

Cover Sheet: Request 11432

EEL 4XXX - Resonant MEMS

Info

| | |
|------------------------|--|
| Process | Course New Ugrad/Pro |
| Status | Pending |
| Submitter | Chillingworth,Shannon M schill@ece.ufl.edu |
| Created | 1/27/2017 2:58:15 PM |
| Updated | 3/13/2017 8:16:17 AM |
| Description of request | New course approval. |

Actions

| Step | Status | Group | User | Comment | Updated |
|--|----------|---|------------------|----------------------------|-----------|
| Department | Approved | ENG - Electrical and Computer Engineering 011905000 | Fox, Robert M | | 1/30/2017 |
| No document changes | | | | | |
| College | Approved | ENG - College of Engineering | Caple, Elizabeth | | 2/10/2017 |
| Replaced 4XXX_Resonant_MEMS_UCC1_Syll.docx | | | | | 2/3/2017 |
| Replaced 5XXX_Resonant_MEMS_UCC1_Syll.docx | | | | | 2/3/2017 |
| Deleted 5XXX_Resonant_MEMS_UCC1_Syll.docx | | | | | 2/3/2017 |
| Added 4XXX_Resonant_MEMS_UCC1_Syll.docx | | | | | 2/3/2017 |
| University Curriculum Committee | Comment | PV - University Curriculum Committee (UCC) | Case, Brandon | Added to the March agenda. | 2/27/2017 |
| No document changes | | | | | |
| University Curriculum Committee | Pending | PV - University Curriculum Committee (UCC) | | | 2/27/2017 |
| No document changes | | | | | |
| Statewide Course Numbering System | | | | | |
| No document changes | | | | | |
| Office of the Registrar | | | | | |
| No document changes | | | | | |
| Student Academic Support System | | | | | |
| No document changes | | | | | |
| Catalog | | | | | |
| No document changes | | | | | |
| College Notified | | | | | |
| No document changes | | | | | |

Course|New for request 11432

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Description of request: New course approval.

Submitter: Chillingworth, Shannon M schill@ece.ufl.edu

Created: 1/27/2017 2:58:15 PM

Form version: 1

Responses

Recommended PrefixEEL

Course Level 4

Number XXX

Category of Instruction Advanced

Lab Code None

Course Title Resonant MEMS

Transcript Title Resonant MEMS

Degree Type Baccalaureate

Delivery Method(s) On-Campus

Co-Listing Yes

Co-Listing Explanation This course is co-listed with the graduate class. The homework portion of the graduate section will involve additional work and more advanced concepts with respect to the undergraduate section. The exams will also involve more advanced concepts with respect to the undergraduate section.

Grading for the homework and projects are different from the undergraduate course. For the undergraduate section, the homework has a higher grading percentage while the project has a lower grading percentage. Graduate students will present material from a research paper of their choosing and will also submit a written report.

Effective Term Fall

Effective Year 2017

Rotating Topic? No

Repeatable Credit? No

Amount of Credit 3

S/U Only? No

Contact Type Regularly Scheduled

Weekly Contact Hours 3

Course Description Fundamentals of resonant micro-electro-mechanical systems (Resonant MEMS) and their applications.

Prerequisites EEL 3135 & EEL 3112 or per instructor's permission

Co-requisites None

Rationale and Placement in Curriculum This course exposes students to the basics of MEMS resonant devices: their principles of operation, theoretical limits of performance and applications. Introduce resonator-based frequency references, physical sensors and signal processors.

Course Objectives Learn the basics of MEMS resonant devices: their principles of operation, theoretical limits of performance and applications. Introduce resonator-based frequency references, physical sensors and signal processors. Design micro-resonators to meet desired needs and specifications.

These objectives will be accomplished through:

1. Introductory analysis of Resonant MEMS through basic analytical models.
2. Discussion on the sensitivity of Resonant MEMS to physical perturbations.
3. Review of Resonant MEMS applications in consumer electronic systems.
4. Introduction to a finite element simulation software for mixed-domain modeling of Resonant MEMS.

Course Textbook(s) and/or Other Assigned Reading Required Textbooks and Software

The course notes are developed by the instructor.

Title: Resonant MEMS: Fundamentals, Implementation and Application

Author: Oliver Brand, et. al.

Publication date, edition, and publisher: 1st Ed., Wiley-VCH, 2015

ISBN number: 978-3-527-33545-9

Software: COMSOL Multiphysics (Note: The instructor provides access of students, in few groups, to the licenses purchased by IMG.)

Recommended Materials

Books:

V. Kaajakari, Practical MEMS, Small Gear Publishing, 2009

J. Rosenbaum, Bulk acoustic wave theory and devices, Artech House, 1988.

Primary Journals:

Applied Physics Letters (AIP)

Trans. On Ultrasonics, Ferroelectrics and Frequency Control (IEEE/UFFC)

J. Microelectromechanical Systems (IEEE/ASME)

Trans. On Electron Devices (IEEE/EDS)

Sensors and Actuators (Elsevier)

Major Conferences:

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Informative Websites:

www.kaajakari.net/~ville/research/tutorials/tutorials.shtml (MEMS tutorials)

www.memsjournal.com Premiere online journal of MEMS-related news

www.memsnets.org General MEMS and Nanotechnology Information

Weekly Schedule of Topics Week Topic

Due Dates (estimated)

- | | | |
|---|---|-----|
| 1 | Course overview, Intro to resonant MEMS devices, Damped oscillation of microstructures | |
| 2 | Integrated transducers and electromechanical coupling efficiency, Lumped element modeling | HW1 |
| 3 | Performance sensitivity of MEMS resonators to ambient variables: Temperature, Pressure, Viscosity | |
| 4 | Compensation and tuning of MEMS resonators | HW2 |
| 5 | Dissipation mechanisms and quality factor | |
| 6 | Finite element modeling of MEMS resonators | HW3 |
| 7 | Resonant MEMS in timing & frequency references | |
| 8 | Resonant MEMS for physical sensing: Environmental sensors, Gravimetric sensors | |

- HW4
- 9 Resonant MEMS for signal processing: Electrically and mechanically coupled VHF filters
- 10 Resonant MEMS for signal processing: Acoustically coupled UHF filters, Resonant RF switches HW5
- 11 Power handling and non-linearity in MEMS resonators
- 12 Acoustic phonons and dispersion curves HW5
- 13 Phonon traps and evanescent waves HW7
- 14 Multi-mode phonon traps
- 15 Combinatorial phononic sensors HW8

Links and Policies A "C-" will not be a qualifying grade for critical tracking courses. In order to graduate, students must have an overall GPA and an upper-division GPA of 2.0 or better (C or better). Note: A "C-" average is equivalent to a GPA of 1.67, and therefore, it does not satisfy this graduation requirement.

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Course Evaluation

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Software Use

All faculty, staff and student of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Campus Resources:

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Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. <https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. <https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. <https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus:
https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.

Grading Scheme Evaluation of Grades:

| | |
|-------------------|---------------------------|
| Assignment | Percentage of Final Grade |
| Homework Sets (8) | 35% |
| Midterm Exam | 20% |
| Final Exam | 25% |
| Presentation | 20% |
| TOTAL | 100% |

Note: This course is co-listed with the graduate class. The homework portion of the graduate section will involve additional work and more advanced concepts with respect to the undergraduate section. The exams will also involve more advanced concepts with respect to the undergraduate section.

Grading for the homework and projects are different from the undergraduate course. For the undergraduate section, the homework has a higher grading percentage while the project has a lower grading percentage. Graduate students will present material from a research paper of their choosing and will also submit a written report.

Instructor(s) Dr. Roozbeh Tabrizian

Resonant MEMS
EEL 4XXX Section XXXX
Class Periods: TBD
Location: TBD
Academic Term: TBD

Instructor

- Name: Roozbeh Tabrizian
- Email Address: rtabrizian@ufl.edu
- Office Phone Number: 352-846-3017
- Office Hours: TBD

Teaching Assistants

Please contact through the Canvas website

- No TA is needed.

Course Description

Fundamentals of resonant micro-electro-mechanical systems (Resonant MEMS) and their applications. Credits: 3.

Course Pre-Requisites / Co-Requisites

Introduction to Signals and Systems (EEL 3135) and Circuits 2 (EEL 3112); or per instructor's permission.

Course Objectives

Learn the basics of MEMS resonant devices: their principles of operation, theoretical limits of performance and applications. Introduce resonator-based frequency references, physical sensors and signal processors. Design micro-resonators to meet desired needs and specifications.

These objectives will be accomplished through:

1. Introductory analysis of Resonant MEMS through basic analytical models.
2. Discussion on the sensitivity of Resonant MEMS to physical perturbations.
3. Review of Resonant MEMS applications in consumer electronic systems.
4. Introduction to a finite element simulation software for mixed-domain modeling of Resonant MEMS.

Materials and Supply Fees

NA

Professional Component (ABET)

This course consists of 1.5 credits of Engineering Design and 1.5 credits of Engineering Science.

Relation to Program Outcomes (ABET)

Engineering Criteria

- a - an ability to apply knowledge of mathematics, science, and engineering
- b - an ability to function on multi-disciplinary teams
- c - an ability to identify, formulate, and solve engineering problems
- d - an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

EE Program Criteria

- EE1 - knowledge of mathematics, basic and engineering sciences necessary to analyze and design complex systems

Required Textbooks and Software

The course notes are developed by the instructor.

- Title: **Resonant MEMS: Fundamentals, Implementation and Application**
- Author: Oliver Brand, et. al.
- Publication date, edition, and publisher: 1st Ed., Wiley-VCH, 2015
- ISBN number: 978-3-527-33545-9
- Software: COMSOL Multiphysics (Note: The instructor provides access of students, in few groups, to the licenses purchased by IMG.)

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- Applied Physics Letters* (AIP)
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Course Schedule

| Week | Topic | Due Dates (estimated) |
|-------------|---|------------------------------|
| 1 | Course overview, Intro to resonant MEMS devices, Damped oscillation of microstructures | |
| 2 | Integrated transducers and electromechanical coupling efficiency, Lumped element modeling | HW1 |
| 3 | Performance sensitivity of MEMS resonators to ambient variables: Temperature, Pressure, Viscosity | |
| 4 | Compensation and tuning of MEMS resonators | HW2 |
| 5 | Dissipation mechanisms and quality factor | |
| 6 | Finite element modeling of MEMS resonators | HW3 |
| 7 | Resonant MEMS in timing & frequency references | |
| 8 | Resonant MEMS for physical sensing: Environmental sensors, Gravimetric sensors | HW4 |
| 9 | Resonant MEMS for signal processing: Electrically and mechanically coupled VHF filters | |

| | | |
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| 10 | Resonant MEMS for signal processing: Acoustically coupled UHF filters, Resonant RF switches | HW5 |
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| 14 | Multi-mode phonon traps | |
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Evaluation of Grades:

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| 77 - 79 | B- | 2.67 |
| 73 - 76 | C+ | 2.33 |
| 70 - 72 | C | 2.00 |
| 67 - 69 | C- | 1.67 |
| 63 - 66 | D+ | 1.33 |
| 60 - 62 | D | 1.00 |
| 57 - 59 | D- | 0.67 |
| 0 - 56 | E | 0.00 |

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Resonant MEMS
EEL 5XXX Section XXX
Class Periods: TBD
Location: TBD
Academic Term: TBD

Instructor:

- Name: Roozbeh Tabrizian
- Email Address: rtabrizian@ufl.edu
- Office Phone Number: 352-846-3017
- Office Hours: Wednesday, 4:00 pm – 6:00 pm, LAR 217
-

Teaching Assistants:

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- No TA is needed.

Course Description

Fundamentals of resonant micro-electro-mechanical systems (Resonant MEMS) and their applications. Credits: 3.

Course Pre-Requisites / Co-Requisites

Familiarity with ordinary differential equations, elementary signals and systems and circuit theory.

Course Objectives

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Health and Wellness

U Matter, We Care:

If you or a friend is in distress, please contact umatter@ufl.edu or 352-392-1575 so that a team member can reach out to the student.

Counseling and Wellness Center: <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
<https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.

