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Microstrip Patch Antenna – Designing at 2.4 GHz Frequency

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Abstract: A simple microstrip patch antenna consists of metallic patch and ground between which is a dielectric medium called the substrate. Microstrip patch antennas are used for communication purposes especially in military and civil applications. In this paper a simple microstrip patch antenna is designed in CST Microwave Studio at a resonant frequency of 2.4 GHz. The gain of the designed antenna is 8.27 dB and VSWR of 1.18.

Keywords: VSWR, radiation pattern, beamwidth, directivity, gain

1. Introduction

Microsrtip antennas are used for number of wireless applications such as WLAN [1][2], Wi-Fi[3], Bluetooth [4] and many other applications.

A simple microstrip patch antenna consists of a conducting patch and ground plane between them is a dielectric medium called the substrate having a particular value of dielectric constant. The dimensions of a patch are smaller as compared to the substrate and ground. Dimensions of a microstrip patch antenna depend on the resonant frequency and value of the dielectric constant.

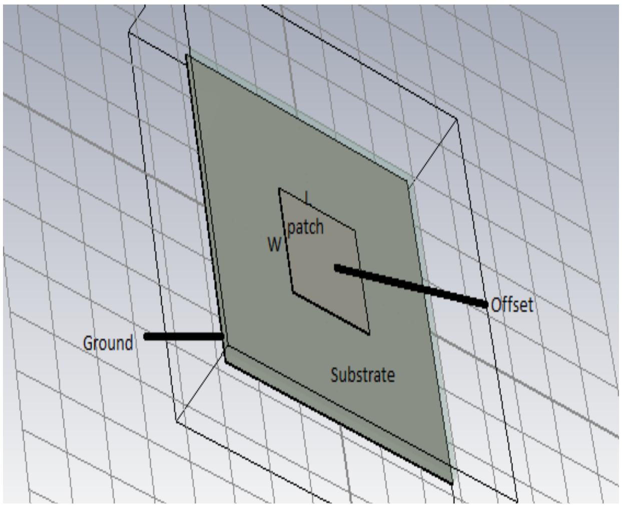

Fig. 1

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2. Designing

For designing of a microstrip patch antenna, we have to select the resonant frequency and a dielectric medium for which antenna is to be designed. The parameters to be calculated are as under.

Width (W):

The width of the patch is calculated using the following equation [5][3][6]

$$W = \frac{C_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \tag{1}$$

Where,

W = Width of the patch

C_0= Speed of light

ε_r= value of the dielectric substrate

Effective refractive index:

The effective refractive index value of a patch is an important parameter in the designing procedure of a microstrip patch antenna. The radiations traveling from the patch towards the ground pass through air and some through the substrate (called as fringing). Bath the air and the substrates have different dielectric values, therefore in order to account this we find the value of effective dielectric constant. The value of the effective dielectric constant (ε_{reff}) is calculated using the following equation [5][3][6]:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2}, W/h > 1 \tag{2}$$

Length:

Due to fringing, electrically the size of the antenna is increased by an amount of (ΔL). Therefore, the actual increase in length (ΔL) of the patch is to be calculated using the following equation [5][3][6]:

$$\frac{\Delta L}{h} = 0.412\frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)} \tag{3}$$

Where 'h'= height of the substrate

The length (L) of the patch is now to be calculated using the below mentioned equation [5][3][6]:

$$L = \frac{C_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \tag{4}$$

Length (Lg) and widtg (Wg) of ground plane:

Now the dimensions of a patch are known. The length and width of a substrate is equal to that of the ground plane. The length of a ground plane (Lg) and the width of a ground plane (Wg) are calculated using the following equations [7]:

$$L_g = 6h + L \tag{5}$$

$$W_g = 6h + W \tag{6}$$

For feeding the microstrip patch antenna, there are different methods for example, feed line method, coaxial probe feeding method etc. But mostly coaxial probe method is used.

3. Findings and Results

Using the equations mentioned above, a square microstrip patch antenna is designed at a resonant frequency of 2.4 GHz. The length width (W) and length (L) of the patch at a resonant frequency of 2.4 GHz is found to be 38 mm while the feeding offset position is 6 mm. the height of the substrate is 3 mm. for ground plane, the length (Lg) and width (Wg) of the ground plane is calculated to be 56 mm (Lg= Wg because patch is square).

For feeding the microstrip patch antenna, coaxial probe feeding method is used having offset feeding position as 6mm. the simulation is carried out in CST Microwave Studio software.

The following figure-1 shows the gain pattern of the antenna in the farfield. The direction of the maximum gain of the antenna is above the patch (i-e, in the direction of theta), while minor lobes are on the opposite side.

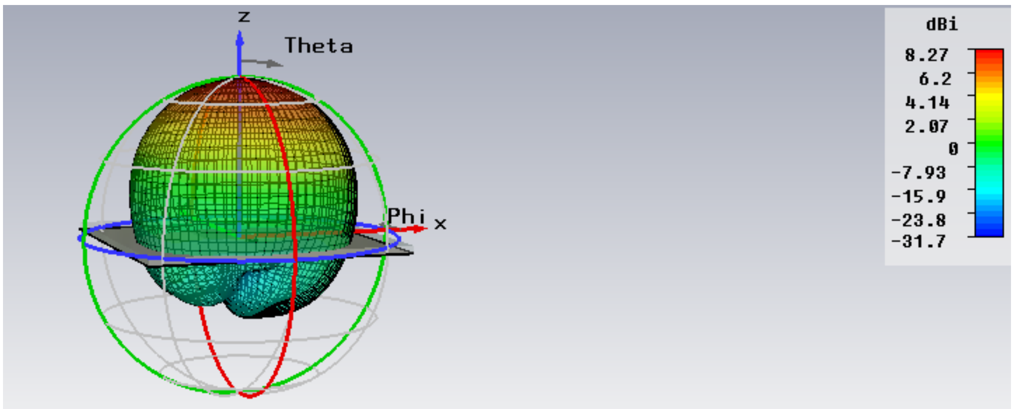

Figure 2

The figure-3 shows the 2D view radiation pattern of the antenna. The maximum gain of the antenna is 8.27 dB. The half power (3 dB) beam width is 69.6 degrees.

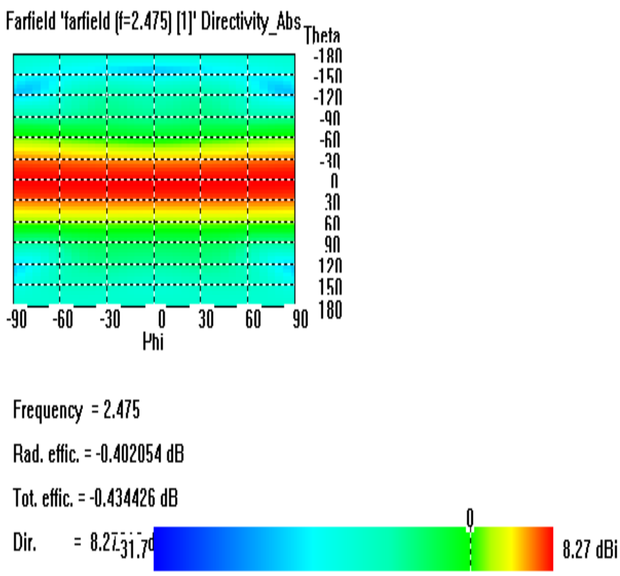

Figure 3

The figure-4 shows the S-parameter of the antenna. The return loss of the antenna is minimum at 2.4 GHz.

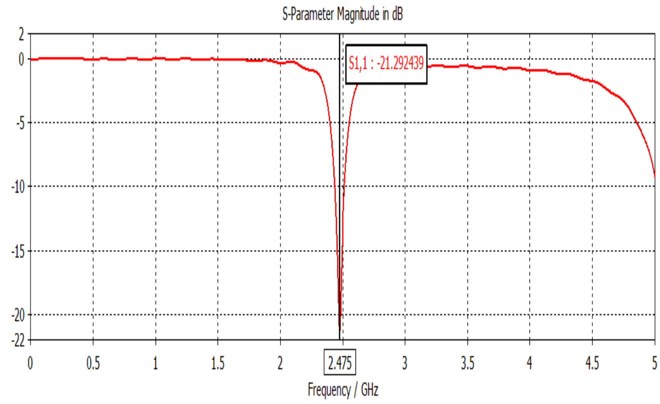

Figure 4

The figure-5 below shows the Voltage Standing Wave Ratio (VSWR) versus frequency graph of the designed antenna. The VSWR is minimum (equal to 1.1886031) at 2.4 GHz.

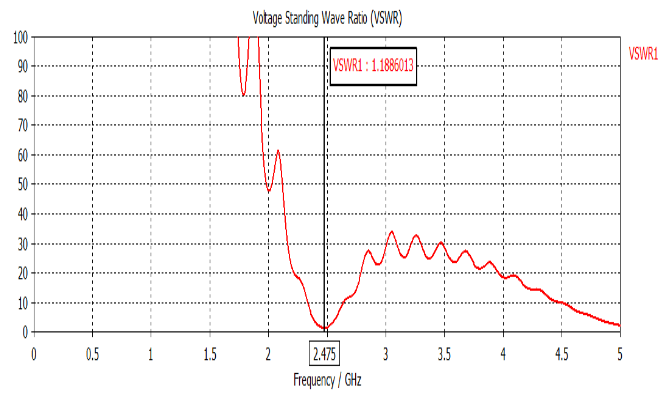

Figure 5

4. Conclusion

In this paper a microstrip patch antenna is successfully designed at a resonant frequency of 2.4 GHz. The antenna shows a healthy gain if 8.27 dB. The VSWR of the antenna is 1.18.

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