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Compact Size and Slotted Patch Antenna for WiMAX and WLAN

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Abstract

Objectives: Dual-Band, reduced size, coaxial fed probe, Inverted C-slot patch antenna for wireless communication is designed in this paper. The excellent dual-band performance is attained by using inverted C-slots on the patch. **Methods/ Statistical Analysis:** The slots provide two notched bands covering 2.7 GHz to 4.04 GHz for WiMAX and 5.32 GHz to 6 GHz for WLAN with excellent return loss and satisfactory VSWR. **Findings:** Two resonant peaks obtained are at 3.2 GHz and at 5.4 GHz. The proposed antenna size is 29 mm × 29 mm. The antenna has been effectively simulated on HFSS and tested on VNA tool. The peak gain of 4.65 dB and efficiency of 95% is obtained. The antenna presentation is analyzed on the basis of size of antenna, VSWR, bandwidth, return loss and efficiency. The presented antenna is an excellent choice for WLAN and WiMAX. **Improvements:** As compared to conventional Microstrip Patch Antenna return loss is improved with 67% and area minimization of 63% has been attained.

Keywords: C-Slot, Dual-Band, HFSS, Patch Antenna, VNA, VSWR, WiMAX, WLAN

1. Introduction

Wireless devices are the essential components of communication now a days and antennas plays a pivotal role in the performances of these wireless devices hence there is a great demand of antennas that provide multiple frequency bands with wide bandwidth coverage. The operating bands required for the WLAN (Wireless Local Area Network) are 2.4/5.2/5.8 GHz and for worldwide interoperability for Microwave Access (WiMAX) are 2.5/3.5/5.5 GHz bands. To accomplish this multi-frequency operating antenna with lesser cost, small dimensions and antenna with advanced performances are required. However narrow bandwidth can be observed in multi-band antennas.

Due to modernization in technology the wireless devices sizes are also decreasing rapidly which demands compact size of antennas. Therefore, different techniques are adopted in order to cover multiple communication frequency standards along with size reduction in an antenna[1]. A higher permittivity substrate can considerably decrease the antenna dimensions by 90%. Bob Munson, in 1972, developed the first Microstrip Patch Antenna consisting of a radiating patch and a ground plane[2]. Due to the absence of machined parts, these antennas were light in weight and easy to manufacture as well.

However narrow bandwidth and comparable large size were some of the major drawbacks that these antennas suffered[3].

The patch antennas used in communication systems were able to cover only one single frequency band with narrow bandwidth hence it could not fulfill the demands of modern communication at all. Different methods were adopted to enhance the bandwidth and to cover multiple communication standards with reduced size in Microstrip Patch Antennas[4–9]. Some of the techniques used are engraving different shapes on the antenna patch or cutting slots on the ground plane and defected ground structures were also used[10–14]. However, still low gain remained a problem in these antennas (< 3 dBi).

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One common technique that is being used these days to surge the gain of the antenna is stacked patch structure[2]. Though this structure provides the expected results the antenna has a striking increase in volume.

Hence, C-shaped and U-shaped slots on the top radiating patch of the antenna is introduced which causes a size reduction, improved gain and bandwidth of the antenna[15–21].

In this research work, a reduced size dual-band patch antenna is manufactured. The presented antenna comprises of concentric C-slots that introduce notches in the band coverage. The different slots were able to provide a two distinct frequency bands with working frequencies of 3.2 GHz and 5.4 GHz with return loss -46.15 dB and -24.31 dB respectively. The antenna provides a very good radiation pattern with gain of 4.65 dB. The antenna has a very compact structure and area hence it can be easily be mounted inside the housing of the phone.

Section 2: Explains the optimized dimensions, parameters and geometry of the presented antenna.

Section 3: The Simulated results like radiation, gain, scattering parameters patterns and VSWR are depicted.

Section 4: Hardware results.

Section 5: Conclusion of the proposed antenna.

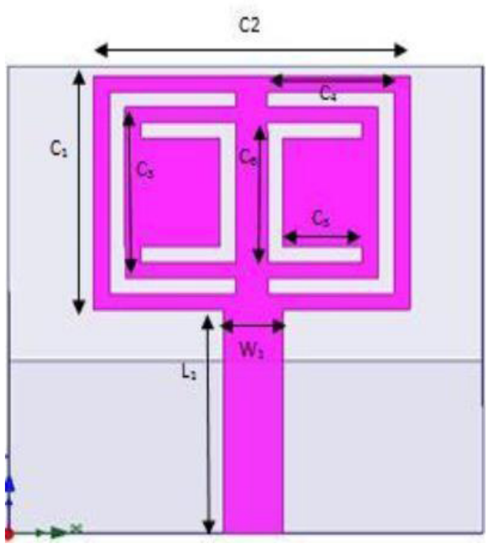

Figure 1. Designed patch antenna – 2D view.

2. Antenna Specifications

The simulated antenna's geometry is shown in Figure 1. The antenna consists of concentric C-slots that introduce notches in the band coverage.

Table 1. Optimized dimensions of designed antenna

SPECIFICATIONS		SIZE(mm)
Length of patch (C_1)		15
Width of patch (C_2)		18
Length of 1 Slot(C_3)		13
Width of 1 slot (C_4)		8
Height of antenna (H)		1.6
Length of 2 slot (C_5)		7
Width of 2 slot	(C_6)	5
Length of feed	(L_1)	14
Width of feed	(W_1)	3.5

The volume of patch with concentric C-slots is 15 mm × 18 mm and that of patch antenna is 29 mm × 29 mm × 1.6 mm^3. The area of the antenna is adequate enough to be placed inside a mobile phone. With relative permittivity of 4.4 the thickness of the patch antenna is 1.6 m. The sizes of the ground plane of the designed antenna are 29 mm × 11 mm. The antenna is excited using lumped port. The proposed antenna covers multiple frequency bands with excellent return loss that will be discussed in next section.

The final proposed antenna shows a wide frequency range in two distinct frequency bands such as 3.2 GHz and 5.4 GHz covering different WLAN and WiMAX communication standards. Table 1 describes the dimensions details of the designed antenna. The presented antenna is simulated on a tool called ANSOFT HFSS software v 13.

3. Results and Discussions

3.1 Simulated Results

3.1.1 Return Loss Plot

Return loss is the loss of power in the signal returned/reflected by a discontinuity in a transmission. It is the difference between the forward and reflected power. – 10 dB is taken as the base value. The antenna operates at different wireless standard such as WiMAX and WLAN. The proposed antenna resonates at 3.2 GHz and 5.4 GHz with return loss -46.15 and -24.31 respectively. The antenna also covers a bandwidth of 2.7 GHz to 4.04 GHz and 5.3 GHz to 5.99 GHz at respective resonant frequencies. Figure 2 depicts return loss parameter of presented antenna. Table 2 describes the resonant loss and return frequencies.

Table 2. Resonant frequency and return loss

Resonant Frequency	Return Loss
3.2 GHz	-46.15 dB
5.4 GHz	-24.31 dB

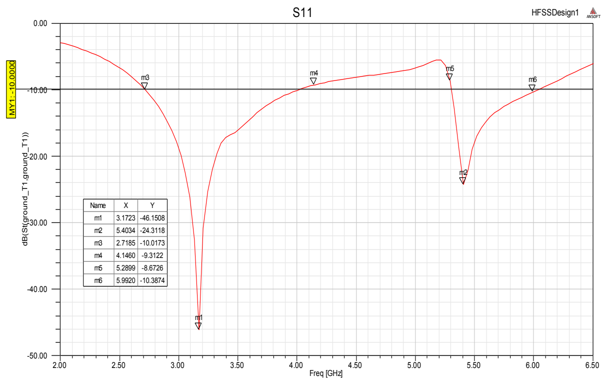

Figure 2. Simulated return loss.

3.1.2 Voltage Standing Wave Ratio (VSWR)

VSWR describes how well the antenna is impedance matched to the radio line it is connected to. The plot obtained after simulation is shown in Figure 3. The value of VSWR should lie between 1<VSWR<2 and ideally it should be 1. In case of Microstrip Patch Antenna the value of VSWR < 2 is considered good. VSWR obtained at 3.2 GHz and 5.4 GHz are 0.5 and 1.3 respectively as presented in Table 3.

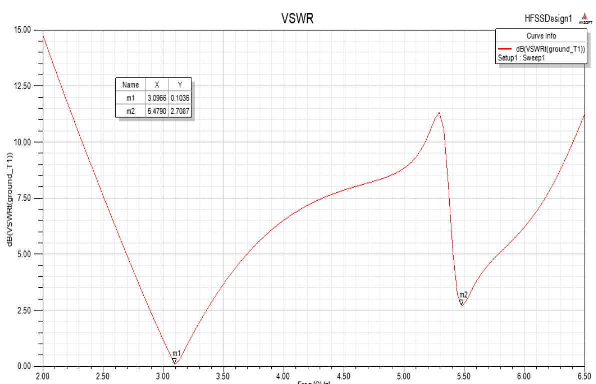

Figure 3. Simulated VSWR.

3.1.3 Gain Pattern

The efficiency of the antenna is described by the gain pattern. The presented antenna shows an excellent peak gain of 4.65 dB as shown in Figure 4.

Table 3. Resonant frequency and VSWR

Resonant	VSWR
Frequency	
3.2 GHz	0.5
5.4 GHz	1.03

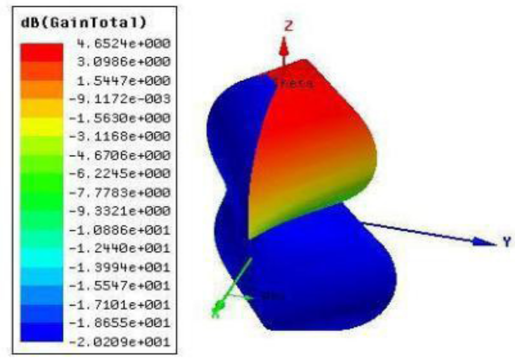

Figure 4. Gain pattern of designed antenna.

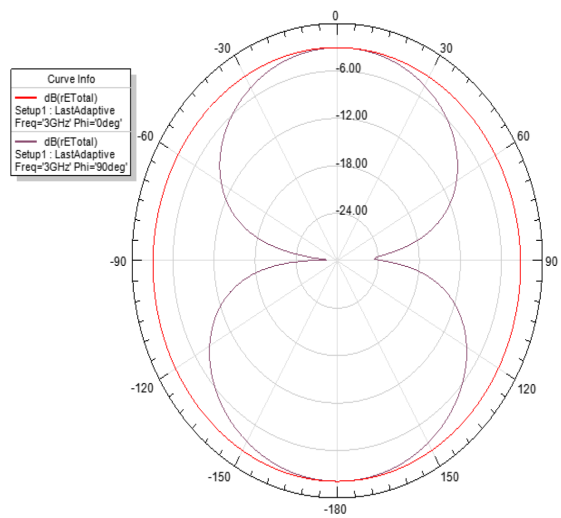

Figure 5. Simulated radiation pattern – 3D view.

3.1.4 Radiation Pattern

It is well-defined as graphical demonstration of the antenna radiation properties w.r.t space coordinates. Figure 5 depicts the radiation pattern in 2D view of the intended antenna with a behavior of omni-directional radiation pattern.

Results have shown that the antenna has improved the gain characteristic and it is covering a wide bandwidth at each resonant frequency with reduced size. The comparison between conventional patch antenna and proposed antenna is given in Table 4.

Table 4. Comparison of conventional and designed antenna

Parameters	Conventional antenna[19]	Designed antenna
Resonant frequency	3.8 Ghz and 5.8 Ghz	3.2 Ghz and 5.4 Ghz
Return Loss	-15.5 and -24 dB	-46.16 and 24.3 dB
Bandwidth	600 MHz and 300 MHz	1290 MHz and 708.4 MHz
VSWR	< 2	< 1.5
Gain	1.85 dB	4.65 dB
Efficiency	90%	95%

4. Hardware Results

As shown in Figure 6, the proposed antenna is fabricated using FR4 substrate material.

- Antenna - Return loss.
- Comparison of results - The measure return loss plot is as shown in Figure 7. There is a little disagreement between simulated and hardware results which are mainly due to errors during processing time, environmental conditions and due to SMA connect. Comparison of both simulated and measured return loss is shown in Figure 8 and rest of the results is presented in Table 5.

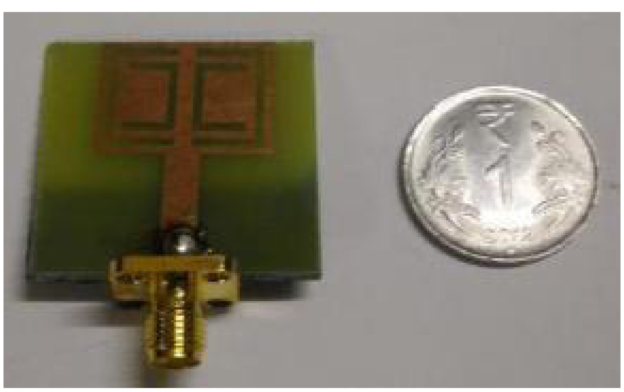

Figure 6. Designed antenna.

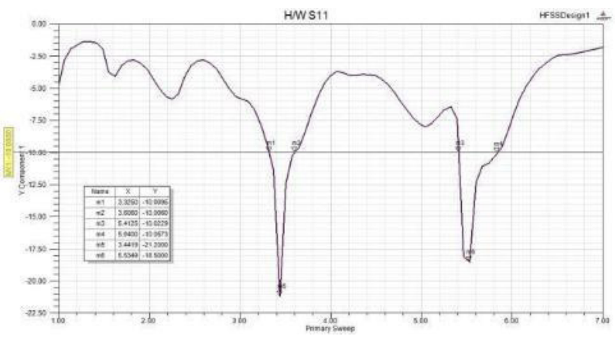

Figure 7. Measured return loss.

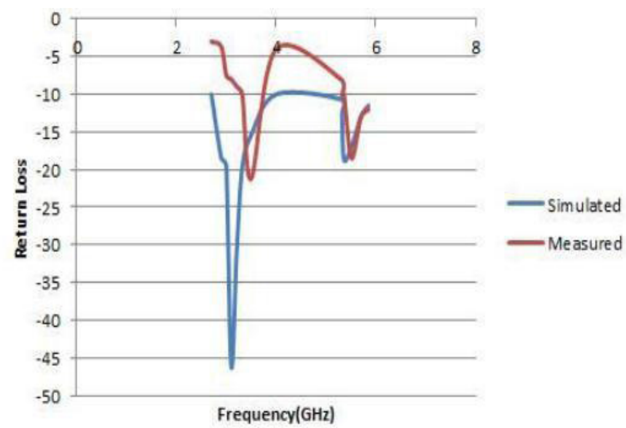

Figure 8. Comparison between simulated and measured return loss.

5. Conclusion

In this novel work, a dual band compact antenna with inverted C slots is designed for WiMAX and WLAN. Here coaxial probe feed antenna with multi-frequency applications is designed by introducing inverted C slots and notches are generated which results in smaller size and multi-band antenna. The antenna structure with volume 30 mm × 30 mm × 1.6 mm is very compact and can be easily placed in the housing of the mobile phone. ANSOFT HFSS software is used for the simulation of antenna and later on the manufactured antenna has been tested on VNA tool. The designed antenna shows good

Table 5. Showing the comparison between reference antenna[15] and design proposed

Antenna	Resonant Frequencies	VSWR	Efficiency	Gain	Return Loss	Bandwidth
Base Paper Antenna	3.8 and 5.8 GHz	<2	92%	1.85 dB	-15.5 dB, -24 dB	600 MHz, 300 MHz
Fabricated Antenna	3.2 and 5.4 GHz	<1.5	95%	4.65 dB	-46.16 dB, -24.31 dB	1290 MHz, 708.4 MHz

radiation pattern with gain of 4.65 dB. The antenna resonates at 3.2 GHz and 5.4 GHz with return loss of -46.15 and -24.31 respectively and can be used in WLAN and WIMAX wireless standards. The efficiency obtained is 95%. The power of an antenna is in its compact geometry with satisfactory gain and radiation pattern which makes it a good choice for WLAN and WiMAX particularly in case of reduction of sizes of modern communication devices. Thus, the presented antenna could be capable for numerous modern wireless communication applications.

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