Ethiopian TVET-System

BASIC ELECTRICAL/ELECTRONIC

EQUIPMENT SERVICING Level I

Based on May 2011 Occupational standards

October, 2019

Module Title: TESTING ELECTRICAL&ELECTRONIC PARTS

TTLM Code: EEL BEE1TTLM 0919 v1

This module includes the following Learning Guides

LG36: Plan and prepare to identify/test electrical/electronic part

LG Code: EEL BEE1 M10 LO1LG-36

LG37:-Identifying and testing Electrical/electronic parts

LG Code: EEL BEE1 M10 LO2LG-37

LG38:-: Test the construction of electrical/ electronic circuits

LG Code: EEL BEE1 M10 LO3LG-38

Instruction Sheet	LG36: Plan and prepare to identify/test electrical/ electronic part

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics

- Checking materials according to specifications and tasks
- *Selecting appropriate tools and test instrument according to task requirements*
- Planning task to ensure occupational health and safety (OHS) guidelines and following procedures
- Identifying and preparing Electrical/electronic parts
- Testing and de-soldering/soldering of electronic parts

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to:-**

- Check materials according to specifications and tasks
- Select appropriate tools and test instrument according to task requirements
- Plan task to ensure occupational health and safety (OHS) guidelines and following procedures
- Identify and prepare Electrical/electronic parts correctly for testing, de-soldering/soldering of electronic parts in accordance with instructions and work procedures

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1, Sheet 2, Sheet 3 and Sheet 4,sheet 5" **in page 3, 13, 20, 23nd 30** respectively.
4. Accomplish the "Self-check 1, Self-check 2, Self-check 3 and Self-check 4" "**in page 12, 19, 22,24 and 33** respectively

5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3 ”**in page ---.**
6. Do the “LAP test” **in page – --**

1.1 Concept of Specification (spec)

Exact statement of the particular needs to be satisfied, or essential characteristics that a customer requires (in a good, material, method, process, service, system, or work) and which a vendor must deliver. Specifications are written usually in a manner that enables both parties (and/or an independent certifier) to measure the degree of conformance. They are, however, not the same as control limits (which allow fluctuations within a range), and conformance to them does not necessarily mean quality (which is a predictable degree of dependability and uniformity).

1.2 Types of specification

Specifications are divided generally into two main categories:

(1) Performance specifications: conform to known customer requirements such as keeping a room's temperature within a specified range.

(2) Technical specifications: express the level of performance of the individual units, and are subdivided into (a) individual unit specifications which state boundaries (parameters) of the unit's performance consisting of a nominal (desired or mandated) value and tolerance (allowable departure from the nominal value, (b) acceptable quality level which states limits that are to be satisfied by most of the units, but a certain percentage of the units is allowed to exceed those limits, and (c) distribution specifications which define an acceptable statistical distribution (in terms of mean deviation and standard Deviation) for each unit, and are used by a producer to monitor its production processes.

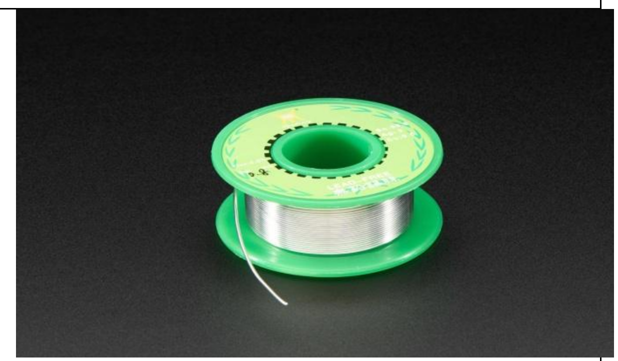
1.3 **Importance of specification**

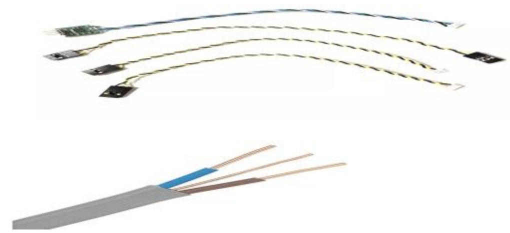
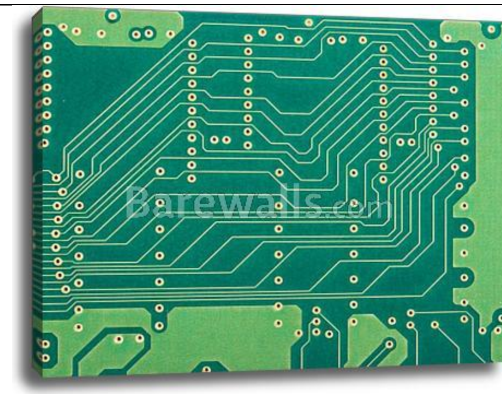
When completing a job for someone else you should always try and follow every specification so you can get future work from them.

You may have to make sure that you follow every specification when you are trying to set up a new factory.

It is not only sufficient to plan the required materials, tools and equipments for the lesson, it needs to check and identify which of them are: defect free (normal), to be maintaining easily and not to be maintained. In addition to the above consumable components, it is intended that the following consumable materials, tools and testing instruments which are going to be used in this UC are listed in the table below. The details list of these materials, tools and instruments (with their specification, quantities, items to trainee's ratio) are present in Annex "Resource Requirement" in the corresponding curriculum. Hence, based on both these information, the trainer can prepare consumable materials, tools and equipment request detail plan before the practical training time.

Table 1: examples of some materials with their specification and tasks

Materials	Specification	Tasks	Picture /image of materials
Soldering lead	We provide soldering wire of grade 63/37sn/pb,62/38,60/40,50/50 and 40/60 0.8mm, 1mm	-used to attach a wire to the pin of a component on the rear of PCB	
Flux	Rosin used as flux for soldering A flux pen used for electronics rework Multicore solder containing flux Wire freshly coated with solder, still immersed in molten rosin Flux	-is a chemical cleaning agent, flowing agent, or purifying agent. Fluxes may have more than one function at a time.	

Cables	**3x2.5mm^2** **3x4mm^2**	-an assembly one or more wires which may be insulated, used for transmission electrical power or signal.	
Printed circuit board (PCB)	PCB materials Conductive ink Laminate materials: BT-Epoxy Composite epoxy material , CEM-1,5 Cyanate Ester FR-2 FR-4 , the most common PCB material Polyimide PTFE , Polytetrafluoroethylene (Teflon)	A printed circuit board (PCB) mechanically supports and electrically connects electronic components or electrical components using conductive tracks, pads and other features Etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate. Components are generally soldered onto the PCB to both electrically connect and mechanically fasten them to it.	 bwc2035289 Barewalls

Electrical/Electronic parts and components (resistor, diode, transistor, capacitor etc.)	**1kohm, 10w**		
Wires	$1mm^2$,$1.5mm^2$, and $2.5mm^2$	**-**Used for transmission of electricity or electrical signals	
AC/DC power supply	Total Max Power: 250 W Total Max Current: 20.8 A Input Voltage: 90 V to 264 V Output Voltage: 12 V to 52.8 V Outputs: Single Size (L x W x H): 4.000" x 2.000" x 1.290" Warranty: 3 years Operating	A power supply is an electrical device that supplies electric power to an electrical load . The primary function of a power supply is to convert electric current from a source to the correct voltage , current, and frequency to power the load. As a result, power supplies are sometimes referred to as electric power converters	

	Temperature: -20 to 70 °C		
Data book	ECG book	-is a document that summarizes the performance and other characteristics of a product, machine, component (e.g., an electronic component), material, a subsystem (e.g., a power supply) or software in sufficient detail that allows a buyer to understand what the product and a design engineer to understand the role of the component in the overall system.	
Soldering iron	Specifications Max Temp 460°c Min Temp Room Terperature Temperature Control? No Voltage 230V Watts 20-50W Colour Hot Rod Red Bit type out-of-box Chisel 50W Rated Plug Round Indian Type	-It supplies heat to melt solder so that it can flow into the joint between two workpieces. A soldering iron is composed of a heated metal tip and an insulated handle. Heating is often achieved electrically, by passing an electric current (supplied through an electrical cord or battery cables) through a resistive heating element .	

Soldering Sucker	Length 19cm Diameter 2cm	Solders can be removed using a vacuum plunger (on the right) and a soldering iron . In electronics, desoldering is the removal of solder and components from a circuit board for troubleshooting , repair, replacement, and salvage.	

Self-Check -1	Written Test

Directions: Answer all the questions listed below.

I. Match column "A" with column "B"

"A"	**" B"**
________1. Specifications	A. It supplies heat to melt solder so that it can flow into the joint between two workpieces.
________2. Soldering Sucker	
	B. Express the level of performance of the individual units
________3. Data book	C. Removes solders using a vacuum plunger
________4. Flux	D. is a chemical cleaning agent, flowing agent, or purifying agent.
________5. Soldering iron	E. Is a document that summarizes the performance and other characteristics of a product, machine, component

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Information Sheet-2	Selecting appropriate tools and test instrument

2.1 Introduction to Selecting appropriate tools and test instrument

The following table shows tools and instruments which are appropriate to perform the electrical/electronic tasks given under this topic.

Table 2: tools and instruments

Tools	**Test instrument & other equipments**	**Consumable materials**
Different Pliers	Multimeter	Wire, Cable
Screw Drivers	Megger	Solder lead, Flux
Wrenches	Frequency meter	PCB
Pipe cutter	Inductance meter	
Steel rule	Oscilloscope	
	Power supply	
	Soldering gun	
	Digital IC Tester	

2.2 Types of appropriate tools and test instrument

- **Tools**

✓ **Pliers** are available with both insulated and uninsulated handles, which are used in handling and twisting wires. The handle insulation is not considered sufficient protection alone. Other safety precaution must be observed. Common types of pliers are:

***Figure 1** different kind of pliers*

- ✓ **Screw drivers** come in various sizes and shapes. They are used to drive and pull out screws. They are made of insulated handles with either sharp or square tips. The width of the screw driver should match the width of the screw slot. Common types of screw drivers are:

Standard type Phillips Offset

Figure

F ***Figure** 2: different screw drivers*

- ✓ **Drilling Equipment** is needed to make holes in building structure for passage of wires and conduit in both new and old installation, indoor or outdoor wiring. Common types of drilling tools and equipments are:

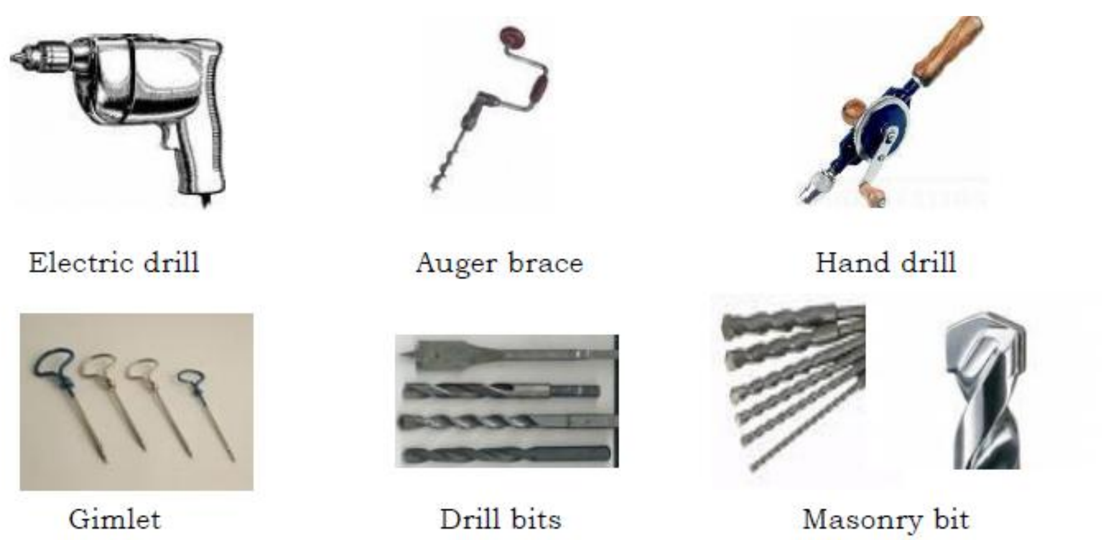


__Figure 3:__ different kinds of drilling equipments

Soldering tools are used in making splices and taps connections of wires.

Soldering iron

Soldering gun

Blow torch

__Figure 4:__ different kinds of soldering tools

Hammers are used to drive and pull out nails. They are made of either hard steel or plastic. Common examples of hammer are:

Claw hammer

Ball pin hammer

Mallet (Plastic or rubber hammer)

__Figure 5:__ Different kinds of hammers

- ✓ **Measuring tools and instrument**:- The electrician uses the following measuring tools and instruments to measure value of voltage, current and resistance, wire length, opening sizes of wire, conduit and other items.

Metric rule

Wire gauge

Veneer caliper

Multitester

Voltmeter

Ammeter

Galvanometer

Micrometer caliper

Clamp meter

Megger

Phase Sequence Tester

High Potential Tester

Sawing and cutting tool. Two of the commonly used saw are:

Hack saw

Keyhole saw

***Figure 6**: tools and measuring instruments*

Self-Check -2	Written Test

Directions: Answer all the questions listed below.

Choose the best answer from the given choices

1. _______are used in handling and twisting wires.

   A. Pliers B. wrenches C. screw drivers D. hammers

2. Which of the following tool is used to make holes in building structure for passage of wires and conduit in both new and old installation, indoor or outdoor wiring

A. Hammers B. wrenches C. drilling equipment D. soldering gun

3. _______ are used to drive and pull out nails.

A. Pliers B. hammers C. wrenches D. screw drivers

4. _______ are used to drive and pull out screws.

A. Pliers B. wrenches C. screw drivers D. hammers

5. Which of the following **is not** an example of instruments to measure electrical quantities

A. Ammeter B. ohmmeter C. galvanometer D. pliers

Note: **Satisfactory rating - 3 points Unsatisfactory - below 3 points**

Score = ___________

Rating: ____________

Information Sheet-3	Planning task to ensure occupational health and safety

3.1 Introduction to planning task to ensure occupational health and safety

The purpose of an OHS program is to prevent injuries and occupational diseases and to deal effectively with any accidents or incidents that occur.

✓ **Incorporating safe work practices into workplace activities**

➢ **Safe work practices**

Safe work practices and procedures are necessary to ensure that the workplace in the work shop is a safe as possible for yourself, your friends, resources(materials tools and equipments). Safe work practices are designed to ensure that OHS regulations are obeyed in the workplace. Safe work practices are ways of doing your work safely. The main safe work practices you have to know are:-

a. Use correct manual handling method
b. Use personal protective equipments as required
c. Use tools and measuring instrument in correct handling and Appling method
d. Use safe posture and movement
e. Avoid getting tired by taking rest and rotating tasks
f. Use hazardous/dangerous equipments safely such as sharp knife, hot surfaces, electrical appliances
g. Handle hazardous substances safely
h. Pay attention to safety signs
i. Identify and remove or control hazards from your own work area

➢ **Hazard control responsibilities(OHS rules)**

- ✓ Identify potential hazards through regular inspections and either eliminate or control the hazards with Out delay.
- ✓ Remedy any workplace conditions that are hazardous to worker health or safety.
- ✓ Develop written safe work procedures.
- ✓ Encourage workers to express concerns and suggest improvements on health and safety issues,for example
- ✓ through safety talks, meetings,or consultation with worker representatives

Self-Check -3	Written Test

Directions: Answer all the questions listed below.

I. **Write true or false for the following statements**

1. Safe work practices and procedures are necessary to ensure that the workplace in the work shop is a safe as possible for yourself, your friends, and resources.
2. One of an example of Safe work practices is to use correct manual handling method.
3. Safe work practices are not designed to ensure that OHS regulations are obeyed in the workplace.
4. Safe work practices are ways of doing your work safely.
5. Potential hazards can be identified through regular inspection.

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-4	Identifying and preparing Electrical /Electronic parts

4.1 Introduction to Identifying and preparing Electrical/electronic parts

An electronic circuit is composed of various types of components. Some of these components are termed as active components because they take part in the transformation of the energy while other components, which only dissipate or store energy, are called as passive components. The vacuum tubes, rectifier, transistors are some of the common active while the resistances, which dissipate the power and energy storing elements such as capacitances and inductances are known as passive elements. The transformers may be regarded as a matching device. The success of any electronic circuit depends not only on proper selection of the active elements but on the passive and matching elements too. The proper function, of an active device is decided by .the proper values of these passive elements.

4.2 Types of electrical/electronic components

Electrical/electronic components/parts are categorized in two groups.

These are:

- **Active elements:-**those generate (transform) energy such as vacuum tube, diode, transistor; IC, rectifier, Active components or semiconductor devices rely on a source of energy and usually can inject power into a circuit. Semiconductor.
    - ✓ Devices have made the electronic equipment to operate at very high speed and reducing the size of the equipment. All the semiconductor devices is consist of 'p' and 'n' type of semiconductors and their junctions
- **Passive elements:-**those do not generate energy; rather they dissipate or store energy. Passive components can't introduce net energy into the circuit. As a

consequence they can't amplify but it can increase the power of a signal, a voltage or current by a transformer or resonant circuit. Passive components include such as resistors, capacitors, inductors, and transformers

Passive Components: resistors, capacitors inductors, and transformers

Active components: Transistor, diode, thyristors, etc

- **Logic gates(*NOT, OR, AND, etc***

Logic gates are the basic building blocks of any digital system. It is an electronic circuit having one or more than one input and only one output. The relationship between the input and the output is based on certain logic. Based on this logic gates are named as AND gate, OR gate, NOT gate etc.

In this module we will be concentrating on the fundamentals of digital and analogue circuits. We should start by ensuring that you understand the difference between a digital signal and an analogue signal.

✓ **An analogue signal**

This is a signal that can have any value between the minimum and maximum of the power supply. Changes between values can occur slowly or rapidly depending on the system involved. Graphically this is represented by a graph similar to that shown below.

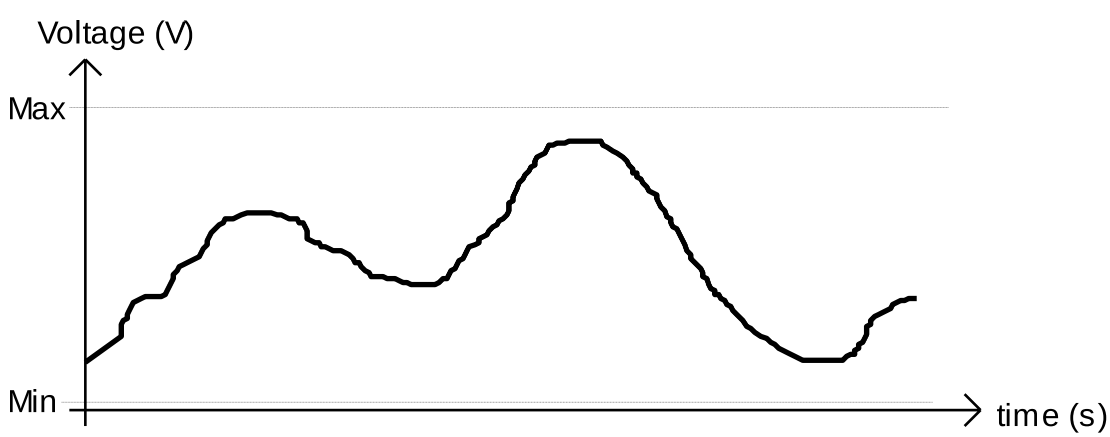


Figure 7: Analogue signal

✓ **A digital signal**

This is a signal that can only have two finite values, usually at the minimum and maximum of the power supply. Changes between these two values occur instantaneously. Graphically this is represented by a graph similar to that shown below.

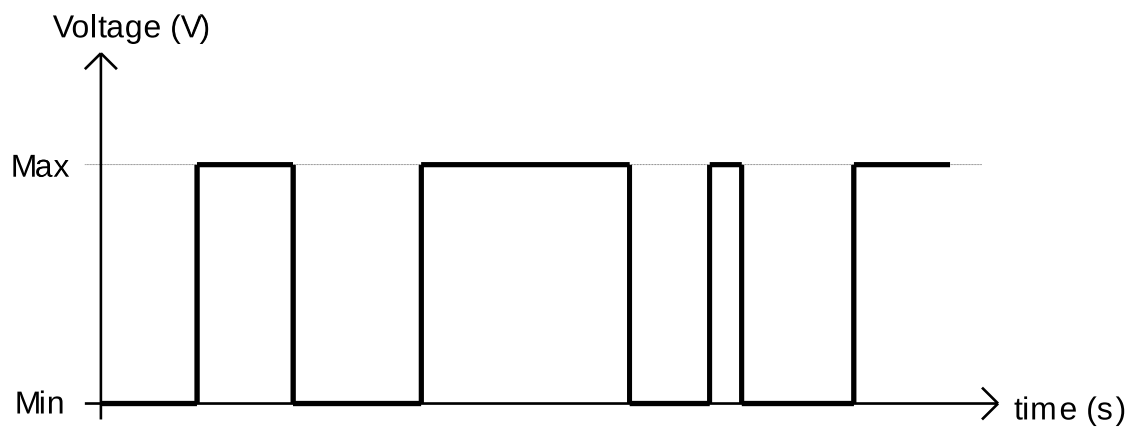


Figure 8: digital signal

For the time being we will concentrate on digital systems. We have to introduce some more terms that are used to describe digital signals, because there are a number of different power supplies available which may cause confusion if we start to talk about outputs being at a particular voltage.

Therefore there is a standard terminology used when dealing with digital systems as we have here. When an input or output signal is at the minimum power supply voltage (usually 0V) this is referred to as a LOW signal or LOGIC 0 signal. When an input or output signal is at the maximum power supply voltage this is referred to as a HIGH signal or LOGIC 1 signal.

So now that we understand the terms lets start by looking at the basic building block of all digital systems, the logic gate.

The term logic gate actually gives a clue as to the function of these devices in an electronic circuit. ‘Logic’ implies some sort of rational thought process taking place and a ‘gate’ in everyday language allows something through when it is opened.

A Logic Gate in an electronic sense makes a 'logical' decision based upon a set of rules, and if the appropriate conditions are met then the gate is opened and an output signal is produced.

Logic gates are therefore the decision making units in electronic systems and there are many different types for different applications.

- **Integrated Circuit**

An integrated circuit, or IC, is small chip that can function as an amplifier, oscillator, timer, microprocessor , or even computer memory. An IC is a small wafer, usually made of silicon, that can hold anywhere from hundreds to millions of transistors, resistors, and capacitors. These extremely small electronics can perform calculations and store data using either digital or analog technology.

Digital ICs use logic gates, which work only with values of ones and zeros. A low signal sent to to a component on a digital IC will result in a value of 0, while a high signal creates a value of 1.

Digital ICs are the kind you will usually find in computers, networking equipment, and most consumer electronics. Analog or linear ICs work with continuous values. This means a component on a linear IC can take a value of any kind and output another value. The term "linear" is used since the output value is a linear function of the input. For example, a component on a linear

IC may multiple an incoming values by a factor of 2.5 and output the result. Linear ICs are typically used in audio and radio frequency amplification.

- **Data book Reading skill**

A data book is a collection of datasheets, in printed book form, from a single manufacturer.

Nomograms, tables, and charts supply information on international frequencies, the production and transmission of communication signals, passive and active components and circuits, mathematical formulas and symbols, and the principle of physics.

For anyone who doesn't know, Data books are a common class of books published specially long running ones in which the creative team put out vital and/or non- vital statistics concerning characters, events, backgrounds, consequences, abilities and plot-lines for the respective title.

Self-Check -4	Written Test

Directions: Answer all the questions listed below.

I: **Write true or false for the following statements**

Match column "A" with column "B"

"A"	**"B"**
1. A collection of datasheets, in printed book form, from a single manufacturer.	A. Logic gate
2. Small chip that can function as an amplifier, oscillator, timer, microprocessor , or even computer memory	B. Data book
3. The basic building blocks of any digital system	C. Passive components
4. Do not generate energy; rather they dissipate or store energy	D. Integrated circuit
5. a signal that can only have two finite values, usually at the minimum and maximum of the power supply	E. Digital signal

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ___________

Rating: ____________

Information Sheet-5	Testing and de-soldering/soldering of electronic parts Introduction

5.1. ntro

duction to testing and de-soldering/soldering of electronic parts

Testing is essential to clear the doubt whether the component has actually got defected or not. Many a time a component which has been thought to be faulty is found correct on isolated testing. Many times the value of components gets deviated in resulting in voltage or current variations. It is required that the service technician is aware of correct procedure of testing of the components.

The electronic circuits have the assembly of both active and passive components. The correct test procedure of testing any component requires full knowledge of its construction and behavior. Testing involves the measuring parameters of the components and comparing these measured values with the actual values of the parameter required of the component. If there is big mismatch between the measured and the correct values supposed of it, then the component is faulty.

A component may be classified as passive or active. A passive component as ones that cannot supply energy themselves, whereas a battery would be seen as an active component since it truly acts as a source of energy.

5.2. **De-soldering/soldering of electronic parts**

- **Solder**

Solder is a low-melting alloy, especially one based on lead and tin, used for joining less fusible metal. 5.3.

- **Soldering**

Soldering is joining with this alloy. Prior to soldering it is a good idea to have all components organized as it will make populating the PCB more efficient.

Soldering quality and performance vary depending on tip geometry, board thickness, temperature, flux type, solder type, technique, etc

- **Soldering Iron:**

Soldering iron is an essential tool for soldering. A soldering iron should give sufficient heat to melt solder by heat transfer when the iron tip is applied to be soldered. The selection of the soldering iron can be made as regard to its tip size, shape and wattage. The tips are made in shape of pencil, flat and rectangular. Soldering irons have different wattages depending on the types of work required. Example 25W, 40W, 60W, 100W etc.

- **Soldering Techniques**

Soldering is the act of heating two metals (a pad and a lead) and a solder alloy to form a solder joint. As the joint cools, a strong electrical and mechanical connection is formed.

- Select the correct tip and tip temperature (see previous sections).
- Turn on the system; wait for the tip to heat up (5-10 seconds).
- Clean the tip on a sponge with the following qualities:
    - ✓ Damp, not dry—use de-ionized water.
    - ✓ Clean, not dirty.
    - ✓ Sulfur-free (do not use household sponges).
- Contact the terminal and the pad simultaneously, and feed wire core solder into the joint.
- Do not feed solder into the tip while you solder. Feeding solder into one part of the tip may cause the flux to activate in only one spot. This feeding may cause a hole in the iron plating of the tip
- Hold the tip steady until the joint is filled evenly with solder.
- Do not rub the tip against the lead.
- Do not apply too much pressure to the joint.
- Good contact with a wet surface is sufficient to pass heat efficiently into the solder joint.

- After soldering, clean the tip on the sponge, tin the tip with RMA solder, and turn the system off.
- **Flux**

Flux is a cleaning agent to remove oxidation during soldering. Heating a metal uses rapid oxidation. Oxidation prevents solder from reacting chemically with a metal. Flux cleans the metal by removing the oxide layer.

Self-Check -5	Written Test

Directions: Answer all the questions listed below.

I. Write true or false for the given statements bellow

1. Soldering is the act of heating two metals and a solder alloy to form a solder joint..
2. It is possible to feed solder into the tip while you solder.
3. Soldering iron is used to remove oxidation during soldering.
4. Selecting the correct tip and tip temperature is one of an example of soldering technique.
5. Testing is essential to clear the doubt whether the component has actually got defected or not.

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Instruction Sheet	LG37:-Identifying and testing Electrical/electronic parts

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics

- Observing safety procedures in using appropriate personal protective equipment and hand tools/test instrument at all times
- Undertaking work safely
- Identifying Important Electrical/Electronic Components/parts
- Using appropriate range of *methods* in testing electrical /electronic circuits & parts
- Following correct use of test/measuring instrument
- Confirming the electrical/electronic parts data, function and value of parts/component specification Observe safety procedures in using appropriate personal protective equipment and hand tools/test instrument at all times.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to:-**

- Observing safety procedures in using appropriate personal protective equipment and hand tools/test instrument at all times.
- Undertake work safely
- Identify Important Electrical/Electronic Components/parts
- Use appropriate range of *methods* in testing electrical /electronic circuits & parts
- Follow correct use of test/measuring instrument
- Confirm the electrical/electronic parts data, function and value of parts/component specification

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5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3 ”**in page ---.**
6. Do the “LAP test” **in page – ---**

1.1. Introduction to Observing safety procedures in using appropriate personal protective equipment and hand tools/test instrument at all times

- **Observing safety procedures in using appropriate personal protective equipment**

Personal Protective Equipment shall be controlled and maintained in good order by ensuring:

- Personnel undertake regular inspections of their PPE, and if required, repair or replace. Personnel shall not use PPE which is not in good working order;
- PPE that either does not comply with specifications, or is damaged, shall be removed from use and tagged Out of Service;
- PPE that is not of a disposable nature is regularly cleaned and, where applicable, kept in hygienic or controlled conditions. Storage facilities, appropriate for the equipment type shall be provided for all such PPE after or between uses;
- PPE must be worn correctly and should not create secondary safety or health risks which cannot be appropriately controlled;
- The use of one type of PPE should not adversely affect the use of another type of PPE. For example, the use of safety glasses should not take away from the effectiveness of ear muffs from preventing the muff from sitting around the whole ear;
- PPE must comply with relevant Ethiopian Standards, or if one does not exist, another recognized standard such as EN or ANSI;
- PPE must be worn and used as designed; any deviation from the intended design specifications may render it useless and may not provide the protection that was intended by the manufacturer. The user must ensure that structural interference or alteration of PPE does not occur; and
- Composite toe cap safety footwear and safety helmets that have sustained a significant impact must be replaced, irrespective of visible damage being present.

✓ **Goggles**

Goggles: - Goggles or safety glasses are forms of protective eyewear that usually enclose or protect the area surrounding the eye in order to prevent particulates, water or chemicals from striking the eyes.

Fig1.1 Different types of goggles

✓ Gloves

GLOVE: - is a garment covering the hand. Gloves have separate sheaths or openings for each finger and the thumb

Gloves protect and comfort hands against cold or heat, damage by friction, abrasion or chemicals, and disease; or in turn to provide a guard for what a bare hand should not touch.

Fig 1.2 *Different types of gloves*

- **Safe procedures in using tools/test instrument**

Hand tools get little attention in the safety world, as we focus more on the safe use of power tools. Discussing the safe use of power tools is important because power tool accidents account for 400,000 emergency room visits per year, but hand tools can cause over exertion and injuries to hands and eyes if not used properly.

➢ Hand Tool Hazards

Hand tools are so common in workplaces it's easy to forget the hazards. Here are some examples of accidents that can occur if hand tools are misused: If a screwdriver is used as a chisel, the handle or tip may break and fly off, hitting the user or other employees. If a wooden handle on a tool, such as a hammer or an ax, is loose, splintered or cracked, the head of the tool may fly off, striking the user or other employees.

If the jaw of a wrench is sprung, the wrench might slip, causing a hand injury. If struck (hammered) tools (e.g., chisels, wedges or drift pins) have mushroomed heads, the heads might shatter on impact, sending sharp fragments flying toward the user or other employees. If a hammer is left on the floor, it could cause a slip, trip or fall.

Test Your Hand Tool Safety Procedures

Answer the following ten questions to see how well you are protecting your employees from potential hand tool accidents:

1. Are hand tools that develop mushroomed heads, such as chisels or punches, reconditioned or replaced as necessary?

2. Are broken or fractured handles on hammers, axes or similar equipment replaced promptly?

3. Are tools secured when an employee is working from height?

4. Do employees use appropriate safety glasses, face shields and similar equipment when using hand tools or equipment that might produce flying materials or be subject to breakage?

5. Are jacks checked periodically to ensure they are in good operating condition?

6. Are tool handles wedged tightly in the heads of all tools?

7. Are tool cutting edges kept sharp so that tools will cut smoothly without binding or skipping?

8. Do employees use eye and face protection when they strike or tempered tools, bits or nails?

9. Are employees trained on how to use the tools and how to select the right tool for the job?

10. Do employees put tools back where they belong after use?

Consider the Role Ergonomics Plays in Hand Tool Use

Self-Check -1	Written Test

Directions: Answer all the questions listed below.

I. Match column "A" with column "B"

"A"	"B"
1. A garment covering the hand have separate sheaths or openings for each finger and the thumb	**A.** Personal protective equipment
2. Safety glasses are forms of protective eyewear	**B.** Glove
3. PPE	**C.** Goggle

Note: **Satisfactory rating - 2 points** **Unsatisfactory - below 2 points**

Score = ___________   Rating: ____________

Information Sheet-2	Undertaking work safely

2.1 Introduction to Undertaking work safely

- **SAFE WORK PRACTICES**

A safe work environment is not enough to control all electric hazards. You must also work safely. Safe work practices help you control your risk of death from workplace hazards. If you are working on electrical circuits or with electrical tools and equipment, you need to use safe work practices.

- Before you begin a task, ask yourself:
- What could go wrong?
- Do I have the knowledge, tools, and experience to do this work safely?

All workers should be very familiar with the safety procedures for their jobs. You must know how to use specific controls that help keep you safe. You must also use good judgment and common sense.

- **Cleaning**

- Clean the tools immediately after use.
- Wash the tools using water. A wire brush may be useful to loosen the soil stuck to the blades.
- Avoid the risk of spreading pathogens while the tools are being cleaned.
- Coat the blades with light oil like WD-40 on areas prone to rust.

- **Lubrication** is the process or technique employed to reduce friction between, and wear of one or both, surfaces in proximity and moving relative to each other, by interposing a substance called a lubricant in between them. The lubricant can be a solid, (e.g. Molybdenum disulfide MoS_2)a solid/liquid dispersion, a liquid such as oil or water, a liquid-liquid dispersion (a grease) or a gas.

  - With fluid lubricants the applied load is either carried by pressure generated within the liquid due to the frictional viscous resistance to motion of the lubricating fluid between the surfaces, or by the liquid being pumped under pressure between the surfaces.
  - Lubrication can also describe the phenomenon where reduction of friction occurs unintentionally, which can be hazardous such as hydroplaning on a road.
- **Storage**
- Store tools in a dry, sheltered environment. Place tools on a rack for easy safety and easy access.

Place similar tools close together so that workers can see easily the available tool

Self-Check -2	Written Test

Directions: Answer all the questions listed below.

I. <u>Say True or False</u>

1. If you are working on electrical circuits or with electrical tools and equipment, you need to use safe work practices.

2. Store tools not in a dry, sheltered environment.

3. When cleaning tools avoid the risk of spreading pathogens.

4. Lubrication is the process or technique employed to reduce friction between, and wear of one or both.

5. Similar tools should be placed close together so that workers can see easily the available tools

.

***Note:* Satisfactory rating - 3 points** **Unsatisfactory - below 3points**

Score = ___________
Rating: ____________

Information Sheet-3	Identifying Important Electrical/Electronic Components/parts

3.1. Introduction to Identifying Important Electrical/Electronic Components/parts

- **Electrical/electronic theory**
  - ✓ **Basic electrical quantities (V,I,R,P,W)**
  - ✓ **The nature of electricity**

All atoms consist of protons, neutrons and electrons. The protons, which have positive electrical charges, and the neutrons, which have no electrical charge, are contained within the nucleus. Removed from the nucleus are minute negatively charged particles called electrons. Atoms of different materials differ from one another by having different numbers of protons, neutrons and electrons. An equal number of protons and electrons exist within an atom and it is said to be electrically balanced, as the positive and negative charges cancel each other out. When there are more than two electrons in an atom the electrons are arranged into shells at various distances from the nucleus.

All atoms are bound together by powerful forces of attraction existing between the nucleus and its electrons. Electrons in the outer shell of an atom, however, are attracted to their nucleus less powerfully than are electrons whose shells are nearer the nucleus. It is possible for an atom to lose an electron;

The atom, which is now called an **ion**, is not now electrically balanced, but is positively charged and is thus able to attract an electron to itself from another atom. Electrons that move from one atom to another are called free electrons and such random motion can continue indefinitely. However, if an electric pressure or **voltage** is applied across any material there is a tendency for electrons to move in a particular direction. This movement of free electrons, known as **drift**, constitutes an electric current flow. **Thus current is the rate of movement of charge.**

- ✓ **Conductors**

Conductors are materials with electrons that are loosely electron bounds to their atoms, or materials that permit free motion of a large number of electrons. Atoms with only one valence electron, such as copper, silver, and gold, are examples of good conductors. Most metals are good conductors.

- ✓ **Insulators**

Insulators, or nonconductors, are materials with electron that are tightly bound to their atoms and require large amount of energy to free them from the influence of the nucleus. The atoms of good insulators have their valence electrons, which mean they are more than half filled. Any energy applied to such an atom will be distributed among a relatively large number of electrons. Examples of insulators are rubber, plastics, glass, etc.

- ✓ **CURRENT**

The movement or the flow of electrons is called current. To produce current, the electrons must be moved by a potential difference. Current is represented by the letter symbol I. The basic unit in which current is measured is the ampere (A). One ampere of current is defined as the movement of one coulomb past any point of a conductor during one second of time.

The unit used to measure the **quantity of electrical charge Q** is called the **coulomb C** (**where 1 coulomb**= **6.24x10^{18}electrons**)

If the drift of electrons in a conductor takes place at the rate of one coulomb per second the resulting current is said to be a current of one ampere.

Thus 1 ampere =1 coulomb per second or1A=1C/s

Hence 1 coulomb =1 ampere second or 1C=1As

Generally, if **I** is the current in amperes and **t** the time in seconds during which the current flows, then **Ixt** represents the quantity of electrical charge in coulombs, i.e. quantity of electrical charge transferred, **Q=I×t** coulombs

$$\boxed{Q = I \times t \text{ coulombs}}$$

Problem 1. What current must flow if 0.24 coulombs is to be transferred in 15 ms?

Since the quantity of electricity, $Q = It$, then

$$I = \frac{Q}{t} = \frac{0.24}{15 \times 10^{-3}} = \frac{0.24 \times 10^3}{15}$$

$$= \frac{240}{15} = 16\text{ A}$$

Alternating Current & Direct Current

- **Direct current**

Direct current (**DC**) is the unidirectional flow of electric charge. Direct current is produced by sources such as batteries, power supplies, thermocouples, solar cells, or dynamos. Direct current may be obtained from an alternating current supply by use of a rectifier, which contains electronic elements (usually) or electromechanical elements (historically) that allow current to flow only in one direction. Direct current may be converted into alternating current with an inverter or a motor-generator set.

Direct current is used to charge batteries and as power supply for electronic systems. Very large quantities of direct-current power are used in production of aluminum and other electrochemical processes. It is also used for some railways, especially in urban areas. High-voltage direct current is used to transmit large amounts of power from remote generation sites or to interconnect alternating current power grids.

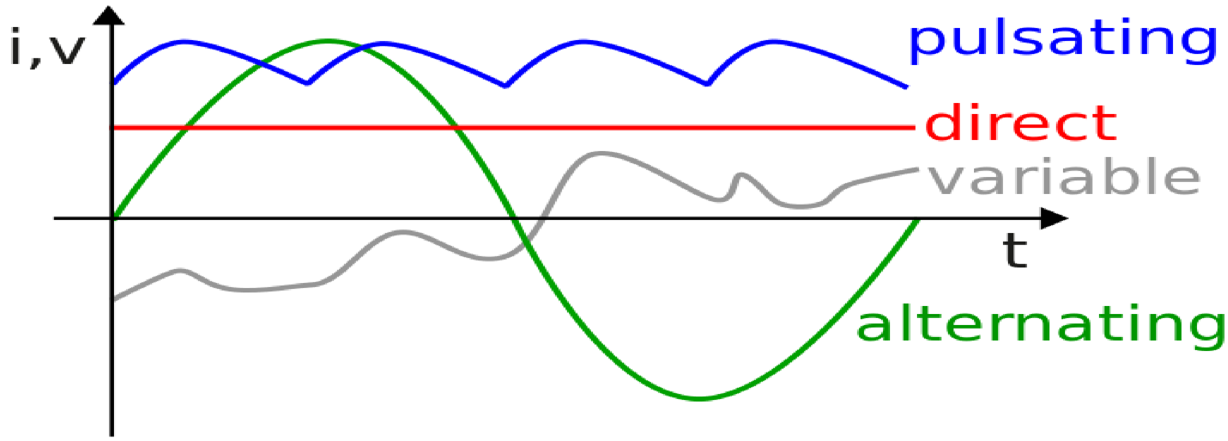


Fig 3.1 *Dc current*

The supply of current for electrical devices may come from a direct current (DC) source or an **alternating current (AC)** source. In a direct current circuit, electrons flow continuously in one direction from the source of power through a conductor to a load and back to the source of power. Voltage polarity for a direct current source remains constant. DC power sources include batteries and DC generators.

- **Alternating current**

By contrast, an AC generator makes electrons flow first in one direction then in another. In fact, an AC generator reverses its terminal polarities many times a second, causing current to change direction with each reversal.

AC Sine Wave Alternating voltage and current vary continuously. The graphic representation for AC is a sine wave. A sine wave can represent current or voltage. There are two axes. The vertical axis represents the direction and magnitude of current or voltage. The horizontal axis represents time.

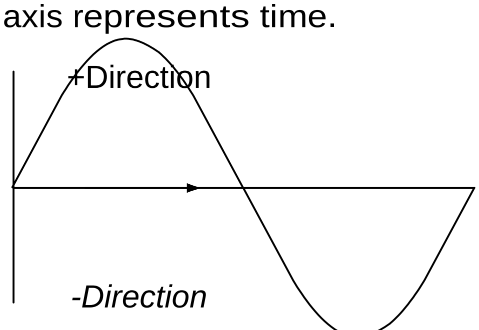


Fig 3.2 *Ac current*

When the waveform is above the time axis, current is flowing in one direction. This is referred to as the positive direction. When the waveform is below the time axis, current is flowing in the opposite direction. This is referred to as the negative direction. A sine wave moves through a complete rotation of 360 degrees, which is referred to as one cycle. Alternating current goes through many of these cycles each second.

- **Potential difference and resistance**
  - ✓ **Potential difference**

Also called Electromotive Force, Pressure of electricity or the amount of force it takes to move electrons. Measured in volts.

For a continuous current to flow between two points in a circuit a potential difference (p.d.) or voltage, V, is required between them; a complete conducting path is necessary to and from the source of electrical energy. The unit of p.d. is the volt, V.

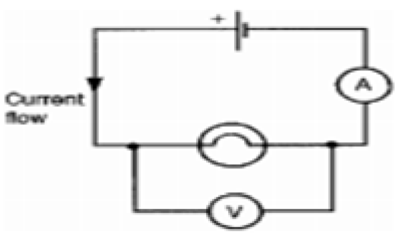


Fig 3.3 *ammeter and voltmeter connection*

Figure shows a cell connected across a filament lamp. Current flow, by convention, is considered as flowing from the positive terminal of the cell, around the circuit to the negative terminal.

- **Resistance:-**Anything that impedes or slows the flow of electrons. Measured in ohms. The flow of electric current is subject to friction. This friction, or opposition, is called **resistance R**and is the property of a conductor that limits current. The unit of resistance is the **ohm**; 1 ohm is defined as the resistance which will have a current of 1ampere flowing through it when 1 volt is connected across it,

i.e. $\boxed{\text{resistance } R = \dfrac{\text{Potential difference}}{\text{current}}}$

✓ **Electrical power**

Electrical power is the rate of energy consumption in an electrical circuit. Power **P** in an electrical circuit is given by the product of potential difference **V** and current **I**, The unit of power is the watt, **W**

Hence $$\boxed{P = V \times I \text{ watts}} \qquad (1)$$

From Ohm's law, $V = IR$. Substituting for V in equation (1) gives:

$$P = (IR) \times I$$

i.e. $$\boxed{P = I^2R \text{ watts}}$$

Also, from Ohm's law, $I = V/R$. Substituting for I in equation (1) gives:

$$P = V \times \frac{V}{R}$$

i.e. $$\boxed{P = \frac{V^2}{R} \text{ watts}}$$

There are thus three possible formulae which may be used for calculating power.

✓ **Electrical energy**

If the power is measured in watts and the time in seconds then the unit of energy is watt-seconds or joules. If the power is measured in kilowatts and the time in hours then the unit of energy is **kilowatt-hours**, often called the 'unit of electricity'. The 'electricity meter' in the home records the number of kilowatt-hours used and is thus an energy meter.

$$\boxed{\text{Electrical energy} = \text{power} \times \text{time}}$$

Example. A 12 V battery is connected across a load having a resistance of 40Ω. Determine the current flowing in the load, the power consumed and the energy dissipated in 2 minutes.

Current $I = \frac{V}{R} = \frac{12}{40} = \mathbf{0.3\ A}$

Power consumed, $P = VI = (12)(0.3) = \mathbf{3.6\ W}$

Energy dissipated $=$ power $\times$ time $= (3.6\ \text{W})(2 \times 60\ \text{s}) = \mathbf{432\ J}$

(since 1 J = 1 Ws)

Example2. A source of e.m.f. of15 V supplies a current of 2 A for six minutes. How much energy is provided in this time?

Energy = power x time, and power = voltage x current

Hence energy = $VIt = 15 \times 2 \times (6 \times 60) = 10\,800$ Ws or J = **10.8 kJ**

Multiples and sub-multiples

Currents, voltages and resistances can often be very large or very small. Thus multiples and submultiples of units are often used, as stated in chapter 1. The most common ones, with an example of each, are listed in Table 2.1

Table 2.1

Prefix	*Name*	*Meaning*	*Example*
M	mega	multiply by 1 000 000 (i.e. $\times 10^6$)	$2\,M\Omega = 2\,000\,000$ ohms
k	kilo	multiply by 1000 (i.e. $\times 10^3$)	$10\,kV = 10\,000$ volts
m	milli	divide by 1000 (i.e. $\times 10^{-3}$)	$25\,mA = \frac{25}{1000}\,A = 0.025$ amperes
μ	micro	divide by 1 000 000 (i.e. $\times 10^{-6}$)	$50\,\mu V = \frac{50}{1\,000\,000}\,V = 0.000\,05$ volts

- ✓ **Basic electrical/ electronic circuits**
  - ✓ Series circuit
  - ✓ Parallel circuit
  - ✓ Series-parallel circuit

Ohm's Law

For many conductors of electricity, the electric current which will flow through them is directly proportional to the voltage applied to them. When a microscopic view of Ohm's law is taken, it is found to depend upon the fact that the drift velocity of charges through the material is proportional to the electric field in the conductor. The ratio of voltage to current is called the resistance, and if the ratio is constant over a wide range of voltages, the material is said to be an "ohmic" material. If the material can be characterized by such a resistance, then the current can be predicted from the relationship:

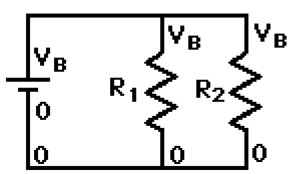
Ohm's Law

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

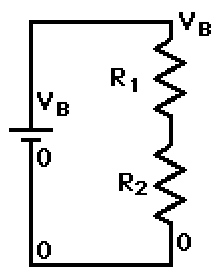
Electric current = Voltage / Resistance

Voltage Law

The voltage changes around any closed loop must sum to zero. No matter what path you take through an electric circuit, if you return to your starting point you must measure the same voltage, constraining the net change around the loop to be zero. Since voltage is electric potential energy per unit charge, the voltage law can be seen to be a consequence of conservation of energy. The voltage law has great practical utility in the analysis of electric circuits. It is used in conjunction with the current law in many circuit analysis tasks.



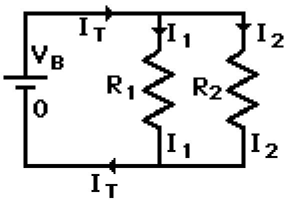
The voltages across elements in parallel are equal. This is one of the implications of the voltage law - since the change across either R_1 or R_2 must be equal to the battery voltage V_B, then they are equal to each other.



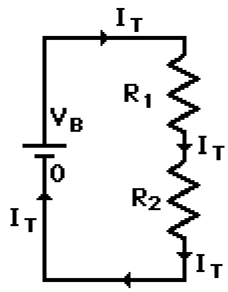
For a series combination, the sum of the voltage drops across R_1 & R_2 must sum to equal V_B.

Current Law

The electric current in amperes which flows into any junction in an electric circuit is equal to the current which flows out. This can be seen to be just a statement of conservation of charge. Since you do not lose any charge during the flow process around the circuit, the total current in any cross-section of the circuit is the same. Along with the voltage law, this law is a powerful tool for the analysis of electric circuits.



For a parallel circuit the current divides such that $I_T = I_1 + I_2$



The current is the same at all points in a series circuit.

Resistance

The electrical resistance of a circuit component or device is defined as the ratio of the voltage applied to the electric current which flows through it:

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

If the resistance is constant over a considerable range of voltage, then Ohm's law, I = V/R, can be used to predict the behavior of the material. Although the definition above involves DC current and voltage, the same definition holds for the AC application of resistors.

Whether or not a material obeys Ohm's law, its resistance can be described in terms of its bulk resistivity. The resistivity, and thus the resistance, is temperature dependent. Over sizable ranges of temperature, this temperature dependence can be predicted from a temperature coefficient of resistance.

Resistivity and Conductivity

The electrical resistance of a wire would be expected to be greater for a longer wire, less for a wire of larger cross sectional area, and would be expected to depend upon the material out of which the wire is made. Experimentally, the dependence upon these properties is a straightforward one for a wide range of conditions, and the resistance of a wire can be expressed as

$$R = \frac{\rho L}{A}$$

ρ = resistivity
L = length
A = cross sectional area

The factor in the resistance which takes into account the nature of the material is the resistivity . Although it is temperature dependent, it can be used at a given temperature to calculate the resistance of a wire of given geometry.

The inverse of resistivity is called conductivity. There are contexts where the use of conductivity is more convenient.

Electrical conductivity = $\sigma = 1/\rho$

Resistivity Calculation

The electrical resistance of a wire would be expected to be greater for a longer wire, less for a wire of larger cross sectional area, and would be expected to depend upon the material out of which the wire is made (resistivity). Experimentally, the dependence upon these properties is a straightforward one for a wide range of conditions, and the resistance of a wire can be expressed as

$$R = \frac{\rho L}{A}$$

Resistance = resistivity x length/area

Enter data and then click on the quantity you wish to calculate in the active formula above. Unspecified parameters will default to values typical of 10 meters of #12 copper wire. Upon changes, the values will not be forced to be consistent until you click on the quantity you wish to calculate.

Commonly used U.S. wire gauges for copper wire.

AWG	Diameter (inches)	Typical use
10	.1019	Electric range
12	.0808	Household circuit
14	.0640	Switch legs

Standard wire gauges

Resistivities of some metals in ohm-m($\times 10^{-8}$) at 20°C.

Aluminum	2.65	Gold	2.24
Copper	1.724	Silver	1.59
Iron	9.71	Platinum	10.6
Nichrome	100	Tungsten	5.65

Table of resistivities

The factor in the resistance which takes into account the nature of the material is the resistivity. Although it is temperature dependent, it can be used at a given temperature to calculate the resistance of a wire of given geometry.

The combination rules for any number of resistors in series or parallel can be derived with the use of Ohm's Law, the voltage law, and the current law.

- **Basic electrical/ electronic circuits**

✓ **Series circuit**

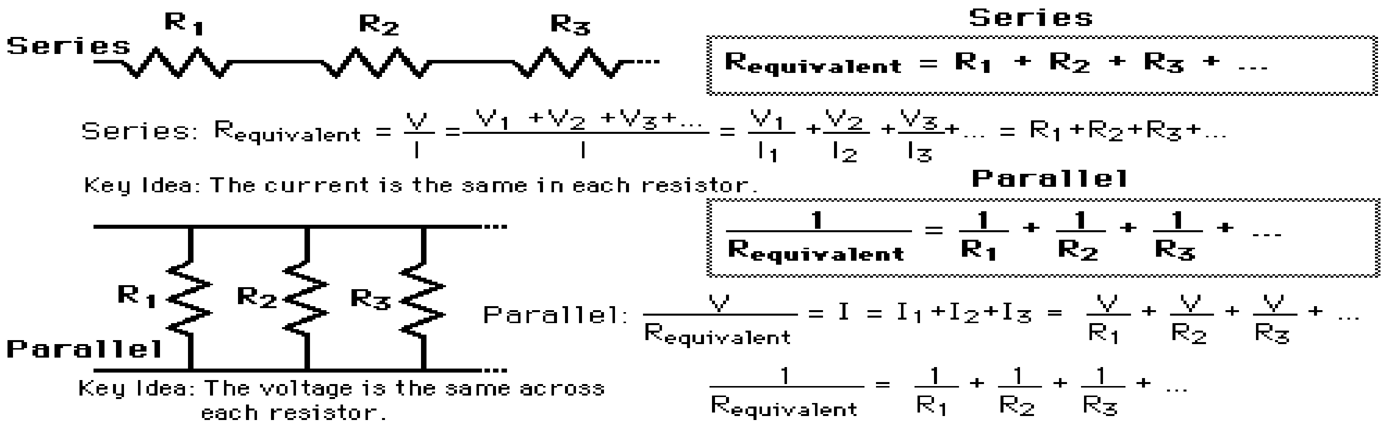


Fig 3.4 series and parallel connection of resistors

DC Series Circuit

Series circuit has more than one resistor *(anything that uses electricity to do work)* and gets its name from only having one path for the charges to move along. Charges must move in "series" first going to one resistor then the next. If one of the items in the circuit is broken then no charge will move through the circuit because there is only one path. There is no alternative route. Old style electric holiday lights were often wired in series. If one bulb burned out, the whole string of lights went off.

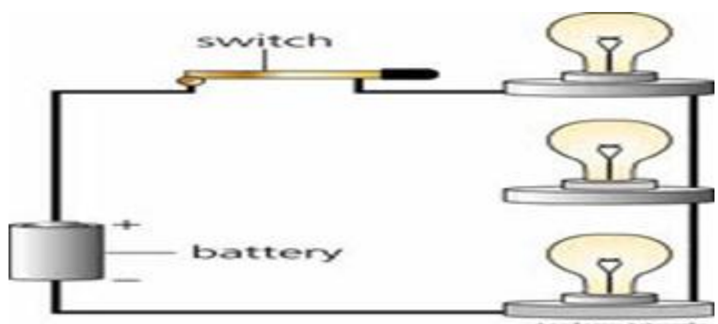


Fig 3.5 series connection of lamps

The following rules apply t o a series circuit:

1. The sum of the potential drops equals the potential rise of the source.

   VT=V1+V2+V3…………….

2. The current is the same everywhere in the series circuit.

It=I1=I2=I3=I4…………..

3. The total resistance of the circuit (also called effective resistance) is equal to the sum of the individual resistances.

^{R}T = R1+R2+R3………..

Example Series Problems

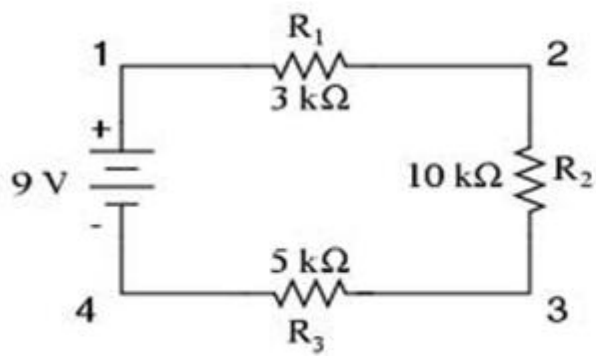


Fig 3.6 series connected resistors

From the Figure Find

a) Total Resistance

b) Current in the Circuit

c) Voltage Drop in R2

Solution

a) ^{R}T= R1+R2+R3= 3k+10k+5k=18K ohms

b) It= Vt/Rt=9V/18K= 0.5mA

c) V_{R2}= It*R2=0.5mA*10Kohms =5 volts

✓ **Parallel circuit**

DC Parallel Circuit

Comparison of parallel and series circuits with the same resistors and the same battery voltage applied.

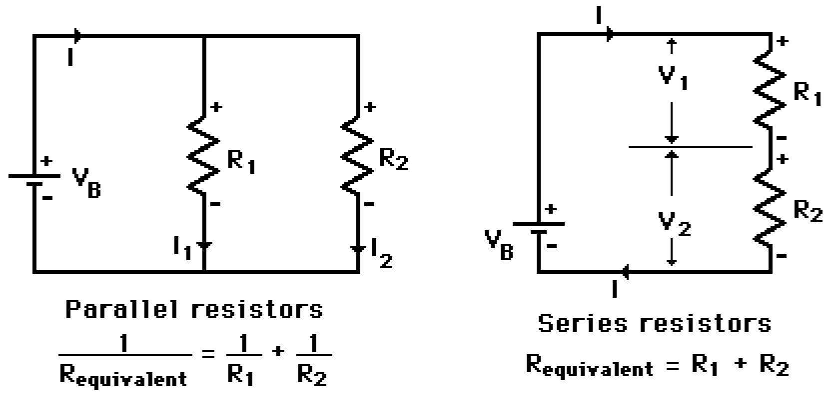


Fig. Two resistors in series and in parallel

- **Parallel circuit**

  A parallel circuit has more than one resistor *(anything that uses electricity to do work)* and gets its name from having multiple (parallel) paths to move along . Charges can move through any of several paths. If one of the items in the circuit is broken then no charge will move through that path, but other paths will continue to have charges flow through them. Parallel circuits are found in most household electrical wiring. This is done so that lights don't stop working just because you turned your TV off.

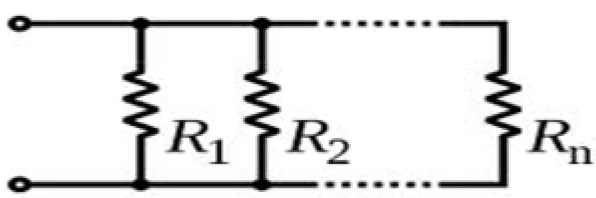


Fig 3.7 parallel circuit

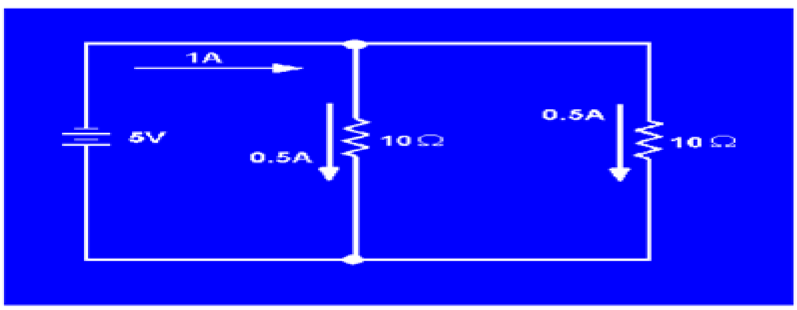
The following rules apply to a parallel circuit:

1. The potential drops of each branch equal the potential rise of the source. **Vt=V1=V2=V3=V…………………………..**
2. The total current is equal to the sum of the currents in the branches. **It=I1+I2+I3+I…………………..**

The inverse of the total resistance of the circuit (also called effective resistance) is equal to the sum of the inverses of the individual resistances.

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

Example Problem



Find Rt

Given:

Vt=5V,It=1A

Solution:

Rt=Vt/It=5V/1A=5ohms

or

Rt=R1*R2/(R1+R2)=10*10/(10+10)=100/20=5ohms

Comparison of parallel and series circuits with the same resistors and the same battery voltage applied.

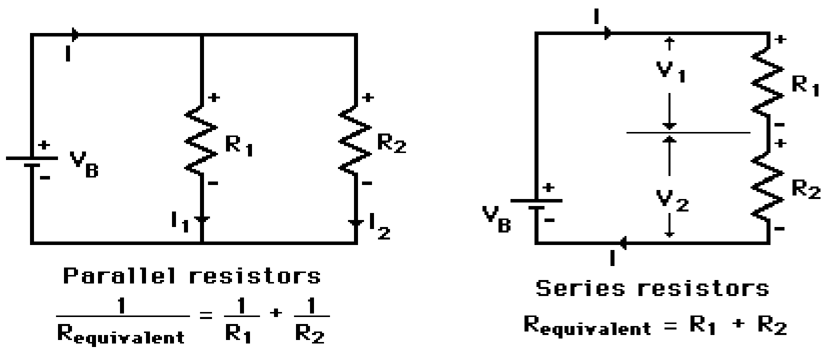


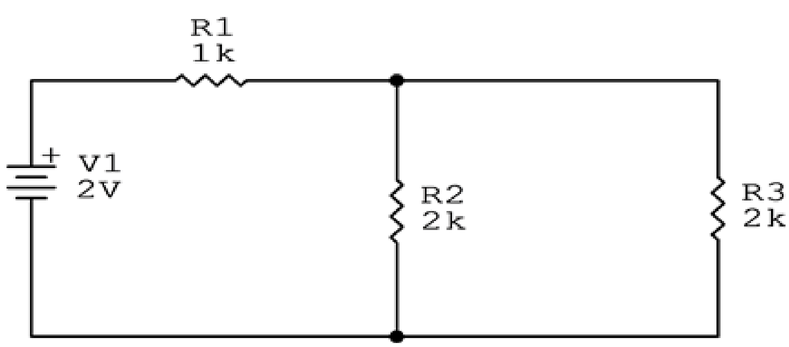
Fig 3.8 comparison of parallel and series circuit

✓ **Series-parallel circuit**

Series –Parallel Combination

A series –parallel circuit consists of combinations of both series and parallel .Its is important to know how the circuit was arrange in terms of series and parallel.

Example



Find:-

a) Rt

b) It

c) Voltage in R2

d) Current in R3

Solution

a. Rt= (R3//R2)+ R1=((2*2)/(2+2))+1K= 2Kohms

b. It=Vt/Rt= 2V/2Kohms= 1mA

c. V@R2= I2*R2= 0.5 mA* 2K ohms = 1 V

Current in R3= 1mA/2=0.5mA

https://www.youtube.com/watch?v=mc979OhitAg

https://www.youtube.com/watch?v=WoN1nou5t1Q

-

- **Electrical/Electronic parts and components**
  - **Passive components*(capacitor, resistor, inductor, etc)***

Passive components can't introduce net energy into the circuit. As a consequence they can't amplify but it can increase the power of a signal, a voltage or current by a transformer or resonant circuit. Passive components include such as resistors, capacitors, inductors, and transformers.

Resistors

Resistors (R) are the most fundamental and commonly used in all the electronic circuits.

The principal job of a resistor within an electrical or electronic circuit is to “resist,” regulate or to set the flow of electrons (current) through them. Resistors can be used as voltage droppers, voltage dividers or current limiters within a circuit. The electrical property of a resistor that opposes the flow of current is known as resistance. The unit of resistance is ohms (abbreviated as Ω). There are two types of resistors:

- Fixed resistors and
- Variable resistors
- **Fixed resistors**

Fixed resistors are those for which the value of resistance is fixed.(eg carbon composition resistors and wire wound resistors). Fixed resistors have a fixed value of resistance, which is displayed in the form of color coding for carbon resistors while it is written on the wire-wound resistors.

Resistor color code

The resistance of the resistor and its tolerance are marked on the resistor with color code bands that denotes the resistance value. There are 3 types of color codes:

- ✓ 4 bands: digit, digit, multiplier, tolerance.
- ✓ 5 bands: digit, digit, digit, multiplier, tolerance.
- ✓ 6 bands: digit, digit, digit, multiplier, tolerance, temperature coefficient.

Table1 Color code and tolerance

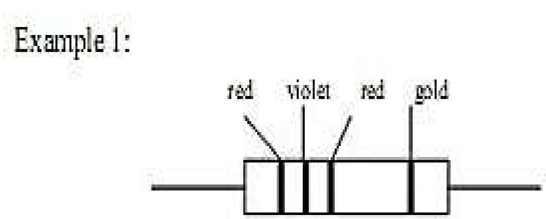
	1st Digit	2nd Digit	3rd Digit	Multiplier	Tolerance	Temperature Coefficient
4bands	1	2		3	4	
5bands	1	2	3	4	5	
6bands	1	2	3	4	5	6
Black	0	0	0	$\times 10^0$		
Brown	1	1	1	$\times 10^1$	±1%	100 ppm/ºK
Red	2	2	2	$\times 10^2$	±2%	50 ppm/ºK
Orange	3	3	3	$\times 10^3$	$\pm$3%	15 ppm/ºK
Yellow	4	4	4	$\times 10^4$	$\pm$4%	25 ppm/ºK

Green	5	5	5	$\times10^{5}$	±0.5%	
Blue	6	6	6	$\times10^{6}$	±0.25%	10 ppm/ºK
Violet	7	7	7	$\times10^{7}$	±0.1%	5 ppm/ºK
Grey	8	8	8	$\times10^{8}$	±0.05%	
White	9	9	9	$\times10^{9}$		
Silver				$\times10^{-2}$	±10%	
Gold				$\times10^{-1}$	±5%	
None					±20%	

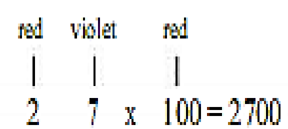
Figure 3.9 Resistor color code

Typical Example on How to Calculate the Resistor Color Codes

Reading from left to right, the first band close to the edge gives the first digit in the numerical value of R. The next band marks the second digit. The third band is then decimal multiplier, which gives the number of zeros after the two digits.



The first band is red for 2 and the next band is violet for 7.The red multiplier in the third band means add two zeroes to 27.The result can be illustrated as follows:



Therefore, thisRvalueis2700Ωwithtolerance+5%theresistortolerancemeans theamountbywhichtheactualRcanbedifferentfromthecolour-codedvalue.For instance, thealoneresistorvalue2700Ωresistorwith+5percenttolerancecanhave resistance 5 percent above or below the coded value.

This R, therefore, is between 2565Ω and2835Ω.The calculations are as follows:

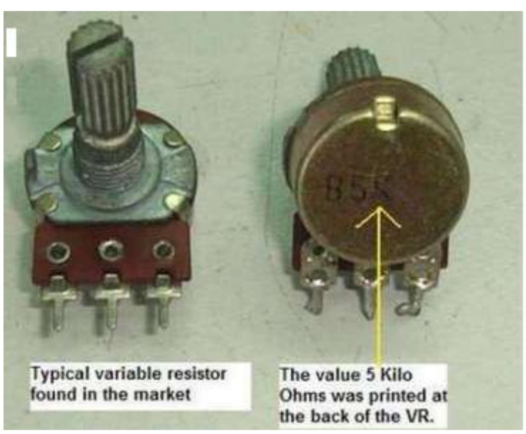
5 percent of 2700 is 0.05 x 2700 = 135

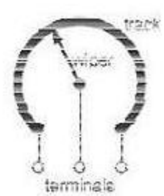
For +5 percent, the value is 2700 + 135 = 2835 Ω

For -5 percent, the valueis2700- 135 = 2565 Ω

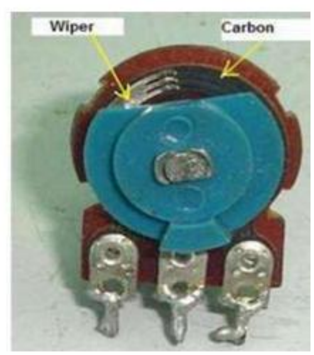
- **Variable Resistors:** whose resistances values can be changed from zero to maximum with the help of a movable arm? Variable resistors also called potentiometers or rheostats, employ a movable metal blade resting alone gain go resistive film. You can change the resistance by turning the knob.

A wire wound potentiometer (pot) that can dissipate 5 and more watts is often referred to as a rheostat. The resistance wire is wound on an open ring of ceramic which is covered with vitreous enable, except for the track of the wiper arm. Rheostats are used to control motor speeds, x-ray tube voltages, ovens and many other high power applications.





Internal view of Variable resistor



Variable resistor (potentiometer)

Fig 3.10 variable resistor

a. **Semi variable Resistors (preset):** whose value changed slightly whenever it is trimmed by screw driver.

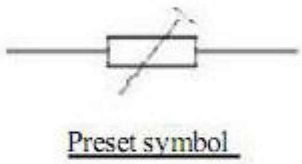


Fig 3.11 variable resistor preset symbol

A small plastic screwdriver or similar tool is required to adjust presets

These are miniature versions of the standard variable resistor. They are designed to be mounted directly on to the circuit board and tuned only when the circuit is built. For example to set the colors of Computer Monitor by turning the preset in the Cathode Ray Tube (CRT) board.

Presets are much cheaper than standard variable resistors so they are sometimes used in electronic projects where a standard variable resistor would normally be used.

- **Capacitor**

Capacitor, also known as condenser, is one of the most essential components in designing an electronic circuit. Radio, television and monitor circuits use a number of capacitors. Capacitor has a tendency to store electrical charge and then release it as current in the circuit where it is connected. So the use of capacitor is to store and then release electrical charge. This concept may sound simple enough, but it has important applications when the capacitor is combined with other components (inductors, resistors)in filter or timing circuits. Capacitor is symbolized as shown in below and it is denoted by a letter C.

- **HOW A CAPACITOR WORKS**

There are two ways to describe how a capacitor works. Both are correct and you have to combine them to get a full picture.

A capacitor has INFINITE resistance between one lead and the other.

This means no current flows **through** a capacitor. But it works in another way.

Suppose you have a strong magnet on one side of a door and a piece of metal on the other. By sliding the magnet up and down of the door the metal rises and falls.

The metal can be connected to a pump and you can pump water by sliding the magnet up and down.

A capacitor works in exactly the same way.

If you raise a voltage on one lead of a capacitor, the other lead will rise to the same voltage.

It works just like the magnetic field of the magnet through a door.

The next concept is this:

Capacitors are equivalent to a tiny rechargeable battery.

They store energy when the supply-voltage is present and release it when the supply drops.

These two concepts can be used in many ways and that's why capacitors perform tasks such as filtering, time-delays, passing a signal from one stage to another and create many different effects in a circuit.

- **Unit of capacitance**

Capacitance is measure in farads (F).Practically farad is a large unit. The smaller units are microfarads, nano-farads and Pico-farads.

1 microfarad= 1/1,000,000 farad

1 nano farad=1/1,000,000,000 farad

1 Pico farad=1/1,000,000,000,000 farad

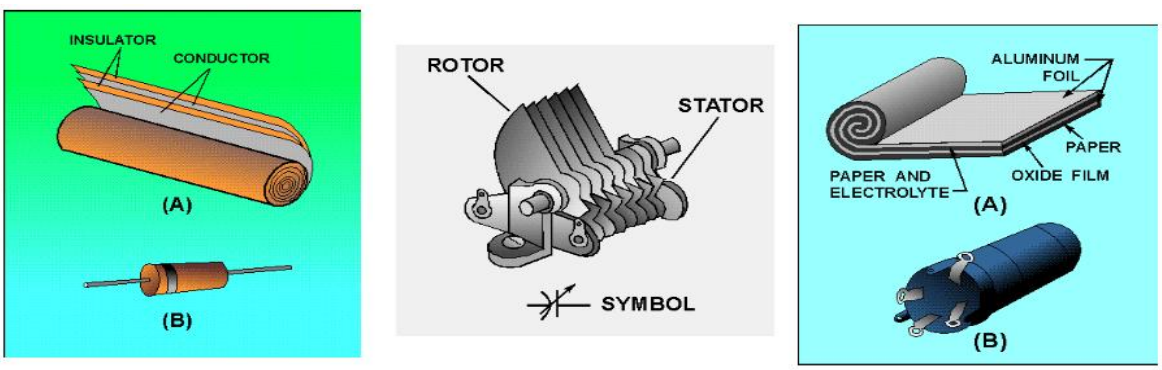
So, 0.01µF = 10nF = 10,000pF

Micro farad can be written as MFD, MF or µF or simply M. Nano-farad is written as NF.Pico-faradiswrittenasP.FCapacitorsratedinpico-faradsarefoundinRFand highfrequencycircuits.Capacitorsratedinmicrofaradsareincorporatedinlow- frequency and DC circuits, like power supplies, audio amplifiers, and digital and timer circuits.

- **Construction**

✓ Different types for different applications

✓ Choose for capacitance, size, voltage rating, leakage, series resistance..



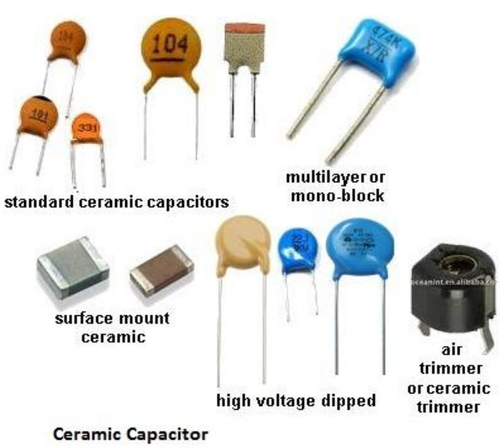
Metal film capacitor | Variable capacitor | Electrolytic capacitor

Fig. 3.12 capacitors

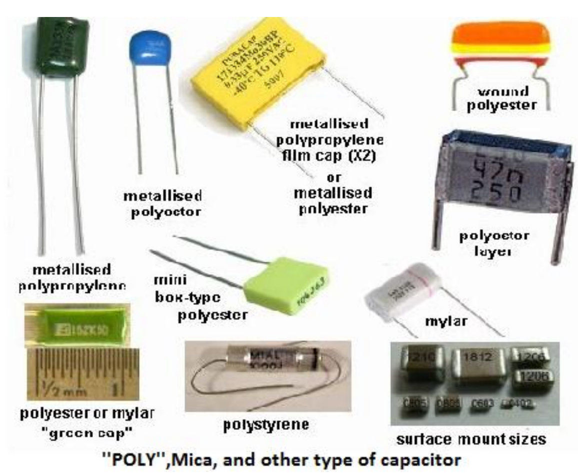
- **Types of capacitors**

There are basically two types of capacitors i.e.

- **Non-Polarized Capacitor**
    - ✓ MICA
    - ✓ Paper
    - ✓ Ceramic
    - ✓ Polyester
    - ✓ Polystyrene



None Electrolytic capacitor



- P o l

arized Capacitor

- ✓ Electrolytic capacitor
- ✓ Tantalum capacitor

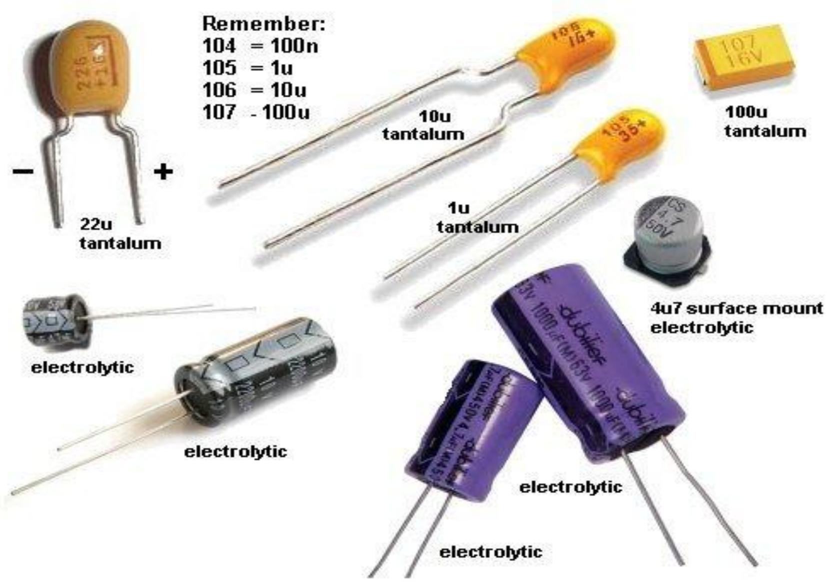


Fig3.13. different types of capacitors

Non-polarized capacitors mean that they can be inserted in to a circuit in any orientation. While polarized capacitors must be inserted in the proper orientation with respecttoappliedvoltage.Ifthepolarizescapacitorsisconnectedinopposite polarity, it may explode.

- ✓ **Voltage Rating of Capacitors**

Capacitors also have a voltage rating, usually stated as WV for working voltage ,or WVDC. This rating specifies the maximum voltage that can be applied across the capacitors without puncturing the dielectric. Voltage ratings for general purpose paper, mica, and ceramic capacitors are typically 200 to 500VDC. Ceramic capacitors with ratings of 1to5kv are also available. Electrolytic capacitors are commonly used in 25, 50, 100, 150,and 450v ratings. In addition, 6 and 10V electrolytic capacitors are often used in transistor circuits.

- ✓ **CAUTION**

If a capacitor has a voltage rating of 63v, do not put it in a 100v circuit as the insulation (called the dielectric) will be punctured and the capacitor will "short-circuit."

It's ok to replace a 0.22uF 50WV capacitor with 0.22uF 250WVDC.

- ✓ **SAFETY**

A capacitor can store a charge for a period of time after the equipment is turned off.

High voltage electrolytic caps can pose a safety hazard. These capacitors are in power supplies and some have a resistor across them, called a bleed resistor, to discharge the cap after power is switched off.

If a bleed resistor is not present the cap can retain a charge after the equipment is unplugged.

- ✓ **How to discharge a capacitor**

Do not use a screwdriver to short between the terminals as this will damage the capacitor internally and the screwdriver.

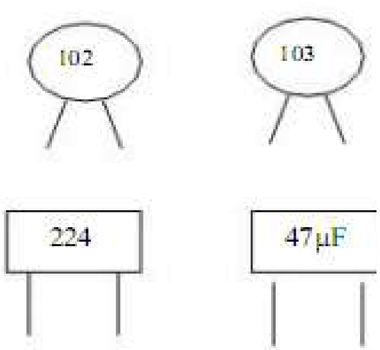
Use a 1k 3watt or 5watt resistor or 100watt bulb on jumper leads and keep them connected for a few seconds to fully discharge the electro.

Test it with a voltmeter to make sure all the energy has been removed.

Before testing any capacitors, especially electrolytic, you should look to see if any are damaged, overheated or leaking. Swelling at the top of an electrolytic indicates heating and pressure inside the case and will result in drying out of the electrolyte. Any hot or warm electrolytic indicates leakage and ceramic capacitors with portions missing indicates something has gone wrong.

- ✓ **How to read capacitor numeric code**

The non-polarized capacitor of nominal value of less than 1000pF is usually plain marked. For instant, for a 220pF capacitor, it will be marked 220only. For capacitance values of 1000pF or more, a three digit code is used. The first two digits represent the two significant digits and the third digit represents the decimal multiplier. For instance, 102 represents a capacitance of 10×10^2=1000pFand104 represents a capacitance of 10×10^4=100000pF=0.1µF. Basically it has the same calculation method as resistor.



Ceramic disc capacitor

Fig 3.14 ceramic capacitor

Example 1: What is the capacitance value of these capacitors marked

a.22=>22 microfarad

b.330=>330 microfarad

c.471=>47x10= 470 microfarad

d.562=>56x10² = 5600 microfarad or 5.6 nanofarad

e.103=>10x10³ = 10000 microfarad or 10nanofarad

f.224=> microfarad22x10 = 220000 microfarad or 220 nanofarad or .22

g. 335=>33x10=3300000picofarador3300nanofarador3.3 microfarad

Electrolytic capacitor shave their capacitance, voltage rating, and polarity printed on the case as shown in Figure below

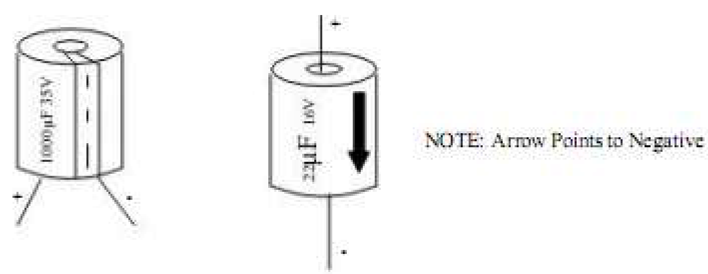


Fig.15 polarity of capacitors

Value of color coded capacitor can be determined in similar way as that of color coded resistor except the voltage rating of capacitor can be indicated in the color code technique

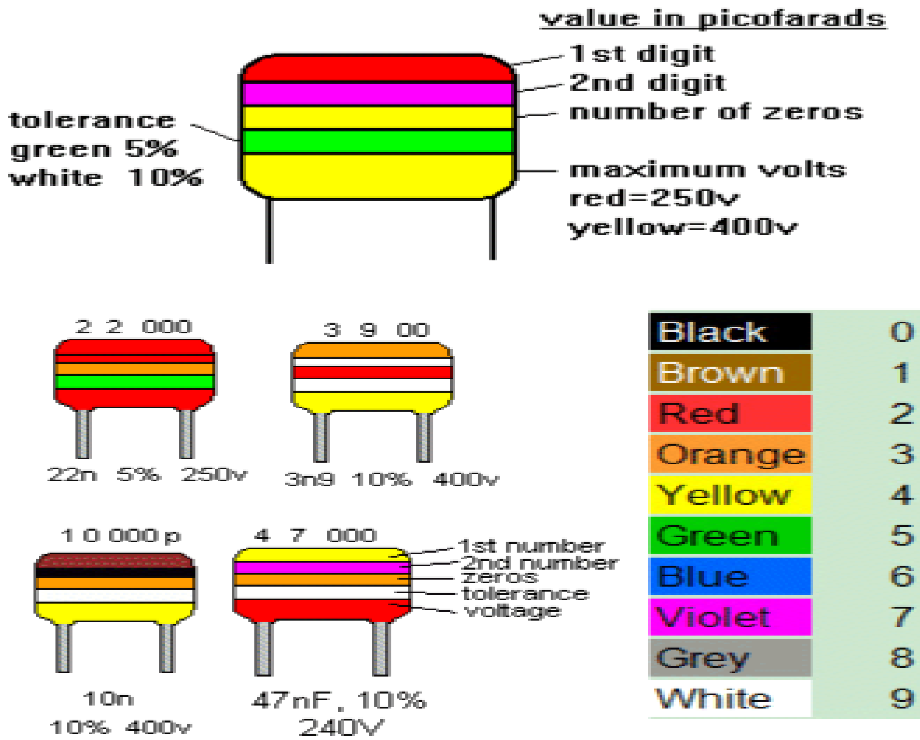


Fig.16 capacitor color code

- ✓ **Capacitance Tolerance**

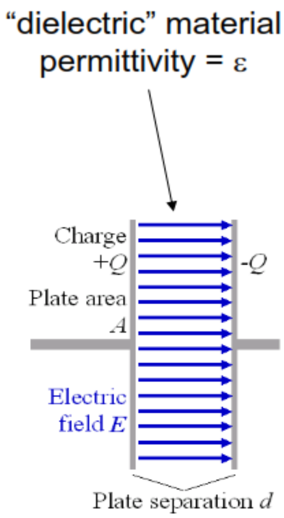
Ceramicdiskcapacitorsforgeneralapplicationsusuallyhaveatoleranceof+20 percent.Papercapacitorsusuallyhaveatoleranceof+10percent.Forcloser tolerances, micacapacitorsareused.Ithastolerancevalueof+2to20percent.The letterafterthecapacitancenumericalcodeindicatesthetolerancei.e.:M=20%; K=10%;J=5%.Soa103Kcapacitorisa10,000pFor10nFor0.010µF10% capacitor with 10 % tolerance.

Electrolyticcapacitorshaveawidetolerance.Forinstant,a100µFelectrolyticwith tolerance of ñ10 percent, +20 percent may have a capacitance of 90 to 120µF.

- ✓ **Capacitor Equations**

•A capacitor holds charge *Q* proportional to the voltage across it:

•T h e *capacitance C*(units of *Farads)* is set by the construction of the capacitor:



$$C \approx \frac{\epsilon A}{d}; A \gg d^2$$

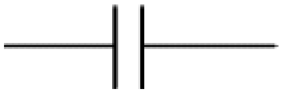
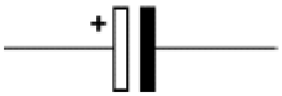
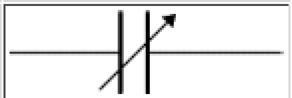
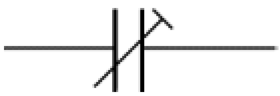
- **Capacitor behavior**
  - ✓ Current through capacitor proportional to rate of change in voltage across it:

$$i = \frac{\Delta Q}{\Delta t} = C\frac{\Delta V}{\Delta t}$$

- ✓ Capacitors act to resist changes in voltage
- ✓ Capacitor current can change (very) quickly
- ✓ Capacitors store energy:

$$E_{\text{stored}} = \frac{1}{2}CV^2 \Leftrightarrow E_{\text{stored}} = \frac{1}{2}\frac{Q^2}{C}$$

Table 3.1 symbols of capacitors

Capacitors circuit symbols and their functions		
Component	**Circuit Symbol**	**Function of Component**
Capacitor		A capacitor stores electric charge. A capacitor is used with a resistor in a timing circuit. It can also be used as a filter, to block DC signals but pass AC signals.
Capacitor, polarised		A capacitor stores electric charge. This type must be connected the correct way round. A capacitor is used with a resistor in a timing circuit. It can also be used as a filter, to block DC signals but pass AC signals.
Variable Capacitor		A variable capacitor is used in a radio tuner.
Trimmer Capacitor		This type of variable capacitor (a trimmer) is operated with a small screwdriver or similar tool. It is designed to be set when the circuit is made and then left without further adjustment.

- **INDUCTORS**

Like capacitors, inductors also store energy in one part of AC cycle and return it during the next part of the cycle.

Inductance is that property of a device that reacts against a change in current through the device. Inductors are components designed for use in circuits to resist changes in current and thus serve important control functions.

Inductor designed is based on the principle that a varying magnetic field induces a voltage in any conductor in that field. Thus, a practical inductor may simply be a coil wire. The current in each loop of the coil produces a magnetic field that passes through neighboring loops. If the current through the coil is constant the magnetic field is constant and no action takes place. A change in the current, however, produces a change in the magnetic field. The energy absorbed or released from the changing magnetic field reacts against the change in current, and this is exhibited as in induced voltage (electromotive force, emf), which is counter to the change in applied voltage. The inductor thus behaves as an impedance to ac current.

symbolical representation

Fig 3.17 Inductors

The counter emf is directly proportional to the rate of change of current through the coil (V=L [$\Delta i/\Delta t$]). The proportionality constant is the inductance L, which has the unit of henrys (H) In an ac circuit, as shown in, the inductor offers reactance to alternating current. The inductive reactance X_L has the units of ohms and is given by

$$X_L = wL = 2\pi fL$$

Total inductance

$$L = L_1 + L_2 + L_3 \text{ -----------}$$

Inductances in parallel :

$$1/L = 1/L_1 + 1/L_2 + 1/L_3$$

Inductor behavior

Voltage across inductor is proportional to the rate of change of current through it:

$$V = L\frac{\Delta I}{\Delta t}$$

- Inductors act to resist changes in current

•Inductor voltage can change quickly

•Inductors store energy:

Transformer

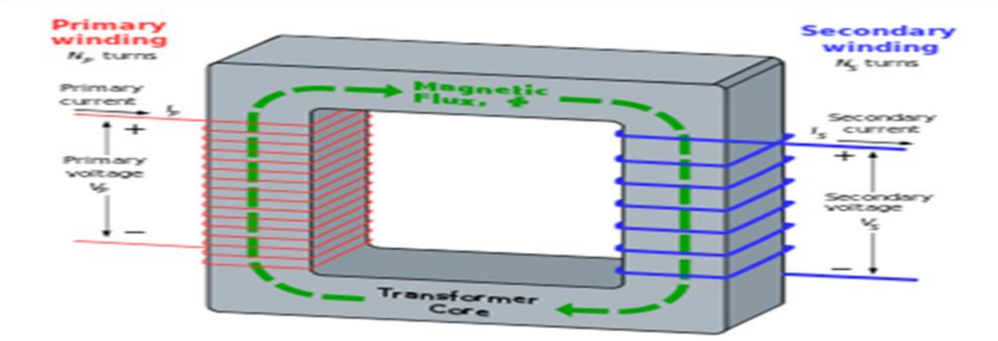


Fig 3.18 transformer

A transformer is an electrical device that transfers energy between two or more circuits through electromagnetic induction.

A varying current in the transformer's primary winding creates a varying magnetic flux in the core and a varying magnetic field impinging on the secondary winding. This varying magnetic field at the secondary induces a varying electromotive force (emf) or voltage in the secondary winding. The primary and secondary windings are wrapped around a core of infinitely high magnetic permeability. So that all of the magnetic flux passes through both the primary and secondary windings.

Types of transformers

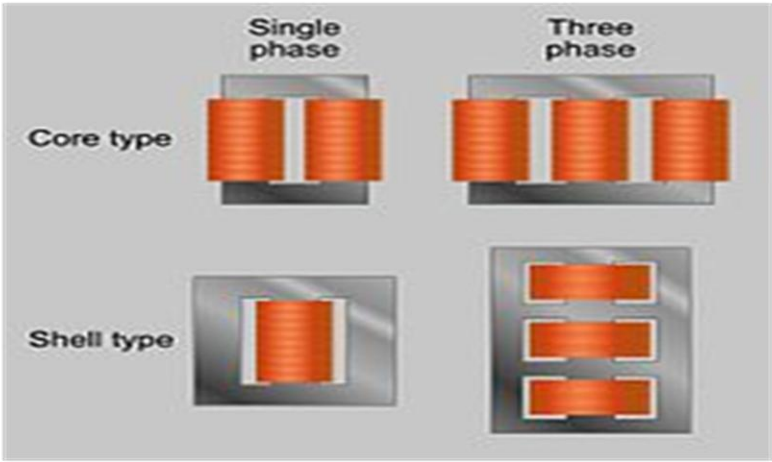


Fig 3.19 Core form = core type; shell form = shell type

Closed-core transformers are constructed in 'core form' or 'shell form'. When windings surround the core, the transformer is core form; when windings are surrounded by the core, the transformer is shell form. Shell form design mostly used for distribution transformer applications due to the relative ease in stacking the core around winding coils. Core form design is more economical than shell form design for high voltage power transformer applications at the lower end of their voltage and power rating ranges (less than or equal to, nominally, 230 kV or 75 MVA). At higher voltage and power ratings, shell form transformers tend to be more prevalent. Shell form design tends to be preferred for extra high voltage and higher MVA applications because, though more labor-intensive to manufacture, shell form transformers are characterized as having inherently better kVA-to-weight ratio, better short-circuit strength characteristics and higher immunity to transit damage.

$$E_{\text{stored}} = \frac{1}{2}LI^2$$

- **Active components**

Active components: diode, transistors, ICs, gates

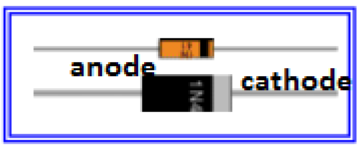
- **Diodes**: General purpose diode, Rectifier diode, Zener diode, LED, photo diode

Diode is unidirectional PN-junction electronics device used in many applications. Such as:tie

- ✓ Converting AC power from the 60Hz line into DC power for radios, televisions, telephone answering machines, computers, and many other electronic devices.
- ✓ Converting radio frequency signals into audible signals in radios.
- ✓ Used as rectifier in DC Power Supplies**.**
- ✓ In Demodulation or Detector Circuits**.**
- ✓ In clamping networks used as DC Restorers
- ✓ In clipping circuits used for waveform generation.
- ✓ As switches in digital logic circuit.

PN Junction Diodes

Example:



Circuit symbol:

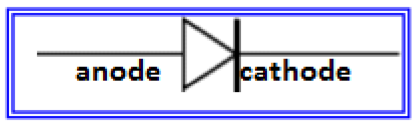


Fig 3.20 A p–n junction is a boundary or interface between two types of semiconductor material,

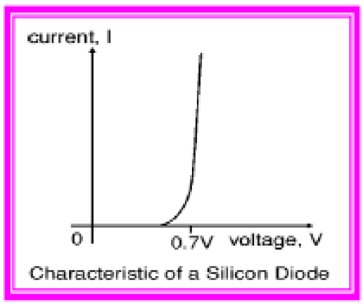
p-type and **n-type**, inside a single crystal of **semiconductor**. p–n junctions are elementary "building blocks" of most **semiconductor electronic devices** such as **diodes**, **transistors**, **solar cells**, **LEDs**, and **integrated circuits**. After joining p-type and n-type semiconductors, electrons from the n region near the p–n interface tend to diffuse into the p region. The regions nearby the p–n interfaces lose their neutrality and become charged, forming the **space charge region** or **depletion layer**

Function

Diodes allow electricity to flow in only one direction. The arrow of the circuit symbol shows the direction in which the current can flow.

Forward Voltage Drop

When a forward voltage is applied to diode, a small voltage experiences across a conducting diode, it is called the **forward voltage drop** and is about 0.7V for all normal diodes which are made from silicon. The forward voltage drop of a diode is almost constant whatever the current passing through the diode so they have a very steep characteristic (current-voltage graph).



Characteristic of a Silicon Diode

Fig 3.21 forward voltage drop

Reverse Voltage

When a reverse voltage is applied a perfect diode does not conduct, but all real diodes leak a very tiny current of a few µA or less. This can be ignored in most circuits because it will be very much smaller than the current flowing in the forward direction. However, all diodes have a **maximum reverse voltage** (usually 50V or more) and if this is exceeded the diode will fail and pass a large current in the reverse direction, this is called **breakdown**.

Ordinary diodes can be split into two types: Signal diodes which pass small currents of 100mA or less and Rectifier diodes which can pass large currents. In addition there are other types of diodes as such : LEDs, Zener diodes ,Tunnel diode, PIN diode, Photo diode and Varicap diode etc.

Signal diodes (small current)

Signal diodes are used to process information (electrical signals) in circuits, so they are only required to pass small currents of up to 100mA.

General purpose signal diodes such as the 1N4148 are made from silicon and have a forward voltage drop of 0.7V.

Germanium diodes such as the OA90 have a lower forward voltage drop of 0.2V and this makes them suitable to use in radio circuits as detectors which extract the audio signal from the weak radio signal.

For general use, where the size of the forward voltage drop is less important, silicon diodes are better because they are less easily damaged by heat when soldering, they have a lower resistance when conducting, and they have very low leakage currents when a reverse voltage is applied.

Biasing of Diode: the process of applying an external voltage is called as "biasing"**.**

There are two ways in which we can bias a pn junction diode.

- ✓ Forward bias
- ✓ Reverse bias

Forward Bias – The voltage potential is connected positive, (+ve) to the P-type material and negative, (-ve) to the N-type material across the diode which has the effect of **Decreasing** the PN junction diodes's width. Reverse Bias – The voltage potential is connected negative, (-ve) to the P-type material and positive, (+ve) to the N-type material across the diode which has the effect of **Increasing** the PN junction diode's width.

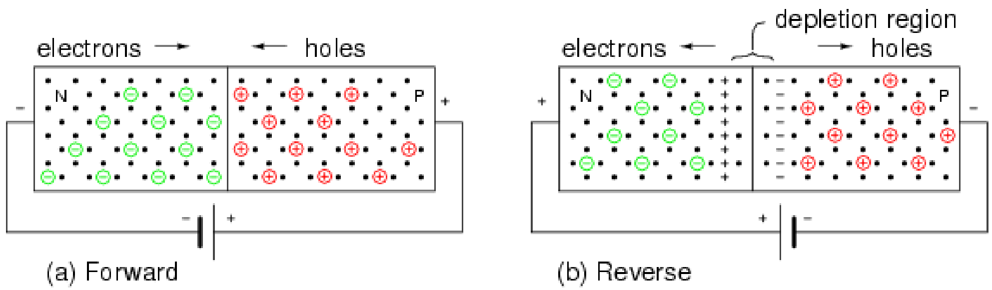
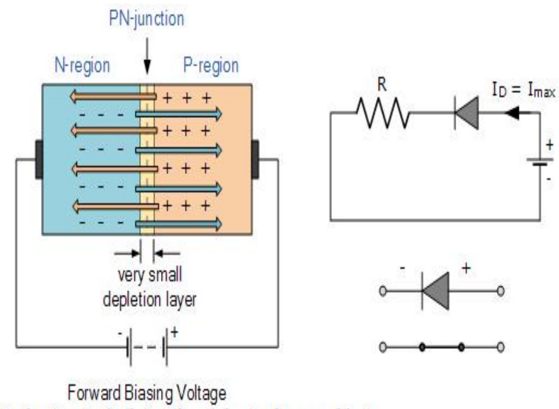


Fig3.22 Forward & Reverse bias & V-I characteristics of PN junction Diode

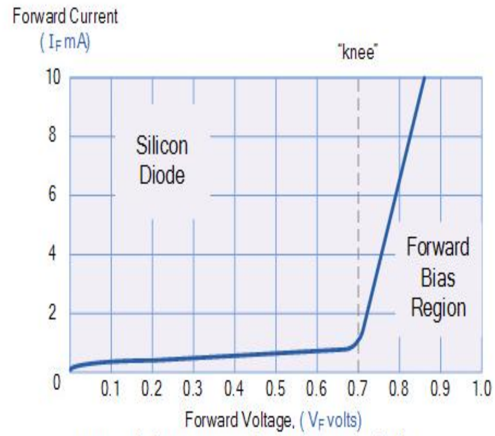
Forward Biased PN Junction Diode

When a diode is connected in a **Forward Bias** condition, a negative voltage is applied to the n-type material and a positive voltage is applied to the p-type material. If this external voltage becomes greater than the value of the potential barrier, approx. 0.7 volts for silicon and 0.3

volts for germanium, the potential barriers opposition will be overcome and current will start to flow.



Reduction in deplation layer due to forwared baise



Forward characterstics for PN junction diode

Reverse

Fig23. Forward biasing voltage

Biased PN Junction Diode

When a diode is connected in a **Reverse Bias** condition, a positive voltage is applied to the N type material and a negative voltage is applied to the P-type material. The positive voltage applied to the N-type material attracts electrons towards the positive electrode and away from the junction, while the holes in the P-type end are also attracted away from the junction towards the negative electrode. Thus

- The depletion layer grows wider due to a lack of electrons and holes and presents a high impedance path, almost an insulator.

- The result is that a high potential barrier is created thus preventing current from flowing through the semiconductor material.

- A high resistance value to the PN junction and practically zero current flows through the junction diode with an increase in bias voltage. However, a very small **leakage current** does flow through the junction which can be measured in microamperes, (µA).

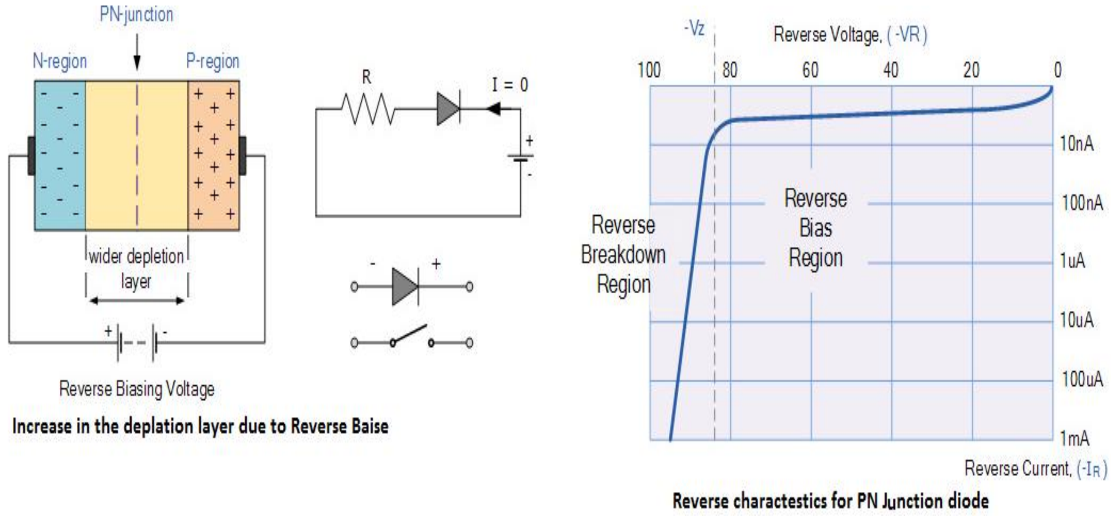


Fig. 3.24 Reverse biasing voltage

Junction Diode Summary

The PN junction region of a **Junction Diode** has the following important characteristics:

- Semiconductors contain two types of mobile charge carriers, **Holes** and **Electrons**.
- The holes are positively charged while the electrons negatively charged.
- A semiconductor may be doped with donor impurities such as Antimony (N-type doping), so that it contains mobile charges which are primarily electrons.
- A semiconductor may be doped with acceptor impurities such as Boron (P-type doping), so that it contains mobile charges which are mainly holes.
- The junction region itself has no charge carriers and is known as the depletion region.
- The junction (depletion) region has a physical thickness that varies with the applied voltage.
- When a diode is **Zero Biased** no external energy source is applied and a natural

Potential Barrier is developed across a depletion layer which is approximately 0.5 to 0.7v for silicon diodes and approximately 0.3 of a volt for germanium diodes.

- When a junction diode is **Forward Biased** the thickness of the depletion region reduces and the diode acts like a short circuit allowing full current to flow.
- When a junction diode is **Reverse Biased** the thickness of the depletion region increases and the diode acts like an open circuit.

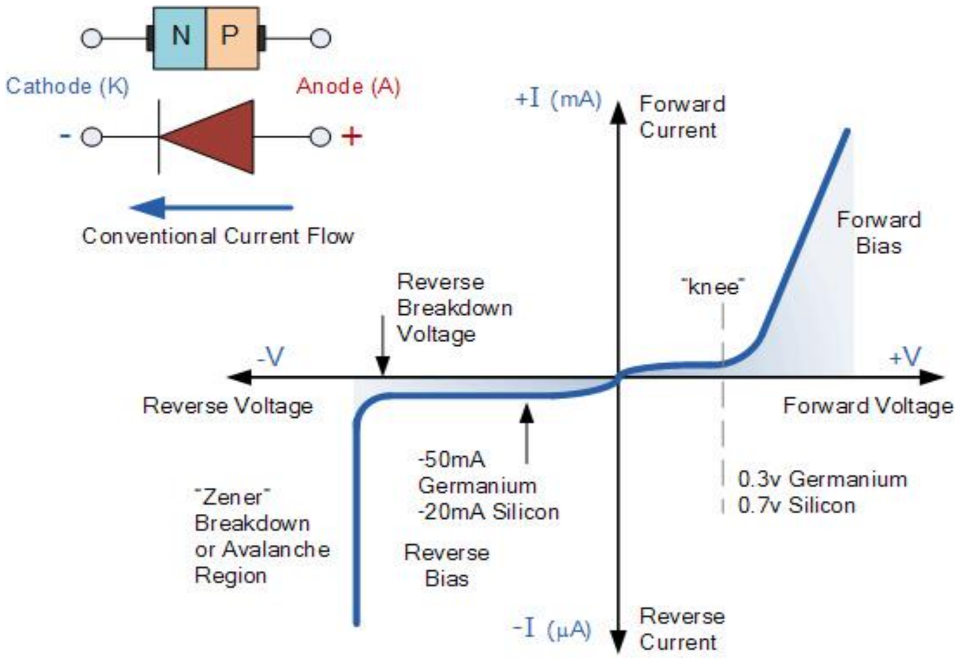


Fig 3.25 Voltage-current characteristics of silicon and germanium diodes and its symbol

Rectifier diode:- Convert AC to DC

The conversion of bidirectional alternating current (a.c.) into unidirectional direct current (d.c.)is called rectification. Electronic devices can convert a.c. power into d.c. power with very high efficiency.

Half wave rectifier: In this type the rectifier conducts current only during the + ve half cycles of the a.c. supply. In this type , the rectifier utilizes both half cycles of a.c. input voltage to produce the d.c output.

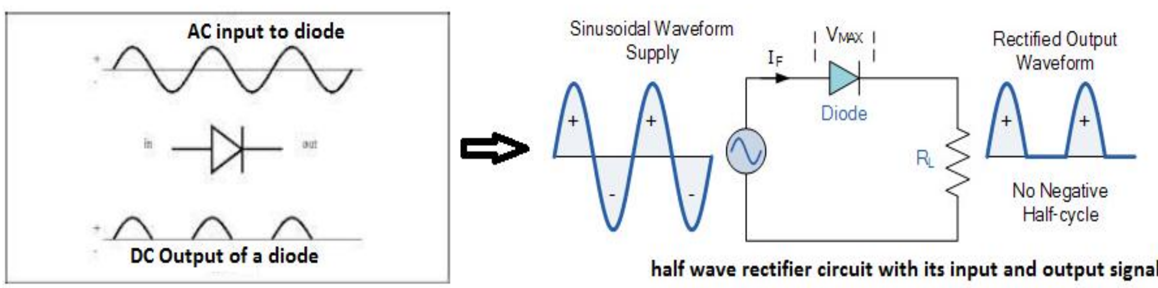


Fig. 3.26 Half wave rectifier

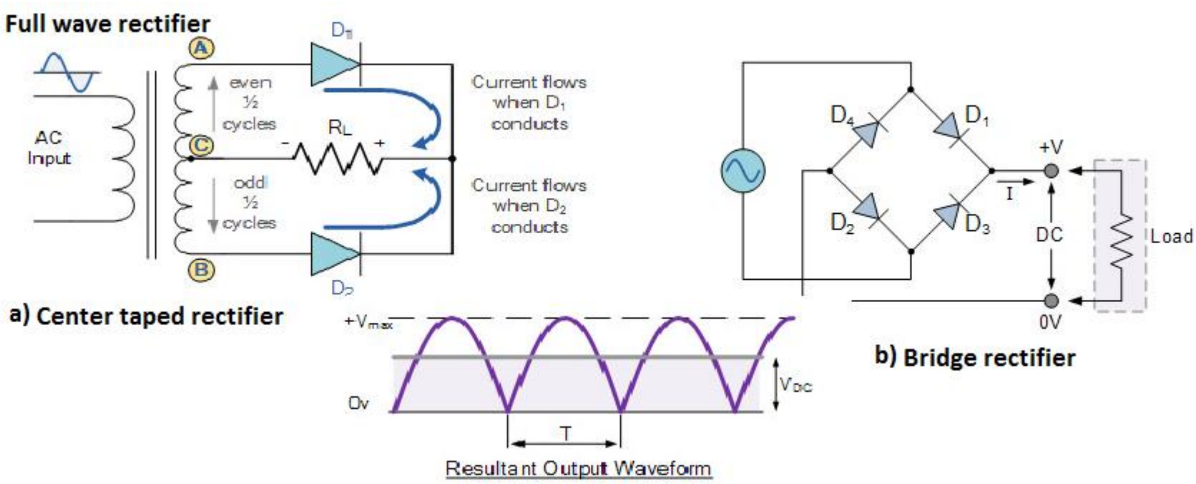
Here – ve half cycles are suppressed i.e. during –ve half cycle no current passes through the diode hence no voltage appears across the load.

Max. rectifier Efficiency= Max. d.c. output power/ a.c. input power =40.6%

Full Wave Rectifier:

a) Full Wave Rectifier(Centre Tapped Type)

During the positive half cycle of the supply(look at the following figure .a), diodeD1 conducts , while diodeD2 is reverse biased and the current flows through the load as shown .Similarly ,during the negative half cycle of the supply, diodeD2 conducts , while diodeD1 is reverse biased and the current flows through the load as shown .



b) Bridge Full wave rectifier:

Fig.3.27 Full wave rectifier

During the positive half cycle of the supply(look at figure. b above), diodes D1 and D2 conduct in series while diodes D3 and D4 are reverse biased and the current flows through the load as shown below.

During the negative half cycle of the supply, diodes D3 and D4 conduct in series, but diodes D1 and D2 switch “OFF” as they are now reversing biased. The current flowing through the load is the same direction as before.

Notice: the detail discussion about rectifier is presented in UC “AC/DC Power supply”

Zener diodes

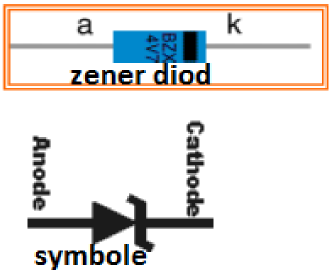
Zener diodes or as they may sometimes be called, reference diodes operate like an ordinary diode in the forward bias direction. They have the normal turn on voltage of 0.6 volts for a silicon diode. However in the reverse direction their operation is rather different. Zener diodes are used to maintain a fixed voltage. They are designed to 'breakdown' in a reliable and nondestructive way so that they can be used **in reverse** to maintain a fixed voltage across their terminals. The diagram shows how they are connected, with a resistor in series to limit the current.

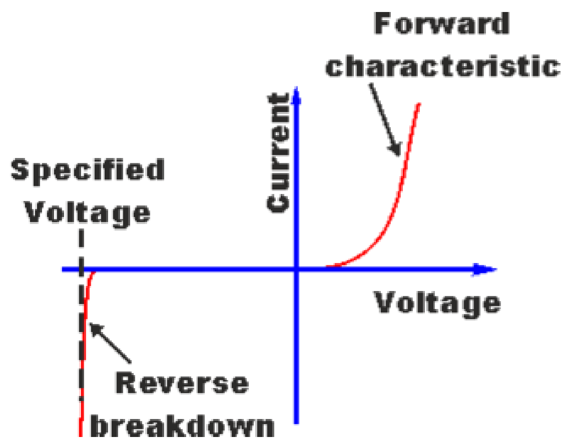
Zener diodes can be distinguished from ordinary diodes by their code and breakdown voltage which are printed on them. Zener diode codes begin BZX... or BZY... Their breakdown voltage is printed with V in place of a decimal point, so 4V7 means 4.7V for example. Some of Zener diodes are rated by their breakdown voltage and maximum power:

- The minimum voltage available is 2.7V.
- Power ratings of 400mW and 1.3W are common.

Zener v-i characteristic

The vi characteristic of the Zener to voltage reference diode is the key to its operation. In the forward direction, the diode performs like any other, but it is in the reverse direction where its specific performance parameters can be utilized.





Characterstics of zener diode

Fig. 28. Characteristics of zener diode

Application of Zener

Used in Voltage Stabilizer, Clipper Circuit, Reference voltage limiter circuits

Simple Zener diode circuit for voltage regulator

When used in a regulator circuit, the Zener diode must have the current entering it limited. If a perfect voltage source was placed across it, then it would draw excessive current once the

Break down voltage had been reached. To overcome this Zener diode must be driven by a current source. This will limit the current to the chosen value. The value of the series resistor is simple to calculate. It is simply the voltage across the resistor, divided by the current required. The level of Zener current can be chosen to suit the circuit and the Zener diode used.

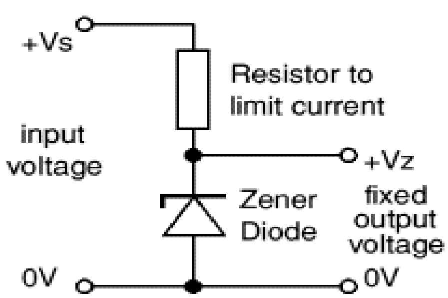


Fig 3.28 Zener diode in regulator circuit

Light emitting diode (LED)

A light emitting diode (LED) is known to be one of the best optoelectronic devices. The device is capable of emitting a fairly narrow bandwidth of visible or invisible light when its internal diode junction attains a forward electric current or voltage. The visible lights that an LED emits are usually *orange, red, yellow, or green.* The invisible light includes the infrared light.

We know that a P-N junction can connect the absorbed light energy into its proportional electric current. The same process is reversed here. That is, the P-N junction emits light when energy is applied on it. This phenomenon is generally called electro luminance, which can be defined as the emission of light from a semi-conductor under the influence of an electric field. The charge carriers recombine in a forward P-N junction as the electrons cross from the N-region and recombine with the holes existing in the P-region. Free electrons are in the conduction band of energy levels, while holes are in the valence energy band. Thus the energy level of the holes will be lesser than the energy levels of the electrons. Some part of the energy must be dissipated in order to recombine the electrons and the holes. This energy is emitted in the form of heat and light.

The electrons dissipate energy in the form of heat for silicon and germanium diodes. But in Galium-Arsenide-phosphorous (GaAsP) and Gallium-phosphorous (GaP) semiconductors, the electrons dissipate energy by emitting photons.

LED Circuit Symbol

The circuit symbol of LED consists of two arrow marks which indicate the radiation emitted by the diode.

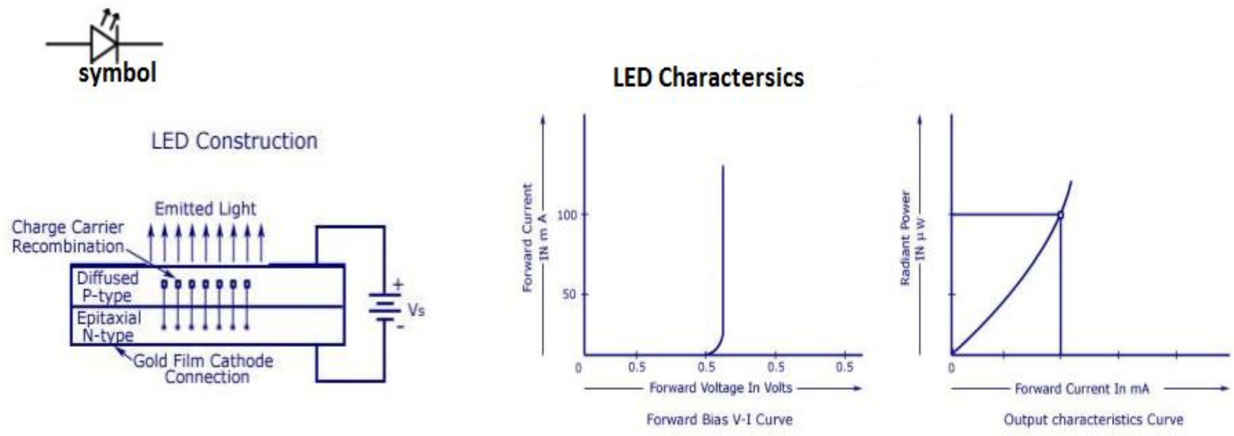


Fig 3.30 The forward bias Voltage-Current (V-I) curve and the output characteristics curve is shown in the figure above.

LED as an Indicator

The circuit shown below is one of the main applications of LED. The circuit is designed by wiring it in inverse parallel with a normal diode, to prevent the device from being reverse biased. The value of the series resistance should be half, relative to that o f a DC circuit.

Fig 3.31 LED Circuit

Advantages of LED

- Very low voltage and current are enough to drive the LED.
- Voltage range – 1 to 2 volts.
- Current – 5 to 20 milli amperes.
- Total power output will be less than 150 milli watts.
- The response time is very less – only about 10 nanoseconds.
- The device does not need any heating and warm up time.
- Miniature in size and hence light weight.
- Have a rugged construction and hence can withstand shock and vibrations.
- An LED has a life span of more than 20 years.

Disadvantages

- A slight excess in voltage or current can damage the device.
- The device is known to have a much wider bandwidth compared to the laser.
- The temperature depends on the radiant output power and wavelength.

Photodiodes

A **photodiode** is a semiconductor device that converts light into current. The current is generated when photons are absorbed in the photodiode. A small amount of current is also produced when no light is present.

A *photodiode* is a diode optimized to produce an electron current flow in response to irradiation by ultraviolet, visible, or infrared light. Silicon is most often used to fabricate photodiodes; though, germanium and gallium arsenide can be used. The junction through which light enters the semiconductor must be thin enough to pass most of the light on to the active region (depletion region) where light is converted to electron hole pairs.

In photo diode construction shown in the figure bellow, shallow P-type diffusion into an N-type wafer produces a PN junction near the surface of the wafer.

The P-type layer needs to be thin to pass as much light as possible. A heavy N+ diffusion on the back of the wafer makes contact with metallization. The top metallization may be a fine grid of metallic fingers on the top of the wafer for large cells. In small photodiodes, the top contact might be a sole bond wire contacting the bare P-type silicon top.

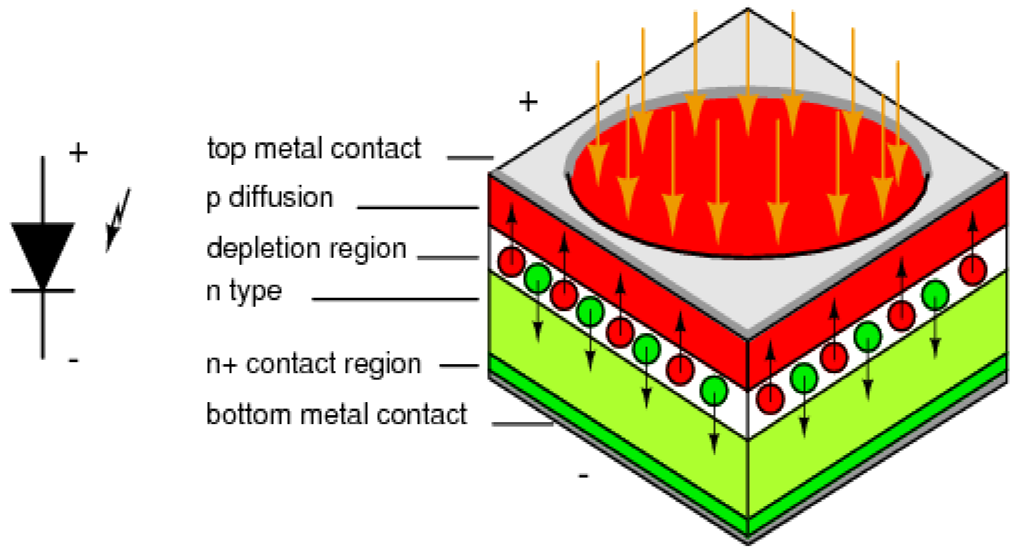


Fig 3.32 Photodiode: Schematic symbol and cross section (below Photo diodes)

Applications:

Photodiodes are used in consumer electronics devices such as compact disc players, smoke detectors, and the receivers for infrared remote control devices used to control equipment from televisions to air conditioners. For many applications either photodiodes or photoconductors may be used. Either type of photo sensor may be used for light measurement, as in camera light meters, or to respond to light levels, as in switching on street lighting after dark.

Photodiodes may contain optical filters, built-in lenses, and may have large or small surface areas. Photodiodes usually have a slower response time as its surface area increases. The common, traditional solar cell used to generate electric solar power is a large area photodiode.

Transistors

Transistors are solid-state, active non-linear devices that facilitate signal amplification and act as switching (controlling) device.

There are two main classes of transistors: bipolar-junction transistors (BJT) and field-effect transistors (FET).

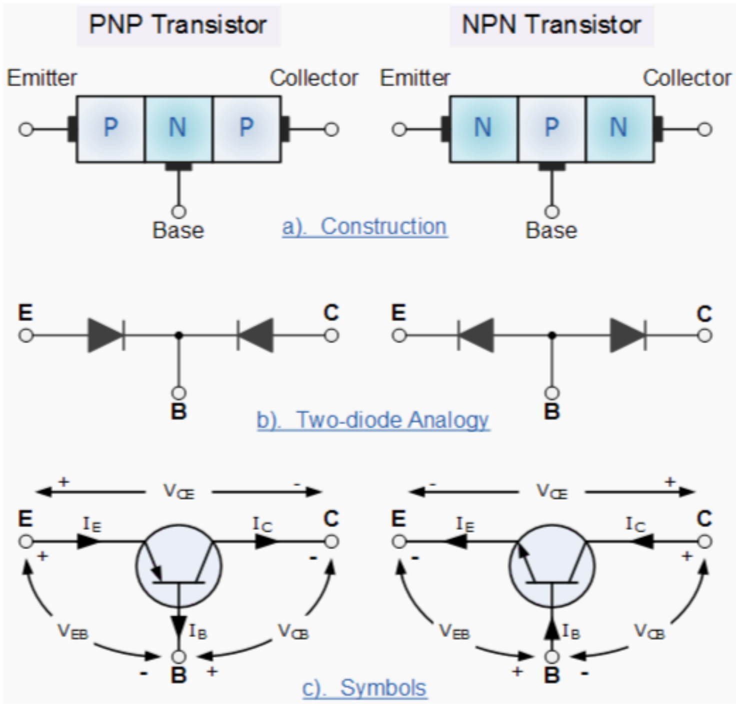
Bipolar Junction Transistors (BJT)

If we join together two individual signal diodes back-to-back, this will give us two PN-junctions connected together in series that share a common P or N terminal. The fusion of these two diodes produces a three layer, two junctions, three terminal device forming the basis of a **bipolar junction Transistor**, or **BJT** for short.

The word Transistor is an acronym, and is a combination of the words Transfer Varistor used to describe their mode of operation way back in their early days of development. There are two basic types of bipolar transistor construction, NPN and PNP, which basically describes the physical arrangement of the P-type and N-type semiconductor materials from which they are made.

The **Bipolar Transistor** basic construction consists of two PN-junctions producing three connecting terminals with each terminal being given a name to identify it from the other two. These three terminals are known and labeled as the Emitter (E), the Base (B) and the Collector (C) respectively.

BJT Construction



d) transistor pictorial diagram

Fig 3.33 BJT construction

The construction and circuit symbols for both the NPN and PNP bipolar transistor are given above with the arrow in the circuit symbol always showing the direction of "conventional current flow" between the base terminal and its emitter terminal. The direction of the arrow always points from the positive P-type region to the negative N-type region for both transistor types, exactly the same as for the standard diode symbol.

Bipolar Transistors are current regulating devices that control the amount of current flowing through them in proportion to the amount of biasing voltage applied to their base terminal acting like a current-controlled switch. The principle of operation of the two transistors types NPN and PNP, is exactly the same the only difference being in their biasing and the polarity of the power supply for each type.

Transistors are three terminal active devices made from different semiconductor materials that has an ability to change between an insulator or a conductor states by the application of a small signal voltage between base and emitter which enables it to have two basic functions: "switching" (digital electronics) or "amplification" (analogue electronics). Then bipolar transistors have the ability to operate within three different regions:

1. Active Region - the transistor operates as an amplifier and Ic = ß.Ib
2. Saturation - the transistor is "fully-ON" operating as a switch and Ic = I(saturation)
3. Cut-off - the transistor is "fully-OFF" operating as a switch and Ic = 0

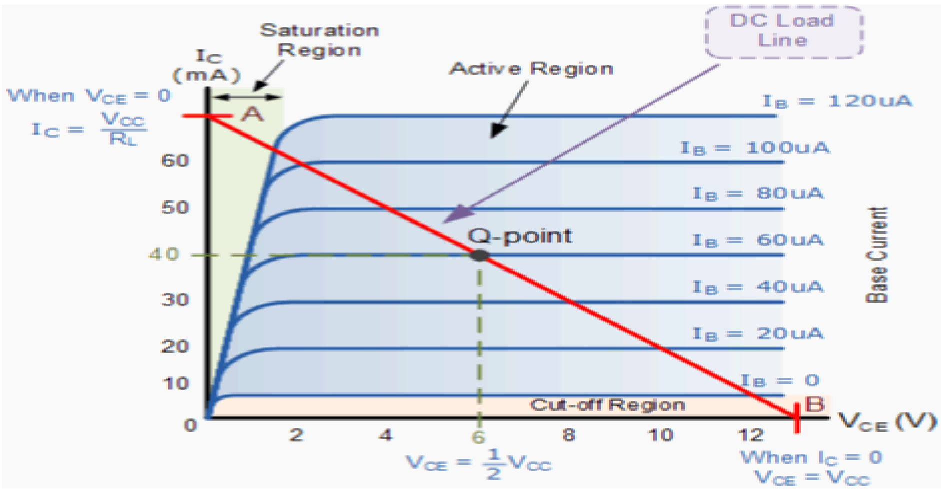
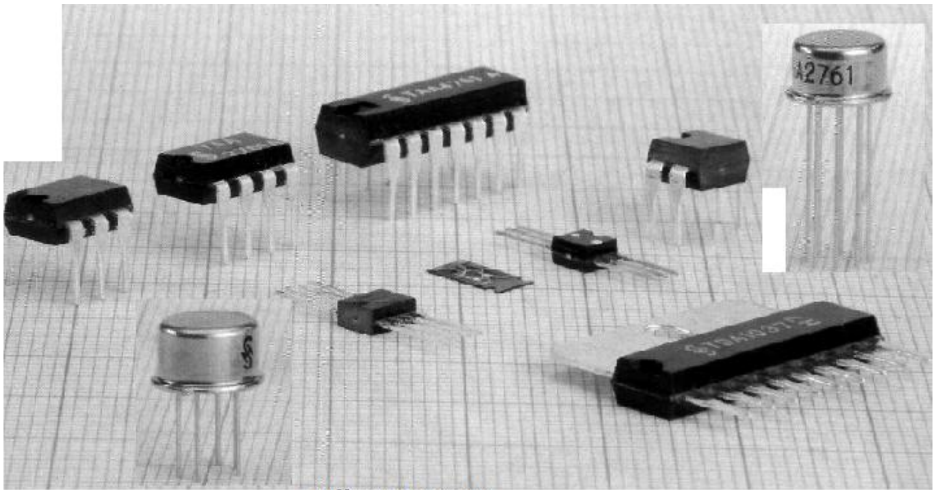


Fig3. 35 Output characteristic curves for a typical BJT

Integrated circuits

An integrated circuit (IC), sometimes called a *chip* or microchip, is a semiconductor wafer on which thousands or millions of tiny resistors, capacitors, and transistors are fabricated. An IC can function as an amplifier**,** oscillator, timer, counter, computer memory**,** or microprocessor. A particular IC is categorized as either linear analog or digital, depending on its intended application.

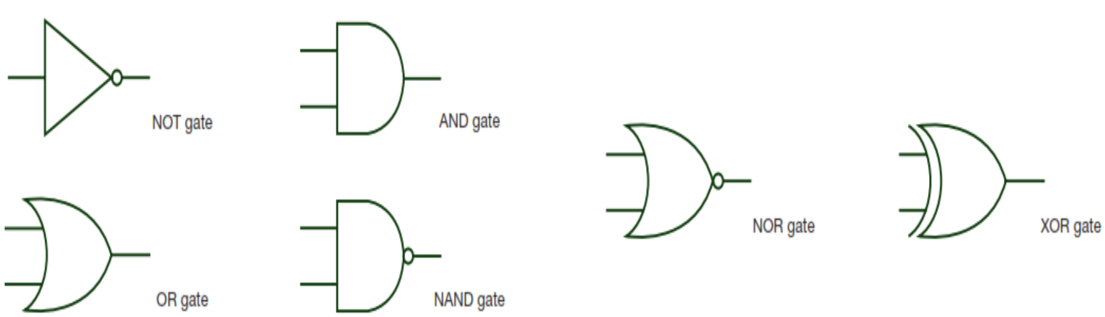


Differnt types ICs

IC's are of Linear, digital and mixed types. *Linear ICs* have continuously variable output (theoretically capable of attaining an infinite number of states) that depends on the input signal level. As the term implies, the output signal level is a linear function of the input signal level. Linear ICs are used as audio-frequency **(**AF**)** and radio-frequency **(**RF**)** amplifiers. The *operational amplifier* (op amp) is a common device in these applications.

Digital ICs operate at only a few defined levels or states, rather than over a continuous range of signal amplitudes. These devices are used in computers, computer networks, modems, and frequency counters. The fundamental building blocks of digital ICs are logic gates, which work with binary data, that is, signals that have only two different states, called low (logic 0) and high (logic 1) or OFF and ON or this can be represented by False and True .

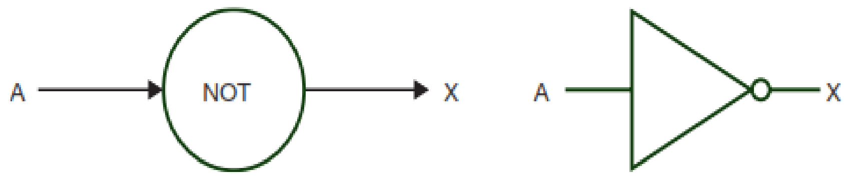
Logic gate symbols



Truth Table

- Digital gates use one or more inputs to produce an output.
- Truth tables are the easiest way of describing how a gate behaves. The truth table gives the state of the output for all possible values of inputs.
- Conventionally, letters A,B,C…etc are used for inputs and Q for output.

NOT gate



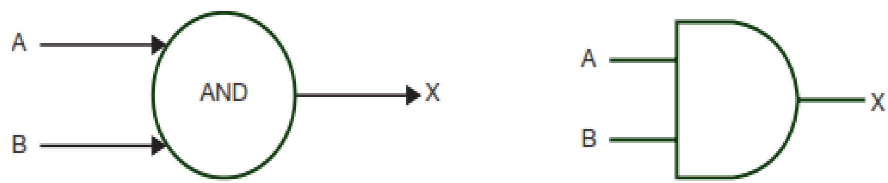
The output (X) is **true** (i.e. 1 or ON) if:

INPUT A is **NOT TRUE** (i.e. 0 or OFF)

Truth table for: ***X* = *NOT A***

INPUT A	OUTPUT X
0	1
1	0

AND gate



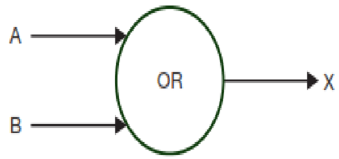
The output (X) is **true** (i.e. 1 or ON) if:

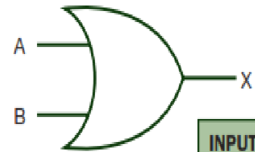
INPUT A AND INPUT B are **BOTH TRUE** (i.e. 1 or ON)

Truth table for: ***X* = *A AND B***

INPUT A	INPUT B	OUTPUT X
0	0	0
0	1	0
1	0	0
1	1	1

OR gate





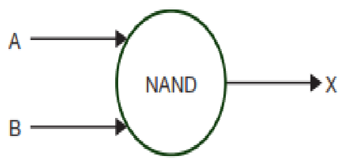
The output (X) is **true** (i.e. 1 or ON) if:

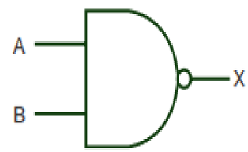
INPUT A OR INPUT B is **TRUE** (i.e. 1 or ON)

Truth table for: ***X = A OR B***

INPUT A	INPUT B	OUTPUT X
0	0	0
0	1	1
1	0	1
1	1	1

NAND gate





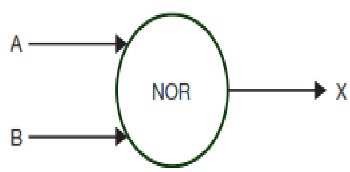
The output (X) is **true** (i.e. 1 or ON) if:

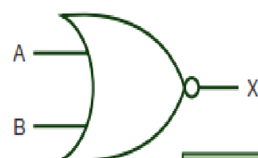
INPUT A AND INPUT B are **NOT BOTH TRUE** (i.e. 1 or ON)

Truth table for: ***X = NOT A AND B***

INPUT A	INPUT B	OUTPUT X
0	0	1
0	1	1
1	0	1
1	1	0

NOR gate





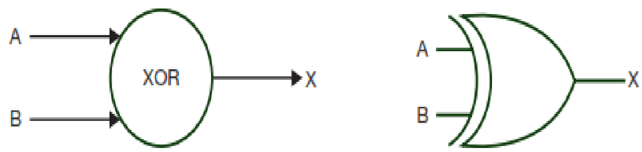
The output (X) is **true** (i.e. 1 or ON) if:

INPUT A OR INPUT B are **NOT BOTH TRUE** (i.e. 1 or ON)

Truth table for: ***X = NOT A OR B***

INPUT A	INPUT B	OUTPUT X
0	0	1
0	1	0
1	0	0
1	1	0

XOR gate



The output (X) is **true** (i.e. 1 or ON) if:

INPUT A OR (NOT INPUT B) OR (NOT INPUT A) OR INPUT B

is **TRUE** (i.e. 1 or ON)

Truth table for: ***X = A OR (NOT B) OR (NOT A) OR B***

INPUT A	INPUT B	OUTPUT X
0	0	0
0	1	1
1	0	1
1	1	0

Universal Gates:

A universal gate is a gate which can implement any Boolean function without need to use any other gate type.

The NAND and NOR gates are universal gates.

In practice, this is advantageous since NAND and NOR gates are economical and easier to fabricate and are the basic gates used in all IC digital logic families.

In fact, an AND gate is typically implemented as a NAND gate followed by an inverter not the other way around!!

Likewise, an OR gate is typically implemented as a NOR gate followed by an inverter not the other way around!!

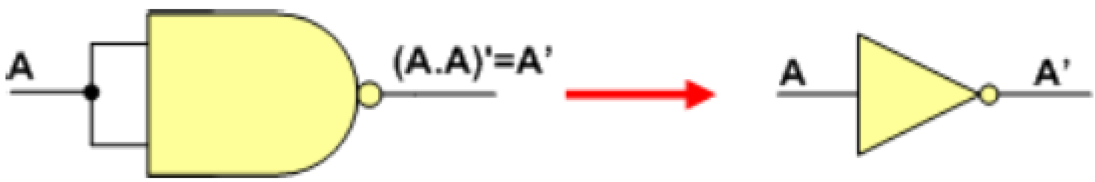
NAND Gate is a Universal Gate:

To prove that any Boolean function can be implemented using only NAND gates, we will show that the AND, OR, and NOT operations can be performed using only these gates.

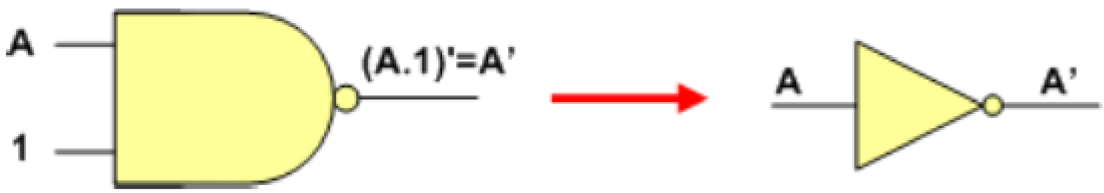
Implementing an Inverter Using only NAND Gate

The figure shows two ways in which a NAND gate can be used as **an inverter (NOT gate)**.

1. All NAND input pins connect to the input signal **A** gives an output **A**'.

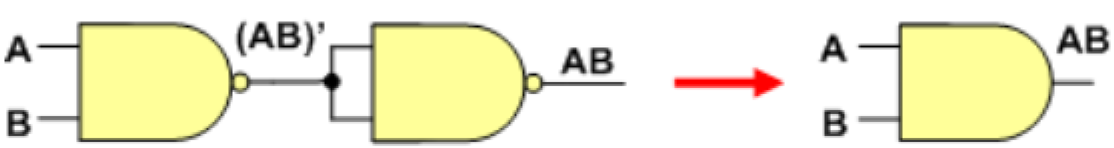


2. One NAND input pin is connected to the input signal **A** while all other input pins are connected to logic **1**. The output will be **A'**.



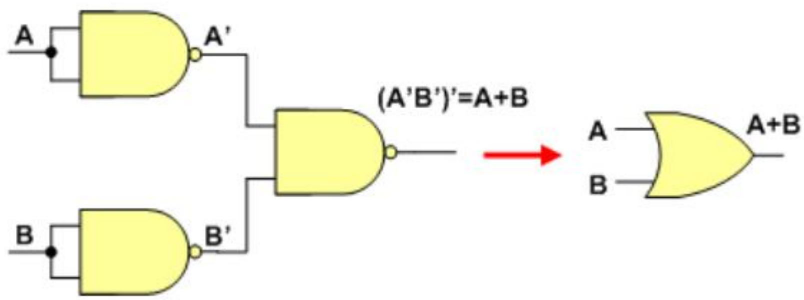
Implementing AND Using only NAND Gates

An AND gate can be replaced by NAND gates as shown in the figure (The AND is replaced by a NAND gate with its output complemented by a NAND gate inverter).



Implementing OR Using only NAND Gates

An OR gate can be replaced by NAND gates as shown in the figure (The OR gate is replaced by a NAND gate with all its inputs complemented by NAND gate inverters).

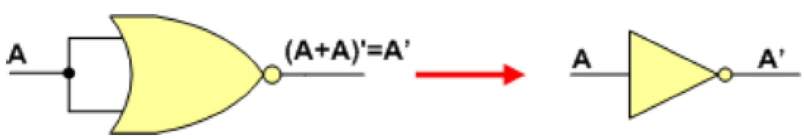


Thus, the NAND gate is a universal gate since it can implement the AND, OR and NOT functions.

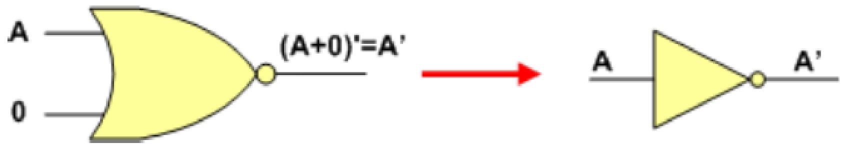
Implementing an Inverter Using only NOR Gate

The figure shows two ways in which a NOR gate can be used as **an inverter (NOT gate)**.

1. All NOR input pins connect to the input signal **A** gives an output **A'**.

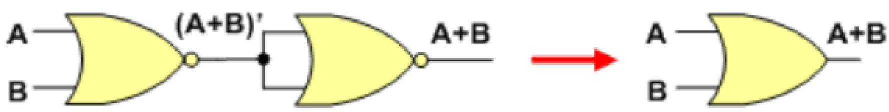


2. One NOR input pin is connected to the input signal **A** while all other input pins are connected to logic **0**. The output will be **A'**.



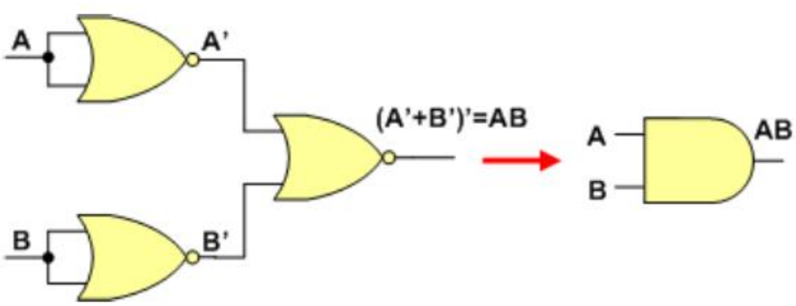
Implementing OR Using only NOR Gates

An OR gate can be replaced by NOR gates as shown in the figure (The OR is replaced by a NOR gate with its output complemented by a NOR gate inverter)



Implementing AND Using only NOR Gates

An AND gate can be replaced by NOR gates as shown in the figure (The AND gate is replaced by a NOR gate with all its inputs complemented by NOR gate inverters)



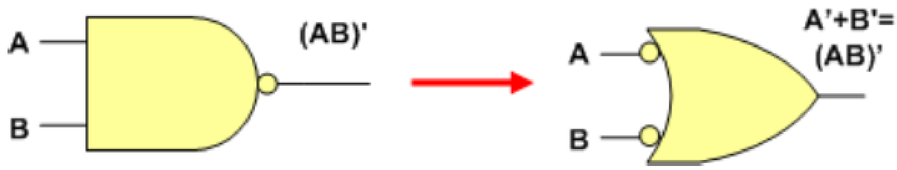
Thus, the NOR gate is a universal gate since it can implement the AND, OR and

NOT functions.

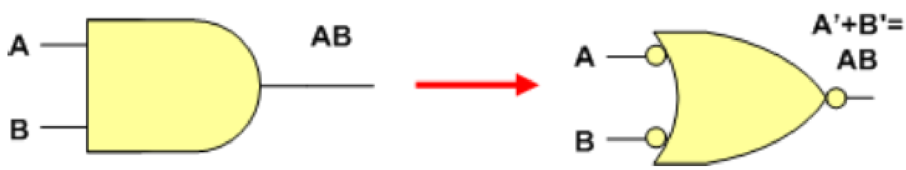
Equivalent Gates:

The shown figure summarizes important cases of gate equivalence. Note that bubbles indicate a complement operation (inverter).

A NAND gate is equivalent to an inverted-input OR gate.



An AND gate is equivalent to an inverted-input NOR gate.



A NOR gate is equivalent to an inverted-input AND gate.

An OR gate is equivalent to an inverted-input NAND gate.

Two NOT gates in series are same as a buffer because they cancel each other as A'' =

A.

Self-Check -3	Written Test

Directions: Answer all the questions listed below.

I. <u>Choose the best option & circle the letter of your choice.</u>

1. What is the name for the flow of electrons in an electric circuit?

A. Voltage B. Resistance C. Capacitance D. Current

2. Which of the following will remain the same in all parts of a series circuit?

(A) Voltage (B) Current (C) Power (D) Resistance

3. A battery is a source of (A) DC voltage. (B) 1 φ AC voltage. (C) 3 φ AC voltage. (D) AC or DC voltage.

4. What is the name of the pressure that forces electrons to flow through a circuit?

A. Magneto motive force, or inductance B. Electromotive force, or voltage

C. Farad force, or capacitance D. Thermal force, or heat

5. What limits the current that flows through a circuit for a particular applied DC voltage?

A. Reliance B. Reactance C. Saturation D. Resistance

6. What are three good electrical conductors?

A. Copper, gold, mica B. Gold, silver, wood

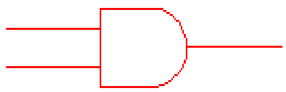
C. Gold, silver, aluminum D. Copper, aluminum, paper

7. What are four good electrical insulators?

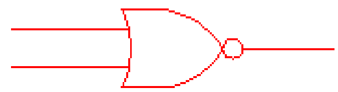
A. Glass, air, plastic, porcelain B. Glass, wood, copper, porcelain

C. Paper, glass, air, aluminum D. Plastic, rubber, wood, carbon

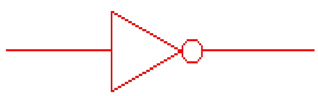
____8. Which of the following symbols represents a NOR gate



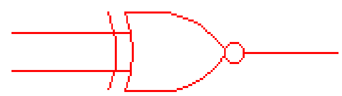
A)



B) B)

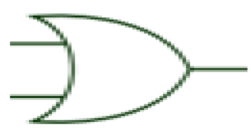


C)



D)

___ 9. What type of logic gate does this symbol represent?



A) Exclusive OR C) OR

B) Exclusive NOR D) NOR

10. ----------is a semiconductor device that converts light into current.

A. Rectifier Diode B. A photodiode C.Zener diode D. Tunnel Diode

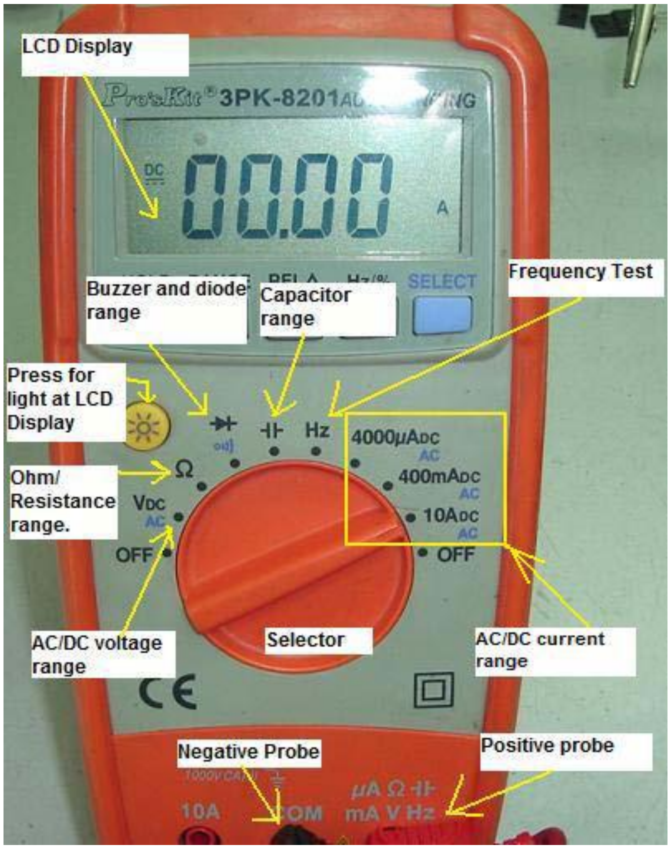
Note: **Satisfactory rating 10 and above points, Unsatisfactory - below 10 points**

Score = ___________
Rating: _____________

Information Sheet-4	Using appropriate range of *methods* in testing electrical /electronic circuits & parts

4.1 Introduction

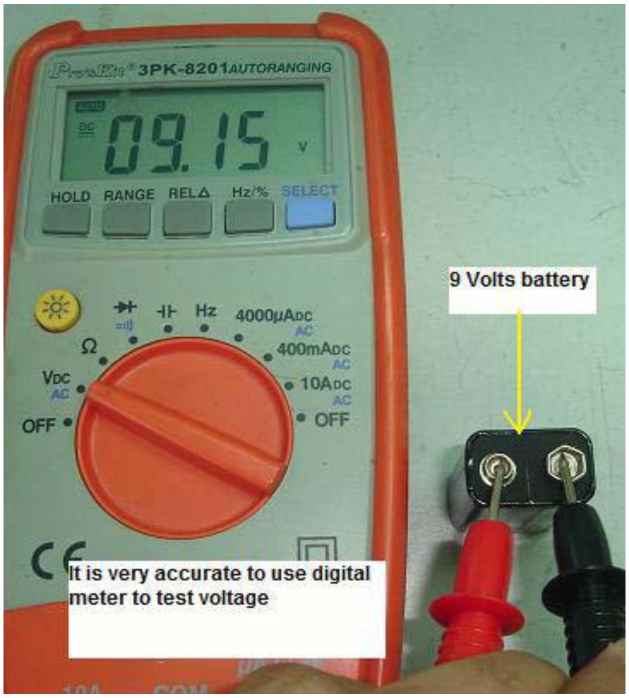
Digital multimeter is the most common testing instrument used to test every electronic component. In order to test these components it is important to know the different ranges of multimeter shown below.



4.2. Using appropriate range of *methods* in testing electrical /electronic circuits

➢ **TESTING AC AND DC SOURCE**

In order to accurately test AC and DC voltage, we use the digital meter as it shows more precise reading than the analogue meter. Set your multi meter to its appropriate function (DCV or ACV), then select the proper range. Note, an auto ranging digital meter will select its own range. Place your test leads across (in parallel with) the part under test as shown in all the photos below and read voltage directly from the panel meter.

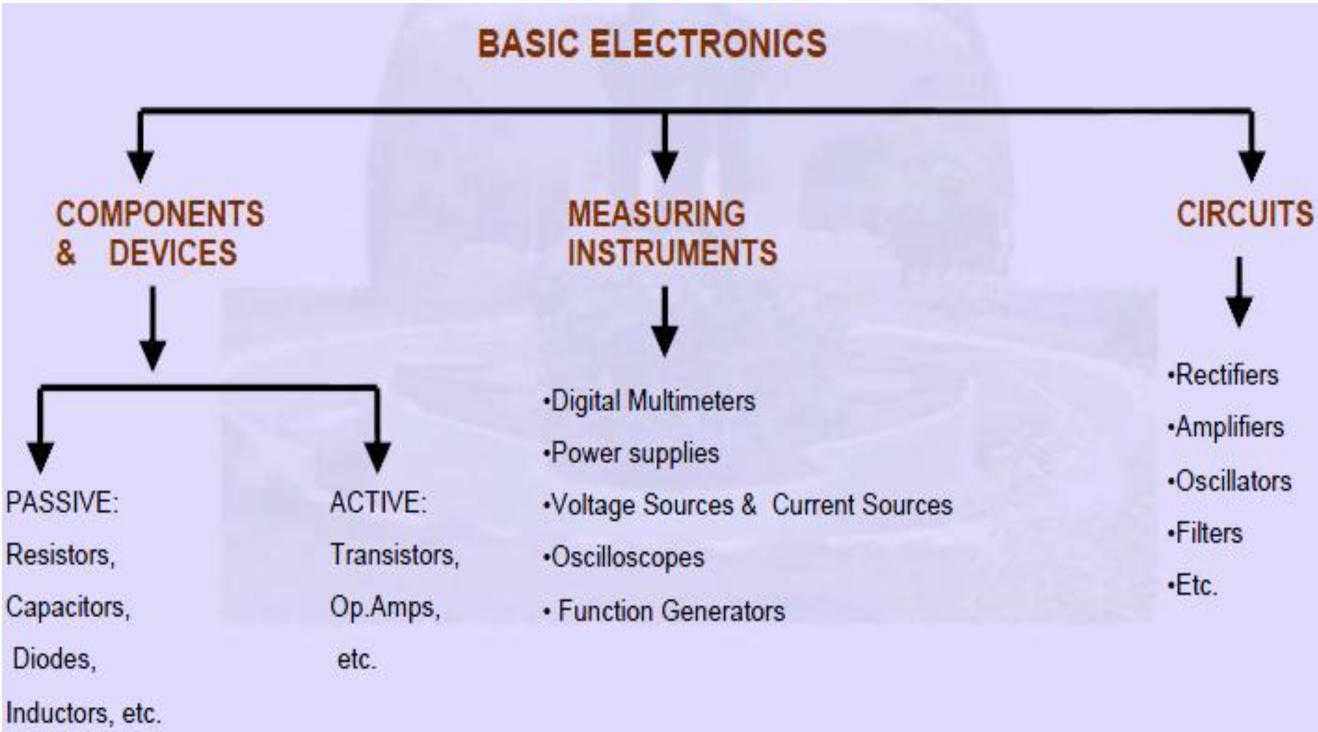


Using appropriate range of *methods* in testing electrical /electronic parts

Testing and troubleshooting are the areas of maintenance that require the greatest technical skill.

Testing procedures are referred to as **measurements**, **tests**, and **checks**. The definitions of these terms often overlap, depending on their use and the results obtained.

Electronic devices are simplified as components in which electrical conduction takes place by motions of electrons through them.



Analog and Digital meters behave quite differently when testing linear and nonlinear devices like diodes and transistors. Analog multimeter or VOM (Volt Ohm milliammeter) is the most widely used electrical instrument in design, development, repair, service and maintenance laboratories. It is usually a moving coil meter, which by switching and the selection of probe jacks can become a dc voltmeter, an AC voltmeter and DC milli-ameteror an ohm meter. Digital Multi-meters are characterized by high input impedance and better accuracy and resolution. They usually have auto-ranging auto-polarity and auto-zero facilities, which means that the user need only set the function switch and get the reading. The digital multimeter converts an input analog signal into its digital equivalent and displays it.

- **Safety Considerations**

None of the tests described in this document require probing live circuits. Safety guidelines for high voltage and/or line powered equipment first.

Before touching, probing, or unsoldering any component, make sure the equipment is unplugged and any large capacitors have been safely discharged. Not only can coming in contact with a live circuit or charged capacitor run your entire day, your test equipment could be damaged or destroyed as well.

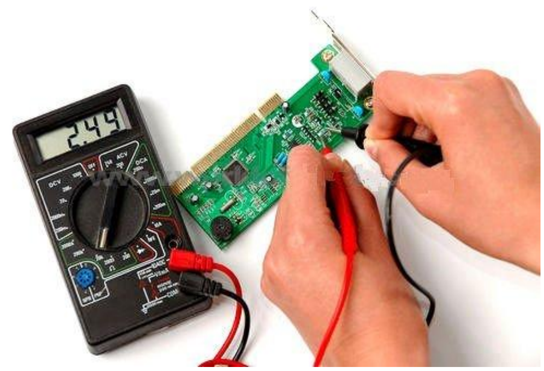
- **Testing (measuring) resistors:**

1. Adjust the meter in resistance range which is greater than the expected value

2. Turn a circuit off before measuring resistance.

3. Hold the leads of the meter across the resistor legs

4. Read the values of the resistor.



If the reading is equal to the expected one, the resistor is normal and we can use the reading, but if the value is unexpectedly large (infinite) or very small (approximately zero) it is expected to be open or short circuit faulty respectively***.***

Notice: if a resistor is not disconnected from the circuit during measurement and any voltage is present, the value of resistance will be incorrect. You cannot measure a component while it is in-circuit. You should disconnect at least one of the leg of the resistor to be measure from a circuit.

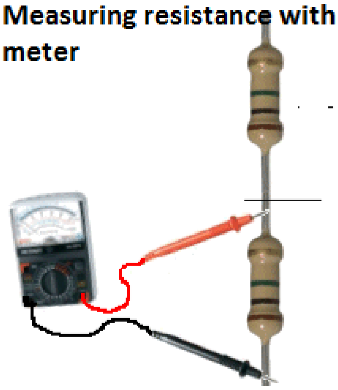
This is because the meter is actually measuring a voltage across a component and calling it a "resistance."

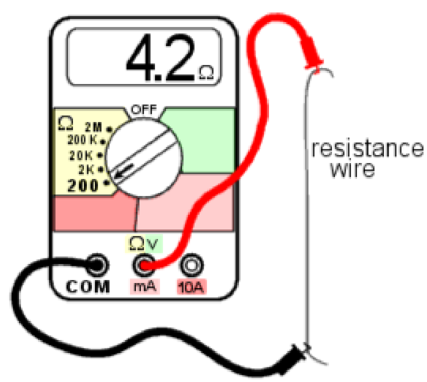
The voltage comes from the battery inside the meter. If any other voltage is present, the meter will produce a false reading. If you are measuring the resistance of a component while still "in circuit," (with the power off) the reading will be lower than the true reading.

1. Do not measure the "resistance of a battery." The resistance of a battery (called the internal impedance) is not measured as shown in the diagrams above. It is measured by creating a current-flow and measuring the voltage across the battery. Placing a multimeter set to **resistance** (across a battery) will destroy the meter.

2. Do not try to measure the resistance of any voltage or any "supply."

Measuring resistance with anlog and digital meter

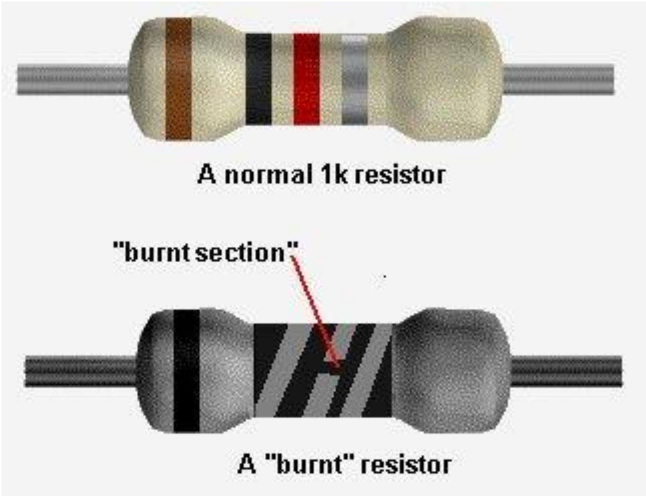




Measuring the resistance of a piece of resistance-wire

A "BURNT" RESISTOR - normally and technically called a "burnt-out" resistor.

The resistance of a "burnt" resistor can sometimes be determined by scraping away the outer coating - if the resistor has a spiral of resistance-material. You may be able to find a spot where the spiral has been damaged.



Clean the "spot" (burnt section of the spiral) very carefully and make sure you can get a good contact with the spiral and the tip of your probe. Measure from one lead of the resistor to the end of the damaged spiral. Then measure from the other lead to the other end of the spiral.

Add the two values and you have an approximate value for the resistor. You can add a small amount for the damaged section.

This process works very well for damaged wire-wound resistors. They can be pulled apart and each section of the resistance-wire (nichrome wire) measured and added to get the full resistance.

There is another way to determine the value of a damaged resistor.

Get a set of resistors of the same wattage as the damaged component and start with a high value. It's handy to know if the resistor is in the range: 10ohm to 100ohms or 1k to 10k etc, but this is not essential.

Start with a very high value and turn the circuit ON. You can perform voltage tests and if you know the expected output voltage, decrease the resistance until this voltage is obtained.

If you do not know the expected voltage, keep reducing the value of resistance until the circuit works as designed.

This is the best advice in a situation where you do not know the value of a resistor.

There is a third way to determine the value and this requires measuring the voltage drop across the resistor and the current-flow. By multiplying the two you will get a wattage and this must be less than the wattage of the resistor being replaced.

TESTING POTENTIOMETERS (variable resistors)

To check the value of a variable resistor, it should be removed from circuit or at least 2 legs should be removed. A Rheostat is a variable resistor using only one end and the middle connected to a circuit.

The resistance between the two outside pins is the value marked on the component and the center leg will change from nearly zero to the full resistance as the shaft is rotated. "Pots" generally suffer from "crackle" when turned and this can be fixed by spraying up the shaft and into the pot via the shaft with a tube fixed to a can of "spray-lubricant" (contact cleaner).

"Pre-set pots" and "trim pots" are miniature versions of a potentiometer and they are all tested the same.

TESTING A CAPACITOR

There are two things you can test with a multimeter:

1. A short-circuit within the capacitor

2. Capacitor values above 1u.

You can test capacitors in-circuit for short-circuits. Use the x1 ohms range.

To test a capacitor for leakage, you need to remove it or at least one lead must be removed from the circuit. Use the x10k range on an analogue or digital multimeter.

For values above 1u you can determine if the capacitor is charging by using an analogue meter. The needle will initially move across the scale to indicate the cap is charging, then go to "no deflection." Any permanent deflection of the needle will indicate leakage.

You can reverse the probes to see if the needle moves in the opposite direction. This indicates it has been charged. Values below 1u will not respond to charging and the needle will not deflect.

This does not work with a digital meter as the resistance range does not output any current and the electrolytic does not charge.

Rather than spending money on a capacitance meter, it is cheaper to replace any suspect capacitor or electrolytic.

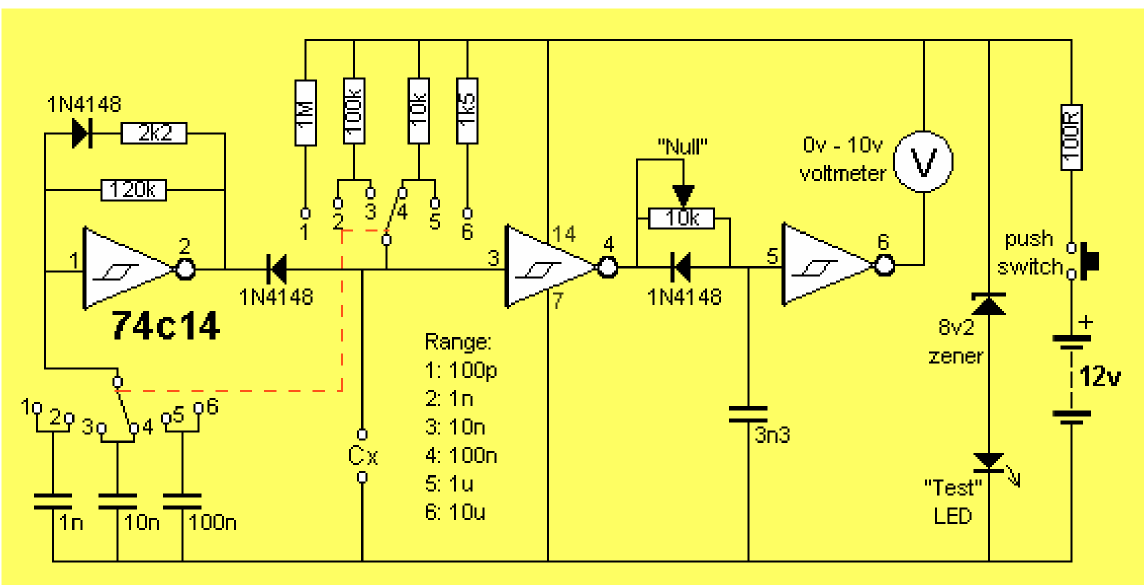
Capacitors can produce very unusual faults and no piece of test equipment is going to detect the problem.

In most cases, it is a simple matter to solder another capacitor across the suspect component and view or listen to the result.

This saves all the worry of removing the component and testing it with equipment that cannot possibly give you an accurate reading when the full voltage and current is not present.

Finding the Value of a Capacitor

If you want to find the value of a surface-mount capacitor or one where the markings have been removed, you will need a CAPACITANCE METER. Here is a simple circuit that can be added to your meter to read capacitor values from 10p to 10u.



ADD-ON CAPACITANCE METER

REPLACING A CAPACITOR

Always replace a capacitor with the exact same type.

A capacitor may be slightly important in a circuit or it might be extremely critical.

A manufacturer may have taken years to select the right type of capacitor due to previous failures.

A capacitor just doesn't have a "value of capacitance."

It may also has an effect called "tightening of the rails."

In other words, a capacitor has the ability to react quickly and either absorb or deliver energy to prevent spikes or fluctuations on the rail.

This is due to the way it is constructed. Some capacitors are simply plates of metal film while others are wound in a coil. Some capacitors are large while others are small.

They all react differently when the voltage fluctuates.

Not only this, but some capacitors are very stable and all these features go into the decision for the type of capacitor to use.

You can completely destroy the operation of a circuit by selecting the wrong type of capacitor.

No capacitor is perfect and when it gets charged or discharged, it appears to have a small value of resistance in series with the value of capacitance. This is known as

"ESR" and stands for EQUIVALENT SERIES RESISTANCE. This effectively makes the capacitor slightly slower to charge and discharge.

- **The only solution is to replace a capacitor with an identical type**.

However if you get more than one repair with identical faults, you should ask other technicians if the original capacitor comes from a faulty batch.

Some capacitor is suitable for high frequencies, others for low frequencies.

TESTING COILS, INDUCTORS and YOKES

You can test this component for continuity between the ends of the winding and also make sure there is no continuity between the winding and the core.

It is important to understand the turns are insulated but a slight fracture in the insulation can cause two turns to touch each other and this is called a "SHORTED TURN" or you can say the inductor has "SHORTED TURNS."

When this happens, the inductor allows the circuit to draw MORE CURRENT. This causes the fuse to "blow."

The quickest way to check an inductor is to replace it, but if you want to measure the inductance, you can use an INDUCTANCE METER. You can then compare the inductance with a known good component.

An inductor with a shorted turn will have a very low or zero inductance, however you may not be able to detect the fault when it is not working in a circuit as the fault may be created by a high voltage generated between two of the turns.

Faulty yokes (both horizontal and vertical windings) can cause the picture to reduce in size and/or bend or produce a single horizontal line.

A TV or monitor screen is the best piece of Test Equipment as it has identified the fault. It is pointless trying to test the windings further as you will not be able to test them under full operating conditions.

MEASURING AND TESTING INDUCTORS

Inductors are measured with an INDUCTANCE METER but the value of some inductors is very small and some Inductance Meters do not give an accurate reading.

The solution is to measure a larger inductor and note the reading. Now put the two inductors in SERIES and the values ADD UP - just like resistors in SERIES. This way you can measure very small inductors.

TESTING ACTIVE COMPONENTS

TESTING DIODES

Diodes can have 4 different faults.

1. Open circuit in both directions.

2. Low resistance in both directions.

3. Leaky.

4. Breakdown under load.

TESTING A DIODE ON AN ANALOGUE METER

Testing a diode with an **Analogue Multimeter** can be done on any of the resistance ranges. [The high resistance range is best - it sometimes has a high voltage battery for this range but this does not affect our testing]

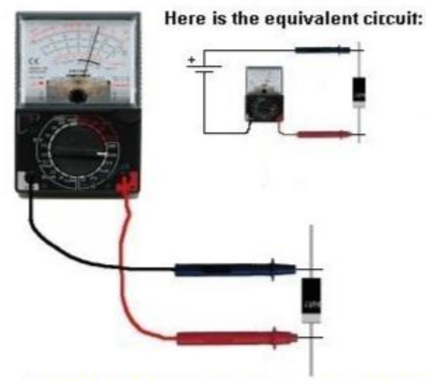
There are two things you must remember.

1. When the diode is measured in one direction, the needle will **not move at all**. The technical term for this is the diode is **reverse biased**. It will not allow any current to flow. Thus the needle will not move.

When the diode is connected around the other way, the needle will swing to the right (move up scale) to about 80% of the scale. This position represents the voltage drop across the junction of the diode and is NOT a resistance value. If you change the resistance range, the needle will move to a slightly different position due to the resistances inside the meter. The technical term for this is the diode is **forward biased**. This indicates the diode is not faulty.

Testing diode with analoge meter

The diode is **REVERSE BIASED** in the diagram above and diodes not conduct.



The diode is **FORWARD BIASED** in the diagram above and it conducts

The needle will swing to a slightly different position for a "normal diode" compared to a Schottky diode. This is due to the different junction voltage drops.

However we are only testing the diode at very low voltage and it may break-down

when fitted to a circuit due to a higher voltage being present or due to a high current flowing.

2. The leads of an **Analogue Multimeter** have the positive of the battery connected

to the black probe and the readings of a "good diode" are shown in the following two diagrams:

TESTING A DIODE ON A DIGITAL METER

Testing a diode with a Digital Meter must be done on the "DIODE" setting as a digital meter does not deliver a current through the probes on some of the resistance settings and will not produce an accurate reading.

The best thing to do with a "suspect" diode is to replace it. This is because a diode has a number of characteristics that cannot be tested with simple equipment. Some diodes have a fast recovery for use in high frequency circuits. They conduct very quickly and turn off very quickly so the waveform is processed accurately and efficiently.

If the diode is replaced with an ordinary diode, it will heat up as does not have the high-speed characteristic.

Other diodes have a low drop across them and if an ordinary is used, it will heat up.

Most diodes fail by going: SHORT-CIRCUIT. This can be detected by a low resistance (x1 or x10 Ohms range) in both directions.

A diode can also go OPEN CIRCUIT. To locate this fault, place an identical diode across the diode being tested.

A leaky diode can be detected by a low reading in one direction and a slight reading the other direction.

However this type of fault can only be detected when the circuit is working. The output of the circuit will be low and sometimes the diode heats up (more than normal).

A diode can go open under full load conditions and perform intermittently.

Testing BJT Using Analog Meter

Step 1 - FINDING THE BASE and Determining NPN or PNP

Get an unknown transistor and test it with a multimeter set to "x10"

Try the 6 combinations and when you have the black probe on a pin and the red probe touches the other pins and the meter swings nearly full scale, you have an NPN transistor. The black probe is BASE

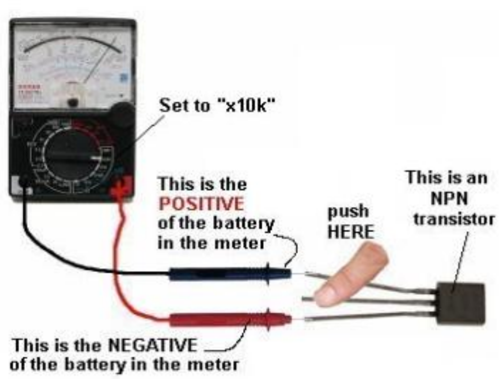
If the red probe touches a pin and the black probe produces a swing on the other two pins, you have a PNP transistor. The red probe is BASE

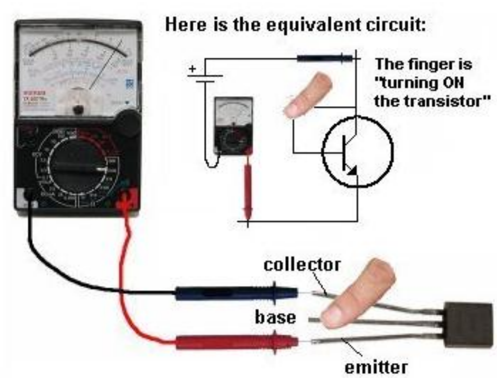
If the needle swings FULL SCALE or if it swings for more than 2 readings, the transistor is **FAULTY.**

Step 2 - FINDING THE COLLECTOR and EMITTER

1. **Set the meter to "x10k."**

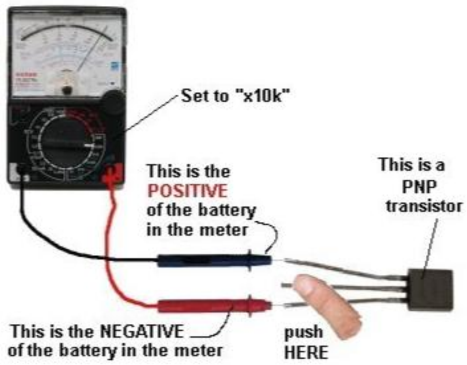
For an NPN transistor, place the leads on the transistor and when you press hard on the two leads shown in the diagram below, the needle will swing almost full scale.

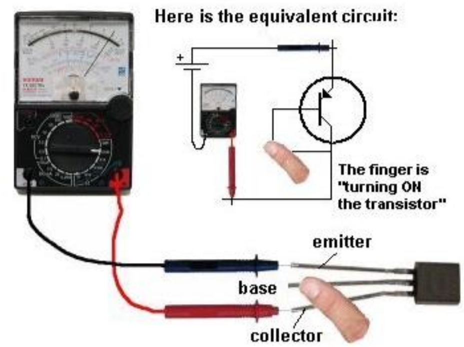




You have found collector, Base and emitter

For a PNP transistor, set the meter to "x10k" place the leads on the transistor and when you press hard on the two leads shown in the diagram below, the needle will swing almost full scale.





You have found collector, Base and emitter

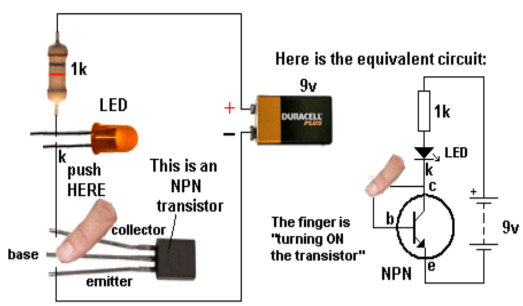
Notice: In the same way, you can test using digital multimeter but the black lead is negative and the red lead is positive.

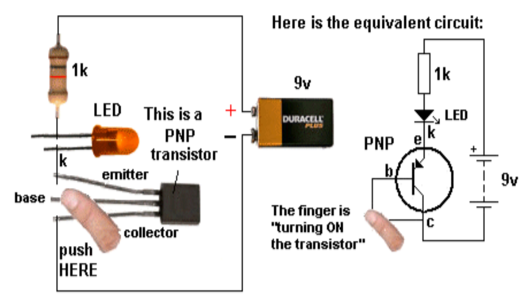
SIMPLEST TRANSISTOR TESTER

The simplest transistor tester uses a 9v battery, 1k resistor and a LED (any color).

Keep trying a transistor in all different combinations until you get one of the circuits below. When you push on the two leads, the LED will get brighter.

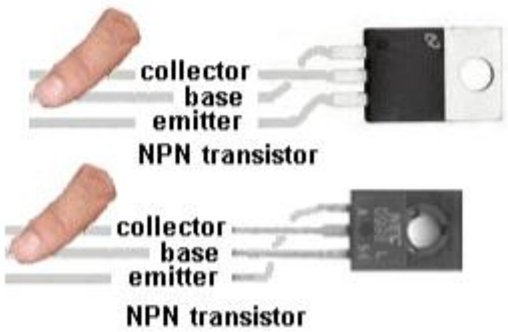
The transistor will be NPN or PNP and the leads will be identified:





The leads of some transistors will need to be bent so the pins are in the same positions as shown in the diagrams. This helps you see how the transistor is being turned on.

This works with NPN, PNP transistors and Darlington transistors.



TRANSISTOR FAILURE

Transistor can fail in a number of ways. They have forward and reverse voltage ratings and once these are exceeded, the transistor will ZENER or conduct and may fail. In some cases a high voltage will "puncture" the transistor and it will fail instantly. In fact it will fail much faster via a voltage-spike than a current overload.

It may fail with a "short" between any leads, with a collector-emitter short being the most common. However failures will also create shorts between all three leads.

A shorted transistor will allow a large current to flow, and cause other components to heat up.

Transistors can also develop an open circuit between base and collector, base and emitter or collector and emitter.

The first step in identifying a faulty transistor is to check for signs of overheating. It may appear to be burnt, melted or exploded. When the equipment is switched off, you can touch the transistor to see if it feels unusually hot. The amount of heat you feel should be proportional to the size of the transistor's heat sink. If the transistor has no heat sink, yet is very hot, you can suspect a problem.

Do Not Touch A Transistor If It Is Part Of A Circuit That Carries 240vac.

Always switch off the equipment before touching any components.

Testing IC's ("Chips")

ANALOGUE CHIPS (also see above)

Analogue chips are AUDIO chips or AMPLIFIER chips.

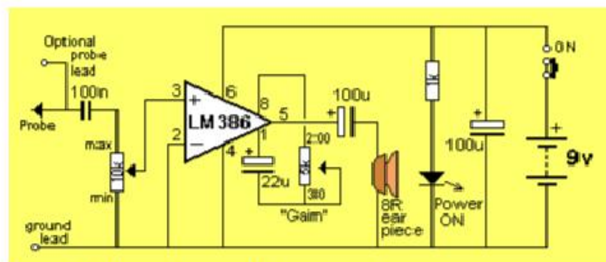
To test these chips you will need three pieces of test equipment:

1. A multimeter - this can be digital or analogue.

2. A Signal Injector

3. A Mini Bench Amplifier.

mini bench amplifier



mini bench amplifier circuit

Start by locating the power pin with a multimeter.

If the chip is receiving a voltage, you can use the Mini Bench Amplifier to detect an output.

Connect the Ground Lead of the Mini Bench Amplifier to 0v and touch the Probe tip on each of the pins.

You will hear faint audio on the Input pin and very loud audio on the Output pin.

If no input is detected, you can use a Signal Injector to produce a tone.

Connect the clip of the Signal Injector to 0v and the probe to the input pin of the amplifier chip. At the same time, connect the Mini Bench Amplifier to the output pin and you will hear a very loud tone.

These pieces of test equipment can also be used to diagnose an amplifier circuit constructed with individual components.

Amplifier circuits using discrete components are very hard to trouble-shoot and these pieces of test equipment make it very easy.

DIGITAL CHIPS

It is always best to have data on the chip you are testing, but if this is not available, you will need three pieces of equipment:

1. A multimeter - this can be digital or analogue.

2. A Logic Probe,

3. A logic Pulser.

Firstly test the chip to see if power is being delivered. This might be anything from 3v3

to 15v.

Place the negative lead of the multimeter on the earth rail of the project - this might

be the chassis, or the track around the edge of the board or some point that is obviously 0v.

Try all the pins of the chip and if you get a reading, the chip will have "supply."

Identify pin 1 of the chip by looking for the "cut-out" at the end of the chip and you may find a small dimple below the cut-out (or notch). This is pin 1 and the "power pin" can be directly above or any of the other pins.

Next you need to know if a signal is entering the chip.

For this you will need a LOGIC PROBE.

A Logic Probe is connected to the same voltage as the chip, so it will detect a HIGH and illuminate a red LED.

Connect the Logic Probe and touch the tip of the probe on each pin.

You will not know if a signal is an input or output, however if you get two or more active pins, you can assume one is input and the other is output. If none of the pins are active, you can assume the signal is not reaching this IC.

If only one pin is active, you can assume the chip is called a CLOCK (or Clock Generator). This type of chip produces pulses. If more than two pins are active, you can assume the chip is performing its function and unless you can monitor all the pins at the same time, you don't know what is happening.

This is about all you can do without any data on the chip.

If you have data on the chip, you can identify the input(s) and output(s).

A Logic Probe on each of these pins will identify activity.

A Logic Probe has 3 LEDs. Red LED indicates a HIGH, Green indicates a LOW and

Orange indicates a PULSE (activity).

Some Logic Probes include a piezo and you can hear what is happening, so you don't take your eyes off the probe-tip.

It is important not to let the probe tip slip between the pins and create a short-circuit.

LOGIC PULSER

If you have a board or a single chip and want to create activity (clock pulses), you can use a Logic Pulser. This piece of test equipment will produce a stream of pulses that can be injected into the clock-line (clock input) of a chip.

You can then use a Logic Probe at the same time on the outputs to observe the operation of the chip.

You can also use the Mini Bench Amplifier to detect "noise" or activity on the inputs and outputs of digital chips.

This only applies if the frequency is in the audio range such as scanning a keyboard or switches or a display.

This is how to approach servicing/testing in a general way. There are thousands of digital chips and if you want to test a specific chip for its exact performance, you will need to set-up a "test-bed."

Testing Some Electrical Components

Generally the test to be performed before a new installation or an addition to an existing installation is connected to the supply mains are follows.

- Insulation Resistance
  - ✓ The insulation resistance between the wiring and earth will all fuses (breakers) and lamps in and all switches 'ON'
  - ✓ The insulation resistance between the conductors with all lamps out and all switches 'ON'
  - ✓ Testing of polarity of switches.
  - ✓ Testing of earth continuity path
  - ✓ Testing of earth-electrode resistance

Testing of Switches

Switches are used in electronic systems for power 'ON' and 'OFF'. The common types of switches used in electronic equipment are:-

- ✓ Push-Button and Toggle Switches
- ✓ Power Switches
- ✓ Slide Switches
- ✓ Rotary Switches
- ✓ Key Lock Switches

In the field of electrical/electronic the most common switch are toggle switch.

Selecting a Switch: - There are three important features to consider when selecting a switch:

- **Contacts** (e.g. single pole, double throw)
- **Ratings** (maximum voltage and current)

- **Method of Operation** (toggle, slide, key etc.)

Switch Contacts: - Several terms are used to describe switch contacts:

- **Pole** - number of switch contact sets.
- **Throw** - number of conducting positions, single or double.
- **Way** - number of conducting positions, three or more.
- **Momentary** - switch returns to its normal position when released.
- **Open** - off position, contacts not conducting.
- **Closed** - on position, contacts conducting, there may be several on positions.

Causes of malfunctioning of switches: - the defects occurring in various switches used in electronic equipment, most of often can be characterized as follows:-

- ✓ Broken contacts
- ✓ Burned contacts
- ✓ Shorted contacts
- ✓ Defective spring
- ✓ Burned switch body

Testing of Circuit breakers

It is a device designed to open and close a circuit by non-automatic means, and to open the circuit automatically on a predetermined over current without injury to itself when properly applied within its rating. A circuit breaker is combination device composed of a manual switch and an over current device. A circuit breaker has several advantages over any type of fuse.

- ✓ In the event of fault or overloaded, all the poles are simultaneously disconnected from the supply
- ✓ Overloaded and time-lags are capable of adjustment within limits.
- ✓ The circuit can be closed again quickly onto the fault safety. Circuit breakers are rated in amperes just as fuses are rated.

Like fuse breakers are tested in open air to carry 110% of their rated loads indefinitely without tripping.

Testing of Relays

A relay is an **electrically operated switch**. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

Relays are usually Single Pole Double throw (SPDT) or Double Pole Double Throw (DPDT) but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available.

The supplier's catalogue should show you the relay's connections. The coil will be obvious and it may be connected either way round. Relay coils produce brief high voltage 'spikes' when they are switched off and this can destroy transistors and ICs in the circuit. To prevent damage you must connect a protection diode across the relay coil.

The relay's switch connections are usually labelled COM, NC and NO:

- ✓ **COM** = Common, always connect to this; it is the moving part of the switch.
- ✓ **NC** = Normally Closed, COM is connected to this when the relay coil is **off**.
- ✓ **NO** = Normally Open, COM is connected to this when the relay coil is **on**.

- ✓ Connect to COM and NO if you want the switched circuit to be **on when the relay coil is on**.
- ✓ Connect to COM and NC if you want the switched circuit to be **on when the relay coil is off**.

Choosing a relay:-You need to consider several features when choosing a relay:

- ✓ **Physical size and pin arrangement**: - If you are choosing a relay for an existing PCB you will need to ensure that its dimensions and pin arrangement are suitable.
- ✓ **Coil voltage**: - The relay's coil voltage rating and resistance must suit the circuit powering the relay coil. Many relays have a coil rated for a 12V supply but 5V and 24V relays are also readily available. Some relays operate perfectly well with a supply voltage which is a little lower than their rated value.
- ✓ **Coil resistance**: - The circuit must be able to supply the current required by the relay coil. You can use Ohm's law to calculate the current:

$$\text{Relay coil current} = \frac{\text{supply voltage}}{\text{coil resistance}}$$

- ✓ For example: A 12V supply relay with a coil resistance of 400Ω passes a current of 30mA. This is OK for a 555 timer IC (maximum output current 200mA), but it is too much for most ICs and they will require a transistor to amplify the current.
- ✓ **Switch ratings (voltage and current)**:- the relay's switch contacts must be suitable for the circuit they are to control. You will need to check the voltage and current ratings. Note that the voltage rating is usually higher for AC, for example: "5A at 24V DC or 125V AC".
- ✓ **Switch contact arrangement (SPDT, DPDT etc)**:- Most relays are SPDT or DPDT which are often described as "single pole changeover" (SPCO) or "double pole changeover" (DPCO). Relays and transistors compared, like relays, transistors can be used as an electrically operated switch

Advantages of relays:

- ✓ Relays can switch **AC and DC**, transistors can only switch DC.
- ✓ Relays can switch **higher voltages** than standard transistors.
- ✓ Relays are often a better choice for switching **large currents** (> 5A).
- ✓ Relays can switch **many contacts** at once.

Disadvantages of relays:

- ✓ Relays are **bulkier** than transistors for switching small currents.
- ✓ Relays **cannot switch rapidly** (except reed relays), transistors can switch many times per second.
- ✓ Relays **use more power** due to the current flowing through their coil.
- ✓ Relays **require more current than many ICs can provide**, so a low power transistor may be needed to switch the current for the relay's coil.

Self-Check - 4	Written Test

Directions: Answer all the questions listed below.

I. <u>Choose the best option & circle the letter of your choice.</u>

1. A leaky diode can be detected by a low reading in one direction and a slight reading the other direction.

2. A shorted transistor will allow a large current to flow, and cause other components to heat up.

3. Transistors can also develop an open circuit between base and collector, base and emitter or collector and emitter.

4. An inductor with a shorted turn will have a very low or zero inductance

5. Capacitors can produce very unusual faults and no piece of test equipment is going to detect the problem.

***Note:* Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ___________
Rating: ____________

Information Sheet-5	Following correct use of test/measuring instrument

5.1 Introduction to correct use of Test/measuring instrument

5.2 Types of correct use test/measuring instrument

Capacitance meter

A **capacitance meter** is a piece of electronic test equipment used to measure capacitance, mainly of discrete capacitors. Depending on the sophistication of the meter, it may display the capacitance only, or it may also measure a number of other parameters such as leakage, equivalent series resistance (ESR), and inductance. For most purposes and in most cases the capacitor must be disconnected from circuit; ESR can usually be measured in circuit.

Simple checks without a true capacitance meter

Some checks can be made without a specialized instrument, particularly on aluminium electrolytic capacitors which tend to be of high capacitance and to be subject to poor leakage. A multimeter in a resistance range can detect a short-circuited capacitor (very low resistance) or one with very high leakage (high resistance, but lower than it should be; an ideal capacitor has infinite DC resistance). A crude idea of the capacitance can be derived with an analog multimeter in a high resistance range by observing the needle when first connected; current will flow to charge the capacitor and the needle will "kick" from infinite indicated resistance to a relatively low value, and then drift up to infinity. The amplitude of the kick is an indication of capacitance. Interpreting results requires some experience, or comparison with a good capacitor, and depends upon the particular meter and range used.

Simple and non-bridge meters

Many DVMs (digital volt meters) have a capacitance-measuring function. These usually operate by charging and discharging the capacitor under test with a known current and measuring the rate of rise of the resulting voltage; the slower the rate of rise, the larger the capacitance. DVMs can usually measure capacitance from nanofarads to a few hundred microfarads, but wider ranges are not unusual.

- Measure the capacity of rotary capacitor with digital multimeter
- 

C_{min} = 29 pF

- 

C = 269 pF

- 

C_{max} = 520 pF

It is also possible to measure capacitance by passing a known high-frequency alternating current through the device under test and measuring the resulting voltage across it (does not work for polarised capacitors).

When troubleshooting circuit problems, a few problems are intermittent or only show up with the working voltage applied, and are not revealed by measurements with equipment, however sophisticated, which uses low test voltages. Some problems are revealed by using a "freezer" spray and observing the effect on circuit operation. Ultimately, in difficult cases routine replacement of capacitors (relatively cheap components) is easier than arranging measurements of all relevant parameters in working conditions.

Some more specialized instruments measure capacitance over a wide range using the techniques described above, and can also measure other parameters. Low stray and parasitic capacitance can be measured if a low enough range is available. Leakage current is measured by applying a direct voltage and measuring the current in the normal way.

Ammeter

An ammeter (from Ampere Meter) is a measuring instrument used to measure the current in a circuit. Electric currents are measured in amperes (A), hence the name. Instruments used to measure smaller currents, in the milliampere or microampere range, are designated as *milliammeters* or *microammeters*. Early ammeters were laboratory instruments which relied on the Earth's magnetic field for operation. By the late 19th century, improved instruments were designed which could be mounted in any position and allowed accurate measurements in electric power systems. It is generally represented by letter 'A' in a circle.

Digital

In much the same way as the analogue ammeter formed the basis for a wide variety of derived meters, including voltmeters, the basic mechanism for a digital meter is a digital voltmeter mechanism, and other types of meter are built around this.

Digital ammeter designs use a shunt resistor to produce a calibrated voltage proportional to the current flowing. This voltage is then measured by a digital voltmeter, through use of an analog to digital converter (ADC); the digital display is calibrated to display the current through the shunt. Such instruments are often calibrated to indicate the RMS value for a sine wave only, but many designs will indicate true RMS within limitations of the wave crest factor.

There is also a range of devices referred to as integrating ammeters. In these ammeters the current is summed over time, giving as a result the product of current and time; which is proportional to the electrical charge transferred with that current. These can be used for metering energy (the charge needs to be multiplied by the voltage to give energy) or for estimating the charge of a battery or capacitor.

Pico ammeter

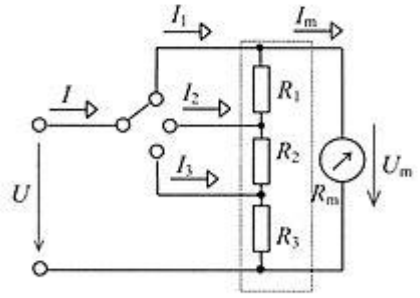
A picoammeter, or pico ammeter, measures very low electric current, usually from the picoampere range at the lower end to the milliampere range at the upper end. Picoammeters are used for sensitive measurements where the current being measured is below the theoretical limits of sensitivity of other devices, such as Multimeters.

Most picoammeters use a "virtual short" technique and have several different measurement range that must be switched between to cover multiple decades of measurement. Other modern picoammeters use log compression and a "current sink" method that eliminates range switching and associated voltage spikes.[8] Special design and usage considerations must be observed in order to reduce leakage current which may swamp measurements such as special insulators and driven shields. Triaxial cable is often used for probe connections.

Application

The majority of ammeters are either connected in series with the circuit carrying the current to be measured (for small fractional amperes), or have their shunt resistors connected similarly in series. In either case, the current passes through the meter or (mostly) through its shunt. Ammeters must not be connected directly across a voltage source since their internal resistance is very low and excess current would flow. Ammeters are designed for a low voltage drop across their terminals, much less than one volt; the extra circuit losses produced by the ammeter are called its "burden" on the measured circuit.

Ordinary Weston-type meter movements can measure only milliamperes at most, because the springs and practical coils can carry only limited currents. To measure larger currents, a resistor called a *shunt* is placed in parallel with the meter. The resistances of shunts are in the integer to fractional milliohm range. Nearly all of the current flows through the shunt, and only a small fraction flow through the meter. This allows the meter to measure large currents. Traditionally, the meter used with a shunt has a full-scale deflection (FSD) of 50 mV, so shunts are typically designed to produce a voltage drop of 50 mV when carrying their full rated current.



Ayrton shunt switching principle

Transistor tester

Transistor testers are instruments for testing the electrical behavior of transistors and solid-state diodes.

Types of tester

There are three types of transistor testers each performing a unique operation.

- Quick-check in-circuit checker
- Service type tester
- Laboratory-standard tester

In addition, curve tracers are reliable indicators of transistor performance.

Circuit Tester

A circuit tester is used to check whether a transistor which has previously been performing properly in a circuit is still operational. The transistor's ability to "amplify" is taken as a rough index of its performance. This type of tester indicates to a technician whether the transistor is dead or still operative. The advantage of this tester is that the transistor does not have to be removed from the circuit.

Service type transistor testers

These devices usually perform three types of checks:

- Forward-current gain,or beta of transistor.
- Base-to-collector leakage current with emitter open(ico)
- Short circuits from collector to emitter and base.

Some service testers include a go/no-go feature, indicating a pass when a certain h_{fe} is exceeded. These are useful, but fail some functional but low h_{fe} transistors.

Some also provide a means of identifying transistor elements, if these are unknown. The tester has all these features and can check solid-state devices in and out of circuit.

Transistor h_{fe} varies fairly widely with Ic, so measurements with the service type tester give readings that can differ quite a bit from the h_{fe} in the transistor's real life application. Hence these testers are useful, but can't be regarded as giving accurate real-life h_{fe} values.

Laboratory-standard transistor tester or Analyser

This type of tester is used for measuring transistor parameters dynamically under various operating conditions. The readings they give are absolute. Among the important characteristics measured are:

- I_{cbo} collector current with emitter open (Common base)
- ac beta (Common emitter)
- R_{in} (Input resistance)

Transistor testers have the necessary controls and switches for making the proper voltage, current and signal settings. A meter with a calibrated "good" and "bad" scale is on the front. In addition, these transistor testers are designed to check the solid-state diodes. There are also testers for checking high transistor and rectifiers.

LCR meter

Handheld LCR meter

Bench top LCR meter with 4-wire (Kelvin sensing) fixture

An **LCR meter** is a type of electronic test equipment used to measure the inductance (L), capacitance (C), and resistance (R) of an electronic component.[1] In the simpler versions of this instrument the impedance was measured internally and converted for display to the corresponding capacitance or inductance value. Readings should be reasonably accurate if the capacitor or inductor device under test does not have a significant resistive component of impedance. More advanced designs measure true inductance or capacitance, as well as the equivalent series resistance of capacitors and the Q factor of inductive components.

Operation

Usually the device under test (DUT) is subjected to an AC voltage source. The meter measures the voltage across and the current through the DUT. From the ratio of these the meter can determine the magnitude of the impedance. The phase angle between the voltage and current is also measured in more advanced instruments; in combination with the impedance, the equivalent capacitance or inductance, and resistance, of the DUT can be calculated and displayed. The meter must assume either a parallel or a series model for these two elements. An ideal capacitor has no characteristics other than capacitance, but there are no physical ideal capacitors. All real capacitors have a little inductance, a little resistance, and some defects causing inefficiency. These can be seen as inductance or resistance in series with the ideal capacitor or in parallel with it, and so likewise with inductors. Even resistors can have inductance (especially if they are wire wound types) and capacitance as a consequence of the way they are constructed. The most useful assumption, and the one usually adopted, is that LR measurements have the elements in series (as is necessarily the case in an inductor's coil) and that CR measurements have the elements in parallel (as is necessarily the case between a capacitor's 'plates'). Leakage is a special case in capacitors, as the leakage is necessarily across the capacitor plates, that is, in series.

An LCR meter can also be used to measure the inductance variation with respect to the rotor position in permanent magnet machines. (However, care must be taken, as some LCR meters will be damaged by the generated EMF produced by turning the rotor of a permanent-magnet motor; in particular those intended for electronic component measurements.)

Handheld LCR meters typically have selectable test frequencies of 100 Hz, 120 Hz, 1 kHz, 10 kHz, and 100 kHz for top end meters. The display resolution and measurement range capability will typically change with the applied test frequency since the circuitry is more sensitive or less for a given component (i.e., an inductor or capacitor) as the test frequency changes.

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Multimeter

An analog multimeter, the Sanwa YX360TRF

A **multimeter** or a **multitester**, also known as a **VOM** (volt-ohm-milliammeter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter can measure voltage, current, and resistance. **Analog multimeters** uses a microammeter with a moving pointer to display readings. **Digital multimeters** (DMM, DVOM) have a numeric display, and may also show a graphical bar representing the measured value. Digital multimeters are now far more common due to their lower cost and greater precision, but analog multimeters are still preferable in some cases, for example when monitoring a rapidly varying value.

A multimeter can be a hand-held device useful for basic fault finding and field service work, or a bench instrument which can measure to a very high degree of accuracy. Multimeters are available in a wide range of features and prices.

History

1920s pocket multimeter

Avometer Model 8

Operation

A multimeter is the combination of a DC voltmeter, AC voltmeter, ammeter, and ohmmeter. An un-amplified analog multimeter combines a meter movement, range resistors and switches; VTVMs are amplified analog meters and contain active circuitry.

Probes

Multimeter test leads

A multimeter can use many different test probes to connect to the circuit or device under test. Crocodile clips, retractable hook clips, and pointed probes are the three most common types. Tweezer probes are used for closely spaced test points, as for instance surface-mount devices. The connectors are attached to flexible, well insulated leads terminated with connectors appropriate for the meter. Probes are connected to portable meters typically by shrouded or recessed banana jacks, while benchtop meters may use banana jacks or BNC connectors. 2 mm plugs and binding posts have also been used at times, but are less commonly used today. Indeed, safety ratings now require shrouded banana jacks.

The banana jacks are typically placed with a standardized center-to-center distance of $^{3}\!/_{4}$ in (19 mm), to allow standard adapters or devices such as voltage multiplier or thermocouple probes to be plugged in.

Clamp meters

Clamp meters clamp around a conductor carrying a current to measure without the need to connect the meter in series with the circuit, or make metallic contact at all. Those for AC measurement use the transformer principle; clamp-on meters to measure small current or direct current require more exotic sensors like for example hall effect based systems that measure the non changing magnetic field to determine the current.

Ohmmeter

An **ohmmeter** is an electrical instrument that measures electrical resistance, the opposition to an electric current. Micro-ohmmeters (microhmmeter or micro ohmmeter) make low resistance measurements. Megohmmeters (also a trademarked device Megger) measure large values of resistance. The unit of measurement for resistance is ohms (Ω).

An analog ohmmeter

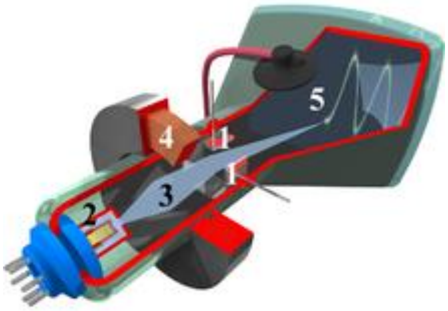
A more accurate type of ohmmeter has an electronic circuit that passes a constant current (I) through the resistance, and another circuit that measures the voltage (V) across the resistance. These measurements are then digitized with an analog digital converter (adc) after which a microcontroller or microprocessor make the division of the current and voltage according to Ohm's Law and then decode these to a display to offer the user a reading of the resistance value they're measuring at that instant. Since these type of meters already measure current, voltage and resistance all at once, these type of circuits are often used in digital multimeters.

Precision ohmmeters

For high-precision measurements of very small resistances, the above types of meter are inadequate. This is partly because the change in deflection itself is small when the resistance measured is too small in proportion to the intrinsic resistance of the ohmmeter (which can be dealt with through current division), but mostly because the meter's reading is the sum of the resistance of the measuring leads, the contact resistances and the resistance being measured. To reduce this effect, a precision ohmmeter has four terminals, called Kelvin contacts. Two terminals carry the current from and to the meter, while the other two allow the meter to measure the voltage across the resistor. In this arrangement, the power source is connected in series with the resistance to be measured through the external pair of terminals, while the second pair connects in parallel with the galvanometer which measures the voltage drop. With this type of meter, any voltage drop due to the resistance of the first pair of leads and their contact resistances is ignored by the meter. This four terminal measurement technique is called Kelvin sensing, after William Thomson, Lord Kelvin, who invented the Kelvin bridge in 1861 to measure very low resistances. The Four-terminal sensing method can also be utilized to conduct accurate measurements of low resistances.

Oscilloscope

Oscilloscope cathode-ray tube



The interior of a cathode-ray tube for use in an oscilloscope are 1. Deflection plates 2. Electron gun 3. Electron beam 4. Focusing coil 5. Phosphor-coated inner side of the screen

An oscilloscope displaying capacitor discharge

An **oscilloscope**, previously called an **oscillograph** and informally known as a **scope** or **o-scope**, **CRO** (for cathode-ray oscilloscope), or **DSO** (for the more modern digital storage oscilloscope), is a type of electronic test instrument that graphically displays varying signal voltages, usually as a two-dimensional plot of one or more signals as a function of time. Other signals (such as sound or vibration) can be converted to voltages and displayed.

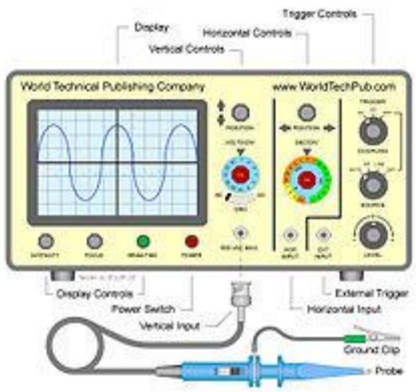
Oscilloscopes display the change of an electrical signal over time, with voltage and time as the Y- and X-axes, respectively, on a calibrated scale. The waveform can then be analyzed for properties such as amplitude, frequency, rise time, time interval, distortion, and others. Modern digital instruments may calculate and display these properties directly. Originally, calculation of these values required manually measuring the waveform against the scales built into the screen of the instrument.[3]

The oscilloscope can be adjusted so that repetitive signals can be observed as a continuous shape on the screen. A storage oscilloscope can capture a single event and display it continuously, so the user can observe events that would otherwise appear too briefly to see directly.

Oscilloscopes are used in the sciences, medicine, engineering, automotive and the telecommunications industry. General-purpose instruments are used for maintenance of electronic equipment and laboratory work. Special-purpose oscilloscopes may be used for such purposes as analyzing an automotive ignition system or to display the waveform of the heartbeat as an electrocardiogram.

Early oscilloscopes used cathode ray tubes (CRTs) as their display element (hence they were commonly referred to as CROs) and linear amplifiers for signal processing. Storage oscilloscopes used special storage CRTs to maintain a steady display of a single brief signal. CROs were later largely superseded by digital storage oscilloscopes (DSOs) with thin panel displays, fast analog-to-digital converters and digital signal processors. DSOs without integrated displays (sometimes known as digitisers) are available at lower cost and use a general-purpose digital computer to process and display waveforms.

Features and uses



Basic oscilloscope

Description

The basic oscilloscope, as shown in the illustration, is typically divided into four sections: the display, vertical controls, horizontal controls and trigger controls. The display is usually a CRT (historically) or LCD panel laid out with horizontal and vertical reference lines called the *graticule*. CRT displays also have controls for focus, intensity, and beam finder.

The vertical section controls the amplitude of the displayed signal. This section has a volts-per-division (Volts/Div) selector knob, an AC/DC/Ground selector switch, and the vertical (primary) input for the instrument. Additionally, this section is typically equipped with the vertical beam position knob.

The horizontal section controls the time base or "sweep" of the instrument. The primary control is the Seconds-per-Division (Sec/Div) selector switch. Also included is a horizontal input for plotting dual X-Y axis signals. The horizontal beam position knob is generally located in this section.

The trigger section controls the start event of the sweep. The trigger can be set to automatically restart after each sweep, or can be configured to respond to an internal or external event. The principal controls of this section are the source and coupling selector switches, and an external trigger input (EXT Input) and level adjustment.

In addition to the basic instrument, most oscilloscopes are supplied with a probe. The probe connects to any input on the instrument and typically has a resistor of ten times the oscilloscope's input impedance. This results in a .1 (-10X) attenuation factor; this helps to isolate the capacitive load presented by the probe cable from the signal being measured. Some probes have a switch allowing the operator to bypass the resistor when appropriate.

Wattmeter

Wattmeter

The **wattmeter** is an instrument for measuring the electric power (or the supply rate of electrical energy) in watts of any given circuit. Electromagnetic wattmeters are used for measurement of utility frequency and audio frequency power; other types are required for radio frequency measurements.

Electrodynamic

Early wattmeter on display at the Historic Archive and Museum of Mining in Pachuca, Mexico

The traditional analog wattmeter is an electrodynamic instrument. The device consists of a pair of fixed coils, known as *current coils*, and a movable coil known as the *potential coil*.

The current coils are connected in series with the circuit, while the potential coil is connected in parallel. Also, on analog wattmeters, the potential coil carries a needle that moves over a scale to indicate the measurement. A current flowing through the current coil generates an electromagnetic field around the coil. The strength of this field is proportional to the line current and in phase with it. The potential coil has, as a general rule, a high-value resistor connected in series with it to reduce the current that flows through it.

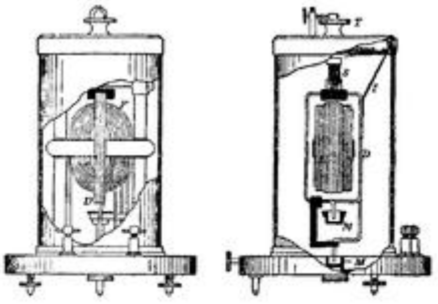
The result of this arrangement is that on a DC circuit, the deflection of the needle is proportional to *both* the current (I) *and* the voltage (V), thus conforming to the equation $P=VI$.

For AC power, current and voltage may not be in phase, owing to the delaying effects of circuit inductance or capacitance. On an AC circuit the deflection is proportional to the average instantaneous product of voltage and current, thus measuring active power, $P=VI \cos \varphi$. Here, $\cos\varphi$ represents the power factor which shows that the power transmitted may be less than the apparent power obtained by multiplying the readings of a voltmeter and ammeter in the same circuit.

The two circuits of a wattmeter can be damaged by excessive current. The ammeter and voltmeter are both vulnerable to overheating — in case of an overload, their pointers will be driven off scale — but in the wattmeter, either or even both the current and potential circuits can overheat *without* the pointer approaching the end of the scale. This is because the position of the pointer depends on the power factor, voltage and current. Thus, a circuit with a low power factor will give a low reading on the wattmeter, even when both of its circuits are loaded to the maximum safety limit. Therefore, a wattmeter is rated not only in watts, but also in volts and amperes.

A typical wattmeter in educational labs has two voltage coils (pressure coils) and a current coil. The two pressure coils can be connected in series or parallel to change the ranges of the wattmeter. The pressure coil can also be tapped to change the meter's range. If the pressure coil has range of 300 volts, the half of it can be used so that the range becomes 150 volts.

Electronic



Siemens electrodynamometer, circa 1910, F = Fixed coil, D = Movable coil, S = Spiral spring, T = Torsion head, M = Mercury cups, I = Index needle

Prodigit Model 2000MU (UK version), shown in use and displaying a reading of 10 watts being consumed by the appliance

Electronic wattmeters are used for direct, small power measurements or for power measurements at frequencies beyond the range of electrodynamometer-type instruments.

Digital

A modern digital wattmeter samples the voltage and current thousands of times a second. For each sample, the voltage is multiplied by the current at the same instant; the average over at least one cycle is the real power. The real power divided by the apparent volt-amperes (VA) is the power factor. A computer circuit uses the sampled values to calculate RMS voltage, RMS current, VA, power (watts), power factor, and kilowatt-hours. The readings may be displayed on the device, retained to provide a log and calculate averages, or transmitted to other equipment for further use. Wattmeters vary considerably in correctly calculating energy consumption, especially when real power is much lower than VA (highly reactive loads, e.g. electric motors). Simple meters may be calibrated to meet specified accuracy only for sinusoidal waveforms. Waveforms for switched-mode power supplies as used for much electronic equipment may be very far from sinusoidal, leading to unknown and possibly large errors at any power. This may not be specified in the meter's manual.

Watthour meters

Itron Open Way wattmeter with two-way communications for remote reading, in use by DTE Energy

An instrument which measures electrical energy in watt hours is essentially a wattmeter which accumulates or averages readings. Digital electronic instruments measure many parameters and can be used where a wattmeter is needed: volts, current,in amperes, apparent instantaneous power, actual power, power factor, energy in [k]W·h over a period of time, and cost of electricity consumed.

Voltmeter

Demonstration analog voltmeter

A **voltmeter** is an instrument used for measuring electrical potential difference between two points in an electric circuit. Analog voltmeters move a pointer across a scale in proportion to the voltage of the circuit; digital voltmeters give a numerical display of voltage by use of an analog to digital converter.

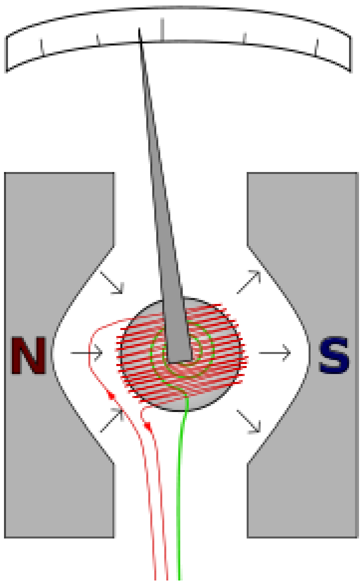
A voltmeter in a circuit diagram is represented by the letter *V* in a circle.

Voltmeters are made in a wide range of styles. Instruments permanently mounted in a panel are used to monitor generators or other fixed apparatus. Portable instruments, usually equipped to also measure current and resistance in the form of a multimeter, are standard test instruments used in electrical and electronics work. Any measurement that can be converted to a voltage can be displayed on a meter that is suitably calibrated; for example, pressure, temperature, flow or level in a chemical process plant.

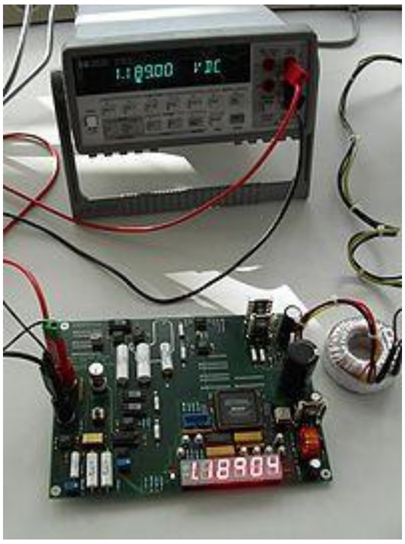
General purpose analog voltmeters may have an accuracy of a few percent of full scale, and are used with voltages from a fraction of a volt to several thousand volts. Digital meters can be made with high accuracy, typically better than 1%. Specially calibrated test instruments have higher accuracies, with laboratory instruments capable of measuring to accuracies of a few parts per million. Meters using amplifiers can measure tiny voltages of microvolts or less.

Part of the problem of making an accurate voltmeter is that of calibration to check its accuracy. In laboratories, the Weston Cell is used as a standard voltage for precision work. Precision voltage references are available based on electronic circuits.

Analog voltmeter



Digital voltmeter



Two digital voltmeters. Note the 40 microvolt difference between the two measurements, an offset of 34 parts per million.

A **digital voltmeter** (DVM) measures an unknown input voltage by converting the voltage to a digital value and then displays the voltage in numeric form. DVMs are usually designed around a special type of analog-to-digital converter called an integrating converter.

DVM measurement accuracy is affected by many factors, including temperature, input impedance, and DVM power supply voltage variations. Less expensive DVMs often have input resistance on the order of 10 MΩ. Precision DVMs can have input resistances of 1 GΩ or higher for the lower voltage ranges (e.g. less than 20 V). To ensure that a DVM's accuracy is within the manufacturer's specified tolerances, it must be periodically calibrated against a voltage standard such as the Weston cell.

The first digital voltmeter was invented and produced by Andrew Kay of Non-Linear Systems (and later founder of Kaypro) in 1954.[1]

Frequency counter

A **frequency counter** is an electronic instrument, or component of one, that is used for measuring frequency. Frequency counters usually measure the number of cycles of oscillation, or pulses per second in a periodic electronic signal. Such an instrument is sometimes referred to as a cymometer, particularly one of Chinese manufacture

Systron-Donner frequency counter from 1973 with Nixie tube display

Operating principle

Most frequency counters work by using a counter which accumulates the number of events occurring within a specific period of time. After a preset period known as the *gate time* (1 second, for example), the value in the counter is transferred to a display and the counter is reset to zero. If the event being measured repeats itself with sufficient stability and the frequency is considerably lower than that of the clock oscillator being used, the resolution of the measurement can be greatly improved by measuring the time required for an entire number of cycles, rather than counting the number of entire cycles observed for a pre-set duration (often referred to as the *reciprocal technique*). The internal oscillator which provides the time signals is called the *timebase*, and must be calibrated very accurately.

If the event to be counted is already in electronic form, simple interfacing to the instrument is all that is required. More complex signals may need some conditioning to make them suitable for counting. Most general purpose frequency counters will include some form of amplifier, filtering and shaping circuitry at the input. DSP technology, sensitivity control and hysteresis are other techniques to improve performance. Other types of periodic events that are not inherently electronic in nature will need to be converted using some form of transducer. For example, a mechanical event could be arranged to interrupt a light beam, and the counter made to count the resulting pulses.

Frequency counters designed for radio frequencies (RF) are also common and operate on the same principles as lower frequency counters. Often, they have more range before they overflow. For very high (microwave) frequencies, many designs use a high-speed prescaler to bring the signal frequency down to a point where normal digital circuitry can operate. The displays on such instruments take this into account so they still display the correct value. Microwave frequency counters can currently measure frequencies up to almost 56 GHz. Above these frequencies the signal to be measured is combined in a mixer with the signal from a local oscillator, producing a signal at the difference frequency, which is low enough to be measured directly.

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Self-Check -5	Written Test

Directions: Answer all the questions listed below.

I: Say **True Or False**

1. A capacitance meter is a piece of electronic test equipment used to measure capacitance, mainly of discrete capacitors.

2. An ammeter (from Ampere Meter) is a measuring instrument used to measure the current in a circuit.
3. Transistor testers are instruments for testing the electrical behavior of transistors and solid-state diodes.
4. An LCR meter is a type of electronic test equipment used to measure the inductance (L), Capacitance (C), and resistance (R) of an electronic component
5. Clamp meters clamp around a conductor carrying a current to measure without the need to connect the meter in series with the circuit, or make metallic contact at all.
6. Oscilloscope is a type of electronic test instrument that graphically displays varying signal voltages, usually as a two-dimensional plot of one or more signals as a function of time.

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ____________

Rating: _____________

Information Sheet-6	Confirming the electrical/electronic parts data, function and value of parts/component specification

6.1 Introduction electrical/electronic parts data function and value of parts/component specification

A data sheet , data-sheet , or spec sheet is a document that summarizes the performance and other characteristics of a product, machine, component (e.g., an electronic component), material, a subsystem (e.g., a power supply) or software in sufficient detail that allows a buyer to understand what the product and a design engineer to understand the role of the component in the overall system. Typically, a datasheet is created by the manufacturer and begins with an introductory page describing the rest of the document, followed by listings of specific characteristics, with further information on the connectivity of the devices. In cases where there is relevant source code to include, it is usually attached near the end of the document or separated into another file. Data-sheets are created, stored and distributed via Product information management or Product data management systems.

Depending on the specific purpose, a datasheet may offer an average value, a typical value, a typical range, engineering tolerances, or a nominal value. The type and source of data are usually stated on the datasheet.

A datasheet is usually used for the commercial or technical communication to describe the characteristics of an item or product. It can be published by the manufacturer to help people choose products or to help use the products. By contrast, a technical specification is an explicit set of requirements to be satisfied by a material, product, or service.

The ideal datasheet specifies characteristics in a formal structure, according to a strict taxonomy, that allows the information to be processed by a machine. Such machine readable descriptions can facilitate information retrieval, display, design, testing, interfacing, verification, system discovery, and e-commerce. Examples include Open Ice cat data-sheets, transducer electronic data sheets for describing sensor characteristics, and Electronic device descriptions in CAN open or descriptions in markup languages, such as Sensor ML .

6.2 Types of Datasheet

- **Product data-sheet information**

A product data-sheet (PDS), like any data-sheet, has a different data model per category. It typically contains: Identifiers like manufacturer & manufacturer product code, GTIN Classification data, such as UNSPSC Descriptions such as marketing texts Specifications Product images Feature logos Reasons-to-buy Leaflets, typically as PDFs Manuals, typically in PDF. Product videos, 3D objects, and other rich media assets.

In Open Icecat, the global open catalogue or open content project in which hundreds of manufacturers and thousands of e-commerce sellers participate, the data models of tens of thousands of taxonomy classes are defined, and millions of free PDSs can be found conforming these data-sheet data models.

- **Material Safety Data Sheets**

A Material Safety Data Sheet (MSDS), Safety Data Sheet (SDS), or Product Safety Data Sheet (PSDS) is an important component of product stewardship and occupational safety and health. These are required by agencies such as OSHA in its Hazard Communication Standard, 29 C.F.R. 1910.1200. It provides workers with ways to allow them to work in a safe manner and gives them physical data (melting point, boiling point, flash point, etc.), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill-handling procedures. The MSDSs differ from country to country, as different countries have different regulations. In some jurisdictions, it is compulsory for the SDS to state the chemical's risks, safety, and effect on the environment.

The SDSs are a commonly used classification for logging information on chemicals, chemical compounds, and chemical mixtures. The SDSs often include the safe use of the chemical and the hazardous nature of the chemical. Anytime chemicals are used these data sheets will be found.

There is a need to have an internationally recognized symbol when describing hazardous substances. Labels can include hazard symbols such as the European Union standard black diagonal cross on an orange background, used to denote a harmful substance.

The purpose of an SDS is not so that the general public will have a knowledge of how to read and understand it, but more so that it can be used in an occupational setting to allow workers to be able to work with it.

- **Chemical data**

Data sheets and pages are available for specific properties of chemicals in

Chemical elements data references example, Melting points of the elements (data page). Specific materials have technical data in individual sheets such as Ethanol (data page): this includes subjects such as structure and properties, thermodynamic properties, spectral data, vapor pressure, etc. Other chemical data sheets are available from individual producers of chemicals, often on their web pages.

- **Data sheets for automobiles**

Data sheets for automobiles may be described under several names such as features, specs, engineering data, technical summary, etc. They help communicate the technical information about a car to potential buyers and are useful for comparisons with similar cars. They might include: critical inside and outside dimensions, weight, fuel efficiency, engine and drive train, towing capability, safety features and options, warranty, etc.

- **Similar Documents**

Brochure focuses more on the benefits and advantages of a products, and states less details, especially less quantitative parameters to describe the product. The beginning parts of a brochure and a datasheet for the same product may look the same and include the name of the product, manufacturer's name, logo and contact details, brief description, photo of scheme of the product.

Catalog presents a variety of products and in comparison to datasheets, that presents one product or a relatively small group of similar products. Catalog may present many of the parameters that are stated in the datasheets of the products, but usually catalogs are not as comprehensive as datasheets.

User guide deals more with the step-by-step usage of a products, and may include a brief or complete list of parameters that describe the product, usually as an appendix for the actual user guide document.

Application notes is a document that gives more specific details on using a component in a specific application, or relating to a particular process (e.g., the physical assembly of a product containing the component). Application notes are especially useful for giving guidance on more unusual uses of a particular component, which would be irrelevant to many readers of the more widely read datasheet. application notes may either be appended to a datasheet, or presented as a separate document.

A technical specification is an explicit set of requirements to be satisfied by a material, product, or service

6.3 Component replacement

If you can't get an exact replacement, refer to a component substitution guide to identify a near equivalent.

The important parameters are:

1. Voltage
2. Current
3. Wattage
4. Maximum frequency of operation

The replacement part should have parameters equal to or higher than the original.

Points to remember:

- Polarity of the components

- At least the same voltage, current and wattage rating.

- Low frequency or high frequency type.

- Check the pin out of the replacement part

- Use a desoldering pump to remove the component to prevent damage to the printed circuit board.

- Fit the heat sink.

- Check the mica washer and use heat-sink compound

- Tighten the nut/bolt - not too tight or too loose.

- Horizontal output transistors with an integrated diode should be replaced with the same type.

6.3 Specification

A specification often refers to a set of documented requirements to be satisfied by a material, design, product, or service.[1] A specification is often a type of technical standard .

There are different types of technical or engineering specifications (specs), and the term is used differently in different technical contexts. They often refer to particular documents, and/or particular information within them. The word specification is broadly defined as "to state explicitly or in detail" or "to be specific".

Using the term "specification" without a clear indication of what kind is confusing and considered bad practice.

according to whom?

A requirement specification is a documented requirement, or set of documented requirements, to be satisfied by a given material, design, product, service, etc. [2] It is a common early part of engineering design and product development processes, in many fields.

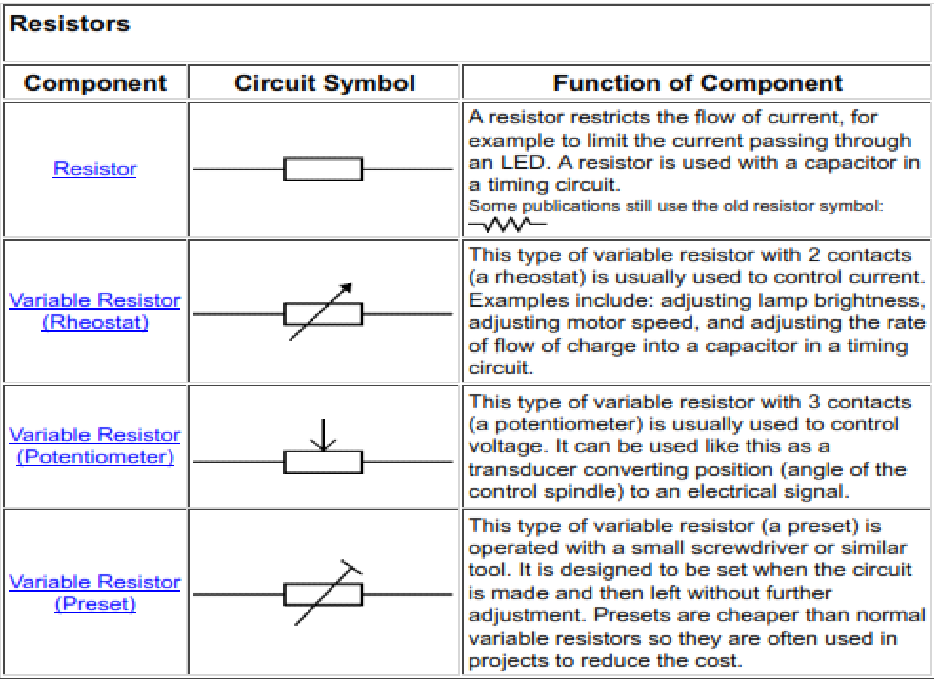
A functional specification is a kind of requirement specification, and may show functional block diagrams.[citation needed]

A design or product specification describes the features of the solutions for the Requirement Specification, referring to either a designed solution or final produced solution. It is often used to guide fabrication/production. Sometimes the term specification is here used in connection with a data sheet (or spec sheet), which may be confusing. A data sheet describes the technical characteristics of an item or product, often published by a manufacturer to help people choose or use the products. A data sheet is not a technical specification in the sense of informing how to produce.

An "in-service” or "maintained as "specification, specifies the conditions of a system or object after years of operation, including the effects of wear and maintenance (configuration changes).

Specifications are a type of technical standard that may be developed by any of various kinds of organizations, both public and private. Example organization types include a corporation, a consortium (a small group of corporations), a trade association (an industry-wide group of corporations), a national government (including its military, regulatory agencies, and national laboratories and institutes), a professional association (society), a purpose-made standards organization such as ISO , or vendor-neutral developed generic requirements. It is common for one organization to refer to (reference, call out, cite) the standards of another. Voluntary standards may become mandatory if adopted by a government or business contract.

Table 6.1 an example of function of various resistors



Resistors		
Component	**Circuit Symbol**	**Function of Component**
Resistor		A resistor restricts the flow of current, for example to limit the current passing through an LED. A resistor is used with a capacitor in a timing circuit. Some publications still use the old resistor symbol:
Variable Resistor (Rheostat)		This type of variable resistor with 2 contacts (a rheostat) is usually used to control current. Examples include: adjusting lamp brightness, adjusting motor speed, and adjusting the rate of flow of charge into a capacitor in a timing circuit.
Variable Resistor (Potentiometer)		This type of variable resistor with 3 contacts (a potentiometer) is usually used to control voltage. It can be used like this as a transducer converting position (angle of the control spindle) to an electrical signal.
Variable Resistor (Preset)		This type of variable resistor (a preset) is operated with a small screwdriver or similar tool. It is designed to be set when the circuit is made and then left without further adjustment. Presets are cheaper than normal variable resistors so they are often used in projects to reduce the cost.

Self-Check -6	Written Test

Directions: Answer all the questions listed below.

I: Say **True Or False**

1. A Material Safety Data Sheet (MSDS), Safety Data Sheet (SDS), or Product Safety Data Sheet (PSDS) is an important component of product stewardship and occupational safety and health.

2. Data sheets for automobiles help to communicate the technical information about a car to potential buyers and are useful for comparisons with similar cars. They might

3. Catalog presents a variety of products and in comparison to datasheets it presents one product or a relatively small group of similar products.

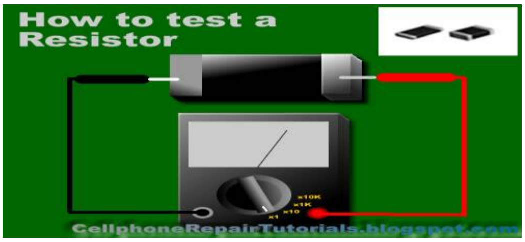
4. A design or product specification describes the features of the solutions for the Requirement Specification, referring to either a designed solution or final produced solution.

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ___________
Rating: ____________

Operation Sheet 1	Using appropriate range of *methods* in testing electrical /electronic circuits & parts

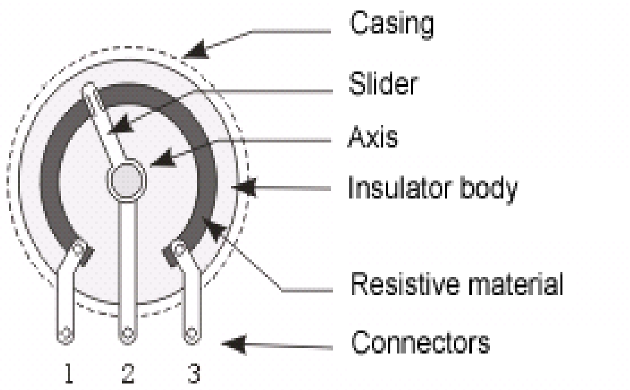
Operation Title: Testing a resistor



Steps:

1. Switch "ON" the multimeter and point selector switch in "Ω" section.
2. Connect the leads to "V/Ω" and "COM" sockets.
3. Read the indicated color code value indicated in Schematic symbol then select the Ohm-scale within but not away below the indicated value.
4. Set the multi-tester in resistance (ohms) mode with higher rating mode.
5. Place the black probe of the multi-meter in one terminal of the resistor.
6. Place the red probe of the multi-meter in the other terminal of the resistor.
7. Observe the needle point of the multi-meter. If the needle deflects from zero to infinite or close to the indicated value then the resistor is good.
8. While no resistance reading at all on the ohmmeter scale settings means that the resistor is open.
9. A zero resistance reading on all ohmmeter scale settings means that the resistor is shorted.

Operation Title:-Testing Potentiometer and Preset



Steps

1. Set the multimeter to resistance measurement section.
2. Plug/ Connect the leads to “V/Ω” and “COM” sockets .
3. Connect the tips of multimeter leads to terminal 1 and 3 of the multimeter.
4. The multimeter should show the resistance equal to rating or maximum value of the potentiometer.
5. Now connect one tip of multimeter probe to terminal 1 and the other to central sliding contact terminal 2.
6. When the spindle is rotated towards terminal 1 the resistance value should go on decreasing up to zero.
7. When the spindle is rotated away from terminal 1, the multimeter should show increasing resistance.
8. Next connect the multimeter probes to terminal 3 and central contact 2.
9. When the spindle is rotated towards terminal 3 the multimeter should show decreasing resistance .And when the spindle is rotated away from the terminal 3, the multimeter should show increasing resistance to the maximum value of potentiometer rating.

Operation Title:- Capacitor testing

Steps:

1. Discharge the capacitor by placing a resistor across the two legs of the capacitor the resistor value can be around 2.2 to 4.7kilo ohms or shorting the two terminals of the capacitor if it is small power. Before doing it make sure that you wear your goggles.

2. Set the multimeter to Rx10 or Rx1K scale or in resistance (ohms) mode with higher rating mode.

3. Place the black probe of the multi-meter in the negative terminal of the capacitor.

4. Place the red probe of the multi-meter in the positive terminal of the capacitor.

5. Observe the needle point of the multi-meter. If the needle deflects from zero to infinite then the capacitor is good.

- A good indication for electrolytic capacitor shows the meter needle deflecting towards zero and moves back again to infinite resistance position.
- For ceramic Mylar and other capacitor with a capacitance with less than 1.0 uF the meter will not deflect at all.
- A defective indication for an electrolytic capacitor shows that the meter will rest on zero and remain stationary at a point which is an indication that the capacitor is shorted.

Operation Title:- Testing Inductors and Transformers

Steps:

1. Set the multi-meter to X1 or select the lowest range of resistance, the multimeter should show very low resistance. A good and working coil have a reading.
2. If the multi-meter shows the “open”, it means the coil wire or the end terminal is disconnected.
3. If the multi-meter shows “zero” resistance, the insulation may be damaged. Without any reading means the coil is open or busted.

Testing of Transformers

Steps

1. Select the lowest range of the resistance.
2. Measure the resistance of the Primary winding and the secondary winding; this will be very low resistance like inductors.
3. Connect one probe of multimeter lead to a primary wire connector and second to the secondary wire, the multimeter should show “open”, if the multimeter shows low or zero resistance the primary and the secondary coils are mutually shorted.
4. Connect one probe of multimeter to primary and the other to the core of transformer, the multimeter should show open or infinite resistance. Repeat this step for secondary winding the result should be the same.

Operation Title:- Diode testing

Steps:

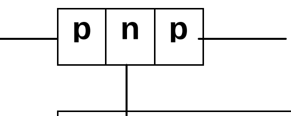
1. Set the multi-tester in resistance (ohms) mode with lowest rating mode.

2. Connect the positive probe of the multi-meter to the anode and the negative probe to the cathode. A good indication will show the meter deflected very little or shows a low resistance, this can be from tens of ohms to few hundreds of ohms depending on the voltage in the leads.

3. Then connect the positive probe to the cathode and the negative probe to the anode of the diode. A good indication will show the meter does not deflected or there is no any reading.

A defective indication shows that the meter won't deflect at all even when the probes are reversed. Or the meter deflects at the same time or almost the same resistance reading for both steps. Some digital multimeter have diode checking facility in them, which is marked “→▶|–” on multimeter. If multimeter is switched to this position the multimeter should show 0.5 to 0.8V for silicon and 0.2 to 0.4 for Germanium in forward bias and open in reverse bias.

Operation Title:- Transistor testing



Steps:

1. Set the multi-tester in resistance (ohms) mode with higher rating mode.
2. Place the black probe of the multi-meter in the center terminal of the transistor for a PNP type transistor.
3. Place the red probe of the multi-meter in the other terminal of the transistor.
4. Observe the needle point of the multi-meter. If the needle deflects from zero to infinite then the two terminals of the transistor is good.
5. Now remove the red probe of the multi-meter and then put it in the other/remaining terminal of the transistor.
6. Observe the needle point of the multi-meter. If the needle deflects from zero to infinite then the two terminals of the transistor is good.
7. Place the red probe of the multi-meter in the center terminal of the transistor for a NPN type transistor.
8. Measure the resistance between base and emitter by connecting the black probe to the emitter, the junction will be forward biased, the multi-meter shows low resistance. If the terminal is exchange the junction will be reverse bias, the multi-meter shows open or infinite resistance.
9. Measure the resistance between base and collector by connecting the black probe to the collector, the junction will be forward biased, the multimeter shows low resistance. If the terminal is exchange the junction will be reverse bias, the multimeter shows open or infinite resistance.
10. Measure resistance between collector and emitter terminals, in both direction the multi-meter shows open.

Some defective indications of transistors:

- Resistance between any pair of the terminals is less than 10 ohms means that the transistor is shorted.
- Resistance between base and emitter or base collector for both the forward and reverse application of ohmmeter probes is infinity (meter needle don't deflect) means that the transistor is open.

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

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

Task 1- Test the following passive components for open, short its normal operation.

A. Fixed resistor :carbon resistors, wire wound resistors
B. Variable resistor: rheostat, potentiometer
C. Inductor, transformer
D. Capacitor: polarized, non polarized

Task 2 test the following active components for open, short and its normal operation

A. Diode : rectifier, Zener , and LED
B. Transistor: BJT

Instruction Sheet	LG38:-: Test the construction of electrical/ electronic circuits

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics

- Conducting testing of the completed construction of electrical/electronic circuits
- Checking the accurate operation of the constructed circuit
- Responding unplanned events or conditions

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to:-**

- Conduct testing of the completed construction of electrical/electronic circuits ifor compliance with specifications and regulations using appropriate procedures and equipment
- Check the accurate operation of the constructed circuit

- respond unplanned events or conditions to in accordance with established procedures

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1, Sheet 2, Sheet 3 and Sheet 4,sheet 5" **in page 3, 11, 16, 19 and 25** respectively.
4. Accomplish the "Self-check 1, Self-check 2, Self-check 3 and Self-check 4" "**in page 10, 15, 18,24 and 28** respectively
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3 "**in page --.**
6. Do the "LAP test" **in page – ---**

Information Sheet-1	**Test The Construction of Electrical/ Electronic Circuits**

1.1 Introduction to Test the Construction of Electrical/ Electronic Circuits

Testing an electrical device or electrical circuit is the process of checking the actual operational condition of it. It is the process of comparing the actual reading (value against the standard (true) value. In order to know the actual value the device under question should be measured. The convenient electrical parameter to be measured in a circuit with the presence of power is voltage.

- **How to test voltage and current?**

In most electronic troubleshooting and repair, you will rarely take current measurements. Most general purpose digital millimeters' allow you to measure AC current (ACA or Iac) and DC current (DCAorIdc) in a circuit, although there are often few ranges to choose from. Normally analogue meter do not have the AC current range. As with voltage measurements, current is measured in a working circuit with power applied, but current must be measured in series with the circuit or component under test. You can take many voltage-measurements in a circuit. You can measure "across" a component, or between any point in a circuit and either the positive rail or earth rail (0v rail).

- ✓ **Testing voltage**

(Adjusting voltmeter range)

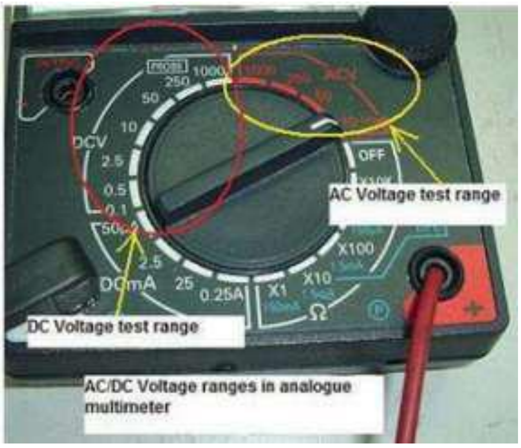
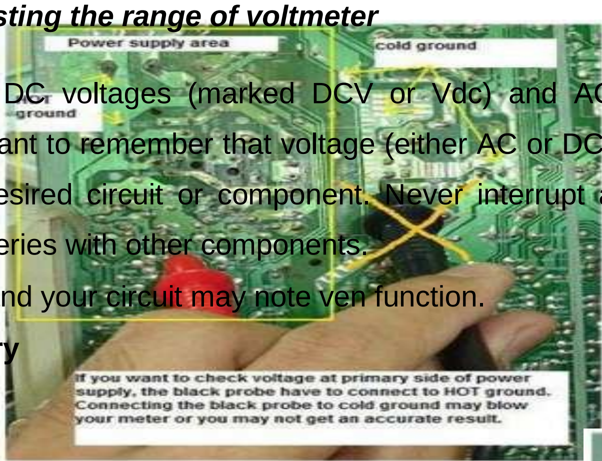


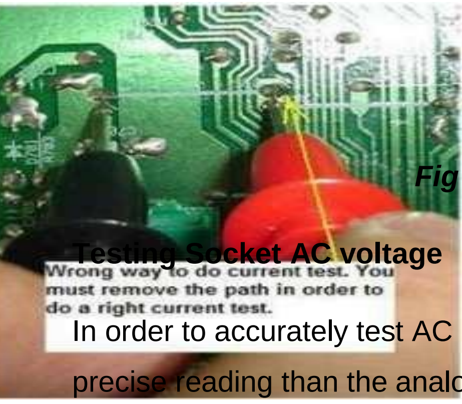
Fig 1.1 adjusting the range of voltmeter



Analogue multimeter can measure both DC voltages (marked DCV or Vdc) and AC voltages (marked ACV or Vac). It is important to remember that voltage (either AC or DC) must be measured in parallel with the desired circuit or component. Never interrupt a circuit and attempt to measure voltage in series with other components.

Any such reading would be meaningless, and your circuit may note ven function.

Measuring (testing) DC voltage of Battery



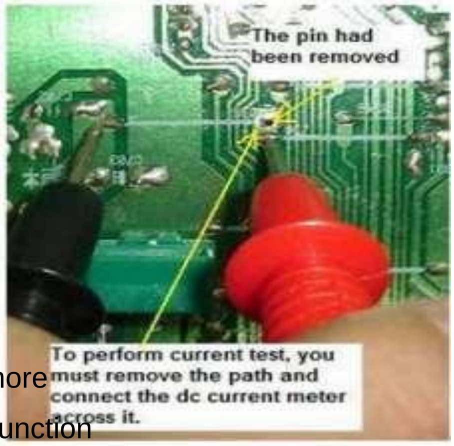


Fig 1.2 steps to measure supply of the battery

Testing Socket AC voltage

In order to accurately test AC and DC voltage, use the digitalmeter as it shows more precise reading than the analogue meter. Set your multimeter to its appropriate function (DCV or ACV), then select the proper range. Note, an auto ranging digital meter will select its own range. Place your test leads across (in parallel with) the part under test as shown in all the photos below and read voltage directly from the pane meter.

How to take voltage measurement in electronic equipment (circuit)?

If you want to test voltage in electronic equipment, your meter black probe must connect to the chassis as shown in the photo below. The red probe then can be use to touch on the DC voltage points. Note: you must have a good understanding about electronic circuit and safety before you do any voltage testing.

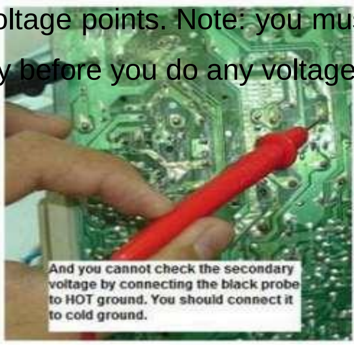


Fig 1.3 taking measurement of voltage in electronic circuit

Warning: A switch mode power supply has primary and secondary section. In order tochecksecondaryvoltagethemeter'sblackprobehavetoconnecttocoldground (chassis ground) and if you want to test on the primary voltage, the black probe have to connect to primary ground! If you are not familiar of what I am saying, please ignore this test or get a repair friend to assist you.

- **Perform current Test**

Ammeter range adjustment

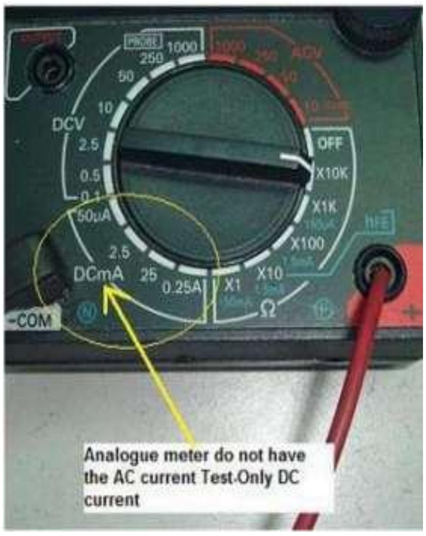


Fig1.4 an ammeter range adjustment

Inserting ammeter in series, however, is not always an easy task. In many cases you must physically interrupt a circuit at the point you wish to measure, and then connect test lea across the break. Although it may be easy to interrupt a circuit , keep in mind that you must also put the circuit back together.

Set your multimeter to the desired function (DCA or ACA) and select the appropriate range .If you are unsure, set the meter to its largest range. Make sure that the meter can handle the amount of current you are expecting.

Turn off all power to a circuit before inserting a current meter as shown in Fig below. Insert the meter and reapply power. Read Current directly from the panel meter.

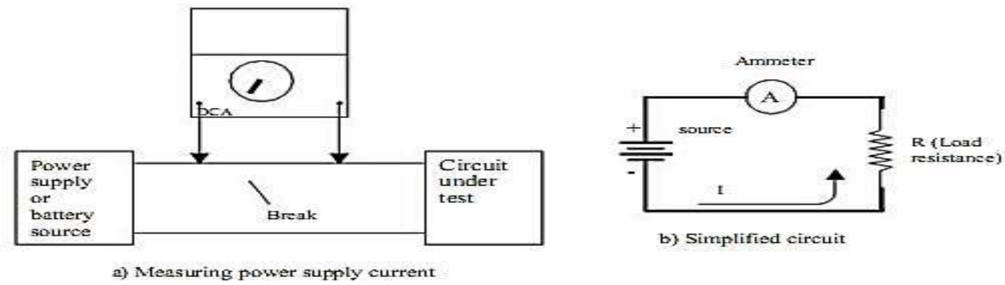


Fig 1.6 measuring current in a circuit

Caution!

Never try to read current in parallel. Placing a current meter in parallel can cause a short circuit across a component that can damage the part, the circuit under test, or your multimeter.

Continuity or short circuit test

Continuity checks ensure are liable, low resistance connection between two points.

For example, check the continuity of a cable between two connectors to ensure that both ends are connected properly. Set your analogue multimeter to a low resistance scale(X1Ohms),short(touch)theredandtheblackprobestogether,thepointerwill go to zero ohm. If it is not zero, adjust the zero adjuster for bringing the pointer to exact zero Ohms.

Fig 1.7 short circuit and open circuit test

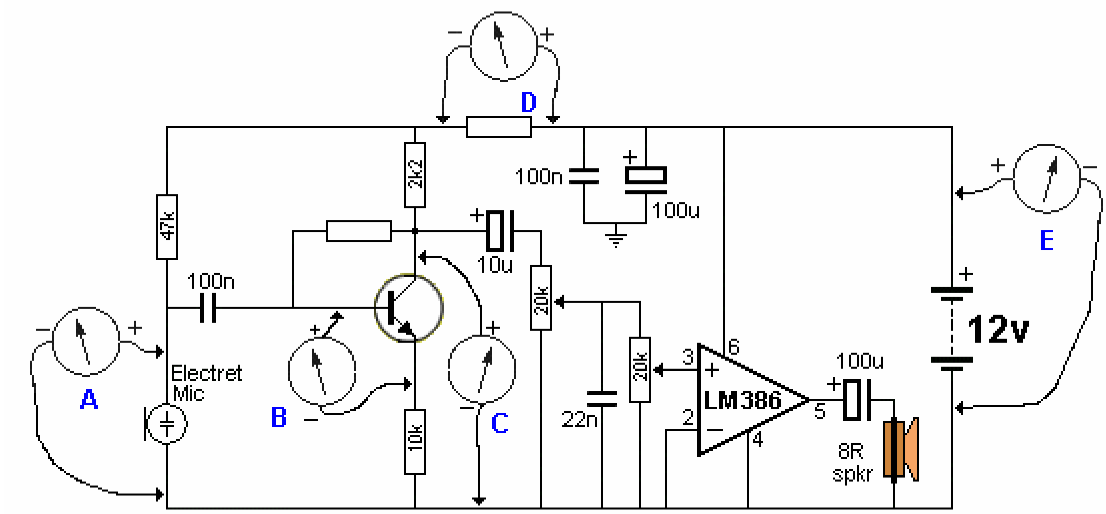
Now, connect the two probes to the points where the short or continuity is to be checked as shown in the photo in previous page. If the meter shows zero Ohm, it means the continuity is present or the connection internally not broken.Ideally,a good continuity should be about 0 Ohm.

You can also use a digital meter (as shown below) that has the buzzer sound to test the connection. If you heard the buzzer sound while measuring the wire or connection, this means that the connection or internal wire is good.

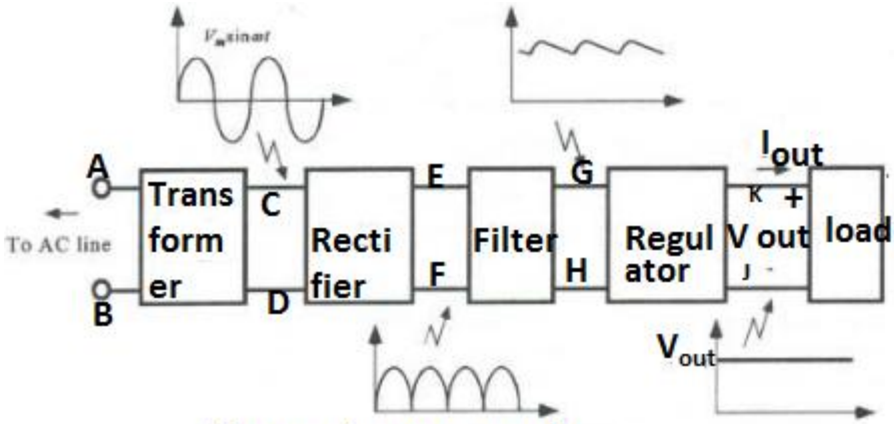
Fig 1.8 continuity test

In the following amplifier circuit, the 5 most important voltage-measurements are shown. Voltage "A" is across the electrets microphone. It should be between 20mV and

500mV. Voltage "B" should be about 0.6v. Voltage "C" should be about half-rail voltage. This allows the transistor to amplify both the positive and negative parts of the waveform. Voltage "D" should be about 1-3v. Voltage "E" should be the battery voltage of 12v.



Testing Power supply unit: stage by stage test

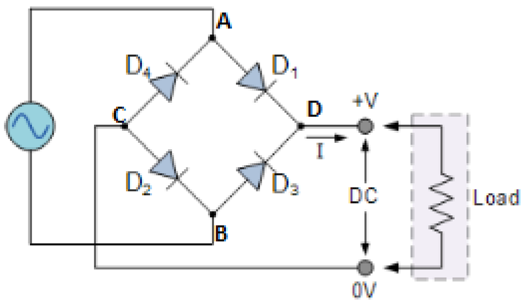


Stages of power supply

Let assume the above power supply does not have voltage output at the load side, check(test) stage by stage as follows using multimeter and compare the meter reading with their corresponding true values until you get where the fault is.

1. Adjust your multimeter at AC range and >220v
2. Measure AC power at the socket or between point A and B (V_{AB})
3. Check fuse. Perform continuity test
4. Measure transformer output (reduced AC voltage)between point C and D (V_{CD})
5. Adjust your meter at voltage greater than the expected rectifier output in DC voltage range.
6. Measure DC voltage between point E and F,G and H, K and J to know the actual rectifier output, regulator output, filter output respectively.

- **Testing Rectifier Circuit:**



Applying the same technique which you use in power supply measuring section to investigate

the normal condition of AC and DC voltage at their corresponding points and to diagnosis open circuit fault.

Measure AC voltage across point A and B, and DC rectifier output voltage between Points C and D. compare each actual (measured) values with their corresponding expected true values. If the rectifier circuit is expected to have faulty component(s), disconnect the power supply and de-solder the expected faulty diode to test it by applying diode testing technique(as discussed before).

If the fault is expected in any other part of the circuit, perform continuity test starting from the source side to the load side on each paths (positive and negative(0) lines) separately until you get where the open circuit is.

Self-Check -1	Written Test

Directions: Answer all the questions listed below.

1. Never try to read current in parallel (2 point)

A. True ***B.False***

2. If you want to test voltage in electronic equipment, your meter black probe must connect to the chassis. (2 pt)

A False B. True

3. write the steps of Continituity test step (2 point)

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ___________

Rating: ____________

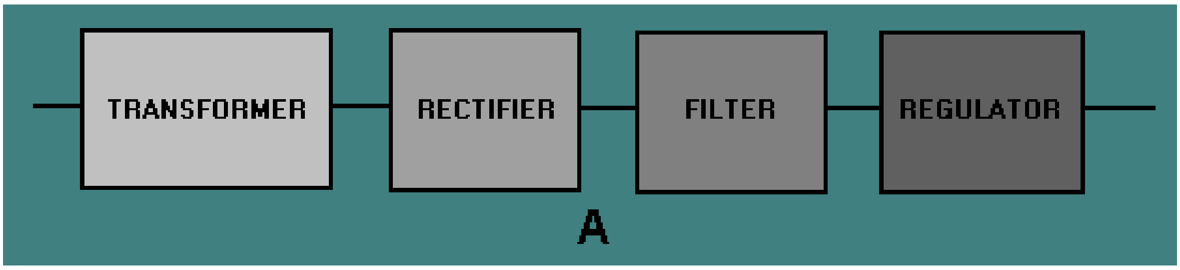
1.

Information Sheet-2	Checking the accurate operation of the constructed circuit

Electrical/electronic circuit

- **Power supply**

Power supplies are electronic circuits designed to convert ac to dc at any desired level. Almost all power supplies are composed of four sections: transformer, rectifier, filter, and regulator Figure A. - Block diagram of a basic power supply.



The first section is the TRANSFORMER. The transformer steps up or steps down the input line voltage and isolates the power supply from the power line. The RECTIFIER section converts the alternating current input signal to a pulsating direct current. However pulsating dc is not desirable. For this reason a FILTER section is used to convert pulsating dc to a purer, more desirable form of dc voltage. The final section, the REGULATOR maintains the output of the power supply at a constant level in spite of large changes in load current or input line voltages.

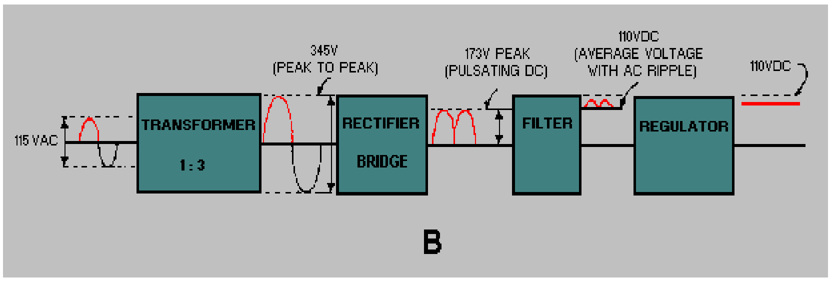
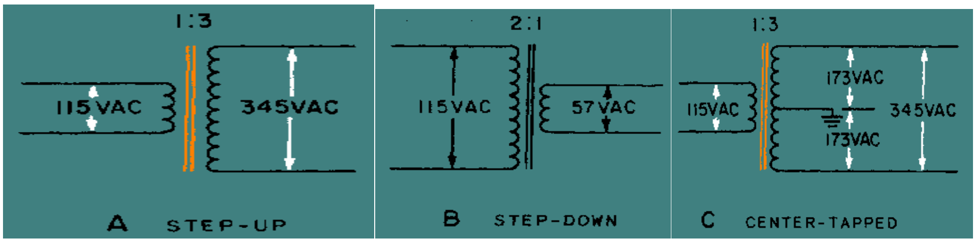


Figure B. - Block diagram of a basic power supply.

On figure B an input signal of 115 volts ac is applied to the primary of the transformer. The transformer is a step-up transformer with a turn's ratio of 1:3. The output for this transformer will be 115 volts ac X 3 = 345 volts ac (peak-to-peak) at the output. Because each diode in the rectifier section conducts for 180 degrees of the 360-degree input, the output of the rectifier will be one-half, or approximately 173 volts of pulsating dc. The filter section, a network of resistors, capacitors, or inductors, controls the rise and fall time of the varying signal; consequently, the signal remains at a more constant dc level. The output of the filter is a signal of 110 volts dc. The regulator maintains its output at a constant 110-volt dc level, which is used by the electronic equipment (more commonly called the load).

Common types of transformers



Step-up step-down center-tapped

Figure - Common types of transformers.

- ## Rectifier

Rectification is the conversion of an alternating current to a pulsating direct current. Rectification occurs in both a half-wave and a full-wave rectifier.

✓ **The Half-Wave Rectifier**

The half-wave rectifier uses only one diode. During the positive alternation of input voltage, the sine wave applied to the diode makes the anode positive with respect to the cathode. The diode then conducts, and current (I) flows from the negative supply lead (the secondary of the transformer), through the ammeter, through the diode, and to the positive supply lead.

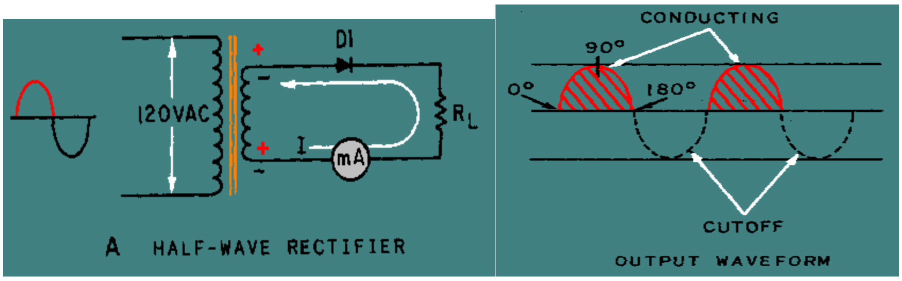


Figure - Simple half-wave rectifier and its output waveform.

During the negative alternation of input voltage (dotted polarity signs), the anode is driven negative and the diode cannot conduct. During which time no current flows in the circuit. Current that flows in pulses in the same direction is called PULSATING DC.

Rms, Peak, and Average Values

A comparison of the rms, peak, and average values of the types of waveforms associated with the half-wave rectifier. Ac voltages are normally specified in terms of their rms values. Thus 115-volt ac power source is mentioned is specifying the rms value of 115 volts ac.

The peak value is always higher than the rms value. In fact,

$E_{peak} = E_{rms}$ X 1.414 therefore,

E_{peak} = 115 volts ac X 1.414

E_{peak} = 162.6 volts

$E_{rms} = E_{peak}$ X .707

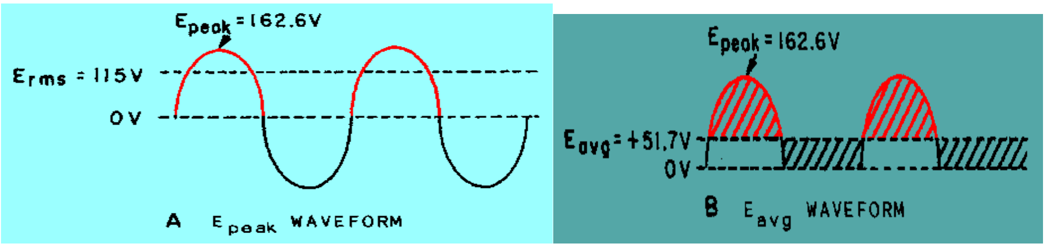


Figure - Comparison of E_{peak} to E_{avg}in a half-wave rectifier.

The average voltage (E_{avg}) is determined by the equation:

Where:$E_{avg}= E_{peak}$ X .318
Thus:E_{avg} = 162.6 X .318
E_{avg} = 51.7 volts

✓ Full-Wave Rectifier

A full-wave rectifier is a device that has two or more diodes arranged so that load current flows in the same direction during each half cycle of the ac supply.

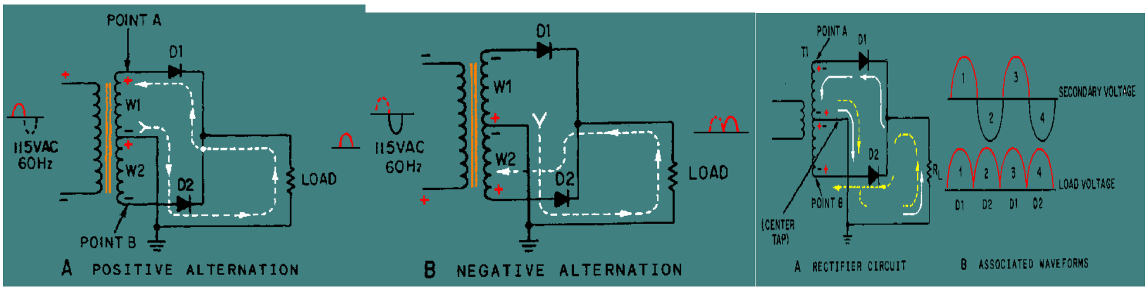
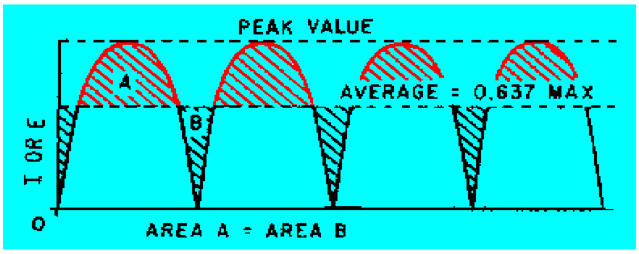


Figure simple full-wave rectifier

The transformer supplies the source voltage for two diode rectifiers, D1 and D2. This power transformer has a center-tapped, high-voltage secondary winding that is divided into two equal parts (W1 and W2). W1 provides the source voltage for D1, and W2 provides the source voltage for D2. At the specific instant of time shown in the figure, the anode voltage on D2 is negative, and D2 cannot conduct. Since the anode of D1 is positive, D1 conducts, it acts like a closed switch causing current to flow through the load resistor in the direction shown by the arrow. View B shows the next half cycle of secondary voltage. Now the polarities across W1 and W2 are reversed. During this alternation, the anode of D1 is driven negative and D1 cannot conduct. The anode of D2 is positive, permitting D2 to conduct. Notice that the anode current of D2 passes through the load resistor in the same direction as the current of D1 did. Since both alternations of the input voltage cycle are used, the circuit is called a FULL-WAVE RECTIFIER. In terms of peak value, the average value of current and voltage at the output of the full-wave rectifier is twice as great as that at the output of the half-wave rectifier. The average current or voltage is 63.7 percent (or 0.637) of the peak current or voltage.

Figure 4-7. - Peak and average values for a full-wave rectifier.



As an equation: Where:

E_{max} = the peak value of the load voltage pulse

E_{avg} = 0.637 X E_{max} (the average load voltage)

I_{max} = The peak value of the load current pulse

I_{avg} = 0.637 X I_{max} (the average load current)

Example: The total voltage across the high-voltage secondary of a transformer used to supply a full-wave rectifier is 300 volts. Find the average load voltage.

Solution: Since the total secondary voltage (E_S) is 300 volts, each diode is supplied one half of this value, or 150 volts. Because the secondary voltage is an rms value, the peak load voltage is:

$E_{max} = 1.414 \text{ X } E_S$

$E_{max} = 1.414 \text{ X } 150$

$E_{max} = 212$ volts

The average load voltage is:

$E_{avg} = 0.637 \text{ X } E_{max}$

$E_{avg} = 0.637 \text{ X } 212$

$E_{avg} = 135$ volts

- ✓ **The Bridge Rectifier**

When four diodes are connected as shown in figure below the circuit is called a BRIDGE RECTIFIER.

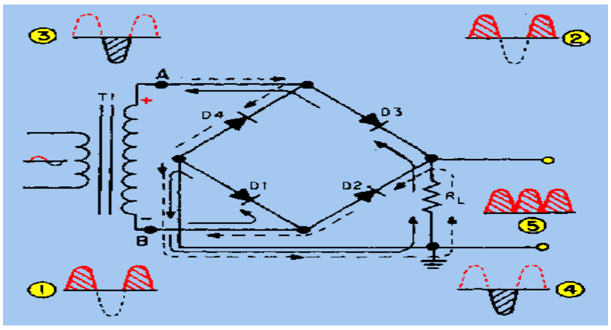


Figure - Bridge rectifier.

Let us assume the transformer is working properly and there is a positive potential at point A and a negative potential at point B. The positive potential at point A will forward bias D3 and reverse bias D4. The negative potential at point B will forward bias D1 and reverse bias D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow. The path for current flow is from point B through D1, up through R_L, through D3, through the secondary of the transformer back to point B. This path is indicated by the solid arrows. Waveforms (1) and (2) can be observed across D1 and D3. One-half cycle later the polarity across the secondary of the transformer reverses, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through R_L, through D2, through the secondary of T1, and back to point A. This path is indicated by the broken arrows. Waveforms (3) and (4) can be observed across D2 and D4. You should have noted that the current flow through R_L is always in the same direction. In flowing through R_L this current develops a voltage corresponding to that shown in waveform (5). One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional full-wave circuit.

- **FILTERS**

While the output of a rectifier is a pulsating dc, most electronic circuits require a substantially pure dc for proper operation. Filtering is accomplished by the use of capacitors, inductors, and/or resistors in various combinations. Inductors are used as series impedances to oppose the flow of alternating (pulsating dc) current. Capacitors are used as shunt elements to bypass the alternating components of the signal around the load (to ground). Resistors are used in place of inductors in low current applications.

- **REGULATORS**

The output of a power supply varies with changes in input voltage and circuit load current requirements. Circuits that maintain power supply voltages or current outputs within specified limits, or tolerances are called REGULATORS, because many electronic equipment require operating voltages and currents that must remain constant. Regulator circuits sense changes in output voltages and compensate for the changes.

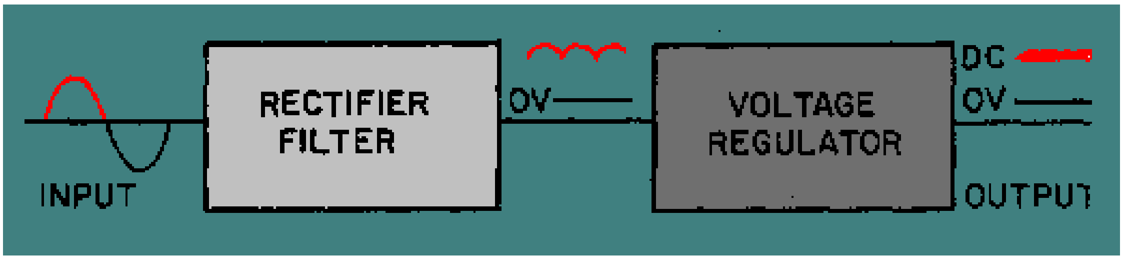


Figure - Block diagram of a power supply and regulator.

Series and Shunt Voltage Regulators

Basic voltage regulators are classified as either SERIES or SHUNT, depending on the location or position of the regulating element(s) in relation to the circuit load resistance.

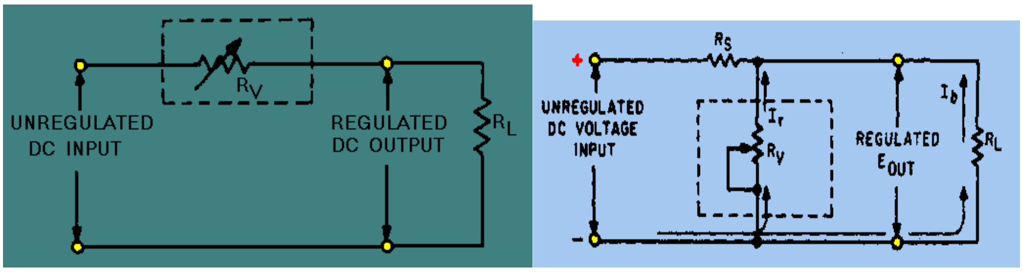
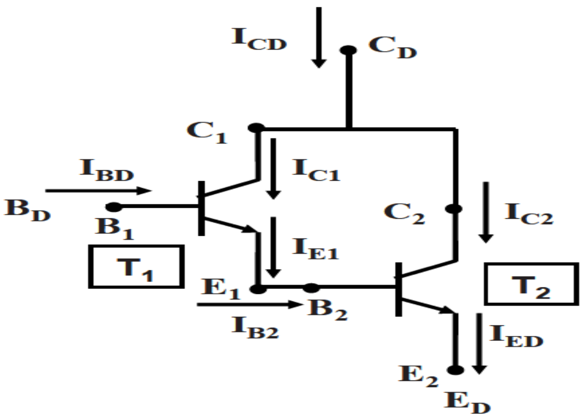


Figure - Series voltage regulator. Shunt voltage regulator

- ## Amplifier



These transistors are found in different types of applications such as power regulators, motor controllers, audio amplifiers, etc. Many opto-isolator circuits are made with Darlington transistors to have high current

Self-Check -2	Written Test

Directions: Answer all the questions listed below.

I. Say True or False

1. The transformer steps up or steps down the input line voltage and isolates the power supply from the power line.

2. The RECTIFIER section converts the alternating current input signal to a pulsating direct current.

3. FILTER section is used to convert pulsating dc to a purer, more desirable form of dc voltage.

4. REGULATOR maintains the output of the power supply at a constant level in spite of large changes in load current or input line voltages.

Note: **Satisfactory rating - 2 points** **Unsatisfactory - below 2 points**

Score = ____________
Rating: _____________

Information Sheet-3	Responding unplanned events or conditions

capacity at the output stage. Let us look in brief about this transistor with applications.

Unplanned Events

- **Introduction**

Unplanned events are episodes that are not expected to occur during the Project's normal Construction and Operational Phase activities, such as accidents. The Project follows safety and engineering design criteria that aim to avoid unplanned events that could lead to adverse environmental, socio-economic or health and safety impacts

Installing single Phase system, resulting in an Unplanned Event (Commissioning and Operational Phase)

- ✓ **Unplanned learning** occurs when an event occurs that causes a learning activity to be undertaken or carried out without any prior thought or planning (e.g. through reading a journal, undertaking an activity or task, or a discussion with a colleague owing to an interaction during your normal working day)

Table 1: Installing single Phase system, resulting in an Unplanned Event (Commissioning and Operational Phase)

Activity	Event	Receptors	
		Environmental	Socio Economic & Health
Installing single phase system	short circuit	X	X
	Fires and explosions	X	X
	Shock & injury		X
	Death		X

In order to prevent the potential adverse environmental effects of accidental erosion and sedimentation events, erosion and sediment control measures are a key management feature used during Construction and Operation. These measures will be in place to minimize the potential for erodible soils exposed during Construction and Operation activities from eroding and for silt-laden water to enter water courses or wetlands and affect water and wetland quality. Typical erosion and sediment control measures include but are not limited to the use of geotextile fabric, straw, hydro seeding, silt fences, straw bale barriers, diversion berms, and sediment traps.

Based on these considerations, the potential accidents, malfunctions and unplanned events that were considered by the Study Team for the Sisson Project are:

- ✓ Loss of Containment from Tailings Storage Facility (TSF)
- ✓ Erosion and Sediment Control Failure
- ✓ Pipeline Leak
- ✓ On-Site Hazardous Materials Spill
- ✓ Release of Off-Specification Effluent from the Water Treatment Plant
- ✓ Failure of a Water Management Pond
- ✓ Failure of a Water Management Pond Pump
- ✓ Off-Site Trucking Accident
- ✓ Vehicle Collision
- ✓ Uncontrolled Explosion
- ✓ Fire

- **Failure of a Water Management Pond**

  A failure of a water management pond is defined as a significant failure of one of the embankments of these ponds, or of the liner placed at the bottom of it, that leads to the release of large quantities of mine contact water and/or seepage into the receiving environment.

- **Uncontrolled Explosion**

An uncontrolled explosion is defined as an unmanaged or uncontrolled detonation of explosives, or inadvertently combined emulsion constituents, or detonators associated with blasting of the open pit or quarry, or the detonation of explosives resulting in property damage from fly rock or higher-than-Standard-practice vibration levels. As considered by

Moose Mountain Technical Services as experts in open pit design and pit optimization, this scenario was not considered to be credible in consideration of normal industry practice and the design basis for the Project. Their analysis follows.

- **Erosion and Sediment Control Failure**

- **On-Site Hazardous Material Spill**

  An On-Site Hazardous Material Spill is a spill of materials associated with the Project that is considered to be hazardous due to its inherent physical or chemical properties, or because of its toxicity, flammability, corrosiveness, or explosiveness.

  The following measures will be in place to reduce or eliminate the potential for a major release arising from an on-site hazardous material spill:

  ✓ the storage of liquid hazardous materials within buildings, in secure and Contained areas;
  ✓ the provision of impermeable containment berms (or other forms of secondary containment);
  ✓ placement of protective barriers as appropriate;
  ✓ siting of such facilities in locations that represent a relatively low risk and afford an opportunity
  ✓ for containment during emergency response;
  ✓ provision of alarms on secondary containment measures;
  ✓ careful implementation of fuel transfer operations; and
  ✓ Provision of an emergency response plan for the immediate isolation and clean-up of a release.

- **Aquatic Environment**

  Any accidental releases of off-specification effluent will be short-term (i.e.,12 hours maximum) and while there may be some uptake from various aquatic species, this short-term exposure is not anticipated to exceed the significance criteria for the Aquatic Environment.

- **Off-Site Trucking Accident**

  An Off-Site Trucking Accident is defined as a vehicle accident resulting in the spill of materials associated with the Project during the Construction or Operation phase that occurs on roads beyond the PDA, including provincial highways and existing forest resource roads that will be used to access the Project site It includes a spill of petroleum products (e.g., gasoline or diesel), chemicals (e.g., reagents), and/or concentrate or APT outside of the Project site. An Off-Site Trucking Accident resulting in a spill of these materials has the potential to affect both land and water.

- **Vehicle Collision**

  A Vehicle Collision is defined as a Project-related vehicle accident occurring on the road transportation network leading to or from the Project site. A vehicle collision would pose a danger to the public, workers traveling to and from the Project site, and wildlife crossing or otherwise using access roads. a vehicle collision, defined herein as a collision between two vehicles or pedestrian strike, can result in property damage, injury to people involved, and in extreme cases, mortality.

Self-Check -3	Written Test

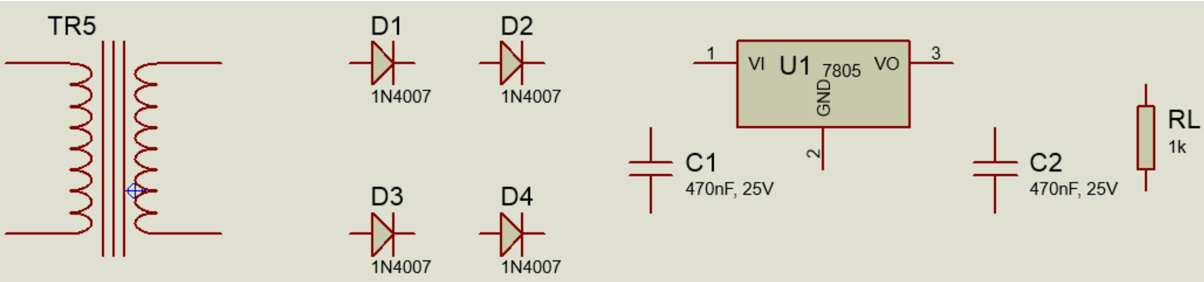
Directions: Answer all the questions listed below.

I. Say true or false for the following questions

1. Unplanned events are episodes that are not expected to occur during the Project's normal Construction and Operational Phase activities
2. One of an example of unplanned event is accident.
3. The Project follows safety and engineering design criteria that aim to avoid unplanned events.
4. It is impossible to respond to unplanned events or conditions
5. Electricalfires and explosions could lead to adverse environmental, socio-economic or health and safety impacts

Operation Sheet 1	Test The Construction of Electrical/ Electronic Circuits

Operation title: techniques of testing complete construction of electrical/electronc circuit



Step1: connect the four diodes as bridge rectifier.

Step2: connect one terminal of the transformer between D1 and D2.

Step3: connect another terminal of the transformer between D3 and D4.

Step4: connect (-) terminal of the capacitor c1 between D1 and D3, GND of the regulator IC, (-) terminal of c2, and one terminal of the resistor.

Step5: connect (+) terminal of c1 between D1 and D4,vi of the regulator IC

Step6: connect vo of the regulator IC with (+)terminal of c2 and one terminal of the resistor.

Step7: connect the primary of the transformer with Ac 220v supply.

Step 8: test the circuit by measuring the output voltage across RL and across other points.

Step9: measure the Dc current that flows in the RL.

LAP TEST

NAME__________________ **DATE_____________**

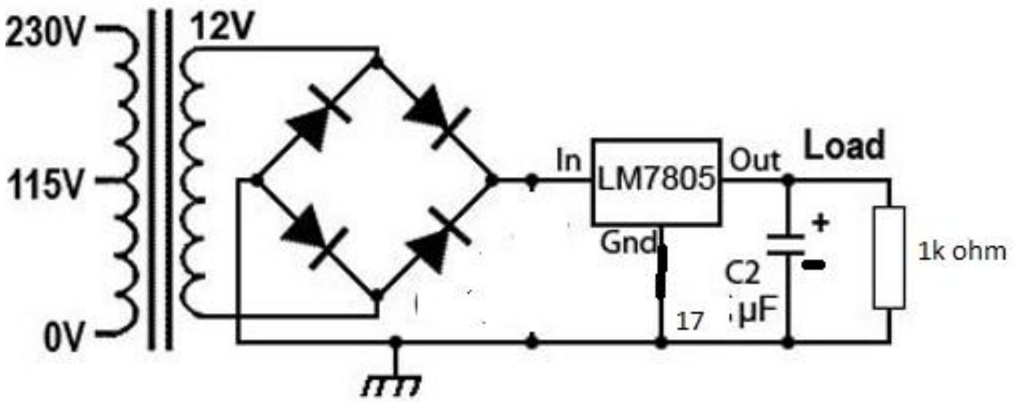
TIME STARTED_________ **TIME FINISHING________**

INSTRUCTION:-select appropriate tools and materials

- Construct the circuit as shown in the fig.
- Test bridge rectifier
- Check the out puts at different points

The trainer will be evaluating at the finishing of the work.

Complete power supply (without regulator).



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5	Mokennen G/Hawariat	Oromia / Adama polytechnic College	Msc in control technology	27 years	Leulmoke45@gmail.com 0911027886
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