Design of Arc-Shaped Patch Antenna Arrays for GPS Applications

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***Abstract*— This paper proposes the design of an arc-shaped patch antenna for GPS arrays that is composed of an arc-shaped patch with two parasitic elements. The antenna is then arranged in a three-element circular array with an inter-element spacing of about a quarter wavelength, and the isolation characteristics are further improved by inserting a slot to the ground plate. Detailed design parameters are optimized by using the GA, and reflection coefficient, axial ratio, and radiation gain are measured in a semi anechoic chamber. The results demonstrate that the antenna is suitable to be used for GPS antenna arrays with good circular polarization properties.**

Keywords—component; formatting; style; styling

I. Introduction

The Global positioning system (GPS) is widely used in many applications for location and time information. However, the performance of the system is degraded in the presence of unwanted interferences, such as multi-path signals [1]. To prevent such performance degradation, GPS antenna arrays are used for controlled reception pattern antenna (CRPA) operation. They increase the signal-to-interference-plus-noise ratio (SINR) of the system by forming pattern nulls in the direction of the interference [2]. In CRPA operations, individual GPS antennas that have good matching characteristics, circular polarization (CP) properties, and high isolation among array elements, are needed to prevent pattern distortions in the array beam patterns. Much efforts has been focused on the use of microstrip patch antennas to satisfy these requirements; however, most of the previous researches have concentrated mainly on improving the performance of stand-alone antennas [3-4]. More sophisticated works from an array pattern standpoint, are required to improve the system performance using GPS antenna arrays.

In this paper, we propose the design of a patch antenna array for GPS applications. The individual elements of the array consist of an arc-shaped patch and two parasitic elements surrounding the patch, which are inserted to achieve circular polarization in the GPS L1 band. The array is mounted on a circular ground platform with an inter-element spacing of about 50 mm (about λ/4 at 1.57542 GHz), and a ground slot is inserted to increase the isolation of array elements. To improve the performance of the antenna, detailed parameters were optimized using a genetic algorithm (GA) [5], in conjunction with the FEKO EM simulator developed by EM Software and Systems [6]. To verify the suitability of the proposed system, the antenna array was fabricated on a CER10 substrate (ε_r = 10, tanδ = 0.0032) manufactured by Taconic Co., Ltd., and characteristics of the antenna, such as the reflection coefficient, radiation gains, axial ratio, and radiation patterns, were measured. The results prove that the proposed antenna array has suitable radiation characteristics for CRPA systems in GPS applications.

II. Proposed Design and Performance

Fig. 1(a) shows the design parameters of the proposed antenna, which consists of an arc-shaped resonating patch and two parasitic elements that are inserted to achieve circular polarization. The three identical antennas are arranged in a uniform circular array, and their design parameters are optimized using the GA. The arc-shaped patch is proposed because it allows the antennas to be placed efficiently on a circular substrate while maintaining high isolation among the elements. To further increase the isolation of array elements, a slot is inserted in the ground plate, as shown in Fig. 1(b). The optimized values of the design parameters are r_1 = 18.6 mm, l_1 = 5.1 mm, l_2 = 0.8 mm, l_3 = 40.9 mm, l_4 = 1.0 mm, l_5 = 3.3 mm, l_6 = 10.6 mm, l_7 = 1.8 mm, l_8 = 3.9 mm, l_9 = 3.7 mm, l_{10} = 29.0 mm, g_1 = 9.5 mm, g_2 = 45.7 mm, and f_1 = 28.9 mm. They are printed on a CER10 substrate having a thickness of 12.56 mm.

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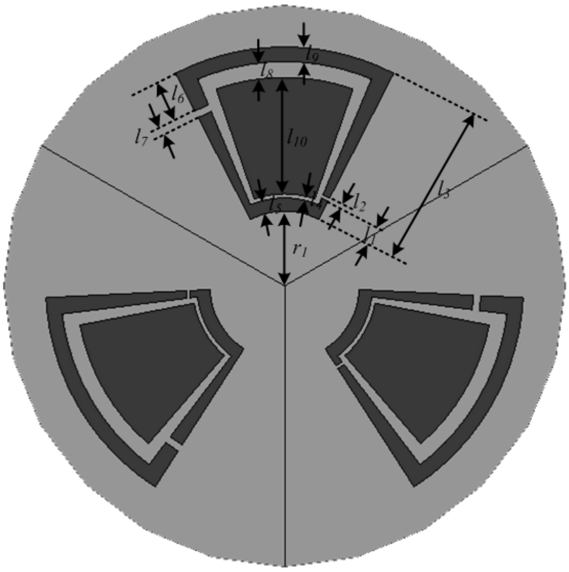
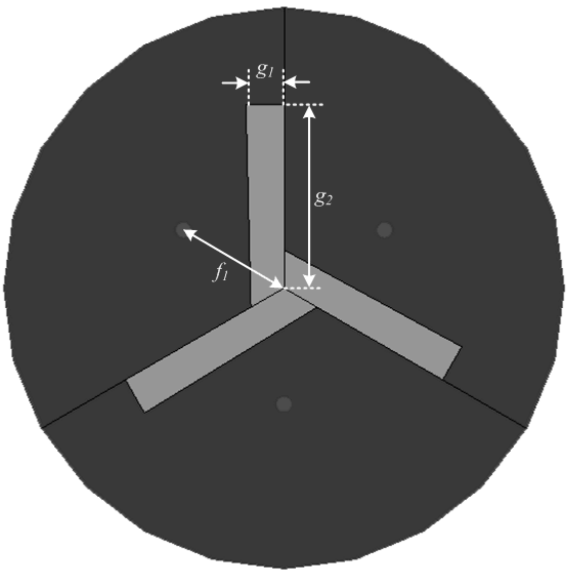


(a) Top view



(b) Bottom view

Fig. 1. Geometry and design parameters of the proposed antenna.

Fig. 2 shows the measured reflection coefficients of the proposed antenna in comparison with the simulated data. The measurement shows a value of -7.7 dB at 1.57542 GHz (GPS L1 band), which agrees well with the simulation. Fig. 3 illustrates a comparison of bore-sight gains between the simulation and the measurement. The RHCP gain of the simulation is 0.8 dBic and is similar to that of the measurement, which is 0.9 dBic.

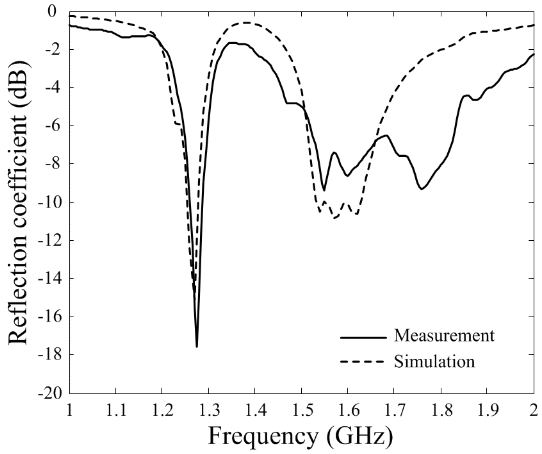


Fig. 2. Reflection coefficient of the proposed antenna.

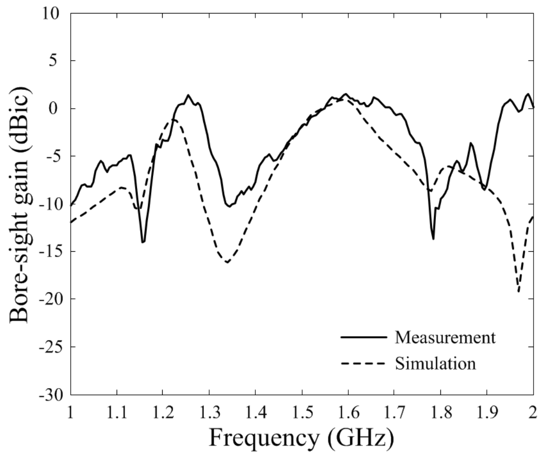


Fig. 3. Bore-sight gain of the proposed antenna.

III. Conclusion

We described the design of an arc-shaped patch antenna for GPS arrays. The individual elements of the array consist of an arc-shaped patch and two parasitic elements to achieve circular polarization in the GPS L1 band. The array was mounted on a circular ground platform, and a ground slot is inserted to increase the isolation of the array elements. The design parameters were optimized by using a GA, and the optimized design was then fabricated on a CER10 substrate, and its reflection coefficient, radiation gain, and axial ratio were measured. The antenna showed a reflection coefficient of -7.7 dB with a bore-sight gain of 0.9 dBic at 1.57542 GHz, which demonstrated that the antenna is suitable for use in GPS antenna arrays.

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