Fabricated Bandwidth Analysis of Microstrip Hybrid Patch Antenna for C-band Application

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ABSTRACT

In this paper, a compact size microstrip hybrid Patch Antenna is designed and analyzed. The bandwidth enhancement of microstrip Hybrid patch [MSHP] is done by rectangular tri-slotted technique. The designed antenna may be used to reduce return loss and increase the bandwidth. The overall gain has been improved up to 5.354 dBi, directivity 6.65 dBi and efficiency 99.54%. The proposed rectangular tri-slotted MSP antenna is applicable for C-band (Wi-Fi & Wi-Max) operations. MSP is mainly focussed on design of the compact sized broadband microstrip antenna. But inherently, MSP have narrow bandwidth. The MSHP antenna has wider bandwidth, and so they are analysed by different band techniques for enhancing the bandwidth. The proposed MSHP antenna is simulated using Simulation Software (ADS 2009) based on the Parameter (Momentum). Then, the fabrication can be analyzed by PCB Design Software and it was tested by using Vector network Analyzer. The antenna is also fed by 50 Ohm microstrip line feed.

KEY WORDS: Ground plane, Microstrip patch (MSP), Microstrip Hybrid Patch (MSHP), Enhance bandwidth, ADS 2009 Simulator, Vector Network Analyzer, Microstrip line feed.

1. INTRODUCTION

Microstrip antenna 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. It consists of dielectric substrate, with ground plane on the other side. In this paper, the purpose of a new designed antenna enable is used to enhance the bandwidth of microstrip hybrid Patch antenna for many broadband applications.

The major drawbacks of MSP antennas are having narrow bandwidth and low gain. They may use many techniques to enhance the bandwidth and gain of MSHP antennas. By using, thick substrates with low dielectric constant and slotted patch to enhance the bandwidth and gain of antennas up to greater extent.

The MSP antenna has good features such as low cost, low profile, light weight, high efficiency, easy to implement with circuits. The design structure components of antenna will become small in size and have low processing cost.

In this letter, transmission line method is used to analysis the Microstrip Hybrid Patch antenna. The design resonated frequency of proposed MSHP antenna is 5 GHz & 5.8 GHz (C-band) with 50 Ω microstrip line feed. The proposed MSHP antenna is characterized by using thickness (h), dielectric constant (ε_r).The designed MSHP antenna can be simulated by ADS 2009 Simulation Software. The performance of the designed MSHP antenna can be analyzed by radiation pattern, return loss, gain, bandwidth, directivity and VSWR. The Proposed MSHP Antenna can be fabricated and tested by using Vector Network Analyzer.

2. PROPOSED SUBSTRATE DESIGN

2.1. 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 rectangular tri-slotted technique for improve the bandwidth and reduce the return loss of the MSP antenna. Using the multi dielectric substrate, the return losses are minimized (Compared with ordinary MSP antenna).The proposed antenna is fed by 50Ω microstrip line feed.

For design purpose, the antenna can be simulated by ADS 2009 software. We take FR-4 substrate with different resonated frequency and dielectric constant ε_r= 4.4 (Single Layer Substrate). After introducing, the Multilayer Substrates [FR-4 and Rogers Corps (ε_r= 3.5→R04003C)], we can take resonated frequency as 5 GHz (Wi-Fi) and 5.8 GHz (Wi-Max). The height between the patch and ground is taken as 1.6 mm and 1.524 mm.

(i) Width of Rectangular MSP Antenna,

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

Where $c=3*10^8\ ms^{-1}$, ε_r= 4.2

Effective Dielectric Constant:

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

H=1.6 mm

(iii) Length Extension of Antenna,

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

(iv) Length of Rectangular MSP Antenna,

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

2.2. 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 50**Ω** microstrip line feed is fed into patch. Calculated dimensions are obtained by formula and compact rectangular tri-slotting is done on the rectangular patch.

Table.1.Antenna design specifications

Antenna Parameter	Data
Resonant Frequency (f_r)	5 GHz & 5.8 GHz
Substrate thickness (H)	1.6 mm & 1.524 mm
Dielectric Constant (ε_r)	4.2 & 3.5

2.3. 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 & 1.524 mm).

2.4. Steps in Microstrip Hybrid Patch Antenna: The Steps followed in designing Microstrip Hybrid Patch antenna design can be operated at different resonated frequencies (GHz) for various broadband applications is shown in Figure 1.

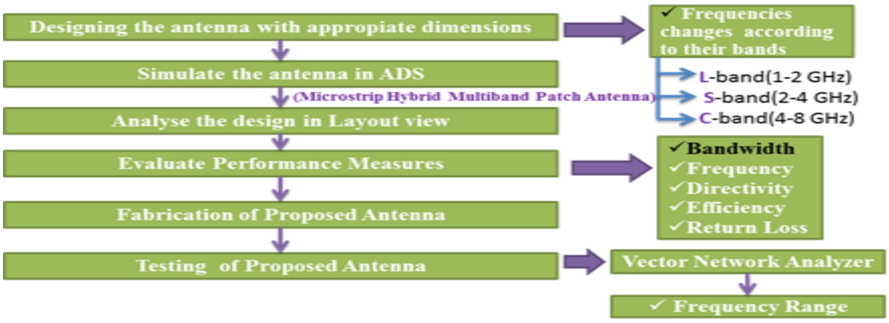

Figure.1.Steps followed in Hybrid Patch Antenna

3. RESULTS AND DISCUSSIONS

The designed microstrip hybrid patch antenna is analyzed by both Single layer substrate and multilayer substrate for C-band is shown in Figure 2.

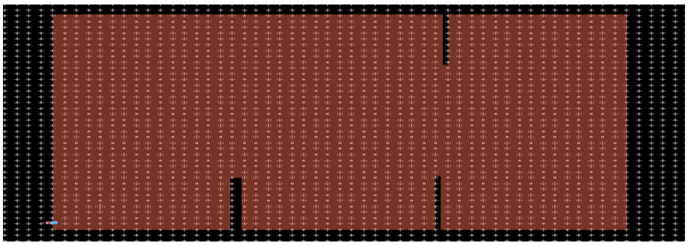

Figure.2.Microstrip Hybrid patch antenna

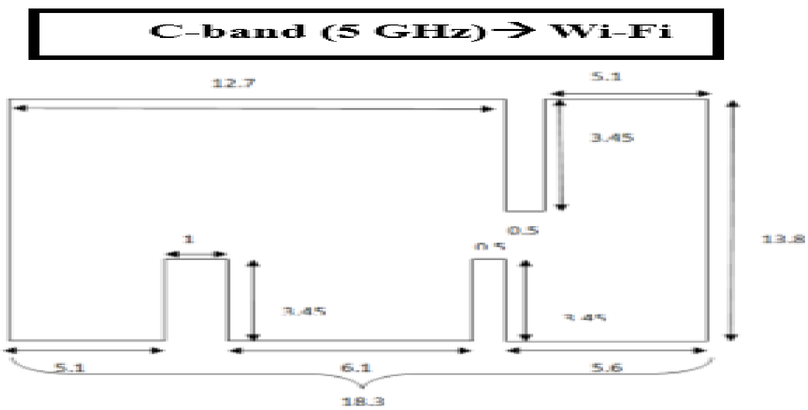

Figure.3.Geometry of Proposed Antenna (C-band→Wi-Fi)

Return loss and resonant frequency: The return loss and resonant frequency of single layer substrate is calculated as -10.46 dB and 4.943 GHz. The simulated result is shown in Figure 4.

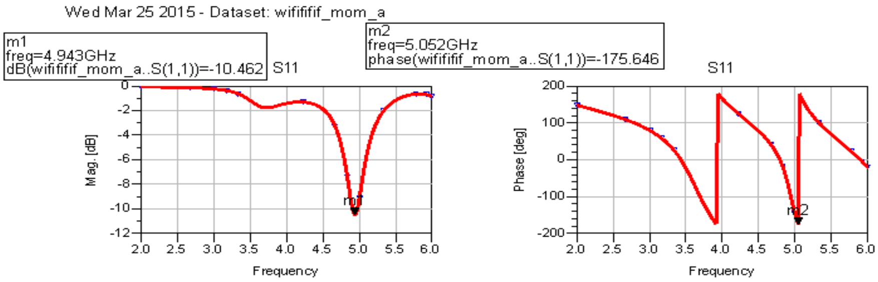

Figure.4.Momentum (S-Parameters) using Single Layer Substrate

The return loss and resonant frequency of multilayer substrate can be also calculated by Momentum (S-Parameters) as -23.18 dB and 4.889 GHz. The simulated result is shown in Figure 5.

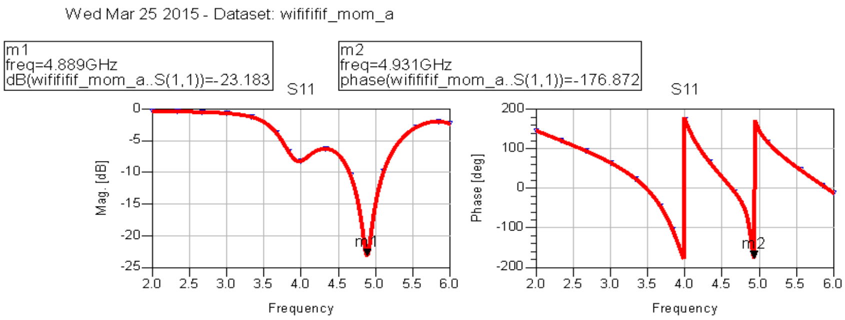

Figure.5.Momentum (S-Parameters) using Multilayer Substrate

Antenna Parameters and Radiation Pattern: The antenna parameters of Single Layer Substrate is shown in Figure 6.

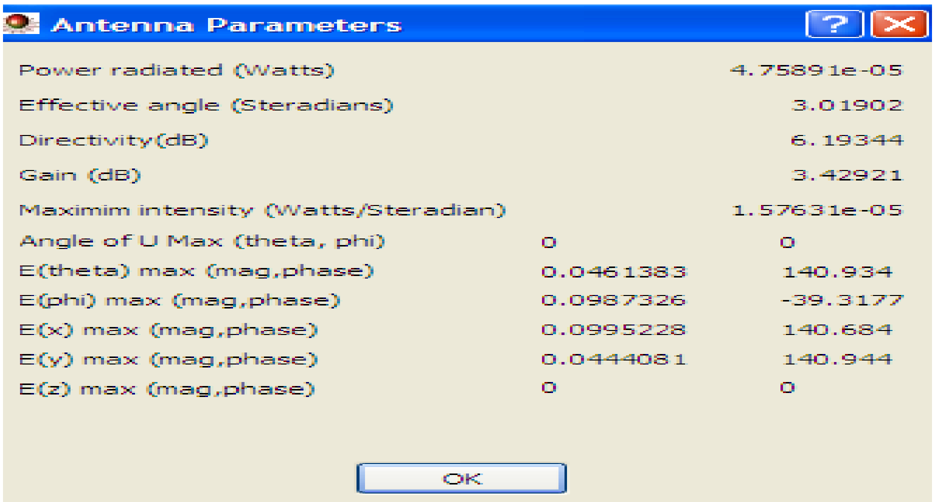

Figure.6.Antenna Parameters using Single Layer Substrate

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

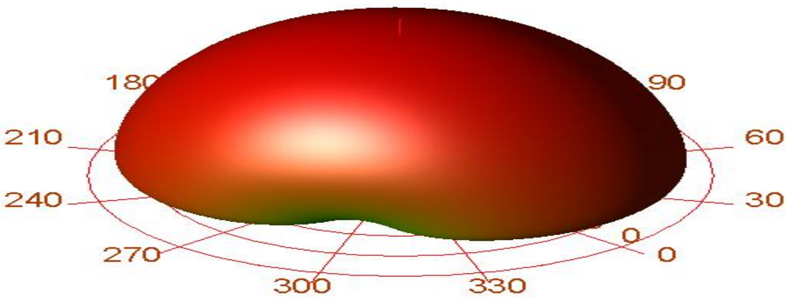

Figure.7.Radiation Pattern using Single Layer Substrate

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

Figure.8. Antenna Parameters using Multilayer Substrate

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

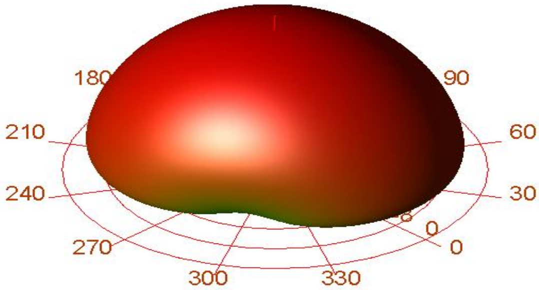

Figure.9. Radiation Pattern using Multilayer Substrate

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.2.Comparison of Single Layer Substrate and Multilayer Substrate (C-band) →Wi-Fi

Parameters	Single Layer Substrate	Multi-Layer Substrate
Frequency resonated	4.943 GHz	4.889 GHz
Return Loss	-10.462 dB	-23.183 dB
VSWR	1.8565	1.1489
Directivity	6.23905 dB	6.65029 dB
Gain	5.46586 dB	5.35476 dB
Bandwidth	**4.5GHz -5.3GHz (0.8 GHz)**	**4.5 GHz -5.5 GHz (1.0 GHz)**

The effect of bandwidth on Single layer substrate and Multilayer Substrate in C-Band (Wi-Fi) can be calculated as 0.8 GHz& 1.0 GHz is shown in Table II. The gain and resonant frequency of multilayer substrate of Microstrip Hybrid Patch antenna is calculated as 5.355 dB and 4.889 GHz.

Table.3.Comparison of Single Layer Substrate and Multilayer Substrate (C-band) →Wi-Max

Parameters	Single Layer Substrate	Multi-Layer Substrate
Frequency resonated	5.741 GHz	5.639 GHz
Return Loss	-12.134 dB	-44.149dB
VSWR	1.6572	1.0125
Directivity	6.19344 dB	6.65205 dB
Gain	3.42921 dB	3.45084 dB
Bandwidth	**5.2GHz -6GHz (0.8 GHz)**	**5 GHz -6 GHz (1.0 GHz)**

The effect of bandwidth on Single layer substrate and Multilayer Substrate in C-Band (Wi-Max) can be calculated as 0.8 GHz&1.0 GHz is shown in Table III. The gain and resonant frequency of multilayer substrate of Microstrip Hybrid Patch antenna is calculated as 3.45 dB and 5.639 GHz. Generally, the new concept has been introduced that the bandwidth obtained in multilayer substrate is greater than the single layer substrate. The resonant frequency of multilayer substrate of MSHP Antenna is slightly greater than the Single layer substrate.

Fabrication and Testing of Proposed Antenna: The Proposed MSHP Antenna is fabricated by designing the layout in PCB design Software and the feed point is inserted in layout by SMA Connector. The testing of MSHP Antenna is analyzed by Vector Network Analyzer. The Parameters of tested Antenna is analyzed by return loss, Resonated frequency, Gain, Directivity and bandwidth.

Fabrication of MSHP Antenna: The Fabrication of MSHP Antenna is designed by PCB design Software for layout and the copper is coated by etching with multilayer Substrates. Then the feed point is analyzed and the SMA Connector is inserted in antenna by soldering.

Figure.10.Fabrication of MSHP Antenna

Testing of MSHP Antenna: The fabricated MSHP Antenna is inserted in the Port of the Vector Network Analyzer (Figure 11) for testing.

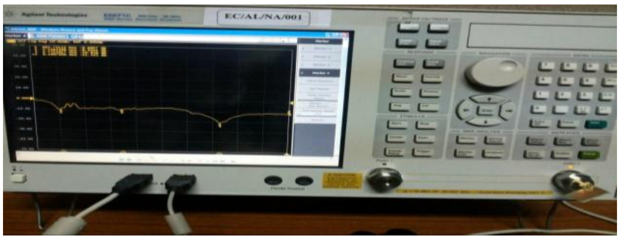

Figure.11.Testing of MSHP Antenna

The MSHP Antenna is analyzed in Figure 12 by setting the Start frequency, Stop frequency and Sample Points. The return loss and resonated frequency of tested MSHP Antenna is analyzed in Figure 13.

Figure.12. Testing of MSHP Antenna (By Setting the Start frequency, Stop frequency & Sample Points)

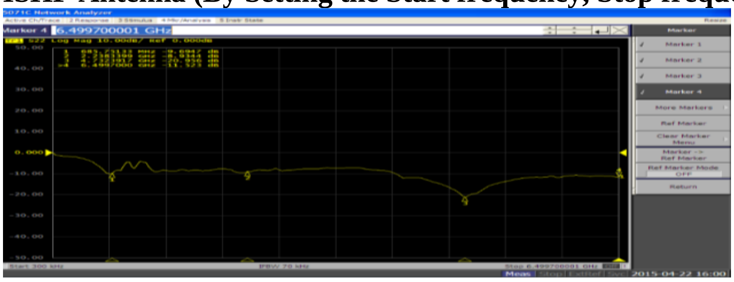

Figure.13. Determining the Return Loss & Resonated Frequency

Table.4.Parameters to be analysed [Tested MSHP Antenna] (C-band) →Wi-Fi

Parameters	Multi-Layer Substrate
Frequency resonated	4.74 GHz
Return Loss	-25.760 dB
VSWR	1.1086
Directivity	6.65 dB
Gain	5.47 dB
Bandwidth	4.5 GHz -5.5 GHz (1.0 GHz)

The effect of bandwidth on Multilayer Substrate in C-Band (Wi-Fi) for tested MSHP antenna can be calculated as 1.0 GHz is shown in Table IV. The gain and resonant frequency of multilayer substrate of Microstrip Hybrid Patch antenna is calculated as 5.47 dB and 5.47 GHz.

CONCLUSION

A microstrip hybrid patch antenna has been designed by multidielectric tri-slotted rectangular patch and it was aimed to operate at two different resonated frequencies and they are analyzed by Agilent ADS 2009 software. Then the Proposed MSHP Antenna can be fabricated and tested by Vector Network Analyzer. The enhanced bandwidth of designed MSHP antenna in C-band is calculated as 1.0 GHz (5 GHz to 6 GHz). The bandwidth is obtained for both Single layer substrate (0.9 GHz) and multilayer substrate (1 GHz) effectively. The Gain and Directivity of the proposed MSHP antenna is achieved as 5.47 dB and 6.65 dB. The Proposed MSHP antenna proves to be Effective Bandwidth in multilayer substrate better than single layer substrate in C-band → Wi-Fi (5 GHz) [f_r=4.74 GHz, VSWR=1.1086 & Return Loss= -25.760 dB]. The proposed MSHP antenna is better in C-band (Wi-Fi) to resonate the good frequency with good return loss (Useful in Military Applications).

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