INDRAPRASTHA INSTITUTE *of*
INFORMATION TECHNOLOGY
DELHI

Department
of
Electronics & Communication Engineering

ECE113|Basic Electronics

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Lab_1:

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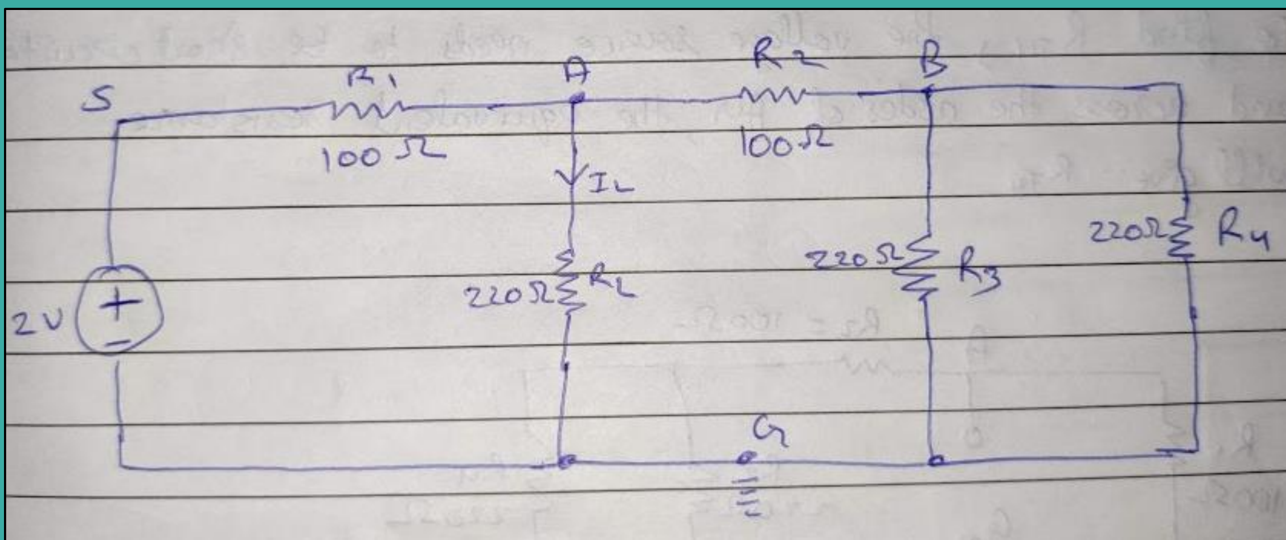
Date: 19/06/21

Part 1)

Aim: Verify Thevenin's and Norton's equivalent representations using TinkerCAD.

Material Required: Voltage Source, Multimeter, Resistors, wires, etc.

Circuit Diagram:



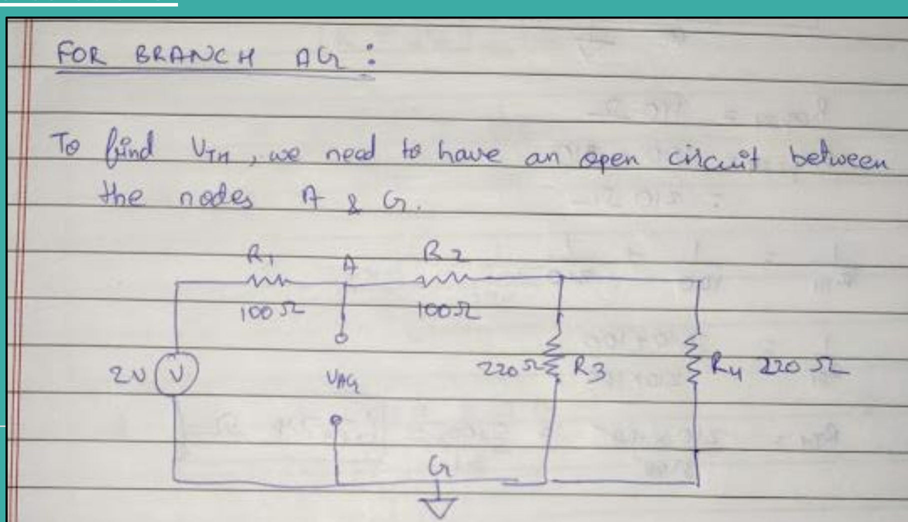
Tinkercad Link:

1) For Branch AG : https://www.tinkercad.com/things/63bTSfYzXBi-lab1ag/editel?sharecode=iAspqsiQDNffHoEFkGpqAENPqxN-OzhXT6ga9pXuGnw

2) For Branch AB: https://www.tinkercad.com/things/0ZObZUJuy6G-lab1ab/editel?sharecode=RgUoMMWIQq8RMTsXn2fGVX_dbnxqJv1HvnKBjaI8DHc

Software/Tools Used: TinkerCAD website (https://www.tinkercad.com/)

Theoretical Calculations:



$$V_{TH} = \frac{V(R_2 + R_{eq34})}{R_1 + R_2 + R_{eq34}}$$

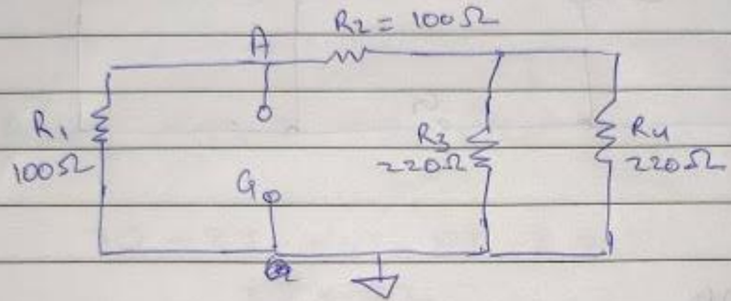
$$\frac{1}{R_{eq34}} = \frac{1}{220} + \frac{1}{220} = \frac{2}{220} \quad \frac{1}{110}$$

$$R_{eq34} = 110$$

$$V_{TH} = \frac{2(100 + 110)}{100 + 100 + 110}$$

$$= \frac{2 \times 210}{310} = \boxed{1.35\ V}$$

To find R_{TH}, the voltage source needs to be short circuited and across the nodes of AG, the equivalent resistance will give R_{TH}



$$R_{eq34} = 110\ \Omega$$

$$R_{eq234} = 100 + 110$$

$$= 210\ \Omega$$

$$\frac{1}{R_{TH}} = \frac{1}{100} + \frac{1}{210}$$

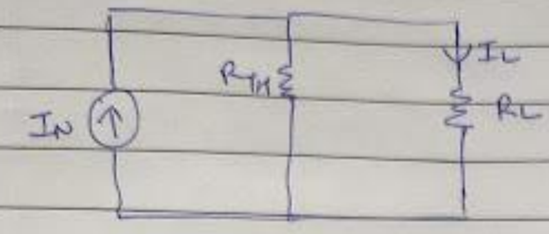
$$\frac{1}{R_{TH}} = \frac{210 + 100}{210 \times 100}$$

$$R_{TH} = \frac{210 \times 10\cancel{0}}{31\cancel{0}} = \frac{2100}{31} = \boxed{67.74\ \Omega}$$

I_N (Norton's Current),

$$I_N = \frac{V_{TH}}{R_{TH}} = \frac{1.35}{67.74} = 0.0199 \simeq \boxed{20\ mA}$$

Calculating I_L (load current) using Norton's Theorem,



$$I_L = \frac{I_N\left(\frac{1}{R_L}\right)}{\left(\frac{1}{R_L} + \frac{1}{R_{TH}}\right)}$$

$$= \frac{20\times10^{-3} \times \frac{1}{220}}{\frac{1}{67.74} + \frac{1}{220}}$$

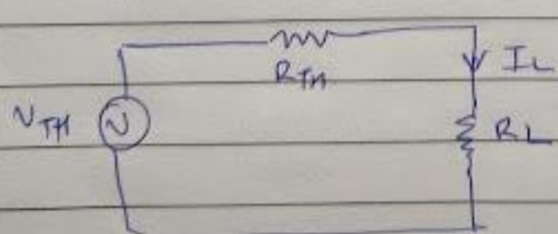
$$= \frac{20\times10^{-3} \times \frac{1}{220}}{\frac{220+67.74}{67.74\times220}}$$

$$= \frac{20\times10^{-3} \times 67.74}{287.74}$$

$$= 4.71\times10^{-3}$$

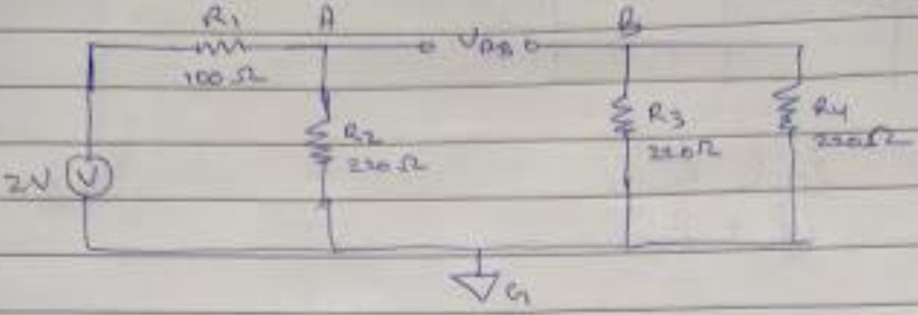
$$I_L = \boxed{4.71\ mA}$$

Calculating I_L using Thevenin's Circuit,



$$I_L = \frac{V_{TH}}{R_{TH}+R_L} = \frac{1.35}{220+67.74} = \frac{1.35}{287.74} = \boxed{4.71\ mA}$$

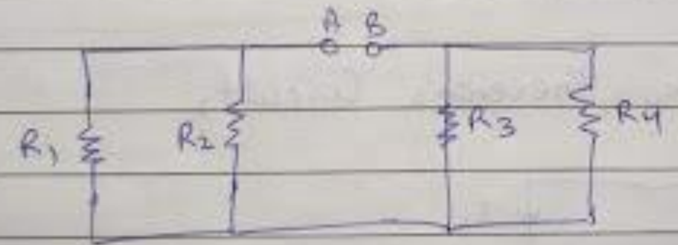
FOR BRANCH AB:



$$V_{TH} = \frac{(V).(R_2)}{R_2 + R_1} = \frac{2 \times 220}{220 + 100}$$

$$= \frac{44\cancel{0}}{32\cancel{0}} = \boxed{1.375 \text{ V}}$$

To find R_{TH}, the voltage source needs to be short-circuited and across the nodes of the branch AB, the equivalent resistance will give R_{TH}.



$$\frac{1}{R_{eq_{12}}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{100} + \frac{1}{220}$$

$$= \frac{220 + 100}{220 \times 100}$$

$$R_{eq_{12}} = \frac{2200\cancel{0}}{32\cancel{0}} = 68.75$$

Page No.

$$Req_{34} = \frac{R_3 \cdot R_4}{R_3 + R_4}$$

$$= \frac{220 * 220}{220 + 220} = \frac{220}{2}$$

$$= 110\ \Omega$$

$$R_{TH} = Req_{12} + Req_{34}$$

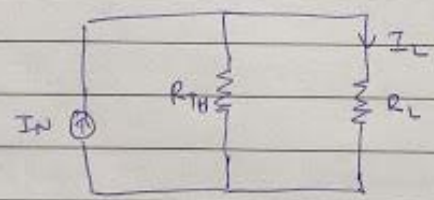
$$= 68.75 + 110$$

$$\boxed{R_{TH} = 178.75\ \Omega}$$

I_N (Norton's Current),

$$I_N = \frac{V_{TH}}{R_{TH}} = \frac{1.375}{178.75} = 0.00769 = \boxed{7.69\ mA}$$

Calculating I_L (Load current) using Norton's Circuit,



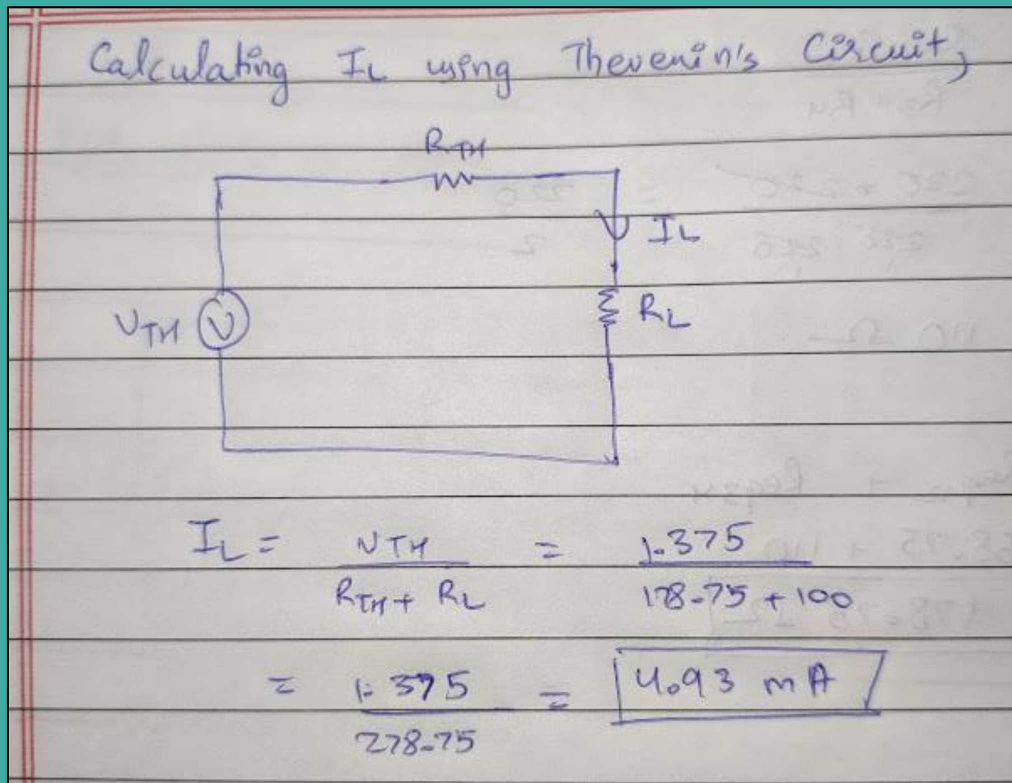
$$I_L = \frac{(I_N) \times \left(\frac{1}{R_L}\right)}{\left(\frac{1}{R_L} + \frac{1}{R_{TH}}\right)}$$

$$= \frac{7.69 \times 10^{-3} \times \frac{1}{100}}{\frac{1}{100} + \frac{1}{178.75}}$$

$$= \frac{7.69 \times 10^{-3} \times \frac{1}{100}}{\frac{178.75 + 100}{100 \times 178.75}}$$

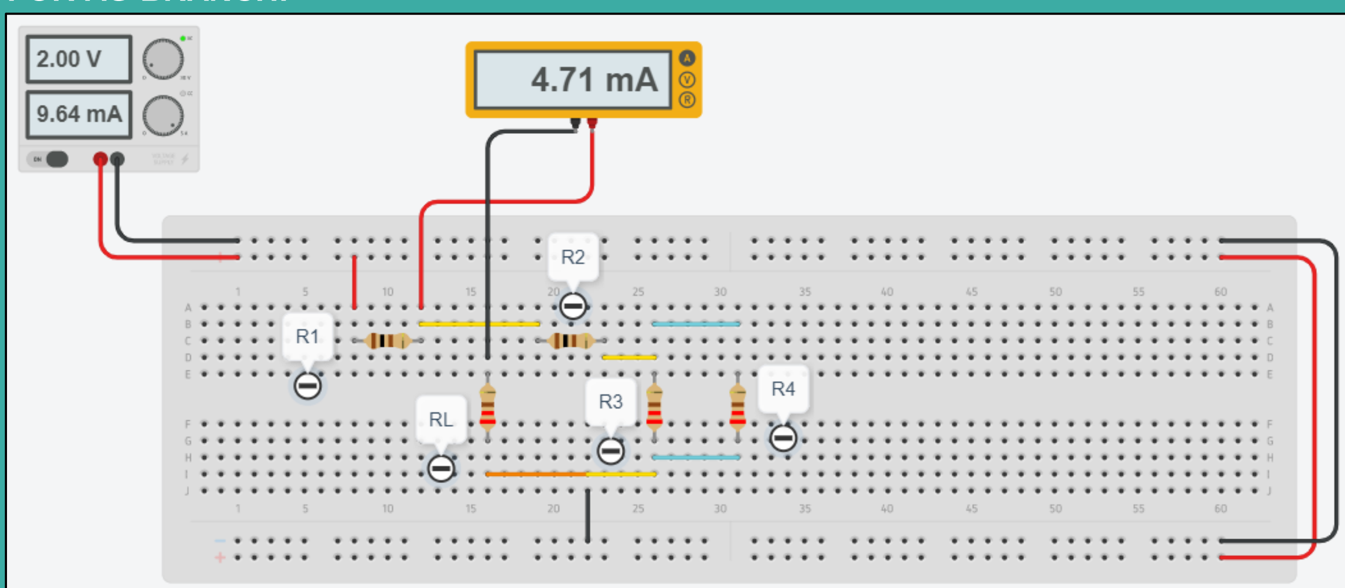
$$= \frac{7.69 \times 10^{-3} \times 178.75}{278.75}$$

$$I_L = 4.93 \times 10^{-3} = \boxed{4.93\ mA}$$

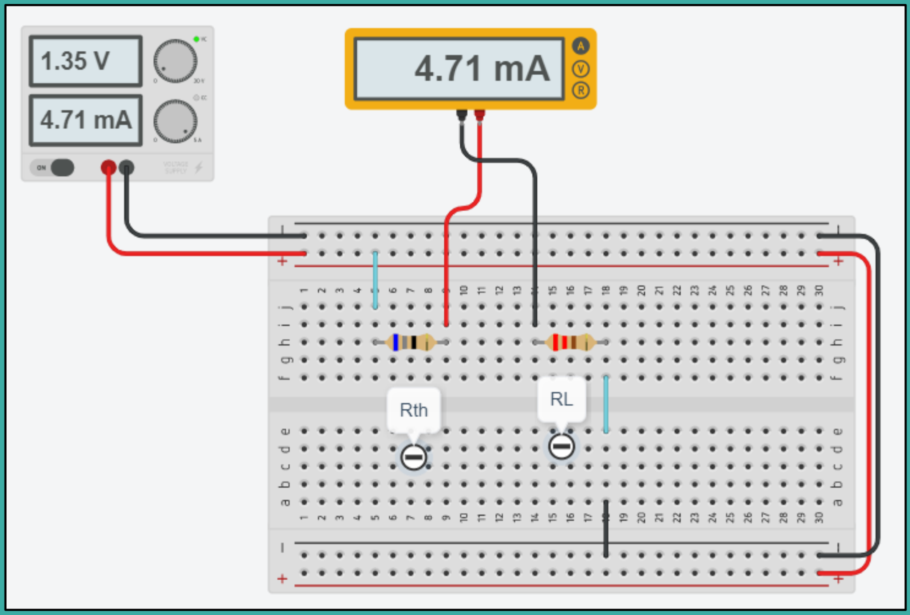


TinkerCAD Screenshots:

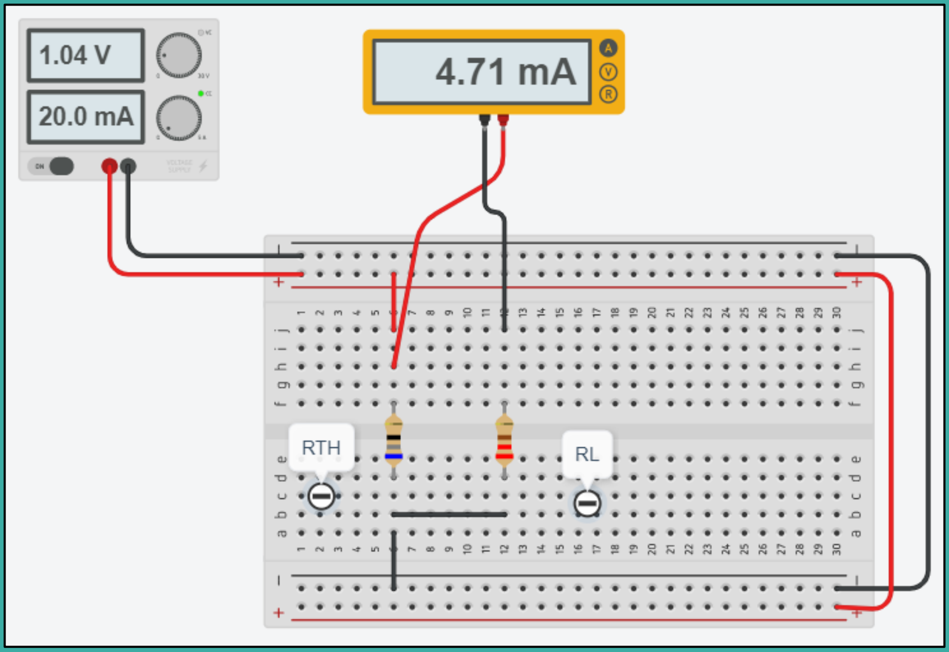
FOR AG BRANCH:



A) Original Circuit

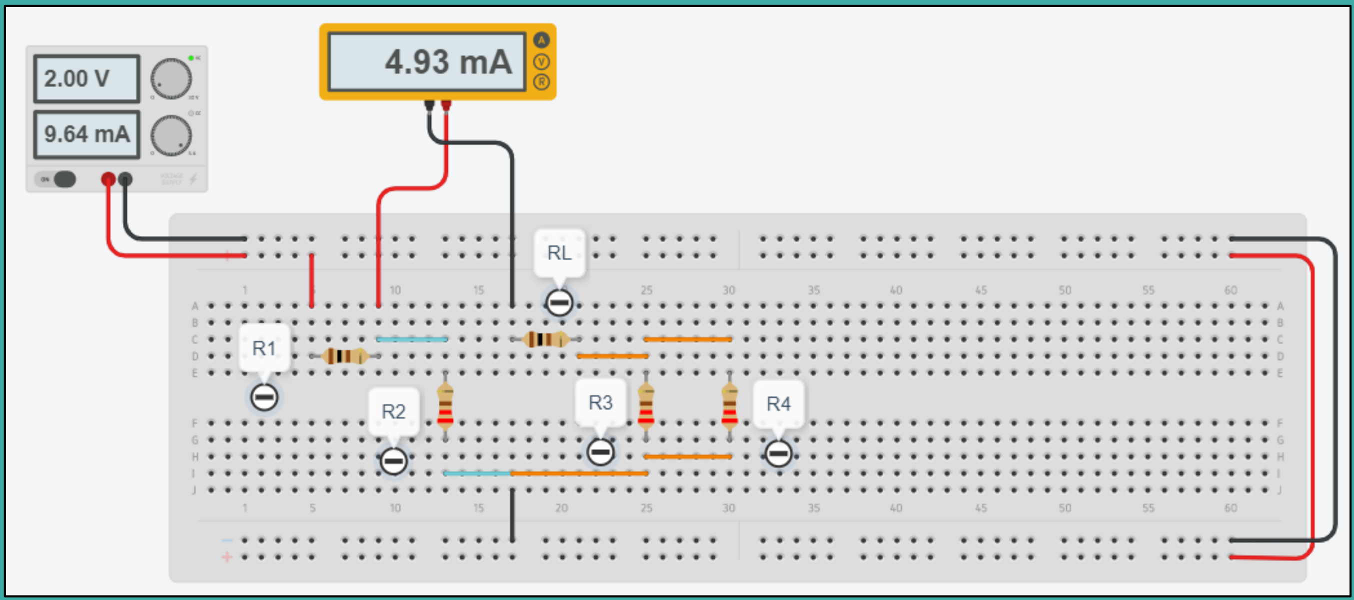


B) Thevenin's Circuit

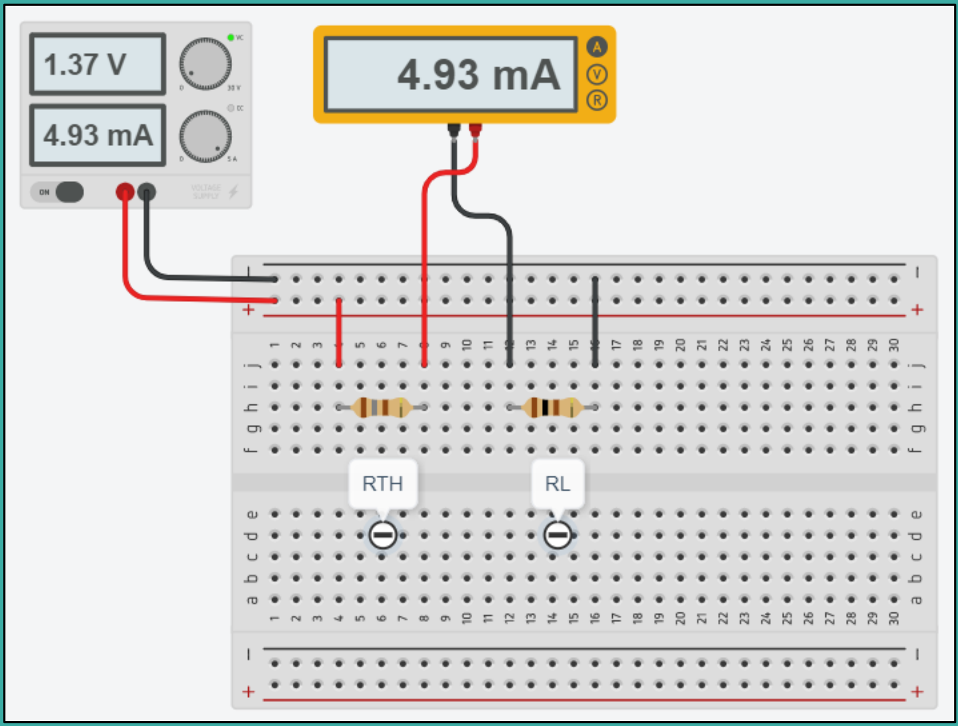


C) Norton's Circuit

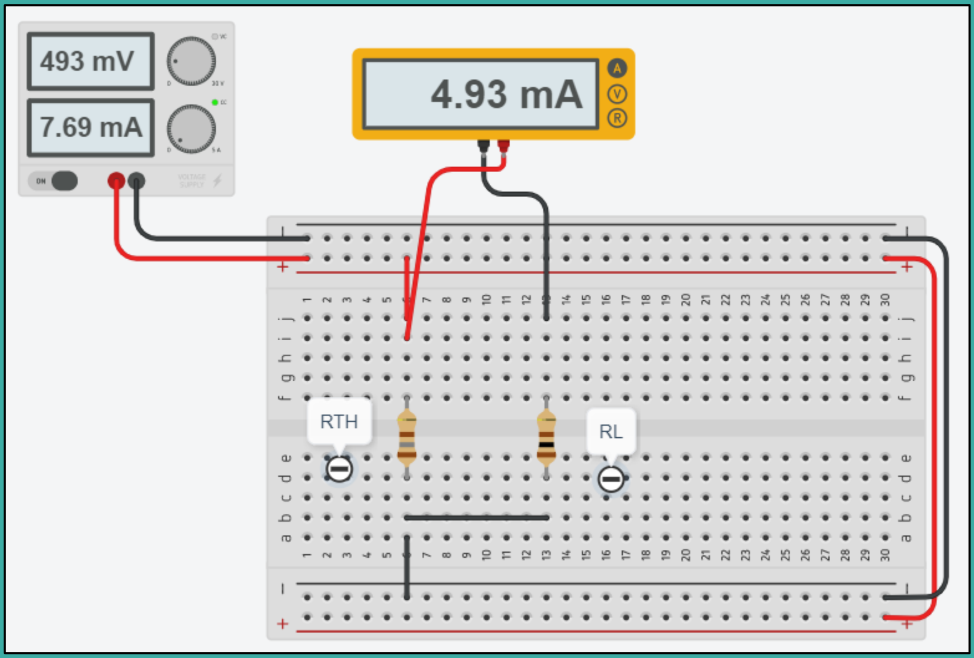
FOR AB BRANCH:



A) Original Circuit



B) Thevenin’s Circuit



C) Norton's Circuit

Observation Table:

FOR BRANCH AG:

S.No	R_L	I_L (from Original Circuit)	I_L (from Thevenin's Circuit)	I_L (from Norton's Circuit)	V_{AG} (from original Circuit)	V_{AG} (from Thevenin's Circuit)	V_{AG} (from Norton's Circuit)
1	220 Ω	4.71 mA	4.71 mA	4.71 mA	1.35 V	1.35 V	1.35 V
2	100 Ω	8.08 mA	8.07 mA	8.08 mA	1.35 V	1.35 V	1.35 V
3	150 Ω	6.22 mA	6.22 mA	6.22 mA	1.35 V	1.35 V	1.35 V
4	110 Ω	7.62 mA	7.62 mA	7.62 mA	1.35 V	1.35 V	1.35 V
5	120 Ω	7.22 mA	7.21 mA	7.22 mA	1.35 V	1.35 V	1.35 V

FOR BRANCH AB:

S.No	R_{AB}	I_{AB} (from Original Circuit)	I_{AB} (from Thevenin's Circuit)	I_{AB} (from Norton's Circuit)	V_{AB} (from original Circuit)	V_{AB} (from Thevenin's Circuit)	V_{AB} (from Norton's Circuit)
1	100 Ω	4.93 mA	4.93 mA	4.93 mA	1.37 V	1.37 V	1.37 V
2	220 Ω	3.45 mA	3.45 mA	3.45 mA	1.37 V	1.37 V	1.37 V
3	150 Ω	4.18 mA	4.18 mA	4.18 mA	1.37 V	1.37 V	1.37 V
4	110 Ω	4.76 mA	4.76 mA	4.76 mA	1.37 V	1.37 V	1.37 V
5	120 Ω	4.60 mA	4.60 mA	4.60 mA	1.37 V	1.37 V	1.37 V

Observations/Results: In both branches AG and AB, the value of I_L (Load Current) & Voltage are equal for all the circuits, i.e. Original Circuit, Thevenin's Circuit and Norton's Circuit respectively. Due to this observation we can say that these theorems are applicable and are effectively justified by the tables made.

Applications:

For Thevenin's Theorem:

1) It is very useful for analyzing power systems and other circuits where on particular load resistor and recalculation of the circuit is essential with each trial value of load resistance, to find the voltage across it and current through it.
2) Source modelling and resistance measurement by using the Wheatstone bridge provide applications for thevenin's theorem.

For Norton's Theorem:

1) It is used to reduce a complex circuit into a simple circuit.
2) Norton's theorem is useful to solve problems on parallel generators with unequal emf's and unequal impedances.

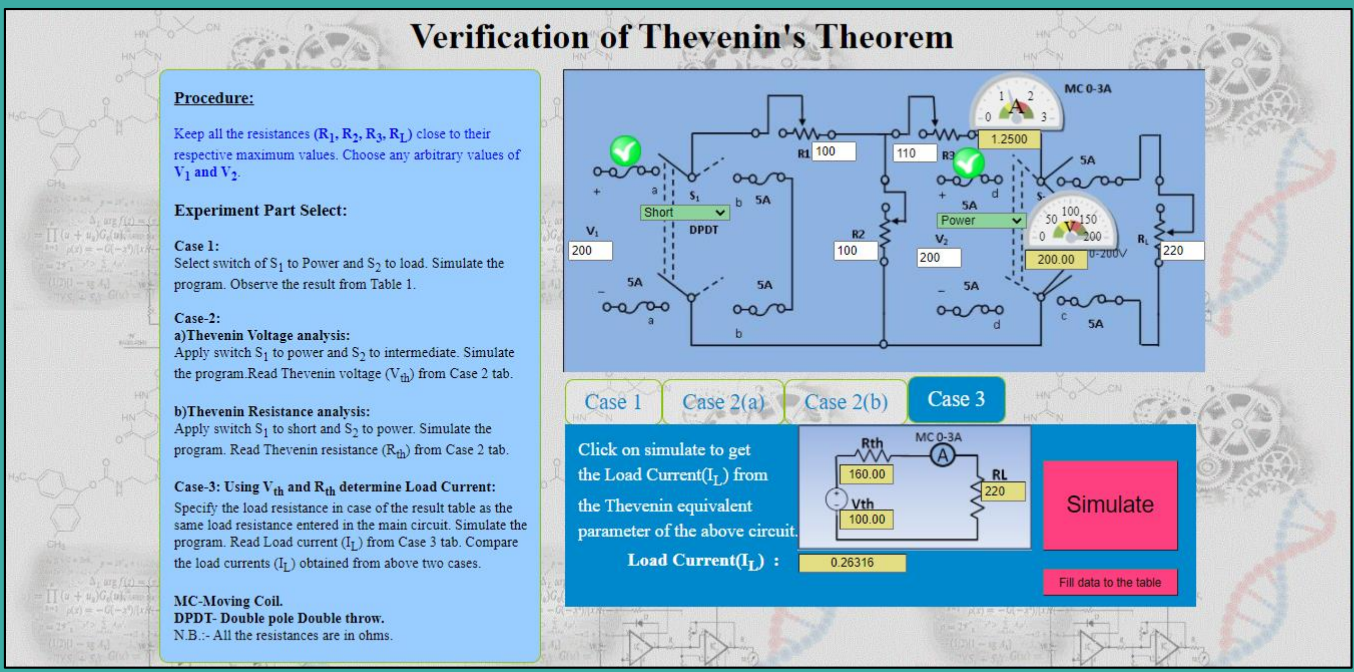
Part 2)

Aim: Verify Thevenin's and Norton's equivalent representations using Virtual Labs.

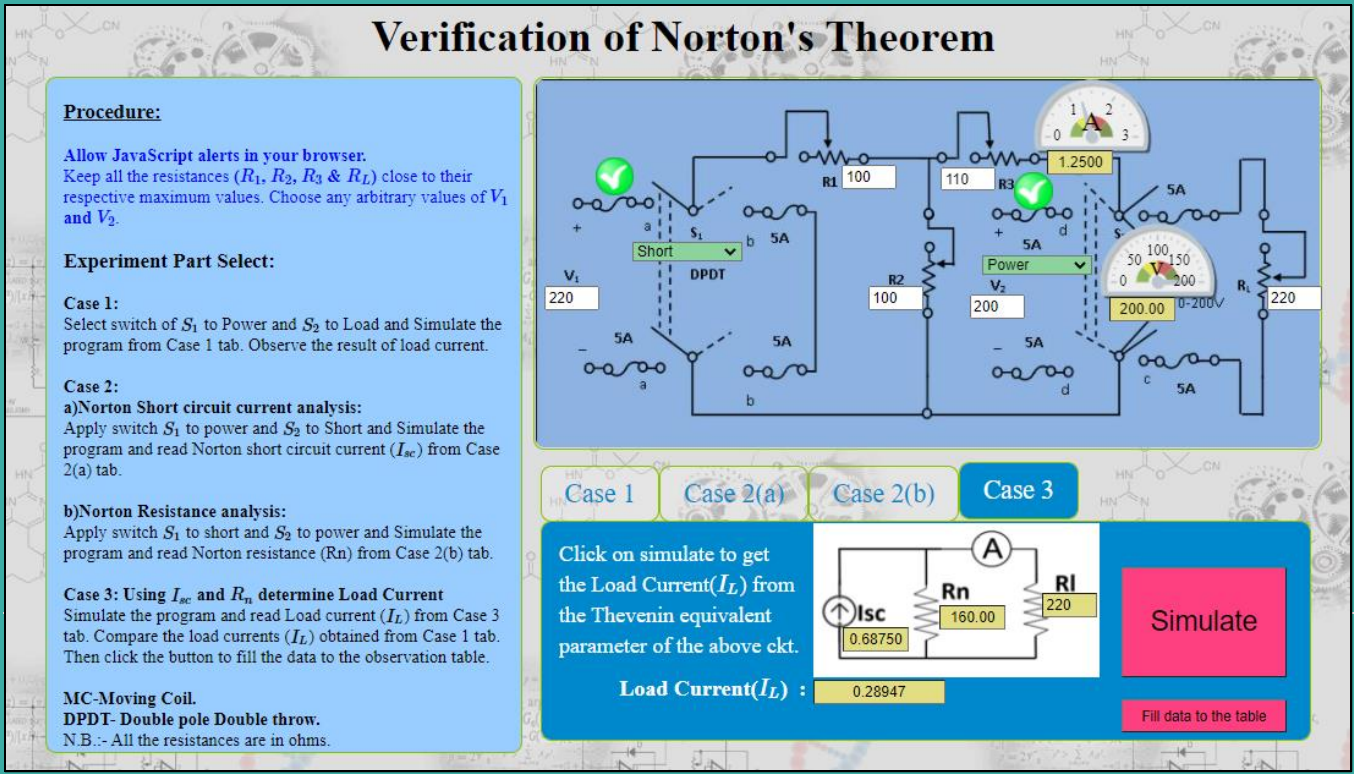
Material Required: Voltage Source, Multimeter, Resistors, wires, etc.

Virtual Lab Screenshots:

1) Verification of Thevenin's Theorem



2) Verification of Norton's Theorem



Observation Table:

1) For Thevenin's Theorem

Observation Table:

Serial no. of Observation	Load Current(I_L) from case 1	Load Voltage(V_L)	Load Resistance (R_L)=V_L/I_L	Thevenin Voltage(V_{th}) from case 2(a)	2nd Voltage source(v) for case 2(b)	Ammeter Reading(I) from case 2(b)	Thevenin Resistance R_{th}=V/I	Load current (I_L)=V_{th}/(R_{th}+R_L)
1st	0.26316	57.8952	220	100.00	200	1.2500	160.00	0.26316
2nd	0.38462	38.462	100	100.00	200	1.2500	160.00	0.38462
3rd	0.32258	48.3869999	150	100.00	200	1.2500	160.00	0.32258
4th	0.37037	40.7407	110	100.00	200	1.2500	160.00	0.37037
5th	0.35714	42.8568	120	100.00	200	1.2500	160.00	0.35714

2) For Norton's Theorem

Observation Table:

Serial no. of Observation	Load Current(I_L) from case 1	Load Voltage(V_L)	Load Resistance (R_L)=V_L/I_L	Norton current(I_{sc}) from case 2(a)	2nd Voltage source(v) from case 2(b)	Ammeter Reading(I) from case 2(b)	Norton Resistance R_n=V/I	Load current (I_L)=I_{sc}*R_n/(R_n+R_L)
1st	0.28947	63.683	220	0.68750	200	1.2500	160.00	0.28947
2nd	0.42308	42.308	100	0.68750	200	1.2500	160.00	0.42308
3rd	0.35484	53.226	150	0.68750	200	1.2500	160.00	0.35484
4th	0.40741	44.815	110	0.68750	200	1.2500	160.00	0.40741
5th	0.39286	47.143	120	0.68750	200	1.2500	160.00	0.39286

Observations/Results:

We can see that after implying the Thevenin's Theorem the Load Current is same in both Original Circuit and Thevenin Circuit, then we can say that Thevenin's theorem is applicable and justifiable from the above mentioned readings.

We can see that after implying the Norton's Theorem the Load Current is same in both Original Circuit and Norton Circuit, then we can say that Norton's theorem is applicable and justifiable from the above mentioned readings.

Applications:

For Thevenin's Theorem:

1) It is very useful for analyzing power systems and other circuits where on particular load resistor and recalculation of the circuit is essential with each trial value of load resistance, to find the voltage across it and current through it.
2) Source modelling and resistance measurement by using the Wheatstone bridge provide applications for thevenin's theorem.

For Norton's Theorem:

1) It is used to reduce a complex circuit into a simple circuit.
2) Norton's theorem is useful to solve problems on parallel generators with unequal emf's and unequal impedances.

Software/Tools Used: Virtual Labs (http://vlabs.iitkgp.ac.in/vlt/)

Source of applications:

https://www.iceeet.com/thevenin-theorem/

https://electricalinsider.com/nortons-theorem-dc-circuits-solved-examples/