VTVM Adapter

makes a Vacuum Tube Voltmeter out of any standard Multi-meter

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The VTVM adapter adopts a 6SN7-GTA tube triplet in the manner shown in the circuit diagram. A multi-meter set on its 0-volt DC range is plugged into J and J. Then with adapter lead tests show that the silver-sheath potentiometer R, is adjusted to eliminate any difference of potential between the plates of the triodes. This condition is indicated when the multi-meter needle reads zero. At this condition, each plate of the 6SN7-GTA in the model illustrated is precisely 150 volts above ground. When the adapter test leads are applied to a voltage point and ground, the bias on one half of the 6SN7-GTA is upset and this half shows current. This causes a difference of potential between the plates of the twin triodes, and of course the multi-meter reads this difference. The high range of this adapter reads 0 to 400 volts the middle range 0 to 40 volts, and the low range 0 to 4 volts—all reading on the 0-50 scale of the multi-meter.

In the circuit shown, little difference was apparent when using multi-meters varying in resistance from 1000 ohms per volt to 20,000 ohms per volt. Thus although the multi-meters drew some current from the plate circuit of the VTVM tube, it was not enough to affect the meter readings. And, of course, with the high input resistance of the VTVM, very little current is drawn from the circuit under test. It is quite conceivable that slight variations in the Adapter circuit would cause a wider variation in the operation of different multi-meters.

Three different multi-meters were tried with this VTVM Adapter and all gave the -readings when set on their 50-volt ranges. In one case, the current reading was 2.5 volts which is a 75-volt range. In checking against a laboratory standard power supply, it was found that this particular multi-meter used above a read a little high. This same error was reflected in the readings when the VTVM Adapter was used and the multi-meter set on its 75-volt range.

This multi-meter also has a 110-volt range, a 15-volt range and a 7.5-volt range. However, when set on the 11- and 7.5-volt ranges and connected to the VTVM Adapter the errors at low voltages rendered readings almost useless due to the low value of resistance available across the 6SN7-GTA plates. This multi-meter has a resistance of 1000 ohms per volt. With the multi-meter set on its 150-volt range, readings were usable, but more in error than when the 75-volt range was used because of the difficulty in reading the low end of the scale.

When balanced, 120 volts is on each plate of the 6SN7-GTA in the model illustrated. Tests showed that when 1 volt is applied to the Adapter input (with the Adapter range set plugged into the 0 to 10 volt range tip-jack), the potential on one plate of the 6SN7-GTA drops 121 volts while the other plate remains at 120 volts, the same as the Adapter input. When 300 volts is applied to the Adapter input (with the Adapter tip-plug in the 0 to 600 volt tip-jack), the plate of the 6SN7-GTA drops to 300 volts and the other plate remains at substantially 120 volts. This, also, indicates a 10-volt gain in the Adapter.

In this adapter, voltages up to 4, 10, and 40 volts were measured with precision, but above this point the 6SN7-GTA became saturated and further increases in voltage caused a difference equal to the scale of the multi-meter. (This actually is a safety feature. For obvious reasons the voltages of many times the full-scale value will not harm the meter, whereas on many types of meters, due to the non-ohmic nature of the meter, the meter may be damaged even though the meter needle may not be harmed.) Thus it was found that the usable difference of potential between the plates of the 6SN7-GTA ranges between 0 and 40 volts. The simplest calibration procedure for testing the performance of an Adapter multi-meter combination against a good standard VTVM and other the range range which gives the best readings. This involves such that particular range of the Adapter was found to be the 50-volt range or thereabouts in the multi-meter (tend).
CONSTRUCTION DETAILS

A 6-inch utility box provides more than enough room for the essential "works"—and, in addition, leaves space for incorporating a meter into the unit if desired. The tube was mounted outside the box to eliminate the necessity for a special tube socket bracket, to keep the heat outside the box, and to act as a pilot light. A builder anticipating rough usage could, of course, place the tube inside.

Red and black tip-jacks are used for the positive and negative multi-meter leads. The 0 to 5, 0 to 10, and 0 to 100 range tip-jacks are labeled accordingly. The flexible cord with the tip-plug which changes the range could be replaced by a switch.

The chassis connector for the RF probe is merely connected in parallel with the low-range input tip-
Circuit diagram of VTVM Adapter and

R=1 megohm
R=3.3 megohms
R=0.1 megohms
R=91 megohm
R=1 megohm
R=10,000-ohm, 10 watt
R=5000-ohm wire-wound potentiometer
R=600-ohm, 1-watt
R=10 megohms
R=100-ohm, 5-watt
C=500 microfarad ceramic
C=0.01 to 0.03 mfd
C=10 to 20 mfd, 6.3 volt
D=Type IN18 germanium
R=100,000 ohm, 0.1 ma
D=717, 6.3 volt
(Dimmer R9015 or
P=Phone plug (to
P=Single-contact slide
P=Plug plug
J=Single-contact slide
J=Tip jack
Jack — this separate connector being provided to accommodate the round cable and to permit the RF probe to be detached when not in use. If the DC test leads are not fed into the circuit, as in the model illustrated, care should be taken not to allow the positive lead to touch a high-voltage circuit when the RF probe is in use.

The RF probe is easily constructed with a 4-foot length of RG59/U and a phone plug. A plug with solder lugs instead of the machine screw type designed for phone plugs was chosen because it provides more room for the resistor, diode and capacitor as well as convenient solder tip points for those components. The construction is clearly shown in the Illustration. In this model, the plug was turned and the center conductor shaft drilled and tapped to receive a machine screw. The screw then was "bushed" and fed to a point. With some types of plug it may be possible to merely reduce the tip to serve as the test lead point. The ground clip lead is soldered on the base of the plug as shown in the illustrations.

Practically any selenium rectifier referred to operate in a 120-volt half-wave rectifier circuit can be used as current drain is very small. A separate power supply can be used, of course, by those who may have a utility supply at hand and wish to avoid the expense of building one to incorporate in this unit. However, if an external supply is used, care must be taken to make sure the supply voltage is precisely the same as the operating voltage. Variations in the supply voltage may upset the calibration.

**Using the VTVM**

A range of voltage tests made on a grid dip oscillator illustrates the usefulness of a VTVM. The GDO was adjusted so its meter read 1 milliamperes. Then the plate voltage was read with first the multi-meter alone, then with an Adapter-multi-meter combination, and finally with a highly expensive commercially-built VTVM which had been checked against laboratory standards. In each case the effect of the measurement on the GDO readings is shown.

The multi-meter alone read 16 volts and the GDO reading was 15.6 milliamperes. The Adapter reading was 15.6 volts and the GDO reading dropped only a hair's breadth during the test. The commercially-built VTVM read 15.5 volts and showed only the tinny flicker on the GDO meter.

The average commercially-built VTVM is granted an error of ± 5% — which means in the instance cited above that the 15.6 volts read with the standard VTVM actually could have been anywhere between 15.2 and 16.0 volts without being first checked against a laboratory standard. The Adapter reading came within this range; but the multi-meter reading dropped far below this minimum tolerance. In fact, the 16-volt reading obtained with the multi-meter alone is an error of more than 5%.

The operational dials for the GDO under test specifies a plate voltage of 40 to 60 volts. So in this case, the use of a multi-meter would not have led an experimenter too far astray. However, it is quite conceivable that a minimum of 50 volts might have been specified. Had this been the case, the multi-meter scale would have indicated insufficient voltage, whereas in fact the voltage was well over the 50-volt limit.

The use of a GDO with which a VTVM can be put to well illustrated in the ARS, "Cours in Radio Fundamentals" and in many standard electronics texts. In addition, the grid dip oscillators often describe how the usefulness of such instruments can be extended when used in conjunction with a VTVM.
For instance, the Q of a tuned circuit may be measured by using a GDO and VTVM. Using the RF probe, the VTVM is connected across the tuned circuit. The GDO is loosely coupled to the circuit and output frequency adjusted until a maximum reading is obtained on the VTVM. This frequency (f) can be noted by checking against a calibrated receiver. The GDO frequency then should be increased until the VTVM reading drops to 70.7% of its original value. Once again the frequency (f) should be noted by checking against the receiver. Then the GDO frequency should be set between f and a point where once again the VTVM reads 70.7% of the peak value and this third frequency (f) noted on the receiver. Then:

\[ Q = \frac{f}{f_1 - f_2} \]

The balanced DC amplifier type circuit used in this adapter is the type most often employed in commercially built VTVM's. The L-to-ratio resistor in the positive DC test lead is incorporated in the probe to minimize the capacity effect of the long test lead and thus allows the instrument to be used to make dynamic voltage measurements in circuits carrying oscillatory or signal voltages.

Similarly, the crystal diode and associated rectifying components are built into the plug which forms the separate RF probe to provide low capacity to ground. It is possible with a VTVM to measure AVO voltages in receivers quite accurately—a measurement not possible with conventional voltmeters because their comparatively low internal resistance will shunt out a high resistance AVC circuit. This is particularly true in circuits of the diode clipper type. Consequently, makes a convenient probe for obtaining an output reading when filling up the RF and IF stages of a receiver.

The operation of an oscilloscope can be checked over its intended frequency range by measuring the value of grid voltage at the oscillator tube socket while tuning the circuit over its range.

Since the high impedance of the VTVM allows it to be placed directly on the grid of a tube without seriously disturbing the circuit, it is possible to tell whether or not a tube is good. A gassy tube will cause a positive voltage to appear across the grid resistor instead of the usual negative voltage. This same condition can exist, however, due to a leaky coupling capacitor—so it is wise not to discard a tube without first also checking the capacitor for leakage.

Because the loading effect of the VTVM is negligible, it is possible to measure current without opening a circuit to insert a milliammeter. The only requirement is the presence of a resistor of known value in the circuit. In this case it is merely necessary to measure the voltage at each end of the resistor. Subtract the test point drop. From the total voltage, the current can be determined. In designing equipment, it is often quite possible to insert 100-ohm resistors at certain points especially for this purpose.

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Another important innovation—which we neglected to mention in our article on the subject last time—is silicone rubber. This material has excellent properties, as well as outstanding resistance to ozone, corona, sunlight and heat.

For those who might wish to add this insulation to the table of statistics given in the May-June, 1954, issue of QST, HAM RADIO (Vol. 9, No. 5), here are the ratings: Resistivity (ohm-inches): 5 x 10^12; dielectric constant, 3.5 to 3.6; power factor, 0.5 to 0.6; 0.5 at 1 megapond strengths of a 5,000-volt ampere. 500 to 500 volts per mil. Silicone rubber is partly organic and partly inorganic; it is one of the two general classes of materials that can be used to make the insulators.

While the electrical properties of silicone rubber are of minor order of magnitude as organic materials at room temperature, they are greatly superior at high temperatures where "pure" organic materials can no longer be used. Silicone rubber is, of course, but one of a large family of materials.

The silicons, incidentally, are something like the silhouettes of comic strip albums. We mean nothing derogatory in saying that. As you will recall, the silhouettes could do anything. And it's much the same with the silicones. For instance, every article we've ever read on the silicones has left us groggy and bewildered. For the story to unfold, we beg to forget the silicones used that were reviled in the beginning.

Let's put it this way. Silicones are a new class of man-made chemicals, combining the best qualities of silicon, coal, and oil. Their key material is silicon, which is derived from sand—the second most abundant element on earth. As a wartime development, the silicones were under wraps for quite a while after the initial report at the General Electric Research Laboratory in the 1930s.

In its commonest form—a water-white oil—the amazing chemical can pass as the most ideal and yet serviceable liquid on earth—degree F. As a "refractive" material, it can be used as an electric insulator and also as a sealant, or as a rubber substitute. As a release agent, silicones keep rubber and plastic objects from sticking in machines. In paint, silicons can be added to obtain extremely high flash of heat to 1000 degrees F for 73 consecutive hours.

The various silicones are combinations of oxygen and one or more hydrocarbons, with silicon. By varying the proportions and types of hydrocarbons, the chemical can be made to possess amazing properties. One can be made from volatile liquids to semisolid elastomers. They are used as sealants, gaskets, adhesives, and puttylike materials, working on insulation and textiles, as gasket insulation on spark-plug terminals, and in many places where a non-conductive seal is needed.

Scientists see in the future silicones replacing damaged vital parts of human tissue, silicone gels that will last the life of the car, silicone human parts and hygienic baby parts, stain- and spot-resistant clothes and—well, it does get bewildering. Think we'll try spraying a drop or two into the atmosphere to see if it will dissipate the QRM.

A dozen 10-meter mobiles from these parts went out to a nearby reservoir one recent weekend and provided communications for a "strip-shooting contest." The shooting was done by bow and arrow and shooting kept up to the minute by five mobile stations reporting in to a HQ station. Ham radio came in for quite a bit of praise and a trophy was awarded the ham for their work. The boys' big question now is what are they going to do with the trophies? Who's going to keep the trophy? They don't all belong to one club. They can pass it around for a while. Then what? Any suggestions?

To succeed in amateur operating a fellow has to develop a fairly high degree of patience, an oldtimer knows very well. A recent example of this was brought to our attention when a ham we have attempted to recruit a friend of a visitor in his shack. He kept being interrupted and had to leave the visitor when the fellow always asked on the air near a certain frequency around 8 o'clock at night. While the victim sat and waited without much hope of making the contact, our friend attempted several times to fix the specified frequencies, called a few times and alerted several other hams working nearby. Pretty soon they heard someone talking—but there was the contact. The visitor was much impressed—but our friend thought nothing of it.

Another example of ham patience is reported in a recent issue of the Broadcaster. (V. Y.) Amateur Radio Association Rep. W2BFW followed the Clypster during an amateur contest last April, for periods of 12 hours at 6:30 one morning. He called constantly until the following morning at 10 when he made the contact.

Our editor thinks he may have received one of the last QRL cards from Nicaragua—straiten for a time. He got a card from a VNY—who he worked on 75-meter SSB with a 10A and 6146—together with a letter which said the VNY's wife were the air due to "some internal difficulty." A week to a month news from all of his old army ships and old QSL cards and everything had nothing to do with the "internal difficulty."

—Lighthouse Larry
SLICING UP ELECTRONIC TUBES

What seating exists between the components of a tube after it is put together? Breaking sample tubes open and looking at them in a condenser beam shows the dismantling process could disturb the placement of the elements.

G.E. solves this inspection problem by filling samples from the production line with plastic—and then slicing the tubes crosswise and/or lengthwise to check the spacing of elements.

In some cases, the tube is immersed in a clear liquid plastic, and the glass lip broken off. Because of the vacuum inside the tube, normal atmospheric pressure presses the plastic into the tube. In other instances, a hole is drilled in the tube (see hole in end of the 7C55A illustrated) and tube is immersed in a special vessel which also contains the plastic liquid.

Chemical action and baking harden the plastic in a few hours with the elements undisturbed. Then the glass envelope can be cracked away, and the plastic-covered elements sliced into sections and polished for inspection.

Careful inspection of the illustration will reveal the filament, grid and even the grid of one pin—just as they actually ended up in a finished tube.