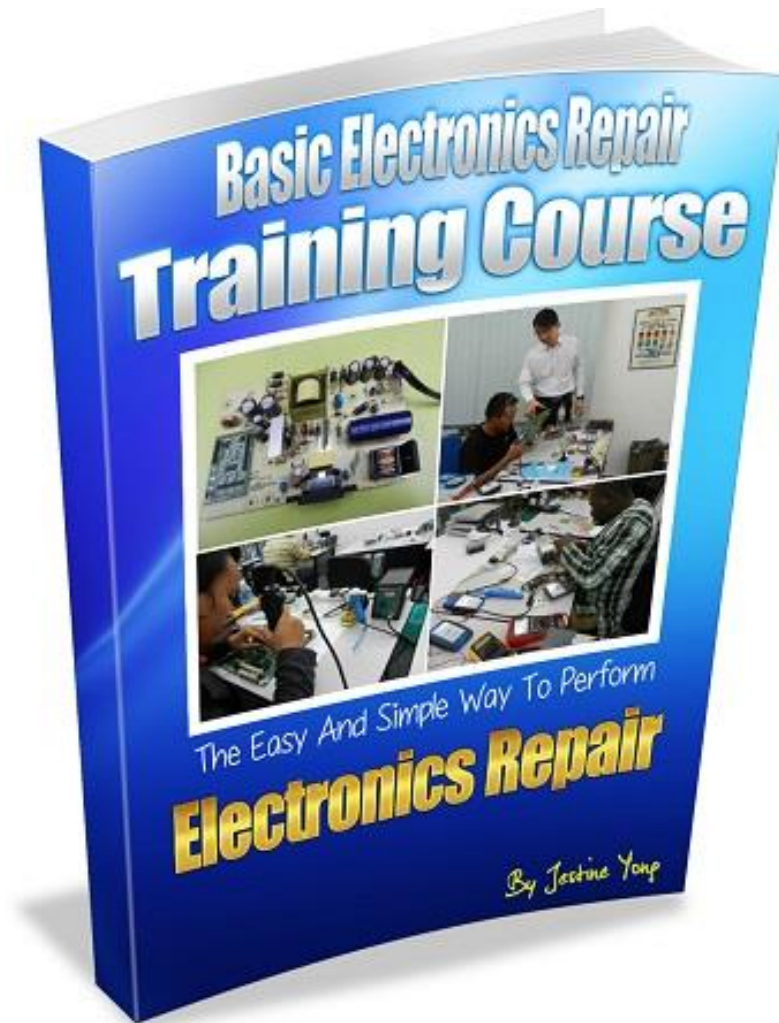


Basic Electronics Repair Training Course



Brought to you by Jestine Yong

<http://www.TestingElectronicComponents.com>

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This training course is dedicated to my
wonderful wife Michelle. Without
her loving encouragement and support,
this material would still have been possible-
but not nearly worth the trouble.

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Safety First



Whenever you're working on any electronic equipment, your own safety has to come first. Every electronic technician must always take safety precautions before he or she starts work. Electricity must be handled properly, or else it can injure or cause fatalities. Here are some basic steps that show you how to avoid accidents from occurring.

1. *Electrical Shock*

Once you open up a set cover, you're actually exposing yourself to the threat of electric shock. Always keep in mind that safety has to come first. A serious shock may stop your heart and if a large electric current flows through your body, you will receive serious burns. Here are some rules, which should help you to avoid electricity hazards:

- a) Always turn off the equipment and unplug it before you begin to work.
- b) If you have to run tests while the equipment is operating, turn the equipment on, make your test carefully, and then turn the equipment off again.
- c) Wear rubber bottom shoes or sneakers.
- d) Try to do the work with one hand, while keeping the other in your pocket. That keeps the possible current paths away from the heart.
- e) Don't attempt repair work when you are tired or rushed.
- f) Always assume that all the parts in the power supply are "**HOT**".
- g) Use only plastic screwdriver for shock protection during service operation.

2. ***Discharging Switch Mode Power Supply (SMPS) Capacitors***

Most SMPS have a resistor to drain the charge in the main filter capacitor. But some resistors may fail and the capacitor can hold this charge even after you have turned off the equipment. This capacitor has a range of about 150uf to 330uf at 400 working voltage.

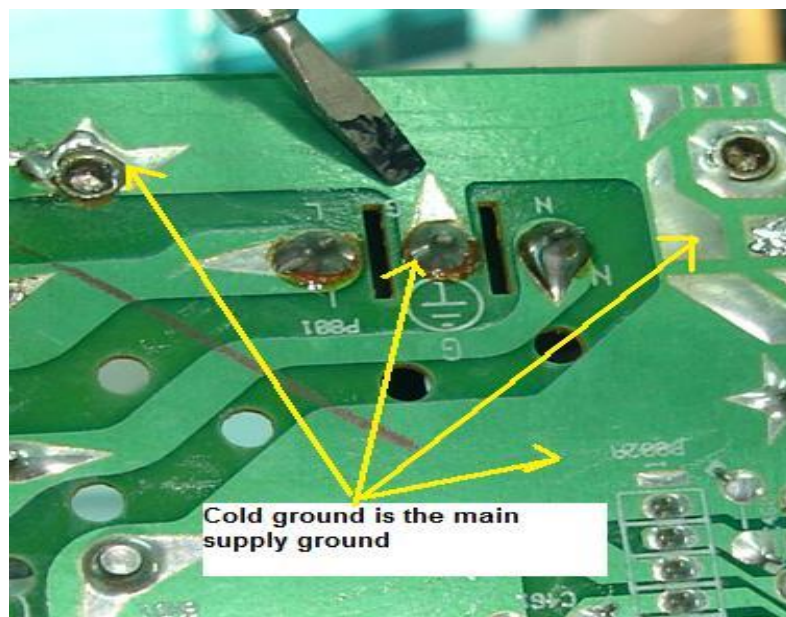
Before you start to work on a power supply, always turn off the power and discharge the capacitor. You can do this by placing a resistor across the two legs of the capacitor. The resistor value can be around 2.2 to 4.7 kilo ohms 10watt. It takes only a few seconds to fully discharge a capacitor. Double-check the capacitor with a voltmeter after every discharge. I will cover more details in the capacitor topic on how to discharge capacitors.

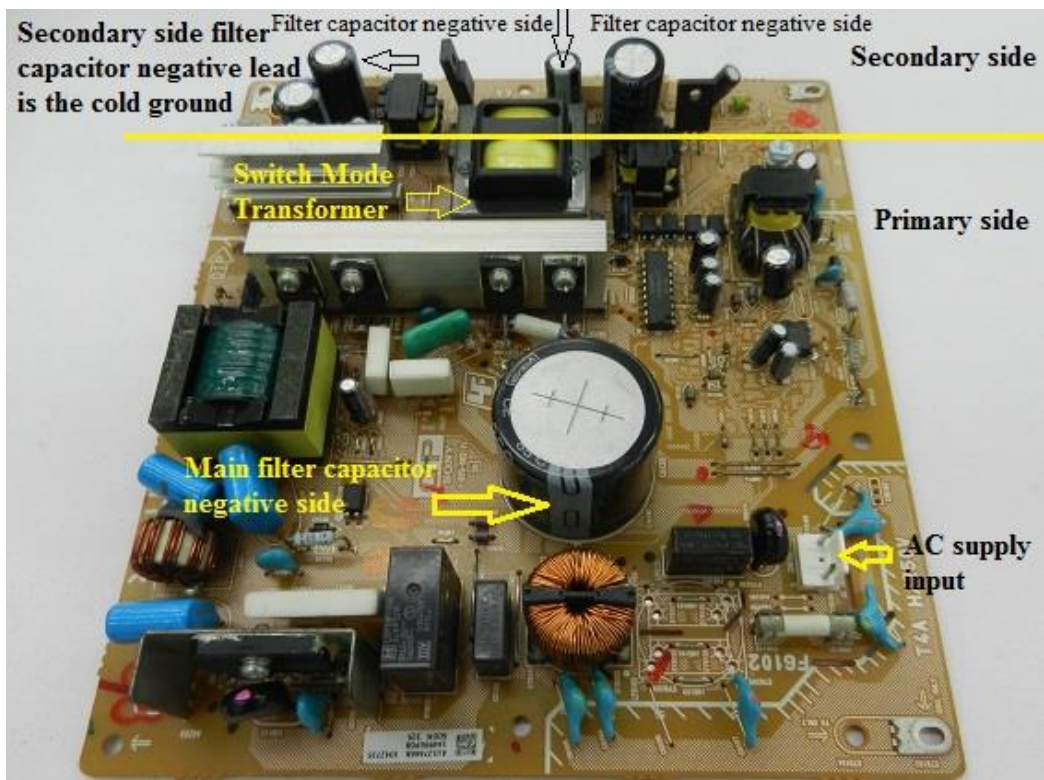
NOTE / WARNING:

Do not discharge capacitor with screwdriver because: -

- i. It may melt the tip of the screwdriver.
- ii. It will damage the capacitor and its terminal.
- iii. If we are too near to the point of discharge, the heavy spark generated may cause injury to our eyes.

3. ***Hot Ground Problem***





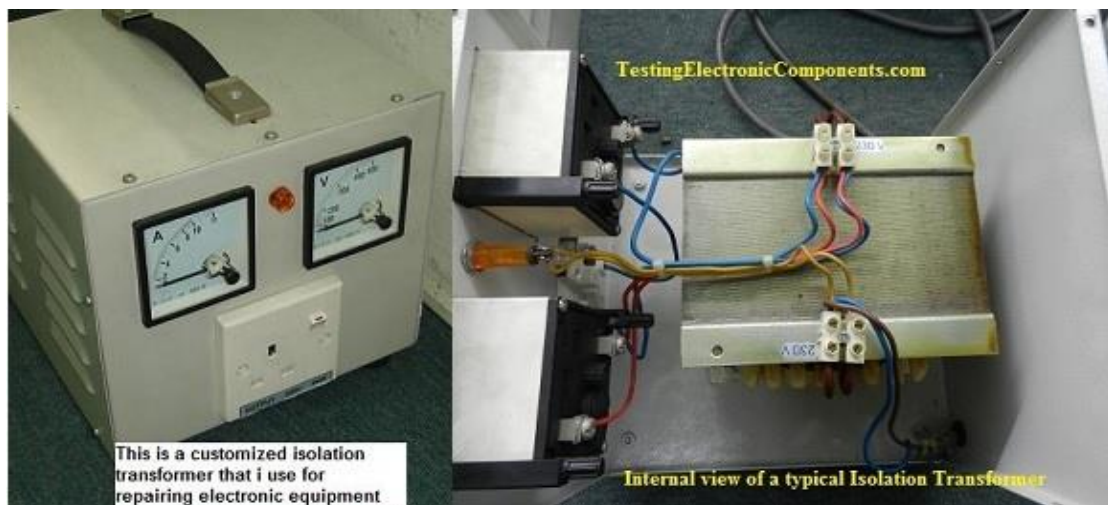
Modern equipment consists of two grounds, one of which is a “hot” ground while the other is a “cold” ground or earth ground. **Hot ground is in the primary side of a switch mode power supply** while the cold ground is the equipment ground and located in the secondary side. Both grounds are separated by the switch mode transformer.

Be careful when taking voltage measurements around these grounds. For example, if you want to check the primary circuit of a power supply with power On, always ground your meter’s black probe to the hot ground (Main filter capacitor negative side/lead)-see the above photo. If you want to check the secondary side then connect the meter’s black probe to the cold ground.

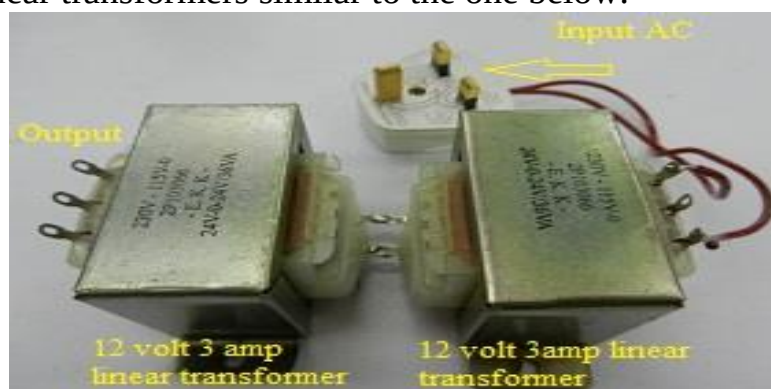
If you measure the primary side DC voltage and the meter’s black probe you connected to secondary side cold ground or if you measure the secondary side DC voltage but the meter’s black probe you connected to primary side hot ground, the result of voltage measurement might not be correct and it may destroy your meter.

Note: More information about measuring DC voltage using a multimeter will be covered in the following chapter.

4. Isolation Transformer



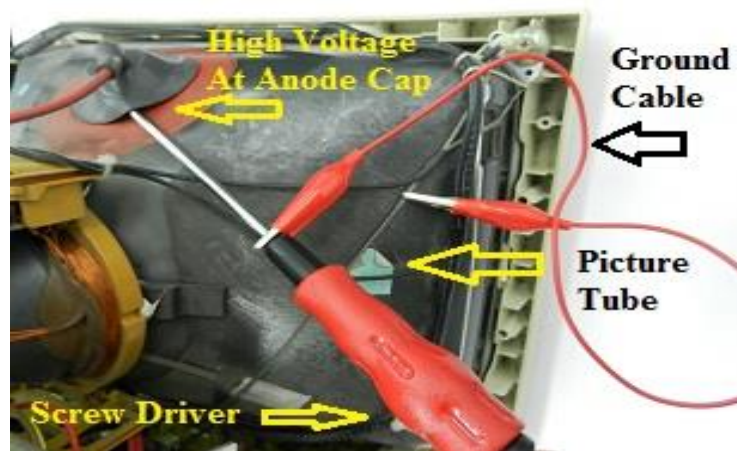
When servicing any electronic equipment, always use an isolation transformer to protect yourself from an electrical shock. During servicing, the isolation transformer is connected between the equipment and ac power line. An isolation transformer is a transformer that has a 1:1 turn ratio to provide the standard line voltage at the secondary outlet. This means that it does not change the voltage. The transformer still produces 230V AC at its outputs, but both sides of this AC lines are independent of ground. If you were to accidentally touch one of these outputs, you would be protected. The isolation transformer must be rated to handle the power of any equipment connected to it. Typical ratings are 250 to 500W. If you go to Google Images and type “Isolation transformer schematic” you would be able to see the diagram and how you can build one using two identity linear transformers similar to the one below:



Note: A variable transformer or variacs is not an isolation transformer. If you would like to use an oscilloscope to check on the primary side of the switch mode power supply, an isolation transformer is a must otherwise connecting the scope black probe to hot ground will cause the room ELCB to trip.

5. ***Discharging the Cathode Ray Tube (CRT) Anode***

The CRT of a monitor and TV can hold a dangerous charge, even if the monitor and TV have not been used for several days. All CRTs have graphite coating on the internal and external surfaces of the glass bell. This conductive graphite coating is commonly known as aquadag coating and it forms the two plates of a high voltage filter capacitor using the glass in between as dielectric. The external coating is always connected to the monitor and TV chassis ground by a spring arrangement around the CRT. This high voltage filter capacitor has very low leakage. Before removing a CRT, ensure that you discharge this capacitor in order to prevent shocks or serious injuries.



Discharging a picture tube

6. ***High Voltage***

Monitors and TVs have sections that use very high DC voltages. The high voltage is needed for the CRT to attract the electron beam to the phosphor. This high voltage could be as low as 12,000 volt in a monochrome monitor or as high as 30,000 volt in large colour monitor. Flyback Transformer is the part that is used to generate the high voltage. The high voltage circuit inside a monitor or TV can give you a dangerous electric shock and causes you to jerk violently. You could cut yourself by accidentally knocking a limb on the sharp chassis edges. Be familiar with the high voltage circuits before you work on any high voltage equipment.

7. ***X-Radiation***

An X-ray is a form of radiation produced when a beam of electrons strikes some material at a relatively high speed. The only source of X-ray in a modern monitor or TV is from the CRT. Prolonged exposure to X-rays can be harmful. However, the CRT does not emit measurable X-rays if the high voltage is at the high voltage adjustment value only. When high voltage is excessive, only then are X-rays capable of penetrating the shell of the CRT, including the lead in glass material.

Test the brightness and use a high voltage probe to monitor the high voltage each time a monitor or TV comes in for repair. When the brightness is raised, usually the high voltage will go-down, and when brightness is reduced the high voltage will go-up. When troubleshooting a monitor or TV with excessively high voltage, avoid being unnecessarily close to the set. Do not operate the monitor or TV for longer than it is necessary to locate the cause of excessive voltage. To ensure continuous X-ray protection, replace the CRT with one that is of same or equivalent type as the original.

8. *Wearing Safety Goggles*

If you would like to repair CRT TVs or Monitors then you need to wear a safety goggle. The CRT has a complete vacuum inside. It must be handled carefully and safely. Always wear goggles, to protect the eyes from flying glass, in the event of an implosion when removing an old tube from the set and installing a replacement. Do not lift the CRT by the neck; instead hold the CRT with both hands on the heavy glass front of the tube. Also be sure to place the CRT facing downwards on a soft surface.



Typical Safety Goggles

9. *Electrostatically Sensitive Devices (ESD)*

Integrated circuits (IC) & some field-effect transistors are examples of ESD devices. These components can be easily damaged by static electricity. There are several techniques which can reduce the incidence of component damage, caused by static electricity.

- a) Immediately, before handling any ESD devices drain the electrostatic charge from your body by touching a known earth ground.
- b) Store ESD devices in conductive foam pad until installation in circuit.
- c) Wear a grounding strap, attached to your wrist.



A Typical Wrist Strap

d) Use only a grounded tip soldering iron to solder or desolder ESD devices. (Some suggest using a battery powered soldering iron when working on ESD circuits).

10. **Fire**

Before returning the equipment to the user, every reasonable precaution is taken to avoid fire hazards. Be sure to use only direct replacements and not one that defeats some safety measure. For example, the fuses in your equipment are carefully designed. Fuses must be replaced only with the same size, type and ratings. Should you install a fuse that is too large than the original rating, chances are that the equipment will be flammable.

11. **Lifting**

Some equipment like TVs, Hi-fis or monitors can easily weigh around 15 to 30 kilograms. Many problems arise when lifting this equipment from the floor. Wrong posture when lifting equipment may cause acute back pain. The right way to lift is keep your back straight and upright, and use your legs to supply the lifting power.

12. **Ventilation**

Be sure that your work place has good ventilation. Prolonged exposure or excessive inhalation of vapours from chemical spray and fumes from lead may cause damage to your nervous system or body.

13. **Laser Warning Labels**



If you are troubleshooting DVD, VCD, laser printer and other laser-related products, you will notice a laser warning label on or near the laser head assembly. Do not stare at the laser beam at any time. Always avoid directly exposing your eyes to the beam. Prolonged exposure of laser beam to the eyes may cause eye injury or loss of sight. Do not attempt to adjust the laser gain controls by any methods, other than those described in the service manual. Incorrect adjustment can increase the laser radiation beyond acceptable limits. You have to use a laser power meter to confirm the existence of a laser beam.

Understanding Analogue and Digital Multimeters



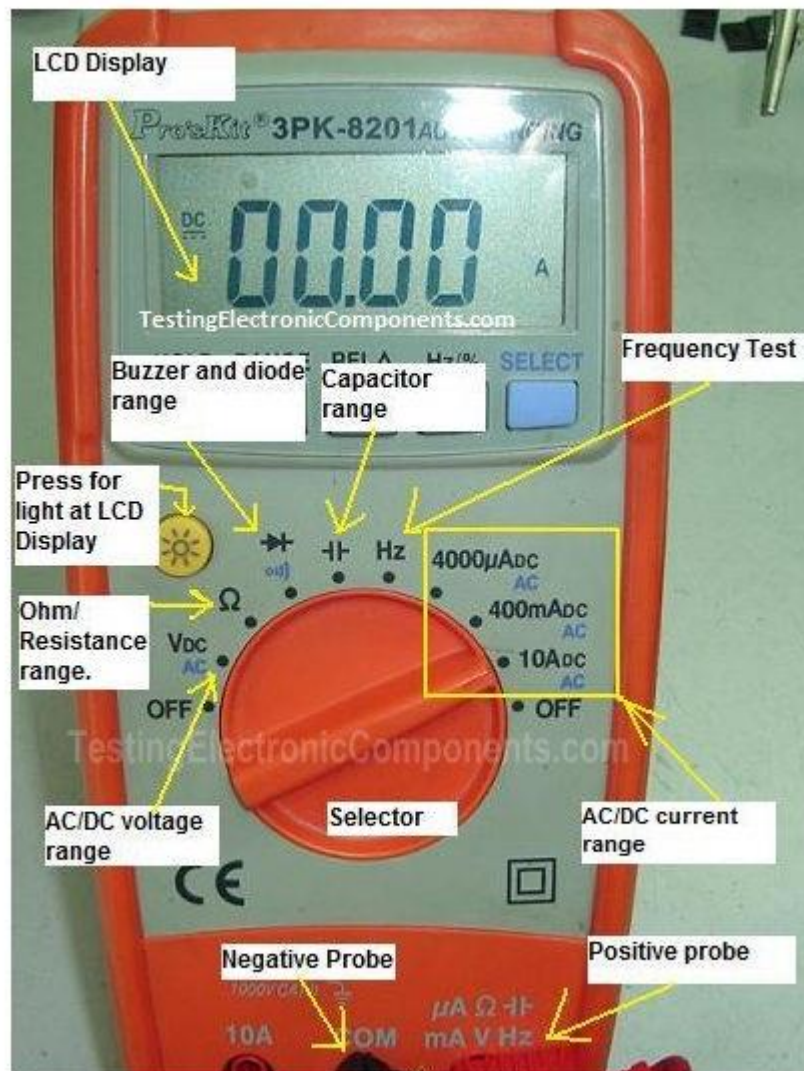
Multimeters (analogue and digital) are one way in which you can “see” what’s going on in an electrical circuit. Voltmeters, ohmmeters, and ammeters are essential in all electric work. Multimeters can go by many

A multimeter is as basic to an electronic technician as a brush is to a painter. In this chapter, you will learn the features of analogue and digital multimeters and in the following chapters you will learn how to measure electrical voltage, current, and resistance. Learning how to connect a meter and read these electrical circuit values is a fundamental skill that every electronics repairer must know in order to successfully perform basic tests, troubleshooting and repairing.

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First, just before you make any measurement you must know what you are checking:

- If you are measuring voltage then select the AC (10V, 50V, 250V, or 1000V) or DC (0.5V, 2.5V, 10V, 50V, 250V, or 1000V) range.
- If you are measuring the resistance, select the Ohms range ($R \times 1\Omega$, $R \times 10\Omega$, $R \times 100\Omega$, $R \times 1k\Omega$ or $R \times 10k\Omega$).
- If you are measuring the current then select the appropriate current range (DCmA) as shown in the photo in the previous page.



The black test lead plugs into the meter terminal marked, $\ominus$ “Com”, or Common

Red test lead plugs into meter terminal marked $\oplus$ or V- Ω -mA.

Now that you know the very basics of a multimeter, I’ll describe how you can use the meters (analogue and digital) to take voltage, resistance, and current readings in the next few chapters.

Precaution While Using Multimeter

Don't give any shocks or vibrations to the multimeter, especially analogue meters, which have a delicate meter movement. Sometimes even a slight fall from the repair bench to the floor could cause the digital meter LCD panel to crack!

Even if after the zero ohm adjuster is turned to maximum, the pointer still does not reach zero, replace the batteries. Dead batteries must be immediately removed from the meter, otherwise components inside will get corroded by leakage of the battery electrolyte.

When you are not certain of the voltage or current value, measurement is always started on the **highest range** to know its approximate value. Lower ranges may be selected accordingly.

Read and understand the manual that comes with your multimeter.

Don't replace any meter fuse with one having a higher current rating or slower response time. In other word, do not replace the fast blow fuse with a slow blow fuse. Go to the fuse chapter to know more fuses.

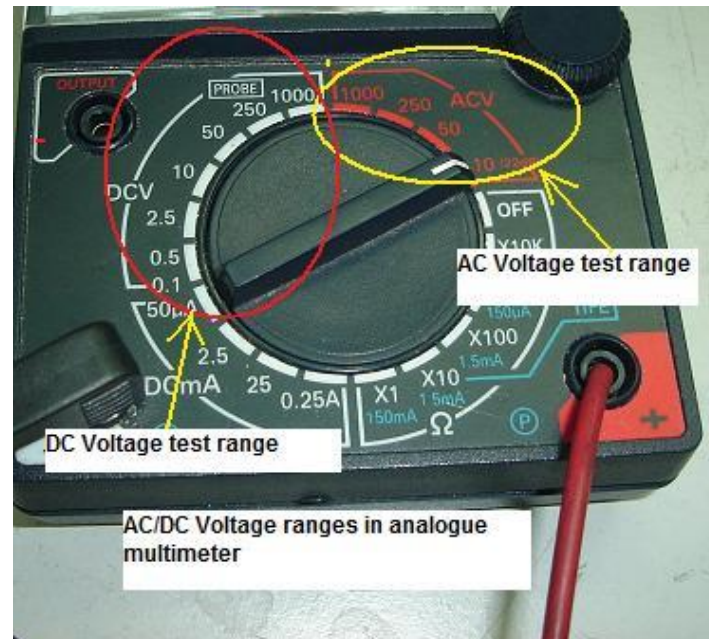
Don't take any resistance (Ohm) measurements in a circuit that has any power applied otherwise it may cause the components inside the meter to blow.

Don't connect your ammeter (meter set to current range) directly across a power source, such as a battery or power supply output. An ammeter must always be connected in series with the load.

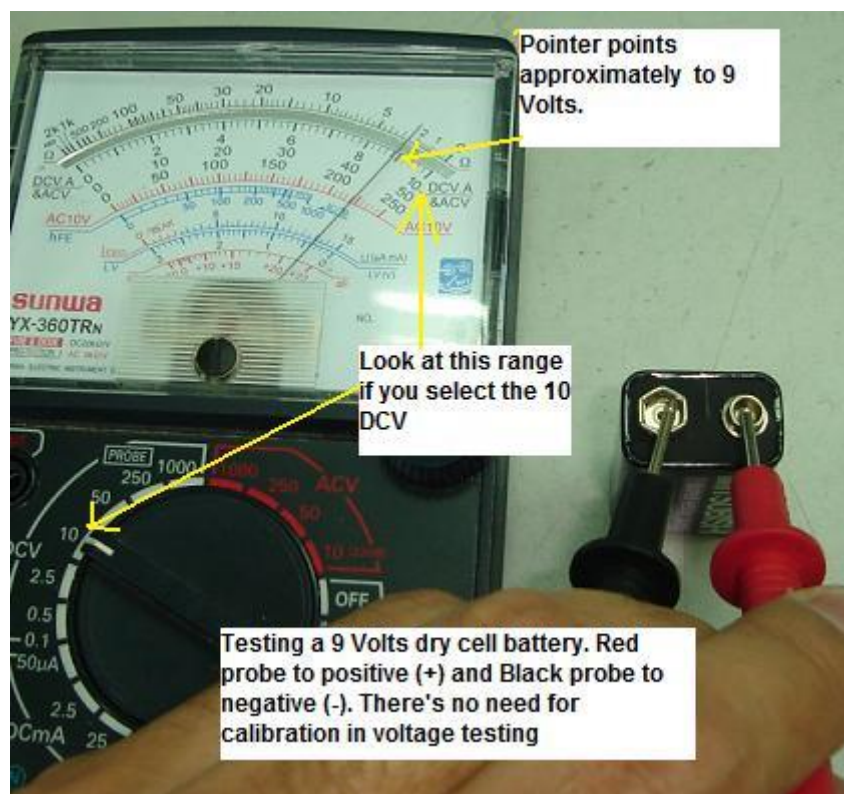
Always treat all electrical circuits with respect! Knowing what you're doing is important. If you don't know what you're doing in areas that could prove dangerous, such as in 240 volt household circuits, then don't do it! Get more information or just ask a repair friend to show you the right way to test electrical circuits.

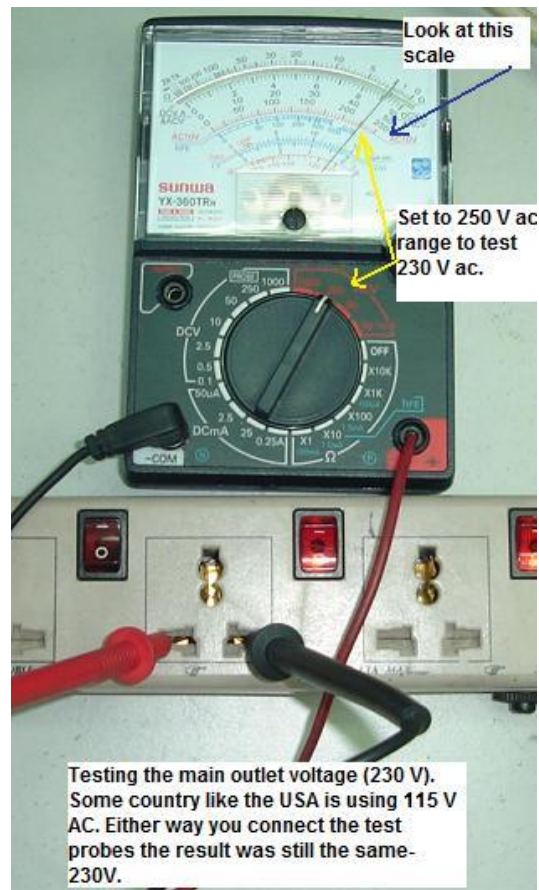
Lastly, there are many differences among various makes of digital and analogue multimeters. Always study the instruction booklet that comes with a particular meter to ensure you are using it properly and safely.

How To Test AC/DC Voltage

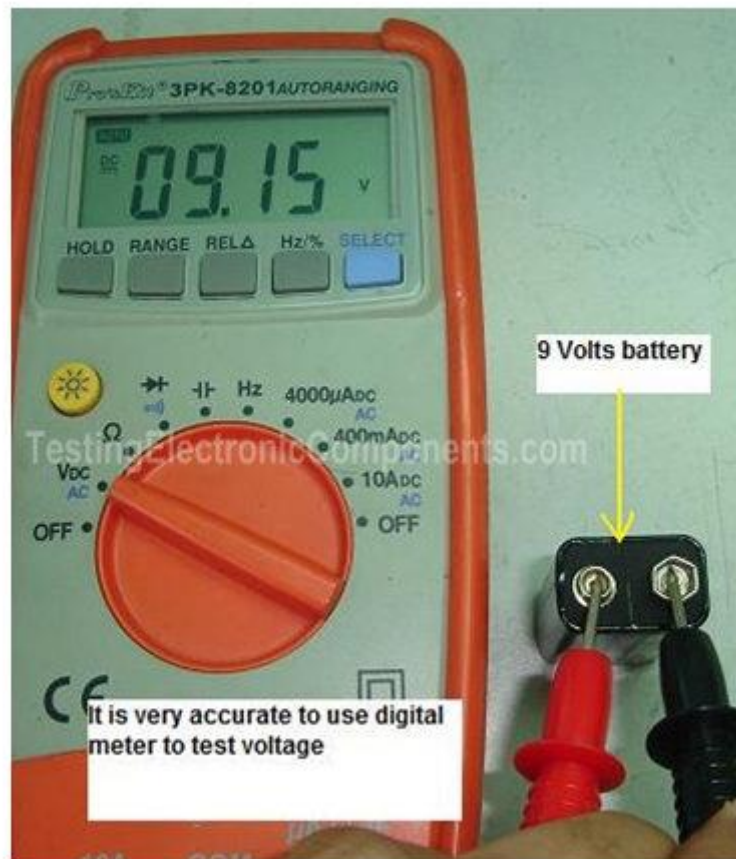


Analogue multimeters can measure both DC voltages (marked DCV or Vdc) and AC voltages (marked ACV or Vac). It is important to remember that all voltage (either AC or DC) must be measured in parallel with the desired circuit or component. Never interrupt a circuit and attempt to measure voltage in series with other components. Any such reading would be meaningless, and your circuit may not even function. If you are unsure of what range to use, start with **the largest range to prevent possible damage to the meter**. To check the 9 Volt batteries, I've selected the 10 DCV range as shown below.





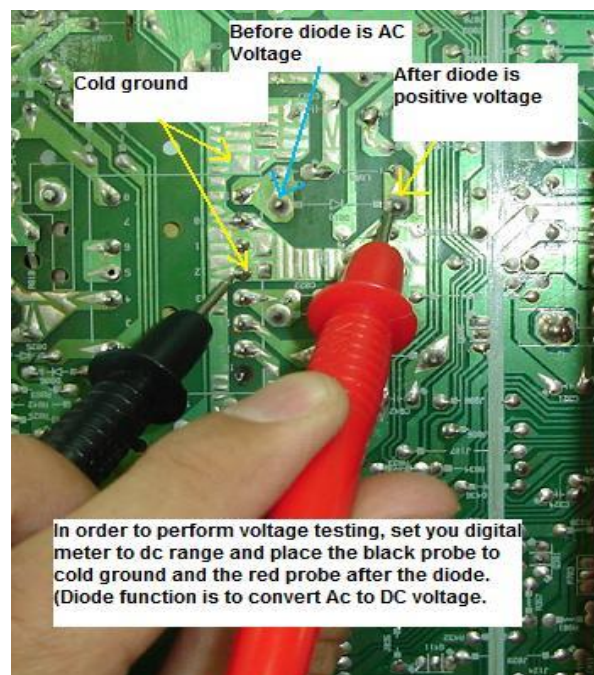
In order to accurately test AC and DC voltage, I only use the digital meter as it shows more precise reading than the analogue meter. Set your multimeter to its appropriate function (DCV or ACV), then select the proper range. Note, **an auto ranging digital meter will select its own range**. Place your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

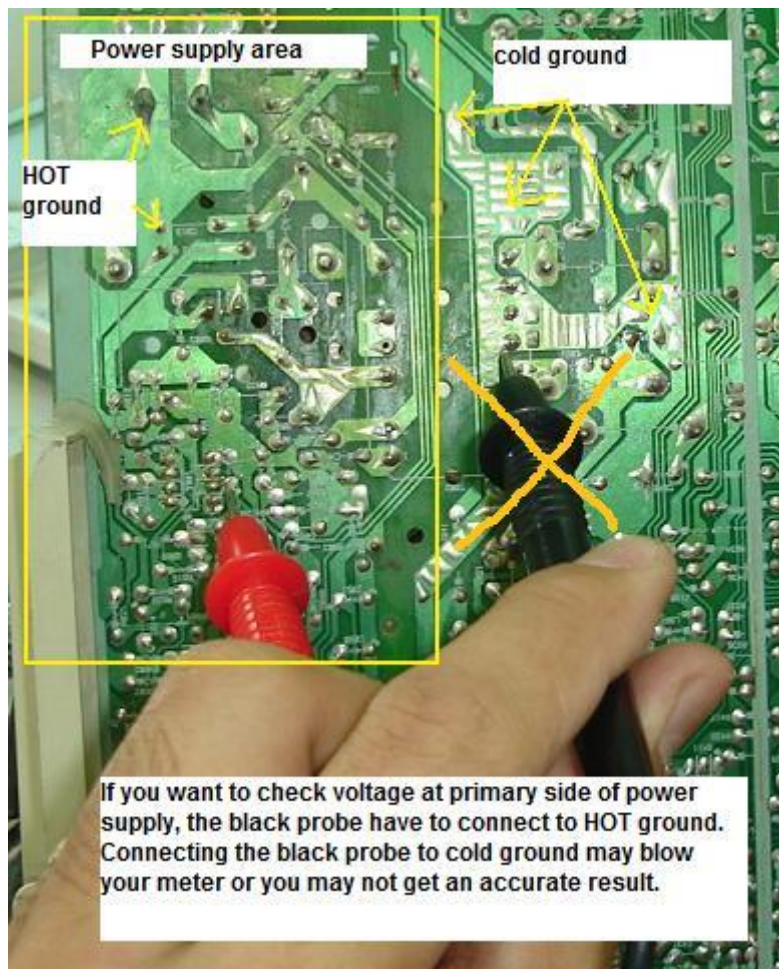
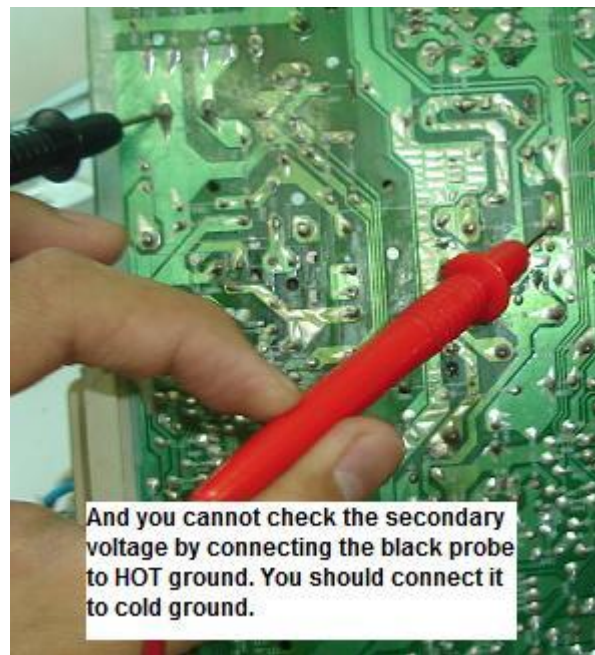




How to take voltage measurement in electronic equipment

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







Warning: A switch mode power supply has a primary and secondary section. In order to check secondary voltage the meter's black probe has to connect to cold ground (chassis or earth ground) and if you want to test the primary side voltage, the black probe has to connect to primary ground which is hot ground! If you are not familiar with what I am saying, please ignore this test or get a repair friend to assist you.

How To Perform Current Testing



In most electronic troubleshooting and repair, you will rarely take current measurements. Most general purpose digital multimeters allow you to measure AC current (ACA or I_{ac}) and DC current (DCA or I_{dc}) in a circuit, although there are often few ranges to choose from. **Normally analogue meters do not have the AC current range.**

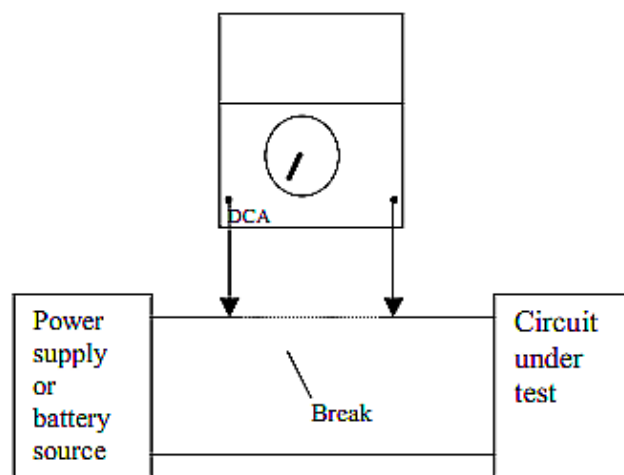
As with voltage measurements, current is measured in a **working circuit with power applied**, but current must be measured in series with the circuit or component under test.



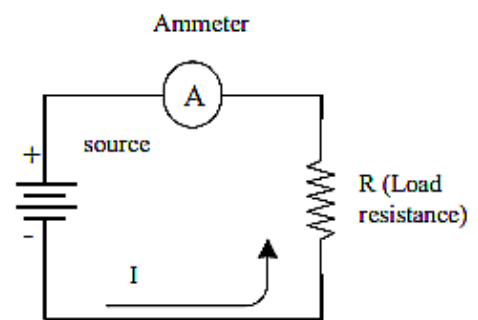
Inserting a meter in series, however, is not always an easy task. In many cases you must physically interrupt a circuit at the point you wish to measure, and then connect test leads across the break. Although it may be easy to interrupt a circuit, keep in mind that you must also put the circuit back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

Set your multimeter to the desired function (DCA or ACA) and select the appropriate range. If you are unsure about proper range, 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.

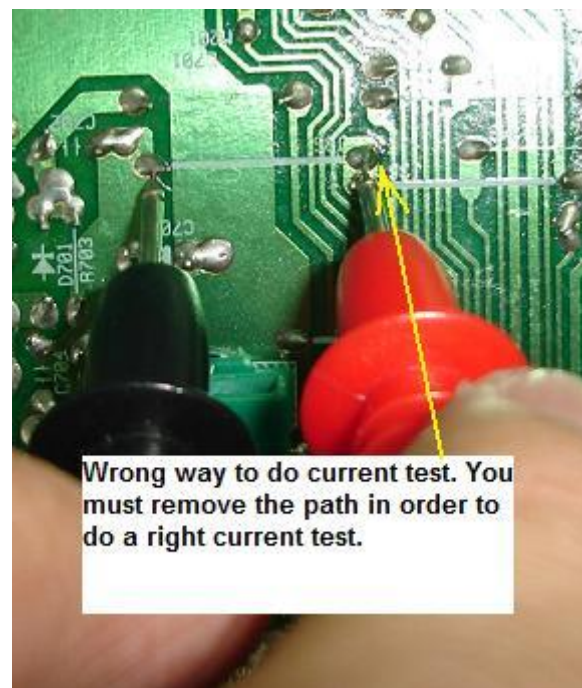


a) Measuring power supply current

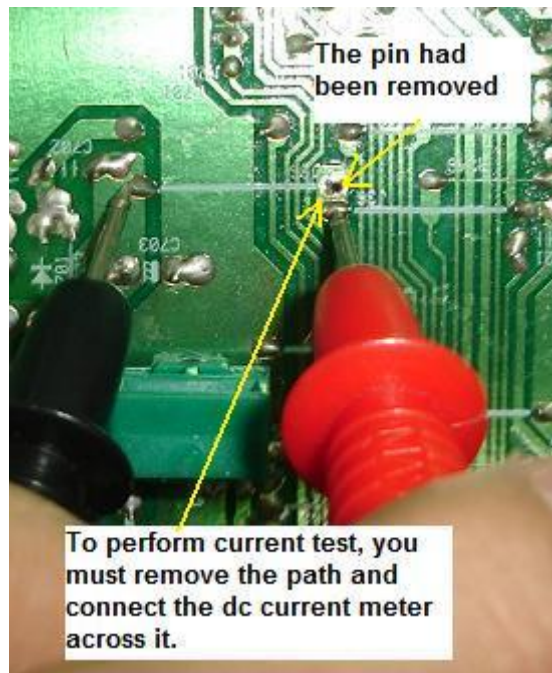


b) Simplified circuit

Measuring Currents



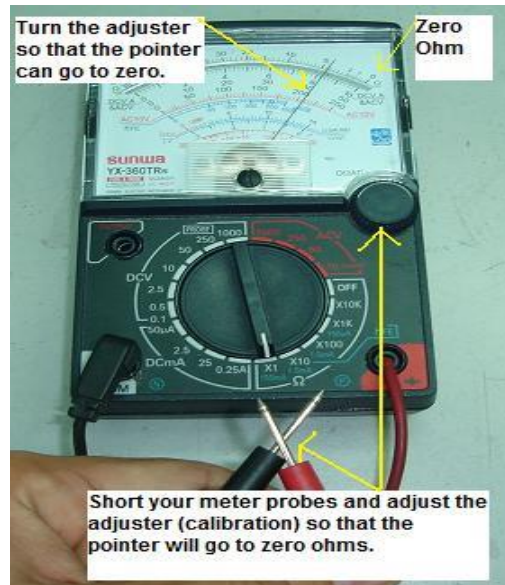
Wrong way to do current test. You must remove the path in order to do a right current test.



Caution!

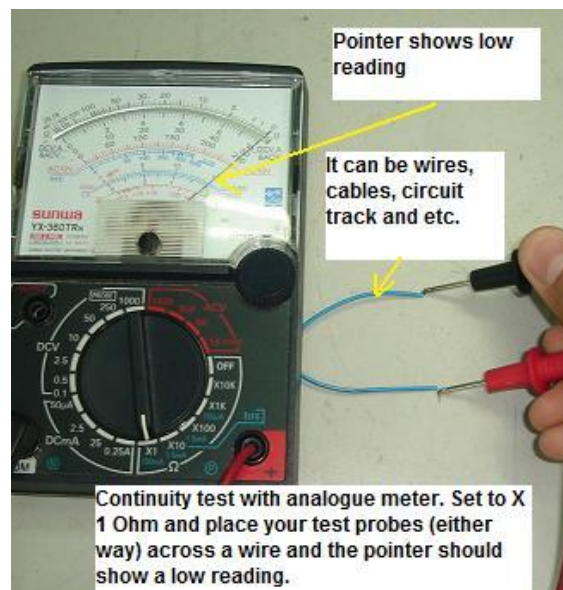
Never try to read current in parallel. Placing a current meter in parallel can cause a short circuit across a component that can damage the part, the circuit under test, or your multimeter.

Continuity Test

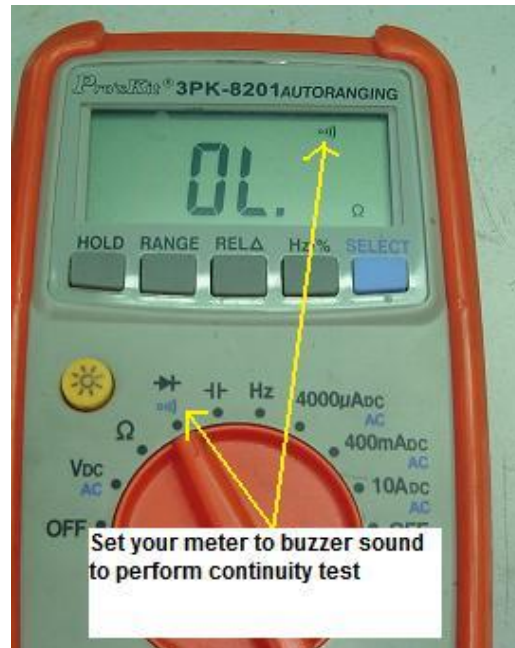


Continuity or short circuit test

Continuity checks ensure a reliable, 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 (X1 Ohms), short (touch) the red and the black probes together, and the pointer will go to zero ohms. If it is not zero, adjust the zero adjuster for bringing the pointer to exactly zero ohms.



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 that has a 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.

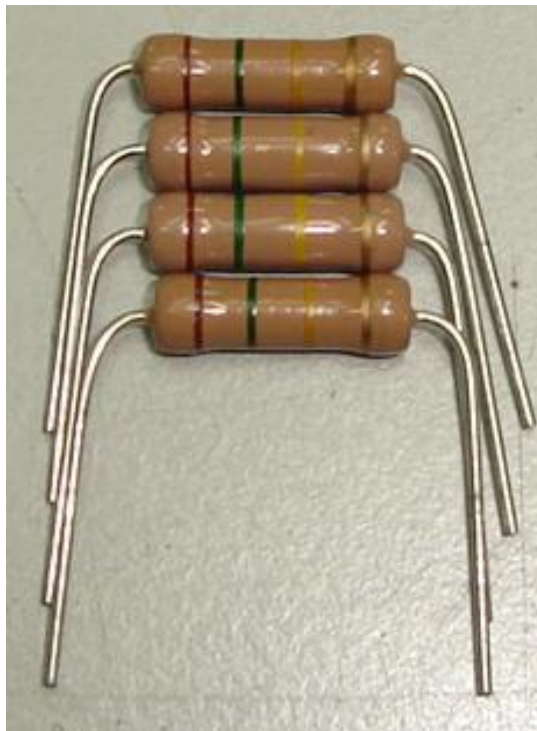
Resistance and Resistors

The word resistance means opposition to some action. In electricity resistance means the opposition to the flow of current. The resistance is measured in ohms (Ω). Resistance is also expressed in kilo-ohms, milli-ohms etc. With $1000\Omega = 1$ kilo ohms, $1000000\Omega = 1$ mega ohms. The symbol of resistance is show as:



Symbol of a resistor.

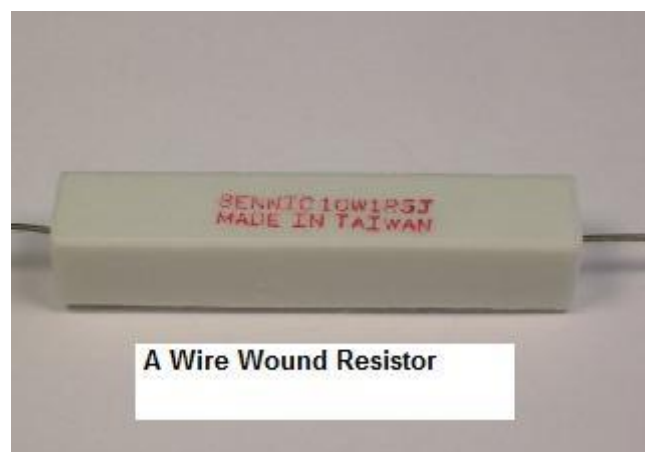
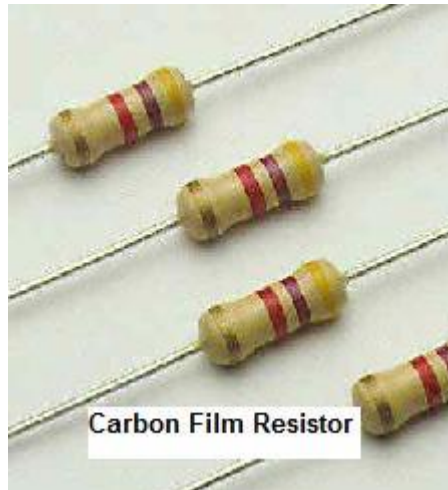
It is noted by a letter R.



The main two characteristics of resistors are its resistance “R” in ohms and its power rating in watts, “W”. Resistors are available in a very wide range of “R” values from a fraction of an ohm to many mega ohms. The power rating may be as high as several hundred watts or as low as 1/8 watt. Always use a replacement resistor with a power rating that is equal to or greater than the original. The value of the resistance can be measured by a multimeter.

Types of Resistors

- i. Carbon-Composition Resistors
- ii. Carbon-Film Resistors
- iii. Metal-Film Resistors
- iv. Wire Wounds
- v. Fusible Resistor
- vi. Variable Resistor



Resistor Colour Code Calculation

Fixed resistors are marked in several ways. These are:

- i. Color coding
- ii. Straight numerical value
- iii. Certain numerical codes that can be easily translated.

Because carbon resistors are small physically, they are color coded to mark their R value in ohms. In memorizing the colors, note that the darkest colors, black and brown, are for the lowest numbers, zero and one, through lighter colors to white for nine. Technicians must know this code. Table 1 and 2 shows the colour code and their meanings.

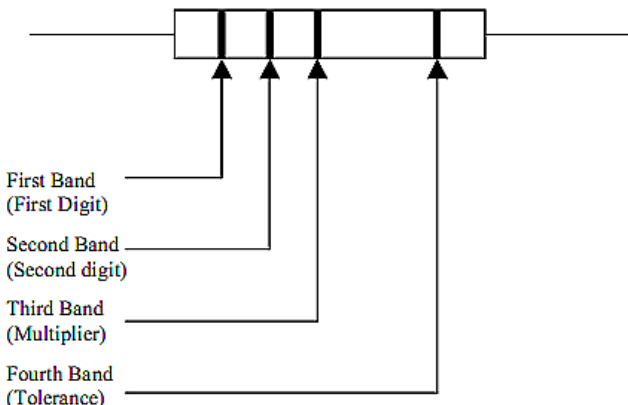
	Colour	Digit	Multiplier	Tolerance
	Black	0	1	-
	Brown	1	10	-
	Red	2	100	-
	Orange	3	1000	-
	Yellow	4	10000	-
	Green	5	100000	-
	Blue	6	1000000	-
	Violet	7	10000000	-
	Grey	8	-	-
	White	9	-	-
	Gold	-	0.1	±5%
	Silver	-	0.01	±10%
	No colour	-	-	±20%

TABLE 1- Showing four colours band of resistor and their meanings.

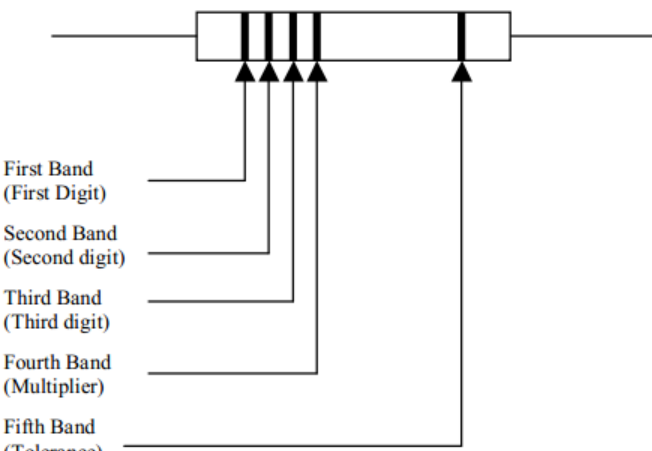
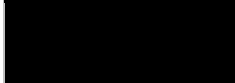
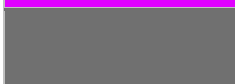
	Tolerance Code	
	Black	-
	Brown	±1%
	Red	±2%
	Orange	-
	Yellow	-
	Green	±0.5%
	Blue	±0.25%
	Violet	±0.1%
	Grey	±0.05%
	White	-
	Gold	±5%
	Silver	±10%

TABLE 2- Showing five colours band of resistor and their meanings.

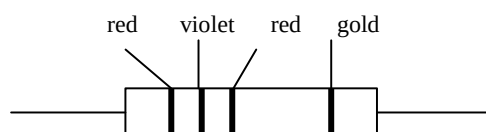
Colors	Numbers
	Black= 0
	Brown= 1
	Red= 2
	Orange= 3
	Yellow= 4
	Green= 5
	Blue= 6
	Violet= 7
	Grey= 8
	White= 9
	Gold= 5%
	Silver= 10%

Resistor Colour 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 the decimal multiplier, which gives the number of zeros after the two digits.

Example 1:



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:

$$\begin{array}{ccccc} \text{red} & \text{violet} & & \text{red} & \\ | & | & & | & \\ 2 & 7 & \times & 100 & = 2700 \end{array}$$

Therefore, this R value is 2700Ω with tolerance $\pm 5\%$

The resistor tolerance means the amount by which the actual R can be different from the colour-coded value.

For instance, a 2700Ω resistor with ± 5 percent tolerance can have resistance 5 percent above or below the coded value.

This R, therefore, is between 2565Ω and 2835Ω . The calculations are as follows:

$$5 \text{ percent of } 2700 \text{ is } 0.05 \times 2700 = 135$$

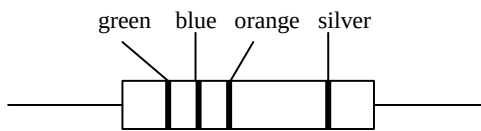
For +5 percent, the value is

$$2700 + 135 = 2835 \Omega$$

For -5 percent, the value is

$$2700 - 135 = 2565 \Omega$$

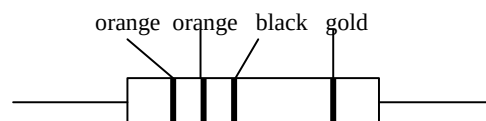
Example 2:



$$\begin{array}{ccccc} \text{green} & \text{blue} & \text{orange} & \text{silver} & \\ | & | & | & | & \\ 5 & 6 & \times & 1000 & = 56000\Omega \end{array}$$

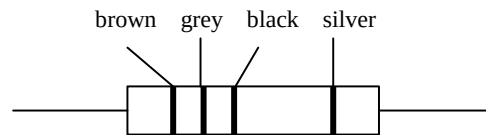
Therefore, the R value is 56000Ω or $56k\Omega$ with tolerance $\pm 10\%$. (Silver is 10%-please refer back to table 1)

Example 3:



Example 3 illustrates that black for the third band just means “do not add zeroes to the first two digits”. Since this resistor has orange, orange, and black band, the R value is 33Ω with tolerance $\pm 5\%$.

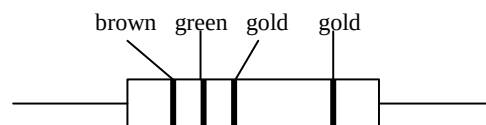
Example 4:



$$18 \times 1 = 18\Omega$$

Therefore, the R value is 18Ω with tolerance $\pm 10\%$.

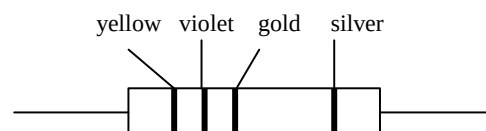
Example 5:



For these values, the third band is gold, indicating a fractional decimal multiplier. When the third band is gold, multiply the first two digits by 0.1. (Refer back to table 1). The R value is

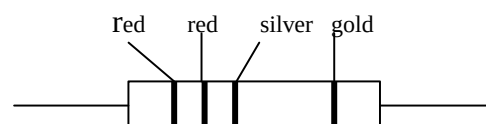
$$\begin{array}{ccccccc} \text{brown} & \text{green} & & \text{gold} & & \text{gold} \\ | & | & & | & & | \\ 1 & 5 & \times & 0.1 & = & 1.5\Omega \pm 5\% \end{array}$$

Example 6:



$$47 \times 0.1 = 4.7\Omega \pm 10\%$$

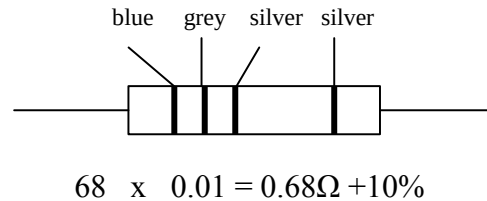
Example 7:



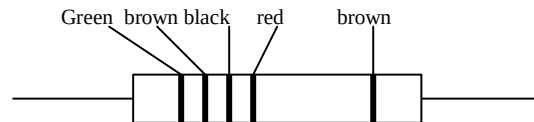
For these values, the third band is silver. When the third band is silver, multiply the first two digits by 0.01. (refer back to table 1). The R value is

$$\begin{array}{ccccccc} \text{red} & \text{red} & & \text{silver} & & \text{gold} \\ | & | & & | & & | \\ 2 & 2 & \times & 0.01 & = & 0.22\Omega \pm 5\% \end{array}$$

Example 8:



Example 9:

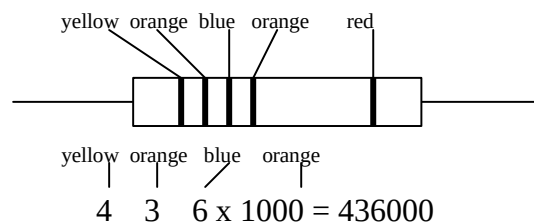


The first band is green for 5; the next band is brown for 1 and the black for 0. The red multiplier in the fourth band means add two zeroes to 510. The result can be illustrated as follows:

$$510 \times 100 = 51000$$

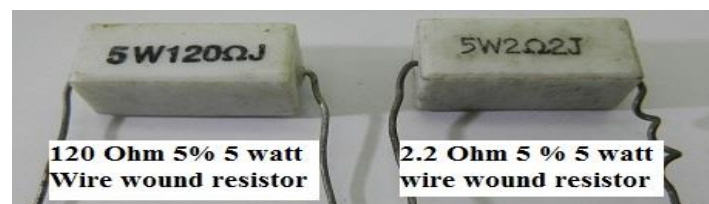
Therefore, this R value is 51000Ω or 51kΩ with tolerance $\pm 1\%$ (brown)

Example 10:



Therefore, this R value is 436000Ω or 436kΩ with tolerance $\pm 2\%$.

Note: In **wire wound resistor**, the resistance value is printed on its body. A R27 means .27 Ohm, 2R7 means 2.7 Ohm, 27R is 27 Ohm. Similarly, a 2K7 means 2.7KOhm. The letter of J means 5% tolerance and W means wattage. See the two examples below:



In Surface Mount Device (SMD) resistors, the coding is printed on top of the tiny resistors. Example, 100=10 Ohms, 101= 100 Ohms, 102=1000 Ohm or 1 Kilo ohms, 103=10000 Ohms or 10 Kilo Ohms and etc.



Testing Resistors

There are two ways of testing resistors; using an analogue or digital multimeter. Normally if a resistor fails they will either increase in value or open up fully (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. Always be aware of possible back (parallel circuit) circuits when checking in-circuit resistance measurements.

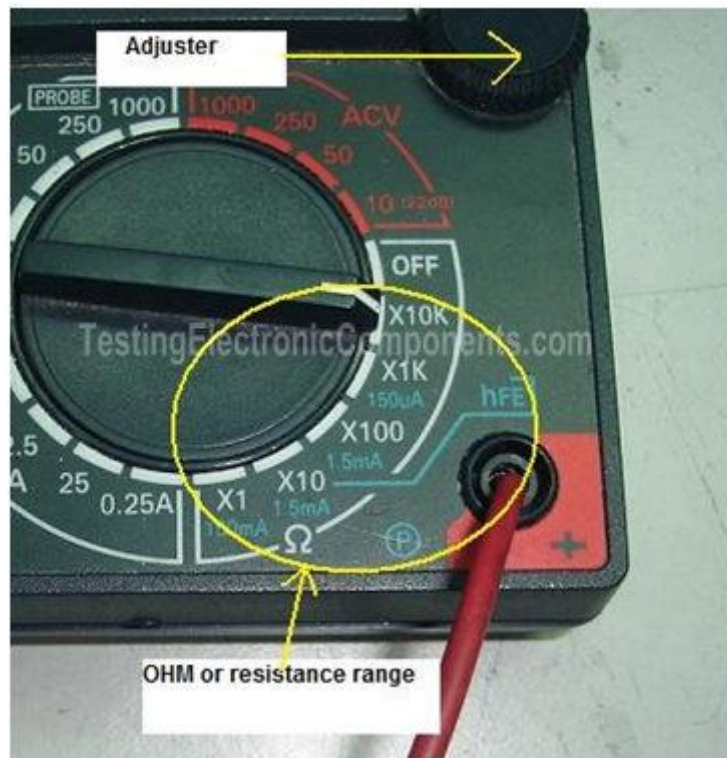


Testing Resistor With Analog Multimeter



Testing Resistor With Digital Multimeter

Using An Analogue Meter to Test Resistors



First you must know the resistor value before you take any measurements. With the resistor colour band calculation you have read from the previous section, I'm sure you'll have no problem in identifying resistor values by looking at the colour bands. Assuming you are measuring a resistor with the colours of “yellow, purple, black and gold”, from calculation it is a 47 Ohm resistor with 5% tolerance.

Now set your analogue meter to X1 Ohm, shorting the probes and calibrate the pointer so that it will stay at zero Ohms. Place your meter probes to the two points of the resistor as shown in the photo. It doesn't matter which probes to which two points because resistor does not have polarity (positive and negative) like a battery. You should get somewhere near 47 ohm by observing the pointer.

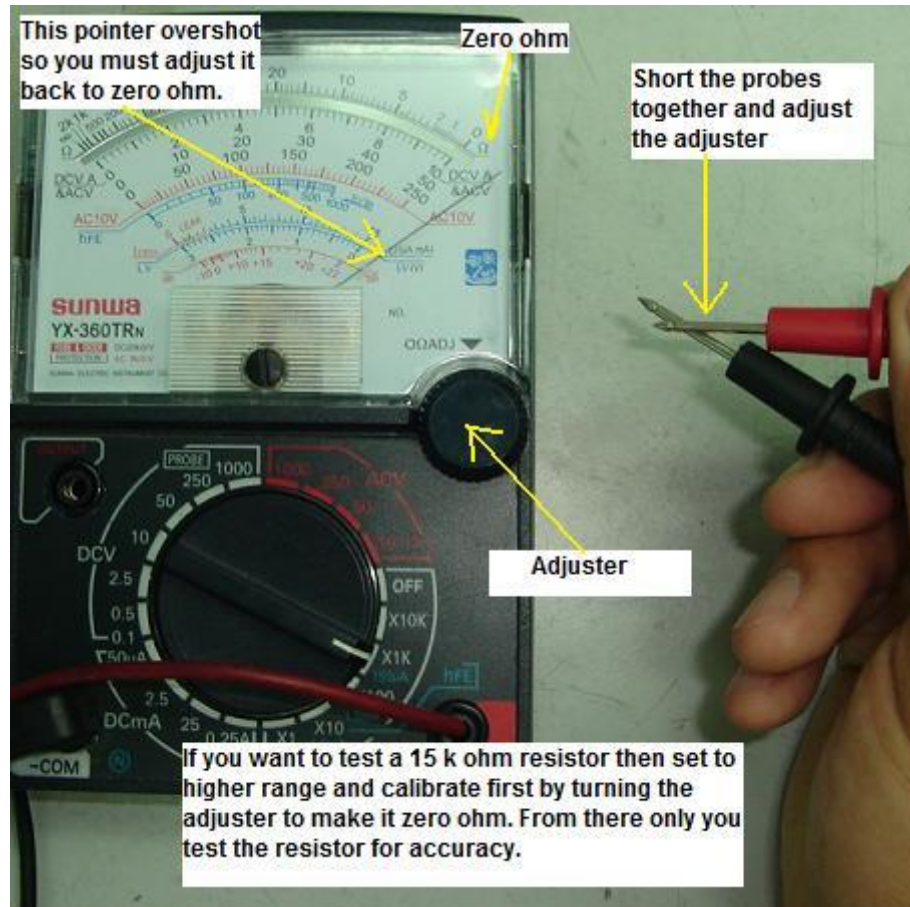
Note: When doing the calibration, if setting to x1 Ohm and shorting the probes did not bring the pointer to zero Ohms, this means the internal 2 x 1.5 volt batteries are already weak.

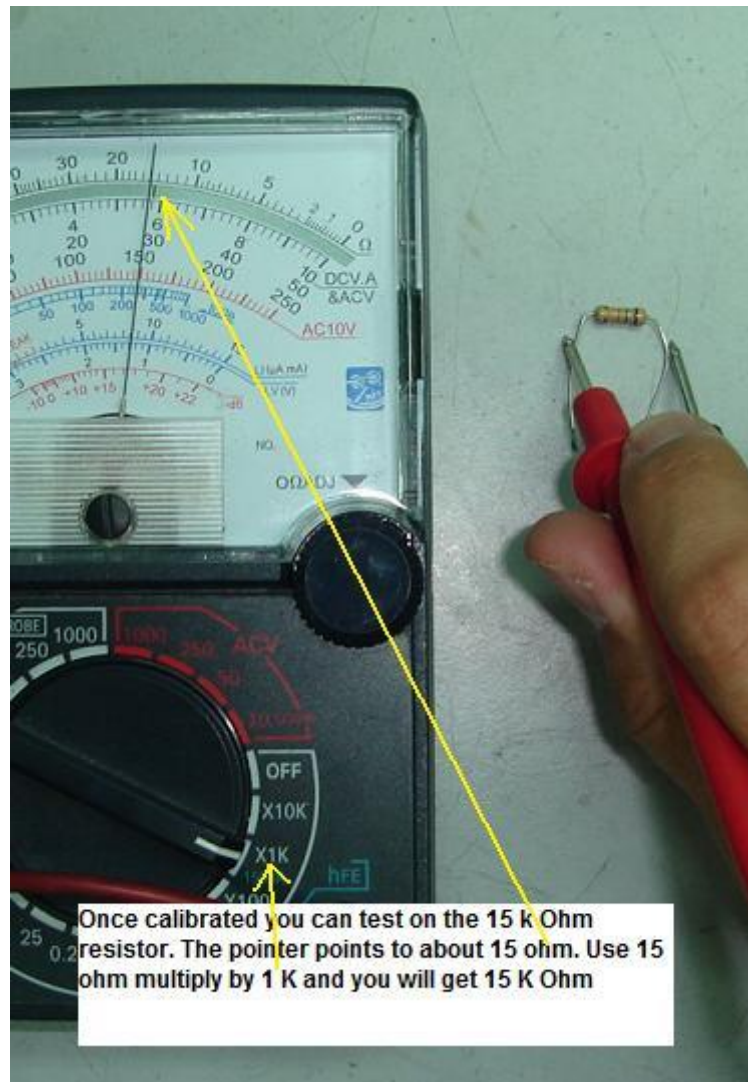


If you get more than 47 ohms, say 150 ohms, this means that the resistor has gone up in resistance and needs replacement. If it doesn't show any reaction after putting the probes across the two points of the resistor, then we can conclude that the resistor has an open circuit (bad). Remember to press a little bit hard on the leads of the resistor while measuring it otherwise you may not get a precise reading or an intermittent reading could occur.

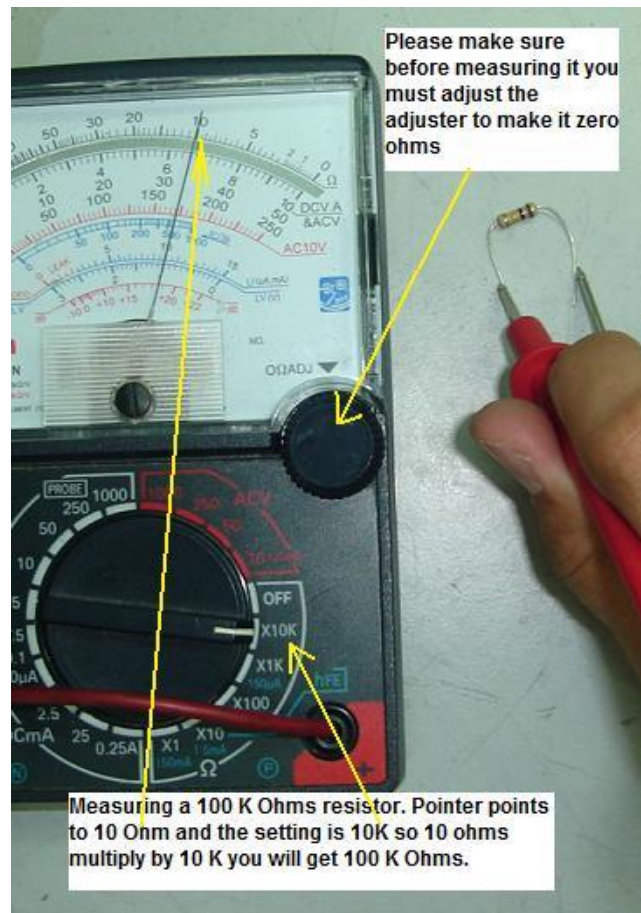
Note: When you check a resistor on a circuit board, **you need to lift one leg up from the board** for accurate measurement. If you measure it directly on board you may not get the actual reading because that resistor may parallel with another component side by side which can lower down the Ohm reading.

Similarly if you want to check a 15 K ohm resistor, short the two probes together and calibrate by adjusting the adjuster (knob). You have to set your meter to X1 K ohm range so that the measurement is within the range. Using the X1 Ohm range to test a 15 K Ohm **resistor won't cause the pointer to move at all**. Even if the pointer can move, it will only move a little bit higher only.





Check the result to see if the pointer points to near or exact 15 K Ohm. If the resistor has 5% tolerance the pointer should point between the values of 14.25K to 15.75K Ohm. Any value you get that is not between the tolerance ranges, you should replace the resistor.

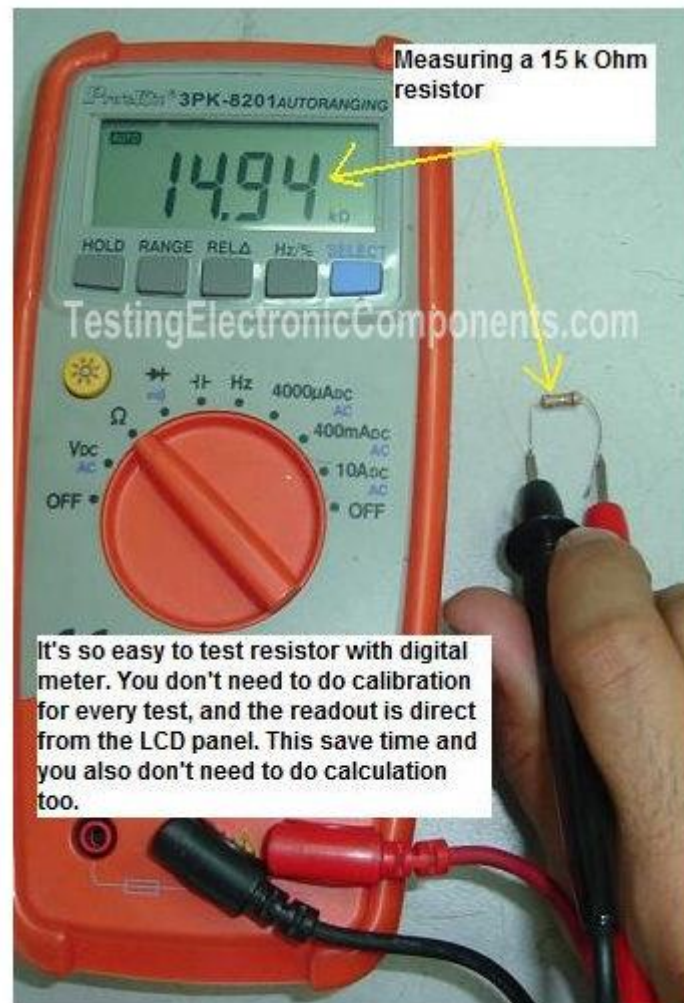


In order to check a 100 K ohm resistor you have to select the X10 K Ohm range. Follow the procedure explained above and you should be able to get the measurement.

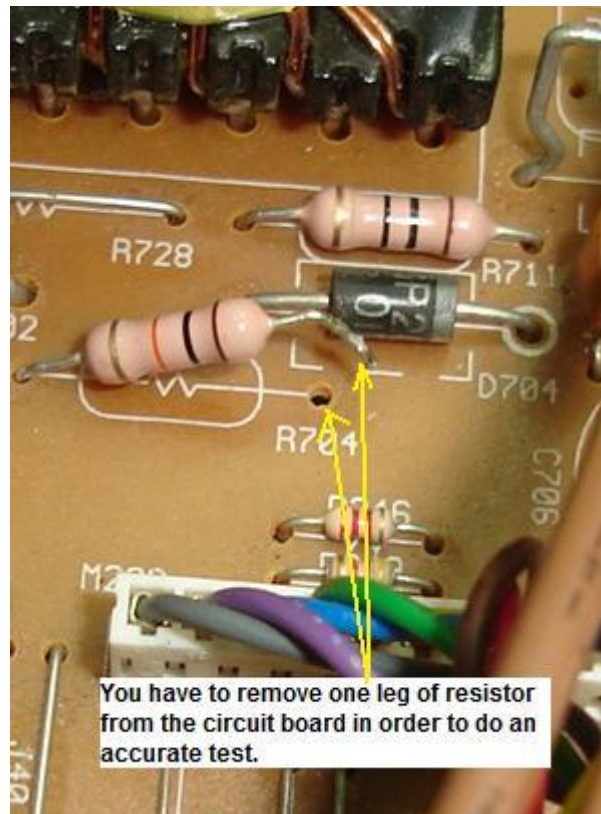
Using a Digital Meter to Test Resistors



Personally I do not use an analogue meter to test resistors as the result shown on the meter panel only makes you have to guess what the resistor value is. You may ask yourself, is it 47 ohm or 47.5 ohm or even 47.7 ohm? By using a digital meter the LCD display on your meter will show you the **exact value** of the resistance under test. It is more accurate than using analogue meter.



First, select the Ohm range and place your test probes across the two points of the resistor as shown in the photo. **Digital meters do not need any calibration compared to analogue meters** where you have to adjust the adjuster to make it zero Ohms before you begin to do measurement. The result shown at the LCD display of the digital meter is **the exact resistance value of the resistor**. **Digital meters really removed all the guess work!** Not only that, many digital meters are “auto-range”. That means whatever value of resistor you want to check it will automatically give you the result without you having to adjust to a suitable range in order to test the resistor. This saves time and is accurate too!

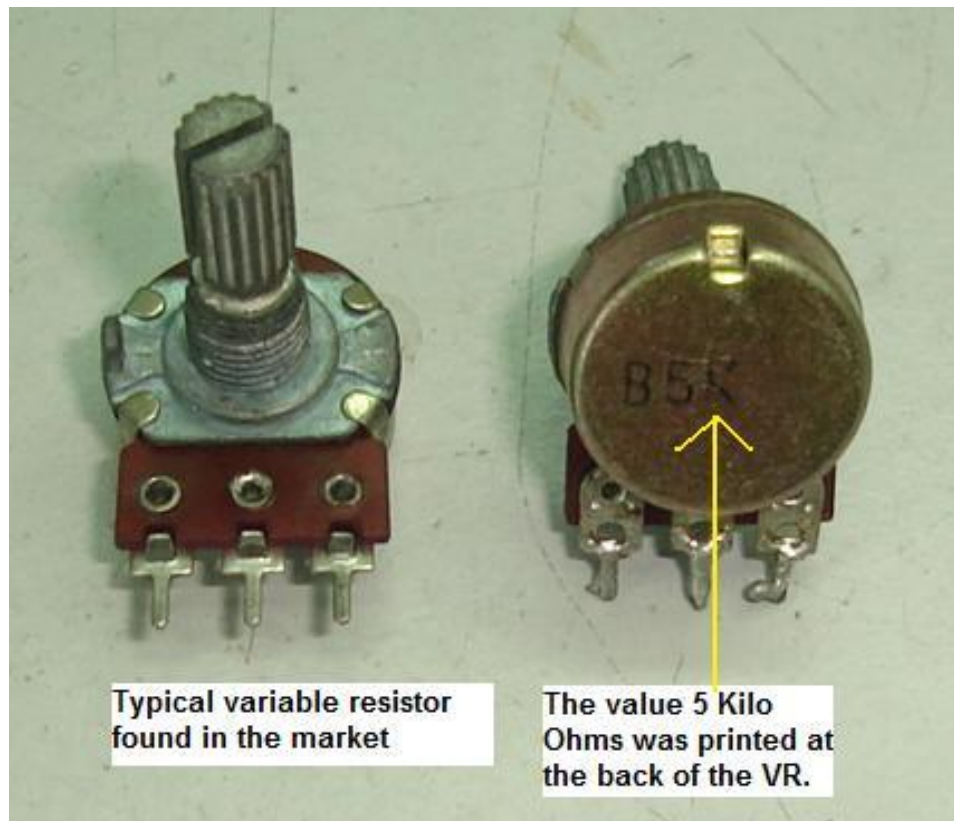


If you are a beginner I strongly recommend that you remove all the resistor legs (I mean only one leg) and test it with your **digital meter**.

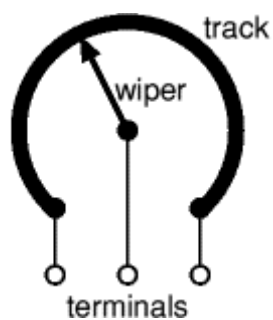
Note: When you check a resistor on a circuit board, you need to lift one leg up from the board for accuracy measurement. If you measure it directly on board you may not get the actual reading because that resistor may parallel with another component side by side which can lower down the Ohm reading.

I hope with this secret, checking resistors should not be a problem to you anymore.

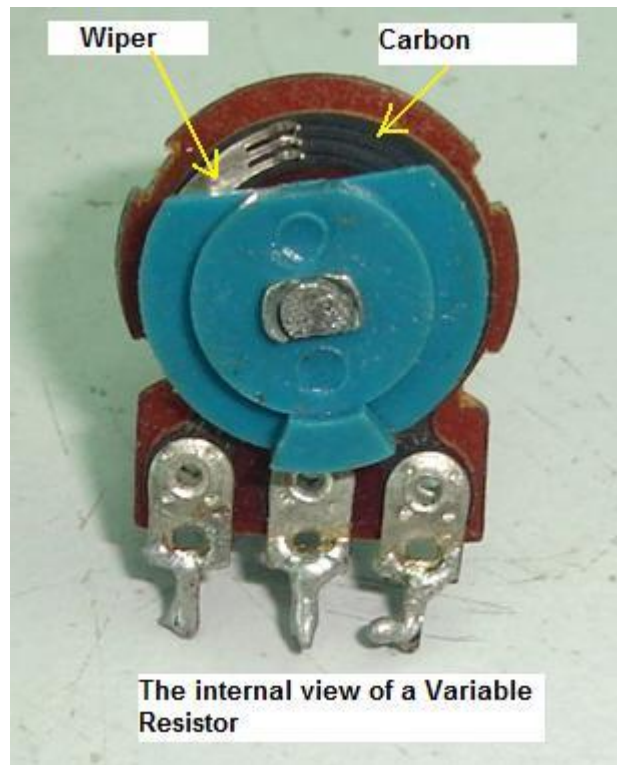
Testing Variable Resistors



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



Internal view of Variable resistor



Failure among variable resistors usually takes the 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. Remember, that film slowly wears away as the wiper moves back and forth across it. After some time the overall film can wear away and the wiper cannot make a good contact at certain points. 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.



You can check the variable resistor resistance with an analogue multimeter set to ohm's range as shown in Fig 1 below.

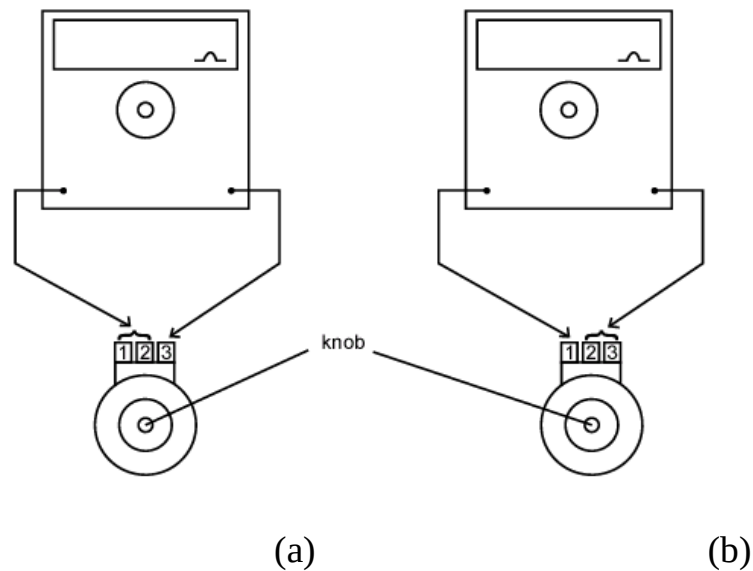
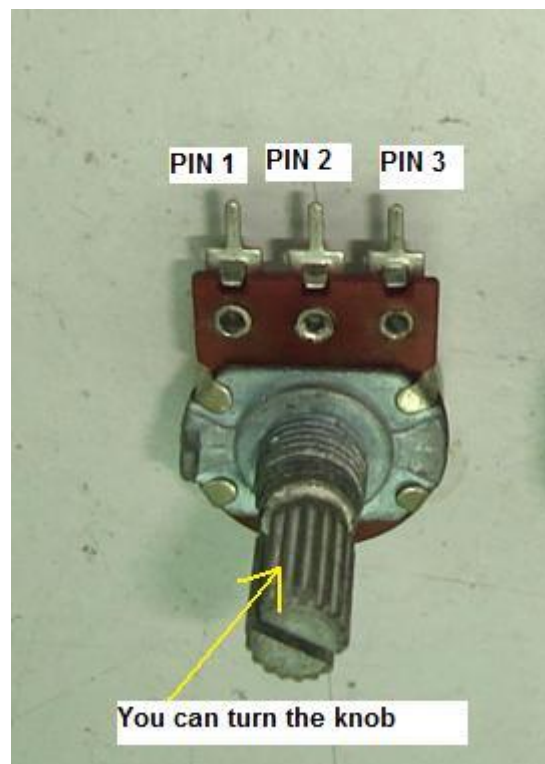


Fig 1: Testing a variable resistor with an analogue multimeter



If you measure pin 1 and 3 you will get the variable resistor maximum Ohms reading. Now use either one of the probes to touch pin 1 and 2 (Fig

1a) of the variable resistor while the other probe touches pin 3. Turn the knob clockwise and counter-clockwise to see the changing of resistance. The meter should show a smooth reading. If the reading is erratic, the pointer will move intermittently, in which case you should service or replace the variable resistor. Say the variable resistor is $10\text{k}\Omega$, the value should vary from 0Ω to $10\text{k}\Omega$ or $10\text{k}\Omega$ to 0Ω as you turn the knob clockwise and counter-clockwise.

Now, using the probe that touches pin 3, short to pin 2 (Fig 1b) while the other probe connects to pin 1, test for the result. The reading should be the same except that the ohms range instead of starting at 0Ω should now start at $10\text{k}\Omega$.

Here is some of the simple calculation to determine the meaning of the code printed on the variable resistor and preset:

12= 100 = 100 ohm

13=1000= 1000 ohm = 1 Kilo Ohm

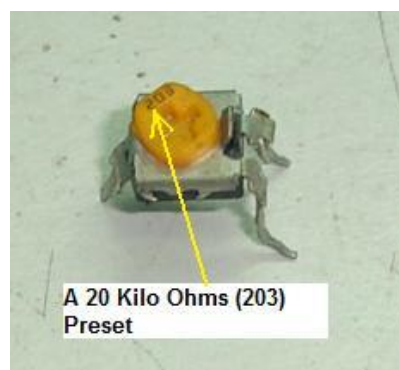
54=50000=50000 ohm= 50 Kilo Ohm

102=10 00=1000 ohm= 1 Kilo Ohm

203=20 000=20000 ohm= 20 Kilo Ohm

504=50 0000=500000 ohm= 500 Kilo Ohm

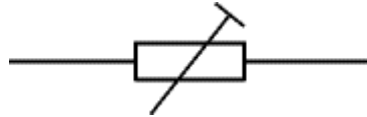
Testing Presets



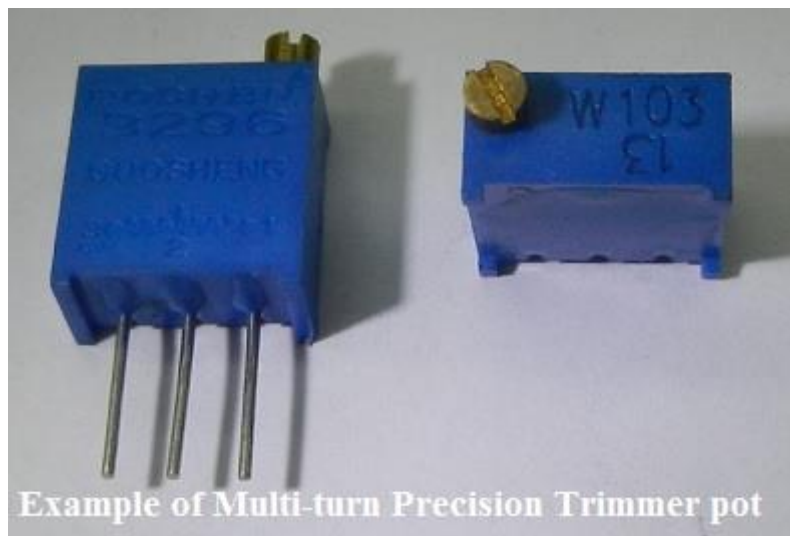
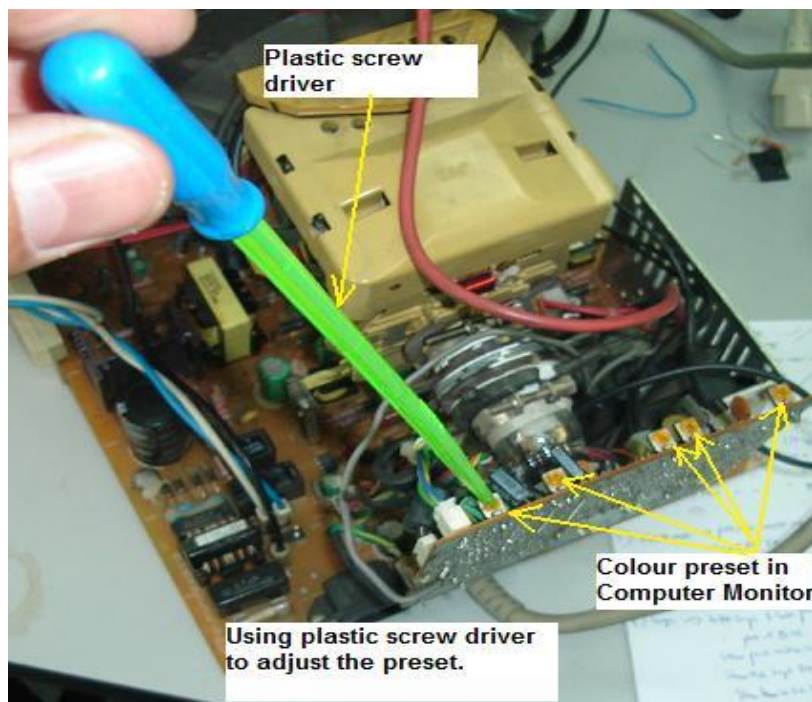
These are miniature versions of the standard variable resistor. They are designed to be mounted directly onto the circuit board and tuned only when the circuit is built. For example to set the colours of a computer monitor by turning the preset in the Cathode Ray Tube (CRT) board. Preset also can be found in switch mode power supplies

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

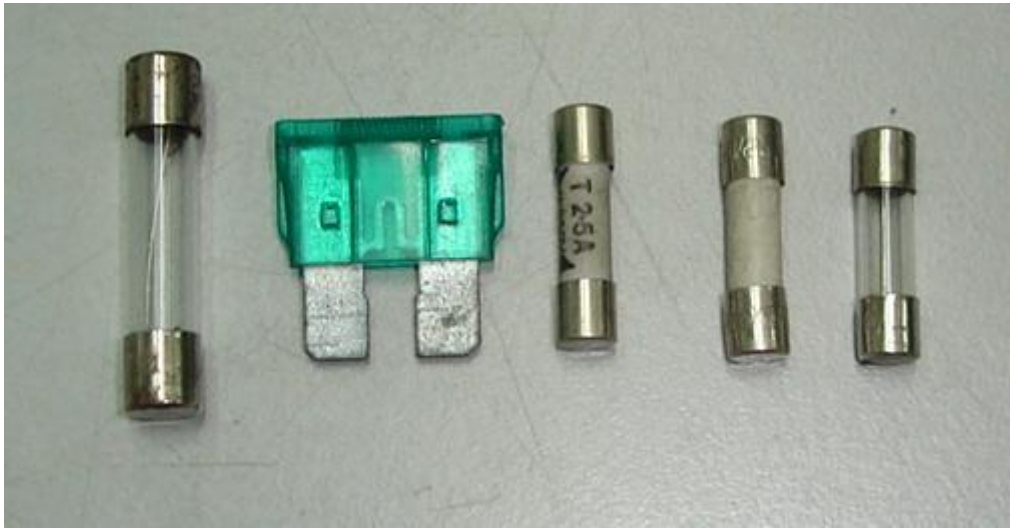
Presets are much cheaper than standard variable resistors so they are sometimes used in electronic projects where a standard variable resistor would normally be used. **Testing presets is exactly the same procedure as testing variable resistors.**



Preset symbol



Testing Fuses



Typical example of fuses

It's very easy to test a fuse. A fuse is a very thin wire, which either melts or vaporizes when current flow through it exceeded the fuse rating. The thin wire of fuse may be made of aluminium, tin-coated copper or nickel. The resulting opening in the circuit stops current flow. In electronic equipment, most fuses are cylindrical glass or ceramic types with a metal cap at each end. The current rating and voltage also can be seen on one of the two metal end caps.



A Fuse symbol

There are two popular physical sizes: 1 – ¼ X ¼ - inch and 5X20mm. The 1 – ¼ X ¼ - inch size is used in many automobiles. You'll find both sizes in much electronic equipment, but the smaller 5X20mm has become more common. Fuses are available with current ratings from 1/500 ampere to hundreds of amperes. A fuse is labeled as "F" in a circuit board.

Before showing you how to test or check a fuse, first you need to understand the purpose of a fuse. The function of fuses is to stop higher than normal current from flowing through an electronic circuit. It is designed to protect equipment and save electronic components from being damaged and also to stop overheating, which could cause a fire.

Sometimes when there is a lightning strike on equipment, you will be surprised that only the fuses were damaged and not the power supply section or components.



There are two basic types of fuses: the fast acting and slow blow type. The fast acting fuse will open very quickly when their particular current rating is exceeded. This is very important for analogue multimeters, which can quickly be destroyed when too much current flows through them, for even a very small amount of time.

Even if you are an experienced repairer, sometimes we do make a mistake by accidentally touching the probe to the testing points where it should not be touched! The slow blow fuse has a coiled construction inside the glass. Slow blow fuses are designed to open only on a continued overload, such as a short circuit. The function of the coiled construction is to stop the fuse from blowing on just a temporary current surge.

Don't replace a slow blow fuse in place of a fast acting fuse because it may not open fast enough to prevent components being damaged under a high current condition. It's not dangerous to substitute a slow blow fuse with a fast-acting fuse, but it will probably open up unnecessarily every now and then when the equipment is first switched on such as when you switch on a computer monitor.

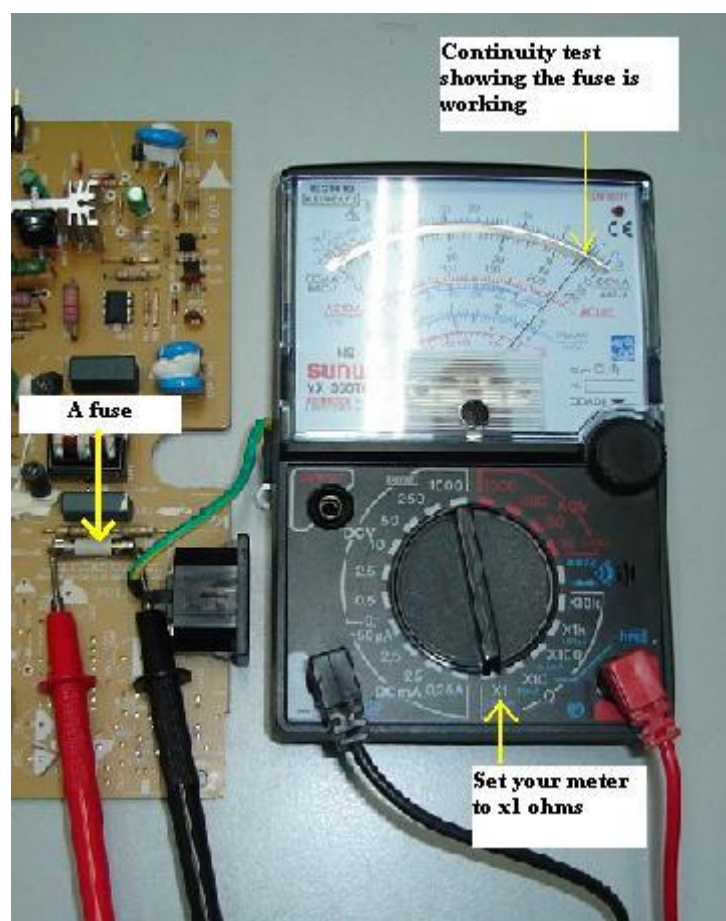


A blown fuse can indicate how severe the short circuit is.

Here's a secret for you. A blown fuse can indicate something about the problem. If the glass case of the fuse appears clear or transparent, and if you can still see the slight broken pieces of the fuse element, this means

that there's no major short circuit in the circuit. Replacing the fuse with one of the same type and rating usually will bring the equipment back to life again. However, sometimes a replacement might blow the fuse right away when you switch on the equipment. To save the fuse, you can use the series light bulb trick which I'm going to share with you in another section.

Some fuses even die of old age because fuses have lifespans too. But if the inside of the glass fuse is black or darkened, and there is no trace of the fuse element (the centre connector), you know that there was a major short circuit somewhere in the circuit and it most probably is the power supply unit.



Measuring a fuse on board with an analogue multimeter

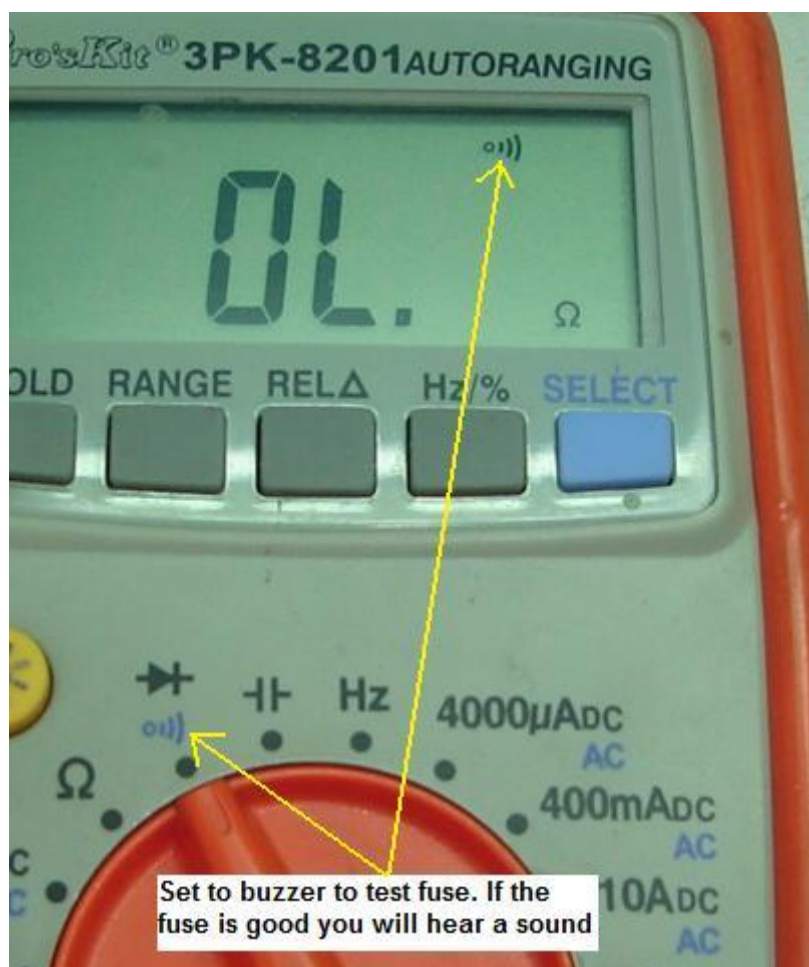
The common type and current rating of a fuse in a switch mode power supply is a slow blow 3.15A to 5 Ampere 250 Volts.

Now, how do you test the fuse? Switch off the power of the equipment, remove the casing and you will see a fuse usually located in the AC input area or power supply section. 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.

Touch the probes to both end of the fuse. You can check the fuse while it still in circuit. A good fuse reading should show continuity or read ZERO ohms. A blown fuse is open which will not show any reading on your meter.

You may also set to the buzzer range to test a fuse with digital meter. If the fuse is ok, the buzzer will sound and if the fuse is broken (internally) there will be no sound.



Setting buzzer range to test a fuse with digital meter



The red and black test probes can be either way when testing fuses

Testing fuses is one of the simplest tasks in electronic troubleshooting-it is easy and fast. **For fuse replacement, use only the same current and voltage ratings** as the original one. Fuses can be easily found in electronic shops.

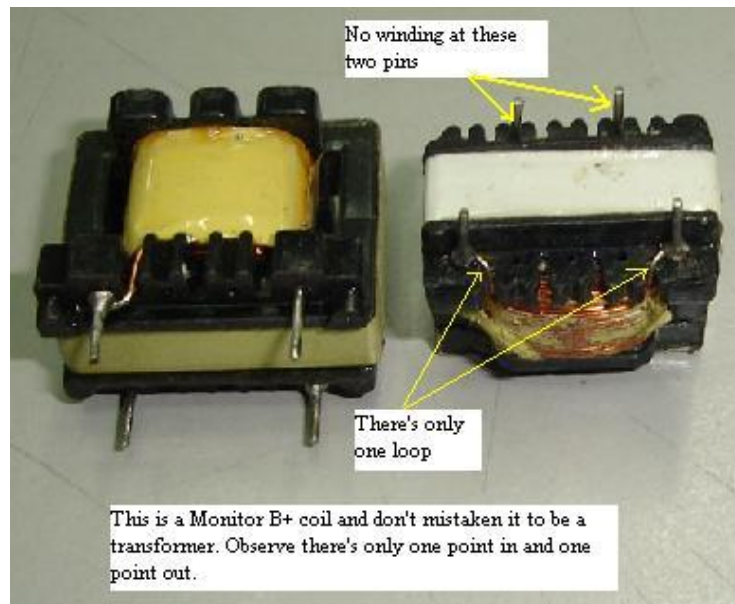
Testing Coil/Inductor



Testing coils is very easy compared to checking three leads components such as SCR, FET, etc. In general, a coil consists of many turns of wire wrapped around a common core. The core could be made of iron, ferrite or even air. It is labeled as “L” on the circuit board.

When an electric current passes through the coil, a magnetic field is produced. A coil in some respects acts just opposite a capacitor. A capacitor blocks DC while allowing AC to flow through it; a coil allows DC to flow through it while restricting AC current flow. Another name for a coil is an inductor.





Coils or inductors can be tested using an analogue, inductance or a coil meter such as the [Blue Ring Tester](#). A coil that is small in size, I would usually just test with an analogue meter and you could check it on board too. Set your analogue meter to X1 ohm and place the probes across the small coil.

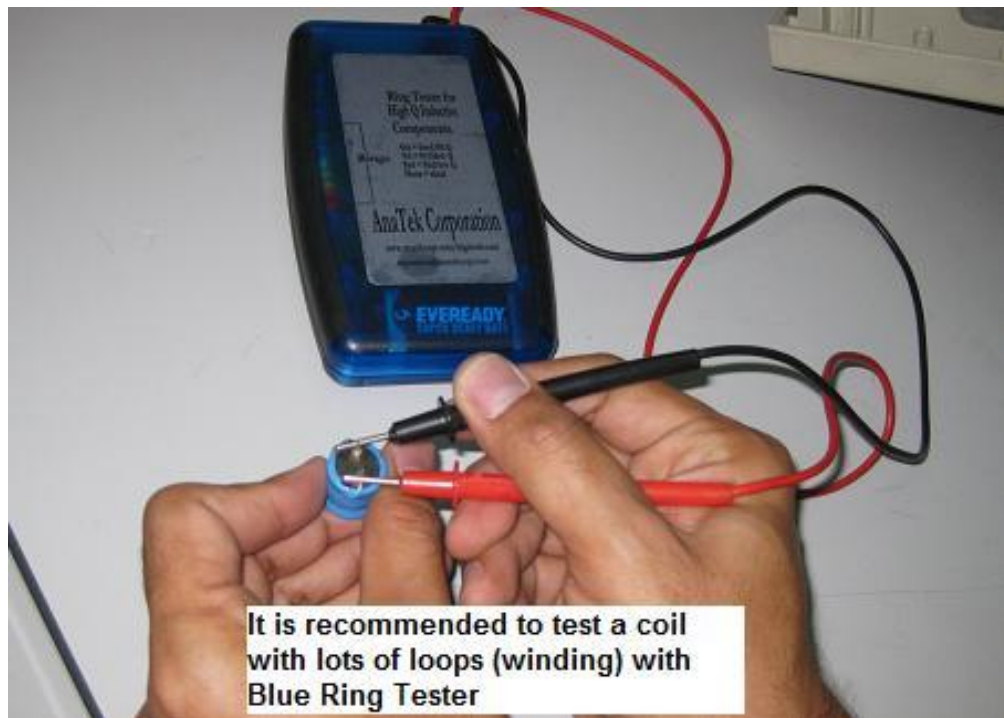
The meter should show some reading (or continuity) and this proves that the coil winding is okay. Small coils are seldom spoilt because they have less winding compared to big coils which have many turns of winding and chances for it to short (between windings) is very high.



For testing bigger coils or inductors such as the computer monitor B+ coil you need an inductance meter to find out the exact inductance value which is in the unit of Henry (h). From experience, using an inductance meter to check coils to see if they are good or bad is not recommended because a shorted coil (shorted between winding) could have a good inductance value and you would miss out on the fact it is a bad coil.

Unless you want to use the inductance meter to calculate the reading and do rewinding, looping, etc. on that coil. I would only test a big coil with Blue Ring Tester. Any shorted winding in it could be easily detected by this meter.

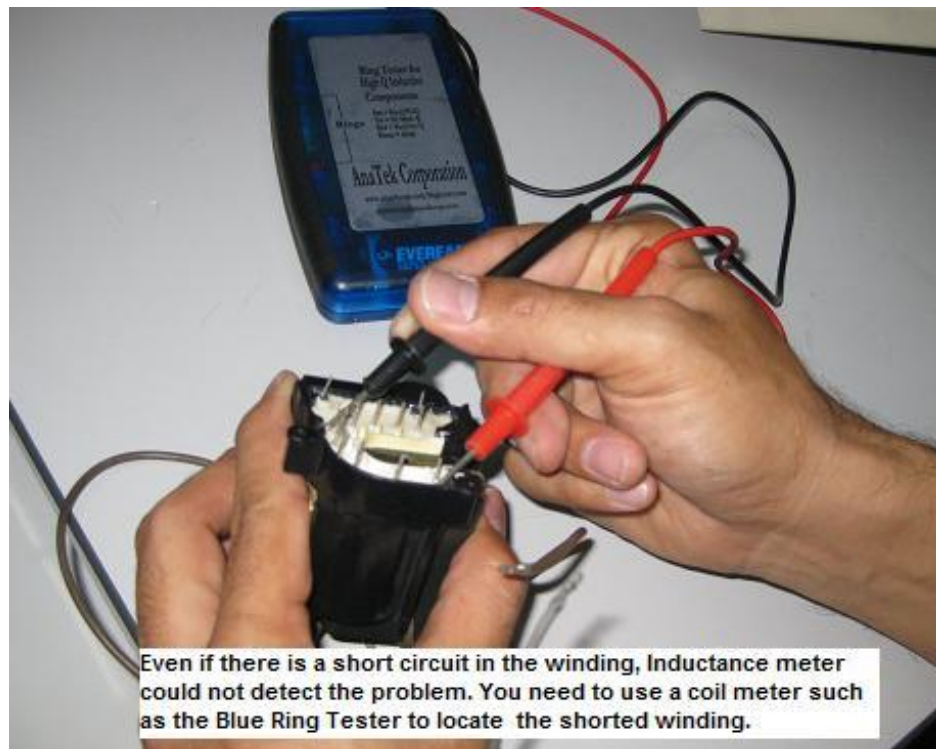




Here is a true case example: a computer dealer sent me a monitor for repair with a power blink symptom. Usually I do not straight away repair the monitor but would first use the flyback tester to scan all the major coils (switch mode transformer, flyback transformer, B+ coil and horizontal deflection coil) before using my digital or analogue meter to do testing.

When measuring the B+ coil, the LED lights went off though it was supposed to show at least 5 LED bars and above. Upon soldering out the coil, I did not see any burn marks at the winding or loop and in fact it looked shiny. Because I trust the meter, I opened up the winding and to my surprise the internal winding had burnt into crisp but the outer winding looked good indeed! A new B+ coil restored the monitor to life.

By using the Blue Ring Tester or coil tester for testing coils, it has helped me to locate many shorted coils in switch mode power transformer primary windings, B+ coils, flyback transformer primary windings and horizontal deflection coils. The Blue Ring Tester can even be used to check the condition of ballasts in fluorescent lamps too!



Using Blue Ring Tester To Test Flyback Transformer

If you need to get the Blue Ring Tester you may click on the link below for more information:

<http://www.ElectronicRepairGuide.com/Blue-Ring-Tester.html>

Testing Switches

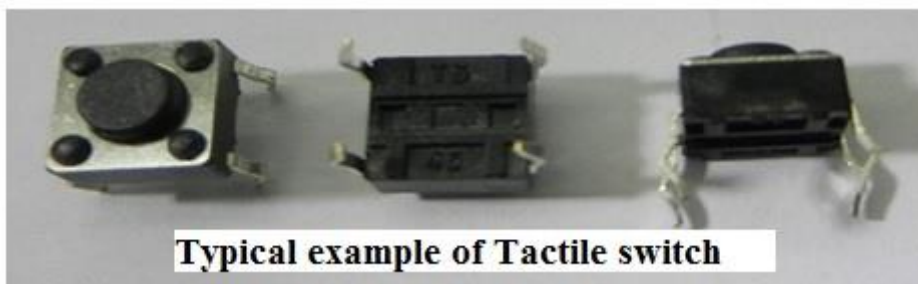


A mechanical on/off switch

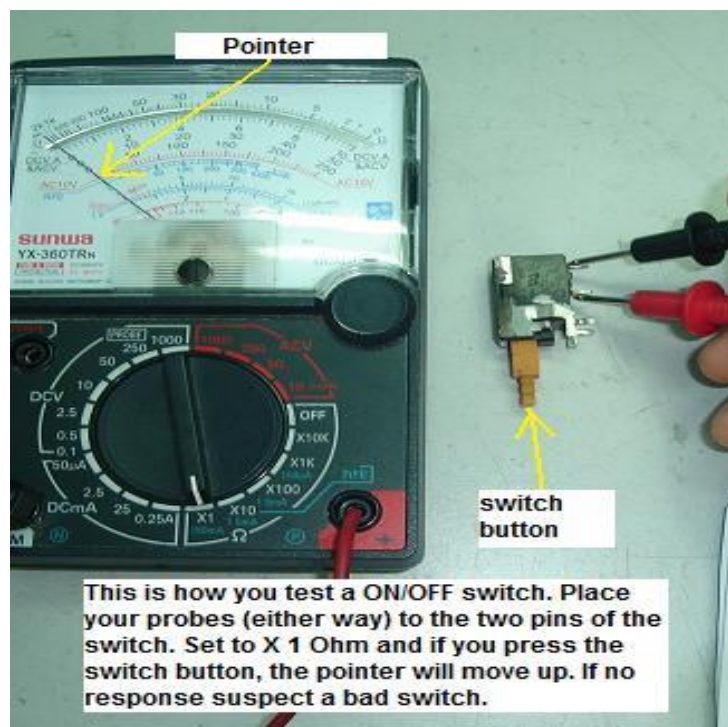


A common Switch symbol

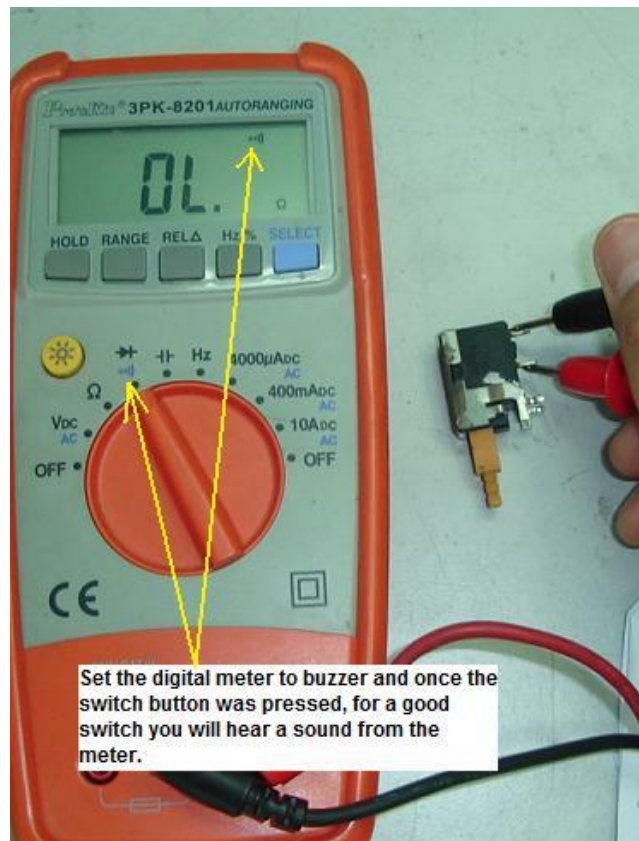
There are many types of switches in the market; some are on/off mechanical switches while some are tactile switches.



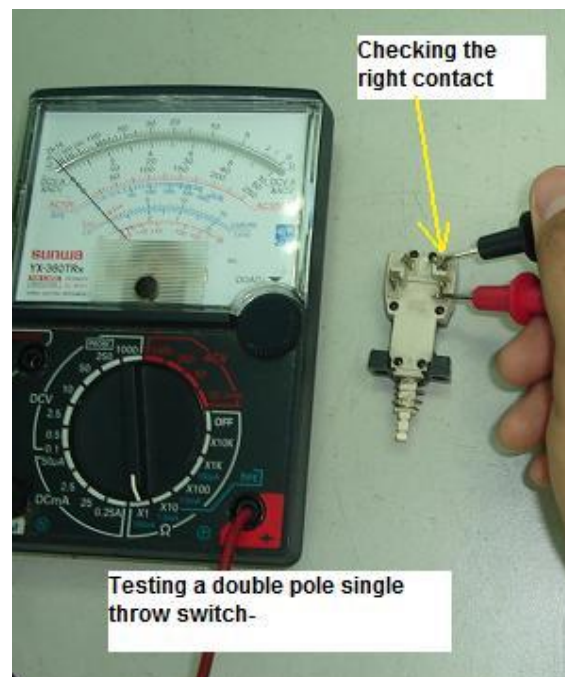
Typical example of Tactile switch

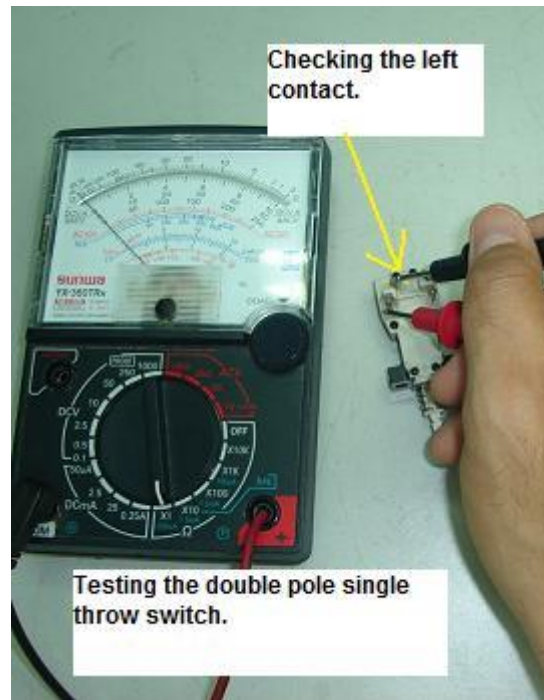


The function of the switch is to act as a contact between two points either to let current flow or to stop it. It is very easy to test switches, just set your meter to X1 ohm and place your meter test probes to either leg (pin). Now press the switch and you should see the meter's pointer shows zero ohm.

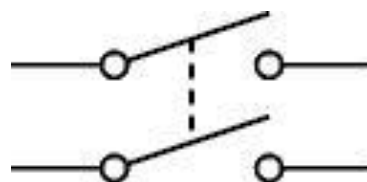


If after pressing the switch nothing happens, suspect a bad switch. Similarly, you can use a digital meter set to a buzzer sound to test a switch. A good switch with a good contact should make the digital meter produce the buzzer sound. No sound means the switch is defective.



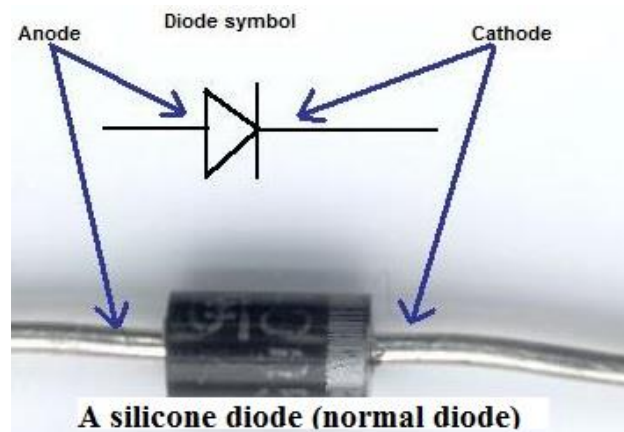


Some switches have dual on/off contact and is called “double pole single throw switch” (DPST). A DPST switch is often used to switch mains electricity because it can isolate both the live and neutral connections. Testing the DPST switch is relatively simple, test the contact at one time before you test the other contact. Testing method is the same just as when you are testing the single on/off switch above. Look at the photos and should understand what I meant.



**Dual on/off switch
Symbol**

Testing Diodes

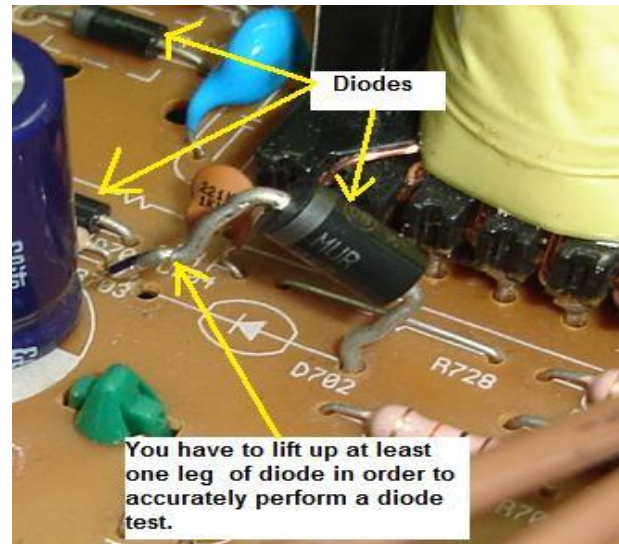


When comes to testing diodes (general purpose diodes) or normal diodes, you need a special method to test them. If you do not know how to accurately check a diode, you will not be able to repair or troubleshoot electronic equipment because a spoilt diode you may think is good and you will definitely waste your precious time. A diode is labeled as “D” on a circuit board. Usually a rectifier diode can fail in one of the four ways.

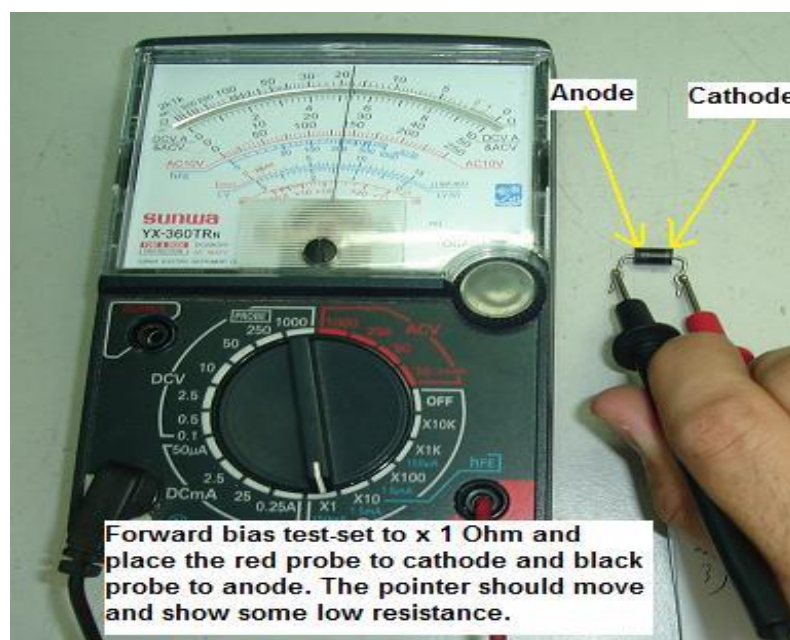
It can become open circuit, short circuit, leaky, or break down when under full load. An analogue multimeter or digital multimeter can be used to test or check for all the first three conditions except the last one which is the diode will break down in full operating voltage. Diode breakdown when under full load means the diode tested okay with your meters but failed when a high voltage was put across it.

From my experience in the electronic troubleshooting field, I discovered that testing diodes using an analogue multimeter is more accurate or precise than using a digital multimeter. I do not know about you but I really came across quite a number of diodes where it tested ok with digital multimeter but failed when checked with the analogue multimeter.

The first step on **how to test a diode** accurately is to **remove one of the diode leads** from circuit board. 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.

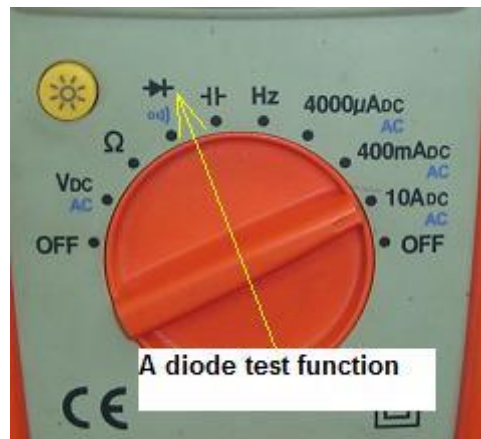


To be absolutely sure, you will need to lift, or disconnect, one diode lead from the circuit to avoid back circuits, unless you are very sure about the board you are checking. Sometimes I do find bad diodes when checking it on board. Your experience will tell you when to test a diode on-board or off-board. **If you are a beginner, I highly suggest that you measure a diode with a lead removed from the board to avoid any confusing results from your meter.**



If you reverse the probes the pointer will not move at all

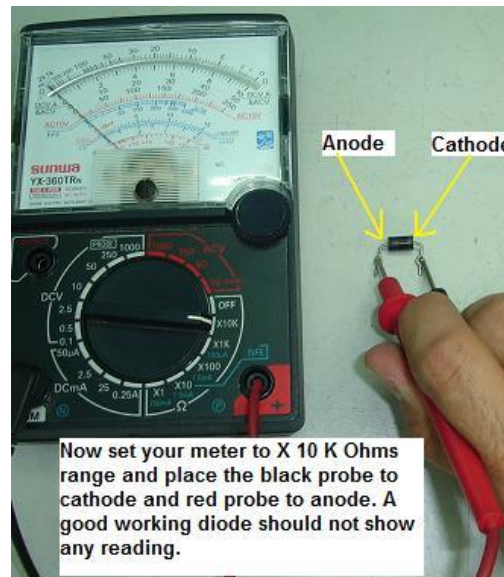
Set your analogue meter to x1 ohms range to check for current diode leakage with reverse and forward testing. Connecting the red probe of your meter to the cathode and black probe to the anode, the diode is **forward biased**, the meter should read some value of resistance. Touch the black probe of your 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 likely the diode is shorted or leaky and you should replace it.



If you don't get any reading either forward or reverse bias, the diode is considered an open circuit. The real problem when testing a diode using the diode test function of a digital meter is that on 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) being around 500mv to 2v.

An analogue meter set to x1 ohms range has an output of 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 x1ohms range checking a diode, **this doesn't mean that the diode is good.**

Important Note: Sunwa and some other brands of analogue multimeters have a reverse output. That means when you are attempting to identify cathode and anode ends of semiconductor junctions, **the actual polarity of the tester's voltage is opposite of the test probes colors.** The red probe is the negative source and the black probe is positive.



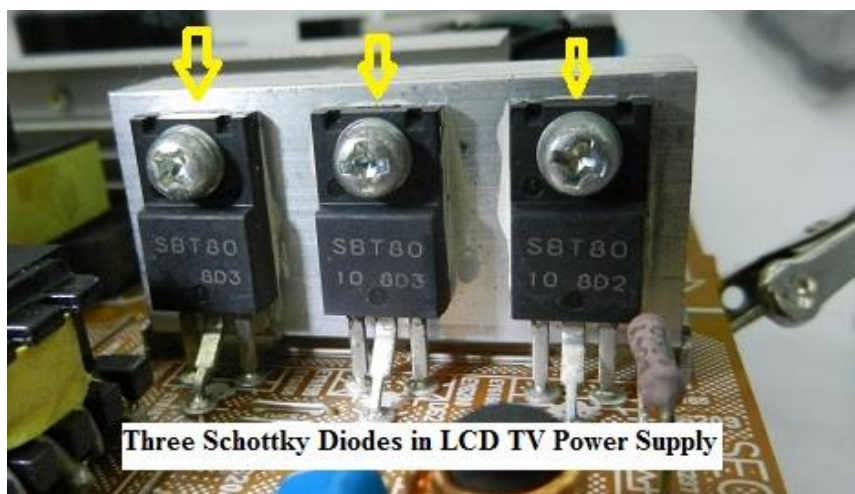
You now have to set your meter to x10Kohm range to test the diode again. The output voltage of x10k ohms is about 12 Volt (remember the 9 volt battery in your meter - 1.5 volt + 1.5 volt + 9 volt = 12 volt). Again the diode under test should show only one reading. The exception is a Schottky diode where it has two readings but not a shorted reading. I will explain how to test Schottky diodes in the next section.

If the meter showed one reading then the diode under test is good. If it has two readings then most probably the diode is either shorted or leaky. The digital meter can't test it because the output from the meter is only about 500mv to 2 volt. If a diode broke down when under full load, there is no way to test the diode (unless you have a very expensive diode checker or tester which is specially designed to track this type of fault). Substituting with a known good diode is often the only way to prove that an intermittent diode is causing a particular problem. Sometimes an intermittent diode could be located using a coolant spray and hair blower. Diodes are rated in Voltage and Amperes. Refer to a semiconductor data book for the exact specification. **Always replace a diode with the same or higher rating than the original specification.**

Caution: Be certain that power is removed from any circuit before performing any of the following diode checks, otherwise meter or circuit damage could result.

Conclusion: In order to correctly test diodes you need to use an analogue multimeter and set the range to x1 ohm and x10 kilo-ohms range. With these tips I'm sure you will have the confidence to check any diodes that come your way.

Testing Schottky Diode

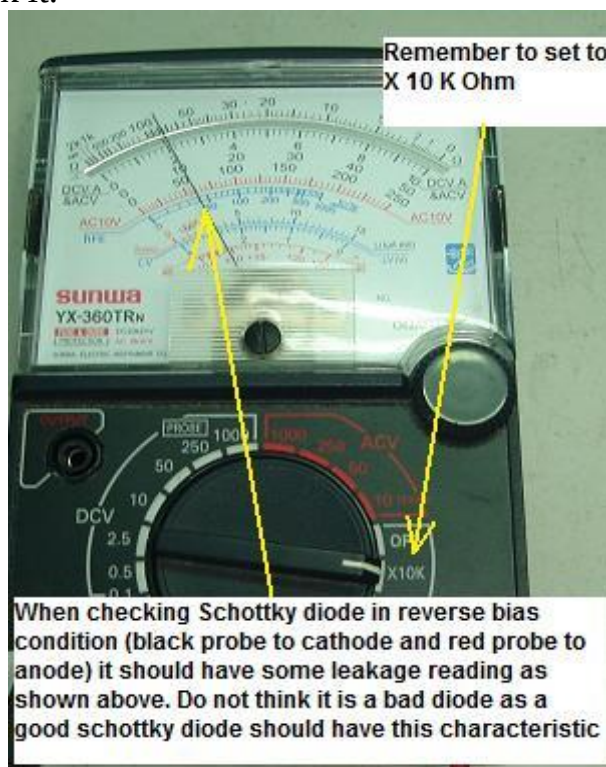


Schottky Diodes

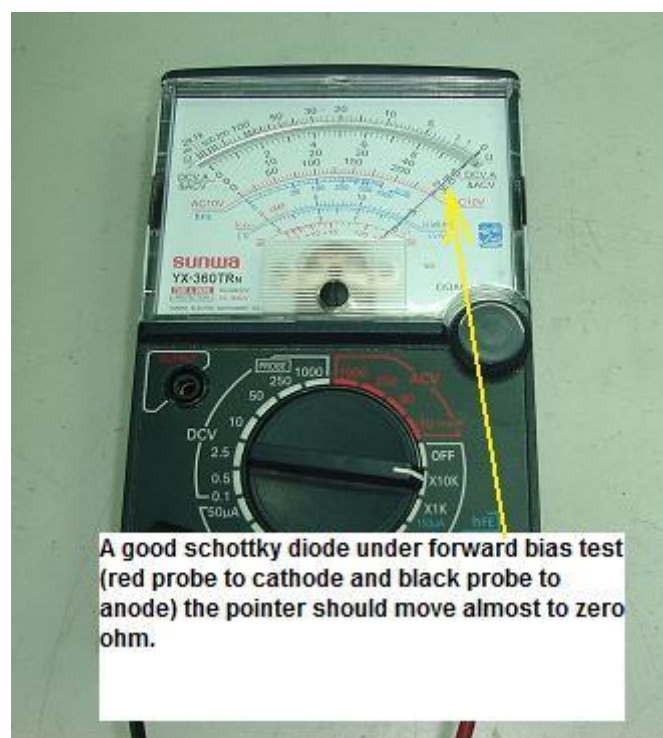
The Schottky diode or Schottky barrier rectifier is designed for uses in high efficiency rectification essential for applications like switched mode power supply (SMPS) circuits, switching regulators, etc. Its primary function is to convert AC to DC. If you observe any electronic schematic diagram and layout, the Schottky rectifier symbol (“D”) looks exactly the same as a normal diode.

Even the look, shape and design look just like a normal diode. The major difference between a normal diode and Schottky barrier diode is the **part number**. You can try Google for this part number SB3100 and the datasheet will tell you that this is a 100 Volt, 3 ampere Schottky Rectifier. Because they look the same, many electronic repairers thinks that measuring Schottky diodes is done the same way as **testing** normal diodes. If you use the normal diode checking method to test a Schottky diode then chances are high that you will not solve the problem.

In this book I will show you the basic accurate method to test Schottky diodes so that you will not be confused anymore. Using the semiconductor data book and with the help of search engines, you will easily find out whether the diode you are checking is a Schottky diode, General purpose diode (normal diode) or Ultra fast recovery diode. In electronic repair, you should not guess what component it is; just locate the data and confirm it so that you are 100% sure what are the best methods to check it.



Once you have confirmed that the diode you are going to test is a Schottky diode then you have to use the right way to measure it. Using an analogue multimeter, set it to times 10k ohm range, put the red probe to the cathode and the black probe to the anode. You should see the pointer move to the full scale. Now, reverse the probes and you will get some leakage reading. In other words, the pointer will move up a little bit. This is a good characteristic of a Schottky diode when you get this type of reading. However if you test a normal diode (general purpose diode such as 1N4007) and you discovered that it has two readings then the diode is said to be defective and needs replacement.



A shorted Schottky barrier diode will show two full scale readings registered on the meter. Assuming an electronic repairer doesn't know how to test a Schottky diode, he or she may think that the diode registered some leakage reading and replace it. Schottky diodes are not easy to get from a local electronic distributor.

Looking for a Schottky diode replacement will take you time but it is not necessary if you know how to check it. The electronic repairer might just simply install a 'normal diode' as a replacement and hope that it will work. Well, the equipment will still not work because you have replaced a working diode (Schottky diode) with another good normal diode! The actual fault is still out there and is not the Schottky diode.

Sometimes, replacing a Schottky with a normal diode may cause the equipment to be unstable especially in a sensitive circuit. The best thing to do is to replace with original part numbers or a specification that is a higher voltage and current or same spec with the original diode. Typical part numbers for a Schottky diode are 1N5818, 1N5819, 1N5820, STPR10 and SB530. You can Google for the datasheet and find out the specification of these part numbers. If you have one, try testing it with your analogue meter and you will be surprised that there are two readings **but not a shorted reading**.

Note: Lately, many new number of Schottky diode such as SB3100 has only one reading when tested it both ways. This means it has the same reading like when you are testing a normal diode.

Note 1: Checking an Ultra Fast Recovery diode is the same way as when you check a normal diode. It should have only one reading when tested it both ways.

Important Note: Sunwa and some other brands of analogue multimeters have a reverse output. That means when you are attempting to identify cathode and anode ends of semiconductor junctions, **the actual polarity of the tester's voltage is opposite of the test probes colors**. The red probe is the negative source and the black probe is positive.

Testing Bridge Rectifiers

Using an arrangement of four diodes called a full-wave bridge rectifier in a power supply is very common. The function of the bridge rectifier in the power supply is to **convert the AC supply voltage into DC voltage**. For full-wave rectification, it is not necessary to use four individual diodes since all four diodes can be obtained in one package as shown in Fig 1. Each package has two AC input terminals and two DC output terminals marked (+) and (-).



A schematic for the full wave bridge rectifier is drawn in Fig 2. Bridge rectifiers are classified in the same way as single diodes, i.e. by their maximum reverse voltage or Peak Inverse Voltage (PIV) and Forward Current (IF). It is labeled as “BR” or “BD” and sometimes as “D” also in the electronic circuit.

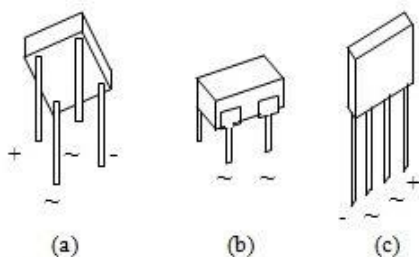


Fig 1: Some examples of bridge rectifiers

a) Marked b) in-line c) dual-in-line (DIL)

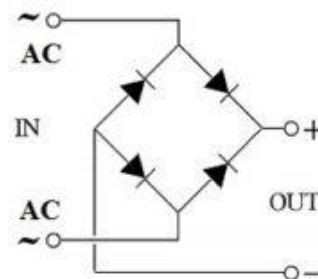


Fig 2: Schematic for diodes wired as a full-wave bridge rectifier

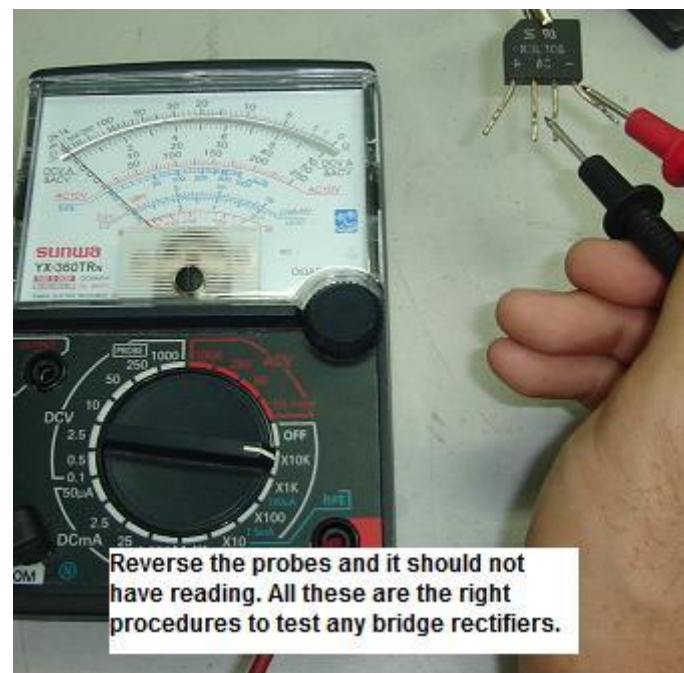
Testing Bridge Rectifiers

Set your analogue meter to X10 K Ohms and place your meter probes to + and ~ ac pin. It doesn't matter which probes to which pin but as long as it doesn't show two similar low resistance readings registered by your meter when you reverse the probes, it is okay. It should have only one reading. Next, again place your probes to the + and to another ~ AC pin (there are two "~" AC symbols in bridge rectifiers) and you should have only one reading even though you had reversed the probes.

Similarly you want to test the – (negative) with the first ~ AC and then – (negative) with the other ~ AC. Look at the photos and you should understand it. Assuming you found one of the diodes shorted in the bridge rectifier, you'll have to replace the whole package. Replace it with the same or higher voltage and ampere rating!







Testing Light Emitting Diodes (LED)



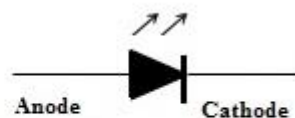
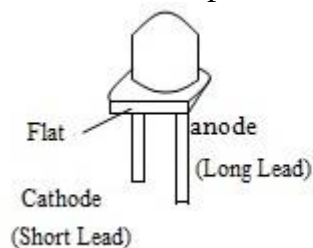
Typical LED

A 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 **reversed-biased**. The LED is used as a low current indicator lamp in many types of consumer and industrial equipment, such as monitors, TVs, printers, hi-fi systems and machinery control panels.

The plastic lens is very important in directing and modifying the small amount of light emitted by the LED chip. The light can be visible, such as red, green, yellow and white. It is labeled as “LED” on a circuit board.

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.

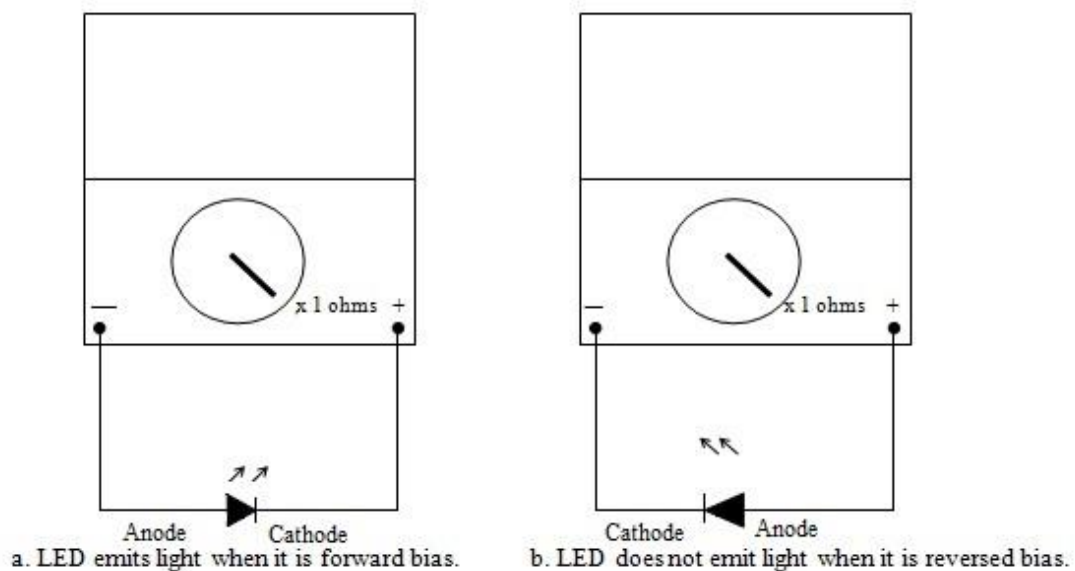
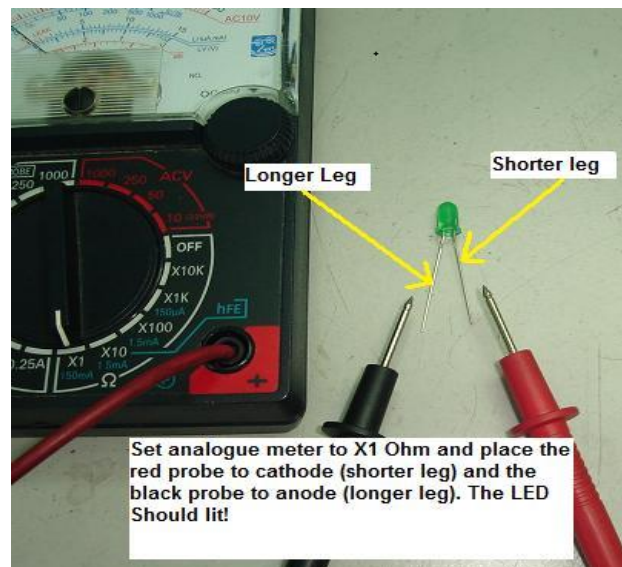
The cathode of the LED is identified on the package by the flat side on the plastic. The life expectancy of LED is about 100,000 hours.



General appearance and Symbol for a Light Emitting Diode

Testing LEDs

Remember that the LED only emits light when it is forward bias and the LED does not emit light when it is reversed-biased. If the 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 checking the LED.



Testing with an analogue meter

Important Note: Sunwa and some other brands of analogue multimeters have a reverse output. That means when you attempting to identify the cathode and anode ends of semiconductor junctions, **the actual polarity of the tester's voltage is opposite of the test probes colors.** The red probe is the negative source and the black probe is positive.

Testing Zener Diodes



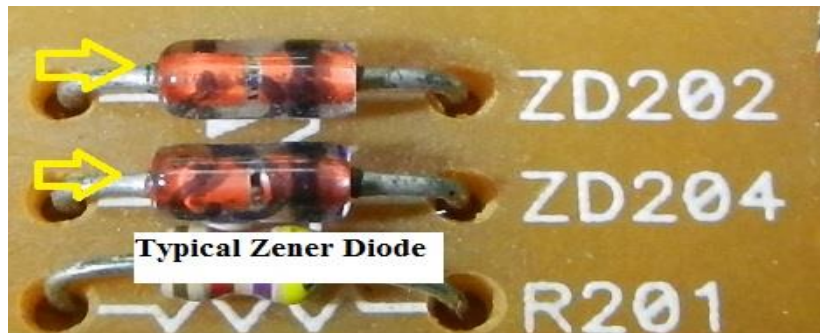
Zener diode

Anode



Cathode

Symbol



The method of testing zener diodes is totally different from testing regular diodes. You need an analogue meter to do the job. Before you start to test any zener diode, you must first understand the marking or part number and then look for the voltage ratings. Once you know the zener diode voltage from internet search then it is easy to check with your meter to see if it is leaking, open or shorted.

A wrong part number installed may cause your equipment to malfunction and behave strangely. Precious time and money will be lost due to the lack of knowledge in zener diode spec identification. If you can't find out what the code or part numbers mean then it is very difficult to repair the equipment. Do not worry as this book here is to guide you to successfully read the zener diode marking:

2.4=2.4 Volt zener diode

2V4=2.4 Volt

10= 10 Volt

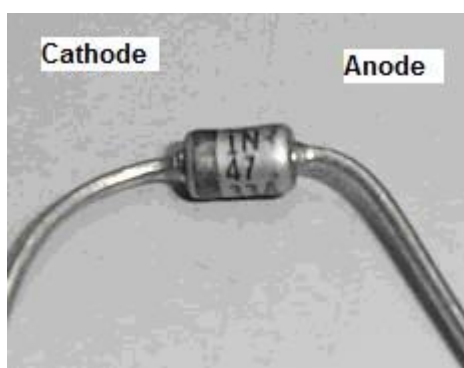
10V= 10 Volt

BZX85C18=18 Volt 1 watt zener diode

BZY85C18=18 Volt 1/2 watt zener diode

1N4746= 18 Volt 1 watt zener diode.

Sometimes you may think a normal signal glass type diode is a zener diode thus you will not get the exact measurement. If you have confirmed that the diode you want to measure is zener diode then you can proceed to use my method to accurately test it. For your knowledge, a zener diode with 2.4 volt to 12 volt should have two readings when tested with an analogue meter set to times 10K ohm range. But these readings are not a shorted reading!



A 1N4733A zener diode

Let me guide you: when you put your meter probes across the zener diode of 2.4 volt using the times 10 k 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 toward 0 ohms. If you now connect the probe the other way (black probe to cathode and red probe to anode) the pointer will point to around 2- 4 ohms!

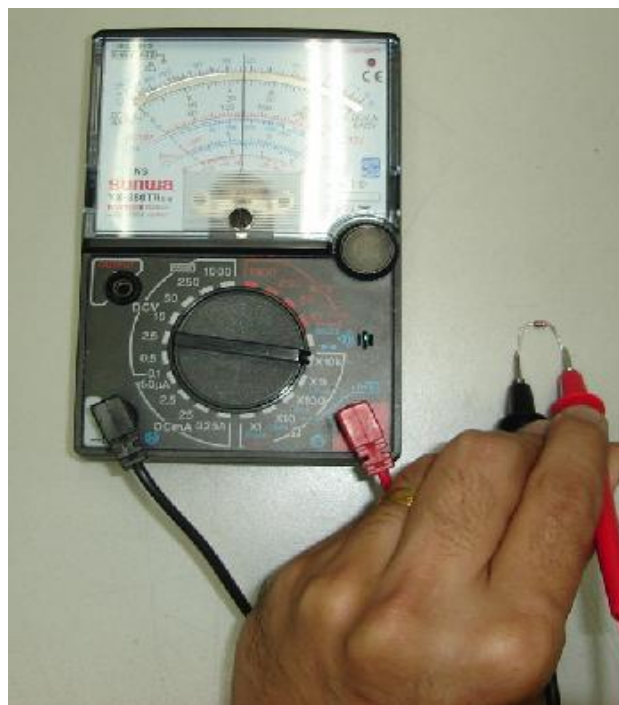
If both ways of testing caused the pointer to point to zero ohms then the zener diode is **considered shorted**. When you measure a 5.1 volt zener diode, as usual one way will point to zero ohms while the other way will show a higher resistance which is in the 20 to 60 ohms range. These are the characteristics of a **good working zener diode** so don't think that the meter showing two readings means the zener diode is faulty.

If you get two same readings when you measure a normal diode, then the diode is shorted. As I mentioned above, testing zener diodes is totally different from checking a normal diode.

When you connect your probe and measure a 13 volt zener diode and higher voltage, it should show only one reading using the times 10 K ohms range. That's when you are touching the red probe to the cathode and black probe to the anode. Reversing the probes **should not show any reading**.

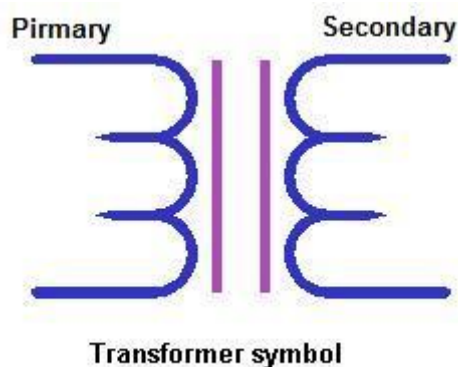
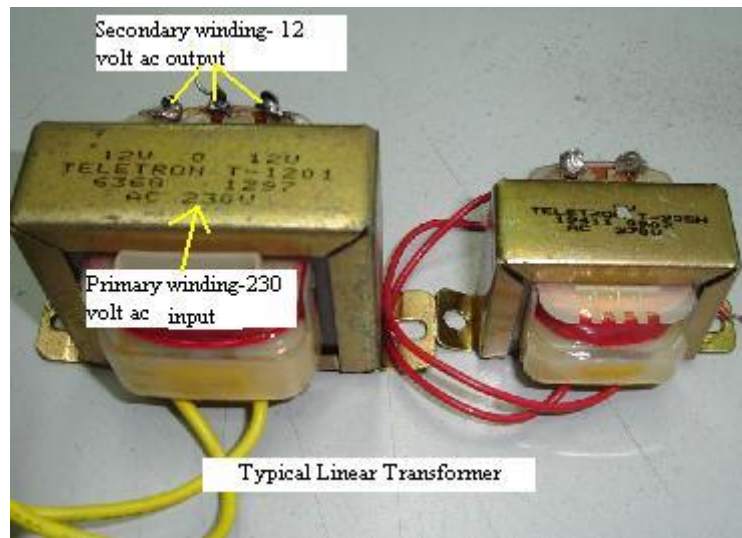
If the results show two similar readings then the zener diode is confirmed to be shorted .

Start measuring zener diodes taken out from your component's rack or from a scrapped electronic board; compare a good zener diode and a shorted one and see for yourself. Write down in a book the results that you get when comparing and checking a good and a bad zener diode. It won't take you long to become familiar in testing zener diodes accurately. One more tip: replace only a zener diode with the same or higher wattage. If possible use the exact voltage and watts if you want the equipment that you repair to last longer.

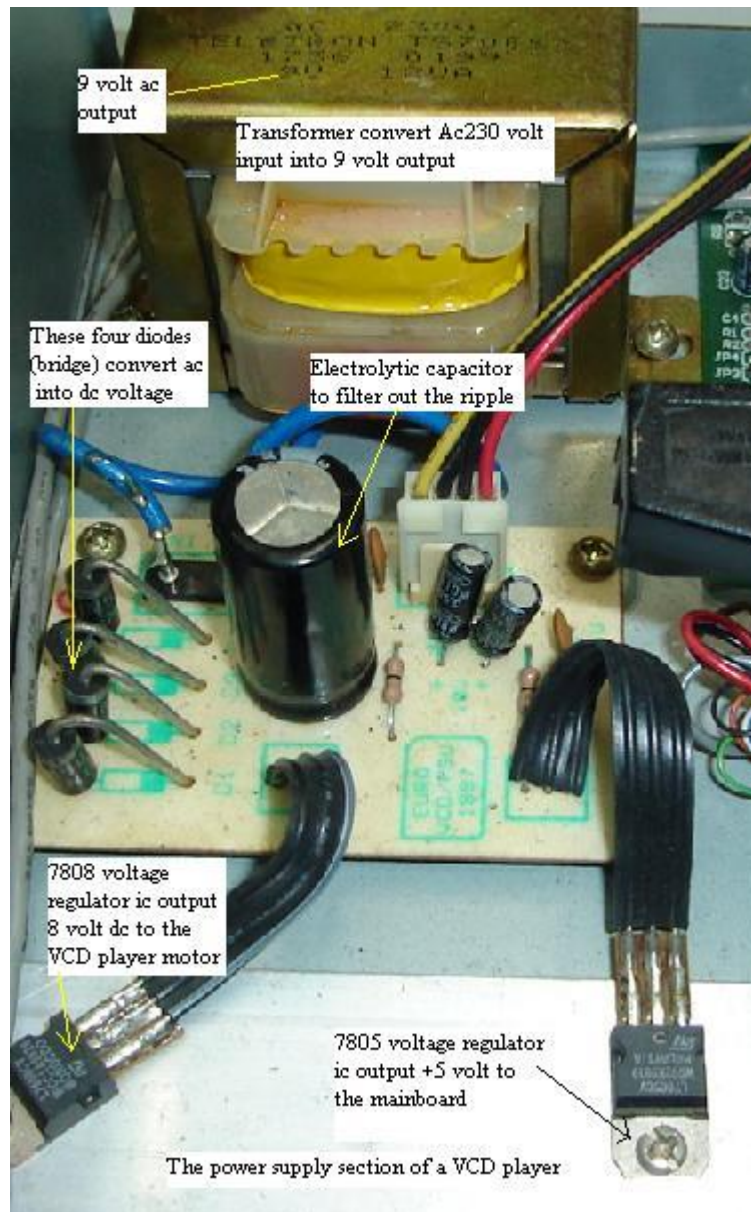


Using analogue multimeter to test zener diode

Testing Linear Transformers

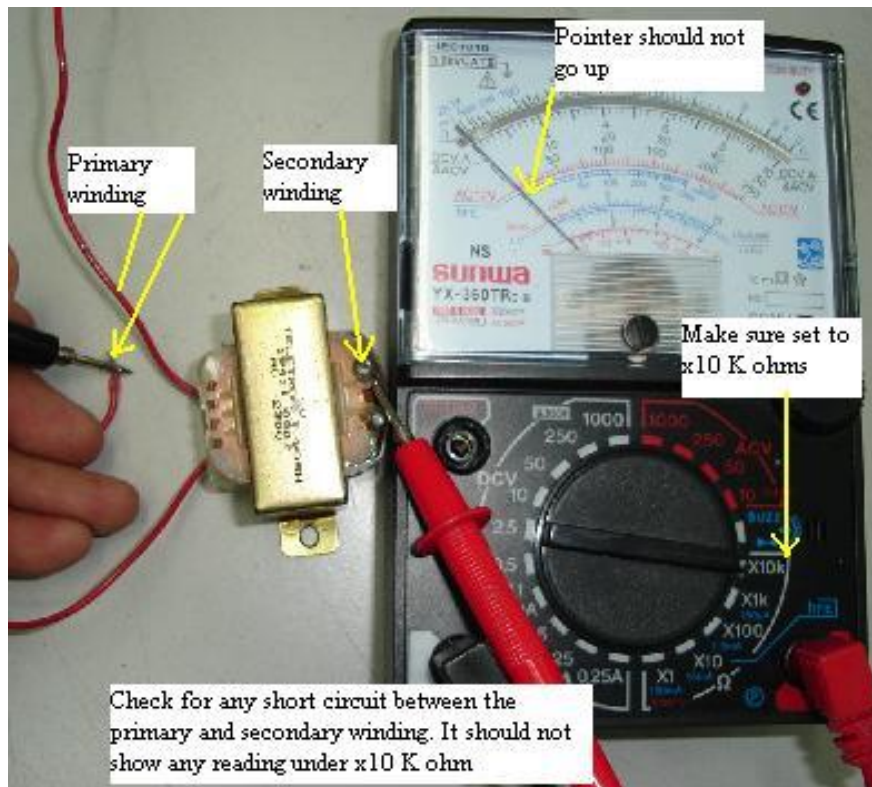


Testing transformers is very easy if you follow the procedure explained in this book. Generally there are two types of transformers on the market: the linear type and the switch mode power transformer. In this chapter I'll only be explaining how to test the linear transformer. I will explain about the switch mode transformer in next chapter. Before that, I would like you to know what the function of a transformer is. **The function of a transformer is to change AC voltage.** A transformer cannot change direct current (DC) voltage. A transformer is labeled as "T" on a circuit board.

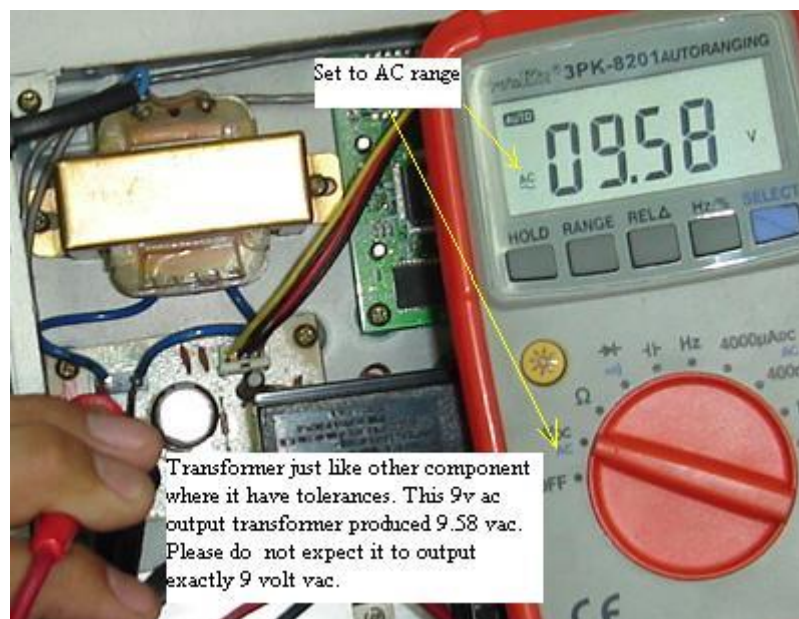


There are three types of linear transformers:

- 1) **Step up transformer** - to increase the output voltage. Typical example is 240v ac input with a 480 volt ac output (high voltage).
- 2) **Step down transformer** - to decrease the output voltage. Typical example is 240v ac input with a 12 volt ac output (low voltage).
- 3) **Isolation transformer** - produces the same amount of voltage as the input voltage. Typical example is 240 v ac input with a 240 volt ac output.



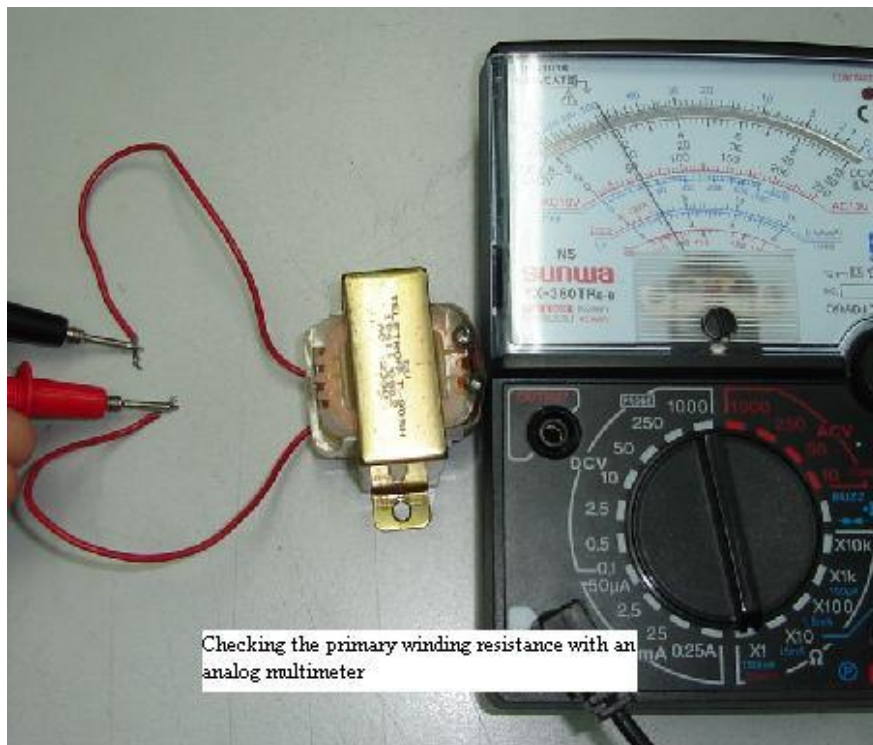
A single transformer can have different independent outputs to serve as step up transformers as well as step down transformers. The output voltages are then converted into DC voltages with the help of diodes. I will not go into too much detail on transformer theory as this page deals with how to test a linear transformer. There are three ways or techniques on how to test a transformer:

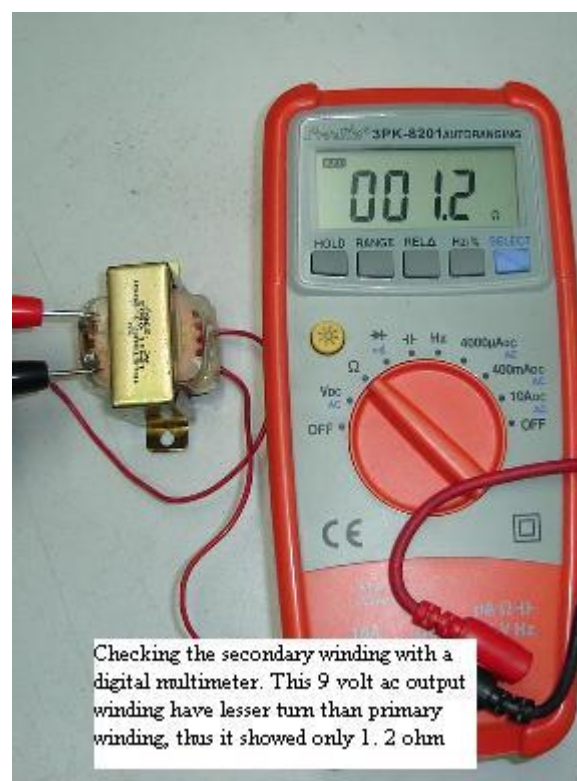
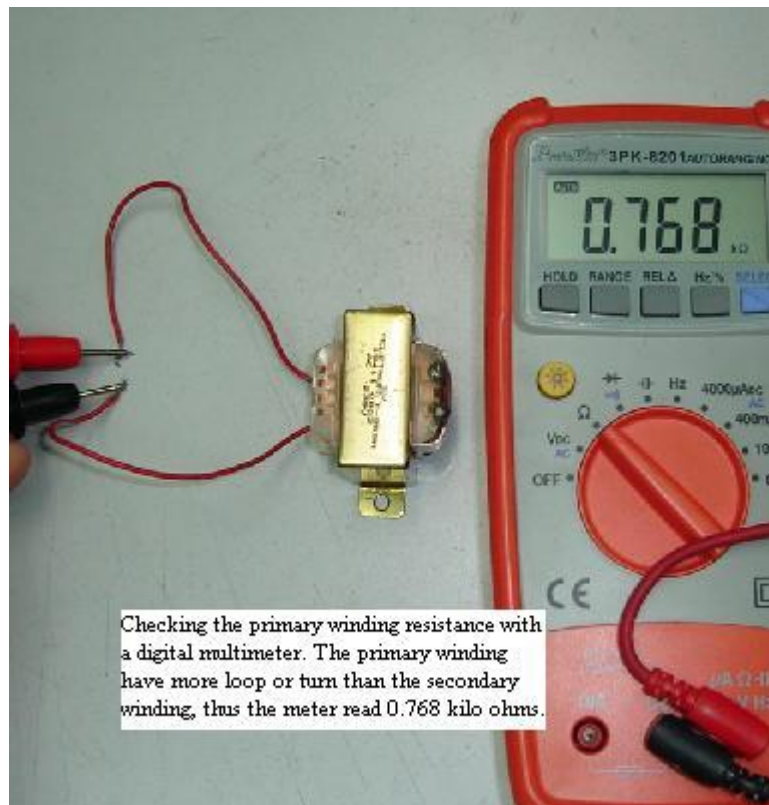


Switch the equipment on and measure the input and output voltage of the transformer with either an analogue or digital meter. If there is no voltage or lower voltage then it is supposed to be, the transformer needs replacement. **I personally like this method because you are testing the transformer under full operating voltage which is very accurate.** The disadvantage is that you must be very careful when checking it especially when the power is 'on'. Make sure you have someone to guide you or you can try the second method where you don't need to power On the transformer. Simply measure the primary and secondary winding ohms value.

With the power off, remove the transformer from the board and perform a resistance or continuity test on the primary and secondary winding as shown in the pictures in the next page. If there is no resistance or ohms reading on the primary and secondary winding, suspect an open winding and the transformer needs to be replaced. The advantage of this method is you are safe because no power is applied to the transformer.

The disadvantage of this is that the checking of the resistance for an ohms reading is not as accurate as when you perform a ringing test as mentioned in the third method. A shorted primary or secondary winding is still checked well under resistance tests. However the good news is when either the primary or secondary winding develops a short circuit, it will usually produce a bad smell and the transformer gets very hot on its core or casing.

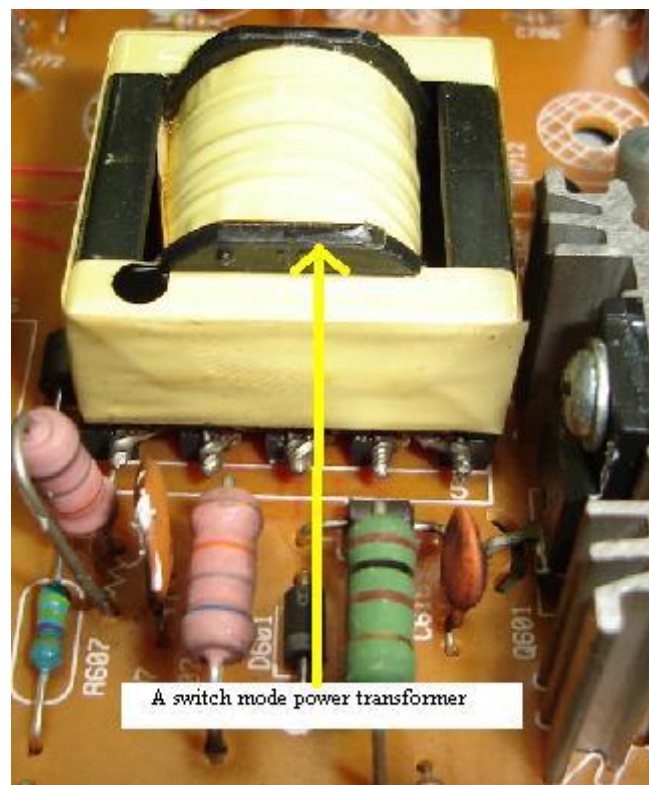




Performing a ringing test

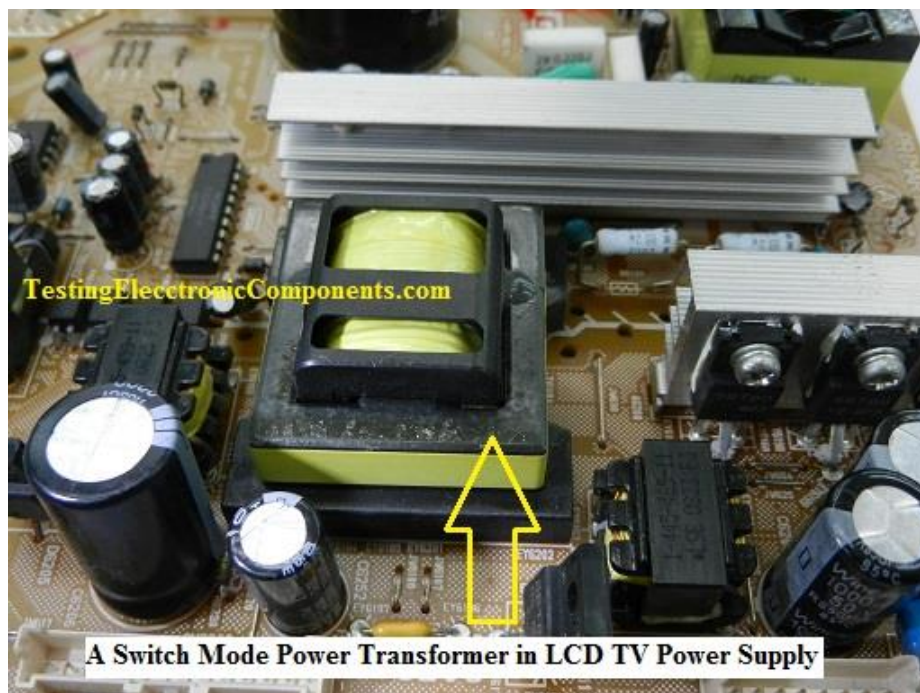
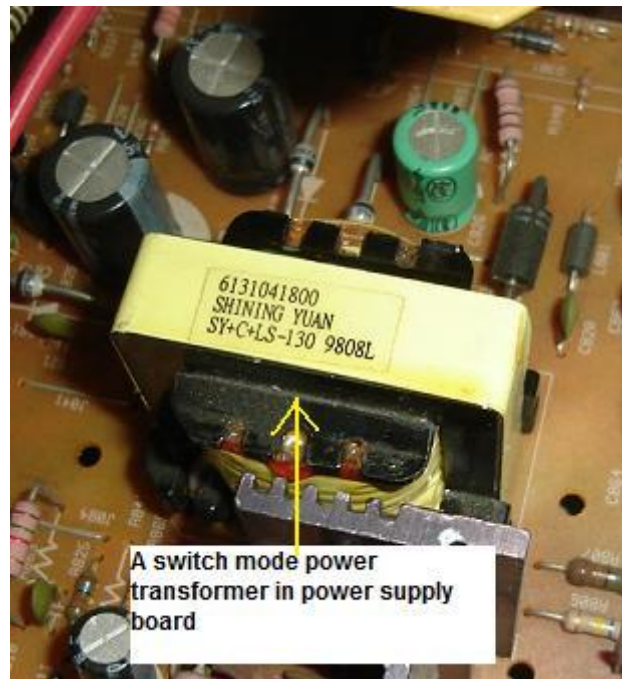
Perform a ringing test with a ringer tester like the Blue Ring Tester. Checking the ohms resistance or continuity on a linear transformer is not accurate as compared when using a ringer tester. However there is still one disadvantage which is the winding can go shorted when under full operating voltage even though both windings checks okay with a ringer test.

Conclusion- **The first method (voltage testing) is the best choice to test a linear transformer accurately, but first you must know how transformers work and get an experienced technician/friend to help you out before performing the test on your own.** For some transformers like the UPS (uninterruptible power supply) you need wiring diagrams to assist you because there are so many secondary windings you may get confused. Lastly, checking switch mode power transformers is different than testing linear transformers. I will cover how to test a switch mode transformer in next chapter.



A Switch Mode Power Transformer

Testing Switch Mode Power Transformers



Switch Mode Power Transformers (SMPT) are used in switch mode power supplies in electronic equipment such as LCD/LED TVs, Computer Monitors, DVD players, etc. The function of a SMPT is to convert the AC wave to some other value, lower or higher. The input is called the primary winding while the outputs are the secondary windings.

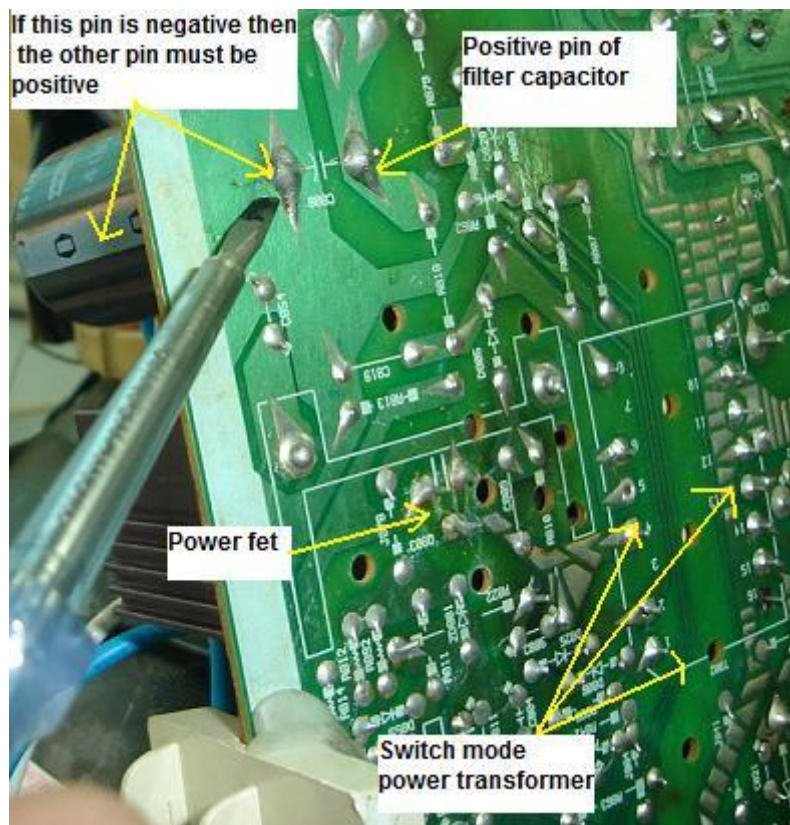
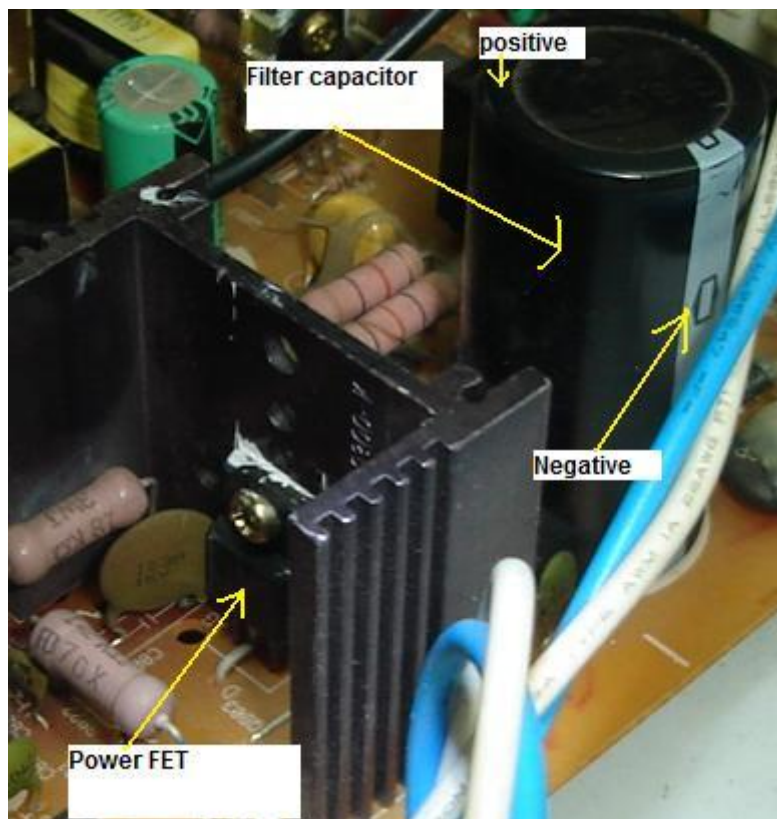


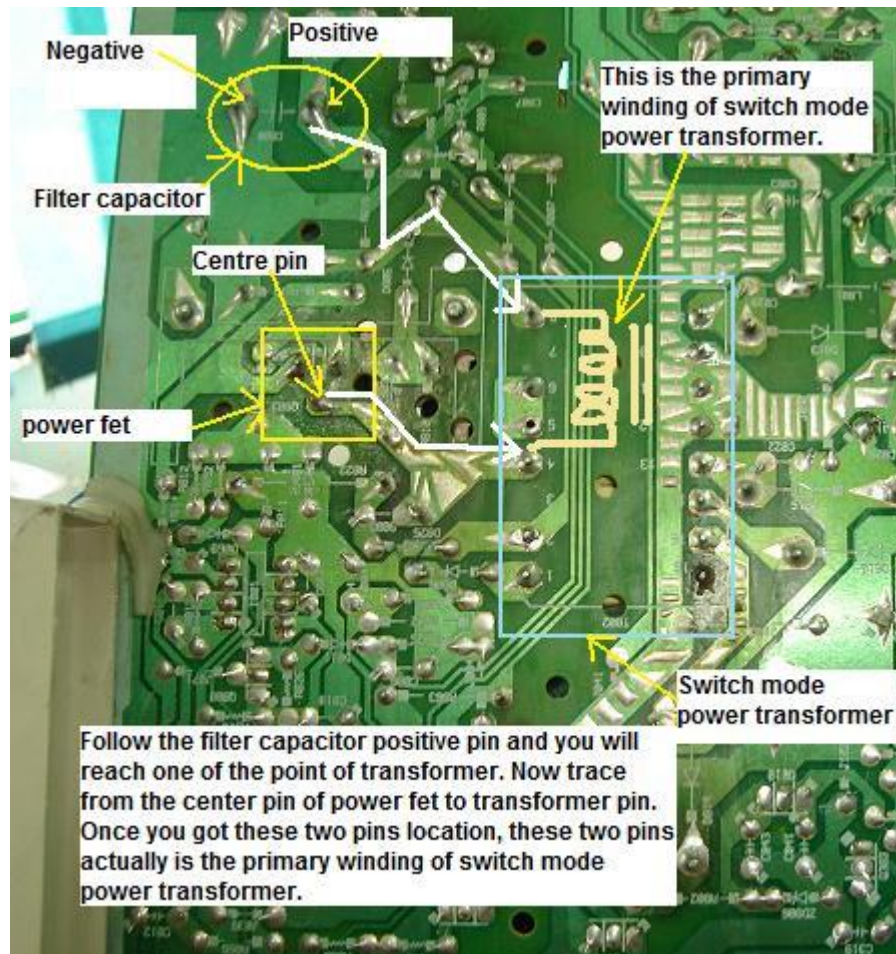
Switch mode power transformers rarely breakdown and if they do breakdown it will usually cause power section components to blow or totally blow up the main fuse and trip the ELCB (Earth Leakage Circuit Breaker). If a SMPT failed, normally it was the primary winding shorted. The secondary windings are very robust and seldom have problems.

In order to accurately test the primary winding, one cannot use the multimeter resistance (Ohm) test as it is not accurate and will give a false reading. In other words, a shorted primary winding will test good with ohmmeter but failed when test with coil tester. The most popular coil tester is the Blue Ring Tester. For more information about this tester you may click on the link below:

<http://www.electronicrepairguide.com/Blue-Ring-Tester.html>

Testing SMPT





First you must find the primary winding of the SMPT. It is very easy by simply referring to the photo given. Look at the positive sign of the big filter capacitor. **Note: make sure you discharge it first by referring to the capacitor chapter.** Trace from the positive pin and eventually you will reach one of the SMPT pins. Now trace from the centre pin of the power FET transistor. Again this FET pin will lead you to one of the pin of SMPT as shown in the photo above. Remove the SMPT and test the two pins with the Blue Ring tester.



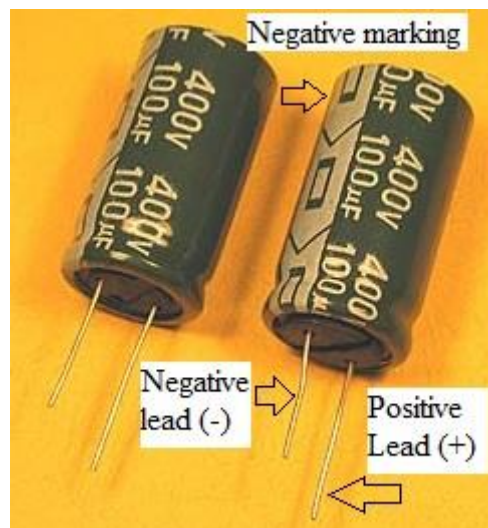
Placing the Blue Ring tester probes to the primary winding of the switch mode power transformer, a good measurement will usually be between 4-8 LED bars lighting up. If it indicates only one or two LED bars or the Blue Ring tester LED goes off (no light), this is proof that the primary winding has a problem. If the primary winding is shorted, you can send the SMPT to a rewinding shop for repair (usually hard to find) or you can buy a new transformer from online website.

Understanding Capacitors

A capacitor, also known as a condenser, is one of the most essential components in designing an electronic circuit. Radio, television and monitor circuits use a number of capacitors. Capacitors have 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 in filter or timing circuits. A capacitor is symbolized as shown in below and is denoted by a letter C.



Non Polarity Capacitor Symbol Electrolytic Capacitor Symbol



100uf 400 Volt Electrolytic Capacitor

Capacitance

Capacitance is measure in farads (F). A farad is a large unit. The smaller units are microfarads (uf), nanofarads(nf) and picofarads(pf).

$$1 \text{ microfarad} = 1/1,000,000 \text{ farad}$$

$$1 \text{ nanofarad} = 1/1,000,000,000 \text{ farad}$$

$$1 \text{ picofarad} = 1/1,000,000,000,000 \text{ farad}$$

$$\text{So, } 0.01\mu\text{F} = 10\text{nF} = 10,000\text{pF}$$

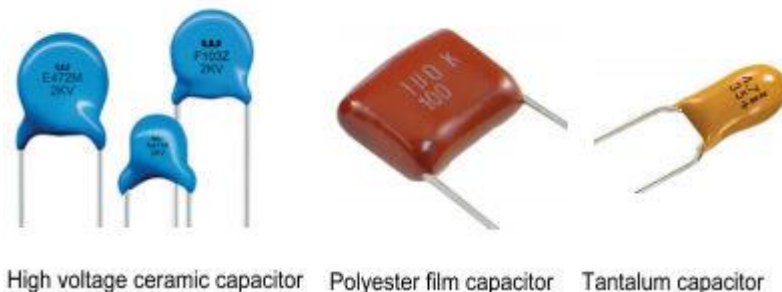
Microfarad can be written as MFD, MF or μF or simply M. Nanofarad is written as NF. Picofarad is written as PF. Capacitors rated in picofarads are found in RF and high frequency circuits. Capacitors rated in microfarads are incorporated in low-frequency and DC circuits, like power supplies, audio amplifiers, and digital and timer circuits.

Types of Capacitors

There are basically two types of capacitors i.e.

Non-Polarized Capacitor	Polarized Capacitor
a) MICA	a) Electrolytic capacitor
b) Paper	b) Tantalum capacitor
c) Ceramic	
d) Polyester	
e) Polystyrene	

Non-polarized capacitors mean that they can be inserted into a circuit in any orientation. While polarized capacitors must be inserted in the proper orientation with respect to applied voltage. If the polarized capacitors are connected in opposite 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 500 VDC. Ceramic capacitors with ratings of 1 to 5kv 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 – Never use a capacitor in a circuit with higher voltages than the capacitor is rated for otherwise it becomes hot and may explode. It's all right to replace a 0.22 μ F of 200WV capacitor with one rated 0.22 μ F, 250WVDC.

Capacitor Safety

A capacitor can store a charge for some time after equipment is powered off. High voltage electrolytic caps, and even large value, low voltage electrolytic, can pose a safety hazard. Usually these caps are in power supplies and almost always have a resistor in parallel with the cap(s), called a bleeder resistor, to discharge the cap after power is switched off. If a bleeder resistor is open, or there is none, then the cap can retain a voltage charge after the unit is unplugged.

A large 75V capacitor in a high power audio amplifier can easily melt the tip of a screwdriver, accompanied by flying metal sparks if the tool shorts across the capacitor terminals. This could cause eye injury, burns, or secondary injury. When in doubt, take time to discharge power supply capacitors before working on a piece of equipment. If possible, wear a goggle before you do a discharge on a big capacitor.

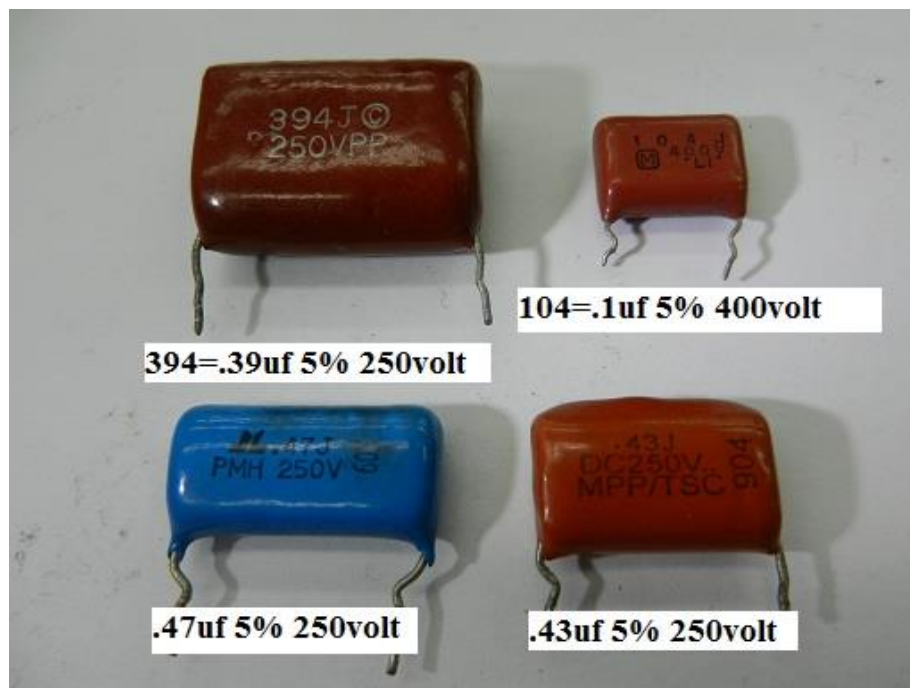
Be sure to connect electrolytic capacitors in the right polarity (i.e. negative to negative and positive to positive). If the electrolytic is connected in opposite polarity, the reversed electrolysis forms gas in the capacitor. It becomes hot and may explode. This is a possibility only with electrolytic capacitors.

How to read a capacitor numeric code

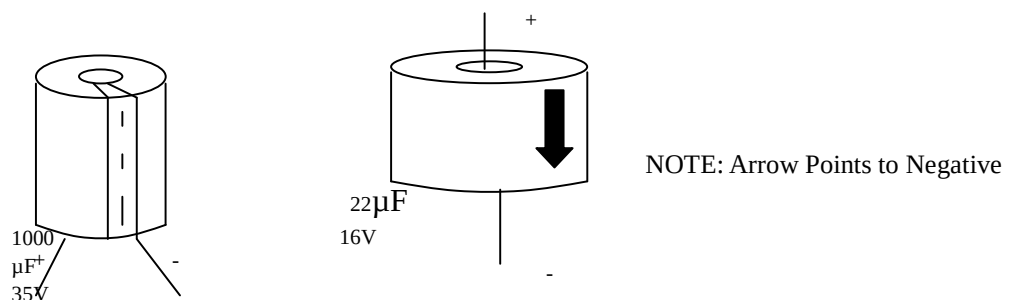
The non-polarized capacitor of nominal value less than 1000pF is usually plain marked. For instance, for a 220pF capacitor, it will be marked 221 only. For capacitance values of 1000pF or more, a three digit code is used. The first two digits represent the two significant digits and the third digit represents the decimal multiplier. For instance, 102 represents a capacitance of $10 \times 10^2 = 1000\text{pF}$ and 104 represents a capacitance of $10 \times 10^4 = 100000\text{pF} = 0.1\mu\text{F}$. Basically it has the same calculation method as a resistor.

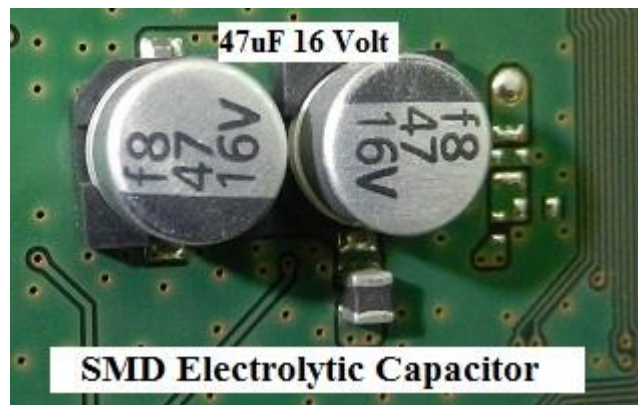
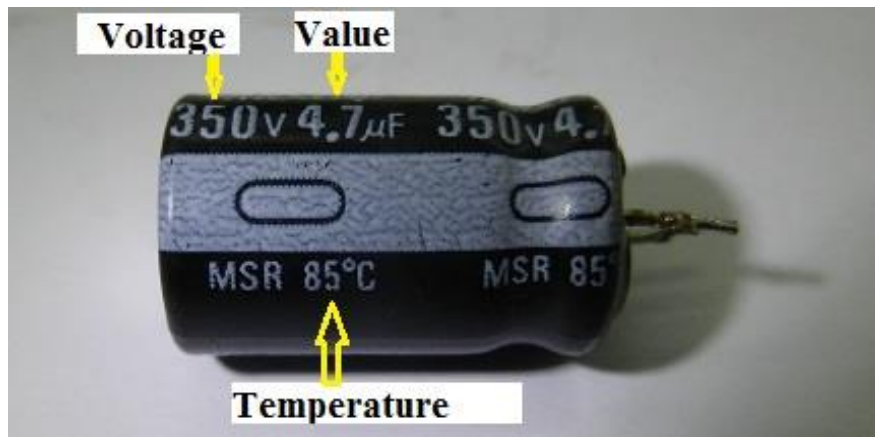
Example 1: What is the capacitance value of these capacitors?

- a. 22 $\Rightarrow$ 22 picofarad
- b. 330 $\Rightarrow$ 33 picofarad
- c. 471 $\Rightarrow$ $47 \times 10 = 470$ picofarad
- d. 562 $\Rightarrow$ $56 \times 10^2 = 5600$ picofarad or 5.6 nanofarad
- e. 103 $\Rightarrow$ $10 \times 10^3 = 10000$ picofarad or 10 nanofarad
- f. 224 $\Rightarrow$ $22 \times 10^4 = 220000$ picofarad or 220 nanofarad or .22 microfarad
- g. 335 $\Rightarrow$ $33 \times 10^5 = 3300000$ picofarad or 3300 nanofarad or 3.3 microfarad



Electrolytic capacitors have their capacitance (μF), voltage rating (V or WV), Temperature (either 85 Celsius or 105 Celsius) and polarity printed on the case as shown in figure below and in the next page:





Capacitance Tolerance

Ceramic disk capacitors for general applications usually have a tolerance of +20 percent. Paper capacitors usually have a tolerance of +10 percent. For closer tolerances, mica capacitors are used. It has tolerance value of +2 to 20 percent. The letter after the capacitance numerical code indicates the tolerance i.e.: M=20%; K=10%; J=5%. So a 103K capacitor is a 10,000pF or 10nF or 0.010µF 10% capacitor with 10 % tolerance.

Electrolytic capacitors have a wide tolerance. For instance, a 100µF electrolytic with a tolerance of –10 percent, +20 percent may have a capacitance of 90 to 120µF.

How To Discharge A Capacitor

Capacitor discharge is the first thing you should do as an electronic repairer before touching the power supply section. The large filter capacitor in the power supply section can hold dangerous high voltage even if the unit has been off for few days. It is advisable to discharge the filter capacitor first before you start to troubleshoot in order protect yourself from being electrocuted.

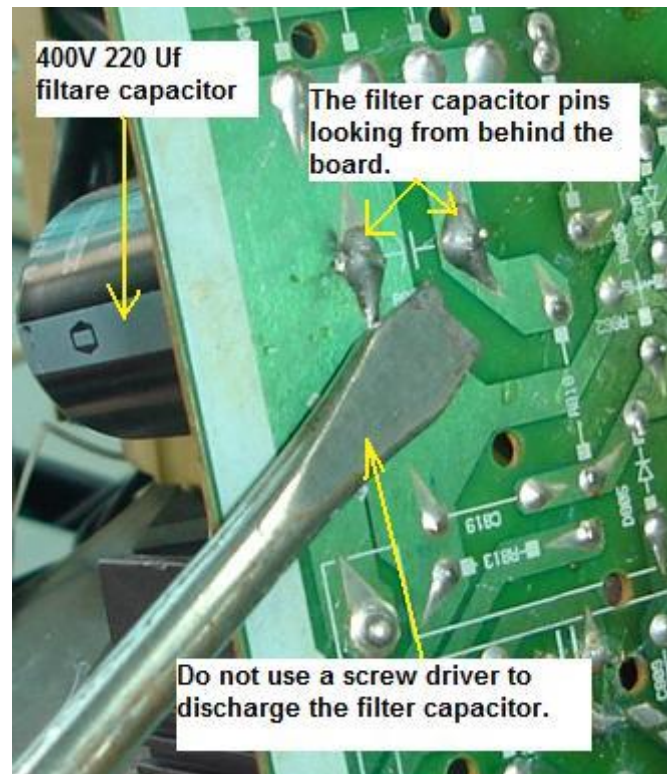
Though the capacitor current stored in the capacitor can't kill you, it is enough to burn your hand, fingers and your skin when you accidentally touch it and the worst case is while you're carrying the monitor or TV, you might just throw the equipment when you get a shock from the filter capacitor and the cathode ray tube monitor may break and the flying glass may hit your body or eyes.

Just be cautious when handling the power supply area. You can always use a meter to confirm whether there is still charge in the capacitor. Place your meter's black probe to the capacitor's negative pin (you can see the negative marking on the sleeve of the capacitor) and the red probe to the other pin. If there is high voltage registered on your meter then you have to discharge the capacitor, otherwise you may proceed to repair the equipment. Typical value for this type of filter capacitor is 220 to 330 microfarad with a 400 to 450 voltage rating.



The large filter capacitor in power supply section

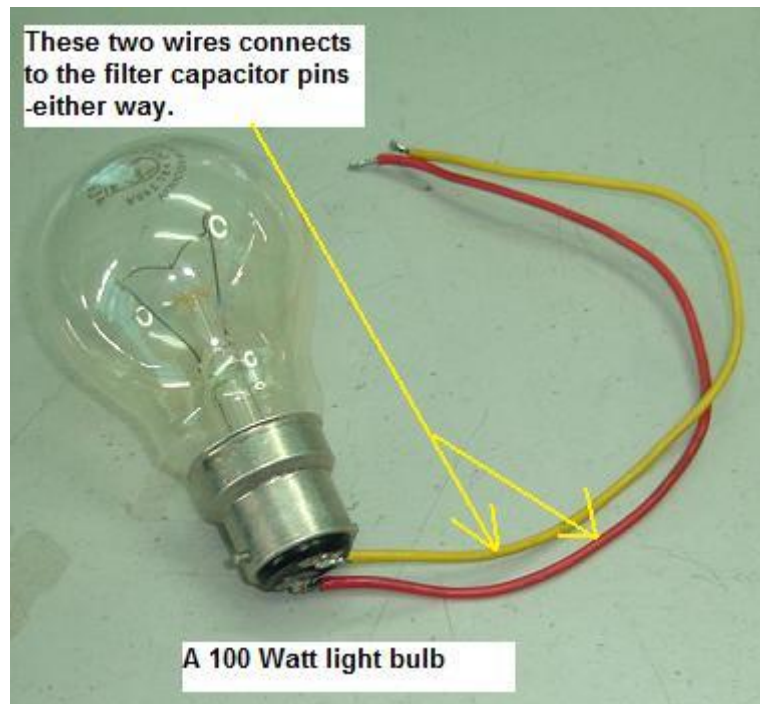
There are three ways to discharge the large filter capacitor in switch mode power supplies.



Please DO NOT use this method to discharge filter capacitor!

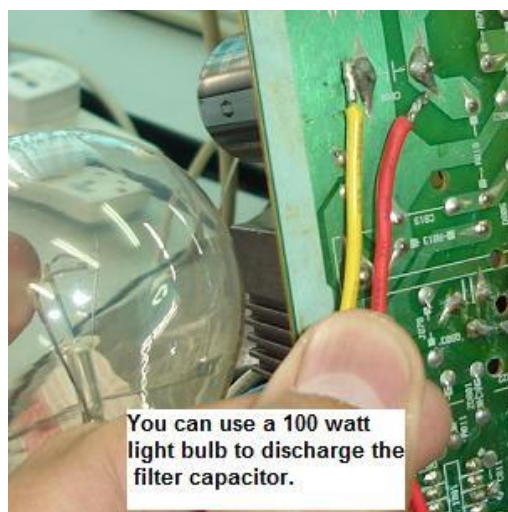
Discharging the capacitor with a screwdriver (not recommended). The reason for not using the screw driver to discharge a capacitor is because the printed circuit board or circuitry can be damaged due to the spark generated while discharging the high voltage in the capacitor. I once have blown the power area using this method. However, if you know that the capacitor stored voltage is not too large after confirmed it with a meter, you can easily discharge it with a small screw driver.

Just place the screwdriver tip to touch the two pin of the capacitor, within seconds the charge will be gone. If the capacitor holds a heavier charge of electricity then discharging the capacitor with a screw driver may melt the tip of the screw driver and the copper on the printed circuit board. Sometimes a big spark may cause small disintegrated solder lead or copper to fly out from the circuit board and might injure your eyes or body. This is why you need to wear a Goggle before you discharge a big capacitor.



A 100 watt bulb use to discharge filter capacitor

Another method is that you can use is a 100 watt electric light bulb and touch the two wires coming out from the light bulb on the leads of the capacitor. This method had been used by many electronic repairers around the world for the light bulb will act as an indicator to see if the capacitor still holds the charge. If there is a charge the light bulb will light and after discharged the light bulb will go off. I still prefer the third method because with the light bulb method you have to use both hands to touch on the capacitor lead.



The right way to discharge capacitor with light bulb



Use a resistor to discharge the capacitor leads

Third method and also my favourite method are to place the leads of a high wattage resistor on the leads of the capacitors you want to discharge. **You can use either a 1.8 k or a 2.2 kilo ohm 5 to 10 watt resistor** to discharge the high voltage capacitor in a switch mode power supply. It is very simple to use and very effective. It takes only a couple of seconds to fully discharge the capacitor. **Please do not hold the two ends of the resistor with your finger, only hold the body of the resistor.** Otherwise your fingers may get the discharge from the capacitor! Using only one hand, you can do the job while the other hand can hold a solder gun or secure the equipment casing.

I strongly recommend to those who are using the screw driver to discharge a capacitor in power supply to **consider the second and third method as these is the safest methods.** It not only protects the circuit, it also protects you. If you have discharged the capacitor and you are still not sure or no confident whether the charge is gone, you can always use a meter to confirm it.

Testing Capacitors



An Analog Multimeter

First method: Before you test a capacitor, make sure you use an analogue multimeter set to time 1 ohm range and connect a capacitor to the test probes. See on the dial if the pointer flicks up and comes down or not; this represents charging and discharging. If it is not flicking or there is no response then set your meter to time 10 ohm and then to 1k ohm and lastly to 10 kilo ohm range.

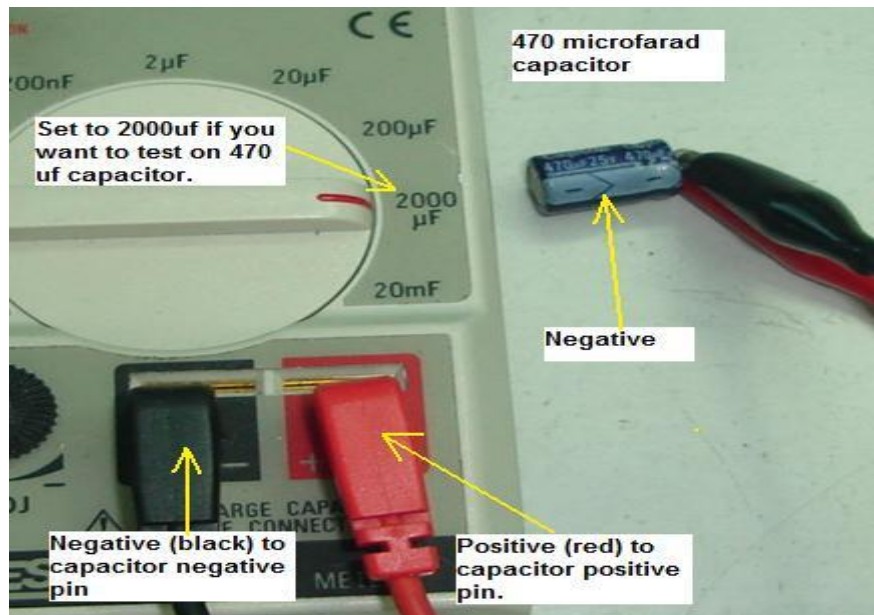




If it still does not flick then the capacitor under test has developed an open circuit. This is a rather old method to test capacitors because even though a capacitor can charge and discharge, **it does not mean the capacitor value is good**. Due to this problem, a digital capacitance meter was developed.



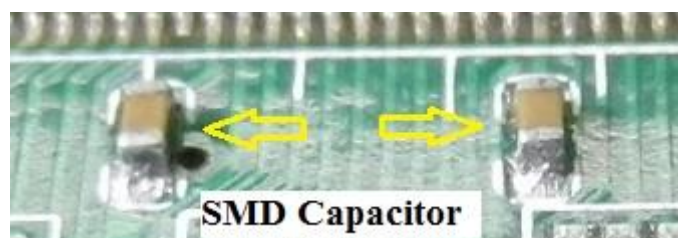
A Digital Capacitance Meter



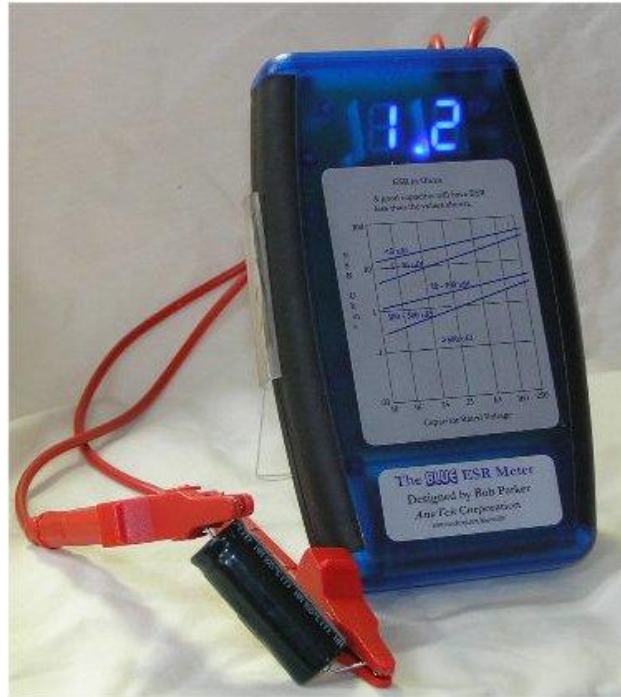
Testing electrolytic capacitors with digital capacitance meter

The second method to test capacitors is to use a digital capacitance meter. It is a little more accurate compared to an analogue multimeter. 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 somewhere between 90 microfarad to 120 microfarad. Remember, capacitors have tolerance just like resistors.

Be sure to discharge the capacitor first before testing. A reading of 60 microfarad means the capacitor has lost its capacitance and needs to be replaced. This meter is more expensive than an analogue meter. Somehow digital capacitance meters have their own disadvantage, which is, it can't check capacitors that are breaking down when under load and it can't check capacitors in circuit. It's still worth to invest in this meter because it can check almost 80-90% of capacitor failure.



Although the SMD capacitor is small, the digital capacitance meter still able to test it. Usually a circuit board have many SMD capacitors with similar color, length and diameter. You can always remove one out from the board and test the capacitor and compare the result with the other one.



The Blue ESR Meter

The third and most accurate method is to use an ESR meter which stands for Equivalent Series Resistance. This is the latest technology in testing capacitors. It is used to check on electrolytic capacitors and the advantage is that you can perform capacitor testing while the capacitor is still in circuit and have the accuracy of 99% compared to other meters. The Blue ESR meter is the most reliable and accurate meter that I've ever invested in. For more information please visit:

<http://www.electronicrepairguide.com/blue-esr-meter.html>



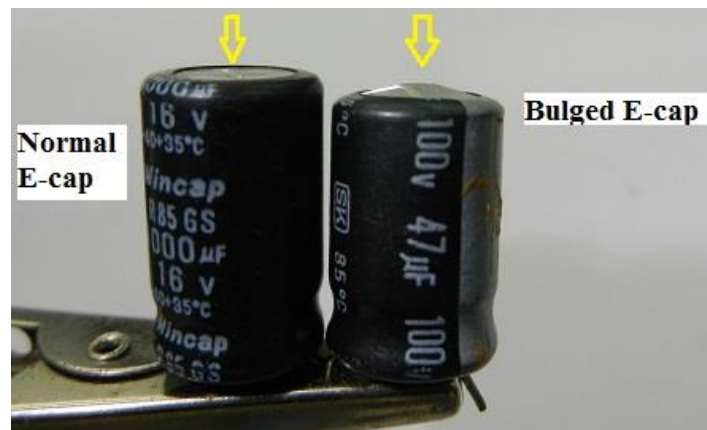
A Sencore LC103 Capacitor & Inductor Analyzer

If you have the budget, you may consider to invest in the high end capacitor tester such as the SENCORE meter LC102 or LC103 model. These meters have the capability of measuring any type of capacitors with four tests:

- measure capacitor values
- checking for leakage
- equivalent series resistance (ESR) and
- Dielectric absorption

It can test aluminum electrolytic capacitors, film capacitors, ceramic, high voltage capacitors, etc. It also has the function to check inductors or coils too. A capacitor failure when under load is very rare. Using the ESR capacitor meter alone can solve most of the electrolytic capacitor problems in electronic circuits.

Below are two examples of faulty electrolytic capacitors you can easily notice:



A burst or exploded Electrolytic Capacitor

In the above case, you do not need to check the capacitors, just direct replace it and retest the equipment.

Testing Capacitors That Breakdown When Under Full Operating Voltage

Testing capacitor breakdown when under full load or voltage only can be done by using special meters. Normal digital capacitance meters and analogue meters can't test this type of failure. Have you encountered a power problem where when you switch on the power supply, the fuse blows immediately? You have measured all the components in the power (primary) and secondary area and all the components seem to be working! Where is the culprit?

A fuse blown into a dark colour were usually caused by a lightning strike, a shorted bridge rectifier, defective Varistor in LCD/LED/OLED TVs, a shorted power transistor or FET field effect transistor, shorted primary winding in a switch mode power transformer, shorted secondary output diode, etc.



One time I was frustrated as to where the cause of the power problem was. Every time I switched on the power supply, the fuse would blow immediately (the fuse becomes dark colour and this indicates that there is a major short circuit in the power supply section or surrounding area which I've already mentioned above). I had tested all the components in the power supply section and didn't find the cause of the problem.

Then, I began to substitute all the suspected parts one by one and replaced them with good working components.

I eventually found the cause of the power supply problem. Guess what? It was the main power filter capacitor (220 microfarad 400 working voltage). After replacing the filter capacitor the fuse would not blow when switch on and the power supply worked perfectly fine. I began my detective work to explore why this particular capacitor can cause the fuse to blow even though the filter capacitor was already confirmed working with all my faithful meters.

The meters that I used to test the filter capacitor were analogue multimeter, digital capacitance meter and the famous ESR meter. I assume that many of you who read this book already know how to perform capacitor measurement with all the meters I've just explained in previous section.

Using an analogue meter to measure this filter capacitor showed capacitor was charging and discharging (meaning the pointer would flick up and then gradually goes down), testing with a digital capacitance meter showed around 220 microfarad (still within the capacitor tolerance range) and with the most powerful electrolytic capacitor tester which is the ESR meter, it showed a low ESR reading which is also a good reading! Then, how did I know the filter capacitor was faulty since all the meters tested ok on the filter capacitor?

What I've checked on the filter capacitor is just the value, ESR and the charging and discharging test but there is another test you should not miss which is the capacitor dielectric or leakage test. Use this test only when you want to check capacitors that have working voltage exceeding 250 volts. By using an analogue insulation meter you will be able to test the capacitor leakage.



An Analogue Insulation Tester



A Digital Insulation Tester
(Photo Excerpt from Aliexpress.com)

When I connected a filter capacitor to the meter and press the ready button it showed a very low resistance and this proved that a short circuit occurred between the plates when high voltage was applied! A good filter capacitor will just show a charge and discharge in the insulation tester just like when you are testing a capacitor using an analogue meter. This proved the bad capacitor breakdown when under full operating voltage.

You can get an insulation tester from any electronic supplier. It comes in a few ranges of 100v, 250v, 500v, 1000v and even 5000 volts! If you want to test a capacitor of 220 microfarad 400 volt then you have to select 250 volt. If you select 500 volt, it will blow your capacitor that is under test because the voltage you have selected is higher than 400 volts! If possible, you should get exact value and voltage for capacitor replacement.

Capacitor breakdown when under full voltage is quite rare and only happens to those capacitors that have 250 volts and above. If you come across some tough dog repair and could not locate the fault in the electronic board, I'm sure you will know what meter to use now. Go find the culprit.

Testing Ceramic Capacitors

Ceramic capacitor leakage quite often happens when there is a high voltage applied into it. Under normal testing, a digital capacitance meter or an analogue meter will not reveal any symptoms and you may think that the ceramic capacitor that you checked is ok. If you skip that capacitor, the chances for you to repair the equipment are very slim. In LCD TVs and Monitors, the ceramic disc capacitor and high voltage resin coated type is frequently found in the power supply, high voltage inverter area. When it fails in the inverter section, it can cause erratic or intermittent problems to the display such as blinking display, no display, shut down once the set is turned On and etc.



Resin coated ceramic disc capacitors

Using analogue and digital capacitance meters won't accurately test the ceramic capacitor failure even out of circuit. Ceramic capacitor leakage on an electronic board can pull down the voltage and cause a lot of intermittent problems to the equipment. I will explain to you my real life experience about this type of capacitor: In a computer monitor's cathode ray tube (CRT) board, the screen line (G2) had about 200 to 600 volts. The ceramic capacitor in the screen voltage line is usually rated at 102, 103, and 472 and voltage rating of 1 kilovolt to 2 kilovolt.

If this ceramic capacitor dielectric breaks down, it can pull down the screen voltage to a very low level and cause no display or picture. There is no way for an ohmmeter with 12v output from the test probes and a digital capacitance with 3v output to accurately check the ceramic disk capacitor that have the voltage rating of 1-2 kilovolt or even 3 kilovolt in

certain types of circuits such as the inverter circuit in an LCD TV and Monitor.

So the right way to check the ceramic capacitor leakage is to use an insulation tester. If you have an analogue insulation tester or meter, the meter panel will show a short circuit when certain voltages are applied to check the ceramic capacitor dielectrics or materials. The voltages that you can select depend on the brand or model you have. Some have the range of 50v to 1000v and some have the range from 100v to 5000v. It is optional whether you should have one.

If you have one then it would be an added advantage to you. The other option that you have is to **directly replace** the suspected failure ceramic capacitor. In my country, you can get a new one for less than US \$150 or you may bid on a used unit from eBay. Sometimes you don't need any meter to test the ceramic disc capacitor because the burnt mark on its coating already proved it has gone through some serious heat or high temperature and needs to be change.



A Kyoritsu Analogue Insulation Tester

You may also sometimes see cracking in its body. Ceramic capacitor do not have polarity and when you need a replacement; get the exact or

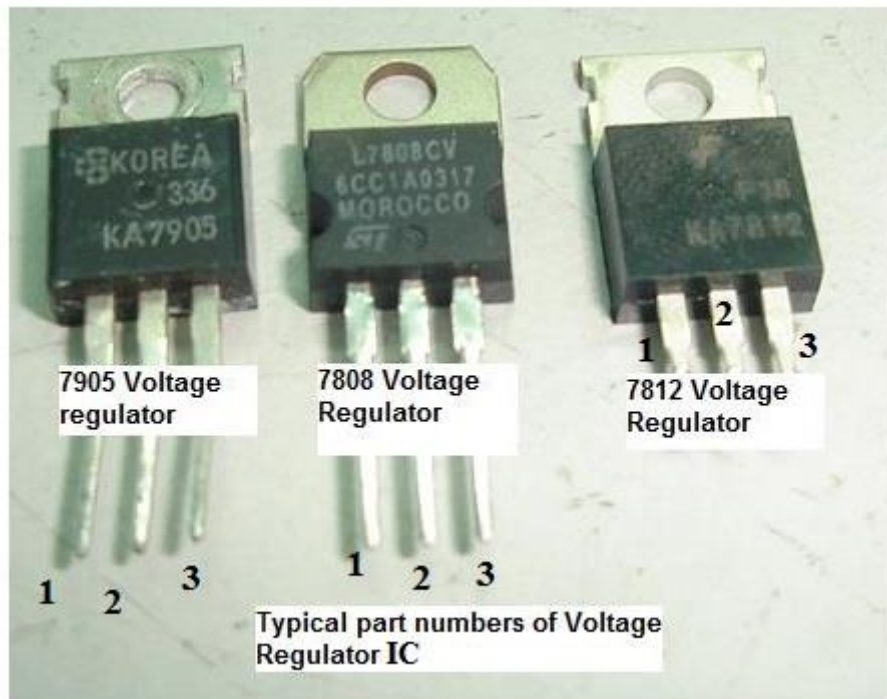
higher voltage rating with the same capacitance value.

To test the small blue resin coated ceramic disc capacitor that has the capacitor marking of 104 50v, besides using a digital capacitance tester to check for the capacitance value, I also use an analogue meter. Set it to times 10Kohm range that has 12 volt output from the probes to check this type of ceramic capacitor failure. Many times it will reveal the bad intermittent capacitors. You will be shocked to see the digital capacitance meter tested ok when checking the capacitor but show a shorted reading when check with an analogue meter.

In the market there is certain brand of analogue meter that has the range of 100kohm. If you remove the cover, you can't see the 9 volt battery in it, what you see is only 2 pieces of 1.5 volt batteries. This type of meter can't accurately detect the ceramic capacitor leakage **because the output voltage from the probes is only 3 volts!**

Ceramic capacitor manufacturers produce many different constructions and types of capacitors, and if the ceramic disc capacitor always fails even though you have replaced it with a new one then try another type which is the **resin coated ceramic disk capacitor**. Replacing a higher voltage rating than the original one may also help to prolong the life of the ceramic capacitor.

Testing Voltage Regulator ICs

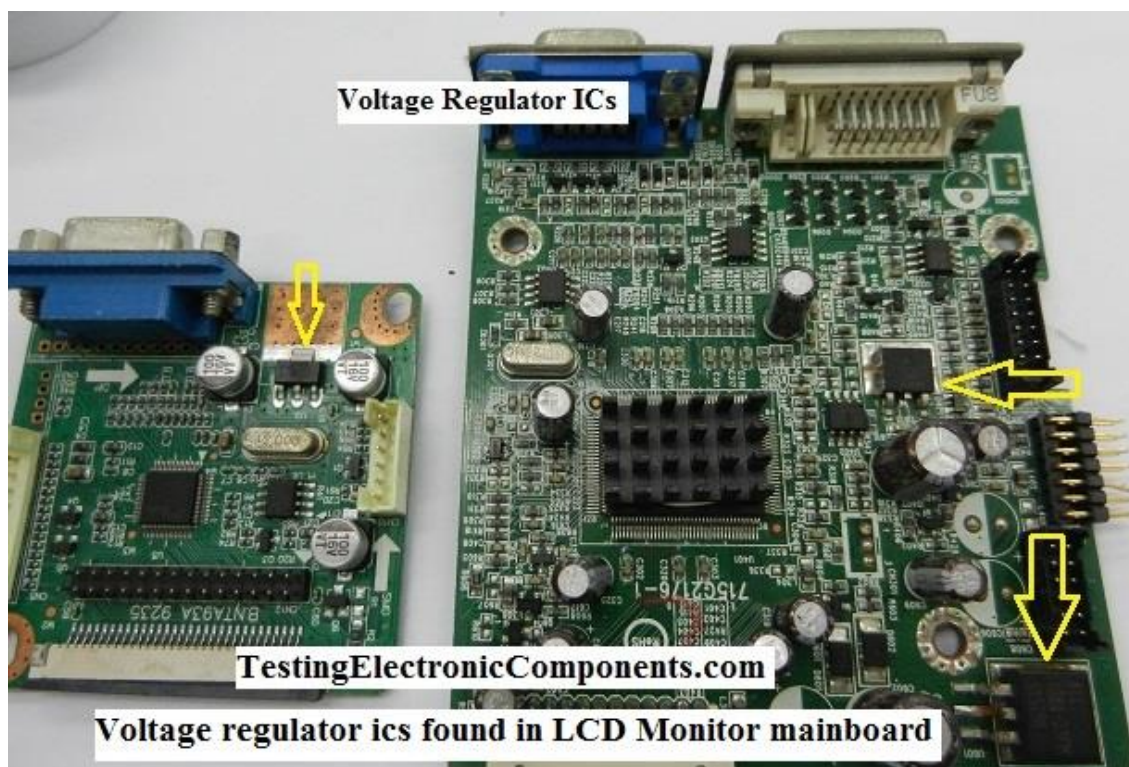
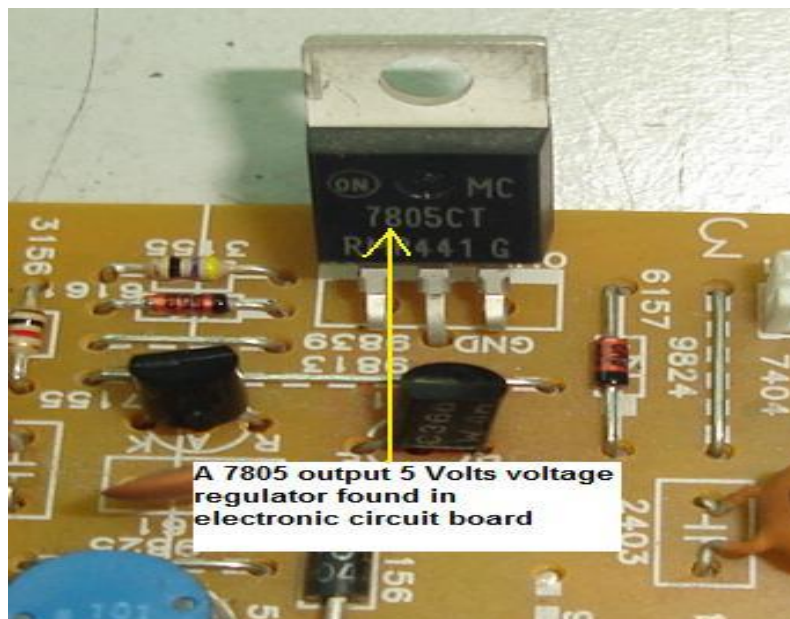


A voltage regulator IC

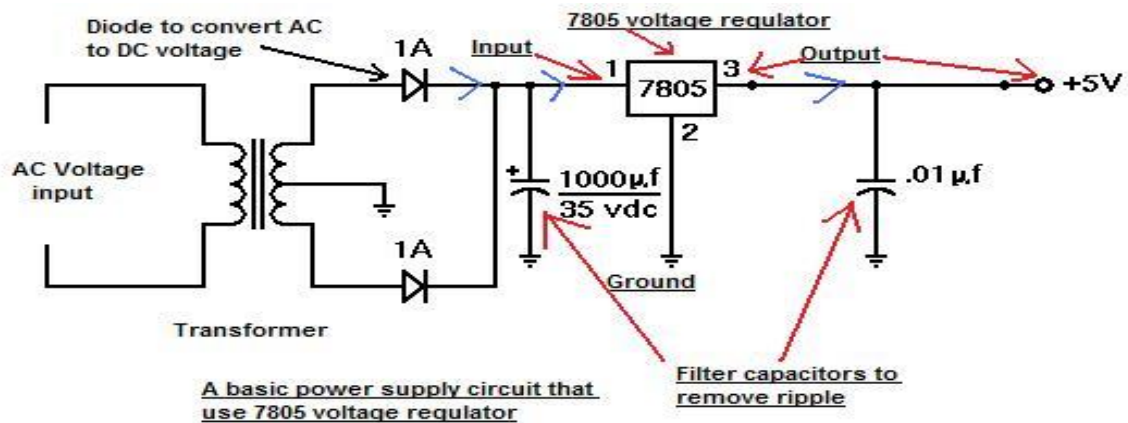
As the name suggest, this electronic component “regulates” an output voltage. For 7805 IC, Pin 1 is the input dc voltage, pin 2 is the ground and pin 3 is the output. As the circuitry adds more load to a power supply, the output voltage tends to drop. A regulator circuit (voltage regulator) keeps the output voltage steady, **in spite of changes in the load.**

To put it simple, any dc voltage from 7V to about 38 V enters pin 1 of 7805 voltage regulator then expects a +5 V output at pin 3. Any voltage in

between 7V to 38V will cause the voltage regulator to produce a steady 5V output. Do not exceed the 38 V rating otherwise the voltage regulator may burn. You may check from the internet for the datasheet about the specification of any voltage regulator. Some famous part numbers used in electronic circuits are 7805, 7812, 7905, and 7912. Part numbers that start with 78XX have **positive output** while the 79XX series have **negative output**.

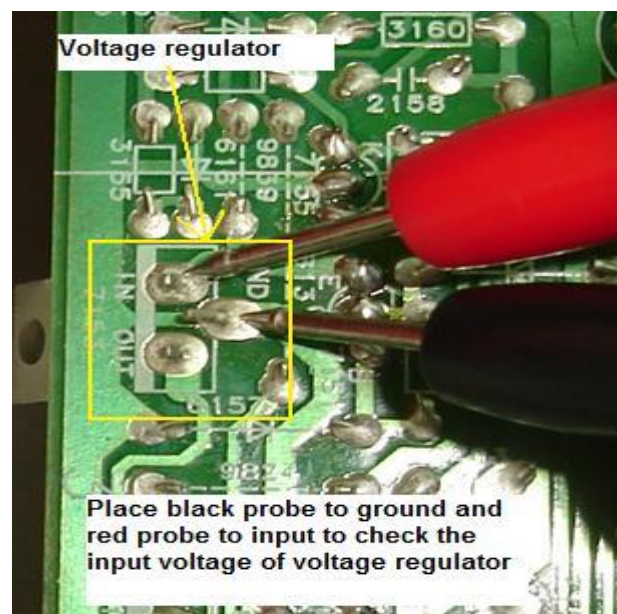


For your information the input voltage must have at least two volts higher than the output voltage. That's mean if you want to get a 12 V output from a 7812 voltage regulator, the input voltage has to be at least 14 V and above. Don't expect to use a 5V dc input to produce 12 V output, **this way won't work!** Take a look at the diagram below:



The ac transformer (linear transformer) **converts** the main line ac voltage to another lower ac voltage and the lower ac voltage will flow to both the diodes. The function of the diodes is to convert the ac voltage to DC voltage and the 1000uf capacitor is used to filter off the ripple in the line. The clean DC voltage (assuming 7 Volts) is now entering pin 1 of the 7805 voltage regulator IC as input voltage. Pin 2 is connected to ground and pin 3 will be the output which is +5 Volts. The 0.1uf capacitor at the output line again acts as a filter to remove the high frequency interference.

Testing Voltage Regulators



Place the red probe to output pin and you can test the output voltage

You can't test a voltage regulator IC the same way you test on other components. You have to test the voltage regulator with **power "ON"**. That's right, you have to switch "ON" the equipment in order to accurately test voltage regulator. Identify the voltage regulator IC in circuit board first and normally it is label as IC. Look at the part number and if it is 7808 then you will automatically know that the input must more than 8 Volts and the output should be 8 Volts.

Place your digital meter black probe to the equipment ground and the red probe to pin 3 of the voltage regulator IC. Power "On" the equipment and see the result. If you get 8 Volts then the IC is working fine. If you get 0 volts or 3 to 5 Volts then you have to measure the input voltage. Make sure it has more than 10 Volts input voltage. If the input voltage is lesser than 10 Volts (say 6 Volts), then suspect a fault in the power supply line or a leaky voltage regulator.

A leaky voltage regulator can pull down the input voltage. Sometimes bad components in the output line can also pull down the output voltage of regulator. The best is to direct replace with a new voltage regulator and retest it. A new voltage regulator IC is very cheap and I encourage you to keep some spare for yourself for future use in electronic troubleshooting.

You may also desolder (remove) the output pin (pin 3) so that it will not touch the line but pin 1 and 2 is still connected. Power "ON" the equipment and check the pin 3 voltage. If there is a good input but the pin 3 output still low (say 3 Volts), most probably the voltage regulator has turned bad and need to be replaced.

Testing voltage regulator is not difficult and if you have no confident in testing the IC with power "ON", I suggest you get someone who have experienced in the voltage testing to help you out.

Note: To check other type of IC's, one has to find out the datasheet or the specification of the IC and locate the supply voltage, input and output pin. Every IC need supply voltage to run and a missing or low supply voltage would cause the IC not to produce output. If you have the oscilloscope you can check the waveform of the IC output pin. Sometimes, bad corresponding components would also cause the IC to malfunction.

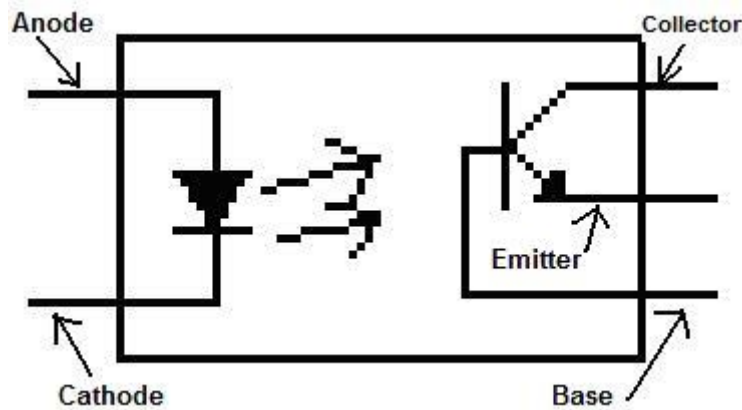
Testing Opto-Isolator IC



A Motorola 4N35 Optocoupler

A lot of electronic equipment nowadays is using an Optocoupler in the circuit. An Optocoupler or sometimes referred to as “Optoisolator” allows two circuits to exchange signals yet remain electrically isolated. This is usually accomplished by using light to relay the signal. The standard Optocoupler circuit design uses an LED shining on a phototransistor. Usually it is a NPN transistor and not PNP. The signal is applied to the LED, which then shines on the transistor in the IC.

The light is proportional to the signal, so the signal is thus transferred to the **phototransistor**. Optocouplers may also come in a few modules such as the SCR, photodiodes, TRIAC or other semiconductor switch as an output, incandescent lamps, neon bulbs or other light source. I also came across two led and two phototransistors in a package in the power supply of a NEC printer. In this book I will explain only the most commonly used Optocoupler which is the combination of LED and phototransistor. See the Optocoupler IC schematic diagram in the next page:



An Optocoupler Symbol or Schematic

The Optocoupler is usually found in switch mode power supply circuits in much electronic equipment. It is connected in between the primary and secondary section of power supplies. The Optocoupler **application** or function in the circuit is to:

Monitor high voltage

Output voltage sampling for regulation

System control micro for power on/off

Ground isolation

If the Optocoupler IC breaks down, it will cause the equipment to have low power, blink, no power, erratic power and even power shut down once you switch on the equipment.

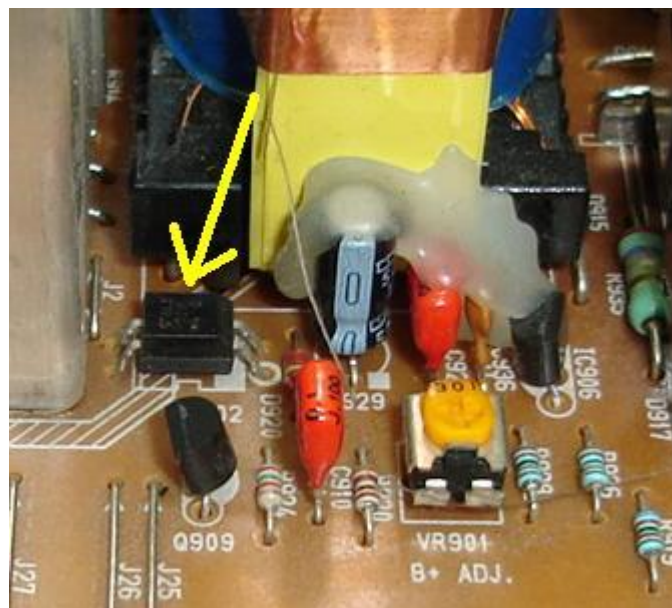


Many technicians and engineers do not know that they can actually test the Optocoupler with their analogue multimeter. Most of them think that there is no way of **testing** an IC with an analogue meter. Since we already knew the Optocoupler pin out from the schematic diagram, testing this IC is just the same as measuring a normal bipolar transistor and LED.

In order to accurately check an Optoisolator IC, you need to use an analogue multimeter. Test the LED using the times

10k ohms range. It should have one reading when checking both ways. If you have 2 readings then the LED has become shorted. The testing method is exactly the same when you are checking a normal diode. The LED is mainly connected internally to pin 1 and 2 of the Optocoupler IC.

To check the phototransistor, set your meter to times 1 ohm range and place your black probe to the base of the transistor and the red probe to collector and emitter. It should show 2 similar readings. Then move your black probe to collector and red probe to base and emitter of the transistor. It should not register any reading. The last step is to place your black probe to emitter and the red probe to base and collector of the transistor. Again it should not register any reading in the multimeter.

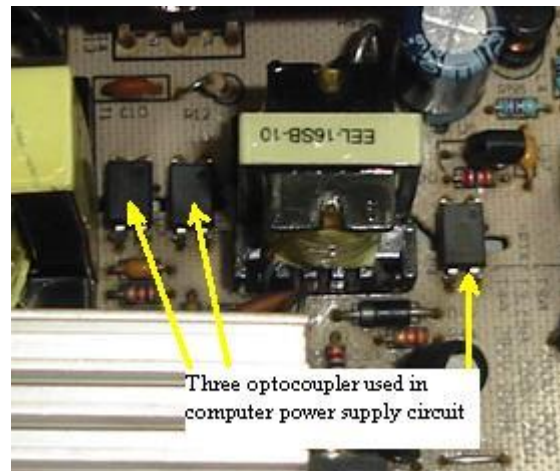


An Optoisolator in Electronic Board

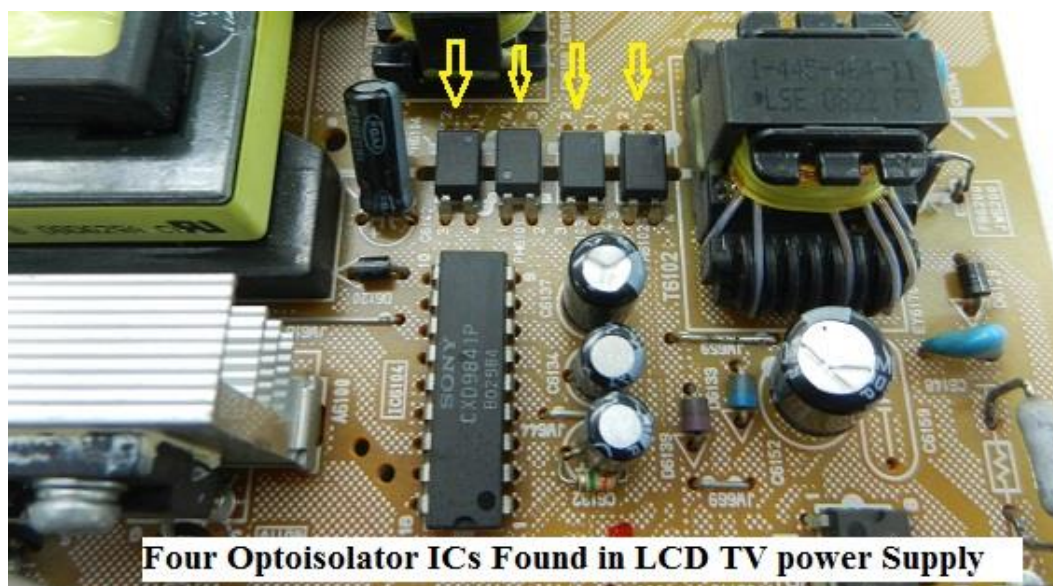
Now turn your meter selector to times 10k ohm range to measure the collector and emitter of the transistor. It should have no reading one way and the other way should have a slight reading. Which means the meter's pointer will move a little bit up from the infinity scale of the analogue meter. If you get two readings then the Optocoupler is faulty. Some of the famous part numbers for Optoisolator IC are 4N35, PC817 and PC123.

If you want to know more about the internal diagram of any Optocoupler IC, I suggest that you search the internet for its dataset. From the schematic it is easier to describe whether it is a phototransistor, photodiode, SCR or Triac type at the output of the Optocoupler IC. Once

you know which type of components are inside the IC then you can use the necessary testing method to test on the IC.



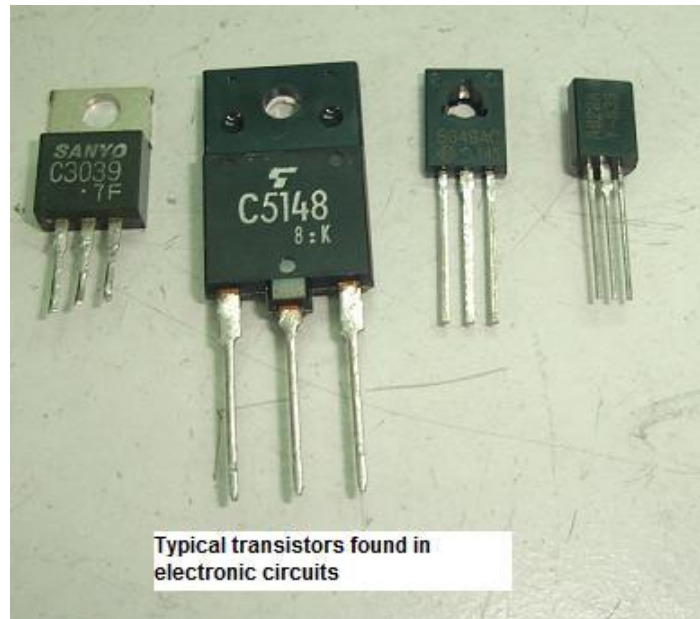
Optoisolator ICs in Power Supply



Note: If you come across an Optoisolator IC that has 4 pins, just test pin 1 and 2 like a diode. It should have one reading. For pin 3 and 4 which is the collector and the emitter pin, it should show one high ohm reading only under x 10k ohm. If you are not sure about the Collector and Emitter please refer to the Testing Transistor chapter in the next page. There will be no Base pin in a 4 pin Optoisolator IC.

Important Note. In some cases, the Optoisolator IC can breakdown when under load. This means it can test good but will fail when under full load. In this case, you need to direct replace the Optoisolator IC and retest the set.

Testing Transistors



Transistors are solid-state devices similar in some way to the diodes you have studied. Transistors are more complex and can be used in many more ways. They are very important and can be found in almost all modern electronic equipment. The name transistor is derived from “trans resistor”, meaning that it **changes resistance**. Unlike a diode, a transistor has three leads. The three transistor leads are designated as **Base (B)**, **Collector (C)**, and **Emitter (E)**.

There are two configurations for a common transistor: NPN and PNP as shown in Figure 1. Notice the different symbols for the NPN and PNP transistor. The emitter arrow points away from the transistor body for an NPN and toward the transistor body for PNP.

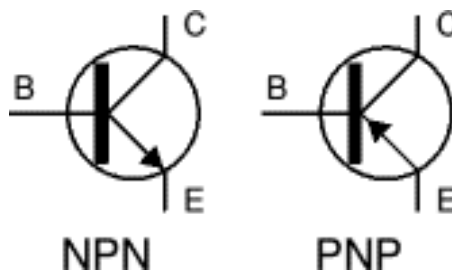
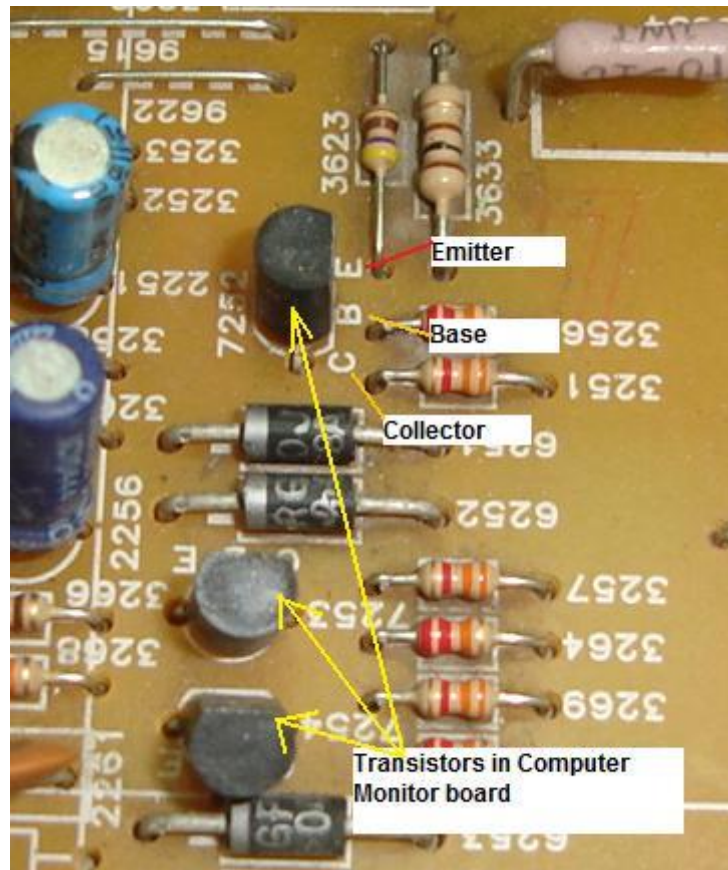


Fig 1 : The circuit symbols for the two transistor types: NPN and PNP



Transistor's Function

The main operational characteristic of a transistor is that a small voltage placed on one of the three leads can control a large amount of current flow through the other two leads. This enables a transistor to perform two basic functions:

- i. A transistor can act as an electronic switch, turning current flow ON and OFF.
- ii. A transistor can amplify a signal, making it larger in amplitude.

Since the transistor is capable of amplifying a signal, it is said to be an active component. **Devices such as resistors, capacitors, inductors and diodes are not able to amplify and are therefore known as passive components.**

Either type transistor, NPN or PNP, can perform essentially the same function in an electronic circuit. The main difference between an NPN and a PNP transistor in a circuit is the direction in which electrons flow between emitter and collector.

Transistor Heat sink



The heat generated by current flowing between the collector and emitter junctions of a transistor causes its temperature to rise. This heat must be conducted away from the transistor otherwise the temperature rise may be high enough to irreparably damage the P-N junctions inside the transistor. Power transistors produce a lot of heat, and are therefore usually mounted to a piece of aluminium with fins, called a heat sink.

The heat sink draws heat away from the transistor, allowing the transistor to handle more power than if there were no heat sink. Low power signal transistors do not normally require heat sinking.

Some transistors have a metal body thus a **mica sheet** has to be used to prevent the body from touching the heat sink.



Transistor Failure

Transistors can fail in a number of different ways. Transistors have forward and reverse current and voltage ratings like diodes do. Exceeding either rating can destroy a transistor. A bad transistor may short-circuit from the “base” to the “collector” or from the “base” to the “emitter”. Sometimes a transistor is damaged so badly that short circuits develop between all three of the leads. A short-circuit often allows a large current to flow, and causes the faulty transistor to heat up. The transistors also can develop open circuit between “base” to “collector” or “base” to “emitter”.

The first step in identifying a bad transistor is to check for signs of overheating. A bad transistor may appear to be burnt or melted. 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 part has a large heat sink, you can expect it to be hot but not to the extent of burning the hand or fingers. 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 THE CIRCUITRY THAT CARRIES 240VAC”**. Always switch off the equipment before touching any components.

Transistor Replacement

If for some reason, you can’t get the exact replacement, refer to one of the transistor substitution guides, and try to identify a “near replacement”. Beware, however a substitution guide will sometimes list a replacement for your part, even though the two parts are not very similar. The important parameters are:

- Voltage
- Ampere
- Wattage

The replacement part should have a **voltage, ampere and wattage rating equal to or higher than the original**. The best is to get an exact part number for the transistor - it’s worth the trouble.

TRANSISTOR SPECIFICATIONS

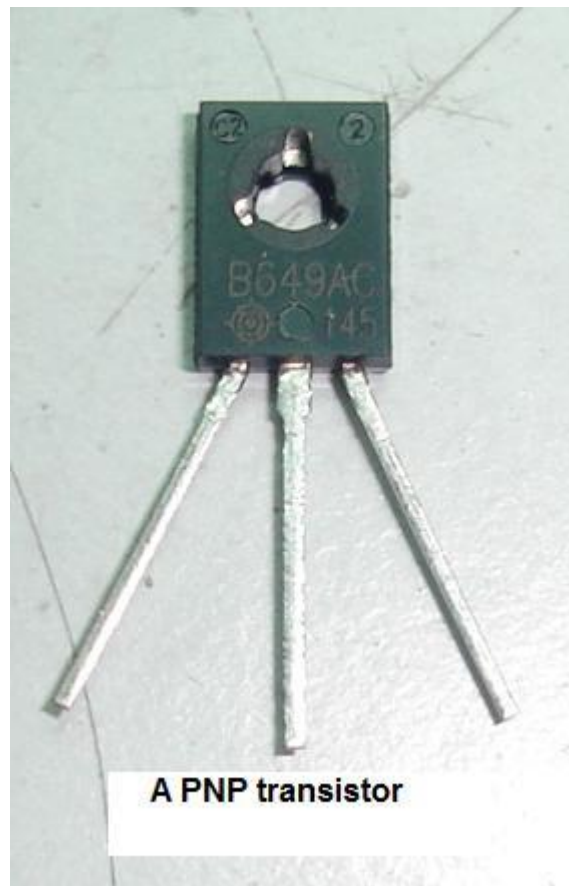
Diodes are numbered 1N for example 1N4148, 1N4007, 1N5408, etc. Transistors are numbered 2N for example 2N3904, 2N3906 and etc. The

first digit is the number of junctions. However, Japanese transistors have different numbers. The following designations are generally used:

Japanese transistors number	European Type	Type	Typical example
2SA	A	PNP, High frequency	2SA733=A733
2SB	B	PNP, Low frequency	2SB861=B861
2SC	C	NPN, High frequency	2SC5048=C5048
2SD	D	NPN, Low frequency	2SD2125=D2125
2SJ	J	P-Channel FET	2SJ306=J306
2SK	K	N-Channel FET	2SK792=K792

Note that S is used to indicate a semiconductor. If you found a transistor with the part number of C945, you will immediately know that it is a NPN transistor.





Points to remember when replacing transistors with substitutes:

- Polarity of the transistor i.e. whether it is PNP or NPN.
- Substitute transistor should have almost same voltage, current and wattage rating.
- Whether transistor which is being replaced is of low frequency or high frequency type.
- Whenever replacing a transistor see that base, collector and emitter are soldered in their proper position.
- While replacing transistor desoldering pump must be used and soldering iron should not be kept on the leads for a long time; it may damage the transistor as well as the printed circuit board.
- Transistor used for output circuit must have **proper heat sink**. If supply is given without heat sink the transistor may get damaged.
- Whenever replacing horizontal output, switching output or power output transistor it should be kept in mind that **mica sheet** being used should not be broken, otherwise output transistor collector will short with body and it will go off immediately or the supply voltage will drop.
- Whenever replacing output transistor, nut/bolt should not be too

tight or too loose.

- Horizontal output transistor, with integrated diode should be replaced with the same type of transistor.

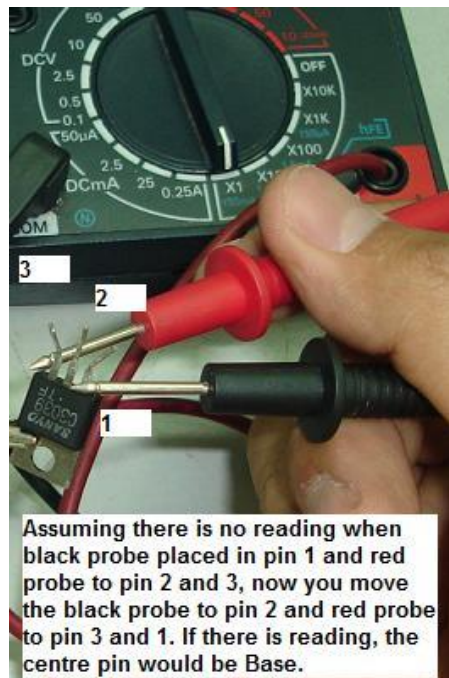
Transistor Testing and Identifying the Leads

A transistor can be checked out of circuit with any of the many different transistor testers on the market. The suspected transistor can also be checked out of the circuit with resistance measurement (Ohms range) from an analogue multimeter. Use the ohmmeter scale to detect a leaky, open or shorted transistor. **I do not encourage testing transistors with a digital meter as I've encountered many times that a transistor tests good with digital meter but fails with an analogue meter.**

Checking Transistors with an Analogue Multimeter

An analogue multimeter can be used to perform a basic test on a transistor; the diagram in the figure below will help you to identify the base, collector and emitter leads for commonly used transistors. You should refer to the transistor data guidebook if you are in doubt about the connections of a transistor. But if you are about to use a transistor of an unknown type, i.e. NPN or PNP, the following simple test will give the answer. It will also allow you to check a transistor if it is leaky, opened, or is shorted.





The diagram in Figure 2 assumes you are testing an unknown type of transistor. Set your meter to the lowest ohm's range i.e. **Rx1Ω**. From the six combinations of test results you will know of which type the transistor belongs.

Test No	Black probe is connected to pin no	Red probe is connected to pin no	Reading in ohms
1	1	2	Low
2	1	3	Low
3	2	1	High (∞)
4	2	3	High (∞)
5	3	1	High (∞)
6	3	2	High (∞)

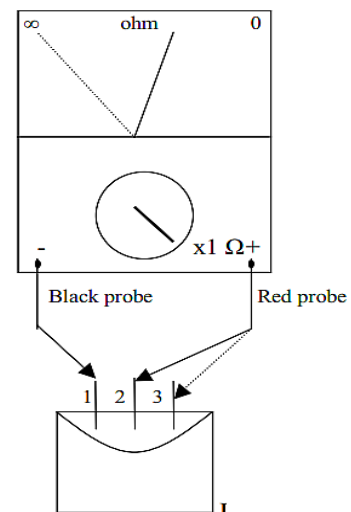
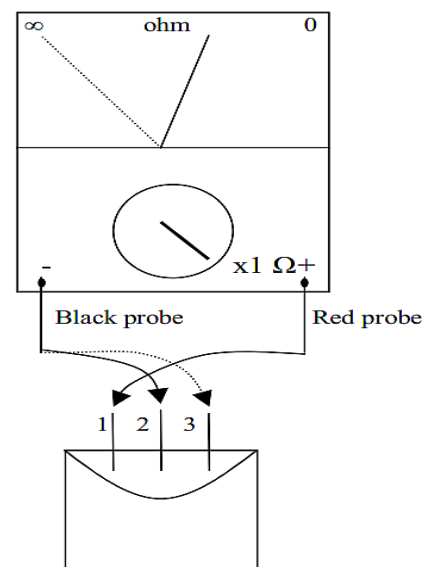
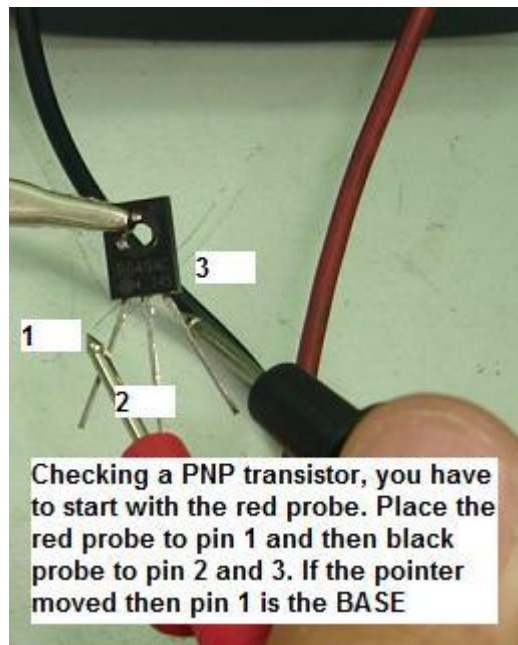


Figure 2: Identifying transistor type and pin leads

1. Connect the black probe of the multimeter to one of the transistor leads, and connect the red probe to any of the other leads.
2. If two low readings are found for one connection of the black probe (test no 1 & 2), while each of the other two positions gives two high readings (test no 3, 4, 5 & 6), then the transistor is NPN type.

3. The pin where the black probe is connected to showed two low readings when the red probes are connected to the other two leads shows high readings is the “**Base**”. In the above case pin 1 is the “base”.



Your test probe placement must be reversed in order to check for a PNP type of transistor as shown in Figure 3.

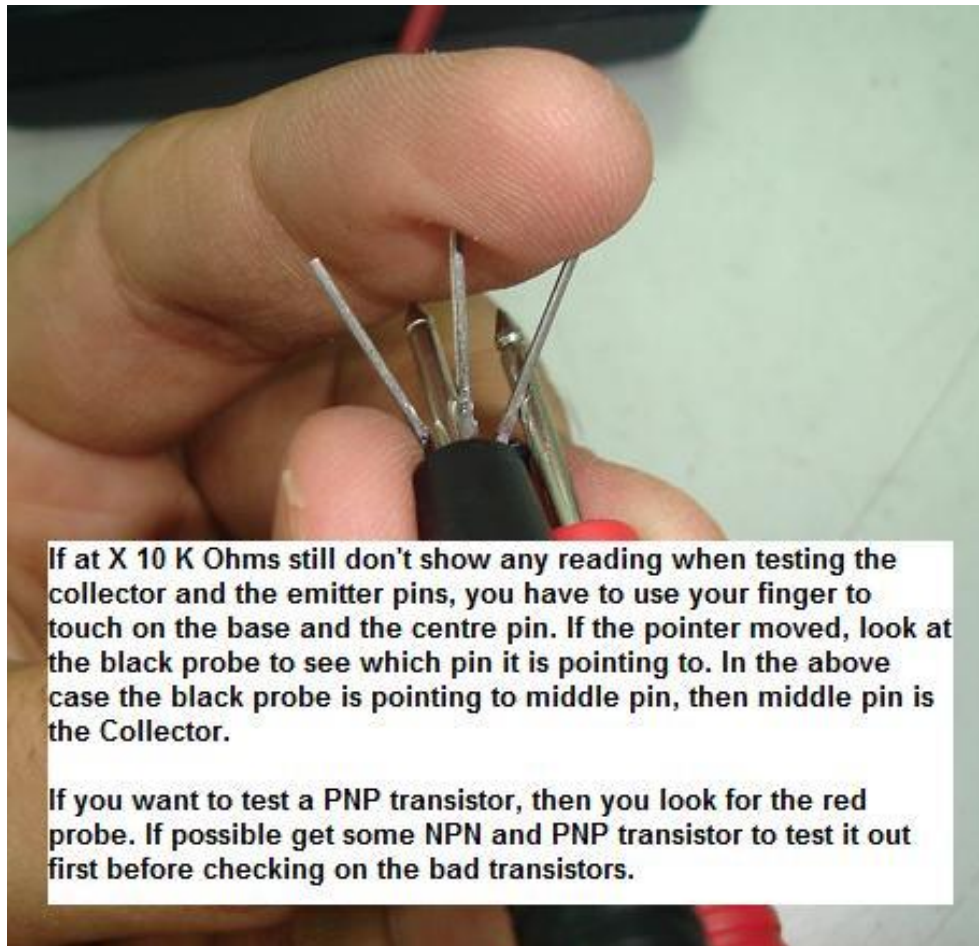
Test No	Red probe is connected to pin no	Black probe is connected to pin no	Reading in ohms
1	1	2	Low
2	1	3	Low
3	2	1	High (∞)
4	2	3	High (∞)
5	3	1	High (∞)
	3	2	High (∞)

Figure 3 : Identifying a PNP Type of Transistor and pin leads

1. Connect the red probe of the multimeter to one of the transistor leads and connect the black probe to any of the other leads.
2. If two low readings are found for one connection of the red probe

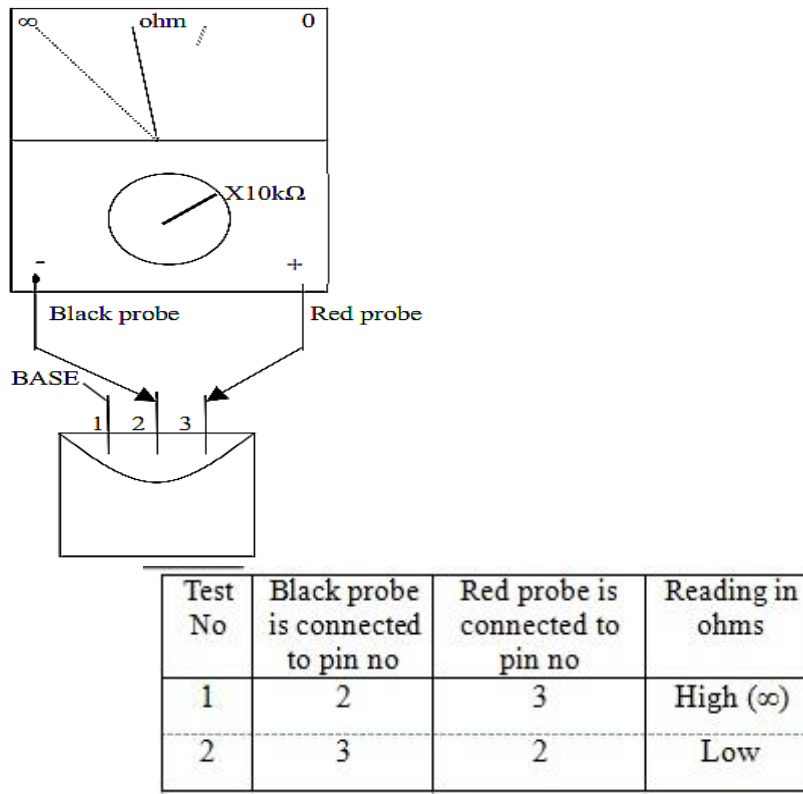
(Test no 1&2), while each of the other two position gives two high readings (Test no 3, 4, 5 & 6), then the transistor is PNP type.

3. The pin where the red probe is connected to showed two low reading when the black probes connected to other two leads shows high reading is the “**Base**”. In the above case pin 1 is the “Base”.



Now you must determine which lead is the “emitter”, and which is the “collector”. Assuming you are checking an NPN type of transistor and you already know that lead number 1 is the base, you now must determine which lead (lead 2 or 3) is the collector.

First, set your **multimeter ohm's range to x10kΩ**. Connect the test probe according to the diagram shown in Figure 4.



NOTE: Certain Transistor might showed high (∞) reading on both test (either way).

Figure 4 : Identifying the collector lead of an NPN transistor

1. Look for the high ohm reading (Test no: 1) and see which lead the black probe is connected to.
2. From Figure 4 the black probe is connected to lead 2 and this lead is the “**Collector**” and lead 3 is the “**Emitter**”.
3. Some transistors will show two high ohms readings and if it is the case you should use your finger to touch the base (first pin) and the middle pin while you are still holding the probes on the transistor middle and the third pin. Assuming your finger is touching the base and the middle pin the pointer will show some resistance, then look at the probes. If it is the black probe on the middle pin then the middle pin is the “**Collector**”. If middle pin is the collector, the third pin must be the “**Emitter**”. If the red probe is on the middle pin, touching your finger between the base and the middle pin, the pointer will not move at all! In other words, if you test a NPN transistor, look for the black probe and if you test PNP transistor look for the red probe. If there is no response from

the meter (pointer won't move) even after you have use your finger to touch one the pins, then the transistor has developed an open circuit.

Note: For checking PNP transistors, perform the same test by **reversing the test probe**.

These tests also give some indication of a transistor's condition. If the transistor does not check out as described above, there may be that something has gone wrong with the part. For example, if the emitter collector junction shows a low resistance in **both directions at x 10 K Ohms**, the transistor is shorted.



For many of you, this probably seems like a lot of transistor information to absorb. Checking transistors is not as easy as checking the two leads devices like the resistor, capacitors, diodes and etc. In reality, this is only the surface of a fairly deep subject. **Experimenting with a few transistors and a multimeter as you go back through the material is an excellent way to gain greater understanding of how to accurately check transistors.**

You can purchase several types of general-purpose replacement transistors for less than RM 1.00 each from many electronics suppliers. Get a few NPNs and a couple of PNPs, grab your multimeter, and see for

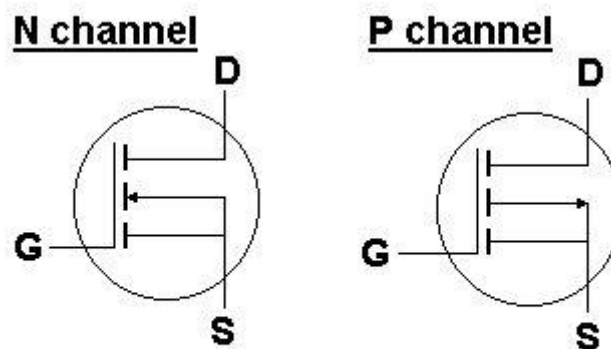
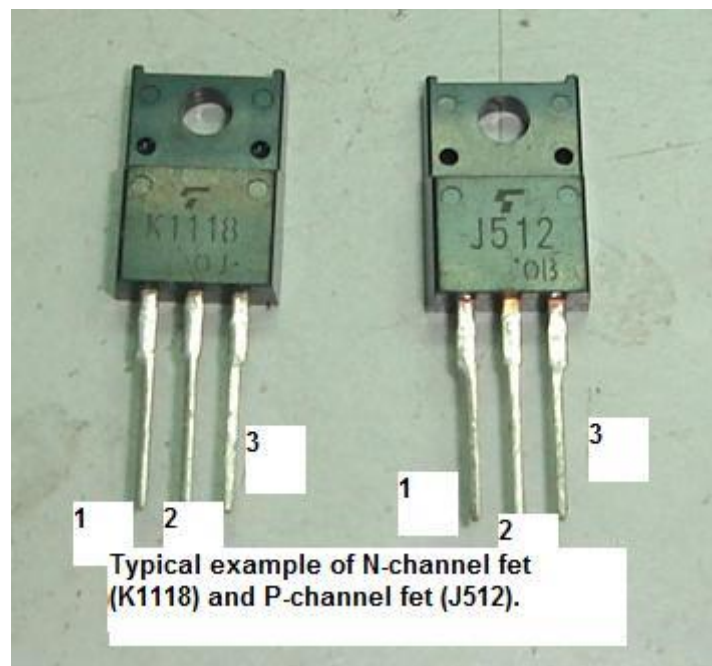
yourself. **With some actual hands-on activity, it won't take you long to become confident performing a basic transistor test.**

If you have a budget you may buy a specialized transistor tester where you clip 3 of the tester wires to the three pins of any transistor. After analyzing, it will prompt to you which leg is the base, collector and emitter and also it will tell you if the transistor is good, leaky or completely shorted.



A Transistor Tester

Testing Field Effect Transistors (FET or Mosfet)



Mosfet symbol

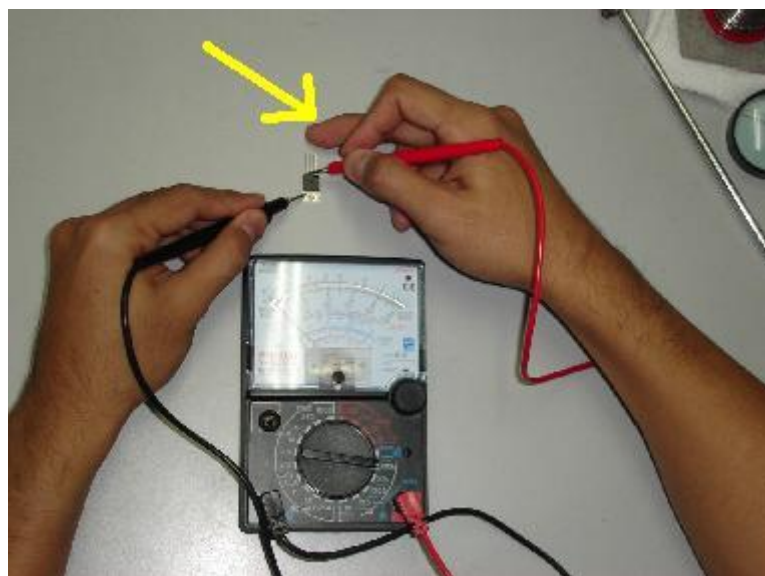
The right way of testing a mosfet transistor is to use an analogue multimeter. Mosfet stand for Metal Oxide Semiconductor Field Effect transistor or we just called it FET. Switch mode power supplies and many other circuits use FET transistors as part of their circuits. Mosfet failure and leakage is quite high in a circuit and you need to know how to accurately test it. FET is labeled as “Q” in a circuit board.

Measuring components that have two leads such as the resistors, capacitors, and diodes are much easier than measuring transistors and FETs which have three legs. Many electronic repairers have difficulty especially in checking the three leads components. First, find out the gate,

drain, and source pin out from a semiconductor replacement book or search for its datasheet on a search engine.

Once you have the cross reference or diagram for each pin of the mosfet, then use your analogue multimeter, set to times 10K ohm range, to check it. Assuming you are testing the N channel mosfet then put the black probe to the drain pin.

Touch the gate pin with the red probe to discharge any internal capacitance in the mosfet. Now move the red probe to source pin while the black probe is still touching the drain pin. Use your right finger and touch the gate and drain pin together and you will notice the analogue multimeter pointer will move forward to centre range of the meter's scale.

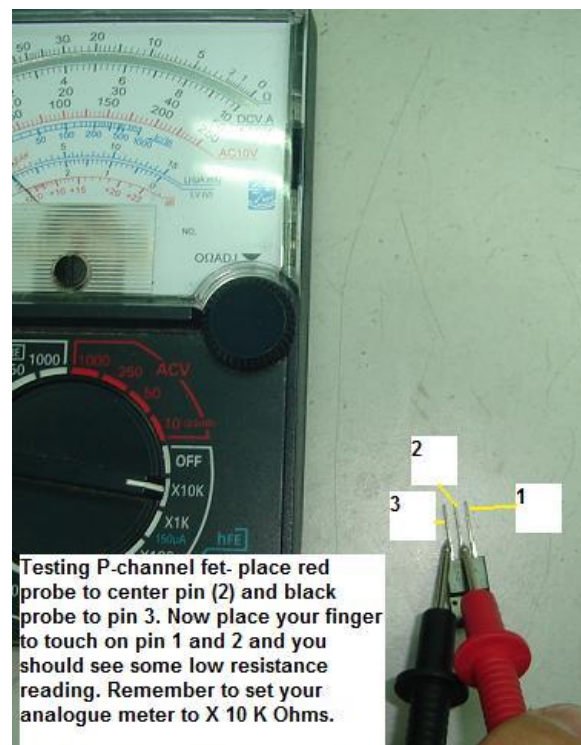
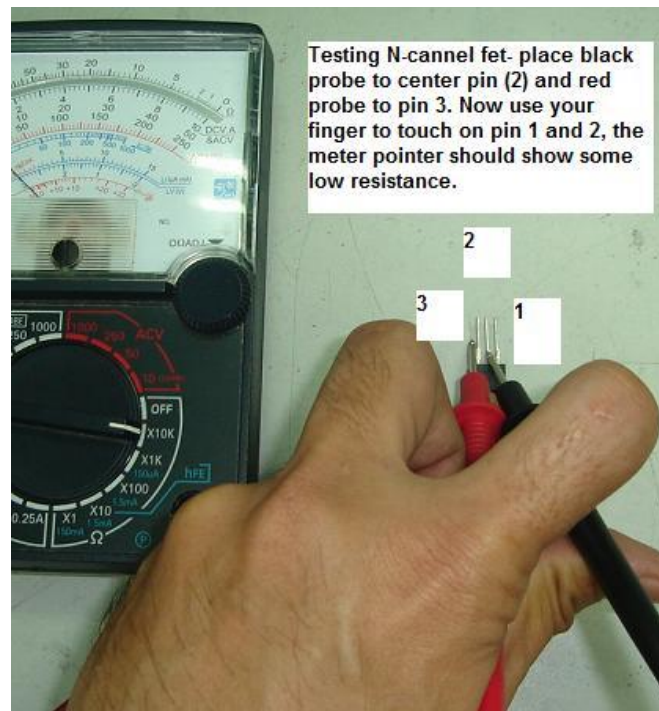


Use your finger to touch on the gate and drain pin.

Lifting the red probe from the source pin and putting it back again to the source pin, the pointer will still remain at the middle of the meter's scale. To discharge it you have to lift the red probe and touch just one time on the gate pin. This will eventually discharge the internal capacitance again.

At this time, use the red probe to touch on the source pin again. The pointer will not kick at all because you have already discharged it by touching the gate pin. These are the good mosfet characteristics. You need to practice more by taking some FET from your bench or from your

component compartments. Once you know the secrets, testing mosfets is as simple as testing diodes.



If you notice that all the results that you measured kicked towards zero ohms and will not discharge, then the FET is considered shorted and needs replacement.

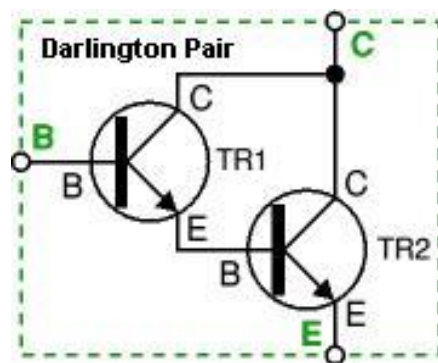
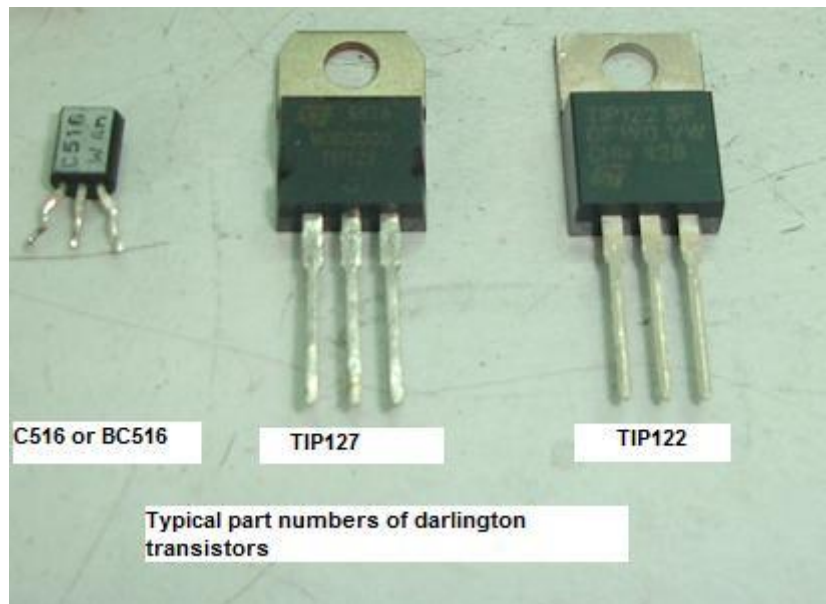
Testing the P channel FET field effect transistor is just the same way as how you checked the N channel FET. What you do is switch the probe polarity when checking the P channel. Some analogue multimeters have the times 100k Ohm range. This type of meter can't really test FETs due to the absence of a 9 Volt battery inside the multimeter. This type of meter will not have enough power to trigger the mosfet. Make sure you use a meter that have the times 10k ohm range selector.

Typical N channel mosfet part numbers are 2SK791, K1118, IRF634, IRF 740 and P channel FET transistor part numbers are J307, J516, IRF 9620 and etc. You can also get a mosfet tester from the market; one of the famous brands is the SENCORE tf46 Portable Super Cricket transistor and FET tester. You can bid on one from EBay.



Sencore TF46 FET Tester

Testing Darlington Transistors



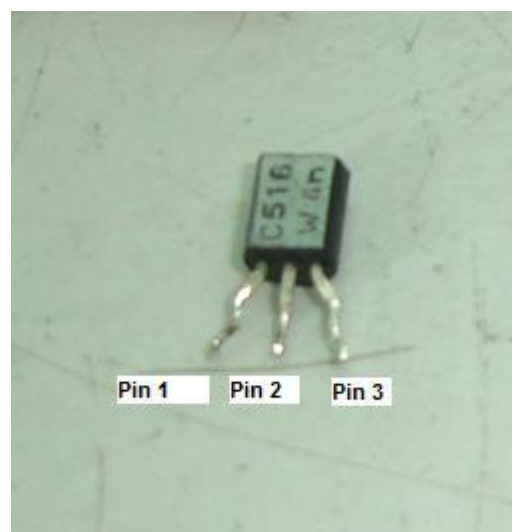
A darlington pair transistor schematic

This is two transistors connected together of two emitter followers in cascade so that the amplified current from the first is amplified further by the second transistor. This package provides higher input resistance and a very high current gain such as 10000. Darlington pairs are sold as complete packages containing the two transistors. They have three leads (Base, Collector and Emitter-PNP and NPN) which are equivalent to the leads of a standard individual transistor. There are two types of Darlington transistors-one that is without a built in diode and one that has a diode in it. You have to refer to a semiconductor data book to check if the Darlington transistors have a built in diode or not.

Testing Darlington transistors without built in diode.

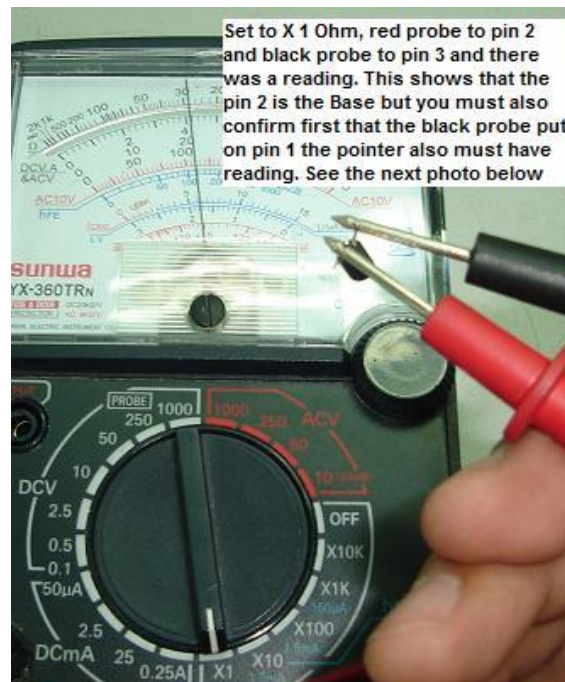
One example part number of a Darlington transistor that does not have a build in diode is the C516 (or BC516). If you refer to semiconductor data book, it is stated as PNP Darlington transistor.

BC 508	Si-N	Uni, 60V, 0,2A, 0,36W, 200MHz
BC 509	Si-N	=BC 508: ra
BC 510	Si-N	=BC 508: 40V, ra
BC 512	Si-P	=BC 513: 50V
BC 513	Si-P	Uni, 30V, 0,2A, 0,3W, >200MHz
BC 514	Si-P	=BC 513: ra
BC 516(P)	Si-P-Darl	Uni, 40V, 0,4A, 0,625W, 250MHz, B>30k
BC 517(P)	Si-N-Darl	Uni, 40V, 0,4A, 0,625W, 220MHz, B>30k
BC 520	Si-N	Uni, ra, 60V, 0,05A, 0,625W, >100MHz
BC 521	Si-N	=BC 520: 45V
BC 522	Si-N	=BC 520: 20V
BC 523	Si-N	=BC 520: 15V
BC 524	Checking the transistor data with the help of semiconductor data book	
BC 525	From the data book, we know that the	
BC 526	BC516 is a PNP type darlington transistor	



Since you already know that it is a PNP type Darlington transistor, you have to **start testing it by using the red probe**. The procedure of finding the Base, Collector and Emitter is **exactly the same as how you test on a normal transistor**. Set your analogue multimeter to X1 Ohms and place the red probe to pin 1 of the BC516 and the black probe to pin 2 and 3. If the pointer shows no movement, shift the red probe to pin 2 (middle pin) and the black probe to pin 1 and 3. If there is movement in the meter's pointer when the black probe touches on pin 1 and 3 then pin 2 is the Base.

If you move the red probe to pin 3 and the black probe to pin 1 and 2, a good Darlington transistor should not have any reading.



Since you have confirmed that pin 2 is the Base, we now move to the other steps to find the Collector and the Emitter. Set to X 10 K Ohms and

place any of your test probes to pin 1 and 3. Assuming the black probe is to pin 3 and the red probe is to pin 1 and you **don't get any reading** then pin 1 is the Collector. If you reverse the test probes, you will definitely see the pointer kick up. In other words we must look for the measurement that doesn't get any reading and see which pin the red probe connects to. If the red probe connects to pin 2 then pin 2 is the Collector. If it connects to pin 1 then pin 1 is the Collector.



In the above case, since pin 1 is the Collector then pin 3 must be Emitter. Although a semiconductor data book does show which pin is the base, collector and emitter, we can't fully depend on it as I found it not 100% accurate. The best you can do is test and find it on your own.

Testing Darlington transistors with a built in Diode

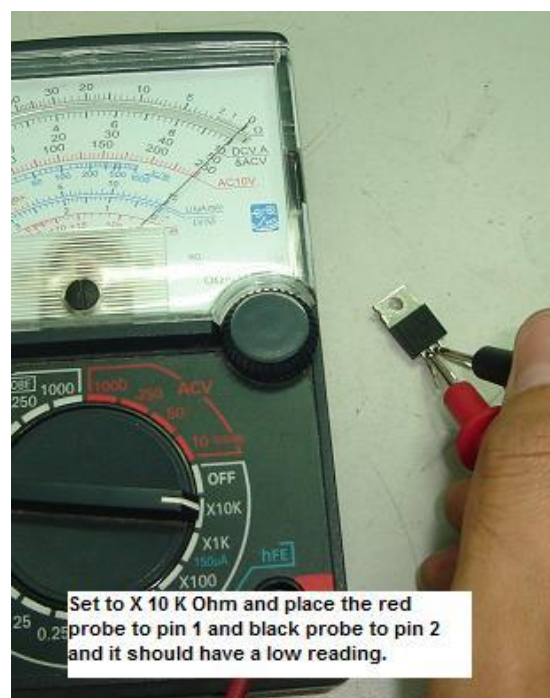
Again we have to depend on semiconductor data books to help us to locate if the particular transistor that you want to test is a **Darlington transistor with or without built in diode.**

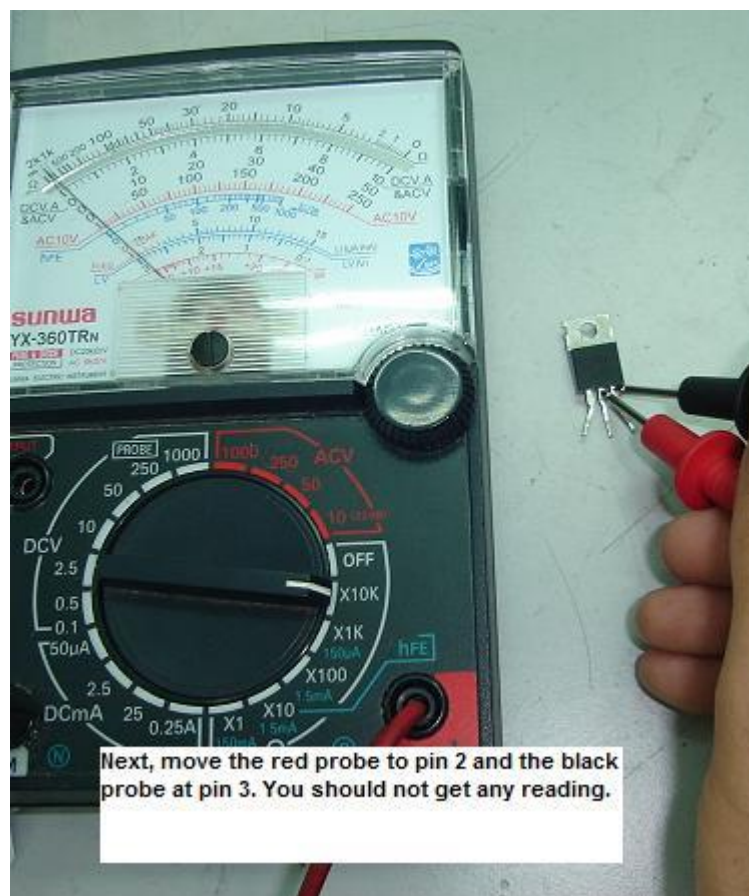
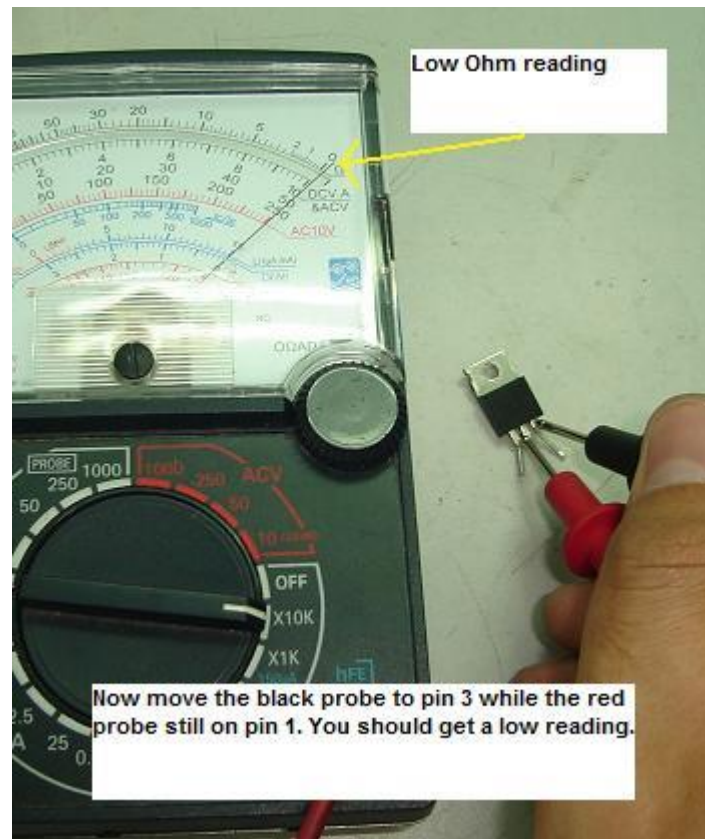
TIP 120	Si-N-Darl+Di	NF/S-L, 60V, 5A, 65W, B>1000
TIP 121	Si-N-Darl+Di	=TIP 120: 80V
TIP 122	Si-N-Darl+Di	=TIP 120: 100V
TIP 125	Si-P-Darl+Di	NF/S-L, 60V, 5A, 65W, B>1000
TIP 126	Si-P-Darl+Di	=TIP 125: 80V
TIP 127	Si-P-Darl+Di	=TIP 125: 100V
TIP 130	Si-N-Darl+Di	NF/S-L, 60V, 8A, 70W, B>1000
TIP 131	Si-N-Darl+Di	=TIP 130: 80V
TIP 132	Si-N-Darl+Di	=TIP 130: 100V
TIP 135	Si-P-Darl+Di	NF/S-L, 60V, 8A, 70W, B>1000
TIP 136	Si-P-Darl+Di	=TIP 135: 80V

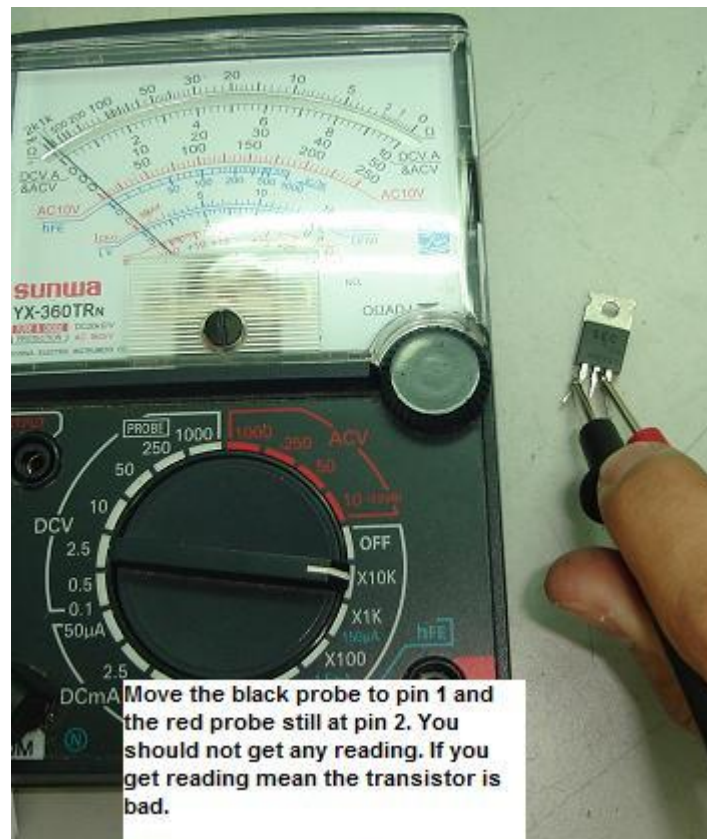
Again from the data book we know that the TIP122 is a NPN type darlington + a diode transistor. Same to TIP 127-it is a PNP type darlington + a diode transistor.

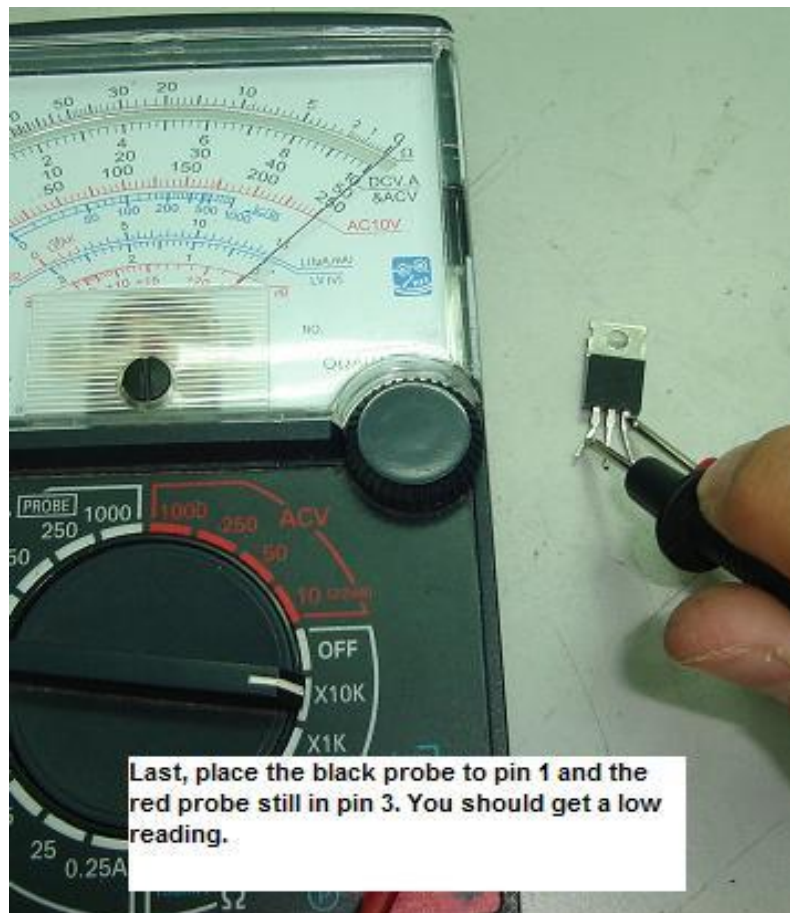
Because of the built in diode, the result that you get is completely different from testing the Darlington transistor that has no diode built into it. It is difficult to find the Base, Collector and the Emitter pins due to the built in diode. I guess you have to refer to semiconductor data books or even the internet to look for its pin outs.

Testing this type of transistor is easy. Please refer to the photos below:





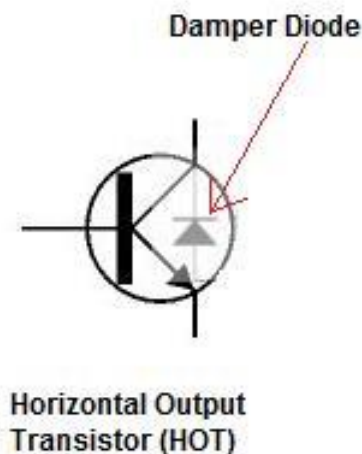
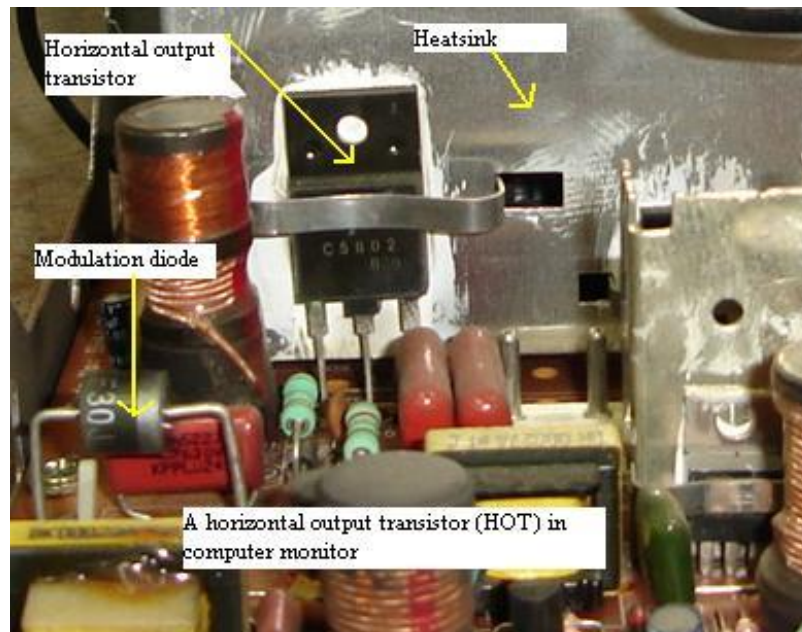




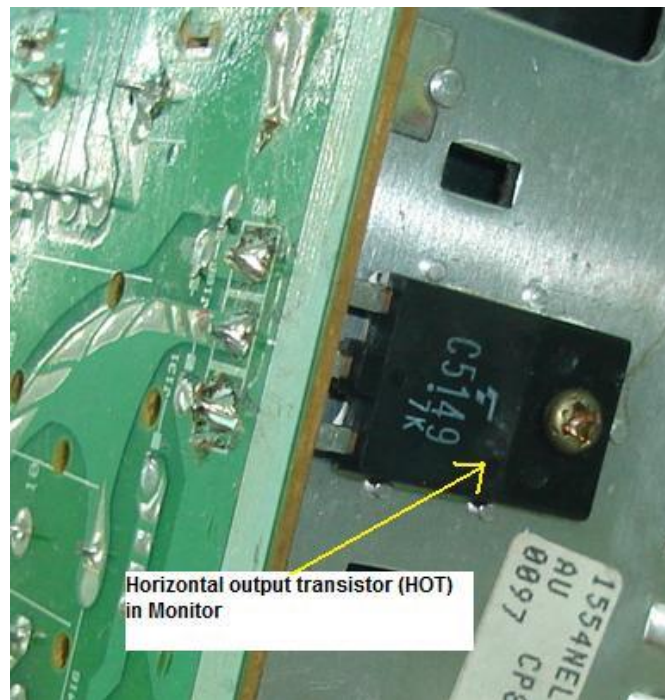
I suggest that you get few Darlington transistors from electronic suppliers (with and without built in diodes) and play around with it. Take note of all the steps you have taken to successfully test this type of transistor before you test a bad or faulty Darlington transistor.

If you have the budget you can always get a transistor tester that can automatically tests all kinds of transistors but I can't guarantee it will give an accurate reading, especially checking the Darlington transistors that have the built in diode. **Practice makes perfect in testing electronic components.**

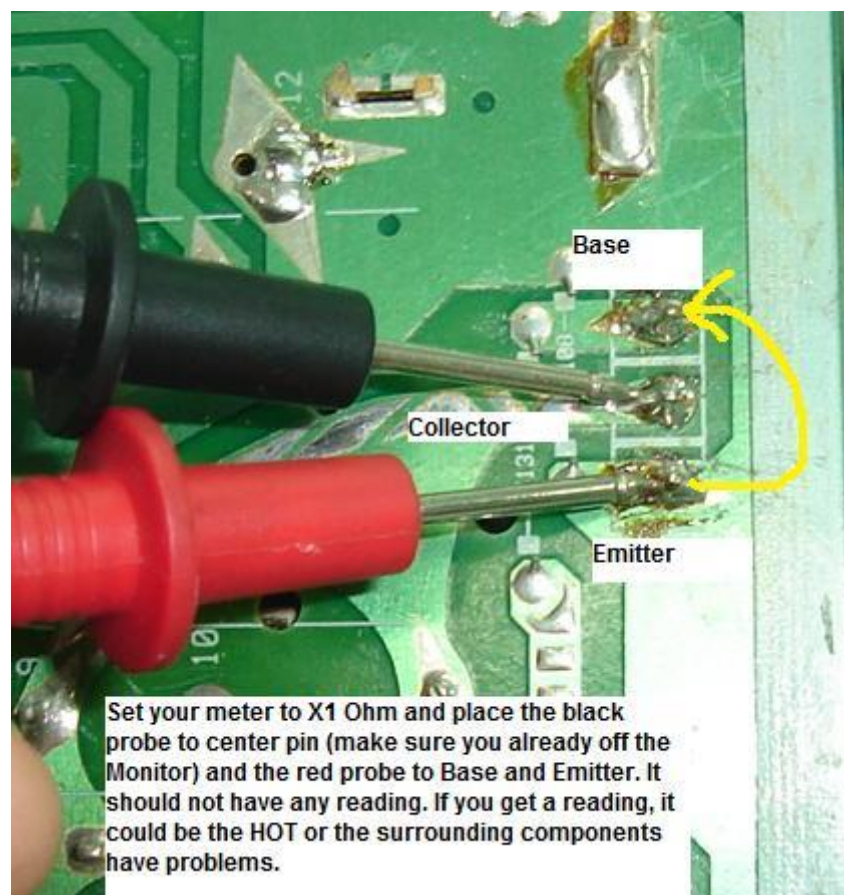
Testing Horizontal Output Transistors



If you are repairing a television and computer monitor, I'm sure you have seen a horizontal output transistor (HOT) before. This transistor is used to switch the flyback transformer and is prone to becoming defective due to the stress of dealing with high voltage. A shorted HOT will usually cause no power, low power, power cycling or power to shutdown. The HOT is mainly a NPN transistor.



Testing HOT on board



It is very easy to check on board if the HOT is shorted or not. Using your analogue meter set to X 1 Ohm, place the back probe to centre (collector)

pin and the red probe to both sides of the HOT, one at a time. The pointer should not kick (meaning no reading). If you get a reading when the red probe touches on either one of the pins at the right (base) or left (emitter) chances are high the HOT has shorted. You need to remove the HOT from the board and retest again.

The above method only applies when checking HOTs on board. Checking HOTs off board is completely different from the above.

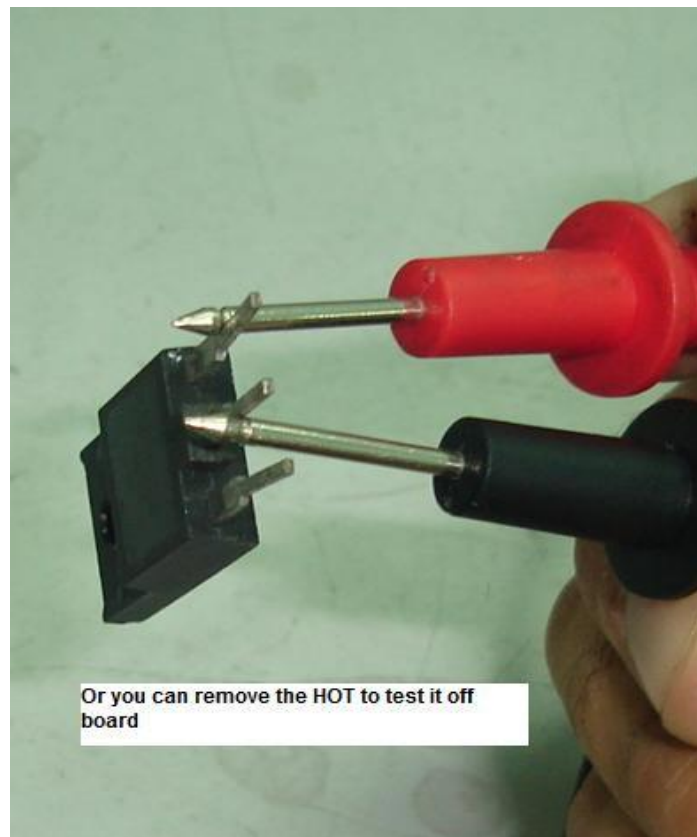
Testing HOT off board

BU 2508 DX	Si-N+Di	=BU 2508D: Iso, 45W
BU 2515 AF	Si-N	PC Monitor HA, 1500/800V, 9A, 45W
BU 2515 AX	Si-N	=BU 2515AF:
BU 2515 DF	Si-N+Di	BU 2515AF: integr. Damper-Diode
BU 2515 DX	Si-N+Di	BU 2515AF: integr. Damper-Diode
BU 2520 A	Si-N	CTV-HA, hi-res, 1500/800V, 10A, 125W
BU 2520 AF	Si-N	=BU 2520A: Iso, 45W
BU 2520 AW	Si-N	=BU 2520A:
BU 2520 AX	Si-N	=BU 2520A: Iso, 45W
BU 2520 D	Si-N+Di	=BU 2520A: integr. Damper-Diode
BU 2520 DF	Si-N+Di	=BU 2520D: Iso, 45W
BU 2520 DW	Si-N+Di	=BU 2520D:
BU 2520 DX	Si-N+Di	=BU 2520D: Iso, 45W
BU 2522 A	Si-N	1500/800V, 10A, 125W
BU 2522 AF	Si-N	=BU 2522A: Iso, 45W
BU 2522 AX	Si-N	=BU 2522A:
BU 2522 DX	Si-N+Di	=BU 2522A: Iso, 45W, int. Damper-Dio

Checking the specification of HOT with the help of semiconductor data book

There are two types of HOTs: I.E. **one is without a damper diode while the other one is with a damper diode**. How do we know if a particular HOT comes with damper diode or not? It's easy, check from the semiconductor data book or search the internet. **Checking a HOT that does not have the built in damper diode is exactly the same as how to test a NPN bipolar transistor (please refer to the testing NPN bipolar transistor).**

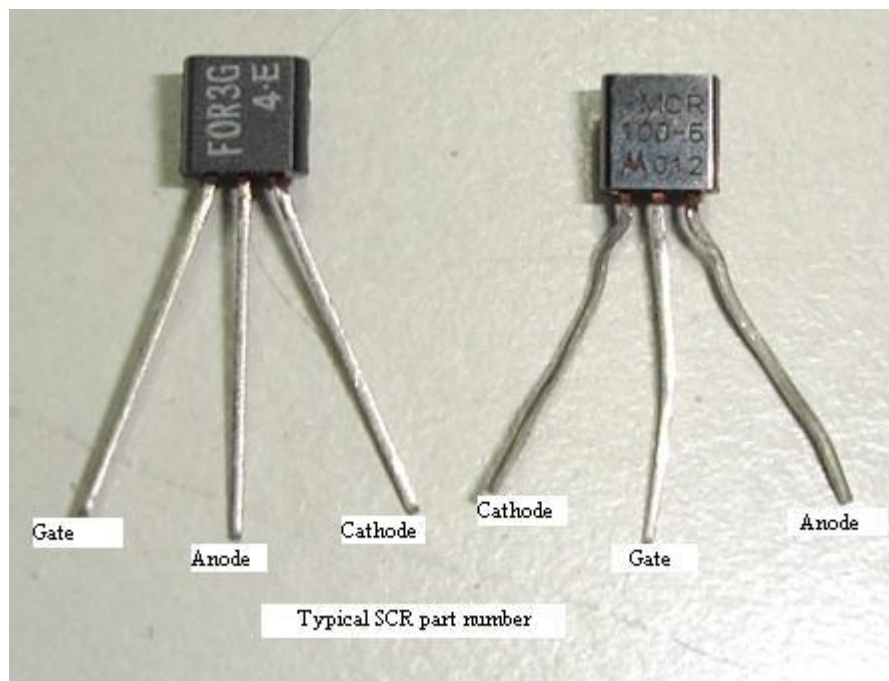
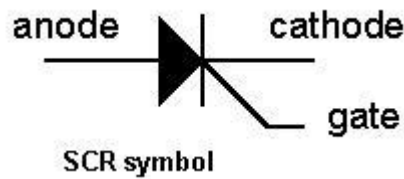
If the HOT has a built in damper diode, then you have to follow this way to test it: Set your analogue meter to X10 K Ohm and place the black probe to centre (collector) pin. Now, moving the red probe touching the first (base) and the third (emitter) pin, it should not show any readings. If you get even a single reading the HOT is considered shorted.

**Conclusion:**

- If you measure base (black probe) and collector (red probe) it should have a reading.
- If you measure base (black probe) and emitter (red probe) it should have a reading.
- **If you measure collector (black probe) and base (red probe) it should have no reading.**
- **If you measure collector (black probe) and emitter (red probe) it should have no reading.**
- If you measure emitter (black probe) and base (red probe) it should have a reading.
- If you measure emitter (black probe) and collector (red probe) it should have a reading.

Overall a good HOT should have 4 readings and if you get 5 or 6 readings the HOT is considered shorted.

Testing Silicon Controlled Rectifiers

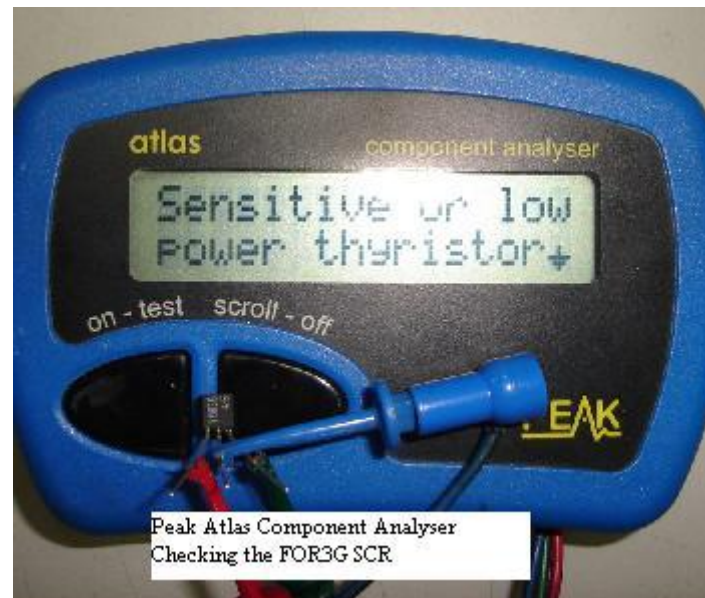


Testing a SCR (silicon controlled rectifier) can be done by using an analogue multi meter or specialized tester (such as the Peak electronic atlas component analyzer-<http://www.peakelec.co.uk>) designed to check semiconductor devices easily. SCRs can be found in many electronic circuits. Part numbers such as the FOR3G and MCR 100-6 are very commonly used in computer monitors.

Some call SCRs “thyristors” but in actual fact the word thyristor should not be associated exclusively with the silicon controlled rectifier. It is in fact a general name given to all four layer PNP devices including the commonly used SCR. The diac, the Triac, and the SCS are the other popular devices belonging to the family of thyristors.

SCRs consists of three pins of Gate (G), Anode (A) and Cathode (C). In order to identify the pin out, you can search the internet. The datasheet

will list out the general specification of the SCR such as the volt and ampere. Usually the SCR manufacturers will provide the full datasheet for those who want it.



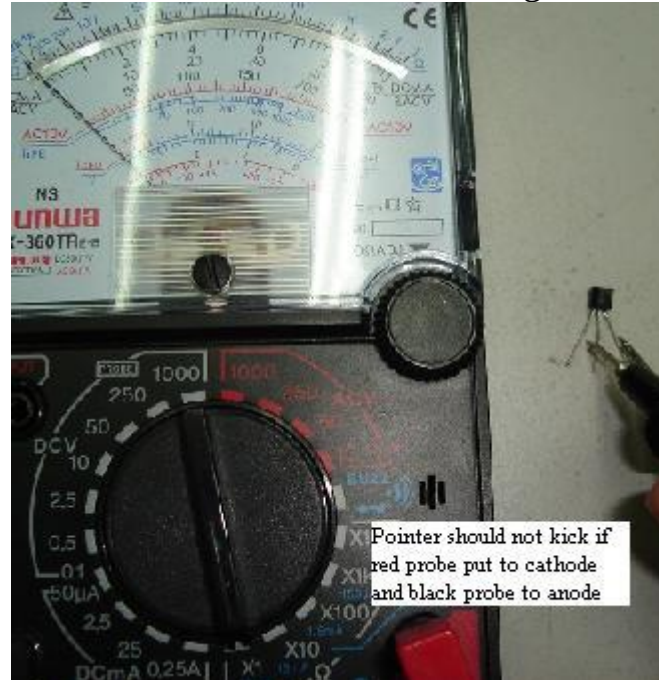
Once you know the pin outs of the G, A and C legs you can begin to test the SCR. If you have the Peak electronic atlas component analyzer tester, what you need to do is to connect the three small clips to each pin of the SCR (any part number will do).



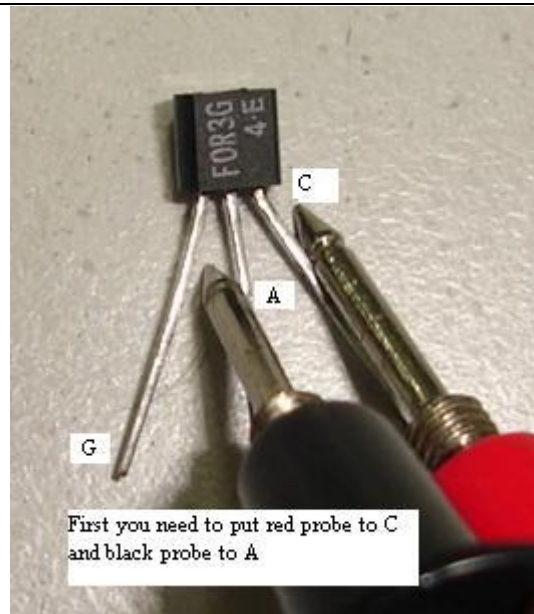
The tester will begin to analyze the SCR and prompt you with the display such as “Sensitive or low power thyristor” before it tells you the exact pin outs of G, A and C. After the first test, the tester will eventually show you

the answer at the LCD display. Red is Gate, Green is Cathode, and Blue is Anode.

It is a simple process and you will know the answer in less than 10 seconds. If there is a problem in the SCR, the tester would not be able to show the results instead it shows a shorted reading.



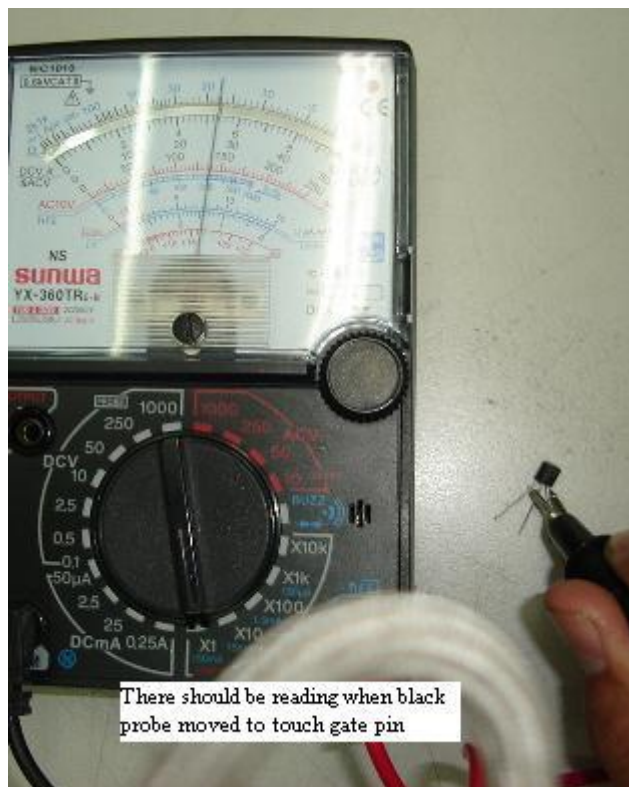
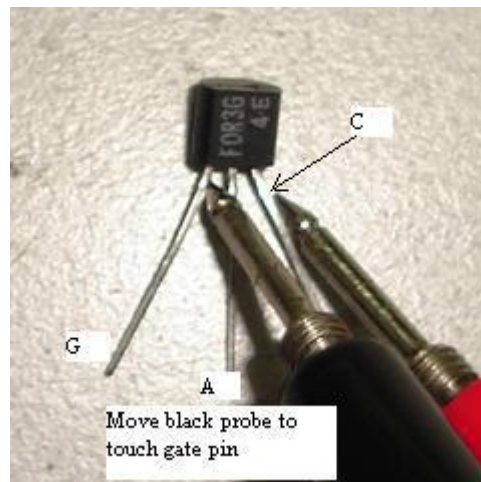
Make sure set to X1 ohms to test SCR



Showing the right way to check SCR

If you don't have this tester for checking SCR, I'm going to show you another easy way to test SCRs fast. **You need an analogue meter set to X1 ohm.** Place the red probe to the Cathode and black probe to the Anode pin. At this time the meter doesn't show any reading. Now gently move the black probe and touch the Gate pin (the black probe still touching the

Anode pin) and you will notice the meter's pointer will kick as shown at the picture (low resistance).



Removing the black probe from the GATE pin (the black probe still touching the Anode pin) you will notice that the resistance continues to be there (low resistance). This is due to the conduction of SCR as the meter battery is usually able to supply current more than the holding current.

If at this stage you removed the black probe from the Anode pin and connected it back, the pointer will drop back to infinity (high resistance). If the SCR could hold the resistance then the SCR is considered good. If it

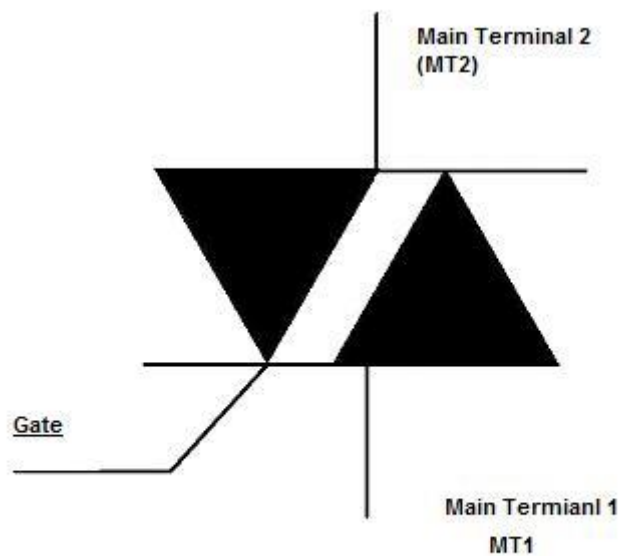
can't hold then the SCR is faulty.

Conclusion: Practice testing SCRs more often to see how the results are. Try some different part numbers and power SCRs - and if the resistance doesn't hold using X1 ohm, you may try X10 ohm, etc.

Testing Triac



Typical example of Triac

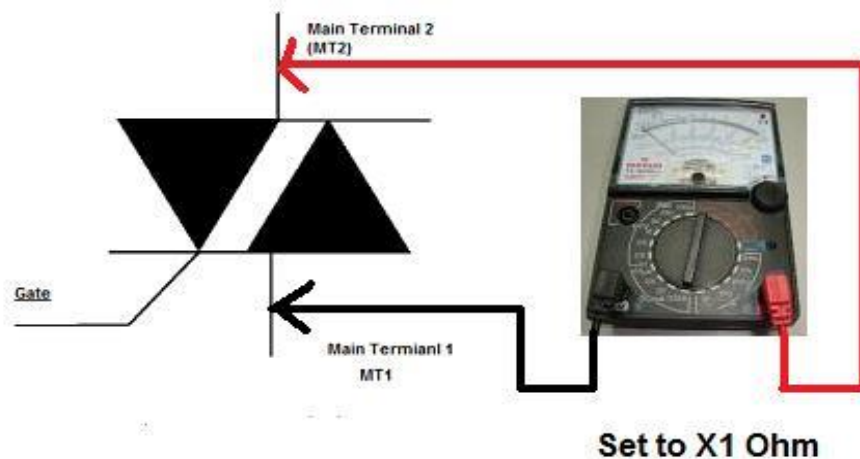


The TRIAC symbol

The triac is an electronic switch or relay with three terminals. It comes in many shapes, sizes and colors. It is an open circuit with no gate signal present, but conducts in both directions when gate voltage is applied. Triacs are used extensively in power control circuits.

They are particularly suited for AC power control applications such as motor speed controls, light dimmers, temperature controls and inverters. They are also employed for over-voltage protection in DC power supplies.

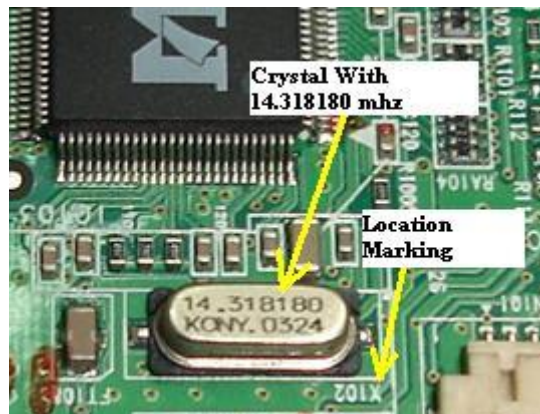
Testing Triac



- 1) First make sure you know the terminals of the triac. If you do not know, you can always refer to a semiconductor data book or browse through the internet. Once you have located the terminals, it is time to use your analogue meter set to X1 Ohm or X10 Ohm.
- 2) Place the red probe to terminal 2 and the black probe to terminal 1. You should get a high resistance reading.
- 3) Now, use a screwdriver tip to create a momentary short between the gate and terminal 2 or you can just move the red probe touching the gate while the red probe is still on terminal 2. This short will cause the triac to turn “ON” and you will see a low resistance reading at the meter panel and it will remain low even though the gate connection is broken.
- 4) Reverse the probes and retest again and you should expect the same result.

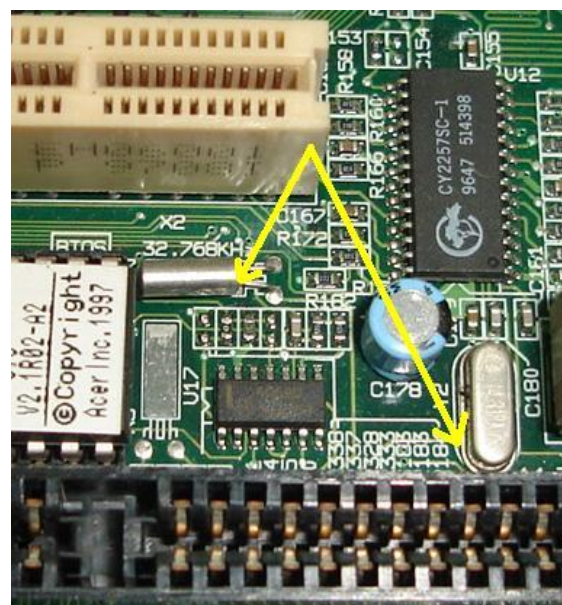
These readings are approximate and may vary with manufacturer or different specifications from the triac. **From experience: any result that is significantly different would point to a faulty triac.** If possible, get some triacs with different specifications and measure them to take down their measurements for future comparison.

Testing Crystal Oscillators



A Crystal and location marking

It's simple to test a crystal with a tester or checker. Crystal oscillators are used to generate precise, stable radio frequencies and are found in a wide variety of electronic equipment such as computers (motherboards and monitors), television, telecommunications systems (mobile phones), etc. The function is to keep the frequency of the clock from drifting. If the signal from this clock stops producing frequency, or is weak, or the pulses begin to vary or change, the electronic equipment might show intermittent problems or might stop altogether.

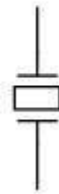


Crystals in a Computer Motherboard

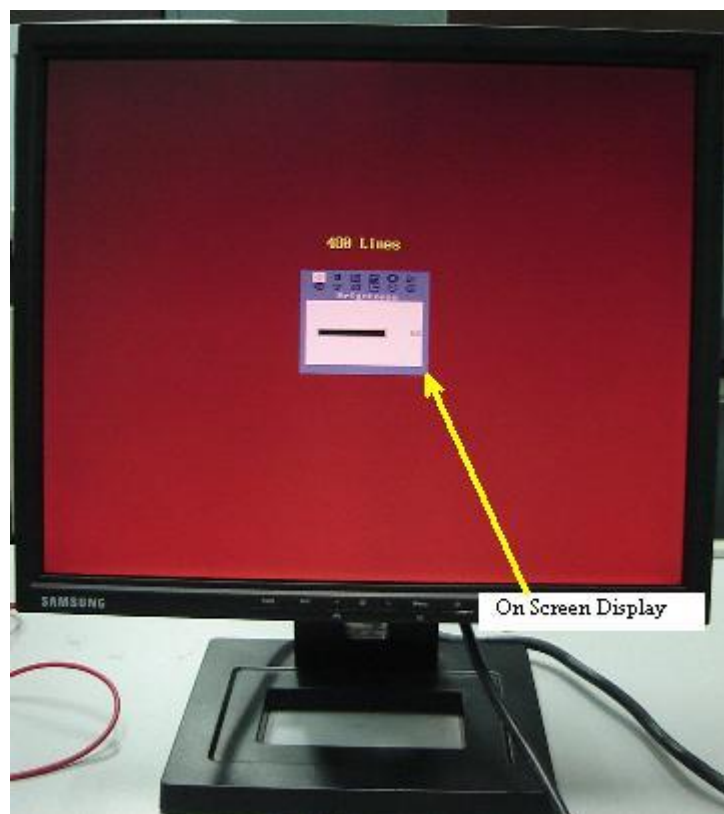
The microprocessor pins that hold the crystal oscillator are usually called OSC IN and OSC OUT and the frequency is marked on the crystal. The location of the crystals are labelled as XTAL or X. Some examples of

crystal oscillator frequencies are 4 mega hertz (MHz), 8 MHz, 16 MHz and so on.

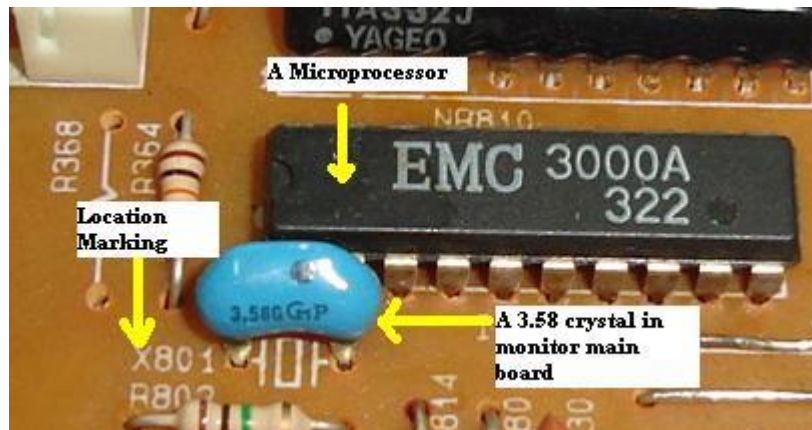
Crystal Symbol



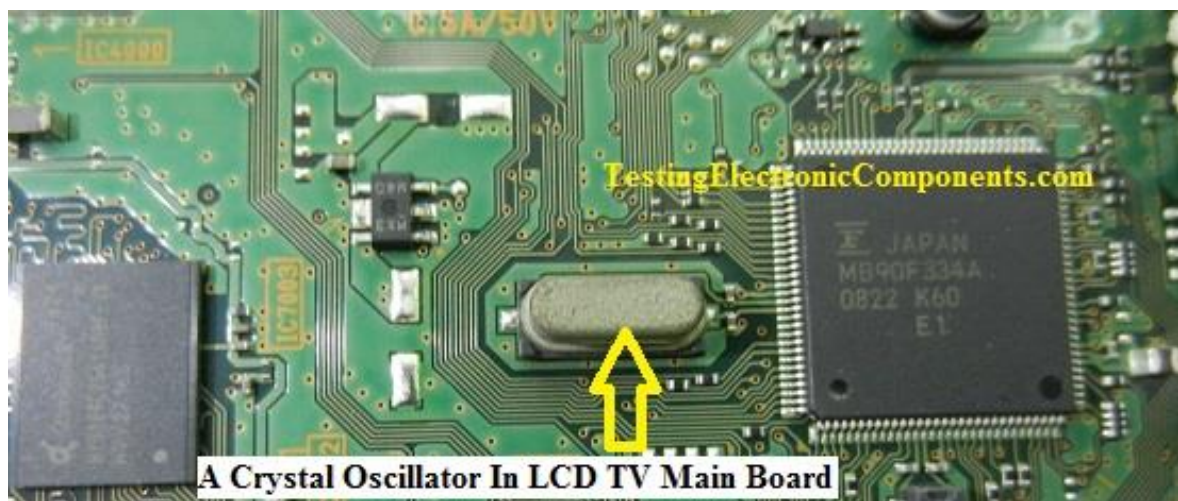
I've experienced quite a number of computer monitor crystal breakdowns causing the On Screen Display (OSD) to disappear from the screen. Some On Screen Displays were even missing half of the display and were also erratic. Replacing only the crystal solves the OSD problem in monitors. A loose crystal connection in a computer motherboard could cause the system to 'hang' after running for sometimes.



Crystals are quite fragile components because of their construction and designed. Unlike a resistor or a capacitor, if you drop one on the ground from a decent height, there's a 50/50 chance whether it will function again. Though crystals don't become faulty easily like a resistor or capacitor, it is important for an electronic repairer to know how to test a crystal.



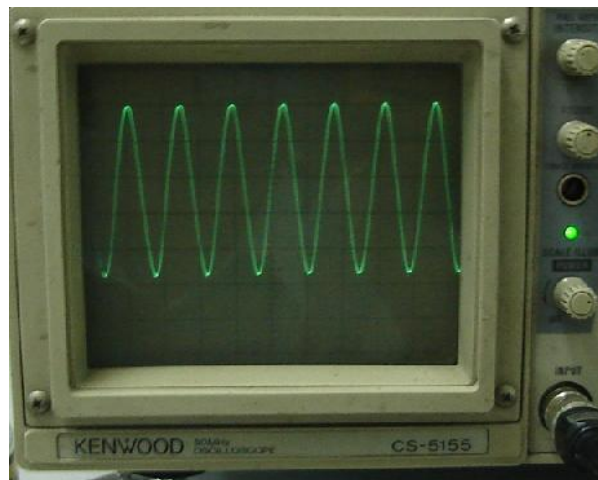
A Crystal and its location marking in a Computer Monitor



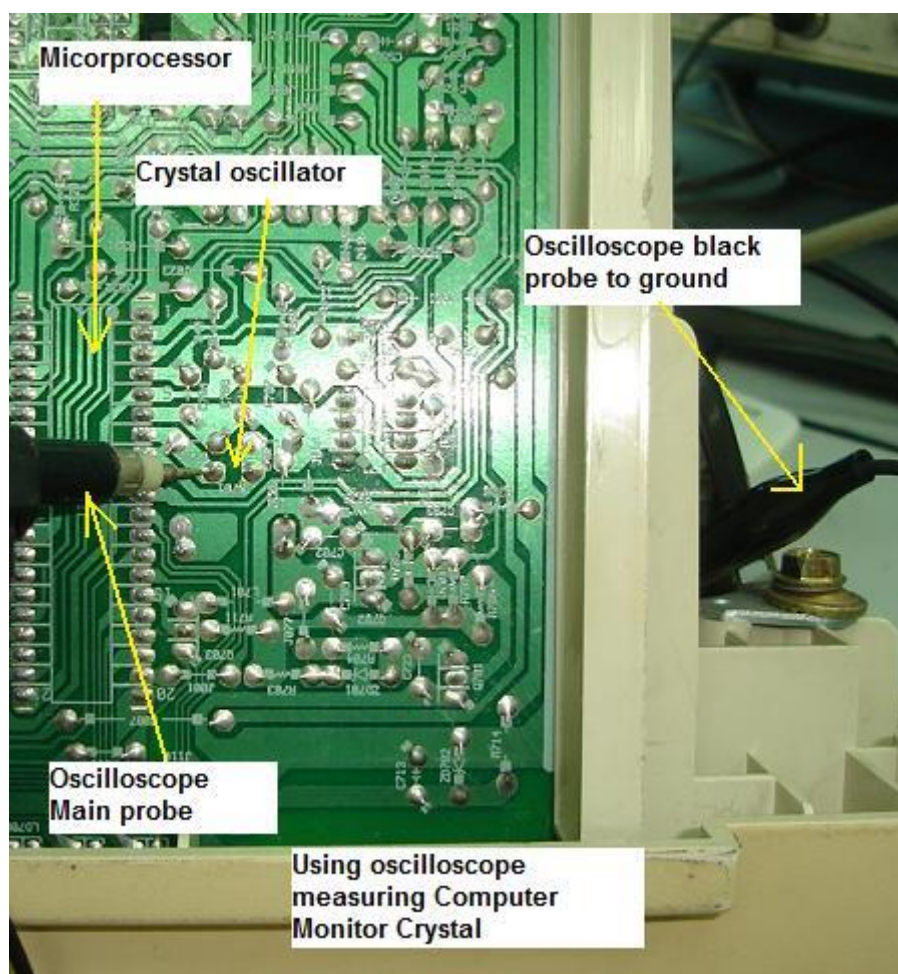
Testing the crystal is not a breeze either. You cannot just take out your trusty meter and test the crystal with it. In fact, there are three methods to test a crystal:

Using an Oscilloscope - A crystal oscillator produces a sine wave when excited. It is appropriate then, to see a waveform representative of a sine wave on the clock pins. If the clock is not working properly, replace the crystal. Test the crystal with the power on. Place the scope black probe to cold ground and the main probe pin to the crystal pins. Normally microprocessors are usually very reliable but not in this case of a Compaq MV720 monitor.

The monitor came in with a no high voltage symptom. Using the scope to check on the crystal revealed a very unstable waveform and replacing the microprocessor solved the no high voltage problem and the crystal waveform shown a perfect sine wave-see next page.



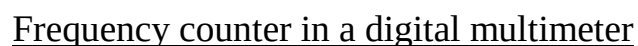
A crystal oscillator sinewave



How to measure crystal frequency with oscilloscope

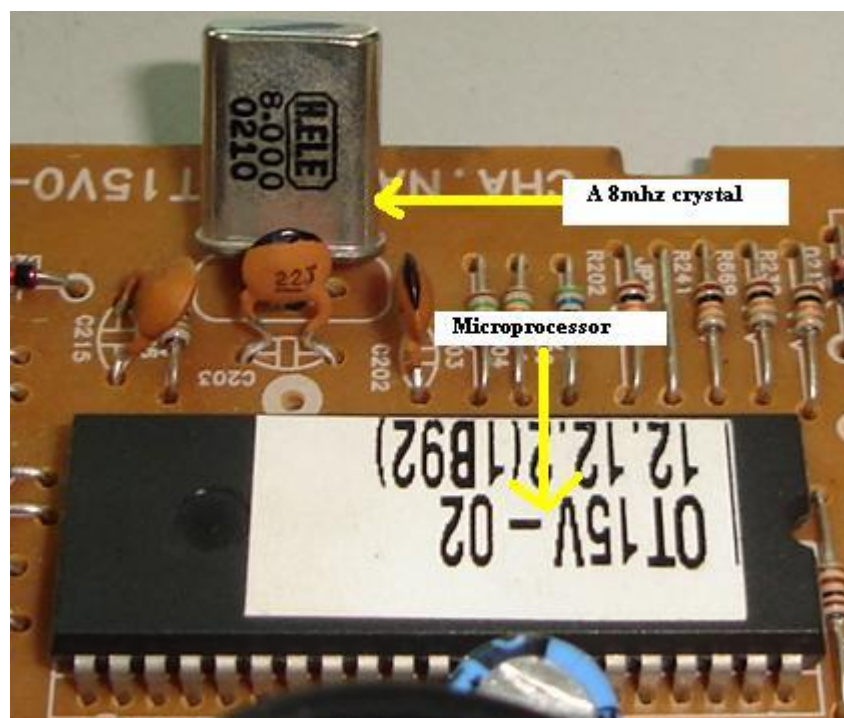
The second method is to use a frequency counter to check the frequency of the crystal oscillator. The measurement must be taken when the equipment power is 'On'. Put the probe of the meter or frequency counter to the crystal pin and read the measurement. That means place the black

If the crystal is 8 MHz then your meter should have the range to be able to check that frequency. Assuming the readout of the crystal is 2.5 MHz, you know that the crystal is not functioning well and needs to be replaced. Normal digital multimeters usually have a small range for checking frequency. However the digital meter (Greenlee brand) that I'm using is able to measure up to 48 MHz. You can read the specification of your meter manual and see how high is the range.





The right way to test crystal oscillator in electronic equipment

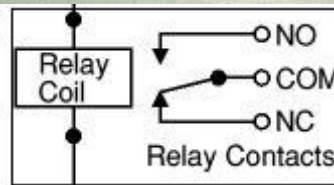


A Crystal oscillator and microprocessor (CPU) in a main board

The third method is to use a Crystal Checker - With this way; normally the crystal is placed in the feedback network of a transistor oscillator. If it oscillates and the LED is lightening up, this means that the crystal is functioning. If the crystal doesn't work, the LED will go off. Instead of using an LED as an indicator, some other expensive crystal checkers use a panel meter to indicate if the crystal is functioning or not.

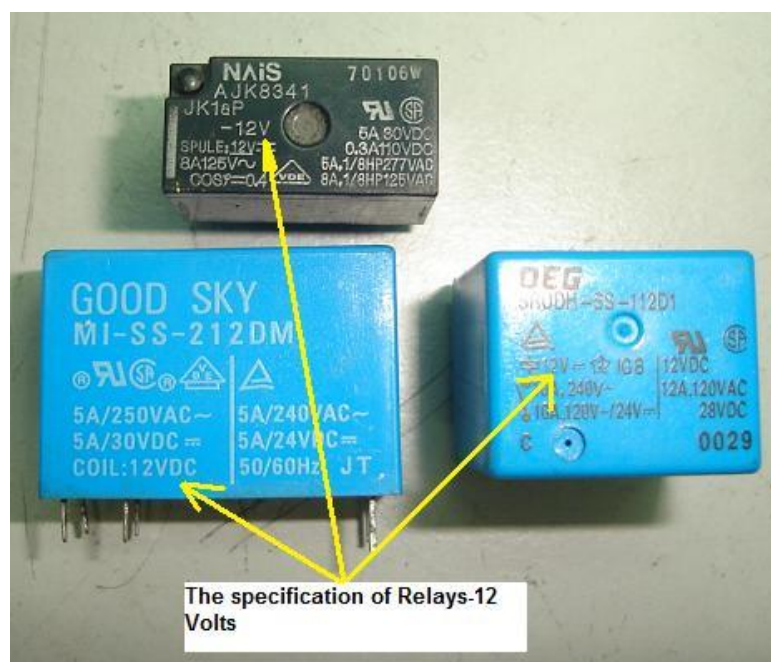
If you search crystal information on the internet, you will find some websites that provides tips on how to test crystals as well as how to build testers. Just go to Google Images and type “**Crystal Tester Circuit**” and you will find tons of information and diagram about Crystal Tester/Checker.

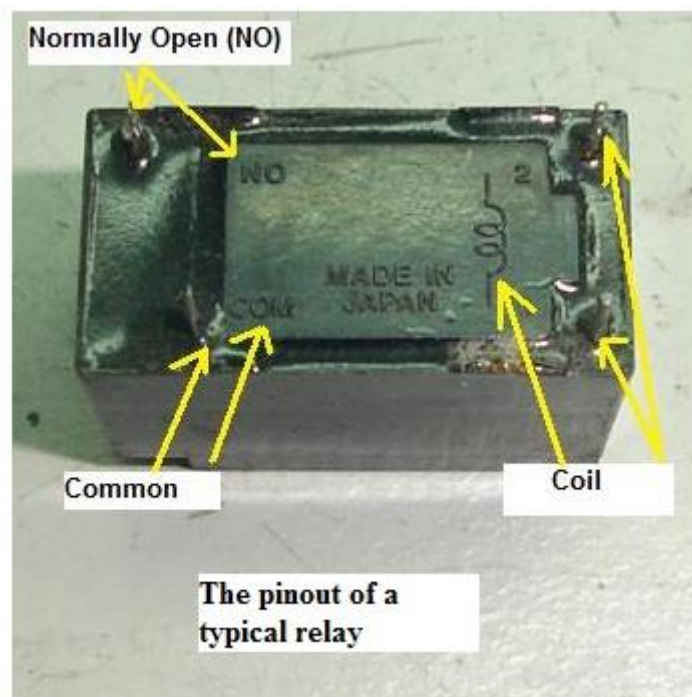
Testing Relays



A circuit symbol of relay

An electromagnetic relay is basically a switch operated by magnetic force. This magnetic force is generated by flow of current through a coil in the relay. The relay opens or closes a circuit when current through the coil is started or stopped. The specification of relays normally are 5V, 12V, 18V, 24V, etc. and with amperes rating too. All these specifications are printed on the relay body as shown in the photo below:





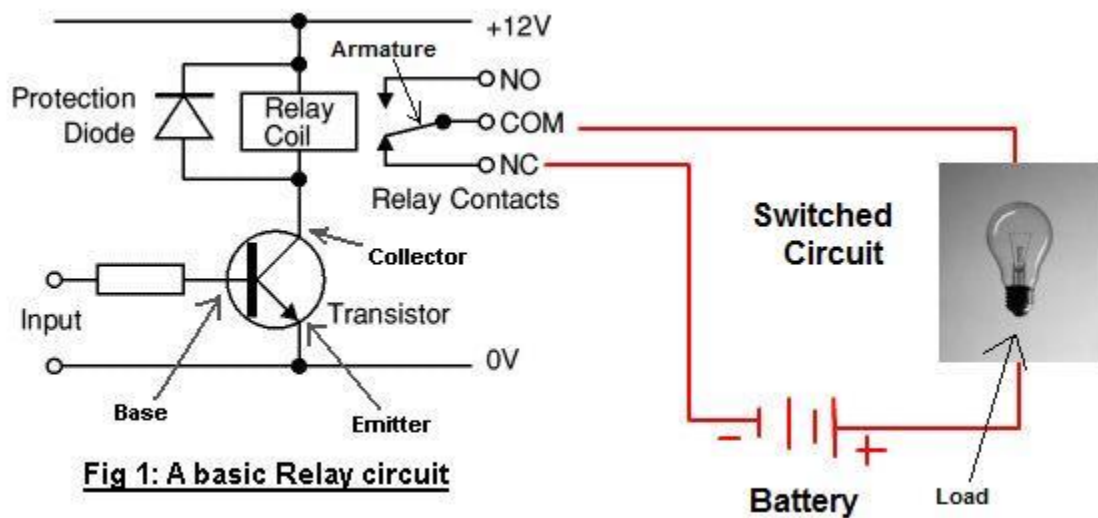
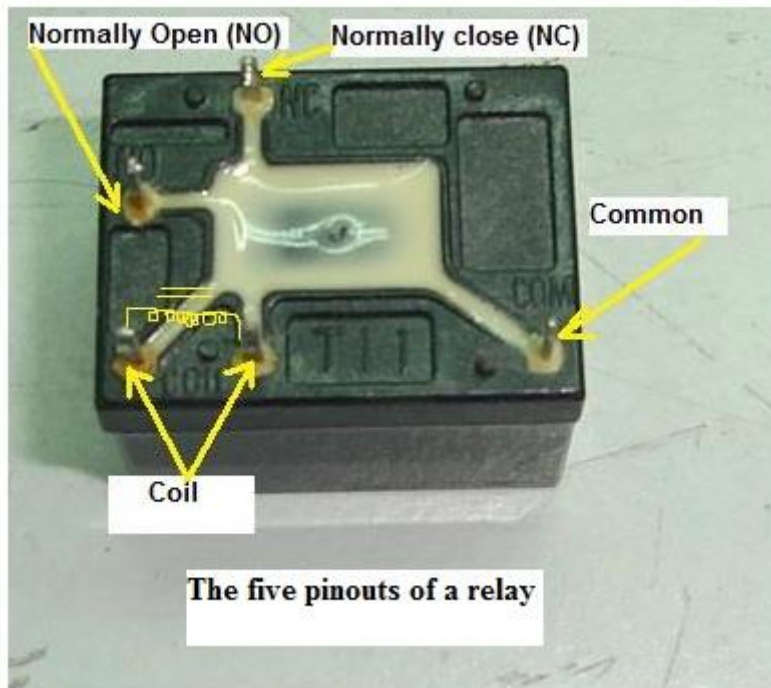
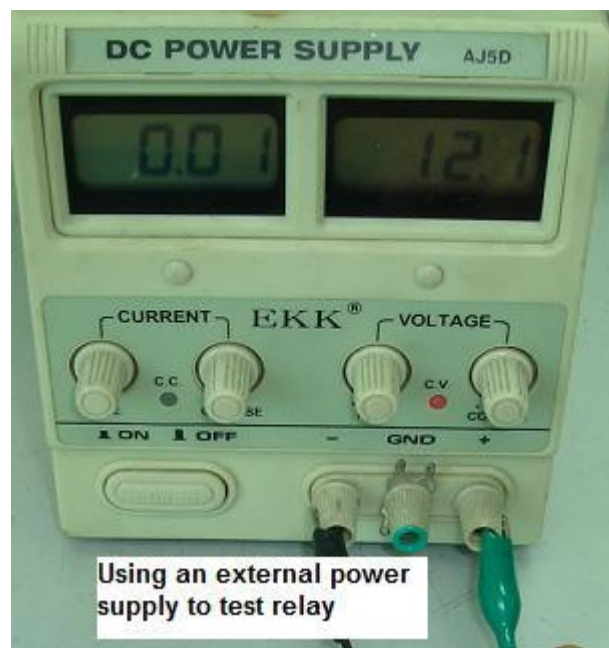
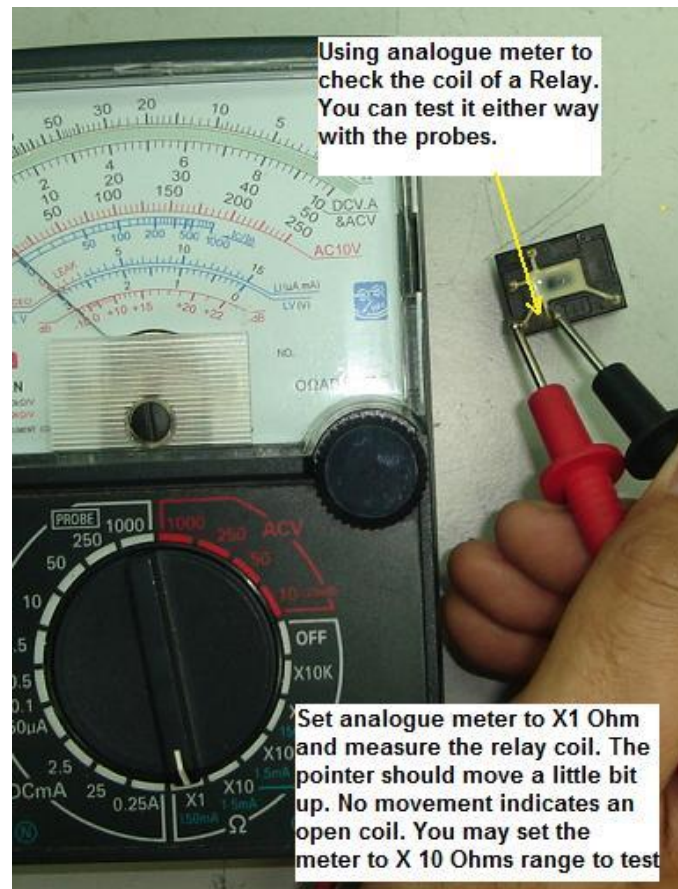


Figure 1 shows a basic relay circuit. If there is an input signal going to the base of the transistor, the transistor will conduct and the 12V will flow through the relay coil, collector, and out from the emitter and to ground (0V). This will energize the relay coil and cause the armature to switch from the “normally closed (NC)” to the “normally open (NO)” state. When the armature is in the “normally open (NO)” state, no current will flow to the lamp (load) and the lamp will go off.

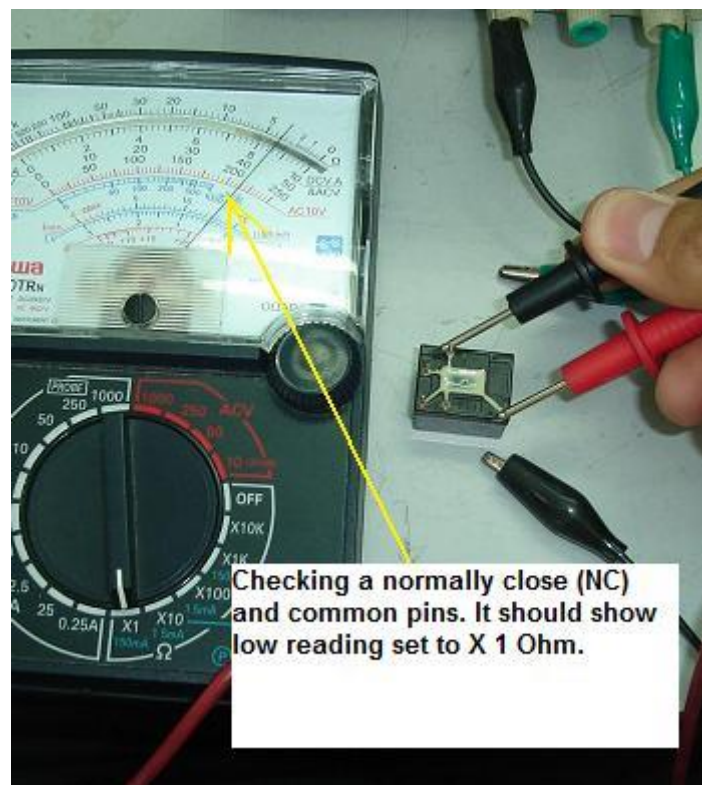
There are two steps to test relays: First use your analogue meter set to X1 Ohm and place across the relay coil as shown from the photo on the next page. This is to make sure that the relay coil is not open circuit. If it opens

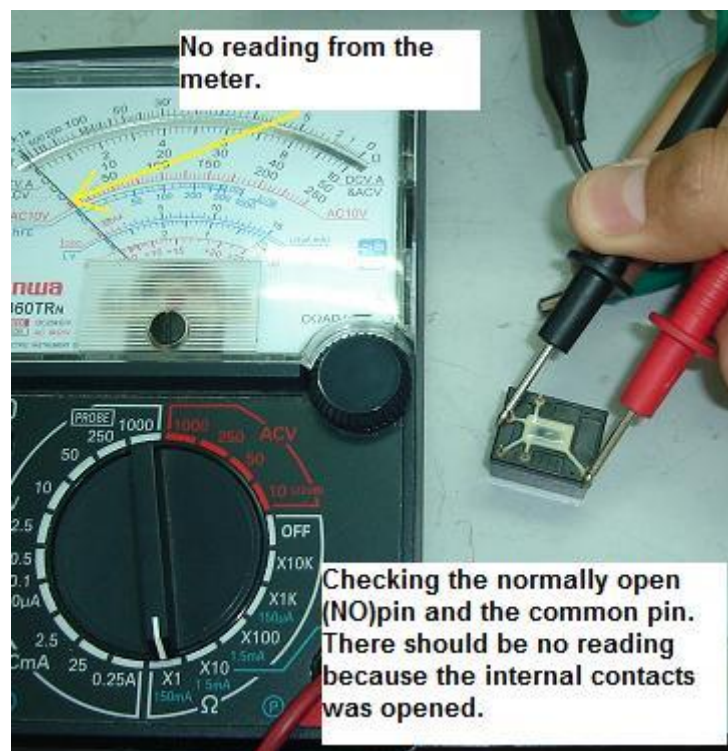
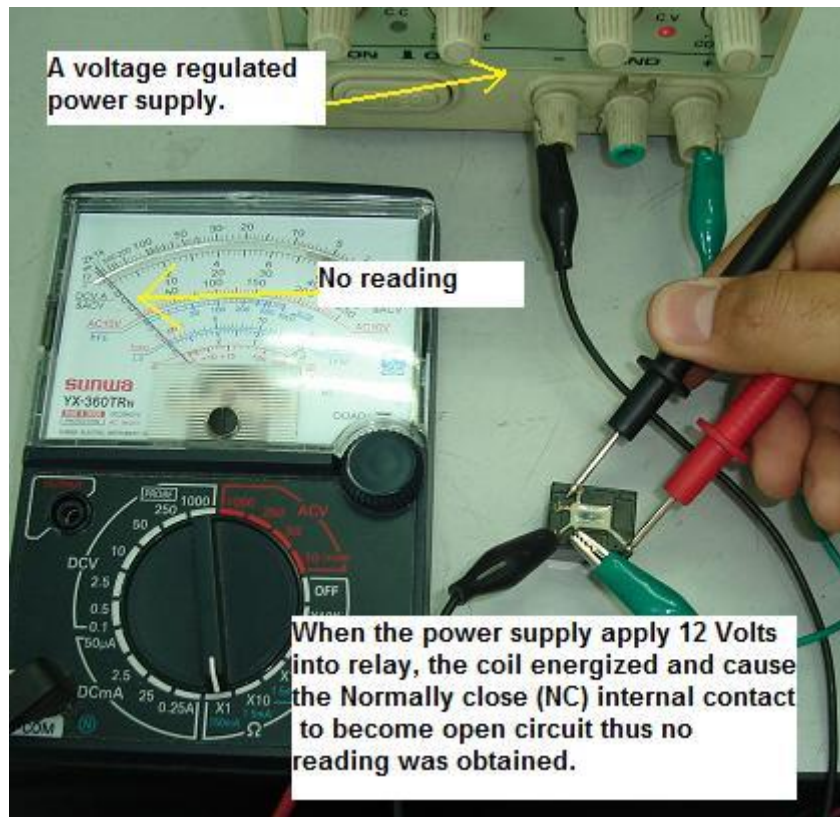
circuit there will be no reading registered on your analogue meter. A good coil should show resistance.

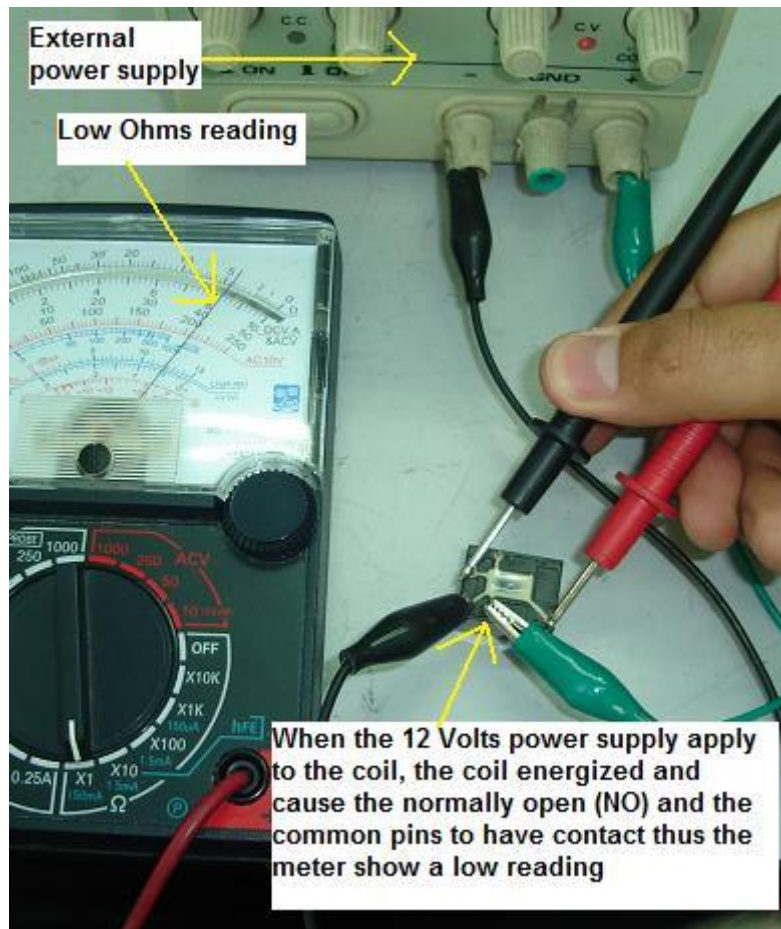


The next step is to connect a power supply across the relay. Use a variable regulated power supply to adjust to the same voltage as what the relay can handle. That means if the relay specification is 5V then you

adjust the power supply to 5 V. Any voltage higher than 5 V will burn the relay coil. Now connect the positive and negative alligator clip to the relay coil. When the relay coil has the 5 V run through it, the coil will begin to energize and start pulling the internal armature. You actually could hear a “tic” sound from the relay when it is energized!







If you place your analogue meter probes set to X 1 Ohm across the “common (Com)” and the “normally closed (NC)” pin and when you hear the “tic” sound, you will see that the meter pointer will drop from the zero Ohm to infinity (indicating open circuit).

Similarly when you place the probes across the “common (COM)” and the “normally open (NC)” pin and when you hear the “tic” sound, you will see that the meter pointer will move up from infinity to zero Ohms (indicating closed circuit).

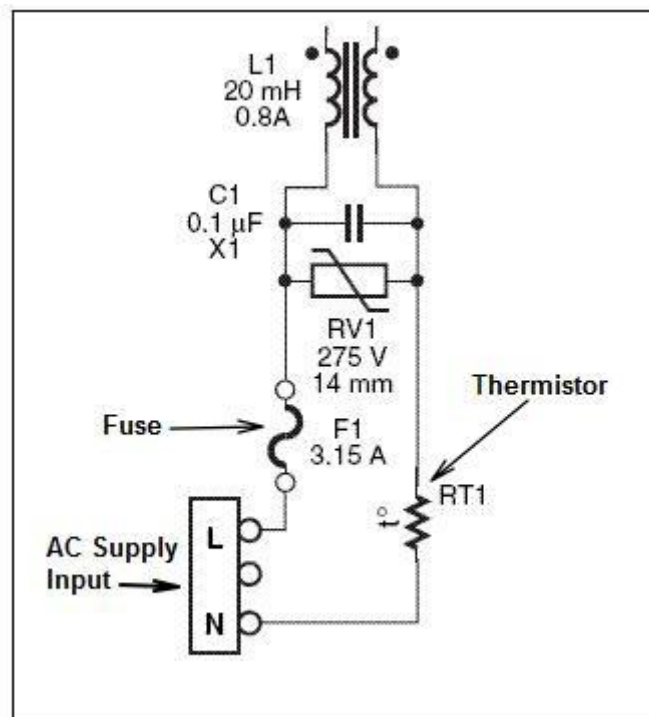
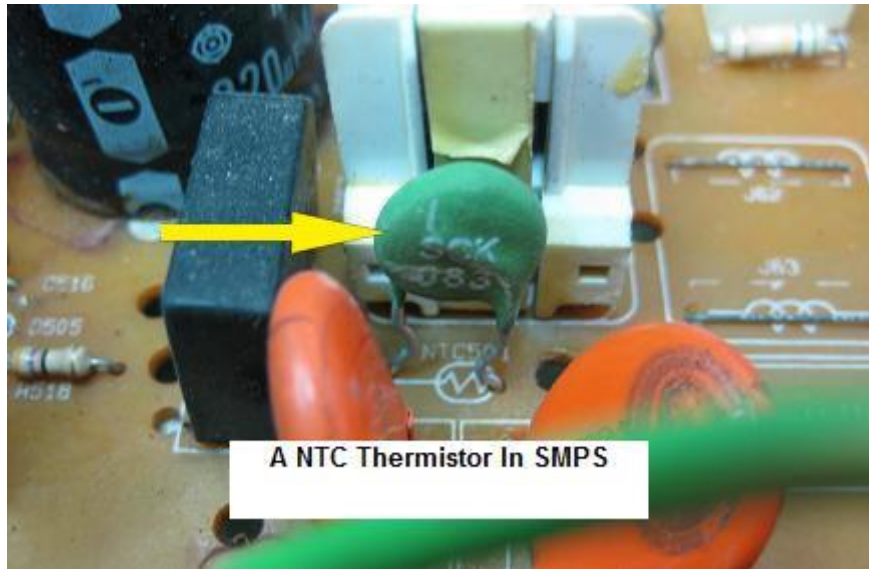
If you get such reading that means the relay is working fine. If there is no response from the meter (pointer won't move) even though the relay coil already has been connected with the power supply, the relay needs replacement.

Testing Negative Temperature Coefficient (NTC) Thermistors



Negative temperature coefficient (NTC) Thermistors (**board location marked as “TH”, “R” “RT” or “NTC”**) are usually found in the switch mode power supply (SMPS) and it is located near the AC supply socket area. The function of the Thermistor is to limit the inrush current that can kill the components in the power section during start up. An NTC Thermistor has about 3 to 30 Ohms resistance at room temperature, so at turn-on, it limits the current charging the load's rail capacitors (the big main filter capacitor usually rated as 400 volt). As the Thermistor heats up, its resistance drops, so the power supply becomes relatively low impedance.

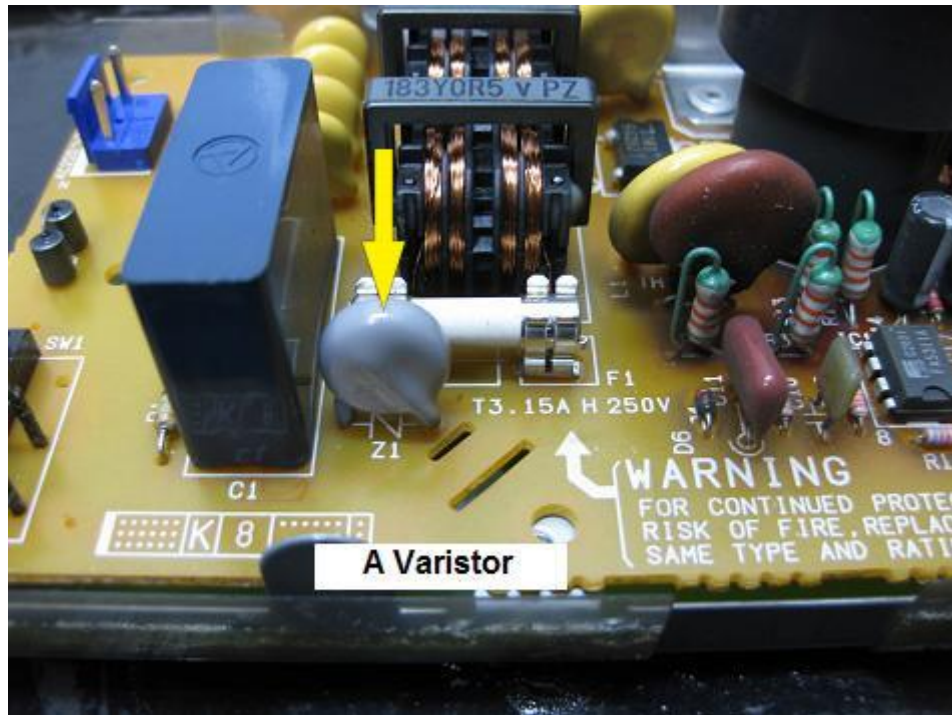
Note: You can do a test on it. Place the Ohmmeter probes on the Thermistor leads (either way) and measure the resistance. Assuming you got 14 Ohms, now turn on a hair dryer and blow directly to the Thermistor and you will see that the resistance Ohms value will drop. Once you have turned off the hair dryer, the resistance of the Thermistor will increase back to its original ohm value.



You can test it using an analogue meter set to X 1 Ohm and it should show a **low ohms reading (Typically between 3 to 30 Ohms)**. If you did not get any reading that means the Thermistor is already open circuit and needs to be replaced. For your information not all SMPS use this component in their design. In some SMPS, the designer may add in a resistor in series (usually low ohm resistor with higher wattage) to the input line to limit the initial peak inrush current whenever the power supply is switched on.

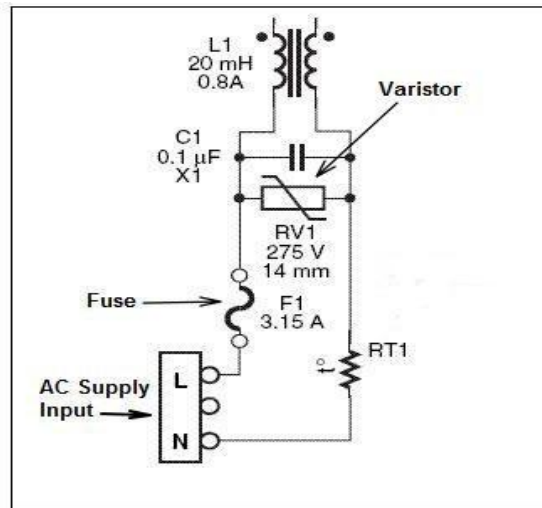
Assuming if the NTC is tested bad and if you really can't get the part, the only choice you have is to replace it with a jumper wire. The consequence is the SMPS has no protection against high inrush current anymore. Before you send the SMPS back to your customer you need to test (switch "On" and "Off") many times to really make sure the SMPS is stable and would not blow the fuse, otherwise I guess you may need to put in the NTC to avoid the fuse blow problem.

Testing Varistor



Varistor (**board location marked as “Z”, “RV” or “ZNR”**) - Metal Oxide Varistor (MOV) is voltage dependent symmetrical resistors intended to protect equipment from transient voltages resulting from lightning strikes. It has many colours. This component is located near the ac supply input and before the bridge rectifier. The use of MOV not only reduces the chance of electrical damage but also improves equipment reliability. Whenever the Varistor has a problem, the top part always darkens in colour and splits open (blown)!





Sometimes it looks perfectly good from the outside but is actually shorted when you test it with a meter. If it is shorted the main fuse will definitely blow. In order to test MOV you can use an analogue meter set to X 10 K ohm and it should show no reading on both ways. A good Varistor should show an open circuit reading. **If there are any readings, then it has developed a short circuit.**

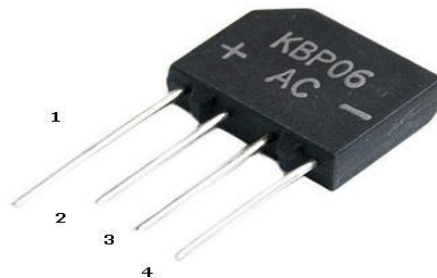
For your information not all SMPS have a Varistor in the circuit. Assuming that you have come across one burnt or shorted Varistor, you have the option to replace with a new one or **just remove** the Varistor from the circuit. After the removal of the Varistor, the SMPS would still work except that the SMPS no longer has resistance toward surge in the days to come. These are the risks that you are going to take if you have decided not to put in a new Varistor. Probably you want to save cost or you just could not locate the original or equivalent part number for the Varistor.

The Varistor part number or the code is quite similar to Capacitor coding. For example, the code of 471 means a 470 volt Varistor. See the photo below:



Summary Of The Right Way To Test Electronic Components

1. AC/DC Voltage- Digital Multimeter (On voltage test)- **Set to DCV or ACV and test**
2. Resistors- Digital Multimeter- Ohm range (Off board test)- **You need calculate the resistor color band before measuring it**
3. Diode- Analogue Meter set to x 10 K ohm (Off board test)- **It should have one reading when testing both ways of the diode**
4. Bridge Rectifier- Analogue Meter set to x 10 K ohm (Off board test). **Test all the four individual diodes- Pin 1 and 2, pin 1 and 3, pin 4 and 2, pin 4 and 3**



5. Zener Diode- Analogue Meter (Off board test)- **2.4 volt to 12 volt have two readings but not shorted reading-13 volt and above should have only one reading.**
6. LED-Analogue meter set to x1 ohm (On board test)- **one of the ways it should light up the LED.**
7. Cable/wire- Ohm meter or buzzer (On/Off board test)- **For Ohm meter see the needle deflection to 0 Ohm. For buzzer from your Digital meter- listen to the sound**
8. On/ off switch- Ohm meter or buzzer (On/Off board test)- **Switch On, set to x 1 Ohm and see the needle deflection to 0 Ohm. For buzzer- listen to the sound. Switch off, Ohmmeter needle no deflection and no sound from the buzzer.**
9. Bipolar Transistor- Analogue meter set to x 1 and x10 K ohm (Off board test)- **X1 is to find the base pin. X 10 K is to find the collector and emitter pins.**
10. Darlington Transistor- Analogue meter (X1 have 3 readings and x 10 k ohm have 4 readings) (Off board test)
11. Horizontal output transistor (HOT) with Damper diode- Analogue meter (X1 and X10 K ohm must have 4 readings) (Off board test)
12. Fuse- Ohm meter or buzzer (On board test) - **For Ohm meter see the needle deflection to 0 Ohm. For buzzer- listen to the sound**

13. Coil/Inductor- X1 Ohm Meter to check small coil and Blue Ring Tester to check on Big coils (Off/On board test)
14. Non polar capacitor- Digital Capacitance Meter (Off board test)-
Calculation in pf, nf or uf is needed.
15. Electrolytic Capacitor- Digital Capacitance meter (Off board test)
Calculation in nf or uf is needed. For Blue ESR meter (On board test) please refer to the chart given when you purchase the meter.
16. Field Effect Transistor (FET)- Analogue Meter set to X10 K ohm (Off board test)- **For N channel, black probe to center pin (drain pin or D) and red probe to Source pin (S) while finger touching Gate (G) and Drain (D) pins. The needle should kick up and charged and stay. However to some FETs, the needle will charge up and drop back to infinity. To check a P channel is the reverse of N channel. Just switch the probes and do the same test.**
17. Integrated circuit (IC)- Voltmeter to check the supply voltage (VCC) and oscilloscope to check on the IC input/output pin waveform (On voltage test)
18. Linear Transformer- Ohm meter to check on primary and secondary winding resistance (Off board check) and AC voltage test by AC voltmeter (On voltage test)
19. Switch Mode Transformer- **Blue Ring Tester (On board test) check on the primary winding of the power transformer**
20. Thermistor- Ohmmeter- Should show low resistance from 5 to 30 Ohm (Off/On board test)
21. Varistor- Analogue meter set to X 10 K Ohm- **Should have no readings either side of the Varistor (Off board test)**
22. Crystal- Frequency meter or Oscilloscope (On voltage test). **For frequency meter, place the black probe to cold ground and red probe to the Crystal pin and read the frequency. Made sure your Digital Multimeter can support the frequency under test. If it is rated 10Mhz max then it can't be used to check on a 20Mhz frequency. For Oscilloscope, look at the sine wave waveform. Made sure the Oscilloscope can support the frequency under test.**

Note:

- **On voltage test** means you have to turn the equipment “On” in order to perform the test
- **Off board test** means you have to remove the component out from the circuit board and test it with your Multimeter. You can remove just one lead or the whole component.

Tools And Test Equipment That You Need To Buy

Tools:

- 1) Long Nose Plier
- 2) Wire Cutter
- 3) Soldering paste
- 4) Soldering Helping Hands
- 5) Test Pen
- 6) Desoldering Pump (Sucker)
- 7) Solder lead (60/40) 0.8mm diameter
- 8) Solder Gun 25 to 30 watt or you can get the Hakko 981
Dual Mode solder gun 20watt/130watt
- 9) X4 and x10 Magnifier Glass
- 10) Thinner solution or isopropyl alcohol to remove the
additional flux on circuit board after the repair work.
- 11) A piece of small brush. Dip this small brush into the
Thinner or Isopropyl alcohol and then clean the circuit board
area.

Test Equipment:

- 1) Sunwa YX-360Tre Analogue Multimeter or any Analogue
Multimeter that has the X10 Ohm range.
- 2) Any branded autorange Digital Multimeter like Fluke,
Sanwa, Kyoritsu and etc)
- 3) TES 1500 Digital Capacitance Meter or any Digital
Capacitance meter that can measure from 1pf to more than
10,000uf
- 4) [Blue ESR meter](#) (to check electrolytic and low ohm
resistors)
- 5) [Blue Ring Tester](#) (to check on coils/inductors)
- 6) SMD Rework Station (Optional)
- 7) [Smart Tweezer](#) for checking SMD components (Optional)

Technical Books For Reference (Bibliography)

1. Basic Electronics (Hard Copy Book) – By: Bernard Grob
McGrawhill Publication
2. Electronics-Principles and Applications - By: Schuler
McGrawhill Publication
3. The Illustrated Dictionary of Electronics - By: Stan Gibilisco
McGrawhill Publication
4. ECG-Semiconductor and Master Replacement Guide (taken over by <http://www.nteinc.com>)
You can try <http://www.Sayal.com> to get the NTE replacement guide By: ECG Philips
5. Up-to-Date World's Transistor-Diodes- Thyristors & IC's Comparison Tables Volume I & II By: Tech Publication
Singapore

Conclusion

With the information you have acquired, you should have a basic understanding of how to test almost all of the electronic components found in electronic circuits. I strongly suggest you get **started right away** with all of the tips and tricks you have learned from this Training course E-book.

What you need to do now is to buy few electronics project kits from your favourite electronic stores and begin to assemble it. This is one of the practical ways to improve your soldering skill, testing electronic components, understanding components coding and part number and etc.

Once you are good in fixing the electronic projects kits and testing electronic components you then can look for broken equipment to repair. If you can't find any broken electronics equipment for repair, you can try to buy the cheap equipment (junk/broken) from Ebay.com or from any local electronics store to perfect your repair skill.

I wish you all the best and look forward to hearing your success story.

To your success,



Jestine Yong

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<http://www.JestineYong.com>

My other best seller repair Ebooks:

<http://www.PowerSupplyRepairGuide.com>

<http://www.LCD-Monitor-Repair.com>

<http://www.LCDMonitorCaseHistories.com>

<http://www.FindBurntResistorValue.com>

<http://www.ElectronicsRepairArticles.com>

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