

# A Circuit Model to an Encoche Coplanar Antenna for a Radio Frequency Identification TAG

Abdelhak Ferchichi, Ali Gharsallah

Unit of research Electronics HF Systems and Circuits, Faculty of Science, El Manar University

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## ABSTRACT

In this paper, Miniature Encoche Coplanar antennas are proposed. To validate our structure and to develop an analytic method to determine the geometry parameters, the Lumped theory is used. The proposed structure is simulated using ADS and then Compared to the electrical Model. The proposed circuit has the same resonant aspect when comparing to the Encoche antenna with a much reduced simulation time. The compact coplanar antenna has a box with a size of  $36*52*0.2 \text{ mm}^3$ . This antenna will be designed to an RFID TAG that resonates on 2.45 GHz.

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## Corresponding Author:

Abdelhak Ferchichi,  
Unit of research Electronics HF Systems and Circuits,  
Faculty of Science,  
El Manar University  
Rommana 1068, Tunis, Tunisia.  
Email: [abdelhakferchichi@yahoo.fr](mailto:abdelhakferchichi@yahoo.fr)

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## 1. INTRODUCTION

RFID technology has a bright future in a future where all or objects that surround us can communicate with each other through a network such as the Internet thanks to RFID chips, this vision is called "Internet of Things". It is based on the concept of ubiquity whose goal is to provide easy communication with any object, any time and in any place. So if we ever get to this stage, there will be a disruption of our daily lives. In fact, RFID tags will be present everywhere, not only in our identity cards and passports, but also in all objects, even inside our bodies. This is the digital revolution of the next years, where all the objects that surround us can communicate with each other autonomously making the daily lives of human beings more comfortable, [1]-[6].

Some protests not reason to exist because RFID technology itself has several variants that differ mainly seen from the point of reading distance. But the problem is that the majority of actors in civil society are not expert in the technical aspects of RFID technology. This could slow down the deployment of RFID technology. However, history shows that any technology that can increase the comfort of the everyday life of citizens, managed to win despite any inconvenience that may arise.

Currently there is a need to develop an identification system for managing communication in different applications. This is because currently, there is a great difficulty for simplify identification and control operations. In the last years, many works are developed to offer an important antenna for RFID applications. In our case, we focus on RFID TAG antenna where we need to propose a miniaturized structure with acceptable parameters. In order to achieve this goal, we have seen some recent publications. First, H-D.Chen et al design a miniaturized coupled Fed TAG antenna, in their work, the polarization was circularly and the structure is mounted in a metallic surface, [7]. In [8], C-H-Lin et all present a miniaturized Inverted-F Antenna, the structure is designed to on-body communication and resonate on 2.45 GHz. Third,

R.O.Ouedraogo et al use the metamaterial techniques to propose a miniaturized patch antenna with CSSR structure, [9]. In [10], Z.Fang et al present a dipole for an active RFID TAG.

This paper is organized as follow, in the first section we will describe an ordinary planar Encoche antenna which resonate on 2.45GHz. In the second section, a novel coplanar Encoche is designed and simulated. In the third paragraph we build an electrical model to the two structures of Encoche antenna. Finally, we conclude our paper and we suggest some perspectives.

## 2. AN ENCOCHE PLANAR ANTENNA

### a. Geometry

The proposed geometry is a classical Encoche planar antenna. The structure is designed to resonate at 2.45 GHz and it is mounted on a substrate material with a thickness  $h = 1.6$  mm. the used substrate is the FR4 epoxy, Figure 1.

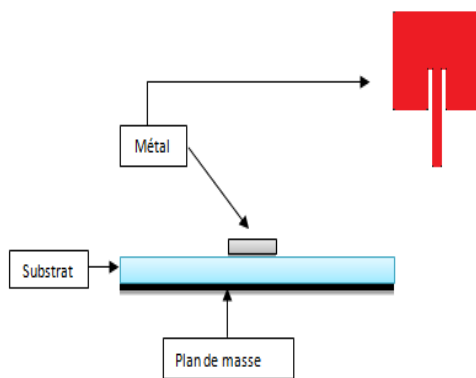


Figure 1. An Encoche planar antenna

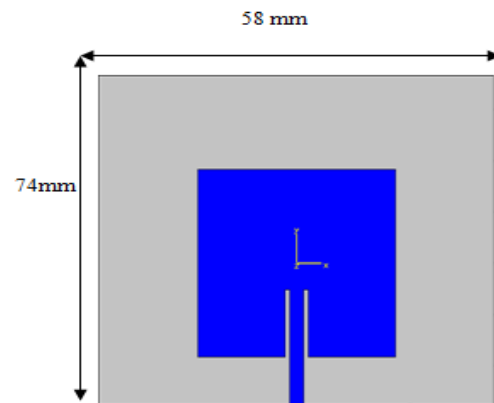


Figure 2. The geometry dimension of the Encoche antenna

The geometry dimension of the box containing the antenna is about  $58*74*1.6$  mm, Figure 2

### b. Simulation Results

The proposed antenna is simulated using ADS. As be shown in figure 3, the resonant frequency is equal to 2.45GHz, one of the RFID frequencies. The Band width is about 80MHz. which is acceptable for an RFID TAG.

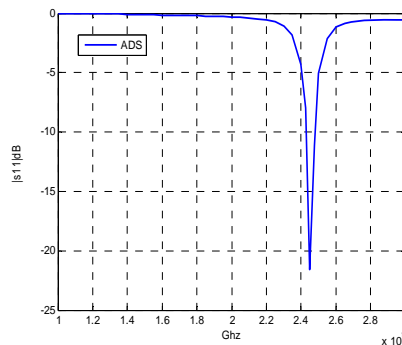


Figure 3. Simulation Results of Encoche planar antenna

## 3. COPLANAR ANTENNA AND ANALYSIS

### a. Coplanar Technique

Coplanar lines are excellent waveguides integrated. They are low-cost technology, easily achievable and propagate quasi-TEM mode. Coplanar lines have a characteristic that differentiates them from other

types of lines: all conductive strips are located on the same plane of the substrate. They have the advantage of being less dispersive compared to other types of lines.

The configuration of fields in a CPW is different when compared to planar structure. The fields are not entirely confined in the dielectric and extend in the air above the substrate. This contributes to the dispersion and radiation. The currents are highly concentrated in the edges of the conductor which increases the losses that the edges are rougher than the surface. The magnetic field is quasi-planar above the central strip, and rotates around the ribbon. The electric field is substantially planar in the slots, and loop tape to the ground planes. CPW lines are well suited for the connection of lumped elements in parallel.

CPW lines have resonances dimensional when their length is of the order of a fraction of a wavelength, for example half-wave, which means only some frequencies, can be stationary wave and there is an absorption peak of the transmission.

### b. Geometry

The Encoche coplanar geometry is different to planar one. The difference is that the ground and the patch are in the plane. We used the same substrate (FR4 epoxy). The proposed antenna is more compact and the high of substrate is only 0.2mm, Figure 4

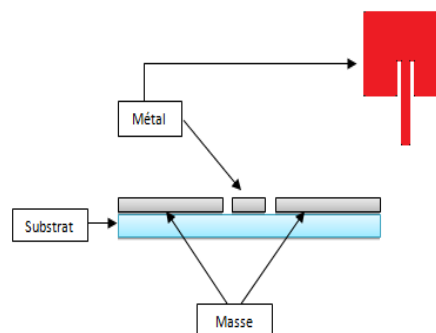


Figure 4. The Geometry of an Encoche Coplanar Antenna

The box containing antenna has a size equal to 36\*52\*0.2mm, which means a reducing of size of the antenna. The compact antenna will be very important in the case of RFID TAG.

### c. Simulation Results

The reflection coefficient  $S_{11}$  of the antenna shows a resonant frequency of about 2.45 GHz with a bandwidth of about 70MHz, Figure5. In addition, the gain is about 5.7 dB and the directivity is about 6.12 dB. The proposed antenna has acceptable characteristics for RFID systems.

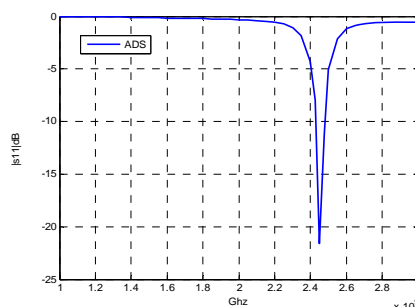


Figure 5. Return Loss of Encoche Coplanar Antenna

## 4. ELECTRICAL MODEL OF ENCOCHE COPLANAR ANTENNA

### a. Electrical Model Technique

To design antenna structures, many techniques are developed. These techniques use numerical methods based on solving the electromagnetic equations in different form. For this reason, a lot of software

has been used as ADS simulator, simulator HFSS, CST Microwave. These simulators give their full results solve the electromagnetic equations in their integral or differential forms. Those techniques can be useful in some applications but they present some limits. Firstly, we cannot take in account all kind of losses. In addition, after the simulation structures, we have no ability to control the antenna parameters such as yield loss, input impedance when modifying the geometry of the antenna, the type of substrate.

Therefore, the replacement of an antenna by an equivalent circuit is very important in the parametric analysis of the proposal structure. In this way, the model techniques are of great interest. One of these solutions is modeling of an antenna by an electric model. Construction of an electrical model means replacing antenna by a RLC circuit. As shown in previous work, [11]-[13], the electric model is used in different applications to simplify antenna design operation.

In the next section, we will build an electrical model to both planar and coplanar antenna. The importance of the lumped circuit will be seen in analytic discussion of Encoche coplanar antenna.

### b. Circuit Model of Encoche planar Antenna

The electrical model was built using the same technique as a single patch but with a few different. We followed the steps below:

1. The excitation line is replaced by the electric model of a single patch where the parameters  $r$ ,  $s$  and  $c$  are determined using the equations developed in [11];
2. The active patch is modeled by two resonant cavities. Parameters  $R$ ,  $L$  and  $C$  are calculated using the same equations of rectangular patch described in our previous works[12];
3. A coupling capacitance  $C_c$  is integrated in the structure to introduce the coupling between the excitation line and the two resonant cavities, [13].

The model is described in the figure below, Figure 6.

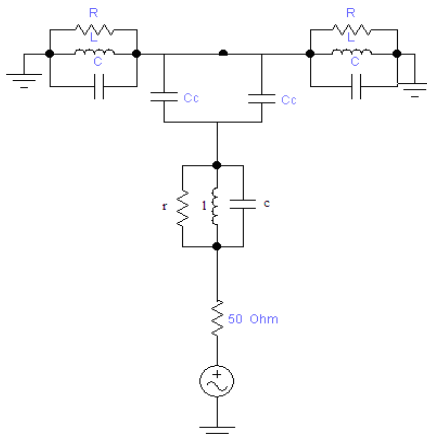


Figure 6. Electrical model of Encoche planar Antenna

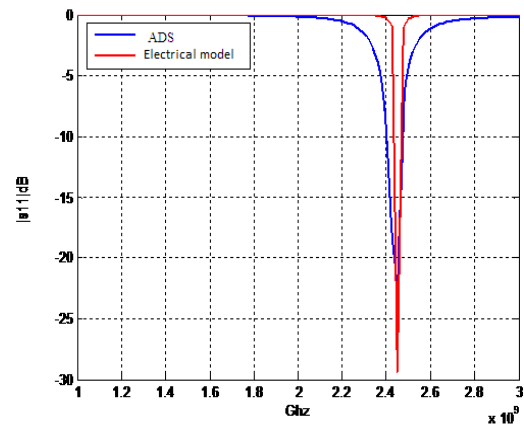


Figure 7. Simulation results of Electrical model of Encoche planar Antenna

Simulation of our structure and the electrical model give us the results shown in Figure 7.

According to the above figure, we can see that there is a good agreement between the results obtained using either the ADS or the electric model with a slight difference in bandwidth. Given the accuracy of the model built electric and speed, it was thought to control the bandwidth of this structure in the parameters of the proposed model. Our study showed that the variation of the coupling capacitance  $C_c$  modifies the BP. Indeed,  $C_c$  depends essentially on the distance between the line and the two excitation cavities forming the rectangular patch.

### c. Circuit Model of Coplanar Encoche Antenna

To build the electric model of the proposed antenna, we tried to study the geometry and introduce a specific model. The major problem in our case is the absence of ground plane unlike the planar patch that allowed us to change the technical construction of the electric model, Figure 8. This technique can be described by the following steps:

1. Determine the resonance resistance  $R$  reflecting all losses in the patch: losses in the metal, the dielectric losses, radiation losses

2. Determine the total capacitance  $C$  of the structure which is composed of 4 capacities:
  - Two capacitances of the two resonant cavities,  $C_1$
  - Two coupling capacitances between the two lines forming the CPW ground plane and the two resonant cavities,  $C_{c1}$
  - Two coupling capacitances between the excitation line and the two resonant cavities,  $C_{c2}$
  - 2 capabilities gap between the excitation line and the two lines of the CPW ground plane,  $C_g$

Finally, the total capacitance can be obtained by using the equation bellow:

$$C = 2 C_1 + 2 C_{c1} + 2 C_{c2} + 2 C_g \tag{1}$$

3. Determine the total inductance  $L$  for the resonance frequency equal to 2.45 GHz

The simulation results of the proposed model are shown in figure 9. As can be seen, we obtain the same resonant frequencies with a few differences in the band width. The variation of the band width can be resolved by an analytic discussion of the different parameters models.

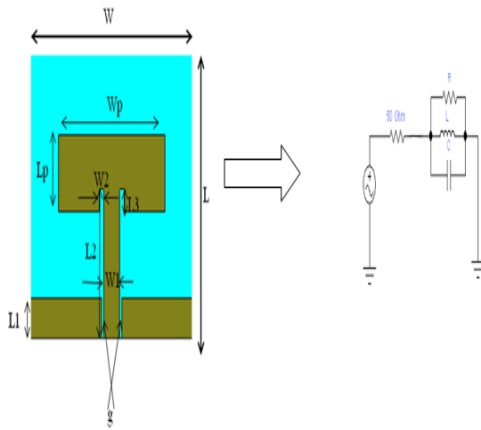


Figure 8. Electrical model of Encoche Coplanar Antenna

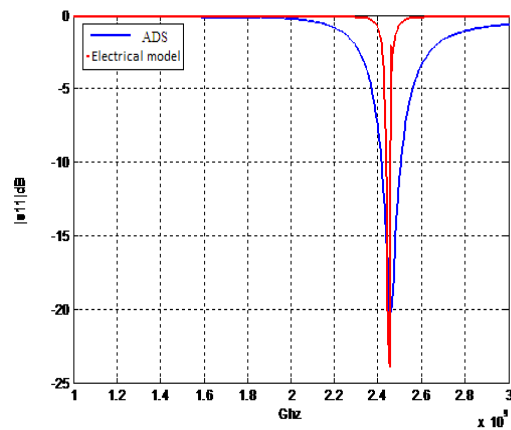


Figure 9. The reflexion Coefficient of Encoche Coplanar Antenna

**d. Comparison between the Encoche Antenna**

When comparing the different parameters of the two proposed antenna, we can see the added value by using a Coplanar Encoche antenna and the simplification of the task by using circuit model, Table 1:

Table 1. A Comparison between the two proposed Encoche Antenna

	ADS			Electrical Model		
	$f_r$ GHz	$B_{3dB}$ MHz	$T_{3dB}$ second	$f_r$ GHz	$B_{3dB}$ MHz	$T_{3dB}$ second
Encoche planar antenna	2.45	80	240	2.45	40	2
Encoche Coplanar antenna	2.45	75	280	2.45	40	2

**5. CONCLUSION**

A compact Encoche coplanar antenna is developed and proposed in this paper. The antenna is designed to an RFID TAG and it presents many advantageous comparing to a classical planar Encoche antenna. The use of a simple and an efficient circuit model was very useful and helps us to do a good analytic study. Besides, the simulation time was reduced which means a fast tools of simulation.

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**BIOGRAPHIES OF AUTHORS**

**Abdelhak Ferchichi** is an Assistant Professor of electrical engineering. Since 2006 he has been with the faculty of Science of Tunis. His current research includes Antenna, RFID Technology, and Substrate Integrated Waveguide SIW.



**Ali Gharsallah** is a Professor of electrical engineering. Since 1991 he has been with the Faculty of Science of Tunis. His current research interests include antennas, multilayered structures and microwave integrated circuit.