
# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## ANALYSIS AND SIMULATION OF HIGH ACCURATE AIRBORNE RADAR SYSTEM

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology Electronic (Telecommunication) (Hons.)

by

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# DECLARATION

I hereby, declare that this thesis entitled "Analysis and Simulation of High Accurate Airborne Radar System" is the result of my own research except as cited in the references.

**Signature** : ……..

**Name** : ……..

**Date** : ……..

# APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as one of the requirements for the award of Bachelor's Degree of Electronic Engineering Technology (Telecommunications) with Honours. Below is the name of my supervisor.

……..

(Supervisor)

# ABSTRAK

Keselamatan Sistem Radar Airborne secara langsung akan menjejaskan keselamatan keseluruhan pesawat dan penerbangan. Radar berkesan boleh mengesan cuaca dan rupa bumi keadaan yang buruk di hadapan pesawat, membantu juruterbang mengelakkan kawasan cuaca berbahaya lebih awal, untuk memastikan keselamatan penerbangan, jadi keselamatan untuk keselamatan sistem dan keselamatan penerbangan adalah sangat penting. Akhirnya, semua mod kegagalan adalah diletakkan berdasarkan kritikal mereka untuk mengetahui mod kegagalan kritikal atau komponen, yang boleh menawarkan beberapa nasihat pengajaran untuk meningkatkan kecekapan pengoptimuman keselamatan sistem

# ABSTRACT

The safety of the Airborne Radar System will directly affect the safety of the whole aircraft and the flight. The radar can effectively detect the bad weather and terrain situation ahead of the aircraft, help pilots avoid dangerous weather area in advance, to ensure flight safety, so its safety for the system safety and the safety of the flight is very important. At last, all the failure modes are ranked based on their criticality to find out the critical failure modes or components, which can offer some instructional advices to enhance the efficiency of the safety optimization of the system.

# DEDICATIONS

To my parents,
Nik Abdullah bin Nik Daud and Faridah binti Ismail
for raising me to become who I am today.

# ACKNOWLEDMENT

First and foremost, I would like to express my deepest gratitude to Sir Chairulsyah bin Abdul Wasli for giving me this opportunity to be working under his supervision throughout this project. I also would like to thank Sir Md Ashadi bin Md Johari for taking up his place when he's not available during his leaves. This project would not be completed under the time frame without their supervision.

Not forgetting the staffs of Faculty of Engineering Technology; my academic advisor, Miss Gloria Tanny for her professional advices in programming the system, lab engineers for their assistance during my laboratory sessions, and also to the other staffs who had been helping me indirectly.

Special thanks to my friends who had been providing me remarkable ideas to improve the project, my family who support me physically, emotionally and financially throughout the project.

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# LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

| | | |
|---|---|---|
| S/N | - | Signal-to-noise |
| GUI | - | Graphical User Interface |
| EA | - | Electronic Attack |
| PRI | - | Pulse Repetition Internal |
| FMCW | - | Frequency Modulated Continuous Wave |
| RCS | - | Radar Cross Section |

# CHAPTER 1
# INTRODUCTION

## 1.1 Introduction

This chapter introduces the project with its background, problem statement, objectives, project scope, project significance and to provide a sense of purpose and reasons to proceed with the project.

## 1.2 Background

Airborne radar is an object-detection system that uses radio waves to determine the range, angle, or velocity of objects ahead of the plane. The radar systems can be networked together so the total system is greater than the sum of its parts, and can serve several different functions includes for wide-area search, target tracking and weather monitoring. Airplanes are equipped with radar devices that warn of obstacles in or approaching their path and give accurate altitude readings.

This project will design and analyze the radar from the theoretical, measurement and simulation aspect. The parameter such power loss, delay, signal-to-noise ration (SNR) and other parameter that will be affected. The measurements cover many parameters such as: power loss, signal-to-noise ratio (S/N), stability, range, power input, distance, size of object, object speed and other related parameters. This project uses Graphical User Interface (GUI) to collect the data of the parameters.

The radar system needs to have highly accurate detection to make sure it would not hit the object ahead. It can detect clouds, weather or hitch. The system knows when to be switched on based on the distance between the object and the system itself.

## 1.3 Problem Statement

i. Misinterpreting what the radar tells.
ii. Radar performance can drop off gradually with time.
iii. Measuring the performance of airborne radar system is difficult to do.

## 1.4 Objectives

The main objectives of this research are deeply concentrated on the aspect below:

i. To study the concept of airborne radar system.
ii. To understand the simulation of airborne radar system by using Graphical User Interface (GUI).
iii. To analyze the result of calculation and simulation of airborne radar system

## 1.5 Project Scope and Limitations

For this project, it will take place in a company or university laboratory. It only involves in study literature, design, animation and simulation. Comparison between simulation and calculation will also take place. This project will only focus on the parameter that can affect the airborne radar system such as power loss, signal-to-noise ratio (S/N), stability, range, power input, distance, size of object, object speed and others. For this project, Matlab is an instrument that can be used to simulate the results. Lastly, the thesis writing will need to be done based on the project.

## 1.6 Project Significance

The impact of this project is that it will give convenience to the use of airborne radar system. The performance of the radar will be improved by analyzing the parameters used in determining the performance of the airborne radar system. The calculation and simulation of the parameters used will be compared and analyzed to give the best value to make sure the performance can be improved.

# CHAPTER 2
# LITERATURE REVIEW

This chapter provides understandings of theories and previous researches that are related to this project. This includes an overview of radar systems; types, operations and applications.

## 2.1 Introduction

Radars are active radio frequency devices used to determine the location of targets of interest within the radar coverage area.

Radar is a man's sensor equipment that can afford new services. It enables objects to be detected and located at a distance far from it. Radar measures the distances from the echoes it reflects and also the speed of the object towards or away from the observing station. It sends out radio waves from a transmitter so that the measured energy will be reflected from the seen- object to a receiver that is located usually at the same site as the transmitter (Ridenour, n.d.).

Most advanced radar equipments only show the gross outline of a large object. For example, eyes can only see a ship by looking at fine details such as the rails on the deck. This grossness of radar vision makes the objects that can be seen by radar are not as many as the objects that can be distinguished by the eye.

## 2.2 Radar System

Radar systems operate in the basic manner. The systems operate in bi-static mode where the transmitted and received antennas are separated (Adrian graham)

### 2.2.1 Types of Radar

There are many types of radar exist in the world. For example, pulse radar, microwave radar, airborne radar and tracking radar.

i. Microwave Radar

Microwave radar focuses the energy into sharp beams so that the direction and range of targets can be determined. The sharpness of a beam that passes through an aperture of a given size depends on the ratio of diameter of the aperture to the wavelength of the radiation in the beam. The sharpness of a beam produced by a radar antenna depends on the antenna dimensions to the wavelength used. The breadth of a beam produced by an antenna of a given size is proportional to the wavelength (Ridenour ,n.d.).

ii. Airborne Radar

It is important to produce sharp radar beams with a modest size antenna. Therefore, it demands the use of microwaves. Microwaves are radio waves that have less than 30 cm wavelength. Targets which have same range can be differentiated by radar if they are separated in azimuth (horizontal axis) by an angle larger than one beamwidth. Thus, a quality of a picture afforded by the radar is improved as the beamwidth is reduced. Beamwidth can be decreased only by lowering the wavelength of an antenna (Ridenour ,n.d.)

iii. Tracking Radar

A tracking radar is used in the terminal phase of a weapon system. When the radar locks onto a target, it imagines that the weapon is directed at the target. The electronic attack (EA) system in the target area is employed to cause the tracking radar to break-the-lock so that the information guidance will be used by the weapon. Therefore, the weapon will be abstracted from the target.

### 2.2.2 Application

There are many applications that can be used by the radar system. For example, applications in military used, air traffic control and safety of the ship.

i. Military

In military, radar system is part of air defence system, offensive missiles and weapons operations. Radar system is used for detecting targets, tracking and controls weapons (Akshay Palkar, 2009).

ii. Air Traffic Control

A radar is used to control air traffic at airports and enroute the planes on the air. The radar is called as ground vehicular traffic and aircraft taxing. Air traffic control has regions of mapping about the rain in the vicinity of the airports and weather (Nirav Gupta, 2009).

iii. Ship Safety

Radars are located in the ships to avoid collision and to observe the buoy's navigation of object in the sea. Shore-based radars has the function of surveillance for harbours (Rohit Mathur, 2009).

## 2.3 Airborne Radar System

Airborne radar system is an equipment that can help pilots in detecting and determining their distances or range from the echoes the radar reflects on. Doppler effect has a connection with the airborne radar system where it determines the speed and range rate of the reflected object (Stimson et al, 1998).

Most airplanes reflect radio waves which are also called as the flow of electromagnetic energy. For airborne radars, they actually have high frequencies with short wavelengths (Stimson et al, 1998).

An airborne radar consists of three elements: a radio transmitter, a radio receiver tuned to the transmitter's frequency and an antenna. The transmitter generates radio waves which are radiated by the antenna itself to detect the presence of an object. The receiver listens for echoes of the waves which are picked by the antenna. To avoid the transmitter interfering with the reception, radio waves are transmitted in pulses while the receiver is turned off during the transmission. Figure 2.1 below shows the basic elements of an airborne radar system (Stimson et al, 1998).

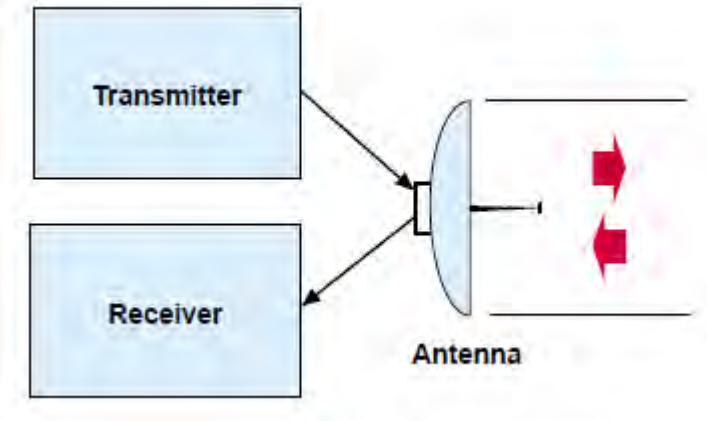


Figure 2.1: Basic elements of an Airborne Radar System

The Figure 2.2 below shows a connection between signal strength and the range of an object. The strength of the object's echoes is inversely proportional to the range of the object's range to the fourth power ($\frac{1}{R^4}$). As a distant object approaches, its echoes will grow rapidly stronger. The range at which they become stronger depends on some factors include the power of the transmitted waves, size of the antenna, wavelength of the radio waves and the strength of background noise. Figure 2.2 below shows a graph of signal strength against range of an object (Stimson et al, 1998).

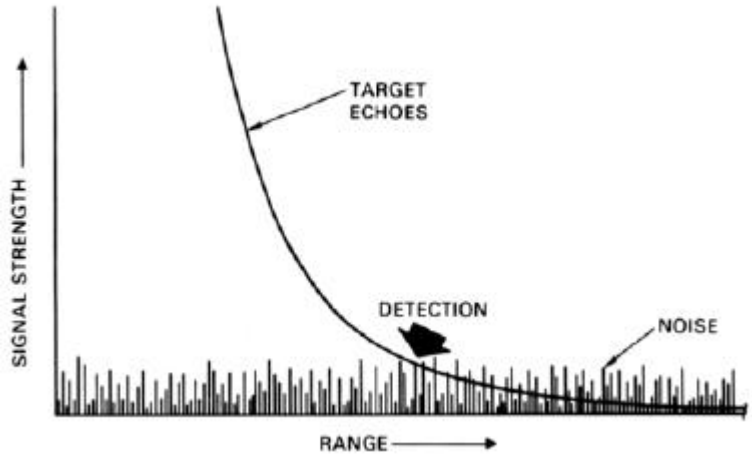


Figure 2.2: A graph of Signal Strength against Range of An Object

The time is measured and the time delay between transmission pulse is observed and the echo received by the pulse. Pulse width, $\tau$,.is in μs or less. Chirp pulse compression technique is used to increase the frequency of transmitted pulse at its duration. Received echoes are passed through a filter which introduces a delay. Figure 2.3 below shows a chirp pulse modulation (Stimson et al, 1998).

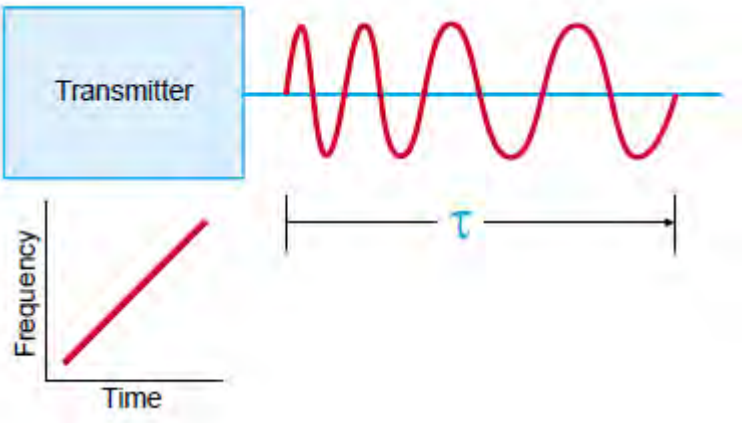


Figure 2.3: Chirp Pulse Modulation

### 2.3.1 History of Airborne Radar System

It started with experiments by Heinrich Hertz in the late 19th century which the experiments showed that radio waves were reflected by metallic objects. The possibility was suggested by James Clerk Maxwell in his seminar work on electromagnetism. In the early 20th century, a German inventor Christian Hulsmeyer has built a ship detection device that was to help avoid collisions in fog. It was the same for numerous systems which provided directional information to objects over short ranges. The systems were developed over the next 20 years.

Political climate at the end of World War II did not give much appreciation to Germany for technological developments. The destruction and division of post-war Germany made the discovery and credit for German radar advances difficult.

In the middle of 1930s, radar principles were known and being actively developed by Japan, Germany, Russia, Britain and America. But it was the British who had the most pressing need, and Nazi aggression caused the British to increase their defensive capability.

### 2.3.2 Overview of Airborne Radar System's Operation

i. Track-While-Scan

It is ideal in maintaining situation awareness because it gives accurate data of the target in launching guided missiles. For such uses, the antenna is trained on the target continuously in a single-target track mode (Stimson et al, 1998).

ii. Antenna Servo

Antenna servo is for comparing the actual position of the antenna itself with the wanted position, where it gives error signal. Figure 2.4 below shows the operation of an antenna servo (Stimson et al, 1998).

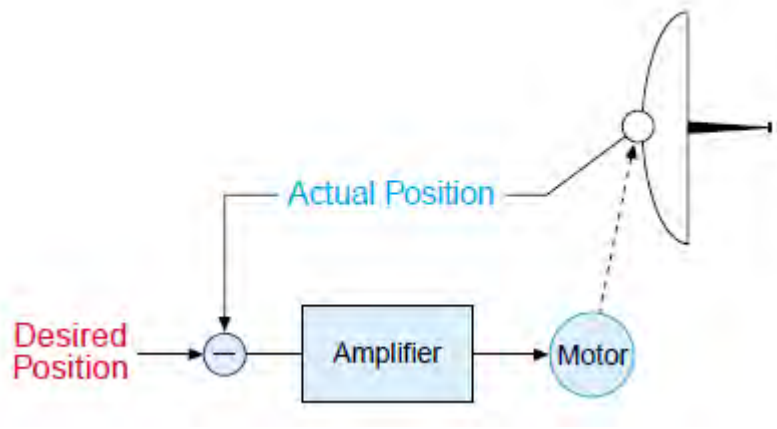


Figure 2.4: Operation of an Antenna Servo

iii. Exciter in Pulse-Doppler Radar

The function of this exciter is to generate stabled and power signal of the wanted frequency which is low. Figure 2.5 below shows the principle elements of a pulse-doppler radar (Stimson et al, 1998).

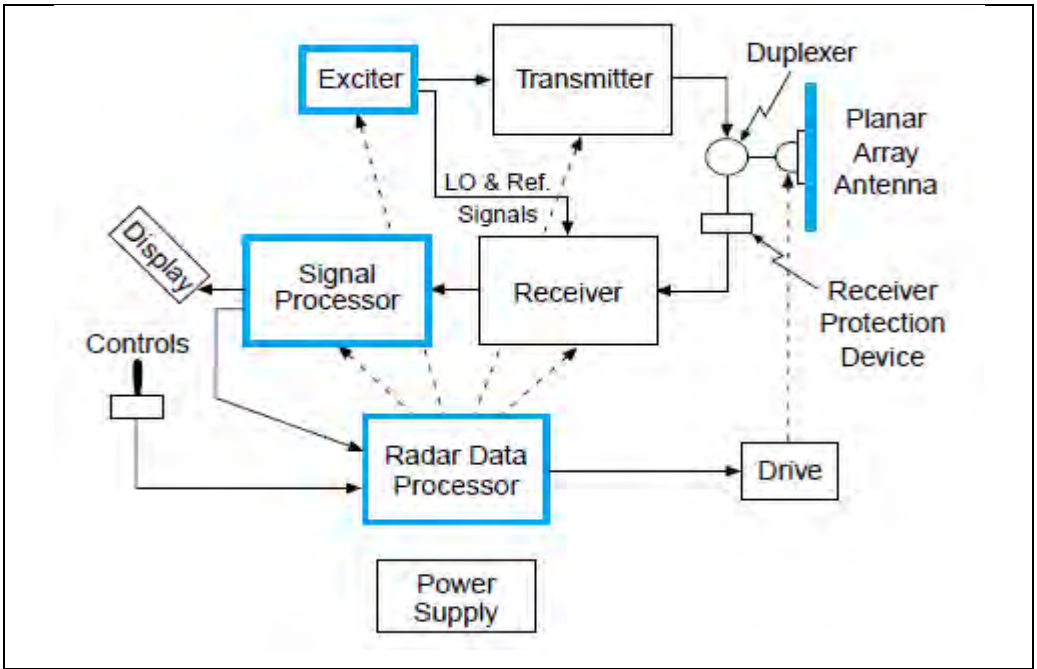


Figure 2.5: Principal elements of a pulse-doppler radar

iv. Military

In military, airborne radar system proves that it has ability to see through concentrated target ahead. It is used to detect targets ahead and to track large numbers of target in spread area at that very moment (Stimson et al, 1998).