ANTENNA DESIGN FOR PASSIVE RFID TAGS

Do Trung Kien, Nguyen Anh Tuan, Tran Vinh Thang, Dang Hung

Department of Physics, College of Science, VNU

Abstract: The recent results of development and application of RFID are discussed. The loop antenna, the heart of RFID system, is made by erodent method. The influence of turn number, track width, track thickness and spacing between coils on inductance was studied. The balance bridge principle was used to measure inductance value less than 10μH. The inductance data obtained from the Matlab program are close to experiment. The results of this study are useful for RFID research and development in the future.

Keywords: RFID - Radio Frequency Identification

1. Introduction

RFID is a highly reliable way to electronically control, detect and track a variety of items using FM transmission methods. A small tag, or transponder, embedded into virtually any object individually identifies the object using a unique, factory-programmed, unalterable code. RFID tags come in two types: active and passive. Active transponders include a battery while passive transponders obtain their energy from a radio frequency signal sent from the interrogation unit or reader [1].

The main application is in electronic anti-theft devices for goods in shops. That system is made up of the following components: the antenna of a 'reader', the security element or tag, and an optional deactivation device for deactivating the tag after payment [2]. With task of energy and data transfer of antenna coils, the antenna designing is important in RFID technique and is also the main target of this study.

Operating principle of one RFID system [2]:

Transponders are almost operated passively (figure 1). A capacitor connected in parallel with the reader's antenna coil works with the coil inductance of the antenna coil to form a parallel resonant circuit that resonanting with the transmission frequency of the reader. If a transponder is placed within the magnetic alternating field of the reader's antenna, the transponder draws energy from the this field. The resulting feedback of the transponder on the reader's antenna can be represented as transformed impedance Z_T in the antenna coil of the reader. Switching a load resistor on and off at the transponder's antenna therefore brings about a change in Z_T, and thus voltage changes at the reader's antenna. If the timing with which the load resistor is switched on and off is controlled by data, this data can be transferred from the transponder to the reader. This type of data transfer is called load modulation.

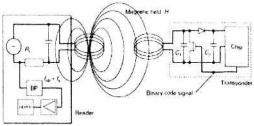

Fig.1. Generation of load modulation in the transponder by switching the drain-source resistance of an FET on the chip

2. Experimental

The experimental setup includes a loop antenna circuit made on PCB by erodent method (figure 2). The parameters a =10 cm, b = 5 cm, s = 0.1 cm, w = 0.1 cm.

In practice, for a 13.56 MHz system, given an antenna voltage of approximately 100V, a useful signal of around 10mV can be expected (=80dB signal/noise ratio). Detecting this slight voltage change requires highly complicated circuitry. A balance bridge circuit is used for this purpose. The motivation is due to its simplicity and high accuracy.

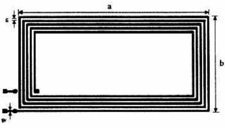

Fig.2. Typical frame antenna of a RF system

Shown in figure 3: fine variable resistor R_1=100 Ω, R_2 = 10 K, R_4 = 10 Ω; C_2 = 10 nF for inductances below 5μH, and 20 nF for inductances above 5 μH; antenna with inductance L_3 and inner resistance R_3. Value of L_3 can be obtained by adjustment R_1 for getting balance of bridge.

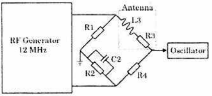

Fig.3. Maxwell bridge circuit for inductance measurement

Some of theoretical formulas are used in calculations of conductance with six input parameters (N, a, b, s, w, t-thickness of coil layers). Matlab language is recommended for computer work [3, 4].

3. Results and discussions

3.1. Turn number investigation

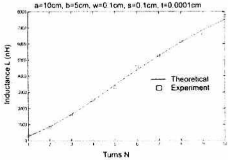

Fig.4. Dependence of antenna inductance on turn number

The inductance of antenna increases with increasing number of turns N (figure 4). The results obtained from calculation and experiment are almost identical, due to the present of mutual induction between currents in calculating.

With few turns, same direction currents in tracks are near each other and far away from contrary direction. Positive mutual induction is dominant and increase with increasing of N (N is from 1 to 5). In remaining cases (N > 5), the opposite tracks are closer, more negative mutual induction, leads to decreased rate of rising inductance.

3.2. Trace width, trace thickness and space between tracks parameters

Transponder tag is identified in small range so the coupling between reader and transponder is transformer coupling. Because the wavelength of the frequency range used (<135 kHz: 2400 m, 13.56 MHz: 22.1 m), it is difficult to design transponder's antenna follow 1/4 wavelength condition. On the other hand, quality coefficient Q of parallel resonant circuit is proportional with $1/\sqrt{L}$, and resonant voltage is proportional with turn number N and antenna area. That means RFID antenna designing is finding the suitable inductance L. L ≈ 3 μH is suitable for working frequency of 13.56 MHz [4]. The experiment parameters: a = 10 cm, b = 5 cm, s = 0.1 cm, w = 0.1 cm, t = 0.0001 cm.

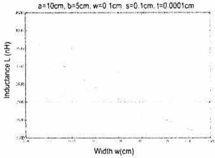

Fig.5. Dependence of antenna inductance on track width

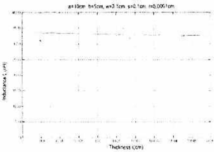

Fig. 6. Dependence of antenna inductance on track thickness

Figure 6 show that the inductance is almost not influenced by the thickness of coil layers. L decreases about 3% (from 3.36 μH to 3.26 μH) with thickness increasing 500 times (from 0.001 to 0.5 mm). The wider track width and the broader track spacing make strong decreasing of inductance L. The reason is due to the positive mutual induction become small with large space between the currents in tracks

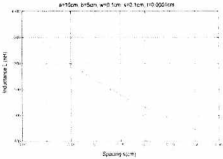

Fig.7. Dependence of antenna inductance on track spacing

4. Conclusion

A series of loop antennas were fabricated. The inductance L was measured by the simple and accurate balance bridge circuit with ability of below 10 μH measurement. The suitability between experiments and theoretical calculations shows the important contribution of mutual induction. The investigation of square shape antenna above is a foundation for other shape. For completed RFID system, next research will be concerned about signal encode/decode, modulation/demodulation, transmit/receive.

References

1. Anthony Sabetti, *Applications of RFID*, Texas Instruments.
2. Klaus Finkenzeller, *RFID handbook: Fundamentals and Applications in Contacless Smart Cards and Identification*, John Wiley & Sons, 2003.
3. V. G. Welsby, *The Theory and Design of Inductance Coils*, John Wiley & Sons, Inc.,1960.
4. Youbok Lee, *Antenna Circuit Design for RFID Applications*, Microchip Technology Inc., 2003.
5. *Bridges impedance measurement*, 2002.