A Novel Coaxial Fed Swastika (卐) Shaped Slotted Circular Microstrip Patch Antenna for Wireless Applications

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Abstract--- In this paper a novel circular microstrip patch antenna loaded with "Swastika (卐)" shaped slot with 2.4 GHz frequency reponse is investigated and designed. A swastika shaped slot is etched on center of circular patch (radius of 17 mm and thickness of 0.5 mm). The proposed swastika shape slotted circular microstrip patch antenna (CMSA) is designed and analyzed by using Finite Element Method (FEM) based High Frequency Structure Simulator (HFSS™) EM software. The radiation pattern, return loss and VSWR plots are presented for the proposed antenna. Good return loss and VSWR was achieved for the proposed geometry as depicted in the plots. The presented antenna can be used at 2.4 GHz ISM (Industrial, Scientific and Medical) band applications. Another antenna with modified structure is also presented which gives triple band frequency response.

Keywords: Circular Microstrip Patch Antenna (CMSA), Return Loss, VSWR, Multi Band, Compact.

I. INTRODUCTION

Microstrip patch antennas (MSA) have been much attracted due to their low profile, lighter weight, and easy fabrication process so it can be widely used in the various communication application like satellite and wireless mobile communication applications [1].There are various types of geometries of patch configuration are available like rectangular or square, circular disk, triangular, annular ring etc. and are the most extensively analyzed patch antenna geometries in recent years and now these geometries are modified as per the application to improve their performance and to use it in desired applications [2]. Circular microstrip patch antenna is simple patch configuration for design purpose and can be easily fabricated. There are various types of models such as: cavity model, mode matching with edge admittance, transmission line model and Finite Difference Time Domain (FDTD) are given in literature for analyzing the circular patches [1-4]. Circular disk patches were reported to lose less energy by radiation and thus provide larger quality factors than other configurations for example rectangular patches or square patches. The directivity of circular patch antenna is also more when compared with rectangular patch antenna. The patch structure can be modified to have application specific resonating frequency and to have higher gain and bandwidth response [5]. Among many existing techniques like cross slot embedded in the center, embedding a circular hole and using slits etc. were reported. Here ISM band is achieved by swastika shape slot at center of circular patch.

II. ANTENNA DESIGN AND SIMULATION RESULTS

The geometry of the proposed antenna is shown in Fig. 1. The antenna parameters are also given in Fig.1. The antenna is mounted on Roger RT/Duriod 5880(tm) substrate having reletive permittivity of 2.2 and dielectric loss tangent tan δ=0.009. The antenna is fed by a coaxial transmission line the method called probe feeding.

The Simulation results of proposed antenna were performed by HFSS™ which stands for High Frequency Structure Simulator.

It is a high-performance full-wave Electro Magnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface (GUI). It integrates simulation, visualization, solid modeling, and automation in an easy-to-learn environment where solutions to your 3D EM problems are quickly and accurately obtained.Ansoft's HFSS™ employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give you unparalleled performance and insight to all of your 3D EM problems. Ansoft HFSS™ can be used to calculate parameters such as S Parameters, Resonant Frequency, and Fields [6].

The antenna structure uses patch with radius of 17 mm and is kept variable and thickness of 0.5 mm, ground plane with thickness of 1 mm both made from copper plate with relative permittivity of 1.Feed with inner conductor radius of 0.12 mm is located at 12 mm. Excitation to patch conductor is given using waveport.Simulation were performed with proper feed location to obtain frequency reponse extending from 1 GHz to 5 GHz. It gives return loss (S_{11}) which is further used to calculate VSWR (Voltage Standing Wave Ratio).

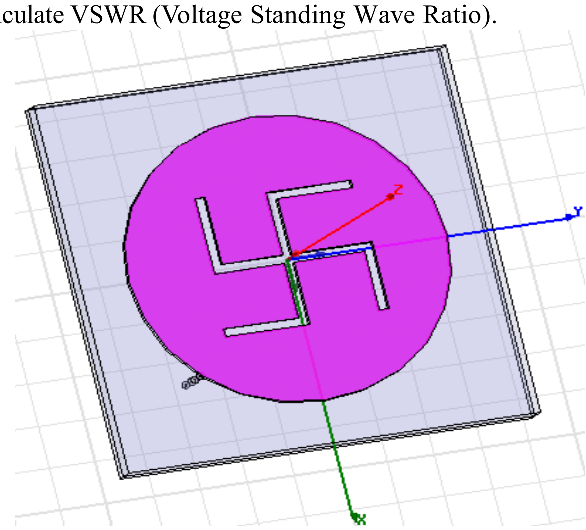


Fig. 1: Geometry of Proposed Antenna configuration 1

Antenna Parameters: Substrate Dimension: 44 mm x 44 mm x 2 mm, Patch Radius =17 mm, Patch Height =0.5 mm, Slot dimension: Width=16 mm Length=16 mm, feed location (fx,fy)=(12mm,-12mm)

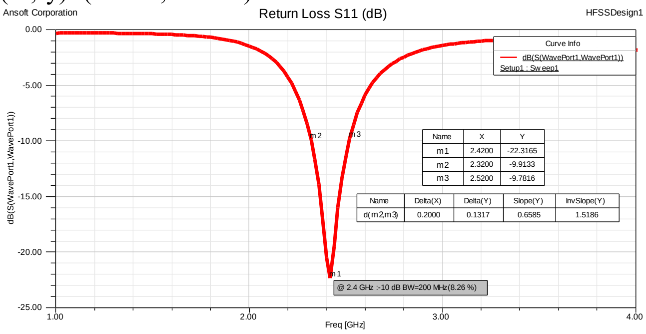


Fig. 2: Return Loss (S11 dB) vs. Frequency Plot

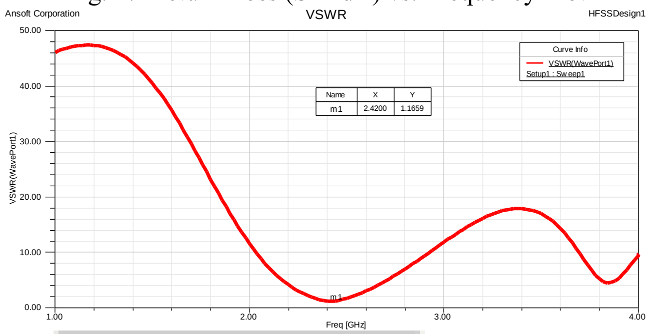


Fig. 3: VSWR Plot

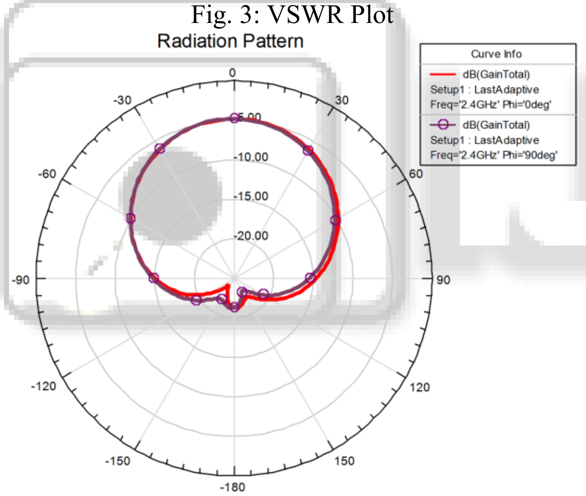


Fig. 4: Radiation Pattern Plot at Phi=0 Deg (E-plane) and Phi=90 Deg (H-plane)

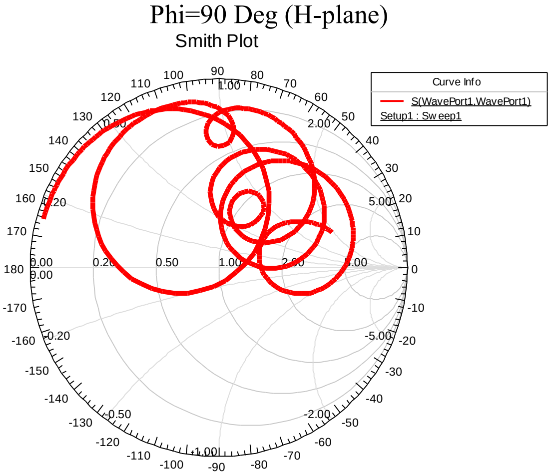


Fig. 5: Smith Chart Plot

Figure 2 shows return loss vs. frequency plot of antenna configuration shown in figure 1.Good return loss of -22.31 dB at 2.4 GHz resonance frequency is obtained with VSWR of 1.16 as shown in figure 3. Figure 4 shows radiation pattern plot at Phi (φ)=0 Deg (E-plane) and Phi (φ)==90 Deg (H-plane).Figure 5 shows smith chart and figure 6 shows antenna 3D polar plot. The E-field distribution in circular patch and mesh plot is shown in figure 7 and 8 respectively.

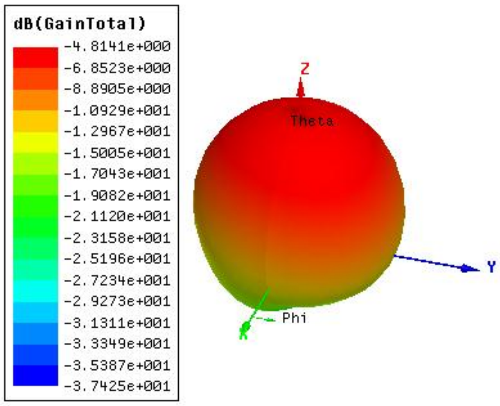


Fig. 6: 3D Ploar Plot

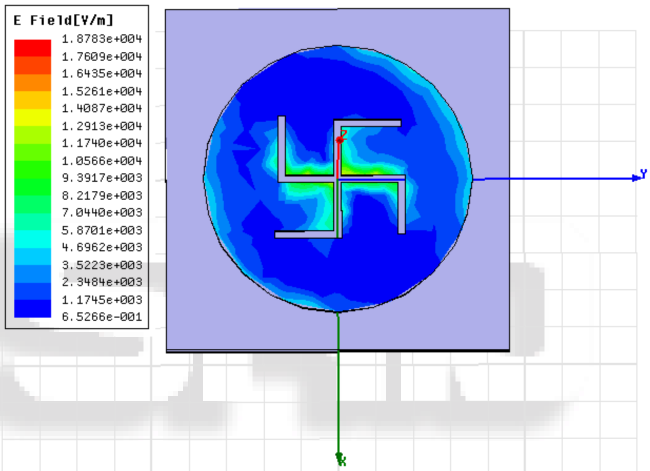


Fig. 7: E-Field Distribution in Patch

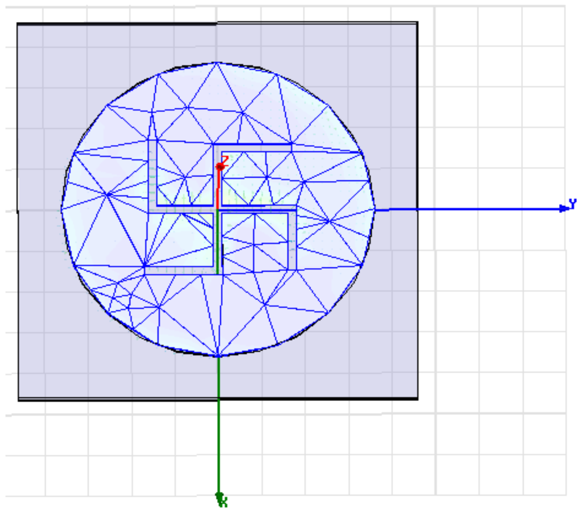


Fig. 8: Mesh Plot

The modified antenna configuration by introducing extra circular slots in same antenna is shown in figure 9. With the effect of these extra circular slots and tuning antenna parameter like patch radius and feed location triple band frequency response was achieved as shown in return loss (S11) plot of figure 10.

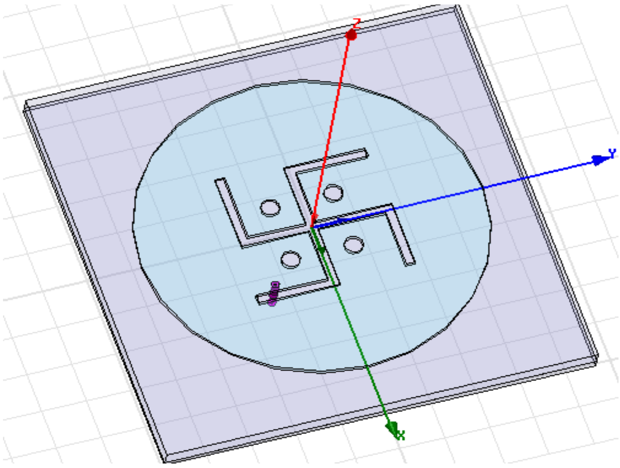


Fig. 9: Geometry of Proposed Antenna configuration 2

Antenna Parameters: Substrate Dimension: 44 mm x 44 mm x 2 mm, Patch Radius =19 mm, Patch Height =0.5 mm, Slot dimension: Width=16 mm Length=16 mm, Circular slots radius=1 mm at location of 3 mm from coordinates, feed location (fx,fy)=(6mm,-6mm).

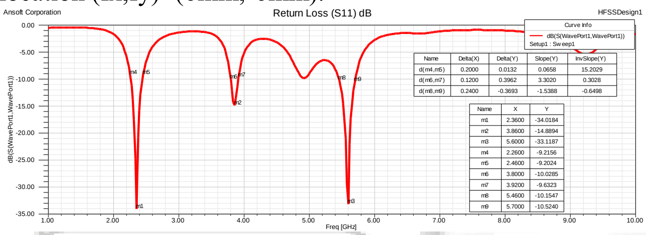


Fig. 10: Return Loss (S11 dB) vs. Frequency Plot

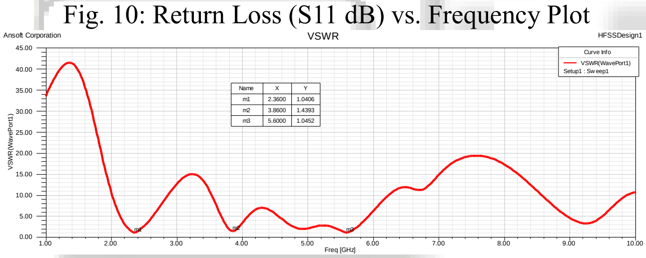


Fig. 11: VSWR Plot

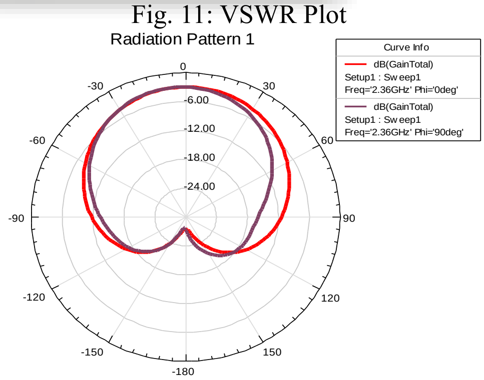


Fig. 12(a):

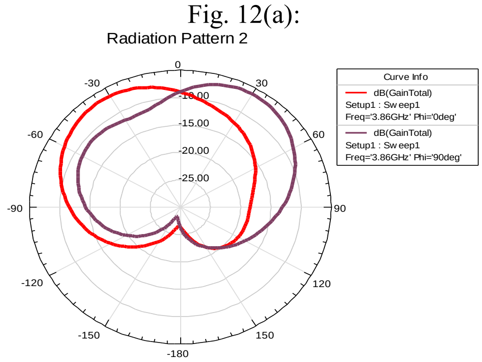


Fig. 12(b):

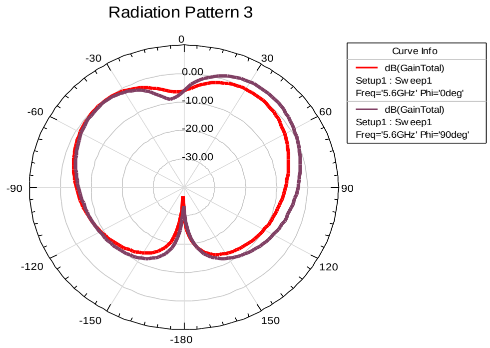


Fig. 12(c):

Figure 12: Radiation Pattern Plot at Phi=0 Deg (E-plane) and Phi=90 Deg (H-plane) (a) at 2.38 GHz (b) at 3.38 GHz and (c) at 5.6 GHz.

Figure 11 shows VSWR Plot at all three frequencies and figure 12 shows radiation patterns.

Table 1 and Table 2 shows simulated results of both proposed antennas.

Figure 13 shows E-Field Distribution and Mesh Plots of antenna configuration shown in figure 9.

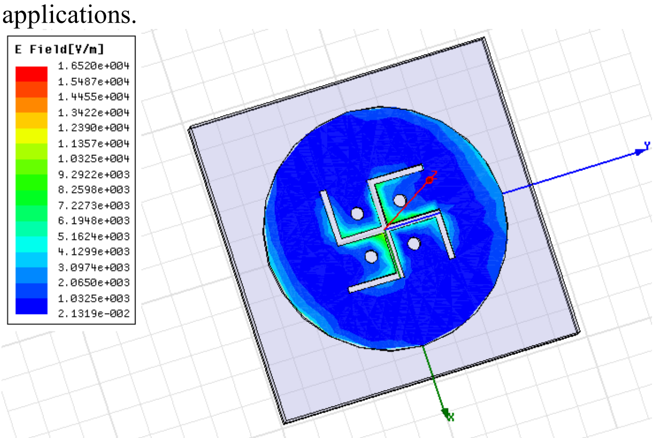
Feed Location (Fx,Fy)	Resonance Frequency (GHz)	Return Loss (dB)	Bandwidth (MHz)	Return Loss BW (%)	VSWR	Impedance (Ohm)
(12,-12)	2.4	-22.31	200	8.26	1.16	75.37

Table. 1 : Simulated Antenna Results of configuration shown in Figure 1

Feed Location (Fx,Fy)	Resonance Frequency (GHz)	Return Loss (dB)	Bandwidth (MHz)	Return Loss BW (%)	VSWR
(6,-6)	2.4	-34.18	200	8.47	1.04
(6,-6)	3.8	-14.89	120	3.10	1.43
(6,-6)	5.6	-33.12	240	4.28	1.04

Table. 2: Simulated Antenna Results of configuration shown in Figure 2

These antennas covers ISM band so can be used for different Wireless applications. Also antenna 2 works both at 2.4 and 5.6 GHz so can be suited for Wi-Fi wireless application.3.8 GHz frequency suitable for LTE & WiMax applications.



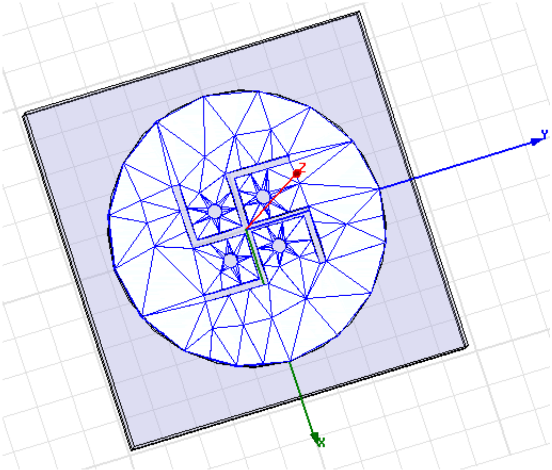


Fig. 13: E-Field Distribution and Mesh Plot

III. CONCLUSION

The aim of this paper is to introduce swastika (卐) slotted circular microstrip patch antenna working at ISM radio spectrum at 2.4 GHz. By tuning the antenna elements by introducing slots in patch and changing the feed location good return loss and bandwidth can be achieved. The second configuration gives triple frequency response as compared to configuration 1. Very good response was obtained as depicted in the plots.

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