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YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie / Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo

ANALOG ELECTRONICS ENE310

PRACTICAL 2 LECTURE

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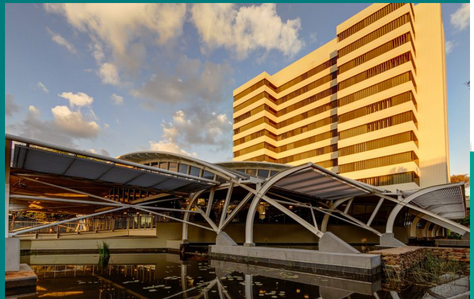
PRACTICAL 2 PRE-PRAC

Active Filter design



Introduction

- Filters are arguably the most common analogue electronic subsystem found in electronic systems
- Active filter applications
  - Use in pure analogue systems
  - Analogue front-ends before digitisation

Practical requirements (1)

- Design, implement and compare two filter systems:

  1. 2^{nd} order filter, cascaded 4 times (copy & paste) to achieve an overall 8^{th} order system
  2. 8^{th} order filter using a high order filter design methodology. Using the cascade higher order filter design tables.

Practical requirements (2)

- Groups will be assigned a specific and unique filter response (Butterworth, Bessel or Chebyshev) and natural frequency (some frequency between 10 – 100 kHz)
- Design frequency :$f = 10\ kHz + Group\ numer\ * 900\ Hz$
- Groups [0 - 28] : Butterworth response
- Groups [29 - 56] : Bessel response
- Groups [57 - 99] : Chebyshev response

Practical requirements (3)

- An op-amp based configuration (KRC, multiple feedback, etc.) must be used
    - Selection is for the group to decide (motivation required)
    - Groups are welcome to explore configurations not covered in lecturers

Practical requirements (4)

- A low-pass or high-pass filter may be designed
  - Motivation for your selection is required
- Any dual voltage power supply with values between 10 - 20 V_{p-p} will be acceptable (motivation required)
- Any gain larger than 1 V/V will be acceptable.
  - Your gain will form part of the questions component and should be well motivated
- No limit on the number of components

Design and simulation (1)

Make sure the following tasks are part of your preparation and well documented in your lab-books

- Derive expressions for the transfer function of both systems
- Determine the circuit component values that would satisfy the above requirements and specifications for both systems
- Simulations (OrCAD/LTSpice) of both systems in both the time and the frequency domains
  - Make sure to indicate the specifications your design achieved on the simulated graphs
- Use simulation tools to investigate the effect of component tolerance

Considerations and procedure (1)

- Consider the input and output signals for both systems in the time domain using a signal generator and an oscilloscope and confirm:
  - the phase difference introduced by each system
  - the voltage gain of each system (and that no clipping occurs on the output)
- Consider the input and output signals for both systems in the frequency domain using the FFT functionality of the oscilloscope
  - Useful to also use the ‘persist’ function while sweeping the input frequency with the signal generator.

Considerations and procedure (2)

- Confirm (for both systems)
  - the natural frequency for each system
  - the gain for each system
  - the quality factor for each system

Practical analysis (1)

- Measure the input / output voltages and construct the Bode plots for both systems over a sufficiently large frequency range
- Determine the gain, natural frequency and quality factor from your graphs
- Construct a simulated filter (Matlab/Python) response using your measured filter specifications (the three above) and plot this on the same graph as your measured results
    - You should see a very good fit with your measured data

Practical analysis (2)

- Compare your analytic, simulated and measured results. Discuss any differences.
- Draw meaningful conclusions about your results and implementation.

Practical demonstration

- During this demonstration your group will be asked to demonstrate both constructed filter circuits
- You need to show the measured results as well as the comparison between the measured results and the simulated results (tip: tabulate your results)
- Practical sessions are there for demonstration purposes and you should construct your circuit in your own time or during laboratory sessions
- The circuit may be built on breadboards

Practical demonstration

- Measurements: Frequency and time domain responses of both filters need to be demonstrated. Pay special attention to your -3dB cut-off frequency.
- Quality of technical work: Output noise, response calibration, quality factor.
- Additional work and creativity: Alternative design methods and effects of component tolerances etc
- Questions: 5 questions will be asked in order to test groups insight.

Practical 2 components

- Resistors
- Capacitors
- Potentiometers
- Op-amps (Dual-rail)

Demo due: 8 April 2018

Schedule will be on ClickUp day before demonstration

Practical reports (1)

- Practical reports are submitted in group context
- Submission requires both an electronic version uploaded, as well as a signed hardcopy of your front page before the specified deadline.
- Front page template on EECE clickup page (includes plagiarism statement).
- Remember group number, ORGINAL signatures and percentage contribution on the front page.
- A deadline extension will not be granted. Resubmission of reports will only be considered under special and justified circumstances

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Practical reports (3)

- Poor language/grammar/format and spelling errors are not acceptable.

- Own original signatures in pen MUST be present on hard copy submission of all group members. Report is considered not submitted if this is not adhered to.

- Prepare the electronic file in PDF format with a filename of GN_PPPPPPPP_QQQQQQQ_RRRRRRRR_SSSSSSSS (make SSSSSSS=0000000 for a 3-member group).

Practical report content

- The report should present the complete design approach and final circuit with sufficient detail for anyone else to repeat.
- Should contain
  - Table of content
  - Abstract/Introduction
  - Design objectives
  - Detail design
  - Results
  - Discussion
  - Conclusion
  - Referencing
- Pay special attention to editing.

Practical report references

- IEEE Format

[1] Federal Communications Commission. (2012, May) FCC ONLINE TABLE OF FREQUENCY ALLOCATIONS. [Online]. Available: http://transition.fcc.gov/oet/spectrum/table/fcctable.pdf

[2] G. L. Matthaei, L. Young and E. M. T. Jones, "Band-Stop Filters," in *Microwave Filters, Impedance Matching Networks, and Coupling Structures*. Dedham, MA: Artech House Books, 1964, ch. 12, pp. 725-773.

[3] B. M. Schiffman and G. L. Matthaei, "Exact Design of Band-Stop Microwave Filters," *IEEE Trans. Microw. Theory Tech.*, vol. 12, no. 1, pp. 6-15, January 1964.

[4] H. C. Bell, "L-Resonator Bandstop Filters," *IEEE Trans. Microw. Theory Tech.*, vol. 44, no. 12, pp. 2669-2672, December 1996.

[5] D. R. Jachowski, "Passive Enhancement of Resonator Q in Microwave Notch Filters," in *IEEE MTT-S Int. Microw. Symp. Dig., 2004*, pp. 1315-1318.

[6] A. C. Guyette, I. C. Hunter, R. D. Pollard, and D. R. Jachowski, "Perfectly-Matched Bandstop Filters using Lossy Resonators," in *2005 IEEE MTT-S Int. Microw. Symp. Dig.*, 2005, pp. 12-17.

Report due: To be Confirmed

Soft copy on ClickUp,
hardcopy at ENE 310 box in
CEFIM building

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Questions?

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