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A Novel Design of Ultra-Wideband Antenna (UWB) Using Slot-Based Structures

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Abstract

Radio communications using ultra wideband (UWB) frequency have rapidly developed since the beginning of the year 2000. This technique offers advantages that made it attractive to a large number of civilian and military applications.
The aim of this work is the study of the geometry features of a UWB antenna and the improvement of the bandwidth by inserting slots. To obtain a very large bandwidth operating from 2 GHZ to 11 GHZ we have inserted slots both on ground plane and antenna.
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Keywords: *planar antenna, Ultra Wide Band Antenna, Slots.*

1. Introduction

The printed antennas have been involved for many applications in telecommunication systems. Modeling of several parameters in antenna's structures promotes higher performances.
The technical advantages of printed antennas converge for many success results such as:
The low weight, the minimal thickness congestion, and the possibility to generate a circular polarization adapted to curved surfaces.
In order to qualify antenna and integrate it into different systems, some disadvantages must be avoided, for instance: low bandwidth, small gain and strong influence of dielectric substrate.
In this paper, we are interested to study the design of patch antenna using Ultra Wide Band (UWB), numerical results of slot-based structures are presented to illustrate the behavior of reflection coefficient and radiation pattern.

2. Design of UWB antenna

The conception relies on transmission line method. The below list of equations obtained from the transmission line matrix (TLM) can be used to calculate effective length and width of the patch antenna [1]. The structure of the designed antenna is shown in Fig.1.

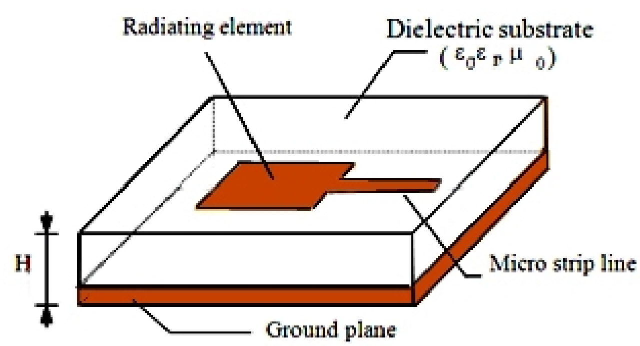

Fig 1: Structure of the patch antenna.

The dimensions of the patch antenna are given as follows [2]:

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$$W = \frac{c}{2 \cdot f_r} \cdot \sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

$$f_r = f_0 \cdot \left[\frac{1 - \frac{2 \cdot h}{\varepsilon_{eff} \cdot l \cdot \pi \cdot \alpha}}{1 + \frac{2 \cdot h}{\varepsilon_{eff} \cdot l \cdot \pi \cdot \alpha} \cdot ln\left(\frac{\sqrt{\varepsilon_{eff}} \cdot 2 \cdot l}{\gamma \cdot h}\right)} \right] \quad (2)$$

$$f_0 = \frac{c}{2 \cdot l \cdot \sqrt{\varepsilon_{eff}}} \quad (3)$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \cdot \left(1 + \frac{10 \cdot h}{w}\right)^{-1/2} \quad (4)$$

$$\mathrm{L} = \mathrm{L_{eff}} - 2\Delta \mathrm{L} \quad (5)$$

$$\mathrm{L_{eff}} = \frac{\mathrm{C}}{2\mathrm{f_0}\sqrt{\varepsilon_{\mathrm{eff}}}} \quad (6)$$

$$\Delta \mathrm{L} = 0.412\ \mathrm{h}\ \frac{(\varepsilon_{\mathrm{eff}} + 0.3)\left(\frac{\mathrm{W}}{\mathrm{h}} + 0.24\right)}{(\varepsilon_{\mathrm{eff}} - 0.258)\left(\frac{\mathrm{W}}{\mathrm{h}} + 0.8\right)} \quad (7)$$

For this antenna, the dielectric substrate used is FR4 with:
Dielectric permittivity $\varepsilon r=4.3$
Substrate height: h=1.58mm
Dielectric losses, $\tan\delta=0.025$
Thickness of metallization: t=35µm
fr = radiation frequency.
$\gamma = 1.78107$
c = 3.10^8 en m/s
h = dielectric height (1.58 mm of FR4)
w = width of the patch
L = length of the patch
εr = dielectric constant

3. Simulation and measurement:

Firstly, we simulated the patch antenna without slots. In the second step, we have done a new simulation taking into account including slots at the front of antenna and finally we did a third simulation by adding the slots at the ground plane [3].

3.1 Antenna structure without slot

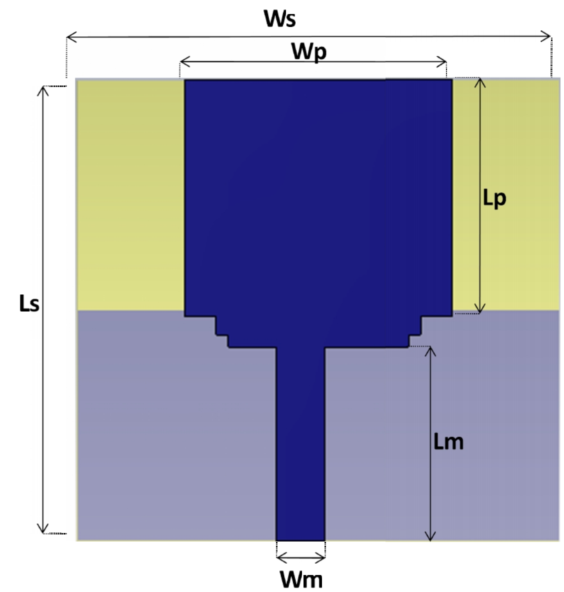

Fig 2: antenna structure without slot.

Table 1: Dimension by (mm) patch antenna.

Ws	Ls	Wp	Lp	R	Wm	Lm
40	38	22.22	19.5	7	4	15.6

The simulation of the structure is illustrated in fig 2.

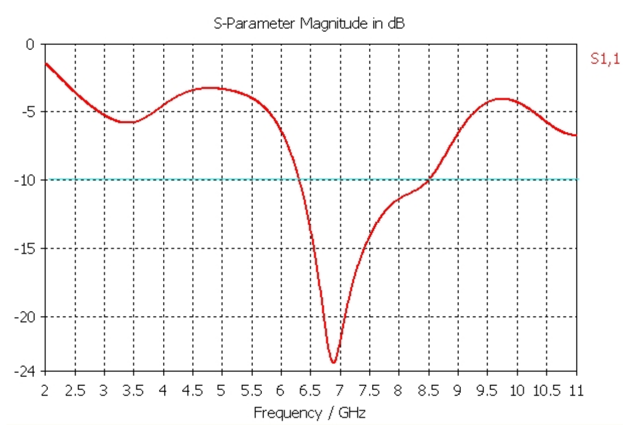

Fig. 3: Parameter S11 versus frequency.

3.2 Antenna structure with slots

In order to improve the bandwidth of the rectangular patch antenna, we have introduced slots into the antenna. The

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results are in good agreement with those done by Duroc et all [4]:

3.2.1 Slots at the antenna's front

In this part, we have studied the influence of the slots on the antenna (fig. 4) and the results are shown in fig.5.

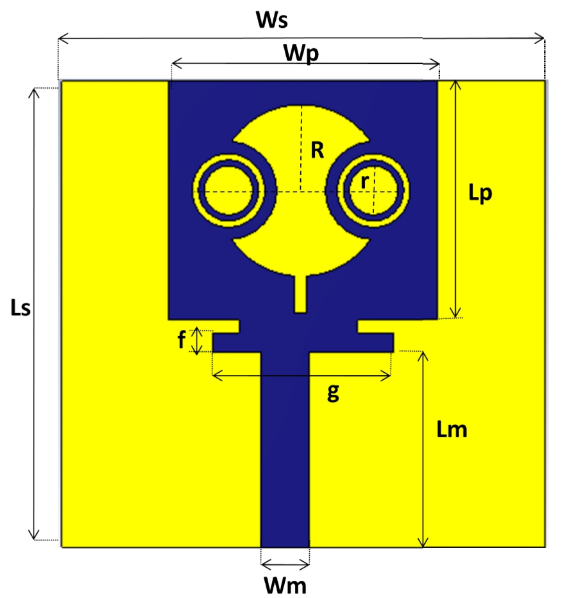

Fig 4: Antenna structure with slot.

Table 2: Dimensions in (mm) of patch antenna

g	F	R	r
15	1.6	7	2

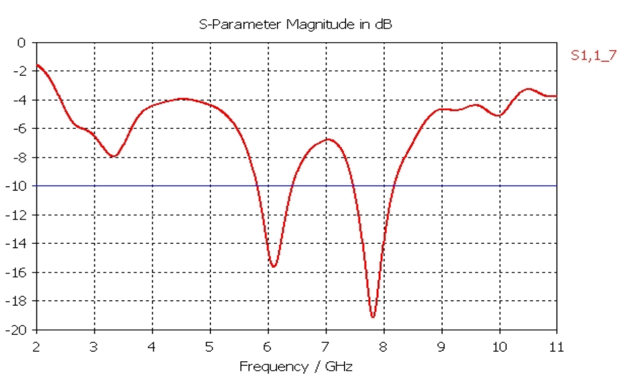

Fig. 5: Parameter S11 of the patch antenna with slots on the upper layer.

Fig.5 shows the effect of the slots on the increase of bandwidth, and we extend the insertion slots on the ground plane.

3.2.2. Slots at the ground plane

It is worth mentioning that the presence of an opening in the ground plane of a rectangular micro band patch antenna inevitably affects the resonance properties of the antenna (fig.6), it has been proved, for the micro band antennas, that this opening can be used as a way to adjust the resonance frequencies. So the point is that this opening in the ground plane adds new conception parameters that can be used as adjustments components [5].

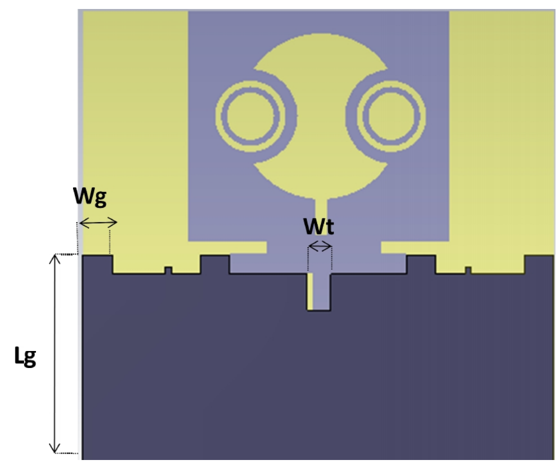

Fig 6: Slots in antenna and in ground plane.

Table 3: Dimensions in (mm).of ground plane

Lg	Wg	Wt
17.4	2.5	2

According to fig 7, we notice that we could have a band extending from 2.3GHz to 11.6 GHz thus an extension around 7 GHz compared to the first conception, hence the importance of inserting slots.

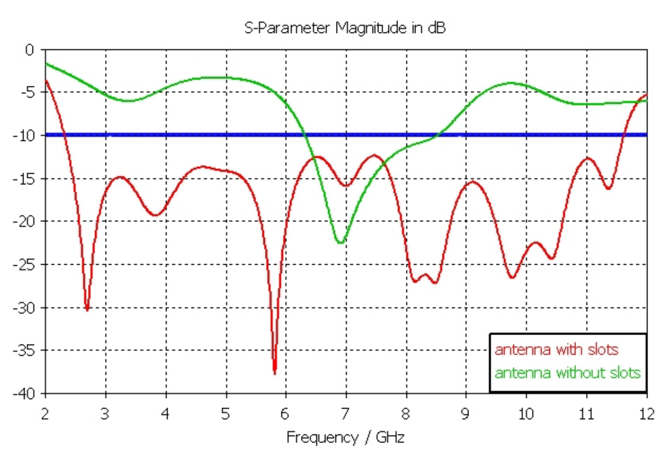

Fig. 7: Development of bandwidth.

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The radiation pattern of the simulated antenna is described in fig 8; it represents a Gain of 4.94dBi for 5.8 GHz frequency and an opening angle of 89 degrees.

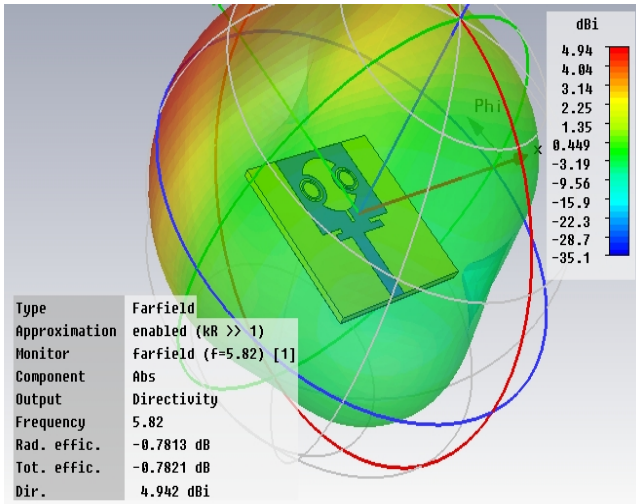

Fig.8: Radiation Pattern at f=5.8GHz.

Fig. 9 shows the simulated maximum gain of the proposed antenna. Note that the gain drops significantly at the notched bands. However, the proposed antenna shows good gain performance at other frequencies across the UWB band.

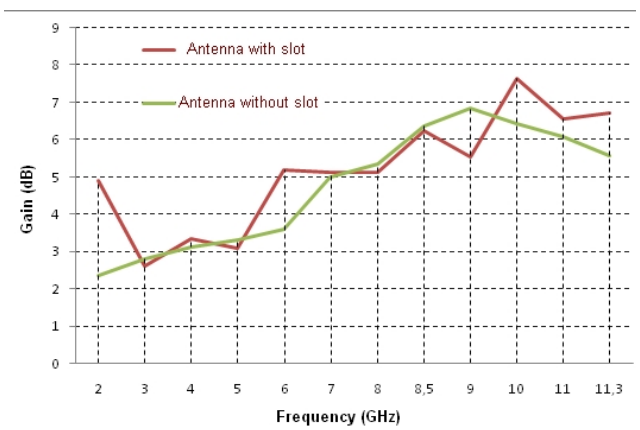

Fig.9: simulated gain are plotted here as a function of frequency.

4. Conclusion

Throughout the study and the conception of a planar antenna with a bandwidth of 2 GHz. By inserting slots at the front of the antenna and on ground plane we notice a significant improvement of this bandwidth. Thus is easy to use it in micro-wave circuits.

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