ANALOG FILTER DESIGN/ INTEGRATED CIRCUITS FILTER

(ELEC 6081)

(Winter 2011-'12 term)

Project#1 (Graduate)

An equi-ripple band-pass filter is required to satisfy the specifications:

(a) The pass-band extends from ω=1000 rad/s to 4000 rad/s.
(b) The peak-peak ripple in the pass-band not to exceed 0.5 dB.
(c) The magnitude characteristic is to be at least 30 dB down at ω=12000 rad/s.

1. Synthesize the filter transfer function (it will be of order >2). (**5%** marks)
2. Provide a decomposition of the transfer function as cascade of second order and possibly first order transfer functions. (**5%** marks)
3. Verify that the transfer function obtained satisfy the given specification (use numerical simulation, i.e., MATLAB). (**5%** marks)

4. Provide a design[1] for the above filter, using

   Operational Simulation principle with OP-AMP based active filter. (**30%** marks)

If you can produce your design using realistic model for the OP-AMP more credit will be given.

5. From the work in step 2 above, use one of the second order transfer functions for the following tasks.

(a) Produce a design of the second order filter using OA. Use of nearest practical values of R,C elements (as obtained from the lab bins, i.e., for R= 1.231 kΩ, use 1.2 kΩ, and for C=0.125 µF. use 0.1 µF, or 0.1 µF plus 20 nF in parallel) is encouraged. Provide SPICE simulation results and a comparison with the theoretical transfer function (second order). The theoretical transfer function can be obtained using numerical simulation (i.e., MATLAB). Use model of a practical OA such as µ741 from the SPICE data base. (**15%** marks)

(b) Produce a design of the second order filter using OTA and capacitors. Use of nearest practical values for the C elements (as obtained from the lab bins, i.e., for C=0.125 µF. use 0.1 µF, or 0.1 µF plus 20 nF in parallel) is encouraged. Provide SPICE simulation results and a comparison with the theoretical transfer function (second order). The theoretical transfer function can be obtained using numerical simulation (i.e., MATLAB). Use model of a practical OTA (as used in the lab work) from the SPICE data base. (**15%** marks)

[1] The mark for each component of a design as in items 4, 5(a)-(c), is prorated according to the distribution under item 6(a(-(f).

(c) Produce a design of the second order filter using OA and switched capacitors. Use a clock frequency of 64 kHz. Use minimum capacitor value of 1 pF. Provide SPICE simulation results(exploit transmission line model for the z^{-1} variable) and a comparison with the theoretical transfer function (second order). The theoretical transfer function can be obtained using numerical simulation (i.e., MATLAB). Use model of a practical OTA (as used in the lab work) from the SPICE data base. (**15%** marks)

6. Submit a report about your design work. The report must include the following. **If you omit any one part, you will lose the % mark for that part.** Do not commit *plagiarism* in producing your work. Such act will result in severe disciplinary actions against the student(s).

For each design:

(a) Design equations (active device and filter system) used for each specific case (**10%** marks).
(b) One set of sample calculations for circuit elements used in the design. (**10%** marks).
(c) Schematic of the final network with *practical* component values shown in a **table** (**15%** marks).
(d) Circuit Simulation results using SPICE or similar program (**15%** marks).
(e) Comparison of the ideal response (numerical simulation) and the designed response, as obtained via circuit simulations (**5%** marks).
(f) Discussion of your results and comments on your accomplishments (**5%** marks).

For the overall report:

(g) Front cover and a table of contents (**5%** marks)
(h) List of references (**5%** marks)

Interpretation of the marks distribution for the project and report

1. Items 1-3 amounts to **15%**
2. Items 6 (g)-(h) amounts to **10%**
3. Items 4 and 5(a)-(c) amounts to **75%** (=30%+15%+15%+15%). Each subdivision of this 75% is distributed as in items 6 (a)-(f). Thus if you score 70% (i.e 42 in 60) in the items of 6 (a)-(f), in relation to task 4, your score in that part will be (42/60) times 30, i.e 21 in 30. The same score in 6(a)-(f) in relation to task 5(a) will give you (42/60) times 15, i.e., 10.5 in 15.

Note: The above amounts to **50%** of the *course marks.* Thus a score of 80 in items (1)-(3) above will turn out to be 40 in the course. An additional **5%** is assigned to a student according to his/her rating given by his/her peers in the project group.

***Academic Code of Conduct (related to the expectation of originality):**

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Form ENCS-SAS (03/04)

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Course Number:______________________________ **Instructor:**______________________________

Type of Submission (Please check off reponses to both a & b)

a. __ Report __ Assignment __ Lab Report __ Software

b. __ Individual submission __ Group Submission (All members of the team must sign below)

Having read both sides of this form, I certify that I/we have conformed to the Faculty's expectations of originality and standards of academic integrity.

Name: ____________________ ID No: ________ Signature: __________________Date: _______
(please print clearly)

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Do Not Write in this Space – Reserved for Instructor

EXPECTATIONS OF ORIGINALITY & STANDARDS OF ACADEMIC INTEGRITY

ALL SUBMISSIONS must meet the following requirements:

1. The decision on whether a submission is a group or individual submission is determined by the instructor. Individual submissions are done alone and should not be identical to the submission made by any other student. In the case of group submissions, all individuals in the group must be listed on and must sign this form prior to its submission to the instructor.
2. All individual and group submissions constitute original work by the individual(s) signing this form.
3. Direct quotations make up a very small proportion of the text, i.e., not exceeding 5% of the word count.
4. Material paraphrased from a source (e.g., print sources, multimedia sources, web-based sources, course notes or personal interviews) has been identified by a numerical reference citation.
5. All of the sources consulted and/or included in the report have been listed in the Reference section of the document.
6. All drawings, diagrams, photos, maps or other visual items derived from other sources have been identified by numerical reference citations in the caption.
7. No part of the document has been submitted for any other course.
8. Any exception to these requirements are indicated on an attached page for the instructor's review.

REPORTS and ASSIGNMENTS must also meet the following additional requirements:

1. A report or assignment consists entirely of ideas, observations, information and conclusions composed by the student(s), except for statements contained within quotation marks and attributed to the best of the student's/students' knowledge to their proper source in footnotes or references.
2. An assignment may not use solutions to assignments of other past or present students/instructors of this course or of any other course.
3. The document has not been revised or edited by another student who is not an author.
4. For reports, the guidelines found in Form and Style, by Patrick MacDonagh and Jack Borden (Fourth Edition: May 2000, available at http://www.encs.concordia.ca/scs/Forms/Form&Style.pdf) have been used for this submission.

LAB REPORTS must also meet the following requirements:

1. The data in a lab report represents the results of the experimental work by the student(s), derived only from the experiment itself. There are no additions or modifications derived from any outside source.
2. In preparing and completing the attached lab report, the labs of other past or present students of this course or any other course have not been consulted, used, copied, paraphrased or relied upon in any manner whatsoever.

SOFTWARE must also meet the following requirements:

1. The software represents independent work of the student(s).
2. No other past or present student work (in this course or any other course) has been used in writing this software, except as explicitly documented.
3. The software consists entirely of code written by the undersigned, except for the use of functions and libraries in the public domain, all of which have been documented on an attached page.
4. No part of the software has been used in previous submissions except as identified in the documentation.
5. The documentation of the software includes a reference to any component that the student(s) did not write.
6. All of the sources consulted while writing this code are listed in the documentation.

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ANALOG FILTER DESIGN/ INTEGRATED CIRCUITS FILTER

(ELEC 6081)

(Winter 2011-'12 term)

Project#2 (Graduate)

A band-reject filter is required to satisfy the specifications:

(a) The stop-band extends from 1kHz to 10kHz.
(b) The peak-peak ripple in the pass-band not to exceed 1.0 dB.
(c) The magnitude characteristic at 2 kHz is to be at least 30 dB down from its peak value at DC.

1. Synthesize the filter transfer function (it will be of order >2). (**5%** marks)
2. Provide a decomposition of the transfer function as cascade of second order and possibly first order transfer functions. (**5%** marks)
3. Verify that the transfer function obtained satisfy the given specification (use numerical simulation, i.e., MATLAB). (**5%** marks)

4. Provide a design[2] for the above filter, using

   Operational Simulation principle with OTA-C based active filter (**40%** marks)

5. From the work in step 2 above, use one of the second order transfer functions for the following tasks.

(a) Produce a design of the second order filter using OA. Use of nearest practical values of R,C elements (as obtained from the lab bins, i.e., for R= 1.231 kΩ, use 1.2 kΩ, and for C=0.125 μF. use 0.1 μF, or 0.1 μF plus 20 nF in parallel) is encouraged. Provide SPICE simulation results and a comparison with the theoretical transfer function (second order). The theoretical transfer function can be obtained using numerical simulation (i.e., MATLAB). Use model of a practical OA such as μ741 from the SPICE data base. (**20%** marks)

(b) Produce a design of the second order filter using OTA and capacitors. Use of nearest practical values for the C elements (as obtained from the lab bins, i.e., for C=0.125 μF. use 0.1 μF, or 0.1 μF plus 20 nF in parallel) is encouraged. Provide SPICE simulation results and a comparison with the theoretical transfer function (second order). The theoretical transfer function can be obtained using numerical simulation (i.e., MATLAB). Use model of a practical OTA (as used in the lab work) from the SPICE data base. (**15%** marks)

[2] The mark for each component of a design as in items 4, 5(a)-(b), is prorated according to the distribution under item 6(a(-(f).

6. Submit a report about your design work. The report must include the following. **If you omit any one part, you will lose the % mark for that part.** Do not commit *plagiarism* in producing your work. Such act will result in severe disciplinary actions against the student(s).

For each design:

(a) Design equations (active device and filter system) used for each specific case (**10%** marks).
(b) One set of sample calculations for circuit elements used in the design. (**10%** marks).
(c) Schematic of the final network with *practical* component values shown in a **table** (**15%** marks).
(d) Circuit Simulation results using SPICE or similar program (**15%** marks).
(e) Comparison of the ideal response (numerical simulation) and the designed response, as obtained via circuit simulations (**5%** marks).
(f) Discussion of your results and comments on your accomplishments (**5%** marks).

For the overall report:

(g) Front cover and a table of contents (**5%** marks)
(h) List of references (**5%** marks)

Interpretation of the marks distribution for the project and report

1. Items 1-3 amounts to **15%**
2. Items 6 (g)-(h) amounts to **10%**
3. Items 4 and 5(a)-(b) amounts to **75%** (=40%+20%+15%). Each subdivision of this 75% is distributed as in items 6 (a)-(f). Thus if you score 70% (i.e 42 in 60) in the items of 6 (a)-(f), in relation to task 4, your score in that part will be (42/60) times 30, i.e 21 in 30. The same score in 6(a)-(f) in relation to task 5(a) will give you (42/60) times 15, i.e., 10.5 in 15.

Note: The above amounts to **50%** of the *course marks.* Thus a score of 80 in items (1)-(3) above will turn out to be 40 in the course. An additional **5%** is assigned to a student according to his/her rating given by his/her peers in the project group.

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a. __ Report __ Assignment __ Lab Report __ Software

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ANALOG FILTER DESIGN/ INTEGRATED CIRCUITS FILTER

(ELEC 441)

(Winter 2011-'12 term)

Project#1 (UG)

An equi-ripple band-pass filter is required to satisfy the specifications:

(a) The pass-band extends from ω=1000 rad/s to 4000 rad/s.
(b) The peak-peak ripple in the pass-band not to exceed 0.5 dB.
(c) The magnitude characteristic is to be at least 30 dB down at ω=12000 rad/s.

1. Synthesize the filter transfer function (it will be of order >2). (**5%** marks)
2. Provide a decomposition of the transfer function as cascade of second order and possibly first order transfer functions. (**5%** marks)
3. Verify that the transfer function obtained satisfy the given specification (use numerical simulation, i.e., MATLAB). (**5%** marks)

4. Provide a design[3] for the above filter, using

   (a) Cascade of OP-AMP based active filter. (**30%** marks)
   (b) Cascade of OTA-C based active filter. (**30%** marks)

You are encouraged to use realistic model for the OP-AMP in (a) above.

5. From the work in step 2 above, use one of the second order transfer functions for the following task.

(a) Produce a design of the second order filter using OA and switched capacitors. Use a clock frequency of 64 kHz. Use minimum capacitor value of 1 pF. Provide SPICE simulation results(exploit transmission line model for the z^{-1} variable) and a comparison with the theoretical transfer function (second order). The theoretical transfer function can be obtained using numerical simulation (i.e., MATLAB). (**15%** marks)

6. Submit a report about your design work. The report must include the following. **If you omit any one part, you will lose the % mark for that part.** Do not commit *plagiarism* in producing your work. Such act will result in severe disciplinary actions against the student(s).

For each design:

[3] The mark for each component of a design as in items 4, 5(a), is prorated according to the distribution under item 6(a(-(f).

(a) Design equations (active device and filter system) used for each specific case (**10%** marks).
(b) One set of sample calculations for circuit elements used in the design. (**10%** marks).
(c) Schematic of the final network with *practical* component values (as obtained from the lab bins, i.e., for R= 1.231 kΩ, use 1.2 kΩ, and for C=0.125 μF. use 0.1 μF, or 0.1 μF plus 20 nF in parallel) shown in a **table** (**15%** marks).
(d) Circuit Simulation results using SPICE or similar program (**15%** marks).
(e) Comparison of the ideal response (numerical simulation) and the designed response, as obtained via circuit simulations (**5%** marks).
(f) Discussion of your results and comments on your accomplishments (**5%** marks).

For the overall report:

(g) Front cover and a table of contents (**5%** marks)
(h) List of references (**5%** marks)

Interpretation of the marks distribution for the project and report

1. Items 1-3 amounts to **15%**
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1/2

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ANALOG FILTER DESIGN/ INTEGRATED CIRCUITS FILTER

(ELEC 441, 6081)

(Winter 2011-'12 term)

Project#2 (UG)

A band-reject filter is required to satisfy the specifications:

(a) The stop-band extends from 1kHz to 10kHz.
(b) The peak-peak ripple in the pass-band not to exceed 1.0 dB.
(c) The magnitude characteristic at 2 kHz is to be at least 30 dB down from its peak value at DC.

1. Synthesize the filter transfer function (it will be of order >2). (**5%** marks)
2. Provide a decomposition of the transfer function as cascade of second order and possibly first order transfer functions. (**5%** marks)
3. Verify that the transfer function obtained satisfy the given specification (use numerical simulation, i.e., MATLAB). (**5%** marks)

4. Provide a design[4] for the above filter, using

(a) Cascade of OP-AMP based active filter. (**30%** marks)
(b) Cascade of OTA-C based active filter. (**30%** marks)

You are encouraged to use realistic model for the OP-AMP in (a) above.

5. From the work in step 2 above, select one of the second order transfer functions for the following task.

(a) Produce a design of the second order filter using OA and switched capacitors. Use bilinear transformation with a clock frequency of 64 kHz. Use minimum capacitor value of 1 pF.
Use the design capacitance values to derive the designed transfer function and compare the designed response with the theoretical response (as obtained after bilinear transformation). The theoretical transfer function can be computed using numerical simulation (i.e., MATLAB). (**15%** marks)

6. Submit a report about your design work. The report must include the following. **If you omit any one part, you will loose the % mark for that part.** Do not commit *plagiarism* in producing your work. Such act will result in severe disciplinary actions against the student(s).

[4] The mark for each component of a design as in items 4, 5(a), is prorated according to the distribution under item 6(a(-(f).

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(a) Design equations (active device and filter system) used for each specific case (**10%** marks).
(b) One set of sample calculations for circuit elements used in the design. (**10%** marks).
(c) Schematic of the final network with *practical* component values (as obtained from the lab bins, i.e., for R= 1.231 kΩ, use 1.2 kΩ, and for C=0.125 μF. use 0.1 μF, or 0.1 μF plus 20 nF in parallel) shown in a **table** (**15%** marks).
(d) Circuit Simulation results using SPICE or similar program (**15%** marks).
(e) Comparison of the ideal response (numerical simulation) and the designed response, as obtained via circuit simulations (**5%** marks).
(f) Discussion of your results and comments on your accomplishments (**5%** marks).

For the overall report:

(g) Front cover and a table of contents (**5%** marks)
(h) List of references (**5%** marks)

Interpretation of the marks distribution for the project and report

1. Items 1-3 amounts to **15%**
2. Items 6 (g)-(h) amounts to **10%**
3. Items 4(a)-(b) and 5(a) amounts to **75%** (=30%+30%+15%). Each subdivision of this 75% is distributed as in items 6 (a)-(f). Thus if you score 70% (i.e 42 in 60) in the items of 6 (a)-(f), in relation to task 4(a), your score in that part will be (42/60) times 30, i.e 21 in 30. The same score in 6(a)-(f) in relation to task 5(a) will give you (42/60) times 15, i.e., 10.5 in 15.

Note: The above amounts to **50%** of the *course marks.* Thus a score of 80 in items (1)-(3) above will turn out to be 40 in the course. An additional **5%** is assigned to a student according to his/her rating given by his/her peers in the project group.

*Academic Code of Conduct (related to the expectation of originality):

Cheating is a serious offence. You must abide by the Academic Code of Conduct as described in the University Calendar. Any suspected violation of the Code will be reported to the Associate Dean for investigation. Penalties can be as severe as dismissal from the University.

The Code forbids *plagiarism*. For example, you may not copy any part of an assignment or report from a student who took the course in a previous year or the present year. The code also forbids you from providing the material to another student. If you allow another student to copy your work you have behaved unethically and have committed an offence.

Form ENCS-SAS (03/04)

Faculty of Engineering and Computer Science
Expectations of Originality

This form has been created to ensure that all students in the Faculty of Engineering and Computer Science comply with principles of academic integrity prior to submitting coursework to their instructors for evaluation: namely reports, assignments, lab reports and/or software. All students should become familiar with the University's Code of Conduct (Academic) located at http://web2.concordia.ca/Legal_Counsel/policies/english/AC/Code.html

Please read the back of this document carefully before completing the section below. This form must be attached to the front of all coursework submitted to instructors in the Faculty of Engineering and Computer Science.

Course Number:_________________________________ **Instructor:**_________________________________

Type of Submission (Please check off reponses to both a & b)

a. __ Report __ Assignment __ Lab Report __ Software

b. __ Individual submission __ Group Submission (All members of the team must sign below)

Having read both sides of this form, I certify that I/we have conformed to the Faculty's expectations of originality and standards of academic integrity.

Name: ________________________ ID No: __________ Signature: ____________________Date: ________
(please print clearly)

Name: ________________________ ID No: __________ Signature: ____________________Date: ________
(please print clearly)

Name: ________________________ ID No: __________ Signature: __________________ _ Date: ________
(please print clearly)

Name: ________________________ ID No: __________ Signature: ___________________ Date: ________
(please print clearly)

Name: ________________________ ID No: __________ Signature: ___________________ Date: ________
(please print clearly)

Name: ________________________ ID No: __________ Signature: ___________________ Date: ________
(please print clearly

Do Not Write in this Space – Reserved for Instructor

1/2

EXPECTATIONS OF ORIGINALITY & STANDARDS OF ACADEMIC INTEGRITY

ALL SUBMISSIONS must meet the following requirements:

1. The decision on whether a submission is a group or individual submission is determined by the instructor. Individual submissions are done alone and should not be identical to the submission made by any other student. In the case of group submissions, all individuals in the group must be listed on and must sign this form prior to its submission to the instructor.
2. All individual and group submissions constitute original work by the individual(s) signing this form.
3. Direct quotations make up a very small proportion of the text, i.e., not exceeding 5% of the word count.
4. Material paraphrased from a source (e.g., print sources, multimedia sources, web-based sources, course notes or personal interviews) has been identified by a numerical reference citation.
5. All of the sources consulted and/or included in the report have been listed in the Reference section of the document.
6. All drawings, diagrams, photos, maps or other visual items derived from other sources have been identified by numerical reference citations in the caption.
7. No part of the document has been submitted for any other course.
8. Any exception to these requirements are indicated on an attached page for the instructor's review.

REPORTS and ASSIGNMENTS must also meet the following additional requirements:

1. A report or assignment consists entirely of ideas, observations, information and conclusions composed by the student(s), except for statements contained within quotation marks and attributed to the best of the student's/students' knowledge to their proper source in footnotes or references.
2. An assignment may not use solutions to assignments of other past or present students/instructors of this course or of any other course.
3. The document has not been revised or edited by another student who is not an author.
4. For reports, the guidelines found in Form and Style, by Patrick MacDonagh and Jack Borden (Fourth Edition: May 2000, available at http://www.encs.concordia.ca/scs/Forms/Form&Style.pdf) have been used for this submission.

LAB REPORTS must also meet the following requirements:

1. The data in a lab report represents the results of the experimental work by the student(s), derived only from the experiment itself. There are no additions or modifications derived from any outside source.
2. In preparing and completing the attached lab report, the labs of other past or present students of this course or any other course have not been consulted, used, copied, paraphrased or relied upon in any manner whatsoever.

SOFTWARE must also meet the following requirements:

1. The software represents independent work of the student(s).
2. No other past or present student work (in this course or any other course) has been used in writing this software, except as explicitly documented.
3. The software consists entirely of code written by the undersigned, except for the use of functions and libraries in the public domain, all of which have been documented on an attached page.
4. No part of the software has been used in previous submissions except as identified in the documentation.
5. The documentation of the software includes a reference to any component that the student(s) did not write.
6. All of the sources consulted while writing this code are listed in the documentation.

Important: Should you require clarification on any of the above items please contact your instructor.