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A CPW Fed Dual band Monopole Antenna for Wireless Applications

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***Abstract*: In this paper, a compact CPW fed dual band microstrip monopole antenna for WiMax and satellite band applications is proposed. The dual band nature is obtained using the ground plane and the stub on the same side of the substrate, thus more advantageous in terms of compactness as compared to double sided printed antennas. The antenna proposed has a gain of 4.7 dB for the resonant frequency 3.7 GHz and 5.30 dB for 7 GHz. It shows S11 < -10dB and VSWR < 2 at the operating bandwidth from 3.55-3.85 GHz and 6.8-7.25 GHz, respectively. The simulation result proves that the antenna proposed is suitable for WiMax and satellite band applications.**

***Index Terms*: dual band, monopole, stub, WiMAX, satellite band.**

I. INTRODUCTION

Wireless applications are growing rapidly in today's world of communication. The range that wireless communication accommodates can be a few meters to thousands of kilometers. Now, it is impossible to imagine a world without wireless communication since, we are so heavily dependent on it. Mobile phones, Wi-Fi, GPS, etc., are some of the most commonly used wireless communication systems. Antennas, particularly multiband antennas (antenna operating at more than one band, thus supporting diverse wireless applications simultaneously) play a very dominating role in wireless communication [1-3]. Corresponding to the versatility of the multiband antennas literature reports various types of multiband antennas. In [4], an antenna with two bands is proposed for GPS applications. The antenna proposed is aperture-coupled and exhibits circular polarization. It operates at 1.5 GHz and 1.2 GHz. In [5], the dual band antenna has 4 T-shaped slits at the edges of the patch. This helps in achieving its dual band nature. The design has single feed and it is circularly polarized. In [6], a two band antenna is proposed with a feed port located diagonally to the patch. Two bands are achieved for X and Ku-band by utilizing the slot.In [7], dual band patch antenna designed for satellite applications is presented. The antenna

proposed has a unique design wherein a microstrip patch antenna operating in X-bandis placed into a L-shaped patch. They share the substrate. In [8], a monopole antenna is proposed which also has two bands. The antenna generates two resonant modes achieved by having two T shaped monopoles, both sized differently. In [9] a rectangular microstrip antenna of a small size and dual band nature is proposed. There are two slots in the patch and one in the ground plane which help to create a wide band. This paper presents a uniplanar dual band microstrip antenna. The antenna operates at 3.7 and 7 GHz. The substrate used is FR4 epoxy with height 1.6mm, relative permittivity 4.4, and a loss tangent 0.02. The antenna proposed is unique since, it has a very simple structure, with only a ground plane, radiating stub and a CPW feed. The ground plane and the stub are on the same side of the substrate which reduces the use of copper which would otherwise create interference. It also makes the antenna compact. The dimensions of the antenna are varied until satisfactory results are obtained to finalize the shape and size. High Frequency Structural Simulator (HFSS) by Ansoft [10] is used to carry out the simulations.

II. METHODOLOGY

The design proposed with dimensions is illustrated in Figure 1. The objective is to design a multiband monopole antenna for WiMax and satellite band applications. The overall methodology is represented in the form of flow chart as presented in Figure 1.

Thus, using the formula for monopole,

$$L = \frac{\lambda_g}{4}$$

Where,

$$\lambda_g = \frac{c}{f_r}$$

Where, f_r is chosen to be middle WiMAX frequency 3.7 GHz. So on calculation,

$$L = \frac{c}{4f_r} \approx 11\ mm$$

Thus, the maximum dimension of the antenna is chosen to be 11mm. The proposed configuration of the antenna is outlined in Figure 2. The antenna consists of a rectangular stub of size $11 \times 2\ mm^2$, placed in the vicinity of a rectangular partial ground plane of size$19 \times 2.5\ mm^2$.

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A CPW feed of dimension $2 \times 2\ mm^2$ is utilized to energize the antenna. One can easily observe that the antenna has the advantage of simple configuration with uniplanar structure thus more flexible and compact as compared to the antennas presented in [3-8].

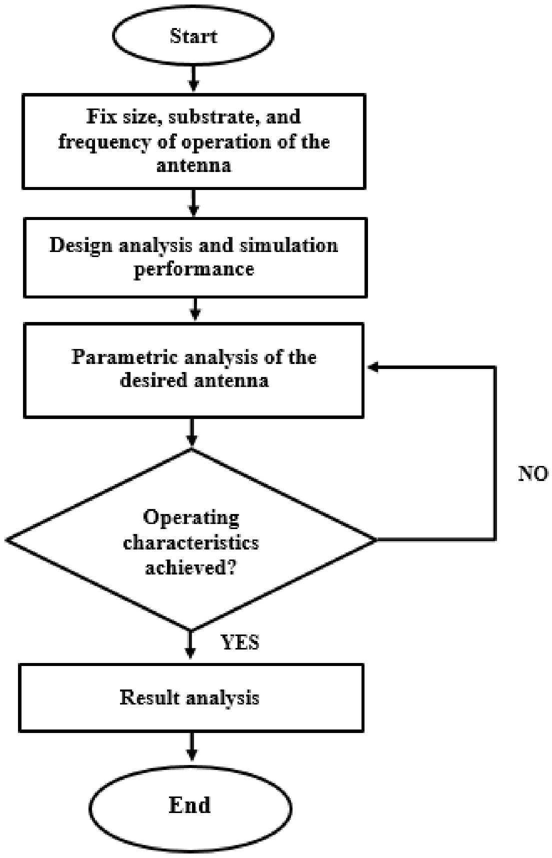

Fig. 1The overall proposed methodology

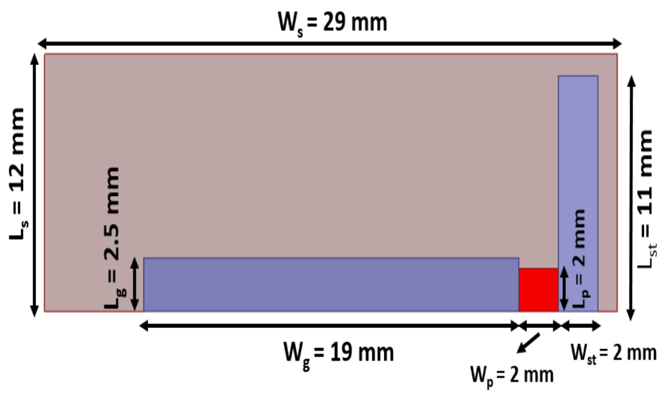

Fig. 2 Proposed antenna design

III. PARAMETRIC ANALYSIS

To fix the dimension of the antenna in order to get desired performance at the targeted applications it parametric investigations are carried out. The parametric analysis is performed by varying certain antenna dimensions while keeping the other constant. The first analysis is carried out by varying the length of the ground plane. For Lg=3.5mm, there is poor impedance matching and therefore it is not suitable. Lg=1.5mm has good impedance matching but there is a shift in frequency from the desired value. The overall performance of Lg=2.5mm is better than that of Lg=1.5mm and is therefore the most optimum. The results are as shown in Figure 3.

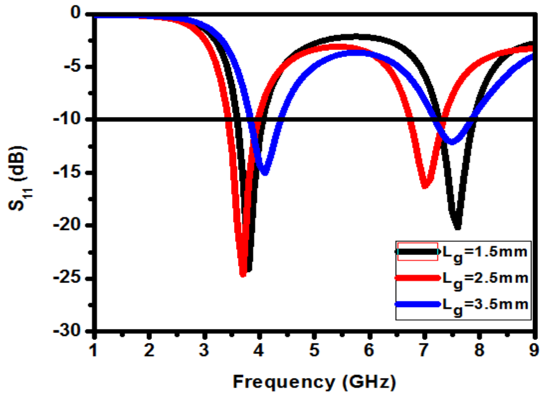

Fig. 3 Analysis by varying the length of the ground plane

Next the ground plane width is varied. For Wg=18mm, the impedance matching at higher frequencies barely crosses the -10dB mark. It is observed that the most optimum result occurs at Wg=19mm as outlined in Figure 4.

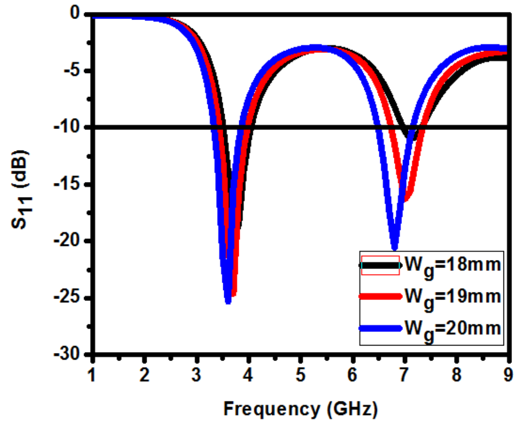

Fig. 4 Analysis by varying the ground plane width

The third part of the parametric analysis is conducted where the length of the radiating stub is varied. The results are as shown in Figure 5. Lst=12 mm doesn't perform well at the higher frequency band. Among the two, it is observed that the most optimum result is achieved for Lst=11mm.

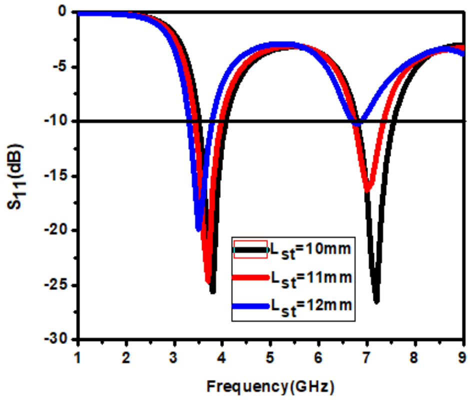

Fig. 5 Analysis by varying the patch length

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The last analysis is carried out by varying the width of the stub. The best performance is observed for Wst =2mm. Wst =1mm has less impedance matching for the higher resonant frequency. Between Wst =2mm and Wst =3mm, the Wst =2mm performs better at lower frequencies and is therefore preferred as outlined in Figure 6.

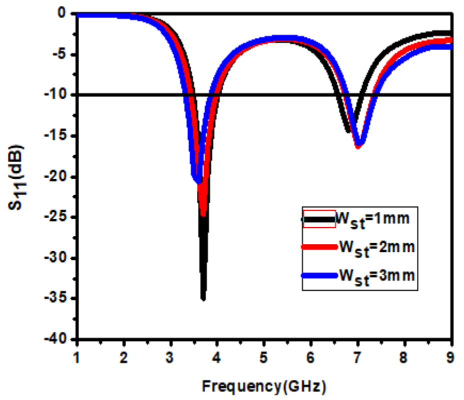


Fig. 6 Analysis by varying the width of the stub

IV. RESULTS

The S_{11} characteristics of the antenna configuration is presented in Figure 7. The antenna exhibits two bands, first at 3.7 and another at 7 GHz, with a bandwidth of 8.1%, 300 MHz (3.55-3.85) and 5.71%, 400 MHz, (6.8-7.2 GHz), respectively.

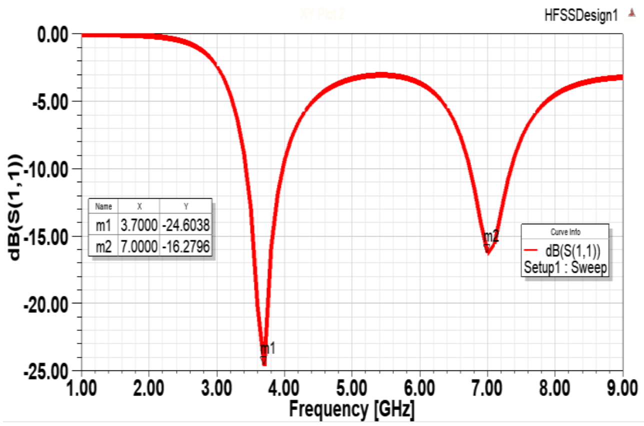


Fig. 7 Simulated S_{11} plot of the proposed configuration

The input impedance of the dual band antenna is presented in Figure 8. The first band is inductive in nature with input impedance of (48.8 + j5.7) Ω at the operating frequency 1.6 GHz. The second band has resonance at 7 GHz which is capacitive in nature with input impedance of (64.8 – j9.6) Ω.

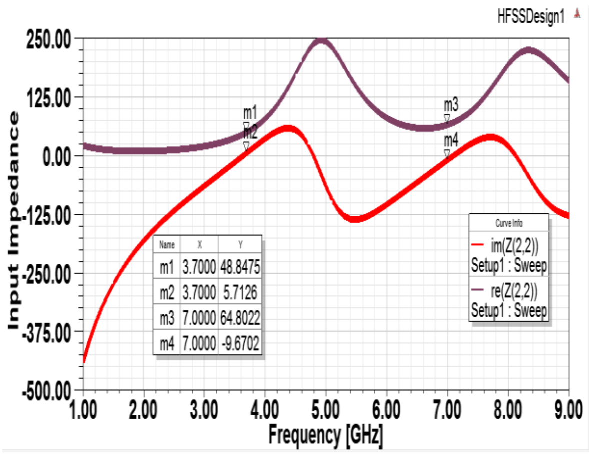


Fig. 8 Input impedance of the proposed configuration

The VSWR characteristics achieved for the antenna are as shown in Figure 9. For both bands antenna has VSWR less than two.

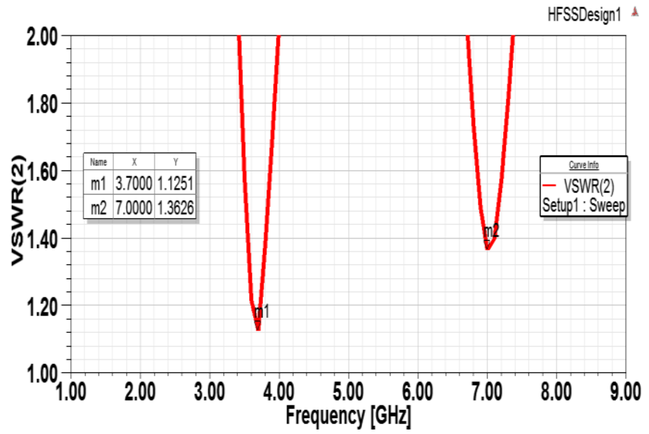
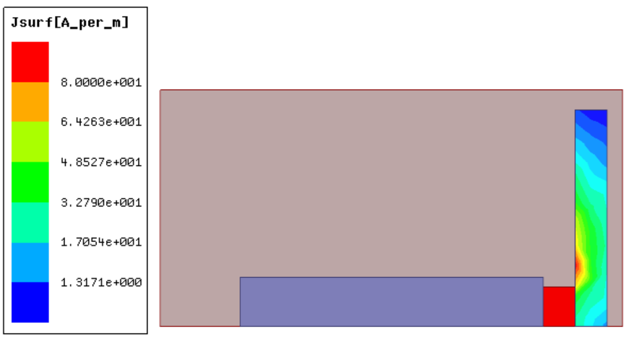
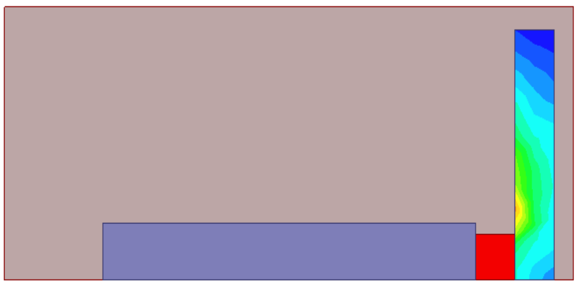


Fig. 10 VSWR characteristics of the proposed configuration

The surface current distribution for the resonant frequencies 3.7 and 7 GHzare shown in Figure 10.



(a)



(b)

Fig. 10 Surface current variations for (a) 3.7 and (b) 7 GHz

The radiation pattern of the proposed antenna for both the frequency bands are outlined in Figure 11. The patterns are bidirectional for $\varphi = 0°$ (E plane) as well as $\varphi = 90°$ (H-plane)

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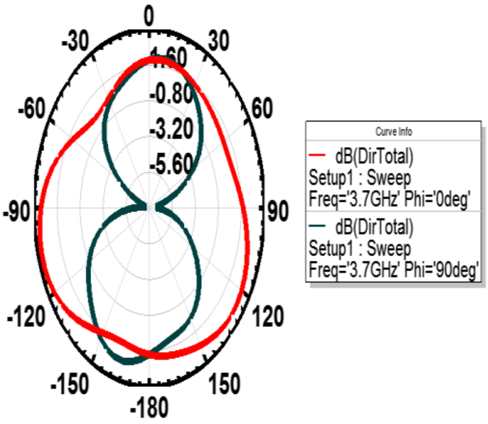
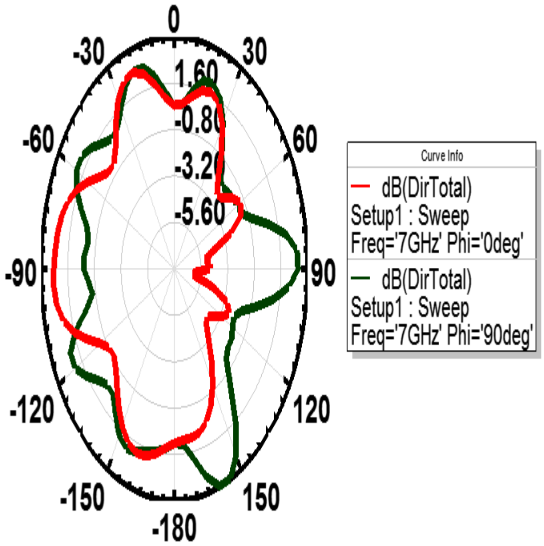


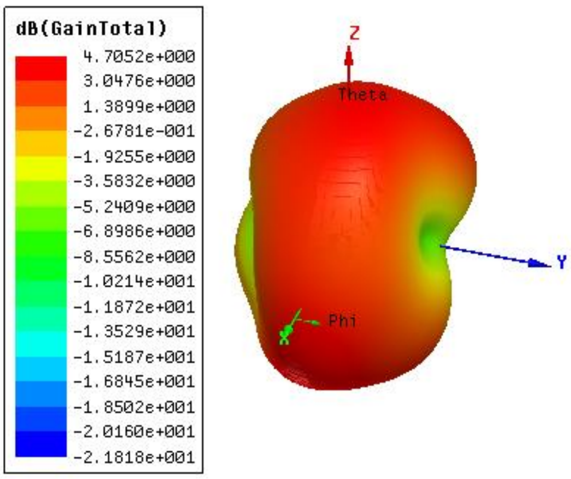
(a)



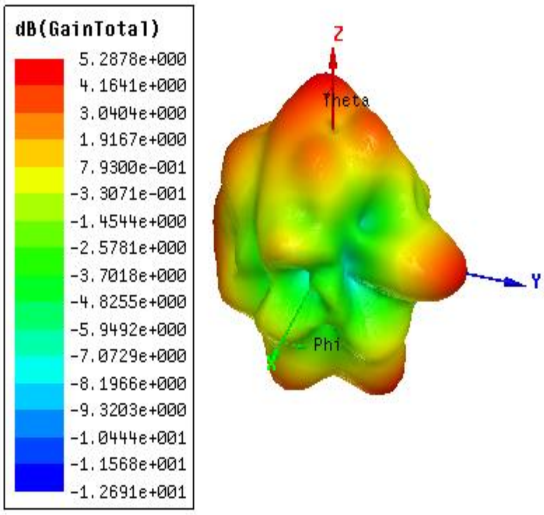
(b)

Fig. 11 Radiation pattern of the configuration proposed at (a) 3.7 and (b) 7 GHz

The total gain patterns of the antenna are shown in Figure 12. The antenna achieves a gain of 4.7dB for the resonant frequency 3.7 GHz and 5.30dB for 7 GHz. At the higher frequency, we can observe that the pattern is slighty bulged since at higher frequencies, lower modes as well as higher modes both resonate forming the bulged pattern.



(a)



(b)

Fig. 12 Total gain pattern of the configuration proposed at (a) 3.7 and (b) 7 GHz

A comparison between the proposed antenna configuration and some of the other dual-band antennas discussed in literature is done and outlined in Table 1.

Table 1: Comparison between the proposed antenna configuration and other dual-band antennas

Ref	Size (mm^2)	Operating frequencies (GHz)	Gain (dBi)
5	40×40	1.5/3	3.9/1.5
6	40×30	5.5/10.4	6.5/7.3
7	50×75	2.4/5.2	1.5/1.2
9	12×8	5.1/5.7	1.7/2.1
Prop	**29×12**	**3.7/7**	**4.7/5.3**

V. CONCLUSION

In this paper, the proposed design is a dual band monopole antenna which exhibits operation at 3.7 and 7 GHz. The structure is analysed and simulated using HFSS. The antenna ha a miniaturized size of $29 \times 12\ mm^2$ and has wide tuning range of 30% and 40% at the operating frequency 3.7 and 7 GHz, respectively. The radiating stub and the ground are both on the same plane of the substrate, which reduces the use of copper thereby making it cost effective and compact. The antenna is applicable for WiMAX and satellite communication conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

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