

# A Printed *H*-plane Horn Antenna with Loaded Dielectric-metal Composite Lens in Ka band

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**Abstract** - A printed *H*-plane horn antenna with loaded composite *E*-plane metal lens in Ka band is proposed and analyzed in this paper. The horn antenna is utilizing the Substrate Integrated Waveguide technique, which is fed by a balanced microstrip line. This antenna aperture is loaded with a series of metal-via arrays to achieve parallel metal surfaces with *E*-plane. The final Simulated results by CST Microwave Studio<sup>®</sup> indicate that the reflection coefficient of the antenna in 27.4-33.59GHz is lower than -10dB, the gain is 2.2dB higher than that of the antenna without the *E*-plane lens at 30GHz. This type of antenna can be widely used for antenna array in Ka band.

**Index Terms** — *E*-plane metal lens, *H*-plane horn antenna, Substrate Integrated Waveguide, printed antenna.

## 1. Introduction

With the rapid development of mobile communication, more and more requirements are put forward for the communication capacity, the traditional L/S band system is difficult to meet these requirements, and the operating frequency is extended to Ka band. In this frequency range, many new antenna design ideas are put forward, such as *H*-plane horn antenna based on Substrate Integrated Waveguide (SIW) [1-5]. This kind of antenna has the characteristics of small size and light weight, however, the gain is usually low. Therefore, the research on how to improve its gain has received extensive attention.

A printed *H*-plane horn antenna with loaded composite *E*-plane metal lens in Ka band is proposed and analyzed in this paper. The *E*-plane metal lens is achieved by a series of metal-via arrays which make the wave converge. Meanwhile, the antenna still has a wide bandwidth in the case of loading the lens, and its application scope has been expanded.

## 2. Structure of the Antenna

The structure schematic of the antenna is shown in fig. 1. The antenna consists of four components, including the lens part, *H*-plane horn antenna part, SIW part and balanced micro-strip line part, moreover, the lens part is composed of a series of metal-via arrays. The longitudinal length of the array is not smooth and all the dimensions are shown in fig. 1. It can be seen that the antenna is the type of double side printed circuit board with the thickness of the substrate  $h=5\text{mm}$  and the relative permittivity  $\epsilon_r=3.5$ .

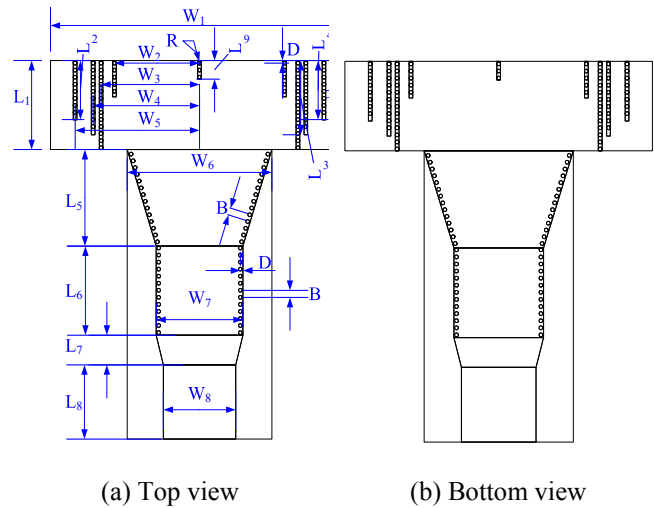
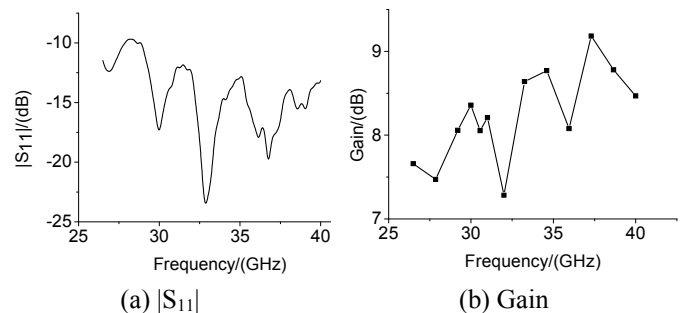


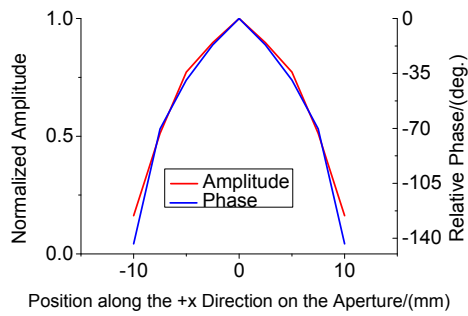
Fig. 1. Schematic diagram of antenna structure ( $W_1=41.2\text{mm}$ ,  $W_2=11.75\text{mm}$ ,  $W_3=13.60\text{mm}$ ,  $W_4=14.70\text{mm}$ ,  $W_5=17.20\text{mm}$ ,  $W_6=20\text{mm}$ ,  $W_7=1\text{mm}$ ,  $W_8=8\text{mm}$ ,  $L_1=12\text{mm}$ ,  $L_2=4.9\text{mm}$ ,  $L_3=8\text{mm}$ ,  $L_4=10\text{mm}$ ,  $L_5=13\text{mm}$ ,  $L_6=12\text{mm}$ ,  $L_7=4\text{mm}$ ,  $L_8=10\text{mm}$ ,  $L_9=2.5\text{mm}$ ,  $B=0.95\text{mm}$ ,  $R=0.25\text{mm}$ ,  $D=0.1\text{mm}$ )

## 3. Simulation and Analysis

### (1) Simulated Results of the *H*-plane Horn Antenna

The results in Fig. 2 are the simulated results of the antenna in Fig. 1, but without the lens. Similar to the literature, the gain is low. The simulated results of CST Microwave Studio<sup>®</sup> show that the antenna  $|S_{11}| < -10\text{dB}$  operating frequency range is 28.8-40GHz, with relative bandwidth 32.4%, and the gain is only 8.4dBi on typical operating frequency 30GHz as shown in Fig. 2. This is because the horn aperture size is small, and phase is non-uniform distribution on the aperture field.



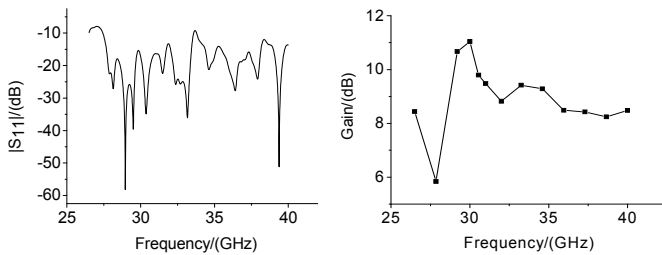


(c) Amplitude and Phase

Fig. 2. Simulated results of H-plane horn antenna

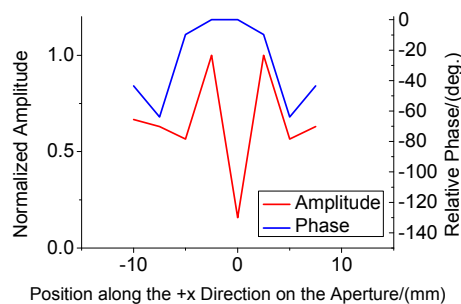
## (2) Simulated Results of H-plane Horn Antenna Loaded with E-plane Metal Lens

The results in Fig.3 are the simulated results of the antenna in Fig. 1, including  $|S_{11}|$ , gain, distribution of amplitude and phase on the aperture field and the radiation pattern. It can be seen that the antenna gain is significantly improved after loading lens. This can be analyzed from the distribution of amplitude and phase on the aperture field. After loading the lens, the distribution of amplitude and phase on the aperture field is more uniform. The utilization coefficient of the aperture can be significantly improved, so the gain is increased.

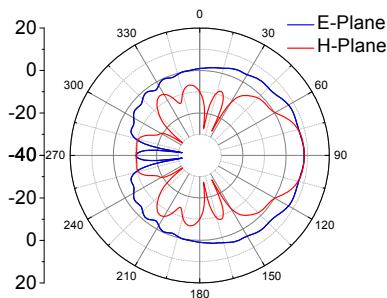


(a)  $|S_{11}|$

(b) Gain



(c) Amplitude and Phase



(d) Pattern

Fig. 3. Simulated Results of H-plane Horn Antenna Loaded with E-plane Metal Lens

The simulated results show that the relative bandwidth of the antenna is 37.4% and the gain is 11.0 dB at 30GHz. Compared with the horn antenna without load, the bandwidth is increased 5% and gain is increased by 2.2dB.

## 4. Conclusion

A novel printed H-plane horn antenna with loaded composite E-plane metal lens in Ka band is proposed. Compared with the horn antenna without lens, the antenna gain is significantly improved. The proposed antenna has a small size and a high gain, and can be used as array element of antenna array in Ka band.

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