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A CIRCULARLY POLARIZED MICROSTRIP ANTENNA USING SINGLY-FED PROXIMITY COUPLED FEED

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1. Introduction

Many types of antenna have been proposed and investigated to enable airplanes, ships, and cars to maintain mobile satellite communications[1],[2]. Mobile satellite communications require circularly polarized patch antennas.

A proximity coupled microstrip antenna excited by a microstrip line is suitable for constructing a thin, light, and multi-layered feed network. This antenna has several well-known advantages compared with an edge-fed patch antenna. An optimal feed-patch configuration has been proposed for linear polarization[3]. Moreover, for circularly polarized operation, a 90 degree hybrid coupler is commonly used.

The purpose of this paper is to propose a simple new antenna configuration using a rectangular patch antenna with an offset microstrip line from center for circular polarization without the need for a 90 degree hybrid coupler. The results of experiments are described. Good impedance and axial ratio characteristics have been obtained.

2. Antenna configuration for circular polarization

An antenna configuration which gives circular polarization is shown in Fig.1. The rectangular patch antenna and microstrip line are formed of substrates with a dielectric constant εr, and thicknesses h and t, respectively. The length of the patch antenna is Lp and the width is Wp. Lo is the offset length from the center of the rectangular patch antenna to the microstrip line. The characteristic impedance of the microstrip line is 50Ω. S is the distance between the edge of the patch antenna and the edge of the microstrip line.

The operation of this antenna is based on the fact that the generated mode, which is excited in the electrically thin cavity of the microstrip antenna, can be separated into two orthogonal modes due to the effects of the offset microstrip line as shown in Fig.2. The generated modes are separated into the orthogonal modes #1 and #2, which are excited in equal amplitude and 90 degree out of phase at frequency fo by adjusting the aspect ratio Lp/Wp and offset length Lo. Hence, a circularly polarized antenna can be obtained with this configuration.

3. Experimental results

Antennas were designed and tested to verify the circularly polarizing operation of the proposed configuration. The experimental models were made of copper-clad thick Teflon Fiberglass with a εr=2.6. The aspect ratio, Lp/Wp, was 0.966.

Figure 3 shows the measured impedance and return loss for a proximity coupled rectangular patch antenna with Lo = 14.4 mm and S = 13.8 mm, respectively. Good impedance matching was achieved and the bandwidth for VSWR<2 was 3.5 %. Figure 4 shows the measured radiation pattern in the y-z plane at 1.575GHz. A 0.3 dB boresight axial ratio was obtained and an axial ratio of less than 2 dB was obtained in the 60 degree range. Figure 5 shows the measured axial ratios. The axial ratios are given as a parameter of the offset length Lo. The bandwidth of the 2dB axial ratio was 0.55 %.

Table 1 shows the measured axial ratios as parameters of the offset length Lo and the microstrip line length S. Boresight axial ratio < 2 dB was obtained over a wide range from the center to the edge of the rectangular patch antenna.

In the case of Lp<Wp and 0<Lo<Wp/2, left-hand circularly polarized waves are radiated by this antenna configuration. On the other hand, right-hand circularly polarized waves are radiated when -Wp/2<Lo<0.

4.Array antenna

Sequential array antennas consisting of 3, 4, and 6 of the proposed antenna elements were designed to increase the bandwidth of return loss and axial ratio, respectively.

Figure 6 shows the measured return loss of the 6-element array antenna. Figure 7 shows the measured axial ratios. From Fig.7, the bandwidth of the 2 dB axial ratio was determined to be about 6 %. These bandwidths satisfy the required values for L-band mobile satellite communications.

5.Conclusion

This paper describes the results of measurements made on a simple circularly polarized microstrip antenna. A patch antenna with an axial ratio of less than 0.3 dB was obtained using the proposed antenna configuration. The feed network can be made simplified, because only a microstrip line, offset from the center of the rectangular patch antenna, is used to generate the circularly polarized waves.

The proposed antenna is suitable for a phased array antenna with a multi-layered feed network in mobile satellite communications.

References

[1] J.L.Keer, "Microstrip Polarization Techniques," Proc.1978 Antenna and Propagat., Symp., Sept., 1978.

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[3] M.Davidovitz and Y.T. Lo, "Rigorous Analysis of a Circular Patch Antenna Excited by a Microstrip Transmission Line," IEEE Trans., Antenna and Propagt., vol.AP-37, no.8, Aug., 1989.

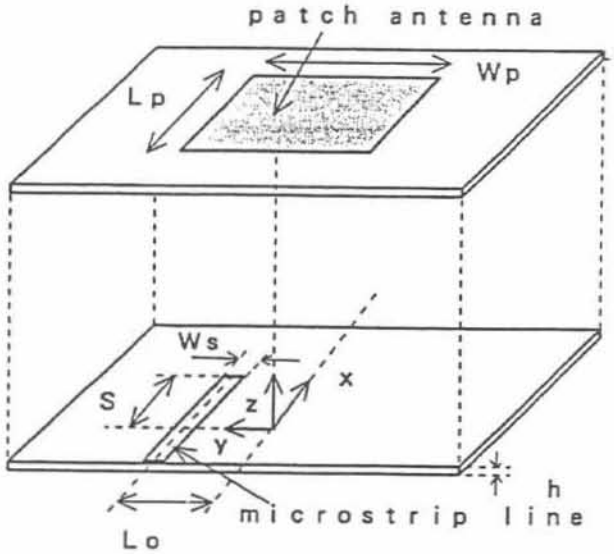

Fig.1 Configuration of a rectangular patch antenna.

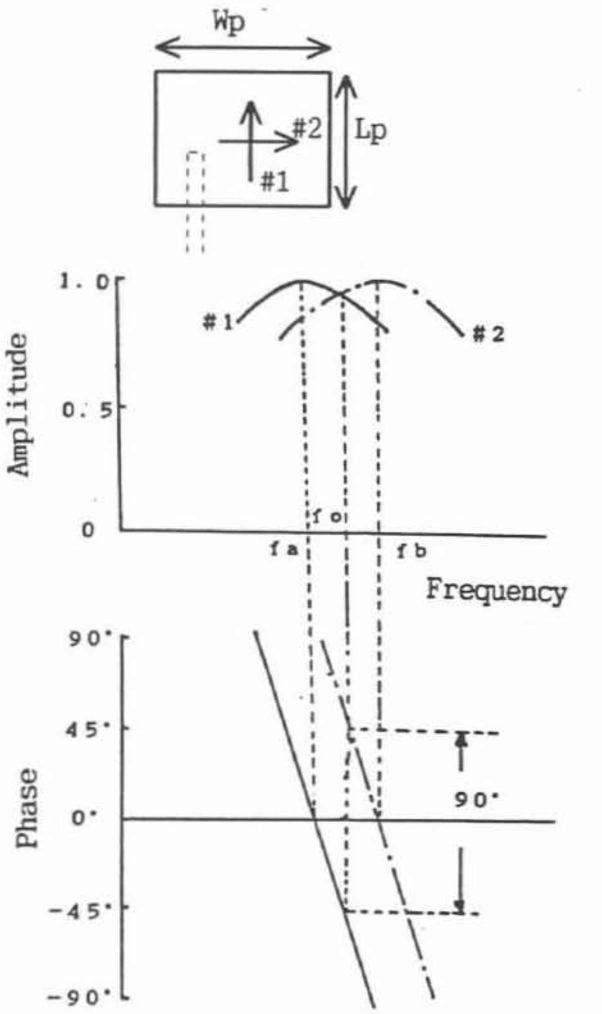

Fig.2 Schematic explanation of circularly polarized operation.

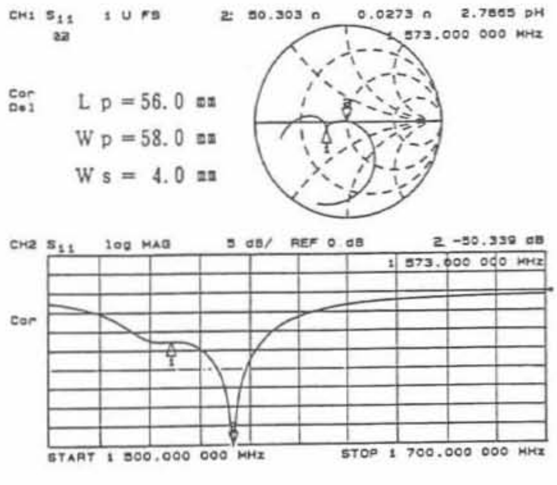

Fig.3 Measured input impedance and return loss.

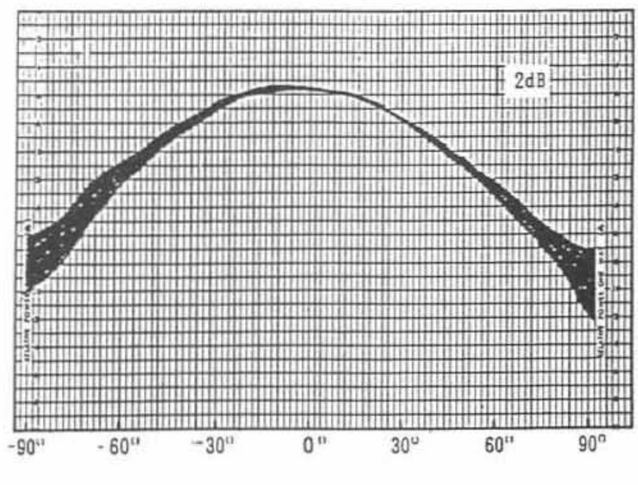

Fig.4 Measured radiation pattern. (y-z plane)

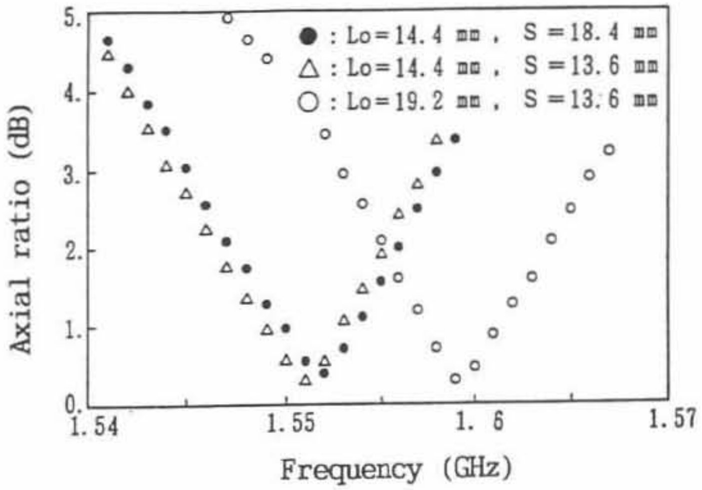

Fig.5 Measured axial ratio.

Table1 Measured axial ratios as a function of offset length Lo and microstrip line length S.

S \ Lo	4.8	9.6	14.4	19.2	24.0	28.8 (mm)
52.0	2.0	3.52	1.20	2.32	3.60	3.24
47.2	2.43	3.68	1.44	1.76	3.28	2.43
42.4	3.45	3.45	3.36	1.45	2.77	3.20
37.6	2.80	2.88	1.36	1.60	3.20	2.64
32.8	3.39	3.36	1.55	1.74	2.16	2.24
28.0	3.23	2.88	0.86	1.31	2.22	1.47
23.2	3.37	3.17	0.56	0.72	1.66	1.68
18.4	3.93	2.60	0.40	0.77	2.56	1.45
13.6	3.60	2.83	0.32	0.32	1.92	1.26
8.8	4.24	2.48	0.32	0.32	1.56	1.07
4.0	5.15	2.08	1.42	0.48	1.36	0.88 (dB)
(mm)						

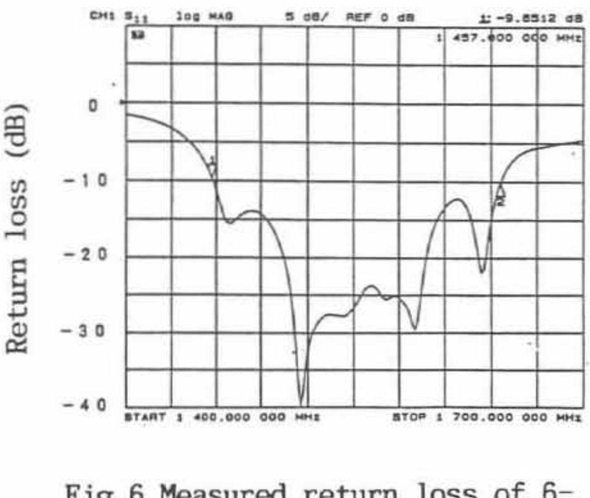

Fig.6 Measured return loss of 6-element array antenna.

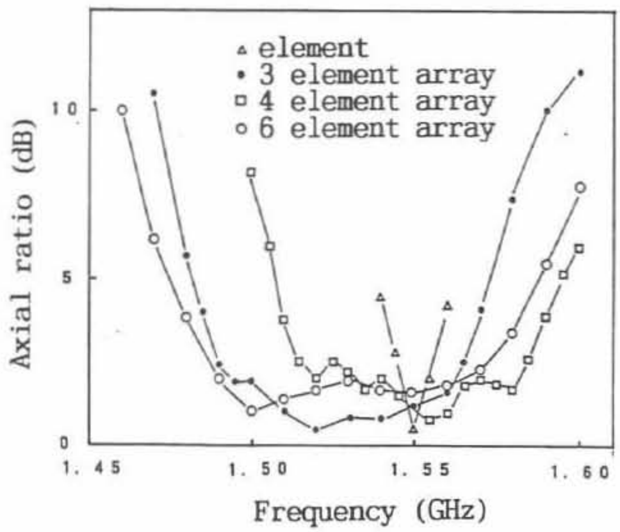

Fig.7 Measured axial ratios of array antennas.