A Compact Rectangular Shaped Microstrip Antenna for UWB Applications

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***Abstract*— In this paper, coplanar monopole Compact Ultra Wideband (UWB) patch antenna is proposed. It consisted of rectangular shaped patch of Lx = 16mm by Ly = 12:5mm dimensions with two squares profiles into its two corners. Simulated and measured prototype is printed on a partial grounded FR4 epoxy substrate of 30mm by 30mm dimensions. Both of inserted square geometrical shapes provide different electric lengths with variations which are adjusted to enhance the impedance bandwidth and reduce the VSWR between the main resonance frequencies of the rectangular patch. The excitation is launched through a 50-Ω microstrip feed line. Design and performances are analysed using Ansoft HFSS electromagnetic simulator based on the finite element method and measured using a vector network analyser where the calibration plane is the SMA connector jack used to connect the antenna. Various prototypes are simulated and measured in order to view the correlation parameter between the impedance bandwidth and the both square geometries. The best antenna simulated and measured results correspond to a prototype with two squares forms of 2.5mm radius. Nevertheless, the bandwidth is ranging from 3 GHz to 4 GHz for S11 < ϒ10 dB.**

***Keywords*— *Ultra Wideband Antenna, coplanar Microstrip Antenna, Partial Ground Plane,SMA connector,Vector Network Analyser*.**

I. Introduction

In February 14, 2002, the Federal Communications Commission (FCC) amended the Part 15 rules which govern unlicensed radio devices to include the operation of UWB devices. The FCC also allocated a bandwidth of 7.5GHz, i.e. from 3.1GHzto 10.6GHz to UWB applications [1], by far the largest spectrum allocation for unlicensed use the FCC has ever granted. Ultra-wideband (UWB), a radio transmission technology which occupies an extremely wide bandwidth exceeding the minimum of 500MHz or at least 20% of the center frequency [1], is a revolutionary approach for short range high-bandwidth wireless communication. In recent applications of RF communications and remote sensing at radio, microwave and terahertz frequencies, the design of a small ultra-wide band (UWB) antenna printed on short range radio devices plays a significant role in modern wireless communications. It is a carrier less short range communications technologies which transmits the information in the form of very short pulses. The variety in design that is possible with microstrip antennas probably exceeds that of any other type of antenna element. Microstrip antennas where size, weight cost better performance, compatibility with microwave and millimetre wave integrated circuits (MMICs), robustness, ability to conform to planar and non-planar surfaces, etc. are required. Despite the advancements in this field, microstrip antennas are still limited by the inherent narrow bandwidth, low gain (6 dB), the most of the patch microstrip antennas radiate in the half plane, support exclusively lower power (100W) and radiation losses by surfaces waves. For this reason, an enormous amount of research literature is available on broad banding techniques for microstrip patch antennas which can grow up to 70% by using multilayer substrate and the gain can grow up to 30% by using microstrip patch antennas array. Notably, other broad banding techniques include: thicker substrate, shaping the patch antennas [1], stacking [2], aperture coupling [2], slot compact planar design [3] and parasitic patch either in another layer (staked geometry) or in the same layer (coplanar geometry) [4]. In order to more enhance the bandwidth, reduce the VSWR between the main resonance frequencies of the rectangular planar antenna and create a smoothly variation of the return loss coefficient, we have proposed a non uniform radiator whose profile is characterized by two Squares steps into its two corners. Various prototypes have been simulated using the commercial electromagnetic simulator Ansoft HFSS which is based on the infinite element method to view the correlation parameter between the radius of each circled curve and the return loss coefficient without forgetting the radiation parameters such as the gain, directivity, radiation pattern. A comparison with measured results in terms of impedance bandwidth is also established for the best UWB simulated prototype in order to view the concordance degree between the simulated and measured results.

II. ANTENNA GEOMETRY AND SIMULATED RESULTS

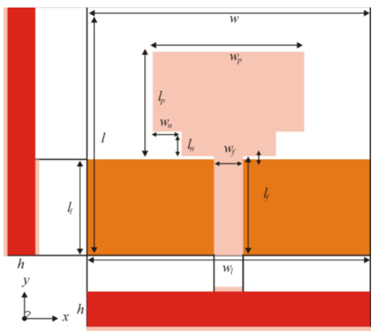


Fig 1: Geometry of the proposed UWB antenna with two rectangular removed Steps shapes
(a) Side View (b) Top View (c) Front View

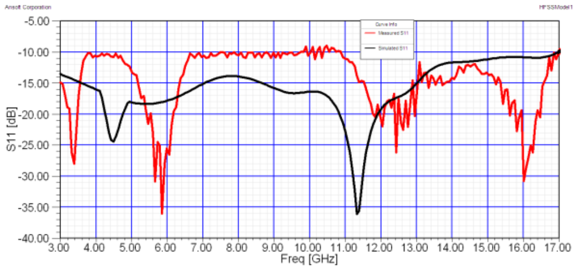


Fig. 2: Return loss coefficient /S11/ dB of the rectangular patch antenna with two removed Rectangular shapes.

A. Antenna Design

The antenna showed by Figure 1 consists of a rectangular patch printed on an FR4 epoxy dielectric substrate with a permittivity constant of 4.4, a tang losses of 0.018 and a thick of 1.5 mm, it is fed through a 50-Ω microstrip line partial grounded substrate. Two triangular removed forms defined by $W_n = I_n = 2.5$mm dimensions as depicted by Figure 1 are truncated from two corners of the rectangular patch in order to reduce the VSWR between the resonance frequencies. The dimensions of the proposed antenna are summarized in the Table 1 below.

Table 1. Antenna dimensions

W_p	(length of the rectangular patch)	16mm
I_p	(Width of the patch)	12.5mm
W	(length of the substrate layer)	30mm
I	(width of the substrate layer)	30mm
Lg	(width of the ground plane)	11.5mm
W_n	(length of the removed triangular conductor sheet)	2.5mm
I_n	(width of the removed triangular conductor sheet)	2.5mm

B. S Parameters

Several simulations using Ansoft HFSS commercial software were performed in order to study the impedance bandwidth of the antenna. A commonly used definition of impedance bandwidth is the frequency range over the voltage standing wave ratio (VSWR) is less than 2 : 1. Based on this impedance bandwidth, simulated results depicted by Figure 2 and Figure 3 in terms of return loss coefficient and VSWR respectively proved that this antenna can operate from 3.5 GHz to 14 GHz for a VSWR < 2.

III. PLANAR NON-UNIFORM UWB RADIATORS

A. Antenna Design

Several electromagnetic simulations have been realised in order to more reduce the return loss coefficient at the bandwidth frequency of this antenna. For this aim, we have essayed smoothly variation profiles among various lengths of square curves as depicted by Figure 4. Several prototypes were simulated and analyzed using Ansoft HFSS electromagnetic software in order to view the correlation parameter between each square curve Length and the impedance bandwidth without forgetting the exam of radiation pattern, gain and directivity.

B. S Parameters Simulated Results

The behaviour of the return loss for different lengths of the removed square forms is showed by Figure 4. It proves that if the length R increases the resonance frequency around 12 GHz moved forward at the left.

- *Simulated and Measured Results of a Realised Antenna with Two Square Curves Forms*

A realised rectangular patch with two Square curves of R = 2.5mm length as depicted by Figure 5 was measured using an Agilent Performance Vector Network analyser [reference de l'analyseur] (10MHz to 15GHz). The calibration plane is the SMA connector jack used to connect the antenna. Figure 1 shows the measured and simulated return loss coefficient using Ansoft HFSS concords from 3 GHz to 12 GHz for S11 < ϒ10 dB.

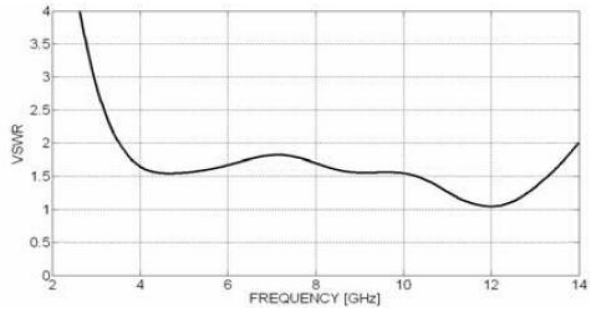


Fig. 3: VSWR of the rectangular patch antenna with two square removed shapes.

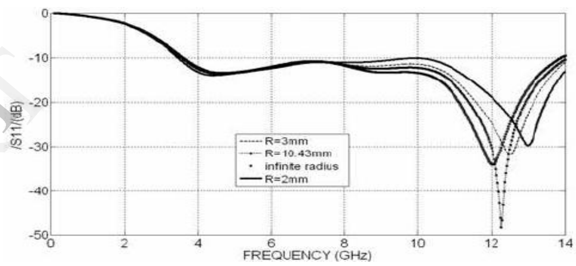


Fig. 4: Behaviour of the return loss coefficient as function of the Length of the two square shaped profiles.

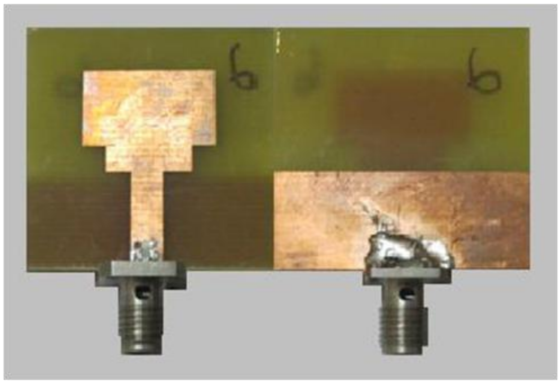
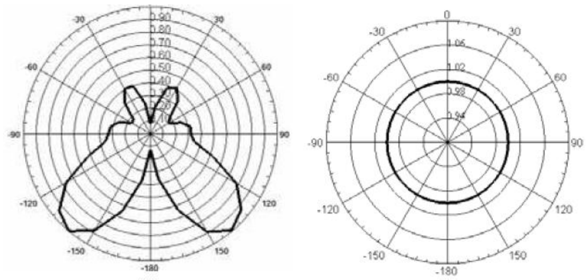
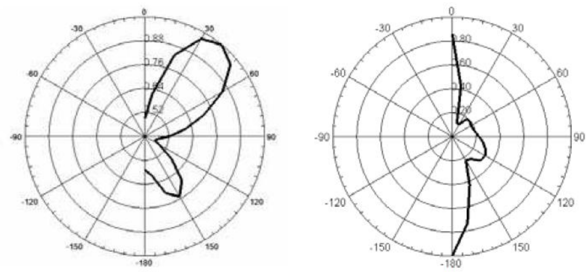


Fig. 5: Prototype of Rectangular Patch UWB Antenna with Corner Steps



(a) (b)

Fig. 6: Simulated radiation pattern of an antenna with two square shaped curves of R = 2.5mm radius at 9.5 GHz. (a) Theta cuts for 90º. (b) Theta cuts for 0º.



(a) (b)

Fig. 7: Simulated radiation pattern of an antenna with two square shaped curves of R = 2.5mm radius at 9.5 GHz.
(a) Phi cuts for 90º. (b) Phi cuts for 0º.

- *Radiation Pattern and Electrical Parameters*

Figures 6 and 7 show the simulated conical (theta) and planar (phi) cuts normalized radiation patterns at 9.5 GHz. It is apparent that the proposed antenna has maxima for ' = [110˚; 165˚] and for ' = [205º; 255º], nulls at ' = 0˚ and ' = 180˚. The radiation pattern is omnidirectional at theta = 0º.

Tables 2 and 3 summarizes the main electrical parameters of this antenna at 9.5 GHz frequency.

Table 2: Antenna parameters at 9.5 GHz frequency.

Antenna parameter	Value
Max U	0.25651 W/Sr
Peak directivity	3.733
Peak gain	3.242
Peak realized gain	3.2234
Radiated power	0.86349W
Accepted power	0.99428W
Incident power	1W
Radiation efficiency	0.86846

Table 3: Maximum field datas at 9.5 GHz frequency

E field	*Value*	*At phi (º)*	*At theta (º)*
Total	*13.907V*	*140*	*80*
X	*10.04V*	*130*	*80*
Y	*10.649V*	*140*	*70*
Z	*6.1258V*	*290*	*50*
Phi	*13.848V*	*140*	*80*
Theta	*8.408V*	*280*	*40*

IV. CONCLUSION

In order to get a smoothly variation of the electrical length and reduce the impedance bandwidth between the resonance frequencies of a rectangular partial grounded substrate planar patch antenna, some geometrical forms have been inserted into two corners witch are triangular, concave and convexcircled shapes. Ultra wide band behaviour is achieved making these prototypes suitable for mobile and wireless network applications. Nevertheless, measured and simulated results of an antenna with two convex circled forms of 3mm radius concords successively and showed that this compact radiator has a bandwidth that is ranging from 3.55 GHz to 4.6 GHz and from 7.4 GHz to 11.7 GHz for S11 < ¡10 dB. The simulated electrical parameters results showed also that this antenna is characterized by a peak directivity of 3.6657 at 9.5 GHz frequency. Numerical analysis using a CFDTD code will be presented in the final version of this paper.

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