Lecture-7

Series Type Ohmmeter

7.1 Introduction

Ohmmeters are essential tools in the field of electrical and electronics engineering, used to measure the resistance of electrical components or circuits. They operate on the principle of Ohm's law, which states that resistance is the ratio of voltage to current. Over time, various types of ohmmeters have been developed to suit different applications and measurement requirements.

Resistance measurement is crucial for troubleshooting, testing, and ensuring the proper functioning of electrical and electronic systems. Modern ohmmeters are often integrated into multimeters, which combine the functionality of a voltmeter, ammeter and ohmmeter in a single device.

7.2 Classification of Ohmmeters

Ohmmeters can be broadly categorized into the following types based on their construction and application:

1. Series Ohmmeter
2. Shunt Ohmmeter
3. Digital Ohmmeter
4. Analog Ohmmeter
5. Megohmmeter
6. Micro-ohmmeter
7. Milli-ohmmeter

In this lecture, the series type ohmmeter will be studied in detailed.

7.3 Series Type Ohmmeter

This type is the commonly used in the practical and industrial fields. It is used to measure the resistance of heaters, motors coils, fuses, connections of electrical circuits and to check the short and open circuits.

The connection of a simple single range series type ohmmeter is shown in Figure 7.1.

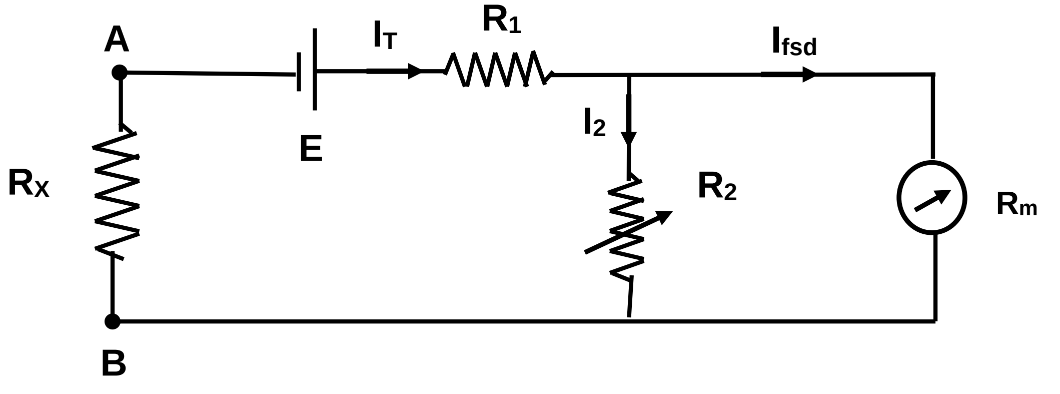


Figure 7.1 Single range series type ohmmeter

Where,

R_1 = is a current limiting resistance.

R_2 = is a zero setting resistance.

R_m = is the internal resistance of the moving-coil.

R_X = is the resistance to be measured.

E = is a battery.

When $R_X = 0$, the terminals A and B will be short circuited and R_2 is adjusted to give full-scale deflection (FSD) current. When the terminals A and B are disconnected i.e. ($R_X = \infty$), the current will be zero and the pointer indicates infinity as shown in Figure 7.2:

Figure 7.2 The arrangement of the scale of series type ohmmeter

The convenient quantity to use in the design of the series type ohmmeter is the value of R_X which causes half-scale deflection of the meter.

When $R_X = R_h$,

I_T will be I_h and

I_{FSD} will be 1/2 I_{FSD}

Therefore, the circuit diagram of the series type ohmmeter will be as shown in Figure7.3:

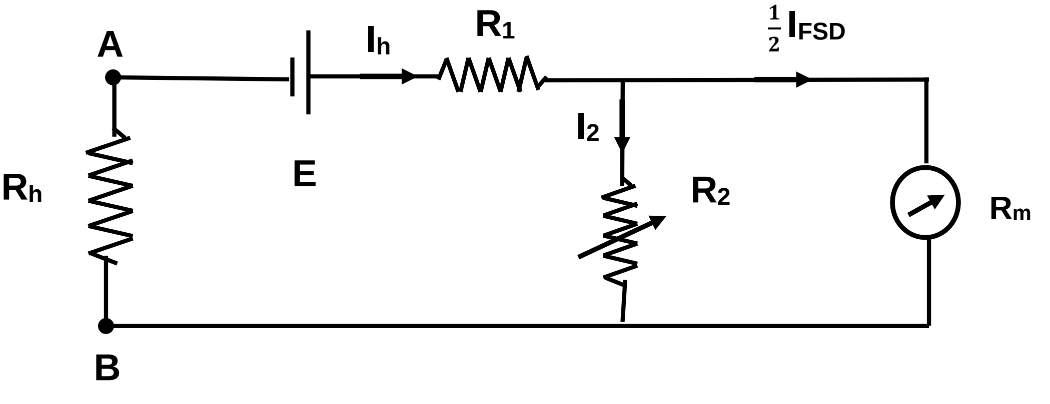


Figure 7.3 Series type ohmmeter with half scale

The scale of ohmmeter will be reduced to half when $R_x = R_h$, in this case

$$R_h = R_1 + \frac{R_2 R_m}{R_2 + R_m}$$

And

$$I_h = \frac{E}{R_h + R_1 + \frac{R_2 R_m}{R_2 + R_m}}$$

Or

$$I_h = \frac{E}{R_h + R_h}$$

Or,

$$I_h = \frac{E}{2R_h}$$

The voltage across the shunt resistance R_2 is equal to the voltage across the moving coil resistance R_m, i.e:

$$V_2 = V_m$$

Therefore,

$$I_2 \, R_2 = \frac{1}{2} \, I_{FSD} \, R_m$$

From which,

$$R_2 = \frac{\frac{1}{2} I_{FSD} R_m}{I_2}$$

But,

$$I_2 = I_h - \frac{1}{2} \, I_{FSD}$$

Therefore,

$$\boldsymbol{R_2 = \frac{\frac{1}{2} I_{FSD} R_m}{I_h - \frac{1}{2}\, I_{FSD}}}$$

But,

$$\boldsymbol{I_h = \frac{E}{2R_h}}$$

Therefore,

$$\boldsymbol{R_2 = \frac{\frac{1}{2} I_{FSD} R_m}{\frac{E}{2R_h} - \frac{1}{2}\, I_{FSD}}}$$

In this case,

$$\boxed{\boldsymbol{R_2 = \frac{I_{FSD} R_m R_h}{E - I_{FSD} R_h}}}$$

Now, we have that:

$$\boldsymbol{R_1 = R_h - \frac{R_2 R_m}{R_2 + R_m}}$$

By Substituting the value of R_2 into the above equation, we get:

$$\boldsymbol{R_1 = R_h - \frac{\frac{I_{FSD} R_m R_h}{E - I_{FSD} R_h} R_m}{\frac{I_{FSD} R_m R_h}{E - I_{FSD} R_h} + R_m}}$$

With some arrangements, we get:

$$\boxed{\boldsymbol{R_1 = R_h - \frac{I_{FSD} R_m R_h}{E}}}$$

The main problem in the ohmmeter method is the internal battery E which is dropped with time so that the instrument does not read zero resistance when the terminal A and B are short circuited. Therefore, the pointer is bring to zero point by setting the resistance R_2.

Features of Series Type Ohmmeters

- **Simple Construction**: It consists of a battery, meter movement, and resistors.
- **Range Limitation**: It is most effective for measuring medium resistance values.
- **Scale Nonlinearity**: The scale is nonlinear because the current decreases as resistance increases.

Applications of Series Type Ohmmeters

- Troubleshooting simple circuits.
- Testing resistors and other components in educational labs.

Examples – L7

Ex7.1 A series-type ohmmeter has a moving-coil of 50 Ω internal resistance with a FSD current of 1 mA and a battery of 3V. If a resistance of 2 KΩ is used to give half-scale deflection, calculate:

(a) The zero setting resistance.
(b) The current limiting resistance.
(c) The value of the zero setting resistance that is required to compensate for 10% drop of the battery voltage.
(d) The half-scale mark error when the battery voltage is dropped by 10%.
(e) Sketch the electric circuit diagram of the designed instrument.
(f) For what class of resistance measurement this instrument is suitable.

Sol. **(a)**

$$R_2 = \frac{I_{FSD} R_m R_h}{E - I_{FSD} R_h}$$

Or

$$R_2 = \frac{1 \times 10^{-3} \times 50 \times 2 \times 10^3}{3 - 1 \times 10^{-3} \times 2 \times 10^3}$$

Therefore,

$$R_2 = 100\ \Omega$$

(b)

$$R_1 = R_h - \frac{I_{FSD} R_m R_h}{E}$$

Or

$$R_1 = 2000 - \frac{1 \times 10^{-3} \times 50 \times 2 \times 10^3}{3}$$

$$R_1 = 1966.67\ \Omega$$

(c)

$$10\ \%\ of\ the\ battery\ voltage = \frac{10}{100} \times 3 = 0.3\ V$$

Therefore,

$$The\ battery\ volage\ \ becomes\ \ 3 - 0.3 = 2.7\ V$$

In this case, the value of the zero setting resistance will be:

$$R_2 = \frac{I_{FSD} R_m R_h}{E - I_{FSD} R_h}$$

Or,

$$R_2 = \frac{1 \times 10^{-3} \times 50 \times 2 \times 10^3}{2.7 - 1 \times 10^{-3} \times 2 \times 10^3}$$

Therefore,

$$R_2 = 142.86\ \Omega$$

(d)

The resistance that makes half scale is R_h, where,

$$R_h = R_1 + \frac{R_2 R_m}{R_2 + R_m}$$

But R_2=142.86 Ω for 10% drop of the battery voltage.
Therefore,

$$R_h = 1966.67 + \frac{142.86 \times 50}{142.86 + 50}$$

Or

$$R_h = 2003.7\ \Omega$$

Therefore,

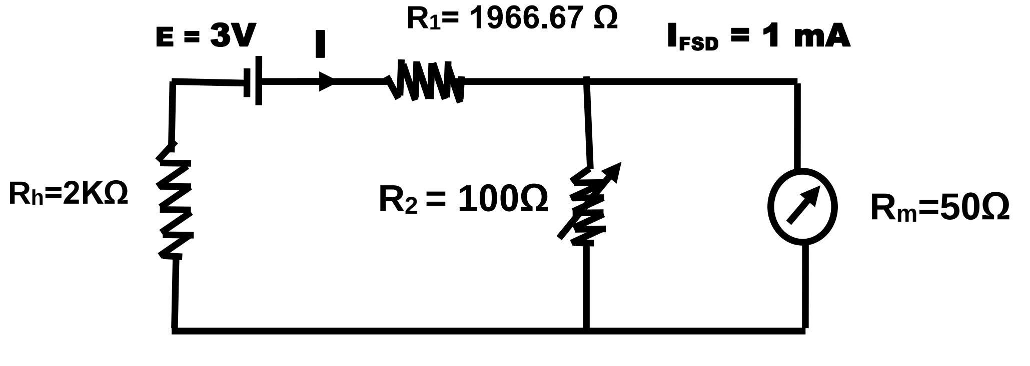
$$The\ scale\ error = \frac{|2000 - 2003.7|}{2000} \times 100\ \%$$

Or,

$$The\ scale\ error = 0.185\ \%$$

(e)

The circuit diagram of the designed instrument will be as shown in figure below:



(f)

This instrument is suitable for measurement of medium resistance.