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Axial Ratio Correction for GNSS Antennas in Asymetrically Coupled Environments

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***Abstract*—The paper demonstrates a technique to correct the axial ratio of dual-fed circularly-polarized antennas in the presence of strong coupling with surrounding components or asymmetrically reduced ground plane. It demonstrated – based on a standard GPS L1 patch antenna - that for certain situations a phase shift of up to 135° may be beneficial compared to the routinely used 90°, allowing for AR improvement from 7.8 dB (for 90°) to 2.1 dB (135°).**

Keywords*—*Axial ratio; GNSS; Circularly polarized antenna

I. Introduction

Circularly-polarized antennas are key components of GNSS systems, using circular polarization to reject major multipath signals and thus contributing to better localisation accuracy. To perform this task, an antenna needs to exhibit good polarisation purity, measured by Axial Ratio (AR). The simplest technique to ensure this over a wide frequency range is to use dual-fed antennas, where each port is excited with a relative 90° phase shift [1]. However the need for miniaturization often requires the antenna's placement in close proximity to other components/structures or reduction of ground plane in a given direction, destroying the symmetry and consequently decreasing the AR.

Although it is a common belief that the antenna requires a 90° shift to achieve good AR, in reality is not exactly so. Recently [2, 3] demonstrated that by introducing small variations into traditionally used 90° one can control the direction of optimum AR without impacting the realized gain of the dominant polarisation or reflection coefficients. This paper further extends this study by demonstrating a similar principle that can be exploited to correct for proximity coupling with elements surrounding antenna in real-life products.

II. Antenna

The impact of AR for an asymmetric proximity environment is studied using a standard microstrip patch antenna depicted in Fig. 1. It is a simple dual-feed patch tuned to GPS L1 frequency at 1.575 GHz. A single PCB realized on Taconic RF-35 is used (ε_r = 3.5; *tan* δ_{loss} = 0.0018; h = 1.53 mm), backed by a solid ground plane on the back side.

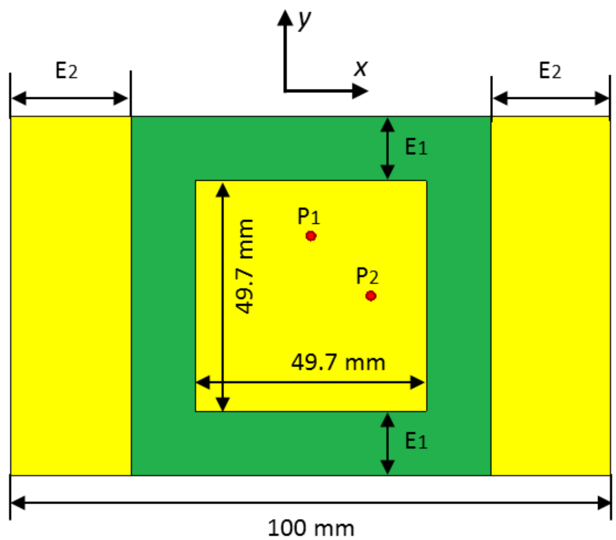

Fig. 1. Exemplary antenna used for the study.

For the purpose of the study, the edges of both substrate and ground plane in vertical directions (along y-axis) are placed at a varying distance E_1 from the patch. This will influence the fringe capacitance and thus alter the reactance of the vertical component. This corresponds to the real-life scenario where miniaturization prompts manufacturers to reduce ground plane size.

In the horizontal plane (along x-axis) the patch is surrounded by metallic strips of varied width E_2. Since overall width of the structure is constant at 100 mm, wider strips (i.e. greater values of E_2) will have their inner edges closer to the patch, producing stronger coupling effect. This will alter the reactance of the horizontal component. Such strips may be used in practical scenarios, e.g. to house additional circuitry required for GPS localization or facilitate mounting.

III. Results

The antenna was simulated using CST Microwave Studio time domain solver. All parameters discussed in the study exhibited both S_{11} and S_{22} < -10 dB and S_{12} < -35 dB at the operating frequency of 1.575 GHz and a constant 5.6 dBic

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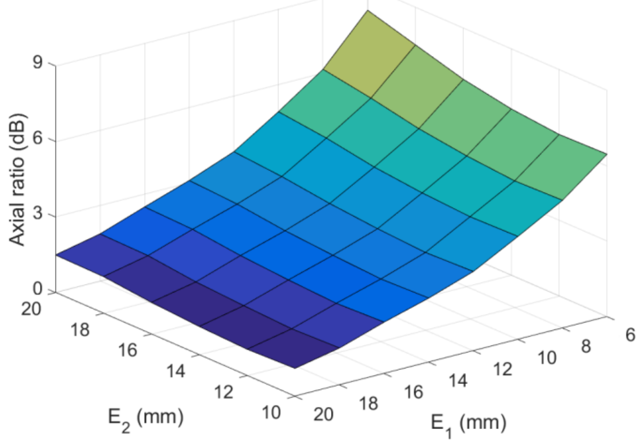

Fig. 2. Axial ratio at boresight with 90° phase shift for various values of E_1 and E_2.

right-hand circularly polarized realized gain, regardless of the phase shift used (results not shown for brevity). Fig. 2 demonstrates the simulated AR at boresight for a constant phase shift of 90°, as a function of E_1 and E_2. It can be seen that the reduced ground plane (E_1) has a more significant effect than the proximity of metallic strips. It is seen that all configurations with $E_1 \leq 12$ mm exhibit high cross-polarization level with AR > 3 dB.

Four extreme configurations were selected to demonstrate the proposed technique: (E_1 = 6; E_2 = 20), (E_1 = 6; E_2 = 10), (E_1 = 20; E_2 = 20) and (E_1 = 20; E_2 = 10), which were respectively excited with phase shift of: 135°, 125°, 100° and 98°. Fig. 3 demonstrates AR in *xz*-plane with and without corrections. It can be seen, that even for the most extreme configuration shown in Fig. 3a one can achieve AR = 2.1 dB when applying a phase that differs as much as 45° from the traditionally used value, as opposed to 7.8 dB achieved with traditional technique. On the other hand for good AR exhibited in Figs. 3c and 3d additional improvement is still possible, albeit by using phase that differs just by a few degrees. For all configurations the corrected AR allows a better value at boresight, but the total 3 dB AR beamwidth becomes narrower. This is in accordance with finding in [2].

It is also worth mentioning, that for E_1 = 4 mm no phase perturbation was able to achieve AR < 3 dB at boresight. This is probably due to the fact, that S_{11} = -7.5 dB. Due to smaller accepted signal by vertically polarized component its amplitude was too different from the horizontal component to allow for the proposed correction.

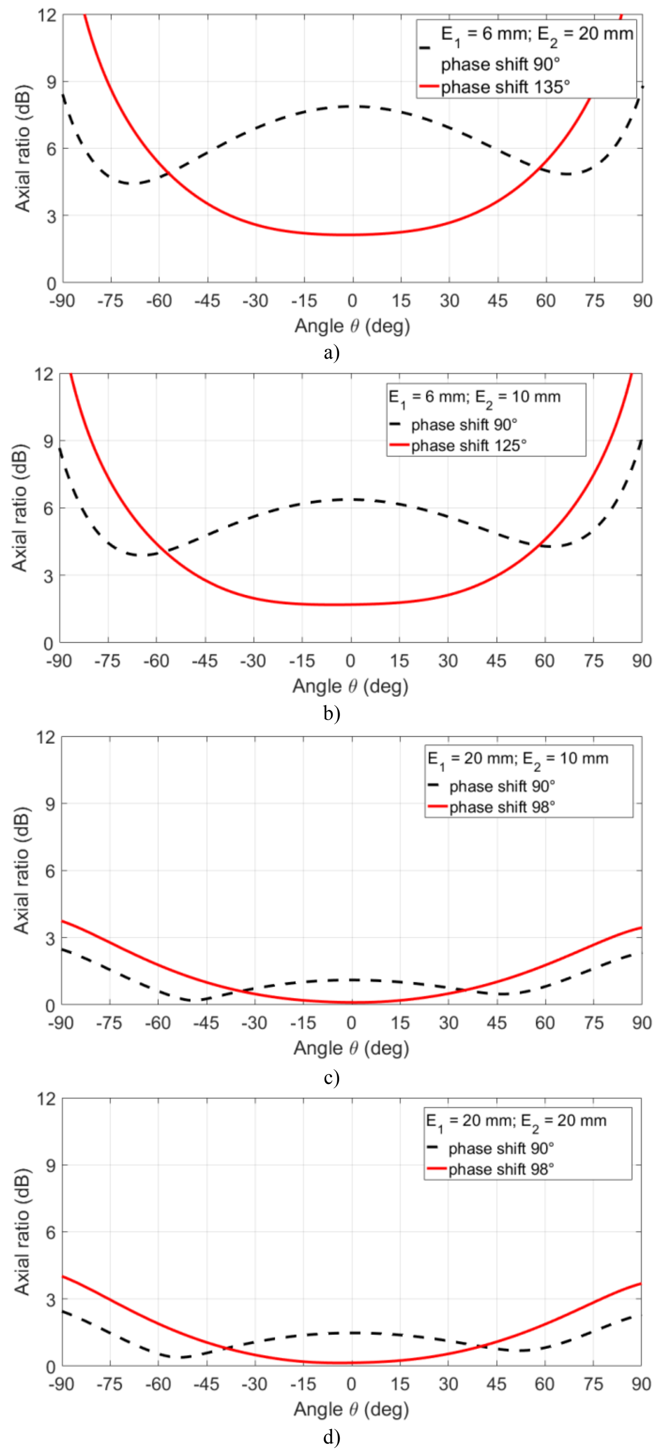

Fig. 3. Axial ratios (*xz*-plane at 1.575 GHz) for four extreme configurations with and without proposed AR correction. All RHCP realized gains were constant at 5.6 dBic (not shown for brevity).

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