ELEN 458 Lab 4

Active Filter Synthesis & Approximation: Designing an Band Pass Filter Using OTA

I Objective

The objective of the lab is to familiarize the student with a band pass filter and further demonstrate the 'adjustability' of OTA circuits by varying the amplifier's bias current, I_{ABC}, which directly changes the transconductance, *gm*, of the amplifier

II Component List

- LM13600
- Components (resistors and capacitors) necessary for lab will vary depending on your design.

III Introduction

Filters can be found in a variety of systems. Any system that needs to convert back and forth from analog and digital signals usually needs a filter. The main function is usually to improve the signal quality. The most widely used filter type is the band pass filter. It is used in RF systems, audio processing, oscilloscopes, function generators, etc. In audio processing, they are utilized in equalizers, synthesizer, and various other products. In previous lab, the student has designed a cross-over filter that could selectively filter signals in high/low frequencies. In this lab the student is asked to design, through FIESTA2, a basic band pass filter using different approximation techniques and then build one of the designs in the laboratory.

IV Prelab

Using the FIESTA2 software, design a band pass filter. The box constraints are as follows:

- Band Pass Filter
  - Lower Stop Frequency : 3kHz
  - Lower Pass Frequency : 5kHz
  - Band Width : 2kHz
  - Higher Pass Frequency : 7kHz
  - Higher Stop Frequency : 9kHz
  - Order Fixed at 4

  (note : by specifying the order of filter, the minimum attentuation is automatically determined).

- Perform the design using the ***Butterworth*** and ***Chebyshev*** approximation methods.

In the pre-lab report :

- Draw neat schematics for each filter synthesized.
- For each filter, obtain a HSPICE input file and be sure to use the LM13600 macro model in the simulations - *Note : in the synthesis menu, the macro model of idealop is used. Modified the model file to LM13600 in the 'edit simulator file' in the 'simulation menu' and execute HSPICE.*
  For e.g. if you specify it to be amplifer model name : 'idealota', you will get (part of circuit) :

```
.subckt idealota 1 2 3
rin 1 2 1.0e12
g1 3 0 1 2 3.921503e-4
.ends idealota0

xt0 0 3 2 idealota0
```

changed the above to :

```
.subckt LM13600/NS 1 2 3 4 5 6 7 8 11
        ….. get the model file from web page (as in lab 2)
.ends

xt0 ib0 0 0  vp0 vn0 out0 vss 0 0 vdd lm13600/ns
iabc0 vdd 1000 dc 0.0206m
```

note : ignored rin (meant for converging solution for SPICE), calculate your iabc using the value of g1 (3.1295e-4) based on the 'h' value you obtained from lab2.Setup your circuit by writing a HSPICE input netlist specifying the nodal connections. You may ground the diode bias pin.

- From the HSPICE netlist generated from HSPICE, use the nearest standard component value for each component included on the schematic.
- Simulate the filters using HSPICE and provide plots of magnitude and phase response (you will have at least a total of 8 graphs). For each filter, plot all the magnitude response and phase responses together.
- Make sure you turn in all FIESTA2 files (approximation data, e.g. transfer function, view magnitude, phase plot). When running FIESTA2, carefully observe all the different responses generated by the GRAPHICS output option for each approximation methods – *Butterworth* & *Chebyshev* (this will be important for the Final lab report).

V Lab Procedure

Build and test the band pass filter using the ***Chebyshev*** approximation (be sure that the TA verifies your circuit for proper operation). Some hints :

- You may want to make a quick check on your OTA to make sure it is function properly before you connect up your circuit.
- If your circuit does not meet the specs, refer to Appendix B for tuning OTA cascade filter system.
- Adjust Gain, then adjust bandwidth (bit by bit e.g. desired : 600Hz, now you have only 300Hz, tuned to 400Hz first), and then adjust center frequency (bit by bit) also. Iterate the adjustment steps.

In the Final Report :

- Provide a plot of the magnitude and phase response in the lab report.
- Compare and contrast the approximation methods listed above.
- What are the advantages and disadvantages of each method?
- Be sure to base your analysis on the following factors (besides others): center frequency, ripple in the pass band / stop band, phase response, group delay response, time domain response.