ELEC2133
Analogue Electronics

Course Outline – Semester 2, 2015

Never Stand Still | Faculty of Engineering | School of Electrical Engineering and Telecommunications

Course Staff

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Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. Lecturer consultation time is on Wednesday from 2pm to 3pm. Other consultation times may be arranged with the lecturer but prior appointments must be made via email. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions on this course and can also provide you with consultation times. ALL email enquiries should be made from your student email address with ELEC2133 in the subject line, otherwise they will not be answered. In this course, Moodle will be used as an online learning and teaching platforms. The course page on Moodle can be accessed at https://moodle.telt.unsw.edu.au/login/index.php. Students are also encouraged to post their questions on Moodle for discussion among their peers and academic staffs of the course.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via the course page on Moodle. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Course Summary

Contact Hours

The course consists of 3 hours of lectures, a 1-hour tutorial, and a 3-hour laboratory session each week. Tutorials and laboratory sessions will start in week 2 and week 5, respectively.

Lectures	Day	Time	Location
	Monday	1pm - 3pm	CLB 8
	Wednesday	1pm - 2pm	CLB 6
Tutorials	Monday	3pm – 4pm	Ainswth 201
	Monday	5pm – 6pm	Ainswth 101
	Tuesday	4pm – 5pm	Quad G045
	Wednesday	12pm – 1pm	Quad G032
	Friday	12pm – 1pm	Ainswth 201
Laboratories	Tuesday	9am – 12pm	ElecEng101
	Tuesday	1pm – 4pm	ElecEng113
	Wednesday	3pm – 6pm	ElecEng113
	Friday	9am – 12pm	ElectEng113
	Friday	1pm – 3pm	ElectEng113

Context and Aims

Analogue circuits are integral parts of any electronic system. They are used to realize important signal processing and conditioning functions such as amplification, comparison, waveform generation, analogue to digital and digital to analogue conversion. Analogue circuits consist of transistors and diodes in addition to resistors, capacitors and inductors often in an integrated circuit form. In previous courses, students were introduced to circuit analysis and synthesis techniques involving passive circuit elements. This course endeavors to build on this knowledge and further expand students' skill in analyzing and designing analogue circuits involving transistors and diodes. The first half of the course covers: (i) the basic principles of operation and device characteristics of diodes, Bipolar Junction Transistors (BJT), and Metal Oxide Semiconductor Field Effect Transistors (MOSFET) that underpin the analysis, design and implementation of analogue circuits; (ii) multi-stage linear amplifiers, operational amplifiers, effects of feedback on the performance and stability of amplifiers. The second half of the course deals with nonlinear circuits such as Schmitt triggers, waveform generators, comparators, A/D, and D/A converters. The aims of the course are

- To further develop skill and knowledge in analysis and design of analogue circuits such as amplifiers, and waveform generators.
- To develop a more thorough understanding of why analogue circuits behave in a certain way and how performances can be improved when feedback is applied.
- To introduce various A/D and D/A conversion techniques and their limitations
- To introduce the basic principle operations, device and circuit characteristics of diodes and BJT and MOSFET transistors.
- To develop intuitive feel for circuit analysis and design

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1	Introduction
Week 2	Operational Amplifiers
Week 3	Semiconductor Devices for Electronics
Week 4	Transistor Amplifiers (BJT): DC and small signal **Assignment I released**
Week 5	Transistor Amplifiers (MOSFET): DC and small signal
Week 6	Frequency Response of Amplifiers
Week 7	Feedback in Amplifiers (Part I) **Assignment I due**
Break	
Week 8	Feedback in Amplifiers (Part II) **Assignment II released**
Week 9	Feedback in Amplifiers Stability and Compensation
Week 10	Non-Linear Circuits – Waveform generation
Week 11	Digital-Analogue Interface (Part I) **Assignment II due**
Week 12	Digital-Analogue Interface (Part II)

Indicative Laboratory Schedule

Period	Summary of Laboratory Program
Week 4	
Week 5	Lab I: Operational amplifier – Design
Week 6	Lab I: Operational amplifier – Gain and frequency response
Week 7	Lab I: Operational amplifier – Frequency compensation
Break	
Week 8	Lab II: Feedback amplifier (two stage amplifier) – Design
Week 9	Lab II: Feedback amplifier (two stage amplifier) – (open-loop)
Week 10	Lab II: Feedback amplifier (two stage amplifier) – (close-loop)
Week 11	Lab III: Waveform generators – Schmitt Trigger
Week 12	Lab III: Waveform generators – VCO
Week 13	**Lab Exam**

Assessment

Laboratory Practical Experiments	15%
Lab Exam	5%
Fortnight online quizzes	5%
Assignments	15%
Final Exam (3 hours)	60%

Course Details

Credits

This is a 6 UoC course and the expected workload is 10–12 hours per week throughout the 13 week semester.

Relationship to Other Courses

This is a 2nd year course in the School of Electrical Engineering and Telecommunications. It is a core course for students following a BE (Electrical) or (Telecommunications) program and other combined degree programs. It is a pre-requisite course for ELEC3106, ELEC3117, and ELEC4603.

Pre-requisites and Assumed Knowledge

The pre-requisite for this course is ELEC2134, Circuits and Signals. It is essential that you are familiar with fundamentals of circuit analysis techniques those concepts covered in ELEC1112 or ELEC1111 in addition to advanced techniques introduced in ELEC2134 before this course is attempted. You are strongly advised to revise those circuit analysis techniques from ELEC1111(2) and ELEC2134 in their own time to get yourself ready for this course. It is also further assumed that you are familiar with use of laboratory equipment such as oscilloscope, signal generator, power supply and multi-meters and have a good computer literacy.

Following Courses

The course is a pre-requisite for ELEC3106 (Electronics), ELEC3117 (Electrical Engineering Design) and ELEC4603 (Solid State Electronics).

Learning outcomes

After successful completion of this course, you should be able to:

1. Understand and demonstrate the use of operational amplifiers in realizing various analogue functions.
2. Analyze and design various analogue electronic circuits based on operational amplifiers.
3. Explain the basic principles of operation of diodes, BJTs and MOSFETs.
4. Understand and demonstrate the use of circuit models of diodes, BJTs and MOSFETs in the analysis and design of electronic circuits.
5. Analyze, design, and implement various multi-stage linear amplifier circuits.
6. Identify various feedback topologies and explain their advantage and disadvantage.
7. Analyze, design and implement feedback amplifiers.
8. Explain frequency compensation, stability and behavior of oscillators.
9. Analyze, design and implement waveform generators and voltage control oscillators using Schmitt trigger.
10. Describe the operation of and identify various D-A and A-D convertor circuits.
11. Analyze and design various D-A and A-D convertor circuits.

This course is designed to provide the above learning outcomes which arise from targeted graduate capabilities listed in ***Appendix A***. The targeted graduate capabilities broadly support the UNSW and Faculty of Engineering graduate capabilities (listed in ***Appendix B***). This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix C***.

Syllabus

Device physics of diodes, BJTs and MOSFETs, Nonlinear transistor models: Ebers-Moll, transport, Full and simplified models of BJTs and MOSFETs (inc. small-signal models). Zener and Schottky diodes, DC biasing, biasing using current sources, operating point, large-signal analysis, Linearisation, small-signal analysis, Input and output impedances, power gain, Two-ports, Feed-back, effects of feed-back; stability and compensation techniques, Circuits with non-ideal op-amps, Common base, emitter and collector amplifiers, differential pairs, Multistage amplifiers, cascades, cascodes. AC response of 1-stage amplifiers, Miller effect, Non-linear circuits: oscillator, Schmitt trigger. A-D and D-A converter principles.

Teaching Strategies

Delivery Mode

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- Formal face-to-face lectures, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding;

- Tutorials, which allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material;
- Laboratory sessions, which support the formal lecture material and also provide you with practical construction, measurement and debugging skills;

Learning in this course

You are expected to attend all lectures, tutorials, and labs in order to maximize learning. You must prepare well for your laboratory classes and your lab work will be assessed. In addition to the lecture notes, you should read relevant sections of the recommended text. Reading additional texts will further enhance your learning experience. Group learning is also encouraged. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

Lecture classes

The lectures form the core of this subject. Topics presented in lectures will generally be followed by detailed examples to provide students with the real-life applications. Detailed explanations of the topics will be available to students in the form of lecture slides, lecture videos and notes which will be uploaded on Moodle and the prescribed textbook.

Tutorial classes

The tutorial problems provide students with in-depth quantitative understanding of the topics covered in lectures. The problems and their solutions will be posted on Moodle prior to the tutorial class to encourage students to attempt and learn from the solutions before coming to the tutorial. The importance of adequate preparation prior to each tutorial cannot be overemphasized, as the effectiveness and usefulness of the tutorial depends to a large extent on this preparation. Group learning is encouraged. You will be given 5-10mins to discuss the problems and their solutions in group. The tutor will then focus on the complex questions and issues raised by the students.

Laboratory program

The laboratory schedule is deliberately designed to provide practical, hands-on exposure to the concepts conveyed in lectures. There will be three laboratory experiments in the course, each of which consisting of either two or three parts. The experiments are supported with detailed theoretical background in addition to concepts introduced in lectures and design guidelines that you are required to step through to complete preliminary preparatory problems. You must come to the laboratory having read the laboratory notes and completed the preliminary laboratory problems. Laboratory demonstrators will go around and mark your preliminary preparatory solutions. **You will not be marked and lose points if you come to the laboratory session without completing the preliminary preparatory design tasks.** You will implement your design on a PCB board. The PCB board contains the layout of the circuits used in each laboratory experiment with plug-in ICs, resistors, capacitors and jumpers that allow you to construct the desired circuit and perform measurement.

A bonus lab task will be available to students after the successful completion of all laboratory exercises. The bonus lab task will be carried on from the last lab exercise and will be accompanied by minimal guidelines, allowing students to further demonstrate their ability to analyze and resolve issues independently.

You are required to attend laboratory from Week 5 to Week 12 every week. Your timetable may show odd and even week laboratory slots that carried over from last year. **This year, there will not be odd and even week allocations and you will have laboratory class every week. If your timetable shows you have a laboratory class, for example, on Tuesday from 9am-12pm every odd week, this means you will have the laboratory**

class on Tuesday from 9am-12pm every week starting from week 5 to week 12. Laboratory attendance WILL be kept, and you MUST attend at least 80% of labs.

The laboratory manual will be available for sale through the school office (EE&T). Every student should have the hard copy of the laboratory manual and must bring it to the laboratory class. All data and marks will be recorded in spaces provided in the laboratory manual. The marker will sign, date and stamp inside your laboratory manual for each marked checkpoint.

Laboratory Exemption

There is no laboratory exemption for this course. Regardless of whether equivalent labs have been completed in previous courses, all students enrolled in this course for Semester 2, 2015 must take the labs. If, for medical reasons, (note that a valid medical certificate must be provided) you are unable to attend a lab, you will need to apply for a catch-up lab during another lab time, as agreed by the laboratory coordinator.

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the semester. Ongoing assessment occurs through the fortnight online quizzes, lab checkpoints (see lab manual), lab exams and the two assignments.

Laboratory Assessment

The laboratory work will contribute to 15% of the overall mark. It is essential that you complete the laboratory preparation before coming to the lab. Your laboratory preparation will be marked and checked. Each lab exercise will have three checkpoints. Each checkpoint is expected to be completed in one week or less. It will be marked, dated, signed and stamped by one of the laboratory demonstrator. Although there is only one check point for each week, there are a number of results that students are required to demonstrate when marked for the check point. Therefore, students are strongly advised to: (i) record results in spaces provided in the laboratory manual; (ii) save the data plotted on the laboratory PC; (iii) keep the working circuit for the demonstrator to check. Demonstrators will be available to help students with any questions or difficulties.

Upon completion of a checkpoint, you will be required to write down your student and bench numbers on the laboratory Queue sheet and wait for the laboratory assessor to mark your work. You may continue working on subsequent lab tasks while waiting to be assessed. You will be required to show the working of your task for each checkpoint and answer questions asked by the assessor to demonstrate your understanding of the ideas addressed within each task. The marking guidelines are provided in the laboratory manual.

Students will work in pair, but be marked individually. Each student will be asked a few questions. There will also be a mark for the group based on demonstrating the required lab tasks.

There will be 5% bonus mark available for those students who wish to attempt the additional lab task at the completion of all laboratory exercises. The exercises may require a substantial amount of time to complete successfully and students attempting it are expected to work independently as there will be minimal support provided for this task. It should be stressed, however, that marking of bonus lab is subjected to the availability of demonstrators and other course staff members. Every possible effort will be made to accommodate the marking.

It is essential that you complete the laboratory preparation before coming to the lab. The laboratory preparation will be marked and recorded by the laboratory demonstrators.

Laboratory Exam

There will be a laboratory exam in week 13 and it contributes 5% towards the overall mark. The exam will assess students' technical understanding of the laboratory experiments. Students will be given a design problem based on the laboratory experiments, asked to implement their design and demonstrate the working circuit.

Assignment

The assignments, which will consist of analysis and design problems, form 15% of the overall mark. There will be two assignments for this course due at the end of week 7 and 11. Late submission will attract a penalty of 10% per day (including weekends). The assignments will be released at the end of week 4 and 8, respectively, on Moodle. The assignments will consist of one or more analytical and design problems and students are required to provide a complete solution. Students will be expected to work independently on their implementation and be able to justify any unique design choices along the way.

Fortnight quizzes

There will be fortnight quizzes throughout the semester. The purpose of the quizzes is to keep students up-to-date with the lecture material and to test their basic understanding of the course concepts. The fortnight quizzes will make up 5% of the overall mark. Each quiz will consist of a number of multiple choice questions and will be marked according to the number of correct answers. The quizzes are mandatory component of the overall assessment and failure to attempt a quiz will result in no mark being given to the quiz. Each quiz will be available for a period of two weeks and the results per quiz will be published at the end of the period. No late attempts will be permitted. **Students must attempt all quizzes to pass this subject.**

The quizzes will be delivered through Moodle and will each be made available for a period of two weeks from Saturday 9:00am to the following Saturday at the same time after which a new quiz will become available. The first quiz will be released at the end of week 2.

Final Exam

The exam in this course is a standard closed-book 3-hour written examination, comprising four compulsory questions. It is worth 60% of the overall mark. University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion. Questions may be drawn from any aspect of the course (including laboratory), unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses. *Please note that you must pass the final exam in order to pass the course.*

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes										
Assessment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Laboratory practical assessments	✓	✓	-	-	✓	✓	✓	-	✓	-	-
Lab exam	✓	✓	-	-	✓	-	✓	-	✓	-	-
Fortnight online quizzes	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓
Assignment	✓	✓	-	✓	✓	✓	✓	-	✓	-	-
Final exam	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Course Resources

Textbooks

Prescribed textbook

- Sedra & Smith, *Microelectronic Circuits*, 6th ed, Oxford University Press, 2011

Reference books

- Millman & Grabel, *Microelectronics,* McGraw Hill, 2nd ed., NY
- Burns & Bond, *Principles of Electronic Circuits*, PWS, 2nd ed, 1997
- Higgins, *Electronics with digital and Analog Integrated Circuits*, 1983.
- Bogart, *Electronic Devices and Circuits*, 3rd ed, Merril, 1993.
- Horowitz & Hull, *The Art of Electronics*, 2nd ed, Cambridge University Press, 1989.

On-line resources

Moodle

The course web page is hosted on the UNSW's Moodle server, which can be accessed at: https://moodle.telt.unsw.edu.au/login/index.php. All lectures, tutorial, lab and any other notes will be available on this page, as well as access to the fortnightly quizzes, student marks, discussion forums and official course announcements. It is a requirement of the course that students check this page for new announcements on a daily basis.

Mailing list

Announcements concerning course information will be given in the lectures and/or on Moodle and/or via email (which will be sent to your student email address).

Other Matters

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other people's work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a form of academic misconduct, and the University has very strict rules that include some severe penalties. For UNSW policies, penalties and information to help you avoid plagiarism, see https://student.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://student.unsw.edu.au/guide), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **ten to twelve hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both face-to-face classes and *independent, self-directed study*. In periods where you need to need to complete assignments or prepare for examinations, the workload may be greater. Over-commitment has been a common source of failure for many students. You should take the required workload into account when planning how to balance study with employment and other activities.

Attendance

Regular and punctual attendance at all classes is expected. UNSW regulations state that if students attend less than 80% of scheduled classes they may be refused final assessment.

General Conduct and Behaviour

Consideration and respect for the needs of your fellow students and teaching staff is an expectation. Conduct which unduly disrupts or interferes with a class is not acceptable and students may be asked to leave the class.

Work Health and Safety

UNSW policy requires each person to work safely and responsibly, in order to avoid personal injury and to protect the safety of others.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You should seek assistance early if you suffer illness or misadventure which affects your course progress. All applications for special consideration must be **lodged online through myUNSW within 3 working days of the assessment**, not to course or school staff. For more detail, consult https://student.unsw.edu.au/special-consideration.

Continual Course Improvement

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback (positive or negative) on the course to the course convener or via the Course and Teaching Evaluation and Improvement Process. You can also provide feedback to ELSOC who will raise your concerns at student focus group meetings. As a result of previous feedback obtained for this course and in our efforts to provide a rich and meaningful learning experience, we have continued to evaluate and modify our delivery and assessment methods. The following modifications are incorporated into the course

- The laboratory class will start in week 5 as opposed to week 2 in previous years in order to align the topics covered in the lecture and tutorial with the laboratory tasks. With the change in place, students will have covered the subject matter of the laboratory tasks in lectures and tutorials at least in some details before the scheduled laboratory session.

- Students will implement the circuits in the laboratory tasks on a PCB board as opposed to a breadboard in previous years. Majority of students tend to spend significant amount of time constructing circuits (often involved ones in case of multi stage amplifiers) and debugging them on a breadboard. More often than not, the debugging is carried out on the circuit that has not been properly connected and checked beforehand and has ICs destroyed as a consequence of power supply and input signal applications. As a result, students spend small percentage of their laboratory time in executing the most important part of the laboratory tasks which are measurement, recording and analysing data, and verifying theories. With this change in place, circuit layout is properly made on a PCB board and students can concentrate on circuit design and measurement. It will significantly reduce debugging and circuit implementation time. The tasks required from the students are simplified to: (i) calculate resistor and capacitor values according the given requirements; (ii) implement the desired circuit on the PCB board by plugging in the circuit components and forming the required connections through jumpers; (iii) proceed with measurement.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School and UNSW policies:
http://www.engineering.unsw.edu.au/electrical-engineering/policies-and-procedures
https://my.unsw.edu.au/student/atoz/ABC.html

Appendix A: Targeted Graduate Capabilities

Electrical Engineering and Telecommunications programs are designed to address the following targeted capabilities which were developed by the school in conjunction with the requirements of professional and industry bodies:

- The ability to apply knowledge of basic science and fundamental technologies;
- The skills to communicate effectively, not only with engineers but also with the wider community;
- The capability to undertake challenging analysis and design problems and find optimal solutions;
- Expertise in decomposing a problem into its constituent parts, and in defining the scope of each part;
- A working knowledge of how to locate required information and use information resources to their maximum advantage;
- Proficiency in developing and implementing project plans, investigating alternative solutions, and critically evaluating differing strategies;
- An understanding of the social, cultural and global responsibilities of the professional engineer;
- The ability to work effectively as an individual or in a team;
- An understanding of professional and ethical responsibilities;
- The ability to engage in lifelong independent and reflective learning.

Appendix B: UNSW Graduate Capabilities

The course delivery methods and course content directly or indirectly addresses a number of core UNSW graduate capabilities, as follows:

- Developing scholars who have a deep understanding of their discipline, through lectures and solution of analytical problems in tutorials and assessed by assignments and written examinations.
- Developing rigorous analysis, critique, and reflection, and ability to apply knowledge and skills to solving problems. These will be achieved by the laboratory experiments and interactive checkpoint assessments and lab exams during the labs.
- Developing capable independent and collaborative enquiry, through a series of tutorials spanning the duration of the course.
- Developing independent, self-directed professionals who are enterprising, innovative, creative and responsive to change, through challenging design and project tasks.
- Developing citizens who can apply their discipline in other contexts, are culturally aware and environmentally responsible, through interdisciplinary tasks, seminars and group activities.

Appendix C: Engineers Australia (EA) Professional Engineer Competency Standard

	Program Intended Learning Outcomes	
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	✓
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing	✓
	PE1.3 In-depth understanding of specialist bodies of knowledge	✓
	PE1.4 Discernment of knowledge development and research directions	
	PE1.5 Knowledge of engineering design practice	✓
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice	
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving	✓
	PE2.2 Fluent application of engineering techniques, tools and resources	✓
	PE2.3 Application of systematic engineering synthesis and design processes	
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects	
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability	
	PE3.2 Effective oral and written communication (professional and lay domains)	✓
	PE3.3 Creative, innovative and pro-active demeanour	✓
	PE3.4 Professional use and management of information	✓
	PE3.5 Orderly management of self, and professional conduct	
	PE3.6 Effective team membership and team leadership	✓