Wideband Circularly Polarized Antenna With Backside Plates

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Abstract **- In this study, a novel circularly-polarized microstrip antenna fed by microstrip line to excite wideband and circularly polarized (CP) radiation is proposed. The CP antenna consists of a tapered slot and a delay line phase shifter. The proposed antenna excited wideband return loss better than 10 dB from 4.18 to 7.57 GHz, possessing the 3 dB axial ratio bandwidth from 4.25 to 6.75 GHz, and the measured antenna gain is about 9 to 10.5 dBic with the broadside radiation pattern.**

Index Terms **— Circular Polarization, Antenna, propagation, Microstrip Patch.**

I. INTRODUCTION

Circularly polarized (CP) antennas possess the ability of multi-path effect rejection and better mobility and weather penetration than the linearly polarized antenna. Hence, the (CP) antennas are widely used in many applications, such as radar, global positioning satellite and mobile communication systems,

The CP radiated wave can be produced by many antenna structures, which can be classified into three types: single-fed, multi-fed and balun-fed antenna. The single-fed CP antenna excites the CP radiation by using the asymmetric structure. The simplest single-fed CP antenna is a rectangular patch antenna with feeding probe at the diagonal position or trimming the opposite corners [1]. This kind of the antennas can be designed and fabricated easily, but the CP wave radiated only in a narrow bandwidth.

The CP bandwidths of the dual-fed and balun-fed CP antennas depend on bandwidth of their radiator and the feeding network. The L-probes fed stacked patch with the wideband phase shifter was proposed to achieve a wideband CP antenna in many studies [2], but huge size and complex feeding network limit its applications. The feeding network as a delay line phase shifter or a branch-line coupler, which has simple construction but narrow bandwidth of 90° phase difference, is also used in the design of CP antennas [3]. Furthermore, the balun vertically connected to the symmetrical open loop structure to excite wideband circular polarization was presented [4]. The feeding network of dual-fed CP antenna is still complex to design, limiting its applications.

In this study, a novel design of wideband CP antenna with simple structure is developed. The proposed antenna structure consists of a tapered slot and a delay line phase shifter. The tapered slot is composes of two circles with different radius, and two T-shaped probes from output ports of the delay line phase shifter are inserted into the tapered slot. Using the tapered structures to provide smooth input impedance and board bandwidth are useful in wideband RF circuit and antenna design.

II. ANTENNA CONFIGURATION

In this study, the proposed antenna is fabricated on the RT/duroid 5880, 0.787 mm substrate thickness, dielectric constant of 2.2, and loss tangent of 0.0009. The simulation is based on the commercial full-wave software Zeland IE3D, and all of the measured and simulated axial-ratio results of the antenna are shown at angle of $\theta = \phi = 0^o$. Fig. 1 describes configuration of the proposed slot antenna, which consists of a tapered slot radiator and a simple feeding network. The proposed slot antenna has following dimension: L_1 = 3.56 mm, L_2 = 11.83 mm, L_3 = 0.78 mm, L_4 = 9.28 mm, L_5 = 11.59 mm, L_6 = 5 mm, R_1 = 14 mm, R_2 = 7 mm, D_1 = 2.42 mm, D_2 = D_3 = 0.7 mm, D_4 = 1 mm, $\theta_1 = 225^\circ$, $\theta_2 = 90^\circ$, $\theta_3 = 90^\circ$, $\theta_4 = 30^\circ$. The feeding network of the proposed antenna is a delay line phase shifter, which is a T-junction power divider with a $\lambda/4$ length difference between two output ports, L_2 and L_3. The input port impedance of the T-junction power divider is 50 Ω and the two output port impedances are both 100 Ω . The radiator of the proposed antenna is a tapered slot, which formed with two circles with different radius, R_1 and R_2, and an interval between centers of two circles is L_6. The outer circle is a slot etched on the ground, and the inner circle is a metal patch mounted over the board. Two T-shaped probes fed this tapered slot radiator in orthogonal direction, and joined to the delay line phase shifter. The proposed slot antenna can be optimized by shifting the impedance of inner circle to 50 ohm, and thus wider bandwidth of axial ratio can be obtained from 4.8 to 6.4 GHz.

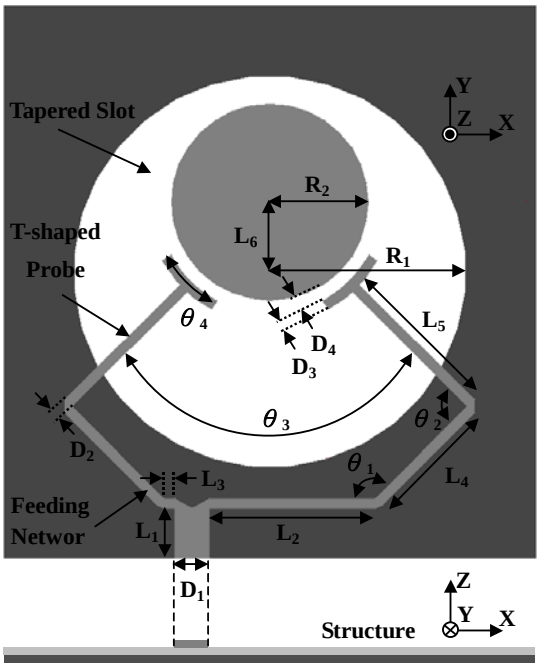

Fig. 1. Configuration of the proposed slot antenna.

III. Experimental Result

The final optimumed dimensions of the proposed slot antenna above the metal plate are: L_1 = 3.56 mm, L_2 = 11.64 mm, L_3 = 0.98 mm, L_4 = 8.57 mm, L_5 = 10.38 mm, L_6 =3.95 mm, R_1 = 14 mm, R_2 = 7 mm, D_1 = 2.42 mm, D_2 = D_3 = 0.7 mm, D_4 = 1.5 mm, θ_1 = 225°, θ_2 = 90°, θ_3 = 90°, θ_4 = 30°, H = 15 mm. The measured and simulated results of proposed slot antenna are shown in Fig. 2 and 3. Fig. 2 shows the compartion of the simulated and measured return loss, and the measured return loss is better then 10 dB for 57.7 % from 4.18 to 7.57 GHz. The axial ratio and CP gain are discribed in Fig. 3. The measured axial ratio is below 3 dB for 45 % from 4.25 to 6.75 GHz. Therefore, the impedance bandwidth overlaps the bandwidth of the axial ratio completely. The CP gain of the proposed slot antenna is better than 9 dBic over the CP bandwidth. The circularly polarized radiation patterns of the proposed CP antenna are also simulated and measured on the XZ-plane at 4.5, 5.5, and 6.5 GHz. A good agreement in terms of full-wave simulated and measured results demonstrate the proposed slot antenna resulting broad CP bandwidth, even the feeding network only has narraw bandwidth of 90° phase difference.

Conclusion

The proposed wideband and circularly polarized dual-fed slot antenna has been designed, simulated, and experimentally verified. The delay line phase shifter and the dual-fed slot antenna have been combined successfully for a broad CP bandwidth even the delay line phase shifter only has narrow bandwidth of 90° phase difference. Also, the diffractions of ground edge influence on the radiation characteristics of antenna have been investigated, and the ground edge has been designed to form of a half-circle to

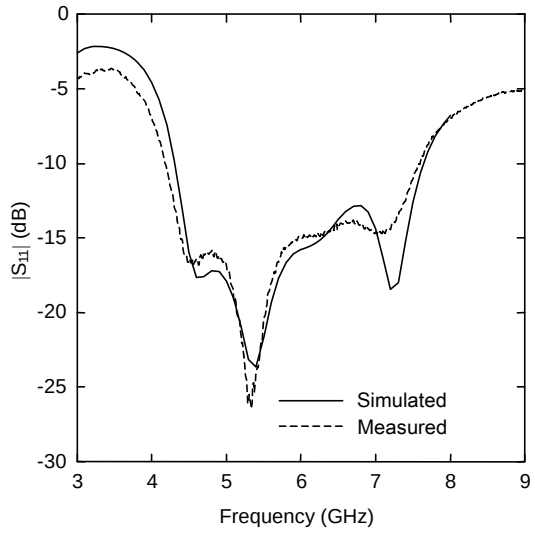

Fig. 2 Simulated and measured return loss of the proposed slot antenna.

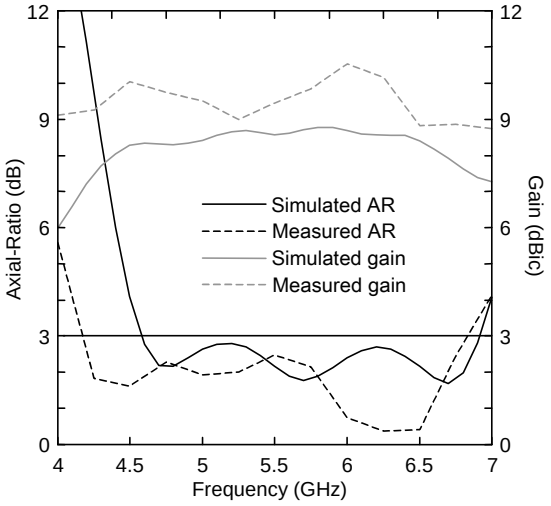

Fig. 3 Simulated and measured axial ratio and CP gain of the proposed slot antenna.

enhance the CP purity and bandwidth. The measured return loss is better then 10 dB for 57.7 % from 4.18 to 7.57 GHz, and measured axial ratio is below 3 dB for 45 % from 4.25 to 6.75 GHz. Moreover, the measured radiation patterns of the porposed antenna are boardside patterns and shown stable, and the measured CP gain is about 9 to 10.5 dBic.

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