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A New Design of Truncated Four-Cornered Printed Antenna for WIMAX and WLAN Applications

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Abstract-In this paper, we present a new shape of bi-band micro-strip antenna for WIMAX and WLAN applications. The proposed antenna consists of a rectangular patch can be achieved by using U-shaped slot and 4-side truncated corners fabricated on the FR4 Substrate. The proposed antenna is designed to operate at WIMAX (3.40-3.70 GHz) and WLAN in USA (5.15 - 5.35 GHz, 5.725 - 5.875 GHz) standards. We validated the simulation results obtained by the CST software by comparison with HFSS software. The results obtained by the two softwares showed satisfaction in terms of return loss, radiation pattern and gain. Subsequently, we performed a parametric study of the U-shaped slots to analyze their influence on the performance of the patch antenna. This modification showed the effects of adaptations on the width of the two bands, two resonance frequencies. At the end of this theoretical study we carried out the fabrication of this proposed antenna. Comparative discussions between the simulation results and measurement results show the importance of utility of the performances of this antenna in the WIMAX and WLAN applications.

Index Terms- Microstrip, truncated corners, Bi-band antenna, HFSS, CST, WIMAX and WLAN, fabrication.

I. INTRODUCTION

Wireless communication has been progressing extensively since last few decades and still demand for new technologies is enormous. Two major technologies among wireless communication systems that are serving this demand are WiMAX and WLAN. WiMAX provide high-speed data rates and internet access throughout wider coverage area. It operates at three different licensed bands at WIMAX (3.40-

3.70 GHz) and WLAN in USA (5.15 - 5.35 GHz, 5.725 - 5.875 GHz) [1]. Today they are no longer simple communication devices. With the development of new standards and design constraints, phone manufacturers and new wireless devices now prefer integrated antennas. The needs of these services, which are constantly increasing, have imposed an implementation of several functions on the same device, hence the notion of multi-band antennas [2]. The new telecommunication systems must be able to include a large number of functionalities in order to meet the requirements to cohabit several standards on the same antenna (LTE, GSM, UMTS, GPS, WIFI, WiMAX, etc.) with other users, to improve the throughput of the transmissions, to avoid the phenomena of fading, to ensure a better efficiency in the reception of the signal. Because of this, extended antennas must be able to adapt to such an environment. The radiation pattern of wireless antennas is also a common preoccupation that must be taken into account during the optimization and design process [3]. The bi-band coverage antennas are operational due to the communication standard evolution [4-5]. WLAN and WiMAX standards specify many bandwidth and many operating frequencies around the world, so to satisfy this applications a multi band antennas are required for the future communication terminal. Modern antennas must meet the requirement of bi-band to sufficiently cover the possible operating bands. The antenna must also be small enough to be placed inside the minimizing wireless communication systems [6-16].

This work has been devoted to the development of a new printed antenna with a ground plane to

two frequency bands. This antenna was designed in CST microwave studio software and the same design is compared with HFSS. This simulation will be performed and the result will be taken with the best result obtained. For experimental measurement, the geometry of an antenna is fabricated and their various parameters are tested using a vector network analyzer. The goal of this paper devoted to bi-band antennas operating bands for mobile application.

II. ANTENNA DESIGN

In this paper, we have proposed a corner-truncated antenna prototype consisting of a rectangular patch with 4-truncated corners dedicated for mobile phone application. The designed antenna is printed at on a FR-4 substrate and simple feeding using a microstrip line feed, which has compact dimensions of ($26 \times 30 \text{ mm}^2$), is printed in the front of substrate FR4 epoxy of thickness $h = 1.6 \text{ mm}$, relative permittivity 4.3 and loss tangent 0.018 the choice of substrate is important in terms of antenna performance. The dimensions truncated corners are ($6.5 \times 6 \text{ mm}^2$). The dimensions of the ground plane are chosen to be $26 \times 10 \text{ mm}^2$ in this study.

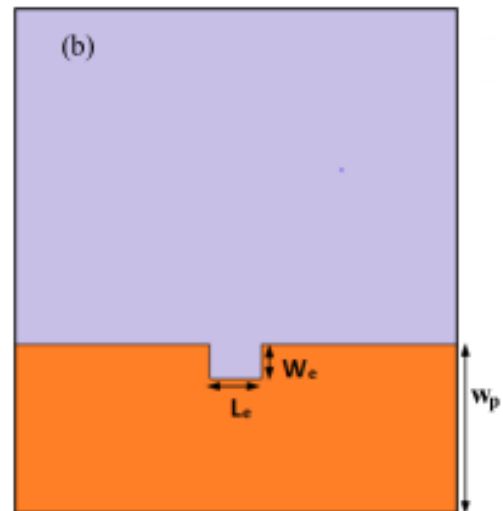
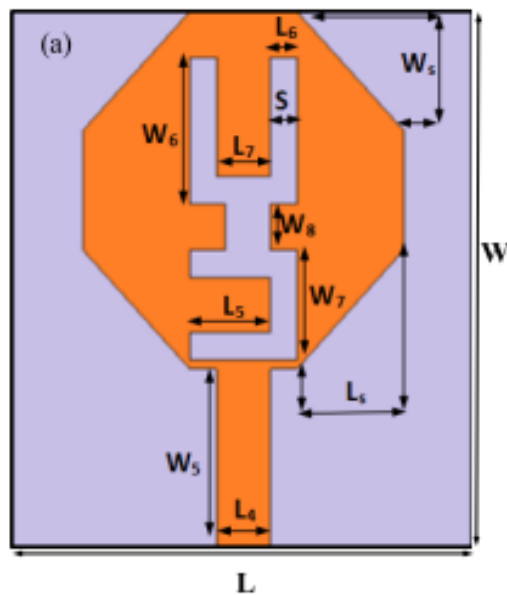


Fig. 1. Basic printed truncated four-cornered antenna. (a) Front view, (b) Back view.

The geometrical parameters of the antenna are : $L=26 \text{ mm}$; $L_4=3 \text{ mm}$; $L_5=6 \text{ mm}$; $L_6=1 \text{ mm}$; $L_7=5 \text{ mm}$; $W=30 \text{ mm}$; $W_5=10 \text{ mm}$; $W_6=6.5 \text{ mm}$; $W_7=5.5 \text{ mm}$, $W_8=25 \text{ mm}$; $W_9=6 \text{ mm}$; $L_9=6.5 \text{ mm}$; $L_{10}=3 \text{ mm}$; $W_c=2 \text{ mm}$; $W_p=10 \text{ mm}$.

III. SIMULATIONS AND RESULTS

The simulation is done by varying feeding positions and S-parameters are recorded. As it is given in Table I the results show the various parameters on which the performance of the antenna depends. We simulate the antenna to operate at 3.52 GHz for WIMAX and 5.74 GHz for WLAN applications. Also, we can see that the antenna operates in a wideband of (3 - 6.78 GHz) at $S_{11} < -10 \text{ dB}$. The CST software obtained results are presented in Fig. 2 in the frequency range from 0 to 9 GHz.

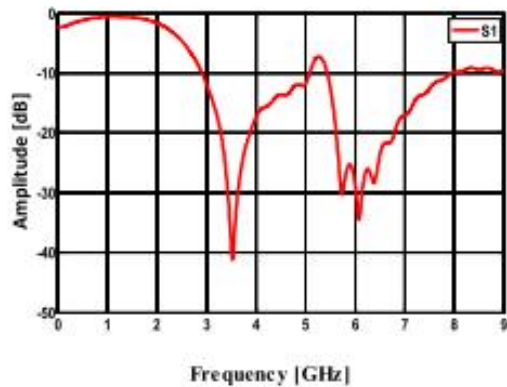


Fig. 2. Bi- band antenna computed return loss.

The proposed antenna is feasible for WLAN, WIMAX, has a good adaptation with a return loss of - 41 dB at the resonant frequency 3.52 GHz and with a peak of -30 dB at the resonant frequency 5.74 GHz. It is also found that this antenna has a better adaptation with respect to the base antenna in the same frequency band.

IV. MEASUREMENT RESULTS AND DISCUSSION

The parametric study was carried out to optimize the antenna design. This study is very interesting before the manufacture of antenna can be made. The Fig. 3 presents the simulated return losses for different values of S of the slot in the frequency range from 0 to 9 GHz.

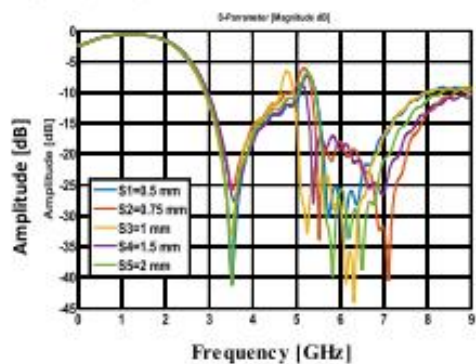


Fig. 3. Simulated return losses for different values.

The geometry of the truncated patch antenna is fabricated and their various parameters are tested using a vector network analyzer.



(a)



(b)

Fig. 4. The fabricated 4-cornered antenna. (a) Front view, (b) Back view.

The antenna is designed and simulated using CST software based on FIT method and Ansoft HFSS employs the Finite Element Method FEM. Comparison between the return loss of measured and simulated results of proposed antenna is shown in Fig.5.

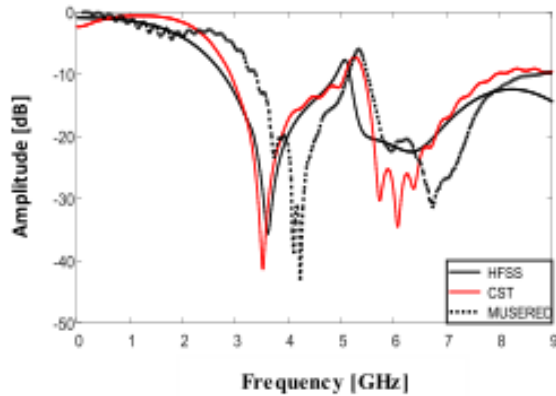


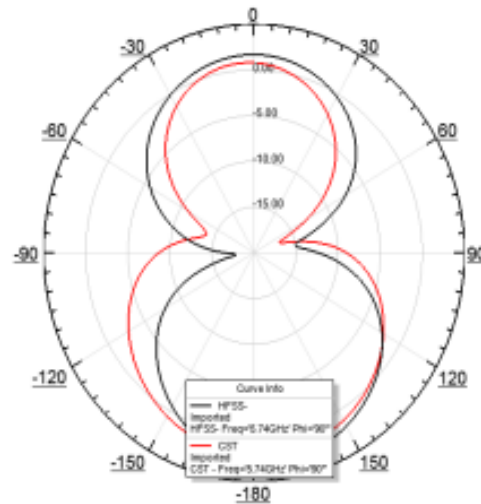
Fig. 5. Bi- band antenna computed return loss.

Comparison between simulation and experimental print antenna results shows that there is a good agreement between simulation results and measurements are observed for both frequencies in terms of reflective coefficient, we observe a good adaptation in the frequency band of [0-9 GHz], we record a peak of the order of -41 dB to 3.52 GHz,-30 dB to 5.74 GHz, the HFSS simulator showed a peak of -30 dB to 3.54 GHz and a peak of -20 dB to 5.72 GHz , the simulation results measured with a peak of -25 dB at the frequency of 3.54 GHz and -23 GHz frequency of 5.75 GHz. A small frequency shift is recorded between the three curves usually due to measurement errors. These results correctly respond to mobile phone applications in WIMAX (3.400 - 3.700 GHz) and WLAN (5.15 - 5.35 GHz, 5.725- 5.875 GHz). According to the curves in Fig. 6, there is a very good correlation between simulated and measured results.

Table 1: Comparison between the FHSS software CST and measured result.

Frequency Band	software	Peak [GHz]	S ₁₁ [dB]
Wimax [3.40- 3.70 GHz]	CST	3.52	-41
	HFSS	3.54	-36
	Measured	3.54	-25
WLAN [5.15 - 5.35 GHz, 5.725- 5.875 GHz]	CST	5.74	-30
	HFSS	5.72	-20
	Measured	5.75	-23

The simulated radiation pattern obtained by CST and HFSS software for this antenna for 3.52 GHz and 5.74 GHz are shown in Fig. 6. The good agreements between two simulation software have been found excellent peak. The results demonstrate an excellent performance of antenna



proposed operating mobile phone application.

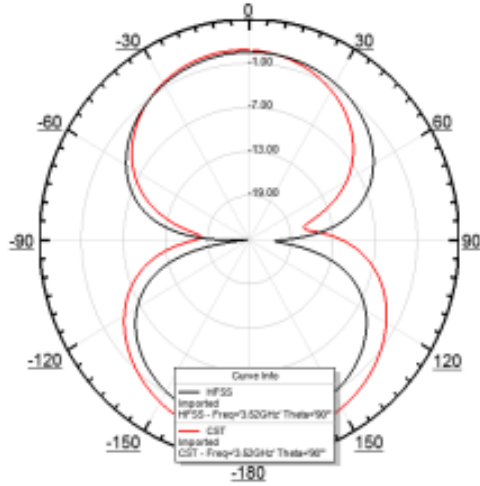


Fig. 6. Simulated radiation patterns for proposed antenna at 3.52 GHz, 5.74 GHz.

V. ANTENNA GAIN

Gain of the proposed antenna printed at different frequency values is detailed in table 2. Fig. 8 indicates peak and minimum trend in the working frequency range. Peak gain was achieved at 6 GHz with a value of 2.8 dBi and minimum value of gain is at 2 GHz with a gain of 0.8 dBi. The performance of the antenna has been studied and its simulated gain is shown in Fig. 7.

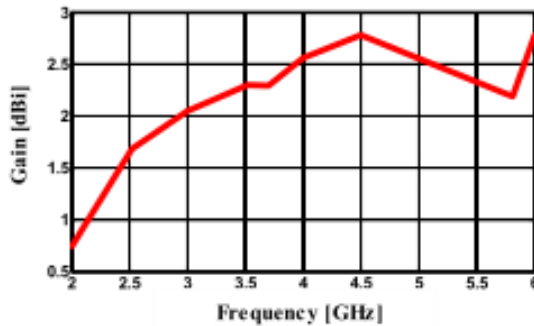


Fig. 7. The gain as a function of viewing frequency.

Table 2: Proposed antenna gain at different frequencies

Frequency [GHz]	Gain [dBi]
2	0.8
2.5	1.7
3	2.3
4	2.6
4.5	2.8
5.74	2.2
6	2.8

To show the correct functioning of patch antenna in the operating band, we plotted the gain of the antenna according to the frequency. The gain is greater and the best result demonstrating the correctness of our approach for mobile phone application. The computed gain reaches 2.8 dB at the resonant frequency 4.5 GHz. A comparison table with already existing work in terms of the size of the structure, peaks, bandwidth and gain is shown in table 3.

Table 3: A comparative table with existing works

[17]	Our work
Parameters and value (mm)	Parameters and value(mm)
$W_0 = 16, L_0 = 29, L_1 = 14, W_1 = 3, L_2 = 13, L_3 = 3, L_4 = 12, L_5 = 12, L_6 = 3, H = 1.6$	$L = 26, L_1 = 3, L_2 = 6, L_3 = 1, W = 30, W_0 = 10, W_1 = 6.5, L_4 = 5.5, W_2 = 2.5, W_3 = 6, L_5 = 6.5, L_6 = 3, W_4 = 2, W_5 = 10, H = 1.6$
The FR4 antenna substrate with a relative dielectric constant of 4.4 and loss tangent 0.02.	The FR4 antenna substrate with a relative dielectric constant of 4.3 and loss tangent 0.018.
1-Frequency band $f_1 = 2.4$ GHz $f_2 = 5.2$ GHz 2-Return loss For: $f_1 = 2.4$ GHz, $S_{11} = -20$ dB, For: $f_2 = 5.2$ GHz, $S_{11} = -19$ dB. 3-Gain: 4 dBi	1-Frequency band $f_1 = 3.52$ GHz $f_2 = 5.74$ GHz 2-Return loss For: $f_1 = 3.52$ GHz, $S_{11} = -41$ dB, For: $f_2 = 5.74$ GHz, $S_{11} = -30$ dB. 3-Gain: 2.2 dBi

VI. CONCLUSION

In this paper, we proposed a new promising design of printed truncated 4-cornered antenna with U slot for bi-band operations covering two

frequency bands (3.4–3.7 GHz) for the WiMAX and (5.725–5.872 GHz) for WLAN system. A challenge in designing such multiple wireless communication protocol systems is to design, low cost and specific type of miniature antenna with small sizes. The results obtained are simulated using a finite integration technique using the CST MW Studio and compared with FEM method using HFSS software and compared with measured results. The obtained good performances of antennas satisfy the demands of mobile phone application.

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