An wideband single ridge waveguide-based slot antenna with low profile

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Abstract—This article designed an antenna slotted in the long side of single ridge waveguide, through the ridge waveguide-rectangular waveguide transition structure, it broads array's working frequency, Meanwhile, two in a line of ridge waveguide Chebyshev slit aperture distribution, reducing the antenna side-lobe level, also broadening the bandwidth. Single ridge waveguide slot antenna gains 17.7dBi in Center frequency, the relative bandwidth is about 6.4% below VSWR of 2 and the 2 * 8 designed antenna array has 500MHz bandwidth below VSWR of 1.5, it gains 27.18dBi in Center frequency, Chebyshev aperture distribution direction side-lobe level is -27dB structural dimensions is 388.36mm * 299mm*23mm. The antenna array has high gain, low profile, compact structure, low Side-lobe level, small size, ease of processing, which is suitable for portable satellite communication stations.

Keywords—*single ridge waveguide*;*wideband*;ridge waveguide-rectangular waveguide transition structure

I. Introduction

Waveguide slot antenna having a high aperture efficiency, low side-lobe level, whose aperture distribution is easy to control, which is more and more applied in radar and communications [1]. ridge waveguide TE10 mode's Cutoff wavelength is longer than the mode of rectangular waveguide, in the same cross-sectional dimension, ridge waveguide operating bandwidth is wider than the rectangular waveguide's bandwidth, while the more the number of slits on the ridge waveguide, the narrower the bandwidth is, the higher the gain is. In order to take into account the gain and bandwidth, select the appropriate number of slits is the key [2].

This article designs a 12 slots single ridge waveguide antenna, the relative bandwidth of 6.4% below the VSWR of 2, the 2 * 8 ridge waveguide slot array antenna gains more than 27.18dBi in the operating frequency band, whose VSWR is better than 1.5, the deputy lobe level is -27dB.Antenna array's feed network combined with the ridge waveguide - rectangular waveguide junction and T-shaped waveguide structure. it has a high gain, wide frequency band, low profile, low side-lobe level and easy to process.

II. Antenna design

1. Calculation of cutoff wavelength

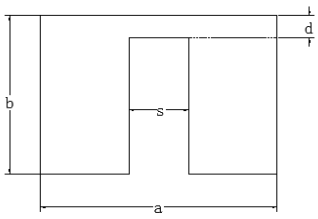
Engineering waveguide cutoff wavelength is calculated as follows:

where: λ is the wavelength of free space, λc *is* the cutoff wavelength, θ is the phase radian, dd for the length of the waveguide, θ is calculated as follows:

$$\vartheta = n\times\pi - \deg(S21)/180\times\pi \qquad \text{n=1,2,3....} \quad (1)$$

where: S21 is waveguide transmission coefficient ,n is the number of peaks transmitted in ridged waveguides. The cutoff wavelength is:

$$\lambda_c = \frac{\lambda}{\sqrt{1-\left(\frac{\lambda\times\vartheta}{2\pi\times dd}\right)^2}} \qquad (2)$$



Figures 1 section size of single ridge waveguide

Combined with HFSS electromagnetic simulation, and take appropriate positive integer n, obtained waveguide cutoff wavelength.

2. Waveguide-rectangular waveguide transition structure

Rectangular-ridge waveguide junction is a key factor affecting the antenna bandwidth[3]. Due to excessive waveguide discontinuity, there will be loss of bandwidth, How to solve the structure of the ridge waveguide to a rectangular waveguide, the issue has important engineering significance.

The article designs single ridge waveguide slot antenna, In the ridge waveguide transition to the rectangular waveguide ,at high ridge slope transition to zero, where both sides of the ridge of high shrink to zero size, rectangular waveguide to be transferred., The transition , a vertical semi-circular structure to rectangular waveguide feed network, to achieve a smooth rectangle - ridge waveguide transition, and array antenna combiner below the waveguide, reducing the surface area of the antenna, making full use of the space below.

3. Single-standing ridge waveguide slot antenna design

Require: single-standing ridge waveguide slot receiving antenna works in the Ku-band (12.25-12.75GHz), gain of 27dBi, the VSWR of pass-band is less than 1.5, structure size is smaller than 400mm * 400mm * 40mm, side-lobe level is less than - 25dB.

Single ridge waveguide dimensions a = 17mm, b = 7mm, s = 4.25mm, d = 1mm, the thickness of the waveguide aa = 1mm.

The single ridge waveguide dimensions combines HFSS simulation results, using engineering calculations obtains the ridge waveguide's wavelength is 25.1mm, the gap spacing is 12.55mm. One single ridge waveguide slot number is 12.

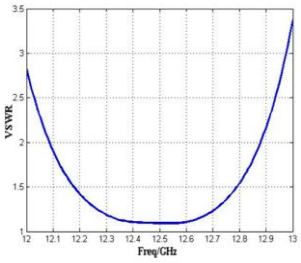
Each ridge waveguide slits in the long side, a total of 12 slits, two ridge waveguide arranges in a row, an interval of 1mm, Cut slits arranged to Chebyshev diameter distribution. Since the Chebyshev aperture distribution symmetrical, gives only one single ridge waveguide slot offset (offset) and the gap length (L), The other ridge waveguide slot parameters symmetrically.

Table 1 ,single ridge waveguide gap parameter table

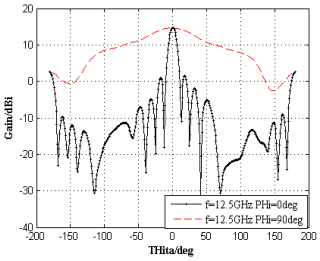
number	1	2	3	4	5	6
offset/mm	0.65	0.65	0.94	1.26	1.58	1.98
L/mm	11.76	11.76	11.80	11.86	12.00	12.02
number	7	8	9	10	11	12
offset/mm	2.24	2.38	2.46	2.48	2.52	2.61
L/mm	12.1	12.1	12.22	12.25	12.3	12.31

4. The simulation results

Single ridge waveguide slot antenna's simulation results are shown in Figures 2 and Figures 3. Single ridge waveguide slot antenna's relative bandwidth is 6.4% below VSWR of 2, The center frequency is 12.5GHz, Absolute bandwidth is 800MHz, Near the center frequency standing waves are desirable, Antenna gain at the center frequency is 13.7dBi, H-plane direction of the side-lobe level is -16dB, Pitch angle at 0 degrees gains maximum.



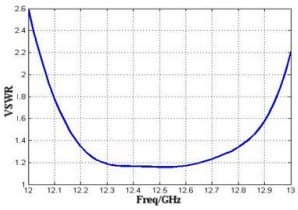
Figures 2 antenna's VSWR

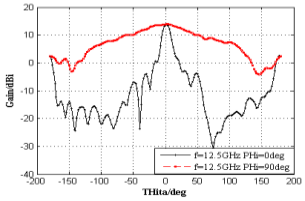


Figures3 antenna's pattern

Single ridge waveguide slot antenna with rectangular - ridge waveguide junction, the simulation results shown in Figure 4 and Figure 5. Single ridge waveguide slot antenna's relative bandwidth is 7.28% below VSWR of 2, The center frequency is 12.5GHz, Absolute bandwidth is 910MHz, Near

the center frequency standing waves are also desirable, Antenna gain at the center frequency is 13.6dBi, H-plane direction of the side-lobe level is -16dB, Pitch angle at 0 degrees gains maximum.





Figures 4 antenna's VSWR combined with rectangular-ridge

Figures 5 antenna's pattern with rectangular-ridge Waveguide junction

Single ridge waveguide slot antenna with rectangular-ridge waveguide junction increases 120MHz bandwidth, Gain almost unchanged, rectangular-ridge waveguide junction, in a certain extent, broaden the bandwidth, enabling broadband combiner.

2*8 single ridge waveguide slot array antenna model shown in Figure 6.

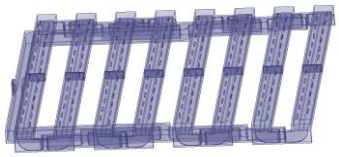
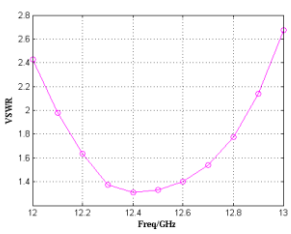


Figure 6 2*8 single ridge waveguide slot array antenna model

2x8 single ridge waveguide slot array antenna's simulation results is shown in Figures 7 and Figures 8,In the array's(12.25GHz-12.75GHz) pass-band ,VSWR <1.5. Antenna array at the center frequency of 12.5GHz gains 27.18dBi, H-plane direction of the side-lobe level is -27dB, E-plane direction of the side-lobe level is -13.5dB, Pitch angle at 0 degrees gains maximum.



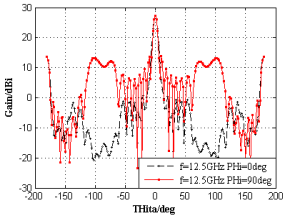


Figure 7 2x8 single ridge waveguide antenna's VSWR

Figure 8 2x8 single ridge antenna's pattern

2x8 single ridge waveguide slot array antenna's size is 388.36mm * 299mm * 23mm, The voids left is a 16*16 horn antenna array, Used as a receiving antenna, not described here. The entire transceiver antenna has compact structure, Low profile, easy conformal, gains more than 27dBi and easy process, which is suitable for portable satellite communication stations.

III. Conclusion

Based on the analysis of single ridge waveguide slot antenna characteristics, choice reasonable ridge waveguide size, Using MATLAB program, combined with HFSS electromagnetic simulation to determine the precise wavelength of ridge waveguide; The designed rectangular-ridge waveguide junction, transformed the ridge waveguide TE10 mode to rectangular waveguide mode smoothly. The simulation can be seen Rectangular-ridge waveguide junction, to some extent, expands working bandwidth. Through a T-junction power splitter to a road, the rational use of the space below the antenna array, reducing the surface area of the antenna. two in a line of ridge waveguide Chebyshev slit aperture distribution, reducing the antenna side-lobe level to -27dB. Slot array's intermediate space places a 16 * 16 horn antenna array, which is used as the transmitting antenna. Finally, the transceiver planar antenna has compact structure, low profile, high gain, low side-lobe level.

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