DESIGN & DEVELOPMENT LOW COST RFID ANTENNA

[1]JAGDISH. M. RATHOD, [2]NAVDEEP SINGH, [3]SARABJEET SINGH, [4]Y.P.KOSTA

[1] Lecturer, Electronics Engg Department B.V.M.Engg College,
Vallabh Vidya Nagar-Gujarat, India.
[2] Research scholar, Department of physics, Dr B R Ambedkar National Institute of Technology,
Jalandhar, Punjab, India
[3]Head of the Department, Physics, Dr B R Ambedkar National Institute of Technology, Jalandhar, Punjab,
India.
[4] Principal, Charotar Institute of Technology, Changa-Gujarat, India

E-mail: jmr.bvm@gmail.com

ABSTRACT

This document describes how Low Cost HF (13.56 MHz) antennas can be built and tuned so that their characteristics match the requirements of the high performance reader and third party RF modules. This third edition places greater emphasis on antennas for the higher power readers. In general, the distance at which a Tag-it™ transponder inlay (tag) can be read is related to the size of the Reader's antenna system and its associated magnetic field strength, the larger the antenna, the greater the range. Depending on the type and make of the long range RFID reader, more gate pedestals can be configured and integrated to a single reader. For a three pedestal gate, its antenna pedestals are spaced at up to 1.2 meter apart. Optionally, each gate pedestal can be equipped with a flasher light.

Key Words: *RF ID Antenna, tag, Transmitter, Receiver*

1. INTRODUCTION

The future of the communication systems is even more challenging, and their efficacy will depend on what we, as antenna engineers and scientists, can invent and contribute. In fact, some of the future services and performances of wireless communication may be dependent on and limited by antenna designs which will require our imagination and vision to push the outer limits of the laws of physics. For example, handheld mobile units, which in 2008 numbered nearly 1 billion subscribers, are ubiquitous from the smallest rural village to the largest urban city and provide numerous services, such as voice, video, email, news, weather, stock quotes, GPS, TV, satellite, wireless LAN, Bluetooth, WiFi, WiMax, Radio Frequency ID (RFID), Radio Frequency Identification (RFID) was first used in World War II to identify the friendly aircraft. Since then, the use has improved for asset management, inventory control, security system, animal tracking, keyless entry, automatic toll debiting. In most cases, the identification can be accomplished by bar-coded labels and optical readers commonly used in Malls or by magnetic identification system used in libraries. These two methods are basically available with low price as compared to RFID.It is normally used in Harsh environments where dirt, smoke and dust are present or where the requirement of the precise alignment is there. RFID is wireless means non-contacting technique range from inches to feet. Tag and reader can be reusable as it is programmable device [1].The RFID tags have been normally used at many frequencies from 50 KHz to 10 GHz [2].

2. DESCRIPTION

The antenna products connect to Radio Frequency Modules (RFM) and reader/writers to form the interface to the low frequency UHF 13.56 MHz Instruments transponders. In combination with a reader/writer they transmit energy and signals to the transponder and receive the response from the tag. The antenna is capable of creating a specific size and shape of read zone to meet the requirements of the target application. In general the gate antennas create a large read zone including greater read distance. This antenna is a single-loop

Vol 7. No 1. (pp 058 - 062)

transmit/receive antenna with preset matching electronics for a transmitter frequency of 13.56MHz and impedance of 50 Ω.This document is aimed at providing 13.56 MHz RFID systems designers with a practical cookbook on how to optimize RFID systems and antennas. A thorough analysis of the most important RFID system parameters is presented. The emphasis is placed on physical concepts, rather than on lengthy theoretical calculations. In the wireless world, antennas are used to transmit radio frequency energy from location A to location B in the most efficient manner. That is they do radiate the power that is fed to them. If we were dealing with UHF RFID systems, this hypothesis would be true. However, at 13.56MHz, the picture is quite different. And even if we do, the amount of radiated power will remain quite small. Let us consider an example. Say that we have a loop antenna and that its area is one square meter. The radiation resistance is given by: RR,this yields RR=130 milliohms and we probably have used 4 meters of wire to construct the loop, assuming a square shape so, if we do not radiate energy, how do we transfer it to the tag we intend to communicate with? The answer is magnetic coupling. Some people refer to RFID base stations as "couplers". This terminology is certainly quite appropriate in our case. We have indeed to consider the RFID system, antenna plus tag, as a loosely coupled transformer [7], with the base station antenna acting as the primary of this transformer. Loop antennas form another antenna type, which features simplicity, low cost and versatility. Loop antennas can have various shapes: circular, triangular, square, elliptical, etc. They are widely used in applications up to the microwave bands. In fact, they are often used as electromagnetic (EM) field probes in the microwave bands; too. Loop antennas are usually classified as electrically small and electrically large [3]. Electrically small loops of single turn have very small radiation resistance (comparable to their loss resistance). Their radiation resistance though can be substantially improved by adding more turns. Multi-turn loops have better radiation resistance but their efficiency is still very poor. That is why they are used predominantly as receiving antennas, where losses are not so important. The radiation characteristics of a small loop antenna can be additionally improved by inserting a ferromagnetic core. Radio-receivers of AM broadcast are usually equipped with ferrite-loop antennas. Such antennas are widely used in pagers, too. The small loops, regardless of their shape, have a far-field pattern very similar to that of a small dipole (normal to the plane of the loop).

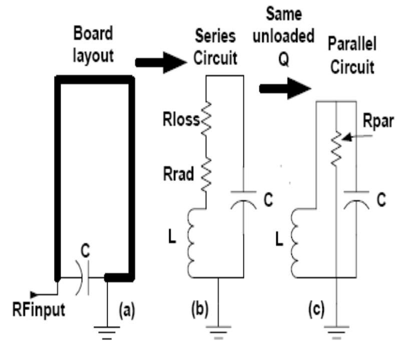

Figure 1 (a) Loop antenna physical implementation (b) the standard loop antenna model.

(C)Transformed where all resistances are viewed in parallel.

This is to be expected because of the equivalence of a magnetic dipole and a small current loop [4]. Of course, the field polarization is orthogonal to that of a dipole. As the circumference of the loop increases, the pattern maximum shifts towards the loop's normal, and when, the maximum of the pattern is at the loop's normal [5].

See in Fig 1. Increasing the diameter of the loop antenna but keeping the current constant changes the radiation pattern, similar to expanding the length of a dipole antenna with sinusoidal current distribution. The radiated (far-zone) electric and magnetic fields for a circular loop of diameter *a* carrying constant current *I* .For larger loops, the current distribution can no longer be considered constant. Instead, it can be considered to be represented by the Fourier series

3. ANTENNA DESIGN

Fundamental too many of the equations used in the design process is the accurate measurement of the inductance of a loop (L). This can be done in a number of ways:

A loop antenna is a tuned LC circuit and for a particular frequency, when the inductive impedance (XL) is equal to the capacitive impedance (XC) the antenna will be at resonance. This relationship is expressed as follows:

$$f = \frac{1}{2\pi\sqrt{LC}} \qquad (1)$$

As can be seen from the equation, the relative values of the inductance (L) and capacitance (C) are interrelated.

For this frequency though, if the antennas are made too large, the inductance rises to a point were very small capacitor values are required. Once

Vol 7. No 1. (pp 058 - 062)

the inductance exceeds 5 µH, capacitance matching becomes problematic. Two techniques can help to limit the rise of inductance:

1. Use low resistance copper tube in place of wire.
2. Connect two antennas in parallel thus halving the inductance

This is the least accurate way and although equations may be accurate for round antennas, they are an approximation for rectangular designs.

The formula below is reasonably accurate for square antennas made from tube:

$$L = side \times 0.008\left[LN\left(\frac{side \times 1.414}{2 \times Diameter}\right) + 0.379\right] \quad (2)$$

Where,
Side = Centre to centre length of antenna side (cm)
Diameter = Tube diameter (cm)

L (µH) = 5.27 µH

In this case 13.56 MHz and the instrument will measure the Capacitance, Resistance and Inductance of the Antenna. This will allow the correct tuning components to be selected for the antenna.

$C_{RES} = 1/\omega^2 L$

C (resonance) = $1/(2\times \pi \times 13.56 \times 10^{6})^2 \times 5.27 \times 10^{-6}$

C (resonance) = 26.1 pf.

Chosen capacitor range: 17 to 120 pF.

The performance of an antenna is related with its Quality (Q) factor. In general, the higher the Q, the higher the power output for a particular sized antenna. Unfortunately, too high a Q may conflict with the band-pass characteristics of the reader and the increased ringing could create problems in the protocol bit timing. For these reasons the Q or the antenna when connected to a 50-Ohm load (i.e. the reader) should be 20 or less. The total ac resistance at resonance is difficult to calculate or measure without sophisticated equipment. It is easier to assume a Q value and work backwards. First it is necessary to calculate the total parallel resistance of the finished antenna, having the required Q of 20. Example if L = 5.27µH, f = 13.56 MHz

Q = 20

$$R\ (par) = 2\,\pi\, f\, L\, Q \quad (3)$$

R (par) = 8980 Ω

Then take Q=50

R (par, antenna = 22450.19 Ω

$$R = \frac{1}{\frac{1}{Rpar} - \frac{1}{Rpar,antenna}} \quad (4)$$

R = 14.96 KΩ nearly taking R= 15 k Ω, The Quality factor (loaded) of an antenna can be readily measured if you have an instrument capable of generating frequencies between 13 MHz and 14 MHz. see in table 1.The Antenna Analyzer is connected to the antenna under test and a pick-up loop, connected to the spectrum analyzer, is positioned about 300 mm away from the antenna. The spectrum analyzer should be set to the 1dB/div scale and the Antenna Analyzer frequency is adjusted until the maximum amplitude of the signal is seen. By lowering and raising the frequency, the upper and lower -3dB points can be found and recorded. The three frequencies (f1, f0, f2) from Figure 10 can be used in the

$$Q = \frac{fo}{f2 - f1},\ Q = 19 \quad (5)$$

For optimum performance, the antenna and its feeder coaxial cable must have impedance of 50 Ohms. Matching changes the impedance of a resonant loop to 50 Ohms and the accuracy of the matching is checked by the Voltage Standing Wave Ratio (< 1:1.2) on the VSWR meter. There are numerous matching techniques but this document will detail only four methods: Gamma Matching / T-Matching, Transformer Matching Capacitance Matching. T-matching is 'balanced' as both screen and centre core of the coax cable are tapped [8]. Tapping can be external or internal to the loop. See in Fig 2. The matching arms need to have at least 40mm separation from the loop to prevent capacitive coupling. The exact matching points will vary with the Q- the higher the Q, the closer together the matching points are- the lower the Q, the farther apart the matching points are.

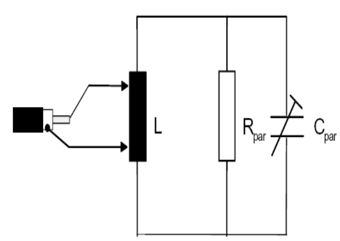

Figure 2 T-Matching Circuits

As for T- matching, the matching arms need to have at least 40-mm separation from the loop to prevent capacitive coupling. The exact matching points will vary with the Q - the higher the Q, the closer together the matching points are - the lower the Q, the farther apart the matching points are. See in Fig 3 and Fig 4.

Figure 3 T-Matched Tape Antenna

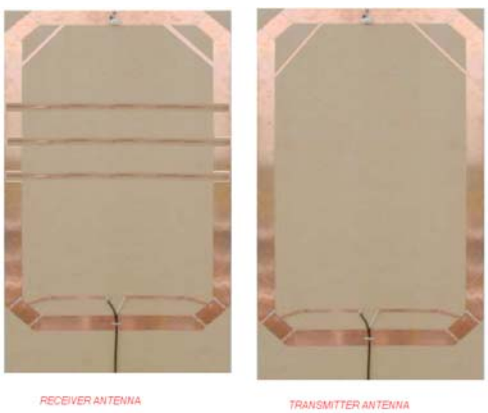

Figure 4 TX-RX Antennas

4. RESULT AND DISCUSSION

Using along range reader, we are able to detect the

Operating frequency	13.56 MHz
Reading distance	1.2 m
Dimensions	1450mmX600mmX15.88mm
Inductance	5.27 µH
Impendence	50Ω
Transmitting Power	5 W

tag using the software softronica.Fig 5 is Tag.

TABLE I DESIGN CONSIDERATION

The larger the size of loop of an antenna provides advantages but it may reduce the Signal to Noise Ratio. Matching between antennas to the reader will be difficult, and efficiency is also decreased.

We have taken operating frequency of 13.56 MHz. its reading distance is around 1.2 meters that is mentioned in above Table 1. In general, the distance at which a Tag-it™ transponder inlay (tag) can be read is related to the size of the Reader's antenna system and its associated magnetic field strength the larger the antenna the greater the range.

Figure 5.RFID Tag

Figure 6 RFID Gate Antennas

Figure 7 RFID Reader

Vol 7. No 1. (pp 058 - 062)

5. CONCLUSION

In general the distance at which tag can b e read is related to the size of the loop antenna and its associated magnetic field strength. This design is cost effective its VSWR is around 1.288. We describe how HF (13.56 MHz) antennas can be built and tuned so that their characteristics match the requirements of the readers and third party RF modules.

6. ACKNOWLEDGEMENT

The Authors would like to thanks Principal & H.O.D, Electronics Department of B.V.M.Engg.College for their support and Encouragements, and Twin Engineers, Baroda-Gujarat-India for given testing and development facility for this work. We are highly thankful to Director, Dr B R Ambedkar National Institute of Technology, Jalandhar, Punjab, India.

REFERENCES

[1] Kai Chang,''RF and Microwave Wireless System," John Wiley & sons, inc-2000, pp 313-316.

[2] J.Eagleson,"Matching RFID Technology to Wireless Applications," Wireless Systems May 1996, pp.42-48.

[3] Matthew Sadiku "Elements of Electromagnetics," Oxford University Press-2007, pp 642-643.

[4] S.Drabowitch, A.Papiernik & Smith, "Modern Antennas,"Springer-2005, pp 123.

[5] J.D.Krauss & Marhefka"Antennas for all application," Tata mchill-2002, pp 197-199.

[6] C.A.Balanis"Antenna Theory,"Wiley-2005, pp 204-210.

[7] Paul Wade"RF ID system & Applications 1995, 1998.

[8] H.Airont wireless comm. Inc"Loop Antenna & Design:

BIO DATA OF AUTHORS

Jagdish M.Rathod: is born in 1972 .He has received his BE & ME in 1995 & 2005 with in Electronics & Communication Engg respectively. He is working as a lecturer in B V M Engg **College since 1997.He got** Fourteen years of experience as a lecturer. He is pursuing his PhD since Oct-2006 in Electronics & Communication from S P University under the kind support of Dr.Y.P.Kosta, CIT, Changa-Gujarat. He is a Life member of I.E.T.E & IE (I) & I.S.T.E.He has published a Thirty one number technical and fundamental research papers in national and International journals and conferences.

Navdeep Singh: is born in 1980 .He has received his M.Sc degree in 2003 from Punjabi University, Pataiala, Punjab, India in Physics. He is working as a Research Scholar in Department of Physics, Dr B R Ambedkar National Institute of Technology, Jalandhar, Punjab, India. He got a three years of teaching as well as research experience in Physics. He is pursuing his PhD since Sept-2006 in Physics from Dr B R Ambedkar National Institute of Technology, Jalandhar, Punjab, India under the kind support of (Prof) Dr.Sarabjit Singh, H.O.D, Department of Physics, Dr B R Ambedkar National Institute of Technology, Jalandhar, Punjab, India. He has attended various workshops and conferences.