

1.11 Characteristics of meter

1.11.1 Full scale deflection current(I_{FSD})

The current required to bring the pointer to full-scale or extreme right side of the instrument is called full scale deflection current. It must be as small as possible. Typical value is between $2 \mu A$ to $30mA$.

1.11.2 Resistance of the coil(R_m)

This is ohmic resistance of the moving coil. It is due to ρ , L and A. For an ammeter this should be as small as possible.

1.11.3 Sensitivity of the meter(S)

$$S = \frac{1}{I_{FSD}} (\Omega / \text{volt}), \uparrow S = \frac{Z \uparrow}{V}$$

It is also called ohms/volt rating of the instrument. Larger the sensitivity of an instrument, more accurate is the instrument. It is measured in Ω/volt . When the sensitivity is high, the impedance of meter is high. Hence it draws less current and loading affect is negligible. It is also defend as one over full scale deflection current.

1.12 Error in M.I instrument

1.12.1 Temperature error

Due to temperature variation, the resistance of the coil varies. This affects the deflection of the instrument. The coil should be made of manganin, so that the resistance is almost constant.

1.12.2 Hysteresis error

Due to hysteresis affect the reading of the instrument will not be correct. When the current is decreasing, the flux produced will not decrease suddenly. Due to this the meter reads a higher value of current. Similarly when the current increases the meter reads a lower value of current. This produces error in deflection. This error can be eliminated using small iron parts with narrow hysteresis loop so that the demagnetization takes place very quickly.

1.12.3 Eddy current error

The eddy currents induced in the moving iron affect the deflection. This error can be reduced by increasing the resistance of the iron.

1.12.4 Stray field error

Since the operating field is weak, the effect of stray field is more. Due to this, error is produced in deflection. This can be eliminated by shielding the parts of the instrument.

1.12.5 Frequency error

When the frequency changes the reactance of the coil changes.

$$Z = \sqrt{(R_m + R_S)^2 + X_L^2} \quad (1.70)$$

$$I = \frac{V}{Z} = \frac{V}{\sqrt{(R_m + R_S)^2 + X_L^2}} \quad (1.71)$$

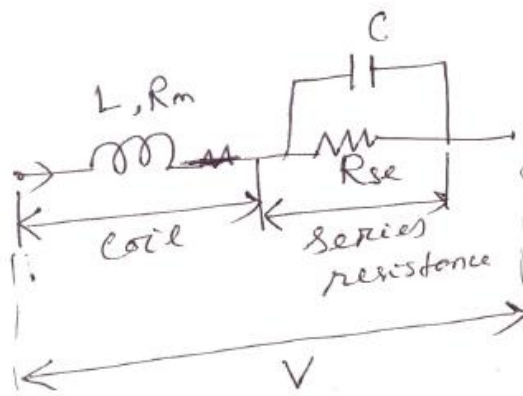


Fig. 1.18

Deflection of moving iron voltmeter depends upon the current through the coil. Therefore, deflection for a given voltage will be less at higher frequency than at low frequency. A capacitor is connected in parallel with multiplier resistance. The net reactance, $(X_L - X_C)$ is very small, when compared to the series resistance. Thus the circuit impedance is made independent of frequency. This is because of the circuit is almost resistive.

$$C = 0.41 \frac{L}{(R_S)^2} \quad (1.72)$$

1.13 Electrostatic instrument

In multi cellular construction several vanes and quadrants are provided. The voltage to be measured is applied between the vanes and quadrant. The force of attraction between the vanes and quadrant produces a deflecting torque. Controlling torque is produced by spring control. Air friction damping is used. The instrument is generally used for measuring medium and high voltage. The voltage is reduced to low value by using capacitor potential divider. The force of attraction is proportional to the square of the voltage.

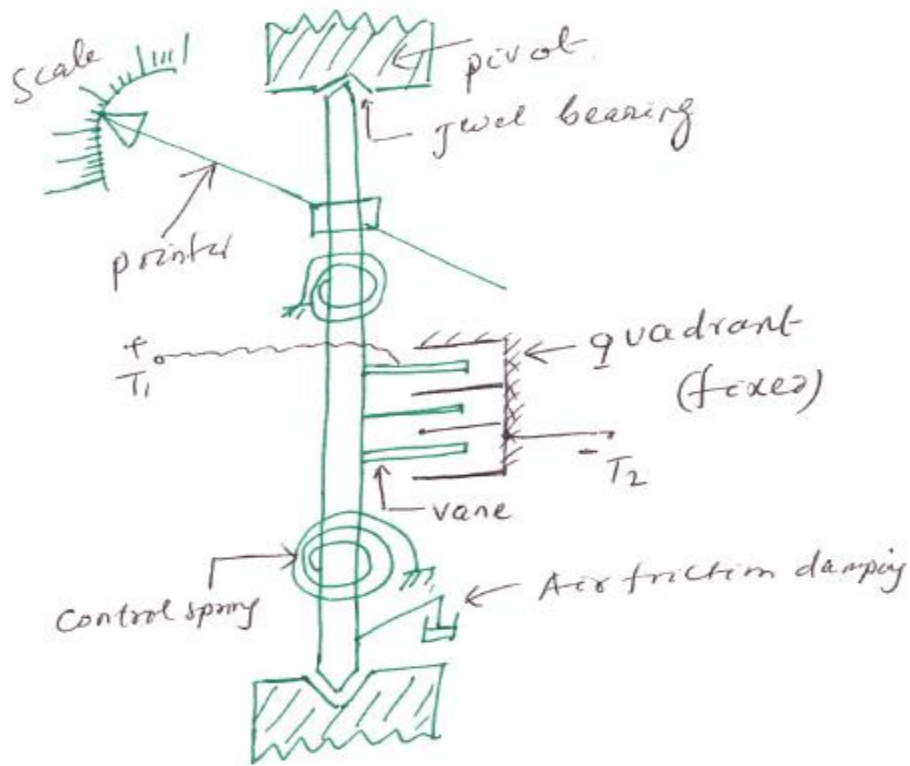


Fig. 1.19

Torque develop by electrostatic instrument

V=Voltage applied between vane and quadrant

C=capacitance between vane and quadrant

$$\text{Energy stored} = \frac{1}{2} CV^2 \quad (1.73)$$

Let 'θ' be the deflection corresponding to a voltage V.

Let the voltage increases by dv, the corresponding deflection is 'θ + dθ'

When the voltage is being increased, a capacitive current flows

$$i = \frac{dq}{dt} = \frac{d(CV)}{dt} = \frac{dC}{dt} V + C \frac{dV}{dt} \quad (1.74)$$

V × dt multiply on both side of equation (1.74)

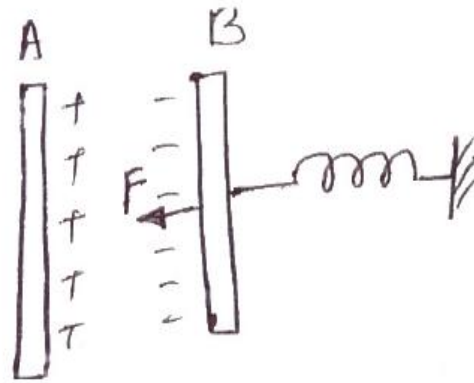


Fig. 1.20

$$Vidt = \frac{dC}{dt} V^2 dt + CV \frac{dV}{dt} dt \quad (1.75)$$

$$Vidt = V^2 dC + CVdV \quad (1.76)$$

$$\text{Change in stored energy} = \frac{1}{2} (C + dC) (V + dV)^2 - \frac{1}{2} CV^2 \quad (1.77)$$

At steady state condition, $T_d = T_C$

$$K\theta = \frac{1}{2}V^2 \left(\frac{dC}{d\theta} \right) \quad (1.81)$$

$$\theta = \frac{1}{2K}V^2 \left(\frac{dC}{d\theta} \right) \quad (1.82)$$

$$\begin{aligned} &= \frac{1}{2}[(C + dC)V^2 + dV^2 + 2VdV] - \frac{1}{2}CV^2 \\ &= \frac{1}{2}[CV^2 + CdV^2 + 2CVdV + V^2dC + dCdV^2 + 2VdVdC] - \frac{1}{2}CV^2 \\ &= \frac{1}{2}V^2dC + CVdV \\ V^2dC + CVdV &= \frac{1}{2}V^2dC + CVdV + F \times r d\theta \end{aligned} \quad (1.78)$$

$$T_d \times d\theta = \frac{1}{2}V^2dC \quad (1.79)$$

$$T_d = \frac{1}{2}V^2 \left(\frac{dC}{d\theta} \right) \quad (1.80)$$

Advantages

- ✓ It is used in both AC and DC.
- ✓ There is no frequency error.
- ✓ There is no hysteresis error.
- ✓ There is no stray magnetic field error. Because the instrument works on electrostatic principle.

Disadvantages

- ✓ Scale is not uniform
- ✓ Large in size
- ✓ Cost is more

1.14 Multi range Ammeter

When the switch is connected to position (1), the supplied current I1

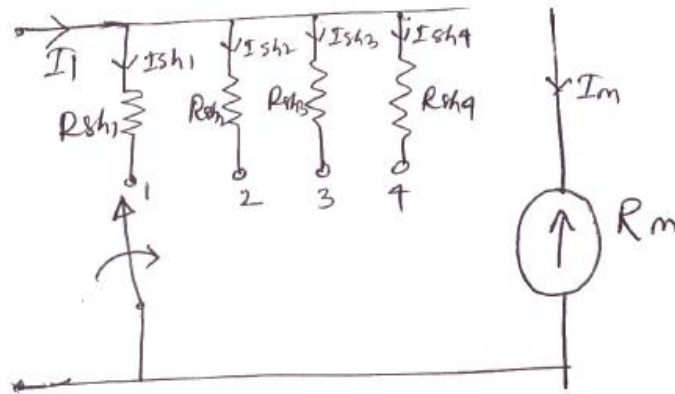


Fig. 1.21

$$I_{sh1}R_{sh1} = I_m R_m \quad (1.83)$$

$$R_{sh1} = \frac{I_m R_m}{I_{sh1}} = \frac{I_m R_m}{I_1 - I_m} \quad (1.84)$$

$$R_{sh1} = \frac{R_m}{\frac{I_1}{I_m} - 1}, R_{sh1} = \frac{R_m}{m_1 - 1}, m_1 = \frac{I_1}{I_m} = \text{Multiplying power of shunt}$$

$$R_{sh2} = \frac{R_m}{m_2 - 1}, m_2 = \frac{I_2}{I_m} \quad (1.85)$$

$$R_{sh3} = \frac{R_m}{m_3 - 1}, m_3 = \frac{I_3}{I_m} \quad (1.86)$$

$$R_{sh4} = \frac{R_m}{m_4 - 1}, m_4 = \frac{I_4}{I_m} \quad (1.87)$$

1.16 Multi range D.C. voltmeter

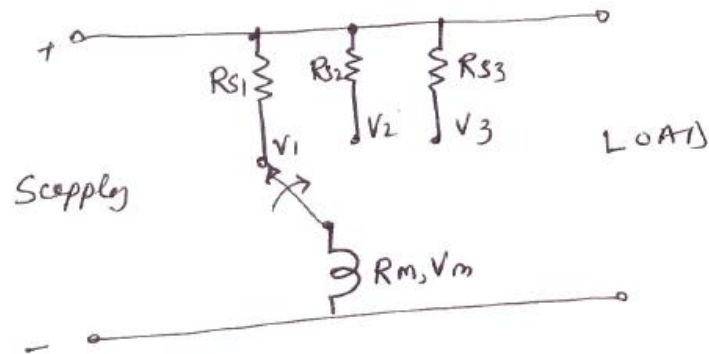


Fig. 1.23

$$\begin{aligned} R_{s1} &= R_m(m_1 - 1) \\ R_{s2} &= R_m(m_2 - 1) \\ R_{s3} &= R_m(m_3 - 1) \end{aligned} \quad (1.92)$$

$$m_1 = \frac{V_1}{V_m}, m_2 = \frac{V_2}{V_m}, m_3 = \frac{V_3}{V_m} \quad (1.93)$$

We can obtain different Voltage ranges by connecting different value of multiplier resistor in series with the meter. The number of these resistors is equal to the number of ranges required.