The Gigohmer

An inexpensive gigaohm adapter for your multimeter.

BY R. JAYARAMAN,* VU2JN

This article describes a highly sensitive adapter which extends the range of any inexpensive multimeter to as high as 1 gigaohm (1000 megohms). The only components used in the "Gigohmer" are two transistors, and while the unit enables one to measure very high resistances, its total "impedance" is as low as 3 "ohms"!

The Gigohmer can be used with any multimeter of 4,000 to 20,000 ohms-per-volt sensitivity, put in the high-resistance range. For reliable operation and safety of the transistors, the internal battery voltage of the multimeter should be not less than 3 and not more than 6 volts.

The Circuit

There is not much circuitry involved in the unit. Two Darlington-connected transistors are placed across the multimeter terminals and the resistor to be measured is placed across the collector and base of the input transistor (fig. 1). The minute current through the resistor is amplified by the transistors which present a corresponding virtual resistance at the multimeter terminals. A calibration chart showing the test resistance versus percentage meter deflection enables direct estimation of the value of the resistor. The chief merits of the unit are: 1. low cost and simplicity; 2. No need for an external high or low voltage supply; 3. The multimeter or the adapter cannot be damaged by any wrong connection.

Electronic circuit-designers may scoff at the use of a non-compensated nanoampere d.c. amplifier and the operation of the transistors under near-starvation conditions. But repeated tests made by the author confirm the reliability of the unit. It may be noted that the voltage across the transistors drops as the current increases, thereby providing some measure of automatic drift-compensation. Meter readings are quite repeatable, and the maximum day-to-day spread (for a variation of about 10°C in the ambient temperature) is about 2% f.s.d. in the mid-scale region. Part of this drift may be due to changes in the values of the calibration resistors themselves.

If the calibration chart is prepared for the mean readings, the maximum likely error in the meter indication is only 1% f.s.d. in the mid-scale region. Up to 100 megohms, resistances may be read to an accuracy of 10% and up to 1000 megohms, to an accuracy of 20%. However, because of the low-voltage operation, the Gigohmer may not give reliable readings in observations in which contact-potentials exist.

The choice of the transistor Q_1 is rather critical. It should have extremely low collector leakage and a respectable current-gain at very low collector currents. The writer is using a SG840 NPN silicon planar transistor,[1] now being made in India. This transistor, specially developed for low-level low-drift d.c. amplifier applications, has a collector

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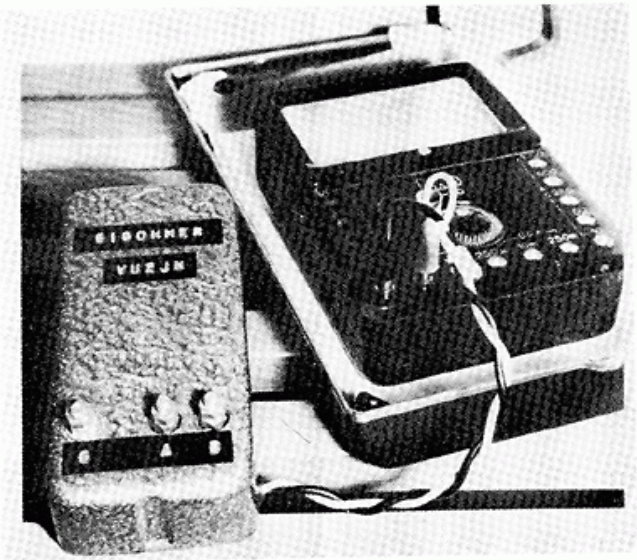


The Gigohmer connected to the author's inexpensive multi-meter. Note that terminals A and B simply pass through holes in the aluminum box.

[1] Made by Semiconductors Ltd., Poona-14, India.

leakage of less than 10 nanoamperes at 6 volts and a minimum current-gain of 30 at a current of 1 microampere, 100 at 10 microamperes, and 300 at 1 milliampere. Q_2 can be any high-gain NPN silicon transistor with a collector leakage of not more than 0.1 microampere at 6 volts and a current-gain of not less than 400 at a collector current of 1 milliampere.

Construction

The Gigohmer is built inside a small aluminum box. Wiring is critical in one respect. The two transistors should be mounted on a really good ceramic strip with three terminals G, A and B. No other tie-point or circuit-board should be used, except for the output leads. The writer is using a 1⅞" × ⅜" × 3/16" ceramic strip which, fortunately, had holes in the right positions. 5/32" brass bolts form the three terminals. In order to safeguard against degradation of insulation, the ceramic strip is supported at one point only, namely the ground terminal G which is fixed to the box, leaving a clear gap between the ceramic strip and the box. The other terminals A and B simply pass through holes in the box with a small circumferential clearance.

Testing

The zero-adjustment of the multimeter in the high-resistance range is first carried out carefully. Before coupling the Gigohmer to the multimeter, the polarity of the multimeter leads in the resistance range should be checked. Usually the black lead will be the positive one.

With the unit coupled to the multimeter, there should be little or no deflection of the meter. If the meter deflects by more than 0.5% f.s.d. in the case of a 20,000 ohms-per-volt multimeter, the ceramic strip and the transistors should be checked. Two measuring ranges are available. In range A of the instrument in which the test resistor is connected between the terminals G and A, the Darlington pair comes into action, while in range B in which the resistor is connected between the terminals G and B, only the second transistor comes into action. With a 4,000 ohms-per-volt multimeter, range A is suitable for measuring 15 to 1000 megohms, while range B is suitable for 0.5 to 15 megohms. While measuring body-to-ground resistances etc., the terminal G should be connected to a good ground.

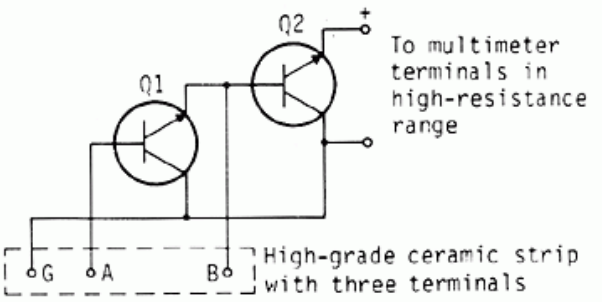
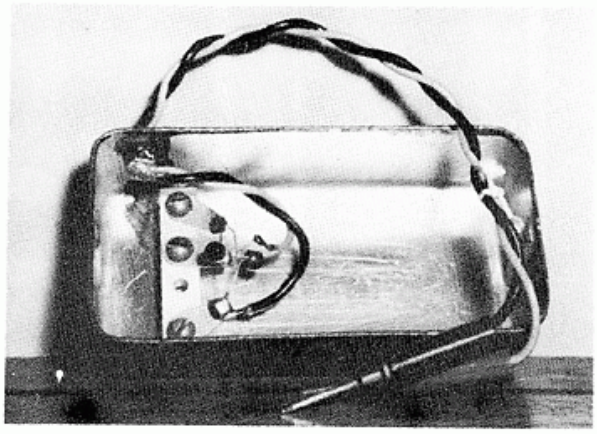


Fig. 1—Circuit of the Gigohmer, a simple adapter for the vom permitting resistance measurements to 1000 megohms. Q_1 is a low-level low-leakage NPN transistor. Q_2 is a high gain NPN silicon transistor. See text for more details.

Calibration

For calibrating the Gigohmer, a set of precision resistors of the following values are desirable: 1M, 3M, 10M, 30M, 100M, 300M, and 1000M. It will be found that when the test resistance is zero, the meter will not show f.s.d. because of the saturation voltage across the transistors. A graph prepared on semi-logarithmic graph-paper, as in fig. 2, enables direct readout of the resistance. With the author's multimeter, a 1000-megohm resistor, representing a 3-nanoampere input current, produces a meter deflection of 2% of full-scale, representing a 5-microampere output current. For resistance values of 100 to 500 megohms, the author was able to verify experimentally an inverse relationship between the resistance and the meter deflection. In this region, the product of the test resistance in megohms and the percentage meter deflection is 3200 with the writer's multimeter. The calibration chart prepared for one multimeter may not apply to others of the same sensitiviy.



Inside view of the Gigohmer is sure to catch an approving look even from amateurs who usually "don't have time to build anything!"

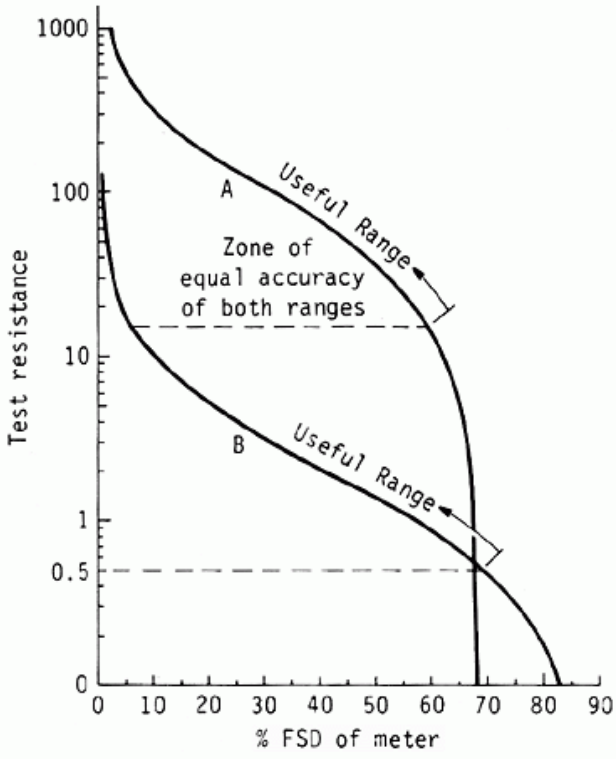


Fig. 2—Calibration chart of the Gigohmer when used with the author's 4000 ohms per volt vom in the high resistance range. Internal batteries are two 1.5 v. cells. Note that the useful portion of each range is shown. This chart is correct for the author's meter and not necessarily correct with other instruments, which must be calibrated as described in the text.

In spite of its simplicity, the Gigohmer is an ultra-sensitive instrument. It should preferably be stored in a closed box so as to prevent moisture and colloidal dust particles from settling on the ceramic strip and playing havoc with the readings (If you just blow your breath on the ceramic strip, you will get a meter deflection equivalent to about 300-M!). In humid climates, the Gigohmer should, before use, be warmed up under a lamp till the meter deflection drops to zero.

Uses

The Gigohmer will find a hundred-and-one uses in the shack of a ham; to mention a few—checking the insulation resistance of all electrical equipment, checking power transformer insulation, checking grid leak resistors, checking paper capacitors, checking the reverse resistance of silicon diodes and transistor junctions, checking the gate resistance of FET's, etc. Good silicon transistor junctions and FET gates will produce little or no meter deflection, indicating a reverse resistance of over 5,000 megohms!

Only after using a gadget like this, one gets the "feel" for high resistances. If after using this gadget, you happen to read about a v.t.v.m. amplifier, its input impedance of 10 gigaohms will no longer appear to you as an abstract incomprehensible quantity like the distance of the Andromeda galaxy! If you have not used similar instruments before, you may have to shed some of your notions about high resistances! For example, you will realize that while many of the substances used as insulators in household electrical articles do not give even 10-megohm insulation, really good insulators can give more than 1000-megohm insulation. You will start appreciating the superiority of Teflon and polyethylene over many other insulators such as bakelite, PVC, rubber and mica. If you check a few old paper capacitors with the Gigohmer, you will, most probably, decide to replace immediately all the paper capacitors in your "good-old" receiver!

You can demonstrate the sensitivity of the Gigohmer by an interesting experiment. Connect terminal G of the unit to the house ground connection. Spread a thin polyethylene sheet over the floor of the shack (assum-

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ing it to be a cement or timber floor without any high-insulation carpeting). Standing with your bare feet over the sheet, touch the terminal A of the unit. The meter will kick to more than 25% f.s.d. and come back to a perfect zero, indicating that you and the polyethylene sheet are acting as a capacitor with respect to ground. You can "discharge" yourself by just touching any of the usual objects in the room, or by placing a foot on the floor! Comparison with a good mica capacitor will indicate a body-to-ground capacitance of more or less 2000 pf, depending on the thickness of the sheet and the size of your feet!

The writer hopes that many among the readers of *CQ* will decide straightaway to construct this useful and interesting gadget! ■