EE 114/214A: Fundamentals of Analog Integrated Circuit Design

Department of Electrical Engineering
Stanford University

General Information
Lectures: Mon & Wed, 4:30 – 5:50 PM at Thornton 102 (live-streamed via Panopto).
Review Session: 2 – 3 PM via Zoom (check Canvas for link).
Units: 3-4 **(Undergraduates must take EE114 for 4 units)**.
Prerequisite: EE 101B.
Website: Canvas https://canvas.stanford.edu/courses/177289
Ed Discussion https://edstem.org/us/courses/47549/discussion/

Course Description
This course will cover the analysis and simulation of elementary transistor stages, current mirrors, supply- and temperature-independent bias, and reference circuits. Course material begins with an overview of integrated circuit technologies, circuit components, component variations, and practical design paradigms before covering differential circuits, frequency response, and feedback principles. It then concludes with an introduction to electronic noise concepts and distortion. Throughout the course, circuit performance evaluation will be conducted using computer-aided design tools.

Course Information
Lectures for the course will be live-streamed using the Panopto video conferencing system and can be accessed from Canvas via the Panopto tab for students who cannot attend in-person (e.g. SCPD students). They will automatically be recorded and will be posted in this same location after the lecture to be available for on-demand viewing. During lecture, students joining remotely can ask questions using Panopto's Discussion tab; a TA will monitor the Discussion tab and provide responses to questions in the chat. Note that TAs may be unable to relay questions in real-time to the instructor; for such questions directed to the instructor, therefore, it is recommended you attend in-person. Review sessions will be led by a TA and will be held online over Zoom; these sessions will also be recorded and posted for later viewing.

Check Canvas for updated information regarding office hours, review sessions, etc. Canvas will also be used for posting lecture notes, homework, and grades. Announcements will be emailed via Canvas. Please plan ahead and make use of office hours in order to resolve course-related questions. Ed Discussion will also be available for questions about course content and will be a valuable source for student-student assistance. Instructors will monitor Ed Discussion and provide clarification where necessary. Instructor emails are also provided but should generally only be used for private, student-specific questions; for these, include "EE114/EE214A" in the email's subject. Students may also post privately to instructors on Ed Discussion if deemed necessary.

Instructor
Amin Arbabian
For questions related to the EE 114/214A class, please post on Ed Discussion.
For other matters, please use arbabian@stanford.edu.
Office hours:
Mon 3 PM – 4 PM in Allen 201
Thu 5 PM – 6 PM via Zoom

Teaching Assistants
Ajay Singhvi (email: asinghvi@stanford.edu)
Felipe Monteiro (email: fmonte@stanford.edu)
Naazneen Rana (email: nrana@stanford.edu)
You can reach out via email for student-specific questions, but otherwise just use Ed Discussion.

Office hours:
Mon 2 PM – 3 PM: Ajay in Packard 104
Mon 8 PM – 9 PM: Naazneen on Zoom
Tue 11 AM – 12 PM: Felipe in Packard 106

Wed 7 PM – 8 PM: Felipe on Zoom
Thu 10:30 AM – 11:30 AM: Naazneen in Packard 109

Zoom links: Please check Canvas calendar/Zoom section.
Useful information on attending via Zoom can be found here.

Administrator
Helen Niu
Email: helen.niu@stanford.edu
Office: Packard 310

Recommended Texts
1. B. Murmann, *Analysis and Design of Elementary MOS Amplifier Stages*, NTS Press, 2013.
2. B. Razavi, *Fundamentals of Microelectronics,* 2nd ed., Wiley, 2008.
3. P. R. Gray, P. J. Hurst, S. H. Lewis, R. G. Meyer, *Analysis and Design of Analog Integrated Circuits*, 5th ed., Wiley, 2009.

Texts are recommended but not required. All texts are reserved in Terman Engineering Library.

Grading
1. Homework – 35% (Drop lowest score + bonus problems towards HW grade)
2. Midterm Exam – 20%
3. Final Exam – 25%
4. Project – 20% (Plus bonus component towards overall grade)
5. Class Participation and Ed Discussion – up to 10 % bonus towards overall grade

Ed Discussion
Ed Discussion will be a valuable open forum for students to interact among themselves and discuss questions/course content. Instructors will also monitor Ed Discussion and provide clarification/help where needed. Occasionally, we will be using Ed Discussion to post clarifications on assignments, though most announcements will be made via Canvas. Note that answers containing complete solutions to the homework problems are not allowed and will be modified by the TAs. To facilitate student interaction**, extra credit** (up to 10% towards overall grade) will be given to the students with the highest participation in answering questions (correct answers will be endorsed by instructors). For such content-related questions, therefore, instructors will first wait for any student responses before providing help themselves. **Class participation** will also contribute to this extra credit score.

Honor Code
We encourage students to collaborate on assignments. However, each student must write down the solutions independently. In other words, each student must understand the solution well enough in order to reconstruct it by themselves; students may not look at each other's solutions. In addition, please do not treat Ed Discussion as a way of "checking" answers to homework questions, as we expect everyone to abide by Stanford's honor code. Just as a reminder, the honor code applies to all parts of all classes; more information can be found at:
https://communitystandards.stanford.edu/student-conduct-process/honor-code-and-fundamental-standard#honor-code

Course Privacy Statement
Video cameras located in the back of the room will capture the instructor presentations in this course. For your convenience, you can access these recordings by logging into the course Canvas site. These recordings might be reused in other Stanford courses, viewed by other Stanford students, faculty, or staff, or used for other education and research purposes. Note that while the cameras are positioned with the intention of recording only the instructor, occasionally a part of your image or voice might be incidentally captured. If you have questions, please contact a member of the teaching team.

As noted in the University's recording and broadcasting courses policy, students may not audio or video record class meetings without permission from the instructor. If the instructor grants permission or if the

teaching team posts videos themselves, students may keep recordings only for personal use and may not post recordings on the Internet, or otherwise distribute them. These policies protect the privacy rights of instructors and students, and the intellectual property and other rights of the university. Students who need lectures recorded for the purposes of an academic accommodation should contact the Office of Accessible Education.

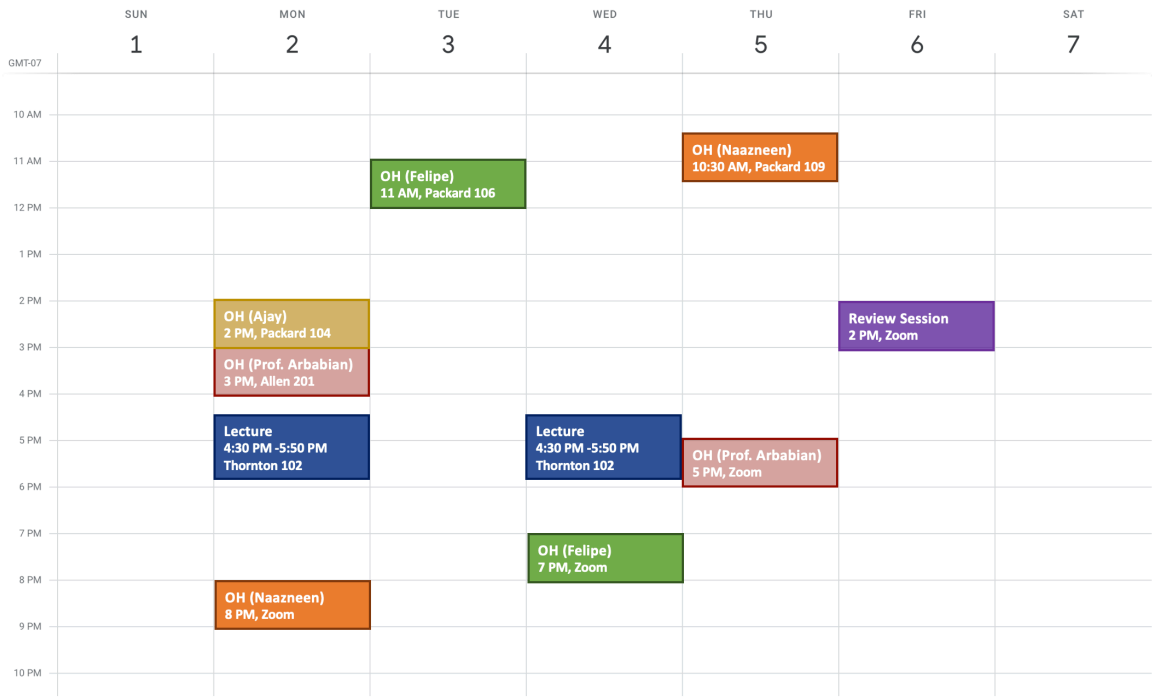
Students with Documented Disabilities
Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty. Unless the student has a temporary disability, Accommodation letters are issued for the entire academic year. Students should contact the OAE as soon as possible since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk (phone: 723-1066, URL: https://oae.stanford.edu/).

Homework Submission
Homework will be handed out on Tuesday and will be due the following Tuesday at 11:59pm, unless otherwise stated. All students (on campus and SCPD) should submit their homework electronically through Canvas (using the linked Gradescope assignment). Please make sure your homework is legible after scanning or photographing. Do not email your homework to the teaching staff. Your lowest homework score will be dropped (and no late homework will be accepted).

Regrading Policy
1. If you request a regrade of your assignment, the whole assignment will be regraded.
2. Regrade request must be submitted within a week from when the grades are released.

Best Practices for Learning in this Course
1. Download slides beforehand and take careful notes during lecture.
2. Ask immediately if something is not clear to you during lecture.
3. Participate actively on Ed Discussion; do think critically before posting a question.
4. Always review after each lecture; every slide exists for an important reason so do know the importance of each slide; derivations are important to carry out on your own.

Weekly Schedule *(subject to change)*



Tentative Course Schedule *(subject to change)*

Week	Date	Topics	Assignments	Reading
Week 1	9/25 9/27	NO CLASS Introduction	(Optional/ Ungraded) Background Quiz	Razavi: Ch. 6,7 Murmann: Ch. 2 Gray: Ch. 1,3
	9/29	Logistics Circuit/System Examples SPICE Setup		
Week 2	10/2	IC Technology and Trends Long Channel MOS Model Common Source Amplifier Small Signal Model	Background Quiz due HW1 out	Razavi: Ch. 7,11 Murmann: Ch. 2,3 Gray: Ch. 1
	10/4	Operating Point Calculations		
	10/6	Review of Common Source Amplifier		
Week 3	10/9	Gain, Biasing, and Finite Output Resistance Intrinsic Capacitance Extrinsic Capacitance	HW1 due HW2 out	Razavi: Ch. 7,11 Murmann: Ch. 3,4 Gray: Ch. 3,7
	10/11	Miller Approximation		
	10/13	Port Impedances; Brief Intro to G_m/I_D		
Week 4	10/16	Dominant Pole Approximation ZVTC Analysis	HW2 due HW3 out	Razavi: Ch. 7,9, 11 Murmann: Ch. 3,4,5 Gray: Ch. 3,4,7
	10/18	Common Gate Amplifier		
	10/20	Frequency response; CG, CD Amplifier Review		
Week 5	10/23	Common Drain Amplifier PVT Variation and Device Mismatch Current Mirrors and References	HW3 due HW4 out	Murmann: Ch. 5 Gray: Ch. 3,4,11
	10/25	Voltage Biasing and Bandgap References		
	10/27	Midterm Review		
Week 6	10/30	Midterm Exam (In Class)	HW4 due HW5 out Project out	Razavi: Ch. 10 Murmann: Ch. 6 Gray: Ch. 3,6,12
	11/1	Differential Pair		
	11/3	Design Project Overview Amp Design Examples		
Week 7	11/6	Multi-Stage Amplifiers	HW5 due	Murmann: Ch. 5,6 Gray: Ch. 4,6,11,12
	11/8	Multi-Stage Amplifiers (2)		
	11/10	Midterm Discussion Amp Design Examples		
Week 8	11/13	Electronic Noise Noise in Circuit	Project checkpoint due HW6 out	Razavi: Ch. 12 Gray: Ch. 8
	11/15	Introduction to Feedback		
	11/17	Noise Analysis + Review of Feedback 1		
	11/20 - 11/24	Thanksgiving Recess (no classes)	-	
Week 9	11/27	Ideal Feedback Configurations Feedback with 2-port Networks Practical Feedback	HW6 due HW7 out	Razavi: Ch. 12 Gray: Ch. 8,9
	11/29	Return Ratio: Introduction		
	12/1	Review of Feedback 2		
Week 10	12/4	Port Impedances using Return Ratio Feedback and Stability	HW 7 due Project report + netlist due	
	12/6	Distortion Course Conclusion		
	12/8	Summary of the Course		
Week 11	12/11	Final Exam		