New Design of RFID TAG Using the Non Uniform Transmission Lines

Mohamed Boussalem, Mohamed Hayouni, Tan-Hoa Vuong, Fethi Choubani and Jacques David

Abstract The issue of our paper is to expose an original technique to improve the performance of RFID TAG in terms of its geometric dimensions and radiation pattern. This technique exploits the non uniform transmission lines (NUTLs) features to design the passive antenna element on the RFID TAG. We have yet demonstrated that geometric dimensions are reduced and the radiation pattern of the tag was improved by such use of NUTLs. Optimization of the profiles of the different elements of non uniform Lines achieves the appropriate radiation diagram and improves the radiation intensity, consequently.

Keywords Nutls · Hill equation · RFID antenna · Radiation intensity · Radiation pattern · Effective angle

1 Introduction

To improve the performance of microwave circuits and particularly the passive RFID tags suggested the use of non uniform transmission lines due to their appropriate frequency behaviour [1].

Their fundamental property allows the reduction of the geometric dimensions and improvement of the tag's radiation pattern [2, 3] .The analysis of such structures is achieved by a numerical calculation program based on the work of Hill, which consists of determining the general solution of the propagation distribution equation of the electric and magnetic fields and deducing the accurate model of the transmission line. Therefore, several non uniform transmission lines with various profiles (hyperbolic, linear and exponential) have been analyzed. Their contribution

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to improve the pattern and reduce the dimension of passive antenna RFID TAG has been experimentally validated.

2 Analysis of NUTLs

The modelling of a non uniform structure passes by determining the explicit expression describing accurately its behaviour and deducing its scattering matrix S.

The first step is to derive the propagation equations adequately for the non uniform profile. Secondly, we perform mathematical manipulations to transform these equations in the form of a traditional Hill's equation without a first derivative term. Next, the obtained equation is solved using the Floquet theorem, to explicit the general and particular solutions, respectively. Finally, we use these solutions to calculate the different elements of the scattering matrix S of the lines. More investigations will be carried out to validate this analytic approach and by further developments and experimental prototypes. Results obtained of a simple, exponential and hyperbolic lines optimized to resonate at a fundamental frequency equal to 1 GHz (Figs. 1, 2 and 3) are showed in Table 1.

Actually, the non uniform transmission lines have a frequency behaviour which strictly depends upon their forms and their profiles of non homogeneity. While the transmission structures resonate in a regular multiple of fundamental frequencies, the non uniform lines resonate on frequencies which are different from integer multiples of fundamental.

3 Experimental Application of LNUT

Our methodology consists of replacing uniform structures present on the RFDI TAG and its passive antenna, by equivalent non uniform parts. Indeed, classical passive RFID TAGs in microwave are based on elements used as antennas [4]. Usually, these elements are designed like uniform transmission lines.

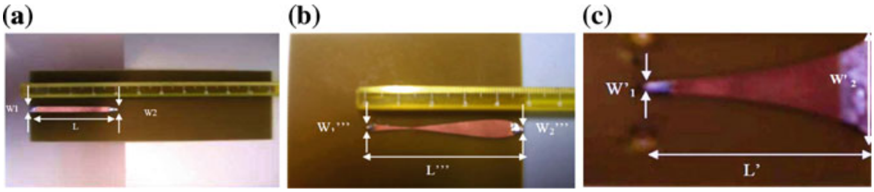

Fig. 1 **a** Simple λ/4 short-circuits line W1 = 2.988 mm, W2 = 2.88 mm and L = 3.14 cm substrate: epoxy 1.52 mm. **b** Non uniform λ/4 short-circuits line with linear and hyperbolic profile W1‴ = 2.988 mm, W2‴ = 2.88 mm and L‴ = 4.73 cm Substrate: Epoxy 1.52 mm. **c** Non uniform λ/4 short-circuits line with exponential profile, W1′ = 2.988 mm, W2′ = 2.88 mm and L′ = 4.73 cm substrate: epoxy 1.52 mm

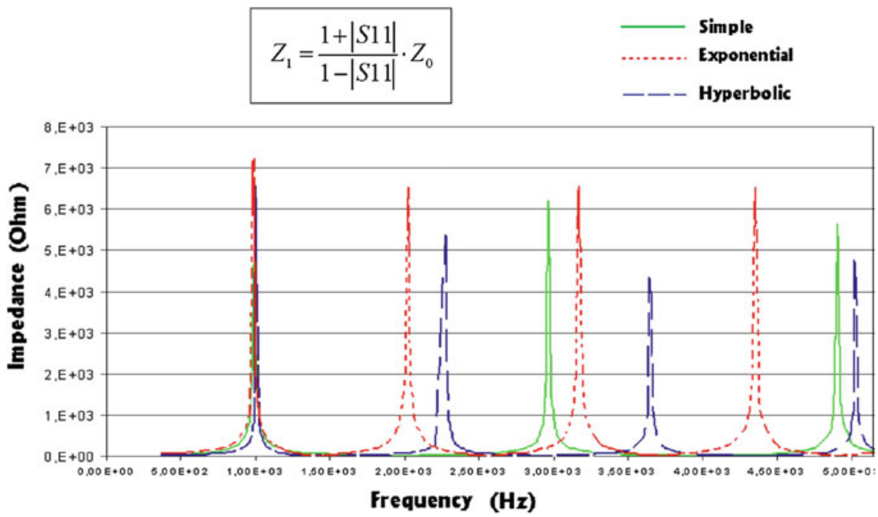

Fig. 2 Impedance of different NUTLs depending on the frequency

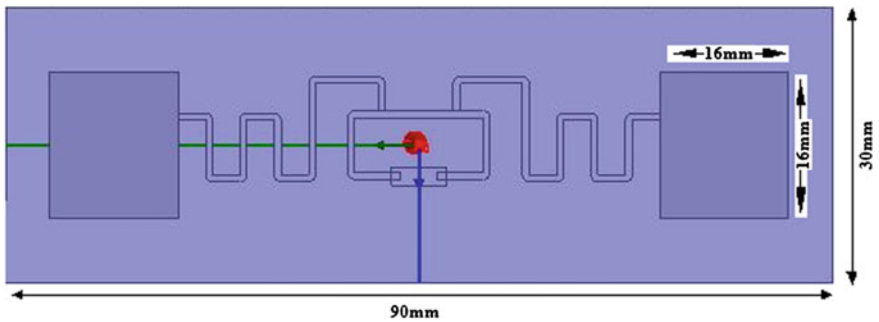

Fig. 3 Passive UHF RFID tag designed with simple lines

Table 1 Resonant frequency of simple and non uniform lines

	Fundamental frequency (GHz)	1st harmonic frequency (GHz)	2nd harmonic frequency (GHz)
Simple line	1	3	5
Exponential profile	0.95	2.14	3.43
Hyperbolic profile	1	2.3	3.6

The purpose of this work is to develop the same printed circuit structure for both types of RFID chips that operate on two separate frequencies, one at 2.45 GHz and the other at 5.8 GHz. With a Substrate: FR4 (Epoxy glass) and Tag Size: 30 × 90 mm.

Figures 4, 6 and 8 perfectly illustrates the value of using "NULTs" in this type of device. We expect RFID chips in our industrial partner to validate our concept and contribution of adjustments according to the results of measurement campaigns (Figs. 5 and 7).

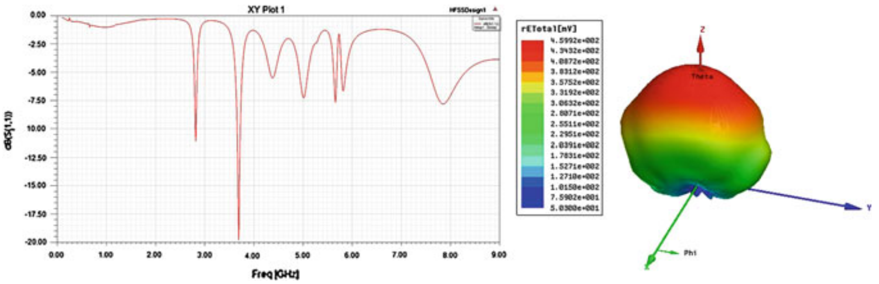

Fig. 4 Operating frequency and radiated pattern of RFID TAG designed with simple lines

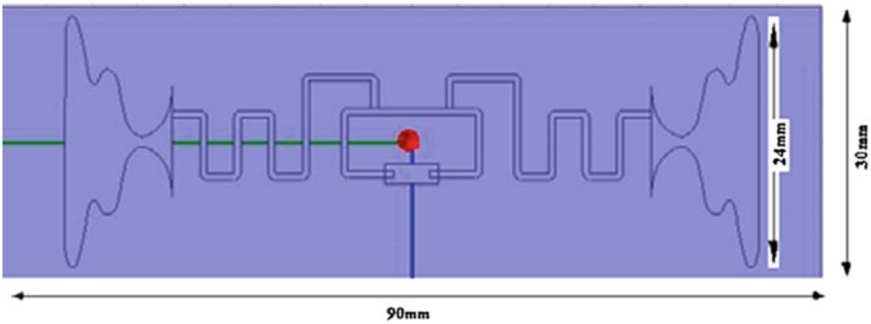

Fig. 5 Passive UHF RFID tag designed with non uniform line LNUT1

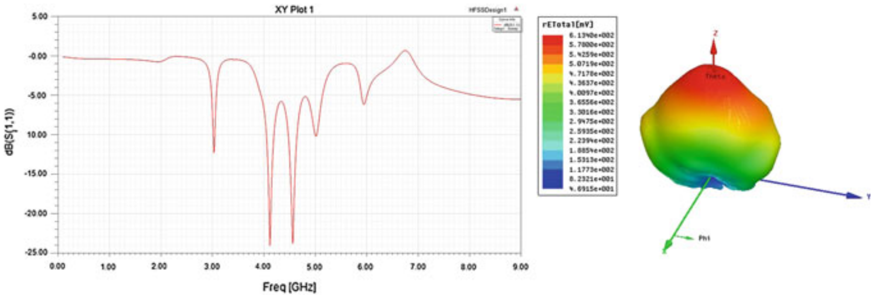

Fig. 6 Operating frequency and radiated pattern of RFID TAG designed with LNUT1

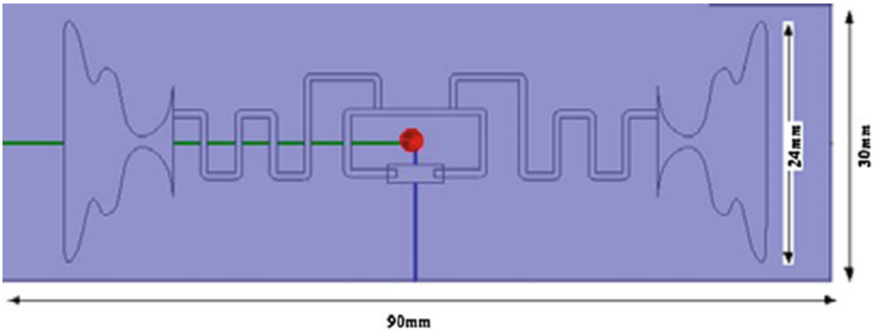

Fig. 7 Passive UHF RFID tag designed with non uniform line NUTL2

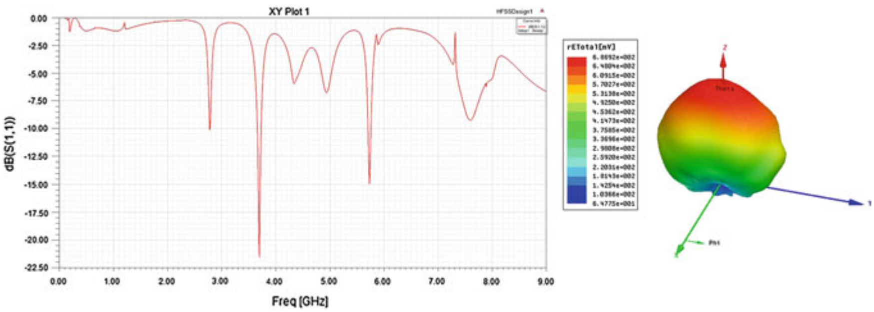

Fig. 8 Operating frequency and radiated pattern of RFID TAG designed with NUTL2

4 Conclusion

Analysis of NUTLs using Hill's equation is achieved using an efficient iterative method based on Fouquet' exponents determination. Once voltages and currents are defined over each point along the transmission structure, S parameters and other pertinent parameters s can be easily derived.

Te NUTLs have a frequency behaviour depending tightly on their geometric profiles. This fundamental property was used for reducing RFID tag dimension and improving its radiation pattern. Non uniform structures have exhibited attractive results and obtained results showed good agreement with experience.

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