TÉCNICO LISBOA

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 1kΩ resistors
  - At most three 10kΩ resistors
  - At most three 100kΩ resistors
  - At most three 220nF capacitors
  - At most three 1μF capacitors
- The merit figure is given by $$M = \frac{1}{Cost\left(voltage\ gain\ deviation + central\ frequency\ deviation + 10^{-6}\right)}$$
  - The voltage gain is expressed in linearly (not in dBs) and has no units since it is a quotient of voltages
  - cost = cost of resistors + cost of capacitors + cost of transistors
  - cost of resistors = 1 monetary unit (MU) per kOhm
  - cost of capacitors = 1 MU/μF
  - cost of diodes = 0.1 MU per diode
  - 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.