International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org Volume 2 Issue 5 ǁ May. 2013 ǁ PP.49-59

Design of Different Slotted Microstrip Patch Antenna for Rfid Applications

Renuga Devi M [1], Poongodi C[2] and Shanmugam A[3]

[1]*PG Scholar, Dept. of ECE, Bannari amman Institute of Technology, Sathyamangalam, India*
[2]*Associate Professor, Dept. of IT, Bannari amman Institute of Technology, Sathyamangalam, India*
[3]*Principal, Bannari amman Institute of Technology, Sathyamangalam, India*

ABSTRACT: *A compact cross, circular and square shaped slotted microstrip patch antennas are designed for circularly polarized (CP) radiation. Asymmetric, cross-shaped slot is embedded along one of the diagonal axes of the square patch for CP radiation and antenna size reduction. The designed antenna is contrived by using RT-Durid 5880 substrate . The design simulation and optimization is done by ADS software.The simulated return loss of this proposed antenna is less than -25dB at 2.5GHz with a bandwidth of 3MHz which is most suitable for RFID application. 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 circular polarization and radiation pattern parameters are compared for square, circular and cross shaped antennas. The simulated gain is more than 5dBi for all three antennas. 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, square and circle shaped) slots, circular polarization, gain, Directivity, radiation pattern, RFID.*

I. INTRODUCTION

Circular polarization is one of the most common polarization types used in existing wireless communication systems, as it is free of the transmitting and receiving antenna directions. Many applications need compact CPMAs, where the overall antenna size is a major consideration, such as receiver antennas for medical entrenched applications[1],[2], mobile wireless, radio frequency identification(RFID) readers[3],[4], and portable wireless devices. For handheld and portable wireless systems, antenna size is very essential, especially for low frequency bands, with respect to the antenna gain and bandwidth. However, the antenna should concealment atleast the desired frequency bands for the intentional wireless applications, such as ultra-high frequency(UHF) RFIDs[2] and ISM bands(402–405MHz,900MHz)for implanted antennas.

The single feed based CPMAs[5] are usually compact when compared with the dual-feed based CPMAs[6]. The dual feed CP antenna structure needs a larger ground plane area for the serving network circuit than the single feed CP antenna structure, but it delivers a relatively larger CP bandwidth. The single feed based CP configuration needs a slightly distressing patch radiator structure at the suitable locations with respect to the feed location, to excite two orthogonal modes with 90 degree phase shift. CP radiation can be attained with a circular microstrip antenna by adding a tuning stub[13]. However, the tuning stub method is not use ful for a compact CPMA design.

The circular- ring microstrip antenna with two symmetric inner stubs can also be used for CP radiation[14]. The circular, square, and cross shaped slotted microstrip patches are also studied and compared based on the CP radiation (minimum axial ratio) with fixed antenna size. Slot perimeter limits for 3-dB AR are carried out with these three different slot shapes. The variation of perimeter limits is larger for 3-dB AR of the cross shaped slotted microstrip antenna when compared with the circular and square shaped slotted microstrip patches. Across shaped slotted microstrip patch based compact CPMA is fabricated and measured.

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 precarious. However, the antenna must cover atleast one UHFRFID band with bandwidth of few MHz. The small size of the CPMA can be achieved at the cost of limited gain, narrow 3-dB AR bandwidth and impedance bandwidth. Various techniques have been published [5]–[10] to generate the CP radiation of the single-feed microstrip antennas. In this paper, novel CP antennas are proposed for the UHFRFID handheld reader applications. For this proposed antenna, by slightly varying the radius of the circular-slots in dia gonal direction so square patch, CP radiation of the antenna can be obtained. The symmetric slits are embedded along the orthogonal directions on the CP antenna for further size reduction of the microstrip antenna. In addition, the slits can also be used for tuning of the operating frequency band. The

CP antenna with slits is designed and fabricated. The measured results are compared with the simulated results obtained from the ADS software.

II. ANTENNA DESIGN

The geometry of the square shaped microstrip antenna with cross shaped slot is given in fig. 1. The size of the square patch is 70 mm× 70 mm is contrived on RT-Durid 5880 substrate with athickness of 3.2 mm and a dielectric constant of 2.2. 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 mounted on square patch radiator for CP radiation and good impedance matching. The circular, square and cross-shaped slotted microstrip patches are also studied and compared.

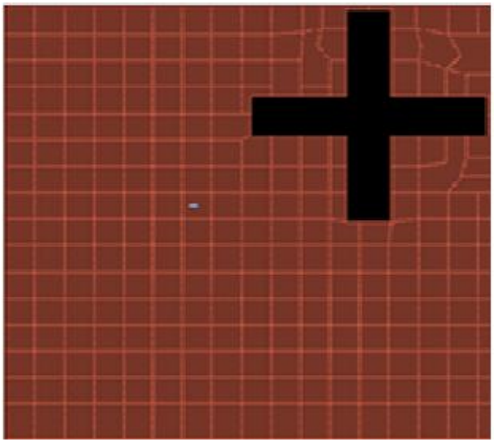

Fig.1 Geometry of a cross shaped slotted microstrip patch antenna

The picture of the designed antenna with cross shaped slotted patch antenna structure contrived on a RT-Durid 5880 substrate. Fabricated antenna with

square and circular shaped slot is shown in fig. 2 and fig.3. This fabricated antenna is more suitable for RFID frequency range applications.

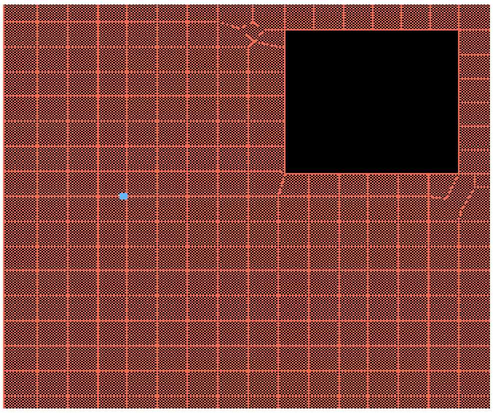

Fig.2 Geometry of a square shaped slotted microstrip patch antenna

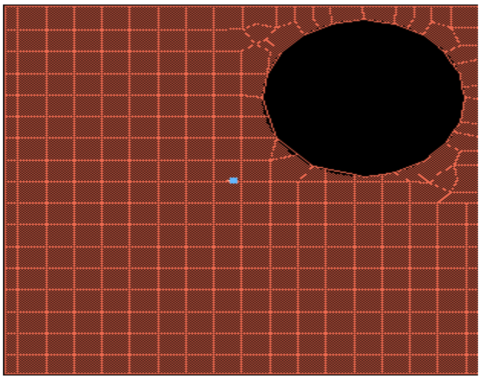

Fig.3 Geometry of a circle shaped slotted microstrip patch antenna

III. RESULT AND DISCUSSION

1. S Parameter of different slot antennas

S-parameters describe the input-output relationship between ports in an electrical system. A port can be loosely defined as any place where we can deliver voltage and current. Return loss is a measure of the effectiveness of power delivery from a transmission line to a load such as an antenna. The return loss of general microstrip patch antenna is as minimum as expected. The simulation of the design is carried out by the method of moment's technique using ADS software. Fig 4, Fig 5 and Fig 6 shows S parameter of the cross, square and circular shaped slotted patch antennas at 2.5GHz respectively. The return loss of existing single slotted microstrip patch antenna is -16dB.

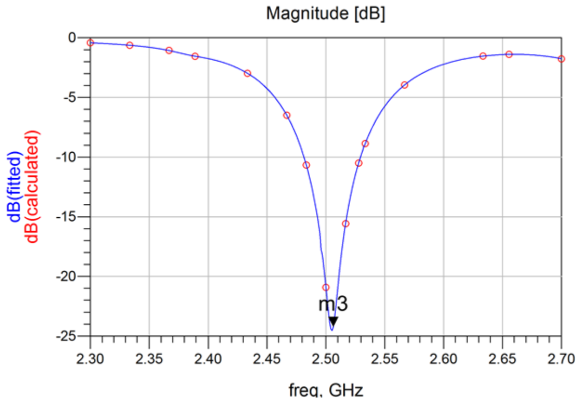

Fig.4 Simulated S11 Parameter of cross shaped slotted microstrip patch antenna

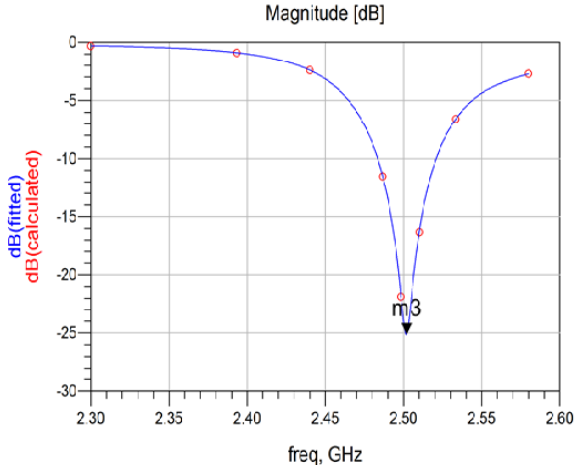

Fig.5Simulated S11 Parameter of square shaped slotted microstrip patch antenna

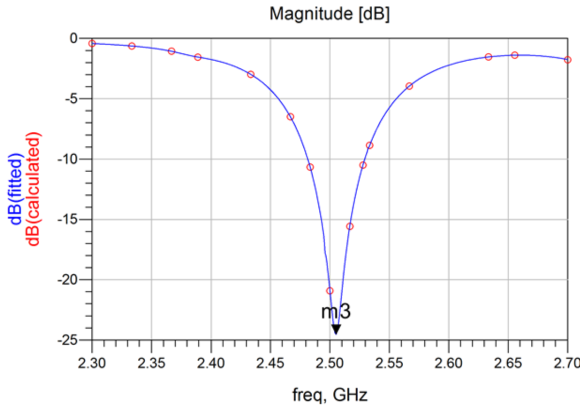

Fig.6Simulated S11 Parameter of circle shaped slotted microstrip patch antenna

The simulated resonance frequency occurs at 2.5GHz with return loss value of -25 dB. Fig 8, fig 9 and Fig 10 shows simulated electric current distribution of cross, square and circular shaped slotted patch antennas at 2.5GHz 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.

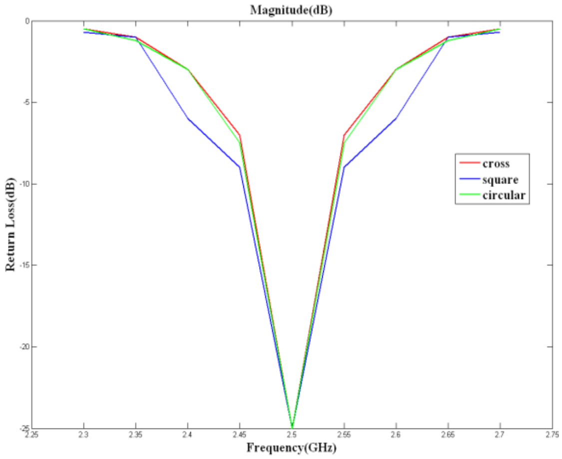

Fig 7. Measured S11 (Return Loss) of the slotted patch antenna

Fig.7 shows that the shows that the measured return loss of slotted microstrip patch antennas in three different (cross, square, circle) configurations. All three slots are same minimum return loss of -25dB.

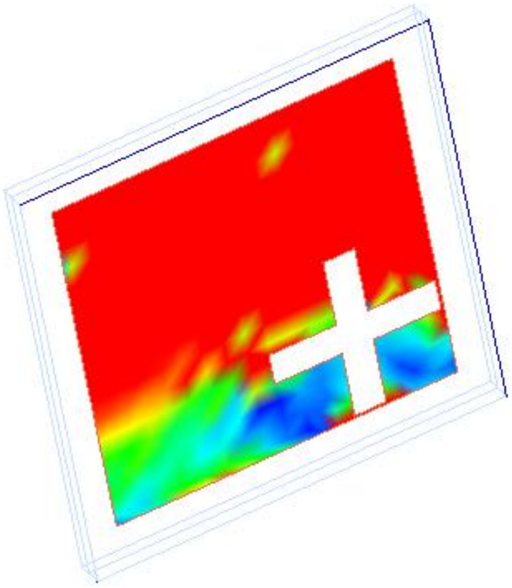

Fig 8. Simulated electric current distribution of the cross shaped slotted patch antenna at 2.5GHz.

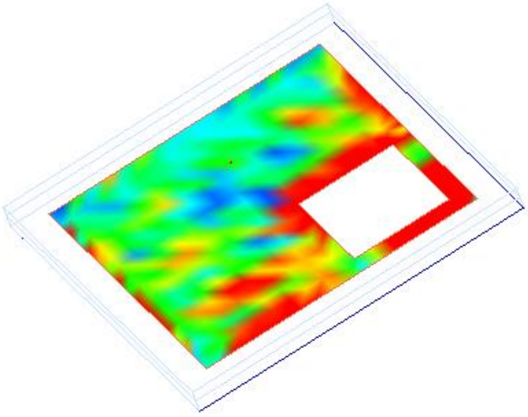

Fig 9. Simulated electric current distribution of the square shaped slotted patch antenna at 2.5GHz.

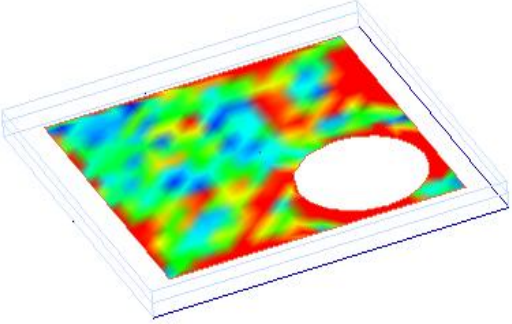

Fig 10. Simulated electric current distribution of the circle shaped slotted patch antenna at 2.5GHz.

2. Radiation Pattern Of Different Slot Microstrip Antennas

The E&H plane radiation pattern of cross shaped slotted patch antenna at 2.5GHz 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. Fig. 12 and fig.13 shows simulated E&H plane circularly polarized pattern of square and circular shaped slot antenna at 2.5GHz. The cross shaped slot power level is higher than the square and circular slots.

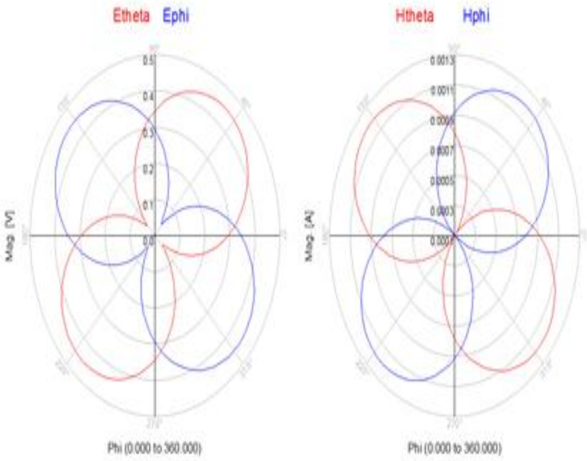

Fig11. Simulated E&H plane radiation pattern of cross shaped slotted patch antenna at 2.5GHz

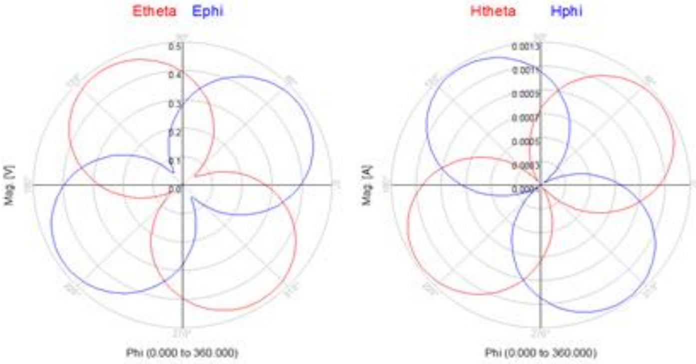

Fig12. Simulated E&H plane radiation pattern of square shaped slotted patch antenna at 2.5GHz

The radiation pattern of the cross, square and circle shaped microstrip patch antenna is well-suited to RFID applications at 2.5GHz compared to the radiation pattern of 3 different (cross, square and circular) shaped slotted microstrip antenna at 920MHz. These different slotted microstrip patch antenna radiates more power at 2.5GHz compared to radiated power of the slotted microstrip patch antenna at 920MHz.Comparing electric current distribution of cross, square and circle shaped slotted patch antennas, cross slot patch antenna induces more current.

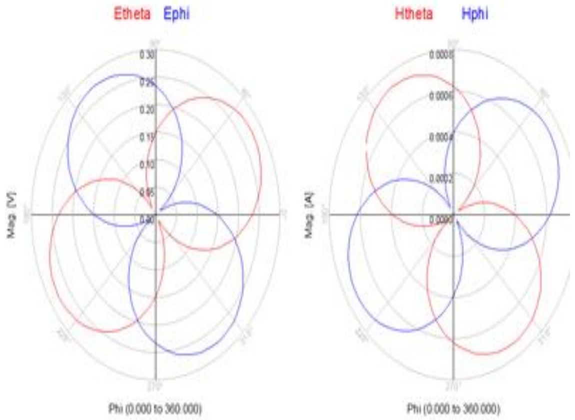

Fig13. Simulated E&H plane radiation pattern of circle shaped slotted patch antenna at 2.5GHz

3. Circular Polarization

Circular polarization (CP) is usually a result of orthogonally fed signal input.When two signals of equal amplitude but 90degree phase shifted the resulting wave iscircularly polarized. Circular polarization can result in Left hand circularly polarized (LHCP) where the wave is rotating anticlockwise, or Right hand circularly polarized (RHCP) which denotes a clockwise rotation. The main advantage of using CP is that regardless of receiver orientation, it will always receive a component of the signal. This isdue to the resulting wave having an angular variation.The circular polarization plot gives that normalized electric field components consists of two orthogonal components , that are right electric field component(E_Right), and left electric field component, (E_Left).The circular polarization of cross, patchantenna at 2.5GHz is shown inFig 14, fig 15 and fig 16

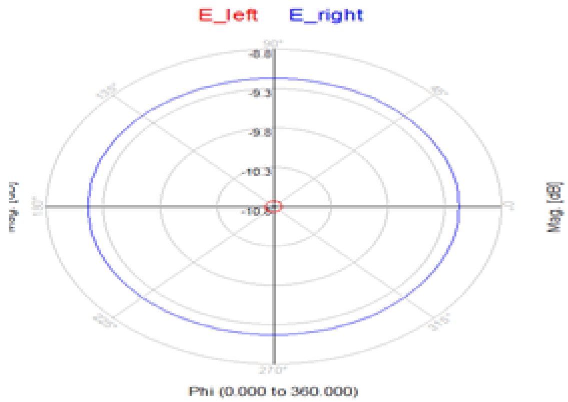

Fig14. Simulated circularly polarized H electric field pattern of cross shaped slot antenna at 2.5GHz

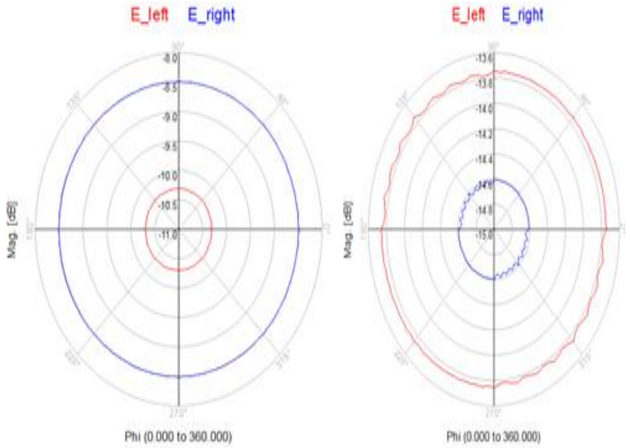

Fig15. Simulated circularly polarized H electric field pattern of square and circle Shaped slot antenna at 2.5GHz

4 .Gain and Directivity

Gain is not a quantity which can be defined in terms of a physicalquantity such as the Watt or the Ohm, but it is a dimensionless ratio. Gainis given in reference to a standard antenna. The two most commonreference antennas are the isotropic antenna and the resonant half-wave dipole antenna.The method of measuring gain by comparing the antenna under testagainst a known standard antenna, which has a calibrated gain, istechnically known as a gain transfer technique.

Directivity is the ability of an antenna to focus energy in a particulardirection when transmitting, or to receive energy better from a particulardirection when receiving. In a static situation, it is possible to use the antenna directivity to concentrate the radiation beam in the wanteddirection. However in a dynamic system where the transceiver is notfixed, the antenna should radiate equally in all directions, and this is known as an Omni-directional antenna.

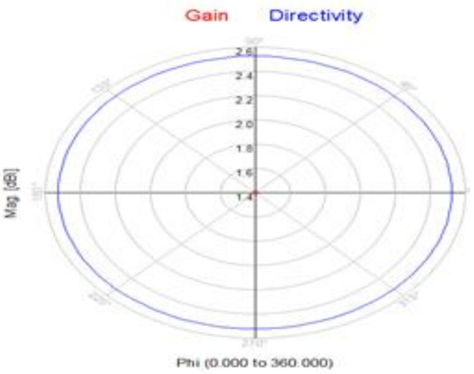

Fig16. Simulated Gain & Directivity of cross shaped slot antenna at 2.5GHz

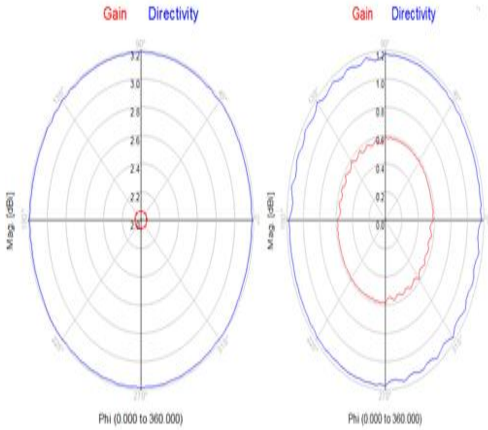

Fig17. Simulated Gain & Directivity of square and circle shaped slot antennas at 2.5GHz

Table I Simulated Results of Patch Antenna with Different Slot Configurations

Antenna Parameters	Antenna Type		
	Cross shaped slotted patch antenna	Square shaped slotted patch antenna	Circle shaped slotted patch antenna
Gain (dBi)	5.53	5.49	6.05
Directivity (dBi)	6.65	6.62	6.63
Effective Angle (Steradians)	2.714	2.736	2.7229
Eθ	0.684	0.704	0.484
EΦ	0.251	0.146	0.188

The gain, directivity, radiated power, maximum intensity and efficiency of patch antenna in three different slot configurations is shown in Table I. It shows that gain cross shaped slot is better than square and circular shaped patch antenna.

IV. ASYMMETRIC CROSS & CIRCULAR SHAPED SLOTTED ANTENNAS DESIGN

The cross-section view of the proposed asymmetric-cross &circular shaped slotted (unbalanced) square microstrip patch antenna is shown in Fig.18 & Fig.19. Length of the square patch is (70 mm). The overall antenna size is 70mm×70mm designed based on the handheld/portable RFID reader requirements.

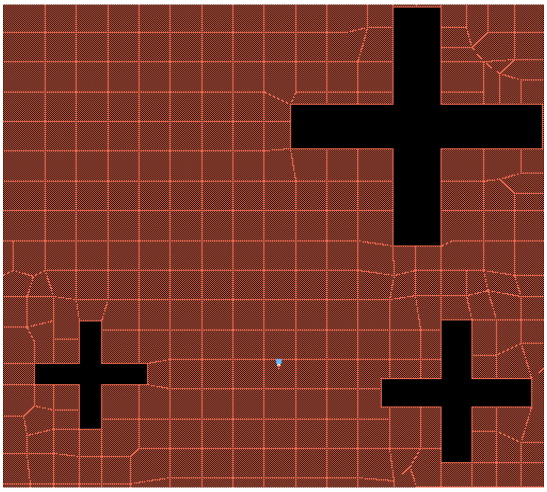

Fig.18. Geometry of 3-slot cross shaped micristrip patch antenna

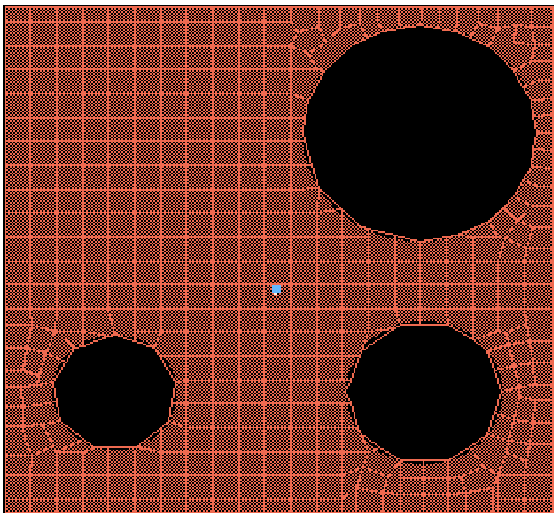

Fig.19. Geometry of 3-slot circle shaped micristrip patch antenna

The substrate used here is Rogger RT-Durid 5880 with a thickness of 3.2 mm and a dielectric constant of 2.2. Fig.20, Fig.21 shows simulated electric current distribution of 3-slotted cross and circular shaped slotted patch antennas at 2.5GHz respectively. The current distribution of 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. Radiated power of the 3-slotted cross and circular shaped microstrip patch antenna is more compared to the single slotted cross and circular shaped microstrip patch antenna. The size of the antenna is reduced up to 15% of the original single slotted microstrip patch antenna. The utilization of bandwidth is more in 3-slotted cross and circular shaped microstrip patch antenna.

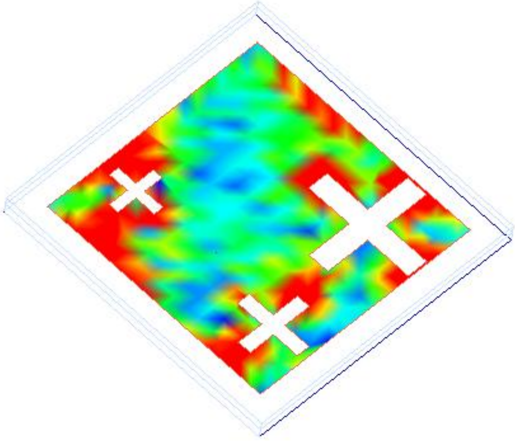

Fig 20. Simulated electric current distribution of the cross shaped slotted patch antenna at 2.5GHz.

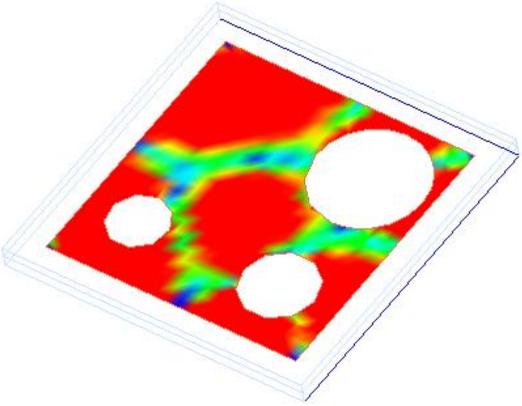

Fig 21. Simulated electric current distribution of the circle shaped slotted patch antenna at 2.5GHz.

The input power is transformed into radiated power and surface wave power while a small portion is dissipated due to conductor and dielectric losses of the materials used. Surface waves are guided waves captured within the substrate and partially radiated and reflected back at the substrate edges. Surface waves are not excited when air dielectric is used.

Radiation pattern shows a graphical representation of radiation properties of an antenna. The 3D representation of the radiation pattern of 3-slot cross shaped microstrip patch antenna is measured at 2.5GHz which is illustrated in Fig.22. A symmetric figure eight pattern is obtained for proposed antenna. The 3D representation of the radiation pattern of 3-slot circle shaped microstrip patch antenna is measured at 2.5GHz which is illustrated in **Fig.23**.

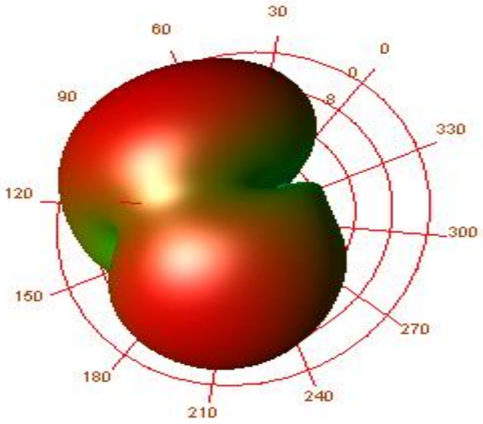

Fig.22. Simulated Radiation Pattern of 3-Slot Cross Shaped Micro Strip Patch Antenna

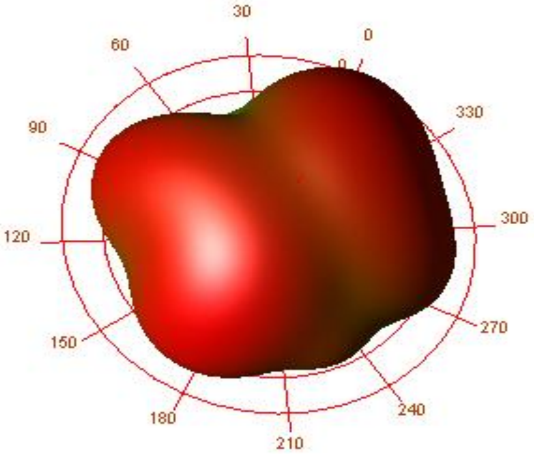

Fig.23. Simulated Radiation Pattern of 3-Slot Circle Shaped Micro Strip Patch Antenna

The Fig.22 & Fig.23 shows that the maximum radiation at red colour and minimum radiation at green colour.Compared to single slot patch antenna, the 3-slot patch antenna provides more radiation. The gain and directivity of 3-slot microstrip patch antenna also high compare with single slot microstrip patch antenna. The efficiency of antenna at 920MHz is 16.67% but in the proposed microstrip patch antenna efficiency is 87.34% at 2.5GHz.The size of antenna reduced from (90×90) mm to (70×70) mm.The gain and directivity of antenna is increased at 2.5GHz compared to the antenna resonant frequency at 920MHz. A microstrip or patch antenna is a low profile antenna that has a number of advantages over other antennas it is lightweight, inexpensive, and easy to integrate with accompanying electronics.

V. CONCLUSION

A compact cross, square and circle-shaped slotted micro strip 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 2.5GHz RFID systems. The cross & circle shaped 3-slotted patch antenna provides better results. It affords consistent radiation pattern and appropriate gain characteristics. The antenna gain at 920MHz is only 3.32 dBi and directivity is 6.22dBi.But the antenna gain at 2.5GHz is 5.53 dBi and directivity is 6.65dBi.So, the antenna gain and directivity at 2.5GHz is far better compared to antenna gain and directivity at 920MHz. Hence this proposed antenna might be more suitable for RFID applications.

ACKNOWLEDGEMENT

This work was supported by All India Council for Technical Education under Research Promotion Scheme of India.

REFERENCES

[1]. Nasimuddin, Zhi Ning Chen, and Xianming Qing, “A Compact Circularly Polarized Cross-Shaped Slotted Microstrip Antenna”,
[2]. IEEE Transactions on Antennas and Propagation, Vol. 60, No. 3, March 2012.
[3]. Nasimuddin,Zhi Ning Chen and Xianming Qing, “Asymmetric-Circular Shaped Slotted Microstrip Antennas for Circular
[4]. Polarization and RFID Applications”, IEEE Transactions on Antennas and Propagation, Vol. 58, No. 2, December 2012.
[5]. H. Chung, Y. Lee, and J. Choi, “Miniaturization of an UHF RFID reader antenna using an artificial magneto-dielectric,” Microw. Opt.Technol. Lett., vol. 52, no. 9, pp. 1926–1930, Sep. 2010.
[6]. Nasimuddin, Z. N. Chen, and X. Qing, “Asymmetric-circular shaped slotted microstrip antennas for circular polarization and RFID applications,” IEEE Trans. Antennas Propag., vol. 58, no. 12, pp. 3821–3828, Dec. 2010.
[7]. R. Garg, P. Bhartia, I. Bahl, and A. Ittipboon, Microstrip Antenna Design Handbook. Boston, MA: Artech House, 2001.
[8]. S. D. Targonski and D. M. Pozar, “Design of wideband circularly polarized aperture-coupled microstrip antennas,” IEEE Trans. AntennasPropag., vol. 41, no. 2, pp. 214–219, Feb. 1993.
[9]. P. C. Sharma and K. C. Gupta, “Analysis and optimized design of single feed circularly polarized microstrip antennas,” IEEE Trans. Antennas Propag., vol. 31, no. 6, pp. 949–955, Jun. 1983.
[10]. H. Iwasaki, “A circularly polarized small size microstrip antenna with cross slot,” IEEE Trans. Antennas Propag., vol. 44, no. 10, pp.1399–1401, Oct. 1996.
[11]. J. S. Row and C. Y. Ai, “Compact design of single-feed circularly polarized microstrip antenna,” Electron. Lett., vol. 40, no. 18, pp. 1093–1094, Sep. 2004.
[12]. J.-H. Lu, C.-L. Tang, and K. L.Wong, “Single-feed slotted equilateraltriangular microstrip antenna for circular polarization,”
[13]. IEEE Trans.Antennas Propag., vol. 47, no. 7, pp. 1174–1178, Jul. 1999.
[14]. W.-S. Chen, C.-K.Wu, and K. L.Wong, “Compact circularly polarized circular microstrip antenna with cross slot and peripheral cuts,” Electron.Lett., vol. 34, no. 11, pp. 1040–1041, 1998.
[15]. K. L. Wong, Compact and Broadband Microstrip Antennas, Chapter 5 (Compact Circularly Polarized Microstrip Antennas). New

York, USA: Wiley, 2002.

[16]. 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.

[17]. H. Iwasaki, "A circularly polarized small size microstrip antennas with cross slot," IEEE Trans. Antennas Propag., vol. 44, no. 10, pp. 1399–1401, 1996.

[18]. K. L. Wong and Y. F. Lin, "Circularly polarized microstrip antenna with a tuning stub," Electron. Lett., vol. 34, no. 9, pp. 831–832, 1998.

[19]. H. M. Chen and K. L. Wong, "On the circular polarization operation of annular-ring microstrip antennas," IEEE Trans. Antennas Propag., vol. 47, pp. 1289–1292, 1999.

[20]. W. S. Chen, C. K. Wu, and K. L. Wong, "Novel compact circularly polarized square microstrip antenna," IEEE Trans. Antennas Propag., vol. 49, pp. 340–342, 2001.

[21]. J. S. Row and C. Y. Ai, "Compact design of single-feed circularly polarized microstrip antenna," Electronics Letters, vol. 40, no. 18, pp. 1093–1094, 2004.

[22]. [19] D.M.Pozar and S. M. Duffy, "A dual-band circularly polarized aperture-coupled stacked microstrip antenna for global positing satellite,"IEEE Trans. Antennas Propag., vol. 45, no. 11, pp. 1618–1624, 1997.

[23]. [20] Advanced Design System, 2011–ADS 2011.01, Agilent Technologies, Inc.2000.