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High-Gain Slotted Waveguide Antennas for Wireless THz and Optical Fiber Front-Ends

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Abstract

We design slotted waveguide antennas and observe their characteristics for application in THz bands. The antenna consists of a rectangular waveguide, radiation slots, and a feeding port. By modifying the number of the radiation slots, the characteristics of the slot waveguide antenna become changed. The antenna gain of up to 17.5 dBi and a beamwidth of 1.8° can be achieved for an operational frequency of 300 GHz bands. The proposed antenna is promising for wireless THz and optical fiber front ends by integrating optical modulators or detectors.

1. Introduction

Research and development of the communication technology are always improved to meet the user demands, especially in the future, such as high-quality data with high-speed transfer [1]. Recently the beyond 5G technology is the hot issue to provide high bandwidth and low latency.

In order to establish the future 6G technology, several approaches can be used, one of them by considering high operational frequency in terahertz (THz) bands since it has large bandwidth [2,3]. However, the THz bands have large propagation loss in the metal cable and air medium. Considering this drawback, the combination of photonic and radio technology can be adopted since the optical fiber has extremely low propagation loss with lightwave as the carrier signal.

When the photonic and radio technology is adopted, the wireless THz and optical fiber front-ends are required by integrating between the THz antenna and optical modulator/ detector. Furthermore, the THz antenna should be designed with a high-gain and beam-steering controller [4].

Here, a slotted waveguide antenna is proposed for application in THz bands. High-gain and pencil-beam can be achieved by controlling a number of radiation slots. The detailed design and analysis of the proposed antenna are reported.

2. Antenna Design

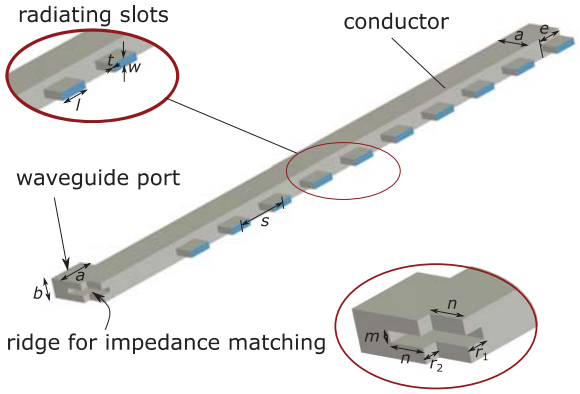

Figure 1. Basic structure of the proposed slotted waveguide antenna for THz applications.

Figure 1 shows the basic structure of the proposed slotted waveguide antenna. The design is based on the antenna published in [5] but with an additional number of radiating slots to see the tradeoffs between operation bandwidth and gain performance. The proposed antenna is designed using a rectangular metal conductor with a dimension of 1.728 mm x 0.434 mm. It consists of several radiating slots along the waveguide. Additionally, the slot waveguide antenna is connected to the D-band waveguide feeding port.

Table 1. Antenna design parameters

Parameter	Size (mm)
a	0.868
b	0.436
e	0.581
l	0.544
m	0.115
n	0.432
r_1	0.210
r_2	0.374
t	0.004

The proposed slotted waveguide antenna was designed for THz band of about 300 GHz using electromagnetic software analysis. The design parameters are shown in Table 1. The slotted waveguide antenna was designed with several slots to achieve high-gain performance and a narrow beam.

3. Results and Discussion

Figure 2 shows the simulated reflection coefficient of the designed slotted waveguide antenna for varying numbers of radiation slots. The designed slotted waveguide antenna has an effective operational frequency in 300 GHz bands. By changing the number of radiation slots, the operating bandwidth is changed. The bandwidth becomes narrow when the number of radiation slots is added. Additionally, good impedance matching can be achieved with the low number of radiation slots due to the coupling and propagation losses.

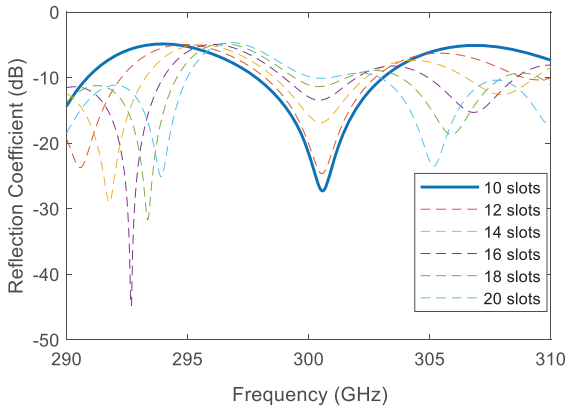

Figure 2. Simulated reflection coefficients of the antenna for varying numbers of radiation slots.

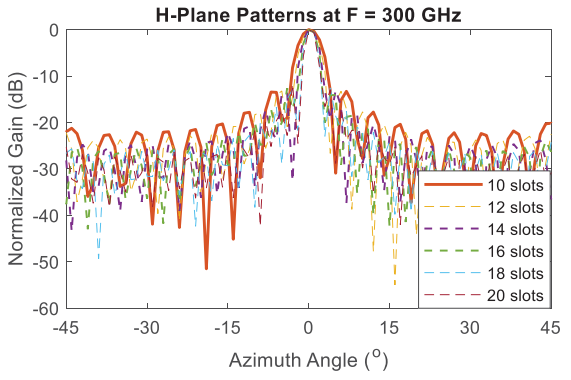

Figure 3. Simulated normalized radiation patterns at F = 300 GHz for various radiation slots.

Figure 3 shows the simulated normalized radiation patterns at 300 GHz operational frequency for varying radiation slots. We can see that the radiation patterns become narrow by increasing the number of radiation slots. Based on this, the designed slot waveguide antenna's calculated gain can be achieved up to 17.5 dBi.

Table 2. Antenna performance comparison with varying number of slots radiation

Total Slots	Bandwidth (GHz)	H-Plane Beamwidth (°)	Gain (dBi)
10	5.22	4.1	15.4
12	4.57	3.4	16.1
14	3.83	2.8	16.7
16	3.02	2.5	17.1
18	2.15	2.1	17.4
20	0.72	1.8	17.5

A summary comparison for varying numbers of the radiation slots is shown in Table 2.

4. Conclusion

The slotted waveguide antenna was proposed for wireless THz and optical fiber front ends. The proposed antenna was designed using electromagnetic software analysis and observed its characteristics in 300 GHz bands. The antenna bandwidth and impedance matching were observed by the simulated reflection coefficients. The antenna gain and beamwidth were analyzed by the simulated radiation patterns. The antenna gain of up to 17.5 and a beamwidth of 1.8° can be achieved for an operational frequency of 300 GHz bands. The proposed antenna is promising for wireless THz and optical fiber front ends by integrating optical modulators or detectors.

References

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