Electrical Basics Related to Automotive Instruments.

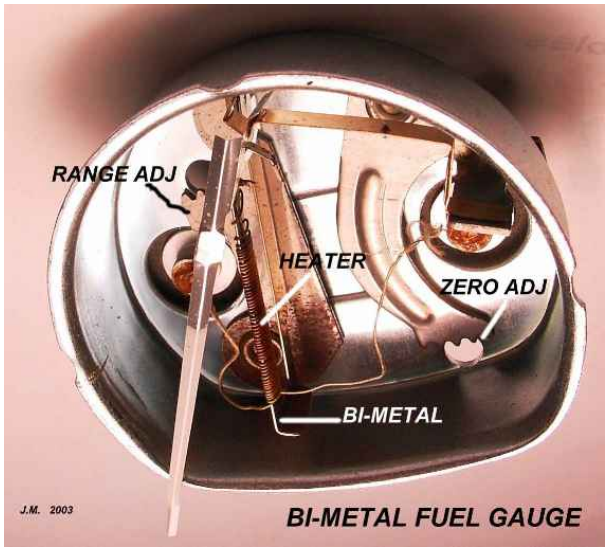
Automotive environments are electrically noisy and the voltage on the system varies according to the condition of the charging system. While the battery is nominally rated for 12V it typically is closer to 12.5V. To charge the battery, it is necessary for the alternator or generator to put out a higher voltage than this to "push" the electricity back into the battery's cells. Typically this will be about 1.5-2V higher giving the operating vehicle a system voltage close to 14.5V.

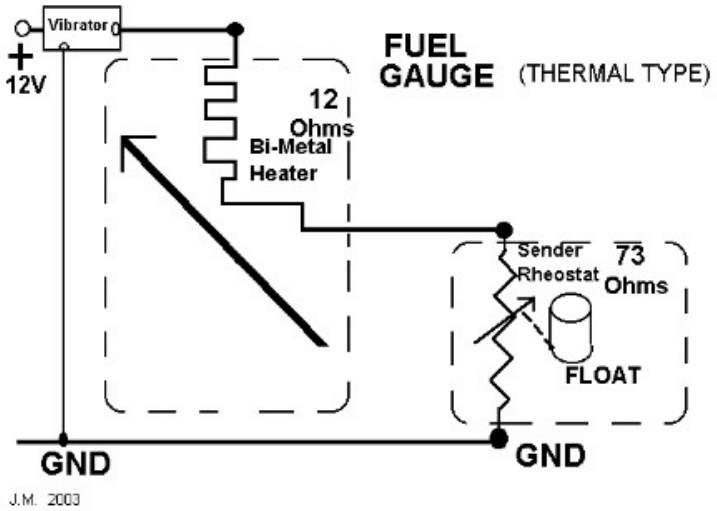
For electrical gauges to read accurately it is necessary for them to operate at a more constant and controlled voltage. In the early 1960s most manufacturers started adding a device called a voltage stabilizer to the gauge systems. While the term is still used, it is more common with today's electronics to refer to this device as a voltage regulator. On virtually all modern cars this voltage stabilizer (or regulator) supplies power to the instruments at a controlled, steady 10V regardless of the battery condition or output from the alternator/generator.

Since it is typically beyond the resources of most vehicle owners to locate and tap into that controlled 10V supply in modern cars, aftermarket gauges are typically fitted with their own INTERNAL voltage stabilizer. Thus, aftermarket gauges are hooked directly to a switched 12V supply on the car's wiring harness.

Modern gauges typically work by passing electrical current from the instrument THROUGH a resistive sending unit to the vehicle's chassis ground. Resistance is, as its name implies, the tendency of an electrical device to resist the flow of electricity. The higher the resistance, the less electrical current is flowing. There is a fundamental mathematical relationship used to calculate basic electrical flow: $V = I \times R$. In this equation, V is the voltage and is synonymous with "pressure", it is the force pushing electrical flow. I is the current or "flow" of electricity and is measured in Amps. R is the resistance to the flow of electricity and it is measured in Ohms.

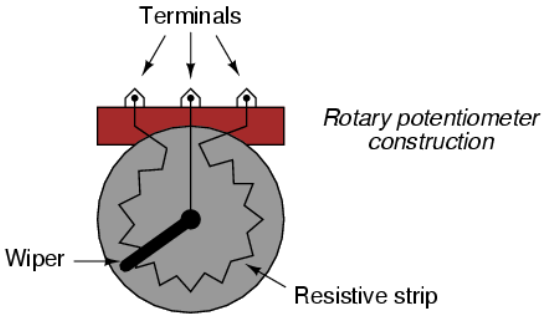
On analog electrical gauges (those with pointers or needles) the needle is actuated by the heating of a bimetallic strip connected to the pointer. A resistance heating wire (like in a toaster) is wound around the bimetallic strip. As current passes through the resistance wires they heat up which in turn heats the bimetallic strip causing it to bend and deflect the needle on the gauge. The sending unit limits the amount of current that can flow through the resistance wires (and thus limits the heating). In the case of a temperature gauge, the sending unit screws into some location that will get "hot" as operating temperature is reached. When the engine is cold the sending unit's resistance is "high" and not much current can flow... thus limiting the heating and deflection of the gauge's pointer. (Returning to the formula $V=I \times R$, $V / R = I$. When R is large, I is small). As the sending unit heats up its resistance drops significantly and moves towards zero ohms. (In the $V=I \times R$ example, $V/R=I$... when R approaches zero, the I value goes toward infinity. In fact, the current cannot become infinite because the resistance heating wire in the gauge limits the current flow). See the link below:
http://www.nls.net/mp/volks/htm/fuel_ga.htm
The pictures below are from this site. It is for VolksWagens... but that doesn't matter. The principles are the same. The item labeled "vibrator" is the voltage stabilizer providing the controlled 10V. Rheostat is another name for "potentiometer" which will be mentioned below. The reference to "thermal type" is another way of saying "bimetallic type".

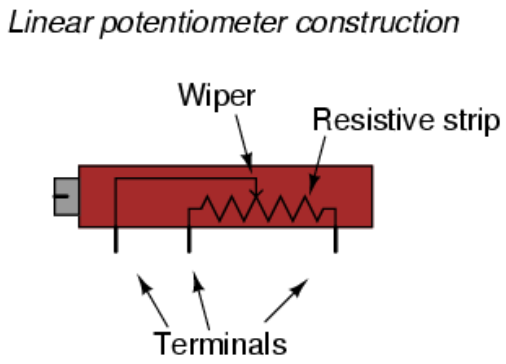


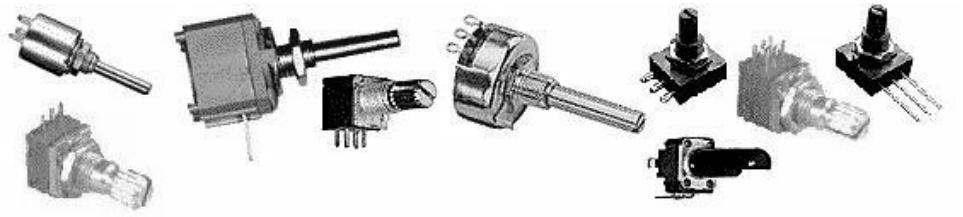


To test your new gauge and what it needs for resistance values you're going to need to borrow or buy a volt/ohm electrical meter. Most DIY centers and automotive parts stores should have them. You'll find them useful around the home after you realize what else you can check with them. If you've never used one, find a friend who has and spend a few minutes with them.

As I mentioned in the tech section of TheMiniForum, you need to determine what resistance value your new fuel gauge needs for empty and what it needs for full. First get that volt/ohm meter. Second, make or buy some jumper wires to temporarily hook your new instrument up to your car's battery and the car's fuel sending unit. Third, buy a potentiometer that is rated for about 100 ohms (these are variable resistors like what you'd use to set the volume on your television or radio). Potentiometers have three connections, two mark the end of an internal resistor, the third connection is for the "wiper". As you turn the adjusting knob on the potentiometer and measure from the wiper connection to either of the other two terminals you'll see the resistance value change.







To test your new gauge, hook it up as follows. Assuming you buy a "round" potentiometer as shown in the first picture, connect one outer terminal as shown above to the gauge's earth connection. Connect the center terminal to the gauge's input connection. Connect earth and power to the gauge to activate its display. Turn the potentiometer's knob until the gauge reads "empty". Without moving the knob further, disconnect the potentiometer wire from the gauge's input/sending unit connection and measure the resistance across earth and the disconnected wire. Record this number, then reconnect the potentiometer wire to the gauge's input. Turn the potentiometer's knob until you see the gauge display "full". As before, disconnect the input wire from the potentiometer to the gauge and measure the wire's resistance to ground. Record this value. One of the two numbers will be near Zero ohms, the other (based on your earlier comments) should be near 90 ohms. IF zero ohms is the value measured for the gauge to display "full", you will be able to add a resistor NEAR 135 ohms in value across the Mini's two sending unit contacts and connect your new gauge as normal. If zero ohms causes your display to read "empty", you will need to source an early fuel tank with the bolt-on sending unit. These operated between 0-90 ohms Empty to full.

To test the 135 ohm resistor with your gauge wait until your fuel tank is almost empty. From inside your car's boot, remove the two wires from the fuel sending unit. The black wire will be on the spade terminal directly connected to the sender's metal plate and is the earth connection. The green/black wire will be on an insulated terminal and goes to the standard gauge in the dash. Note each wires' position before pulling the wire off the sending unit. Connect the 135 ohm resistor across the earth and sending unit input on the back of your new gauge. Also connect jumper wires to the back of the gauge at this time. Connect two black wires to the gauge's earth connection. Connect a green wire to the gauge's +12V connection. Connect some other colored wire to the gauge's sending unit input connection. (Preferably this wire would be green/black but it's unlikely that you'll find that color readily available). Connect these wires as follows. Connect one black wire to a good, clean chassis ground connection or to the battery (-) terminal. Connect the other black wire to the earth terminal on the sending unit. Connect the (would be) green/black wire from the new gauge to the Mini sending unit's insulated terminal. Connect the gauge's green wire to the battery (+) terminal. The gauge should turn on and display the current position of the float arm. Use a coat hanger through the tank's filler neck to lift and lower the arm. When all the way up the gauge should read near full, when all the way down the gauge should read empty. If this works you should be able to install the new gauge permanently in your new dash with the 135 ohm load on the back of the instrument.