

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 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.
- e) That keeps the possible current paths away from the heart.
- f) Don't attempt repair work when you are tired or rushed.
- g) Always assume that all the parts in the power supply are
- h) **"HOT"**.
- i) Use only plastic screwdriver for shock protection during service operation.

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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 an arrangement of about 150uf to 330uf at 400 working voltage.

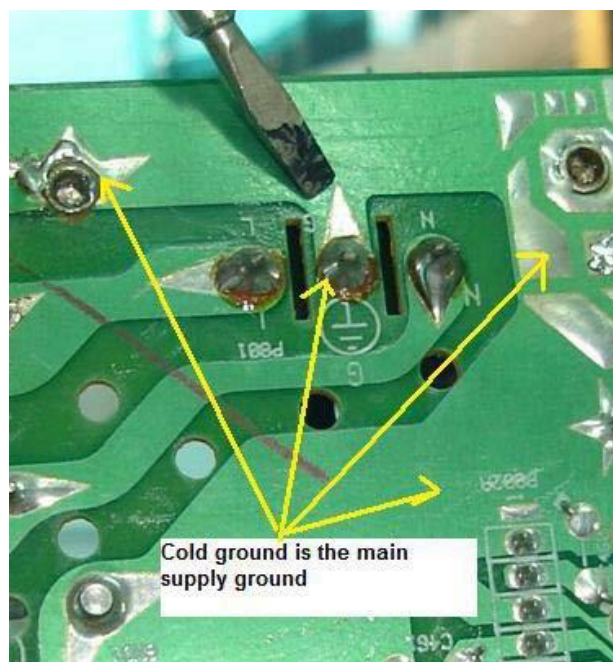
Before you start to work on a power supply, always turn off the power and discharge the capacitor. You can do this by placing a resistor across the two legs of the capacitor. The resistor value can be around 2.2 to 4.7 kilo ohms 10watt. It takes only a few seconds to fully discharge a capacitor. Double-check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

NOTE / WARNING:

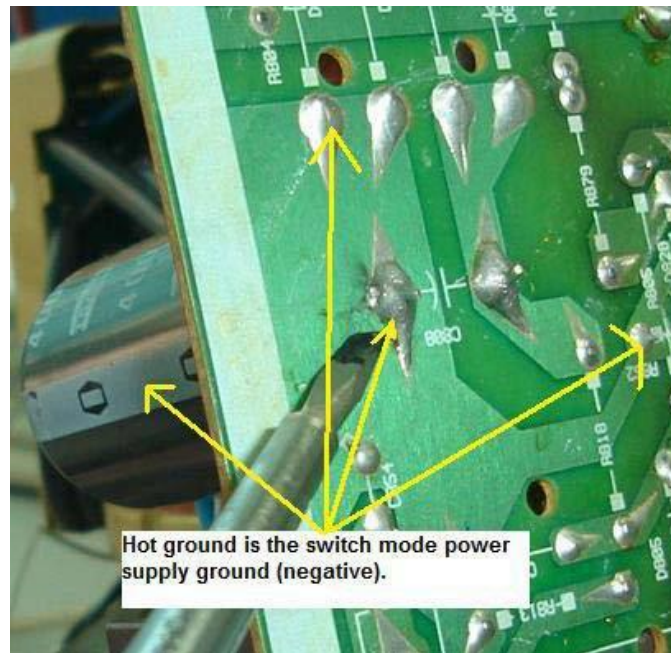
Do not discharge capacitor with screwdriver because: -

- 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*



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Modern equipment consists of two grounds, one of which is a “hot” ground while the other is a “cold” ground. Hot ground is in the primary side of a switch mode power supply while the cold ground is the equipment ground.

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 or scope to the hot ground, while

If the “Hot” ground is not used and you use only the cold ground, the voltage measurement might not be correct and it may destroy your meter. One way to prevent this is to use an “isolation transformer”.

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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 240V 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.

Note: A variable transformer or variacs is not an isolation transformer.

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 several days. All CRT have graphite coating on the internal and external surfaces of the glass bell. This conductive graphite coating are commonly

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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.

6. *High Voltage*

Monitors and TV have sections that use very high DC voltages. The high voltage is needed to be applied to 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. Fly back 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 on 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. Prolong exposure to X-ray can be harmful. However, the CRT does not emit measurable X-ray if the high voltage is at the high voltage adjustment value only. When high voltage is excessive, then only X-ray is 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.

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8. *Wearing Goggles*

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 and 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.

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.
- 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 TV, Hi-fi or Monitor can easily weight around 15 to30 kilogram. 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.

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12. *Ventilation*

Be sure that your work place has good ventilation. Prolong 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. Prolong 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 Multimeter

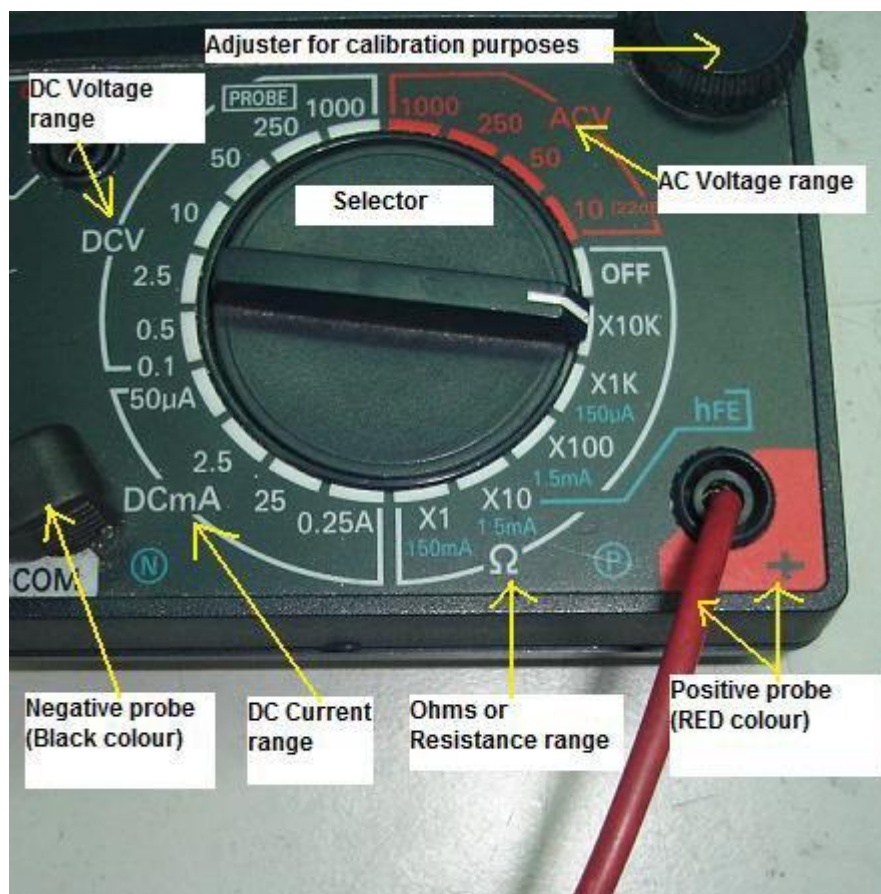


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Multimeters (analogue and digital) are one way in which you can “see “what’s going on in an electrical circuit. Voltmeters, ohmmeters, and ammeter are essential in all electric work. Multimeters can go by many names. Some people call them as “multimeter” or just “meter”, while others refer them as “VOMs” or “multitesters” or even “tester”. They are among the simplest and least expensive pieces of test equipment available that every electronic enthusiast should have.

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 multimeter 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 repairers must know in order to successfully perform basic tests, troubleshooting and repairing.

Meter’s Function and Range



Analogue and digital multimeters have either a rotary selector switch or push buttons to select the appropriate function and range. Some Digital Multimeter (DMMs) are auto ranging; they automatically select the correct range of voltage, resistance, or current

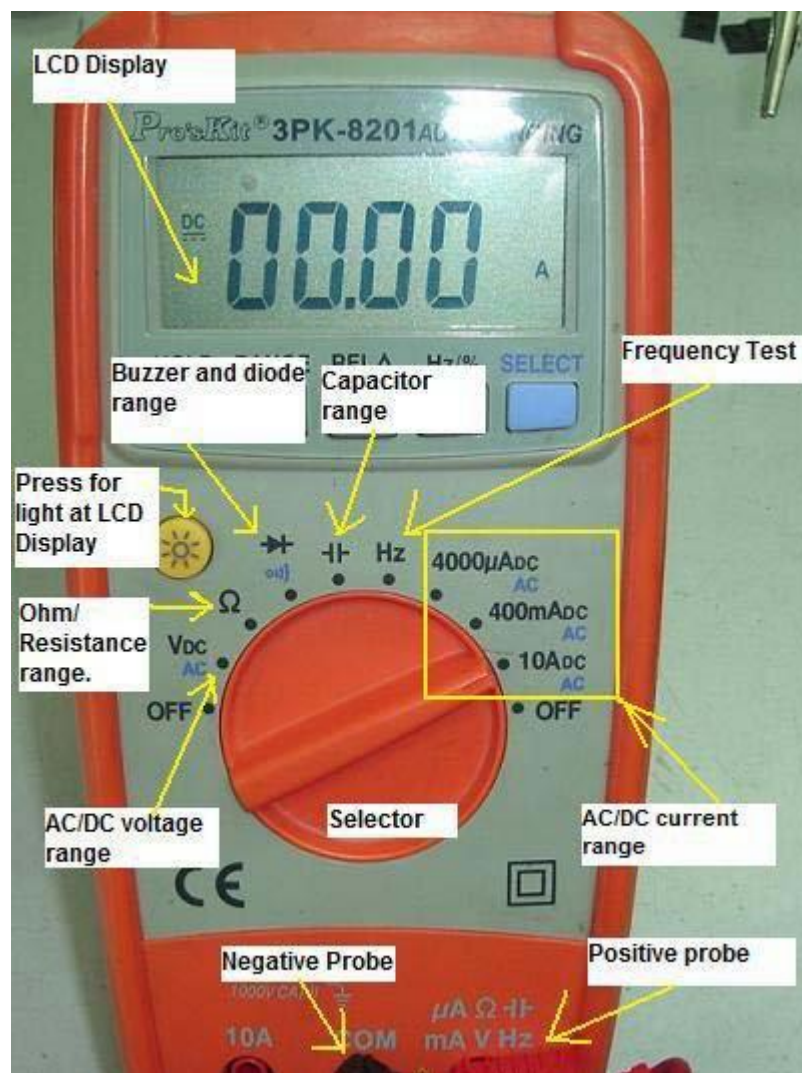
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when doing a test.

However you still need to select the function.

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.



Black test lead plugs into meter terminal marked Common, Com, or \ominus
Red test lead plugs into meter terminal marked \oplus or $V-\Omega-mA$.

Now that you know the very basic 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.

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Precaution While Using Multimeter

Don't give shock or vibration to the multimeter especially analogue meters, which have a delicate meter movement. Sometimes even a slightfall from the repair bench to the floor could cause the digital meter LCD panel to cracked!

Even if after the zero ohm adjuster turned to maximum, the pointer still does not reach zero, replace the batteries. Batteries out of life 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 range may be selected accordingly.

Read and understand the manual book 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 fuse chapter to know more fuses.

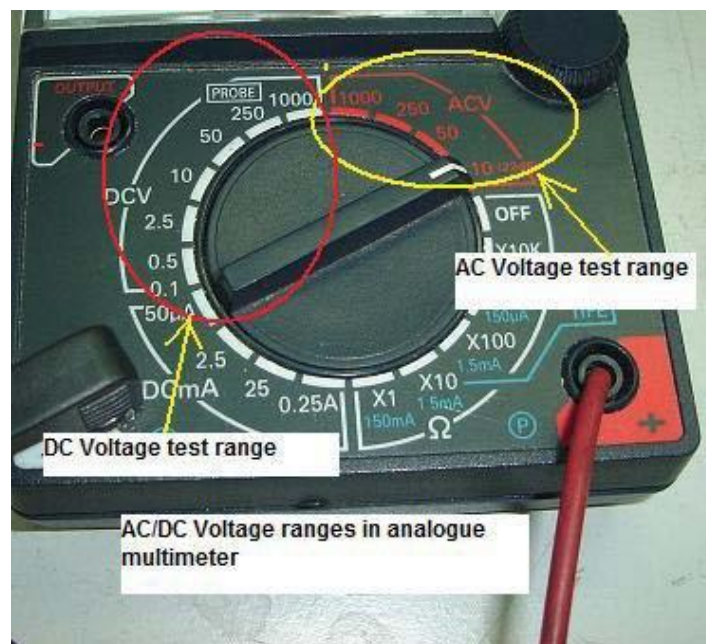
Don't take any resistance (Ohm) measurement in a circuit that has any power applied otherwise it may cause the components inside the meter to blow.

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 or guide you the right way to test electrical circuits.

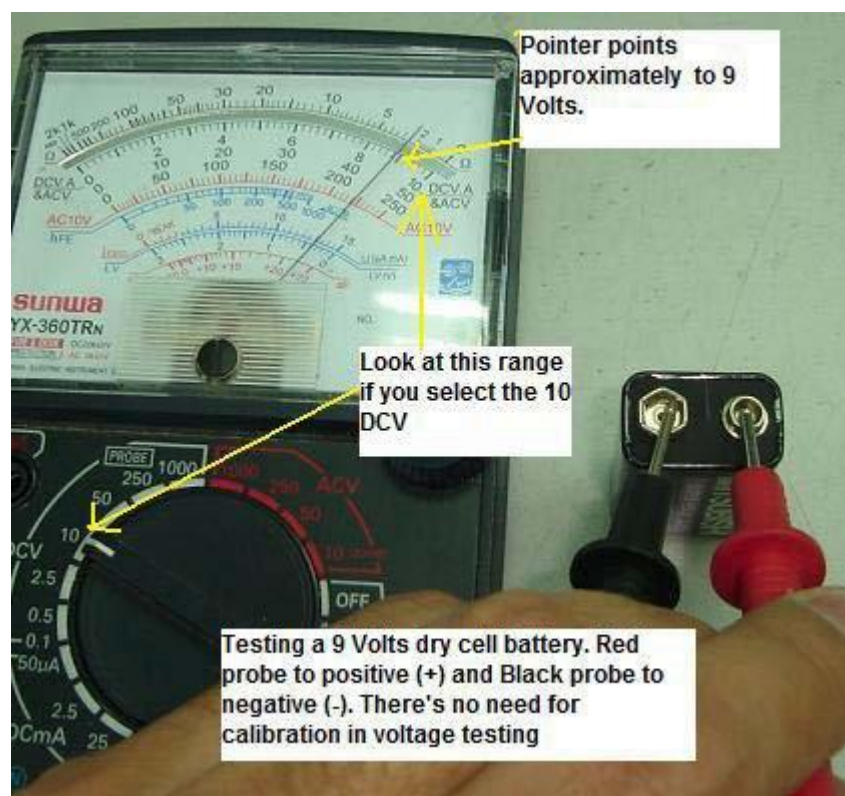
Lastly, there are many differences among various makes of digital and analogue multimeters. Always study the instruction booklet that comes with a particular meter to ensure you are using it properly and safely.

How To Test AC/DC Voltage

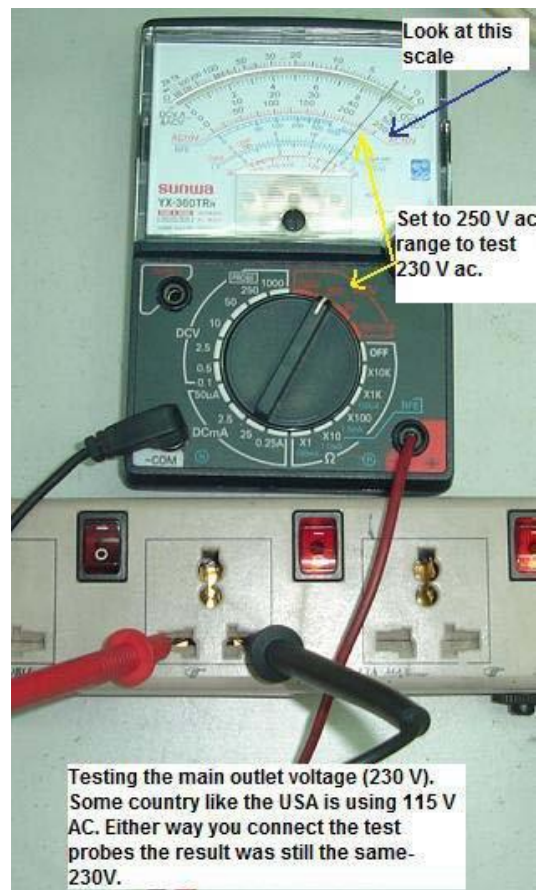


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Analogue multimeters can measure both DC voltages (marked DCV or Vdc) and AC voltages (marked ACV or Vac). It is important to remember that all voltage (either AC or DC) must be measured in parallel with the desired circuit or component. Never interrupt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



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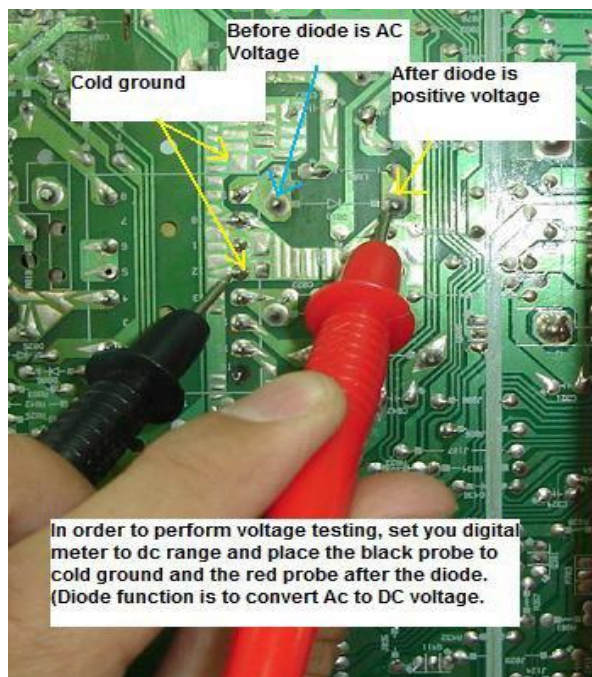
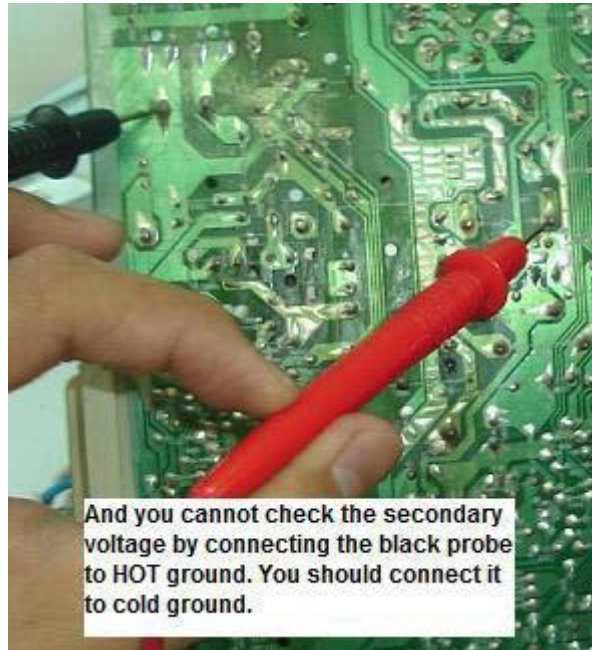
In order to accurately test AC and DC voltage, I only use the digital meter as it shows more precise reading than the analogue meter. Set your multimeter to its appropriate function (DCV or ACV), then select the proper range. Note, an auto ranging digital meter will select its own range. Place your test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



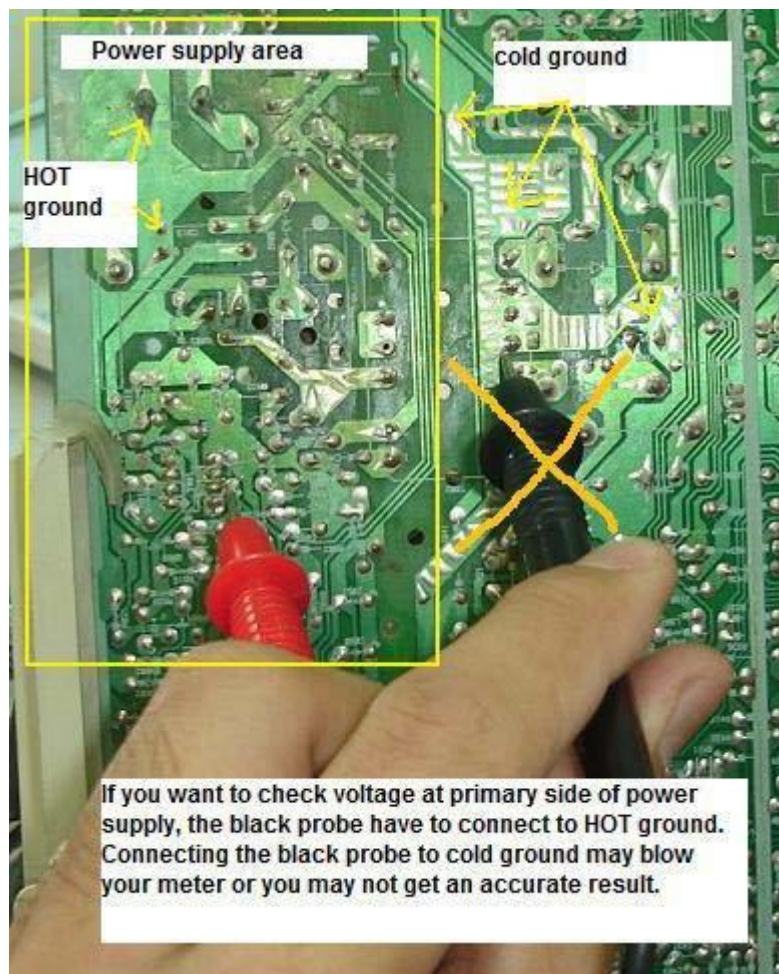
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How to take voltage measurement in electronic equipment

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



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



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 meter do not have the AC current range.**

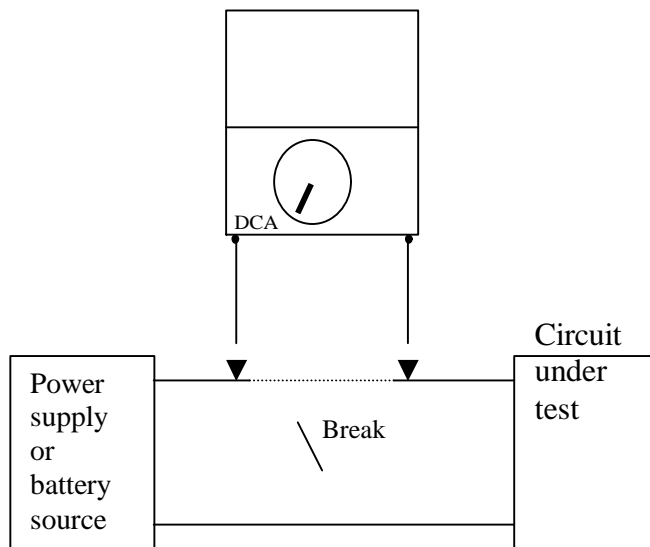
As with voltage measurements, current is measured in a **working circuit with power applied**, but current must be measured in series with the circuit or component under test.

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.

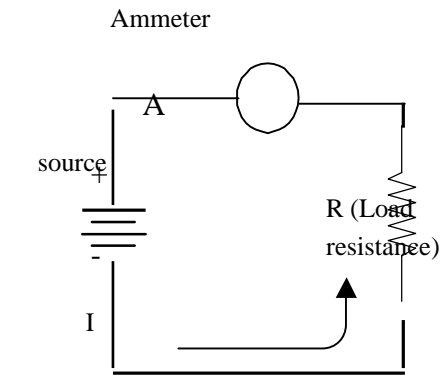
Set your multimeter to the desired function (DCA or ACA) and select the appropriate range. If you are unsure about proper range, set the meter to its largest range. Make sure that the meter can handle the amount of current you are expecting.

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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.

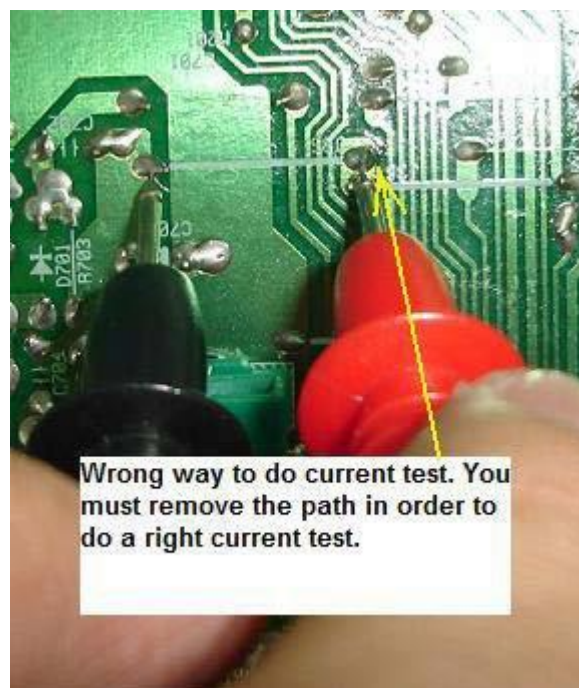


a) Measuring power supply current

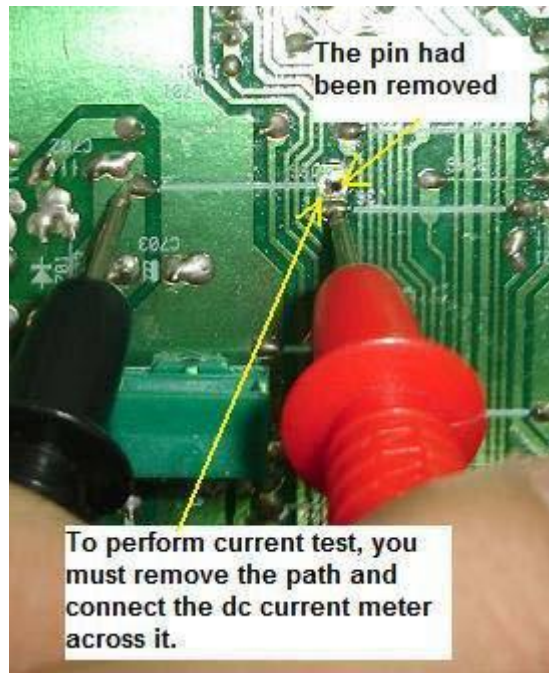


b) Simplified circuit

Measuring Currents



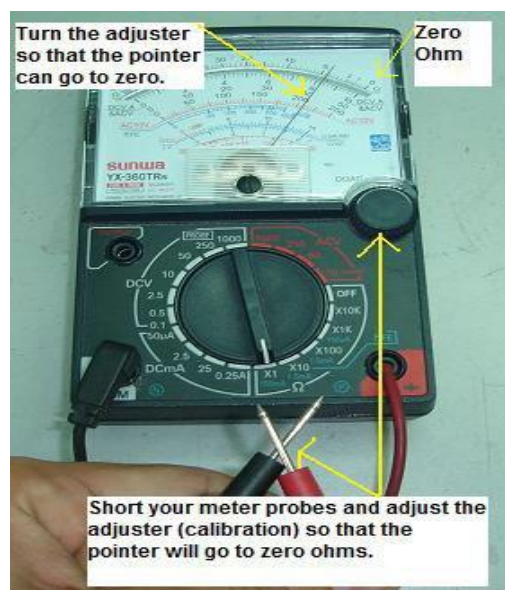
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Caution!

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.

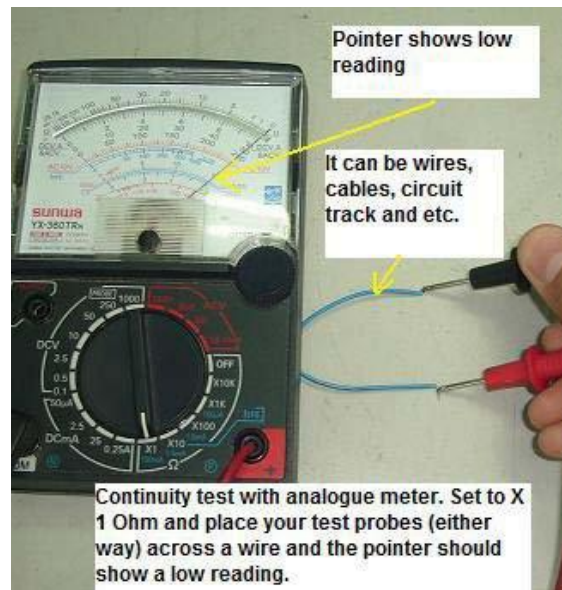
Continuity Test



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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, the pointer will go to zero ohm. If it is not zero, adjust the zero adjuster for bringing the pointer to exact 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 have the buzzer sound to test the connection. If you heard the buzzer sound while measuring the wire or connection, this means that the connection or internal wire is good.

Resistance and Resistors

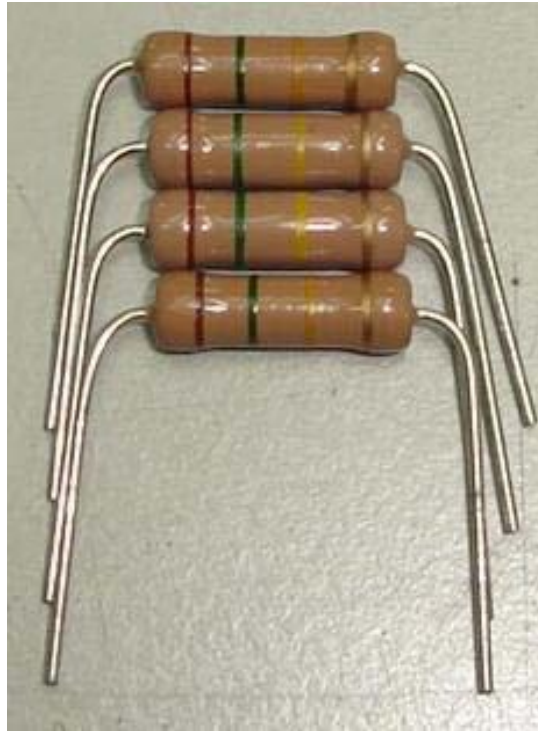
The word resistance means opposition to some action. In electricity resistance means the opposition to the flow of current. The resistance is measured in ohm (Ω). Resistance is also expressed in kilo-ohms, milli-ohms etc. With $1000\Omega = 1$ kilo ohms, $1000000\Omega = 1$ mega ohms. The symbol of resistance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

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Symbol of a resistor.

It is noted by a letter R.

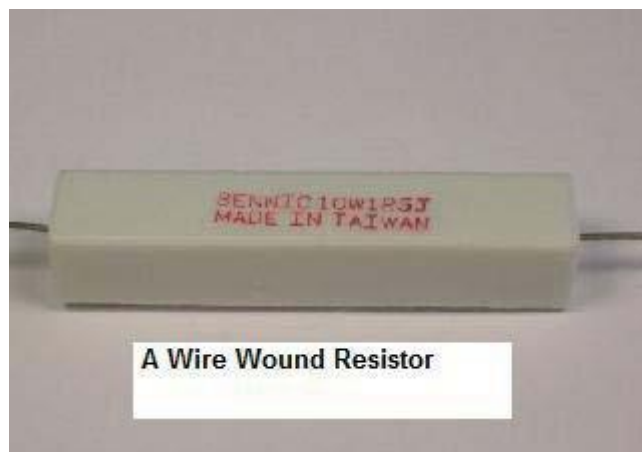
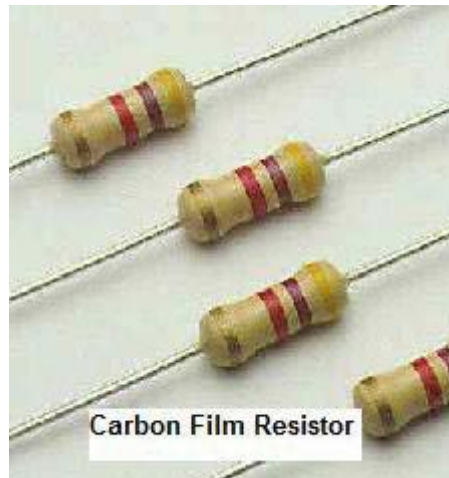


The main two characteristics of a resistor are its resistance R in ohms and its power rating in watts, W . Resistors are available in a very wide range of R values from a fraction of an ohm to many mega ohms. The power rating may be as high as several hundred watts or as low as $1/8$ watt.

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 Resistor

- 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.

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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.

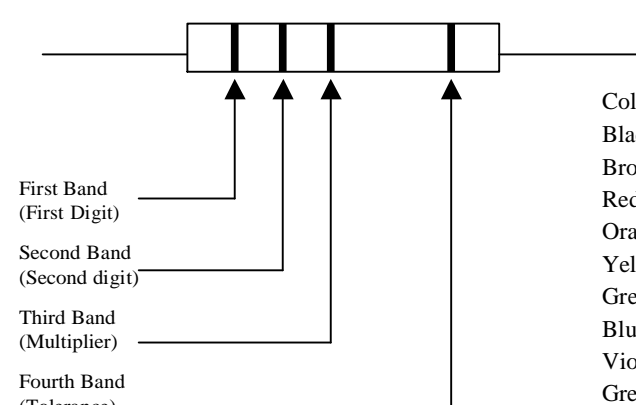
 <p>First Band (First Digit)</p> <p>Second Band (Second digit)</p> <p>Third Band (Multiplier)</p> <p>Fourth Band (Tolerance)</p>	Colour	Digit	Multiplier	Tolerance
	Black	0	1	-
	Brown	1	10	-
	Red	2	100	-
	Orange	3	1000	-
	Yellow	4	10000	-
	Green	5	100000	-
	Blue	6	1000000	-
	Violet	7	10000000	-
	Grey	8	-	-
	White	9	-	-
	Gold	-	0.1	$\pm 5\%$
	Silver	-	0.01	$\pm 10\%$
	No colour	-	-	$\pm 20\%$

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

First Band
(First Digit)

Second Band
(Second digit)

Third Band
(Third digit)

Fourth Band
(Multiplier)

Fifth Band
(Tolerance)

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

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

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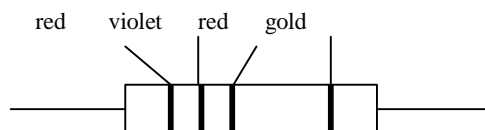
Colors	Numbers
	Black= 0
	Brown= 1
	Red= 2
	Orange= 3
	Yellow= 4
	Green= 5
	Blue= 6
	Violet= 7
	Grey= 8
	White= 9
	Gold= 5%
	Silver= 10%

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:

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

Therefore, this R value is 2700Ω with tolerance ±5%

The resistor tolerance means the amount by which the actual R can be different from

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the colour-coded value.

For instance, the alone resistor value 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 percent of 2700 is $0.05 \times 2700 = 135$

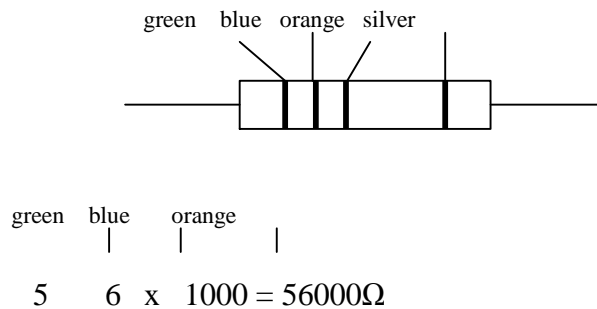
For +5 percent, the value is

$$2700 + 135 = 2835 \Omega$$

For -5 percent, the value is

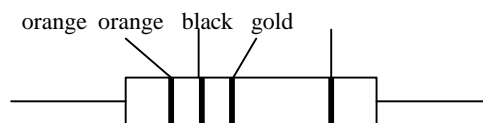
$$2700 - 135 = 2565 \Omega$$

Example 2:



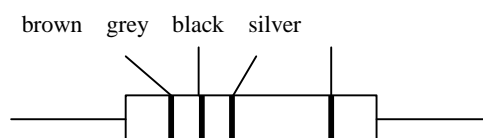
Therefore, the R value is 56000Ω or $56k\Omega$ with tolerance $\pm 10\%$. (Silver is 10%-please refer back to table 1)

Example 3:



The 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:

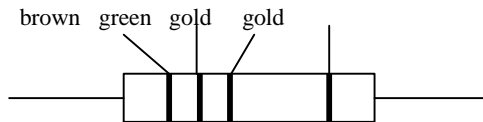


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$$18 \times 1 = 18\Omega$$

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

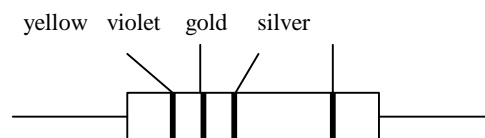
Example 5:



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

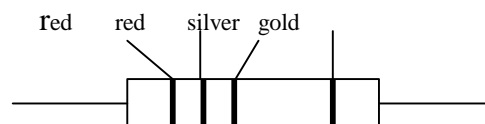
$$\begin{array}{ccccccc} \text{brown} & \text{green} & & \text{gold} & & \text{gold} & \\ | & | & & | & & | & \\ 1 & 5 & \times & 0.1 & = & 1.5\Omega & \pm 5\% \end{array}$$

Example 6:



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

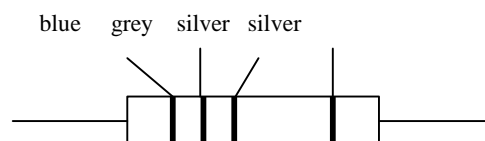
Example 7:



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

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

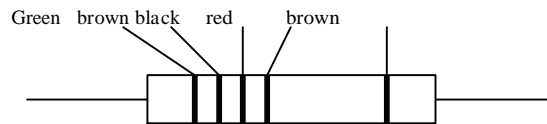
Example 8:



$$68 \times 0.01 = 0.68\Omega + 10\%$$

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Example 9:

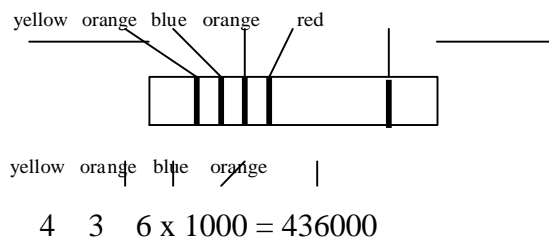


The first band is green for 5; the next band is brown for 1 and the black for 0. The red multiplier in the fourth band means add two zeroes to 510. The result can be illustrated as follows:

$$510 \times 100 = 51000$$

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 $\pm 2\%$.

Testing Resistor

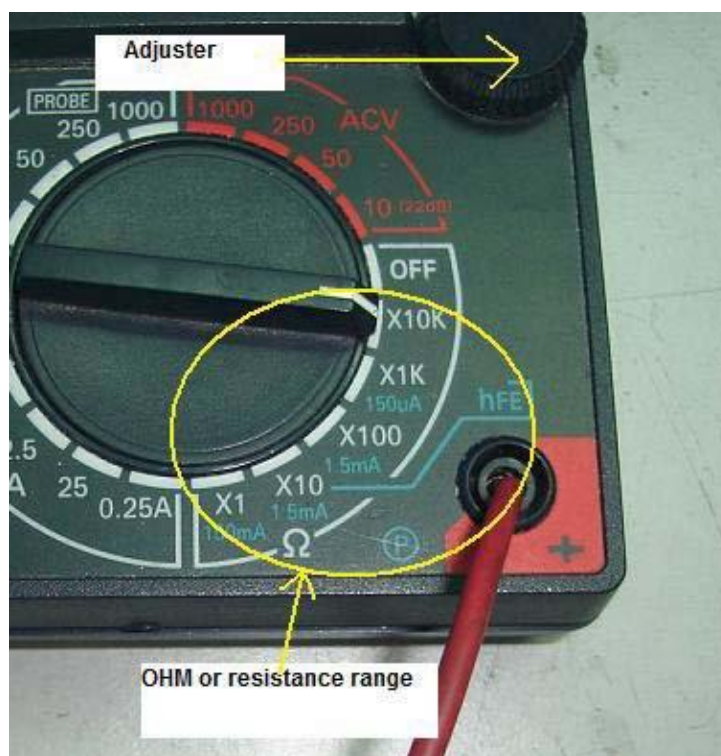
There are two ways of testing resistor; using an analogue or digital multimeter. Normally if a resistor fails they will either increase in value or open up at all (open circuit). You can check the resistor resistance by selecting the ohmmeter range in the analogue and digital multimeter. If the resistor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



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Using Analogue Meter to Test Resistor



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

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calculation it is a 47 Ohms resistor with 5 % tolerance.

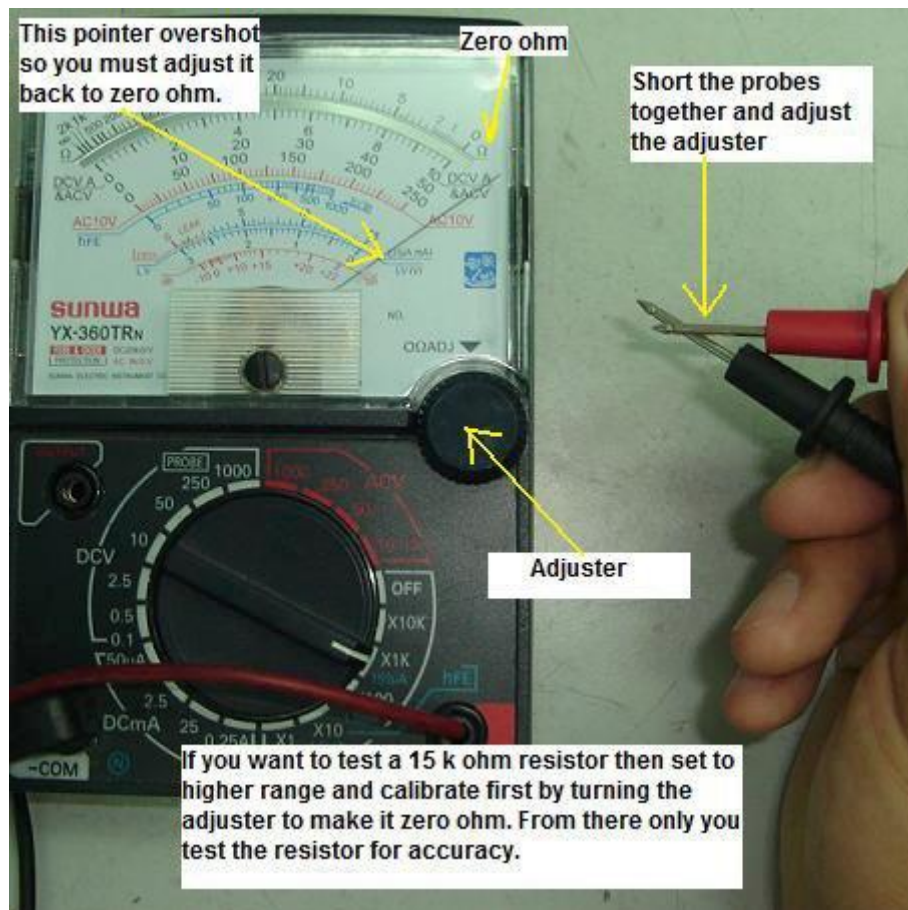
Now set your analogue meter to X1 Ohm, shorting the probes and calibrate the pointer so that it will stay at zero Ohm. Place your meter probes to the two points of the resistor as shown in the photo. It doesn't matter which probes to which two points because resistor does not have polarity (positive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



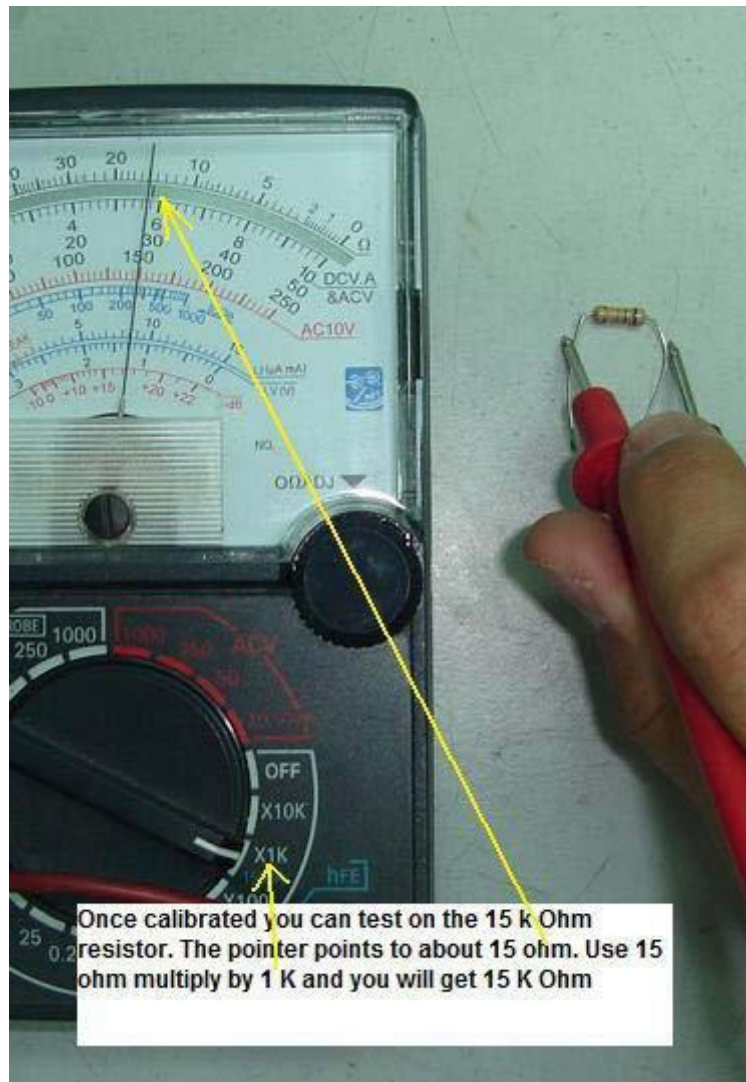
If you get more than 47 ohm say 150 ohm, this mean that the resistor has gone up in resistance and need replacement. If it doesn't show any reaction after putting the probes across the two points of the resistor, thenwe can conclude that the resistor has open circuit (bad). Remember to press a little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

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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.

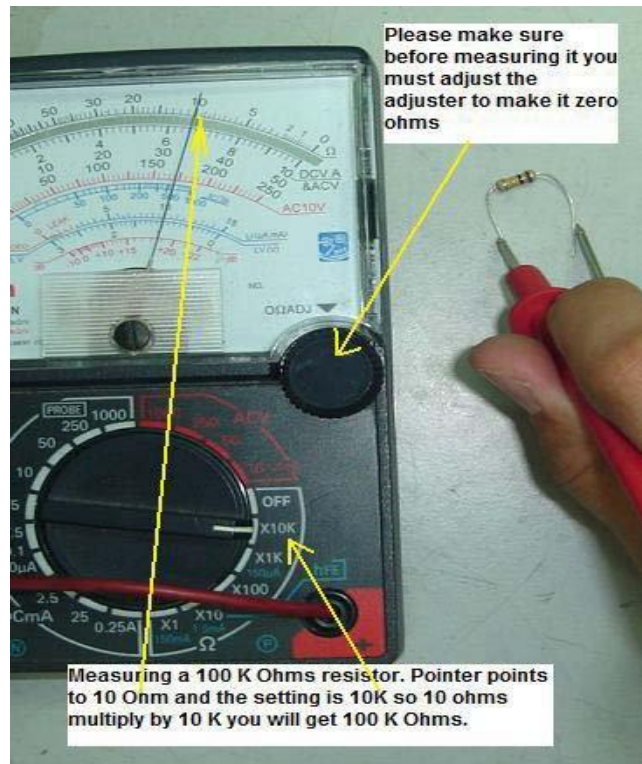


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Check the result to see if the pointer point to near or exact 15 K Ohm. If the resistor has 5% tolerance the pointer should point between the values of 14.25K to 15.75K Ohm. Any value you get that is not between the tolerance ranges, you should replace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

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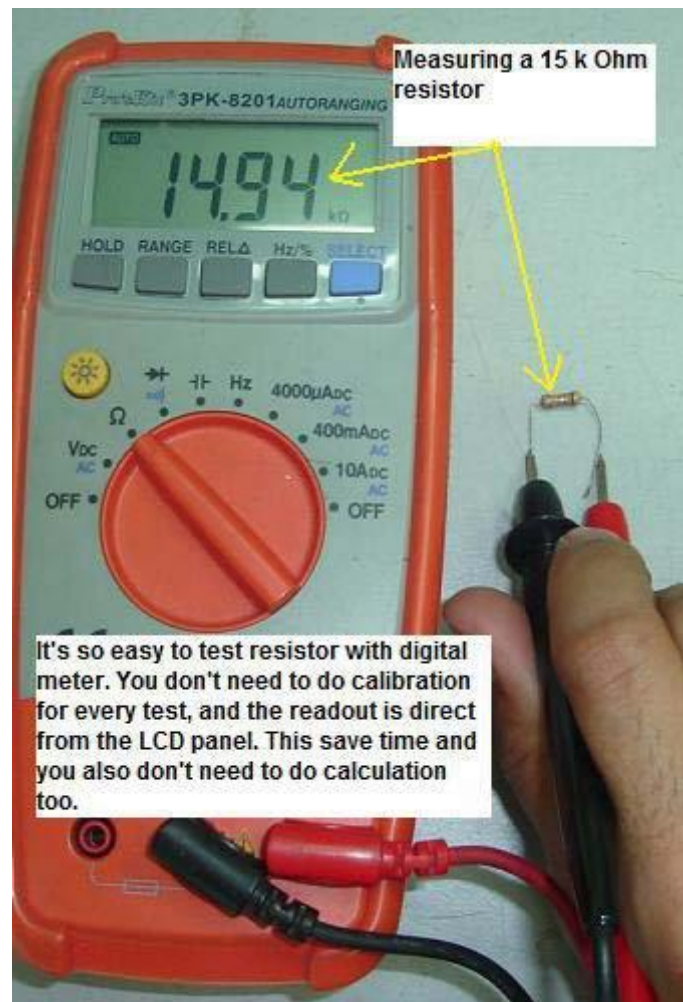
In order to check a 100 K ohm resistor you have to select the X 10 K Ohm range. Follow the procedure explained above and you should be able to get the measurement.

Using Digital Meter to Test Resistor



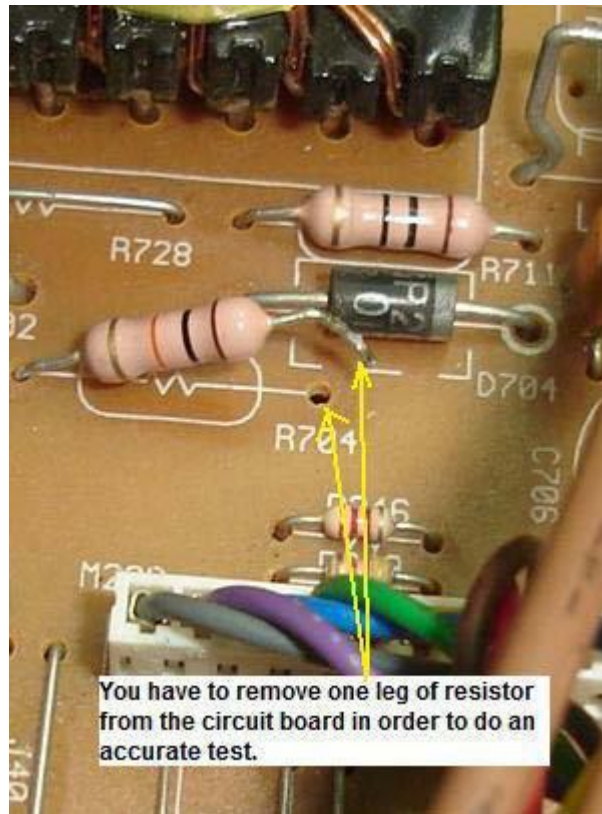
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Personally I do not use analogue meter to test resistor as the result shown on the meter panel only makes you have to guess what the resistor value is. You may ask yourself, is it 47 ohm or 47.5 ohm or even 47.7 ohm? By using digital meter the LCD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



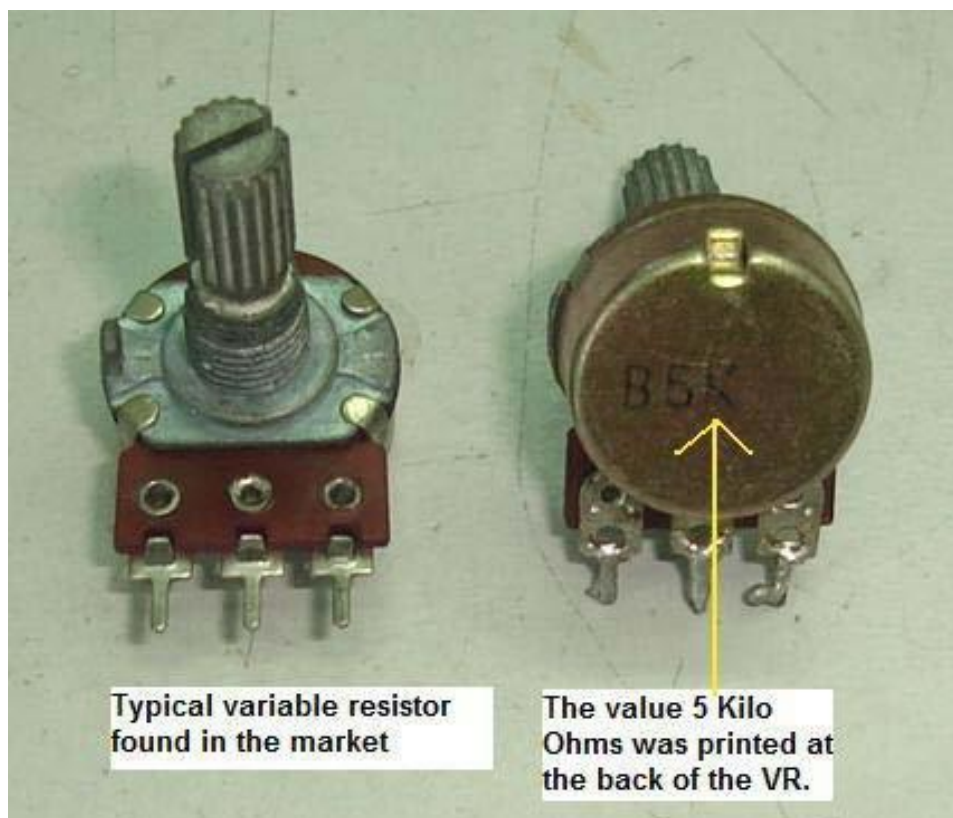
First, select the Ohm range and place your test probes across the two points of the resistor as shown in the photo. **Digital meter does not need any calibration compare to analogue meter** where you have to adjust the adjuster to make it zero Ohm before you begin to do measurement. The result shown at the LCD display of the digital meter is the exact resistance value of the resistor.

Digital meter really removed all the guess work! Not only that, many digital meter is auto range that's mean what ever value of resistor you want to check it will automatically prompt you the result without having you to adjust to a suitable range in order to test the resistor. This saves time and accurate too!



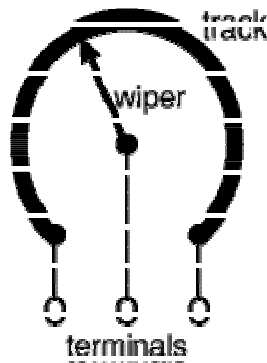
If you are a beginner I strongly recommend that you remove all the resistors leg (I mean only one leg) and test it with your **digital meter**. Hope with this secrets, checking resistor should not be a problem to you anymore.

Testing Variable Resistor

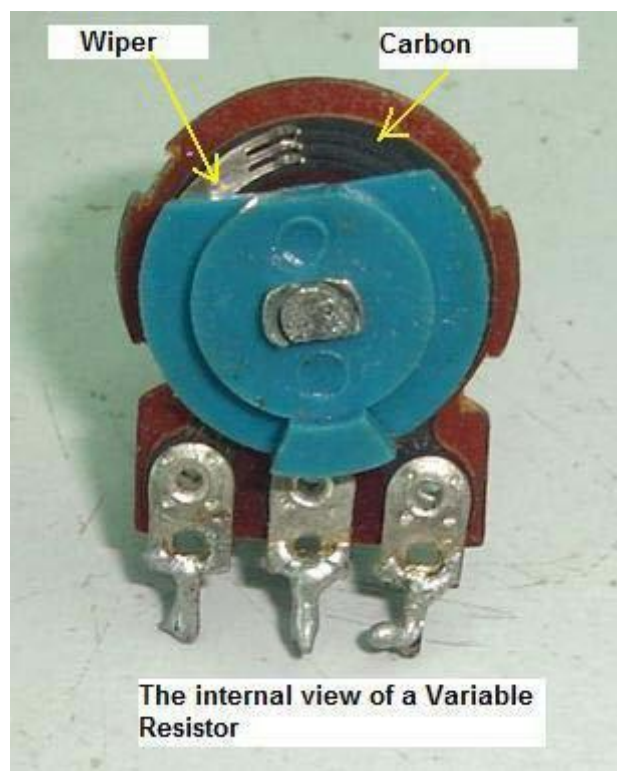


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Variable resistors also called potentiometers or rheostats, employ a movable metal blade resting along a ring of resistive film. You can change the resistance by turning the knob.



Internal view of Variable resistor



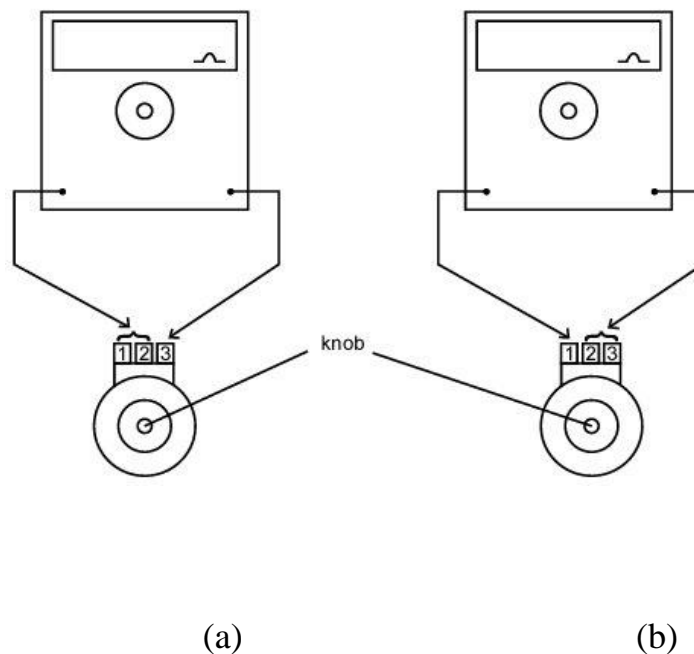
Failure among variable resistors usually takes form of intermittent connections between the wiper blade and resistive film. Sometimes it also can be burnt due to overload of currents and develop an open circuit. Remember that film slowly wears away as the wiper moves back and forth across it. After sometimes the overall film can wear away that which the wiper cannot make a good contact at certain points. The poor contact can cause all types of erratic or intermittent operation.

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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.

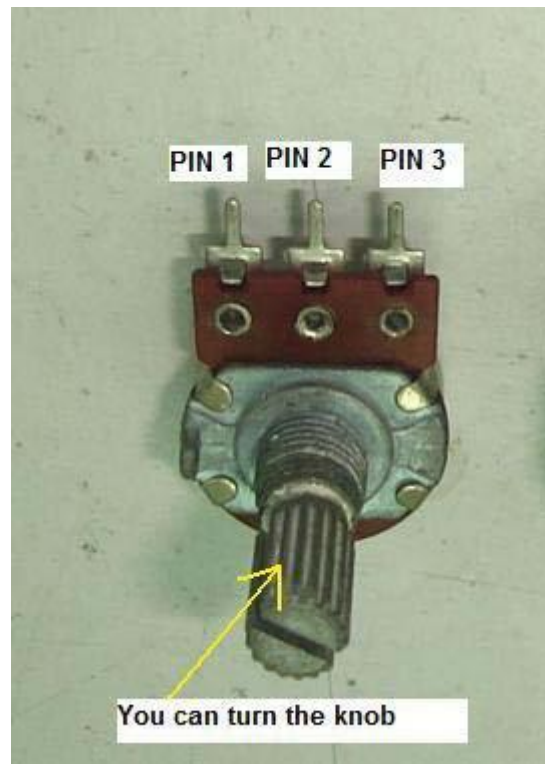


You can check the variable resistor resistance with analogue multimeter set to ohm's range as shown in Fig 1 below.



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Fig 1: Testing a variable resistor with a analogue multimeter



If you measure pin 1 and 3 you will get the variable resistor Ohms reading. Now use either one probe to touch pin 1 and 2 (Fig a) of variable resistor while the other probe touching pin 3. Turn the knob clockwise and anti-clockwise to see the changing of resistance. The meter should show a smooth reading. If the reading is erratic, the pointer will moved intermittently. You can service or replace the variable resistor. Say if the variable resistor is $10\text{k}\Omega$ the ohms, 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 anti-clockwise.

Now, using the probe that touches pin 3 short to pin 2 (Fig b) 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:

$$12 = 100 = 100 \text{ ohm}$$

$$13 = 1000 = 1000 \text{ ohm} = 1 \text{ Kilo Ohm}$$

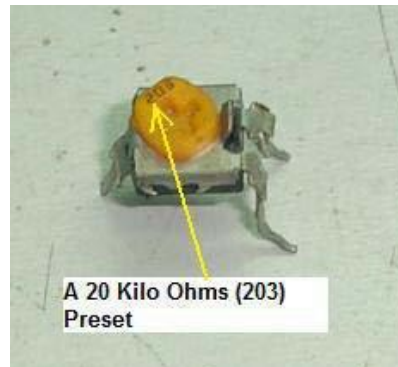
$$54 = 50000 = 50000 \text{ ohm} = 50 \text{ Kilo Ohm}$$

$$102 = 10 \text{ } 00 = 1000 \text{ ohm} = 1 \text{ Kilo Ohm}$$

$$203 = 20 \text{ } 000 = 20000 \text{ ohm} = 20 \text{ Kilo Ohm}$$

$$523 = 52 \text{ } 000 = 52000 \text{ ohm} = 52 \text{ Kilo Ohm}$$

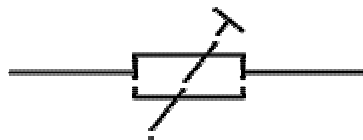
Testing Preset



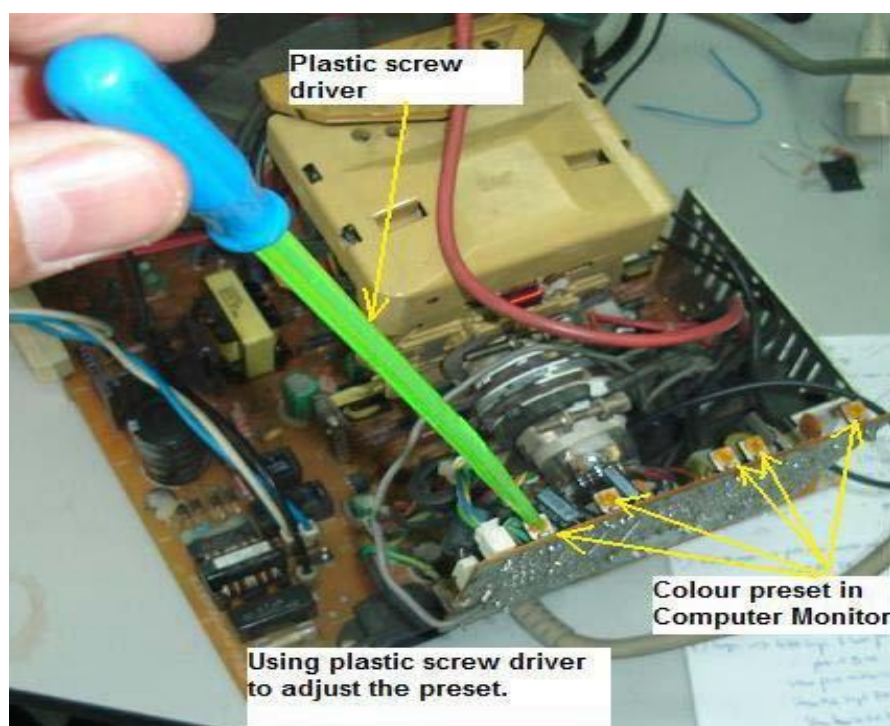
These are miniature versions of the standard variable resistor. They are designed to be mounted directly onto the circuit board and tuned only when the circuit is built. For example to set the colours of Computer Monitor by turning the preset in the Cathode Ray Tube (CRT) board.

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 preset is exactly the same procedure as when you are testing the variable resistor.**



Preset symbol



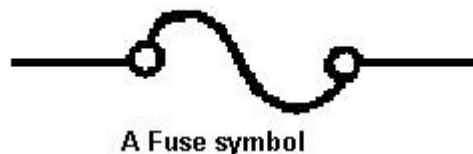
Testing Fuse



Typical example of fuses

It's very easy on how to test a fuse. 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 open in the circuit stops current to flow. In electronic equipment, most fuses are cylindrical glass or ceramic type with a metal cap at each end! The current rating and voltage also can be seen in one of the two metal end caps.



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 many electronic equipment, but the smaller 5 X 20mm has become more common. Fuses are available with current ratings from 1/500 Ampere to hundreds of amperes. Fuse is label as "F" in circuit board.

Before showing you on 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 to flow to

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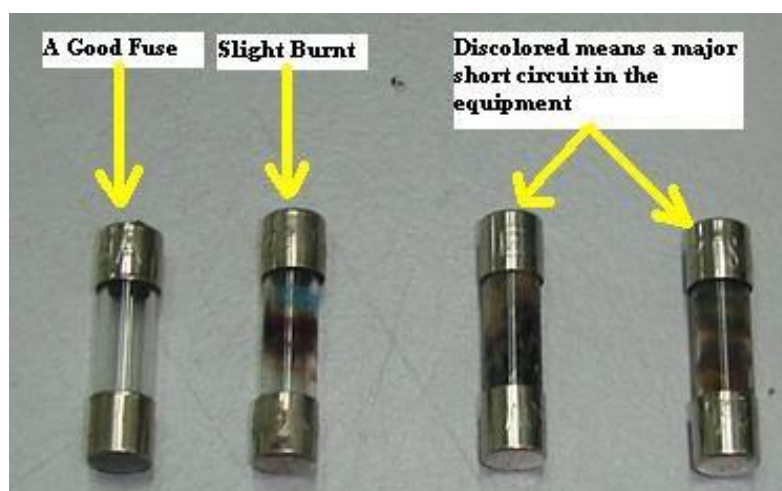
an electronic circuit-it is designed to protect equipment and save electronic components from being damaged and also stop overheating, which could cause a fire. Sometimes though there were lightning strike on an equipment, you will be surprised that only fuse were damaged and not the power supply section or components.



There are two basic types of fuses which is 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 multimeter, 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 made mistake by accidentally touching the probe to the testing points where it should not be touch! 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 damage 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 switch on such as when you switch on a Computer Monitor.

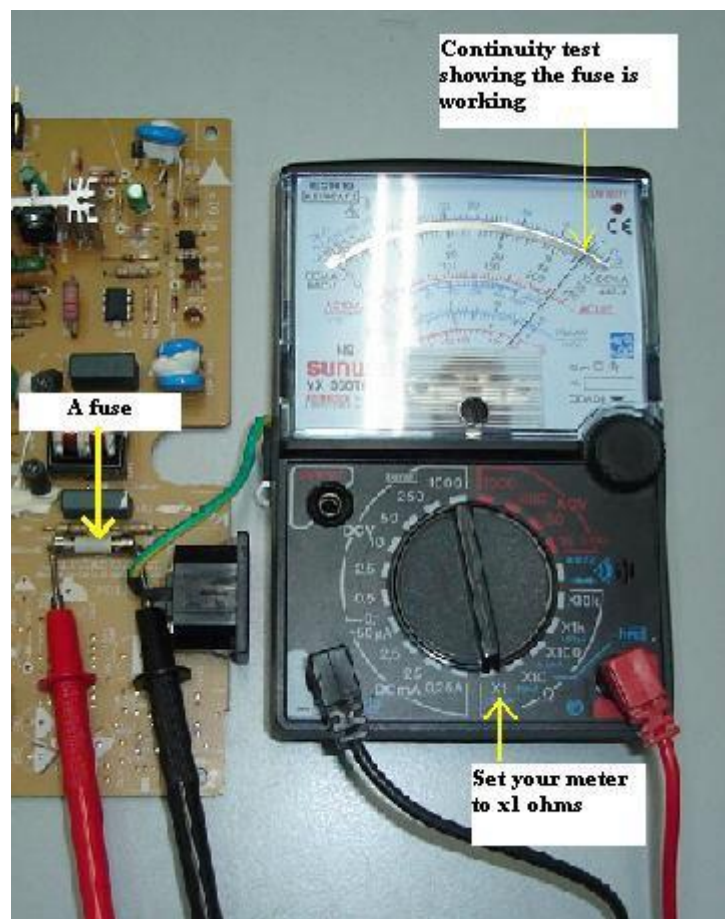


A blown fuse can indicate how severe the short circuit is.

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There'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 to you in other article.

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



Measuring a fuse on board with an analogue multimeter

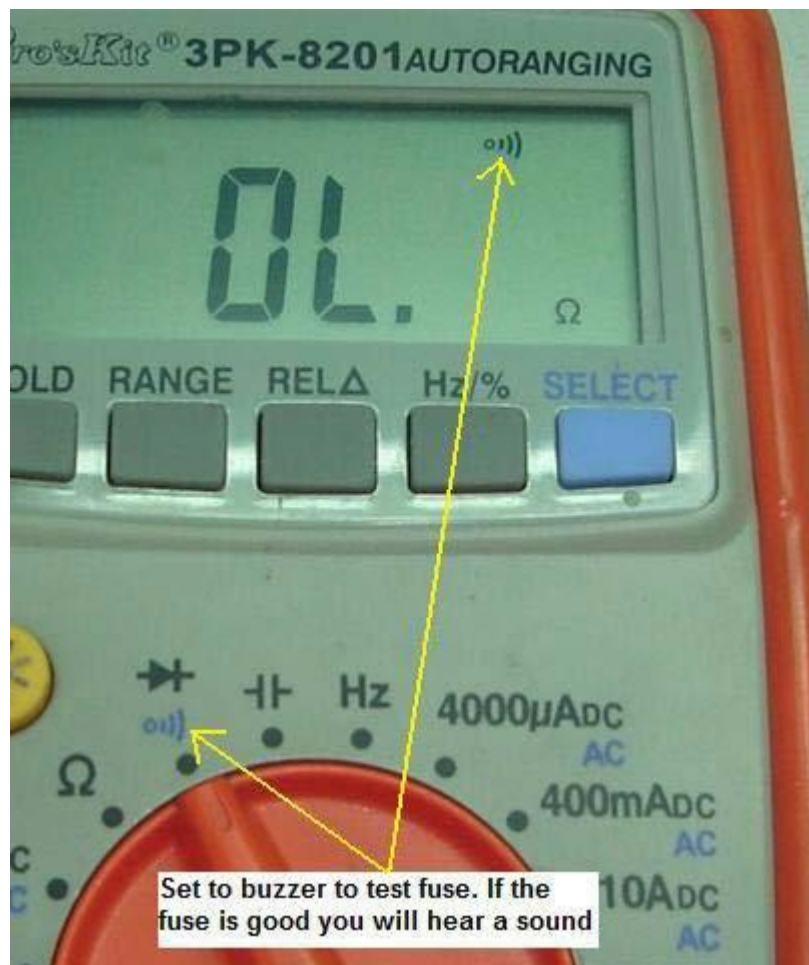
The common type and current rating of a fuse in a Monitor and Power Supply is slow blow 3.15A to 5 Ampere 250 Volts. Here is the part on how to test a fuse. Switch off the power of the equipment, remove the casing and you will see a fuse

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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 showed 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

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

Testing fuse 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.**

Testing Coil/Inductor



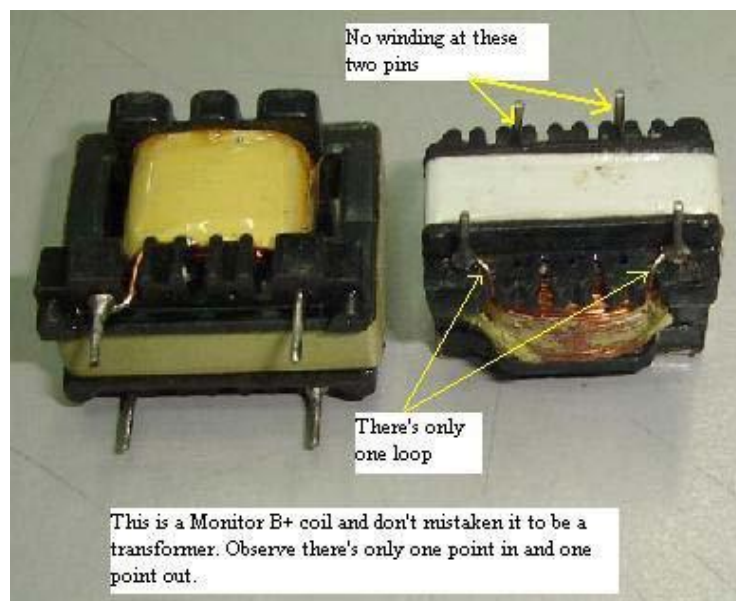
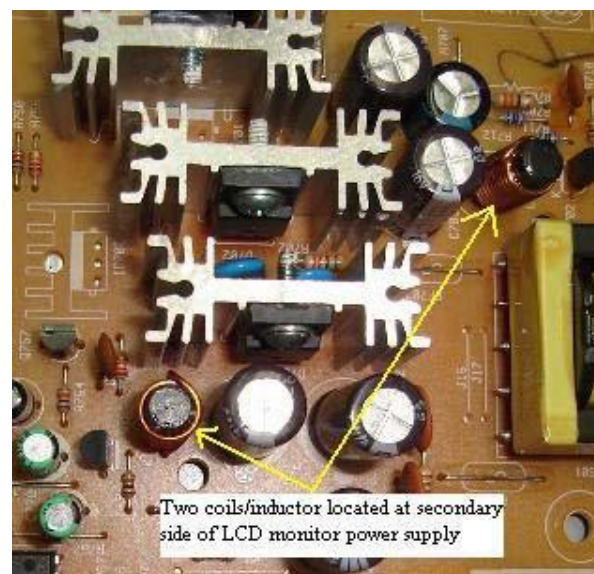
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Testing coil is very easy compares to checking three leads components such as SCR, FET and etc. In general, a coil consists of many turns or wire wrapped around a common core. The core could be made of iron or even air. It is label as “L” on circuit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



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Coil or inductor can be test using an analogue, inductance or a coil meter such as the dick smith fly back tester. A coil that is small in size, **I would usually just test it with 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 proved that the coil winding is okay. Small coils seldom spoilt because it have less winding compares to big coils where it could have many turns of winding and chances for it to go shorted (between windings) is very high.



Testing bigger coil or inductor 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 experienced using an inductance meter to check coils to see if it good or bad is not recommended because a shorted coil (shorted between winding) could have a good inductance value and you would miss out checking a bad coil.

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

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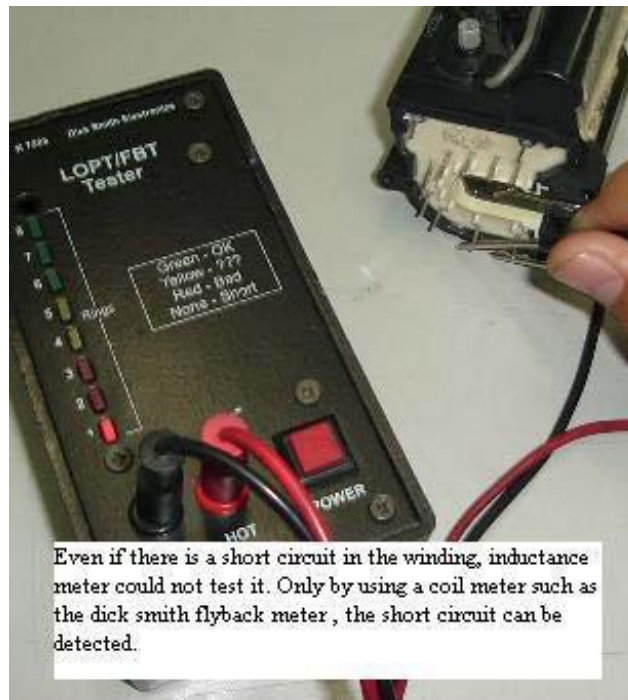


Now is the time to share my true case example- a computer dealer send me a monitor for repair with power blink symptom. Usually I do not straight away repair the monitor but I would first use the fly back tester to scan all the major coils (switch mode transformer, flyback transformer, B+ coil and horizontal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

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

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By using a flyback tester or coil tester for testing coil, it has helped me to locate many shorted coils in switch mode power transformer primary winding, B+ coil, flyback transformer primary winding and horizontal deflection coil. The flyback meter can even be used to check the condition of ballast in fluorescent lamp too!



Using Flyback Tester To Test Flyback Transformer

As for the flyback tester, you can either buy or make one yourself.

Recently I found that the **main supplier temporarily stopped production** on this dick smith flyback tester. However you can make one yourself by visiting this website:

Testing Switches



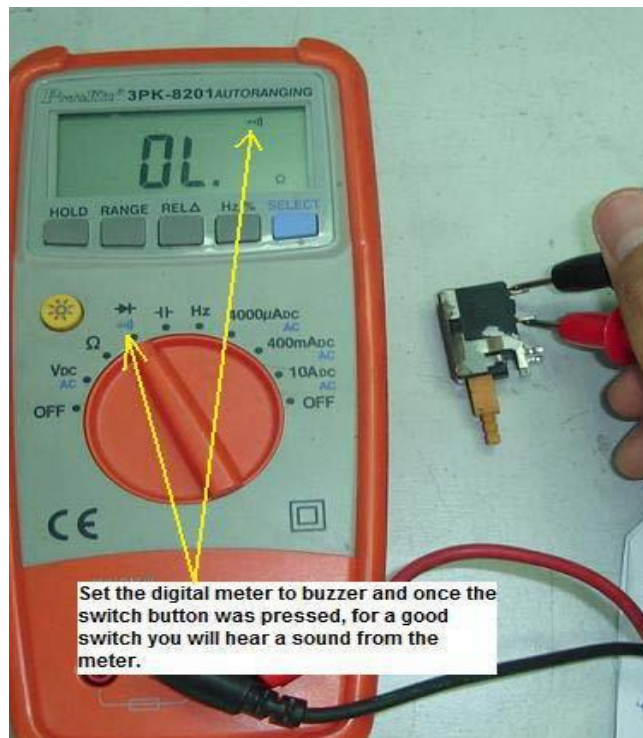
A common Switch symbol





There are many type of switches in the market, some are on/off mechanical switch while some are micro 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 X 1 ohm and place your meter test probes to either leg (pin). Now press the switch and you should see the meter's pointer shows zero ohm.

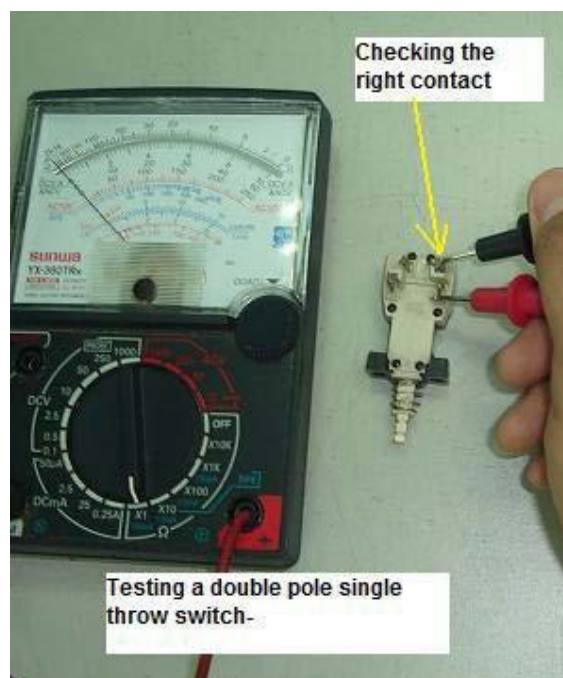
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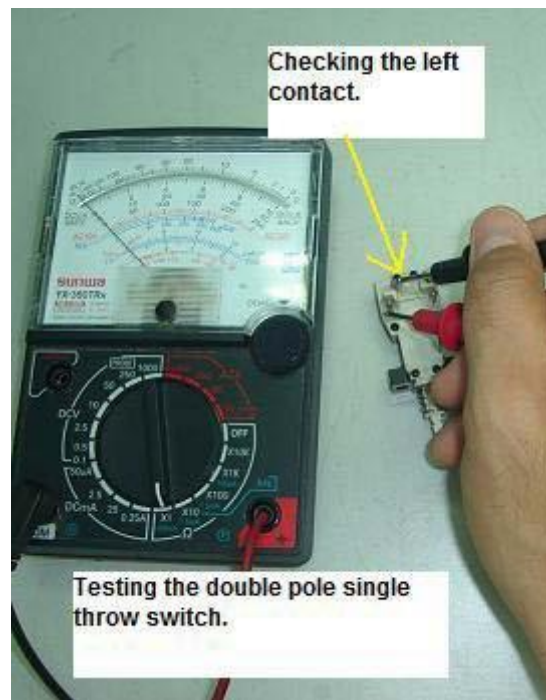
If after pressing the switch and nothing happen, suspect a bad switch.

Similarly, you can use a digital meter set to buzzer sound to test a switch.

A good switch with a good contact should make the digital meter to produce the buzzer sound. No sound means the switch is defective.

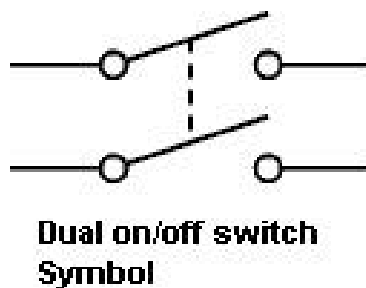


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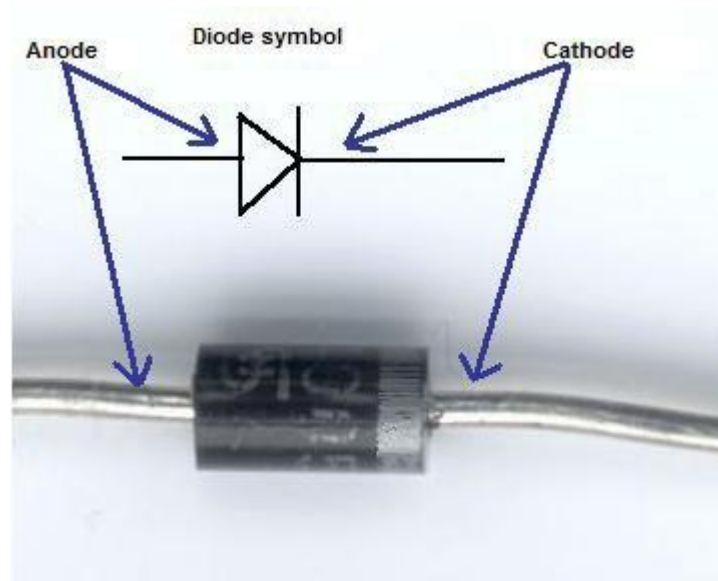


Some switches have dual on/off contact and is called double pole single throw switch (DPST). A DPST switch is often used to switch mains electricity because it can isolate both the live and neutral connections.

Testing the DPST switch is relatively simple, test the contact at one time before you test on 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.



Testing Diode



When comes to testing diode, you need a special method to test it. 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 that it is good and you will definitely waste your precious time.

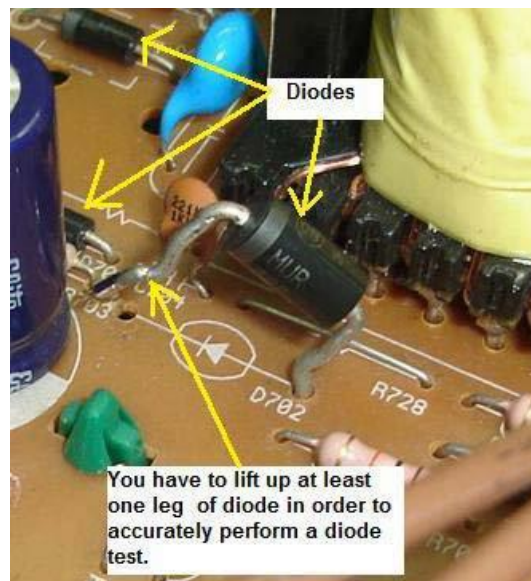
Diode is label as “D” in circuit board. Usually a rectifier diode can fail in one of the four ways.

It can become open circuit, short circuit, leaky and breakdown 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 breakdown in full operating voltage. Diode breakdown when under full load means the diode test okay with your meters but failed when a high voltage flows through it.

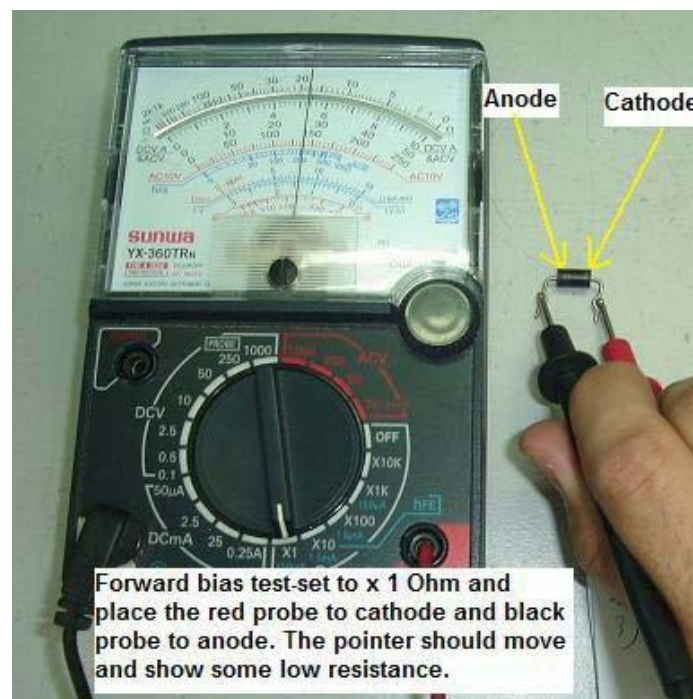
From my experienced in the electronic troubleshooting field, I discovered that testing diode using an analogue multimeter is more accurate or precise than using a digital multimeter. I could explain to you in details why I preferred analogue meter. I do not know about you because I really came across quite a number of diodes where it tested ok with digital multimeter but failed when check with analogue multimeter. The first step on **how to test a diode** accurately is to remove one of the diode lead.

You can't always be certain if a diode is good or bad if you perform in-circuit test, because of back circuits (parallel connection) through other components.

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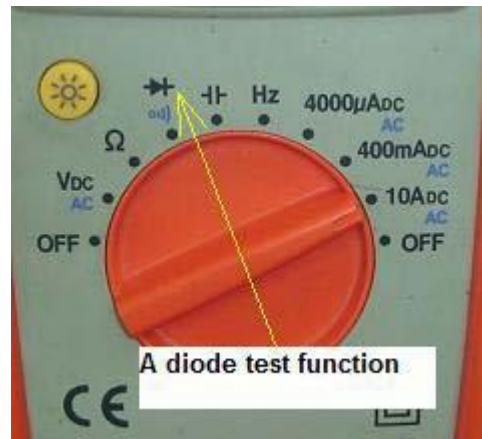
To be absolutely sure, you will need to lift, or disconnect, one diode lead from the circuit to avoid back circuits. Unless you are very sure about the board you are checking. Sometimes I do found bad diodes when checking it on board. Your experienced will tell you when to test a diode on-board or off-board.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



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

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



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

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



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You now have to select your meter to x10Kohm range to test the diode again. The output voltage of x10k ohms is about 12 Volt (remember the 9volt battery in your meter-1.5 volt + 1.5 volt + 9 volt = 12 volt). Again the diode under test should show only one reading. This is exception to Schottky diode where it has two readings but not shorted reading. I will explain how to test Schottky diode 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 breakdown 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 Ampere. Refer to semiconductor data book for the exact specification. **Always replace a diode with the same or higher rating than the original specification.**

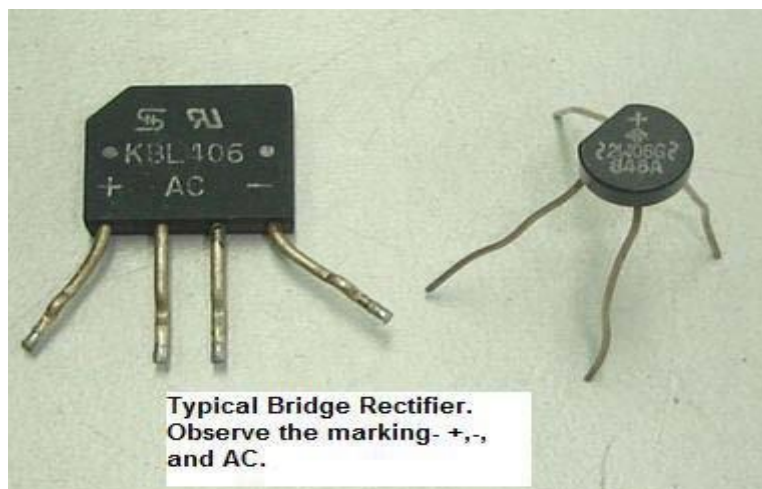
Caution: Be certain that power is removed from any circuit before performing any of the following diode checks, otherwise meter or circuit damage could result. Conclusion- **In order to correctly testing diode you need to use analogue multimeter and set the range to x1 ohm and x10 kilo ohms range.** With this tips I'm sure you will have the confident to check any diodes that comes on your way.

Testing Bridge Rectifier

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 terminal marked (+) and (-).



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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, I_F . It is label as “BR” in electronic circuit.

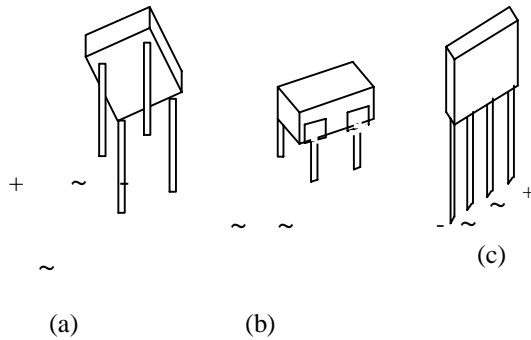


Fig 1: Some examples of bridge rectifier

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

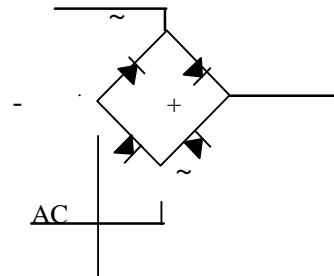


Fig 2: Schematic for diodes wired as a full-wave bridge rectifier

Testing Bridge Rectifier

Set your analogue meter to X 10 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 won't show two similar low resistance reading 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 symbol in bridge rectifier) and should have only one reading even though you had reversed the probes.

Similarly when 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 when you found one of the diode shorted in the bridge rectifier, you have to replace the whole package. Replace it with the same or higher voltage and ampere rating!



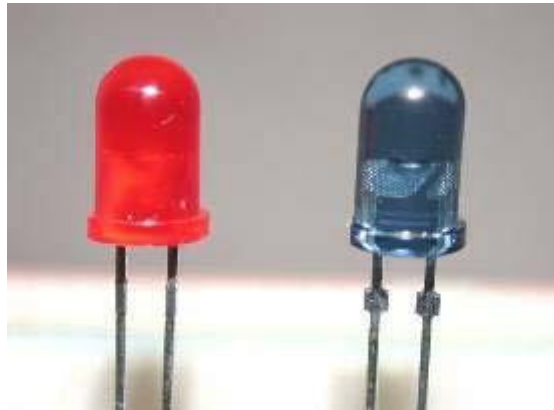
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Testing Light Emitting Diode (LED)



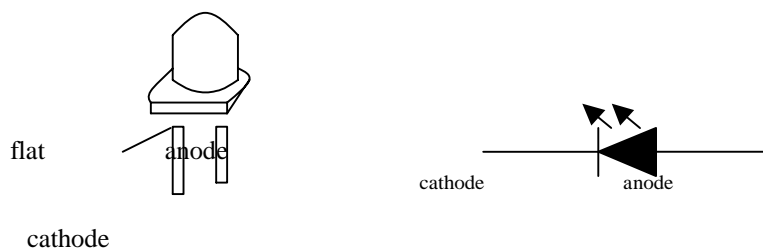
Typical LED

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 equipments, such as monitors, TV, 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. Light can be visible, such as red, green, yellow and white. It is label as “LED” in 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.

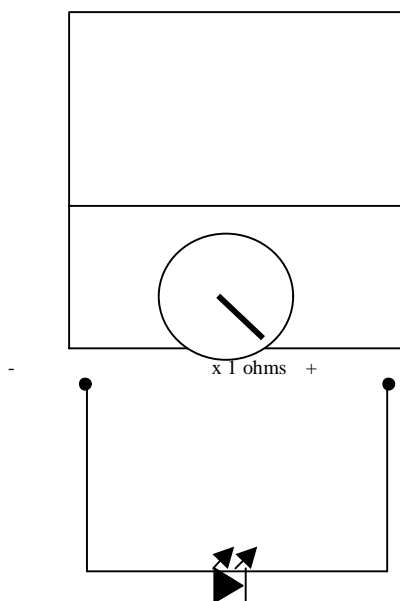
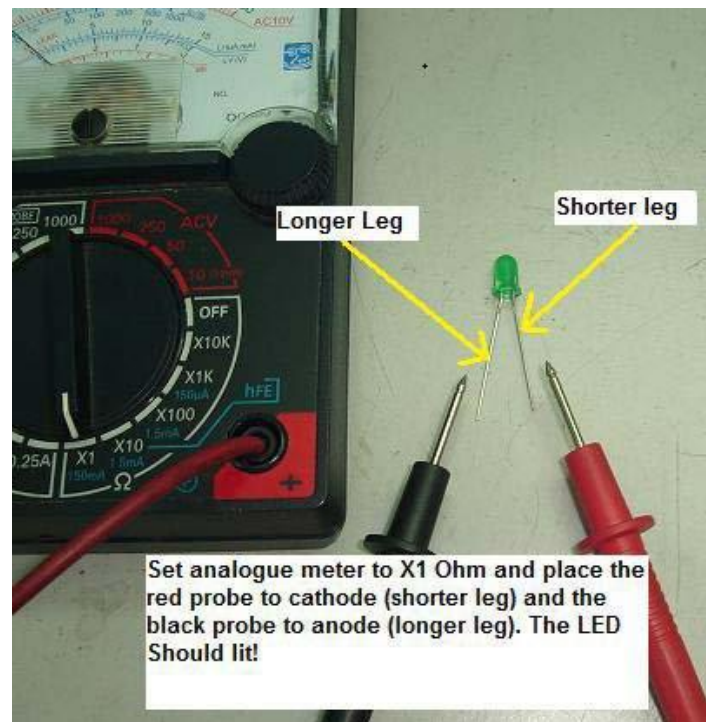


General appearance and Symbol for a light emitting diode.

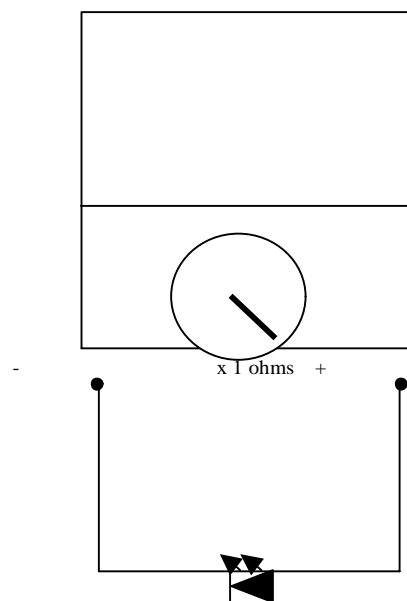
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Testing LED

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 LED does not emit light when it is forward bias then it has developed an open circuit and should be replaced. Power must be off when check the LED.



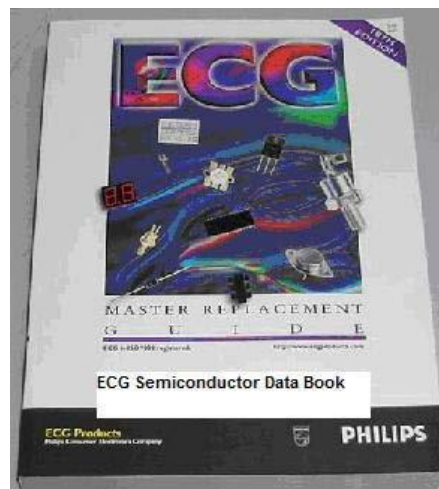
a. LED emits light when it is forward bias.



b. LED does not emit light when it is reversed bias.

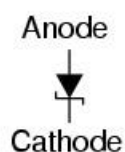
Testing LED with analogue meter

Testing Zener Diode



Method of testing zener diode is totally different from testing diode. 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 your favourite data book such as the **Philip ECG semiconductor masterreplacement guide** then it is easy to check with your meter to see if it leak, open or shorted.

Zener diode



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

2.4=2.4 Volt zener diode

2V4=2.4 Volt

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10= 10 Volt

10V= 10 Volt

BZX85C18=18 Volt 1 watt zener diode (you have to refer to Philips ECG

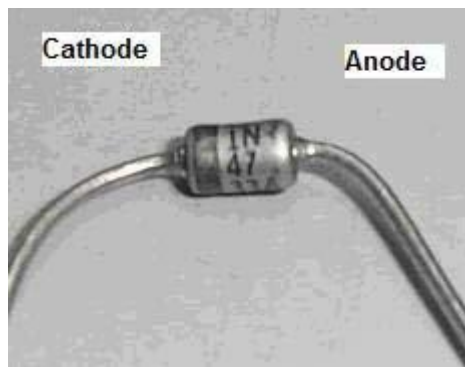
Semiconductors Transistor Cross Reference Guide)

BZY85C18=18 Volt 1/2 watt zener diode

Note: There is also part number such as BZVXXXXX where you have to find it from Philips ECG SEMICONDUCTOR BOOK.

1N4746= 18 Volt 1 watt zener diode.

Sometimes a normal signal glass type diode you may think 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 test with an analogue meter set to times 10K ohm range. But these readings are not 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 towards the 0 ohms scale, 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. These are the characteristics of a good working zener

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diode and don't think that themeter shows two reading means the zener diode is faulty.

If you get two reading when you measure a normal diode, then the diode is shorted.

As I mentioned above, testing zener diode is totally different from checking a normal diode.

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

If the result shows two readings then the zener diode is confirmed to be shorted or have developed a leakage. Start measuring zener diode taken out from your component's rack or from scraped electronic board, compare a good zener diode and a shorted one and see for yourself.

Write it down in your book what are the results that you get when comparing and checking a good and a bad zener diode. It would not take you a long time to become familiar in testing a zener diode accurately.

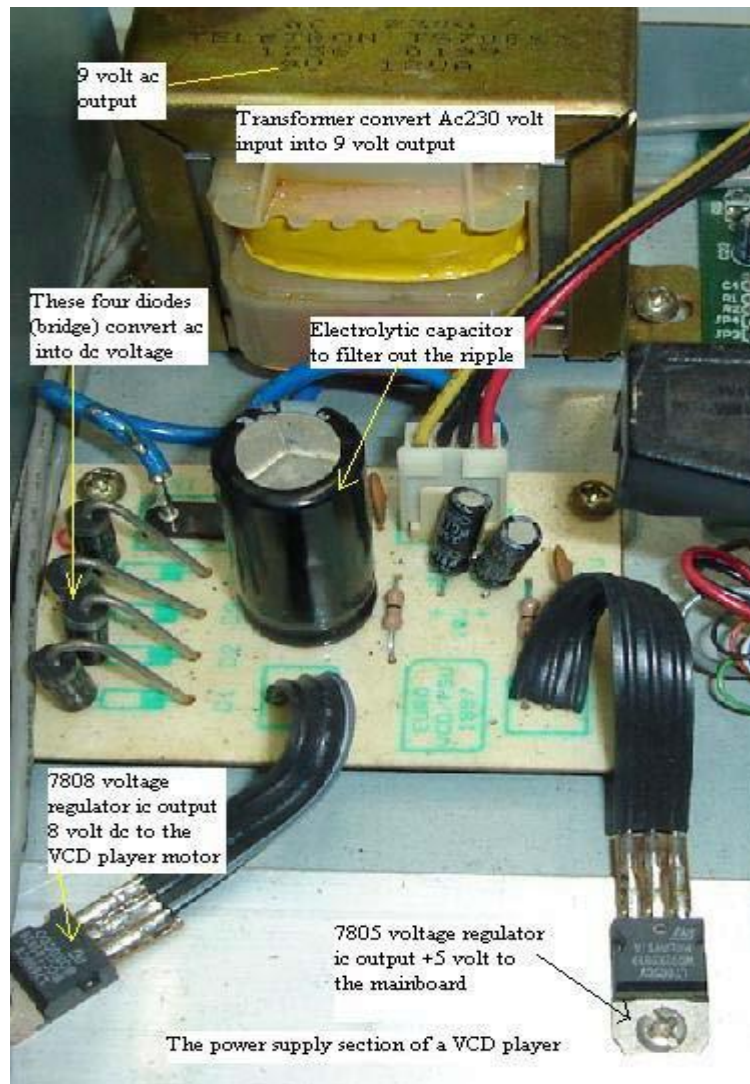
One more tip, replace only a zener diode with the same or higher wattage.

If possible use the exact voltage and watt if you want the equipment that you repair to last longer.



Use analogue multimeter to test zener diode

Testing Linear Transformer



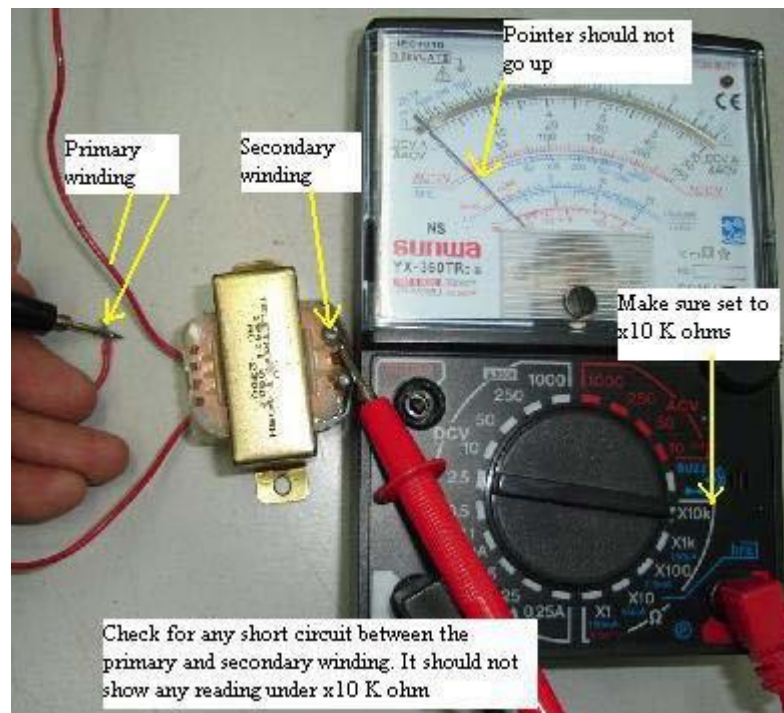
Testing transformer is very easy if you follow the procedure explained in this book. Generally there are two types of transformer in the market i.e. the linear type and the switch mode power transformer. In this page I'm only explain on how to test the linear transformer. I will explain about the switch 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. Transformer is label as "T" in circuit board.

There are three types of linear transformer:-

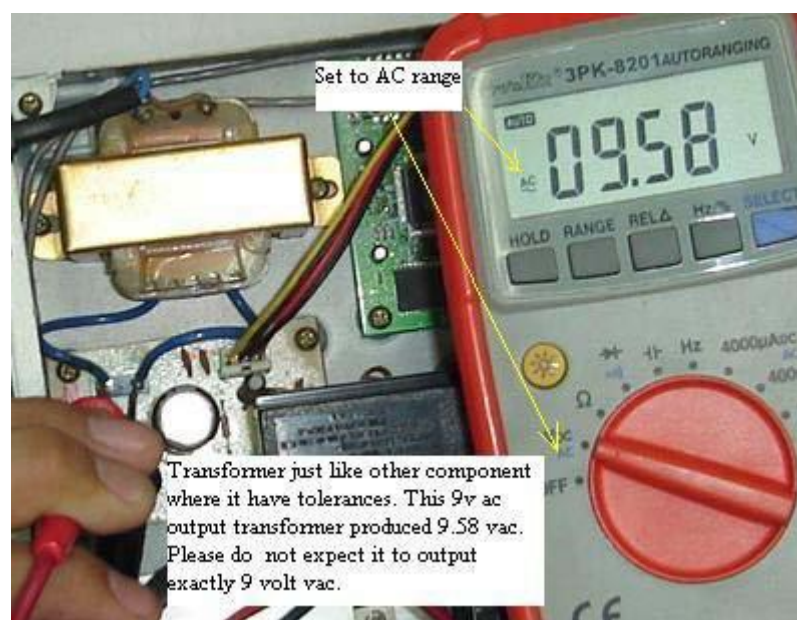
- 1) Step up transformer-to increase the output voltage. Typical example is 240v ac input with a 480 volt ac output (high voltage).

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- 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-produce 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 a step up transformers as well as step down transformer. The output voltages are then converted into DC voltages with the help of diodes. I would not go too details into transformer theory as this page touch on the topic of how to test a linear transformer. There are three ways or techniques on how to test a transformer:



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Switch “ON” the equipment and measure the input and output voltage of the transformer with either an analogue or digital meter. If there are no voltage or lower voltage then it suppose to be, the transformer need replacement. **I personally liked this method because you are testing the transformer under full operating voltage which is very accurate.**

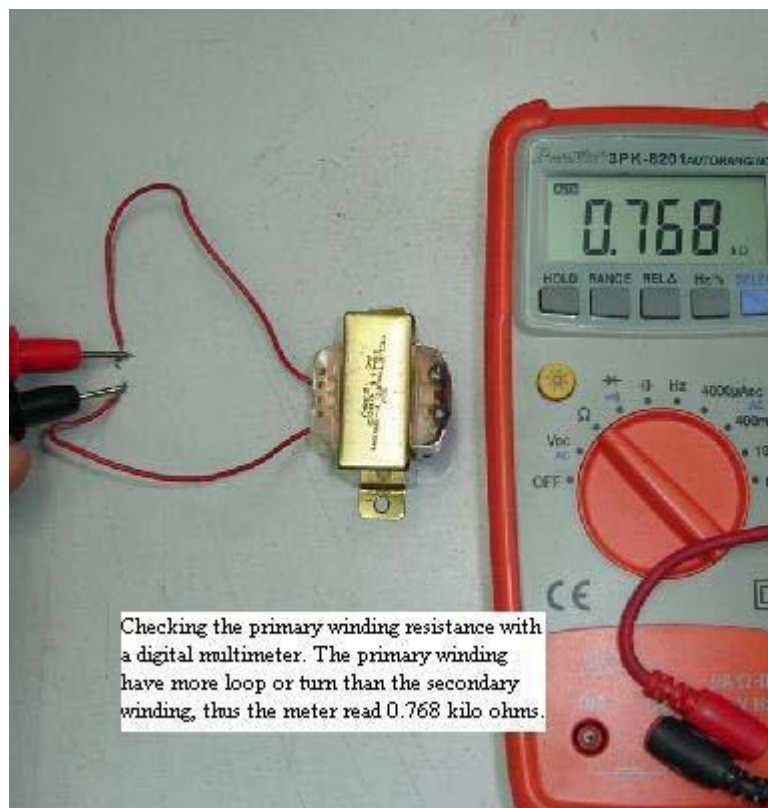
The disadvantage is that you must be very careful when checking it especially when the power is ‘on’. Make sure you have someone to guide you or else you can try the second method.



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

The disadvantage is checking the resistance for ohms reading is not as accurate as when you perform a ringing test mentioned on 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 developed a short circuit, it will usually produced a bad smell and the transformer gets very hot on its core or casing.

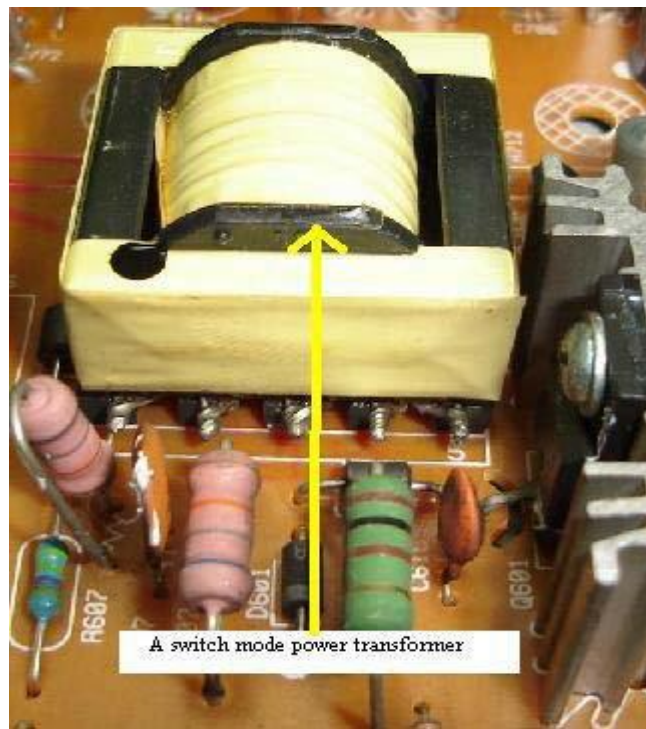


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Perform a ringing test with a ringer tester like using the dick smith coil tester. Checking the ohms resistance or continuity on a linear transformer is not accurate as compared when using a ringer tester. However there is still one disadvantage which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

Conclusion- The first method (voltage testing) is the best choice to test linear transformer accurately, but first you must know how transformer work and get an experienced technician's 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 and you may get confused. Lastly, checking switch mode power transformer is different from testing linear transformer. I will cover on how to test a switch mode transformer in next chapter.



A Switch Mode Power Transformer

Testing Switch Mode Power Transformer



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Switch Mode Power Transformer (SMPT) are used in switch mode power supplies in electronic equipment such as Computer Monitor, TV, DVD and etc. The function of SMPT is to convert the AC wave to some other value, lower or higher. The input is called primary winding while the outputs are secondary windings.

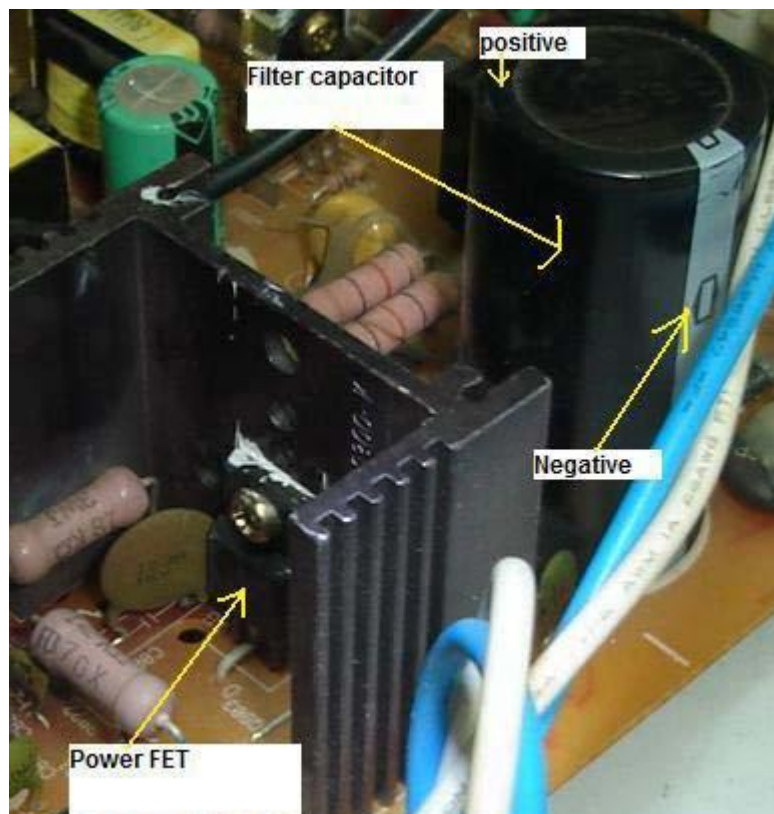


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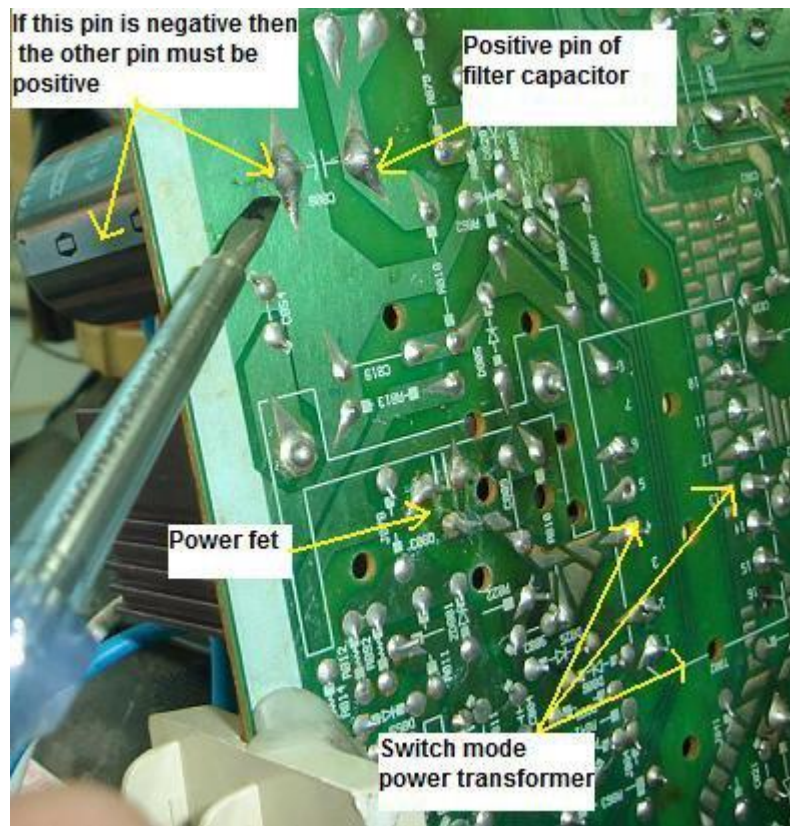
Switch mode power transformer rarely breakdown and if it breakdown it will usually cause power section components to blow or totally blow up the main fuse and trip the ELCB (Earth Leakage Circuit Breaker). If a SMPT failed, normally it was the primary winding shorted. The secondary windings are very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

In order to accurately test the primary winding, one cannot use the multimeter resistance (Ohm) test as it was 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 famous coil tester is the Dick smith flyback tester. You can build the flyback tester by visiting this website <http://www.flippers.com/pdfs/k7205.pdf>. Study the manual and you will definitely know more about coil measurement and other useful information.

Testing SMPT

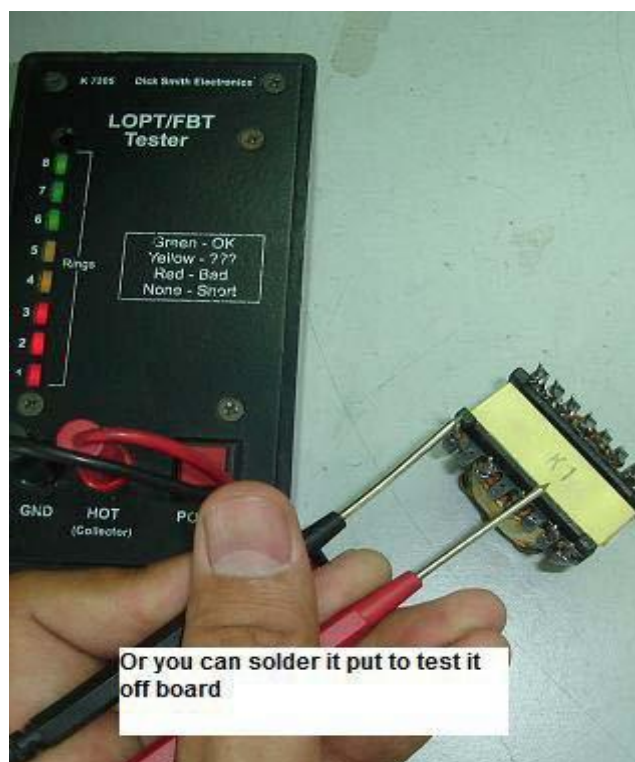


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First you must find the primary winding of the SMPT. It is very easy by simply referring to the photo given. Look at the positive sign of the big filter capacitor. **Note: make sure you discharge it first by referring to the capacitor topic.** Trace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

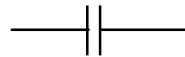


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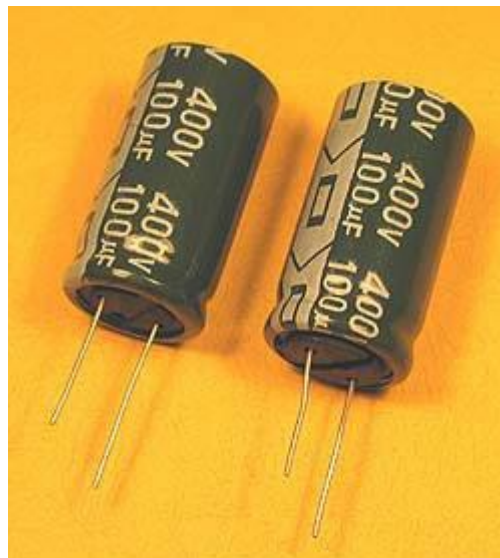
Placing the flyback tester probes to the primary winding of the switch mode power transformers, a good measurement will usually between of 4-8 bars LED lights up. If it indicates only one or two LED bars or the flyback tester LED goes off (no light), this proof that the primary winding have problem. If the primary winding shorted, you can send the SMPT to a rewinding shop for repair.

Understanding Capacitors

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



Symbol of a capacitor



Electrolytic Capacitor

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Unit of capacitance.

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

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

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

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

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

Microfarad can be written as MFD, MF or μF or simply M. Nanofarad is written as NF. Picofarad is written as P.F 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.

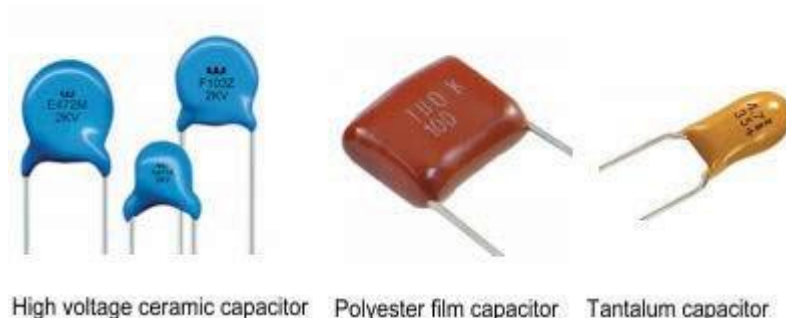
Non-Polarized Capacitor

- a) MICA
- b) Paper
- c) Ceramic
- d) Polyester
- e) Polystyrene

Polarized Capacitor

- a) Electrolytic capacitor
- b) Tantalum capacitor

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, they may explode.



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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.

CAUTIONS – Never use a capacitor into 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 power 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 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.

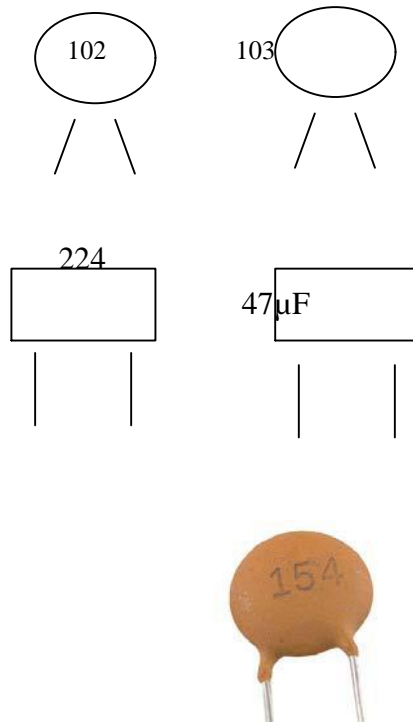
A large 75V capacitor in a high power audio amplifier can easily melt the tip of a screwdriver, accompanied by flying metal sparks if the tool shorts across the capacitor terminals. This could cause eye injury, burns, or secondary injury. When in doubt, take time to discharge power supply capacitors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

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 capacitor numeric code

The non-polarized capacitor of nominal value of less than 1000pF is usually plain marked. For instant, for a 220pF capacitor, it will be marked 220 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 resistor.

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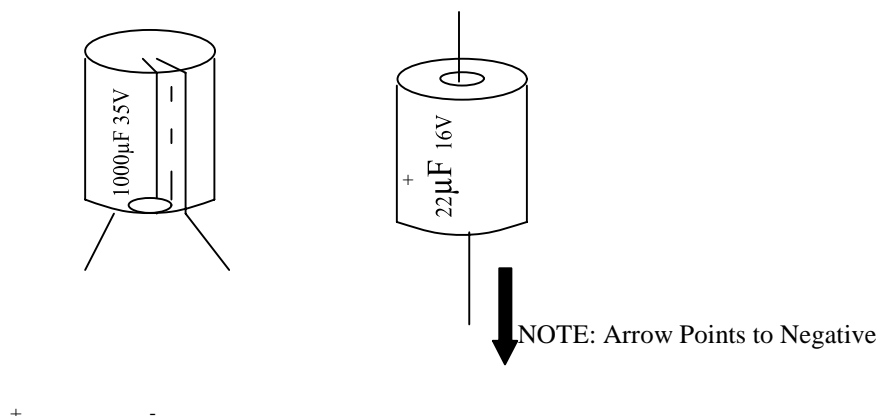


Ceramic disc capacitor

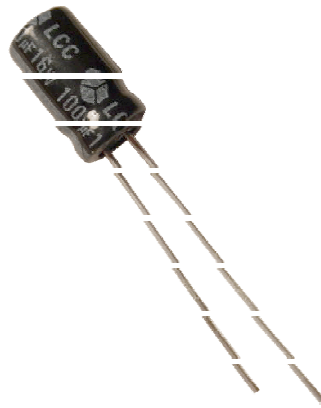
Example 1: What is the capacitance value of these capacitors that marked

- a. 22 \Rightarrow 22 picofarad
- b. 330 \Rightarrow 330 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, voltage rating, and polarity printed on the case as shown in Figure below



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A 100 microfarad 16 volt electrolytic capacitor

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 instant, a 100µF electrolytic with tolerance of -10 percent, +20 percent may have a capacitance of 90 to 120µF.

How To Discharge 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 electrocuted.

Though the capacitor current stored in the capacitor can't kill you but 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 off the equipment when you got a shocked from the filter capacitor and the cathode ray tube monitor may break and cause the flying glasses to 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 negative pin (you can see the negative marking at the sleeve of the

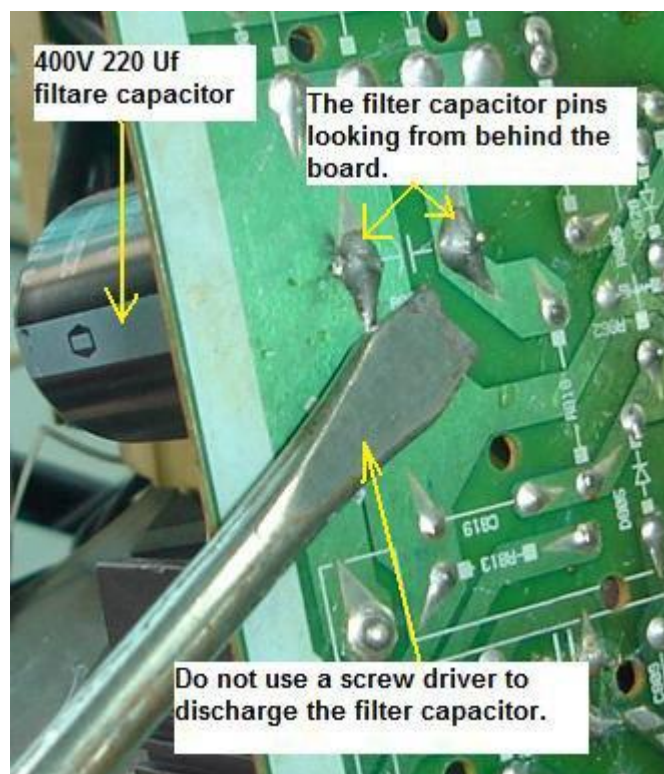
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capacitor) and the red probe to other pin. If there is high voltage registered in your meter then you have to discharge the capacitor otherwise you may proceed to repair the equipment. Typical value for this type of filter capacitor is 220 to 330 microfarad 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 a switch mode power supplies.



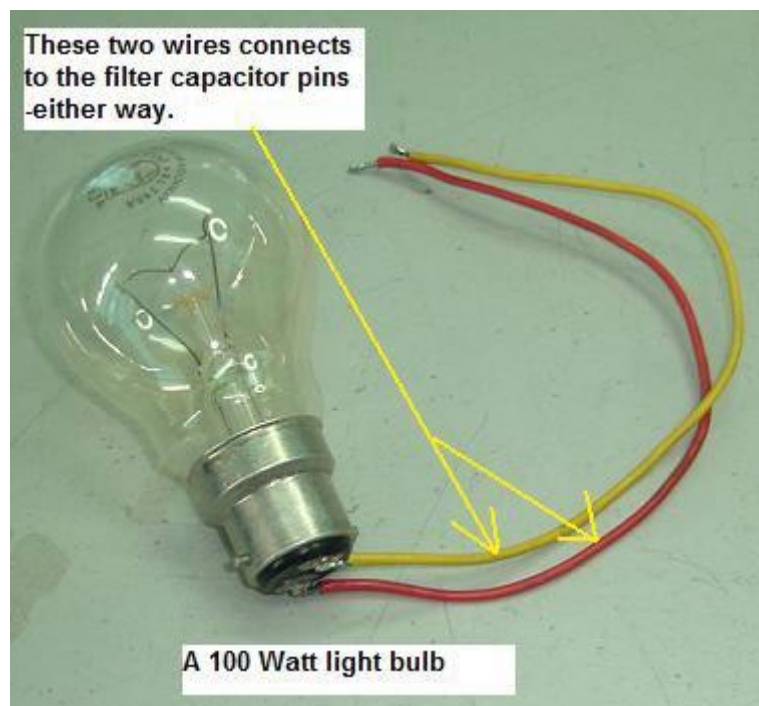
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Please don't use this method to discharge filter capacitor

Discharging the capacitor with a screw driver (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 knew 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 screw driver 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 injured your eyes or body.

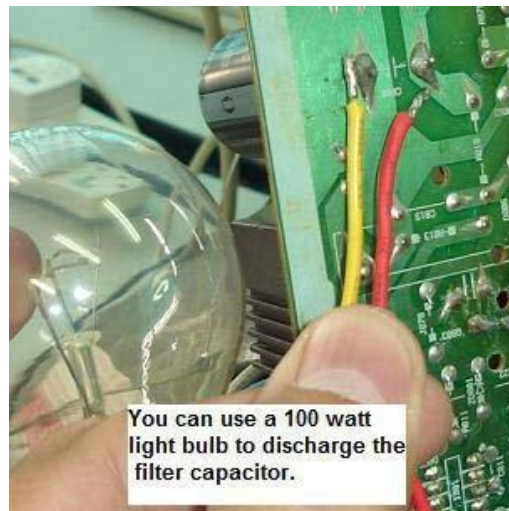


A 100 watt bulb use to discharge filter capacitor

Another method is that you can use 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

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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 preferred the third method because 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 supplies. It is very simple to use and

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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 discharge from the capacitor! Using only one hand, you can do the job while the other hand you still 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 had discharge the capacitor and you are still not sure or no confidence whether the charge already gone, you can always use a meter to confirm it.

Testing Capacitor



An Analog Multimeter

First method, before you test capacitor, make sure you use an analogue multimeter set to time 1 ohm range and connect a capacitor to the test probe. See the panel if the pointer flick up and comes down or not, this represent charging and discharging. If it still cannot flick or no response then set your meter to time 10 ohm and then to 1k ohm and lastly to 10 kilo ohm range.

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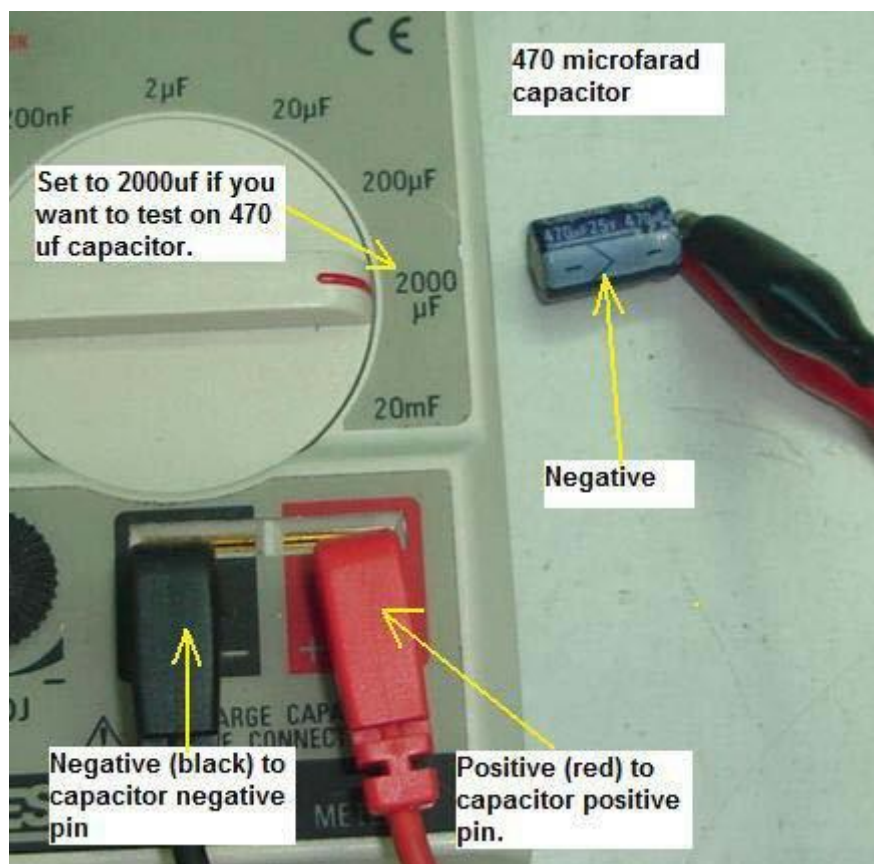


If it still don't flick then the capacitor under test have developed an open circuit. This is a rather old method to test capacitors because even though a capacitor can charge and discharge, **this does not mean the capacitor value is good**. Due to this problem, digital capacitance meter was developed.

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A Digital Capacitance Meter

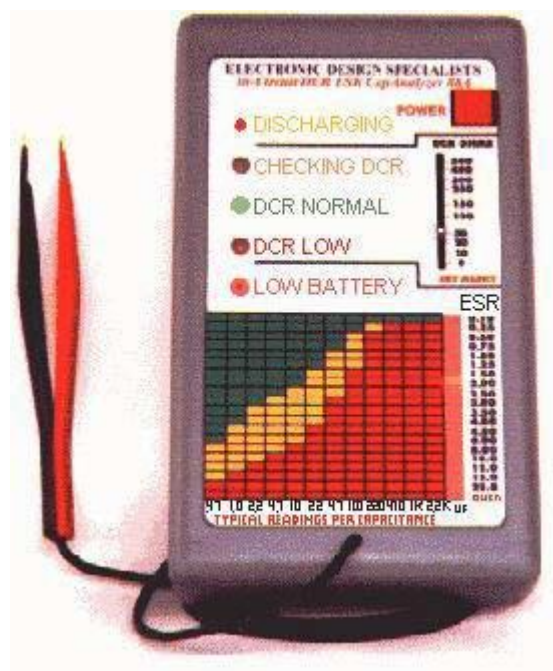


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Testing electrolytic capacitor with digital capacitance meter

The second method to test capacitor is to use digital capacitance meter and is a little more accurate compares to 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 90 microfarad to 120 microfarad. Remember, capacitors havetolerance just like resistors.

Be sure to discharge capacitor first before testing. A reading of 60 microfarad means the capacitor has lost its capacitance and need to be replaced. This meter is more expensive than analogue meter. Somehow digital capacitance meter have its own disadvantage, which is, it can't check capacitor that is 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 capacitors failure.



Eds Capanalyser 88A Esr Meter

The third and most accurate method is to use an ESR meter which stand for equivalent series resistance. This is the latest technology in testing capacitors. It can only check 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% compare to other meters. It is fast and can discharge a capacitor before it begin to test the capacitor and save you a lot of time. ESR meter is the most reliable and accurate meter that I've ever invested.



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, these meters have the capabilities 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 capacitor, film capacitor, ceramic, high voltage capacitor and etc. It also has the function to check inductors or coils too. A capacitor failure when under load is very rare.

Using ESR capacitor meter alone can solve most of the electrolytic capacitor problem.

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 meter. Normal digital capacitance meter and analogue meter can't test this type of failure. Have you encountered power problem where when you switch on the power supply, the fuse blow 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?

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A fuse blown into dark colour were usually caused by lightning strike, ashorted bridge rectifier, defective Posistor in computer monitor and TV circuit, a shorted power transistor or FET field effect transistor, shorted primary winding in switch mode power transformer, shorted secondary output diode and etc.



A Filter Capacitor in Switch Mode Power Supply

I'm frustrated as to where be the cause of the power problem. Every time when I switch on the monitor the fuse will blow immediately (the fuse became 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 have tested all the components in the power supply section and can't find the cause of the problem. Then, I began to substitute all the suspected parts one by one and replaced with a goodworking component.

I eventually found the caused of the power supply problem. Guess what?

It was the main power filter capacitor problems (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 begin my detective work to explore why this particular capacitor can caused the fuse to blow even though the filter capacitor 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 assumed that many of you who read

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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 is charging and discharging (meaning the pointer will flick up and then gradually goes down), test 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 do I know if the filter capacitor is faulty since all the meters tested ok on the filter capacitor?

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



An Insulation Tester

When I connect the 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 applied! A good filter capacitor will just showed a charge and discharge in the insulation tester just like when you are testing a capacitor using analogue meter. This proved that the bad capacitor breakdown when under full operating voltage.

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You can get an insulation tester from any electronic suppliers. It comes in few ranges of 100v, 250v, 500v, 1000v and even 5000 volt! If you want testing 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 volt! If possible, you should get exact value and voltage for capacitor replacement.

Capacitor breakdown when under full voltage is quite rare and only happen to those capacitor 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 Capacitor

The ceramic capacitor leakage quite often happened when there is a high voltage applied into it. Under normal testing with a digital capacitance meter or an analogue meter will not revealed 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 computer monitor, the ceramic disc capacitor and high voltage resin coated type is frequently found in the power supply, high voltage and cathode ray tube monitor area. When it fails, it can cause erratic or intermittent problem to the monitor such as blinking display, no display, missing one of the colour bar and etc.



Resin coated ceramic disc capacitors

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Using analogue and digital capacitance meter won't accurately test the ceramic capacitor failure even out of circuit. A ceramic capacitor leakage in electronic board can pull down the voltage and cause a lot of intermittent problem to the equipment. I will explain to you my true life experienced about this type of capacitor. In computer monitor Cathode ray tube (CRT) board, the screen line (G2) has about 200 to 600 volt. 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 breakdown, it can pull down the screen voltage to a very low level and causing no display or picture. There is no way for an ohmmeter with 12v output 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 kilo volt in certain types of circuit such as the inverter circuit in LCD monitor.

So the right way to check the ceramic capacitor leakage is to use an insulation tester. If you have the analogue insulation tester or meter, the meter panel will show a short circuit when certain voltage are applied to check the ceramic capacitor dielectrics or materials. The voltages that you can select is depends on the brand or model you had. 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 direct replace the suspected failure ceramic capacitor. In my country, you can get a new one in less than US150 or you may bid a used unit from eBay. Sometimes you don't need any meter to test the ceramic disc capacitor because the burnt marked in its coating already proven it has gone through some serious heat or high temperature and need to be change.



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A Kyoritsu Insulation Tester

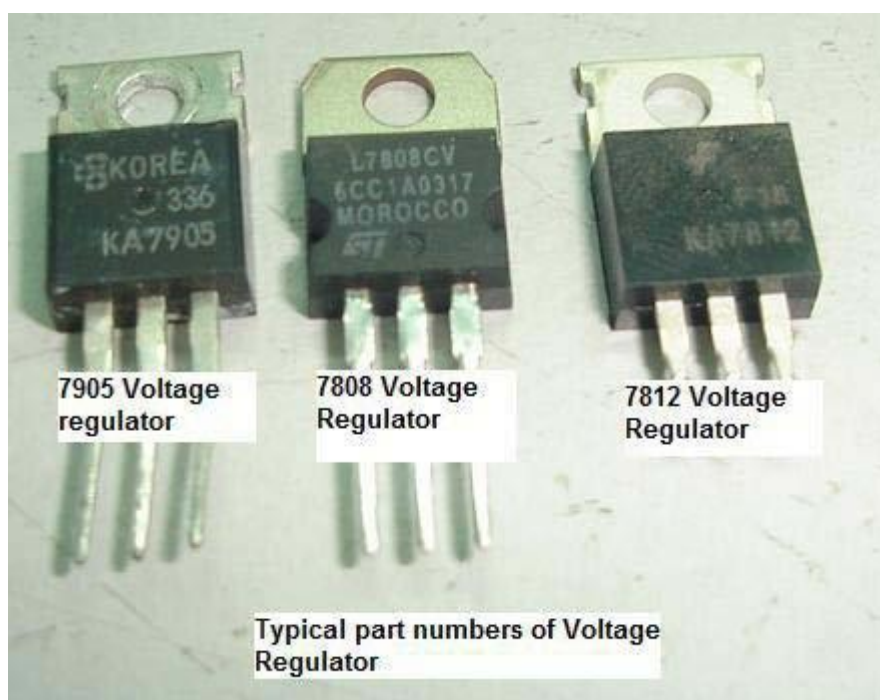
You may also sometimes see cracking in its body. Ceramic capacitor doesnot have polarity and when you need a replacement; get the exact or higher voltage rating with the same capacitance value.

To test the small blue resin coated ceramic disc capacitor that have the capacitor marking of 104 50v, besides using digital capacitance tester to check for the capacitance value, I also use an analogue meter. Set 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.

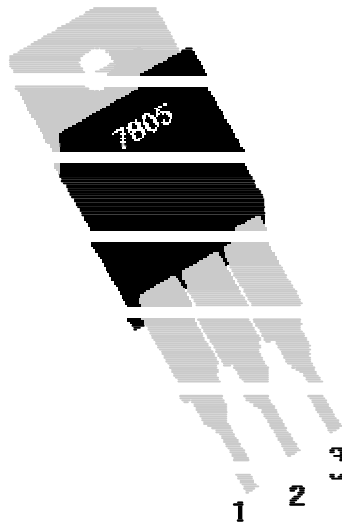
In the market there is certain brand of analogue meter that have the rangeof 100kohm. If you remove the cover, you can't see the 9 volt battery in it, what you see is only the 2 pieces of 1.5 volt batteries. This type of meter can't accurately detect the ceramic capacitor leakage because the output voltage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

Ceramic capacitor manufacturer produced many construction and types of capacitors, and if the ceramic disc capacitor always failed even though you had replaced 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 IC



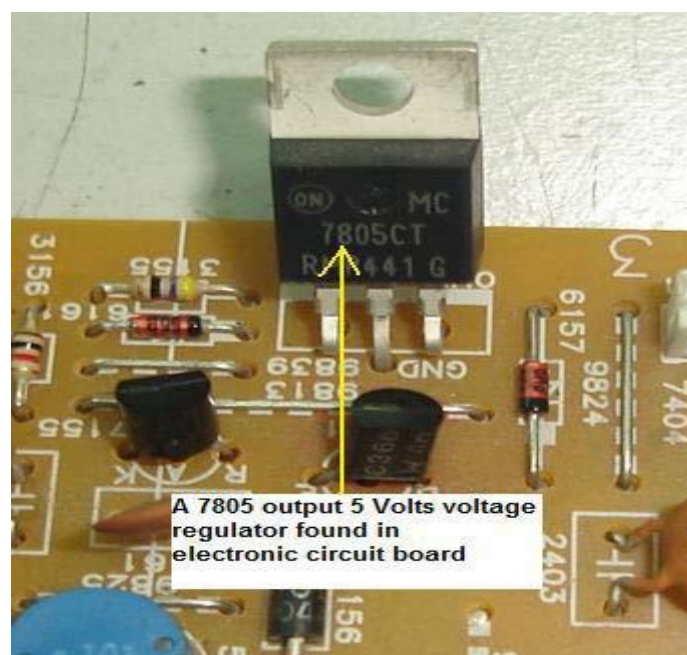
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A voltage regulator IC

As the name suggest, this electronic component “regulates” an output voltage. 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.**

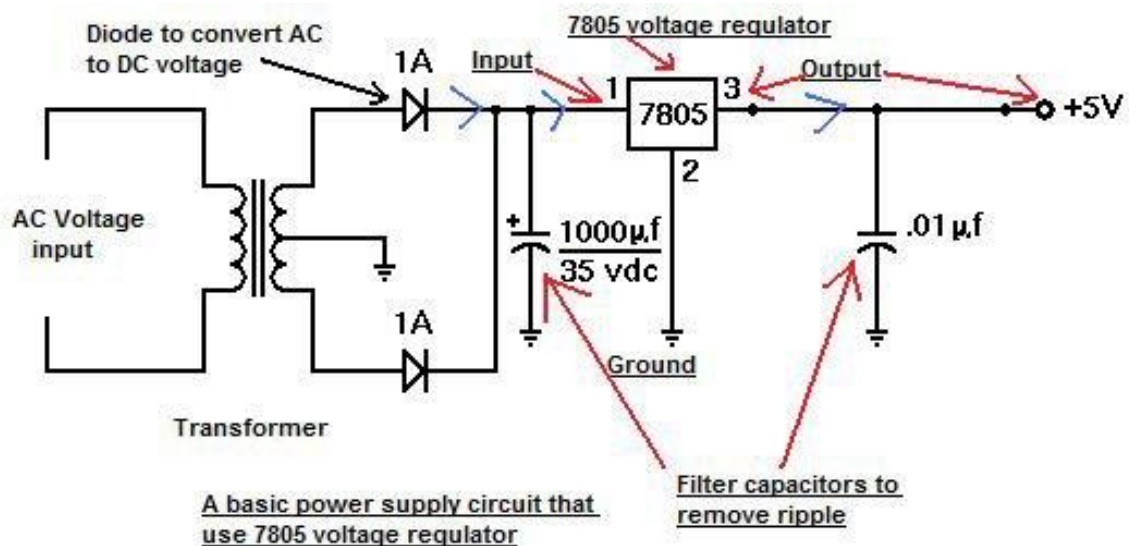
Put it simple, any dc voltage from 7V to about 38 V enters the pin 1 of 7805 voltage regulator then expect a +5 V output at pin 3. Any voltage inbetween 7V to 38V will cause the voltage regulator to produce a steady 5V output. Do not exceed the 38 V rating otherwise the voltage regulator may burn. You may check from the internet or any semiconductor data book (preferably ECG master replacement guide) about the specification of any voltage regulator. Some famous part number uses 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.



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

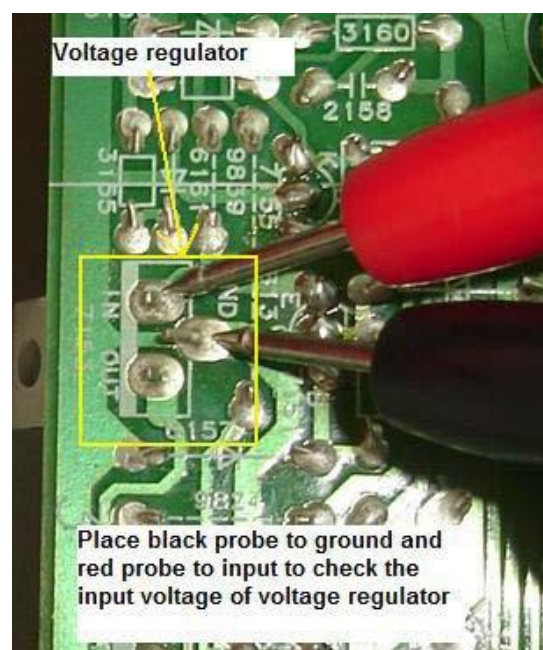
Take a look at the diagram below:



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 use to filter off the ripple in the line.

The clean DC voltage (assuming 7 Volts) is now entering pin 1 of 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 filter to remove high frequency interference.

Testing Voltage Regulator



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Place the red probe to out 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 automatic 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. You may even e-mail me for the support.

Testing Opto-Isolator

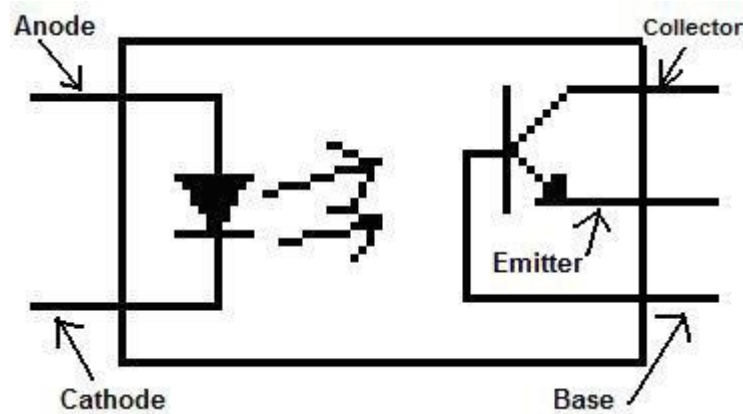


A Motorola 4N35 Optocoupler

A lot of electronic equipment nowadays is using optocoupler in the circuit. An optocoupler or sometimes refer 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 a 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 few modules such as the SCR, photodiodes, TRIAC or other semiconductor switch as an output, and incandescent lamps, neon bulbs or other light source. I also came across two LEDs 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 below:

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An Optocoupler Symbol or Schematic

The optocoupler usually found in switch mode power supply circuit in many 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 breakdown, it will cause the equipment to have low power, blink, no power, erratic power and even power shut down once switch on the equipment.

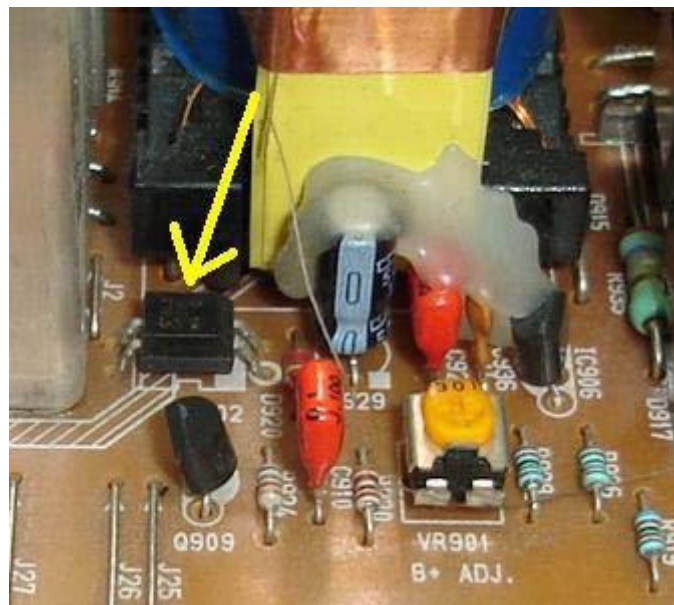
Many technicians and engineers do not know that they can actually test the optocoupler with their analogue multimeter. Most of them thought that there is no way of **testing** an IC with an analogue meter. Since we already knew the optocoupler pin out from the schematic diagram, testing this IC is just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

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In order to accurately check 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 have become shorted. The testing method is exactly the same when you are checking a normal diode. The LED 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.

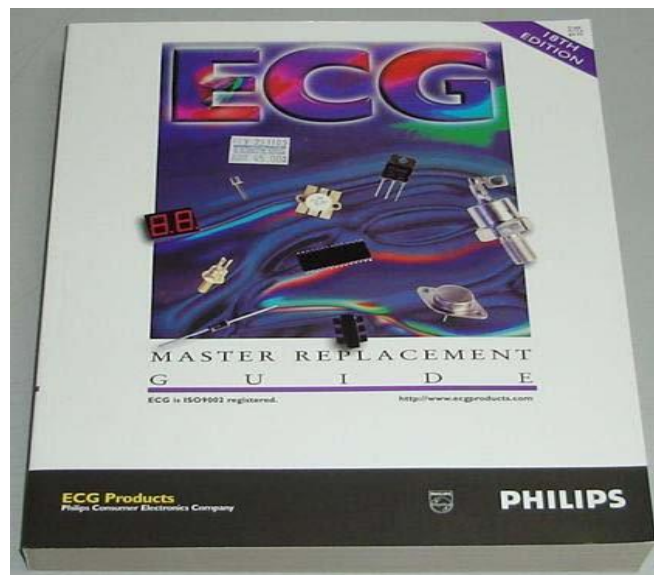


An Optoisolator in Electronic Board

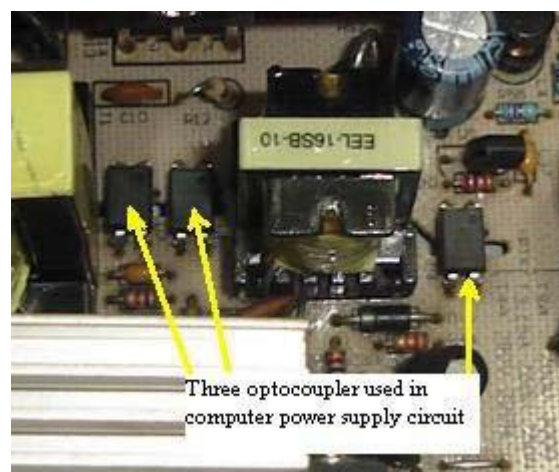
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Now turn your meter selector to times 10k ohm range to measure the collector and emitter of the transistor. It should have no reading on oneway and the other way should have a slight reading. Which mean the meter's pointer will moved a little bit up from the infinity scale of the analogue meter. If you get two readings then the optocoupler is faulty. One of the most famous part numbers of optoisolator is the 4N35.

If you want to know more about the internal diagram of any optocoupler IC, I recommend that you check from the Philip ECG semiconductor master replacement guide book for the correct datasheet. 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 inside the IC then you can use the necessary testing method to apply to the IC.

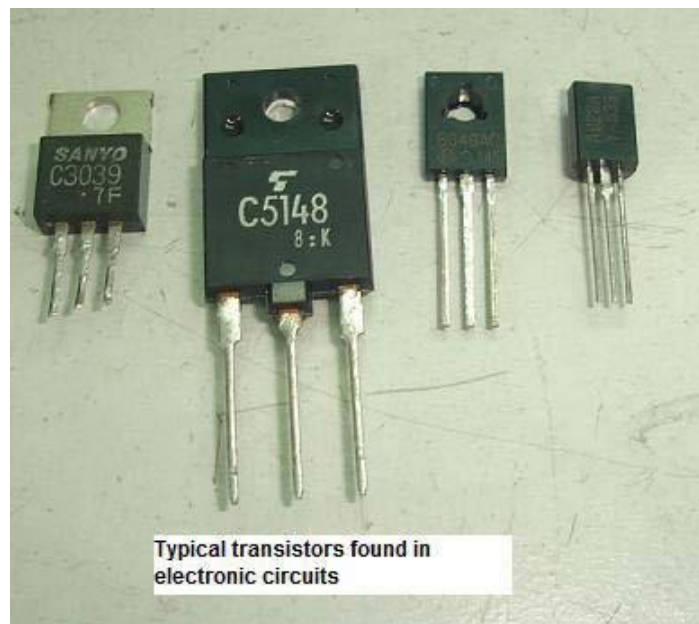


Philips ECG Master Replacement Guide



Optoisolator in Power Supply

Testing Transistor



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 difference symbols for NPN and PNP transistor. The emitter arrow points away from the transistor body for an NPN and toward the transistor body for PNP.

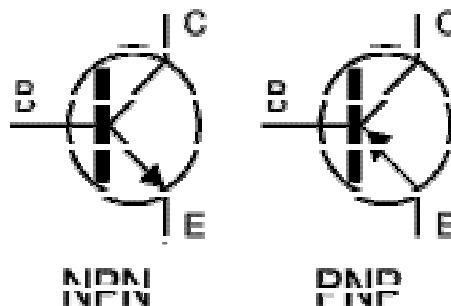
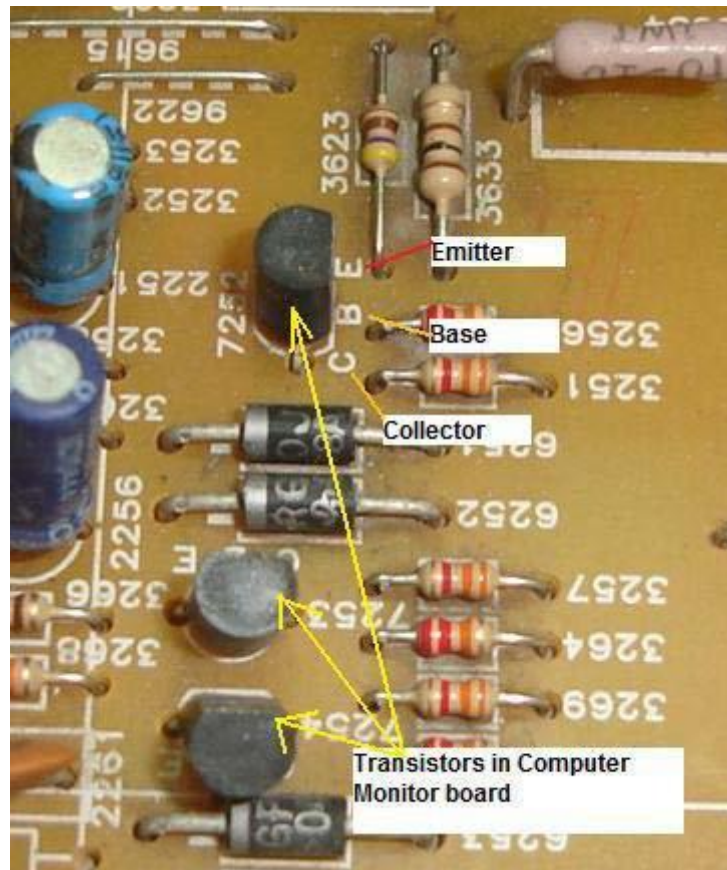


Fig 1 : The circuit symbols for the two transistor types a) NPN b) PNP



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.

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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 transistor; 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.



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Transistor Failure

Transistor 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 developed 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 too hot but not until the extend 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 transistor- it’s worth the trouble**.

TRANSISTOR SPECIFICATIONS

Diodes are numbered 1N for example 1N4148, 1N4007, 1N5408 and etc.

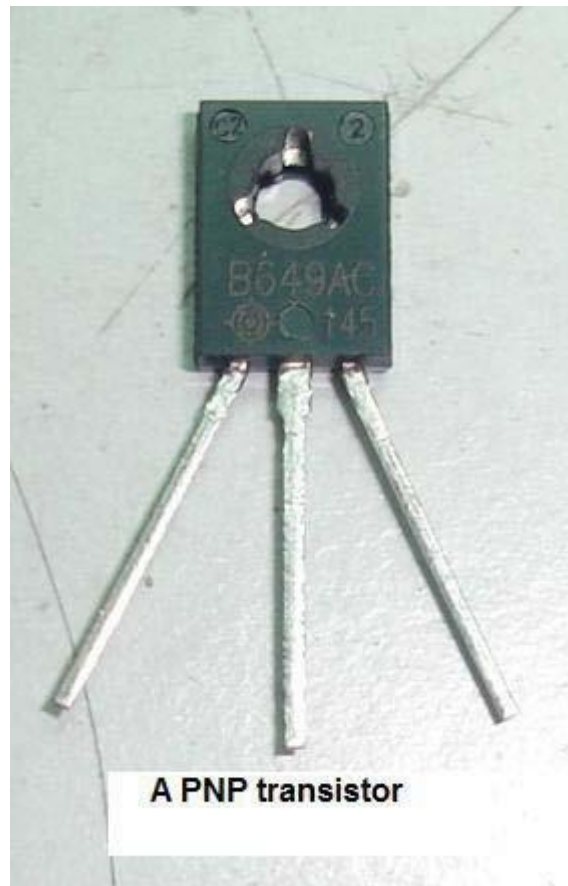
Transistors are numbered 2N for example 2N3904, 2N3906 and etc. The first digit is the number of junctions. However, Japanese transistors have different type numbers. The following designations are generally used.

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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 transistor 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 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 for longer time, it may damage the transistor as well as 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.

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- 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.

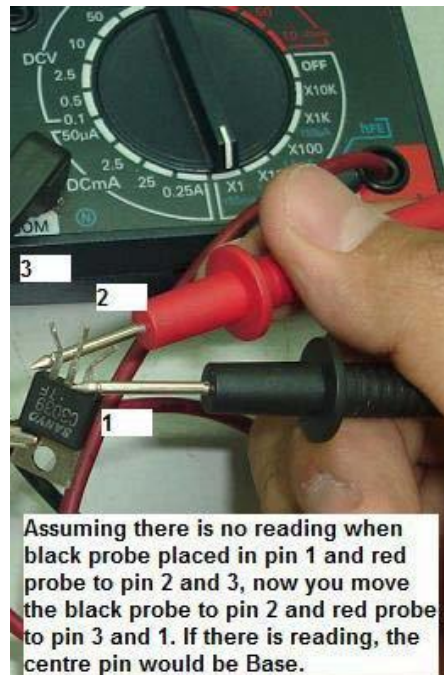
Transistor Testing and Identifying the Leads

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

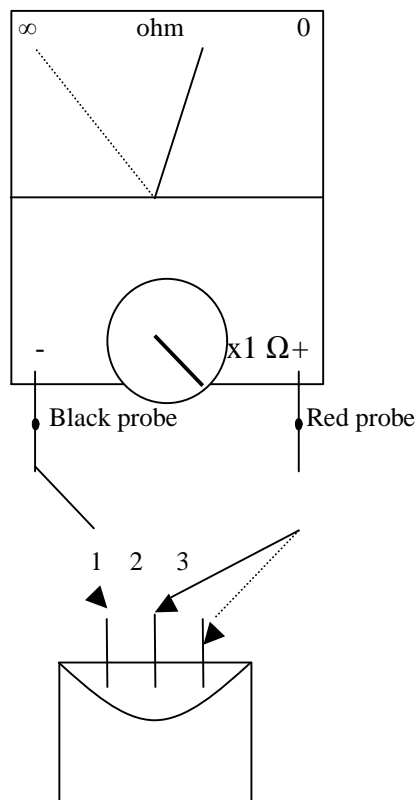
Checking transistor with an analogue multimeter

An analogue multimeter can be use to perform a basic test on a transistor;the diagram in Figure below will help you to identify the base, collector and emitter leads for commonly used transistor. 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, opens or 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 combination of test result you will know the transistor is belonging to which type.

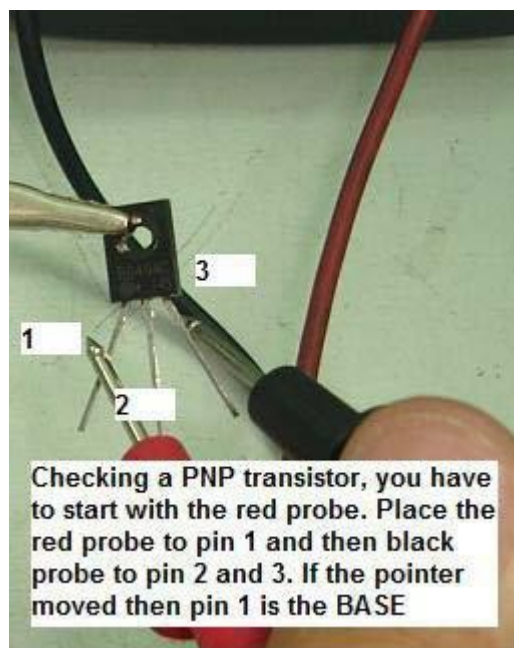


Test No	Black probe is connected to pin no	Red probe is connected to pin no	Reading in ohms
1	1	2	Low
2	1	3	Low
3	2	1	High (∞)
4	2	3	High (∞)
5	3	1	High (∞)
6	3	2	High (∞)

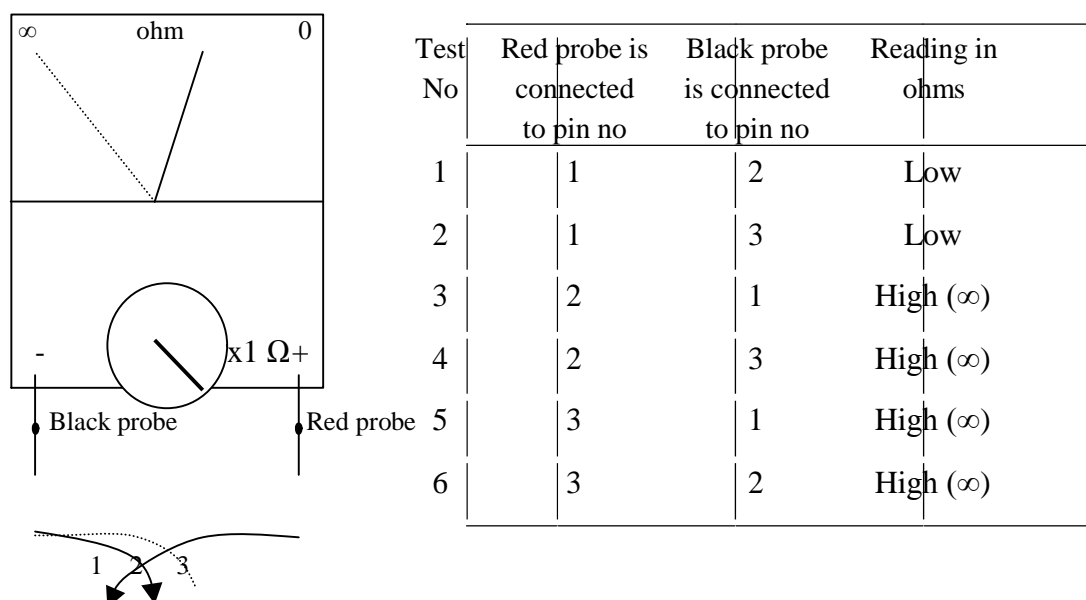
Figure 2 : Identifying transistor type and pin leads

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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 position 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 reading when the red probes connected to the other two leads shows high reading is the **“Base”**. In the above case pin 1 is the “base”.



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



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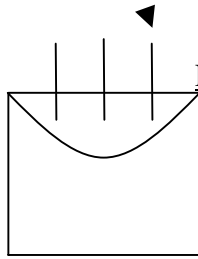


Figure 3 : Identifying a PNP Type of Transistor and pin leads

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”.



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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, and now you 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.

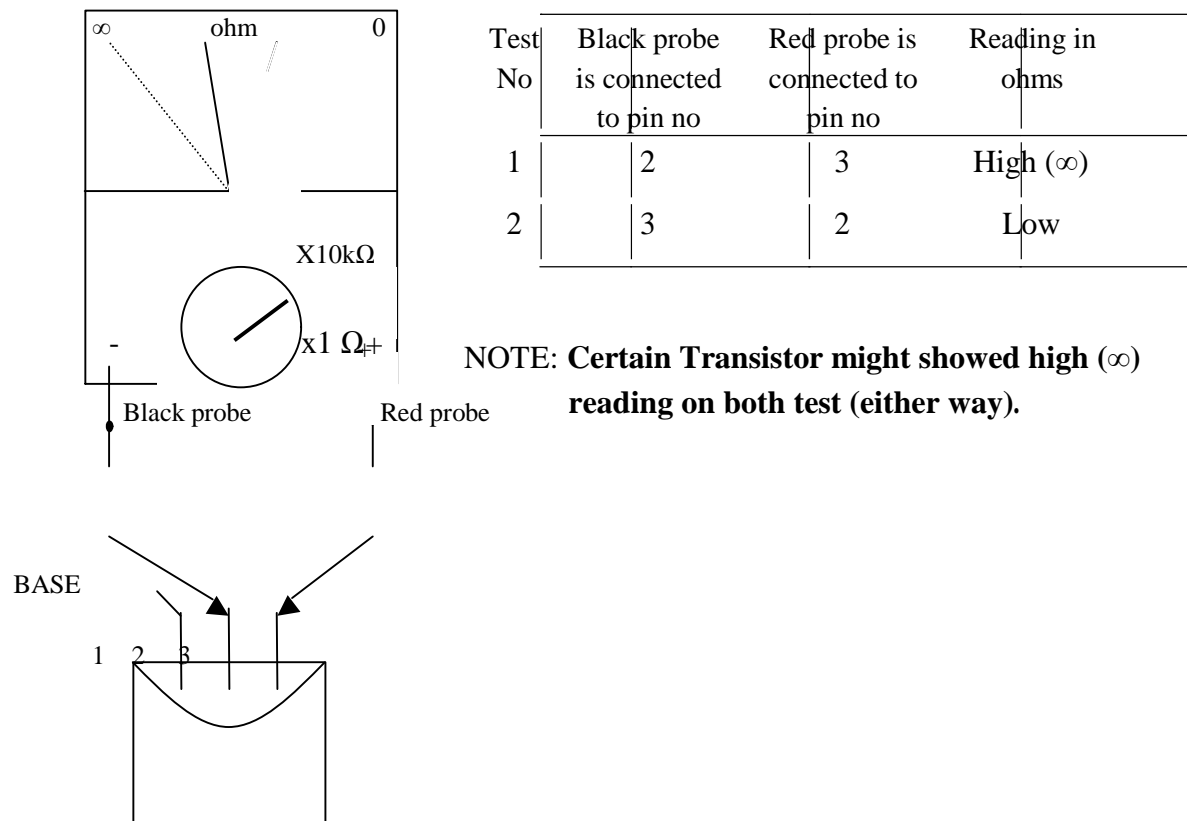


Figure 4 : Identifying the collector lead of an NPN transistor

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**”.

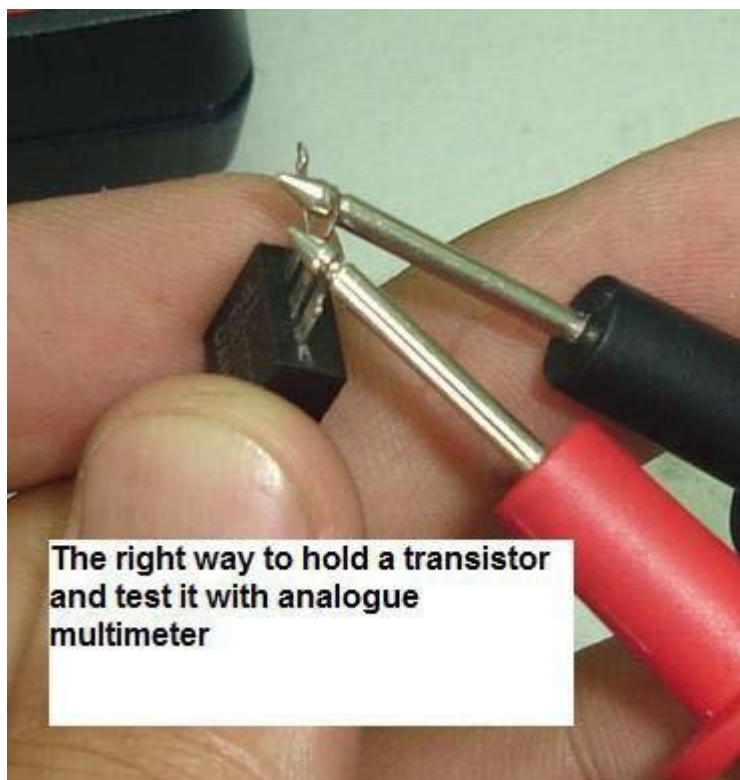
3. Some transistor will show two high ohms readings and if it is the case you should use your finger to touch on the base (first pin) and the middle pin while you are still holding the probes on the transistor middle and the third pin. Assuming while your finger touching the base and the middle pin, the pointer show some resistance then looks at the probe. 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

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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 on the pins, then the transistor has developed an open circuit.

Note: For checking PNP transistor, 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 describe above, there may be 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 transistor 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.

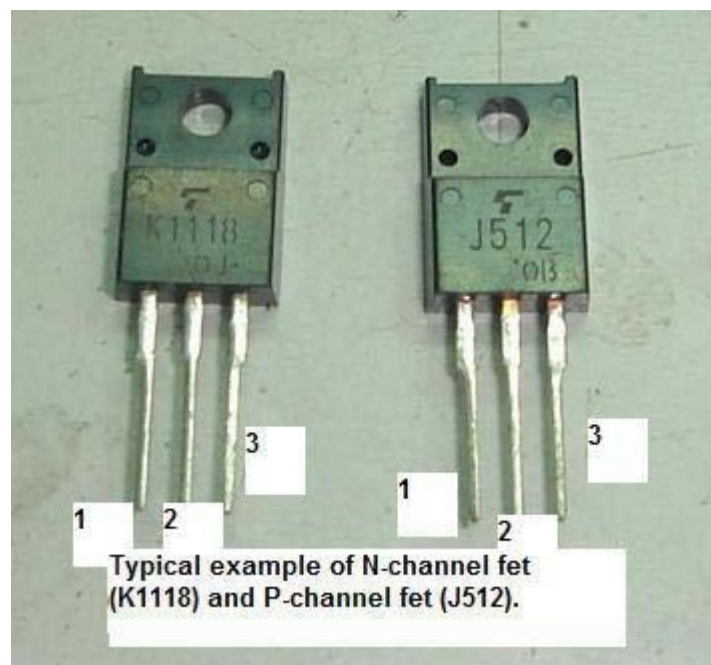
Get a few NPNs and a couple of PNPs, grab your multimeter, and see for yourself.

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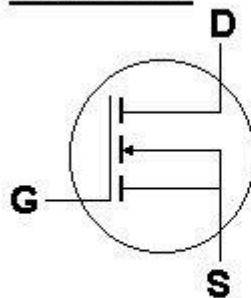
With some actual hands-on activity, it won't take you long to become confident performing a basic transistor test.

If you have a budget you may buy specialized transistor tester where you clip 3 of the tester wires to the three pins of any transistors. 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.

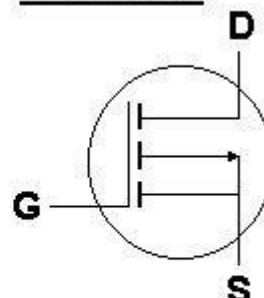
Testing Field Effect Transistor (FET or Mosfet)



N channel



P channel



Mosfet symbol

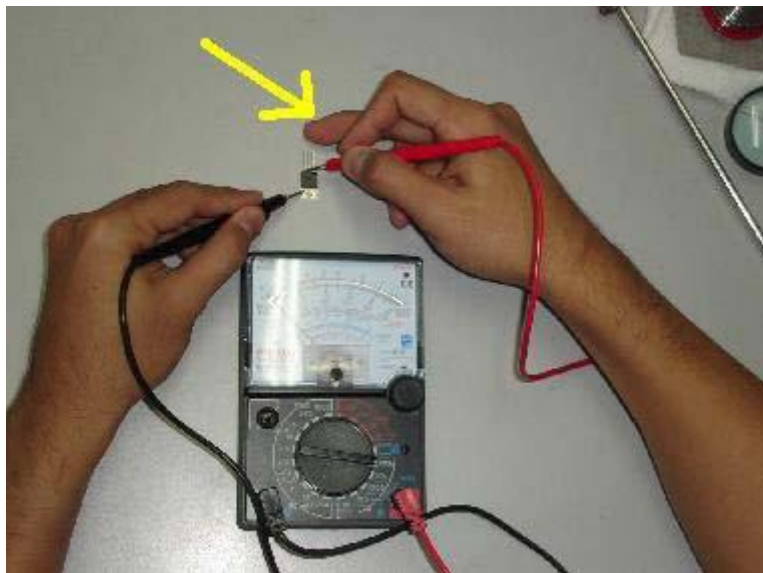
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The right way of testing mosfet transistor is to use an analogue multimeter. Mosfet stand for Metal oxide semiconductor field effect transistor or we just called it FET. Switch mode power supply and many other circuits use FET transistors as part of a circuit. Mosfet failure and leakage are quite high in a circuit and you need to know how to accurately test it. FET is label as “Q” in circuit board.

Measuring component's that have two leads such as the resistors, capacitors and diodes are much easier than measuring transistor and FET which have three legs. Many electronic repairers have difficulty especially checking the three leads components. First, find out the gate, drain and source pin out from semiconductor replacement book or searchits datasheet from 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 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.



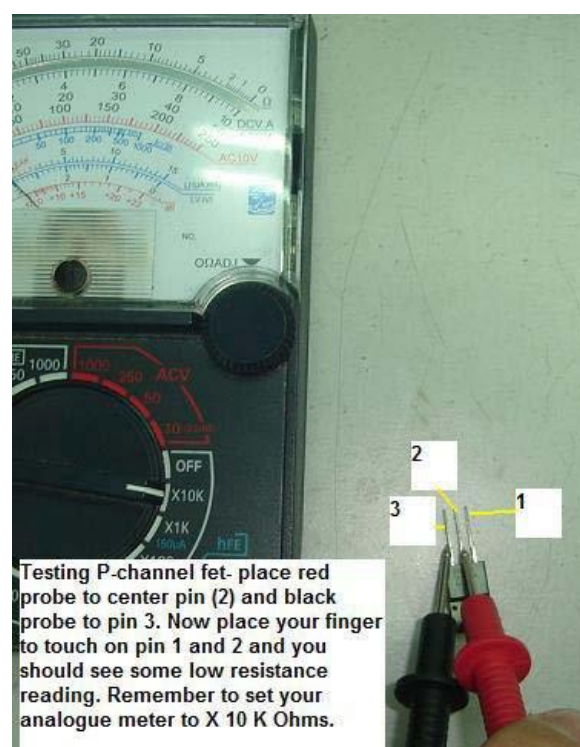
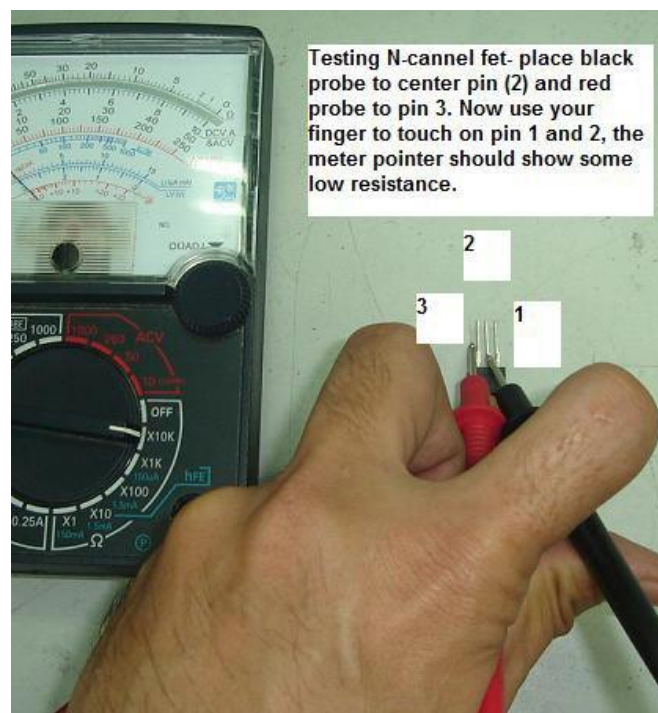
Use your finger to touch on the gate and drain pin.

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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 would not kick at all because you have already discharge it by touching the gate pin. These are the good mosfet characteristic. You need to practice more by taking some FET from your bench or from your component's compartment. Once you know the secrets, testing other mosfet is as simple as testing diode.



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If you notice that all the result that you measured kicked towards zero ohms and will not discharge, then the FET is considered shorted and need replacement. Testing the P channel FET field effect transistor is just the same way as when you check N channel FET. What you do is to switch the probe polarity when checking the P channel. Some analogue multimeter have the times 100k Ohm range, this type of meter can't really test FET due to the absent of 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,

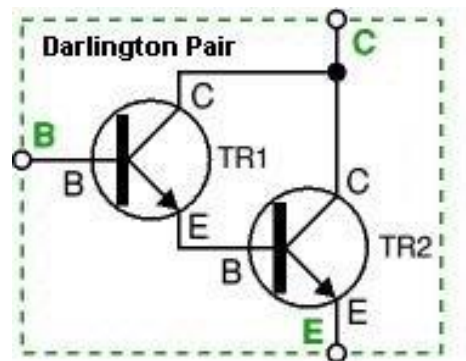
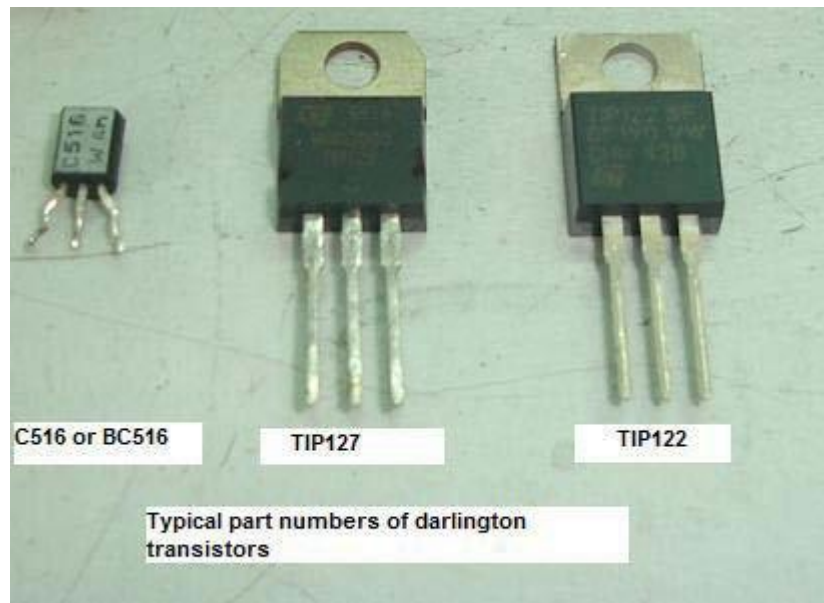
IRF 740 and P channel FET transistor part number are J307, J516, IRF 9620 and etc.

You can also get a mosfet tester from the market and one of the famous brands is the SENCORE TF46 portable super cricket transistor and FET tester. You can bid one from EBay.



Sencore TF46 FET Tester

Testing Darlington Transistor



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 without a built in diode while the other type has a diode in it. You have to refer to semiconductor data book to check if the Darlington transistors

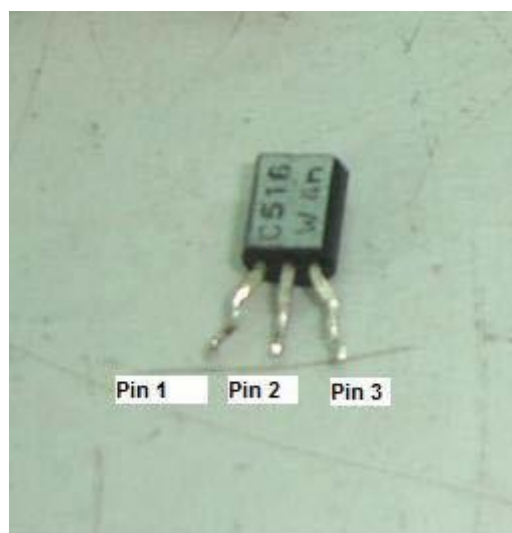
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have a built in diode or not.

Testing Darlington transistor without built in diode.

One example part number of a Darlington transistor that do 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: 45V
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	

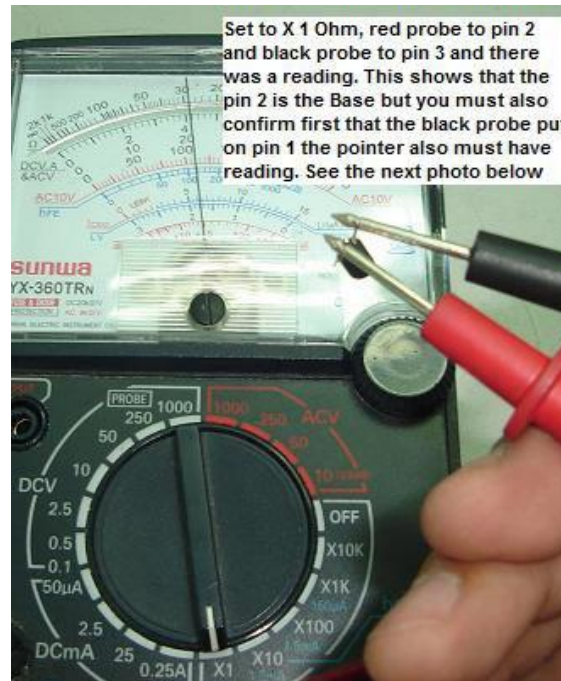


Since you already know that it was a PNP type Darlington transistor, then you have to **start testing it by using the red probe**. The procedure of finding the Base, Collector and Emitter is **exactly the same as when you test on the normal transistor**. Set your analogue multimeter to X1 Ohm and place the red probe to pin 1 of BC516 and the

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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.



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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 to pin 3 and the red probe 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 don't get any reading and see the red probe connects to which pin. 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 semiconductor data book do 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 test and find it on your own.

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Testing Darlington transistor with built in Diode

Again we have to depend on semiconductor data book to help us to locate if the particular transistor that you want to test is belong to **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

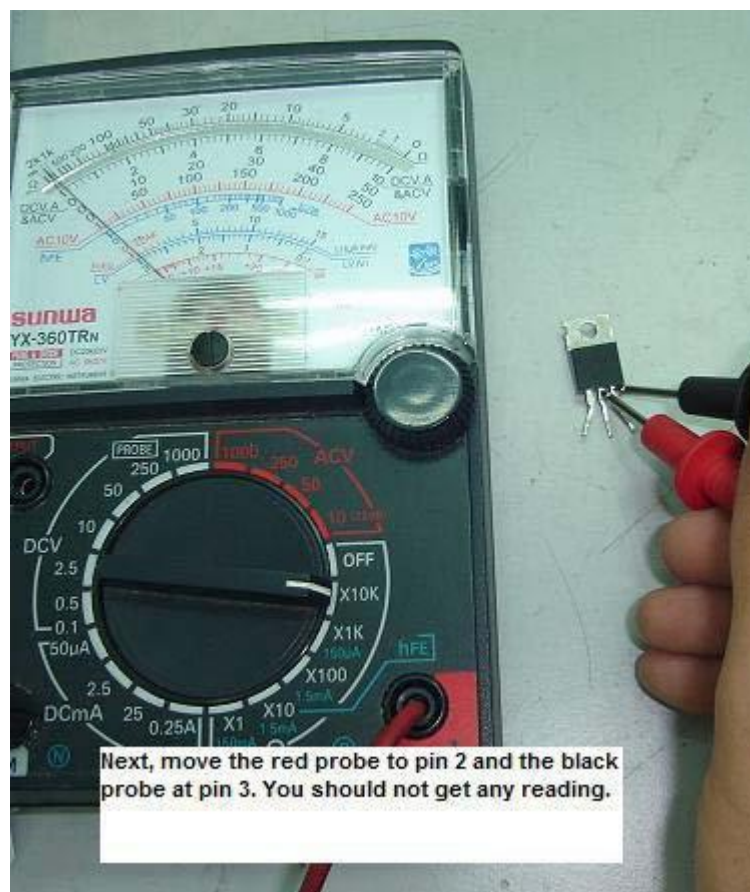
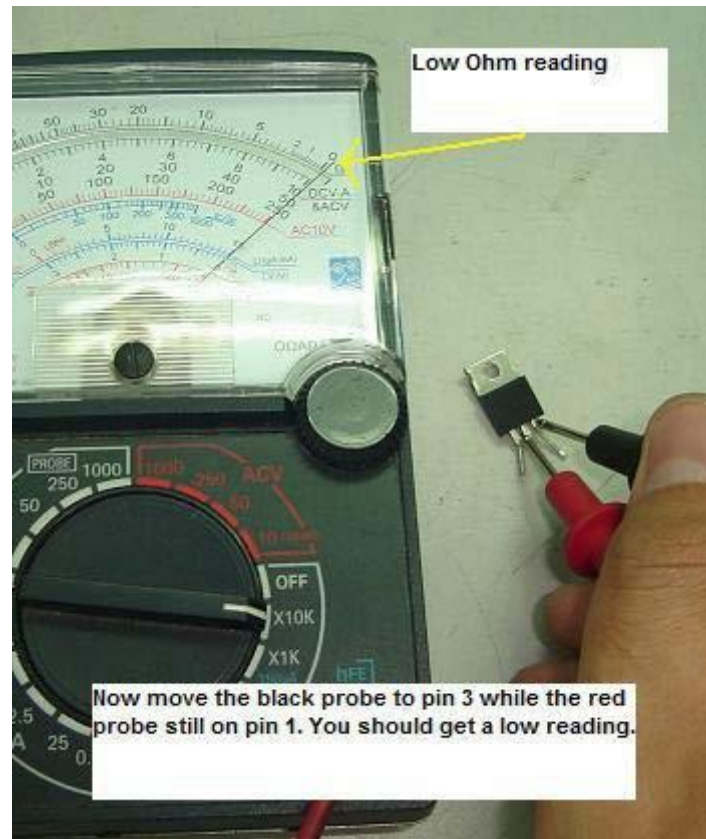
Again from the data book we know that the TIP122 is a NPN type darlington + a diode transistor. Same to TIP 127-it is a PNP type darlington + a diode transistor.

Because of the built in diode, the result that you get is completely different from testing the Darlington transistor that have 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 refers to the photos below:



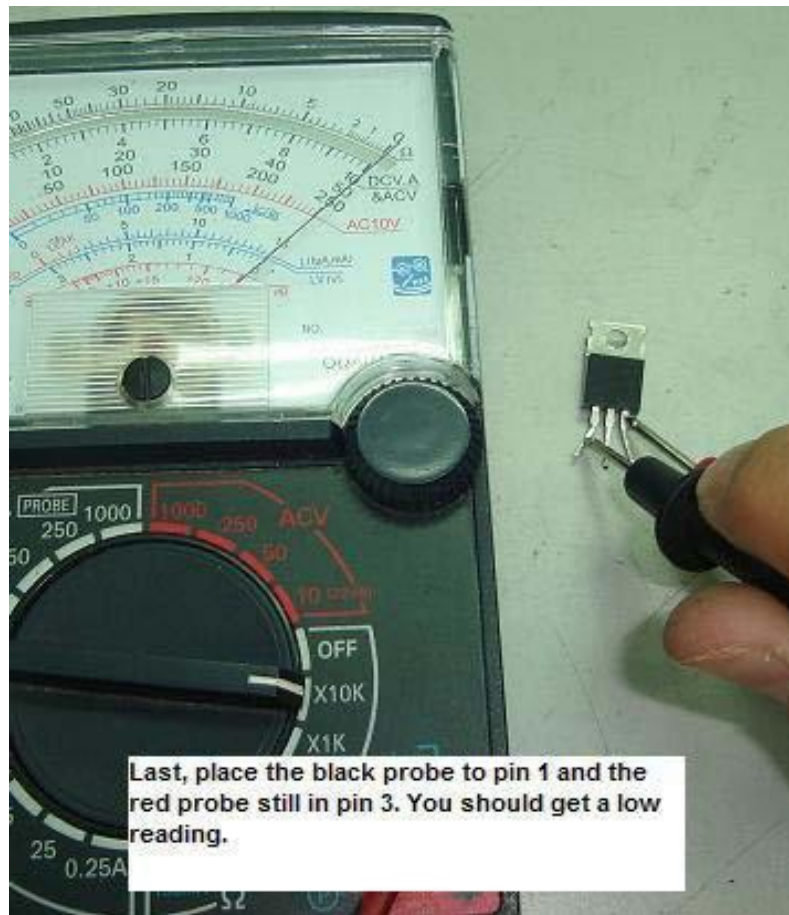
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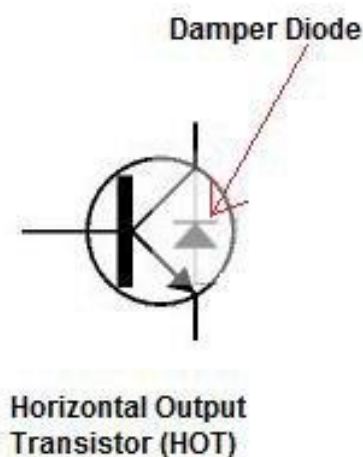
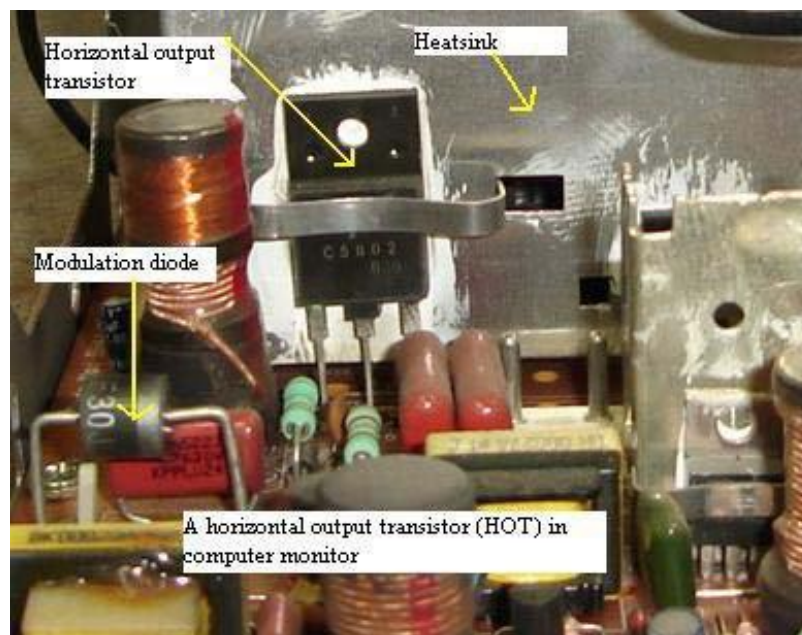
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I suggest that you get few of the Darlington transistor from electronic suppliers (with and without built in diode) to play around with it. Record down all the steps you have taken to successfully test this type of transistors before you test on the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

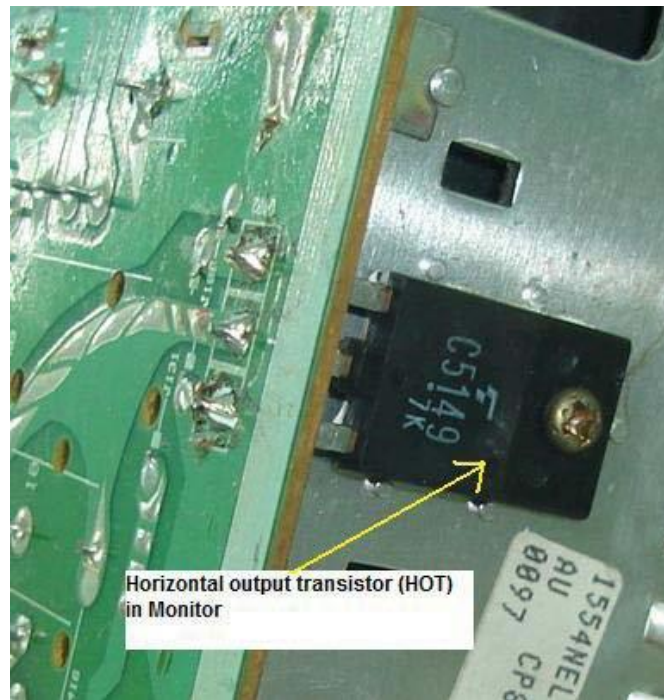
If you have the budget you can always get a transistor tester that can automatically test all kind of transistors but I can't guarantee whether it will give an accurate reading especially checking the Darlington transistor that have the built in diode. **More practice only makes you perfect in testing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

Testing Horizontal Output Transistor



If you are repairing Television and Computer Monitor, I'm sure you had seen a horizontal output transistor (HOT) before. This transistor is use to switch the flyback transformer and prone to become defective due to the stress of dealing with high voltage. A shorted HOT will usually caused no power, low power, power cycling and power to shutdown. The HOT is mainly a NPN transistor.

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Testing HOT on board



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It is very easy to check on board if the HOT is shorted or not. Using your analogue meter set to X 1 Ohm and place the black probe to centre (collector) pin and the red probe to both side of the HOT one at a time, the pointer should not kick (means 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 had shorted. You need to remove the

HOT from the board and retest again.

The above method only applies when checking HOT on board. Checking HOT 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	integr. Damper-Diode
BU 2515 DX	Si-N+Di	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 DF	Si-N+Di	=BU 2522A: Iso, 45W, int. Damper-Dio

Without damper diode

With damper diode

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

There are two types of HOT i.e. **one is without damper diode while the other one is with damper diode**. How do we know if a particular HOT comes with damper diode or not? It's easy, check from the semi conductor data book or searches the internet. **Checking a HOT that does not have the built in damper diode is exactly the same when you are testing a**

NPN bipolar transistor (please refer to the testing NPN bipolar transistor).

If the HOT have 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 blackprobe to centre (collector) pin. Now, moving the red probe touching the first (base) and the third (emitter) pin and it

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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 reading.

-If you measure base (black probe) and emitter (red probe) it should have reading.

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

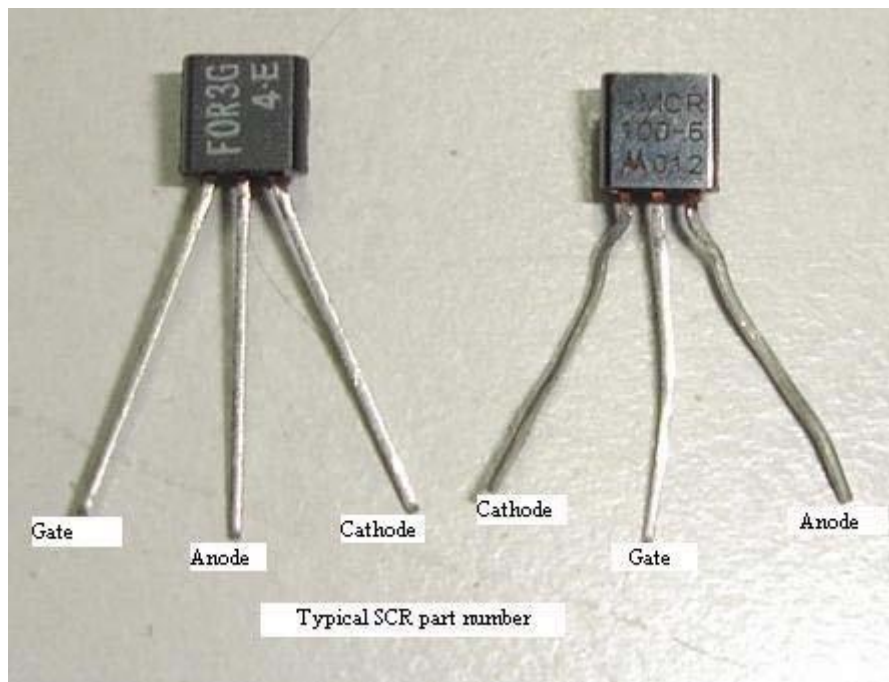
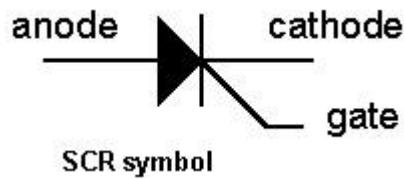
-If you measure collector (black probe) and emitter (red probe) it should have no reading.

-If you measure emitter (black probe) and base (red probe) it should have reading.

If you measure emitter (black probe) and collector (red probe) it should have 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 Rectifier



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

Some called SCR as thyristor but in actual fact the word thyristor shouldnot 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.

SCR consists of three pin of Gate (G), Anode (A) and Cathode (C). In order to identify the pin out, one must find it from semiconductor data

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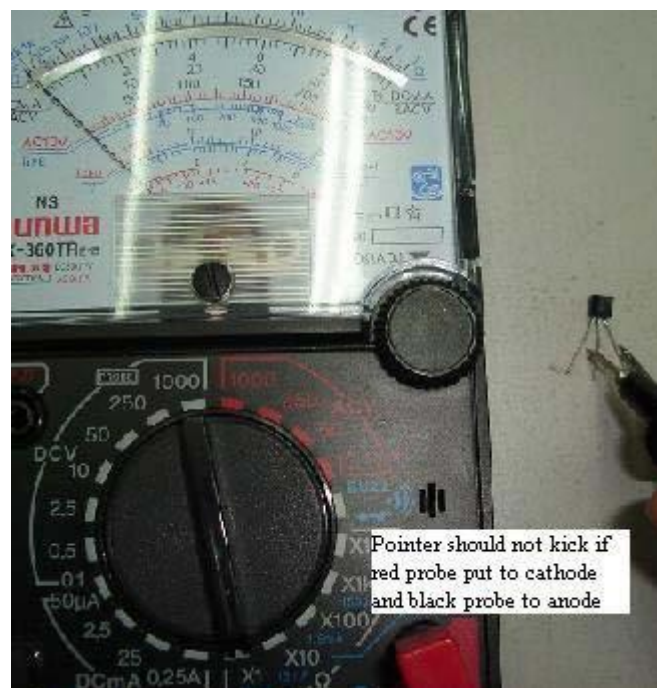
book such the famous Philips ECG master semiconductor replacement guide. The data book will list out the general specification of the SCR such as the volt and ampere. You may go to google.com search engine and key in the part number and get the SCR specification. Usually the SCR manufacturers will provide the full datasheet for those who want it.



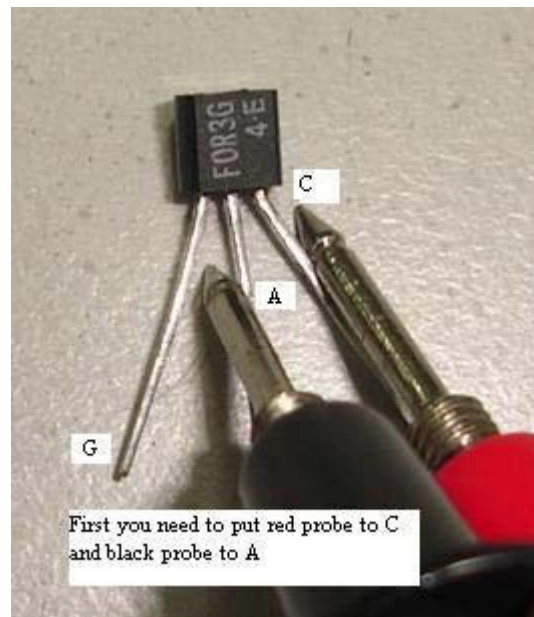
Once you know the pin outs of the G, A and C legs you can begin to test the SCR. If you have the Peak electronic atlas component analyzer tester, what you need to do is to connect the three small clips to each pin of the SCR (any part number will do).

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.

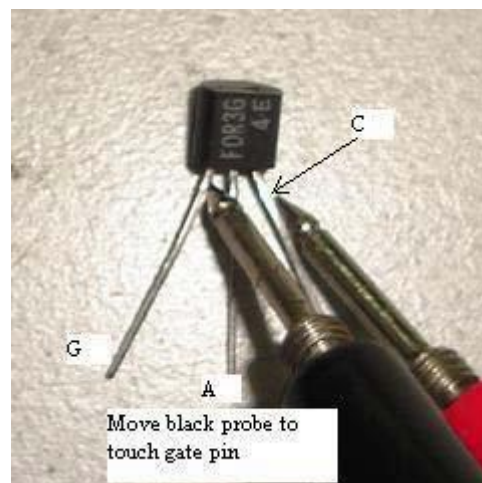


Make sure set to X1 ohms to test SCR



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 on how to test SCR fast. **You need an analogue meterset 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 would 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 connect 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.

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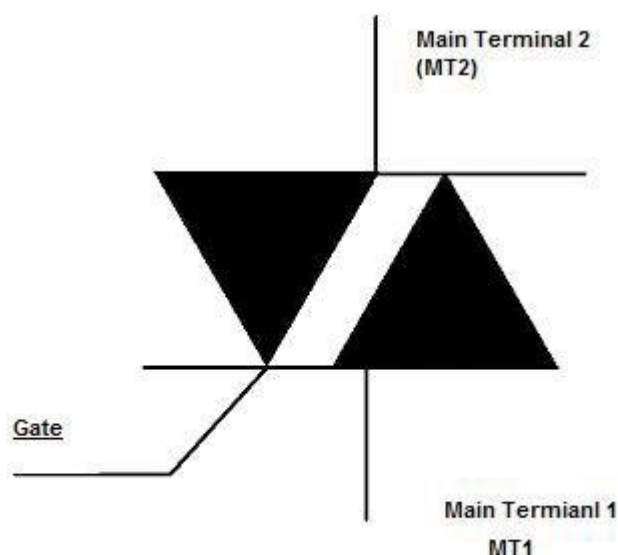


Conclusion- Practice testing SCR more often to see how's the result like.
Try some different part numbers and power SCR-and if the resistance don't hold using X1 ohm, you may try X10 ohm and etc.

Testing Triac



Typical example of Triac



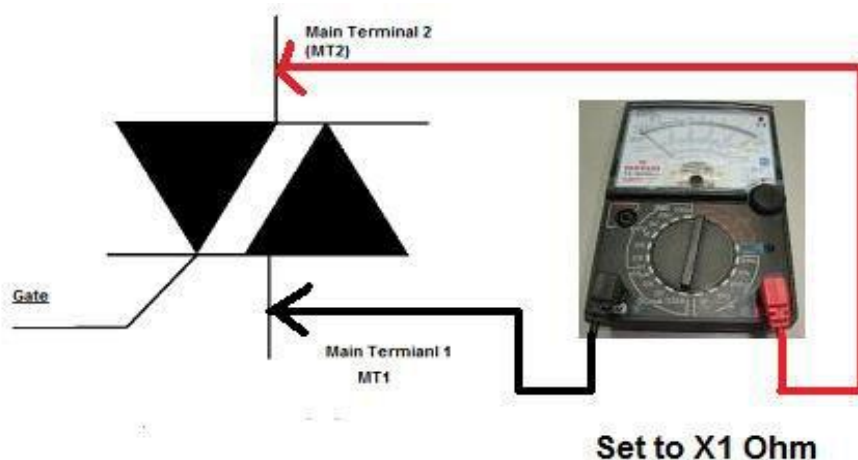
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The triac is an electronic switch or relay with three terminals. It comes in many shapes, sizes and colors. It is an open circuit with no gate signal present, but conducts in both directions when gate voltage is applied. Triacs are used extensively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

They are particularly suited for AC power control applications such as motor speed control, light dimmers, temperature control 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 the time to use your analogue meter set to X 1 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.

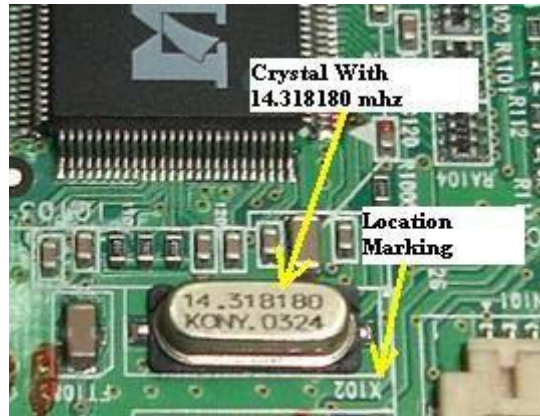
3) Now, use a screw driver tip to create a momentarily short between the gate and terminal 2 or you can just move the red probe touching the gate while the red probe is still on the terminal 2. This short will cause the triac to turn “ON” and you will see a low resistance reading at the meter panel and remain low even 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 specification from the triac, **from experienced; any result that is significantly**

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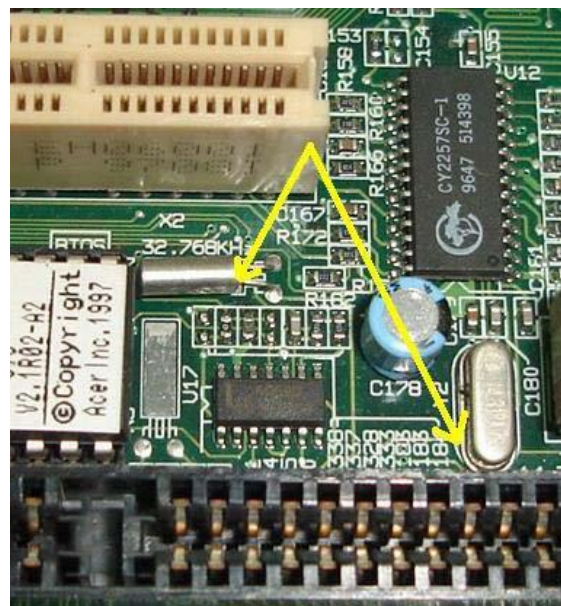
different would point to a faulty triac. If possible, get some triac with different specification and measure it to take down their measurement for future comparison.

Testing Crystal Oscillator



A Crystal and location marking

It's simple on how 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 (motherboard and monitor), Television, Telecommunications systems (mobile phone), and 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 equipments might show intermittent problems or might stop altogether.

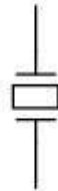


Crystals in Computer Motherboard

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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 was labelled as XTAL or X. Some examples of crystal oscillator frequency are 4 mega hertz, 8 MHz, 16 MHz and so on.

Crystal Symbol



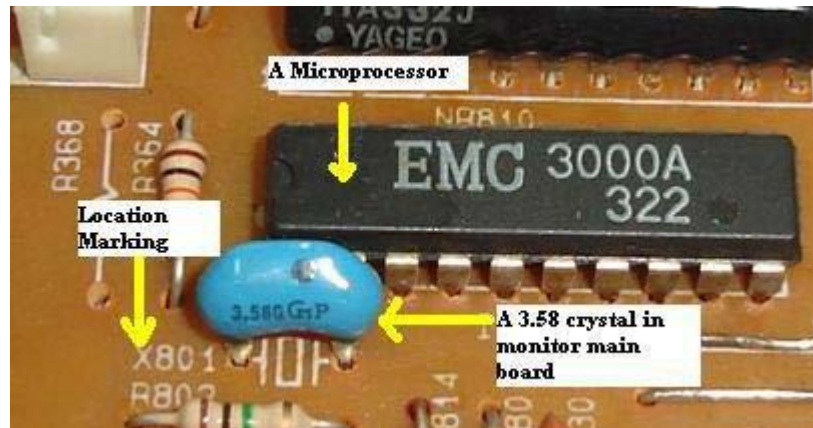
I've experienced quite a number of Computer Monitor crystal breakdowns causing the On Screen Display (OSD) to disappear from the screen. Some On Screen Display even missing half of the display and also erratic. Replacing only the crystal solve the OSD problem in Monitor. A loosen crystal connection in Computer Motherboard could cause the system to 'hang' after running for sometime.



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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, it's a 50-50 chances whether it will function again.

Though crystal 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

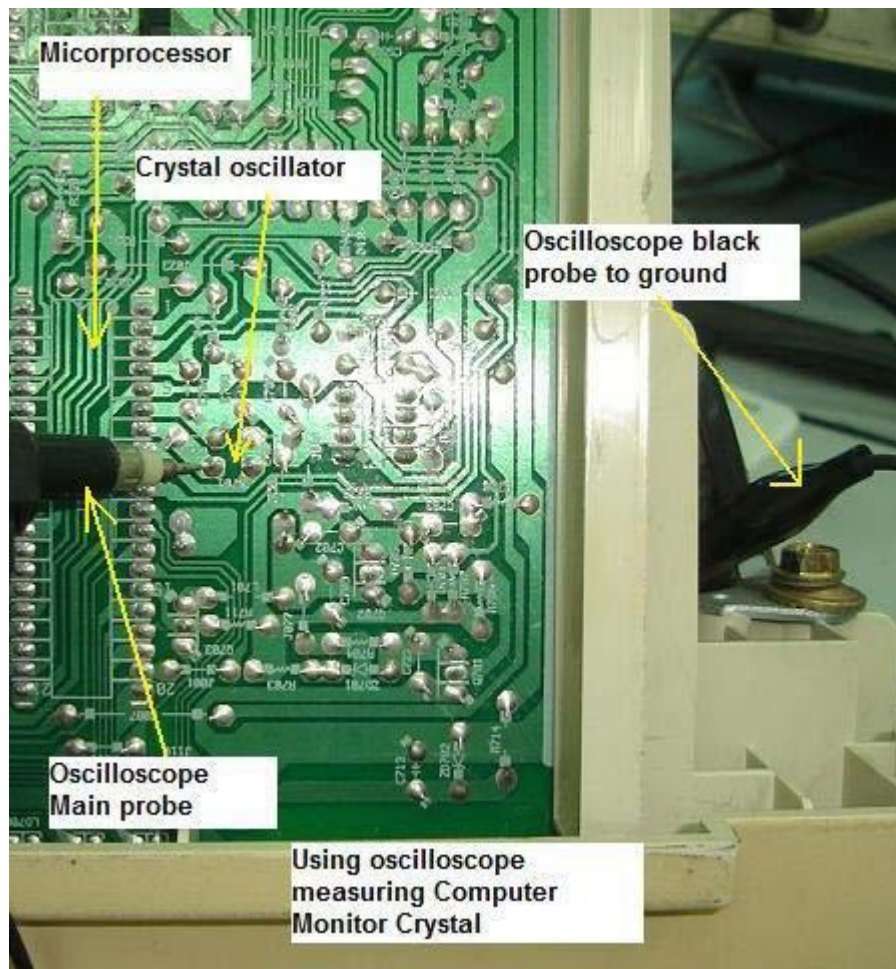
Testing the crystal is not a breeze either. You cannot just take out your trusty meter and test the crystal in it. In fact, there are three methods to test a crystal: -

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 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.

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

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A crystal oscillator sinewave



How to measure crystal frequency with oscilloscope

Second method is to use 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's mean place the black probe to cold ground and the red probe to the crystal pins. Make sure your frequency counter meter has the range that is higher than the crystal frequency you are checking.

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 then you know that the crystal is not functioning well and need to be replaced. Normal digital multimeter usually has a small range for checking frequency. However the digital meter (Greenlee

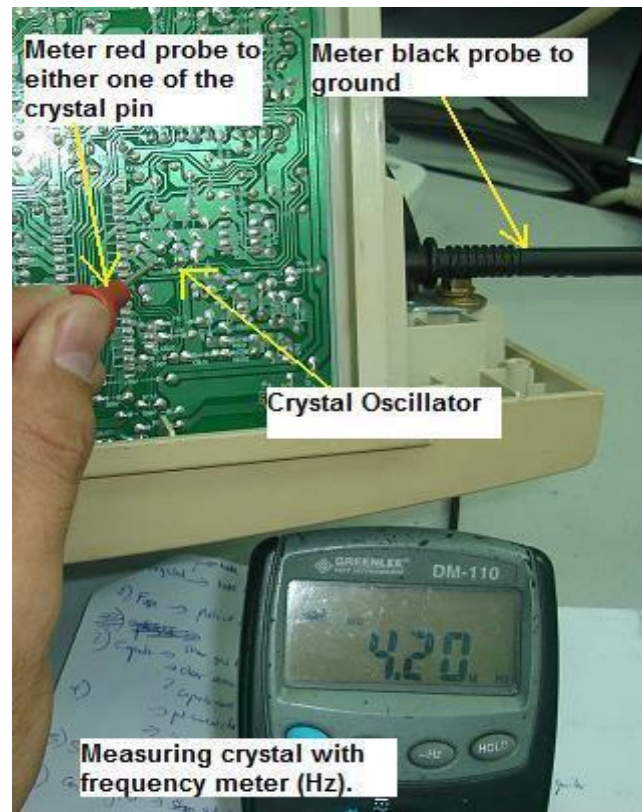
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brand) that I'm using is able to measure up to 24 MHz. You can read the specification of your meter manual and see how high is the range is.

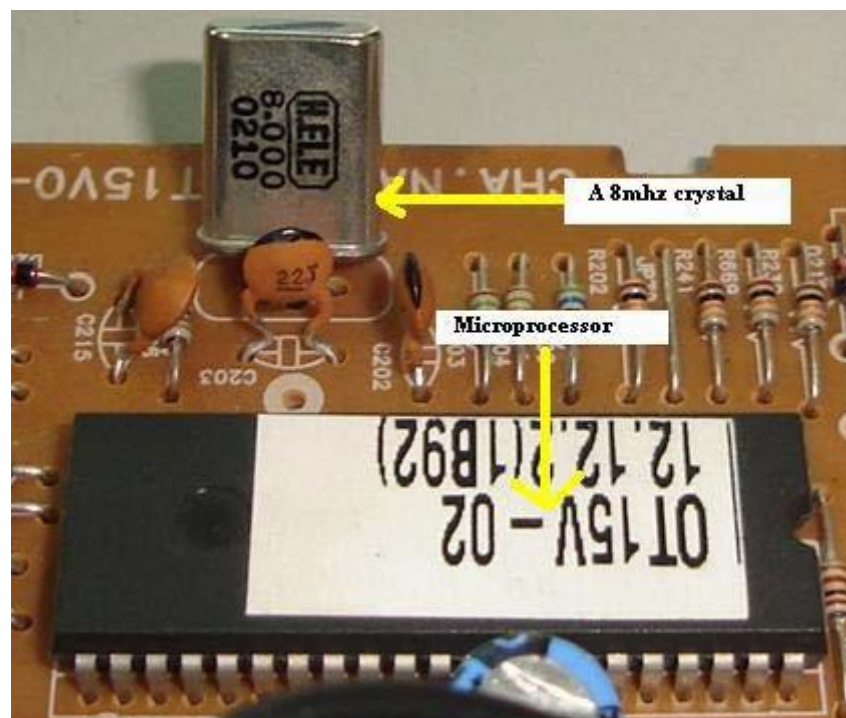


Frequency counter in a digital multimeter

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The right way to test crystal oscillator in electronic equipment

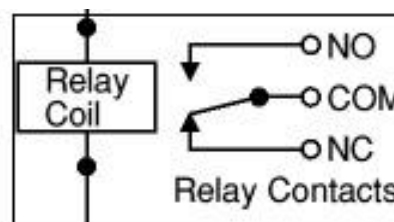


A Crystal oscillator and microprocessor (CPU) in a main board

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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 goes off. Instead of using LED as indicator, some other expensive crystal checker uses a panel meter to indicate if the crystal is functioning or not. If you search crystal information on the internet, you will find some websites that provides tips on how to test crystal as well as how to build one. You may build simple crystal tester by going to this website:

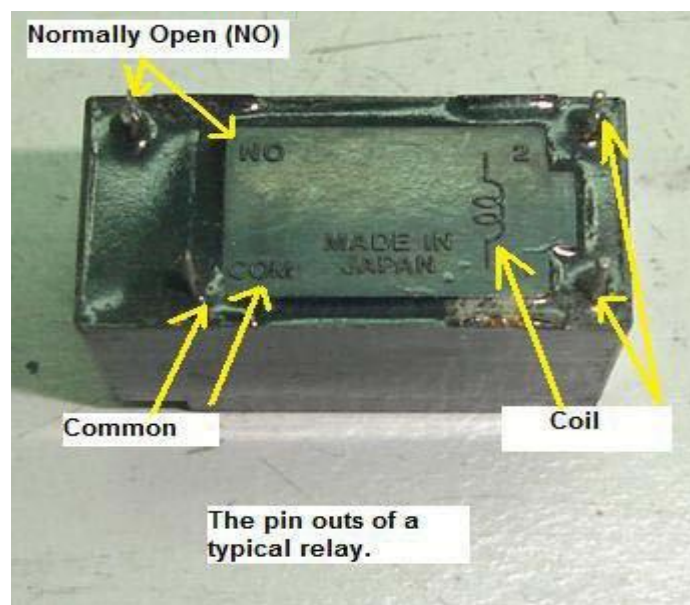
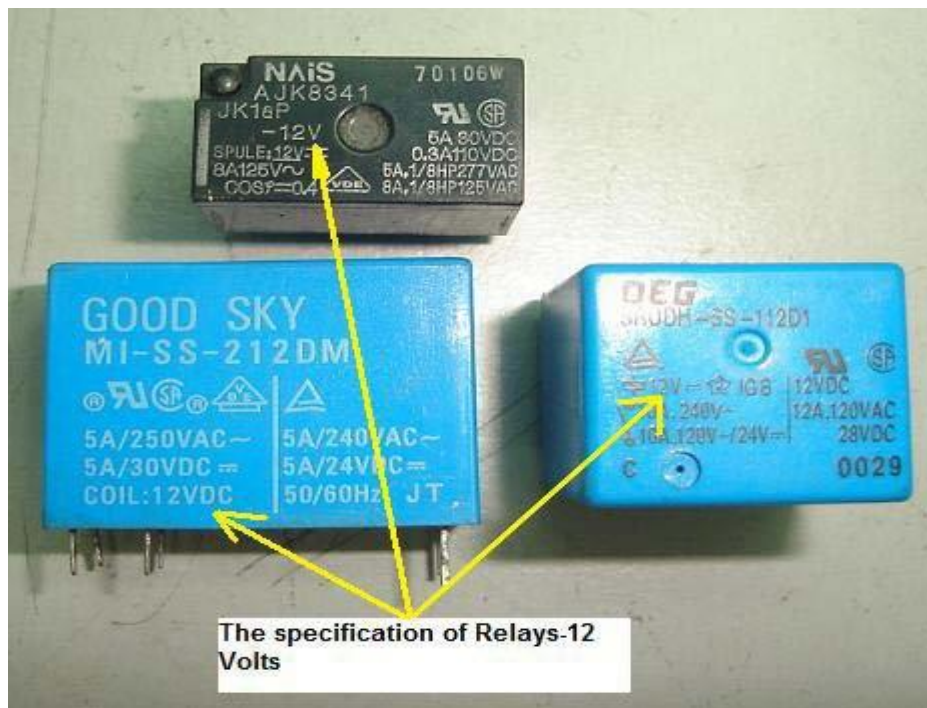
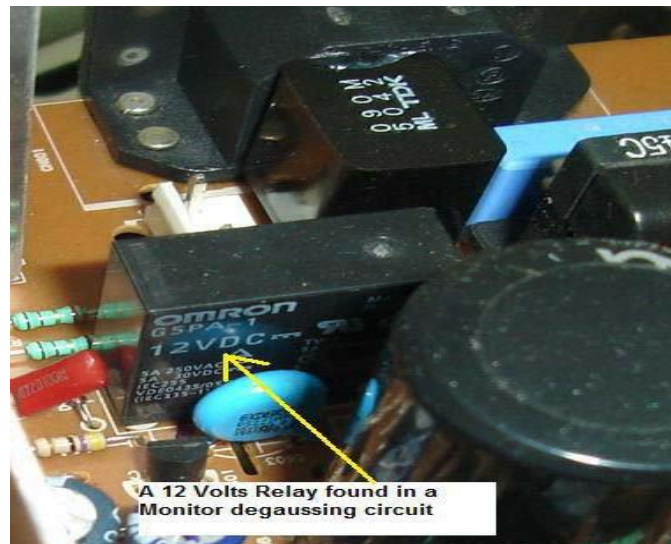
Testing Relay



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 relay normally are 5V, 12V, 18V, 24 V and etc and with amperes rating too. All these specification you could see printed on the relay body as shown in the photo below.

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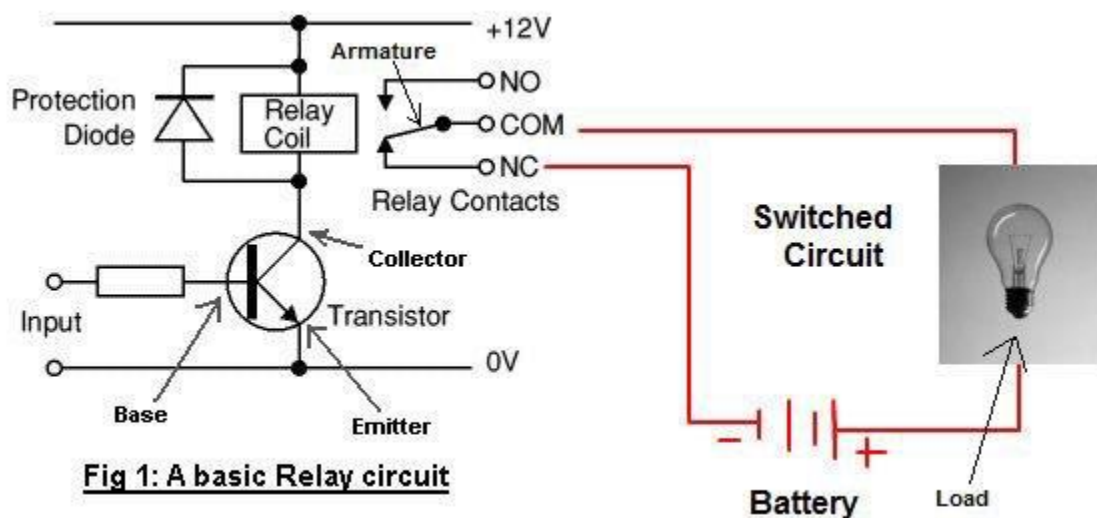
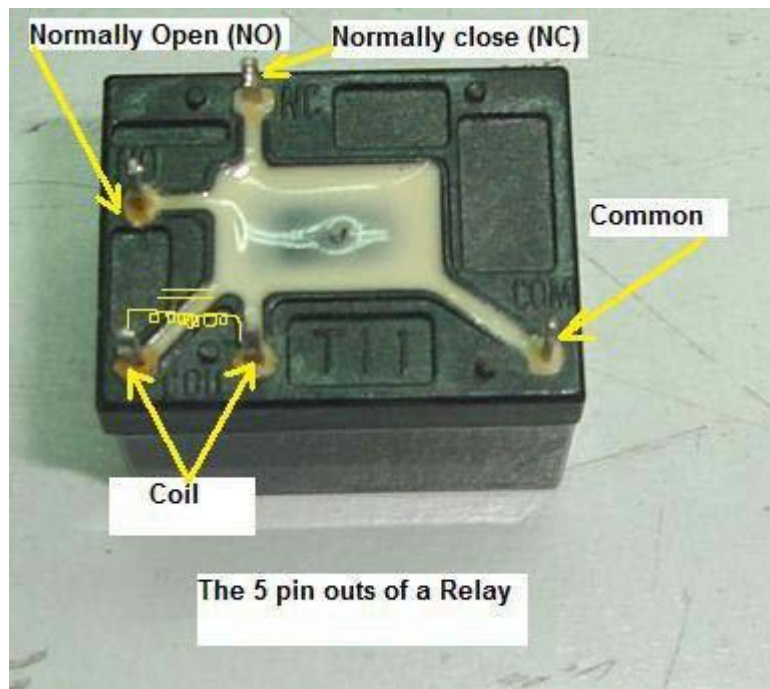


Fig 1: A basic Relay circuit

Figure 1 show a basic relay circuit. If there is an input signal going to the base of transistor, the transistor will conduct and the 12V will flow through the relay coil, the collector, out from emitter and to ground (0V).

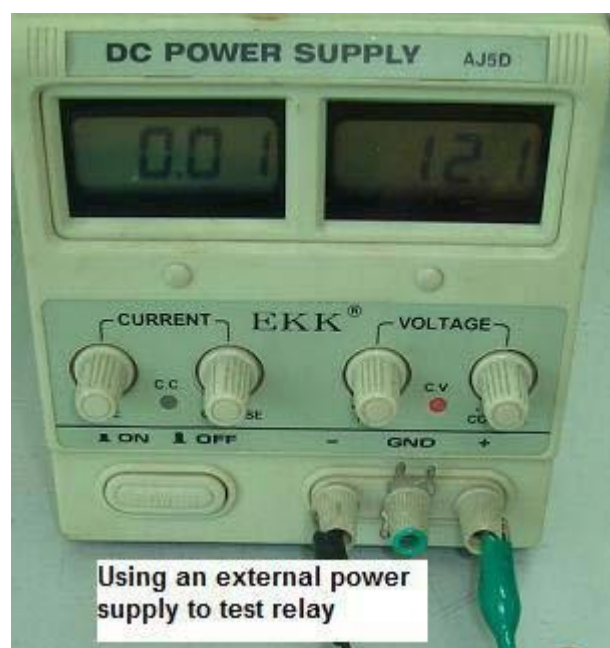
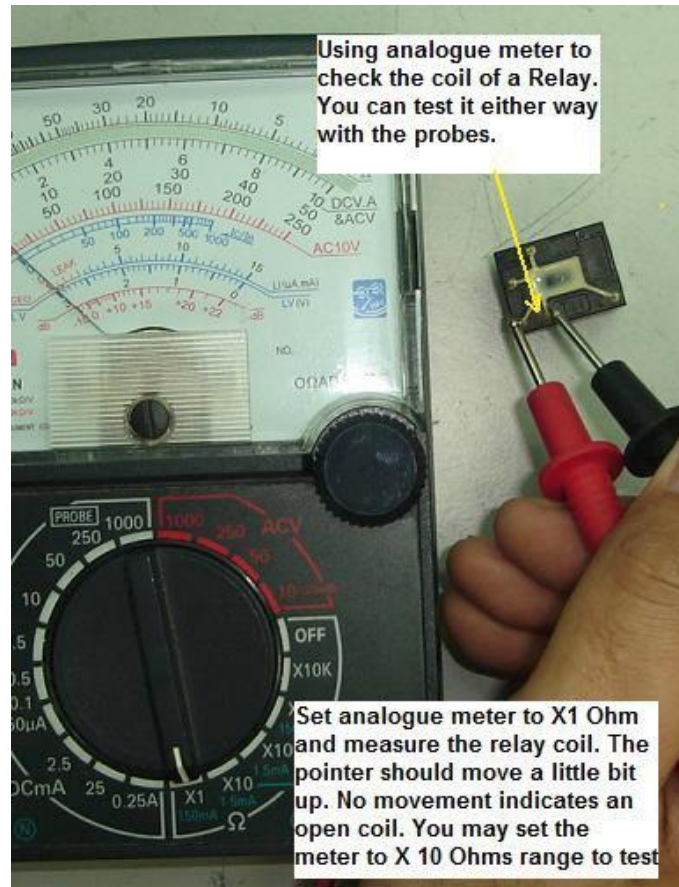
This will energize the relay coil and cause the armature to switch from the “normally close (NC)” to “normally open (NO)”. When the armature in the “normally open (NO)” state, no current will flow to the lamp (load) and the lamp will go off.

There are two steps to test relay, first use your analogue meter set to X 1

Ohm and place across the relay coil as shown from the photo in next page. This is to

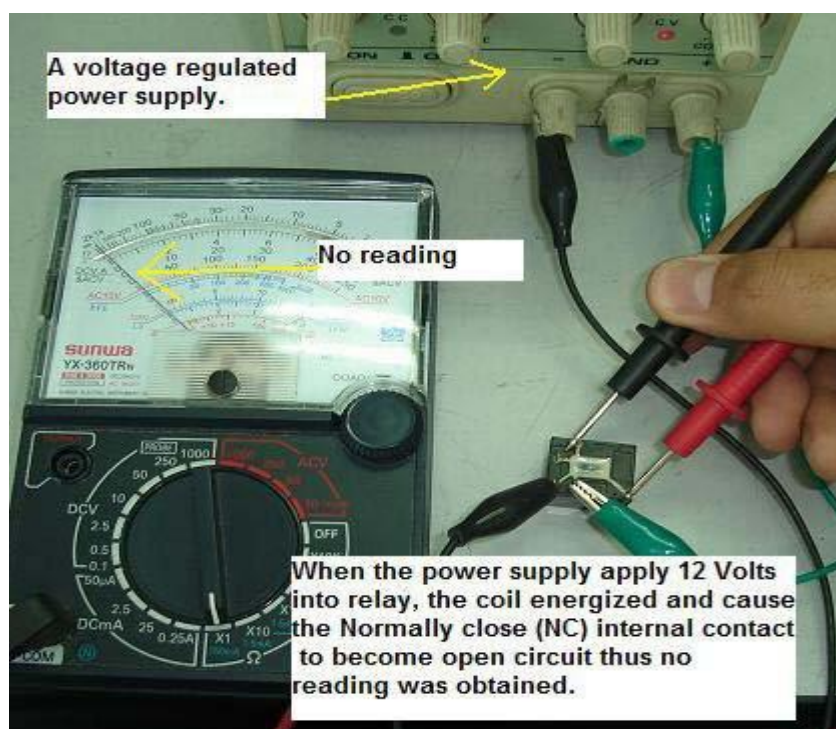
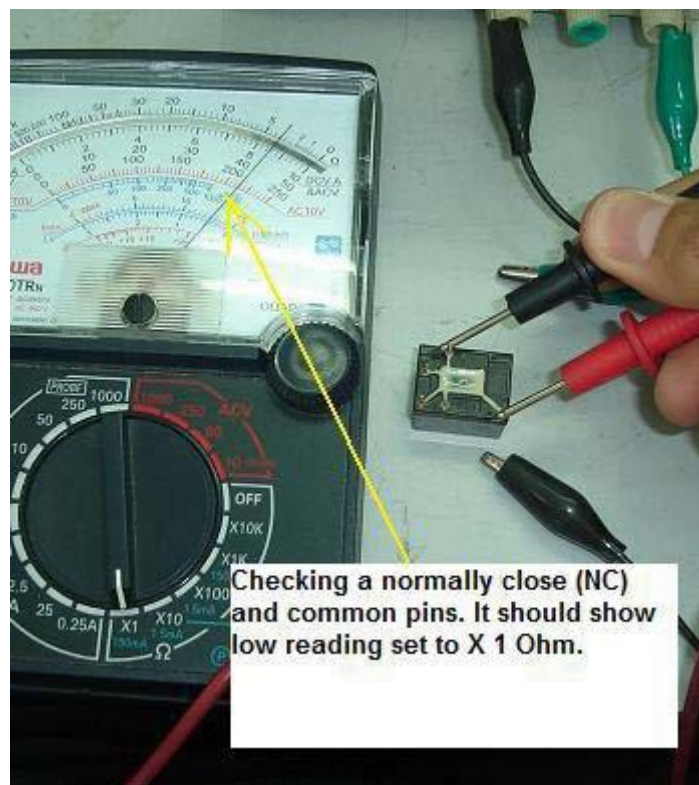
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make sure that the relay coil is not open circuit. If it opens circuit there will be no reading registered at your analogue meter. A good coil should show resistance.

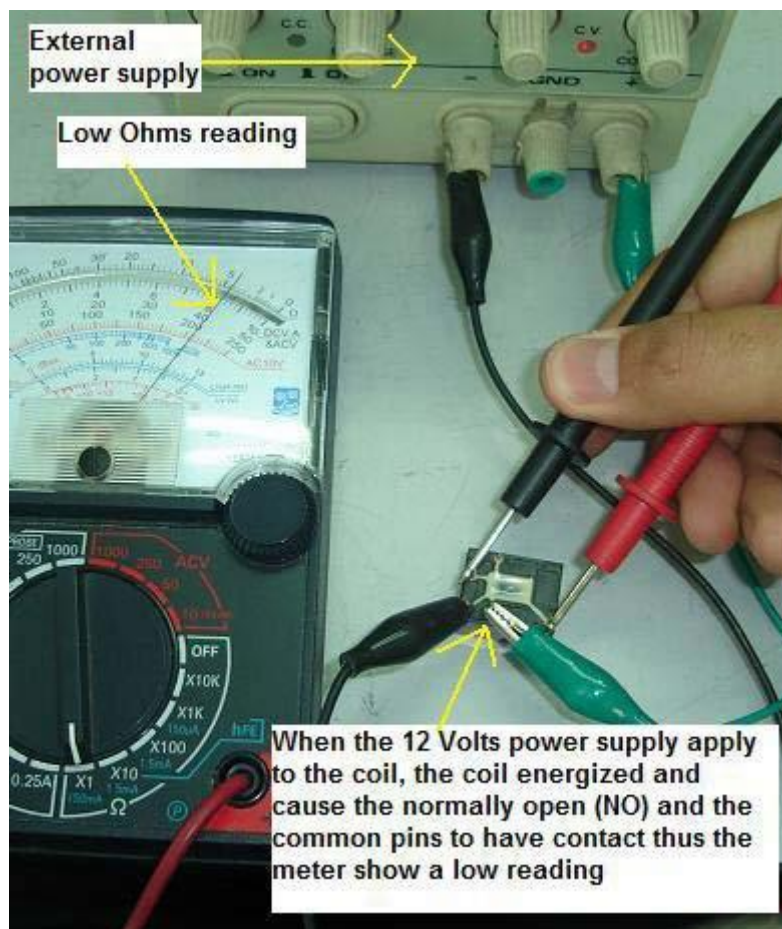
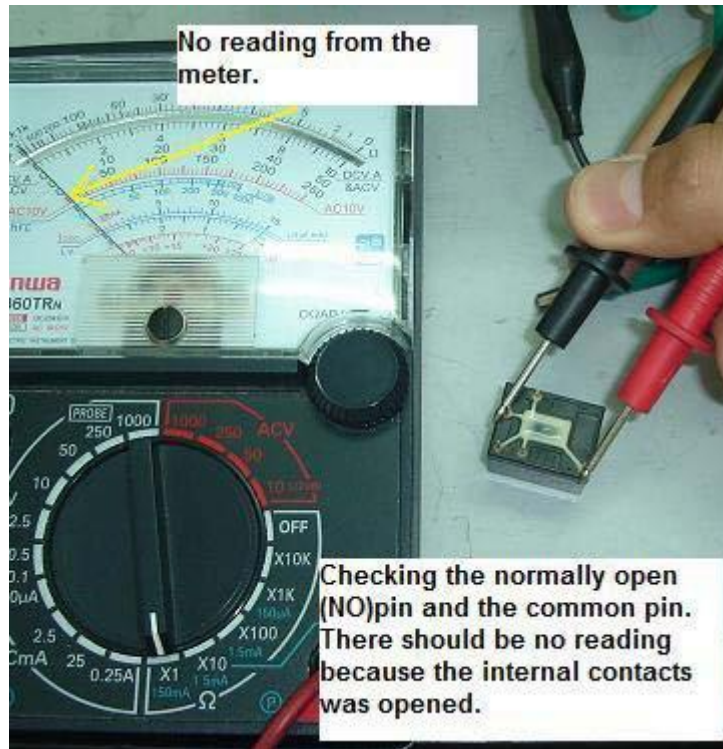


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The next step is to connect a power supply across the relay. Use a variable regulated power supply to adjust to the same voltage as what there lay can handle. That's mean; if the relay specification is 5V then you adjust the power supply to 5 V. Any voltage higher than 5 V will burn the relay coil. Now connect either the positive and negative alligator clip to the relay coil. When the relay coil have 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!



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If you place your analogue meter probes set to X 1 Ohm across the “common (Com)” and the “normally close (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 the infinity to zero Ohms (indicating close circuit).

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