IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 7, July 2016
ISSN (Online) 2348 – 7968 | Impact Factor (2015) - 4.332
www.ijiset.com

Design of an I-shaped Dual Band Patch Antenna for Direct and Broadcast Applications

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Abstract:- In this paper, a novel method of an I-shaped dual-band slotted Patch Antenna for direct and broadcast application purposes has been proposed.U-shaped slots are introduced in the four sides of the patch in order to achieve dual band operation at Ku(12-18 GHz) band.The antenna has a reduced structure where patch dimension is about 19 X 18 mm leading to good bandwidths covering 507 MHz and 725 MHz.Proposed antennaa at 12 GHz and 18 GHz resonate with good return loss of -34 dB and -26 dB.The radiation patterns are almost omnidirectional with fair gain in both the operating frequencies.The proposed antenna iss fed using co-axial feed and by choosing optimum position of the feed,antenna is absolutely matched with 50 ohms impedance. CST Microwave studio software has been used to design and simulate this proposed patch antenna.

Keywords:U-shaped slots,Co-axial Feed, CST Microwave Studio, Ku band,

I. Introduction

Today's era of miniaturization and trend of Wireless communication needs any component not to be bottleneck in size of the devices. Antenna is important part of Wireless Communication so Antenna size is important factor as well. So study of Microstrip Patch antenna becomes quite important. But as limitations associated with Microstrip antenna it needs to be reconsidered and solved out problems like Narrow Bandwidth, size constraints associated with defining Bandwidth, Impedance Matching and directivity desired. Microstrip antenna offers advantages like low profile, small size etc. which make it perfect candidate for next generation wireless systems. Further limitations discussed above in Microstrip patch antenna can be sorted out considering different shapes of Metallic patch. Also slots can be cut to improve Bandwidth, improving impedance matching etc. different feeding techniques can also be used to improve performance further. Determining substrate thickness with its dielectric constant is important parameters as it decides Q (quality factor), Bandwidth, frequency of resonance for any antenna.[2]-[6]

A compact microstrip antenna such as VSAT systems is one of the most suitable applications to support high mobility satellite communication devices. Ku-band (12-18 GHz) is one of the most preferred choices in VSAT systems.VSAT can be adopted for satellite television broadcast and satellite television.Moreover,VSAT is a one of the best emergency communication backup system during disasters.[7]-[12] The antenna devices with single radiator that can transmit and receive multiple frequency bands become more efficient and desirable for commercial activities.

In this paper, four U shaped slots have ccut in four sides of the patch antenna in order to make the patch aantenna ddual with good return losss.Length of the patch is varied in order to make to make antenna resonate desired frequencies.The ku (12-18GHz) band is used in VSAT which covers all applications of direct and broadcast communication .The proposed antenna gives dual frequency operation which covers the range of Ku band without interference of any other band.

II. Antenna Design Considerations

In this paper,an I shaped patch with dimensions 9.5 mm by 9 mm has been designed. Four U shaped slots are cut from the patch having length

approximate 6mm 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 :

1. **Frequency of operation (f_o)**

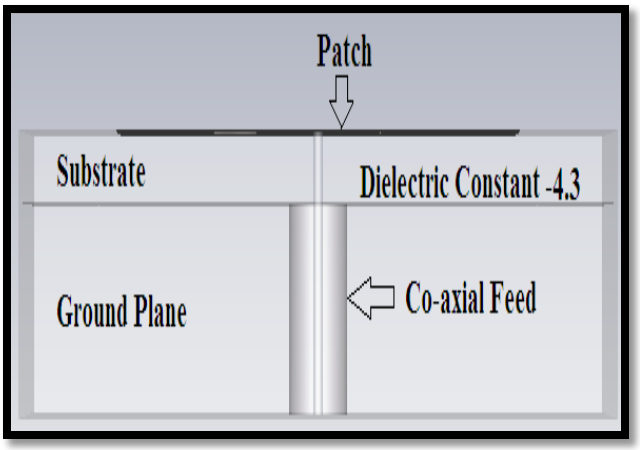
The resonant frequency of the antenna must be selected appropriately. The resonant frequency for the antenna design is 12 GHz.

2. **Dielectric constant of the substrate (ε_r):**

The substrate considered for the design is FR4 sheet which has a dielectric constant of 4.3.[1] A substrate with a high dielectric constant diminishes size of the antenna.

2. **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 is 1.574mm.The proposed considerations that are taken and calculated are shown in Fig. 1.

Figure 1. Bottom View of Dual Band Microstrip Patch Antenna

Figure 2 shows front view of the proposed I shaped antenna for dual band operation. First by considering the essential parameters of the patch antenna all dimensions of the radioating patch and ground are caluculated and geometrical structure of the proposed antenna has been designed.As shown in figure,four U slots are cut in each side of the patch. These slots have significant effect on the frequency and returen loss of the proposed antenna. which has been shown in next section. Optimised 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)	19 mm
2.	Width of Patch(Wp)	18 mm
3.	Length of Substrate (Ls)	28mm
4.	Width of Substrate (Ws)	28mm
5	Subsrate height (h)	1.547
6.	Dielectric Constant (Er)	4.3
7.	Feed to Patch	Co-axial feed

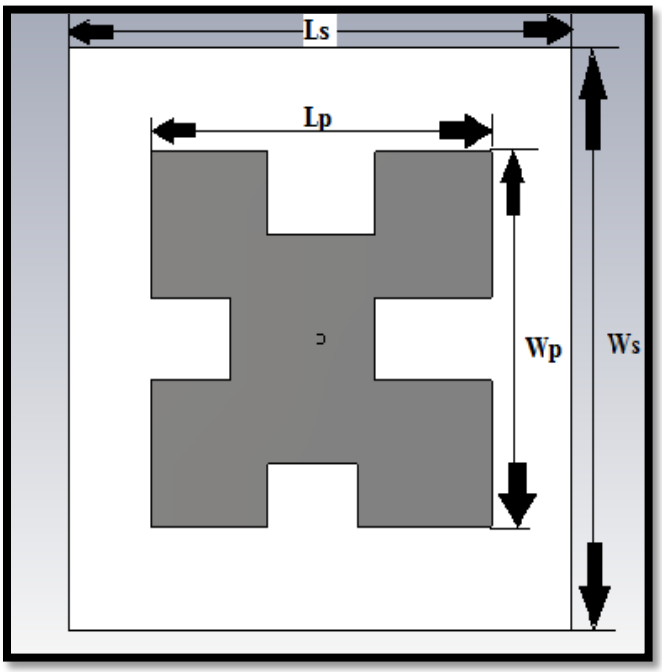


Figure 2: Front View of Patch Antenna

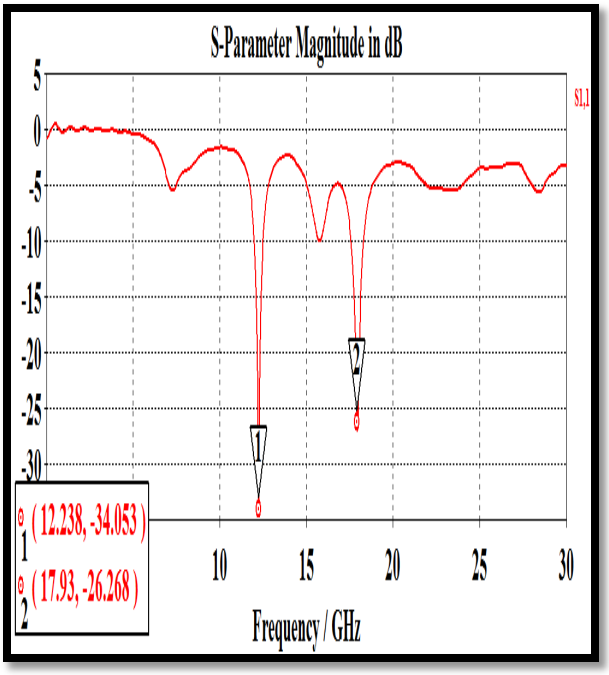
The proposed antenna has been designed and simulated using CST microwave studio simulation software.The patch antenna is optimized by considering various antenna parameters.Dimensions of patch and slots have great impact on the results of the antenna.The proposed antenna gives good wideband impedance with excellent return loss which

shows that maximum power is being transferred to the load. Slots are cut in order to have dual operation which covers the range of Ku (12-18 GHz) band.Length and width of the slots are varied in order to have as possible as minimum return loss with wide bandwidth where all the characeteristics of the proposed antenna satisfy the basic operation of dual band microstrip patch antenna for direct and broadcast applications in space.

III. Result and Discussion

The optimization or simulation of the antenna is done in order to achieve compact sized dual band antenna with good performance characteristics at Ku (12-18GHz) band.During simulation length and width of the patch and substrate are varied which directly relates with the frequency operation of the dual band antenna.Throughout the simulation procedure of dual band patch antenna a range of parameters are cconsidered for example length (Ls) and width (Ws) of substrate,shape of slots and their dimesions,feeding point,dimensions of patch in order have desired frequency response with matched impedance,wide bandwidth,low return loss and VSWR values.

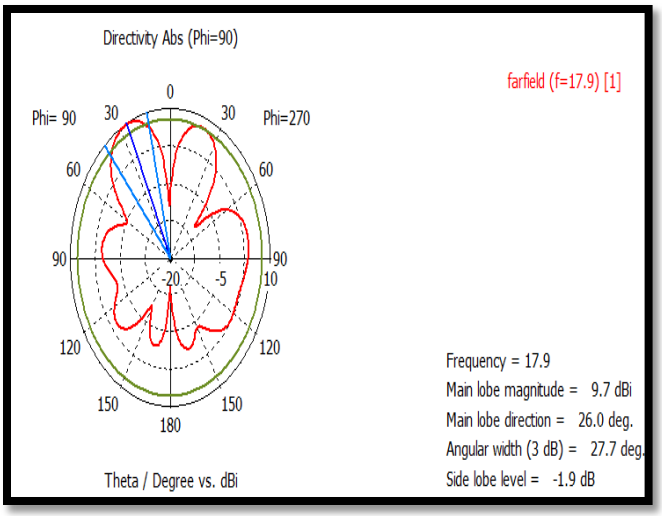
This antenna structure has two different bands which cover frequency range of the Ku band as



shown in the Fig.3.As shown in figure 3 the designed I shaped patch antenna is covering the range of Ku band from 12 GHz to 18 GHz with -34 dB and -26 dB return loss.Moreover,no other band or frequency interfere with these resonating frequencies.The impedance bandwidth at 12GHz and 17.99GHz is 507 MHz and 725 MHz respectively.

Figure 3. Return Loss versus Frequency Plot of Patch Antenna

.The bandwidth and wide impedance matching with compact size of the antenna is achieved. The gain/directivity pattern of dual band antenna is shown in Fig. 4 and 5.At 12 Ghz and 18 Ghz frequencies proposed antenna is having ommi directional directivity pattern of 1.9 dB and



9.6dB values.The waves pattern of antenna is depends on the profile of the radiating patch and the slot which is cut away from the radiatinpatch, so by the changing the shape of the radiating patch or the U-slots of the radiating patch the waves pattern of antenna can be changed. The radiation pattern of antenna can also be changed by changing the dielectric loss of the FR-4 substrate and changing the distance between the ground plane and the substrate.

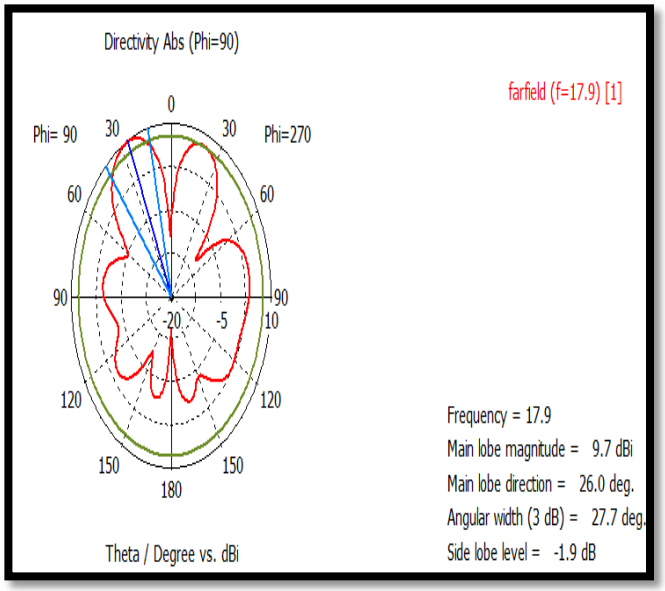


Figure 4 and 5: Polar plot of Directivity/Gain at 12.2 GHz and 17.9 GHz frequencies.

To excite the patch antenna Co-axial feed has been used.The position of co-axial 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

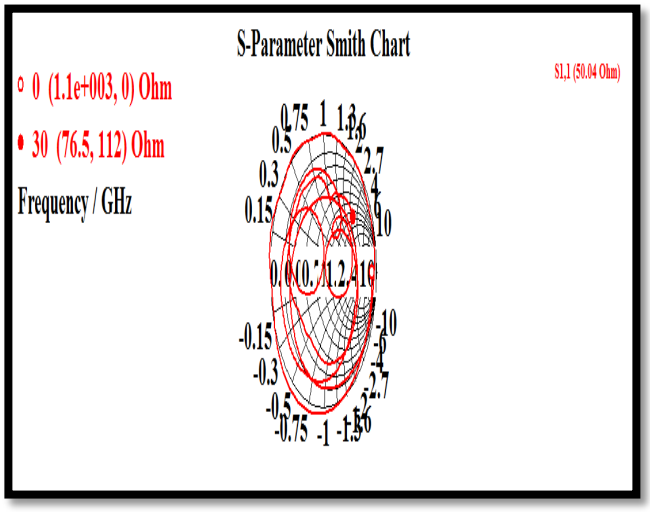


Figure 6: Smith Chart for Dual Band Microstrip Patch Antenna

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 the ku (12-18 GHz) band 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

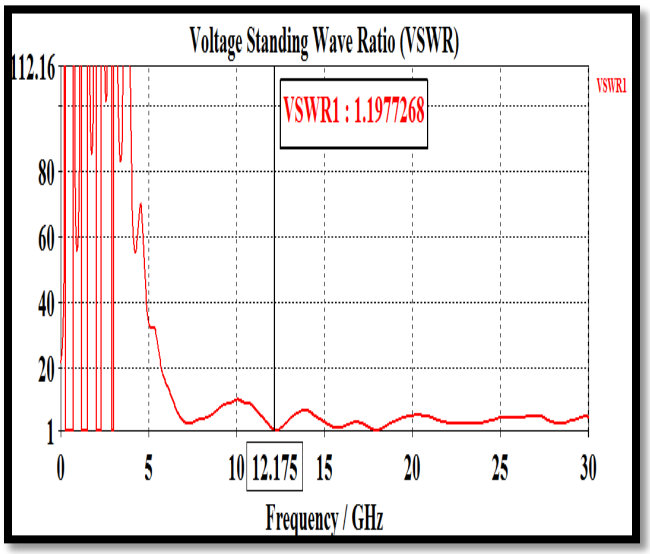


Figure 7: Simulated VSWR value at 12 GHz

because, only 0.7 % power is reflected back from the antenna and the value of mismatch loss is only about 0.04 dB for VSWR=1.It also concludes that maximum power transfer takes place in the proposed dual band antenna.

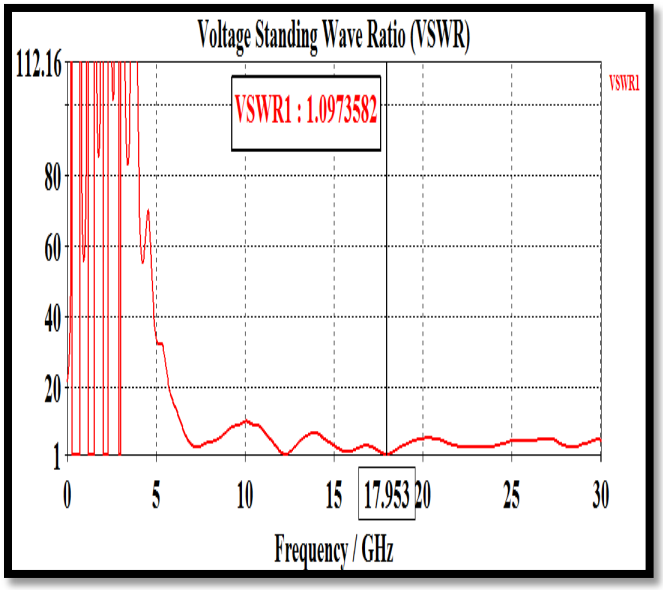


Figure 8: Simulated VSWR value at 17.9 GHz

IV. CONCLUSION

An I-shaped Dual Band Miccrostrip Patch antenna at Ku band has been successfully designed. The simulated performance results shown in this paper show that designed antenna satisfies all the essential parameters for for realistic function.The dimesions of patch,substarte and slots affect the frequency response of antenna after doing predetermined set of simulations antenna gives approximate -34 dB return loss at 12 Ghz frequency band and -26 dB return loss at 18 GHz band.Figure and specifications of the slots enhance the return loss and directivity pattern of the patch antenna.The designed dual band antenna has ommidirectional radiation pattern at Ku (12-18GHz) bands with 1.9 dB and 9.6 dB gain respectively.From Smith chart and VSWR graphs it is clear that patch antenna is perfectly matched with characteristic impedance of 50 ohm.The proposed I-shaped patch antenna has 507 MHz and 725 MHz bandwidth at 12 GHz and 17.99 GHz respectively covering the ku band.As 12 GHz band has lower bandwidth and gain than 18 GHz band,in future work bandwidth and gain of lower band can be enhanced further by applying defected ground structure.The designed I-shaed dual band antenna can be used for VSAT system which covers all the direct and broadcast applications in the space.

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