1. Introduction

This project has been conducted in Laboratoire d'Electronique, Antennes et Télécommunications (LEAT) in Sophia Antipolis and is funded by Universiti Malaysia Pahang (UMP) under the doctorate grant awarded by the Ministry of Education Malaysia (MOE). The supervisor for this project is Claire Migliaccio (Professor at University Nice Sophia Antipolis) and assisted by Jerome Lanteri (Associate professor at University Nice Sophia Antipolis).

The objective of this project is to design and fabricate a reconfigurable reflectarray with beam scanning capability at 20 GHz for unmanned aerial system (UAS) communication link. Reflectarray is a type of antenna that shares similar functionality to parabolic reflector antenna. The main difference is the physical and geometry appearance of the antenna where reflectarray has flat reflecting panel instead of parabolic reflector. The reflecting panel consists of elementary cell which is used to control the reflected phase of the incident wave. By controlling the reflected phase on each elementary cell, the radiation pattern of the antenna can be focused to any desired direction.

The integration of the phase control mechanism in the elementary cell is the main challenge that needs to be solved and studied. This consists of understanding the theory of the reflectarray, designing the reconfigurable elementary cell with optimum performance and cost effective material, evaluating the reflectarray performance and integrating the phase control system.

This manuscript is written in 4 main chapters. The first chapter discusses the introduction of the reflectarray, the beam scanning working principle and the latest technologies existing to create a reconfigurable reflectarray. This chapter also presents the chosen technology and discusses the main reason behind the choice.

The second chapter is about the reflectarray theory and the different calculations to produce radiation pattern of the reflectarray. These calculations are used to create in house reflectarray simulator in order to help and to accelerate the design process of the active reflectarray.

In third chapter the process of designing a reconfigurable elementary cell is discussed and explained. Material comparison is made to evaluate the improvement over the reflectarray performance. Simulation results are shown in order to demonstrate the beam scanning capability achieved using the active cell.

The final chapter shows the work realized for the diode controller part which is used to steer the focused beam direction. This includes the simulation, fabri-
cation and validation of the diode controller circuit using LED panel matrix that represented the phase distribution of the reflectarray.

General conclusion is made in the end of the fourth chapter. The overview of the project completion and the possible improvement for the future work are discussed in this section.
2. Bibliography

2.1. Overview

Antenna is the critical part in any wireless communication system, where antenna is functioning as the main entrance or departure point in signal reception and transmission. This main point needs to be optimized and carefully designed in order to ensure the functionality of the communication system. There are many types of antennas in different physical forms and technologies for different types of applications. Recently, radar application has been identified as an important application in security and imaging fields, especially in aviation industry.

Radar application requires antenna with high directivity and low secondary lobes. In this application, antenna array is among of the good candidates. By combining small unit of antenna into arrays, the directivity of the antenna can be increased and there is possibility to control the focused beam direction. Antenna array uses microstrip lines to feed the antenna unit. As the size of the array increases, the design of the feed lines will be more complicated and this will increase the loss in the feed transmission lines. To overcome these problems, the transmission lines can be replaced by optical transmission. This is similar to parabolic reflector antenna, which uses optical feed as the primary source. In this category, antenna is able to function based either on transmission or reflection method. When the method chosen is based on the transmission, the antenna is known as “transmitarray” and when the method is based on the reflection, the antenna is known as “reflectarray”.

Both methods share the same designs complexities, which reside in the design of the unit cell or known as the elementary cell. To create a large antenna, the same unit cells designs are combined together. This simplifies the process to create and design passive or active antenna because the same units cell design is repeated for the whole structure. [1] is the recent examples of the reflectarray designed for radar application. The reflectarray functions at 120 GHz and has been designed to enable active phase shifter integration to achieve electronic beam scanning capability.

Beside radar application, there are recent applications which function above 100 GHz and at sub-millimeter wavelengths, such as earth observation, imaging system, and molecular spectroscopy [2, 3, 4, 5] that require reconfigurable reflectarray. Such requirements have created interest among researchers and engineers to design active reflectarray and create new different technologies for controllable reflectarray. This includes MEMS [6], non-linear material such as Ferroelectric films [7] and liquid crystals [8].