Research Article

Microstrip Patch Antenna Design and Analysis for Wireless Communication

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Abstract— The microstrip antenna required for wideband correspondence ought to be lightweight, ease in fabrication and smaller in size. The present situation plan is to create a simple geometrical shaped structure of the microstrip antenna, which would give decent broadband. The paper presents the design analysis of rectangular and square shaped microstrip antenna. Both the antennas used microstrip line for feeding purpose. The square-shaped microstrip antenna is offering wider bandwidth as compared to rectangular microstrip and sufficient return loss. The compact antenna is mean for its operation in X band of frequency. The proposed microstrip antenna is showing a wide bandwidth of 500 MHz with a high return loss of -24 dB. This high bandwidth provides its usefulness in many wideband utilities in X- band.

Keywords—Broadband, Microstrip Antenna, Reflection coefficient, Stub Matching.

1. INTRODUCTION

The usage of a Microstrip antenna is an achievement in wireless communication systems and it is satisfying the necessity of the most recent age of wireless communication technology corresponding to new innovation. Microstrip antennas are being utilized in each of these systems because of their many advantages [1], such as very lightweight, planner structure, and very economical efficiency. However, the narrow operating bandwidth is the limitation of it, and this imposes restrictions in its use in wireless systems [2]. Broadband application performing various tasks and wireless gadgets have comes out to be a fundamental part of our day by day correspondence life. Therefore the requirement for low profile wideband has been scaled down [3]. Microstrip antenna satisfies the greater part of the requirements for mobile and satellite equipment, and numerous business requirements are satisfied by the utilization of it. The measure of electronic circuits required for wireless applications are contracting definitely, where the microstrip is very much suitable. The size of the antennas being used for the most of application is also shrinking drastically. Microstrip antenna fix design fulfillment with the needs of these. Different techniques has been considered [4-6] and it found that proper impedance bandwidth of the microstrip antenna can be one reason for improvement. The carving effect of notches [7,8]. and slots [9-11] is found in plenty as reported by various studies in its broadening. A very basic form of the Microstrip antenna can be constructed using dielectric substrate as a base material and a radiating conducting material itched on the upper side of the substrate. The shape of the radiating conducting material is of any geometrical shape as a basic form or some other common shape for the simplification of the analysis and performance prediction.

2. ANTENNA DESIGN AND ANALYSIS

The initial phase in planning of the microstrip antenna is to choose working frequency and proper substrate determination. The working frequency of the antenna must be reasonably chosen. The planned antenna must be worked under wanted frequency band. The working frequency in our design is picked to be 11GHz, which is in X-band region. The subsequent stage in the antenna structuring is to pick appropriate substrate. The height and dielectric of the substrate steady rely upon the electromagnetic features of the antenna [12]. The dielectric material selected for the design is Duroid. High dielectric substrate reduces the dimensions of the antenna since the dimensions are inversely proportions to the dielectric constant [13]. The feeding method in use is microstrip feedline. The length, L, and width, W, of the antenna are found out by using the following equations.

$$W = \frac{c}{2f} \times \sqrt{\frac{2}{(\varepsilon_{r+1})}}$$

$$L = \frac{c}{2f}\left(\frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\sqrt{\left[1 + 12\frac{h}{W}\right]}\right)^{\frac{-1}{2}} - 2\Delta L$$

Here, $\mathcal{E}r$ is the dielectric constant of the substrate. The chosen substrate, wideband, is Duroid with $\mathcal{E}r$ of 3, and the working frequency, f, is taken to be 11 GHz. The effective length is subjected to the correction factor, ΔL, and this correction factor is found to be nearly 0.07. The corresponding length, LG, and the width WG, of the substrate is in correspondence with its height, h, and the dimension (length and width) of the antenna. These values are found out from the given equations.

$$W_G = W + 6h$$
$$L_G = L + 6h$$

3. RESULTS AND DISCUSSION

The proposed antenna has been designed and simulation is done using HFSS software here the designing aspects of two set of antenna structure is presented. One is rectangular shaped and another is square shaped antenna. In the view of above equations, microstrip antenna has been designed, and the width and length of patch are evaluated as 11 mm and 9 mm respectively. The height of the substrate is 1.57 mm. For substrate plane, the length (Ls) and width (Ws) is taken out as 48 mm by 48 mm respectively. Simulation has been done using HFSS tool. In the first set of observation, the height of the substrate are varied from 1.17 mm to 2.47 mm. The corresponding reflection coefficient and bandwidth is tabulated in table 1.

Height (h)(mm)	Bandwidth (MHz)	Reflection coefficient (-dB)
1.17	350	18.5
1.37	360	22.5
1.57	460	25
1.77	430	38
2.47	510	15.5

Table 1: Bandwidth and reflection coefficients at different height

It has been observed that at height 1.17 mm, the bandwidth is 350 MHz with a reflection coefficient of -18.5 dB. As the substrate's height is going to increase from 1.17 mm to 1.57 mm, the simulated result shows that, at the 1.57 mm height of substrate, the antenna resonates at 10.8 GHz of frequency and exhibiting a maximum bandwidth of 500 MHz and maximum reflection coefficient of -25 dB. Furthermore, as the substrate's height increase from 1.57 mm to 1.77 mm, the antenna resonant 10.7 GHz. With substrate height of 1.77 mm, maximum reflection coefficient of -38 dB is obtained, but the bandwidth reduces a little. A plot of bandwidth and reflection coefficient with different substrate height of antenna is shown in Figure 1.

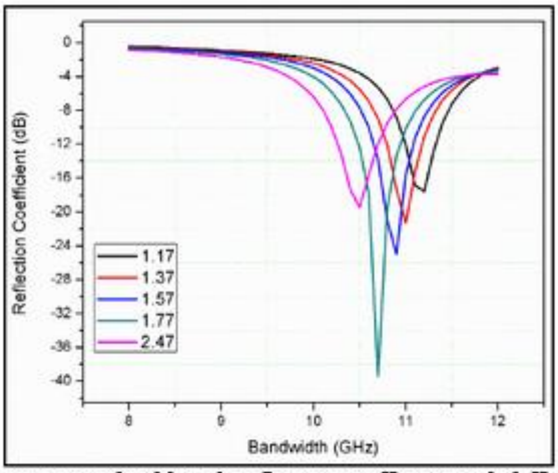

Fig 1: Bandwidth and Reflection coefficient with different height.

n all further design, the height of the substrate is kept at 1.57 mm.

(i) Rectangular Antenna Design- The basic structure of first set of rectangular shaped microstrip antenna, designed for frequency of 11 GHz, is shown in Figure 2. The width (W) and length (L) of the resonating patch is 11 mm and 9 mm respectively. The width of feeding element is 0.8 mm. For the substrate plane, the length (LG) and width (WG) of the ground plane is 18 mm and 20 mm respectively. This structure gives a bandwidth of 340 MHz ith a reflection coefficient of -17 dB as shown in Figure 2.

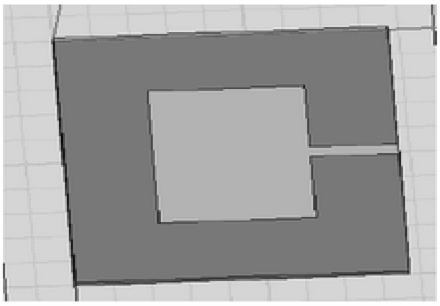

Fig 2: Rectangular type-1 Antenna

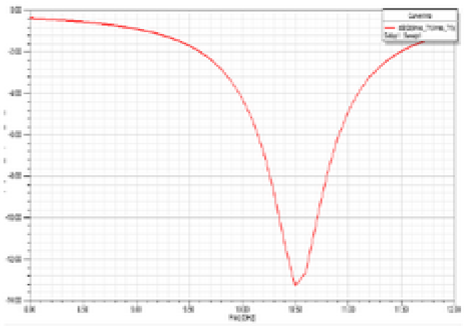

Fig 3: Bandwidth and Reflection coefficient of Rectangular type-1 Antenna

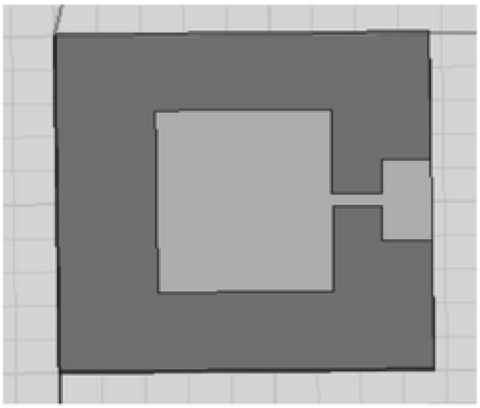

Fig 4: Rectangular type-2 Antenna

The type-2 rectangular microstrip antenna structure is shown in figure 4. In this antenna, the feedline is modified with an addition of stub the source side. This result is good matching and it is found that the bandwidth is increased to 400 MHz with reflection coefficient of -18 dB as shown in figure 4.

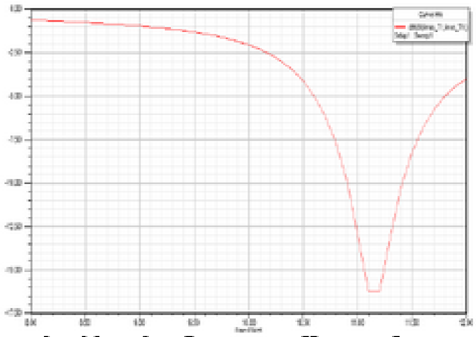

Fig 5: Bandwidth and Reflection coefficient of Rectangular type-2 antenna with stub feedline.

(ii) Square Antenna Design- In Square Antenna design, we have taken the same geometry as in rectangular shaped antenna. For this design structure, the side (length and width) is 9 mm and the side of the substrate plane is 28 mm. the shape of the ground plane is also square, and it is shown in figure 6 and figure 8. The first figure is for simple feedline, whereas the second one for stub feedline.

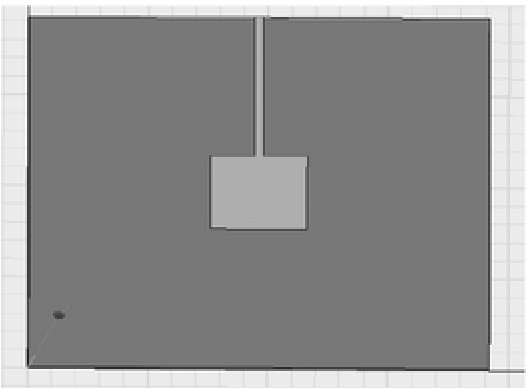

Fig 6: Square type-1 Antenna

Square type 1 antenna shows a high reflection coefficient of -29 dB, and a bandwidth of 430 GHz. Its result is shown in figure 8. In square type-2 square shaped antenna, with has stub feedline, the bandwidth enhanced to 500 MHz and the corresponding reflection coefficient comes out to be – 24 dB. So by adding stub at source side a 70 MHz enhanced bandwidth is obtained. This result is shown in figure 9.

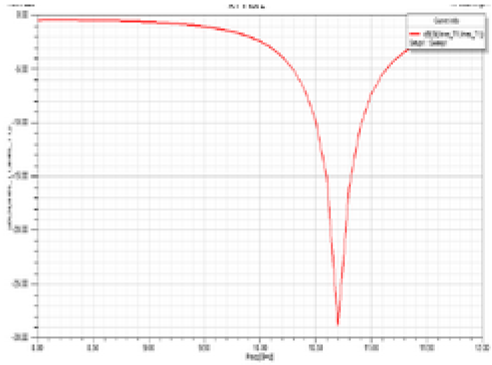

Fig 7: Bandwidth and Reflection coefficient of Square type-1 Antenna

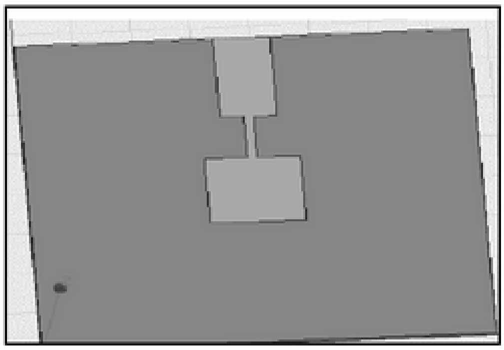

Fig 8: Square type-2 Antenna with stub feedline

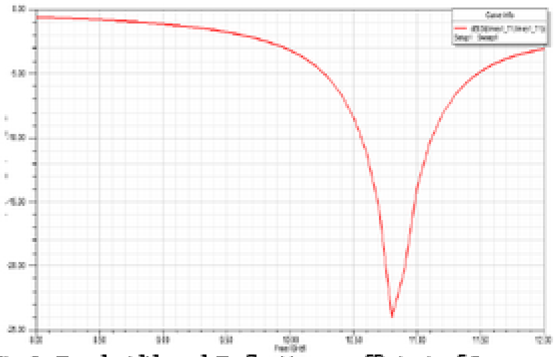

Fig 9: Bandwidth and Reflection coefficient of Square type-2 Antenna with stub feedline

The table 2, summarized the design results.

Type of antenna	Height (h)(mm)	Bandwidth (MHz)	Reflection coefficient (-dB)
Rectangular Type-1	1.17	340	17
Rectangular Type-1	1.37	400	18
Square Type-1	1.57	430	29
Square Type-1	1.77	500	24

Table 2: Summary of the results for various antenna structure.

CONCLUSION

The proposed microstrip square shaped antenna with stub feedline show a good wider bandwidth of 500 MHz. It also exhibits a high reflection coefficient of -24 dB with the substrate height of 1.57 mm. This is validating in all the designed aspects of the different structure of the antenna. The broadening of the antenna is attained by the proper impedance matching by stub feedline at the source point of the antenna. This good bandwidth and high return loss might be useful for many wireless applications. The simple antenna would find considerable for good wide band wireless application.

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