CHAPTER 1
INTRODUCTION

1.1 Background

Radar is an electromagnetic sensor for object or target detection, where some information such as position, distance, speed and characteristic can be known. It operates using the principle of radiation of electromagnetic wave, where the echo will be obtained from the reflection of electromagnetic wave of object or target [1]. Reflection of electromagnetic waves from the object will be processed in the radar signal processing to find out the information of the object. Radar can be designed to see through conditions impervious to normal human vision, such as darkness, haze, fog, rain and snow [2]. Radar has several advantages, such as being able to measure the distance, position, speed and other characteristic of object.

Based on the type of waveform, there are two types of radars, Continuous Wave (CW) Radar and Pulse Radar [3]. CW radar is the simplest radar waveform which is transmitted continuously while receiving target echoes on a separate antenna. While, pulse radar will transmit the pulses waveform and then the radar system will be switch to receiver part for getting the echo signal from a target, because pulse radar will share the same antenna between transmitter part and receiver part [3]. Most of the modern radar systems employ a pulsed waveform which provides range information accurately. The primary advantage of pulsed radar is the transmitter and the receiver can share the same antenna due to pulsating nature of the waveform. In this thesis we design and analyze some waveforms for radar pulse compression.

1.2 Description Method

A good radar system can detect two or more targets with long distances, where the distance between each target is very close, the parameter of range resolution in radar system will separate closely spaced targets and it relates to the pulse width of the waveform [5]. Waveform design of radar is an important part for radar performance. Two important parameters that obtained by waveform design are detection of maximum range and resolution of radar [4]. The parameter of power transmits will be influence to detection range of radar. Increasing the power transmits will improve the range of radar detection because it equals to increase the pulse energy of radar. But this conventional method required big power supply, big dimension, safety and reliability problem in the radar [1].

The high resolution of radar can be achieved by narrowing the pulse width of the coming signal from the object reflection. But if the pulse width is decreased, the amount of energy in the pulse is decreased and hence maximum range detection will be reduced [5]. To overcome limitation problem between parameters of detection and parameter of resolution, pulse compression is used in the radar systems.

Pulse compression is a technique of transmitting pulses with long durations, so the high energy of the pulse can be maintained to obtain the maximum detection while compression process is done in the receiver to produce a much narrower pulse width to obtain the high resolution of radar. In pulse compression technique, the echo signal has received by radar receiver, it will pass through the matched filter to maximize the output of Signal to Noise Ratio (SNR) [4]. The results of previous research, some methods or techniques have been developed in the pulse compression process to obtain a better level of radar performance. The waveform design of pulse compression is usually using frequency or phase modulation [8]. Linear Frequency Modulation (LFM) is pulse compression type which is commonly used in current radar systems because of its simplicity and doppler tolerant [6]. However, this pulse compression has a drawback in its high sidelobe level, the matched-filtered response of this waveform has a sidelobe level about -13dB to the peak of the main lobe at the receiver [7], [10], [11]. The high sidelobe will be decrease the radar detectability especially on the weak echoes of the target [6]. One of the solutions to reduce sidelobe level of LFM is required weighting function for pulse compression. Hamming, Kaiser and Chebyshev with LFM reduced the sidelobe level of pulse compression but with weighting function will be reducing the SNR of pulse compression [3].

Non Linear Frequency Modulation (NLFM) is another pulse compression technique to overcome this lack [6], [7], [9], [11]. NLFM waveforms can achieve the good range resolution and at the same time low range side lobe levels without windowing. NLFM didn't require any weighting function because they have inbuilt one [11]. This thesis will analyze some waveform of NLFM to improve the performance of radar pulse compression.

1.3 The Gap of Real Condition and Future

Some research to improve the performance of Non Linear Frequency Modulation (NLFM) have been done in 2011. Some methods of NLFM waveform have investigated for sidelobe reduction, their focus on three different aspects of the NLFM compressed pulsed i.e. SNR loss, maximum sidelobe level for Doppler frequency shift up to 20 KHz and the mainlobe widening [7]. In the same year, the efficient NLFM waveform for high-resolution surveillance radar have been done where comparative study between NLFM and LFM waveforms had been performed [13]. Then in 2015, comparison between LFM waveform and some NLFM waveform have integrated with FPGA that have compared to obtain the lowest sidelobe [9] and in the same year, S-shaped of NLFM waveform is analyzed for the performance of detection times [11]. In 2016, pulse compression using curve-shaped NLFM was introduced for sidelobe suppression with the best achieve in PSL -18.6 dB [6]. This thesis will analyze some waveform of NLFM for radar pulse compression, such as S-shaped, Curve-shaped, Tri Stage Piece Wise (TSPW) and Taylor. The shaped will be investigated and optimized to improve the performance of pulse compression.

1.4 Problems

The problem of this thesis as follows:

1. Linear frequency modulation (LFM) is a waveform type in pulse compression which commonly used in radar pulse compression. But this method has high peak sidelobe level about -13 dB which will reduce the radar detectability especially on the weak echoes of a target.
2. Some Non Linear frequency modulation (NLFM) waveforms have a different performance for radar pulse compression.
3. Doppler effect is the important parameter in the radar where LFM method has a good doppler tolerance. So, we have to evaluate the doppler effect of some NLFM method.

1.5 Objectives

The purpose of this thesis as follows:

1. Find a new method to overcome LFM problem by suppressing the sidelobe level of pulse compression using Non Linear Frequency Modulation (NLFM) to improve radar detectability without additional weighting function.
2. Compare and evaluate some types of NLFM waveform, that is NLFM Tri Stage Piece Wise+, NLFM Tri Stage Piece Wise-, NLFM S+, NLFM S-, NLM Curve+, NLFM Curve- and NLFM Taylor.
3. Evaluate some parameters assessment of the NLFM waveform to improve the performance of radar pulse compression for peak sidelobe level, width of mainlobe, pulse compression ratio, background noise and Doppler effect.

1.6 Hypotheses

The NLFM waveform is designed to provide the desired amplitude spectrum so that there is no time or frequency weighting [4]. In the NLFM method some optimizations are performed with various of waveforms model such as S-model, Curve model, Tri Stage Piece Wise model and Taylor model. Some pulse compression parameters will be tested to analyze the performance of some NLFM waveforms, which is best for increasing pulse compression, especially for sidelobe level presses and increased the range of resolution. NLFM waveforms have many models that will be divided into two major groups, where each group has a point of strength and weakness to improve pulse compression performance. The first group of NLFM will suppress the sidelobe level of pulse compression, but the second group will reduce the width of pulse compression.

1.7 Scope of Work

The work contains of three parts activities below:

1. Designing NLFM waveform for NLFM Tri Stage Piece Wise+, NLFM Tri Stage Piece Wise-, NLFM S+, NLFM S-, NLFM Curve+, NLFM Curve- and NLFM Taylor.
2. The research utilizes MATLAB and Microsoft Excel for data collecting and analysis.
3. Analysis of performance NLFM waveform for Peak Sidelobe Level (PSL), Width of Mainlobe, Pulse Compression Ratio (PCR), Background Noise and Doppler Effect.
4. Experiments Models and Applications for Surveillance Radar.