CHAPTER 1
INTRODUCTION

1.1 Background

Small displacement is a parameter used to identify phenomena or problems in a number of fields. The displacement of the soil surface in the slope area can be used to predict landslides. The shift that occurs on the slope before the landslide occurs slowly and can be categorized as a small displacement. By monitoring small displacements, landslides can be anticipated and can assist in the disaster mitigation process [1-2]. In large civil building structures such as long bridges, and high rise building then the structure health can be influenced by the burden occurring and environmental conditions. Mitigation of the impact of structural failure that may occur needs to be done, therefore it is necessary to monitor the small displacement in these structures [3]. Another phenomenon of small displacement is the vibration of large mechanical structures. Vibration at a certain scale can be associated with problems in mechanical systems [4, 5]. Vital signs in humans such as breathing or heart rate can be detected based on a small displacement event related to respiratory activity or heart rate. For example, human breathing can be detected based on the movement of the chest wall and abdominal wall when inhaling and exhaling.

The detection method using contact sensors in some needs is not suitable to be applied and creates new problems. For example, to detect a small displacement over a large area such as a landslide or large building, a large number of contact sensors are required in its implementation. Installation and collection of data from many sensors will provide complexity in implementation. The use of contact sensors to measure or detect breathing poses constraints on hygiene and comfort aspects. The development of non-contact sensors for small displacement detection then becomes an interesting research topic. For example, the use of optical sensors such as cameras was used in the development of non-contact displacement detection methods [6]. The accuracy that can be achieved is 6.5 mm at 200 m. However, this method is limited with the need for sufficient light intensity and the presence of barrier. Exploiting the varying reflection coefficient of the antenna when the antenna located close to the vibration target also proposed, however this method only provides a good detection result when the distance detection is small [4].

Radar system has been studied as a method to detect small displacement phenomenon. A number of research in developing non-contact sensors for small displacement based on radar systems have been performed in a number of cases such as Structure Health Monitoring [3], vibration [4, 5], and vital sign detection [7-10]. The continuous-wave (CW), frequency Modulated continuous wave (FMCW) and ultra-wideband (UWB) radar systems have been adopted in the detection of human vital signs. In conventional radar perspective, small displacement means the need of radar with high resolution detection capability. A very large bandwidth is required to obtain the detection capability [11, 12]. Increasing the bandwidth will give several consequences such as hardware complexity, interference problem and regulation that need to be considered in the implementation.

Several studies to improve detection accuracy have been suggested previously [13-16]. Developing a radar system with better accuracy without increasing bandwidth is expected in developing non-contact sensors for small displacements. Making use of the phase information from the radar signal can be used to improve accuracy. A number of methods have been proposed as phase detection methods such as demodulation IQ and Six Port Network. Demodulation IQ has been studied for a phase detection mechanism in FMCW signals [17-19]. Six Port network has also been proposed in detecting the phase of radar signal [20, 21]. CW radar has lower bandwidth than other radar system, however the radar has a limitation on detecting the target distance. In detecting the small displacement, the location information is also important. in this research the improvement of CW radar system by generating multi-frequency of sinusoidal signal within a certain frequency range. The cross correlation and IQ demodulation are employed for further processing of radar output in order to achieve the detection capability that included distance detection and small displacement detection. Noise is important problem in radar system that need to be investigated to anticipate the reduction in detection performance. Amplitude and phase noise are considered in this radar system. The phase detection result that represented the small displacement detection result is potentially influence by the phase noise that arise from multi-frequency signal generator. Theoretical analysis and simulation experiment were conducted to study the MFCW method performance in detecting small displacement under noise condition.

This research proposes to assess the MFCW radar system's ability to detect small displacements under noise condition. Cross-correlation and demodulation of IQ are used for further processing of the radar output to achieve detection capability. Theoretical analysis and simulation experiments were carried out to study the proposed method. Simulation studies and laboratory experiments for the detection of small displacement over large areas will be carried out on a basis using non-contact sensors. Software Defined Radio (SDR) is a technology used to realize a wireless system through software [10]. Vector Network Analyzer (VNA) is a measuring tool used to measure the scattering parameters of a N polar network or system. A study on the implementation of the MFCW Radar system for small displacement detection using SDR devices and VNA devices was carried out in this study. BladeRF is one type of SDR device which is then used in experiments.

1.2 Problem Identification

The MFCW radar system has several advantages such as small bandwidth for small displacement purpose and the capability in detecting the target distance from the radar. However, the use of a number of sinusoidal signal generators for generating MFCW signal has the potential to increase phase noise. Therefore, that the influence of phase noise and noise amplitude needs to be investigated to get the description of MFCW radar performance in detecting small displacements under the influence of noise.

1.3 Objective

The purpose of this study is to analyze the performance of the MFCW system in detecting small shifts with a size of 2 mm - 5 cm which can later become a reference for implementation of a number of landslide area monitoring systems, monitoring the condition of large structures or mechanical structures and detecting vital signs in humans such as heart rate and respiration using non-contact sensors.

1.4 Scope of Work

The limitation of the problem that will be discussed in this research is research based on the detection of small displacements over a large area by taking into account a number of problems such as low bandwidth, low power and it is possible to realize it by analyzing whatever the effect of noise in this MFCW system method. Noise Amplitude and Phase Noise are aspects of noise which will then be studied in the MFCW system in small displacement monitoring. The testing phase was carried out with computer simulations and simulations with laboratory testing with SDR and VNA-based implementation experiments. .

1.5 Research Methodology

In this thesis I will carry out several steps that are carried out, namely identifying the effect of the assessment parameters and the performance of the MFCW Radar system and simulation analysis will be carried out by modeling computer simulations using numerical computational software and then in the second stage analysis of laboratory experiments using SDR and VNA will be carried out.

1.6 Hypothesis

The expected result of this research is to identify the effect of each parameter in the Radar system in detecting small displacement which is more efficient for monitoring large areas on a non-contact sensor basis. Further research on the ability to detect targets under noise conditions which can be used as a reference for development, as well as the efficacy of the proposed method to support low-power radar systems and reduction of frequency spectrum ocupancy**.**

1.7 Stucture of Thesis

The rest of this thesis is organized as follows:

Chapter II Basic Concept

This chapter contains basic concepts and theories related to research.

CHAPTER III THE PROPOSED METHOD AND RESEARCH METHOD

This chapter as a whole discusses the methods proposed for research and plans the structure of the methods to be used in the research.