

Introduction to SIW Waveguide, SIW & CPW feed antenna and its transition Feed

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Abstract

A Substrate Integrated waveguide (SIW) is simulated operating at millimeter wave frequencies (i.e., 37 GHz). It is used to feed Microstrip antenna and comparison is made with coplanar waveguide (CPW). In order to improve the return loss and efficiency of microstrip antenna feeding is done by CPW-SIW Transition feed which combines the advantage of both CPW & SIW.

Index Terms : 37GHz Frequency, Microstrip antenna, SIW, CPW, CPW-SIW transition.

I. INTRODUCTION

In Antenna technology, there is lots of feeding technique, initially it was Microstrip line which suffers from high ohmic losses and introduce significant spurious radiation into the system, both leading to substantial reduction of gain and aperture efficiency of antennas. But in Coplanar Waveguide¹ all the conductors are in the same plane; namely on the top surface of the dielectric substrate. The performance of coplanar lines is comparable to and sometime even better than microstrip line in terms of guide wavelength, dispersion and losses. Active elements such as MESFETs can easily be connected to coplanar lines because they are coplanar in nature. But it requires infinitely thick substrate and is more sensitive to covers or shield placed above the guide. Now, Substrate integrated waveguide (SIW)² also called post-wall waveguide or laminated waveguide, is promising candidate for millimeter-wave and terahertz applications. This periodic waveguide is composed of two rows of conducting cylinders embedded in dielectric substrate that connect two parallel metal plates. In this way, a synthetic rectangular metallic waveguide filled with dielectric material is constructed in planar form, thus allowing a complete integration with planar transmission-line circuits such as microstrip and coplanar waveguide on the same substrate.

II. SUBSTRATE INTEGRATED WAVEGUIDE

A. Microstrip Antenna

In millimeter wave application^{12,13} substrates are often much thicker than at lower frequencies. Important factors for antennas on electrically thick substrates include surface waves and mutual coupling. The lowest order surface waves (TM₀) has a zero cut off frequency, and thus is excited to some degree even on very thin substrates. As the substrate becomes

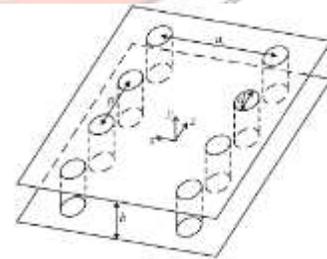
thicker, more surface wave mode can exit, and more power can be coupled into these waves. Mutual coupling between elements in array involves the transfer of power from one element to a nearby element via space waves (direct radiation) or by surface waves. For application in millimeter wave substrates permittivity ranges from 2.55 to 12.8. But as we know that as the permittivity increases, losses of the antenna also increase. So we have taken lowest permittivity in these range and i.e., 2.55

The antenna dimensions for millimeter wave applications are evaluated by equations.^{9,10,11}

B. SIW (Substrate Integrated Waveguide)

For investigation on periodic structures such as SIW there has been a numerical technique that has been developed³. Several physical parameters are used to illustrate the geometry and medium of the SIW structure^{3,4}.

Design Rules:



1. $p > d$
2. $\frac{p}{\lambda_c} < 0.25$
3. $\frac{a_l}{k_0} < 1 \times 10^{-4}$

FORMULAS FOR SIW

$$1. W_{RWG} = \xi_1 + \frac{\xi_2}{\frac{s_{via}}{d_{via}} + \frac{\xi_1 + \xi_2 - \xi_3}{\xi_3 - \xi_1}}$$

$$2. \xi_1 = 1.0198 + \frac{0.3465}{\frac{w_{siw}}{s_{via}} - 1.0684}$$

$$3. \xi_2 = -0.1183 + \frac{1.2729}{\frac{w_{siw}}{s_{via}} - 1.2010}$$

$$4. \xi_3 = 1.0082 + \frac{0.3465}{\frac{w_{siw} + 0.2152}{s_{via}}}$$

$$5. \frac{a_{rec}}{w_{siw}} = W_{RWG}$$

$$6. p = s_{via}$$

$$7. d = d_{via}$$

SIW (substrate Integrated Waveguide)

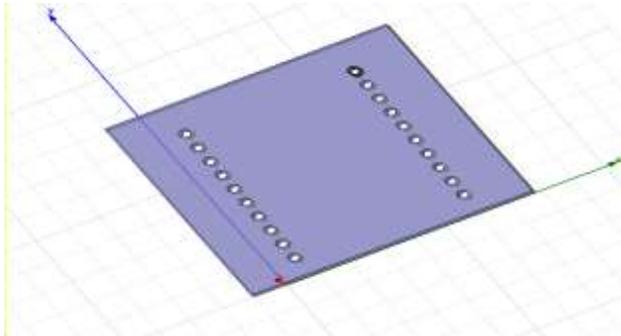


Figure1: Design

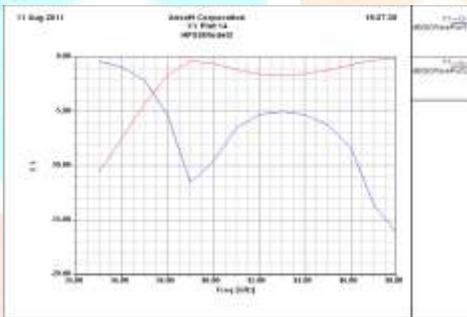


Figure2: S-parameter

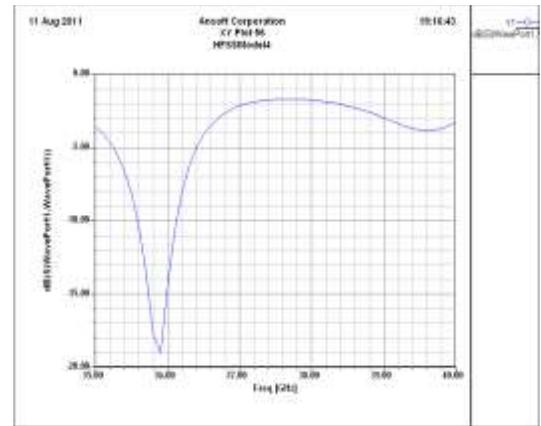


Figure 4: S-parameter

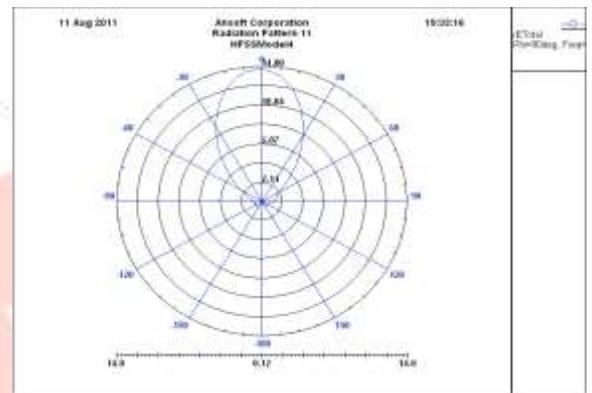
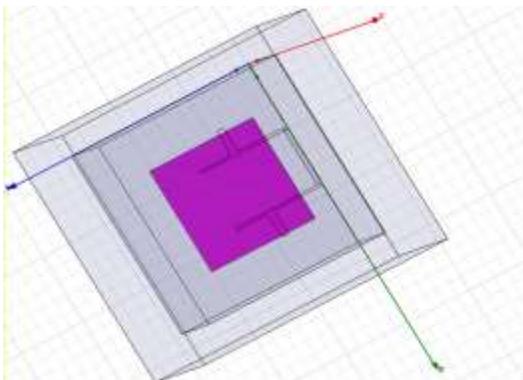


Figure 5: Radiation Pattern

C. CPW (Coplanar Waveguide) fed Microstrip Antenna

For the analysis of this structure, we invoke the assumption that the capacitance due to the lower half-plane is the sum of the free-space capacitance and the capacitance of the dielectric layer with permittivity ($\epsilon_r - 1$).^{5,6}



Design

Figure 3:

D. SIW (Substrate Integrated Waveguide) fed Microstrip Antenna

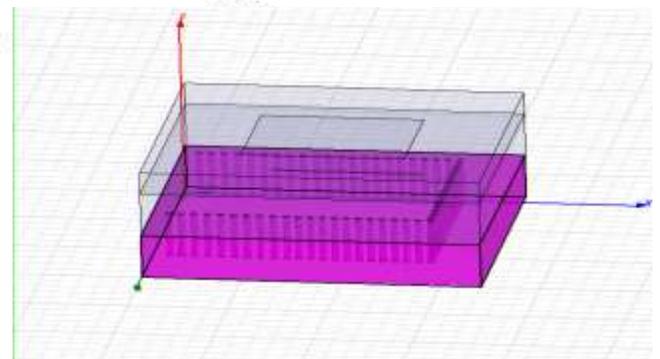


Figure 6: Design

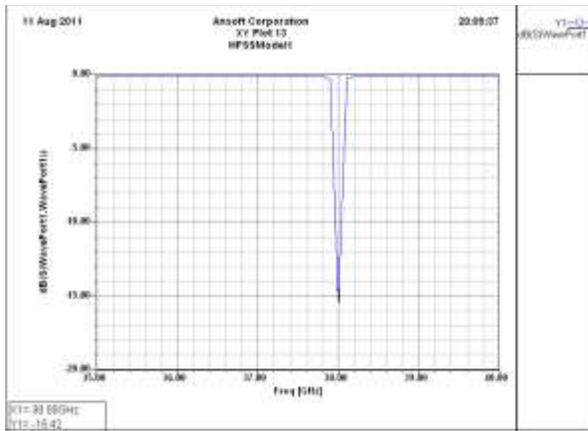


Figure 7: S-parameter

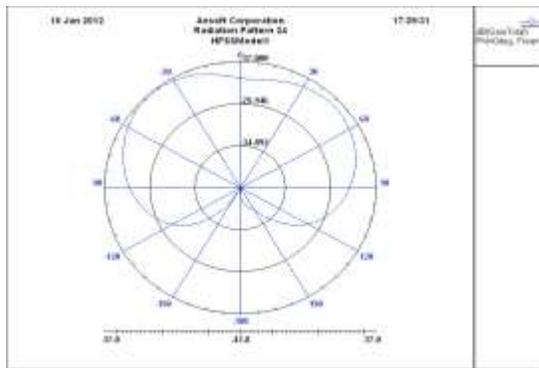


Figure 8: Radiation Pattern

E. CPW-SIW Transition fed Microstrip Antenna

It consists of a coplanar waveguide with 90° bend on each slot. A stub is added on the CPW line to match the transition and rectangular waveguide is constructed with the via hole arrays. The back metallic plane is added only under the transition and the rectangular waveguide. Two via holes, one for each side of the stub, are added to remove a potential parallel plate mode that can propagate between the CPW and the back plane before the rectangular waveguide. The stub length (l), the stub width(s), and the slot length (L) and the slot width (d), must be optimized in this structure to minimize the insertion loss and match the transition over wide bandwidth.^{7,8}

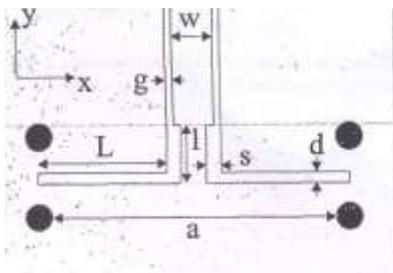


Figure 9: Proposed design of CPW-SIW transition

The length of each bend slot (L) on the CPW is given by $L = \lambda/4$
 The stub width(s) is given by, $s = \frac{1}{2}$ CPW line Width

The slot width (d) is given by, d = Same value as the slot over the stub of the CPW

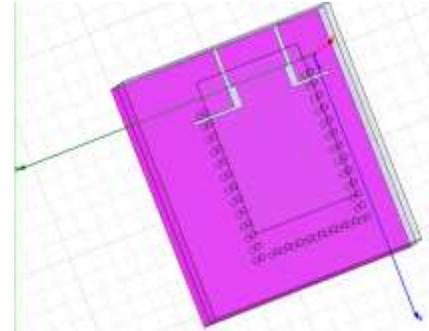


Figure 10: Design

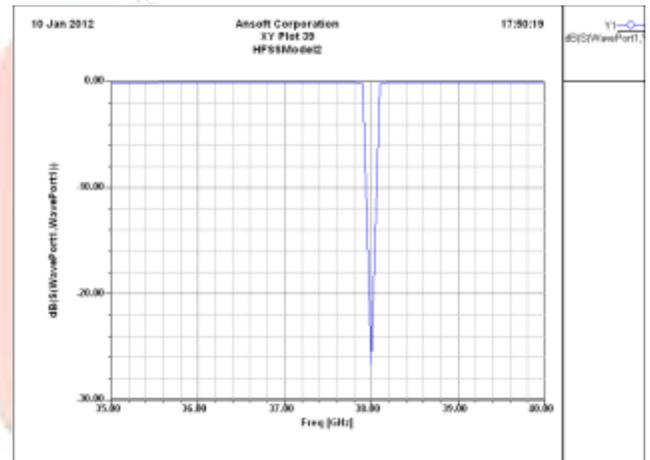


Figure 11: S-parameter

III. CONCLUSION

The S-parameter of SIW fed millimeter wave antenna shows that $S_{11} = -15$ dB at operating frequency of 38GHz. But when we compare the results we see that S_{11} is very sharp in case of SIW fed antenna in comparison to CPW fed antenna, which clearly shows that spurious side lobe radiation is minimized in the case of SIW, the purpose for which it is used in our thesis instead of CPW.

The S-parameter of CPW-SIW fed millimeter wave antenna at 37 GHz shows that

$S_{11} = -28$ dB at operating frequency of 38GHz. Also we see that side lobe radiation is not occurred in this and return loss is minimized as compared to both CPW and SIW fed. So, this feeding technique has advantage over both CPW and SIW feeding techniques

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