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A Compact Square Circular and Cross Shaped Slotted Patch Antenna for RFID Application

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ABSTRACT: A compact cross, circular and square shaped slotted microstrip patch antennas are designed for circularly polarized (CP) radiation. The designed antenna is fabricated on RO4003C substrate and measured using Agilent network analyzer. The simulated return loss of this proposed antenna is less than -16dB at 920MHz with a bandwidth of 3MHz which is most suitable for RFID application. The circular polarization radiation pattern and axial ratio parameters are compared for square, circular and cross shaped antennas. The simulated gain is more than 3dBi for all three antennas. A symmetric, cross shaped slot is embedded along one of the diagonal axes of the square patch for CP radiation and antenna size reduction. The overall size of the antenna with CP radiation can be reduced by increasing the perimeter of the symmetric cross-shaped slot within the first patch quadrant of the square patch. The return losses of the measured results are in agreement with simulated results, the measured S parameters and radiation pattern showed that the proposed design is suitable for RFID frequency regions.

Keywords: Microstrip antenna, cross shaped slot, circular polarization, gain, radiation pattern, substrate, RFID

I. Introduction

Recently, radio frequency identification (RFID) technology has been rapidly developing in many service industries, distribution logistics, manufacturing companies and goods flow systems. The range and the scalability of RFID systems are much dependent on the radio frequency. For RFID reader antenna design, challenges lie not only in having a good impedance matching, low axial ratio (AR), and high gain while also keeping low profile but also in other design constraints such as size and cost [1]. Since the RFID tags are always arbitrarily oriented in practical usage and the tag antennas are normally linearly polarized, circularly polarized (CP) reader antennas have been used in UHF RFID systems for ensuring the reliability of communications between readers and tags. Frequencies that have been reserved for ISM (Industrial, Scientific, medical) bands can be used for the RFID applications. Due to the rapid growth in the radio frequency technology, very small size RFID antennas are manufactured and these antennas are operating in ultra high frequency (860 to 960 MHz) and microwave frequency (2.45 GHz and 5.8 GHz) range [2]. The total frequency span of the UHF band used for RFID systems is 840–960 MHz. However, there is not a UHF range accepted worldwide for the RFID applications [3].

The system operates at the bands of 902–928 MHz in America, 865–867 MHz in Europe, and 840–955 MHz in Asia-Pacific region. In Asia-Pacific region, the UHF RFID frequency range is different in different countries and except the America UHF RFID frequency-band, in other countries UHF RFID allocation bandwidths are between 3 to 6 MHz. The broadband CPMA designs to cover total frequency span of the UHF band for RFID applications have been reported [2], [3]. The sizes of the broadband CPMAs are bulky and not suitable for handheld or portable reader applications. The single-feed CPMAs are usually more compact as compared to the dual-feed CPMAs [4]. The major consideration for the CP microstrip antenna design of handheld/portable RFID reader applications is overall compact size of the antenna; the antenna gain and bandwidth are not so critical. However, the antenna must cover at least one UHF RFID band with bandwidth of few MHz.

Different methods for the single-feed CPMAs have been published in the literature. In 1983, Sharma and Gupta [7] proposed a method to generate CP radiation of the square patch using the truncated corners method. However, the truncated corners method did not provide any size reduction of the CPMA [2]. Later in 1996, Iwasaki [8] demonstrated a single-feed CP technique using a cross-shaped slot embedded at the center of the circular patch. The antenna structure is based on the proximity feed. Coaxial-fed cross-shaped slotted circular patch antennas and triangular microstrip antennas were also proposed for CP radiation and size reduction [9]–[12]. CP radiation can be achieved with a circular microstrip antenna by adding a tuning stub [13-14]. However, the tuning stub method is not useful for a compact

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CPMA design. Two inner symmetric stubs are used to generate the CP radiation of the antenna. CP dual square-shaped slotted square patches and an arrow-shaped slot-coupled antenna were proposed for UHF RFID reader applications [16]. A cross-shaped, square and circular slotted microstrip patch based compact CPMA is fabricated and measured [17-18]. The measured results are compared with the simulated results obtained from the ADS simulator.his document is a template.

II. ANTENNA DESIGN

The geometry of the square shaped microstrip antenna is given in fig. 1. The square patch of length 78mm and ground-plane area of 90.0 mm * 90.0 mm is fabricated on RO4003C substrate with a thickness of 4.572 mm and a dielectric constant of 3.48. Three different slot shapes are simulated for CP radiation. The square, circular and cross-shaped slotted microstrip antenna performances are compared based on the CP radiation (minimum axial-ratio) with fixed antenna size. A symmetric cross-shaped slot is placed in the first quadrant center of the square patch radiator for CP radiation and good impedance matching. The circular, square and cross-shaped slotted microstrip patches are also studied and compared.

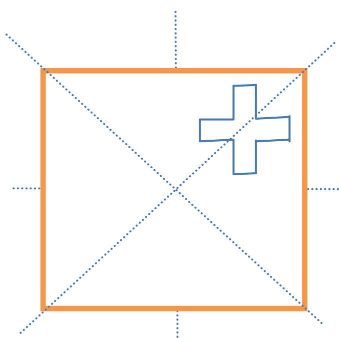

Fig 1. Geometry of a cross shaped slotted microstrip patch antenna

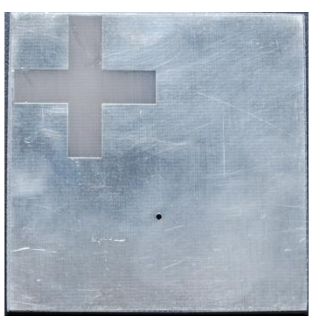

Fig 2. Fabricated patch antenna with cross shaped slot on RO4003C substrate.

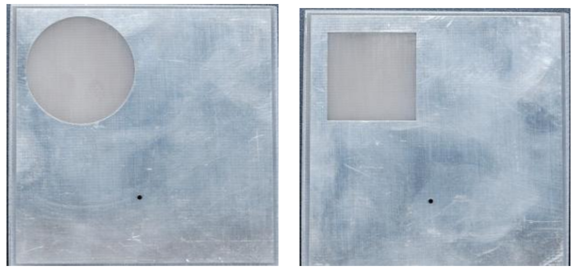

Fig 3. Fabricated patch antenna with square and circular shaped slot on RO4003C substrate.

The picture of the designed antenna with cross shaped slotted patch antenna structure fabricated on a RO4003C substrate is shown in Fig. 2. Fabricated antenna with square and circular shaped slot is shown in fig. 3. This fabricated antenna is more suitable for RFID frequency range applications.

III. RESULT AND DISCUSSION

The simulation of the design is carried out by the method of moment's technique using ADS software [19]. Fig 4, fig 5 and Fig 6 shows simulated electric current distribution of square, circular and cross shaped slotted patch antennas at 920MHz respectively. The current distribution of square and circular slot, distributes only at the edges of material which indicates that current distribution is not uniform; however it was uniform in cross shaped slot. Fig 7 shows simulated return loss of the square slot antenna. The simulated resonance frequency occurs at 920MHz with return loss value of -15.55 dB. Fig 8 and fig 9 shows simulated return loss of circular and cross shaped slot antnna which is -16 dB at 924MHz and -13.61 dB at 920MHz respectively.Fig 10 shows measured return loss of patch antennas in three different slot configuration which is measured by Agilent 100MHz-3.5GHz network analyzer

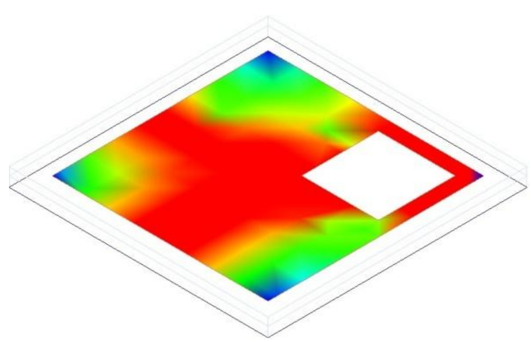

Fig 4. Simulated electric current distribution of the square shaped slotted patch antenna at 920MHz.

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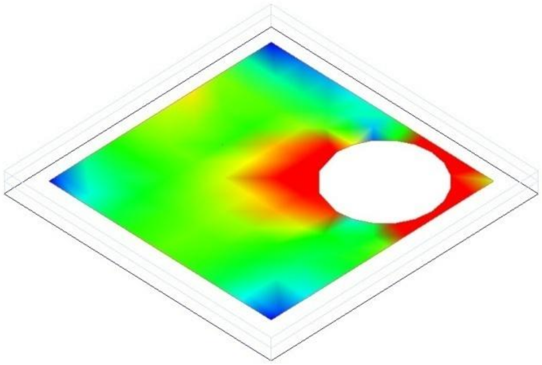

Fig 5. Simulated electric current distribution of the circular shaped slotted patch antenna at 920MHz.

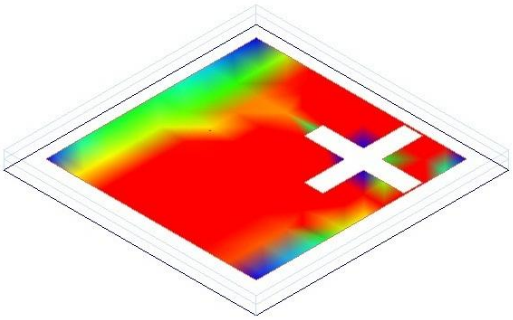

Fig 6. Simulated electric current distribution of the cross shaped slotted patch antenna at 920MHz.

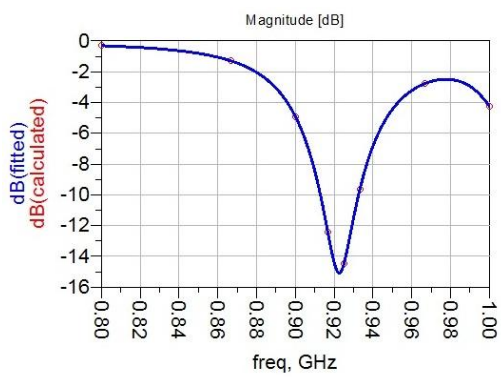

Fig 7. Simulated return loss (|S11|) of the square shaped slotted patch antenna

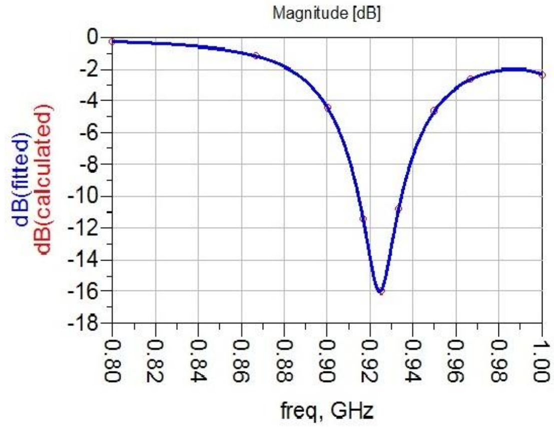

Fig 8. Simulated return loss (|S11|) of the circular shaped slotted patch antenna

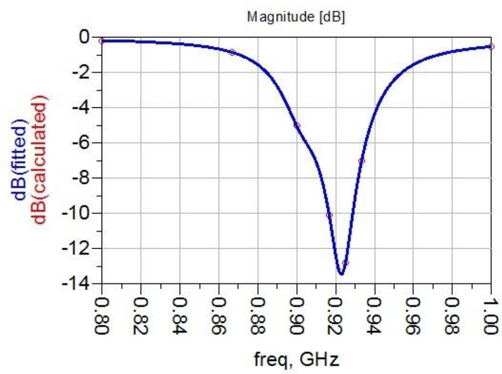

Fig 9. Simulated return loss (|S11|) of the cross shaped slotted patch antenna

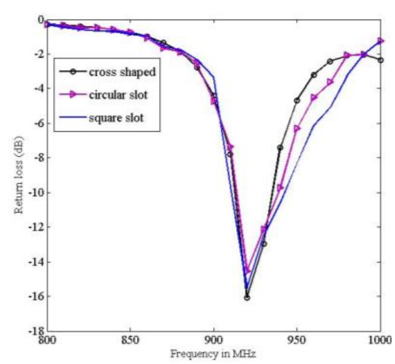

Fig 10. Measured return loss (|S11|) of the slotted patch antenna

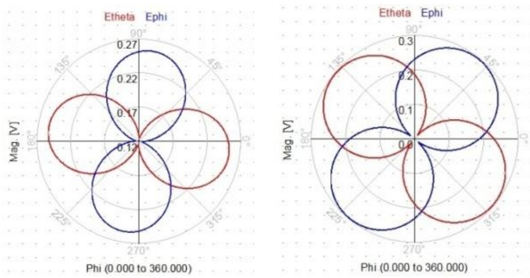

Fig 11. Simulated H plane radiation pattern of cross and square shaped slotted patch antenna at 920MHz

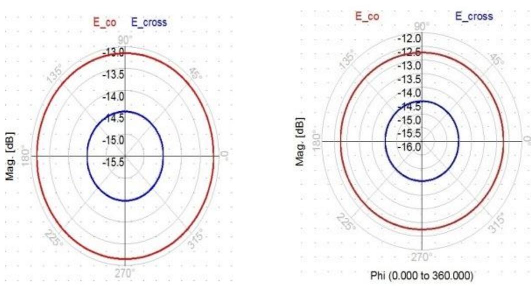

Fig 12. Simulated H plane co-polarized and cross-polarized radiation pattern 920MHz. a) circle slot b) square slot antenna

The H plane radiation pattern of cross and square shaped slotted patch antenna at 920MHz is shown in fig.11. This radiation pattern is similar to that of a conventional half-wavelength dipole antenna which has a figure eight radiation pattern in the H-plane. Fig. 12 and fig.13 shows simulated H plane circularly polarized pattern of circular, square and cross shaped slot antenna at 920MHz. This pattern shape is purely omni-directional and its level is in between -10 dB and -20dB in cross shaped slot which is higher than the square and circular slot. The normalized co-polarized and cross-polarized H-plane radiation pattern of the proposed antennas at 920MHz is shown in Fig. 14 and fig.15. It can be observed that the H-plane co-polar radiation pattern is in the shape of omni-directional and cross-polar radiation pattern is -17dB in cross shaped slot which is higher than square and circular slot.

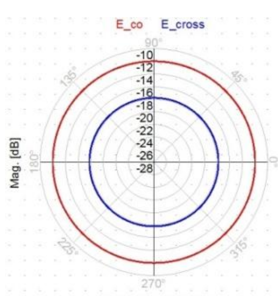

Fig 13.Simulated H plane co-polarized and cross-polarized radiation pattern of cross shaped slot antenna at 920MHz

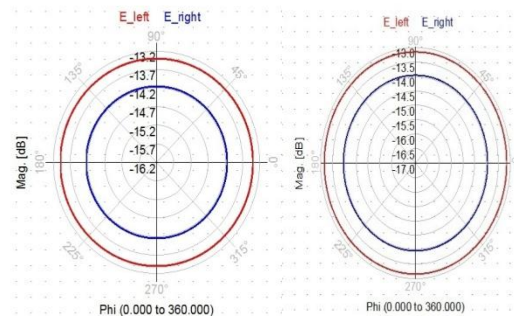

Fig 14. Simulated circularly polarized H electric field pattern at 920MHz a) circle slot b) square slot antenna

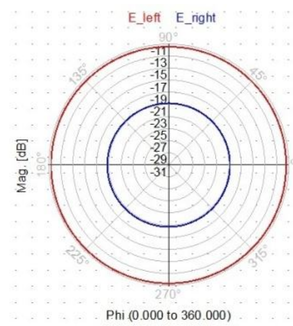

Fig 15. Simulated circularly polarized H electric field pattern of cross shaped slot antenna at 920MHz

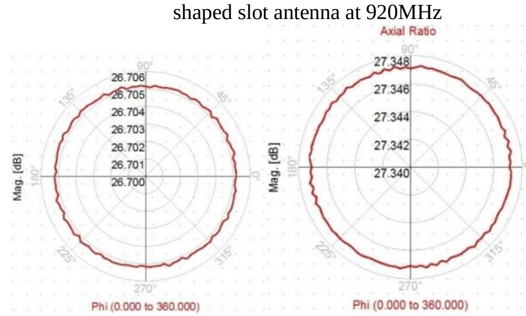

Fig 16. Simulated Axial ratio of circular slot and square slot antenna at 920MHz.

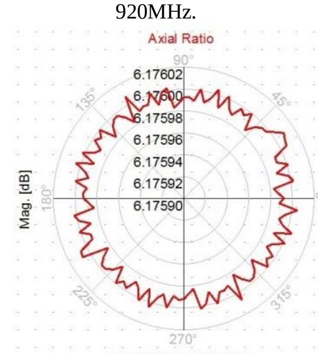

Fig 17. Simulated Axial ratio of cross shaped slotted patch antenna at 920MHz

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TABLE I
SIMULATED RESULTS OF PATCH ANTENNA WITH DIFFERENT SLOT CONFIGURATIONS

Antenna parameters	Antenna type		
	Square shaped slotted patch antenna	Circular shaped slotted patch antenna	Cross shaped slotted patch antenna
Gain (dbi)	3.2	3.12	3.32
Directivity (dbi)	6.2120	6.211	6.2229
Radiated power (μW)	352	335	318
Max intensity (mW/ ster)	117	111	106
E_θ	0.0334	0.029	0.2353
E_ϕ	0.2915	0.288	0.1567

Fig 16 and fig 17 shows axial ratio of patch antenna which is greater than 6dB in all configuration. The gain, directivity, radiated power, maximum intensity and efficiency of patch antenna in three different slot configuration is shown in table I. It shows that gain and directivity of cross shaped slot is better than square and circular shaped patch antenna.

IV. CONCLUSION

A compact circular, square and cross-shaped slotted microstrip antenna has been designed and simulated for RFID application. The measured and simulated results of return loss proved that this proposed antennas can be applied to 920MHz RFID systems. The cross shaped slotted patch antenna provides better results interms of gain and directivity. It affords consistent radiation pattern and appropriate gain characteristics. The peak antenna gain at 920MHz is 3.32 dBi and direcivity is 6.22dBi. Hence this proposed antenna might be suitable for RFID application.

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BIOGRAPHY

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