**Ac Voltmeter:** The instrument, which is used to measure the Ac Voltage across any two Points of electric circuit

classification of Ac voltmeter:

1. Average responding [using HWR & FWR]
2. Peak responding
3. RMS responding

If the Ac voltmeter consists of rectifier, then it is said to be rectifier based Ac voltmeter

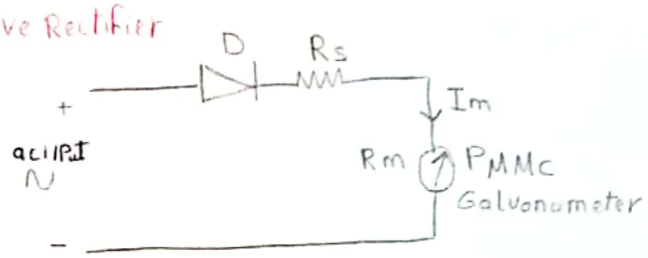
Types of rectifier based Ac voltmeter:

a) Ac voltmeter using Half Wave Rectifier.

b) Ac voltmeter using Full Wave Rectifier.

(1) Ac voltmeter using Half wave Rectifier

D conduct only during Positive half cycle




The rms value of sinusoidal (Ac) i/p Voltage signal is

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

$$\therefore V_m = \sqrt{2}\, V_{rms} = 1.414\, V_{rms} \qquad V_m = V_P = \text{Peak voltage}$$

$V_m \rightarrow$ is the maximum value of sinusoidal (Ac) i/p Voltage signal

The dc or average value of the Half wave rectifier o/p signal is

$$V_{av} = V_{dc} = \frac{V_m}{\pi} \qquad V_m = 1.414\, V_{rms}$$

$$\therefore V_{dc} = \frac{1.414\, V_{rms}}{\pi} = 0.45\, V_{rms}$$

∴ The Ac voltmeter Produces an o/p voltage, which is equal to 0.45 times the rms value of the sinusoidal (Ac) i/p Voltage signal.

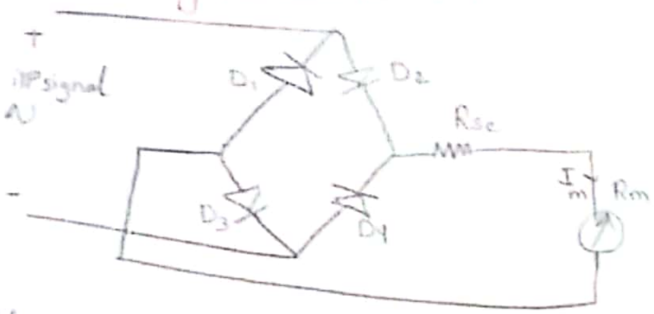
The value of series multiplier (Rs) can be obtained

$$R_{se} = \frac{E_{dc}}{I_{dc}} - R_m$$

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

$I_{dc} \rightarrow$ Full scale deflection current

## [2] Ac Voltmeter using Full wave Rectifier




$$V_{rms} = \frac{V_m}{\sqrt{2}}$$ $\quad V_m = V_p = 1.414\, V_{rms}$

$V_m \longrightarrow$ maximum Value of i/P signal

$$V_{av} = V_{dc} = \frac{2V_m}{\pi} = \frac{2 * 1.414\, V_{rms}}{\pi} = 0.9\, V_{rms}$$

$V_{av}$ & $V_{dc} \longrightarrow$ average or Dc Value of the full wave rectifier o/P signal

The multiplier resistance can be obtained as

$$R_{se} = \frac{E_{dc}}{I_{dc}} - R_m = \frac{0.9\, E_{rms}}{I_{dc}} - R_m$$

## Average Responding Ac Voltmeter

$\longrightarrow$ The scale on Ac Voltmeters are ordinarily calibrated in rms Values of a sinusoidal wave form.

$$\text{Form Factor } (k_f) = \frac{V_{rms}}{V_{avg}}$$

For Avg Responding Ac Voltmeter using FWR

$$k_f = \frac{V_{rms}}{V_{avg}} = \frac{V_{rms}}{0.9\, V_{rms}} = 1.11$$

Sheet (1)

[1] a.c Voltmeter using $\boxed{HWR}$ & $I_{dc} = 1mA$ & $R_m = 200\,\Omega$ & $E_{rms} = 10V_{rms}$
Calculate the multiplier resistance ($R_s$)

Soluation

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

$$= \frac{0.45 * 10}{1 * 10^{-3}} - 200\,\Omega = 4300\,\Omega = 4.3\,k\Omega \;\#$$

$\boxed{2}$ a.c Voltmeter uses $\boxed{FWR}$ & $I_{dc} = 2mA$ & $R_m = 500\,\Omega$ & $E_{rms} = 10\,V_{rms}$
Calculate multiplier resistance $R_{se}$

Saluation

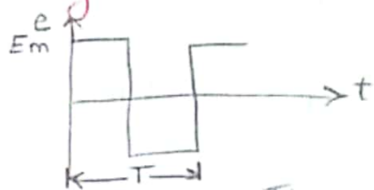
$\because$ a.c Voltmeter uses FWR

$\therefore E_{dc} = 0.9\,E_{rms}$

$$\therefore R_{se} = \frac{0.9\,E_{rms}}{I_{dc}} - R_m = \frac{0.9 * 10}{2 * 10^{-3}} - 500\,\Omega = 4000\,\Omega = 4k\,\Omega \;\#$$

$\boxed{3}$ Average responding Voltmeter
Calculate $k_f$ of square wave & error in the meter reading

Solution




$$E_{rms} \text{ of square wave} = \sqrt{\frac{1}{T}\int_0^T e^2\,dt}$$

$$= \sqrt{\frac{1}{T}\int_0^T E_m^2\,dt} = \sqrt{\frac{1}{T} E_m^2 T}$$

$$= E_m$$

$$V_{av} = \frac{2}{T}\int_0^{T/2} V_{in}\,dt$$

$$E_{avg} = \frac{2}{T} E_m \frac{T}{2} = E_m$$

average value $E_{avg}$ for square wave $= E_m$

$$\therefore k_f = \frac{\text{rms value}}{\text{average value}} = \frac{E_{rms}}{E_{avg}} = \frac{E_m}{E_m} = 1$$

$\therefore$ scale is calibrated in terms of the rms value of purely sinusoidal waveform

$$k_f \text{ for sinusoidal} = \frac{E_{rms}}{E_{avg}} = \frac{E_{rms}}{0.9\,E_{rms}} = 1.11$$

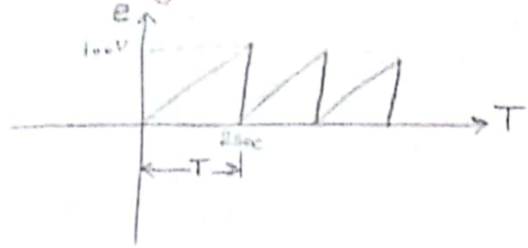
$\therefore E_{rms} = 1.11\,E_{avg}$ for sinusoidal

$E_{rms} = E_{av}$ for square wave

$$\because \text{reading on Voltmeter will be higher by factor } \frac{k_f \text{ for sinusoidal}}{k_f \text{ for square wave}} = \frac{1.11}{1} = 1.11$$

$$\therefore \text{Percentage error in the reading} \quad e\% = \frac{\text{true} - \text{measured}}{\text{True}} * 100 = \frac{1 - 1.11}{1} * 100 = -11\% \;\#$$

[4] calculate the Percentage error in the reading




$e = At$

$A \longrightarrow$ slope of ramp

$A = \frac{100-0}{2-0} = 50$

$\therefore e = 50t \qquad 0 \leq t \leq T$

$$E_{rms} = \sqrt{\frac{1}{T}\int_0^T e^2\,dt} = \sqrt{\frac{1}{T}\int_0^T (50t)^2\,dt}$$

$$= \sqrt{\frac{1}{T}(50)^2\frac{T^3}{3}} = \sqrt{\frac{T^2}{3}(50)^2} = \frac{50T}{\sqrt{3}}$$

$T = 2sec$

$\therefore E_{rms} = \frac{100}{\sqrt{3}}V$

$$E_{av} = \frac{1}{T}\int_0^T e\,dt = \frac{1}{T}\int_0^T 50t\,dt = \frac{1}{\cancel{T}}\frac{50T^{\cancel{2}}}{2} = 25T = 25 * 2 = 50V$$

$k_f$ (form factor) $= \frac{E_{rms}}{E_{avg}} = \frac{100/\sqrt{3}}{50} = 1.155$ For saw tooth

$k_f$ for sinusoidal wave $= 1.11$

$\therefore$ The meter will read less by factor $\frac{k_f\,sine}{k_f\,sawtooth} = \frac{1.11}{1.155} = 0.961$

$\therefore$ Percentage error $= \frac{True - measured}{True} * 100 = \frac{1-0.961}{1} * 100 = 3.87\,\%$ #

[5] $I_{dc} = 25mA$ & $R_m = 100\,\Omega$ & $200\,V_{rms}$ & Forward resistance of diode $= 500\Omega$
calculate the value of the series resistance to limit the current to the rated value
at the rated voltage

solution

$\because$ a.c voltmeter uses the bridge $\therefore$ FWR

$E_{dc} = 0.9\,E_{rms}$

$\therefore R_s = \frac{E_{dc}}{I_{dc}} - R_m =$

$\because$ diode forward resistance $= 500\,\Omega$ & due to the bridge configuration, two diode will be in series at a time $\therefore R_D =$ diode resistance $= 2R_f = 1000\,\Omega$

$\therefore R_m' = R_m + R_D = 100 + 1000 = 1100\,\Omega$

$\therefore R_s = \frac{0.9 * 200}{2 * 10^{-3}} - 1100 = 6100\,\Omega$ #