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The Incredible Digiohm

How to put ten million resistors in the palm of your hand? Build the ultimate substitution box.

Did you ever notice how complicated your life is becoming? Back in the good old days, resistors with a 20% tolerance rating were basic in all electronic circuitry. Through the years we have "progressed" through the 20% to 10% to 5% to 1% tolerance resistors. Granted there are many circuits where the 20% resistors are still used quite extensively, but as we strive for higher precision, lower noise, higher speed, lower cost, etc., we are seeing an increasing use of 1% resistors.

A listing of standard 1% resistor values for values from ten to one million Ohms contains over 480 different resistor values. Not only do you have to purchase a ridiculous number of resistors, but you must also keep them sorted. Have you ever tried to read the color code on a 1%, ¼-W resistor? Next to impossible! If you can read five color bands on a resistor that is only ¼" long, you're in the wrong hobby, you should be a stamp collector. What's the answer to this problem? Read on.

Digiohm, the portable resistance box, was designed to make life simple again. Digiohm is capable of any of ten million resistance values from 0 to 9,999,999 Ohms. Digiohm uses a lever-operated switch to dial in any resistance value. Each of the seven switch sections has ten positions labeled 0 to 9. With the proper connection of 63 resistors to the switch, any of the ten million resistance values can be selected in a matter of seconds just by dialing in the value needed. For less than $20.00 and some junk-box parts (and a little time), you can build Digiohm.

Digiohm's theory of operation is simple: When resistors are connected in series, the total resistance equals the sum of the individual resistances. Fig. 1 shows the schematic diagram of Digiohm. As you can see, there are seven identical decade (10-position) switch sections. Each switch section contains nine resistors. The switch section on the right (ones-unit switch) contains nine 1-Ohm resistors. When the switch is placed in the zero position, current flows directly through the switch without passing through any of the 1-Ohm resistors, and thus the resistance of the first switch section would be zero Ohms.

When the right switch is placed on any value 1 through 9, the corresponding number of 1-Ohm resistors are switched into the circuit to provide the appropriate resistance value.

The switch section second from the right is called the tens-unit switch. The tens-unit switch has nine 10-Ohm resistors connected in series and is capable of the following resistances: 0, 10, 20, 30, 40, 50, 60, 70, 80, and 90 Ohms. The other five

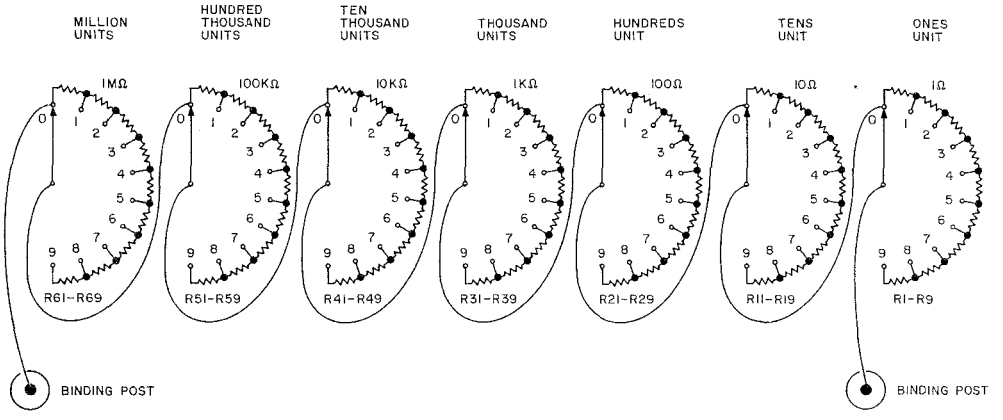

Fig. 1. Schematic.

Dial	Common Connection to:
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

Fig. 2. Truth table.

switches are similar. Each consists of nine resistors connected in series. See Fig. 1.

Before construction can begin, it will be necessary to purchase or locate the switch assembly, resistors, binding posts, and box. The binding posts and box are not critical and can be purchased locally if you do not have them in your junk box. The resistors are all ¼ Watt, 1% tolerance except for the 1-Ohm resistors, which are 5% tolerance. I used 5% for the 1-Ohm resistors because I had difficulty purchasing 1-Ohm resistors with a 1% tolerance rating at a reasonable price. Nine resistors of each of the values shown in the parts list are required; however, for the small extra cost, it is recommended that ten resistors of each value be purchased. The extra resistor may be necessary to replace a resistor which was damaged during construction.

The switch assembly is the most critical part of Digiohm. The basic switch section is a single-pole ten-position switch with the numbers 0 through 9 indicated. Fig. 2 shows the truth table for the switch. The switch assembly used to build Digiohm is a Digitran model 28531-7. This switch assembly is available from Electronic Design and Sales, as shown in the parts list. The model 28531-7 switch assembly is similar to a thumbwheel switch except that it has miniature levers which are used to operate the switch. The lever-operated switch has a couple of benefits over a thumbwheel switch. First, the switch can be reset to zero with a sweep of the hand, permitting instant reset. Second, the lever operation permits rapid switch setting when compared to the standard thumbwheel switch. Although I have discussed the thumbwheel-type switch, any ten-position switch can be used as long as it matches the truth table shown in Fig. 2.

If you purchase the switch assembly from Electronic Design and Sales, it is likely that it will appear as in Photo A. The switch assembly was originally planned to be installed in medical equipment before being purchased as surplus equipment. As Digiohm does not use multiplexer circuitry in conjunction with the decade switch, it will be necessary to remove the bus wiring. This can be done by cutting the wires between switch sections and using a soldering iron and needle-nose pliers to remove the short wire segments. It is a good idea to pull the short wire segments from the side opposite the conductor so that the conductor is not accidentally pulled from the board. After the wires have been removed, it will be necessary to remove the excess solder from the holes.

After the switch has been prepared, the resistors can be inserted and soldered to the switch. Fig. 3 shows the resistor connection. During construction you will dis-

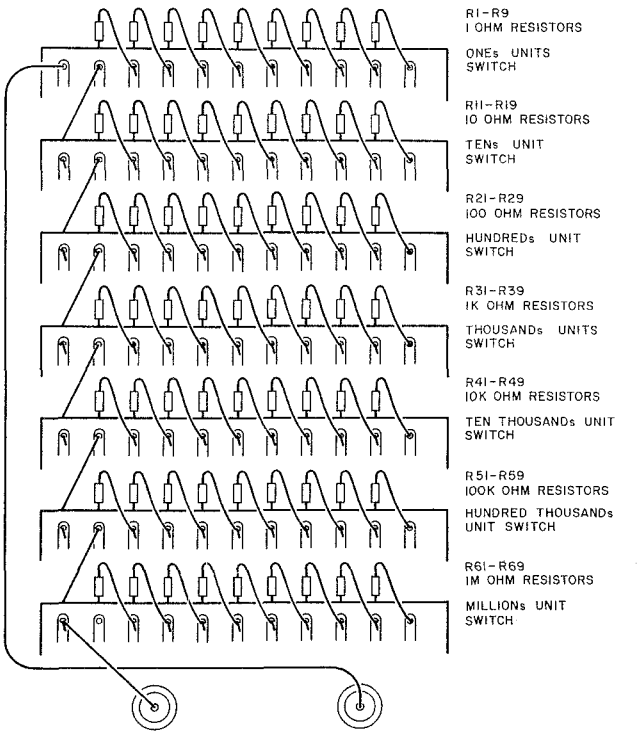

Fig. 3. Back view of the switch assembly showing resistor layout and connection.

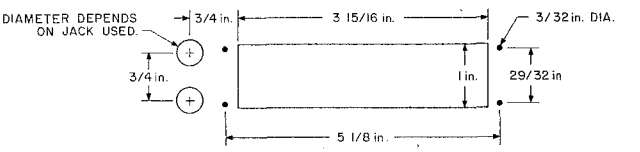

Fig. 4. Cutout dimensions.

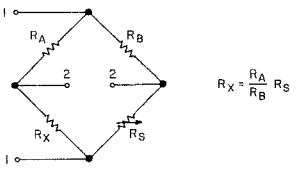

Fig. 5. Digiohm can be used as Rs in a Wheatstone-bridge circuit.

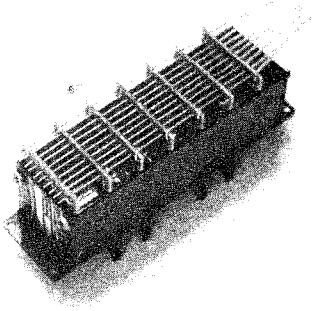

Photo A. Switch assembly with bus wiring.

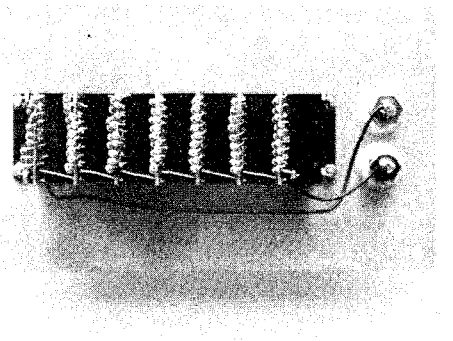

Photo B. Switch assembly with resistors and wiring installed.

cover why ¼-Watt resistors were specified: ¼-Watt resistors fit quite nicely, whereas ½-Watt resistors would have been more difficult to install. Some care should be taken when bending the resistor leads, as they can break from the resistor body.

After you have finished soldering the 63 resistors, you'll be ready for a change. The next step is to cut out the front panel for the mounting of the switch assembly and the binding posts. Fig. 4 shows the cutout dimensions. Layout is not critical. Before drilling holes for the binding posts, check their diameter.

Photo C. The finished product.

The next step is to mount the switch assembly and the binding posts. After you have mounted the switch assembly and binding posts, you will need to solder the two wires as shown in Photo B.

You are now ready to check out Digiohm. Connect an ohmmeter to the binding posts and set the ohmmeter to the lowest resistance range. With all the switches on Digiohm set to zero, the ohmmeter should read zero Ohms. Next, move the rightmost switch (ones-unit switch) through every position while watching the ohmmeter reading. The ohmmeter should correspond to the value set on Digiohm. After you have checked out the ones-unit switch, return it to zero and check the remaining switches in a similar manner. It will be necessary to set the ohmmeter to the appropriate range and zero it before checking each section.

If you run across a problem, it will most likely be a poor solder joint or the installation of a resistor with the wrong value. By using the above checkout, you should be able to locate the problem without much difficulty.

After you have completed the checkout and have made any required corrections, the front panel can be mounted. I used ½" rub-on vinyl letters to write the word Digiohm on the front panel. Photo C shows the finished product.

In addition to using it as a resistance substitution box, Digiohm can be used as Rs in the Wheatstone bridge shown in Fig. 5.

Whenever using Digiohm, you must be aware of its electrical specifications. Since ¼-Watt resistors are used, care must be taken not to exceed their rating. The Digitran model 28531-7 switch is rated for maximum switching of 28 volts ac or dc and 50 milliamps of resistive current. In the non-switching mode, the switch is rated at 1 Amp. The switch has a dielectric rating of 500 volts rms. These ratings are typical for thumbwheel-type switches.

If you build the Digiohm, you will find that it is a welcome addition to any hobbyist's bench. Good luck and happy switching. ■

Parts List

All resistors are ¼ Watt
R1 -R10 1 Ohm, 5%
R11-R20 10 Ohms, 1%
R21-R30 100 Ohms, 1%
R31-R40 1000 Ohms, 1%
R41-R50 10,000 Ohms, 1%
R51-R60 100,000 Ohms, 1%
R61-R70 1,000,000 Ohms, 1%
Note: Only nine resistors of each value are required for the project (see text).

J1-J2—binding posts, Radio Shack #274-662 or equivalent

S1—switch assembly, ten position, seven sections. Digitran switch model 28531-7 or equivalent (see text)

Box—Radio Shack #270-627 or equivalent size, 6¼" × 3¾" × 2"

The following is available from Electronic Design and Sales, PO Box 502, Columbus NE 68601: Digitran model 28531-7—$13.00, ten resistors of each value—$4.00, complete Digiohm assembled—$59.95; Nebraska residents add 3½% sales tax. Please include $2.50 for postage and handling.