Study and Design of anAarray Meandering Dipole Antenna for RFID Applications

Loubna BERRICH, Lahbib ZENKOUAR

Abstract—Radio-identification, more often referred to as RFID ("Radio Frequency Identification") is a method for remotely storing and retrieving data using markers called radio tags ("RFID Tag").The most used antennas for the RFID application are of the planar dipole type. To design the antenna, it's must have an impedance value equal to the conjugate of the impedance of the integrated circuit CI. To have a good adaptation allowing the maximum transfer of power, there are several techniques. In this work, in a first place, we are interested in the adaptation technique T-match which is based on the insertion of a second folded dipole in the center of the first dipole. This technique is modeled by an equivalent circuit to be able to calculate the size of the folded dipole to have a new input impedance of the antenna equal to the conjugate of the impedance of the IC. To decrease the physical length of an antenna without reducing its electrical length, we used the miniaturization technique. In a second place we designed an array planar dipole antennas meandering and adapted by T-match techniques. The results obtained by the Ansoft HFSS platform, allowed us to obtain almost uniform radiation diagrams and return loss that exceed -37 dB.

Index Terms— Radio Frequency Identification (RFID), RFID tag; Dipole antenna, IC integrated circuits, T-match technique, Impedance matching, Microstrip dipoles, Meanders.

1 Introduction

These last years, Radio Frequency Identification (RFID) has become more and more popular in many applications, such as logistics, supply chain management, asset tracking, and vehicle positioning. Among a variety of RFID systems using radio frequencies, a UHF RFID system has attracted a lot of attention because of its many benefits, such as cost, size, and long-range reading. In these radio communication systems the antenna is a key element for radiofrequency designers. This technology makes it possible to identify an object, to follow the path and to know its characteristics from a distance thanks to a label emitting radio waves, attached or incorporated into the object. RFID technology allows the reading of labels even without direct line of sight and can cross thin layers of materials (paint, snow, etc.). In this research work, we introduced the T-match adaptation technique. Then, we have reduced the physical length dipole palanire without reducing its electrical length, then we designed an array planar dipole antennas meandering and adapted by the T-match techniques. Simulation results obtained by the right dipole antenna, designed by the Ansoft HFSS platform that is based on the Finite Element Method (FEM). The theoretical model of the dipoles considered in this research work, is a wired microstrip model with a sinusoidal distribution of the current density, very suitable for evaluating the radiation characteristics of many antennas such as dipoles. The results obtained by the Ansoft HFSS platform, allowed us to obtain almost uniform radiation diagrams and return loss that exceed -37 dB.

2 Thory

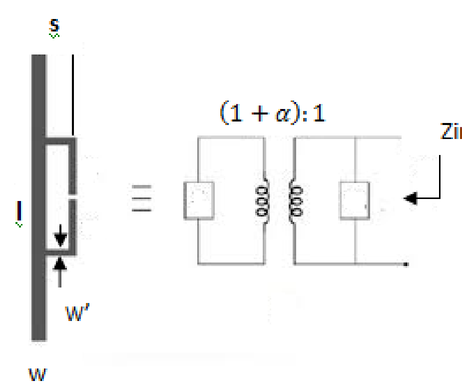
2.1 T-match Technique

T-match is a technique of impedance matching of the antenna microstrip dipoles. With this method, the planar dipole length l and width w is connected to a second planar dipole length l′ such as (l′< l) and width w′, placed at a distance (s) from the first dipole center (fig.1 (a)). This second dipole is considered a folded dipole two-legged. T-match behaves like the equivalent circuit, shown in fig.1 (b). It can be proven that the impedance at the antenna point source is given by:

$$Z_{in} = R_{in} + jX_{in} = \frac{2Z_t\,[(1+\alpha)^2 Z_a]}{2Z_t + [(1+\alpha)^2 Z_a]} \quad (1)$$

$\alpha = \frac{ln(s/r_{e'})}{ln(s/r_e)}$ is the current division factor between the two conductors of length s, with $r_e = 0.25w$ et $r_{e'} = 0.25w'$

$Z_t = jZ_0 \tan\left(\frac{Kl'}{2}\right)$ is the impedance of short stub input, formed by the transmission line of two conductors of length $l'/2$, width w and w′ and the separation s (fig.2), with K= $2\pi/\lambda$ is the wave number, $Z_0 \cong 76log_{10}\left(\frac{s}{\sqrt{r_e r_{e'}}}\right)$ is the characteristic of the two-conductor transmission line impedance (fig.1).



(a) (b)

Fig. 1. T-match : (a) For a planar dipole (b) The circuit equivalent.

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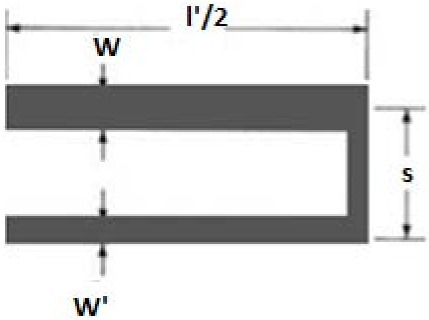

Fig. 2. Short-circuit formed by the transmission line of two conductors of length « l'/2 », width "w" and "w" 'and the separation "s".

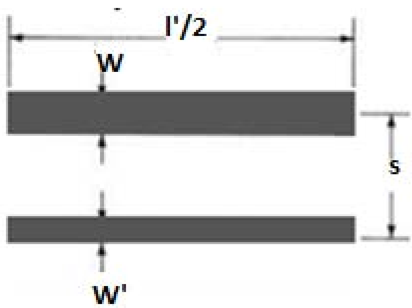

Fig.3. Transmission Line has two conductors

The geometrical parameters, l′, s and w′ of T-match, may be added to have an antenna input impedance Z_{in} equal to the conjugate of the impedance of integrated circuitZ_{Ic} . For this we have designed a planar half-wave dipole antenna, to compare the results of suitable antenna with T-match using the platform Ansoft HFSS.

2.2 Array Antenna

The use of a unique printed antenna may be insufficient to meet the imposed radiation constraints. the performance of printed antennas, especially gain and directivity, can be improved by integrating several resonator prints on the same substrate to form an array antenna. The excitation network may have various architectures as needed. All power structures are assumed to be uniform from a power distribution point of view (the print must be fed with the same power). It must be emphasized that the signals emitted by the sources all have the same frequency as a function of time.

3 Simulation and Results

Figure (4) shows the antenna proposed for this work. It is a design of a planar dipole antenna with meanders adapted with the T-match technique. The length of the planar dipole before folding is 21 = 92 mm and of width w = 3 mm, after the miniaturization of our antenna the physical length becomes 2l = 52 mm on the HFSS platform, it operates on a resonant frequency 5.8 GHz. The substrate was chosen as the FR4 epoxy having a relative permittivity εr = 4.6 and the height is 1.8 mm.

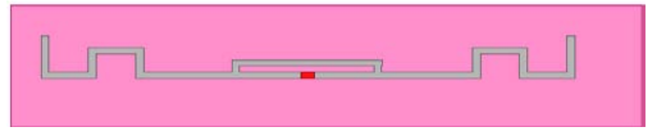

Fig.4. Meandered dipole antenna adapted with t-match

The simulation result of our planar dipole antenna with meanders gives a reflection coefficient S11 = -37 dB, it means that our antenna is well adapted.

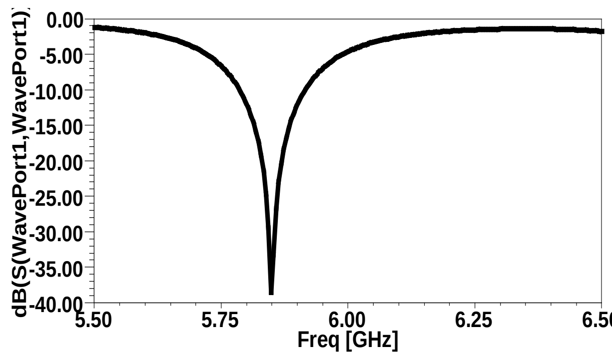

Fig.5. Return loss of the meander antenna

Another primordial character for knowing the parameters of the antenna is the two-dimensional radiation pattern in Plans E & Plan H which is illustrated in Figure (6), which represents 2 main lobes.

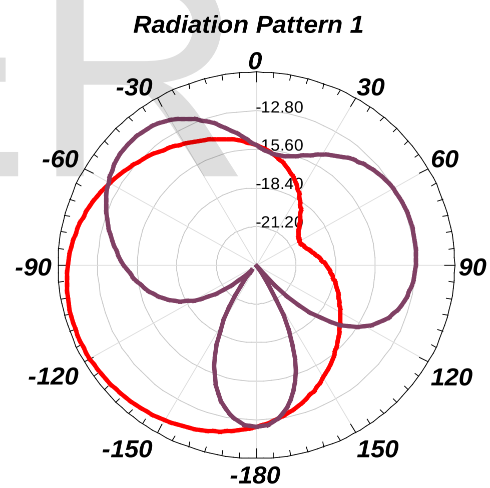

Fig.6. Radiation pattern of the dipole antenna

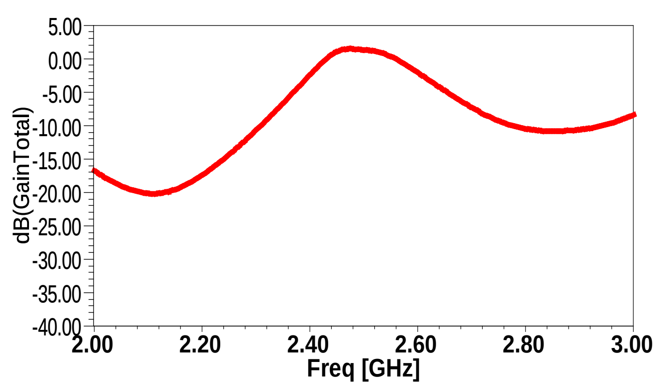

Fig.7. Gain of antenna

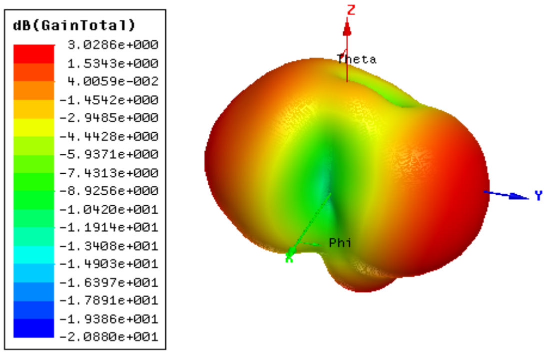

Fig.8. Radiation diagram

The maximum gain of the planar dipole antenna with meanders is 3 dB.

The geometrical configuration of a meandering antenna array in wired technology is shown in fig.9:

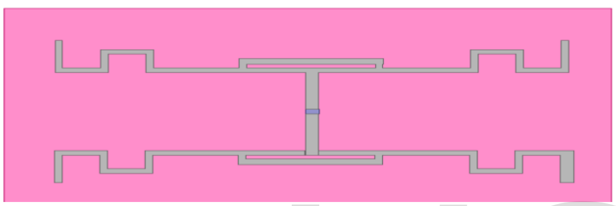

Fig.9. Structure of Array dipoles antenna

The simulation of the dipole antenna array that resonates at the 5.8 GHz resonance frequency gives the following results: Fig.10 shows the reflection coefficient of the network, S_11 = -43dB.

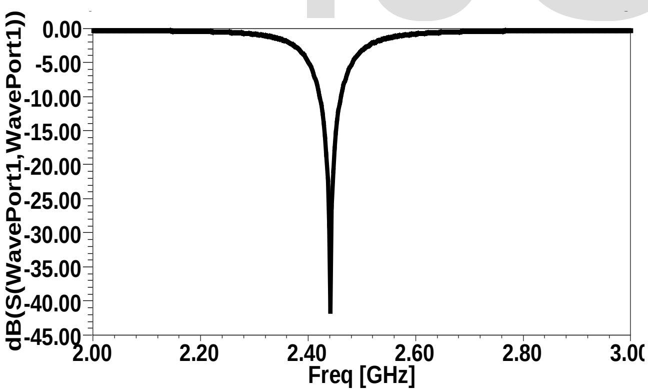

Fig.10. Return loss of array antenna

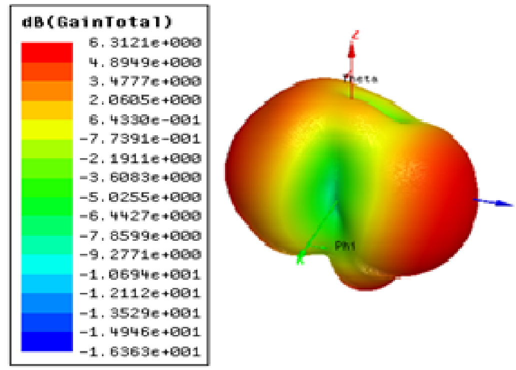

Fig.11. Radiation diagram of array antenna

The maximum gain of this meandering wired antenna array is 6 dB.

4 Conclusion

In this work, we presented the study and the design of a meandering planar dipole antenna adapted with the T-match technique, adding a folded dipole with two legs. Then the design of array planar dipole antennas to improve the results obtained. The simulation tool used in this work is the Ansoft HFSS software, which give satisfactory results for our proposed antennas, minimal reflection with a return loss exceeding -37 dB, a gain of 3 dB. For the array meandering planar dipole antenna and adapted with the T-match technique we obtained as a result a return loss of -43 dB and a maximum gain of 6 dB. The results obtained in this work are very satisfactory for our intended application.

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