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Multi Band U-Slot Microstrip Patch Antenna for WLAN and Wi-MAX Applications

Shalina Garg, Ratish Kumar

Abstract-A dual U-slot Microstrip patch antenna for WLAN & WI-MAX applications is presented. The proposed antenna is designed using FR4 substrate having dielectric constant 4.4 and fed through 50 ohm Microstrip line. The patch antenna is designed and simulated in CST microwave studio. The proposed antenna generates the three frequency bands 2.431GHz, 5.16GHz 5.518GHz for WLAN and Wi-MAX .The measured results demonstrate that the proposed antenna has appreciable bandwidth, return loss, VSWR and radiation pattern is thus suitable for WLAN and Wi-MAX applications. The return loss of antenna are -12.831dB, -24.65dB,-35.74dB and bandwidth 2.18%, 1.9%, 4.7%. Which suggest good antenna performance.

Index Terms— Microstrip Antenna, W-LAN, WI-MAX, Dual U-slot, CST Microwave studio.

I. INTRODUCTION

The technologies of wireless communication system have been rapidly ever growing demands for broad band service and transmission speeds to support multimedia, image, speech and data communication. In order to response the rapidly growing demands, an antenna should be responsible in many frequency bands with simple structure, compact size and easy integration [1]. Microstrip patch antenna due to its advantages such as low weight, low profile planner configuration, and small size, low fabrication cost etc. is very well suited for wireless applications WLAN and Wi-MAX [2]. Microstrip patch antenna have some disadvantages like surface wave excitation, narrow bandwidth etc. The bandwidth of Microstrip patch antenna can be improved by various methods like by cutting U-slot [3] and increasing substrate height, low dielectric constant of substrate, various impedance matching, feeding techniques, multiple resonators and multilayer structure etc. [4]. The basic geometry of U-slot antenna was introduced by Huynh and Lee in 1995. It is found that in planar and ultra wideband antennas the presence of U-slot introduces a band notch and is utilized to minimize interference [5]. The IEEE standards IEEE 802.16 i.e. Wi-MAX i(Worldwide Interoperability for Microwave Access) and IEEE 802.11 i.e. WLAN (Wireless local area network) have been widely applied in mobile devices such as hand held computers and smart phones the allow data transmission using multiple broadband frequency range. There are following bands of operation for Wi-MAX – 2.5-2.69 GHz, 3.3-3.8 GHz and 5.25-5.85 GHz for WLAN 2.4-2.483 GHz, 5.15-5.35 GHz, and 5.725-5.85 GHz [6].

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A comparative study of multiband planar antenna with different shapes is reported and U-slot has best results [7]. A dual wide band square slot antenna with a U-shaped printed tuning stub for personal wireless communication system was proposed [8]. Recently have been proposed to achieve multiband for wireless applications [9] - [13].

In this paper, U-slot micro strip patch antenna is proposed with dielectric substrate FR4 for WLAN and Wi-MAX applications. The total size of ground plane is 40mm×47mm and size of radiated patch is 40mm×47mm, fed by 50 Ohm Microstrip line. There are many methods for the design of antenna [14]. From them we use transmission line analysis method.

A. Resonant Frequency

$$f_0 = \frac{c}{2W\sqrt{\varepsilon_r + 1}} \qquad (1)$$

Where

Fo =Resonance Frequency
C=speed of light
W=Width of Patch
ε_r=Relative dielectric constant

B. Length [L]

$$L_{eff} = \frac{C}{2f_0\sqrt{\varepsilon_{reff}}} \qquad (2)$$

ε_{reff}= Effective dielectric constant

C. Effective dielectric constant

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \qquad (3)$$

H=height of substrate
W=width of patch

D. Width [W]

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \qquad (4)$$

Recently, many communication standard like WiMAX/WLAN etc. are developed for high frequency and high speed communication. This rapid increase in the communication standard has lead to a great demand for multiband and broadband antennas with low real estate area, low fabrication cost etc. for the past decades, the Microstrip, slot patch antennas have been used to implement multiband.

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II. ANTENNA CONFIGURATION

Fig.1 illustrates the geometry of the proposed patch antenna. Substrate selection is the first practical step in designing a patch antenna. Flame retardant (FR-4) which has relative permittivity of 4.9 and a loss tangent of 0.025 is used as substrate for MPA. The patch fabricated on the substrate suspends above a ground plane shown in figure 1. These values are carefully chosen to meet our performance and bandwidth requirement because dielectric material is crucial for determining the performance of antenna. The antenna is fed by 50 ohm Microstrip feed line. The overall size of the antenna is L×W×H where L is the total length of antenna, W is the width of antenna and H is the thickness. The proposed antenna consist of a patch having dimensions 40mm × 47mm with two U-slots.

In the MPA to U slot are introduced to achieve triple band. The rectangular patch generate the lower frequency band of 2.4 GHz and the two U slots generate the middle and upper frequency band. To obtain the 50ohm characteristic impedance, the optimized dimension of the transmission line is 20mm × 2mm.. The optimized design parameters of the proposed patch antenna as follows:

Table 1. Parameters of proposed antenna

Parameters	Units (mm)
A	47
A1	30
A2	15
A3	20
B	60
B1	25
B2	15
B3	2
C1	5
C2	3

In the proposed antenna two U slots are combined together in a single antenna patch to study overall antenna behavior. The two U slots are connected using a bridging element of dimensions C1 and C2.the main function of bridge is to shift the higher frequency band to a lower value.

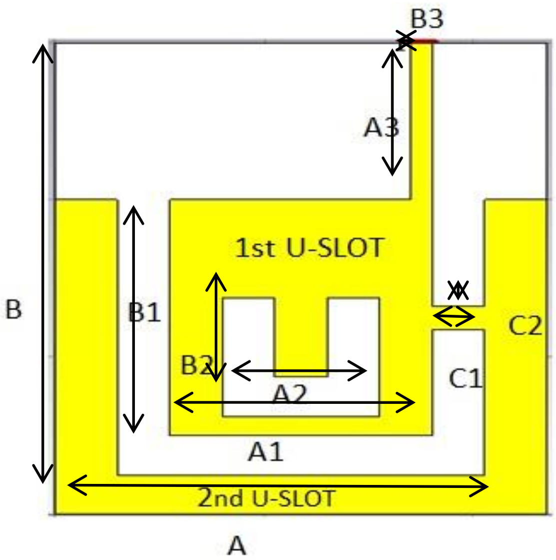

Fig. 1 Structure of Proposed Antenna

III. SIMULATION RESULTS

The model of the Microstrip array antenna is established and optimized. Simulation results of return loss, VSWR, gain, radiation pattern, power pattern, fractional bandwidth are presented as follow:-

A. Reflection coefficient or return losses [S_{11}]

The return loss is a way of expressing mismatch. 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 transmission line. It should be less than -10dB for the acceptable operation. Figure shows the simulated return loses for WLAN and Wi-MAX band 2.431GHz, 5.16GHz 5.518GHz are -12.831dB, -24.65dB, -35.74dB.

$$\text{Return loss [dB]} = 20log_{10}\frac{SWR}{SWR-1} \qquad (5)$$

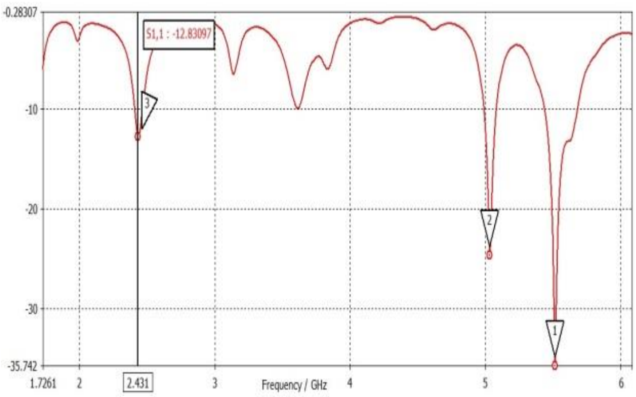

Fig. 2 Reflection Coefficient S_{11} [dB]

B. Voltage standing wave ratio (VSWR)

VSWR is an indication of the quality of the impedance match. A VSWR value under 2 is considered suitable for most antenna applications. Figure shows the VSWR and Wi MAX operating bands.

$$\text{VSWR} = \frac{V_{max}}{V_{min}} \qquad (6)$$

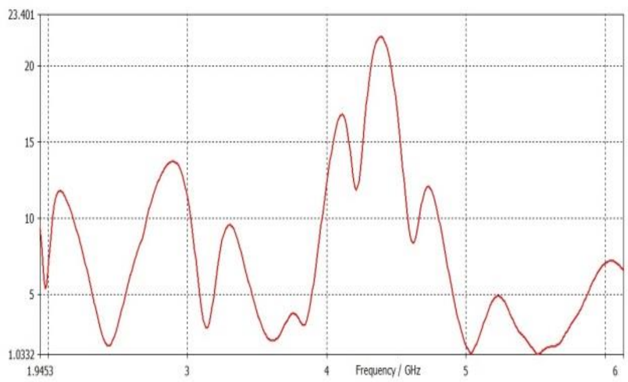

Fig. 3 VSWR

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C. Radiation Pattern

Radiation or antenna pattern describes the relative strength of the radiated field in various directions from the antenna at a constant distance. The antenna should not have the side lobes and back lobes ideally. The radiation pattern is three-dimensional, but usually the measured radiation patterns are a two dimensional slice of the three-dimensional pattern, in the horizontal or vertical planes.

D. H-Plane radiation pattern's

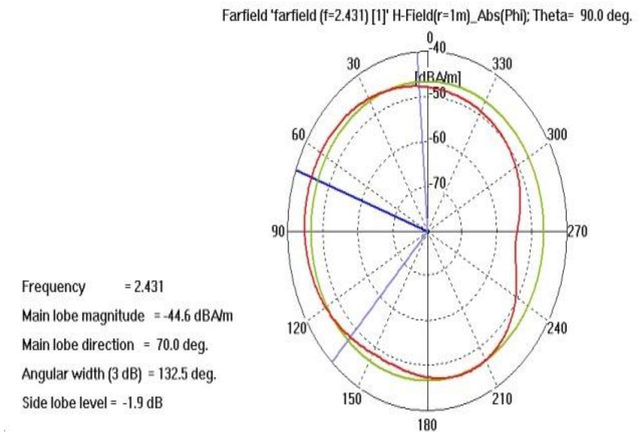

Fig. 4.1 Radiation pattern for frequency 2.431GHz

Figure 4.1 H-plane (theta=90º, phi=varying) radiation patterns for proposed antenna configuration at the resonating frequency of 2.431 GHz.

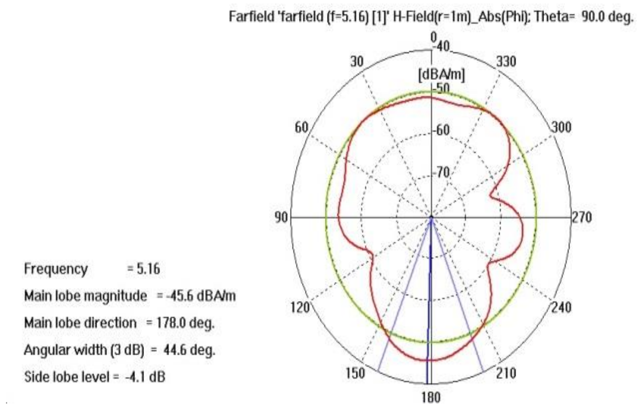

Fig. 4.2 Radiation pattern for frequency 5.16GHz.

Figure 4.2 H-plane (theta=90º, phi=varying) radiation patterns for proposed antenna configuration at the resonating frequency of 5.16 GHz.

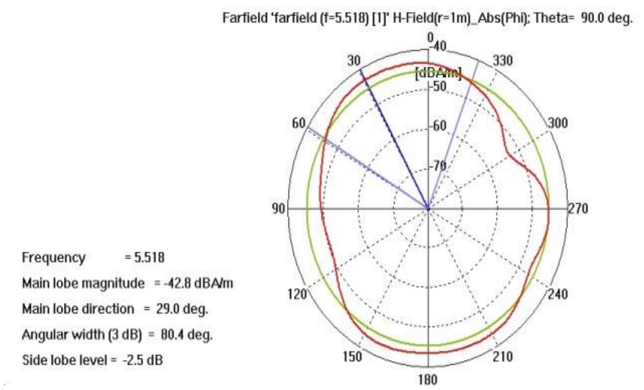

Fig. 4.3 Radiation pattern for frequency 5.518GHz.

Figure 4.3 H-plane (theta=90º, phi=varying) radiation patterns for proposed antenna configuration at the resonating frequency of 5.518 GHz.

E. E-Plane radiation pattern's

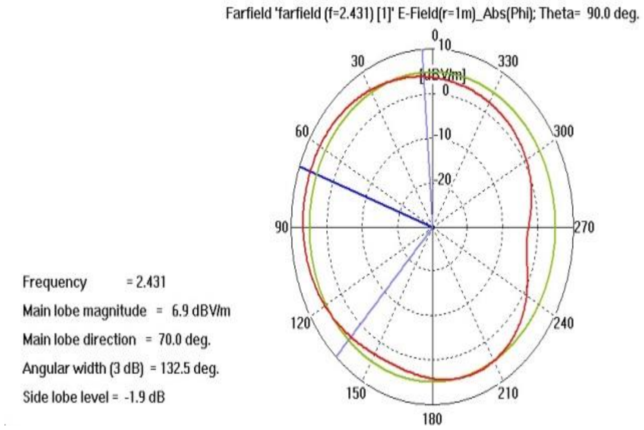

Fig. 5.1 Radiation pattern for frequency 2.431 GHz.

Figure 5.1 E-plane (phi=90º, theta=varying) radiation patterns for proposed antenna configuration at the resonating frequency of 2.431 GHz.

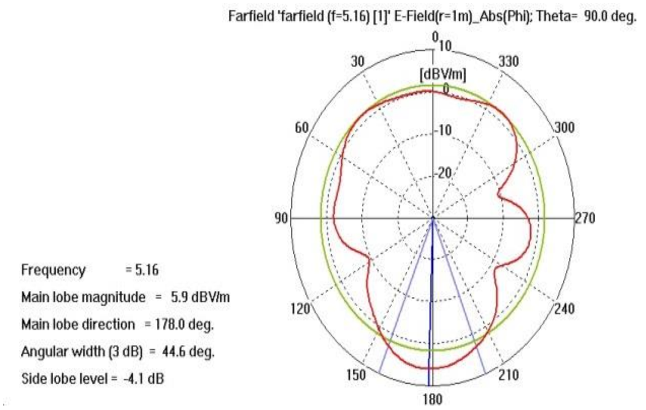

Fig. 5.2 Radiation pattern for frequency 5.16GHz.

Figure 5.2 E-plane (phi=90º, theta=varying) radiation patterns for proposed antenna configuration at the resonating frequency of 5.16 GHz.

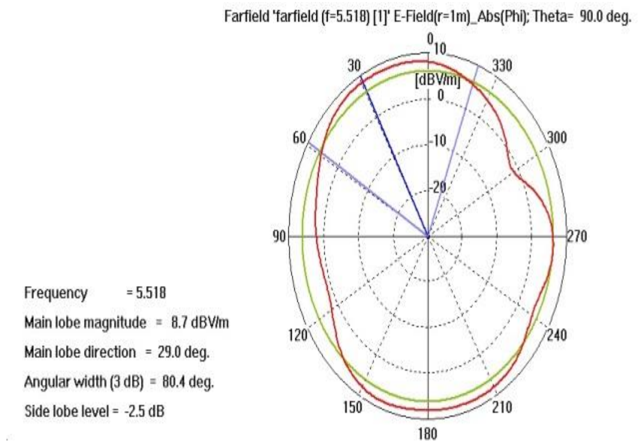

Fig. 9 E-plane radiation pattern for frequency 5.518GHz.

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Figure 5.3 E-plane (phi=90º, theta=varying) radiation patterns for proposed antenna configuration at the resonating frequency of 5.518.' GHz.

F. Bandwidth

Bandwidth of antenna is a measure of how wideband the antenna is. It is often defined as the range of frequencies over which the power gain is maintained to within 3dB of its maximum value. The bandwidth can also be described in terms of percentage of the center frequency of the band.

$$BW = 100 \times \frac{F_H - F_L}{F_C} \qquad (7)$$

Where FH is the highest frequency in the band, FL is the lowest frequency in the band, and FC is the center frequency in the band. The measured bandwidth for three frequency bands 2.431GHz, 5.16GHz 5.518GHz is 2.18%, 1.9%, 4.7%.

G. Directivity

Directivity is the ability of an antenna to focus in a particular direction when transmitting or receiving energy is better from a particular direction when receiving.

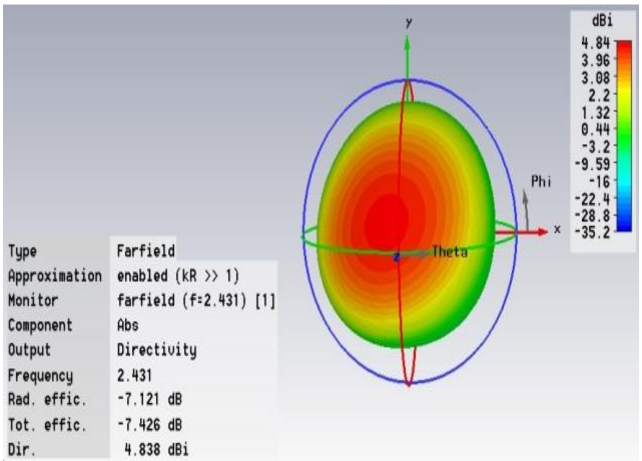

Fig. 6.1 Directivity at 2.431GHz.

Figure 6.1 shows the simulated 3D radiation pattern with directivity of 4.838 dBi for proposed antenna configuration at resonating frequency 2.431 GHz.

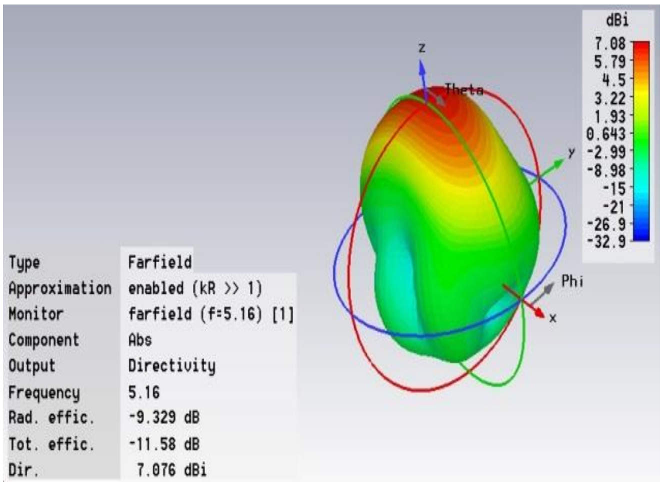

Fig. 6.2 Directivity at 2.16GHz.

Figure 6.2 shows the simulated 3D radiation pattern with directivity of 7.076 dBi for proposed antenna configuration at resonating frequency 5.16 GHz.

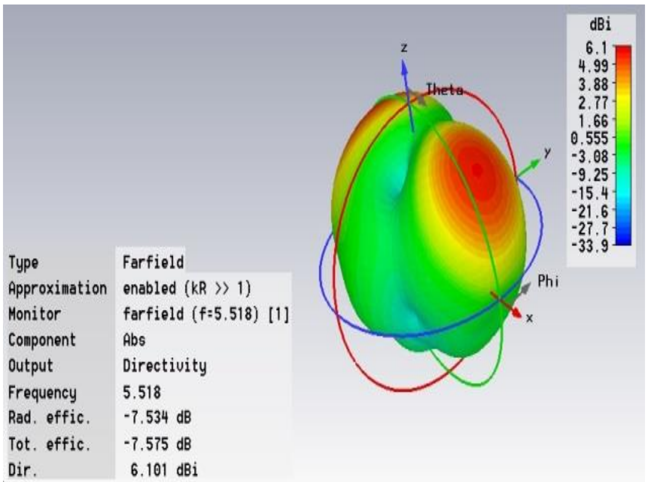

Fig. 6.3 Directivity at 5.518GHz.

Figure 6.3 shows the simulated 3D radiation pattern with directivity of 6.101 dBi for proposed antenna configuration at resonating frequency 5.518 GHz.

H. GAIN

Gain of antenna is the ratio of maximum radiation intensity in a particular direction from the test antenna to the maximum radiation intensity from reference antenna, when same input power is applied to both antennas. Gain is the practical value of directivity. The relationship between gain and directivity include a new parameter (ɳ) which describes the efficiency of antenna.

$$G = \eta . D \qquad (8)$$

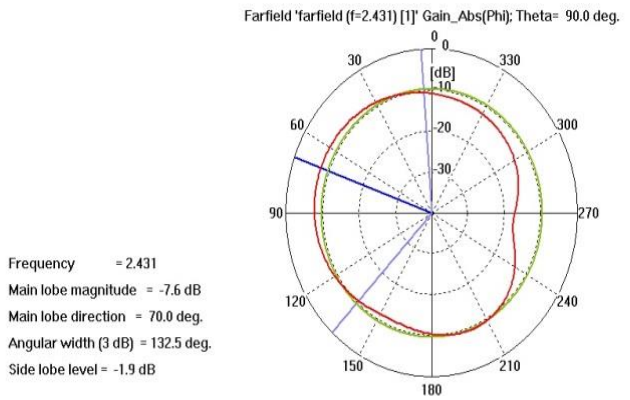

Fig. 7.1 Gain at 2.431GHz.

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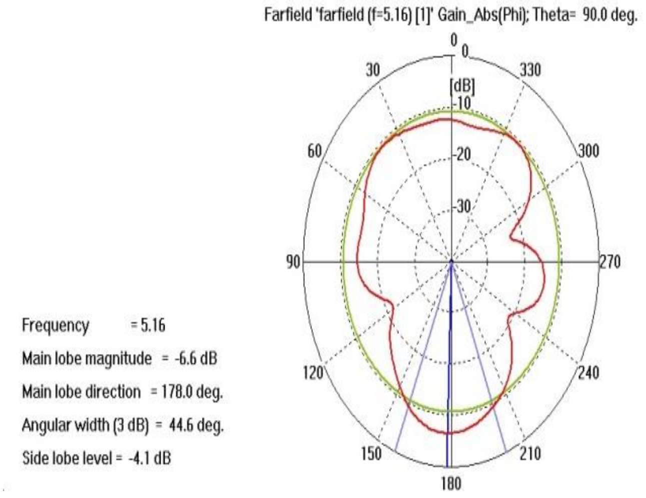

Fig. 7.2 Gain at 5.16 GHz.

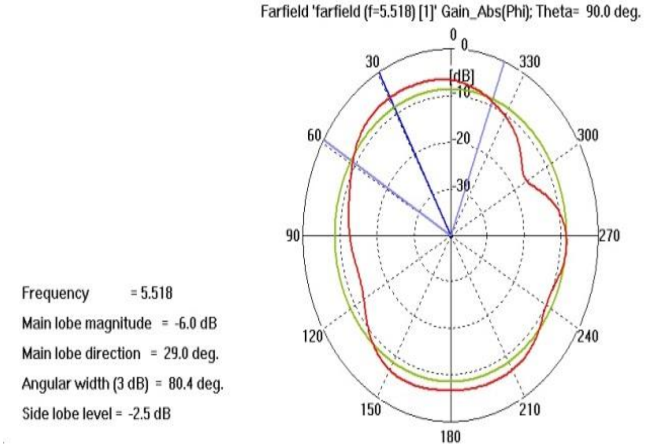

Fig. 7.3 Gain at 5.518 GHz.

IV. CONCLUSION

In this paper, a micro-strip patch antenna with dual U-slot for WLAN and Wi MAX APLLICATIONS is proposed. The results show that the designed antenna covers three bands for W-LAN and Wi-MAX are 2.431GHz, 5.16GHz, and 5.518GHz. The return loss of antenna are less than -10dB and VSWR is below 1.5.Good performance make the proposed antenna suitable for wireless applications.

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