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Design of Microstrip Hybrid Patch Antenna for Tri-slotted wideband Applications

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Abstract

In this paper, a compact size microstrip hybrid Patch Antenna is designed and analyzed. The bandwidth enhancement of microstrip patch [MSP] is done by rectangular slotted technique.The designed antenna may be used to reduce return loss and increase the bandwidth.The gain has beenimproved up to 8.729dBi, directivity 11.47dBi and efficiency 99.54%. The proposed rectangular slotted MSP antenna is used for L-band and S-band operations. Study of literature of past few year shows that, the leading work on MSP is focused on designing compact sized broadband microstrip antenna. But inherently MSP have narrow bandwidth so to enhance bandwidth various techniques are engaged. The proposed antenna is simulated using ADS 2009 simulation software based on Momentum and EMDS. The antenna is fed by 50Ω microstrip line feed.

Index Terms: *Ground plane, Microstrip patch [MSP], Enhance bandwidth, ADS 2009 Simulator, Microstrip line feed.*

INTRODUCTION

Microstrip antenna [1] consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. The major disadvantages of Microstrip antennas are lower gain and very narrow bandwidth [2,3]. It consists of dielectric substrate, with ground plane on the other side.

In this paper, the purpose of a new designed antenna presents to enhance the bandwidth of microstrip hybrid multiband antenna for many broadband applications [4], [7]. The major drawbacks of MSP antennas are narrow bandwidth and low gain. They may use many techniques to enhance bandwidth and gain of MSP antennas. By using thick substrate with low dielectric constant and slotted patch can enhance the bandwidth and gain of antennas up to greater extent [5].

The MSP antenna have some good features such as low cost, low profile, light weight, high efficiency, easy to implement with circuits[2],[5],[6]. The design structure components of antenna become small in size and have low processing cost [3].

In this letter, transmission line method is used to analysis the Hybrid Multiband Patch antenna. The design resonant frequency of proposed antenna is 2.2 GHz with 50Ω microstrip line feed. The proposed antenna is characterized by using thickness (h), dielectric constant (ε_r) and length(b, d), width(a, c) of ground plane and patch. The performance of designed antenna such as radiation pattern, return loss, directivity, VSWR and gain are simulated by using ADS 2009 Software.

PROPOSED SUBSTRATE DESIGN

A. Antenna Dimensions

The mathematical formula is used to calculate the dimensions of ground plane and microstrip patch in the form of length and width. Here we use the slotted technique for improve the bandwidth and reduce the return loss of the microstrip patch antenna. By using multidielectric substrate the return loss are minimized while compare to the MSP antenna. The

proposed antenna is fed by 50Ω microstrip line feed.
For design the antenna we use ADS 2009 software. We take FR-4 with 2.2 GHz frequency and dielectric constant ε_r= 4.2, the height between the patch and ground is 1.6 mm.

(i) Width of Rectangular MSP Antenna [8], [9]

$$W = \frac{c}{f_r}\sqrt{\left(\frac{2}{1+\epsilon_r}\right)} \text{---------- (1)}$$

Where c=3*10^8 ms-1, ε_r= 4.2, f_r=2.2 GHz

(ii) Effective Dielectric Constant [9], [10]

$$\epsilon_{eff} = \left(\frac{\epsilon_r+1}{2}\right) + \left(\frac{\epsilon_r-1}{2}\right)\left[1+\frac{12H}{W}\right]^{-0.5} \text{----------(2)}$$

H=1.6 mm

(iii) Length Extension of Antenna [8], [9]

$$\Delta L = 0.412H\left(\frac{\epsilon_{eff}+0.3}{\epsilon_{eff}-0.258}\right)\left[\frac{\left(\frac{W}{H}\right)+0.264}{\left(\frac{W}{H}\right)+0.8}\right] \text{---------(3)}$$

(iv) Length of Rectangular MSP Antenna [4],[11]

$$L = \left(\frac{c}{2f_r\sqrt{\epsilon_{eff}}}\right) - 2\Delta L \text{---------- (4)}$$

(v) Length of Ground Plane of Antenna [8],[9]

$$L_g = L + 6H \text{---------- (5)}$$

(vi) Width of Ground Plane of Antenna [8], [9]

$$W_g = W + 6H \text{---------- (6)}$$

B. Antenna Design Specification

Calculated dimensions of ground plane is constructed by using the resonant frequency(f_r), dielectric constant(ε_r), substrate thickness(H) and loss tangent(tan δ) and 50Ω microstrip line feed is fed into patch. Calculated dimensions are obtained by formula.

Table 1: *Antenna Design Specifications*

S.No	Antenna Parameter	Data
1.	Resonant Frequency(f_r)	2.2 GHz
2.	Substrate thickness(H)	1.6 mm
3.	Dielectric Constant (ε_r)	4.2
4.	Loss Tangent (tan δ)	0.0013

C. Antenna Design Procedure

Using the above equations and geometrical parameters, dimensions of antenna is calculated. In the design of antennas is constructed by using dimensions after that slots cut in to the microstrip patch.

Table 2: *Calculated Antenna Dimensions in mm*

S.No	Parameters	Value
1.	Ground Plane width, a	51.1
2.	Ground Plane length, b	40.6
3.	Patch width, c	41.5
4.	Patch length, d	31
5.	e	19
6.	f	18.4
7.	g	16.8
8.	h	7
9.	i	7.2

10.	j	9.7
11.	k	20.2
12.	l	4.1

MICROSTRIP HYBRID PATCH ANTENNA DESIGN

The proposed Microstrip Hybrid Patch antenna design is as shown in Figure 1. The antenna is built by single layer substrate and multilayer substrate with dielectric constant (ε_r = 4.2 & 3.5) and thickness (t =1.6 mm).

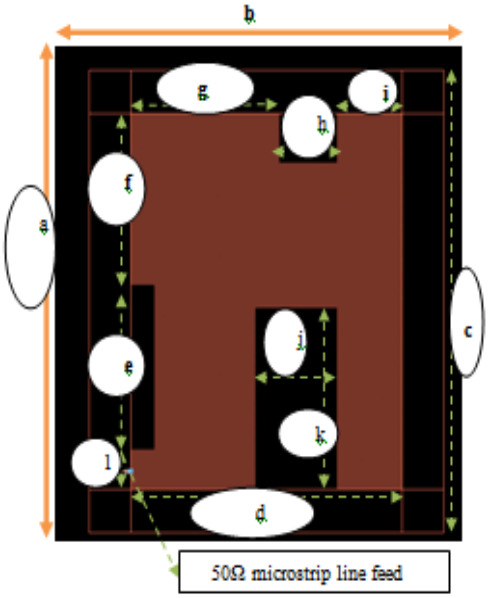

Fig 1: *Geometry of Proposed Antenna*

A. Steps in Microstrip Hybrid Patch Antenna

The Steps followed in designing Microstrip Hybrid Patch antenna design operate at 2.2 GHz for various broadband applications is shown in Figure 2.

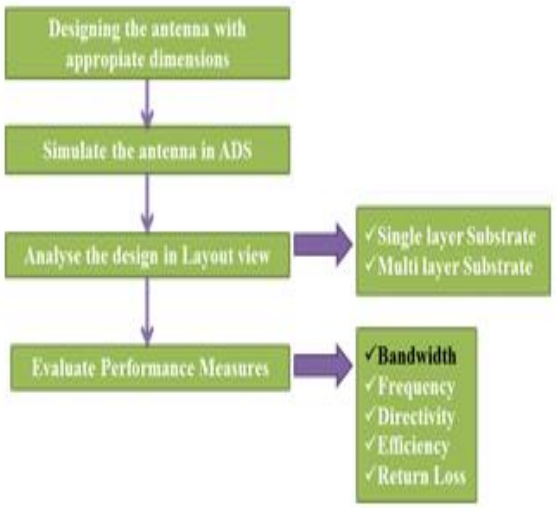

Fig 2: *Steps followed in Hybrid Patch Antenna*

RESULTS AND DISCUSSIONS

The designed microstrip hybrid patch antenna is analyzed by both Single layer substrate and multilayer substrate is shown in Figure 3.

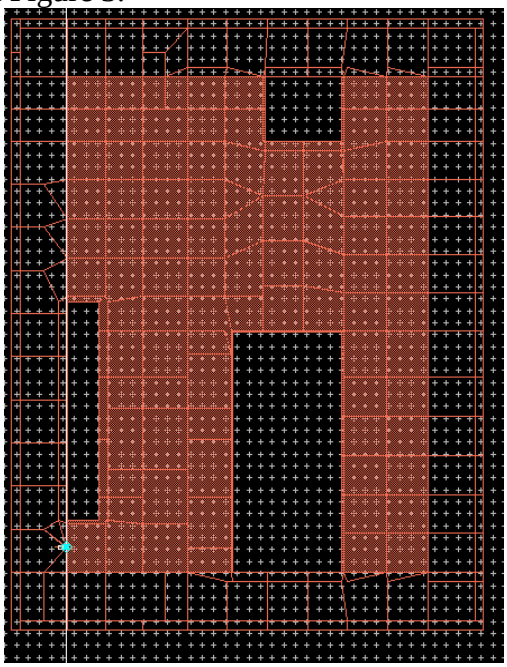

Fig3*: Microstrip Hybrid patch antenna*

A. Return loss and resonant frequency

The return loss and resonant frequency of single layer substrate is calculated as -11

dB and 2.279 GHz. The simulated result is shown in Figure 4.

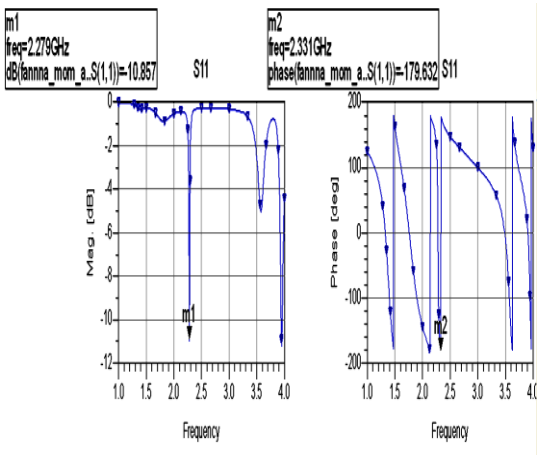

Fig 4: *Momentum (S-Parameters) using Single Layer Substrate*

The return loss and resonant frequency of multilayer substrate can be also calculated by EMDS (S-Parameters) as -16.830 dB and 1.680 GHz. The simulated result is shown in Figure 5.

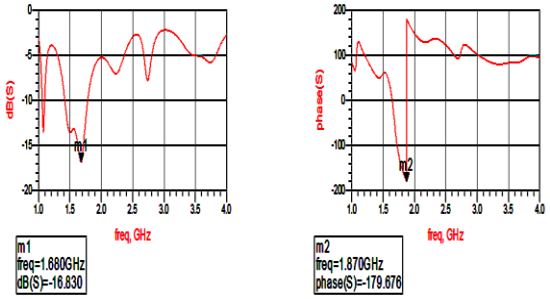

Fig 5: *EMDS (S-Parameters) using Multilayer Substrate*

B. Antenna Parameters and Radiation Pattern

The antenna parameters of Single Layer Substrate is shown in Figure 6.

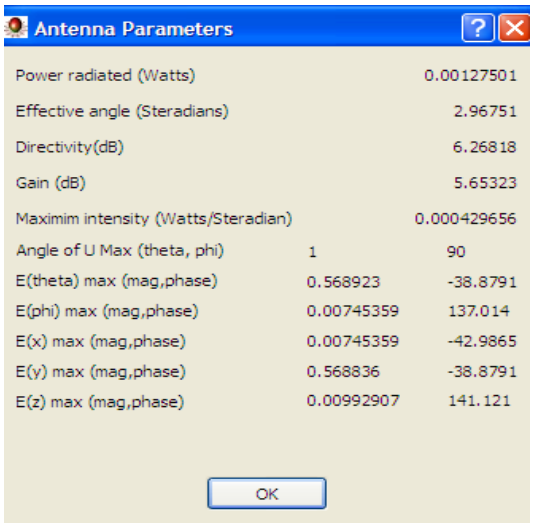

Fig 6: *Antenna Parameters using Single Layer Substrate*

The Radiation Pattern of Single Layer Substrate is shown in Figure 7.

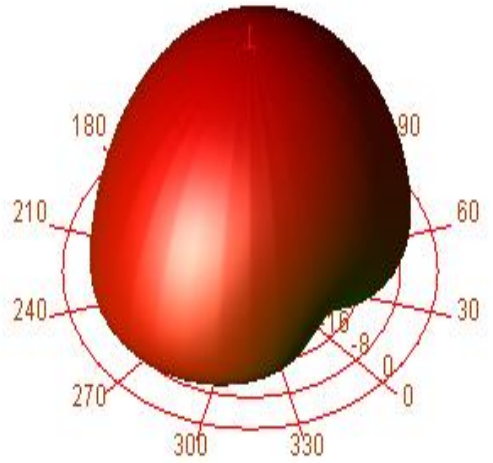

Fig 7: *Radiation Pattern using Single Layer Substrate*

The antenna parameters of Multilayer Substrate is shown in Figure 8.

Power radiated (Watts)		0.00494378
Effective angle (Steradians)		0.895741
Directivity(dBi)		11.4703
Gain (dBi)		8.72897
Maximim intensity (Watts/Steradian)		0.00551921
Angle of U Max (theta, phi)	36	359
E(theta) max (mag,phase)	2.03868	-30.2381
E(phi) max (mag,phase)	0.0476937	-26.8059
E(x) max (mag,phase)	1.64991	-30.2364
E(y) max (mag,phase)	0.0190315	-21.6107
E(z) max (mag,phase)	1.19831	149.762

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Fig 8: *Antenna Parameters using Multilayer Substrate*

The Radiation Pattern of Multilayer Substrate is shown in Figure 9.

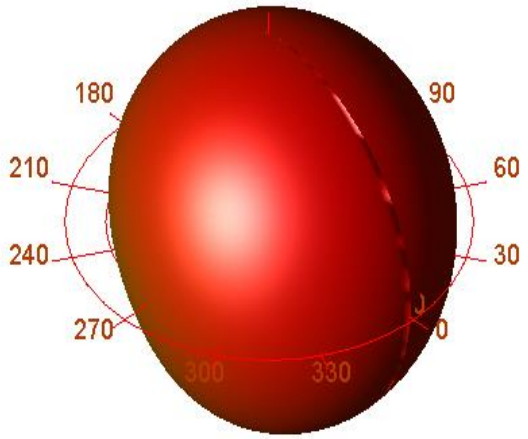

Fig 9: *Radiation Pattern using Multilayer Substrate*

V. BANDWIDTH ENHANCEMENT ANALYSIS

The Bandwidth Enhancement analysis is defined as the difference between the highest frequency and lowest frequency. **Highest Return Loss taken (up to 20 dB),**

$$BW = f_{(high)} - f_{(low)}$$

Table 3: *Comparison of Single Layer Substrate*

Parameters	Single Layer Substrate	Multi Layer Substrate
Frequency resonated	2.279 GHz	1.935 GHz
Return Loss	-11 dB	-16.844dB
VSWR	1.785	1.336
Directivity	6.2618 dB	11.4703 dB
Gain	5.65323 dB	8.72897 dB
Bandwidth	**2GHz -2.5GHz (0.5 GHz)**	**1.3 GHz -2 GHz (0.7 GHz)**

The Bandwidth Enhancement of Microstrip Hybrid Patch Antenna can be analyzed by Single layer substrate and Multilayer substrate. The effect of bandwidth on Single layer substrate and Multilayer substrate can be calculated as 0.5 GHz and 0.7 GHz is shown in Table 3. So, the bandwidth obtained in multilayer substrate is greater than the single layer substrate. The gain and resonant frequency of multilayer substrate of Microstrip Hybrid Patch antenna is calculated as 8.729 dB and 1.935 GHz. The resonant frequency of multilayer substrate of Microstrip Hybrid Patch Antenna is slightly greater than the Single layer substrate.

CONCLUSION

A microstrip hybrid patch antenna has been designed by multi-dielectric slotted patch aimed to operate at 2.2 GHz and they are analyzed by Agilent ADS 2009 software. It is based on the rectangular patch antenna (slotted technique). Slotted technology is used to enhance the bandwidth of antenna by reducing the return loss. The enhance bandwidth of designed microstrip Hybrid Patch antenna is calculated as 0.7 GHz (1.3 GHz to 2 GHz). A hybrid multiband antenna was

optimized to obtain a high performance.The gain of the antenna is 8.729 dBi at 1.935 GHz frequency and VSWR< 2 or it is 1.336 with return loss -16.844 dBi. So, the antenna had an excellent performance of wide bandwidth that can be used as broadband applications such as missile, wireless, satellite, mobile communication and military purposes.

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