

# Introduction to Electronic Defence EEE5106S

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# 1 Introduction

Electronic Defence (ED) is a military action whose ultimate aim is to control the electromagnetic spectrum (EMS). The objective is to exploit, reduce or prevent hostile use of the electromagnetic spectrum while still retaining friendly use thereof. Electronic Defence (ED) comprises of three main disciplines, which have found numerous electromagnetic (radio frequency (RF), optical etc.) as well as acoustic civilian and military applications.

1. Electronic Support (ES), previously known as Electronic Support Measures (ESM).
2. Electronic Attack (EA), previously known as Electronic Countermeasures (ECM).
3. Electronic Protection (EP), previously known as Electronic Counter-Countermeasures (ECCM).

These disciplines are shown in Figure 1 and are described in detail in subsequent study themes.

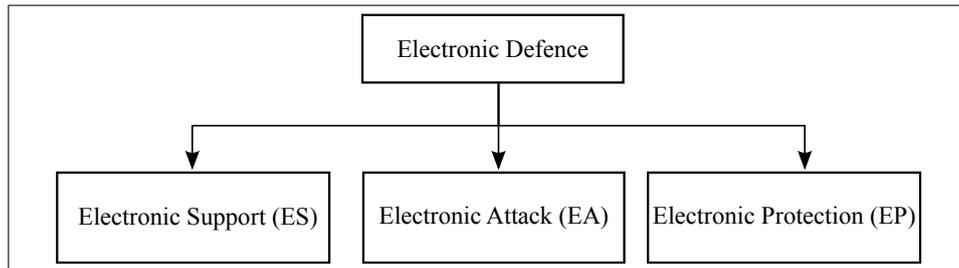


Figure 1: Breakdown of the main ED disciplines.

## 2 Lecturer Information

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### 3 Course Objectives and Study Themes

The course aims to introduce the student to Electronic Defence. A good prior knowledge on the topics of digital signal processing, electromagnetics, mathematics and statistics is highly recommended for this course. A relatively good knowledge of radar and a moderate knowledge of communications would be very beneficial to students. Students should be competent in using scientific programming languages such as Matlab or Octave.

Students have to master fundamental concepts in Electronic Defence on a high-level (identification of tactics and applications) as well as on a detail level (the design of a suitable detector to required specifications). Students are required to link theoretical concepts in Electronic Defence to typical applications and to solve problems of an engineering nature.

#### 3.1 Theme 1: The History of Electronic Defence

Ever since long distance radio transmission was invented by Guglielmo Marconi, the potential to communicate and sense influenced the way militaries and societies function. Alongside this work, Heinrich Hertz showed that radio waves reflected off metallic objects, but it wasn't until the early 1930's when many nations independently developed their own versions of radar. Radar presented nations with a great tactical advantage and the countering thereof gave rise to what is now referred to as Electronic Defence.

*Theme objective:* To review how the developments in radar gave rise to Electronic Defence and how critical conflicts such as World War II, the Six-Day war and the first Gulf war shaped this kind of defence.

*Study material:* Lecture material as well as literature supplements and historical internet references.

*Theme outcome:* The student is required to identify the approach, techniques and mechanisms developed at each point in history that counteracted the capabilities of radar.

#### 3.2 Theme 2: Overview of Electronic Defence

Since the early days, Electronic Defence has developed into such a critical capability that it has become a subject of study on its own. It has found applications in many domains such as communications, optronics, acoustics and cyber. The key to successful Electronic Defence is an intimate knowledge of the *target*, whether it be radar or infra-red (IR) missile seekers.

*Theme objective:* Given the historical developments of advanced sensors, the student will be exposed to the formal definition of Electronic Defence and the three main disciplines thereof. After a brief review of relevant radar and communication concepts, students will learn about the application of Electronic Defence.

*Study material:* The prescribed textbook, lecture material as well as literature supplements.

*Theme outcome:* The student is required to recognise and apply any of the main Electronic Defence principles to case studies. Case studies are typically formulated in a setting where radar and/or communications are exploited for a given objective.

### **3.3 Theme 3: Electronic Support**

Practically every Electronic Defence operation starts by performing Electronic Support (ES). It provides the necessary information, description and intelligence to enable (or support) effective ED. Electronic Support is defined as *the search for, the interception, the location and the classification of sources of intentional and unintentional radiated EM energy*. The detection of low probability of intercept (LPI) emissions is very valuable. In turn the accurate estimation of emitter parameters would enable successful exploitation (via EA) or avoidance (via EP) thereof

*Theme objective:* The student will learn about the various approaches to ES against radar and communications systems. Here, the technical details and capabilities are presented that make each approach unique. LPI radar will be a case study and search, detection, location and classification principles are applied.

*Theme material:* The prescribed textbook, lecture material as well literature supplements.

*Theme outcomes:* The student is required to have an understanding of ES and be able to analyse emitter detectability and design (in concept) a suitable ES solution for a given scenario.

### **3.4 Theme 4: Electronic Attack**

Electronic Attack (EA) deals with the deliberate actions taken to radiate or reflect EM energy in order to disable or degrade the EM spectrum to enemy capabilities. EA comprises of impairing, disrupting and deceiving enemy sensors (or assets) to gain control in a given scenario. A typical EA case would be an aircraft having to create phase front distortion towards a tracking radar in order to break it's track. There many different methods in EA are referred to as jamming, spoofing and deception jamming. EA may be categorised further into, active radiation of EM energy, passive EA (for example, chaff and passive decoys) and the reduction of radar observations of targets.

*Theme objective:* The student will learn about the various EA techniques and the radar or communications components that are targeted. Here, the technical details of EA are presented. Both radar and communication jamming will be cases of study.

*Theme material:* The prescribed textbook, lecture material as well as literature supplements.

*Theme outcomes:* The student is required to have an understanding of EA and be able to analyse jamming effectiveness and design (in concept) a suitable EA solution in a given scenario.

### 3.5 Theme 5: Electronic Protection

Actions taken to protect facilities and equipment from any effects of friendly or enemy EA is commonly referred to as Electronic Protection (EP). Many designers of radar and communication systems regularly make use of EP. The following strategies are regarded as *protecting* facilities against EA:

1. Overpowering of jammers.
2. Intelligent signal design to reduce jamming effectiveness.
3. Preventing receiver overload.
4. Radar versus jamming signal discrimination.
5. Avoiding jamming signals altogether.

Examples of EP are emissions control and communication security. By controlling where, when, how often and on which frequency you are transmitting the would-be jammer will find it difficult to meet all the conditions for effective EA. Furthermore, securing transmitted data using encryption protects the content of data even if it is intercepted.

*Theme objective:* The student will learn about the various aspects of EP. Here, the technical details of EP are presented.

*Theme material:* The prescribed textbook, lecture material as well as literature supplements.

*Theme outcome:* The student is required to have an understanding of EP and its relevance in radar and communication system design.

## 4 Prescribed Text and Relevant Material

Electronic Defence with all its components cover a broad scope of multiple topics, which make a single definitive text on it rather impossible. The prescribed text book will be used as a guideline, with reference to many other sources during the course. The prescribed book for this course and a short description thereof follows,

D. Curtis Schleher, *Electronic warfare in the information age*, Artech House, 1999, ISBN 9780890065266.

This book is an advanced guide to the latest concepts and threats associated with modern electronic warfare (EW). It identifies and explains relevant radar and communications threats, and provides EW and radar engineers, managers, and technical professionals with practical, "how-to" information on designing and implementing EA and EP systems.

#### 4.1 Relevant Material

The following texts provide useful information that would supplement the content presented during lectures as well as the prescribed textbook. It is advisable to form study groups and borrow these books from the university library or browse them on-line otherwise.

1. James Tsui, *Digital Techniques for Wideband Receivers*, 2nd-Edition, SciTech Publishing, 2004, ISBN 9781891121265.
2. Richard G. Wiley, *ELINT: the interception and analysis of radar signals*, Artech House, 2006, ISBN 9781580539258.
3. Richard G. Wiley, *Electronic intelligence, the interception of radar signals*, Artech House, 1985, ISBN 9780890061381.
4. D. Curtis Schleher, *Introduction to electronic warfare*, Artech House, 1986, ISBN 9780890061428.
5. David Adamy, *Introduction to electronic warfare modeling and simulation*, Artech House, 2003, ISBN 9781580534956.
6. David Adamy, *EW 101: a first course in electronic warfare*, Artech House, 2001, ISBN 9781580531696.
7. David Adamy, *EW 102: a second course in electronic warfare*, Artech House, 2004, ISBN 9781580536868.
8. Richard Poisel, *Modern communications jamming principles and techniques*, Artech House, 2004, ISBN 9781580537438.
9. Filippo Neri, *Introduction to electronic defense systems*, Artech House, 1991, ISBN 9780890065532.
10. Sergei A. Vakin, Lev N. Shustov and Robert H. Dunwell, *Fundamentals of electronic warfare*, Artech House, 2001, ISBN 9781580530521.
11. Phillip E. Pace. *Detecting and classifying low probability of intercept radar*, Artech House, 2004, ISBN 9781580533225.
12. Merrill Ivan Skolnik, *Radar handbook*, McGraw-Hill, 2007, ISBN 9780071485470.

## 5 Recommended Approach

It is strongly advised to interact and participate during the lecture week, as it provides the only opportunity for face-to-face contact time. The study material, assignments and the exam will be communicated during that week. Any interaction after the lecture week will be dealt with via e-mail. All the themes (and their respective assignments) are introduced and discussed before the next theme is considered.

## 6 Assessment

### 6.1 Assignments

There are four (4) assignments scheduled for this course. Each assignment will test the student's ability to apply the concepts learned during each study theme. Each assignment will be introduced during the lecture week and are due at 16:00 on the day specified in the schedule. Assignments must be submitted electronically and must be self contained.

### 6.2 Exam

The exam will test the student on every study theme in the course. It is a three (3) hour written exam.

## 7 Course Schedule 2011

Date	Event
3 to 7 October	Thematic Lectures
14 October	Assignment 1: History and Introductory Concepts
21 October	Assignment 2: Electronic Support
28 October	Assignment 3: Electronic Attack
4 November	Assignment 4: Electronic Protection
18 November	Exam (on all study themes)

## 7.1 Lecture Programme

<b>Time</b>	<b>Monday 3 October</b>	<b>Tuesday 4 October</b>	<b>Wednesday 5 October</b>	<b>Thursday 6 October</b>	<b>Friday 7 October</b>
<b>08h00</b>	Welcome & Overview	Theme 3: ES Introduction	ED in Communications	Theme 4: EA Introduction	Coherent SL Cancellation
<b>09h00</b>	Theme 1: History of ED	Emitter Search	ED in Communications	Expendables	RCS Reduction & Stealth
<b>10h00</b>	History of ED	Detection	ED in Communications	EA Methods	EP for Search & Tracking radar
<b>11h00</b>	<b>Tea</b>	<b>Tea</b>	<b>Tea</b>	<b>Tea</b>	<b>Tea</b>
<b>11h30</b>	Theme 2: ED Overview	Emitter Location	Integrated Sensors	Cross-eye Jamming	Theme 5 Wrap & Assignment 4
<b>12h00</b>	Overview of ED	Classification	Theme 3 Wrap & Assignment 2	Directed Energy & EA Architectures	Conclusion & Exam Briefing
<b>12h30</b>	<b>Lunch</b>	<b>Lunch</b>	<b>Lunch</b>	<b>Lunch</b>	<b>Lunch</b>
<b>13h30</b>	Overview of ED	Signal De-Interleaving	Excursion	Theme 4 Wrap & Assignment 3	
<b>14h30</b>	Overview of ED	LPI Intercept	Excursion	Theme 5: Introduction	
<b>15h30</b>	<b>Tea</b>	<b>Tea</b>	Excursion	<b>Tea</b>	
<b>16h00</b>	Theme 1-2 Wrap & Assignment 1	ES Receiver Architectures	Excursion	Sidelobe Blanking	
<b>17h30</b>	<b>Close</b>	<b>Close</b>	<b>Close</b>	<b>Close</b>	

The excursion will be a visit to Peralex (<http://www.peralex.com/>) at 14h00. Peralex produces high performance wideband radio receivers, analogue to digital converter boards, DSP based processor boards, signal processing and analysis software. They are a well established South-African company serving clients locally and internationally.