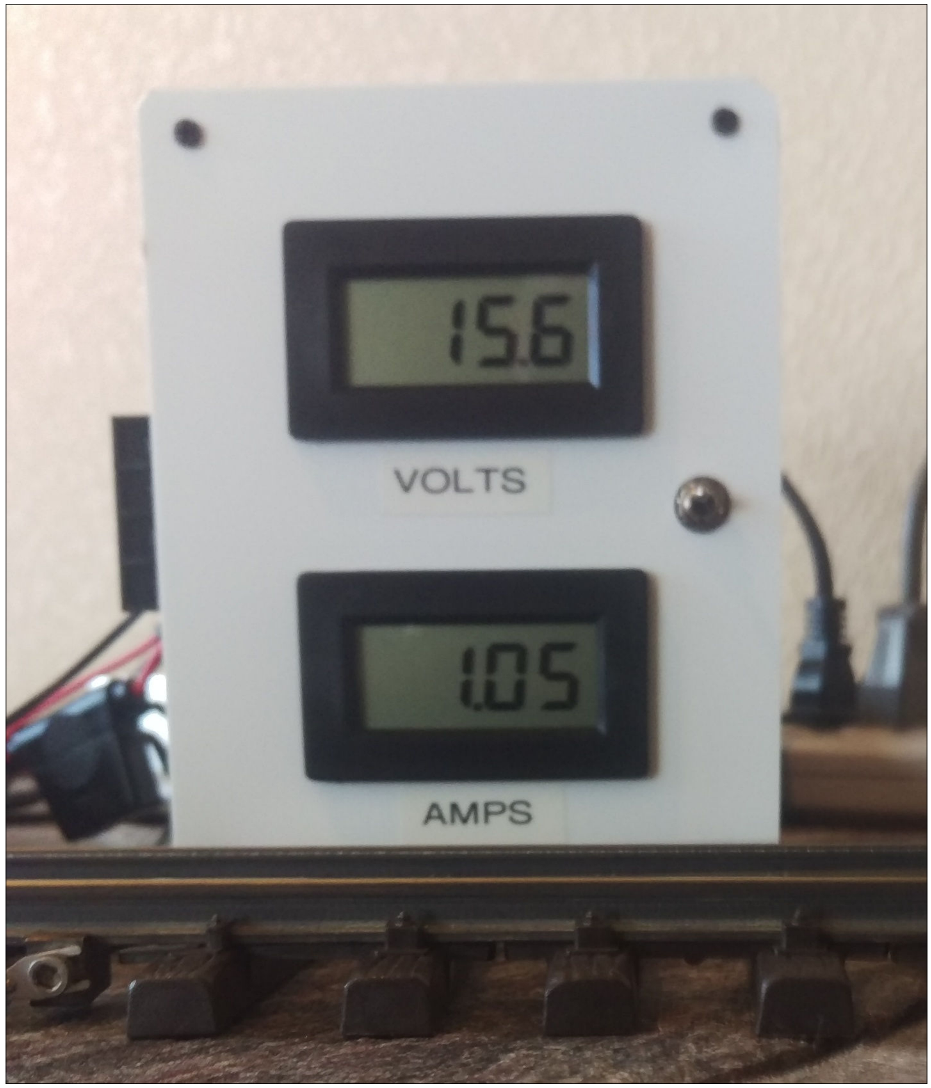
Build a Digital Track Volt-Ammeter

by Del Tapparo



One of the oldest electrical projects for model train layouts is a meter panel showing track voltage and current. Often associated with an operators panel, it gives you some indication of what is going on with your locomotive and track. For operations, the voltage is an indication of speed, so you can use the voltmeter to easily return to your favorite running speed. Current (read by an Ammeter) is an indication of load. This can be used as a diagnostic tool. Watching it may show trouble spots in the track work when it jumps around, or it may tell you something is wrong with a loco that is drawing more current than usual.

Analog Meters

In the past, we always used analog meters, since that was all that was available at the time. Analog meters have their advantages. They are easy to connect, and you can readily see changes in voltage or current via movement of the needle. With any kind of meter in this application, you must account for changes in track polarity. Center scale analog meters read negative to the left of center, and positive to the right of center. However, center scale meters may be hard to find these days, and can also be very expensive.

Connecting analog meters is fairly easy. Connect the voltmeter in parallel with the track voltage, and the ammeter in series with one leg of the track voltage. (Fig. 1)

Digital Meters

Of course these days, most everything is digital. There are a bunch of very low cost digital meters available that you may be tempted to use for this project. But beware, most of them are not bidirectional; i.e. when you change track polarity to change direction of the train, the meter quits working. And the self powered variety don't even work until the input voltage is greater than 5 volts.

The type of digital meter needed to handle the changing polarity is called a "Digital Panel Meter". These meters require a power source to operate, which allows them to read voltages down to zero, and either polarity. They can be found with LED displays, or LCD

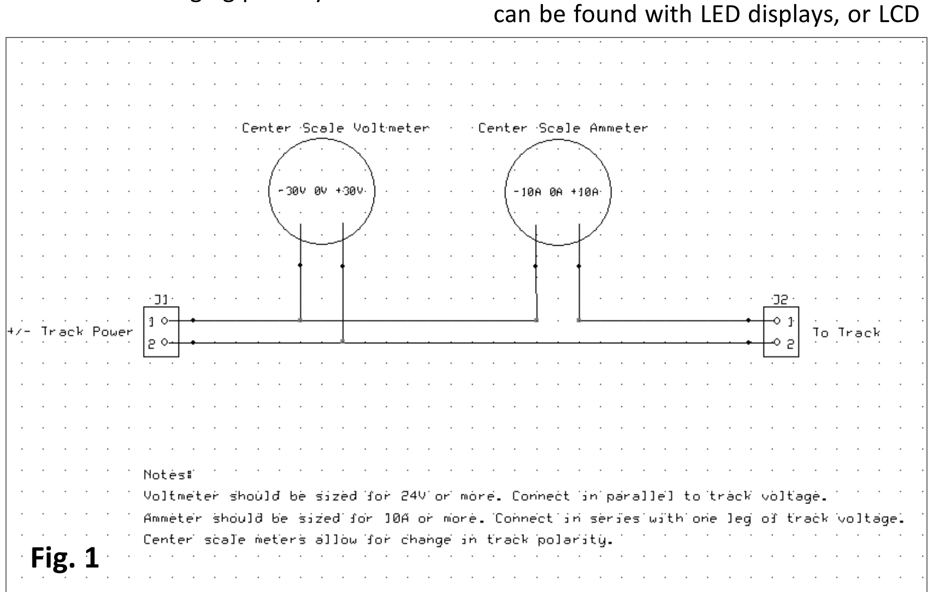


Fig. 1

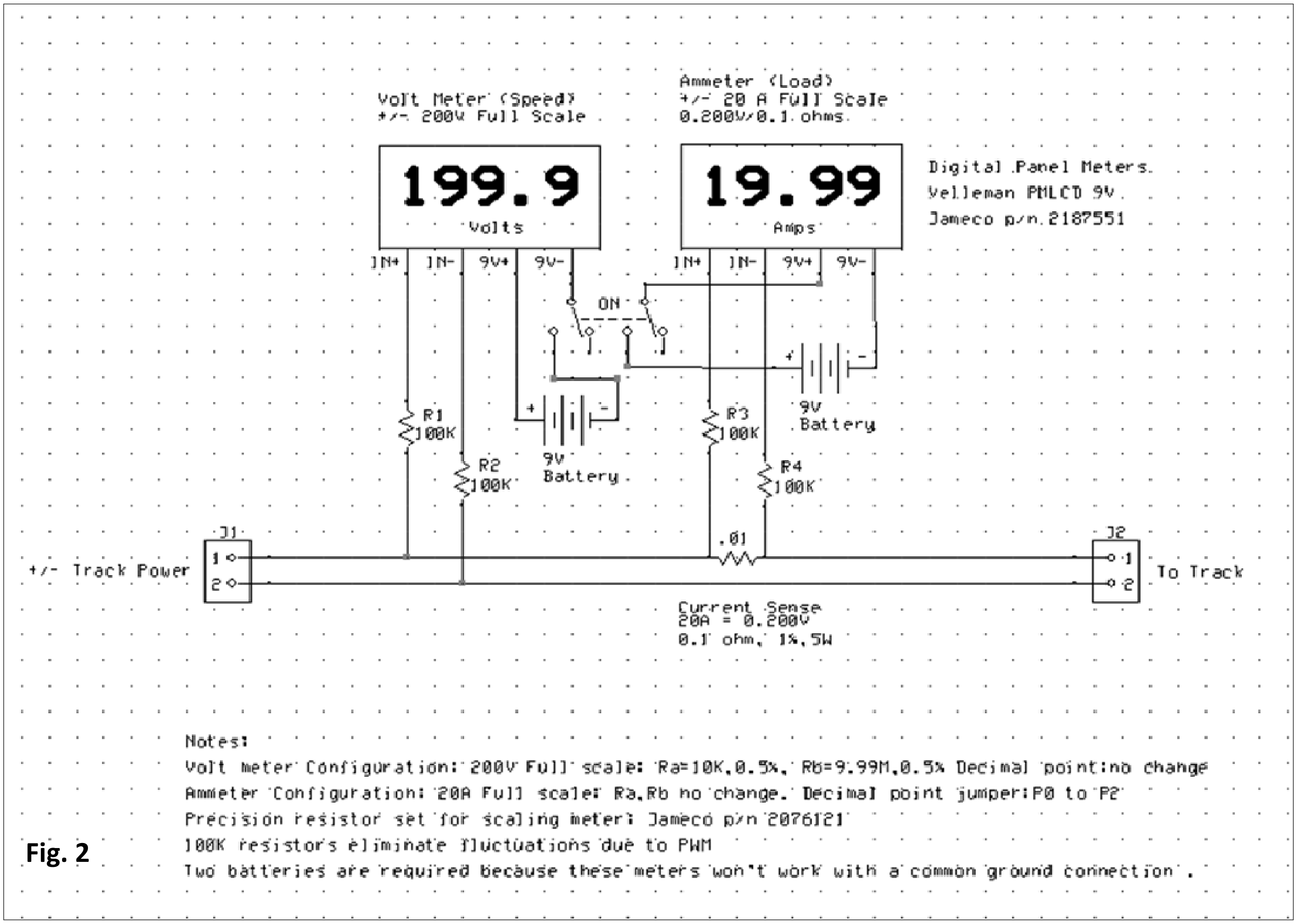


Fig. 2

displays. The LCD displays use much less current making it the choice for a stand-alone 9 volt battery powered unit. The LED displays are much easier to read, but will drain the battery faster.

I settled on some LCD Digital Panel Meters from Jameco.com (p/n 2187551, $6.79). They only come as voltmeters, not ammeters, but that is easily rectified by using a "current shunt". The voltmeter measures the voltage across the current shunt, and when scaled appropriately, reads the value of current. The meters are configurable for different voltage ranges; 0.200V, 20.0V, 200V. Using the 0.200V range and a 0.01 ohm resistor, we get a scale of 20 amps (I wanted to measure at least 10 amps). i.e. when measuring 0.200V across the 0.01 ohm resistor, the meter will read 20 amps. (0.200V / 0.01 ohm = 20 amps). The 0.01 ohm resistor must be precision (1% or less) and capable of handling the full current load. 20 amps through 0.01 ohms is 4 watts, so you need at least a 5 watt resistor.

As shipped, the voltmeter is configured for the 0.200V range. But the decimal point will be in the wrong place; it will indicate 2.0 amps full scale, instead of 20. This is fixed by removing the short across P0 to P1 (a solder blob on the meter's PCB), and replacing it with a short across P0 to P2 (another solder blob across the PCB traces). So yes, this project will require some soldering skills and a fine tipped soldering iron.

The meter to be used as the voltmeter must be scaled for 200V, chosen since I want to accommodate 24 to 28V power sources. This requires removing the little surface mount zero ohm resistor across Rb on the PCB of the meter, and replacing it with a 9.99M ohm, 0.5% resistor. Then install a 10K ohm, 0.5% resistor across Ra. A pack of scaling resistors for this meter is also available from Jameco.com (2076121, $1.19). No changes to the decimal point are needed for the volt meter.

The meters can be calibrated by adjusting a little potentiometer on the back of the meter. Do this by applying about 1/2 scale voltage or current and comparing to a known good meter.

Connecting the meters as track volt/ammeter is similar to the analog; volt meter in parallel, ammeter in series, but we also need to supply power to each meter. These particular meters will not work with a common ground between them, so we must use a separate 9V battery for each meter. We also need a battery on/off switch to turn off the meters when not in use.

Another minor complication for these meters; they don't play well with PWM (Pulse Width Modulation), as used by the G-Scale Graphics TrackSide

R/C and other systems. Installing 100K resistors in the measurement input lines easily solve this. (Fig. 2)

I mounted the meters in a plastic project box. I used 0.080" styrene for the face plate instead of the one supplied with the box, so it would be easy to replace if I made a mistake. The holes in the face plate were cut out to fit the meters using a Dremel rotary tool, a nibbler, and a file. And my favorite drill bit, the step drill, was used to make the 1/4" hole for the DPDT power on/off switch.

Wiring this simple circuit proved to be the hardest part. Where to terminate the multiple connections? The meters have pins, which I didn't want to solder on, so I used some female connectors. The 100K resistors were spliced into the meter input wires and then covered with heat shrink tubing. An external terminal strip was mounted on the side of the box. Wiring from the meters and the terminal strip were terminated on a crude little project circuit board using screw terminals. This allows for easy disassembly, if required. The only things on the circuit board are the two 0.02 ohm resistors in parallel (to get the desired 0.01 ohms with parts I had on hand), and the remaining circuit connections. The 100K resistors could have gone here too. Two 9V rechargeable NiMh batteries were mounted in simple 9V battery clamps and wired to the meters again using female connectors. All of these connections could be done any number of ways. Just do what works for you. Make sure to use heavy gage wire (20 ga. or even 18 ga.) for all wires except the inputs to the meters (22 ga. Or 24 ga.)

While this box probably won't be used on every run, it can be turned on with the flick of a switch, whenever the need arises.

(Thanks to Glenn Sheldon for inspiring me to do this project)