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Design Investigation of Dual Band H-Plane SIW Horn Antenna with Elliptical Shaped Radiating Aperture

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Design Investigation of Dual Band H-Plane SIW Horn Antenna with Elliptical Shaped Radiating Aperture

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***Abstract*— In this paper a dual band substrate integrated waveguide H-plane horn antenna is proposed. The radiating aperture of modified antenna is half elliptical shaped with specified major and minor radius. To improve backward radiation and directivity of the proposed antenna, a reflector plate is located around the radiating aperture. The proposed antennas are numerically investigated using High Frequency Structure Simulator (HFSS) software. Radiation performance of the modified horn is presented and compared with those of the conventional horn. Results illustrate that proposed structures provide directivity of 10 dB at the first band, which is 3.1 dB more than directivity of the conventional horn. For the other band, antenna directivity is enhanced up to 7.36 dB.**

Keywords: ***antenna, substrate integrated wave guide (SIW), horn antenna.***

I. Introduction

Horn antennas have been widely used due to their attractive radiation features including stable radiation beam, wideband and simple structure at microwave frequencies as the feed antenna of reflector antenna systems. By introducing substrate integrated waveguide (SIW) technology, it is possible to make a planar H-plane horn using provide low profile unlike bulky geometry of conventional horns using metallic waveguides. Moreover, the planar horn SIW antennas are easy to integrate with microwave circuits and provide suitable way in array applications [1-6].

A high gain and narrow beamwidths in both E- and H-planes using dielectric loaded SIW H-plane horn antenna is introduced to obtain. Also, an horn antenna with broadside patterns is proposed implemented by SIW technology [7].

In this paper, a new type's dual band H-plane horn SIW is designed and studied at 25.8 GHz. The radiation aperture of the horn proposed antenna is the modification of the SIW horn structure introduced in [8]. The introduce SIW horn is numerically investigated using High Frequency Structure Simulator (HFSS). It is shown that directivity of the proposed antenna is improved, whereas its size is not changed compared to the size of the conventional horn. The numerical results of the proposed horn is presented and compared with those obtained for the conventional SIW horn.

II. Antenna Strutures

The SIW horn is made using two flaring rows of metal vias which integrated to a rectangular waveguide by the substrate of the structure. They are fed at the fundamental mode of the structure by a 50 Ω coaxial line with inner radius of R_1 and outer radius of R_2.

Fig 1 shows the geometry of the conventional H-plane SIW horn antenna. The distance between two adjacent Vias is W and radius of each via is denoted by R. The design rules for rectangular and sectoral portions of the proposed horn obey same principles as for the metallic conventional horns and.

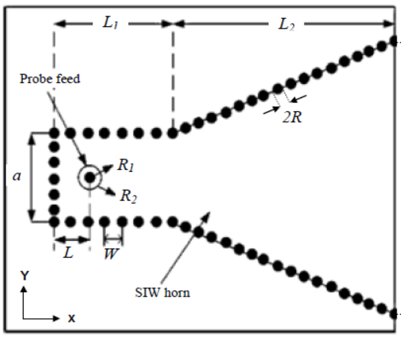

Fig. 1: Geometry of the conventional SIW H-plane horn antenna.

The geometry of the new horn structure is depicted in Fig. 2-a. The radiation aperture of this structure is an elliptical shaped to improve antenna gain. The major length of the ellipse is the length of the radiating aperture and its minor length is L_3 equal to a quarter wavelengths at 25.84 GHz, leading to obtain same radiating phase between the middle and endpoints of the aperture. The elliptical shaped arc is made in numerical mode using the HFSS facilities.

In order to improve backward radiation performance and obtain stable patterns, a metallic reflector plate is placed around the aperture [9], as shown in Fig 2-b. Both, horn

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antennas are made on a single layer Rogers TMM4 substrate with ε_r = 4.5, tangent loss of 0.002 and height of h=2.5 mm and are fed by a coaxial probe same as the feeding structure of the conventional horn. The three dimensional view of the proposed antenna with reflector plate is shown in Fig 2-c. The geometrical parameters of proposed antennas including conventional horn are summarized in Table I.

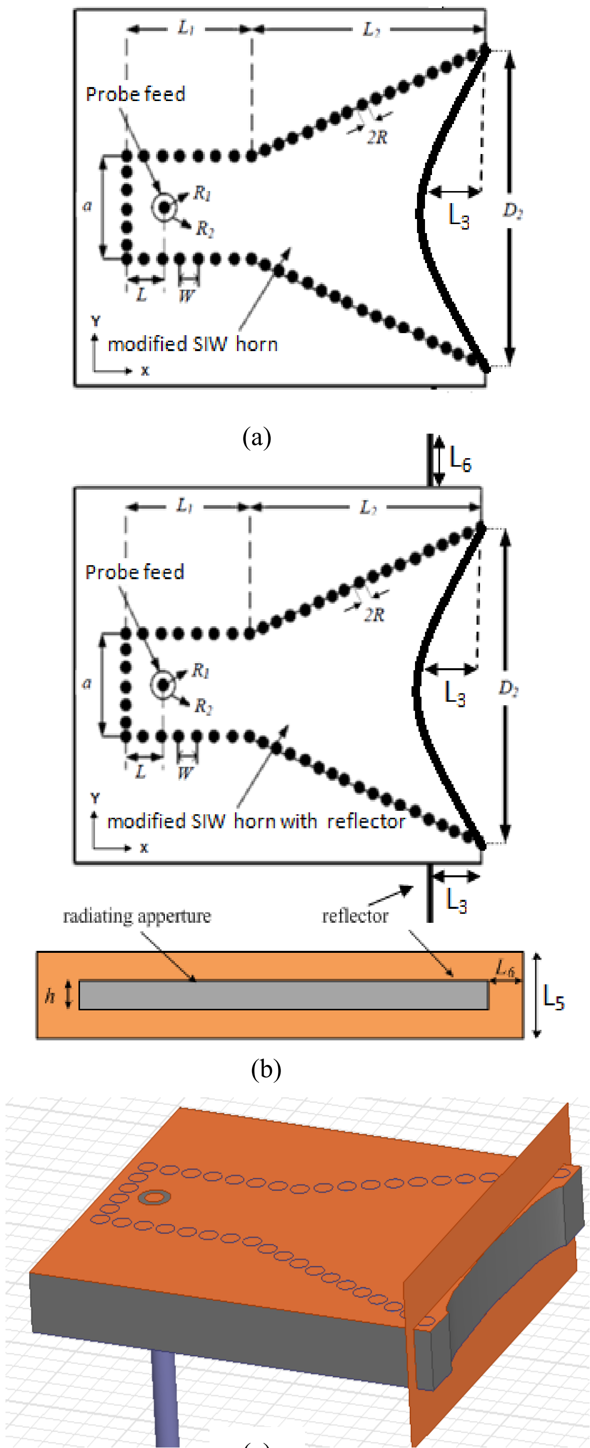


Fig 2: Geometry of the antennas proposed, a) new structure 1, b) new structure with reflector, c) 3-D view.

III. Results and Discussion

Reflection coefficient of the new proposed structures including to that of the conventional SIW horn antennas are shown in Fig. 3 versus frequency. It can be seen two distinct resonate frequency at 25.4 GHz and 27.2 GHz with poor matching at its frist band. While, with arc shaped radiating aperture two resonate frequency with acceptable level of matching is obtained. The other advantage of the new structure is decreasing the electrical length the antenna without any change in antenna size.

Table 1: Geometrical parameters of different horn antennas (all dimensions in mm)

Parameter	conventional horn	Modified horn	Modified horn with reflector
D_2	14	14	14
L_1	7	7	7
L_2	10	10	10
L_3	-	1.3	1.3
L	1.8	1.4	1.4
a	5	5	5
h	2.5	2.5	2.5
W	1	1	1
R_1	0.5	0.5	0.5
R_2	0.2175	0.2175	0.2175
R	0.4	0.4	0.4
L_6	-	-	0.8
L_5	-	-	7.1

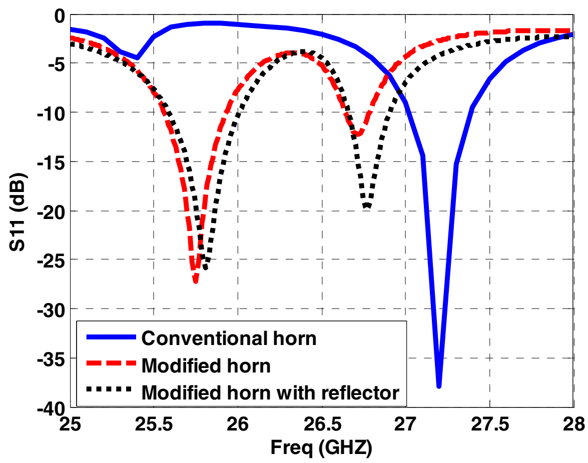
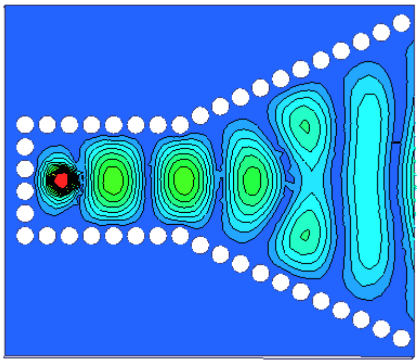


Fig 3: Simulated S_{11} of different horn antennas.

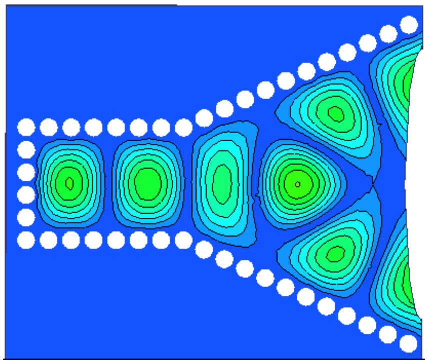
Numerical results for field distribution on the radiating aperture for the conventional and new horn are shown in Fig. 4. It can be seen that field distribution for the new horn is zero at the middle of the aperture at the first band, lead to considering array structure for the proposed antenna and hence, antenna directivity is improved.

Radiation patterns of all horn antennas including conventional horn at different frequencies are illustrated in Fig

5 and Fig. 6. It can be seen from Fig 5-b that the new structure without reflector provides narrower H-plane beamwidth compare to that of the conventional horn, while E-plane beamwidth of both antennas are nearly the same. In case of adding the reflector plate to the new structure, backward radiation is decreased and in turn, antenna directivity is increased.



(a)



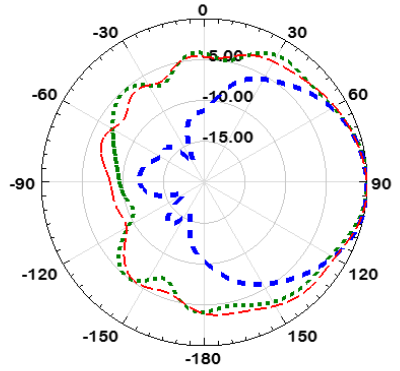
(b)

Fig. 4: Simulated E-field distribution along radiation aperture, a) conventional horn at 27.2 GHz, b) new structure at 25.84 GHz.

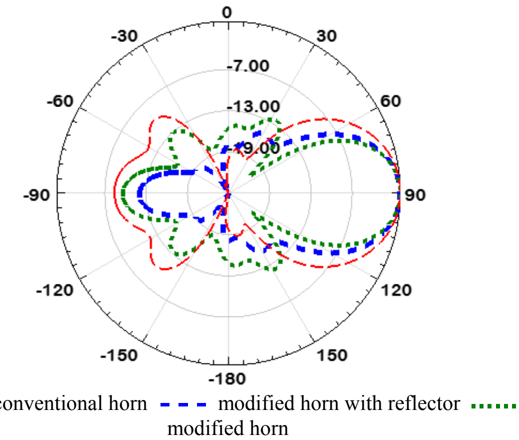
Radiation patterns at the second resonate frequency of 26.7 GHz for the new structure with and without reflector are depicted in Fig 6. It can be seen that E- and H-plane patterns of antenna without reflector is including few grating lobes, while by adding the reflector plate, grating lobe is omitted and an E-plane patterns with one main beam is obtained leading to improvement of antenna directivity. For H-plane patterns, the new structure provides two identical beams at 40° and 120°, which could be very useful in some applications such as radar systems.

To study the effect of reflector height on the radiation performance of the new structure, a parametric study is carried out and the variation of SLL and antenna directivity is shown in Fig. 7 versus L_5 the high of reflector. It can be seen that with increasing L_5 up to 7.1 mm, directivity and SLL is improved. Further increasing L_5 from 7.1 mm SLL and directivity is not changes.

Simulation results of the proposed antenna including radiation performance of the conventional horn are summarized in Table II.

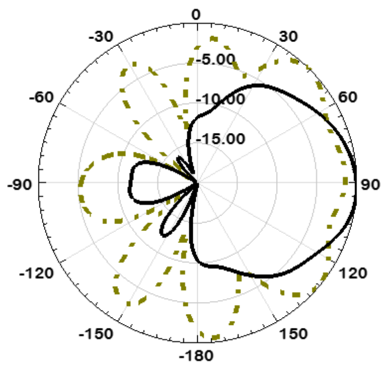


(a)

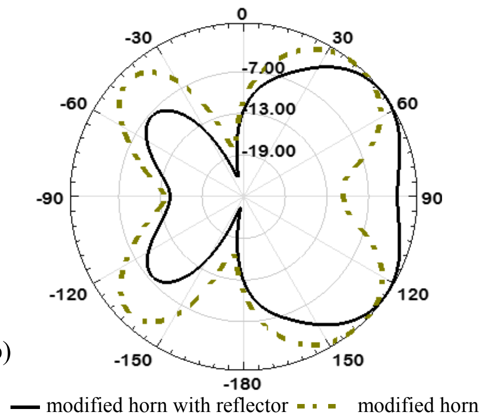


(b)

Fig. 5: Simulated radiation patters of all horns at 25.84 GHz for new structure and 27.2 GHz for conventional horn, a) E-plane, b) H-plane.



(a)



(b)

Fig. 6: Simulated radiation patters of new structure with and without reflector at 26.7 GHz, a) E-plane b) H-plane.

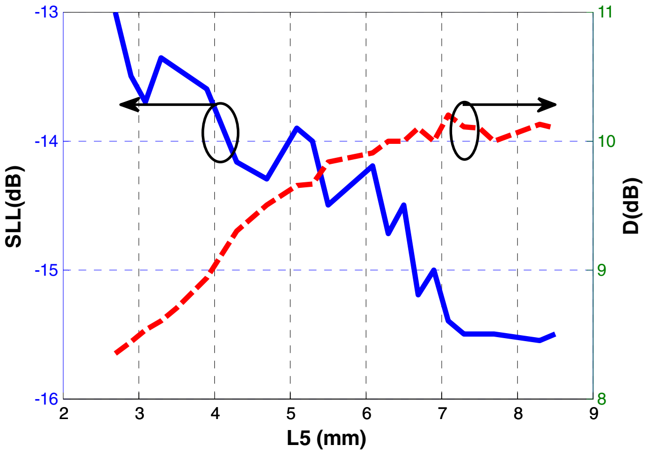


Fig. 7: Simulation results of directivity and *SLL* versus L_7 for horn structure II.

IV. Conclusions

In this paper a new technique is introduced to improve radiation characteristics of a SIW horn antenna. The radiating aperture of the modified H-plane horn is an elliptical arch shaped to increase antenna directivity, provides dual band operation at 25.84 GHz and 26.7 GHz. In order to improve, backward radiation a reflector plate is placed around the radiating aperture. This plate not only improves FTBR, but also decreases both E-plane beamwidth and H-plane SLL. Simulation results show that for the modified horn structure directivity of 8.3 dB is obtained while for conventional horn directivity is 6.9 dB. In case of adding reflector to the modified horn, antenna directivity is improved up to 10 dB and FTBR is increased from 6.7 dB for conventional horn to 12.2 dB for the modified horn with reflector.

Table II: Radiation performance of the different SIW H-plane horn antennas.

Parameter	Conventional horn		Modified SIW		Modified SIW with reflector	
	Without Reflector	With Reflector	25.84 GHz	26.7 GHz	25.84 GHz	26.7 GHz
Centre frequency (GHz)	27.2	27.2	25.84	26.7	25.84	26.7
H-plane half power beam width	48°	58°	36°	120°	38°	110°
E-plane half power beam width	124°	86°	124°	125°	80°	81°
Directivity (dB)	6.9	8.8	8.3	4.7	10	7.36
Front to Back Ratio (dB)	6.7	11.6	9.5	4.5	12.2	9.7
Side Lobe Level (dB)	-18	-21	-12.3	-	-15.4	-
Antenna size (mm^3)	18.5×15.8×2.5	18.5×15.8×7.1	18.5×15.8×2.5	18.5×15.8×2.5	18.5×15.8×7.1	18.5×15.8×7.1

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