

EE599 – Analog, Mixed Signal, and RF Integrated Circuit Measurements

4 units

Spring 2025

Tuesday and Thursday at 12:00pm-1:50pm in OHE230

Instructor:

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PHE628

Office Hours: Tuesday and Thursday after class from 1:50-2:50pm in OHE230

Teaching Assistants:

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Catalogue Description

Characterization of analog, mixed signal, and RF ICs. Previously designed, fabricated, and packaged circuits from EE505 will be measured on custom PCB test benches.

Course Description

EE599 is an introductory analog, mixed signal, and radio frequency (RF) integrated circuit (IC) measurement class. This class concerns the characterization of devices and circuits designed and fabricated in the previous EE505 tapeout course which employed TSMC 180nm and 65nm CMOS technology. Students will work together in small teams of 2-3 students to build test bench designs for the returned fabricated and packaged ICs which included MOSFETS, resistors, capacitors, inductors, transmission lines, transimpedance amplifiers (TIA), operational amplifiers (OpAmp), and voltage-controlled oscillators (VCO). If students have done extra individual designs such as an analog to digital converter (ADC) in EE505, then that will also be tested. Printed circuit boards (PCB) with custom test benches will be created by students using software such as KiCAD and fabricated. The returned ICs to be experimentally measured will be wire-bonded, packaged, and mounted on the PCB with other parts ordered and soldered onto it as needed by students. Students will then physically test the circuits for various desired parameters. Measurements to be done include DC current, voltage, and power device specifications, along with AC, analog, mixed signal, and radio frequency related tests. Electronics laboratory equipment such as multimeter, function generator, DC power supply, oscilloscope, vector network analyzer, spectrum analyzer, etc. will be utilized as needed to take these measurements. At the end of the semester, students will present and report the specifications in corresponding data sheets for each measured device/circuit to be reused for future EE599/EE505ab classes circuit libraries.

Learning Objectives

By the end of this course, students will be able to report their findings in data sheets for the integrated circuits previously designed and fabricated in EE505 such as the TIA, VCO, and OpAmp. Students will have learned custom analog, mixed signal, and radio frequency PCB test bench design and how to measure various AC and DC signals (e.g. current, voltage, and power) while reporting specifications and figures of merit (FOM) from custom IC designs.

Prerequisite(s): EE536a or EE505 or EE348L/EE477L are adequate prerequisites

Co-Requisite(s): none

Concurrent Enrollment: none

Recommended Preparation: Knowledge of the Cadence tool and running analog IC simulations in other software such as Pspice or LT Spice; prior PCB design experience can help, but not necessary.

Course Notes

EE505 is a 2 hour "studio" format on Tuesdays and Thursdays in which lecture is taught in the first part of class on Tuesdays and Thursdays led by the instructor and the students then can work on their assigned projects in the second part of the class in lab with the help of the Teaching Assistant (TA) and Professor and/or give present their project updates, all in the same setting. All classes meet in OHE230 from 12:00-1:50pm. The class will be recorded on Zoom via Brightspace so students can review the lecture/lab and participate remotely as needed. Students will also be given access to OHE240 with their USCard so that they can work on their designs at other times.

The instructor and teaching assistant will help monitor a Blackboard EE505b discussion board where you can post any questions you have regarding the projects, so that everyone, including all students can help answer any issues that may arise with Cadence, the process design kit (pdk), the PCB software (KiCAD), the soldering in lab, etc. as we go together through the semester. We ask that you first post in the discussion board to ask any questions or share information you may encounter that can help others here instead of emailing directly the instructor or teaching assistant if it has to do with work on the assigned projects, thus aiding in collaboration with all students in the course.

Grades shall be assigned with a Letter grade.

Technological Proficiency and Hardware/Software Required

Cadence, LTSpice or PSpice, and KiCAD PCB design software will be utilized in the class.

Required Readings and Supplementary Materials

Course notes will be provided by the instructor as needed.

Optional Readings and Supplementary Materials

None.

Description of Assignments and How They Will Be Assessed

Each assignment will be reviewed based on timely submittal and presentation of the in-class design review(s) for the component to be tested/presented (10%), final PCB test bench design/board (5%), and data sheet submittal with reported specifications (10%). The design review scores (10% for each project) will be assigned individually based on division, presentation, and mastery of work.

Participation

Teams of 2 students may be assigned for each of the projects. If you would like to work individually, please let the instructor know as this can be arranged.

Grading Breakdown

The EE599/EE505b grade is based on the following components which include the design and testing of the following test benches and resulting data sheets which will report the specs:

Project 1: Basic Off-the-Shelf Discrete Circuit Cell of Student's Choice (examples: MOSFET, Resistor, Capacitor, Inductor, Transmission Line) Custom PCB Test Bench and Data Sheet with Measurements and Design Reviews: 25%

Project 2: IC Transimpedance Amplifier: DC and AC PCB Test Bench and Data Sheet with Measurements and Design Reviews: 25%

Project 3: IC Voltage Controlled Oscillator: DC and AC PCB Test Bench and Data Sheet with Measurements and Design Reviews: 25%

Project 4: IC OpAmp DC and AC PCB Test Bench and Data Sheet with Measurements and Design Reviews: 25%

Due dates and design review days to be announced at the start of the projects.

Grading Scale

Grading scale in the letter form follows the University prescribed scale which can be found here: <https://catalogue.usc.edu/content.php?catoid=11&navoid=3437>

Assignment Submission Policy

Assignments shall be uploaded on the course website on Brightspace when due. Late assignments will have a 10% penalty per day.

Course-Specific Policies

Apart from numerical grades for the assignments above, final class letter grades will be posted on Blackboard by May 5, 2025. It is the student's responsibility to verify (and possibly contest) these grades **before** the grade deadline on May 8, 2025. **Once assigned, a letter grade will not be changed except for grossly erroneous circumstances.**

Please note that there is no final exam in this course.

The last day to drop the class without a W grade is March 4, 2025, without a refund (February 4, 2025, with a refund). The last day to drop the class with a W is April 11, 2025. Incomplete grades (IN) are rarely assigned. The IN grade may only be justified in exceptional cases such as student illness or a personal tragic event that occurs in the semester. Visit <https://classes.usc.edu/term-20251/classes/ee/> for more information.

Attendance

Attendance for class is highly recommended each class day as we will be working together to build the test bench designs and taking measurements. Mandatory attendance is required on design review days to be announced in class as shown on the class schedule. If you cannot attend physically on the design review days, a Brightspace Zoom session will be available and recorded as needed for presentations. Please speak to the instructor if you will need to do the design review via Zoom. Work outside of class is encouraged and entrance into the lab in OHE240 will be given to students to work on their projects with the lab equipment for testing. More information will be provided at the start of class for how to use your USCard to do so.

Academic Integrity for this Class

Unless otherwise noted, this course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). The general USC guidelines on Academic Integrity and Course Content Distribution are provided later in this syllabus.

For this class Team Projects will be submitted together. In team design reviews, it is important to highlight the division of tasks which demonstrates individual mastery of the course concepts. Design review grades will be given for each individual in a team based on this. Test bench and data sheets will be submitted per team and the score shared among teammates.

If you are caught in academic violation or use unauthorized assistance, you will receive a grade of F in the course and you will be reported to the Office of Student Judicial Affairs for further disciplinary action.

Please ask the instructor if you are unsure about what constitutes unauthorized assistance on an assignment, or what information requires citation and/or attribution.

Class Recordings and Course Content Distribution: You may not record this class without the express permission of the instructor and all other students in the class. Distribution of any notes, recordings, exams, or other materials from a university class or lectures — other than for individual or class group study — is prohibited without the express permission of the instructor; violations will be considered an intentional act to facilitate or enable academic dishonesty and reported to the university.

Use of Generative AI in this Course

Generative AI is not permitted: This course aims to develop creative, analytical, and critical thinking skills. Therefore, all assignments should be prepared by the student working individually or in groups as described on each assignment. Students may not have another person or entity complete any portion of the assignment other than their teammate. Developing strong competencies in these areas will prepare you for a competitive workplace. Therefore, using AI-generated text, code, or other content is prohibited in this course, will be identified as plagiarism, and will be reported to the Office of Academic Integrity.

Course Evaluations

Course evaluation occurs at the end of the semester university-wide. It is an important review of students' experience in the class. The process and intent of the end-of-semester evaluation will be sent via email from the university for students to participate.

Course Schedule (Tentative)

	Topics/Daily Activities	Readings/Preparation	Deliverables
Week 1	Introduction Project 1: student choice	KiCAD software download/tutorial	Project 1: Proposal
Week 2	DC/AC basic PCB test bench design	Finalize Project 1 design	Project 1: PCB test bench submit
Week 3	Introduce Project 2: TIA/ Project 1: Measurements	Review TIA specs/FOM desired/receive PCB back	Project 1: Design review #1/specs
Week 4	Project 2: TIA PCB test bench design	Finalize data sheet structure	Project 1: Data Sheet Submittal
Week 5	Project 2: TIA PCB test bench design con't	Prepare Design Review on TIA PCB Design	Project 2: Proposal/Design Review 2a TIA PCB test bench design
Week 6	Project 2: TIA PCB test bench design con't	Finalize Project 2 Design	Project 2: PCB TIA Test Bench Submit for fabrication
Week 7	Introduce Project 3: VCO/ Project 2: RF measurements	Review VCO Specs/FOM	Project 3: Design Review 2b/Specs
Week 8	Project 3: VCO PCB test bench design	Finalize data sheet structure for TIA	Project 2: Data Sheet Submittal
Week 9	Project 3: VCO PCB test bench design con't	Prepare Design Review on VCO PCB Design	Project 3: Proposal/Design Review 3a VCO PCB test bench design
Week 10	Project 3: VCO PCB test bench design con't	Finalize Project 2 Design	Project 3: PCB VCO Test Bench Submit for fabrication
Week 11	Introduce Project 4: OpAmp/Project 3: VCO measurements	Review VCO Specs/FOM	Project 3: Design Review 3b/Specs
Week 12	Project 4: OpAmp PCB test bench design	Finalize data sheet structure for VCO	Project 3: Data Sheet Submittal
Week 13	Project 4: OpAmp PCB test bench design con't	Prepare Design Review on OpAmp PCB Design	Project 4: Proposal/Design Review 4a OpAmp PCB test bench design
Week 14	Project 4: OpAmp PCB test bench design con't	Finalize Project 2 Design	Project 4: PCB OpAmp Test Bench Submit for fabrication
Week 15	Project 4: Mixed signal measurements	Finalize data sheet structure for OpAmp	Project 4: Design Review 4b/Specs and data sheet submittal
FINAL			No Final Exam

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct — which includes any act of dishonesty in the production or submission of academic work (either in draft or final form) — is in contrast to the university’s mission to educate students through a broad array of academic, professional, and extracurricular programs.

This course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). All students are expected to submit assignments that are their own original work and prepared specifically for this course and section in this academic term. You may not submit work written by others or “recycle” work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

Academic dishonesty has a far-reaching impact and is considered a serious offense against the university. Violations will result in a grade penalty, such as a failing grade on the assignment or in the course, and disciplinary action from the university itself, such as suspension or even expulsion.

For more information about academic integrity see the [student handbook](#) or the [Office of Academic Integrity’s website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment or what information requires citation and/or attribution.

Course Content Distribution and Synchronous Session Recordings Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relation to the class, whether obtained in class, via email, on the internet, or via any other media. Distributing course material without the instructor’s permission will be presumed to be an intentional act to facilitate or enable academic dishonesty and is strictly prohibited. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Statement on University Academic and Support Systems

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. [The Office of Student Accessibility Services \(OSAS\)](#) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Student Financial Aid and Satisfactory Academic Progress:

To be eligible for certain kinds of financial aid, students are required to maintain Satisfactory Academic Progress (SAP) toward their degree objectives. Visit the [Financial Aid Office webpage](#) for [undergraduate](#)- and [graduate-level](#) SAP eligibility requirements and the appeals process.

Support Systems:

[Counseling and Mental Health](#) - (213) 740-9355 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline consists of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-2500

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

[Diversity, Equity and Inclusion](#) - (213) 740-2101

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

[USC Emergency](#) - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

[USC Department of Public Safety](#) - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call

Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or otfp@med.usc.edu

Confidential Lifestyle Redesign services for USC students to support health-promoting habits and routines that enhance quality of life and academic performance.