JAMMING TOWARDS RADAR DETECTION AND TECHNIQUES TO COUNTER THE EFFECT

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ABSTRACT

Burn-through range was defined as the range to the target at which the radar has adequate signal quality to track the target while Electronic Counter-Counter Measure (ECCM) was defined as military action involving the use of equipment techniques to prevent or to deny the hostile use of the electromagnetic spectrum. The objectives of this project is to determine the burn-through range due to radar echo and jammer signal received at radar antenna and the methods known as ECCM that can be applied by a radar in order to improve its performance. In order to understand the overall project, it will begin with an explaination on theory and literature review based on radar and electronic warfare concept. Clarification will focus on the principles of basic communication system, basic radar and electronic warfare system and the pass discussion related to this project based on author perspectives. The next stage is to determine the radar and jammer parameters based on hardware setup and experimentally performed at Electronic Warfare Training Centre Laboratory, Sungai Buloh Selangor. Subsequently based on the understanding concept performed at the laboratory, several typical values for both parameters was obtained from internet, radar and electronic warfare books and specified documents such as Jane’s collection based on their application in current modern warfare. Finally, the determination of burn-through range was performed by an analysis their parameters towards test equipment result and calculating approach for the information obtained from the specified sources. To gives an appropriate presentation, the results was simulate thru Microsoft Excel in order to depict it in graph manner and by referring to a burn-through range sketch, several methods can be applied by a radar in order to improve its performance. A proposal methods can be divided into two parts which is firstly, by shifting the burn-through range towards jammer thru burn-through range parameters adjustment and secondly, by preventing the jammer effectiveness towards radar performance.

ABSTRAK

‘Burn-through range’ di definasikan sebagai jarak di mana radar mempunyai keupayaan yang memadai untuk melaksanakan tugas bagi mengesan objek sementara ‘Electronic Counter-Counter Measure (ECCM)’ di definasikan sebagai tindakan ketenteraan melibatkan penggunaan teknik - teknik pada sistem bagi pencegahan di samping penafian penggunaan ‘Electromagnetic Spectrum’ oleh pihak musuh. Objektif projek ialah bagi mendapatkan ‘burn-through range’ berdasarkan kepada isyarat radar dan isyarat ‘jammer’ yang di perolehi pada ‘antenna’ di mana kuasanya bersamaan dan kaedah yang boleh diapplikasikan oleh radar (ECCM) bagi pemambahbaikan keupayaan prestasi sistem. Bagi mendapatkan pemahaman yang lebih jelas bagi keseluruhan projek ini, pendekatan awal adalah berkaitan dengan pendedahan secara teori dan kajian literature ke atas sistem radar dan sistem peperangan elektronik. Penjelasan di khususkan ke atas asas sistem perhubungan, asas sistem radar dan peperangan elektronik dan perkara yang berkaitan dengan tajuk projek ini dari persepsi pengarang-pengarang yang berpengalaman. Pendekatan berikutnya adalah bagi mendapatkan parameter-parameter radar dan ‘jammer’ berdasarkan perkakasan- perkakasan yang digunakan bagi melaksanakan eksperimen di Makmal Pusat Latihan Peperangan Elektronik di Sungai Buloh Selangor. Berikutnya berdasarkan kepada pemahaman konsep di makmal tersebut, beberapa nilai parameter-parameter radar dan ‘jammer’ di perolehi dari dokumen-dokumen yang terhad. Peringkat terakhir adalah mendapatkan jarak ‘burn-through range’ dari makmal eksperimen dan dokumen berkaitan. Jarak ini akan disimulasikan dengan menggunakan ‘Microsoft Excel’ bagi mendapakan graf yang sesuai dan dengan merujuk kepada graf tersebut, cadangan penambahbaikan keatas prestasi sistem di perkenalkan dikenali sebagai ‘ECCM’.

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CHAPTER 1

INTRODUCTION

1.1 Burn-through Range

Noise jamming is a battle between the radar and the jammer and the outcome of the battle is decided by who has the power advantages. Ground based or long range airborne radar transmitters are more powerful than airborne jamming transmitter. Furthermore, noise jammers transmit a constant amount of power. The radar experience a two way propagation loss of energy as compared with a one way loss of energy between the jammer and the radar. If the jamming signal is more powerful than the radar return, the radar will be jammed. If the radar return is more powerful than the jamming signal, the jamming will not be successful and the target will be visible [1].

If we take the situation of a noise jammer equipped aircraft flying toward radar, as the aircraft approaches the radar the strength of the radar return will increase because the range has decreased. As the jammer approaches the radar there will be a range at which the radar returned signal becomes equal to the jamming signal. This is known as the burn-through range. At ranges greater than the burn-through range the jamming signal should mask the radar signal. At ranges less than the burn-through range, the radar echo will be stronger than the jamming signal and the target will be visible. Figure 1.1 illustrates the scenario.

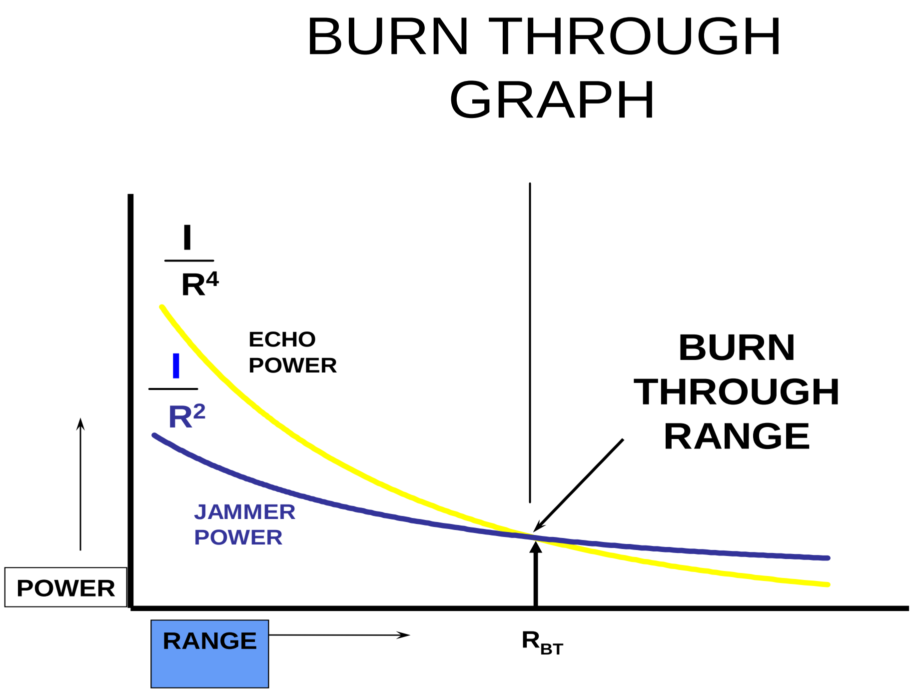

Figure 1.1 Burn-through range graph

1.2 Electronic Counter-Counter Measures

It is recognized that the enemy's use of Electronic Counter Measure s (ECM) may seriously degrade the performance and operational capability of friendly early warning, surveillance, target tracking and missile guidance radars. Friendly ECM techniques can also be a threat to friendly radar systems. Similarly, Anti Radiation Missiles (ARM) can target friendly radars operating on the same frequency as enemy radars. Directed Energy Weapons (DEW) also affects enemy and friendly radar systems alike. To survive in an environment generated by the threats on the modern battlefield, radar systems require electronic protection. This may come in the form of equipment design techniques, operational procedures and tactics [2].

Electronic Counter-Counter Measures (ECCM) is the third element of the Electronic Warfare (EW) family but unlike ECM and Electronic Support Measures (ESM) the effects of ECCM are rarely seen. This is because the majority of ECCM techniques are designed into the radar system and ECCM procedures and tactics are only visible when ECM is taking place. ECCM techniques, procedures or tactics are often highly classified as they represent a country's operational capability.

1.3 Radar Definition

The term RADAR as an acronym for **Ra**dio **D**etection **a**nd **R**anging. Radar is a system that uses radio waves to detect, determine the direction and distance and/or speed of objects such as aircraft, ships or rain and map them. Speed detection is measured by the amount of doppler effect frequency shift of the reflected signal. A transmitter emits radio waves which are reflected by the target and detected by a receiver, typically in the same location as the transmitter (monostatic). Although the radio signal returned is usually very weak, radio signals can easily be amplified (part of processing) before been display as a target. Figure 1.2 illustrates the radar block diagram [3].

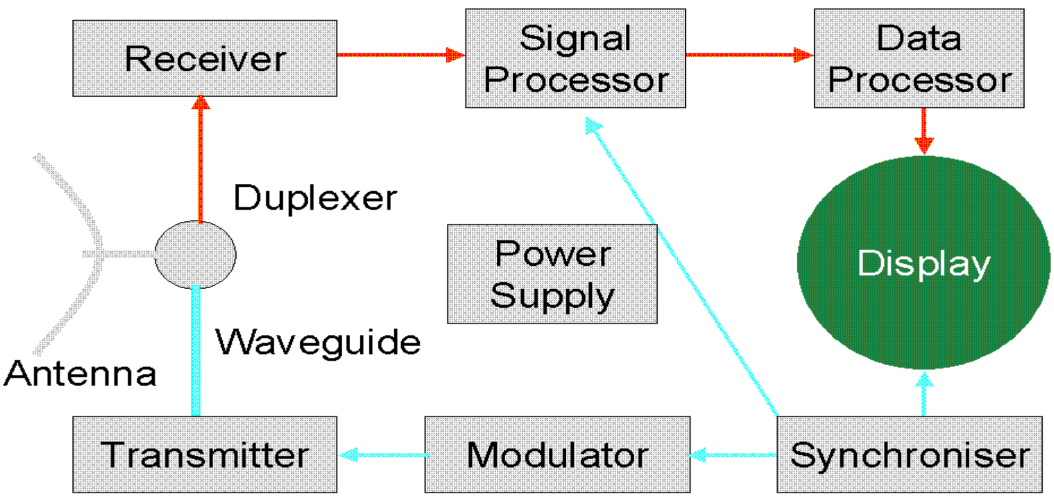

Figure 1.2 Radar block diagram

1.4 Electronic Warfare Definition

EW is military action to exploit the Electromagnetic (EM) spectrum which encompasses the interception, identification and location of EM emissions. The employment of EM energy to reduce or prevent hostile use of the EM spectrum and actions to ensure its effective use by friendly forces. The EW techniques and system categories are illustrates as in Figure 1.3 [4].

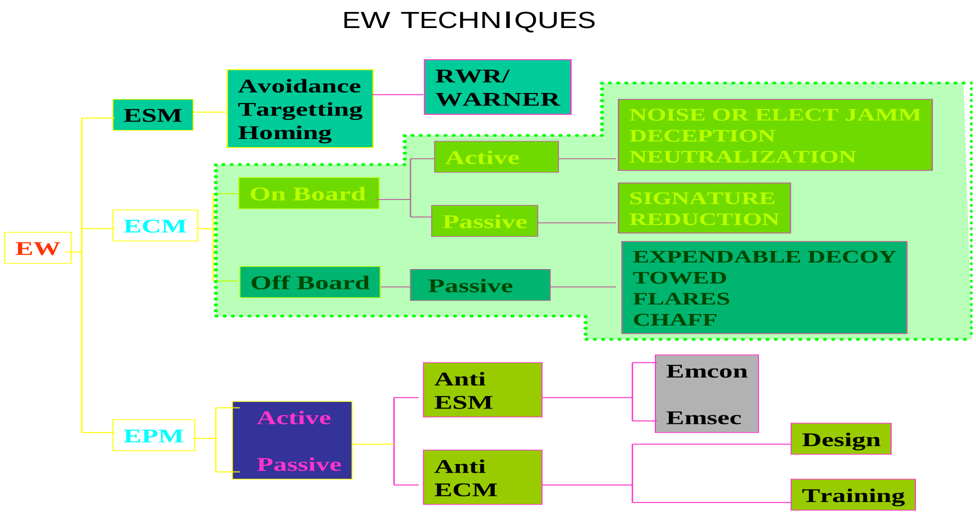

Figure 1.3 EW techniques

1.5 Thesis Background

This thesis was implemented in order to give an awareness of importance in EW especially in military application.The thesis background are as follows:

a. The function of radar is to detect the target within the coverage range. However, the target can be camouflage by apply one of the ECM method known as noise jamming.

b. In order to define the range of jamming, the concept of burn-through range was introduced where the range above this point give an advantages to the jammer (jammed) and the range below this point give advantages to the radar (detected).

c. In this project, the aim is to determine the burn-through range based on information obtained, performed a data analysis and proposed method for system performance improvement.

1.6 Problem Scenario

The information was obtained based on experimentally performed at Military Laboratory (Mil Lab) and followed by information obtained from radar & EW books and several specified documents such as Jane's Collection. Subsequently, study case been made by comparing radar echo and jamming signal by simulating their parameters respectively and finally several proposed method known as ECCM been presented. The parameters accounted in this calculation is called simplified because it does not take into account the losses occurred in the system and the influence of statistical parameters such as Signal to Noise Ratio (SNR) and others.

For an accurate result, all the parameters listed by Blake Chart Sample can be referred to as a complete guideline in order to determine the exact radar range equation. Figure 1.4 illustrates the Blake Chart Sample [5].

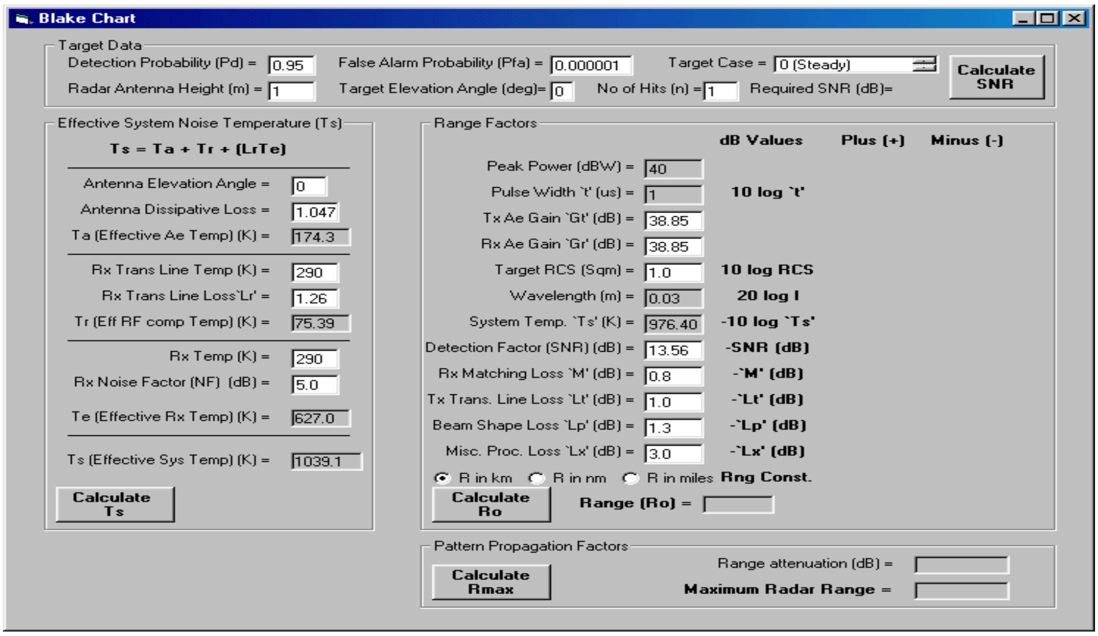

Figure 1.4 Blake chart sample

It was noticed that the simple form of the radar equation expressed the maximum radar range R_{max} in terms of the key radar parameters and the target's Radar Cross Section (RCS) when the radar sensitivity was limited by receiver noise was written by [6]:

$$R^4_{max} = \frac{P_R G_R \sigma A_R}{16 \pi^2 S_{min}} \qquad [1.1]$$

where

S_{min} = Minimum detectable signal, W

P_R = Transmitted peak power, W

G_R = Antenna gain, dB

σ = Radar cross section, m^2

A_R = Antenna capture area, m^2

R = Range to target, m

Except for the target's radar cross section, the parameters of the simple form of the radar equation are under the control of the radar designer. It states that if long ranges are desired, the transmitted power should be large, the radiated energy should be concentrated into a narrow beam (large transmitting gain), the echo energy should be received by a large antenna aperture (also synonymous with large gain) and the receiver should be sensitive to weak signals.

In practice, however, this simple form of the radar equation does not adequately predict the range performance of actual radars. It is not unusual to find that when equation is used, the actual range might be only half that predicted. The failure of the simple form of the radar equation is due to:

a. The statistical nature of the minimum detectable signal (usually determined by receiver noise).
b. Fluctuation and uncertainties in the target's RCS.
c. The losses experienced throughout a radar system.
d. Propagation effects caused by the earth's surface and atmosphere.

The statistical nature of receiver noise and the target cross section requires the maximum radar range be described probabilistically rather than by a single number. Thus the specification of range must include the probability that the radar will detect a specified target at a particular range and with a specified probability of making a false detection when no target echo is present. The range of a radar therefore will be a function of the Probability of Detection (Pd) and the Probability of False Alarm (Pfa).

1.7 Problem Statement

The parameters indicates at Lamont Blake Chart is a complete one and it is impossible to find most of the parameters in a books availabled at the market. Unless all the branches of EW been applied to get the parameters as many as possible for a closed accurate result hence for this project, the writer only be able to apply simplified equation based on several limitation related to this subject. Furthermore, most of the parameters are categorized under classified information.

Beside that, several uncertainty issues such as the safe distance for burn-through range and the maximum jamming range start to occur is not clearly defined. Meanwhile the techniques proposed in ECCM branch based on information obtained from the books is difficult to understand theoretically unless for those who are in the system design field and experienced in the EW scenario.

1.8 Objective

The objectives of this thesis is to determine the burn-through range due to radar echo signal and noise jamming received at the radar antenna and the methods known as ECCM that can be applied by the radar in order to improve its performance.

The methodology of this thesis is by using tools and test equipment at Mil Lab as a first approach on how to understand the concept behind the burn-through range and followed by simulating the result by using Microsoft Excel. The tools and test equipment currently availabled at laboratory are transmitter and receiver equipment, phased array antenna, display, test target, jamming pod and antenna testing and measurement system.

Upon completion of the analysis, the thesis is to study and simulate the real values availabled at restrict sources to see the performance of the radar system. Further investigation is carried out to observe improvements using ECCM techniques. In summary, the task of the thesis are as follows:

a. To determined the burn-through range. The analysis can be mapping to the standard burn-through range applies to a real radar and jamming system.
b. To setup and evaluate the test equipment capabilities in various aspect involved EW.

c. To simulate and produce antenna radiation pattern and burn-through range at any values inserted.

d. To further investigate performance improvement with ECCM.

1.9 Thesis Outline

Towards to analyze burn-through range based on typical radar specification and typical jammer specification available at limited sources and it will begin with practical analyze for all possible parameters at Mil Lab for better understanding. The thesis is organized into five chapters that completely cover this project.

Chapter 1 covers the introduction of burn-through range, ECCM, EW and simulation modeling applied. It also defines the thesis background, problem statement, objectives, outline and summary.

Chapter 2 provides three stages of understanding begin with the concept behind the principles of basic communication systems followed by the discussion on radar and EW matters and finally the pass discussion related to this thesis based on author perspectives.

Chapter 3 provides the explanation for the methodology applied to complete the project. It describes the hardware setup at Mil Lab as a system level modeling and simulation by using Excel for burn-through range determination. Here it explains how information is assimilated in the project and explains in details of the model itself with all of its composition and components. As an extension, the typical value for real system been applied to obtain the results.

Chapter 4 provides the explanation of results and discussion. It is a result based on information yield from a transmitter and receiver with test target and jammer in between for hardware setup and parameters are inserted in simulation for graph depicted. In addition, several typical values for radar and jammer can be evaluated for a real illustration.

Chapter 5 provides the conclusion and future work that can be undertaken to refine the project. The final chapter also provides an overall conclusion of the work conducted in this project. Future works and recommendations are outlined.

1.10 Summary

The title and objective project are explained. A general explanation of EW which covers radar and burn-through range is presented. Project background and problem statement is stated. The following chapters described in the thesis outline. An important information was explained in chapter 2 which provides theoretical aspect and past work related to this thesis.

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