# Multiband Microstrip Patch Antenna Using Parasitic Patch Configuration

**Amit Joon[1] Anjali Grover[2] Pranav Sharma[3] Prateek Rao[4] Vikas[5] Ved Prakash[6]**
[1]Students and Lecturer
[1, 2, 3, 4, 5, 6]Department of Electronics and Communication, Amity University, Haryana

**Abstract**—*This paper presents a method to get a multi band in microstrip patch antenna by introducing four parasitic patches one by one. Firstly, an antenna using inset microstrip line feed (with dimensions in mm, x: 4.89, y: 37.495, z: 3.2) is designed for 5.4 GHz. Then, one, two, three and four parasitic patches are introduced one by one and their individual bandwidth and gain is calculated. Both the bandwidth and gain are found to increase as the number of parasitic patches increase. CST studio is used as the software tool. Duroid substrate having a dimension of 56 mm ×84 mm×1.6 mm is used as the base of the antenna, giving the volume of the antenna to be 7.526cm*$^3$.
**Keywords**: - *Bandwidth, Duroid, Microstrip, Parasitic.*

## I. Introduction

With the rapid growth of the wireless mobile communication technology, the great demands in future technologies are very small size wide band antennas. For this Microstrip patch antenna is the better part. Microstrip patch antenna has become very popular nowadays because of its ease of analysis and Fabrication, low cost, light weight, easy to feed and their attractive radiation characteristics. Although microstrip patch antenna has numerous advantages, it has inherent limitation of narrow bandwidth, low gain. To overcome its inherent limitation of narrow impedance bandwidth and low gain, many techniques have been suggested and investigated for Microstrip antenna. We can mention multilayer structures [2], broad folded flat dipoles [3],curved line and spiral antennas [4], impedance matched resonator antennas [5], resonator antennas with capacitive coupled parasitic patch element [6], log periodic structures [7-8], modified shaped patch antenna (H-shaped [9]).

In this paper Parasitic patches along with main patch type microstrip patch antenna is analyzed and compared with rectangular patch antenna. Actually, the parasitic elements cause some resonance frequencies to appear near that of the main element and lead to the wide–banding of the antenna. Furthermore, parasitic elements bring about better impedance matching and radiation characteristics of antenna. However, they pose an impediment on the miniaturization of antennas. In this paper, we intend to search for a method to use parasitic elements and a slot, while keeping its size limited. The result of this paper will show that enhancement of the original bandwidth which can be achieved by using parasitic patches and cutting a slot in the main patch. The bandwidth, gain and radiation pattern are evaluated using CST software.

## II. Literature Review

Microstrip patch antenna consists of a radiating patch which is generally made of conducting material such as gold or copper and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate which has a ground plate as shown in Fig. 1. In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular or elliptical in shape. Rectangular shape is used in this paper as shown. For a rectangular patch, the length L of the patch is usually $0.333\lambda o < L < 0.5\lambda o$, where $\lambda o$ is the free space wavelength. The patch is selected to be very thin such that the patch thickness $t \ll \lambda o$. The height h of the dielectric constant of the substrate ($\varepsilon r$) is typically in the range $2.2 \leq \varepsilon r \leq 12$. The microstrip patch antenna radiates primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, the choice of substrate used is an important factor.

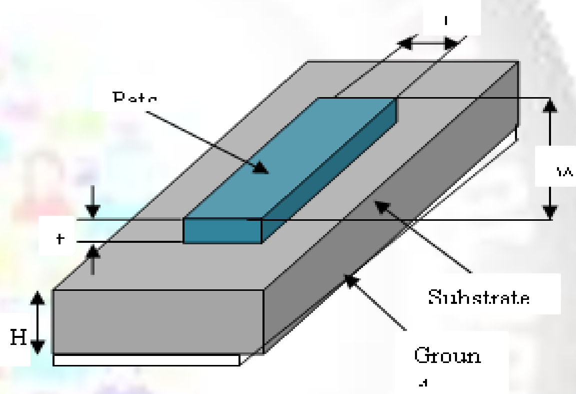


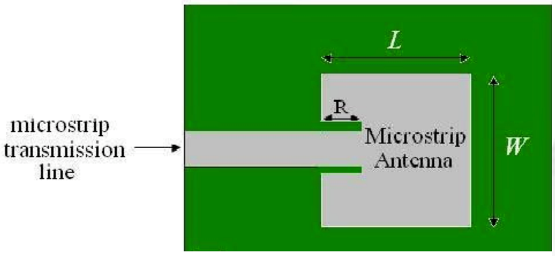

Fig. 1: Structure of Microstrip patch antenna

There are numerous substrates that can be used for the design of microstrip antennas within the dielectric constants range of $2.2 \leq \varepsilon r \leq 12$. The low dielectric constant $\varepsilon r$ is about 2.2 to 3, the medium around 6.15 and the high approximately above 10.5[10-11]. A thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation. However, such a configuration leads to a larger antenna size. In order to design a compact microstrip patch antenna, substrate with higher dielectric constants must be used which are less efficient and result in narrower bandwidth. Hence, a trade-off must be realized between the antenna dimensions and antenna performance.

Microstrip patch antenna can be fed by a variety of different methods. The four most popular feed techniques used for the Micro strip patch are:

- Inset feed
- Pin feed
- Aperture coupling
- Proximity coupling

Direct feed typically yields high input impedance. Since the current is low at the ends of a half wave patch and increases in magnitude toward the centre, the input impedance could be reduced if the patch was fed closer to the centre [11]. One method of doing this is by using an inset feed (a distance R from the end) as shown in the Fig. 2. Since the current has a sinusoidal distributions, moving in a distance R from the end will increase the current by cos(π*R/L) - this is just nothing that the wavelength is 2*L, and so the phase difference is 2*π*R/ (2*L) =π*R/L




Fig, 2: Patch antenna with inset feed

In this paper, only inset feed antenna is dealt with.

## III. Proposed Methodology

Firstly, an antenna using inset microstrip line feed will be designed for 5.4 GHz. The specifications of the antenna are calculated as per the requirement. The parameters then used are shown in Table 1. Further a parasitic patch is introduced and then the number of parasitic patch is increased one by one (maximum 4) and the return loss graph is analyzed to measure the bandwidth difference between antenna without patch and the one after introducing the patches.

| **Name** | **Value** |
|---|---|
| Lp(Length of patch) | 2.61 |
| Lg(Length of ground) | 71 |
| Lf (Length of feed) | 4.89 |
| Lpp(Length of parasitic patch) | 23.11 |
| Wp(Width of patch) | 5.5 |
| Wg(Width of ground) | 55 |
| Wf(Width of feed) | 37.5 |
| Wpp (Width of parasitic patch) | 16.93 |

Table 1: Microstrip antenna parameters used

The parameters of the main patch, parasitic patch and the ground as mentioned in Table 1 are pictorially represented in Fig. 3. CST studio will be used as the software tool to simulate all the antenna and to display their return loss graphs

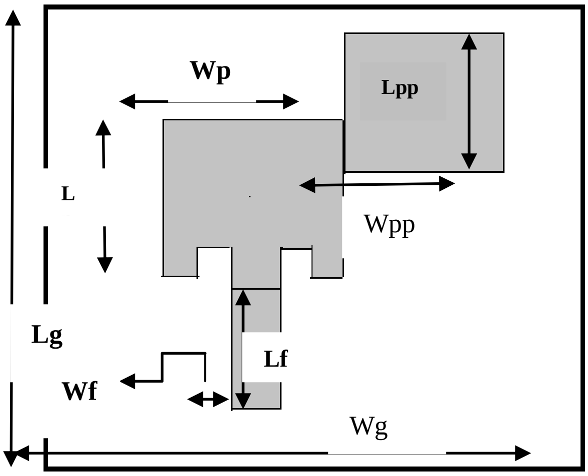



Fig. 3: Parameters of patch, parasitic patch and ground.

## IV. Antenna Geometry

### *A. Without Parasitic Patch*

Fig. 4, shows a basic microstrip antenna with inset feed without any parasitic patch. By feeding antenna with the help of this technique the input impedance can be decreased.

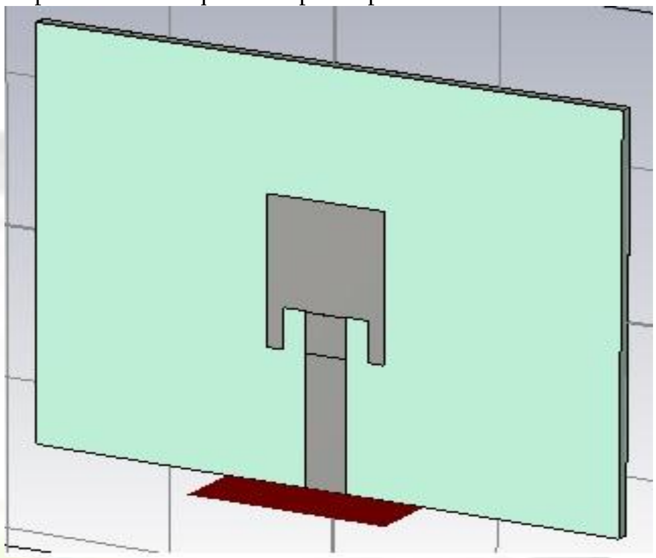


Fig. 4: Microstrip antenna with inset feed without parasitic patch

### *B. With one Parasitic Patch*

Now, one parasitic patch is placed along with the main patch which is fed with inset feed technique. Figure 5 shows the diagram of microstrip antenna with single parasitic patch which takes on the feed through main patch and then radiates.

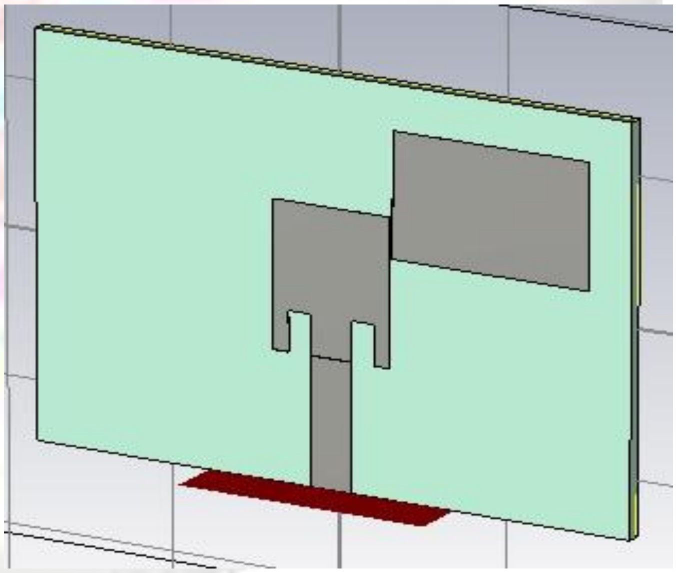


Fig. 5: Diagram of microstrip patch antenna with one parasitic patch

### *C. With two parasitic patches*

Again, one more parasitic patch is added to the main inset feed patch resulting in Fig. 6. Both bandwidth and gain are calculated for two parasitic patches. The rest of the dimensions are kept same as when one parasitic patch is placed.

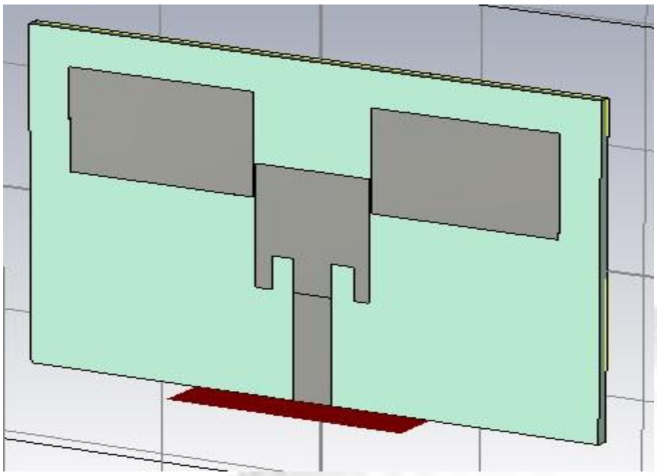


Fig. 6: Diagram of microstrip patch antenna with two parasitic patches

### D. *With three parasitic patches*

One more parasitic patch is added to the main patch, giving a total of three parasitic patches along with the main patch as shown in Fig.7. Rest of the dimensions are kept same as in other cases where one and two parasitic patches are being used.

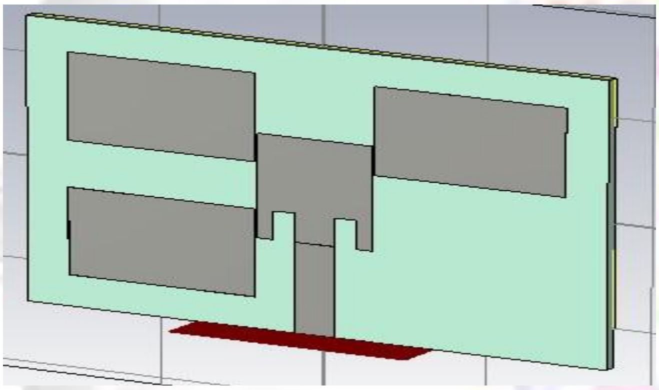


Fig. 7: Diagram of microstrip antenna with three parasitic patches

### E. *With four parasitic patches*

A same size fourth patch is now added to the previous geometry as shown in Fig.8. Again, the dimensions of substrate, ground, feed, and patch are the same as in the rest of the cases with one, two and three parasitic patches. And then this antenna is stimulated and its results including both bandwidth and gain are noted.

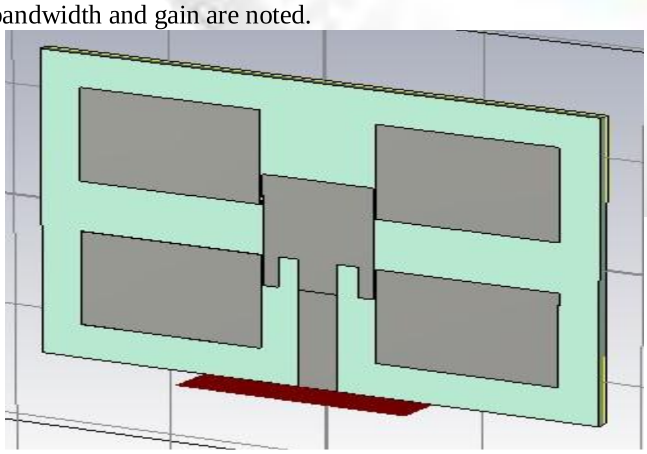


Fig. 8: Diagram of microstrip antenna with four parasitic patches.

## V. Result And Discussion

### A. *Return Loss*

The return loss is a way of expressing mismatch. It is a logarithmic ratio measured in dB that compares the power reflected by the antenna to the power that is fed into the antenna from the transmission line. The relationship between VSWR and return loss is as follows

$$Return\ loss\ in\ dB = 20\log_{10}\frac{(VSWR\ )}{(VSWR\ -1)} \quad (1)$$

#### 1) *Return Loss for antenna with no parasitic patch*

As seen in Fig. 9, a return loss graph of microstrip patch antenna with inset feed without parasitic patch has no resonating frequency with a gain of 6.3dB, and hence does not profit in any possible way, therefore the need arises to add parasitic patches to the main patch.

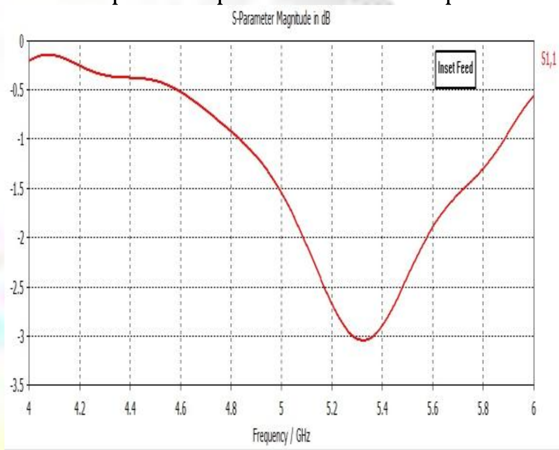



Fig. 9: Return loss graph of antenna without parasitic patch.

### B. *Return loss for one parasitic patch*

When return loss graph of microstrip patch antenna with one parasitic patch is calculated from Fig. 10, resulting bandwidth comes out to be 196 MHz which is the difference between 5.17GHz and 4.97 GHz. And the resulting gain is 6.9dB. Also, a very small second dip can be seen in the graph.

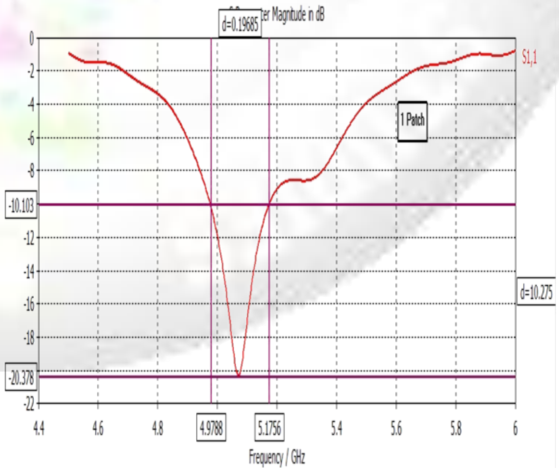



Fig. 10: Return Loss graph of microstrip antenna with one parasitic patch

#### 1) *Return Loss for antenna with two parasitic patches*

Fig. 11, depicts the bandwidth of microstrip antenna with two parasitic patch is approximately 514MHz which is the difference between 4.94GHz and 5.45GHz. And the gain comes out to be 7.5dB.

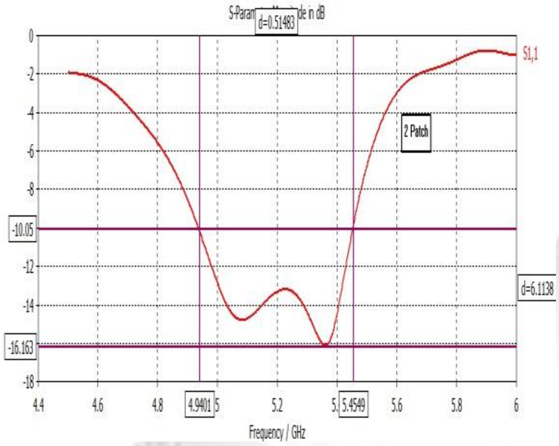



Fig. 11: Return Loss graph of microstrip antenna with two parasitic patches.

*2) Return Loss for antenna with three parasitic patches*

From Fig.12, it can be concluded that when a microstrip patch antenna is used with three parasitic patches, triple dip is produced with the bandwidth 913MHz, which is the difference between 4.48GHz and 5.50GHz. Also, the gain of this antenna comes out to be 8,32dB.

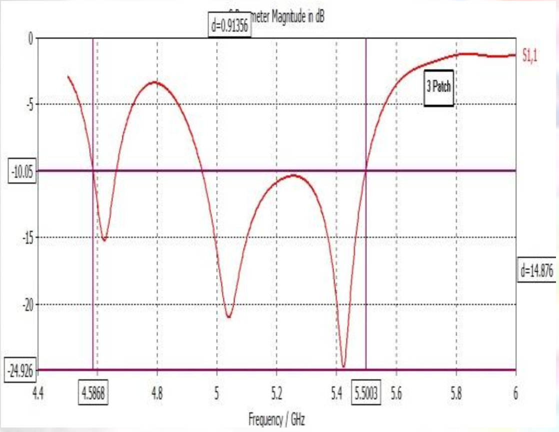



Fig. 12: Return loss graph of microstrip antenna with three parasitic patches.

*3) Return Loss for antenna with four parasitic patches*

Fig.13 gives the bandwidth of microstrip patch antenna with four parasitic patches to be 943MHz, which is the difference between 4.62GHz and 5.57GHz. And the gain of this antenna is found to be 9.02dB.

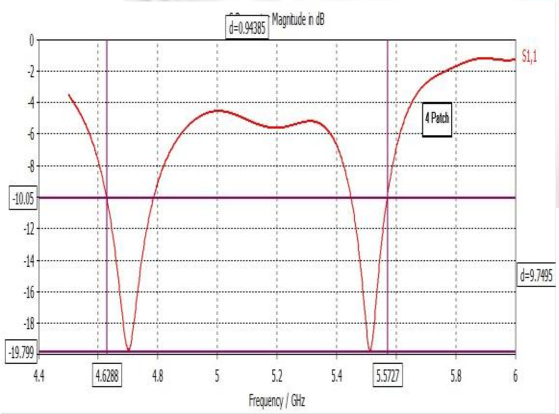



Fig. 13: Return loss graph of microstrip antenna with four parasitic patches.

## VI. Conclusion

The placement of parasitic patches in the microstrip antenna results in multi bands and hence the bandwidth and also the gain of the microstrip patch antenna increases. Earlier, in case of microstrip patch antenna there was no resonating frequency but after placing four parasitic patches, double dip with the bandwidth 943 MHz comes up. Thus, this technique of introducing parasitic patches is found to be very advantageous in various practical real life applications of microstrip antenna for 5.4 GHz.

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