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Inset Feed Microstrip Patch Antenna

Jaget Singh

UIET, Panjab University Chandigarh

Abstract: An inset feed microstrip patch antenna is designed to increase the bandwidth and return loss. RT-Duriod with dielectric constant of 4.4 is used as a substrate for the proposed antenna. RT-Duriod is a having a lowest dielectric constant and can reduce the dielectric losses associated with microstrip patch antenna. This antenna is useful for 2.4 GHz frequency, which comes under ISM (Industrial, Scientific and Medical) band of frequency. The designed antenna shows the return loss of -40.5 dB and 6.69 dBi gain at the designed frequency of 2.4 GHz with an 80 MHz bandwidth. The inset feed and slot improves the impedance matching and return loss.

Index terms: Inset feed, RT-duriod, microstrip patch.

Introduction:

Microstrip patch antennas are popular due their light weight, low profile and easy to fabrication with monolithic microwave integrated circuits (MMICs). Due to their compact and planar structure Microstrip antennas are popular for their attractive features like: light weight, low profile, ease of fabrication and compatibility with Monolithic Microwave Integrated Circuits (MMICs). Due to their planar structure and compactness these antenna are better to use for applications like satellite and wireless communications [1]. Popularity of the wireless network has been increased to meet the need of consumer demand in today's advancements in wireless technology. In different countries Bluetooth have been developed to regulate the interaction of different devices in such wireless networks [2]. Despite some disadvantages like- low efficiency, narrow bandwidth, less gain because of their small size and high return loss of microstrip patch antennas these antennas are very popular. By making some modifications like slot cut and different shapes many researchers have try to overcome the demerits of these antennas [3]. The return loss of antenna is controlled by proper impedance matching of feed line and patch. The inset feeding is one of the popular techniques for perfect matching. Impedance of patch varies with feeding location like the coaxial probe feed patch. Various antenna performance parameters can be controlled by proper feeding technique and location [4].

Design Theory: For designing of a microstrip patch antenna selection of substrate is very important. Without proper selection of substrate's parameter like length, width, height and dielectric constant a good antenna cannot be designed. Material like FR4, PTFE, RT duroid 5880 are some of the common used material used as a substrate depending on the requirement and performance. Here FR4 substrate of thickness 1.57 mm and relative permittivity of 4.4 is used. The size of patch in this paper is determined by Eq (1) and following Eqs. (2)-(5) and marked in Fig.1. Width of patch W=29.10 mm and length of patch L=40 mm. The antenna feeding should be designed carefully since it must provide a correct impedance matching. At high-signal frequencies feeding line also play very important role for antenna performance. For better results feeding line should be having the impedance equal to the characteristics impedance of patch. For the proper feeding of the antenna inset feed technique is used in this paper. The patch antenna was fed with a microstrip line connected to a point inside patch where the input impedance is 50 Ω. In this simulation, the inset-fed length y_0 =7 mm was calculated using eq. (6).

The microstrip patch antenna design is accomplished by following steps [5][6]:

Step 1: Calculation of the Width of patch (W)

The width of patch is given by (1) $$\mathrm{w} = \frac{\mathrm{c}}{2\mathrm{f}_0\sqrt{(\varepsilon_\mathrm{r}+1)/2}} \qquad (1)$$

Where, c is free space velocity of light. f_0 is resonant frequency in GHz for the current design. ε_r is dielectric constant of the substrate kept at 4.4 for FR4 . By using these values the width of the patch of antenna is found to be 29.1 mm.

Step 2: Calculation of effective dielectric constant

$$\varepsilon_{reff} = \frac{(\varepsilon_r+1)}{2} + \frac{(\varepsilon_r-1)}{2}\left[1 + 12\frac{h}{w}\right]^{-1} \tag{2}$$

Where, h is height of the substrate or thickness of the substrate given as 1.57 mm.

Step 3: Calculation of the length extension ΔL, which is given by

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

Step 4: Now length of patch is given by

$$L = \frac{\lambda_0}{f_0\sqrt{\varepsilon_{reff}}} - 2\Delta L \tag{4}$$

Where the effective length of the patch L_{eff} is 46.92 mm and is calculated as:

$$L_{eff} = \frac{\lambda_0}{f_0\sqrt{\varepsilon_{reff}}} \tag{5}$$

Step 5: Calculation of position of inset feed point where the input impedance is 50 ohms.

$$Y_0 = \frac{L}{\pi}\cos^{-1}\left(\sqrt{\frac{Z_{in}}{R_{in}}}\right) \tag{6}$$

Where, Z_{in} and R_{in} is the resonant input impedance and resonant input resistance respectively. The Y_0 is found to be 7 mm. Using these parameters antenna is designed in CST microwave studio.

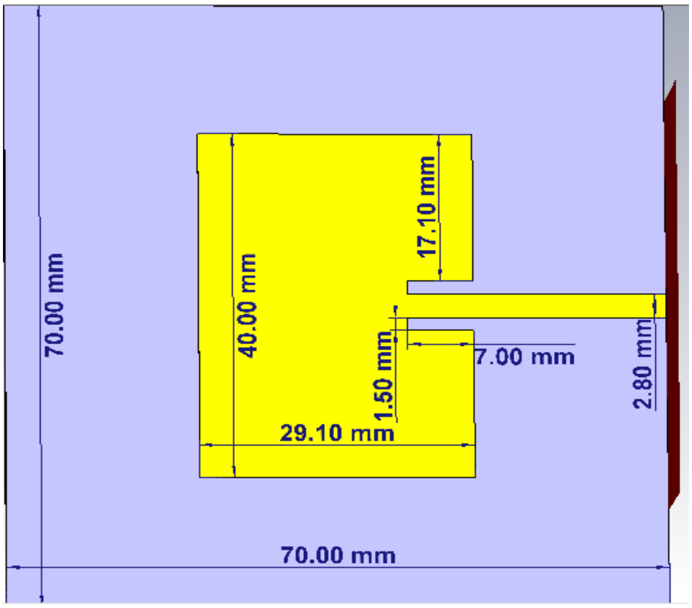

Fig.1 Inset feed microstrip patch antenna

Result and discussion: The proposed antenna was designed on FR4 substrate and simulated using the CST studio Suite. The dimensions of antenna were estimated by using the equation (1)-(6). The S-parameter (S_{11}) is shown in fig.2 and shows good resonance at the designed frequency of 2.4 GHz.

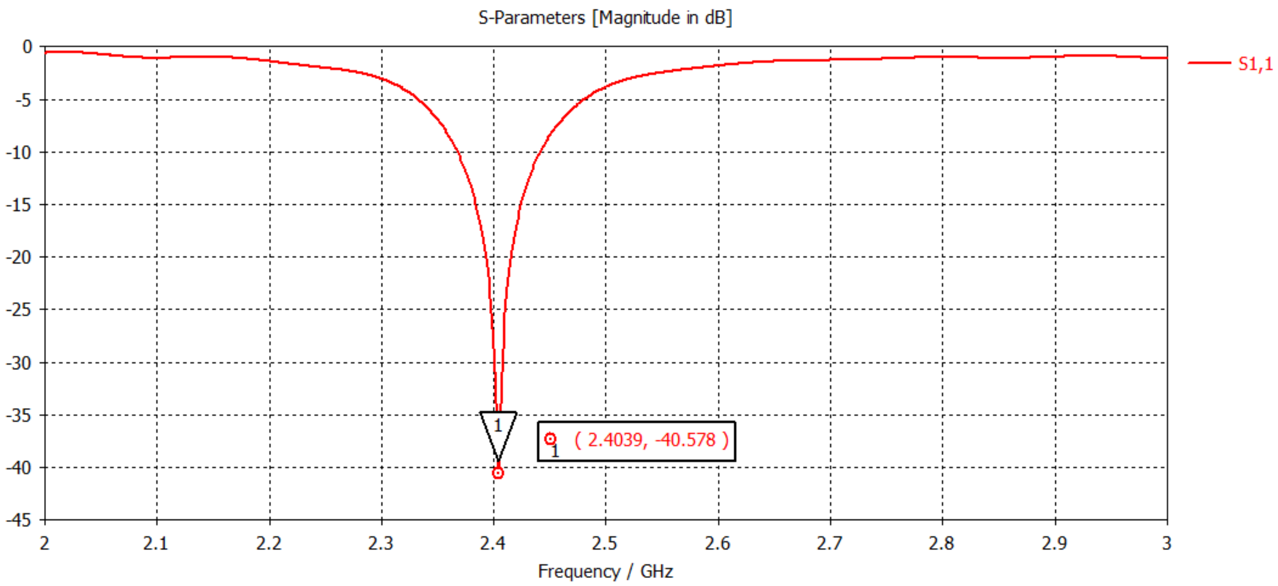

Fig.2 S-parameter S_{11}

The VSWR of designed antenna is shown in fig.3 which is well in the acceptable range at the designed frequency.

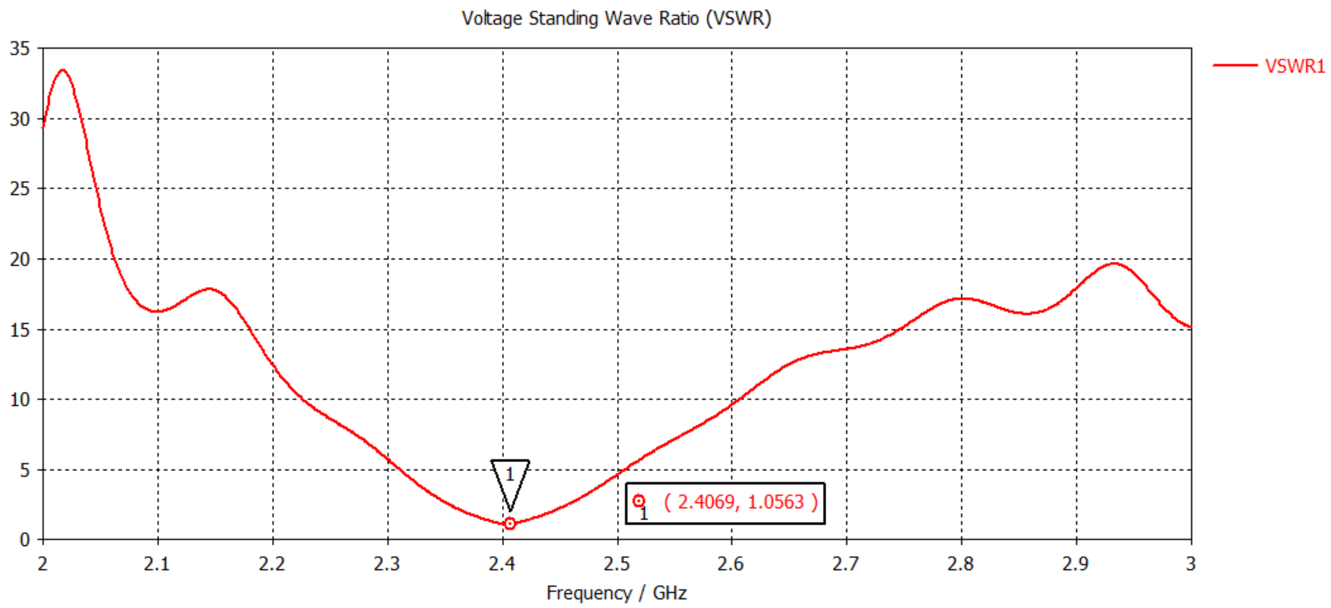

Fig.3 VSWR of antenna at 2.4 GHz frequency

The radiation pattern of antenna is shown in fig.4. The maximum gain of antenna is 6.69 dBi at 2.4 GHz and $\emptyset = 0$. The half power points are observed at 86.5 degree.

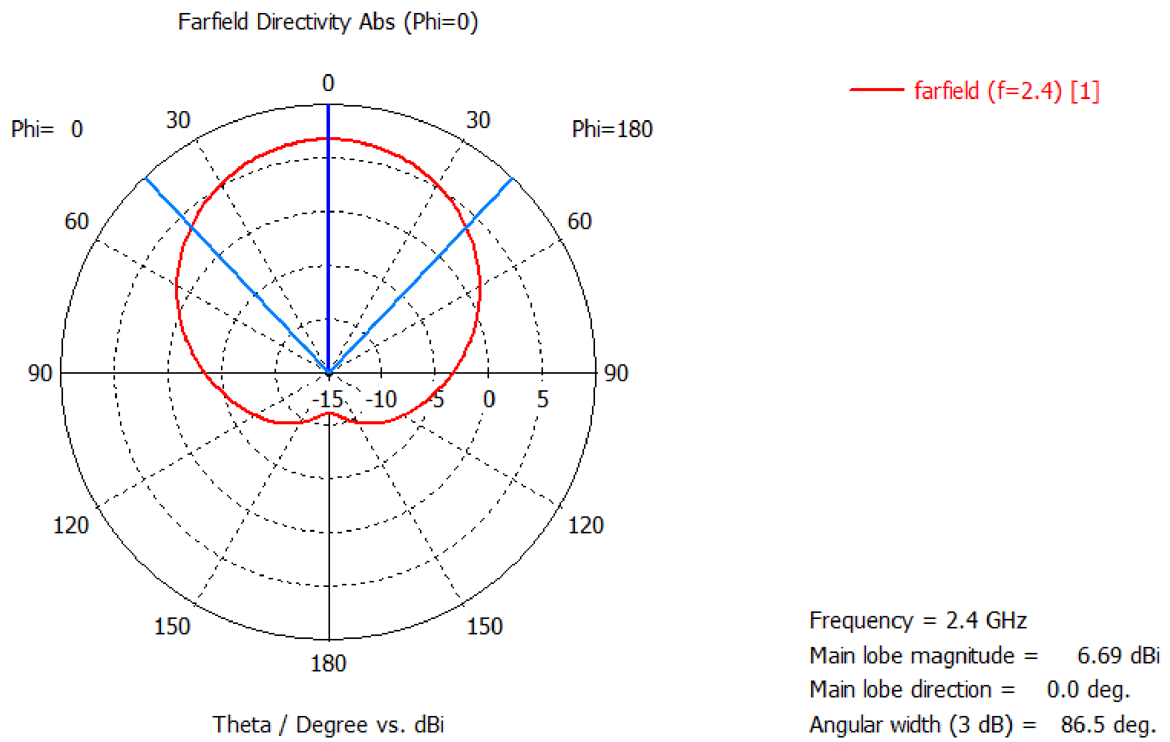

Fig.4 Radiation pattern of antenna at 2.4 GHz and $\emptyset = 0$ degree

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