ELEC4604
RF Electroniocs

Course Outline – Semester 1, 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 times will be advised during lectures. 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 ELEC4604 in the subject line, otherwise they will not be answered.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via online learning and teaching platforms – in this course, we will use Moodle https://moodle.telt.unsw.edu.au/login/index.php. 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 2 hours of lectures, a 1-hour tutorial, and a 2-hour laboratory session each fortnight. Tutorials and Laboratory classes start in week 4.

Lectures	**Day**	**Time**	**Location**
	Monday	1 pm – 3 pm	Quad G053
Tutorials	Monday	3 pm – 4 pm	Quad G053
Laboratory sessions	Wednesday	1 pm – 4 pm	EER301B (w4-7) EE125 (w8-13)

Context and Aims

The course aims to make the student familiar with RF circuits and enable them with the understanding of the RF fundamentals, leading to knowledge enabling the design and implementation of various RF circuits.

This course will look at the hardware aspects of wireless systems from a radio frequency perspective. The course will introduces several of the RF building blocks present in any RF communication transceiver system. It will cover basic passive and active RF components, RF device models, recapitulation of transmission line principles and Smith charts, generalized matrix representation of RF circuits, analysis of multiport RF networks, introduction to modern planar technologies, lumped and distributed circuits, analysis of microstrip circuits, RF resonators, RF filters, RF amplifiers and antennas. Other components and modern microwave technologies will be also introduced.

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1	Introduction
Week 2	Recapitulation of fundamental concepts
Week 3	Theory background 1
Week 4	Theory background 2
Week 5	Current rf and microwave technologies
Week 6	Microwave passive devices 1
Week 7	Microwave passive devices 2/ **Mid-session test**
Break	
Week 8	Microwave passive devices 3
Week 9	Microwave passive devices 4
Week 10	Microwave active devices 1
Week 11	Microwave active devices 2
Week 12	Microwave active devices 3 / Lab reports are due
Week 13	**Lab reports are due for all students**

Indicative Laboratory Schedule

Period	Summary of Laboratory Program
Week 4	Impedance Measurement
Week 5	Impedance Measurement
Week 6	Antenna Pattern Experiment
Week 7	Antenna Pattern Experiment
Break	
Week 8	Computer aided design of microwave components 1
Week 9	Computer aided design of microwave components 1 cont.
Week 10	Computer aided design of microwave components 2/ Calibration and measurements of passive components
Week 11	Computer aided design of microwave components 2 / Calibration and measurements of passive components cont.
Week 12	Characterization of active devices
Week 13	Characterization of active devices

Assessment

Laboratory Practical Experiments with Reports	20%
Mid-Semester Exam	20%
Final Exam (2 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 an elective course in the School of Electrical Engineering and Telecommunications. The course is offered to students enrolled in the fourth level of undergraduate studies in the School of EE&T at the University of New South Wales. The course gives the foundation for radio frequency / microwave engineering design principles. The course should be taken by students that plan to design overall communications systems.

Pre-requisites and Assumed Knowledge

The pre-requisite for this course is ELEC3115 Electromagnetics engineering and ELEC3106 Analog Electronics. It is essential that the students are familiar with circuit theory, basic analogue electronics and communication principles before this course is attempted. Electromagnetic theory and circuit theory techniques are assumed knowledge for this subject. It is further assumed that the students are familiar with SPICE-like circuit simulators, have good computer literacy and are able to operate electronics equipment.

Following Courses

The course will provide essential basic understanding to attempt ELEC 9702 RF Integrated Circuits, TELE 9344 Cellular and Mobile and Communications, and TELE 4652 Mobile and Satellite Communications, which are core courses in the Microsystems and Microelectronics, Telecommunications and Master of Engineering Science post-graduate specialisation coursework program, offered by the School.

Learning outcomes

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

1. Understanding of the limitations of conventional low frequency circuit and microwave circuit analysis.
2. Analyze and design microwave circuits;
3. Use modern CAD design techniques to simulate microwave circuits;
4. Use modern instrumentation to measure the microwave circuit parameters

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

The general flow of the course is: applications, systems, components; applications of microwaves: (terrestrial and satellite communications, radar, remote sensing, wireless); system requirements for elements are to be analyzed; propagation modes (TEM, TE, TM, quasi-TEM), attenuation, dispersion, S-parameters are parts of general fundamentals; analysis of microwave circuit components and MIC are to be introduced.

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;
- Video on research topics, small periodic quizzes (non-assessed) that provide with reflection on the subject.

Learning in this course

You are expected to attend all lectures, tutorials, labs, and mid-semester exams in order to maximise learning. You must prepare well for your laboratory classes and your lab work will be assessed. In addition to the lecture notes/video, 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.

Tutorial classes

Tutorial classes are held every fortnight. You should read the lecture notes and attempt all of your problem sheet questions in advance of attending the tutorial classes. 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. Answers for these questions will be discussed during the tutorial class and the tutor will cover the more complex questions in the tutorial class. In addition, during the tutorial class, 1-2 new questions that are not in your notes may be provided by the tutor, for you to try in class. These questions and solutions may not be made available on the web, so it is worthwhile for you to attend your tutorial classes to gain maximum benefit from this course.

Laboratory program

The laboratory schedule is deliberately designed to provide practical, hands-on exposure to the concepts conveyed in lectures soon after they are covered in class. You are required to attend laboratory from Week 4 to Week 12. Laboratory attendance WILL be kept, and you M

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 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 lab checkpoints (see lab manual), lab exams and the mid-semester exam.

Laboratory Work has 20% weight

Mid-Semester Exam has 20% weight

Final Exam (2 hours) has 60% weight

Laboratory Assessment

Laboratories are primarily about practical learning, and the laboratory assessment is designed mainly to check your knowledge as you progress through each stage of the laboratory tasks. You are required to maintain a lab book for recording your observations. A lab book is an A4 size notebook containing a mix of plain pages and graph sheets. You have to purchase your own lab book from any stores.

You are required to write the aim of the experiment and draw the circuit diagrams in your lab book. This will be verified and signed by your demonstrators in the lab. You will be recording your observations/readings in your lab book first and then completing and submitting the results sheet before leaving the lab or as set for each experiment by your lecturer guidelines.

After completing each experiment, your work will be assessed by the laboratory demonstrator. Assessment marks will be awarded according to your preparation (completing set preparation exercises and correctness of these or readiness for the lab in terms of how much of the lab you were able to complete, your understanding of the experiments conducted during the lab, the quality of the code you write during your lab work (according to the guidelines given in lectures), and your understanding of the topic covered by the lab. To check that you have achieved the practical learning outcomes for the course, you will be examined in the laboratory on equipment characteristics and analytical calculations. The questions will be based on what you have learned in your laboratory classes and lectures, and marks will be awarded for the correct understanding of practical and relevant theoretical concepts, correct operation of laboratory equipment, and correct interpretation of measured results. Laboratory questions from your lab demonstrator will be marked throughout the session and will be reflected in the final lab mark.

Laboratory Reports

The tasks allow self-directed study leading to the solution of partly structured problems. Marks will be assigned according to how completely and correctly the problems have been addressed, the quality of the code written for the tasks (must be attached to the report), and the understanding of the course material demonstrated by the report.

The lab report will be due at the Wednesday last lab sessions in Week 12 and 13 for the two groups. *Late reports* will be accepted *by* Friday noon Week 12 and Week13 respectively*. Penalties will be attracted of 10% per day* (including weekends) after that date.

Your lab book, lab work and reports will be assessed by the lab demonstrator. The laboratory mark (20% weight) will be the result of the assessment and report marks.

Mid-Semester Exam

The mid-session examination tests your general understanding of the course material, and is designed to give you feedback on your progress through the analytical components of the course. Questions may be drawn from any course material up to the end of week 6. It may contain questions requiring some (not extensive) knowledge of laboratory material, and will

definitely contain numerical and analytical questions. Marks will be assigned according to the correctness of the responses.

Final Exam

The exam in this course is a standard closed-book 2 hour written examination, comprising five compulsory questions. 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**
Laboratory practical assessments	✓	✓	-	✓
Lab exam	✓	✓	✓	✓
Mid-semester exam	✓	-	-	-
Final exam	✓	✓	✓	✓

Course Resources

Textbooks

Prescribed textbook

- R. Ludwig and G. Bogdanov, RF Electronics – Theory and Applications, 2nd Ed. Prentice Hall 2008.

Reference books

- R.S. Elliott, Guided Waves and Microwave Circuits, Prentice Hall, 1999.
- A.S. Sedra and K.C. Smith, Microelectronic Circuits, Oxford University Press, 6th Ed., 2015.
- D. K. Cheng, Field and Wave Electromagnetics, Addison Wesley, 2nd Ed., 1992.
- D. Pozar, Microwave Engineering, John Wiley, 4th Ed. 2013.
- R. Collins, Foundations of Microwave Circuits, Mc Graw Hill, 2nd Ed., 2000.

CAD Resources

Agilent ADS will be used for some lab units. It is installed in EE125. ADS is extensively used by the industries for RF and MW applications and have proven to be a very valuable tool. Most graduates and post graduates can easily find a design or research job if they show competency in manipulation of simulating tools, along with their knowledge of design principles.

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and occasionally quizzes. Assessment marks will also be made available via Moodle: https://moodle.telt.unsw.edu.au/login/index.php.

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 set deadline**, 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 myExperience 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.

Previous students told us that, they thought that the best things about the course were that teachers were helpful and supportive, and that the course was interesting and engaging. 90% of them felt part of a learning community and 90 % felt that the assessment tasks were appropriate.

Students suggested that the course could be improved by more in-class work and less evaluation. We have responded to this feedback that the evaluation such as mid-term test has the important role to assure the base minimum relevant knowledge is reviewed and in place for the final learning outcomes of the course.

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:
https://student.unsw.edu.au/guide
https://www.engineering.unsw.edu.au/electrical-engineering/resources

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 digital and information literacy and lifelong learning skills through CAD work.
- 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	✓
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	
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 Effective team membership and team leadership	✓