CHAPTER I
INTRODUCTION

1.1 Background

Radar (radio detection and ranging) in many applications provides advantages in the detection process of non-contact with the object. One application of radar in the process is detecting vital signs of breathing. The non-contact respiratory detection process provides benefits in wider fields such as in the disaster mitigation process to detect victims behind the rubble, the health sector in the process of monitoring patient breathing, and the military sector in supporting the identification of enemies hiding behind walls [1][2]. Research on respiratory identification using radar has been carried out using Ultra-Wideband (UWB) radar [3],[4], Continuous Wave (CW) radar [5], and Frequency Modulated Continuous Wave (FMCW) radar [1],[2],[6]. The FMCW Radar type has advantages over others such as the ability to detect multi-targets [7], simple transmitter architecture, and resistance to interception [8],[9]. With this capability, the FMCW radar can be used to detect human breathing in more than one object.

Respiratory detection using FMCW radar uses the phase detection method to process FMCW output with increased resolution [2],[6]. Wide bandwidth is needed in phase processing in detecting vital signs on multi-targets. From the hardware side, it is done by improving the demodulation technique on the receiver side. The beamforming method is a technique that has the potential to be used to detect multi-target respiration by improving the beam direction to select and direct the beam in a certain direction. All objects in different directions with the same distance from the antenna receive almost the same power level [10],[11]. This technique can improve the radar's ability to detect multi-targets in different directions without having to move the antenna using a mechanical motor drive system [11].

Buttler Matrix (BM) is one of the low-cost, simple, wider bandwidth, and widely used passive network switching beamforming methods [12],[13]. The use of BM in C-

Band has been proven to produce beams in different directions with high gain values [13]. Other research [14] has been conducted at a working frequency of 60 GHz for 5G cellular communications using microstrip lines as transmission lines. The design made at mm-wave frequencies has a very small transmission line width. Radar devices used in detecting small breathing displacements generally work at millimeter wave (mm-wave) frequencies. In the implementation of microstrip lines in mm-wave, there are constraints on the dimensions of the small cross-section and conduction losses in the microstrip line become more significant because electron currents tend to flow on the surface of the conductor with a lower depth. This can result in increased power losses in the form of heating in the conductor. In detecting small breathing displacements, the reflected signal from the target is very small so the attenuation problem becomes a concern in choosing a transmission line.

Further research [15] on automotive radar with a frequency of 24 GHz. The system developed is compact and low-cost, using a Substrate Integrated-Waveguide (SIW) antenna array and 4×4 matrix beamforming. The results showed that the target was successfully detected using a four-element BM with higher returned signal power which can increase the radar range. The use of SIW at high frequencies has been proven to provide advantages in terms of transmission. SIW can be equivalent to a rectangular waveguide containing a dielectric that shows a mode dispersion similar to Transverse Electric mode 10 (TE10).

From several studies described above, it can be concluded that BM can be used to direct the beam antenna in a certain direction. However, there has been no study discussing BM used in small displacement detection radar. In this thesis, a beamforming system is proposed on a 24 GHz FMCW radar that has more than one beam (multi-beam) so that it can improve the radar's reception capability in detecting small displacement breathing of several objects. Improving the demodulation technique on the radar receiver side is expected to produce several antenna beams that can reach targets in different directions. The use of the Substrate Integrated Waveguide (SIW) technique on the beamforming transmission line allows for reducing losses that occur on the mm-wave transmission line so that the reflected signal from the object can increase. This study was conducted to prove the truth of the beamforming concept in multi-target detection.

1.2 Problem Formulation

To detect small changes in the breathing process, a very wide bandwidth is required. The respiratory signal reflected from the target and received by the radar has a small amplitude so that the signal will be reduced when there is noise from the reflection of surrounding objects. Improved demodulation on the radar receiver side by using a beamforming network to select and direct the beam in a certain direction in multi-target respiratory detection needs to be studied and reviewed to produce an antenna beam that can reach targets in different directions.

Radar devices used in detecting small respiratory displacements generally work at mm-wave frequencies. In mm-wave, attenuation constraints on the transmission line can cause the signal from the target to be distorted so that the information obtained cannot be read by the radar. The a need for a study of the beamforming transmission path using SIW that works at a frequency of 24GHz so detecting small shifts in human respiratory on several targets can be identified.

1.3 Objectives

The thesis research was carried out to design an FMCW radar beamforming system using the Substrate Integrated Waveguide (SIW) technique. The resulting beamforming works in the 24 GHz frequency range. The resulting beamforming is expected to be able to point in a certain direction so that it can detect several targets. The results of this design are expected to prove the truth of the beamforming concept in directing the beam to select targets in different directions.

1.4 Scope of Work

Based on the problem formulation, the scopes of the problem in this thesis are:

1. This research focuses on the design and realization of butler matrix beamforming using the SIW technique.
2. The proposed SIW will work at a frequency of 24 GHz and the design and simulation process will be carried out using software to obtain parameter data for the beamforming method being developed.
3. This experiment was designed to assess the characteristics of the transmission line using the SIW technique and the accuracy of the proposed method, as well

as to evaluate the phase difference at the butler matrix output to produce a 4-way beam in experiments detecting the breathing process.

4. The prototype beamforming testing stage is carried out on a laboratory scale to collect data on the parameters of the fabrication results and detect small movements in the breathing process.

1.5 Methodology

The process steps in completing this thesis are as follows.

1. Literature Study

   At this stage the concept of the proposed method is studied and reviewed by collecting literature studies from papers, journals, previous research, and books related to radar system information that will be used in breathing detection, Butler Matrix beamforming systems, phased array antennas, and transmission line techniques using Substrate Integrated Waveguide (SIW).

2. Beamforming Method Design

   The design was carried out to determine the 24 GHz FMCW Radar beamforming method that will be used to produce the expected beam and comply with the provisions. Designing a simulation model using computer simulation is also carried out as a representation of beamforming.

3. Simulation and Experimentation Process

   After the design process is carried out, a simulation will be carried out to validate the concept obtained through the literature study and prove that the expected hypothesis can be realized. Next, the testing process in the laboratory is carried out with several parameters being tested so that the results obtained can be used as a basis and later results can be obtained that can be used to improve the Radar system equipment so that when testing is carried out in the field, results can be obtained that meet the hypothesis.

4. Data Processing and Analysis Process

   After the data from the previous step is collected, the data will be processed to analyze the performance of the beamforming that was created. In addition to the data from the beamforming prototype, the data in the detection process is processed to extract the breathing signal received from the beamforming device that was created. The data will then be further analyzed to determine whether the proposed system can produce 4 beam directions that can improve the radar's ability to detect small breathing displacements of several targets in different directions.

5. Conclusion

   The analysis obtained through the entire process will be concluded and used to answer the problems raised in this thesis research.

1.6 Thesis Structure

This research is divided into several topics of discussion which are systematically arranged as follows:

Chapter 1 INTRODUCTION

This chapter contains the background, problems, objectives, research methods, and systematic writing.

Chapter 2 BASIC THEORY

This chapter contains an explanation of the theory, tools, and equipment used.

Chapter 3 PROPOSED METHOD

This chapter contains the method that will be used to solve the problem.

Chapter 4 RESEARCH METHODOLOGY

This chapter contains the workflow and system design flow.

Chapter 5 RESULTS AND ANALYSIS

This chapter contains the steps of the test, results, and an analysis of the test results obtained.

Chapter 6 CONCLUSION

This chapter contains the conclusions and suggestions of this thesis.