The University Of Sheffield.

Electronic & Electrical Engineering.

EEE347 COMMUNICATION ENGINEERING

Credits: 20

Course Description including Aims

This course is about understanding the fundamentals of antennas and radar systems, it will also provide a basic introduction to airborne navigation and landing systems. Moreover, this course considers the theory and techniques used by a wide range of communication systems, particularly the more recent digital systems.
The main aim is to create a theoretical background that applies to all communication systems and is not affected by any particular technology.

The basic properties and characteristics of some of the most commonly used antenna systems will be examined. The emphasis will be on practical design and the applications of antennas. The radar part of the course will introduce the basic concepts of radar and examine various types of commercial and military radar systems in common use. Throughout the course emphasis will be placed on 'first-order' analysis techniques in order to reduce the use of advanced mathematics.

An engineer completing this course should feel at least acquainted with most types of antennas and radar system and will be able to do rough and ready performance calculations.

Outline Syllabus

Basic properties of antennas, dipole antennas, basic loop antennas, aperture antennas, array antennas, introduction to radar systems, radar range equation, designing a radar system, radar surveillance, tracking radar, Doppler radar, radar detection theory, radar cross section, stealth, counter measures, bistatic radar, introduction to navigation systems. Noise in AM and FM Modulation Systems. Comparison of analogue and digital modulation techniques. Matched filtering. Information and entropy. M-Ary signaling. Error correction. Spread spectrum objectives and techniques. PN codes. Examples of digital communication systems. Guest lecturer material will provide information on design of modern systems and commercial context.

Time Allocation

48 hours lectures and 4 hours of other material.

Recommended Previous Courses

2nd year of any of the EEE degrees

Assessment

3 hour examination, answer 5 questions out of 8

Recommended Books

Kingsley S & Quegan S	*Understanding Radar Systems*	Scitech
Balanis C.A.	*Antenna Theory : Analysis and Design, 2nd ed*	Wiley

Sklar, B	*Digital Communications, 2nd ed*	Prentice-Hall
Young, P.H	*Electronic Communication Techniques, 3rd ed*	Prentice-Hall
Ziemer	*Introduction to digital communications, 2nd ed*	Prentice-Hall
Benoit	*Digital television, 2nd ed*	Elsevier

Objectives

By the end of the module successful students will be able to

1. Demonstrate an awareness of various types of antenna and their application
2. Calculate basic antenna parameters such as gain and radiation pattern for simple antenna topologies
3. Use the radar equation to calculate system parameters such as range resolution and unambiguous range for various radar systems
4. Demonstrate an awareness of various types of radar including continuous wave and pulsed Doppler systems
5. Demonstrate an awareness of the principles of stealth and basic forms of electronic counter measures
6. Calculate the signal to noise performance for a range of analogue modulation systems.
7. Understand that the signal to noise performance of an FM system can change abruptly with received signal strength, and the benefits of pre-emphasis and de-emphasis FM systems.
8. Understand what is meant by a matched filter as well as being familiar with various implementations thereof.
9. Understand what is meant by information and entropy, as well as some techniques to increase effective signalling speed of a channel.
10. Calculate the probability of error and know of some techniques to improve the error performance of a communications link.
11. Demonstrate familiarity with the properties and use of PN codes.
12. Display knowledge of some basic SS architectures and the benefits they offer.

Detailed Syllabus

- Introduction and outline of course
- Basic properties of antennas
  - What is an antenna? Why use an antenna, Radiation mechanism
  - Outline of basic antenna types
  - Radiation patterns 2-D and 3-D
  - Far-field parameters
  - Beamwidth and sidelobes, Directivity and gain, antenna equivalent area
  - Polarisation – linear, circular
  - Input impedance, antenna equivalent circuits, radiation efficiency, matching and bandwidth
- Dipole antennas
  - Concept of electric and magnetic fields
  - E and H fields from short dipole (minimum maths)
  - Radiated power, radiation resistance, directivity
  - Half-wave dipole, monopole, feed structures
- Basic loop antennas
  - Small loop, large loop, helix

- Introduction to aperture antennas
  - Concept, far-field of a line source and a rectangular aperture
- Introduction to antenna arrays
  - Concept of element pattern and array factor
- Introduction to radar systems
  - Types of radar systems and applications
- Radar range equation
- Introduction to radar systems
- Designing a radar system
- Radar surveillance
- Tracking radar
- Doppler radar systems
- Radar cross-section (RCS)
- Introduction to Stealth
  - Designing for stealth
  - Stealth materials and coatings
- Radar detection counter measures
- Bistatic radar
- Calculation of noise in AM and FM systems, threshold effect in FM, pre-emphasis and de-emphasis systems. Relative merits of analogue and digital modulation techniques.
- Principle of matched filtering. Mathematical description of a matched filter Transversal filter, integrate and dump matched filter, correlator receiver and matched filter for PCM codewords.
- Information and entropy. Source coding including examples of Huffman and Psycho-acoustic encoding.
- Probability of error. Simple parity checks, brief description of RS and convolutional codes. Use of Forney interleaving to increase code efficiency. Hard and soft decisions.
- Properties of PN codes, generation of PN codes. Special PN codes.
- Benefits of SS systems. DSSS systems, searching and tracking circuits, resistance to interference. FHSS systems, coding gain. Scrambling in DAB systems, conditional access.
- M-Ary signalling. BPSK, waveforms, spectra and bandwidth efficiency. QPSK, spectra, bandwidth efficiency, variants (OQPSK, DQPSK, MSK, GMSK). M-PSK, robustness vs. bandwidth efficiency. QAM, generation, vector addition, BER vs. CNR, trade-offs.
- COFDM systems. Why AM and FM has problems. How FDM helps combat multipath. Orthogonality. Guard intervals. Limits of multipath rejection, Single frequency networks. Architecture of a basic system, discussion of how data is structured in time and frequency. Robustness – CSI and its use in decoding, time + frequency interleaving and how this helps combat selective fading. Discussion of DAB, DVB-T, DVB-H, DMB and DRM.

UK-SPEC/IET Learning Outcomes

Outcome Code	Supporting Statement
SM1p	The basic principles of antennas radar are introduced. Antenna theory is examined by applying Maxwell's equations to a dipole. Radar systems are analysed including pulsed and Doppler systems. Signal to noise ratio in analogue communication system is considered and the derivation of the required equations. Comparison of digital and

analogue communication system. Assessed in exam.

SM1m Learn the fundamental components of a digital communication system such as source and channel coding, spread spectrum, match filters as well as M-ary signalling. This will be assessed by a formal exam.

SM2p / SM2m Mathematics is used to describe and analyse antennas starting with Maxwell's equations. Vector calculus, line, surface and volume integration. Statistical methods are covered in radar detection. Detailed mathematical description of matched filtering, the physical meaning of the equations and their subsequent use in the design of a matched filter. Assessed in exam.

SM3p/SM3m When considering the design of a stealth air vehicle, an appreciation of aeronautical engineering is required. Students will learn how to use probability theory in errors predictions and study method to minimise those errors. Assessed in exam.

EA1p Various aspects of radar system performance are analysed using the radar equation. Information theory and its use in data compression (using a number of coding techniques such as Huffman coding). Assessed in exam.

EA1m Understanding of engineering principles and the ability to apply them to undertake critical analysis of key engineering processes.

Electromagnetic theory is used to analyse and design antenna components (elements) and more complex array antenna systems.

Learn the principles of orthogonal and non-orthogonal M-ary signalling and apply them to analysed and decide which is more suitable for a particular communication system.

These will be assessed by a formal exam.

EA2p Mathematical methods such as volume and surface integration are used to analyse and quantify the performance of various types of antenna. The ability to evaluate the properties of pseudo noise codes using a defined procedure. Consideration of the signal to noise ratio performance at the output of AM and FM modulators using the relevant derived equations. Assessed in exam

EA2m Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques

Learn how to calculate the achievable SNR improvement at the output of a demodulator using mathematical equations for AM and FM modulations techniques. This will be assessed by a formal exam.

EP2p/EP2m Materials and products used in electronic warfare such as stealth coatings and chaff are discussed. Assessed in exam.

EA3p Learn how to compress data streams using Huffman or run length coding. This will be assessed by a formal exam.

EA3m Use the mathematical description of the matched filter to design a correlate receiver that can be used to detect arbitrarily shaped signals. Explain the capabilities and limitations of matched filters in detecting PCM codewords.

D2m/D2p Study the detailed operation of MFSK and MPSK and evaluate the performance and constraints of each. Understand when to use MFSK or MPSK in practice. This will be assessed by a formal exam.

D3p / D3m Work with information that may be incomplete or uncertain, quantify the effect of this on the design and, where appropriate, use theory or experimental research to mitigate deficiencies. Learn about the presence of random noise, or jamming signals, during the communication process and how to employ spread spectrum solutions in the design to minimise these effects. This will be assessed by a formal exam.

ET2p /ET2m Understand the commercial applications of PN codes and study the widely used commercial PN sequence that is known as Barker code. This will be assessed by a formal exam.

ET3p/ET3m Understand how an engineer can decide on choosing MFSK or MPSK in a practical problem. This will be assessed by a formal exam.

EP6p / EP6m Learn COFDM systems and DAB, DVB-T, DVB-H, DMB and DRM. . This will be assessed by a formal exam.