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A Novel Design of Multiband Plus Shape Slotted Microstrip Patch Antenna for Wireless Applications

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ABSTRACT

This paper proposes a multi band plus shaped slotted microstrip patch antenna for wireless applications, using 0.287mm thickness duroid substrate and a metallic ground plane. The proposed antenna generates five bands of frequencies those are 1.57GHZ (GPS), 1.95GHZ (UMTS), 3.11GHZ (WIMAX), 3.17GHZ (Radio location) and 4.05GHZ(WLAN). The proposed antenna has VSWR<1.3 at all the frequencies. The Scattering and far-field parameters of the designed antenna are analysed using Ansys HFSS software version 15.0.Theperformance characteristics of the proposed antenna is analysed on the basis of VSWR, Efficiency, Gain, Radiation pattern and Return loss.

Keywords: *U-shaped antenna; U-shaped array; U-shaped 5G antenna.*

1.0 Introduction

With the enormous growth of the wireless mobile communication technology, the future technologies needs a very small antenna and also need of multiband antenna is increased to avoid more antennas. Instead of utilizing single band antenna we prefer multiband antenna because it can save money and space. Moreover, if the multibands are not used at a time in any case than multiband is far better than the single band antenna.

Global Positioning System(GPS). The most common application of GPS is tracking loctions.GPS is a radio navigation system it uses radiowaves between satellites and a receiver inside your phone to provide location and time information to any software that needs to use it.

Universal Mobile Telecommunication System (UMTS) is a third generation mobile cellular system for networks based on the GSM standard, packet based transmission of text, digitized voice, video, and multimedia at data rates up to 2 megabits per second (MBPS).

WIMAX developed to provide wireless broadband access to buildings. It can also be used to connect WLAN hotspots to the internet. WIMAX is also intended to provide broadband connectivity to mobile devices.

Radiolocating is the process of finding the location of something through the use of radio waves. It generally refers to passive uses, particularly radar as well as detecting buried cables, water mains, and other public utilities.

A WIFI hotspot is simply an area with an accessible wireless network. The term is most offen used to refer to wireless networks in public areas.

Slot antennas are used typically at frequencies between 300MHZ and 24GHZ. The slot antenna is popular because they can be cut out of whatever surface they are to be mounted an, and radiation patterns that are roughly omnidirectional. When the plate is driven as an antenna by a driving frequency, the slot radiates electromagnetic waves in a way similar to a dipole antenna.

Co axial feeding is used in this proposed antenna as-

- Easy of fabrication
- Easy to match
- Low spurious radiation

In a dual band Microstrip patch antenna is designed, fabricated and tested. The proposed antenna consists of an I-slot in a rectangular patch

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over a partial ground which operates at higher order TM02 mode [1]. The presented design is suitable for 3G and WLAN applications as it produces dual beams at 1.9GHz and 5.7GHz respectively. Return loss, VSWR and radiation pattern are obtained and analyzed using HFSS.

Amicrostrip-fed circular ring slot antenna (CRSA) with a fundamental mode at 2.45 GHz is initially studied. To suppress the additional harmonic modes excited by the ring slot, a single inverted U-shaped slot (or defected ground structure, DGS) is integrated into the CRSA [2]. Through this, harmonic suppression over a wide bandwidth (approximately between 3 and 9 GHz) is achieved. This DGS can also be applied to other microstrip-fed ring slot antennas, such as square and triangular ring slot antennas. In this reference [3]. A review of the active integrated antenna (AIA) technologies. After a brief introduction on the definition and some historical remarks, the paper concentrates on the research effort on the past decades or so. The AIAs are reviewed in its various functions. First, an oscillator-type AIA is presented, followed by very interesting aspects of coupled oscillator arrays for phase control. Use of an AIA concept for efficient RF front end is described with examples on high-power amplifier AIAs. Next, a phase-conjugation-based retrodirective array is reviewed. Finally, AIA systems for receiving, transmitting, and duplexing are reviewed.

A triangular ring slot antenna is proposed which is designed to operate at 5.5GHz. Apart from this fundamental mode, additional harmonics are produced [4]. These harmonics are suppressed by integrating an inverted U-shaped slot into the antenna. This defected ground structure is used to achieve harmonic suppression at 11GHz and15GHz. Further a tilted slot is embedded in the ring slot antenna to produce circular polarization. A compact CPW-fed antennas with harmonic suppression are presented and investigated in detail [5]. By inserting symmetrical slots connected to the end of CPW transmission line in the ground plane, and exploiting parasitic technique, harmonic suppression, compact size, as well as wide bandwidth are obtained. General performances of the proposed antennas are studied by equivalent transmission line circuits. Moreover, the steps of constructing such harmonic suppression antennas are derived. Eventually, the experiment results verified the validation of the proposed harmonic suppression antennas.

The higher order modes can hamper the system efficiency, and thus, the filter antennas are used to eliminate the harmonic radiation [6] . In this paper, the distribution of standing wave fields in patch antenna having been presented and then the characteristic mode theory having been employed, the influences of feeding location and the indentation of patch edges on the suppression of higher order harmonics and their spurious modes are investigated. It is indicated that indenting the radiating edges of the patch element works more effectively on the control of spurious modes while indenting the non-radiating edges can eliminate the harmonics by shifting down the fundamental mode. By selecting feed position and indenting the patch edges, a microstrip patch antenna with both harmonic and spurious mode controls is proposed. Two wide rectangle-shaped microstrip-fed 2.6-GHz slot antennas using defected ground structures (DGSs) with a low design complexity are proposed to achieve wideband harmonic suppression [7]. To accomplish this, two rectangular DGSs (RDGSs) in the first antenna and two circular DGSs (CDGSs) in the second one with various dimensions are etched into the ground plane, which could have a wideband-stop characteristic. Simulated and measured reflection coefficients indicate that the two proposed structures effectively suppress the second and third harmonics up to 23 dB between 3.5 and 10.5 GHz with a maximum ripple of 2.4 dB. In addition, the radiation patterns and peak gains of the antennas can be suppressed at least 17 dB and 7.1 dBi, respectively, at the third harmonic frequency of 7.86 GHz.

A microstrip fed ring slot antenna is designed for 2.4GHz frequency range [8]. To suppress the harmonics in the ring slot antenna inverted U-shaped slot is integrated into CRSA. By this, harmonic suppression over a wide bandwidth is achieved. This DGS can also be applied for the stacked annular ring microstrip-fed ring slot antennas.

The design of a microstrip-fed annular-ring slot antenna ARSA with circular polarization CP radiation to obtain CP radiation with broad 3-dB axial ratio AR bandwidth that can cover the WiMAX 2.3 GHz 2305-2320 MHz, 2345-2360 MHz and WLAN 2.4 GHz 2400-2480 MHz bands [9]. To suppress the harmonic modes induced by the CP ARSA, the technique of integrating a defected ground structure into the annular-ring slot is further introduced. From the measured results, 10-dB impedance bandwidth and 3-dB AR bandwidth of 44.86 and 9.68% were achieved by the proposed harmonic suppressed CP ARSA. Furthermore, average gain and radiation efficiency of ~4.7 dBic and 71%, respectively, were also exhibited across the bands of interest.

Compared with conventional antennas, Microstrip patch antennas have more advantages and better prospects [10]. They are lighter in weight, low volume, low cost, low profile, smaller in dimension and ease of fabrication and conformity. Moreover, the Microstrip patch antennas can provide dual and circular polarizations, dual-frequency operation, frequency agility, broad band-width, feed line flexibility, and beam scanning omnidirectional patterning. In this paper we discuss the Microstrip antenna, types of Microstrip antenna, feeding techniques and application of Microstrip patch antenna with their advantage and disadvantages and the benefits of using slots.

A microstrip patch antenna has been used for microwave frequency [11]. The patch antenna is printed on RT/DUROID 5880. In addition a rectangular conducting plate of comparable dimensions was placed above the patch in order to enhance the bandwidth. The package was used to analyze the effect of the top patch, in particular the variation of VSWR with two parameters, namely the distance between the two patches and the size of the upper patch. Simulation and experiment result of a constructed array of two multipatchmicrostrip antenna with resonance frequency at 5.2 GHz shows the return loss S11 of about -29 dB, gain level of about 10.683 dB with 23.07% bandwidth improvement and after that we have designed an array of three multipatchmicrostrip antenna and achieved a bandwidth about 29.61% with directivity about 11.47 dB and return loss -29 dB at the frequency 5.74GHz.

Microstrip circular patch antenna for dual frequency application [12]. The antenna operates at S-Band at 2.39 GHz and 3.88 GHz with operational band width of 132.4 MHz and 125.6 MHz. The antenna has been designed and simulated on an FR4 substrate with dielectric constant of 4.4 and thickness of 0.2979 cm. The design is analysed by Finite Element Method based HFSS Simulator Software (version 14.0), the simulated results shown that the proposed antenna provides good performance in term of return loss and radiation pattern for dual frequency applications.

Two wide rectangle-shaped microstrip-fed 2.6-GHz slot antennas using defected ground structures (DGSs) with a low design complexity are proposed to achieve wideband harmonic suppression [13]. To accomplish this, two rectangular DGSs (RDGSs) in the first antenna and two circular DGSs (CDGSs) in the second one with various dimensions are etched into the ground plane, which could have a wideband-stop characteristic. Simulated and measured reflection coefficients indicate that the two proposed structures effectively suppress the second and third harmonics up to 23 dB between 3.5 and 10.5 GHz with a maximum ripple of 2.4 dB. In addition, the radiation patterns and peak gains of the antennas can be suppressed at least 17 dB and 7.1 dBi, respectively, at the third harmonic frequency of 7.86 GHz.

It is omnidirectional and stable radiation pattern. Hence rectangular shape antenna can be simulated using ANSOFT HFSS software [14]. Parameters such as return loss, VSWR and radiation pattern are taken. Micro strip slot patch antenna becomes very popular day to day because of easy analysis and fabrication, low cost, light weight, easy fabrication. This paper proposed some shapes using feeding techniques are which has effective transmission based on frequencies. Micro strip patch antennas offer an attractive solution compact, conformal and low cost design of many wireless application systems. By increasing the substrate thickness and decreasing the permittivity of substrate the percentage of band width is increased. HFSS software is used for simulation and design of micro strip patch antenna where its version is 11.0. HFSS means High Frequency Structure simulator this was launched by the ANSOFT, designs are four slot patch antennas and the antennas work in the frequency ranges as follows 4.15-4.39 GHz, 10-11.6 GHz, 13.2-14.3 GHz, 16-17.1 GHz, 19.1-20 GHz, 4.4-4.5 GHz, 8.7-9.1 GHz, 11.54-12.85 GHz, 1.65 GHz, 2.24 GHz, 4.4-4.6 GHz, 5.6- 5.8 GHz, 7.45-8.15 GHz It's main objective is used for MIMO applications, WLAN, Wi-MAX and RADAR, UWB, mobile communications, satellite space communications and microwave frequencies.

Table 1: Existed I-slot Antenna Results

Frequency	Return loss	VSWR	Bandwidth	Gain	Applications
1.9GHZ	-14.1dB	1.64	19%	17dBi	3G Technology
5.7GHZ	23.78dB	1.26	5.61%	19dBi	

Table 2: Microstrip Circular Antenna Results

Frequency	Return loss	Gain	Efficiency	Applications
2.39GHZ	-13.93dB	2.99dBi	67%	S-Band applications
3.88GHZ	-17.52dB	4.76dBi	68%	

Table 3: Existed E-slot Antenna Results

Frequency	Gain	Applications
4.15GHZ	-15.6dB	MIMO Applications
5.8GHZ	-18.4dB	
7.9GHZ	-20dB	
9.0GHZ	-17dB	

Table 4: Existed H-slot Antenna Results

Frequency	Return loss	Bandwidth	Applications
1.07GHZ	-21dB	13.08%	WLAN
4.5GHZ	-20.24dB	3.11%	Wi-Fi, WIMAX
7.51GHZ	-17.52dB	1.86%	IMT
13.81GHZ	-34.82dB	7.44%	LTE

2.0 Antenna Design

As shown figure1 plus shaped rectangular patch antenna is designed whose substrate dimensions are Ls x Ws and the material rogersRT5880 is used which has 2.2 dielectric constant and standard height of the substrate i.e. 0.287mm is used.

Dimensions of the proposed antenna are calculated using the well knownmicrostrip patch antenna formulae which are specified below.

- Width of the patch is$W = \frac{c}{2fo\sqrt{\frac{(\varepsilon r+1)}{2}}}$
- Effective Dielectric is $\varepsilon_{reff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}[1 + 12\frac{h}{w}]^{1/2}$
- Effective length of patch is $L_{eff} = \frac{c}{2fo\sqrt{\varepsilon_{reff}}}$
- Actual length of the patch is L=L_{eff}-2ΔL
- Length extension of the patch $\Delta L = 0.412h\frac{(\varepsilon_{r+0.3})(\frac{W}{h}+0.264)}{(\varepsilon_{reff-0.258})(\frac{W}{h}+0.8)}$
- Length of the ground plane is$L_{g=6h+L}$
- Width of the ground plane is $W_{g=6h+w}$
- Length of the feed line is$L_{f=\frac{\lambda g}{4}}$
- Guided wave length is$\lambda_{g=\frac{\lambda}{\sqrt{\varepsilon_{reff}}}}$
- Radiation box position is$(\frac{-\lambda g}{6}, \frac{-\lambda g}{6}, \frac{-\lambda g}{6})$
- Length of the radiation box is$\frac{\lambda g}{3} + L$
- Width of the radiation box is$\frac{\lambda g}{3} + W$
- Height of the radiation box is $\frac{\lambda g}{3} + H$ (H=$\frac{0.0606\lambda}{\sqrt{\varepsilon_r}}$)

Figure 1: Geometry of Proposed Coaxial Feed Antenna

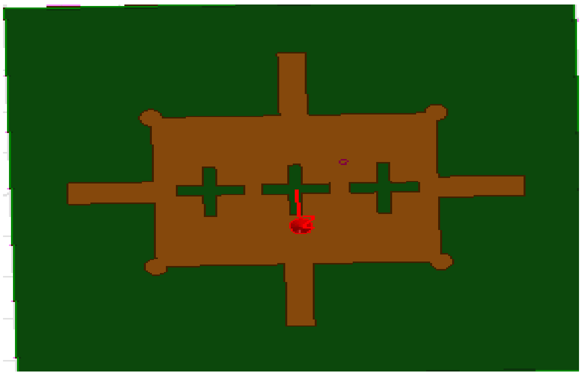
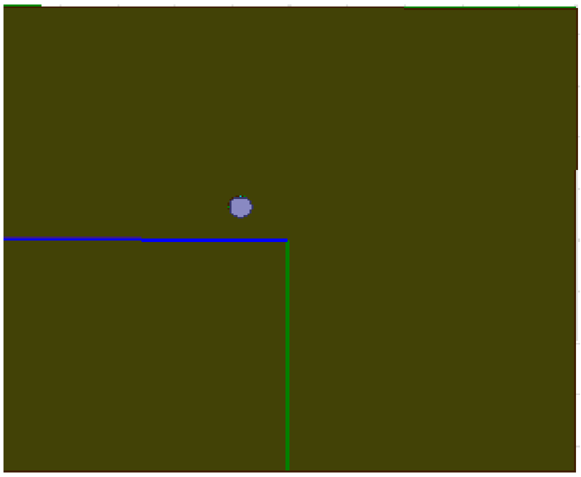


Figure 2: Back View ground



3.0 Simulation Results

3.1 Return loss plot

Return loss is the loss of power in the signal returned/reflected by a discontinuity in a transmission line.S-parameter'S1' represents how much power is reflected from the antenna and hence it is known return loss or reflection coefficient.

Table 5: Proposed Antenna Results

Frequency	VSWR	Gain	Efficiency	Bandwidth	Applocations
1.57GHZ	1.09	4.65dB	97%	2.9%	GPS
1.95GHZ	1.19	6.49dB	98%	3.7%	UMTS
3.11GHZ	1.16	3.85dB	90%	2.3%	WIMAX
3.17GHZ	1.25	4.15dB	98%	1.9%	Radio location
4.05GHZ	1.16	6.23dB	88%	7.9%	WLAN

3.2.VSWR

The parameter VSWR is a major that numerically describes how well the antenna is impedance matched to the radio or transmission line it is connected to. VSWR standard for voltage standing wave ratio and is also referred to as standing wave ratio(SWR)VSWR is a function of the reflection coefficient which describes the power reflected from the antenna. VSWR should be a real and positive number. The smaller the values of VSWR, better the performance of the antenna.

Figure 3: Return Loss

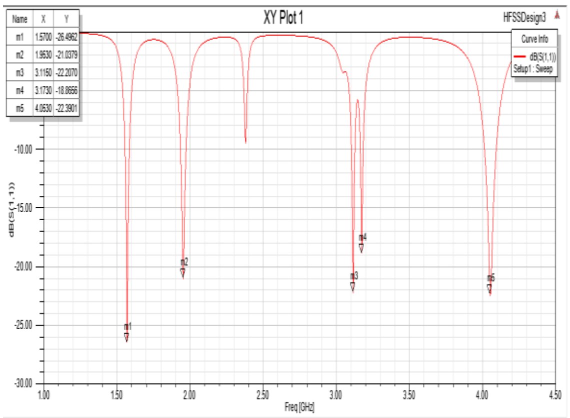
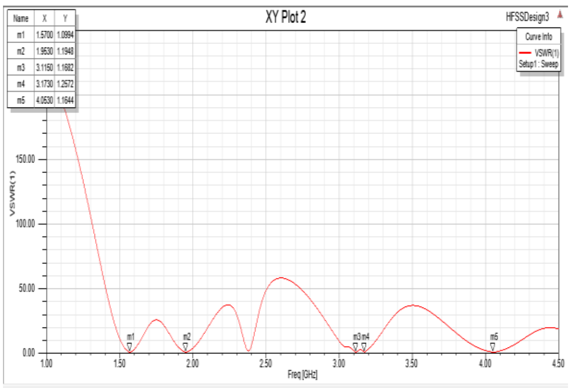


Figure 4: VSWR



The characteristic parameters of proposed antenna in terms of operating frequencies, return loss, gain, directivity, bandwidth and efficiency is tabulated.

Figure 5: Radiation Pattern at 1.57GHZ

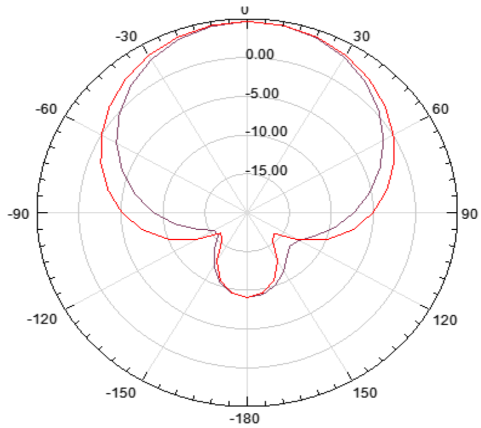


Figure 6: Gain at 1.57GHZ

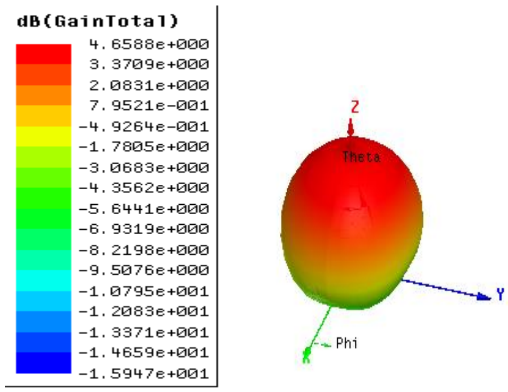


Figure 7: Radiation Pattern at 1.95GHZ

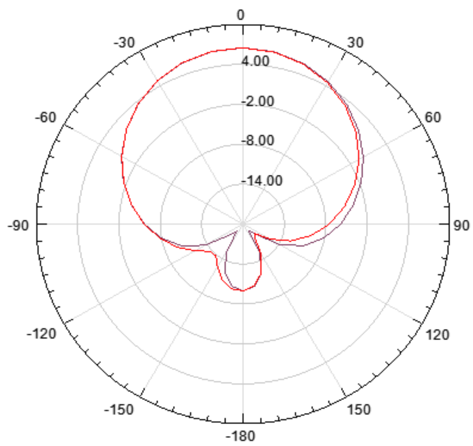


Figure 8: Gain at 1.95GHZ

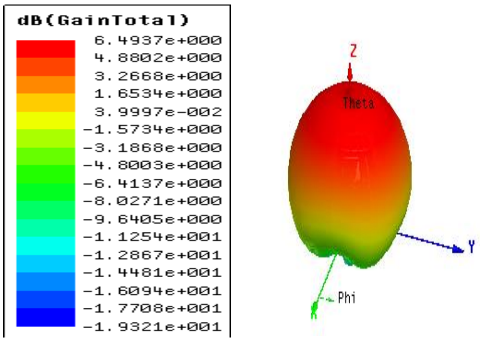


Figure 9: Radiation Pattern at 3.11GHZ

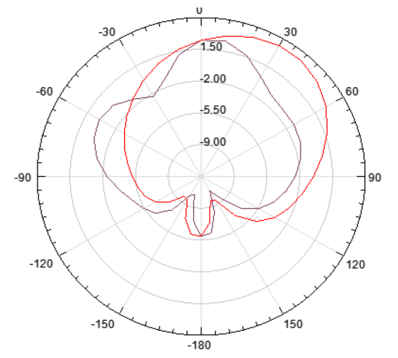


Figure 10: Gain at 3.11GHZ

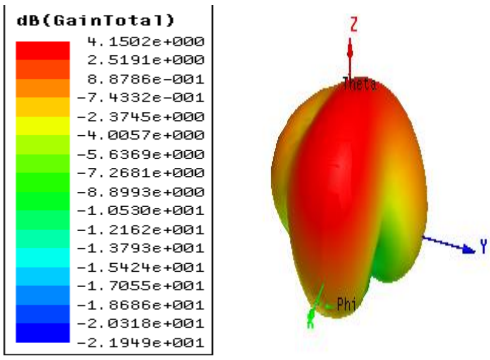


Figure 11: Radiation Pattern at 3.17GHZ

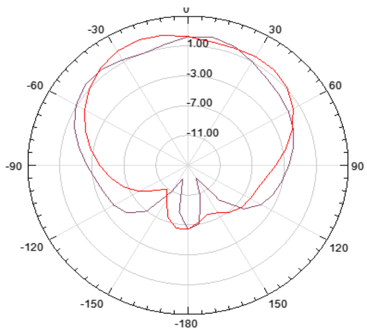


Figure 12: Gain at 3.17GHZ

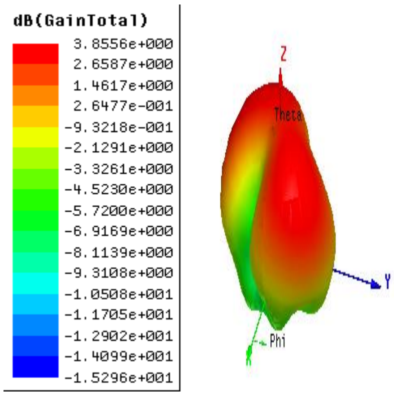


Figure 13: Radiation Pattern at 4.05GHZ

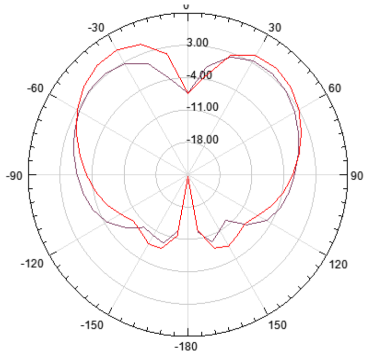
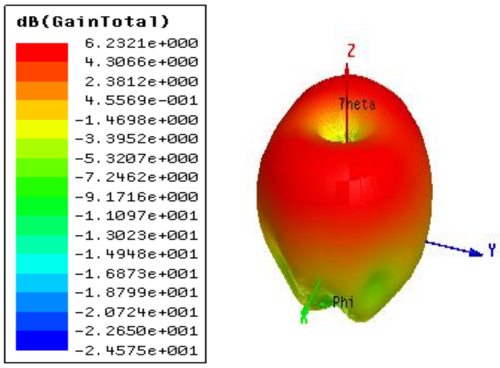


Figure 14: Gain at 4.05GHZ



4.0 Conclusions

In this research a wide penta band plus shaped slotted rectangular patch antenna is proposed for wireless applications. The proposed antenna provides five frequencies for wireless applications. It yields a gain of 6.49dB at 1.95GHZ, 6.23dB at 4.05GHZ, 4.65dB at 1.57GHZ, 4.15dB at 3.17GHZ and 3.85dB at 3.11GHZ. This antenna has high gain, bandwidth, radiation efficiency and VSWR as shown in table which proves that it apt for wireless applications such as UMTS, WLAN, GPS, WIMAX and Radio location.

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