32nd URSI GASS, Montreal, 19-26 August 2017

Compact and Small Size antenna for an UHF RFID Tag Placed over a Metallic Thing

T. Andriamiharivolamena and S. Tedjini
University Grenoble Alpes – LCIS – 50 Barthélémy de Laffemas, 26000 Valence, FRANCE

Abstract

We report in this paper the design of a compact and small size patch antenna for a RFID tag in American UHF band. The size of the proposed antenna is 91 x 36 x 6.34 mm^3. The antenna presents good performances. A good matching of -22 dB and a high gain of 4.7 dBi are achieved at the resonant frequency (918 MHz). The proposed antenna is well adapted for a compact and small size RFID tag placed over a metallic thing.

1. Introduction

Having a tag which is well isolated to the thing on which it is placed is something that we dream. It allows to place a tag on everything while maintaining good performances. This is be possible if the antenna is well isolated to the thing. Currently, designing such an antenna for a RFID tag remains a challenge especially for a metallic thing. The intended application is the RFID in American UHF band. The tag is placed over a metallic thing and the size of the antenna should be less than 91 x 36 x 6.34 mm^3. Compared to the wavelength,λ_0, in free space, the size of the antenna should be less than 0.29λ_0 x 0.11λ_0 x 0.02λ_0.

Up to now, most of antennas used for UHF RFID tag is a dipole. But, it is well known that a dipole antenna cannot work over a metallic thing. It is obvious that an antenna with a ground plane is more suitable. The cavity-backed slot antenna in a Substrate-Integrated Waveguide (SIW) is an antenna with a ground plane. However, it is not easy to realize and recent works [1-3] show that the antenna size, compared to the wavelength in the free space, is larger than our desired size. The monopole antenna over a High Impedance Surface (HIS) is also an antenna with a ground plane. However, as the cavity-backed slot antenna in a SIW, the antenna size is larger than the desired size as shown in [4-6]. The patch antenna seems a good candidate because it has a ground plane and its size is less than those one of the cavity-backed slot antenna in a SIW and of the monopole antenna a HIS. Nevertheless the antenna size remains larger than the desired size as shown in [7-8]. The sizes of the antennas proposed in [1-8] are given in Table 1.

In this paper, we show that a small size patch antenna is achieved by using a high permittivity substrate. To maintain a high gain, a thick substrate compared to a conventional patch is used.

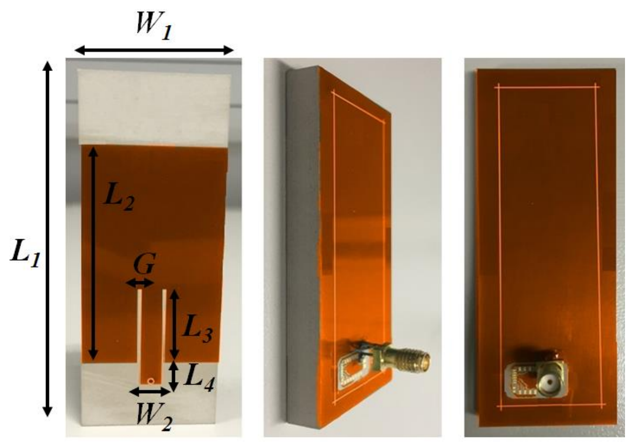
The paper is organized as follows. The structure of the proposed antenna is described in Section 2. After that, the simulation results is presented in Section 3. Finally, concluding remarks are reported in the last section.

TABLE 1. SIZES OF THE ANTENNAS PROPOSED IN [1-8]

Reference	Size compared to λ_0
[1]	1.030λ_0 x 1.070λ_0 x 0.032λ_0
[2]	0.530λ_0 x 0.440λ_0 x 0.032λ_0
[3]	1.020λ_0 x 0.760λ_0 x 0.032λ_0
[4]	0.536λ_0 x 0.536λ_0 x 0.027λ_0
[5]	0.554λ_0 x 0.554λ_0 x 0.031λ_0
[6]	0.500λ_0 x 0.300λ_0 x 0.028λ_0
[7]	0.410λ_0 x 0.370λ_0 x 0.032λ_0
[8]	0.347λ_0 x 0.347λ_0 x 0.016λ_0

2. Antenna Design

The structure of the proposed antenna is shown in Figure 1. It is a patch antenna with length L_2 and width W_2. The conductor used is a copper with thickness of 18 µm. The latter is disposed on a RT6010 substrate with length L_1, width W_1, thickness 6.34 mm, high permittivity value (ε_r = 10.2) and low loss (tan (δ) = 0.0023). The antenna is fed by a microstrip transmission line by using the inset fed technic of length L_3 and gap G. The microstrip transmission line has a length L_4 and a width W_2. Since the chip is desired to be placed at the back side of the antenna, a via with a radius of 0.5 mm is used to connect the central strip of the transmission line to one of the RF pin of the chip. The other RF pin of the chip is connected to ground plane. In Figure 1, the chip is replaced by a 50 Ω SMA connector. This allows to measure the antenna. The 3D electromagnetic simulatorCST Microwavestudio is used to optimize the patch antenna.



(a) (b) (c)

Figure 1. Structure of the realized antenna. (a) Top view. (b) Side view. (c) Bottom view.

3. Simulation Results

As said in section 1, the tag is placed on a metallic thing. Indeed, the tag is placed directly over a huge metallic cylinder with a radius of 35.5 mm and a length of 652mm. Since the patch antenna supports the surface wave, the later propagates along the cylinder and thus modifies the matching and the radiation pattern of the antenna as shown in Figures 2 and 3. The reflection coefficient was calculated compared to the impedance of the chip.The maximum gain value is shifted by 49° from 90° to 41°. To overcome this problem, the whole structure is inclined by 41° compared to 0°. Thus the maximum gain is at 90°. However, the resonant frequency is shifted toward the higher frequencies by 12 MHz and matching is decreased by 10 dB.This problem cannot be solved without changing the dimensions of the patch antenna. This demonstrates that the metallic cylinder must be taken into account during the optimization of the patch antenna.

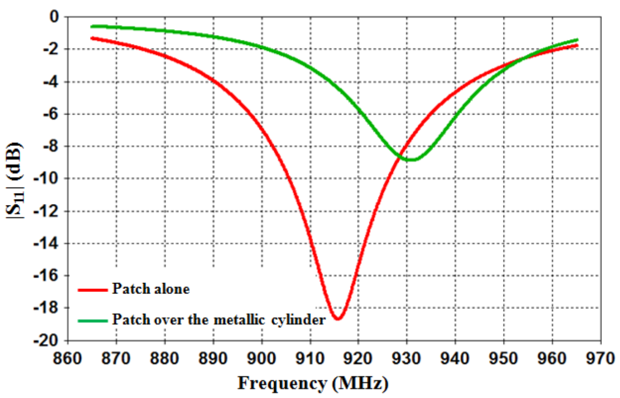


Figure 2. Simulated reflection coefficients of the patch alone and of the patch over the metallic cylinder.The reflection coefficient was calculated compared to the impedance of the chip.

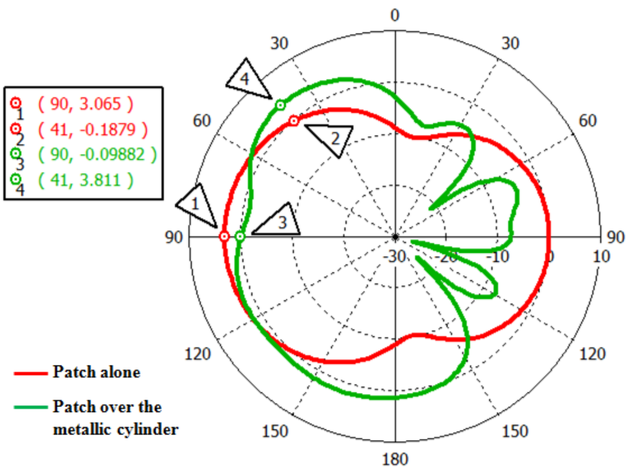


Figure 3. Simulated radiation patterns of the patch alone and the patch over the metallic cylinder at 918 MHz.

Using a specific support, the patch antenna placed over the metallic cylinder is inclined by 41° compared to 0°. The whole structure was optimize and the obtained values of the different physical parameters are given in Table 2. Compared to the impedance of the chip, a good matching of -22 dB is achieved at the resonant frequency, 918 MHz as shown in Figure 4. The radiation pattern of the patch antenna is shown in the Figure 5. A high gain value of 4.7 dBi is achieved at 90°. The gain is 1 dB greater than the case of without the specific support (3.8 dBi). This is due to the reflection of the later.

TABLE 2. GEOMETRICALPARAMETERS OFTHEPATCH ANTENNA

Parameter	Value	Parameter	Value
L_1(mm)	91	W_1(mm)	36
L_2(mm)	56.11	W_2(mm)	5.3
L_3 (mm)	20.1	G(mm)	1
L_4 (mm)	6.035		

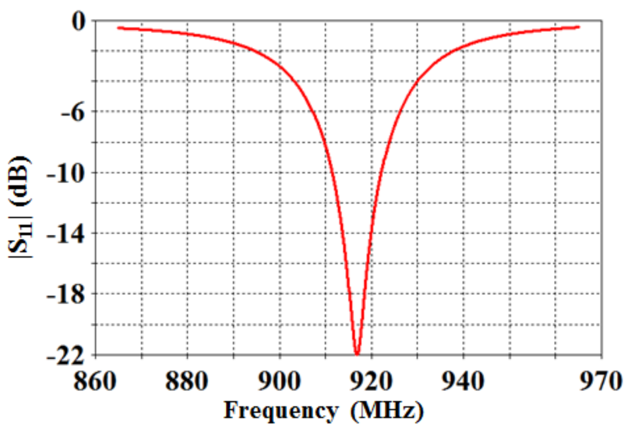
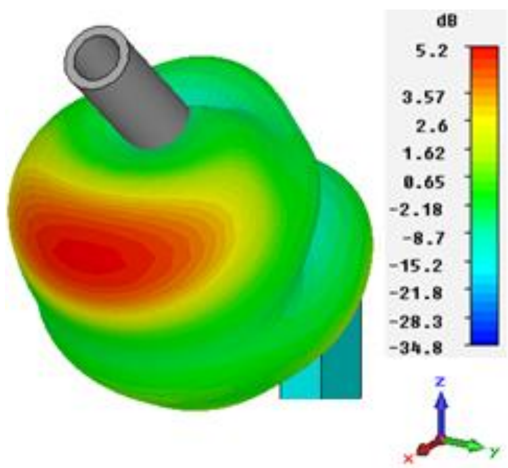
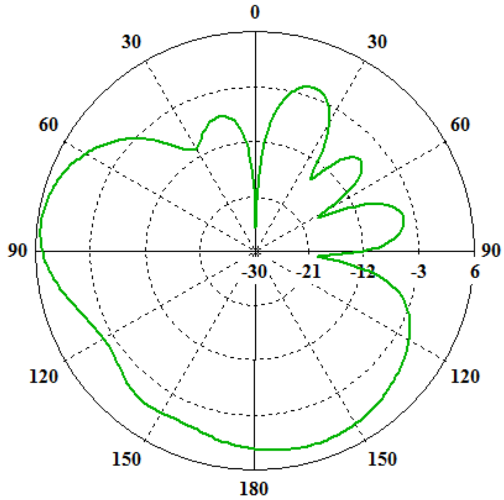


Figure 4. Simulated reflection coefficients of the optimized patch antenna placed over the metallic cylinder. The reflection coefficient was calculated compared to the impedance of the chip.



(a)



(b)

Figure 5. Simulated radiation pattern of the optimized patch antenna placed over the metallic cylinder at 918 MHz. (a) In 3D. (b) In (*xz*-Plane).

4. Conclusion

A compact and small sizepatch antenna for a RFID tag in American UHF band was presented. The patch antenna is intended to be placed directly over a huge metallic cylinder. It was demonstrated that the metallic cylinder must be taken into account during the optimization of the patch antenna. It was also demonstrated that a good matching and a high gain are achieved. A prototype of the patch antenna was realized and measured. Measurement results will be shown at the conference.

5. References

1.R. Moro, S. Agneessens, H. Rogier, and M. Bozzi, “Wearable textile antenna in substrate integrated waveguide technology,”*Electron. Lett.*,**48**, 16,2012, pp. 985–987.

2. S. Agneessens, S. Lemey, R. Moro, M. Bozzi, and H. Rogier, “The next generation textile antennas based on substrate integrated waveguide technology,”*in: Gen. Assem. Sci. Symp. XXXIst URSI*, *URSI GASS 2014*, 2014, pp.1–4.

3. S. Lemey, F. Declercq, and H. Rogier, “Dual-band substrate integrated waveguide textile antenna with integrated solar harvester,”*IEEE Antennas Wirel. Propag. Lett.*,**13**, 2014, pp. 269–272.

4. H.R. Raad, A.I. Abbosh, H.M. Al-Rizzo, and D.G. Rucker, “Flexible and compact AMC based antenna for telemedicine applications,”*IEEE Trans. Antennas Propag.*,**61**, 2, 2013, pp. 524–531.

5. T. Andriamiharivolamena, P. Lemaitre-Auger, S. Tedjini, and F. Tirard, “Compact planar monopole antenna for wearable wireless applications,”*ComptesRendus Physique*, **16**, 9,2015, pp. 851–861.

6. ZhiHao Jiang, D. E. Brocker, P. E. Sieber, and D. H. Werner, “A Compact, Low-Profile Metasurface-Enabled Antenna for Wearable Medical Body-Area Network Devices,”*IEEE Trans. Antennas Propag.*,**62**, 8, 2014, pp. 4021‑4030.

7. C. Hertleer, H. Rogier, L. Vallozzi, and L. Van Langenhove, “A textile antenna for off-body communication integrated into protective clothing for firefighters,”*IEEE Trans. Antennas Propag.*,**57**, 4,2009, pp. 919–925.

8. E.K. Kaivanto, M. Berg, E. Salonen, and P. de Maagt, “Wearable circularly polarized antenna for personal satellite communication and navigation,”*IEEE Trans. Antennas Propag.*,**59**, 12,2011, pp. 4490–4496.