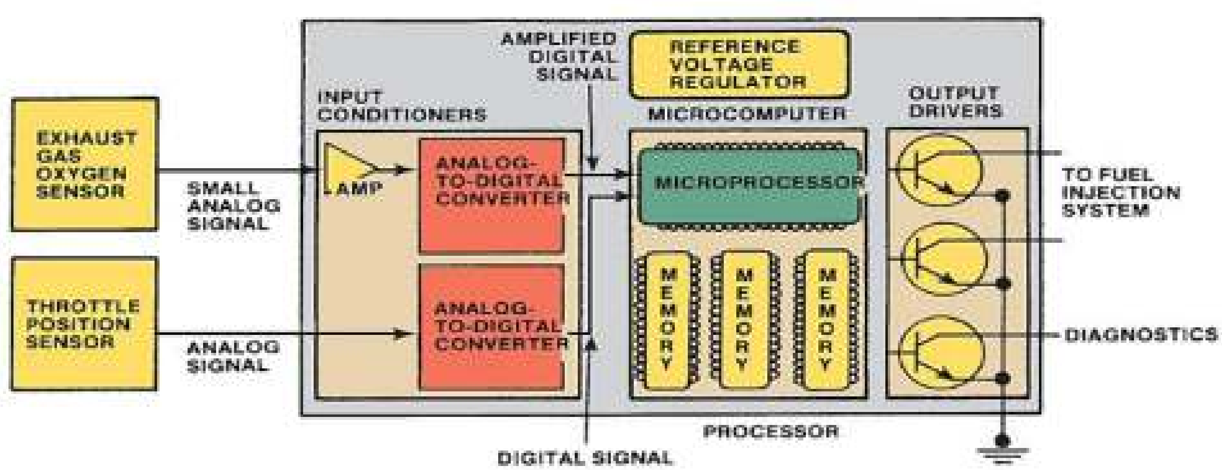


Figure 4-7 Block Diagram of powertrain control module

2. **Pictorial Diagram:** It shows the picture of actual components and wiring connections. Although, it does not provide the exact size of the components, it shows the exact shape in proportion to the actual component.

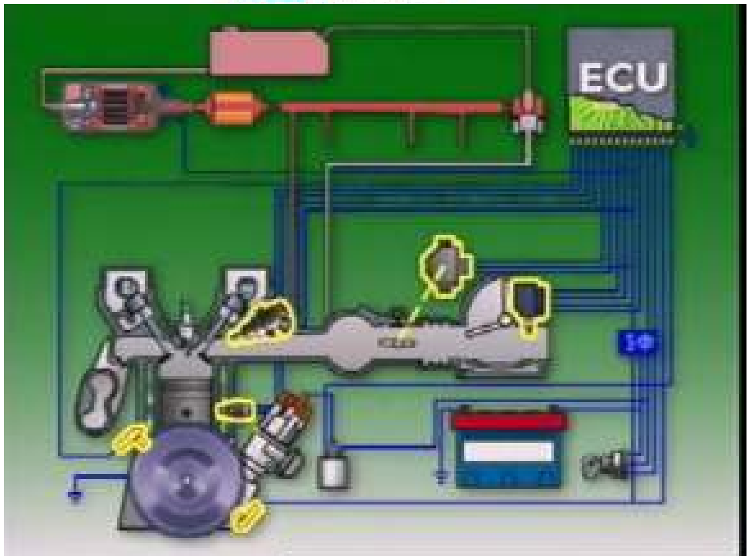


Figure 4-8 Pictorial diagram of engine management system

3. **Schematic Diagram:** A schematic diagram is actually a map showing the path of current that takes through the various components. This type of diagram is a graphically representation (represented by a symbols) which shows the electrical construction of a system or circuit. However, it does not give the exact shape or size of the entire circuit.

Self-check 4

Directions: Answer all the questions listed below.

Part 1. Choose the correct answer from the given alternatives (1point)

1. Which one is a circuit testers are used to check for voltage in an electrical circuit?
   - A. Test light
   - B. OHM`s meter
   - C. volt meter
   - D. all
2. It is type of diagram uses rectangular or triangle to represent a component, a group of components?
   - A. Schematic Diagram
   - B. Pictorial Diagram
   - C. Block Diagram
   - D. All
3. What one is included under electrical testing tool?
   - A. Test light
   - B. OHM`s meter
   - C. oscilloscope
   - D. all
4. One is an electrical one-way check valve (unidirectional valve) that will allow current to flow in one direction only?
   - A. Diode
   - B. Transistor
   - C. fuse
   - D. All

Operation sheet 4.1 open-circuit voltage test

Operation Title: Electrical circuit test

Purpose: to know how to measure how to test voltage.

Conditions or situations for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ **Battery**
- ✓ voltmeter

Steps in doing the task:

1. Connect the voltmeter to the battery as shown?

2. Observe the result on the meter

Quality Criteria: Assured performing of all the activities according to the procedures

Operation sheet 4.2 check lighting circuit resistance

Operation Title: Electrical circuit test

Purpose: to know how to measure how to test resistance of a circuit.

Conditions or situations for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment

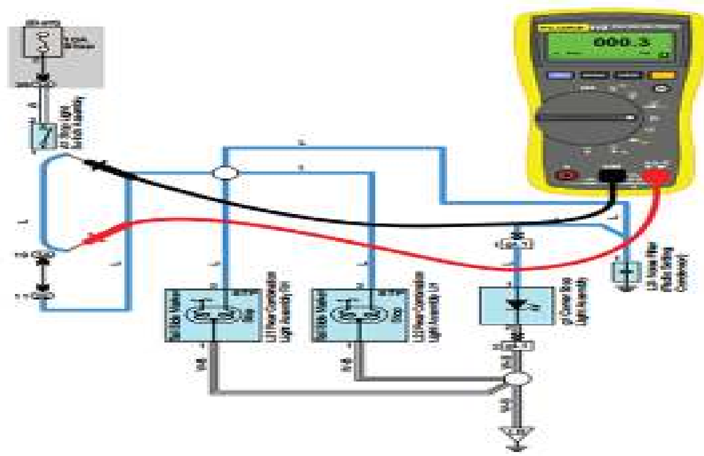
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ voltmeter
- ✓ lighting circuit

Steps in doing the task:

1. Disconnect the section of the circuit that you are testing.
2. Connect the DMM leads and note the resistance reading on the display.
3. Measure resistance of the harness
4. Wiring resistance should be very close to 0 ohms.



Quality Criteria: Assured performing of all the activities according to the procedures

Lab Test

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 5 hours.

Task 1. open-circuit voltage test

Task 2. check lighting circuit resistance.

Reference

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6. Different learning guides
7. MANAGING ELECTRICAL RISKS IN THE WORKPLACE by safe work austria
   www.safeworkaustralia.gov.au

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