KIET IJCE KIET International Journal of Communications & Electronics
Volume. No. 6, Issue No. 1, Jan-June 2018, ISSN: 2320 – 8996

Dual Band SIW Bowtie Antenna for X – band Applications

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ABSTRACT

A Dual band SIW Bowtie Antenna for X – Band applications is presented in this paper. The SIW technology has been used to design the antenna in a bow tie structure. The antenna has a dual band working at frequencies 10.19 GHz and 11.12 GHz. The simulated gains at these frequencies are 10 dB and 8.6 dB respectively. HFSS simulation software is used for all the simulations.

***Keywords*:** Substrate integrated waveguide, Bow Tie Antenna, X band.

INTRODUCTION

The fundamental concept of Substrate Integrated Circuits (SIC) is to synthesize non planar structures in a planar form which is completely compatible with other planar structures. This can be achieved by creating artificial channels [1,4,7].

Substrate integrated waveguide is used as converting non planar structure to planar structure. It is a technology which is dielectric filled waveguide with metallic vias on the side walls of the waveguide. These artificial wave guiding channels are embedded in planar substrate with arrays of periodic metalized vias or slots.

The vias or slots act as electrical walls for waveguides. In [2] substrate integrated waveguide cavity backed slot antenna is used. Here bow tie antenna slot is cut to achieve broader bandwidth performance. A high gain bow tie antenna using substrate integrated technology has been presented in [3].

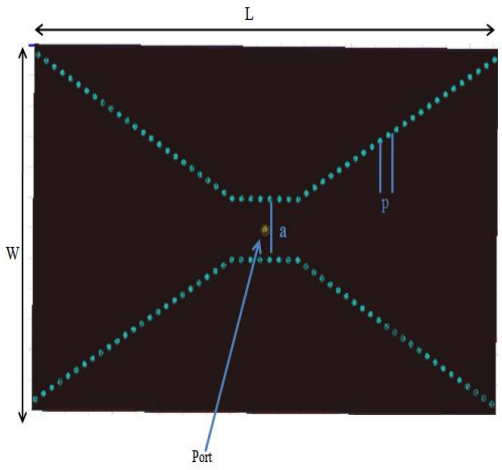
The antenna has a pair of bow tie radiator on the opposite of the common dielectric substrate. The bow-tie-shaped slot antenna is also studied as a most preferable antenna for broadband application since few years [3]. Studies on this type of antenna reported that this type of antenna has a potential to exhibit 20%–36% bandwidth with appropriate design of feeding network.

In this paper, a Dual band Bowtie antenna is designed using Substrate Integrated Waveguide (SIW). A SIW consists of substrate with metalized vias acting as two side walls and two metallic walls (upper and lower).

This antenna will work on a X – band frequency range (8-12 GHz). It is a low cost efficient design of a dual band antenna and will find a number of applications in the X-band frequency range. The basic parameters of antenna i.e. Gain, Radiation pattern, Current distribution and S – parameter are simulated in Ansys HFSS software [12].

ANTENNA DESIGN

The proposed configuration of bow tie substrate integrated waveguide is shown in fig 1. Bow tie antenna is formed by placing metallic vias in bow tie form. A bow-tie substrate integrated waveguide antenna is formed on a 0.8-mm-thick dielectric substrate with $\in_r$=2.33 (RT Duroid 5870). The metallic side walls of the antenna are used to avoid leakage. The feed of this antenna is excited by applying discrete port as shown in fig.1. Firstly SIW (substrate integrated waveguide) aims to work for a cut off frequency of 10 GHz with the design specifications of substrate integrated waveguide such as width of the SIW a= 8.30 mm, center-to-center distance between the metallic vias p= 2 mm and diameter of the metallic vias d= 0.8 mm. These values are calculated by using the design equations of SIW, given below:



antenna designed with design parameters L= 98mm, W= 60mm,$\in_r$= 2. 33, h
Fig.1. Proposed geometry of SIW Bow =0.8mm, a= 8.30mm, p = 2 mm , R= 0.5

Deign Equations of Substrate Integrated Waveguide

SIW consists of two parallel conducting arrays of via holes represented by 'd'. *TE*10 mode is the dominant mode for wave propagation in SIW as of the conventional rectangular waveguide [5]. 'a' is the parameter between the two arrays which determines the propagation constant of the fundamental mode. Similarly parameters'd' is the diameter of vias d and p are set so as to minimize the leakage through the vias.

A. The metalized via hole diameter is

$$d < \frac{\lambda_g}{5}$$

B. The spacing between the via holes is

$$P \leq 2d$$

C. The physical width of SIW is

$w_{eff} = a - 1.08\frac{d^2}{p} + 0.1\frac{d^2}{a}$,where weff is the width of the waveguide.

Now this Substrate integrated waveguide is modified to form the antenna in Bow tie type (as shown in fig.1.). The bow tie substrate integrated waveguide is designed on RT duroid substrate with 0.8mm thickness. The substrate length 'L' of the antenna is 98mm and 'W'= 60mm. It is designed for the X- band Applications. The SIW is designed with the lowest dielectric constant (εr=2.33), distance between the consecutive cylinders, P =2mm. and the diameter of vias is 1mm. The aperture length is 60mm, flare angle is 26.56̊ and the distance between two parallel rows of vias is 10mm. Bow tie substrate integrated antenna has a dual band behavior working in two frequencies. The frequencies of the antenna are 10.19 GHz and 11.12 GHz. The above antenna has an application in X band.

RESULTS AND DISCUSSION

Return Loss

The designed antenna was simulated using software Ansys HFSS. The antenna is excited by using discrete port indicated in fig. 1. The simulated reflection coefficients of the antenna are shown given in Fig. 2. The operating frequencies of the antenna have an application in X band. The antenna has dual band characteristics with resonant frequency of 10.19 GHz and 11.12 GHz. The simulated return loss is value defined by S11 < −10 dB in 10.19 GHz is -27 dB and at 11.2 GHz is -24dB (as shown in fig.2.).

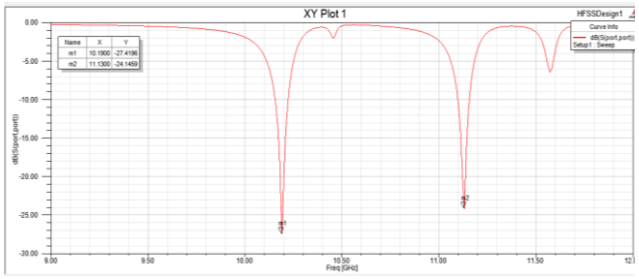


Fig.2 Return loss of the proposed antenna in dB showing two cutoff frequencies (Dual Band) at 11.12 GHz and 10.19 GHz

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Current Distribution

The current distribution for the antenna is shown in fig.3 and fig .4. The current distribution is calculated for both of the frequencies of the antenna i.e. 10.19 GHz and 11.12 GHz.

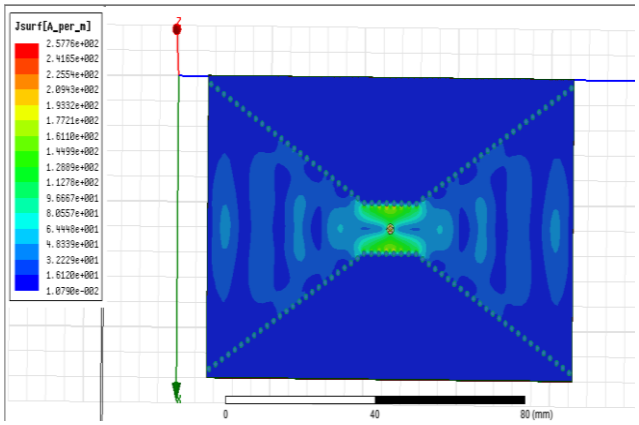

Fig. 3 Current Distribution in SIW Bowtie antenna at 10.19 GHz frequency

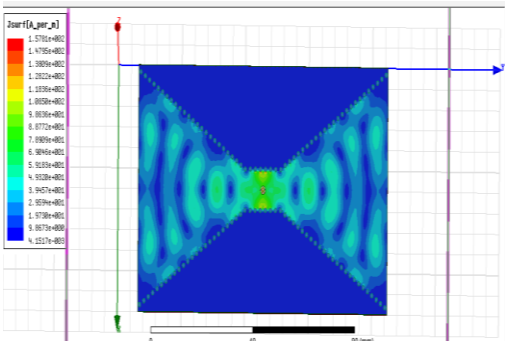

Fig. 4 Current Distribution in SIW Bowtie antenna at 11.12 GHz frequency

Radiation Pattern

The radiation pattern for the bow tie substrate integrated antenna is shown in fig.5. The antenna is radiated in both of the direction with a high gain at both the frequencies. The pattern demonstrated for the antenna is in end fire direction with a gain of 10 dB at 10.19 GHz and 8.6 dB at 11.12 GHz. Gain vs frequency plot is calculated (as shown in fig. 6) for different frequencies.

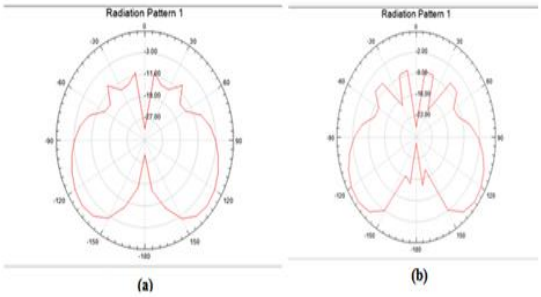

Fig. 5. Radiation Pattern of the bow tie substrate integrated waveguide at (a) 10.19 GHz and (b) 11.12 GHz

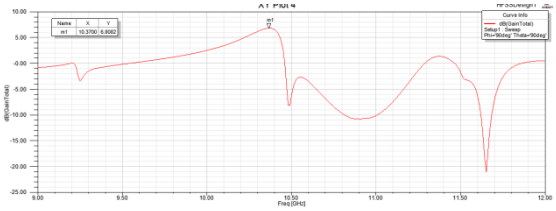

Fig. 6 Gain vs frequency plot for the proposed antenn.

CONCLUSION

In this, a Dual band Bowtie antenna is designed using Substrate Integrated Waveguide (SIW). A SIW consists of substrate with metalized vias acting as two side walls and two metallic walls (upper and lower). This antenna will work on a X – band frequency range (8-12 GHz). It is a low cost efficient design of a dual band antenna and will find a number of applications in the X-band frequency range. This type of antenna shows a dual band behavior at two different frequencies i.e. 10.19 GHz and 11.12 GHz. The results are simulated using software Ansys HFSS.

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