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A PRINTED STAIRCASE SERRATED CPW ANTENNA FOR UWB APPLICATIONS

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ABSTRACT

A novel compact coplanar slot antenna designed for UWB applications and presented in this paper. A slot antenna with CPW feed technique is implemented which works more efficiently unlike antennas having microstrip feed line feeding and leading to improved bandwidth in the antenna. The current antenna structure is included with serration in the radiating element, which intern improved the bandwidth. Design and analysis of the proposed antenna is totally carried out in Ansys Electronics Desktop (AED) tool. The bandwidth of this antenna ranges from 1GHz to 11GHz with a return loss up to -40 dB at 2.6 GHz. The simulation results of radiation patterns, return loss, gain are presented in this work. A comparison between antenna with serrations and antenna without serrations has also been done and the results are also presented.

Keywords: slot antenna, CPW antenna, compact antenna, serrated patch, UWB antennas.

1. INTRODUCTION

Basically an antenna is designed to ease the overall communication process. To make this transmission of information easier and efficient new techniques are implemented in different antennas improving their performance. At the early stage of this invention, the requirement was for the antennas which work at different frequencies and are called multiband antennas [1-4]. Later on, increasing demands for wireless communication has increased the need of compact antenna along with wider band so as to increase the rate of data transmission. The next invention was the use of printed antenna which achieved multiband range of frequencies (WLAN, WIMAX and ISM bands). Microstrip patch antennas are one such evolution. These have many advantages over other antennas, like low profile, can be printed on PCB's easily and also shows good radiation pattern, but they lack the advantage of wideband for which they couldn't be used for emerging new technologies [5-8].

Next advancement in technology has come through the development of slots in antennas. With varying sizes and shapes of the slots in the antenna we can bring changes in impedance bandwidth and also the antenna working frequency range will be increased. The design of slot antennas is simpler and also they are robust in nature [9-12]. We can determine the radiation pattern distribution from the shape and size of the antenna.Previously L-shaped slot antenna, U-shaped slot antenna, and rectangular slot antenna with stubs and circular slot antennas were designed, but from the literature review it has been concluded that these antennas have a drawback of complex structure and limited bandwidth. In printed slot antennas alignment problems occur due to multiple layers of the antenna, hence we have adapted CPW feed line technique which is a single layer structure [13-15]. Also CPW has lower loss than the micro strip line. When we use a CPW slot antenna it is easier to integrate it with a system that utilizes fiber optics.We can achieve good impedance match at these range by using CPW feed line instead of normal microstrip feed technique [16-19]. Also CPW has ground on the same plane of the patch so this structure is simple and has single metallic layer. Hence in this paper we presented a novel compact CPW-fed printed slot antenna.

2. ANTENNA DESIGN

The basic antenna design has three models with different number of slots which has successively improved the return loss of the antenna. Hence the evolution of basic antenna design is presented in Figure-1. The antenna we have presented in this paper (Figure-2 and Figure-3) has an overall size of 40X50 mm. This structure is simple since it consists of single layer of substrate. FR4 epoxy having a good throughput has been opted as the material for substrate. It has dielectric constant Ɛr=4.4. The width of the substrate is w=1.58 mm. CPW that has been used in this antenna is of width s=3.2mm which separates itself from ground plane on either side with g = 0.4 mm. The width and gap of CPW can be used to determine the characteristic impedance of the antenna (Z_0)

$$Z_0=\frac{30\pi}{\sqrt{\varepsilon r}}\frac{K(k_0{}')}{K(k_0)} \tag{1}$$

Where the modulus of complete elliptic integrals $K(k_0{}')$, $K(k_0)$ are

$$k_0=\frac{s}{s+g},\ k_0{}'=\sqrt{1-k_0{}^2} \tag{2}$$

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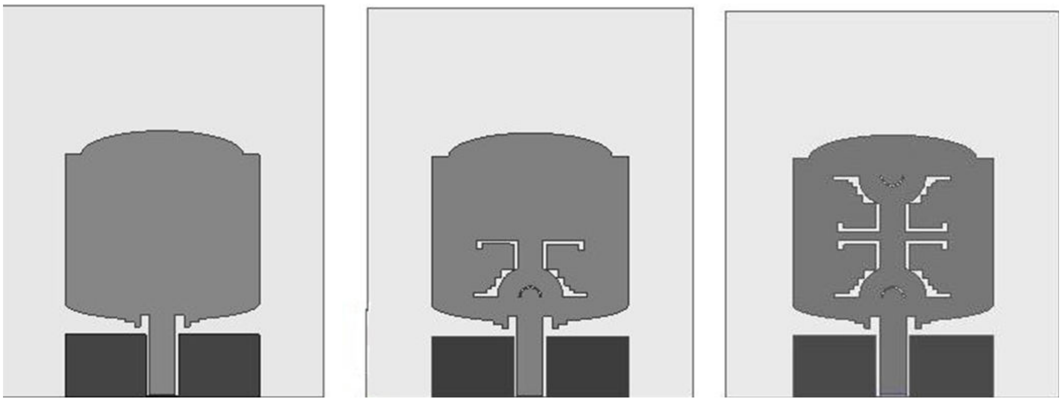

Figure-1. Evolution of basic antenna design.

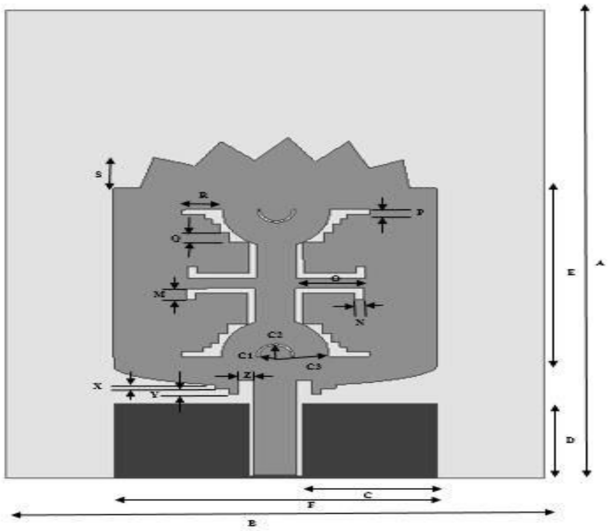

Figure-2. Geometry of proposed antenna.

This is a single layer structure as we have implemented both feed line and the ground plane on the same plane upon the substrate. The results for the proposed design are deduced from ANSYS Electronic tool (HFSS). The dimensions of the antenna design are mentioned in the Table-1.

Table-1. Dimensions of the proposed antenna.

Parameters	Value (mm)	Parameters	Value (mm)
A	40	M	1.2
B	50	N	0.7
C	10	O	0.7
D	8	P	0.5
E	19	Q	4
F	24	R	3
C1	1.2	S	3.4
C2	1.4	X	0.6
C3	4	Y	0.5
		Z	1.1

3. RESULTS AND DISCUSSIONS

The basic model of the antenna has been modified by attaching a serrated structure at the top of it. This structure has improved the bandwidth from (2.2GHz-4.4GHz) to (1GHz-11GHZ). The compared results of the basic model and proposed model are shown in Figure-3. Maximum return loss for basic model is observed at 2.3GHz and for the proposed model we observed a return loss at 2.6GHz.

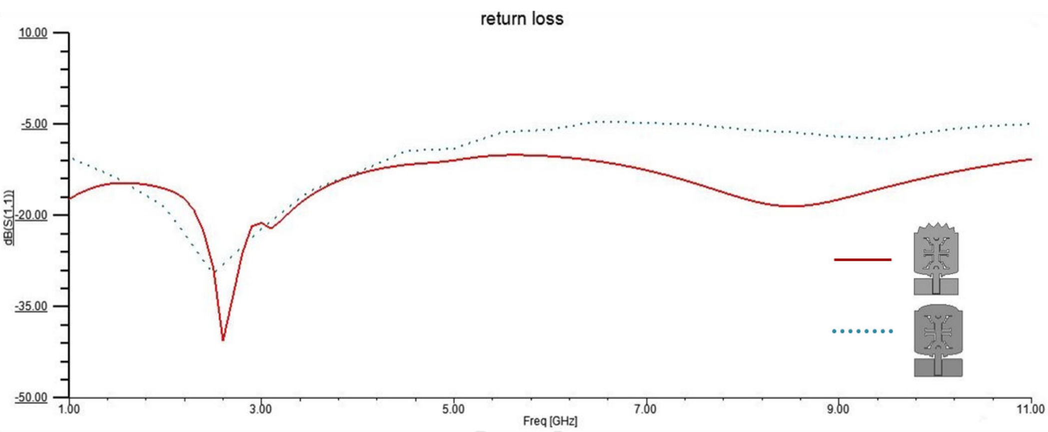

Figure-3. Compared result of basic antenna and proposed antenna.

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Return loss also known as reflection coefficient (S11) usually represents the discontinuity in the power of signal that is returned back which is mainly caused due to impedance mismatch. The centre frequency of the antenna is 2.6GHz where we can observe maximum return loss of -40dB in Figure-4. Now, this shows that we have minimum power loss at 2.6GHz frequency.

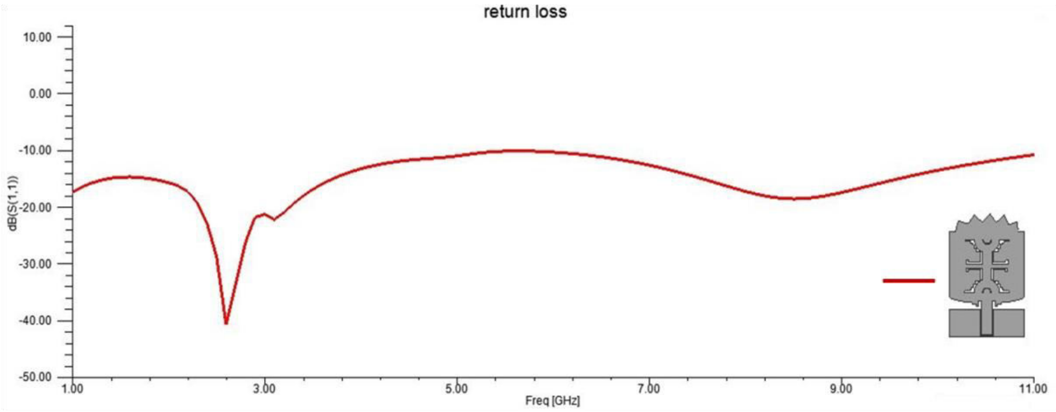

Figure-4. Return loss of the proposed antenna.

VSWR is voltage standing wave ratio which is inversely proportional to the power transmitted and has got delivered to the antenna. Lesser the value of VSWR greater will be the power delivered to receiving antenna. This parameter is directly related to reflection coefficient. Figure-5 depicts the VSWR within antenna frequency range which shows a good variation from 1.25 to 2.

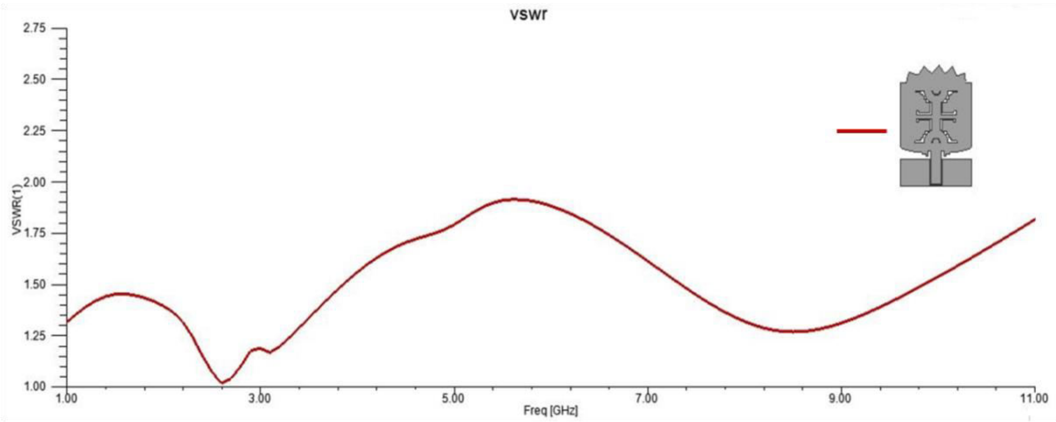

Figure-5. Voltage standing wave ratio of the proposed antenna.

For this antenna design we achieved a gain from 2.14dB to 6dB which is shown in the Figure-6. Gain is a combinational representation of directivity and efficiency of the antenna.

Gain in dB can be mathematically deduced from gain factor.

$G_{dBi}=10\log_{10}(G)$, where G is the gain factor of the antenna.

When gain is measured and averaged by considering all the directions instead of specific direction we get peak gain which is usually maximum gain of the antenna.

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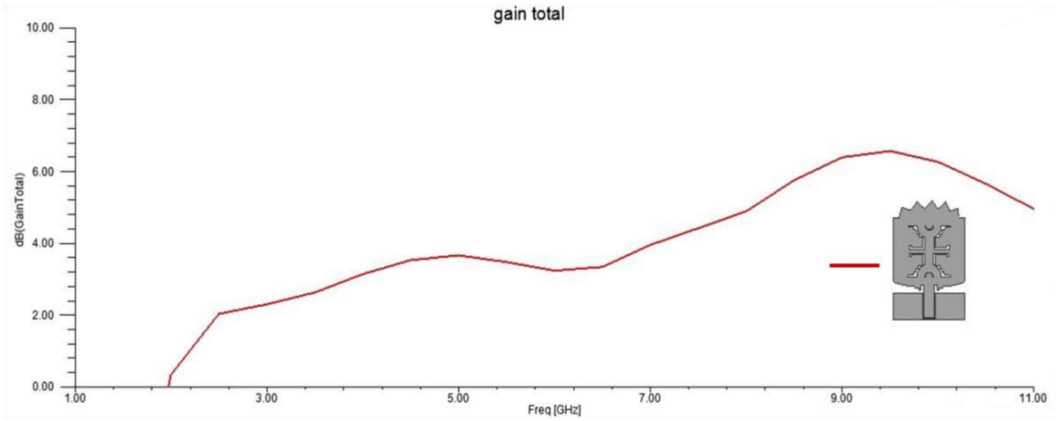

Figure-6. Gain vs. frequency plot

Radiation pattern of the antenna is calculated for gain theta and gain phi for different values of phi and theta respectively. Figure-7 represents how gain is varied with respect to the radiation of the antenna in space. We achieved quasi omni directional radiation patterns both for gain theta and gain phi.

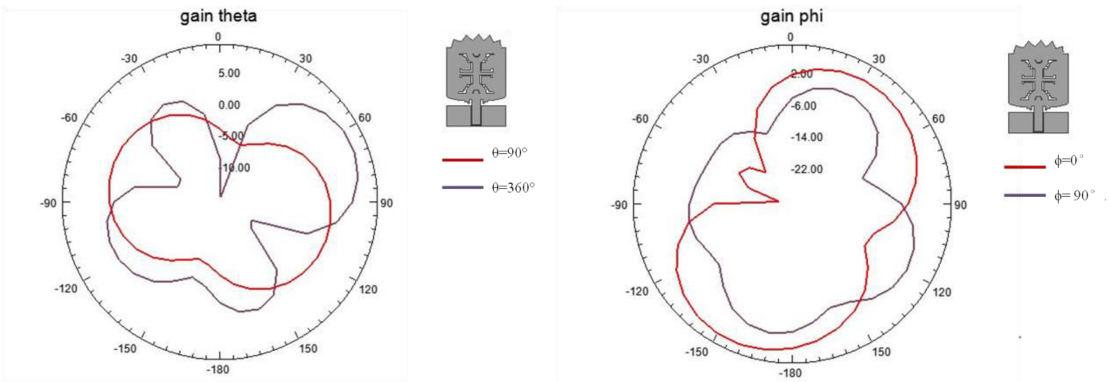

Figure-7. Radiation pattern of the proposed antenna.

Radiation pattern for Gain theta is measured at 2.6GHz frequency and with ϕ=0° and ϕ= 90°.

Radiation pattern for gain phi is measured at 2.6GHz frequency and θ=90° and θ=360°.

Current distribution determines the flow of current through the antenna. Areas where we can observe maximum current flow are the place from which we can obtain maximum radiation. Figure-10 displays the currents distribution of the proposed antenna from which it can be deduced that there is maximum current flow through the CPW feed line towards ground. Also there is good current flow near rectangular slots and bottom area of the radiating patch. Figure-11 shows E-field plot for the proposed antenna.

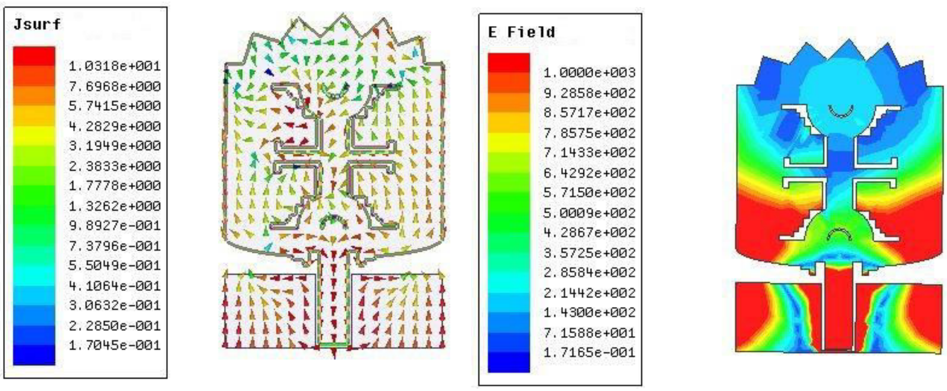

Figure-8. Current distribution and E-Field distribution of the proposed antenna.

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4. Parametric Analysis

The parametric analysis for the proposed antenna was done to fine tune the dimensions as per the desired operation. The width of the feed line 'w' is varied and found the best suitable dimension and the resultant analysis is produced in Figure-9.

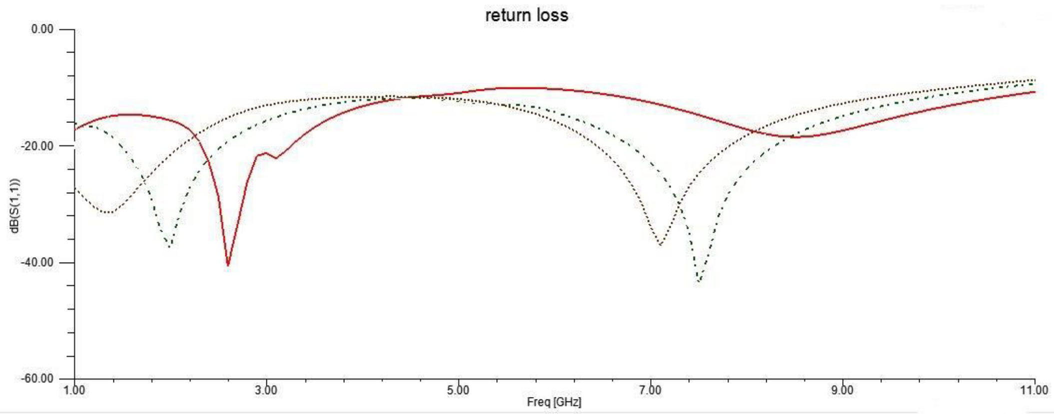

Figure-9. Result obtained by doing parametric analysis of feed width (w).

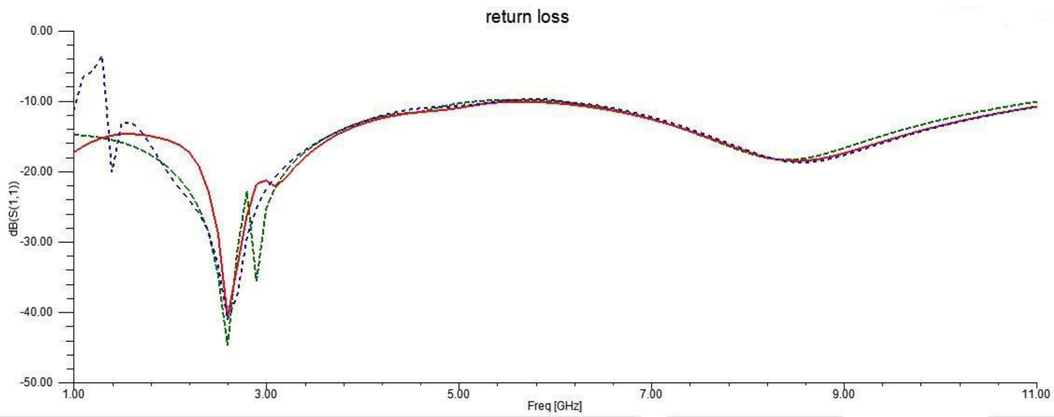

Figure-10. Parametric analysis of gap between the rectangular slots.

The parametric analysis with respect to the gap between the slots are also analyzed and presented in Figure-10. At lower band the shift in resonant frequency can be observed from the results. There is no significant change at higher operating band.

CONCLUSIONS

This antenna is designed in such a way that it works in UWB range of (1GHz-11GHz) which covers most of the communication band applications. A combination of CPW feed line and stair slot technique makes this antenna work efficiently with higher bandwidth. A unique serrated structure is adjoined at the top of the antenna, which is the responsible candidate for achieving the UWB range with higher impedance bandwidth. The proposed antenna shows a variation in gain from 2 dB to 6 dB with omni-directional radiation pattern in the operating band.

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