SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME : 23EET206 CONTROL SYSTEMS AND INSTRUMENTATION

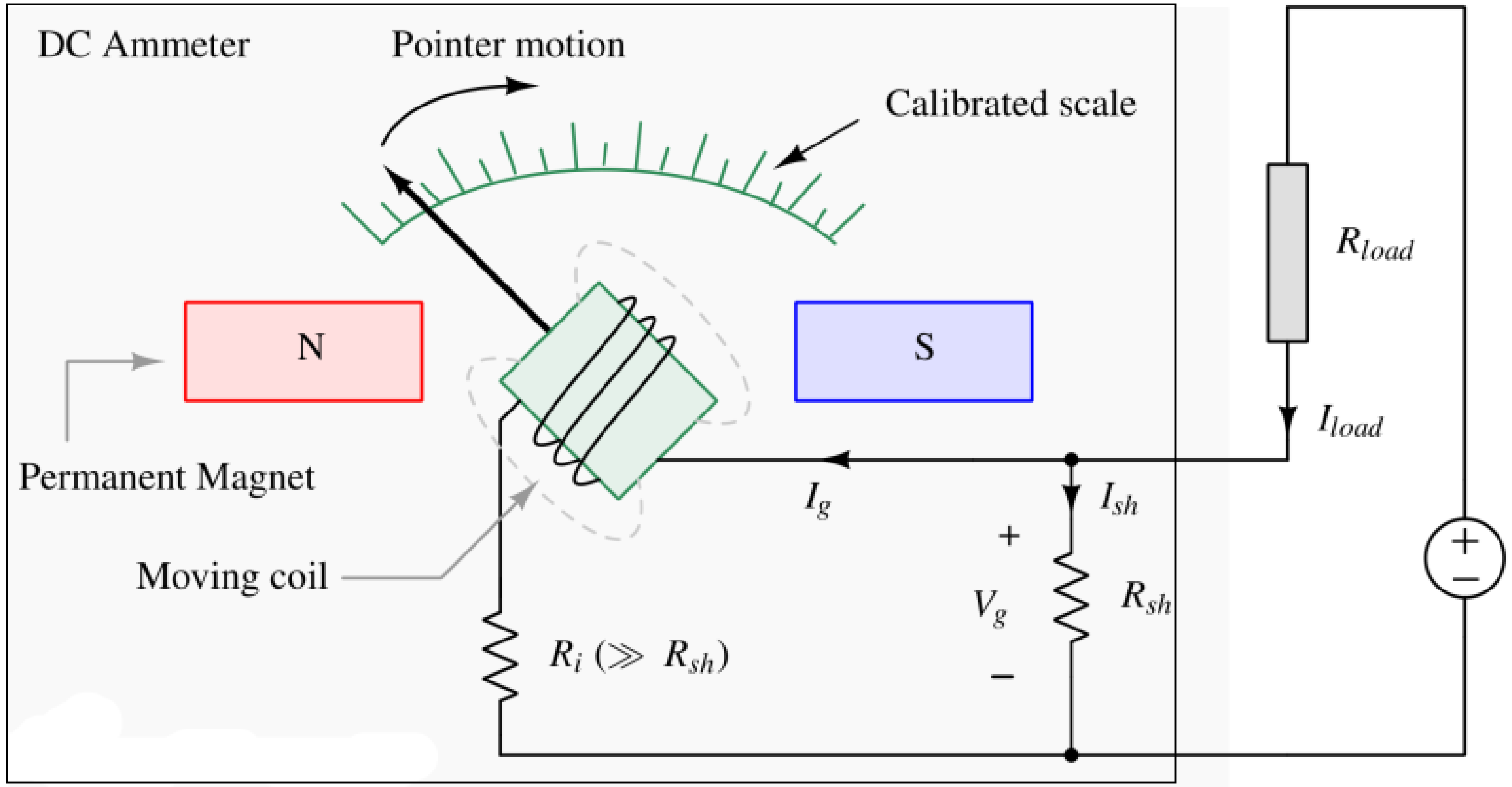
II YEAR ECE /III SEMESTER

Unit 4- Electronic Instruments & Transducers

Topic 2 : Ammeter

AMMETER

- An ammeter is defined as a device that measures the electric current in a circuit in amperes.
- Ammeters must have low resistance and inductive reactance to minimize voltage drop and power loss, and they are connected in series to measure current accurately.



AMMETER

1. R_i = Internal resistance of an ammeter/galvanometer.

2. R_{sh} = Shunt resistance; this will carry the majority of the current.

3. V_g = Voltage across the R_{sh}

4. I_g = Galvanometer current

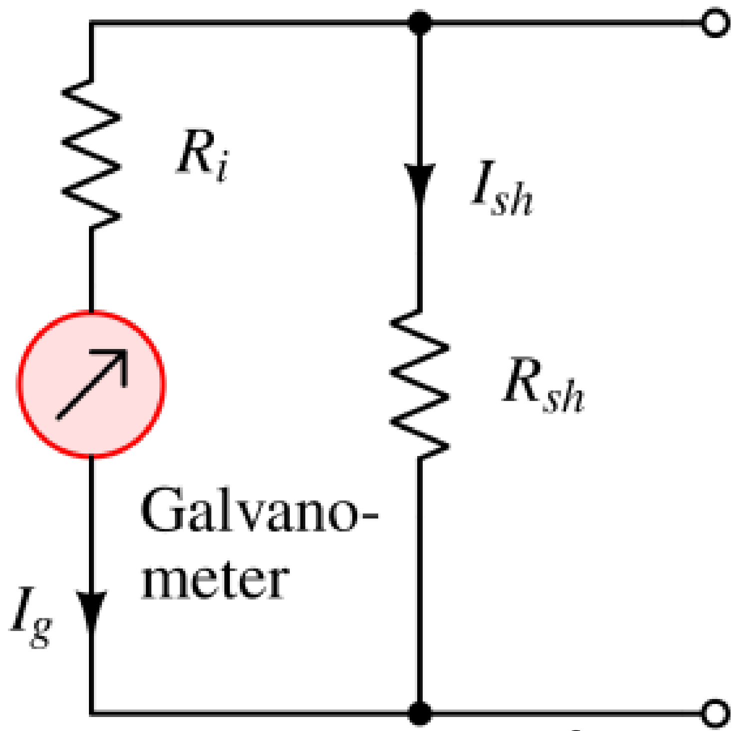
5. $I_{load} = I_{sh} + I_g$

The instrument will sense the voltage (because its own impedance is high, R_i). Let's derive the circuit current from know parameters. Unknown is I_{load}. We know Vg, R_i, R_{sh}.

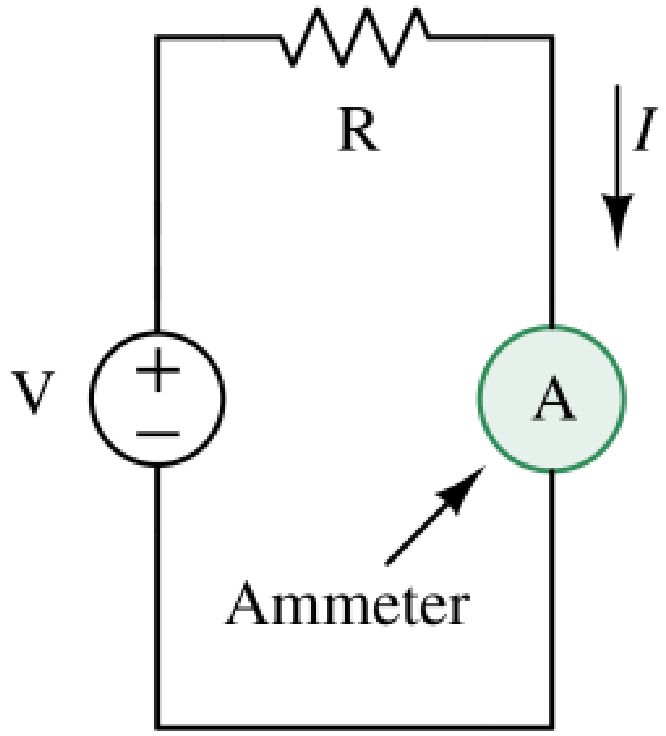
AMMETER

$$I_{sh} = \frac{V_g}{R_{sh}}$$

$$I_{load} = I_{sh} + I_g = \frac{V_g}{R_{sh}} + \frac{V_g}{R_i}$$



Circuit representation of ammeter



The working **principle of an ammeter** is that it must have very low resistance and inductive reactance. This low impedance is essential to minimize voltage drop and power loss.

AMMETER CONNECTION

- Ammeters are connected in series because the current remains the same in a series circuit, ensuring accurate measurements.
- Because of its low impedance, the power loss in an ammeter is minimal. Connecting it in parallel would create a short circuit, causing all the current to flow through the ammeter, which could burn out the instrument. Therefore, ammeters must be connected in series.

DC AMMETER

Principle

When current carrying conductor placed in a magnetic field, a mechanical force acts on the conductor, if it is attached to a moving system, with the coil movement, the pointer moves over the scale.

EXPLANATION

As the name suggests it has permanent magnets which are employed in this kind of measuring instruments. It is particularly suited for DC measurement because here deflection is proportional to the current and hence if current direction is reversed, deflection of the pointer will also be reversed so it is used only for DC measurement. This type of instrument is called D Arnsonval type instrument. It has major advantage of having linear scale, low power consumption, high accuracy. Major disadvantage of being measured only DC quantity, higher cost etc.

AMMETER

Deflecting torque,

$$T = BiNlbNm$$

Where,

B = Flux density in Wb/m^2.

i = Current flowing through the coil in Amp.

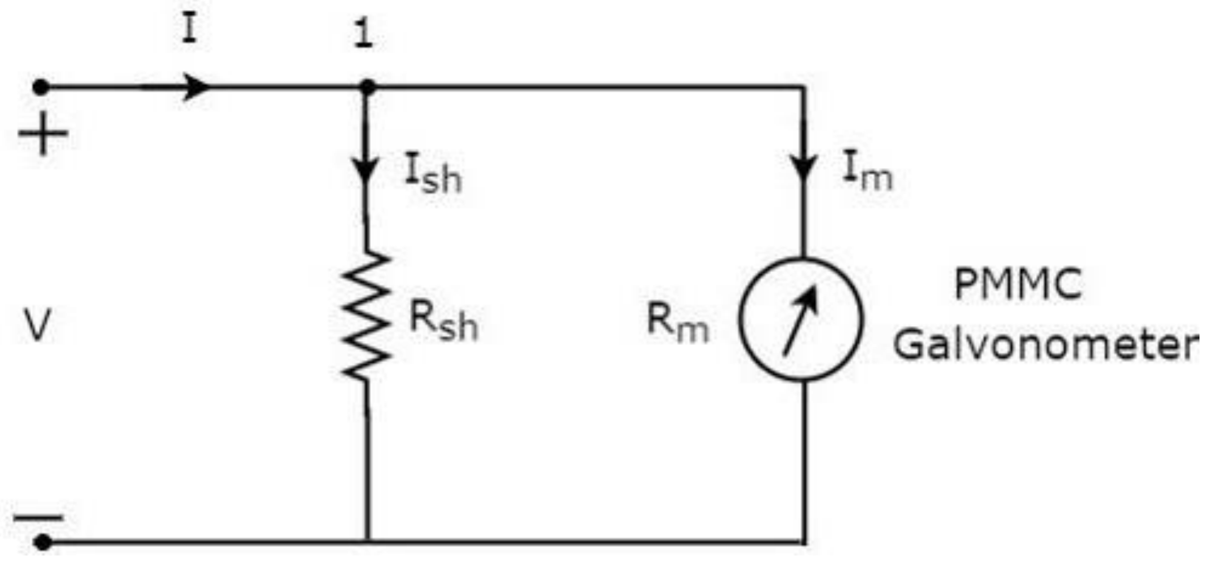
l = Length of the coil in m.

b = Breadth of the coil in m.

N = No of turns in the coil.

AMMETER

DC ammeter is connected in series with the branch of an electric circuit, where the DC current is to be measured. The voltage across the elements, which are connected in parallel is same. So, the voltage across shunt resistor, RshRsh and the voltage across galvanometer resistance, RmRm is same, since those two elements are connected in parallel in above circuit. **Mathematically**, it can be written as



AMMETER

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

$$\Rightarrow R_{sh} = \frac{I_m R_m}{I_{sh}} \qquad \text{(Equation 1)}$$

The **KCL equation** at node 1 is

$$-I + I_{sh} + I_m = 0$$

$$\Rightarrow I_{sh} = I - I_m$$

Substitute the value of I_{sh} in Equation 1.

$$R_{sh} = \frac{I_m R_m}{I - I_m} \qquad \text{(Equation 2)}$$

Take, I_m as common in the denominator term, which is present in the right hand side of Equation 2

$$R_{sh} = \frac{I_m R_m}{I_m(\frac{1}{I_m} - 1)}$$

$$\Rightarrow R_{sh} = \frac{R_m}{\frac{I}{I_m} - 1} \qquad \text{(Equation 3)}$$

AMMETER

Take, I_m as common in the denominator term, which is present in the right hand side of Equation 2

$$R_{sh} = \frac{I_m R_m}{I_m(\frac{1}{I_m} - 1)}$$

$$\Rightarrow R_{sh} = \frac{R_m}{\frac{I}{I_m} - 1} \qquad \text{(Equation 3)}$$

Where,

R_{sh} is the shunt resistance

R_m is the internal resistance of galvanometer

I is the total Direct Current that is to be measured

I_m is the full scale deflection current

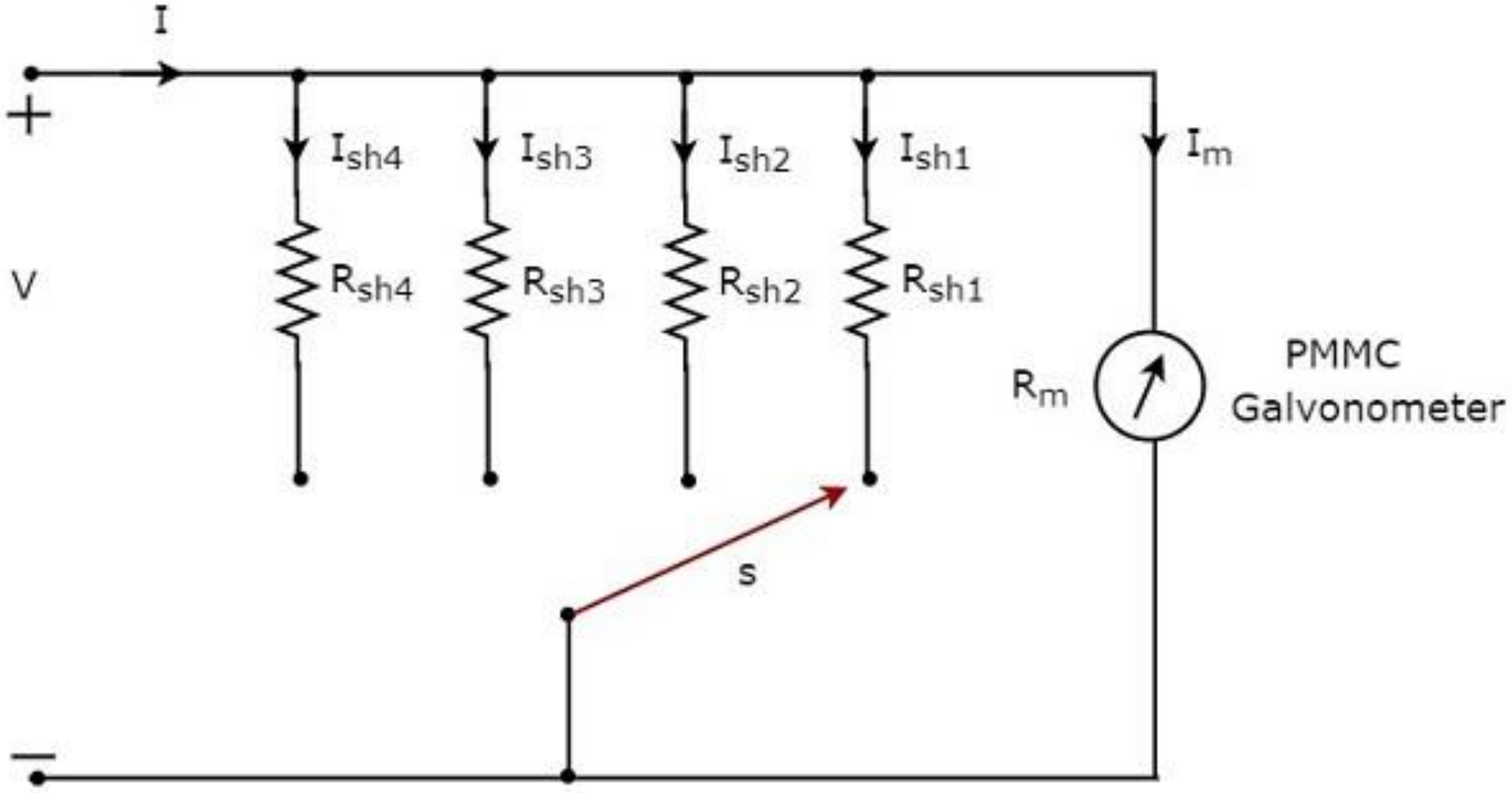
The ratio of total Direct Current that is to be measured, I and the full scale deflection current of the galvanometer, I_m is known as **multiplying factor, m**. Mathematically, it can be represented as

$$m = \frac{I}{I_m} \qquad \text{(Equation 4)}$$

$$R_{sh} = \frac{R_m}{m-1} \qquad \text{(Equation 5)}$$

We can find the **value of shunt resistance** by using either Equation 2 or Equation 5 based on the available data.

MULTIRANGE AMMETER



If the DC ammeter is used for measuring the Direct Currents of **multiple ranges**, then we have to use multiple parallel resistors instead of single resistor and this entire combination of resistors is in parallel to the PMMC galvanometer.

MULTIRANGE AMMETER

Let, m_1, m_2, m_3 and m_4 are the **multiplying factors** of DC ammeter when we consider the total Direct Currents to be measured as, I_1, I_2, I_3 and I_4 respectively. Following are the formulae corresponding to each multiplying factor.

$$m_1 = \frac{I_1}{I_m}$$

$$m_2 = \frac{I_2}{I_m}$$

$$m_3 = \frac{I_3}{I_m}$$

$$m_4 = \frac{I_4}{I_m}$$

In above circuit, there are four **shunt resistors**, $R_{sh1}, R_{sh2}, R_{sh2}$ and R_{sh4}. Following are the formulae corresponding to these four resistors.

$$R_{sh1} = \frac{R_m}{m_1 - 1}$$

$$R_{sh2} = \frac{R_m}{m_2 - 1}$$

$$R_{sh3} = \frac{R_m}{m_3 - 1}$$

$$R_{sh4} = \frac{R_m}{m_4 - 1}$$

References

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2. Sawhney A K., "Course in Electrical, Electronic Measurements and Instrumentation", Shree Hari Publications, 2021(Unit IV-V).
3. Patranabis D, "Principles of Industrial Instrumentation", Mc-Graw Hill Education, 3rd Edition, 2017 (Unit IV-V).

Thank You