Design of Antenna for Near-Field and Far-Field UHF RFID Applications

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Abstract - *Radio Frequency Identification (RFID) is the wireless non-contact use of radio frequency waves to transfer data. Tagging items with RFID tags allows users to automatically and uniquely identify and track inventory and assets. This work deals with the design construction of a compact Microstrip antenna which has a high Gain along with a sufficient Return Loss (S11) and Impedance bandwidth that will work for India RFID band (860 MHz – 960 MHz) ISM band RFID Applications. The antenna has been designed and simulated on a Fire Resistant FR4 Epoxy substrate. The antenna has overall dimensions of 34 x 46 x 1.5 mm3 and has a Microstrip line feed matched to 50Ω. The impedance bandwidth achieved by the final design is about 49 MHz at the 857MHz - 1000MHz ISM band and has an S11 about -32 dB. The final design has a very good radiation pattern. The antenna has been designed using Ansoft High Frequency Simulation Software (HFSS). Software and hardware results are similar.*

Key Words: RFID, Return Loss, Impedance matching, radiation pattern

1. INTRODUCTION

The major development in the field of RFIDs has led to the requirement of low profile and small sized components that are easy to implement and test. Generally, there are two types of RFID systems, far field and near-field system. The far-field RFID systems only operate at UHF (860 MHz – 960 MHz) bands with electromagnetic waves propagating between the readers and tags whereas the near-field systems can operate at low frequency (LF, 125-134 kHz), high frequency (HF, 13.56 MHz) and UHF bands. The conventional LF/HF near-field RFID tag has complex multiturn loop structure, and the data transmission rate is lower compared to UHF near-field systems. Thus, RFID system for both nearfield and far-field applications at UHF band simultaneously is drawing the world's attention. However, the challenge in this type of system is that the mobile reader antenna must have both near-field and far-field RFID operation for various applications. Inductively coupled near-field operation is usually used for objects surrounded by metals or liquids. Then electromagnetically far-field operation is commonly used to achieve long reading range. The typical UHF RFID reader antenna works with pure far- field characteristic. Recently, a few UHF reader antennas have been considered with pure near-field characteristic. But there are few papers about antenna for both near-field and far- field UHF operations, and they all have too large size to use in mobile. In this design, the antenna for near-field and far-field UHF RFID applications is being proposed. In reference to RFIDs, Impedance matching and Return Loss are very important parameters. Impedance matching is the practice of designing the input impedance of an electrical load or the output impedance of its corresponding signal source to maximize the power transfer or minimize signal reflection from the load. Return loss is a measure in relative terms of the power of the signal reflected by a discontinuity in a transmission line. This discontinuity can be caused by a mismatch between the termination or load connected to the line and the characteristic impedance of the line. It is usually expressed as a ratio in decibels (dB). Thus, we need to have an antenna that has a desirable return loss and impedance should be matched perfectly. In the proposed research work, all such important parameters and points have been taken into account and worked upon. Hence, we came to the conclusion of the idea and the need to design an antenna that is not only compact in size but also has a very low return loss. In this work, the main objective will be to propose a design that has a low profile, a reasonable S11 and a very good impedance matching.

2. UHF NEAR FIELD RFID READER ANTENNA DESIGN

Like LF/HF near-field RFID systems, the coupling between the tags and the UHF near-field RFID reader antennas can be either electric (capacitive) or magnetic (inductive). Inductive coupling systems are preferred in most applications, in which most reactive energy stored in magnetic field. The systems are only affected by objects with high magnetic permeability which rarely can be encountered in daily life. Such systems are able to operate in close proximity to liquids and metals. On the other hand, electric coupling systems are hardly used in practical applications because the energy is stored in electric field which is severe affected by objects with high dielectric permittivity and loss. The performance will become worse when such systems are operated in close proximity to liquids and metals. Figure 1 shows a typical inductive coupling RFID system, where both the reader and tag antennas are loop (coil) antennas.

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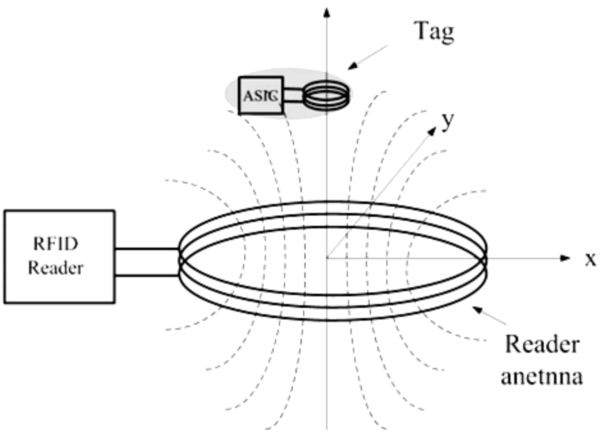

Figure 1: Inductive coupling in near-field RFID systems

The coupling coefficient between the antennas can be expressed as

$$C \propto f^2 N_{tag}^2 S_{tag}^2 B^2 \alpha$$

Where Ntag is the number of turns in tag antenna coil, f is the frequency, Stag is the cross-section area of the coil, α is the antenna misalignment loss, and B is magnetic field density at the tag location created by the reader antenna. The main design consideration of the reader antenna for inductive coupling UHF near-field RFID applications is to allow the current along the loop to remain in a single direction flow and in phase, so as to produce uniform and strong magnetic field distribution in the interrogation region.

3. ANTENNA DESIGN CONFIGURATION

The scheme of the proposed loop antenna printed on a FR4 PCB is shown in Figure. 2(A). The parameters of the FR4 PCB are that: relative permittivity μ=4.4; thickness H=1.6mm; loss angel tangent 0.02. The structure of Figure 2(A) is printed on one side of the FR4 PCB, while the structure of Figure. 2(B) is printed on the other side. The feed point of the antenna can be seen in Figure. 2(A), and the line paralleling to the feed point gets connect to the structure of Figure. 2(B), as well as connecting to the ground point of the coaxial. The proposed loop antenna is indicated with the main geometrical parameters as: The length equal to 46mm and the width equal to 34mm, the length and width of inner arms, the gap between two arms, the dimensions of the reflector are shown in the figure. The single direction current flow along the loop antenna and the impedance matching can be achieved by optimizing these parameters.

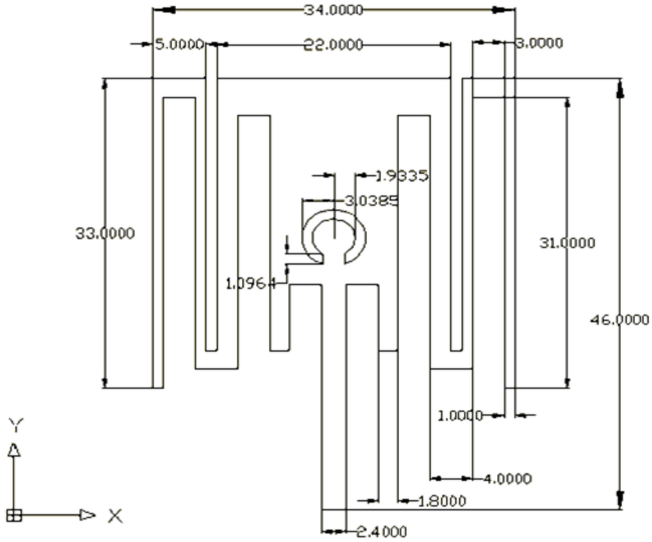

Figure 2(A): Inductive coupling in near-field RFID systems

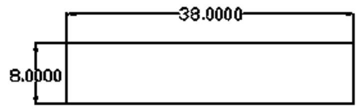

Figure 2(B): Inductive coupling in near-field RFID systems

4. RESULT OF ANTENNA DESIGN

Figure 3(A) and Figure 3(B) shows the photo of the antenna prototype. The antenna was designed with the aid of the HFSS15 software. The dimensions of the antenna prototype shown in Figure 3 are L1=34mm, L2=46mm

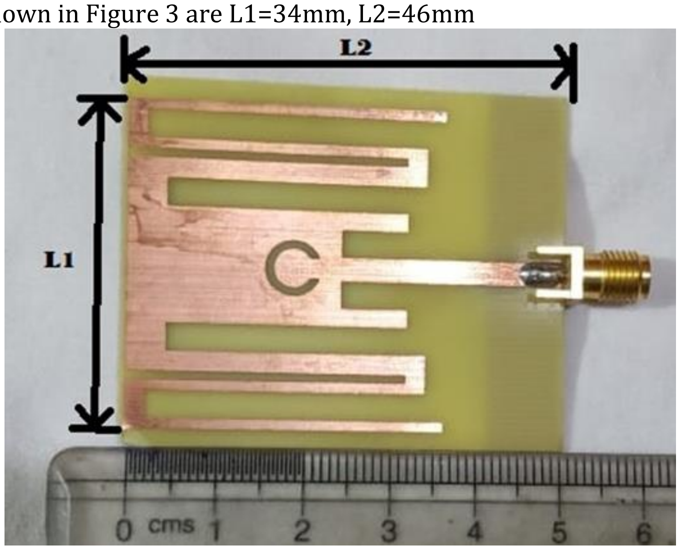

Figure 3(A): photo of the antenna prototype

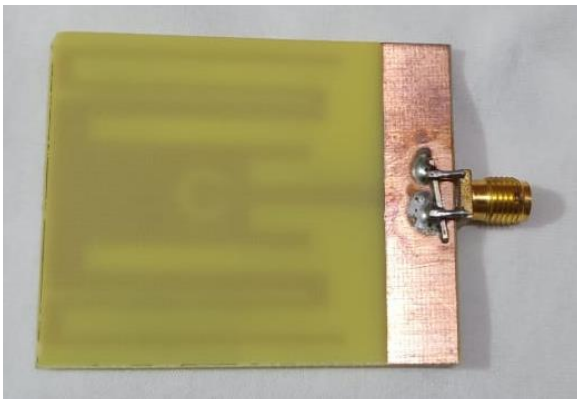

Figure 3(B): photo of the antenna prototype

Figure 4 and figure 5 compares the measured and simulated impedance matching of the proposed antenna, good agreement is observed

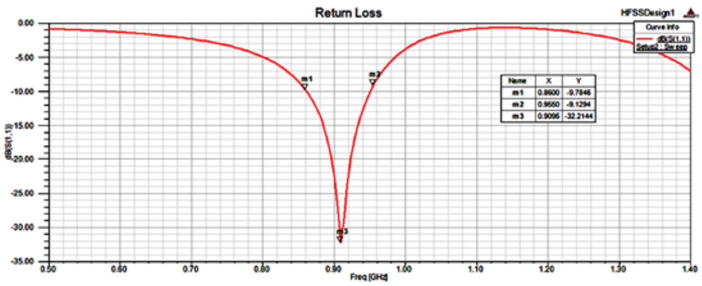

Figure 4 Simulated S11

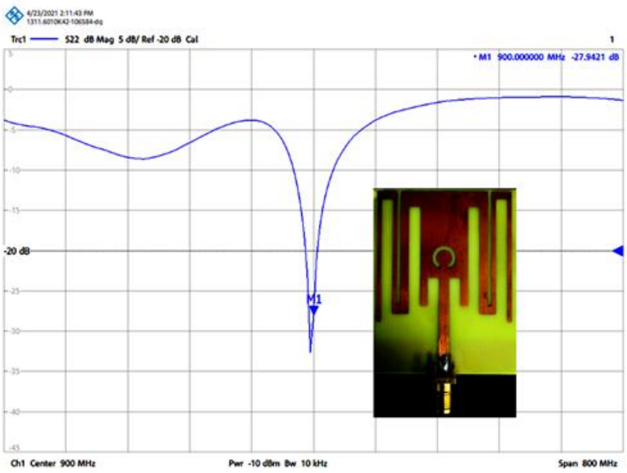

Figure 5 Measured S11

Figure 6 demonstrates the simulated radiation pattern in E plane of the proposed antenna. Figure 7 demonstrates the simulated radiation pattern in H plane of the proposed antenna. The single direction current flow along the loop is observed at Figure 6. Figure 8 illustrates the impedance matching at the frequency of 900 MHz. The uniform field distribution is achieved over the region, which is enclosed by the antenna, no nulling area is observed, which is desired for RFID applications.

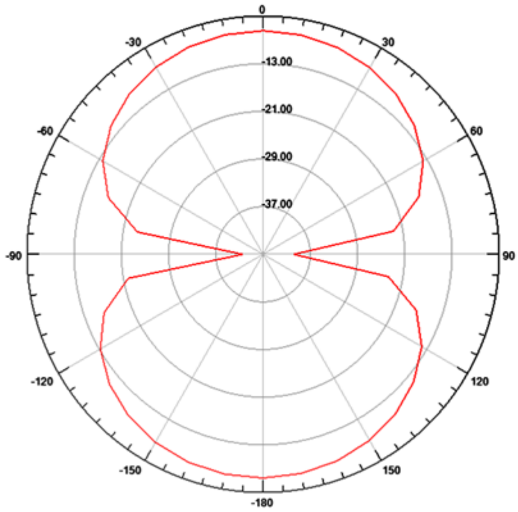

Figure 6 radiation pattern in E plane

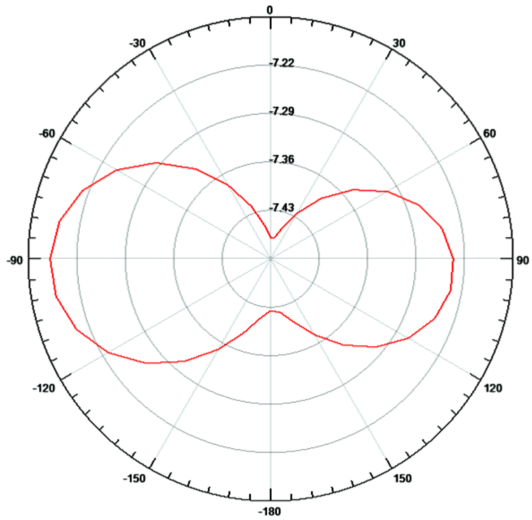

Figure 7 radiation pattern in H plane

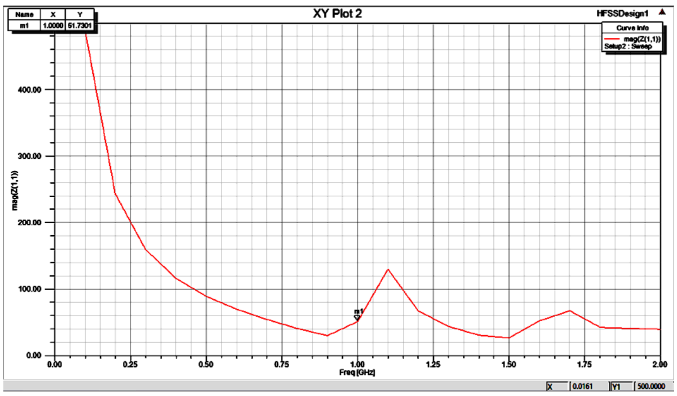

Figure 8 Impedance matching

Figure 5 and Figure 6 illustrates the software and hardware testing for RFID applications simultaneously. Simulation output results at the frequency of 955MHz and its S11 is

-32dB. The reader is working at the frequency of 912MHz and its S11 is -33dB. The tag and the reader both support ISO18000-6C (EPC GEN2) protocol.

5. CONCLUSIONS

In this paper, a novel compact antenna is proposed. Owing to parasitic arms inserted, the proposed antenna realized good size reduction, uniform magnetic near-field distribution and available far-field gain. Further, the parasitic element of proposed antenna can be modified to handle different UHF RFID bands in this article. Finally, the antenna prototype, with a compact size of 34 x 46 x 1.6 mm3, provides 49 MHz bandwidth (857MHz – 1000MHz), which can cover the India RFID band (860 MHz – 960 MHz) completely. With a nearfield button-type RFID tag, the maximum read range obtained is 66 mm. The near-field reading performance is not degraded when the RFID tag is placed on different objects (human body, paper, liquid and fruit surface). On the other hand, the far-field reading range, with a common dipole RFID tag, is approximately 1.2 m, but the performance is seriously affected by surrounding. Such an antenna design has suitable near-field and far-field performance for mobile UHF RFID application.

6. REFERENCES

[1] R. Caso, A. Michel, A. Buffi, P. Nepa , "A Modular Antenna for UHF RFID Near-Field Desktop Reader", 2014 IEEE RFID Technology and Applications Conference (RFID-TA).

[2] Deepak C. Karia, Bhushan Bhimrao Dhengale, Siddhant A. Goswami, "A 1x2 Array Circularly Polarised Microstrip Antenna with a high Gain for RFID Applications", 2015 Intl. Conference on Computing and Network Communications (CoCoNet'15), Dec. 16-19, 2015, Trivandrum, India

[3] Karoliina Koski, Elena Simona Lohan, Lauri Sydänheimo, Leena Ukkonen, "Electro-Textile UHF RFID Patch Antennas for Positioning and Localization Applications", 2014 IEEE RFID Technology and Applications Conference (RFID-TA)

[4] Manikanta Lalkota, Gaurangi Gupta and A. R. Harish, "UHF Reader Antenna for Near and Far Field RFID Operation", 2018 IEEE International Conference on RFID (RFID)

[5] Yun-liang Liu, Xiao-Zheng Lai, Ze-ming Xie, Xin Wang, "Near-Field RFID Reader Antenna Design", Proceeding of the IEEE International Conference on RFID-Technology and Applications, Guangzhou, China, 17 - 19 June 2010

[6] A. Michel, P. Nepa, M. R. Pino, "An Overview on Modular Antennas for Near-Field UHF-RFID Systems", 2016 IEEE International Conference on RFID Technology and Applications (RFID-TA)

[7] Aleksey L. Popov, and Orest G. Vendik, "A Loop Antenna Model for UHF RFID Systems", IEEE 2012 International Conference on RFID -Technologies and Applications (RFID - TA)

[8] Finkenzeller, K., RFID Handbook: Radio-frequency Identification Fundamentals and Applications, 2nd Edition, Wiley, New York, 2004.

[9] Chae, J. and S. Oh, "Information report on mobile RFID in Korea," ISO/IEC JTC1/SC 31/WG4 N0922, Information Paper, ISO/IEC JTC1 SC31 WG4 SG5, 2005.

[10] Lee, J. and H. Kim, "RFID code structure and tag data structure for mobile RFID services in Korea," Proc. ICACT , 1053–1055, Feb. 2006.

[11] Fuschini, F., C. Piersanti, L. Sydanheimo, L. Ukkonen, and G. Falciasecca, "RFID code structure and tag data structure for mobile RFID services in Korea," IEEE Trans. Antennas Propag., Vol. 58, No. 5, 1759–1770, Dec. 2010.

[12] Razalli, M. S., M. A. Mahdi, A. Ismail, S. M. Shafie, and H. Adam,"Design and development of wireless communication transceiver to support RFID reader at UHF band," Journal of Electromagnetic Waves and Applications, Vol. 24, Nos. 14–15, 2063–2075, 2010.

[13] Nikitin, P. V., K. V. S. Rao, and S. Lazar, "An overview of near field UHF RFID," Proc. IEEE Int. Conf. on RFID, 167–174, Mar. 2007.

[14] Lee, J. N. and J. H. Jung, "Design of the planar cross dipole reader antenna for UHF RFID systems," Journal of Electromagnetic Waves and Applications, Vol. 26, No. 7, 962–972, 2012.

[15] Viani, F., M. Salucci, F. Robbl, G. Oliveri, and A. Massa, "Design of a UHF RFID/GPS fractal antenna for logistics management," Journal of Electromagnetic Waves and Applications, Vol. 26, No. 4, 480–492, 2012.

[16] Wang, P., G. Wen, J. Li, Y. Huang, and Q. Zhang, "Wideband circularly polarized UHF RFID reader antenna with high gain and wide axial ratio beamwidth," Progress In Electromagnetics Research, Vol. 129, 365–385, 2012.

[17] Tiang, J. J., M. T. Islam, N. Misran, and J. S. Mandeep, "Circular microstrip slot antenna for dual-frequency RFID application," Progress In Electromagnetics Research, Vol. 120, 499–512, 2011.

[18] Wang, L., Z. J. Xing, J. Y. Li, K. Wei, M. S. Sandikie, and J. D. Xu, "Fast carrier cancellation for UHF near field RFID system," Journal of Electromagnetic Waves and Applications, Vol. 26, No. 7, 863–874, 2012.

[19] Xie, Z. M., X. Z. Lai, and R. J. Hu, "Compact UHF RFID reader antenna using bended fold dipole structure," International Conference on Machine Learning and Cybernetics, Vol. 1, 414– 417, Jul. 2011.

[20] Li, X., J. Liao, Y. Yuan, and D. Yu, "Eye-shaped segmented reader antenna for near-field UHF RFID applications," Progress In Electromagnetics Research, Vol. 114, 481–493, 2011.

[21] Shrestha, B., A. Elsherbeni, and L. Ukkonen, "UHF RFID reader antenna for near-field and far-field operations," IEEE Antennas Wireless Propag. Lett., Vol. 10, 1274–1277, Nov. 2011.

[22] Borja, A. L., A. Belenguer, J. Cascon, and J. R. Kelly, "A reconfigurable passive UHF reader loop antenna for near-field and far-field RFID applications," IEEE Antennas Wireless Propag. Lett., Vol. 11, 580–583, Nov. 2012.

[23] Lin, D. B., C. C. Wang, J. H. Chou, and I. T. Tang, "Novel UHF RFID loop antenna with interdigital coupled section on metallic objects," Journal of Electromagnetic Waves and Applications, Vol. 26, Nos. 2–3, 366–378, 2012.

[24] Xiong, J., Y. F. Yu, Y. M. Liu, and X. Geng, "An electrically small planar loop antenna with high efficiency for mobile terminal applications," Journal of Electromagnetic Waves and Applications, Vol. 26, Nos. 5–6, 744–756, 2012.

[25] Yu, H. Z. and Q. X. Chu, "An omnidirectional small loop antenna based on first-negative-order resonance," Journal of Electromagnetic Waves and Applications, Vol. 26, No. 1, 111–119, 2012.

[26] Lin, Y. C., W. S. Chen, B. Y. Lee, S. Y. Lin, and H. W. Wu, "Small inverted-U loop antenna for GPS application," Journal of Electromagnetic Waves and Applications, Vol. 24, Nos. 8–9, 1033– 1044, 2010.