Meters and Test Equipment

OBJECTIVES

- Describe the difference between a DMM and a VOM.
- Describe the methods for measuring Low Voltage and High Current.
- Discuss the use of Test Lights in the mobile installation environment.

INTRODUCTION

The most common electrical tester for all forms of electronics is the Multimeter. It comes in various forms, most notably the VOM and DMM. The VOM (volt-ohm-milliammeter) is often known as an Analog Multimeter. It may be tempting to use a test light when installing car audio equipment but using one place delicate electronic equipment at unnecessary risk. It is better to learn how to properly use the correct tool for the job "The DMM".

Meters and Test Equipment

DMM's and VOM's

A VOM (volt-ohm-milliammeter) uses a needle and scale style of readout and can measure voltages, resistances and low-level current up to a few amperes. The DMM (Digital Multimeter) is essentially a VOM that uses a digital readout instead of a scale. The measurements are conducted in the same fashion with a few major differences.

- The readout on a DMM is direct and requires no real interpretation as opposed to a VOM. The VOM requires the installer to interpret the measurement based on the range setting of the meter and the position of the needle across the scale. Many times, reading a VOM accurately is difficult because of the positions in which installers find themselves in under the dash.

- The circuitry inside the VOM meter can be very parasitic (meaning electrically recognized or altered) to a sensitive circuit like an automotive computer. The high resistance of the DMM is virtually invisible to the circuit under test.

- DMM's are considerably more rugged than a VOM due to the lack of moving parts. Many DMM's have ruggedized protective cases that make them ideal for mobile electronics installers to use while in and out of vehicles. In the event that a DMM is dropped with a ruggedized case protector, the DMM will probably continue working properly whereas a VOM may not.

There are various differences in how these two meter types work, affecting both the visual readings and resolution.

- An Analog Multimeter can have higher resolution due to its infinite ability, but operator reading errors will offset this benefit. The infinite reading ability is due to the lack of sampling circuits in the DMM that round up or down.

- A Digital Multimeter is easier to read due to a multiple decimal place readout, but the reading will be rounded up or down due to the sampling nature of an analog to digital converter within the meter. For mobile electronics measurements, the resolution of most DMM's is more than adequate.

Measurement Considerations

Measuring Voltage

Interpreting Voltage Readings

To properly interpret a voltage reading, it is important to understand what can affect the result. If the wrong scale is chosen, the reading can be off by factors of thousands. If the circuit is not properly loaded, the reading may also be off by a large amount. Follow these simple guidelines whenever taking voltage measurements.

- Set your meter to the correct range and confirm that this is higher than the voltage you expect to see.

- Consider what you expect to see for a reading. If you have not considered what is reasonable, you may either be surprised by the extreme reading, or will miss the significance of a reading.

- Make sure that the component is operating at the time you take the reading. You might read 12.6 volts at an amplifier's power terminals, but miss the fact that when the amplifier is turned on, the voltage drops to an unusable 10 volts.

- Be certain that your test equipment actually works and is connected properly. A broken test lead or poor ground can easily send you tracking down a problem that does not exist.

For the first guideline listed, an auto ranging DMM would negate the necessity to worry about range settings of a Multimeter during a voltage measurement. The rest of the suggested guidelines are simply common sense.

Illusions at Low Voltage

Using a higher range when reading a small voltage can increase error of the reading. It is best to reduce the range until the reading is near the limit of the meter (but not over). Reading errors decrease as a meter reads toward the high end of its range limit because the resolution of the measurement is more precise.

The difference between 2 volts and 2.1 volts is a much bigger difference than the difference between 500 volts and 500.1 volts. The higher the voltage, the less difference small amounts of error (or resolution limits) make to the voltage measurement. For voltages below 1 volt, most DMM's have a "mV" (millivolt) setting to further increase voltage measurement accuracy.

Measuring Current

Low Current Measurements

Current measurements are substantially different from voltage measurements in a number of ways. "In-line current measurements are taken in series rather than in parallel as is done for voltage measurements. Instead of the meter sampling the voltage, the meter becomes a circuit element. This means that the current must pass through the meter (to be counted) and the meter must be capable of passing the current levels. As current measured in series through a meter increases, so does the circuit resistance of the meter, which can create inaccuracy of the measurement. Since most DMM's are limited to 10 amperes of current, higher amounts of current flow in a circuit could cause meter damage.

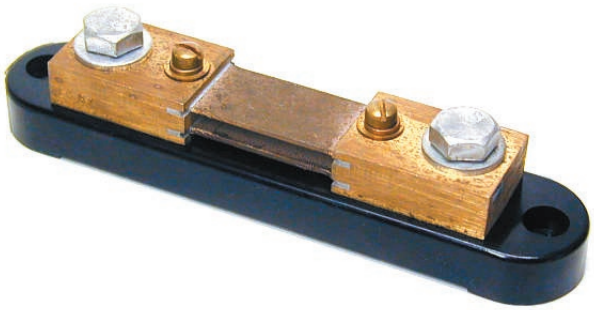
This inaccuracy is often referred to as 'burden voltage', where the small amount of resistance that is inherent in the meter will cause the whole circuit to behave differently. Taking current measurements in circuits powered by AC, having branches containing inductors and capacitors, can be hazardous. This type of circuit may have very high currents circulating at a particular frequency.

High Current Measurements

In order to read high currents over 10 amperes, either a current shunt or a Clamp- On meter is necessary. 10 amperes is the safe limit of measuring current in series through most Multimeters. Exceeding this range may burn the traces of the circuit board inside the Multimeter or (if equipped) blow the protection fuses in the meter.

Current Shunts

A current shunt is a piece of calibrated, resistive metal that will not burn up when high currents are passed through it. Since it has resistance, a voltage reading taken across this resistance will allow you to accurately calculate the current using Ohm's Law. Current shunting is the method used by many ammeter gauges in vehicles. Due to the lack of portability, especially when measuring high current in a vehicle, most current shunts are found on a test bench rather than in an installers toolbox.



Current Clamps

Clamp-On current meters (also called current clamps) are very portable as well as being extremely easy to connect for a measurement. The Clamp-On meter derives the current flowing in a circuit by measuring the amount of magnetic energy around a conductor. For this reason, positive and negative leads must be separated since they have opposing field directions. If an installer enclosed both (+) and (-) leads of a circuit within the jaws of a current clamp, the measurement of magnetism from the opposing polarities would cancel each other out for a measurement of zero regardless of the actual current draw.

Inductive Current Clamps

A Clamp-On ammeter is usually sold in two forms; an inductive style meter is inexpensive but will not read DC current, rather it's intended for AC measurements. When using an inductive probe for AC measurements, a line splitter is available which will separate the two wires for an accurate reading.

Hall Effect Current Clamps

Measuring DC current requires a current clamp with a "Hall Effect" Sensor. These current clamps are usually double the price of an inductive current clamp. The Hall Effect sensor in the clamp converts the strength of the magnetic field to a small amount of voltage that the meter can display easily. Current clamps are available as accessories that plug into a DMM or simply as stand alone devices, which may or may not have the ability to make additional measurements such as voltage or resistance.

Measuring Resistance

Care must be taken to ensure both accuracy and safety when measuring resistance. Analog VOM's produce a small current through the object under test, and then calculate the resistance based on the current flowing (Ohm's Law). Digital Multimeters (DMM's) use a converter to convert resistance to a voltage, and then measure the voltage. As a result, a reasonable quality DMM can have input impedances as high as 10 MΩ and is usually no lower than 1MΩ. Analog meters at around 20kΩ per volt will increase circuit loading at higher measured values, compromising accuracy. Analog meters are fairly good when measuring voltage and current, but are poor at resistance measurements common to mobile electronics

such as speaker voice coils, grounds, and variable resistance switching circuits found in newer vehicles.

Higher quality meters will have higher resolution, or the ability to measure small resistances without appreciable errors. An inexpensive meter with lots of features can be out of accuracy by as much as 400%, where a higher quality, more expensive meter is likely to have high resolution and accuracy.

Safety Precautions

Always remember that testing resistance of any component must be done with the device or the circuit power OFF. This is so that the meter can take the most accurate reading, but also because the meter may sustain damage if the current flowing in the active circuit under test exceeds the current that the meter puts out for it's resistance measurement. The DMM probe tip current is very small with input impedances over 1MΩ. Even a small amount of current could damage a meter if the circuit is active.

Additional cautions when resistance measurements are taken are to avoid probe tip contact with open wounds or cuts. A small amount of voltage contained on the probe tips can use the human body to conduct a current across the tips. Depending on the nature of the cut, a small current could interrupt the function of the heart causing serious injury. Current always takes the path of least resistance and, while skin has a very high resistance, open cuts expose the low resistance areas of the body.

Test Lights

"Computer Safe" Test Lights

Since the dangers of using a conventional incandescent test light on computer equipped vehicles became commonly known, a new form of test light has emerged. This new device uses LED's that draw far less current than the incandescent bulb. This is intended to reduce the risk of damage to vehicle circuits. While something labeled "computer safe" may sound like a good idea to use, the measurement tool of choice for mobile electronic installation professionals should be the Multimeter.

Safety

Since these "computer safe" devices still draw current, they are potentially able to load down a sensitive circuit to the point of damage. The current draw of a computer safe test light is around .02 amps, which means that its equivalent resistance at 12 volts is about 600 Ω. In contrast, quality Multimeters have an input resistance of over 1,000,000 Ω (1MΩ) between the probe tips while in a voltage measurement mode.

Accuracy

A test device should be totally benign to the circuit under test. In other words, the circuit should not know that there is an object trying to sample from the circuit. One million ohms (as found in a typical Multimeter) is so much resistance that the circuit essentially doesn't really "see" the load of the Multimeter. If the circuit doesn't recognize the load of the multimeter, it won't operate differently, which means the Multimeter presents very little chance of causing any electrical problems. The same can't be said for test lights, "computer safe" or not! The typical computer safe test light is obvious to

many circuits under test. In the example of a Chrysler vehicle, one of these test lights can be interpreted by the vehicle as an open door. A truly accurate tester would not be discovered by a circuit.

Since the measurement device becomes part of the circuit during testing, the devices own characteristics can change the whole circuit. This can lead to wildly incorrect readings.

It's common knowledge among installation professionals that a high quality DMM is the preferred measurement tool in the installation bay. The use of a computer safe test light, or ANY test light for that matter, isn't worth the risk of vehicle damage. About the only safe use these days for an incandescent test light is discharging capacitor banks.