Design of a dual-band GPS antenna with a microstrip grid

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Abstract This paper proposes the design of dual-band GPS antennas with a microstrip grid to minimize the distortion of the radiation properties on the anisotropic platform without the blockage effect. The proposed antenna consists of upper and lower radiating patches fed by the microstrip grid, and the shape of the microstrip grid is optimized by the genetic algorithm. The proposed antenna shows the simulated bore-sight gains of 4.2 dBic and 4.1 dBic that are similar to the measured values of 3.0 dBic and 4.1 dBic at 1.575 GHz and 1.227 GHz, respectively.

Keyword Antenna, Coupled-feed antenna, GPS antenna, Dual-band antenna

1. Introduction

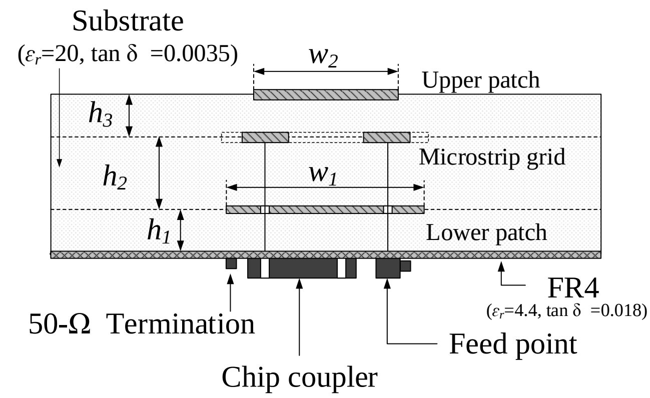
Microstrip patch antennas have gained popularity for dual-band GPS antennas due to ease of fabrication, low profile, and high durability. However, their narrow matching bandwidth lowers the radiation efficiency when there is an undesired frequency shift caused by the fabrication error and mutual coupling in a small array. Thus, coupled feed structures using either an additional feeding patch [1] or small pads [2] have been proposed to allow for independent tuning of dual resonant frequencies. However, the feeding patch inserted between two radiating elements causes a blockage effect that degrades the gain in the bore-sight direction, especially in the lower frequency band. In addition, radiation properties, such as gain and the axial ratio, are easily distorted for the antennas with the feeding pads, when the antennas are placed on an anisotropic ground platform.

In this paper, we propose the design of dual-band GPS antennas with a microstrip grid to minimize the distortion of the radiation properties on the anisotropic platform without the blockage effect. The proposed antenna consists of upper and lower radiating patches fed by the microstrip grid, and the shape of the microstrip grid is optimized by the genetic algorithm in conjunction with full-wave electromagnetic (EM) simulations. To verify the feasibility, the optimized structure is fabricated on a high-dielectric ceramic substrate, and its radiation properties are measured in a full anechoic chamber. The results demonstrate that the antenna is suitable for dual-band GPS applications without serious distortions on radiation patterns.

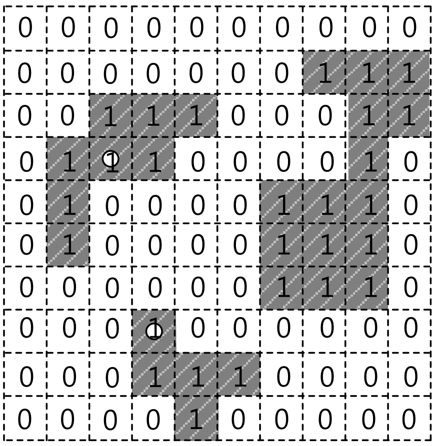
2. Proposed Antenna Structure

Fig. 1(a) shows a cross-section view of the proposed antenna. The antenna consists of the upper patch, lower patch, and the microstrip grid that are printed on high-dielectric ceramic substrates (ε_r = 20, tanδ = 0.0035) with different thicknesses of h_1, h_2, and h_3. The upper and lower patches resonate in the GPS L1 and GPS L2 bands with edge lengths of w_1 and w_2 and are electromagnetically coupled to the microstrip grid. The microstrip grid is composed of 10 × 10 squares with an edge length of 2 mm, and the two ports of the hybrid chip coupler having a phase difference of 90° are connected to the microstrip grid for quadrature excitation. The shape of the grid is encoded into binary numbers, for example, the square representing the conducting grid is expressed by '1', and the area of dielectric squares are marked as '0'. This shape is optimized by the genetic algorithm in conjunction with the FEKO EM simulator to maximize the gain in the bore-sight direction with the right-hand circular polarization. Note that, we adopted the 3 × 3 median filter to smoothen the shape of the microstrip grid for more efficient optimization. Fig. 1(b) shows the optimized shape of the microstrip grid, and the detailed values of the antenna are listed as follows: w_1 = 27.2 mm, w_2 = 20.2 mm, h_1 = 2 mm, h_2 = 5 mm, h_3 = 2 mm.

Fig. 2 presents the simulated and measured bore-sight gains of the optimized antenna. A dashed line indicates the simulated data, and the measured data are specified by '+' markers. The antenna shows the measured bore-sight gain of 3.0 dBic at 1.575 GHz and 4.2 dBic at 1.227 GHz, which agrees well with the simulated results of 4.2 dBic (1.575 GHz) and 4.1 dBic (1.227 GHz).



(a) Cross-section view



(a) Optimized shape of the microstrip grid

Fig. 1. Geometry of the proposed antenna.

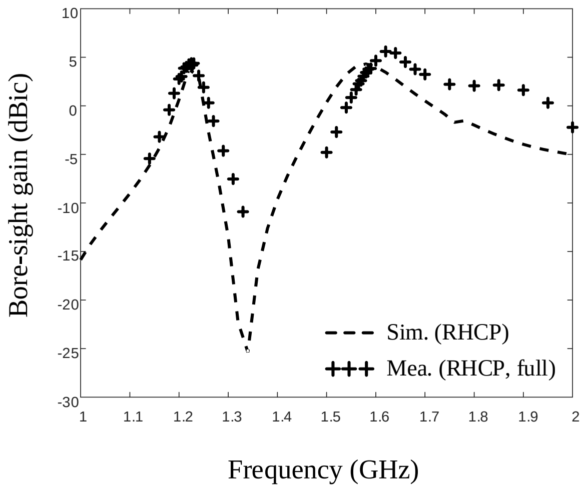


Fig. 2. Bore-sight gain of the proposed antenna.

3. Conclusion

We proposed the design of dual-band GPS antennas with the microstrip grid. The shape of the microstrip grid was optimized by the genetic algorithm, and the median filter was adopted to smoothen the grid shape. The optimized antenna showed the simulated bore-sight gains of 4.2 dBic and 4.1 dBic with measured values of 3.0 dBic and 4.1 dBic at 1.575 GHz, and 1.227 GHz, respectively.

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