A Via-Less EBG Horn Antenna

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Abstract

In this paper we present a compact horn antenna that incorporates Electromagnetic Band Gap (EBG) and horn antenna principles. An EBG structure is used as a medium to guide an electromagnetic wave within the substrate, instead of providing a border for the waveguide. The structure consists of a series of periodic holes drilled within the substrate that is bounded on the top and bottom by metallic layers, where no metallic via has been used. The resulting antenna is only 1.575 mm thick and achieves a 7.2 dBi peak gain.

1. Introduction

Recently, Electromagnetic Band Gap (EBG) structures have been applied to antennas for various innovative antenna designs. One typical application includes embedding a periodic structure into the ground plane [1] for wire antenna size reduction. Periodic metallic EBG structures have also been used to form substrate integrated waveguides [2], to form rectangular coaxial cables [3], or even horn antennas using a woodpile structure [4].

EBG structures can be applied to substrate integrated horn antennas for size reduction as will be discussed in the following sections. Traditional horn antenna designs are typically large and bulky at lower frequencies since they must make use of thick metallic walls as supporting structures. To resolve this problem, a new approach is proposed in this paper. We apply the use of a two dimensional EBG structure embedded into a 1.575 mm thick Rogers 5880 substrate by drilling holes into the substrate and covering the holes with a metallic conducting layer, as shown in Fig. 1. The proposed structure is described in Section 2.

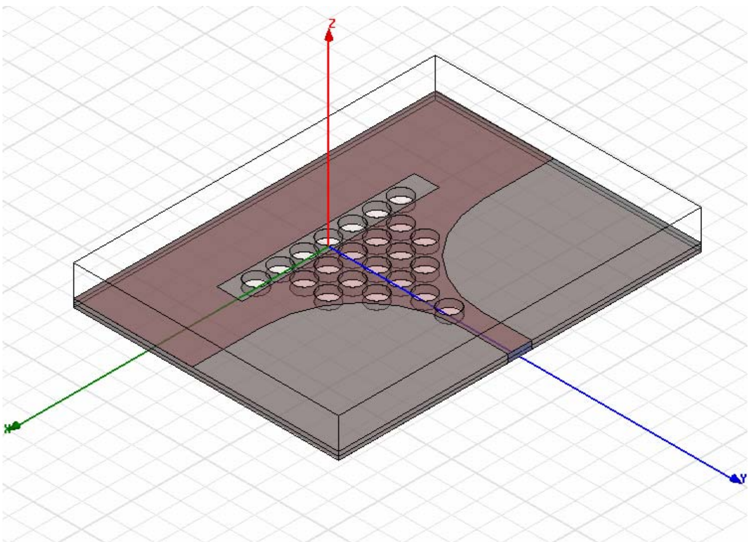

Fig. 1. A via-less substrate integrated horn antenna structure

2. Antenna Structure

The proposed structure is shown in Fig. 1. A regular microstrip line slowly tapers into the top metallic layer which covers a triangular EBG structure. The EBG structure itself consists of holes drilled into the substrate in a square periodic pattern. This EBG structure does not require any metallic vias as opposed to [5] or [2], where metallic vias are necessary. The structure then leads to a slot in the top metallic layer that forms the mouth of the horn, as discussed in [5]. Placing the aperture of the horn broadside to the substrate avoids the need for any metallic plates [6], caps [7], or other devices, while maintaining a compact size. Other advantages and disadvantages of this technique are discussed in [5].

For the antenna discussed here, the EBG structure serves to reduce the effective dielectric constant of the substrate to improve radiation efficiency, as well as aiding the wave propagation, as discussed in [8]. In Fig. 1, the proposed antenna structure is shown using a single substrate (Rogers 5880, $\varepsilon r = 2.2$, t = 1.575 mm, total dimension = 5.4 cm × 7.4 cm × 1.575 mm).

3. Simulation Results

The internal electric field pattern, return loss and radiation patterns were found using the commercial software HFSS [9]. In Fig. 2 we have plotted the electric field pattern within the substrate. This is done to verify that the flow of energy from the microstrip line to the aperture is consistent with a horn antenna design.

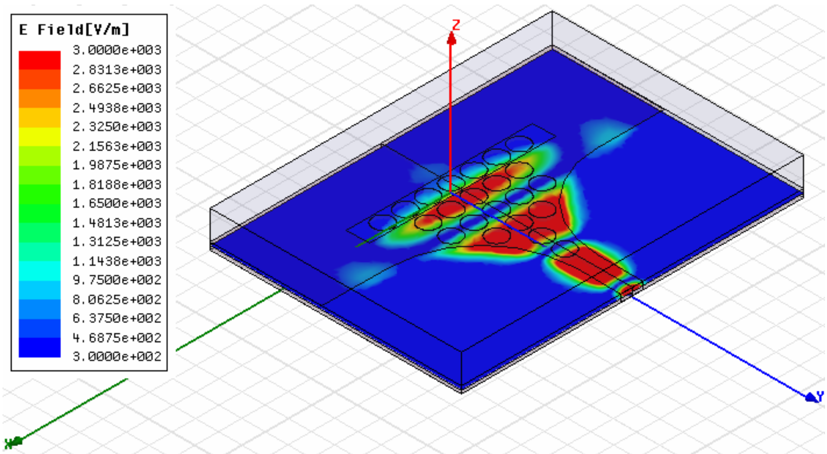

Fig. 2. Electric field pattern within the substrate for the via-less substrate integrated horn antenna.

In Fig. 3. we have plotted the return loss of the antenna. The simulated 10 dB bandwidth is approximately 14 % at 8 GHz. The bandwidth may be improved in future designs, however, is very useable in this case.

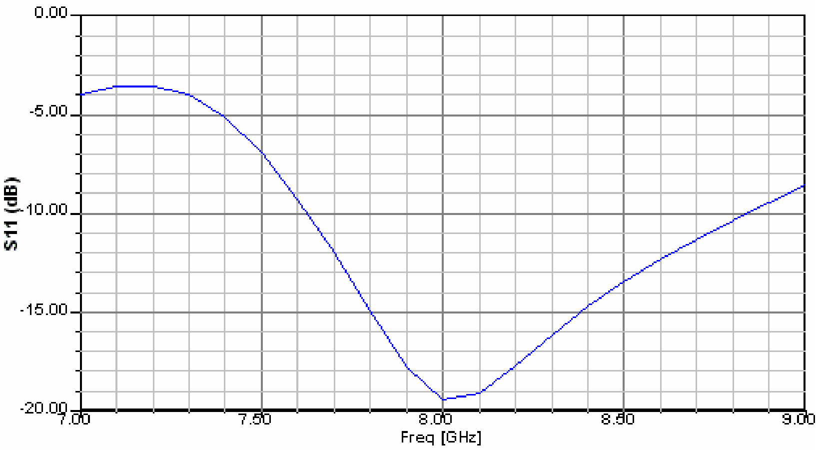

Fig. 3. Return Loss for the via-less substrate integrated horn antenna.

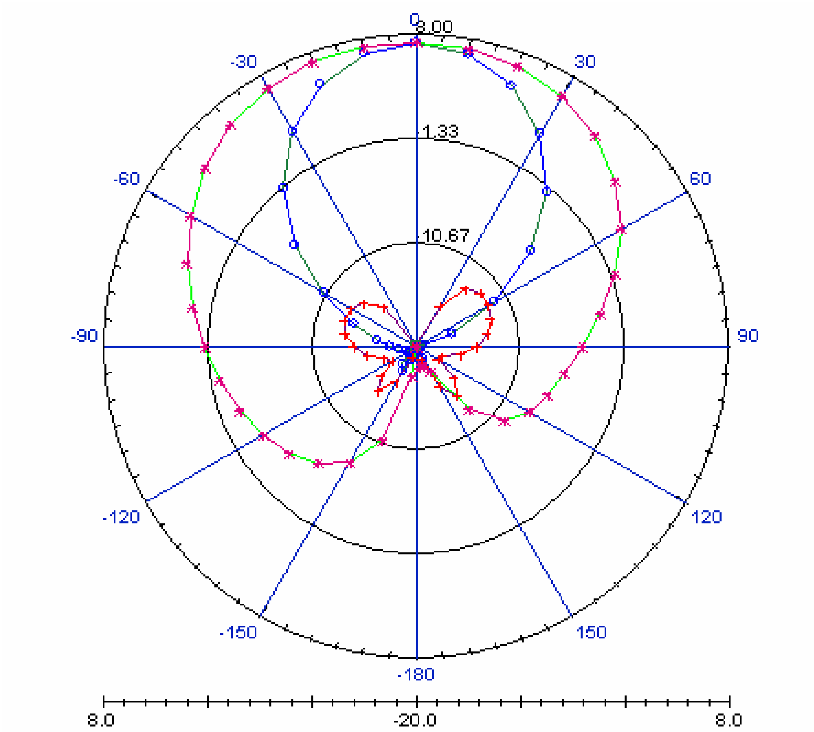

Fig. 4. Radiation pattern (Gain) at 8 GHz (dBi). Co-Pol (E_θ) E plane (φ= 0º) (○) and H plane (θ = 90º) (*). Cross-pol patterns in the E plane (+), H plane (□) (not visible) are less than -20 dBi from the peak gain in both planes.

Figure 4 shows the radiation pattern of the antenna in the E- and H-plane. We see that the shape of the pattern is very similar to that of a horn antenna, however, is slightly skewed due to the phase difference between the + and –y sides of the aperture. Note that, in this case, the finite size of the ground plane was not taken into account.

4. Conclusion

In this paper, we have presented simulation results for a via-less horn antenna that can be integrated into a single layer substrate. The measured gain was approximately 7.2 dBi at 8 GHz with a 10 dB bandwidth of approximately 14 %.

5. References

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[9] HFSS, Ansoft Corporation Version 10.1.2, Copyright 2006.