Department of Electrical Engineering

Radar Remote Sensing Group

Professor Michael Inggs

Private Bag X3, Rondebosch 7701, South Africa
Room 7.16, George Menzies Building, Upper Campus
Tel: +27 (0) 21 650 2799 Fax: +27 (0) 21 650 3465
E-mail: Michael.Inggs@uct.ac.za

EEE5104F INTRODUCTION TO RADAR

1 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). Many of the problems can be solved using a spreadsheet, since they are largely parametric studies. The treatment is at systems level, so the depth of knowledge of these fields can be corrected with some extra reading while working through the course.

2 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.

The course Calendar is the governing document for planning: please monitor it frequently.

https://sites.google.com/site/radarmasters/schedule

Course interaction is via the UCT Vula System. You will have access to this information once you have registered for the course. It is important that you provide your preferred email address (one that it checked frequently) for your Vula registration.

3 Staff

Convener	Prof. M.R. Inggs	UCT	mikings(a)gmail.com
Lecturer:	Prof. M.R. Inggs	UCT	mikings(a)gmail.com
Tutor:	Roaldje Nasjiasnagar	UCT	neddje(a)gmail.com

4 Course description:

This course presents the principles and techniques fundamental to the operation of a radar system. Radar Engineering is very much a system level topic, as the field requires at least some knowledge of a wide range of other engineering specialities. The course follows the recommended text book very closely. Specific course topics include:

4.1 Overview

Introduction and Radar Overview, covering the basic concepts of radar and the format of the course

itself.

The Radar Equation, which allows us to estimate the performance of a radar system, and thus, to design radars for a specific purpose.

Radar search and overview of detection and interference, which improves our models of performance, to be used in design.

4.2 External Factors

Propagation Effects and Mechanisms investigates the influences of the atmosphere on the EM waves used in radar systems.

Clutter refers to unwanted signals from the surface of the earth (trees, buildings, and so on), as well as reflections from raindrops and other atmospheric targets in the radar beam.

Target Reflectivity is an overview of the properties of targets that makes them good or bad radar reflectors, also key to performance prediction.

Target Fluctuation Models predict the real behaviour of reflectors, whose aspect to the radar is changing, leading to fluctuations in the returned power, and hence, changes in radar performance.

Doppler Phenomenology and Data Acquisition discusses the apparent shift in target reflection wave frequency due to motion of the target or, the radar itself, as well as how this shift in frequency can be measured.

4.3 Subsystems

Radar Antennas are key in coupling radar energy to the propagating medium, and allowing for special responses that can be used to locate the target in angle.

Radar Transmitters are examples of microwave power engineering, and are essential for creating suitable waveforms for the radar, at a level sufficient to allow for detection of targets.

Radar Receivers are responsible for processing of received energy, without adding significant thermals noise and susceptibility to other EM signals. The energy is then presented for signal processing.

Radar Exciters are specialised hardware for creating radar waveforms and synchronising the radar circuitry.

The Radar Signal Processor is responsible for taking the radar signals from the receiver and processing them further to extract target information. This topic is taken up in much more detail in another course in this series.

4.4 Software Expertise

Students must be proficient in tools such as Octave, MathCad, Mathematica, Simulink/Matlab, spreadsheets (OpenOffice, Excel), as they are used extensively in the analysis and design examples. Students will use the tools most familiar to themselves.

5 Learning outcomes:

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

5.1 Knowledge Base:

1. Understand the fundamental operation of radar to measure distance, angle, velocity using a modulated carrier;
2. Describe the key subsystems of a typical radar sensor;
3. Be able to identify which kind of radar sensor is best for a particular application;
4. Identify the key effects of the propagation medium on sensor performance and some countermeasures;
5. Describe the properties of targets and their fluctuations;

5.2 Engineering ability:

1. Explain in simple words the working principles and basic building blocks of a different types of radar system;
2. Model radar systems using appropriate mathematical techniques, including probability distributions, link power budgets, effects of clutter;
3. Have a top level understanding of important parameters relating to subsystems (antennas, amplifiers, transmitters, targets) to be able to design a radar system;

5.3 Practical skills:

1. Carry out top level designs and trade-offs of radar sensors, taking into account the important characteristics of the subsystems and other factors;
2. Simulate all or part of a radar system using computer software;
3. Calculate results of designs using programming techniques (languages or spreadsheets).

6 Textbook

No notes are given for this course and all students are expected to have a copy of, “Principles of Modern Radar” Volume 1, Ed. Richards, Scheer and Holm, Scitech Publishing, 2010.

7 Lecture Programme

Table 1: EEE5104F Introduction to Radar 2011 Programme (topics expanded below)

Time	Mon 21/2	Tues 22/2	Wed 23/2	Thurs 24/2	Fri 25/2
08h00	Overview	Overview	S7	Overview	Overview
09h00	S1	S4	S7	S9	S12
10h00	S1	S4	S8	S9	S12
11h00	Tea	Tea	Tea	Tea	Tea
11h30	S2	S5	S8	S10	S13
12h30	Lunch	Lunch	Lunch	Lunch	Lunch
13h30	S2	S5	Break[1]	S10	S13
14h30	S3	S6	Break	S11	T4
15h30	S3	S6	Break	S11	Conclude
16h30	Tea	Tea	Break	Tea	
17h00	T1	T2	Break	T3	
18h00	Close	Close	Break	Close	

Table 2: Descriptions of Topics

Code	Topics	Code	Topics
S1	Introduction and Radar Overview	S8	Doppler Phenomenology and Data Acquisition
S2	The Radar Range Equation	S9	Radar Antennas
S3	Radar Search and Overview of Detection in Interference	S10	Radar Transmitters
S4	Propagation Effects and Mechanisms	S11	Radar Receivers
S5	Characteristics of Clutter	S12	Radar Exciters
S6	Target Reflectivity	S13	The Radar Signal Processor
S7	Target Fluctuation Models		

1 It is likely that a visit to a radar installation will be organised during the afternoon.

8 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 creditted 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.

9 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.

10 Course Load

Item	Number	hrs/per	Hours
Lectures	40	1	40
Assimilation	40	2	80
Seminar Attendance	5	2	10
Drill Problems	5	3	15
Examination preparation	1	8	8
Examination	1	3	3
TOTAL			156