

# Electrical Circuit Project

– Fundamentals of Electrical Engineering –

*Adina-Maria Amzărescu*

311CA, Faculty of Automatic Control and Computer Science  
University POLITEHNICA of Bucharest

adina.amzarescu@stud.acs.upb.ro

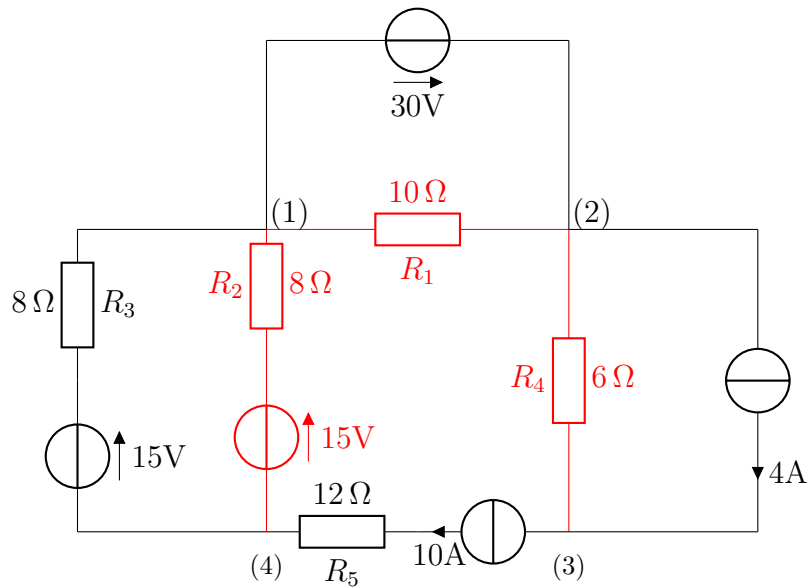
May 2021

## Table of contents

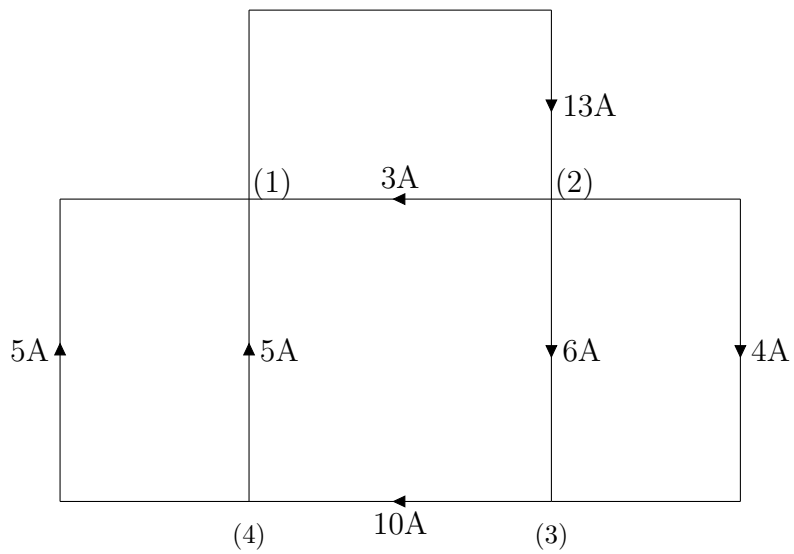
<b>1</b>	<b>The circuit</b>	<b>3</b>
<b>2</b>	<b>Efficient Systematic Methods</b>	<b>4</b>
<b>3</b>	<b>Equivalent Voltage/Current Generator</b>	<b>6</b>
3.1	Equivalent Generator's Characteristic . . . . .	6
3.2	Semiconductor diode . . . . .	10
<b>4</b>	<b>Dependent sources. Spice simulation of dependent sources circuits</b>	<b>11</b>
4.1	SUCU . . . . .	11
4.2	Diagram . . . . .	12
<b>5</b>	<b>Solving alternating current circuits using numerical software tools</b>	<b>13</b>

# 1 The circuit

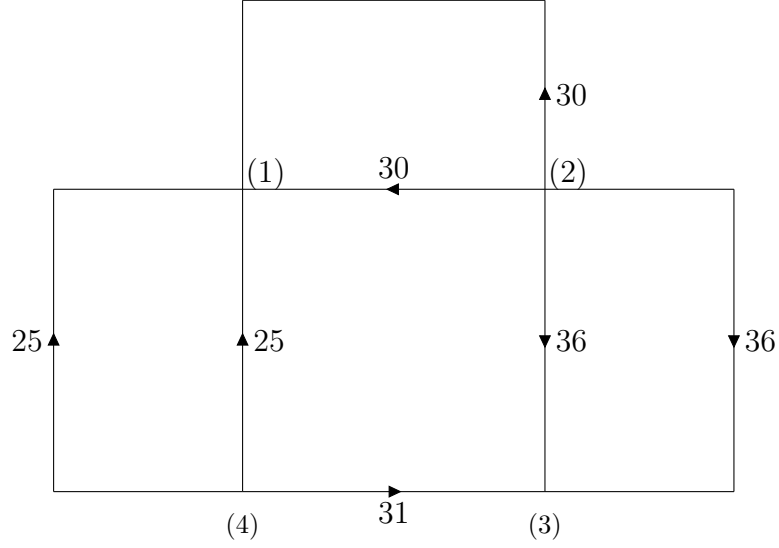
The circuit:



Electric current intensity graph:



Voltage graph:



## 2 Efficient Systematic Methods

Method	Number of equations
Kirchhoff classic	$2L = 14$
Kirchhoff's current law	$L - N + 1 = 4$
Kirchhoff's voltage law	$N - 1 = 3$
String current	$L - N + 1 - n_{SIC} = 3$
Tensions in branches	$N - 1 - n_{SIT} = 2$

In the above circuit, there are 4 nodes, marked with numbers from 1 to 4 and 7 sides. At the same time, in the circuit there are an ideal current source (SIC) and an ideal voltage source (SIT).

The tree has  $N-1 = 3$  branches, colored above with red, and  $N-1-n_{SIT} = 2$  sections.

The sections:

1. The first section is composed of:  $(1) \rightarrow (4)$  and  $(4) \rightarrow (3)$ ; branch:  $(4) \rightarrow (1)$ .
2. The second section is composed of:  $(3) \rightarrow (4)$  and  $(3) \rightarrow (2)$ ; branch:  $(3) \rightarrow (2)$ .

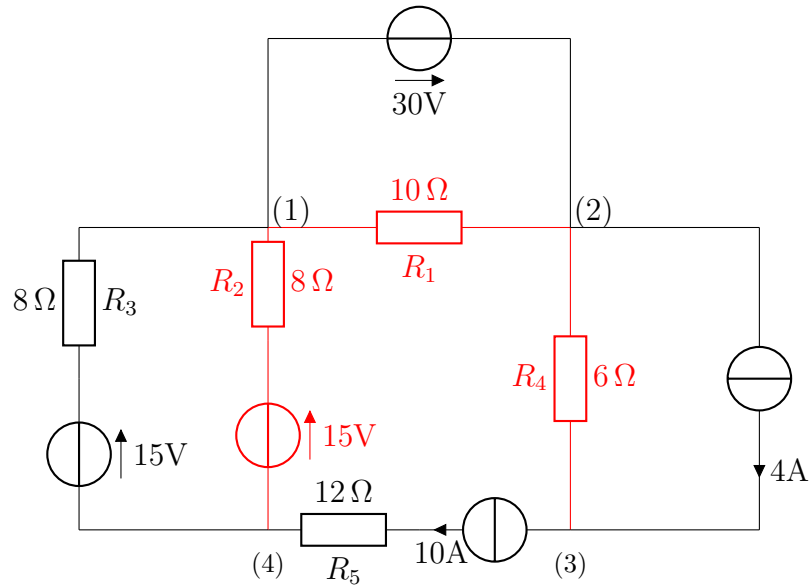
Using the branch tension method. (the most efficient) It is efficient because it's necessary to write only 2 Kirchhoff equations. If the string current method is used, there will be 3 equations. For the 2 chosen sections, the Kirchhoff's current law (1st law) is used, and more precisely in the (3) and (4) nodes.

$$\begin{cases} 1 : \frac{U_{41}+15}{8} + \frac{U_{41}+15}{8} = 10 \\ 2 : \frac{U_{32}}{6} + 10 = 4 \end{cases} \quad (1)$$

By calculating:  $U_{41} = 25V$  and  $U_{32} = 26V$  as can be seen in the voltage graph, written at the beginning.

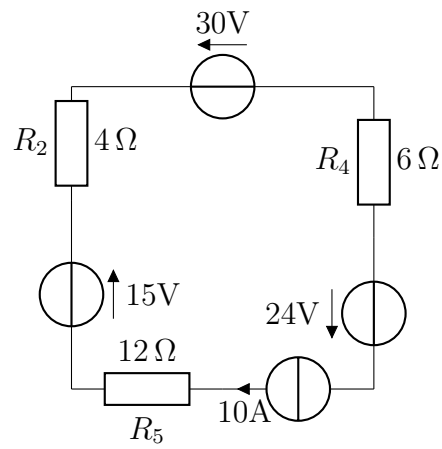
### 3 Equivalent Voltage/Current Generator

The initial circuit:

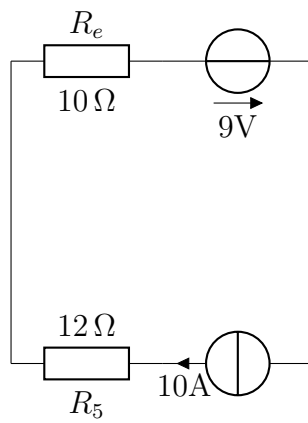


#### 3.1 Equivalent Generator's Characteristic

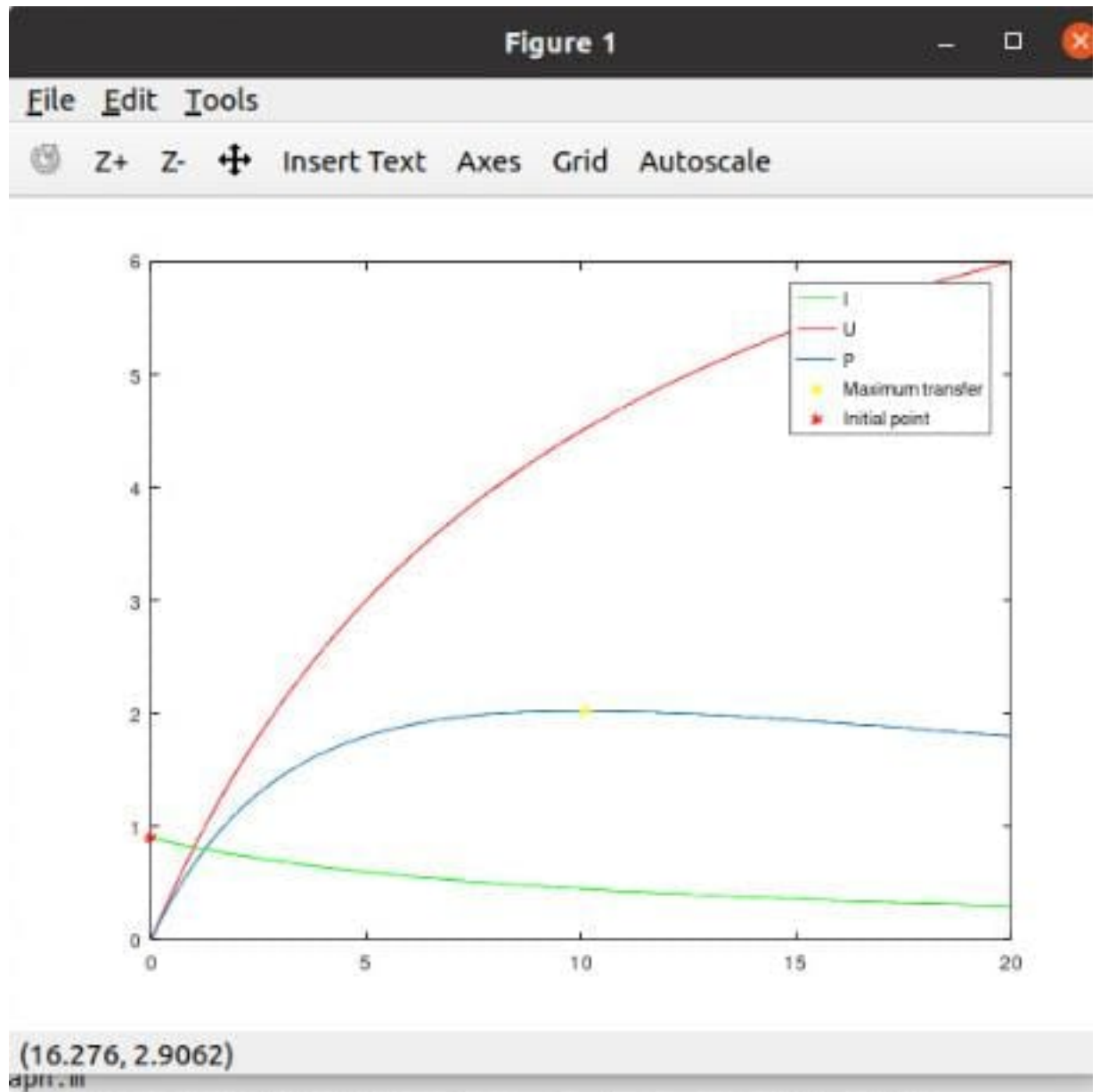
The idea is to find out the dependence of intensity, voltage and power in the  $R_5$  resistor. To do this, we make  $E_{equivalent}$  on the left loop, and  $R_{equivalent}$ . On the top loop, there is a SIT in parallel with a resistor, which results in the initial SIT, and on the right loop there is a SRC, which is turned into SRT. In the figure there is the data (after performing these operations).



Now it's time to calculate  $E_{equivalent}$  in this loop, and  $R_{equivalent}$ , without  $R_5$ . The final results are shown in the figure below.



The graph of the maximum power and intensity dependence by  $R_5$  is:





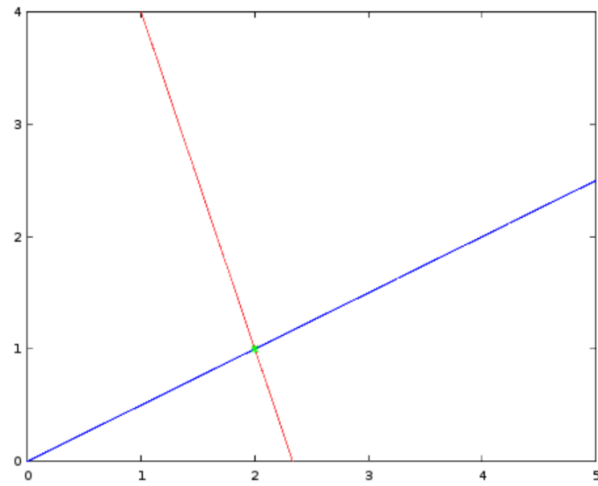
The OCTAVE function:

```
1 function graph()
2
3     E_final = 9;
4     R_final = 10;
5     power = zeros(1, 100);
6     rez = linspace(0, 20, 100);
7     voltage = zeros(1, 100);
8     intensity = zeros(1, 100);
9
10    for (i = 1 : 100)
11        intensity(i) = E_final / (rez(i) + R_final);
12        voltage(i) = intensity(i) * rez(i);
13        power(i) = voltage(i) * intensity(i);
14    endfor
15
16    plot(rez, intensity, "g");
17    hold on;
18    plot(rez, voltage, "r");
19    hold on;
20
21    max_power = max(power);
22    finder = find (max_power == power);
23
24    plot(rez, power);
25    hold on;
26    plot(rez(finder), power(finder), "y*");
27    hold on;
28    plot(0, intensity(1), "r*");
29    hold on;
30
31    legend('I', 'U', 'P', "Maximum transfer", "Initial point");
32    hold on;
33
34 endfunction
35
```

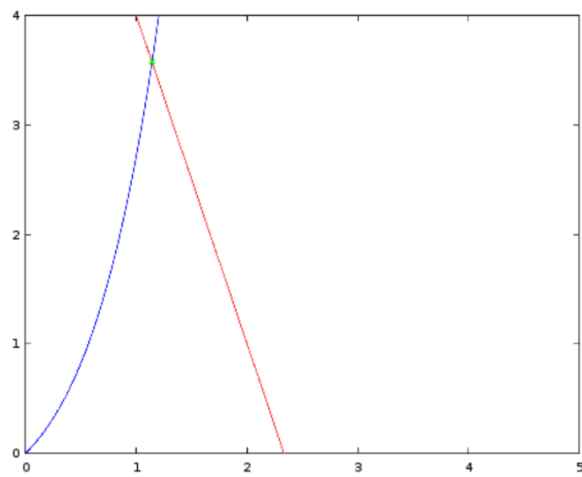
### 3.2 Semiconductor diode

The resistor is replaced with a diode, highlighting the static points:

Resistor:



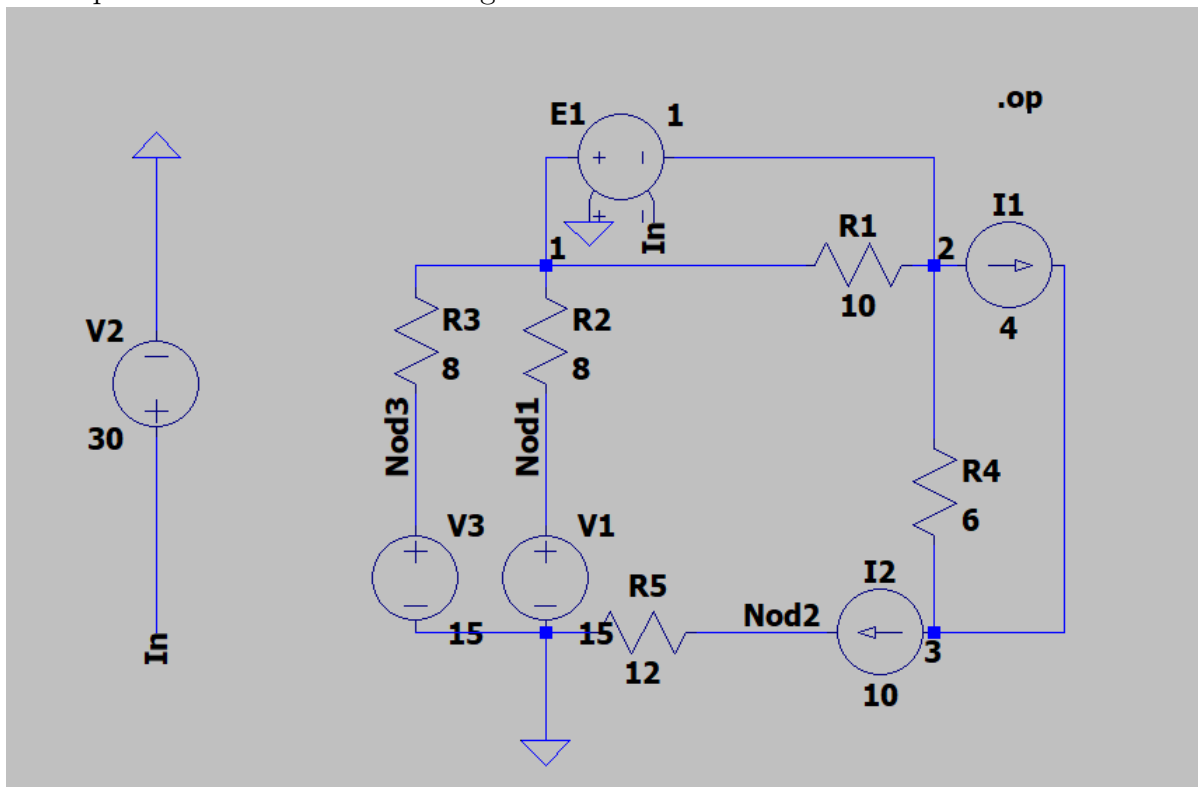
Diode:



## 4 Dependent sources. Spice simulation of dependent sources circuits

### 4.1 SUCU

The equivalent circuit with a voltage controlled source:



## 4.2 Diagram

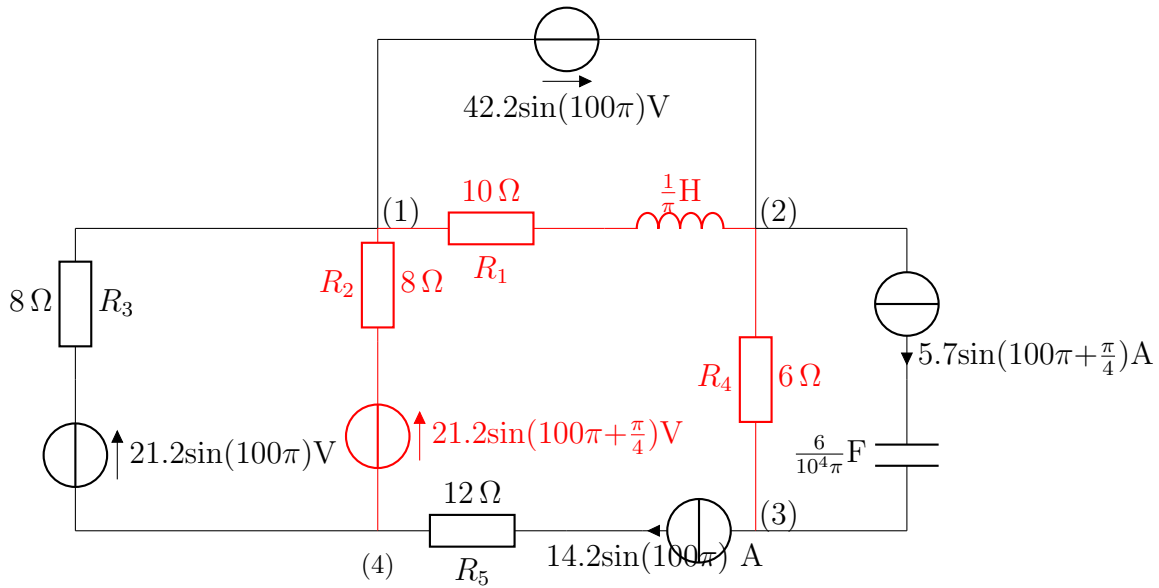
The diagram, corresponding to the circuit in the figure above is:

**--- Operating Point ---**

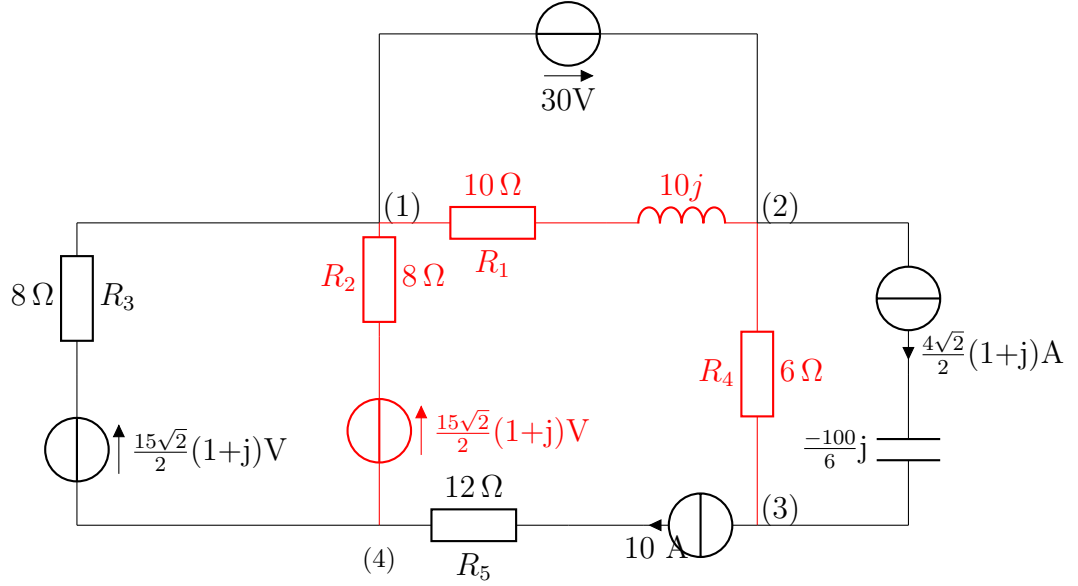
V(2) :	5	voltage
V(1) :	-25	voltage
V(nod1) :	15	voltage
V(in) :	30	voltage
V(nod3) :	15	voltage
V(3) :	-31	voltage
V(nod2) :	120	voltage
I(I2) :	10	device_current
I(I1) :	4	device_current
I(R5) :	10	device_current
I(R4) :	6	device_current
I(R3) :	-5	device_current
I(R2) :	-5	device_current
I(R1) :	3	device_current
I(E1) :	13	device_current
I(V3) :	-5	device_current
I(V2) :	0	device_current
I(V1) :	-5	device_current

## 5 Solving alternating current circuits using numerical software tools

The sinusoidal circuit:



The algebraic form of the circuit:



For the 2 chosen sections, the Kirchhoff's current law (1st law) is used, and more precisely in the {3} and {4} nodes.

$$\begin{cases} = > 1 : 2 * \frac{U_{41} + \frac{15\sqrt{2}}{2}(1+j)}{8} = 10 \\ = > 2 : \frac{U_{32}}{6} + 10 = \frac{4\sqrt{2}}{2}(1+j) \end{cases} \quad (2)$$

The results:

$$U_{41} = 29,4 - 10,6jV$$

and

$$U_{32} = -43,03 + 17jV$$

as can be seen in the voltage graph, written at the beginning.

The script for finding out  $U_{41} + U_{32}$  :

$$U_{41} = \frac{40 - 15\sqrt{2}*(1+j)}{2}$$

$$U_{32} = (\frac{4*\sqrt{2}*(1+j)}{2} - 10) * 6$$