Design of a small dual-band array antenna with superstrate loading for tuning the dual-frequency-band ratio

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Abstract In this paper, we propose a novel single-layer patch array antenna with superstrate loading, which can tune the dual-frequency-band ratio in GPS L1 and L2 bands. The measurements of the bore-sight gain are −1.3 dBic and −2.8 dBic at 1.5754 GHz and 1.2276 GHz, respectively. The minimum dual-frequency-band ratio of 1.271 is obtained at the superstrate height of 8 mm. The results demonstrate that unwanted frequency shifts in small array can be easily adjusted by loading the superstrate, which can control the dual-frequency-band ratio.

Keyword Superstrates, Dual-band, Dual-frequency-band ratio, Array antenna

1. Introduction

Array patch antennas for dual-band operation have been widely used to obtain precise position information from the global positioning systems (GPSs) in many applications such as aircraft, missiles, and ships. The elements of the array are typically fabricated as a multi-layer structure to achieve dual-frequency operation, but the multi-layer configuration has disadvantages of complicated manufacturing process, low durability, and difficulty in frequency tuning compared to a single-layer structure. Thus, patch antennas for dual-band operation with a single-layer, such as using two adjacent patch antennas [1] and inserting stubs [2] or slots [3], have been studied recently. However, the single-layer structure has a problem that undesired frequency shift easily occurs due to the strong mutual couplings among adjacent array elements in dual-band operation. Therefore, there is a need for a simple method to tune the shifted frequency without significant changes in antenna performances. In this paper, we propose a novel single-layer patch array antenna with superstrate loading to tune the dual-frequency-band ratio.

2. Proposed antenna with superstrates

Fig. 1 shows a geometry of the proposed antenna, where the array elements are located on the circular substrate with a height of h_1 and a diameter of w. Each element placed at the equal distance r_c from the center of the substrate has two ring patches having widths t_1 and t_2. The inner and outer ring patches operate in the GPS L1 band (f_1) and L2 band (f_2), respectively. Frequency tuning is then achieved by loading the additional superstrates with a radius of r_s on top of the inner ring patch. The superstrate height affects the dual frequency band ratio of f_1/f_2.

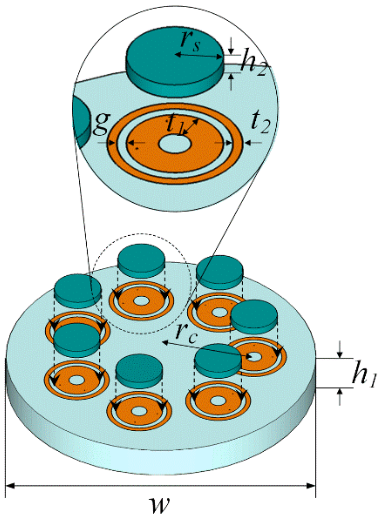

Fig. 1. Geometry of the proposed antenna

Fig. 2 illustrates the simulated and measured reflection coefficients of an element of the proposed array. The reflection coefficients show good matching characteristics of -21.9 dB at 1.5754 GHz and -20 dB at 1.2276 GHz by measurement. Fig. 3 is the active element gains at bore-sight directions, and the measurement shows −1.3 dBic at 1.5754 GHz and −2.8 dBic at 1.2276 GHz. Both the measured reflection coefficients and the bore-sight gains agree well with the simulations.

Fig. 4 shows the variation in the dual-frequency-band ratio as the height of the superstrate increases. Δf is the resonant frequency ratio between GPS L1 band and L2 band. As can be seen, the dual-frequency-band ratio decreases as the height of the superstrate increases since the superstrate effect results in a lower resonance frequency of the L-band. The minimum ratio of 1.271 is observed at the height of the superstrate of 8 mm.

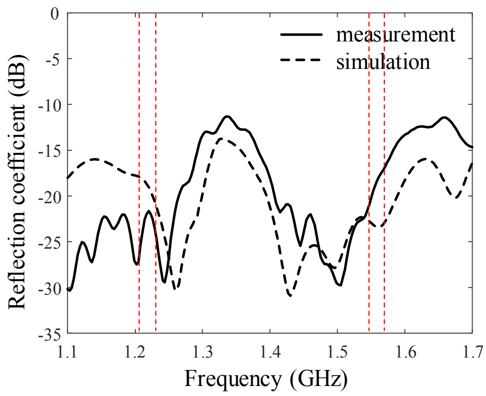

Fig. 2. Simulated and measured reflection coefficients.

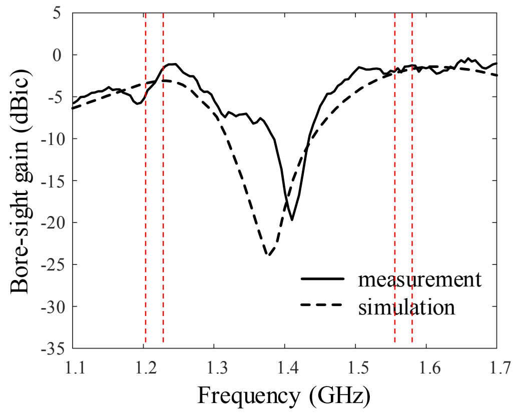

Fig. 3. Simulated and measured bore-sight gains.

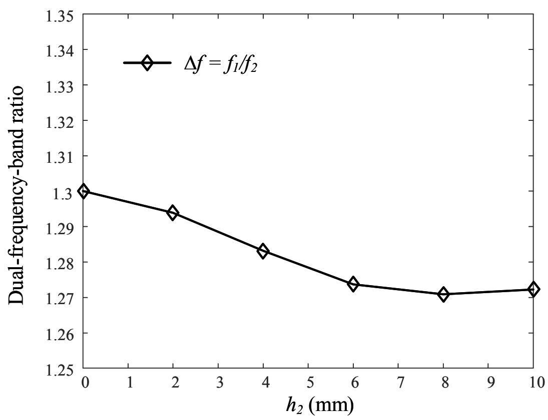

Fig. 4. Dual-frequency-band ratio vs. the height of the superstrates.

3. Conclusion

We proposed a single-layer patch array antenna with superstrate loading that can easily tune the dual-frequency-band ratio. The antenna showed the bore sight gain of −1.3 dBic and −2.8 dBic at 1.5754 GHz and 1.2276 GHz, respectively. The minimum dual-frequency-band ratio of 1.271 was achieved by varying the superstrate height. The results confirmed that unwanted frequency shift in small array can be easily adjusted by the superstrate, which can control the dual-frequency-band ratio.

Acknowledgement

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