Nanoscale Reports

RESEARCH ARTICLE

Eleyon Publishers

DOI:10.26524.nr.4.3

4(1) (2021) 15-18

OPEN ACCESS

Modeling and Simulation of Dual layered U-slot multiband microstrip patch antenna for wireless applications

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Abstract

The Multi-band characteristics for wireless communications are achieved by U-slot patch in the microstrip patch antennas. Unlike previous work on the conventional U-slot micro strip patch antennas, the effect of the inverted dual U-slot inclusion on the performance of the patch antenna is studied across the entire achieved multiband characteristics. A low cost and compact triple band aperture coupled microstrip patch antenna for Wireless Local Area Network (WLAN) is presented. The proposed antenna has inverted U-slots and dual substrate with thickness of 3.2mm to achieve the triple band characteristics. The combination of inverted U-slots, dual substrate and modified ground plane results in the required operational frequency bands—namely, Wireless LAN. Design details of the proposed triple band antenna and parametric study is also presented. The dual- band antenna resonates at 3.6GHz and 5.2 GHz whereas triple- band antenna resonates at 3.6 GHz, 5.2 GHz and 5.8 GHz. For U-slot dual- band antenna, the directivity of 6.345 dBi and 5.725dBi is obtained at lower resonant frequency 3.6 GHz and upper resonant frequency 5.2 GHz respectively. U- slot triple-band antenna shows 6.103 dBi, 6.371 dBi and 5 dBi directivity at lower resonant frequency of 3.6 GHz, middle resonant frequency of 5.2 GHz and upper resonant frequency of 5.8 GHz respectively.

Keywords: Multiband, U-slot, aperture coupled, return loss, dielectric constant, electromagnetics, dual substrate.

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How to cite this article: Satheesh Kumar, Modeling and Simulation of Dual layered U-slot multiband microstrip patch antenna for wireless applications 4(1), 15-18 Retrieved from https://nanoscalereports.com/index.php/nr/article/view/66

Received: 3 March 2021 **Revised:** 5 April 2021 **Accepted:** 7 April 2021

I.INTRODUCTION

The basic geometry of U-slot antenna was introduced by Huynh and Lee in 1995. [1] In planar and ultra wide band antennas, it has been found that the presence of U-slot introduces a band notch and is utilized to minimize interference. [2-3] It is firmly established that the U-slot patch antenna can provide impedance bandwidths in excess of 30% for air substrate thickness of about 0.08 λo and inexcess of 20% for microwave substrates of similar thickness. [3-4] Initially microstrip patch antenna with U-slot was mainly used for bandwidth enhancement. However, subsequent researches revealed that wideband characteristic can be modified to multiband characteristic by intelligent placement of U-slot, thereby perturbing the surface current flow in the patch. [5,6,7] In this paper, we show that the U-slot technique can also be used to design patch antennas with dual- and triple- band characteristics. Our approach is to start with simple aperture coupled microstrip antenna. The aperture coupled microstrip antenna is of great interest since it allows for the separation of the radiating element (microstrip patch) and feed network50Ω microstrip(transmission line) with a conductive layer(ground) and this provides shielding to an antenna from spurious feed radiation. Energy is coupled to the patch through an aperture in ground plane. For better coupling from the feed line, the aperture is also of U-shape instead of common rectangular shape. By cutting a U-slot in the patch,notch is introduced within the matching band, resulting in dual band antenna. Similarly, by cutting two U- slots in the patch, notches are introduced within the matching band,resulting in triple band microstrip patch antenna.

II. ANTENNA CONFIGURATION

The basic aperture coupled microstrip antenna is shown in Fig.1. The patch is fed through an aperture coupled 50Ω microstrip line under the feed substrate. Stub length (Ls), the extension of feed line after the aperture is used to tune the excess reactance. The overall size of the antenna is L×W×Hand the overall thickness (H) of the antenna is 3.18 mm. The patch antenna intended to operate at centre resonant frequency having length (Lp) and width (Wp) is formed on the dielectric substrate above the ground plane. The FR-4 substrate with dielectric constant (εr) = 4.4 and thickness (h)is 1.57 mm is used for both patch and feed substrate. The coupling aperture is also of U- shape having length (L_a) and width (W_a).

2.1Dual Band U-slot Microstrip Antenna

For dual band aperture coupled microstrip antenna,single U- slot is cut in the patch. Basically a simple aperture coupled microstrip antenna with rectangular patch, without any slot in it, results in single band antenna. However, when a U-slot is cut in the rectangular patch, a notch is introduced within the matching band results in dual band operation.

2.2 Triple Band U-slot Microstrip Antenna

For triple- band aperture coupled microstrip antenna, another U slot is cut in the same patch is shown in Fig. 2 With these two U-slots, two notches are introduced within the matching band, results in triple- band antenna. The optimal dimensions of U-shaped aperture in ground are same as used in dual- band antenna. The other optimal dimensions for triple-band antenna are tabulated in Table 1.

2.3 SIMULATION RESULTS

Simulation of proposed antenna has been performed in High Frequency Simulation Software(HFSS), commercial electromagnetic simulation software. The two antennas, dual band and triple band resonate at two same frequencies i.e. 3.6 GHz and 5.2GHz and one different frequency of triple band antenna is 5.8 GHz. The return loss of proposed U- slot dual-band antenna is shown in Fig. 3(a). The lower band resonance is at 3.6GHz with return loss of -32.46 dB and upper band resonance occurs at 5.2GHz with return loss of -23.30 dB.U-slot triple band antenna resonates at 3.6 GHz, 5.2 GHz and 5.8 GHz with return loss of -17.7 dB, -26.85 dB and -23dB respectively as shown in Fig.3(b).The two antennas,dual band and triple band resonates at two same frequencies i.e. 3.6GHz and 5.2GHz and one different frequency of tripleband antenna is 5.8 GHz.The proposed dual band and triple band U- slot microstrip patch antenna shows considerably good gain and directivity values. Measured 10dB return loss band width without any stacking, gain and directivity at different resonant frequencies for U-slot dual and triple band antenna are tabulated in Table 2.The directivity plots for U-slot dualband antenna and triple band antenna at resonant frequency 3.6 GHz. Fig.4 shows the fabricate antenna.

2.4 CONCLUDING REMARKS

U-slot patch antenna is used for providing wide band characteristics but in this paper, we have shown that cutting of U-slots in the patch antenna, results in dual band and triple band antenna. The dual band antenna operates at 3.6 GHz and 5.2 GHz whereas triple band antenna operates at 3.6 GHz, 5.2 GHz and 5.8 GHz frequency and can be used for wireless and WLAN applications. Even though this paper presents simulation based results, the use of HFSS for simulation ensures that there would not be large discrepancies between the simulated and measured results incase the proposed antennas are fabricated and measured.The proposed U-slot dual band and triple band antenna provides dual band and triple band characteristics without any stacking and provides moderate values of 10 dB band width.These antennas can be further improved in terms of resonant frequencies and bandwidth by stacking of dielectric substrates and patches.

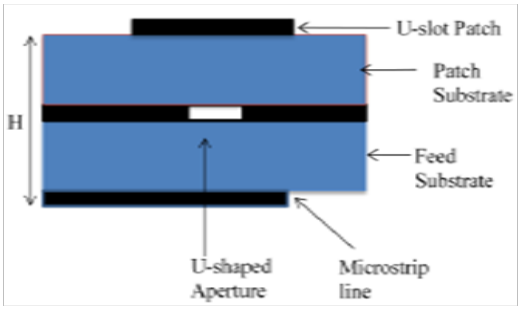


Fig. 1 Geometry of aperture coupled antenna

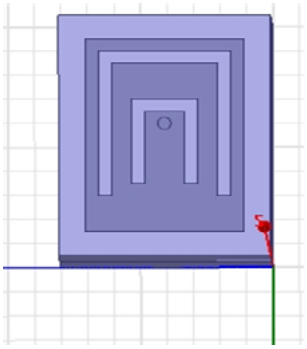


Fig. 2(a) Geometry of U-shaped Aperture antenna (Top View)

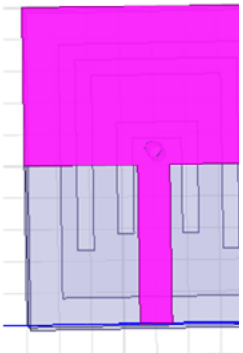
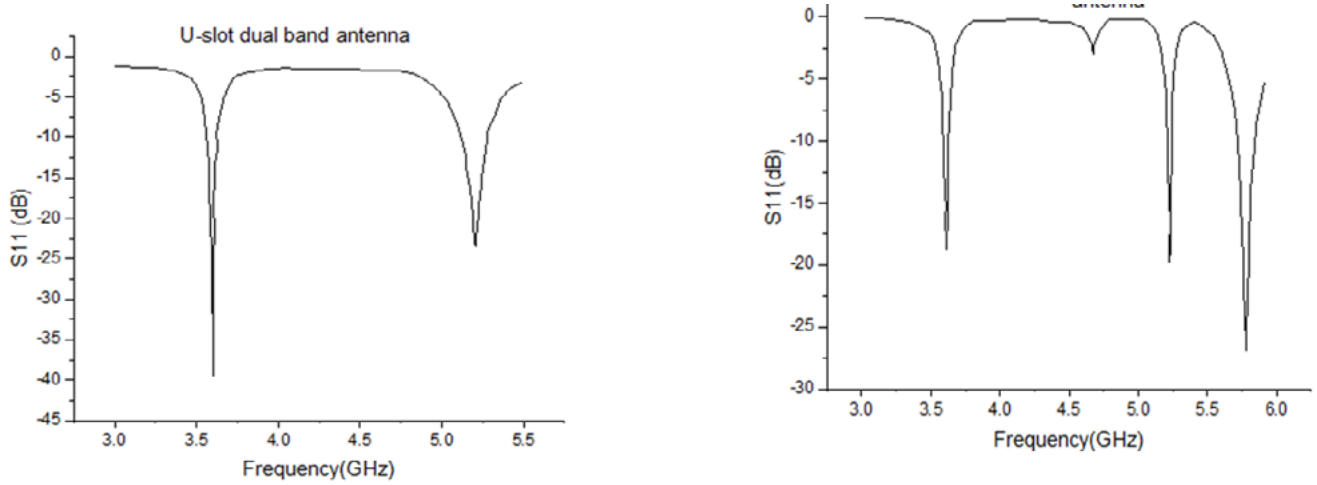


Fig. 2(a) Geometry of U-shaped Aperture antenna (Bottom View)

Fig. 2(a) Geometry of U-shaped Aperture antenna (Side View)

Table 1 Proposed parameters of U-slot Triple band antenna

Parameters	Unit(mm)	Parameters	Unit(mm)
L	32	Ts	3.6
W	40	La	3.04
Lp	20.98	Wa	7
Wp	27.8	Ba	0.5
Ls	11	Ha	2.6
Ws	10	Ta	12
Bs	1	Wf	3.2
Hs	10	Ls	6



(a) **(b)**

Fig.3Return loss (a) U-slot dual band antenna (b) U-slot triple bandantenna

Table 2(a) Gain and Directivity plot -Dual band antenna

Frequency(GHz)	Gain(dB)	Directivity(dBi)	10 dB Bandwidth(%)
3.6	6.068	6.345	16.28
5.2	5.234	5.725	28.09

Table 2(b) Gain and Directivity plot -Triple band antenna

Frequency(GHz)	Gain(dB)	Directivity(dBi)	10 dB Bandwidth (%)
3.6	5.838	6.103	10.8
5.2	6.115	6.371	6.00
5.8	3.775	5	22.24

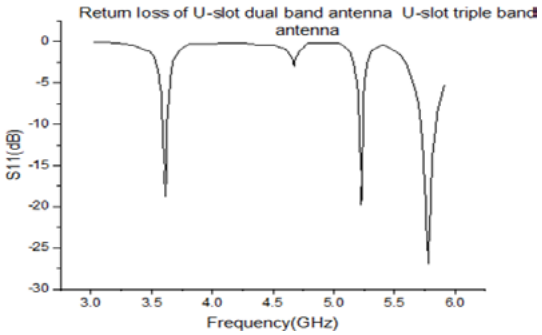


Fig. 3 b)

Fig.4 (a) Fabricated Structure of the antenna(Top View)

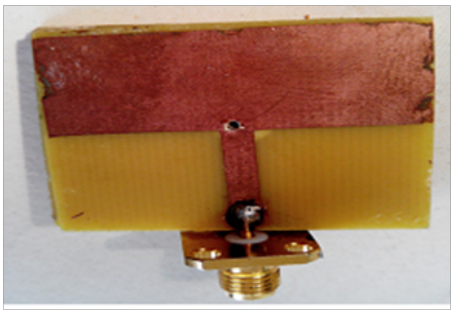


Fig.4 (b) Fabricated Structure of the antenna(BottomView)

Acknowledgemet

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Funding

No funding was received to carry out this study.

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