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A Compact Triple Band Antenna for WLAN and WPAN Applications

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Abstract **--**The antenna covers 2.4/5 GHz WLAN and 7.4 GHz WPAN frequency bands. To obtain the triple band nature of antenna two additional rectangular slots are incorporated in ground plane. The optimized dimensions of the proposed uniplanar antenna are 19 mm x 21 mm x 1.6 mm when printed on a substrate of dielectric constant 4.4 and height 1.6 mm. The antenna exhibits good gain characteristics in operating bands. Details of the antenna design, simulation, and results are presented and discussed.

Keywords: ACS fed; triple band; uniplanar antenna; WLAN; WPAN.

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I. INTRODUCTION

In recent years, more emphasis has been devoted to WPAN technology. The future WPAN (wireless personal area network) focuses on reliable wireless connections among computers and portable devices [1]. In last few decades several researchers have developed antennas that satisfy the demands of the wireless communication for improving performances especially in term of miniaturization and multiband operations [2]. Compact uniplanar antennas have the compensation of easy integration with active circuits and MMICS. In this article, we present an asymmetric coplanar strip (ACS) fed triple band antenna. The use of the 2.4 GHz and 5.2 GHz WLAN and 7.4 GHz WPAN bands are becoming a significant way of wireless communications [1, 2]. So it is essential to propose and develop a suitable compact uniplanar antenna for mentioned applications. However the limitation with miniaturization is the size of antenna. To overcome this restriction an asymmetric coplanar strip fed antenna came into existence [4]. In this paper we present an asymmetric coplanar strip fed triple band antenna consisting rectangular slots for WLAN and WPAN applications. The simple structure of antenna makes it easy for design. The proposed antenna is an improved design over an inverted L shaped antenna discussed in reference [2] which exhibits only a single resonance centered at 2.3 GHz yielding a bandwidth of 348 MHz [1,3]. HFSS antenna simulation software is used for design and analysis of proposed structure [7]. The resulting antenna operates at 2.4 GHz (2.2-2.6 GHz), 5.2 GHz (4.7-5.6 GHz) WLAN and 7.4 GHz (6.6 to 8.8 GHz) WPAN applications.

I. DESIGN OF THE THE FINAL TRIPLE BAND ANTENNA

In this section, an asymmetric coplanar strip (ACS) fed triple band rectangular slots in ground plane antenna is discussed. An asymmetric coplanar strip (ACS) fed is an impressive feed for unipolar antenna. The geometry of the proposed antenna is shown in fig. 1, in this design the excitation is provided by coaxial probe. The width of the signal strip 'Wi' = 3 mm and the gap 'g' = 0.5 mm of the ACS transmission line are derived from standard design equations and is found to be 63 Ω [8]. This antenna is printed on FR4 substrate with a dielectric constant 4.4 and a thickness of 1.6 mm with a loss tangent of 0.02. To obtain two additional resonances in the structure some modification is done into the ground plane without affecting the compactness of the antenna [5, 6]. The second resonance at 5.2 GHz is obtained by subtracting rectangular slot of area say 'Ls1 x Ws1' mm^2 from the ground plane of antenna. The third resonance is obtained by inserting a rectangular slot of area say 'Ls2 x Ws2' mm^2.

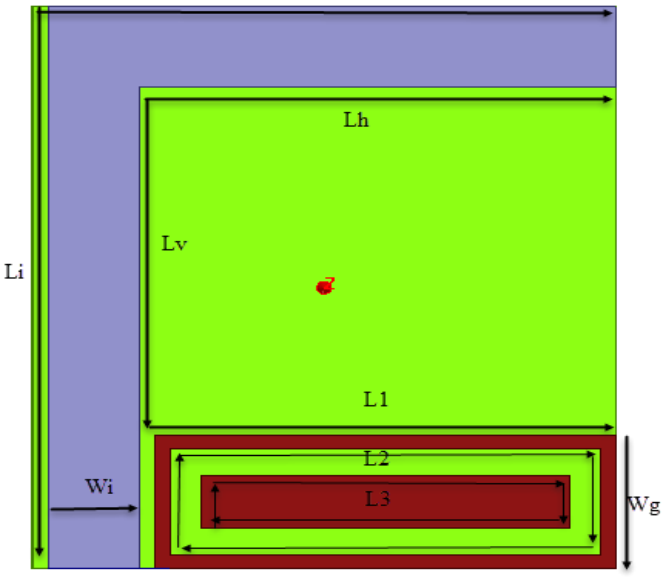

Fig.1. Proposed ACS FED triple band antenna

The current paths L1, L2 and L3 lead to the desired resonances covering both WLAN and WPAN frequency bands. The optimized dimension of proposed antenna are 'Wg' = 5 mm, 'Ls'=21 mm, 'Ws'=3 mm, 'Ls1xWs1'= 14 mm x 4 mm, 'Ls2 x Ws2' = 12 mm x 2 mm.

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II. RESULT AND DISCUSSION

In order to achieve resonance in mentioned applications, path length 'L1' is made nearly equal to half of dielectric wavelength in the substrate corresponding to 2.4 GHz. And the path lengths of two another frequency bands are nearly kept equal to the dielectric wavelengths in the substrate corresponding to 5.2 GHz and 7.4 GHz respectively. The formula for evaluating the path lengths 'L1', 'L2' and 'L3' are given as:

$$L1 = 0.5\ \lambda_d \quad (1)$$

$$L2 = L3 = \lambda_d \quad (2)$$

$$\lambda_d = \lambda / (\varepsilon eff)^{1/2} \quad (3)$$

$$\varepsilon_{eff} = (\varepsilon_r + 1)/2 \quad (4)$$

Here, λ_d is the wavelength of guided wave in the dielectric, ε_r is relative dielectric constant and ε_{eff} is effective dielectric constant. From the above calculation the 'L1' comes out to be 39.5 mm and 'L2' is equal to 35 mm and 'L3' is equal to 26.5 mm. The reflection coefficient verses frequency curve for the proposed antenna is shown in fig. 2.

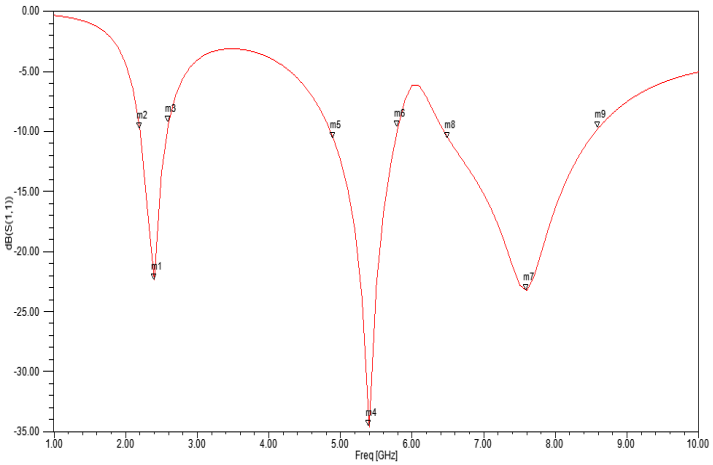


Fig.2 Reflection characteristics of triple band antenna

The antenna shows first resonance at 2.4 GHz with bandwidth of 400 MHz (2.2 GHz to 2.6 GHz), second resonance at 5.2 GHz with bandwidth of 900 MHz (4.7 GHz to 5.6 GHz) and third resonance occurs at 7.4 GHz with bandwidth of 2 GHz (6.6 GHz to 8.8 GHz) for WLAN And WPAN applications. The first slot improves the return loss characteristics for first resonance and generates second frequency band also but it is not satisfactory as shown in fig. 3. It is analyzed that the slot 'Ls2 x Ws2' has insightful influence upon the impedance matching of the antenna. It can be noticed from the figure 2 that by insertion of second slot of area 'Ls2 x Ws2' into the ground plane the return loss characteristics for the second resonances greatly improves as well as the third resonance also occurs for the WPAN application.

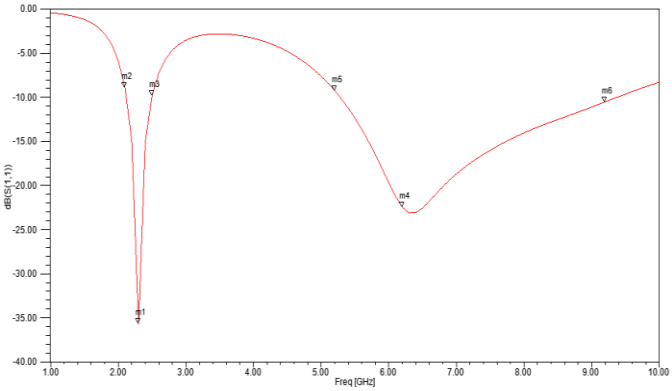
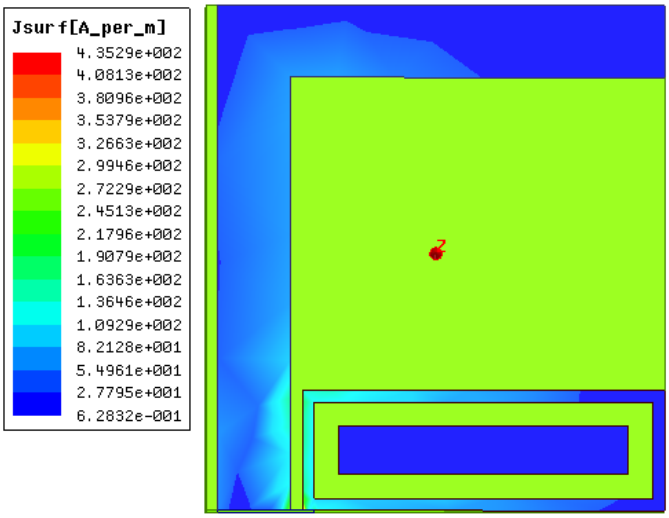
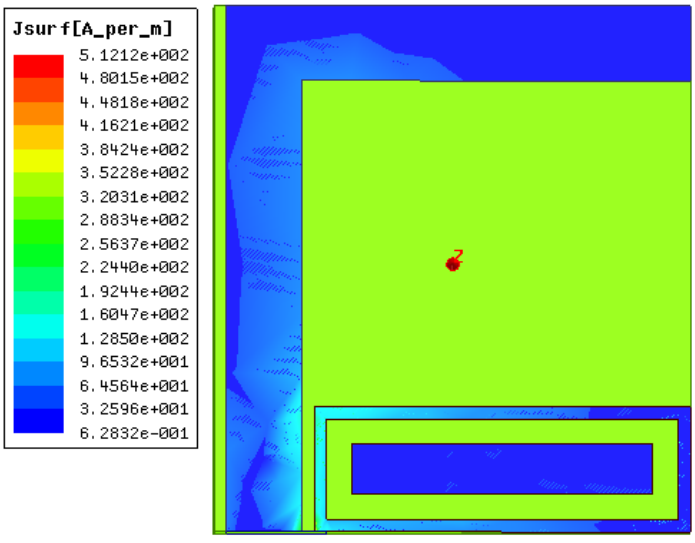


Fig.3- Reflection characteristics of triple band antenna for second frequency band



(a)



(b)

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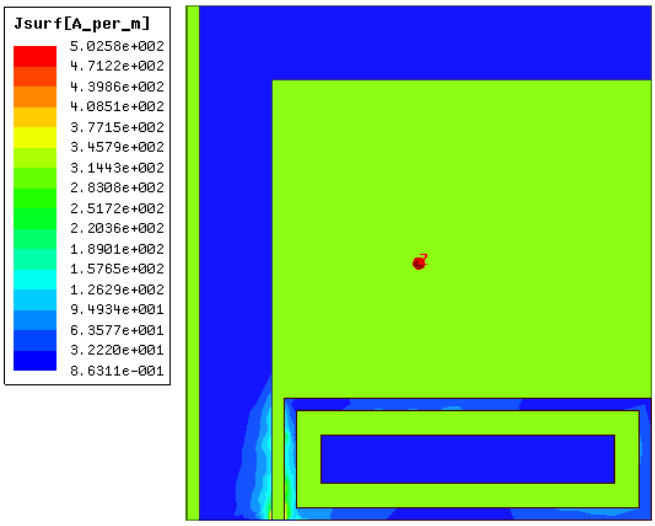
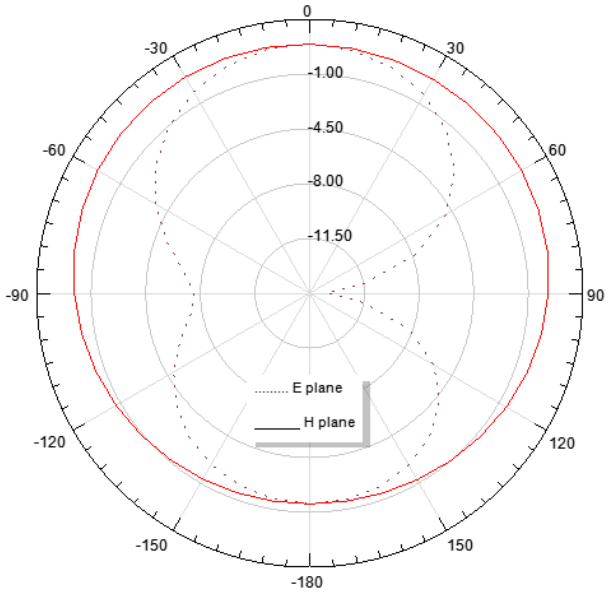


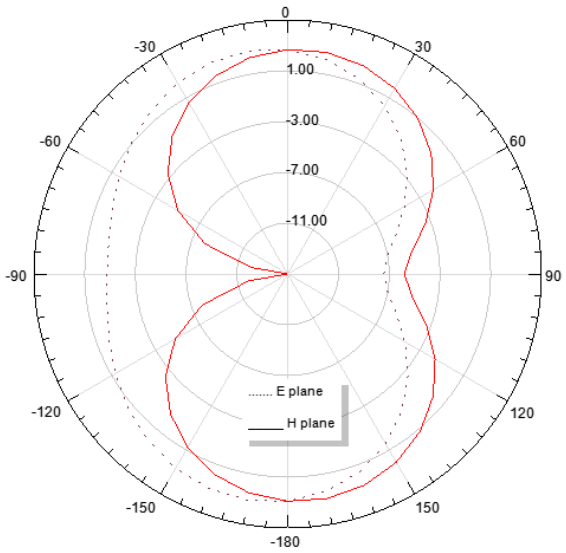
(c)

Fig.4. Current distribution of triple band (a) 2.4 GHz (b) 5.2 (c) 7.4 GHz.

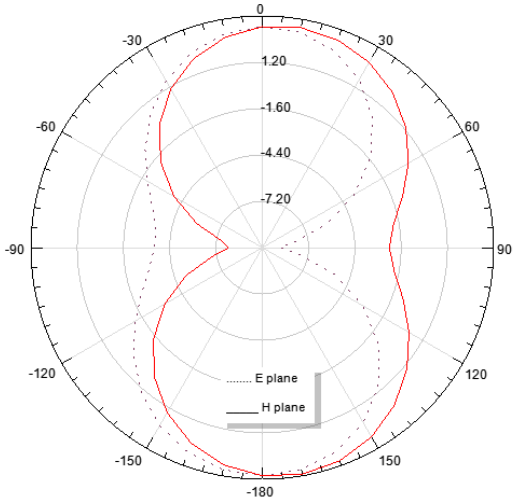
`Figure 4(a), 4(b) and 4(c) shows the simulated current distribution of the proposed antennas at 2.4 GHZ, 5.2 GHz and 7.4 GHz respectively. Figure 5(a), 5(b) and 5 (c) shows the simulated radiation pattern of the proposed antennas at 2.4 GHz, 5.2 GHz and 7.4 GHz respectively. The dotted line shows the (*xz* - plane) E plane pattern and the solid line shows the (*yz* - plane) H plane pattern. It can be seen that for the 2.4 GHz the E plane pattern of antenna is near figure of eight and H plane pattern is omnidirectional and also for the high frequency bands the patterns are satisfactory. The gain of the antenna is also discussed and it is found to be 8.71dB at 2.4 GHz, 2.76 dB at 5.2 GHz and 4.50 dB at 7.4 GHz respectively. The bandwidth efficiency of the antenna is 16.66 % and 17.63 % for WLAN and 30 % for WPAN applications.



(a)



(b)



(c)

Fig.5. Radiation pattern at (a) 2.4 GHz (b) 5.2 GHz (c) 7.4 GHZ

III. CONCLUSION

An asymmetric coplanar strip fed triple band antenna for WLAN and WPAN applications is proposed. The antenna has a uniplanar structure and compact dimensions of 21 mm × 19 mm × 1.6 mm when fabricated on an FR4 substrate of dielectric constant 4.4.and height 1.6 mm. Good reflection coefficient characteristic with moderate gain is also noted. The simple structure, compact dimensions, makes it an ideal candidate for the 2.4/5.2 GHz WLAN and 7.4 GHz WPAN applications.

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