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Internal Assessment Test 1 – Sept. 2017

Sub:	Electronic Instrumentation			Sub Code:	15EC35	Branch:	ECE/TCE
Date:	21/ 09 / 2017	Duration:	90 minutes	Max Marks: 50	Sem	3rd Sem	OBE

Answer FIVE FULL Questions

		MARKS	CO	RBT
1 (a)	Define the following terms i)Random error ii)Significant figure iii)Resolution	[03]	CO1	L1
1 (b)	A component manufacturer constructs certain resistances to be anywhere between 1.14 $k\Omega$ and 1.26 $k\Omega$ and classifies them to be 1.2 $k\Omega$ resistors. What tolerance should be stated? If the resistance values are specified at 25$°C$ and the resistors have a temperature coefficient of $+500\ ppm/°C$.Calculate the maximum resistance that one of these components might have at 75$°C$.	[07]	CO1	L3
	OR			
2 (a)	Explain the working of a transistor based voltmeter with neat diagram.	[06]	CO2	L2
2 (b)	Write a note on differential voltmeter.	[04]	CO2	L2
3 (a)	Explain loading effect with respect to voltage measurement.	[03]	CO1	L2
3 (b)	Find the voltage reading and % error in each case if the voltmeter is used on (i) 10V range and (ii) 30V range. The instrument has a 20KΩ/V sensitivity and is connected across $R2$ of Fig.3(b)	[07]	CO1	L3

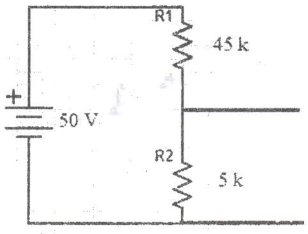


Fig 3(b)

		MARKS	CO	RBT
	OR			
4	With a neat block diagram and waveforms explain the working of Dual Slope Integrating type digital voltmeter. Derive the expression for measured value.	[10]	CO2	L2
5 (a)	Convert a basic D'Arsonval movement into a dc voltmeter and derive the resistance equation.	[03]	CO2	L2
5(b)	Design an Ayrton shunt to provide an ammeter with a current range of 0 – 1 mA ,0 – 10 mA , 0 – 50 mA and 0 – 100 mA . A D'Arsonval movement with an internal resistance of 100Ω and full scale current of 50 µA is used.	[07]	CO2	L3
	OR			
6 (a)	How to convert a basic Galvano meter to an AC voltmeter? Explain two types of rectifier type AC voltmeters and derive an expression for the multiplier resistor in each case.	[07]	CO2	L2

230
+ 65+5 = 70

Divyavarchasvi
18/09/17

230+70
[CCI]

320

6(b)	Convert a Galvano (PMMC instrument) with $I_m = 100\mu A$ and $R_m = 100\Omega$ to an AC voltmeter. Calculate the value of multiplier resistor required for a full wave rectifier type AC voltmeter with a range of 100 V rms.	[03]	CO2	L3
7	Explain the working of Successive approximation type DVM with a neat block diagram. Depict the conversion steps in table format, for an 8 bit converter with a reference voltage of 5V and the voltage to be measured is 4V.	[10]	CO2	[illegible]
8(a)	Determine the resolution of a $3\frac{1}{2}$ digit display on 1V, 10V and 100V range.	[05]	CO2	L2
8(b)	Write a note on statistical analysis of error.	[05]	CO1	L2

Q1 (a) (i) Random error :- No electronic component or instrument is perfectly accurate, all have some error or inaccuracy. Errors of unexplainable origin are classified as Random errors. Random errors are due to unknown causes, not determinable in the the ordinary process of making measurements. Such errors are normally small and follow the laws of probability hence can be treated mathematically.

(ii) Significant figure :- The number of significant figures used in a measured quantity indicate the resolution of measurement.

eg For the 8·135V measurement, the four significant figures show that the ~~td~~ measurement resolution is 0·001V or 1mV if the measurement is done using three significant figures ie 8.13V the resolution is 0·01V ie 10mV.

hence the number of significant figures in a quantity defines the resolution of the measuring instrument

(iii) Resolution :- The smallest change in measured quantity that can be observed is known as resolution of the instrument.

Q 1(b)

Absolute error $= 1.26\,k\Omega - 1.2\,k\Omega = +0.06\,k\Omega$

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

hence Absolute error $= \pm 0.06\,k\Omega$

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

$$= \pm 5\,\%$$

Largest possible resistance at $25^\circ C$

$$R = 1.26\,k\Omega$$

Resistance change$/^\circ C$ = 500 ppm of R

$$= \frac{500}{1000000} \times 1.26\,k\Omega$$

$$= 0.63\,\Omega/^\circ C$$

Temp increase $= 75^\circ C - 25^\circ C$

$= 50^\circ C$

Total resistance increase = ~~$50^\circ C \times 0.63\,\Omega/^\circ C$~~

$= 50^\circ C \times 0.63\,\Omega/^\circ C$

$= 31.5\,\Omega$

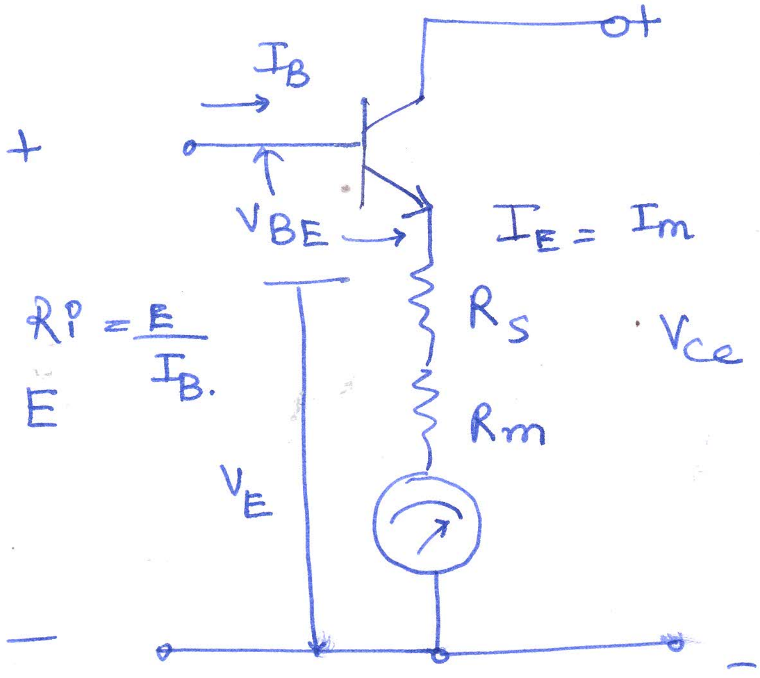
Maximum Resistance at $75^\circ C$ → Ans.

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

$= 1.2915\,k\Omega$

Q2 (a) Tansistor Voltmeter

Voltmeter loading can be greatly reduced by using an emitter follower. An emitter follower offers a high input resistance to voltages being measured, and provides a low o/p resistance to drive current through the coil of a deflection meter.



$$I_B \cong \frac{I_m}{h_{FE}}$$

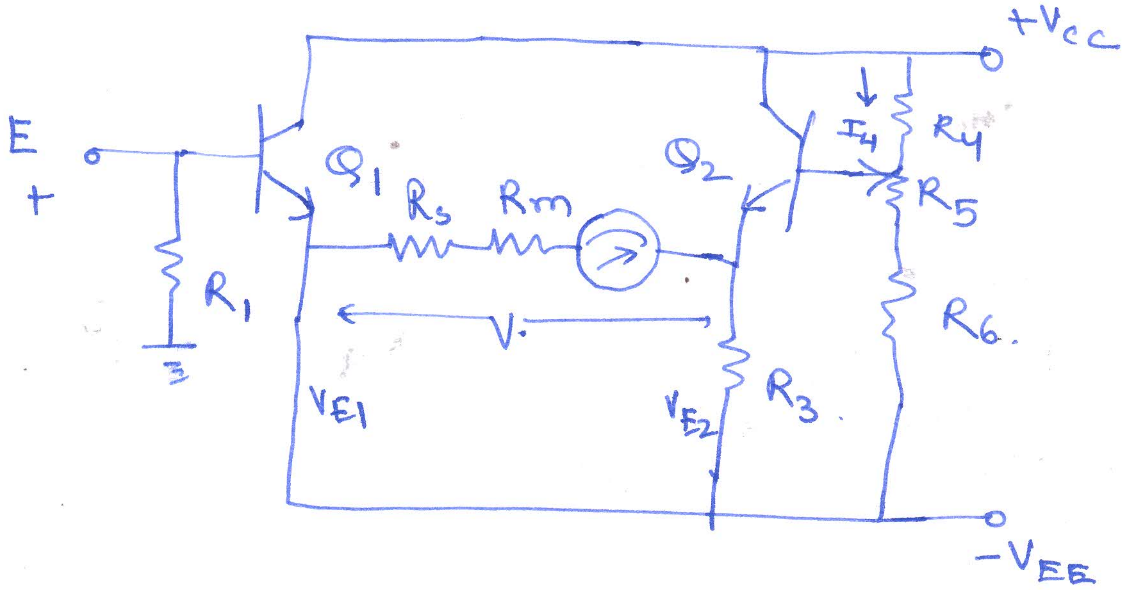
where h_{FE} is the transistor current gain. Thus the circuit input impedance

$$R_i = \frac{E}{I_B}.$$ which is much larger than the meter circuit resistance $(R_s + R_m)$

$$E = V_{BE} + V_E .$$

$$\boxed{V_E = E - V_{BE}}$$

This error can be eliminated by using a potential divider and an additional emitter follower



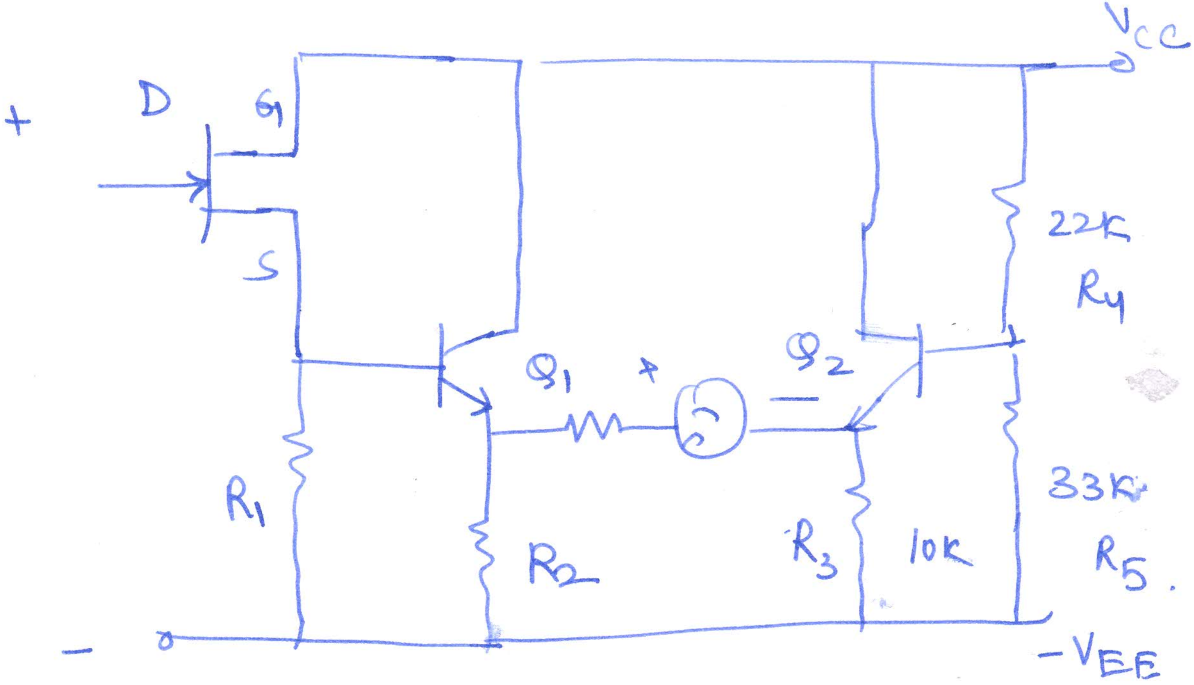
Circuits input impedance is R

$$V = V_{E1} - V_{E2}$$

$$= (V - V_{BE1}) - V_{E2}$$

$$= 5V - 0.7V - (-0.7V).$$

$$= 5V.$$

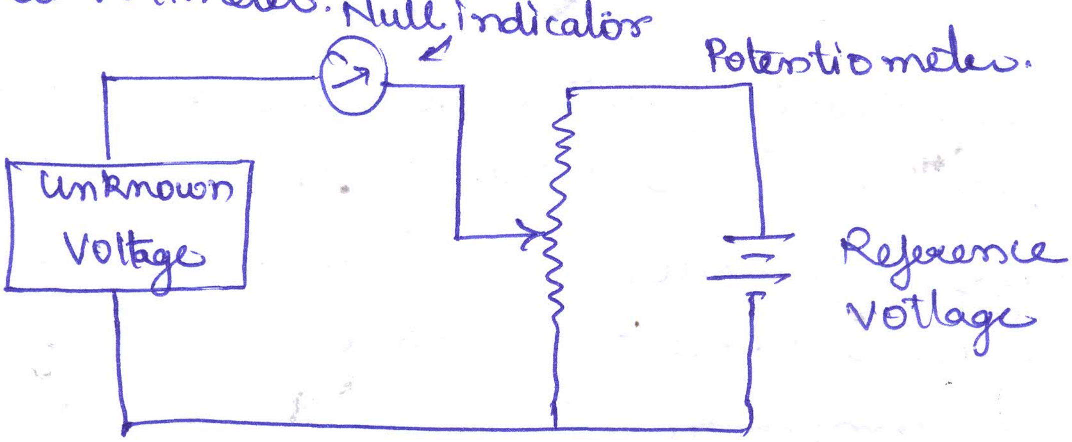

+
D
G
S
−
R1
R2
Q1
+
−
Q2
R3
10K
22K
R4
33K
R5
Vcc
−VEE

Q2 (b)

Differential Voltmeter

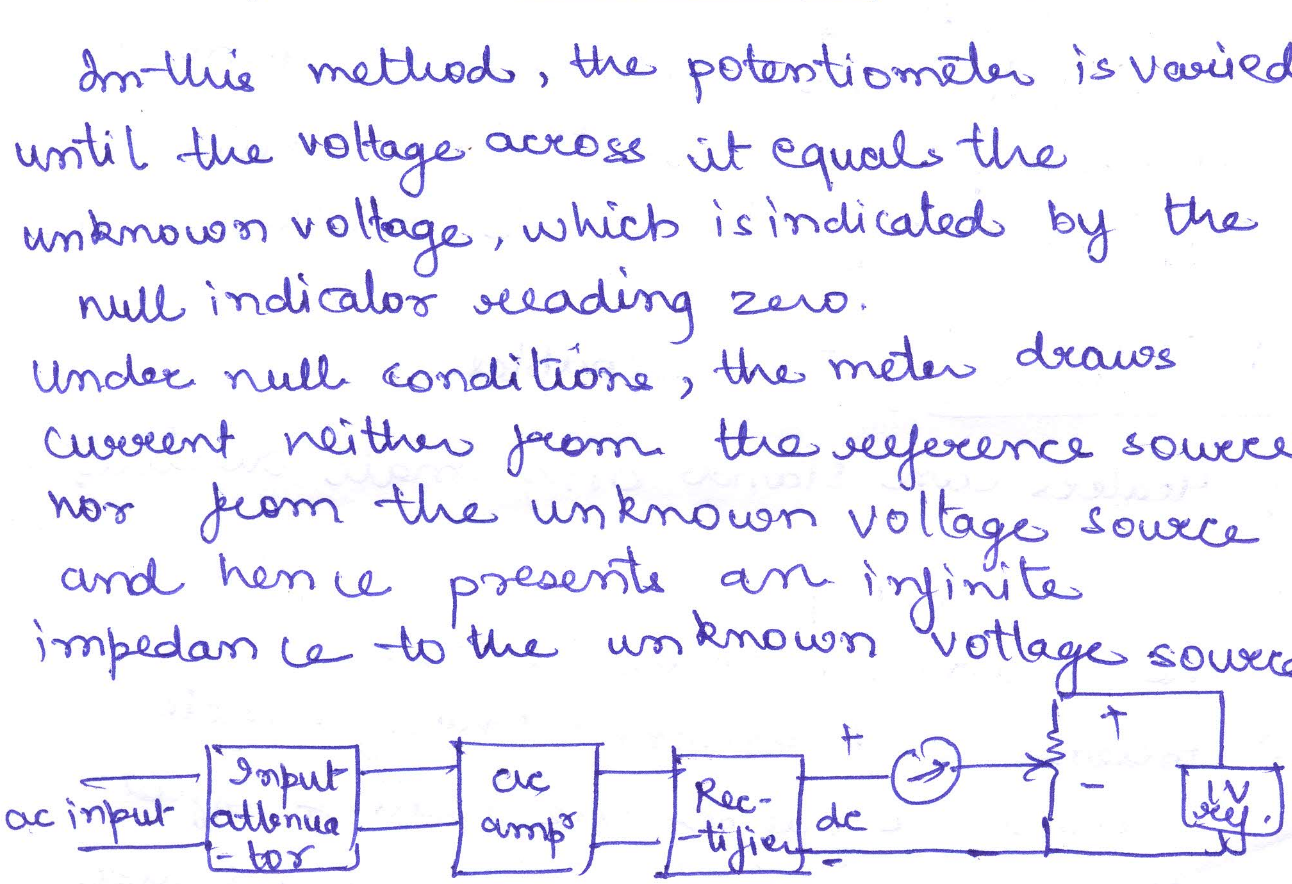
The differential voltmeter technique, is one of the most common and accurate methode of measuring unknown voltages. In this method unknown voltage is compared with a known voltage.

Potentiometric voltmeter or Basic differential voltmeter.



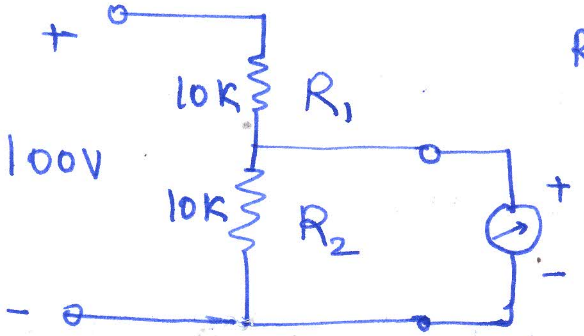
In this method, the potentiometer is varied until the voltage across it equals the unknown voltage, which is indicated by the null indicator reading zero.

Under null conditions, the meter draws current neither from the reference source nor from the unknown voltage source and hence presents an infinite impedance to the unknown votlage source.



Block daigram of an ac differential Voltmeter.

Q3(a) Loading effect :- A voltmeter when connected across two points in a resistive circuit to measure the voltage drop, It acts as a shunt for that portion of the circuit, reducing the total equivalent resistance of that portion of the circuit ~~e~~ for example in the circuit given below.



$R_{eq} = \underline{R_2 \parallel R_V}$

$V_{eq} = \dfrac{R_{eq} \times V}{R_{eq} + R_1}$

The voltmeter then indicates a lower reading than what existed before the meter was connected. This is called loading effect. Loading is more for voltmeters having low sensitivity.

~~Q4~~

Q3 (b) Inspection of the circuit indicates that the voltage across the R2 resistance is

$$50V \times \frac{5k}{50k} = 5V.$$

hence this is the true voltage across R_2

Case I. Range of the voltmeter is 10V.

Sensitivity = 20kΩ/V

Hence the voltmeter resistance = 200kΩ

Connecting the meter across R_2 causes the resistance to change to parallel combination of R_2 and the voltmeter resistance

$$\text{Hence } R_{eq} = R_2 \parallel 200k\Omega$$

$$= \frac{5k \times 200k\Omega}{205k\Omega} = 4.878k\Omega$$

Hence Now the voltage across 4.878 kΩ will become

$$V = \frac{50 \times 4.878k}{45k + 4.878k} = 4.889V.$$

Hence the voltmeter indicates 4.889V.

$$\text{and the \% error} = \left(\frac{5 - 4.889}{5}\right)^{\times 100} = 2.2\%.$$

Case II (ii) 30V Range.

sensitivity = 20 kΩ/V

Hence the resistance offered by the voltmeter = 20 kΩ/V × 30 V

= 600 kΩ

Connecting meter across R_2 causes the resistance to change to parallel combination of 600kΩ || R_2

$$R_{eq} = \frac{600\,k\Omega \times 5\,k\Omega}{605\,k\Omega} = 4.96\,k\Omega.$$

Hence the voltage across 4.96 kΩ is..

$$V_{eq} = \frac{50 \times 4.96\,k\Omega}{4.96\,k\Omega + 45\,k\Omega} = 4.962\,V.$$

The indication on the voltmeter will be 4.962 V due to loading.

$$\% \text{ error} = \left(\frac{5 - 4.962}{5}\right) \times 100 = 0.76\,\%.$$

ANS. (i) meter Reading = 4.889V

% error = 2.2%.

(ii) meter Reading = 4.962V

% error = 0.76%.

Q4

Dual slope Integrating Type DVM.

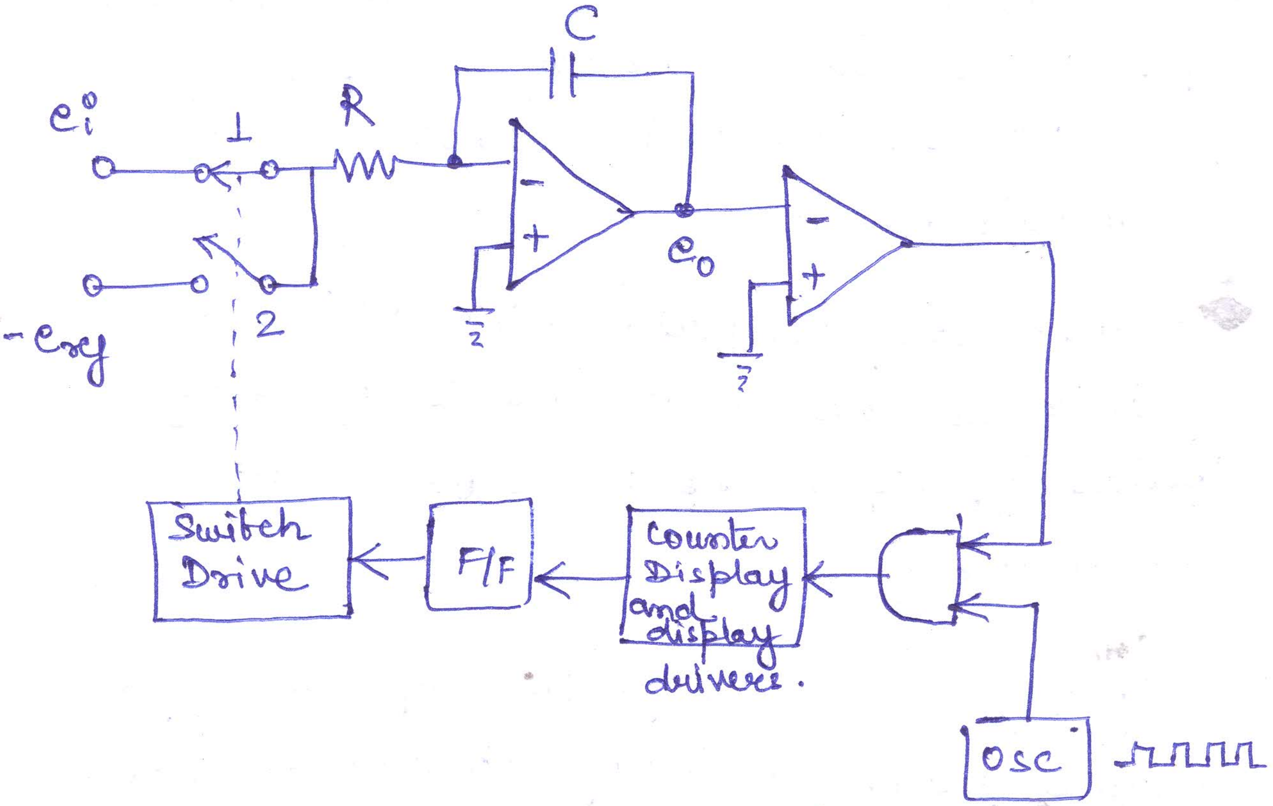
- For accurate voltage measurements, ramp-type DVMs require precise ramp voltages. and precise time periods, both are difficult to maintain.

- Dual-slope-integrator DVM virtually eliminates these requirements by using a special type of ramp generator circuit ie Integrator

Principle :- The integrator capacitor is first charged from the analog input voltage, and then discharged at a constant rate to give a time period that is measured digitally

- The charge and discharge results in two slopes (Voltage Vs time curve) hence the name dual slope.

Block diagram of a dual slope type DVM.



when switch 1 is closed. The capacitor C starts charging from zero level. The rate of charging is proportional to input level

$$e_0 = -\frac{1}{RC}\int_0^{t_1} V_{in}\,dt$$

$$e_0 = -\frac{1}{RC} V_{in} t_1 \quad \text{—①}$$

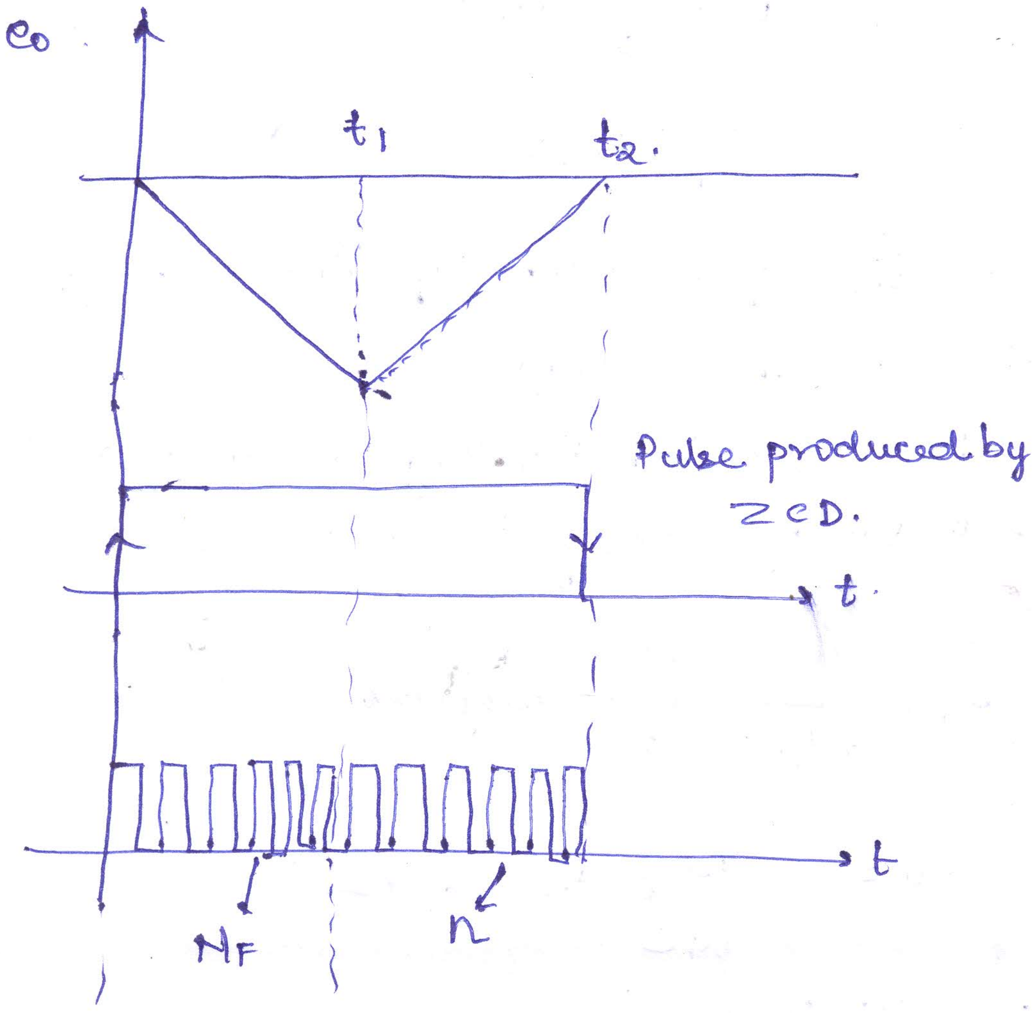
$t_1 \Rightarrow$ time for which capacitor is charged

V_{in} = input voltage

After t_1 time the input voltage is disconnected and a -ve voltage $-e_{ref}$ is connected to the integrator

The capacitor starts discharging linearly and the o/p at the integrator increases linearly. The output of zero crossing detector is still +ve, hence gating circuit is on. So the counter still counts the pulses. when voltage reaches ~~t2~~ becomes zero at t_2 and crosses zero.

ZCD gives a -ve falling edge from high to low which makes the ~~gaunt~~ gating circuit to off. At t_2 the capacitor completely discharges.



$$V_c = \frac{1}{C}\int_{t_1}^{t_2} I\,dt + \text{initial voltage.}$$

$$= \frac{1}{C}\int_{t_1}^{t_2} \frac{-V_{ref}}{R}\,dt + \frac{V_m t_1}{RC}$$

$$= -\frac{V_{ref}}{RC}(t_2-t_1) + \frac{V_m t_1}{RC}$$

~~Vo~~ $e_o = -V_c = \frac{V_{ref}(t_2-t_1)}{RC} - \frac{V_m t_1}{RC}$

at t_2 $e_o = 0$.

at t_2

$$\frac{V_{ref}(t_2-t_1)}{RC} = \frac{V_m t_1}{RC}.$$

Let in time t_1 no. of clk pulses counted $= N_1$

and during t_2-t_1 no. of clk pulses counted $= N_2$

then $$\frac{V_{ref}\, N_2 \times t_{clk}}{RC} = \frac{V_m\, N_1\, t_{clk}}{RC}.$$

$$\frac{V_{ref}}{V_m} = \frac{N_1}{N_2}$$

$$\boxed{\text{or } V_m = \frac{N_2}{N_1} V_{ref}}$$

→ The dual slope Technique has excellent noise rejection because noise and superimposed ac are averaged out in the process of integration.

→ less speed as conversion time is $N_1 t_{clk} + N_2 t_{clk}$.

→ As we are integrating voltage for time duration we are calculating true average value. So if an AC signal or noise is superimposed on V_m. it will be averaged. Hence effect of noise is less.

→ No dependency on RC and freq of Clock hence accuracy is more.

5(a) Convert a basic D'Arsonval movement into a dc voltmeter and derive the resistance equation.

A Basic D'Arsonval meter can be converted to a DC voltmeter by connecting a resistance in series with the meter. The purpose of this resistor is to limit the current through the basic meter. The resistor is termed as multiplier resistor.

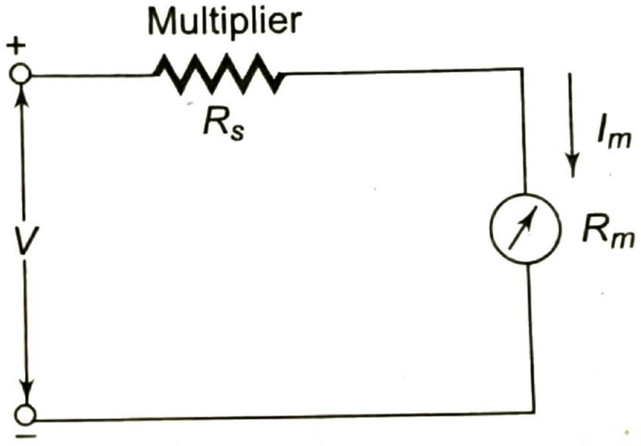


Fig 5.1 DC voltmeter

Fig 5.1 shows a DC voltmeter, where V is the range, Im the full scale reading of Basic Galvano meter and Rm the internal resistance of basic meter.

By applying KVL to the circuit in Fig 5.1

$$V = I_m(R_s + R_m) \qquad (5.1)$$

Or

$$R_s = \frac{V}{I_m} - R_m \qquad (5.2)$$

5(b)Design an Ayrton shunt to provide an ammeter with a current range of$0 - 1\ \mathrm{mA}$,$0 - 10\ \mathrm{mA}$, $0 - 50\ \mathrm{mA}$ and $0 - 100\ \mathrm{mA}$. A D'Arsonval movement with an internal resistance of 100Ω and full scale current of 50 µA is used.

Given Im= 50 µA and Rm=100Ω

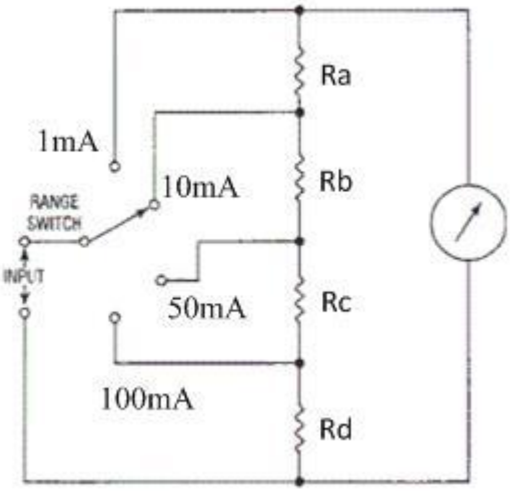


Fig 5.2 Ayrton shunt ammeter

$$R_{sh_1} = \frac{I_m R_m}{I_1 - I_m} = \frac{(50\mu)(100)}{1m - 50\mu} = 5.26\ \Omega$$

$$R_{sh_2} = \frac{I_m(R_m + R_{sh_1})}{I_2} = \frac{(50\mu)(100 + 5.26)}{10\ mA} = \frac{5.26 \times 10^{-3}}{10\ mA} = 0.526\ \Omega$$

$$R_{sh_3} = \frac{I_m(R_m + R_{sh_1})}{I_3} = \frac{(50\mu)(100 + 5.26)}{50m} = 0.105\ \Omega$$

$$R_{sh_4} = \frac{(I_m)(R_m + R_{sh_1})}{I_4} = \frac{(50\mu)(100 + 5.26)}{100m} = 0.0526$$

$$R_{sh_1} = R_a + R_b + R_c + R_d$$

$$R_{sh_2} = R_b + R_c + R_d$$

$$R_{sh_3} = R_c + R_d$$

$$R_{sh_4} = R_d$$

$$R_d = 0.0526\ \Omega$$

$$R_c = R_{sh_3} - R_{sh_4} = 0.105 - 0.0526 = 0.0524\ \Omega$$

$$R_b = R_{sh_2} - R_{sh_3} = 0.526 - 0.105 = 0.421\ \Omega$$

$$R_a = R_{sh_1} - R_{sh_2} = 5.26 - 0.526 = 4.734\ \Omega.$$

6.(a) How to convert a basic Galvano meter to an AC voltmeter? Explain two types of rectifier type AC voltmeters and derive an expression for the multiplier resistor in each case.

A basic Galvano can be used to measure RMS value of an applied ac signal by incorporating a rectifier element and a multiplier resistance. Multiplier resistor is used to limit the current through Galvano. Silicon diodes are preferred because of their low reverse current and high forward current ratings. Figure 6.1 gives an ac voltmeter circuit consisting of a multiplier, a bridge rectifier and a PMMC movement.

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. The meter scale is usually calibrated to give the RMS value of an alternating sine wave input. Practical rectifiers are non-linear devices particularly at low values of forward current .Hence the meter scale is non-linear and is generally crowded at the lower end of a low range voltmeter.

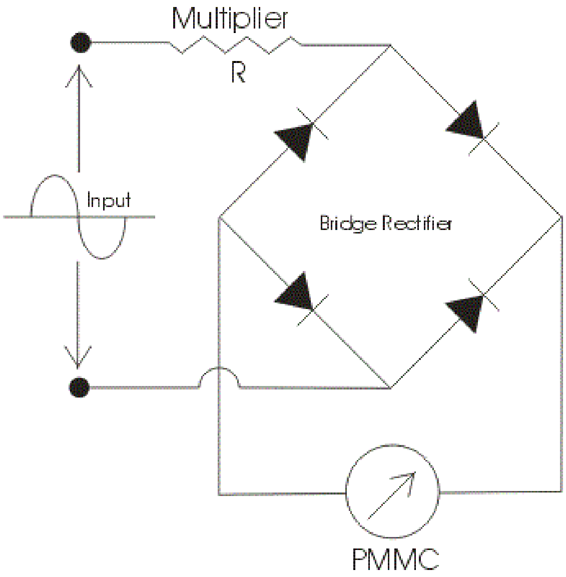


Fig 6.1 Full wave rectifier type AC voltmeter

Multiplier Design:

Since the meter will be metering the average value, the maximum applied input would be (considering full wave average voltage)

$$V_{dc} = \frac{2\sqrt{2}V_{rms}}{\Pi} \qquad (6.1)$$

If Rm is the meter resistance and Im the full deflection current, then the total voltmeter resistance should be

$$R_m + R_s = \frac{V_{dc}}{I_m} \qquad (6.2)$$

Using eqn 6.1 and 6.2 , the multiplier resistance can be derived as

$$R_s = \frac{V_{dc}}{I_m} - R_m \qquad (6.3)$$

$$R_s = \frac{V_{rms} * 0.9}{I_m} - R_m \qquad (6.4)$$

From eqn 6.4 it is clear that the sensitivity of such a meter is 90% of a DC voltmeter.

Figure 6.2 gives an ac voltmeter circuit consisting of a multiplier, a half wave rectifier and a PMMC movement.

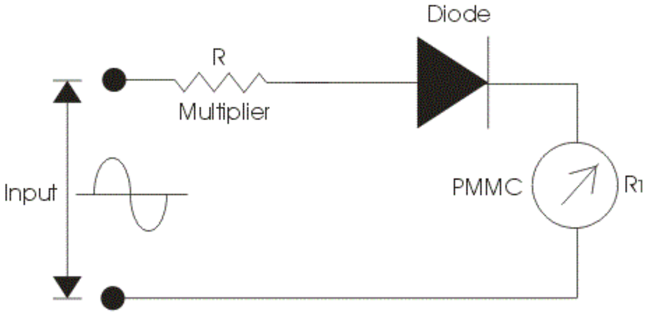


Fig 6.1 Half wave rectifier type AC voltmeter

Here

$$V_{dc} = \frac{\sqrt{2}V_{rms}}{\Pi}$$

Thus

$$R_s = \frac{V_{rms} * 0.45}{I_m} - R_m$$

General observation on Rectifier type AC voltmeter:

1. Rectifier type of instrument is calibrated in terms of root mean square values of sinusoidal wave of voltages and current. The problem is that the input waveform may or may not have same form factor on which the scale of these meter is calibrated.
2. The non linear characteristics of bridge may distort the current and voltage waveform.
3. There may variation in the temperature due to which the electrical resistance of the bridge changes hence in order to compensate this kind of errors we should apply multiplier resistor with high temperature coefficient .
4. The sensitivity of Rectifier type instruments is low in case of ac input voltage.

Advantages of Rectifier Type Instruments:

1. The accuracy of rectifier type instrument is about 5 percent under normal operating condition.
2. The frequency range of operation can be extended to high value.
3. They have uniform scale on the meter.
4. They have low operating value of current and voltages.

The loading effect of an ac rectifier voltmeter in both the cases (i.e. half wave diode rectifier and full wave diode rectifier) is high as compared to the loading effects of DC voltmeters as the sensitivity of the voltmeter either using in half wave or full wave rectification is less than the sensitivity of DC voltmeters.

6(b). Convert a Galvano (PMMC instrument) with $I_m = 100\mu\text{A}$ and $R_m = 100\Omega$to an AC voltmeter. Calculate the value of multiplier resistor required for a full wave rectifier type AC voltmeter with a range of $100\ V$ rms.

Using eqn 6.4

$$R_s = \frac{V_{rms} * 0.9}{I_m} - R_m$$

$$R_s = \frac{100 * 0.9}{100\mu} - 100$$

$$R_s = 899900\Omega = 899.9K\Omega$$

7 . Explain the working of Successive approximation type DVM with a neat block diagram. Depict the conversion steps in table format, for an 8 bit converter with a reference voltage of 5V and the voltage to be measured is 4V.

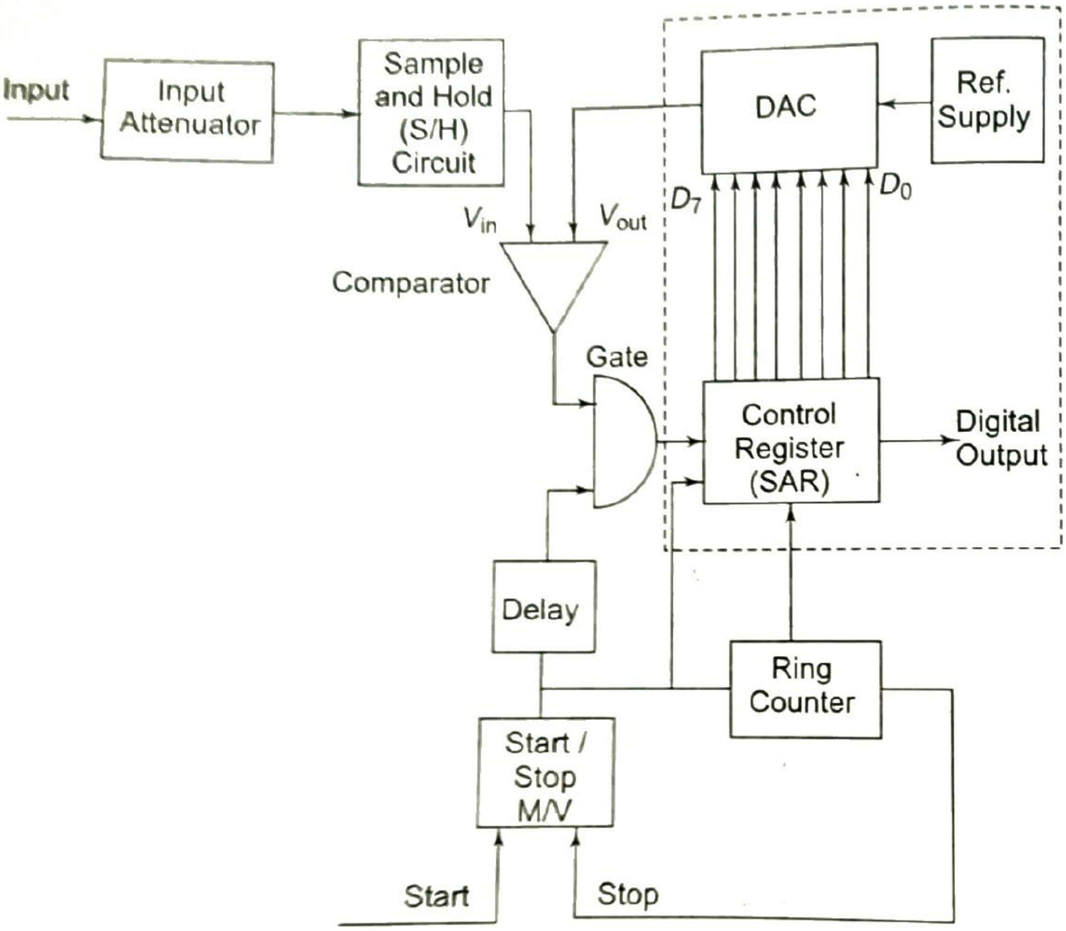


Fig 7.1 Block Diagram of Successive Approximation Type DVM

The successive approximation DVM works on the principle of comparison. The unknown signal is compared with half the reference value and depending on whether the input signal is higher or lower additional comparison voltage is added or removed. Then the process continues for a predefined number of comparisons.

Its basic block diagram is shown in Fig. 7.1. When the start pulse signal activates the control circuit, the successive approximation register (SAR) is cleared. The SAR register is an 8 bit one. The output of the SAR is 00000000. V_{out} of the D/A converter is 0. Now, if $V_{in} > V_{out}$ the comparator output is positive. During the first clock pulse, the control circuit sets the D_7 to 1, and V_{out} jumps to the half reference voltage. The SAR output is 10000000. If V_{out} is greater than V_{in} the comparator output is negative and the control circuit resets D_7. However, if V_{in} is greater than V_{out} the comparator output is positive and the control circuits keep D_7 set. Similarly the rest of the bits beginning from D_7 to D_0 are set and tested. Therefore, the measurement is completed in 8 clock pulses.

At the beginning of the measurement cycle, a start pulse is applied to the start-stop multivibrator. This sets a 1 in the MSB of the control register and a 0 in all bits (assuming an 8-bit control) its reading would be 10000000. This initial setting of the register causes the output of the D/A converter to be half the reference voltage, i.e. 1/2 V. This converter output is compared to the unknown input by the comparator. If the input voltage is greater than the converter reference voltage, the comparator output produces an output that causes the control register to retain the 1 setting in its MSB and the converter continues to supply its reference output voltage of 1/2 V_{ref}.

The ring counter then advances one count, shifting a 1 in the second MSB of the control register and its reading becomes 11000000. This causes the D/A converter to increase its reference output by 1 increment to 1/4 V_{ref}, i.e. 1/2 V_{ref} + 1/4 V_{ref}, and again it is compared with the unknown input. If in this case the total reference voltage exceeds the unknown voltage, the comparator produces an output that causes the control register to reset its second MSB to 0. The converter output then returns to its previous value of 1/2 V_{ref} and awaits another input from the SAR. When the ring counter advances by 1, the third MSB is set to 1 and the converter output rises by the next increment of 1/2 V_{ref} + 1/8 V_{ref}. The measurement cycle thus proceeds through a series of successive approximations. Finally, when the ring counter reaches its final count, the measurement cycle stops and the digital output of the control register represents the final approximation of the unknown input voltage.

Table 7.1 depicts the steps involved in the voltage measurement if Successive approximation type DVM is used.

V_{in} =4V, V_{ref}= 5V

Sl no	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	V'_{ref}	Condition	Decision	V_{out}
1	1	0	0	0	0	0	0	0	2.5V	$V_{in}>V'_{ref}$	D_7 set	2.5V
2	1	1	0	0	0	0	0	0	3.75V	$V_{in}>V'_{ref}$	D_6 set	3.75V
3	1	1	1	0	0	0	0	0	4.375V	$V_{in}<V'_{ref}$	D_5 reset	3.75V
4	1	1	0	1	0	0	0	0	4.0625V	$V_{in}<V'_{ref}$	D_4 reset	3.75V
5	1	1	0	0	1	0	0	0	3.90625V	$V_{in}>V'_{ref}$	D_3 set	3.90625V
6	1	1	0	0	1	1	0	0	3.984375V	$V_{in}>V'_{ref}$	D_2 set	3.984375V
7	1	1	0	0	1	1	1	0	4.023438V	$V_{in}<V'_{ref}$	D_1 reset	3.984375V
8	1	1	0	0	1	1	0	1	4.00391V	$V_{in}<V'_{ref}$	D_0 reset	3.984375V

Table 7.1 Steps

Final SAR data = 11001100

The voltage displayed by the meter = 3.984375V

8 (a) Determine the resolution of a $3\frac{1}{2}$ *digit display on 1V, 10V and 100V range.*

- The resolution of a $n\frac{1}{2}$ digit diplay is $\frac{1}{10^n}$ on 1V scale

Then

The resolution of a $3\frac{1}{2}$ digit diplay is $\frac{1}{10^3}$ (1mV) on 1V scale.

The resolution on any range is given by

- Resolution(Sensitivity) = $\frac{1}{10^n} * Range$

On 10v range: resolution = 1mv*10=10mV

On 100v range: resolution = 1mv*100=100mV

8 (b) Write a note on statistical analysis of error

Statistical Analysis of Error in Measurement:

The random errors coming out from the unknown sources are very difficult to correct. Once systematic errors have been sufficiently minimized and the remaining error is random, we can use statistics to describe the data set .Here , statistical approaches are normally preferred to minimize the random errors. These techniques used are

1 Mean:

If we take N measurements of a certain quantity x, the best estimate of the actual quantity is the mean, x , of the measurements:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

2 Deviation and Average Deviation:

We can also estimate the error using the average or mean. To do this, we look at how far away the individual measured values are from the mean. The value $d_i = X_i - \overline{X}$ is the deviation of a particular trial from the mean. The deviations always sum to zero.

Avearge deviation:The magnitude of all deviation sum together devided by the number of samples considered. $D = \frac{\Sigma d_i}{N}$. This parameter speaks about precision in measurement.

3 Standard Deviation:

Since the deviations always sum to zero, to estimate error more accurately, the solution, then, is to square the deaviations, sum them, and then take the square root of that sum, resulting in a value referred to as the standard deviation, σ.

$$\sigma_x = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

The standard deviation characterizes the average uncertainty of measurements x1,…,xN. It is also sometimes known as the root-mean-squared (RMS) deviation.