School of Electrical Engineering and Telecommunications

Term 1, 2021
Course Outline

TELE4653
Digital Modulation and Coding

Updated on 8 February 2021

COURSE STAFF

Course Convener: Prof. Wei Zhang, Elec Eng Room 416, w.zhang@unsw.edu.au
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Course Website: https://moodle.telt.unsw.edu.au/course/view.php?id=57170

Consultations Hour:

Available upon an appointment made and confirmed by email.

Contact Hours

The course consists of 2 hours of lectures, a 1-hour tutorial, a 1-hour repeated tutorial, and a 3-hour laboratory session each week.
Tutorials start in week 2.
Labs start in week 2.

	Day	Time	Location
Lectures	Monday Weeks 1-10	11am-1pm	Online
Tutorials	Tuesday Weeks 2-10	4pm-5pm	Online
Labs	Weeks 2-9	See Your Timetable	Elec Eng 219 or Online

Course Aims

- TELE4653 introduces the fundamental concepts in both digital modulation and coding. It comprises fundamentals of communications concepts (signal space, random variables, random process), digital modulation and demodulation techniques,

performance analysis, synchronization techniques, coding theory (block codes and convolutional codes), and multi-carrier modulation and coding.

- The course aims to assist students to be familiar with fundamentals of telecommunications, develop understanding of digital modulation and coding theory, and deduce and analyse the behaviour of a telecommunication system.

Lecture Schedule

TELE4653 **T1, 2021**	**Monday (Weeks 1-10)** **11:00am - 1:00pm**	**Topics**	**Reference [1]**
Week 1	15 February	Fundamentals	Chapter 2
Week 2	22 February	Modulation	Chapter 3
Week 3	1 March	Modulation	Chapter 3
Week 4	8 March	Modulation	Chapter 3
Week 5	15 March	Synchronization	Chapter 5
Week 6	22 March (flexibility week)		
Week 7	29 March	Channel Coding	Chapter 7,8
Week 8	5 April	Detection	Chapter 4
Week 9	12 April	Detection	Chapter 4
Week 10	19 April	Detection	Chapter 4

1. John G. Proakis and Masoud Salehi, *Digital Communications*, 5th Ed., McGraw-Hill, 2008.

TELEL4653 Lab Schedule

Labs start in Week 2 and finish in the end of Week 10.
There are 4 different labs in total which you must attend **once every two weeks**.

Lab 1	Lab 2	Lab 3	Lab 4
Weeks 2-3	Weeks 4-5	Weeks 7-8	Weeks 9-10

Please check your enrolled lab session code (e.g., class number).
http://timetable.unsw.edu.au/2020/TELE4653.html

Assessment

- Laboratory work 20% (4 labs, 5 marks each)
- Assignment 20% (2 assignments, 10 marks each)
- Final Exam (2 hours) 60%

COVID19 - Important Health Related Notice

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate**. We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed.

If you are required to self-isolate and/or need emotional or financial support, please contact the Nucleus: Student Hub. If you are unable to complete an assessment, or attend a class with an attendance or participation requirement, please let your teacher know and apply for special consideration through the Special Consideration portal. To advise the University of a positive COVID-19 test result or if you suspect you have COVID-19 and are being tested, please fill in this form.

UNSW requires all staff and students to follow NSW Health advice. Any failure to act in accordance with that advice may amount to a breach of the Student Code of Conduct. Please refer to the Safe Return to Campus guide for students for more information on safe practices.

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

TELE4653 is a 4th year technical elective in the wireless communications discipline. It is aimed at students wishing to specialise in telecommunications in their degree, and possibly, their future careers.

- **Pre-requisites**: TELE3113: Analogue and Digital Communications, or equivalent, is required. It is also desirable that students have completed ELEC3104: Digital Signal Processing, as several of the ideas taught in that course lay the foundation in some areas of this subject. In addition, a substantial level of mathematics and statistics is required to adequately master the subject matter.
- **Assumed Knowledge**: A basic knowledge and understanding of communication systems and the communication problem, as would be gained from TELE3113, is assumed. Basic knowledge of Fourier theory, digital filters and signal processing is also assumed. Above average competency in the fields of algebra, analysis, and statistics, gained from the second year core mathematics course, commensurate with a student wishing to specialise in telecommunications, will also be required. The assignments and tutorials will require students to be familiar with MATLAB, or some other equivalent numerical computing platform. The on-site laboratories are to be performed on TIMS, the signal processing platform extensively used in TELE3113 and ELEC3104.

Following Courses

As a final year technical elective, it is planned that the standard reached by students at the end of this course would be commensurate with that expected of a graduating telecommunications engineer. There are no follow on courses as such, but students will find that the underlying principles of communication systems taught in this course will provide deeper insight into specialist communications courses in wireless communications, mobile and satellite communications, and optical fibre communications.

Learning Outcomes

After successful completion of this course, students should

1. be familiar with all the key elements of a digital communication system and at a theoretical level can identify and quantify the factors that determine the performance of a digital communication system.
2. be familiar with major modulation techniques, their practical considerations, and be capable of quantifying the performance of a generic modulation scheme.
3. Understand the importance and rationale of channel coding in communication, and implement and analyse block coding and convolutional coding schemes.

This course is designed to provide the above learning outcomes that 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**.

Teaching Strategies

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;

During the lecture, theories and other relevant information will be expounded by the lecturer. Core materials of the course will be elaborated with a variety of practical examples of digital modulation and coding. As the course emphasizes interactive learning, students are encouraged to ask questions and express feedback during the lectures.

The tutorial provides students in-depth quantitative understanding of digital modulation/demodulation and coding techniques. Students will practise their problem-solving skills in the form of discussion and class exercises.

The laboratory work offers students hands-on experience in generating and detecting wireless data signals in various modulation formats, and thus helps students understand the core materials of the course.

Learning in this Course

You are expected to attend all lectures, tutorials, labs, and final exam 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.

Assessments

Laboratory Assessments (20 marks):

- There are 4 laboratory experiments to complete in total from **week 2 to week 9**.

- 【For on-campus labs only】Students must attend the laboratory every fortnight at their allotted time. If students find they must miss a lab session for any reason (illness, family or work commitments), they are required to contact the lecturer and make alternative arrangements PRIOR TO the lab session in question. Students who have not done so will receive a mark of zero for the missed lab session – there will be no exceptions. Some lab periods may need to be rescheduled due to public holidays, and the announcement of alternative arrangements will be made during the lectures.

- 【For on-campus labs only】Students must be marked off by a lab demonstrator at the end of each lab session and have their mark recorded by the demonstrator. It is the responsibility of the student to make sure this is done. If no mark is recorded at the end of the lab for whatever reason, a mark of zero will be given – once again, there will be no exceptions.

- 【For on-campus labs only】Students are required to maintain a laboratory journal, and the marks obtained directly correspond to the quality of this journal. The journal should record all equipment settings and connections, as well as any measurements and observations made. It is important for all engineers to accurately document all experimental work, and emphasis is placed on the lab journal in this course to ensure that students develop this important attribute of a professional engineer.

- 【For online labs only】Students must complete the online labs available at Moodle course website every fortnight and submit the lab reports by the due time. For more details, please refer to online lab section at Moodle course website.

Assignments (20 marks):

- There are TWO assignments to complete. The details of the assignments will be made available on the course website in Week 5 and Week 10, respectively. The assignments are to be submitted to the lecturer's email (w.zhang@unsw.edu.au) in PDF file with an email subject "**TELE4653 Assignment - student ID & name**". Students must submit the assignment on or before the due date. Later submission will suffer a penalty of 2 marks per day late.

Final Exam (60 marks):

The final examination is a standard closed-book 2-hour written examination, held **after week 11**, comprising not more than 7 compulsory questions. The final examination will test students' understanding of the course material and analytical

skills. Assessment is a graded mark according the correct fraction of the answers to the exam questions.

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes		
Assessment	**1**	**2**	**3**
Laboratory practical assessments	✓	✓	-
Assignment	✓	✓	✓
Final exam	✓	✓	✓

Course References

- Prescribed textbooks

1. John G. Proakis and Masoud Salehi, *Digital Communications*, 5th Ed., McGraw-Hill, 2008.

- Reference books

2. Simon Haykin, *Communication Systems*, 4th Ed., John Wiley & Sons, 2000.
3. Nevio Benvenuto, Roberto Corvaja, Tomaso Erseghe, and Nicola Laurenti, *Communication Systems: Fundamentals and Design methods*, John Wiley & Sons, 2006.
4. Simon Haykin and Michael Moher, *Introduction to Analog & Digital Communications*, 2nd Ed, John Wiley & Sons, 2006.
5. Thomas M. Cover and Joy A. Thomas, *Elements of Information Theory*, 2nd Ed., John Wiley & Sons, 2006.

On-line Resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials. 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://my.unsw.edu.au/student/atoz/ABC.html), 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 *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.

Course Evaluation and Development

- Any feedback on the course to improve the quality of learning and teaching is appreciated. Please feel free to talk to your lecture staff about it.
- Students' feedback is gathered periodically on-class and such feedback will be considered carefully with a view to acting on it constructively wherever possible.
- The feedback is gathered using various means, including the Course and Teaching Evaluation and Improvement (CATEI) tool.

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 assignment work.

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	1,2,3
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing	1,2,3
	PE1.3 In-depth understanding of specialist bodies of knowledge	1,2
	PE1.4 Discernment of knowledge development and research directions	1
	PE1.5 Knowledge of engineering design practice	1,2
	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	1
	PE2.2 Fluent application of engineering techniques, tools and resources	1,2,3
	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)	1
	PE3.3 Creative, innovative and pro-active demeanour	1,2
	PE3.4 Professional use and management of information	1
	PE3.5 Orderly management of self, and professional conduct	
	PE3.6 Effective team membership and team leadership	