Design of S band Cylindrical Waveguide Slot Omnidirectional Antenna

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Abstract—**This paper presents a cylindrical waveguide slot omnidirectional antenna. The antenna has a certain number of vertical slots cut in the surface of the cylindrical waveguide to form a slot array. The vertical slots are cut at equal length. The antenna has omnidirectional radiation characteristics in the E-plane, and "8" radiation characteristics approximately in H-plane. The test results show that the antenna has broadband characteristics and the amplitude changes in the E-plane under ripple ±1 dB in S-band. The antenna has been successfully applied to products and can be used as a communication and radar antenna, among other uses.**

Keywords- cylindrical waveguide slot array; omnidirectional; broadband; antenna.

I. INTRODUCTION

The forms of the slot antenna are varied [1]. Due to the characteristics of the waveguide field distribution, the position of a single slot antenna is more flexible than the dipole antenna. Using a simple excitation method, then the slot can generate radiation [2].

Usually, in order to enhance the direction of the slot antenna, a number of slots of equal size are cut in the cylindrical waveguide sidewall by following a certain rule [3]. This becomes a cylindrical waveguide slot array antenna.

The cylindrical waveguide slot array antenna has a good mechanical strength, compact structure, high radiation efficiency, corrosion resistance, is easy to produce and has a series of other advantages, as indicated in [4]. It is widely used in the radar, microwave communications and television broadcasting systems. The cylindrical waveguide slot antenna can be widely implemented in the L, S, C, X, and other bands of horizontal polarized antenna.

In this paper, the cylindrical waveguide slot antenna is made into S band omnidirectional antenna. The test results show the antenna has an omnidirectional radiation characteristic, its amplitude changes under ripple ±1 dB in the E-plane, and has "8" radiation characteristic approximately in H-plane. It also had broadband characteristics. The design has been successfully applied to the radar and communication antennas.

The rest of the paper is structured as follows. In Section 2, we describe how to design and simulate the antenna. In Section 3, we present the test results. We conclude the paper in Section 4.

II. DESIGN AND SIMULATION

The slot array antenna can be divided into resonant array (standing wave array) and non-resonant array (traveling wave array) [2]. In the case of the standing wave of the cylindrical waveguide slot array antenna, six to seven longitudinal slots are cut around the cylindrical waveguide. The diameter φ value of the cylindrical waveguide is chosen so that the distance between the adjacent slots is about λg/2 (λg is the waveguide wavelength).The length of each slot is about λ/2 (λ is the vacuum wavelength), and the width of each slot is 2~3mm.The terminal of cylindrical waveguide is placed with metallic board for short circuit; the board is about λg/2 from the center of the terminal slots [3]. An excitation probe is provided on one side of the center of each slot. The slots of the antenna array are then excited in equal phase [4]. The harmonic waves are stimulated in cylindrical waveguide, then radiate to the outside [5]. The maximum radiation direction is perpendicular to the cylindrical waveguide surface [6]. In this paper, each slot array had six longitudinal slots in a circumference of the cylindrical waveguide. In order to obtain a higher gain, two rows of slot arrays were cut in the cylindrical waveguide. The cylindrical waveguide slot antenna structure is shown in Figure 1 and the top view of the cylindrical waveguide slot antenna is shown in Figure 2.

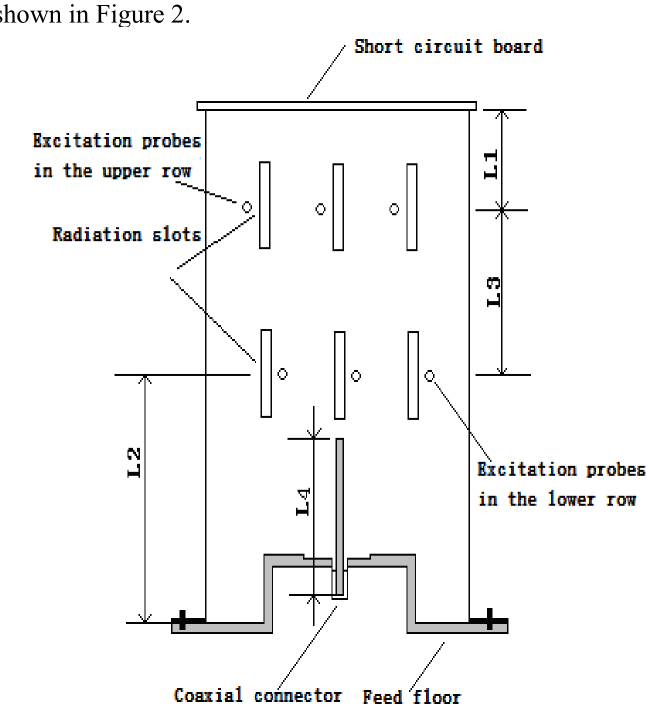

Figure 1. The cylindrical waveguide slots antenna structure diagram.

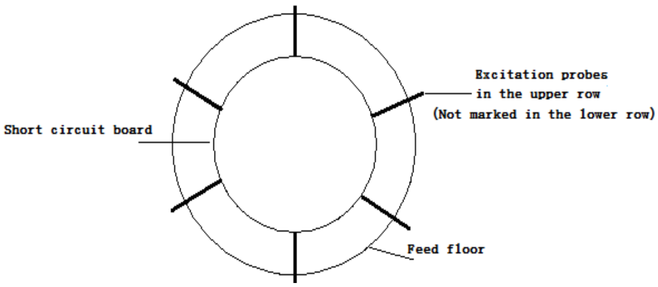

Figure 2. The cylindrical waveguide slot antenna from top view.

After the basic parameters of the antenna were calculated, the antenna was simulated and optimized by radio frequency simulation software, then given the cylindrical waveguide diameter φ= 100mm, L1 = 47mm, L2 = 143mm, L3 = 57mm, L4 = 51mm. The diameters of the probes were not obvious to the electrical performance of the antenna. The diameter of the probes was chosen to be 3mm in this paper. The experiments show that the length of the probes into the cylindrical waveguide were sensitive to the performance of the antenna. The lengths may be determined by debugging [7].

III. TEST RESULTS

The array antenna was manufactured using the above optimization calculation results. The test results showed that the lengths of the probes extending into the cylindrical waveguide had obvious influence on the performance of the antenna. The performance of the antenna was mainly changed in the standing wave and the azimuth amplitude. The changes are shown in Table I. After debugging, when the probes extended into the cylindrical waveguide with the length of 23 mm, the better electrical performance can be given. The curve of Voltage Standing Wave Ratio (VSWR) is shown in Figure 3. The far field radiation patterns of antenna in the high, medium and low frequency in E-plane, H-plane are shown in Figure 4. The antenna has omni-directional characteristic in the 360° range, its amplitude fluctuation of far field radiation pattern in E-plane does not exceed 1.9dB, and "8" radiation characteristic approximately in H-plane.

TABLE I. EFFECT OF THE LENGTH OF THE PROBE EXTENDING OUT OF THE WAVEGUIDE ON THE PERFORMANCE OF THE ANTENNA

Extending into length (mm)	The change of VSWR(Center frequency)	amplitude fluctuation in E-plane(Center frequency /dB)
15	1.36	4.2
18	1.45	3.0
23	1.52	1.9
27	1.89	1.7
30	2.21	1.5

From Table I, when the probes extended into the cylinder waveguide with the lengths of 23 mm, the values of electrical performance were better.

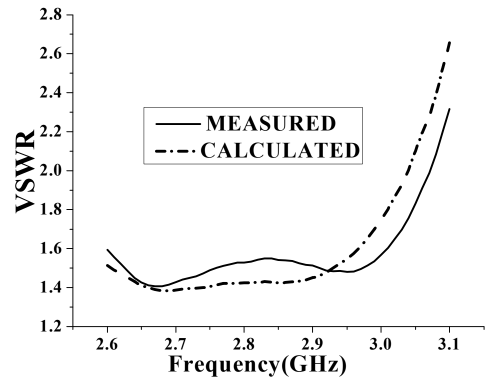

Figure 3. The curve of VSWR by measured and calculated

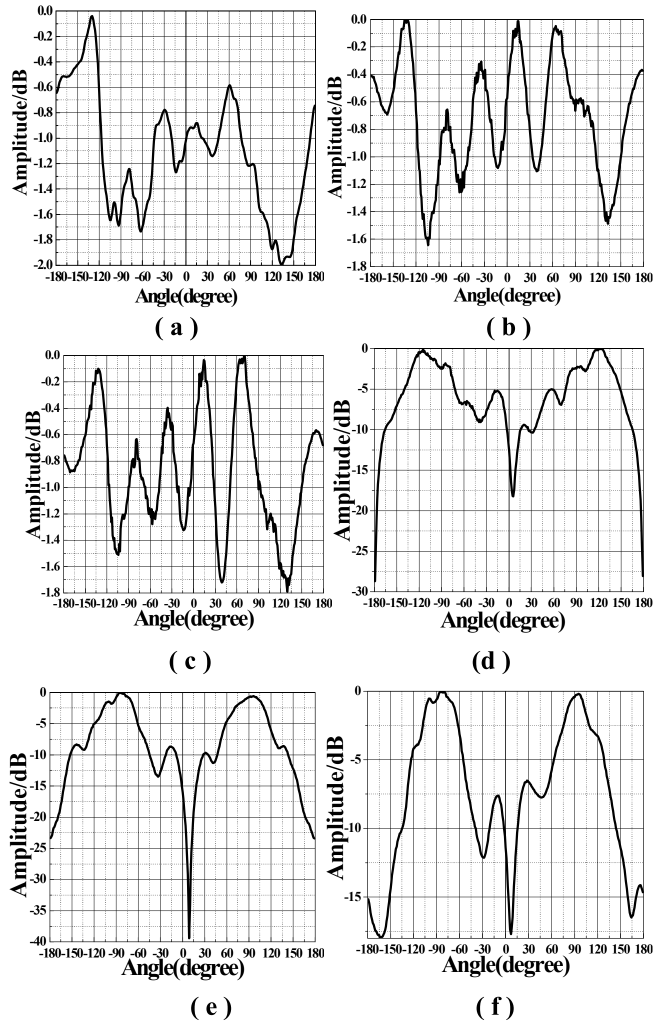

Figure 4. Measured radiation pattern.

(a) E-plane at 2.6GHz. (b) E-plane at 2.8GHz. (c) E-plane at 3.0GHz. (d) H-plane at 2.6GHz. (e) H-plane at 2.8GHz. (f) H-plane at 3.0GHz.

As seen in Figure 3, when the lengths of the probes in the cylinder waveguide were 23 mm, the values of VSWR were smaller. The value of VSWR can be less than 1.6 in 2.6 ~ 3.0 GHz frequency range.

IV. CONCLUSION

In this paper, an S band cylindrical waveguide slot omnidirectional antenna was presented. The antenna had an omnidirectional radiation characteristic in the E-plane and an "8" radiation characteristic approximately in H-plane. It had broadband characteristics and its amplitude changed under ripple ±1 dB in the E-plane. It can be used as communication and radar antenna.

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