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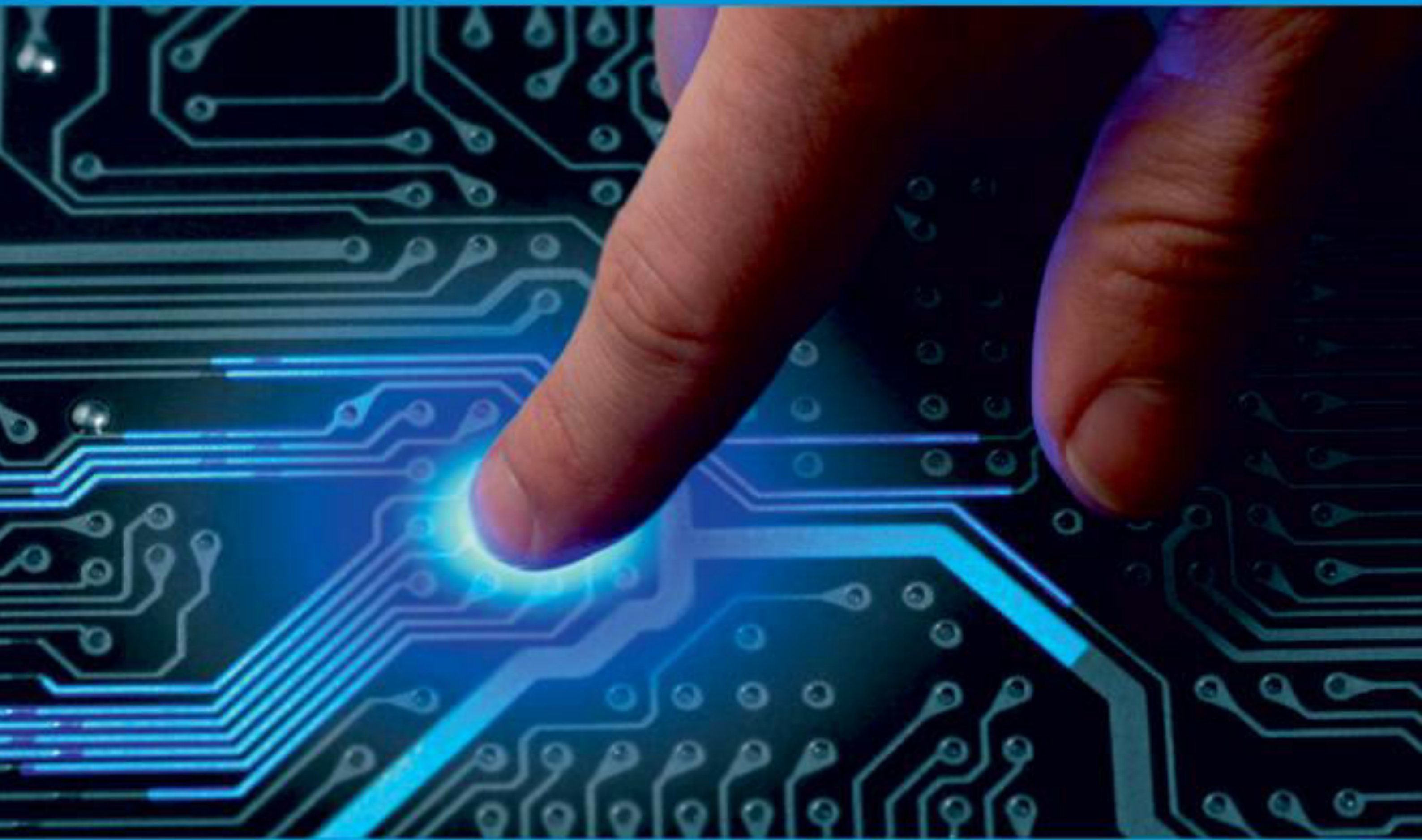

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Design and Analysis of a Compact K-band Substrate Integrated Waveguide (SIW) Slot with Microstrip Patch Antenna for Satellite and Radar Applications

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ABSTRACT: Now a days microstrip patch antenna is using in all satellite band applications. The K band is used for satellite communications, astronomical observations, and radars. Radars in this frequency range provide short range, high resolution and high throughput. The development in communication systems requires the development of low cost, minimal weight and low profile antennas that are capable of maintaining high performance over a wide spectrum of frequencies. Substrate integrated waveguide (SIW) is a new form of transmission line that has been popularized in the past few years and microstrip patch antenna significance by some researchers. This paper proposed the substrate integrated waveguide (SIW) using RO4350B with microstrip patch antenna at k-band. Simulated results show that the optimized bandwidth is approx 10GHz with -33.15dB return loss. The resonant frequency is -24.49 GHz.

KEYWORDS: Microstrip, SIW, RO, K-band, Radar, Satellite, Antenna.

I. INTRODUCTION

In telecommunication, a microstrip antenna (also known as a printed antenna) usually means an antenna fabricated using photolithographic techniques on a printed circuit board (PCB).[1] It is a kind of internal antenna. They are mostly used at microwave frequencies. An individual microstrip antenna consists of a patch of metal foil of various shapes (a patch antenna) on the surface of a PCB (printed circuit board), with a metal foil ground plane on the other side of the board. Most microstrip antennas consist of multiple patches in a two-dimensional array.

The antenna is usually connected to the transmitter or receiver through foil microstrip transmission lines. The radio frequency current is applied (or in receiving antennas the received signal is produced) between the antenna and ground plane. Microstrip antennas have become very popular in recent decades due to their thin planar profile which can be incorporated into the surfaces of consumer products, aircraft and missiles; their ease of fabrication using printed circuit techniques; the ease of integrating the antenna on the same board with the rest of the circuit, and the possibility of adding active devices such as microwave integrated circuits to the antenna itself to make active antennas [2] Patch antenna.

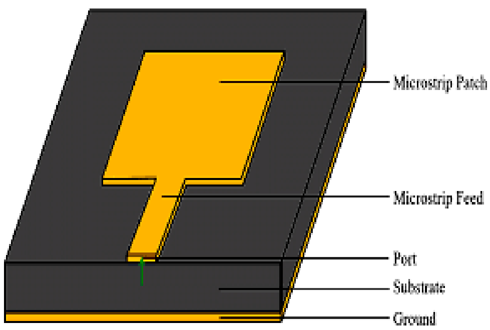

Figure 1: Microstrip Patch

The most common type of microstrip antenna is commonly known as patch antenna. Antennas using patches as constitutive elements in an array are also possible. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit

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board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. Some patch antennas do not use a dielectric substrate and instead are made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices.

A Substrate integrated waveguide (SIW) (also known as post-wall waveguide or laminated waveguide) is a synthetic rectangular electromagnetic waveguide formed in a dielectric substrate by densely arraying metallized posts or via-holes which connect the upper and lower metal plates of the substrate. The waveguide can be easily fabricated with low-cost mass-production using through-hole techniques where the post walls consist of via fences. SIW is known to have similar guided wave and mode characteristics to conventional rectangular waveguide with equivalent guide wavelength. Generally, due to the presence of the dielectric substrate, the width of SIW is narrower than that of the conventional waveguide. Owing to the limited thickness of the dielectric substrate, the electromagnetic field, along the height of SIW remains constant. Hence, the propagation and non-propagation of modes get excited inside its cavity [8].

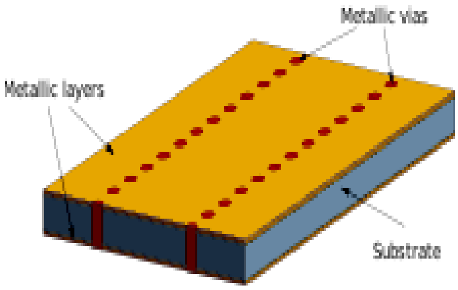

Figure 2: SIW Antenna

A SIW is composed of a thin dielectric substrate covered on both faces by a metallic layer. The substrate embeds two parallel rows of metallic via-holes delimiting the wave propagation area. The width of a SIW is the distance a between its two vias rows, which is defined from center-to-center. An effective width may be used to characterize more precisely the wave propagation. The distance between two successive vias of the same row and the vias diameter is denoted by d.

II. DESIGN METHODOLOGY

The proposed antenna calculation, design and optimization is done by using following steps-

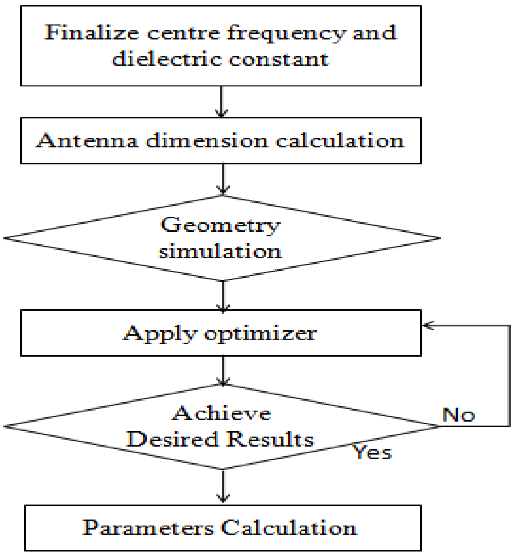

Figure 3: Flow Chart

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The flow chart work as following steps-

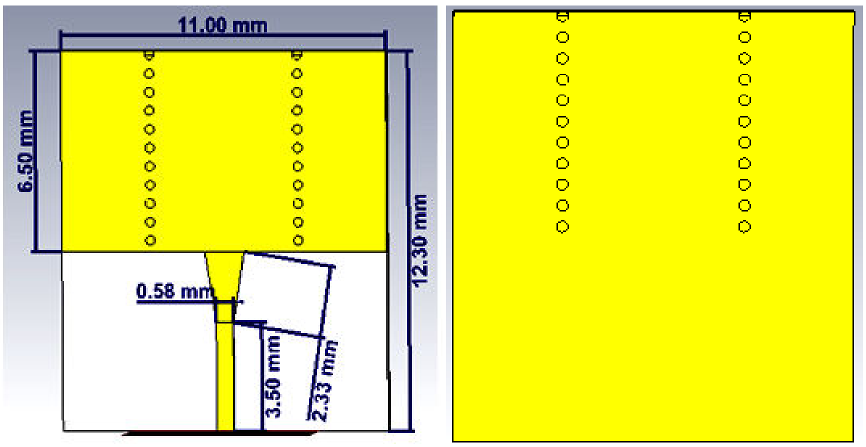
1. First find application and define requirement.
2. Next steps is finding out major specification of antenna
3. Resonating Frequency of antenna (according to application define in initial step of CST).
4. Choose a suitable substrate, it may depend upon various factor like availability of material, integration of antenna with other circuit components on board. Dielectric constant and height of substrate are important for SIW antenna parameter calculation.
5. Calculate SIW antenna dimension. Most of the time antenna used in wireless communication is not simple antenna, these are customized structure.
6. Calculate antenna width and length using standard formula.
7. Antenna height (Its define in substrate material already for microstrip antenna its usually 1.5mm-1.6 mm). It can be selected using CST.
8. Draw antenna geometry and define materials.
9. Run simulation and check performance parameters values.

Now the use of CST microwave studio software, make the design using calculated dimensions.

Parameter List

Name	Expression	Value
diaThick	= 0.254	0.254
metalThick	= 0.035	0.035
x	= width+6	11
y	= pitch*20	12
width	= 5	5
dia	= 0.3	0.3
pitch	= 0.6	0.6
p	= 1.5	1.5
Mw50	= 0.58	0.58
transL	= 2.3	2.3
transW	= 1.33	1.33
gap2	= width/2-transW/2	1.835
tempW	= width/2-dia/2-0.2-mw50/2...	1.66
ratio	= tempW/sqr(tempW^2+tra...	0.585233084123165
ratio1	= transL/sqr(tempW^2+tran...	0.810865116556193

Figure 4: Antenna dimension parameters and values



(a) (b)

Figure 5: (a) Top view of proposed microstrip SIW design with Antenna Dimension (b) Bottom Structure

Figure 5 is showing the top view of proposed design with antenna dimension and bottom structure. The RO4350B dielectric material is used for substrate layer and copper material is used for design of microstrip SIW structure. The dimension of proposed antenna is 11 X 6.50 X 1.64 mm^3.

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III. SIMULATION RESULTS

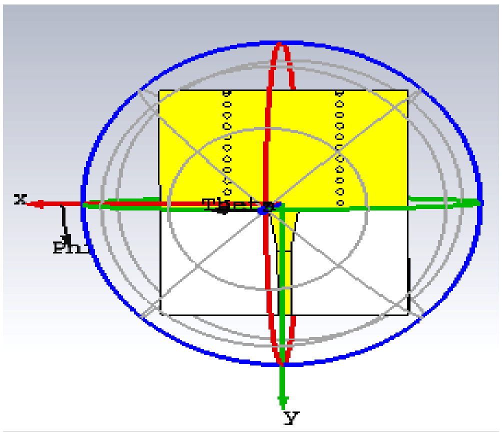

Figure 6: Simulation and fields of proposed antenna

CST microwave studio used to recreate the proposed plan. Figure 5 is demonstrating reenacted electric and attractive field in round organize framework.

Return loss

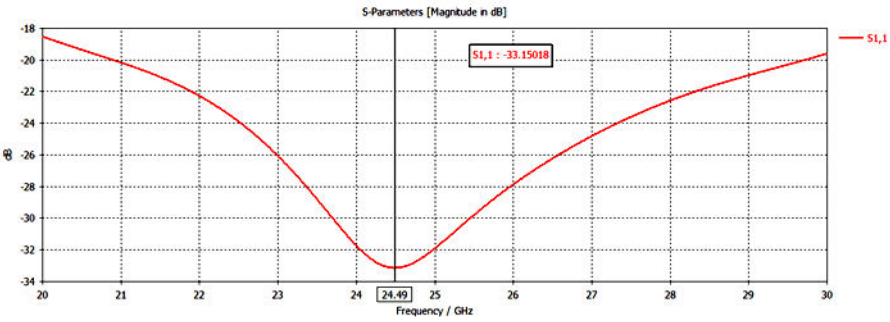

Figure 7: Return loss

Figure 7 is showing the obtained value of S11 or return loss that is -33.15 dB for 24.49 GHz resonant frequency, where antenna provides significant applications at k band.

Voltage Standing Wave Ratio (VSWR)

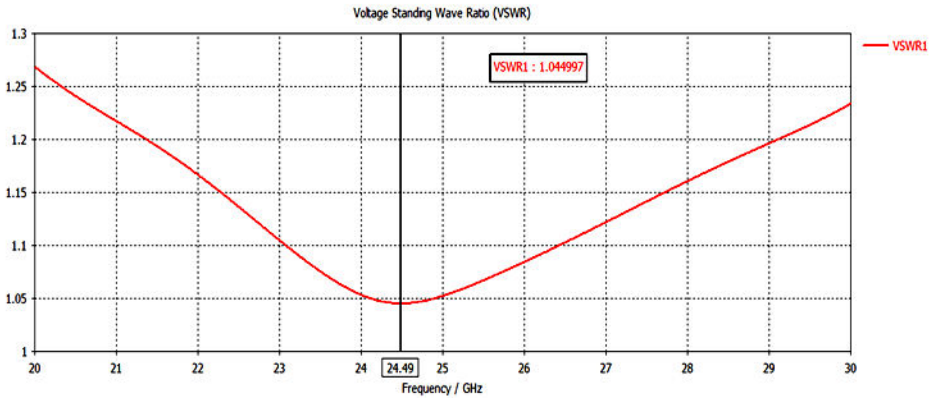

Figure 8: VSWR

Figure 8 shows VSWR esteem, it is voltage standing wave proportion; VSWR must lie in the range of 1-2, which has been achieved for the frequencies 24.49 GHz. The value for VSWR is 1.044.

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Bandwidth

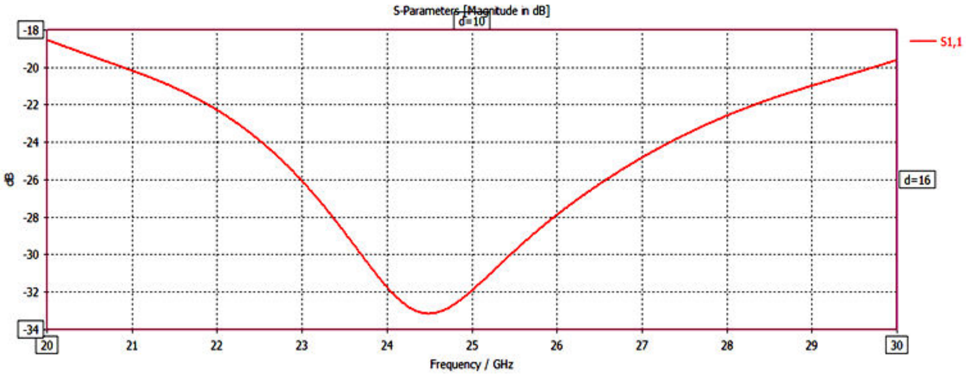

Figure 9: Bandwidth

For broadband antennas, the bandwidth is expressed as a percentage of the frequency difference (upper minus lower) over the center frequency of the bandwidth. The bandwidth of proposed antenna is 10 GHz, (30GHz – 20GHz).

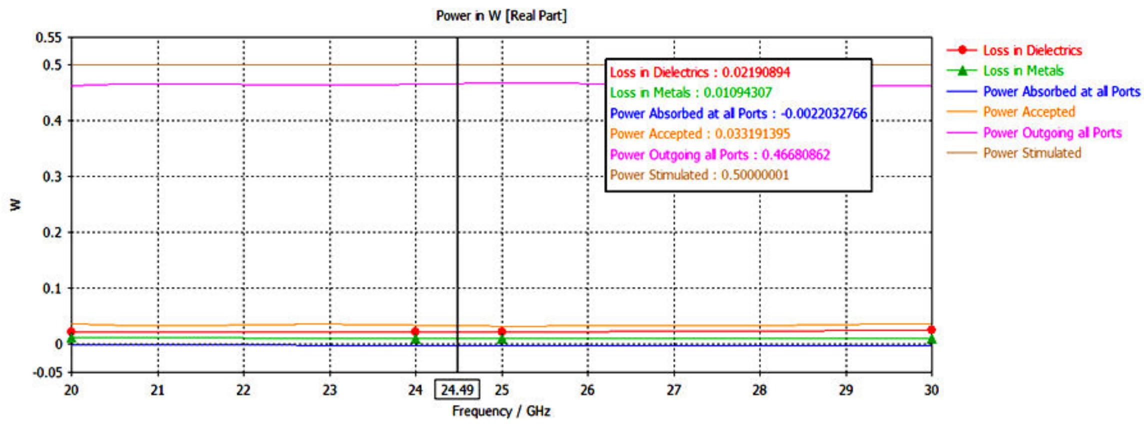

Figure 10: Power

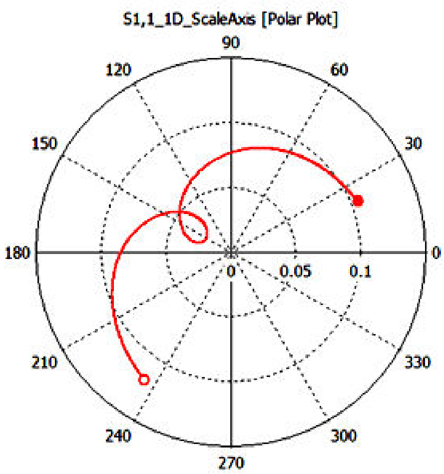

Figure 11: Polar plot radiation pattern

Figure 11 shows the polar plot radiation pattern. The proposed microstrip SIW antenna provides the better results than existing structure.

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Table 1: Simulated Results of Proposed Antenna

Sr No.	Parameter	Optimized Band
1	S11 or Return Loss	-33.15 dB
2	Band Width	10 GHz
3	VSWR	1.0449
4	Resonant Frequency	24.49 GHz

Table 1 shows performance parameters like return loss, bandwidth, VSWR and resounding recurrence. It is clear by observing reenacted values from table 1, proposed antenna accomplish siginificant improved outcome.

Table 2: Comparison of proposed design result with previous design result

Sr No.	Parameter	Previous work	Proposed work
1	S11 or Return loss	-25 dB	-33.15 dB
2	Band Width	500 MHz	10 GHz
3	VSWR	1.0714	1.0449
4	Resonant Frequency	9.6 GHz	24.49 GHz

Table 2 is showing comparison between previous design and proposed design. It is clear from this table and results the proposed microstrip SIW antenna design have significant good and improved result than previous results.

IV. CONCLUSION

The proposed design of microstrip SIW antenna characteristics on a Roger Substrate Integrated Waveguide antenna for k band application which includes the radar and satellite applications has been investigated. Different parameters like VSWR values are 1.0449 for the respective frequencies 24.49 GHz. In the last, the new types of proposed antenna (microstrip SIW antenna), which are more appropriate for various application under the 5G communication.

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