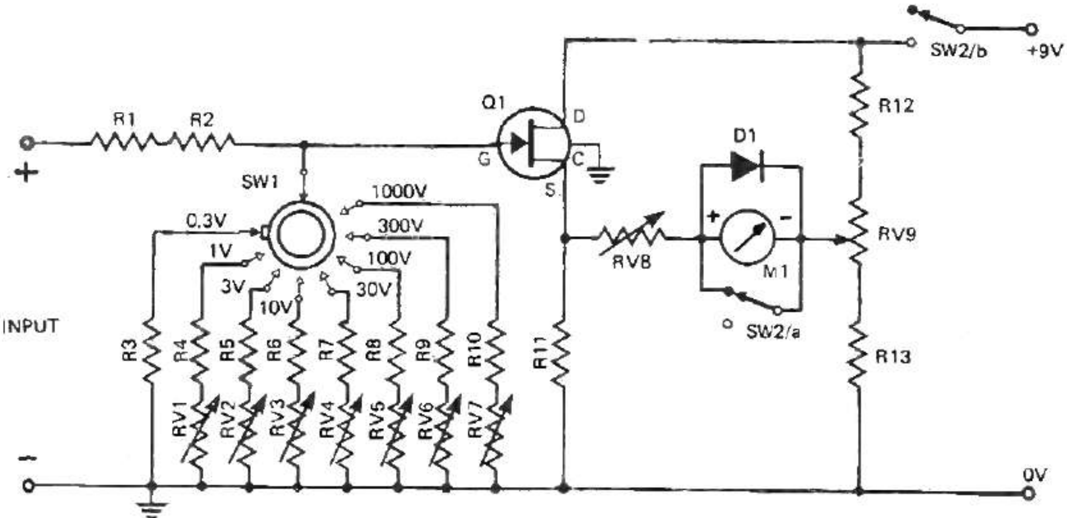
FET DC VOLTMETER

ETI PROJECT 110



This cheap and easily constructed dc voltmeter has 10 Megohm input resistance.

Fig. 1. Circuit of complete instrument.

PARTS LIST – ETI 110

R1, R2	–	5 Meg 5% ½W
R3	–	18M
R4	–	2.2M
R5	–	560k
R6	–	180k
R7	–	56k
R8	–	18k
R9	–	5.6k
R10	–	1.8k
R11	–	4.7k
R12	–	680 ohm
R13	–	120 ohm
RV1	–	470k trim pot
RV2	–	220k "
RV3	–	47k "
RV4	–	22k "
RV5	–	4.7k "
RV6	–	2.2k "
RV7	–	470 ohm "
RV8	–	4.7 ohm "
RV9	–	250 ohm ww pot
Q1	–	BFW 61 BFW 10 BFW 11
D1	–	OA91
SW1	–	Single pole eight position rotary switch
SW2	–	DPDT Toggle Switch
M1	–	50 uA meter 0-10 and 0-3.16 scales.

For accurate voltage measurements in high impedance circuits it is essential that the measuring instrument has an input impedance that is very much higher than the circuit being measured. If the meter drains current away from the point being measured then an inaccurate reading will be obtained.

The valve voltmeter (VTVM), with its inherently high input impedance has for many years been used for such measurements.

But until the advent of the field effect transistor (FET), solid state technology was not commonly used in these instruments, for the bi-polar transistor has the disadvantage of having an inherently low input impedance.

The field effect transistor, on the other hand, has a *high* input impedance and because of this, forms an excellent basis for a high input impedance voltmeter.

Here then are constructional details of a simple yet accurate FET dc voltmeter having an input impedance greater than 10 megohms on all ranges.

The attainable accuracy is very much determined by the quality of the 50 uA meter (M1). We have not specified any particular make or type, for this will be determined by the accuracy required. Generally however the meter chosen should be at least four inches in diameter and should have a guaranteed 1% to 2% accuracy at full scale deflection.

Three types of FET may be used in this circuit – BFW10, BFW11, and BFW61. Of these the BFW61 is the cheapest and this is the one that we have used in this project.

High stability resistors must be used throughout. These should be of 5% tolerance (or better). Metal film resistors – such as those produced by Philips are ideal. Corning Electrosils are also an excellent choice.

CONSTRUCTION

The physical design of the instrument is determined primarily by the size and shape of the 50 uA meter. Within reason the larger this is the better.

A good quality switch must be used for SW1 – preferably of ceramic construction. A single-pole twelve-way switch was used in the prototype (four of the available positions were not used for switching).

The electronic components may be located on tag strips or on matrix

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board. A matrix board layout is shown in Fig. 2.

As FET's are a bit touchy about input voltage it is wise to keep their terminal leads shorted together by a thin strand of wire whilst soldering them into the circuit.

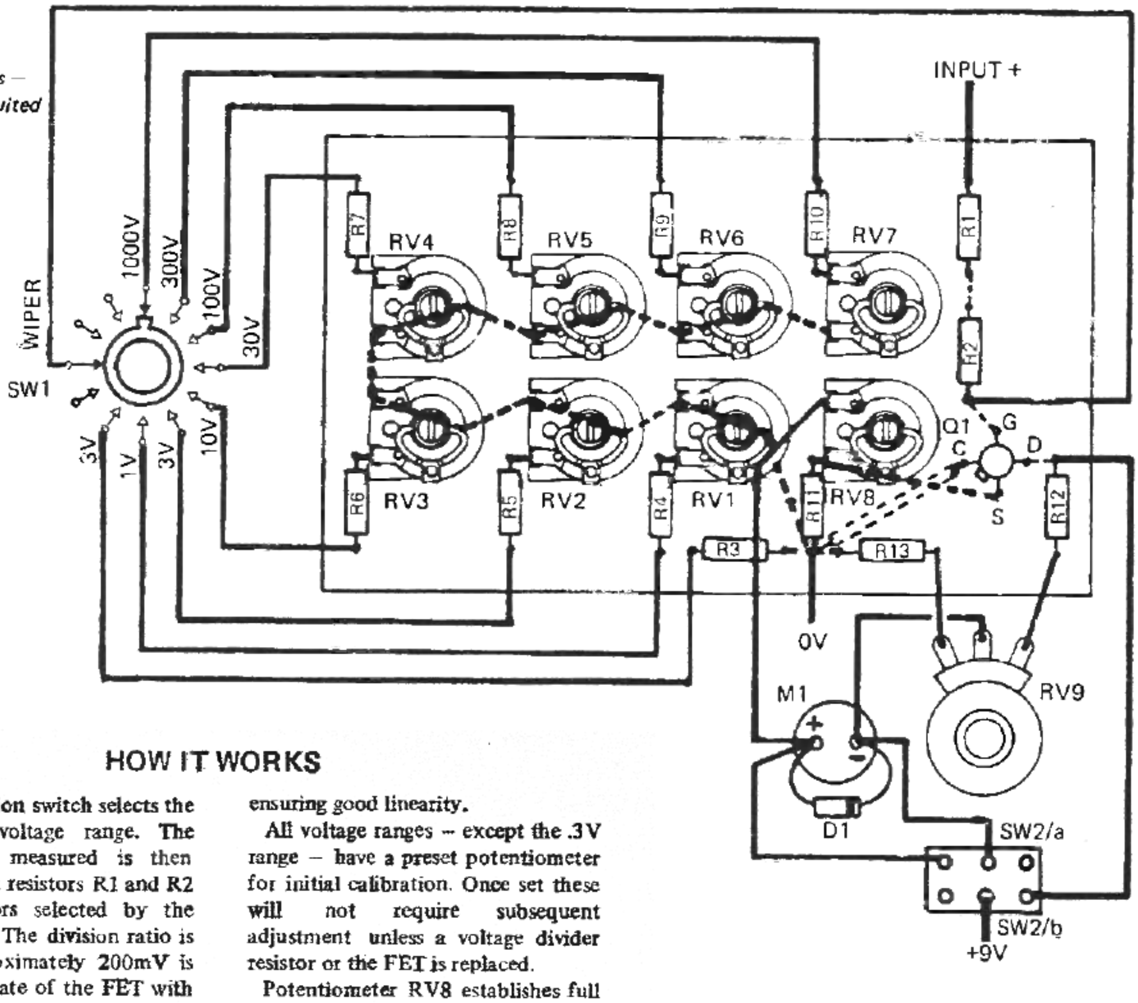
The battery 'on/off' switch should be double-pole double throw. When it is in the 'off' position the second set of switch contacts place a short circuit across the meter movement thus protecting it against mechanical damage whilst the instrument is not in use.

This switch together with range switch SW1 and 'zero-adjust' potentiometer RV9 must be mounted on the front panel of the instrument case.

CALIBRATION

1. Connect the meter to a nine volt battery. Make sure that the polarity is correct. Switch the instrument to 'on'.
2. Switch SW1 to the .3V range. Short circuit the input terminals and adjust the 'zero-set' potentiometer (RV9) for zero meter deflection. Then remove the short circuit.
3. Apply an accurately known 300mV to the meter input terminals and adjust RV8 to obtain full scale deflection on the meter.
4. Repeat steps 2 and 3 until the meter reads correctly both at zero and full scale deflection. Once this has been achieved do not readjust RV8. during any subsequent operation.
5. Switch the meter to the 1V range, apply an accurately known 1V and adjust RV1 to obtain full scale deflection.
6. Now switch to the other ranges in turn and, in a similar fashion to operation 5, apply the appropriate input voltage and adjust the appropriate potentiometers for each range (RV2, RV3, RV4, RV5, RV6, and RV7) to obtain full scale deflection on each range. This completes calibration. ●

Fig 2 Interconnections — layout shown here is suited to matrix board construction



DOTTED LINES REPRESENT INTERCONNECTIONS ON THE UNDERSIDE OF THE BOARD

HOW IT WORKS

An eight position switch selects the desired Input voltage range. The voltage to be measured is then divided by input resistors R1 and R2 and the resistors selected by the setting of SW1. The division ratio is such that approximately 200mV is applied to the gate of the FET with 100% input.

The naturally high input resistance of the FET together with negative feedback from R11 ensures that, even on the lowest range, there is never less than 18 Megohms in parallel with the lower end of the input voltage divider. This will have a negligable effect on meter accuracy.

Another advantage of using negative feedback is that this limits the working range of the FET thus ensuring good linearity.

All voltage ranges – except the .3V range – have a preset potentiometer for initial calibration. Once set these will not require subsequent adjustment unless a voltage divider resistor or the FET is replaced.

Potentiometer RV8 establishes full scale deflection on the 0-3V range. It is also used to correct for any spread in the transfer conductance (gain) of the FET.

The 250 ohm wire wound potentiometer RV9 is mounted on the front panel of the instrument and is used as a 'zero adjustment'. In effect it cancels out the voltage appearing at the source terminal of the FET when there is zero voltage at the input.