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Numerical Analysis of Dual Band Mirrored-F Antenna for WLAN and Mobile WiMAX Applications

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ABSTRACT
The numerical simulation of a low-profile dual band mirrored-F antenna for 3.5/5.5 GHz WiMAX and 5.2 GHz WLAN applications is proposed. It has a dimension of 29×14.5 mm^2 and the two resonant modes of the antenna provide bandwidth of 13.8% (3.35 GHz-3.85 GHz) and 17.4% (4.9 GHz-5.85 GHz) with maximum gain of 3.36 and 7.35 dBi respectively. The peak values of return loss are -22.124 and -52.282 dB and VSWR varies between 1.83~1.17 and 1.004~1.9 at the lower and upper resonant frequency bands. In addition, the antenna also provides almost omnidirectional radiation characteristics and excellent impedance matching.

Keywords
Mirrored-F antenna, WiMAX, WLAN, Method of Moments (MoM), Numerical Electromagnetic Code (NEC).

1. INTRODUCTION
Wireless communication has brought a revolutionary change in modern communication technology. It has experienced tremendous growth in the last decade, resulting in more and more ubiquitous communications. Today wireless communication covers a very wide array of applications such as wireless local area network (WLAN), worldwide interoperability for microwave access (WiMAX), other wireless local loop (WLL) and a variety of satellite systems. The demand of WLANs are increasing numerously worldwide, because they provide high speed connectivity and easy access to networks without wiring also in recent times of WiMAX, which can provide a long operating range with a high data rate for mobile broadband wireless access, faultless internet access for wireless users becomes more popular. The rapid growing WLAN operating bands are IEEE 802.11 b/a/g at 2.4 GHz (2400–2484 MHz), 5.2 GHz (5150–5350 MHz) and 5.8 GHz (5725–5825 MHz) also the bands of WiMAX operation in the 2.5 GHz band (2500–2690 MHz), 3.5 GHz band (3300–3700 MHz) and 5.5 GHz band (5250–5850 MHz) [1].

To cope up with the widespread modern wireless communication application urges on the need of dual band or multiband antennas including attractive features like ease of fabrication, low cost, omnidirectional radiation characteristics and little or no maintenance. Recently, the design of dual band or multiband antennas has received the attention of antenna researchers like A Compact Loop Type Antenna for Bluetooth, S-DMB, Wibro, WiMax, and WLAN Applications [2], A Compact Tri-Band PIFA Antenna for 2380–2550 MHz and 4810–5560 MHz WLAN and WiMAX Applications [3],

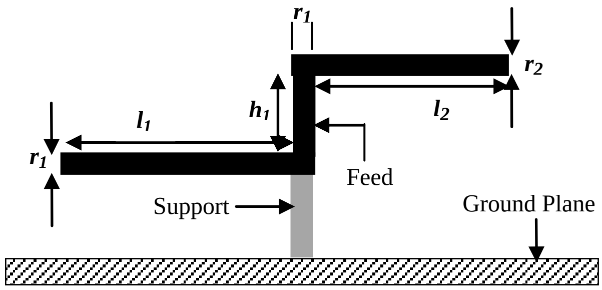

Figure 1: S-shaped antenna

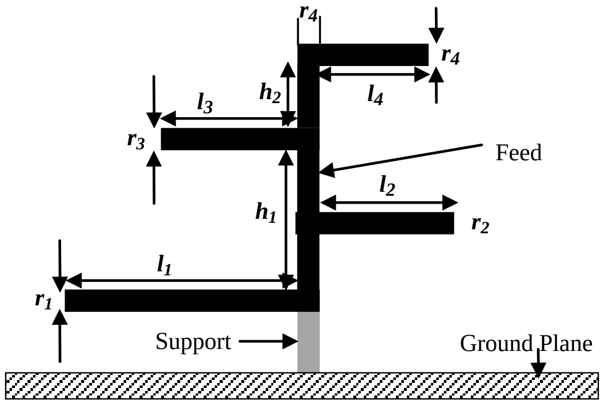

Figure 2: Mirrored F-antenna

A Printed Multiband Antenna operating at 2.4/3.5/5.2/5.5/5.8 GHz for Cellphone Applications [4], Capacitively Fed Hybrid Monopole/Slot Chip Antenna for 2.5/3.5/5.5 GHz WiMAX Operation in the Mobile Phone [5], Dual Wideband Printed Monopole Antenna for WLAN/WiMAX Applications [6], Internal Composite Monopole Antenna for 2500–2690/3400–3600/5250–5850 MHz WLAN/WiMAX Operation in a Laptop Computer [7], Multiband CPW-Fed Triangle-Shaped Monopole antenna for 2.4/3.4/5 GHz Wireless Applications [8] have been reported.

This paper proposes the simulation of a low profile, dual band and high forward gain performance for realizing 3.5/5.5GHz WiMAX and 5.2 GHz WLAN applications using Method of Moments (MoM) in Numerical Electromagnetics Code (NEC).

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Table 1. Dimension of proposed antennas

Antenna	Parameter	Length (mm)	Dimension
S-shaped antenna	l_1	14	24×3 (mm^2)
	l_2	10	
	h_1	3	
	r_1	1.05	
	r_2	1	
Mirrored F-antenna	l_1	18.5	29×14.5 (mm^2)
	l_2	10.5	
	l_3	10	
	l_4	8	
	h_1	9.5	
	h_2	5	
	r_1	1.05	
	r_2	0.5	
	r_3	1.1	
	r_4	1	

2. ANTENNA DESIGN

In designing the mirrored F-antenna to provide the applications of WLAN and WiMAX with high gain, better performance and simple structure, we studied different types of shapes and lengths using Method of Moments (MoM) in NEC. We conducted our study in a trial and error basis to be ascertain of the effect of different loading on the antenna performance to find out the optimal design. Initially an S-shaped antenna which has a dimension of 24×3 mm^2, is selected as prototype and its characteristics is simulated in NEC. But, in search of a dual band characteristics, the S-shaped antenna is modified by loading it with a similar shape placed on top of it, together giving it a mirrored F-shape. The proposed antenna has a size of 29×14.5 mm^2. Figure 1 shows the geometry of the primary design of S-shaped antenna while Figure 2 shows the actual antenna geometry of mirrored-F antenna. The antenna is assumed to feed by 50 Ω coaxial connector, with its central conductor connected to the feeding point and its outer conductor soldered to the ground plane. The dimension of the ground plane considered as 60 mm × 60 mm. The lengths and diameters of the antenna as given in Table 1 are so chosen so as to provide the applications of WLAN and mobile WiMAX with high gain, good impedance matching and omnidirectional radiation pattern.

3. SIMULATION RESULT

The proposed antennas are constructed and numerically analyzed using NEC simulator. Figure 3 shows the simulated frequency responses of return loss for the proposed design. Both the antennas provide appreciable return loss in the respective frequency bands than the commonly required level of -10 dB. As it is seen, the S-shaped antenna offers only a single band covering a bandwidth of 1500 MHz (4.76-6.26 GHz) resonating at 5.26 GHz. But the mirrored F-antenna (modified S-shape) offers two distinct resonant frequencies at 3.6 GHz and 2.45 GHz, respectively. It is then further modified to get an optimized structure which would offer a better frequency band characteristics. This is shown in Figure 4. The peak values of return loss is -44.126 dB for S-shaped

Table 2. Characteristics of the proposed antennas

Antenna	Frequency (GHz)	Band (GHz)	Bandwidth (MHz)	Gain (dBi)
S-shaped antenna	5.26	4.76-6.26	1500 (28.5%)	8.9
Mirrored F-antenna	3.6	3.35-3.85	500 (13.8%)	3.36
	5.45	4.9-5.85	950 (17.4%)	7.35

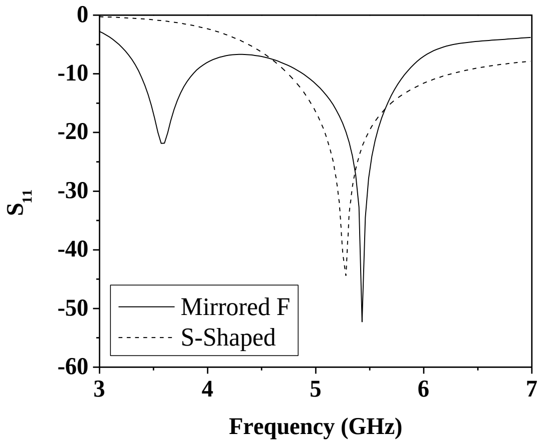


Figure 3: Return loss variation of the proposed antennas

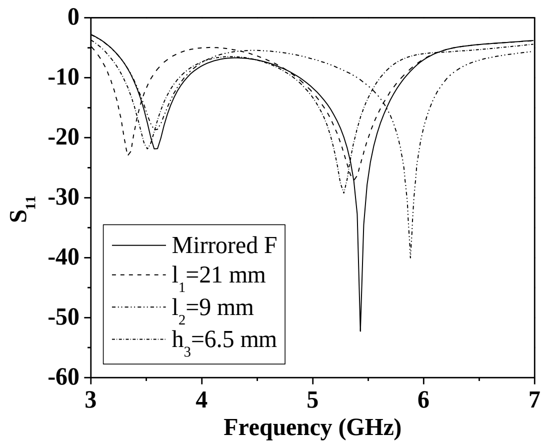


Figure 4: Return loss variation with length of F-antenna

antenna and -22.124 and -52.282 dB for mirrored F-antenna. The relative characteristics of the proposed antennas are also summarized in Table 2.

The variation in voltage standing wave ratio (VSWR) as a function of frequency for S-shaped and mirrored F-shaped antenna is shown in Figure 4. At resonant frequency we obtain VSWR as 1.0093 for S-shaped and 1.169 and 1.004 for F-shaped antenna. The value of VSWR is near about 1 and its variation within the operating band is very small. In a same fashion other characteristics for the both shapes are compared graphically (illustrated from Figure 5 to 8) for a better understanding. The input impedance for both antennas is obtained as 49.566 and 50.03 Ω and variation within the bandwidth is very small. The phase shift decreases in the mirrored F-shaped antenna. It is due to the application of load to the S-shaped antenna. The S-shaped antenna has a forward

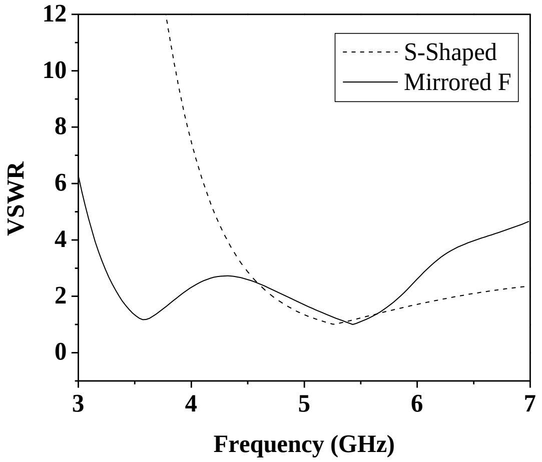


Figure 5: Variation of VSWR with frequency of proposed antenna

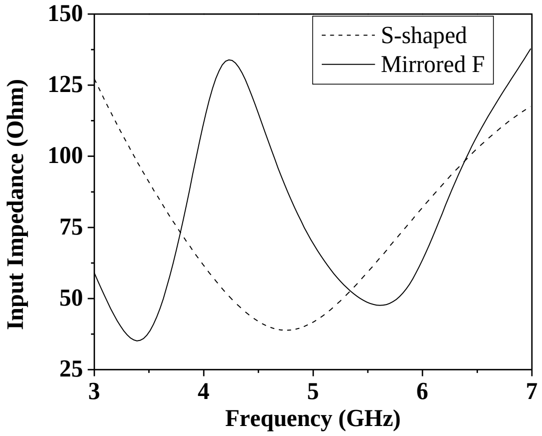


Figure 6: Impedance variation of the proposed antennas

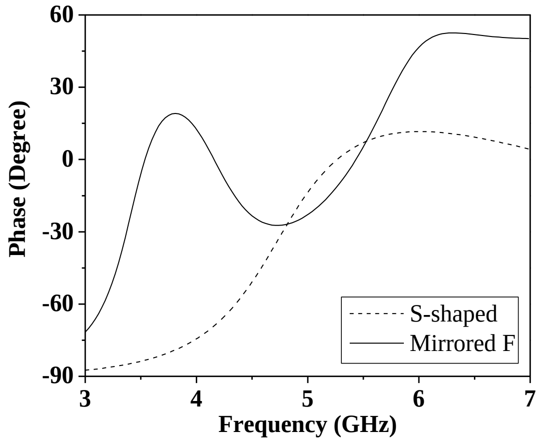


Figure 7: Phase variation of the proposed antennas

gain of 8.9 dBi while the F-shaped antenna has 3.36 and 7.35 dBi in the operating bandwidth. From the compared gain characteristics, the S-shaped antenna has a better gain (8.9 dBi) than the mirrored F antenna (7.35 dBi) has. Peak gain comparison with the proposed antenna and reference antenna for mobile WiMAX, Wi-Fi, WLAN and Bluetooth application are listed in Table 3. From the comparison table, proposed mirrored F antenna has much higher gain than the antenna have been proposed for mobile WiMAX, WLAN and Wi-Fi operation. Figure 9 shows the normalized radiation patterns

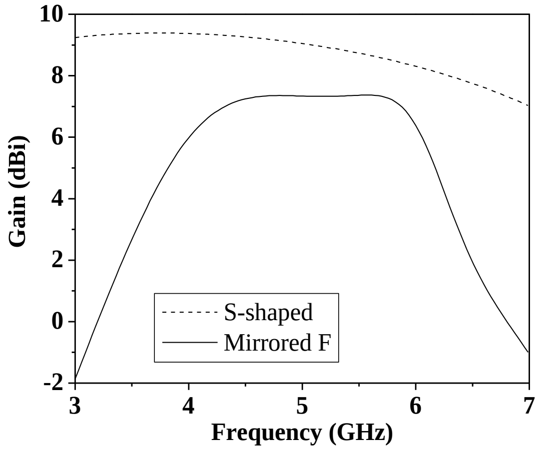
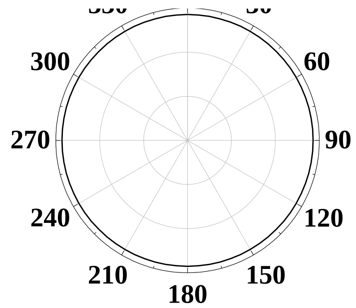
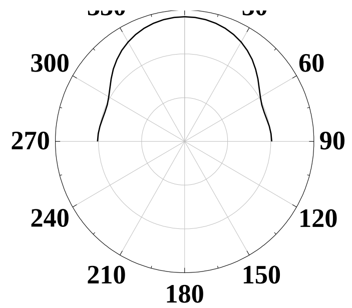


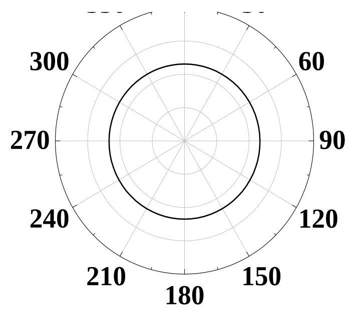
Figure 8: Total gain of the proposed antennas with frequency



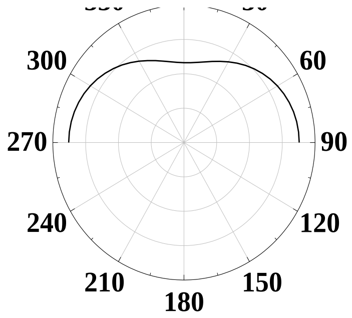
(a)



(b)



(c)



(d)

Figure 9: Radiation pattern of S-shaped antenna (a) total gain in horizontal plane (b) total gain in vertical plane and mirrored F-antenna (c) total gain in horizontal plane (d) total gain in vertical plane.

Table 3. Comparison between existing antenna and our proposed antenna

Antenna	Gain (dBi)			
	3.5 GHz WiMAX	**5.2 GHz WLAN**	**5.5 GHz WiMAX**	**5.8 GHz WLAN**
S-shaped Antenna (Proposed)	-	8.93	8.73	8.5
Mirrored F-antenna (Proposed)	3.36	7.33	7.36	7.22
Compact Loop Type Antenna [2]	-	6.41		
Compact Tri-Band PIFA Antenna [3]	-	2.3	-	4.4
Printed Multiband Antenna [4]	0.78	1.6	3.07	1.49
Capacitively Fed Hybrid Chip Antenna [5]	2.6-4.6	-	2.7-5.8	-
Wideband Printed Monopole Antenna [6]	2.1	-	4	
Composite Monopole Antenna [7]	3.2-3.7	4.6-5.3		
Triangle-Shaped Monopole antenna [8]	2.54	3.59	-	3.05

for the resonant frequency are shown as total gain in vertical (YZ/XZ plane) and horizontal plane (XY plane). The antenna's normalized total radiation in vertical and horizontal plane is almost omnidirectional at the 5.2/5.8 GHz WLAN and 3.5/5.5 GHz WiMAX operating frequency. The proposed antennas has radiation efficiency of 100% and 93.1% respectively.

4. CONCLUSION

A simple structured dual frequency mirrored F-antenna have been proposed. The proposed antenna has a compact dimension of 29×14.5 (mm^2) and obtained operating bandwidths can cover the 5.2 GHz WLAN band and the 3.5/5.5 GHz mobile WiMAX band. Because of its compact size, the antenna can be embedded within different portable devices that employs the applications of WLAN and WiMAX. Minimum return loss, unity VSWR, high forward gain, good impedance matching, and omnidirectional radiation characteristics of the proposed antenna reflects its efficacy in mobile and wireless communication applications.

We are currently working on the improvement of antenna gain, reducing its size and to find some sharper frequency bands.

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