Development of Aperture Coupled Stacked Filtered Microstrip Patch Antenna

Jitendra Ahir[1], Bharti Courasia[2]

PG Student (ECE),Scope College of Engineering Bhopal , M.P, India[1]

HOD(ECE), Scope College of Engineering Bhopal , M.P, India[2]

Abstract— This paper presents a twin band aperture coupled stacked filtered microstrip antenna with the introduction of an air hole 10 mm between the aircraft and the upper layer substrate for WLAN functions. There are various extensive banding tactics used for the MSAs. However many huge banding tactics corresponding to utilizing triangular slots in the patch require an inductive coupled feed (probe feed). But complete planar (2nd) procedures for manufacturability wishes capacitive filter coupling. So the parametric learn, design, fabrication and testing of a with huge band aperture coupled antenna has been attempted in this assignment. And an aperture coupled antenna with up to 234.8 MHz and 684.9 MHz band width was designed at 2GHz to 5GHz range accordingly realizing 20% band width, which makes it a suitable choice to be used on the frequencies bands of WLAN.

Keywords - Microstrip Antenna, Stacked Patch Antenna, Dual-Band Antenna, Network Analyzer, Bandwidth.

I. INTRODUCTION

Microstrip patch antennas are very popular among various types of antennas because of their planar configuration, low profile, conformability, low cost and ease of fabrication. The aperture coupled procedure to feed the microstrip patches furnish the competencies of separating spurious feed radiations by way of a long-established ground aircraft [1]. This process also avoids the drawback related with the massive probe self reactances and it enables the construction procedure for the reason that no soldering is required as in probe fed manner [2]. The aperture coupled process supplies scale back parasitic radiation and higher radiation pattern symmetry.

The editions in the dimensions of the aperture facilitates impedance matching of the antenna. It is good identified incontrovertible fact that the coupling of a few resonances lead to an develop in bandwidth, which is fascinating for functions within the telecommunications discipline [3].

The main barrier to enforce the microstrip antennas in many purposes is their slender bandwidth and to overcome this hindrance much work has been dedicated to develop the bandwidth. There are quite a lot of bandwidth enhancement tactics considered one of which is the use of a non resonant aperture (huge aperture) with a thick substrate [4]. However this method has a disadvantage of big amount of radiation creation with the aid of the aperture, which results in a radiation sample having terrible entrance to again ratio.

The opposite bandwidth enhancement procedures include utilizing reducing dielectric steady, parasitic patches, chopping slots or notches like U-slot, utilising air substrate, E-shaped, H-shaped patch antennas [5],[6],[7],[8]. The an extra bandwidth enhancement process that has been largely used is stacked patches, where a parasitic element (stacked patch) is positioned over the driven aspect (shrink patch) and the electromagnetic coupling between the parasitic detail and the driven aspect increases the impedance bandwidth [9],[10].

The fast tendencies in the wireless communications demand antenna designs that might be used for a couple of frequency bands. These antennas are called as multi-band antennas. These antennas have the potential to combine a few frequency bands on single antenna constitution which make them valuable for a couple of frequency degrees [11]. So this paper grants a twin band aperture coupled microstrip stacked filtered patch antenna for WLAN purposes, protecting the complete frequency band from 2.15 GHz to 5.35 GHz and it additionally covers IMT applications for some neighborhood of the frequency band from 3.4 GHz to 4.2 GHz. In this paper, the geometry and the antenna design of the proposed twin band antenna constitution with filtering technology with the introduction of an air hole between the bottom aircraft and the higher layer substrate is presented in part II, the Simulation outcome are provided in section III and in section IV a brief conclusion is given.

II. ANTENNA DESIGN

An aperture coupled microstrip patch antenna resonating at two frequencies is designed utilizing filter stacking. Filtering & stacking is a technique to reap the twin band behavior and to increase the impedance bandwidth of the antenna. It includes a multilayered constitution inclusive of quantity of dielectric substrates and patches. In it parasitic factors (or stacked patches) are placed over the pushed detail (or the foremost patch). The electromagnetic coupling between the parasitic aspect and the pushed detail raises the impedance bandwidth. Additionally an air hole of 10 mm has been introduced between the higher layer substrate to develop the bandwidth of the antenna. FR-4 is the material used for antenna substrate (for each the upper substrate layers) and feed substrate (the slash substrate layer). The fabric has a thickness (h) of 1.6 mm and dielectric permittivity of four.4 with tangent loss element as zero.0009. The antenna constitution has a bottom patch of rectangular shape over the substrate material supported through the bottom plane. The highest patch of the antenna is of a rectangular form having a rectangular slot of dimensions precisely equal as the scale of the backside patch. The twin band antenna is fed by way of an aperture reduce in the ground airplane coupled to a 50 microstrip line beneath the feed substrate. The facet view of the antenna showing quite a lot of layers businesses with placement of waveguide port is proven in figure 1.

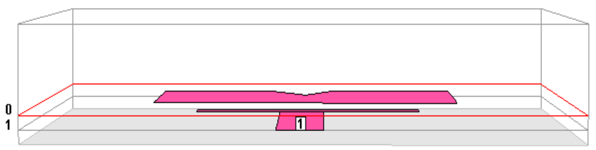


Figure 1 Side view of the Dual Band ACSFMPA

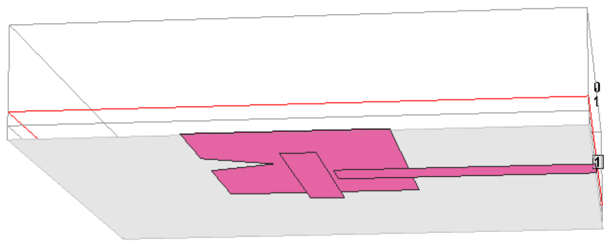


Figure 2 bottom view of the Dual Band ACSFMPA

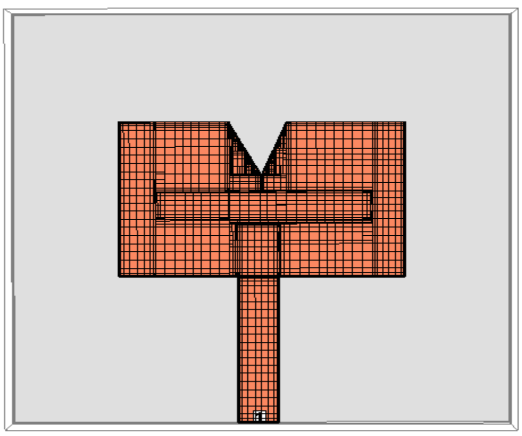


Figure 2 Front view of the antenna showing position of the bottom patch below the slot cut in the top patch

Figure 2 depicts the every layer view of the antenna with labelled dimensions. Figure 2 (a) depicts the rectangular top patch of the antenna structure having rectangular slot in it placed over upper layer substrate 1 followed by rectangular bottom patch placed over upper layer substrate as shown in Figure 2 (b), supported by the ground plane having a rectangular aperture shown in Figure 2 (c), below the ground plane there is lower layer substrate, on the rear side of which there is microstrip feed line of 50 ohms as shown in Figure 2 (d). The front view of the antenna is shown in Figure 2.

The design specifications of the dual band ACSFMPA has been given in Table 1.

Resonance Frequencies (f_r)	2 GHz, 5 GHz
Patch (top as well as bottom patch) Substrate Material, Feed Substrate Material	FR-4
Patch (top as well as bottom patch) Substrate Thickness, Feed Substrate Thickness (h)	1.6 mm
Dielectric Constant of the material used (ε_r)	4.4
Thickness of PEC Material (t)	0.02 mm
Height of Air Gap	10 mm

Table 1 Design specifications of the proposed dual band ACSFMPA

Also the various dimensions of the antenna has been calculated by the design equations from C A Balanis [1]. The dimensions of the top patch, bottom patch, ground plane, substrate layers, slot and the feedline of the designed dual band antenna has been given in Table 2.

Parameters	Description	Values
L	Length of the Top Patch	40.83 mm
W	Width of the Top Patch	26.5 mm
L_b	Length of the Bottom Patch	30.87 mm
$W\ b$	Width of the Bottom Patch	4.7 mm
L_g	Length of the Ground Plane	71 mm
W_g	Width of the Ground Plane	70 mm
W_s	Width of the Aperture in the ground plane	1.6 mm
W_f	Width of the Feedline	6.00 mm

Table 2 Various dimensions of the proposed dual band ACSFMPA

III. SIMULATION RESULTS

Sonnet Studio 2014 has been used to simulate the proposed dual band aperture coupled microstrip patch antenna with an air gap and various simulation results like return loss, smith chart, VSWR and farfield patterns of the gain and directivity of the antenna has been observed. The (S_{11})versus frequency plot of the antenna also shows two dips indicating dual frequency operation of the antenna at the resonance frequencies of 2.05 GHz and 5.6 GHz. The value of reflection coefficients are 0.05175 and 0.02441 at the corresponding resonance frequencies as seen from the Figure 4.

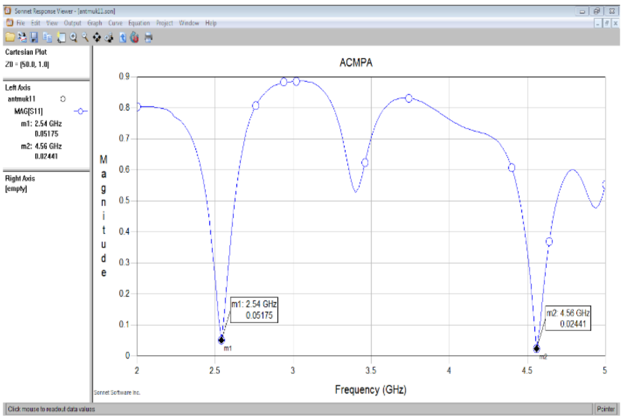


Figure 4 S-parameter versus frequency plot of the proposed dual band ACSFMPA

The return loss values are -25.72 dB and -32.25 dB at the corresponding resonance frequencies. The S11 parameter represents the power reflected from the antenna. The whole power is reflected from the antenna and nothing is radiated for S11 = 0 dB. S11 = -20 dB indicates 20% of the power is reflected. The bandwidth of the dual band antenna can be calculated from the return loss versus frequency plot. The bandwidth of the antenna is the range of frequencies over which the return loss is larger than -10 dB and it corresponds to a VSWR value of The measured -20 dB bandwidth of the designed antenna is 2.54 GHz and 4.56 GHz at the lower resonant frequency of 2 GHz and the upper resonant frequency of 5 GHz respectively as seen from Figure 5.

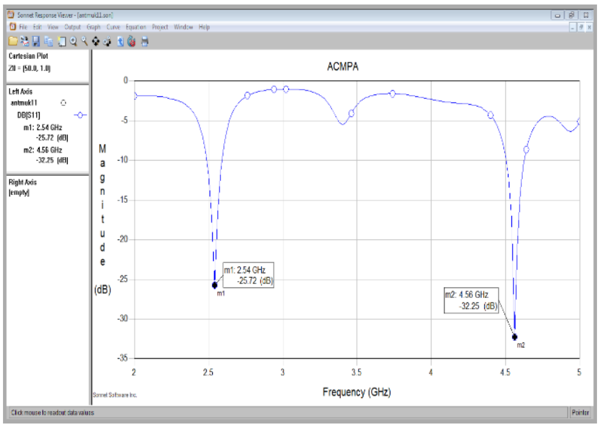


Figure 5 Return loss (S11) versus frequency plot of the proposed dual band ACSFMPA

The smith chart of the dual band antenna has been shown in Figure 6 which depicts the impedance values (resistance as well as reactance) of the antenna at the marked frequency values. The almost real value of the impedance (with a very small reactance) at the resonance frequencies indicates the antenna requires lesser tuning to be done to match the antenna's impedance with the transmission line.

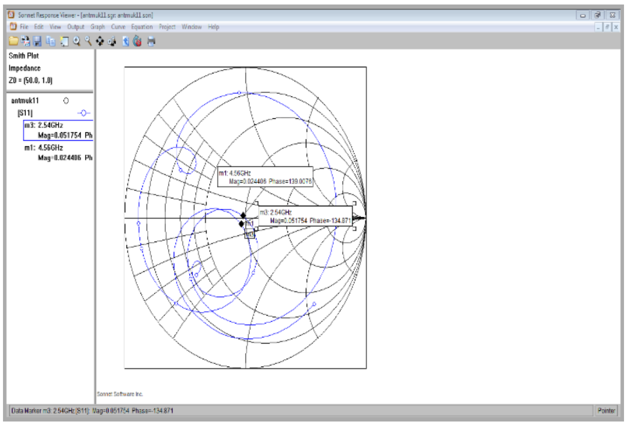


Figure 6 Smith Chart of the proposed dual band ACSFMPA

The VSWR versus frequency plot of the dual band antenna has been shown in Figure 7 which depicts the VSWR values at both the resonance frequencies. The antenna achieves a VSWR value of 1.109 at the lower band frequency of 2.54 GHz and 1.105 at the upper band frequency of 4.56 GHz.

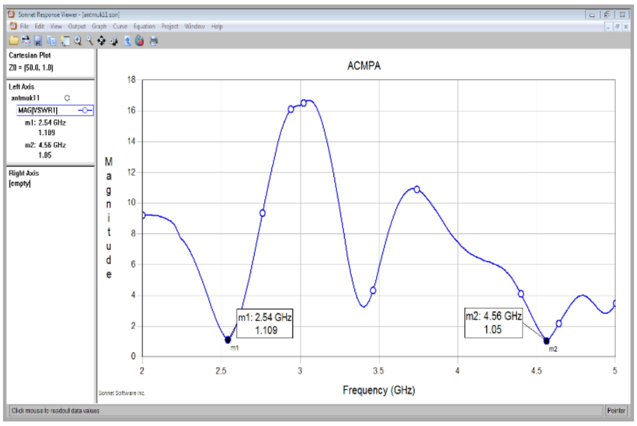
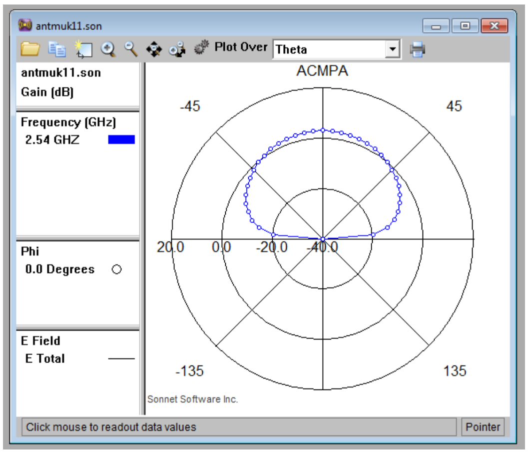


Figure 7 VSWR plot of the dual band ACSFMPA



The polar plot of the directivity with the elevation angle (θ degrees) at the azimuth angle (ϕ) phi equal to 90 degrees of the dual band antenna with stacked technology at both the resonance frequencies of 3.905 GHz and 5.36 GHz is shown in Figure 9(a), (b)

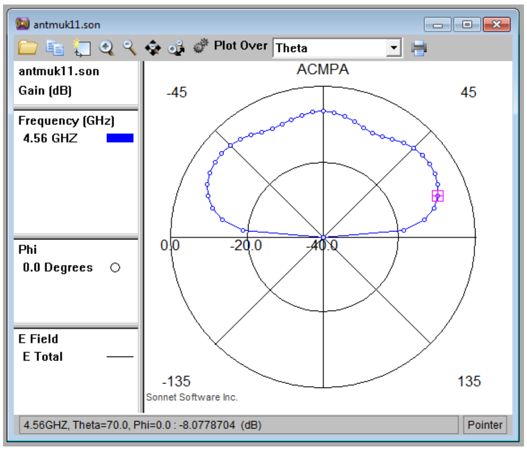


Figure 8 Polar plot of the directivity of the dual band ACSMPA at frequency (a) 2.54 GHz, (b) 4.56 GHz

IV. CONCLUSION

In this paper aperture coupled microstrip stacked patch antenna operable at two resonant frequencies of 2.54 GHz and 4.56 GHz has been designed for wireless and WLAN applications. The designed antenna has -20 dB return loss bandwidth of 234.8 MHz and 684.9 MHz at 3.0 GHz and 5.0 GHz respectively. The designed dual band antenna has a VSWR value of 1.09 and 1.05 at the corresponding lower and upper band resonant frequencies.

REFERENCES

[1] C. A. Balanis, “Microstrip Antennas,” Antenna Theory Analysis and Design, Third Edition, John Wiley & Sons, pp 811-876, 2010.

[2] Sullivan, P., and Daniel H. Schaubert. "Analysis of an aperture coupled microstrip antenna." antennas and propagation, IEEE Transactions on 34.8 (1986): 977-984.

[3] Giauffret, L., and J-M. Laheurte. "Theoretical and experimental characterization of CPW-fed microstrip antennas." IEE ProceedingsMicrowaves, Antennas and Propagation 143.1 (1996): 13-17.

[4] Chen, Wei, Kai Fong Lee, and R. Q. Lee. "Input impedance of coaxially fed rectangular microstrip antenna on electrically thick substrate." Microwave and Optical Technology Letters 6.6 (1993): 387-390.

[5] Ansari, Jamshed Aslam, and Ram Brij Ram. "Broadband stacked U-slot microstrip patch antenna." Progress In Electromagnetics Research Letters 4 (2008): 17-24.

[6] Ayoub, A. F. A. "Analysis of rectangular microstrip antennas with air substrates." Journal of Electromagnetic Waves and Applications 17.12 (2003): 1755-1766.

[7] Ang, Boon-Khai, and Boon-Kuan Chung. "A wideband E-shaped microstrip patch antenna for 5-6 GHz wireless communications." Progress In Electromagnetics Research 75 (2007): 397-407.

[8] Ansari, J. A., Singh, P., Dubey, S. K., Khan, R. U., and Vishvakarma, B. R. (2008). H-shaped stacked patch antenna for dual band operation. Progress In Electromagnetics Research B, 5, 291-302.

[9] Croq, Frederic, and David M. Pozar. "Millimeter-wave design of wide-band aperture-coupled stacked microstrip antennas." Antennas and Propagation, IEEE Transactions on 39.12 (1991): 1770-1776.

[10] Croq, F., and A. Papiernik. "Large bandwidth aperture-coupled microstrip antenna." Electronics Letters 26.16 (1990): 1293-1294.

[11] Yuan, D., Du Z., Gong K., and Feng Z. “A novel dual band printed diversity antenna for mobile terminals.” Antennas and propagation, IEEE Transactions on 55.7 (2007): 2088-2096.