Dual Tag Antenna for UHF RFID Applications

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ABSTRACT
Continuous researches are carried out on different identification technologies. The Radio Frequency IDentification (RFID) is the well-known one.
The most RFID systems used are the passive systems based on backscattering modulation.
In this paper, analysis and design of a Dual IFA (Inverted F Antenna) Tag antenna are proposed for UHF RFID applications.
The antenna is designed to operate at 0.4 GHz and 2.4 GHz; it is fabricated on the FR4 substrate with dielectric constant of 4.4. The antenna fundamental parameters such as return loss, radiation pattern and current distribution are presented.
Simulation tool, based on the FIT (Finite Integration technique),(CST Micro Wave Studio) has been used to analyze the antenna.
The proposed dipole antenna is simple and robust in design.

General Terms
RFID (Radio Frequency Identification), Return loss, Radiations pattern, current distribution.

Keywords
RFID, Dual Band, IFA, Tag antenna, UHF, Finite Integration Technique.

1. INTRODUCTION
Contactless Identification has become a mature technology worldwide [1]; nowadays the UHF Radio Frequency Identification is the most widespread one.
An RFID system uses wireless radio communication technology to uniquely identify tagged objects or people.
There are three basic components to an RFID system, as shown in“Figure 1” [1][2]:

- A tag (transponder), which is composed of a semiconductor chip, an antenna, and sometimes a battery; “Figure 2” illustrate the tag components;
- An interrogator (reader), which is composed of an antenna, an RF electronics module, and a control electronics module;
- A controller (host), most often takes the form of a computer running database and control software.

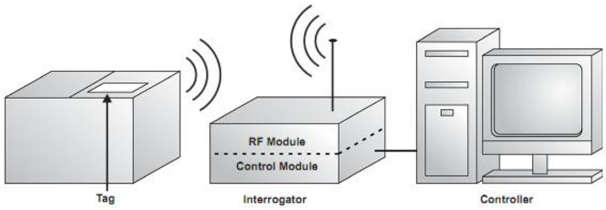

Fig1: RFID tag

2. UHF RFID TAG
We will focus our studies on the tag; which has as a basic function to store Data and transmit data to the interrogator.
As it is mentioned previously, Tag consists of an electronics chip and an antenna “Figure 2”encapsulated in a package to form a usable tag, some tags also contain batteries, and this is what differentiates active tags from passive tags.
The more used RFID systems are based on the passive tags due to their low cost.

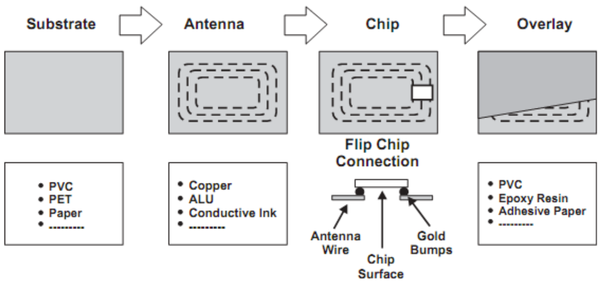

Fig2: RFID Tag Components

Passive Tags are activated and powered by the electromagnetic waves radiated or coupled by the reader. They respond via the modulation of their backscattering aperture. “Figure 3” illustrates better the passive operating; detailed description of the physical concept can be found on [1] [3].

UHF RFID system performance hinges in large part, on tag performance, and the tag, in turn relies on a handful of elements that determine its performance; the antenna being an especially critical one.

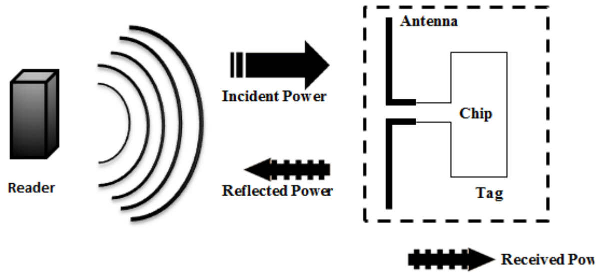

Fig3: Passive UHF RFID

3. UHF IFA Tag antenna

Small Size is among the tag's antenna challenges, many antennas manufactures are offered, like IFA (Inverted F Antenna), PIFA (Planar Inverted F Antenna), ILA (Inverted L Antenna), PILA (Planar Inverted F Antenna) and meandering configurations.

The IFAs were inspired from the λ/4 antennas. They are widely widespread in contactless applications thanks to their performances as to their simple design, their light weight, their low cost and their attractive radiation pattern. The desired length is equal to the quarter wavelength since they are resonant in this case. By using the same analogy, it was proposed the following empirical equation for finding the resonant frequency of an IFA [4][5].

$$f_0 = \frac{C}{4(W+L+H)} \quad (1)$$

Where C is the light speed, L, H and W are respectively length, width and thickness of the patch antenna, and $f_0$is the resonant frequency. Equation 1 means that the sum of the dimensions of the top plate should be equal to the quarter wavelength [3].

IFAs are considered as the antennas exhibiting good behavior on multiband frequencies.

Multiband operating is reached by some techniques like empiling, folding patches or inserting slots…..., this type of operating facilitate grasping few application on one time.

In this paper, the antenna proposed is a dual UHF IFA for RFID applications.

It operates on the 0.4 GHz and 2.4 GHz; the first frequency has as applications identification and Tracking, though the second is appropriate to remote road tolls payment; and to real-time location.

4. ANTENNA GEOMETRY

The original design was introduced in [6]. Our interest was focused on miniaturization and multiband operating.

For that, we formed the new radiating element by stacking an IFA and an ILA antennas, distant each one to other by a distance (*d2*).

The parameters having an effect on the performance of an IFA are radiating element's length (*l1*), the distance from the added patch to the principle radiating element (d2) equal to *4mm*, the used substrate and antenna's position on ground plane (*d3*).

The patch is related to the ground plane by a short circuit. We choose copper as material to design our antenna; which is closest to reality from the PEC (Perfect Electronic Conductor).

The integral antenna structure is shown on "Figure 4.a" and "Figure 4.b"; and its dimensions are presented in"Table 1".

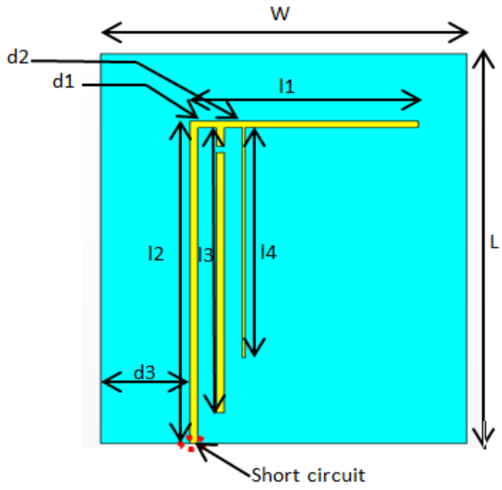

Fig 4.a: the front of the Geometry

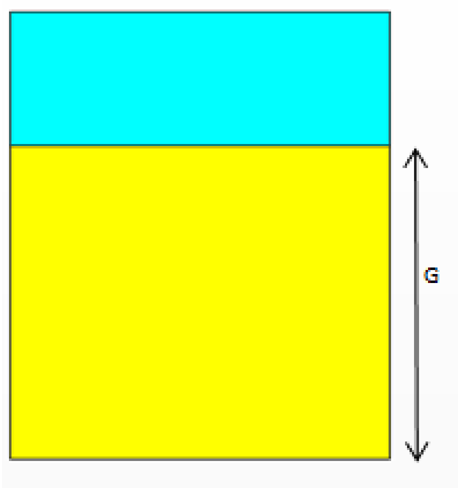

Fig 4.b: the back of the Geometry

Table 1.Dimensions of the antenna

parameters	l1	l2	l3	l4	d1	d3	W	L	G
Values(mm)	30	60	50	45	4	17	50	70	50

This antenna is printed on the FR4 substrate (*50 x 70 mm*^{2}) having a relative permittivity of $\varepsilon r = 4.4$ and a loss tangent parameter $tan\delta = 0.01$; with thickness2.4mm .

To estimate the antenna performances, we replace the chip by a discrete port.

The CST Microwave Studio® is used to perform the antenna structure.

5. RESULTS AND DISCUSSIONS

The computational method used by CST MWS is FIT (Finite Integration Technique) m.

5.1 Return Loss S11

Figures 5 and 6 illustrate the simulated return loss against frequency of the antenna.

In“Figure. 3”,we can see the return loss (S11 = -29.29dB) of the antenna, which shows that the antenna is well matched to the 400MHz frequency.

“Figure. 4” shows the return loss of the antenna at the UHF band 2.4GHz, as the first band, it is very well matched at -48.26dB.

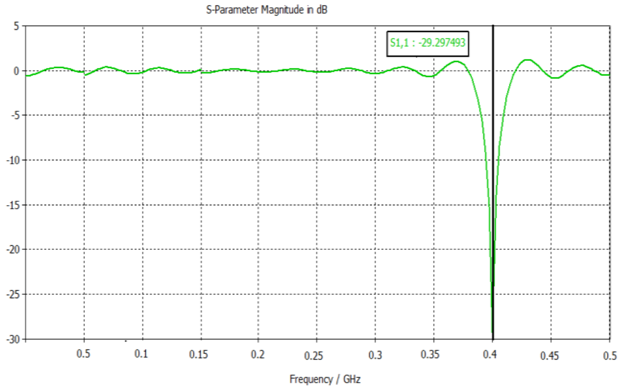

Fig 5: Return loss (S11) at 400MHz

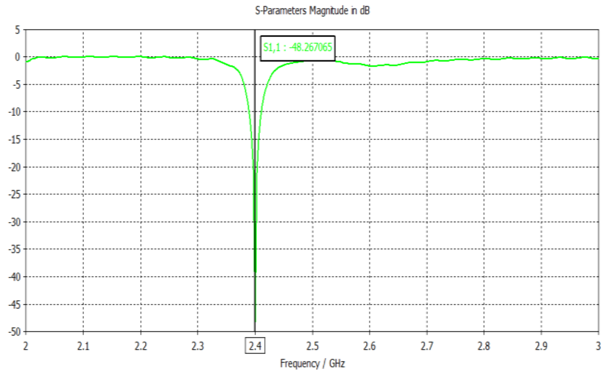

fig6: Return loss (S11) at 2.4 GHz

5.1 Radiation pattern

Figures 7 and 8 present the radiation pattern schemas in the resonant frequencies 0.4GHz and 2.4GHz.

From “Figure 7”, we can see the radiation pattern of the dual band antenna at the UHF RFID frequency of 400MHz. The radiation pattern of the antenna shows a Bi-directionnel radiation pattern suitable to the desired application witch is tracking though it needs improvement.

In the same way, in “Figure.8”, we can see the E plane of the radiation pattern of the dual band antenna at 2.4GHz, which seems reasonable regard to the application.

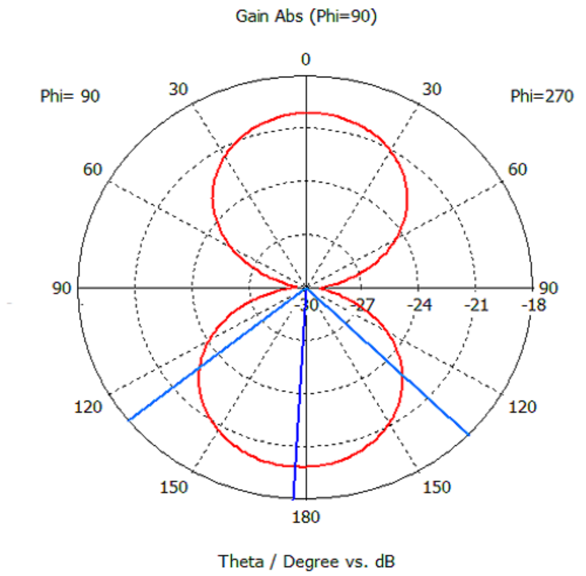

Fig7:Radiation pattern at 0.4 GHz

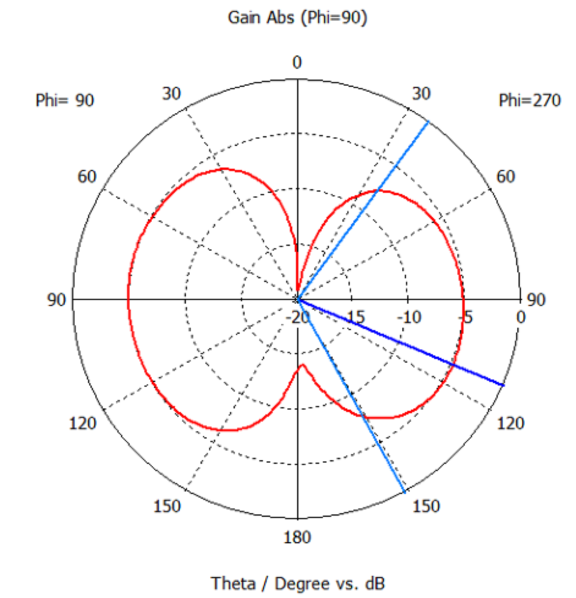

Fig8:Radiation pattern at 2.4 GHz

5.2 Current Distribution

To visualize which antenna’s area is charging to generate resonant frequencies, we show the distribution current figures:

From “Figures. 9 and 10”; we can deduce that the larger pin generates the 400MHz frequency while the smaller pin is charging to produce the second frequency.

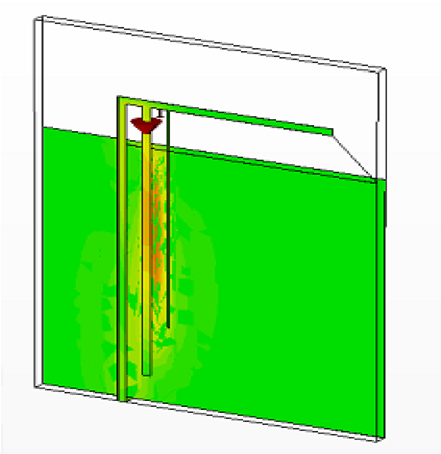

Fig8: Distribution current at 400 MHz

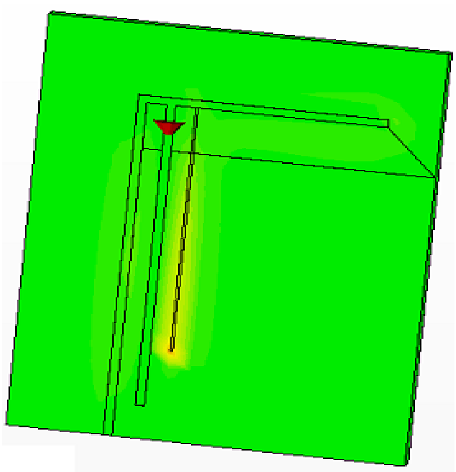

Fig8: Distribution current at 2.4GHz

6. CONCLUSIONS

IFA antennas are considered as the most appropriate antennas to wireless applications thanks to their performances, their small size and their low cost.

In this paper, we presented a bi-band UHF IFA tag antenna for RFID applications. The main challenge was to design an antenna with different resonant frequencies for separated applications in the RFID technology; we obtained doubleoperating frequencies (0.4GHz and 2.4 GHz); our antenna presents good performances suitable to the desired applications.

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