UNIVERSITEIT·STELLENBOSCH·UNIVERSITY

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Electrical and Electronic Engineering

EEE5107S: ANTENNA THEORY FOR RADAR AND ELECTRONIC DEFENCE

PREREQUISITES

This course requires students to have a good background in Mathematics, Physics, and computer programming, probably at an Honours Level (4 years of study). In addition students must have completed course in Electromagnetics on at least the third year level of an engineering undergraduate course.

COURSE FORMAT AND DATES

The course is given in a five day, intensive format, followed by a further five tutorial and seminar sessions over the weeks following the intensive session. These sessions are based on problem sets which the student must attempt in order to gain benefit from the seminars. In addition, students may book appointments with the Course Convener and the Tutor.

Course interaction is via the UCT Vula System.

STAFF

Convener	Prof. K.D. Palmer	US	palmer(at)sun.ac.za
Lecturers:	Prof. K.D. Palmer	US	palmer(at)sun.ac.za
	Prof J.H. Cloete	US	jhcloete(at)sun.ac.za

COURSE DESCRIPTION:

This course presents the principles and techniques fundamental to the operation of the antennas as used in radar systems. The course may be divided into two halves with the first concentrating on general antenna fundamentals and the second half devote to specializing this knowledge to cover radar antennas and applications. Specific course topics include:

RADIATION MECHANISMS AND KEY PROPERTIES OF ANTENNAS

Radiation of a current source vs radiation based on a time domain perspective. The rationale for the key antenna specifications and typical values. Electrical properties and review of appropriate transmission line and matching theory for feed lines. Radiation properties of search and track radars.

OPERATION AND DESIGN OF SIMPLE RADAR PATCH ANTENNAS AS USED IN IMAGING RADAR.

The antenna design cycle with the microstrip patch antenna used as a teaching example. Emphasis is on design based on insight into physics of the antenna's radiation and feed characteristics. Various feeding mechanisms and polarization modes are dealt with in detail.

COMPUTER SIMULATION OF ANTENNAS

Modern antenna design relies heavily on computational simulations and a large part of the general antenna section is devoted to this topic. The physics of the underlying method of operation of two major commercial codes are discussed along with as well as their user operational aspects.

THE DESIGN AND TEST CYCLE

High frequency laboratory equipment is discussed with reference to antenna measurements. Each individual will design, build and test a simple patch antenna with time being available for a second design cycle of a more complex antenna array.

AUTOMATED DESIGN SOFTWARE

Students will be exposed to and use automated design software to enable a large number of antenna types to be covered in detail. The Antenna Magus package is the premier world product in this regard and students will have the opportunity to generate designs and evaluate them computationally.

THE RADAR ANTENNA SUITE

Various radar antennas are covered in detail. Topics include: monopulse systems; aperture antennas; horns, simple and compound reflectors, waveguide arrays and antennas suitable for Radar Warning Receivers (RWR)

LEARNING OUTCOMES:

Having successfully completed this course, students should be able to:

KNOWLEDGE BASE:

- Understand the principles of microstrip and slotted waveguide arrays.
- Understand reflector antennas
- Understand monopulse tracking antennas
- Understand multi-octave bandwidth spiral antennas for ED applications

ENGINEERING ABILITY:

- Specify antennas for surveillance and tracking radars, and ED receivers

PRACTICAL SKILLS:

- Design simple microstrip patch arrays, the linear slotted waveguide array, the horn fed parabolic reflector antenna, and cavity backed Archimedes spiral antennas using Antenna Magus
- Estimate their performance using Antenna Magus and FEKO
- Build and measure the performance of microstrip patch antennas using a swept-frequency network analyzer and microwave anechoic chamber

TEXTBOOK

Limited notes are given for this course. Students are referred to the Antenna Magus notes.

LECTURE PROGRAMME

Table 1: EEE5107S: Antenna Theory with Applications to Radar and Electronic Defense

		Mon 23-May		Tue 24-May		Wed-25-May (Stellenbosch)		2011/05/26 Reflector Antennas		2011/05/27 Slotted Waveguide Arrays & RWRs
08:00	A 1	Course Introduction. Radiation mechanisms	B1	Microstrip Antennas. Circular Polarisation	C 1	Antenna Measurements	D 1	Rectangular waveguide	E1	Linear slotted waveguide array
09:00	A 2	Introduction to Antennas	B2	Microstrip Antennas. Design and Examples	C 2	Laboratory: Antenna Measurements, DEMO	D 2	Magic T	E2	Planar waveguide array
10:00	A 3	Matching the antenna to the feed	B3	Printed structures. Selected topics	C 3	Laboratory: Antenna construction	D 3	Sum and difference horn array	E3	2D cosecant squared slotted waveguide array
11:00		Tea		Tea		Tea		Tea		Tea
11:30	A 4	Microstrip Antennas. Introduction and History	B4	Array theory	C 4	Laboratory: Measure own antenna	D 4	Monopulse tracking	E4	3D waveguide array: AWACS
12:30		Lunch		Lunch		Lunch		Lunch		Lunch
13:30	A 5	Microstrip Antennas. The Basic Rectangular Patch antenna	B5	Baluns & Feeds	C 5	*Computational* issues with antennas (Freq vs time domain Simulation)	D 5	Paraboloidal reflector antenna	E5	RWR antennas

14:30	A 6	Numerical *Modelling* and Computation	B6	Computer Lab Practical. Arrays	C 6	Antenna design using Antenna Magus	D 6	Twist-Cassegrain reflector antenna	E6	ARM sensors
15:30	A 7	Computer Lab Practical. FEKO Dipole	B7	Computer Lab Practical. Design	C 7	Antenna design using Antenna Magus	D 7	Offset Cassegrain monopulse tracking antenna		**Conclude**
16:30		Tea		Tea		Tea				
17:00	A 8	Computer Lab Practical. FEKO Patch	B8	Propagation and Noise for Radar and other antennas	C 8	Antenna design using Antenna Magus	D 8	An operational Cassegrain tracking antenna		
18:00		Close		Close		Close		Close		

DRILL PROBLEMS

Students are expected to complete five sets of Drill Problems, handed out after the intensive lecture period. Students will be provided with at least 5 seminar opportunities of about an hour each with the lecturer, convener and tutors, and will be expected to attend 4 out of the 5 seminars, and attendance is only credited if the solutions have been submitted. The student's solutions to the problem set must be submitted on Vula before the start of the seminar. The seminars will be carried out with access by Skype for students off campus after the lecture session. For bandwidth reasons, the number of parallel sessions will have to be limited. For example, all students resident in the same city will be expected to attend at a common venue, and students will have to organise their own venue and projection facilities. Screen sharing will be enabled, but it is unlikely that video will be supported, again due to bandwidth limitations. Within reason, and with prior arrangement, students can approach the tutor / and / or the lecturer for help with problem sets.

COURSE ASSESSMENT AND EXAMINATION

The assessment of this course is wholly dependent on a three hour, written examination, with the Duly Performed (DP) requirement of 4 out of 5 seminars attended. The examination is closed book, i.e. no notes may be brought into the examination venue. Students are not expected to memorise any formulas: all formulas and results will be supplied on the examination paper. Students may write the examination in their home location, provided satisfactory supervision of the examination can be arranged in good time.

COURSE LOAD

Table 2 : Load calculation EEE5107S

Item	Number	hrs/per	Hours
Lectures	33	1	33
Assimilation	33	4	132
Seminar Attendance	5	2	10
Task Problems	5	3	15
Examination preparation	1	8	8
Examination	1	3	3
TOTAL			**201**