A Low Side-lobe Waveguide Antenna integrated with Solar cell Using Non-offset Slots

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Abstract

This paper proposes a ridge waveguide antenna integrated with solar cell using non-offset slots. This waveguide antenna has 8 radiation slots, each radiation slot is longitudinally arranged on the center line of the broad side of the waveguide without offset, and a metal pin is set on one side of the slot in the waveguide to excite electromagnetic wave radiation. Low sidelobe is achieved by adjusting the length of the metal pins. Two rectangle solar cells are arranged on both sides of the slots. The scanning VSWR of the antenna in the working frequency of 9.6GHz-9.8GHz is less than 1.7, the maximum gain is about 14.45dBi and the side-lobe level is less than-25dB. Moreover, the introduction of solar cells has little effect on the antenna performance.

Antenna Design

The simulated waveguide antenna is shown in Fig.1 and Fig.2. The metal pin is set on one side of the slot. The solar cells are arranged on both sides of the radiating slots of the ridge waveguide antenna. A matching conductor block is placed in the center of the waveguide to increase the bandwidth of the antenna. The feeding probe is attached below the matching conductor block. The thickness of the metal wall is 1.6mm. The entire monocrystalline silicon solar cell is composed of metal electrodes, N-P silicon layer and aluminum substrate. Moreover, we add 0.05mm of ethylene vinyl acetate (EVA) film to isolate the rear electrodes of the solar cell from the aluminum ground of the antenna. In the simulation, the N-P silicon layer was simplified to a silicon semiconductor. In order to reduce the impact of solar cells on the antenna, two rectangular blocks with a thickness of 0.5mm were dug out on both sides of the radiation slots to place the solar cells.

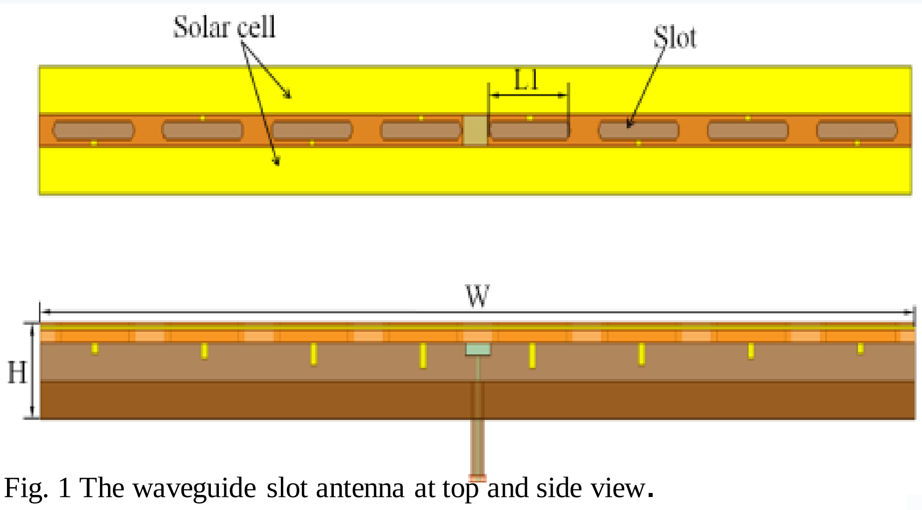

Fig. 1 The waveguide slot antenna at top and side view.

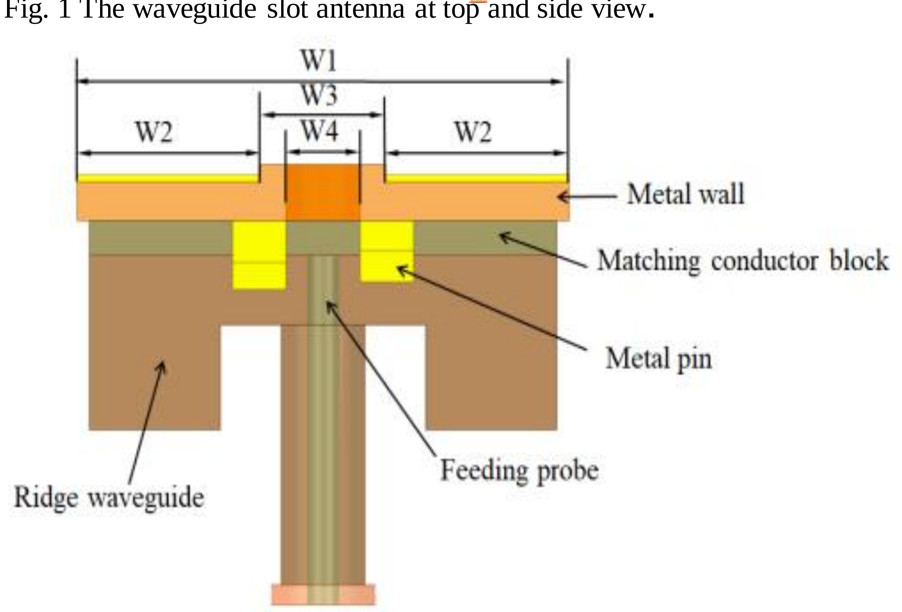

Fig. 2 Configuration of the waveguide slot antenna at front view

To ensure that the antenna has ± 30° scanning capability, a ridge is used to limit the width of the antenna. In order to obtain lower side-lobe, Taylor weighting is employed. Taylor's distribution is an effective method to obtain low side-lobe antennas. We used metal pins of different lengths to control the radiation field intensity of the radiation slot and achieved low side lobe. This approach not only ensures that the radiation slots are placed on the center line of the broad side of the waveguide, but also increases the coverage area of the solar cell.

The simulated scanning VSWR curves are shown in Fig. 3. The simulated scanning VSWR is less than 1.7 at 9.6GHz~9.8GHz. The scanning VSWR of the SCant and Ant were similar over the scanning angle range of ±30°. Further, the gain of the SCant and Ant at different frequencies is shown in Fig.4. . We have achieved a low side lobe of -25dB by adjusting the length of the metal pins. The detailed numerical values of the gain, half power beamwidth (HPBW) and sidelobe are summarized in Table I.

Results

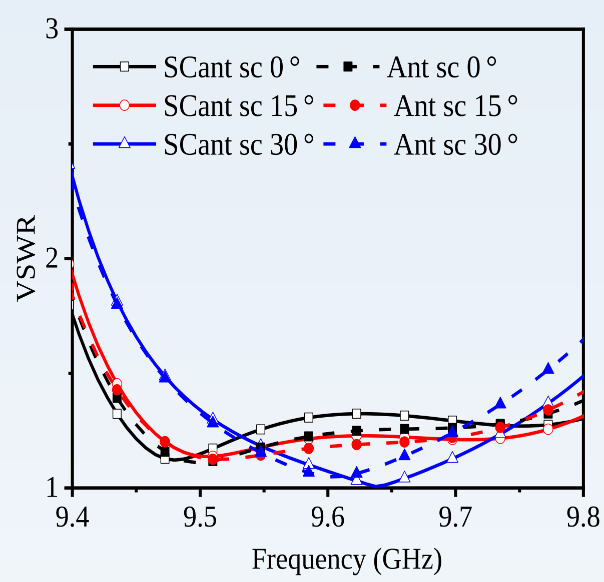

Fig. 3 The scanning VSWR of the SCant and Ant.

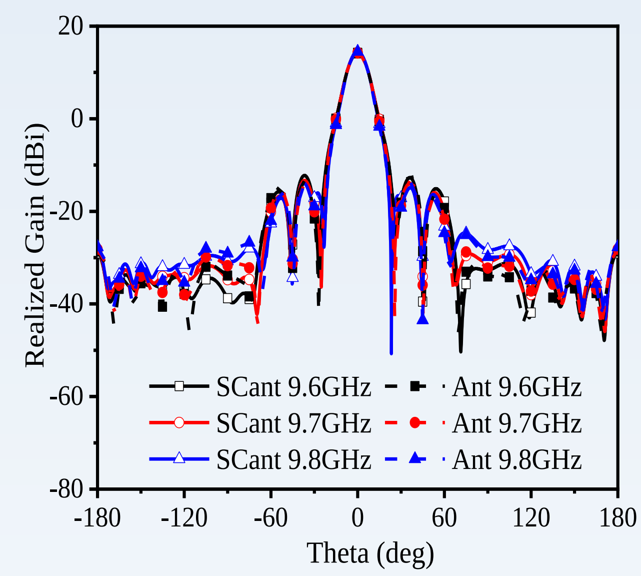

Fig. 4 The gain pattern of the SCant and Ant.

TABLE I. THE GAIN,SIDELOBE AND HPBW OF THE ANTENNA

Name	Frequency(GHz)	Gain(dBi)	HPBW(°)	SLL(dB)	
SCant	9.6	14.10	12.67	-26.08	-27.67
	9.7	14.20	12.53	-27.36	-28.81
	9.8	14.45	12.10	-28.27	-29.32
Ant	9.6	14.21	12.81	-26.82	-26.35
	9.7	14.30	12.67	-28.24	-27.53
	9.8	14.47	12.18	-29.31	-28.40

[a] SCant: the antenna with the solar cell, Ant: the antenna without the solar cell.

It is clear that the biggest gain of 19.45dBi is realized at 9.8GHz. The gain increases and the HPBW decreases when the frequency increases. The sidelobe of this antenna is less than-26dB. In addition, the simulation results of the Ant are also displayed. It can be seen that the gain of the Ant is 0.02dB higher than that of the SCant at 9.8GHz. The maximum gain difference is only 0.11dB at other frequencies, less than 0.2dB.The HPBW of the Ant is also almost the same as the SCant. The maximum sidelobe difference is 1.3dB at above frequencies, but the effect is not very large. It meets the antenna design requirements. It means the solar cell has little influence on the gain of the antenna. The proposed antenna well eliminates the influence of the solar cell on the electromagnetic performance of the ridge waveguide slot antenna.

Conclusion

In this paper, we have proposed a single ridge waveguide antenna with solar cell. Radiating elements consist of non-offset slots on the center of the waveguide and metal pins in the waveguide. Taylor weighting is employed to obtain lower side-lobe. It shows a wide working bandwidth and a good one-dimensional ±30° phase scanning capability. What's the more, the solar cell has little influence on the electromagnetic performance of the antenna. It is a good experiment in the waveguide slot antenna design, and may be beneficial for future engineering applications.