EEM076 Lab1

Group Number 16

Albin Boklund, Samuel Runmark Thunell

April 25, 2023

1 Measuring currents

1.1 Calculations

Calculate the currents I_1 and I_2 in *Figure 1*.

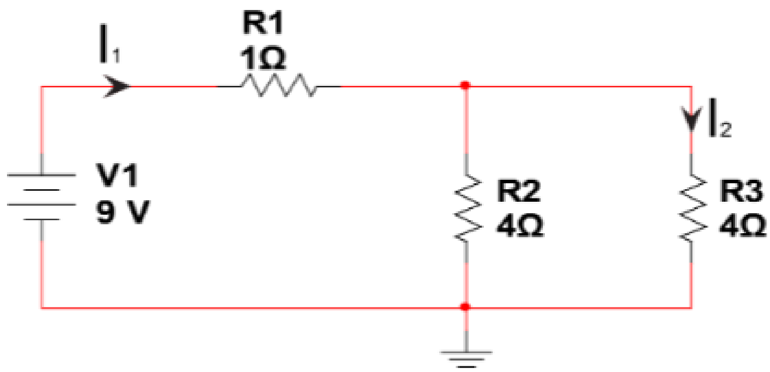
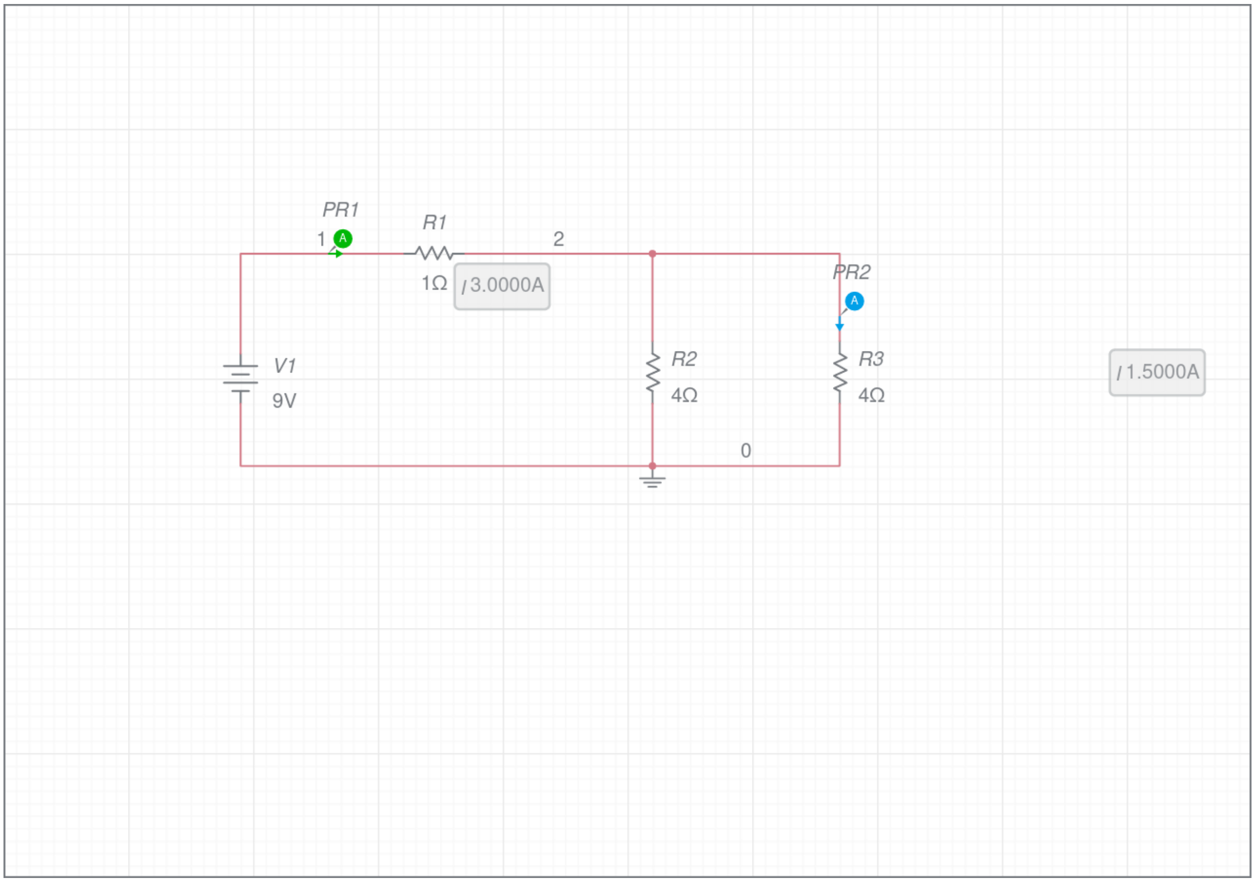


Figure 1. The first circuit to analyze. It consists of a DC voltage source and resistors.

The value of I_1 can be calculated using $V = I * R$. This gives us $I_1 = \frac{V1}{R1} = \frac{9V}{3\Omega} = 3A$. Since the circuit is parallel the current will be distributed accordingly to the difference between R2 and R3. Since the difference is 0 the current will be divided equally (KCL). Giving us $I_2 = \frac{3A}{2} = 1.5A$

1.2 Circuit design and Simulation



2 Mesh analasys

2.1 Calculations

Calculate the currents I_1, I_2 and, I_3.

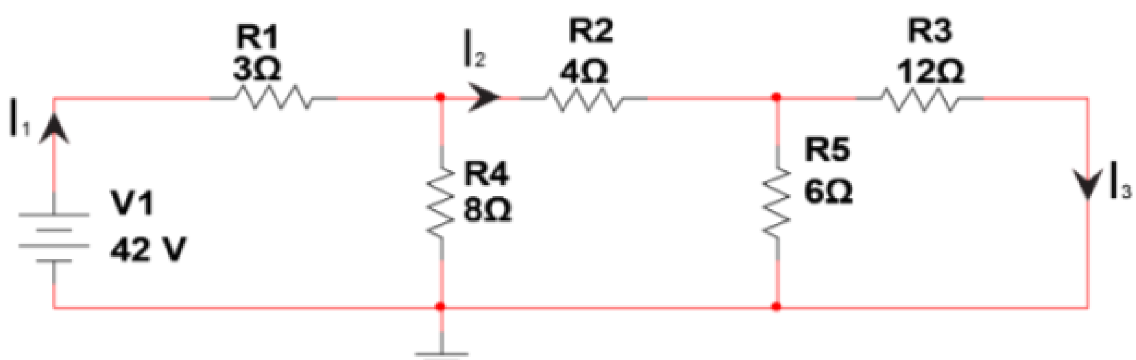
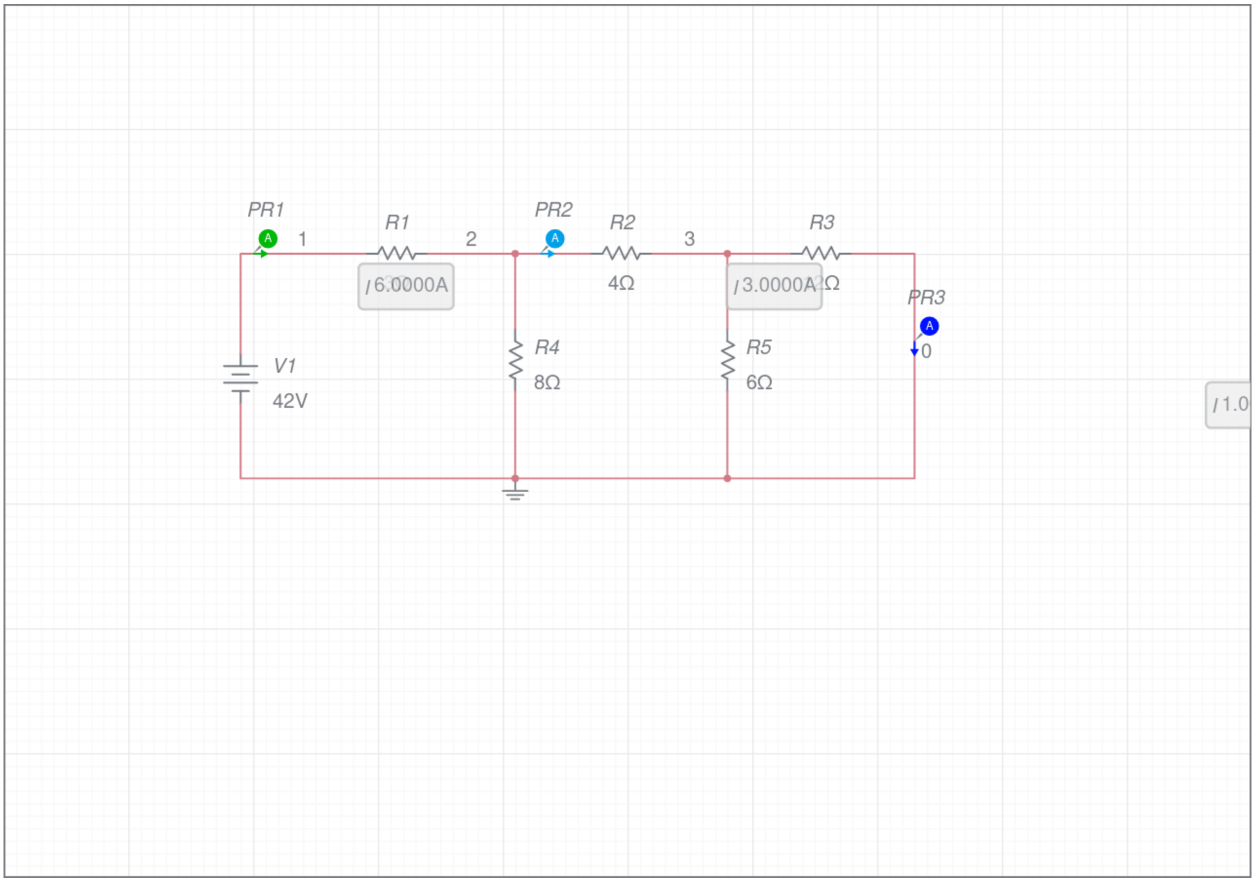


Figure 4. The circuit to simulate in Task 2 consists of three meshes.

We first simplified the circuit using resistor equivalence for parallel resistors and then also for serial resistors. This gives us $R235 = 8\Omega$. We know that the voltage will be 0 at the ground and using this information and KCL we get the following equation $42V = 3I_1 + 8(\frac{I_1}{2}) => 42 = 7I_1 => I_1 = \frac{42}{7} = 6A$.

Using $I_1 = 6A$ we can use KCL to calculate $I_2 = 3A$ and $I_3 = 1A$.

2.2 Circuit design and Simulation



3 The Superposition Principle

3.1 Calculations

Calculate the voltage V_x once when V1=0 V and I_s=2 A, then once when V1=42 V and Is=0 A. *Hint: A voltage source will become a short circuit when set to zero while a current source will become an open circuit.*

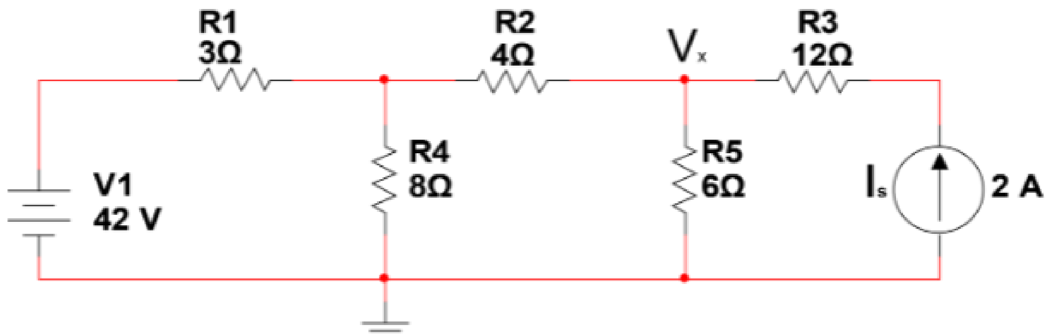


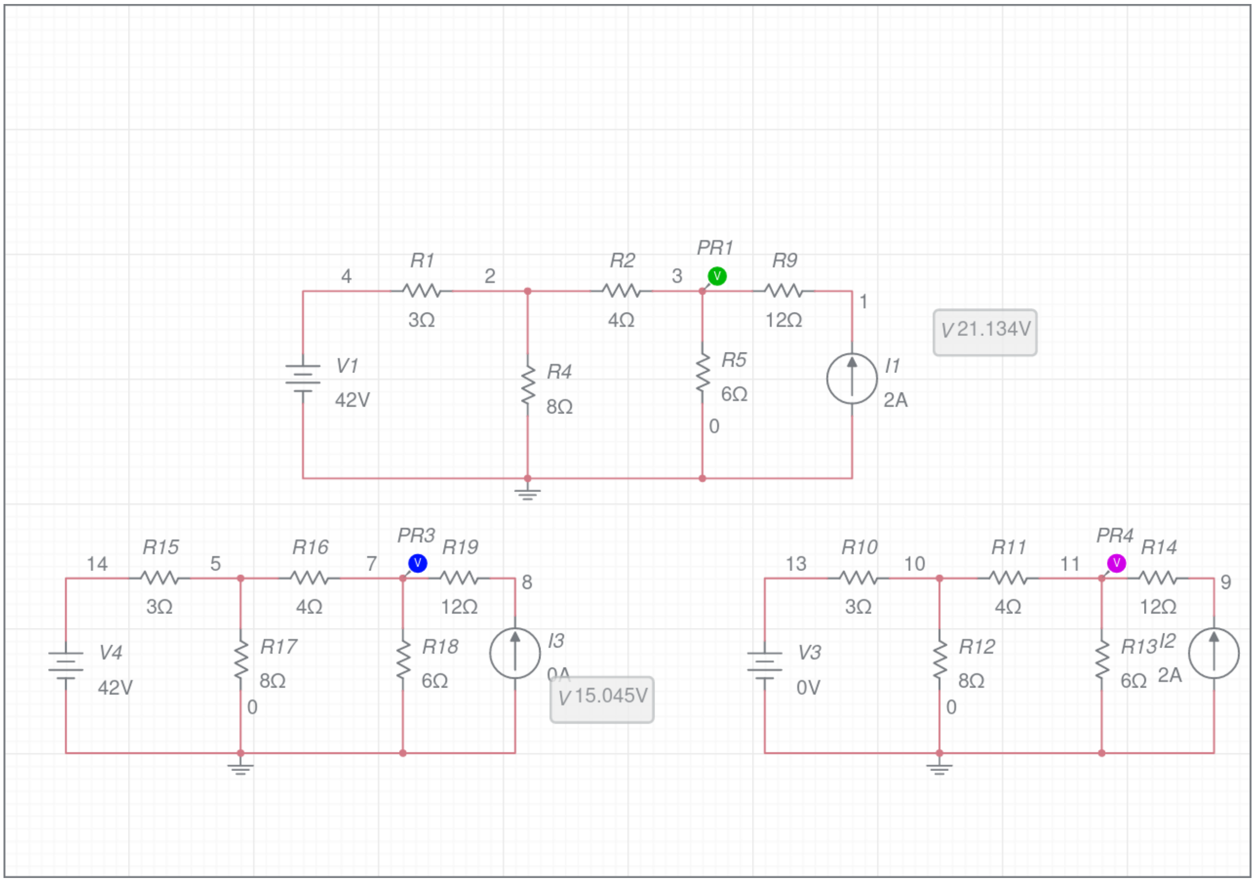
Figure 5. The circuit for Task 3 where the superposition principle is used.

In the open circuit we can remove $R3$ from the circuit. We then calculate the serial resistor equivalence of $R2$ and $R5$ which gives us $R25 = 10\Omega$. We then use parallel resistor equivalence between $R4$ and $R25$ which equals $R425 = \frac{40}{9}\Omega$ Using this resistor we can then calculate the voltage between $R1$ and $R425$ using voltage divider (we call this voltage $V2$): $V2 = \frac{\frac{40}{9}}{\frac{40}{9}+3} * 42 = \frac{1680}{67}V$. We can then return one step in the simplification and then use the same tactic to calculate $V_x = \frac{R5}{R2+R5} * V2 = \frac{6}{4+6} * \frac{1680}{67} \approx 15.04V$

In the short circuit we use parallel resistor equivalence between $R1$ and $R4$, then serial resistor equivalence of $R14$ and $R2$ and then another parallel resistor equivalence between $R142$ and $R5$ which results $R1425 = \frac{204}{67}\Omega$. The highest voltage of the circuit can then be calculated to $V_{tot} = 2A*(12+\frac{204}{67})$ Using voltage divider we can get $V_x = \frac{R1425}{R3+R1425}*V_{tot} = \frac{\frac{204}{67}}{12+\frac{204}{67}}*2*(12+\frac{204}{67}) = 6.08955$

To get the correct V_x we add $V_{x_{Opencircuit}}$ and $V_{x_{Shortcircuit}}$ which gives $15.04+6.08955 = 21.12955V$

3.2 Circuit design and Simulation



4 Input and Output impedance

4.1 Calculations

4.1 Calculations

Calculate the gain $F = \frac{V_{out}}{V_{in}}$ given the circuit in *Figure 6*. Furthermore, calculate the Thévenin and Norton equivalent (V_{Th}, I_N, R_{Th}) and draw the equivalent circuits.

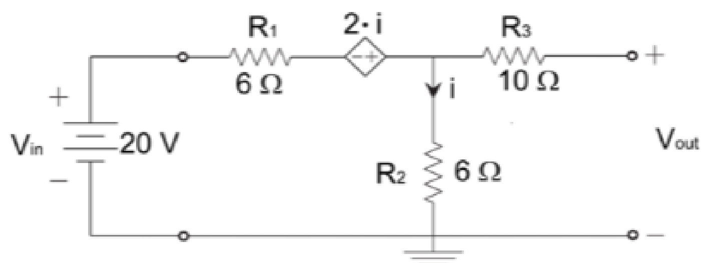


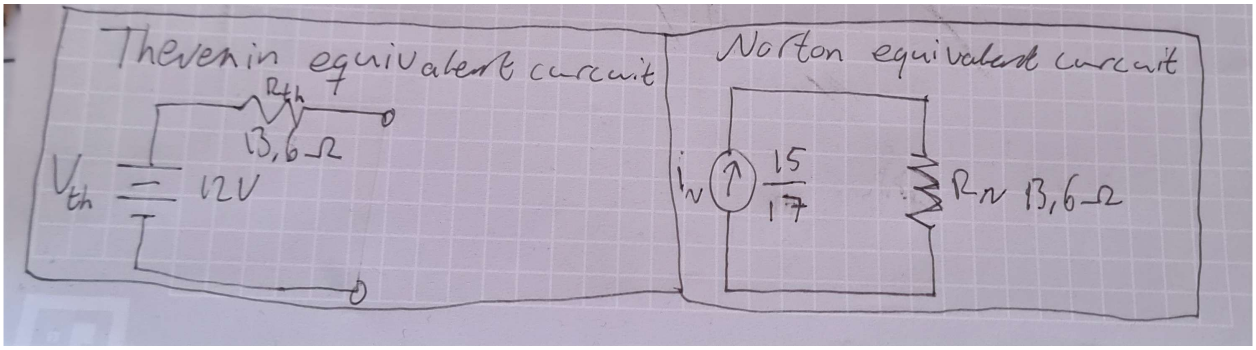
Figure 6. Amplifier circuit.

To start calculating the output voltage, we first need to calculate the current i if we want to count or dependent source. We start by rewriting the circuit as an open circuit, that means that we are left with only a loop, with V_{in}, R_1, R_2 and the dependent source. Then we use KVL to calculate $i \Rightarrow R_1 * i - 2i + R_2 * i = 20$. Which leaves us with $i = 2$. We can now calculate $V_{out} = i * R_2 = 2A * 6\Omega = 12V$. The gain of the circuit is therefore $F = \frac{V_{out}}{V_{in}} = \frac{12}{20} = 0.6$.

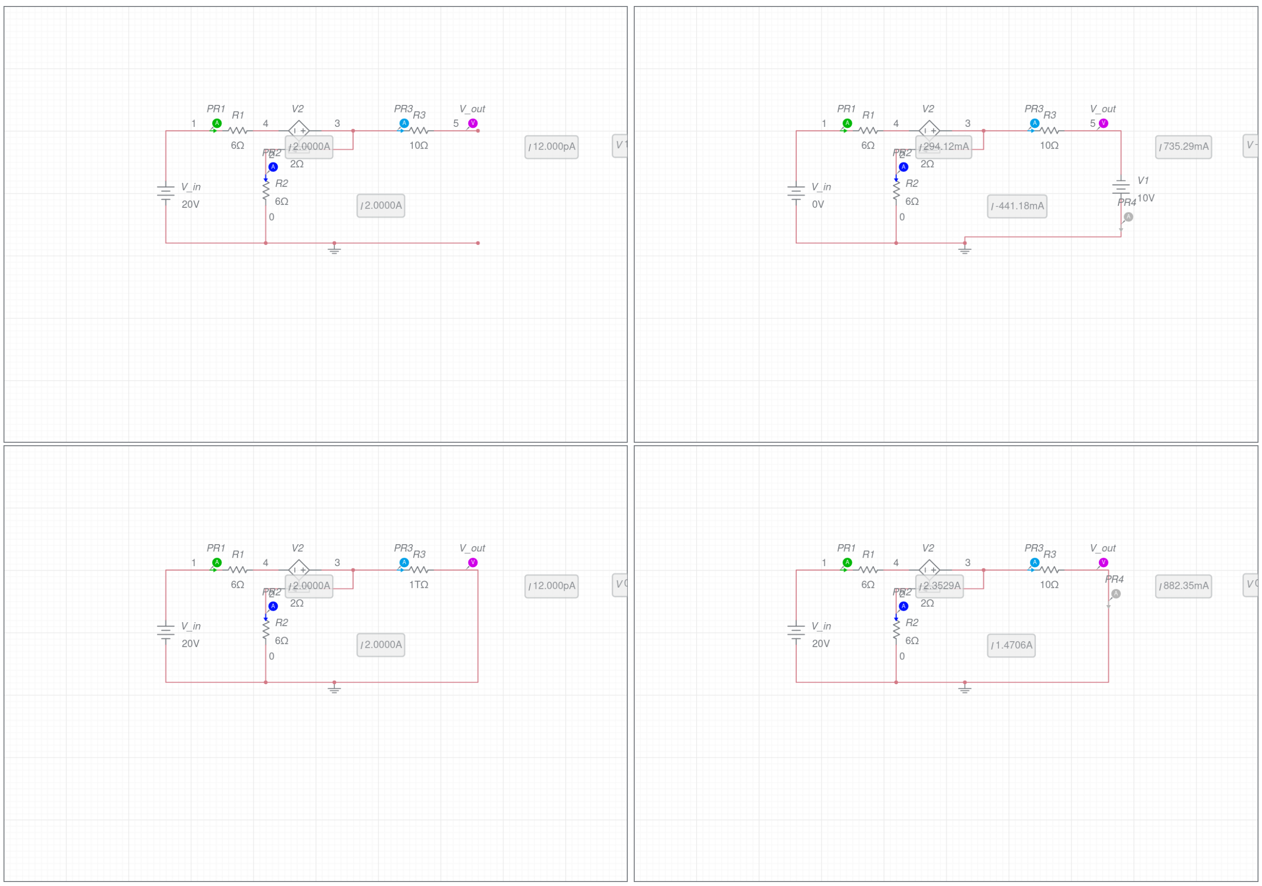
To calculate the Thévenin and Norton equivalent circuits we can start by rewriting it as a closed circuit. We can now define the currents over the resistors with their corresponding numbering. Using KVL on both loops and KCL at the junction right after the dependent source, we get three equations:

$$\begin{cases} -V_{in} + R_i * i_1 - 2 * i_2 + R_3 * i_3 = 0 \\ R_3 * i_3 = R_2 * i_2 \\ i_1 = i_2 + i_3 \end{cases}$$

Solving for i_3, we get $i_3 = \frac{15}{17}$ which is also our Norton current i_N.
We can now calculate R_{th} using $V_{th} = V_{out}$ and i_N.
$R_{th} = \frac{V_{th}}{i_N} = \frac{12}{\frac{15}{17}} = \frac{68}{5}$



4.2 Circuit design and Simulation



5 Maximal power from a voltage source

5.1 Calculations

Calculate the value of the load resistance R_L for which the maximum power is delivered to the output, V_{Th}=1 V and R_{Th}=50 Ω. *Hint: Express the output power as a function of R_L and find its maximum.*

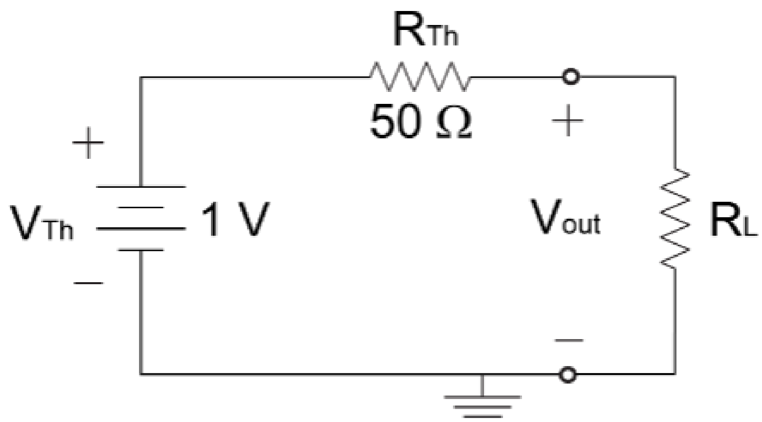
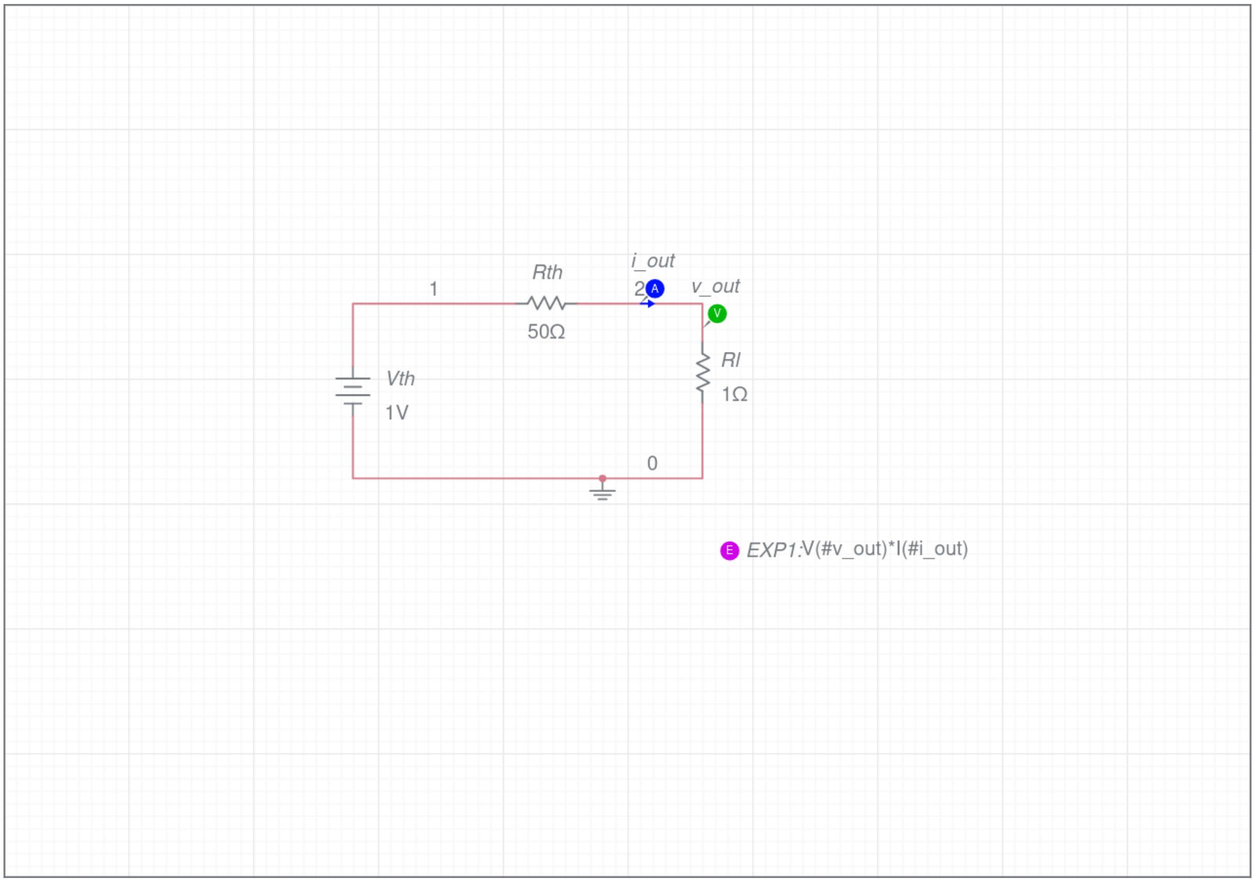
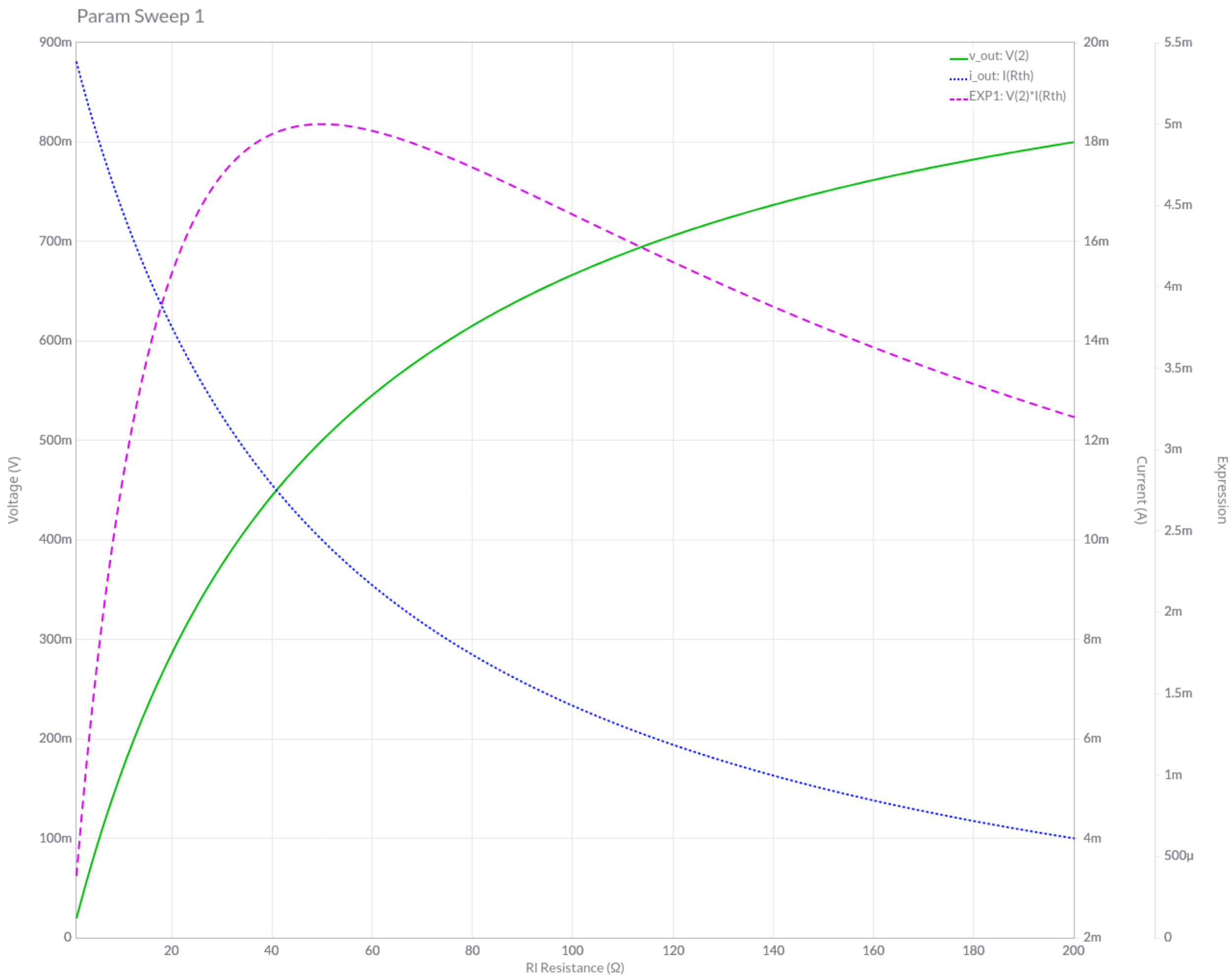


Figure 7. A Thevénin equivalent circuit delivering power to a load resistance R_L.

To get the Power (P) we use the formula $P = i * R$. We want to calculate the power over R_L so we use R_L as R. This gives us $(\frac{1}{50+R_L})^2 * R_L = \frac{R_L}{(50+R_L)^2}$. Simulating this in GeoGebra we get that the maximum power is $0.01W$ at $R_L = 50\Omega$. This is also supported by the maximum power theorem.

5.2 Circuit design and Simulation





Param Sweep 1
v_out: V(2)
i_out: I(Rth)
EXP1: V(2)*I(Rth)
Voltage (V)
Current (A)
Expression
Rl Resistance (Ω)
900m
800m
700m
600m
500m
400m
300m
200m
100m
0
20m
18m
16m
14m
12m
10m
8m
6m
4m
2m
5.5m
5m
4.5m
4m
3.5m
3m
2.5m
2m
1.5m
1m
500µ
0
20
40
60
80
100
120
140
160
180
200

6 Maximum power from a current source

6.1 Calculations

Calculate the output impedance of the circuit in *Figure 8* without any load resistance R_L (open circuit output) and draw the schematics of the Thevénin equivalent circuit. Specify the numerical values of V_{Th} and R_{Th} in your schematics.

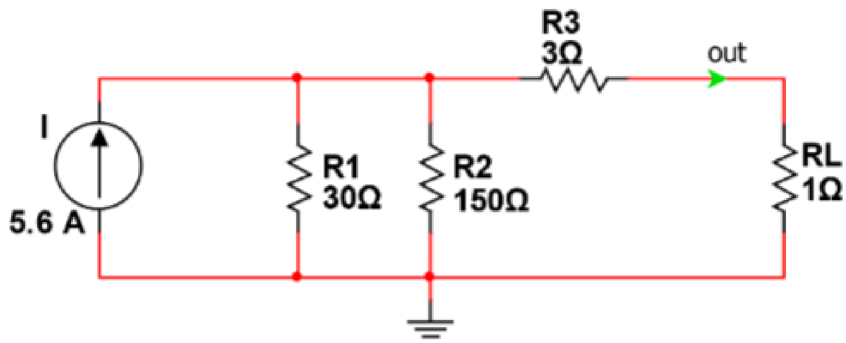


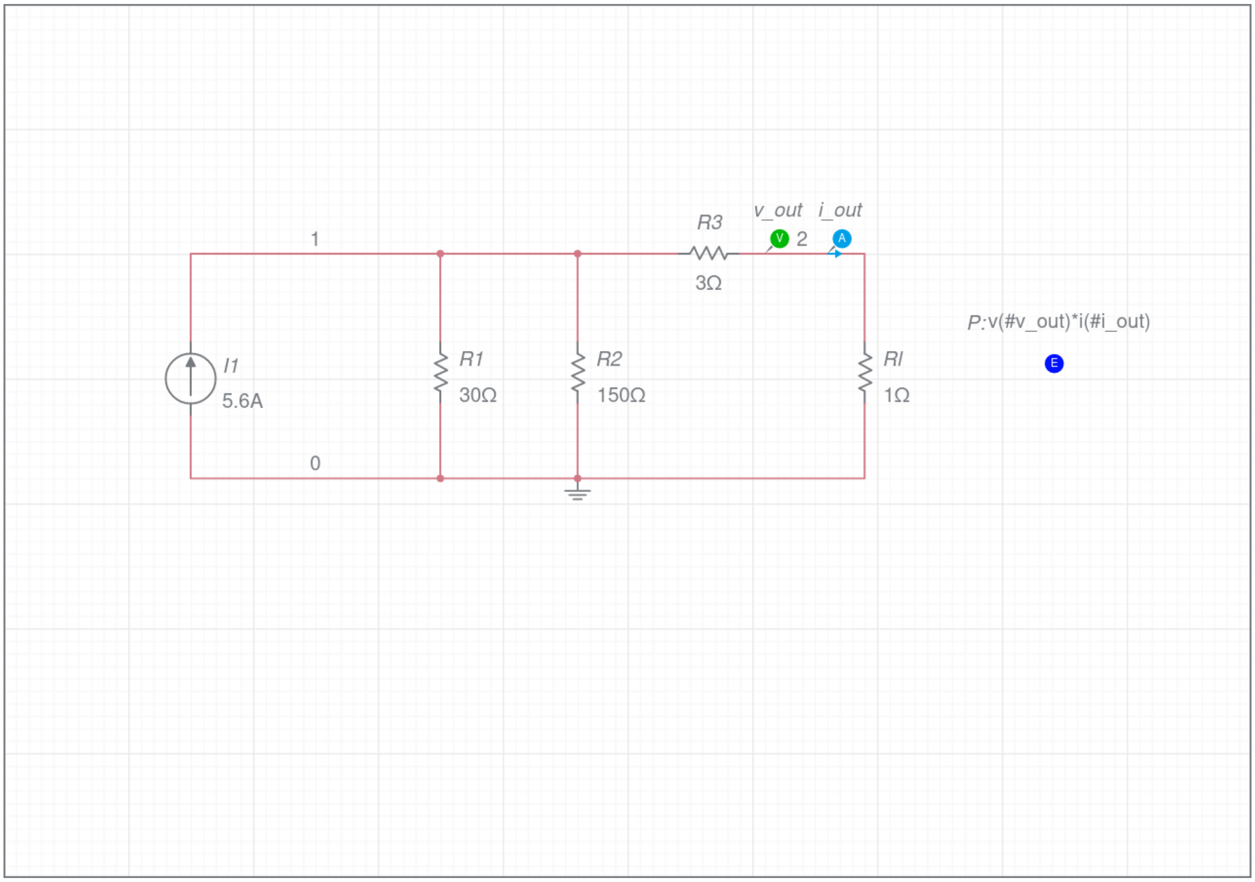
Figure 8. A loaded circuit that can be expressed with a Thevénin equivalent circuit and its load.

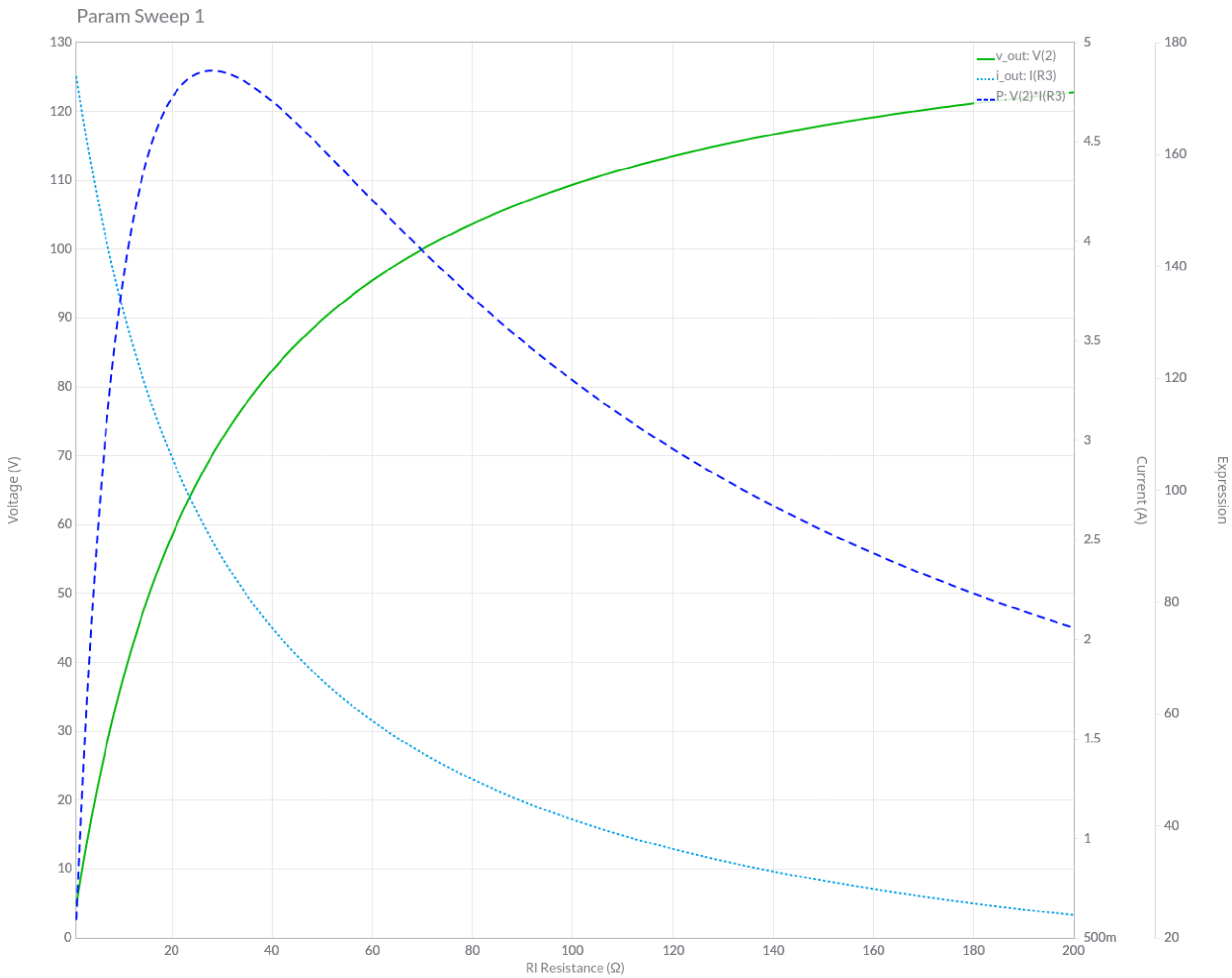
We started by calculating the Norton and Thévenin equivalent circuits of the given circuit. The first step was to calculate the Thévenin resistance by rewriting it as an open circuit by opening both the load resistance and the current source. We continue by combining the resistances into one equivalent. This turned out to be a single resistor with 28Ω. This means that $R_{th} = 28\Omega$.

The next step was to short the circuit to calculate the Thévenin voltage. We combine the two parallel resistors by $frac30\Omega * 150\Omega30\Omega + 150\Omega = 25\Omega$ The Thévenin voltage is therefore calculated by: $V_{th} = I * R = 5.6 * 25 = 140V$.

$R_N = 28\Omega$
$I_N = 5.6A$
$R_{th} = 28\Omega$
$V_{th} = 140V$

6.2 Circuit design and Simulation





Our calculations are supported by the simulation, we can see that we attain our max power at $R_L = 28\Omega$. Which we also calculated before.