Determine the internal resistance of the source and analyzing the circuit using mesh and nodal Analysis

Aim:

1. To find the internal resistance of the source.
2. To calculate the loop current and node voltages of the given circuit practically and verify using mesh and nodal analysis theoretically.

Apparatus Required:

Item	Quantity Required
1. Regulated Power Supply (0-15 V 0-1 A)	1
2. Digital Multimeter	2
3. Decade resistance box	1
4. Different values of resistors (10 Ω -1kΩ)	5

Theory:

Any device which produces a voltage output has a limit to the current it can provide. The voltage source includes batteries, power supplies, function generators, amplifiers, logic gates etc.

The voltage source can be represented as a resistance in series with the *ideal* voltage output of the device. When the power source delivers current, the measured voltage output is lower than the no-load voltage and the difference can be attributed to the voltage drop caused across the internal resistance. The concept of internal resistance applies to all kinds of electrical sources and is useful for analyzing many types of electrical circuits.

Mesh Analysis is a technique for the rigorous solution of many electrical circuits. With this method, the user can systematically find sufficient and necessary equations for the solution of the problem. Kirchhoff's Voltage Law is satisfied around each mesh in the circuit with the resulting equations written in terms of the mesh currents which are the

variables for the solution. The current flow in a circuit element will be determined from the appropriate mesh currents which flow through that element. Kirchhoff's Voltage Law (KVL) states that the algebraic sum of all branch voltages around any closed path in a circuit is always zero at all instants of time.

Nodal analysis is a method applied to electrical circuits to determine the nodal voltages. In electrical circuits nodes are points where two or more electrical elements such as resistors meet. This nodal analysis method uses the Germen scientist's, Kirchhoff's rules, to determine the voltage of each node in a circuit. Kirchhoff's Current Law states that the amount of current entering a node must equal to the amount of current leaving the node. And that the algebraic sum of all currents entering and exiting a node must sum to zero.

Maximum Power transfer theorem:

The Maximum Power Transfer Theorem is another useful Circuit Analysis method to ensure that the maximum amount of power gets dissipated across the load resistance when the value of the load resistance is exactly equal to the resistance of the power source.

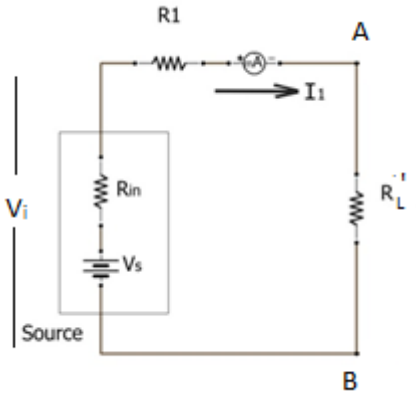

Figure 1

From the figure 1,

Power transferred to R_L': $P_L = V_{AB}^2 / R_L'$

$= V_s^2 R_L' / (R_{in} + R_1 + R_L')^2$

Condition for Maximum power transfer theorem is,

$$dP_L/dR_L' = 0$$

$$(R_{in} + R_1 + R_L')^2 \; V_s^2 - 2V_s^2 R_L' (R_{in} + R_1 + R_L') / (R_{in} + R_1 + R_L')^4 = 0$$

$$\Rightarrow \; R_L' = R_{in} + R_1 \text{ ----------(1)}$$

Finding the value of R_L' in the given circuit below

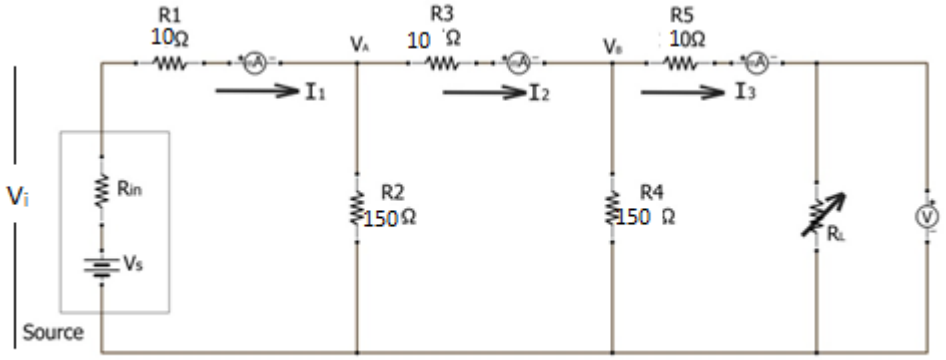

Figure 2

$$R_L' = R_2 \parallel \{R_3 + (R_4 \parallel (R_5 + R_L))\} \text{ --------(2)}$$

Apply the Kirchhoff's law and form the equations for finding the values of I_1, I_2 and I_3,

$$V_i - I_1 R_1 - (I_1 - I_2) R_2 = 0$$

$$I_1 (R_1 + R_2) - I_2 R_2 = V_i \text{ ----------(3)}$$

$$(I_1 - I_2) R_2 - I_2 R_3 - (I_2 - I_3) R_4 = 0$$

$$I_1 R_2 - (R_2 + R_3 + R_4) I_2 + I_3 R_4 = 0 \text{ ---------(4)}$$

$$(I_2 - I_3) R_4 - I_3 R_5 - I_3 R_L = 0$$

$$I_2 R_4 - (R_4 + R_5 + R_L) I_3 = 0 \text{ ----------(5)}$$

Determine the value of voltages V_A and V_B using I_1,I_2 and I_3.

$$V_A = (I_1 - I_2) \; R_2 \text{----------(6)}$$
$$V_B = (I_2 - I_3) \; R_4 \text{ ----------(7)}$$

Procedure:

- Connect the circuit as shown in figure 2 using known value of resistances.
- Measure the voltage V_i using the multimeter.

- Take readings of voltages (V_L), V_A and V_B and measure the current I_1 by varying the decade resistance box.
- Calculate the power across R_L using $P_L = V_L^2/R_L$.
- Plot Power (P_L) Vs Resistance (R_L) graph. Find internal resistance (R_{in}) using maximum power transfer theorem.
- Determine the value of R_L corresponding to the maximum power from the graph.
- Using equation (2), determine the value of R_L'.
- By substituting the value of R_L' in equation (1) , determine the R_{in}.
- Apply the Kirchhoff's law and solve the equations(3,4,5) for finding the values of I_1 , I_2 and I_3 .
- Compare the theoretical using equations(6,7)and experimental values of V_A and V_B.
- Note down the loop currents and node voltages at maximum power transfer. Calculate theoretically loop currents and node voltages using mesh and nodal analysis.

Table1: To find maximum power.

R_1 = , R_2 = , R_3 = , R_4 = , R_5 =

Sl. No	V_L (volt)	I_1 (A)	R_L (ohm)	V_i (volt)	V_A (volt)	V_B (volt)	$P = V_L^2/R_L$ (Watts)
1							
2							
3							
4							

5							
6							
7							
8							
9							
10							

Table2: Practically determined value of loop current using equation

Loop current	Theoretical	Practical
I1		
I2		
I3		

Table3: Node Voltage theoretical Vs practical

Node Voltage	Theoretical	Practical
V_A		
V_B		

Results and calculation:

1. Internal resistance of the source is.....
2. Loop current and node voltages of the given circuit are found practically and verified using mesh analysis and nodal analysis.