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CHARACTERIZATION OF GPS ANTENNA

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Abstract: In this work the design of a circularly polarized patch antenna for GPS application is done. The theoretical analysis is done to find out reflection coefficient and radiation pattern of the antenna at 1575.42 MHz. Finally the fabricated antenna is measured and results shows VSWR bandwidth of 2.046 MHz, and right hand circular polarization. The gain varies up to 5.0 dB and axial ratio is below 3 dB over the frequency band of operation.

Keywords GPS, patch Antenna, gain, radiation pattern, axial ratio.

INTRODUCTION

Global Positioning System (GPS) is a satellite-based service which has grown to have significant commercial applications, and now there are many thousands of civil users of GPS worldwide.GPS system made of twenty-four satellites circling the Earth every twelve hours at an altitude of 20,200 km. Each satellite transmits at two frequencies in L band, at any time four of these satellites will enable users on the ground to determine their positions every 100 nanoseconds. The GPS ground antenna has to be circularly polarized, omnidirectional, wide-beam and low gain antenna. When it comes to size, mass and cost at L-band, the microstrip patch antenna is the best candidate.GPS and GSM systems require highly specialized wireless antenna systems in order to communicate effectively with satellites and relay real-time information to drivers. GPS Patch Antennas offer 5 dBic gain. They are compact in size and come with a semi-hemisphere radiation pattern for efficient performance [1-5].

Most commonly used GPS antenna is made of ceramic patch, which has quite large are but a relatively low profile. When a large ground plane is used the patch antenna behaves as an efficient radiator and can have very good right hand circular polarization (RHCP) characteristics, matching the polarization characteristics of the signals radiated by the GPS satellites. An alternative to the patch is the helix antenna, which has similar electrical characteristics but is higher in profile and correspondingly smaller in area. The disadvantage of the patch antenna is due to narrow bandwidth and the tight manufacturing tolerance required for maintaining the frequency tuning. Generally small ceramic patches mounted on small ground planes are less efficient, less stable and have worse RHCP characteristics. As large ceramic patches has high gain and narrow beam antenna pattern characteristics which helps to receive stronger signals from the satellite. But due to narrow beamwidth the radiation pattern of the antenna installed in a mobile phone handset is getting obstructed by the users head when the phone is used for incoming/outgoing call. Otherwise if the handset is in idle condition placed horizontally the antenna pattern is getting exposure of the sky. An antenna on the back of the handset is exposed to the sky partially. In contrast a low gain antenna receives signals from more satellites and the system is less sensitive to orientation. It is seen that it is useful to get signals from few satellites with a good carrier-to-noise ratio (C/N) compared to the data received from more satellites at lower signal strength since GPS receiving chip and software can process and make use of the data from more satellites in its calculation of position.

Technically, the GPS has two services, the Precise Positioning Service, PPS, for the military and the Standard Positioning Service, SPS, which is less accurate, but still very effective for civilians [1]. SPS transmits messages on to the L1 signal at the carrier frequency of 1575.42 MHz with a bandwidth of 2.046MHz and with right hand circular polarization [1]. This paper will focus on the L1 civilian frequency.

DESIGN

The analysis and design of the GPS antenna under consideration, simulation and measurement results are discussed here. FR4 is proffered over silicon for use in antennas. High performance silicon antennas are much more complex to fabricate compared to other dielectric substrate based antennas. The typical range of the dielectric of PCB is much less than the counterpart of silicon substrates, which allows for greater radiation. They are compact in size and come with a semi-hemisphere radiation pattern for efficient performance.

The aim is to design a circularly polarized GPS antenna. The design of a planar microstrip antenna with the following characteristics:

i) Resonance frequency: 1.57 GHz;

ii) Right handed circular polarization;

Iii) VSWR<2;

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iv) Gain > 5 dBi

To realize the patch antenna, RT Duriod 5880 is used as dielectric and as per calculation the theoretical patch dimension is 57.3mm. To excite the metallic patch, three methods exist by probe fed, by microstrip line and by coupling through the ground plane. The first method is chosen because it allows an easy patch association. To obtain the circular polarization, the patch is feed at a point to excite both TE_{01} and TE_{10} modes. EM simulations of the patch excited by a coaxial feed (circular polarization) are made in order to obtain optimized dimensions of the same. The patch antenna under consideration is suitable for low cost highly stable circularly polarized GPS and the frequency response and radiation pattern is verified from the experimental and simulation result. GPS signals are low power, high frequency (1.57542 GHz) digital signals. A radiating antenna amplifies signals from satellites where the signal strength is not enough for the GPS to get a clear signal.

SIMULATION & MEASUREMENT

The GPS antenna under consideration is shown in figure. 1. The radiation pattern, the directivity, the gain, the polarization, and finally the impedance bandwidth of the GPS antenna is computed using MATLAB. Although radiation patterns define an antenna's electric field characteristics, one particular method to determine the radiation pattern is based on the electric surface current model. The radiation pattern is highly dependent on distance of observation, the permeability of free space, and the wave number. The current characteristic, the ground effects and substrate contribution are related and are highly dependent on the antenna's geometry. The far-field radiation patterns is obtained by finding the limit of the electric or magnetic field to infinity The distance of observation has a large influence with the electric and magnetic fields.

Directivity and gain are related and both depend on the direction of the maximum radiation intensity. The magnitude of the maximum radiation divided by the average radiated power is related through the Pointing vector in watts, which determines the directivity, or gain at the maximum radiation relative to either the radiated power or the input power, respectively. The fabricated GPS antenna is shown in figure 1.The measured impedance bandwidth of the fabricated antenna is more than -10 dB as shown in figure 2. The measured S11 of the antenna at 1.5754 GHz is -14.0dB, which is sufficient for GPS applications and measured impedance bandwidth is 20MHz.

The antenna radiation pattern is simulated and measured and shown in figure 3 and 4. The measured gain and axial ratio is shown in figure 5 and 6. The gain varies up to 5.0 dB and axial ratio is below 3 dB over the frequency band of operation.

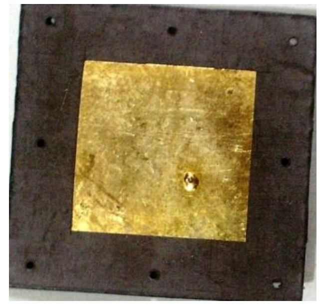

Figure 1. Fabricated GPS Antenna

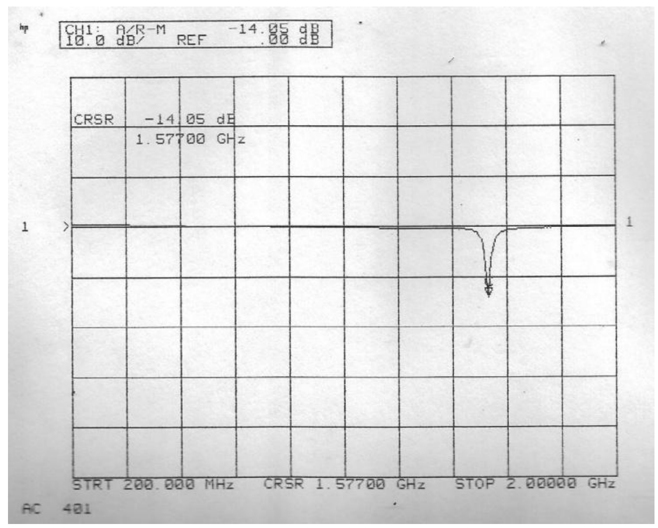

Figure 2 Measured Return Loss Plot of GPS Antenna

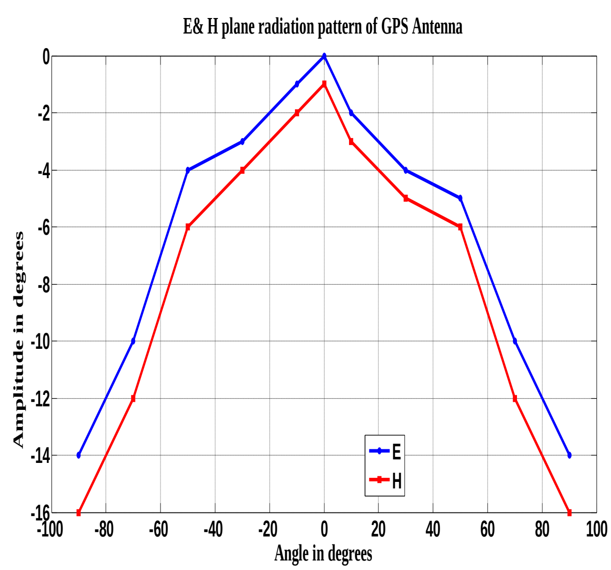

Figure 3 Simulated E& H plane radiation pattern of GPS antenna

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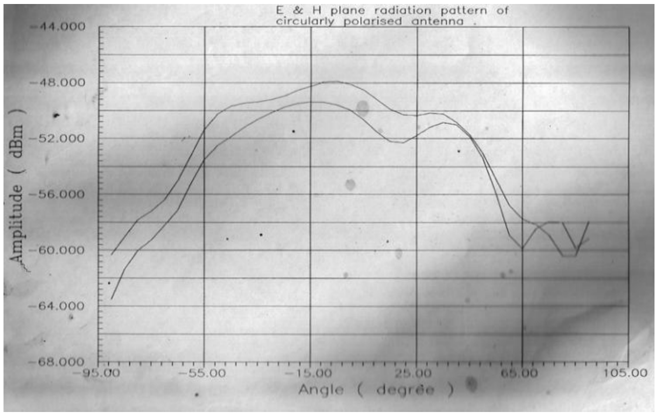

Figure 4 Simulated E& H plane radiation pattern of GPS antenna

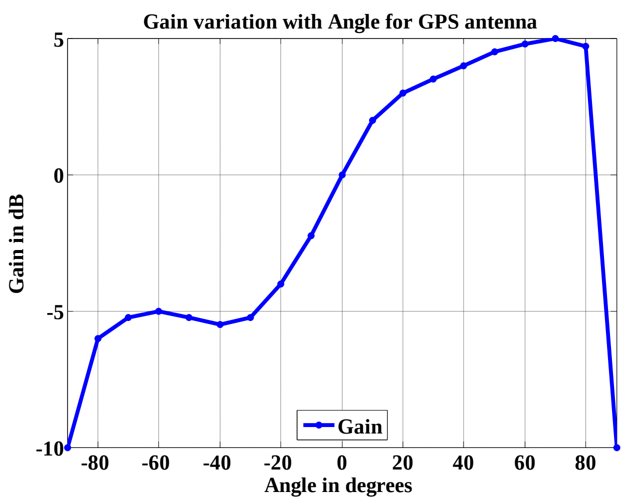

Figure 5 Gain variations with Angle

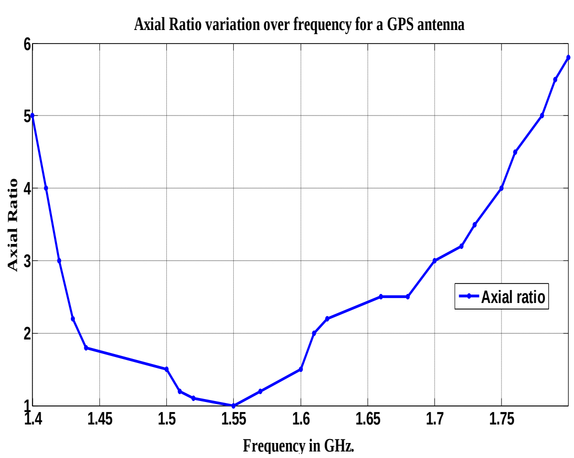

Figure 6 Axial Ratio variation with frequency

CONCLUSION

The design and measurements of a patch antenna for GPS application is presented in this paper. The antenna has a dimension of 57.3mm X 57.3mm and is designed to operate at 1.5754 GHz (L band).

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[2] R. Garg, P. Bhartia, I. Bahl, and A. Ittipiboon, Microstrip Antenna Design Handbook, Norwood: Artech House, Inc., 2001.