

# **Circuit Theory and Electronics Fundamentals**

Lab 5: Bandpass filter using OP-AMP

# Bandpass filter

- Based on Lectures 23-25, dimension and implement a BandPass Filter (BPF) with the following specifications:
  - Central frequency: 1kHz
  - Gain at central frequency: 40dB
- To implement the BPF you are only allowed the following components
  - One 741 OPAMP
  - At most three 1k $\Omega$  resistors
  - At most three 10k $\Omega$  resistors
  - At most three 100k $\Omega$  resistors
  - At most three 220nF capacitors
  - At most three 1 $\mu$ F capacitors
- The merit figure is given by  $M = 1/(\text{cost} * \text{gain deviation} * \text{central frequency deviation})$ 
  - cost = cost of resistors + cost of capacitors + cost of transistors
  - cost of resistors = 1 monetary unit (MU) per k $\Omega$
  - cost of capacitors = 1 MU/ $\mu$ F
  - cost of transistors = 0.1 MU per transistor

# Simulation Analysis

- Write an Ngspice script to simulate BPF. Start with the provided script
- Use the provided OPAMP model
- Measure the output voltage gain in the passband, the central frequency, and the input and output impedances at this frequency
- Try to improve the merit figure

# Theoretical Analysis

- 1) Compute the gain, input and output impedances at the central frequency.
- 2) Compute the frequency response  $V_o(f)/V_i(f)$ , using the incremental circuit, solving the circuit for a frequency vector in log scale with 10 points per decade, from 10Hz to 100MHz.

# Lab report

- 1) Produce all tables and plots required in the simulation and analysis sections
- 2) Compare Octave and Ngspice results side by side looking for accuracy or discrepancy, and explaining both. Read the repository's README file.
- 3) The results of interest are, obviously,
  - the frequency response (gain and phase)
  - input /output impedances
  - the cost of the components used

# Evaluation criteria

- 1) The instructor should *git pull* your repo, and run *make flawlessly*
- 2) The report should not have obvious mistakes in figures, tables, formulae, section titles or main sentences
- 3) 1 bonus point (mark can be 5 offsetting previous grade losses) for the 5% best merit figures
  - if your work is in the top 5%, expect a more thorough review
- 4) If, to achieve a high merit, your circuit becomes not practical, you'll get the bonus but you may be discounted on the regular evaluation of the work.