School of Electrical Engineering and Telecommunications

Term 1, 2019
Course Outline

ELEC3104
Digital Signal Processing

Course Staff

Course Convener: Dr Vidhyasaharan Sethu, EE 442, v.sethu@unsw.edu.au

Project Design: Prof. E. Ambikairajah & Dr Vidhyasaharan Sethu

Tutorial-Lab Coordinator: Dr Saad Irtza, s.irtza@unsw.edu.au
Consultations: Dr Jianbo Ma, jianbo.ma@unsw.edu.au

Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. In addition, a weekly open consultation time of 1 hour will be provided (details announced on Moodle). Any email enquiry regarding the course should be made from your student email address with ELEC3104 in the subject line; otherwise they will not be answered. All tutorial-lab and project related emails should be directed to Dr Sarith Fernando or Dr Jianbo Ma in the first instance.

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 4-5 hours of lectures, and a 3-hour of integrated tutorial-lab each week.

	Day	Time	Location	Name
Lectures	Monday	16:00-18:00/19:00	ChemSc M17	Dr. V. Sethu
	Thursday	10:00-12:00	ChemSc M17	
Tutorial-Labs	Mon - Fri	Enrolled times	EE108	Lab Demonstrators
Consultations	Wednesday	14:00-15:00	EE Gnd 01	Dr. Ma / Dr. Fernando / Dr Sethu

Note: Week 10 and 11 schedules are different due to public holidays. Please check online at http://classutil.unsw.edu.au/ELEC_T1.html#ELEC3104T1

Context and Aims

Signal Processing is the process of measuring, manipulating or analysing information. Signals of interest include biomedical data, audio, still or moving images, radar, and even DNA. Filtering techniques can be crucial in revealing and interpreting information present in a signal. ELEC3104 Digital Signal Processing is an introductory signal processing course which takes students through the steps necessary to design and implement filters for a range of signals.

Aims

The course aims to equip students with:

- An understanding of the behaviour of a system, in terms of both its time domain and frequency domain representations.
- The skills to identify the correct type of filter required for a given problem and be able to demonstrate the design and implementation of a digital filter.
- The ability to explain the concept of aliasing and its effect on the design of practical systems.
- An understanding of multi-rate processing and multi-rate systems.

Indicative Lecture Schedule

The indicative lecture schedule is listed in the following table.

Week	Lecture	Tutorial-Labs
1	Introduction to DSP + Understanding Signals (5hrs)	
2	Understanding Signals (2hrs) + Analysis of Discrete Systems (3hrs)	Tutorial-Lab 1
3	Analysis of Discrete Systems (4hrs)	Tutorial-Lab 1 + Quiz
4	Discrete Fourier Transform (4hrs)	Tutorial-Lab 2
5	Discrete Fourier Transform (4hrs)	Tutorial-Lab 2 + Quiz
6	Project Discussion (2hrs) + Filter Design (2hrs)	Tutorial-Lab 2
7	Filter Design (4hrs)	Tutorial-Lab 3 + Quiz
8	Filter Design (2hrs) + Multi-rate Processing (2hrs)	Tutorial-Lab 3
9	Multi-rate Processing (4hrs)	Tutorial-Lab 3 + Quiz
10	Quantisation (2hrs)	Project Assessment

Note:

1. MATLAB Tutorial Videos: **http://eemedia.ee.unsw.edu.au/MatlabTutorial/index.htm**
2. There are 3 tutorial-lab sheets –they will be released in week 2.
3. The project will be released in week 5.

Assessment

Lab Quiz (4 Quizzes)	20%
Project Presentation (Individual)	30%
Final Exam (2 hours)	50%

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 a 3rd year course in the School of Electrical Engineering and Telecommunications at the University of New South Wales. It is a core course for students following a BE (Electrical) or (Telecommunications) program and other combined degree programs, and an elective for Computer Engineering students.

Pre-requisites and Assumed Knowledge

The pre-requisite for this course is ELEC2134, Circuits and Signals. It is essential that students are familiar with basic circuit theory, signal analysis and transform methods. It is further assumed that students are familiar with the MATLAB environment, and have good computer literacy.

Following Courses

The course is a pre-requisite for all professional electives in the Signal Processing group, including ELEC4621 Advanced Digital Signal Processing and ELEC4622 Multimedia Signal Processing

Learning outcomes

At the end of the course students should:

1. Be able to apply transform methods to the analysis of analogue and digital linear time-invariant systems
2. Develop the appropriate competency in converting between time and frequency domain representations of signals and systems
3. Understand the practical aspects of sampling and reconstruction and be able to select a suitable sampling rate for a given signal processing problem
4. Design and analyse analogue and digital filters for a given specification
5. Demonstrate an understanding of the use and applications of the Discrete Fourier transform
6. Have gained practical experience with the implementation of digital filters
7. Be able to implement a simple multi-rate system

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

Syllabus

Processing and analysis of continuous (analogue) and discrete-time (digital) signals. Sampling continuous signals: the sampling theorem, reconstruction, aliasing and the z-transform. Analogue filters: Butterworth filters. Filter impulse and frequency responses, stability and digital oscillators. The Discrete Fourier Transform (DFT). Fundamentals of the design and realisation of finite impulse response (FIR) and infinite impulse response (IIR) digital filters. Linear and non-linear phase filters. Decimation, interpolation, multi-rate digital signal processing.

Teaching Strategies

Delivery Mode

This entire course will be delivered via live lectures. Lecture notes of mathematical concepts and relationships will also be provided to complement the lectures. Please note that the notes and the lectures are designed to be complementary, you should not treat the notes as a replacement for lectures.

Learning in this course

1. You are expected to attend all lectures, tutorial-labs, and the project presentation in order to maximise learning.
2. You must prepare well for your tutorial-lab classes.
3. Reading additional texts will further enhance your learning experience.
4. Group learning is also encouraged.
5. You are encouraged to discuss your project design with your peers, but you should implement the project on your own.
6. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

Tutorial-Laboratory classes

The integrated tutorial-laboratory sessions are designed to help you develop your analytical skills and see how they are applicable in a practical context. You may divide your time between the analytical and the laboratory components as per your convenience, but you should complete both within the allocated time. The analytical problems you will be given in these sessions will tend to be more involved than the sample problems in the reference books and will also tend to involve more than one topic. **It is expected that you are able to solve the sample problems in each chapter and the recommended reference books prior to undertaking the tutorial-lab questions.**

A total of 3 tutorial-laboratory question sheets will have to be completed in this course and are designed to provide practical, hands-on exposure to the concepts conveyed in lectures soon after they are covered in class. While you are free to divide your laboratory time between these 3 sheets and project as you choose to, **you must complete tutorial-lab sheet 1 by week 3, tutorial-lab sheet 2 by week 6 and tutorial-lab sheet 3 by week 9.** Laboratory attendance WILL be kept, and you MUST attend all tutorial-labs.

The project is designed to provide a hands-on exposure to the applications of the concepts learnt in the course in implementing a DSP system. As previously mentioned, you are free to split your laboratory time between the tutorial-lab sheets and the project, but you are strongly encouraged to discuss your project implementation with your lab demonstrators to complement your self-directed learning. **The project will be assessed based on an INDIVIDUAL presentation in week 10. Attendance for this is compulsory.**

Tutorial-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, please meet the co-ordinator (Saad Irtza) to discuss the situation.

Pre-requisite to pass the course

A satisfactory performance (50% or greater) in **each** of the following, is a necessary requirement to pass this course:

- **Individual Project Presentation**
- **Final Exam**

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the term. Ongoing assessment occurs through lab quizzes and the project presentation in the final week.

Lab Quizzes	20%
Individual Project Presentation (Week 10/11)	30%
Final Exam (2 hours)	50%

Lab Quizzes (20%)

The lab quizzes are multiple choice tests that will be given at the start of the labs in weeks 3, 5, 7, and 9. These will focus on analytical concepts covered in the tutorial-lab sheets.

Project (30%)

The project will be released in week 5 and you can divide your laboratory time between the project and the tutorial-lab sheets as per your convenience. In week 10/11 you will be required to make an **individual** presentation (15-20mins) to a panel of lab demonstrators explaining your implementation (based on a working demonstration and suitable analyses) as well as your understanding (based on your verbal answers to questions from the demonstrators – the questions may cover all topics in the course and not restricted to your specific project work). Your project mark will be awarded by the lab demonstrators based on this presentation. **You must pass the project to pass the course.**

Final Exam (50%)

There will be one final examination, testing your understanding of the principles and your analytical skills through a number of set problems. If for medical reasons, (note that a valid medical certificate must be provided to the university) you are unable to attend the final exam, you will be given another exam (either oral or written, at the discretion of the course convenor). **You must pass this final exam to pass the course.**

- The final exam will be 2 hours long
- The final exam will cover all chapters covered in the term

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes						
Assessment	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Lab Quizzes (20%)	✓	✓	✓	✓	✓	-	-
Project (30%)	✓	✓	✓	✓	✓	✓	-
Final examination (50%)	✓	✓	✓	✓	✓	-	✓

Course Resources

Reference books

- A. V. Oppenheim, R. W. Schafer, & P. Buck, Discrete-Time Signal Processing, Prentice-Hall, 2010.
- S. K. Mitra, Digital Signal Processing, McGraw-Hill, 2011.
- R. G. Lyons, Understanding Digital Signal Processing, 3rd ed, Prentice-Hall, 2011
- J. Proakis & D. Manolakis, Digital Signal Processing, Prentice-Hall, 2007.
- A. Antoniou, Digital Signal Processing – Signals, Systems and Filters, McGraw-Hill, 2016

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. As of Term 1 2019, assessment of applications for Special Consideration will be managed centrally and the University has introduced a "fit to sit/submit" rule. You will no longer be required to take your original documentation to The Nucleus for verification. Instead, UNSW will conduct source checks on documentation for verification purposes. You can apply for special consideration when illness or other circumstances beyond your control interfere with an assessment performance. If you need to submit an application for special consideration for an exam or assessment, you must submit the application **prior to the start** of the exam or before the assessment is submitted, except where illness or misadventure prevent you from doing so. If you sit an exam or submit an assignment, you are declaring yourself well enough to do so.

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 (from 2015-2017) and in our efforts to provide a rich and meaningful learning experience, we have:

1. Introduced a new project to provide additional hands-on learning of implementation of DSP systems
2. Introduced a set of quizzes for on-going feedback.
3. Provided additional MATLAB resources including a series of videos

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

Important Points

Please note the following:

- During your tutorial-labs, a lab demonstrator will be present and will be able to guide you in your laboratory-based learning.
- MATLAB resources will be made available on the course Moodle.
- Guidelines on learning that inform teaching at UNSW are available at www.guidelinesonlearning.unsw.edu.au

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: 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	