DE 2 - Electronics 2: Signals, Systems, and Control

Course Planning Document (version 5.3)

AIM

This course is a follow on from Year 1's Electronics 1 module by providing a system perspective to electronic systems. The focus of this year's module will be on: signal interpretation, processing and manipulation; system characterization and modeling; feedback control and tuning of feedback systems. By the end of this module, together with what have been covered in the first year, students will have most of the fundamental concepts of electrical and electronic engineering necessary for a design engineer.

THE NEW APPROACH

The planning of this module took a new approach when it was first designed in 2016. The capstone project was first created. Then Laboratory sessions for students to acquire the necessary knowledge and skills to conduct the project was designed. Finally, the lectures and tutorial problems were designed to support the Laboratory sessions.

LEARNING OUTCOMES

On successful completion of the module, students should be able to:

- analyse and interpret signals in both analogue and digital forms;
- analyse and interpret signals in both time and frequency domains;
- use Matlab or similar tools to perform analysis of signals and systems;
- extract useful information from signals through analysis, filtering and other form of signal conditioning;
- understand system behaviour in terms of its response to impulses and step functions;
- dynamic behaviour of systems;
- employ principles of feedback to improve various performance parameters in an electronic system;
- design and tune a proportional-integral-differential (PID) controller;
- implement both signal processing and control algorithms in a standalone, embedded electronic system using real-time programming techniques in Python.

TEACHING STAFF

Module Leader: Professor Peter Y. K. Cheung
Assisted by: Professor Andrew McPherson (2nd examiner/marker)

COURSE WORKLOAD (100 HOURS, 5 ECTS)

This module will take place in the Spring term in 2022 over a 10-week period consisting of:

- 20 hours lectures (two or three hours lectures in a week, front-loaded)
- 10 hours of tutorial/problem classes (1-hour sessions per week, week 3 to 10)
- 30 hours scheduled laboratory (3-hour session per week, week 2 to 10)
- 40 hours self-study

ASSESSMENT

- 40% coursework: two lab orals (20% EACH)
- 60% 1.5-hour written examination paper (week 1 of Summer Term)

SCHEDULE (SPRING TERM 2025)

Week (starting)	Lectures	Lab	Comments
0 (5 Jan)	-	-	Exam week
1 (12 Jan)	1, 2, 3, 4	Lab 1 – Sig Proc & Matlab	
2 (19 Jan)	5, 6	Lab 2 – Sig Proc & Pybench	
3 (26 Jan)	7, 8	Lab 3 – Systems	
4 (2 Feb)	9, 10	Lab 4 – IMU & OLED	
5 (9 Feb)	-	LAB Oral	DRAW week
6 (16 Feb)	11, 12	Lab 5 – real-time systems	
7 (23 Feb)	13, 14	Lab 6 – Motor Control	
8 (2 Mar)	15, 16	Lab 7 – Challenges	
9 (9 Mar)	17	Lab 8 – Challenges	
10 (16 Mar)	-	FINAL LAB Oral	Final week

TUTORIAL PROBLEM SHEETS

There will be 6 tutorial problem sheets to support this module.

LABORATORY EXPERIMENTS

Lab Sessions will be in person. The class will be divided into pairs of students and you may choose your lab partner.

You and your partner will share a set of Lab equipment consisting of a custom-built printed circuit board with modules, and a set of other modules and motors. These are to be returned at the end of the module for use next year. Since we will NOT be constructing any circuits in this module, you will not need DMM or oscilloscope for this module.

Lab 1 – Signal Processing and Matlab

This is a gentle start to the practical work of this module with learning to use Matlab to perform some basic signal processing operations. It also include a section for you to check out the hardware platform, the **Pybench Board**, which is a bespoke system design and made to support this module.

Lab 2 – Real-time Signal Processing

Students will learn how to analysis the spectrum of generated sinewave, square wave and triangular wave using Matlab; how to analyse real-time spectrum using Pybench board and its ***microphone***/amplifier/ADC circuits; understand the impact of sampling signal at too low a frequency and the aliasing effect; the impact of rectangular window on the spectrum of signals and how to mitigate this using Hamming window.

Lab 3 – System characterization and modelling

Students will learn how to use the Pybench board to find the dc gain characteristic, the frequency response and the step response of a highly oscillatory 2nd order system; relating the theoretical behaviour of such a system to an actual electronic circuit; the impact of the non-linear effect of the system on the step response; understand how the transfer function of the system and its relationship to the natural frequency and the damping factor.

Lab 4 – IMU and OLED

Students will learn how to use an inertia motion unit (IMU) to provide a good estimate of the pitch angle and rate of change of pitch angle; to use the OLED display unit; to use the driver packages written for the IMU and the OLED display.

Lab 5 – Motor, Interrupts and Digital Filter

Students will learn how to control the two dc motors, use interrupts to estimate the motor speed and use an N-tap moving average filter to low-pass filter real-time signals.

Lab 6 – PID Controller for motor speed

Students will perform various tasks helpful to their team project.

Lab 7 – Challenges

Just like Electronics 1, you will apply what you have learned in Lab 1 to 6 to complete one or more open-ended challenges.

The assessment of the experiments will be in the form of a 15-minutes individual oral examination on Labs 1 to 4 with one of the members of staff/GTA helping in the laboratory during DRAW week and a second individual oral in the last week of term.