Investigation on the Deployment of HF and UHF RFID Tag in Livestock Identification

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Introduction

Radio Frequency Identification (RFID) has been deployed in livestock industry for animal identification and tracking since 1970s [1]. The common frequency used in livestock tagging is the Low Frequency (LF) band , spanning 125 - 134 kHz. LF RFID operation is standardized by ISO 11784/85. LF RFID system normally cannot handle a dense tag environment. Also, LF requires large antenna components and hence is difficult to implement. LF RFID is also susceptible to electrical noise, which HF can handle [2].

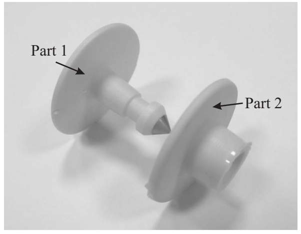
Although a new enhanced version of an LF chip is available [3] with anti-collision capability, a traditional LF tag in compliance with ISO 11784/85 does not offer such capability. Without anti-collision, only a single LF tag can be present in the reader antenna interrogation zone at a time. For practical real life applications, large antennas are attached to a race where animals will pass by one by one. Examples include cattle and sheep farming. However for piggeries, it may be possible for more than one animal to be in the field of the RFID reader at the same time. Hence, this paper presents the design of RFID tag for pigs using ISO 18000 Part 3 (HF) and ISO 18000 Part 6 (UHF).

An Existing Livestock Tag

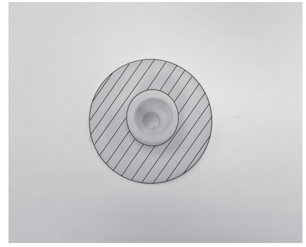
Livestock ear tags deployed in Australia must be accredited by National Livestock Identification System (NLIS), Australia. An example of these livestock ear tags with embedded RFID tag can be found in [4], which is ISO 11784/85 compatible. A livestock ear tag before any RFID tag is embedded is as shown in Fig. 1(a). One part of the ear tag has a hole in the middle to allow both parts to be pinned together on the ear of livestock. The space to attached an RFID tag is hence restricted to a circular disc with a hole in the middle as shown in Fig. 1(b). The outer diameter of the space available is 28.3 mm, while the inner diameter is 12 mm.

Using HF RFID Tag

An HF antenna needs to provide sufficient inductance through its coil turns to resonate with the tag chip capacitance at the frequency of operation, which is 13.56 MHz. In the case of a size constraint, a HF tag would not have sufficient inductance, and extra capacitance would be added by making the HF antenna double sided and introducing capacitance through the two overlapping plates. To have a high capacitance value, it is desirable for the tag to be as thin as possible to reduce



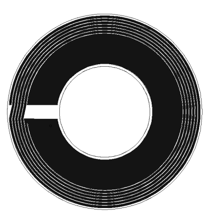
(a)



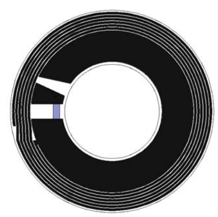
(b)

Figure 1: (a) Two parts of a livestock tag so that it can be pinned on ears of livestock. (b) The possible space for RFID tag allocation on a livestock tag.

the distance between the overlapping coils and plates. The final design of our HF antenna is as shown in Fig. 2. The chip used is the Texas Instrument Tag-it HF-I Standard Transponder IC [5], which is based on the ISO/IEC 15693 and ISO/IEC 18000-3 standards, and has an nominal input capacitance of 23.5 pF. Simulation was carried out using Ansoft HFSS to ensure that the tag will resonate at 13.56 MHz.



(a) Front view



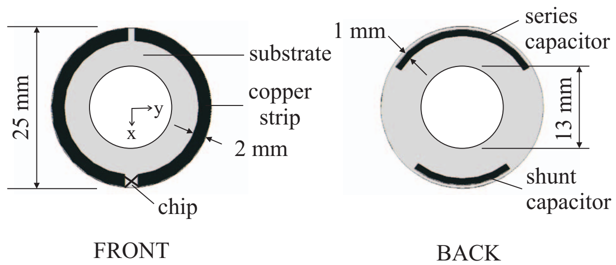
(b) Back view

Figure 2: HF RFID Tag to be embedded in a livestock ear tag.

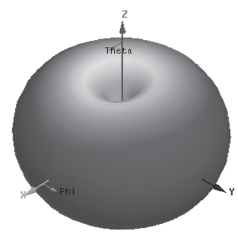
For testing purposes, we used ID ISC.LR2000 HF reader and ID ISC.ANT300 reader antenna, both from FEIG Electronics. The width and length of the reader antenna are both approximately 0.33 m. In HF operation, the maximum possible read range is proportional to the size of the reader antenna [6]. As a rule of thumb in real life deployment, the maximum read range is approximately equals to the dimension of the reader antenna. We obtained a read range of 0.34 m in free space and of approximately 0.32 m when attached to a human hand, which simulates the environment where a tag is attached to the pig's ear. To increase the read range, we can increase the size of the reader antenna in a way presented in [6].

Using UHF RFID Tag

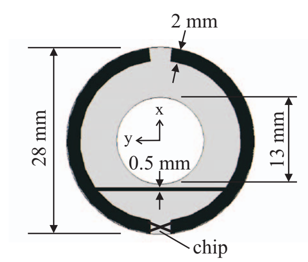
Two different UHF tag designs have been considered in our study. Both UHF tags have been designed for operation at 923 MHz in Australia. The tag chips used for both tags are from Alien Technology [7], and have impedance of approximately $20 - j141\ \Omega$ at 923 MHz.



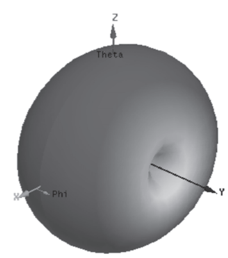
(a) Tag 1



(b) Tag 1:
radiation pattern



(c) Tag 2



(d) Tag 2:
radiation pattern

Figure 3: Two UHF pig tags.

The first UHF tag design consists of a circular loop antenna with a two element matching network to match the impedances of the tag antenna and tag chip. More detailed design steps of this tag can be found in [8]. However, the tag has been made slightly larger in diameter compared to that presented in [8] to suit the application studied in this paper. The structure and dimensions of this tag is shown in Fig. 3(a). The tag is made using a thin FR4 board with substrate thickness h = 0.36 mm and relative dielectric permittivity $\varepsilon_r = 4.4$. This tag design utilizes both sides of the FR4 board. From Fig. 3(a), the front view is the circular loop antenna and the back view is the implementation of the matching network that consists of a series and a shunt capacitor. The tag antenna structure is simulated using Ansoft HFSS and the simulated impedance is $10 + j148\ \Omega$, which is the conjugate of the tag chip impedance. The radiation pattern of the antenna is as shown in Fig. 3(b), with maximum directivity of 1.65 dB.

The second UHF tag design considered consists of a curved electric dipole antenna with an inductance track across the dipole for impedance matching purpose. The structure and dimensions of this tag is shown in Fig 3(c). This tag is made using a FR4 board with substrate thickness h = 1.6 mm and relative dielectric permittivity $\varepsilon_r = 4.4$. This tag design is single-sided. The tag antenna structure is simulated using Ansoft HFSS and the simulated impedance is $1 + j152\ \Omega$. As can be seen, the impedance of the tag antenna structure is not exactly the conjugate of the tag chip impedance and hence, the tag antenna and chip impedances are not perfectly match.

Table 1: Read Range for UHF Tags

	UHF Tag 1	UHF Tag 2
Tag in free space (m)	1.00	0.48
Tag attached to hand (m)	0.20	0.27

However, the inductance track across the dipole does provide sufficient inductance to tune with the capacitance of the tag chip. The radiation pattern of the antenna is as shown in Fig. 3(d), with maximum directivity of 1.83 dB. As can be seen, although the general shape of the radiation pattern of the first and second UHF tags is almost the same, the maximum directivity of these two tags occur at different directions with respect to the plane of the tags. Both UHF tags are tested and the read range results are shown in Table 1.

Conclusion

This paper presents the design of an HF and a UHF tag design that can be used in livestock HF and UHF RFID system, as opposed to the conventional livestock LF system. Laboratory testing indicated that both HF and UHF systems have the potential to be used as livestock RFID system. Both HF and UHF systems using ISO 18000 Part 3 (HF) and ISO 18000 Part 6 (UHF) offer the livestock industry the ability to read multiple tags in the race at the same time. Actual field testing will be carried out in the future before large scale deployment is carried out.

1 References

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