

Design of U Shaped Triple Band Microstrip Patch Antenna for Wireless Application

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Abstract

This paper presents an effective design of multi band microstrip patch antenna. In this paper, the patch antenna can be designed for triple band application by creating U shapes on the patch and this technique is applied to the single fed patch. The triple band antenna is designed for the frequency range from 3.8 GHz to 4 GHz, 5.75 GHz to 5.85 GHz and 7.45 GHz to 7.6 GHz. This design has producing good response of return loss and impedance bandwidth. These parameters were studied with the aid of FDTD numerical analysis. This could be used for WLAN applications and Metrological satellite service.

1. Introduction

Microstrip patch antennas were first proposed in the early 1970s and since then a plethora of activity in this area of antenna engineering has occurred, probably more than in any other field of antenna research and development. Microstrip patch antennas have several well-known advantages over other antenna structures. It has light weight, low cost of production, low profile, conformal nature, robust nature, and compatibility with optoelectronic integrated circuits (OEICs) and microwave monolithic integrated circuits (MMICs) technologies. Because of these advantages, forms of the microstrip patch antenna have been utilized in many applications such as in space borne satellite communication systems, mobile communication base stations, and even mobile communication handset terminals.

The U-slot antenna was first introduced in 1995 by Huynh and Lee. Since, this design has been extensively studied for different applications. The U-slot technique is used to introduce new bands and improve the bandwidth. The presence of U-slot is utilized to minimize the interference. The U-slot patch antenna can provide impedance bandwidths in excess of 20% for microwave substrates thickness of about $0.08\lambda_0$ and in excess of 30% for air substrate of similar thickness.

The multiband antenna characteristic is certainly more efficient than having many antennas for each frequency band. Recently, multiband patch antennas are investigated because of coverage of many wireless communication services such as GSM, DCS, CDMA, WIMAX, WLAN and satellite application. Recently many wireless/mobile communication systems use several frequency bands such as GSM (Global System for Mobile communication), GPS (Global Positioning System), UMTS (Universal Mobile Telecommunication Systems), WiMAX (Worldwide interoperability for Microwave Access), Wi-Fi (Wireless Fidelity), WLAN (Wireless Local Area Networks) and

Radio altimeters

In this paper, we show that the single fed U-shaped slot technique can also be used to design a patch antenna with triple band characteristics. Our approach is to design a microstrip patch antenna by creating U-shaped slot on the patch resulting in triple band antenna and return loss can be improved by creating U shape on the ground plane with respective dimensions. This design has the advantages of simple structure, simplicity of the feed as well as having only one layer and only one patch.

2. Antenna Configuration

The geometry of the single fed microstrip patch antenna is shown in Fig.1. The overall thickness (H) of the antenna is 1.67 mm, ground plane size is $40\text{mm} \times 40\text{mm}$. The patch is intended to operate at centre resonant frequency having width and length is formed on the dielectric substrate above the ground plane. Thickness of the ground plane and patch metal is 0.035mm. Copper is used as a material in ground plane and patch. FR4 lossy is used as a substrate, and its thickness is 1.6mm. This U-shaped microstrip patch antenna is fed by a microstrip line feeding and its characteristic impedance is 50Ω , dielectric permittivity of the substrate is $\epsilon_r=4.5$.

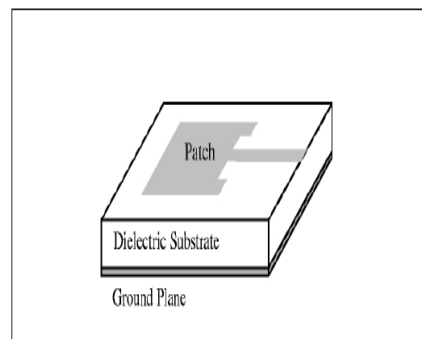


Fig: 1.Geometry of the Single fed Microstrip Patch Antenna

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A. U Shaped Triple Band Microstrip Patch Antenna

The geometry of U shaped triple band microstrip patch antenna is shown in fig.2. In this figure the top view of the antenna is shown. Because the substrate and ground plane are in same dimension (40mm × 40mm) . This antenna structure is simple and simple feeding methodology can be used. Basically a simple U shape microstrip antenna used for wide band application. However, when an additional slots created in the patch results in triple band operation. The optimal parameters for triple band antenna are tabulated in Table 1.

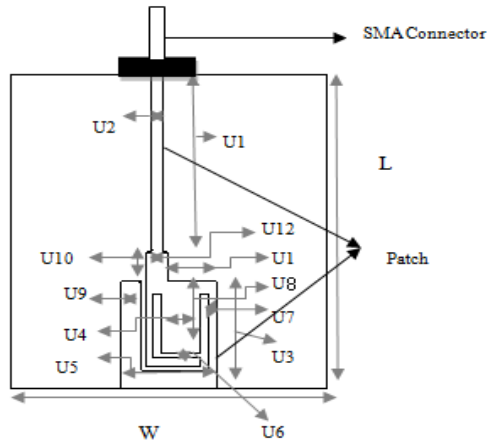


Fig. 2. Geometry of U shaped Triple Band Microstrip Patch Antenna (Top view)

B. Proposed Parameters of U Shaped Triple Band Microstrip Patch Antenna

Parameters	Unit(mm)
W	40
L	40
H	1.67
U1	22.7
U2	1.4
U3	13.6
U4	4.9
U5	12
U6	1
U7	1
U8	9.175
U9	2.5
U10	3.7
U11	6
U12	3

3. Simulation Results

Simulation of the proposed U shaped Triple band microstrip patch antenna has been performed in FDTD simulator tool, commercial electromagnetic simulation software. The proposed design having three resonant frequencies at 3.8 GHz to 4 GHz, 5.75 GHz to 5.85 GHz and 7.45 GHz to 7.6 GHz corresponding Return loss value is -27dB, -9dB, -14dB. The return loss of proposed U shaped tripled antenna is shown in Fig.3. Typically an antenna is tuned for a specific frequency, and is effective for

a specific range of frequencies that are usually centered on that resonant frequency. For Efficient transfer of energy, the impedance of the Antenna and feeding must be the same. For good impedance matching resonant frequency must lie below -10 dB and Efficiency will be high in that frequency. These three resonant frequencies widely used for WLAN and Metrological Satellite applications.

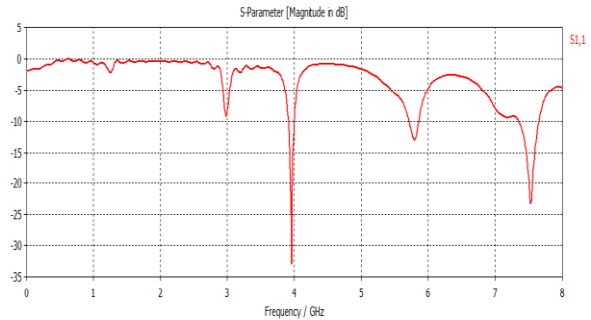


Fig. 3. Return loss of the U Shaped Triple band Microstrip Patch Antenna

A. Return Loss

Return loss is another way of expressing mismatch and Antenna efficiency. The characteristics of antenna depend on return loss (S11 in dB). It is a logarithmic ratio measured in dB that compares the power reflected by the antenna to the power that is fed into the antenna from the feeding. The proposed U shaped triple band microstrip patch antenna shows considerably minimum return loss. These return loss values are shown in Table 2.

$$\text{Return Loss} = -10\log|S_{11}|^2$$

or

$$\text{Return Loss} = -20\log |S_{11}|$$

Table: 2. Return Loss of Triple Band U Shaped Microstrip Patch Antenna

Resonant Frequencies	Return Loss (S11 in dB)
3.8 GHz to 4 GHz	-27
5.75 GHz to 5.85 GHz	-9
7.45 GHz to 7.6 GHz	-14

B. Impedance Bandwidth

Return loss can be maintained in a given range of frequencies. These range of frequencies measured as impedance bandwidth. Bandwidth is refers to the certain range of frequencies, the difference between highest frequency signal and lowest frequency signal of an electromagnetic radiation on the given medium. The proposed U shaped triple band microstrip patch antenna can provide increased impedance bandwidth. These impedance bandwidth values are shown in Table 3.

$$\text{Impedance Bandwidth} = ((F_H - F_L) / F_c) \times 100\%$$

F_H = higher frequency,
 F_L = lower frequency,
 F_C = Centre frequency.

Table: 3. Impedance Bandwidth of Triple Band U Shaped Microstrip Patch Antenna

Resonant Frequencies	Impedance Bandwidth (GHz)
3.8 GHz to 4 GHz	5.128
5.75 GHz to 5.85 GHz	1.724
7.45 GHz to 7.6 GHz	1.993

4. Conclusion

In this paper, we have designed a U shaped triple band microstrip patch antenna. It supports many wireless and mobile applications. This antenna results in a structure which is simpler and easier to fabricate and it supports triple band frequencies are 3.8 GHz to 4 GHz, 5.75 GHz to 5.85 GHz and 7.45 GHz to 7.6 GHz for multiple wireless applications such as WLAN and Metrological satellite

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service. The resulting antenna does not involve a complicated feed and does not require, more than one layer and more than one patch. This U shape antenna provides triple band characteristics without any stacking and provides moderate values of 10 dB bandwidth. This antenna can be further improved in terms of resonant frequencies and bandwidth by creating additional U shapes on the patch.