Electrical Circuit Project

– Fundamentals of Electrical Engineering –

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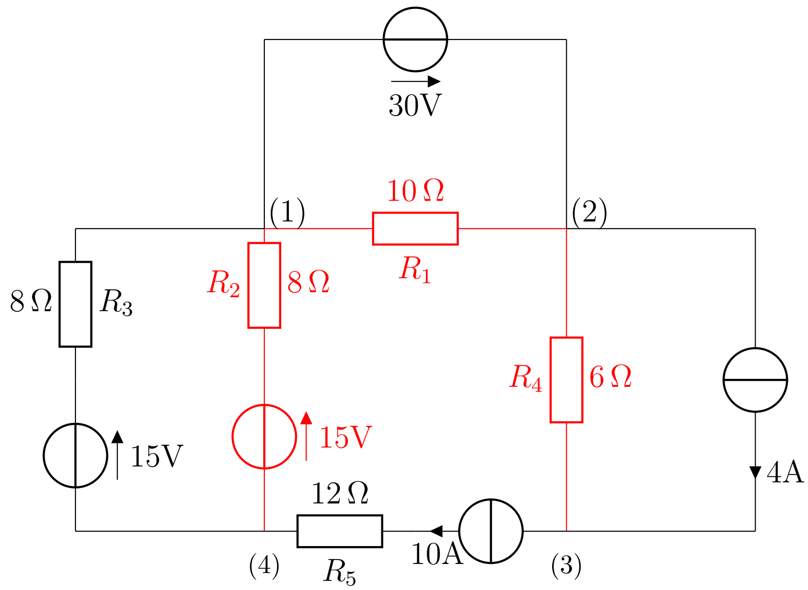
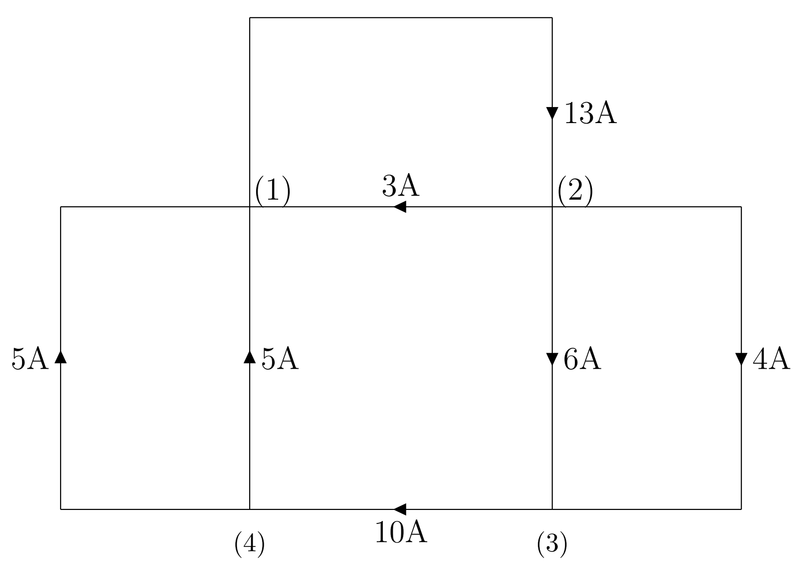
1 The circuit

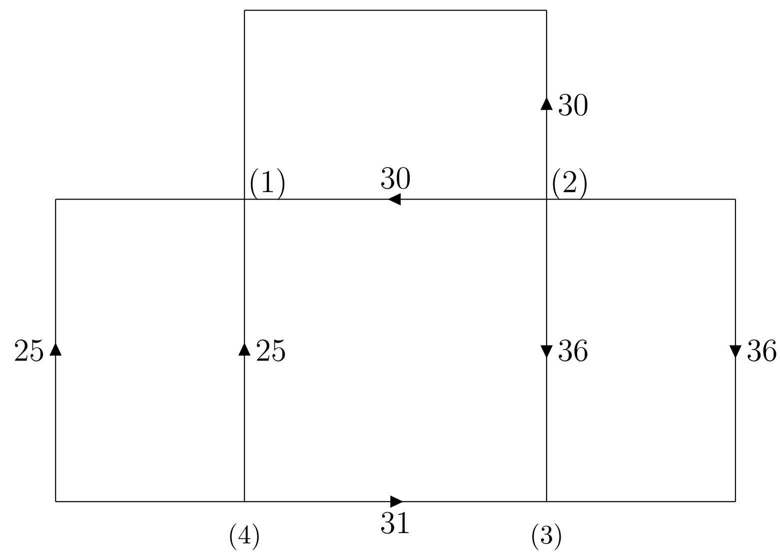
The circuit:



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)→(4) and (4)→(3); branch:(4)→(1).
2. The second section is composed of:(3)→(4) and (3)→(2); branch:(3)→(2).

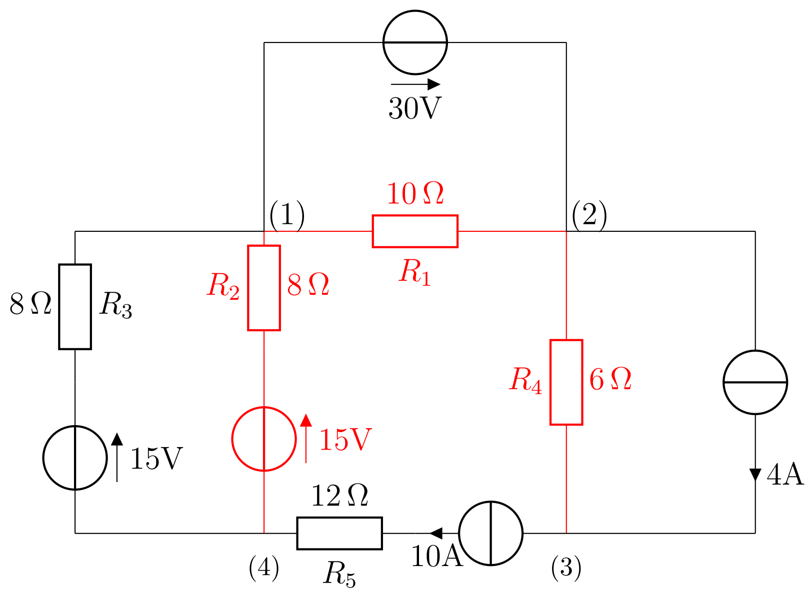
Using the branch tension method. (the most efficient) It is efficient because it's necessarily to write only 2 Kirchhoff equations. If the string current method is use, there will be 3 equations. For the 2 chosen sections, the Kirchhoff's current law (1st law) is used, and more precisely in the (3) and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

$$\begin{cases} 1 : \frac{U_{41}+15}{8} + \frac{U_{41}+15}{8} = 10 \\ \qquad 2 : \frac{U32}{6} + 10 = \;\; 4 \end{cases} \tag{1}$$

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

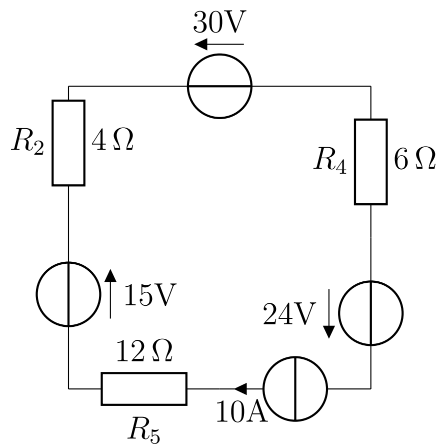
3 Equivalent Voltage/Current Generator

The initial circuit:

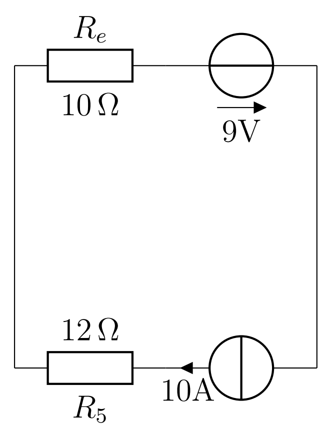


3.1 Equivalent Generator's Characteristic

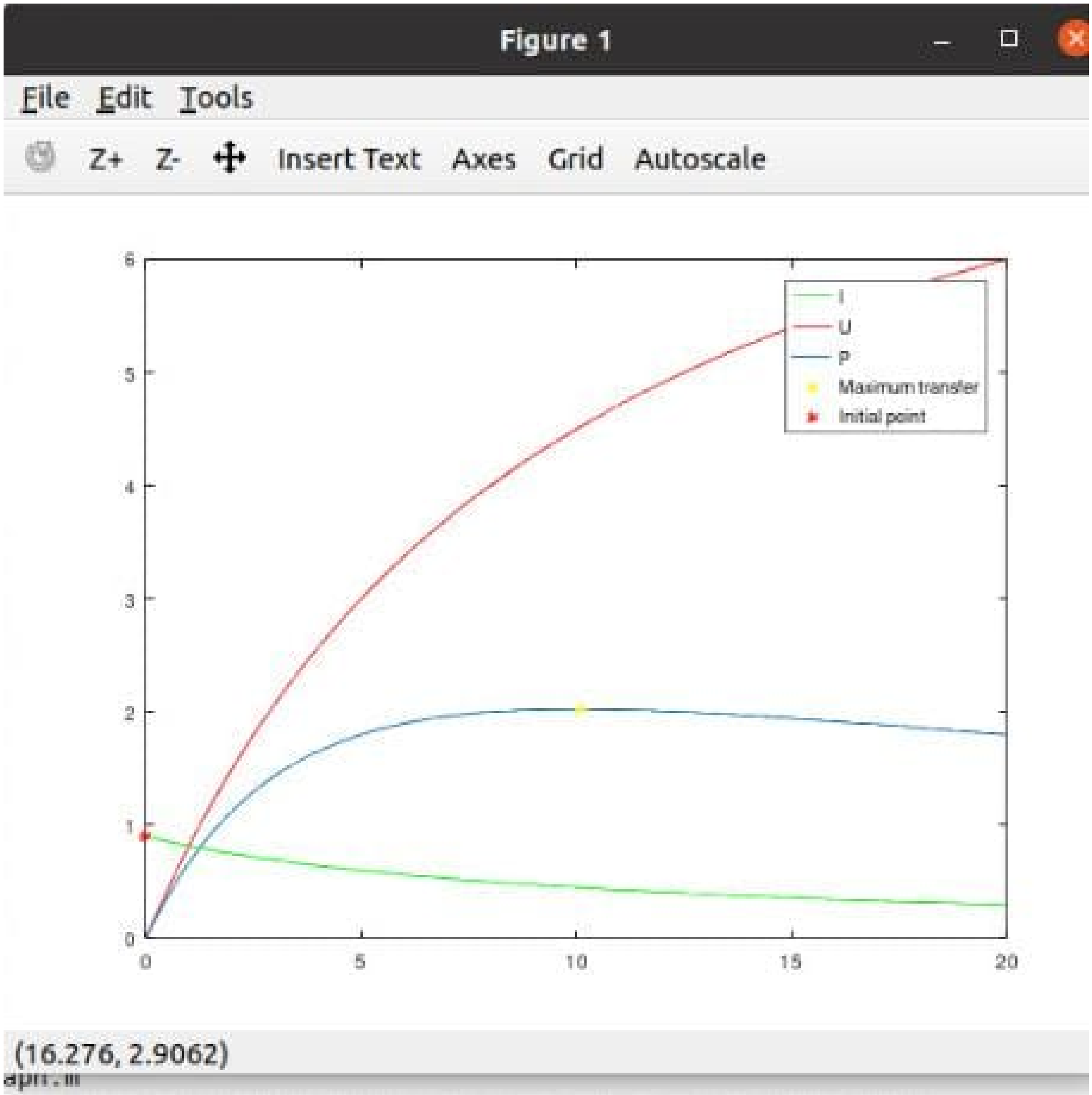
The idea is to find out the dependence of intensity, voltage and power in the R5 resistor. To do this, we make $E_{equivalent}$ on the left loop, and $R_{equivalent}$. On the top loop, there is a SIT in parallel with a resistor, which results in the initial SIT, and on the right loop there is a SRC, 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:



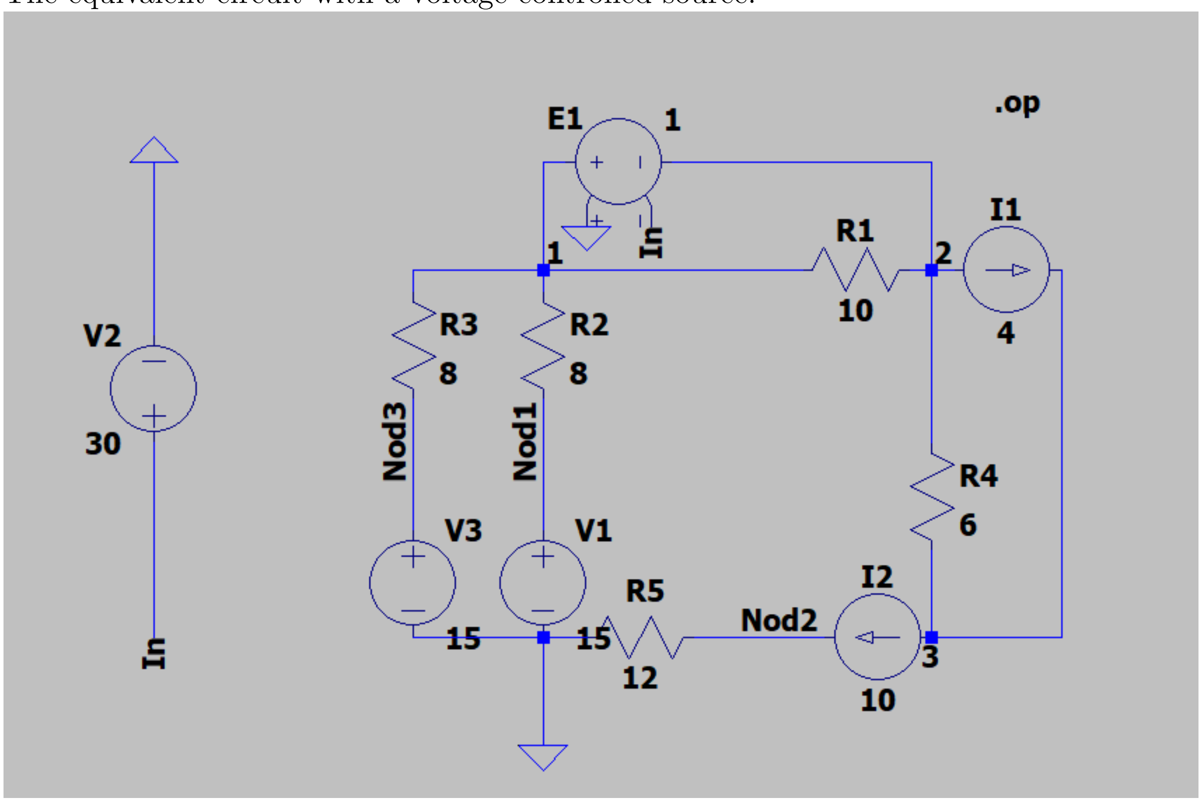
The OCTAVE function:

```
function graph()

  E_final = 9;
  R_final = 10;
  power = zeros(1, 100);
  rez = linspace(0, 20, 100);
  voltage = zeros(1, 100);
  intensity = zeros(1, 100);

  for (i = 1 : 100)
    intensity(i) = E_final / (rez(i) + R_final);
    voltage(i) = intensity(i) * rez(i);
    power(i) = voltage(i) * intensity(i);
  endfor

  plot(rez, intensity, "g");
  hold on;
  plot(rez, voltage, "r");
  hold on;

  max_power = max(power);
  finder = find (max_power == power);

  plot(rez, power);
  hold on;
  plot(rez(finder), power(finder), "y*");
  hold on;
  plot(0, intensity(1), "r*");
  hold on;

  legend( 'I', 'U', 'P', "Maximum transfer", "Initial point");
  hold on;

endfunction

```

4 Dependent sources. Spice simulation of dependent sources circuits

4.1 SUCU

The equivalent circuit with a voltage controlled source:



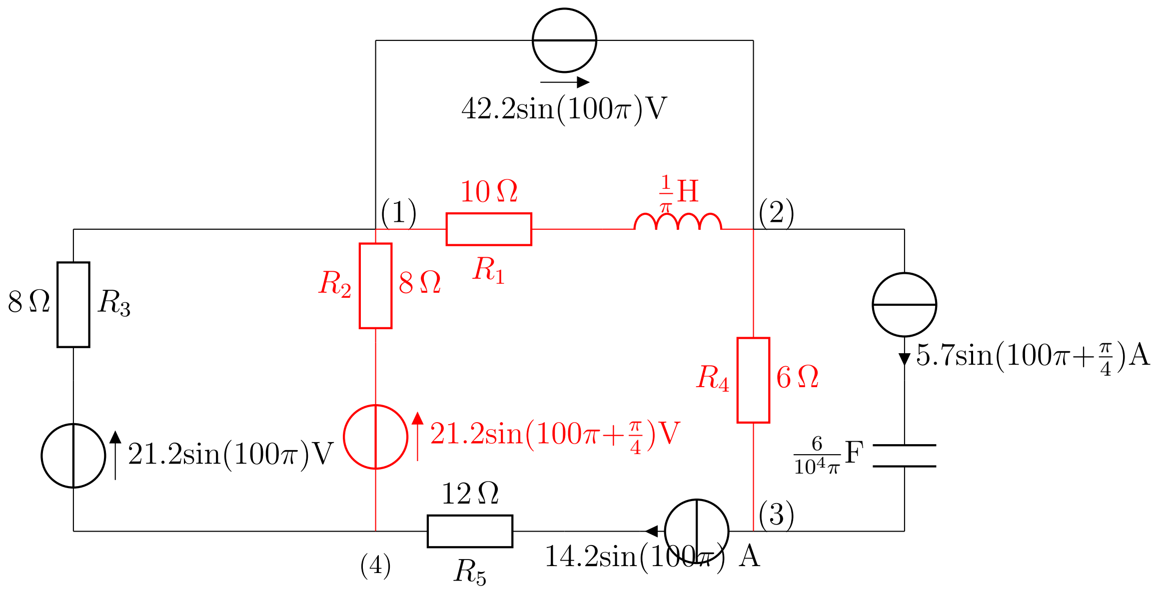
4.2 Diagram

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

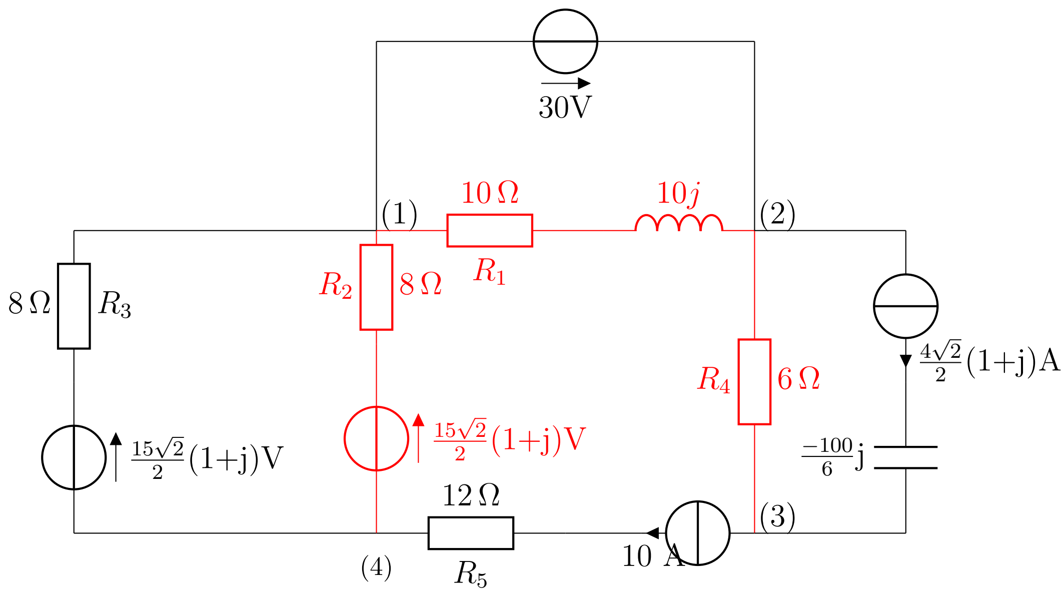
```
        --- Operating Point ---

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.

$$\begin{cases} => 1 : 2 * \frac{U_{41}+\frac{15\sqrt{2}}{2}(1+j)}{8} = 10 \\ => 2 : \frac{U32}{6} + 10 = \frac{4\sqrt{2}}{2}(1+j) \end{cases} \tag{2}$$

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} $+U_{32}$:
$U_{41} = \frac{40-15*\sqrt{2}*(1+j)}{2}$
$U_{32} = (\frac{4*\sqrt{(2)}*(1+j)}{2} - 10) * 6$