Lecturer  
Prof A Flewitt [1]

Timing and Structure  
Weeks 6-8 Lent term. 6 lectures, 2 lectures/week

Aims  
The aims of the course are to:

- To understand the Maxwell Equations of Electric and Magnetic Fields allows us to understand the propagation of electromagnetic waves through free space and how such waves interact with other conducting and insulating materials.
- To understand what a transmission line is, and how by analysing an equivalent circuit for a short length of the line allows us to understand wave propagation along the line.
- To appreciate how we can engineer the propagation of waves in free space and along transmission lines with a focus on communications applications.

Objectives  
As specific objectives, by the end of the course students should be able to:

- To be able to create and solve a wave equation for an ideal transmission line from an equivalent circuit and appreciate how this differs in a lossy transmission line.
- To understand the characteristic impedance of a transmission line, and be able to use this to solve problems involving reflection and transmission of waves along transmission lines.
- To understand the physics significance of the Maxwell Equations and how the differential (vector calculus) form can be produced from the integral form.
- To use the Maxwell Equations to produce a wave equation for the free-space propagation of electromagnetic waves and deduce their behaviour (e.g. direction of propagation relative for the E and H field, the Poynting vector).
- To understand the basic operation of antennas and their figures of merit.
- To use the intrinsic impedance to understand how electromagnetic waves are reflected and transmitted at interfaces with dielectrics.
- To understand how electromagnetic waves interact with conductors.

Content  
Transmission Lines  
- What is a transmission line?
- Ideal transmission line equivalent circuit
- The Telegrapher's Equations
- The wave equation solution to the Telegrapher's Equations
- Expressions for current and voltage waves
- Description of how waves propagate along transmission lines.
- Importance of the wavelength in considering whether wave effects on a line need to be considered
The 'lossy' transmission line equivalent circuit and how this affects wave propagation
Characteristic impedance
Reflections from a load impedance
Input impedance of a terminated line
Ringing

The Maxwell Equations in Integral and Differential (Vector Calculus) Form

The Gauss Law of Electric Fields
The Gauss Law of Magnetic Fields
The Faraday Law of Magnetic Fields
The Ampère-Maxwell Law

Electromagnetic Waves in Dielectrics

Derivation of wave equation for electric and magnetic fields from the Maxwell Equations
Expressions for the electric and magnetic fields in plane electromagnetic waves
Intrinsic impedance
The power in an electromagnetic wave and the Poynting Vector

Antennas

What is an antenna and a description of how they work
Figures of merit for antennas including the Antenna Gain, Radiation Resistance and Effective Area

Electromagnetic Waves at Interfaces

Boundary conditions: the conservation of E, D, H and B at interfaces
Polarised plane electromagnetic waves
Reflection and refraction of plane waves
Polarisation by reflection and the Brewster Angle
Anti-reflection coatings

Electromagnetic Waves in Conducting Media

Derivation of wave equation for electric and magnetic fields from the Maxwell Equations
Expressions for the electric and magnetic fields in plane electromagnetic waves
The Skin Effect
Intrinsic impedance of a conducting medium
Waves at conducting interfaces

Booklists

Please see the Booklist for Part IB Courses [2] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

The UK Standard for Professional Engineering Competence (UK-SPEC) [4] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has
been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the 'Accreditation of Higher Education Programmes' (AHEP) document [5] which sets out the standard for degree accreditation.

The Output Standards Matrices [6] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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**Links**

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