Washington State University
MAJOR CURRICULAR CHANGE FORM - - NEW/RESTORE COURSE

- ☐ **Please attach rationale for your request, a complete syllabus**, and explain how this impacts other units in Pullman and other campuses (if applicable).
- ☐ **Obtain all required signatures with dates.**
- ☐ **Provide original stapled packet of signed form/rationale statement/syllabus** PLUS **10 stapled copies** of complete packet to the **Registrar's Office**, campus mail code 1035.
- ☐ **Submit one electronic copy of complete packet** to wsu.curriculum@wsu.edu.

Requested **Future** Effective Date: Fall 2016 (term/year) Course Typically Offered: Fall

DEADLINES: For fall term effective date: **October 1st**; for spring or summer term effective date: **February 1st**. See instructions.

NOTE: Items received after deadlines may be put to the back of the line or forwarded to the following year. Please submit on time.

☒ **New Course** ☐ Temporary Course ☐ **Restore Course**

ECE	537	High Frequency Circuit Design
course subject/crosslist	course no.	title

3	(3 -)	ECE 370 and ECE 425
Credit hrs	lecture hrs per week / lab or studio hrs per week	prerequisite

Description for catalog: Active microwave components (diodes, transistors), microwave transistor amplifiers, oscillators, mixers, stability criteria and circles, noise in microwave circuits, noise figure.

Additional Attributes: Check all that apply.

☐ Crosslisting (between WSU departments)* ☐ Conjoint listing (400/500):_____

☐ Variable credit:_____ ☐ Repeat credit (cum. max. hrs):_____

Special Grading: ☐ S, F; ☐ A, S, F (PEACT only); ☐ S, M, F (VET MED only); ☐ H, S, F (PHARMACY, PHARDSCI only)

☐ Cooperative with UI ☐ Other (please list request): _____

The following items require prior submission to other committees/depts. (SEE INSTRUCTIONS.)

☐ Request to meet Writing in the Major [M] requirement **(Must have All-University Writing Committee Approval.)**

☐ Request to meet UCORE in _____ **(Must have UCORE Committee Approval › › See instructions.)**

☐ Special Course Fee_____ **(Must submit request to University Receivables.)**

Contact: Tutku Karacolak Phone number: (360) 546-9185 Campus mail code: 98686

Email: tutku.karacolak@wsu.edu Instructor, if different:_____

8/28/15	8/31/15	
Chair/date	**Dean/date**	**All-University Writing Com / date**
Chair (if crosslisted/interdisciplinary)*	**Dean (if crosslisted/interdisciplinary)***	**UCORE Committee Approval Date**
Catalog Subcommittee Approval Date	**GSC or AAC Approval Date**	**Faculty Senate Approval Date**

***If the proposed change impacts or involves collaboration with other units, use the additional signature lines provided for each impacted unit and college.**

Rationale: ECE 537 High Frequency Circuit Design

ECE 537 High Frequency Circuit Design is being proposed to give electrical engineering graduate students the opportunity to have a depth of knowledge in the design of active microwave circuits such as amplifiers, oscillators, and mixers. It aligns with WSU Vancouver's electrical engineering curriculum as a continuation of ECE 425, RF Devices and Circuits. ECE 425 covers fundamentals of microwave theory and introduces passive microwave devices and will be a prerequisite for this course. ECE 537 also supports the proposed MSEE program's Lab-on-Chip (LoC) focus by teaching students the techniques necessary to design low-power circuits of the LoC operating in the high frequency range.

It does not affect other units in Pullman and other campuses.

ECE 537 High Frequency Circuit Design Course Syllabus

Description: Active microwave components (diodes, transistors), microwave transistor amplifiers, oscillators, mixers, stability criteria and circles, noise in microwave circuits, noise figure.

Credits: 3

Prerequisite: ECE 370 Electromagnetic Fields and Waves and ECE 425 RF Devices and Circuits

Required Text: Reinhold Ludwig and Gene Bogdanov, *RF Circuit Design: Theory and Applications, 2nd. Ed.*, Pearson Prentice Hall, 2009.

Instructor: Dr. Tutku Karacolak

Office: VECS 201N
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Email: tutku.karacolak@wsu.edu
Office hours: Open door policy
Lectures: VECS 104, MW 9:00-10:15 Am

Topics Covered

- Review of network analysis, scattering parameters
- Matching networks
- Microwave filter design
- Characteristics of microwave diodes and transistors
- Gain and stability considerations
- Noise in microwave systems (dynamic range and noise sources, equivalent noise temperature, noise figure)
- Microwave amplifier design (single stage amplifier, broadband amplifier, low-noise amplifier, power amplifiers)
- Microwave oscillators
- Mixers
- Microwave Integrated Circuits

Course Procedures

There will be three hours of lecture each week. Reading from the required textbooks and journal articles from the literature will be assigned each week. There will be 6 or 7 homework assignments, approximately one every two weeks. In addition to the homework assignments, students will work on a term project to design high frequency circuits. Students will also use computer-aided design tools to design their circuits.

Student Learning Outcomes (SLO) and Assessment

Student Learning Outcomes for this Course: **At the end of this course, students should be able to:**	**Course Topics/Dates:** **The following topic(s)/date(s) will address this outcome:**	**Evaluation of Outcome :** **This outcome will be evaluated primarily by:**
Apply stability circles, stability criteria to solve stable and potentially unstable networks	Power gain considerations, Stability considerations (week 5); constant-gain circles and design for specified gain (week 6)	Exams, Homework
Design and analyze microwave amplifiers	Amplifier design (weeks 9, 10)	Exams, homework, design project
Have a depth of knowledge in the design of oscillators and mixers	Oscillator design (week 11); mixers (week 12)	Exams, homework, design project
Present results of design projects regarding high frequency circuit design and measurements through oral presentations and project reports	Gain and stability considerations (weeks 5, 6); noise (week 8); amplifier design (weeks 9, 10); oscillator and mixer design (weeks 11, 12)	Design project

Website

All course materials (lecture notes, assignments, etc.) will be available on the course Blackboard website at https://learn.wsu.edu/.

Attendance Policy

Lecture attendance is highly encouraged but not required. Students are nevertheless responsible for knowing any and all material presented in lecture.

Composition of final grade

The course grade will be determined as follows:

Homework:	20%
Midterm Exam:	20%
Final Exam:	30%
Design Project:	30%
Total	100%

Grading Scale (% of total score)

A 95-100; A- 90-94; B+ 85-89; B 80-84; B- 75-79; C+ 70-74; C 65-69; C- 60-64; D+ 55-59; D 50-54; F <50

NOTE: Grades will be rounded up to the next point as letter grades for the course are assigned at the end.

Make-up Exam/Assignment Policy

No make-up exam, assignments or quizzes will be given unless a medical or other emergency was the reason for missing the exam or the assignment. For any other reason you must first contact the instructor **before** missing an exam, a quiz or an assignment.

Late Homework Submission Policy

Late homework will not be entertained unless dire circumstances warrant it. Without a valid reason, there will be a 10% deduction grade for submitting late by a day. If the submission is two days late, a 20% deduction in grade will be enforced. The homework will not be accepted after three days of original submission.

Design Project

Students will work on a term project that includes a complete design procedure of an active circuit such as amplifier, oscillator, mixer, etc. The circuit will be designed utilizing computer-aided tools to match design specifications. Following the design, students will fabricate and test their circuits and compare with simulations. A detailed project report will be submitted and project results will be presented to class.

- The project teams will be formed and topics will be chosen during *third and fourth weeks*.
- Advanced Design System (ADS) and ANSYS HFSS will be used during the design process for the simulations.
- Dielectric substrate (**FR4:** $\boldsymbol{\varepsilon_r = 4.4, \tan\delta\,(loss\ tangent) = 0.02, thickness = 1.5\ mm}$) will be provided for fabrication. The circuits will be built in VECS 322 (RF Research Laboratory).
- Computer simulations and experimental results should match, and they should be around the preselected design specifications. Measurements will be performed in VECS 322.
- The device that you manufacture should be solid enough such that same results must be obtained in many consecutive measurements.
- A formal report will be submitted *due week 14*. Report will include the sections of abstract, theoretical background (introduction), design process, layout of the design with its picture, results and analysis (computer simulations vs. measurements), and conclusion. Students will also present their results through *oral presentations to class during weeks 13 and 14*.

Academic Integrity

Academic integrity is the cornerstone of the university and will be strongly enforced in this course.
Any student found in violation of the academic integrity policy will be given an "**F**" for the course and will be referred to the Office of Student Conduct. For additional information about WSU's academic integrity policy/procedures, please contact (360) 546 9573.

Student with Disabilities

Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please call the Access Center at (360) 546-9238 or van.access.center@wsu.edu. Accommodations may take some time to implement so it is critical that you contact the Access Center as soon as possible.

Emergency Notification System

WSU has made an emergency notification system available for faculty, students, and staff. Please register at zzusis with emergency contact information (cell, email, text, etc.). You may have been prompted to complete emergency contact information when registering for classes at RONet. In the event of a building evacuation, a map at each classroom entrance shows the evacuation point for each building. Please refer to it. Finally, in case of class cancellation campus-wide, please check local media, the WSU Vancouver web page and/or http://www.flashalert.net/. Individual class cancellations may be made at the discretion of the instructor. Each individual is expected to make the best decision for their personal circumstances, taking safety into account. Safety plan website.

Audio, video, digital, commercial note-taking and other recording during class

 During this course students are prohibited from making audio, video, digital, or other recordings during class, or selling notes to or being paid for taking notes by any person or commercial firm without the permission of the faculty member teaching this course.

ECE 537 Tentative Weekly Schedule

Week	Topics	Homework / Exam
1	Review of network analysis, scattering parameters	
2	Matching networks (lumped element design, single and double stub tuners, quarter-wavelength transformers, multisection matching transformers)	HW # 1
3	Review of microwave filter design	Project teams formed
4	Characteristics of microwave diodes and transistors	Projects assigned, HW #2
5	Power gain considerations, Stability considerations	
6	Constant-gain circles and design for specified gain	HW # 3
7	**Review and Midterm Exam**	Midterm
8	Noise in microwave systems, noise figure circles	
9	Single-stage amplifier design, Low-Noise Amplifier design	HW # 4
10	Broadband amplifiers, high-power amplifiers, multistage amplifiers	HW # 5
11	Microwave oscillator design	
12	Characteristics of Mixers	HW # 6
13	Microwave Integrated Circuits, fabrication and processing techniques	Oral Presentations
	Thanksgiving holiday – no class	
14	RF Transceiver Architectures, wireless communications, link budget, radar systems	Project report due, Oral Presentations cont.
15	Review	
16	FINAL EXAM	