DESIGN OF A 6 U-SLOT PATCH ANTENNA WITH DUAL BAND CHARACTERISTICS

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***Abstract*-- A novel 6 U-slot patch antenna operating from 7.7 to 9 GHz is proposed in this paper. The developed antenna resonates at a dual band of frequencies 8.05GHz and 8.91GHz, with an impedance bandwidth of 16.4% at -10dB return loss. The performance of antenna in terms of impedance bandwidth is analyzed by varying the position of the slots. The developed system can be widely used for WLAN and WiMAX applications.**

***Keywords*-- Microstrip feed, impedance bandwidth, return loss.**

I. INTRODUCTION

With the rapid development of wireless communication systems and increase in their applications, compact and wideband antenna design has become a challenging issue [1].Printed slot antennas are being used in a vast variety of communication systems as they have two orthogonal resonance modes, which are merged to provide a wide impedance bandwidth [2].

Patch antennas are being widely used since 1970s due to their special features like low profile, light weight, compact size and amenable to low-cost PCB (Printed Circuit Board) fabrication processes. However, patch elements basically resonate at a single frequency and typically have less than 2% bandwidth [3]–[6], which limits their applications in wireless communications. A lot of techniques are used to enhance the bandwidth of patch antennas. A simple technique to increase the bandwidth of patch antenna is to use substrates with low dielectric constant [7]. Increasing substrate thickness enhances antenna bandwidth. However, this technique has a disadvantage of high cross polarization level which leads to distortion in the co-polarization patterns. The method of phase cancellation [8], [9] can effectively suppress the cross polar power, but it requires complex matching networks to provide 180^{o} phase difference between the feeds.

The input impedance matching of microstrip patch antenna depends upon type and location of feed because impedance matching of source at feeding point of antenna is very important for efficient operation of antenna. But it is not an easy task to achieve for a simple microstrip antenna.

There are several feeding techniques available such as Microstrip line feeding ,Coaxial cable or probe feeding, Aperture Coupled Feed, Proximity coupling Feed available to feed or transmit electromagnetic energy to a microstrip patch antenna. Out of the various feeding techniques, Microstrip line feed and Co-axial feed are most commonly used in the design of the patch antennas.

In co-axial feeding, the inner conductor of the coaxial connector propagates through the dielectric and soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location on the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation

In Microstrip Line Feeding technique, a conducting strip is connected directly to the edge of the Microstrip patch. The conducting strip is smaller in width as compared to the patch and this type of feed arrangement has the advantage that the feed can be placed on the same substrate to provide a planar structure. The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need of any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding technique, since it provides ease of fabrication and simplicity in modeling as well as impedance matching. [10]

Due to many attractive features, microstrip antenna has drawn the attention of researchers over the past work. Microstrip antennas are used in numerous applications, ranging from biomedical diagnosis to wireless communications

In the present scenario, the patch antennas are designed with various designs and shapes. The most widely studied antennas are E shaped patch antennas, H shaped patch antennas, U slotted patch antenna.[11] In the present work, a patch antenna with 6 u-slots is designed and simulated. The impedance bandwidth of a single U-slot antenna is about only 11.8% [12]. The bandwidth of the antenna is improved to 16.44% by placing a number of slots on the radiating patch. Due to the increase of slot area, current path is increased resulting in improved bandwidth.

II. ANTENNA DESIGN

The schematic configuration of the proposed 6 U-slot planar antenna with dual band frequency operation is shown in Fig.1. For the design, the radiating patch is etched on the substrate of dielectric constant 2.2 and thickness of 3.175mm. Various dimensions of the antenna are taken as W_g = 67,L_g = 74,W = 37,L= 34,W_s = 12,L_s = 28.25,W_r = 4,L_r = 8,a = 2,W_f

= 4,L_f = 20,Y_f = 5.5,a_1 = 1,d=12.(All the dimensions are in mm).

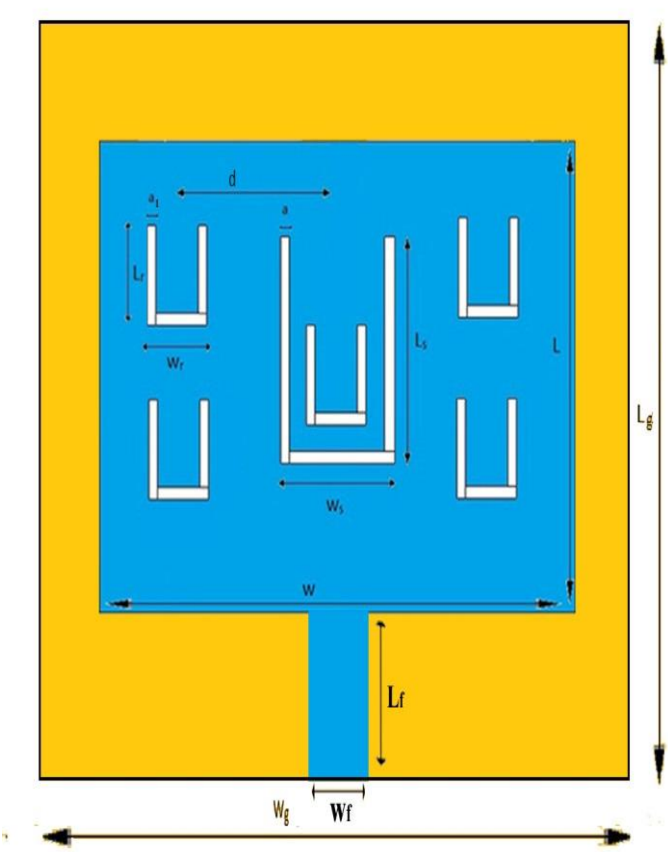

Fig 1: Structure of the proposed antenna

First, a rectangular patch of size 37 X 34 mm^2 is placed on a substrate of size 67 X 74 mm^2. Then, a main U-slot of length 12mm, width 28.25mm and internal gap of 2mm is cut on the patch. The single U-slot could provide an impedance bandwidth of only 11.8%. Additionally, 5 U-slots of length 4mm, width 8mm and internal gap of 1mm are cut on the patch as shown in the above figure. By providing additional slots, the lengths of the current paths on the patch are increased, creating multiple resonances, leading to the bandwidth improvement. The proposed antenna is excited by using microstrip feeding technique. The microstrip feed line is a conducting strip, usually of much smaller width compared to the radiating patch. The feed line of size 4 X 20mm^2 is connected to the patch.

III. RESULTS AND DISCUSSION

The S11 plot for the 6 U-slot patch antenna designed in this paper is shown in Fig.2. The dimensions of the antenna are selected such that the antenna resonates at dual band frequencies of 8.05GHz and 8.91GHz with an impedance bandwidth of 16.44%. The antenna is analyzed by varying the distance between the slots which is denoted by'd'. The comparison of the S11 plots for different values of'd' are shown in Fig.3.

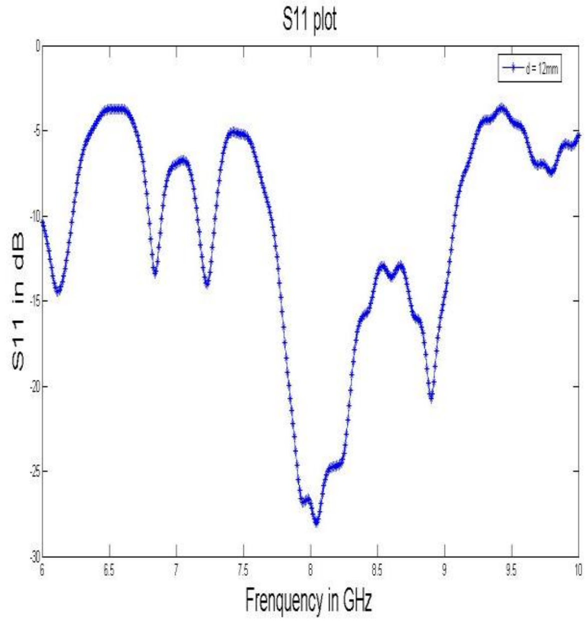

Fig 2: S11 plot for the proposed antenna

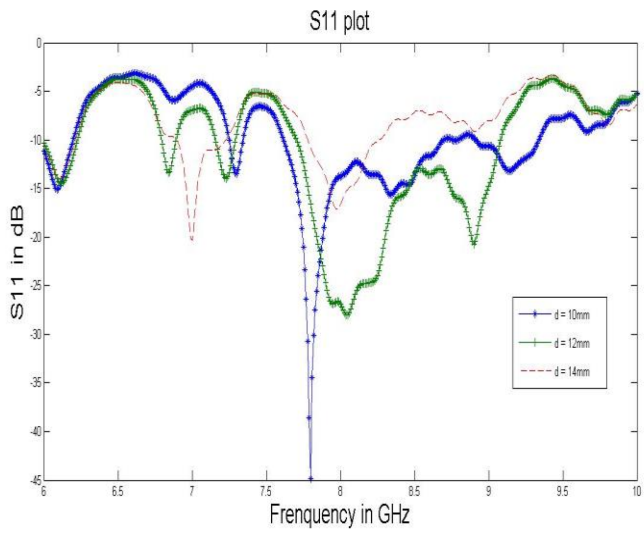

Fig 3: Comparison of S11 plots for variation of 'd'

From Fig.3, it can be observed that the impedance bandwidth is maximum for d=12mm.The impedance bandwidth of the proposed antenna is 16.44% while it is 13.12 % for d=10mm and 5.25 % for d=14mm. Hence, the optimum value of d is selected as 12 mm.

In order to operate an antenna efficiently, maximum power must be transferred between the transmitter and the antenna. Maximum power transfer can take place only when the impedance of the antenna is matched to that of the transmitter. The higher the VSWR, the greater is the mismatch. VSWR plot for the proposed antenna is shown in

Fig.4. From the plot, it can be observed that VSWR is less than or equal to 2 in the radiating frequency. Thus, the mismatch is very less in the radiating band.

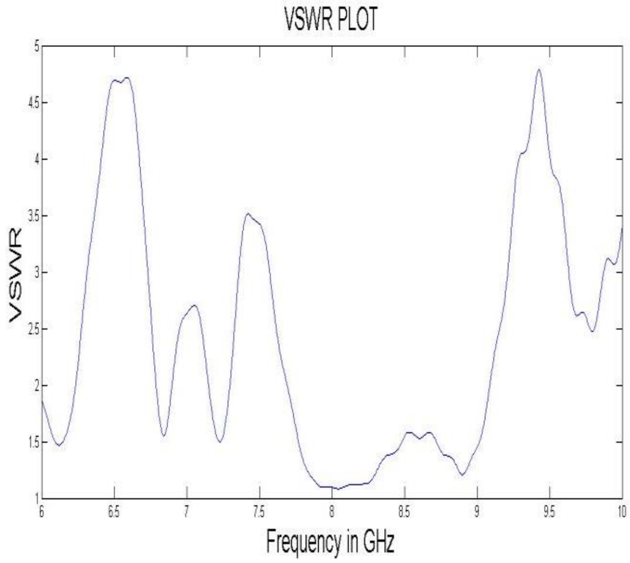

Fig 4: VSWR plot

The radiation pattern of an antenna is a plot of far-field radiation properties of an antenna as a function of the spatial co-ordinates which are specified by the elevation angle θ and the azimuth angle φ. The radiation patterns for the proposed antenna at resonating frequencies 8.05GHz and 8.91GHz are shown in Fig.5 and Fig.6 respectively. From the figures, it can be observed that the maximum radiation is obtained at an angle of 50^o at resonating frequency 8.05GHz while maximum radiation is observed at an angle of 32^o at resonating frequency 8.91GHz. The gain plot of the proposed antenna is shown in Fig.7.

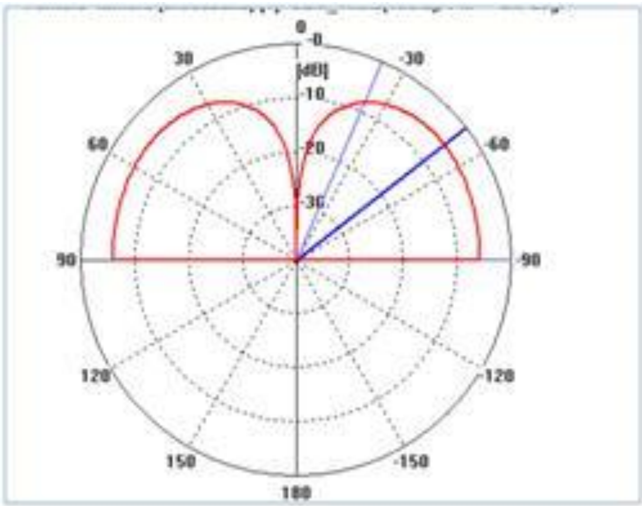

Fig 5: Radiation pattern at resonating frequency f = 8.05GHz

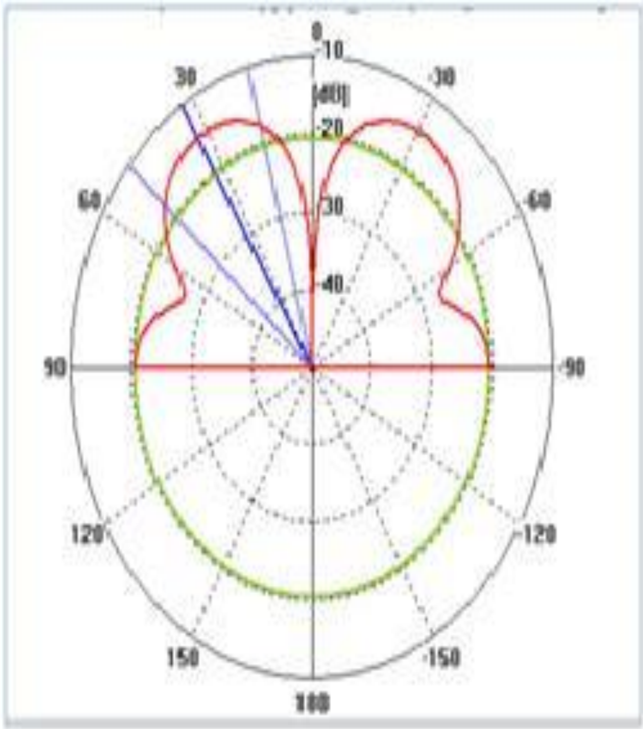

Fig 6: Radiation pattern at resonating frequency f= 8.91GHz

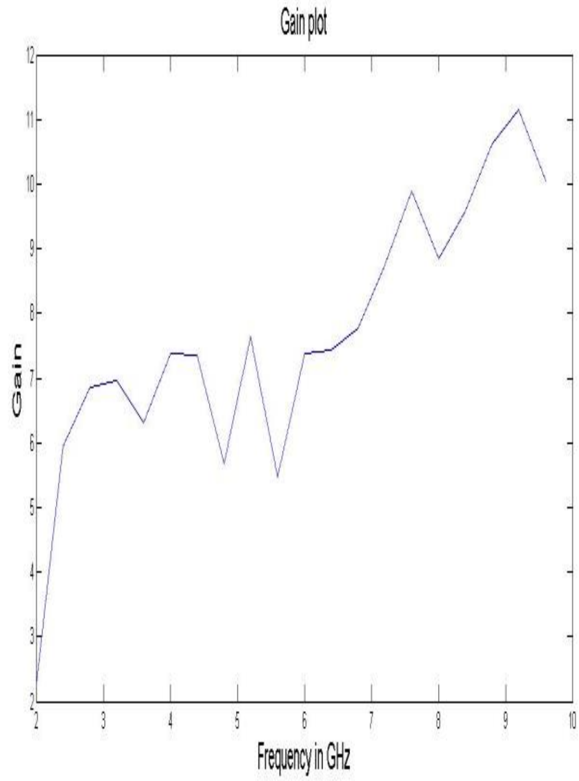

Fig 7: Gain plot of the proposed antenna

IV.CONCLUSION

In this paper, a novel multi slot antenna is designed and simulated. The proposed antenna produces a dual band which resonates at 8.05GHz and 8.91GHz.The bandwidth of the antenna is improved by varying the distances between the slots. A maximum of impedance bandwidth of 16.44% is achieved by setting the distance between the slots as 12mm. The proposed antenna is expected to have numerous applications in the modern communication system. The proposed design is desirable for stationary terminals of various indoor wireless communication networks.

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