Coplanar Waveguide Aperture-Coupled Microstrip Patch Antenna

Richard Q. Lee, *Member, IEEE,* and Rainee N. Simons, *Member, IEEE*

Abstract—**The performance characteristics of a coplanar waveguide (CPW) aperture-coupled microstrip patch antenna was investigated experimentally. A grounded CPW with a series gap in the center strip conductor was used to couple microwave power to the antenna through an aperture in the common ground plane. Results indicate good coupling efficiency and confirms the feasibility of this feeding technique.**

I. Introduction

Aperture-coupled feeding is attractive because of advantages such as no physical contact between the feed and radiator, wider bandwidths, and better isolation between antennas and the feed network. The use of coplanar waveguide (CPW) as transmission media can also provide lower radiation losses and ease of monolithic microwave integrated circuit (MMIC) device integration in MMIC phase arrays [1]. Furthermore, aperture-coupled feeding allows independent optimization of antennas and feed networks by using substrates of different thickness or permittivity. Recently, it has been demonstrated that using a "dogbone" aperture can greatly improve the coupling efficiency [2]. CPW feed structures using probes as well as apertures to couple microwave power to the antenna have also been reported to have excellent coupling efficiency and antenna patterns [3], [4].

This letter reports an experimental investigation of a new aperture-coupled feeding technique where a grounded CPW with a series gap in the center strip conductor is used to couple microwave power to a microstrip patch antenna through an aperture in the common ground plane. This design permits the insertion of solid state devices in the series gap of the CPW feed and thus, is suitable for use in active antenna or quasi-optical combiner/mixer designs. To optimize the coupling efficiency three different feed configurations have been designed and tested.

II. Design Description

Fig. 1 shows the CPW aperture-coupled microstrip patch antenna configuration used in the experiment. In the experimental antenna, the patch and the CPW feed structure, with a series gap in the center strip conductor, are fabricated on separate substrates, and the aperture is etched on the common ground plane. The aperture is located directly above the series gap. Thus, microwave power is coupled from the ground CPW feed line to the patch through the aperture. The aperture is displaced by about 0.32 cm from the center of the patch to provide a proper impedance match. The inset in Fig. 2 shows the three different feed configuration designs reported here. In the first design, the length and width of the series gap and the aperture are L_1 and S, and L_2 and W_2, respectively. In the second design, the width of the series gap is increased from S to S_1 by flaring the center strip conductor of the CPW feed line near the gap location. In the third design, the rectangular aperture is replaced by a dumbbell aperture of identical length and width. The design parameters for the antennas tested can be found in the figure caption.

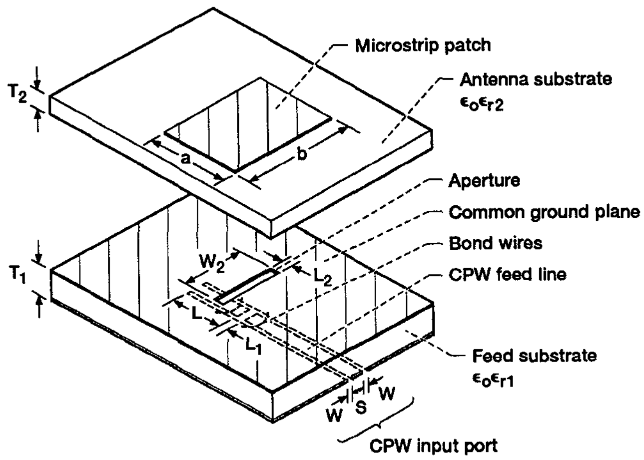

Fig. 1. Schematic of the CPW aperture-coupled microstrip patch antenna: $S = 0.076$ cm, $W = 0.025$ cm, $L = 0.711$ cm, $L_2 = 0.205$ cm, $W_2 = 0.69$ cm, $a = 0.76$ cm, $b = 1.14$ cm, $T_1 = 0.051$ cm, $\epsilon_{r1} = 2.2$, $T_2 = 0.025$ cm, $\epsilon_{r2} = 2.2$.

III. Results and Discussions

The measured return losses for the three different feed configurations are shown in Fig. 2. As indicated in the composite curves, the return losses are improved from –8.2 dB for (a) to –13.2 dB for (b) to –16.9 dB for (c). In the experiment, the short circuited CPW stub length, L, was set at about one third of a wavelength initially, and by reducing the stub length with an adhesive 3M copper tape, the coupling efficiency was improved by about 1 dB. Results also indicate that the coupling efficiency was improved by more than 3 dB each by using an enlarged series gap or a dumbbell aperture. However, the geometrical change in the series gap and aperture of the feed structure produced a slight change in the resonance frequency.

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The authors are with NASA Lewis Research Center, MS 54–8, 21000 Brookpark Road, Cleveland, OH 44135.
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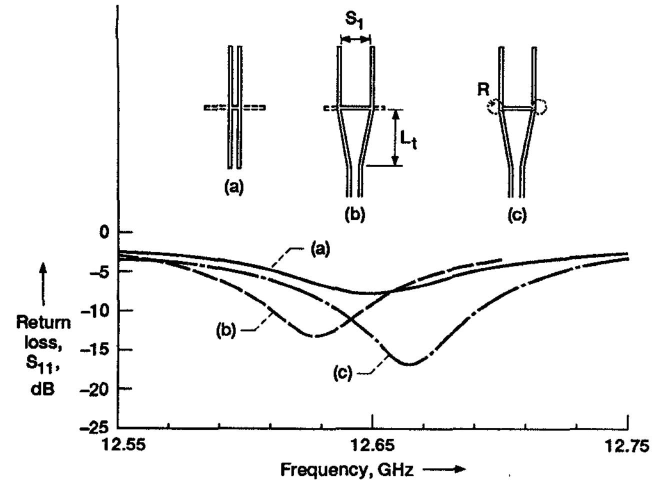

Fig. 2. Measured return vs. frequency for feed structures with (a) a series gap and a rectangular aperture; (b) an enlarged series gap and a rectangular aperture; (c) an enlarged series gap and a dumbbell aperture ($S_1 = 0.355$ cm; taper length, $L_t = 0.711$ cm; and radius, $R = 0.0843$ cm).

Typical measured E- and H-plane patterns for the CPW aperture-coupled microstrip patch antenna are displayed in Figs. 3(a) and 3(b), respectively. The patterns look fairly symmetrical and exhibit a 3-dB beamwidth of about 61 degrees for the E-plane and 50 degrees for the H-plane. The measured front-to-back ratio is about 14 dB, which is typical for an aperture fed antenna configuration.

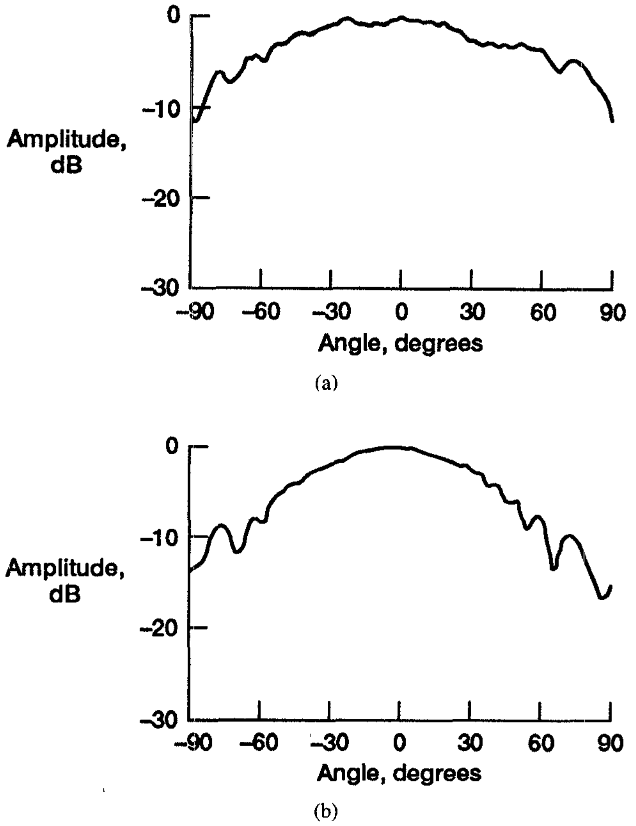

Fig. 3. Measured radiation patterns for the CPW aperture-coupled microstrip patch antenna: (a) E-plane, (b) H-plane.

IV. Conclusion

A new type of microstrip patch antenna utilizing a series gap in the center strip conductor of the CPW feed line for coupling power to the antenna has been demonstrated. This design allows easy insertion of solid state devices in the CPW feed line, and therefore, has advantages over other CPW aperture coupled microstrip antenna designs in realization of active antennas. Techniques for improving coupling efficiency are described and discussed. Measured results indicate excellent radiation patterns and coupling efficiency.

References

[1] W. P. Harokopus, Jr. and P. B. Katehi, "Microstrip antenna fed by a coplanar waveguide feeding structure," PIERS Proc., 1991, p. 360.

[2] D. M. Pozar and S. D. Targonski, "Improved coupling for aperture coupled microstrip antennas," *Electron. Lett.*, vol. 27, no. 13, pp. 127–129, June 1991.

[3] R. N. Simons, R. Q. Lee, and G. R. Lindamood, "New coplanar waveguide/stripline feed network for seven patch hexagonal CP subarray," *Electron. Lett.*, vol. 27, no. 6, pp. 533–535, Mar. 1991.

[4] R. N. Simons, R. Q. Lee, and G. R. Lindamood, "Electromagnetic coupling between coplanar waveguide and microstrip antennas," accepted for publication in the *Microwave Optical Technol. Lett.*, vol. 5, Feb. 1992.