MAKE YOUR OWN SHUNTS!

While they might not be as accurate as the commercial units, these easy-to-make shunts are more than sufficient for many uses, and cost far less.

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Using a modern multimeter to measure current can sometimes be difficult. Many of these meters will only measure up to one amp. However, many 12-volt DC-powered projects draw a lot more than that. If you have ever thought of purchasing a commercial shunt to solve the problem, you know just how expensive they can be. Commercial shunts, while very precise, frequently cost more than the projects they are measuring!

However, there is a better and cheaper alternative that will work perfectly well in most situations: With only a few cents worth of wire and a little know-how, you can make your own shunts. It only takes a few minutes, and it's fun!

What Is A Shunt? A shunt is simply a resistor of very low value (frequently less than one ohm) that is used to help measure current. As shown in Fig. 1, the shunt resistor R_{SH} is placed in parallel with a meter to decrease its sensitivity by a known amount. The shunt does that by bypassing or "shunting" most of the current around the meter. The shunt resistor therefore lets you take a standard meter, such as a 0–1 milliammeter, and turn it into, say, a 0- to 20-amp meter.

The Shunt Meter. Before you can make a shunt, you must find a suitable shunt meter. Surplus analog meters can be found at hamfests or mail-order sources for only a few dollars each, and they make excellent shunt meters. For a list of mail-order sources of surplus analog meters, as well as new ones, see the sidebar.

When selecting a meter, try to pick a 0–1 milliammeter in good physical condition and one with a convenient scale on the faceplate. For example, if you need the meter to read 10-amps full scale, then select a meter graduated from 0 to 1. If you need a full scale reading of 30 amps, select one with a 0 to 3 graduation.

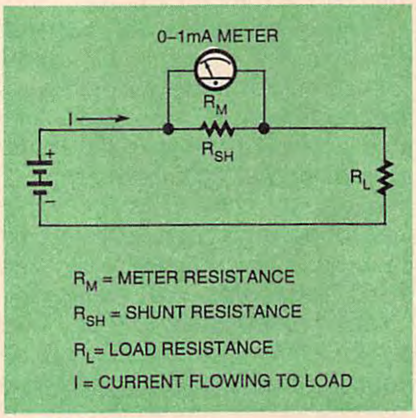

Fig. 1. A shunt is simply a resistor of very low value (frequently less than one ohm) that is used to help measure current. It is placed in parallel with a meter to decrease its sensitivity by a known amount.

To make a shunt, you will need to know the internal resistance of your meter. Therefore, select a unit that has its internal resistance printed on it, most likely in small letters on the meter face or on the back near the terminals.

If you already have a meter on hand but do not know its internal resistance, there is a simple way it can be determined. If you have a modern *digital* multimeter, set it to its highest resistance range. Connect the multimeter's red (positive) lead to the positive analog meter terminal and the black (common) lead to the analog meter's negative terminal.

Digital multimeters measure resistance by passing a small amount of current through the device under test. Do not attempt to use an *analog* multimeter to make this measurement. These older multimeters use much more current to test resistance, enough to potentially destroy some milliammeters

Watching your analog meter, work your way down the DMM's resistance ranges (remember you began at the highest range) until the analog meter's needle moves to a full-scale reading. Note the reading on your DMM, and write it on the back of the meter using a permanent marker. Be careful and take your time. If you go too fast and accidentally pin the meter, it could easily be damaged.

Making The Shunt. The shunt is made from a short length of copper wire. All wire has resistance, so we can use that property to make a shunt resistor. To make the shunt, you first need to determine how much current will flow through it. For example, if your meter is going to measure 20 amps full scale, then the shunt wire must be safely able to carry that amount of current.

Let's say you are going to make a 20-amp shunt using a surplus analog 0–1 milliammeter whose faceplate is graduated from 0–1. Go to a copper-wire table (there is one in the *ARRL Handbook for Radio Amateurs*; if you don't have a copy, it is available at almost any public library) and select an appropriate gauge wire. Remember that the smaller the wire gauge, the larger its diameter and the more current it can safely carry. For most hobby applications, 250 circular mils per amp is more than adequate.

To find the circular mils per amp for the shunt wire, divide the circular mils for the selected wire (found in the copper wire table) by the

Surplus and New Analog-Meter Suppliers

All Electronics Corp.
P.O. Box 567
Van Nuys, CA 91408-0567
Tel: 800-826-5432

Digi-Key Corp.
701 Brooks Ave. South
P.O. Box 677
Thief River Falls, MN 56701-0677
Tel: 800-344-4539

Fair Radio Sales Co.
P.O. Box 1105
1016 E. Eureka St.
Lima, OH 45802
Tel: 419-223-2196

Mouser Electronics
2401 Highway 287 North
Mansfield, TX 76063-4827
Tel: 800-346-6873

RadioShack
Stores nationwide

The Electronic Gold Mine
P.O. Box 5408
Scottsdale, AZ 85261
Tel: 602-451-7454

current you intend to pass through the wire:

Circular Mils per amp = (circular mils for wire)/(current through the wire) (Eq. 1)

By using the copper wire table , you will find that 12-gauge wire has a cross-sectional area of 6530 circular mils. By dividing that by 20 amps, we get 326 circular mils/amp, which should work fine. Twelve-gauge wire is very common, and can be purchased in most hardware stores.

To find the resistance of the shunt, use this equation:

$$R_{SH} = R_M/(n-1) \qquad \text{(Eq. 2)}$$

Where R_{SH} is the resistance of the shunt, R_M is the resistance of the surplus meter, and n is the shunt's multiplication factor. In our example, since we are using a 0–1 milliammeter and 1 milliamp = 0.001 amps, n = 20 amps/0.001 amps, or 20,000.

Next, let's suppose that the resistance of your meter was 81 ohms. Plugging that resistance and n = 20,0000 into Equation 2 yields:

$$R_{SH} = 81V/(20{,}000-1) = 0.00405V$$

That's not very much resistance, is it! A shunt having that resistance will pass 19.999 amps thought it, and 0.001 amps (1 mA) will pass through the meter for a full-scale reading.

Next, we need to calculate the length of our shunt. Note that as stated in the copper-wire table, 12-gauge wire has a resistance of 1.619 ohms/1000 ft. Therefore, the length of the shunt wire (L_S) can therefore be determined using:

$$L_S = R_{SH}/(XV/1000 \text{ ft.}) = 0.00405/(1.619V/1000 \text{ ft.}) = 2.5 \text{ ft.}$$

So the 12-gauge wire shunt should be 2 feet 6 inches long when using a 0–1 mA meter having an internal resistance of 81 ohms to measure 20 amps full scale.

If we made the shunt this long, however, we might have trouble with contact resistance. That is because even a good solder joint has a lot of resistance when compared to a 0.00405-ohm shunt. To make sure that the circuit's contact resistance is not part of the shunt resistance, two *sense* wires are used. These sense wires are spaced L_S apart on the shunt wire as shown in Fig. 2. Any type of wire may be used for the sense wires; they are noncritical. This simple feature will greatly increase the accuracy of your shunt.

Now we are ready to make our shunt. Cut a length of 12-gauge solid copper wire about 3-feet long. Remove the insulation from the wire using a hobby knife, being careful not to nick it. Now measure about 2 inches from one end and solder one sense wire there. Carefully measure 2 ft 6 inches from that sense wire and solder the second sense wire in position. Connect the shunt to its meter as shown in Fig. 2, and you're ready to measure current! If you want to make the shunt a little more compact, you can wind it over an insulated screwdriver handle or something similar such as a non-conductive wood dowel.

Calibrating the Shunt. Shunts made using this method can be very accurate. However, improved accuracy can be achieved by calibrating the shunt to a known standard, *i.e.*, a calibrated meter. To do this, build the circuit shown in Fig. 3. Make sure that the load resistance, R_L can safely handle the power. I have found that car taillight lamps make a convenient load for the circuit.

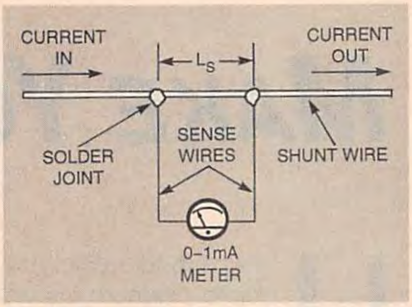

Fig. 2. Two sense wires can be used to make sure that the circuit's contact resistance is not part of the shunt resistance.

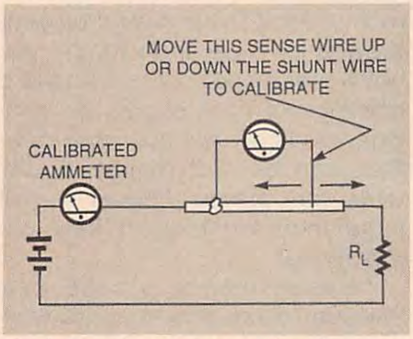

Fig. 3. To make sure that your shunt is as accurate as possible, this setup can be used. An automobile taillight lamp is a good candidate for the load resistance.

To calibrate the shunt, solder one sense wire into position as described above. Power up the circuit and slide the second sense wire up and down the shunt wire until you find the spot where the shunt meter reads the same current as the calibrated meter. Remove power from the circuit and solder the second sense wire at that spot.

Conclusion. Using these methods you can make shunts for almost any range of DC currents. What's more, with a little care you should be able to make shunts accurate to within 5–10% if you keep them near room temperature. Of course, these shunts are not nearly as precise or temperature-stable as the commercial versions. Still, if you need one for a non-demanding application, or just want to have some fun, grab a few cents worth of wire and make your own shunt! Ω