INTRODUCTION

Nowadays increasing the need for security and visibility of goods and assets automatic identification is required. RFID system has become very popular in industries, such as the service industry, inventory control, distribution logistics, security systems, transportation and manufacturing process control. RFID system is more efficient method of automatic identification than bar code and optical scanners. It works in different frequency bands. The information is transferred between reader and tag through the electromagnetic coupling or antennas. To cover a long read range, high reading speed and small size UHF RFID band is used as compared to the LF or HF RFID band. There are many antennas used for RFID system but to achieve planar structure and compact size, microstrip patch antenna is a good choice.

1.1 Overview of Microstrip Patch Antenna (MPA)

Microstrip patch antennas were first proposed in the early 1970s. It is a narrowband, wide-beam antenna [1]. It consists of three layers ground plane, dielectric substrate and radiating patch. The conducting patch on ground plane is separated by dielectric substrate [2]. The patch and ground plane is generally made of conducting material such as copper or gold [3]. The patch radiator can take any shape like square, rectangular, circular, elliptical, annular ring, triangular etc. but rectangular and circular configurations are the most commonly used configurations.Low dielectric constant substrates are generally preferred for maximum radiation [2]. FR-4 (Flame Retardant-4) is generally used as substrate. A microstrip antenna is characterized by its Length, Width, Input impedance, and Gain and radiation patterns [1].Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane.

Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are extremely compatible for embedded antennas in handheld wireless devices such as cellular phone, RFID, pagers etc...

1.2 Some common shapes of Patch Radiator

The microstrip antenna is also known as patch antenna. Patch can have any shape. Some common shapes of radiating patches are rectangular, square, circular, elliptical, triangular, disk sector, annular ring.

1.2.1 Rectangular and square patch

These patches are first and probably the most utilized patch conductor. Square patches are used to generate CP and on the other hand rectangular patches have larger impedance bandwidth because they have larger size than other patches [4].

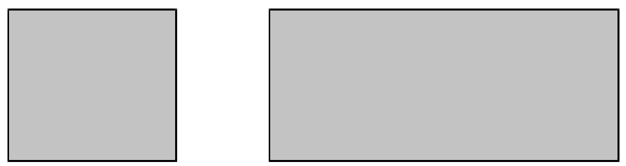

Fig. 1.7 Square and Rectangular Patch

1.2.2 Circular and elliptical patch

These patches are slightly smaller than their rectangular patches, so they have slightly lower gain and bandwidth [4].

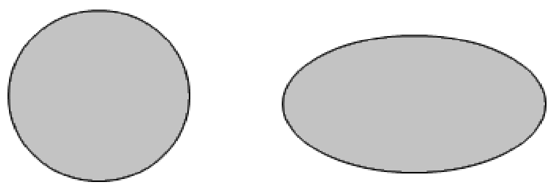

Fig. 1.8 Circular and Elliptical Patch

1.2.3 Triangular and disk sector patch

These are smaller than their rectangular and circular patches, but have more reduction in bandwidth and gain than circular and elliptical patches. Triangular patches are used to generate cross-polarization at higher level, because they are asymmetric in the configuration. Dual-polarized patches can be developed using these conductor shapes; however, the bandwidth is typically very narrow [4].

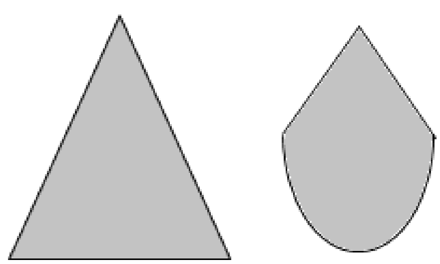

Fig. 1.9 Triangular and Disk Sector Patch

1.2.4 Annular ring patch

These are the smallest conductor shape. These patches have lesser gain and bandwidth than all above discussed patches. Problem associated with an annular ring is that it is not a simple process to excite the lowest order mode and obtain a good impedance match at resonance. Noncontact forms of excitation are typically required [4].

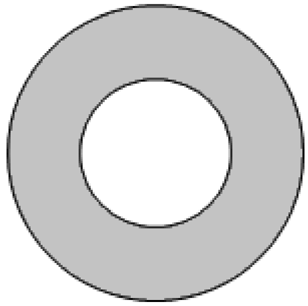

Fig. 1.10 Ring Patch

1.3 Advantages and Disadvantages of Microstrip Patch Antenna

Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are highly compatible for embedded antennas in handheld wireless devices [1]. Some of the major advantages are:

- Light weight and low volume.
- Low profile planar configuration.
- Low fabrication cost.
- Supports both linear and circular polarization.
- Easy to form large array.
- Easy to modify and customize.
- Capable of multiple frequency operations.
- Mechanically robust when mounted on rigid surface.

Microstrip patch antennas have some drawbacks as compared to conventional antennas. Some of the major disadvantages are given below:

- Narrow bandwidth.
- Low Gain.
- Low Gain.
- Low power handling capacity.
- Surface wave excitation.

1.4 Introduction to RFID System

It is an automatic identification technology. This technology provides wireless identification and tracking capability that is more convenient than use of bar codes and optical scanners. It transmits data without contact and Line-Of-Sight (LOS). Thus, the tagged items can be identified within the field without regard to orientation or position to affixed tag whereas; in bar code and optical scanners the line-of-sight is necessary. The information is sent to and read from RFID tags by the reader using radio waves. This allows for many items to be interrogated instanteounsly without manual manipulation of the items. The information is sent to and read from RFID tags using radio waves.

Figure 1.17 shows the RFID system. RFID technology can support many applications like identification, tracking, asset tracking, healthcare, inventory management, defense, etc.

A RFID system typically consists of

- Tag
- Reader
- Information Management System.

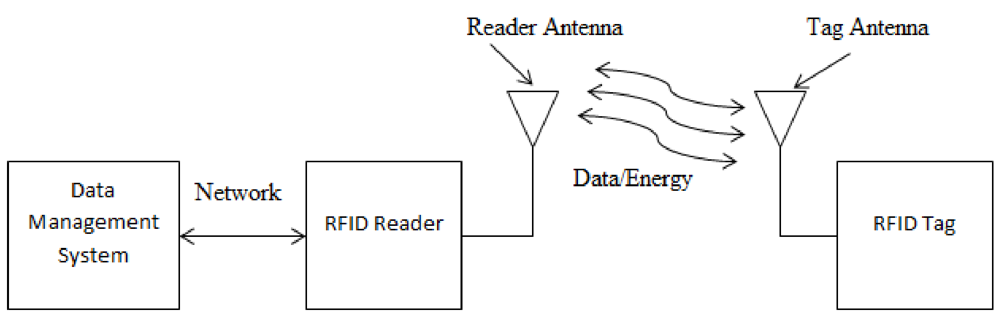

Fig. 1.17 RFID System

There are several frequency bands used in RFID which are low frequency (LF), high frequency (HF), ultra high frequency (UHF) and microwave. Different frequency bands are listed in table 1.1

Table 1.1 RFID Frequency Bands

Frequency Band	**Read Range**	**Advantages**	**Disadvantages**	**Application**
Low Frequency (LF) 30 - 300KHz	Up to 20 inches	Good penetration in moist environment. No Anti-collision.	Slow data rate.	Animal tracking, Access control, Vehicle key locks.
High Frequency (HF) 3 – 30 MHz	Up to 3 feet	Good penetration in moist environment	Poor performance in metal environment.	Item level tagging, libraries, Smart cards,

				Airline baggage.
Ultra High Frequency (UHF) 300 – 3000MHz	Passive: Up to 16 feet Active: More than 30 feet	Good penetration in moist environment. Fast data rate.	-------------------	Item level tagging, libraries, Smart cards, Airline baggage.
Super High Frequency (SHF)" Microwaves" 3 – 30 GHz	2+ Meters	Good penetration in moist environment. Fast data rate.	Poor performance in metal environment. High cost.	Item tracking, Toll collection.

LITERATURE SURVEY

In order to start my dissertation, it is important to have a deep understanding of microstrip antenna and RFID system

Jaehoon Choi.et.al [6] had discussed design of RFID reader antenna for UHF RFID handheld systems. In this paper, two types of compact UHF reader antennas for handheld applications had been proposed. Firstly, the antenna is designed by using aperture coupled feeding technique. In aperture coupled feeding technique, an annular ring shaped patch with rectangular stubs is placed on a substrate having a ground plane with ring slot on another side. A feed line is placed on FR4 substrate which is separated from top layer by an air gap. The resonant frequency of antenna is 915MHz. The 3dB axial ratio bandwidth is 30MHz. The measured 10dB return loss bandwidth is 60MHz. The gain of antenna is up to 2.9dBic. The overall size of antenna is $100 \times 100 \times 9.6mm^3$. Secondly, the antenna is designed by using artificial magneto-dielectric structure. This antenna consists of a square radiating patch, a magneto-dielectric material with an SRR array structure; a microstrip feed line using a Wilkinson power divider, and a ground plane. Each component is printed on four FR4 substrates with different thickness. The measured axial ratio of antenna is under 3dB under the desired band of frequency. This antenna has a return loss of 15dB over Korean UHF RFID frequency band. The gain of antenna is up to -3.75dBic. The overall size of antenna is $100 \times 100 \times 3.2mm^3$.

S. S. More.et.al [7] had proposed compact microstrip antenna for RFID application. In this paper, the author had made the design with a square patch radiator using co-axial feed. Four unequal slots are cut diagonally on a square patch radiator. These slots provide circular polarization. Four symmetric slits are also embedded along the orthogonal direction of the square patch radiator to further reduce the size of antenna. The resonant frequency of antenna is 863MHz. The 10dB return loss bandwidth is 50MHz. The size of ground plane is $90\times 90mm^2$ and the size of patch radiator is$90\times 90\ mm^2$.

YaunChih Lin.et.al [8] had presented a novel circular polarization RFID reader antenna with a multi-bending feeding strip for handheld applications. This antenna consists of radiating patch, an antenna ground plane, a multi- bending feeding strip with 50ohm SMA connector and a system ground plane. The patch radiator is printed on the upper side of ceramic substrate with a ground plane on the lower side. The proposed antenna is placed on system ground plane etched on FR4 substrate. The circular polarization can be achieved by multi-bending feeding strip. The central resonant band can be controlled by adjusting the size of radiating patch. The resonant frequency of antenna is 925MHz. The return loss bandwidth of antenna is 17.0MHz. The proposed antenna has an overall size of around 80 × 80 × 4.8mm^3.

Yi-Fang Lin.et.al [9] had proposed proximity fed circularly polarized slotted patch antenna for RFID handheld reader. In this paper, the author had made the design with a square patch radiator on FR4 substrate material using proximity feed. The author had purposed a new compact x-shaped slotted square patch antenna for circular polarization. A cross strip with tuning stubs is embedded along X- shaped slot on the square patch to produce circular polarization radiation. Two pairs of T-shaped slots are cut orthogonally on the square patch and are connected to the center of X-shaped slot. These slots provide antenna size reduction and circular polarization. The resonant frequency of antenna is 923MHz. The 10dB return loss bandwidth is 909-937MHz. The axial ratio bandwidth is 12.0MHz. The gain of antenna is 4.0dBic. The overall size of antenna is $0.19\lambda_0 \times 0.19\lambda_0 \times 0.046\lambda_0$ at 923MHz.

Akash Porwal.et.al [10] had presented quad squares center circular slotted microstrip RFID applications antenna. In this paper, the author had made the design with a square patch radiator on FR4 epoxy substrate material using co-axial feed. In this design, a new quad squares center circular slotted, orthogonal slits with truncated corner patch structure had been proposed. The slits and truncated corners reduce the size of antenna with circularly polarized radiation. The resonant frequency of antenna is 900MHz. The axial ratio is 0.7741dB. The impedance bandwidth is 45.0MHz. The measured gain of antenna is 4.0dB. The size of ground plane is 90× 90 mm^{2}at 900MHz.

SyamimiMohd Norzeli.et.al [11] had discussed designing an UHF RFID reader antenna. In this paper, the author had made the design with E-shaped patch radiator on FR4 substrate material using microstrip feed. The resonant frequency of antenna is 900MHz. The return loss of antenna is 12.653dB.The gain of antenna is 5.829dB. The VSWR of antenna is 1.61. The overall size of antenna is around $108.3 \times 86.3 \times 1.6mm^3$.

Poongodi C.et.al [12] had proposed a compact square, circular and cross shaped slotted patch antenna for RFID application. In this paper, the author had made the design with a three different types of patch radiator on RO4003C substrate material using coaxial feed. The return loss of these antennas is less than -10dB at 920MHz and is covering a bandwidth of 3MHz which is suitable for RFID application. The gain is more than 3dBi for all three antennas. The axial ratio for all three antennas is greater than 6dB. The overall antenna size is around $90 \times 90 \times 4.572mm^3$.

Nasimuddin.et.al [13] had presented a compact circularly polarized cross shaped slotted microstrip patch antenna. In this paper, the author had made the design with a square patch radiator on RO4003C substrate material using co-axial feed. A symmetric cross shaped slot is cut along one of diagonal axes of the square patch radiator. The slot provides CP radiation and antenna size reduction. The resonant frequency of antenna is 910MHz. The measured 3dB axial ratio bandwidth is 6.0MHz. The measured 10dB return loss bandwidth is 18.0MHz. The gain of antenna is up to 3.8dBic. Three different shaped (circular, square, cross) patch radiator on RO4003C substrate material using coaxial feed are also made. These three different shapes slotted microstrip patch antenna had been also compared and studied with respect to the variation of perimeters based on good CP radiation with fixed antenna size. The overall size of antenna is $90\times 90\times 4.572\ mm^3$ at 910MHz.

Nasimuddin.et.al [14] had discussed slotted microstrip antennas for circular polarization with compact size. In this design, the author had proposed circularly polarized diagonal symmetric different shaped slotted microstrip patch antenna with compact size. These designs are made on square patch radiator on RO3004C substrate material using co-axial feed. Different shapes (circular, circular ring, square, cross slot, truncated corner and rectangular slot) are studied and compared. The cross shaped slotted diagonal symmetric microstrip patch antenna is compact in comparison with other slots based microstrip patch antennas. To validate the proposed technique cross shaped diagonally symmetric microstrip patch antenna was demonstrated experimentally. The resonant frequency of antenna is 905MHz. The measured 3dB axial ratio bandwidth is 6.0MHz. The measured impedance bandwidth is 18.0MHZ. The measured gain of antenna is 3.3dBic. The overall antenna size is 154× 100 × 1.6 mm^3 at 905MHz. This cross shaped slotted antenna can be useful for RFID handheld reader applications.

Chow-Yen Desmond Sim.et.al [15] had presented circularly polarized equilateral triangle patch antenna for UHF RFID reader applications. In this paper, the author had made the design with an equilateral triangle shaped patch radiator on FR-4 substrate material. The CP is achieved by loading a near semi-circular notch into the patch. The 3dB axial ratio bandwidth is 27.0MHz. The impedance bandwidth is 248.0MHz. The gain of antenna is between 6.21dBic and 6.77dBic over the observed RFID band. The overall antenna size is 150× 150 × 34.4mm^3.

Chow-Yen Desmond Sim.et.al [16] had proposed a slot loaded circularly polarized patch antenna for UHF RFID reader. In this paper, the author had made the design with a circular shaped patch radiator on FR4 substrate material. The circular polarization is achieved by loading a semicircular slot into the circular patch radiator. The 3dB axial ratio bandwidth is 29.0MHz. The impedance bandwidth is 220.0MHz. The gain of antenna is between 6.8dBic and 7.32dBic over the observed RFID band. The overall antenna size is 150× 150 × 34mm^3.

ZhiNing Chen.et.al [17] had discussed a universal UHF RFID antenna. This antenna is composed of two corner truncated patches and a suspended microstrip line with open-circuited termination. The main patch is fed by four probes which are sequentially connected to the suspended microstrip feed line. The return loss of this antenna 15dB, gain of 8.3dBic, axial ratio (AR) of 3dB. Therefore, the proposed antenna is universal for UHF RFID applications worldwide at the UHF band of 840–960MHz. The overall size of antenna is 250× 250 × 5mm^3.

Yen-Ming Tseng.et.al [18] had presented a compact circularly polarized circular microstrip RFID tag antenna. The antenna is fabricated on a FR4 substrate with thickness 1.6mm. It consists of circular patch with a cross slot of width of 1mm unequal arm lengths S_x and $S_y$located at the center along x-axis and y-axis respectively. To excite the radiating circular patch by electromagnetic coupling the pairs of arc microstrip lines are used. The measured 10-dB return-loss bandwidth of the tag antenna is 40 MHz (901−941 MHz) and its 3-dB axial-ratio bandwidth is 6 MHz (912−918 MHz). The read range of this tag antenna when measured with the LP reader in free space is 1.62m to 1.92m at all ϕ angles and when it is mounted on metal its range is 3.0m to 3.58m. The read range of this tag antenna when measured with the CP reader in free space is increased from 1.92m to 2.4 and when it is mounted on metal its range is increased from 3.58m to 4.6m. The overall size of antenna is $80 \times 80 \times 1.6\ mm^3$.

Horng-Dean Chen.et.al [19] had proposed CP RFID tag design for metal surface mount. This antenna is fabricated on FR-4 substrate with the thickness of 1.6mm. It consists of radiating square patch with cross slot of S_y and $S_{x.}$ This slot is inserted to achieve compact size and circular polarization. S_y is longer than S_x will results in obtaining Left-Hand Circular Polarization (LHCP). The L-shaped open end line is connected to a tag chip and terminated by a shorting pin is capacitively coupled to the patch. The measured 10 dB impedance bandwidth of tag antenna is 48MHz (906-954MHz) centered at 930MHz and 3dB circular polarization bandwidth is 6MHz (922-928MHz). The value of axial ratio(AR) is 0.69 at 925MHz. Read range can be achieved up to 2.8m when mounted on metallic surface at different orientation. The overall size of antenna is $70 \times 70 \times 1.6mm^3$.

Horng-Dean Chen.et.al [20] had discussed a compact broadband dual coupling feed circularly polarized RFID tag antenna mountable on metallic surface. It is fabricated on FR-4 substrate. The antenna consists of radiating square patch with centrally loaded by a cross slot of S_1 and S_2. In this antenna dual coupling feed is used. The measured 6-dB return-loss bandwidth of the tag antenna is 25MHz (902–927 MHz), and its corresponding 3-dB axial-ratio (AR) bandwidth is 20 MHz (903–923 MHz). Read range of this antenna is 4.39m in free space and 4.62m when mounted on metallic surface. The size of antenna is $100 \times 100 \times 1.6mm^3$.

Ran Liu.et.al [21] had proposed a novel circularly polarized annular-ring tag antenna for RFID UHF band mounted on metallic surfaces. The antenna is fabricated on a FR-4 substrate with thickness 1.6mm. The radiating patch is annular-ring with two slits along x-axis which makes the antenna size much less than that of regular circularly polarized circular microstrip antenna. The pairs of arc microstrip lines are used to excite the radiating annular-ring patch by electromagnetic coupling. The 10 dB return-loss bandwidth of the tag antenna is measured to be 215MHz (720-935MHz), while its 3 dB axial-ratio bandwidth is 6MHz (919-925 MHz). The read range of this antenna is 3.5m in free space at all angles and increased to 5.5m when mounted on metal surface. The overall size of antenna is $74 \times 74 \times 1.6mm^3$.

Pradeep Mirchandani.et.al [22] had presented Performance analysis of miniaturized microstrip patch antennas for UHF RFID applications. This paper presents the theoretical analysis and experimental testing of three compact microstrip patch antennas designed for the RFID Readers in the UHF band of 865-868MHz. The characteristics and performance of the new miniaturized antenna is compared to a conventional quarter wave patch antenna and an enhanced truncated square patch with shorting pins. The proposed patch antenna is compact and measures 80 mm by 70 mm along with its ground plane. Due to its dual circular polarization, it offers a read range of up to 9 feet for horizontal and vertical tag orientation.

2.2 Inferences Drawn

Above literature review discussed the different designs of microstrip patch antenna. Different shapes of patches and feeding techniques were used. There were different type ofslots and slits also introduced on patch radiator and ground plane to get desired frequencies and compact size antennas. It is clear from the above discussed paper; the main problem of microstrip patch antenna is its size for RFID systems.

So, I have to reduce the size of proposed antenna with its required specifications.

PROPOSED WORK

3.1 Problem Definition

As it is known that for the purpose of security the automatic identification is very important. RFID technology is used for automatic identification. This technology has many advantages over other identification systems. Antenna is the main part of RFID system for transferring information between tag and reader through RF signal. The size of antenna is main issue because for handheld RFID reader its size should be small as possible. It is necessary to optimize a small size reader antenna with its specific requirements. So the main problem of RFID reader antenna is its size.

3.2 Objectives of Research

As the problem is based upon size of handheld RFID reader antenna so our main objectives are:

- Reduce overall size of antenna.
- To get desired operating frequency band.
- Achieve Circular Polarization
- Good gain

3.3 Methodology

The optimization and simulations of microstrip patch antenna for handheld RFID applications with its requirements is done by using HFSS (High Frequency Structure Simulator). The methodology is as given below.

- Selection of design parameters.
- Modeling of microstrip patch antenna.
- Simulating and optimizing design parameters.
- Comparison and result validation.

REFERENCES

[1] Asadullah Noor,“Design of microstrip patch antennas at 5.8GHz” Master Thesis, Kapsch Traffic Comm AB, Jonkoping, Sweden.

[2] Amritesh, Kshetrimayum Milan Singh, “Design of square patch microstrip antenna for circular polarization using IE3D software” B.Tech Thesis, NIT Rourkela, Orissa.

[3] Tanya Sharma, Osh Atal,“Design of ultra-small microstrip patch antenna for wireless communication application” B.Tech Thesis, NIT Rourkela, Orissa.

[4] Tanveer Kour Raina,“Design, fabrication and performance evaluation of microstrip patch antennas for wireless applications using aperture coupled feed” M.E., Thaper University, Patiala.

[5] NehaAhuja, “Study and investigations on various microstrip patch antennas for wireless applications” M.E., Thaper University, Patiala.

[6] Jaehoon Choi, Uisheon Kim and Taeik Kim, “Design of RFID reader antennas for UHF RFID handheld systems” IEEE International workshop on Antenna Technology, March 2011, pp. 33- 36.

[7] S. S. More and M. P. Turuk , “Compact microstrip antenna for RFID application” International Journal of Emerging Technology and Advanced Engineering, Vol. 2, Issue 7, July 2012, pp. 493-496.

[8] Yuan-Chih Lin, Wen-Shan Chen, Bau-Yi Lee, Tzu-Chen Hung and Chii-Ruey Lin, “A novel circular polarization RFID reader antenna with a multi-bending feeding strip for handheld applications” Progress In Electromagnetics Research C, Vol. 39, 2013, pp. 255-264.

[9] Yi-Fang Lin, Chun-Hsieg Lee, Shan-Cheng Pan and Hua-Ming Chen, “Proximity-fed circularly polarized slotted patch antenna for RFID handheld reader” IEEE Transaction on Antennas and Propagation, Vol. 61, October 2013, pp. 5283-5286.

[10] AkashPorwal and Dr. NeelamSrivastava, “Quad squares center circular slotted microstrip RFID applications Antenna” International Journal of Scientific & Engineering Research, Volume 4, Issue 12, December-2013, pp. 926-930.

[11] SyamimiMohdNorzeli, Ismarani Ismail, MohdFazruisyamMohdBusu, “Designing an UHF RFID reader antenna” IEEE Symposium on Humanities, Science and Engineering Research, June 2012, pp. 599-602.

[12] Poongodi C, Deepa D and Shanmugam A, “A compact square circular and cross shaped slotted patch antenna for RFID application” International Journal of Advanced Research in Computer and Communication Engineering, Vol. 2, Issue 3, March 2013,pp. 1610-1615.

[13] Nasimuddin, ZhiNing Chen and Xianming Qing, “A compact circularly polarized cross-shaped slotted microstrip antenna” IEEE Transaction on Antennas and Propagation, Vol. 60, March 2012, pp. 1584-1588.

[14] Nasimuddin, ZhiNing Chen, and Xianming Qing, “Slotted microstrip antennas for circular polarization with compact size” IEEE Magazine on Antennas and Propagation Vol. 55, April 2013, pp. 124-137.

[15] Chow-Yen-Desmond Sim and Yi-Wen Hsu, “Circularly polarized equilateral triangle patch antenna for UHF RFID reader applications” IEEE Conference on Antenna and Propagation, November 2013, pp. 397-399.

[16] Chow-Yen-Desmond Simand Chin-Jen Chi, “A slot loaded circularly polarized patch antenna for UHF RFID reader” IEEE Transaction on Antennas and Propagation, Vol. 60, October 2012, pp. 4516-4521.

[17] ZhiNing Chen, Xianming Qingand Hang Leong Chung, “A universal UHF RFID reader antenna” IEEE Transaction on Microwave Theory and Techniques, Vol. 57, May 2009, pp. 1275-1282.

[18] Yen-Ming Tseng, Shang-Huang Kuo, Horng-Dean Chen, and Chow-Yen-Desmond Sim, “Circularly polarized circular microstrip RFID tag antenna” IEEE Conference on Microwave, December 2012, pp. 1142-1144.

[19] Homg-Dean Chen, Wen-Shan Chen, Chow-Yen-Desmond Sim and Shang-Huang Kuo, “CP RFID tag design for metal surface mount” IEEE Conference on Radio Science and Wireless Technology, Vol.1, July 2011, pp. 491-493.

[20] Horng-Dean Chen, Chow-Yen-Desmond SimandShang Huang Kuo, “Compact broadband dual coupling-feed circularly polarized RFID microstrip tag antenna mountable on metallic surface” IEEE Transactions on Antenna and propagation, vol. 60, December 2012, pp. 5571-5577.

[21] Ran Liu, Yuan Yao, Youbo Zhang, HongbinGe, Wenjing Lee, Junsheng Yu, and Xiaodong Chen, “Design of a novel circularly polarized annular-ring RFID tag antenna for metallic surfaces” IEEE Conference on Microwave, November 2013, pp. 245-247.

[22] PradeepMirchandani, KashmiraDeshpande and Rukhsana Khan, “Performance analysis of miniaturized microstrip patch antennas for UHF RFID applications” IEEE International Conference on Signal Processing, Communication, Computing and Networking Technologies, July 2011, pp. 244-249.