TUTORIAL 01

Question: 1 An emf source of 6.0V is connected to a purely resistive lamp and a current of 2.0 amperes flows. All the wires are resistance-free. What is the resistance of the lamp? Also answer the following.

a) Where in the circuit does the gain in potential energy occur?
b) Where in the circuit does the loss of potential energy occur? What are the limitations of Ohm's law?

Question: 2 For the circuit shown in fig. 1, find the value of R_L that absorbs maximum power from the circuit and the corresponding power under this condition. Estimate the maximum power across the load using Superposition and Thevenin's theorems.

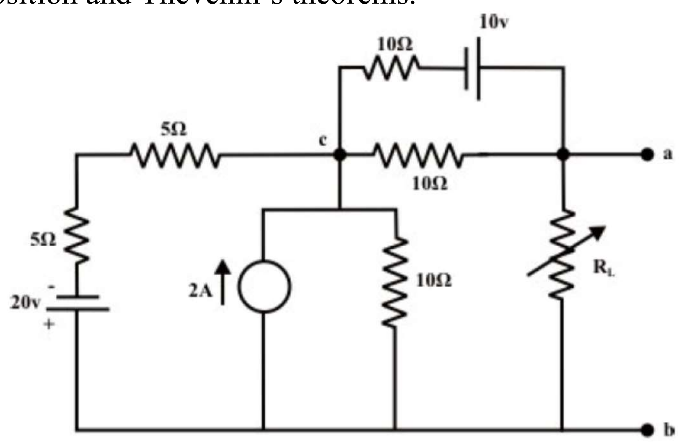

Figure 1

Question: 3 Explain the concept of current gains in CE and CB BJT configurations?

Question: 4 Explain the four regions of operation of BJT?

Question: 5 Mention the mathematical relationship between I_C and I_{CBO} for BJT.

Solution 1)

$$V = I R$$

$$R = V/I$$

$$R = 3.0\ \Omega$$

a) The gain of potential energy occurs as a charge passes through the battery, that is, it gains a potential of $\mathcal{E} = 6.0V$.
b) No energy is lost to the wires, since they are assumed to be resistance-free. By conservation of energy, the potential that was gained (i.e. $\mathcal{E} = V = 6.0V$) must be lost in the resistor.

In Ohm's law the resistance is taken as constant. But there are many practical examples where the resistance of the element through which current flows, is not constant it varies with applied voltage. This type of elements will not obey Ohm's law perfectly. Ohm's law also is not applicable to the unilateral elements because they behave differently when the direction of current changes. For example, we can consider a diode whose current voltage relationship is totally different in the case of forward biased and reverse biased condition. Moreover Ohm's law cannot be applied to the non-linear elements like powdered carbon, thyrite, electric arc etc.

Solution 2)

Load resistance R_L is disconnected from the terminals 'a' and 'b' and the corresponding circuit diagram is re-drawn as shown in fig 1.1.

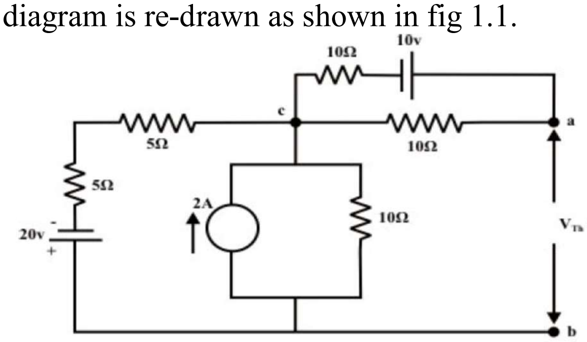

Figure 1.1

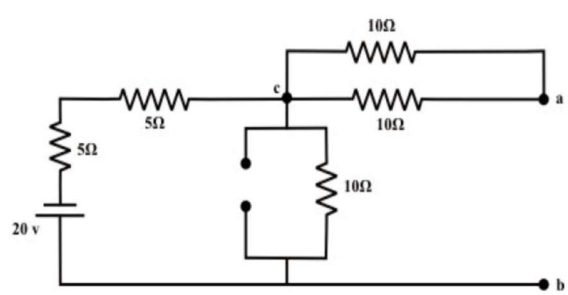

Figure 1.2

The above circuit is equivalently represented by a Thevenin circuit and the corresponding Thevenin voltage V_{Th} and Thevenin resistance R_{Th} are calculated by following the steps given below:

Now applying 'Super position theorem', one can find V_{Th} (voltage across the 'a' and 'b' terminals, refer fig. 1.2. Note any method (node or mesh analysis) can be applied to find V_{Th}.

1. **Considering only 20v source only:**

From the above circuit the current through 'b-c' branch $= \frac{20}{20} = 1A$ (from 'b' to 'a') whereas the voltage across the 'b-a' branch $v_{ba} = 1 \times 10 = 10\ volt$. ('b' is higher potential than 'a'). $\therefore v_{ab} = -10\, volt$

2. **Considering only 10v source only:**

Note: No current is flowing through 'cb'-branch.

$\therefore V_{ab} = 5v$ ('a' is higher potential than 'b')

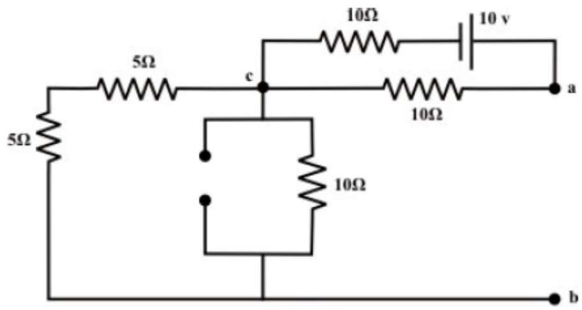

Figure 1.3

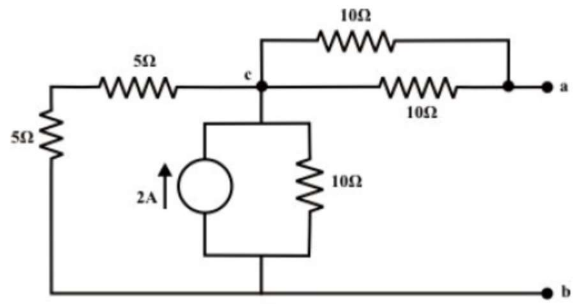

Figure 1.4

3. **Considering 2A Current source only:**

Note that the current flowing the 'c-a' branch is zero

$\therefore V_{ab} = 10$ v ('a' is higher potential than 'b' point).

The voltage across the 'a' and 'b' terminals due to the all sources = $V_{Th} = V_{ab}$ (due to 20v) + V_{ab} (due to 10v) + V_{ab} (due to 2A source) = - 10 + 5 + 10 = 5v (a is higher potential than the point 'b').

To compute R_{Th}: Replace all voltage and current sources by their internal resistance of the circuit shown in fig. 1.5.

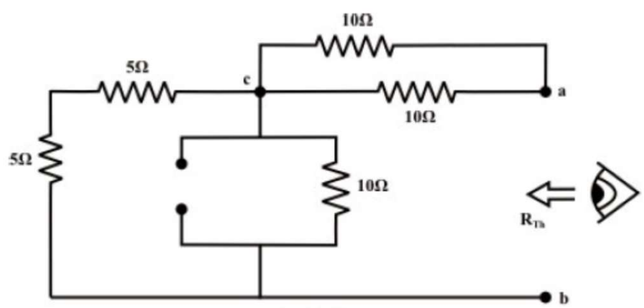

Figure 1.5

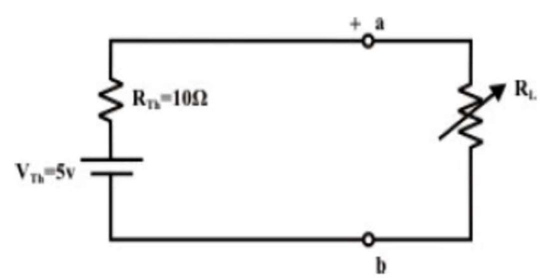

Figure 1.6

$$R_{Th} = R_{ab} = ((5+5) \parallel 10) + (10 \parallel 10)$$
$$= 5 + 5 = 10\ \Omega$$

Thevenin equivalent circuit is drawn below:

The choice of R_L that absorbs maximum power from the circuit is equal to the value of Thevenin resistance R_{Th}

$R_L = R_{Th} = 10\Omega$

Under this condition, the maximum power dissipated to R_L is

$$P_{max} = \frac{1}{4}\frac{V_{Th}^2}{R_{Th}} = \frac{1}{4}\cdot\frac{25}{10} = 0.625 \text{ watts.}$$