A Compact Feed Network for Wideband Circularly Polarized 2 × 2 Spiral Array Antenna for GPS Applications

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***Abstract*—A wideband feed network for a small-spiral 2 × 2 antenna array has been developed. The antenna is fed by a 4 port-network with a 90° sequential phase shift between the ports to provide circular polarization radiation. The feed is comprised of a balun and two multi-section quadrature hybrid splitters to provide an almost constant 90° differential phase shift across a 440 MHz bandwidth. The measurement results show maximum deviation of ±9° (off of the ideal 90°) over the entire frequency band and an amplitude imbalance of less than ±0.6 dB. The developed design is compact, simple, and has a relatively wide bandwidth and low loss over 1.16 GHz to 1.6 GHz.**

I. Introduction

Navigation with Galileo, GLONASS and GPS satellites requires wideband antennas that operate over a 1.16 GHz to 1.61 GHz frequency range. A broadband 2 × 2 circularly polarized antenna array of small spirals was developed by [1]. In this structure each spiral is fed with a 90° progressive phase shift to transmit/receive circular polarization radiation. Typically, to provide a broadband 90° phase shift, digital phase shifters such as the MAPS-011007 chip by MACOM can be used, but they have more than 3.5 dB insertion loss over the frequency band of interest. An alternative is utilizing multiple quarter-wave length microstrip lines [2]; however, quarter-wave length microstrip lines are only adequate for narrowband operation. When a wider bandwidth is needed, the differential phase shift can deviate by up to ±30° beyond 90° over the 1.16 GHz to 1.6 GHz range if only quarter-wave length microstrip lines are used. In this paper, a simple and compact approach is presented to obtain a 90° sequential phase shift with minimal loss to feed the antenna presented in [1].

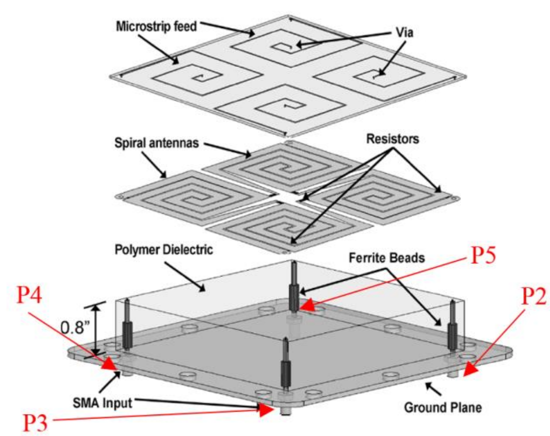

Fig. 1. The 4-spiral antenna (11cm by 11cm) [1].

II. Design

First, we used a rat-race splitter to obtain a 180° phase shift between its output two ports (i.e. a balun). Each port is then followed by a quadrature hybrid coupler to provide a 90° differential phase shift between the outputs of each quadrature 3-dB coupler. The combined structure (shown in Fig. 2) is a four port network and, if designed correctly, should have 0°, 90°, 180°, and 270° differential phase shift differences. In this design and layout, we used microstrip lines printed onto one layer. The board is 11 cm by 11 cm. Meanwhile, to operate over wide frequency range, we use multi-section quadrature hybrids [3,4]. This structure can provide a broadband 90° phase shift. The balun's center frequency is 1.35 GHz and optimized to provide a broadband operation of 440 MHz.

A single section quadrature hybrid has only about 15% bandwidth, but using a multi-section hybrid, a wider frequency operation can be achieved [3]. Due to size constraints in this design, we used two sections to cover over 440 MHz of bandwidth.

The fabricated feed network was measured and the results can be seen in figures 3, 4 and 5. Good agreement between measured and simulated results of return loss, insertion loss and 90° progressive phase shift have been demonstrated over the broadband operation of the feed network.

In simulation, the return loss is better than -13 dB as shown in Figure 3. In Figure 4, the insertion loss is within -5.66 dB to -7.1 dB at the lower frequency range, and from -5.98 to -7.59 at the higher frequency range. The differential phase shift over the band is within ± 9°.

The antenna and feed network were connected with coaxial cables to be measured. Results show maximum gain of 4.3 dB, axial ratio of 2.2 dB, and a return loss of better than -15 dB.

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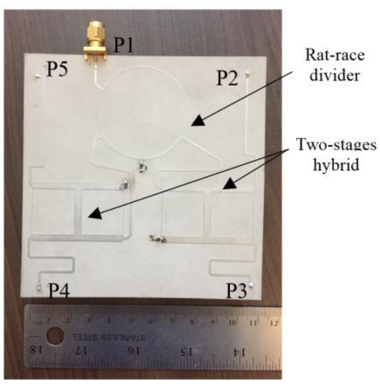

Fig. 2. The fabricated feed network (11 cm by 11 cm).

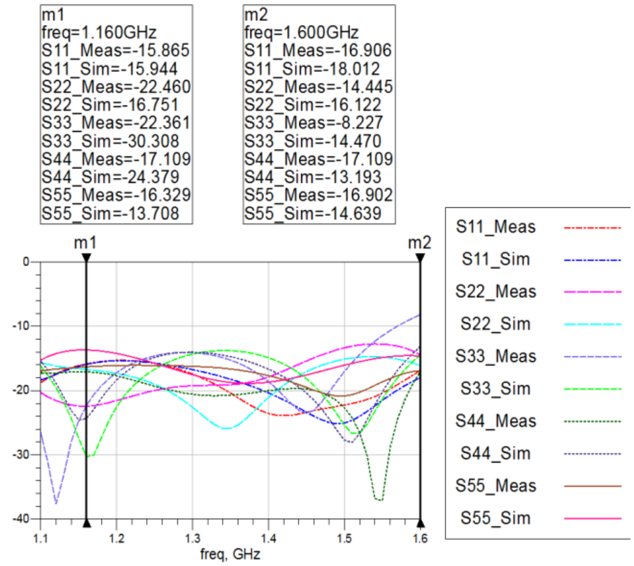

Fig. 3. Return loss of the ports.

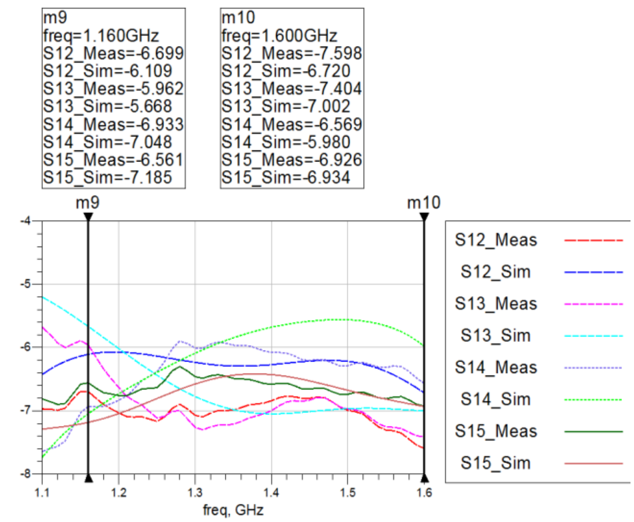

Fig. 4. Insertion Loss of the ports.

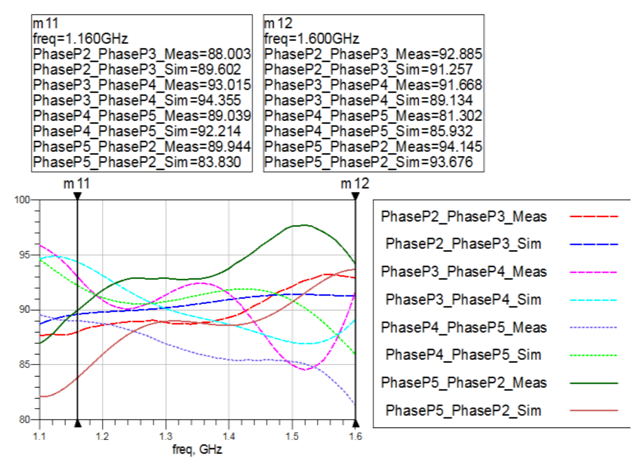

Fig. 5. Wideband 90° progressive phase shift.