Construction of passive RFID testing system and double label mutual coupling effect analysis based on BP neural network

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Abstract

In this paper, the RFID system test platform based on on BP neural network is developed in combination with the requirement of the project. The practical application of RFID was based on the test platform and commercial RFID equipment. The paper analyzes and tests the influence of the polarization mismatch between the reader and the tag antenna. The mutual affect the antenna and the multi-path in the tag-intensive environment. Research and rapid deployment of end-user equipment provide theoretical guidance. Based on the relationship between tag antenna and load impedance matching, two port network and single tag was analysis. The expression of mutual impedance between antennas in tag-dense environment based on system propagation link parameters is derived.

Keywords: Radio frequency identification, mutual coupling effect, valuation method, linear regression, BP neural network.

1. INTRODUCTION

Internet of Things (IOT) refers to the "Internet connected by objects", which refers to the information of the items encoded by two-dimensional code (Kim et al., 2013; Rahimi-Vahed and Mirzaei, 2007). Radio frequency identification, laser scanner and sensors, using a variety of wired and wireless long-short-distance communication network to complete the interoperability of information (Zhu et al., 2011). The application integration and cloud computing-based software operation, and thus to achieve safe and reliable items and personalized "management, control, operation" integration (Raore et al., 2011). At this stage, Internet of things refers to the physical world in the physical deployment of a certain perception, computing power and execution of information sensing equipment, through a variety of communication networks to achieve information collection, transmission, coordination and processing, in order to achieve wide area or within a certain range of people and things, between objects and the exchange of information and interconnection (Boldyreva, 2003).

RFID technology is an automatic identification technology based on radio frequency communication (You et al., 2013). RFID technology to radio frequency communication and large scale integrated circuit technology as the core, the use of electromagnetic wave inductive coupling and backscattering and other basic principles of static and moving objects to automatically identify and real-time access to target information data, through the Internet technology to achieve a global target tracking and information sharing. RFID technology, as one of the core technologies of Internet of things, which has been widely used in logistics and supply chain management, industrial manufacturing, transportation, access control and asset management and medical health (Auzou et al., 2995). However, due to the different needs of different application areas and the relevant standards of the agreement has not yet unified the status quo, making the RFID system architecture greatly improved the complexity.

In this paper, the RFID system test platform based on software radio and virtual instrument technology is developed in combination with the requirement of the project and the practical application of RFID. Based on the test platform and commercial RFID equipment, the paper analyzes and tests the influence of the polarization mismatch between the reader and the tag antenna, the mutual coupling effect between the antenna and the multi-path effect in the tag-intensive environment. Research and rapid deployment of end-user equipment provide theoretical guidance.

2. MATERIALS AND METHODS

2.1 BP neural network

Here the use of the BP neural network model with multi-input and single-output as a building management evaluation, the topology is shown in Figure 1. (Boltz, 1998).

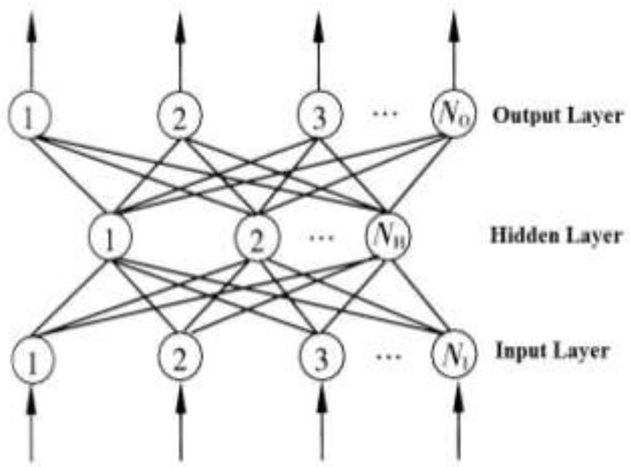

Figure1. The Three Layers BP Neural Network Topology

Non-linear relationship between the output and input between each node is described as Sigmoid function, that is (Bosnyak et al., 2004; Bradshaw and Mchenry, 2005):

$$\bar{p}(x,y) = \frac{1}{N} \cdot \text{the number of occurrences of } (x,y) \quad (1).$$

In order to express this event, following characteristic function can be used.

$$f(x,y) = \begin{cases} 1, & if\ \ y = \text{"write"and "tready" follows} \\ 0, & otherwise \end{cases} \quad (2)$$

It is a binary function, event is the $Y \times X$ space is mapped into (0,1) space. For any characteristic function f_i, experience expectation on training sample is

$$E_{\bar{p}} f_i = \sum_{x,y} \bar{p}(x,y) f_i(x,y) \quad (3).$$

The expectation of characteristic function f_i is

$$E_p f_i = \sum_{x,y} \bar{p}(x) p(y/x) f_i(x,y) \quad (4)$$

$\bar{p}(x)$ represents experience marginal distribution of x in the training sample. The expectation value calculated by model should be consistent with experience expectation value.

$$C = \{ p / E_p f_i = E_{\bar{p}} f_i, i \in \{1,2,...,K\} \} \quad (5)$$

In all probability distribution, p^* is selected, which meets the following equation.

$$H(p) = -\sum_{x,y} \overline{p}(x) p(y/x) \log p(y/x) \tag{6}$$

$$p^* = \arg\max_{p \in C} H(p) . \tag{7}$$

$H(p)$ represents condition entropy used to represent evenness of condition probability $p(y/x)$.

$$p^*(y/x) = \frac{1}{Z(x)} \exp\left(\sum_{i=1}^{K} \lambda_i f_i(x,y) \right) \tag{8}$$

$$Z(x) = \sum_{x} \exp\left(\sum_{i=1}^{K} \lambda_i f_i(x,y) \right) \tag{9}$$

This task is converted to solve optimal solution of λ_i, $i = 1, 2, \dots, K$. It can be solved by generalized iterative scaling algorithm. For any $(x, y) \in X \times Y$, the sum of characteristic function is

$$\sum_{i=1}^{K} f_i(x,y) = C , \quad \lambda_i^{(0)} = 1 \tag{10}$$

$$\lambda_i^{(n+1)} = \lambda_i^{(n)} \left[\frac{E_{\overline{p}} f_i}{E_{p^{(n)}} f_i} \right]^{\frac{1}{C}} . \tag{11}$$

$$E_{p^{(n)}} f_i = \sum_{x,y} \overline{p}(x) p^{(n)}(x/y) f_i(x,y) \tag{12}$$

$$p^{(n)}(x/y) = \frac{1}{Z(x)} \exp\left(\sum_{i=1}^{l} \lambda_i^{(n)} f_i(x,y) \right) \tag{13}$$

Log-likelihood value of $\overline{p}$ is

$$L(p) = \sum_{x,y} \overline{p}(x,y) \log p(y/x) . \tag{14}$$

$$L(p^{(n+1)}) \geq L(p^{(n)}) , \quad \lim_{n \to \infty} p^{(n)} = p^* . \tag{15}$$

To obtain the inverse local fractional Hilbert transform, write again Eq. (16) as

$$\hat{f}_H^{\alpha}(x) = \frac{1}{\Gamma(1+\alpha)} \int_{-\infty}^{\infty} \frac{f(t)}{(t-x)^{\alpha}} (dt)^{\alpha} = \frac{1}{\Gamma(1+\alpha)} \int_{-\infty}^{\infty} f(t) g(x-t) (dt)^{\alpha} = f(x) * g(x), \tag{16}$$

Variable $x^{(0)}$ has the original data series $x^{(0)} = \left[x^{(0)}(1), x^{(0)}(2), ..., x^{(0)}(n)\right]$, with a 1-AGO order to generate an accumulated generating sequence $x^{(1)} = \left[x^{(1)}(1), x^{(1)}(2), ..., x^{(1)}(n)\right]$. Among them:

$$X^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i) \tag{17}$$

Since the sequence $X^{(1)}(k)$ has an exponential growth law, and the solution is just a first-order differential equations exponential growth in the form of solution. So it can be considered the sequence $X^{(1)}$ satisfies the following first-order linear differential equation model.

2.2 Composition and working principle of RFID system

2.2.1 RFID system components

The basic structure of the RFID system can be divided into tags, readers, antennas, middleware and terminal application software in five parts, as shown in Figure 2.

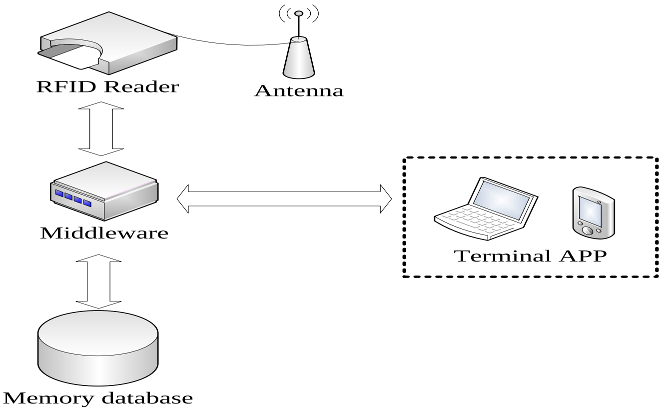

Figure 2. The basic structure of the RFID system

RFID work is divided into passive tags, active tags and semi-active tags three categories.

Readers was also known as reader (reader), interrogator (interrogator), its main role is based on the requirements of the terminal application software to complete the tag read, write and other operations. At the same time, the reader also interacts with the middleware and the terminal application software to execute the instructions required by the terminal application software and upload the data. Reader and middleware and terminal application software, including RS232/485 communication interface, Ethernet interface.

Antenna is the reader and the label to achieve signal transmission between the connecting device. The tag antenna is integrated with the tag, and its impedance matching relationship with the tag chip is an important factor to determine the RFID system performance.

Middleware is a message-oriented, independent system software or service program. On the one hand, the middleware can shield the underlying hardware caused by the application environment, hardware interfaces and standards caused by unreliable; the other hand, the middleware can also provide end-application software for multi-layer, distributed and heterogeneous information environment Business information and management information collaboration.

Terminal application software is a human-computer interface directly facing the end user. Its function is to convert the terminology of reader setting and operation instruction specified by the relevant standard into business event which is easy for the end user to understand and execute, and provides a visual operation interface . Terminal application software is directly related to the end-user's user experience of RFID systems, RFID technology is an important factor in the promotion of one.

2.2.2 Work principle of RFID system

Different frequencies of electromagnetic waves have different electromagnetic characteristics, making different frequency RFID systems using different working principles of signal and energy transmission. The operating frequency also affects the performance of the RFID system, such as recognition distance, recognition rate and reliability. Therefore, the operating frequency is an important factor to determine the performance and application of RFID system. RFID system operating frequency was shown in Table 1.

Table 1 RFID system operating frequency

Low frequency	135kHz	N cm	animal identification
High - frequency	13.56MHz	1m~1.5m	generation ID card and student card rail card
UHF	433MHz860~960MHz	100m	penetration of metal and moisture is weak
Microwave	2.45GHz	high-frequency and ultra-high frequency	strong electromagnetic field environment dry

2.2.3 Communication link and mutual coupling effect

Suppose the self-use space, the forward link reader transmit antenna and tag antenna gain are:

$$G_T(\theta,\varphi) \& G_r(\theta,\varphi) \tag{18}$$

According to the Friis transmission equation, the received power P t-r of the tag antenna is given by:

$$P_{t-r} = S_r A_{et} = \frac{P_{r-t} G_T(\theta,\varphi) G_t(\theta,\varphi) \lambda^2}{4^2 \pi^2 d_f^2} \tag{19}$$

Where, λ is the system operating frequency wavelength, $S_r == \frac{P_{r-t} G_T(\theta,\varphi)}{4\pi d_f^2}$ is the reader to transmit the antenna radiation electromagnetic waves to the tag antenna power density, $S_r == \frac{G_T(\theta,\varphi)\lambda^2}{4\pi}$ is the effective area of the tag antenna.

Reverse link, the tag by adjusting the antenna and load impedance matching relationship to achieve the signal backscatter modulation. Label load impedance Zl1 and Zl2 when the tag antenna induced current I1 and I2 are:

$$P_{t-b1,2} = \frac{1}{2} I_{1,2}^2 R_a G_t(\theta,\varphi) \tag{20}$$

Passive UHF RFID tags generally use the central feed point of the half-wavelength linear symmetric dipole antenna, then C = 1, so the tag antenna backscatter power was:

$$P_{t-b}^{diff} = \left|P_{t-b1} - P_{t-b2}\right| = \frac{1}{2}\left|I_1 - I_2\right| R_a G_t(\theta,\varphi) \tag{21}$$

3. RESULTS AND DISCUSSION

3.1 RFID system test platform

The overall scheme of the test platform is shown in Figure 3. The overall scheme of the RFID system test platform is based on the idea of virtual instrument. Based on the general computer, the RF communication interface based on the modular I/O board and the simulated application scene using the frequency conversion motor and servo motor control as the hardware foundation, through PCI, PXI / PXI Express and RS 232 to achieve the hardware components of the interconnection and signal transmission. Through the Windows XP operating system management computer hardware and software resources, to test the system to provide a working platform for other software, and control the operation of other software.

The test platform uses LabVIEW, MATLAB and S7-200 PLC as the software development environment, and utilizes the open connection functions of LabVIEW, such as MATLAB Script and OPC Servers. It integrates software functions such as radio frequency communication, data analysis and application scenario control into LabVIEW environment. The test platform supports RFID standards developed by various organizations such as ISO / IEC, EPC and UID, and on this basis, the RFID system performance and conformance testing, as well as transmission belt, access control, packaging, pallet and gantry and other fields Of the RFID system application testing, combined with the relevant physical performance test equipment, to provide users with a complete RFID system testing solutions.

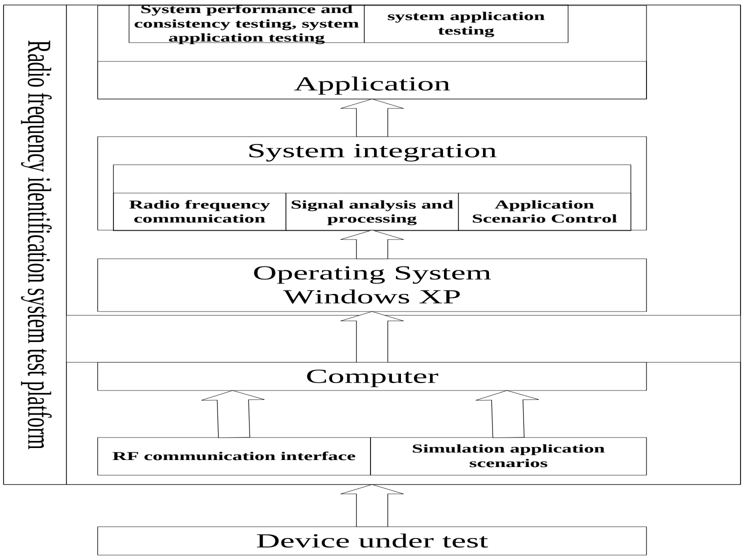

Figure 3. The overall scheme of the test platform

3.2 Double label mutual coupling effect on system performance

The effect of the mutual coupling effect on the system performance is non-monotonic change, and the performance is enhanced or decreased. Practical application, the label spacing should be greater than 1.5λ, to reduce the mutual coupling effect on the RFID system performance. The minimum transmit power (1, 2, ... , 9) of the tag i reader antenna is shown in Figure 4.

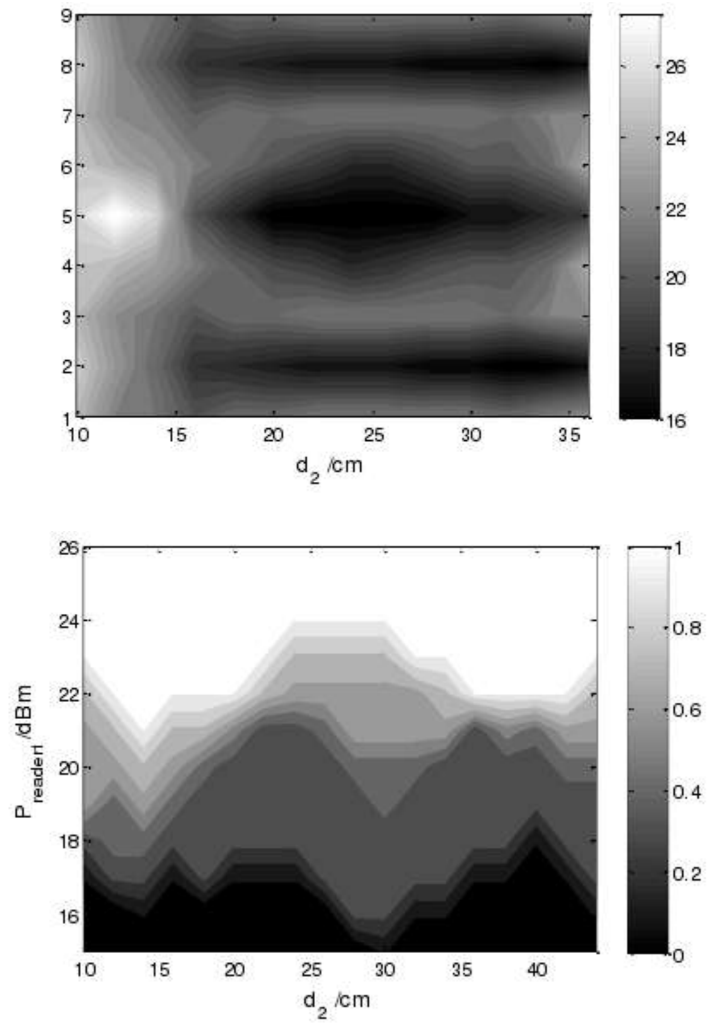

Figure 4. The minimum transmit power (1, 2, ... , 9) of the tag i reader antenna

The influence of mutual coupling effect on the performance of RFID system is analyzed by using the power transfer coefficient and the label modulation factor. The theoretical analysis and test results show that the mutual coupling effect has great influence on the system performance when the label spacing is less than 1.5 times of the wavelength of the system operating frequency. The effect of the mutual coupling effect on the system performance is non-monotonic change, which can be enhanced or decreased. In the case of double tag, the rate of change of the minimum transmitting power of the reader antenna is (-7%, 11.6%). Increasing the transmitting power of the reader antenna can reduce the mutual coupling effect on the system performance.

4. CONCLUSION

In this paper, the RFID system test platform based on software radio and virtual instrument technology is developed in combination with the requirement of the project and the practical application of RFID. Based on the relationship between tag antenna and load impedance matching and two - port network analysis in single - tag single tag scenario, the expression of mutual impedance between antennas in tag - dense environment based on system propagation link parameters is derived. Based on the test platform and commercial RFID equipment, the paper analyzes and tests the influence of the polarization mismatch between the reader and the tag antenna, the mutual coupling effect between the antenna and the multi-path effect in the tag-intensive environment. Research and rapid deployment of end-user equipment provide theoretical guidance.

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