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A Compact Microstrip Patch Antenna with "SWASTIKA" Shape Slot

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Abstract: In this paper, a micro strip patch antennas for a single frequency 2 GHz with proximity coupled feeding technique is presented. The various parameters like patch size, return loss, VSWR and bandwidth etc. have been studied and compared. We can see that selection of the feeding technique for a micro strip patch antenna is an important decision because it affects the bandwidth and other parameters also. A microstrip patch antenna excited at different frequencies and at different dimensions gives different bandwidth, different gain, different efficiency etc. The maximum bandwidth can be achieved by this proximity coupled antenna with comparison to the base paper. It also gives the best impedance matching and good radiation efficiency. So in this paper, a microstrip line fed antenna resonating at 2 GHz. Loading slots at the non-resonating sides of the patch of single band antenna make its bandwidth wide for S-Band Applications (2- 4 GHz). The parametric study of the designed antenna has been attempted in this thesis. The antenna parameters like operating frequency, input impedance, VSWR, Smith Chart, Radiation pattern, Bandwidth, Return loss (S-Parameter) and gain are determined for each antenna configuration.
Keywords: Swastika shape, Rectangular microstrip patch antenna, S-Parameters, smith chart, radiation pattern, bandwidth, VSWR, resonant frequency, HFSS13.0.

I. INTRODUCTION

Now a day, the demand of low profile antenna design is very high. The communicating device should be smaller in wireless communication. As a result, the antenna used in such devices should be small also but the cost should not be increased. Similarly if we want to place an antenna in space, any aircraft, parabolic reflector antenna or Yagi antenna that have high bandwidth and gain can be placed in that place but, it will affect highly on the space and aircraft because of their 3D structure, hence it becomes inefficient to plant those antenna structure on the space and aircraft. The solution is to use planner or 2D antenna configuration to this type of difficulties.

These antennas can be easily mounted on the surface of any such equipment. Advances in wireless communications have introduced tremendous demands in the antenna technology. It also paved the way for wide usage of mobile phones in modern society resulting in mounting concerns surrounding its harmful radiation [1-6]. In a single layer rectangular patch antenna of wide-band has been explained where impedance bandwidth of greater than 20% has been obtained.

Antenna is the most fundamental block of the wireless communication. Recently, the growth of wireless systems leads to a lot of innovations in the Microstrip antenna designs. Microstrip patch antenna has become an integral part of these devices working in ultra to super high frequency ranges.

The patch and slot are the two parameters which affect the overall antenna's performance. Microstrip patch antennas are useful in various applications having requirements like broader bandwidth, smaller in size, lighter in weight, lower in cost and compatibility with integrated circuits [1-2]. A variety of wireless communication engineering applications, such as wireless links, remote sensing, cellular mobile phones and internet are in extensive demand and have witnessed a tremendous growth recently. The microstrip antenna has narrow bandwidth of the order upto 5%.

This low bandwidth is not useful for many wideband wireless applications. Previously published literature has reported several possible techniques to improve bandwidth of the microstrip antenna.

Microstrip Patch Antennas has quite a lot of advantages over other antennas due to their light weight, low profile, low cost of production, and are easily well-suited with optoelectronic integrated circuits (OBICs) and microwave monolithic integrated circuits (MMICs). Due to these striking features, the researchers are having noteworthy attention towards microstrip antennas. Microstrip patch antennas are used in extensive range of applications such as in wireless communication and biomedical diagnosis [3]. In recent years, the widespread proliferation of wireless communication has augmented the demand for compact broadband antennas for handheld devices, satellite systems, etc.

II. METHODOLOGY AND DEIGN FORMULAS

The parameters used for the design of a rectangular Microstrip Patch Antenna are:

A. Frequency of operation (*fr*): The proposed antenna is designed with two feeding technique for X-Band application at a single frequency of 2 GH

B. Dielectric constant of the substrate (Є*r*): The dielectric material selected for proposed design is FR4 which has a dielectric constant of 4.

C. Dielectric substrate Height (*h*): Height of the dielectric substrate is selected as 1.6 mm as the microstrip patch antenna.

For efficient radiation, the width *W* is

$$W = \frac{\lambda_o}{2 f_o \sqrt{\frac{(\epsilon_r + 1)}{2}}} \quad (1)$$

Now to calculate the length of patch becomes:-

$$L = L_{eff} - 2\Delta L \quad (2)$$

The effective length of the patch L_{eff} now becomes:-

$$L_{eff} = \frac{\lambda_0}{f_o \sqrt{\epsilon_{reff}}} \quad (3)$$

Calculation of effective dielectric constant, ϵ_{reff} which is given by:

$$\varepsilon_{reff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (4)$$

ϵ_{reff}= Effective dielectric constant

ϵ_r= Dielectric constant of substrate

h = Height of dielectric substrate

W = Width of the patch

λ_o= Free space wavelength.

Calculation of the length extension, ΔL, which is given by:-

$$\frac{\Delta L}{h} = 0.412 \frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (5)$$

Calculation of ground dimensions:-

The transmission line is applicable to infinite ground planes only. However for practical considerations, it is essential to have a finite ground plane. It has been shown that similar result for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimension is approximately six times the substrate thickness all around the periphery.

Hence, for this design, the ground plane dimensions would be:-

$$L(g) = 6h + L \quad (6)$$

$$w(g) = 6h + w \quad (7)$$

III. DESIGNS AND THEIR RESULTS

A. Proposed Antenna Using Proximity Coupled Feed

In this chapter, a microstrip patch antenna is designed for IMT-Advance (4G) application at a single frequency of 2 GHz using proximity coupled feeding techniques and a comparison is made between various parameters.

The Bandwidth, return loss, VSWR, smith chart and radiation pattern have also been studied.

In this type of feeding technique, two dielectric substrate are used such that the feed line is between the two substrate and radiating patch is on the top of the upper substrate. The main advantage is that it eliminates spurious feed radiation and provides high band width.

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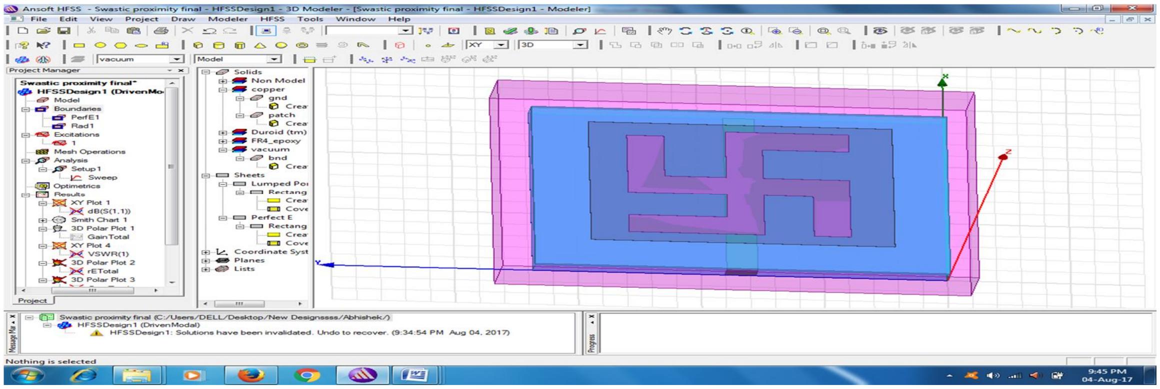

Figure 1 Proposed Swastika Shape Design using Proximity coupled feed

B. Result

1) Observation from -10dB return loss

Resonant frequency =2.02 GHz at -40.29dB

Band width= f2-f1= 2.0659-1.9933= 0.0726 GHz= 72.6 MHz

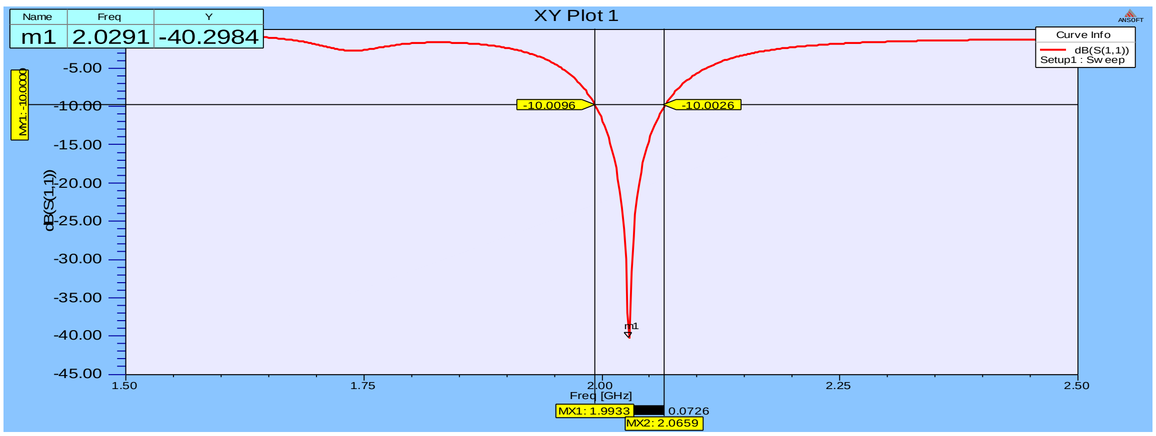

Figure 2 Return Loss curve of Proximity Coupled Feed

B. Observation from VSWR

1) VSWR at resonant frequency 2.02 GHz=1.0195

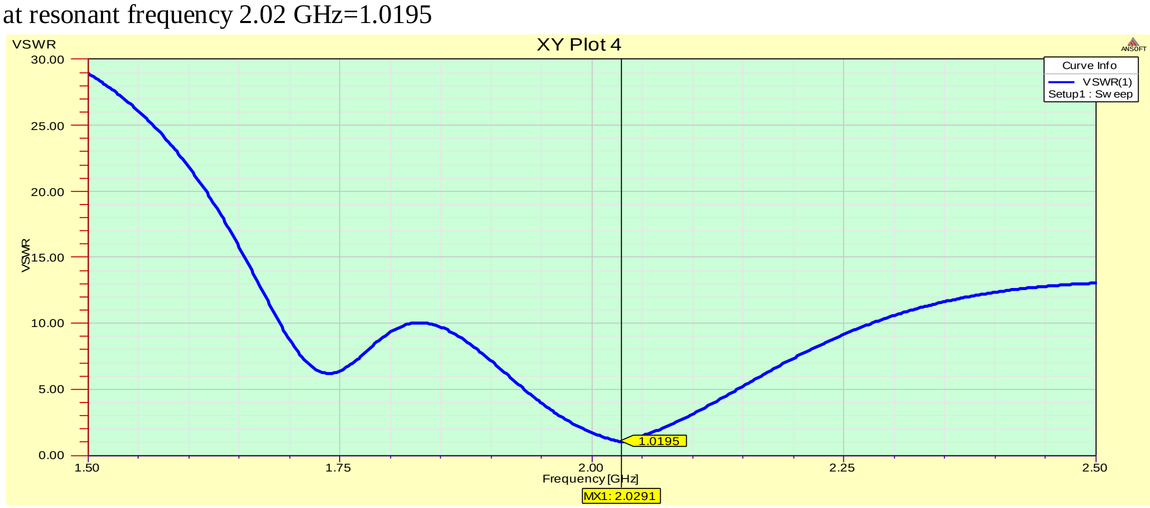

Figure 3 VSWR curve of Proximity Coupled Feed

C. Radiation Pattern

The radiation pattern of Proximity Coupled feed is shown in figure.

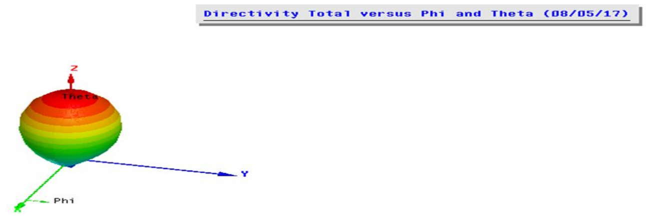

Figure 4 Radiation pattern curve of Proximity Coupled Feed

D. *Smith Chart*

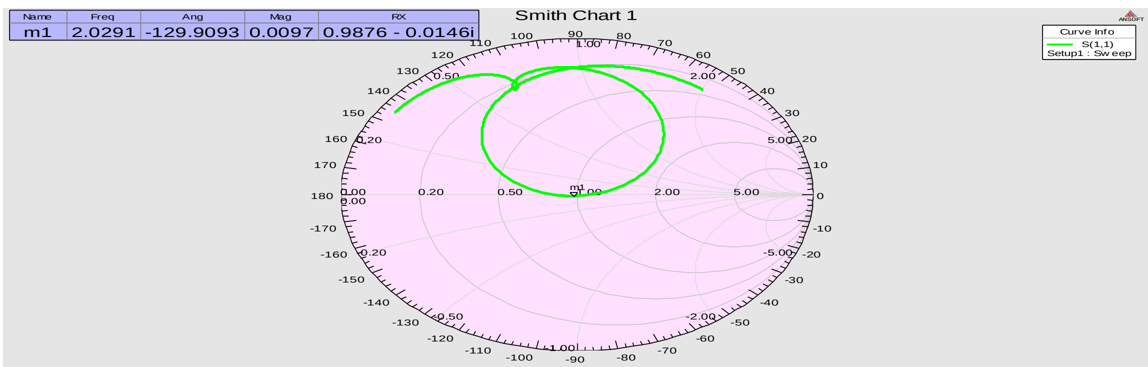

Figure 5 Smith chart curve of Proximity Coupled Feed

E. *Proposed Antenna Using Defected Ground*

Now the bandwidth of proposed antenna is enhanced using four rectangular wide slot in ground instead of full ground as taken in reference and proposed antenna while the other design dimensions remain the same. This will not only modify the bandwidth by 21.3 MHz but also change the resonant frequency from 2.02 GHz to 1.92 GHz.

The modified results at almost same frequency are discussed as shown below:

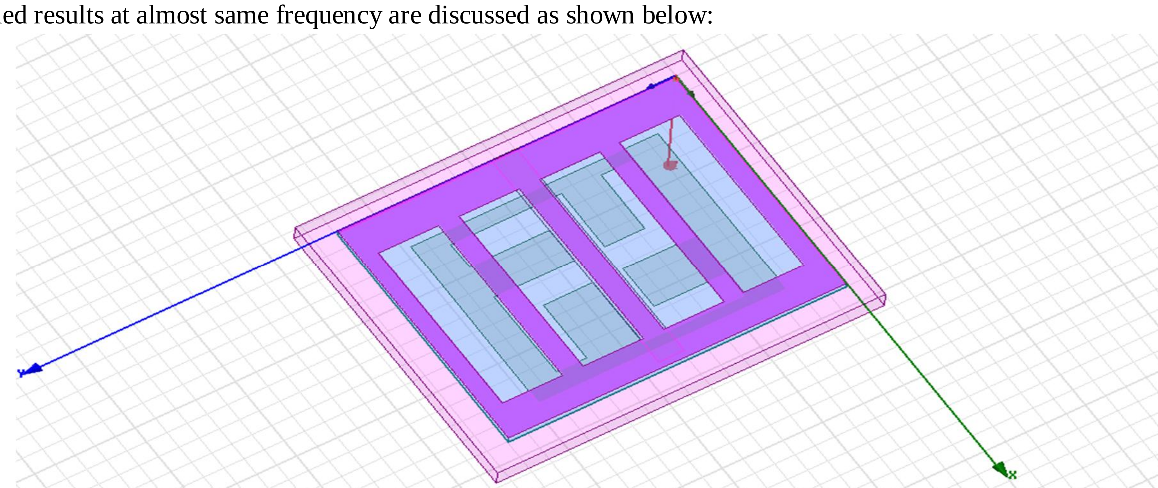

Figure 6 Designing using DGS

F. Result Discussion

1) *Observation from -10dB return los*
2) Resonant frequency =1.9289 GHz at -40.40Db
3) Band width= f2-f1= 1.9770- 1.8832= 0.0939 GHz= 93.9 MHz
4) Difference in Bandwidth with Proposed Design is (93.9-72.6)MHz=21.3 MHz

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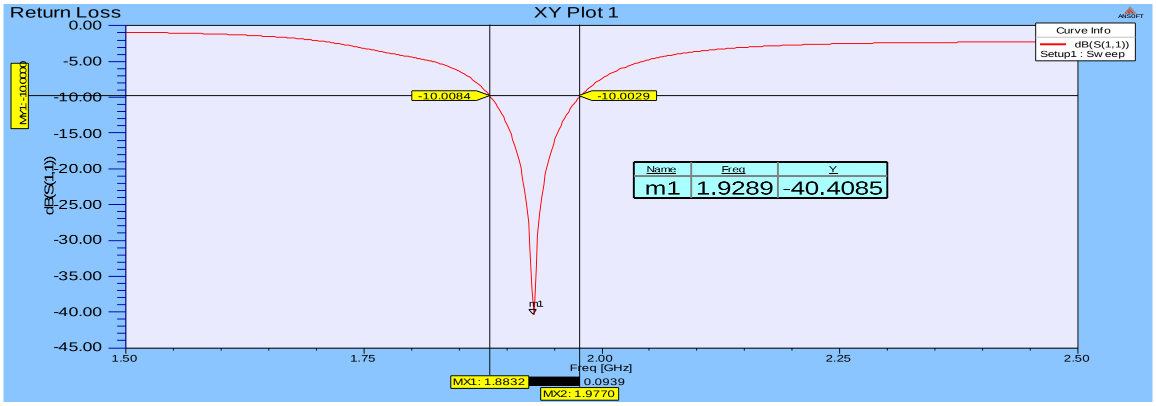

Figure 7 Return Loss curve of DGS Design

F. Observation from VSWR

1) VSWR at resonant frequency 1.9289 GHz=1.0193

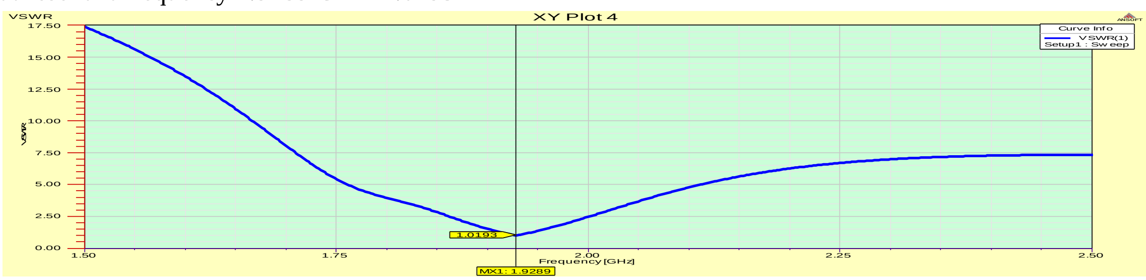

Figure 8 VSWR curve of DGS Design

F. Comparasion of Results of Reference & Proposed Antenna:

Table 5:- Comparison of results

Antenna	Difference in Design	Feeding Technique Used	Resonant Frequency	VS WR	Return Loss	Band width	Impedance Matching
Reference Antenna (Single band)	Swastika design in patch with little gaps in the base of sides	Coaxial Probe Feed (used one substrate)	433 MHz	< 2	-38.01 db	5.87 MHz	Near about Characteristic Impedance 50 ohm
Proposed Antenna (Single band)	Using wider Swastika slot in patch and small in size as reference	Proximity coupled Feed (Using two substrate)	2.02 GHz	1.0 195	-40.29 db	72.6 MHz (Very high with respect to Reference Antenna)	49.38 ohm (Also Near about Characteristic Impedance 50 ohm)
Proposed Antenna using DGS	Using Defected Ground with four wide rectangular slot but other dimensions are same	Proximity coupled Feed (Using two substrate)	1.92 GHz	1.0 193	-40.40 db	93.9 MHz (21.3 MHz wide than Proposed Antenna)	Same as proposed antenna

V. CONCLUSION

As from the thesis, it is observed that because of various advantages of micro strip patch antenna like small size, small weight, low fabrication cost etc. it can be used in various applications where small size and small weight are major constraints. In this paper, a micro strip patch antennas for a single frequency 2 GHz with proximity coupled feeding technique using swastika shape patch design is presented. The various parameters like patch size, return loss, VSWR and bandwidth etc. have been studied and compared. A comparison is made between antennas in terms of bandwidth, return loss, VSWR and patch size and smith chart. We can see that selection of the feeding technique for a micro strip patch antenna is an important decision because it affects the bandwidth and other parameters also. A microstrip patch antenna excited by different excitation techniques gives different bandwidth, different gain, different efficiency etc.

The proposed antenna has been designed by using rectangular type defected patch i.e DGS (Defected Ground Structure). We can also conclude that by changing the feed point where matching is perfect, the high return loss can be achieved at the resonant frequency.

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