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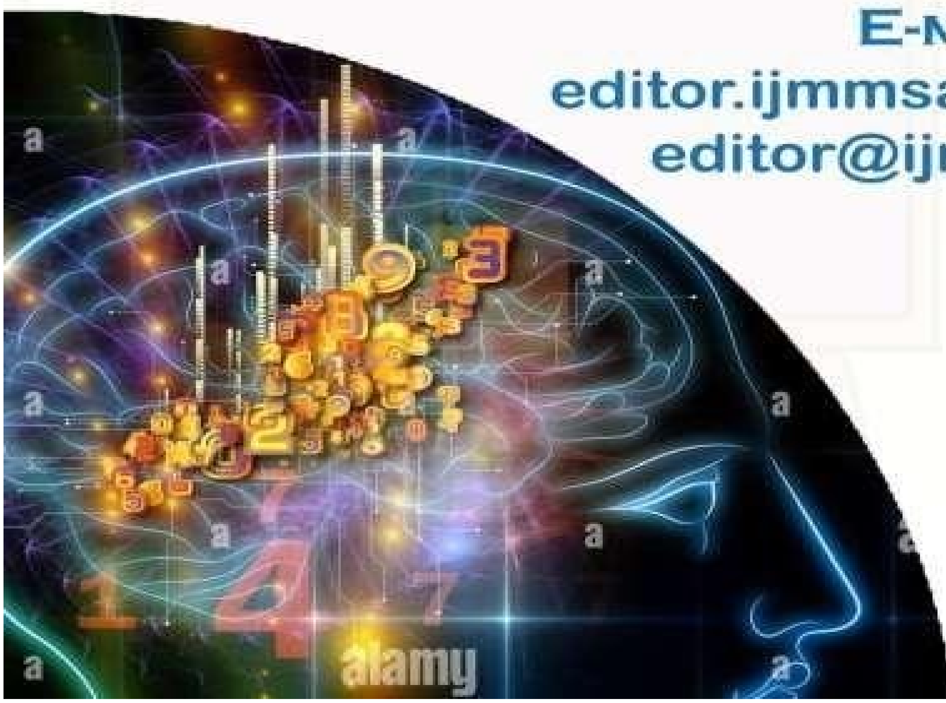

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Analysis and Design of Microstrip Patch Antennas in Wireless Communication Applications

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Abstract:

It is critical that the microstrip antenna used for wideband communication be lightweight, easy to build, and small in size in order to be effective. A basic geometrically organised design for the microstrip antenna is required in the present context in order to achieve appropriate broadband performance. Presented here are the findings from a two-dimensional design study of rectangular and square shaped microstrip antennas conducted by the author. In order to feed both antennas, microstrip line was used in conjunction with each antenna. When compared to the rectangular microstrip antenna used in the preceding example, the square-shaped microstrip antenna provides a wider bandwidth and a more acceptable return loss. Small and lightweight, the small antenna is intended to function in the X band of frequencies, where it will be most effective. According to the results of the antenna performance evaluations, the proposed microstrip antenna has a wide bandwidth of 500MHz and a considerable return loss (-24 dB). Because of its huge bandwidth, it may be used in a wide variety of wideband applications in the X- band spectrum.

Index Terms: Broadband, Microstrip Antenna, Reflection coefficient, Stub Matching.

I. INTRODUCTION

The usage of a Microstrip antenna is a significant advancement in wireless communication systems because it satisfies the needs of the most recent generation of wireless communication technology, which is distinguished by its ability to introduce new concepts and ideas. It is being employed in each of these devices owing to the several benefits [1] that microstrip antennas provide, including the fact that they are incredibly lightweight, have a basic construction, and are highly efficient while being inexpensive. In contrast, the limited operating bandwidth of it is a restriction, and as a consequence, its usage in wireless systems is severely constrained [2]. We have grown to rely on broadband programmes that perform a range of tasks as well as wireless gadgets as crucial components of our day-to-day life. As a consequence, the need for low-profile wideband has been decreased [3] as a result of this development. As well as being able to fulfil the great majority of the requirements for mobile and satellite equipment, microstrip antennas are also capable of addressing an extensive variety of business demands. When it comes to wireless applications, the quantity of electrical circuits required is gradually decreasing, making the microstrip a particularly appropriate match in this case. Additionally, the size of the antennas that are used for the overwhelming majority of applications is shrinking at a frighteningly fast pace. Design of a microstrip antenna fix that satisfies the specifications of these Multiple methodologies have been examined [4-6], and it has been shown that the selection of the appropriate impedance bandwidth of the microstrip antenna may be one of the variables leading to the enhancement of performance. Notches have been shown to elicit craving responses [7,8].

The presence of slots [9-11] has been uncovered by several examinations in the course of its enlargement, and they have been identified in huge numbers. Building a very basic form of the Microstrip antenna using a dielectric substrate as the base material and a radiating conducting material that has been itched onto the top surface of the substrate may be achieved in a short amount of time. It is possible for the radiating conducting material to take on any geometrical shape in its most basic form. In its more complicated form, however, it may take on any other common shape for the purpose of convenience in analysis and prediction of performance.

II. ANTENNA DESIGN AND ANALYSIS

The first step in the design of a microstrip antenna is to determine the operating frequency and the right substrate for the antenna. The operating frequency of the antenna must be selected in a rational manner. The intended antenna must be capable of operating within the desired frequency spectrum. The operating frequency of our design has been selected to be 11GHz, which is in the X-band range of frequencies. It is necessary to choose an acceptable substrate

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for the antenna structure once this step has been completed. The electromagnetic characteristics of the antenna [12] have an impact on the height and dielectric constant of the substrate [13, 14]. Duroid was chosen as the dielectric material for use in the design. Because the dimensions of an antenna are inversely proportional to the dielectric constant [13], a high dielectric substrate causes the antenna's dimensions to be reduced. Microstrip feedline is the way of feeding that is being used. The length, L, and width, W, of the antenna are determined by using the following formulae and formulas.

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

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

The dielectric constant of the substrate is represented by the symbol Ere. The wideband substrate, Duroid, with an Er of 3 is selected, and the working frequency, f, is set at 11 GHz for this application. The effective length is subjected to the correction factor, L, and it is discovered that this correction factor is roughly 0.07 in magnitude. This corresponds to the antenna's height (h) and the dimensions (length and width) of the substrate. The length LG and width WG of the substrate are equal in length and width. These values may be deduced from the formulae that have been provided.

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

III. RESULTS AND DISCUSSION

The proposed antenna has been built, and simulations have been carried out with the help of the HFSS software. The components of two distinct antenna structures are covered in this section, as are the design considerations for each. Additionally, a rectangular-shaped antenna and a square-shaped antenna are also available for purchase. A microstrip antenna has been constructed in accordance with the aforementioned equations, and the width and length of the patch have been found to be 11 mm and 9 mm, respectively, in accordance with the aforementioned equations The substrate has a height of 1.57 centimetres and is made of plastic. This model assumes that the length (Ls) and width (Ws) of the substrate plane are 48 mm in length and 48 mm in width, respectively for the substrate plane. The simulation was carried out with the assistance of the HFSS software. The first set of observational studies shows an increase in the height of the substrate, which ranges from 1.17 mm to 2.47 mm in height. The reflection coefficient and bandwidth for the suitable reflection coefficient and bandwidth are shown in Table 1 for reference.

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

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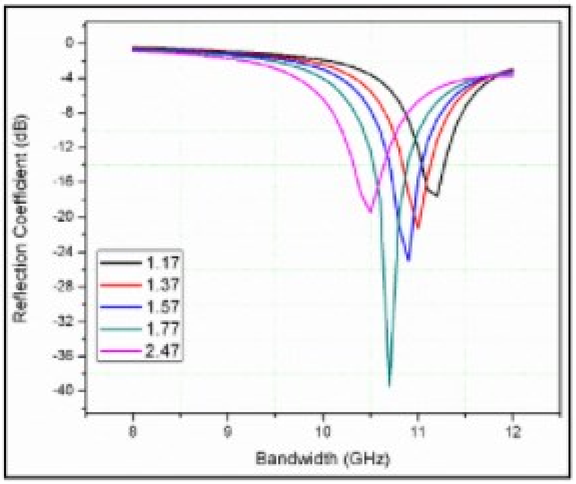

fig 1: Bandwidth and Reflection coefficient with different height.

It is important to note that the height of the substrate remains at 1.57 mm throughout the remainder of the design. Antennas with Rectangular Shapes Designed (A) The basic architecture of the first set of rectangular-shaped microstrip antennas, which were produced at a frequency of 11 GHz and had a rectangular shape, is seen in Figure 2. There is a difference in width (W) and length (L) between the resonating patch and the surrounding area; the width is greater than the length. At its broadest point, the feeding element is 0.8 mm in width. The following are the dimensions of the ground plane for the substrate plane: The ground plane's length (LG) and width (WG) are 18 mm and 20 mm, respectively, in length and breadth. With this configuration, a bandwidth of 340 MHz may be attained while maintaining a reflection coefficient of -17dB, as seen in Figure 1.

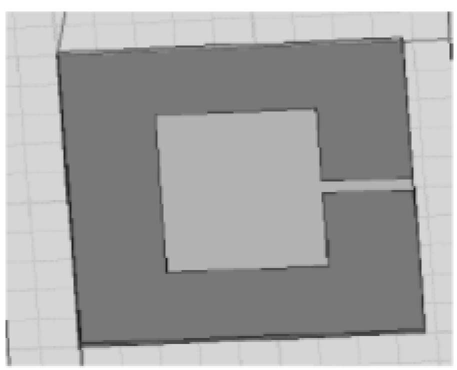

Fig 2: Rectangular type-1 Antenna

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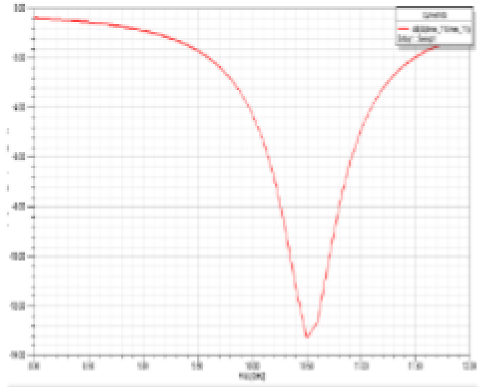

Fig 3: Bandwidth and Reflection coefficient of Rectangular type-1 Antenna

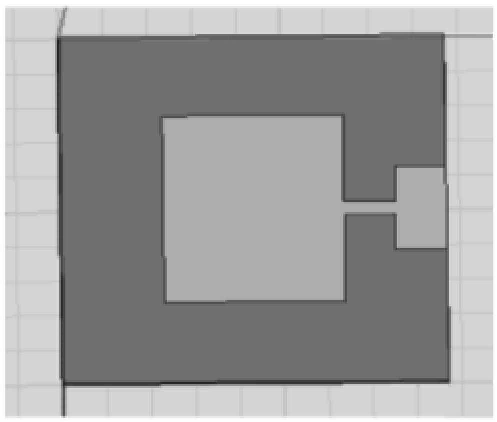

fig 4: Rectangular type-2 Antenna

In Figure 4, you can see the steps involved in building a type-2 rectangular microstrip antenna. It has been decided to modify the feedline of this antenna by adding an additional stub on the source side of the feedline. This time, the findings are excellent, and it is found that the bandwidth has been increased to 400 MHz, with a reflection coefficient of -18dB, as shown in figure 4 of this document.

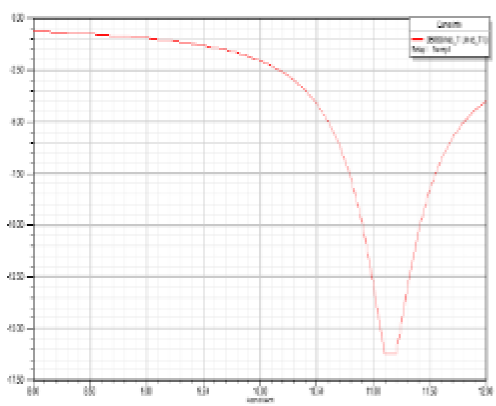

Fig 5: Bandwidth and Reflection coefficient of Rectangular type-2 antenna with stub feedline.

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B. Square Antenna Design

In the design of the square antenna, we used the same geometry as we did in the design of the rectangle shaped antenna. The side of the design structure (both in length and breadth) is 9 mm, and the side of the substrate plane is 28 mm for this design structure. Similarly, the ground plane has a square form, which is seen in figures 6 and 8. The first illustration depicts a basic feedline, while the second depicts a stub feedline, respectively.

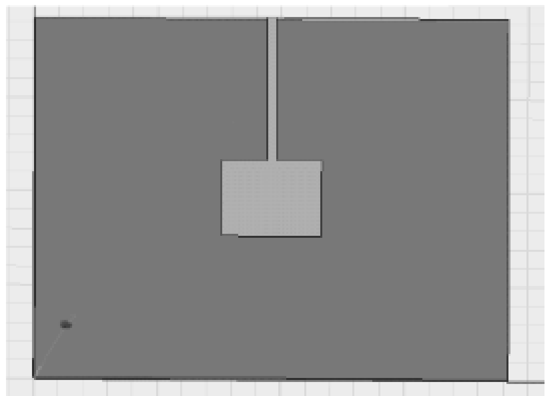

Fig 6: Square type-1 Antenna

The square type 1 antenna has a high reflection coefficient of -29 dB and a bandwidth of 430 GHz, making it an excellent choice for high-frequency applications. Figure 8 depicts the result of the experiment. The bandwidth of a square type-2 square shaped antenna with a stub feedline has been increased to 500 MHz, and the corresponding reflection coefficient is found to be – 24 dB in this configuration. As a result of adding stub at the source side, a 70 MHz increase in bandwidth is obtained. Figure 9 depicts the outcome of this study.

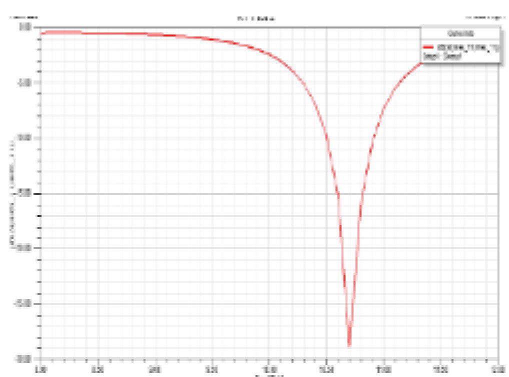

Fig 7: Bandwidth and Reflection coefficient of Square type-1 Antenna

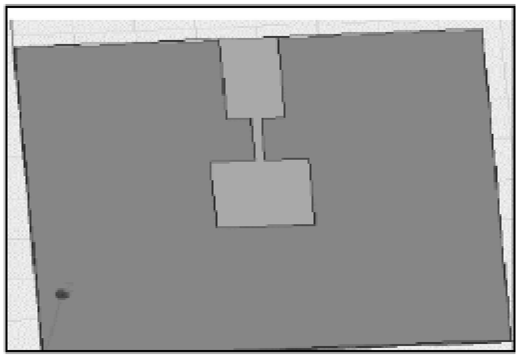

Fig 8: Square type-2 Antenna with stub feedline

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

The table 2, summarized the design results.

CONCLUSION

When compared to other comparable antennas, this microstrip square-shaped antenna with a stub feedline offers a great larger bandwidth of 500 MHz. With a substrate height of 1.57 mm, it also has a high reflection coefficient of -24 dB, which is fairly excellent for this application considering the substrate height. This is validating in all aspects of the antenna's design, including the many different antenna structures that have been used. Using a stub feedline at the antenna's source point, which results in the antenna being wider, it is possible to ensure proper impedance matching of the antenna. It is possible that the high return loss, paired with the wide bandwidth, may be helpful for a number of wireless applications. When it comes to good wide band wireless applications, a simple antenna may make a major difference in terms of performance and reliability.

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