ISSN 2229-5518

Quad Squares Center Circular Slotted Microstrip RFID Applications Antenna

Akash Porwal, Dr. Neelam Srivastava

Abstract— Qu*ad* squares center circular slotted, orthogonal slits and corner truncated novel patch structure are proposed for circularly polarized (CP) Ultra High frequency (UHF) Radio Frequency Identification (RFID) applications. The structure constitutes 0.27λ x 0.27λ x 0.0137λ at 900 MHz ground plane and FR-4 Epoxy substrate. The proposed antenna provides the Return loss S_{11} (dB) of -39.11 dB with 887 MHz – 932 MHz Bandwidth range typically 45 MHZ covering wide Ultra High Frequency (UHF) range, minimum Axial Ratio of 0.7741 dB at 910.7 MHZ and VSWR < 2 is simulated using Electromagnetic High Frequency structure simulator (HFSS). The single coaxial feeded patch Gain and Bandwidth is tuned via electromagnetically coupled parasitic patch with peak gain of about 4dB. The slits and truncated corners reduce the antenna size with circularly polarized (CP) radiation over low cost FR-4 Epoxy substrate.

Index Terms— Axial Ratio (AR), Circular polarization (CP), Circularly Polarized Microstrip Antenna (CPMA), Radio Frequency Identification (RFID), Gain Bandwidth Tuning (GBT), High Frequency Structure Simulator (HFSS), Slotted patch (SP).

---

1 Introduction

The Radio Frequency identification (RFID) is a wireless data transmission and reception technique for tracking and identifying an object that employs the world wide frequency span of 840 MHz - 960 MHz. The technique configuration involves a Reader, a Tag and a data processing system. The reader is typically a trans-receiver that transmits and receives the modulated RF signal scattered from the Tag. The circular Polarized (CP) radiation is desirable due to random orientation of the Tag, as the circularly polarized microstrip antennas (CPMAs) reduce the losses caused by the multipath effects and thus making system more efficient and reliable. With the enhancing technology good gain, highly directive, good impedance match, compact geometry, low cost reader antennas that can be mounted on multiple surfaces are desirable for the applications such as electronic toll collections, assest identification, access control etc. However introduction with sensory systems enlarges the application areas including environment monitoring and health care applications etc.

While designing the antenna Bandwidth i.e. the frequency range of operation with constant gain achievement is the prior consideration. Several techniques developed such as stacking patches over single, double or multi-layer, introduction of multi-layer dielectric substrate or meta- material, introduction of metallic plates inside the dielectric substrate that forms mutual coupling have been reported in literature so far that provide a reliable way of tuning the gain and Bandwidth of design. However the use of parasitic patch generates electromagnetic coupling between the main patch i.e. (patch fed by coax probe) and the patch that is in free space is one easy way to obtain good Gain-Bandwidth results. The relatively thicker substrate prevents the surface wave generation results in good gain achievement. In this paper novel quad squares, center circular slotted, orthogonal slits and corner truncated patch

- *Akash Porwal is currently pursuing masters degree program in Microelectronics from Institute of Engineering and Technology Lucknow, Gautam Buddh Technical University, INDIA. E-mail: porwalakash.1989@gmail.com*
- *Dr. Neelam Srivastava Professor (Electronics Engineering Dept.) Institute of Engineering and Technology Lucknow, Gautam Buddh Technical University, INDIA. E-mail: neelam.srivastava@ietlucknow.edu*

ISSN 2229-5518

structure is simulated. All the squares slots are asymmetric in size and relative center positions to each other. The corner truncations and orthogonal slits reduce the patch size with operational frequency band and Axial ratio tuning for Circularly Polarizes (CP) radiation is presented. The parasitic patch introduced is of similar size of the main patch to improve the Gain-Bandwidth. The geometry is simulated using the electromagnetic ANSOFT High Frequency structure simulator (HFSS) with operating Frequency of 900 MHz using low cost FR-4 Epoxy dielectric substrate.

2 ANTENNA CONFIGURATIONS

The cross section view of the proposed Quad squares, center circular slotted microstrip patch antenna is shown in fig.1 (a) and patch in excitation in fig.1 (b).

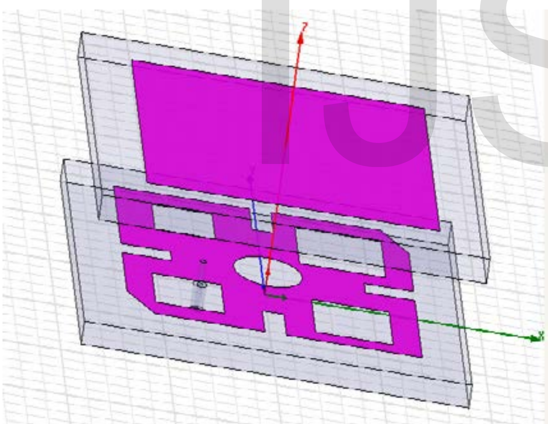

Fig.1 (a) cross section view

The length of square patch is L = 68mm and ground plane size of antenna is 90mm X 90mm. The coaxial feed point from the center is (-15mm, 0mm). The dielectric FR-4 Epoxy substrate height H_1 = 4.572mm, dielectric constant = 4.4 and loss tangent = 0.002. The center circular slot radius R= 16mm. The top right square i.e. first quadrant slot length L_1 = 18mm, top left square i.e. second quadrant slot length L_2= 12mm, bottom left square i.e. third quadrant slot length L_3= 14mm and bottom right square i.e. fourth quadrant slot length L_4= 16mm. The embedded orthogonal slits length L_S = 15mm and width W_S = 5mm respectively.

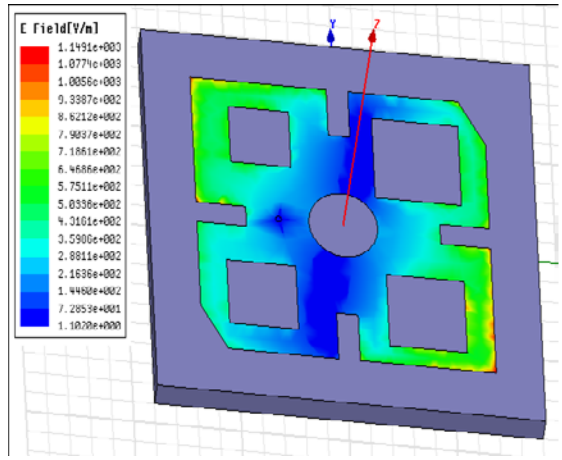

Fig.1 (b) patch in Excitation.

The coax probe impedance is 50 ohms which is randomly located at position (-15mm, 0mm) from center. The electromagnetic coupled patch is of same main patch dimensions without slots at height 25.428mm from the main patch over the FR-4 Epoxy substrate with height of h = 5mm. the simulated Return Loss S_{11} (dB) , Axial Ratio , minimum and maximum Gain values at the bore sight are represented in fig.2 (a) – (c). The total Bandwidth of around 45 MHz with minimum Axial Ratio of 0.7741 dB is achieved. The peak Gain obtained is 3.91 dB.

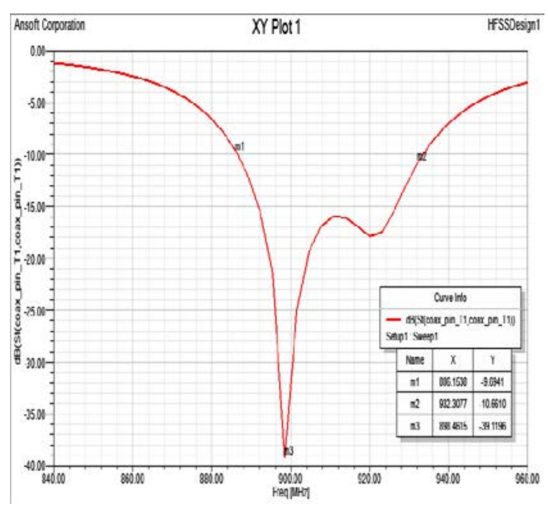

Fig.2 (a) Return Loss S_{11} (dB) plot.

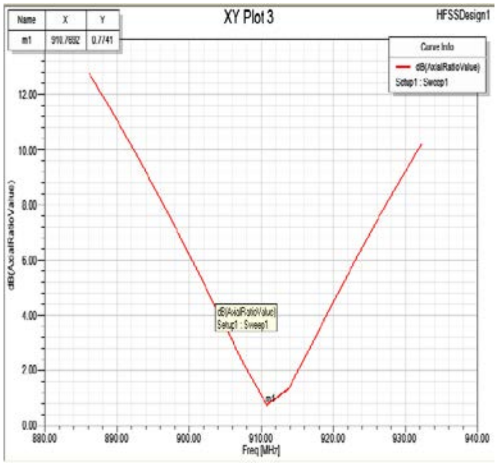

Fig.2 (b) Axial ratio plot.

The proposed antenna found reliable in countries like Singapore, Australia, Taiwan, Korea, Hong Kong, China, and America and covers the majority world wide RFID i.e. Radio Frequency Identification range.

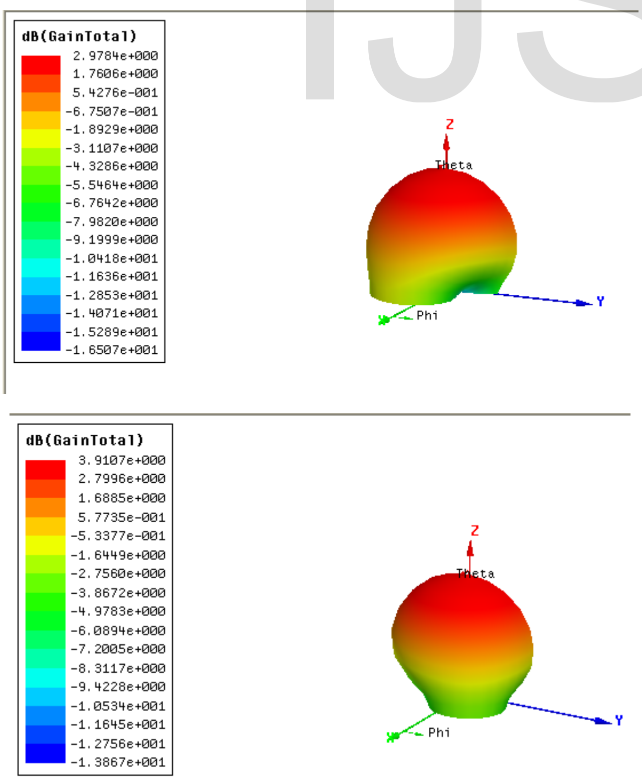

Fig.2 (c) min. and max. Gain values.

3 PARAMETRIC ANALYSIS

3.1 EFFECT OF SLIT LENGTH

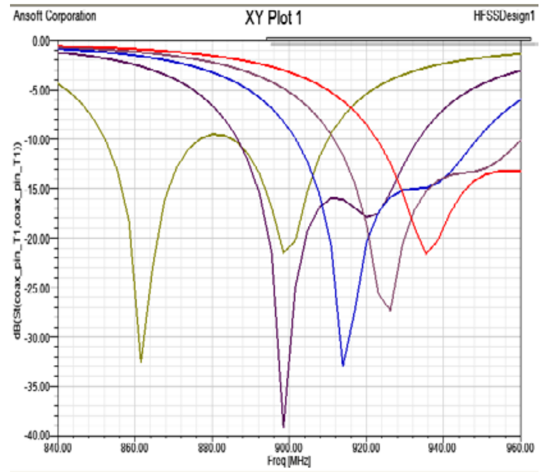

Fig.3 (a) Return Loss S_{11}(dB) Plot.

The fig.3 (a) represents the Return Loss S_{11} (dB) variation for length L_S and width W_S tuning of the orthogonally located slits. The slit length L_S = 15mm and width W_S = 5mm provides the Return Loss S_{11} (dB) of -39.1 dB with frequency band of operation around 900 MHz. The variation step size taken to be 2.5 mm in slit length L_S. The slit tuning provides the desired Frequency of operation.

Table 1
Parametric Configuration

Curve Info
dB(St(coax_pin_T1,coax_pin_T1)) Setup1 : Sweep1 a='0.5cm' coax_pin='0.07cm' coax_radius='0.16cm' cut_out_radius='
dB(St(coax_pin_T1,coax_pin_T1)) Setup1 : Sweep1 a='0.75cm' coax_pin='0.07cm' coax_radius='0.16cm' cut_out_radius=
dB(St(coax_pin_T1,coax_pin_T1)) Setup1 : Sweep1 a='1cm' coax_pin='0.07cm' coax_radius='0.16cm' cut_out_radius='0.
dB(St(coax_pin_T1,coax_pin_T1)) Setup1 : Sweep1 a='1.25cm' coax_pin='0.07cm' coax_radius='0.16cm' cut_out_radius=
dB(St(coax_pin_T1,coax_pin_T1)) Setup1 : Sweep1 a='1.5cm' coax_pin='0.07cm' coax_radius='0.16cm' cut_out_radius='

3.2 EFFECT OF DIELECTRIC HEIGHT

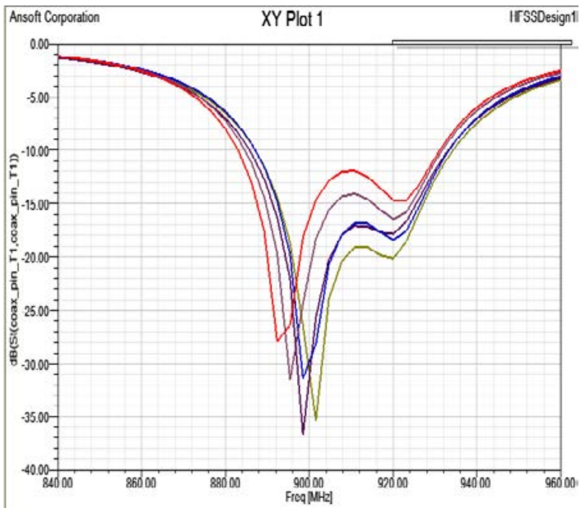

Fig.3 (b) Return Loss S_{11}(dB) Plot.

The larger dielectric height improves the Antenna Gain by reducing surface wave generation and thus improves the Return Loss S_{11} (dB). The dielectric height of 4.572mm provides the best result for the configuration mentioned with Return Loss S_{11} (dB) of -39.11 dB respectively as shown in figure. 3(b). The variation step size taken here is 3mm.

Table 2

Parametric Configuration

Curve Info
dB(St(coax_pin_T1,coax_pin_T1)) Setup1 : Sweep1 dielectric_height='0.4cm'
dB(St(coax_pin_T1,coax_pin_T1)) Setup1 : Sweep1 dielectric_height='0.43cm'
dB(St(coax_pin_T1,coax_pin_T1)) Setup1 : Sweep1 dielectric_height='0.46cm'
dB(St(coax_pin_T1,coax_pin_T1)) Setup1 : Sweep1 dielectric_height='0.49cm'
dB(St(coax_pin_T1,coax_pin_T1)) Setup1 : Sweep1 dielectric_height='0.5cm'

4 CONCLUSION

The proposed antenna performance characteristics are adequate for the Ultra High frequency (UHF) Radio Frequency Identification (RFID) applications with high Bandwidth that covers majority worldwide Frequency span. The parasitic patch improves the Gain- Bandwidth relationship of the configuration. The slits and corner truncations improves the Return Loss S_{11} (dB) and is about -39.11 dB and minimum axial ratio 0.771 dB for circularly Polarized (CP) radiation. The simulated antenna found applications in countries like Singapore, Australia, Taiwan, China, America and Hong Kong. While considering cost as prior value use of low cost FR-4 Epoxy is suitable dielectric material for the design. The slots and corner truncations reduce the patch size in quiet good ratio.

REFERENCES

[1] Nasimuddin, Senior Member, IEEE, Zhi Ning Chen, Fellow, IEEE, and Xianming Qing, Member, IEEE " Asymmetric- Circular Shaped Slotted Microstrip Antennas for Circular Polarization and RFID Applications." IEEE TRANSACTIONS ON ANTENNAS AND PROPOGATION VOL. 58, NO. 12, DECEMBER 2010.

[2] Zhongbao Wang, Shaojun Fang, Shiqiang Fu, and Mujie Fan "Single-Fed Single-Patch Broadband Circularly Polarized Antenna for UHF RFID Reader Applications" 2010 2nd International Conference on Industrial and Information Systems 978-1-4244-8217-7/10/$26.00 ©2010 IEEE.

[3] N. Gautam* (1), P. Deo (2), A. Mehta(1), D. Mirshekar-Syahkal(2), P.J. Massey and H. Nakano(3) "Circularly Polarized Square Patch Antenna with Square Slots for RFID Reader Applications."978-1-4244-4968-2/10/$25.00 ©2010 IEEE.

[4] Donghai Yu, Yao Ma, Zhiyun Zhang, Renjie Sun "A Circularly Polarized Aperture-coupled Patch Antenna for RFID Reader." 978-1-4244-2108-4/08/$25.00 © 2008 IEEE.

[5] Abdi K.H. Obsiye, Hany E. AbdEl-Raouf, and Rafique El-Islam" Modified Printed Crescent Patch Antenna For Ultrawideband RFID (UWB-RFID) Tag" 2008 IEEE INTERNATIONAL RF AND MICROWAVE CONFERENCE PROCEEDINGS December 2-4, 2008, Kuala Lumpur, MALAYSIA.

[6] Nasimuddin, Karu P. Esselle, and A. K. Verma "Wideband High-Gain Circularly Polarized Stacked Microstrip Antennas with an Optimized C-Type Feed and a Short Horn" IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 56, NO. 2, FEBRUARY 2008.

[7] Yanun Liu'*, Mahmoud Shahabadi*, Safieddin Safavi-Naeini', Shady Suleiman Gain "Improvement of an Array of Sequentially Rotated Circularly Polarized Microstrip Antennas Using Stacked Parasitic Patches" 0-7803-7846-61031971.2003 IEEE.

[8] P. C. Sharma and K. C. Gupta, "Analysis and optimized design of single feed circularly polarized microstrip antennas," IEEE Trans. Antennas Propag., vol. 29, pp. 949–955, 1983.

[9] Pei-Ju Lin, Hsien-Chiao Teng and Yu-Jung Huang, Ming-Kun Chen "Design of Patch Antenna for RFID Reader Applications".

ACKNOWLEDGMENT

The author wishes heartiest thanks and regards to Mr. Ranjan Kumar (Indian Institute of Technology Kanpur U.P, INDIA Project Associate) for his help and full support regarding completion of the research.

AKASH PORWAL- Presently Microelectronics M.Tech scholar (Institute of Engineering and Technology, Lucknow). He received the B.Tech degree in Electronics and Communication Engineering in year 2011 from Gautam Buddh Technical University Lucknow, INDIA. His research interest includes Microstrip Antennas, Channel coding and Microelectronics.

Dr. (Prof.) NEELAM SRIVASTAVA - She received BE Electronics Engineering from M.M.M. Engineering College Gorakhpur, M.Tech in Microwave Engineering from IT/BHU Varanasi and Ph.d in Optical Networks from IET, Lucknow from Lucknow University. Her research field includes Antenna Design, Digital Communication and Channel coding etc.