An Aperture Coupled Printed Antenna for Broadband Radio Services

Debashish Pal

Department of Electronics and Communication, Surendra Institute of Engineering and Management
Siliguri, India

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Abstract - *Microstrip patch antennas are increasingly finding applications in modern microwave wireless communication systems because of their various attractive features. A Microstrip patch antenna has been proposed in this project which resonates at 2.56 GHz. The proposed antenna uses aperture coupled technique to obtain a lower cross polarization and to facilitate better isolation between the patch and the feed circuit. Analysis of the structure is done by using An soft Designer. The antenna has low profile, is lightweight and can be easily integrated with other radio frequency circuits. The antenna inclusive of the size of the ground plane has dimensions 65 x 62 mm. The proposed antenna uses a silicon substrate having permittivity of $\varepsilon_r = 11.9$ and a Rogers RT droid super state having permittivity of $\varepsilon_r = 2.2$. Details of the measured and simulated results are presented.*

***Key Words*: Printed Antenna, Microstrip Feed, Return Loss, Aperture coupled antenna, Gain, Bandwidth**

1. INTRODUCTION

Modern wireless communication systems have undergone dramatic changes leading to an ever increased demand for portable printed antennas. Printed antennas originated from the use of planar microwave technologies such as microstrip, slot lines, coplanar lines etc. The first printed antenna was developed in the mid-1970's. Since their introduction they have evolved rapidly in order to to overcome the difficulties such as, narrow bandwidth, low overall efficiency and gain. They are used at frequencies ranging from UHF to millimeter waves [1]. Printed antennas have several advantages including, light weight, small dimension, ease of manufacture using printed circuit technology, ease of integration with other electronic components, conformal structure and possibility of integrating into arrays.

The basic patch antenna consists of a ground plane in the underside with a dielectric region separating the ground and the radiating patch. The electromagnetic waves fringes from the radiating patch into the substrate and are reflected by the ground plane into air. Because of this configuration printed antennas generally behave as resonators, having very low impedance bandwidth, typically a few percentage. The length of the patch determines the operating frequency whereas the width controls the input impedance. Patch width regulates the bandwidth as well as the radiation pattern of the antenna.

Microstrip patch antennas or printed antennas may be excited by different types of transmission lines. The different types of transmission lines include, coaxial, microstrip or coplanar. In electromagnetic coupling there is no direct contact between the radiating patch and the transmission line, but they are placed very close to each other to ensure coupling. The radiating patch may also be fed directly in which there is continuity between the transmission line and the patch.

Compared with classical edge or probe fed microstrip antennas, the aperture coupled microstrip antenna, has a number of advantages, such as isolation between the antenna and feed circuit, many possible variations in patch shape, aperture shape, feed line type, easy integration of arrays and active circuits [2]. It was first proposed by D M Pozar in the year 1985. In the aperture coupled microstrip antenna configuration, the field is coupled from the microstrip line feed to the radiating patch through an electrically small aperture or slot cut in the ground plane. To optimize the individual performances, two different dielectric substrates can be chosen, one for the patch and the other for the feed line. The shape, size, and location of the aperture decide the amount of coupling from the feed line to the patch. The aperture is usually centered under the patch, which leads to lower cross-polarization [3]. The coupling to the patch from the feed line can be maximized by choosing the optimum shape of the aperture. Therefore various shapes have been used to obtain large coupling with smaller aperture area [4]. A thin rectangular aperture gives much stronger coupling compared to the circular aperture.

Two most serious limitations of the microstrip antennas are its low gain and narrow bandwidth. The compact antenna configuration further deteriorates these two parameters. This is because of the fact that there is a fundamental relationship between the size, bandwidth and efficiency of an antenna. As antennas are made smaller, either the operating bandwidth or the antenna efficiency must decrease. The gain is also related to the size of the antenna, that is small antennas typically provide lower gain than larger antennas. Therefore, the size reduction, together with gain and bandwidth enhancement is becoming major design considerations for most practical applications of microstrip antennas for wireless communication. A number of techniques have been reported by the researchers to enhance the gain and bandwidth of microstrip antennas. By increasing the substrate thickness, the bandwidth can be enhanced. But, the substrate thickness cannot be increased to very much extent as the surface waves become dominant. Therefore, the substrate thickness has to be judicially selected to get more bandwidth [5-6].

2. ANTENNA DESIGN

It is well known that the bandwidth of the patch antenna is increased by using multiple layer dielectric substrates. The bandwidth of microstrip antenna is small and varies directly with the size of the patch. Increasing size of patch to improve bandwidth makes it large and bulky. Thus to overcome the bandwidth limitation without increasing size unacceptably, a patch on multiple-layer scheme has been designed. This should ensure that bandwidth increases greatly while size is nearly unaffected.

In this paper a multiple layer substrate is made by introducing a layer of Rogers RT duroid (ε_r=2.2) of thickness 2mm over a silicon substrate (ε_r=11.9) of thickness 1mm separated by a ground plane having a thin rectangular aperture.

The proposed top view and side view of the aperture coupled microstrip antenna is shown in Fig. 1.

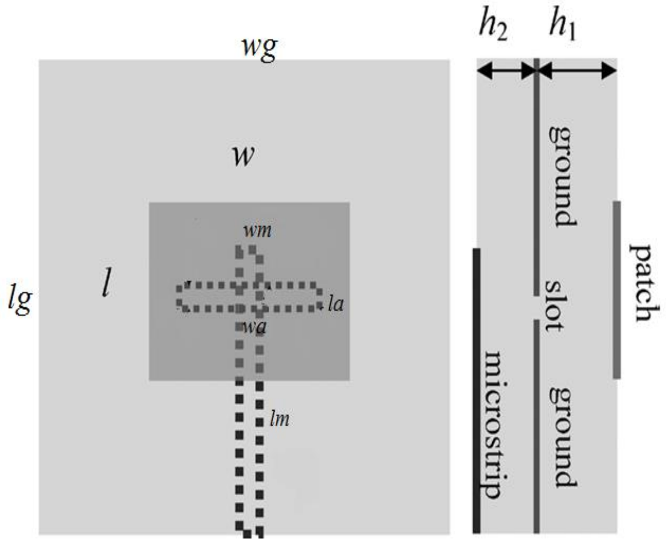

Fig -1: Aperture coupled Microsrtip Patch Antenna top view and side view

In this design, the field is coupled from the microstrip feed line to the rectangular patch through a narrow rectangular aperture cut in the ground plane. The substrate parameters of the radiating patch and microstrip feed line have a significant effect on the input impedance of aperture coupled microstrip antenna. The two substrate materials are used in this design, silicon with dielectric constant εr=11.9 and height h2=1mm is used for feed substrate, Rogers RT duroid with dielectric constant εr=2.2 and height h1=2mm used for patch substrate.

3. DESIGN PARAMETERS

For the final design the proposed geometry is as shown below.

Table -1: Antenna Design Parameters in mm

	MICROSTRIP	SUBSTRATE 2	GROUND	APERTURE	SUBSTRATE 1	PATCH
LENGTH	lm=44	65	lg=65	la=2	65	l=42
WIDTH	wm=3	62	wg=62	wa=20	62	w=62
HEIGHT	0	h2=1	0		h1=2	0
MATERIAL	copper	Silicon ε_r=11.9	copper		Rogers RT duroid ε_r=2.2	copper

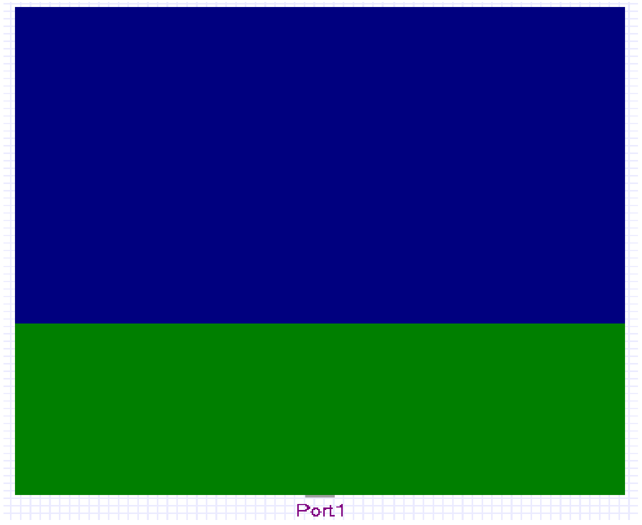

Fig -2: Top view of the proposed antenna

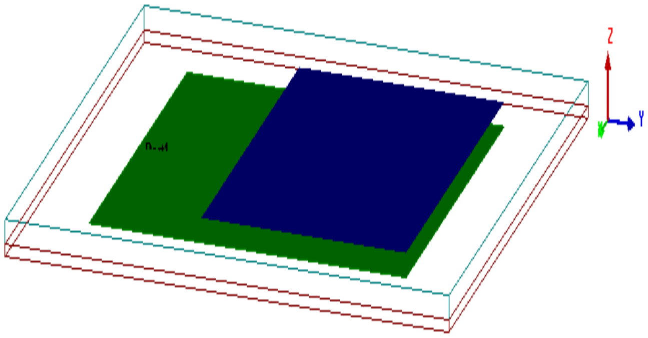

Fig -3: Cross sectional view of the proposed antenna

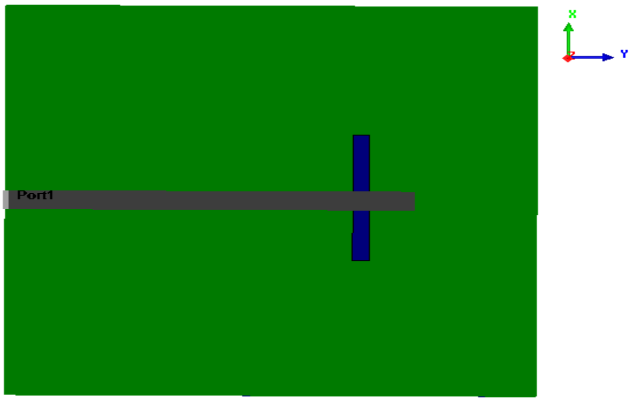

Fig -4: Bottom view of the proposed antenna

4. SIMULATION RESULTS

4.1 Return Loss

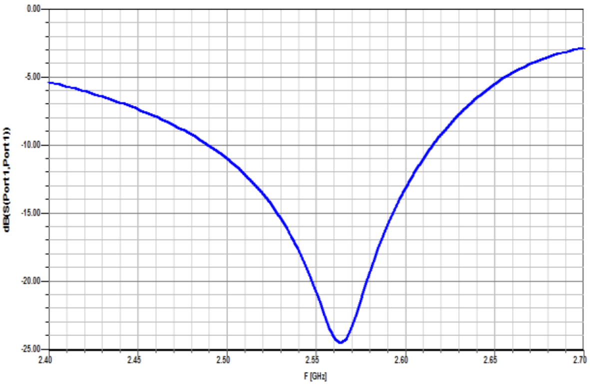

Fig -5: Return Loss Vs Frequency

The proposed antenna resonates at 2.56 GHz having a return loss of -24.5 dB. It has a frequency bandwidth of 140 MHz having a lower cutoff frequency of 2.48 GHz and an upper cutoff frequency of 2.62 GHz.

4.2 VSWR

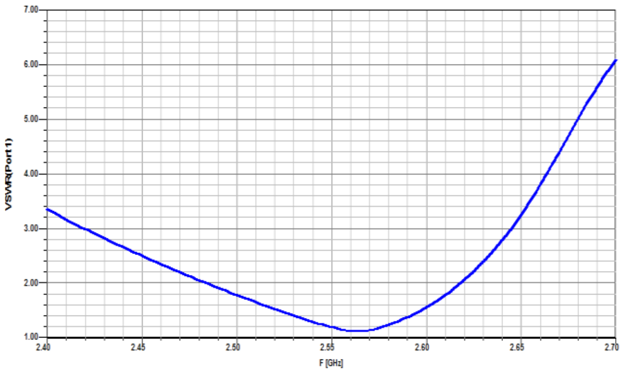

Fig -6: VSWR Vs Frequency

4.3 Radiation Pattern

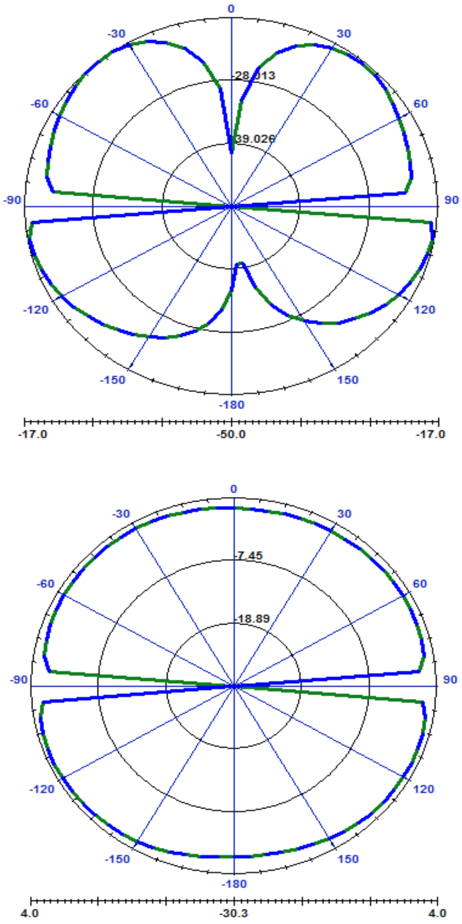

Fig -7: Radiation Pattern at phi=0 degree and 90 degree

4.4 Gain

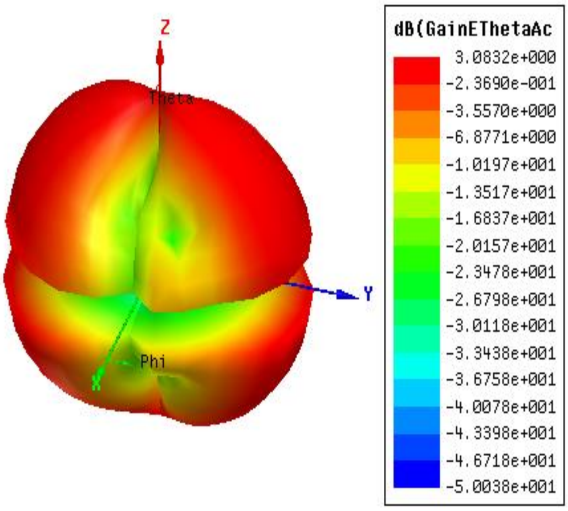

Fig -8: 3D Gain plot at resonant frequency

A maximum gain of 3.08 dBi is also achieved with the proposed antenna at the resonant frequency of 2.56 GHz.

5. CONCLUSIONS

This paper presents an aperture coupled microstrip antenna using a rectangular slot. By using the Ansoft software, the simulation result of return loss and radiation pattern have been achieved. The -10dB return loss bandwidth of the aperture coupled antenna is 140 MHz having a fractional bandwidth of 5.5% and a resonant frequency of 2.56 GHz. This band is used in Broadband Radio service applications. The peak gain at the centre frequency is about 3.08 dB.

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