Wearable Antenna for Radar Applications

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***Abstract* - This paper presents a compact square shaped micro strip patch antenna at an operating frequency of 8.5GHz. The radiating element of the swastika shaped patch using dielectric substrate 4.6 and having the substrate height 1.6mm. The antenna size is very compact (30mm x 30mm x 1.6mm) and covers 5GHz to 10GHz. It can be used for military and marine impulse radar applications. Using ADS (Advance design system) software. The design antenna is simulated. The software simulation results shows that the antenna can realize wide band characteristics having bandwidth of 78MHz (VSWR<=2) for all resonant frequencies. Our aim is to reduce the size of an antenna as well as increase the bandwidth and return loss of an antenna.**

Keywords: - Micro strip antenna; wideband; swastika shape; ADS;

INTRODUCTION:

When we see a wide variety of antennas such as slot antennas, frequency independent antennas, aperture antennas, horn antennas, reflector antennas , microstrip patch antennas are widely used for its low weight , low cost, and its compatiblity with MMIC designs. Currently government and commercial applications like mobile radio and wireless applications that has similar specifications use microstrip antennas. However microstrip antennas have dis advantages like lower efficiency, low power, poor polarisation and narrow bandwidth in frequency , and sometime Q factor can exceed 100 which needs the microstrip antennas to be modified to increase its performance level. To increase the efficiency of the antenna height of the substrate can be increased, but increasing the height of the substrate introduces surface waves which is not desirable because it extracts power from space waves directly and degrade the antenna pattern and polarization characteristics here we have used Flame Resistant 4 (Fr4) substrate with an thickness of 1.6 mm which has a permittivity of 4.6. In this antenna we have used micro strip line feed which is a conducting strip whose width will be smaller compared to the patch. Micro strip line feed is easy to fabricate and simple to match by just controlling the inset position of the feed. Inorder to make the antenna to work in the radar frequency range we have made 4 iterations by removing the patches of different lengths which results in the swastika shaped patch.

a micro strip antenna structure with a typical Swastika symbol shaped slot is proposed which is suitable for micro power impulse radar applications, in which the antenna can be used in the sensor circuit for tracking the trapped people during earthquakes and also this can be used in military applications that can be stitched with the dress material as a badge and can be used for tracking the person from a common control centre.

LITERATURE SURVEY:

From the paper [1] by seyi s.olokede and mohd f.ain demonstrates a novel series fed triangular micro strip ring resonator antenna array, Here to increase gain the feed line was replaced by a quarter wavelength short ended stub which improves performance by reducing the excitation of unwanted modes of radiation. The impedance bandwidth pattern of 5.79 to 5.86GHz covers WLAN networks.

From paper [2] by Zahir Harmouda, Jean-luc wojkiewicz, Alexander A, Pud demonstrates a new generation of printed flexible antenna. The proposed antenna is a elliptical monopole fed by a co-planar waveguide. It uses a kapton substrate and it is optimized to work from 1 to 8 GHz . the antenna structure optimized by means of Ansoft's high frequency structure simulator. The patch is nano composite PANI/MWCNTS (thickness of 110 μm) in which dielectric properties are relative permittivity of 3.48 .it was simulated with ADS software and the characteristics have been investigated in both x and y directions in terms of return loss and radiation pattern

From[3] paper by Vivek Singh Rathor demonstrates a swastika shaped patch micro strip antenna using substrate FR4 having constant 4.2 operates in the frequency at 1.8GHz and 2.49GHz suitable for GSM and WLAN applications. It is simulated with ADS software and the results are obtained. The simulated return loss is -25.6 dB and -22.44 dB and maximum gain and directivity is obtained around 3 dBi and 5dBi.

From [4] by Cheng qi, Peter hillyard, Amalalhusseiny demonstrates a tag less identification and tracking with through-wall received signal strength based radio tomo graphic imaging (RTI) here E- shaped patch antenna is designed and lower localization is achieved. The E shaped patch antenna is designed to avoid impedance mismatches thus increasing the radiations. It uses Fr4 dielectric with relative permittiviy of 3.66 and thickness of 3.2 mm. This patch antenna reduces the median RMSE by upto 43% compared to dipole antenna

From paper [5] byYa-HuiQian and Qing-xinChu demonstrates a single feed micro strip antenna with polarization agility. the distilled water is used for tuning the effective permittivity of the substrate .the distilled water has the relative permittivity of 78 and height is consider for achieving the polarization reconfiguration with fine tuning of resonant frequency the antenna has an excellent circular polarization property over a wide angular range . Thus the antenna is very attractive to many modern advanced communication systems.

From paper [6]As proposed by Dan Sun, Zhaocheng Zhang,XueQuan Yan and Xunya Jiang demonstrates using a square annular cavity in the ground plane of a broadband micro strip patch antenna , with proximity coupling as the feeding mechanism is proposed in this paper the design of antenna is based on swarm optimization(PSO) algorithm . The measured result shows 61% bandwidth high isolation and good radiation pattern. Further, there is a coupling between the cavity and the patch. Hence, the isolation of the antenna is higher than 30dB, but still contains a compact structure. Therefore, if the antenna uses only one pair of ports with balance feeding technique, it can be widely used in broadening the systems without the need of polarization diversity.

From paper [7]by Yi-Fang Lin, Chun-Hsieg Lee, Shan-Cheng Pan and Hua-Ming Chen demonstrates an X-shaped slotted square patch antenna for circularly polarized radiation, two pairs of T-shaped slots are etched orthogonally on the square patch. The slotted patch is electromagnetically coupled from the cross - strip through a gap distance of 0.75mm. FR4 substrate of 0.8mm and relative permittivity of 4.4 is chosen from the upper plane and ground plane of the square patch. It is simulated with HFSS software and return loss is measured using an Agilent N5230A vector network analyser. The measured impedance bandwidth for 10dB return loss is 3.03%, ranging from 909-937 megahertz and efficiency is about 40%. By proximity - fed technique, good CP bandwidth and impedance matching is obtained. It is used in manufacturing companies and good flow systems.

From paper [8] by Joshna M. Kouit, Harish Rajagopalan,Yahya Rahmat-Samii , demonstrates a circular polarization in single layer , single feed , compact patch antenna with improve bandwidth are required. They proposed a circularly polarized E- shaped patch antenna its dimensions with 45% x 39% of a free space wavelength. The size of the slots and gaps are reasonably sized with respect to wavelength (~0.1 λ_0-0.2λ_0) .For the given data the size is smaller than $\lambda_0/2$. Itseeks the highperformance of CP patch designs.

From paper [9] by Fang-Yao Kuo,Ruery-Bing Hwang demonstrates a high isolation printed antenna array. The antenna array is composed of 32 identical square micro strippatches . the patch antenna are arranged in 4 arms each of which contains 8 elements and is series-fed using chebyshev tapering , array was implemented on a 31-mil substrate with a dielectric constant of relative permittivity is 2.2 and a loss tangent of 0.0009 . The square patches operated at a frequency of 9.35 GHz. It was simulated using HFSS software and the antenna gain, 3-dB beam width, side-lobe level and front to back ratio over 22dBi,5.3’, 26.4dB and 38.5 dB .Thus, these are extensively used in radar applications.

From paper [10] by Manoj Kumar Dwivedi and PrgatiSrivastava demonstrates an X-band micro strip patch planar array antenna with high gain and low gain side lobes. The radiating patches are fed using a micro strip feed distribution network on a thin grounded substrate. A high gain of >30 dBi with side lobe of better than -3dB in both the planes are achieved in this array. The antenna finds application in medium range radar systems operating at X- band. The measured return loss was better than 15dB over desired frequency band, thus the design and development of a 16 x 32 planar array antenna realized with direct feed technique. The array antenna is highly suitable for use in ground based lightweight radar system.

From paper [11] by Lihualiu, XinfanXia, Shengbo ye, JinjinShao, andguang you fang demonstrates a compact micro powerultra wideband (UWB) radar by integrating ultra-short balanced transmitter, sampling receiver and antennas into a single package. The developed MIR prototype could be helpful for through-wall imaging, underground penetrating,and pavement detection.

From paper [12] by Ankita Goel, MR TripathysohaibAbbas Zaidi demonstrates a T-shaped micro strip patch antenna is designed using FR4 substrate. It is simulated using HFSS (High frequency structure simulator) software. The proposed antenna is working in triple band. The first operating band is from 5.0417 GHz to 5.2262 GHz. In this band the obtained return loss is -14.29 dB at 5.1 GHz. The obtained gain at 5.1 GHz is 4.42 dB from the analysis of the above papers we have concluded the following swastika shaped design.

2. Antenna Design

Design procedure is outlined which leads to the practical design of swastika shaped micro strip patch antenna. The procedure assumes that the specified information includes the dielectric constant of the substrate, resonant frequency and the height of the substrate. Here microstrip line feed is used. The various parameters needed to design the antenna is listed below , Figure 1 shows the geometry of the design in which the Length of ground plane of Antenna is 30 mm and Width is 30 mm, L & W of the patch is 30 mm & 30 mm. ADS (advanced design system) was used here for computing the radiation characteristics of the antenna .low dielectric constant, thick substrate material increases the fringing field at the patch edges and increases radiating power. Hence the dielectric substrate with height of h=4.6mm is used. The patch width of the swastika shaped square patch is given by the following formula,

$$W = C/2f\sqrt{\epsilon_r}$$

Where c is the velocity of light, ϵ_r is the dielectric constant of substrate, f is the antenna centre frequency, W is the patch non resonant width, and the effective dielectric constant is eff ε of the proposed patch antenna is given by the formula,

$$\epsilon_{eff}=\left(\frac{\epsilon r+1}{2}\right)+\left(\frac{\epsilon r-1}{2}\right)\sqrt{(1+10\frac{H}{W})}$$

The extension length Δ can be calculated by using the formula,

$$\frac{\Delta L}{H} = 0.412\,\frac{(\epsilon_{eff}+0.300)(\frac{W}{H}+0.262)}{(\epsilon_{eff}-0.258)(\frac{W}{H}+0.813)}$$

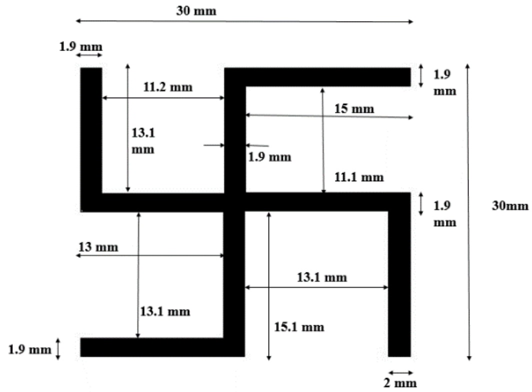
By using above equation we can find the value of actual length of the swastika shaped patch by using the formula,

$$L=\frac{C}{2f\sqrt{\epsilon eff}}-2\Delta L$$

ITERATIONS	FREQUENCY (GHz)	GAIN (dB)	RETURN LOSS	VSWR
1	8.32	2.43	-22 dBi	1.161
2	8.33	2.34	-2.9 dBi	1.263
3	8.302	1.359	-5.185 dBi	1.060
4	8.542	3.828	-32.766 dBi	1.047

Table 1: iterations performed to get the swastika shaped patch

In order to obtain the swastika shaped patch we have performed 4 iterations by removing the different shaped patches from the four sides and making the patch to work in the radar frequency range. The proposed antenna dimension is shown below,



3. Simulated Results

In this paper a compact wideband micro strip swastika shaped patch antenna with compact size is presented which gives a bandwidth of around 78 MHz. This bandwidth covers the frequency bands of X band (Radar) application. Figure 2 depicts the return loss graph of proposed swastika shaped patch antenna having the two resonant frequency points at 7.5 GHz and 8.5 GHz and the simulated return loss is at −19 dB and −32.766 dB respectively. Figure 3 shows the VSWR graph which is less than 2. Figure 4 shows the smith chart of the proposed design. Figure 5 shows the 3D radiation pattern of the proposed design Figure 6 shows the radiation intensity curve of the simulated antenna .Figure 7 shows the Gain Vs. Frequency curve which shows maximum gain is achieved around 3 dBi and Figure 8 shows the electric far field pattern of the proposed antenna design.

Design of Swastika Shaped Wideband Micro strip Patch Antenna for military Application

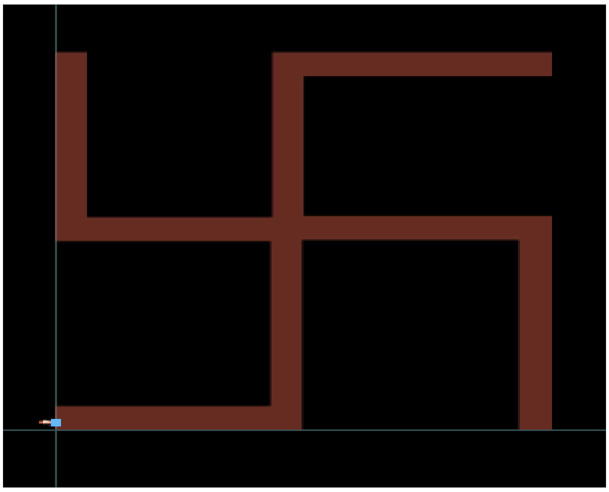
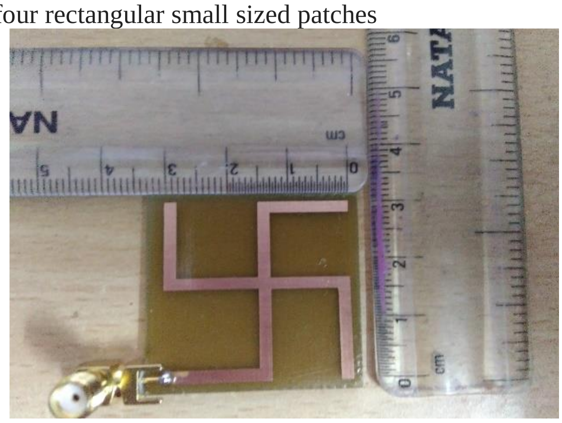


Fig 1: geometry of the proposed antenna

The above geometry shows the proposed antenna patch which demonstrates the swastika shaped patch that has been derived from the 3x3 cm square patch by removing four rectangular small sized patches



The actual proposed antenna is shown in the above figure with feeding given at the lower left arm of the patch.

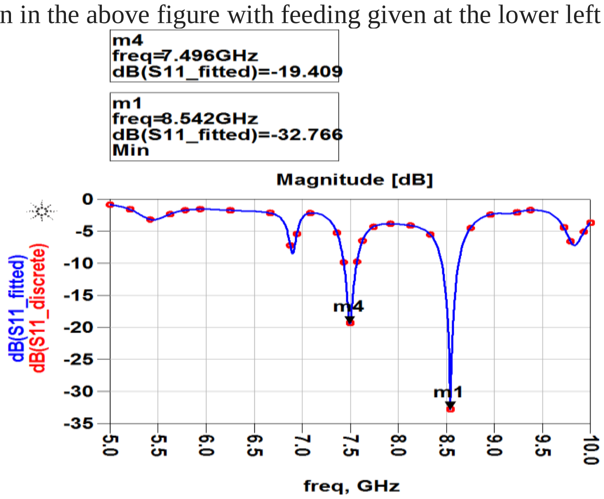


Fig 2: return loss plot of the antenna

The above return loss graph implies that the proposed antenna resonates at 8.5 GHz and 7.5GHz with the return loss of -32.766 dB and -19.409 dB which makes the antenna to have a relatively low standing waves to occur.

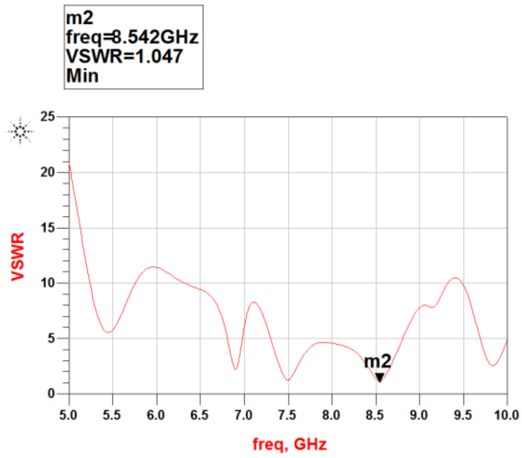


Fig 3: VSWR plot of the antenna

The above graph shows the VSWR plot of the proposed antenna which shows the value of SWR will be nearly equal to unity so that the efficiency of the antenna will be more and also the performance of the antenna increases.

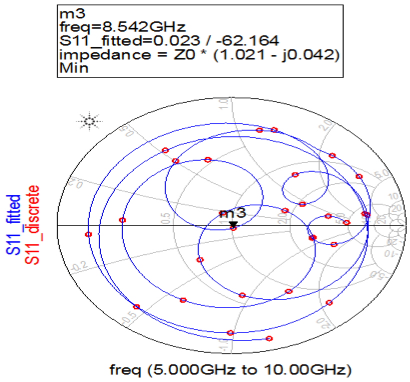


Fig 4: smith chart of the simulated design

The smith chart of the patch implies that for the resonating frequency of the proposed antenna the impedance is matched which is nearly equal to 1.

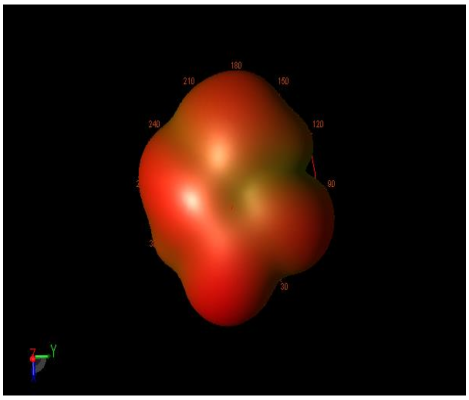


Fig 5: 3D radiation pattern

The 3 dimensional radiation pattern of the proposed antenna is shown here which implies the antenna radiates in only one direction ie, unidirectional so that the proposed antenna can be used for wearable applications so that the radiation will not affect the human body by penetrating inside the skin

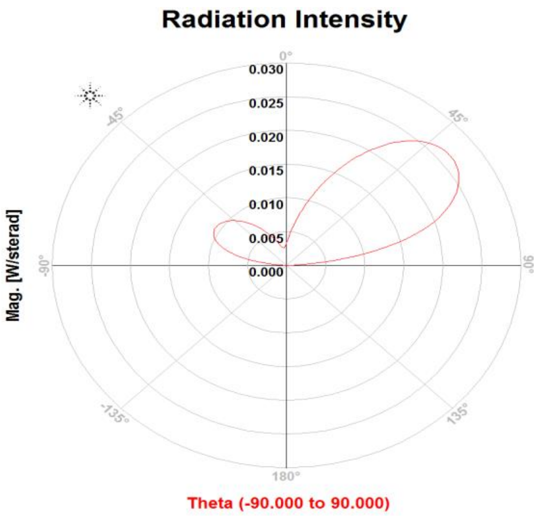


Fig 6: radiation intensity curve

The radiation intensity curve of the proposed antenna is shown here which implies the power radiated from an antenna per unit solid angle. It is also related to far-zone electric field of the antenna . here the radiation intensity is maximum inclined between the angle of 45 deg and 90 deg.

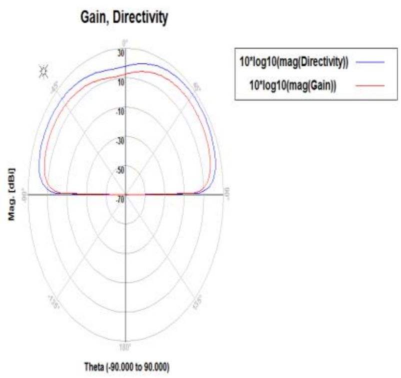


Fig 7: gain vs. frequency curve

the gain of an antenna describes its performance and its related to directivity, it also depends on the operating frequency of the antenna, here the directivity of the antenna is unidirectional and it covers the maximum range between -90 deg and 90 deg.

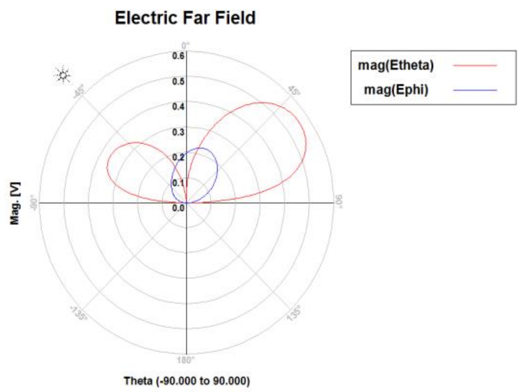


Fig 8: electric field intensity curve

The electric field intensity curve shown above predicts that field intensity of the proposed antenna is maximum along the direction of 45 deg to 90 deg and the E phase component is smaller compared to that of the E theta component.

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CONCLUSION:

In this paper a compact size micro strip antenna has been designed having good impedance matching as well as high covering the frequency range from 5 GHz to 10 GHz which is suitable for micro power impulse radar applications having an return loss of 32.76 dBi and gain of about 3.827 dBi . This antenna can be used for tracking the trapped peoples during the earthquake and other disasteral accidents.

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