# Learning resource

## **Demonstrate knowledge of electrical test instruments and take measurements** (level 2, credits 2)

Trainee Name: ______________________________________________

# Contents

# Introduction

Obviously, you can't see electricity, yet you may work with it every day. It is such a useful form of energy yet so dangerous.

Being able to safely and accurately use test instruments is crucial to you in your work in the electrical industry. You will rely heavily for your safety and wellbeing on test instruments to keep you safe, your life will depend on your instruments.

Your life will also depend on your understanding of electrical instruments and using them safely.

Unless you are able to use electrical test instruments correctly and accurately, you will find it very difficult to locate faults in installations or appliances.

You will also be required to test installations or appliances on completion of any repair in order to be able to provide an electrical safety certificate to the owner or operator.

The electrical quantities you will normally measure are current, voltage, resistance and power. In this unit we will cover a basic understanding of test instruments and talk about how to use them.


*Photo by Graeme Jeffrey*

# Learning objectives

At the conclusion of this module the trainee will be able to make basic electrical measurements of voltage, current, resistance, continuity, and insulation resistance, which includes being able to:

- Demonstrate knowledge of electrical test instruments; and
- Select and use four electrical test instruments.

# Analogue Vs digital instruments


Photo by Graeme Jeffrey

There are essentially two types of measuring instruments, analogue or digital.

As you no doubt know, most modern meters are the digital type and you have probably seen plenty of these.

A digital meter provides the reading in an alphanumeric format. Digital displays are available in either Light Emitting Diode (LED) types, or Liquid Crystal Display (LCD), generally, measuring instruments use LCD digital readouts.


Photo by Graeme Jeffrey

Analogue meters have a scale and a pointer that moves. There are two main types of analogue movements, the moving iron meter, and the moving coil meter.

## Moving iron meters

This is the simplest form of meter. It will operate on either AC or DC. It is robust in construction and can withstand vibration and shock well. It consists of a coil of wire that surrounds two pieces of iron. One piece of iron is fixed and the other attached to a spindle with a pointer mounted on it.

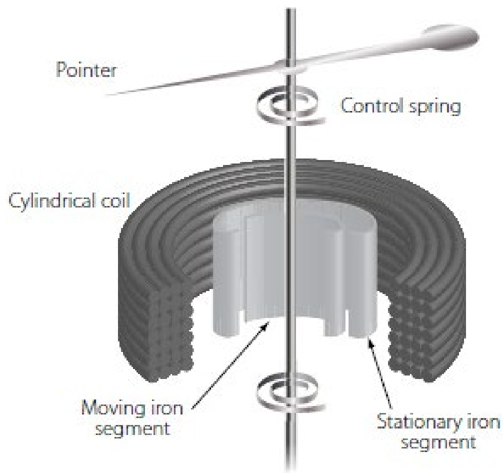
When current flows through the coil, it produces a magnetic field, which induces magnetic poles in the two pieces of iron.

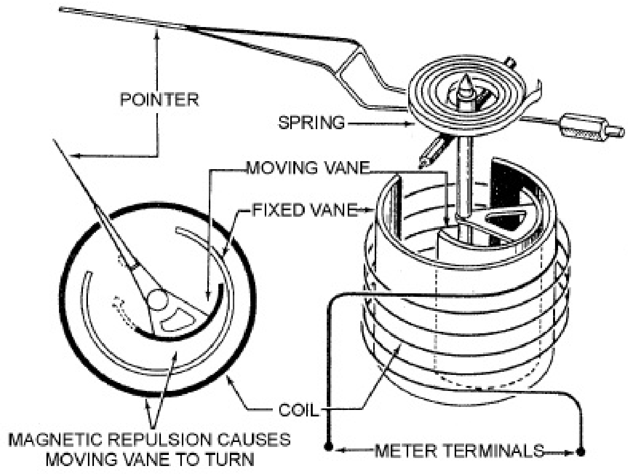
As the induced magnetic poles are the same, the two poles will repel each other forcing the two pieces of iron apart.

Since the one piece of iron is fixed, the movable iron will move on the spindle - turning the pointer with it and so deflecting the pointer across the scale.

The higher the current, the greater the deflection of the pointer.

The turning motion in a moving iron meter is not linear (not directly proportional to the current being measured), so the markings have to be closer together at the low end of the scale, with the distance between markings becoming further apart at the high end of the scale.



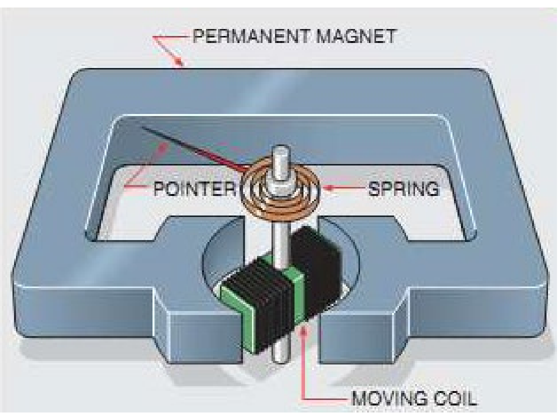



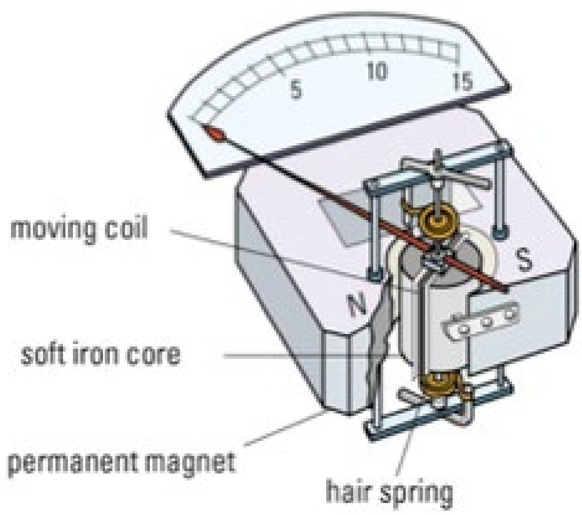

## Moving coil meters

A moving coil meter has a small coil of wire with the pointer fixed to it, and this is mounted onto a pivot, and then placed in a strong magnetic field provided by a permanent magnet.

When current passes through the coil, a magnetic field around the coil which magnetically reacts with the permanent magnet. This reaction causes the pointer to move across the scale.

Since the magnetic field strength is directly proportional to the current flow, the movement of the pointer will be linear. This type of movement is the most suitable for the measurement of circuit voltages.



Moving coil meters are polarity sensitive and will drive backwards if connected to a circuit incorrectly.

This can damage the meter. Also, AC will cause the meter to move in both directions, so in order to use this type of meter for AC measurements, a rectifier must be included in the circuit.

It is important to remember that analogue meters are sensitive, and that excess current or voltage will provide incorrect readings at best or destroy the meter at worst.

Since such meters can only carry a small current, we insert resistors either in parallel (shunts) or in series (multipliers) with the meter.

We call this meter extension, and this means that we are able to use the meter on a range of values rather than just one fixed maximum value.

The shunt resistor ensures that a definite proportional small amount of the current passes through the meter, with the rest diverted through the shunt resistor or resistors.

This works on the Kirchhoff's current law principle, where we divide the total circuit current into branch currents dependent on the parallel resistance paths.

We use this method to extend the range on ammeters.

A multiplier resistor (or resistors) on the other hand, drops some of the voltage prior to the meter to ensure that only a set portion of the voltage is across the meter itself. We use this method to extend the range on voltmeters.

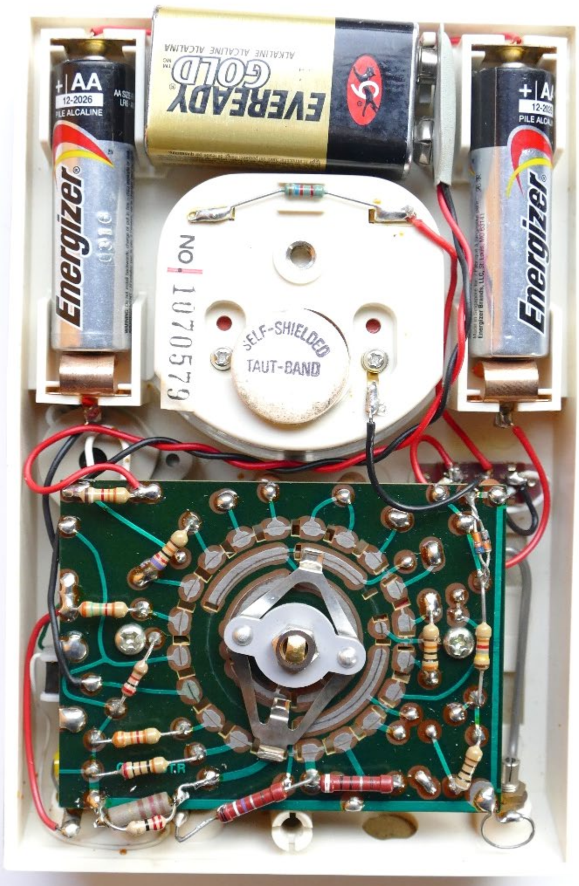



*Photo by Graeme Jeffrey*

# Multimeters


Photo by Graeme Jeffrey

A multimeter is a device that has many testing functions available in one unit. Such functions may be the measurement of voltage, current, resistance, impedance, diode testing and capacitance just to name a few.

The features available on the meter depends on the brand or model chosen.

A multimeter generally consists of:

1. A display meter.
2. Function/range switch and corresponding function/range control circuitry.
3. A battery that is switched into the circuit when the ohms range is selected.


Photo by Graeme Jeffrey

On an analogue meter there is more than one scale shown on the face.

When you select a range, you then have to choose the correct scale to read from. There is also often a mirrored band on the face to help you position your eye in the right place.

When reading the scale, move until the reflection of the needle is directly behind the needle, this makes sure you are not looking at the needle from an angle that may make the reading inaccurate.

The digital multi-meter on the other hand has a digital readout to provide the value of the quantity that you are measuring.

A switch selects whichever instrument function is required on the multimeter.

A lot of modern meters have auto ranging, this is where the meter samples the input and automatically adjusts the range and scale used to give the most accurate reading.

If the meter is not auto ranging, you will have to choose the range to suit the maximum reading.

If you do not know the value of the reading you are likely to get, always start with the highest scale and then once you have established the magnitude of the reading, adjust the scale down to suit the magnitude and to give you a more accurate reading

**Note**

Some meters will not cope if you change scales while they are connected to a live circuit. It is good practice to remove the meter from the circuit while changing scales.

# Types of meters and their use

There are many different types of test instruments and many variations of the same type of meters from all sorts of manufacturers.

You need to get to know the meters you will use regularly, but you will also need to be able to pick another meter up and successfully use it to take measurements.

## Measurement of electrical circuit values

As an electrical worker, you may need to become proficient in the use of the following instruments:

- Multimeter (Voltmeter, Ammeter, Ohmmeter)
- Insulation Resistance Tester
- Clamp meter / clip-on ammeter
- Earth Loop Impedance tester
- Residual Current Device (RCD) tester
- Portable Appliance Tester (PAT)

You may also need to use a:

- Thermal test instrument
- Phase rotation meter


Photo by Graeme Jeffrey

Before using any meter, you will need to become familiar with its scope and operation. You should study and follow the manufacturer’s instructions to avoid damage to the meter.

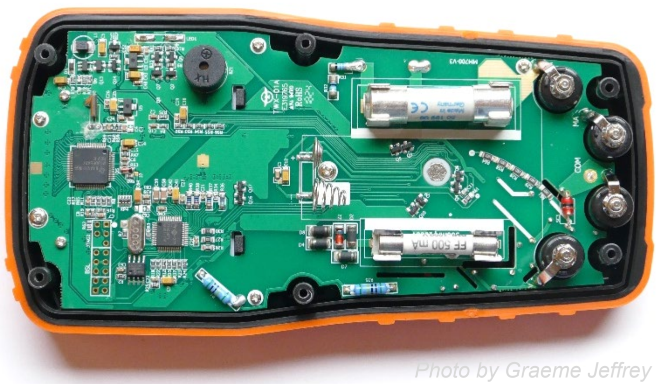


Photo by Graeme Jeffrey

While meters can have many combined functions the primary functions of some test meters are shown here:

| | AC voltage | DC voltage | Current | Prospective short circuit current | Resistance | Impedance | Insulation resistance | Earth leakage current | RCD disconnection time | Heat | Phase order |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Multimeter** | ✓ | ✓ | ✓ | | ✓ | | | ✓ | | | |
| **Insulation tester** | | | | | ✓ | | ✓ | | | | |
| **RCD tester** | | | | | | | | | ✓ | | |
| **Clip-on ammeter** (using clip-on function only) | | | ✓ | | | | | ✓ | | | |
| **Earth Loop Impedance tester** | | | | ✓ | | ✓ | | | | | |
| **Portable Appliance Tester** | | | | | ✓ | | ✓ | | | | |
| **Thermal test instrument** | | | | | | | | | | ✓ | |
| **Phase rotation meter** | | | | | | | | | | | ✓ |

# Meter measurement category

Photo by Graeme Jeffrey

Test meters are manufactured to comply with a category (CAT) classification which indicates the level of protection a meter gives the user against voltage spikes or surges that may happen when you have your meter connected to a circuit.

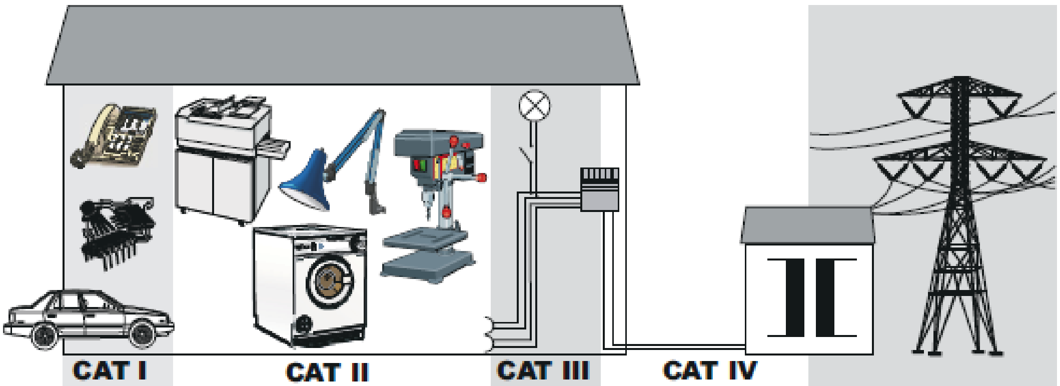
If the rating is not high enough and a fault occurs, your meter may be destroyed and you injured as a result. The higher up the supply chain you are testing, the higher the risk.

A CAT I meter gives the lowest level of protection and they are generally not used in industry. The next level is CAT II, then CAT III and up to CAT IV.

A CAT I meter is only suitable for testing electronic circuitry, CAT II downstream of domestic socket outlets including flexes and appliances.

A CAT III meter is generally accepted as the minimum safety level for testing domestic installations up to the meter box and CAT IV for mains supply cables, supply systems and industrial installations.

Photo by Graeme Jeffrey




As an electrician, you will need at least cat III test instruments and if you are going to work on meter boards and mains, then you should have CAT IV instruments.

The CAT rating includes a voltage rating, a 300V CAT IV meter is okay for a single-phase supply but a 600V CAT IV would be required for a two or three-phase supply.

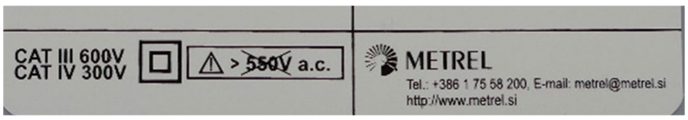


Photo by Graeme Jeffrey

## Meter tolerance

Different meters have different accuracy tolerances. Depending on what tests you are doing, how exact the meter reading is may matter to you.

If you are using a voltmeter to check for the isolation of a bathroom heater before working on it, then you are just really looking for around 230V and then 0V. You are not really needing super accuracy.

If on the other hand, you are doing laboratory testing on electrical equipment, you will definitely need to know how accurate your meter is.

The manufacturers data will tell you the accuracy of a test instrument.

## Meter calibration

Test instruments need to be working properly. What they do is often complex and delicate but they operate in a rough and tumble work environment.

While you need to take good care of your test instruments, even the best ones may, for one reason or another, go out of calibration.

As far as possible, you should be checking your test instruments for calibration from time to time and getting them properly calibrated by a certified laboratory periodically, in line with your company policy.

There are some simple field health checks on some meter functions such as:

- Comparing readings between several meters.
- Comparing readings against a recently calibrated meter.
- Checking readings on a known circuit.
- Using a voltmeter to check the output of an insulation resistance tester.
- Using a variety of known resistors to check resistance readings.
- Touching the leads together on ohms scale.

A meter that has officially been calibrated should have a calibration label attached to it or with it.


Photo by Graeme Jeffrey

## Meter condition

Obviously, as you rely on a meter to stop yourself and other people dying, not only should you treat your meters with care, but you also need to store them correctly where they will not become damaged.

If a meter is broken, showing signs of abuse, in general poor condition, has been too hot or is wet you should not use it.

Meter leads need to be in good condition and the insulation intact.

# Measuring with meters

When taking measurements, you must connect meters into the circuit in a specific way to enable you to measure correctly.

1. Ammeters are connected in series with the circuit.
2. Voltmeters are connected in parallel with the load, or across the supply or component.
3. Ohmmeters are also connected in parallel with the component that is being measured; and
4. A multi-meter, which can measure current, voltage and resistance (and more) is connected as if it was either and ammeter, voltmeter, or ohmmeter, depending on which test you are doing.

When taking measurements with an analogue instrument, remember that these instruments are sensitive to polarity. A digital instrument will provide a reading as well as a symbol indicating the polarity of the circuit, the moving coil analogue meter will not.


Photo by Graeme Jeffrey

## Analysing results

The selection and use of the appropriate function and range on a meter is important when testing or measuring quantities. Failure to do so will certainly result in inaccurate or incorrect readings.

You should also be aware of the following situations and consequences:

1. Incorrect selection of the appropriate meter for the task.
    a. At best, you may get an inaccurate result, or you will not get an appropriate test result such as using a multimeter set to ohms to do an insulation resistance test.
2. Incorrect selection of function and/or range on the meter.
    a. An incorrect result or no result at all.
3. Incorrect connection to the circuit such as connecting an ammeter in parallel.
    a. It may create a short circuit. This may blow the fuse or damage the meter.
4. Reversed polarity – having the positive and negative around the wrong way.
    a. For an analogue meter, the needle will try to move backwards, and the meter may be damaged.
    b. For a digital meter, a negative symbol will display.
5. Use of a multimeter with a broken test lead or an open circuit fuse.
    a. It will produce, a reading of zero volts or amps which could fool the user and lead to an electric shock.

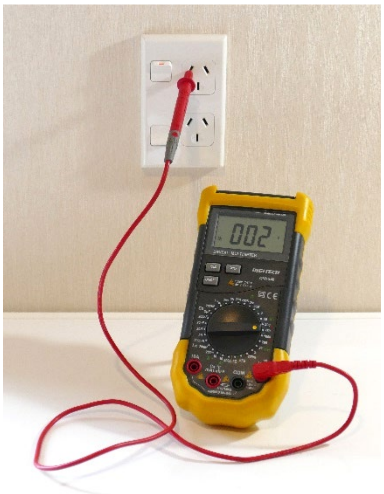


Photo by Graeme Jeffrey

> **Note**
>
> A broken lead is even worse than trying to use one lead to test for voltage, it might fool you into thinking all is well.

6. Use of an Insulation resistance tester with a broken lead.
    a. It will produce an out of range reading (very high resistance) which could be incorrectly presumed to be a correct reading.
7. Meter reading lock/hold on.
    a. The last reading taken will be continuously displayed. This may be confusing or dangerous if that reading was zero volts for example.

Any of these mistakes will result in inaccurate or no readings, which could be taken to indicate no voltage, no current or an open circuit.

Any assumption such as this on your part may well lead you to believe that the circuit is safe and that you can work on it, or that there is a fault when no such fault exists.
Any of these assumptions could place you in personal danger.

# Prove test prove to confirm isolation.

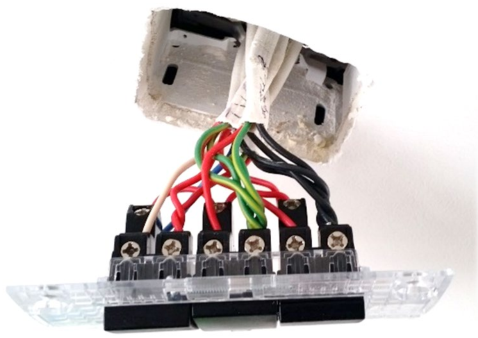


Photo by Graeme Jeffrey

When using a meter to ensure a circuit is isolated before you work on it, it is very important to confirm that your test meter is working properly so that you can trust the results of your tests.

Having isolated a circuit, you need to test the circuit before touching it.

You need to properly test that all the equipment and conductors of the circuit are dead. This is to make sure that every conductor is safe to touch before you start working on it.

Testing for isolation must be done with a suitable test instrument with a correct rating and category.

Things can go wrong, and it is often when problems combine that people get caught out.

When there is a disaster, it is often when two or more factors come into play which turn an everyday situation into a death trap.

There are a number of instances where parts of the circuit may still be energised, for example:

- The circuit is wired incorrectly.
- The isolation switch is not in the phase conductor.
- The wrong circuit has been isolated.
- The wrong switch, fuse or circuit breaker has been operated.
- As the equipment is pulled away from the wall, a cable contact fault is created.
- Damaged insulation or bad termination causing intermittent contact between two conductors, one from another live circuit.
- The appliance or equipment is supplied from two sources, or there are live conductors present from controls such as:
    - ☐ Thermostat switches
    - ☐ Control sensors
    - ☐ 3 plate ceiling roses
    - ☐ Limit switches
    - ☐ And many more possibilities

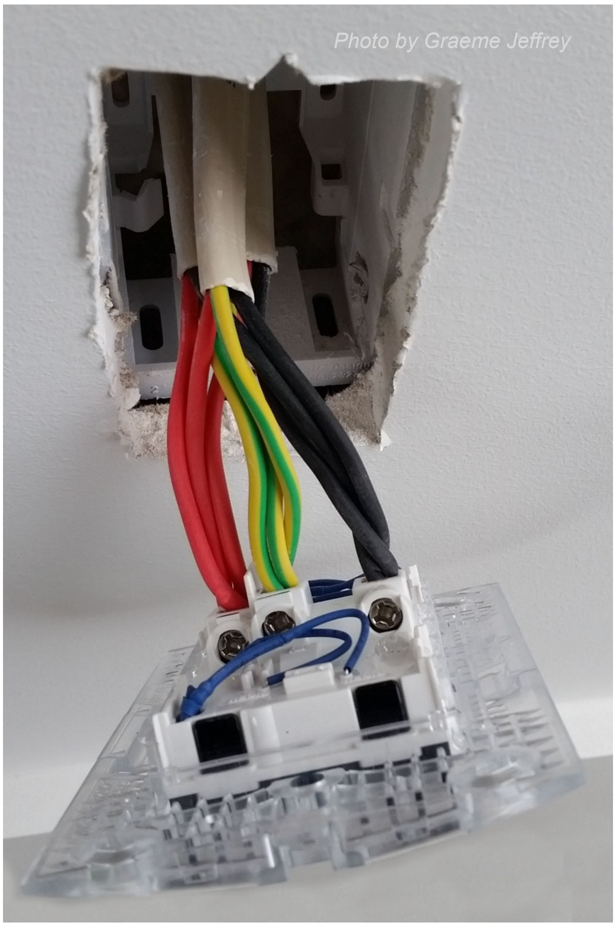
**Remember the two 'Golden rules'**

1. Test before Touch – always test electrical wires are not live before you touch them.
2. Prove-Test-Prove
   a) Prove the meter works on a known supply.
   b) Test for Isolation (and get 0V).
   c) Prove the meter still works on a known supply so you know your meter hasn't failed during the test.

Proving is done by using the test instrument on a live circuit to check that it is working properly and observing the correct measured voltage is displayed.

The reason for this is to prove that the meter is working at the beginning and still working at the end of your testing. You can then be confident that your test result is reliable.

You must check every conductor is not live, it doesn't take long.




**Single phase isolation test procedure:**

(a) Prove the meter is working.
(b) Test phase to neutral.
(c) Test phase to earth.
(d) Test neutral to earth.
(e) Prove the meter is still working.

# Inserting a meter into a circuit

Using a test instrument on a circuit needs to be done carefully and safely, especially if it is live. This is a normal daily function of most electricians and you need to be competent and confident in the use of meters and testing circuits.

## The Voltmeter

When using a multimeter for a voltmeter, ensure that the correct type of voltage is selected, AC or DC and that the voltage range selected is higher than the expected voltage.

Photo by Graeme Jeffrey

**Warning:**

A multimeter incorrectly set to DC while reading AC may give a zero volts or incorrect reading that may not indicate that the circuit is dangerously alive.

The nominal supply for a single-phase electrical circuit or appliance is 230 volts alternating current at 50 cycles per second, i.e. 230V AC 50 Hz.

The nominal supply for a three -phase electrical circuit or appliance is 400V AC 50 Hz.

To measure voltage, connect the voltmeter across the beginning and the end of the electrical circuit that you are going to measure (connected in “parallel to the load).

To measure the voltage of a DC circuit, the red probe is always connected to the positive side of the circuit.

When measuring voltage on an AC circuit, either probe, red or black, may be connected to the phase side of the circuit, but good practice is to use the red for phase.

While it doesn’t affect the result, it is good practice and when it does matter, you will be in the habit of getting it right without thinking about it.

## Other voltage testers

There are a variety of hand-held voltage testers available, while some are designed to simply give an indication of the presence of voltage, some have quite a few other functions.

Photo by Graeme Jeffrey

The type of handheld tester shown here, are great for daily use indicating the amount and presence of voltage rather than accurate measurement of quantities.

They are convenient as they don't require three hands to use like a multimeter and you can see the meter while looking at where you are putting the probe. They have the option of high impedance testing that does not trip RCDs and a higher load mode which can be used to trip RCDs and deal with "phantom" voltage readings.

There are essentially two types of line testers, which are:

1. Solenoid operated, which when a voltage is measured, the internal solenoid will react, and provide an indication of the voltage.
2. Digital type, which utilise solid state circuitry to drive a number of light-emitting diodes, or liquid crystal numerals.

## Non-Contact Voltage detector

Non-contact voltage testers are great for finding circuits, indicating that a conductor is live, and they should be part of any electrician's instrument set.


Photo by Graeme Jeffrey

They are usually suitable for detecting a range of AC voltages without requiring any physical contact with the conductor.

But… they are prone to not indicating occasionally, being affected by surrounding magnetic fields and sometimes their batteries going flat without you knowing. They are not suitable to *ensure* a circuit is isolated.

By all accounts, use one to your advantage, but don't rely on it to ensure isolation.

# The Ammeter

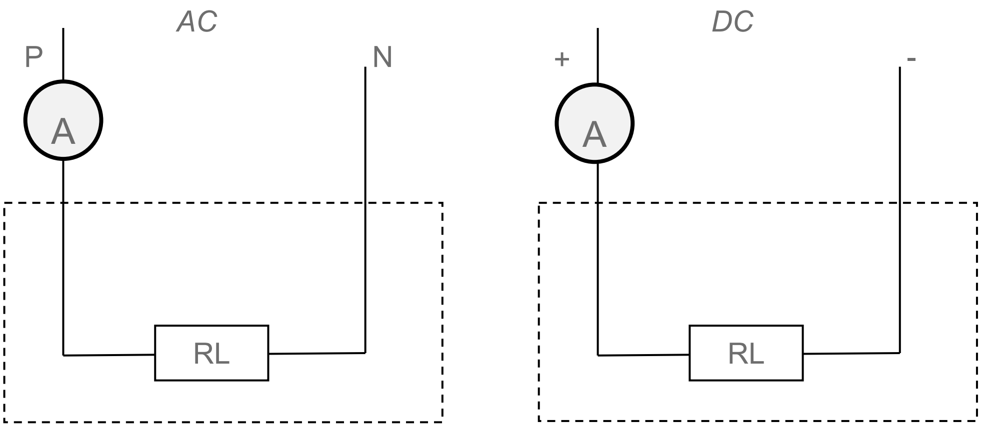
We use an ammeter to measure the value of current in an electrical circuit.

**Note:**

Current is one of the most dangerous types of readings you will take, especially with a multimeter. You must be very careful to have the meter set up correctly.

To measure current flow in amps or milliamps, it is necessary to insert the ammeter into the circuit so that it becomes part of the circuit, (connected in "series" with the load).

It must carry the current you are measuring in the circuit.




The current range selected should be such that the expected current reading would deflect the needle on an analogue instrument to about mid-scale.

When using a multimeter to take current readings, there are often options as to where you plug in the test leads.

Make sure you plug the leads into the correct sockets for the amount of current that will be flowing in the circuit you are going to test, and for the range you have selected.

**Warning:**

After taking a current reading with a multimeter, for safety, get into the habit of returning the leads and settings back to voltage.

While we all should be being very careful when connecting a meter to any circuit for any reason, this will leave the meter in its safest configuration and help prevent accidental short circuits, damage to the meter and potentially, injury to you.

# Clip on or clamp meter

Clamp meters / clip-on ammeters (clamp amps) are absolutely fabulous.

They have a jaw that surrounds a current carrying conductor. This is used to measure the magnetic field around the conductor and indicates the amount of current producing that field.

These meters can also have a range of other functions making them a very useful multimeter.

Clip-on ammeters take away the danger of inserting an ammeter into a circuit and don't require the circuit current to flow through the meter.

They also allow the measurement of high current safely with a small instrument.

To use a clamp meter, normally only one conductor is measured.

- Two phase conductors on the same phase could be measured successfully, but if you put the meter around phase and neutral of the same circuit, the opposite current direction produces magnetic fields that cancel each other out and you will not get a reading.
- Reading two different phases will not give an accurate total current reading because of the phase angle difference.

Photo by Graeme Jeffrey

Set the meter to the appropriate range and clip it over the single conductor you would like to measure the current flow in.

This can be any single conductor including neutral or earth conductors.

Clamp meters also often contain a hold/lock function so that a current reading can be taken in locations where the meter cannot be seen.

Once put on hold/locked, the meter can be removed to a convenient place to see the reading.

If using the lock function, don't forget to unlock the meter again ready for use next time, a locked meter is a trap that has caught out many a sparkie.

# The Ohmmeter

We use an ohmmeter to measure the resistance of an electrical circuit.

Do not use an ohmmeter on live circuits, to take a resistance reading, an ohmmeter has its own battery to supply the voltage required (usually between 1.5 and 9 volts) to enable it to measure the resistance.

Photo by Graeme Jeffrey

An ohmmeter is connected in parallel with the load to be measured.

Current flows from the meter battery, through the circuit you are testing and back to the battery.

The voltage of the battery and the circuit resistance governs the amount of current that flows in the circuit.

The meter indicates the resistance depending on the current flowing in the circuit.

**Important note**

If you put an ohmmeter on 230V for example, you will put 230V across a 1.5 - 9V battery and the low resistance meter circuit.

Can you see that that could be disastrous?

When using an analogue multimeter, for accurate resistance measurements it is necessary to calibrate the meter.

Do this by selecting the appropriate ohm scale and touching the test probes together.

While doing so, adjust the needle to zero with the adjustment knob.

**Note:** If, after calibration, you select a different resistance range, the instrument must be re-calibrated.

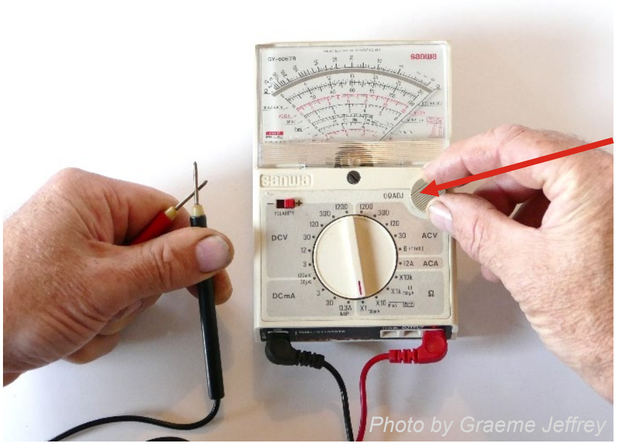
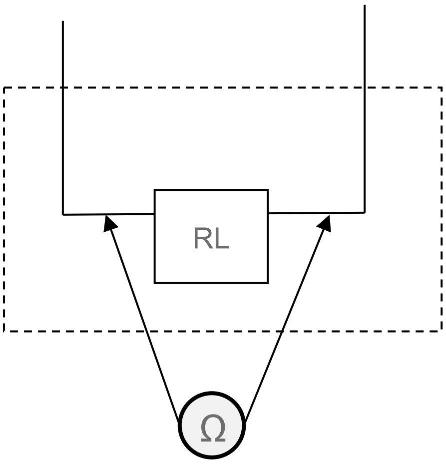


Photo by Graeme Jeffrey

A useful practice is to take readings of typical components of common electrical circuits that you may need to fault find in the future. Record the resistance values from appliances, electrical equipment or components in good order.




This will be helpful when you would like to compare a possible faulty one with what it should be. For example, a 1000 W element of a 230 V water heater has a resistance of approximately 53 ohms when it is in good order.

## Circuit continuity and polarity

If the goal of the test you are doing is purely making sure a circuit is continuous, or that it goes to the right place, you can use a resistance test with an ohmmeter, or the audio continuity function on a multimeter. I

t is convenient as you do not have to be looking at the screen to know you have continuity.

Commercial continuity testers are available and can not only test for continuity but indicate polarity as well.


*Photo by Graeme Jeffrey*

These are only suitable if you do not need to take a measurement of the resistance value. If you have to take a resistance reading, you will need to test as described in the next section.

## Earth continuity

Ohmmeters are used to determine earth continuity. The wiring rules require the earth continuity to be below a certain value of resistance, see AS/NZS 3000 8.3.5.

To test for the value of continuity:

1. Check the meter battery is in good condition.
    - If the low battery warning is showing, or the ohms scale is not zeroing, replace the battery.

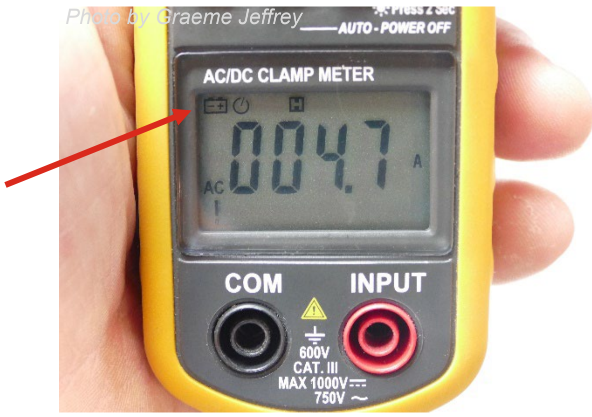



*Photo by Graeme Jeffrey*

2. Set your meter to the lowest appropriate ohms scale and touch the leads together.
   - If the meter is working, the resistance of the meter and test leads should show on the meter. This should be as close to zero as possible.
   - If the reading is not close to zero or showing no connection, check your test leads and the connections. Sometimes the plugs could do with a wiggle down into the meter, or you may have a broken or faulty lead or meter.
3. Once satisfied that the meter and leads are okay, take note of the resistance showing on the meter when the leads are shorted together, or if the meter has a calibration function, zero the meter.
   - If you are needing to use a long "fly" lead to make this test, note the resistance of the complete test lead circuit.

Photo by Graeme Jeffrey

4. Connect the meter to each end of the conductor to be checked.
5. Note the resistance reading on the meter.
   - For a non-zeroed meter, subtract the resistance of the meter and leads (that you noted in point 3 above) from the test result to get the resistance of the conductor you are testing.

To get an accurate reading:


Photo by Graeme Jeffrey

- Make sure that the supply to the device or load is disconnected – ohmmeters have a low internal resistance, and would be destroyed by a voltage of 230 Volts or more;
- Disconnect one end of the circuit under test to prevent current flow and therefore false readings through parallel circuits;
- Zero the meter before using it, to allow for the internal resistance of the meter and the resistance of the leads; and
- Use the lowest possible range, as it will be the most accurate.

# Insulation Resistance Tester


You will use an insulation resistance tester to test the resistance of an insulator. This test is done from one conductor to another, or between conductors and earth.

It is important to get your head around insulation resistance, it can be slightly tricky to understand.

Often there is confusion between insulation resistance and conductor resistance because both tests are testing for resistance. The results are both in ohms, that is true but that is where the similarity should end.

The difference? One is:

- Testing how good the conductor is at conducting current (very low resistance),

And the other is:

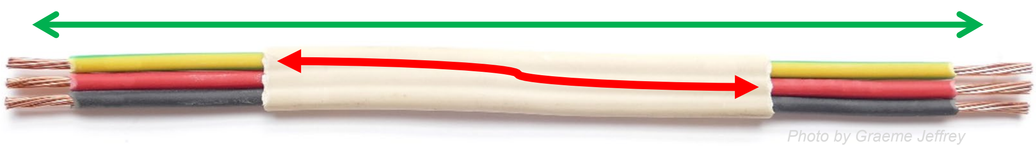
- Testing how good the insulator is at stopping current (very high resistance). Or, how bad an insulator is at conducting - in this case - the bader the better (the higher resistance the better)!

For the earth continuity we want the copper conductor to have as little resistance as possible so that the most current will flow as easily as possible.

Here is a short piece of $2.5mm^2$ TPS from the back of the van. Hopefully it will help to lock in your understanding.

*The copper conductor needs to have very* ***low*** *resistance to boost current flow*

*– this is called the conductor (continuity) resistance (0.1 Ω).*




*The plastic insulation needs to have very* ***high*** *resistance to stop current flow*

*– this is called the insulation resistance (1000 000 000 Ω).*

With insulation resistance, it is the opposite. If the current gets from phase to earth through the plastic for example, then you have a really bad problem. We want the resistance of the (plastic) insulation to be as high as possible - to *stop* current flow.

With an insulation resistance tester, we try very hard to make the insulation leak current by putting at least 500V DC across it see AS/NZS 3000 8.3.6. The insulation resistance tester then indicates how hard the insulation resisted the current flow in ohms, hopefully the resistance was very high.

How high? One million ohms is the least AS/NZS 3000 8.3.6. will accept, and if your test is that low, 1 megohm (one million ohms), then you would be worried about what is wrong. A billion ohms is achievable and would be much better.

## Test the insulation resistance of a socket outlet circuit.

The object of an insulation resistance test is to use DC to stress the insulation of a conductor or electrical equipment, to check that it has a high enough resistance to prevent current flow and to check for damage that may make it unsafe to use.

Depending on the model, an insulation tester usually has multiple output voltage settings that can be selected according to the equipment being tested.

For testing a 400V 3 phase or 230V single phase installations AS/NZS 3000 requires a 500V DC test voltage as a minimum.

Before carrying out insulation resistance tests, you need to check that your insulation resistance tester and batteries are in good condition.

You can check that the output of your insulation resistance tester is correct by connecting a DC voltmeter across the test leads and pushing the test button.

Photo by Graeme Jeffrey

Once you are satisfied that the output is good, you can do a test with the test leads apart and then with the test leads together.

The results should be open circuit (very high resistance) for the first and very low resistance for the second. If yes, then you are good to go.

On a single-phase subcircuit, the insulation resistance tests are carried out between:

1. Phase and earth.
2. Neutral and earth.

It may be necessary to remove the circuit earth from the earth bar to complete insulation resistance testing. If this is done, you must remember to reconnect it and do an earth continuity test after you have.

The minimum acceptable reading is 1 Megohm for any installation, appliance or motor. There are some exceptions where the insulation resistance can be lower, see AS/NZS 3000 8.6.3. Hopefully your result is much higher.

**Caution:**

Circuits in which semi-conductor components are used, for example in RCDs, require special consideration while insulation testing.

Many semi-conductor components will not withstand the higher voltage of an insulation resistance tester and may break down. When testing such electrical circuits, observe the following precautions:

(a) Disconnect semi-conductor components before making an insulation resistance test between phase and neutral; or, if impractical,

(b) Join together both the phase and neutral and then test between this pair and earth.

## Residual Current Device (RCD) Tester

An RCD tester is used to ensure that RCDs operate within their designed values. The tester will let you select the rated leakage current of the device to be tested and will display the amount of current it required to operate, and the time taken.

The purpose of the test is to ensure that an installed RCD will trip fast enough in the event of a fault and therefore prevent electrocution.

The requirements in New Zealand for personal protection are that the RCD, RCBO or RCCB must operate at no more than 30 mA within 300 milli-seconds except when the devices are used in areas of increased risk such as patient care, kindergartens and the like.

The process is:


1. Plug in the tester and set it to the rated current of the RCD
2. Set the test on the test instrument at 0.5 of the RCD's tripping current, push the test button – the RCD must not trip
3. Repeat the test with the test instrument at the RCD's tripping current, push the test button – the RCD must trip in 300 milliseconds or less
4. Repeat the test again with the test instrument at 5 times the RCD's tripping current, push the test button – the RCD must trip within 40milliseconds
5. Repeat the tests at a phase angle of 180˚.

# Earth Loop Impedance Tester

Also known as an earth fault loop impedance (EFLI) test, this test is required for socket outlets that are not RCD protected, see AS/NZS 3000 8.3.9 for more details.

The idea of the test is to check the impedance of the “loop” in which the fault current has to flow, (including the earth conductor) when an earth fault occurs.

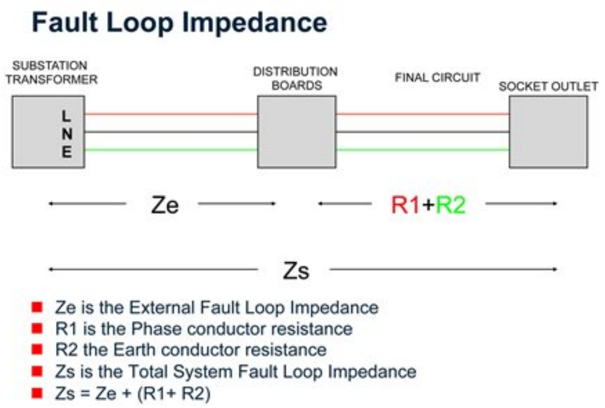
When an earth fault happens, it is important that the fault “pulls” heaps of current through the protective device - to cause it to trip. The EFLI needs to be low enough to cause heaps of current to flow.

This is all about protecting people by stopping the voltage on bare metal getting high enough to cause injury to someone touching it at the time of an earth fault.

When an earth fault loop impedance test is done, the result can be compared to AS/NZS 3000 table 8.1 to check if the result is okay.

If the result complies, then during an earth fault, the protection device will have enough current flowing through it to trip within the times set out in AS/NZS 3000 5.7.

The value of resistance that we are testing for is the Zs.





If it is a Type B, C or D circuit breaker, we need an earth loop impedance which is low enough to ensure that these circuit breakers operate within 400 milliseconds (0.4 seconds).

To perform the test, (depending on the instrument) plug in the instrument, set the range to the correct setting and press test, then record the result.

Compare the result to the required measurement from AS/NZS 3000 Table 8.1.

# Thermal Test Equipment

When things are going wrong in electrical equipment, often, the result is heat. Current flowing through resistance causes heat.

Thermography is a non-destructive test method that is used to detect heat created by poor connections and loose terminations, overloaded cables and equipment and other things like overheating motors or motor bearings in which friction is causing heat.

In its simplest form, an infrared thermometer reads thermal radiation (sometimes called blackbody radiation) emitted by the object being measured.

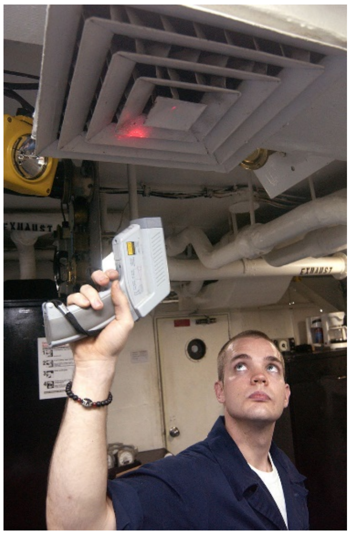


Photo by Dani Jeffrey

Thermal imaging is a very effective and safe way of doing a “health check” on operating equipment such as switchboards, cables and electric motors.

A laser thermometer is a basic thermal imaging instrument. So called because they often use a laser to help aim the thermometer, non-contact thermometers or temperature guns are able to measure temperature from a distance.

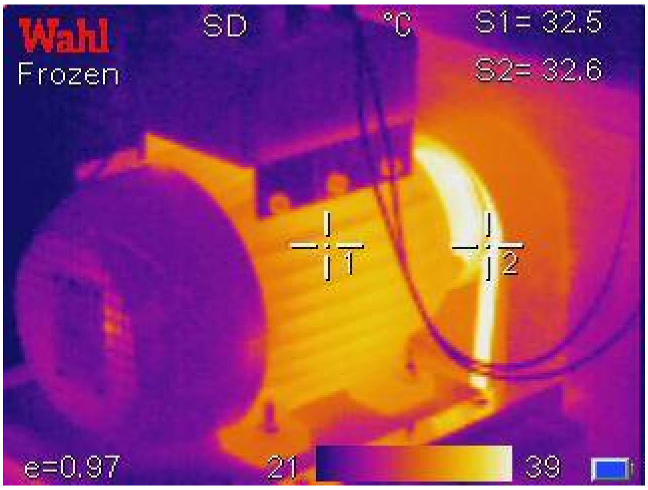
The photo here shows an overloaded extension cord that is heating badly and was about to cause damage had it not been found and rectified.

Another common form of thermal imaging is the infrared camera.

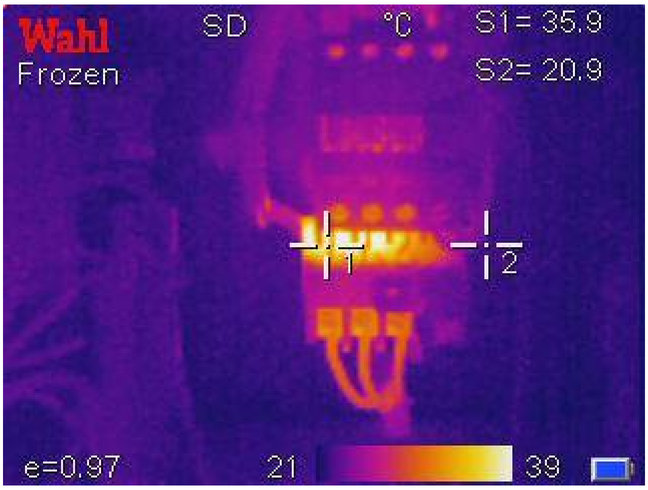
All objects emit electromagnetic radiation. The frequency of this radiation is inversely proportional to the objects’ temperature. Infrared sensors are used in thermal imaging cameras to detect these frequencies and convert them to thermal images or temperatures (depending on the model) which are displayed on the screen.

The camera provides a view of exactly where the heat build-up is occurring, as can be seen in the images on the following page. These are a great tool for identifying issues that are not normally able to be picked up visually.

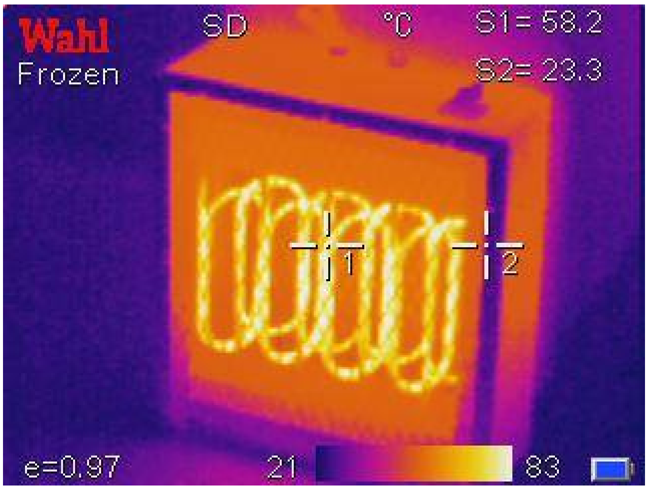
It has become routine in industry to have thermal imagery done, making it possible to identify hot spots so that problems can be fixed before the damage becomes catastrophic.




*Overheating bearings*




*Loose connections in a meter*

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