A Study of RFID Tags Performance in Animal Traceability Application

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1. Introduction

The radio frequency identification (RFID) is a technology that is currently widely used for automatically identifying objects [1]. It is applied for various applications such as access control, logistics, and airline baggage system. For the animal traceability application, the RFID technology is also considered as a suitable solution to quickly track and trace the origin of animals in case of animal disease outbreak, such as avian influenza [2]. In the pilot project of poultry traceability system developed by the RFID Program at National Electronics and Computer Technology Center (NECTEC) [3], the ultra-high frequency (UHF) RFID is used for tracing the poultry cage containing 6-8 chickens. The UHF RFID tag for the cage needs a protective package for protecting the RFID tag from water sterilizing agent, and bumping. We have studied the effect of the dielectric body of the package and cage to the performance of the UHF RFID tag [4]. In [4], we concluded that the effect of the 2-mm package and cage can be reduced by increasing the air gap size between the RFID tag and the package to at least 2 mm.

In this paper, we study the performance of RFID tags when using in the animal traceability application by conducting the measurement. Four commercially-available tags, Squiggle, Dogbone, Frog, and Double T, are used. The package according to [4] is made. The read range and angular sensitivity of these tags in 4 cases: tags placed on polystyrene foam, tags placed in the package, tags placed in the package attached to the empty poultry cage, and tags placed in the package attached to the poultry cage with objects inside, are measured to indicate the effects of the package, the poultry cage, and the objects inside.

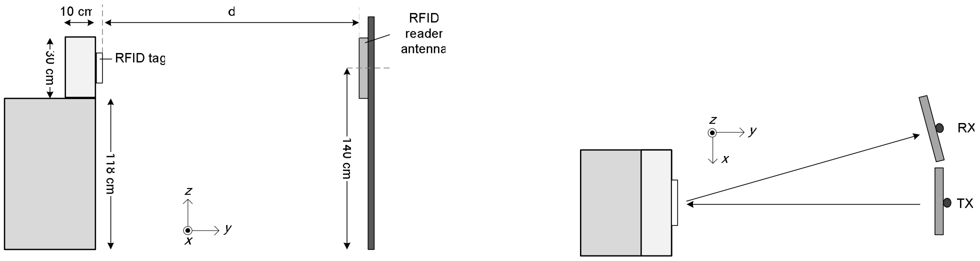
2. Performance Evaluation

2.1 Method

The performance of the UHF RFID tags is evaluated using the read range. The read range is the maximum distance that the RFID tag can respond and transmit data back to the RFID reader. It can be derived using Frii's transmission equation [5]. In the measurement, by fixing the distance *d* between the RFID reader and the RFID tag, the maximum read range of the specific RFID reader can be determined from the minimum power P_{min} that the RFID reader required to communicated with the RFID tag as follows.

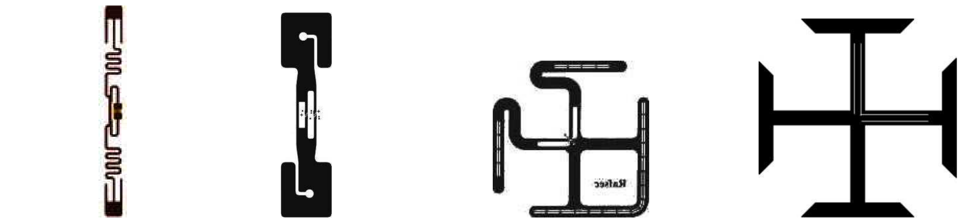
$$r = d\sqrt{\frac{P_{\max}}{P_{\min}}} \qquad (1)$$

P_{max} is the maximum power that the RFID reader can deliver. In this study, we first set the reader transmitting power to the lowest value, and then slowly increase it until the reader can detect the tag more than 80% of 20 reads. The measurement of each tag at each angle is performed three times and the average value is computed.



(a) Side view (b) Top view

Figure 1: Measurement setup for the RFID tag performance evaluation.



(a) Squiggle (8.15 x 94.8 mm) (b) Dogbone (23 x 93 mm) (c) Frog (68 x 68 mm) (c) Double T (90.6 x 90.6 mm)

Figure 2: RFID tags used in the performance evaluation.

2.2 Measurement Setup

Figure 1 shows the measurement setup used in this study. The measurement is performed in an empty space lab at NECTEC. The height of both RFID reader and RFID tag is set to 140 cm. The RFID tag is placed on the 10-cm polystyrene foam as shown in Fig. 1, or placed in the package which is attached to the polystyrene foam or the poultry cage. Both polystyrene foam and poultry cage are put on the cardboard box with the height of 118 cm. The transmitting reader antenna is placed in front of the RFID tag at the distance *d*, which is different for each RFID tag. The receiving reader antenna is placed beside the transmitting reader antenna and face to the RFID tag.

2.3 Instruments

The measuring instruments are listed below.

1.) **RFID reader and antennas**: The Alien Technology ALR-9800 reader is used. The reader operates at the UHF RFID frequency band of Thailand, 920-925 MHz. The maximum power delivered from the reader is 1 W and the maximum power attenuation is 15 dB. The reader antennas are the Alien Technology ALR-9610-AL linear polarization with 6 dBi gain.

2.) **RFID tags**: The Alien Technology Squiggle tag, Rafsec Dogbone and Frog tags, and Symbol Double T tag as shown in Fig. 2 are used. The Squiggle and the Dogbone are directional polarization tags while the Frog and the Double T are omni-directional polarization tags.

3.) **Package**: The package used for protecting the RFID tag from water or sterilizing agent is designed according to [4]. The package size is 10 x 14 cm. The 2-mm package cover is made of acrylic board. The 2-mm cardboard is used as spacer between the RFID tag and the package cover.

4.) **Poultry cage**: The poultry cage used in this study is shown in Fig. 3. The outside dimension is 52 x 72 x 30 cm and the inside dimension is 48 x 68 x 25.5 cm. The cage is made of High density polyethylene (HDPE).

5.) **Objects in poultry cage**: Because measurement is done in the lab, the living chickens cannot be used. The replacement of chickens with fruits or vegetables that has the dielectric constant close to the dielectric constant of the muscle tissue, 55 at 920 MHz, is considered. In [6], fruits and vegetables with the dielectric constant closest to that of the muscle tissue is an avocado, 56 at 1 GHz. However, the size of an avocado is comparatively smaller than a chicken. Therefore, we choose a cantaloupe that the size is bigger and the dielectric constant at 1 GHz is 63. In this study, we use Sun-lady cantaloupes. The circumferences of minor and major axes and the weights of six cantaloupes are listed in Table 1. The placement of these cantaloupes in the poultry cage is shown in Fig. 4.

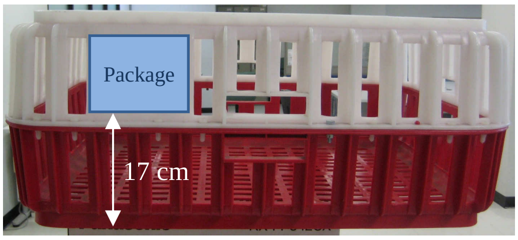
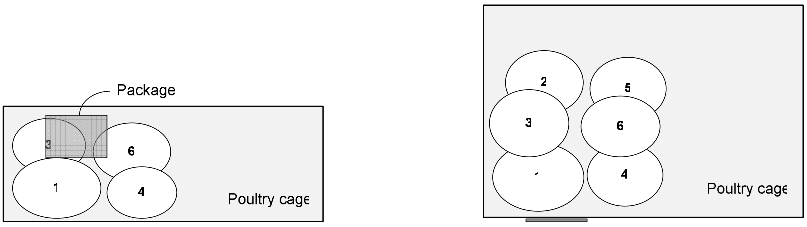


Figure 3: Poultry cage and package attachment.

Table 1: Sizes and weights of cantaloupes.

Cantaloupe	#1	#2	#3	#4	#5	#6
Circumference [cm]	47, 53	41, 46	43, 46	45, 48	41.5, 45	42.5, 45
Weight [kg]	1.760	1.318	1.458	1.668	1.306	1.376



(a) Front view (b) Top view

Figure 4: Placement of cantaloupes in case 4.

3. Measurement Results

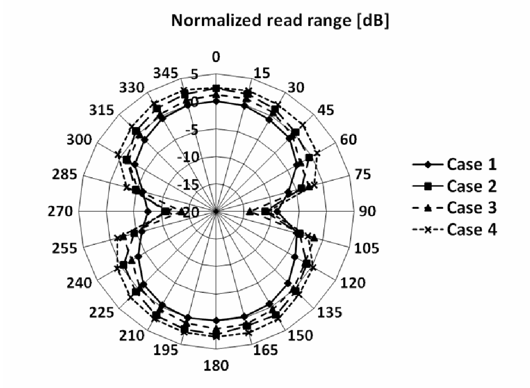
In order to determine the angular sensitivity of tags, we rotate the RFID tags on the XZ plane with a 15-degree step, where 0 degree alignments are as shown in Fig. 2. The read ranges of these tags are measured in 4 cases.

- Case 1: Placing RFID tags on polystyrene foam.
- Case 2: Placing RFID tags inside the package attached to polystyrene foam.
- Case 3: Placing RFID tags inside the package attached to the empty cage.
- Case 4: Placing RFID tags inside the package attached to the cage filled with objects.

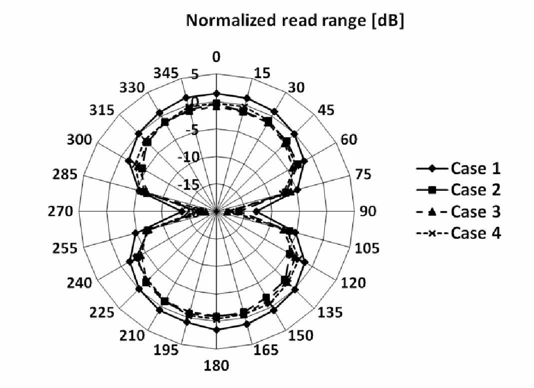
Figure 5 shows the angular sensitivity of all tags in the 4 cases above normalized to the 0-degree read range of the Squiggle tag in case 1. For the directional polarization tags, the read range of the Squiggle tag is lower than that of the Dogbone tag in case 1. However, the read range of the Squiggle tag improves when it is placed inside the package in cases 2-4. On the other hand, the read range of the Dogbone tag decreases. For the omni-directional polarization tags, the read range of the Frog tag changes slightly in all cases, while that of the Double T tag decreases in cases 2-4. Moreover, the angular sensitivity patterns of both the Frog and the Double T tags become more directional when they are placed inside the package than when they are placed on polystyrene foam. However, the effects may be different for living chickens, which cause different and unpredictable placement pattern.

4. Conclusions

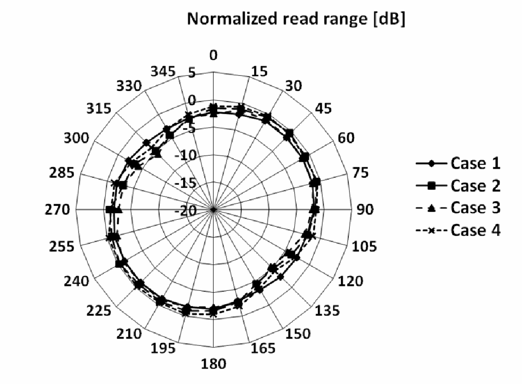
In this paper, we study the effects on the UHF RFID tags performance when using in the poultry traceability application. Four different types of commercially-available directional and omni-directional polarization UHF RFID tags are used. These tags are rotated and the read ranges are measured. The measurements are conducted in four different cases; tags placed on polystyrene foam, tags placed in the package, tags placed in the package attached to the empty poultry cage, and tags placed in the package attached to the poultry cage with objects inside. The measurement results show the significant effects of package, cage, and objects. When the RFID tags are placed inside the package, the read range of the Squiggle tag increased and that of the Dogbone tag decreased, while the read ranges of both omni-directional polarization tags become more directional.



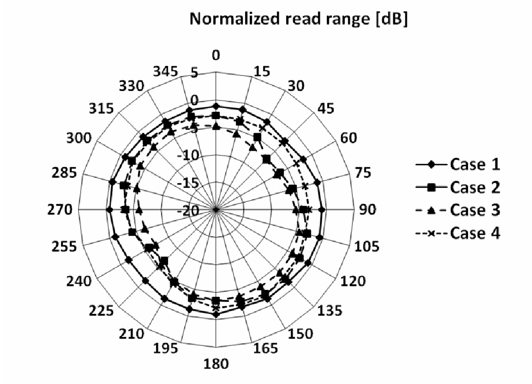
(a) Squiggle



(b) Dogbone



(c) Frog



(d) Double T

Figure 5: Angular sensitivity of RFID tags.

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