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# Design and Analysis of Stair-shaped lotus Microstrip Patch Antenna for UWB Applications

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**ABSTRACT**: The paper presents an antenna for Ultra Wideband Applications (3.1 to 10.6 GHz). This paper proposed the design of a compact Stair-Shaped lotus; line feed Microstrip Antenna for Ultra-Wide Band applications. The antenna is designed on CST MICROWAVE STUDIO™ SUITE 2011. The Designed antenna consists of a half circle with an extra stair shape patch, combining both gives a lotus shaped antenna. The proposed antenna is fabricated on a 44*38*1.6 $mm^3$ FR4 Substrate with dielectric constant of 4.4 and 1.6 mm thickness and is fed by 50 Ω Microstrip line. The proposed Antenna was successfully designed covering the whole UWB range from 3.1 to 10.5 GHz having two notches at 4 and 7.68 GHz. The simulation results of the designed antenna are obtained with return loss ($S_{11}$) at 4 GHz is -47.59 dB and at 7.68 GHz is -50.30 dB. The VSWR obtained at above said frequencies is from 1 to 1.5 and the antenna exhibits the Omni-directional radiation pattern.

**KEYWORDS:** Microstrip antenna, Ultra-wide bandwidth (UWB), VSWR, return loss, radiation pattern.

## I.INTRODUCTION

First in year the 1953 Deschamps introduces the concept of microstrip radiators [1]. The research on microstrip radiator got attention when some good dielectric material were found with better thermal and mechanical properties has a low loss tangent. In 1969 Denlinger found the microstrip radiators with rectangular and circular shape could be able to radiate efficiently [6].

A Microstrip antenna is one that offers low profile and light weight [2]. It is a wide beam narrowband antenna which can be manufactured easily by the printed circuit technology such as a metallic layers in a particular shape bonded on a dielectric substrate which forms a radiating element and another continuous metallic layer on the other side of substrate as ground plane. Not standard basic shapes are there, any continuous shape can be used as the radiating patch. Instead of using dielectric substrate some of the microstrip antennas use dielectric spacers which results in wider bandwidth but in the cost of less ruggedness. Microstrip antennas are low profile antenna and mechanical rugged and can be easily mounted on any planar and non-planar surfaces. The size of microstrip antenna is related to the wavelength of operation generally λ/2. The applications of microstrip antennas are above the microwave frequency because below these frequencies the use of microstrip antenna doesn't make a sense because of the size of antenna. At frequencies lower than microwave, microstrip patches don't make sense because of the sizes required. Now a day's microstrip antenna is used in commercial sectors due to its inexpensiveness and easy to manufacture easily by an advanced printed circuit technology. Ultra wideband (UWB) communication systems can be broadly classified as a communication system whose bandwidth is many times larger than the other applications like WLAN, Wi-Fi [1]. This large bandwidth is the smart characteristic of UWB to use in many applications i.e. satellite and military [**4**].

Over the past years, many individuals and corporations started asking permissions for ultra wide band frequency range from federal communication commission (FCC), then in 2002, the FCC decided to change the rules to allow UWB system operation in a broad range of frequencies [11].UWB is a short distance radio communication technology that can perform high-speed communication with speeds of more than100 Mbps. The UWB systems can be divided into two categories: direct sequence UWB (DS-UWB) and multi-band orthogonal frequency division

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multiplexing (MB-OFDM). The DS-UWB proposal has two different carrier frequencies at 4.104 (low band: 3.1–5.15 GHz) and 8.208 GHz (high band: 5.825–10.6 GHz), while the MB- OFDM format in IEEE 802.15.3 has an interval between 3.1 and 10.6 GHz and is divided into 14 subintervals. Each subinterval covers 528 MHz of bandwidth [21] [11].

## II. ANTENNA DESIGN

In this paper we present a compact size Stair-shaped lotus microstrip antenna for UWB applications. Because of many advantages, UWB received much attention in wireless communications. The antenna is simulated using CST microwave studio software. The designed antenna covers the frequency range from 3.1 to 10.5GHz with two notches at 4 and 7.63 GHz.

Fig .1 shows the front view geometry of the proposed compact size Stair-shaped lotus microstrip patch antenna. This array is placed over the FR-4 substrate having thickness of 1.6mm and dielectric constant of 4.4. The antenna is excited by 50-Ω microstrip line i.e. we are using microstrip line feed method for feeding the antenna. The dimensions of the substrate is 44×38(W×L) with thickness 1.6mm.

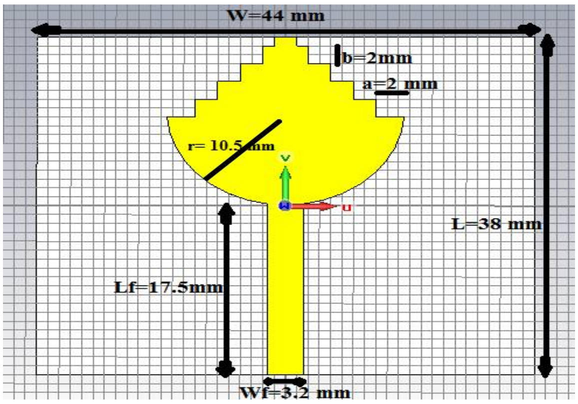


Fig. 1.Front view of the proposed antenna

Fig .2 shows the rear view of proposed antenna. We make the ground plane defective so that designed antenna covers the whole ultra wide band range (3.1 to 10.6 GHz). A U-shaped slot is cut on the defective ground and the dimensions of the above the said slot are Lg1=15.1 mm, Wg1=3.6 mm and the dimensions of the ground plane is 44×17.9 (Wg×Lg).

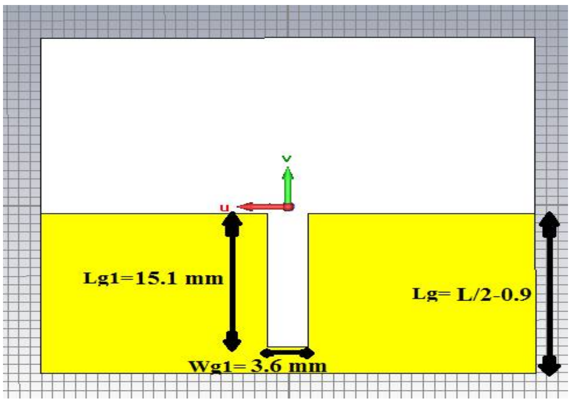


Fig. 2.Rear view of the proposed antenna

The Proposed Antenna is designed on FR-4 (lossy) Substrate. The Parameter specifications of the Stair-Shaped Lotus Microstrip Patch Antenna are mentioned in Table .I.

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Table.I Shows the dimensions of the compact size stair-shaped lotus microstrip antenna.

| Parameter | Length in mm |
|---|---|
| W | 44mm |
| L | 38mm |
| Wg1 | 3.6mm |
| Lg1 | 15.1mm |
| Lg | 17.9mm |
| Lf | 17.5mm |
| Wf | 3.2mm |
| r | 10.5mm |
| a | 2mm |
| b | 2mm |

## III. SIMULATION RESULTS

Simulation work is done on CST software. Different parameters are investigated such as return loss S11, VSWR and radiation patterns.

A. *Return Loss*

Fig.3 shows the simulated reflection coefficient for proposed designed antenna. With U-shaped structure on the ground plane the antenna is covering bandwidth from 3.1 to 10.5GHz. We try for different values of Lg, Lg1 and Wg1but the antenna is not covering entire bandwidth of UWB range. The optimized values at which designed antenna covers whole range of ultra wideband are Lg=(L/2-0.9)mm, Lg1=15.1mm and Wg1=3.6mm and there is notch coming in the bandwidth curve at 4 & 7.68 GHz band so by adding U-shaped structure on the ground plane the antenna covers UWB range.

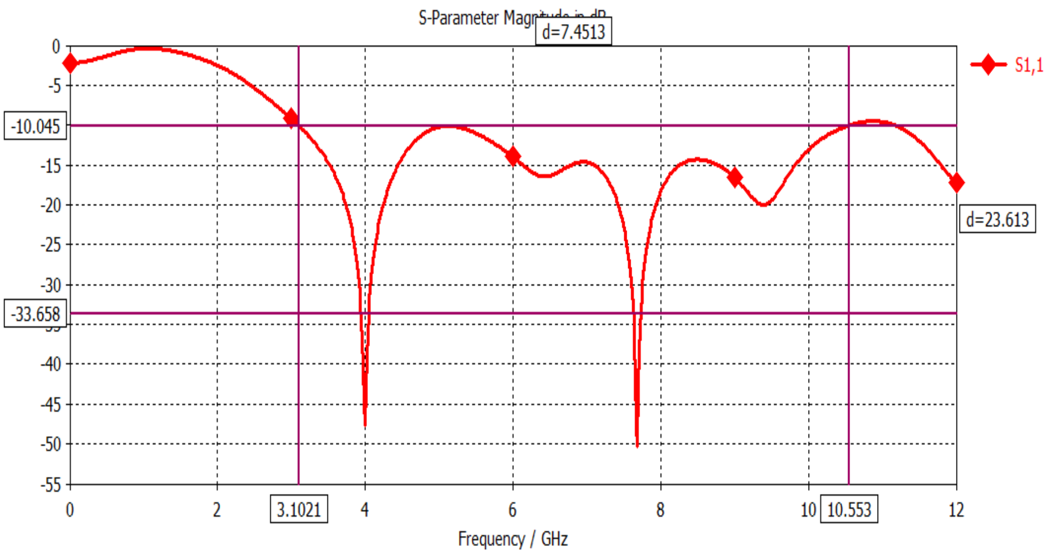


Fig. 3.S-Parameter vs Frequency Curve

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B. *VSWR Charcteristics*

Fig.4 shows the VSWR vs. frequency plot. From the plot we can observe that from frequency range of 3.1-10.5GHz VSWR is maintaining less than 1.5 and at notches it become almost 1 which approaches the ideal value.

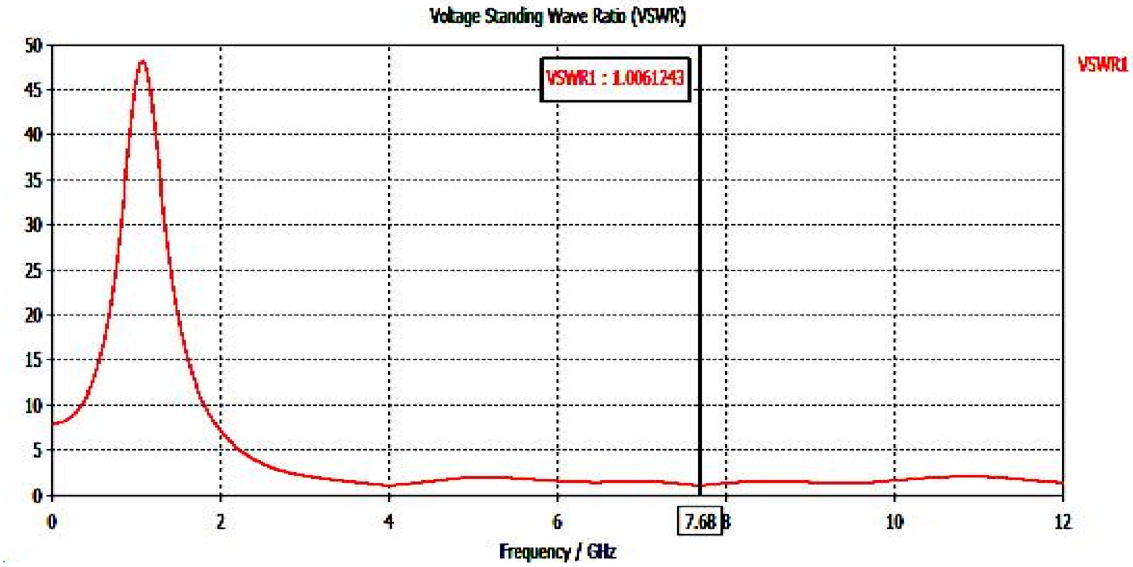
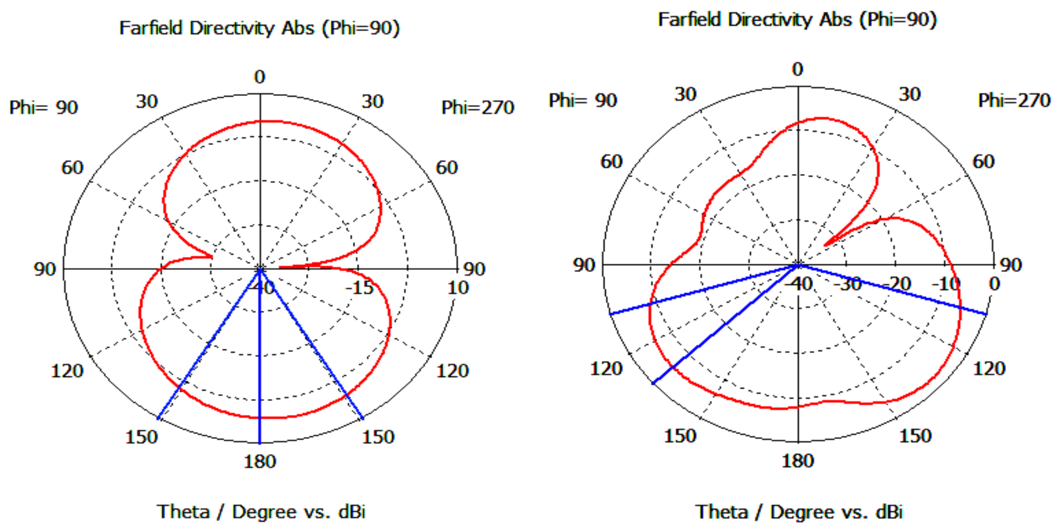



Fig. 4. VSWR vs Frequency curve

C. *Radiation Pattern*

The term radiation pattern refers to the directional (angular) dependence of the strength of the radio waves from the antenna or other source. The simulated radiation patterns for the proposed design are shown in Fig. 5 and Fig. 6. It has been observed that the antenna exhibits Omni-directional radiation characteristics for H-plane and E-planes are in broadside direction.




(a) (b)

Fig. 5. Simulated Radiation Patterns at (a) f = 4 GHz and (b) f = 7.68 GHz

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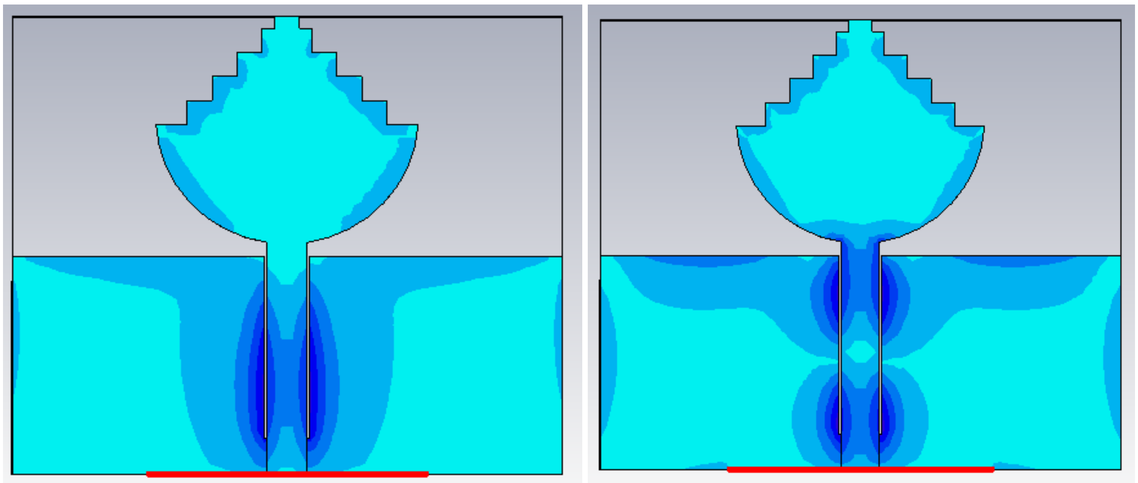
D. *Surface Current Distribution*

Fig. 7 and Fig. 8 depict the current distribution on the patch at resonance frequency 4GHz and 7.68GHz. The direction of current is indicated by arrow sign. It is clearly observed from the current distribution display that the electric current strongly flows at the edge of the stairs slot, especially near the feeding probes of the patch. So, we can say that the slots dominate the antenna performance. Due to the stairs slot, the current flow is controlled which leads the lessening of cross polarization level. At different part of the patch, the current distribution is almost regular.



(a) (b)

Fig.6. Surface Current distribution at (a) f = 4 GHz and (b) f = 7.68 GHz

## IV. CONCLUSION

In this paper a single feed single layer compact stair- shaped lotus microstrip antenna has been proposed. It is shown that the antenna covers the whole UWB range which is 3.1 to 10.6 GHz. The stairs in the lotus shape reduces its size and increase the bandwidth. An optimization with size reduction, bandwidth Enhancement and high gain also maintained in this work. The design of stair-shaped lotus microstrip antenna has been completed using CST software. The Simulated results are presented, shows the usefulness of the proposed antenna structure for UWB applications. The simulation results of indicate that the proposed antenna fulfils the excellent UWB characteristics for various frequency bands and showing the good return loss and radiation patters in the interested UWB. On the basis of the results observed in this research we can say that the designed antenna can be used different frequency bands with good amount of gain as well as efficiency.

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