Compact CPW Fed Balloon Shaped Patch Antenna for UWB & Wi-Max Applications

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***Abstract*— This paper presents the design and performance of CPW fed balloon shaped patch antenna having rectangular stab of overall size 30mm × 26 mm × 1.59 mm. The proposed antenna is simulated by applying CST Microwave studio simulator. This antenna has wide impedance bandwidth of 5.19 GHz (2.81 GHz – 8.00 GHz) with flat gain (close to 3-4dBi) in the desired frequency range. This antenna may be a useful tool for Wi-MAX communication bands and lower and median UWB bands.**

***Keywords*—CPW fed; CST 2013; Wi-MAX communication systems; UWB communication Systems; WLAN communication systems.**

I. INTRODUCTION

The Institute of Electrical and Electronic Engineers (IEEE) proposed three major WLAN band 802.11, 802.11 b and g, which perform in the 2.4-GHz frequency band, and 802.11a, which perform in the 5-GHz band. Recently, a high-speed 802.11 WLAN has been offered—the 802.11n WLAN, which operates in both the 2.4-GHz and 5-GHz bands. Wi-Max bands 3.3GHz/3.5GHz/3.7GHz/5.8GHz are proposed under the IEEE standards 802.16d and 802.16e (1-2). The Federal Communications Commission (FCC), United States also released an unlicensed frequency band(UWB) for commercial communication purpose which have frequency band of 3.1GHz to 10.6 GHz. Communication systems are becoming compact in size and hence compact antennas with improved performance are required for these communication systems. Microstrip antennas may be proved very useful structures for these handsets, if their bandwidth performance improves. Size reduction and bandwidth enhancement are becoming major challenges these days. Conventional microstrip antennas have narrow bandwidth, low gain and operate at a single resonance frequency corresponding to their dominant mode. However they are planar structures and are compact in size, light in weight hence they can be put inside the handset without protruding out (3-5). Looking these advantages extensive efforts were made by researchers to improve their limitations (6-8). Various designs have been presented to improve the bandwidth by introducing sector slots, slits or notch in the microstrip patch, or by adding parasitic patch, stabs with radiating patch etc (9-10). These antennas can fed either through a coaxial cable or through strip line etched on the surface of antenna. Another way of feeding of patch antenna is coplanar wave guide. The coplanar waveguide (CPW) proposed by C. P. Wen in 1969 (11). Numerous advantages such as lesser radiation leakage and less dispersion have been obtained by feeding a patch with CPW.

In this communication, a ballooned shaped patch antenna having a rectangular stab and notch with CPW fed is presented. This antenna is simulated in free space.

II. ANTENNA DESIGN AND ANALYSIS

The design of proposed antenna was started with consideration of CPW fed balloon shaped patch having horizontal radius Rx = 9 mm and vertical radius Ry= 12 mm. The overall size of antenna is 30mm x 26mm. This antenna is designed on glass epoxy FR-4 substrate having relative permittivity ε_r = 4.4, substrate height h = 1.59 mm and loss tangent = 0.025. These dimensions were selected so that designed antenna may resonate in the frequency band allocated for the median band of Wi-MAX / UWB communication system.

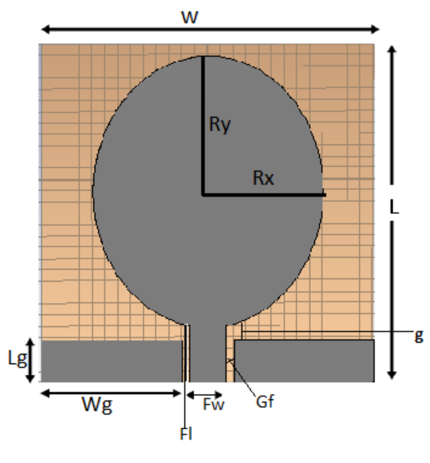

Fig.1 Front view of CPW fed Ballooned shaped patch antenna

For feeding this antenna; 50 ohm CPW feeding line having length F_l = 6 mm and width F_w = 2.80 mm is applied. The gap 'g' between patch and ground is 1.90 mm while the gap G_f

between the strip line and ground plane is 0.60 mm as shown in Fig 1. Numerical values of the antenna dimensions are summarized in table I. This proposed antenna simulated by using CST studio suite 2013 (12).

TABLE I Optimized dimensions of proposed antenna

Dimension of proposed antenna	Value(in mm)
Length of the Substrate (L)	30mm
Width of the Substrate (W)	26mm
Length of the ground (Lg)	3.9mm
Width of the ground (Wg)	11mm
Horizontal radius of the patch (Rx)	9mm
Vertical radius of the patch (Ry)	12mm
Length of the Feed line	6mm
Width of the feed line (Fw)	2.80mm
Gap between patch and ground(g)	1.90mm
Gap between feed line and ground(Gf)	0.60mm

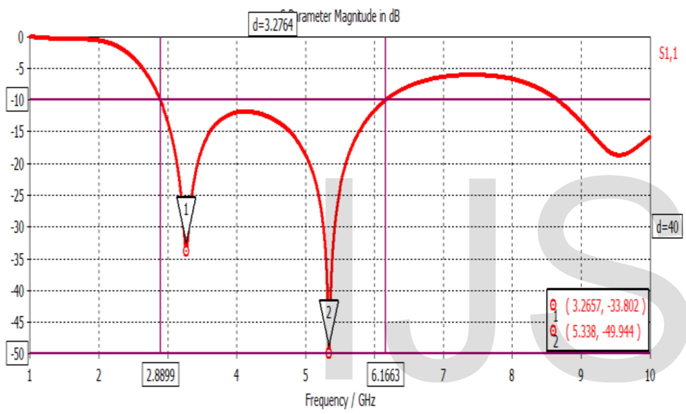

Fig. 2. Simulated variation of reflection coefficient with frequency for CPW fed balloponed shaped patch antenna

The simulated variation of reflection coefficient with frequency for ballooned shaped patch antenna is shown in Fig. 2, which indicates that antenna is effectively resonating at 3.26GHz & 5.33 GHz. The simulated impedance bandwidth of antenna is around 3.27GHz. The simulation results provide broad bandwidth which covers the Wi-Max band and lower band of UWB communications system.

In the next step, we further modified the patch using a tuning stab at appropriate location. The length(Y) and width(X) of this stab is 2 mm respectively. Using this stab, an additional resonance frequency close to 8.45 GHz is realized which is shown in figure 4. For further improvement in antenna performance, an additional rectangular slot is introduced in patch having length (a) 1.0mm and width (b) 3.5mm. With introduction of proposed slot, the current in ground plane gets modified and its further improves the gain as well as the bandwidth of proposed antenna. The proposed CPW fed ballooned shaped modified patch antenna (BMPA) provides much improved impedance bandwidth ~5.19GHz or 96% with respect to central frequency 5.40 GHz as shown in Fig.4. The proposed antenna resonates at three frequencies namely 3.14 GHz, 5.50 GHz and 7.54 GHz.

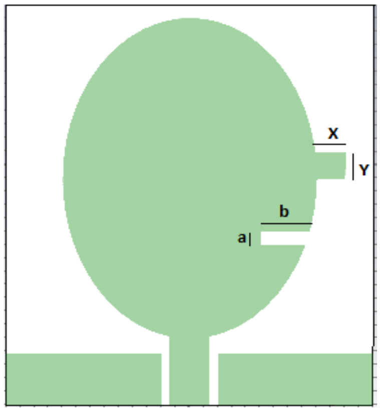

Fig.3 Front view of modified CPW fed ballooned shaped patch antenna

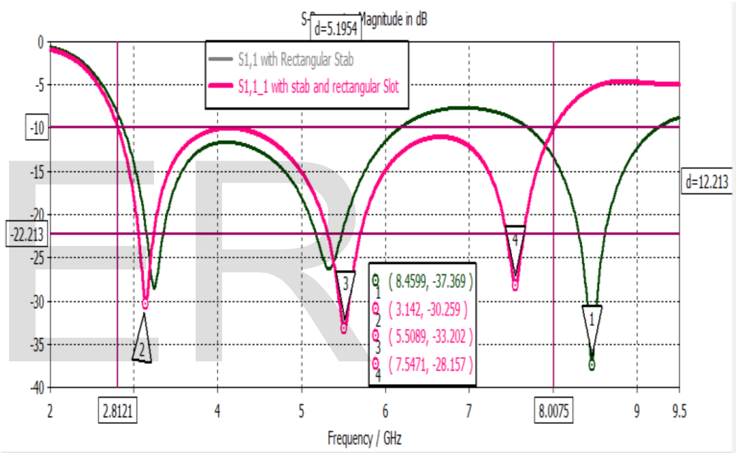

Fig. 4 Simulated variation of reflection coefficient with frequency for CPW fed modified patch antenna

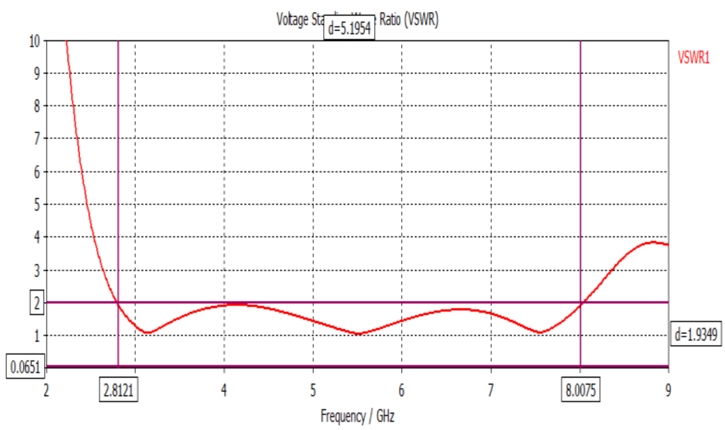

Fig. 5. Simulated variation of VSWR with frequency for proposed CPW fed antenna

Simulated VSWR shown in figure 5 suggests good impedance matching between the feed line and antenna as the VSWR values at the three resonance frequencies are close to 1.0. Simulated variation of gain with frequency curve shows that gain is vary from 2dBi to 4dBi in entire range of impedance bandwidth. The maximum gain of antenna is close to 3.85dBi at frequency 6.00GHz which is better than realized in previous case which is shown in fig. 6. Current distributions of modified patch antenna at the two resonance frequencies are shown in fig 7a, 7b & 7c.

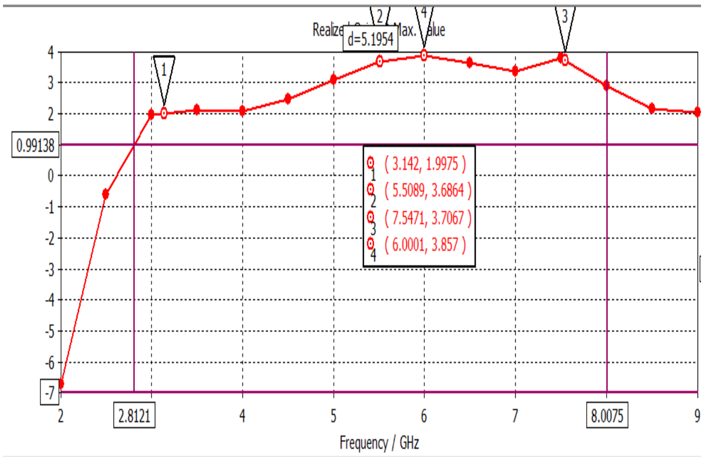

Fig. 6 Simulated variation of gain of antenna with frequency

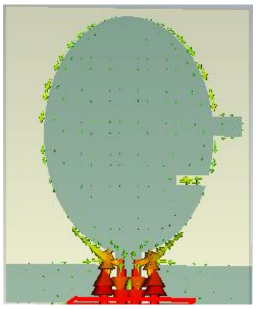

Fig 7a. Current distribution at 3.14GHz

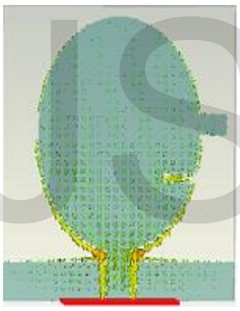

Fig 7b. Current distribution at 5.50GHz

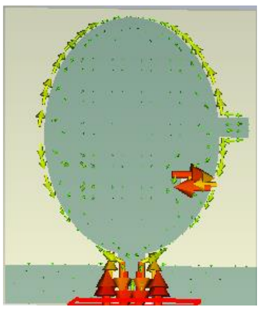

Fig 7c. Current distribution at 7.54GHz

III. Result Analysis

The proposed CPW fed ballooned shaped modified patch antenna provides much improved impedance bandwidth ~5.19GHz or 96% with respect to central frequency 5.40 GHz as shown in Fig.4. The proposed antenna resonates at three namely 3.14 GHz, 5.50 GHz and 7.54 GHz. The first frequency may be used for WLAN/Wi-Max communication systems while the second & third frequencies are suitable for Wi-MAX and median band of UWB communication systems. The third frequency is also very useful for meteorological-satellite (space-to-Earth).The variation of gain of antenna as a function of frequency is shown in Fig. 6 which indicates that gain of antenna in the operating frequency range is almost flat. The maximum gain of antenna is close to 3.85 dBi at frequency 6.00GHz which is better than realized in previous case.

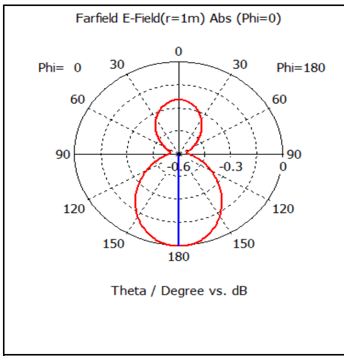

Fig 8a: E plane pattern at 3.14GHz

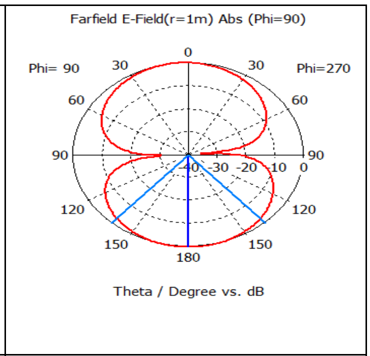

Fig 8b: H plane pattern at 3.14GHz

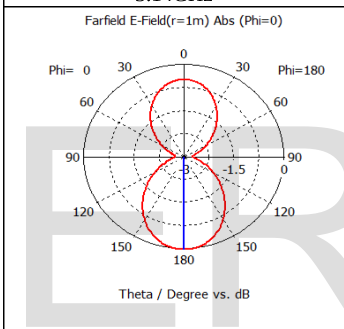

Fig 8c: E plane pattern at 5.50GHz

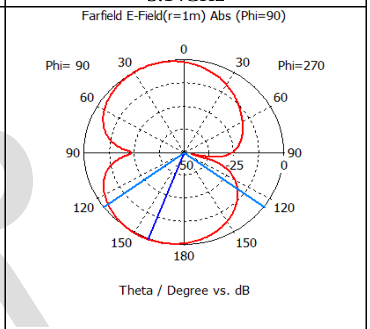

Fig 8d: H plane pattern at 5.50GHz

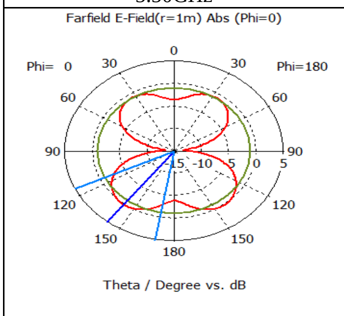

Fig 8e: E plane pattern at 7.54GHz

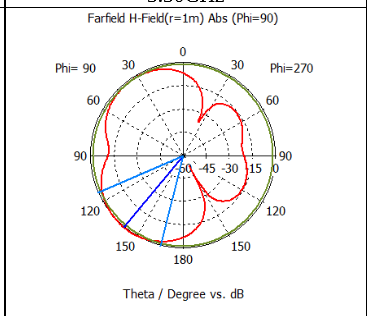

Fig 8f: H plane pattern at 7.54GHz

The two dimensional E and H plane radiation patterns of antenna at three resonant frequencies are shown in Figs. 8a – 8f. These figures indicate that antenna is radiating power both forward and back directions. However patterns are almost omni-directional, two figures have dumble shape which suggests that radiation pattern resembles with that of a dipole antenna. Simulated H plane radiation patterns are more directive than E-plane pattern at all three resonant frequencies.

IV. Conclusions

Proposed CPW fed ballooned shaped patch antenna with rectangular stab and slot provides broader bandwidth (~5.19GHz), desired VSWR (2:1) and nearly flat gain in desired frequency range. The maximum gain of antenna is close to 3.85dBi. The effect of rectangular stab and appropriate slot has been successfully investigated. The antenna operates well at three resonance frequencies of operations. This antenna may be proved a useful structure for modern wireless communication systems including in median band of Wi-Max and lower & median band of UWB communication systems.

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