PH4026 - Signals and Information

Overview
This module provides an introduction to what are signals and information, and how they are measured and processed. It covers the importance of coherent techniques such as frequency modulation and demodulation and phase-sensitive detection. The first part of the module focuses on basic information theory, the relationship between time-domain and frequency domain representations of signals and the basics of measurement, with examples. Data compression and reduction ideas are illustrated with real examples. Coherent signal processing is then discussed, including modulation/demodulation, frequency mixing and digital modulation and multiplexing, basic antenna principles and link gain, with applications to radar.

Aims & Objectives
To provide a clear understanding of just what information is, how we can quantify and process it, and how it can be collected by making measurements.
To develop an understanding of the techniques and basic principles that govern information transmission in the radio and microwave frequency spectrum.
To provide a clear understanding of the techniques used to efficiently communicate, and collect, information.

Learning Outcomes
At the end of the course, students will be expected to:
Explain how the information content of a message may be formally defined in terms of the probability of the symbols that occur in it and calculate and compare it for different examples.
Understand and apply the relationship between time-domain and frequency domain representations of signals and recognise situations in which one representation is preferable over the other.
Understand and explain the operating principles of the discrete Fourier transform, know some basic Fourier transform pairs and be able to explain the basis of windowing.
Explain the costs and benefits of redundancy in information systems and know examples of techniques for allowing the detection and correction of errors.
Explain and apply appropriate expressions to determine the capacity of an information channel based on its noise properties.
Discuss the mechanisms and relative merits of different methods of reducing the amount of data that one needs to describe a message and determine which are best suited to particular circumstances.
Explain the methods and purposes of heterodyne detection systems and be familiar with ways of defining their performance, and be able to make basic design decisions for a particular purpose.
Explain how amplitude and frequency modulation and demodulation may be performed, know the characteristics of the resulting signals and apply them to examples, including basic digital modulation.
Describe and explain different methods of improving the signal-to-noise ratio of measurements, including their limitations and apply them to examples.

Synopsis
What information is and where it some from. Time domain and frequency domain representation of discrete signals, and the relationship between them. The discrete Fourier transform. Noise and its effects on signals. Uncertainty in measurements and signals. Redundancy in signals. Detecting and correcting mistakes in signals. The sampling theorem in the frequency and time domains. The information carrying capacity of a signal channel and how it relates to the signal to noise ratio. Shannon’s equation. The CD player as a measurement system and information channel. Sampling, oversampling, dithering. Data compression, data reduction. Coherence in signals, frequency mixing and conversion, receiver sensitivity and noise considerations, noise temperature, optimization of signal-to-noise, amplitude modulation and demodulation, characteristics of AM signals, frequency modulation and demodulation, the phase-locked loop, phase sensitive detection. Basic properties of antennas, the Hertzian and half-wave dipoles, link-gain. The principle of radar, pulsed radar, frequency modulated radar, digital modulation.

Pre-requisites
PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)])

**Anti-requisites**
None

**Assessment**
2 Hour Examination = 100%

**Accreditation Matters**
This module may not contain material that is part of the IOP “Core of Physics”, but does contribute to the wider and deeper learning expected in an accredited degree programme. The skills developed in this module, and others, contribute towards the requirements of the IOP “Graduate Skill Base”.

**Recommended Books**
Please view University online record: [http://resourcelists.st-andrews.ac.uk/modules/ph4026.html](http://resourcelists.st-andrews.ac.uk/modules/ph4026.html)

**General Information**
Please also read the general information in the School's honours handbook.