The review on tri-band microstrip antenna for GNSS applications

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Abstract : ***The microstrip antenna is very popular for various applications due to its low profile and operation at microwave frequencies. The microstrip antenna is a narrowband antenna which works for only one frequency with very narrow bandwidth. There are some techniques available using which we can get tri-band performance from a microstrip antenna. Different types of slots can be used to get desired application from the microstrip antenna. In this paper, some research papers on microstrip antenna have been reviewed and the results are also shown.***

Key words—return loss, antenna gain, microstrip, GNSS

INTRODUCTION

The microstrip antenna is a type of antenna with low profile, which can be mounted on a flat surface[1]. The basic structure of simple microstrip patch antenna is shown in figure 1. It is a single-layer design which consists generally of four parts which are-patch, ground plane, substrate, and the feeding part.

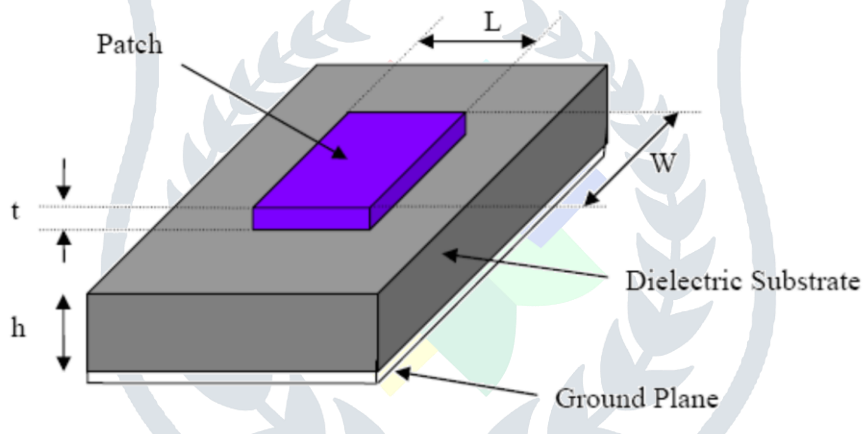

Figure 1 Structure of microstrip patch antenna[2]

The advantages of the microstrip antennas are small size and light weight, conformable to planar and non-planar surfaces. It demands a very little volume of the structure when mounting. These antennas are simple and cheap to manufacture using modern printed circuit technology. The main disadvantages of the microstrip antennas are: low efficiency, narrow bandwidth of less than 5 % and low antenna gain.

GNSS is the standard generic term for Global Navigation Satellite Systems, which provide autonomous geo-spatial positioning with global coverage. GNSS allows the user determine their location (longitude, latitude and altitude) using time signals transmitted from a constellation of satellites[3]. At the present time there are two such operative systems: the American GPS (Global Positioning System) and the Russian GLONASS (GLObal'naya NAvigasionnay Sputnikovaya Sistema). Galileo and COMPASS are emerging GNSSs from European union and China respectively. India too is developing IRNSS (Indian Regional Navigation Satellite System).

It may be noted that accuracy of position determination will improve and time to determine position if it is estimated from more number of constellations. Very often the operating frequencies are different. Hence it may be more appropriate to design a single antenna to operate at multi-band.

REVIEW OF RESEARCH PAPERS

PAPER – 1 Compact Multi-band Rectangular Slotted Antenna for Global Navigation Satellite Systems (GNSS) (IEEE-2013, Author: Mustapha Djebari, Amine Abdelhadi)

In this paper, a multiband rectangular microstrip antenna with two different slots is designed to work for multiple GNSSs. One slot is U-shaped and other is inverted H-shaped as shown in figure 2. The size of designed antenna is 75 mm x 80 mm x 1.6 mm. This antenna works well for four different frequencies as shown in Table 1, which is very good result.

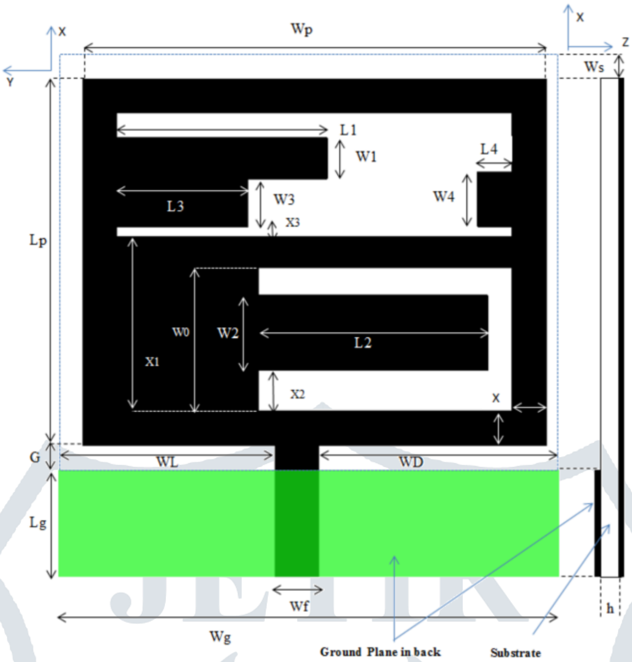

Figure 2 Designed antenna[4]

Table 1 Simulation results[4]

Resonating frequency (GHz)	**Impedance bandwidth(%)**	**Return loss(dB)**	**Antenna gain (dBi)**
1.176	11 (at -15 dB)	-32.65	2.7
1.278	5 (at -15 dB)	-36.80	2.7
1.575	30 (at -15 dB)	-15.55	4.2
1.602	30 (at -15 dB)	-31.08	4.3

PAPER – 2 Design of a triangular fractal patch antenna with slit for IRNSS and GAGAN applications (IEEE-2013, Author: Dr. S. Arivazhagan, H. U. Prasanth, K. Kavitha)

In this paper, a triangular antenna is designed with fractal design which is shown in figure 3. It is designed to work at 3 frequencies: L5 (1176.45 MHz) and S (2492.08 MHz) of IRNSS and L1 (1575.42 MHz) of GAGAN. The design is shown in figure 3 and the results are shown in table 2. The Gain achieved is 5.052 dB and directivity is 6.29723 dB which is quite impressive as this is not an array antenna.

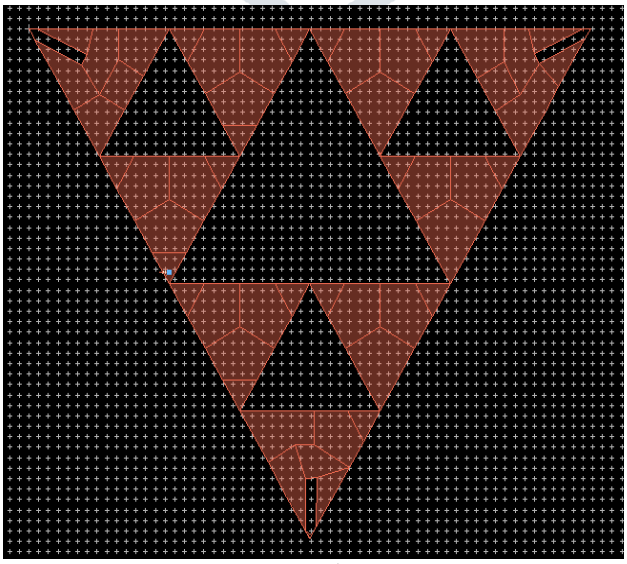

Figure 3 Design layout of antenna in ADS[5]

Table 2 Return Loss at desired frequencies[5]

Frequency	Return loss
1176.42 MHz	-14 dB
1575.42 MHz	-17 dB
2492.08 MHz	-15 dB

PAPER – 3 Tri-band Circularly Polarized Stacked Microstrip Antenna for GPS and CNSS Applications (IEEE-2010, Author: Wen Liao, Qing-Xin Chu and Shu Du)

In this paper, a compact single-feed stacked microstrip patch antenna for tri-band circularly polarized (CP) application is presented. The antenna is designed with two properly square patches. Two pairs of narrow slots parallel to the edges of the top square patch are inserted with two protruding slots perpendicular to the edge.

The top patch can perform CNSS dual frequency (1.61 GHz and 2.49 GHz) CP radiations using a single probe feed. The GPS frequency (1.57 GHz) is achieved by cutting a slit in the bottom square patch and by adjusting the length of the slit. The results are shown in table 3 with respect to axial ratio.

Table 3 Results at desired frequencies[6]

Frequency Band	Axial Ratio Bandwidth (3 dB)
1.567 to 1.577 GHz	0.64% with respect to 1.57 GHz
1.596 to 1.611 GHz	0.93% with respect to 1.61 GHz
2.486 to 2.502GHz	0.64% with respect to 2.49 GHz

PAPER – 4 Investigations of compact tri-band antenna for CNSS application

In this paper, a tri-band antenna is designed with two microstrip patch antennas and a quadruple inverted-F antenna (QIFA) which is inserted in the two layers of substrates to reduce the height and achieve low profile as shown in figure 5.

Two patch elements (patch *L* and patch *S*), which work at 1.615GHz and 2.492GHz, are etched on a microwave substrate with ε_r=9.8 and thickness *h1*=5mm, *h2*=3mm respectively. *L* antenna is doubly-fed microstrip patch antenna, which achieves the LHCP radiation. *S* antenna is a single feed patch with U-shaped slot which is designed to broaden the bandwidth. The corner of the patch is cut to achieve the RHCP. QIFA (*B3*) which works at 1.268GHz is inserted in two layers of substrate, where it is arranged around *L*, *S* antennas. RHCP radiation is obtained by feeding four inverted-F elements in equal magnitude and successive 90 phase delay. The simulated and measured results of this antenna are presented in table 4.

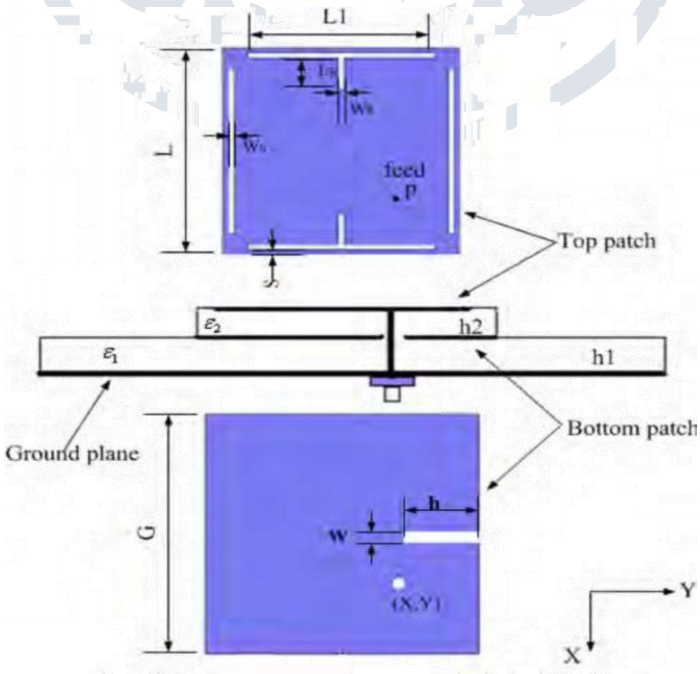

Figure 4 Geometry of Antenna[6]

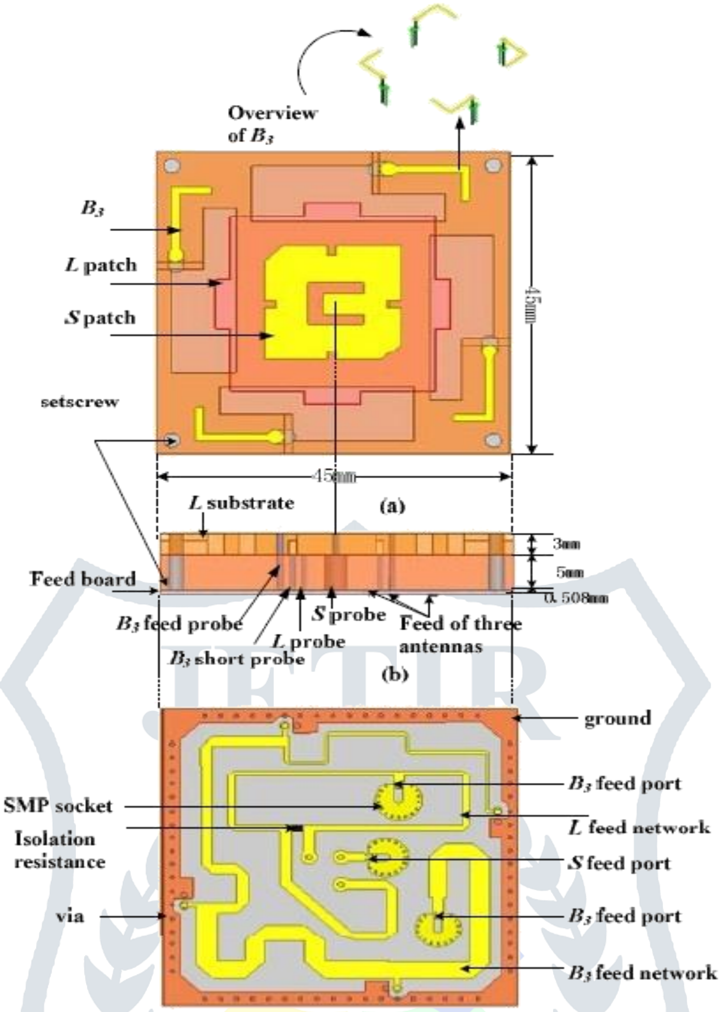

Figure 5 Designed antenna[7]

Table 4 Simulated and measured results[7]

Performances of different frequencies		Simulated	Measured
Reflection Coefficient (dB)	1268MHz±10MHz	-32~-10	-25~-10
		-30~-22	-25~-22
		-13~-11	-22~-18
Gain of CP (dBi)	1615MHz±5MHz	0.7~1.2	0.2~0.8
		3.2~3.5	2.5~3.1
		5~5.2	3.5~4
AR (dB)	2491 MHz±5MHz	1~3	2~3
		0.5~1	1~1.4
		1.5~2	2.2~3

CONCLUSION

Four papers for the design of multi band microstrip antenna have been reviewed. First paper is based on different slots on the same substrate. While the second paper is based on the fractal concept. The third is based on multi-stacking and the fourth one is based on staking with QIFA. Each one has its own merit and demerits one can select the suitable approach base on the application and requirement. From review of different research papers, we can conclude that by using different types of slots, we can achieve tri-band performance from microstrip antenna which is useful in the application of navigation. These antennas have been designed to work for one or more GNSSs.

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