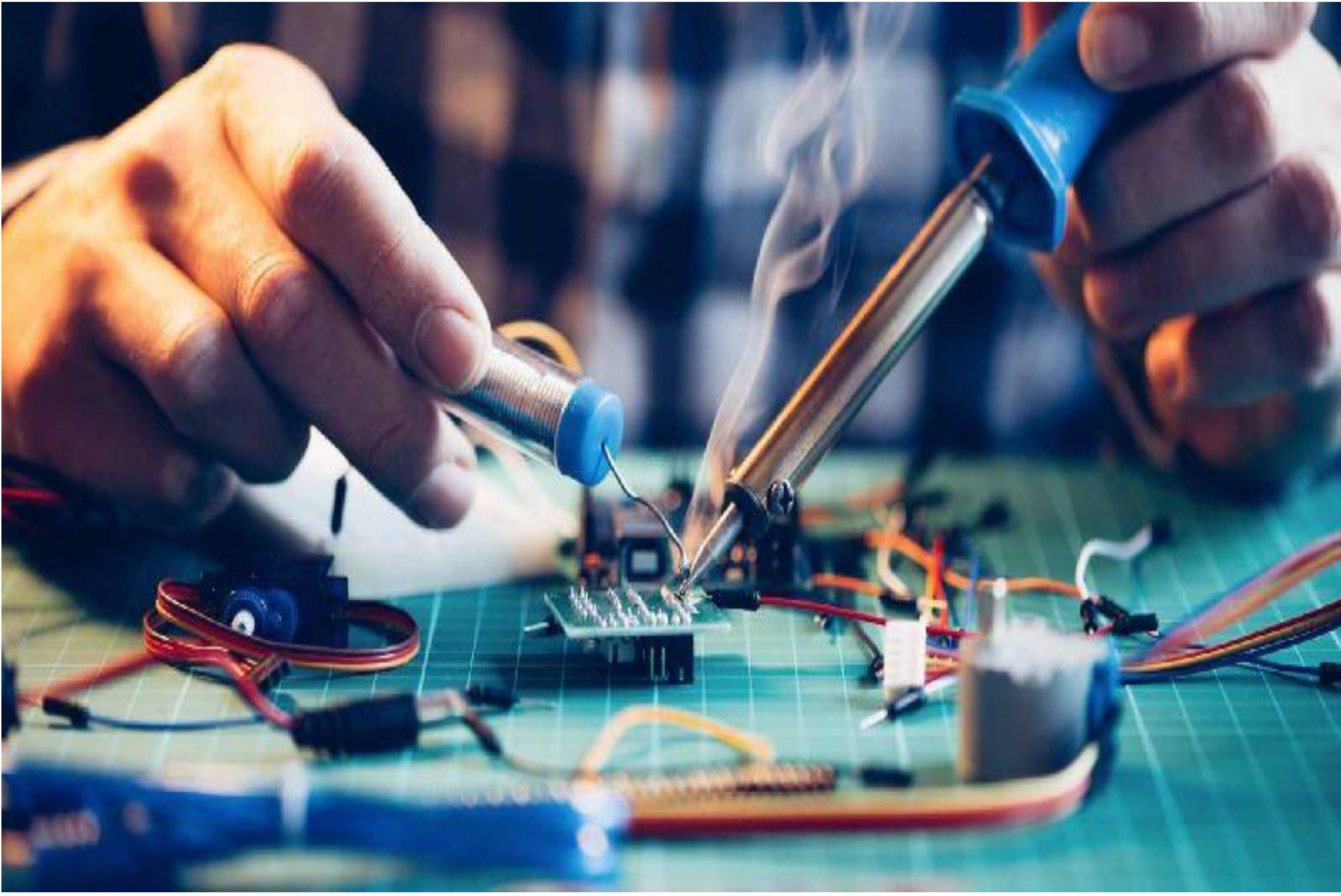

ELECTRONIC EQUIPMENT REPAIR

VOL. 1

By

Mohamed Isa Osman

Azyan Md Zahri

Rodziah Ismail

Malaysian Polytechnics Version

Editor in Chief
Mohamed Isa Bin Osman

Editor
Azyan Binti Md Zahri
Rodziah Binti Ismail

Designer
Azyan Binti Md Zahri

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We would like to acknowledge our colleagues and students for encouraging us to keep writing and for supporting us in transforming our teaching experiences in this field into an e-book for further reference.

Thank you very much.

PREFACE

This e-book is based on the polytechnic syllabus for Electrical and Electronic Engineering students' Electronic Equipment Repair course. This e-book intends to provide students with information and abilities in troubleshooting and repairing electronics equipment using proper diagnosis techniques and tools.

The first chapter covers hand tools, soldering techniques, and soldering tools, while the second chapter covers the operation of electronic test equipment. The third chapter explains the fundamentals of electronic component testing and how to test and identify defects in an electronic component using test equipment such as a multimeter.

All chapters include review questions to help students understand the topics covered in each topic.

CONTENTS

CHAPTER 1

HAND TOOLS AND SOLDERING TECHNIQUE

1.1 Introduction

Troubleshooting is the process of isolating and fixing a problem in malfunctioning equipment so that it returns to its expected performance level. Troubleshooting involves a systematic fault-finding technique.

The symptoms of a malfunction are originally docum ented, and troubleshooting is the act of finding and correcting the sources of these symptoms.

1.2 Safety and Laboratory Procedure

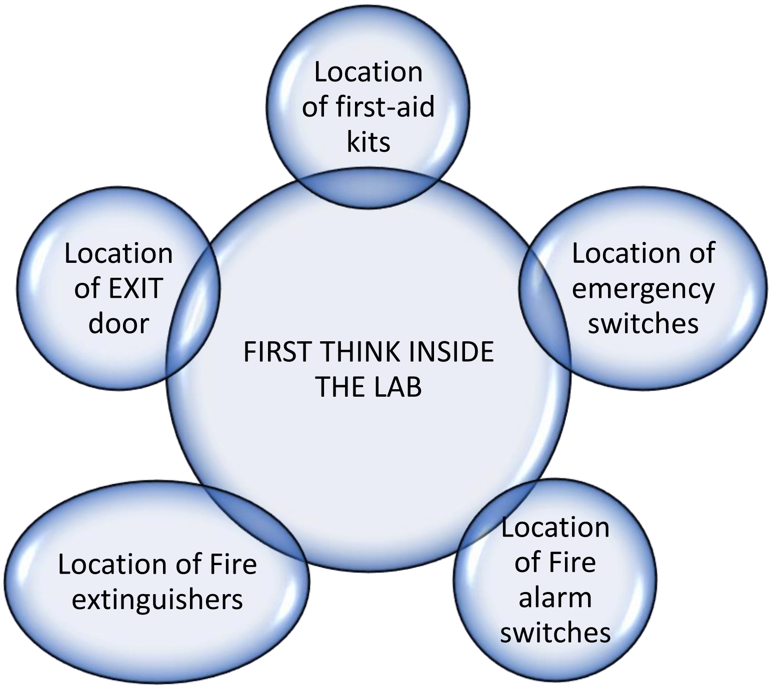


Figure 1.1: Safety and Laboratory Procedure

1.3 General Safety and laboratory procedure

1. Do not work when you are tired or taking medicine that makes you drowsy.
2. Do not work in poor light.
3. Do not work in damp areas or with wet or damp clothing and shoes.
4. Use approved tools, equipment, & protective devices.
5. Remove all metal items when working around exposed circuits.

1.3 General Safety and laboratory procedure

6. Never assume that a circuit is off. Double-check it with an instrument that you are sure is operational.
7. Buddy system is used at circuit breaker supplying power if working on circuit.
8. Never override safety interlocks.
9. Keep all tools and test equipment in good working condition.
10. Discharge capacitors
11. Do not remove grounds and do not use adapters that defeat the equipment ground.
12. Use CO_2 or halogenated-type fire extinguisher to put out electrical fires. Water conducts electricity! (i.e. galley fire in oven).
13. Store solvents and other chemicals in appropriate areas. (i.e. fire personnel incident).
14. Do not work on unfamiliar circuits.
15. Do not cut corners or rush. No horseplay or practical jokes in the labs (i.e. throwing caps, meggering).

1.3 Safety And Laboratory Procedure

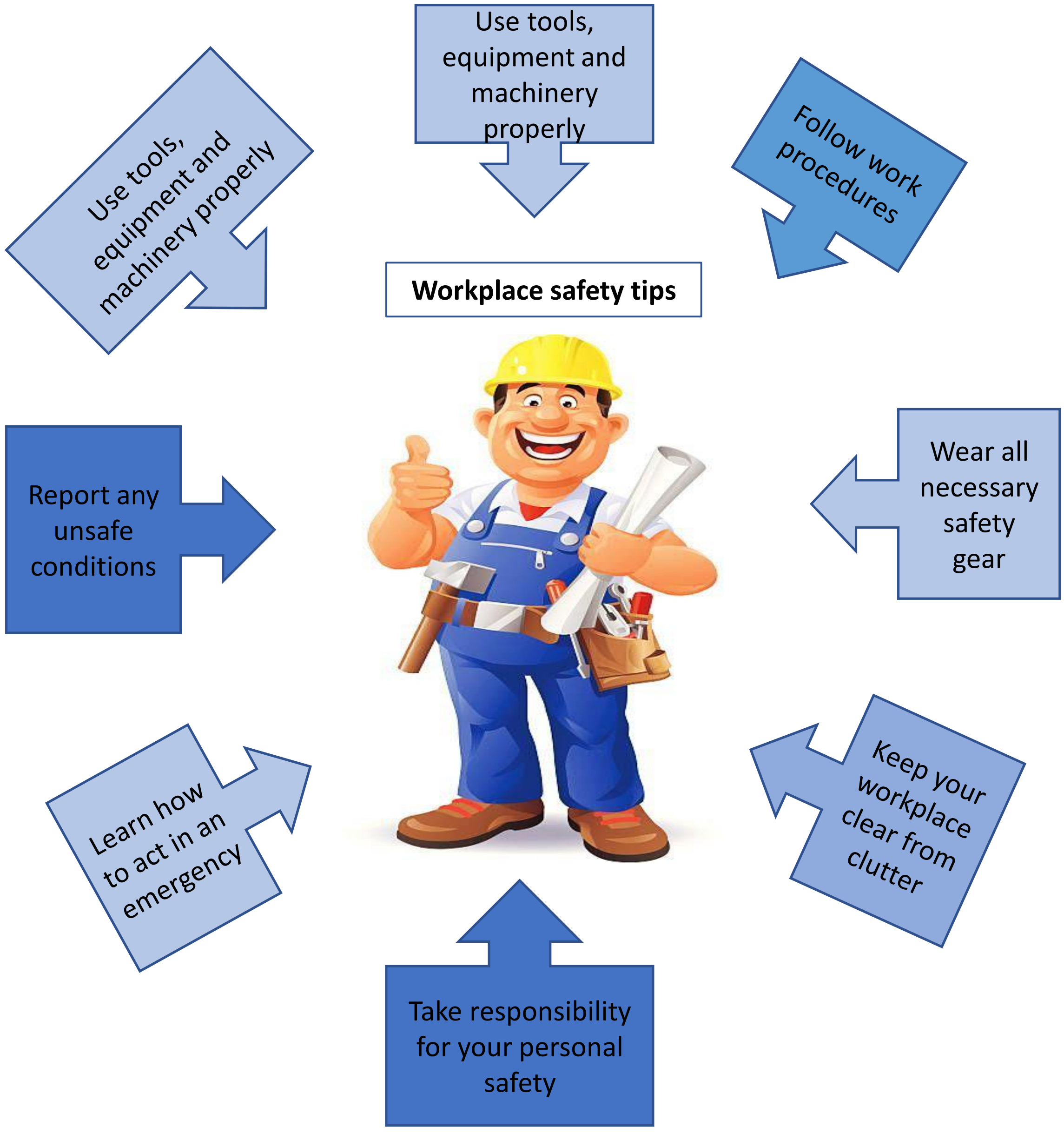


Figure 1.2: Workplace safety tips

1.4 Hand Tools

Using the correct tool for the job ensures that the work is completed more quickly and easily. The correct tool selection usually improves the end product's quality.

Hand tools are faster than machines and less expensive than power tools. Hand tools are considerably more secure than power tools, which is significant for both beginners and amateurs who depend on hand tools for fast repairs.

If properly cared for, high-quality tools can last a lifetime. Ensure that the tools are only used for their intended purpose and that they are lubricated with a light film of oil to avoid corrosion.

Keep the tools clean and sharp, the soldering tips clean and well tinned, and always use the tools correctly by following the directions in the manual.

1.5 Hand Tools Group

1.6 Electronic Specific Hand Cutting Tools

NEEDLE-NOSE PLIERS

- Forming loops on small conductors
- Cutting and stripping small conductors

LINEMAN'S PLIERS (SIDE CUTTERS)

- Cutting large conductors
- Forming loops on large conductors
- Pulling and holding large conductors

DIAGONAL PLIERS (DYKES)

- Cutting small conductors
- Cutting conductors in limited spaces

WIRE STRIPPERS

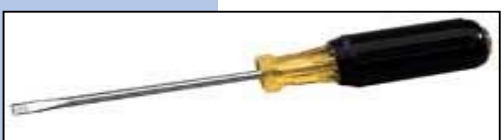
- Stripping insulation from conductors
- Cutting small conductors
- Crimping wire lugs

Figure 1.3: Electronic Hand Cutting Tools

1.7 Electronic Specific Hand Tools

TAP TOOL

- Equipping drill holes with bolt threads
- Re-tapping damaged threads
- Determining bolt size



FLAT-BLADE SCREWDRIVER

- Installing and removing slot-head screws

CENTER PUNCH

- Making center tap in wood or metal for drilling

PHILLIPS SCREWDRIVER

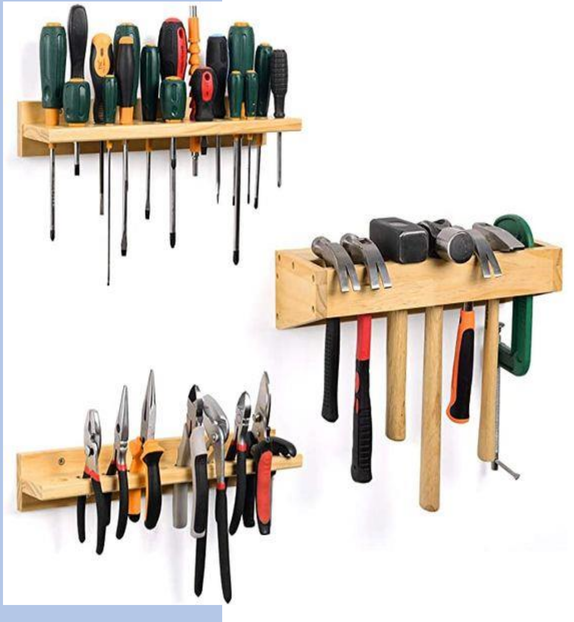
- Installing and removing Phillips-head screws

TWEEZER

- Use to manipulate small parts

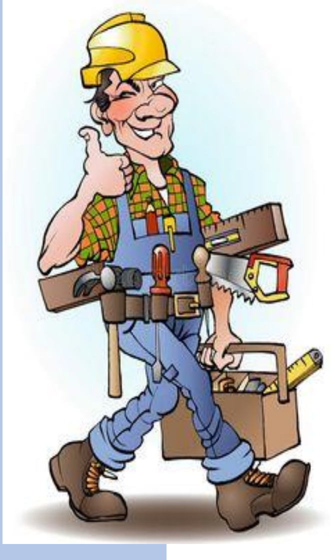
Figure 1.4: Electronic Hand Tools

1.8 Rules for care of hand tools



- There are many more hand and power tools that electricians will use in residential and commercial wiring.
- All tools should be used only for the purpose intended.
- It is the electrician’s responsibility to keep his or her tools sharp, clean, and lubricated.
- A well maintained tool has a longer life and is safer than an improperly maintained tool.
- Repair tools when possible, but discard worn or damaged tools.

1.9 Tool Maintenance Procedures



A. **Screwdrivers**
   1. Regrind worn or damaged flat head screwdriver
   2. Discard damaged Phillips screwdrivers

B. **Pliers**
   1. Keep pliers clean and rust free
   2. Keep cutting edges sharp and smooth
   3. Keep pliers working freely
   4. Repair or replace damaged handle insulation

C. Adjustable wrenches- Keep worm gears clean and lubricated

D. All tools- identify tools by labeling with an electric vibrator pen or scratch all

1.10 Hand Tools And Soldering Technique

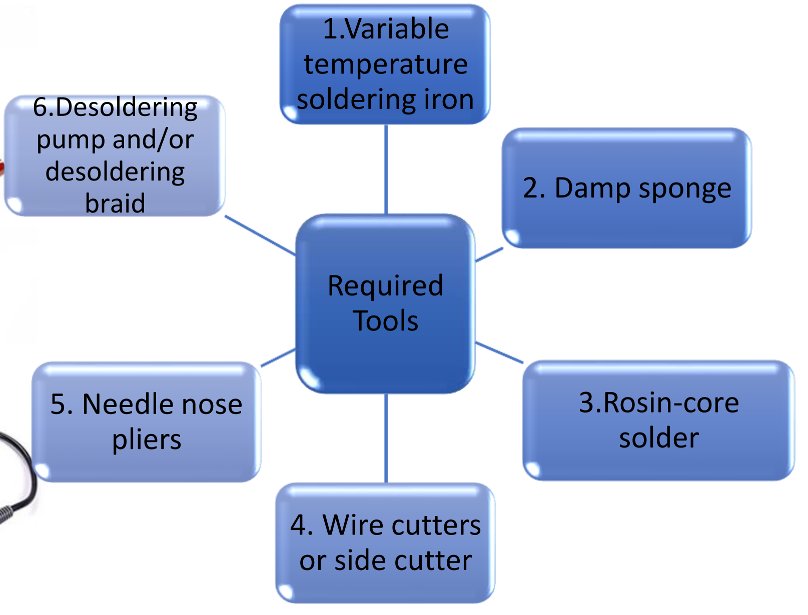
What is soldering?

- Soldering is a method of applying an alloy, of lower melting point, to join metal parts together.
- Soldering can be performed in a number of ways, using electric soldering iron or brazing torch.
- Soldering wire is an alloy of Tin and Lead (60% 40%).
- A Flux is usually used to assist in the joining process.
- The purpose of the flux is to clean the surface

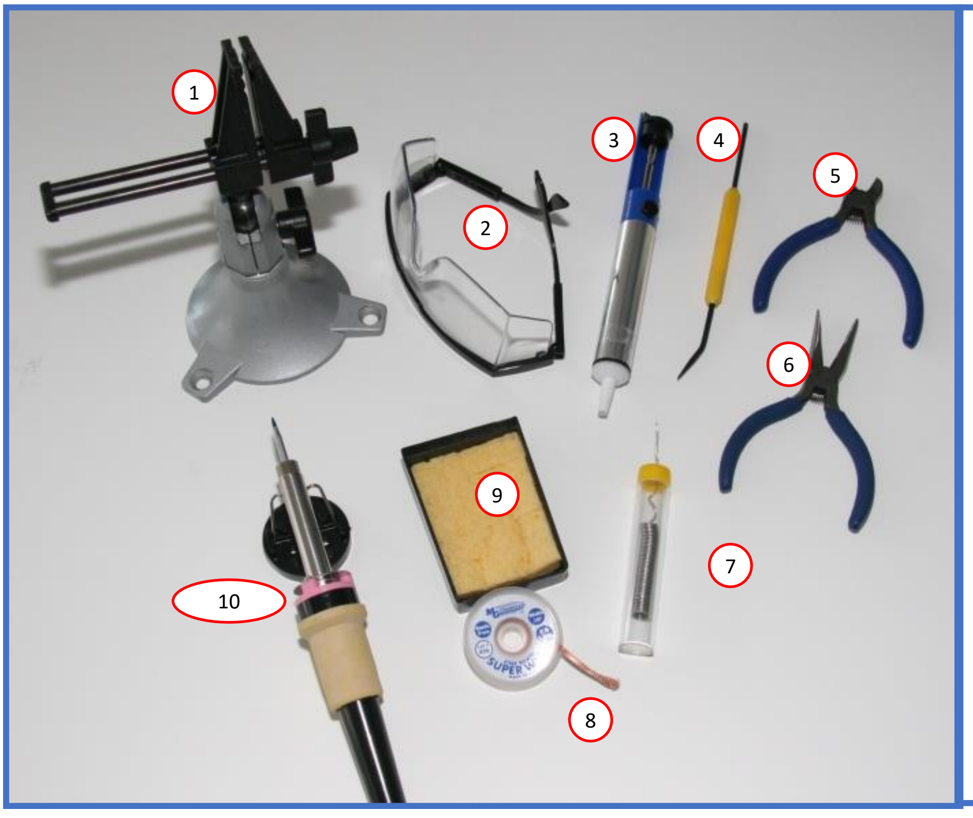
Why use soldering?

- To make a sound electrical and mechanical joint.

1.11 Typical soldering work stations



1.12 Soldering Tools



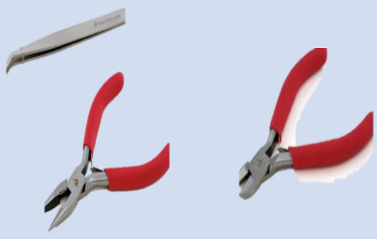
1) Vise
2) Safety glasses
3) Solder sucker
4) Solder tool
5) Diagonal cutters
6) Needle nose pliers
7) Solder
8) Solder wick
9) Damp sponge
10) Soldering iron

Figure 1.5: Soldering Tools

SOLDERING IRON

- ❑ Soldering iron is consist of a handle which is mounted the heating element. On the end of the heating element is known as the "bit", so called because it is the bit that heats the joint up. Solder melts at around 190 degrees Centigrade, and the bit reaches a temperature of over **250** degrees Centigrade.
- ❑ It is also easy to burn through the PVC insulation on the soldering iron lead if you were to lay the hot bit on it.
- ❑ The soldering iron must be placed into the specially designed stand, when not in use.
- ❑ These usually incorporate a sponge for keeping the bit clean.

Table 1.1: Soldering Tools

SOLDER LEADS		➢ Metal "glue" used to join together metal parts ➢ Contains flux ➢ Made of Tin and Copper, sometimes Lead
TWEEZERS, CLIPPERS, & PLIERS		➢ Tools used to handle, bend or cut components and PCBs
SPONGE		➢ Used to clean off soldering iron tip ➢ Can be made of various materials ➢ Should be used every time before soldering a joint
FLUX		➢ Makes solder melt easier ➢ Always use extra flux for rework
SOLDER WICK		➢ Use to remove solder

1.11 Soldering iron features

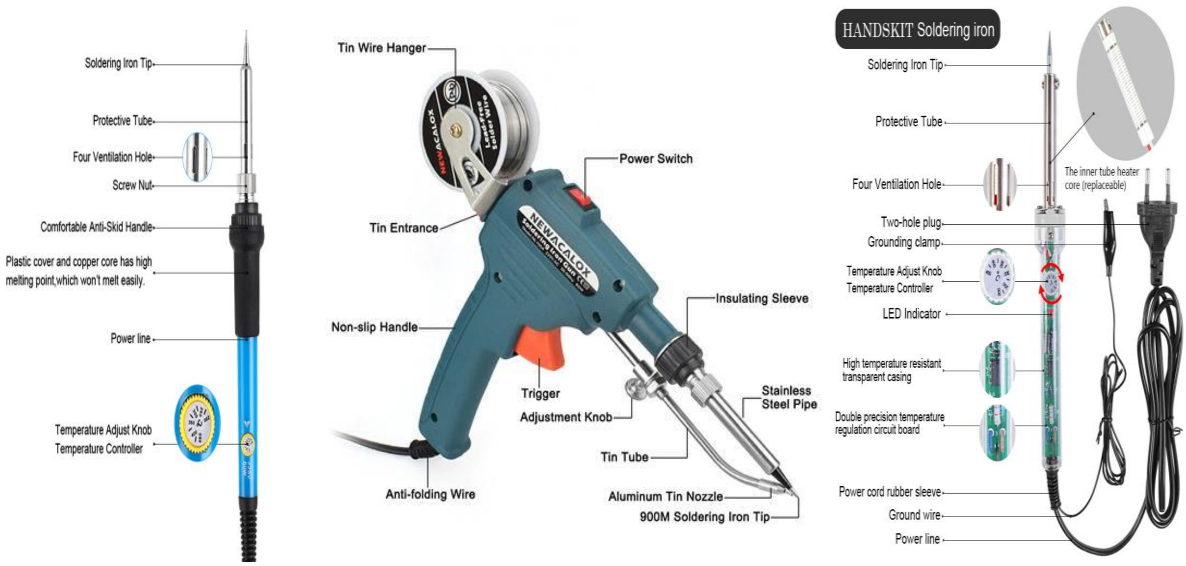


Figure 1.6: Soldering iron features

1.12 Types of Solder

- Leaded

❑ Pb, Tin

❑ Lower melting temperature ~230

❑ Does contain lead

❑ Toxic Fumes

- Unleaded

❑ Tin, copper, silver

❑ No lead = higher melting temperature Station ~330

❑ Uses “rosin core” / flux core

❑ Has an expiration date

Figure 1.7: An example of solder lead

1.13 The Secret To A Good Soldered Joint

Cleanliness

- Firstly, all parts - including the iron tip itself - must be **clean** and **free from contamination**.
- Solder just will not take to dirty parts.

Temperature

- The next step to successful soldering is to ensure that the **temperature** of *all* the parts is roughly the same level before applying solder.
- The melting point of most solder is in the region of 188°C (370°F) and the iron tip temperature is typically 330-350°C (626°-662°F).

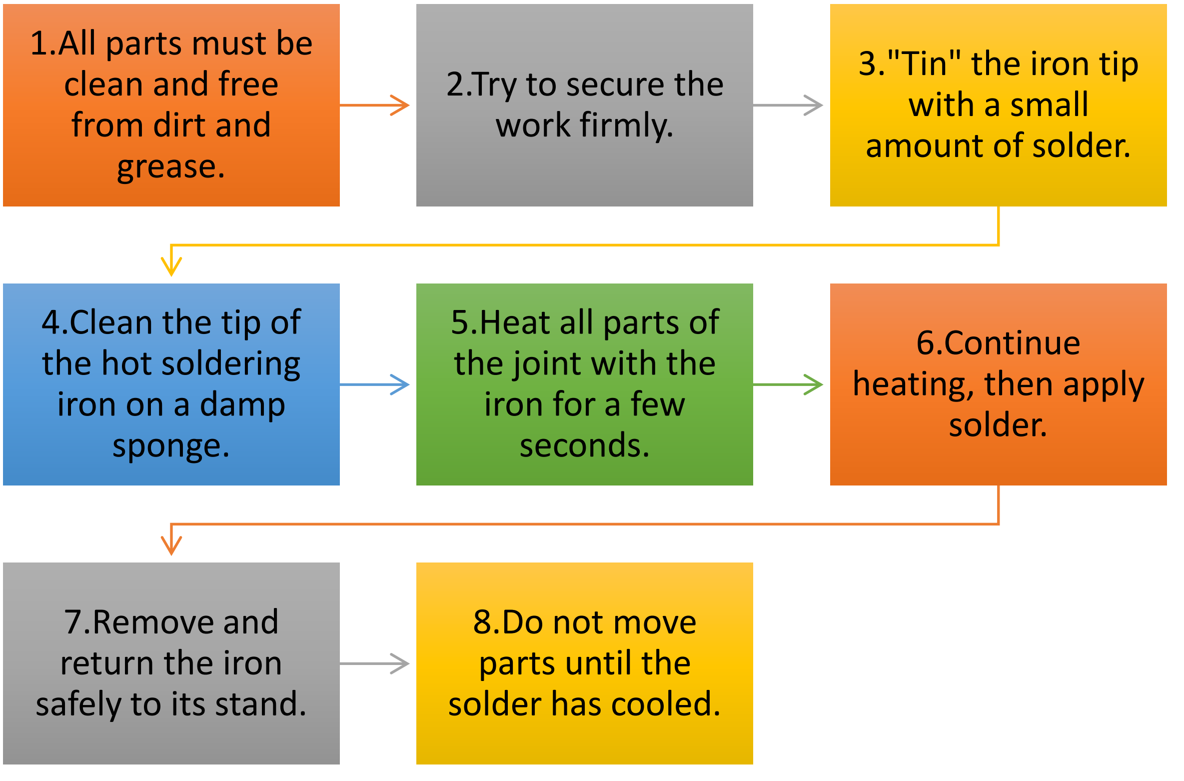
Time

- The joint should be heated with the bit for just the right amount of **time.**
- The heating period depends on the temperature of your iron and size of the joint - and larger parts need more heat than smaller ones - but some parts (semiconductor diodes, transistors and ICs), are sensitive to heat and should not be heated for more than a few seconds.

Solder coverage

- The final key to a successful solder joint is to apply an appropriate amount of solder.
- *Too much solder* is an unnecessary waste and may cause short circuits with adjacent joints.
- *Too little* and it may not support the component properly, or may not fully form a working joint.

1.14 The Making Of The Perfect Solder Joint



1.15 Soldering Iron Care & Maintenance

- A soldering iron must be coated with a thin coat of solder. This will allow for the transfer of heat to the work piece.
- This procedure is called tinning.
- The tip must be kept coated with a shiny layer of solder by occasional wiping and applying solder directly to the tip.

TINNING PROCESS

Apply Solder to Soldering Iron Tip

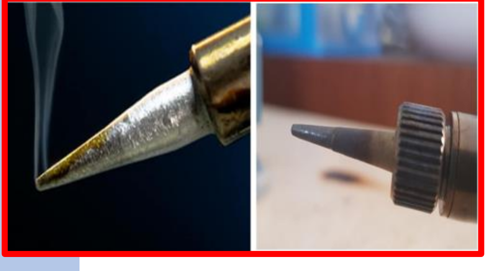
Roll Tip on Damp Sponge

Properly Tinned Soldering Iron Tip

1.16 Cleaning Your Soldering Iron

WHAT IS OXIDIZATION?

- Oxidization is what happens when oxygen breaks down matter
- It impedes heat and electricity transfer
- As a result you must clean your iron tip constantly



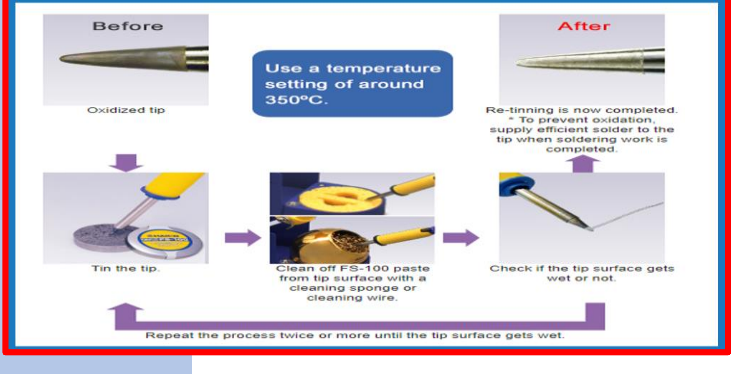


Figure 1.8: Tinning process

1.17 A good soldering joint

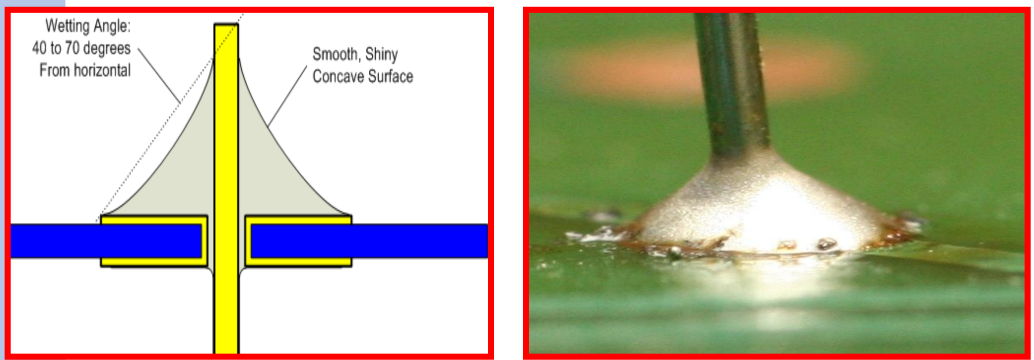


Figure 1.9: An example of good soldering

1.18 Bad Soldering Connections

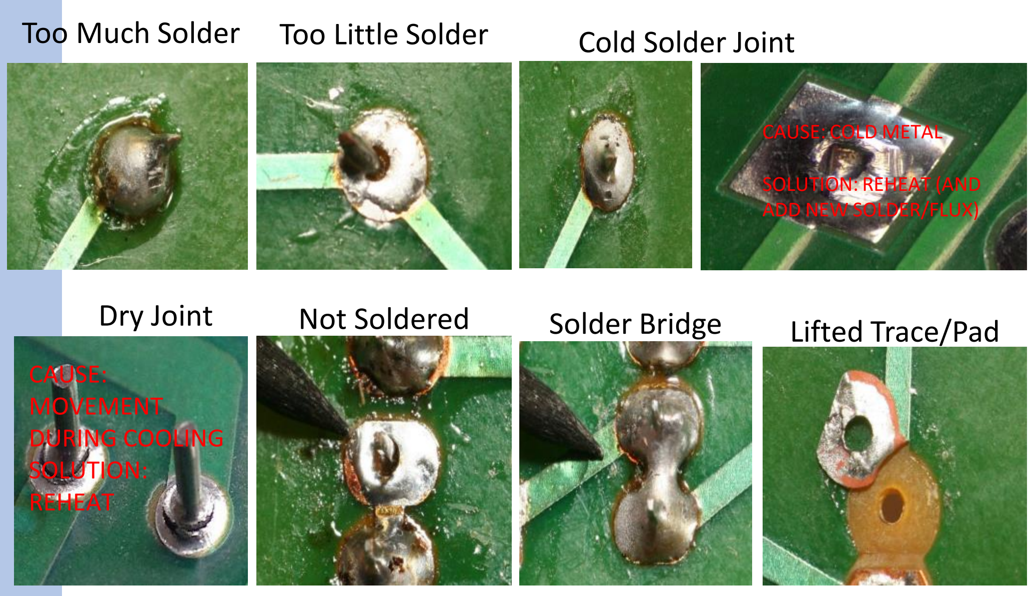
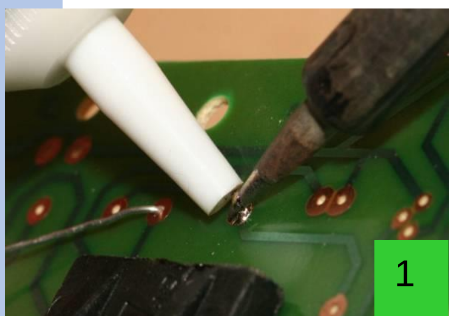


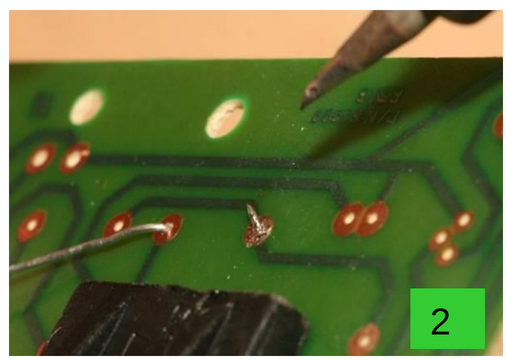
Figure 1.10: An example of bad soldering

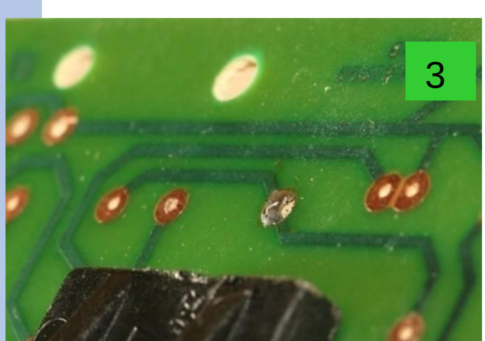
1.19 De-soldering Technique: Solder Sucker



Apply heat to the connection to be de-soldered. When the solder melts, trigger the solder sucker.

Repeat de-soldering as needed until all solder is removed. Remove soldering iron & solder sucker from area.

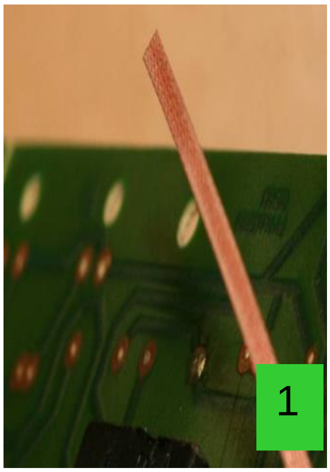




Remove component lead.

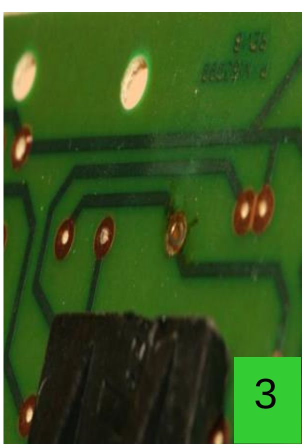
Figure 1.11: Di-soldering Technique by solder sucker

1.20 De-Soldering technique Process: Solder Wick



Solder wick is finely braided copper that is used to *wick away* excess solder from a de-soldered connection.

Apply the solder wick and soldering iron to the de-soldered connection. The solder wick will draw the excess solder off of the PCB pad.



De-soldered PCB pad

Figure 1.12: Di-soldering Technique by solder wick

1.21 Soldering Safety

- Wear safety glasses when soldering. This includes all individuals in the vicinity of someone who is soldering.
- Place soldering iron in an approved holder when not in use. The iron is hot and can cause burns.
- Place the soldering iron so that the cord does not get caught up in your arms or on others.
- Ensure access to proper ventilation.
- Verify that the type of solder is safe to use in your working environment.
- Secure the components to be soldered before beginning the soldering process.
- Provide plenty of space to work.
- Use a properly-sized point for the soldering job to be completed.
- Verify that the tip on the soldering iron has a sharp point and has not been damaged in any way.
- Check the power cord for burned or melted sections that show bare wires.
- Label those cords DO NOT USE and ask the instructor to repair or replace.

- Do not to touch molten solder - it is hot!
- Make sure that the solder strand is long enough to keep fingers away from the hot iron.
- Tie back long hair and remove or tuck loose clothing.
- Use heat sinks for heat-sensitive parts. Provide sufficient cooling time before removing parts.
- Do not flick solder off of the iron. Flicking can cause solder to spray and hit skin or eyes.
- Hold the scrap end when cutting excess leads so that the scrap lead is not thrown into the air.
- Cut leads evenly with wire cutters.
- Make sure that leads do not short across other traces or leads.
- Thoroughly wash your hands after handling solder.

REVIEW QUESTIONS

1. What are the two functions of a solder joint (solder fillet)?
2. What can be the results of incorrect solder joints?
3. Why should you keep your workbench clean?
4. Why do we need to control static electricity in the workplace?
5. How can we eliminate static electricity?
6. What type of irons do we use?
7. When should you use a small soldering iron tip?
8. When should you use a large soldering iron tip?
9. How do you choose the tip size to use?
10. At what temperature does 60/40 tin/ lead solder start to go soft?
11. What is the temperature of 60/40 tin/lead solder when it is completely liquid?
12. What are the 2 metals in solder?
13. What is the purpose of flux?

CHAPTER 2

ELECTRONIC TEST EQUIPMENT

2.1 Introduction

Electronic test equipment is used to test electronic device components to see if they are working correctly. The electronic testing equipment may identify the location of a problem by sending signals to the items being examined and collecting their responses.

Figure 2.1: Electronic Test Equipment

Electronic test equipment includes a power supply, a device to generate the signal, and a device that can read the response to the signal. If any faults are detected, then identified faults can be traced an rectified using electronic testing equipment. Most often all electrical and electronic circuits are tested and troubleshooted to detect faults or abnormal functioning if any.

Voltmeters measure voltage, ohmmeters measure resistance, ammeters measure current, and multimeter measure all three. There is electronic test equipment to measure electric and magnetic fields (EMF metres) as well as charge(electrometers). Oscilloscopes show how voltage varies over time.

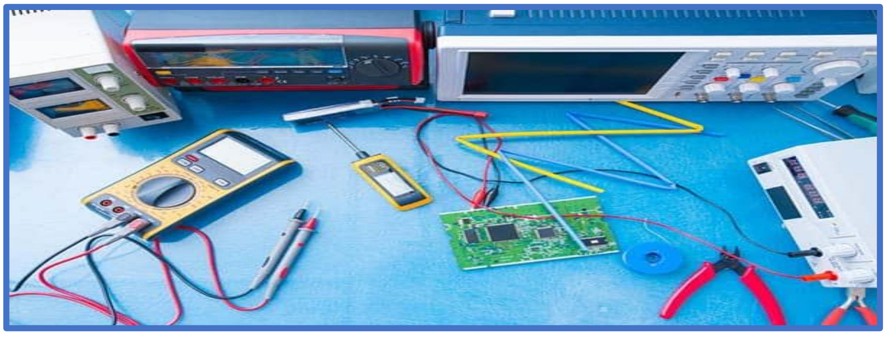


Figure 2.2: Electronic Test Equipment

2.2 Multimeter

A multimeter is an electronic tool used to measure the following basic electrical characteristics: voltage, current, and resistance. It functions as an ohmmeter, voltmeter, and ammeter besides as being utilized for domestic wiring, electric motors, battery testing, and power supply. The multimeter is a handheld device that has a needle that is placed above a numeric LCD digital display for indication. It is also used to test the continuity of an electrical circuit between two sites. There are three sorts of multimeters on the market: digital multimeters, analogue multimeters, and fluke multimeters.

Figure 2.3: Multimeter

2.3 Principle of An Ammeter

The circuit below show how meters are connected into circuits. Diagrams *A* and *B* below show a circuit before and after connecting an ammeter:

- To start with, you need to *break the circuit* so that the ammeter can be connected in series.
- All the current flowing in the circuit must pass through the ammeter.
- Meters are not supposed to alter the behavior of the circuit, or at least not significantly, and it follows that an ammeter must have a very LOW resistance.

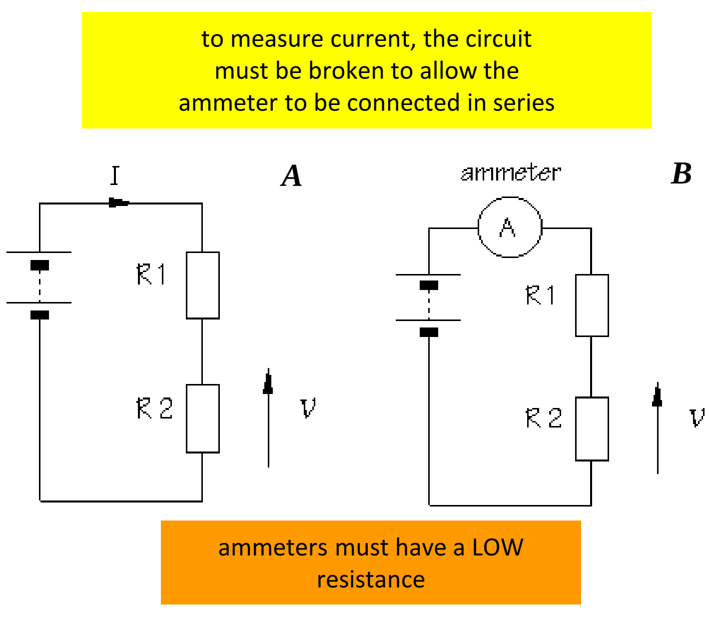


Figure 2.4: Ammeter connection

2.4 Principle Of The Voltmeter

This time, you do not need to break the circuit. The original circuit does not need to be changed. Often, the meter probes are connected simply by touching them to the points of interest.

- The voltmeter is connected in parallel between the two points where the measurement is to be made.
- Since the voltmeter provides a parallel pathway, it should take as little current as possible.
- In other words, a voltmeter should have a very HIGH resistance.
- In fact, voltage measurements are used much more often than current measurements.
- Diagram *C* shows the same circuit after connecting a voltmeter.

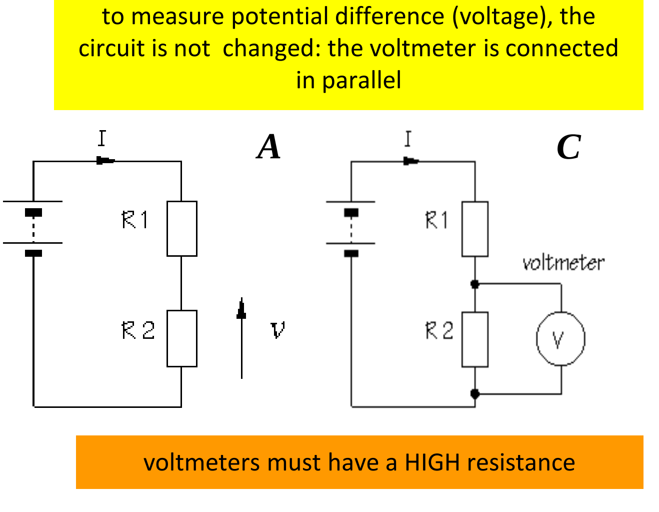


Figure 2.5: Voltmeter connection

2.5 Principle of An Ohmmeter

An ohmmeter does not function with a circuit connected to a power supply. If you want to measure the resistance of a particular component, you must take it out of the circuit altogether and test it separately, as shown in diagram *D.*

- Ohmmeters work by passing a small current through the component and measuring the voltage produced.
- If you try this with the component connected into a circuit with a power supply, the most likely result is that the meter will be damaged.
- Most multimeters have a fuse to help protect against misuse.

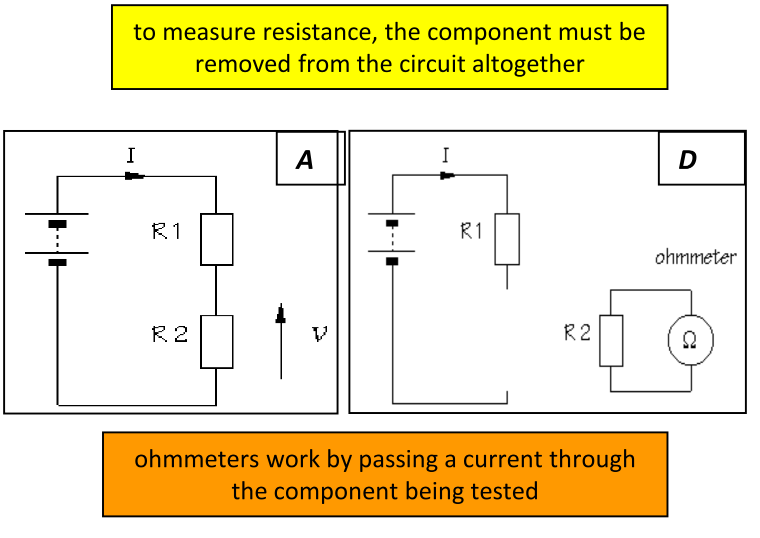


Figure 2.6: Ohmmeter connection

2.6 Circuit Under Test (Cut) Measurement Using Multimeter

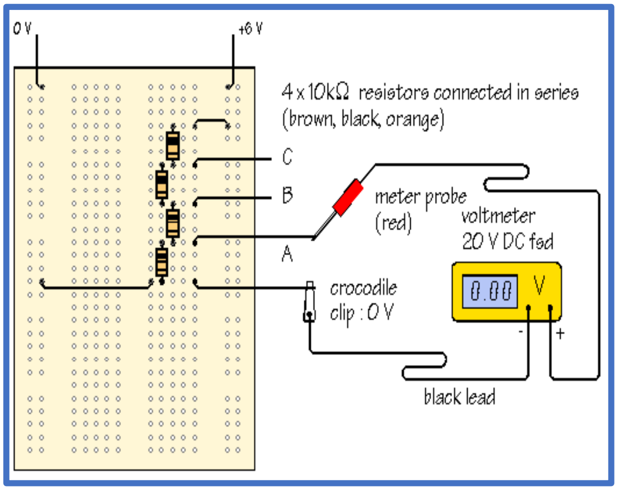


Figure 2.7: Voltage Measurements

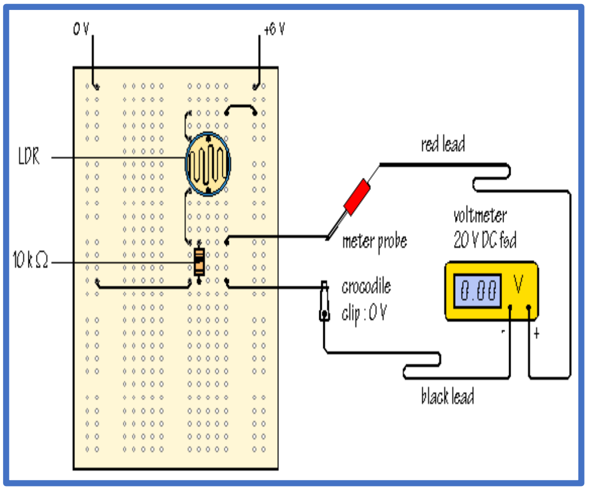


Figure 2.8: Voltage Measurements

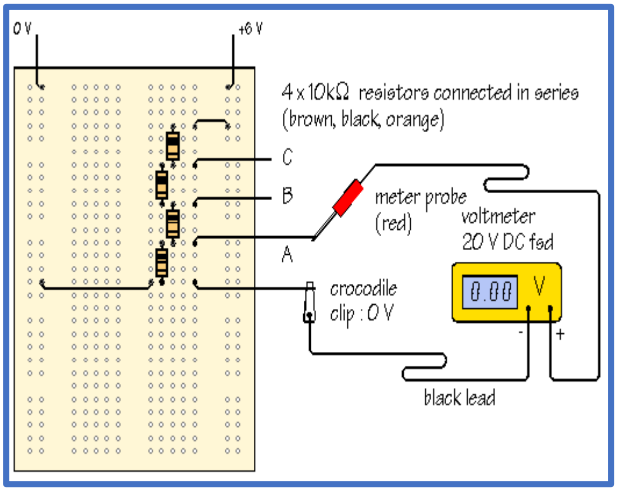


Figure 2.9: Voltage Measurements

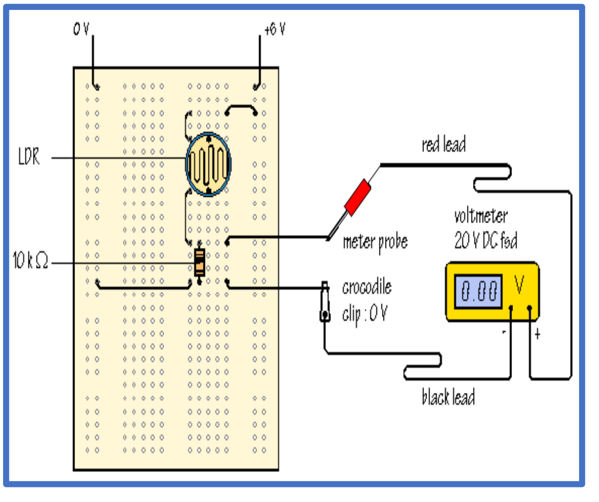


Figure 2.10: Voltage Measurements

2.7 Working Of Analog & Digital Multimeters

A multimeter has multiple functions that depend on the type of the multimeter. These functions can be activated by using the selection dial as well as some buttons. Its main function is to measure current, voltage and resistance.

Figure 2.11: Analog Multimeter

Analog Multimeter

Analog multimeter is the oldest form of a multimeter. It has a needle that rotates along a scale. They are cheap but are difficult to read. However, they are more sensitive than a digital multimeter. It can sense even small changes in the readings.

Figure 2.12: Digital Multimeter

Digital Multimeter

A digital multimeter or DMM measures electrical quantities and shows them on an LCD screen. It computes the readings digitally and displays them on an easily readable digital screen. On the other hand, the analog multimeter displays the readings without any computation thus having a quick response time.

2.8 Function Of Analog & Digital Multimeters

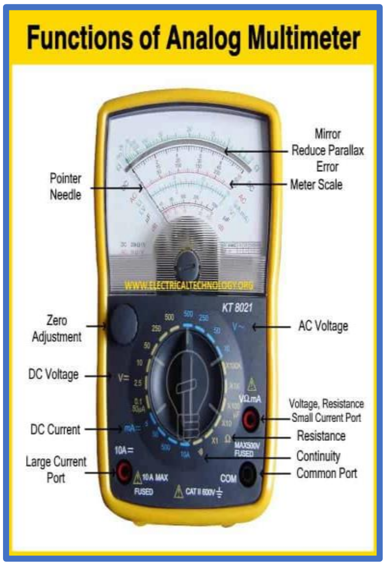


Figure 2.13: Analog And Digital Multimeter Features

2.9 Oscilloscope

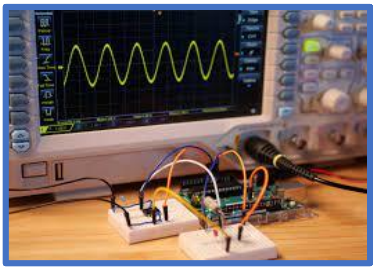


Figure 2.14: Oscilloscope

The oscilloscope is a two-dimensional display of one or more signals as a function of time that is constantly obverse by an electronic test instrument. Oscilloscopes are also known as oscillograph, cathode ray oscilloscope or digital storage oscilloscope. It may also transform non-electrical signals like vibration or sound into voltages and display the results.

Oscilloscopes are used to measure the change in an electrical signal over a period of time, so that voltage and time indicate the shape of the signal and graphed continuously and compared to a calibrated scale. The waveforms obtained can be assessed for properties like as frequency, amplitude, time interval, rising time, and others. Modern digital oscilloscope may directly calculate and show these parameters.

2.10 The Oscilloscope: Basic Features And Functions

Vertical Controls

- Position: Moves the waveform up and down on the display.
- Scale (Volt Per Division): Varies the size of the waveform on the screen.
- Bandwidth limit: Limits the bandwidth of the oscilloscope to the frequency selected to reduce displayed noise.
- Input coupling: Determines which part of the signal is displayed.

Horizontal Controls

- Position: Moves the waveform left and right on the display.
- Scale (Second Per Division): Determines the amount of time displayed.

Trigger Controls: The trigger stabilizes the display.

- Source: Determines which signal is compared to the trigger settings.
- Level: Determines where on the edge the trigger point occurs.
- Slope: Determines whether the trigger point is on the raising edge (positive slope) or falling edge (negative slope) of a signal.

Figure 2.15: An Oscilloscope Features

2.11 Digital LCR Meter

LCR meter is a type of electronic test equipment used to measure the inductance (L), capacitance (C) and resistance (R) of an electronic component. 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.

Figure 2.16: An Example Of LCR Meter

2.12 The ESR Meter

An ESR meter is a two-terminal electronic instrument that is primarily used to measure the equivalent series resistance (ESR) of real capacitors without the need to remove the capacitor from the circuit to which it is connected. Other types of meter, such as standard capacitance meter, cannot be used to measure a capacitor's ESR, though combination meter that measure both ESR and out-of-circuit capacitance are available. Because a continuous direct current cannot be passed through the capacitor, a typical (DC) milli ohmmeter or multimeter cannot be used to detect ESR.

Figure 2.17: An Example Of ESR Meter

Most ESR meters work by discharging a real electrolytic capacitor (roughly equivalent to an ideal capacitor in series with an undesirable resistance, the ESR) and applying an electric current through it for a short amount of time, too short for it to charge considerably. This ends up in a voltage across the device equal to the product of the current and the ESR plus a negligible contribution from a small charge in the capacitor; this voltage is measured and its value divided by the current (i.e., the ESR) displayed on a digital display or by the position of a pointer on a scale. The procedure is repeated tens of thousands or hundreds of thousands of times each second.

Table pen can directly test component capacitance resistance value on the circuit board, no need to remove component from the circuit board

Figure 2.18: An Example Of ESR Meter

Alternatively, an alternating current at a frequency high enough that the capacitor's reactance is much less than the ESR can be used. Circuit parameters are usually chosen to give meaningful results for capacitance from about one microfarad up, a range that covers typical aluminium capacitors whose ESR tends to become unacceptably high.

2.13 The Transistor Meter

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

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.

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.

Figure 2.19: An Example of Transistor Meter

2.14 Signal Generator

- A signal generator is also named as pitch generator, function generator or frequency generator is an electronic device used for generating a variety of electrical signal waveforms either in the analog or digital domains (repeating or non-repeating signals). Signal generators are used in testing, designing and repairing electro acoustic or electronic devices.
- It contains an electronic oscillator, an electronic circuit that is capable of creating a repetitive waveform.

Figure 2.20: An Example of Signal Generator

- The most common waveform is a sine wave, but sawtooth, step (pulse), square, and triangular waveform oscillators are commonly available as are arbitrary waveform generators (AWGs).
- If the oscillator operates above the audio frequency range (>20KHz), the signal generator will often include some sort of modulation including one or more of amplitude modulation (AM), frequency modulation (FM), or phase modulation (PM) as well as a second oscillator that provides an audio frequency modulation waveform.

2.15 Sweep Function Generator

A **function generator** is a piece of electronic test equipment used to generate repetitive waveforms.

- These waveforms can then be injected into a device under test and analyzed as they progress through the device, confirming the proper operation of the device or pinpointing a fault in the device.
- Function generators usually generate a triangle waveform as their basic output. The triangle is generated by repeatedly charging and discharging a capacitor from a constant current source. This produces a linearly-ascending or descending voltage ramp.
- As the output voltage reaches upper and lower limits, the charging and discharging is reversed, producing the linear triangle wave.

Figure 2.21: An Example of Sweep Function Generator

- By varying the current and the size of the capacitor, different frequencies may be obtained. Most function generators also contain a diode shaping circuit that can convert the triangle wave into a reasonably-accurate sine wave.
- Function generators, like most signal generators, may also contain an attenuator, various means of modulating the output waveform, and often contain the ability to automatically and repetitively "sweep" the frequency of the output waveform between two operator-determined limits.
- This capability makes it very easy to evaluate the frequency response of a given electronic circuit.

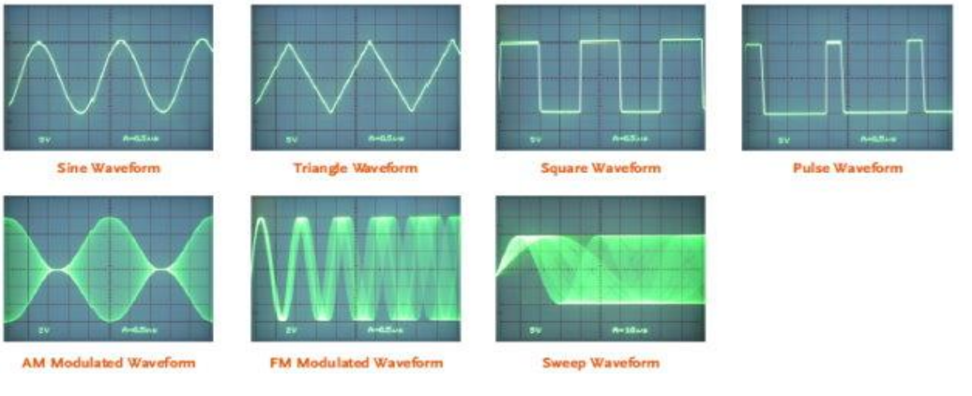


Figure 2.22: An Example of The Generator Signal

2.16 Digital Frequency Generator

Digital frequency counter is an electrical test equipment used for measuring number of cycles of oscillation, or pulses per second in a periodic electronic signal. Digital frequency counters are also used to measure the radio frequency where it is important to measure the precise frequency of a particular signal.

There is a slight difference between the timers and frequency counters in the electronic industry. It is often possible to use both timers and frequency counters to perform the both functions: to measure the time and frequency. Frequency counters are mostly used as general purpose laboratory test equipment to measure higher frequencies.

Figure 2.23: An Example of Digital Counter

2.17 DC Power Supply

A power supply is an electronic instrument that supplies electric energy to an electric load. Regulated power supplies refers to a power supply which supplies a variety of output voltages used for bench testing of electronic circuits, with the variation of output voltages or some preset voltages. Almost all the electronic circuits make use of a DC source of power for operation.

A regulated power supply consists of various blocks such as an ordinary power supply and a voltage regulating device. The output generated from ordinary power supply is fed to the voltage regulating device that provides the final output. The main function of a power supply is to convert one form of electrical energy into another.

Figure 2.24: An Example of DC Power Supply

REVIEW QUESTION

1. Ammeters are always connected in……..with the circuit.
2. A voltmeter is used in…………with the circuit.
3. What does the CRT oscilloscope display ?
4. An oscilloscope is basically designed to convert ?
5. In function generator, the function selector is used to select the desired:
6. The selected wave form in a function generator is available at:

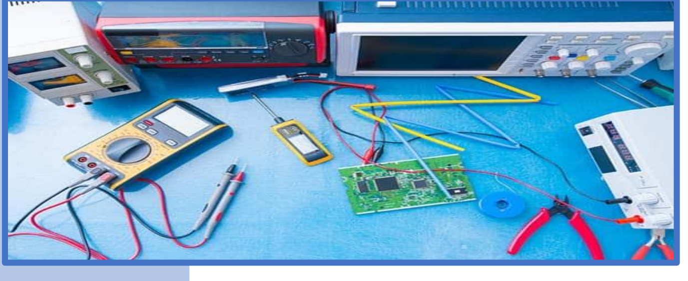
   ____

   ____

CHAPTER 3

ELECTRONIC COMPONENT TESTING

3.1 Introduction



Electronic test equipment is used to test electronic device components to see if they are working correctly. The electronic testing equipment may identify the location of a problem by sending signals to the items being examined and collecting their responses.

Electronic test equipment includes a power supply, a device to generate the signal, and a device that can read the response to the signal. If any faults are detected, then identified faults can be traced an rectified using electronic testing equipment. Most often all electrical and electronic circuits are tested and troubleshooted to detect faults or abnormal functioning if any.

3.2 Testing Resistor

There are two ways of testing resistor; using an analogue or digital multimeter. Normally if a resistor fails they will either increase in value or open up at all (open circuit). You can check the resistor resistance by selecting the ohmmeter range in the analogue and digital multimeter. If the resistor is in circuit, you will generally have to remove the resistor so you are testing only the resistor value and not the other components in the circuit.

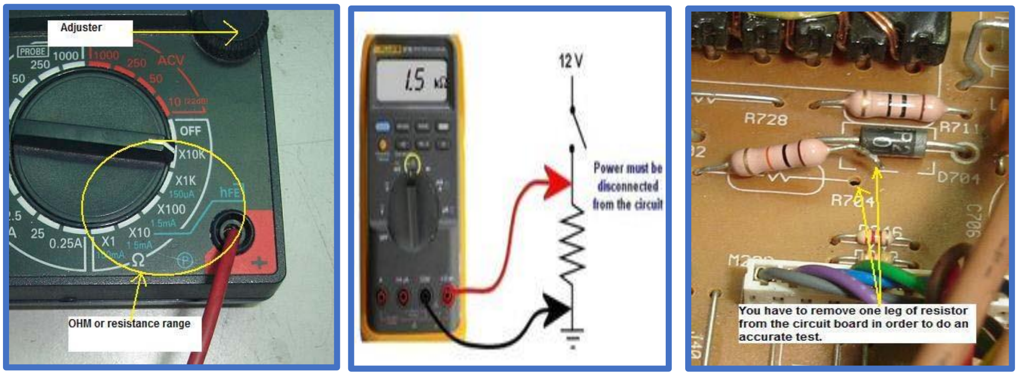


Figure 3.1: Testing resistor using analogue and digital multimeter

3.3 Testing Variable Resistor

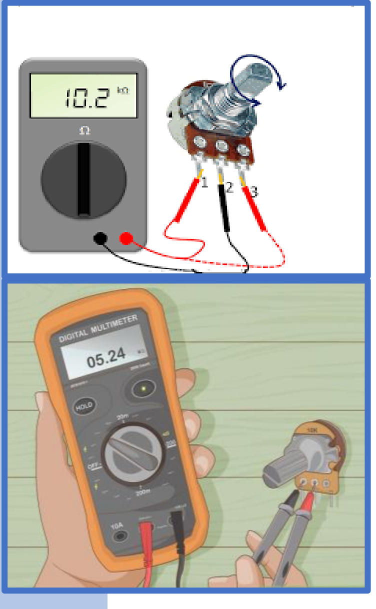


Figure 3.2: Testing variable resistor using multimeter

Variable resistors also called potentiometers or rheostats, employ a movable metal blade resting along a ring of resistive film. You can change the resistance by turning the knob.

Failure among variable resistors usually takes form of intermittent connections between the wiper blade and resistive film. Sometimes it also can be burnt due to overload of currents and develop an open circuit.

The poor contact can cause all types of erratic or intermittent operation. If the intermittent connections are due to dust and debris, using an electronic oil-based contact cleaner may help to solve the problem. But, if the problems are caused by the wearing away of the resistive film, the only option is to replace the variable resistors.

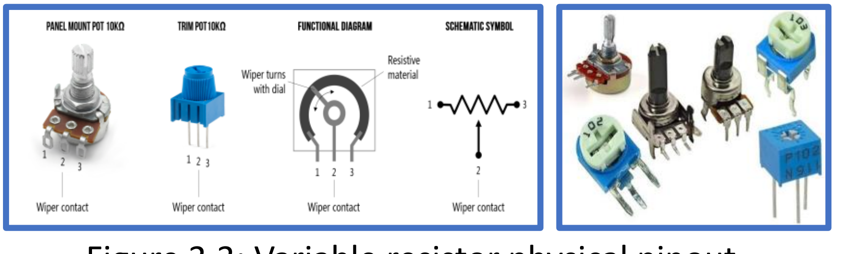


Figure 3.3: Variable resistor physical pinout

3.4 Testing Fuses

Fuse is a very thin wire, which either melts or vaporizes when current flow through it exceeded the fuse rating.

Switch off the power of the equipment, measure the fuse with a either an analogue or a digital multimeter. If you use an analogue meter then select the lowest ohms range which is the x1 ohms.

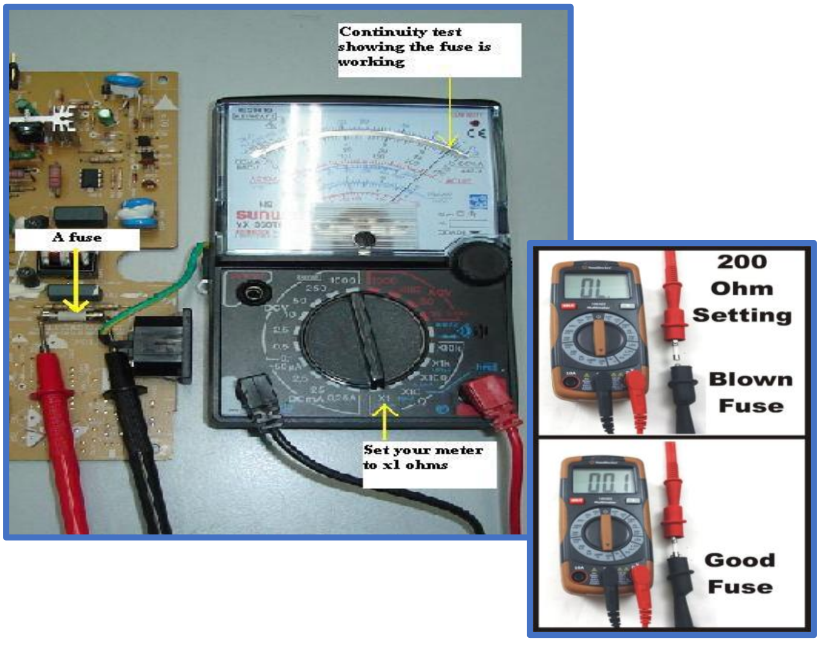


Figure 3.4: Testing fuse using multimeter

3.5 Testing Coils or Inductors

Coils or inductors are just coils (turns) of wire. The wire may be wrapped around a core made of iron or ferrite. It is labeled "L" on a circuit board. 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. The winding can be less than one ohm, or greater than 100 ohms.

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. 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.

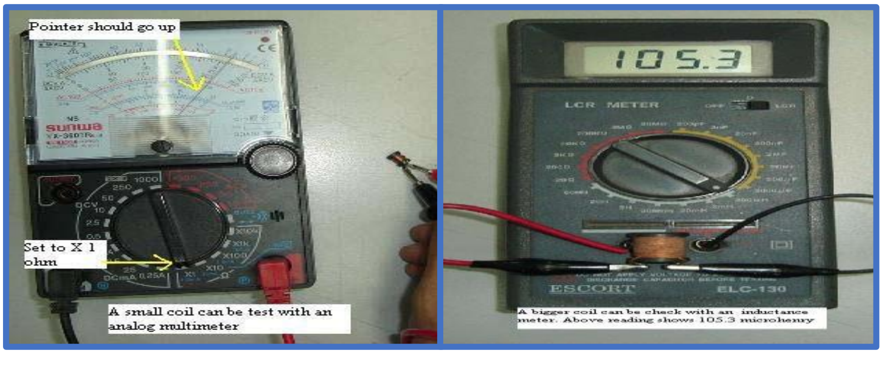


Figure 3.5: Testing inductor using multimeter

3.6 Testing Switches

The function of the switch is to act as a contact between two points either to let current flow or to stop it. It is very easy to test switches, just set your meter to X 1 ohm and place your meter test probes to either leg (pin). Now press the switch and you should see the meter's pointer shows zero ohm. (Figure 3.6)

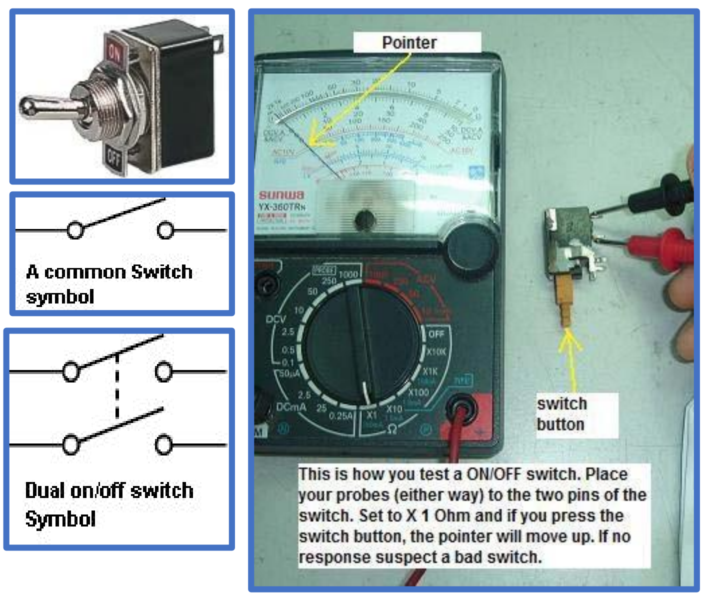


Figure 3.6: Testing switches using multimeter

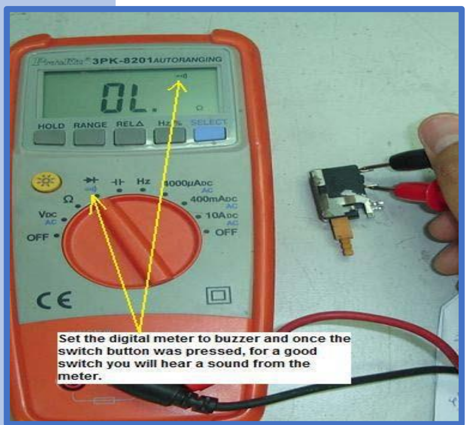
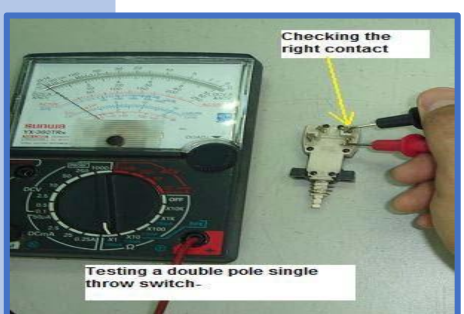


Figure 3.7(a): Testing DPST switches using multimeter

If after pressing the switch and nothing happen, suspect a bad switch. Similarly, you can use a digital meter set to buzzer sound to test a switch. A good switch with a good contact should make the digital meter to produce the buzzer sound. No sound means the switch is defective. (Figure 3.7(a)



Some switches have dual on/off contact and is called double pole single throw switch (DPST).

Testing the DPST switch is relatively simple, test the contact at one time before you test on the other contact. Testing method is the same just as when you are testing the single on/off switch above. (Figure 3.7(b))

Figure 3.7(b): Testing DPST switches using multimeter

3.6 Testing Diode

Diode is label as “D” in circuit board. Usually a rectifier diode can fail in one of the four ways. It can become open circuit, short circuit, leaky and breakdown or failed when a high voltage flows through it.

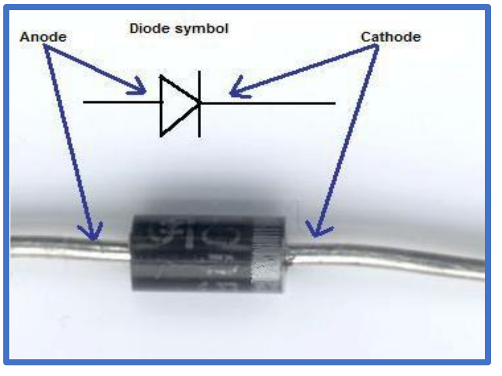


Figure 3.8: Symbol of Diode

The first step on how to test a diode accurately is to remove one of the diode lead. You can't always be certain if a diode is good or bad if you perform in- circuit test, because of back circuits (parallel connection) through other components.

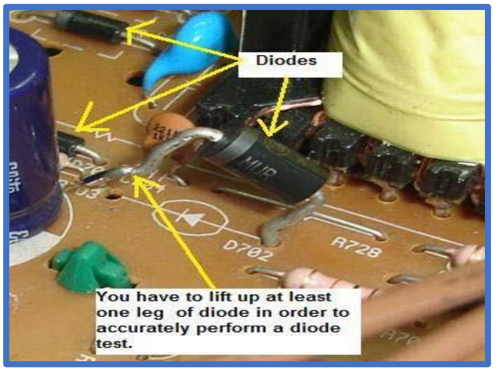


Figure 3.9: Testing Diode

Set your analogue meter to x1 ohms range to check for current diode leakage reverse and forward testing. Connecting the red probe of your meter to the cathode and black probe to the anode, the diode is **forward biased** and the meter should read some value of resistance. Touch the black probe of your meter to the cathode and red probe to the anode, the diode is **reverse biased** and should look like an open reading-the meter pointer not moving. If you get two readings then most probably the diode is shorted or leaky and you should replace it.

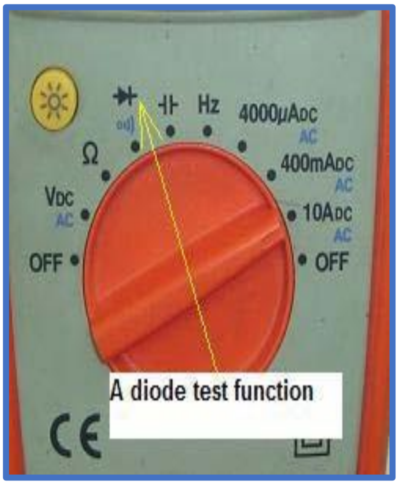


Figure 3.10: Testing diode using multimeter (forward biased)

If you don't get any reading either forward or reverse bias, the diode is considered open circuit. The real problem when testing a diode using the diode test function of a digital meter is that an open or leaky diode, the meter sometimes reads okay. This is due to the digital meter diode test output voltage (which you can measure the output test probe using another meter) is around 500mv to 2v.

An analogue meter set to x1 ohms range have output about 3V (remember the two 1.5V batteries you installed in the analogue meter!). The 3V voltage is adequate to show you the accurate reading of a diode when under test. Even if you have a good reading at x1 ohms range checking a diode, **this doesn't mean that the diode is good.**

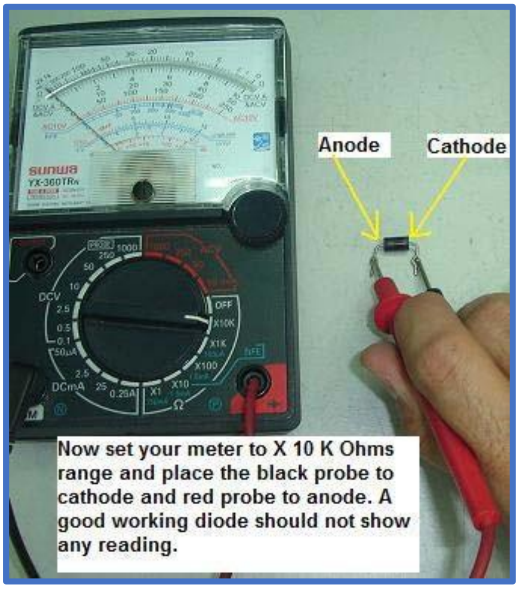


Figure 3.11: Testing Diode using multimeter (reverse biased)

3.7 Testing Light Emitting Diode (LED)

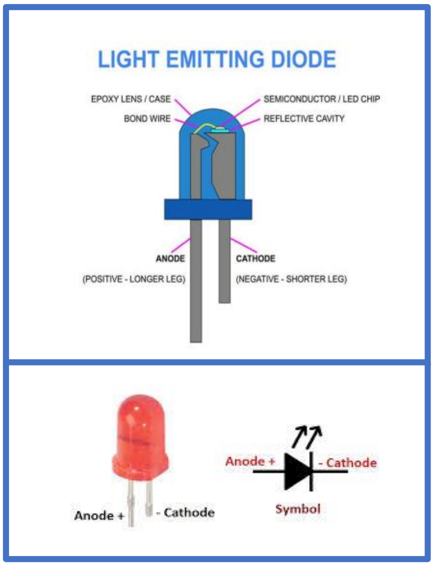


Figure 3.12: LED symbol and construction diagram

Light emitting diode (LED) is a diode that produces light when current flows through it, when it is **forward bias**. The LED does not emit light when it is **revered-biased**. An LED only needs about 2V across its anode and cathode terminals to make it emit light. If a higher voltage is used, the current which flows through it may be high enough to damage it. In order to limit current when an LED is used at higher voltages, a resistor must be connected in series with it.

Remember that the LED only emits light when it is forward bias and the LED does not emit light when it is revered-biased. If LED does not emit light when it is forward bias then it has developed an open circuit and should be replaced. Power must be off when check the LED.

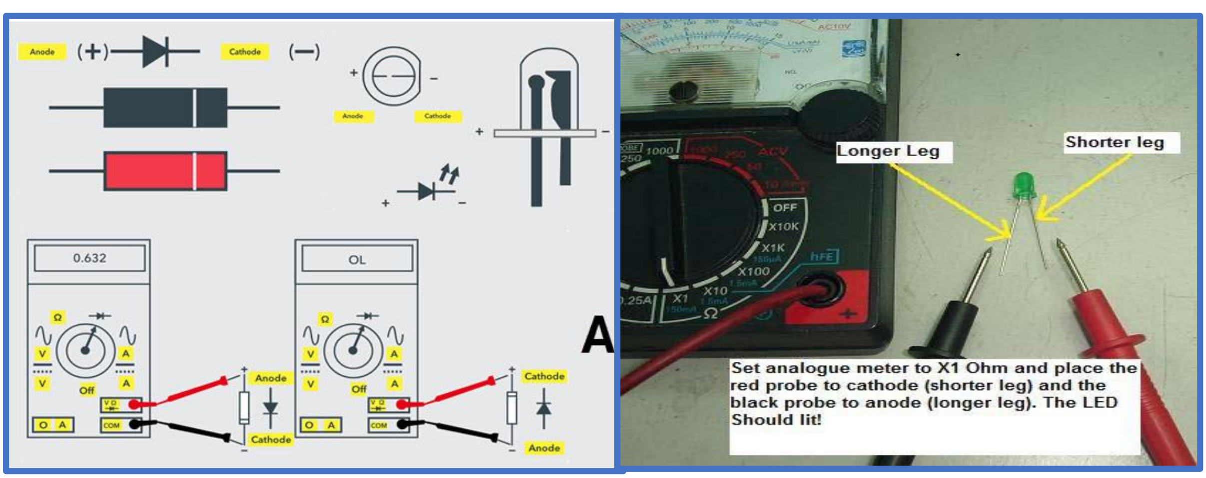


Figure 3.13: Testing LED using multimeter

3.8 Testing Zener Diode

- A Zener Diode is a special kind of diode which permits current to flow in the forward direction as normal.
- The current also flows in the reverse direction when the voltage is above a certain value - the breakdown voltage known as the Zener voltage.
- The voltage drop across the Zener diode is equal to the Zener voltage of that diode no matter how high the reverse bias voltage is above the Zener voltage.
- A Zener diode with 2.4 volt to 12 volt should have two readings when test with an analogue meter set to times 10K ohm range. However, these are not shortened readings.

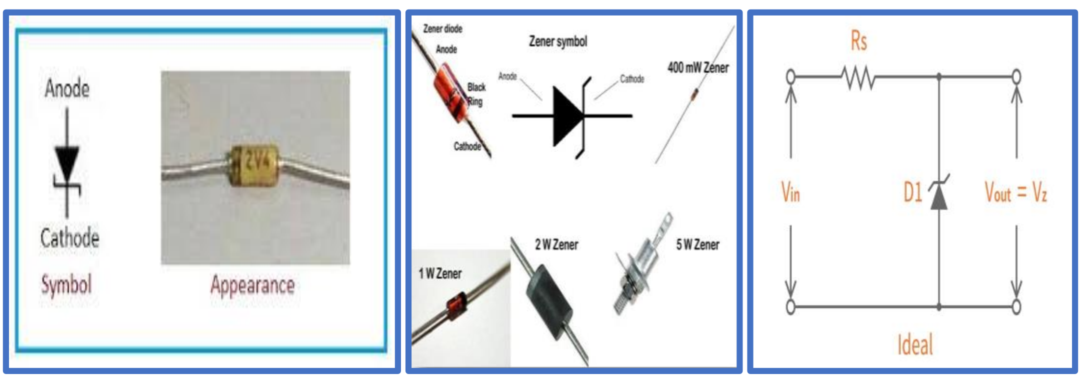


Figure 3.14: Zener diode symbol and testing circuitry

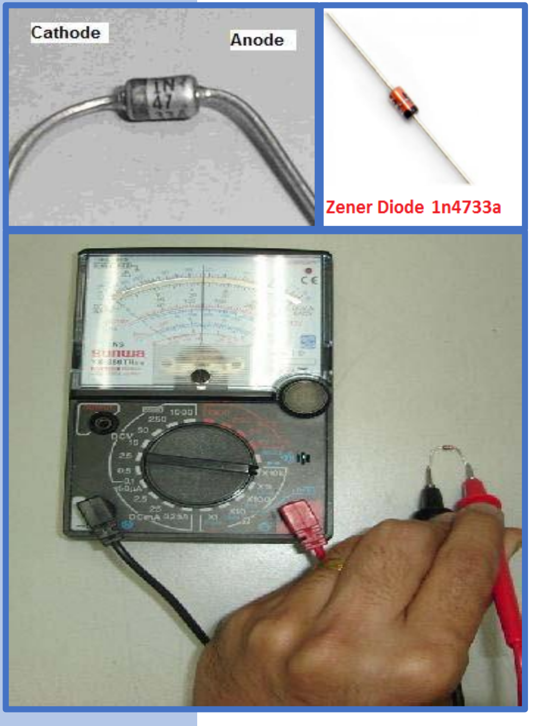


Figure 3.15: Testing zener diode using multimeter

- Put the two probes across the 2.4 volt Zener diode using the times 10k ohm range; one way will show a full scale reading (red probe to cathode and black probe to anode), which means the pointer will point towards the 0 ohms scale; the other way (black probe to cathode and red probe to anode) will point to around 2- 4 ohms.
- If both ways of testing caused the pointer to point to zero ohms then the Zener diode is considered shorted. When you measure a 5.1 volt Zener diode, as usual one way will point to zero ohms while the other way will show a higher resistance which is in the 20 to 60 ohms. These are the characteristic of a good
- working Zener diode and don't think that the meter shows two reading means the Zener diode is faulty.
- **If you get two reading when you measure a normal diode, then the diode is shorted.** As I mentioned above, testing Zener diode is totally different from checking a normal diode.
- When you connect your probe and measure a 13 volt Zener diode and above voltage, it should show only one reading using the times 10 K ohms range. That's mean when you are touching the red probe to the cathode and black probe to the anode. Reversing the probe should not show any reading.
- If the result shows two readings then the Zener diode is confirmed to be shorted or have developed a leakage.

3.8 Testing Linear Transformer

- A Transformer is an electrical device that converts the high-voltage AC to low-voltage AC (Step Down Transformer). Or it converts the low-voltage AC to high-voltage AC (Step Up Transformer).
- The Transformer primarily consists of two coils known as windings; Primary winding and Secondary winding. These windings are usually wound around a core that is made of ferromagnetic material.
- When an AC flows through the primary winding, it generates an alternating magnetic field in the core. This alternating field then induces an alternating voltage in the secondary winding. Depending upon the number of turns of the secondary winding, this voltage can be higher or lower than the primary.

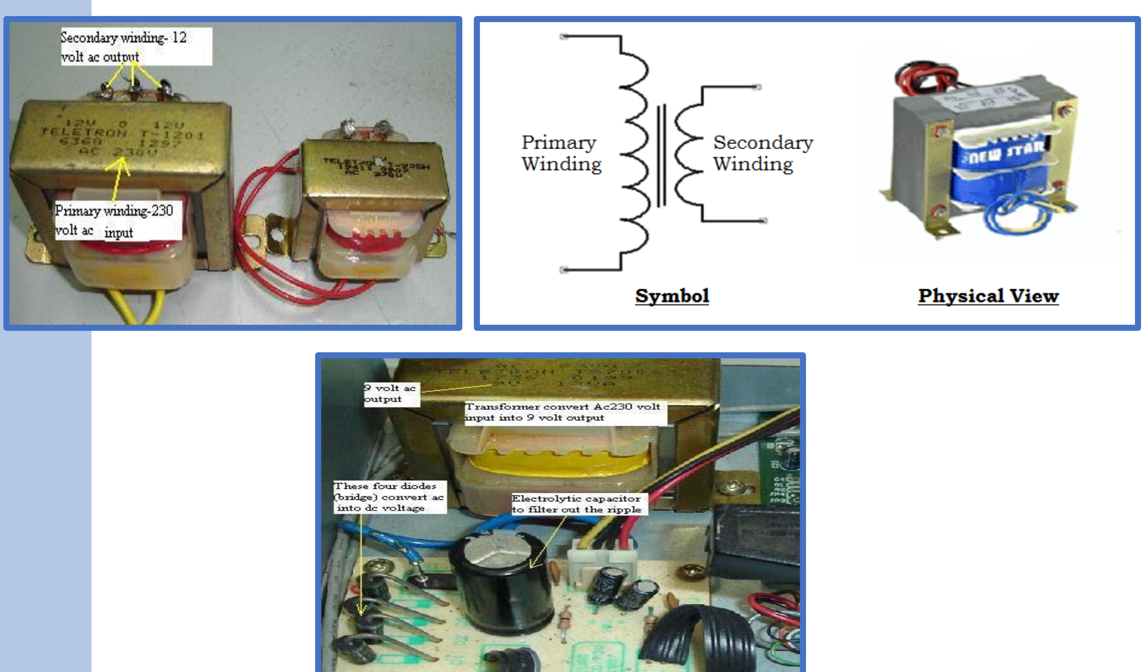


Figure 3.16: Typical linear transformer

There are three methods or techniques for testing a transformer: Turn the equipment "ON" and use an analogue or digital meter to measure the transformer's input and output voltage. If there is no voltage or if the voltage is lower than expected, the transformer must be replaced.

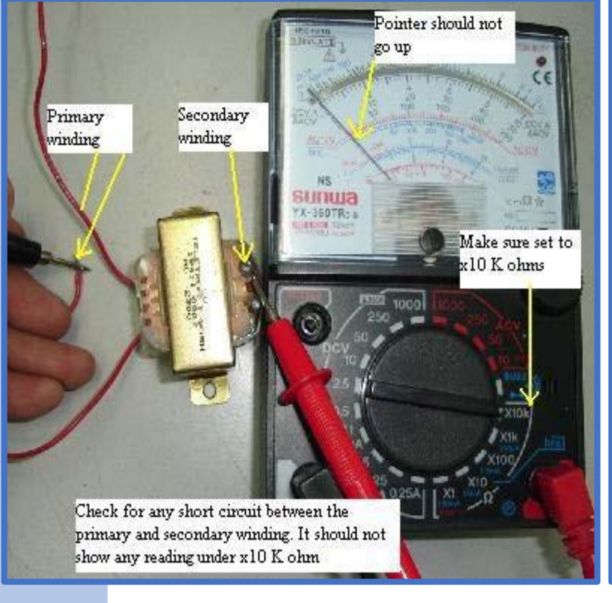


Figure 3.17: Testing linear transformer using multimeter

Remove the transformer from the board while the power is switched off and perform a resistance or continuity test on the primary and secondary windings as illustrated in the transformer picture below. If no resistance or ohms readings are obtained on the primary and secondary windings, an open winding is suspected, and the transformer must be replaced.

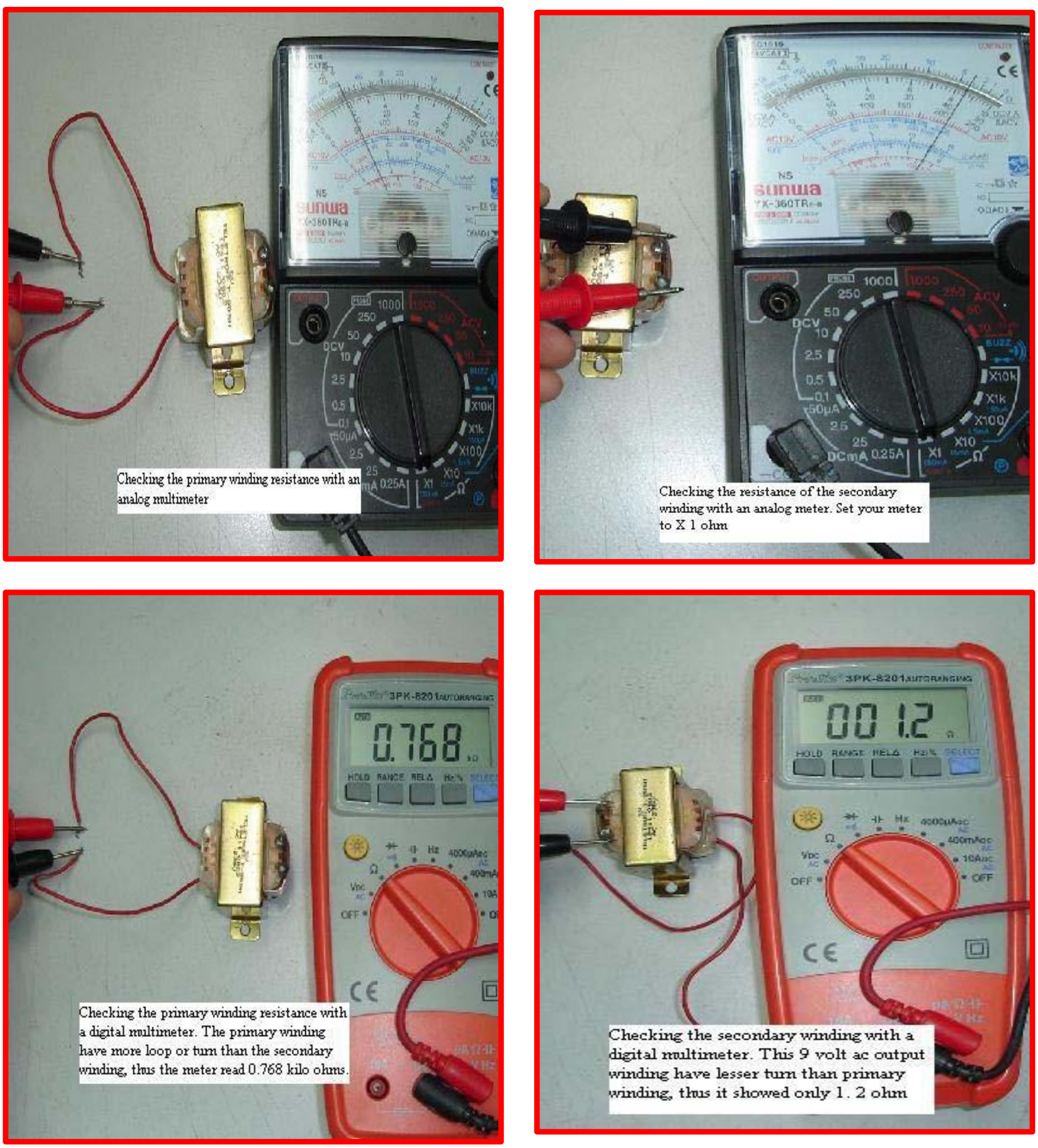


Figure 3.18: Testing linear transformer using multimeter

3.9 Testing Capacitor

A capacitor is a passive two-terminal electronic component used to store electrical energy in an electric field and serves as a very short time battery in the circuits. In the form of a capacitor, it consists of two conducting parallel metal plates separated by an insulating material called the dielectric.

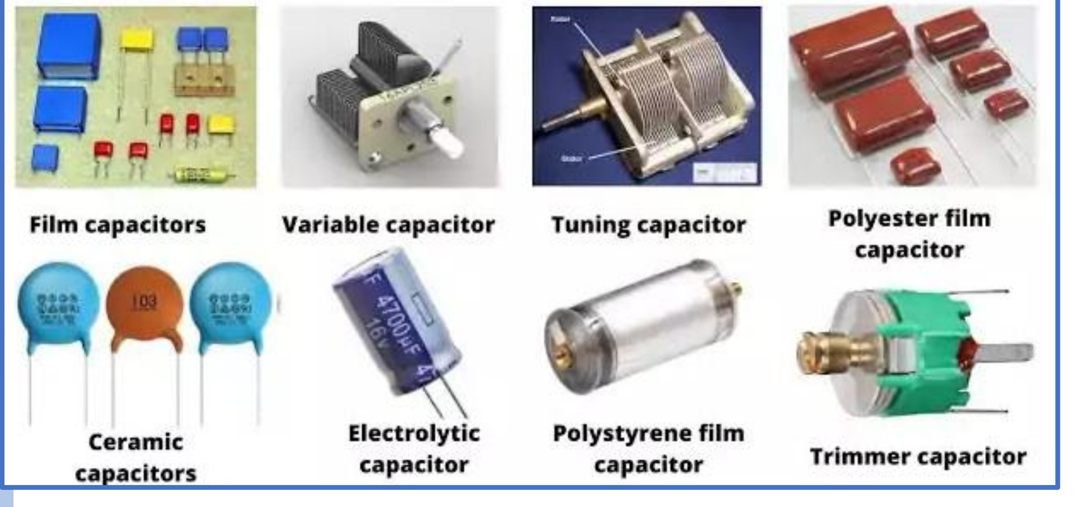


Figure 3.19: Types of capacitor

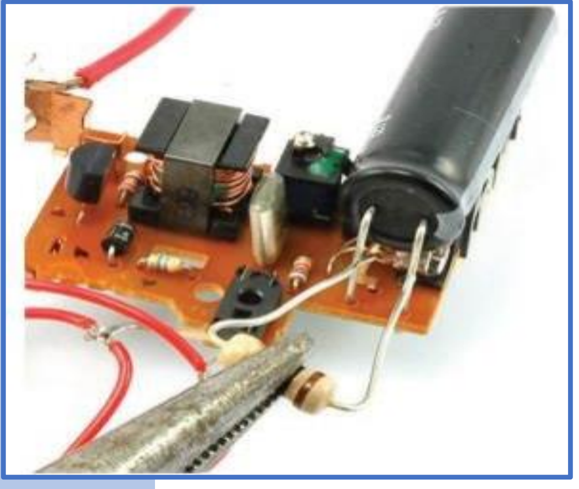


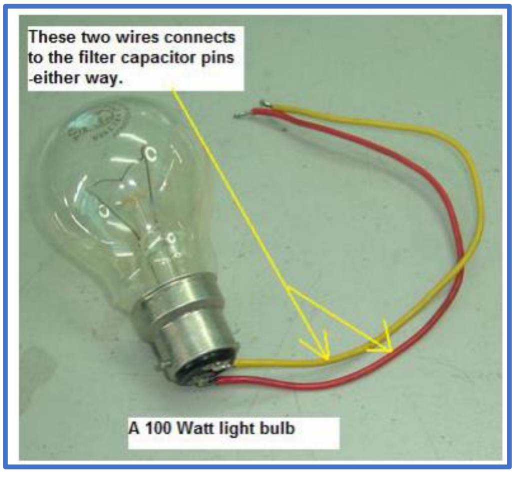
Figure 3.20: Discharge Capacitor Using Resistor

3.9.1 DISCHARGE CAPACITOR USING RESISTOR

- Do not use a screwdriver to short between the terminals as this will damage the capacitor internally and the screwdriver.
- Use a 1 watt or 3 watt or 5 watt resistor on jumper leads (or held with pliers) and keep them connected for up to 15 seconds to fully discharged.
- Before testing any capacitors, especially electrolytics, 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 it being blown.

3.9.2 DISCHARGE CAPACITOR USING BULB

Another method is that can used a 100 watt electric light bulb and touch the two wires coming out from the light bulb on the leads of the capacitors. If there is a charge the light bulb will light and after discharged the light bulb will goes off.



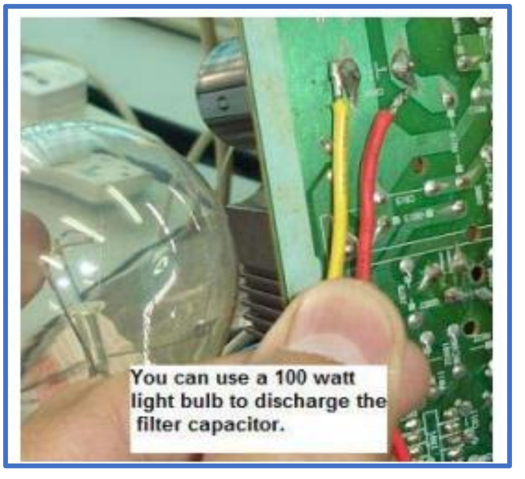


Figure 3.21: Discharge Capacitor Using Bulb

3.9.3 USING AN ANALOUGE MULTIMETER

- 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. Use the x10k range on an analogue or digital multimeter.
- For values above 1uF 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 1uF will not respond to charging and the needle will not deflect.

Figure 3.22 Testing capacitor using an analogue multimeter

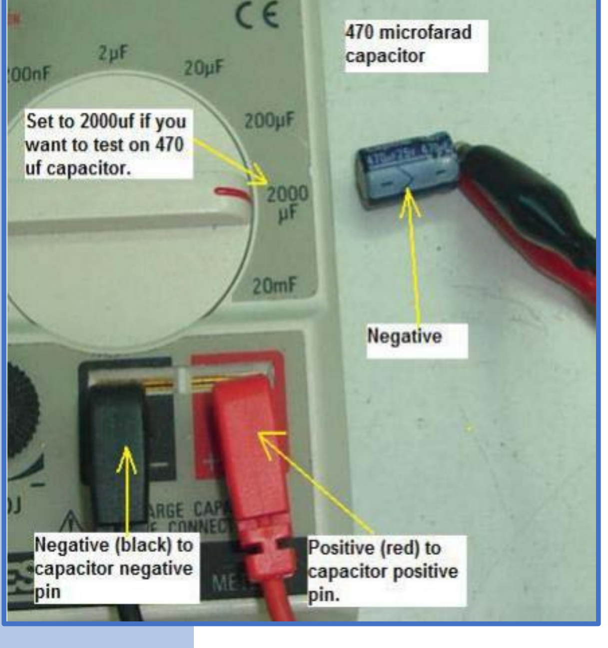


Figure 3.23 Testing capacitor using digital capacitance meter

3.9.4 USING DIGITAL CAPACITANCE METER

- Connect the test probe to the capacitor and read the result from the meter LCD display. Example, a 100 microfarad should have the reading of some ware 90 microfarad to 120 microfarad because the capacitors have tolerances just like resistors.
- A reading out of the tolerances means the capacitors has lost its capacitances and need to be replaced.

3.10 Testing Voltage Regulator IC's

A voltage regulator is a circuit that creates and maintains a fixed output voltage, irrespective of changes to the input voltage or load conditions. Voltage regulators (VRs) keep the voltages from a power supply within a range that is compatible with the other electrical components.

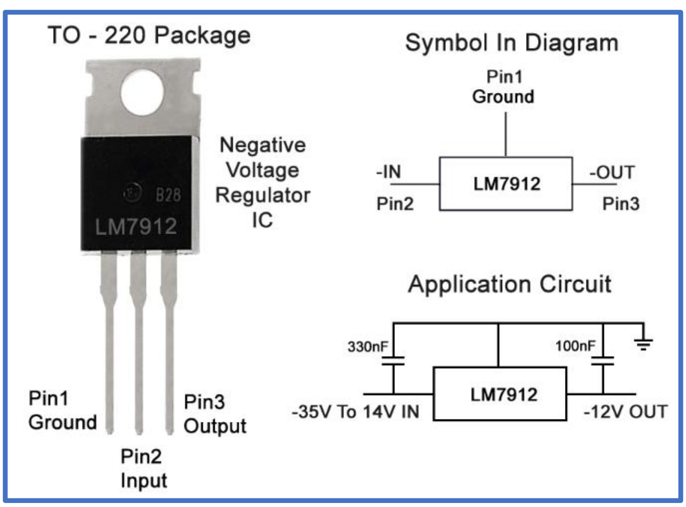


Figure 3.24: Types of voltage regulator IC's

The things you should know and be prepared prior to testing or measuring voltage regulator circuit is:

- To perform the test we need a DC power supply panel equipped with a voltmeter, a DC voltmeter, regulator IC 7805 and the black and red wires as needed
- A type of three-terminal regulator IC regulator will work fine if input voltage is greater than the output voltage around 3V.
- Turn on the DC power supply and adjust the output voltage of about 8V or slightly larger. Or alternatively you can use a battery 9V-12V as voltage source.
- Prepare a DC voltmeter to measure the output voltage of the IC 7805.
- The test results of IC 7805 is good if the pin (3) read +5Vdc.

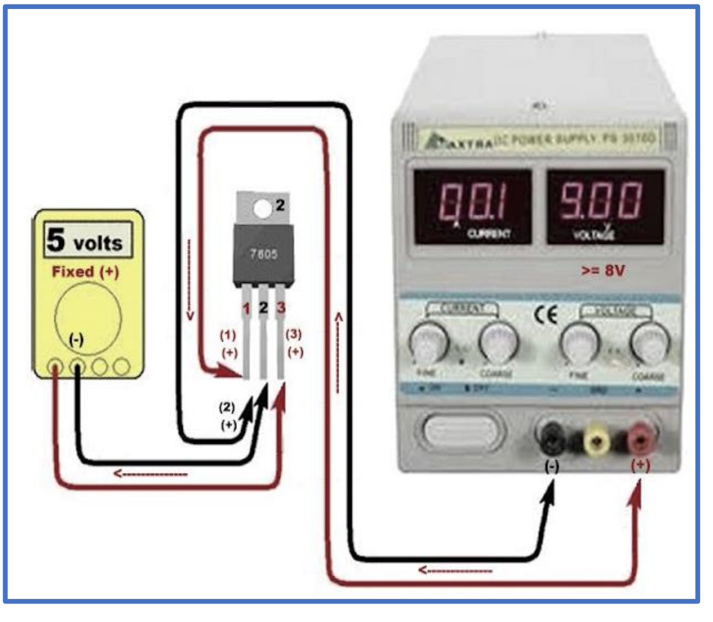


Figure 3.25: Testing voltage regulator IC’s

3.11 Testing Opto – Isolator/Photocoupler

The opto-isolator is simply a package that contains both a light emitting diode (LED) and a photodetector such as a photosensitive silicon diode, transistor, Darlington pair, or silicon controlled rectifier (SCR). The most common type uses an infrared LED and a phototransistor

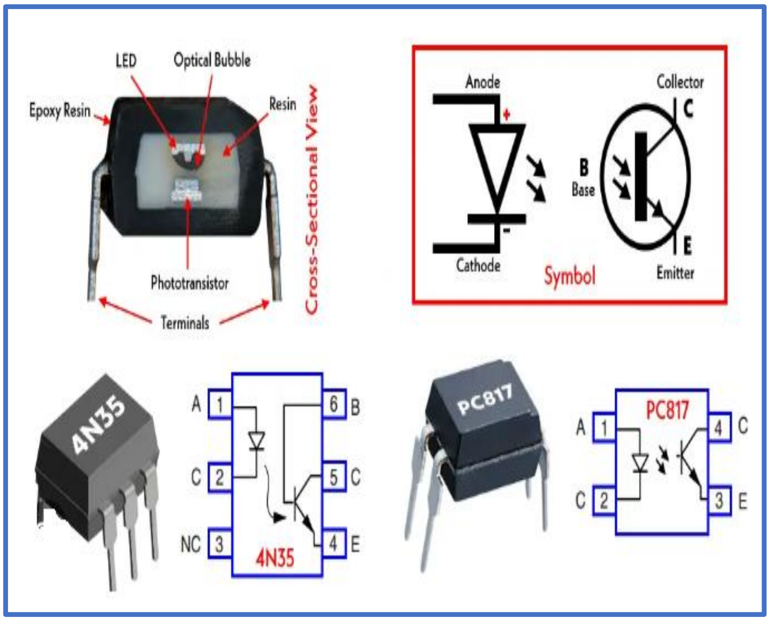
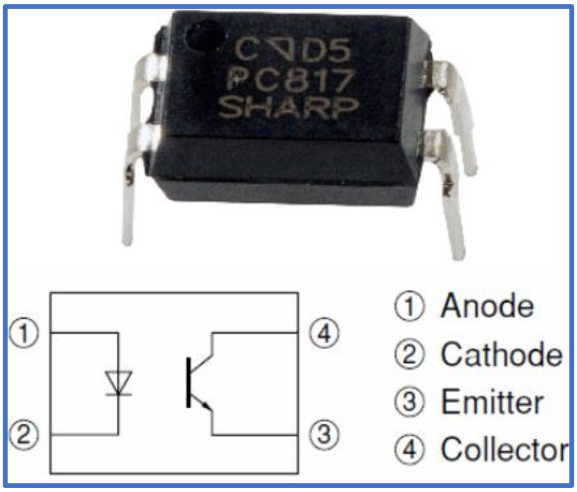
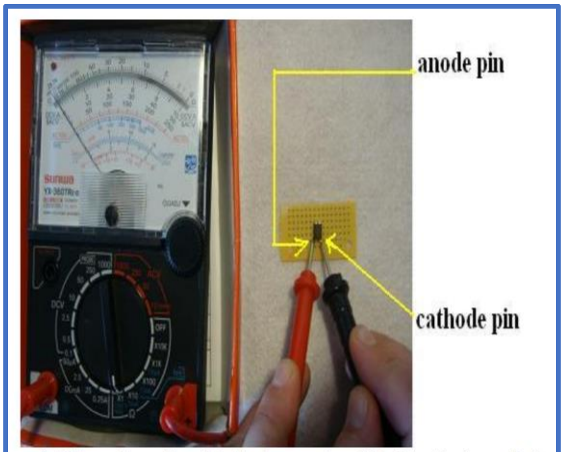


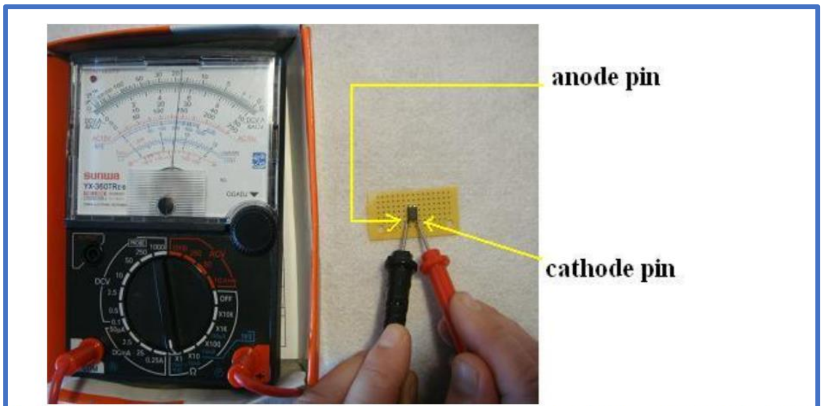
Figure 3.26: Types of opto-isolator

- Place the red test lead on the anode pin and the black test lead on the cathode pin, the reading should be infinite.
- Next place the black test lead on the anode and the red test lead on the cathode, now you should get a resistance reading that is low, typically around 20 ohms or so.





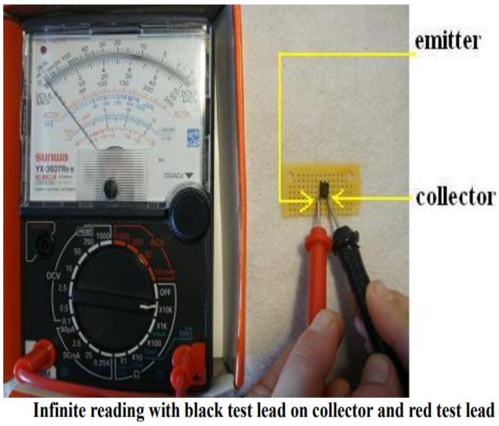
Infinite reading with red test lead on anode and black test lead on cathode.



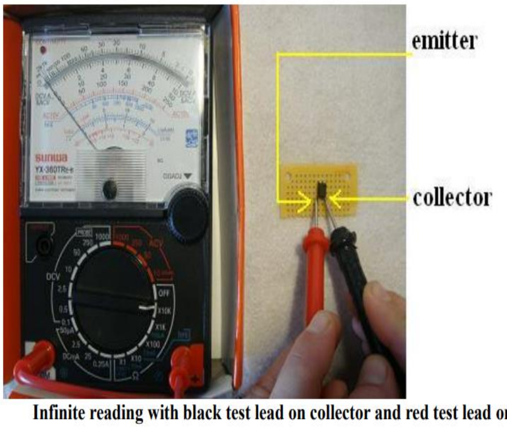
Meter indicates a low resistance reading of 17 ohms with black test lead on anode and red test lead on cathode.

Figure 3.27: Testing opto-isolator

- If you get a low resistance or 0 ohms reading in both directions the LED is considered shorted and the opto-isolator must be replaced. If you get a reading of infinity in both directions the LED is considered open and again the opto-isolator must be replaced.
- Now to test the phototransistor side of the opto-isolator. Set your analogue meter to the x10k ohm range. Place the black test lead on the collector pin and the red test lead on the emitter pin of the opt isolator, you should get a resistance reading of infinity
- Next place the red test lead on the collector and the black test lead on the emitter. You should get a large resistance reading, typically around 500k ohms or so. If you get a 0 ohms or low resistance reading in both directions the collector/emitter junction of the phototransistor is shorted and the opto- isolator must be replaced.



Infinite reading with black test lead on collector and red test lead on emitter.



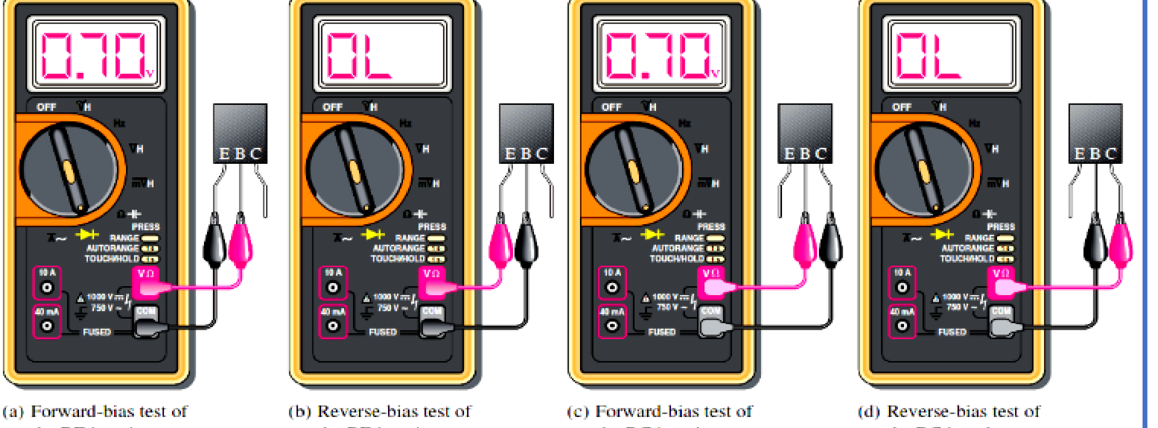
Infinite reading with black test lead on collector and red test lead on emitter.

Figure 3.28: Testing opto-isolator

3.12 Testing Transistor

3.12.1 When the Transistor Is Not Defective

In Figure (a), the red (positive) lead of the meter is connected to the base of NPN transistor and the black (negative) lead is connected to the emitter to forward-bias the base – emitter junction. If the junction is good, you will get a reading of between approximately 0.6 V and 0.8V, with 0.7V being typical for forward bias. In Figure (b), the leads are switched to reverse – bias the base – emitter junction, as shown. If the transistor is working properly, you will typically get an OL indication. The process just described is repeated for the base – collector junction as shown in Figure (c) and (d). For a PNP transistor, the polarity of the meter leads are reversed for each test.

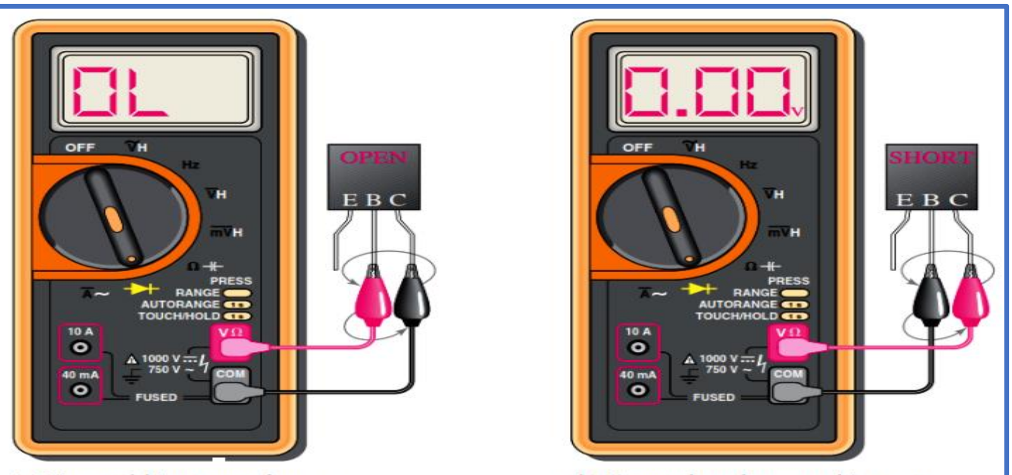


(a) Forward-bias test of the BE junction
(b) Reverse-bias test of the BE junction
(c) Forward-bias test of the BC junction
(d) Reverse-bias test of the BC junction

Figure 3.29: Testing not defective transistor using digital multimeter

3.12.2 When the Transistor Is Defective

When a transistor has failed with an open junction or internal connection, you get an open circuit voltage reading (OL) for both the forward – bias and the reverse – bias condition for that junction, as illustrated in Figure (a). If a junction is shorted, the meter reads 0V in both forward – and reverse – bias test, as indicated in part (b). Some DMMs provide a test socket on their front panel for testing a transistor for the hFE (β_{DC}) value. If the transistor is inserted improperly in the socket or if it not functioning properly due to a faulty junction or internal connection, a typical meter will flash a 1 or display a 0. if a value of β_{DC} within the normal range for the specific transistor is displayed, the device is functioning properly. The normal range of β_{DC} can be determined from the datasheet.



(a) Forward-bias test and reverse-bias test give the same reading (OL is typical) for an open

(b) Forward- and reverse-bias tests for a shorted junction give the same 0 V reading.

Figure 3.30: Testing defective transistor using digital multimeter

3.13 Testing Silicon Controlled Rectifier (SCR)

1. Keep the multimeter in ohm mode.
2. Connect the positive lead of multimeter to an anode of SCR and negative lead of multimeter of cathode lead.
3. As per step above, SCR is in forward blocking mode. The SCR does not conduct. In this condition, the SCR must show infinite resistance and there will be no continuity buzzer. If the resistance of the SCR is high then the SCR is OK as per this test.
4. If the SCR shows continuity, the **SCR is short circuit** and SCR is defective.

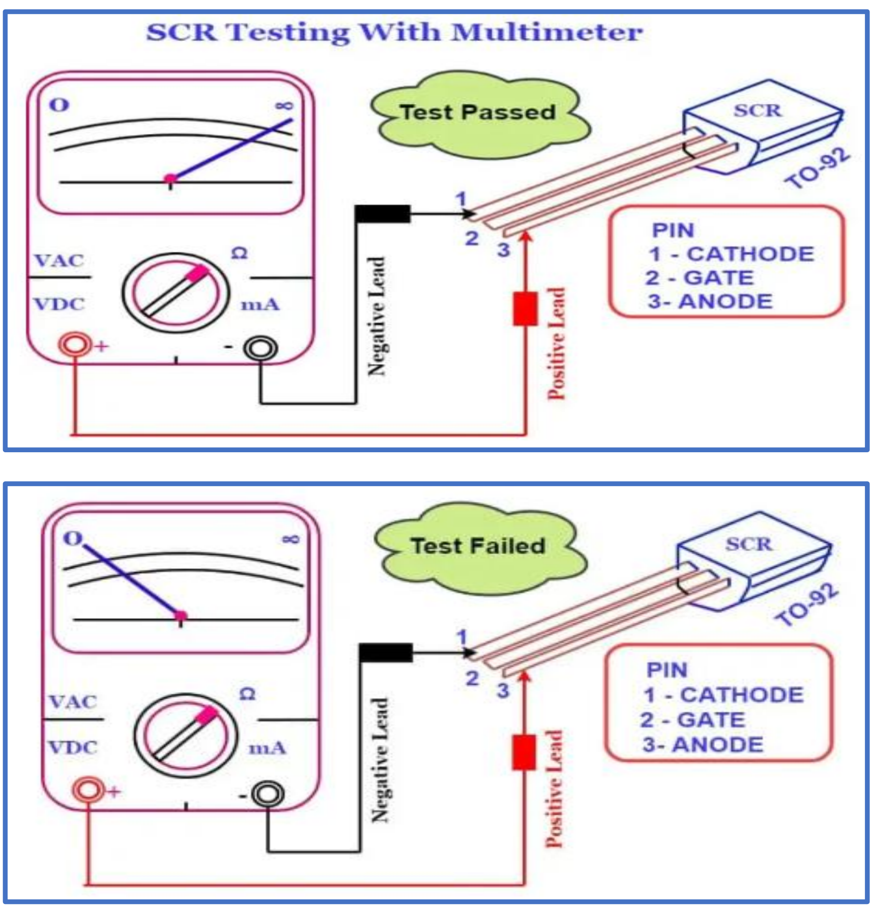


Figure 3.31: Testing SCR using multimeter

- Connect the positive lead of the multimeter to the anode terminal and the negative lead of the multimeter to the cathode of SCR.
- Now, connect the gate through a wire to the anode. If you recall this is the **forward conduction mode** of the SCR. The SCR must be turn on. The **resistance** measured across anode and cathode should be zero. If resistance is zero, it means SCR is in conducting mode. We can say SCR is OK.
- When the gate lead is removed from the anode, conduction may stop or continue depending on whether the ohmmeter is supplying enough gate current to keep the device above its holding current level. If SCR keeps conducting then it is the latching condition of SCR.

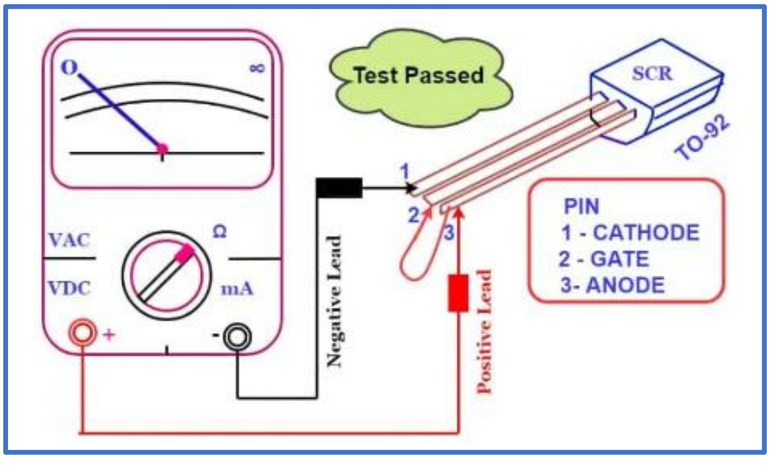


Figure 3.32: Testing SCR using multimeter

3.14 Testing TRIAC

- The TRIAC is 5 layer, 3 terminal Power semiconductor device.
- It has a pair of phase-controlled SCR connected in an inverse parallel manner on the same chip.
- It is a bidirectional device, which means it can conduct current in both directions.

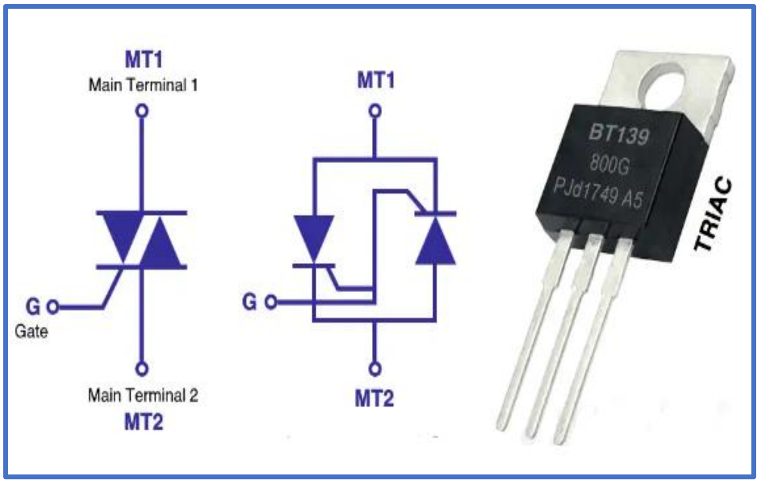


Figure 3.33: Types of TRIAC

3.14.1 TRIAC in Off State

The below steps explains how to test TRIAC with a multimeter.

1. Select the multimeter setting on resistance mode.
2. Find out the polarity of the ohmmeter lead using P-N junction diode. When positive lead is connected to the anode and negative lead is connected to cathode shows continuity.
3. The TRIAC remains in its off state when the positive voltage is applied at MT1 and the negative voltage is applied at MT2 with gate current zero.
4. In a similar way, the TRIAC remains in its off state when the positive voltage is applied at MT2 and the negative voltage is applied at MT1 with gate current zero.

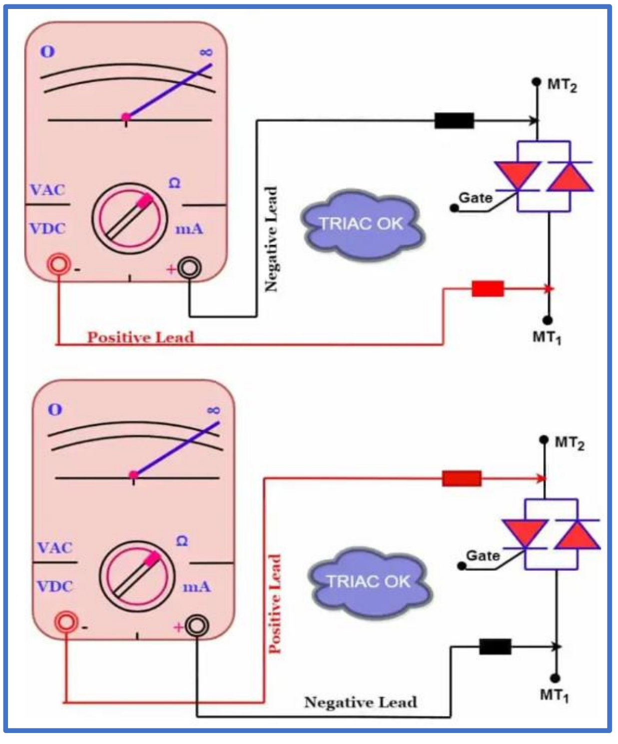


Figure 3.34: Testing TRIAC in off state

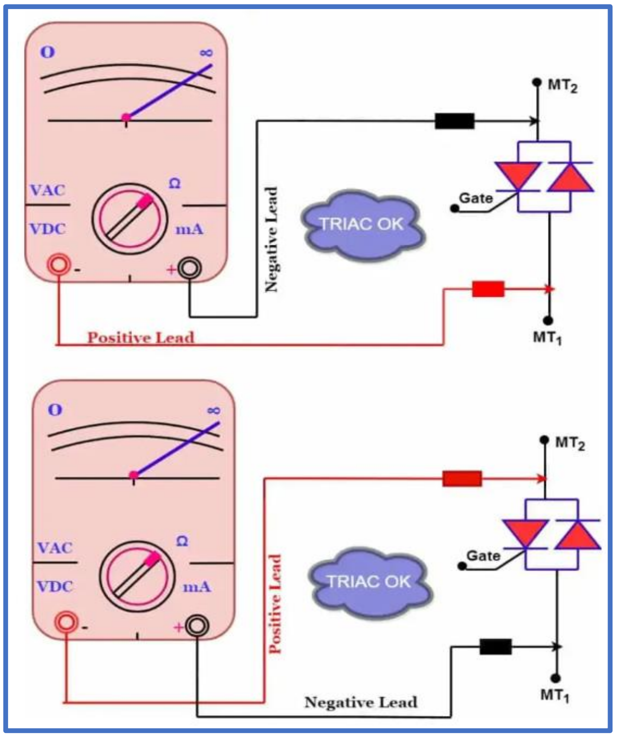


Figure 3.34: Testing defective TRIAC

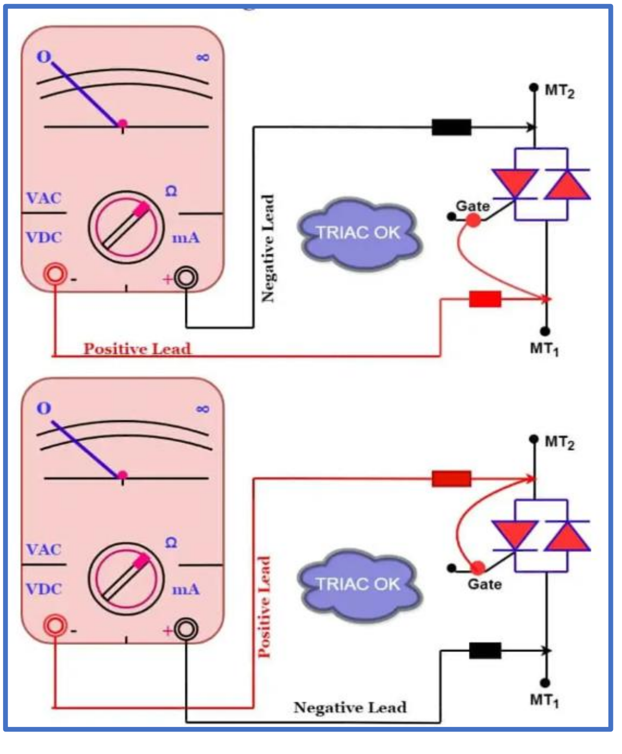


Figure 3.35: Testing good condition TRIAC

3.14.1 TRIAC in defective

5. In steps No. 2 & 3 of TRIAC testing, the ohmmeter should indicate no continuity through the TRIAC. It means TRIAC offers very high resistance.

3.14.2 TRIAC in good condition

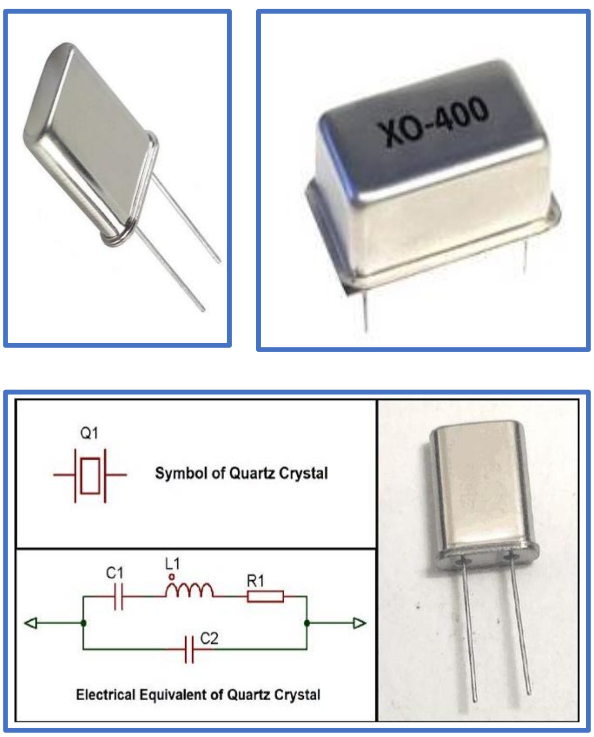
6. Now, if the gate of the TRIAC gets positive voltage the device turns on either MT1 is positive with respect to MT_2 or MT_2 is positive with respect to MT_1. This can be done by connecting the gate of TRIAC positive lead(It may be MT_1 or MT_2 terminal, depending on which terminal has positive voltage through ohmmeter.
7. As per step above, the TRIAC must turn on and must show very low resistance or continuity between MT_1 and MT_2. If TRIAC shows continuity TRIAC under test is OK
8. If TRIAC does not turn on as per step 7, TRIAC offers very high resistance and TRIAC is defective.

3.15 Testing Crystal Oscillator

The crystal oscillator circuit 's function is based on the inverse piezoelectric effect, which states that a mechanical deformation may be induced by applying an electric field across particular materials.

Therefore, the vibrating crystal's mechanical resonance is constructed of a piezoelectric substance to generate an electrical signal at a specific frequency.

Microprocessors and microcontrollers often use a crystal oscillator with a frequency of 8 MHz.



3.36. Types of crystal oscillator

3.15 Testing Crystal Oscillator

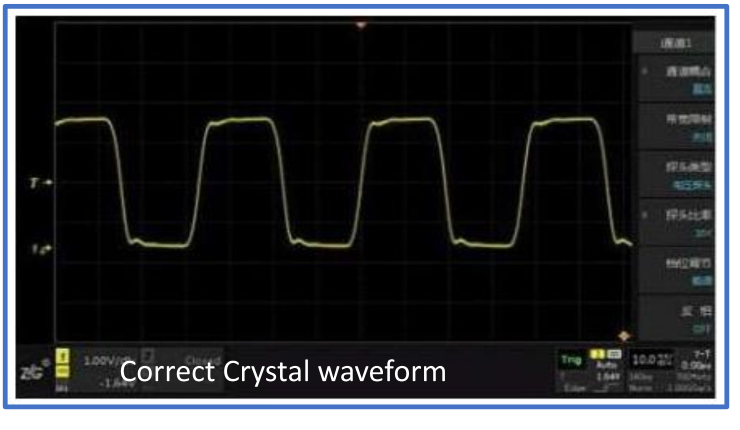
3.15.1 The correct way to test the crystal oscillator by oscilloscope

In order to improve signal fidelity, you should also use the grounding spring that comes standard with the probe instead of grounding the alligator clip to ground.

The crystal oscillator is sensitive to the capacitive load, and the probe capacitance is relatively large, which is equivalent to a very heavy load connected in parallel in the crystal oscillator circuit, which easily leads to the circuit stop the vibration and get the correct measurement results.

When performing the crystal test, it is necessary to ensure sufficient bandwidth and a small input capacitance.

We can definitely test the waveform of 10M crystal with 200M oscilloscope , during the test , adjusts to the probe gear position to ×10. At this time, the probe bandwidth is 250MHz and the input capacitance is 13pF±5pF.



3.37. Testing crystal oscillator using oscilloscope

3.15.2 The correct way to test the crystal oscillator by Digital Multimeter

If the crystal is 8MHz the meter should have Hz range to be able to check that frequency. Assuming the readout of the crystal is 2.5 MHz, so the crystal is not functioning well.

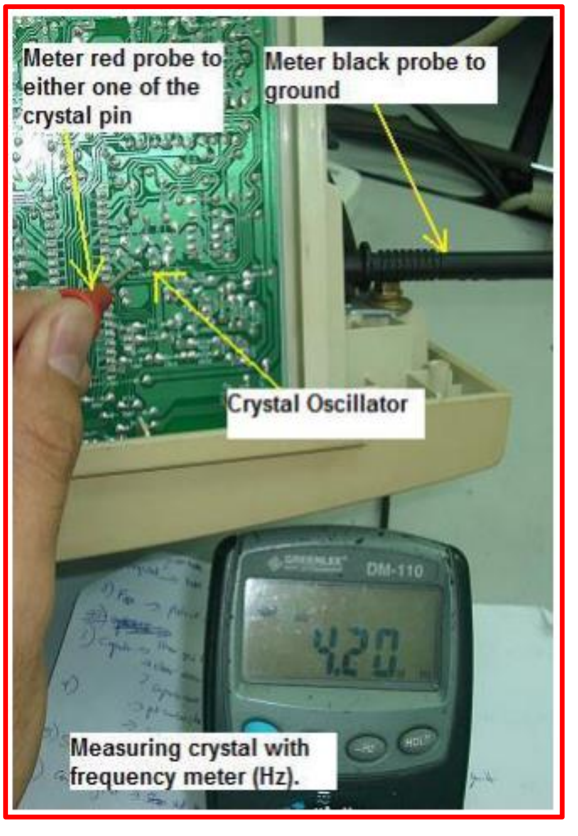


Figure 3.38. Testing crystal oscillator using digital multimeter

3.15.3 The correct way to test the crystal oscillator by Crystal Checker

Normally the crystal is places in the feedback network of transistor. If it oscillator and the LED is lightening up, this means that the Crystal is functioning. If the Crystal doesn't work, the LED will goes OFF. Instead of using LED as indicator, some other expensive crystal checker uses a panel meter to indicate if the crystal is functioning or not. If you search crystal information on the internet.

Figure 3.39: Testing crystal oscillator using crystal checker

3.16 Testing Relay

An electromagnetic relay is basically a switch operated by magnetic force. This magnetic force generated by flow current through a coil in the relay. The relay opens and closes a circuit when current through the coil is started at stopped.

The specification of relay normally are 5V,12V, 18V with amperes rating too

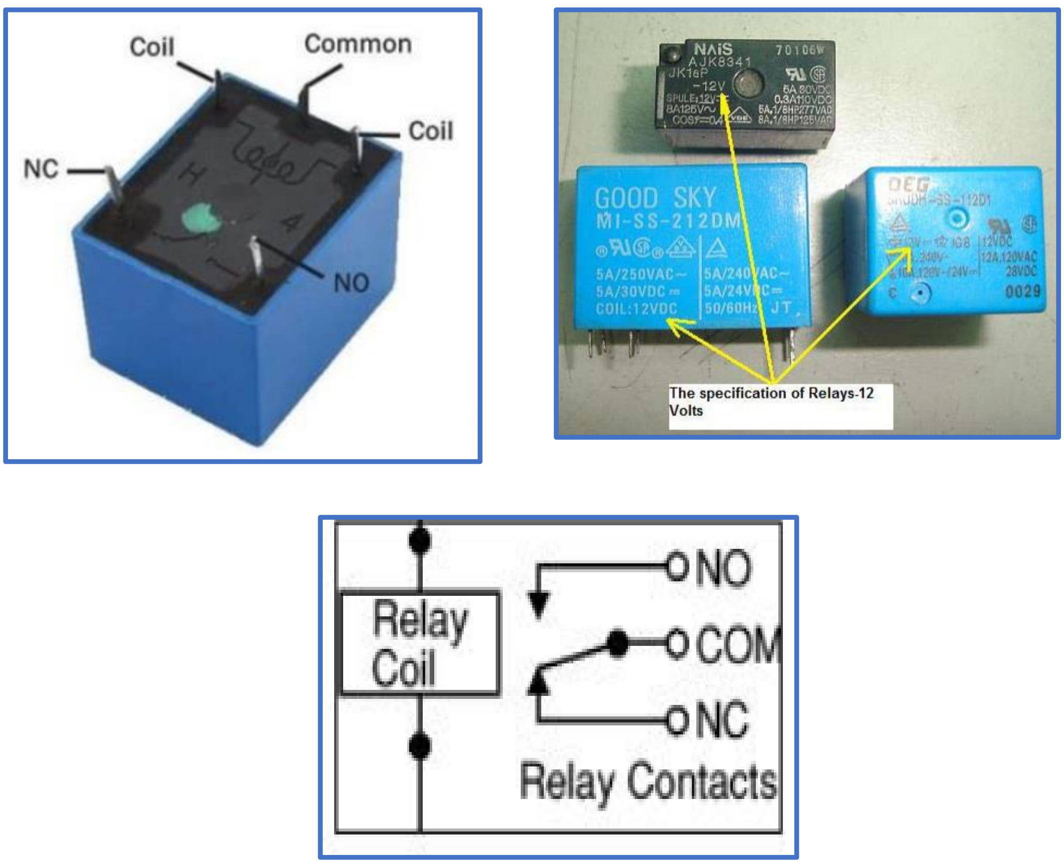


Figure 3.40: Types of relay

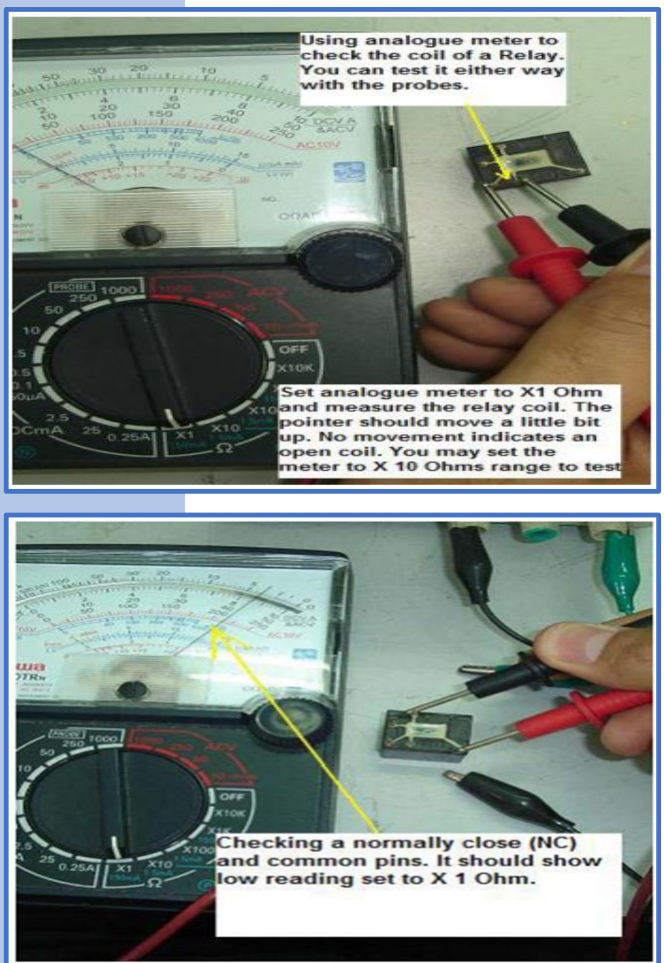
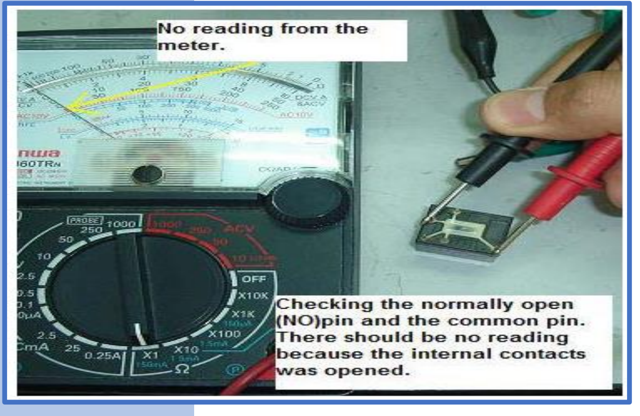


Figure 3.41: Testing relay using analogue multimeter of Normally Close (NC)

Put the multimeter in Resistance Measurement mode (Ohmmeter) in minimum range (200Ω or similar value).

Connect the lead across the coil terminals of the relay. For a normal coil, the multimeter should read anywhere between 40Ω to 120Ω. If the coil is damaged i.e., it is open, the meter shows out of range

Put the multimeter in continuity mode and while the relay is not activated, connect the leads of the multimeter between the COM and NC terminals. The multimeter should start the buzzer if the relay contacts are okay.



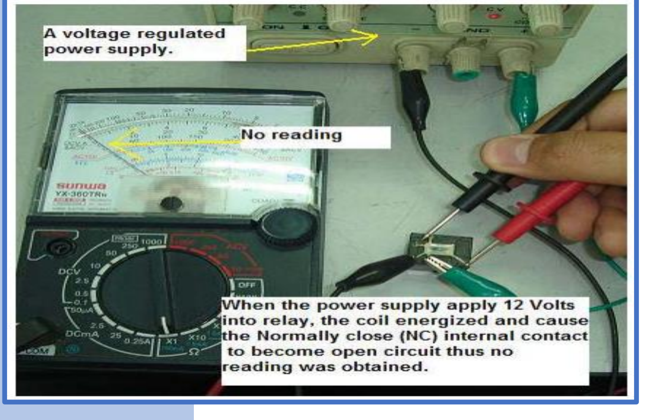


Figure 3.42: Testing relay using analogue multimeter of Normally Open (NO)

Now, energize the relay and test for continuity between COM and NO terminals. If the buzzer is activated in both cases, then the relay is well and good. But if any test fails, then it might be a faulty relay.

Similarly when placed the probe across the Common (COM) and the Normally Open (NC) terminals and hears the “tic” sound, you will see that the pointer will move up from the infinity to zero Ohms (indicating close circuit).

REVIEW QUESTION

1. The rating of resistor is measured in………….and ……………..
2. The rating of an electrolytic capacitor is measured in ………………….and …………..
3. While checking a capacitor with a multimeter, if the pointer deflects and remain there that means the capacitor is …………….circuit.
4. Transistor is ………………………. component.
5. Inductor is ……………………….. component.
6. An electronic components which can process the signals are called ………………………….. components.
7. An open resistor has ……………. current through it.
8. A shorted resistor has ……………… voltage across it.
9. Zener diodes are used as reference ………………….elements.
10. Zener diode is used as a ………………..

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