Gain Enhancement of 60-GHz SIW Cavity-Backed Slot Array Antenna with Metallic Grooves

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***Abstract* - In this paper, a 60-GHz substrate integrated waveguide (SIW) cavity-backed slot array antenna with metallic grooves is proposed. To feed the four slot antenna elements, SIW feed structure with microstrip to SIW transition is used. To account for the effect of an actual connector on the antenna performance, the simulation including the V-band connector model was carried out. The connector model was based on the datasheet from Southwest Microwave. The simulated 10-dB return loss bandwidth of the proposed antenna with connector is 440 MHz (59.85 – 60.29 GHz). To obtain high gian characteristic, 16 metallic grooves are used. By adding the grooves, the electric field is concentrated in +z direction. The broadside gains of the antenna with and without 16 grooves are 15.02 dBi and 4.87 dBi, respectively.**

***Index Terms* — 60-GHz, array antenna, SIW, slot antenna, gain enhancement.**

1. Introduction

Recently, various researches on the design of millimeter-wave antennas have been performed to realize the millimeter-wave communication technologies [1]. In millimeter-wave communications, the high gain characteristics should be obtained to compensate for the high path loss between transmitter and receiver. To obtain the high gain characteristic, an antenna array is commonly used. [2]. One of the major considerations in the design of the array antenna is proper configuration of the feed network.

In a millimeter-wave array antenna, the losses of the feed line and unwanted radiation components due to the feed structure can cause significant problems. Since the substrate integrated waveguide (SIW) feed network has advantages of low loss characteristic and minimizing unwanted radiation, it is more suitable than conventional microstrip feeding network in millimeter-wave applications. However, in a practical large array antenna environment, the SIW feed network is difficult to use because the design complexity is increased. In [3], 60-GHz 2 × 4 slot antenna array with SIW feed structures was proposed. However, it has a complex SIW feed structure to feed eight slot antennas and large antenna dimensions.

In this paper, a 60-GHz SIW cavity-backed slot array antenna is proposed. To feed the four slot antenna elements, SIW feed networks were used. Although four antenna elements were used in the proposed design, the high gain characteristic can be obtained by using the metallic corrugated grooves. To account for the effect of an actual connector on the antenna performance, the simulation including the V-band connector model was carried out.

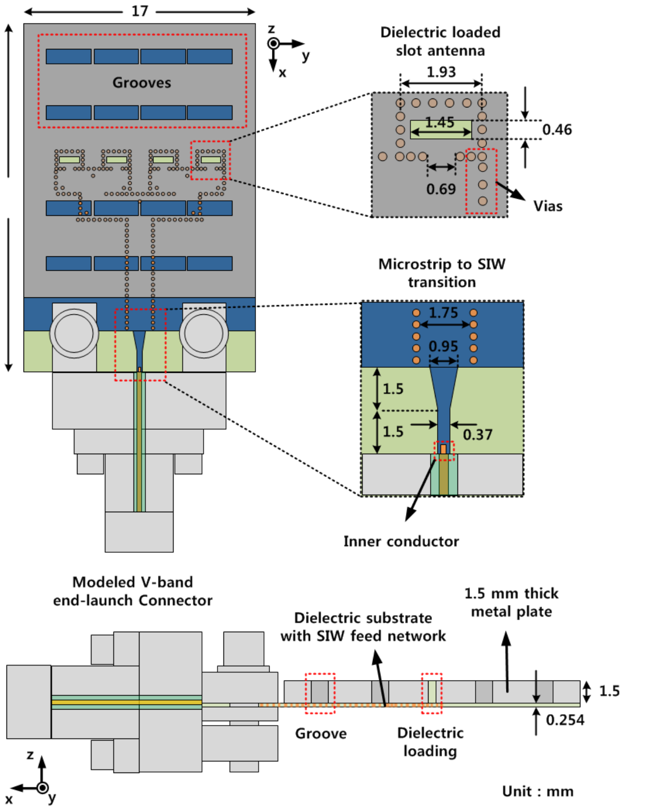


Fig. 1. Geometry of the proposed antenna.

2. Antenna Design and Results

Fig.1 shows the overall geometry of the proposed antenna. The antenna is fed by a modeled 1.85-mm end-launch connector with a microstrip to SIW transition. The connector model was based on the datasheet from Southwest Microwave for a 1.85-mm end-launch connector [4]. The antenna is composed of a SIW feed structure, dielectric-loaded cavity-backed slot antennas, and metallic grooves. The cavity-backed slot antennas are designed on Rogers RO3006 (ε_r = 6.15, tanδ = 0.0025) substrate with overall dimensions of 17 mm × 25.5 mm × 0.254 mm. The 1.5 mm thick metal plate placed on the RO3006 substrate has 16 grooves to enhance the gain characteristic and four dielectric loadings to reduce the size of the slot antenna. The energy excited by a V-band connector transfers to SIW feed structure and radiates through the four dielectric-loaded cavity-backed slot antennas.

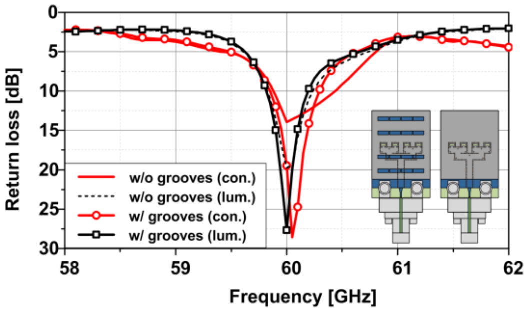


Fig. 2. Simulated return loss characteristics of the antenna with and without grooves.

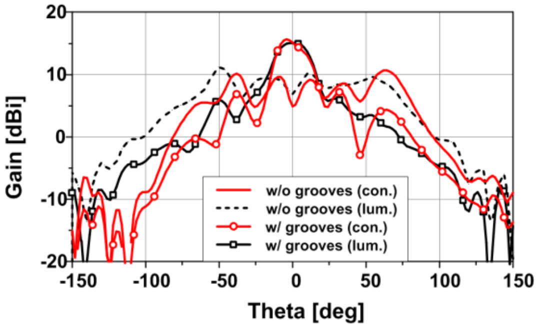


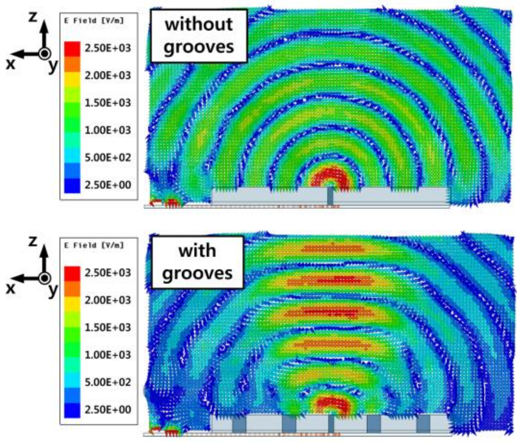
Fig. 3. Simulated radiation patterns of the antenna with and without grooves in xz-plane.

Fig. 2 and 3 show the comparison results of the antenna with and without grooves for lumped port excitation and connector model excitation. As shown in the Fig. 2, the resonant frequency of the antenna does not change significantly when the 16 grooves are added. The simulated 10-dB return loss bandwidth of the proposed antenna with connector excitation is 440 MHz (59.85 – 60.29 GHz). Fig. 3 shows the radiation patterns of the antenna with and without 16 grooves. The broadside gains of the antenna with and without 16 grooves are 15.02 dBi and 4.87 dBi, respectively. The 16 grooves thus improved the gain by 10.15 dB. In Fig. 3, the radiation distortion at around 65° is caused by a modeled connector. When the V-band connector is used in practical 60-GHz applications, the radiation distortion due to the metallic connector should be considered.

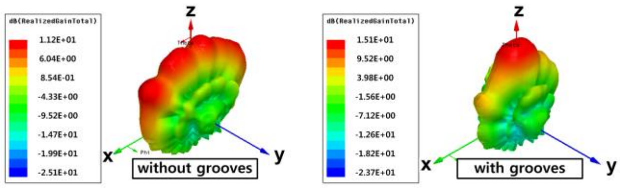
To clarify the radiation phenomenon of the proposed antenna, simulated electric field distributions and 3-D radiation patterns at 60 GHz for the antenna with and without 16 grooves are shown in Fig. 4. In Fig. 4(a), the electric field distributions in xz-plane of the antenna with and without grooves are compared. By adding the grooves, the electric field is concentrated in +z direction. Thus, the fan-beam pattern of the antenna without grooves is changed to the pencil-beam pattern as shown in Fig 4(b). As a result, the gain enhancement along the y-axis is obtained by four slot antenna array, whereas that along the x-axis is obtained by 16 grooves.

3. Conclusion

In this paper, a 60-GHz SIW cavity-backed slot array anten na with metallic grooves is proposed. The proposed antenna has a high gain of 15.02 dBi in broadside direction for millimeter wave communications. The four slot antenna elements are fed by a modeled V-band connector and SIW feed structure. By adding the 16 grooves, the gain enhancement of 10.15 dB is obtained. The proposed antenna could be a good candidate for the millimeter-wave applications



(a)



(b)

Fig. 4. Simulated E-field distributions and 3-D radiation patterns at 60-GHz for the antenna with and without 16 grooves (a) E-field distributions in xz-plane, (b) 3-D radiation patterns.

Acknowledgment

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (No. 2017R1A2B4002811).

References

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