ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 5, May 2013

Dual- and Triple- Band U-slot Microstrip Patch Antenna for WLAN Applications

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Abstract: In this paper, Microstrip patch antenna fed through an aperture coupled 50Ω microstrip line is designed for dual-band and triple- band applications by cutting U-slots in the patch. When a U-slot is cut in the patch, a notch is introduced within the matching band, results in dual- band antenna. If another U-slot is cut in the same patch, antenna becomes a triple- band antenna. For better coupling aperture in ground is of U-shape. The patch antenna has been designed and simulated in CST Microwave Studio. 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 5.725 dBi 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 3.6 GHz, middle resonant frequency 5.2 GHz and upper resonant frequency 5.8 GHz respectively. The proposed antenna is used for WLAN applications.

Keywords: Aperture coupling, CST microwave studio, Dual- band, Triple- band, Microstrip line, Patch antenna, U-slot.

I. INTRODUCTION

The basic geometry of U-slot antenna was introduced by Huynh and Lee in 1995[1]. In planar and ultra wideband 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 0.08λo and in excess 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], and [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 network (50Ω 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×H and 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 (La) and width (Wa) is shown in Fig. 2.

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A. Dual Band U-slot Microstrip Antenna

For dual band aperture coupled microstrip antenna, single U- slot is cut in the patch is shown in Fig. 3. 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. The optimal parameters for dual band antenna are tabulated in Table 1.

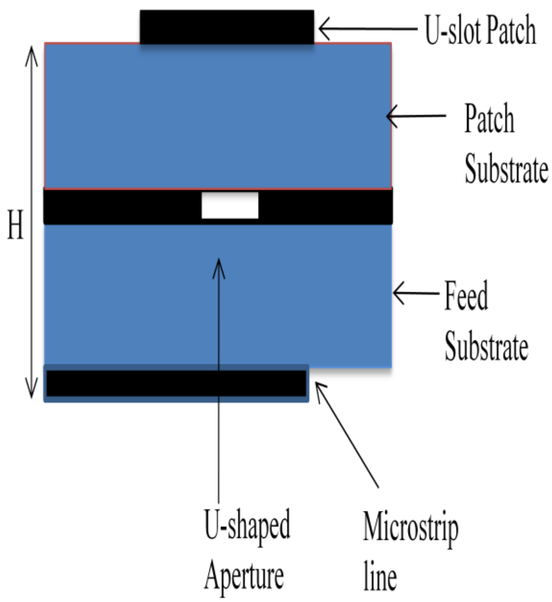

Fig. 1 Geometry of aperture coupled antenna

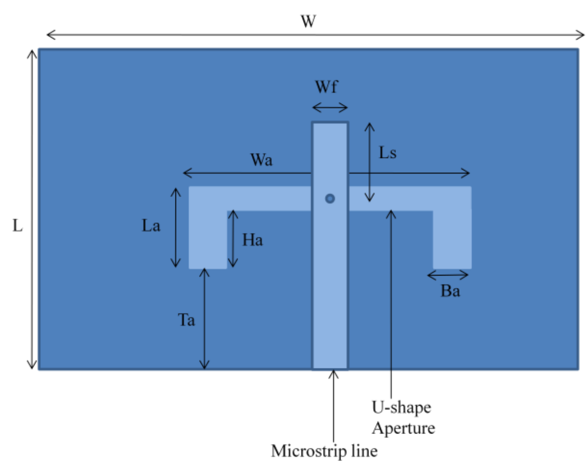

Fig. 2 Geometry of U-shaped Aperture

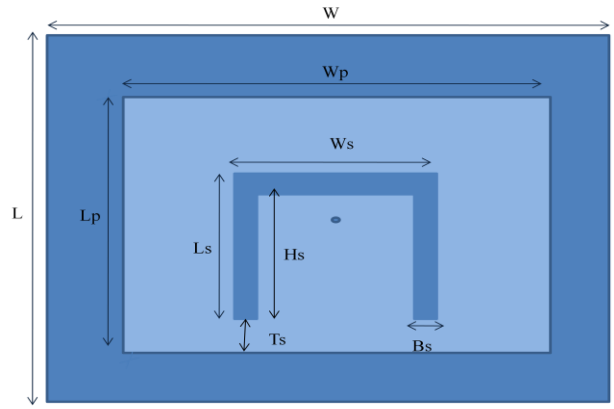

Fig. 3 Geometry of dual-band U-slot antenna

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

Table 1 Proposed parameters of U-slot dual band antenna

B. 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. 4 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 2.

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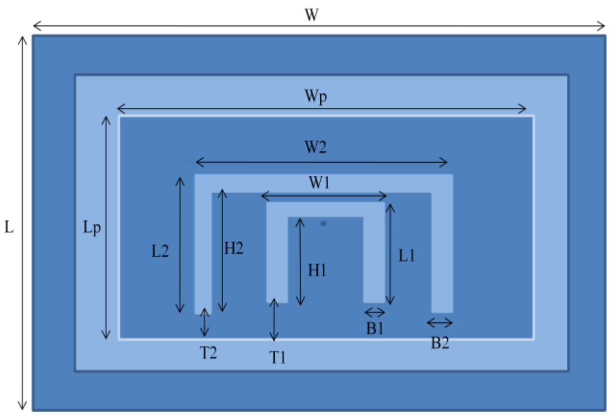


Fig. 4 Geometry of U-slot triple-band antenna

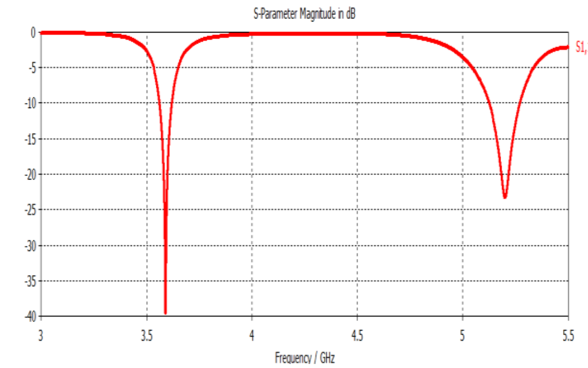
Parameters	Unit(mm)
L	30
W	36
Lp	22.62
Wp	28
L1	7
W1	6
B1	1
H1	6
T1	4.31
L2	11.8
W2	16
B2	2
H2	9.8
T2	4.51

Table 2 Proposed parameters of U-slot triple band antenna

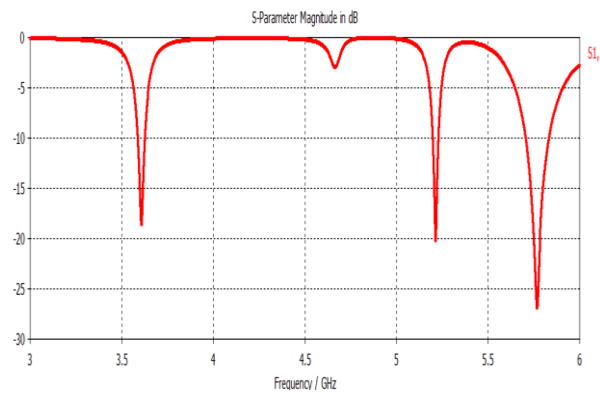
III. SIMULATION RESULTS

Simulation of proposed antenna has been performed in CST Microwave Studio, commercial electromagnetic simulation software. The two antennas, dual band and triple band resonate at two same frequencies i.e. 3.6 GHz and 5.2 GHz 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. 5(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 -23 dB respectively as shown in Fig. 5(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 triple band 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 bandwidth without any stacking, gain and directivity at different resonant frequencies for U-slot dual and triple band antenna are tabulated in Table 3.The directivity plots for U-slot dual band antenna and triple band antenna at resonant frequency 3.6 GHz are shown in Fig. 6.



(a)



(b)

Fig. 5 Return loss (a) U-slot dual band antenna (b) U-slot triple band antenna

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

(a)

Frequency (GHz)	Gain (dB)	Directivity (dBi)	10 dB Bandwidth (%)
3.6	5.838	6.103	10.80
5.2	6.115	6.371	6.00
5.8	3.755	5	22.24

(b)

Table 3 Gain and Directivity plot (a) Dual band (b) Triple band antenna

For dual band antenna, VSWR at 3.6 GHz is 1.23 and at 5.8 GHz is 1.14. Triple band antenna shows 1.33, 1.84 and 1.41 VSWR at 3.6 GHz, 5.2 GHz and 5.8 GHz respectively. The surface current at resonant frequency 3.6 GHz of dual band and triple band antenna are shown in Fig. 7.

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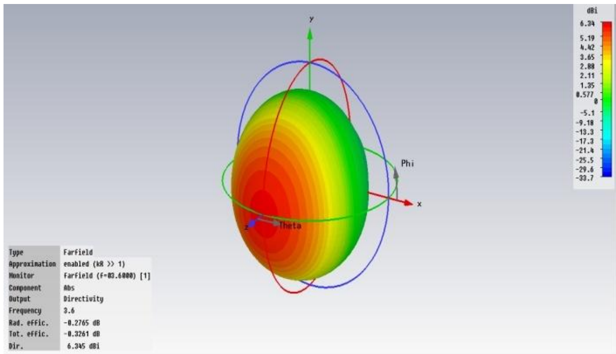
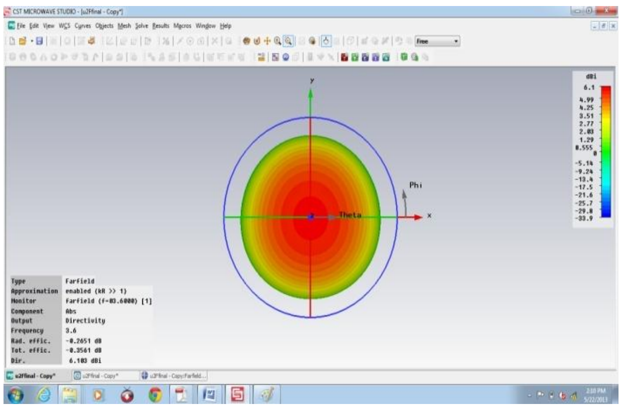
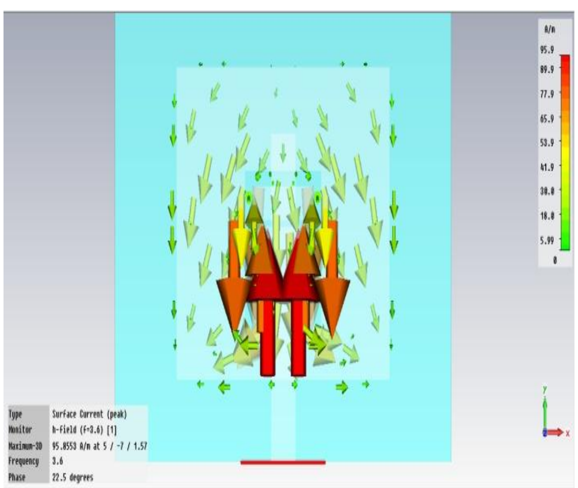


(a)

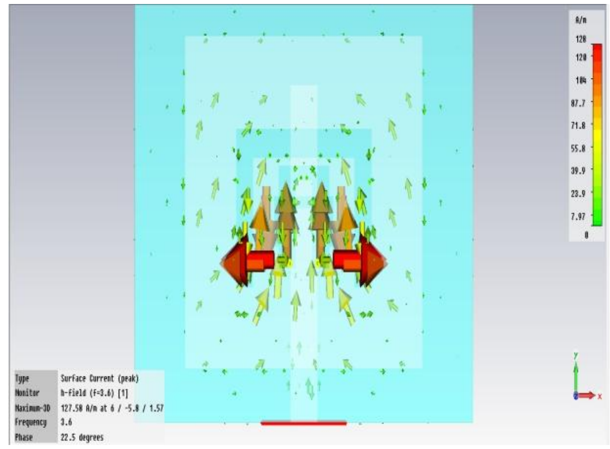


(b)

Fig 6 Directivity plot at 3.6 GHz (a) For U-slot dual- band antenna (b) For U-slot triple- band antenna



(a)



(b)

Fig 7 Surface current distribution at 3.6 GHz (a) For U-slot dual- band antenna (b) For U-slot triple- band antenna

IV. CONCLUDING REMARKS

Mainly U-slot patch antenna is used for providing wideband 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 where as 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 CST Microwave Studio software for simulation ensures that there would not be large discrepancies between the simulated and measured results in case 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 bandwidth. These antennas can be further improved in terms of resonant frequencies and bandwidth by stacking of dielectric substrates and patches.

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