



## RFID Chipless to High Frequency of 5G

Tagleorge M. Silveira <sup>(1,3)</sup>, Pedro Pinho <sup>(2)</sup>, Nuno B. Carvalho <sup>(1)</sup>

(1) University of Aveiro – UA and Institute of Telecommunications – IT Aveiro, Portugal

(2) Instituto Superior de Engenharia de Lisboa, and Institute of Telecommunications – IT Aveiro, Portugal

(3) tagleorge@ua.pt

### Abstract

When performing a literature review on the advancement of Chipless Radio-frequency identification (RFID) tag technology, it was possible to establish a resonant structure with greater sensitivity when using interspersed geometric separation and the insertion of slits in the dielectric of a chipless RFID tag, soon a design was obtained with an average sensitivity of -15 dB for the frequency band between 25 to 35 GHz, resonant in frequency and phase.

### 1 Introduction

At the end of the 19th century, the behavior of electromagnetic waves was demonstrated through equations, having as main names Michael Faraday (1791-1867) and James Clerk Maxwell (1831-1879), however it was Heinrich Hertz (1857-1894) who demonstrated the propagation of the electromagnetic wave and its possible detection, and for such contributions the frequency unit receives its name Hertz (Hz). In parallel Nikola Tesla (1856-1943) outlined the first idea of wireless energy transmission, but in the relentless intention of transmitting large amounts of energy.

Such studies were used in World War II to detect planes via their frequency resonance signatures, making it possible to consider the plane as the first RFID chipless tag. This is due to the fact that its resonance signature is in accordance with its aerodynamic shape, a situation that made it possible to differentiate between a friend or enemy aircraft.

In the early 1990s, International Business Machines Corporation (IBM) developed and patented an RFID system for ultra-high frequency (UHF), thus becoming the first commercial use of this system, but a very expensive technology. In the article [3] published in the RFID Journal in 2005, citations are made in more detail about the history and evolution of RFID technology until 2004.

As we continue our review of the literature, we find great names currently in the scope of scientific research with RFID, these are Professors Tedjini Smail, Etienne Perret, Stevan Preradovic, and Todd Coleman. One of the most

relevant current publications remote to the group of Prof. Etienne Perret, whose paper was published in IEEE Microwave Magazine in June 2019, resuming the concepts of the RFID chipless tag technology and the RFID reader [4].

More specifically, as we study and review Prof. Stevan Preradovic, we observed that we could contribute in the scope of RFID tag design for millimeter frequencies in the 30 GHz band. In observing the different results presented in papers [1] and [2], we decided to combine both applied techniques and add our contribution in the field of geometric positioning and insertion of cracks in the dielectric.

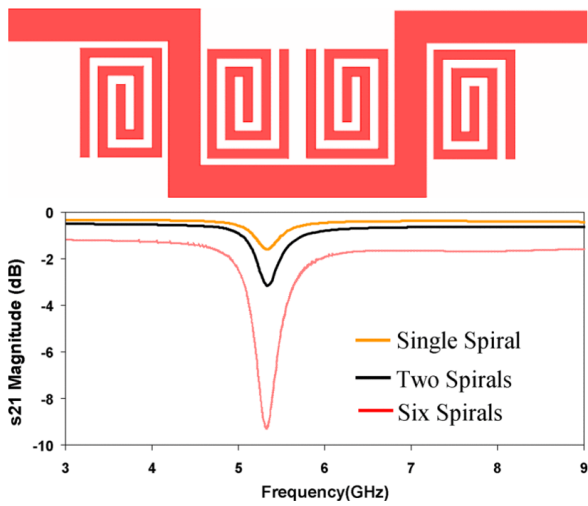
In item 2, the techniques used to obtain the new design are demonstrated in accordance with the bases used, [1] and [2], and in item 3 the conclusions and contributions of this new model are made.

### 2 Design and Results

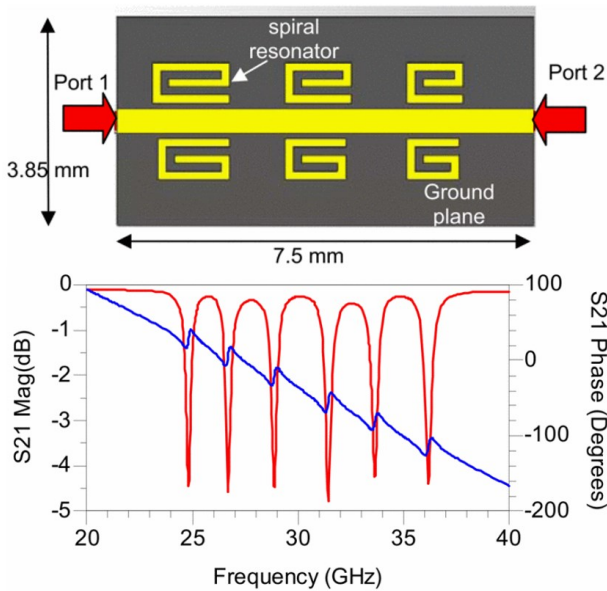
In [1] it is shown that when a chipless RFID tag design is carried out and the resonance structure is repeated, the sensitivity of the tag is increased. This fact is observed in Figure 1, which was adapted in order to verify both the resonator in repetition as the results of repetitions in magnitude, however this technique was applied for the frequency range between 3 to 9 GHz.

In the paper [2] the author demonstrates a very interesting project for the millimeter band between 24 to 36 GHz, but because it has much higher frequencies than in [1], the sensitivity is around -5 dB, with six different resonant elements, as shown in Figure 2, adapted from [2].

In order to overcome the miniaturization barrier of the RFID chipless tag, this work presents a chipless tag with greater sensitivity compared to the work [2], adding the technique of geometric separation of resonators of close frequencies, as shown in Figure 3 and Figure 4, as slits were also inserted in the dielectric in order to decrease the coupling between the frequency resonances, and at the end the technique of repetition of the resonant element shown in [1].

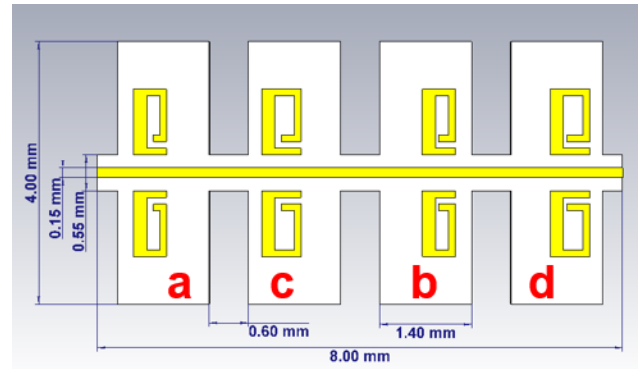


**Figure 1.** Layout of spiral repetition method using four spirals and Simulated attenuation using one, two, and six spiral resonators, withdrawn and adapted [1].

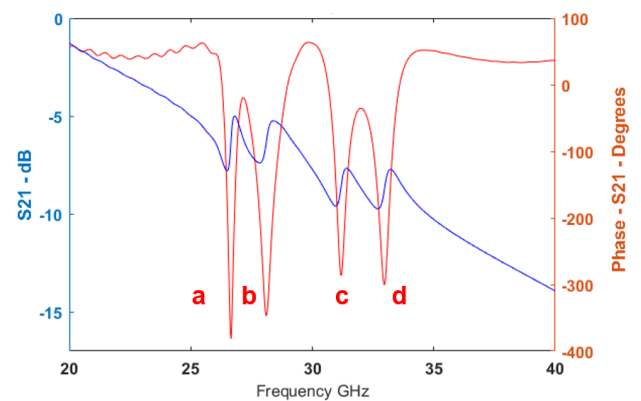


**Figure 2.** Millimeter wave multiresonator circuit designed and Simulated chipless MMID multiresonator s21 parameters, withdrawn and adapted [2].

The Figure 4 shows the four resonances in frequency and phase, and when checking the letters of description of the resonances (a, b, c, d), we can observe that in the projected geometry the close frequencies (a, b) and (c, d) are interspersed geometrically, and that together with the gaps made in the dielectric, these assist in decreasing the coupling between the resonance frequencies and allows the sensitivity of the chipless RFID tag to increase.



**Figure 3.** New design with gaps in the dielectric, interspersed geometric spacing, and double repetition of resonant elements, using CST Studio software, dielectric Rogers RO4360G2, thickness 0.81 mm, cladding 17.5  $\mu$ m and dielectric constant  $\epsilon_r = 6.15$ .



**Figure 4.** Multiresonator simulation in Magnitude (dB) and in Phase (Degrees) made in CST Studio software.

### 3 Conclusion

After an extensive literature review, it was possible to contribute to a new RFID chipless tag design at 30 GHz. By applying gaps in the dielectric, using interspersed geometric spacing and repeating resonators, and at the end, it was possible to obtain a RFID chipless tag with average sensitivity of -15 dB a much higher value compared to the results obtained in [2] than around -5 dB.

### 6 Acknowledgements

The authors acknowledge the help of Institute of Telecommunications – IT Aveiro, and this work is supported by the European Regional Development Fund (FEDER), through the Regional Operational Program of Lisbon (POR LISBOA 2020) and the Competitiveness and Internationalization Operational Program

(COMPETE 2020) of the Portugal 2020 framework [Project INFANTE with Nr. 024534 (POCI-01-0247-FEDER-024534)].

## 7 References

1. S. Preradovic and N. C. Karmakar, "Design of Chipless RFID Tag for Operation on Flexible Laminates," in *IEEE Antennas and Wireless Propagation Letters*, vol. 9, pp. 207-210, 2010. doi: 10.1109/LAWP.2010.2045872.
2. S. Preradovic and N. Karmakar, "Chipless millimeter wave identification (MMID) tag at 30 GHz," 2011 41st European Microwave Conference, Manchester, 2011, pp. 123-126. doi: 10.23919/EuMC.2011.6101942.
3. Mark Roberti, "The History of RFID Technology", *RFID Journal*, January 16, 2005. Available electronically at <<https://www.rfidjournal.com/articles/pdf?1338>>.
4. M. Garbati, E. Perret, R. Siragusa and C. Halope, "Ultrawideband Chipless RFID: Reader Technology From SFCW to IR-UWB," in *IEEE Microwave Magazine*, vol. 20, no. 6, pp. 74-88, June 2019. doi: 10.1109/MMM.2019.2904408