EE175 FILTER DESIGN SPRING 2013

Course Objective

The student will learn to analyze and design passive, active and switched capacitor filters. The theory as well as the tools for classical and modern filter design will be covered. Where applicable computer design aids will be used. Emphasis will be given to the following topics related to passive network analysis and synthesis: complex frequency domain concepts; properties of LC, RC (RL) input impedances; synthesis of ladder networks; properties of second-order systems; sensitivity. In regard to active filter design these topics will be covered: pole-zero control through dependent sources; second-order low-pass, high-pass, band-pass, and other approximations; state variable topology and switched capacitor circuits.

Topics

- Complex frequency domain concepts
- Properties of LC, RC (RL) input impedances
- Synthesis of ladder networks
- Properties of second-order systems
- Pole-zero control through dependent sources
- Second-order low-pass, high-pass, band-pass and other approximations
- Butterworth, Chebyshev, Elliptic and Bessel filters
- State variable topology
- Switched capacitor circuits

Pre/Corequisites

EE112, EE124 or instructor approval

Outcomes

The student should master the following subjects and/or perform the following tasks:

- Understanding of the concept of system functions and their interpretation in the analysis and design of filters
- Knowledge of the concepts of the complex frequency, time domain, Laplace transform, scaling, frequency transformation
- Synthesis of Foster and Cauer input impedance
- Determination of the Butterworth, Chebyshev, Elliptic or Bessel transfer functions of the filter starting from the filter specifications
- Design of passive circuits starting from the transfer function using the ladder synthesis approach
- Design of active circuits starting from the transfer function applying the method of moving poles and zeros using dependent sources
- Design of state variable active filters and switched capacitor filters using the leap frog method
- Application of computer tools for computer aided filter design and analysis
Outcome Assessment

- Class participation
- Two midterms and a final exam
- Regular assignments (book and special problems) and computer assignments
- One special project: submission of a formal report on an assigned filter design project
- Semester-end course and instructor evaluation.

Relationship of Course to Program Objectives

This course supports the achievement of the following objectives (numbers in parentheses refer to specific ABET criteria):

(3.a) an ability to apply knowledge of mathematics, science, and engineering
(3.b) an ability to design and conduct experiments, as well as to analyze and interpret data
(3.c) an ability to design a system, component, or process to meet desired needs
(3.d) an ability to function on multi-disciplinary teams
(3.e) an ability to identify, formulate, and solve engineering problems
(3.f) an understanding of professional and ethical responsibility
(3.g) an ability to communicate effectively
(3.h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(3.i) a recognition of the need for, and an ability to engage in life-long learning
(3.j) a knowledge of contemporary issues
(3.k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

(4) a preparation for engineering practice through this course culminating in a major design experience based on the knowledge and skills acquired in earlier coursework and incorporating engineering standards and realistic constraints

(EE.2) an ability to analyze and design systems containing hardware and software components
(EE.3) a knowledge of advanced mathematics such as differential equations, linear algebra, complex variables, discrete mathematics.

Course Coordinator

Udo Strasilla

Course Instructor: Udo Strasilla

Room ENG 329, TTh 19:30-20:45

Office Hours

Room E259, MW 13:00-14:00, TTh 21:00-22:00

Phone, Email, Website

(408) 924-3920, ee124lab@yahoo.com web: http://www.engr.sjsu.edu/ustrasil
Textbook and Other Requirements


References

Passive and Active Filters, by Wai-Kai Chen, John Wiley & Sons, 1986

Project(s) and Homework

The student is expected to study the material covering the topics in the schedule prior to their discussion in class. Two types of assignments will be assigned approximately every week:
1. Regular assignments covering problems from the textbook or special problems,
2. Computer assignments where computer tools must be used to solve analysis or design problems.

Homework should be stapled together and turned in flat (do not fold). On top center write the Assignment No. (Example: Assmt 1) and in the upper right corner write your name (last, first), the date submitted, and the problem numbers. Late homework will not be accepted.

Each student will be given a web-project. The projects must be submitted in both formats: in printout and on one floppy disk, or CD-ROM. The project consists of a filter design problem (passive and active realization). Each student is given a different specification. Using techniques learned in class the student must show step-by-step in the form of a tutorial how he or she achieves the design. Success of the design must be demonstrated by using PSPICE simulation of the final circuits and superimposing the magnitude and phase versus frequency characteristic in a Bode plot on top of the specification. The paper must meet professional standards as expected in conference proceedings or in journal papers. Microsoft Office software normally is sufficient to accomplish this goal, for example “equation writer”. The work should be submitted in a “Word”-format, not pdf, html etc. The project requires design tools learnt in class. To avoid logjam caused by attempting the project at once at the end of the semester, the student should proceed with the project step-by-step as soon as knowledge obtained in class is available. Informal design-review submissions will be requested at appropriate times. In each design review submission the student must submit the circuit and a graph with the design achieved at that time superimposed with the given spec. Thus, the task close to the project due date will be mainly the documentation of the total design process and end result in a formal report.

Exams

There will be 2 examinations in addition to the final comprehensive examination. The dates of these examinations are shown on the schedule. All exams will be closed-book except for a sheet (both sides may be used) of notes, formulae, etc., that students will be allowed to bring at test time. There will be no make-up exams. Any student who fails to take an examination will receive a letter grade of F for that particular examination.
EE@SJSU
Honesty and Respect for Others and Public Property

EE HONOR CODE

The Electrical Engineering Department will enforce the following Honor Code that must be read and accepted by all students.

“I have read the Honor Code and agree with its provisions. My continued enrollment in this course constitutes full acceptance of this code. I will NOT:

• Take an exam in place of someone else, or have someone take an exam in my place
• Give information or receive information from another person during an exam
• Use more reference material during an exam than is allowed by the instructor
• Obtain a copy of an exam prior to the time it is given
• Alter an exam after it has been graded and then return it to the instructor for re-grading
• Leave the exam room without returning the exam to the instructor.”

Measures Dealing with Occurrences of Cheating

• Department policy mandates that the student or students involved in cheating will receive an “F” on that evaluation instrument (paper, exam, project, homework, etc.) and will be reported to the Department and the University.
• A student’s second offense in any course will result in a Department recommendation of suspension from the University.
The overall grade for the course will be ascertained as follows.

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<thead>
<tr>
<th></th>
<th>2 Midterms 50%</th>
<th>Final 30%</th>
<th>Reg. &amp; Comp. Assmt 12%</th>
<th>Project 8%</th>
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The final grade will be based on the distribution curve based on the sum of the weighted grades.

**Course Schedule**

<table>
<thead>
<tr>
<th>DATE</th>
<th>Day</th>
<th>TOPIC</th>
<th>Budak Chapter</th>
<th>Budak Pages</th>
</tr>
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<tbody>
<tr>
<td>Jan. 24</td>
<td>Th</td>
<td>Introduction</td>
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<tr>
<td>Jan. 29</td>
<td>T</td>
<td>Magnitude and Phase Function</td>
<td>16</td>
<td>486-490</td>
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<td>Jan 31</td>
<td>Th</td>
<td>From $</td>
<td>G(j\omega)</td>
<td>^2$ to $G(s)$</td>
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<tr>
<td>Feb. 5</td>
<td>T</td>
<td>Lowpass Approximations</td>
<td>17</td>
<td>504-532</td>
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<td>Feb. 7</td>
<td>Th</td>
<td>Highpass Approximations</td>
<td>19</td>
<td>560-570</td>
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<tr>
<td>Feb. 12</td>
<td>T</td>
<td>Bandpass and Other Approximations</td>
<td>20</td>
<td>578-592</td>
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<tr>
<td>Feb. 14</td>
<td>Th</td>
<td>Computer Aided Filter Design</td>
<td>-</td>
<td>Handout</td>
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<tr>
<td>Feb. 19</td>
<td>T</td>
<td>System Function, Network Response</td>
<td>1,2</td>
<td>1-54</td>
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<tr>
<td>Feb. 21</td>
<td>Th</td>
<td>Input Impedances</td>
<td>3</td>
<td>55-70</td>
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<tr>
<td>Feb. 26</td>
<td>T</td>
<td>Input Impedances (RC &amp; LC)</td>
<td>3</td>
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<tr>
<td>Feb. 28</td>
<td>Th</td>
<td>Input Impedance Synthesis</td>
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<td>86-99</td>
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<tr>
<td>Mar. 5</td>
<td>T</td>
<td>RC Foster &amp; Cauer Networks</td>
<td>4</td>
<td>99-111</td>
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<tr>
<td>Mar. 7</td>
<td>Th</td>
<td>Ladder Networks</td>
<td>5</td>
<td>112-119; Web project assignment is given</td>
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<tr>
<td>Mar. 12</td>
<td>T</td>
<td>Ladder Synthesis</td>
<td>5</td>
<td>119-134</td>
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<td>Mar. 14</td>
<td>Th</td>
<td>Second Order Systems</td>
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<td>145-152</td>
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<td>Mar. 19</td>
<td>T</td>
<td>Pole-Zero Loci</td>
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<td>152-166</td>
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<tr>
<td>Mar. 21</td>
<td>Th</td>
<td><strong>Midterm I</strong></td>
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<tr>
<td>Mar. 25/29</td>
<td>*** Spring Break ***</td>
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<tr>
<td>Apr. 2</td>
<td>T</td>
<td>Op Amps (Ideal)</td>
<td>7</td>
<td>189-205</td>
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<tr>
<td>Apr. 4</td>
<td>Th</td>
<td>Pole Zero Control</td>
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<td>283-302</td>
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<tr>
<td>Apr. 9</td>
<td>T</td>
<td>Control of Zeros</td>
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<td>302-318</td>
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<tr>
<td>Apr. 11</td>
<td>Th</td>
<td>2nd Order Circuits derived by moving poles/zeros</td>
<td>9</td>
<td>Handout</td>
</tr>
<tr>
<td>Apr. 16</td>
<td>T</td>
<td>Lowpass Realizations</td>
<td>10</td>
<td>19-326; 338-341;350-351; 356-361</td>
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<td>Apr. 18</td>
<td>Th</td>
<td>Bandpass Realizations</td>
<td>11</td>
<td>373-394</td>
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<tr>
<td>Apr. 23</td>
<td>T</td>
<td>Highpass, Bandstop, Allpass, Oscillator</td>
<td>12, 13, 14, 15</td>
<td>411-485</td>
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<tr>
<td>Apr. 25</td>
<td>Th</td>
<td>Multiple Op Amp</td>
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<td>Handout; Project due</td>
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<tr>
<td>Apr. 30</td>
<td>T</td>
<td><strong>Midterm II</strong></td>
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<tr>
<td>May 2</td>
<td>Th</td>
<td>Leap Frog Technique</td>
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<td>Handout</td>
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<tr>
<td>May 7</td>
<td>T</td>
<td>Switched Capacitor Filter Design</td>
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<td>Handout</td>
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<tr>
<td>May 9</td>
<td>Th</td>
<td>Last Class; Review</td>
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<tr>
<td>May 16</td>
<td>Th</td>
<td><strong>FINAL EXAM</strong> (19:45-22:00)</td>
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Rev: 24 Jan 2013