Passive UHF RFID tag Antenna using Polycarbonate and PDMS Material

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Abstract – **This paper proposes a UHF RFID tag antenna design using meander lines traced on a bowtie shape and the propagation measurement of the tag done in free space, directly on human skin, and on PDMS material. The main advantage of this design method is the reduction in size of the antenna compared to the readily available UHF RFID tag. The approach has a couple of notable merits, namely low cost and utilizing easily available items such as copper tape, aluminium tape, and transparency paper. The idea is proven and displayed in two ways: simulation and experimental prototype. The simulations and measurements are done on two antennas, one with copper tape as the radiating element, and aluminium tape on the other. It is found that the proposed design on both radiating elements falls in the UHF Gen2 standard which are from 860 MHz to 960 MHz.**

Index Terms — **UHF RFID tag, bow-tie antenna, meander line antenna, polycarbonate, PDMS.**

1. Introduction

The use of wireless technology is becoming one of the popular trends now. The most common system that enables wireless communication is Radio Frequency Identification (RFID) system. There are generally two types of RFID tags, active and passive. One of the easiest way to differentiate between passive and active tags is the use of battery. Active RFID tags are usually bulky due to the need of battery to be powered on. On the other hand, passive RFID tags harvests its power from the RF energy from the reader signal. Passive RFID can be divided to more branches according to their frequencies and applications. Low frequency (LF) and high frequency (HF) RFID tags can be seen in the form of inlays, cards, or labels which could cost around 50 cents to 2 dollars, meanwhile ultra-high frequency (UHF) RFID tags are produced in the form of labels which costs around 5 cents to 15 cents in 2007. Since current approaches to characterize passive UHF RFID tags are costly and time consuming, an economic deployment is necessary to accelerate this process [1]. To design a wearable UHF RFID tag, several characteristics have to be taken into considerations such as close proximity to body tissues which have significant conductivity and permittivity which would capacitively load the tag antenna, the size of the tag antenna, and finally the high tag input inductance to make it suitable for use on a human body. Despite the simplicity of the UHF RFID tag design in [2], the material used can't be easily obtained and is not economically friendly. The main idea is to achieve smaller size antenna with lesser cost as UHF RFID systems is being implemented in a lot of applications, thus, designing a tag with minimal cost is crucial.

2. Experimental set-up

As a benchmark, Fig. 1 shows the dimension of the readily available UHF RFID tag, UPM RAFLATAC DogBone. The size of the antenna is 93 x 23 mm.

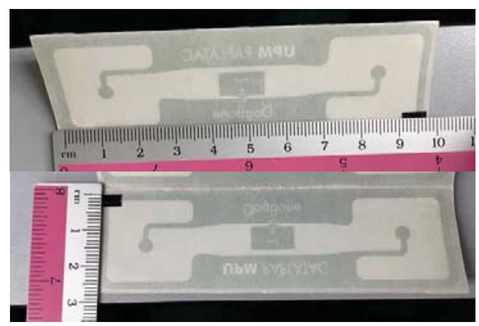

Fig. 1. The dimension of UPM RAFLATAC DogBone

On the other hand, Fig. 2 shows the dimension of the UHF RFID antenna using meandered lines. The meandered lines are traced from a bowtie shaped antenna. Bowtie shaped antenna used for this design has a working frequency of 1.5 GHz. Thus, by tracing the shape of the bowtie antenna using meandered lines, the value dropped to a lower working frequency. The materials used for this antenna are Aluminium tape as the radiating element and transparency paper (polycarbonate) as the substrate with dielectric constant, $\varepsilon_r = 2.9$ and the loss tangent at $\delta = 0.008$.

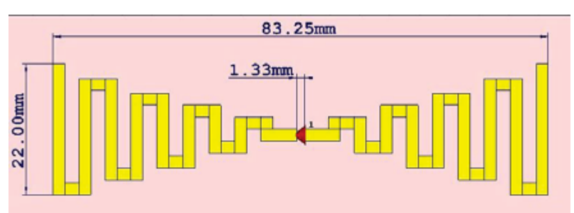

Fig. 2. Antenna dimension

Next, Fig. 3. shows propagation done on the fabricated antenna being put on directly on human skin. Fig. 4. shows the antenna is layered on top of 0.8cm of polydimethylsiloxane (PDMS) material. Finally, Fig. 5 shows the fabricated UHF RFID tag being measured in free space.

Fig. 3. Fabricated UHF RFID antenna directly on skin

Fig. 4. Fabricated UHF RFID antenna on PDMS material

Fig. 5. Fabricated UHF RFID antenna in free space

3. Results and Discussion

The S_{11} obtained from the simulation result shows the through falls at 0.93 GHz with bandwidth of 627 Hz and gain of 1.5dB. Fig. 6 shows the measured S_{11} using portable VNA which indicates the bandwidth of the measured result is 606 Hz, similar to that of the simulated result. On the other hand, Table I list the maximum distance the UHF RFID tag could be detected in various positions.

TABLE I
Maximum distance of detection of antenna in various positions

Position of Antenna	Maximum distance of detection (cm)
On skin	0
On PDMS material	700
Free space	500

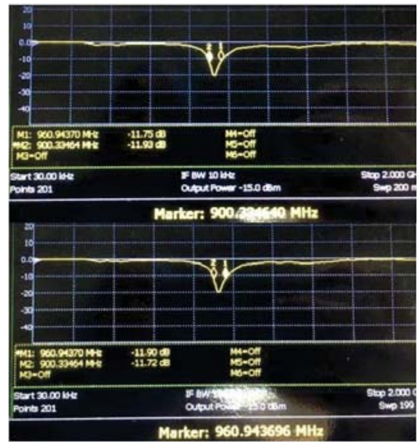

Fig. 6. S_{11} Measurement result obtained from VNA

The results from the study suggest that further improvement in terms of design simplicity and production cost could be done with current UHF RFID tags.

4. Conclusion

As a conclusion when the RFID Tag is attached on the human body the RFID Tag can't be detected. In order to overcome this problem a PDMS material is incorporated with the RFID Tag with a thickness of 1 cm. The tag can be detected by a Reader. The distance from the reader and tag is being increased compared with the Tag in the free space.

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