

RADAR SYSTEM SIMULATION USING MATLAB

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ABSTRACT

Radar is an electromagnetic system that detects and locates objects by transmitting electromagnetic signals to free space, receiving echoes from objects, and extracting information from the echo signal. Radar is used to enhance the capability of human senses for observing the environment, especially the sense of vision. It helps human to improve the sight in unpleasant conditions such as fog, rain, dark or too far away. The objective of the project is to design the radar system simulation that is capable of determining the distance, range and direction of an object. The radar system designed in this project is the S-band Pulse Doppler Surveillance Radar. The radar system simulation is designed using the MATLAB software by implementing the Doppler equation. The distance, velocity and direction are yielded by the Doppler equation. In addition, the power received has been calculated by using the Friis formula that is only valid in the far field region. The radar system designed has the capabilities to detect a target as far as 200KM while determining the target distance, direction and velocity.

ABSTRAK

Radar ialah suatu sistem elektromagnetik yang mengesan dan menyatakan kedudukan sesuatu objek dengan memancarkan isyarat elektromagnetik, menerima isyarat pantulan daripada objek dan mengekstrak informasi daripada isyarat pantulan tersebut. Radar digunakan untuk menambahbaik kebolehan panca indera manusia terutamanya kebolehan melihat keadaan sekeliling. Ia menambahbaik kebolehan manusia untuk melihat didalam suasana kurang konduktiviti seperti ketik berkabus, hujan, gelap ataupun objek yang berada terlalu jauh. Objektif projek ini adalah untuk menghasilkan simulasi sistem radar yang berkemampuan untuk mengenalpasti jarak, arah dan halaju sesuatu objek. Sistem radar yang direka ialah "Radar Pengawasan Doppler Denyut pada Lebar Pita S". Simulasi sistem radar ini direka menggunakan program MATLAB dengan mengimplementasikan persamaan Doppler. Selain itu, kuasa diterima telah dikira menggunakan formula Friis yang mana hanya boleh dipakai pada daerah medan jauh sahaja. Sistem radar yang direka ini berkemampuan untuk mengesan objek sejauh 200Km sambil mengenalpasti jarak, arah dan halaju objek tersebut.

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LIST OF ABBREVIATION

RADAR	Radio Detection And Ranging
R	Range
P _t	Peak transmitted power
G	Antenna gain
λ	Wavelength
σ	Radar cross section
K	Boltzman's constant
T ₀	Temperature,290
B	Bandwidth
F	Noise figure
SNR	Signal Noise Ratio
A _e	Antenna effective Aperture
G _t	Transmitter Gain
G _r	Receiver Gain
f _o	Radar operating frequency
P _t	radar peak transmitted power
c	Speed of light
PRF	Pulse Repetition Frequency
w	wavelength
PRI	Pulse repetition Interval

T	Time interval from one pulse to the other
PW	Pulse width transmitter
PWr	Pulse width receiver
dt	Duty cycle
Pav	Power average of the transmitter
Ru	Range unambiguous
RCS	Radar cross section of the target

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CHAPTER 1

INTRODUCTION

This chapter provides an overview of the project conducted on Radar System Simulation using MATLAB. The objectives and the inspiration of the project are introduced. The introduction of the radar system is also presented in this chapter.

1.1. Introduction

The word radar is an acronym for Radio Detection And Ranging. Radar is defined in “IEEE Standard Radar Definition” [1] as:

An electromagnetic system for the detection and location of objects that operates by transmitting electromagnetic signals, receiving echoes from objects (targets) within its volume of coverage , and extracting location and other information from the echo signal.

In other word radar is the system that consist of the transmitter and receiver as the hardware. The transmitter would radiate the electromagnetic energy to free space. In certain area of the radiation the radiated energy could be intercepted by reflecting objects and produce reflected radiated energy also known as echoes. This echo then received at the antenna and provided information after been processed.

Radar is used to enhance the capability of one's senses for observing the environment, especially the sense of vision. Radar development is not in being a substitute for the eye, but in doing what the eye not capable to do. Radar cannot determine detail as well the eye. In example radar cannot determine the color of the object like the eye can do. However, radar can be designed to see through those conditions that are not normal to human vision, such as fog, snow, haze, rain, and darkness. Moreover, radar has the advantage of being able to measure the range or distance to the object [2].

Radars usually been classified according to the type of waveforms they use, or by their frequency of operating. In term of waveform the radar might be classified as Continuous Wave (CW) radar that is when known stable frequency continuous wave radio energy is transmitted and then received from any reflecting objects while Pulsed Radar is when a train of pulsed waveform being used. The other method in classified the radar is by the operating frequency of the radar system such as S-band (2-4 GHz), C-band (4-8GHz) and more [3].

1.2. Project Summary

Generally, this project is about designing and developing the simulation of Radar System by using MATLAB. Since there is various type of radar system with different method of functioning is developed, this project would focus on designing the radar system by using the Pulsed Doppler method. The simulations are more on the

mathematical function in radar system in determining the direction, velocity and distance of the target.

1.3. Objectives

The objective of this project is to study the Radar System in general. Knowledge gain in the study would be implemented in designing and developing the simulation of early warning radar system. The simulation of the radar system build would have the ability to determine, the range, direction and velocity of the object.

1.4. Problem Statement

There is a need in our daily routine to detecting and estimating the range of object that is cannot be seen by our bear eyes. This is because human have limitation eyesight or hearing ability. Therefore, by exploiting the electromagnetic transmitted signal and echoes human manage to determine the range, direction and velocity of the object that cannot be seen by eyes or hear by ears which mean very far away. By having those ability human can plan and organize thing depending on the result achieved.

1.5. Scope of Project

As the project is about the design and development the simulation of the radar system. The project would focus on designing the radar system simulation using Pulsed Doppler method. The scope covered in this project mainly on the mathematical part of detecting the target distance, direction and velocity by using Doppler frequency

equation. The project would use the MATLAB software as the platform to perform the simulation.

1.6. Report Structure

Generally, this report consists of 5 chapters which are; Chapter 1: Introduction, Chapter 2: Literature Review, Chapter 3: Methodology, Chapter 4: Result and analysis and Chapter 5: Conclusion. Each chapter will be explained briefly on the title that it represent.

The first chapter represented the Introduction part., it is related to the fundamental of the titles that have chosen, project background, the objective, problem statement and scope of work that have been planed and discovered.

The second chapter represented the literature review that involves in this project. Here, the information gathered from different types of sources will be discussed. The graph, picture and equation related to the project would be included in this chapter.

The third chapter is where the methodology will be covered including the theories and method applied in the project. The MATLAB software features and codes related in order to obtain the result will be discussed briefly in this chapter. The simulation code would be attached at the appendix of the report.

The fourth chapter represents the result of the project. Here, the analysis of the result obtained will be discussed briefly. The radar system simulation should be able to

produce accurate range, velocity and direction of the target since the radar design in lossless condition.

The fifth chapter; conclusion will discuss on the result obtain. The reason of choosing each technique and method will be explained briefly in this part. Lastly, the conclusion will be made here to state the status of objective.

CHAPTER 2

LITERATURE REVIEW

This chapter provides the information regarding the radar system and the software that been used. The information in the radar system is about the principle of the radar itself, the standard being used toward the radar design and the formulation in designing the radar system. The software part would provide information on the MATLAB software and it application toward the radar system simulation design.

2.1. Radar Principle

Radar is an electromagnetic system that using radio waves to detect and locate objects. Radar operates by transmitting a particular kind of radio frequency waveform and detecting the nature of the reflected echo. The waveform can be whether Continuous Wave (CW) or the Pulse signals. When radio waves strike an object, some portion of the

radio wave energy is reflected back to the receiver of the radar system. The location and other information regarding the object can be determined by the reflected energy. Monostatic radars have transmitters and receivers that are co-located, whereas bistatic radar has transmitters and receivers that are physically separated [4].

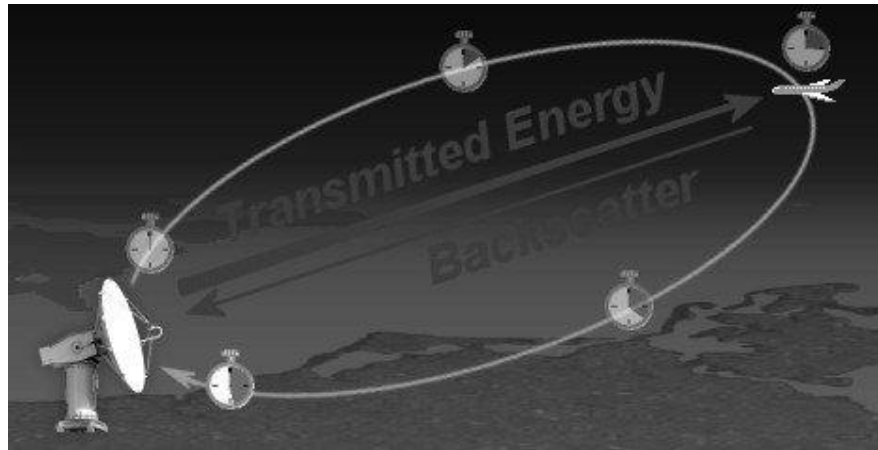


Figure 2.1(a): The measuring of a round trip time of a radio wave [5]

Radar rotates and transmits thousands of radio waves in a second; each one could reach a target and return to the radar. The target could be single or scatter such as ship, building or personnel or distributed such as rain and fog. Figure 2.1(b) illustrates the basic principle of radar [2].

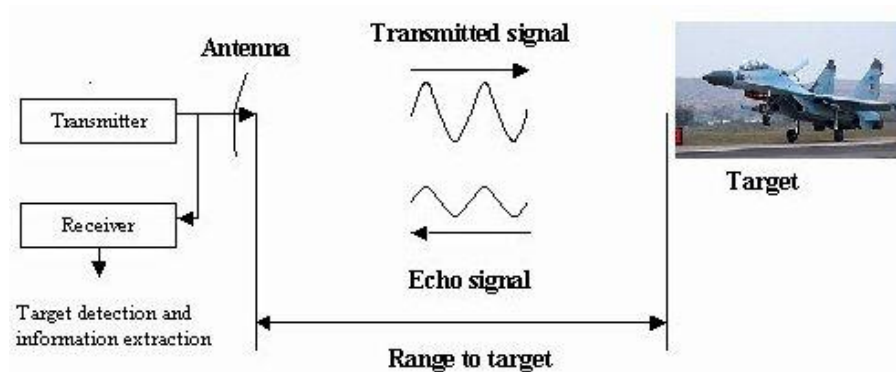


Figure 2.1(b): Basic Principle [6]

The concept of radar dates back to 1886, when Hertz discovered the metallic and dielectric objects reflect radio waves [2]. The most rapid development of radar occurred during the Second World War, originally meant for target detection and early warning. As the technology emerges, radar is being used in other various applications such as navigation, mapping and speed measuring [6]. It is because of its capability of extracting an accurate parametric information about its targets including range, bearing, velocity, configuration and identity [7].

Radar systems consist of many different subsystems, which themselves are composed of another different components. There is a great variety in the design of radar systems based on function, but the fundamental operation and main component of subsystems is the same. The components are antenna for transmitter and receiver, duplexer and indicator [8].

2.2 Radar Operating Frequency

Since the World War 2, radar systems engineers have used letter in describing the operating frequency. This method has continued throughout the years and is now an accepted practice of radar engineers. Radar-frequency letter designations are used for several reasons. Firstly, to provide easy way for describing the band in which the radar operates without using numerical terms. Second, it is used to differentiate the characteristic of each radar-frequency band. Table 2.1 (a) shows the IEEE “Standard Letter Designation for Radar Frequency Band” [9]