Engineering Tripos Part IIB, 4B13: Electronic Sensors & Instrumentation, 2020-21

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 measurands, 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 principles 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 refer to the Booklist for Part IIB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [2].

UK-SPEC

The UK Standard for Professional Engineering Competence (UK-SPEC) [3] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the ‘Accreditation of Higher Education Programmes’ (AHEP) document [4] which sets out the standard for degree accreditation.

The Output Standards Matrices [5] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.