Microstrip Patch Antenna for RFID Handheld Reader Applications- A Review

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Abstract-This paper presents a study of various designs of microstrip patch antenna for Radio Frequency Identification (RFID) handheld reader applications in Ultra High Frequency band (860-960MHZ). In this paper,various characteristics of those antennas are alsodiscussed.

Index Terms- Circular Polarization, Microstrip Patch Antenna, Radio Frequency Identification, RFID Reader Antenna

I. INTRODUCTION

Radio Frequency Identification (RFID) is an automatic identification technique to transmit the identity of an object wirelessly through radio waves. RFID does not need any line of sight to read data and is more robust than barcode. This technology has been rapidly developing in many service industries, distribution logistics, manufacturing companies and goods flow system.
RFID system consists of three components as:

- An antenna or coil.
- A transceiver (RF Reader).
- A transponder (RF tag).

The antenna is used to emits the radio signals to activate the tag and to read and write data to it. An RFID reader emits electromagnetic signals where an RFID tag draws power from it. This power is then used to energize the microchip's circuits. The chip then modulates the waves and sends back this modulated wave to the reader [7].

The RFID system is available at Low Frequency (135KHZ), High Frequency (13.56MHZ), Ultra High Frequency (860-960MHZ) and microwave bands (2.45 & 5.8 GHZ). The frequencies for UHF RFID are not universal worldwide. The frequency is from 840 MHz to 960 MHz with different sub-bands such as 902-928 MHz for North-South America, 865-867 MHz for Europe and 840-955 MHz for Asia-Pacific region. In Asia-Pacific region, the UHF RFID frequency ranges from 840 MHz to 955 MHz in different countries: China (840.5-844.5 MHz, 920.5-924.5 MHz), Japan (952-955 MHz), India (865-867 MHz), Hong Kong (865-868 MHz, 920-925 MHz), Taiwan (920-928 MHz), Korea (908.5-910 MHz, 910-914 MHz), Singapore (866-869 MHz, 923-925 MHz), Australia (920-926 MHz) etc. [3].

RFID Reader consists of RF transmitter and receiver controlled by microprocessor or digital signal processor. The transmitter consists of an oscillator to create the carrier frequency, a modulator to put data commands on this carrier signal and an amplifier to boost the signal quite enough to awaken the tag.The signal is transmitted and received by the antenna to and from the tag.The receiver has a demodulator used to extract the returned data and also contains an amplifier to strengthen the signal. A microprocessor acts as a control unit, which employs an operating system and memory to filter and store the data.

Classification of RFID reader based on communication between reader and tag:

- Passive RFID Reader: A passive reader only receives the signals from an active tag.
- Active RFID Reader: An active reader transmits the interrogator signals and also receives the replies from passive tags.

RFID reader can also be classified based on application:

- Fixed Reader: These readers are used to create portals for automated reading. These readers normally have 2-4 antennas so it can read tags as they pass by. These types of readers can be used to read the tags as they enter the room, pass through warehouse dock door etc.
- Mobile Reader: Mobile reader is a compact solution with an integrated antenna that enables a manual identification of objects. Mobile reader can be handheld or mounted on vehicles. These readers can be used to read the tags for asset tracking, inventory management etc.

II. LITERATURE SURVEY

In this paper [1], a compact circularly polarized microstrip antenna with slits had been proposed for RFID handheld reader applications. A square patch radiator with a length of 80.0mm is used. The substrate material used is RO3004 (thickness= 4.572mm, dielectric constant=3.38, loss tangent= 0.002). The ground plane size (G) is 90 × 90mm^2. Four V-shaped slits are cut diagonally onto the square patch radiator. The four slits are located at (P_1, P_1) and (P_2, P_2) along the diagonal axes from the centre of square patch (P_1=P_2=15.5mm). The areas of these slits depends upon P_1, P_2, d_1, and d_2 (d_1 = 4.6, d_2 = 3.0mm). V_1, V_2, V_3, V_4 are the areas of slits. The areas of diagonal slit pairs are taken same i.e. V_1 = V_3 and V2 = V4. The slits cut on the diagonal axes of patch radiator helps in the size reduction of antenna with circular polarization. The feeding technique used is co-axial feed. The coaxial feed is located on y- axis at a distance of 11.5mm from the centre of square patch. The resonant frequency of

antenna is 920MHZ. A measured 3dB axial ratio bandwidth is 4.0MHZ. The impedance bandwidth is 19.0MHZ. The measured gain of antenna is 3.6 dBic. The overall size of antenna is $0.276\lambda_0 \times 0.276\lambda_0 \times 0.014\lambda_0$. A square patch radiator with slits is shown in figure:

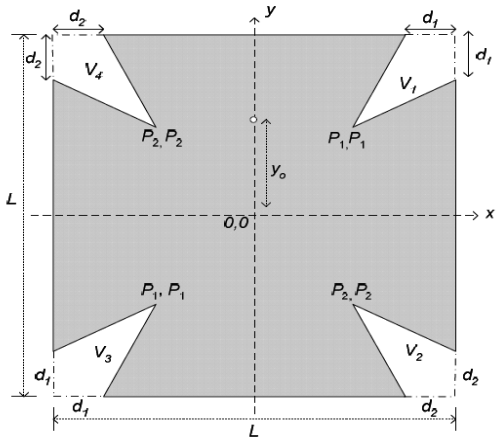

Fig. 1. Square Patch with slits. [1]

In this paper [2], asymmetric circular shaped slotted microstrip patch antennas had been proposed for handheld Radio Frequency Identification reader application. These antennas are made on two different substrates: one is RO4003C and another is FR4 substrate. Firstly, we discussed antenna made on RO4003C substrate. A square patch radiator with a length of 78.0mm is used. The substrate material used is RO4003C (thickness= 4.572mm, dielectric constant=3.38, loss tangent= 0.002). The ground plane size (G) is $90 \times 90mm^2$. Four unequal slots are cut on the square patch radiator and are located symmetrically at S, S (S = 19.5mm) along the diagonal direction from the centre of square patch radiator. The radii of four unequal circular slots are $r_1 = 11.75$, $r_2 = 10.0$mm, $r_3 = 8.0$mm, $r_4 = 6.0$mm respectively. These slots are located at 45^0 to the feed-location axis. Four symmetric slits are cut on along the orthogonal directions on the square patch radiator. The length and width of square patch radiator is s_l= 16.0mm and s_w= 1.0mm respectively. The feeding technique used is co-axial feed. The co-axial feed is located on x-axis at a distance of 15.0mm from the center of slotted square patch. The resonant frequency of antenna is 900MHZ. A measured 3dB axial ratio bandwidth is 6.0MHZ. The impedance bandwidth is 17.0MHZ. The measured gain of antenna is 3.7 dBic. The overall size of antenna is $0.27\lambda_0 \times 0.27\lambda_0 \times 0.0137\lambda_0$ at 900MHZ.

Another asymmetric circular shaped slotted microstrip patch antenna is fabricated on FR4 substrate (thickness = 4.8mm, dielectric constant = 4.3, loss tangent = 0.02). A square patch radiator with a length of 72.0mmis used. The ground plane size (G) is $90 \times 90mm^2$. Two unequal slots are cut on the square patch radiator and are located symmetrically at S, S (S = 19.5mm) along the diagonal direction from the centre of square patch radiator. The radii of for unequal circular slots are $r_1 = 12.0$mm, $r_2 = 5.0$mm respectively. Four symmetric slits are cut on along the orthogonal directions on the square patch radiator. The length and width of square patch radiator is s_l= 10.0mm and s_w= 4.0mm respectively. The feeding technique used is co-axial feed. The co-axial feed is located on x-axis at a distance of 17.0mm from the center of slotted square patch. A measured 3dB axial ratio bandwidth is 12.0MHZ. The impedance bandwidth is 38.0MHZ. The measured gain of antenna is 0.5 dBic. The overall size of antenna is $90 \times 90 \times 4.8mm^{3.}$

It had been concluded that the 3-dB axial ratio bandwidth of antenna on FR4 substrate is more than the antenna on RO4003C. The gain of antenna on RO4003C substrate is more than antenna on FR4 substrate.

The asymmetric circular shaped slotted microstrip patch made on RO4003C substrate is shown in figure:

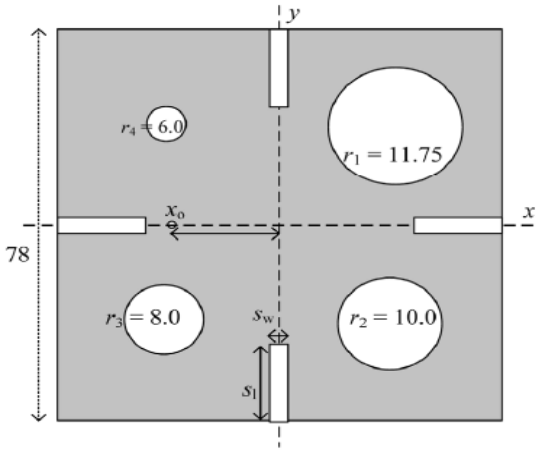

Fig. 2. Asymmetric- circular shaped slotted microstrip patch radiator. [2]

In this paper [3], a compact arc-shaped slotted circularly polarized microstrip antenna has been presented for Ultra High Frequency Radio Frequency Identification handheld reader applications. A square patch radiator with a length of 80.4mmis used. The substrate material used is RO3004 (thickness = 4.572mm, dielectric constant = 3.38, loss tangent = 0.0027). The ground plane size (G) is $90 \times 90mm^2$. Four unequal arc- shaped slots are cut diagonally on the square patch radiator. The outer and inner radii of arc shaped slots are 20.2mm and 16.0mm, respectively. These arc shaped slots are positioned along a circle with a radius of 18.1mm and the centre of patch is taken as the origin. Lengths of these slots are 33.25mm, 30.5mm, 23.0mm, 11.5mm, respectively. The feeding technique used is coaxial feed. The location of coaxial feed on x-axis is at a distance of 16.0 from the centre of slotted square patch. The antenna is designed with IE3D simulator. In this paper, the miniaturization is achieved by embedded slot onto square patch. The circular polarization is achieved by slightly changing the area of circumference of adjacent slots. The resonant frequency of antenna is 924MHZ. The measured 3dB axial ratio bandwidth is 8.0MHZ. The measured 10dB return loss bandwidth is 24.0 MHZ. The gain of antenna is up to 3.7dBic. The overall size of antenna is $0.277\lambda_0 \times 0.277\lambda_0 \times 0.0141\lambda_0$ at 924MHZ. The proposed arc-shaped slotted square patch radiator is shown in figure:

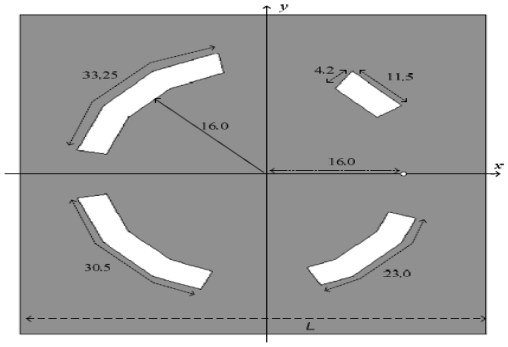

Fig3. Arc-shaped slotted square patch. [3]

In paper [4], a compact slotted slit patch antenna had been proposed for Radio Frequency Identification handheld reader application. A square patch radiator with a length (L) of 76.0mmis used. The substrate material used is RO3004 (thickness = 4.572mm, dielectric constant = 3.38, loss tangent = 0.0027). The ground plane size (G) is 90 × 90mm^2. Two unequal circular shaped slots are cut along one of the diagonally axes on square patch with radii of 9.5mm and 5.0mm, respectively. Four slits are cut along the orthogonal axes on the square patch radiator. The length and width of these slits are 18.25mm and 1.5mm, respectively. The feeding technique used is coaxial feed. The coaxial feed is located on y-axis at a distance of 10.0mm from the centre of patch. The antenna is designed with IE3D simulator. The circular polarization is achieved by using two unequal size circular slots along one of the diagonal axes of the square patch. Slits along the orthogonal axes of square patch can further reduce the antenna size. The resonant frequency of antenna is 910MHZ. The measured 3dB axial ratio bandwidth is 5.0MHZ. The measured impedance bandwidth is 12.0MHZ. The measured gain of antenna is 4.0dBic. The overall antenna size is $0.273\lambda_0 \times 0.273\lambda_0 \times 0.0139\lambda_0$ at 910MHZ. The proposed slotted-slit microstrip patch radiator is shown in figure:

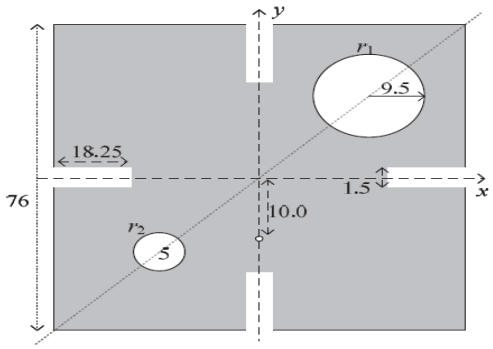

Fig4. Slotted –slit- microstrip patch radiator. [4]

In this paper [5], a novel circular polarization RFID reader antenna with a multi-bending feeding strip had been proposed for handheld application. This antenna consists of radiating patch, an antenna ground plane, a multi- bending feeding strip with 50ohm SMA connector and a system ground plane. A square patch radiator with a length (L) of 19.0mmis used. This antenna is designed on high dielectric constant ceramic substrate (thickness = 4mm, dielectric constant = 60, loss tangent = 0.001) with a size of 27 × 27mm^2. The radiating patch is printed on the upper side of substrate and antenna ground plane is printed on lower side of substrate. Multi-bending feeding strip is printed on the ceramic substrate matches the characteristic of coaxial cable from RF module. The dimensions of multi-bending feeding strip are U_A = 7.5, U_B = 2.5, W = 1, L_A = 6, L_B = 1.5. The system ground plane is etched on FR4 substrate (thickness=0.8mm, dielectric constant=4.4) to create a more concentrated radiation beamwidth and good shielding metal to reduce the user's hand positioning effect. The antenna is simulated using Ansoft HFSS simulator. The resonant frequency of antenna can be controlled by adjusting the size of top radiating patch. Two orthogonal field components with 90^0 phase difference for circular polarization can be obtained by optimizing multi-bending feeding strip. The resonant frequency of antenna is 925MHZ. The return loss bandwidth of antenna is 17.0MHZ. The proposed antenna size is around 80 × 80 × 4.8mm^3. The design of antenna is shown in figure:

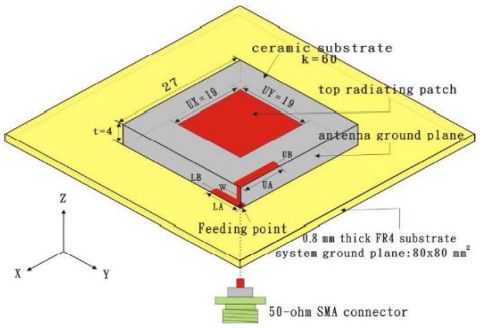

Fig5.3-D view of antenna. [5]

In this paper [6], proximity –fed circularly polarized slotted patch antenna had been proposed for RFID handheld reader application. A square patch radiator with a length of 60mm is used. The substrate material used is FR4 (thickness = 0.8mm, dielectric constant=4.4). The same FR4 substrate is used for ground plane and height of air substrate is selected as 13.4mm. An X-shaped slot of 57.9 × 7.5mm^2 is cut along the diagonal of patch radiator. A cross-strip with width of 1.5mm is embedded in X-shaped slot and has tuning stubs of different length (L_a=17.5mm and L_b=22.5mm).The feeding technique used is proximity feed. A single coaxial probe is located at the centre of square patch radiator and is connected to the cross strip. This patch is electromagnetically coupled from the cross-strip through a gap distance of 0.75mm. Two pairs of T-shaped slots of unequal length (S_x= 17.9mm, S_y= 18.9mm) are cut on patch radiator and connected to the X-shaped slot at an angle of 45^0. The antenna is designed using HFSS simulator. A cross strip is embedded along the X-shaped slot for achieving circular polarization. Two pairs of T-shaped slots cut orthogonally on square patch radiator connected to the centre of the X-shaped slot for circular polarization and size reduction of antenna. The resonant frequency of antenna is 923MHZ. The 10dB return loss bandwidth is 26.0MHZ. 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. The design of antenna is shown in figure:

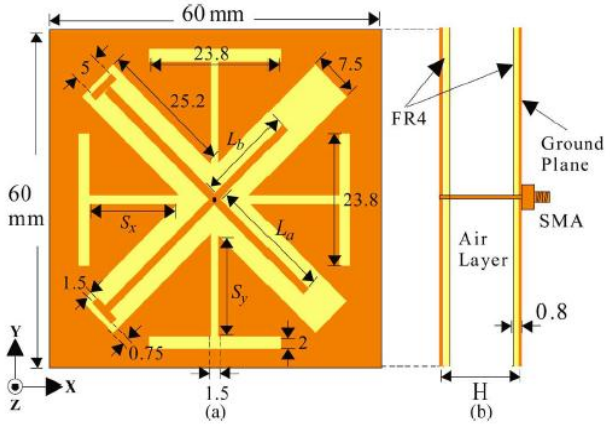

Fig. 6. Geometry of X-shaped slotted patch antenna. [6]

III. CONCLUSION

This paper includes a literature survey of some previous papers on microstrip patch antenna for RFID handheld reader applications. From above discussed papers, it is concluded that the main concern is to design a compact size antenna with good circular polarization in desired frequency band. In this paper we also discussed different characteristics of antenna: resonant frequency, 10dB return loss bandwidth, 3dB axial ratio bandwidth, antenna size and gain and are summarized as:

TABLE I: SUMMARY OF DIFFERENT DESIGNS OF MICROSTRIP PATCH ANTENNA

Antenna's parameter	**Paper's Name**						
	Compact circularly polarized microstrip antenna for RFID handheld reader applications.	**Asymmetric-Circular shaped slotted microstrip antennas for circular polarization and RFID applications.**		**Compact arc-shaped slotted circularly polarized microstrip antenna for RFID Readers**	**A compact circularly polarized slotted-slit-microstrip patch antenna**	**A novel circular polarization RFID reader antenna with a multi-bending feeding strip for hand held applications**	**Proximity-Fed circularly polarized slotted patch antenna for RFID handheld reader**
		Made on RO4003C	**Made on FR4**				
Resonant Frequency (MHZ)	920	900	-	924	910	925	923
10dB return loss band width (MHZ)	19.0	17.0	38.0	24.0	12.0	17.0	26.0
3dB axial ratio band width (MHZ)	4.0	6.0	12.0	8.0	5.0	-	12.0
Gain(dBic)	3.6	3.7	0.5	3.7	4.0	-	4.0
Patch's size	80.0 × 80.0mm^2	78.0 × 78.0 mm^2	72.0 × 72.0 mm^2	80.4 × 80.4 mm^2	76.0 × 76.0 mm^2	19.0 × 19.0mm^2	60.0 × 60.0 mm^2
Ground plane's size	90.0 × 90.0mm^2	90.0 × 90.0 mm^2	90.0 × 90.0 mm^2	90.0 × 90.0 mm^2	90.0 × 90.0 mm^2	80.0 × 80.0 mm^2 (system ground plane size)	Around 60 × 60 mm^2

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