School of Electrical Engineering and Telecommunications

Term 1, 2020
Course Outline

ELEC4604
RF Electronics

COURSE STAFF

Course Convener: Prof. R. Ramer, Room 308, ror@unsw.edu.au
Tutor: as above
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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 ELEC 4604 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 2-3 hours of lectures per week, a 1-2 hours of tutorials per fortnight and a 3-4 hours laboratory per fortnight.

Tutorials and laboratory classes start in week 2. Further details re the laboratory classes TBA.

	Day	**Time**	**Location**
Lectures			
	Wednesday, wk 1-10	09:00 – 12:00	Vallentine Annex 121
Tutorials			
	Thursday, wk 1-4, 6-9	15:00 – 16:00	SEB G05
	Thursday, wk 5, 10	15:00 – 17:00	SEB G05
Labs			
	As per your timetable. Start in week 2.		EE224

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 introduce 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 and recapitulation of fundamental concepts
Week 2	Theory background 1
Week 3	Theory background 2
Week 4	Current rf and microwave technologies
Week 5	Mid-term exam, 18th March, Wednesday 9:30 am - 11 am
Week 6	Microwave passive and active devices 1
Week 7	Microwave devices 2
Week 8	Microwave devices 3
Week 9	Microwave devices 4
Week 10	Microwave devices 5

Indicative Laboratory Schedule

Period	Summary of Laboratory Program
Week 2 - 4	Introductory experiment
Week 5	Computer aided design of microwave components (CAD) 1
Week 6	CAD 2
Week 7	CAD 3
Week 8	CAD 4
Week 9	Calibration. Measurements of passive and active components 1
Week 10	Characterization of active devices 2 Lab report final submission
Week 11	Characterization of active devices 2 cont. Lab report final submission

Note. The laboratory units require different time lengths and may be finished at different pace by individual students. Once satisfied with the results, the students may move to the next laboratory unit during a lab session and must submit the report at the next scheduled lab time.

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 15 hours per week throughout the 10-week term.

Relationship to Other Courses

This is an 4th year elective course in the School of Electrical Engineering and Telecommunications following a BE Electrical or Telecommunications program and other combined degree programs. 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 can 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 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, 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.

Lectures

The lectures will provide the fundamental concepts and theory of engineering electromagnetics.

Tutorial classes

Tutorial classes provide students with an opportunity to discuss problems with others, while being guided by a staff member. 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. Students are required to attend laboratory. Laboratory attendance will be kept, and the student must attend at least 80% of labs.

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.

Out of class work

Lectures can only ever introduce the key ideas. Students must further reflect on these to fully develop their understanding. Students are encouraged to read the textbook and reference materials. Preparation for laboratory exercises provides further understanding of the experiment. The practice tutorial questions develop an in-depth quantitative understanding of basics of rf principles. These problems take the student through all critical course topics and aim to develop and exercise their thinking skills. Students are expected to attempt complete all the problems.

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.

Mid-Semester Exam

A closed-book mid-term test will be held for this course. Further details will be announced closer to the date.

Date: Wednesday, week 5.

Location: lecture room in Vallentine Annexe 121,

Time: 9:30 -11am.

Laboratory Work

Laboratories are primarily about 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 diagram if any 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.

After completing each experiment, your work will be assessed by the laboratory demonstrator. Both the results sheet and your lab book will be assessed by the laboratory demonstrator. Once the laboratory unit is completed, the lab report must be submitted to the lab demonstrator at the start of the next laboratory time.

Marks will be assigned according to how completely and correctly the problems have been addressed, the quality of the results for the tasks and the understanding of the course material demonstrated by the report. Your lab book, lab work and reports will be assessed by the lab demonstrator.

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 material already covered in the course schedule. It may contain questions requiring some (not extensive) knowledge of laboratory material and will 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 Circuit Design – Theory and Applications, 2nd Ed. Prentice Hall 2009.

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.

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

Dates to note

Important Dates available at: https://student.unsw.edu.au/dates

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 **15 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 online student survey myExperience. 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. Based on regular feedback ELEC4604 has been recently structured in a way that encourages in-class individual and group discussion of challenging analytical concepts. In 2020 we aim to improve the experience, to keep it focused more on learning and less on assessment.

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

APPENDICES

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 address 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 assignment work.
- Developing ethical practitioners who are collaborative and effective team workers, through group activities, seminars and tutorials.
- 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, 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	✓