A New Compact and Low loss UHF RFID TAG

Latifa El ahmar[1,2*], *Ahmed Errkik*[1], *Ilham Bouzida*[2], *Anass El Mamouni*[3], *Ridouane Er-Rebyiy*[4]
1 Hassan First University of Settat, Faculté des sciences et techniques Settat, LMIET, Morocco
[2]Digitalization & Microelectronics Smart Devices laboratory, MAScIR, Morocco
[3] LABTIC ENSA of Tangier, University of Abdelmalek Essaadi, Tetouan Morocco
[4]EMSI Marrakech, Morocco

Abstract. This paper aims to present a new compact and low loss UHF RFID TAG using meander technique to obtain a miniaturized Design validated to operate in Moroccan UHF band. The proposed RFID TAG is designed on PI substrate with a relative dielectric constant of 3.5, tangent loss of 0.0027 and height0.0508mm. Using an EM solver, the proposed design is matched to ALIEN H3 microchip with $Z_{Microchip}$=30.39-i*211 Ohm, it's simulated and confirmed in Moroccan UHF band with a return loss around -20.49dB at 868MHz with a bandwidth of 16.8MHz, a simulated gain 1.82dBi and a good theoretical read range about 2.6m. The global dimension of the structure is 25×70 mm^2 which is $\lambda/14 \times \lambda/5$ mm^2, it's very suitable for RFID applications that required a compact and integrated RFID TAG with a middle-read range.

1 Introduction

The RFID technology is an automatic technology which uses radio waves to identify physical items. A RFID system comprised of two parts: a hardware part composed of (RFID TAG, RFID reader and antennas) and software part consists of a RFID middleware. The interaction of RFID tag and reader/antennas permits to collect an electronic product code (EPC) in real time associated to physical item, as shown in Fig.1.

The RFID TAG is divided in three types: passive TAG, active TAG and battery assist passive TAG, this classification is based on the power mode (internal or external source power). The passive TAG is more used in RFID applications for their properties: low cost and high read range. Passive tags can use three bands of frequencies: Ultra high frequency (UHF) band [860-960MHz], High frequency (HF) at 13.56MHz and Low frequency band (LF) [125-134KHz].

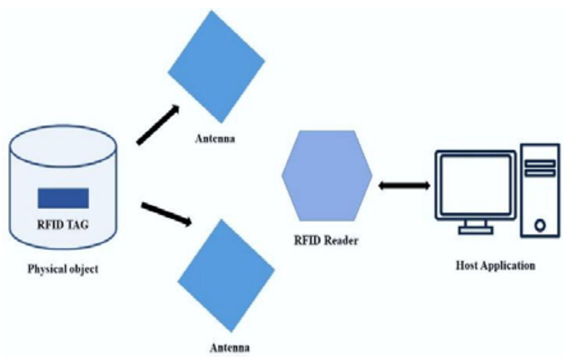

Fig.1. RFID System architecture.

In last decades, RFID technology has been used in industrial applications due to data accuracy, less sources of errors, low cost, and efficiency of RFID devices, also, RFID TAG could have more functionality and give more information associate to other sensors. [1-2]

This present work aims to study a new structure of RFID passive tag validated to operate in Moroccan UHF band using meander technique. The meander technique shows considerable interests due to capability to reduce the length of a dipole antenna specially in small frequency bands such UHF bands which theoretically gives antennas with large dimensions. This paper is organized as a following outlines: The 2^{end} section is devoted for presentation of meander line technique, the proposed RFID TAG Design and its characteristics presented in 3rd section, the 4th section is dedicated to present and analyse the EM simulation and in last section a conclusion and perspectives in future.

2 Meander line technique

The meander line technique is one of the techniques used to reduce the antenna sizes from length λ_0 to a length less than 0.1 $\times\lambda_0$.

A meander line antenna (MLA) is a microstrip antenna, it consists of horizontal and vertical segments, this combination forms turns. The MLA behaves as a resonant LC circuit, the horizontal segment acts as capacitor and vertical segments reacts as an inductor. The number of turns N is related directly to the resonance frequency, enhancing the number of turns decrease the resonance frequency. As illustrated in Fig.2. [3-7]

The total inductance L and capacitance C are computed from equation (1):

* Corresponding author: l.elahmar@uhp.ac.ma

- Total inductance L_T:

$$L_T=\frac{L\times l}{2} \quad (1)$$

With L is inductance per unit length and l is the length of meander line.

- Total capacitance C_T:

$$C_T=C\times l \quad (2)$$

With C is capacitance per unit length and l is the length of meander line.

The theoretical length of MLA id defined in equation (3):

$$N\times S=\frac{\lambda}{10} \quad (3)$$

With: N number of turns, S spacing between two parallel vertical segments.

The characteristics impedance of MLA is identified in equation (4):

$$Z_0=27log(\frac{2\times S}{d}) \quad (4)$$

With d dipole diameter.

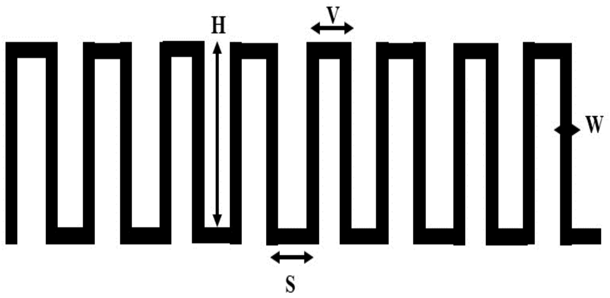

Fig.2. Meander line antenna structure.

3 RFID TAG Design

The art and science of UHF passive TAG Design has been known as a very motivated field of research. An understanding of basics RF physics is obligate to select the best RFID TAG for customer's requirements for their applications.

The RFID TAG has several characteristics that must be validated and considered during the design flow and the applications requirements. Those parameters are listed: Radiation pattern, Gain, Bandwidth, input impedance, Maximum reading distance and impedance coupling. A passive RFID TAG consists of an RFID TAG antenna coupled to a RFID microchip. To ensure an excellent power transmission between RFID TAG antenna and microchip, a highly matching impedance is required as verified in equation (5):

$$Z_{Antenna}=Z^{*}_{Microchip} \quad (5)$$

The purpose of this paper is focusing on a miniaturization of the RFID TAG with low loss. The proposed RFID TAG is designed at 868MHz using meander technique, it's composed of two inverted meander line arms with 8 turns. This design aims to have a TAG RFID highly suitable for difficult application conditions due to the excellent properties of PI, such as: Flexibility, low density, strength, Corrosion resistance and durability. Fig.3 presents the geometry of the proposed RFID TAG and Table 1 lists the electrical specifications of used material.

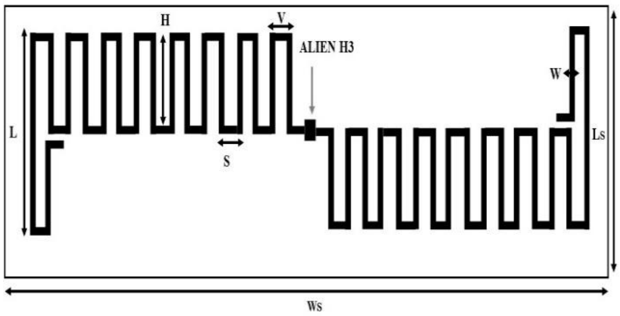

Fig.3. The proposed RFID TAG design.

Table .1. Material Specification

	Dielectric constant	Loss	Thickness [mm]
PI	3.5	0.0027	0.0508
Silver	PEC		0.01

A parametric study and optimisation are carried out to reach the proposed TAG RFID design, which is matched to ALIEN H3 microchip with a complex impedance $Z_{Microchip}$=30.39-i*211 Ohm at 868MHz. The proposed RFID TAG is consisted of two inverted meander arms with 8 turns in each arm. To attempt optimal parameters at 868MHz an EM simulation is done using CST MWS. Table 2 summarizes the optimum parameters at 868MHz.

Table 2. Optimal parameters of the proposed RFID TAG at 868MHz.

	Parameter	**Value [mm]**
Meander line antenna	W	0.5
	V	2.27
	H	11.99
	S	4
	L	22.51
Substrate	Ls	25
	Ws	70

4 Simulation results and Discussion

An EM simulation is done using CST MWS to evaluate the parameters of the RFID TAG. In Fig.4, presents a simulated return loss versus Frequency /GHz, the proposed RFID TAG demonstrates at desired frequency 868MHz a S11=-20.49dB with a bandwidth of 16.8MHz.

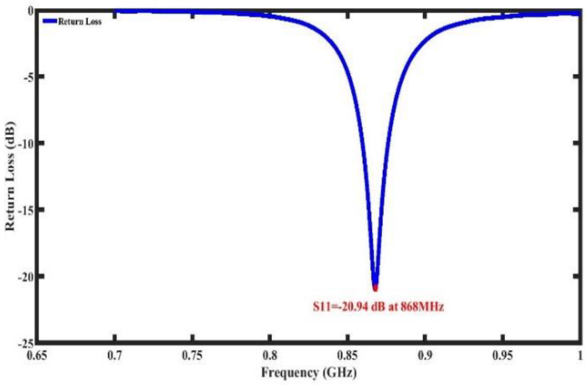

Fig.4. Return loss Vs Frequency /GHz of proposed RFID antenna.

Fig.5 presents a simulated VSWR of the proposed RFID TAG versus Frequency/GHz. The simulated VSWR is around 1.19 at 868MHz, which describes that 99.68% of the power is transmitted to the microchip and 0.32% is reflected. The designed RFID TAG shows a peak directivity of 1.8dBi and an angular width 89.9°, as presented in Fig.6.

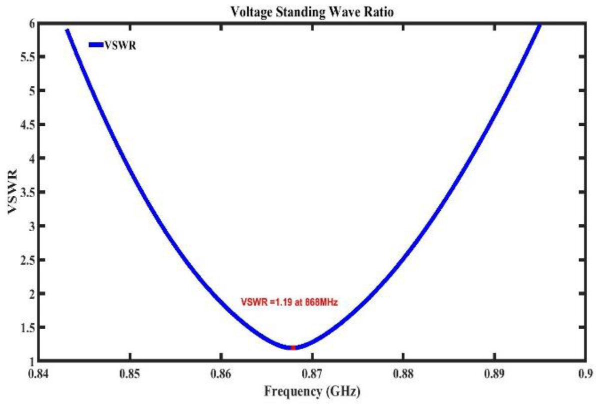

Fig.5. VSWR Vs Frequency /GHz of proposed RFID TAG.

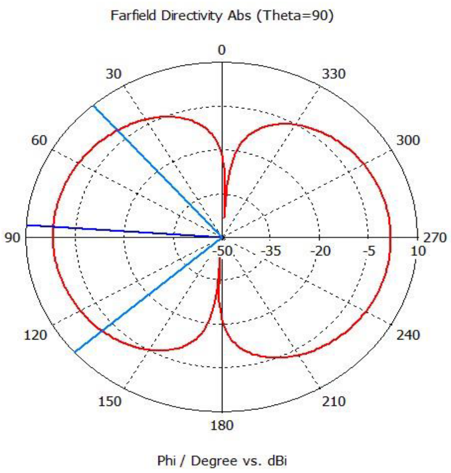

Fig.6. Radiation pattern Vs Frequency /GHz of proposed RFID TAG.

The proposed RFID TAG is designed to ALIEN H3 microchip with impedance $Z_{Microchip}=30.39\text{-}i*211$ Ohm at 868MHz. As presented in Fig.7, the simulated input impedance of the proposed RFID TAG antenna demonstrated is about $Z_{RFID\ TAG\ Antenna}=26.69+i*216.2$ Ohm, it is closely around the conjugate of the microchip impedance. The proposed RFID TAG has been shown an excellent peak gain around 1.82dBi at 868MHz, as shown in Fig.8.

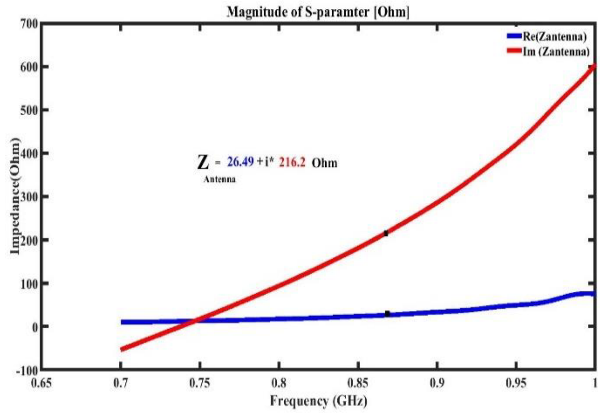

Fig.7. Simulated input impedance Vs Frequency /GHz of proposed RFID antenna.

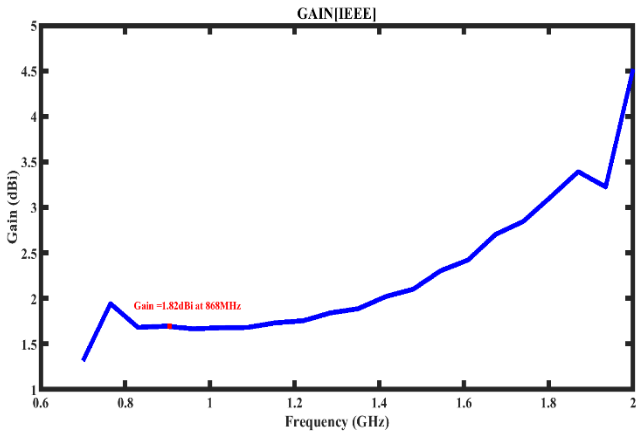

Fig.8. Simulated gain Vs Frequency /GHz of proposed RFID TAG.

Passive UHF RFID TAGs can achieve a long-read range, this criterion is required in RFID application, that demands a large distance of reading. theoretically is defined from FRIIS uplink formula, which is defined in equation (6).

$$\text{Distance}=\frac{\lambda}{4\pi}\sqrt{\frac{P_t G_t G_r}{P_{th}}} \qquad (6)$$

Using equation (6), the reading distance is plotted as a function of the frequency/GHz. As illustrated in Fig.9, the proposed RFID TAG offered a read range about 2.6 m at 868MHz, which is a meddle read-range more suitable for applications such control access for employees or tracking metallic products that needs flexible and adhesive RFID TAG.

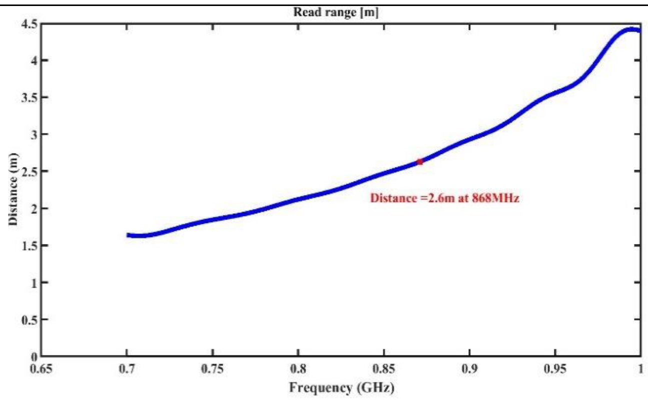

Fig.9. Simulated read range Vs Frequency /GHz of proposed RFID TAG.

5 Conclusion

In this paper, a new RFID TAG is presented using meander technique. The proposed RFID TAG is validated to operate at UHF band especially the Moroccan band[867,5-868MHz], with a return loss -22.49dB at 868MHz and bandwidth of 16.8MHz. It is offered an excellent gain around 1.82dBi and a good read range 2.6m suitable for applications, that's required a middle-read range. The proposed RFID TAG proved a good matching impedance with an input impedance closely around the conjugate of the microchip impedance $Z_{\text{RFID TAG antenna}}$=26.49+i*216.2 Ohm and with conjugate impedance of the microchip $Z^{*}_{Microchip}$=30.29+i*211Ohm. The miniaturized size of the structure is 25×70mm^2 which is $\lambda/14 \times \lambda/5$mm^2, the proposed RFID TAG is suitable for RFID application which required an integrated RFID TAG. The future perspective is to fabricate this structure using ink jet method and test the validation of the simulation results by a reading test using an RFID base station.

References

1. J. Kwangho and S. Lee. *A systematic review of RFID applications and diffusion: key areas and public policy issues.* JOItmC. **1** (2015)
2. Nambiar, Arun N. *RFID Technology: A Review of its Applications.* WCECS (2009).
3. Gonzalez, R. Meneses and L. Montes Peralta, *Antenna Design based on Meander Line Technique to be applied to RFID tag*, WSN, **44** (2016).
4. L.Ying et al, *Design of a Meander Line Dipole RFID Tag Antenna for Temperature Sensor*, ICE2ME (2019).
5. S.Bhaskar,& A.K. Singh, *A Compact Meander Line UHF RFID Antenna for Passive Tag Applications*.PIER, 99, **57-67** (2021).
6. P.Wongsiritorn, C.Phongcharoenpanich,, D.Torrungrueng,& M.Krairiksh ,*Meander-Line UHF RFID Tag Antenna with Semi-Circular Structure*, ISAP (2009).
7. X.L.Travassos, A.C .Lisboa, & D.A. Vieira, *Design of Meander-Line Antennas for Radio Frequency Identification Based on Multiobjective Optimization* ,Int J Antennas Propag, **1-5**(2012).
8. B.D.Braaten, M.T.Reich & J. Glower, A *Compact Meander-Line UHF RFID Tag Antenna Loaded With Elements Found in Right/Left-Handed Coplanar Waveguide Structures,* EEE Antennas Wirel. Propag. Lett*, 8*, 1158-1161(2009).
9. K.Rao, P.V.Nikitin, & S.Lam, *Antenna design for UHF RFID tags: a review and a practical application*, IEEE Trans. Antennas Propag*, 53*, **3870-3876** (2006).
10. M.Rokunuzzaman, M.T.Islam, W.S.Rowe, S.Kibria, M.Jit Singh, &N.Misran, Design *of a Miniaturized Meandered Line Antenna for UHF RFID* Tags, *PLoS* ONE,**11**(2016)