A DESIGN AND DEVELOPMENT OF ANTENNA ROTATIONAL TABLE SYSTEM FOR RADIATION PATTERN TEST FOR SMALL SIZE ANTENNA

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Supervisor Name : Mr. Imran bin Mohd. Ibrahim

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I dedicated this book to my beloved family; father, sisters and brothers and not forgotten UTeM's lecturers and my fellow's friend.

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Assalamualaikum w.b.t………

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whose contribute their help and support to me. Without all the guidance and help from these people I wouldn’t get to finish this project.

ABSTRACT

This project was to design and development of antenna rotational table for small size antenna radiation pattern. Small size antenna is referred to as a microstrip antenna which has a low profile, low weight and small in size. The antenna rotational table design and development consists of hardware and programming implementation. In order to meet the project requirement, a necessary study had been conducted for types of motor available in market. The study is needed to find the most appropriate motor for the table rotation. For microstrip antenna radiation pattern test, the motor must be able to rotate until 180^o but more is better. Antenna radiates in all direction with a different signal level at each point of angle. Thus, a step by step motor is required. The motor will need a controller to run in a desired movement. A PIC is needed for the control purpose. A details study had been done to ensure how the selected motor and an appropriate PIC should be used. In the meantime, the controller circuit is designed and implemented for a complete system.

ABSTRAK

Projek ini dijalankan adalah untuk membina meja putaran antena untuk ujian corak radiasi antena bersaiz kecil. Antena saiz kecil merujuk kepada antena *microstrip* yang kurang menonjol, ringan dan bersaiz kecil. Proses penciptaan dan pembinaan meja putaran antena merangkumi implementasi alat dan pengaturcaraan. Untuk memenuhi kehendak projek, kajian jenis-jenis motor yang terdapat di pasaran telah dilakukan. Ini adalah untuk membolehkan pemilihan motor yang paling sesuai untuk meja putaran tersebut. Untuk ujian corak radiasi antena *microstrip*, motor tersebut harus mampu berputar sehingga 180^{o} ataupun lebih. Antena beradiasi ke semua arah dengan nilai isyarat yang berbeza bagi setiap sudut. Oleh itu, motor yang diperlukan adalah motor yang bergerak dalam urutan langkah bersiri. Motor tersebut juga memerlukan pengawal supaya motor itu boleh dikawal pergerakannya. PIC diperlukan untuk tujuan ini. Kajian dan analisa yang menyeluruh dan terperinci dilakukan untuk mengenalpasti cara motor yang dipilih berfungsi dan jenis PIC yang paling sesuai digunakan. Pada masa yang sama, litar pengawal juga dicipta dan dibina untuk mendapatkan satu sistem yang sempurna.

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ABBREVIATION

AC	Alternating current
ASM	Assembly Language
AUT	Antenna Under Test
CCW	Counterclockwise
CW	Clockwise
DC	Direct current
DSP	Digital Signal Processing
HB	Hybrid
I/O	Input/Output
PCB	Printed Circuit Board
PIC	Programmable Interface Controller
PM	Permanent Magnet
RAM	Random Access Memory
RF	Radio Frequency
VR	Variable Reluctance

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CHAPTER I

INTRODUCTION

This chapter contains the objectives of the project, scope of work and problem statement that draws to the project development and implementation.

1.1 PROJECT OBJECTIVES

There are four main objectives declared for this project to ensure the project target. The objectives of this project are as follows:-

a. To study and understand an antenna measurement is taken for antenna radiation pattern.
b. To study, design and develop an antenna rotational table system using assembly language programming and controller circuit.
c. To learn and practice technical skills to overcome problems occurred in implementing the project.
d. To analyze the system performance for project goal achievement confirmation by comparing it to the theoretical or expected results (analytical skill).

1.2 SCOPE OF WORK

The project implementations are divided into three parts that are programming implementation, hardware implementation and test and analysis. All these parts are explained below:-

a. Part I – Programming implementation
   - Make a comparison of current software available and choose the best one that suits the project program requirement.
   - Design and develop a programming to control and construct the antenna rotational table movement for antenna radiation pattern test.

b. Part II – Hardware implementation
   - A controller circuit is design and construct due to the project requirement.

c. Part III – Test and Analysis
   - An analysis will be performing on every project stage to prevent an error or poor performance at the end of project.
   - The test and analysis are including simulation and experimental.
   - It is constructed to evaluate the performance of the final product and compared to theoretical result to ensure that the system satisfy the objective of project.

1.3 PROBLEM STATEMENT

This project was encouraged from the idea of providing a simple and low cost solution for a small size antenna radiation pattern test. As known, all antennas have directional qualities. They do not radiate power equally in all directions. Different antenna will have different radiation patterns. An antenna under test (AUT) usually will be put on the receiver mode, rotate 360º and radiation intensity received will be plot in a polar or rectangular form. Regarding to the measurement process, the system design should provide the user the ability to measure the antenna radiation pattern in each angle.

CHAPTER II

LITERATURE REVIEW

The antenna rotational table system contains of a hardware which is a controller circuit and a programming, a set of program to be use together with the circuit. There are a few types of motor that serve a rotational function. An appropriate motor for the antenna rotational table chose by studying the various types of motor in market. Since, the rotational table constructed is for antenna measurement, it is important to study on the antenna operation itself. This chapter will discuss about antenna and its radiation pattern test, motor types and a PIC.

2.1 ANTENNA

Antenna is a device that transmits and/or receives electromagnetic waves. By a definition, an antenna acts as a transducer between a guided wave in a transmission line and an electromagnetic wave in space. Antennas are the fundamental component of a modern communication system and the most visible part of the satellite communication system. The antenna transmits and receives the modulated carrier signal at the radio frequency (RF) portion of the electromagnetic spectrum. Antennas demonstrate a property of reciprocity that is an antenna will maintain the same characteristics regardless if it is transmitting or receiving. When a signal is fed into an antenna, the antenna will emit radiation distributed in space a certain way. [1]

2.1.1 Small Size Antenna

Small size antenna can be referred to as microstrip antenna. These antennas are low profile, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces and when the particular patch shape and mode are selected, they are very versatile in terms of resonant frequency, polarization, pattern and impedance.

Often microstrip antennas are referred to as patch antennas. The radiating elements and the feed lines are usually photoetched on the dielectric substrate. The radiating patch may be square, rectangular, thin strip (dipole), circular, elliptical, triangular or any other configuration. Square, rectangular, dipole (strip) and circular are the most common because of ease of analysis and fabrication, and their attractive radiation characteristics, especially low cross-polarization radiation.

Major operational disadvantages of microstrip antennas are their low efficiency, low power, high Q (sometimes in excess of 100), poor polarization purity, poor scan performance, spurious feed radiation and very narrow frequency bandwidth, which is typically only a fraction of a percent or at most a few percent. [2]

2.1.2 Radiation Pattern

All antennas have directional qualities. They do not radiate power equally in all directions. Therefore, antenna radiation patterns or plots are a very important tool to both the antenna designer and the end user. These plots show a quick picture of the overall antenna response. Antenna radiation plots can be quite complex because in the real world they are three-dimensional. However, to simplify them a Cartesian coordinate system (a two-dimensional system which refers to points in free space) is often used. Radiation plots are most often shown in either the plane of the axis of the antenna or the plane perpendicular to the axis and are referred to as the azimuth or "E-plane" and the elevation or "H-plane" respectively.[3]

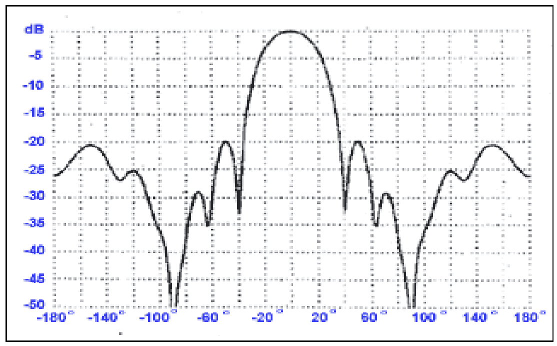

Figure 2.1: Radiation pattern in a rectangular azimuth plot presentation.[3]

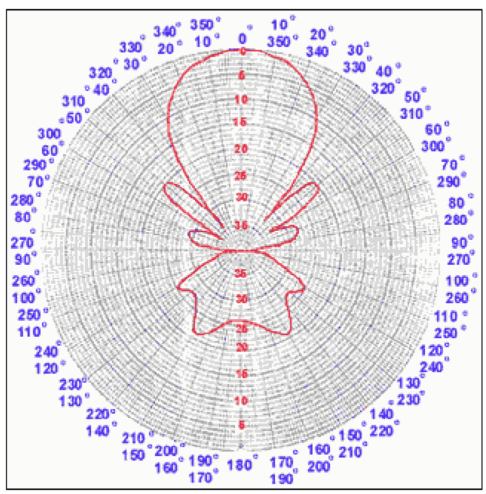

Figure 2.2: Radiation pattern in a polar plot presentation.[3]

The basic pattern-measurement technique that most people are familiar with uses a single-axis rotational pattern. This technique involves an AUT placed on a rotational positioner and rotated about the azimuth to generate a two-dimensional polar pattern. This measurement is commonly done for the two principal axes of the antenna to determine parameters such as antenna beam width in both the E and H planes.

Figure 2.3 shows a typical polar-pattern test setup. The AUT (a cell phone in this case) is placed on a rotating turntable, and a dual-polarized antenna is placed level with the AUT a fixed distance away. The turntable is rotated 360°, and the response between the antennas is measured as a function of angle. Normally, these measurements are performed in a fully anechoic (simulated free-space) environment, but sometimes it may be desirable to measure the pattern over conducting ground, or in some other as-used geometry to get real-world pattern information.[4]

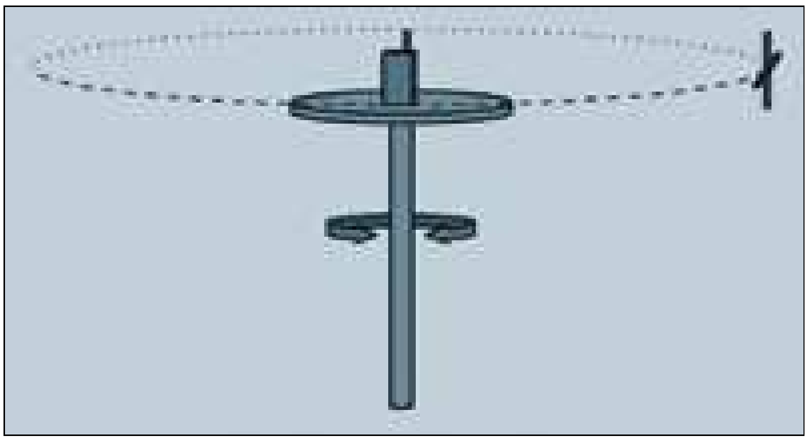

Figure 2.3: Test setup for single-axis polar pattern measurement.[4]

2.1.3 Antenna Rotation Table

Most of the antenna rotational table system in the market comes together as a complete antenna trainer. It contains receiver, transmitter, network analyzer, few types of antenna and some of the antenna trainer provides a PC-based system. Antenna trainer design also take in account of the antenna size which is a bigger antenna trainer design basically can be use for both small and large size of antenna types. A smaller size of an antenna trainer will be used for a smaller size of antenna such as microstrip antenna. A various types of antenna also provided for the test and measurement. The PC-based system provides control for the antenna rotational movement and result simulation using a computer to the user.

A microcontroller is used to control the antenna rotational movement. The antenna trainer is using a DC stepper motor since the power supply voltage needed to run the motor is small that is 6V – 12V. DC stepper motor used is high precision type to get accurate rotational position.

2.2 TYPES OF MOTOR

Electrical motors operate on the principle that two magnetic fields within certain prescribed areas react upon each other. All electric motors use electromagnetic fields to create torque. For many motion engineers, motor selection plays a central part in getting good device performance. Knowing which motor to use in a given application improves the cost, performance, and simplicity of your machine-design process. There are many different electrical motor types, all with their good and bad side. Motion control is the art and science of precisely controlling the position, velocity, and torque of a mechanical drive. Motion-control systems comprise a numerical controller that performs path generation, such as a DSP, an amplifier, and a motor. Positioning-control systems most often employ step motors, dc-brush motors, and brushless-dc (permanent-magnet) motors.

2.2.1 AC Motors

AC motors operate from alternating current (AC) power sources. Figure 2.4 shows the example of an AC motor feature. The magnetic fields typically are generated using coils on the rotor and stator, and the field movement occurs naturally in the stator due to the alternating nature of the input power. These motors are inexpensive to build and operate, reliable, and usually run from standard line power. The power supply frequency determines the speed of an AC motor, so if operated from line power, the speed of rotation is always the same. Variable frequency power drives control the speed of AC motors, but such drives are expensive. Different industries use lots of electrical motors in their applications.

AC induction motor is the most common motor used in industry and mains powered home applicants. Induction motors are also sometimes called squirrel cage motors because the appearance of early rotors. This type of motors are the most common type of industrial AC electric motor, being rugged and requiring neither a separate DC power source nor slip-rings. AC induction motors offer users simple, rugged construction and easy maintenance. An AC induction motor consists of two basic assemblies; stator and rotor, and is analogous to an AC transformer with a rotating secondary. The motor’s name comes from the alternating current (AC) induces into the rotor by the rotating magnetic flux produced in the stator. Motor torque is developed from interaction of currents flowing in the rotor bars and the stator's rotating magnetic field.[5]

Figure 2.4: Example of AC motor

2.2.2 DC Motor

The direct current (DC) motor is one of the first machines devised to convert electrical power into mechanical power. Figure 2.5 shows two examples of DC motor feature. Permanent magnet (PM) direct current converts electrical energy into mechanical energy through the interaction of two magnetic fields. One field is produced by a permanent magnet assembly, the other field is produced by an electrical current flowing in the motor windings. These two fields result in a torque which tends to rotate the rotor. As the rotor turns, the current in the windings is commutated to produce a