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# Design of 8 × 8 Slot Array Antenna based on Inverted Microstrip Gap Waveguide

Jinlin Liu, Abbas Vosoogh, Ashraf Uz Zaman and Per-Simon Kildal
Department of Signals and Systems, Chalmers University of Technology, Gothenburg, Sweden
*Jinlin.Liu, Abbas.Vosoogh, Zaman, Per − Simon.Kildal@chalmers.se*

***Abstract*—In this paper we present the design of a high efficiency corporate-fed 8 × 8 slots array antenna in the 60-GHz band. The antenna is built using four unconnected layers — bed of nails, which works as Artificial Magnetic Conductor (AMC), PCB microstrip feeding networks, groove waveguide cavity and radiation slots layer on the top. The designed antenna shows a relative bandwidth of 14.63% with input reflection coefficient better than -15 dB and an overall efficiency larger than 70% with about 26.5 dBi simulated gain between 57 and 66 GHz.**

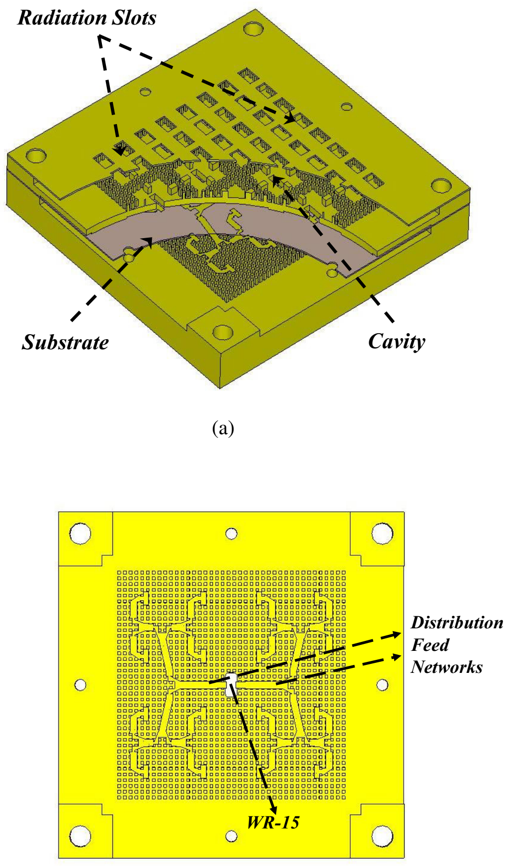
***Index Terms* – Artificial Magnetic Conductor (AMC), gap waveguide, high efficiency, millimeter wave, slot array antenna.**

## I. INTRODUCTION

Gap waveguide technology is a low-loss new type of waveguide which was theoretically introduced in [1]. The structure can be treated as an oversized parallel plate structure with a PEC layer and a PMC layer where a parallel frequency stopband has been created. This large stopband allows a quasi-TEM mode propagating over the frequency of interest within such parallel plate structure. Slot array antenna has been widely applied in radar communication systems at which high efficiency and high gain are required. The gap waveguide technology provides manufacturing advantages for multi-layer structures in particular at millimeter waves as no electrical contact is required among the antenna layers [2]-[5]. In this paper an 8 × 8 slot array antenna based on inverted microstrip gap waveguide is presented.

## II. ANTENNA CONFIGURATION

The 8 × 8 slot array antenna is illustrated in 3-D view in Fig. 1. The structure briefly consists of four layers. The top layer contains 64 radiating slots. These radiating slots are backed by an air filled cavity which are locating at the middle layer. Below the cavity layer there is a PCB containing the distribution networks, which have been designed by using the inverted microstrip gap waveguide. Below the PCB, there is a bottom metal layer with a uniform grid of pins. The coupling between the cavity layer and the feed networks is obtained by using a rectangular coupling slot at the center of the metal layer. The radiating slots are uniformly spaced in both $x$ and $y$ directions. Their distances are kept less than one wavelength in order to minimize the grating lobe level. The size of the radiating slots is 2.5 × 1.5 $mm^2$ and the distances between every two slots in $x$ and $y$ directions are 4 $mm$. The whole structure has the dimentions of 32 × 32 $mm^2$ in both E- and H-planes respectively. The pin dimensions in both metal plate and backed cavity have the same dimensions of 0.4 × 0.4 × 1.2 $mm^3$. The period of pins has kept 0.8 $mm$ in both E- and H-planes respectively. The air gap between substrate and



(a)

(b)

Fig. 1. Configuration for 8 × 8 slots array antenna. (a) 3-D view for the structure. (b) WR-15 interface view and distribution feed networks.

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metallic lid is chosen equal to 0.25 $mm$. Roger 4003 with the thickness of 0.2 $mm$ is utilized as the substrate for inverted microstrip feed line.

## III. SIMULATION RESULTS

In numerical simulation, the slot antenna array is excited by WR-15 standard waveguide at the bottom of whole structure. The simulated reflection coefficient of the designed whole structure is shown in Fig. 2. We observe that $S_{11}$ is below -15 dB over the frequency range 57 - 66 GHz. Simulated far-field patterns of the array antenna over the operating bandwidth at 57 - 66 GHz are also presented in Fig. 3 and Fig. 4. We have observed that the grating lobe levels (GL) in E- and H-planes are below -17 dB and -20 dB respectively over the frequency range 57 - 66 GHz.

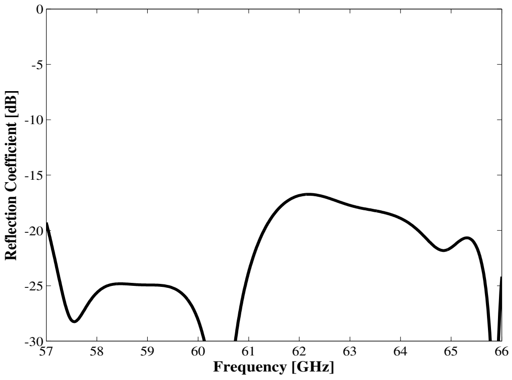

Fig. 2. Simulated reflection coefficient of proposed antenna structure.

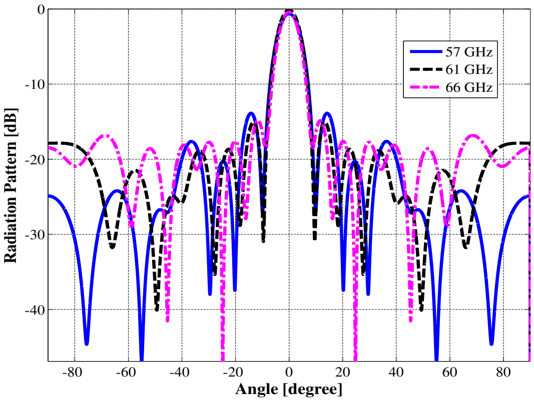

Fig. 3. Simulated E-plane patterns of proposed antenna.

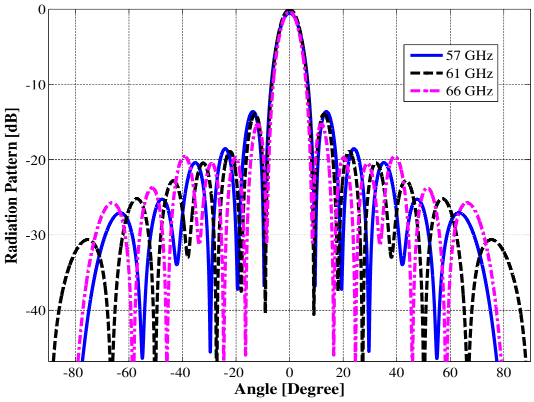

Fig. 4. Simulated H-plane patterns of proposed antenna.

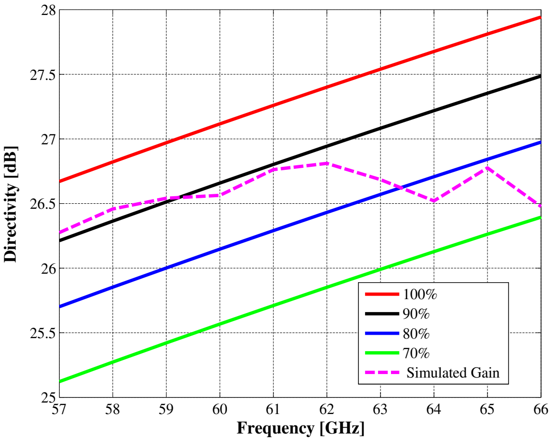

Fig. 5. Simulated gain of proposed antenna.

## IV. Conclusion

In this work we have numerically designed the radiating elements of a wide band planar slot array at 60 GHz. The inverted microstrip gap waveguide is utilized for the feeding. Full-wave simulated results show promising reflection coefficient, radiation pattern and gain. The proposed array antenna is possible to be a promising choice for 60 GHz applications.

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