

## **Quadrant -II- Transcript and Related Materials**

**Programme :- T.Y. B.Sc.**

**Subject : Physics**

**Semester : VI**

**Course Code : PYC109**

**Course Title : Solid State Devices and  
Instrumentation**

**UNIT 1 : Measuring Instrument**

**Module Name : AC and DC Voltmeter, Multirange  
Voltmeter, Extending Voltmeter Range, Transistor  
Voltmeter**

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## **AC VOLTMETER**

**The instrument, which is used to measure the AC voltage across any two points of electric circuit is called AC Voltmeter.**

**If the AC voltmeter consists of rectifier, then it is said to be rectifier based AC Voltmeter.**

**If we want to use DC voltmeter for measuring AC voltages,**

**Then we have to follow these TWO steps.**

**The two types of Rectifier based AC voltmeters are**

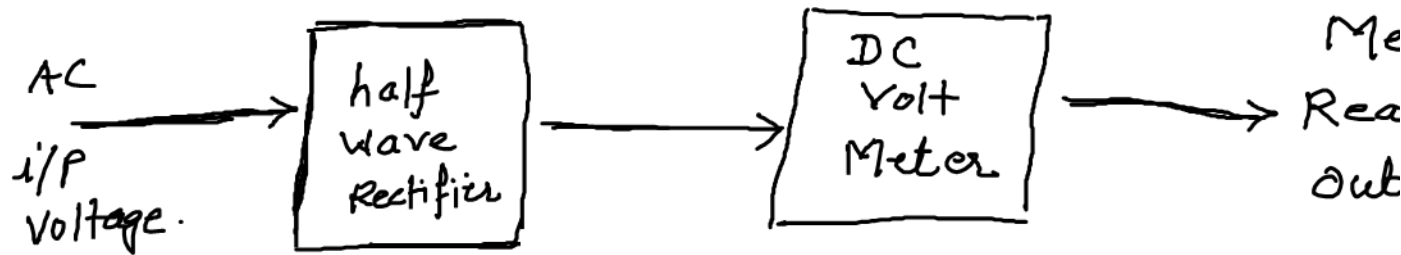
- 1) AC voltmeter using HALF wave rectifier**
- 2) AC voltmeter using FULL wave rectifier**

### **AC voltmeter using Half Wave Rectifier**

**If a Half wave rectifier is connected ahead of DC voltmeter.**

### **Block Diagram of AC Voltmeter**

**The input to be measured is given to the attenuator circuit which performs the operation of selection of a particular range of voltage. The output of attenuator is given to rectifier which converts the AC voltage into pulsating DC voltage. The final output of DC amplifier is given to PMMC meter.**



## DC VOLTMETER

Study and Design DC Voltmeter using Permanent Magnetic Moving Coil (PMMC) Or D'Arsonval movement .

What is D' Arsonval Movement?

D' Arsonval Movement has the basic of a dc ammeter. The coil winding of this PMMC is small and light, it can carry only small

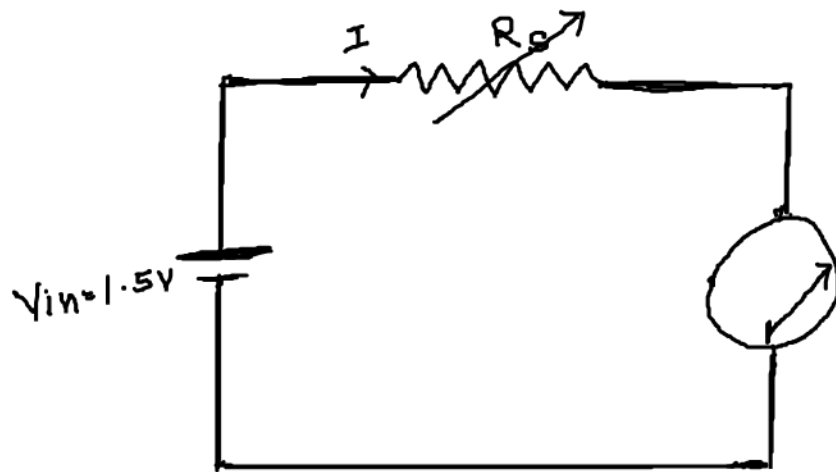
currents. When the large currents are to be measured through

D' Arsonval Movement, it is necessary to bypass a major part of the current through a resistance called SHUNT.

To design PMMC as DC Voltmeter, we should find:-

- 1) Full scale deflection current of the Movement =  $I_{fsd}$
- 2) Internal Resistance of the Movement =  $R_m$

Circuit diagram to determine  $I_{fsd}$  of PMMC



D'Arsonval  
Movement

For full deflection;

Full Scale Deflection current

$$I_{fsd} = \frac{V_{in}}{R_s}$$

- 1) Keep  $V_{in}$  = Constant
- 2) Vary  $R_s$  till you get full scale deflection in the PMMC.
- 3) Connect Resistance Box ( $0-500\Omega$ ) across PMMC
- 4) Remove the resistances from the resistance box, till you  
get half deflection in the meter movement.
- 5) Note down the resistance value of the resistance box and it is Exactly equal to the value of meter resistance.

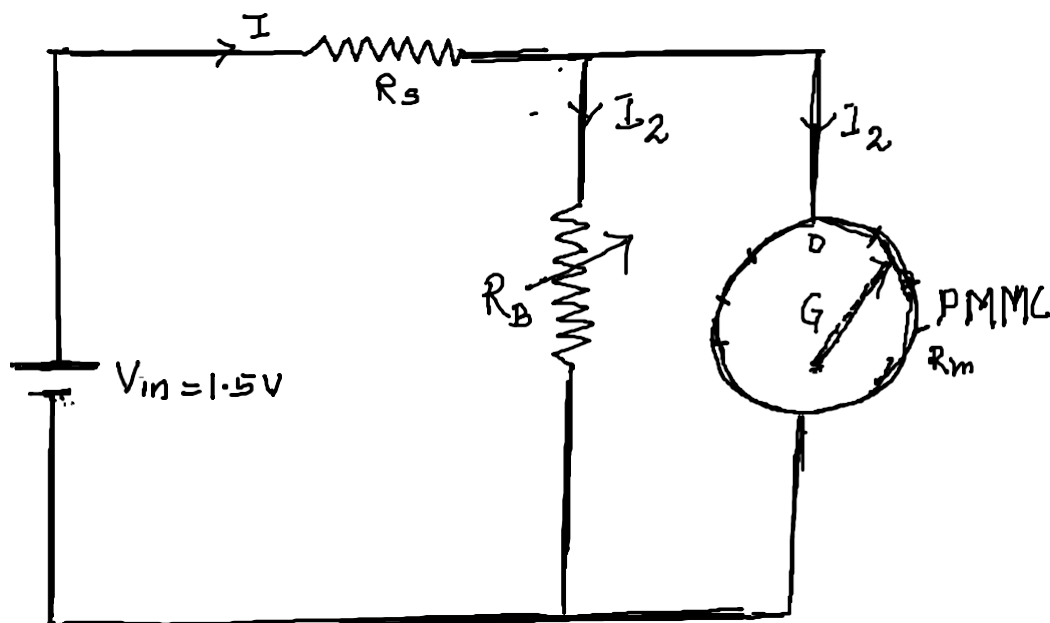
To Find Full Scale Deflection Current =  $I_{fsd}$

- 1) Connect the circuit as shown.
- 2) Vary the resistance  $R_s$ , till you get full deflection in the D' Arsonval Movement

Here Full Scale Deflection Current is

$$I_{fsd} = V_{in} / R_s$$

Circuit Diagram do determine  $R_m$



Total Current

For half de

$$I = I_2$$

$$V/R_B = V/R$$

$$\sqrt{R_M} = \sqrt{R}$$

$$R_M = R_B //$$

**DC VOLTMETER :-** The basic D'Arsonval movement can be converted into a dc voltmeter by adding a series resistor known as multiplier. The function of the multiplier is to limit the current through the movement so that the current does not exceed the full scale deflection value.

A dc voltmeter measures the potential difference between two points in a dc circuit or a circuit component.

**Sensitivity of a meter= S**

$$\text{Sensitivity}=S= \mathbf{1/I_{fsd}.= \text{--- k}\Omega/\text{Volt}}$$

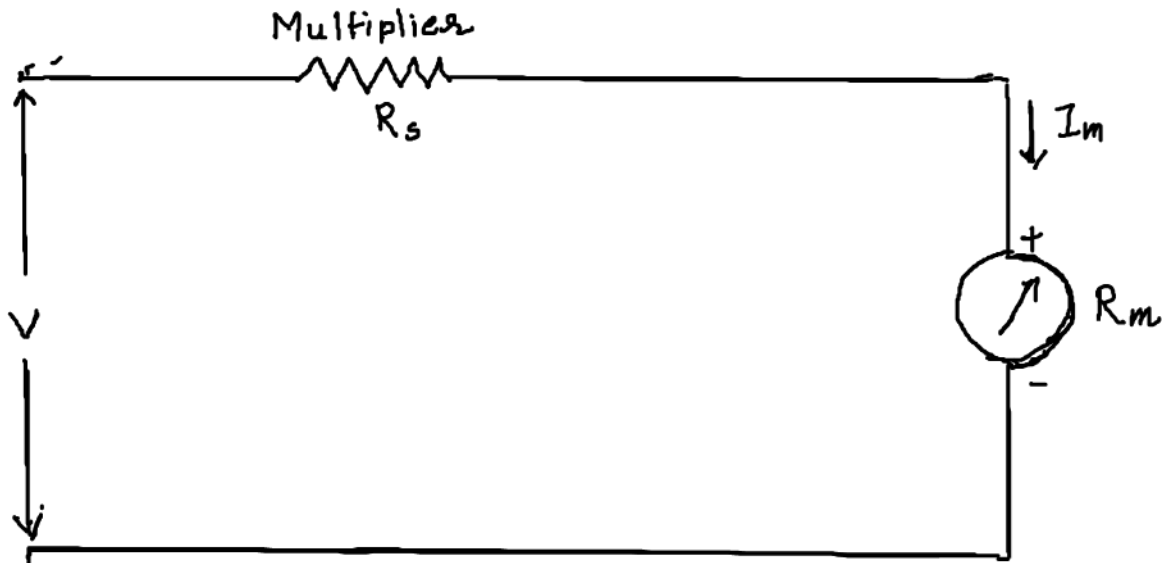
**Calculate the sensitivity of a 200 $\mu$ A meter movement which is**

**To be used as a dc voltmeter.**

$$\text{Sensitivity}=S= \mathbf{1/I_{fsd}.=1/200\mu A = 5\text{ k}\Omega/\text{Volt}}$$

**DC VOLTMETER :-** The basic D'Arsonval movement can be converted into a dc voltmeter by adding a series resistor known as multiplier. The function of the multiplier is to limit the current through the movement so that the current does not exceed the full scale deflection value. A dc voltmeter measures the potential difference between two points in a dc circuit or a circuit component.

**Basic DC VOLTMETER.**



To measure the potential difference between two points in a dc circuit, a dc voltmeter is always connected across them with proper polarity.

The value of the multiplier required is calculated as below,

$I_{fsd} = I_m$  = full scale deflection current of the movement

$R_m$  = Internal resistance of the movement

$R_s$  = multiplier resistance

$V$  = full range voltage of the instrument

From the circuit

$$V = I_m (R_s + R_m)$$

$$\text{i.e. } V = I_m R_s + I_m R_m$$

$$\text{i.e. } I_m R_s = V - I_m R_m$$

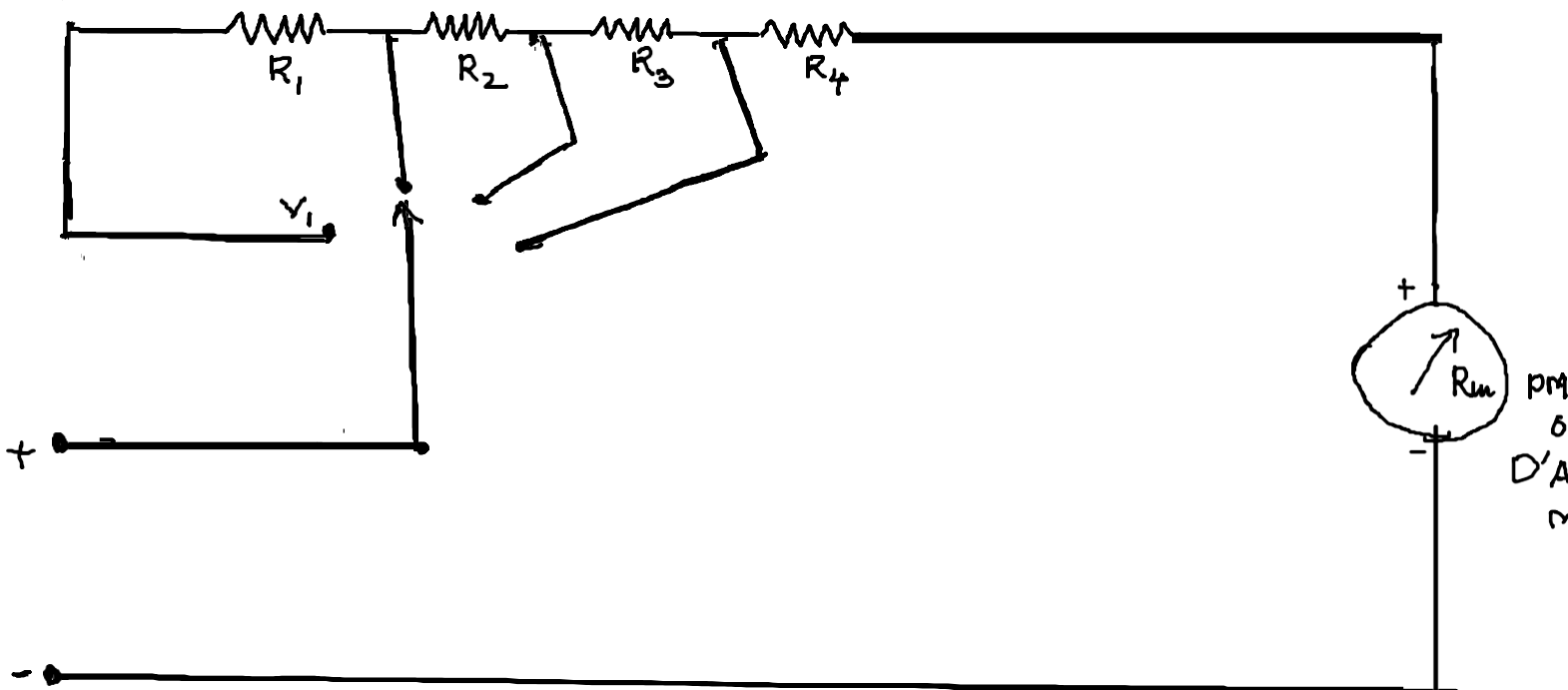
$$\text{Therefore } R_s = \frac{V}{I_m}$$

$$- R_m$$

**MULTIRANGE VOLTMETER:-**Design a multirange voltmeter using D'Arsonval movement with an internal resistance of  $50\Omega$  and a full scale deflection current of  $2\text{mA}$  into a multirange dc voltmeter with voltage ranges of  $0-10\text{V}$ ,  $0-50\text{V}$ ,  $0-100\text{V}$  and  $0-250\text{V}$ .

Given 1)  $R_m = 50\Omega$

2)  $I_{fsd} = 2\text{mA}$



Solution

For  $0-10\text{V}$  range (Position of the switch is at  $V_4$ )

The TOTAL Resistance  $R_t = V/I_{fsd} = 10/2\text{mA} = 5\text{k}\Omega$

Therefore  $R_4 = R_t - R_m = 5\text{k}\Omega - 50\Omega = 4950\Omega$

2) For 0-50V range (Position of the switch is at V3)

The TOTAL Resistance  $R_t = V/I_{fsd} = 50/2mA = 25k\Omega$

Therefore  $R_3 = R_t - (R_4 + R_m) = 25k\Omega - (4950\Omega + 50)$

$$\therefore R_3 = 20k\Omega$$

3) For 0-100V range (Position of the switch is at V2)

The TOTAL Resistance  $R_t = V/I_{fsd} = 100/2mA = 50k\Omega$

$\therefore R_2 = R_t - (R_3 + R_4 + R_m) = 50k\Omega - (20k + 4950\Omega + 50)$

$$\therefore R_3 = 50k\Omega - 25k\Omega = 25k\Omega$$

4) For 0-250V range (Position of the switch is at V1)

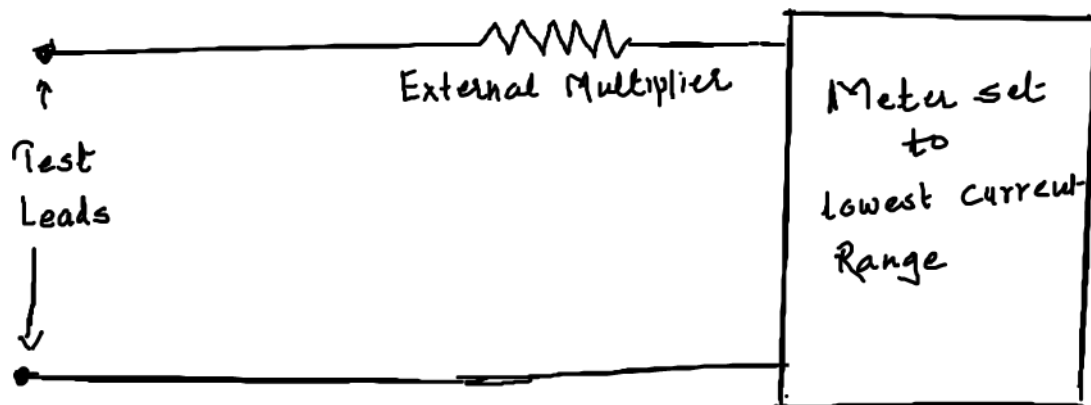
The TOTAL Resistance  $R_t = V/I_{fsd} = 250/2mA = 125k\Omega$

$\therefore R_1 = R_t - (R_2 + R_3 + R_4 + R_m)$   
 $= 125k - (25k + 20k + 4950\Omega + 50)$

$$\therefore R_1 = 125k - (50k) = 75k\Omega$$

## EXTENDING VOLTMETER RANGES

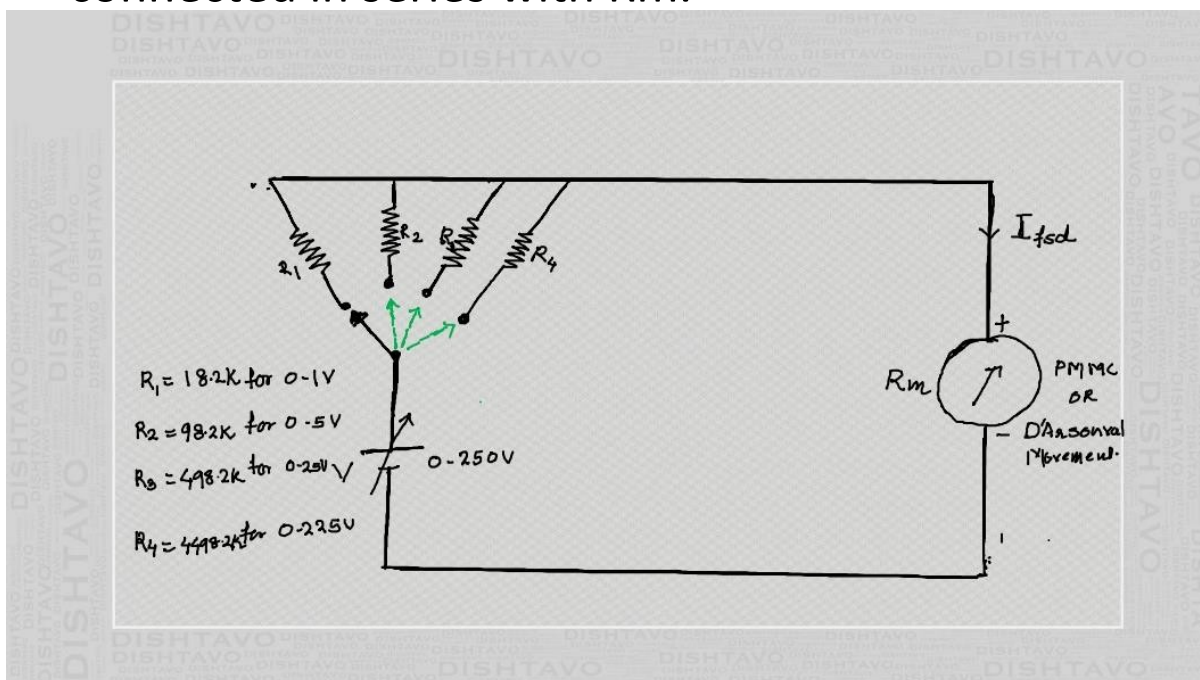
The range of voltmeter can be extended to measure high voltages, by using a high voltage probe or by using an external multiplier resistor i. e. as shown in below figure.



Design a multiple range DC Voltmeter for 0-1V, 0-5V, 0-25V and 0-225V. A basic D'Arsonval movement with a full scale deflection of 50 micro-ampere and an internal resistance of  $1800\Omega$  is available.

Solution:- Given  $I_{fsd} = 50\mu A$  and  $R_m = 1800\Omega$

To design various range voltmeters, we have to calculate the individual resistors which should be connected in series with  $R_m$ .



Calculation of R1,R2,R3 and R4

1) For 0-1V

$$R1 + R_m = V/I_{f_{sd}} = 1/(50 \mu A) = 20K\Omega$$

$$\therefore R1 = 20K\Omega - 1.8K\Omega = 18.2K\Omega$$

2) For 0-5V

$$R2 + R_m = V/I_{f_{sd}} = 5/(50 \mu A) = 100K\Omega$$

$$\therefore R2 = 100K\Omega - 1.8K\Omega = 98.2K\Omega$$

3) For 0-25V

$$R3 + R_m = V/I_{f_{sd}} = 25/(50 \mu A) = 500K\Omega$$

$$\therefore R3 = 500K\Omega - 1.8K\Omega = 498.2K\Omega$$

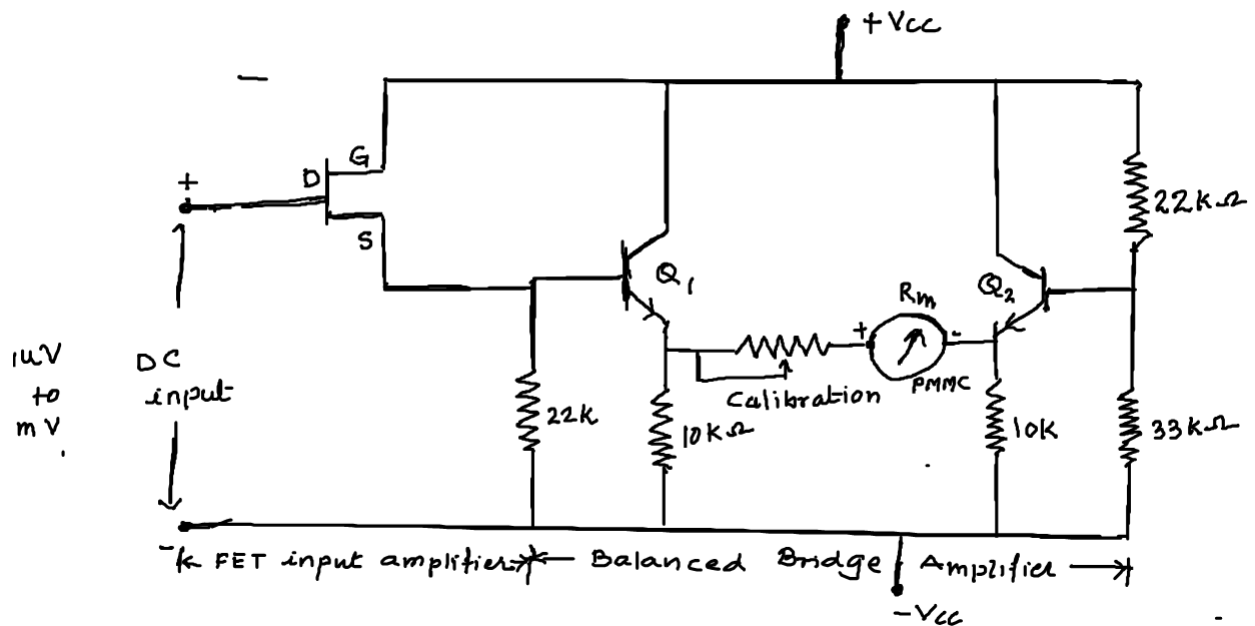
4) For 0-225V

$$R4 + R_m = V/I_{f_{sd}} = 225/(50 \mu A) = 4500K\Omega$$

$$\therefore R4 = 4500K\Omega - 1.8K\Omega = 4498.2K\Omega$$

## TRANSISTOR VOLTMETER (TVM)

Circuit Diagram of TVM



Here the input stage of the amplifier consist of a FET which provides high input impedance to isolate the meter circuit from the circuit under measurement. The input impedance of of a FET is greater than  $10M\Omega$ . Once the bridge is balanced then the dial indicates Zero for Zero input condition.

The two transistors  $Q_1$  and  $Q_2$  forms a dc coupled amplifier driving the meter movement. Within the dynamic range of the amplifier, the meter deflection is proportional to the magnitude of applied input voltage.

APPLICATIONS of TVM :-1)Electronic voltmeters measure voltage both at audio as well as radio frequency power level.

2) Transistor voltmeters can be designed for measuring very high voltages such as to measure thousands of volts.

3) Transistor Voltmeter has faster response and flexibility.

1) H.S. Kalsi, Electronic Instrumentation, TMH (2004)