Engineering Tripos Part IIB, 4B13: Electronic Sensors & Instrumentation, 2019-20

Leader

Dr P A Robertson [1]

Lecturer

Dr P Robertson

Timing and Structure

Lent term. 16 lectures (including examples classes). Assessment: 100% exam

Prerequisites

3B1 assumed.

Aims

The aims of the course are to:

- introduce students to state-of-the-art practice in electronic instrumentation systems, including the design of sensor/transducer elements for physical measureands, their respective interface electronics and precision measurement techniques.

Objectives

As specific objectives, by the end of the course students should be able to:

- design circuits to interface to simple temperature and strain measurement devices.
- demonstrate a knowledge of frequency sources and measurement circuits.
- measure high currents using 4 terminal devices and transformers.
- describe how micromachined silicon sensors are made, their operation and merits.
- describe a range of ultrasonic transducers, their applications and associated electronics.
- understand the operation of electromagnetic sensors for flux, current and position sensing.
- design and analyse sensor circuits and estimate signal to noise ratios.
- design an appropriate interface circuit for a sensor with given characteristics.
- produce an outline design of an instrumentation system to monitor a range of physical parameters including pressure, temperature, flow, position and velocity.

Content

Temperature & Strain Sensors and Interface Electronics (3L, Dr P A Robertson)

- Description of thermocouples, thermistors and strain gauges and associated electronics.
- Drift, noise and bandwidth considerations, signal to noise ratio improvement.

Precision Measurements (2L, Dr P A Robertson)

- Voltage measurements: thermal emfs, guarding, shielding. Precision ADC methods
- Time and frequency measurements: stable frequency sources, timer-counter techniques
- Current measurements: current transformers, 4-terminal measurements of high current

Electromagnetic devices (4L, Dr P A Robertson)

- Selected revision of electromagnetic theory and its application to electronic sensors.
- Flux gate, inductive and Hall effect magnetic devices and interface electronics.
- Synchronous detection method applied to fluxgate sensor.
- Laser range finder and velocity sensing

Microfabricated sensors (3L, Dr P A Robertson)

- Overview of silicon micromachining techniques and their application in accelerometers, gyroscopes, automotive air-bag sensors and pressure transducers. Physical priciples of operation and related signal processing electronics.

Ultrasonic transducers (3L, Dr P A Robertson)

- Description of piezo-electric devices, theory and application in practical sensor designs.
- Case studies of the Polaroid range finder, Doppler motion detector and an electronic gas meter.
- Electronic circuits for driving transducers and signal detection methods.

Practical Demonstration Lecture (1L, Dr P A Robertson)

- Evaluation of micromachined accelerometers and gyroscopes.
- Flux-gate magnetometer using synchronous detection
- Ultrasonic motion and distance sensing.

Booklists

Please see the Booklist for Group B Courses [2] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

US4

An awareness of developing technologies related to own specialisation.

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[1] mailto:par10@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364101&chapterid=50391
[3] https://teaching21-22.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching21-22.eng.cam.ac.uk/content/uk-spec