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Design of a Rectangular Microstrip Patch Antenna for GPS Application

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Abstract - *This paper deals with the design of a rectangular microstrip patch antenna for GPS network. The proposed theory has symmetrical properties and has been designed on FR4_Epoxy substrate with microstrip inset feed input . It radiates at L_1(1.575Ghz). The performance of the antenna is measured in terms of Return loss,VSWR,Gain,Radiation pattern. The return loss S_{11}, Gain and Radiation pattern of the designed antenna was simulated using Ansoft HFSS 15, which is good with experimental data.*

Key Words: GPS, Microstrip patch, Feedlines, return loss(S_{11}), Radiation pattern.

1. 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 Russian Global Navigation Satellite System (GLONASS). A third system, Galileo is under development in Europe.GPS is a global navigation system that provides geo-location and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. Obstacles such as mountains and buildings block the relatively weak GPS signals

The GPS does not require the user to transmit any data, and it operates independently of any telephonic or internet reception, though these technologies can enhance the usefulness of the GPS positioning information. The GPS provides critical positioning capabilities to military, civil, and commercial users around the world. The United States government created the system, maintains it, and makes it freely accessible to anyone with a GPS receiver.

The GPS satellite transmit low power radio signal on multiple frequencies. L1 and L2 are the two basic carrier frequencies that contain the navigational signal. The L1 frequency is 1575.42MHzin the UHF band while the L2 frequency is 1227.6 MHz.

1.1 Antenna Configurations

The antenna is simulated on FR4 Epoxy substrate with a dielectric constant of 4.4, 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

$$w = \frac{c}{2f\sqrt{\frac{\varepsilon+1}{2}}}$$

The Effective di electric constant

$$\varepsilon_{eff=} \frac{\varepsilon+1}{2} + \frac{\varepsilon-1}{2}\left[1+12\frac{h}{w}\right]^{-0.5}$$

The extension length is given by

$$\Delta L = 0.412 * h * \frac{(\varepsilon_{eff}+0.3)}{(\varepsilon_{eff}-0.258)} * \frac{(\frac{w}{h}+0.264)}{(\frac{w}{h}+0.8)}$$

The effective length s given by

$$L_{eff} = \frac{c}{2f_c\sqrt{\varepsilon_{eff}}}$$

Therefore the actual lenght of the patch is calculated by

$L=L_{eff}-2\Delta L$

By substituting the value of operating frequency L2 =1.575GHz, c = 3x108m/s, εr = 4.4 and h = 1.6mm the width of the patch (W) becomes 57.96 mm and Leff=45.55mm, substituting εeff= 4.37 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.

$L=L_{eff}-2\Delta L$

L = 45.55-2x0.73 = 44.09 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

L (g) = 6*(1.59mm) + 44.09mm=53.69mm

W(g) = 6h + WW (g)= 6*(1.59mm) + 57.96mm = 67.56mm

Frequency	1.575GHz
Height of the substrate	1.6mm
ε(Dielectric constant)	4.4
Width of the patch(W)	57.96mm
Extension length(ΔL)	0.73mm
Length of the patch(L)	44.09mm
ε_{eff}	4.37
Return loss(S_{11})	-19.30dB
VSWR	-1.889

2. SIMULATION RESULTS

Figure below shows the designed RMSA with W =57.96mm and L=44.09mm and ground plane dimensions as. Lg = 53.69mm and Wg = 67.56mm Microstrip feed has been used to feed the antenna as in figure below.

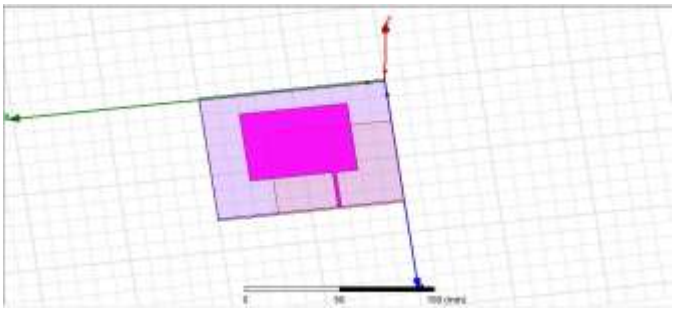

Fig 1 – Designed rectangular microstrip patch antenna

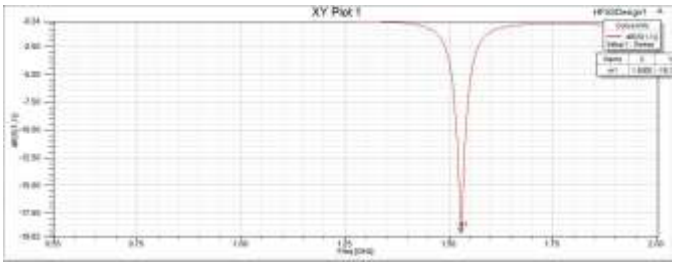

Fig 2- S_{11} diagram of rectangular patch

Fig 2 shows the value of S11 which is equal to – 19.30 dB.

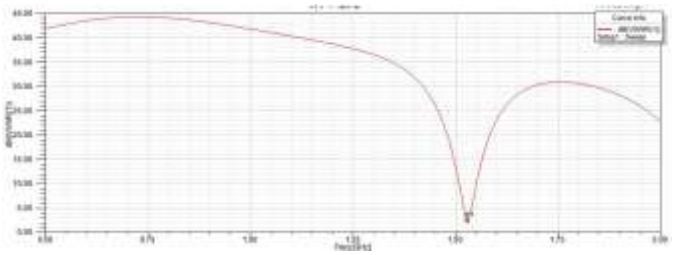

Fig 3- Vswr diagram for rectangular patch

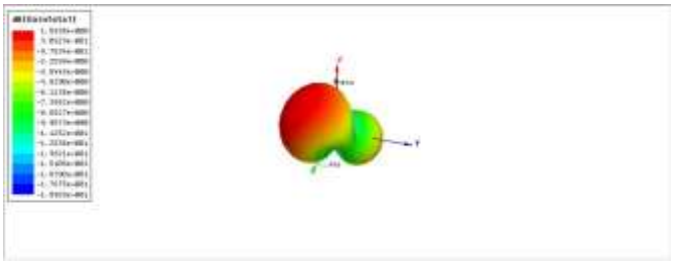

Fig 4- Radiation pattern for rectangular patch

Fig 4 shows the radiation pattern of the designed rectangular patch antenna and it was found that the antenna give a suitable radiation pattern in desired direction

3. CONCLUSION

From the simulation analysis of the proposed antenna it can be easily observed that designed rectangular antenna can operate in the L_1 frequency band, having return loss *S*11is – 19.30db, compatible with intended applications. It is also observed that the antenna offers improved characteristics of matching and radiation at L_1 frequency and its general performance is within acceptable range. Further, the VSWR of the fabricated antenna is ≤ 2(1.889) which is well within accephigh gain, low cost and small footprint meets our goal.

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