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Electronic Circuit Analysis

Electrical Control Systems (ACHA4010)

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a. Calculate the resistance of E and H for the circuit's configuration. [3]

E has a 0.6V potential barrier.

H has a 0.7V potential barrier.

The current will pass through E as it has a lower potential barrier and therefore it is the path of least resistance, meaning the diode H is negligible.

$$V_E = 0.6V$$

$$I = 1A$$

$$V = I.R$$

$$R = \frac{V}{I}$$

$$R_E = \frac{V_E}{I} = \frac{0.6}{1} = 0.6\Omega$$

b. B and C are identical and the current passing through A is 0.5A, calculate the current passing through B and C. [2]

$$I = 1A$$

$$I_A = 0.5A$$

$$I_B = I_C$$

$$I = I_A + I_B + I_C$$

$$I - I_A = I_B + I_C$$

As I_B and I_C are equal, calculate using a common term then divide by 2.

$$I_{BC} = I - I_A$$

$$I_{BC} = 1 - 0.5 = 0.5A$$

$$\frac{0.5}{2} = 0.25A$$

$$I_B = 0.25A$$

$$I_C = 0.25A$$

c. (i) The Resistance of A. [2]

R_A dissipates 1.25 Joules of energy every second.

$$1 \text{ J/s} = 1 \text{ Watts}$$

Therefore, $P_A = 1.25 \text{ Watts}$

$$I_A = 0.5 \text{ A}$$

$$P = I.V \quad V = I.R$$

$$P = I.(I.R) = I^2.R$$

$$P = I^2.R$$

$$R = \frac{P}{I^2}$$

$$R_A = \frac{1.25}{0.5^2} = 5\Omega$$

c. (ii) The Resistance of B and C [3]

$$R_B = R_C$$

$$I_B = I_C = 0.25 \text{ A}$$

$$V = I.R$$

$$V_A = I_A \times R_A$$

$$V_A = 0.5 \times 5 = 2.5 \text{ V}$$

$$V_A = V_B = V_C$$

$$R = \frac{V}{I}$$

$$R_{B/C} = \frac{V_A}{I_{BC}} = \frac{2.5}{0.25} = 10\Omega$$

$$R_B = 10\Omega$$

$$R_C = 10\Omega$$

c. (iii) The potential difference across A, B and C [1]

$$R_{ABC} = \frac{1}{\frac{1}{5} + \frac{1}{10} + \frac{1}{10}} = 2.5\Omega$$

$$V_{ABC} = I \times R_{ABC}$$

$$V_{ABC} = 1 \times 2.5$$

$$V_{ABC} = 2.5V$$

c. (iv) Since the total potential difference across L to M is 6V, calculate the potential difference across D and find its Resistance. [2]

$$V_{LM} = 6V$$

KVL :

$$V_{LM} = V_{ABC} + V_E + V_D$$

$$V_D = V_{LM} - V_{ABC} - V_E$$

$$V_D = 6 - 2.5 - 0.6$$

$$V_D = 2.9V$$

$$R_D = \frac{V_D}{I} = \frac{2.9}{1}$$

$$R_D = 2.9\Omega$$

d. The 'lost volts across one of the cells in the parallel arrangement is 2 V. Calculate r and hence the total resistance of the parallel combination of cells. [3]

$V_{cell} = 2V \rightarrow$ The voltage is the same for each cell in parallel.

$$I_{cell} = \frac{I}{N^{\circ} \text{ of cells}} = \frac{1}{4} = 0.25A$$

$$R_r = \frac{V_{cell}}{I_{cell}}$$

$$R_r = \frac{2}{0.25}$$

$$R_r = 8\Omega$$

Calculate the resistance of the resistors r as they are in parallel,

$$R_r = \frac{1}{\frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8}} = 0.5\Omega$$

$$R_{cell} = R_r \times \text{number of cells}$$

$$R_{cell} = 0.5 \times 4 = 2\Omega$$

e. Given that the resistance F is 6Ω , calculate the voltage drop across it. [2]

Diode G being in reverse bias indicates that no current flows through it.

$$R_F = 6\Omega$$

$$V_F = I \times R_F$$

$$V_F = 1 \times 6 = 6V$$

f. Calculate the total resistance of the circuit, this includes total internal and the resistance cause by the reverse polarity battery and the open diodes in given scenario (ignore any “non-open diodes”). [2]

The 6V cell is connected in reverse polarity meaning that it acts as a resistance of 6Ω .

$$R_{cell2} = 6\Omega$$

$$R_{circuit} = R_{ABC} + R_D + R_E + R_F + R_{cell} + R_{cell2}$$

$$R_{circuit} = 2.5 + 2.9 + 0.6 + 6 + 2 + 6$$

$$R_{circuit} = 20\Omega$$

g. Calculate the emf of each of the cells in the parallel combination. [3]

$$V_{ABC} = 2.5V$$

$$V_D = 2.9V$$

$$V_E = 0.6V$$

$$V_F = 6V$$

$$V_{cell} = 2V$$

$$V_{cell2} = 6V$$

$$EMF = V_{ABC} + V_D + V_E + V_F + V_{cell} + V_{cell2}$$

$$EMF = 2.5 + 2.9 + 0.6 + 6 + 2 + 6$$

$$EMF = 20V$$

h. Updated circuit configuration

