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CPW-fed Dual Notch Monopole Wideband Antenna for P2MP Communication/WLAN

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***Abstract*— A CPW-fed dual notch wideband monopole antenna applicable for radio altimeter and WLAN application is presented. The proposed antenna has been designed and analyzed with Ansoft HFSS V.13. A fabricated prototype is prepared and measured. It is compact with a total size of 34x36x1mm^3. Results of simulation and measurement are in good agreement having center frequency at 3.8GHz and 5.7GHz. The antenna shows negative gain at notch frequencies.**

***Index Terms*—CPW, wideband, notch.**

I. Introduction

Uni-planar monopole antennas are attractive as they are etched on single side of substrate owing to easier fabrication. A coplanar waveguide (CPW) feed is more suitable to be used in compact wireless communication systems [1]. In recent years' researchers and scientists achieve increase in the bandwidth by modifying the shapes of the radiation patch and ground. In [2-4] the monopole antennas were modified to get wide impedance bandwidth and suitable radiation patterns. It is shown in paper [5-6] that, the impedance bandwidth of the antenna can be enhanced by CPW feed. However, WiMAX operating at 3.3-3.7GHz band, WLAN at 5.15-5.825GHz band and other bands can give possible electromagnetic interferences. So design of a band notch i.e. filter characteristic is necessary to avoid the interference. Conventional filtering method requires larger circuits with complex technique to integrate in the patch. The commonly used solution is to incorporate various shapes of slots that are cut in the main patch. In [7] a rectangular slot is cut in the ground plane and a C-shaped slot is cut in the radiator for dual band notch application. An E-shaped slot is introduced by Lee. et. al. in [8]. There are other shaped slots, which are presented by the authors in [9-10].

In this paper a CPW-fed patch antenna is proposed with circle shaped ground plane. Two U-shaped slots are built in the patch to filter out 3.8GHz and 5.7GHz frequency bands, which are applicable for altimeter and WLAN. The optimization and subsequent simulations are done with High frequency structure simulator (HFSS). Details of the design and simulations are presented and the measured results are given in order to demonstrate the performance of the proposed antenna.

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II. Antenna Design

The geometry of the proposed antenna is shown in Fig.1. It consists of a square radiator of size W1 x W1, fed by coplanar-waveguide. The proposed antenna is designed on a FR-4 substrate of size L x W with a dielectric constant of 4.3, thickness of 1mm and loss tangent of 0.002. Radiator patch and the feed line are etched on the same surface of the substrate. Widening of the bandwidth is achieved by arc shaped ground plane that is placed on both sides of the feed line. This ground plane introduces additional resonances. Two U-shaped slots are integrated in the structure to obtain the notch frequencies. The antenna is excited by 50Ω CPW feed line of width W_f. Spacing between the ground plane and the radiator is denoted by 'g1', by which the electromagnetic coupling between the lower edge of the patch and the ground plane can be controlled. While the spacing between feed line and ground plane denoted as 'g'. The parameter 'g' and feed line width W_f are responsible to obtain 50Ω impedance to be properly matched with the source.

To generate the first notch band, a U-shaped (filter structure) slot is cut on the radiator. The frequency of the notch can be controlled by adjusting the dimensions of the U-slot i.e. arm-L1 and arm-Lsc1. The second inverted U-slot gives an additional filter configuration. Arm L2 of second U-slot controls the two notch filters. A detailed parametric study of slot arms is gathered in next section. The optimized parameter values are listed in Table-1.

Table 1 Optimal parameter values of the proposed antenna

Parameter	Values in mm
W	36
L	34
L1	4.8
L2	4.6
Lsc1	10.9
Lsc2	9.9
W1	17.5
W2	0.2
Wg	15.5
g1	0.9
g	0.45
Wf	4.1

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III. Parametric Study

The slot parameters Lsc1, Lsc2, L1, L2 have a significant role upon impedance bandwidth of the patch and are varied to get the optimum result. During the simulation g and g1 are taken as constants.

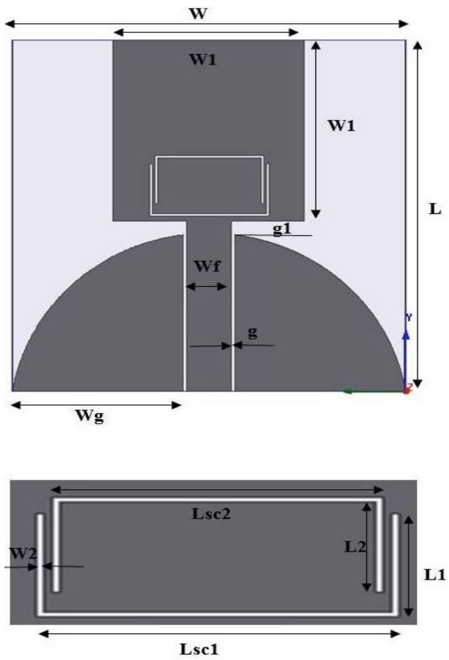


***Fig.1**. Proposed antenna*

A. *Effect of Lsc1*

Since the notch filter depends on the length of the U-slot, the first parameter to optimize is arm length Lsc1, whereas other parameters kept invariant. The notch frequency is sensitive to the variation in Lsc1 as shown in Fig. 2. It can be observed that, increase in the Lsc1 decreases the notch frequency value i.e. notch band shifts towards lower frequency band with a sharp cut off. From this result, one can conclude that higher or lower frequency band notch can be obtained by tuning arm Lsc1. The optimal value of Lsc1 is found to be 10.9mm.

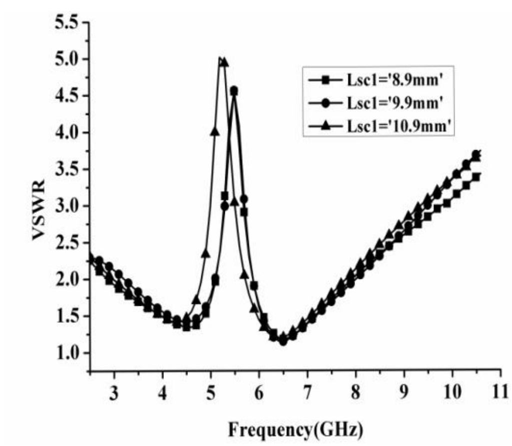


***Fig.2**. variation of Lsc1 on VSWR*

B. *Effect of L1*

The effect of arm length L1 variation keeping Lsc1 constant is shown in Fig. 3. It can be observed that, as length of arm L1 increases the notch frequency decreases. The frequency is inversely proportional to the length of the slot.

At point L1=4.8mm the desired notch from 5-6 GHz centred at 5.5GHz is achieved. So it is chosen as the optimal value.

The total length of the U-slot, (Ltotal=2*L1+Ls1) became 20.5mm and the corresponding notch frequency is related with the total length of the slot by the formula

$$f_{notch} = \frac{C}{2 * L_{total} * \sqrt{\frac{\varepsilon_{eff}+1}{2}}} \quad (1)$$

Where C is the velocity of light in free space.

ε_{eff} is the effective dielectric constant and is given by

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2}$$

From the above relationship, f_{notch} is found to be ~5.5GHz

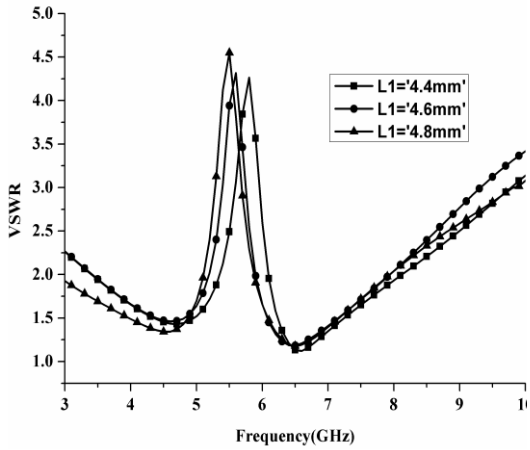


***Fig.3**. Effect of L1 on VSWR*

C. *Effect of Lsc2*

Putting a second inverted U-slot in the patch, gives two different notch bands. Fig-4 shows effects of variation of parameter Lsc2 from 9.3mm to 9.9mm on VSWR result. An additional notch band at lower range frequencies are observed. At 9.3mm and 9.5 mm the lower frequency notch bands has a higher VSWR values compared to higher notch frequencies, while an opposite behaviour is observed at 9.7mm and 9.9mm. Viewing WLAN application having centre frequency 5.5 GHz, value of Lsc2 is chosen to be 9.9mm.

D. *Effect of L2*

The arm length L2 of second U-slot was varied from 4mm to 4.8mm while keeping all other parameters constant. The second U slot gives its impact to both the notch frequency as presented in Fig. 5. It is noticed that taking L2=4mm a single notch is obtained and varying L2 from 4.4mm to 4.8mm, two notches are obtained. The optimized value of L2 is 4.6mm since the two notch frequencies are 3.8GHz and 5.7GHz.

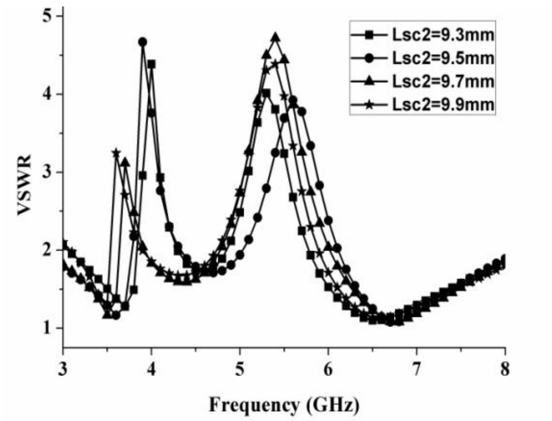


Fig.4. *Variation of Lsc2 on VSWR*

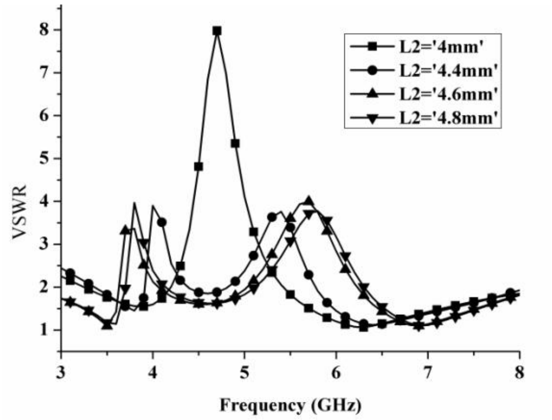


Fig.5. *Variation of L2 on VSWR*

IV. Result And Discussion

A prototype of the recommended structure on FR4 substrate with the dimensions given in Table-1 is fabricated and is shown in Fig. 6. The S_{11} result is measured using vector network analyser (Rohde & Schwar-10MHz to 20GHz). Radiation pattern and gain of the antenna are measured in anechoic chamber and experimental findings are discussed below.

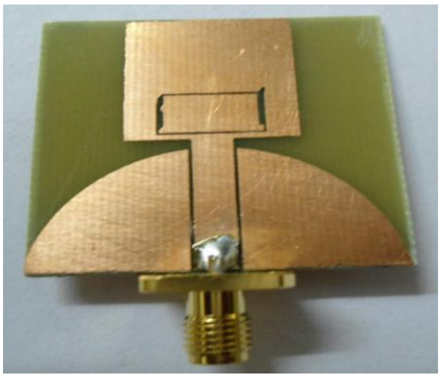


Fig.6. *Fabricated prototype*

A. Impedance Bandwidth

Without U-slot in the rectangular antenna a wide impedance bandwidth of 5GHz from 3GHz to 8GHz is obtained. Implementing U-shaped slot, a destructive interference for the excited surface current will occur in the antenna, which causes the antenna to be non-responsive. The impedance nearby the feed point changes acutely making large reflection at the notch frequencies. The simulated and measured S_{11} (dB) plot of the antenna is shown in Fig. 7. The figure indicates an excellent agreement between the simulated and measured curves and two notches are from 3.7 GHz to 4.2 GHz centered around 3.8 GHz and 5.25 GHz to 6.25 GHz centered around 5.7GHz.

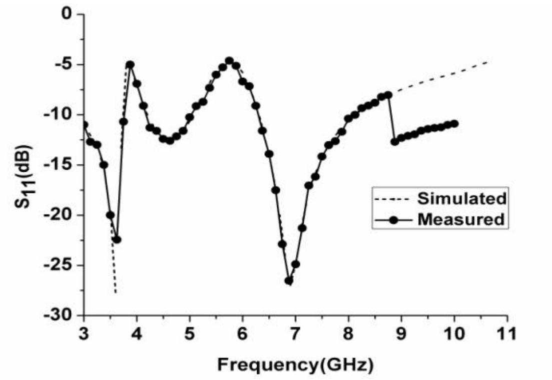


Fig.7. *simulated and measured S_{11} result*

B. Gain and Radiation Pattern

The gain of the antenna from 3 GHz to 10 GHz is measured which is shown in Fig. 8. It can be observed that, at notch band the gain is negative and at other frequencies it is roughly positive. The peak gain of the antenna is 2dB. At 3.8 GHz the gain is -4dB and at 5.7 GHz -2.8dB gain is obtained. The measured radiation pattern of the proposed antenna in E-plane and H-plane at 3.5GHz and 7GHz are shown in Fig. 9(a) and (b) respectively. In E-plane the pattern remains nearly dumbbell shape leading to bidirectional patter. The pattern is dumbbell shaped in E-plane. The variations in patterns are caused by manual alignment of the antenna during measurement.

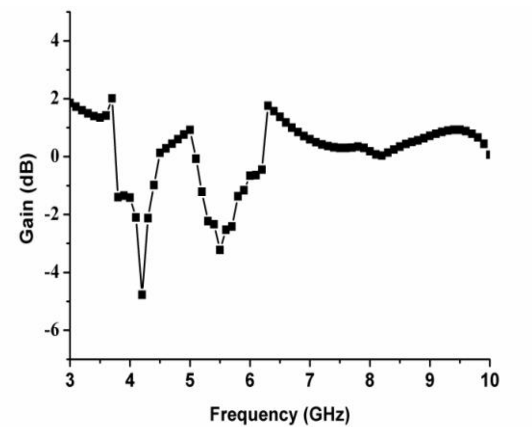
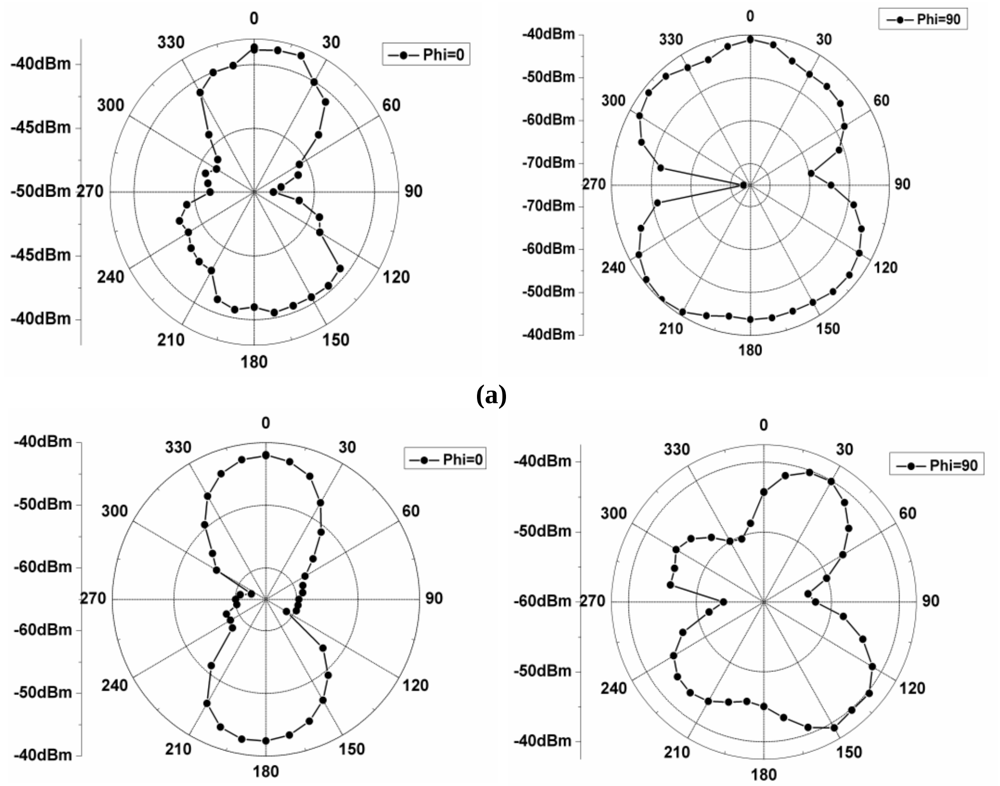


Fig.8. *Measured gain of the structure*

V. Conclusion

A wideband monopole antenna has been designed with dual notch characteristics using two U-slots. The impedance bandwidth covers 5GHz from 3GHz to 8GHz is achieved. Adding two U-slots in the structure two notch bands are from 3.7 GHz to 4.2 GHz and 5.25 GHz to 6.25 GHz. The recommended antenna structure can be implemented in satellite earth stations in support of voice, data and video transmissions, P2MP fixed wireless service and WLAN applications.



(a)

(b)

Fig.9. *Measured radiation patterns at (a) 3.5 GHz (b) 7.0 GHz*

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