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A Wideband Dual Circularly Polarized Array Antenna by using Microwave Multi Layer Technology

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1. Introduction

Circularly polarized antennas are particularly useful for wireless communication technology, mobile satellite communication and Global Positioning System. The single-feed or two-feed circularly polarized antennas have been reported [1]-[2]. These antennas have the attractive advantages such as simple feed structure, low profile and light weight. In these type antennas, for the switching function of RHCP and LHCP, a complicated phase shifter is required.

In this paper, a novel wideband dual circularly polarized antenna is proposed. In this antenna, the 2X2 slot array are excited orthogonally by the phase coupler. By change the two input ports, the RHCP and LHCP can be switched easily. By the electromagnetic simulation results and experimental results, the dual circularly polarized array antenna with switching function of RHCP and LHCP is confirmed. And the simply configuration, wide bandwidth axial-ratio of this antenna can be achieved mainly due to the “Both-Sided MIC technology” [3].

2. The Structure of the Proposed Antenna

A. Configuration of the proposed antenna

Fig.1 shows the basic structure of the proposed dual circularly polarized slot array antenna. The antenna has two input ports (port-1 and port-2). And the feed circuit of this antenna is constructed with 2 layer dielectric substrate and conductive 3 layers. The microstrip lines are on layer-1 and layer-3. The 2X2 slot ring antenna elements and slot lines are on the inner conductor plane of 2 layer dielectric substrates.

Two orthogonal RF signals from port-1 and port-2 excites the 2X2 slot ring elements array. By change the phase shift (90 degrees or -90 degrees) of the two inputs, the RHCP and LHCP can be switched. A excellent isolation of two ports and very simple circuit configuration is obtained due to the “Both-Sided MIC technology”.

B. The Both-sided hybrid multi layer feed circuit

As shown in Fig 1(d), the strip-slot branch circuit and slot-strip branch circuit are used in this antenna.

The strip-slot branch circuit is a parallel power divider. At the equal distance points from the branch point on the slot line, two divided signals have the same amplitude and are in phase. The slot-strip branch circuit is a series power divider. At the equal distance points from the branch point on the microstrip line, two divided signals have the same amplitude and are out of phase.

3. Basic Operation

Fig 2 shows the analytical model for the simulation. The two RF signals which have 90 degrees phase difference from port-1 and port-2 are divided in parallel (in phase) to the two cross-slot

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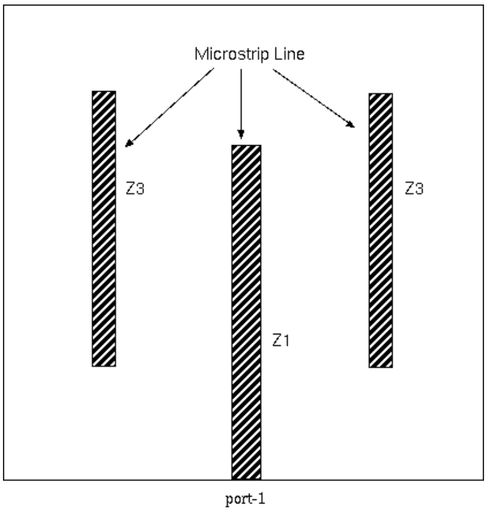
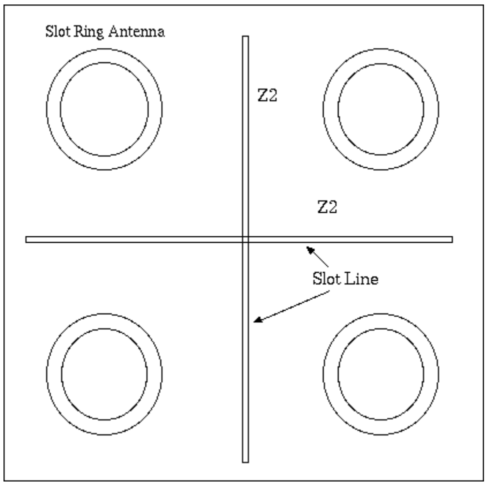
respectively by the strip-slot branch circuit, and then they are divided in series (out of phase) to the microstrip line connected to the antenna elements through the strip-slot branch circuit.

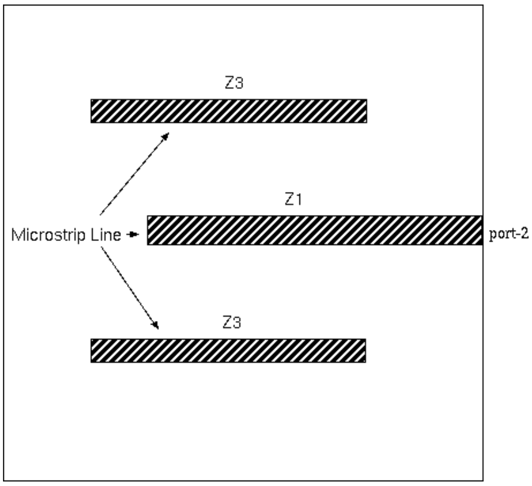
The basic operation of single element excitation is shown in Fig 3. When the two orthogonal RF signals which have 90 degrees phase difference, the RHCP can be realized. And by change the two orthogonal RF signals which have -90 degrees phase difference. The LHCP can be realized.



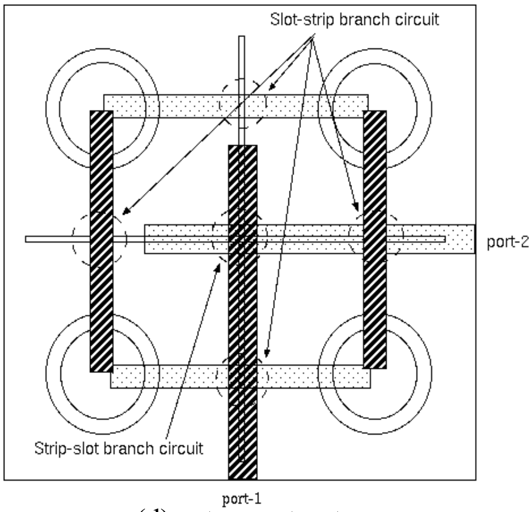
(a) Layer-1



(b) Layer-2



(c) Layer-3



(d) antenna structure

Figure 1 Antenna structure

4. Simulation Result

The simulated S-parameter is shown in Fig.4. Fig.5 shows the frequency characteristic of axial ratio when the phase difference of port-2/port-1 are 90 degrees (RHCP) and -90 degrees (LHCP). And the Fig. 6 shows the directivity of RHCP and LHCP at 7.5GHz.

As the results, the isolation is less than -30dB and the minimum return loss is lower than -20dB at 7.6GHz, the bandwidth for less than -15dB are 5.5% (S22) and 6.1% (S11). The RHCP axial ratio of 2.3dB and gain of 9.93dBi are obtained at 7.5GHz and the relative bandwidth (AR<3dB) is 64%. The LHCP axial ratio of 1.7dB and gain of 10.07dBi are obtained at 7.5GHz, the relative bandwidth (AR<3dB) is 62%.

By this result, the wideband dual circularly polarized microstrip array antenna with switching function of RHCP and LHCP is confirmed.

5. Experimental Investigation

Fig.7 shows the experimental model. The model uses a 3dB hybrid coupler to excite the antenna orthogonally. The model of 3dB hybrid coupler is shown in Fig.8. The input signal (port-1) is divided into port-2 and port-4 with 90 degrees phase difference. The port 3 is an isolated port. When feeding point is changed to the port-3, the output ports are port-2 and port-4, and the port-1 is isolation port. The phase difference of port-2 and port-4 is -90 degrees.

The measured axial ratio is shown in Fig 9. When the input is port-1, the minimum RHCP axial ratio of 0.68dB is obtained at 7.98GHz, and the bandwidth (AR<3dB) is 0.94GHz (the relative bandwidth is 12%). When the input is port-2, the minimum LHCP axial ratio of 2.13dB is obtained at 7.5dB, the bandwidth (AR<3dB) is 0.18GHz (the relative bandwidth is 2.4%). The results are not good as simulation results. Because the experimental model is the combination of the slot array antenna with a 3dB hybrid coupler (simulation model is slot array antenna only). The frequency characteristics of axial ratio of the RHCP don't agree with that of the LHCP due to the unsymmetrical structure of the experimental model.

6. Conclusion

In this paper, a novel wideband dual circularly polarized microstrip array antenna is proposed. By change the input port, the 2X2 slot array are excited orthogonally with 90 degrees or -90 degrees phase difference, the switching function of RHCP and LHCP can be realized.

By the experimental results, the realization of the dual circularly polarized array antenna with switching function of RHCP and LHCP is confirmed.

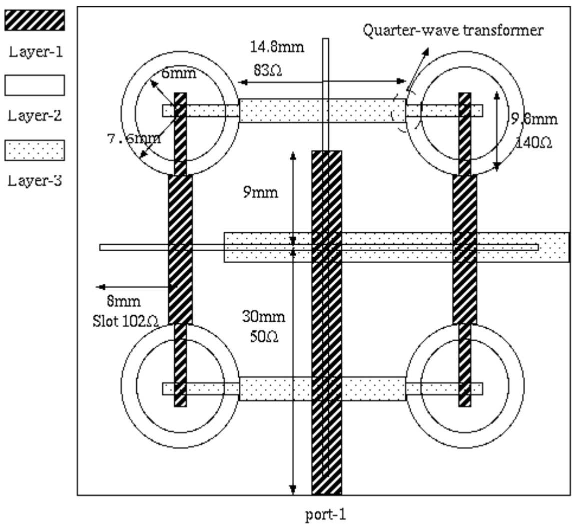


Figure 2 Simulation model
(Parameter of dielectric substrate:
εr = 2.15 and the thickness = 0.8mm)

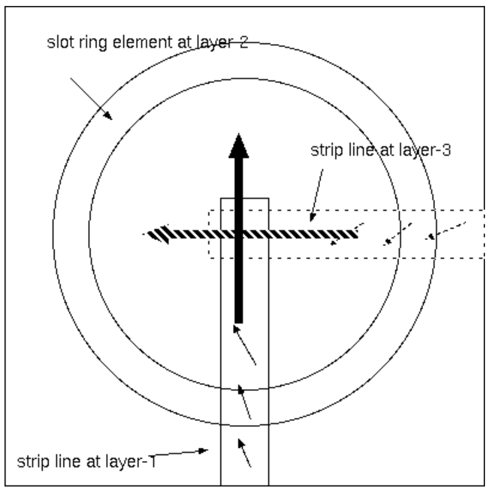


Figure 3 Excitation of element

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[3] M.Aikawa, H. Ogawa, "Double-Sided MIC's and Their Applications," IEEE Trans. Microwave Theory Tech., vol.37, no.2, pp.406-413, Feb. 1989

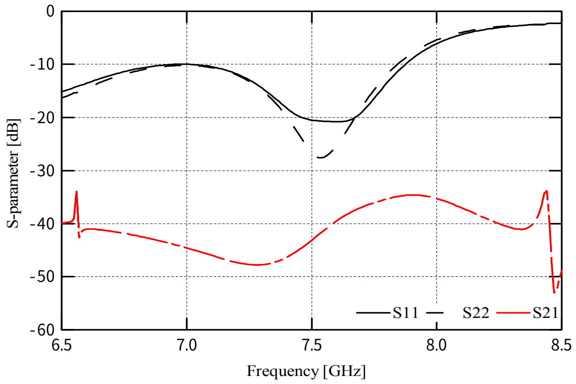

Figure 4 S-parameter

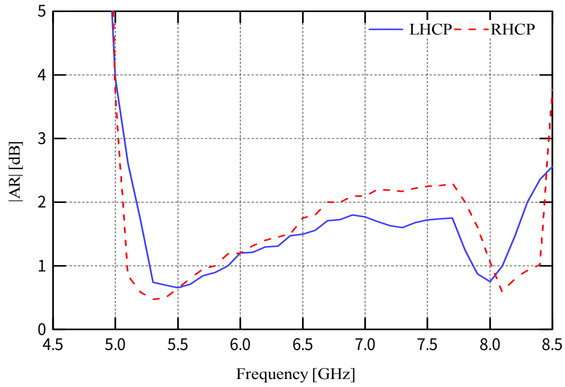

Figure 5 Axial Radio(simulation)

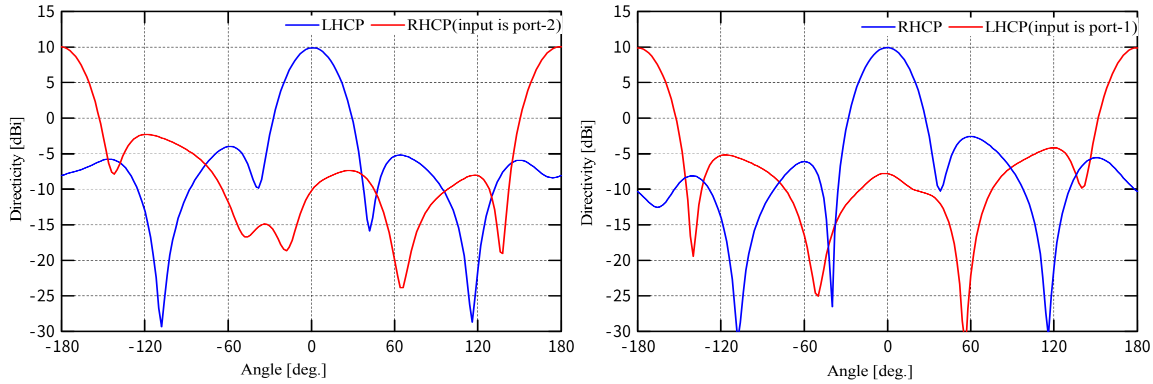

Figure 6 Radiation pattern of RHCP and LHCP

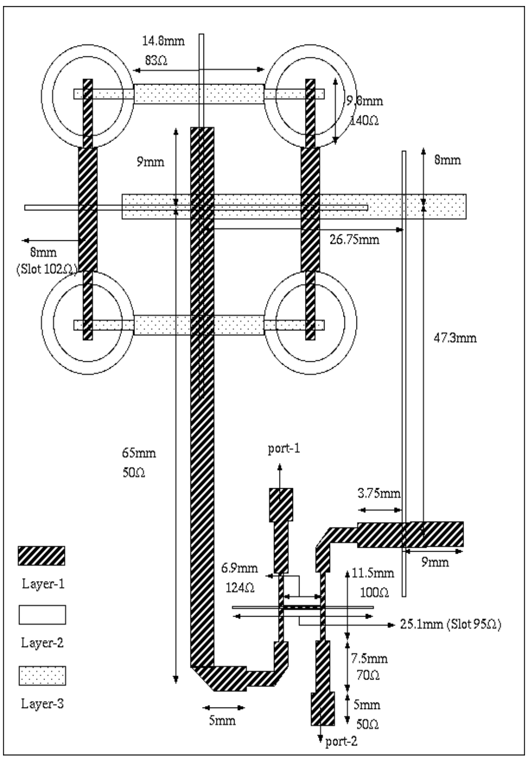

Figure 7 Experimental model

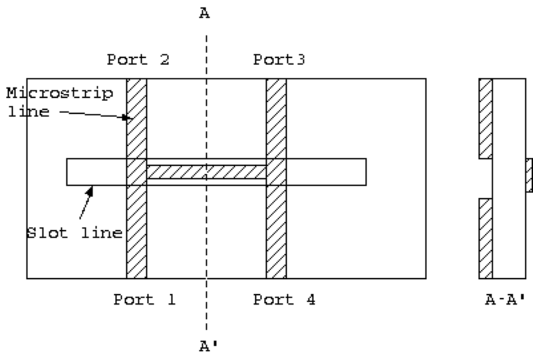

Figure 8 3dB hybrid coupler

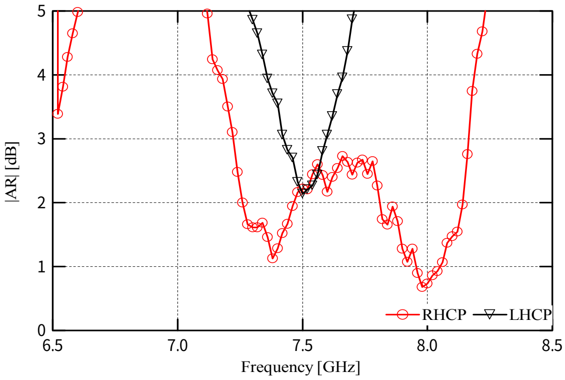

Figure 9 Axial Radio(measured)