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Backlobe Radiations Reduction with Patch Antenna Using Multilayered Dielectric Structure

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Abstract
Backlobe radiations are the key stumbling block to using microstrip patch antennas in wireless communication, but they can be minimised by using a slot-coupled feeding technique. This paper proposes a microstrip patch antenna with a multilayer structure. The Ansoft High Frequency Structure Simulation is used to describe and model this slot-fed antenna, which has an improved gain of 5.6dB and directivity of 5.9dB and resonates at a frequency of 2.25GHz.

Key-words: Back Lobe Radiation, Multilayer Structure, Microstrip Patch Antenna, Slot-coupled.

1. Introduction

All commercial applications have recently focused on Millimeter Wave Communication systems, resulting in an increase in the market for wireless communication devices. Because of their conformal and planar arrangement, microstrip patch antennas are widely used in mobile mobile communications. Patch antennas are also beneficial due to their small size and compatibility with microwave circuit boards.

Two feeding methods are used to excite microstrip antennas for radiation modes: contacting feed type and non-contacting feed type. The first type of feed feeds RF power directly to the patch, while the second type of feed feeds RF power to the patch through electromagnetic coupling.

In a quasi slot-coupled patch antenna, the ground plane isolates the feed network from the emanating portion, reducing the amount of unwanted radiation. This is the primary advantage of this feeding method. [1] has four asymmetrical U-slots fed by a coaxial probe with resonance frequency of 3.35GHz, 3.70GHz, 5.20GHz, and 5.80GHz, with the bandwidth increased by changing the radiating patch's shape. Square microstrip patch antennas with edge feed are designed for Wi-Fi applications and are defined in [2]. In [3] a parasitic patch and an antenna is built using a ceramic substrate. Fractal shapes are used in microstrip antennas in [4] to reduce the antenna area while maintaining the operating frequency. [5] shows that a stacked configuration microstrip slot antenna has a wide bandwidth and a VSWR of less than 2. A multiband planar with parasitic coupling is built in with a steady increase in input impedance and a very minor change from 2.989 GHz for the regular patch to 3.023 GHz [6]. [7][8] [9] reveal a single layer patch antenna with reasonable impedance bandwidth. The gain and bandwidth enhancement of a standard inverted multi-slotted patch presented in [10]. To meet the requirements, the design uses coaxial probe feeding, inverted, and multi-slotted strategies.

2. Antenna Design

The following are the critical parameters to design a rectangular microstrip Patch Antenna:

Length (L): Equal length 3cm each are selected.

Width (W): The two sides of equal length 4cm each are selected.

Frequency of operation (f_0): **2.25 GHz** is selected for the proposed design.

Dielectric constant of the substrate(ε_r): Roger RT Duroid 5800, with a dielectric constant of 2.2, was chosen as the dielectric material for the new structure.

Height of dielectric substrate (h): It is important that the patch antenna used in cellular phones is not bulky. As a result, the dielectric substrate has a height of **0.32 cm.**

Length

The resonant frequency is determined by the duration, making it a crucial factor. None of the findings are certain since the infringing area cannot be correctly accounted for.

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The patch's length is determined by the following formula:

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{eff}}\sqrt{\mu_0\varepsilon_0}} - 2\Delta L \qquad (1)$$

The length extension caused by the fringing field was determined using the following formula:

$$\frac{\Delta L}{h} = 0.412\,\frac{\left(\varepsilon_{eff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{eff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)} \qquad (2)$$

Effective dielectric constant

The rectangular microstrip patch antenna's effective dielectric constant is

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[\frac{1}{\sqrt{1 + \frac{12h}{w}}}\right] \qquad (3)$$

Where h=substrate height

ε_r=dielectric constant

Effective Patch Length

The patch's real length (L) is

$L = L_{eff} - 2\Delta L$

Where

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} \qquad (4)$$

Width

The patch's radiating width is

$$w = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (5)$$

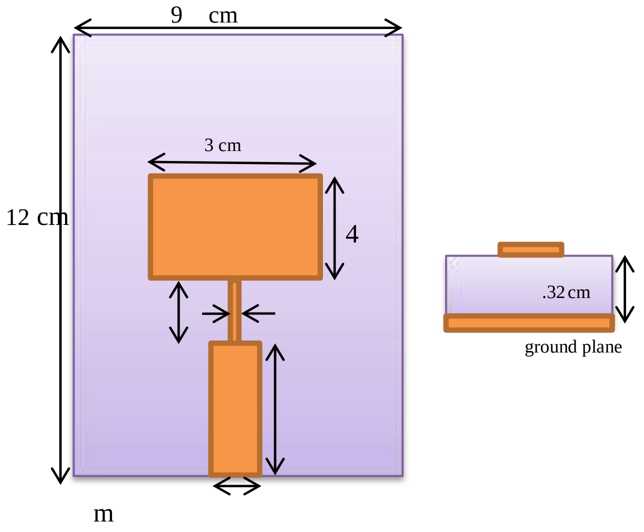
Where, c = free space velocity.

ε_r = dielectric constant.

fr=Resonant frequency

The dielectric's permittivity (ε*r*) has a significant impact on the patch antenna's radiation quality. A thick substrate with low ε*r* and insertion loss is suitable for broadband applications and enhanced efficiency. The measurements are shown in graphical model in fig. 1.

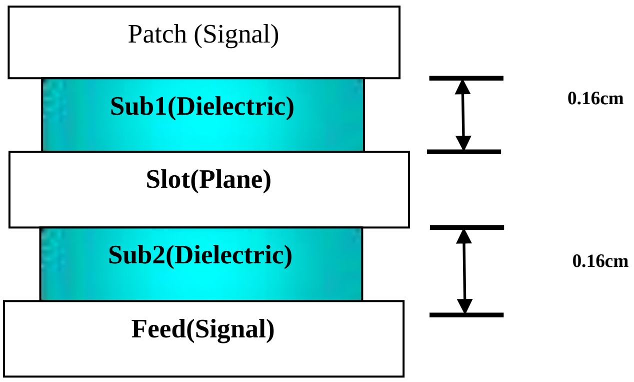
Figure 1 - Rectangular Patch Antenna with Aperture Coupled Feed



3. Antenna Structure

The system consists of a slot plane in between two layers of substrate. The radiating patch is integrated at the top of substrate 1(sub 1) and microstrip line feed is provided at the bottom of substrate 2(sub 2) as shown in fig 2. The type of feed used here is slot coupled feed which couples the slot plane along a microstrip line.

Figure 2 - Multi Layered Structure of the Antenna



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The radiating patch separated from the lower layer by a ground plane. The bandwidth is determined by the amount of coupled power, and the largest bandwidth can be obtained by minimising spurious feed radiation by making direct contact between the feed and the patch. In the proposed framework, two dielectric layers of varying thicknesses are distinguished by a ground plane with a slot that ties the RF power to the patch.

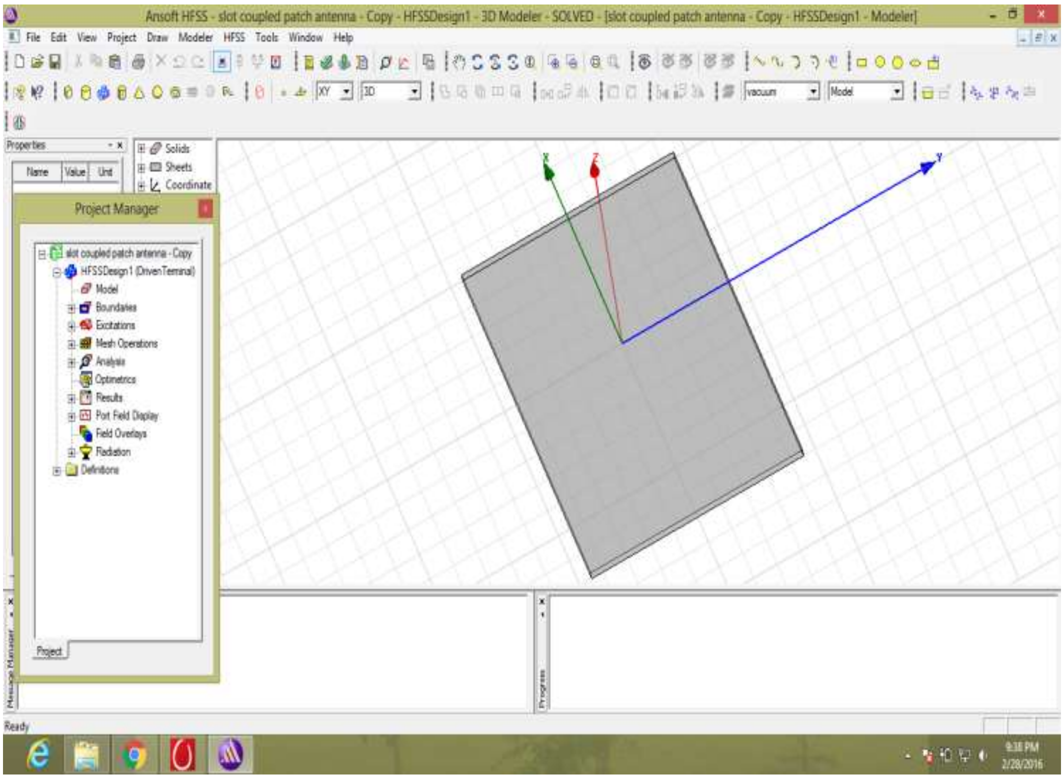
The proposed system's substrate is Roger RT Duroid 5800, which has a dielectric constant of 2.2. PTFE composites reinforced with glass microfibers make up Roger RT Duroid 5800 high frequency laminates.

4. Results and Discussion

HFSS software optimises the antenna's resonant properties.

Figure 3 shows the antenna structure, which has a W L dimension embedded in one of the radiating edges and is fed by an aperture coupled feed.

Figure 3 - Antenna



The dimensions in Table 1 are used to build the geometric pattern.

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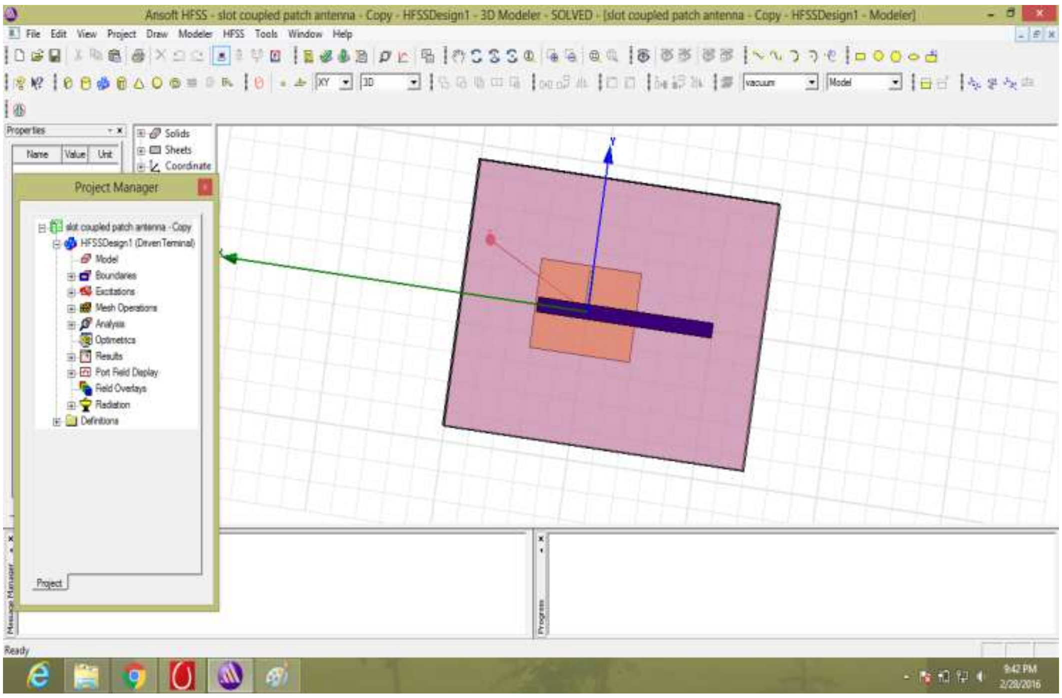
Table 1 - Antenna Design

Parameters	**Value**
Frequency	2.25GHz
Dielectric Constant(ε_r)	2.2
Substrate Thickness (h)	0.32cm
Ground Width	9 cm
Ground Length	12 cm
Slot Width	1.4 cm
Slot Length	0.155 cm
Patch Length (L)	3 cm
Patch Width(W)	4 cm

Figure 4 shows a patch antenna through a ground plane opening slot on the opposite side. This slot-coupling or aperture-coupling technique is used to prevent soldering interactions and protect line leakage from interfering with patch radiation.

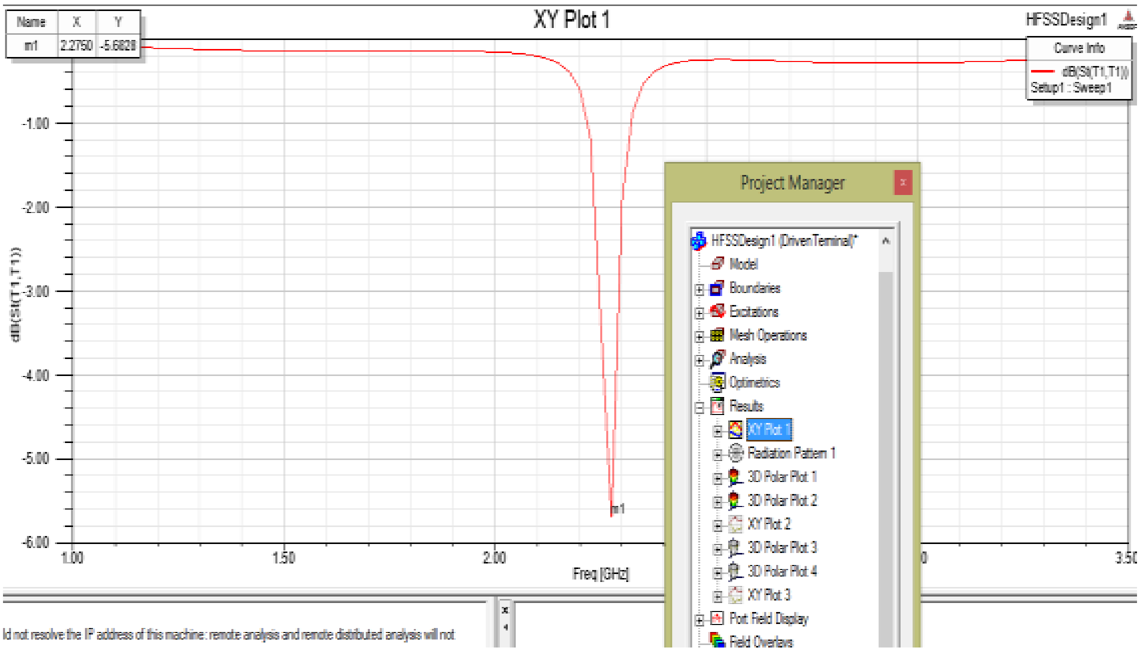
Figure 4 - Aperture Coupled Feed of the Antenna



4.1 Return Loss

Return loss, the sum of power reflected by the antenna. The better the outcome, the lower the value. The antenna has a return loss of -5.682 dB at the resonating frequency of 2.25GHz, as shown in Figure 5.

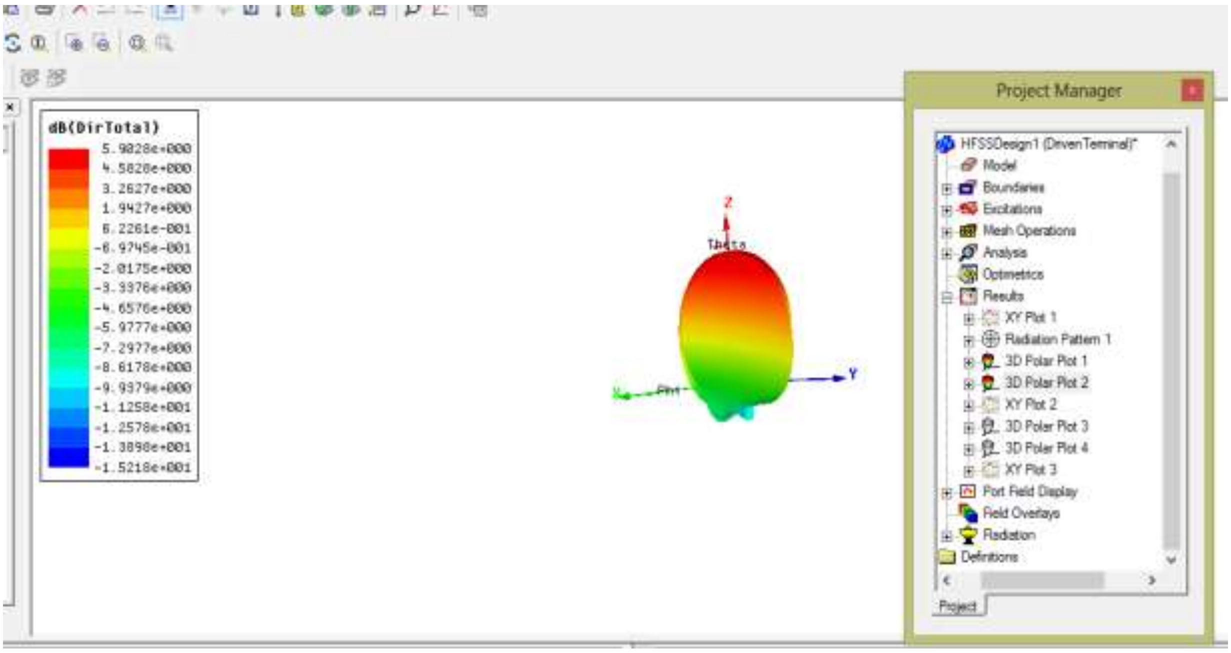
Figure 5 - Rectangular Patch Antenna-Return Loss



4.2. Directivity

The ratio of an antenna's radiation intensity in a given path to the average emission spectrum is known as directivity. Figure 6 shows that the proposed antenna has a directivity of 5.9dB at the resonance frequency of 2.25GHz.

Figure 6 - Directivity of Microstrip Patch Antenna



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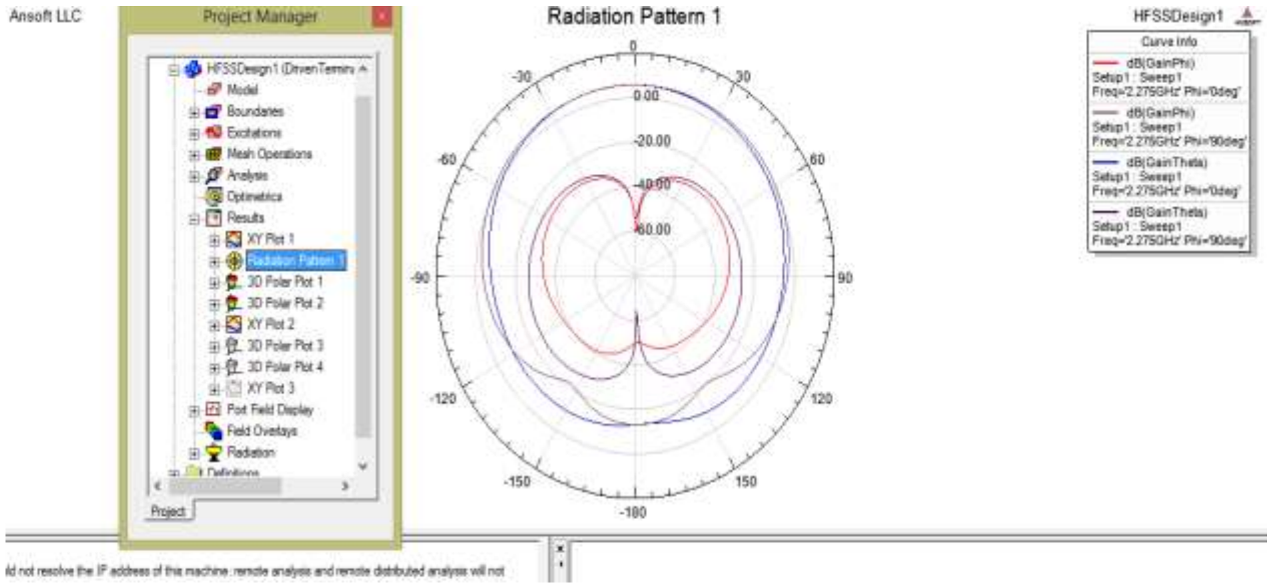
4.3 Radiation Pattern

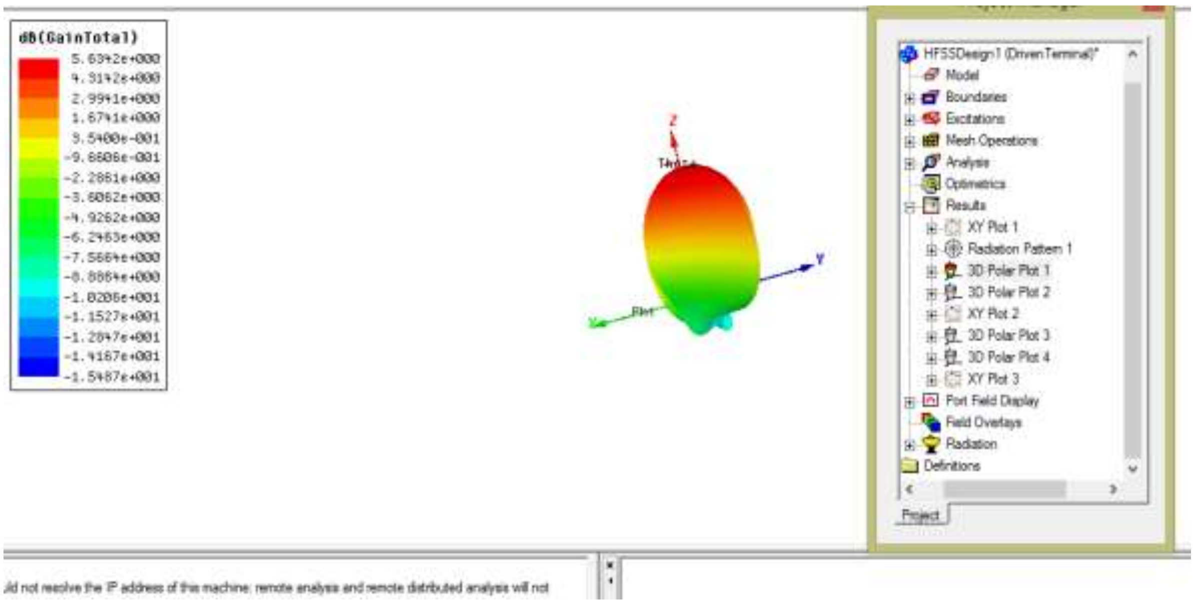
Radiation pattern, spatial distribution of the antenna's electromagnetic field. The proposed antenna's radiation pattern is shown in Figure 7, and the gain obtained at the resonance frequency is 5.6dB. The patch perfectly radiates around the sides, resulting in all radiation and in a high front-to-back ratio.

Figure 7 - Radiation Pattern



The gain of 5.6dB at the resonance frequency is clearly visible in the 3D map, as depicted in figure 8.

Figure 8 - Three Dimensional Radiation Pattern



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4.4 Simulation Output Parameters

Table 2 depicts the designed microstrip patch antenna's various parameters.

Table 2 - Simulation Results

Return Loss (dB)	**Directivity (dB)**	**Gain (dB)**
-5.682	5.9	5.6

5. Conclusion

Slot coupled microstrip patch antenna with a frequency of 2.25GHz is used. This antenna is suitable for S-Band applications such as weather forecasting, military applications, and radar communication, where a precise radiation pattern is needed. Back Lobe radiation is one of the most important limitations of microstrip patch antennas. The aperture coupled feed overcomes this by incorporating a ground plane between two substrates of the same material and feeding through a slot. Various antenna parameters are addressed, including return loss, gain, and directivity. The proposed structure is found to have significantly improved gain and directivity. High Frequency Structure is used to run the simulations and show the effects as plots.

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