



ELEC2133

Analogue Electronics

Course Outline – Semester 2, 2017

Australia's Global University

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 Thursday from 12pm to 1pm. 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 platform. 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 a total of 3 hour lectures, an hour tutorial, and a 3 hour laboratory session each week. Lecture will begin in week 2. Tutorials and laboratory sessions will start in week 3 and week 5, respectively.

Lectures	Day	Time	Location
	Wednesday	2pm - 4pm	Law Theatre G04
	Thursday	11am - 12pm	Rex Vowels
Tutorials	Monday	2pm – 4pm	Civ Eng 101
	Tuesday	1pm – 2pm	Quad G031
	Wednesday	5pm – 6pm	Macauley Theatre
	Thursday	9am – 10am	Ainswth 201
	Thursday	10am – 11am	CLB 1
	Thursday	2pm – 3pm	CLB 3
Laboratories	Monday	3pm – 6pm	ElecEng113

	Tuesday	9am – 12pm	ElecEng113
	Tuesday	12pm – 3pm	ElecEng113
	Wednesday	11am – 2pm	ElectEng113
	Thursday	1pm – 4pm	ElectEng113
	Friday	9am – 12pm	ElectEng113
	Friday	1pm – 4pm	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 conversions. Analogue circuits consist of transistors and diodes active circuit elements in addition to resistors, capacitors and inductors passive circuit elements 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 principle operations 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. Therefore, the aims of the course are

- To further develop skill and knowledge in analysis and design of analogue circuits such as amplifiers, operational amplifiers, comparators and wave form generators.
- To introduce the basic principle operations, device and circuit characteristics of diodes and BJT and MOSFET transistors
- 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 develop intuitive feel for circuit analysis and design
- To introduce various A/D and D/A conversion techniques and their limitations

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 2	Introduction and revision
Week 3	Operational Amplifiers
Week 4	Semiconductor Devices for Electronics
Week 5	Transistor Amplifiers (BJT): DC and small signal Assignment I released
Week 6	Transistor Amplifiers (MOSFET): DC and small signal
Week 7	Frequency Response of Amplifiers
Week 8	Feedback in Amplifiers (Part I) Assignment I due
Week 9	Feedback in Amplifiers (Part II) Assignment II released

Week 10	Stability and Compensation in feedback amplifiers
Break	
Week 11	Non-Linear Circuits – Waveform generation
Week 12	Digital-Analogue Interface (part I and part II) Assignment II due

Indicative Laboratory Schedule

Period	Summary of Laboratory Program
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
Week 8	Lab II: Two stage amplifier – Design
Week 9	Lab II: Two stage amplifier (open loop)- input impedance, output impedance, gain, and bandwidth measurement
Break	
Week 10	Lab II: Feedback amplifier: two stage amplifier(close-loop)-input impedance, output impedance, gain and bandwidth with various feedback factors
Week 11	Lab III: Waveform generators – Schmitt Trigger
Week 12	Lab III: Waveform generators – VCO
Week 13	Lab Exam

Assessment

Laboratory practical experiments	15%
Laboratory reflections	5%
Laboratory examination	5%
Fortnight online quizzes (must be completed)	0%
Assignments	15%
Mid-term exam (take home)	10%
Final exam (2 hours)	50%

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. 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 principle of operations of diodes, BJTs and MOSFETs.
4. 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 for amplifiers and explain their advantage and disadvantage.
7. Analyze, design and implement feedback amplifiers.
8. Explain the behavior and applications of oscillators.
9. Analyze, design and implement waveform generators and voltage control oscillators using Schmitt trigger.
10. Describe and identify the operations of various D-A and A-D convertor circuits.
11. Analyze and design typical 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, Linearization, 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 you to apply concepts introduced in lecture in solving analytical and design based problems;
- 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 which contains the circuits used in each laboratory experiment with plug-in ICs, resistors, capacitors and jumpers. You will plug-in resistor and capacitor values according to your design on the PCB board, use jumpers to construct the desired circuit and perform measurement.

You are required to attend laboratory from Week 5 to Week 12 every week. Your timetable may show the laboratory classes running from week 2 to week 13. But note that laboratory class will not start until week 5. 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 reflections, lab exams, two assignments and take-home mid-term exam.

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.

It is important that students take a good care of boards used in the laboratory. **You will lose mark as a group if you destroy an IC component or a board because of negligence.** If you carefully follow instruction provided in the laboratory manual and seek help from the lab demonstrators whenever in doubt, it is very unlikely that an IC or a board will be destroyed.

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 reflection

You will be required to write an individual laboratory reflection at the end of lab I, lab II, and lab III. The reflection will allow you to summarize the main points you have learned from the lab, your learning experience and general feedback in doing the lab tasks. Detail on how to write and what to include in the reflection will be provided in week 6. The reflection does not have word limit but is not expected to be long and generally less than 500 words. It can be handwritten as long as it is legible. You will submit the reflection to the lab demonstrators in the lab after you are marked for the lab either in the same or following week. It will contribute 5% towards the overall mark. The assessment will provide you with the opportunity to reflect on the lab, and your learning experience. It will also help us to improve the delivery of the lab and better support your individual needs based on your experience and feedback.

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 not contribute the overall mark. The quizzes are mandatory component of the overall assessment and **Students must attempt all quizzes to pass this subject**. Each quiz will consist of a number of multiple choice questions and will be marked according to the number of correct answers. 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.

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 Examination

The final examination in this course is a standard closed-book 2-hour written examination, comprising four compulsory questions. It is worth 50% 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

Assessment	Learning outcomes										
	1	2	3	4	5	6	7	8	9	10	11
Laboratory practical assessments	✓	✓	-	-	✓	✓	✓	-	✓	-	-
Lab exam	✓	✓	-	-	✓	-	✓	-	✓	-	-
Laboratory reflection	✓	✓	-	-	✓	✓	✓	✓	✓	-	-
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, 2nded., 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

- Laboratory reflection is included as an additional assessment in order to provide students with an opportunity to reflect on the laboratory tasks. In previous years, students are required only to complete the lab tasks and get marked. The reflection aims at allowing students to look back at the experimental tasks they have just completed and summarise what and how they have learned. In so doing, it may help the students to understand and thus improve their learning approach. It also aims at identifying some of the shortcomings in the lab in terms of resource and support, and being better informed in order to tackle the shortcomings and improve the delivery of the lab.

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	