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# Design of Dual Band Microstrip Patch Antenna for Satellite Communication and Radar Applications

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## Abstract

In this proposed work, a novel method of dual-band slotted Microstrip Patch Antenna for satellite communication and Radar application purposes has been staged. The proposed dual-band antenna is designed by introducing radiating patch of the antenna and two U shaped slots in order to attain a dual-band operating frequencies. This dual-band patch antenna operates at two different frequency bands at 9.1 GHz and 14 GHz which are in the range of X (8-12GHz) and Ku (12-18GHz) bands respectively. The antenna is designed from perfect electic conductor (PEC) radiating patch located above substrate of the Flame Retardant 4 (FR4) dielectric material and this substrate is a medium that connects the top radiating patch to the ground plane. The proposed antenna of size 14mm×16 mm is fed by coaxial feed and exhibits excellent bandwidth of 1.2 GHz and 833 MHz at X band and Ku band respectively. This proposed dual band antenna is designed and simulated using user friendly software CST Microwave studio 2010.

***Keywords:*** *FR4 Substrate,Co-axial Feed, Perfect Electric Conductor,CST Microwave Studio,X and Ku band*

## 1. Introduction

The recent boom in wireless communication industry, has generated the great demand for dual band or multi band antennas in mobile communication and data communication areas. In such communication areas, the problems to be resolved are broad bandwidth and gain, while striving for miniature geometry.Therefore, occurs an urgent requirement for a economical, condensed, extremely reliable, integrated. antenna is a desirable feature of multifunction antennas used in mobile communication equipment.[1]-[4] A MSPA (Microstrip Patch Antenna) has a radiating PEC materialistic sheet called patch on one side of the dielectric substrate which is connected with ground plane on the other side. The patch is made of conducting material such as copper or gold and can take any possible shape.The patch is generally square, rectangular, circular and triangular or any other shape. Microstrip Patch Antennas can be fed by a number of techniques.The most admired feeding means used are microstrip line, coaxial probe, aperture coupling and proximity coupling. The proposed antenna is designed using coaxial probe feed [5]-[8]. The microstrip patch antennas have more advantages when compared with the conventional antennas .They are lighter, low volume, low cost, smaller in dimension and easy to fabricate. Radar demands a low profile, light weight antenna, the microstrip antennas are an ideal choice. Other application areas of microstrip patch antennas are wireless communication, satellite communication, medical and military systems. But these low cost patch antenna designs have quite a few shortcomings. They have narrow bandwidth, low gain and low efficiency.[9]-[12] There are some methods to recover these problems which embrace adding up fashioned slots to the patch, defected ground structure and fractal geometry. In this paper, two U-shaped slots and various parameters are considered to achieve the desired results. The X and Ku-bands are portions of the electromagnetic spectrum in the microwave range of frequencies which covers 8GHz-12 GHz range and 12 GHz -18 GHz respectively. These bands are primarily used for satellite, radar, space and global communications.[13]-[20]The proposed antenna resonates at dual frequency bands are at 9.1 GHz and 14 GHz which cover X and Ku bands without any interference of any other undesired frequencies.

## 2. Antenna Design Considerations

In this paper,a rectangular patch with dimensions 14 mm×16 mm has been designed. Two equal slots are cut from the patch having length 3mm and width 10.5mm. Here FR4 inexpensive substance is used as a substrate with dielectric constant of 4.3 and loss tangent of 0.02. Coaxial feed has been used and feed point is selected in such way that impedance matching takes place.Before designing the antenna structure following three essential parameters are considered**:**

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1. **Frequency of operation ($f_r$):** The resonant frequency of the antenna must be selected appropriately. The resonant frequency for the antenna design is 8 GHz.

2. **Dielectric Constant of Substrate(Er):**
The substrate considered for the design is FR4 sheet which has a dielectric constant of 4.3.A substrate with a high dielectric constant diminishes size of the antenna.

3. **Altitude of dielectric substrate (h):**

For the microstrip patch antenna it is indispensable that the transmitter is not massive.Therefore, the height of the dielectric substrate is selected as 1.574mm.The proposed consideration that are taken and calculated are made known in Fig. 1.

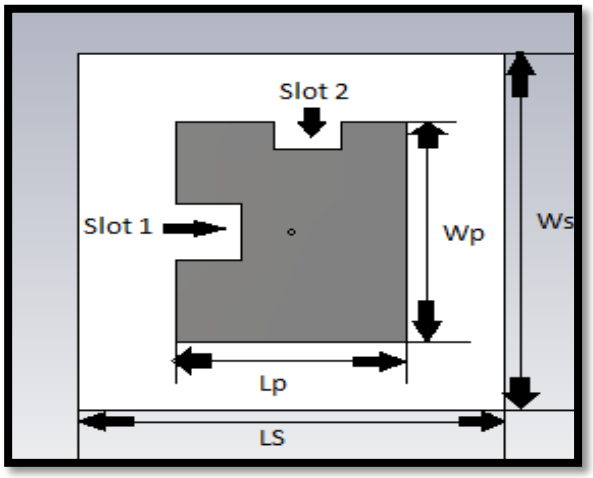


**Fig 1**. Bottom View of Microstrip Patch Antenna

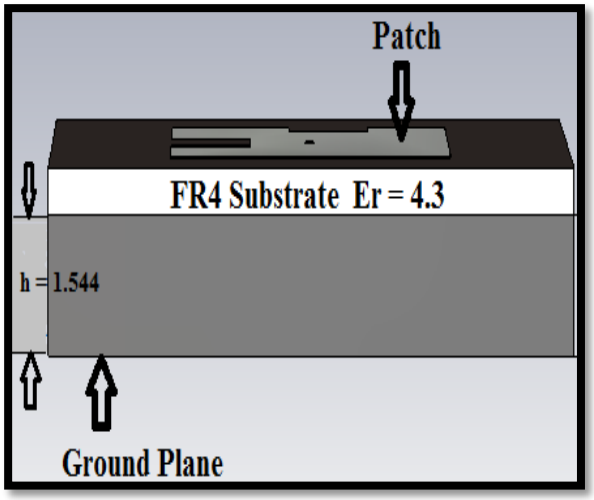


**Fig 2:** Front View of Patch Antenna

Figure 2 shows geometry of the proposed antenna for dual band operation. First a rectangle patch having the dimensions of 14 mm by 16 mm is taken. Then, two U slots are cut in the patch. These slots have significant effect on the results which has been shown in next section. Calculated design specifications are shown in following Table I.

**Table I:** Antenna Design Specifications

| Sr. No. | Antenna Specifications | Dimensions in mm |
|---|---|---|
| 1. | Length of Patch (Lp) | 14 mm |
| 2. | Width of Patch(Wp) | 16mm |
| 3. | Length of Substrate (Ls) | 26mm |
| 4. | Width of Substrate (Ws) | 26 mm |
| 5 | Subsrate height (h) | 1.544 |
| 6. | Dielectric Constant (Er) | 4.3 |
| 7. | Feed to Patch | Co-axial feed |

The CST microwave studio simulation software is used to design and optimize the antenna parameters of dual band operation. The proposed antenna produces wide impedance bandwidth with good radiation pattern. Length (Ls) and Width (Ws) of substrate have great effect on the resonant frequencies of the designed dual band antenna. By optimizing the dimesions of substrate desired dual band frequency response of the antenna can be achieved.U shaped slots improve the return loss of X band and Ku bands and also make antenna to operate at dual frequency bands by eliminating other undesired frequencies.

## 3. Result and Discussion:

The computer simulation is done for the dual band operation and this antenna structure is covering the band of the center frequency 9.1 GHz and 14 GHz. 1During the simulation process of dual band patch antenna various parameters are considered for example length (Ls) and width (Ws) of substrate, shape of slots and their dimesions,feeding point,dimensions of patch in order to give desired dual frequency response with matched impedance,wide bandwidth,low return loss and VSWR values. This antenna structure has two distinct X and Ku frequency bands, as shown in the Fig.3.

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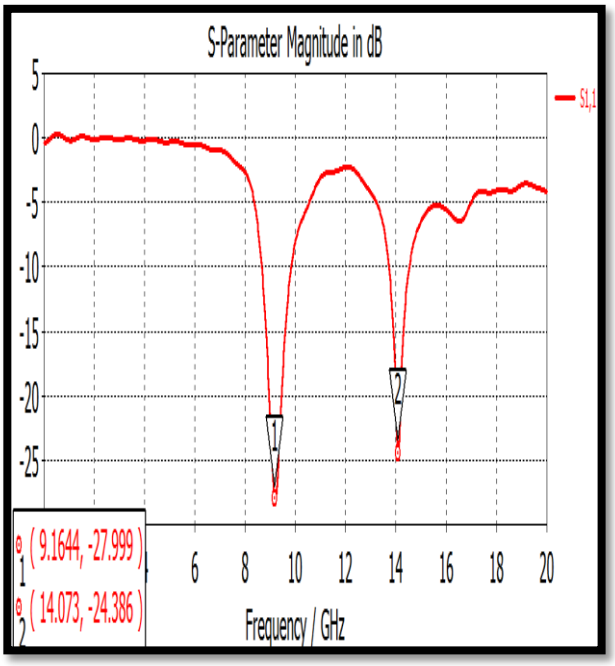


**Fig 3:** Return Loss versus Frequency Plot of Patch Antenna

This antenna structure has two distinct X and Ku frequency bands, as shown in the Fig.3. From Fig.3, it is clear that designed structure is resonating at X band with -27 dB and Ku band with -25 dB return loss that depicts this antenna is workable on these two frequency bands without any interference. The impedance bandwidth at X and Ku bands are 1.2 GHz and 833 MHz respectively. It can be observed here that X band has larger bandwidth than Ku band. The wide bandwidth and wide impedance matching with reduced size of the antenna is achieved.

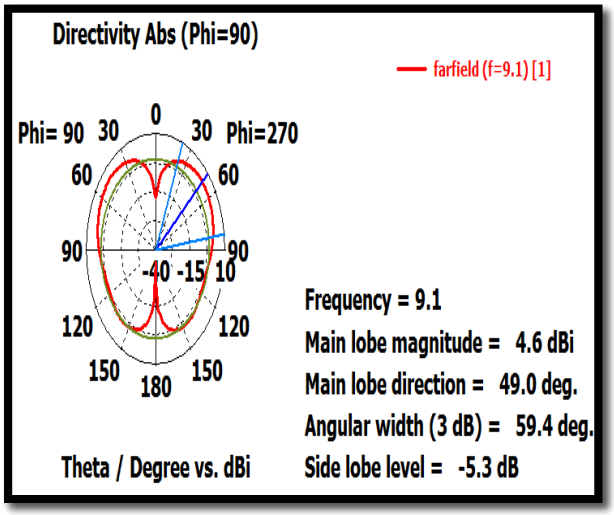


**Fig 4 :** Polar plot of Directivity/Gain at 9.1 GHz frequency.

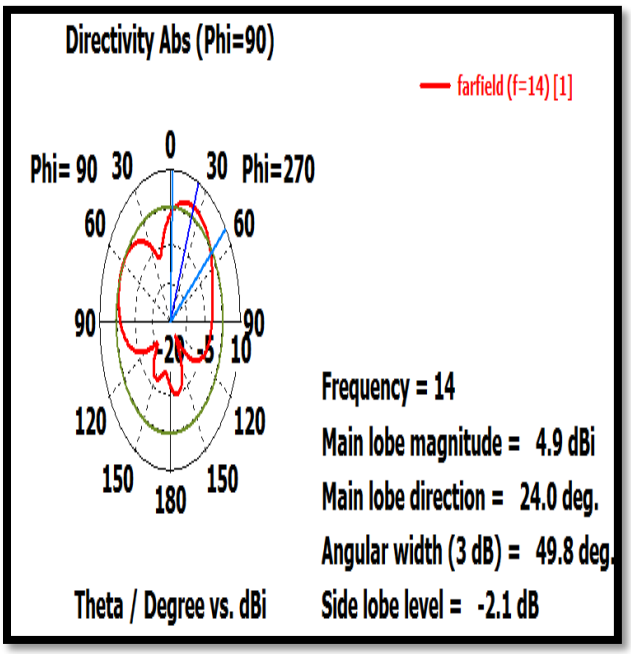


**Fig 5 :** Polar plot of Directivity/Gain at 14 GHz frequency.

The gain/directivity pattern of dual band antenna is shown in Fig. 4 and 5.The described directivity patterns are Omni directional in nature with 4.6 dB directivity at X (9.1 GHz) band and 4.9 dB directivity at Ku Band (14 GHz), so this dual band antenna is radiated in all direction. The radiation pattern or directivity of antenna is depends on the shape of the radiating patch and the slot which is cut away from the radiating patch, so by the changing the shape of the radiating patch or the U-slot of the radiating patch the radiation pattern of antenna can be changed. The radiation pattern can also be changed by changing the dieclrctric loss of the FR-4 substrate and changing the distance between the ground plane and the substrate.

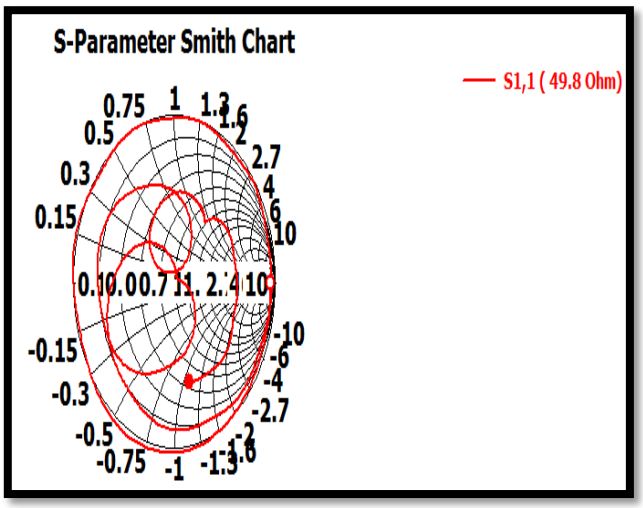


**Fig 6**: Smith Chart for Dual Band MSPA

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Co-axial feed has been used to excite the patch antenna. The position of feeding method is choosen in such a way to match impedance of the proposed antenna. Fig. 6 shows the smith chart of the designed antenna which clearly depicts the impedance of patch antenna is approximate equals to characteristics impedance i.e. 50 Ohms.

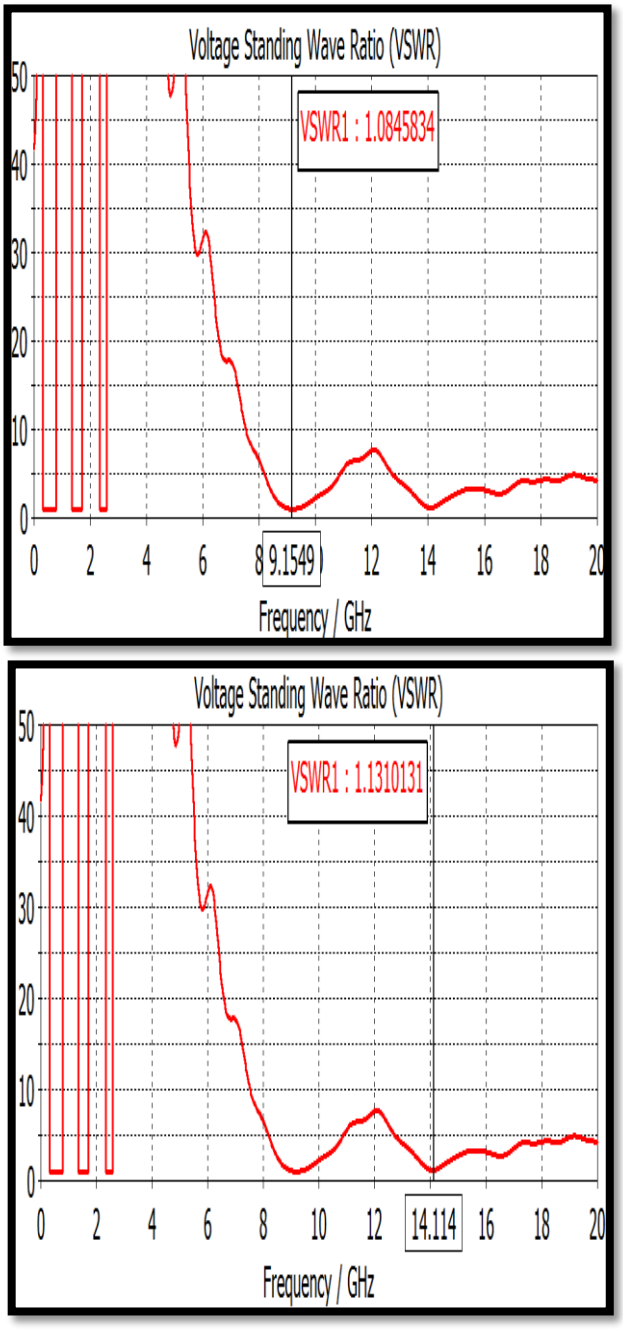


**Fig 7 and 8 :** Simulated VSWR value at X and Ku band respectively

The value of VSWR depends on the value of reflection coefficient and it explains the power that reflected from the antenna. Fig.7 and 8 show the simulated result of VSWR for this dual band MSPA. It can be stated that, the VSWR for X and Ku bands are about 1.1 which is less than 2 and it is proved that the antenna impedance matching for this dual-band MSPA is considered very good. It is because, only 0.8 % power is reflected back from the antenna and the value of mismatch loss is only about 0.04 dB for VSWR=1.

## 4. Coclusion

Dual Band Miccrostrip Patch antenna at X and Ku band has been successfully designed. The optimized results shown in this paper depict that designed antenna verifies all the necessary parameters for for faithful operation.The dimesions of substarte affects the frequency response of antenna after doing finite no. of simulation antenna gives approximate -28 dB return loss at 9.1 Ghz frequency band and -24 dB return loss at 14 GHz band.Shape and dimesions of the slots improve the return loss and radiation pattern of the designed antenna.The designed dual band antenna has ommodirectional radiation pattern at X and Ku bands with 4.6 dB and 4.9 gain.From Smith chart and VSWR graphs it is clear that patch antenna is perfectly matched with characteristic impedance.The proposed microstrip patch antenna has 1.2 Ghz and 833 Mhz bandwidth at X and Ku bands respectively.As ku band has lower bandwidth than X band,in future work bandwidth of ku band can be improved further by applying defected ground structure.The designed dual band antenna can be used for satellite and radar applications.

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