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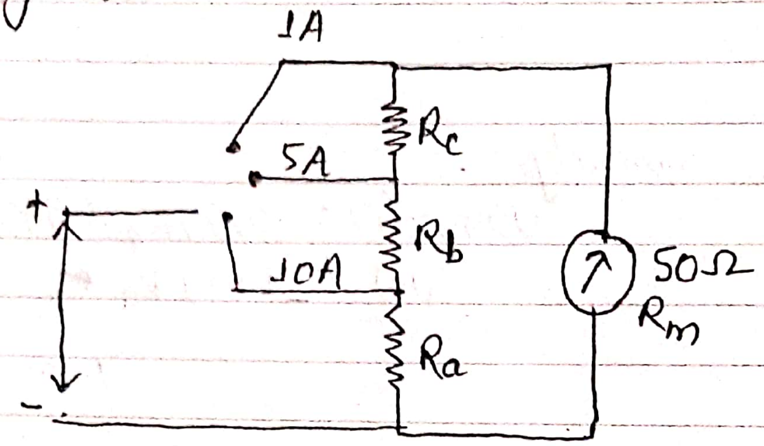
(4) Design an Ayrton shunt to provide an ammeter with current ranges of 1A, 5A and 10A. A D'Arsonval movement with an internal resistance $R_m = 50\Omega$ and full scale deflection current of 1mA is used in the configuration.



⇒ On the 1A range:

$R_a+R_b+R_c$ are in parallel with 50Ω movement. Since the coil requires 1mA for full scale deflection, the shunt will be required to pass a current of 1A − 1mA = 999mA.

So,
$$(R_a+R_b+R_c)\times 999 = 50\times 1$$
$$\therefore R_a+R_b+R_c = \frac{50}{999} = 0.05005\,\Omega \quad \text{——— (I)}$$

On the 5A range:

R_a+R_b are in parallel with $R_c+50\Omega$. In this case 1mA current flows thru (R_c+R_m) and 4999mA flows thru R_a+R_b. So,
$$(R_a+R_b)\,4999 = (R_c+50)\,1$$
$$\therefore R_a+R_b = \frac{R_c+50}{4999} \quad \text{——— (II)}$$

On the 10A range,

R_a is in parallel with $R_b+R_c+R_m$. In this case 1mA flows thru $(R_b+R_c+R_m)$ & 9999mA flows thru R_a. So
$$R_a\times 9999 = (R_b+R_c+R_m)\times 1$$
$$\therefore R_a\,\cancel{\times 999} = \frac{R_b+R_c+R_m}{9999} \quad \text{——— (III)}$$

Solving these three simultaneous eqn (I), (II) & (III), we get,

$$4999 \times (i) : 4999R_a + 4999R_b + 4999R_c = 250.2$$

$$(ii) : 4999R_a + 4999R_b - R_c = 50$$

$$5000R_c = 200$$

$$\therefore R_c = 0.04004\,\Omega$$

Similarly,

$$9999 \times (i) : 9999R_a + 9999R_b + 9999R_c = 500.45$$

$$(iii) : 9999R_a + R_b - R_c = 50$$

$$10{,}000R_b + 10{,}000R_c = 450.45$$

$$\text{or, } 10{,}000R_b + 10{,}000 \times 0.04004 = 450.45$$

$$\therefore R_b = 0.005005\,\Omega$$

$$\& \; R_a = 0.005005$$

The calculation indecates that for larger currents, the value of shunt resistors become very small.