Verification of Thevenin’s, Norton’s and Maximum Power Transfer Theorem

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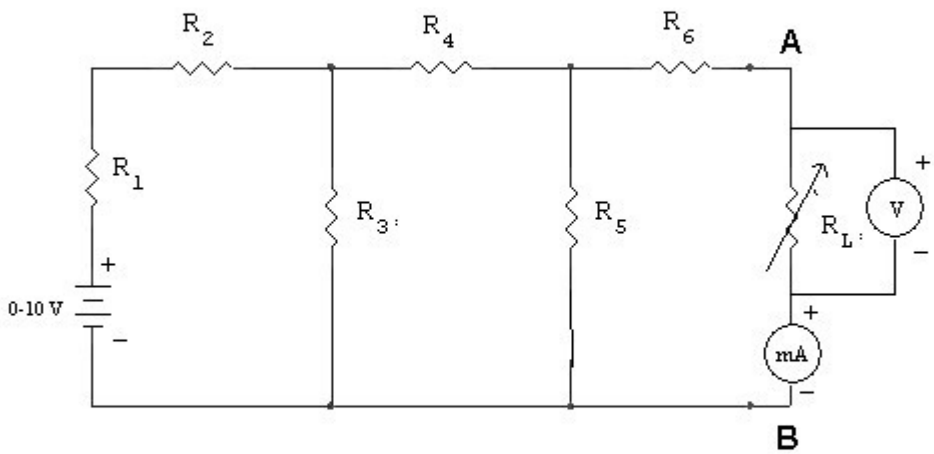
CIRCUIT DIAGRAM:



OBSERVATIONS:

R_1=50Ω_, R_2=50 Ω, R_3=330 Ω, R_4=100 Ω, R_5=370 Ω, R_6=470 Ω, V_1 = 10V

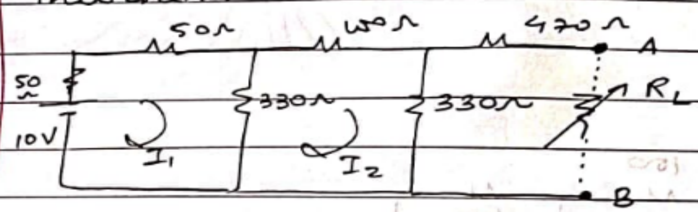
Sr. No.	R_L(Ω)	V_L(V)	I_L(mA)	P_L (mW)	
1	183	1.160	6.3	7.3	
2	283	1.593	5.6	8.9	
3	383	1.946	5.1	9.9	
4	483	2.236	4.6	10.2	
5	583	2.441	4.3	10.61	R_{TH}
6	683	2.676	3.9	10.43	
7	783	2.85	3.6	10.26	
8	883	3.004	3.4	10.21	
9	983	3.13	3.2	10.16	
10	1083	3.26	3.0	9.75	

V_{th}(V)	R_{th}=R_N (Ω)	I_N (mA)
5.16	583	8.1

CALCULATION:

Experiment 3:

Thevenin:



Mesh 1: $-10 + 100 I_1 + 330(I_1 - I_2) = 0$

$-1 + 10 I_1 + 33(I_1 - I_2) = 0$

$\boxed{43 I_1 - 33 I_2 = 1}$ —— (1)

Mesh 2: $100 I_2 + 330(I_2) + 330(I_2 - I_1) = 0$

$760 I_2 - 330 I_1 = 0$

$\boxed{330 I_1 - 760 I_2 = 0}$ —— (2)

Solving (1) & (2) simultaneously we get:

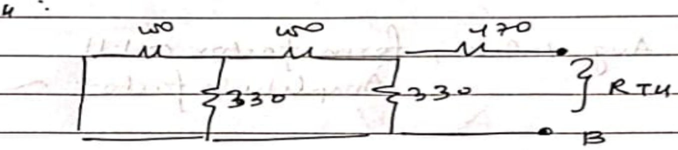
$I_1 = 0.034\ A$

$I_2 = 0.0151\ A$

Thus $V_{TH} = I_2 \times 330$

$= 0.0151 \times 330 = \boxed{4.983\ V}$

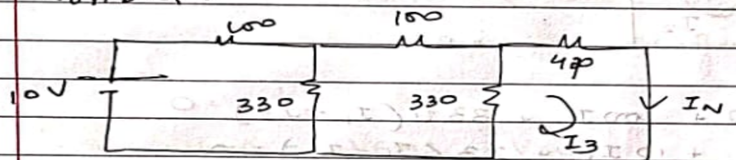
R_{TH} :



$$R_{TH} = \left[(76.744 + 100) \parallel 330\right] + 470$$

$$= 585.098\ \Omega$$

Norton :



Mesh 1 : $-10 + 100 I_1 + 330(I_1 - I_2) = 0$

$$\boxed{43 I_1 - 33 I_2 = 1} \quad \text{—— (1)}$$

Mesh 2 : $330(I_2 - I_1) + 100 I_2 + 330(I_2 - I_3) = 0$

$$\boxed{76 I_2 - 33 I_1 - 33 I_3} = 0$$

Mesh 3 : $330(I_3 - I_2) + 470 I_3 = 0$

$$80 I_3 - 33 I_2 = 0$$

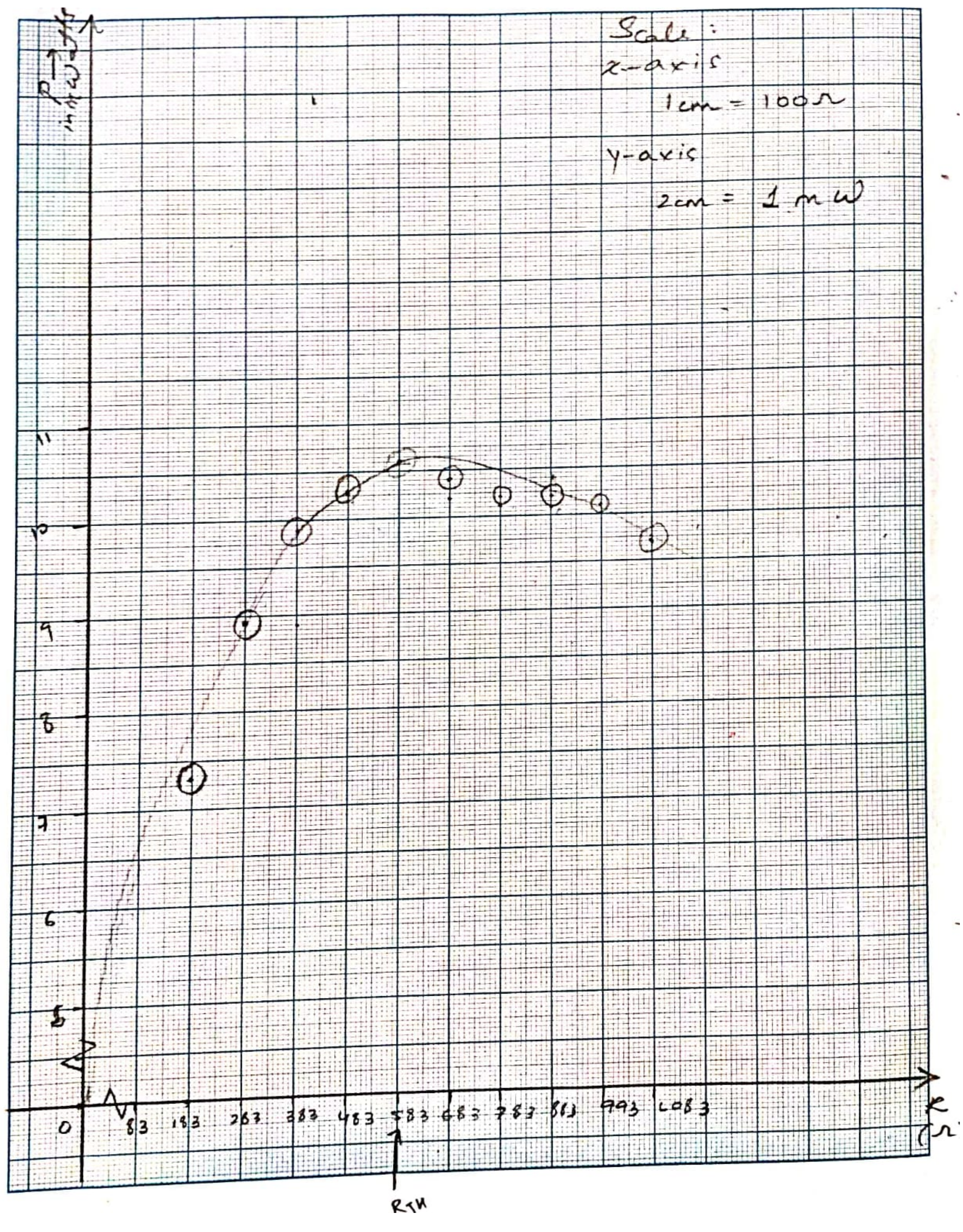
$I_1 = 0.039$ A

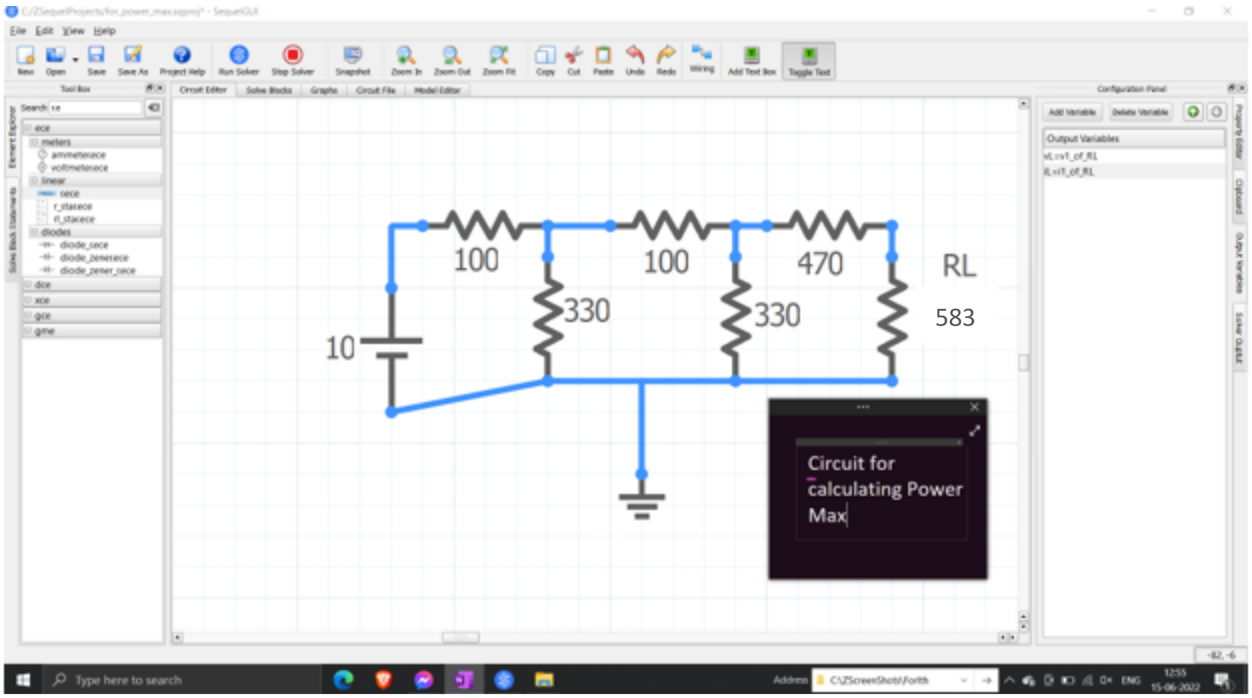
$I_2 = 0.020$ A

$I_3 = 8.54$ mA

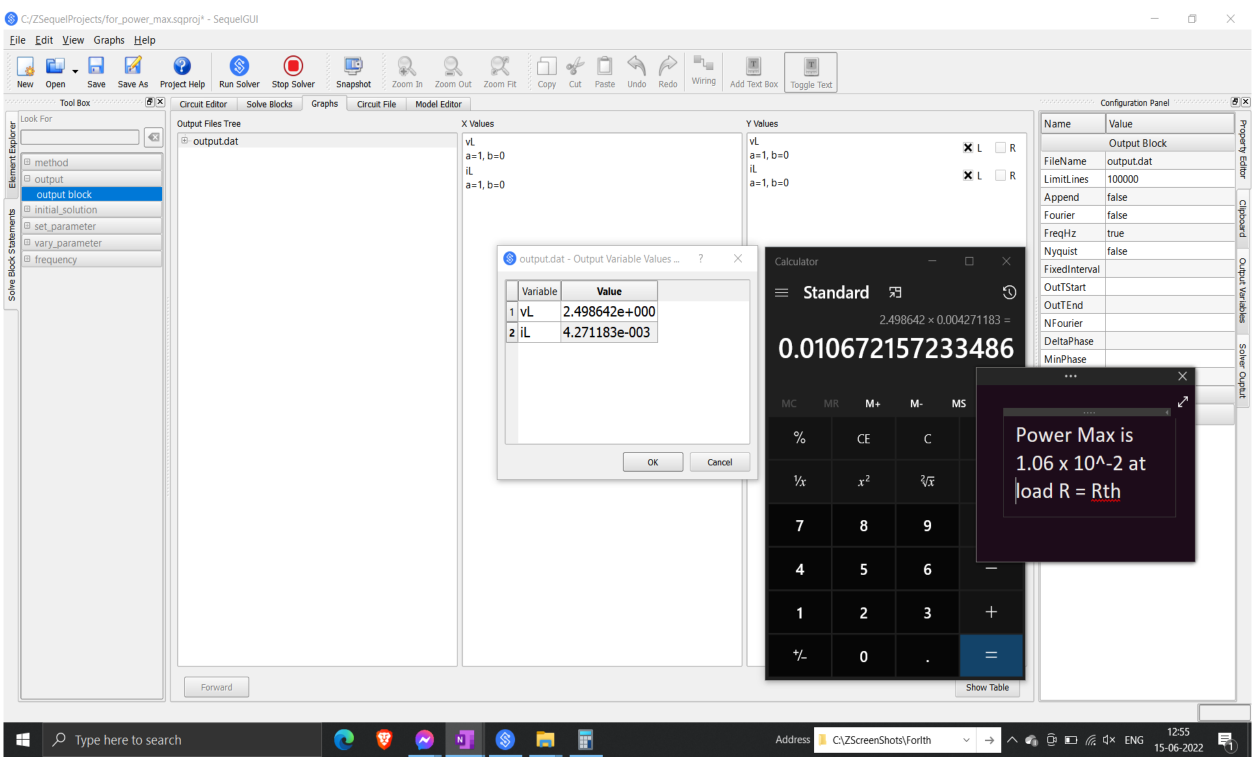
GRAPH FOR POWER V/S LOAD RESISTANCE

*Peak value at Rth

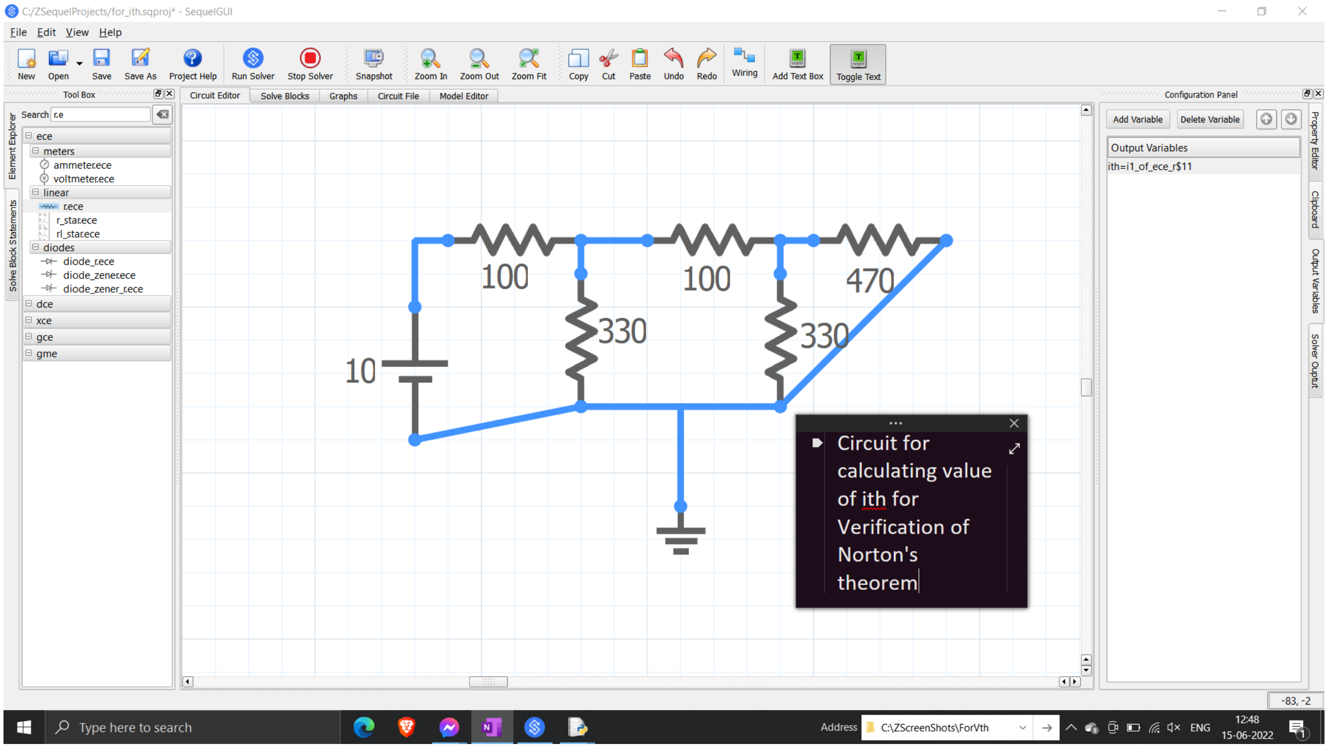


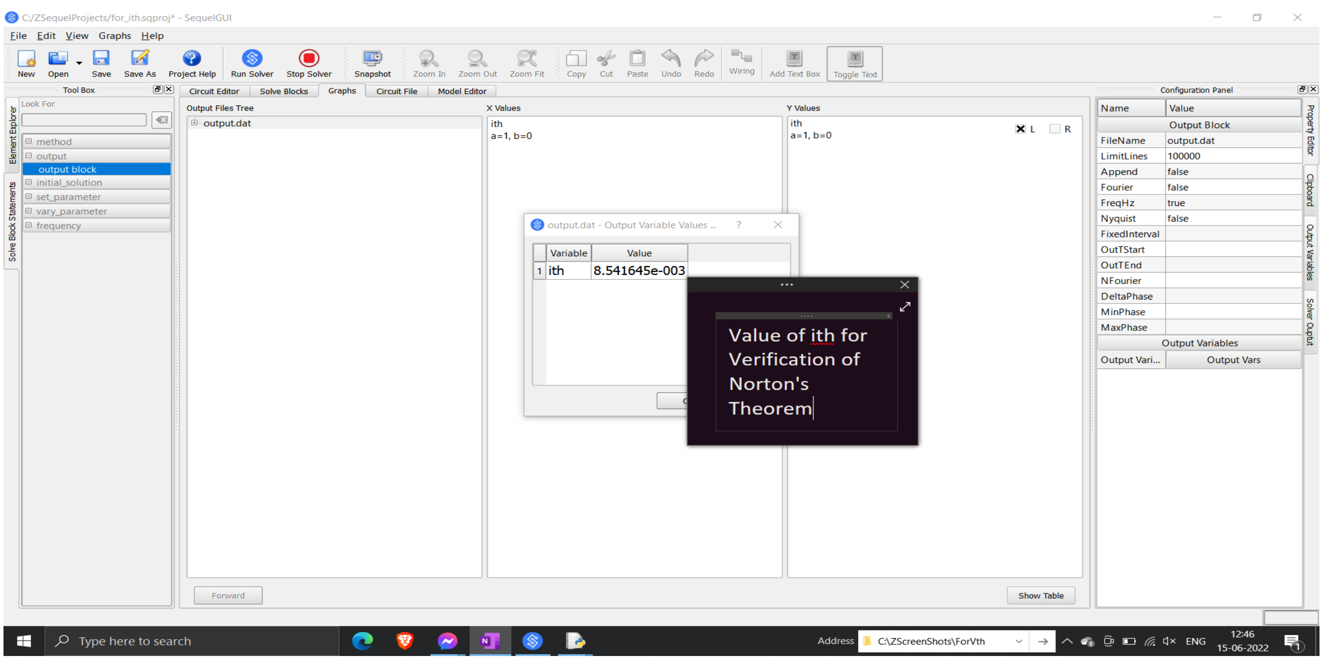


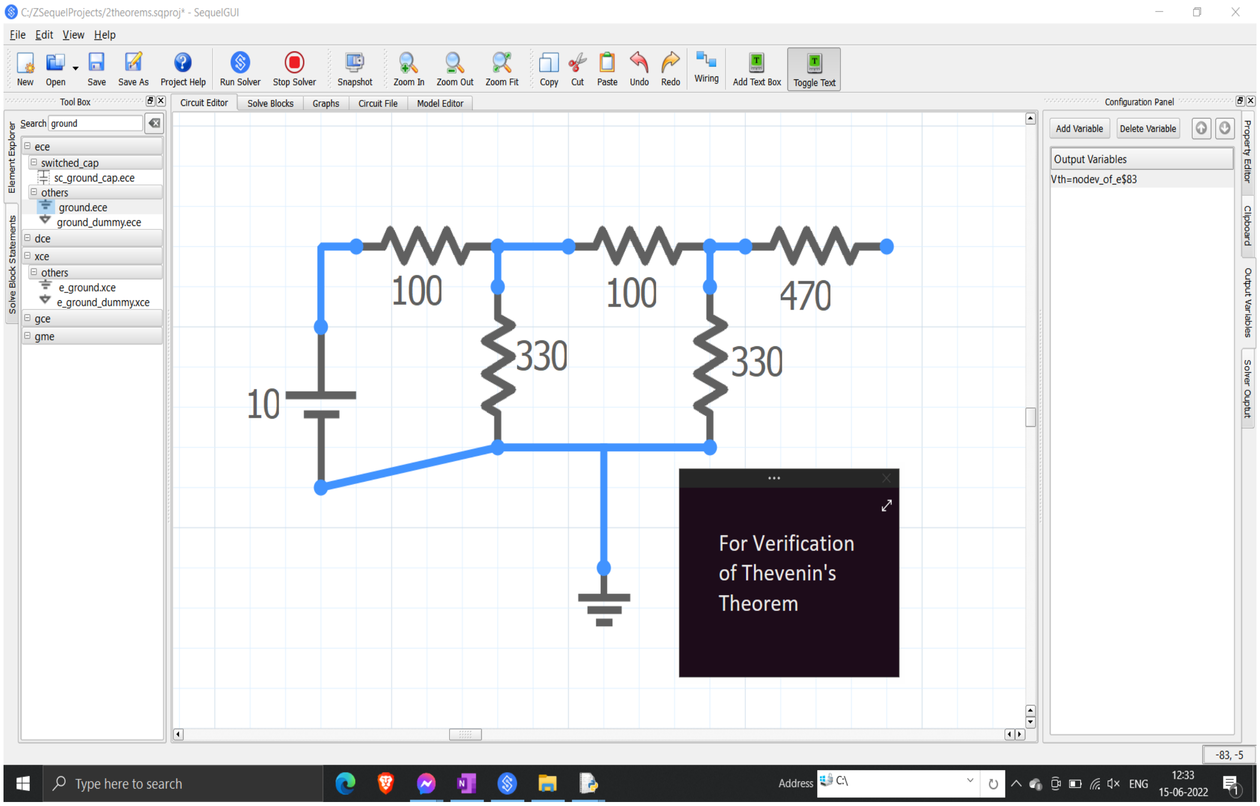
C:/ZSequelProjects/for_power_max.sqproj* - SequelGUI
100
100
470
RL
330
330
583
10
Circuit for calculating Power Max

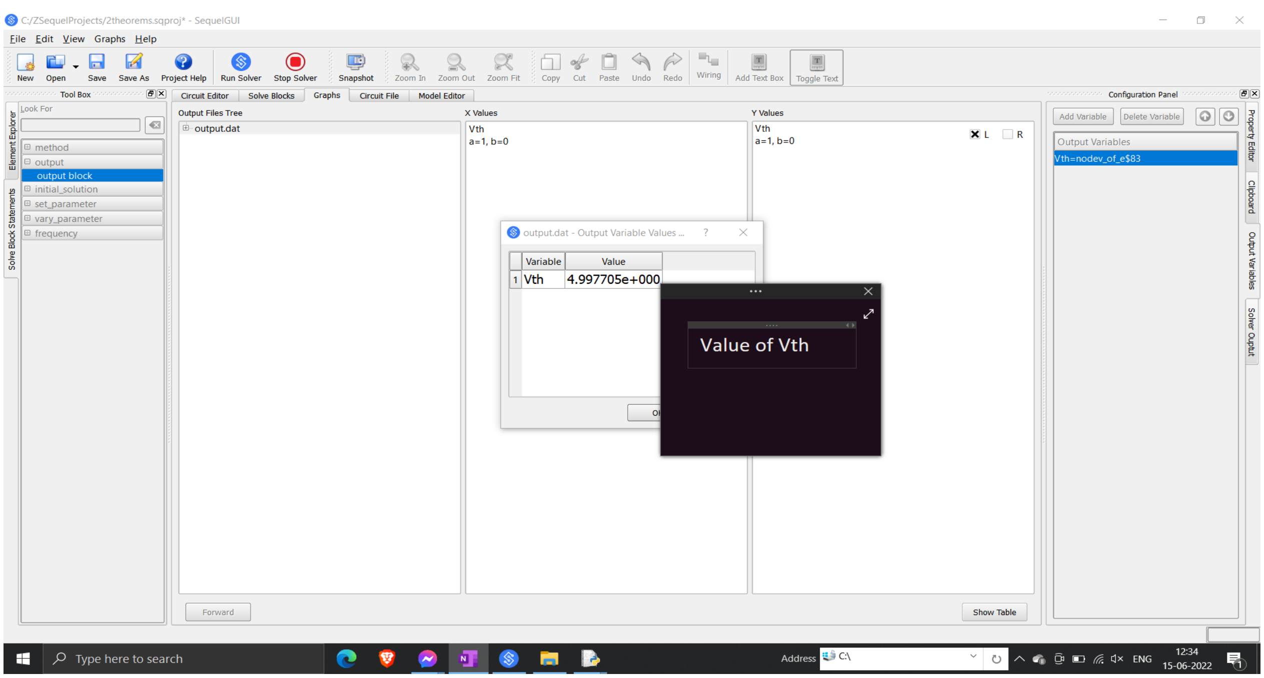


C:/ZSequelProjects/for_power_max.sqproj* - SequelGUI
output.dat - Output Variable Values
Variable Value
1 vL 2.498642e+000
2 iL 4.271183e-003
Calculator
Standard
2.498642 × 0.004271183 =
0.010672157233486
Power Max is 1.06 x 10^-2 at load R = Rth


C:/ZSequelProjects/for_ith.sqproj* - SequelGUI
100
100
470
330
330
10
Circuit for calculating value of ith for Verification of Norton's theorem
Output Variables
ith=i1_of_ece_r$11


C:/ZSequelProjects/for_ith.sqproj* - SequelGUI
output.dat - Output Variable Values
Variable
Value
ith
8.541645e-003
Value of ith for Verification of Norton's Theorem


C:/ZSequelProjects/2theorems.sqproj* - SequelGUI
100
100
470
330
330
10
For Verification of Thevenin's Theorem
Vth=nodev_of_e$83


C:/ZSequelProjects/2theorems.sqproj* - SequelGUI
output.dat - Output Variable Values
Variable
Value
Vth
4.997705e+000
Value of Vth
Vth=nodev_of_e$83

EXPERIMENT NO: 03 **DATE: 21/06/ 2022**

Verification of Thevenin's, Norton's and Maximum Power Transfer Theorem

AIM: To verify Thevenin's, Norton's and Maximum power transfer theorem for the given circuit by circuit implementation on breadboard and using simulator.

APPARATUS AND COMPONENTS REQUIRED:

Resistors(values), DC Voltage source (rating), Ammeter (range), DMM (range), breadboard, Connecting wires, Sequel Simulator

THEORY: Write theory related with following questions:

1) State Thevenin's, Norton's and Maximum Power Transfer Theorem.

→ **Thevenin's Theorem**: Thevenin's theorem states that it is possible to simplify any linear circuit, irrespective of how complex it is, to an equivalent circuit with a single voltage source and a series resistance.

→**Norton's Theorem**: Any linear circuit containing several energy sources and resistances can be replaced by a single Constant Current generator in parallel with a Single Resistor

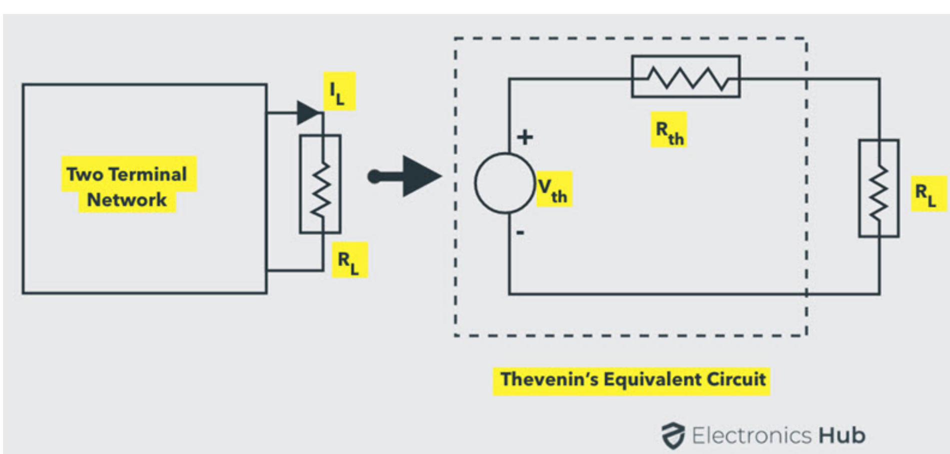
→**Maximum Power Transfer Theorem**: It states that the DC voltage source will deliver maximum power to the variable load resistor only when the load resistance is equal to the source resistance.

2) Prove the condition for Maximum power transfer in a circuit and its value.

→The Maximum Power Transfer Theorem ensures the value of the load resistance, at which the maximum power is transferred to the load.

Consider the below DC two terminal network (left side circuit). The condition for maximum power is determined by obtaining the expression of power absorbed by load using mesh or nodal current methods and then deriving the resulting expression with respect to load resistance R_L.

This is quite a complex procedure. But in the previous tutorials, we have seen that the complex part of the network can be replaced with a Thevenin's equivalent as shown below.



The original two terminal circuit is replaced with a Thevenin's equivalent circuit across the variable load resistance. The current through the load for any value of load resistance is

$$I_L = \frac{V_{Th}}{R_{Th} + R_L}$$

The power absorbed by the load is

$$P_L = I_L^{\ 2} \times R_L$$

$$= \left[\frac{V_{Th}}{R_{Th} + R_L} \right]^2 \times R_L$$

Form the above expression, the power delivered depends on the values of R_{TH} and R_L. However, as the Thevenin's equivalent is a constant, the power delivered from this equivalent source to the load entirely depends on the load resistance R_L. To find the exact value of RL, we apply differentiation to P_L with respect to R_L and equating it to zero as shown below:

$$\frac{dP(R_L)}{dR_L} = V_{Th}^{\ 2} \left[\frac{(R_{Th} + R_L)^2 - 2R_L \times (R_{Th} + R_L)}{(R_{Th} + R_L)^4} \right] = 0$$

$$\Rightarrow (R_{Th} + R_L) - 2R_L = 0$$

$$\Rightarrow R_L = R_{Th}$$

Therefore, this is the condition of matching the load where the maximum power transfer occurs when the load resistance is equal to the Thevenin's resistance of the circuit. By substituting the $R_{TH} = R_L$ in the previous equation, we get:
The maximum power delivered to the load is,

$$P_{max} = \left[\frac{V_{Th}}{R_{Th} + R_L} \right]^2 \times R_L \Bigg|_{R_L = R_{Th}}$$

$$= \frac{V_{Th}^{\ 2}}{4 R_{Th}}$$

PROCEDURE:

1) Connect the circuit as shown in the circuit diagram.
2) Keep the voltage such that the maximum current does not go beyond the range of the milliammeter.
3) Vary the load resistance from minimum to maximum.
4) Note the corresponding load current (I_L) and voltage across the load V_L.
5) Calculate the power dissipated in the load resistance as V_L* I_L.
6) Plot the graph of P_L v/s R_L.
7) Obtain observed values of V_{th} and R_{th} and I_N
8) Implement the given circuit using Sequel Simulator.
9) Simulate the circuit, find V_{th}, I_N and get graph of P_L v/s R_L.
10) Verify with theoretical solution.

RESULT:

V_{th}(V)			R_{th}= R_N(Ω)			I_N(mA)			P_{max}(mW)		
Theoretical	Observed	By simulation	Theoretical	Observed	By simulation	Theoretical	Observed	By simulation	Theoretical	Observed	By simulation
4.983	5.16	4.9973	585.96	583	-	8.54	8.1	8.541654	10.609	10.61	10.672

CONCLUSION:

In this experiment we verified Thevenin's, Norton's and Maximum power transfer Theorem.