

Improving the Performance of Antenna using Substrate Integrated Waveguide Coupler

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Abstract

A compact antenna with a coupler is laid down using Substrate Integrated Waveguide (SIW) technique, which operate at X-band of frequencies. The SIW coupler has a SIW section which includes inserted metallic post. These metallic post acts as an inductive-post. SIW innovation is the most talented contender for the achievement of millimetre wave (mm-wave) coordinated circuits. Supported on planar dielectric substrate with bottom and top metal layers implanted with coated metal holes, it offers a compact, low cost, less loss and flexibility. The SIW has dynamic as well as passive components emanating area on the similar substrate. SIW technology has some attractive advantages, such as compact size, low loss, easy construction, low weight, high integration and is suited for all microwave and millimetre-wave works. The utilization of SIW technology encourages us to trim down return loss when weighed against other printed advances. The manufacturing process can simply be finished by means of normal Printed Circuit Board (PCB) process, where this present procedure's cost will be shortened when assessed with conventional waveguides. The SIW coupler more frequently utilized as a part of radar, point-to-point radio and satellite. Simulations results come about demonstrate the coupler's execution having low insertion loss, low return loss, and expansive operational data transmission and enclose fine seclusion.

Keywords: Micro-Strip Line Feed, Micro-Strip Patch Antenna, Printed Circuit Board, Substrate Integrated Waveguide Coupler

1. Introduction

Wireless systems are giving more interest in recent trend, which is used for each and every microwave and millimeter-wave functions. The assortments of uses have been proposed in the range of 60–94 GHz frequencies, including sensors, radars, remote systems and satellite. The active part is the core of the system, which has mixers, local oscillator and low noise amplifiers along with others. The above apparatus are included on chip-sets format in low cost.

System in Package (SiP) conquer the boundaries of the chip-sets¹, large numeral of chip-sets are joint in a single package which is included along with other components. These components are made-up of diverse technologies. The planar technology is commonly used under low frequencies.

A SIW technology is the utmost hopeful procedure²⁻⁴. The SIWs are fused like waveguides in the midst of two sided metalized gaps, which is set in with the substrate integrated waveguide (Figure 1). Likewise, the non planar rectangular waveguide be able to made into planar waveguide. The above can be processed using regular PCB or Low Temperature Co-fired Ceramic technology (LTCC).

Furthermore, SIW set-ups hold back utmost benefits of conventional metallic waveguides, that is to say high quality factor and high power taking care of potential with self-dependable electrical protection. The most vital advantage of SIW innovation is its probability to assemble every one of the segments on a similar substrate, including active and passive elements and also antennas. Also, there is the likelihood to accumulate more chip sets on the similar substrate. By means of this technique, there

is no need for supplementary technologies to move the signals from one device to other, so this in turn reduces the losses. This is the best means to expand the idea of system in package to the System-on-Substrate (SoS)⁵.

2. Coupler and Antenna Design

The Coupler and antenna are realized on a Rogers RT5880 substrate that has 2.2 comparative dielectric constant and 0.8mm width. The substrate mass is 10.77mm (L) x 13.17mm (W). The resonant frequency is selected in the X-band range.

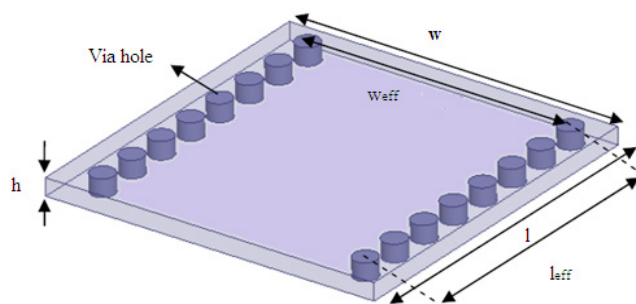


Figure 1. Fundamental arrangement of SIW.

The phase shifters combine the SIW concept and the post based technique, similarly the projected construction is revealed in Figure 2. In the SIW line, the vertical wall of a rectangular waveguide is replaced by a sequence of metal posts, the metal posts are made by drilling holes in the substrate. The SIW coupler is made by piercing holes on the apex and foot of the substrate and the manufactured waveguide shall be employed to change the phase of the event wave by varying their location in the substrate and its diameter⁶.

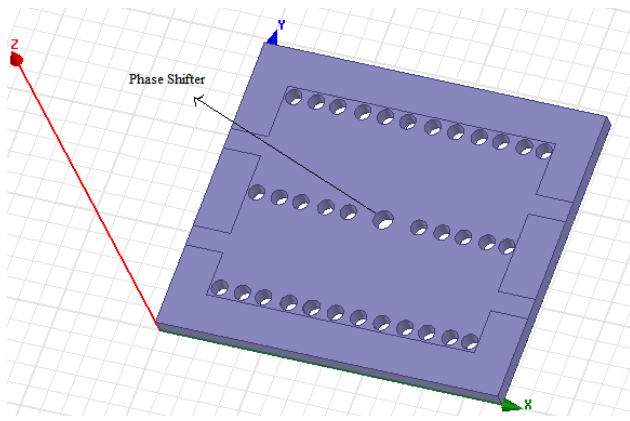


Figure 2. Design of SIW Coupler.

The planned SIW phase shifter was designed by applying the rules given below

$$d < \frac{\lambda_g}{5}$$

$$p \leq 2d$$

The E-shaped micro-strip patch antenna has a substrate dielectric constant (ϵ_r) is 2.2 and substrate width is $h = 0.8$ mm. The width and length of the micro-strip antenna are decided using the below given formula

$$w = \frac{c_0}{2f_r} \sqrt{\left(\frac{2}{\epsilon_r + 1} \right)}$$

where, c_0 - velocity of light in free space

$$\epsilon_{\text{reff}} = (\epsilon_r + 1)/2 + (\epsilon_r - 1)/2 \left[1 + \frac{h}{w} \right]^{-1/2}$$

$$w/h > 1$$

where, ϵ_{reff} is the effective dielectric constant and the width-to-height ratio (W/h), Δl is the dimension of patch along with its length and the normalized additional length, is

$$\frac{\Delta l}{h} = 0.412 \frac{(\epsilon_{\text{reff}} + 0.3) \left(\frac{w}{h} + 0.264 \right)}{(\epsilon_{\text{reff}} - 0.258) \left(\frac{w}{h} + 0.8 \right)}$$

The length of patch can be found using

$$l = \frac{c_0}{2f_r \sqrt{\epsilon_{\text{reff}}}} - 2\Delta l$$

In this manuscript, the E-shaped micro strip patch antenna designed with desired width (W) (13.17 mm) and length (L) (10.77 mm). The width of dielectric layer is 0.79 mm. In this section we will discuss about the parameters effect depends on the act of designed E-shaped micro strip antenna. When the return loss is minimum the antenna was set in feeding point. By altering the position of feeding point this will change the various terms which are related with antenna. Figure 3. gives a HFSS top view of E shaped antenna with above mentioned dimensions⁷.

The SIW was produced using apex and foot metal substrate planes and has two arrays with passing through holes in the both side walls as shown in Figure 1. Fleeting through hole must short to both the planes in order to regulate perpendicular present paths; if not

the transmission characteristics of SIW will consider tainted. Since the perpendicular metal wall is restored by pass through holes, the signals propagate through the waveguide with tiny losses.

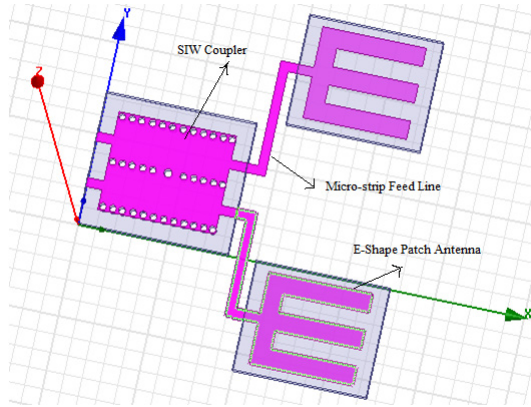


Figure 3. Micro strip Patch Antenna Using HFSS.

By means of equivalence resonant frequency, the SIW void size is determined from

$$f_{101} = \frac{c}{2\pi\sqrt{\mu_r\epsilon_r}} \sqrt{\left(\frac{\pi}{w_{eff}}\right)^2 + \left(\frac{\pi}{l_{eff}}\right)^2}$$

This is to verify that the SIW coupler will convey TE_{10} mode in working frequency range. In SIW the E -field distribution is similar to conventional rectangular waveguide. The SIW effective length and width void can determine from:

$$w_{eff} = w - \frac{d^2}{0.9p}$$

$$l_{eff} = l - \frac{d^2}{0.9p}$$

Where, l and w are the extent of the SIW cavity and thickness. However d is diameter of the cylindrical hole, p is pitch (distance between center to center of adjacent pass hole).

Micro-strip line supply is one of the simple techniques to manufacture, as it is just a conducting strip connection through the patch and it consider as the patch extension. The micro-strip line feed is a simple feed method and easy to match and model which control the inset location⁸.

3. Simulation Results

A. Return Loss

Figure 4. demonstrates the simulated and calculated reflection coefficients for the summation and

differentiation ports. S_{11} and S_{22} are the sum and difference ports reflection coefficients, respectively. Antenna has broadband impedance matching character for the 8–12-GHz frequency band. Since the calculated reflection coefficients are below -10 dB shown in Figure 5.

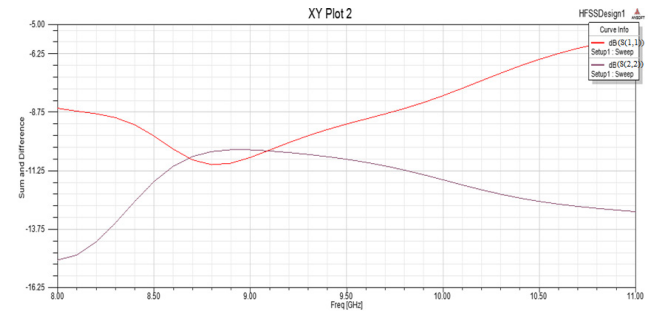


Figure 4. Addition and Differentiation reflection coefficients.

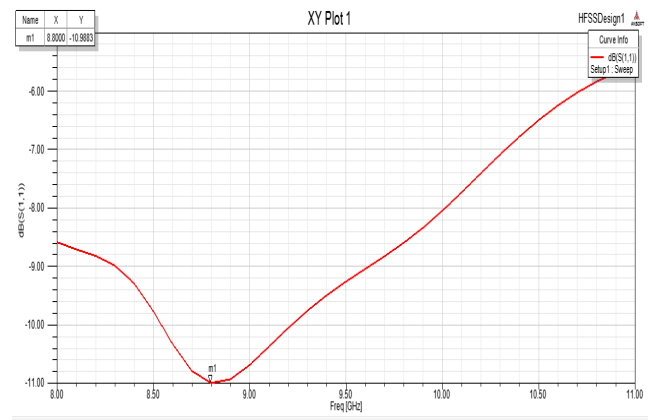


Figure 5. Simulated Return loss graph.

B. Radiation Pattern

The structures achieve good quality radiation at broadside. Antenna gain is roughly around 6 dBi. The power height of the radiation pattern is equal for both positive and negative side shown in Figure 6.

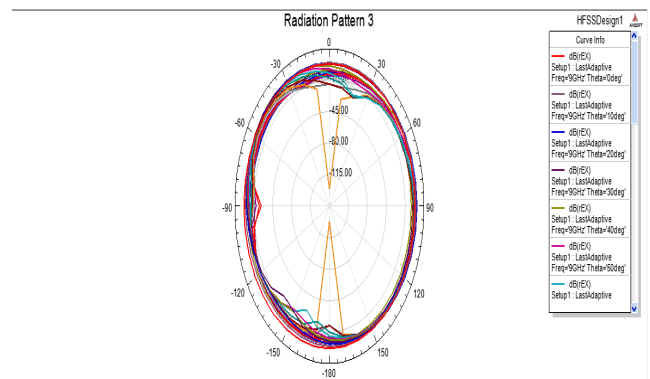


Figure 6. Radiation pattern in polar plot.

The radiation pattern is given in 3D as shown in Figure 7. The polar plot represents the directivity of antenna at frequency in 6dBi. This radiation pattern also shows that by changing feed point, we can get the radiation in the circular polarization.

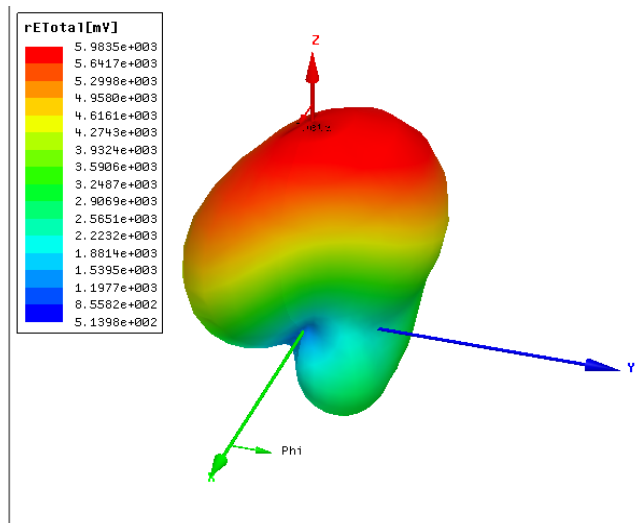


Figure 7. Radiation pattern in 3D.

4. Conclusion

From the simulation analysis of the antenna it is observed that the designed E-shaped micro-strip antenna has a gain of 4.7dB and directivity of the antenna is 6dBi. This kind of coupler is appropriate for high mass integrated microwave and millimeter wave applications. The design method was discussed and the return loss was minimized and the performance of patch antenna has been amplified. By using SIW techniques, the compact sized couplers can

be produced and they are easier to integrate with other planar circuits at ease.

5. References

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