Miniaturisation Using Shorting Posts in C-Shaped and H-Shaped Microstrip Patch Antennas for GPS Applications

S.V. Saravanan, S. Sindhuja

Abstract: ***This paper presents the study of the effects of shorting posts for C-shaped and H-shaped microstrip patch antennas for GPS application. A C-shaped patch and H-shaped patch loadedmicrostrip patch antenna for GPS frequency (1.575 GHz) are designed and simulated. The shorted microstrip patch antenna is a compact antenna but it suffers from the disadvantage that more number of shorting pins is required thereby making fabrication process harder especially when manufactured in larger quantities. An alternate way to reduce the resonance frequency of the microstrip antenna is to increase the path length of the surface by cutting slots in the radiating patch. The slot is taken as the capacitive reactance in the patch.***

Keywords: ***Slot-Loaded Patch, Microstrip Patch Antenna, Global Positioning Satellite (GPS), Shorted.***

I. INTRODUCTION

Compact microstrip antennas can be designed with substrate having a higher dielectric constant ξr. In this case the size of the regularly shaped microstrip antennas will be much smaller than that of the low dielectric constant substrate at a given resonance frequency, but the BW is small. Here we describe the various compact microstrip antenna configurations that are obtained by modifying regular shapes such as rectangular circular and triangular patches by using shorting posts or cutting slots in the metallic patch. In order to simplify analysis and performance prediction the patch is generally square, rectangular, circular, triangular, and elliptical or some other common shape. The basic shapes that the patch can take are square, rectangle, dipole, circle, triangle, circles and ellipse.

The effect of the shorting posts depends on different parameters like the number of the posts, the radius of each post and the thickness of the microstrip antenna which determines the length of the posts. Theoretical analyses and simulation results are presented to show the validity of the proposed shorting technique for circular microstrip patch antenna.

Here we describe the various compact microstrip antenna configurations that are obtained by modifying regular rectangular patch by cutting slots in the metallic patch as in case of C-shaped and H-shaped patch antennas. [18]

II. COMPACT BROADBAND MICROSTRIP PATCH ANTENNA

In many antenna applications, the size of the antenna is considered as an important factor in the design process. Therefore, short circuit microstrip antennas are widely used because the short circuit antenna can realize the same resonant frequency, at about half the size of the standard microstrip antenna. The shorted microstrip antenna is constructed by short-circuiting the zero potential plane of an ordinary microstrip antenna excited with a dominant mode. [2][4][5]

Physically, this short circuit may be complete, by wrapping a copper strip around the edge of the antenna, or it may be simulated by shorting posts. From the manufacturing point of view, construction of shorting posts is much easier than wrapping a copper strip around the edge of the antenna.

A. Compact Shorted H-shaped Microstrip Patch Antenna

The antenna consists of an H-shaped microstrip patch, supported on a grounded dielectric sheet of thickness h and dielectric constant ξr. The H-shaped patch can be divided into three parts consisting of a center conductor strip with length L_1 and width W_1 and two identical conductor strips with length L_2 and width W_2 on its two sides. One of the radiating edges of the patch is shorted by n numbers of equidistant shorting posts where rs is radius of shortingposts and the feed point is located at the central line of the H-shaped patch, at a distance of y_0 from the shorted radiating edge.

A shorted H-shaped MSA shown in figure 3.11b is also a compact configuration. One of the radiating edges of the antenna is shorted by 8 shorting pins of diameter 0.1 cm. The antenna is fabricated on substrate with ξr=4.6 and h=0.16 cm.The outer dimensions of the antenna are L_1=2.9 cm and W_1=3.4 cm.

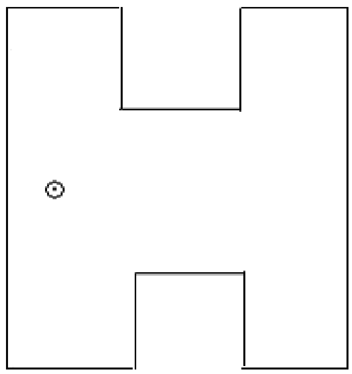

Fig. 1: Unshorted H shaped MSA

Manuscript received January 25, 2019.

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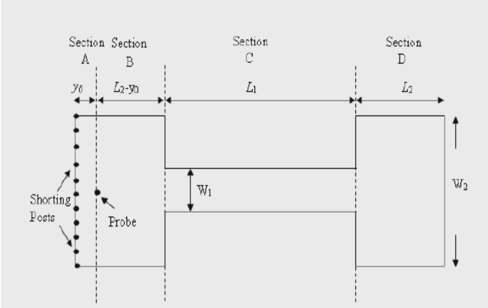

Fig. 2: Shorted H shaped MSA

Radiation mechanism of H-patch antenna is similar to that from rectangular patch provided that the phase difference of the fringing fields between the radiating edges is 180' for the fundamental mode This condition is necessary to give maximum radiated field normal to the surface of the structure As described in the above section 180" phase shift between radiating edges occur at resonance for resonator length θ_T less than 180' if K<l Under this condition there is also no harmonic resonance and the first resonance occurs at a frequency greater than 2*fo*.[6][7]

The result is a small size patch antenna with wide stop band characteristics and pure reactive impedances at 2*f*, and 3*f*, These reactive impedances can be easily matched to get maximum transmitter efficiency when integrated with a power amplifier radiation pattern of H-shaped antenna is slightly different of rectangular patch This is due to the distance reduction between the two slots created at the antenna edges This will affect the E-plane pattern which will be wider than that of the rectangular patch

B. Compact shorted C-shaped Microstrip Patch Antenna

The C-shaped antenna is a compact configuration as compared to the RMSA [8]. A C-shaped MSA with one of its narrow edges partially shorted with 4 shorting pins shown in the figure. The resonance frequency of the C-shaped MSA is reduced by approximately half, when this edge is fully shorted (i.e., ws= (L-1)/2). The C-shaped patch antenna has wide bandwidth and good S11.

The dimensions of the shorted patch are L=6 and W=4 and l=w=2 cm.Shorting posts of diameter 0.1 cm have been used. The antenna is fabricated on a substrate with ξr=4.6, h=0.16 cm and tan δ=0.02.

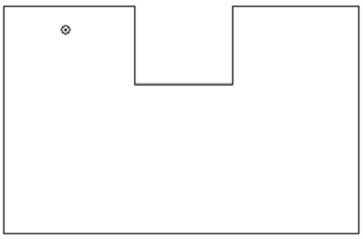

Fig. 3: Unshorted C shaped MSA

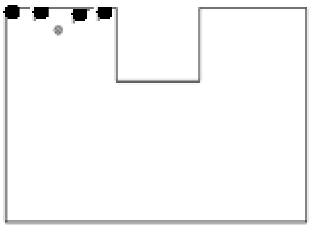

Fig. 4: Shorted C shaped MSA

C. Design Steps Involved in the Miniaturization of Microstrip patch Antennas

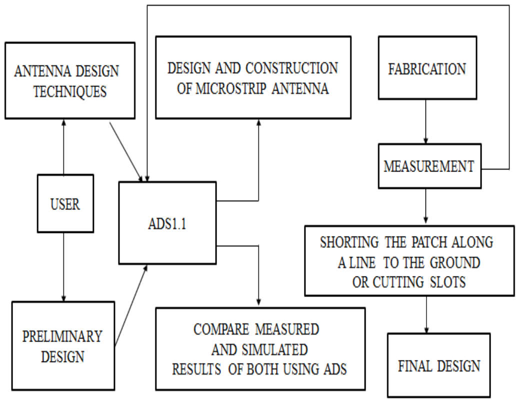

Fig. 5. Design steps

D. Simulation using HP-Advanced Design System

Advanced Design System is the world's leading electronic design automation software for RF, microwave, and high speed digital applications. The Momentum simulator uses a numerical procedure, based on the Method of Moments, to solve passive circuits. Circuits are assumed to be planar (in layout format) and can be as simple as a micro strip transmission line or as complex as a multilayered board with vias and varying substrate thicknesses.

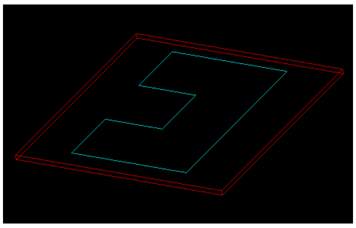

Fig.6: 3D view of unshorted C-shaped patch antenna

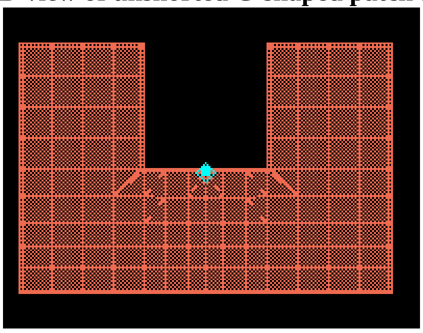

Fig. 7: Design of unshorted C-shaped patch antenna

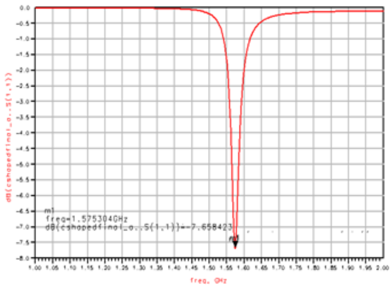

Fig. 8: Simulation result for unshorted C-shaped patch antenna

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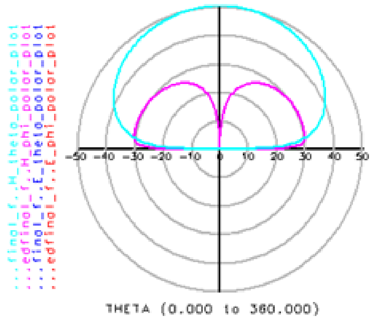

Fig. 9: Radiation pattern for unshorted C-shaped patch antenna

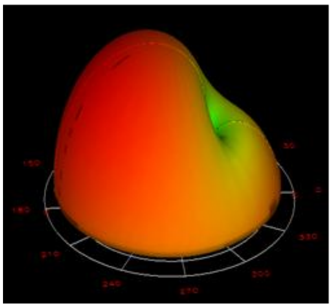

Fig. 10: Radiation pattern for unshorted C-shaped patch antenna

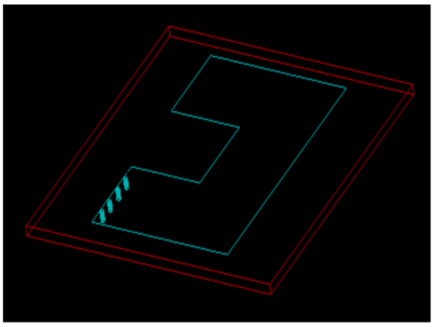

Fig. 11: 3D view of shorted C-shaped patch antenna

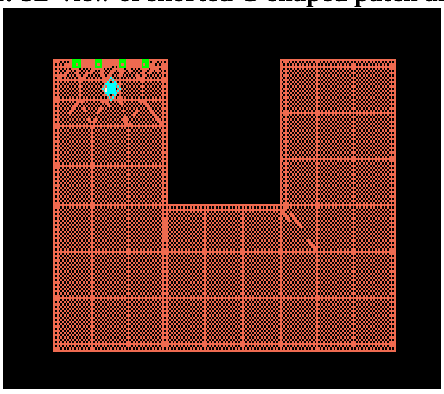

Fig. 12: Design of shorted C-shaped patch antenna

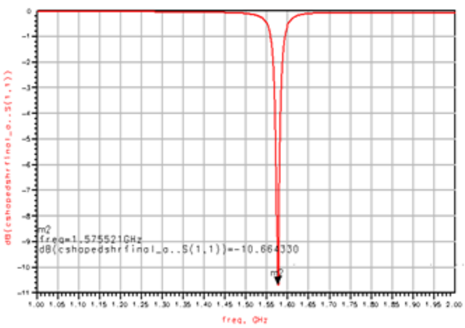

Fig. 13: Simulation result for shorted C-shaped patch antenna

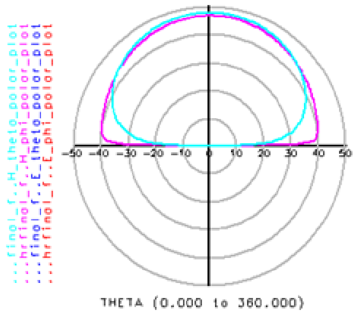

Fig. 14: Radiation pattern for shorted C-shaped patch antenna

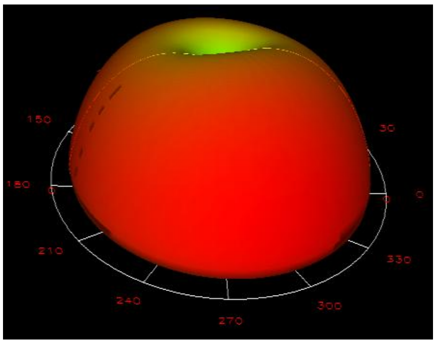

Fig. 15: Radiation pattern for shorted C-shaped patch antenna

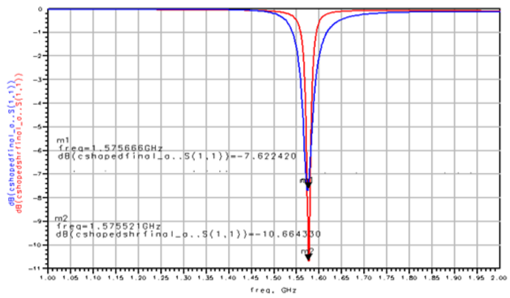

Fig. 16: Comparison of Simulation result for shorted C-shaped patch antenna

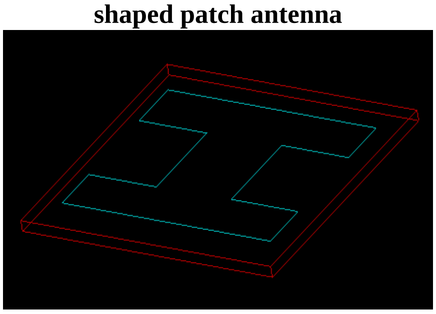

Fig.17: 3D view of unshorted H-shaped patch antenna

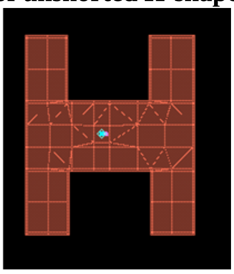

Fig. 18: Design of unshorted H-shaped patch antenna

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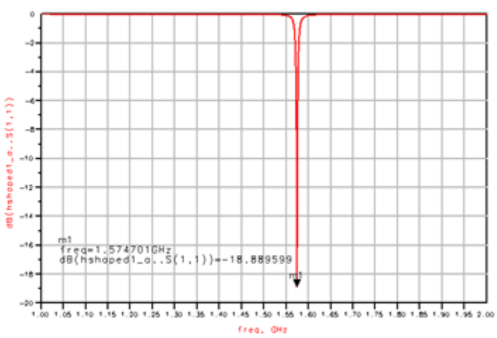

Fig.19: Simulation result for unshorted H-shaped patch antenna

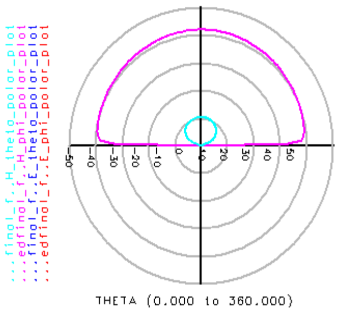

Fig.20: Radiation pattern for unshorted H-shaped patch antenna

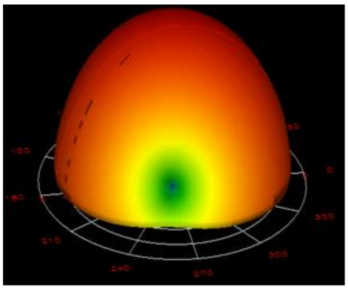

Fig. 21: Radiation pattern for unshorted H-shaped patch antenna

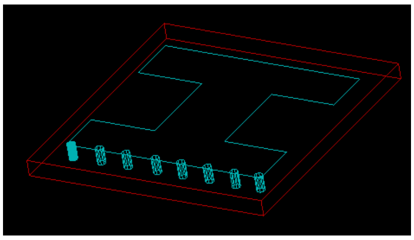

Fig. 22: 3D view of shorted H-shaped patch antenna

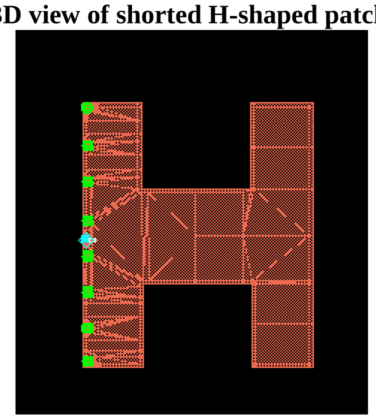

Fig. 23: Design of shorted H-shaped patch antenna

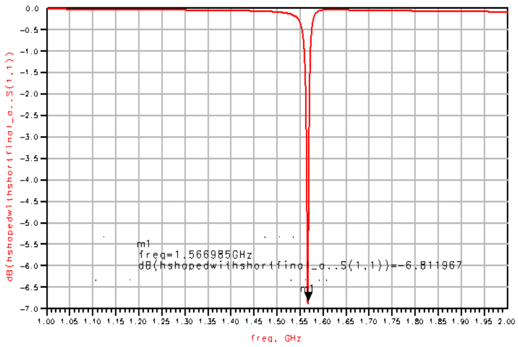

Fig. 24: Simulation result for shorted H-shaped patch antenna

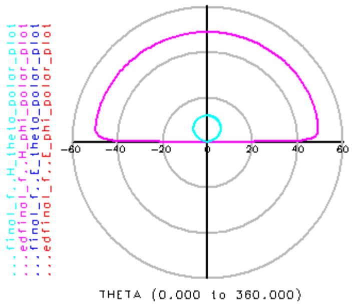

Fig. 25: Radiation pattern for shorted H-shaped patch antenna

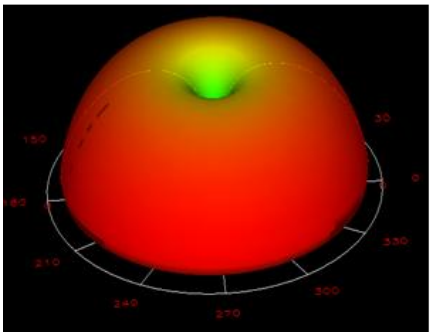

Fig. 26: Radiation pattern for shorted H-shaped patch antenna

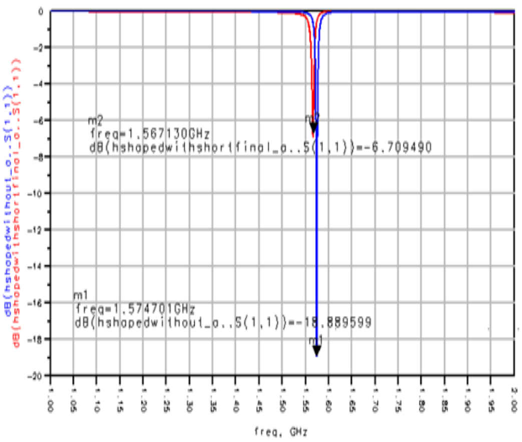

Fig. 27: Comparison of Simulation result for shorted H-shaped patch antenna

The simulation results show Return loss, 3D polar plot of gain and radiation pattern in E and H plane.

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From the simulation results we observe that the radiation pattern has been improved for the shorted C and H-shaped antennas.

Using the shorting pins is one of the optimization techniques and comes under the category of primary reduction. Primary reduction refers to the reduction in antenna size in terms of length, area and volume.

Table I: Size Reduction Unshortedand Shorted Msas

ANTENNA TYPE	UNSHORTED	SHORTED
C-SHAPED PATCH ANTENNA	Width(in cm) = 4.3 Length(in cm) = 6.3	Width(in cm) = 2.9 Length(in cm) = 4.3
H-SHAPED PATCH ANTENNA	Width(in cm) = 3.4 Length(in cm) = 2.9	Width(in cm) = 2.1 Length(in cm) = 1.8

From the results we observe an area reduction of about 53% for C-shaped patch antenna and 62% for H-shaped patch antenna.

III. CONCLUSION

This paper shows how to take advantage of the lightweight, low volume benefits of these antennas, by providing clear explanations of the C-shaped and H-shaped patches and simple design equations that help to analyze and design microstrip antennas.

Further size reduction is still needed in order to meet the requirements of many wireless communications systems. Good antenna performance and impedance matching can be realized by adjusting the probe position and the dimensions of the patch. It can be concluded from the results that the designed antennas have satisfactory performance and hence can be used for GPS applications. In the future, these antennas will be fabricated and measured to compare with the simulation results.

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