Module Title: 4C7 Digital Communications

Code: EE4C07

Level: Senior Sophister (Optional module)

Credits: 5

Lecturer(s): Assist. Prof. Nicola Marchetti (marchetn@tcd.ie)

Module Organisation

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<tr>
<th>Semester</th>
<th>Start Week</th>
<th>End Week</th>
<th>Associated Practical Hours</th>
<th>Lectures</th>
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Total Contact Hours: 48

Module Description

The objective of the 4C7 Digital Communications module is to develop the fundamental theory to enable students to design and analyse digital communication systems. The module builds on the material covered in the 3C1 Signals and Systems and 3C5 Telecommunications modules.

Learning Outcomes

On successful completion of this module the student will be able to:

1. Design a matched filter for detecting a known signal in additive white Gaussian noise.

2. Calculate the bit error rate due to the presence of channel noise.

3. Design a baseband pulse transmission system to combat the effects of inter-symbol interference.

4. Use signal space analysis to design a maximum likelihood decoding scheme for the coherent detection of signals in additive white Gaussian noise.

5. Determine the bit error rate for coherent binary phase-shift keying and quadruphase-shift keying systems.

6. Use linear block, cyclic, convolutional and turbo codes for error-control coding.

7. Explain the principles of modulation and access schemes.
Module Syllabus

- **Mathematical definition of a random process**
  Stationary processes; Mean, correlation, and covariance functions; Ergodic processes; Transmission of a random process through a linear time-invariant filter; Power spectral density; Gaussian Process; Narrowband noise.

- **Baseband pulse transmission**
  Matched filter; Error rate due to noise; Inter-symbol interference; Nyquist's criterion for distortionless baseband binary transmission; Correlative-level coding; Baseband M-ary PAM transmission.

- **Signal space analysis**
  Conversion of the continuous AWGN channel into a vector channel; Likelihood functions; Coherent detection of signals in noise: Maximum likelihood decoding; Correlation receiver; Probability of error.

- **Passband Digital Transmission**
  Binary phase-shift keying; Error probability of binary phase-shift keying; Generation and detection of coherent quadrature-phase-shift keying signals; Error probability of quadrature-phase-shift keying.

- **Error control coding**
  Linear block codes; Cyclic codes; Convolutional codes and their performance; Turbo codes.

- **Advanced topics in digital communications**
  Spread spectrum; Multi-carrier modulation; Channel assignment algorithms; OFDMA and synchronization issues and solutions; Novel waveforms for 5th generation wireless systems; Massive antenna arrays.

Recommended Text(s)


Teaching Strategies
This module is taught using a combination of lectures and problem-solving tutorials. Two software-based lab sessions will demonstrate some of the concepts covered in class.

Assessment
Continuous assessment will be adopted. The final marks for the module will be calculated according to:

- Two in-class quizzes (20% each);
- End-of-year formal written two-hour examination (60%).