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A Common Aperture, Dual Frequency Printed Antenna (900 MHz and 60 GHz)

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This paper presents the combination of a microstrip patch antenna at 900 GHz and a folded reflector antenna in the 60 GHz frequency range integrated in a common aperture. To this extent, the 60 GHz antenna radiates through a grid integrated in the patch of the microstrip antenna.

Introduction: Mobile communication systems work in the lower GHz range (0.9 GHz, 1.8 GHz), while tie lines to the base stations often are realized in the mm-wave range. This paper presents a possible combination of antennas for the 900 MHz and the 58/61 GHz range in a common aperture. This enables a very compact realization of dual frequency systems, e.g. small base stations mounted at some building wall in a densely populated urban scenario. A reduced elevation beamwidth of the 900 MHz antenna can easily be achieved by placing further antenna elements (without integrated mm-wave antenna) below or above the antenna configuration described here.

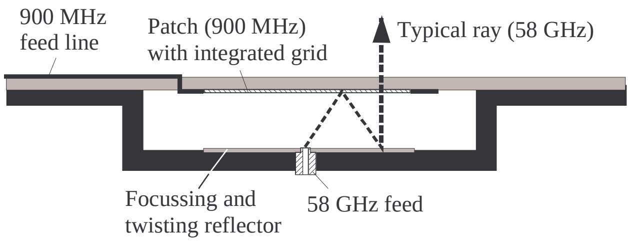

Fig. 1: Set-up of the dual frequency antenna.

Setup of the dual frequency antenna: The 900 MHz antenna is realized as a microstrip patch antenna over a low profile metal box, while the mm-wave antenna is integrated with this lower frequency antenna in the form of a folded reflector antenna [1], [2]. The basic setup of this antenna configuration is shown in Fig. 1, together with a typical "ray" of the high gain 60 GHz antenna.

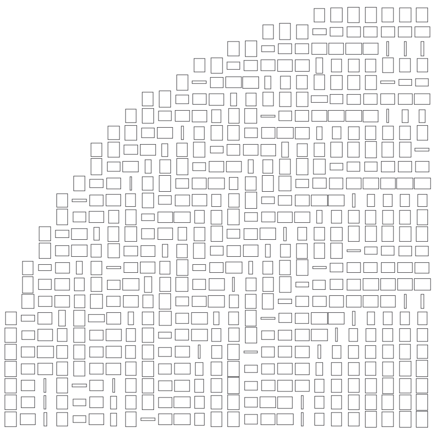

Fig. 2: Layout (one quarter) of the 60 GHz focussing and reflecting array (reflector diameter 100 mm).

The 900 MHz patch (130 mm × 130 mm) is placed on an inverted substrate (ε_r = 2.33, h = 1.58 mm), acting at the same time as radom. The substrate is placed on top of a resonator box with air as dielectric (25 mm depth). The patch antenna is designed in a standard way using conventional CAD and MoM methods [3]. As the current on the patch is concentrated mostly at the edges, a grid structure (diameter 100 mm) easily can be incorporated into the patch metallization, acting as polarizing grid for the mm-wave antenna. A thin reflector substrate (ε_r = 2.22, h = 0.254 mm) with a special metallization pattern for the 60 GHz antenna (Fig. 2) is placed onto the ground plane of the antenna box of the patch antenna. The principal function of the folded reflector antenna is indicated in Fig. 1. The electric field of the feed radiation is polarized is such a way that it is reflected by the printed grid integrated in the low frequency patch. Following this, the wave is incident on the lower substrate with an array of printed dipoles (Fig. 2). The dipoles are tilted by 45° with respect to the incident electric field. The field can be decomposed into components parallel to the axes of the dipoles. The geometrical dimensions of the dipoles are designed in such a way that, on the one hand, a phase difference of 180° occurs between the two components of the reflected wave, leading to a twisting of the polarization of the reflected wave by 90°. Such a twisting performance can be achieved by a large number of combinations of length and width of the dipoles, differing only by the absolute reflection phase angle. This overall phase shift is adjusted according to the focussing requirements. The original design of this antenna is done on the basis of periodic structures using spectral domain calculations.

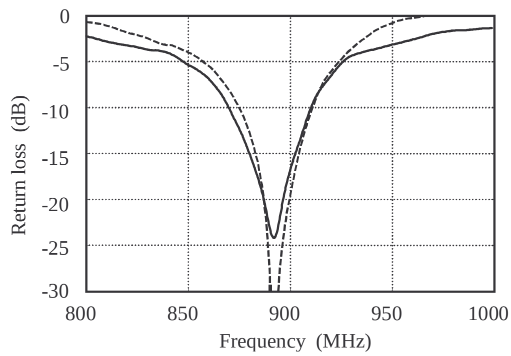

Fig. 3: Return loss of the 900 MHz patch antenna. Solid line: with integrated 58 GHz antenna; dashed line: 900 MHz patch antenna alone.

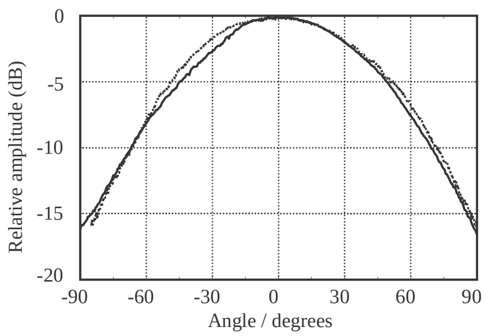

Fig. 4: E-plane antenna radiation diagram of the 900 MHz antenna. Solid line: with integrated mm-wave antenna; dashed line: 900 MHz patch antenna alone.

Results: The patch antenna without grid was originally designed and matched for 900 MHz and tested both for return loss and radiation diagram. In a second step, the grid as well as the reflector substrate and the 60 GHz feed were integrated, and the measurements were repeated. Fig. 3 shows the return loss of the patch antenna without and with integrated grid. Except for the depth of the matching curve, only small differences can be stated. Bandwidth at –10 dB return loss is about 40 MHz (4.5 %) which certainly could be improved by a modified matching circuit. Hardly any influence can be seen with respect to the E-plane radiation diagrams at 900 MHz (Fig. 4); similar results are found for the H-plane diagram. As expected, the typical diagrams of a single patch result.

Radiation diagrams of the mm-wave antenna are plotted in Fig. 5 for 61 GHz, a band for ISM (industrial, scientific and medical) applications and the original design frequency of the folded reflector antenna, and in Fig. 6 for the 58 GHz communication band. Beamwidths are 3.2° and 3.4° in E- and H-plane, respectively. Sidelobe level in both planes is better than –20 dB for 58 GHz and around -24 dB for 61 GHz. Gain has been measured in the 55 GHz to 64 GHz frequency range. Maximum gain is around 34 dB in the 60 GHz to 62 GHz frequency range, and still 32 dB at 58 GHz. The 3 dB gain bandwidth amounts to 7.2 GHz.

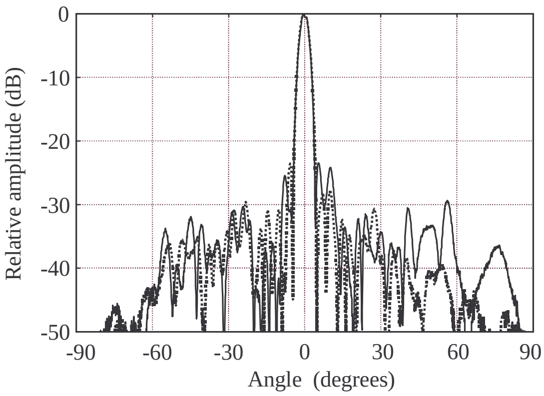

Fig. 5: E- and H-plane radiation diagrams of the integrated folded reflector antenna at 61 GHz.

(solid line: E-plane, dotted line: H-Plane).

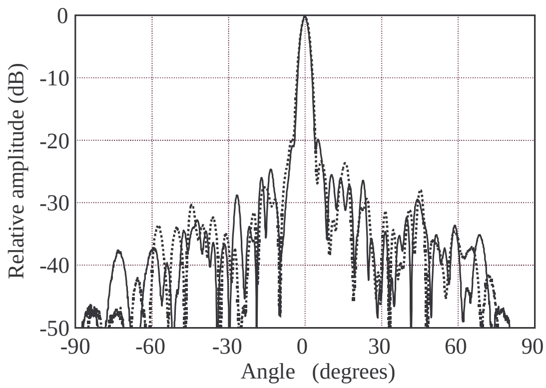

Fig. 6: E- and H-plane radiation diagrams of the integrated folded reflector antenna at 58 GHz.
(solid line: E-plane, dotted line: H-Plane).

Conclusion: This presentation has demonstrated the design of a dual frequency antenna, covering both the mobile communication frequency band around 900 MHz and the communication band at 58 GHz together with the ISM band around 61 GHz. The 900 MHz antenna is based on a resonator backed microstrip patch antenna, while the mm-wave antenna consists of a folded reflector antenna with a polarizing grid integrated into the antenna patch and a twisting and focussing planar reflector placed onto the bottom of the 900 MHz antenna box. Both antennas show excellent performance.

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[2] Pilz, D., Menzel, W.: Printed Millimeter-Wave Reflectarrays. Annales de Telecommunications, Vol. 56 (2001), No. 1-2, pp. 2-11.

[3] Momentum in HP-ADS.