VOL. 11, NO. 21, NOVEMBER 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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QUARTER MODE SUBSTRATE INTEGRATED WAVEGUIDE ANTENNA WITH INVERTED L-STRIPS

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ABSTRACT

In this paper the square shaped antenna with dual L-shaped strips are added for alternative current path using substrate integrated wave guide(SIW) knowledge is presented.The proposed antenna has dimensions 50X50X1.6 mm^3 is designed on FR4 substrate with loss tangent δ=0.02 and dielectric constant of 4.4. An impedance bandwidth ranging from 8.3GHz to 10.5GHz is attained for the proposed antenna model which will cover the X-bandand by using the two inverted L-strips at the excitation point of radiation patch the gain is enhanced. Prototyped antenna is tested on ZNB 20 vector network analyzer and observed the compared the results for validation.

Keywords: band width enhancement, inverted L-Strips, alternative current paths, substrate integrated wave-guide (SIW).

1. INTRODUCTION

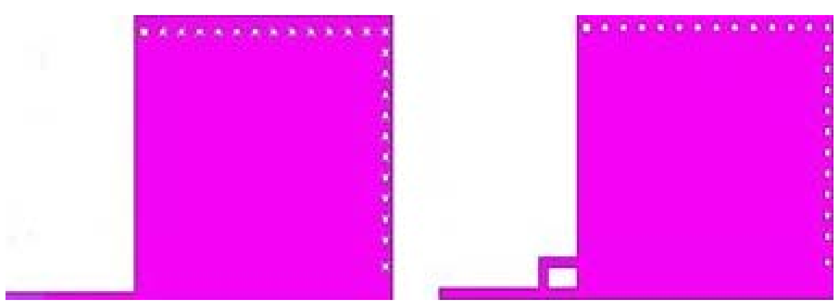
In the modern wireless communication field, Substrate Integrated Technology is the modern approach for the development and implementation of antennas that are compact, economical and with less radiation loss [1-2]. The Substrate Integrated Waveguide (SIW) technology has accelerated at high rate as a high level of awareness has been created in the people in the form of workshops, conferences and also in the industries accordingly. The design of creative SIW structures based on cost and eco-friendly materials has laid a platform to the new era. SIW are used in the broadcast of electromagnetic waves [3-4]. Substrate Integrated Waveguide (SIW) are planer structures which are fabricated using two rows of metallic holes or slots periodically connecting top and bottom ground plane with substrate in middle. As they are planar, they can be fabricated on PCBs and also integrated with other planar components like microstrips [5-6].

A Quarter mode substrate integrated waveguide (QMSIW) which is quarter part of a square waveguide is applied in this antenna. The QMSIW can maintain the distribution in the groundroughly as of the unique SIW [7-8]. In this model paper an antenna is designed based on the proposed Quarter Mode Substrate Integrated Waveguide (QMSIW). The international telecommunication union (ITU) decides the allocation of frequency bands and the X-band frequency is 8-12GHz which is also being known as Super High Frequency (SHF). The X-band is used in military applications and also used in radar applications [9-10]. The radar frequency sub-bands are used in civil and government institutions for weather monitoring, air traffic control, defence tracking and vehicle speed detection.

Inverted L-Strips act as transmission line or waveguides which are fixed or connected at one end alone [11-12]. The other end can be either open circuited or short circuited. The working principle of strips is based on the standing wave ratio of the waves. Initially an antenna is designed based on the QMSIW technology and its parameters are analyzed. Then by placing the strips, the design is altered and the antenna is analyzed [13-15]. Then the comparative study of the parameters of all designs are tabulated and graphed to give effective antenna performance. The size of the ground plane will affect the performance of the antenna the electric currents are spread on both the radiator and the ground plane so that the energy from the ground plane is predictable.

2. ANTENNA CONFIGURATION

The geometry of designed antenna and its position in the co-ordinate system with different iterations are placed in Figure-1. Final proposed antenna model to achieve maximum gain with two- inverted L-strips is displayed in Figure-2.



(a) (b)

Figure-1. QMSIW antenna, (a) Without Strip, (b) With Strip.

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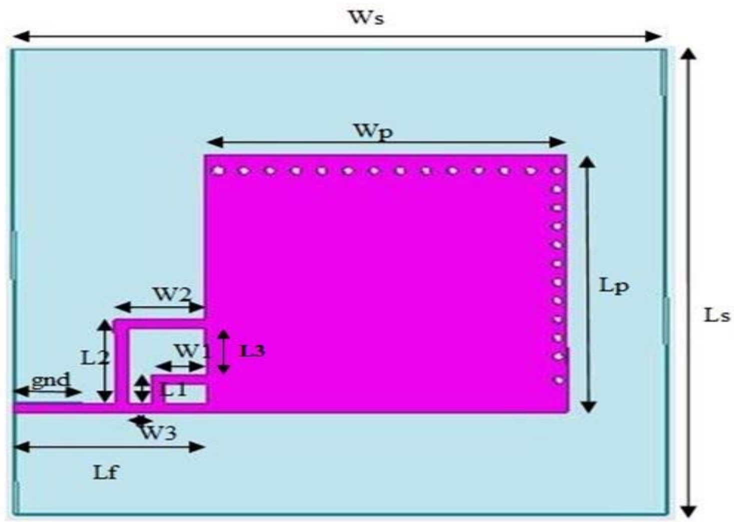

Figure-2. Strip loaded antenna geometry.

Table-1. Proposed antenna dimensions.

Parameters	Ws	Ls	Wp	Lp	W1	L1	gnd	W2	L2	Lf	G	ds	W3	L3
Dimensions(mm)	50	50	27.7	27.7	4.175	3	5	7	9	14.8	3	3	5	5

A square slot antenna is excited by a line feed with small ground plane is designed on a FR4 substrate of thickness 1.7mm.Due to this construction the gain will be improved.

3. RESULTS AND DISCUSSIONS

Figure-3 shows the reflection co-efficient of the basic antenna model shown in Figure-1. At the initial stage there is no L-shaped strip used in the radiating patch. In the second model a single L-shaped strip is considered. The return loss curve for this model is similar as model 1 but there is a small variation in resonant frequency point. After this modification these two models are not given better gain and directivity. By considering all these points, we used model-1 and model-2 to construct the final proposed model with two inverted L-strips. The proposed model is further modified to enhance the gain and directivity. The reflection co-efficient of proposed antenna gives the complete picture regarding bandwidth characteristics. It has been observed that the bandwidth of 2 GHz is obtained from present model.

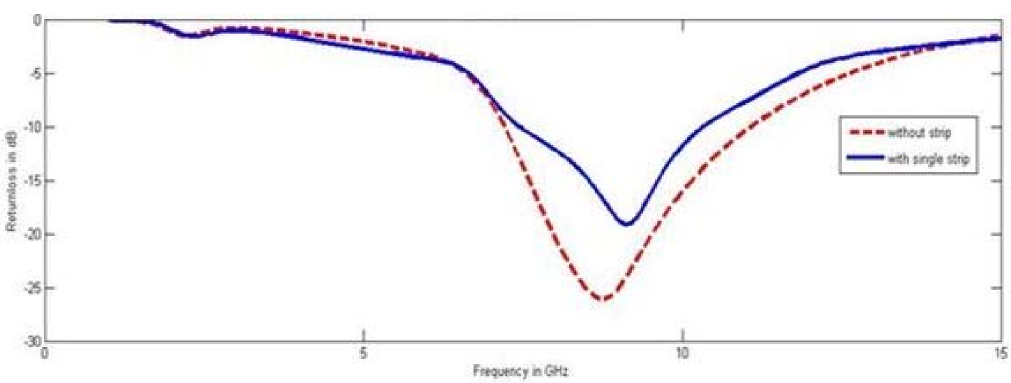

Figure-3. Return loss vs frequency for antenna without L-strip and with single L-strip.

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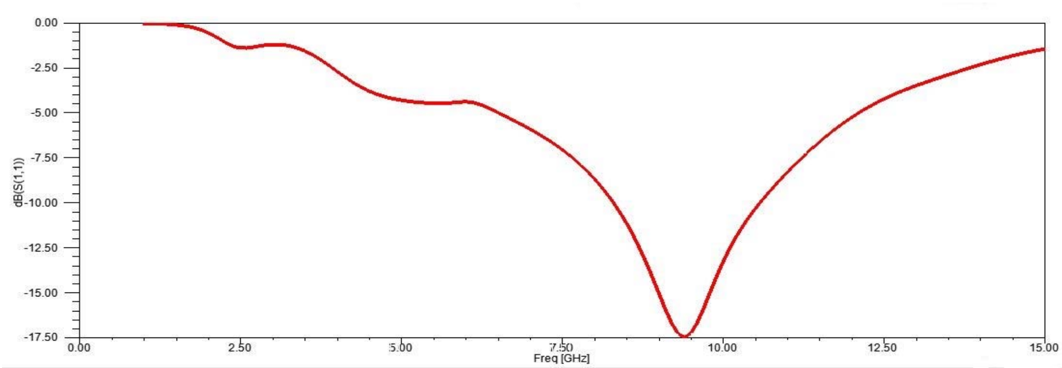

Figure-4. Return loss of the proposed antenna with two inverted L-shaped strips.

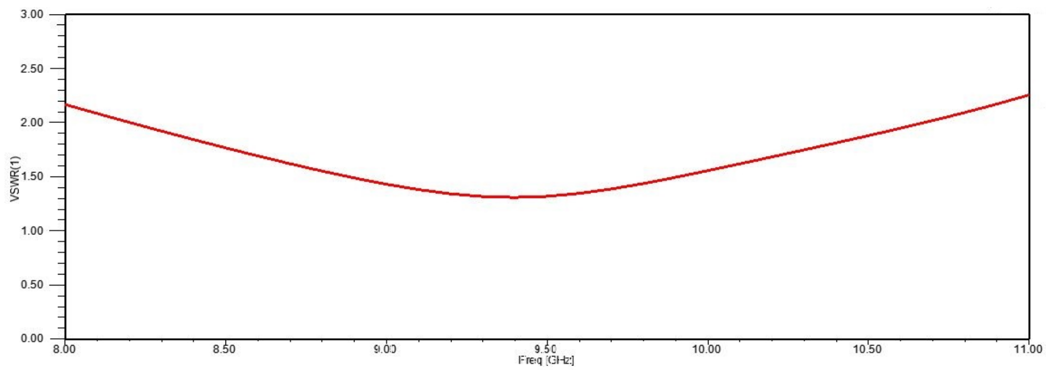

Figure-5. Voltage standing wave ratio vs frequency.

Figure-6 shows the radiating characteristics in operating band 9.5GHZ antenna is showing omni-directional radiation pattern in H-field. In the E-plane the antenna pattern is disturbed and showing more diversity in a particular direction

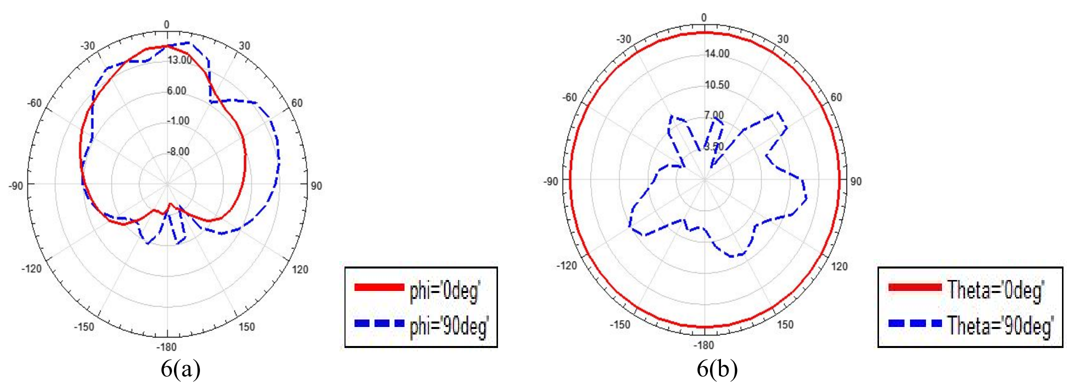

Figure-6. Radiation pattern (a).Radiation pattern(phi=0 and 90),(b).Radiation pattern(theta=0 and 90).

Figure-7 gives the complete information regarding electric field and magnetic field distributions respectively. From Figure-7(a) we can observe the maximum electric field intensity at the edges of the radiating material and also at the feed line. Similarly in case of magnetic field also the most radiation is equally distributed among the edges of the patch. The surface current distribution of the proposed antenna can be observed from Figure-8 the current density is spread among the edges of the patch and also more intensity is observed at the inverted L-strips. On the radiating material most of the current elements are oriented towards Y-axis of the patch.

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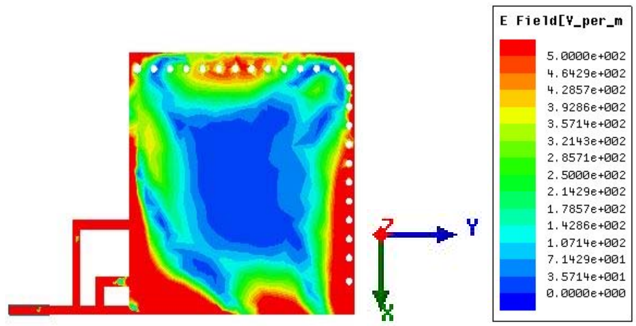

Figure-7(a). E-Field distribution of the proposed antenna.

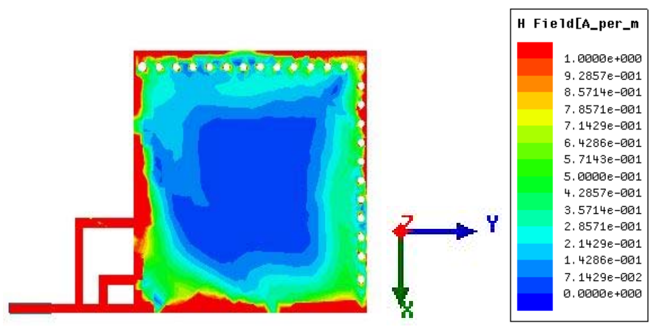

Figure-7(b). H-Field distribution of the proposed antenna.

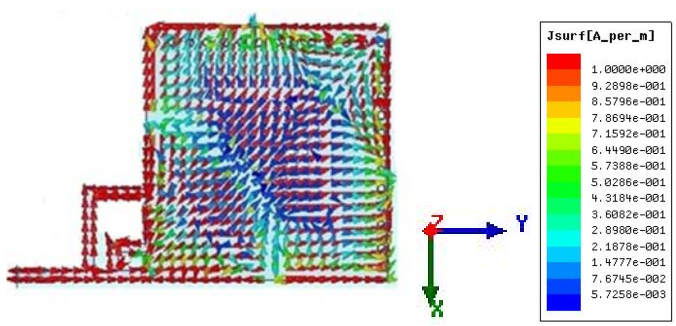

Figure-8. Current distribution of the proposed antenna.

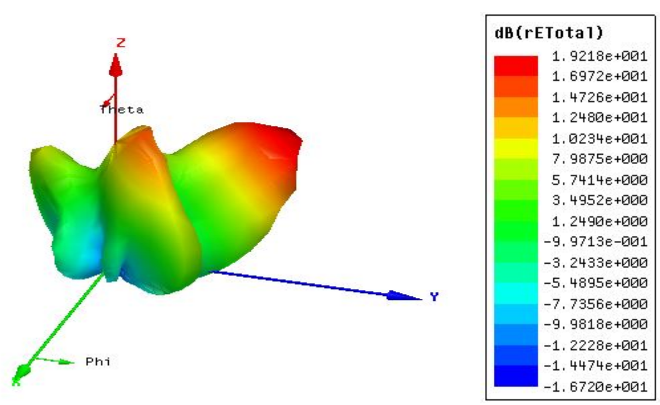

Figure-9. Gain of the antenna 3D-polar plot.

Figure-9 shows the 3-D polar plot for the proposed antenna. At high frequency antenna pattern is distributed and it has been observed that the gain intensity is oriented towards z-direction. By placing two inverted L-strips at the feeding point the gain is increased by 1.5dB. A peak realized gain of 3.3dB at 13.5GHz is achieved. Figure-10 is marked for gain improvement and directivity of 2.8dB at 9.5GHz (X-band) is observed from the proposed antenna. Figure-11 shows the prototyped antenna on FR4 substrate and Figure-12 shows the measured S11 on ZNB 20 vector network analyzer.

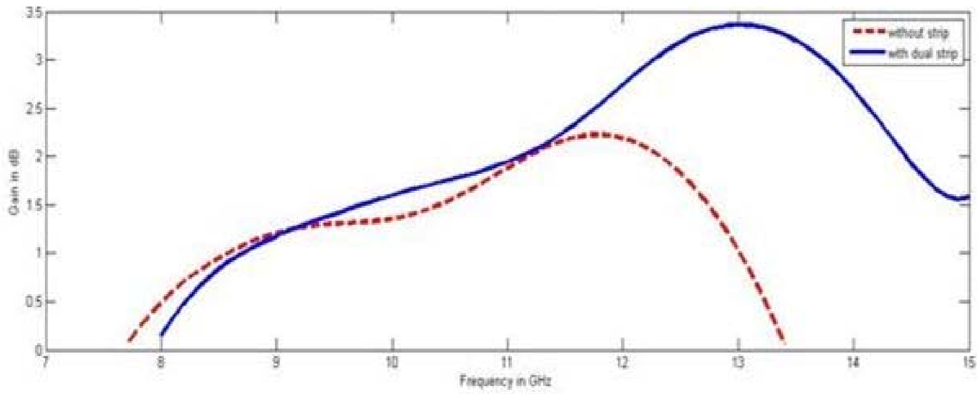

Figure-10. Gain vs frequency of without L-strip and with dual L-strips.

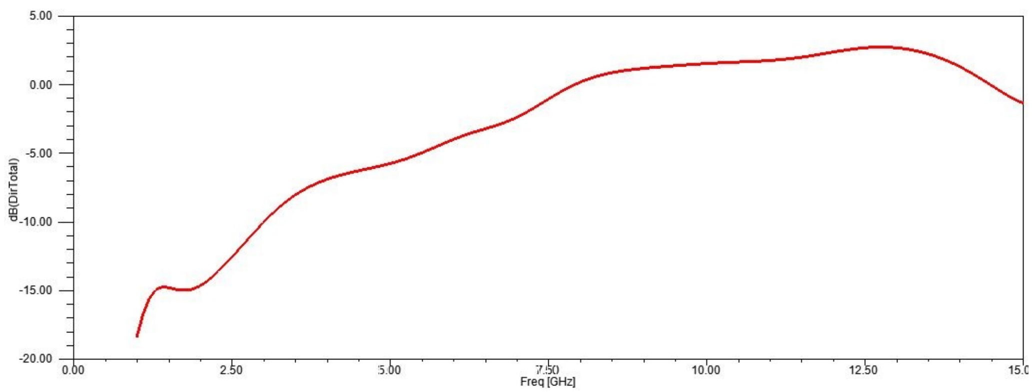

Figure-11. Directivity of the proposed antenna.

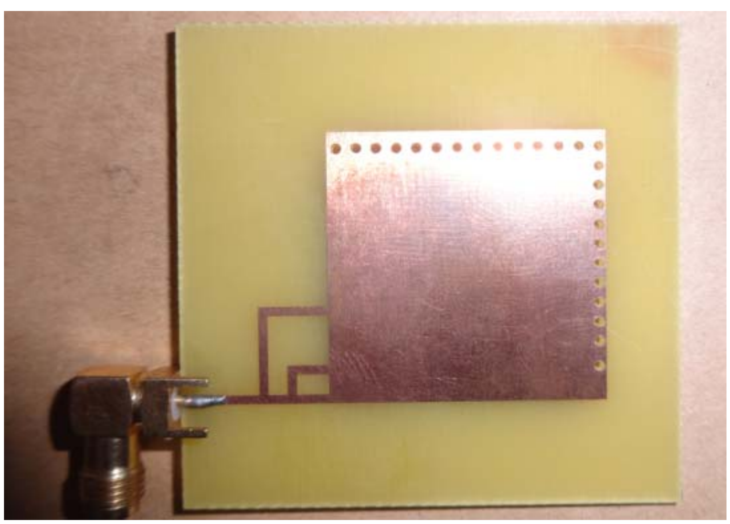

Figure-12. Prototyped antenna on FR4 substrate.

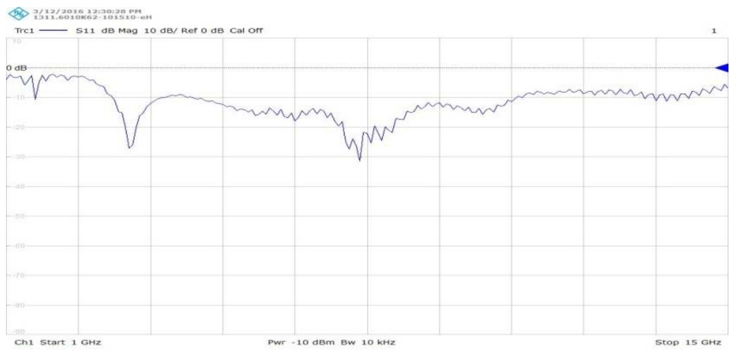

Figure-13. Measures S11 of prototyped antenna on ZNB 20 VNA.

4. CONCLUSIONS

A compact antenna is proposed using SIW technology. The size of the antenna is reduced by using a QMSIW structure. Here the parameters are compared in the proposed antenna with and without Inverted L-strip i.e. with single Inverted L-strip and with two Inverted L-strips. Therefore, the proposed antenna is fit for future substrate integrated circuits or system-on-substrate, where compact size is required and can improve the directivity in particular direction with fine tuning of the strip. The prototyped antenna is tested on ZNB 20 vector network analyzer and observed the similar kind of S11 characteristics when compared with simulation of HFSS. Additional resonant mode is observed in the lower operating band due to mismatch in the connector at feed position with respect to ground.

ACKNOWLEDGEMENTS

Authors like to express their gratitude towards the department of ECE and management of K L University for their support and encouragement during this work. Further Madhav likes to express his gratitude to DST through FIST grant SR/FST/ETI-316/2012.

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