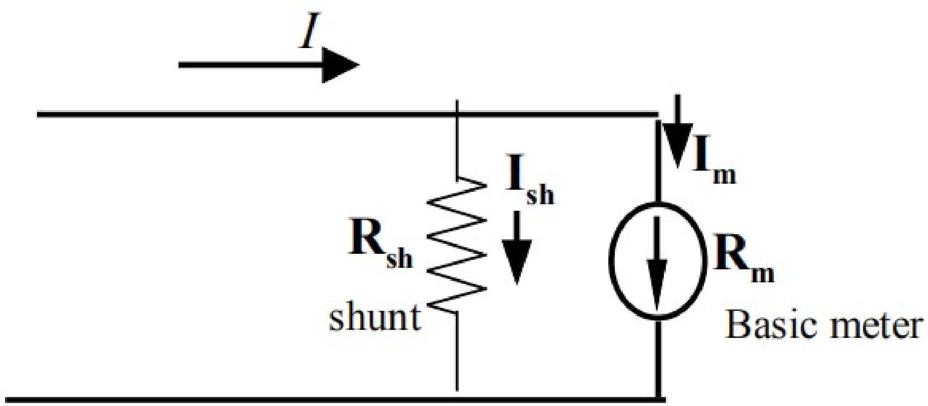
Extension range of Voltmeter and Ammeter

Extension of meter range: ***Ammeter shunts***



Shunt is a very low resistance connected across the basic meter.

R_m = internal resistance of the basic meter.

R_{sh} = Resistance of the shunt

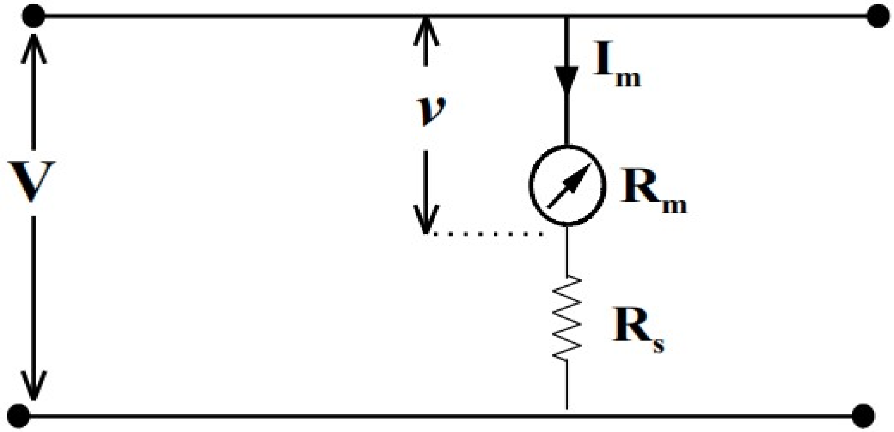
I_m = full scale deflection of basic meter.

I = Current to be measured.

$$(I - I_m)R_{sh} = I_m R_m$$

$$\mathbf{R_{sh} = \frac{I_m R_m}{I - I_m}}$$

Extension of meter range: *Voltmeter multipliers*



Multiplier is a very high resistance in series with the basic meter.

R_m = internal resistance of the basic meter.

R_s = Resistance of the multiplier.

I_m = full scale deflection of basic meter.

v= Voltage across the meter for current I_m

V = Full range voltage of instrument.

$$\mathbf{R_s = \frac{V - I_m R_m}{I_m}}$$

Example 1:- A moving coil ammeter has a full scale deflection of 50 μ Amp and a coil resistance of 1000 Ω. What will be the value of the shunt resistance required for the instrument to be converted to read a full scale reading of 1 Amp.

Solution 1:- Full scale deflection current $I_m = 50*10^{-6}\ A$

Instrument resistance $R_m = 1000\ \Omega$

Total current to be measured $I = 1\ A$

Resistance of ammeter shunt required $R_{sh} = \dfrac{R_m}{\dfrac{I}{I_m} - 1} = \dfrac{1000}{\dfrac{1}{50*10^{-6}} - 1}$

Example 2:- The full scale deflection current of an ammeter is 1 mA and its internal resistance is 100 Ω. If this meter is to have scale deflection at 5 A, what is the value of shunt resistance to be used.

Solution 2:- Full scale deflection current $I_m = 1\ mA = 0.001\ A$

Instrument resistance $R_m = 100\ \Omega$.

Total current to be measured $I = 5\ A$

Resistance of ammeter shunt required $R_{sh} = \dfrac{R_m}{\dfrac{I}{I_m} - 1} = \dfrac{100}{\dfrac{5}{0.01} - 1}$

$$R_{sh} = 0.020004\ \Omega$$

Example 3:- The full scale deflection current of a meter is 1 mA and its internal resistance is 100 Ω. If this meter is to have full-scale deflection when 100 V is measured. What should be the value of series resistance?

Solution 3:- Instrument resistance $R_m = 100\ \Omega$

Full-scale deflection current $I_m = 1\ mA = 1*10^{-3}\ A$

Voltage to be measured $V = 100\ V$

Required series resistance $R_{se} = \dfrac{V}{I_m} - R_m = \dfrac{100}{1*10^{-3}} - 100 = 99{,}900\ \Omega$

Example 4:- A PMMC instrument gives full scale reading of 25 mA when a potential difference across its terminals is 75 mV. Show how it can be used (a) as an ammeter for the range of 0-100 A (b) as a voltmeter for the range of 0-750 V. Also find the multiplying factor of shunt and voltage amplification.

<u>Solution 4:-</u>

Instrument resistance $R_m = \frac{Potential\ drop\ across\ ter\min als}{Instrument\ current} = \frac{75*10^{-3}}{25*10^{-3}} = 3\,\Omega$

(a) Current to be measured $I = 100\ A$

Multiplying power of shunt $m = \frac{I}{I_m} = \frac{100}{25*10^{-3}} = 4000$

Shunt resistance required for full scale deflection at 100 A

$$R_{sh} = \frac{R_m}{m-1} = \frac{3}{4000-1} = \frac{3}{3999} = 7.50*10^{-4} = 0.75\ m\Omega$$

(b) Voltage to be measured $V = 750\ V$

$$R_{se} = \frac{V}{I_m} - R_m = \frac{750}{25*10^{-3}} - 3 = 29{,}997\ \Omega$$

Voltage amplification $= \frac{750}{75*10^{-3}} = 10000$ Ans.

Example 5:- A moving coil instrument gives full scale deflection of 10 mA and potential difference across its terminals is 100 mV. Calculate (a) shunt resistance for full-scale deflection corresponding to 200 A (b) Series resistance for full reading corresponding to 1000 V.

Solution 5:-

Instrument resistance $R_m = \dfrac{Potential\ drop\ across\ terminals}{Instrument\ current} = \dfrac{100*10^{-3}}{10*10^{-3}} = 10\Omega$

(a) Shunt resistance required for full scale deflection corresponding to 200 A

$$R_{sh} = \frac{R_m}{\dfrac{I}{I_m} - 1} = \frac{10}{\dfrac{200}{10*10^{-3}} - 1} = 5.00025*10^{-4}\Omega$$

(b) Series resistance required for full scale deflection corresponding to 1000 V

$$R_{se} = \frac{V}{I_m} - R_m = \frac{1000}{10*10^{-3}} - 10 = 99,990\ \Omega$$