Design and analysis of Rectangular Microstrip Patch Antennas

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ABSTRACT
Modern wireless systems are placing greater emphasis on antenna designs for future development in communication technology because of antenna being the key element in the whole communication system. The microstrip antenna in a system serves as the transducer between the controlled energy residing within the system and the radiated energy existing in free space Wireless technology is one of the main areas of research in the world of communication systems today and a study of communication systems is incomplete without an understanding of the operation and fabrication of antennas. In order to meet the miniaturization requirements of portable communication equipment, researchers have given much attention recently to compact microstrip antennas. Many related compact designs with broadband dual-frequency operation, dual polarized radiation, circularly polarized radiation, and enhanced antenna gain have been reported.

1. INTRODUCTION

Microstrip patch antennas were first proposed in the early 1970s and since then a plethora of activity in this area of antenna engineering has occurred, probably more than in any other field of antenna research and development. Microstrip patch antennas have several well-known advantages over other antenna structures, including their low profile and hence conformal nature, light weight, low cost of production, robust nature, and compatibility with microwave monolithic integrated circuits (MMICs) and optoelectronic integrated circuits (OEICs) technologies. Because of these merits, forms of the microstrip patch antenna have been utilized in many applications such as in mobile communication base stations, space borne satellite communication systems, and even mobile communication handset terminals.

Unfortunately, the expression, "there is no such thing as a free lunch," also applies to microstrip patch technology. Despite the previously mentioned features, microstrip patch antennas suffer from several inherent disadvantages of this technology in its pure form, namely, they have small bandwidth and relatively poor radiation efficiency resulting from surface wave excitation and conductor and dielectric losses. Also, to accurately predict the performance of this form of radiator, in particular, its input impedance nature, typically a full-wave computationally intensive numerical analysis is required Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are highly compatible for embedded antennas in handheld wireless devices such as pagers, cellular phones etc... The telemetry and communication antennas on missiles need to be thin and conformal and are often in the form of Microstrip patch antennas. Another area where they have been used successfully is in Satellite communication

2. Microstrip Patch Antennas

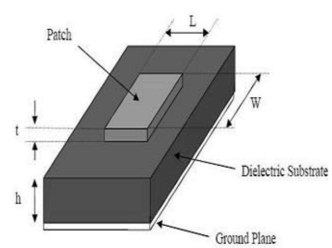

Fig.1. Structure of microstrip patch antenna

Microstrip antennas consists of a very thin metallic strip(patch) placed a small fraction of a wavelength above a ground plane. For simplicity of analysis, the patch is mainly square, rectangular, circular, triangular, and elliptical or some other usual shape. For a rectangular patch, the length of the patch is mainly in the range of 0.3333 0 < < 0.5 0, where 0 is the free space wavelength. The patch in which I am considering is to be very thin such that t << λo (where *t* is the patch

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thickness). The height *h* of the dielectric substrate is usually 0.003 $\lambda_o \leq h \leq 0.05\ \lambda_o$. The dielectric constant of the substrate (εr) is typically in the range $2.2 \leq \varepsilon r \leq 12$.
The microstrip patch is designed so its

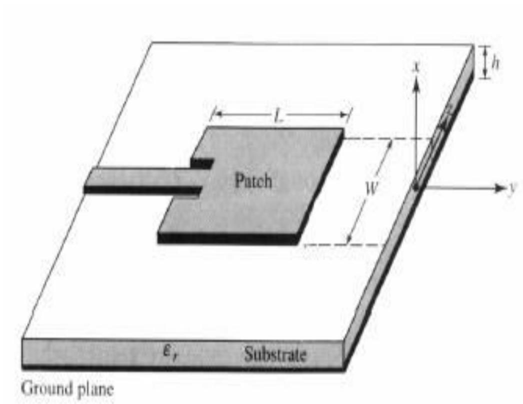

Figure 2: Microstrip antenna

3. Feed Techniques

Coaxial Feed

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As seen from Figure , the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

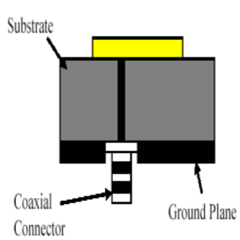

Figure:3 coaxial feed

Aperture Coupled Feed

In this type of feed technique, the radiating patch and the Microstrip feed line are separated by the ground plane as shown in Figure. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane. The coupling aperture is usually centered under the patch, leading to lower cross polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture. Since the ground plane separates the patch and the feed line, spurious radiation is minimized. Generally, a high dielectric material is used for the bottom substrate and a thick, low dielectric constant material is used for the top substrate to optimize radiation from the patch

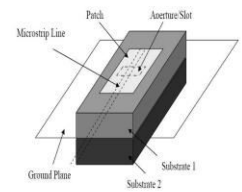

Figure 4 Rectangular Microstrip antenna Aperture coupled feed

Proximity Coupled Feed

This type of feed technique is also called as the electromagnetic coupling scheme. As shown in Figure two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate

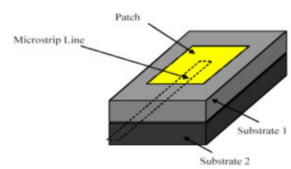

Figure: .5 Proximity coupling

4. Design of Rectangular Microstrip Patch Antennas

Based on the simplified formulation a design procedure is outlined which leads to practical designs of rectangular Microstrip antennas. The procedure assumes that the specified information includes the dielectric constant of the substrate (Єr),the resonant frequency(fr), and the height of the substrate h .The procedure is as follows:
Specify:
Єr,fr (in Hz), and h
Determine: W,L
Design procedure:
For an efficient radiator practical width that leads to good radiation efficiencies is

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}}$$

Determine the effective dielectric constant of the Microstrip antenna determine the length ΔL using

$$\frac{\Delta L}{h} = \frac{0.412[(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{\left[(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)\right]}$$

The actual length of the patch can now be determined by

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{reff}}\sqrt{\mu_0\varepsilon_0}} - 2\Delta L$$

Antenna Design at 9.5 GHz

IE3D is a software simulator. we can define different antenna parametes with the help of this software .As the inset feed-point moves from the edge toward the centre of the patch the resonant frequency also change.

Design parameters for MS antenna at 9.5 GHz

Substrate dielectric constant = 2.2
Height (h) = 1.588 mm
Patch dimensions (L) = 9.06 mm
Patch dimensions (w) = 11.86 mm
Feed Distance = 1.404 mm

5. Simulation Results

Return Loss

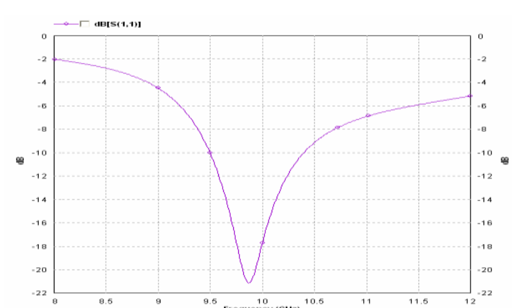

Figure 6 Simulated return loss characteristics at 9.5 GHz

Antenna Efficiency

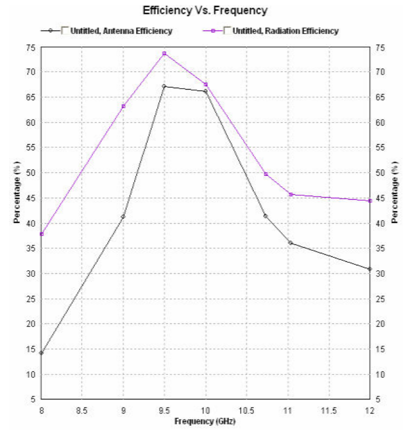

Figure 7 : Efficiency Vs frequency characteristics at 9.5 GHz

Principle Plane Patterns

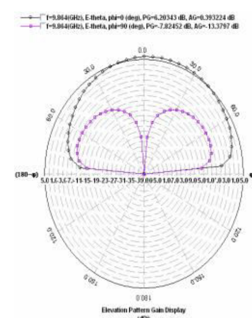

Fig.8 Elevation pattern display

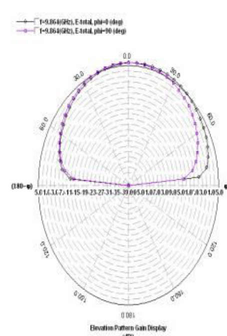

Fig.9 Elevation pattern gain display

6. Result

it is seen that the bandwidth is improved for Microstrip antenna rather than normal antenna and also the return loss characteristics significantly improved consequently a proper matching occurs

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