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Leaky wave Antenna Based on SIW Technology With Polygonal Rings for wide scanning range

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ABSTRACT

This paper presents the results of the study on a new version of a leaky-wave antenna that is based on a substrate integrated waveguide (SIW).SIW's structure consists of two rows of cylinders sandwiched between metal plates. It can be simply manufactured using the normal PCB circuit or LTCC method, and the antenna is designed to radiate in the Ka-band. The Antenna has concentric circular slots whose centers are collinear along the center of the Antenna. The Antenna is made such that, the beam steering can be exhibited, which makes the main lobe and direction of propagation of the antenna can be changed by altering the frequency of propagation.The antenna is designed and simulated in HFSS and the prominent parameters such as S11 and gain plots are studied. We achieved a beam steering of 120˚.

KEYWORDS: Substrate Integrated Waveguide,Leaky wave Antenna,Beam steering,Radiation Pattern,HFSS.

1. INTRODUCTION

The next-generation communication networks require ultra-wide bandwidth for which transmission antennas are required to operate in the Ka-band in particular for satellite and mobile communication. Array antennas have several applications in communications systems. They are usually developed using microstrip or waveguide technologies. However, with the development of a novel technology called substrate integrated waveguide (SIW), Substrate integrated waveguide (SIW) technology has been studied very extensively in recent years and has by now become a widely applied technique in planar microwave circuit design. These waveguide-like structures are fabricated in planar form and are built up by periodically arranged metallic via-holes or via-slots, the advantage of the well-known characteristics of conventional rectangular waveguides, namely, its high Q-factor and high power capacity, as, well as its low losses. Though they have been studied for use in antenna applications. A leaky-wave antenna has been widely used in aerospace applications for many years. The main advantage of these antennas is that they save space and can be located on the external surface of various bodies. They are low cost, can be easily fabricated, and are therefore suitable for mass production Substrate integrated waveguide (SIW) structures.

A.Leaky Wave Antennas

Leakage antennas or LWAs have been widely used in aerospace applications for many years. These are guided structures that use leaked wave propagation as the radiation mechanism. Based on a closed waveguide, the LWA is suitable for mass production as it requires little computational effort to design and can be achieved with simple manufacturing techniques. The first substrate-integrated waveguide was described by Shigeki in 1994. The main purpose of this new type of structure is to increase the integration density while reducing the manufacturing cost of the Antenna. Shigeki demonstrated that the two rows of cylinders between the metal plates can confine the electromagnetic field in the same way as a rectangular waveguide. The board-integrated waveguide (SIW) technology has recently been considered and has become the widely used technology in planar microwave circuit design. These structures have many advantages such as mass production, high-Quality factor, and low losses.

This post uses the HFSS microwave Studio to design a SIW component that works with the CBNB band for TE10 mode. Comparison is created by the exact moment method of momentum software to confirm the resulting result. Since the structure extracts the equivalence guiding, then fittings, calculates the width of the SIW, passage and transport SIW microstrip Use the transition impedance matching equation. After, a leather antenna is constructed based on an integrated waveguide (SIW) with a lateral slot and radiates the main beam that can be controlled by changing the frequency from the reverse direction.

B.Substrate Integrated Waveguide

Substrate Integrated Waveguide (SIW) is a very promising technique in that we can make use of the advantages of both waveguides and planar transmission lines. As a waveguide, we can get such advantages as low loss, high Q factor, high power capability, and small radiation. And as a planar transmission line, we can fabricate it with the Printed circuit Board (PCB) technique which is a relatively low cost. This technique is becoming a new means of signal transmission, have been the basis for the design of many circuit components. Components such as power dividers, resonator cavities, and filters that have been developed using microstrip, stripline, or milled waveguides technologies are now redesigned using the SIW platform, also patch antennas and Leaky Wave Antennas are being redesigned now using SIW. The concept of planar Leaky Wave Antennas (LWAs) due to their multiple advantages like narrow and high directive beams, inherently simple feeding network, and reduced unit cell length, makes us interested in this kind of structure. The low profile and easy manufacturing make them ideally suited for modern communication systems since they give a high-quality performance at a low cost. This type of antenna is on studied last year using the SIW technique and was analyzed and then the scanning angle and gain are optimized by good results were obtained. The criticism that has been raised about these new interconnects and components is that they possess a relatively large footprint.

2.WORKING PRINCIPLE

The antenna array is stimulated from one port, and the residual signal power is absorbed by a match load on the other port, preventing it from being reflected and forming standing waves. Magnetic currents are excited on the slots by the electromagnetic field of a TE10 mode incident wave. A leaky wave is generated by periodic discontinuities in the SIW guiding structure, which permits energy leakage or radiates electromagnetic fields into the free space along the structure. The slot offset and length determine the amount and phase of the voltage stimulated in the slot.

The majority of energy seeps out via the slots in the first half of the antenna, leaving only a few at the other end, indicating that leftover energy is reduced by the time it reaches the other port.

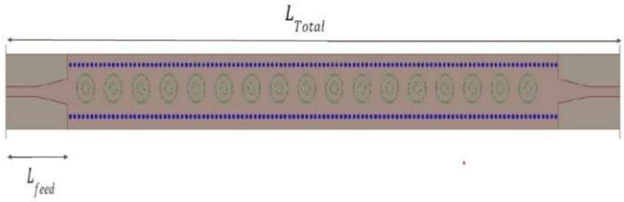
However there has been little to no work put into the viability of image processing to achieve electronic automated invoicing.

3.ANTENNA CONFIGURATION AND DESIGN

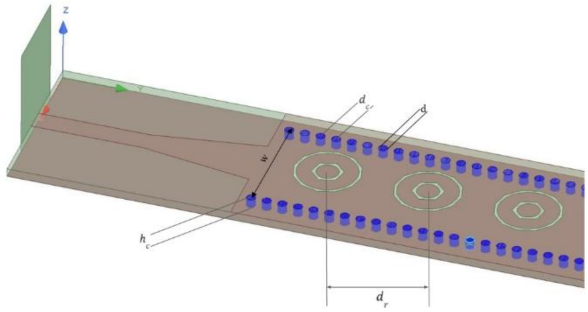
The Proposed Antenna Structure and dimensions are shown below.

A.Proposed SIW LWA Unit Cell

The antenna under consideration is basically a waveguiding structure that possesses a mechanism that permits it to leak power all along its length. In this construct LWA based on SIW as shown in Fig.1.



(a)



(b)

Fig. 1. Configuration of proposed SIW periodic leaky-wave structure (a) top view (b) 3-D view.

Table-1

Parameters of proposed LWA

Parameter	Value(mm)
L_{Total}	200
L_{Feed}	20
D_c	1.4
d_r	9
h_c	0.762
w	10.5
d	0.8

The proposed antenna is designed based on substrate integrated waveguide (SIW) consisting of two horizontal metal plates, the ground plane and the transmission line plate with etching of periodic concentric polygon-shaped concentric collinear rings on the upper plate. The two metal plates are connected together by using metal vias on both sides of the substrate. These vias act as sidewalls of the waveguide. A tapered feed is used on both the ends to provide better impedance matching.

The designed leaky-wave antenna consists of 17 unit-cells. The separation between the adjacent unit-cells is 9 mm. The overall antenna size is 15.3 × 200mm^2, which is printed on grounded Roger/RT Duroid 5880 (tm) substrate. To match the designed antenna to 50-Ω feed line, the two ends of the designed antenna are terminated by tapering matching sections.

B.Reflection Coefficient,Radiation Pattern and VSWR

The S-parameter of the LWA with concentric slots based on SIW is shown in Fig.2.

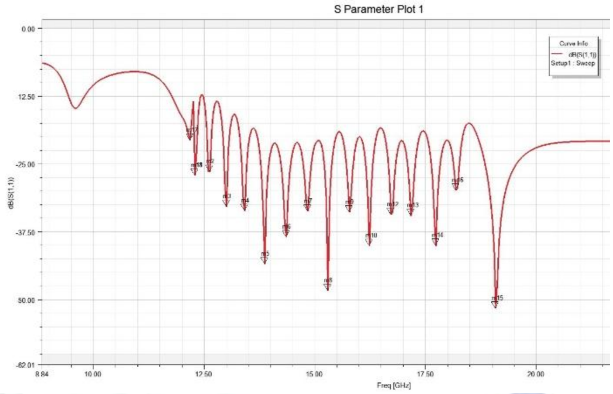
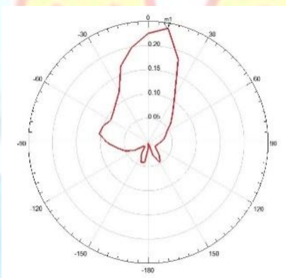
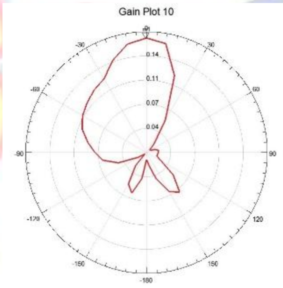


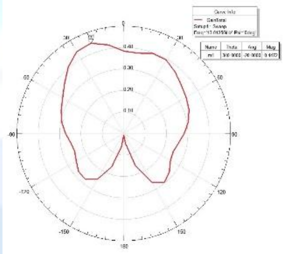
Fig.2. Reflection coefficient S11

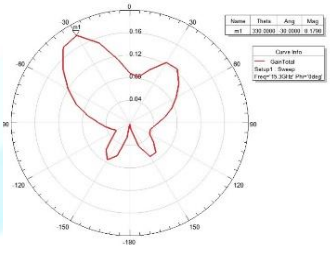
The radiation patterns representation of LWA are depicted in Fig.3.



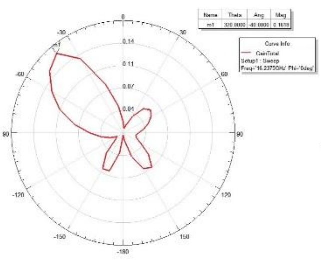


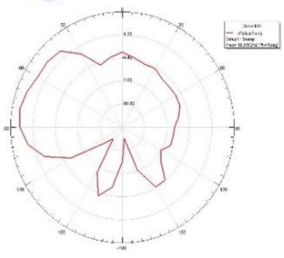
(a) (b)





(c) (d)





(e) (f)

Fig.3. Simulated and measured radiation pattern at (a) 12 GHz, (b) 12.6GHz, (c) 13.01 GHz, (d) 15.3 GHz, (e) 16.23 GHz. and (f) 16.23.

The maximum radiation pattern can be obtained at more than one frequency. Frequency scanning from angle −90˚ to 20˚ is achieved around the resonant frequency as shown in Fig.3. the beam directions are 10°, 0°, -20°, -30°, -40° and -90° calculated respectively the frequencies 12 GHz, 12.6 GHz, 213.01 GHz, 15.3 GHz, 16.23 GHz and 18.37 GHz. About 100 to 120° scanning range can be achieved. The scanning is assured using this technique around the broadside direction.

The VSWR of the proposed design is plotted. From fig.4, it is clear that voltage standing wave ratio (VSWR) at resonant frequencies are less than 2.

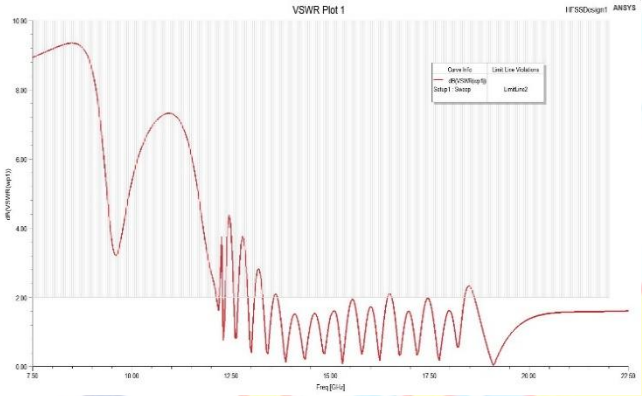


Fig.4. VSWR of Antenna

4.CONCLUSION

This work proposes a new periodic LWA antenna with a unit cell made up of concentric polygonal slots and a post that can sustain a wide scanning range. This antenna is made up of an array of impedance-matched unit cells that run in the propagation direction. In Ka [9.3–21.2 GHz] band radar, the structure offers a wide range of applications. Wherever Beam-Steering is required, the Antenna finds use. The structure features a Frequency scanning angle of −90˚ to 20˚ and a Beam-steering angle of 120°.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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