# Unit T12: Digital Communications in Engineering

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| Unit code: | K/503/7384 |
| QCF level: | 6 |
| Credit value: | 15 |

## Aim

The aim of this unit is to develop learners' understanding of the theory of digital communications and their competency in the practice and application of digital communications in engineering systems.

## Unit abstract

This unit introduces learners to the theory and practice of digital communications and their application in digital engineering systems. The unit aims to develop an analytical approach to problems in digital communication design and operation through an understanding of the problems that affect reliability and efficiency. Learners will use computer simulated packages to gain skills in the implementation of real-time engineering systems.

Learners will gain an understanding of the underlying concepts of discrete communication systems and their advantages over the analogue communication systems, along with an understanding of the mathematical concepts of random processes (in the form of Gaussian noise) that cause errors in the transmitted digital signals. Learners will cover the commonly used methods for modulating data signals and their spectral characteristics and bandwidth for transmission over the signal transmission medium. They will use theory and the application of matched filters and correlator detectors to improve the performance of noisy digital signals, thus reducing the number of errors in the received signal.

## Learning outcomes

**On successful completion of this unit a learner will:**

1 understand the fundamentals of digital signals

2 understand the mathematical concepts of random processes and the effect of noise in transmitted digital signals

3 be able to develop modulated data signals and evaluate the spectra of modulated signals

4 be able to use computer simulation packages for developing and analysing matched filters.

# Unit content

## 1 Understand the fundamentals of digital signals

*Signal conversion*: analogue to digital conversion, sampling; sampling theorems (Nyquist, Shannon); quantisation error; aliasing; advantages of digital signals

*Pulse code modulation (PCM)*: quantisation; coding; companding; differential PCM; adaptive differential PCM

## 2 Understand the mathematical concepts of random processes and the effect of noise in transmitted digital signals

*Random processes*: noisy (random) signals; mean (or average) of noisy signals; root mean square (RMS) of noisy signals; standard deviation of noisy signals; mathematical representation of Gaussian (normal) distribution; probability density function

*Bit error rate*: probability of error of noisy data (baseband) signal; probability of error of modulated data signals for amplitude shift keying (ASK), frequency shift keying (FSK) and phase shift keying (PSK); comparative study of performance for modulated data signals

## 3 Be able to develop modulated data signals and evaluate the spectra of modulated signals

*Modulation of data signals*: purpose of modulation; modulation methods: amplitude shift keying (ASK); frequency shift keying (FSK); phase shift keying (PSK); differential PSK (DPSK); quadrature amplitude modulation (QAM); multi-phase PSK; asynchronous digital subscriber line (ADSL) technique

*Spectra*: transmission bandwidths (ASK, FSK, PSK, ADSL)

## 4 Be able to use computer simulation packages for developing and analysing matched filters

*Matched filters*: concept and purpose; mathematical representation of optimal characteristic of matched filter; representation of matched filter as correlator detector; practical implementation (matched filter, correlator detector); engineering applications, eg correlator detector for Radar application in the presence of noise

*Computer simulation*: matched filter; correlator detector

## Learning outcomes and assessment criteria

| **Learning outcomes**<br>On successful completion of this unit a learner will: | **Assessment criteria for pass**<br>The learner can: |
|---|---|
| LO1 Understand the fundamentals of digital signals | 1.1 Explain the analogue to digital conversion processes<br>1.2 Critically evaluate pulse code modulation in digital communication systems |
| LO2 Understand the mathematical concepts of random processes and the effect of noise in transmitted digital signals | 2.1 Describe the properties of random signals<br>2.2 Explain how random signals affect digital communication systems<br>2.3 Critically evaluate the performance of noisy modulated signals |
| LO3 Be able to develop modulated data signals and evaluate the spectra of modulated signals | 3.1 Justify reasons for modulating data signals before transmission<br>3.2 Describe data modulation methods<br>3.3 Critically evaluate spectra and transmission bandwidth of modulated signals |
| LO4 Be able to use computer simulation packages for developing and analysing matched filters | 4.1 Explain the use of matched filters<br>4.2 Explain the optimum condition equation of a matched filter<br>4.3 Explain the practical difficulties of implementing matched filters in engineering systems<br>4.4 Critically examine the similarity of matched filters and correlator detectors<br>4.5 Analyse the computer simulation of a correlator detector. |

# Guidance

### Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

The learning outcomes associated with this unit are closely linked with:

| Level 4 | Level 5 | Level 6 |
|---|---|---|
| *Unit 1: Analytical methods for Engineers* | *Unit 59: Advanced Mathematics for Engineers* | *Unit T8: Digital Signal Processing* |
| | *Unit 66: Electrical, Electronics and Digital Principles* | |

The content of this unit has been designed and mapped against the Engineering Council's current Learning Outcomes for IEng Accreditation. The completion of the learning outcomes for this unit will contribute knowledge, understanding and skills towards the evidence requirements for IEng Registration.

See *Annexe B* for summary of mapping information for IEng Accreditation.

## Essential requirements

Suitable simulation software packages, such as MATLAB, will be required for the assignments and project work.

## Resources

### Books

Glover I A and Grant P M – *Digital Communications*, 3rd Edition (Pearson Education, 2010) ISBN 978-0273718307

Haykin S and Moher M – *Introduction to Analog and Digital Communications*, 2nd Edition (John Wiley, 2007) ISBN 978-0471432227

Lathi B P and Ding Z – *Modern Digital and Analog Communications*, 4th Edition (Oxford University Press, 2008) ISBN 978-0195331455