University of Macau
Faculty of Science and Technology
Department of Electrical and Electronics Engineering
Part A: Course Outline

Course Title:	Analog Integrated Circuit Design		
Course Code:	ECEB 368 (2014/2015 2nd semester)	Year of Study:	3/4
Course Mode:	Design		
Compulsory/Elective:	Elective		
Course Prerequisites:	N/A		
Prerequisite Knowledge	Circuit analysis, basic MOSFET operation and design principles		
Classroom	E12-G021	Class meet up time	Tue: 3:30-5:15 pm Wed: 9:00-10:15 am
Class Schedule:	2-hour lecturer, and 2-hour tutorial and/or laboratory per week		
Duration	One semester	Credit Units	3
Text Books and References:	Required reading: Behzad Razavi, Fundamentals of Microelectronics, 1st Edition, John Wiley & Sons, Inc., 2008 [ISBN: 978-0-471-47846-1] Recommended reading: Behzad Razavi, Design of Analog CMOS Integrated Circuits, *McGraw Hill, 2001* [ISBN: 0-07-118839-8] Recommended reading: Willy Sansen, Analog Design Essentials, Springer, 2006 [ISBN: 978-0-387-25746-4]		
Course Description:	This course is designed to introduce Analog Integrated Circuit (IC) design fundamentals with emphasis on the current deep submicron and nanometer CMOS technologies. The course content includes single and multiple-transistor amplifiers, current mirrors, current/voltage reference, CMOS operational amplifier and its stability analysis, noise analysis, switched-capacitor and high-frequency circuits. The layout of the individual circuit blocks will be also introduced in parallel with the main course outline, such that the students can have a good understanding of the physical implementation of analog ICs. Students will gain the basic understanding of analog IC design as well as familiar with the necessary IC design and simulation tools (e.g., CADENCE).		
Topics Covered	Basic semiconductor physics, Transistor operation modes (cutoff, subthreshold, triode, saturation) Single-transistor amplifiers and their I/O impedance and gain, Multi-transistor amplifiers and their gain, bandwidth, stability, etc., OpAmp-based building blocks: filter, inverting/non-inverting Amplifiers, integrated components (resistor, inductor and capacitor), Design of Single-Stage and Two-Stage OpAmps, Layout of Integrated Circuits, Circuit Simulations.		
Course Objectives:	1. To introduce to students fundamental analog circuits design skills [a, e, k] 2. To introduce students the basic analog electronics utilized in the industry and how to build up a complex system from basis [a, e, k] 3. To offer students experience on designing and simulating analog circuits using simulation tools [a, b, c, d, e, k]		

<table>
<tr><td>Course Assessment:</td><td>Homework: 10%
Quizzes: 20%
Final Project: 30%
Final Exam. : 40%</td></tr>
<tr><td>Relationship to Program Objectives and Outcomes</td><td>This course primarily contributes to ECE program outcomes that develop students:
a. An ability to apply knowledge of mathematics, science and engineering.
e. An ability to identify, formulate and solve engineering problems.
k. An ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

This course secondarily contributes to ECE program outcomes that develop students:
b. An ability to design and conduct experiments, as well as to analyze and interpret data.
c. An ability to design a system, component or process to meet desired needs.
d. An ability to function on multidisciplinary teams.</td></tr>
<tr><td>Course Contents and Relationship to Program Criteria:</td><td>
<table>
<tr><th>Week no.</th><th>Topics</th><th>Program Criteria</th></tr>
<tr><td>1</td><td>Introduction
The history and state-of-the-art analog circuits in wide type of electronics industry, the fundamental methods and challenges of systematic circuit design in CMOS technologies</td><td>ES</td></tr>
<tr><td>1</td><td>Basic Physics of Semiconductor
Semiconductor materials and their properties, PN junction diodes, diode reverse breakdown</td><td>ES</td></tr>
<tr><td>1</td><td>Basic MOSFET Principles and Single-Stage Amplifiers
Input/output impedance, gain, bandwidth and stability of common-source amplifier, common-gate amplifier and source follower.</td><td>ES</td></tr>
<tr><td>2</td><td>Feeback and OpAmp-Based Building Blocks
Active-resistor-capacitor Filter, Sallen-Key filter, inverting amplifier and non-inverting amplifier, filter design with different approximation such as Butterworth.</td><td>ES, CS, DE</td></tr>
<tr><td>2</td><td>Integrated Components
Basic concepts and selection criteria of integrated resistors such as polysilicon, integrated capacitors such as Metal-Over-Metal and Metal-Insulator-Metal capacitors, inductors such as bondwire and spiral</td><td>ES</td></tr>
<tr><td>1</td><td>The principle of Integrated Circuit Simulation
Brief introduction in the theories on circuit simulations, including DC, AC and Transient analysis, convergence criteria, etc.</td><td>ES, DIC,
DE</td></tr>
<tr><td>1</td><td>Tutorial on Integrated Circuit Design Software
To provide one week tutorial to the Professional Integrated Circuit Design Software – Cadence, which is widely used in industry. The simulation projects are also based on Cadence.</td><td>ES, CS</td></tr>
<tr><td>2</td><td>Layout Design of Integrated Circuits
Introduce how the integrated circuits formed in CMOS, the layout of transistors, capacitors and resistors, and also important analog layout techniques.</td><td>ES</td></tr>
<tr><td>3</td><td>Single-Stage and Two-Stage OpAmps
The single-stage amplifiers – Telescopic, Folded-Cascode, Mirror; The two-stage amplifiers, Frequency Compensation, Common-Mode Feedback, Slew-Rate.</td><td>ES, DIC, CV</td></tr>
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Contribution of Course to meet the professional component:	This course educates students with basic analog circuits design skills related with wide types of CMOS electronics. Students should be able to design apposite circuits for different applications and apply knowledge of mathematics and engineering, identify formulas, build up simulation netlists to simulate electronic circuits, as well as the transferring the circuits into real integrated circuits layout.
Course Instructor(s):	Dr. Man-Kay Law
Prepared by:	Dr. Man-Kay Law, 2013
Revised by:	Dr. Man-Kay Law, 2015

Part B: General Course Information and Policies

Instructor: Dr. Man-Kay Law Office: N21-3013C
Office Hour: Tuesday 2:30-3:30 pm, Thursday 10:30-11:30 am or by appointment
E-mail: MKLaw@umac.mo; Office ext.: 8791

Programme Educational Objectives

1. **Problem Solving:** Graduates have the ability to think in a critical and evaluative manner and to consider a broad perspective, in order to solve technical and nontechnical problems.
2. **Leadership and Communication:** Graduates will provide effective leadership, act in an ethical manner and skills will include the ability to communicate well and to work successfully within diverse groups.
3. **Market Acceptance:** Graduates will have successful careers in the academic environment, industrial and government organizations.
4. **Technical Competence:** Graduates will be technically competent and have a thorough grounding in the fundamentals of math and science in electrical and computer engineering and experience in engineering design. They will be able to use modern engineering techniques, skills, and tools to fulfill societal needs.

Scale: 1 (Highest) to 4 (Lowest)

	Problem Solving	**Leadership and Communication**	**Market Acceptance**	**Technical Competence**
Analog Integrated Circuit Design	1	3	2	2

Remark:

- Objective for "Problem Solving" can be achieved by assignments, quizzes, project, and final exam.
- Objective for "Leadership and Communication" can be achieved by report writing. However, leadership training is not given by this course.
- Objective for "Market Acceptance" can be achieved by the course contents that are required in industries.
- Objective for "Technical Competence" can be achieved by using fundamentals of math and science in electrical and computer engineering and experience in computer simulation.

Program Criteria Policy:

Course VS Program Criteria
Scale: 1 (Highest) to 4 (Lowest)

Course	PS	DIC	BS	CS	ES	DE	LA	CV	DM
Analog Integrated Circuit Design		2		3	1	3		4	

Terms:

Probability and Statistics (PS), Differential and Integral Calculus (DIC), Basic Science (BS), Computer Science (CS), Engineering Science (ES), Differential Equations (DE), Linear Algebra (LA), Complex Variables (CV), Discrete Mathematics (DM)

Relationship of course to Programme Outcomes:

	Program Outcomes											
	a	**B**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**
ECEB368 Analog Integrated Circuit Design	T	P	TP		P						P	P

Course VS Course Outcomes

***T – TEACH; P – PRACTICE; M – MEASURED**

The electrical and computer engineering program outcomes are:

(a) an ability to apply knowledge of mathematics, science, and engineering appropriate to the degree discipline

(b) an ability to design and conduct experiments, as well as to analyse and interpret data

(c) an ability to design a system, component or process to meet desired needs within realistic constraints, such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability

(d) an ability to function on multi-disciplinary teams

(e) an ability to identify, formulate and solve engineering problems

(f) an ability to understand professional and ethical responsibility

(g) an ability to communicate effectively

(h) an ability to understand the impact of engineering solutions in a global and societal context, especially the importance of health, safety and environmental considerations to both workers and the general public

(i) an ability to stay abreast of contemporary issues

(j) an ability to recognise the need for, and to engage in life-long learning

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice appropriate to the degree discipline

(l) an ability to use the computer/IT tools relevant to the discipline along with an understanding of their processes and limitations

Curriculum Detail

ECEB368 Analog Integrated Circuit Design

Timetabled work in hours per week			No of teaching weeks	Total hours	No /Duration of exam papers	Max marks available from:	
Lecturer	Tutorial	Practice				Exams	Course
2	1	1	14	56	1/3 hours	40	60

Term: 6th

Hours			Percentage content of					
Lecturer	Tut/Lab	Other	Maths	Basic Science	Engineering Science	Engineering Design and Synthesis	Complementary Studies	Computer Studies
28	14/14	0	20	0	40	35	0	5

Design Elements

Please use an "X" to indicate the presence of the specific elements in the course/module/subject.

% of Design Content	Design Content in Course Work	Design Project	Design Content in Laboratories
50%	X	X	X

Course Assessment Policy:

- Homework assignments will be given to students according to the course progress, no late homework is accepted. Zero mark will be given when homework is copied.
- 2 quizzes will be held to monitor the students' learning progress.
- 1-2 simulation laboratories will be performed during the semester. 2-3 students form one group and group report should be handed up.
- 1 final exam (3 hours) and 1 design project.

STUDENT DISABILITIES SUPPORT SERVICE

The University of Macau is committed to providing an equal opportunity in education to persons with disabilities. If you are a student with a physical, visual, hearing, speech, learning or psychological impairment(s) which substantially limit your learning and/or activities of daily living, you are encouraged to communicate with your instructors about your impairment(s) and the accommodations you need in your studies. You are also encouraged to contact the Student Disability Support Service of the Student Counselling and Development Section (SCD) in Student Affairs Office, which provides appropriate resources and accommodations to allow each student with a disability to have an equal opportunity in education, university life activities and services at the University of Macau. To learn more about the service, please contact SCD at scd.disability@umac.mo, or 8822 4901 or visit the following website: http://www.umac.mo/sao/scd/sds/aboutus/en/scd_mission.php.