SIMULATION OF A 10 GHZ RECTANGULAR MICROSTRIP PATCH ANTENNA USING MICROWAVE OFFICE 2000

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Encik Kismet Hong Ping

03. 04. 2002

Date

SIMULATION OF A 10 GHZ RECTANGULAR MICROSTRIP PATCH ANTENNA USING MICROWAVE OFFICE 2000

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Dedicated to my beloved family and loved ones

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ABSTRACT

This research describes the design and simulation of the rectangular microstrip patch antenna using MicroWave Office 2000 version 3.22 and subsequently derives several relationships for the purpose to determine the performance of the antenna designed. This research involves software simulation, where several parameters comprising the frequency of operation, dielectric constant, type of dielectric material to be used, tangent loss, etc. were preset prior to the design of the antenna. MicroWave Office 2000 simulation software was used to generate the Smith Chart, VSWR, S11 Magnitude or Return Loss and Impedance Chart. From the charts generated, various results were then tabulated in tabular form. Previous works done by other researchers were also referred to.

ABSTRAK

Kajian ini membincangkan kaedah rekaan dan simulasi "rectangular microstrip patch" antenna dengan menggunakan perisian MicroWave Office 2000 versi 3.22 dan seterusnya mentakrifkan beberapa perhubungan dengan tujuan untuk menentukan tahap pencapaian antenna yang direka. Kajian ini melibatkan penggunaan perisian simulasi, di mana beberapa parameter melibatkan frekuensi operasi, pemalar dielektrik, bahan dielektrik yang akan digunakan dan sebagainya telah ditetapkan sebelum proses simulasi dan rekaan dimulakan. Perisian ini juga digunakan untuk menghasilkan Carta Smith, VSWR, S11 Magnitude atau Carta Return Loss. Daripada keputusan kajian dalam bentuk carta, ianya kemudian ditukar ke dalam bentuk jadual. Hasil kerja yang dilakukan ahli kaji selidik juga telah digunakan sebagai rujukan.

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CHAPTER 1

INTRODUCTION

1.1 Background

An important component in any radar or communication system is the antenna. Antennas play an important role in electromagnetic systems, for they form the only link between free-space and the system. In essence, an antenna is a component that converts a wave propagating on a transmission line to a plane wave propagating in free-space (transmission), or vice versa (reception) [3]. In a communications link, the microwave signal is radiated into space by an antenna at one end, and picked out of space by an antenna at the other end. The same antenna may be acted as both the transmission and reception units.

From the most common use of antennas in household television transmission to radar systems such as airport surveillance, marine navigation, etc., the quality of antennas is undeniably the top consideration in the designing process. Apart from that, the various types of antennas that suit its applications must also be taken into consideration.

1.2 Basic Types of Antennas

How an antenna operate is very much dependent on the geometry of it. In other words, the physical structure and its orientation diversify the characteristics of a typical antenna. Therefore, a wide variety of antenna types and geometries have been developed. The different types of antenna are such as [3]:

i. *Wire antennas* are the simplest types of antennas, and most of the earliest antennas (e.g., as used by Hertz and Marconi) were of this type. Wire antennas are easy to fabricate, easy to feed and are lightweight.

ii. *Rod antennas*. The diameter of the rod is significant. These antennas include whip antennas and dipoles of all descriptions.

iii. *Aperture antennas* are often just flared sections of waveguide, or even open-ended waveguides. Aperture antennas are most commonly used at microwave frequencies and have moderate gains.

iv. *Printed antennas* are a relatively new type of antenna comprising printed conductors on a microstrip or similar type of substrate. This makes them compatible with planar microwave circuit technology.

v. *Reflector antennas* achieve high gain by focusing the radiation from a small feed antenna with an electrically large reflector. They are relatively easy to fabricate and are rugged, but can be large and impractical.

1.3 Objectives

i. To design and simulate a 10 GHz rectangular microstrip patch antenna by using Microwave Office 2000.

ii. To learn more about the basic characteristics and operation of an antenna, and also the various parameters involved in designing the antenna.

iii. To learn antenna-designing software called Microwave Office 2000.

CHAPTER 2

LITERATURE REVIEW

2.1 Microstrip Transmission Line

A microstrip transmission line consists of a flat conducting strip suspended above the ground plane and being open on the top surface. The open structure means that the electromagnetic field is not confined to the solid dielectric, but is partly in the air space. The conducting strip is supported by a dielectric substrate. An example of a microstrip transmission line is shown in *Figure 2.1* below [5].

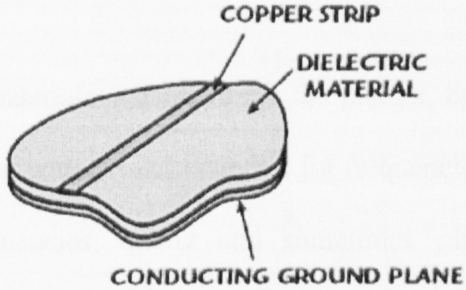

Figure 2.1 A Microstrip Transmission Line

2.2 Characteristics Impedance of Microstrip Lines

The characteristics impedance of a microstrip line is a function of the strip-line width, the strip-line thickness, the distance between the line and the ground the ground plane, and the homogeneous dielectric constant of the board material. Several different methods for determining the characteristic impedance of a microstrip line have been developed.

The better-known equation of the characteristic impedance of a wire-over-ground transmission line is given by [3]: -

$$Z_0 = \begin{cases} \dfrac{60}{\sqrt{\varepsilon_e}} \ln\left(\dfrac{8d}{W} + \dfrac{W}{4d}\right) & \text{for } W/d \leq 1 \\[2ex] \dfrac{120\pi}{\sqrt{\varepsilon_e}\,[W/d + 1.393 + 0.667 \ln (W/d + 1.444)]} & \text{for } W/d \geq 1 \end{cases}$$

where ε_e = effective dielectric constant

W = the width of the microstrip line

d = the height of the dielectric material

2.3 Dielectric Substrate

A range of substrate materials is available in the market, but for production runs alumina is the most widely used material, for frequencies up to about 20 GHz. At higher frequencies, quartz and sometimes sapphire, is used. Dielectric constant, loss tangent and the variation with frequency and temperature, homogeneity, and isotropicity are the substrate properties that have to be considered in choosing the desired dielectric substrate.

2.3.1 Dielectric Constant, ε

The dielectric constant is the *relative permitivity* (ε) of a material. It is dimensionless and always greater than 1. A dielectric constant of "1" is equivalent to the permitivity of a vacuum, which is a fundamental constant (associated with the speed of light). In other words, vacuum has the lowest possible permitivity [7].

Good substrates have dielectric constant tolerances of a few percent or less, but the real problem is caused by variations in permitivity across the substrate, which can be as high as 0.5 to 1 %, especially for high permitivity substrates. The higher the permitivity, the more the energy will be reflected inside the antenna before leaving it, and the more inferior and narrow-banded the antenna will get [7].

Microstrip circuits were originally confined to lower frequency applications (such as VHF or UHF) because of the apparently uncontrolled radiation, which took place at microwave frequencies. This characteristic was overcome when closely controlled high dielectric constant ceramic substrates became available and radiation was reduced to a tolerable level. Circuit patterns and ground planes are usually deposited on the substrates using thin-film or thick-film techniques.