

UNIVERSITI TEKNOLOGI MARA

**GROUND CLUTTER MODEL FOR
FORWARD SCATTER RADAR (FSR)
WITH VERY HIGH FREQUENCY
(VHF) AND ULTRA HIGH
FREQUENCY (UHF) BANDS IN
TROPICAL REGION**

NOR NAJWA ISMAIL

Thesis submitted in fulfillment
of the requirements for the degree of
Doctor of Philosophy

Faculty of Electrical Engineering

January 2018

ABSTRACT

The lack of traditional radar system during this era is the inefficient to detect targets that occupied with radar absorbing material (RAM) coating. Forward scatter radar (FSR) was introduced to overcome the problem by operating via shadowing concept. The target is detected when it crosses the baseline of the transmitter and receiver of the sensor where it creates a Doppler signal to the transmitted electromagnetic wave. Equipped with omnidirectional antennas, FSR is able to form a fencing system that is useful for situational awareness not only for normal targets, but also for stealth targets. However, as the system utilized omnidirectional antennas, positioned on the ground as well as the lack of range resolution due to its configuration, the captured signal from desired target also collect the unwanted signal from the surrounding. This unwanted signal is one of the interference signal known as clutter. Clutter signal will cause false alarm during the operation. Subsequently, it is necessary for the user to indentify the characteristics of the clutter occurred in order to differentiate the signal between the target and the clutter signal. From the characteristics analysis, a clutter model can be developed to generate a simulated clutter signal as a reference signal during the operation. This thesis presents a clutter model for four (4) types of profiles in tropical region, which are seaside, forest, two-profile and free space area. The operating frequencies used to measure the clutter signals are 64, 151 and 434 MHz. There are four (4) levels of clutter strength; low, medium, strong and very strong that are divided based on the wind speed occurred during the measurements. The measured clutter signals are conformed to distribution models, such as Log-Normal, Log-Logistic, Gamma and Weibull distribution using curve fitting approach. This is to ensure the best fitted model which is validated by using goodness-of-fit (GOF) test namely root mean square error (RMSE), where the smallest error indicates the best model. At the end of the analysis, the simulated signals are compared with the measured signals in terms of its Doppler signal with the error below than 10%. The type of model obtained for the simulated signal with its shape factor is also compared to the model obtained from the measured signal. As for this thesis, only measured clutter signal for very strong seaside clutter is discussed due to number of results. It is found that 64 MHz clutter signal fits best to Weibull distribution and the error between the measured and simulated signal is 0.42%, 151 MHz clutter signal fits best to Gamma distribution with 3.42% error and Log-Logistic distribution suits best to 434 MHz clutter signal and the error is 7.69%. It is also found that there is a big difference between clutter model from United Kingdom and clutter model from this research. Lastly, a graphic user interface (GUI) is developed to generate the simulated signal by choosing the operating frequency, type of clutter strength and type of profile.

ACKNOWLEDGEMENT

In the name of Allah. The Most Beneficent and The Most Merciful

All praises to Allah the Al-Mighty for His blessing and guidance during the journey of my doctoral study. Without His blessing, my Doctorate experience would have not been possible.

First and foremost, I would like to express my deepest appreciation and gratitude to my supervisors, Dr Nur Emileen Abd Rashid and Dr Zuhani Ismail Khan for their precious constant guidance, advices, criticism, encouragement and tireless efforts in supervising of my thesis.

It is an honor for me to thank The Ministry of Higher Education Malaysia who has provided financial support throughout my study.

I owe my most sincere gratitude to my late father, Mr. Ismail Abdullah, my mother, [REDACTED] and my beloved husband, Abdul Razak Basarudin, for their endless love, constant support, great patience and extensive encouragement throughout my whole life. They have been always accessible and willing to give me suggestions when I faced challenges. I would also like to express my special thanks to my sisters; Nor Aida Ismail and Nor Izyan Ismail, my brothers; Ahmad Shahir Ismail and Ahmad Zuhri Ismail, my brother-in-law; Mohammad Nor Izam, my sister-in-law; Farah Razali, and my lovely niece; Puteri 'Aisyah Humaira, for their invaluable motivation, prayer and support. Not to forget, my beloved son, Uwais.

Last but not least, I could never put into words how much I am grateful to my friends for their sharing knowledge, support and academic discussions. The technical discussions with them are gratefully appreciated. I am pleased to extend my thanks to everyone else who helped me out with my academic career whether it was a professor or a staff member.

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	x
LIST OF FIGURES	xii
LIST OF NOMENCLATURES	xvii
CHAPTER ONE: INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	2
1.3 Research Objectives	3
1.4 Scope and Limitation of Work	4
1.5 Significance of Study	5
1.6 Thesis Organization	6
CHAPTER TWO: LITERATURE REVIEW	8
2.1 Introduction	8
2.2 Radar	8
2.3 Forward Scatter Radar (FSR)	11
2.3.1 Potential Application of FSR	15
2.4 Clutter	18
2.4.1 Ground Clutter	18
2.5 Statistical Distribution Model	20
2.5.1 Log-Normal Distribution	22
2.5.2 Log-Logistic Distribution	24
2.5.3 Gamma Distribution	25
2.5.4 Weibull Distribution	26

2.6 Goodness-of-Fit (GOF) Test	27
2.7 Summary	28
CHAPTER THREE: HARDWARE DEVELOPMENT	29
3.1 Introduction	29
3.2 Research Methodology	30
3.3 Hardware Development	32
3.3.1 Narrow Band Module Evaluation Kit	32
3.3.2 Hardware Block Diagram and Assembling	35
3.3.2.1 Transmitter	35
3.3.2.2 Receiver	36
3.3.2.3 Sensor	39
3.4 Calibration Testing	41
3.4.1 Transmitter Module	41
3.4.2 Receiver Module	45
3.5 Two-Ray Path Propagation Losses	48
3.6 Receiver Detection Curve and Attenuator	53
3.7 Summary	55
CHAPTER FOUR: EXPERIMENTAL DATA COLLECTIONS	57
4.1 Introduction	57
4.2 Data Collection Set-Up	57
4.2.1 Outdoor Measurement Set-Up	58
4.2.2 Board Test	59
4.2.3 Wind Speed Measurement	62
4.2.4 Data Acquisition	64
4.3 Measurement Test Sites	66
4.3.1 Site Selection	67
4.3.2 Seaside	67
4.3.2.1 Pantai Seberang Marang, Terengganu	68
4.3.2.2 Pantai Kelulut, Terengganu	69
4.3.3 Forest	69
4.3.3.1 Forest Research Institute Malaysia (FRIM), Kepong	70