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Design of a Rectangular Microstrip Patch Antenna for GNSS/GPS System

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***Abstract* - This paper deals with the design of a rectangular microstrip patch antenna for GNSS/GPS network. The proposed antenna has symmetrical properties and has been designed on Rogers TMM4 substrate with corporate feed input. It radiates at L_2 (1227.6MHz) frequency band. The performance of the antenna is measured in terms of Return loss, VSWR, Gain, frequency of operation and radiation pattern. The return loss S_{11}, Gain and radiation pattern of the fabricated antenna was simulated using Ansoft HFSS, which is a good agreement with experimental data.**

***Keywords* – GNSS, Microstrip patch, probe feed, Return loss(S_{11}), VSWR.**

I. INTRODUCTION

The Global Navigation Satellite System (GNSS) is a constellation of satellites, transmitting signals for use in navigation and positioning applications, anywhere on the surface of the earth. There are currently two Global Navigation Satellite Systems in operation: the U.S. Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS). A third system, Galileo, is currently under development in Europe.

Global Navigation Satellite System (GNSS) support applications where high accuracy is required such as precision agriculture, tsunami, surveying, land management and offshore operation. Such techniques are especially sensitive to ionospheric perturbation. The aim of this project is to mitigate the impact of ionospheric disturbances on high accuracy GNSS positioning technique.

Investigation of fenn (2008) shows that an antenna array with adaptive direction beam is a promising method to detect, using GPS/GNSS signal, some disturbances in the ionosphere. Due to increased radiation pattern and high gain such antennas are able to mitigate the impact of ionospheric disturbances.

The GPS satellite transmit low power radio signal on multiple frequencies. L_1 and L_2 are the two basic carrier frequencies that contain the navigational signal. The L_1 frequency is 1575.42MHzin the UHF band while the L_2 frequency is 1227.6 MHz.

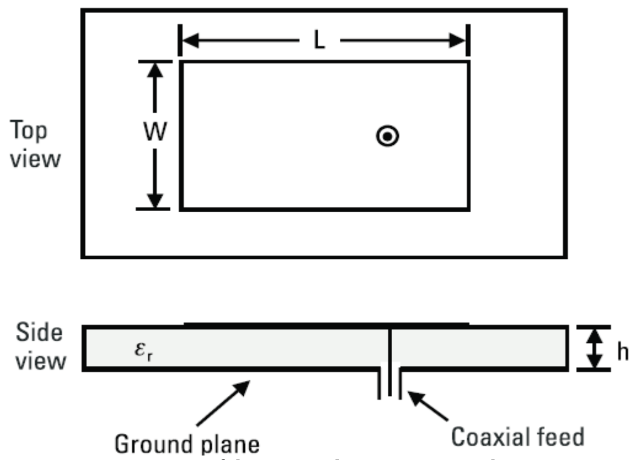

Fig 1- Structure of the rectangular microstrip patch antenna

In this paper a rectangular microstrip antenna is designed at L_2 frequency, suitable for use in space monitoring applications.

II. ANTENNA CONFIGURATION

The antenna is simulated on Rogers TMM4 substrate with a dielectric constant of 4.5, the thickness of substrate is 1.59mm. The length and width of the antenna can be calculated by transmission line method as given below

Width of antenna is given by

$$W = \frac{C}{2.f_c\sqrt{\frac{\varepsilon_r+1}{2}}} \quad (1)$$

The effective dielectric constant

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{-0.5} \quad (2)$$

The extension length is given by

$$\Delta L = 0.412*h*\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad (3)$$

The effective length is given by

$$L_{eff} = \frac{C}{2.fc\sqrt{\varepsilon_{reff}}} \quad (4)$$

Therefore the actual length of the patch is calculated by

$$L = L_{eff} - 2\,\Delta L \qquad (5)$$

By substuting the value of operating frequency L_2 = 1227.6MH$_Z$, c = 3×10^8m/s, ε_r = 4.5 and h = 1.59mm the width of the patch (W) becomes 73.68 mm and Leff= 56.3mm, substituting ε_{eff}= 4.71 and the values of W and h, we get ΔL = 0.73 mm. In final, we obtain the length of the patch using this equation.

$$L = Leff - 2\Delta L \qquad (6)$$

L = 56.3 mm – 1.46 mm = 54.83 mm.

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. Similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the ground plane dimensions would be given as:

$$L(g) = 6h + L \qquad (7)$$

L (g) = 6*(1.59mm) + 54.83mm= 64.37mm

$$W(g) = 6h + W \qquad (8)$$

W (g)= 6*(1.59mm) + 73.68mm = 83.22mm

Hence after calculating all the parameters using the above formulae,the rectangular microstrip patch antenna was designed.

Table 1- Antenna dimensions

Frequency	1227.6MHz
Height	1.59mm
Dielectric constant	4.5
Width of patch (W)	73.68mm
ε_{reff}	4.71
Extention length(Δ L)	0.73mm
Length of patch(L)	54.83mm
Return loss(S_{11})	-19.50db
VSWR	1.84
Gain	6.51%

III. SIMULATION RESULTS

Figure 2 below shows the designed RMSA with W = 73.68mm and L=54.83mm and ground plane dimensions as. Lg = 64.37mm and Wg = 83.22mm. Probe feed has been used to feed the antenna as in figure below. The optimized feed location are calculated using,

$$Y_f = \frac{L}{2\sqrt{\varepsilon_{reff}}} = 12.63\text{mm} \qquad (9)$$

$$X_f = \frac{W}{2} = 36.84\text{mm} \qquad (10)$$

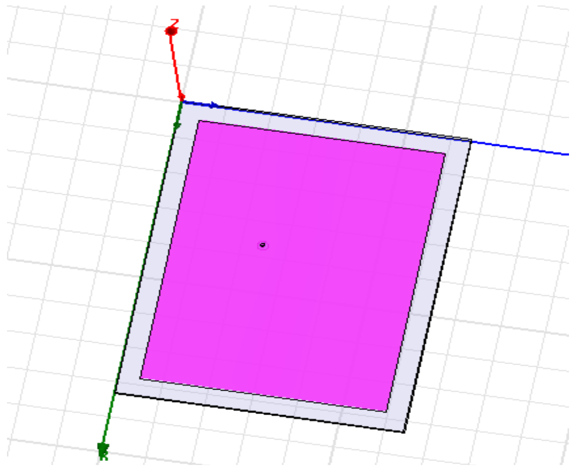

Fig 2 – Designed rectangular microstrip patch antenna

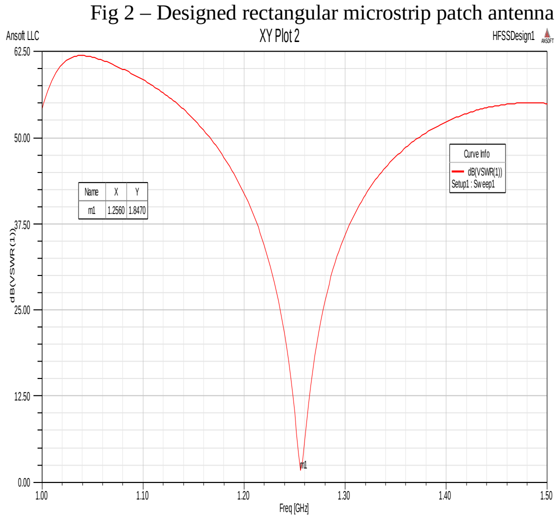

Fig 3 – VSWR diagram of L_2 rectangular patch

However in order to achieve 50Ω match a little trial and error is used and the optimized feed locations are found to beX$_f$= 36.84mm and Y$_f$= 24.63mm. In the present investigation, it was found, at the L2 frequency, that the VSWR ≤ 2 (1.84) which shows that the printed square patch antenna is better matched to its feeding strip line.

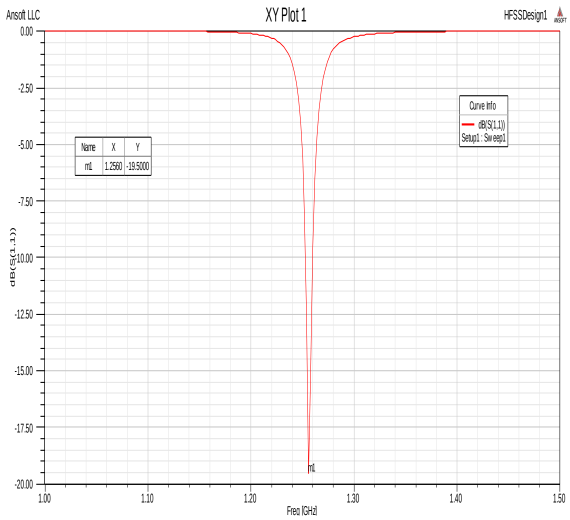

Fig 4 - S11 diagram of L2 rectangular patch

Fig 4 shows the value of S11 which is equal to – 19.50 dB and the bandwidth of the antenna is 6.51% compatible with the intended application. Figure 5 shows the electric field distribution, it can be seen thatthe electric field distribution is maximum at the width of the patch as it's the radiating edge.

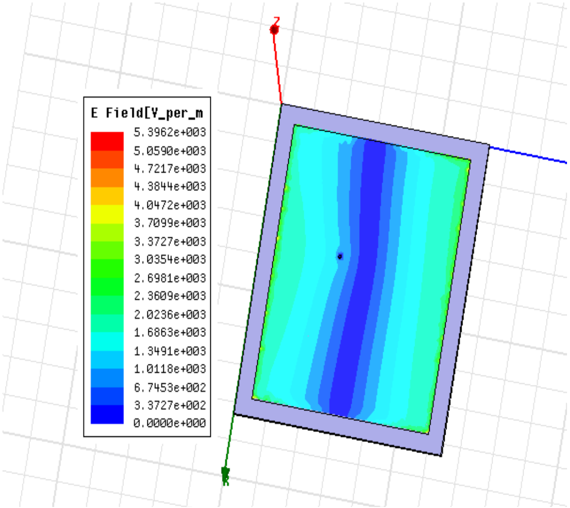

Fig 5 – Electric field distribution

Fig 6 shows the gain and radiation pattern of the designed rectangular patch antenna and it was found that the antenna give a suitable radiation pattern in desired direction and the gain is equal to 5.37db.

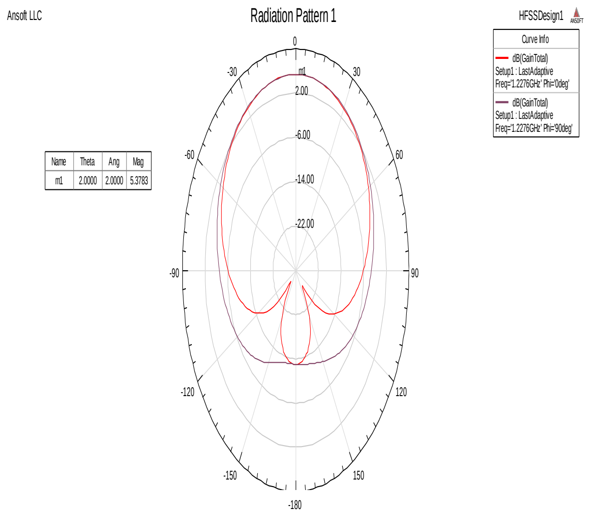

Fig 6 – Gain pattern of rectangular patch antenna

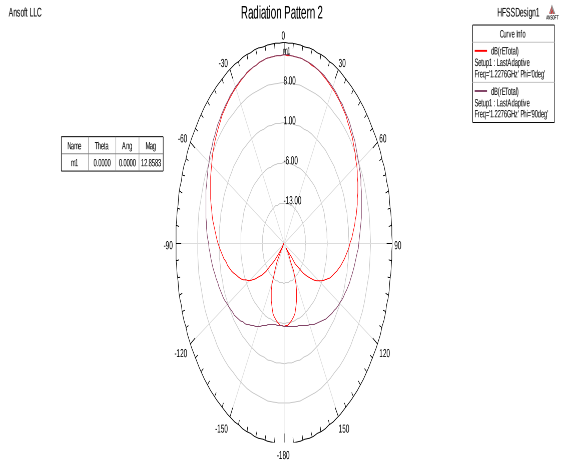

Fig 7 – Radiation pattern of rectangular patch antenna

IV. CONCLUSION

From the simulation analysis of the proposed antenna it can be easily observed that designed rectangular antenna can operate in the L_2 frequency band, having return loss $S_{11}$is – 19.50db, Gain is 5.37dband bandwidth 6.5% compatible with intended applications. It is also observed that the antenna offers improved characteristics of matching and radiation at L_2 frequency and its general performance is within acceptable range. Further, the VSWR of the fabricated antenna is ≤ 2 which is well within acceptable margins.The present network thus proposed with high gain, low cost and small footprint meets our goal.

V. REFRENCES

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