Multiband U Shaped Patch for C and S Band Applications

Sumathi K, Abirami M, Divyabharathi P

Abstract: ***In this paper multiband U-shaped patch antenna is designed for C and S band applications. L-shaped slots introduced in the two corner of the patch antenna which improves the antenna performance to operate with multiband of frequencies and also provide notch characteristics at 3 GHz. The patch is operated at four bands of frequencies. Operating frequency of the antenna is from 1 to 10 GHz. FR-4 substrate with 4.4 dielectric constant is used for antenna design. Simulations results are carried out by ADS tool. U-shaped patch with L slot and stub which is placed on the defective ground plane achieves return loss upto -47dB at 1.7 GHz and 5 GHz. The gain of the patch antenna is about 6 dB.***

Index Terms: U shaped antenna, FR 4 substrate, Multiband, ADS tool, L shaped slot, Notch characteristics.

I. INTRODUCTION

Recently in wireless applications the multiband antenna is used and it has major advantages that it is not necessary to use multiple patch antennas for different applications instead multiband antenna can be tuned to different frequencies to use it with different applications which reduce overall cost of the design. Due to emerging trends in wireless communication, broad frequency ranges and high data rate are required for many applications. In this proposed system antenna design is focus on bandwidth enhancement and multi band application with notch characteristics at certain frequency.

Notch characteristics reduces the non linear characteristics by filtering some frequency band of the antenna, it removes the interference and noises in transmitting and receiving the antenna. By reducing interferences and noise power at certain band of frequency, antenna performance can be improved. It provides sharp stop band characteristics.

Operating frequency range of the S band is from 2 GHz to 4 GHz. It is mainly used for airport surveillance, traffic control in air, weather monitoring radar and other radar and satellite communications. Operating frequency range of C band is between 4 GHz to 8 GHz. It is also used for satellite and radar transmission. The C-band is used for many satellite communications and transmissions. Also it is used in some Wi-Fi devices, cordless telephones, and some weather monitoring radar systems.Portion of C band is used for TV broadcasting and reception systems and Wi-Fi networks.

Revised Manuscript Received on February 05 2019.

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II. LITERATURE REVIEW

ParisaLotfiaetal., (2011) [1], designed a monopole UWB antenna with coplanar waveguide feed is used to achieve rejection of multiband. Inverted U shaped slot is introduced in the patch antenna. A notch characteristic occurs at the frequencies of 2.4 GHz, 3.8 GHz and 5.5 GHz. For an antenna design FR4 substrate with the thickness of 0.8 mm and dielectric constant is about 4.4 is used. Coverage of the antenna is from 2.2 to 11.3 GHz frequency. Multiple slots are introduced in the patch to provide notch characteristics. Simulation measurements are made by varying the length of the slot in the patch antenna.

Pratap N etal., (2015) [2], designed a pentagonal shaped slot antenna to improve the bandwidth and multiband characteristics and it can be used for various wireless applications since it operates at multiband of frequencies. It results broad bandwidth at 4.17 GHz and gain of the antenna is of 4.24 dBi. Reflection co-efficient parameter is compared with different rotation angle of the antenna since the antenna is brought up with various rotational slots at different angles.

PayamBeigi and PejmanMohammadi, (2016), [3] introduced a fractal type monopole antenna for multiband applications. In this paper crinkle fractal design provides an increased resonant frequency based on the number of slots. For substrate design of an antenna FR4 substrate is used. It results omnidirectional radiation pattern. This design can be used for different multiband applications.

N. Prema and Anil kumar, (2016) [4] designed a patch antenna which resonates at 7 different frequencies from 4 to 14 GHz which exhibits multiband characteristics. Different antenna parameters such as radiated power, bandwidth, VSWR, gain etc., are measured for different tuning frequencies. For antenna design Taconic RF35 substrate is used for antenna design. This antenna design provides the results which is suitable to operate for X and C band applications. Manish Sharma etal., (2016) [5] developed an urn shaped patch antenna for wireless applications. Triple band notch characteristics are introduced in UWB band. Wi-Max, WLAN and downlink frequency band of X bands are rejected in this design. T and dual C shaped slots are included in the patch to provide notch characteristics. VSWR parameter is measured for various frequencies to ensure that impedance matching is obtained perfectly. VSWR measurements are 16.54, 22.35, and 6.38 for the frequencies at 3.60 GHz, 5.64 GHz and 7.64 GHz respectively. It achieves wide bandwidth and due to its notch characteristics it can be used as multipurpose system

to access different wireless networks. Operating frequency range of this system is from 2.49 GHz to 19.41 GHz and it results gain of the patch between 2.08 to 5.98 dBi.

Bing Yang and ShaochengQu, (2017), [7] proposed a UWB antenna which is integrated with Bluetooth. It is useful for automotive and mobile applications since it is designed with upper and lower band of WLAN notch characteristics. Proposed antenna is designed with U-shaped antenna with four stubs, the ground plane is designed with slots. This design provides return loss as less than 11 dB and operating frequencies are between 2.39 GHz to 2.49 GHz for Bluetooth and 3.1 GHz to 11.4 GHz for UWB application. Two bands are rejected in WLAN where 4.97GHz to 5.48 GHz and 5.69GHz to 5.99 GHz. In-vehicle environments is tested by designing MIMO antenna with two port.

Hari Shankar Mewaraetal., (2018), [8] designed an antenna with 4 rejection band for UWB applications. The patch has the shape of trapezoidal with ellipse at the top of the patch. I shaped slots are introduced in the inverted U shape of the patch and this acts as a notch characteristics and rejects 4 band of frequencies. It produced omni directional radiation pattern. Notch characteristics are done based on varying length of the slot.

Noor M. Awad and Mohamed K. Abdelazeez, (2018), [8] proposed UWB antenna with two rejected bands at WLAN and X bands. FR-4 substrate with dielectric constant of 4.4 is used for the antenna design. H and U shaped slots are introduced to improve the multi band characteristics of the patch antenna. In the rectangular shaped patch antenna round slots are introduced at every corner of the patch. Coverage of this antenna design is from 3.42 GHz to 11.7 GHz. It results better return loss as -48 dB and good impedance matching characteristics. Omni directional radiation pattern is obtained in this design.

N. Sudhakar Reddy, etal., (2018), [9] developed an antenna with spear shape for wireless applications. CPW feed and RT Duroid substrate is used to design the patch antenna. Antenna operated from 3.1GHz to 10.8 GHz frequency and it is more suitable for UWB applications. Design work is carried out by CST tool. The simulation result is about -40 dB return loss at 5.8 GHz. It exhibits UWB characteristics at the band of 2 to 6 GHz.

Govind R. Tapse and V.V. Yerigeri, (2018) [10] proposed an antenna in the shape of fork which is used for UWB applications. It rejects two bands of frequencies in Wi-MAX and C band by introducing L shaped slots at two side of the patch. Various simulation measurements are done by altering the patch antenna shapes as circular, ring, semi circular with semi circular ring, U shaped patch and finally U patch with L slots which exhibits the fork shaped antenna. FR4 substrate is used with 4.4 permittivity is used for an antenna design.

III. PROPOSED DESIGN METHODOLOGY

A. Simple U shaped patch design

In this paper U shaped patch antenna is designed for multiband application. Operating frequency of the antenna is from 1 GHz to 10 GHz. Width of the patch width is 33 mm and length of the patch is 40 mm. ground plane length and widths are 10 mm and 33 mm respectively. In Fig.no.1 (a) shows the patch design of the antenna,

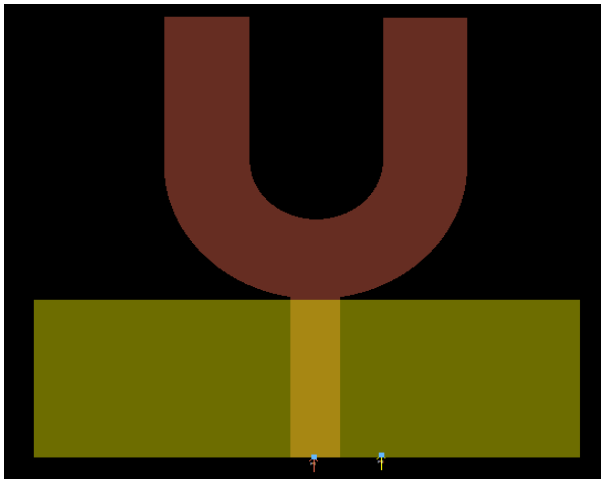

Fig. 1 (a)

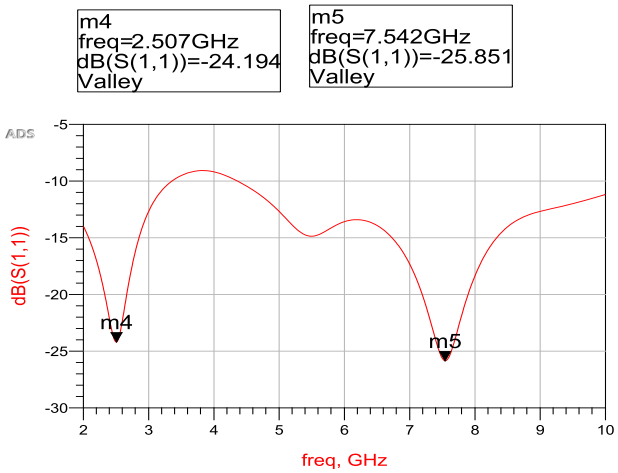

Fig. 1 (b)

Fig. 1 (a) U shaped patch antenna layout design and (b) Return loss graph for simple U shaped patch antenna

The Fig.no.1 (b) shows the return loss graph for the U shaped antenna, which provide dual band at 2.5 GHz and 7.54 GHz. Return losses are upto -24 dB and -25 dB for those two frequencies respectively.

B. U shaped patch with L slot design

Two L shaped slots are introduced in the patch antenna which tune the patch to operate with 4 different frequencies this exhibits the multiband characteristics of the patch antenna. Triple band occurs at 2 GHz, 4.2 GHz and 7.3 GHz. Return losses are -46 dB, -12 dB and -26 dB respectively. Fig.no.2 (a) shows the patch design and (b) shows the return loss graph of the patch antenna.

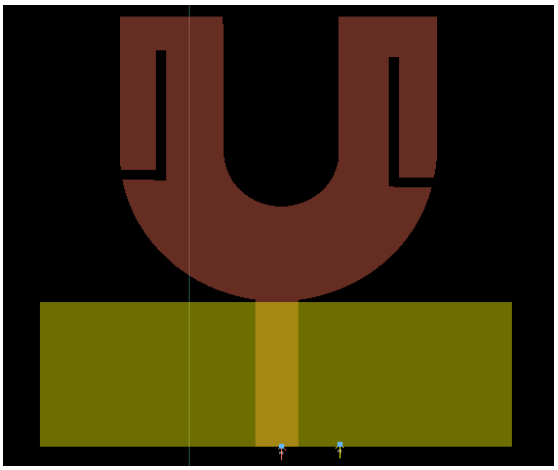

Fig. 2 (a)

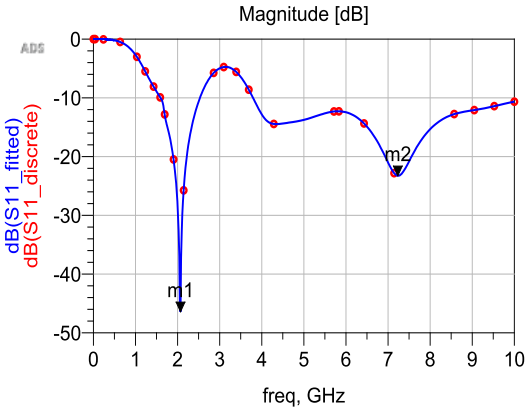

Fig. 2 (b)

Fig. 2 (a) L-shaped slots at the U-shaped patch and (b) Return loss graph for U-shaped patch with L slots

C. U shaped patch with L slot and stub at the center of the patch

A stub is introduced in the center of the patch with the length of 18 mm and width as 3 mm. stub is used to match the impedance so that it produces better return loss. This design operates with 4 bands of frequencies.

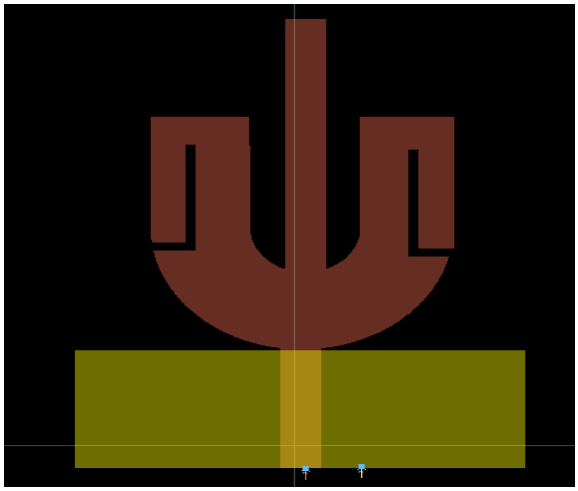

Fig. 3 (a)

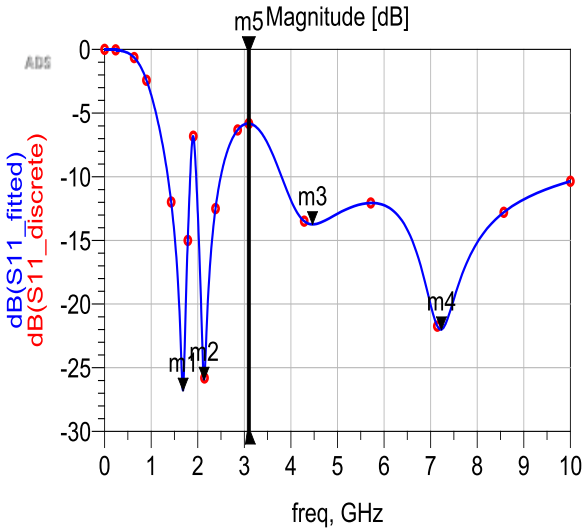

Fig. 3 (b)

Fig. 3 (a) Patch design with L slot and stub at the center and (b) Return loss graph

Fig.no.3 shows the patch design with their corresponding result. Multiband is occur at the frequencies 1.6 GHz, 2.1 GHz, 4.4 GHz and 7.3 GHz. Return losses are at -26 dB, -25 dB, -13 dB and -22 dB respectively. A notch characteristic is produced at the frequency of 3 GHz.

D. U shaped patch with L slot, stub and defective ground structure

In the patch antenna design, rectangular shaped slots are introduced in three location of the ground plane with the length as 5 mm and Width as 4 mm. This design further improves the return loss parameter. It operates with 4 bands of frequencies and produce notch characteristics also.

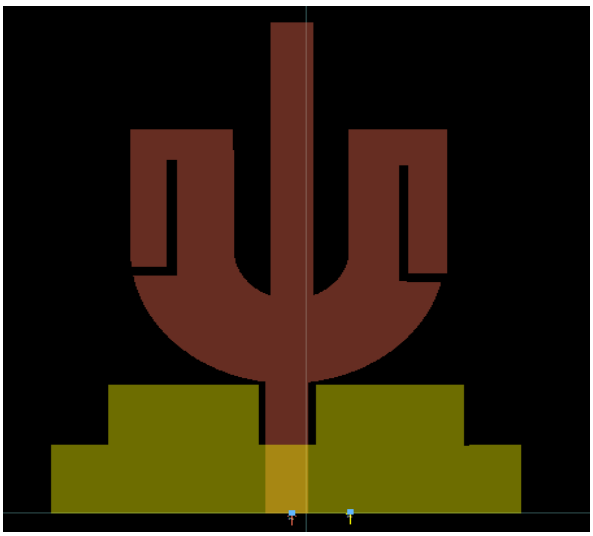

Fig. 4 (a)

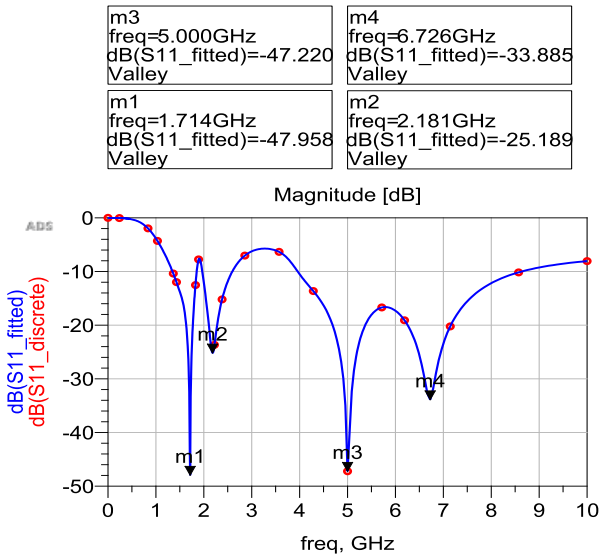

Fig. 4 (b)

Fig. 4 (a) Patch design with L slot and stub along with defective ground structure (b) Return loss graph for patch with defective ground plane

In this design the patch antenna is operated with 4 bands of frequencies which are useful for S and C band applications. Tuning frequencies are 1.7GHz, 2.18 GHz, 5 GHz and 6.726 GHz. Notch characteristics occur at 3 GHz. It produce better return loss and impedance are matched perfectly which in turn improve the overall performance of the antenna

Table. 1 Antenna parameters values for the frequencies from 1 to 10 GHz for the entire patch design

Freq	U shaped patch with slot and stub along with defective ground		
	Directivity	Gain	η
1.429 GHz	6.79	1.522	29.734
1.786 GHz	8.031	2.723	29.46
1.905 GHz	8.449	3.131	29.391
2.143 GHz	7.741	2.234	28.14
2.381 GHz	8.147	2.633	28.092
2.857 GHz	9.004	4.109	32.395
3.095 GHz	8.406	3.929	35.677
4.286 GHz	7.947	2.707	29.925
5.714 GHz	8.668	3.873	33.151
7.143 GHz	9.061	5.206	41.157
8.571 GHz	9.117	6.256	51.751
10.00 GHz	9.429	6.676	53.052

In table 1 antenna parameters such as directivity, gain and efficiency values are listed out for all the tuned frequencies of the final patch design.

IV. CONCLUSION

In this paper U shaped patch antenna is designed for S and C band applications such as satellite and radar communications. This patch antenna is operates at a frequency of 1 GHz to 10 GHz. Slight modifications are made on the patch and ground plane to improve the overall performance of the patch antenna. It is tuned to multi band of frequencies with notch characteristics. It produce gain upto 6 dB and return loss as -47dB at 1.7GHz, -25 dB at 2.18 GHz, -47 dB at 5 GHz and -33 dB at 6.726 GHz.

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