Wide-Band Microstrip Slot Antenna using SIW Structure for KU-Band Application

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Abstract- *The main objective of this paper to design a wideband slot antenna , for KU- band application . Here, Circular slot is excited using microstrip feedline with carefully placed stub with SIW structure. In this structure consist of unique design of patch top on substrate(which is FR4, dielectric constant 4.4) and ground circular slot placed on lower edge of the substrate. The antenna demonstrate wide bandwidth between 12.7708-15.6800 GHz and provide good return loss less than -10 dB in this report. For antenna design using Full wave EM software to obtain experimental results. It has powerful drawing capabilities for 3D antenna design.*

Keywords- Microstrip slot antenna,SIW(Substrate Integrated Waveguide),Bandwidth Enhancement, KU-Band, Full wave EM software.

I. INTRODUCTION

Microstrip Patch Antenna has been great demand in wireless communications due to its compact size, light weight, high power handling capacity and ability to operate at different band of frequencies. It provide good reliability due to its several attractive characteristics extremely suited for mobile phone market, pagers, radio and wireless devices. But Microstrip antenna is often limited by its bandwidth, a number of experimental investigation on further increasing the bandwidth of slot antenna have been reported by various authors [2]-[6] in our work we make use of microstrip feed technique with proximity coupling with carefully design stub and vias.

In addition slot antenna are more advantages such as low profile geometries, easily integrated with active devices or MMIcs .therefore great interest in various type of slot antenna with their feeding methods has been reported in literature [1],[2].

Nowdays , such components can be integrated in the form of chip-sets at reasonably low cost but it not conveniently integrated because of they are too large or required performance cannot be achieved by integrated components. We can therefore conclude that
Wireless systems require a platform for implementing all components with good performance, low cost. So SIW (substrate integrated waveguide) technology is developed platform for achieved the above requirements.[6]-[8] SIW structure preserve most of the advantages of conventional metallic waveguide namely high quality factor and high power handling with self-consistent electrical shielding and possibility to integrate all the components on the same substrate , including passive components, active and even antenna and there are no need for transitions between elements fabricated with different technologies thus reducing losses[13],[14].

One Most Serious issue is narrow bandwidth hence there is many techniques to improved the bandwidth of antenna. In design by using SIW technology reducing bandwidth[3],[4].To improved the bandwidth there are following techniques :

TABLE I

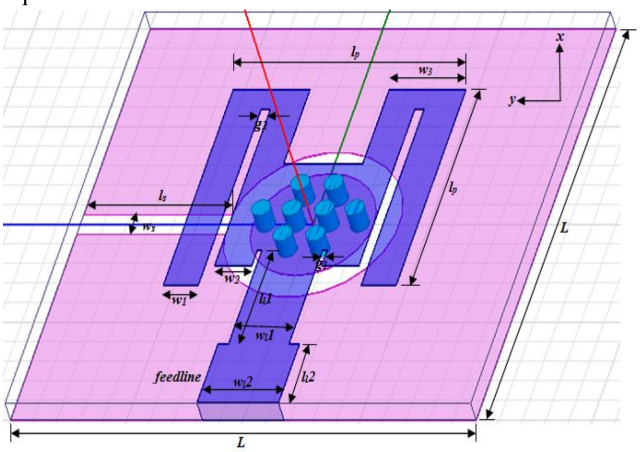
Sr. No.	Sources	Techniques
1	Modified shape of patches	1.Normally use rectangular shape patch but to increase bandwidth we should modified like e, h shape, circular or other.
2	Quality factor (Q)	1. Because of variety of patch shapes using reduction in quality factor of the patch which is due to the less energy stored beneath the patch and higher radiation.
3	Stacked multilayered patch antenna	1. Two patches are vertically stacked and built like multilayered printed circuit board.

4	Impedance matching	1. Introducing slots and stubs in the radiating element.
5	Planer multi-resonator configuration	1. In this technique multiple patches parasitically coupled and made to resonate at different frequency which causes the increase in bandwidth. 2. Using slots in the ground plane or in the radiating element.

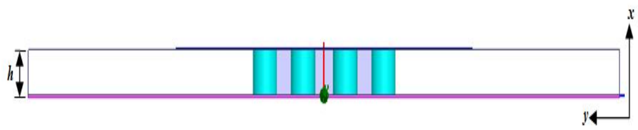
In satellite communication mainly KU-band(resonate at 12-18 GHz) system is considered and it offers a user more flexibility such as smaller dish antenna so, power will increases and generally cheaper in cost. In this paper proposed design is used SIW (Substrate Integrated Waveguide) to obtained frequency with wide bandwidth.

II. PROPOSED ANTENNA DESIGN AND DESCRIPTION

The design topologies of proposed microstrip wideband slot antenna presented in this section. Preliminary the full wave EM software used for designing Antenna. This is standard tool software used Finite Element method for designing and simulating 3D full wave electromagnetic field and there has option to select the solver as per simulation requirement.



(a) front View



(b) Side view

Fig.1(a), (b)Proposed structure of wide band slot antenna using SIW technology (l_s=6.33mm,w_s=1mm and metallic vias gap is 1.3mm).

Table II. Proposed antenna design parameters valve

No.	Element	Parameters	Values(mm)
1	Ground	L	20
		L	20
2	Substrate	L	20
		L	20
		h	0.883
3	Patch	l_p	10
		l_p	10
		w_1	1.5
		w_2	1.6
		w_3	3.3
		g_1	0.2
		g_2	0.4
4	Feedline	l_l1	2
		w_l1	2.6
		l_l2	3
		w_l2	3.5

The proposed wideband slot antenna geometrical structure and physical dimensions is shown in fig. 1(a),(b)and corresponding return losses are shown in fig. (3).In this structure of antenna the unique patch design (instead of conventional circular or rectangular patches) with colored depicts in violet placed on top of the substrate. The ground plane chosen to be square and has a length L×L and square radiating slot of dimensions $l_p \times l_p$. The patch size optimized to achieved miniaturized design .In begins with the design of antenna ,which consists of ring slot is fed by a 50Ω microstrip line of width with simple tuning stub connected with microstrip straight line. In proposed antenna design arranged using proximity coupling feed method with coupling gap using SIW(Substrate Integrated technology)structure where cylinders are use to placed in substrate to connects unique patch and metallic ground[5] and the coupling gap between them with a thickness 0.883mm of FR4 substrate where permittivity is 4.4(ε_r) and tangent loss will be 0.018.A slot is forming on lower side of substrate using a rectangular line with circular ring due to power of surface current will high[3].

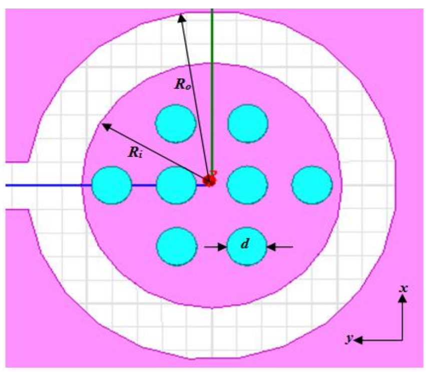


Fig.2 - Schematic view of metallic via-holes. (d=0.8mm, R_o=3.7mm, R_i=2.6mm).

SIW(Substrate Integrated Waveguide) using eight metallic via-holes that having diameter d and uniform separation distance as shown in fig. 2 are connected successfully with a fix manner between unique patch and feedline through substrate. The results shows that the proposed SIW microstrip slot antenna has two resonant modes in the frequency range of 13.8262 GHz and 15.2700 GHz with good return loss and wide bandwidth so is can clearly reveal the SIW structure increasing the impedance bandwidth of antenna.

III. SIMULATION AND EXPECTED OUTCOME

In order to simulate the antenna design using simulating tool full wave EM software to obtained all results such as Return loss, VSWR, gain and radiation pattern, , E-plane or Elevation plane and H-plane (Azimuth) are presented in this section.

A. Return Loss

The return loss obtained by this design is about -24.2405dB and -29.6387dB at frequency 13.8262GHz and 15.2700GHz and obtained wide bandwidth(-10dB) which is from -12.7708dB to -15.6800 dB. Fig.3 shows the return loss curve plot of reflection coefficient (dB) vs frequency (GHz) for the proposed antenna design fed by using proximity coupling feeding.

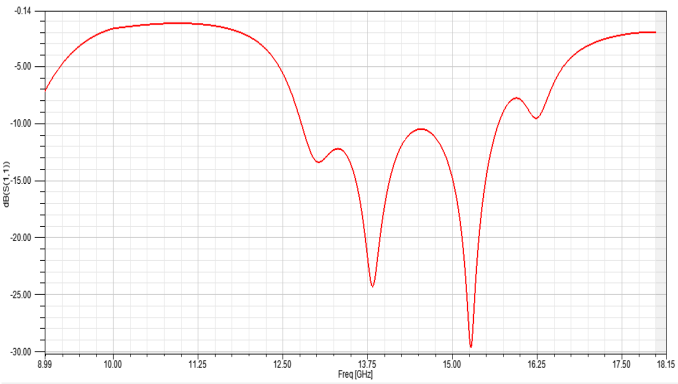


Fig. 3- S-parameter for proposed antenna design

B. Gain and Antenna Radiation Pattern

Fig. 4 and Fig.5 , Fig. 6 gives the 3D polar plot and antenna radiation pattern of antenna (E-plane or Elevation, H-plane or Azimuth) to obtained total gain calculation. Antenna gain is ability to achieved more power in one direction with its effective direction. At the resonant frequency the total gain obtained 4.78 dB and peak gain 3.01dB.

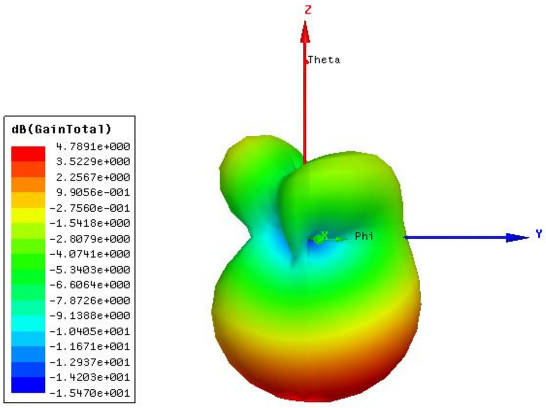


Fig. 4 - Antenna gain pattern of proposed design.

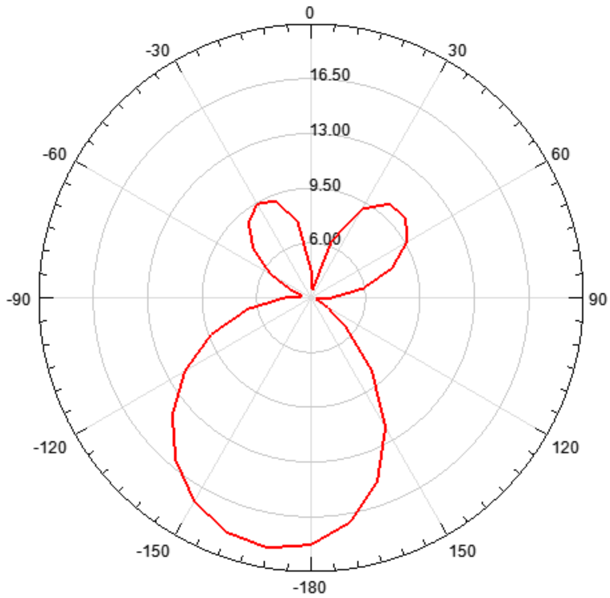


Fig. 5- Measured E-plane.

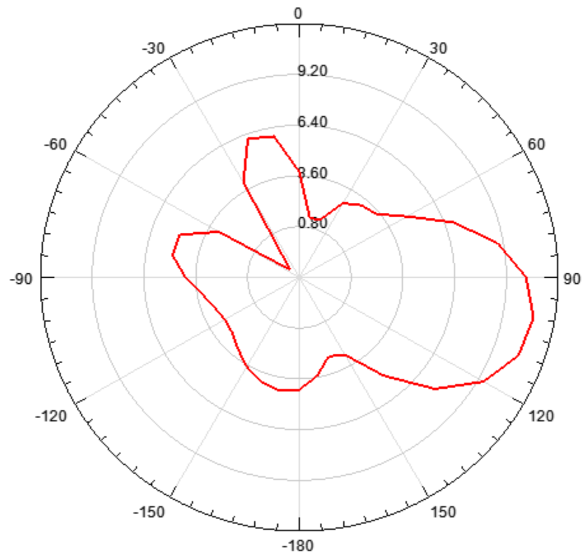


Fig. 6- Measured H-plane.

C. VSWR verses frequency for proposed antenna

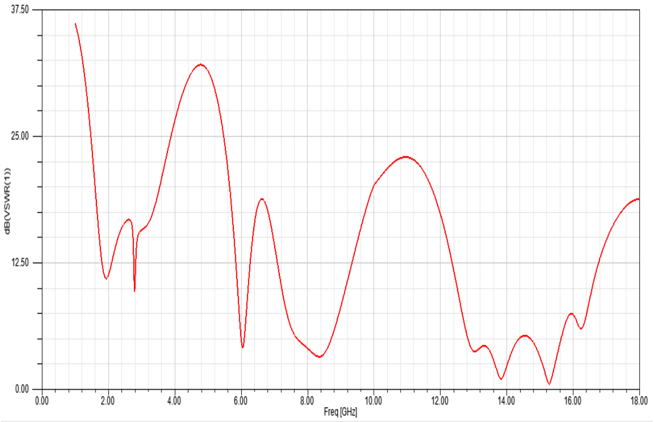


Fig. 8- Measured VSWR

IV. CONCLUSION

The performance of patch antenna is depending upon the dielectric constant (permittivity(ε_r)) major role in the overall. The width, height and length, It affects the characteristic impedance and the length results in altered resonant frequency. The bandwidth of antenna is depends upon the permittivity (ε_r) and thickness of the dielectric substrate. Hence a compromise must be reached between dimensions and antenna performances.

The designing has been done to gives feature like reduce size of antenna and low cost and good antenna performances.As an overall conclusion all the planned works and objectives of this report have been successfully implemented and achieved.

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