Folded Reflectarray Antennas Based on Diagonal Slots Patches

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***Abstract*—Folded reflectarray antennas can provide a good solution for millimeter-wave systems requiring compact, low-cost antennas, e.g. in automotive applications. A rectangular patch with diagonal slots in the edges is investigated and found to present a phase angle range of more than 460˚ due to the two resonances. The novel antenna achieves higher gain and better performance, compared to a reflectarray with simple rectangular elements.**

Keywords—antennas, folded reflectarray, planar arrays, diagonal slots patch

I. INTRODUCTION

A typical printed reflectarray element consists of a dielectric substrate with printed metal rectangular patches. These elements adjust the reflection phase simply by their geometry. Simple rectangular elements suffer from a small phase angle range of only 300˚… 320˚, which may increase the phase error and affects the antenna performance. The modified antennas demand an extended phase range and a flatter phase angle behavior. This problem can be overcome by dual- or triple-layer reflectarrays [1], but suffering from their increased fabrication effort and cost.

In this paper, coupled resonators on a single layer are used to structures where phase angles can be adjusted independently for the two polarizations to finally allow a 180˚ phase shift between reflected waves in the two orthogonal polarizations, and consequently realizing a 90˚ polarization twisting necessary for folded reflectarray antennas [2]. A novel single-layer diagonal slots antenna with two resonances and extended reflection phase angle range is proposed.

II. NOVEL REFLECTOR ELEMENT

A rectangular patch with diagonal slots in the edges is investigated; one quarter of the double symmetric structure is shown in Fig. 1. The elements are printed on an RT Duroid 5880 substrate (ε_r= 2.22, substrate thickness h= 0.508 mm) with backside metallization.

The polarization is parallel to the outer edges of the metallization. The design frequency is 76.5 GHz; the cell size is 2.5 mm×2.5 mm; w= 0.2 mm. l_x= 0.363 Lx and l_y= 0.363 Ly.

The curved surface of the reflection phase angle versus the element change in two dimensions is shown in Figure 2 and the angle ranges is more than 360˚.

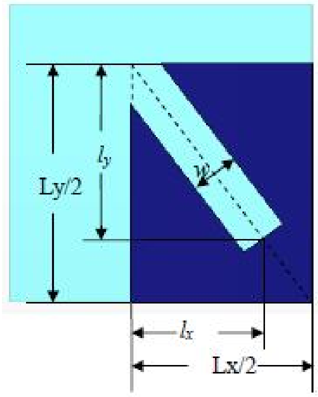

Fig. 1: Sketch of one quarter of the element with diagonal slots in the corners.

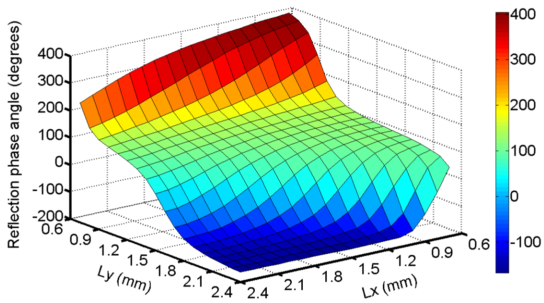

Fig. 2: Phase angle behavior of the diagonal slots antenna at 76.5 GHz.

As seen, the reflection phase angles of the dipoles mainly depend on the patch length Ly. In this paper, a square cell is typically used; then, the reflection properties for the orthogonal polarization can be obtained by interchanging Lx and Ly. After including some minor corrections of the element geometry, the reflectarray can be designed for mostly independent performance in the two polarizations.

III. TEST ANTENNA

The principle of a folded reflectarray antenna is shown in Fig. 3. To test the novel reflectarray structure, two antennas were designed for the frequency of 76.5GHz, built, and

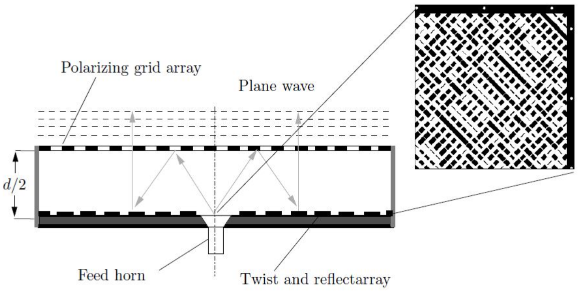

Fig. 3: Sketch of the folded reflectarray antenna showing part of the layout of a typical reflectarray (d= 52 mm).

Fig. 4: Photography of the novel reflectarray.

measured. One of the antennas is based on the novel structures as describe above (Fig. 4), the other one uses conventional rectangular patched [2].

The normalized radiation patterns of the diagonal slot antenna at 76.5 GHz are plotted in Fig. 5. The 3 dB beamwidth of the antenna in the E-plane is 3.29˚, and that in the H-plane 3.37˚. The sidelobe level in the E-plane is -25 dB, and that in the H-plane -28 dB..

Measured gain of the diagonal slot antenna and reference antenna are plotted in Figure 6. At the design frequency of 76.5 GHz, the gain of the diagonal slot antenna is 33.37 dB. The reference antenna gain at 76.5 GHz is 33.8 dB, which is its maximum gain, and the 3 dB bandwidth is 10 GHz. The relative bandwidth ratio is 13%. The maximum antenna gain of the diagonal slot antenna is 34 dB at 73 GHz, and the 3 dB bandwidth is 10.6 GHz. The relative bandwidth is 13.9%, which is slightly larger than that of the reference antenna.

The maximum gain of the diagonal slot antenna is higher than the rectangular antenna because of the large reflection phase angle range, which reduces the phase errors and the losses.

From Fig. 6, it can be seen that the diagonal slot antenna performs better in the lower frequency range; its gain is larger than that of the reference gain within the frequency range of 70…75.5 GHz.

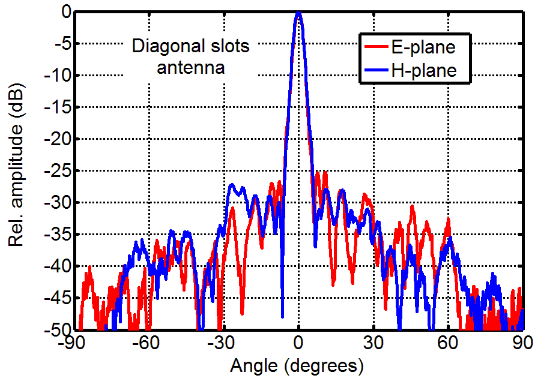

Fig. 5: E-plane and H-plane radiation diagrams of the diagonal slot antenna at 76.5 GHz.

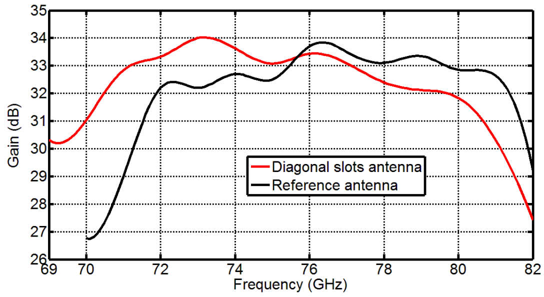

Fig. 6: Measured gain of the diagonal slot antenna and reference antenna.

IV. CONCLUSION

A rectangular patch with diagonal slots in the edges is investigated and found to present a phase angle range of more than 460˚ due to the two resonances. The diagonal slot antenna achieves a better performance compared with the reference one, especially in the lower frequency range. The bandwidth is 10.6 GHz, and the gain of the diagonal slot antenna is 33.37 dB at 76.5 GHz. For the following work, the folded reflectarray antenna principle can be extended to the operation at two separated frequencies [3].

REFERENCES

[1] Maysoun Al-Tikriti, "Multifunction quai-planar antennas," Dissertation, University of Ulm, Sep.2005

[2] W. Menzel, D. Pilz, and M. Al-Tikriti, "MM-Wave Folded Reflector Antennas with High Gain, Low Loss, and Low Profile," *IEEE AP Magazine*, June 2002, pp. 24-29

[3] Jinjing Ren, and Wolfgang Menzel, "Daul-Frequency Folded Reflectarray Antenna," *IEEE AWPL*, vol. 12, 2013, pp. 1216-1219