AN APERTURE-COUPLED LINEAR LEAKY-WAVE ANTENNA ARRAY WITH 2-D DUAL-BEAM SCANNING CAPABILITY

Cheng-Chi Hu,1 Jin-Jei Wu,2 and Christina F. Jou1

 Institute of Communication Engineering National Chiao Tung University
Hsinchu, Taiwan, R.O.C.
Department of Electrical Engineering Kao Yuan Institute of Technology Luchu, Taiwan, R.O.C.

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ABSTRACT: An X-band four-element linear microstrip leaky-wave antenna (LWA) array with a dual-beam radiation pattern and two-dimensional scanning capability is developed. The measured half-power beamwidths of the H-plane and quasi-E-plane radiation patterns are less than 30°. By tuning the dc bias of the varactor phase shifter between the antenna elements, the main beam can be scanned in the azimuth plane from -13° to $+13^{\circ}$ off broadside. In the elevation plane, the beam-scanning angle is close to 20° as the operating frequency is tuned from 11.58 to 12.5 GHz. © 2000 John Wiley & Sons, Inc. Microwave Opt Technol Lett 25: 52-53, 2000.

Key words: leaky-wave antenna; antenna beam steering; antenna array

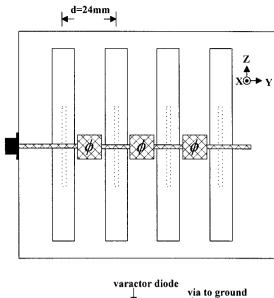
I. INTRODUCTION

A microstrip leaky-wave antenna has the characteristics of wider bandwidth, narrow beam, and frequency-scanning capability [1–3]. Although the microstrip LWA has a narrow radiation beamwidth in the *H*-plane, it also produces a typical wide patch pattern in the cross plane (quasi-*E*-plane), given by a fixed angle to the *x*-axis. Related work in this area includes the development of a dual-beam four-element LWA array [4], which was excited by a CPW feeding network, developing a narrow pencil beam. In particular, the dual-beam antenna characteristic has a great value in mobile communication and automotive radar systems.

Here, we demonstrate an aperture-coupled dual-beam series-fed array of an LWA (Fig. 1) with two-dimensional scanning capability. By introducing a varactor-tuned phase shifter between the microstrip LWA elements, a constant phase progression is achieved by controlling the reverse dc bias of the varactor diodes. Therefore, the pencil beam of the microstrip LWA array can be scanned in the quasi-*E*-plane. The aperture coupling structure of the microstrip LWA array allows the feed network for these elements to be placed below the ground plane, avoiding interference between the feed networks and antenna radiation. This type of feeding has successfully been used for the excitation of an LWA [5]. Further, by feeding a microstrip leaky-wave antenna at its center, a dual-beam pattern can be obtained.

II. DESIGN AND CONSTRUCTION

Figure 1 shows the configuration of the four-element dual-beam aperture-coupled LWA. Each LWA is series-aperture-fed by a microstrip line with a characteristic impedance of 50 Ω . This LWA array has a two-layer configuration, making it easy to fabricate due to its simple structure. The whole circuit is designed and fabricated on an RT/Duroid substrate with a dielectric constant $\varepsilon_r = 2.2$ and a thickness of 20 mils. The aperture is placed at the center of the LWA. We utilized



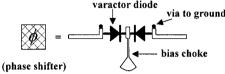


Figure 1 Schematic of the aperture-coupled linear 4×1 dual-beam 2-D scanning microstrip leaky-wave antenna array

a center-fed aperture in the ground plane, which separates the two substrates and couples the signal, thus producing a dual-beam radiation pattern. Here, a GaAs varactor (M/A-COM MA46410) is used as the phase-tuning element. The varactor-tuned phase shifter has a phase progressing from -50 to $+50^{\circ}$ as the varactor diode bias varies from 0 to 15 V.

III. MEASUREMENT RESULTS

The measured return loss of this LWA array is shown in Figure 2, which is measured at two varactor diode bias conditions, 0 and 15 V, respectively. Good matching performance is obtained in the frequency region from 11.5 to 12.5 GHz without using any quarter-wave transformer. The measured VSWR in the desired frequency region (11.5–12.5 GHz) was less than 2:1 throughout the reverse varactor bias from 0 to 15 V.

The radiation pattern was measured under the far-field condition. The measured H-plane radiation patterns are shown in Figure 3 at 11.58 and 12.5 GHz. Two maxima are observed at about $\theta=\pm60^{\circ}$ and $\theta=\pm44^{\circ}$, respectively, which indicate the dual-beam and frequency-scanning characteristics of this LWA array.

The radiation patterns of the linear 4×1 LWA array were measured on a conical surface (quasi-*E*-plane) corresponding to an angle of 45° from the *x*-axis. Figure 4 shows the measured radiation patterns. The measured half-power beamwidths of the *H*-plane and quasi-*E*-plane radiation patterns are less than 30° . These measured quasi-*E*-plane patterns illustrate that the main beam can scan in azimuth from -13 to $+13^{\circ}$ off broadside, corresponding to a reverse dc bias of varactor diode 0–15 V, respectively. The absolute gain measured from the Friss formula is about 10 dB.

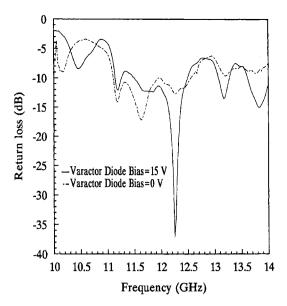


Figure 2 Return loss of the linear LWA array at two varactor diode bias conditions

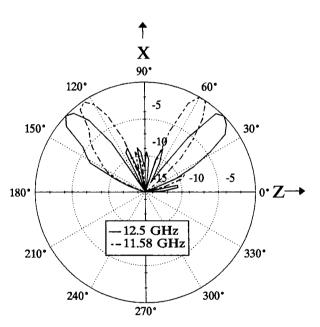


Figure 3 Measured *H*-plane radiation patterns

IV. CONCLUSION

The work reported in this paper extends the ability of the microstrip LWA to obtain a dual-pencil-beam two-dimensional scanning array using a varactor-tuned phase shifter and an aperture-coupled feeding structure. A 4×1 LWA array was demonstrated. A constant phase progression is accomplished by tuning the dc bias of the varactors, while the beam can be scanned in both azimuth and elevation in a conical scan manner. The main beam can be scanned in the azimuth plane from -13 to $+13^\circ$ off broadside. In the elevation plane, the beam-scanning angle is close to 20° . The initial results shows a good potential for using this dual-beam LWA array for low-cost transmitters and collision-warning radar applications.

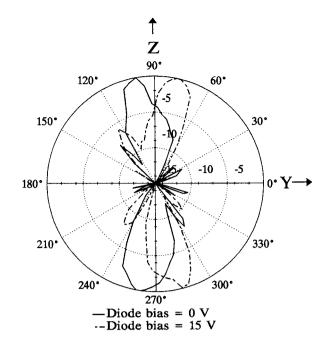


Figure 4 Measured quasi-E-plane radiation patterns at 12.2 GHz

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ON DIRECT AND INDIRECT SCATTERING APPROACHES FOR THE HOMOGENIZATION OF PARTICULATE COMPOSITES

Akhlesh Lakhtakia¹

¹ CATMAS — Computational and Theoretical Materials Sciences Group Department of Engineering Science and Mechanics Pennsylvania State University University Park, Pennsylvania 16808-1401

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ABSTRACT: Theoretical formalisms for the homogenization of particulate composites are identified as following either the direct scattering approach (DSA) or the indirect scattering approach (ISA). Both approaches can take inclusion size dependence and distribution statistics into account. However, the DSA is generally limited to media with direction-independent constitutive properties and inclusions with simple shapes, but the ISA is not hobbled in this manner. © 2000 John Wiley & Sons, Inc. Microwave Opt Technol Lett 25: 53–56, 2000.