Multimeter Modes and Functionality

ANALOG MULTIMETERS

An analog or analogue multimeter is one of the trusty workhorses of the electronics test industry. Analogue multimeters have been in use for very many years and sometimes go by the name VOA as a result of the fact that they measure volts, ohms and amps. These multimeters are extremely flexible and enable many faults to be found in an electronic circuit.

They give an accurate representation for corresponding measurements.

One of the major distinguishing factors is the calibration knob present in most Analog meters. Unlike latest Digital meters, most analog meters require the range of measurement to be specified before the measurement. If too small a range is given, it can cause damage to the pointer mechanism of the meter. Every time you change the range of measurement, it is useful to check the short circuit reading (Shorting the red and black probes) and re-calibrate it to zero (Volt/Ohmmeter mode) using the calibration knob.

Calibration Knob: Re-Calibrating S.C reading to 0.

Advantages over Digital Multimeters.

Simultaneous readings on volt, Ohm, Amp and logarithmic(dB) scale.

Better representation of oscillating signals. It is easier to observe change in quantities in a analog meter compared to constantly changing digits on a digital meter.

Easier to spot fast moving trends

Disadvantages:

Not robust. If too sensitive a scale is set, it can cause damage to the pointer mechanism. Also not going take knocks and falls that well.

Lower degree of precision and resolution when compared to digital meters (depending upon the least count of the device).

Parallax error is hard to avoid.

DIGITAL MULTIMETERS

Modern multimeters are often digital due to their accuracy, durability and extra features. In a digital multimeter the signal under test is converted to a voltage and an amplifier with electronically controlled gain preconditions the signal. A digital multimeter displays the quantity measured as a number, which eliminates parallax errors.

Modern digital multimeters may have an embedded computer, which provides a wealth of convenience features. Measurement enhancements available include:

- **Auto-ranging**, which selects the correct range for the quantity under test so that the most significant digits are shown. For example, a four-digit multimeter would automatically select an appropriate range to display 1.234 instead of 0.012, or overloading. Auto-ranging meters usually include a facility to hold the meter to a particular range, because a measurement that causes frequent range changes can be distracting to the user.
- **Auto-polarity** for direct-current readings, shows if the applied voltage is positive (agrees with meter lead labels) or negative (opposite polarity to meter leads).
- **Sample and hold**, which will latch the most recent reading for examination after the instrument is removed from the circuit under test.
- Current-limited tests for voltage drop across semiconductor junctions. While not a replacement for a proper transistor tester, and most certainly not for a swept curve tracer type, this facilitates testing diodes and a variety of transistor types
- A **graphic representation** of the quantity under test, as a bar graph. This makes go/no-go testing easy, and also allows spotting of fast-moving trends.

Modern meters may be interfaced with a personal computer by IrDA links, RS-232 connections, USB, or an instrument bus such as IEEE-488. The interface allows the computer to record measurements as they are made. Some DMMs can store measurements and upload them to a computer.

The first digital multimeter was manufactured in 1955 by Non Linear Systems. It is claimed that the first *handheld* digital multimeter was developed by Frank Bishop of Intron Electronics in 1977, which at the time presented a major breakthrough for servicing and fault finding in the field.

MODES OF OPERATION

A multimeter is has three parts:

- Display
- Selection Knob
- Ports

The **selection knob** allows the user to set the multimeter to read different things such as milliamps (mA) of current, voltage (V) and resistance (Ω).

Two probes are plugged into two of the **ports** on the front of the unit. **COM** stands for common and is almost always connected to Ground or '-' of a circuit. The **COM** probe is conventionally black but there is no difference between the red probe and black probe other than color. **10A** is the special port used when measuring large currents (greater than 200mA). **mAVΩ** is the port that the red probe is conventionally plugged in to. This port allows the measurement of current (up to 200mA), voltage (V), and resistance (Ω). The probes have a banana type connector on the end that plugs into the multimeter. Any probe with a banana plug will work with this meter. This allows for different types of probes to be used.

Measuring Voltage V⎓, V~

If you're measuring DC voltage (such as a battery or a sensor hooked up to an Arduino) you want to set the knob where the V has a straight line. AC voltage (like what comes out of the wall) can be dangerous, so we rarely need to use the AC voltage setting (the V with a wavy line next to it). If you're messing with AC, we recommend you get a non-contact tester rather than use a digital multimeter.

Interchanging the red and black leads results in adding a –ve sign to the resultant value. This does not cause any damage to the DMM

OVERLOAD CONDITION:

If a voltage range far too low compared to the value to be measured is set, the DMM simply shows 1. No damage is done to the device.

MEASURING RESISTANCES

One important measurement that can be made with a multimeter is a resistance measurement.

Not only can these be made to check the accuracy of a resistor, or check it is functioning correctly, but resistance measurements can be required in many other scenarios as well. It may be to measure the resistance of an unknown conductor, or it may be to check for short circuits and open circuits.

In fact there are many instances where measuring resistance is of great interest and importance. In all these cases a multimeter is an ideal piece of test equipment for measuring resistance.

1. Select the item to be measured: This may be anything where the resistance needs to be measured and estimate what the resistance may be.
2. Insert the probes into the required sockets Often a digital multimeter will have several sockets for the test probes. Insert these or check they are already in the correct sockets. Typically these might be labeled COM for common and the other where the ohms sign is visible. This is normally combined with the voltage measurement socket.
3. Turn on the multimeter
4. Select the required range the digital multimeter needs on and the required range selected. The range selected should be such that the best reading can be obtained. Normally the

multimeter function switch will be labeled with the maximum resistance reading. Choose the one where the estimated value of resistance will be under but close to the maximum of the range. In this way the most accurate resistance measurement can be made.

5. Make the measurement with the multimeter ready to make the measurement the probes can be applied to the item that needs to be measured. The range can be adjusted if necessary.
6. Turn off the multimeter once the resistance measurement has been made, the multimeter can be turned off to preserve the batteries. It is also wise to turn the function switch to a high voltage range. In this way if the multimeter is used to again for another type of reading then no damage will be caused if it is inadvertently used without selecting the correct range and function.

Precautions:

- ***Measure resistance when components are not connected in a circuit:*** It is always advisable **not** to measure the resistance of an item that is in a circuit. It is always best to make the measurement of the component on its own out of the circuit. If a measurement is made in-circuit, then all the other components around it will have an effect. Any other paths that will allow current to pass will affect the readings, making them inaccurate to some degree.
- ***Remember to ensure the circuit under test is not powered on*** Under some circumstances it is necessary to measure resistance values actually on a circuit. When doing this it is **very important to ensure the circuit is not powered on**. Not only will any current flowing in the circuit invalidate any readings, but should the voltage be high enough, the current resulting could damage the multimeter.
- ***Ensure capacitors in a circuit under test are discharged.*** Again when measuring resistance values in a circuit, it is necessary to ensure that any capacitors in the circuit are discharged. Any current that flows as a result of them will cause the meter reading to be altered. Also any capacitors in the circuit that are discharged may charge up as a result of the current from the multimeter and as a result it may take a short while for the reading to settle.
- ***Remember diodes in a circuit will cause different readings in either direction*** When measuring resistance in a circuit that includes diodes the value measured will be different if the connections are reversed. This is because the diodes only conduct in one direction.
- ***Leakage path through fingers can alter readings in some cases.*** When making some resistance measurements it is necessary to hold a resistor or component onto the multimeter test probes. If high resistance measurements are being made the leakage path through the fingers can become noticeable. Under some circumstances the resistance path through fingers can be measured at just a few megaohms, and as a result this can become significant. Fortunately the levels of voltage used in most multimeters when measuring resistance is low, but some specialized meters may use much higher voltages. It is wise to check.

Current Measurement

1. Determine if the current to be measured is ac or dc.
2. Select a clamp accessory for your multimeter that is designed to measure that specific current or one that can measure both ac and dc.

Note: Look at the accessory clamp’s specifications and determine whether the clamp outputs a current level or a voltage level.

3. Determine the circuit's anticipated maximum current by checking the nameplate of a component or the breaker rating. Plug-in clamp accessories are available in a variety of preset ranges. Determine if the range of your multimeter or clamp accessory is high enough to measure it. If not, select an instrument equipped for higher ranges.

   Note: If a meter includes fused current terminals, verify that its fuses are good.

4. Set up your DMM as follows:
   - To measure **ac current** with a current output clamp, turn the dial to mÃ/Ã.
   - Plug the black test lead into the COM jack.
   - For plug-in clamp accessories that produce an ac current output, plug the red test lead into the mÃ/Ã jack. These clamps are designed to measure ac current only and, depending on the clamp's scaling factor, deliver 1 mA to the DMM for every 1 A of measured current (1 mA/A).
   - Follow steps 6-8 below.
   - To measure **ac/dc current** with a voltage output clamp, turn the dial to mVac for ac current, or to mV dc for dc current.
   - Plug the black test lead into the COM jack.
   - For plug-in clamp accessories that produce a voltage output, plug the red test lead into the V jack. These clamps are designed to deliver 1 mV, 10 mV or 100 mV to the DMM for every 1 A of measured current.
   - Follow steps 6-8 below.
5. Open the jaws by pressing the tool's trigger.
6. Enclose a single conductor inside the jaws. Make certain the jaws are completely closed before taking readings.
7. View the reading in the display.

Remember! When you're done using the meter, always return the meter to read voltage (return the probes to the voltage port, set the meter to read the DC voltage range if necessary). It's common to grab a meter and begin to quickly measure the voltage between two pins. If you have left your meter in 'current' mode, you won't see the voltage on the display. Instead you'll see '0.000' indicating that there is no current between VCC and GND. Within that split second you will have connected VCC to GND through your meter and the 200mA fuse will blow = not good. So before you put the meter down for the night, remember to leave your meter in a friendly state.

TESTING FOR CONTINUITY

Continuity testing is the act of testing the resistance between two points. If there is very low resistance (less than a few Ωs), the two points are connected electrically, and a tone is emitted. If there is more than a few Ωs of resistance, than the circuit is open, and no tone is emitted. This test helps insure that connections are made correctly between two points. This test also helps us detect if two points are connected that should not be.

Continuity is quite possibly the single most important function for embedded hardware gurus. This feature allows us to test for conductivity of materials and to trace where electrical connections have been made or not made.

Set the multimeter to 'Continuity' mode. It may vary among DMMs, but look for a diode symbol with propagation waves around it (like sound coming from a speaker).

Now touch the probes together. The multimeter should emit a tone (Note: Not all multimeters have a continuity setting, but most should). This shows that a very small amount of current is allowed to flow without resistance (or at least a very small resistance) between probes.

On a breadboard that is *not* powered, use the probes to poke at two separate ground pins. You should hear a tone indicating that they are connected. Poke the probes from the VCC pin on a microcontroller to VCC on your power supply. It should emit a tone indicating that power is free to flow from the VCC pin to the micro. If it does not emit a tone, then you can begin to follow the route that copper trace takes and tell if there are breaks in the line, wire, breadboard, or PCB.

Continuity and large capacitors: During normal troubleshooting. You will be probing for continuity between ground and the VCC rail. This is a good sanity check before powering up a prototype to make sure there is not a short on the power system. But don't be surprised if you hear a short 'beep!' when probing. This is because there is often a significant amount of capacitance on the power system. The multimeter is looking for very low resistance to see if two points are connected. Capacitors will act like a short for a split second until they fill up with energy, and then act like an open connection. Therefore, you will hear a short beep and then nothing. That's ok; it's just the capacitors charging up.