Poznań University of Technology
Faculty of Computing and Telecommunications
Institute of Multimedia Telecommunications

COMPUTER AIDED DESIGN

LABORATORY

Instruction for the laboratory exercise

LTspice: AC analysis

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1. The aim of the exercise

- learning about the possibilities of AC analysis,
- determination of frequency characteristics,
- testing the characteristics of filters,
- performing calculations in LTspice.

2. The course of the exercise

2.1 Study of the RC circuit

a) Frequency analysis of the RC circuit

1. Create a circuit diagram as shown in Fig. 1. Use shortcut keys:
    - R – inserts a resistor,
    - C – inserts a capacitor,
    - G – inserts ground symbol,
    - F2 – open a list of elements,
    - F3 – turns on the connection drawing mode,
    - F4 – inserts a label (out).:

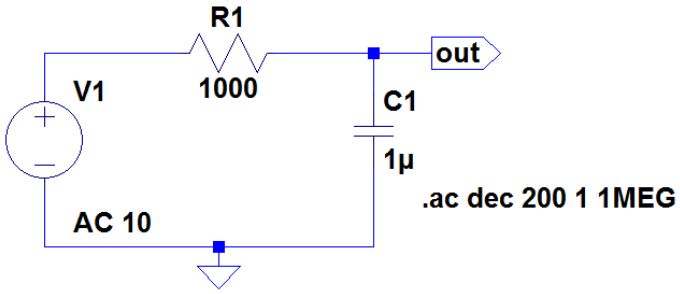

Fig. 1. Diagram of the tested RC circuit.

2. Set the values of elements according to the diagram. Set the value of the voltage source in the field *AC Amplitude*, which is visible in the extended mode (*Advanced* in source settings).

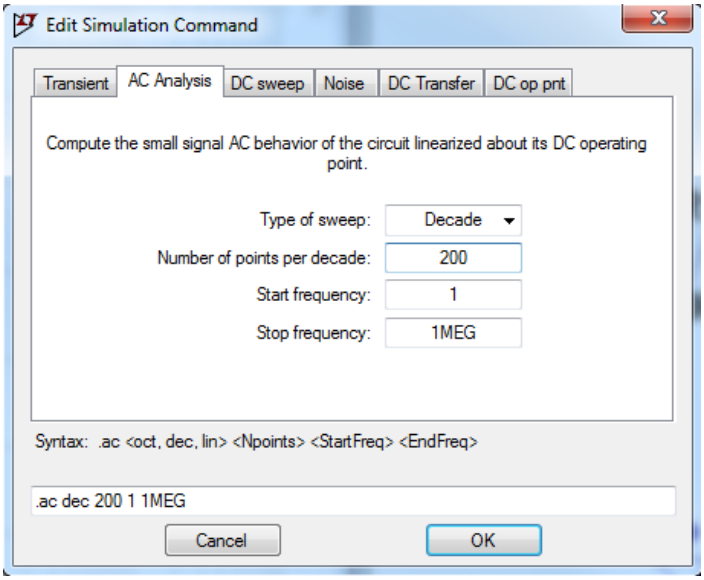

Fig. 2. Declaration of AC analysis parameters.

3. Make an AC analysis. Plot the characteristics of the output voltage V_{out} as a function of frequency.
    - Start the simulation command editor: in the *Simulate* menu, select *Edit Simulation Command*, select the *AC Analysis*.
    - Set the analysis parameters as shown in Figure 2,
    - Start the analysis with the Run button .
4. Read the frequency value from the characteristics that corresponds to a 3dB drop in the output voltage.

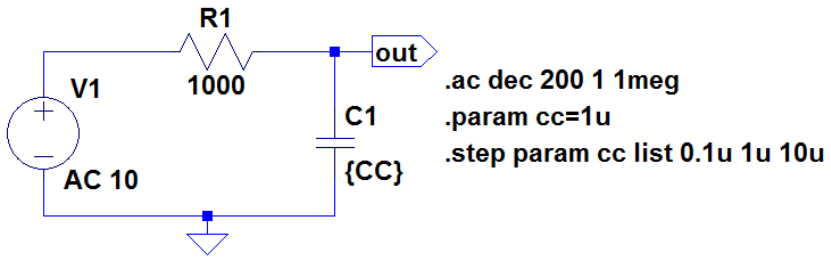

Fig. 3. Scheme of a RC circuit with a declaration of a change in the capacity value.

5. Check the effect of changes in the capacitance of the capacitor on the position of the frequency characteristic. Read the frequency values corresponding to the 3dB drops in the output voltage.
6. To define the *cc* parameter, use the SPICE directive editor (*SPICE directive*). The *.op* button (last on the right) or use the keyboard shortcut - S.

b) Analysis of the low-pass filter system

1. Draw the LPF circuit according to Figure 4.

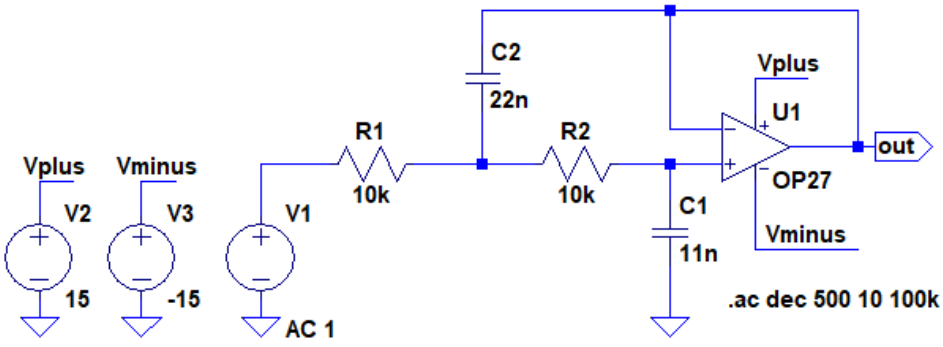

Fig. 4. Scheme of the low-pass filter.

2. Run the simulation and display the output voltage V_{out} as a function of frequency.
3. Read the frequency value from the characteristics that corresponds to a 3dB drop in the output voltage.
4. Check the influence of capacitance value on the characteristics. Take capacitance values of ± 50%. Modify the FDP scheme as shown in Figure 5.

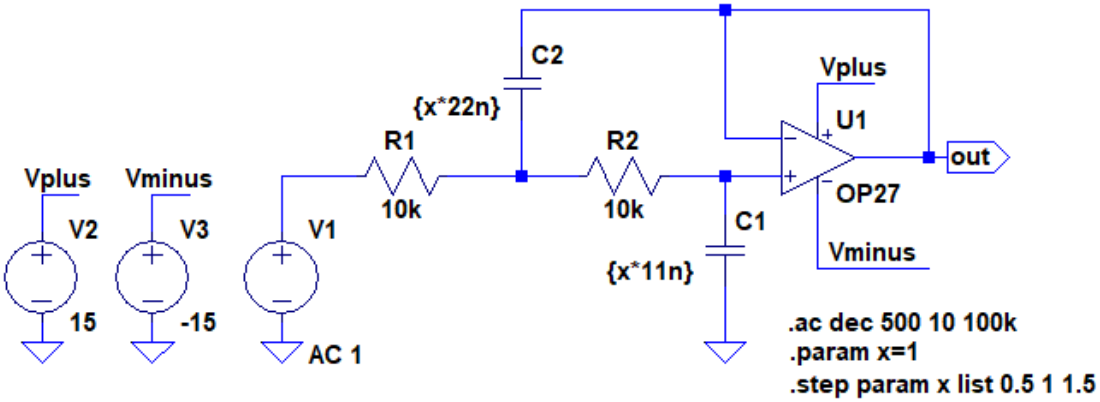

Fig. 5. Study of the effect of changing the capacity.

5. Run the simulation and display the output voltage V_{out} as a function of frequency.
6. From the characteristic curves read the value of limit frequency (cut-off frequency) f_g and read the phase for f_g.
7. In the same way check the influence of changes the resistors R1 and R2 values on the FDP operation, assume the change of resistance ± 20%.

c) Analysis of the band-pass filter

1. Calculate the values of the resistors of the band-pass filter (Fig. 6). Make the following assumptions:
   - capacitors values 10 nF,
   - center frequency f_0 = 1 kHz,
   - quality filter Q = 5,
   - gain for f_0 frequency, k_V = 1.

2. Calculate the resistance values according the equations:

$$R_3 = \frac{Q}{\pi f_0 C}; \quad R_2 = \frac{R_3}{2(2Q^2 - k_V)}; \quad R_1 = \frac{R_3}{2k_V}$$

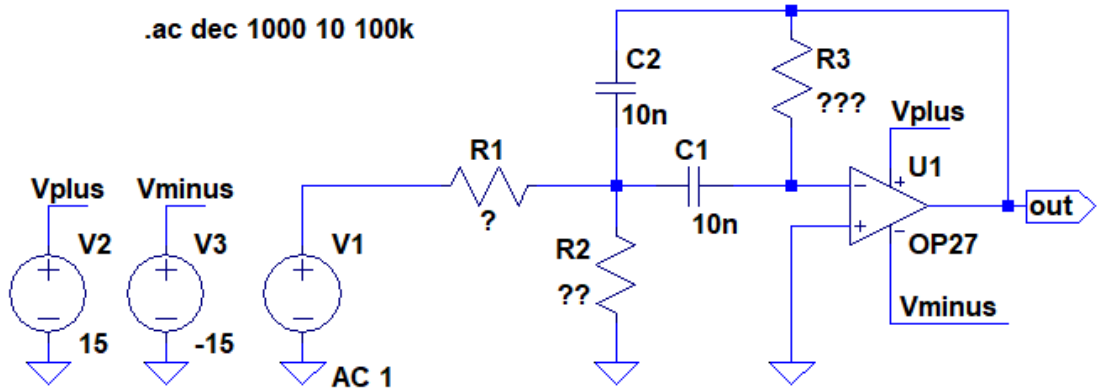

Fig. 6. Band pass filter (BPF).

3. Determine the frequency characteristics of the BPF.
4. Read the filter parameters from the characteristics: f_0, f_1 and f_2,, and use them to determine: Q and k_V, compare these values with the design calculations.

5. Check the effect of changing the elements value (± 20%) on the BPF operation:
    - R1,
    - R2,
    - R3,
    - Both C1 and C2.

6. For the calculated values of the resistors, determine the value of the capacitance C1 and C2, for which the filter will have the center frequency f_0 = 5 kHz. For this purpose, changes should be made to the analyzed system according to Figure 7.

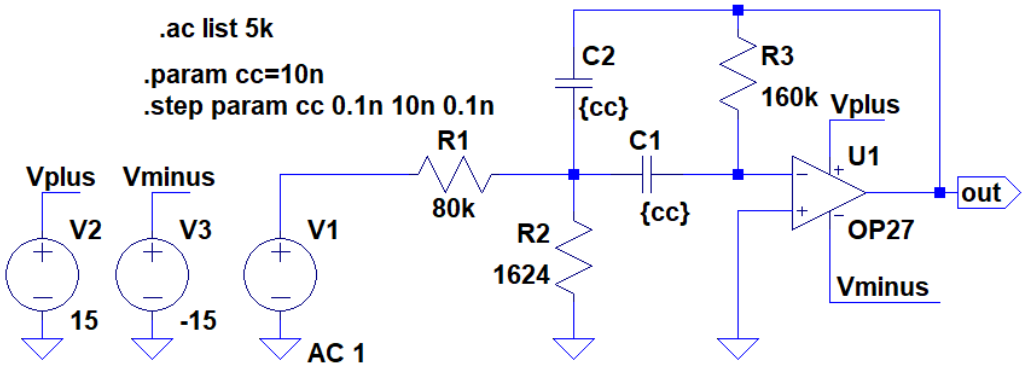

Fig. 7. Circuit for determining the capacitance for f_0 = 5 kHz.

7. Read the capacitance value for which the output voltage is 1V.
8. Assign this read value to capacitors and plot frequency characteristics.
9. Use the *.meas* command to set filter parameters. Modify the analyzed circuit as shown in Figure 8.

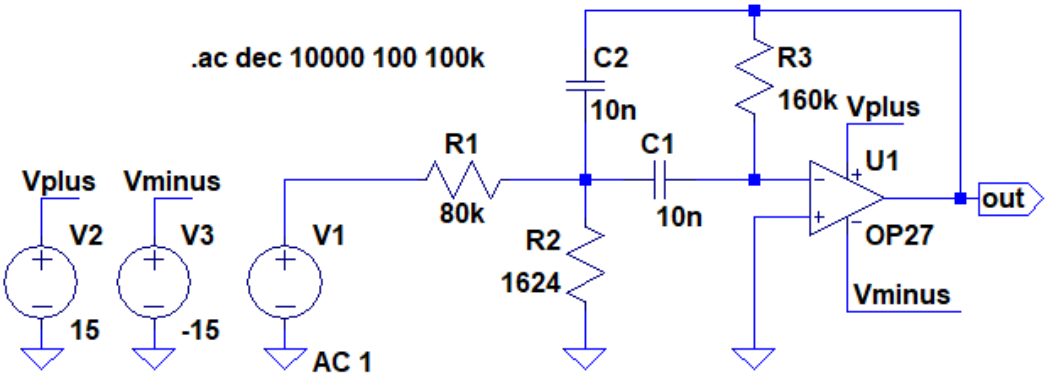

Fig. 8. Use of the *.meas* command.

10. The calculation results are available in the **SPICE Error log** file. View the content of this file from the *View* menu.
11. For the AC analysis, add the change in capacitance in the range from 10nF to 20nF every 1nF (Fig. 9).

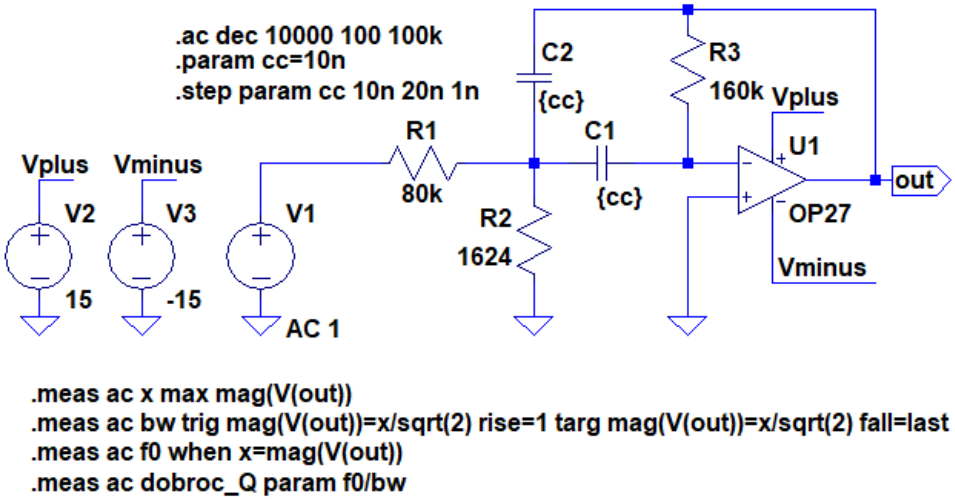

Fig. 9. Using the *.meas* command with changing the parameter value.

12. View the contents of the **SPICE Error log** file. Right-click on it, select the option: **Plot Step'ed .meas data**, on the displayed window, right-click again and select the **Add Traces** option, then select f_0, then the characteristic of changing the central frequency of the filter as a function of capacity will be displayed.

3. Tasks for students to do homework (obligatory)

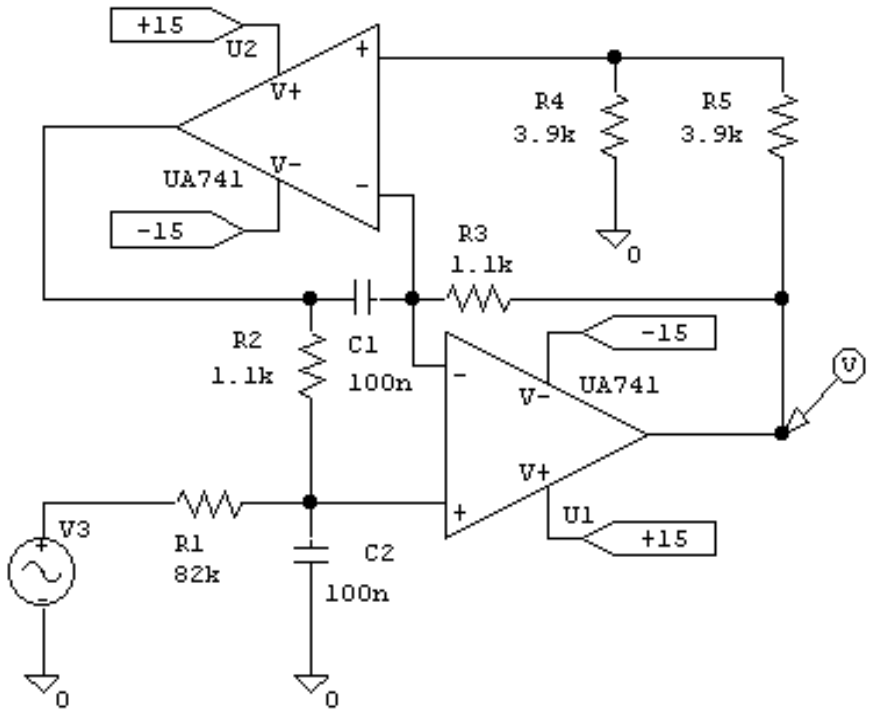

Fig. 10. Schema of the "unknown" filter under study.

1. Draw this circuit in LTspice, identify the type of the filter from Fig. 10, read its parameters from the frequency characteristic.

2. Check influence of changes in the value (± 20%) for elements as:
    - R1,
    - both R2 and R3,
    - both R4 and R5,
    - both C1 and C2.
3. Use the *.meas* command to determine the cutoff frequency of the filter.

4. Additional tasks

Simulate the operation of the:

- low pass filter (BPF) from Fig. 4,
- "unknown" filter (Fig. 10)

in Micro-Cup 12 program.

(manual: https://www.spectrum-soft.com/down/ug12.pdf)
You can see also: https://www.youtube.com/watch?v=60-7P3ooeFQ

5. Report

Should contain:

- all schemes of simulated systems,
- simulation results,
- answers to the questions contained in the manual,
- conclusions.