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Sprayed antenna on cans for WLAN-RFID tags

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A directly printed antenna onto a can body using copper conductive paint and suited for Radio Frequency Identification Wireless LAN (RFID-WLAN) tag applications is presented. The antenna unit is low-cost and compact, provide reasonable gain, and serve prospect RFID transponders with a range of IC impedances. The antenna is fabricated with dimensions of 0.18λx0.20λx3.61e-4λ and is relaxed from manufacturing. A design study has been carried out to assess the tuning of the characteristic impedance of the antenna. Return loss, load impedance and radiation patterns are shown.

Introduction: Radio Frequency IDentification (RFID) is being widely used in real-time identification, management, and assets tracking. It uses RFID backscattered modulated signals technology for the interrogation of transponders (TPDs) [1]. Among the frequency bands that have been allocated to RFID in the microwave region, (i.e.: ~0.9GHz, ~2.4 GHz, and ~5.8 GHz), the latter provides antennas that are less impacted when in close proximity to a reflector and therefore provide more compact and conformal structures. The antenna radiator is directly sprayed onto a can body with adequate performance and can be used in hidden applications. The design is suited for use in RFID networks using the unlicensed band (5725-5875 MHz) of the ETSI standard [2] and demanding for long range and high read data rate [3]. The integration of the antenna with the can body is analysed and a fine tuning of the antenna load for a range of possible IC transponders usage given. Among potential applications are food & beverage cans and metal based containers.

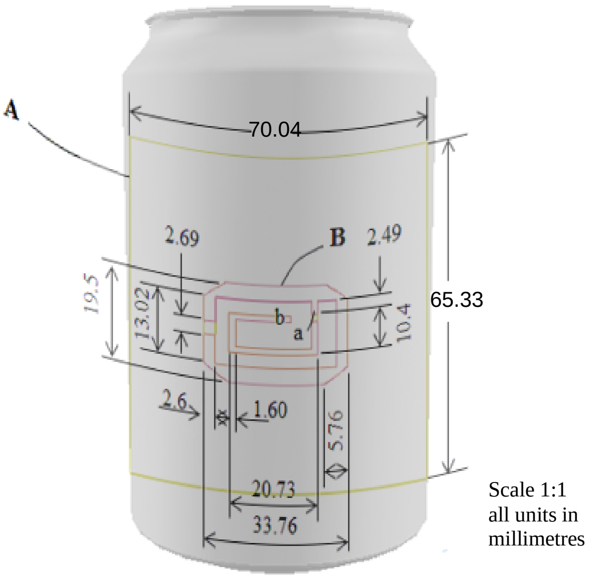

Fig. 1 *Dimensions of the sprayed antenna on a can.*

Antenna structure: The dimensions of the proposed on can conductive paint sprayed RFID-WLAN antenna is shown in Fig. 1. The can dimensions are high=115.5mm and radius=32.9mm in form of a cylinder. This antenna presents a simple structure to realize a compact and conformal manufacturing. It consists of two sprayed planes, A and B (using copper conductive paint – resistivity < 0.015 ohms/sq [4]) each separated by a substrate formed of a sprayed paint (εr = 6.5) of 127µm; the radiating patch, B is on the upper plane, and the resonator A sandwiched between paint layers (substrate). The thickness of the paint layers and antenna conductors are each 127µm. The total volume of the sprayed antenna is 65.33 x 70.04 x 0.127mm3 and the feed is given by the gap a, between the inner and outer radiate elements; this is to offer a convenient interface to the transponders (TPDs). Trimming the radiator inner strip, b to one extend, provides a fine tuning in the characteristic impedance (load) of the antenna with no significant variation in the resonant frequency.

Results: Figure 2 shows a comparison of the measured and simulated return loss (RL) of the sprayed antenna, both over a flat ground plane, C, of dimensions 510 x 800 x 0.75 mm^3 and over the can; the antennas had to be independently fabricated, therefore the non-fair comparison. The simulated and measured results (S11) are in good agreement; manufacturing tolerances are attributed to the small difference. A probe connected to a VNA was used for the measurements and calibrated up to the reference plane of the far end pins using the port extensions (open) function (a delay compensation of 29.243ps); the open circuit presented an infinite impedance response to validate the calibration. The measured results present a RL of -10dB for a bandwidth of 785MHz; a greater 187MHz was achieved using the C plane. Although the non-fair comparison, the RL of the antenna over the plane, C, and over the can present significant similarity and validates the antenna for conformal applications. For the antenna to be hidden (adding a coating paint of 127µm above the antenna radiator), the centre frequency of the antenna resonated at 5.8GHz with no variation in bandwidth, that is a 400MHz lowered frequency than that without the extra paint layer; this supports that the presence of the extra layer of paint has no significant effect in the RL and corroborates the potential for the antenna to be hidden.

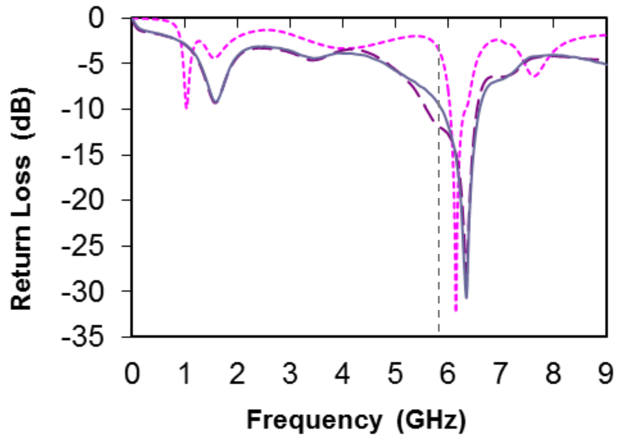

Fig. 2 *Simulated and measured return loss of the antenna*

- - - - simulated reflection coefficient (S11) antenna
—— measured reflection coefficient (S11) antenna
– – – measured reflection coefficient (S11) antenna over C plane

Figure 3 depicts the measured characteristic impedance of the antenna and that using the C plane. Fair agreement is shown between both antenna responses and gives confidence to assume that the impedance response presented in Fig. 4 will apply to both antennas; the antenna is yet to be adjusted for full power transfer between the transponder and the antenna.

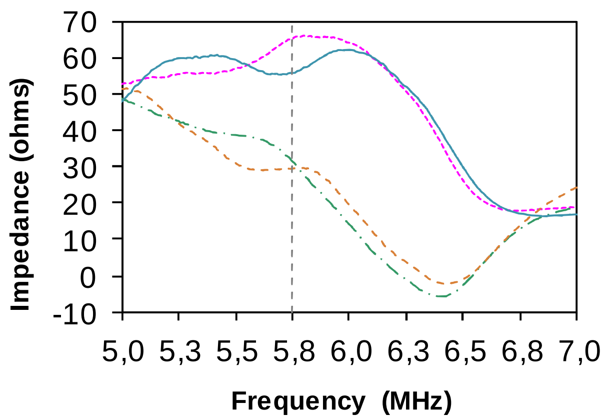

Fig. 3 *Measured characteristic impedance of the antenna*

- - - - measured real impedance antenna
—— measured real impedance antenna + plane C
– – – measured imaginary impedance antenna
– · – measured imaginary impedance antenna + plane C

Figure 4 shows the tuning of the antenna load (measured at 5.8GHz) for a range of likely IC RFID transponders. Typically, the impedance of a transponder is highly capacitive and to be conjugately matched (Zant = ZIC*) to the antenna for full power transfer, the latter must have a highly reactive response and a relatively low real part of the impedance; the response is achieved by trimming the length of the element b (the initial length is 30mm)

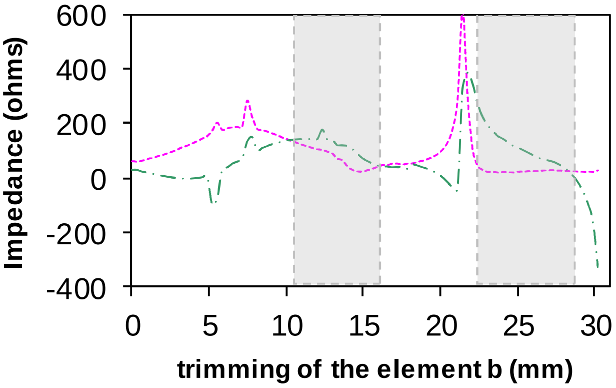

Fig. 4 *Tuning of the characteristic impedance of the antenna, real (resistance) and imaginary (reactance) as a function of the trimming of the length of element, b*

- - - - simulated real characteristic impedance antenna
– · – simulated imaginary characteristic impedance antenna

The radiation patterns were measured in an anechoic chamber in polar patterns and are presented in Fig. 5. For the measurements, the antenna was fed using a 50Ω coaxial probe through a via to the edges of the gap a, and is non-electrically connected to the ground (can body). The connector originated to uncompensated radiation front-to-back ratio patterns, and the antenna radiates in all directions, 360º, for both, the azimuth H- and elevation E-planes. Future work should try to minimise the nulls encountered in the radiation patterns. This 360º antenna characteristic can be useful in the application, since the can is able to be seen in all orientations. Future research will have to look at the interaction between cans as they are piled. The measured antenna gain was 3.04dBi.

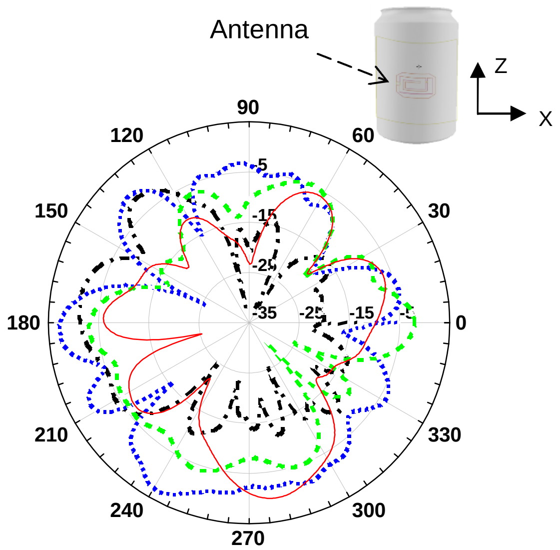

Fig. 5 *Radiation patterns of the can antenna measured at 5.8 GHz.*

- - - - E-plane co-polarisation
—— E-plane cross-polarisation
– – – H-plane co-polarisation
– · – H-plane cross-polarisation

The antenna is adequate for tagging and is intended for hidden applications where the antenna radiator can be covered using a coated paint.

Conclusion: An antenna suitable for tagging using the unlicensed WLAN-RFID band (5725-5875 MHz) has been presented and formed by using a total conductive paint sprayed on a can body with good return loss, gain and 360º radiation patterns for both, the azimuth H- and elevation E-planes. The tuning of the antenna load allows for a range of likely highly capacitive IC RFID transponders.

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2 ETSI standard available [online] at http://www.etsi.org/deliver/etsi_en/300400_300499/30044002/01.03.01_60/en_30044002v010301p.pdf

3 S.Y. Chen and P. Hsu, “CPW-fed folded-slot antenna for 5.8 GHz RFID tags,” Electronics Letter, vol. 40, no. 24, 25th Nov. 2004.

4 Copper Conductive Coating 599-B3755 from Spraylat, available [online] at http://www.spraylat.com