23W-EC ENGR-11L-LEC-1 Module 2: Simple Resistive Networks

SANJIT SARDA

TOTAL POINTS

64 / 65

QUESTION 1

Superposition 15 pts

1.1 Sample Setup Image 1 / 1

✓ **- 0 pts** *Correct*

1.2 Theoretical Analysis 5 / 5

✓ **- 0 pts** *Correct*

- 4 pts Incorrect Values

- 5 pts Major analytical error

- 2 pts Slightly incorrect

- 5 pts Missing

1.3 Voltage and Current Measurement 5 / 6

✓ **- 0 pts** *Correct*

- 3 pts Partially Incorrect

- 6 pts Fully Incorrect

✓ **- 1 pts** *Small Mistake*

- 1 pts Multiple wrong values

+5 and -5 values has been interchanged

1.4 Discussion 3 / 3

✓ **- 0 pts** *Correct*

- 1 pts Slightly incorrect

- 3 pts Incorrect

QUESTION 2

Thevenin/Norton Equivalent 30 pts

2.1 Sample Setup Image 1 / 1

✓ **- 0 pts** *Correct*

- 1 pts Image Missing

2.2 Impedance Measurement 5 / 5

✓ **- 0 pts** *Correct*

- 1 pts Minor Mistake

- 5 pts Missing

2.3 Theoretical Analysis 6 / 6

✓ **- 0 pts** *Correct*

- 1 pts Minor Mistake

- 2 pts Minor Mistake

- 3 pts Major Mistake

- 6 pts Missing

2.4 Voltage and Eq. Resistance in Original Circuit 6 / 6

✓ **- 0 pts** *Correct*

- 1 pts Minor Mistake

- 2 pts Minor Mistake

- 3 pts Major Mistake

- 6 pts Missing

2.5 Voltage in Thevenin Equivalent Circuit 6 / 6

- ✓ **- 0 pts** *Correct*
- **- 1 pts** Minor Mistake
- **- 2 pts** Minor Mistake
- **- 3 pts** Major Mistake

2.6 Discussion 1 3 / 3

- ✓ **- 0 pts** *Correct*
- **- 1 pts** Minor Mistake
- **- 2 pts** Wrong Interpretation.
- **- 3 pts** Missing

2.7 Discussion 2 3 / 3

- ✓ **- 0 pts** *Correct*
- **- 1 pts** Minor Mistake
- **- 2 pts** Wrong Interpretation
- **- 3 pts** Missing

QUESTION 3

Wheatstone Bridge 20 pts

3.1 Sample Setup Image 1 / 1

- ✓ **- 0 pts** *Correct*
- **- 1 pts** Missing

3.2 Theoretical Derivation of Output Voltage 6 / 6

- ✓ **- 0 pts** *Correct*
- **- 6 pts** Incorrect
- **- 6 pts** Missing
- **- 3 pts** Partially wrong
- **- 2 pts** Final ratio not given

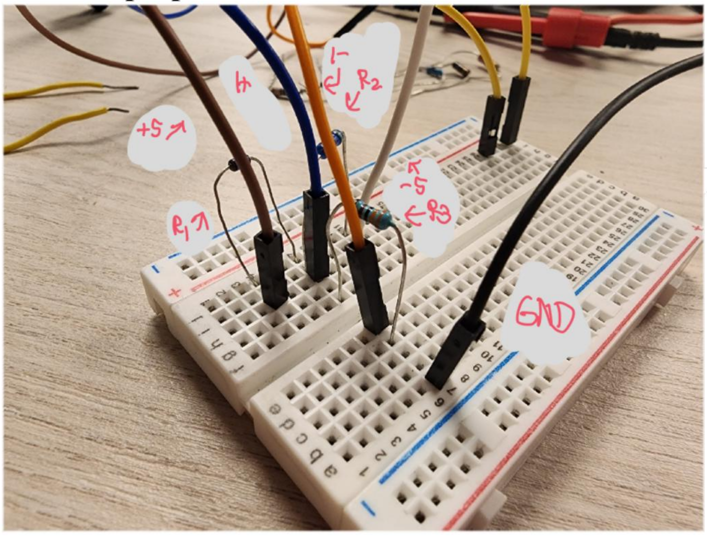
3.3 Wheatstone Bridge Resistor Values 10 / 10

- ✓ **- 0 pts** *Correct*
- **- 2 pts** Slightly incorrect
- **- 10 pts** Missing
- **- 5 pts** Partial answer
- **- 5 pts** Partially incorrect
- **- 7 pts** Major value mismatch
- **- 3 pts** Values interchanged

3.4 Discussion 3 / 3

- ✓ **- 0 pts** *Correct*
- **- 2 pts** Partially wrong
- **- 3 pts** Missing
- **- 1 pts** Minor mistake
- **- 1 pts** Partial explanation

1. Superposition



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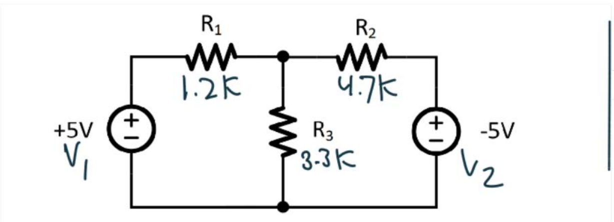
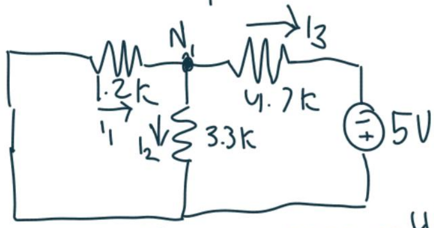


Without V_1



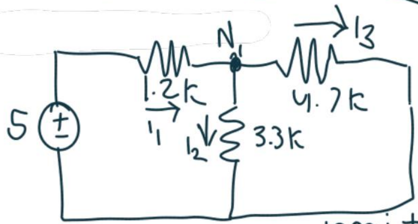
$I_1 = I_2 + I_3$, $5 + 3300 I_2 = 4700 I_3$

$3300 I_2 = 1200 I_1$

$\therefore$ Solving, $I_2 = -0.000239$

$V_{3.3k} = -0.7885$ V

Without V_2



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$\therefore$ Solving, $I_2 = 0.000936$ A

$V_{3.3k} = 3.08841$ V

Combined

$V_{3.3k} = 2.29988$ V

Observed Results:

Sources	R3 Voltage	%E	R3 Current (Computed)
+5V only	-0.792V	.44%	0.00024A
-5V only	3.08V	.26%	0.00093A
Sum of above	2.288V	.52%	0.00069A
Both sources	2.296V	.35%	0.00070A

Discussion

- How did the theoretical results compare with experimental values?

The theoretical values were all within ±1%, thus showing that the experimental values hold with the theoretical values.

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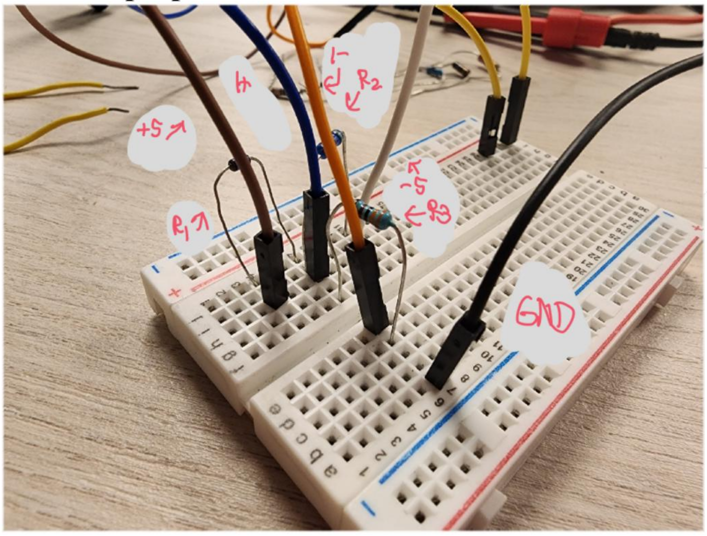

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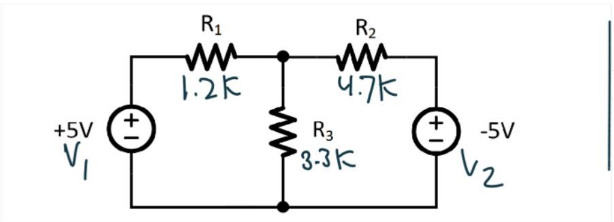

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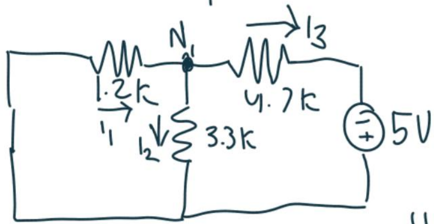

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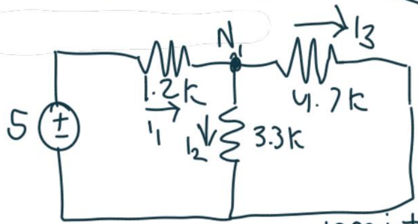

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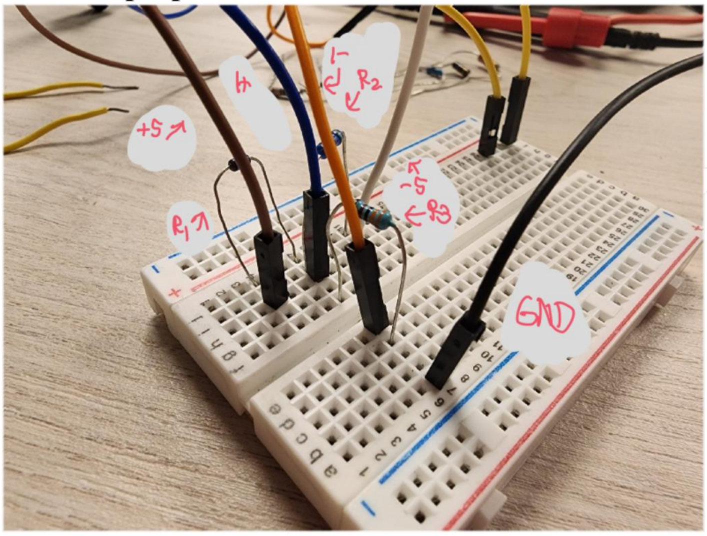

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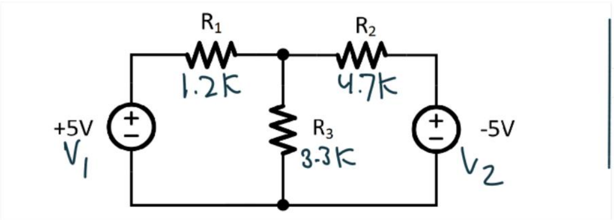

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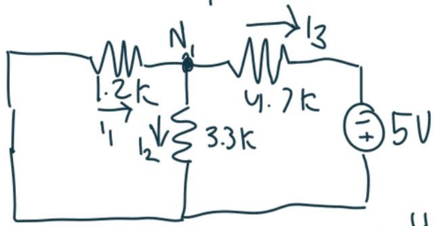

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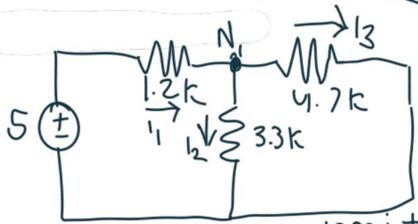

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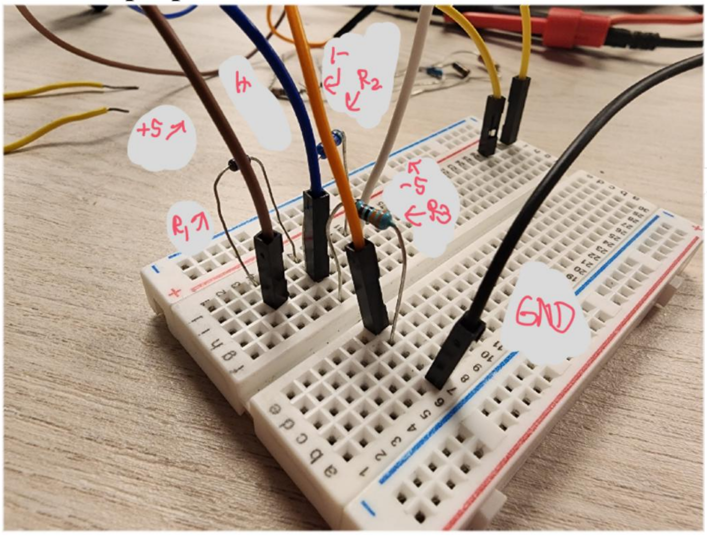

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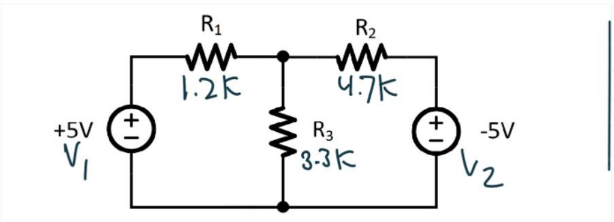

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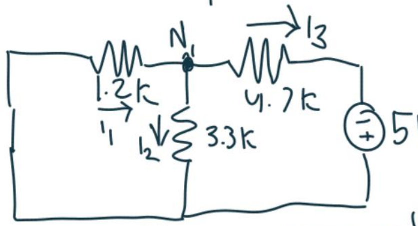

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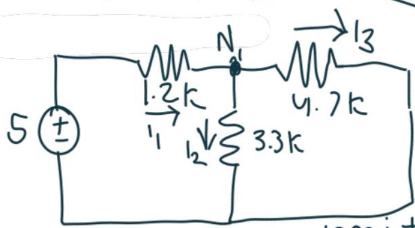

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1.4 Discussion **3 / 3**

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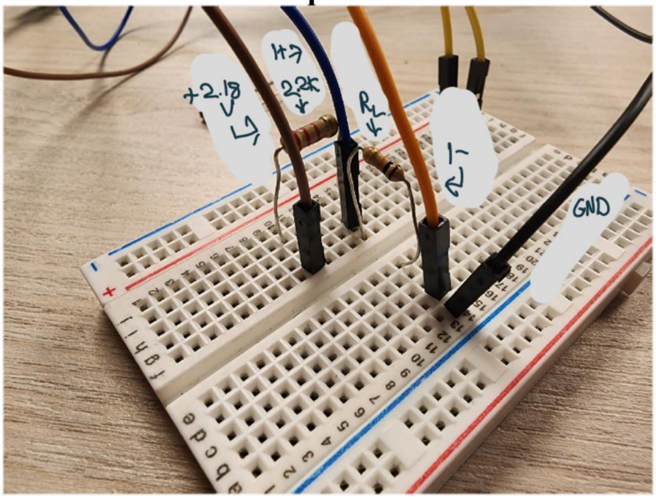
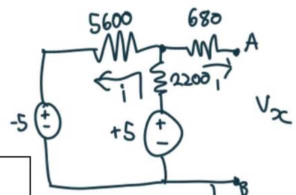
2. Thevenin/Norton Equivalent



Impedance Measurement

Theoretical Resistance (Ω)	Measured Resistance (Ω)
$R_1 = 5.6k\Omega$	5601 Ω
$R_2 = 680\Omega$	67.5 Ω
$R_3 = 2.2k\Omega$	2164 Ω

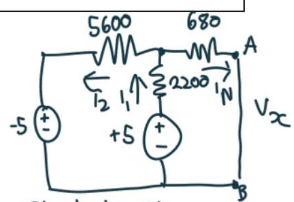


Open Circuit

$5 - -5 = 5600i + 2200i$

$\therefore 10 = i/780$

$\therefore AB = 5 - 2200i = 2.18V$



Short circuit

$5 - -5 = 5600 I_2 + 2200 I_1$

$I_1 = I_2 + I_N$

$5 = 2200 I_1 + 680 I_N$

Solving for I_N,

$I_N = 0.000965A$

$\therefore R_{eq} = \frac{V_{TH}}{I_N} = 2259.07\Omega$

≈ 2200 Ω which is what i will use

Theoretical Analysis:

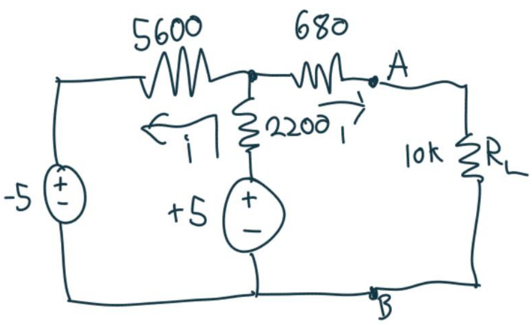
V_{TH}, V	I_N, mA	$R_{TH/N}$, Ω
2.18 V	0.000965A	2259.07Ω

Practical Open Circuit Voltage, Equivalent Resistance in Original Circuit:

V_{OC}, V	I_{SC}, mA	R_{eq}, Ω
2.2 V	0.000983A	2238 Ω

Practical Observations in Thevenin Equivalent Circuit:

Voltage across Load Resistor	1.798V	1.789V
	Eq	Original

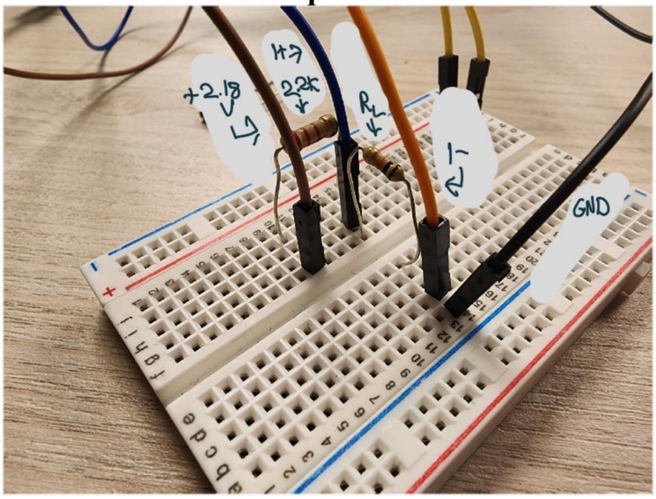


2.1 Sample Setup Image **1 / 1**

✓ **- 0 pts** *Correct*

- 1 pts Image Missing

2. Thevenin/Norton Equivalent



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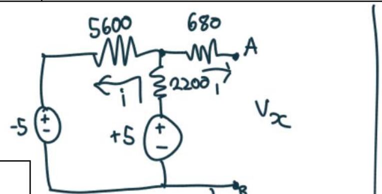

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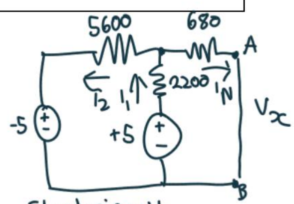

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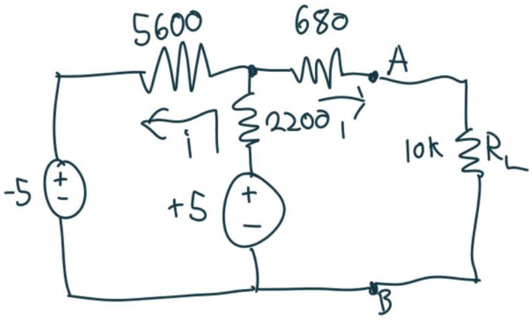

2.2 Impedance Measurement **5 / 5**

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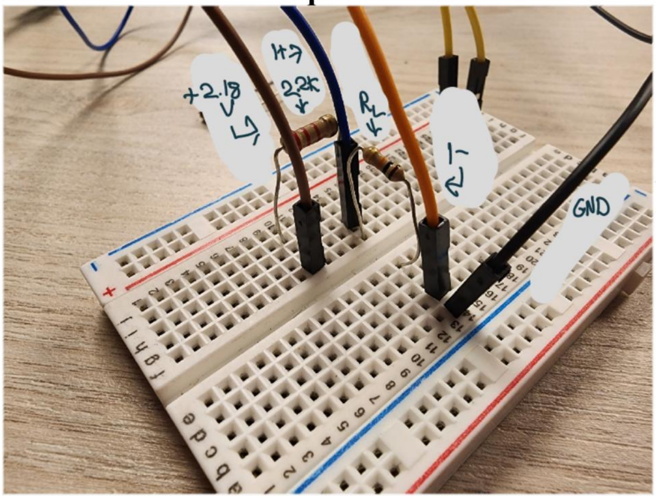
2. Thevenin/Norton Equivalent



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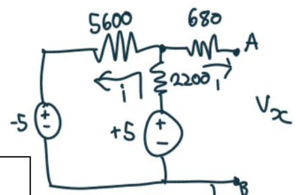

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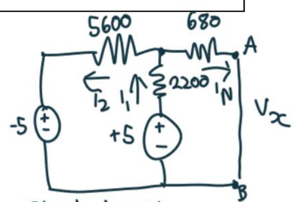

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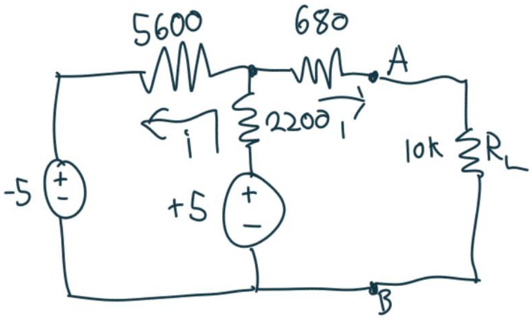

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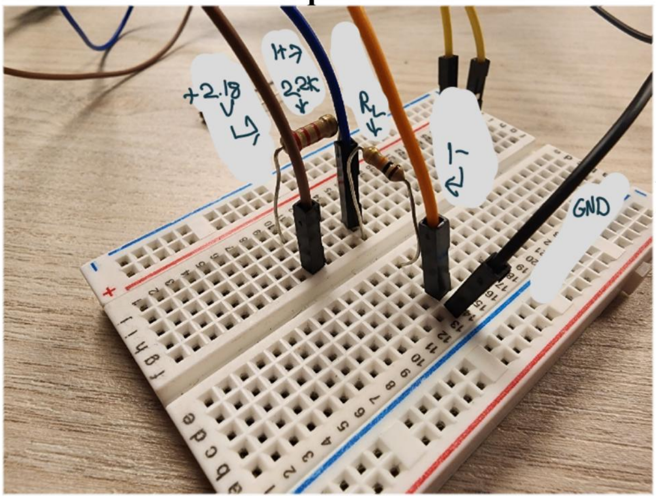

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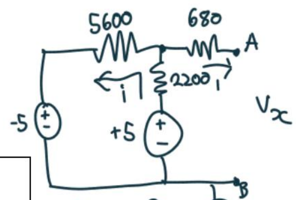

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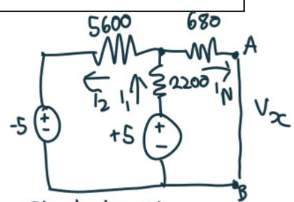

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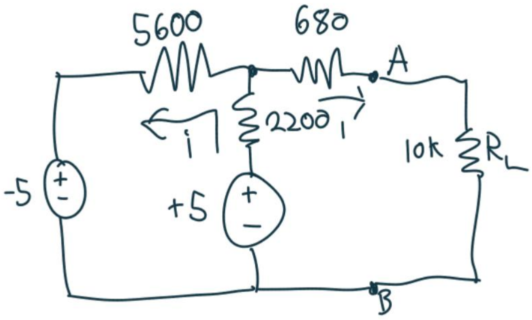

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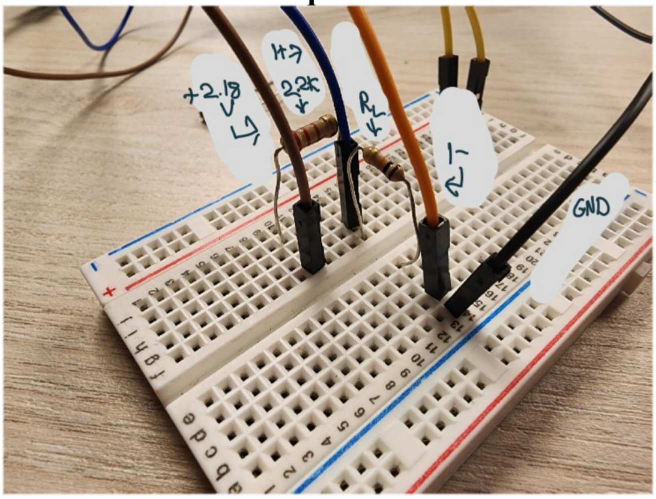

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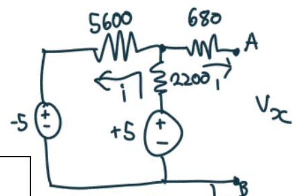

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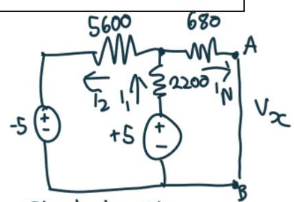

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$5 - -5 = 5600 I_2 + 2200 I_1$

$I_1 = I_2 + I_N$

$5 = 2200 I_1 + 680 I_N$

Solving for I_N,

$I_N = 0.000965A$

$\therefore R_{eq} = \frac{V_{TH}}{I_N} = 2259.07\Omega$

≈ 2200 Ω which is what i will use

Theoretical Analysis:

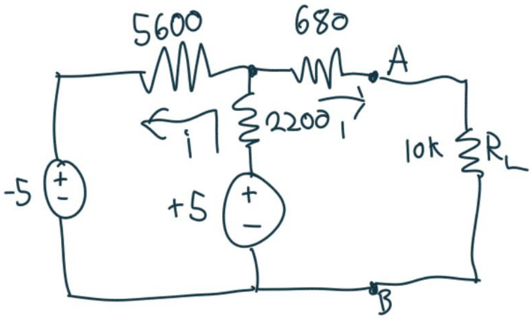
V_{TH}, V	I_N, mA	$R_{TH/N}$, Ω
2.18 V	0.000965A	2259.07Ω

Practical Open Circuit Voltage, Equivalent Resistance in Original Circuit:

V_{OC}, V	I_{SC}, mA	R_{eq}, Ω
2.2 V	0.000983A	2238Ω

Practical Observations in Thevenin Equivalent Circuit:

Voltage across Load Resistor	1.798V	1.789V
	Eq	Original



2.5 Voltage in Thevenin Equivalent Circuit **6 / 6**

- ✓ **- 0 pts** *Correct*
- **- 1 pts** Minor Mistake
- **- 2 pts** Minor Mistake
- **- 3 pts** Major Mistake

Discussion

- How did the voltage across the load compare between the original circuit and Thevenin equivalent circuit?

The original circuit had a V_{drop} of 1.789, vs the Thevenin Eq had a V_{drop} of 1.798V, this equates to a % Error of 0.5%, which is acceptable. Additionally, the theoretical Voltage Drop would equate to $\frac{2.18}{2200+10000} \cdot 10000 = 1.786V$

which is also within an acceptable tolerance.

- If our goal is to achieve maximum power dissipation across the load resistance, what load is the best choice? How does this value compare with the Thevenin equivalent resistance?

To achieve Power dissipation, we want to maximize $P = IV$. $\therefore$ For a Load R_L,

Power = $\left(\frac{2.18}{2200+R_L}\right) \cdot \left(\frac{2.18R_L}{2200+R_L}\right) = \left(\frac{2.18}{2200+R_L}\right)^2 R_L$

$\therefore$ Maximizing R_L, $R_L = 2200 = R_{eq}$

$\therefore$ To maximize the Power dissipation, use R_L such $R_L = R_{eq}$

2.6 Discussion 1 **3 / 3**

✓ **- 0 pts** *Correct*

- 1 pts Minor Mistake

- 2 pts Wrong Interpretation.

- 3 pts Missing

Discussion

- How did the voltage across the load compare between the original circuit and Thevenin equivalent circuit?

The original circuit had a V_{drop} of 1.789, Vs the Thevenin Eq had a V_{drop} of 1.798V, this equates to a % Error of 0.5%, which is acceptable. Additionally, the theoretical Voltage Drop would equate to $\frac{2.18}{2200+10000} \cdot 10000 = 1.786V$

which is also within an acceptable tolerance.

- If our goal is to achieve maximum power dissipation across the load resistance, what load is the best choice? How does this value compare with the Thevenin equivalent resistance?

To acheive Power dissipation, we want to maximize $P = IV$. ∴ For a Load R_L,

Power $= \left(\frac{2.18}{2200+R_L}\right) \cdot \left(\frac{2.18R_L}{2200+R_L}\right) = \left(\frac{2.18}{2200+R_L}\right)^2 R_L$

∴ Maximizing R_L, $R_L = 2200 = R_{eq}$

∴ To maximize the Power dissipation, use R_L such $R_L = R_{eq}$

2.7 Discussion 2 **3 / 3**

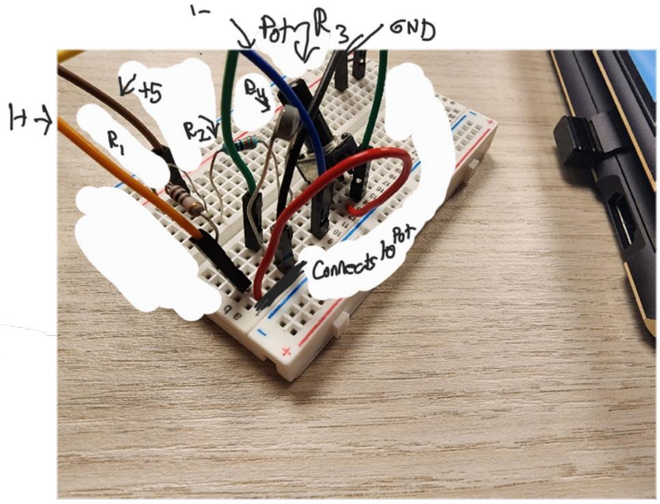
✓ **- 0 pts** *Correct*

- 1 pts Minor Mistake

- 2 pts Wrong Interpretation

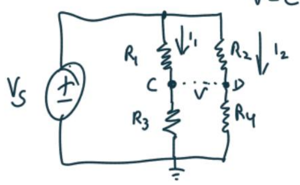
- 3 pts Missing

3. Wheatstone Bridge



- Derive the expression for the voltage 'V' across Wheatstone bridge in terms of resistance values.

$V = C - D$



$$I_1 = \frac{V_s}{R_1 + R_3} \qquad I_2 = \frac{V_s}{R_2 + R_4}$$

$$V_{R_1} = \frac{V_s}{R_1 + R_3} R_1 = V_s - \frac{V_s}{R_1 + R_3} R_3$$

$$V_{R_2} = \frac{V_s}{R_2 + R_4} R_2 = V_s - \frac{V_s R_2}{R_2 + R_4}$$

$$\therefore C = \frac{V_s R_3}{R_1 + R_3}$$

$$D = \frac{V_s R_2}{R_2 + R_4}$$

$$\therefore V = C - D = V_s \left(\frac{R_3}{R_1 + R_3} - \frac{R_2}{R_2 + R_4} \right)$$

$$V = 5 \left(\frac{R_3}{R_1 + R_3} - \frac{R_2}{R_2 + R_4} \right)$$

- What are the resistance values obtained for the Wheatstone bridge?

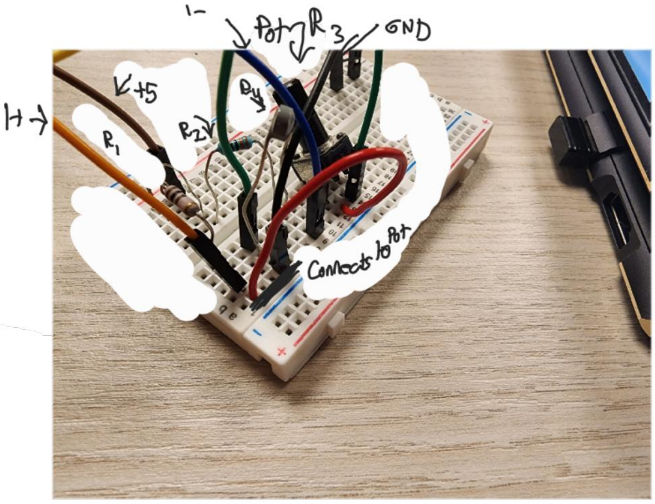
$R_1 = 5600\ \Omega$
$R_2 = 3300\ \Omega$
$R_3 = 1680\ \Omega$ Potentiometer

3.1 Sample Setup Image **1 / 1**

✓ **- 0 pts** *Correct*

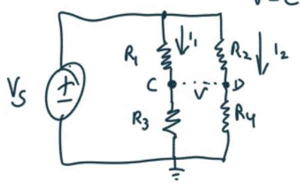
- 1 pts Missing

3. Wheatstone Bridge



- Derive the expression for the voltage 'V' across Wheatstone bridge in terms of resistance values.

$V = C - D$



$$I_1 = \frac{V_S}{R_1 + R_3} \qquad I_2 = \frac{V_S}{R_2 + R_4}$$

$$V_{R_1} = \frac{V_S}{R_1 + R_3} R_1 = V_S - \frac{V_S}{R_1 + R_3} R_3$$

$$V_{R_2} = \frac{V_S}{R_2 + R_4} R_2 = V_S - \frac{V_S R_2}{R_2 + R_4}$$

$$\therefore C = \frac{V_S R_3}{R_1 + R_3}$$

$$D = \frac{V_S R_2}{R_2 + R_4}$$

$$\therefore V = C - D = V_S\left(\frac{R_3}{R_1 + R_3} - \frac{R_2}{R_2 + R_4}\right)$$

$$V = 5\left(\frac{R_3}{R_1 + R_3} - \frac{R_2}{R_2 + R_4}\right)$$

- What are the resistance values obtained for the Wheatstone bridge?

$R_1 = 5600\ \Omega$

$R_2 = 3300\ \Omega$

$R_3 = 1680\ \Omega$ Potentiometer

3.2 Theoretical Derivation of Output Voltage **6 / 6**

✓ **- 0 pts** *Correct*

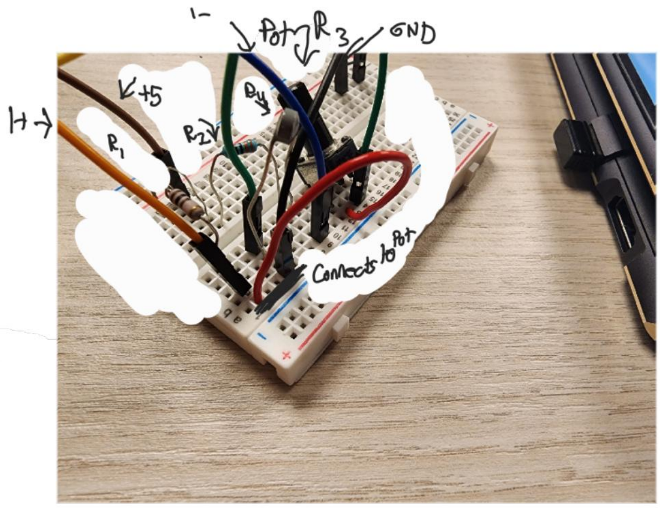
- 6 pts Incorrect

- 6 pts Missing

- 3 pts Partially wrong

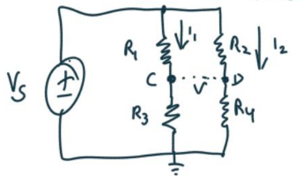
- 2 pts Final ratio not given

3. Wheatstone Bridge



- Derive the expression for the voltage ‘V’ across Wheatstone bridge in terms of resistance values.

$V = C - D$



$$I_1 = \frac{V_S}{R_1 + R_3} \qquad I_2 = \frac{V_S}{R_2 + R_4}$$

$$V_{R_1} = \frac{V_S}{R_1 + R_3} R_1 = V_S - \frac{V_S}{R_1 + R_3} R_3$$

$$V_{R_2} = \frac{V_S}{R_2 + R_4} R_2 = V_S - \frac{V_S R_2}{R_2 + R_4}$$

$$\therefore C = \frac{V_S R_3}{R_1 + R_3}$$

$$D = \frac{V_S R_2}{R_2 + R_4}$$

$$\therefore V = C - D = V_S \left(\frac{R_3}{R_1 + R_3} - \frac{R_2}{R_2 + R_4} \right)$$

$$V = 5 \left(\frac{R_3}{R_1 + R_3} - \frac{R_2}{R_2 + R_4} \right)$$

- What are the resistance values obtained for the Wheatstone bridge?

$R_1 = 5600\ \Omega$
$R_2 = 3300\ \Omega$
$R_3 = 1680\ \Omega$

Potentiometer

3.3 Wheatstone Bridge Resistor Values **10 / 10**

✓ **- 0 pts** *Correct*

- **- 2 pts** Slightly incorrect
- **- 10 pts** Missing
- **- 5 pts** Partial answer
- **- 5 pts** Partially incorrect
- **- 7 pts** Major value mismatch
- **- 3 pts** Values interchanged

Discussion

- The light sensing circuit built earlier was susceptible to input voltage change, and was also biased away from zero. Both characteristics are not desirable in general. How does the temperature sensing circuit employing Wheatstone bridge compare?

For the V_{Drop} on a voltage divider to be near 0, the Ref voltage would need to be much larger than the $R_{measured}$. This is also bad, because if you calculate the error propagation, this will be much larger. On the other hand a Wheatstone bridge performs much better. The wheatstone bridge is not biased against 0. At its natural state it is @0, otherwise it increases or decreases the potential difference.

3.4 Discussion **3 / 3**

- ✓ **- 0 pts** *Correct*
- **- 2 pts** Partially wrong
- **- 3 pts** Missing
- **- 1 pts** Minor mistake
- **- 1 pts** Partial explanation

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Experiment 2: Simple Resistive Networks

ECE11L Lab

Instructor: Sudhakar Pamarti