IAT-1 Solutions (EI)

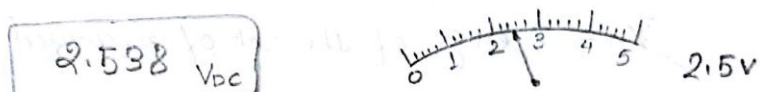
Q.1

Static characteristics of Instrument :-

Accuracy :- The degree of closeness of a measurement compared to the expected or desired value is known as accuracy.

For example when a voltmeter with an error of ±1 % is taken that indicates that the true value of voltmeter is V ± 1% here V indicates the voltage that has been observed.

Similarily for a resistor the tolerance level indicates that how much the observed value will vary from the actual one. Suppose tolerance is ±5% for a 1 kΩ resistor then we can get resistance value ranging between 950 Ω to 1050Ω.



Digital meter with 1mV accuracy

analog meter with 50mV accuracy.

Precision :- A measure of consistency or repeatability of measurement, that means successive readings donot differ.

Let us see the basic difference between accuracy and precision. Suppose for an instrument readings upto 1/1000th unit can be measured, also large zero adjustment is there. So if the readings are same all the time, then we say the instrument is precise. But because of some errors ~~it is not~~ result or output is not accurate then we say instrument is not accurate.

So repeatitive output comes under precision and output that is close to actual output comes under accuracy.

a

IAT-1 Solutions (EI)

Significant figures :-

The precision of the measurement is obtained ~~by~~ from the number of significant figures, in which the output is expressed. The significant figures convey the actual information about the magnitude and the measurement precision of the quantity.

Precision can be expressed as:-

$$P = 1 - \left| \frac{X_n - \overline{X}_n}{\overline{X}_n} \right|$$

where P = Precision

X_n = Value of n^{th} measurement

$\overline{X}_n$ = Average of the set of measured values

Q.1 b

(Ex. 6) A component manufacturer constructs certain resistances to be anywhere between 1.14 kΩ & 1.26 kΩ & classifies them to be 1.2 kΩ resistors. What tolerance should be stated? If the resistance values specified at 25°C and the resistors have temperature coeff. of +500 ppm/°C. Calculate maximum resistance that one of these components might have at 75°C?

Sol:-

~~Abs~~ Given that:- $Y_n = 1.26\,k\Omega, X_n = 1.2\,k\Omega$

& $Y_n = 1.14\,k\Omega$

Absolute error $e = Y_n - X_n$

$e = 1.26 - 1.2 = +0.06\,k\Omega$

or $e = 1.14 - 1.2 = -0.06\,k\Omega$

so $e = \pm 0.06\,k\Omega$

Tolerance $= \dfrac{\pm 0.06\,k\Omega}{1.2\,k\Omega} \times 100\%$

$= \pm 5\%$

largest possible resistance at 25°C

$R = 1.2\,k\Omega + 0.06\,k\Omega$

$= 1.26\,k\Omega$

Resistance ~~per~~ change per °C

500 ppm of $R = \dfrac{1.26\,k\Omega}{10000 \times 1000} \times 500$

$= 0.63\,\Omega/°C$

IAT-1 Solutions (EI)

Temperature increase $\Delta T = 75°C - 25°C$

$\Delta T = 50°C$

Total resistance increase

$\Delta R = 0.63\ \Omega/°C \times 50°C$

$\Delta R = 31.5\ \Omega$

Maximum resistance at 75°C

$R + \Delta R = 1.26k + 31.5\ \Omega$

$R + \Delta R = 1.2915\ k\Omega$ Ans.

Q.2 a

Ex. 9) An 820Ω resistance with an accuracy of ± 10% carries a current of 10 mA. The current was measured by an analog ammeter on 25 mA range with an accuracy of ±2% of full scale. Calculate power dissipated in resistor.

Sol:- $P = I^2 R$ $I = 10\,mA,\ R = 820\,\Omega$

$P = (10\times10^{-3})^2 \times 820$

$P = 82\ mW.$

error in $R = \pm 10\%$

error in $I = \pm 2\%$ of 25 mA (full scale)

error in $I = \dfrac{\pm 2 \times 25\times10^{-3}}{100} = \pm 0.5\ mA.$

$$\% \text{ error} = \frac{e}{Y_n} = \frac{\pm 0.5 \text{ mA}}{10 \text{ mA}} \times 100\% = \pm 5\%$$

$$\% \text{ error in } I^2 = 2(\pm 5\%) = \pm 10\%$$

$$\% \text{ error in } P = (\% \text{ error in } I^2) + (\% \text{ error in } R)$$

$$= \pm(10 + 10)\%$$

$$\% \text{ error in } P = \pm 20\%$$

Q.2 b

Arithmetic mean :- When a number of measurements of a quantity are made and the measurements are not all exactly equal, then the best approximation. For n measurements the arithmetic mean is

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \dots + x_n}{n}$$

where $x_1\ x_2\ x_3 \dots x_n$ are values of corresponding n-measurements. Determining the arithmetic mean of several measurements is one method of minimizi the effects of random errors. As random errors occur ~~due to~~ accidentally or arise due to human made mistakes.

Deviation :- The difference between any one measur value and the arithmetic mean of a series of measurements is termed as deviation. Deviation can be positive or negative and the algebric sum of the deviations is always zero. Then the average deviation can be calculated as :-

$$D = \frac{|d_1| + |d_2| + |d_3| + \dots + |d_n|}{n}$$

IAT-1 Solutions (EI)

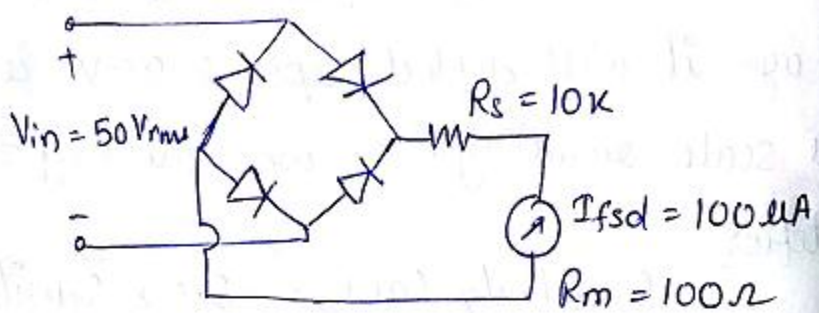
Standard Deviation :-

$$\sigma = \sqrt{\frac{d_1^2 + d_2^2 + \cdots + d_n^2}{n}}$$

Probable error :- Probable error = $0.6745\,\sigma$

Q.3 a

Ex.22 Calculate the value of multiplier resistor for 50 Vrms a.c range on the voltmeter ?



Sol:-

$$S_{dc} = \frac{1}{I_{fsd}} = \frac{1}{100 \times 10^{-6}} = 10\ k\Omega/V$$

A.C. sensitivity = 0.9 (d.c. sensitivity)

$$S_{ac} = 0.9 \times 10 \times 10^3\ \Omega/V$$

$$S_{ac} = 9\ k\Omega/V$$

$$R_s = 9 \times 10^3 \times 50 - 100 = 449.9\ k\Omega.$$

IAT-1 Solutions (EI)

Q. 3b

RF Ammeter (Thermocouple) :-

A thermocouple is a device that is extensively used to measure temperature. It is basically a sensor.

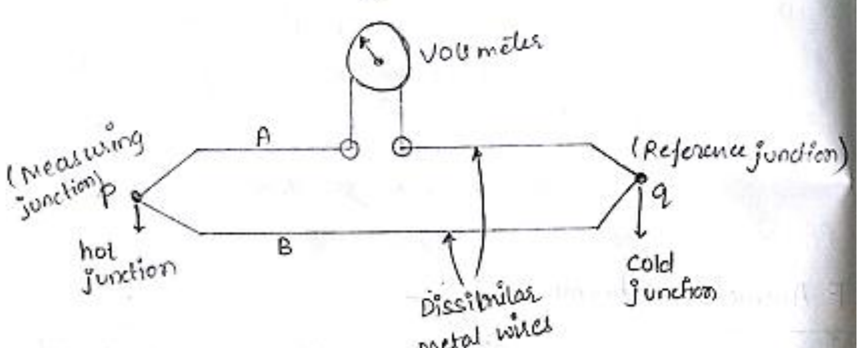
A thermocouple comprise of atleast two metals joined together to form two junctions. One junction is connected to quantity whose temperature is to be measured and another to the measuring junction ie the reference junction. therefore a thermocouple measures temperature of unknown quantity with reference to the temperature of known quantity.

thermocouples basically works on three principles :-

(a) Seebeck effect

(b) Peltier effect &

(c) Thomson effect.



Working:- A thermocouple comprises of two different materials A & B. These two are joined together to form two junctions P & Q which are maintained at temperatures T_1 & T_2.

when the two junctions are maintained at different temperatures emf is induced. The total emf that is induced depends upon the type of material that has been used and also on the temperature of two junctions.

Types of Thermocouple :-

In thermocouple instruments, the current to be measured is used to heat the junction of two metals. This generation of dc voltage by heating the junction is called thermoelectric action and the device is called a thermocouple. The voltage produced is proportional to the heating effect. The alternating current heats the junction, the heating effect is same for both the half cycles because the direction of potential drop will be the same. There are various types of thermocouples :-

① Mutual type:- In this type of thermocouple, the r.f. current to be measured is passed through thermocouple itself. In this type separate heater wire is not required. The major drawback of the mutual type thermocouple is that ammeter shunts the thermocouple.

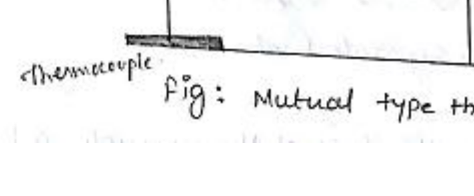


Fig: Mutual type thermocouple.

IAT-1 Solutions (EI)

② **Contact type:-** In this type of thermocouple, a separate heater wire is used so that r.f. current to be measured is passed through heating wire and not the thermocouple. In this type, two thermocouple leads are taken out which are used to conduct heat away from the heating wire. The contact type thermocouple is less sensitive as compared to mutual type.

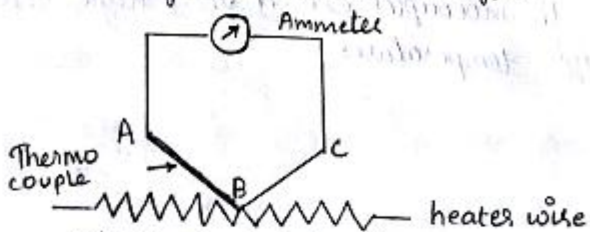


Fig: contact type thermocouple.

③ **Separate heater type:-** In this type, a heater wire is insulated or separated from the thermocouple with the help of glass bead. Due to drop in temperature in glass bead, this instrument is less sensitive. Also the response of the instrument is sluggish. To increase sensitivity the instrument is placed in vaccum which avoids losses in the heat radiation.

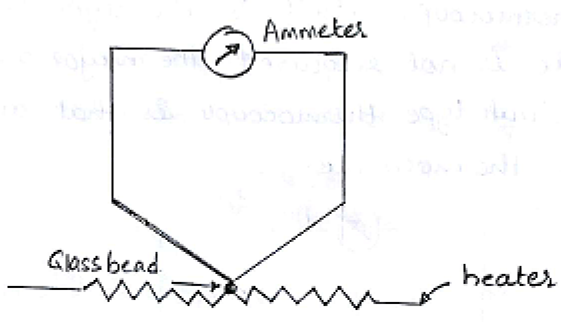


Fig: Separate heater type

(4) Bridge type :- In this type of thermocouple, a bridge circuit is used in which all the four arms of bridge consists similar thermocouples arranged as shown in figure below. The sensitivity of this type thermocouple is same as that of mutual type thermocouple but in this the shunt effects are nullified. To increase the sensitivity bridge type thermocouples are placed in vaccum. These thermocouples exhibit very high sensitivity at high temperatures.

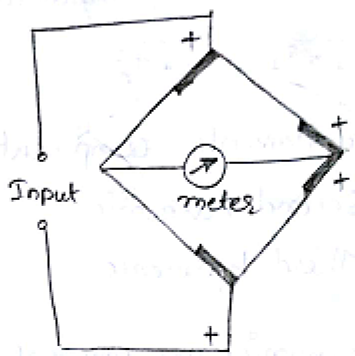


Fig:- Bridge type thermocouple.

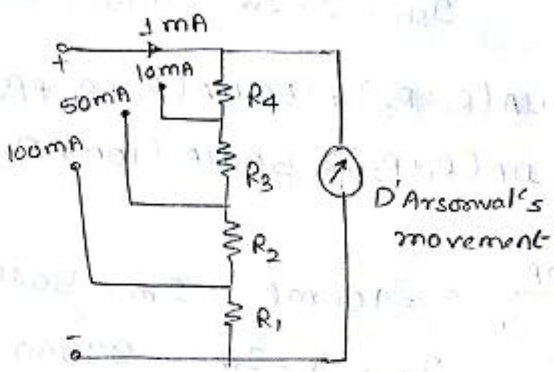
The most commonly used materials are constantan with copper, manganin or platinum alloy to form thermocouple. These combinations generally give emf of 45 µv/°C.

The heater element that are used are different for both open air and vaccum. In air heater the material used is non-corroding platinum & vaccum heater type is copper.

IAT-1 Solutions (EI)

Q.4.

(Ex.15) Design an Ayrton shunt to provide an ammeter with current range 0-1 mA, 10 mA, 50 mA & 100 mA. A D'Arsonval's movement with internal resistance of 100Ω & full scale current of 50 μA is used.



Sol:- Given $R_m = 100\ \Omega$, $I_m = 50\ \mu A$.

For 0 - 1mA range:-

$$I_{sh} \cdot R_{sh} = I_m \cdot R_m \longrightarrow (1)$$

As total current $I = I_{sh} + I_m$

For $I = 1$ mA.

$$I_{sh} = (1000 - 50)\ \mu A.$$

$$I_{sh} = 950\ \mu A$$

from eq^n (1) $\quad 950\mu A \times (R_1 + R_2 + R_3 + R_4) = 50\mu A \times 100$

$$R_1 + R_2 + R_3 + R_4 = 5.26\ \Omega.$$

IAT-1 Solutions (EI)

For <u>0-10 mA</u>. $I = 10\ mA$, $I_m = 50\ \mu A$

$I_{sh} = I - I_m = 9950\ \mu A$

from eqⁿ ①

$$9950\ \mu A (R_1 + R_2 + R_3) = 50\ \mu A (R_m + R_4)$$

$$9950\ \mu A (R_1 + R_2 + R_3) = 50\ \mu A (100 + R_4)$$

$$R_1 + R_2 + R_3 = \quad \rightarrow ②$$

For <u>0-50 mA</u>. $I = 50\ mA$, $I_m = 50\ \mu A$

$I_{sh} = I - I_m = 49950\ \mu A$

$$49950\ \mu A (R_1 + R_2) = 50\ \mu A (R_3 + R_4 + R_m)$$

$$49950\ \mu A (R_1 + R_2) = 50\ \mu A (100 + R_3 + R_4) \rightarrow ③$$

For <u>0-100 mA</u>

$I = 100\ mA$, $I_m = 50\ \mu A$

$I_{sh} = I - I_m = 99950\ \mu A$

$$99950\ \mu A \cdot R_1 = 50\ \mu A (R_2 + R_3 + R_4 + R_m)$$

$$99950\ \mu A \times R_1 = 50\ \mu A (100 + R_2 + R_3 + R_4) \rightarrow ④$$

From equations 2, 3, 4 by substitution method

$R_1 = 0.05263\ \Omega$ $R_3 = 0.4147\ \Omega$

$R_2 = 0.05263\ \Omega$ $R_4 = 4.47\ \Omega$

IAT-1 Solutions (EI)

Q.5 a

Multirange voltmeter :- In case of ammeter, to obtain multirange ammeter, a number of shunts are to be connected across movement with a multiposition switch. Similarily a dc voltmeter can be converted into a multirange voltmeter by connecting a number of resistors along a range switch to provide a greater range.

In figure ① a multirange voltmeter has been shown for three resistance values R_1 R_2 & R_3 & corresponding voltages are V_1, V_2 & V_3.

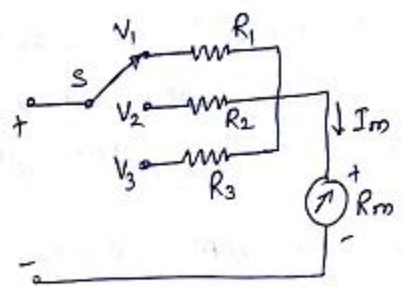


Fig ①.

In this arrangement the resistors are connected i[n] series and a range selector selects the appropria[te] amount of resistance required in series with the movement.

IAT-1 Solutions (EI)

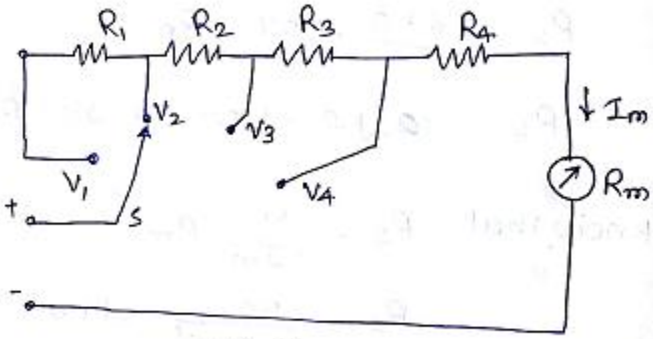


Fig ②

The resistors can be connected in series also like in fig. ②. This method is more advantageous as they are resistors are easily available in Precision tolerances.

Q.5 b

Example 4.13 *Find the voltage reading and % error of each reading obtained with a voltmeter on (i) 5 V range, (ii) 10 V range and (iii) 30 V range, if the instrument has a 20 kΩ/V sensitivity and is connected across R_b of Fig. 4.8 (a).*

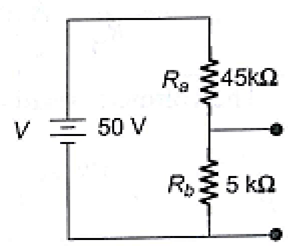


Fig. 4.8 (a)

Solution The voltage drop across R_b without the voltmeter connected is calculated using the voltage equation

$$VR_b = \frac{R_b}{R_a + R_b} \times V = \frac{5\text{ k}}{45\text{ k} + 5\text{ k}} \times 50 = \frac{50 \times 5\text{ k}}{50\text{ k}} = 5\text{ V}$$

On the 5 V range

$$R_m = S \times \text{range} = 20\text{ k}\Omega \times 5\text{ V} = 100\text{ k}\Omega$$

$$\therefore \quad R_{eq} = \frac{R_m \times R_b}{R_m + R_b} = \frac{100\text{ k} \times 5\text{ k}}{100\text{ k} + 5\text{ k}} = \frac{500\text{ k}}{105\text{ k}} = 4.76\text{ k}\Omega$$

IAT-1 Solutions (EI)

The voltmeter reading is

$$VR_b = \frac{R_{eq}}{R_a + R_{eq}} \times V = \frac{4.76\text{ k}}{45\text{ k} + 4.76\text{ k}} \times 50 = 4.782\text{ V}$$

The % error on the 5 V range is

$$\%\text{ Error} = \frac{\text{Actual voltage} - \text{Voltage reading in meter}}{\text{Actual voltage}}$$

$$= \frac{5\text{ V} - 4.782\text{ V}}{5\text{ V}} \times 100 = \frac{0.217\text{ V}}{5\text{ V}} \times 100 = 4.34\ \%$$

On 10 V range

$$R_m = S \times \text{range} = 20\text{ k}\Omega/\text{V} \times 10\text{ V} = 200\text{ k}\Omega$$

$$\therefore \quad R_{eq} = \frac{R_m \times R_b}{R_m + R_b} = \frac{200\text{ k} \times 5\text{ k}}{200\text{ k} + 5\text{ k}} = 4.87\text{ k}\Omega$$

The voltmeter reading is

$$VR_b = \frac{R_{eq}}{R_{eq} + R_a} \times V = \frac{4.87\text{ k}}{4.87\text{ k} + 45\text{ k}} \times 50 = 4.88\text{ V}$$

The % error on the 10 V range $= \dfrac{5\text{ V} - 4.88\text{ V}}{5\text{ V}} \times 100 = 2.34\%$

On 30 V range

$$R_m = S \times \text{range} = 20\text{ k}\Omega/\text{V} \times 30\text{ V} = 600\text{ k}$$

$$\therefore \quad R_{eq} = \frac{R_m \times R_b}{R_m + R_b} = \frac{600\text{ k} \times 5\text{ k}}{600\text{ k} + 5\text{ k}} = \frac{3000\text{ k} \times 1\text{ k}}{605\text{ k}} = 4.95\text{ k}$$

The voltmeter reading on the 30 V range

$$VR_b = \frac{R_{eq}}{R_{eq} + R_a} \times V = \frac{4.95\text{ k}}{45\text{ k} + 4.95\text{ k}} \times 50 = 4.95\text{ V}$$

The % error on the 30 V range

$$= \frac{5\text{ V} - 4.95\text{ V}}{5\text{ V}} \times 100 = \frac{0.05}{5\text{ V}} \times 100 = 1\ \%$$

IAT-1 Solutions (EI)

Q.6 a

True RMS voltmeter

This voltmeter measures rms voltage accurately. This meter produces a meter indication by sensing waveform heating power, which is ~~equal~~ proportional to the square of the rms value of the voltage.

$$\text{ie } Heat \propto V_{rms}^2$$

$$\& \quad V_{rms} = \sqrt{V_{dc}^2 + V_{ac}^2}$$

Thermocouples are nonlinear devices. The balancing can be achieved by placing two thermocouples in the same thermal environment. So any nonlinear behaviour in the input circuit is cancelled by the similar nonlinear effects of the thermocouple connected in feedback circuit.

IAT-1 Solutions (EI)

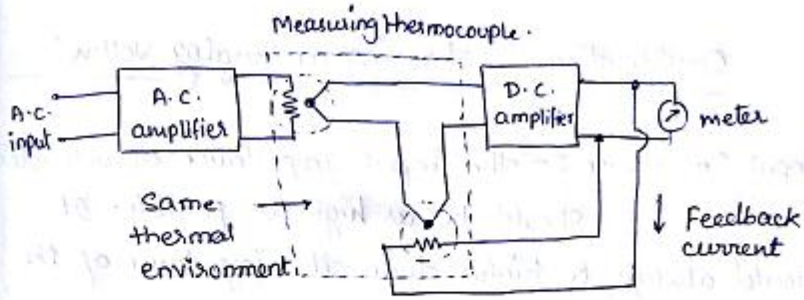


Fig:- True RMS voltmeter

Working :- The two thermocouples form part of a bridge in the input circuit of the D.C. amplifier. The input voltage is amplified and fed to the heating element of the thermocouple. The heat produced by the wire is sensed by the thermocouple which produces proportional D.C. voltage. This D.C. voltage upsets the bridge balance. This unbalanced voltage is amplified by the D.C. amplifier and fedback to the heating element of balancing thermocouple.

Bridge balance is established when both the thermocouples produce same voltage. At this point of time the D.C. current in the heating element of feedback thermocouple is proportional to the a.c. current in the input thermocouple. i.e D.C. is proportional to the input a.c. signal's rms value. This D.C. value is indicated by the meter movement.

Disadvantages:- (1) Accuracy can't be controlled due to the nonlinear behaviour of thermocouple

(2) Thermal variations & sluggish response of thermocouple may lead to burnout.

IAT-1 Solutions (EI)

Q.6 b

Transistor voltmeter

Voltmeter loading can be reduced by using emitter follower. An emitter follower gives high input resistance and low output resistance.

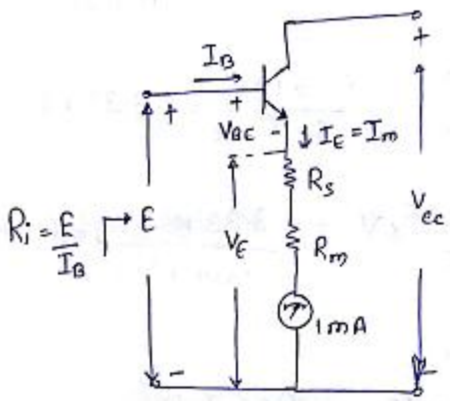


Fig: Emitter follower.

In the dig above a PMMC instrument and a multiplier resistance R_s are connected in series with the transistor emitter. The biasing voltage is V_{cc}. The input voltage is E. Then the input resistance is given by :-

$$R_i = \frac{E}{I_B}$$

Here again the Base current I_B can be calculated as :-

$$I_B = \frac{I_c}{\beta} \quad \text{here } I_c \simeq I_E \simeq I_m$$

$$I_B = \frac{I_m}{\beta}.$$

where β = Amplification factor. OR transistor current gain.

Also input resistance R_i is much greater than $(R_s + R_m)$.

Suppose $R_s + R_m = 9.3\ k\Omega$ & $E = 5V$ & $V_{BE} = 0V$

Then the current $I_B = \frac{E}{R_s + R_m}$

$$I_B = \frac{5}{9.3 \times 10^3} = 0.5\ mA.$$

But if we consider the drop across the transistor

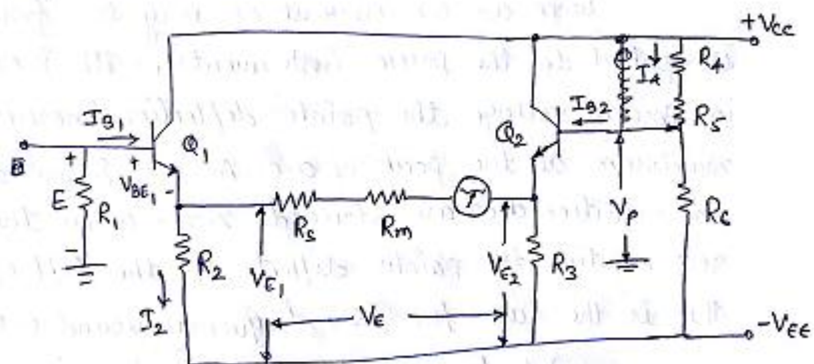
i.e. $V_{BE} = 0.7\ v$

$$\text{Then } I_B = \frac{E - V_{BE}}{R_s + R_m}$$

$$I_B = \frac{5 - 0.7}{9.3 \times 10^3}$$

$$I_B = 0.46\ mA.$$

This reduction in current I_B is an error. To eliminate this error we have to use two transistors as shown in fig. below.



When no input is applied i.e. $E = 0$. The base of Q_2 is adjusted to give zero meter current i.e. $V_P = 0$ &

$$V_{E_1} = V_{E_2} = -0.7$$

$$\text{Then } V = V_{E_1} - V_{E_2}$$

But $V_{E_1} = E - V_{BE_1}$ $\quad V_{E_2} = V_{BE_2}$

$$V = (E - V_{BE_1} - V_{BE_2})$$

$$V = E - V_{BE_1} - V_{BE_2}$$

$$V = 5 - 0.7 + 0.7$$

$$\boxed{V = 5 \text{ Volts}}$$

So we get full input voltage in output and the losses are removed.

Q.7.

Differential voltmeter

The differential voltmeter technique is one of the most common and accurate methods of measuring unknown voltages. In this technique the voltmeter is used to indicate the difference between known & unknown voltages ie the comparision between known and unknown voltage.

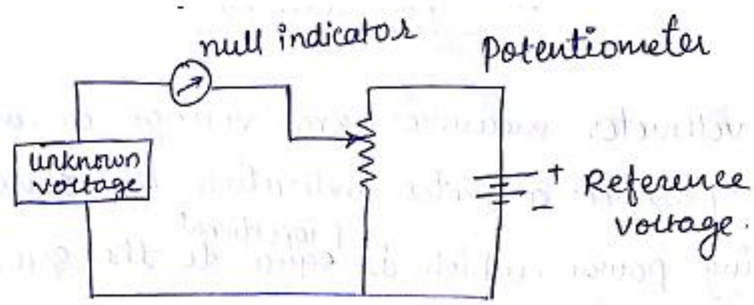


Fig:- Differential voltmeter

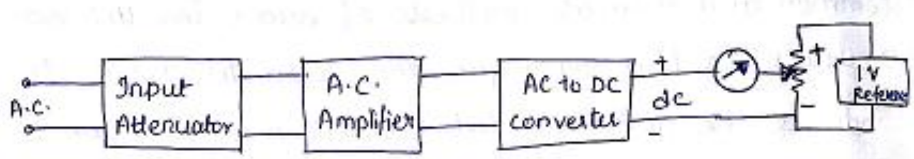
In the diagram a differential voltmeter has been shown with a potentiometer.

In this the potentiometer is varied untilk the voltage across it becomes same ie the unknown voltage is ~~becomes~~ equal to the known voltage, that is indicated by a null indicator and its reading is zero.

Under null conditions the meter draws current from neither reference nor the unknown voltage source and hence differential ~~voltage~~ voltmeter presents an infinite impedance.

To detect small changes the meter should be sensitive but need not be calibrated as it has to indicate zero only.

A.C. Differential voltmeter



IAT-1 Solutions (EI)

Considerations in choosing an analog voltmeter

(1) Input Impedance :- The input impedance of voltmeter should be as high as possible. It should always be higher than the impedance of the circuit under measurement.

(2) Voltage ranges :- The voltage ranges on meter scale depends upon the scale division and it should be compatible with the accuracy of the instrument.

(3) Decibles :- To cover a large range of voltage the use of decible scale is very useful & also effective. Suppose to analyze the frequency response of an amplifier the gain (output / input) is measured in decibles.

(4) Sensitivity Vs Bandwidth :- Noise is nothing but the unwanted frequency components that are present in the useful or important information. Also the noise is a function of bandwidth. When bandwidth is less the noise is less but for wider bandwidth noise will be considerably more. Thus we can say that for lesser frequency the sensitivity is less while for higher frequencies sensitivity is more.

(5) Battery operation:- A voltmeter powered by an internal battery is essential for field work.

(6) A.C. current measurements :-

Current measurements can be made sensitive by an a.c. voltmeter & a series resistor.

(i) For dc measurement, a meter with widest capability meeting ~~of~~ the requirements of the circuit has to be choosen.

(ii) For ac measurements more sensitive meter has to be employed.

(iii) ~~For~~ The peak responding voltmeter with a diode Probe is best for high frequency measurements.

(iv) For rms ~~voltmeter~~ voltage, true rms voltmeter is a better choice.

Q.8.

AC VOLTMETER USING RECTIFIERS

Rectifier type instruments generally use a PMMC movement along with a rectifier arrangement. Silicon diodes are preferred because of their low reverse current and high forward current ratings. Figure 4.16 (a) gives an ac voltmeter circuit consisting of a multiplier, a bridge rectifier and a PMMC movement.

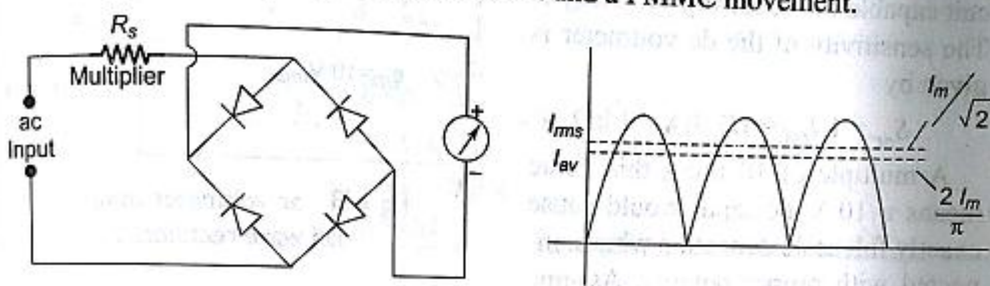


Fig. 4.16 (a) ac voltmeter (b) Average and RMS value of current

The bridge rectifier provides a full wave pulsating dc. Due to the inertia of the movable coil, the meter indicates a steady deflection proportional to the average value of the current (Fig. 4.16 (b)). The meter scale is usually calibrated to give the RMS value of an alternating sine wave input.

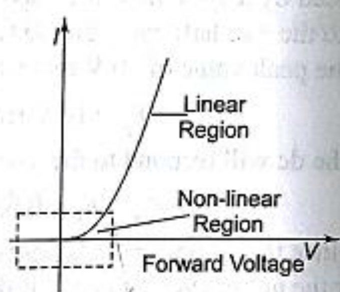


Fig. 4.16 (c) Diode characteristics (Forward)

Practical rectifiers are non-linear devices particularly at low values of forward current (Fig. 4.16 (c)). Hence the meter scale is non-linear and is generally crowded at the lower end of a low range voltmeter. In this part the meter has low sensitivity because of the high forward resistance of the diode. Also, the diode resistance depends on the temperature.

The rectifier exhibits capacitance properties when reverse biased, and tends to bypass higher frequencies. The meter reading may be in error by as much as 0.5% decrease for every 1 kHz rise in frequency.

A general rectifier type ac voltmeter arrangement is given in Fig. 4.17.

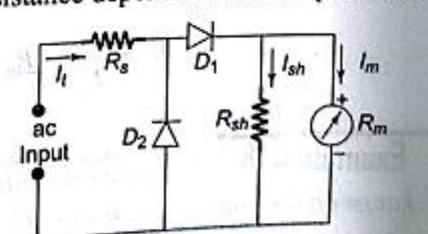


Fig. 4.17 General rectifier type ac voltmeter

Diode D_1 conducts during the positive half of the input cycle and causes the meter to deflect according to the average value of this half cycle. The meter movement is shunted by a resistor, R_{sh}, in order to draw more current through the diode D_1 and move the operating point into the linear portion of the characteristic curve. In the negative half cycle, diode D_2 conducts and the current through the measuring circuit, which is in an opposite direction, bypasses the meter movement.

AC VOLTMETER USING HALF WAVE RECTIFIER 4.13

If a diode D_1 is added to the dc voltmeter, as shown in Fig. 4.18, we have an ac voltmeter using half wave rectifier circuit capable of measuring ac voltages. The sensitivity of the dc voltmeter is given by

$$S_{dc} = 1/I_{fsd} = 1/1\text{ mA} = 1\text{ k}\Omega$$

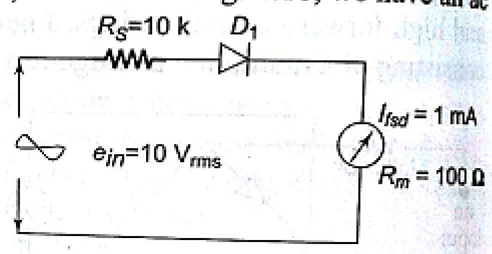


Fig. 4.18 ac voltmeter using half wave rectifier

A multiple of 10 times this value means a 10 V dc input would cause exactly full scale deflection when connected with proper polarity. Assume D_1 to be an ideal diode with negligible forward bias resistance. If this dc input is replaced by a 10 V rms sine wave input. The voltages appearing at the output is due to the +ve half cycle due to rectifying action.

The peak value of 10 V rms sine wave is

$$E_p = 10\text{ V rms} \times 1.414 = 14.14\text{ V peak}$$

The dc will respond to the average value of the ac input, therefore

$$E_{av} = E_p \times 0.636 = 14.14 \times 0.636 = 8.99\text{ V}$$

Since the diode conducts only during the positive half cycle, the average value over the entire cycle is one half the average value of 8.99 V, i.e. about 4.5 V.

Therefore, the pointer will deflect for a full scale if 10 V dc is applied and 4.5 V when a 10 Vrms sinusoidal signal is applied. This means that an ac voltmeter is not as sensitive as a dc voltmeter.

As $$E_{dc} = 0.45 \times E_{rms}$$

∴ The value of the multiplier resistor can be calculated as

$$R_s = \frac{E_{dc}}{I_{dc}} - R_m = \frac{0.45 \times E_{rms}}{I_{dc}} - R_m$$

IAT-1 Solutions (EI)

AC VOLTMETER USING FULL WAVE RECTIFIER

Consider the circuit shown in Fig. 4.20. The peak value of a 10 V rms signal

$$E_p = 1.414 \times E_{\text{rms}}$$
$$= 1.414 \times 10 = 14.14 \text{ V peak}$$

Average value is

$$E_{av} = 0.636 \times E_{\text{peak}}$$
$$= 14.14 \times 0.636 = 8.99 \text{ V}$$
$$\cong 9 \text{ V}$$

Therefore, we can see that a 10 V rms voltage is equal to a 9 V dc for full sca deflection, i.e. the pointer will deflect to 90% of full scale, or

Sensitivity (ac) = 0.9 × Sensitivity (dc)

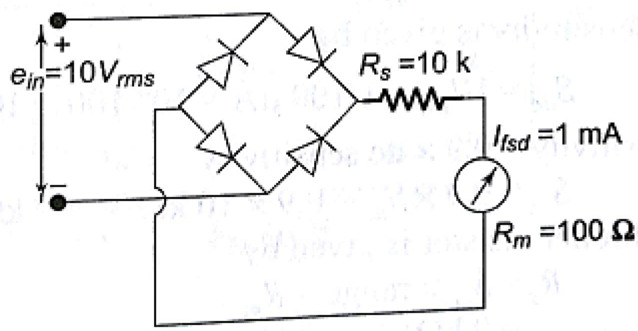


Fig. 4.20 ac voltmeter using full wave rectifier