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Designing of Microstrip Patch Antenna at 60 GHz using Stripline Feeding for Defense Applications

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Abstract: In this paper, a rectangular microstrip patch antenna at 60GHz using stripline feeding for defense applications is presented. The proposed antenna is fabricated on duroid substrate with dielectric constant 2.3 and thickness 0.04mm. 60 GHz frequency is used because of its highly secure and interference immune nature for defense applications. The return loss is 24.77dB at the operating frequency of 60GHz with 50 Ω input impedance. The basic parameters of the proposed antenna such as return loss, gain, directivity and electric field are simulated using Computer Simulation Technology (CST) microwave studio.

Index Terms: Stripline feeding, Duroid substrate, Directivity, Gain etc.

1. INTRODUCTION

60 GHz is going to be a big frequency in the next generation communication. According to the Shannon's theorem because of its huge bandwidth, it further provides large channel capacity and high data rates (25Gbps). As the radio frequency (RF) spectrum is a limited natural resource, therefore the demand for unlicensed frequencies is increasing day by day. 60 GHz frequency gets highly attenuated by the oxygen molecules in the atmosphere, so these cannot travel far beyond their intended users and gets completely absorbed in the environment, which makes it ideal for the defense applications, where troops do not want to give away their position to enemies. Microstrip patch antennas are widely used due to their features like low profile, compact size and easy fabrication.

From (57-64) Ghz a global unlicensed band exits providing 7 GHz of continuous bandwidth. Millimeter Wave (MMW) technology suffers from path loss and therefore preferred for indoor and short range communication. MMW travel solely by line of sight and are blocked by the obstacles and suffers weak penetration. Designing an antenna at high frequency is a challenging task and further difficult to fabricate because of its small dimensions. In this article, a microstrip patch antenna at 60 GHz is designed and presented. In [1], a high gain grid array antenna is presented. In [2], a cost-effective antenna package suitable for the mobile terminal of the wireless file transfer system is presented. In [3], a high gain and efficiency antenna for 60 GHz is presented. In [4], a compact and high gain antenna is presented. In [5], a dual resonant slot patch antenna that functions at 60 GHz is presented.

The rest of the paper is organized as follows: Section 2 presents the antenna design methodology. Simulation results of the proposed antenna are discussed in the section 3. Section 4 discussed the conclusion.

2. ANTENNA DESIGN

Figure 1 represents a rectangular patch antenna using stripline feeding. The main advantage of using rectangular patch is that it gives highest impedance bandwidth than any other patch shapes. The proposed antenna uses strip line feeding technique because it has advantages like planar structure, easy to fabricate and simplicity in modeling. The antenna has been designed over 0.04mm thick Duroid 5870 substrate (dielectric constant = 2.3, loss tangent = 0.0012). The proposed antenna uses 0.01 thick copper (annealed) as the radiating patch and ground material. The feedline is slightly offset from the middle for better impedance matching and improved radiation pattern. Duroid as a substrate gives high gain and its lower thickness further reduces the surface wave propagation.

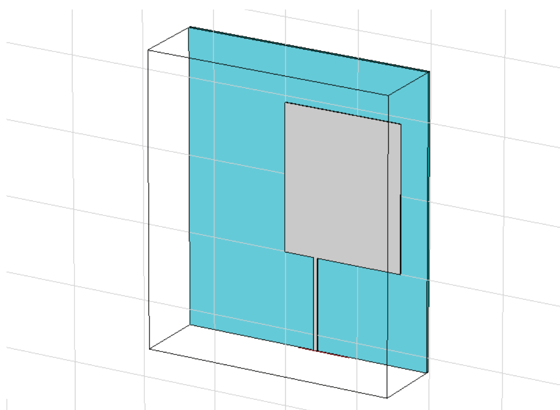

Figure 1: Design of proposed antenna using strip line feeding

The dimensions of the proposed antenna are calculated using transmission line model. The various parameters are given by the following formulas.

$$\varepsilon_{\text{eff}} = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_{r-1}}{2}\left(1+12\frac{h}{w}\right)^{-1/2} \quad (1)$$

$$\text{W} = \frac{\text{C}}{2f_0\sqrt{(\varepsilon_r+1)/2}} \quad (2)$$

$$\text{L} = \text{L}_{\text{eff}} - 2\Delta\text{L} \quad (3)$$

$$\text{L}_{\text{eff}} = \frac{c}{2f_{o\sqrt{\varepsilon_{\text{eff}}}}} \quad (4)$$

where, W and L are the width and length of the patch respectively. Using the above equations the dimensions of the proposed antenna are calculated and by using the iterative trials the parameters are further optimized. The various dimensions of the antenna are. Length of patch = 1.59mm, Width of patch = 1.91mm, Width of stripline = 0.05mm and Length of stripline is 1.2mm. The proposed antenna is designed using waveguide port. The parameters like dielectric constant, length and width of the stripline and feed position are further optimized to get the desired results.

3. SIMULATION RESULTS

In this section the simulation results of return loss, gain, directivity and electric field of designed antenna are presented. The CST microwave studio is used for the antenna simulation and optimization. Figure 2 shows the return loss plot of the antenna operating in the frequency band (57-64) GHz is –24.77dB.

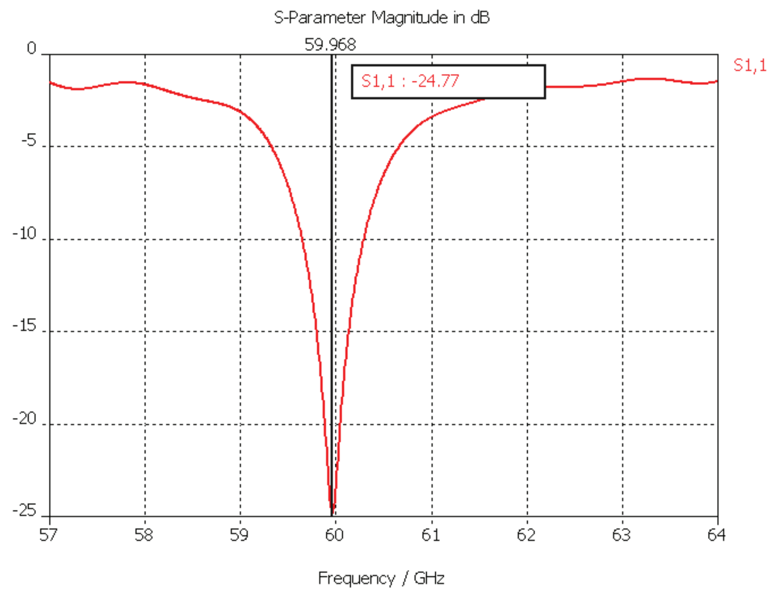

Figure 2: Simulated Return Loss of microstrip patch antenna

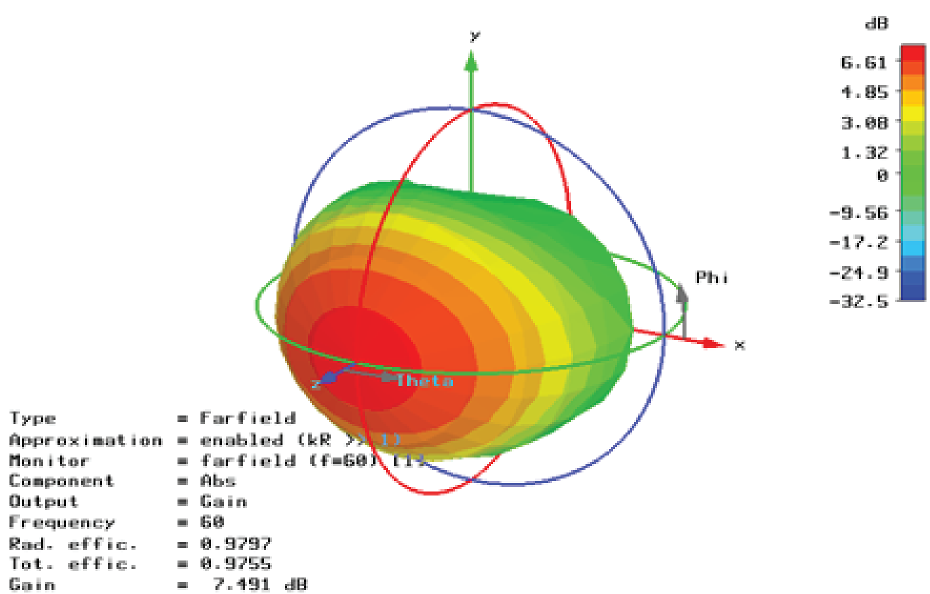

Figure 3: Simulated Gain of the proposed antenna is 7.491dB

4. CONCLUSION

The gain, directivity and return loss of the proposed antenna is good enough to meet the defense applications. The proposed antenna is well suited for the next generation communication as well. In future, we can enhance the bandwidth of proposed antenna by introducing different slots.

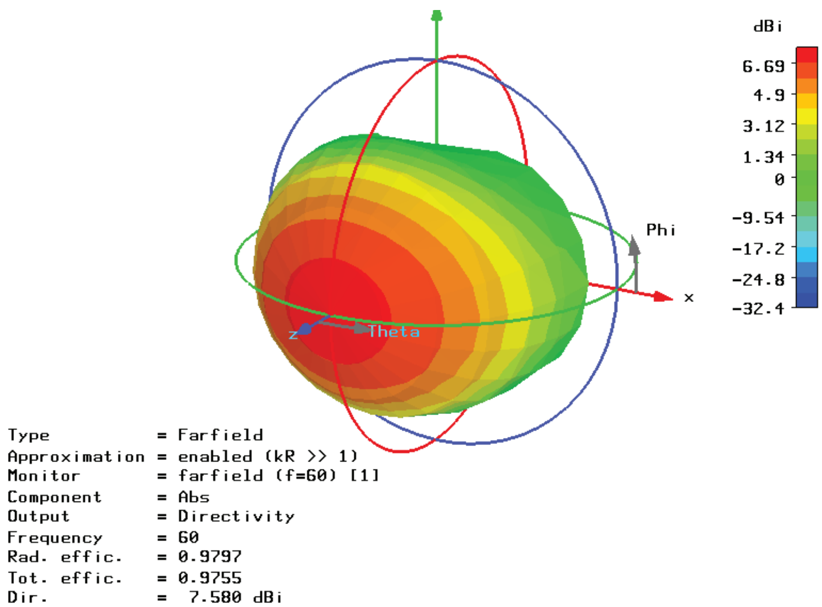

Figure 4: Directivity of the proposed antenna

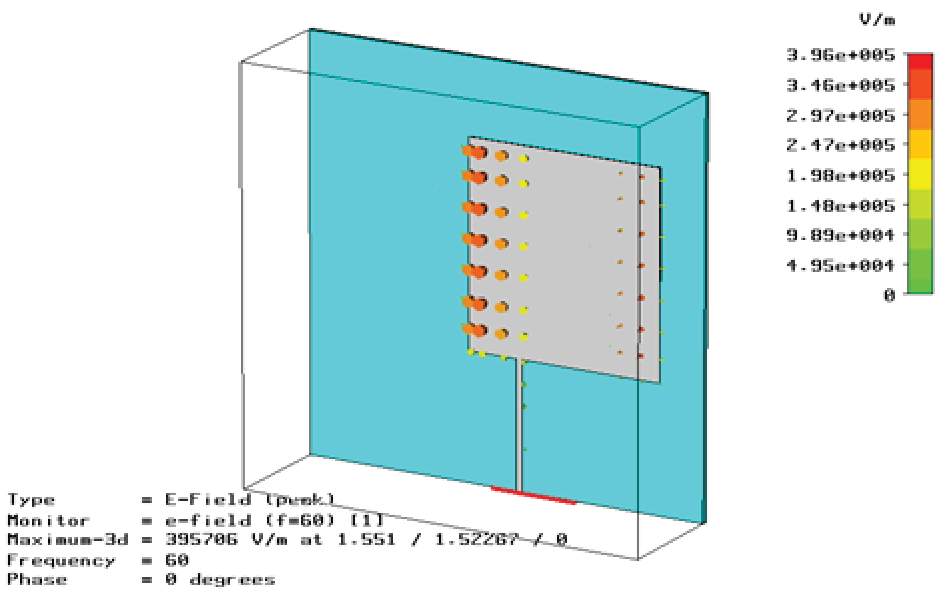

Figure 5: Electric field of the proposed antenna

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