The University Of Sheffield.

Electronic & Electrical Engineering.

EEE6220 ELECTRONIC COMMUNICATION TECHNOLOGIES

Credits: 15

Course Description including Aims

This module aims to provide students with a range of skills that are required when designing circuits at high frequencies covering topics such as circuit interference mechanisms and design techniques, circuit layout, filtering, screening, transmission lines, S-parameters, Smith charts, radio frequency (RF) device design, and measurement techniques..

1. To provide an introduction to the fields of electromagnetic interference, control and compatibility, including nomenclature and methodology.
2. To review the relevant legislation, in particular the EU emc directive.
3. To provide an appreciation of the causes and potential remedies for emi through good design practice and case studies.
4. To introduce the concept of a distributed system and how to handle and model it using high frequency transmission line theory. This will involve vital concepts such as reflection coefficient, insertion loss, transferred impedances and impedance matching.
5. To show how parasitic elements dominate the behaviour of devices at high frequency and to introduce the idea of "S" parameters, used by manufacturers to specify component behaviour, and how to use them in the design process.
6. To introduce an awareness of the various RF devices available and their relative merits, and of the impact that circuit layout and substrate dielectric quality have on circuit performance including the idea of skin depth and its significance for conduction losses in interconnects.
7. To discuss importance of linearity and the related issues of intermodulation in RF power devices and the way these parameters are specified and also to discuss noise and noise figure and ways of minimising both.
8. To introduce the specialist measurement equipment - network analysers, spectrum analysers, signal sources, power meters etc - commonly used in a high frequency design/test environment and outline the principles behind their operation.

Outline Syllabus

The need for emc. engineering. Basic model for emi. Radiated and conducted coupling. Filters and shields. Emc. legislation and compliance. High frequency transmission lines. Device characteristics at high frequency. High power amplifies. Measurement techniques.

Time Allocation

36 lectures in weeks 1 to 18.

Recommended Previous Courses

Second year modules or equivalent.

Assessment
Examination 3 out of 4 questions (75%) plus a written piece of coursework relating to interference in electronic systems (12.5%) and short tests covering objectives 5-12(12.5%)

Recommended Books

Keiser, B.	*Principles of Electromagnetic Compatibility*	Artech House
Marshman, C.	*The Guide to the EMC. Directive*	E.P.A.Press
Williams, T.	*EMC for Product Designers*	Newnes
Ott, H	*Noise reduction techniques in electronic systems*	Wiley
Reinhold Ludwig, Pavel Bretchko	*RF Circuit Design; Theory and Applications*	Prentice-Hall
Vincent F. Fusco	*Microwave Circuits; Analysis and Design*	Prentice-Hall
Jeremy Everard	*Fundamentals of RF Circuit Design*	Wiley

Objectives
By the end of the unit a successful student will be able to

1. Understand the nature and scope of electromagnetic interference (emi) in modern electronic and electrical systems and the need for electromagnetic compatibility (emc).
2. Understand the broad principles of combating emi both at the equipment design stage and during its testing, commissioning and use.
3. Design circuits to minimise electromagnetic emissions
4. Use filtering, screening and appropriate circuit design to minimise sensitivity to emi
5. Display a working knowledge of basic high frequency transmission line behaviour by solving quantitative problems based on reflection coefficient and insertion loss.
6. Use a Smith chart to design RF circuits.
7. Recognise the different forms in which a transmission line may appear.
8. Describe the various forms of active device and subsystems available for RF designs and their relative advantages and disadvantages.
9. Demonstrate knowledge of the high frequency equivalent circuit of both passive and active devices and the ability to use passive device equivalent circuits to predict performance.
10. Use "S" parameters to design simple RF circuits.
11. Use noise specifications to make quantitative estimates of the noise performance of simple RF systems.
12. Understand the terms used to specify linearity in power amplifiers

Detailed Syllabus
1. Outline of course content, objectives, textbooks, abbreviations, the need for emc, examples of electronic systems which have failed for emi reasons. Nature of emi, formal definition of emc. Cost, scheduling and reliability issues.
2. Emc legislation, EC directive, standards, conformity and compliance.
3. The basic model for emi, radiated and conducted paths..
4. Conducted coupling of interference.
5. Ground plane design.
6. Radiated coupling of interference.
7. Low frequency and high frequency emi reduction techniques
8. Circuit layout design techniques
9. Filter specifications. Types of practical filters and why their performance is non-ideal.

10. Shields and their use. Types of shield, problems with bonding and apertures.
11. Skin depth. Shielding effectiveness
12. High frequency transmission lines. Basic TL theory. Smith Chart, impedance matching (stubs, etc.). Pulses on transmission lines, reflections, matching and power transfer. Open, short and matched terminations, standing waves. Types and characteristics of 'modern' lines, microstrip, coax, etc. Basic RF design techniques, impedance matching techniques, e.g. quarter wave transformer, RF chokes, etc.
13. Device characteristics at high frequency. Types of devices used: op-amps, transistors, hybrids, passive lumped/distributed elements. High frequency device specifications, self-resonance, device parasitic. S-parameters, return loss, insertion loss. Noise figure. Small signal characteristics - op-amps. High power amplifies - linearity, gain, efficiency, IMP issues.
14. Measurements: S parameters, VNA phase and amplitude. Spectrum analyser

UK-SPEC/IET Learning Outcomes

Outcome Code	**Supporting Statement**
SM1p	Electromagnetic coupling theory introduced. Explain the fundamental limitations of basic circuit theory at higher frequencies and how it is used as a starting point to develop the transmission lines theory. (Assessed in exam and coursework)
SM1m	Application of SM1p in real life applications. Basic theories expanded to cover a range of frequencies. Introduce concepts such as reflections coefficient, voltage standing ratio,characteristic impedance, return and insertion losses and their significance in various topics such as antennas and amplifiers design. (Assessed in exam and coursework)
SM2p	Learn in details the mathematical derivations of the transmissions line equations and their subsequent applications in the analysis of high speed circuits. (Assessed in exam
SM1fl	Application of SM1p in real life applications. Basic theories expanded to cover a range of frequencies. Introduce concepts such as reflections coefficient, voltage standing ratio,characteristic impedance, return and insertion losses and their significance in various topics such as antennas and amplifiers design. (Assessed in exam and coursework)
EA1p	Analysis of EMI in circuits. Use a Smith chart to design impedance matching networks for amplifiers as well as antennas. (Assessed in exam and coursework)
EA1m	This is achieved throughout the EMC elements of the module, including coupling methods, interference estimation and mitigation. (Assessed in exam and coursework)
EA2p	Students are forced to do this in their coursework. Use the scattering parameters and Smith chart to assess the performance two port networks. (Assessed in coursework)
EA2m	This is achieved in the EMC element by the use of a range of simple to complex estimation techniques and models of systems. (Assessed in coursework and exam) The transmission line principles and two-port networks model are used to assess the gain and noise performances of an amplifier.(Assessed in exam and coursework)
EA3p	Acquire a working knowledge of basic high frequency transmission line behaviour by solving quantitative problems based on reflection coefficient and

	insertion loss. (Assessed in exam)
EA3m	Apply the transmissions line theory and Smith chart in the design of quarter wavelength transformer or double stub matching networks (Assessed in exam and coursework)
EA4p	Learn how to design a complete amplifier system for a specific gain through the independent design of matching networks at the input and output ports. (Assessed in exam)
EA4m	Students are given/choose EMC scenarios where they have to identify coupling mechanisms, estimation technique, solutions and apply this. (Assessed in coursework and exam)
D1fl	The EMC coursework partially meets this with real life EMC situations. The exam element demands the application of mitigation techniques. (Assessed in coursework and exam)
D2fl	Ranges of EMC solutions for a wide range of frequencies are given and coursework allows the students to demonstrate this. (Assessed in coursework) The design of matching networks using various techniques, as well as designing an amplifier for a specific gain and/or noise factor, meet this. (Assessed in exam and coursework)
D3p	The EMC coursework meets this with real life EMC situations. The exam element demands the application of mitigation techniques. (Assessed in coursework and exam)
D3m	The EMC coursework partially meets this with real life EMC situations. The exam element demands the application of mitigation techniques. (Assessed in coursework and exam)
D7m	Ranges of EMC solutions for a wide range of frequencies are given and coursework allows the students to demonstrate this. Gaining in depth knowledge on how to use tools such as Smith chart and scatteringparameters in the design of a maximum, or non-maximum, gain amplifier**,** considering various constraints such as the noise factor. (Assessed in exam and coursework)
EP2p / EP2m	Understand the characteristics of microwave amplifiers such as gain, noise factor, and stability in the context of an equivalent two port network **(Assessed in exam and coursework)**
EP9m	Discuss the main limitation of the recommended distributed elements since, in general, a larger physical size is needed compared to the lumped elements. (Assessed in exam)
EP2m	Study the characteristics and applications of different transmissions line types. (Assessed in exam)
EP1p / EP1m	Understand how the scattering parameters can be used to evaluate the performance of various components such as antennas, amplifiers, and attenuators. (Assessed in exam)
EP10m	Commercial implications of EMC solutions are addressed. (not formally assessed)
EP6p / EP6m	EMC legislation is used throughout and assessed in coursework
EP1fl	Application of SM1p in real life applications. Basic theories expanded to cover a range of frequencies. Introduce concepts such as reflections coefficient, voltage standing ratio,characteristic impedance, return and insertion losses and their significance in various topics such as antennas and amplifiers design. (Assessed in exam and coursework)

EP2fl	Discuss the main limitation of the recommended distributed elements since, in general, a larger physical size is needed compared to the lumped elements. (Assessed in exam)
EP3fl	Commercial implications of EMC solutions are addressed. (not formally assessed)
ET5fl	Covered by EMC legislation and standards. (Not formally assessed.)