# Millimeter Wave Wideband High Gain Antenna Based on Gap Waveguide Technology

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## Abstract

In this work, we present a wideband gap waveguide planar array antenna for millimeter wave point to point communication systems. The proposed antenna is designed using ridge gap waveguide technology and the design is based on the cavity-backed slots as the core radiating elements. There exists a coupling slot in the cavity layer which allows the excitation of the radiating slot elements using ridge gap waveguide feeding section. The designed antenna have 8×8 radiating slot elements and the antenna operate over 15% relative bandwidth from 50-67GHz frequency range with -11 dB reflection coefficient. The measured gain for the slot array is about 27 dBi at the center of the band.

## 1. Introduction

Emerging millimeter-wave applications such as high-resolution imaging, high-speed wireless data links, short-range radar and space applications will require novel antenna architectures with high gain and high efficiency. Waveguide slot array antennas are expected to provide high efficiency and high gain even at mm-Wave frequency range due to lower losses in antenna feed networks [1-2]. Waveguide slot array antennas can be series fed type or parallel fed type. Series-fed slot array antennas have simple geometry but suffer from narrow operational bandwidth due to long-line effect [3-4]. On the other hand, multiple layer cavity-backed slot array antennas can have higher efficiency as well as wider bandwidth. Antennas around 75-80% efficiency and 10% relative bandwidth have been described in [5-6]. But the key challenges with multi-layer antenna structure are high fabrication cost and manufacturing complexity to achieve good electrical contacts among the feed layer, cavity layer and radiating slot layer.

To overcome the problem of electrical joints and problems associated with mechanical assembly in waveguide splits, the gap waveguide technology can be employed successfully. The gap waveguide technology presented in [7-8] uses the cut-off of a PEC-PMC parallel-plate waveguide configuration to control desired electromagnetic propagation between the two parallel plates without the requirement of the electrical contact. This is quite advantageous for the mechanical assembling of mmWave antennas. Also, the Q-factor analysis confirms that the losses in ridge gap waveguide and groove gap waveguide structures are comparable to that of standard rectangular waveguide [9]. Therefore, the feed network losses will be quite low for gap waveguide antennas and the total efficiency of gap waveguide array antennas will be quite high. To date, several gap waveguide antennas have been manufactured at different frequency bands [10-12]. In this work, we present a wideband high gain gap waveguide antenna realized by ridge gap waveguide feeding network. This antenna has been designed at mmWave frequency range.

## 2. High gain wideband slot antenna array

Different configurations of gap waveguide structures are shown in fig.1.

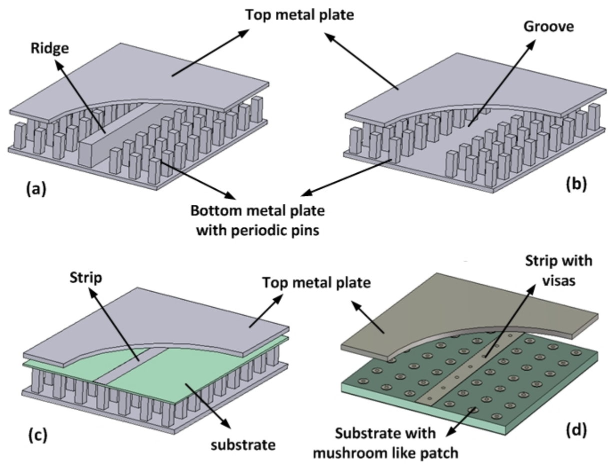


Fig. 1 Different Gap waveguide geometries: a) Ridge gap waveguide, b) Groove gap waveguide, c) Inverted- microstrip gap waveguide, d) Microstrip-ridge gap waveguide.

The intention of this work is to present wideband high gain antenna design based on ridge gap waveguide configuration. The subarray consisting of 2×2 slot element is shown in fig. 2. As shown in fig.2, the antenna subarray consists of cavity backed slot layer in which the cavity is excited by feed waveguide by means of a coupling slot. The size of the subarray is about $8\times8mm^2$. The feeding network for this antenna is designed based on ridge gap waveguide technology. The basic element of the feeding network is a 3-dB power divider which is similar to the one mentioned in [12]. Once the antenna subarray and the feeding network had been designed, the antenna design is completed and the whole 8×8 element slot array is simulated using CST microwave studio. After simulation, the whole antenna is manufactured and measured. The manufactured prototype of the complete 8×8 array is shown in fig.3. Fig. 4 and fig. 5 shows the measured $S_{11}$ result and the measured radiation patterns for the designed antenna in the two principle planes respectively. The measured gain for the 16×16 element slot array is also shown in fig.6. The obtained gain is more than 27 dBi with a measured efficiency higher than 80%.

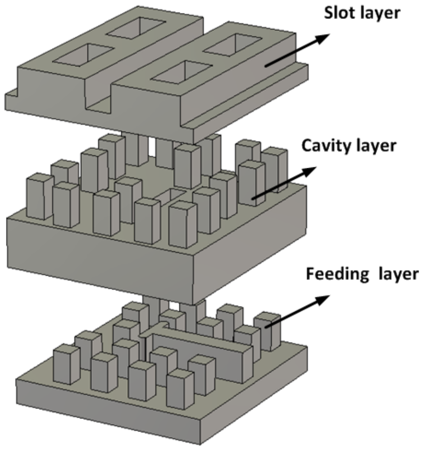


Fig.2 The schematics of the subarray used in the antenna design.

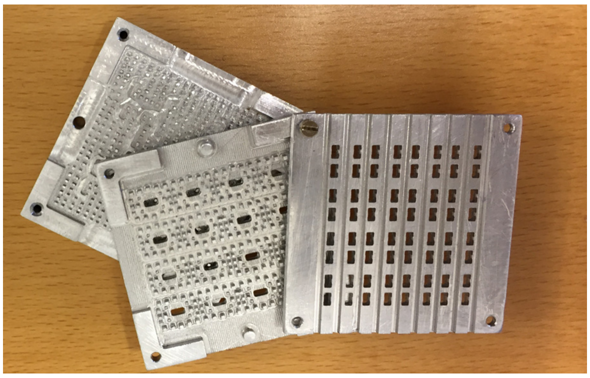

Fig.3 The picture of the prototype.

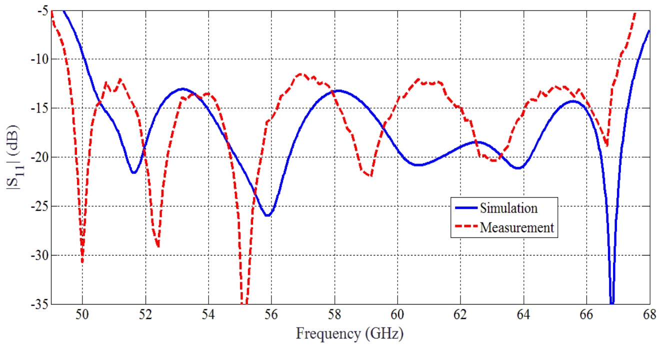


Fig.4 Measured and simulated $S_{11}$ for the complete antenna array.

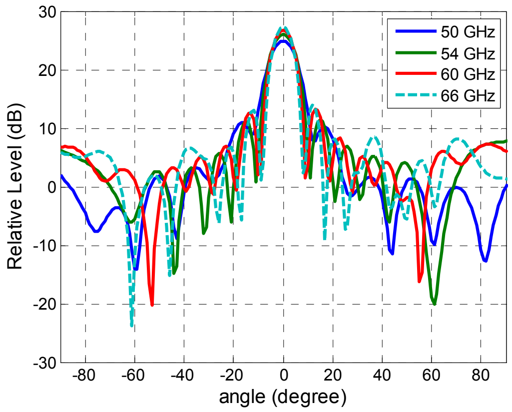


Fig.5 Measured H-plane patterns of the fabricated array at frequencies 50, 54,60 and 66 GHz.

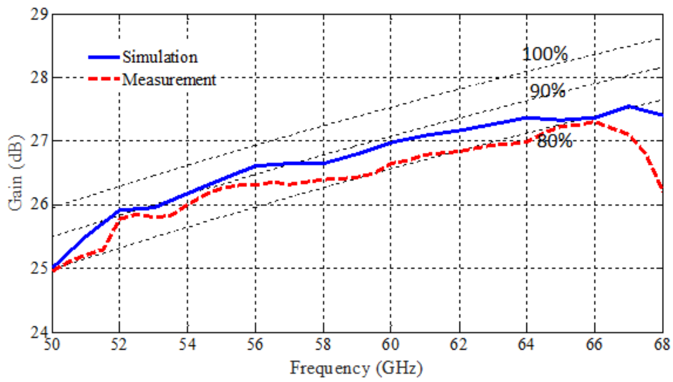


Fig.6 Measured gain vs frequency for the fabricated slot array antenna.

## 3. Conclusion

We present a multi-layer fixed beam slot array antenna design based on ridge gap waveguide technology in this work. The designed antenna has good impedance bandwidth and also good radiation patterns over the band of interest at 60GHz. The main feature of the gap waveguide antennas is the flexibility in mechanical assembly which will allow low cost manufacturing techniques to be used in slot array antenna manufacturing.

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