DESIGN OF SUBSTRATE INTEGRATED WAVEGUIDE SLOT ARRAY FOR WIDEBAND APPLICATIONS

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ABSTRACT-A substrate Integrated Waveguide embedded with slot arrays is designed for wideband application is presented in this paper. It is a simple profile, low weight and economical antenna which is applicable for ku band. A substrate integrated waveguide consists of two rows of metallic cylinders which connect the upper and the lower conductor of a dielectric substrate makes a physical connection. On the upper conductor, slot arrays are etched out in particular intervals to achieve wideband characteristics. The 10 dB return loss has peak resonances of -23, -29 and -38 dB at 11.5, 12.9 and 14.5 GHz respectively. It exhibits a simulated 10 dB impedance bandwidth of about 43.75% from 12.5 to 19.5 GHz due to the presence of slot arrays and the achieved peak gain is 3.2 dB. The designed prototype is simulated using Ansoft HFSS simulator.

***KEYWORDS*-Substrate integrated waveguide, slot array, wideband, impedance bandwidth and gain**

I. INTRODUCTION

In recent years high frequency components are widely used in wireless communication. Traditional transmission lines like coaxial cables and two-wire cables suffer lot of problems like copper loss, radiation loss, dielectric loss and skin effect at high frequencies. Metallic waveguides perform better than these transmission lines at high frequencies but they are bulky and costly. As an alternate, substrate integrated waveguide (SIW) are introduced. They are planar transmission lines and can be integrated with any planar circuits. With the help of SIW technology, non-planar components can be converted to planar components. This SIW is comprised of rows of metallic cylinders connecting upper and lower metal plates of a dielectric substrate forming a physical connection. Like the microstrip lines, SIW components are easy to fabricate, less weight and cost-effective with good performance.

SIW slot antenna has numerous advantages such as simple profile, low cost, moderable gain and easy fabrication. One disadvantage of slot antenna is its narrow band of 1.7% because of rectangular slot [1]. To overcome the issue, rectangular slot is replaced by widened slot to attain bandwidth of 9.9% [2]. Later slot arrays are used to get resonance at higher frequency from 41.2 to 44.8 GHz [3]. The slot antenna also exhibits multi-band frequency characteristics for various applications [4]. For instance, a 2x2 slotted sub array generate dual resonance at 21 and 26 GHz in [5]. Similarly, metamaterials like complimentary split ring resonator (CSRR) are involved to enhance the bandwidth of the antenna [6]. Slot array can be applied to design couplers [7], filters [8] and leaky wave antenna [9].

In this paper, slot arrays are used to enhance the bandwidth of the antenna from 12.5 to 19.6 GHz which finds its application at ku band. Slot arrays are etched on the top metallic conductor and it is excited through 50 ohm microstrip feeding via tapered transition.

II. DESIGN TECHNIQUE OF SIW

The prototype is built form dielectric substrate namely Rogers RT/duroid 5880 having thickness of 0.762 mm, relative permittivity of 2.2, dielectric loss tangent of 0.0009 and relative permeability of 1. The upper and bottom metallic layer are formed by copper of thickness 0.035mm. The prototype is shown in fig 1. The dimension of the prototype is designed to be 58 x 14 x 0.762 mm. The other dimensions are listed in table 1.

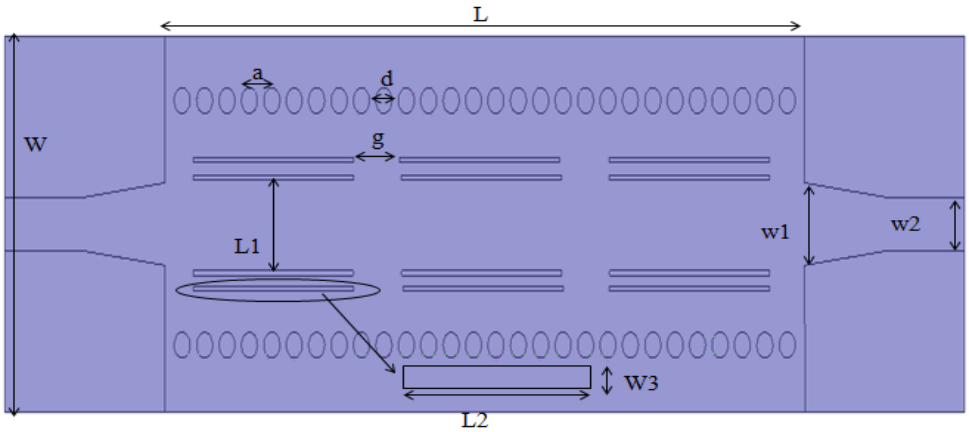


Fig 1: Designed prototype

Table 1 Dimensions of the prototype

S.No	Parameters	Dimensions in mm
1	L x W x H	58 x 14 x 0.762
2	a	1.5
3	d	1
4	g	3
5	L1	4.3
6	L2	10
7	W1	3.22
8	W2	2.1
9	W3	0.2

The diameter of the cylinder (d), the distance between the two consecutive cylinder (a) and the free space wavelength (λ_0) has to follow some conditions to avoid excess leakage of electric field between the cylinders.

$$d/a = 0.5 \text{ and } d/\lambda_0 = 0.1 \quad (1)$$

Three pairs of 2x1 slot arrays are excited with the help of 50 ohm microstrip line and the flow of current is smoothened by the tapered section from the microstrip to the SIW. The prototype is simulated using the Ansoft HFSS software.

III. RESULTS AND DISCUSSIONS

The simulated prototype has strong resonances at 11.5, 12.9 and 14.5 GHz and their return losses are -23, -29 and -38 dB respectively. It exhibits a wide bandwidth ranges from 12.5 to 19.5 GHz and the 10 dB impedance bandwidth is 43.75%. Further, there is a narrow band resonance at 11.5 GHz. The obtained resonances occupy the entire ku band frequency which ranges from 12 to 18 GHz. It finds its main application in satellite communication especially in broadcasting satellite television. The return loss and the insertion loss values are plotted in fig 1 at their respective frequencies as shown in fig 3. The insertion loss is closer to 0 dB at the resonance region. The radiation pattern at the peak resonances which is 11.5, 12.9 and 14.5 GHz are plotted in fig 4. The gain of the antenna at stronger resonance 14.5 GHz is plotted in fig 5. The peak gain of the prototype is found to be 3.2 dB. The E field distribution is shown in fig 2.

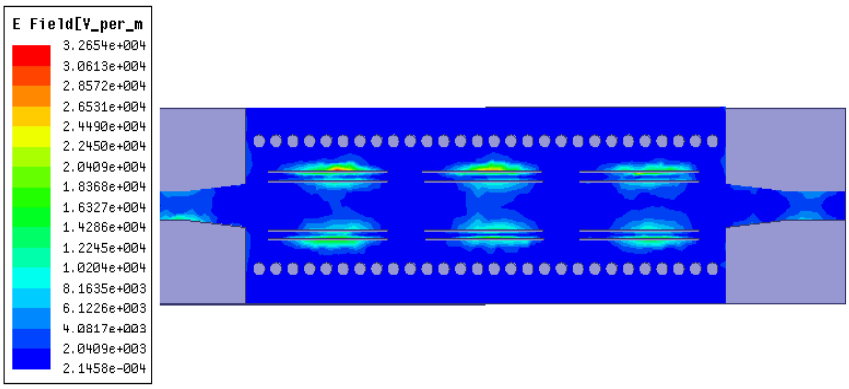


Fig 2 : Electric field distribution in the prototype

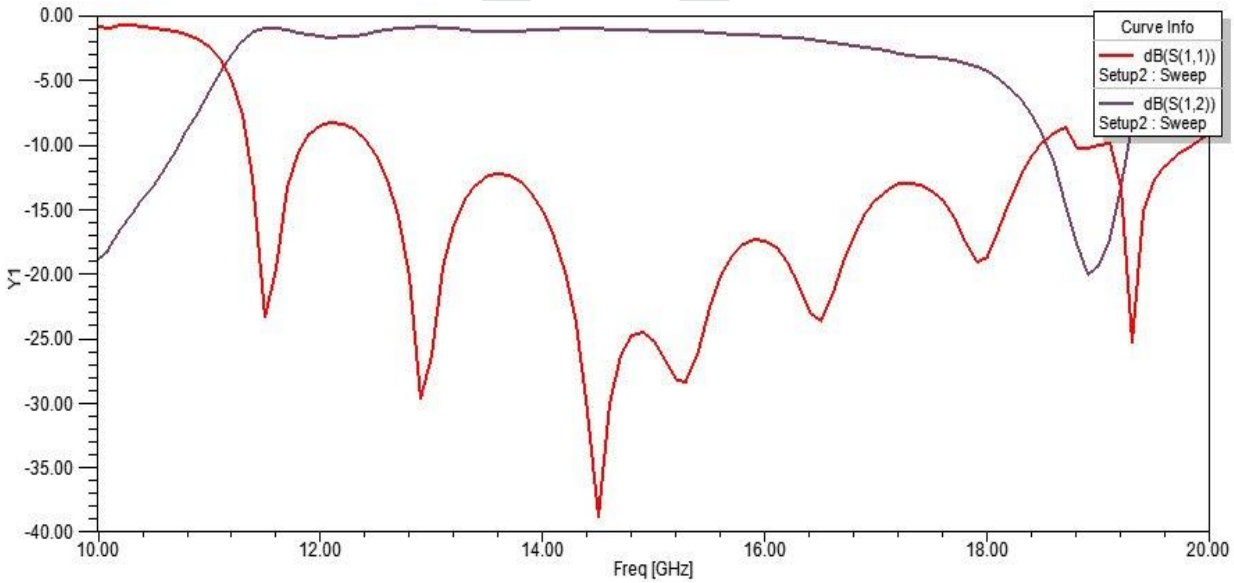
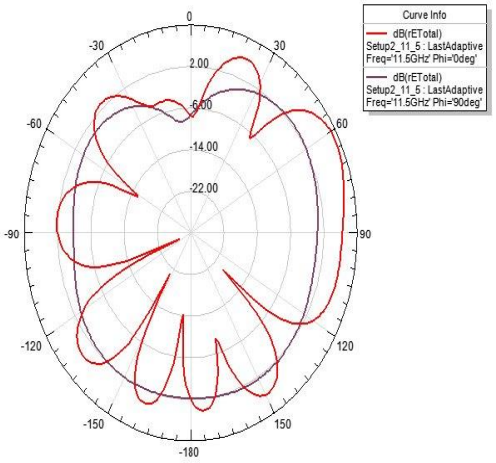
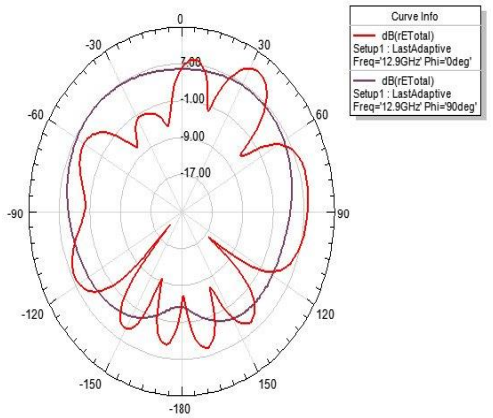


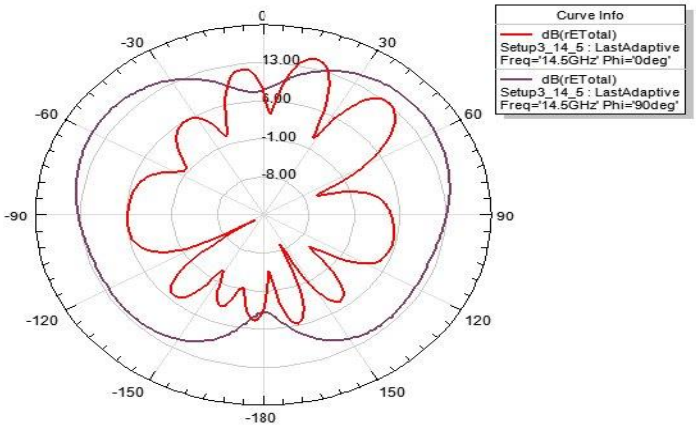
Fig 3: Return loss and Insertion characteristics of the prototype



(a)



(b)



(c)

Fig 4: Radiation pattern of the prototype at (a) 11.5 GHz (b) 12.9 GHz and (c) 14.5 GHz

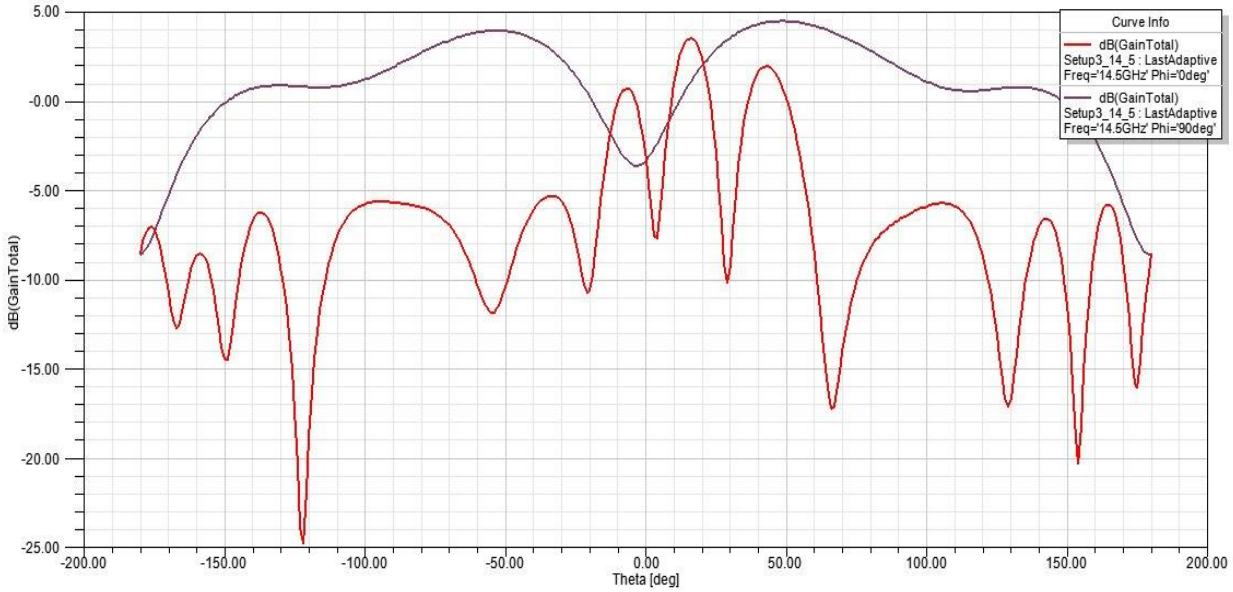


Fig 5: Gain characteristics of the prototype at strong resonance (14.5 GHz)

IV. CONCLUSION

The substrate integrated waveguide slot array (three pairs of 2x1) antenna is discussed in this paper. The slot arrays etched on the top layer gives rise to wide band characteristics. It is fed by 50 ohm microstrip line followed by tapered transition for smooth current flow. The attained 10 dB impedance bandwidth is about 43.75% from 12.5 to 19.5 GHz and the peak gain is 3.2 dB.

This antenna may find its applications in ku band region especially in satellite communication.

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