Horse-Shoe ShapedStacked Microstrip Patch Antenna for WLAN, WiMAX and IMT Applications

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Abstract. This paper illustrates the design and performance analysis of proposed stacked horse-shoe shaped micro strip patch antenna. In the proposed stacked antenna design, a rigid substrate having thickness 1.57mm and flexible substrate having thickness 0.2mm has been stacked. In the proposed antenna design, there are total two layers of substrates, where the flexible substrate has been placed on the upper surface of rigid substrate. The rigid and flexible substrates employed in the proposed antenna design are of duroid material having dielectric constant of 2.2. In the proposed antenna design, the rigid substrate has ahorse-shoe shaped patch on the upper surface and a ground on the bottom surface. The performance of the proposed antenna design has been analysed in terms of resonant frequency, impedance bandwidth, VSWR, impedance, return loss, gain and directivity. The proposed antenna design has resonant frequencies at 2.18 GHz and 5.2 GHz having return loss of -22.496dBand -55.012dB, respectively. The proposed design has two operating bands having operating frequency range of 2.02GHz-2.43GHz and 3.22GHz-6.13GHz. The proposed antenna has been designed and simulated using CST microwave studio 2014. The proposed antenna design can be used for WLAN, WiMAX and IMT applications.

Keywords: Dual band, Duroid, Horse-Shoe, Stacking.

1. Introduction

The rapid growth in wireless communication systems has resulted in a great demand for small devices capable of providing multiple services, for example, Bluetooth operating at 2.4 GHz, WLAN operating at 2.4 GHz, 5.2 GHz and 5.8 GHz.[1]

In recent years, significant advancement in the wireless communication demands antennas having light weight, low profile, superior performance and multiband operation.[2] The micro strip patch antenna is one of the most preferred antenna structure due to their low profile and ease of fabrication.[3] The micro strip patch antenna in simplest form can be explained as antenna with dielectric substrate confined in between two metal patches with radiating patch on the one side and ground patch on the other side.[4] There are variety of substrates available with different dielectric constants but in the proposed antenna design, FR4 material with dielectric constant of 4.4 has been used.[5] An antenna can be fed by various feeding techniques, for example, micro strip feed line, co-axial feed line, proximity coupled micro strip feed.[5] The feeding can be defined as the means to transfer the power from the feed line to the patch, which itself act as a radiator.[6]

The UWB technology was released in February 2002 by Federal Communication Commission (FCC) to cover the frequency range of 3.1GHz-10.6GHz.[7] The Unlicensed National Information Infrastructure (U-NII) band is used for Bluetooth, WLAN and Wi-Fi operations.[8] The Bluetooth technology provides short range of wireless connections between electronic devices.[9] It is one of the Wireless Local Area Network (WLAN) application having operating frequency range of 2.4-2.5GHz.[10]

Apart from above mentioned applications, the low profile antennas have some limitations, for example, narrow bandwidth, low gain, low power handling capacity, etc.[10]

2. Antenna Geometry

The proposed stacked horse-shoe shaped micro strip patch antenna has been designed using CST microwave studio 2014. In the proposed antenna design, a 0.2mm thick flexible substrate has been stacked with the 1.57mm thick rigid substrate as shown in Fig. 1. The employed substrates are of duroid material having dielectric constant of 2.2. The top and bottom view of the bottom rigid substrate is shown in Fig. 2and Fig 3, respectively.A horse-shoe shaped patch has been placed on the upper surface of the rigid substrate and a ground has been placed on the bottom substrate of the rigid substrate as shown in Fig. 1.The flexible substrate has been placed on the upper surface of rigid substrate a shown in Fig. 1. The upper and lower surface of stacked flexible substrate has no copper on the upper and lower surface. The top view of the proposed antenna is shown in Fig. 4. The parameters of proposed antennas design are given in Table 1.

Fig. 1 Side view of the proposed horse shaped stacked MPA

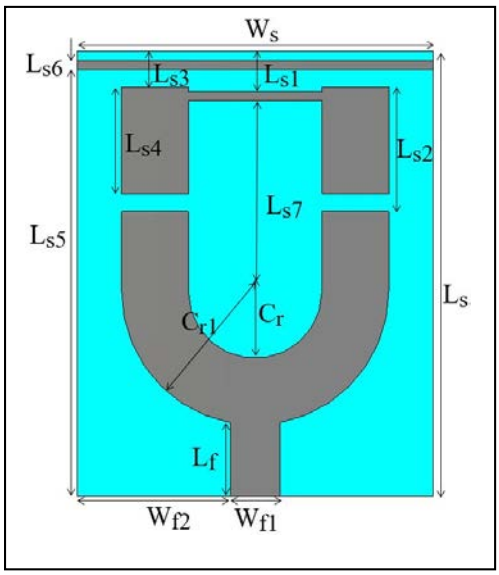

Fig. 2 Top view of rigid substrate

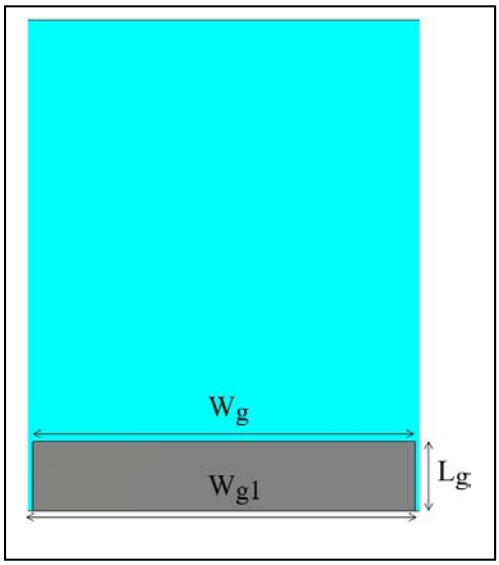

Fig. 3 Bottom view of rigid substrate

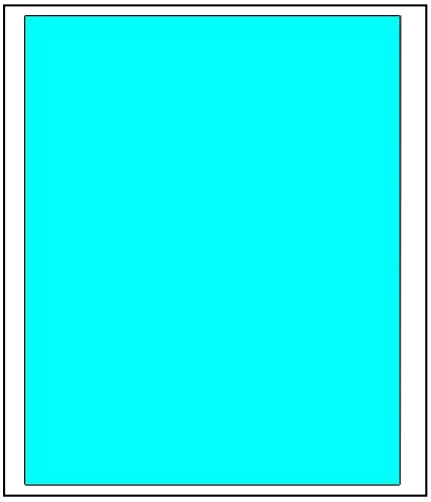

Fig. 4 Top view of the proposed horse-shoe shaped MPA antenna

Table 1. Antenna Parameters

Antenna Parameters	Value (mm)
Ws	40.0
Ls	50.0
Ls1	4.50
Ls2	16.8
Ls3	4.00
Ls4	13.8
Ls5	48.0
Ls6	1.00
Ls7	21.5

Cr1	7.50
Cr2	15.0
Wf1	8.00
Wf2	16.0
Lf	8.00
Lg	7.00
Wg	39.0
Wg1	39.5
Tss	0.20
Tp	0.02
Ts	1.57
Tg	0.02

3. Results

The performance of proposed stacked horse-shoe shaped micro strip patch antenna has been observed in terms of resonant frequency, VSWR, return loss, directivity, gain, impedance bandwidth and impedance. The proposed antenna design has been designed and simulated using CST microwave studio 2014. The proposed antenna design has two operating bands having frequency range of 2.02GHz-2.43GHz and 3.22GHz-6.13GHz. It has been observed that 2.02GHz-2.43GHz and 3.22GHz-6.13GHz band has impedance bandwidth of 0.41GHz and 2.91GHz, respectively.

The Fig. 5 illustrates the return loss plot (S_{11}) of the proposed antenna design. It has been observed that the proposed antenna design has resonant frequencies at 2.18GHz and5.2 GHz with return loss of -22.49dB and -55.01dB respectively. It has been observed that the proposed antenna design has gain of 2.75dB and 5.83dB at resonant frequencies2.18GHz and 5.2GHz, respectively. The Fig. 6(a) and Fig. 6(b) demonstrates the 3D plot of gain at 2.18GHz and 5.2GHz, respectively.

It has been observed that the proposed antenna design has directivity of 2.42dBi and 5.68dBi at resonant frequencies 2.18GHz and 5.2GHZ, respectively. The Fig. 7(a) and Fig. 7(b) depicts the directivity plot of the proposed antenna design at 2.18GHz and 5.2GHz resonant frequencies, respectively. It has been observed that the stacked horse-shoe shaped micro strip patch antenna has impedance of 49.26 Ω. The Fig.8 demonstrates the smith chart plot of the proposed antenna. It has been also observed that the VSWR value of the proposed antenna design is less than the maximum acceptable value i.e. 2. The Fig. 9 illustrates that the VSWR value of the proposed antenna design lies below 2 within the operating impedance bandwidth.

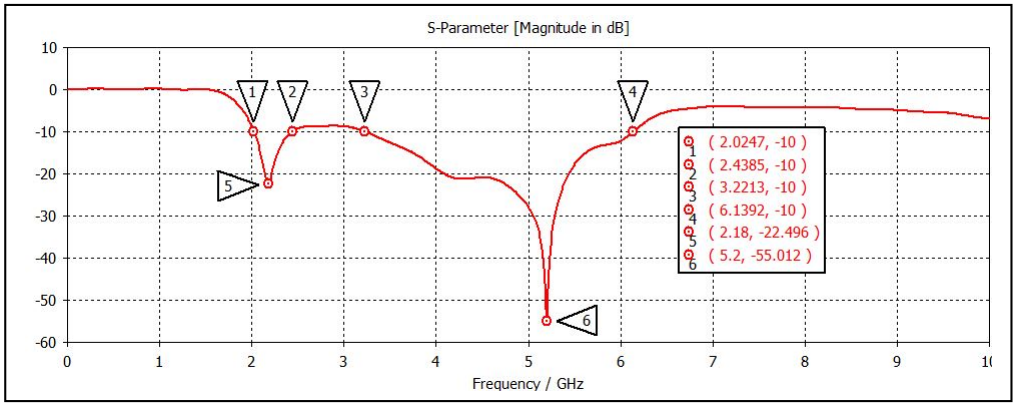

Fig. 5 Return loss plot of the proposed stacked antenna design

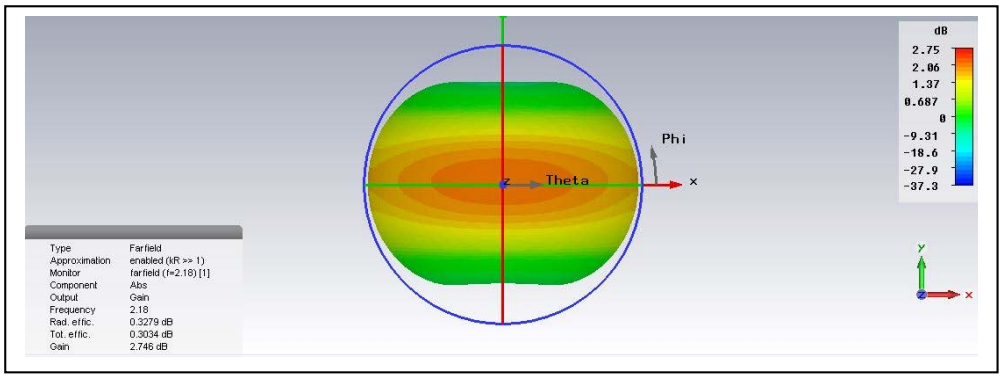

Fig. 6(a) 3D plot of gain of proposed stacked antenna design at 2.18GHz

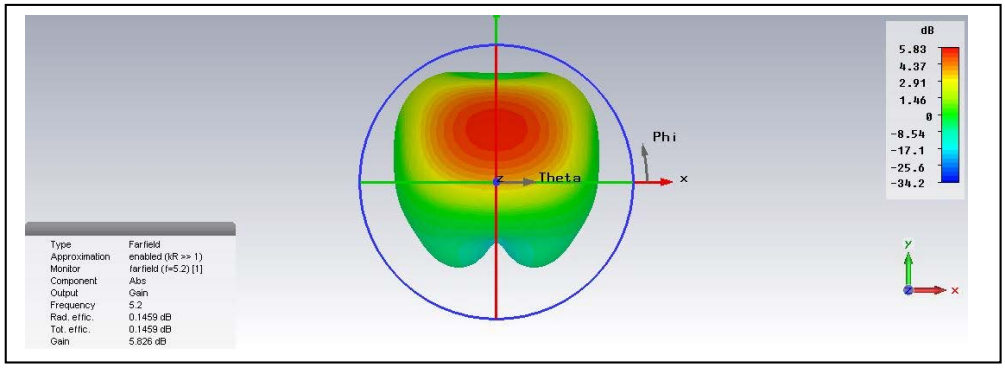

Fig. 6(b) 3D plot of gain of proposed stacked antenna design at 5.2GHz

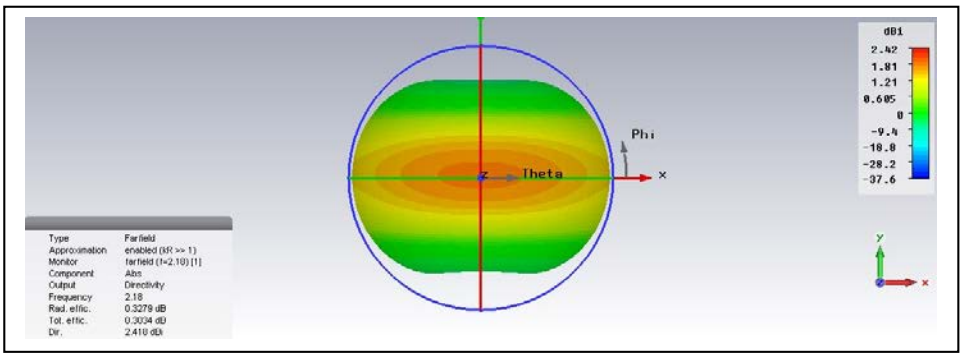

Fig. 7(a) 3D plot of directivity of proposed stacked antenna design at 2.18GHz

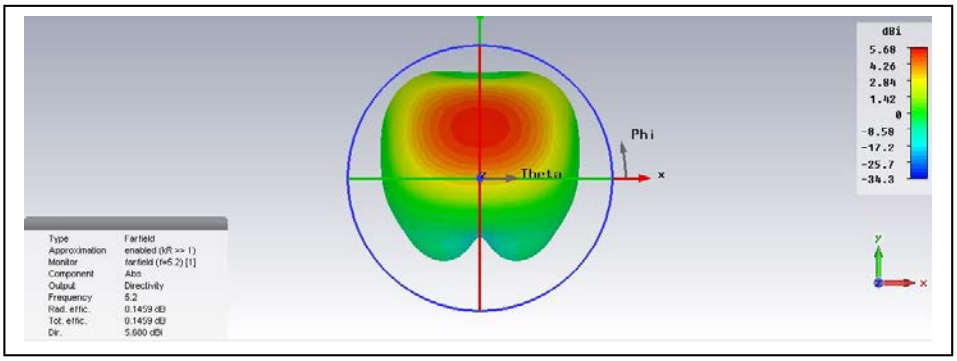

Fig. 7(b) 3D plot of directivity of proposed stacked antenna design at 5.2GHz

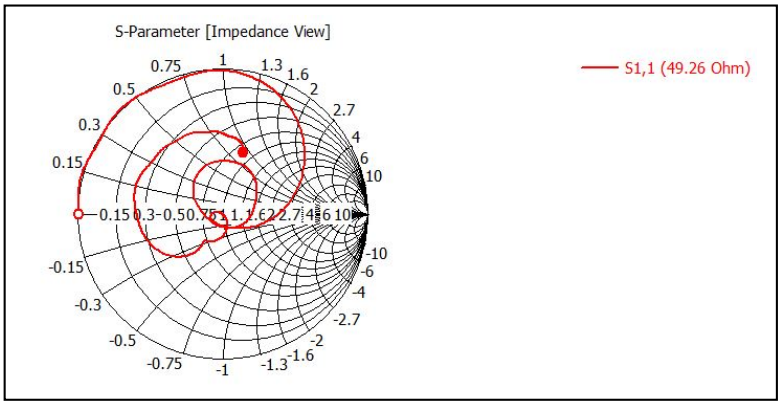

Fig. 8 Smith chart plot of the proposed stacked antenna design

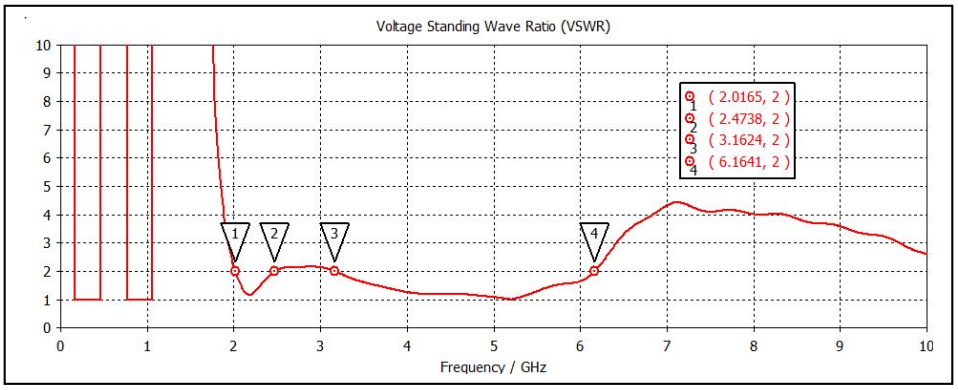

Fig. 9 VSWR plot of the proposed stacked antenna design

4. Conclusion

The proposed horse-shoe shaped micro strip patch antenna has designed using CST microwave studio 2014. In the proposed antenna design, the rigid and flexible substrate of duroid material having dielectric constant of 2.2 has been stacked. The rigid substrate has thickness of 1.57mm whereas the flexible substrate has thickness of 0.2mm. The proposed antenna design has two operating bands having operating frequency ranges of 1.94GHz-2.17GHz and 3.91GHz-6.63GHzwithcorresponding impedance bandwidth of 0.41GHz and2.91GHz, respectively. It has been observed that the proposed antenna design has resonant frequencies

at 2.18GHz, and 5.18GHz with return loss of -22.49dB and -55.01dB, respectively. The proposed antenna has gain of 2.75dB and 5.83dB at 2.18GHz and 5.18 GHz resonant frequencies, respectively. It has been observed that the proposed design has directivity of 2.42dBi and 5.68dBi at resonant frequency 2.18GHz and5.18GHz, respectively. The proposed design has impedance of 49.26 Ω.

5. Applications

The proposed horse-shoe shaped micro strip patch antenna has operating frequency range of 2.02GHz-2.43GHz and 3.22GHz-6.13GHz resonant at 2.18GHz and 5.2GHz resonant frequencies, respectively. It has been concluded that the proposed antenna can be used for WLAN (5.15GHz-5.35GHz and 5.72GHz-5.82GHz)[11], WiMAX(3.4GHz-3.69GHz and 5.25GHz-5.85GHz)[11] and IMT (2.3GHz-2.4GHz, 3.4GHz-4.2GHz and 4.4GHz-4.9GHz)[11] applications.

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