Ku-Band Substrate Integrated Waveguide (SIW) Slot Array Antenna for Next Generation Networks

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Abstract

The design of an antenna based on Substrate Integrated Waveguide (SIW) has been realized in this paper. The structure consists of an array of slot antenna designed to operate in Kuband applications. The effect of introducing arrays of slots has been extensively studied unlike any other recent publications in this field. The basic structure has been designed over a dielectric substrate with dielectric constant of 3.2 and with a thickness of 0.782mm. The design consists of a SIW antenna fed with a microstrip to SIW transition. Multiple slot array effects have been studied and analyzed using CST Microwave Studio full wave EM Simulator which supports Finite Element Method (FEM) of computational Electromagnetics. The design has been supported with its return loss and radiation pattern characteristics to validate Ku-band operation. The effect of increasing the number of slot arrays has also been analyzed to support integration to System-on- Substrate (SoS) which promises more compact layouts.

Index terms— substrate integrated waveguide (SIW), dielectric filled waveguide (DFW), ku-band, antenna design.

1 INTRODUCTION

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), it is possible to attain many advantages like low cost, reduced sizes, easy integration, etc [1].

Substrate Integrated Waveguide (SIW) has emerged as a new concept for millimeter-wave (mmwave) integrated circuits and systems for the next generation due to their manifold advantages. A waveguide based on SIW is considered as a dielectric filled rectangular waveguide whose metallic walls are formed by cylindrical via arrays with diameter d and separation p between vias (pitch). SIW yields high performance from very compact planar circuits [2].

Abstract -The design of an antenna based on Substrate Integrated Waveguide (SIW) has been realized in this paper. The structure consists of an array of slot antenna designed to operate in Ku-band applications. The effect of introducing arrays of slots has been extensively studied unlike any other recent publications in this field. The basic structure has been designed over a dielectric substrate with dielectric constant of 3.2 and with a thickness of 0.782mm. The design consists of a SIW antenna fed with a microstrip to SIW transition. Multiple slot array effects have been studied and analyzed using CST Microwave Studio full wave EM Simulator which supports Finite Element Method (FEM) of computational Electromagnetics. The design has been supported with its return loss and radiation pattern characteristics to validate Ku-band operation. The effect of increasing the number of slot arrays has also been analyzed to support integration to System-on-Substrate (SoS) which promises more compact layouts. SIW are integrated waveguide-like structures fabricated by using two rows of conducting cylinders and slots embedded in a dielectric substrate that connect two parallel metal plates (Fig. 1). In this way, the non-planar rectangular waveguide can be made in planar form compatible with existing planar processing techniques. SIWs exhibit propagation characteristics similar to that of classical rectangular waveguides. The modes of the SIW practically coincide with a subset of the modes of the rectangular waveguide, namely with the TE n0 modes, with n =1, 2, ? In particular, the fundamental mode is similar to the TE 10 mode of a rectangular waveguide, with vertical electric current density on the side walls. TM modes cannot exist in the SIW, due to the gaps between metal vias: in fact, transverse magnetic fields determine longitudinal he next generation communication networks require ultra-wide bandwidth for which transmission antennas are required to operate in the Ku-band in particular for satellite and mobile communication. Nowadays, antenna design in Ku-Band has been one of the major focused areas. Ku-band systems have wide applications in satellite communications, especially in the mobile antenna systems used in vehicles. Apart from communication networks, there are several other application areas of Ku-band systems such as weather radars and fire detection radars. These systems need highly directive antennas with a very wide frequency band covering the entire Ku-Band to transmit signals to the receiver with equal power in the whole frequency range and an automatic tracking system to capture the maximum power incident from the satellite while the time and place of the receiver changed.

advantages of conventional metallic waveguides, namely, high quality-factor and high power handling capability [4]. where, a is the total broad side dimension of the rectangular waveguide, a s is the separation between via rows (centre to centre), d a is the width of DFW, d is the diameter, p is the pitch (as shown in Figure 1) and c is the velocity of light in free space [5][6][7].

Also TE and TM modes represent Transfer Electric Mode and Transfer Magnetic Mode respectively. The suffixes m and n represents number of half waves in design we focused on the Ku-band applications and in our case the antenna has been designed to resonate at frequency of 16GHz. The dimensions of the slots are important for the antenna to behave as a slot antenna. The dimensions of the slots can be obtained with the help of the following relations. The final structure as obtained after a microstrip to SIW transition with 2 slots has been shown in Figure 4. The return loss of the 2 slot structure as obtained using EM CAD tool has been shown in Figure **??**. The antenna has been found to resonate at 15.75GHz with a return loss of 15dB.

Volume XIII Issue V Version I The cut-off frequency of the SIW can be obtained using the above design equations. In our surface current. Due to the presence of the gaps, longitudinal surface current is subject to a strong radiation, preventing the propagation of TM modes [3]. Moreover, SIW structures preserve most of the The 6 slot structure has been found to resonate at 15.5GHz with a return loss of 16dB. As found in 4 slot array structure, the increment of slots is creating separate resonant frequencies. In case of 6 slot array the structure tends to resonate at some other nearby frequencies within Ku-band. The antenna may be made to resonate at one single desired frequency by careful adjustments of the slot dimensions.

2 RADIATION PATTERN

The simulated radiation pattern (co-pole & cross-pole) of the multiple slot array antenna based on SIW technology has been shown in Fig. 10. The results show that the structure comes with a constant gain over the entire band of resonance with an increase of gain with greater number of slots. [1]

1

Figure 1: Figure 1 :

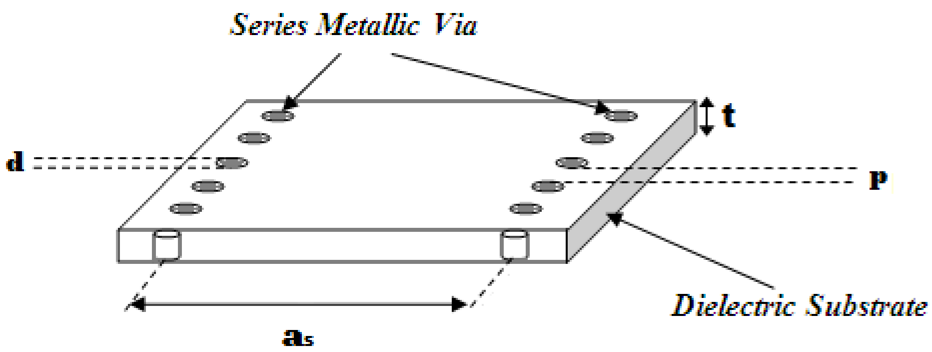

Figure 2:

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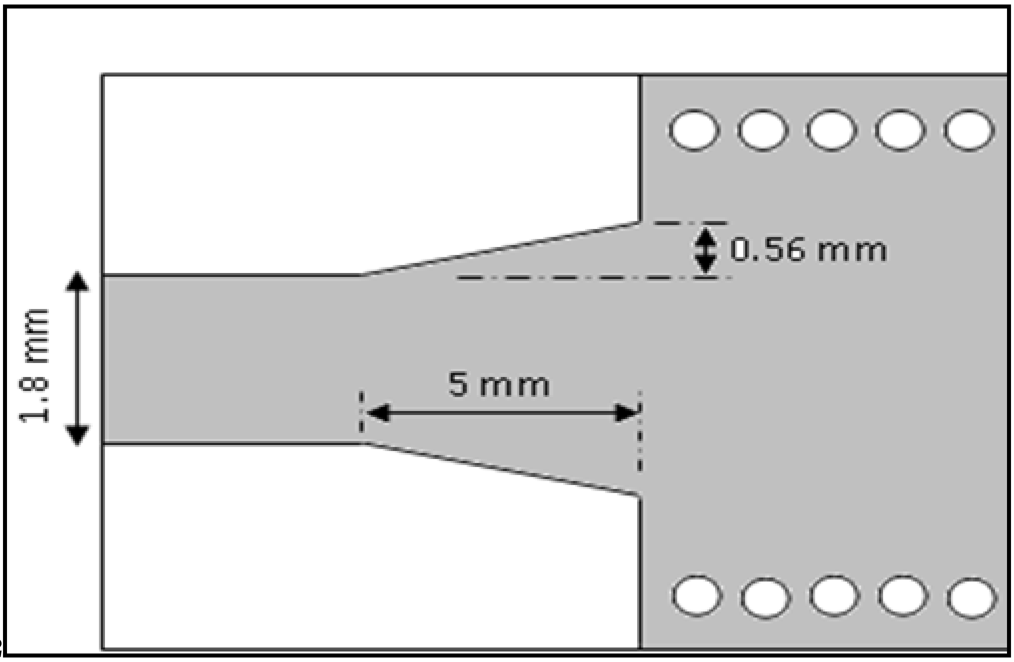

Figure 3: Figure 2 :

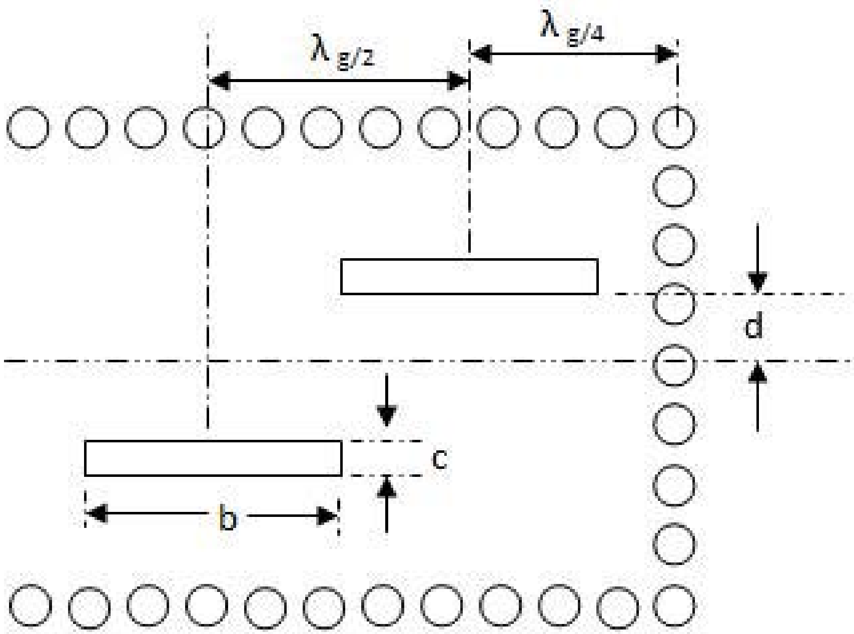

Figure 4:

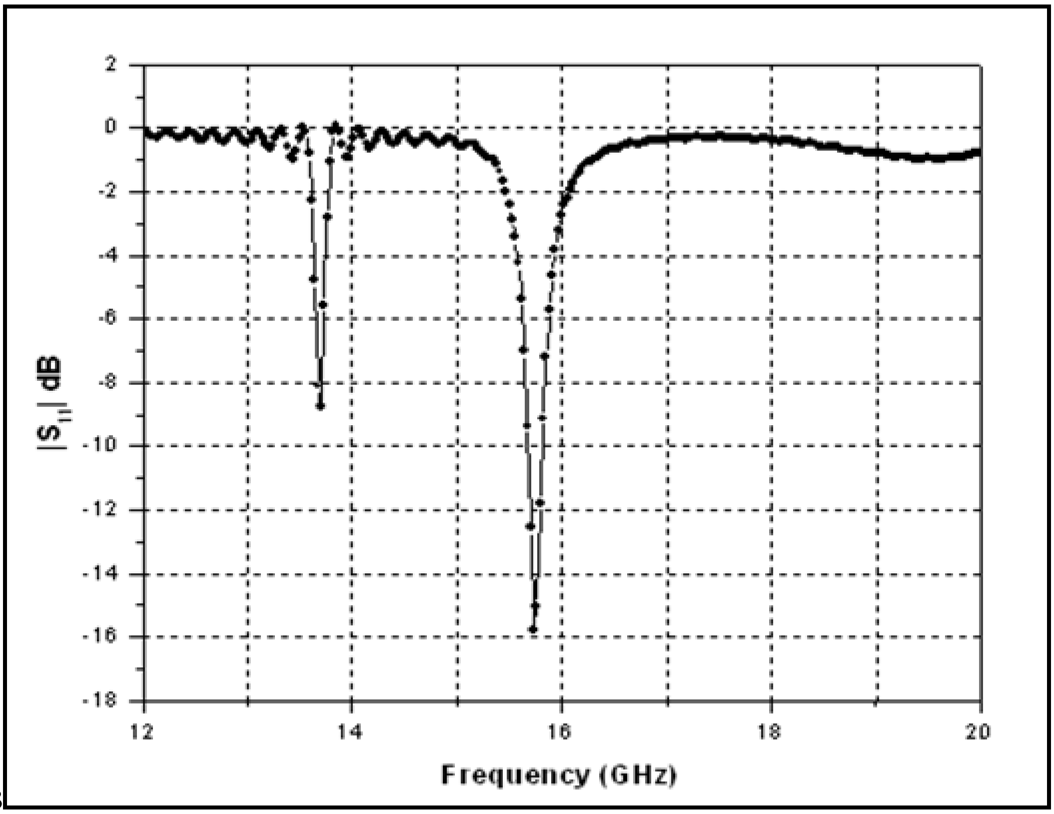

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Figure 5: Figure 3 :

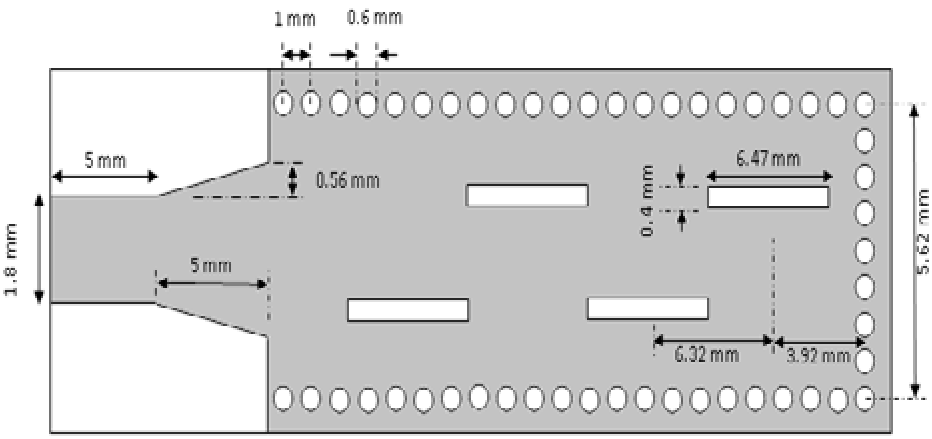

Figure 6: E

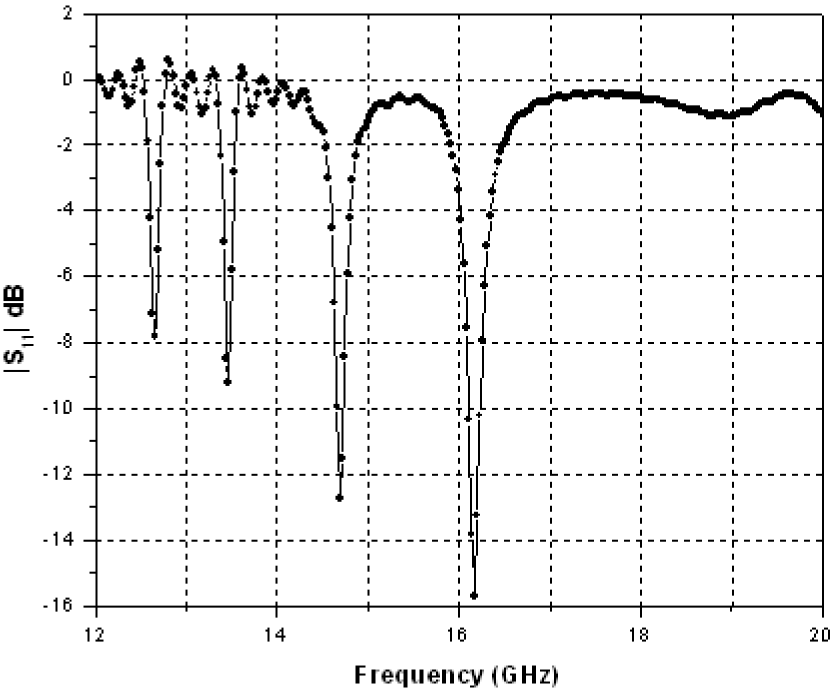

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Figure 7: Figure 4 :

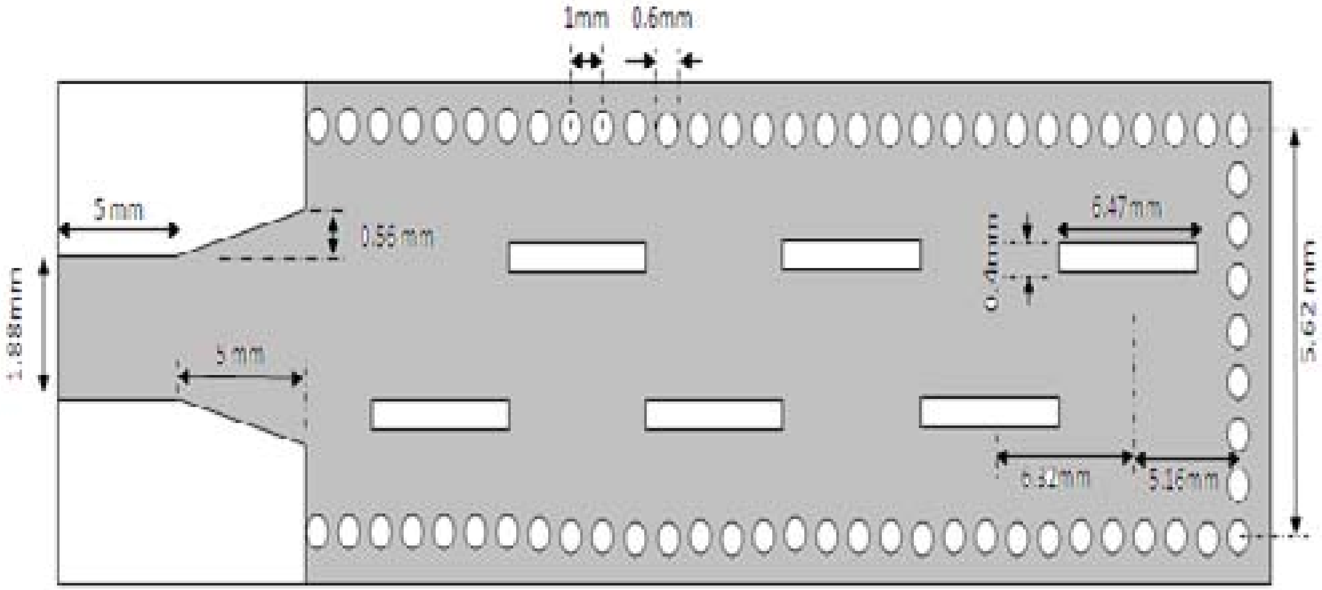

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Figure 8: Figure 6 :

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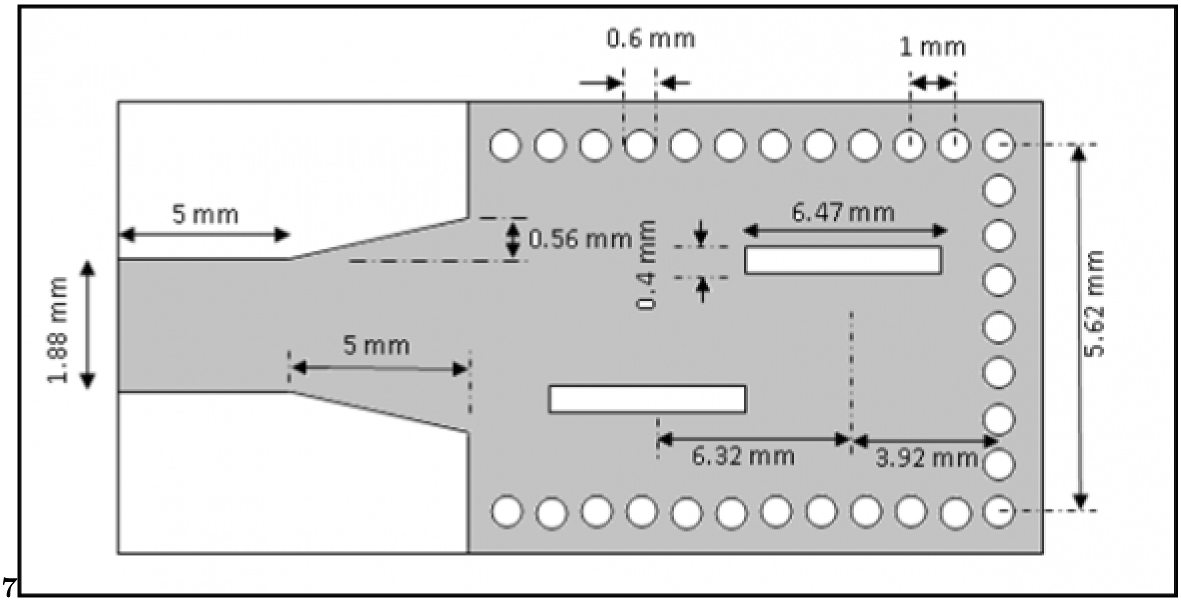

Figure 9: Figure 7 :

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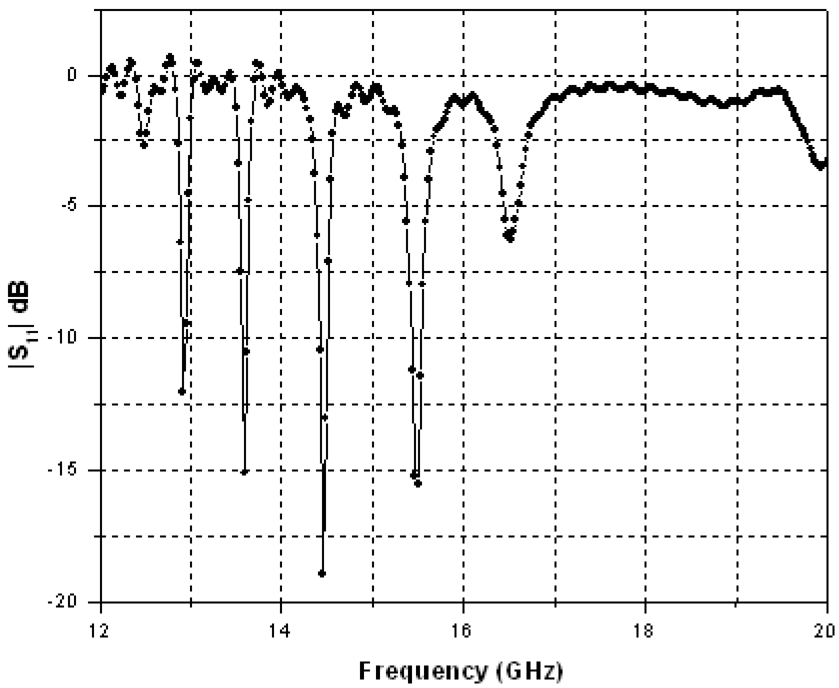

Figure 10: Figure 8 :Figure 9 :

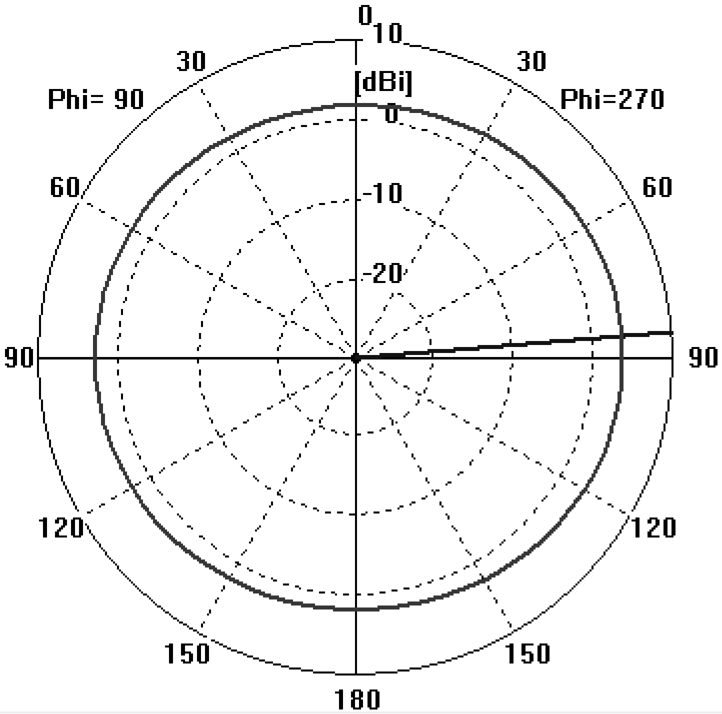

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Figure 11: Figure 10 Figure 10

1

	antenna		
No. of Slots	Resonant Frequency	Return loss (dB)	Gain (dBi)
2	15.75	15	3.7
4	16.16	16	5.7
6	15.5	16	6.3
III.			

Figure 12: Table 1 :

.1 Acknowledgement

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