FLORIDA ATLANTIC UNIVERSITY

COURSE CHANGE REQUEST
Graduate Programs

Department CEECS

College Engineering and Computer Science

UGPC Approval _____
UFS Approval _____
SCNS Submittal _____
Confirmed _____
Banner _____
Catalog _____

***Current* Course Prefix and Number**	***Current* Course Title**
EEE 5321	CMOS Amplifiers

*Syllabus must be attached for **ANY** changes to current course details. See Guidelines. Please consult and list departments that may be affected by the changes; attach documentation.*

Change title to:

Change prefix

From: **To:**

Change course number

From: **To:**

Change credits*

From: **To:**

Change grading

From: **To:**

Academic Service Learning (ASL) **

Add ☐ **Remove** ☐

* Review Provost Memorandum
** Academic Service Learning statement must be indicated in syllabus and approval attached to this form.

Change description to:

Change prerequisites/minimum grades to:

Graduate standing for CEECS students, and instructor's approval for students from other major.

Change corequisites to:

Change registration controls to:

Please list existing and new pre/corequisites, specify AND or OR and include minimum passing grade.

Effective Term/Year for Changes:	**Terminate course? Effective Term/Year for Termination:**
Spring 2021	

Faculty Contact/Email/Phone Hanqi Zhuang/zuang@fau.edu/ 297-3413

Approved by		***Date***
Department Chair	Hanqi Zhuang Digitally signed by Hanqi Zhuang Date: 2020.10.21 15:49:55 -04'00'	
College Curriculum Chair	Francisco Presuel-Moreno Digitally signed by Francisco Presuel-Moreno DN: cn=Francisco Presuel-Moreno, o=Florida Atlantic University, ou=Ocean and Mechanical Engineering, email=fpresuel@fau.edu, c=US Date: 2020.10.22 11:58:57 -04'00'	
College Dean	MCardei Digitally signed by Mihaela Cardei DN: cn=Mihaela Cardei, o=Florida Atlantic University, ou, email=mcardei@fau.edu, c=US Date: 2020.10.25 19:49:27 -04'00'	10/25/2020
UGPC Chair		
UGC Chair		
Graduate College Dean		
UFS President		
Provost		

Email this form and syllabus to UGPC@fau.edu 10 days before the UGPC meeting.

Department of Computer & Electrical Engineering and Computer Science

Florida Atlantic University
Course Syllabus

1. Course title/number, number of credit hours	
CMOS Amplifiers / EEE 5321	3 credit hours
2. Course prerequisites, corequisites, and where the course fits in the program of study	
Prerequisites: Graduate standing for CEECS students, and instructor's approval for students from other major.	
3. Course logistics	
Time: Day & Location:	
4. Instructor contact information	
Instructor's name *Office address* *Office Hours* *Contact telephone number* *Email address*	
5. TA contact information	
TA's name *Office address* *Office Hours* *Contact telephone number* *Email address*	
6. Course description	
Analysis, simulation, and computer-aided design of basic open-loop and feedback, single-stage and differential CMOS amplifiers, taking into account frequency response, noise, and parameters tolerance. Design software includes Excel, Pspice and ADS	
7. Course objectives/student learning outcomes/program outcomes	
Course objectives	a) Better understanding of MOSFET models, especially ones suitable for submicron design. b) Gain knowledge of several modern computer-aided circuit design methods, such as the use of optimizers and employment of harmonic balance. c) Understand better the CMOS fabrication process and its influence on transistor parameters. d) Introduction to the concept of operational transconductance amplifier (OTA) as a fundamental circuit design building block.

	e) Introduction to circuit design by means of switched capacitors technology. f) Introduction to high frequency noise effects and analysis methods.
Student learning outcomes & relationship to ABET a-k objectives	1. The student will demonstrate an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. (k) 2. The student will demonstrate ability to apply knowledge of math, science and engineering. (a) 3. The student will demonstrate the ability to communicate in writing a technical report. (g) 4. The student will demonstrate ability to identify, formulate, and solve engineering problems. (e)

8. Course evaluation method

3 one-hour exams (20% each).

3 simulation projects (20% each)

The best 5 grades (taken from 3 exams and 2 homework assignments, or vice versa – 3 homework sets and two exams) will be totaled. The worst-graded exam or homework assignment will be multiplied by 0.5 and be added as extra credit (that can theoretically reach 10%). The overall total grade will then be capped at 100%.

Exams are closed books and notes except for a single (double-sided) sheet (printed or hand written) with free contents, and a simple scientific calculator.

Homework assignments may be submitted individually or by teams of two.

An attempt will be made to create a Gallery of Best Solutions, even though (as shown in the Course Calendar) it will not be possible to post the solutions on time before the

exams. Any solution selected for the Gallery (if created) will award the participating students 1% bonus each.

Total upper bound on the bonus points is 13% (up to 10% on the extra activity and up to 3% bonus points for best solutions).

9. Course grading scale

Grading Scale:
"A", 90-100: "A-", 85-89: "B+", 80-84: "B", 75-79 : "B-", 70-74: "C+", 65-69: "C", 60-64: "C-", 55-59: "D+", 50-54: "D", 45-49: "D-", 40-44: 39 and below: "F."

There will be no grade-curving of any sort. All final grades that fall within 1% of a grade threshold will be reviewed. Special consideration to overcome a 1% grade deficit will be extended only to students who are in good standing .

10. Policy on makeup tests, late work, and incompletes

Makeup tests are given only if there is solid evidence of a medical or otherwise serious emergency that prevented the student of participating in the exam. Makeup exam should be administered and proctored by department personnel unless there are other pre-approved arrangements
Late homework submission is allowed and is not penalized if the late period is brief. Lengthy delayed submission may incur points penalties.

Incomplete grades are against the policy of the department. Unless there is solid evidence of medical or otherwise serious emergency situation incomplete grades will not be given.

Homework submission guidelines:
Each homework will be submitted via e-mail (as Word or pdf file) or as a printout. Printout versions must be stapled at the upper left corner, must be fully typed (no scanned hand-written parts are allowed) or be very readable in its hand-written sections, be neatly edited and should include the following items:

1) Some manual calculations (in case of a design exercise) predicting approximately the expected outcome. In the case of a design activity always explain your design considerations.
2) Printout of the ADS or PSPICE circuit diagrams.
3) Output printouts – Be selective and use only the most relevant output. Don't dump on the instructor your entire collection of computer printouts. In particular, never submit graphs that you cannot explain.

4) Annotations to the results: It is best to put comments and annotations directly on all output graphs and system diagrams. It is highly recommended (for best readability of your work) to include notes and computations directly on the output graph pages themselves.
5) Brief conclusions – Did the system work as expected? If the results are far from your hand-calculation prediction, where is the difference coming from?

11. Special course requirements

Exams: Exams are closed books and notes except for a single (double-sided) sheet (printed or hand written) with free contents, and a simple scientific calculator.

12. Classroom etiquette policy

Attendance is not mandatory (except for the three exams).

13. Attendance policy statement

Students are expected to attend all of their scheduled University classes and to satisfy all academic objectives as outlined by the instructor. The effect of absences upon grades is determined by the instructor, and the University reserves the right to deal at any time with individual cases of non-attendance. Students are responsible for arranging to make up work missed because of legitimate class absence, such as illness, family emergencies, military obligation, court-imposed legal obligations or participation in University-approved activities. Examples of University-approved reasons for absences include participating on an athletic or scholastic team, musical and theatrical performances and debate activities. It is the student's responsibility to give the instructor notice prior to any anticipated absences and within a reasonable amount of time after an unanticipated absence, ordinarily by the next scheduled class meeting. Instructors must allow each student who is absent for a University-approved reason the opportunity to make up work missed without any reduction in the student's final course grade as a direct result of such absence.

14. Disability policy statement

In compliance with the Americans with Disabilities Act Amendments Act (ADAAA), students who require reasonable accommodations due to a disability to properly execute coursework must register with Student Accessibility Services (SAS) and follow all SAS procedures. SAS has offices across three of FAU's campuses – Boca Raton, Davie and Jupiter – however disability services are available for students on all campuses. For more information, please visit the SAS website at www.fau.edu/sas/

15. Counseling and Psychological Services (CAPS) Center

Life as a university student can be challenging physically, mentally and emotionally. Students who find stress negatively affecting their ability to achieve academic or personal goals may wish to consider utilizing FAU's Counseling and Psychological Services (CAPS) Center. CAPS provides FAU students a range of services –

individual counseling, support meetings, and psychiatric services, to name a few – offered to help improve and maintain emotional well-being. For more information, go to http://www.fau.edu/counseling/

16. Code of Academic Integrity Policy Statement

Students at Florida Atlantic University are expected to maintain the highest ethical standards. Academic dishonesty is considered a serious breach of these ethical standards, because it interferes with the university mission to provide a high quality education in which no student enjoys an unfair advantage over any other. Academic dishonesty is also destructive of the university community, which is grounded in a system of mutual trust and places high value on personal integrity and individual responsibility. Harsh penalties are associated with academic dishonesty. For more information, see University Regulation 4.001.

17. Required texts/reading

Behzad Razavi, "Design of Analog CMOS Integrated Circuits", 2nd Edition, McGraw Hill 2016. [It is okay to use the book's first edition]

18. Supplementary/recommended readings

18. Software: Options: a) Any version of ADS (available on FAU VMWare), b) Orcad Lite 17.3 (PSPICE Demo) - downloaded from the Cadence web page, c) PSPICE Professional Version (Orcad 16.3) (available on FAU VMWare on the All Engineering Students server). Restrictions: i) Orcad Lite 17.3 may suffice only for the initial assignments. Later assignments will require more advanced tools, (ii) FAU currently has only 10 licenses of the professional PSPICE. That is, only 10 people can work on it simultaneously.

19. Course topical outline, including dates for exams/quizzes, papers, completion of reading

Week / Lecture # / Lecture Part	**Recording Date**	**Topics** *Computer activities are shown in italic letters*	**Comments, 2nd Edition Textbook Chapters; HW Deadlines**
		Course Syllabus and Logistics; Brief Review of MOSFET Level 1 I-V Relationship and Model Parameters: Threshold Voltage V_{TH}, Channel-Length Modulation coefficient λ, Body Effect parameter γ	Ch. 2
		PSPICE: MOSFET DC Operation, Computation of g_m ; Demonstration of the Body Effect	Ch. 2
		MOSFET Small-Signal Parameters: equivalent formulas for g_m, the r_o	Ch. 2

		parameter, small-signal model for the body effect	
		Analysis and Design of Common Source (CS) Amplifier: R_D Load, Diode-Connected Load	Ch. 3
		Using EXCEL Solver as Optimizer for the Design of CS Amplifier with R_D Load	Ch. 3
		CS Amplifiers with Diode-Connected Load (cont'd); CS Amplifiers with Current Source Load: Analysis and Design	HW1 given (MOSFET DC Analysis, CS Amplifiers)
		CS Amplifiers with R_S Degeneration Resistor: General Gain Formula, Effects of R_S on R_{out} Analysis of Source Follower Amplifiers	Ch. 3
		PSPICE: Design of CS Amplifiers with Active Load – Allocation of V_{DS} to Transistors and Aspect Ratios (W/L) Tuning	Ch. 3
		Overview: CMOS Processing Technology Part 1	Ch. 18
		Analysis and Design of Common Gate (CG) Amplifiers; Analysis and Design of Cascode Amplifiers	Ch. 3 HW1 due Ch. 5
		ADS: Basic Features – DC, AC and Time Domain Analysis – demonstrated on CS and source follower amplifiers; PSPICE and ADS Comparison	Ch. 3
		Exam 1 (covering computationally: MOSFET level 1 Models and CS Amplifiers; Multiple Choice questions about CMOS Fabrication Technology)	
		Current-Mirror Current Sources: Basic Mirrors, Cascode Mirrors	Ch. 5
		ADS: Cascode Amplifier Design using Optimizer	Ch. 4
		Overview: CMOS Processing Technology Part 2	
		Differential Amplifiers with R_D Load: Differential and Common-Mode Analysis	Ch. 4
		ADS: Harmonic Balance Design of Differential Amplifiers	Ch. 4
		Tutorial on Operational Transconductance Amplifiers (OTA) and Applications Part 1	HW2 given (Source Follower, CG,

			Cascode, Current Mirrors, Differential Amplifiers)
		Differential Amplifier with MOS Load; Gilbert Cell – an Analog Multiplier	Ch. 6
		ADS: Monte Carlo and Sensitivity Analysis of Differential Amplifiers	Ch. 6
		Tutorial on Operational Transconductance Amplifiers (OTA) and Applications Part 2	
		MOSFET High-Frequency Capacitance Effects; Miller's Theorem and Miller Effect in a CS Amplifier	Ch. 7 HW2 due
		ADS: Bandwidth Enhancement by Means of Cascode Amplifiers	Ch. 7
		Exam 2 (covering: Source Followers, CG, Current Mirrors, Cascode Amplifiers, Differential Amplifiers; Multiple Choice Questions about CMOS Processing, Gilbert Cells and OTAs)	
		Bandwidth of CG and Cascode Amplifiers; Bandwidth of Source Follower Amplifiers	Ch. 7
		PSPICE: Bode Plots, Demonstration of Gain-Bandwidth Product; Ideal Op-Amps – E, F, G, H Blocks	Ch. 8
		Overview: Standard Submicron MOSFET Models and Short Channel Effects	Ch.17
		Feedback in CMOS Amplifiers – Basic Concepts: Closed-Loop gain Formula, Basic Large Loop-Gain Design Philosophy, The Gain-Bandwidth Product, Four Amplifier Types	Ch. 8
		PSPICE: Feedback Compensation when Stabilizing a Multi-Stage Operational Amplifier (block diagrams)	Ch. 10
		Overview: Model-Free Submicron CMOS Analog Design by Means of Transconductance Efficiency Part 1	HW3 given (Bandwidth of amplifiers, Feedback)
		W Grade Deadline	
		Feedback in CMOS Amplifiers: Closed Loop R_{in} and R_{out}, Feedback Network Structures	Ch. 8
		ADS: Compensation of an Actual Multi-	Ch. 10

		Stage Amplifier	
		Overview: Model-Free Submicron CMOS Analog Design by Means of Transconductance Efficiency Part 2	
		Tutorial: CMOS Operational Amplifiers: Single and Two-Stage Structures, Gain Boosting, Common-Mode Feedback	Ch. 9
		Tutorial: Switched Capacitors CMOS Circuits	Ch. 13 HW3 due
		Quiz 3 (covering: Bandwidth in Amplifiers, Feedback; Multiple-Choice Questions: Submicron MOSFET models, Model Free design)	