COMPACT GPS MICROSTRIP PATCH ANTENNA

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ABSTRACT

In this paper, the effect of shorting wall length on the circular polarization of shorted microstrip patch antenna is examined. The theoretical analysis is based on the High Frequency Software Simulator (HFSS®). A designed antenna for the GPS application at the civilian GPS frequency (1.575 GHz) has been fabricated and measured. The measured data for the fabricated antenna is taken by 8719 ES vector network analyzer. Results of the designed antenna show good circularly polarized with a reduction in its size by 24.6 % from the conventional rectangular microstrip patch antenna. Simulated and measured results for the proposed antenna are presented.

Keywords: *Circular Polarization Antenna (CPA), Shorted Microstrip Patch Antenna (SMPA), Global Positioning System Antenna (GPSA)*

1. INTRODUCTION

Many applications in communications and radars require circular or dual linear polarization, and the flexibility afforded by microstrip antenna technology has led to a wide variety of designs and techniques to fill this need [1]. In recent years, the demand for compact mobile telephone handsets has grown. Handsets with size of a pocket have begun appearing in the market and, as the demand for increased electronic mobility grows, the need for small handsets will most likely increase. A small antenna size is required as one of the important factors in portable mobile communication systems. The Microstrip Patch Antennas (MPA) is widely being used because of its low volume and thin profile characteristics. The size of MPA is basically determined by its resonance length and width. The reduction of the patch size can be achieved by using patch substrate material with very high permittivity and small substrate height [2]. But, in this case, the low radiation efficiency will reduce the antenna gain. Various techniques have been explored to develop small size antenna. One of these techniques is achieved by using shorting wall [3]. For a rectangular MPA, its resonance frequency is on the order of half-wave length. The length of the antenna is reduced by a factor of two if the half-wave patch is short-circuited to the ground at the zero potential planes. The result is a resonance rectangular patch with length of order $\lambda/4$, called a quarter-wave patch or Shorted Rectangular Microstrip Patch Antenna (SRMPA). The objective of this paper is to study the effect of shorting wall length on the polarization of the SRMPA and to design a compact circularly polarized MPA operates at the civilian resonance frequency (1.575 GHz) for the Global Positioning System (GPS).

2. ANTENNA CONFIGURATION AND SIMULATED RESULTS

The SRMPA geometry is shown in figure 1. The feed point is centered on the x-axis and the shorting wall is at the patch edge. The antenna is circularly polarized (CP) by the single feed technique with a truncated segment setting to the edge of the patch with equal side length ΔL and area of $\delta S/2$. The SRMPA has a side length L/2 and width W [4]. The input impedance and resonance frequency of the SRMPA can be controlled by changing the length of the shorting wall [5]. To study the effects of shorting wall length on the SRMPA parameters, a proposed antenna is specified as in table 1 and simulated with HFSS software with different shorting wall lengths. HFSS® is an interactive software package, developed by Agilent technologies. It is a full-wave field solution for any arbitrarily 3-D passive structures. The simulated results show that when the shorting wall length is reduced the resonance frequency is decreased. To have the same resonance frequency, the patch lengths (L/2, W) have to be reduced resulting in patch size reduction. Due to the reduction in the patch size, the patch axial ratio (AR) will be degraded. To improve the AR, the perturbation segment length ΔL must be readjusted. Table 2 illustrates the relation between shorting wall length (SW), new resonance frequency, new truncated length Δ L to have the best AR at bore-sight (angle $\theta = 0$), and axial ratio for old and new ΔL. Figure 2 shows the variation of the shorting wall length (SW) with patch size to have the desired resonance frequency $f_r = 1.575$, while figure 3 shows the variation of the shorting wall length (SW) with the truncated length (ΔL) for optimum axial ratio.

3. COMPACT CIRCULARLY POLARIZED PARTIALLY SRMPA

As a result of the previous study, the design of a right hand circularly polarized (RHCP) partially SRMPA operating at the civilian resonance frequency of the Global Positioning System is considered. The antenna configuration is shown in figure 1 and antenna parameters calculated from HFSS are given in table 3. The proposed antenna is fabricated using photolithography technique. Scattering parameters and input impedance are measured using 8719 ES network analyzer. Simulated results of the RHCP partially SMPA for the GPS are given in table 4. The simulated results are given by HFSS. Figure 4 shows the comparison between the simulated and measured return loss for the proposed GPS antenna. However, there is a little small deviation between the measured and theoretical results. This deviation may be due to fabrication tolerance. In addition, the tangent loss and bonding of the coaxial feeding are not considered in the simulator software calculation. Figure 5 shows the simulated radiation pattern of the RHCP partially SRMPA at 1.575 GHz. Figure 6 shows the simulated axial ratio results of the RHCP partially SRMPA. The measured and simulated results are accepted and satisfy the requirements for a GPS.

4. CONCLUSION

The effect of short wall length on the antenna polarization is examined. Simulations and measurements on the partially shorted rectangular microstrip patch antenna have provided a useful design for a compact circularly polarized antenna operating at the frequency of 1.575 GHz for the GPS applications. A reduction in antenna size by 24.6 % from the conventional antenna is achieved.

5. RFFERENCES

[1] Kin-Lu Wong, Compact and Broadband Microstrip Antennas, Jon Wiley & Sons, Inc., 2002

[2] J. R. James, P. S. Hall, and C. Wood, Microstrip Antenna Theory and Design, Peter Perigrinus, London, 1981

[3] Sanad, M. "A Small Size Microstrip Antenna Having a Partial Short Circuit" IEEE International Conference on Antenna and Propagation, vol. 1, pp. 465-471, April1995

[4] J. R. James and P. S. Hall, Handbook of Microstrip Antennas, Peter Perigrinus Ltd., London, 1989

[5] T. Taga and K, Tsuna Kawa , “Performance Analysis of a Built-Planar Inverted-F Antenna for 800 MHz Band Portable Radio Units” IEEE Journal on selected areas in communication, Vol.5, NO.5, PP.921-929, June 1987

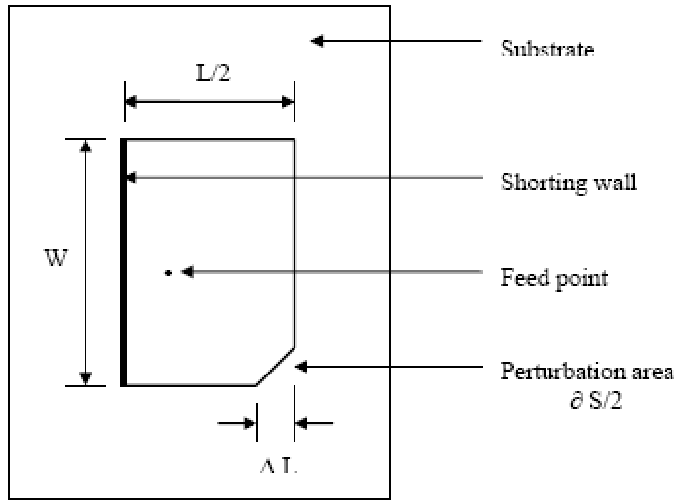

Figure 1: Configuration of single feed circularly polarized SRMPA

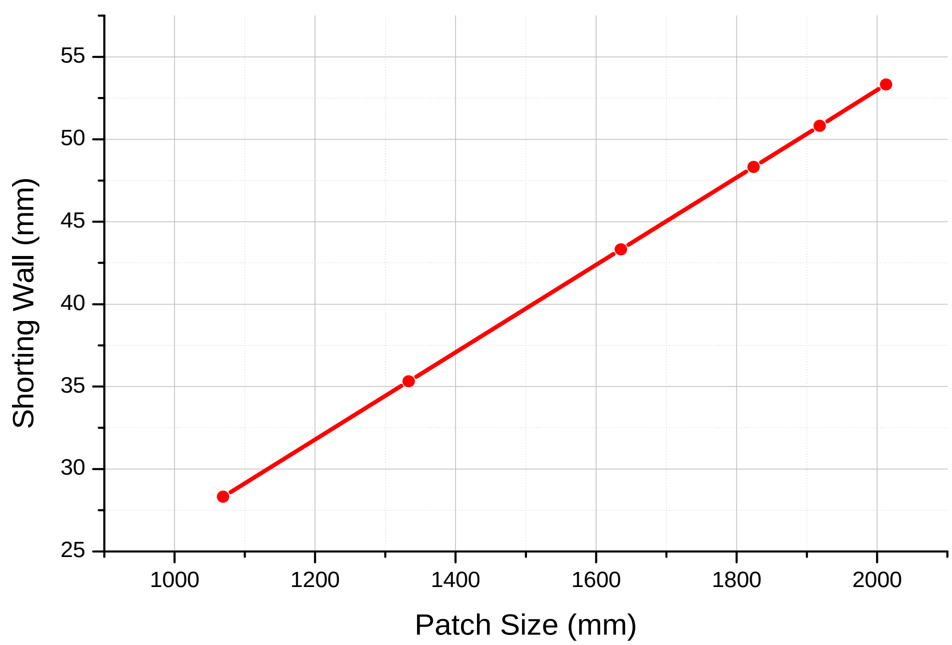

Figure 2: Variation of SW length with patch size to keep the $f_r = 1.575$ GHz

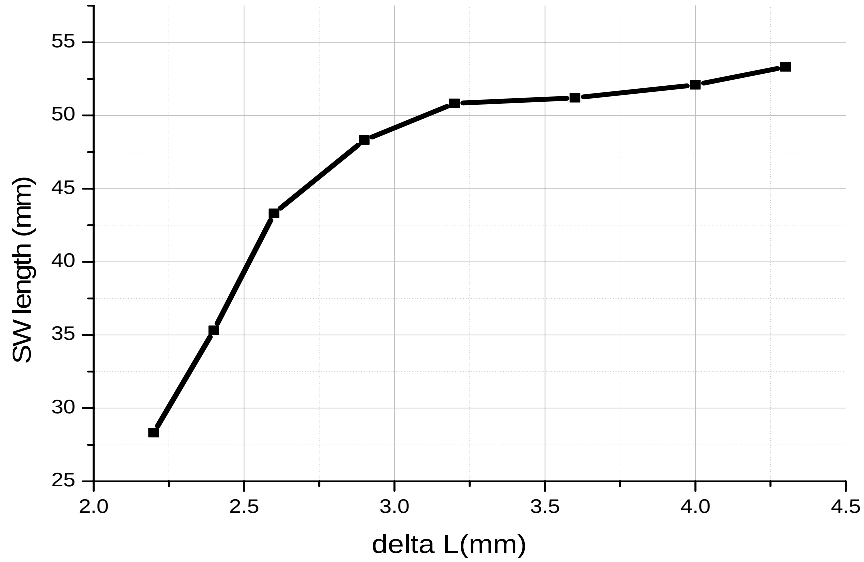

Figure 3: Variation of SW length with ΔL for optimum axial ratio

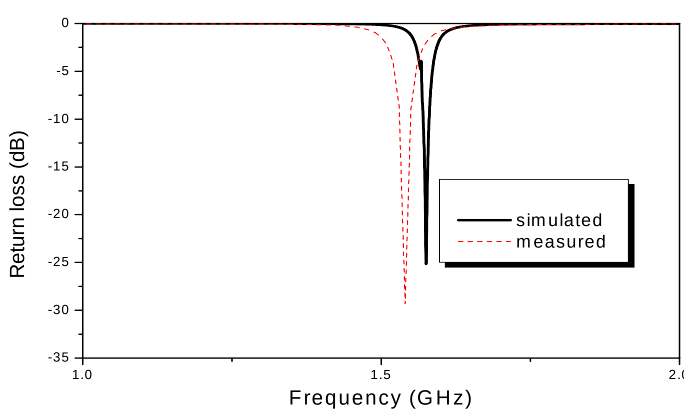

Figure 4: Comparison between simulated and measured return loss (S_{11}) of the RHCP partially SRMPA

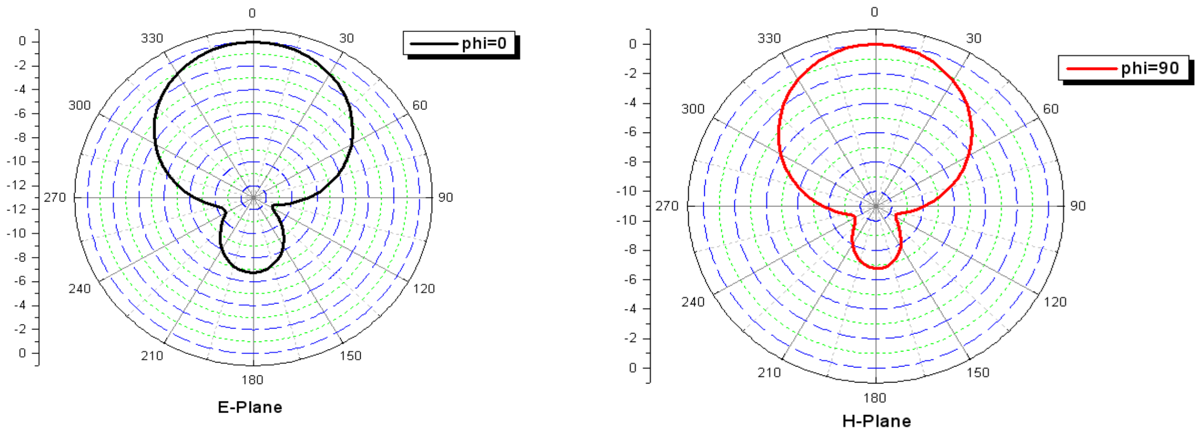

Figure 5: Simulated radiation pattern results of the RHCP partially SRMPA

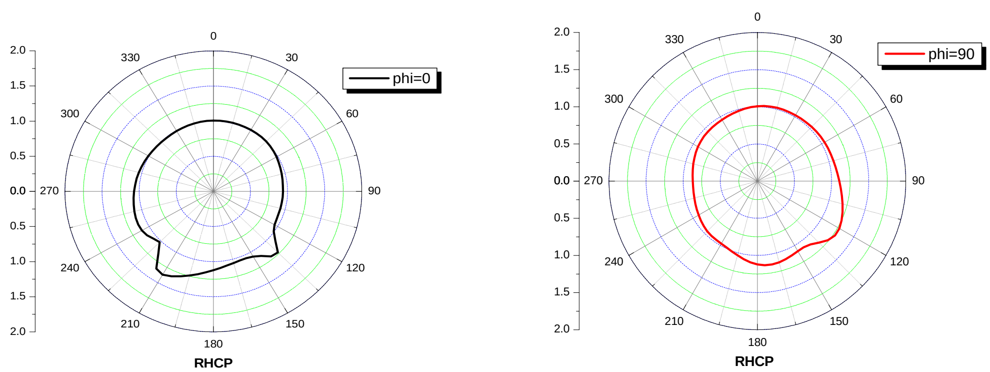

Figure 6: Simulated axial ratio results of the RHCP partially SRMPA

Table 1: Specification of the proposed antenna

f_r	ε_r	h	W	L/2	Δ L
1.575 GHz	2.2	1.58 mm	63.32 mm	37.75 mm	4.3 mm

Table 2: Variation of SW length with resonance frequency and axial ratio

New SW length (mm) (% of SW = 63.32 mm)	New frequency(GHz) (% of f_r = 1.575 GHz)	New ΔL (mm) for best AR	axial ratio for	
			Old ΔL	New ΔL
53.32 (84.2 %)	1.571 (99.7 %)	4.2	6.73	1.16
52.32 (82.6 %)	1.568 (99.5 %)	4	6.32	1.14
51.21 (81.1 %)	1.566 (99.4 %)	3.6	5.91	1.06
50.60 (79.9 %)	1.563 (99.2 %)	3.2	6.72	1.03
48.32 (76.3 %)	1.557 (98.8 %)	2.9	6.43	1.12
43.41 (68.5 %)	1.488 (94.4 %)	2.6	5.26	1.07
35.37 (55.8%)	1.331 (84.5 %)	2.4	6.52	1.02
28.32 (44.7 %)	1.175 (74.6 %)	2.2	6.46	1.00

Table 3: Specifications of the RHCP partially SMPA for the GPS

f_r	ε_r	h	W	L/2	Δ L	SW
1.575 GHz	2.2	1.58 mm	40.40 mm	29.05 mm	2.20 mm	28.32 mm

Table 4: Simulated results of the RHCP partially SMPA for the GPS

Parameters	Partially SRMPA
Beam width	72^0
Directivity	2.78 dB_i
Axial ratio	1.00
Return loss	-27.12