DEPARTMENT OF ELECTRNICS & COMMUNICATION ENGINEERING, KITSW

COURSE: **U14EI 205 - BASIC ELECTRONICS ENGINEERING**	**ECE-I, Semester-II, 2015-16**

ASSIGNMENT-8 HINTS &SOLUTIONS (PART-1)

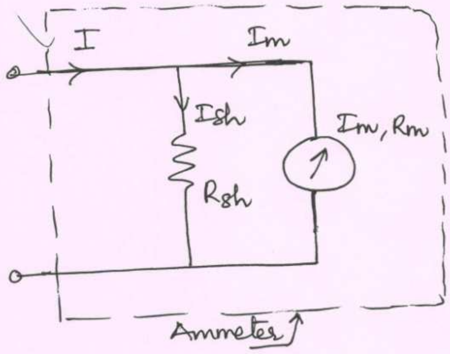
1. A DC ammeter has a PMMC coil resistance and shunt resistance in the ratio 99:1. If the full scale deflection (fsd) is given as 0.1mA, determine the current passing through the ammeter at (i) fsd (ii) 0.5 fsd and (iii) 0.25 fsd.

Sol:

Given:

✓ $\frac{R_m}{R_{sh}} = 99$

✓ $I_{fsd} = 0.1mA$



✓ Ammeter current $(I) = I_{sh} + I_m$ — (1)

✓ Also drop across shunt = drop across meter or coil

$I_{sh} \cdot R_{sh} = I_m \cdot R_m$

$I_{sh} = I_m \cdot \left(\frac{R_m}{R_{sh}}\right)$ — (2)

$I_{sh} = 99\, I_m$ — (3)

(i) what is ammeter current when the basic meter shows f.s.d

$I = I_{sh} + I_m = 99\, I_m + I_m = 100\, I_m$

Here $I_m = 0.1mA$

$\therefore I = 100 \times (0.1mA) = 10\,mA \Rightarrow$ $\boxed{I = 10mA}$

(ii) what is ammeter current when basic meter current is 0.5 fsd

i.e, $I_m = 0.5\,(I_{fsd}) = 0.5\,(0.1mA) = 0.05mA$.

$I = I_{sh} + I_m = 99\, I_m + I_m = 100\, I_m = 100\,(0.05mA)$

$\boxed{I = 5mA}$

(iii) what is ammeter current, when basic meter current is 0.25 fsd

i.e, $I_m = 0.25\,(0.1mA) = 0.025mA$

So $I = 100\, I_m = 100 \times (0.025mA)$

$\boxed{I = 2.5mA}$ //

2. **Discuss briefly about voltmeter loading effect.**

[*You are expected to cover: (i) Define sensitivity of an voltmeter, (ii) State what is loading effect, referring to sensitivity of voltmeter (class notes) (iii) As an example, take the potential divider network problem solved in class and calculate the voltage across* R_2 *as measured by voltmeters of low and high sensitivity, (iv) Comment of the result (i.e % error in voltage measurement) referring to voltmeter sensitivity*]

(refer to class notes)

3. **Explain with a diagram the operation of series type ohmmeter. Show how the scale is marked. What is the significance of half-scale deflection (hsd) and derive expression for unknown resistance at hsd.**

(refer to class notes)

4. **Explain with a diagram the operation of shunt type ohmmeter. Show how the scale is marked. What is the significance of half-scale deflection (hsd) and derive expression for unknown resistance at hsd**

(refer to class notes)

5. Draw the block diagram of a digital multimeter and explain the function of each block.

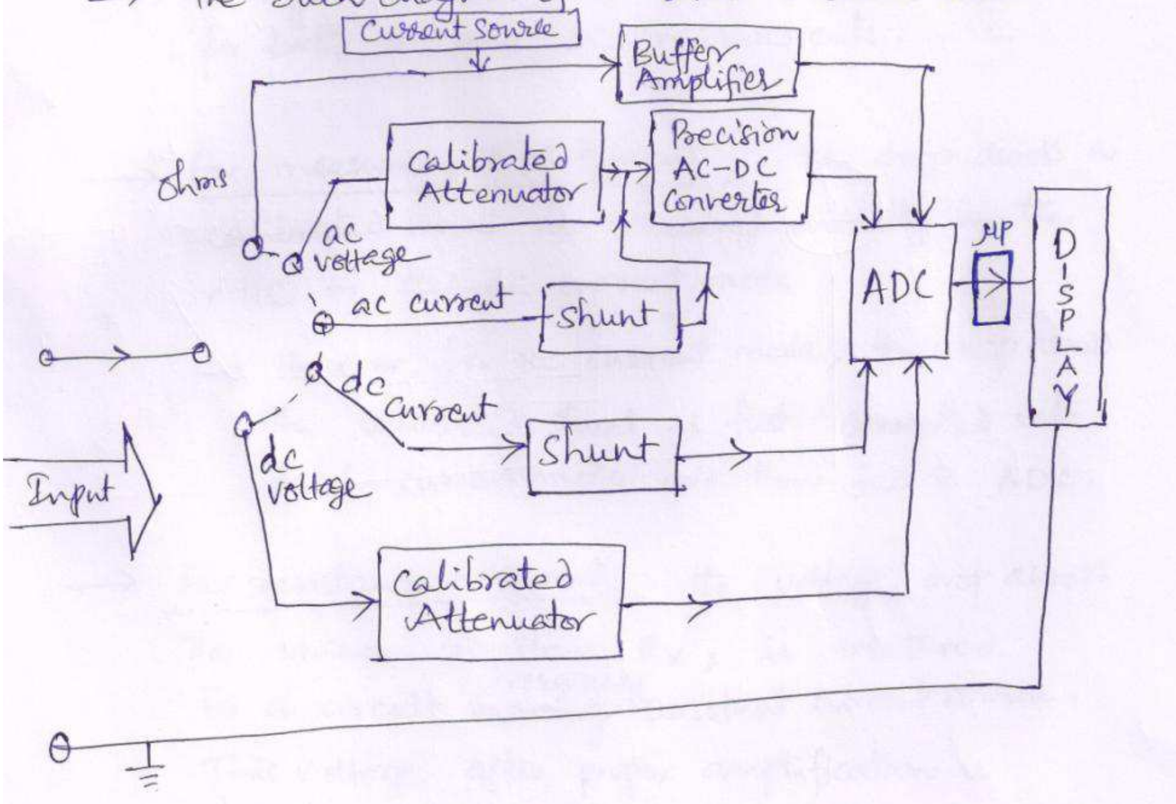
(refer to class notes)

The Digital Multimeter (DMM):

→ A DMM is an electronic instrument which can measure dc and ac voltage & current and resistance.

→ All quantities other than dc voltages are first converted into equivalent dc voltage by some mechanism/device and then measured with the help of digital voltmeter.

→ The block diagram of a DMM is shown below.



→ For the measurement of ac voltage, the input voltage is fed through a calibrated, compensated attenuator.

→ The attenuator output is given to a ~~prec~~ precision Full Wave rectifier (FWR) followed by a ripple reduction filter.

→ The resulting DC is fed to Analog-to-Digital Converter (ADC) and subsequent display system.

→ Many DMMs are provided with same attenuator for both ac and dc measurements.

→ For measurement of current, the drop across a calibrated shunt is measured directly by the ADC in the dc current mode.

→ However, for ac current mode, the drop across the calibrated shunt is first converted into dc in current mode and then fed to ADC.

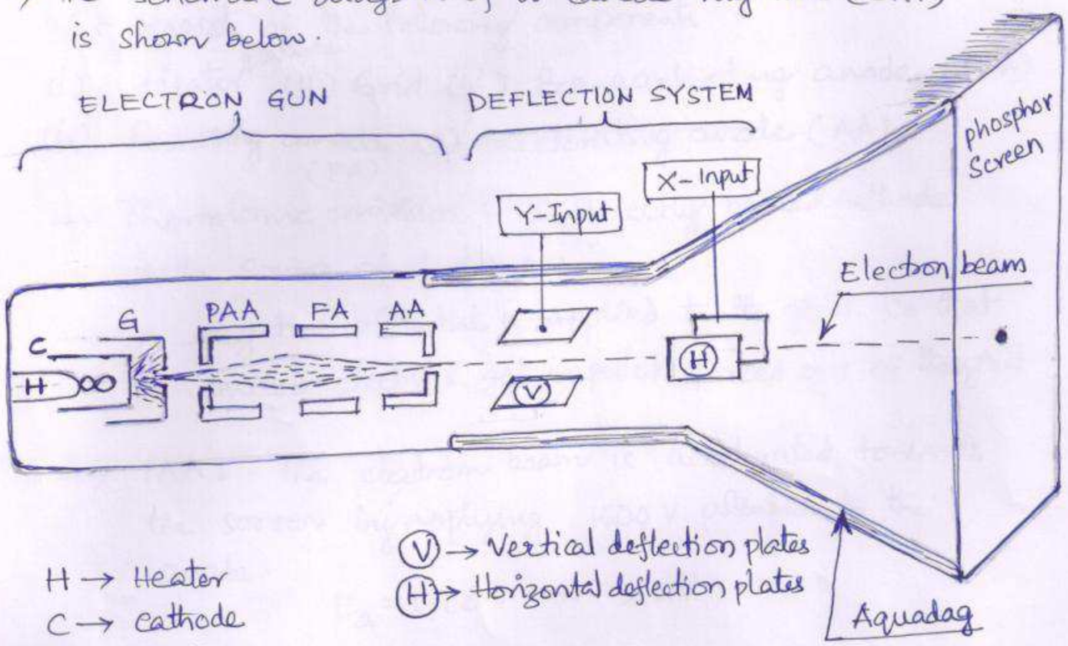
→ For resistance measurement, the voltage drop across the unknown resistance Rx, is measured in a circuit ~~having~~ energised by constant current source. This voltage after proper amplification is fed to ADC for further processing.

(Contd...

6. Explain the construction and working principle of a Cathode Ray Tube (CRT) by deriving an expression for deflection sensitivity of CRT.

Construction and Working of CRT

→ The schematic diagram of a cathode-ray tube (CRT) is shown below.



H → Heater
C → cathode
G → Grid
PAA → Pre-accelerating anode
FA → Focussing anode
AA → Accelerating anode

→ A CRT essentially consists of three basic components
(1) The electron gun
(2) The deflection system
(3) The fluorescent system

These three essential components are assembled inside a highly evacuated glass envelope.

1. The electron gun : It produces a beam of electrons sharply focussed and highly accelerated towards the screen.
It consists of the following components
(i) Heater & cathode (ii) Grid (iii) Pre-accelerating anode (PAA)
(iv) Focussing anode (FA) (V) Accelerating anode (AA)

→ Thermionic emission : Indirectly heated cathode is the source of electrons.

→ A negative potential is applied to the grid so that the emitted electrons get repelled forced out of the grid

→ PAA : The electron beam is accelerated towards the screen by applying 1500 V potential to the anode.

$$E_a = 1500\text{ V} \text{ or } 2\text{ KV}$$

→ FA : The beam is focussed to a very small dot on the screen by the focussing anode.
The FA acts like a lens, whose focal length can be changed by means of a variable voltage of 500V applied to FA.

→ AA : The focussed beam is further accelerated by a voltage of $E_a = 1500\text{ V}$ (or) 2 KV to accelerating anode.

→ Finally the electron gun emits a focussed (narrow) and highly accelerated electron beam.

The speed of electrons as they leave the gun is calculated as follows:

Let V_a = accelerating anode voltage

v_x = velocity of electron in x-direction

The KE of electron leaving gun $\frac{1}{2}mv_x^2 = V_a q$

$$v_x = \sqrt{\frac{2V_a q}{m}} \quad \text{——— (1)}$$

$q \rightarrow$ charge on $\bar{e}$ & $m \rightarrow$ mass of $\bar{e}$ $(9.11 \times 10^{-31}$ kg$)$.

∴ The electron beam enters the deflection system with a velocity given by v_x.

→ Higher the accelerating voltage (V_a), the faster is the velocity of electrons resulting in a brighter spot on the screen.

2. The deflection system:

→ As soon as the $\bar{e}$ beam leaves the gun, it is made to pass through two pairs of deflection plates

(i) Vertical deflection plates

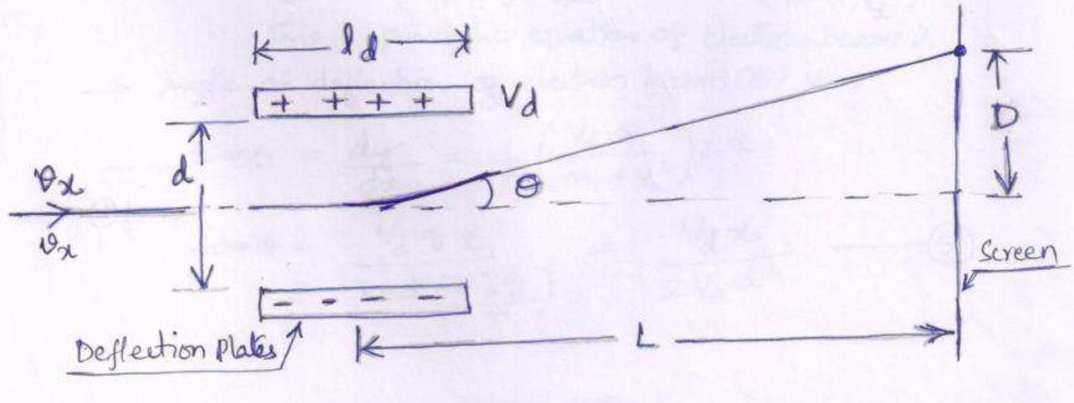
(ii) Horizontal deflection plates

(i) Vertical (Y) deflection plates:

→ Electrostatic deflection is used

→ Any voltage applied to this set of plates, moves the electron beam up or down.

→ The bright spot on the screen will move along Y-axis.



[Let V_d = potential difference applied across plates with the upper plate at higher potential]

Let V_d = deflecting voltage across the Y-plates.
d = distance between the deflection plates

then the electric field intensity $E = \frac{V_d}{d}$

→ The upward force on $\bar{e}$ is $F_y = Eq$

→ the upward acceleration on $\bar{e}$ is $F_y = ma_y$

$$(\text{or})\quad a_y = \frac{F_y}{m} = \frac{Eq}{m} \quad \text{——}$$

$$(\text{or})\quad a_y = \frac{\left(\frac{V_d}{d}\right)\cdot q}{m} = \frac{V_d \cdot q}{m\cdot d} \quad \text{—— (2)}$$

→ the vertical displacement of $\bar{e}$ in time 't' is

$$y = u_y t + \frac{1}{2}a_y t^2$$

with $u_y = 0 \Rightarrow y = \frac{1}{2}a_y t^2 = \frac{1}{2}\left(\frac{V_d \cdot q}{md}\right)t^2$ —— (3)

→ simultaneous horizontal displacement of $\bar{e}$ is

$$x = v_x \cdot t \Rightarrow t = \frac{x}{v_x} \quad \text{—— (4)}$$

using (4) in (3)

$$y = \frac{1}{2}\left(\frac{V_d \cdot q}{md}\right)\left(\frac{x}{v_x}\right)^2 = \frac{1}{2}\left(\frac{V_d \cdot q}{m\cdot d\, v_x^2}\right)\cdot x^2$$

This is parabolic equation of electron beam //

→ Angle of deflection of electron beam (θ) is

$$\tan\theta = \frac{dy}{dx} = \frac{1}{2}\left(\frac{V_d \cdot q}{m\cdot d\, v_x^2}\right)2x.$$

using (1) for v_x

$$\tan\theta = \frac{V_d \cdot q\, x}{m\cdot d\left(\frac{2V_a q}{m}\right)} = \frac{V_d\, x}{2V_a \cdot d} \quad \text{—— (5)}$$

with $x = l_d$ (← effective length of deflection plates), $\tan\theta = \frac{V_d \cdot l_d}{2V_a \cdot d}$

$$\frac{D}{L} = \frac{V_d \cdot l_d}{2V_a \cdot d}$$

(or) $$D = \frac{L \cdot l_d \cdot V_d}{2V_a \cdot d} \quad \text{—— (6)}$$

$D \propto V_d$ (*)

→ Deflection Sensitivity (S) is the deflection (D) of the beam on the screen for the given or applied V_d

$$S = \frac{D}{V_d} = \frac{L\, l_d}{2V_a \cdot d} \;(m/V) \quad \text{—— (7)}$$

→ Deflection factor (G) of the CRT

$$G = \frac{1}{S} = \frac{2V_a \cdot d}{L \cdot l_d} \;(V/m) \quad \text{—— (8)}$$

(*) → (6) indicates that for a given accelerating voltage (V_a), the deflection (D) of the beam on the screen is directly proportional to the deflection voltage (V_d).

→ The beam then enters the x-deflection plates

(ii) Horizontal Deflection Plates:

→ Any voltage applied to this set of plates, moves the electron beam along the x-axis (to the left or right)

→ If horizontal deflection voltage sweeps the beam from left to right at a uniform rate, the beam traces out a graph of vertical voltage as a function of time.

→ If no voltage is applied externally to either set of plates (X and Y), the spot should be located at the centre of the screen.

⊛→ In general,
- Signal to be displayed is applied to Vertical deflection plates
- Sawtooth-wave voltage is applied to Horizontal deflection plates

3. The Fluorescent Screen:

→ The screen is coated on the inside with a phosphor material

→ This material emits light when high-velocity electrons strike it.

→ Depending upon the phosphor material used in the fluorescent screen, it is possible to have either green, orange or white light.

→ Secondary-emission electrons: When electron beam strikes the screen, besides giving out visible light, secondary-emission electrons are also released.

→ Aquadag: The secondary-emission low-velocity electrons are collected by a conductive coating known as aquadag, on inside surface of the glass tube.

→ GRATICULE:

→ The waveforms under investigation are displayed on the screen.

→ The calibrated vertical and horizontal marks placed on the screen is called graticule

→ Graticule is used for measuring Amplitude (vertical divisions) and time period (horizontal lines) of displayed waveforms.

Continued in PART-2 ….