Blowing Fuses: Voltmeters and Ammeters

When students are learning about physics, engineering, electricity, and the functions of circuits will use a common instrument in their labs, a voltmeter and an ammeter, or a combination of many functions called a multimeter. Students will use the multimeter for various reasons, to measure voltage, resistance, or current. What students do not realize though is the difference between measuring voltage and current. When students do not understand the workings of the multimeter they end up blowing the fuse of the multimeter. The cause of fuses to be blown is because of the vast difference between how voltage is measured and how current is measured. While one measurement is meant to be resistive the other measurement is designed to be passive. When students and professionals learn to understand the inner workings of both the voltage meter and the current meter in order to prevent blowing a fuse.

The multimeter must be view as two separate tools: a voltage meter and a current meter. The workings of the voltage meter are opposite of that of an ammeter. There are two types of simple circuits, a series circuits and a parallel circuit. In a series circuit, circuit elements are on the same node. In a parallel circuit, circuit elements share two nodes. While circuit elements exist in a parallel circuit they share the same voltage between the two. The voltage meter takes advantage of this fact in order to measure voltage
across a circuit element. When you measure voltage you place the two leads on both sides of the element, by doing this you are creating a parallel circuit with the multimeter and the circuit element. A basic principle of circuits is that current will travel through the path of less resistance. When you make a connection in parallel with a circuit element the circuit element that has the less resistance will have the most current running through it. A voltmeter is designed with such a high resistance, as close to infinite as possible, in order for the least amount of flow runs through the voltmeter. When measuring voltage we want the most possible amount of current to be running through the circuit element that we are measuring. The greater internal resistance that the voltmeter has the more accurate it is going to be in measuring voltage because less current will be running through the voltmeter then in the measured circuit element.

An ammeter is designed in the complete opposite way than the voltmeter. While the voltmeter is designed with an almost near infinite resistance the ammeter is designed with an almost zero internal resistance. When measuring current the circuit must be disassembled and current must be measured in series. You cannot simply place the leads between circuit elements to measure current like you can with a voltmeter when measuring voltage. An ammeter must measure in series because of the fact that in series circuits current is the same through all circuit elements that are in series. If the ammeter were to be measured through a parallel circuit the current would be split between the ammeter and the circuit and the readings
would be incorrect. In the ammeter the internal resistance is as low as possible so that the most amount of current can run through the ammeter and provide the most accurate reading. It is because of this design that fuses in the multimeter are prone to blow. The closer the ammeter’s resistance is to zero the less current and electrical energy will be depleted through heat, resistance, and the more accurate the ammeter will measure.

The multimeter most commonly used will have two different inserts for the positive leads to be placed in. One you plug in when measuring voltage, which will have a high resistive function and the other for measuring current, which will have a low resistive function. When the lead is inserted into the voltage function it will have a high resistance, so even if the multimeter was set to measure current it would not cause the fuse to blow since all the energy would be depleted through the high resistance. The same cannot be said about when the lead is inserted into the current (amp) function. When you have the positive lead inserted into the (amp) function you must take caution to how you are measuring because it is when the lead is in this function that there is a chance to blow a fuse. Current must not be measured in parallel because of the fact that the ammeter was designed to have an almost zero resistance. With this in mind in the multimeter was connected in parallel the flow of electricity would be directed in the direction of the ammeter and if the current was great enough it would blow a fuse. The circumstance that will most likely cause a fuse to blow is trying to measure voltage while the multimeter lead is connected to the (amp) function. When
you set the multimeter to measure voltage it is expecting to let in as much current as possible because it assumes that its resistance is so high that so little current is going to flow through it anyways. Although when the lead is connected to the (amp) function the resistance is minimal. So the opposite occurs, all of the current flows in the direction of the multimeter. Instead of current running through the multimeter, there is too much energy for the multimeter and the fuse blows.

Once a student understands the difference between how the ammeter and the voltage meters work in a multimeter it will give the student better knowledge of how to prevent blowing a fuse. The consideration of the voltmeter having a high resistance and the ammeter having a low resistance paired with the fact that current flows in the path of least resistance explains why one would not want to measure current in parallel. Students must also understand that parallel circuits separate current while series circuits separate voltage. Fewer fuses will blow when students take notice to where their leads are plugged into and if they are measuring voltage and current and the fact that the lead must be physically switched when switching from voltmeter to ammeter.