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RECTANGULAR MICROSTRIP ANTENNA USING AIR-COUPLED PARASITIC PATCHES FOR BANDWIDTH IMPROVEMENT

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Abstract - Microstrip antennas are becoming increasingly useful these days as they can be printed directly on a circuit board. They are relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry. This is a key feature of microstrip antenna to be used in wireless communication field. Thus bandwidth and gain improvement have become major design consideration for practical application of microstrip antennas. The purpose of this paper is to design a rectangular microstrip antenna with parasitic side patches using air coupling. IE3D simulation software is used for simulation and a comparison is made between the basic patch antenna and improved patch antennas.

Keywords - *Rectangular Microstrip Antenna, IE3D, Bandwidth, Impedance, Return Loss, Inset Feed.*

I. INTRODUCTION

Over the years, sophisticated techniques have been developed for the transfer of information within a communication system using electromagnetic career waves operating at radio frequencies as well as microwave and millimeter wave frequencies. In today's modern communication industry, antennas are the most important component required to create a communication link. Through the years, microstrip antenna structures are most common option used to realize millimeter wave monolithic integrated circuits for microwave, radar and communication purpose. They have various advantages such as low profile, lightweight, and ease of fabrication using printed-circuit technology. They can be designed in many shapes like square, rectangular, elliptical, circular etc. We are using rectangular patch because of its simple geometry. The patch geometry, substrate property and feeding technique affect its performance. The size reduction and bandwidth enhancement are major design considerations for practical applications of microstrip antennas.

II. STRUCTURE OF PATCH ANTENNA

A Microstrip Antenna (MSA) in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side [1]. The top and side views of a rectangular MSA (RMSA) are shown in Figure1[1].

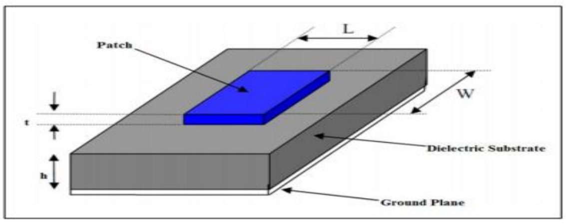

Fig. 1 : Microstrip Patch

For a rectangular patch, the length L of the patch is usually $0.333\lambda_0<L<0.5\lambda_0$, where λ_0 is the free space wavelength. The patch is selected to be very thin such that $t<<\lambda_0$ (where t is the patch thickness). The dielectric substrate height h is usually $0.003\lambda_0<h<0.05\lambda_0$. The dielectric constant is typically in the range $2.2\leq\varepsilon_r\leq12$.The microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For a good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation. However, such a configuration leads to a larger antenna size. In order to design a compact microstrip patch antenna, substrates with higher dielectric constants must be used which are less efficient and result in narrow bandwidth. Hence, a trade-off must be realized between the antenna dimensions and the antenna performance.

TABLE 1
COMPARISON OF MIC & MSA

Parameter	**Microwave Integrated Circuits(MIC)**	**Microstrip Antenna(MSA)**
Height, h	≤ 0.159 cm	≥ 0.159 cm
Dielectric constant, ε_r	≥ 9.8	≤ 9.8
Width, W	Small	Large
Radiation	Minimized	Maximized

III. FEEDING MECHANISMS

Microstrip antennas can be fed by two methods, contacting and non-contacting. RF power is fed directly to the radiating patch using a connecting element such as microstrip line in contacting method. Electromagnetic feed coupling is done to transfer power between the microstrip line and the radiating patch in non-contacting scheme. Here, we are using inset feed for our design.

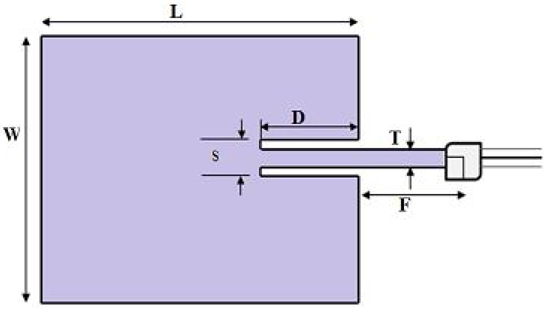

Fig. 2 : Rectangular patch with inset feed

IV. DESIGN OF BASIC PATCH ANTENNA

TABLE 2
DESIGN SPECIFICATIONS

SL.No.	Parameter Name	Designed Values
1.	Resonant Frequency, f_r	2.4Ghz
2.	Substrate Thickness	0.158mm
3.	Patch Length, L	29.8577mm
4.	Patch Width, W	38.0629mm
5.	Reference Impedance	50Ω
6.	Substrate Height, h	1.58mm
7.	Dielectric Constant, ε_r	4.4

1. Design Equations

$$\lambda_0 = \frac{c}{f} = \frac{3 \times 10^8}{2.4 \times 10^9} = 012.5\text{cm} = 125\text{mm} \quad \dots(1)$$

$$W = \frac{v_0}{2 \times f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} = 38.036\text{mm} \quad \dots(2)$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}} = 4.088 \dots(3)$$

$$\Delta L = h \times 0.412 \times \frac{(\varepsilon_{eff} + 0.3)}{(\varepsilon_{eff} - 0.258)} \times \frac{\left(\frac{w}{h} + 0.264\right)}{\left(\frac{w}{h} + 0.8\right)}$$

$$= 0.729\text{mm} \dots(4)$$

$$L = \frac{1}{2 \times f_r\sqrt{\varepsilon_{eff}}\sqrt{\mu_0\varepsilon_0}} = 29.4503\text{mm} \quad \dots(5)$$

$$Z_{in} = 90\frac{\varepsilon_r^{\,2}(L)^2}{(\varepsilon_r - 1)(W)^2} = 243\Omega \quad \dots(6)$$

B. Characteristics of MSA

The MSA has proved to be an excellent radiator for many applications because of its several advantages, but it also has some dis-advantages. The advantages and dis-advantages of the MSA are given in the below sections.

1. Advantages: MSA have several advantages compared to the conventional microwave antennas. The main advantages of MSAs are listed as follows:
   1. They are lightweight and have a small volume and a low-profile planar configuration.
   2. They can be made conformal to the host surface.
   3. Their ease of mass production using printed-circuit technology leads to a low fabrication cost.
   4. They are easier to integrate with other MICs on the same substrate.
   5. They allow both linear polarization and CP.
   6. They can be made compact for use in personal mobile communication.
   7. They allow for dual- and triple-frequency operations.

8. Dis-advantages: MSAs suffer from some dis-advantages compared to conventional microstrip antennas. They are as follows:
   1. Narrow BW
   2. Lower gain
   3. Low power-handling capability

4. Applications:

TABLE 3
MSA APPLICATION

System	Application
Aircraft and Ship antennas	Communication and navigation, altimeters, blind landing systems.
Missiles	Radar, Proximity fuses and Telemetry.
Satellite Communication	Domestic Direct Broadcast TV, Vehicle- based antennas, communication.
Mobile Radio	Pagers and hand telephones, man pack systems, mobile vehicle.
Remote sensing	Large light weight apertures.
Bio-medical	Applications in microwave hyperthermia.
Others	Intruder alarms, personal communication etc.

V. BANDWIDTH IMPROVEMENT TECHNIQUE

Bandwidth of the antenna can be improved by using side patches in addition to the basic patch. By deciding the number of side patches and spacing, them at proper distances from the basic patch can result in considerable improvement in the bandwidth.

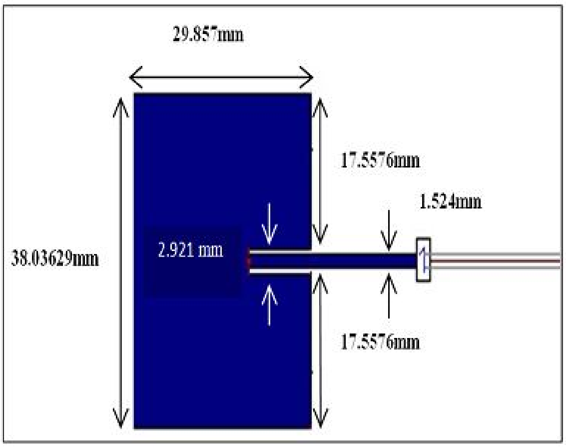

Fig. 3 : Basic Patch

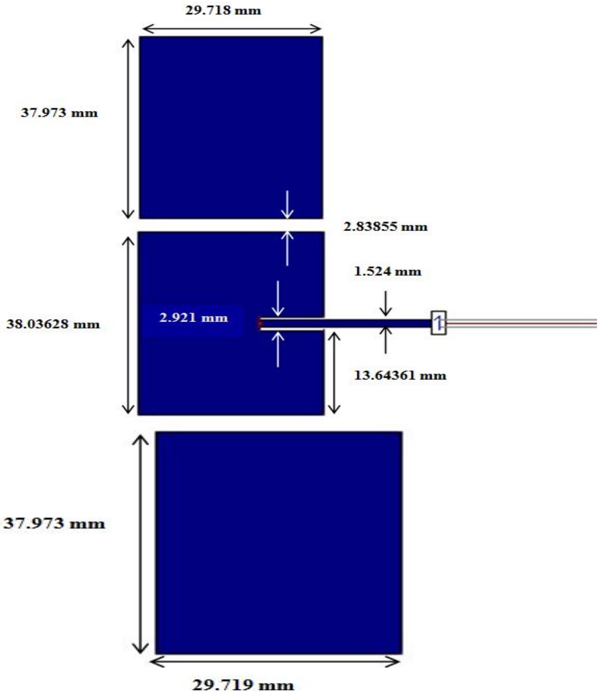

Fig. 4 : Basic patch with side patches

VI. EXPERIMENTAL RESULTS

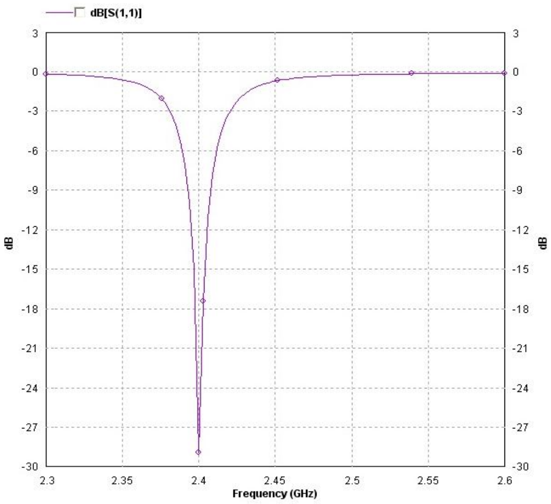

Fig. 5 : The Return Loss curve for basic patch.

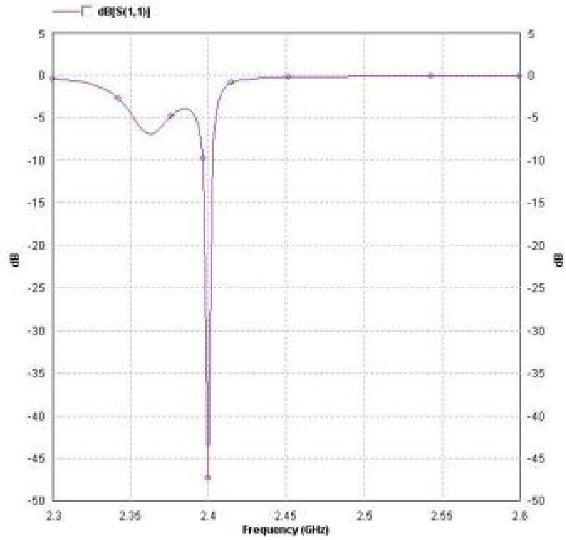

Fig.6 : The Return Loss curve for basic patch with side patches.

Figures 5 and 6 show the return loss curve for basic patch and basic patch with parasitic side patches. It clearly shows decrement in the return loss from -29 dB to -47.5 dB and increment in bandwidth from 375 MHz to 625 MHz, which is 66.6% of the basic patch.

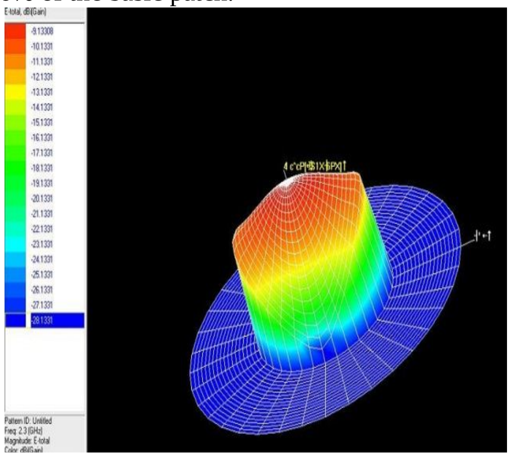

Fig. 7 : Radiation pattern of basic patch

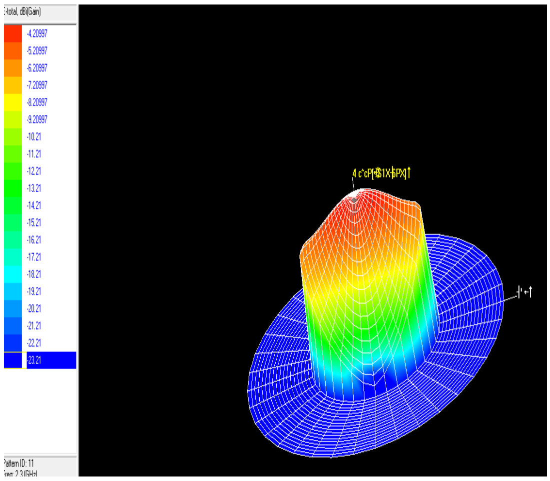

Fig. 8 : Radiation pattern of basic patch with side patches

The radiated power for the basic patch and the modified patch is obtained from figures 7 and 8, which is -9.133 dBi for the basic patch and -4.209 dBi for the modified patch.

VI. COMPARATIVE STUDY

TABLE 4
COMPARISON

Sl. No.	Bandwidth (MHz)	Power dBi)	Resonant Frequency (GHz)	Gain (dBi)	Return Loss (dB)
1.Basic Patch	375	-9.133	2.4	5.8	-29
2. Improved Patch	625	-4.209	2.4	6.1	-47.5

VIII. DESIGNED AND TESTED MICROSTRIP ANTENNAS

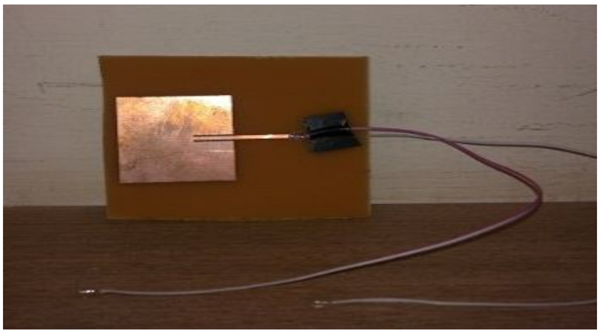

Fig. 9 : Basic patch antenna

Fig.10 : Basic patch antenna with side patches

IX. CONCLUSION

The design, simulation and fabrication of the basic and the improved microstrip patch antenna with all the required parameters is carried out using IE3D simulation software and fabricated using in-house laboratory facilities. It is observed that the improved patch antenna i.e. patch antenna with parasitic side patches has better gain , bandwidth and radiated power than the basic patch antenna. A bandwidth improvement of 66.6% is observed in the modified patch.

X. ACKNOWLEDGEMENT

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