Impact of Feed Point Location on the Bandwidth, Frequency and Return Loss of Rectangular Microstrip Patch Antenna

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Abstract

In this work, a rectangular microstrip patch antenna was considered. The proposed antenna was simulated using Sonnet software, and the results compared, the feed point is selected where the Return loss (RL) is most negative. The feed point location co-ordinate (X, Y) = (18, 14) from the origin (centre of patch) was varied in order to locate the optimum feed point. The optimum feed point is found to be at (X, Y) = (12, 10) where the RL of -17.76 dB is obtained. The bandwidth of the antenna for this feed point location is 30MHz with the centre frequency of 3.78 GHz. The substrate material used for this work is Glass (Pyrex) with dielectric constant of 4.82 and dielectric loss tangent of 5.4e-3. The operational frequency range is from 1GHz to 3.8GHz, with a design frequency of 2.4GHz

1.Introduction

Microstrip patch antenna consists of a radiating patch which is made up of a conducting material like Copper or Gold on one side of a dielectric substrate and ground plane on the other side. The patch could be of different shapes these are, square, rectangular, circular, triangular or elliptical [1].Microstrip antennas have a very high antenna quality factor (Q). This factor represents the losses associated with the antenna and a large quality factor leads to narrow bandwidth and low efficiency. Quality factor can be reduced by increasing the thickness of the dielectric substrate. But as the thickness increases, an increasing faction of the total power delivered by the source goes into a surface wave. This surface wave contribution can be counted as an unwanted power loss since it is ultimately scattered at the dielectric bends and causes degradation of the antenna characteristics. However, surface waves can be minimized by the use of photonic band gap structures [2]. Microstrip antennas have narrow bandwidth, typically 1-5%, which is the major limiting factor for the widespread application of these antennas. Increasing the bandwidth of microstrip antenna has been the major thrust of researches in this field as explained by Chang Won Jung and Franco De Flaviis [3].

2. Bandwidth

The bandwidth could be defined in terms of its VSWR or input impedance variation with frequency or in terms of radiation parameters for the circularly polarizes antenna, bandwidth is defined in terms of the Axial Ratio [3]. Broadening the bandwidth of the rectangular microstrip antenna could be achieved using different methods such as, lowering quality factor, modification of the patch shape. In this work, shifting feed point position was adopted.

3. Construction of microstrip patch

The antenna was constructed over a substrate Glass (Pyrex) with dielectric constant of 4.82 and 1.5mm thick. The antenna was simulated with design frequency of f_o = 2.4GHz. Figure 1 shows the structure of the design antenna.

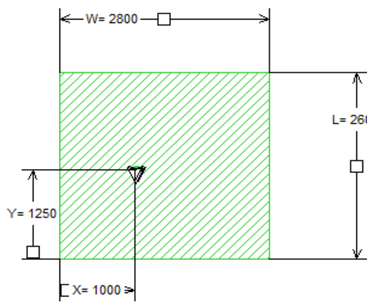

Figure 1. Microstrip patch Antenna

3.1 Resonant frequency

$$fo = \frac{c}{2Le\sqrt{\varepsilon r}} \qquad (1)$$

The resonance frequency for the (1, 0) mode is given (1)

Where, c is the speed of light in vacuum

ε_r is the dielectric constant of substrate.

To account for the fringing of the cavity fields at the edges of the patch, the effective length *Le* of patch is chosen as

$$L_e = L + 2\Delta L \qquad (2)$$

The Hammergtad formula for the fringing extension is [4].

$$\Delta L = 0.412h \frac{(\varepsilon_{eff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{W}{h}+0.8)} \qquad (3)$$

Where, ε_{eff} is the effective dielectric constant, *h* is the height of dielectric substrate and *W* is the width of the patch.

$$\varepsilon_{eff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}(1+\frac{12h}{W})^{-\frac{1}{2}} \qquad (4)$$

3.2 Design Parameters of the proposed antenna

Substrate material used is Glass (Pyrex)

Thickness of dielectric substrate *h* =1.5

Dielectric constant ε_r = 4.82

Design frequency f_o = 2.4GHz

Width of the patch *W* =36mm

Length of the patch L = 28mm

4. Simulation and Results Analysis

The software used to model and simulate the microstrip patch antenna is Sonnet [5]. Sonnet is a full-wave electromagnetic simulator based on the method of moments.

The results tabulated in table 1 are obtained after varying the feed location along the length of the patch from the origin (centre of patch) to its left most edge. The coaxial probe feed was adopted. Frequency range of 1GHz to 3.8GHz was selected. The centre frequency is selected as the one at which the return loss is minimum. The bandwidth was calculated from the return loss (RL) plot. The bandwidth of the antenna can be said to be those range of frequencies over which the RL is less -10dB. (-10dB corresponds to a Voltage Standing Wave Ratio (VSWR) of 2 which is an acceptable figure).

Table 1 Effect of feed location on centre frequency, return loss and bandwidth

Feed location (X, Y)(mm)	Centre frequency (GHz)	Return loss (dB)	Bandwidth (MHz)
(18,14)	3.8	-4.784	-
(16,13)	3.8	-5.296	-
(14,12)	1.9	-9.174	-
(12,10)	3.78	-17.76	30
(10,8)	3.13	-15.41	20
(8,6)	2.37	-8.973	-
(6,4)	2.38	-5.742	-
(4,2)	3.76	-14.28	30
(2,0)	3.78	-7.325	-

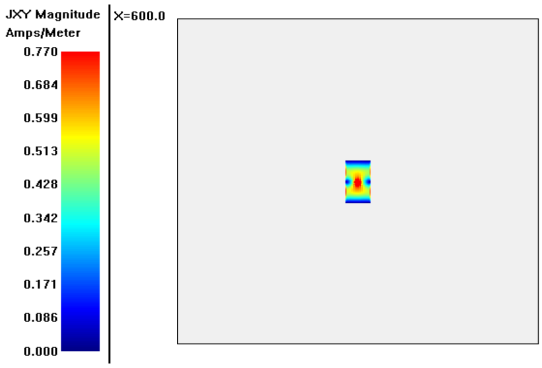

Figure2 Patch shape with current density

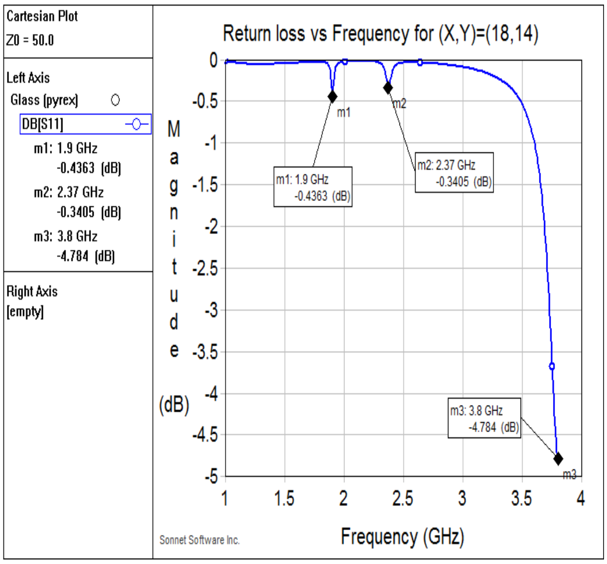

Figure3 Return loss for feed located at (X,Y)=(18,14)

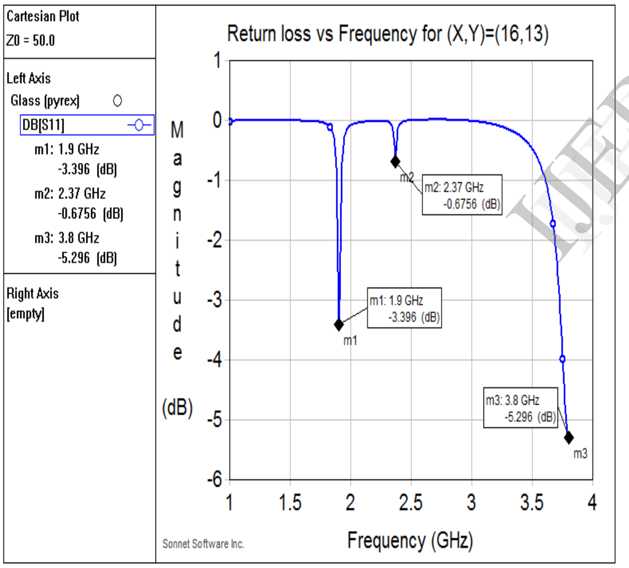

Figure 4 Return loss for feed located at (X,Y) =(16,13)

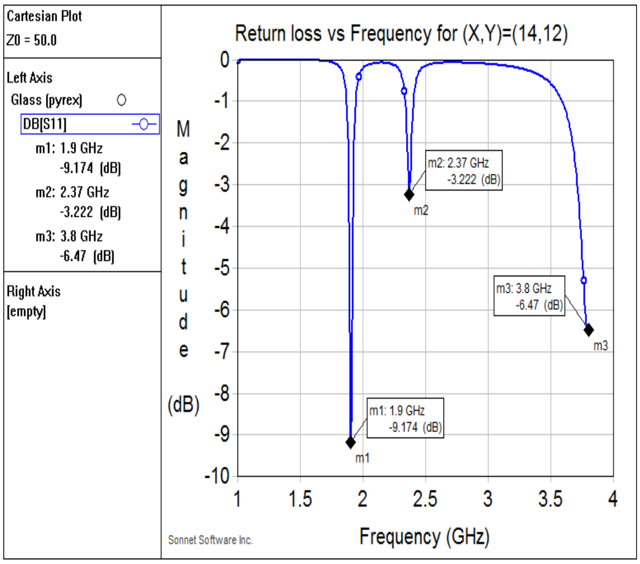

Figure5 Return loss for feed located at (X,Y)=(14,12)

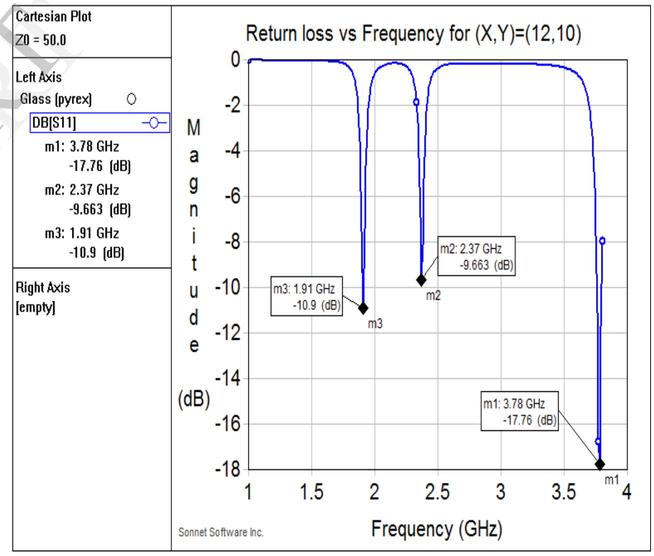

Figure 6 Return loss for feed located at (X,Y)=(12,10)

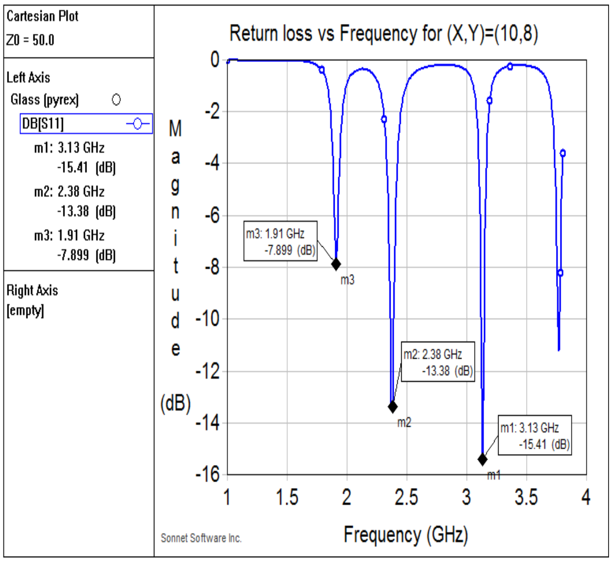

Figure 7 Return loss for feed located at (X,Y)=(10,8)

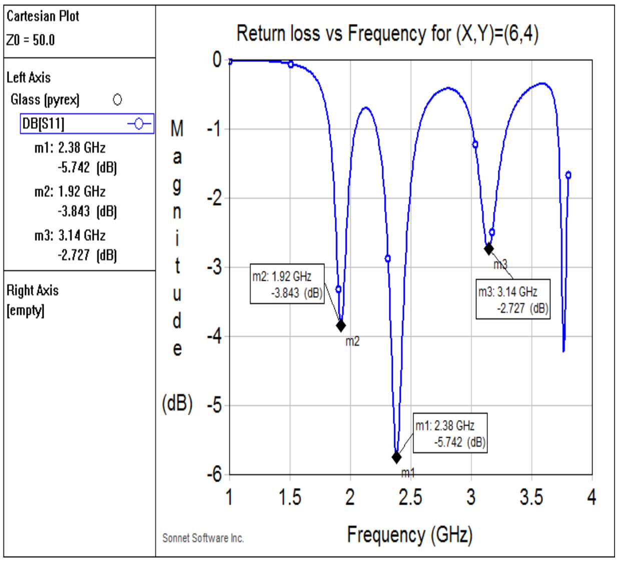

Figure 9 Return loss for feed located at (X,Y)=(6,4)

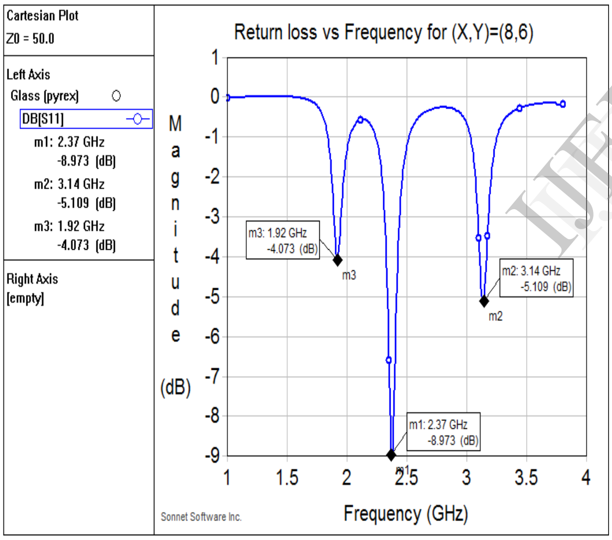

Figure 8 Return loss for feed located at (X,Y)=(8,6)

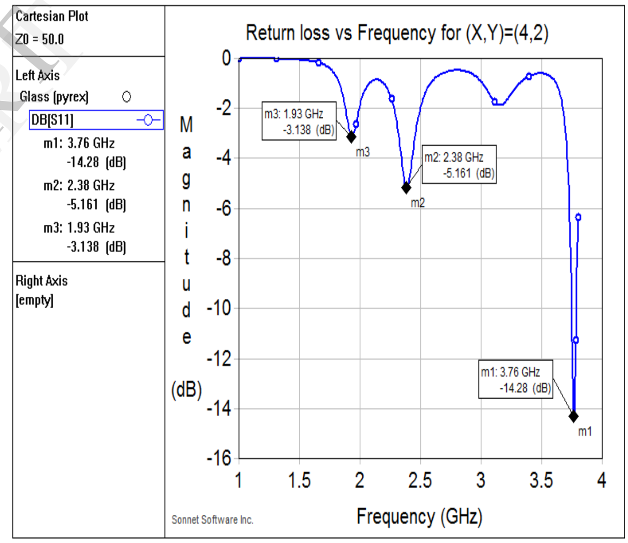

Figure 10 Return loss for feed located at (X,Y)=(4,2)

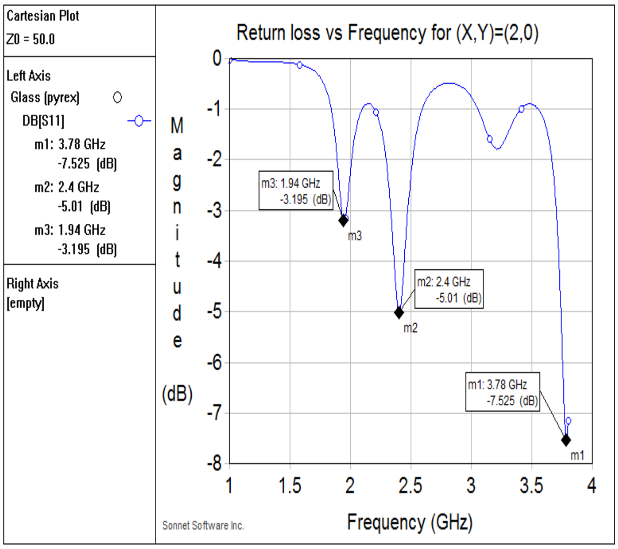

Figure 11 Return loss for feed located at (X,Y)=(2,0)

Figure 3 to figure 11 shows the return loss versus frequency at different feed point locations.

From table 1, the acceptable point is found to be at (X,Y) = (12,10) where RL of -17.76dB is obtained. The bandwidth of the antenna for the feed point location is 30MHz and the centre frequency is 3.78GHz. This is above the desired design frequency of 2.4GHz. We have observed that as the feed point moves away from the centre of the patch, the centre frequency also changes, this variation may be as a result of change in the input impedance.

5. Conclusion

In this work, the aims was targeted at investigating the impact of feed point location on the bandwidth, return loss and centre frequency of rectangular microstrip patch antenna and established the optimum location. We have adopted a trial and error method to locate the feed point. For different locations of the feed point, the return loss RL is compared and that feed point is selected where the RL is most negative. We observed that, feed point location has effect on the performance of rectangular microstrip patch antenna as shown in table 1.

REFERENCE

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[2] K. Rambabu, M. Alam, J. Bornemann and M.A Stuchly, "*Compact wideband dual-polarized microstrip patch antenna*" IEEE, 2004.

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