Effect Of Patch Dimensions On The Behavior Of Resonant Peaks Of A Microstrip Patch Antenna – A Comparative Discussion

Ankan Bhattacharya
Assistant Professor
Department of Electronics and Communication Engg.
Mallabhum Institute of Technology, West Bengal, India

Abstract

In this paper a comparative discussion is presented on the effect of patch dimensions on the behavior of the resonant peaks of a microstrip patch antenna. More specifically, the width of the patch is considered in this case. The patch width is increased sequentially from 10 mm to 100 mm and the behavior of the resonant peaks is studied. The antenna is fabricated on a 60 mil RO4003 substrate from Rogers - Corp with a dielectric constant of 3.4 and loss tangent of 0.002. It has been observed that the number of resonant peaks as well as the number of dips increases gradually as the width of the patch is sequentially increased. The study of this behavior would help us to design a multiband antenna for various applications as well as to choose an optimum patch width while designing an antenna.

Keywords

Microstrip patch antenna, patch width, resonant peaks

1. Introduction

Microstrip Patch Antennas are popular for low-profile applications at frequencies above 100 MHz (λo < 3 m). they commonly consist of a rectangular or square metal patch on a thin layer of dielectric (called the substrate) on a ground plane. The assembly is usually contained inside a plastic radome which protects the antenna structure from damage. Patch antennas are simple to fabricate and easy to modify and customize. Patches may be photo-etched making them adaptive for low-cost, mass production. [1]-[3]

This paper is mainly concerned about the role of patch dimensions, the patch width in particular on the behavior of resonant peaks and dips - sudden drops of parameter S11 are considered as dips in this study. The conclusion is drawn on the basis of several simulation results in a generalized process along with detailed analysis of each simulation result.

2. Design

A 10 *x* 10 mm square patch is designed and simulated in IE3D environment. Let the length and width of the patch be represented as L and W respectively. In this case L = 10 mm and W = 10 mm. Fig. 1 shows the geometrical structure of the designed patch.

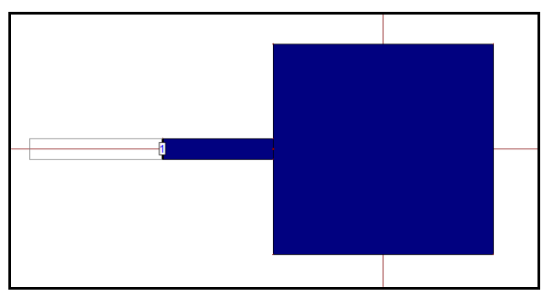

Fig. 1 *A 10 x 10 mm square patch*

IE3D provides an user friendly environment for designing patches of various sizes and shapes. Initially, a square shaped patch is designed of dimensions 10 x 10 mm. The width of the patch is increased sequentially from 10 mm to 100 mm in 10 mm intervals and the results are analyzed in sequential steps.

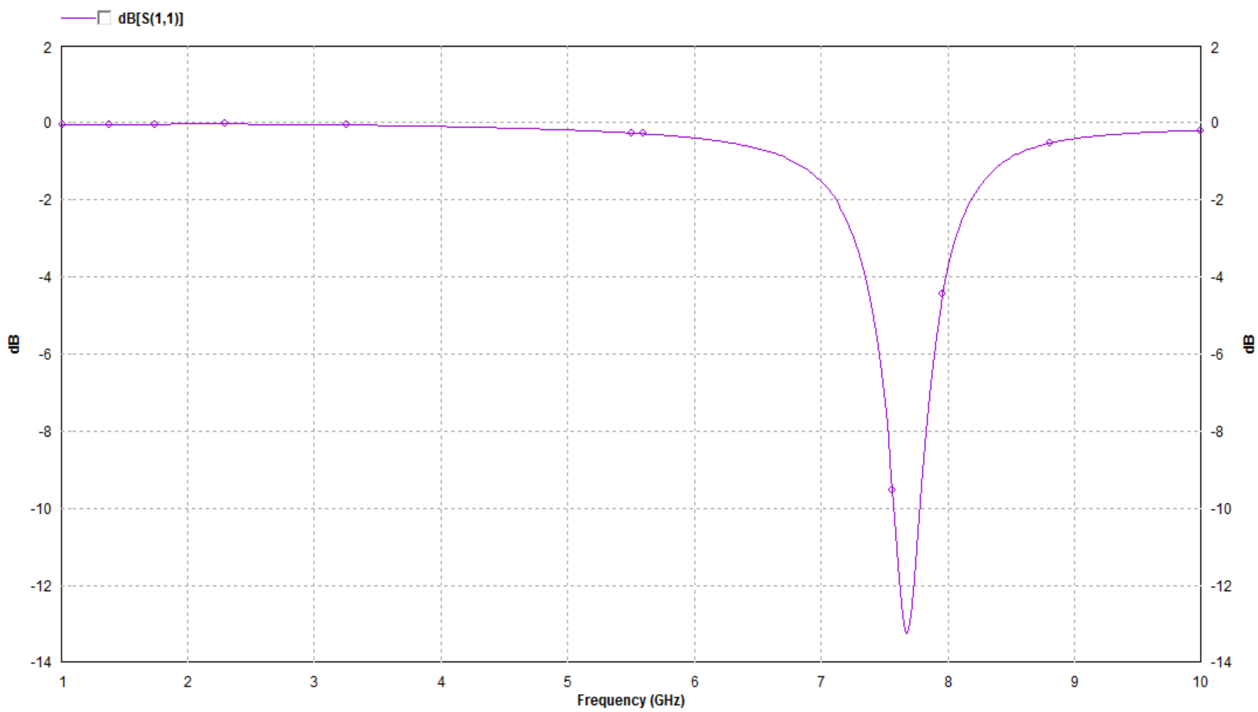

Fig. 2 *S11 vs Frequency plot for a 10 x 10 mm patch*

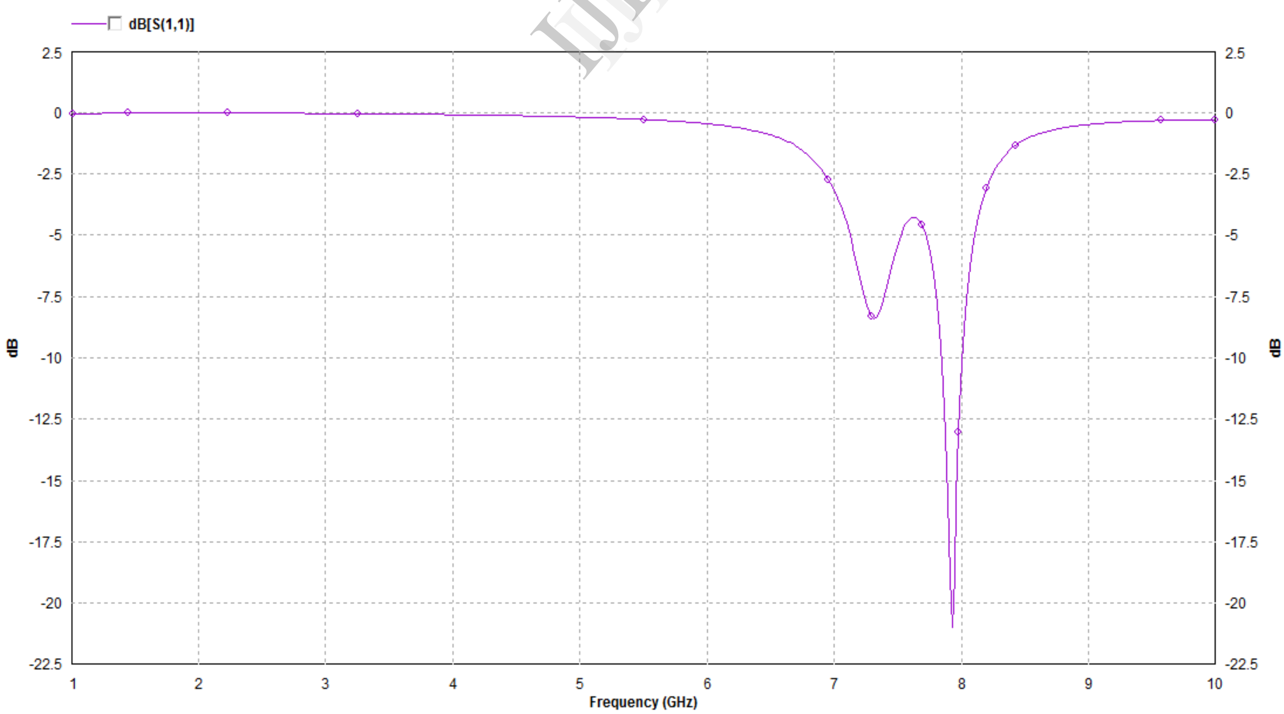

Fig. *3 S11 vs Frequency plot for a 10 x 20 mm patch*

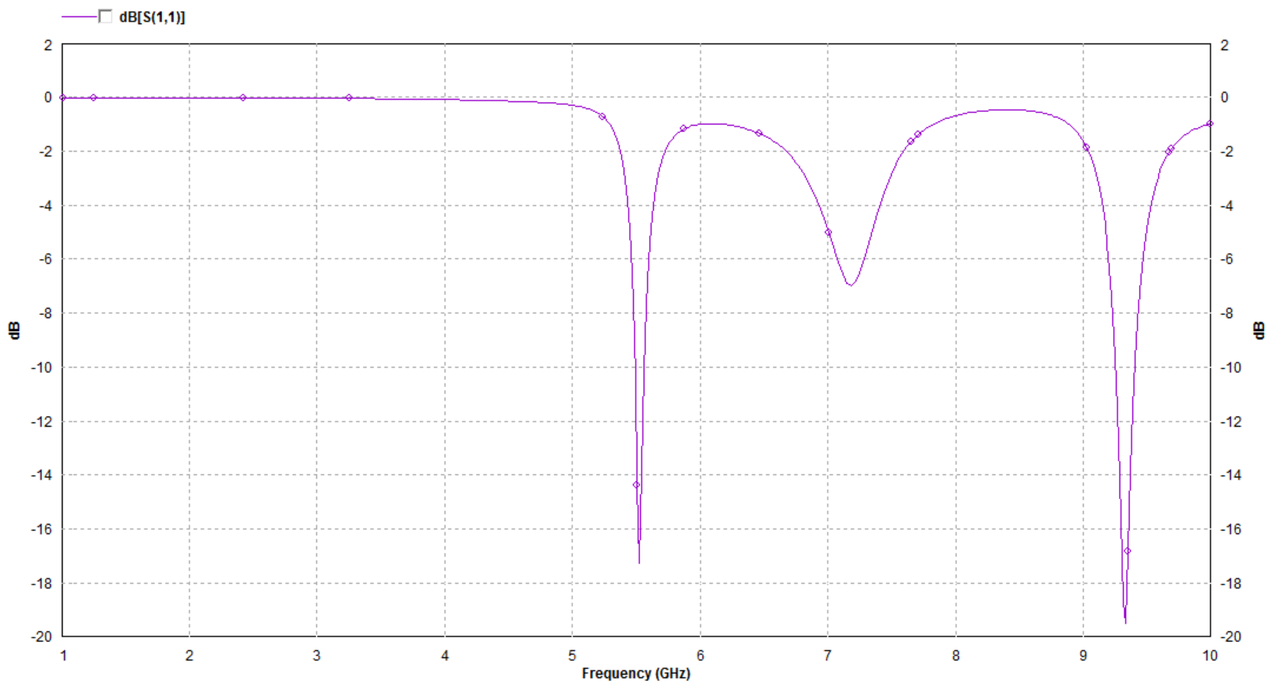

Fig. 4 *S11 vs Frequency plot for a 10 x 30 mm patch*

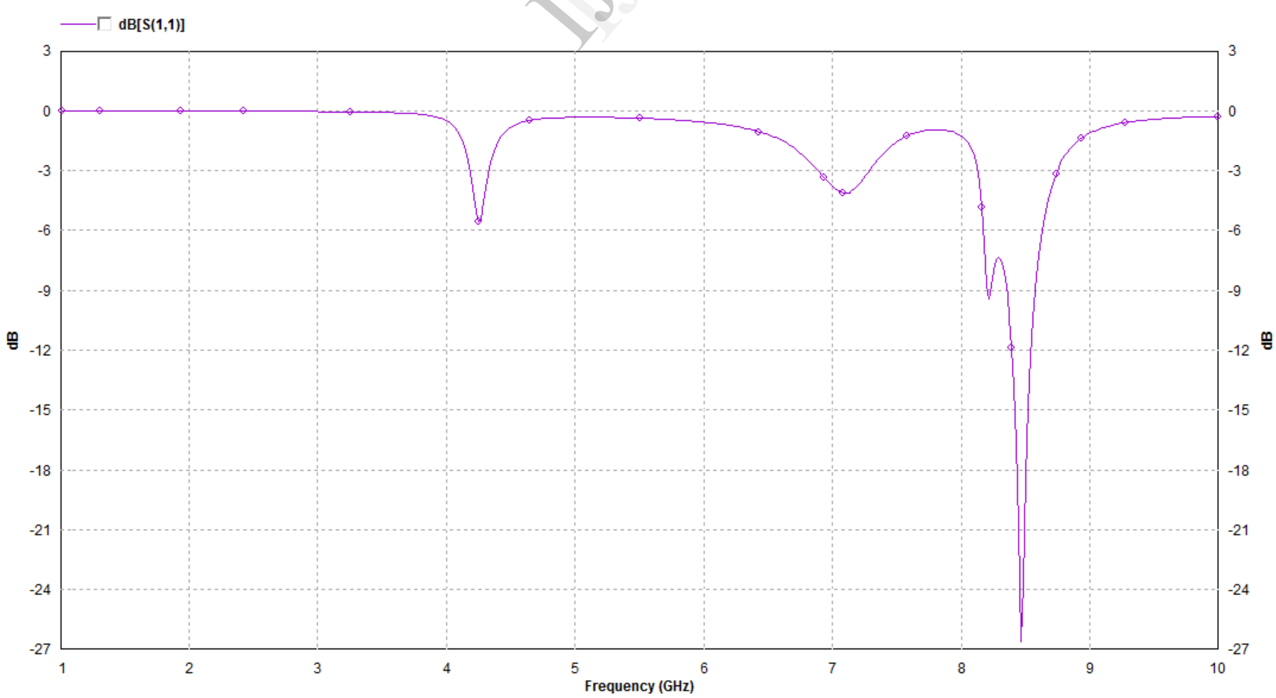

Fig. 5 *S11 vs Frequency plot for a 10 x 40 mm patch*

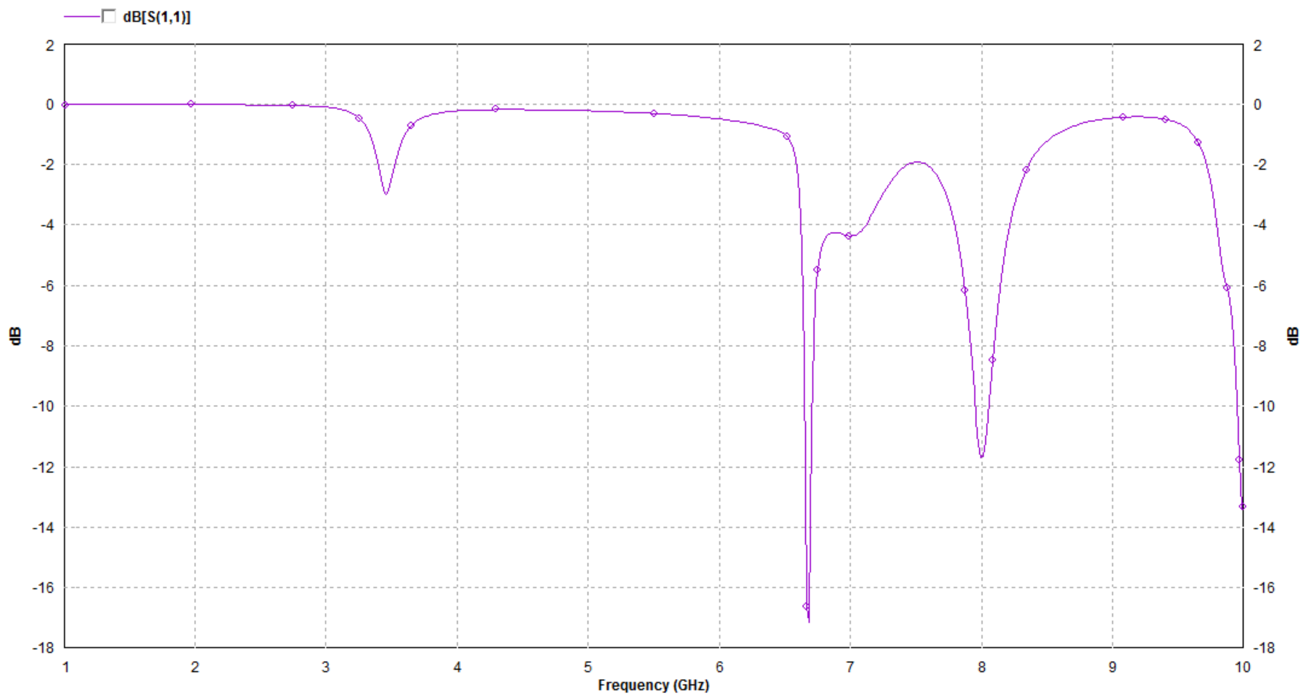

Fig. 6 *S11 vs Frequency plot for a 10 x 50 mm patch*

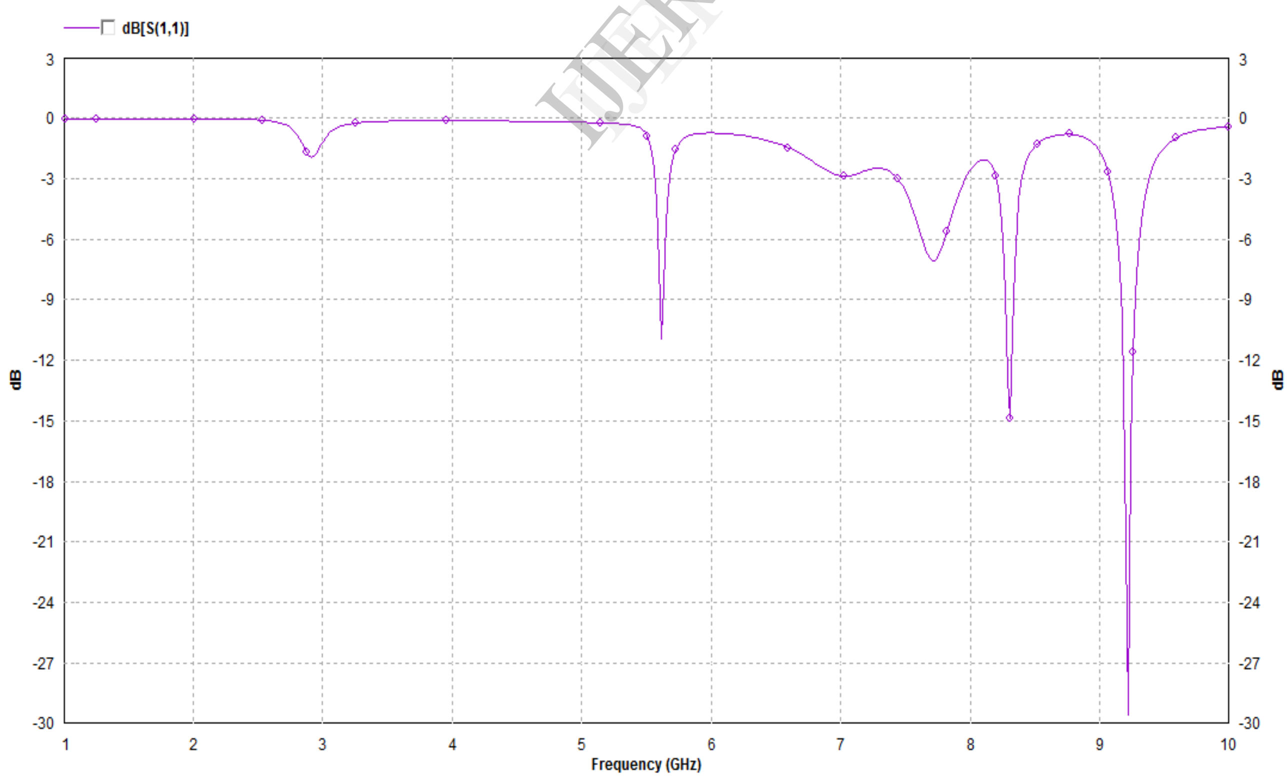

Fig. 7 *S11 vs Frequency plot for a 10 x 60 mm patch*

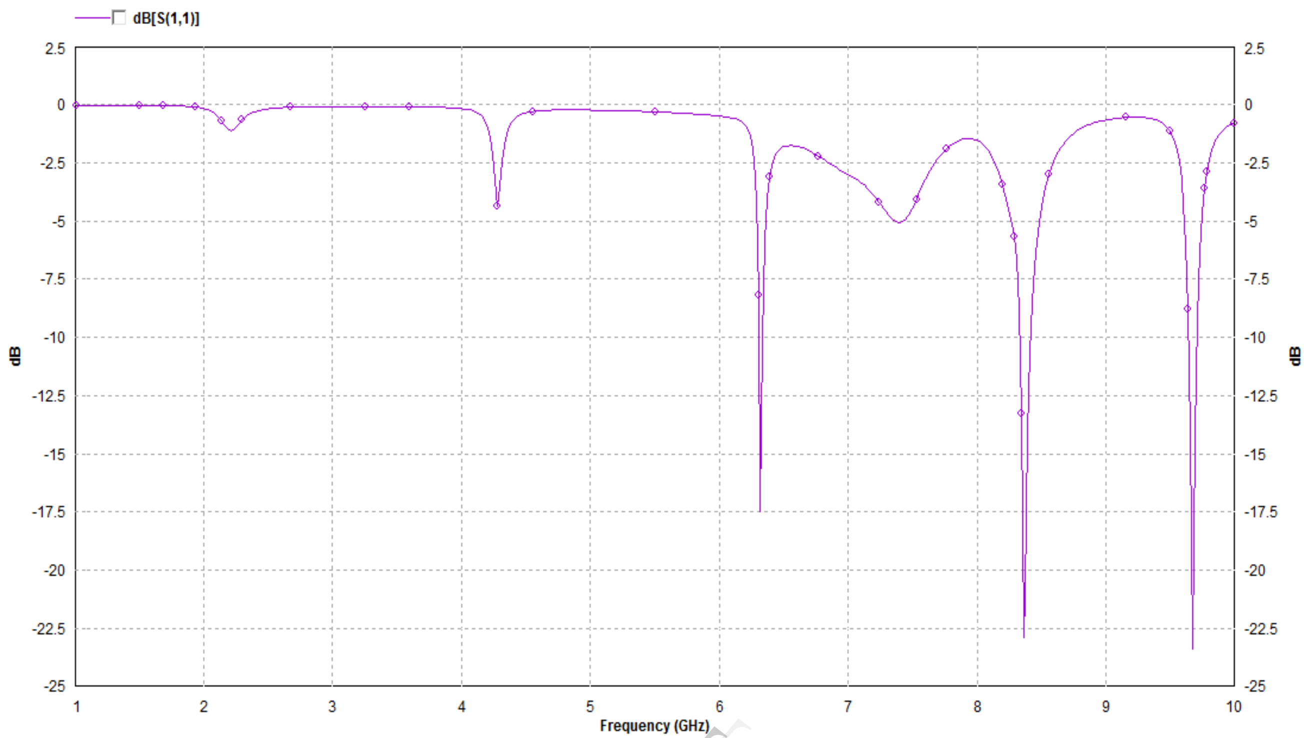

Fig. 8 *S11 vs Frequency plot for a 10 x 70 mm patch*

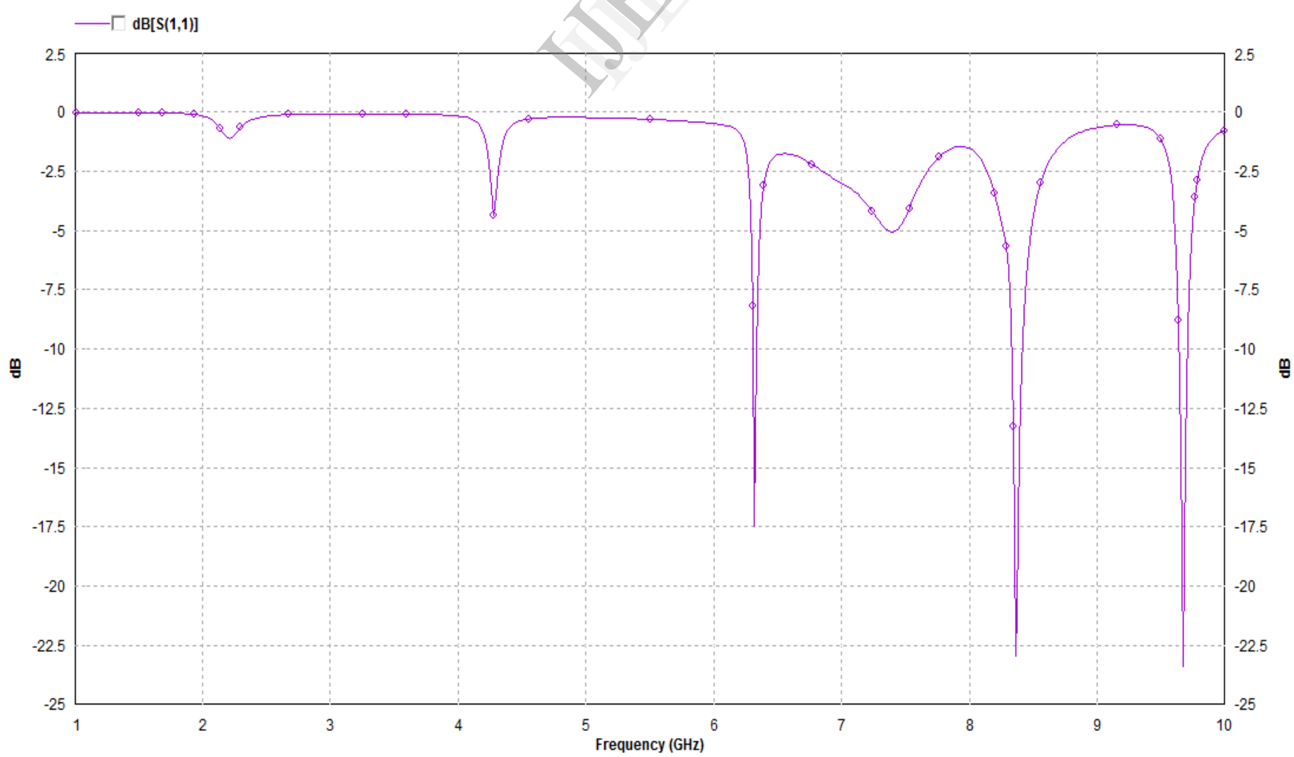

Fig. 9 *S11 vs Frequency plot for a 10 x 80 mm patch*

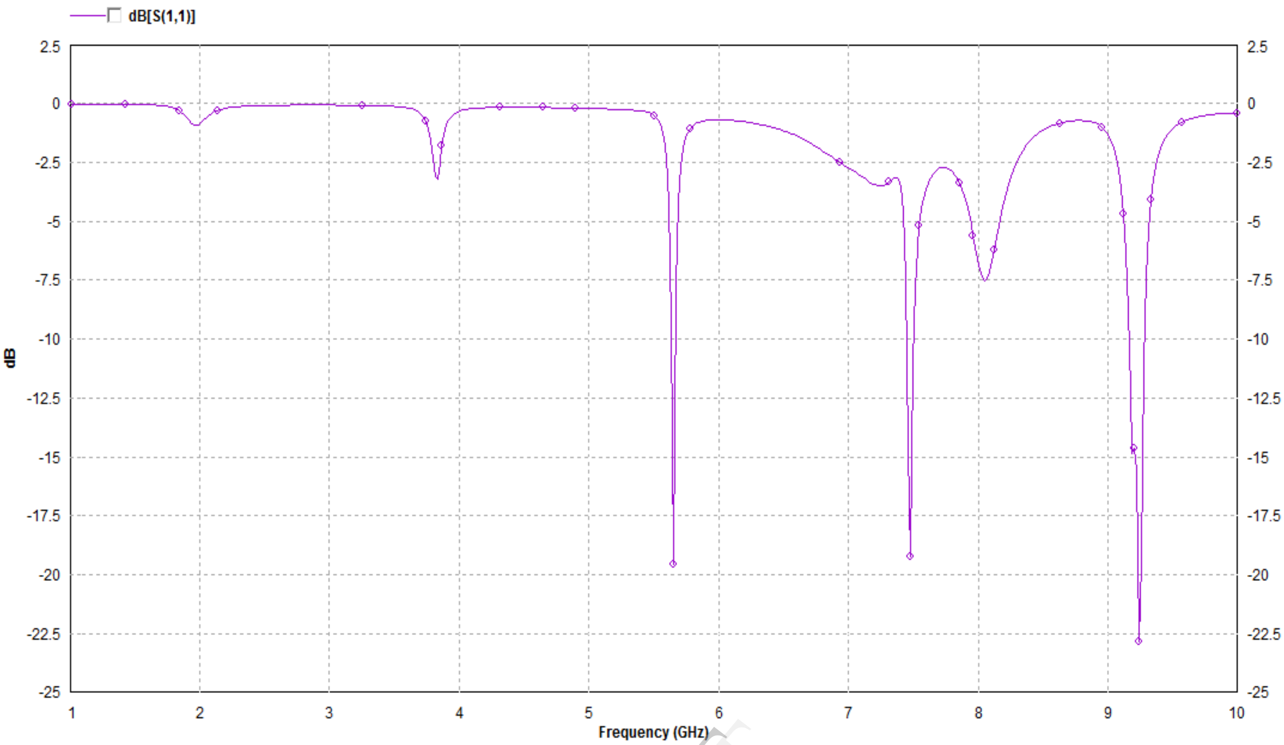

Fig. 10 *S11 vs Frequency plot for a 10 x 90 mm patch*

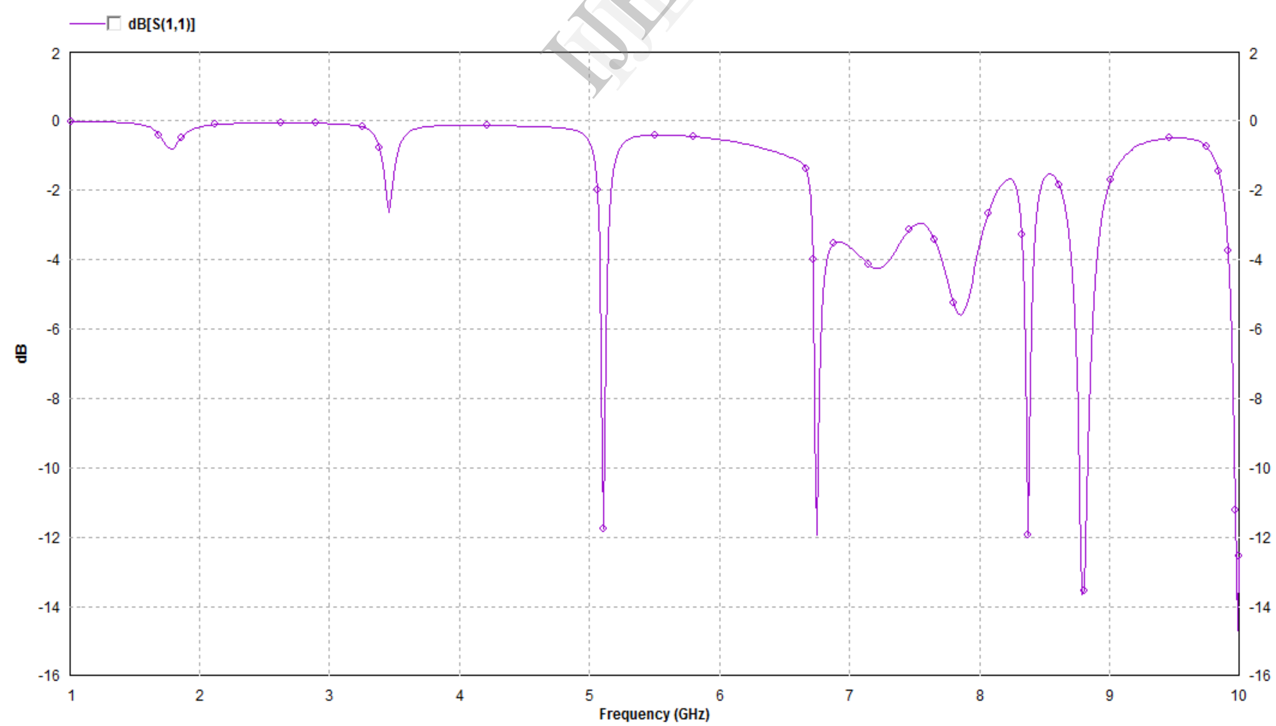

Fig. 11 *S11 vs Frequency plot for a 10 x 100 mm patch*

3. Discussion

S_{11} is a measure of how much power is reflected back at the antenna port due to mismatch from the transmission line. When connected to a network analyzer, S_{11} measures the amount of energy returning to the analyzer – not what's delivered to the antenna. The amount of energy that returns to the analyzer is directly affected by how well the antenna is matched to the transmission line. A small S_{11} indicates a significant amount of energy has been delivered to the antenna. S_{11} values are measured in dB and are negative, ex: -10 dB. S_{11} is also sometimes referred to as return loss, which is simply S_{11} but made positive instead (Return Loss = - S_{11}). So if the antenna Return Loss is 8 dB, S_{11} is -8 dB. The third and final method to measure an antenna's ability to accept power is VSWR (voltage standing wave ratio). VSWR evaluates the ratio of the peak amplitude of the voltage of the wave on the transmission line versus the minimum amplitude of the voltage of the wave. A VSWR of 1 is ideal; this indicates that there is no reflected power at the antenna port. When the antenna and transmission line are not perfectly matched, reflections at the antenna port travel back towards the source and cause a standing wave to form. The worse the mismatch, the larger the amplitude of these reflections. [4] A VSWR < 2 is acceptable for an antenna. So, values of S11 = -10 dB are considered as the margin for resonant peaks - TABLE I. Values of S11 ≤ -10 dB are considered as dips in this study.

TABLE I:

Return Loss, S11, VSWR and Reflection Loss [5]

Return Loss (dB)	S_{11}	VSWR	Reflection Loss (dB)
3.0	-3.0	5.85	3
6.0	-6.0	3.0	1.26
7.0	-7.0	2.6	0.97
8.0	-8.0	2.3	0.75
9.0	-9.0	2.1	0.58
10.0	-10.0	1.9	0.46
11.0	-11.0	1.8	0.36
12.0	-12.0	1.7	0.28
13.0	-13.0	1.6	0.22
14.0	-14.0	1.5	0.18
15.0	-15.0	1.4	0.14
16.0	-16.0	1.4	0.11
17.0	-17.0	1.3	0.09
18.0	-18.0	1.3	0.07
19.0	-19.0	1.3	0.06
20.0	-20.0	1.2	0.04

4. Simulation result

Simulation result of 10 x 10 mm patch:

- Freq: 7.6762 GHz; S11: -13.2335 dB – Resonant Peak

Simulation result of 10 x 20 mm patch:

- Freq: 7.3166 GHz; S11: -08.3908 dB – Dip
- Freq: 7.9252 GHz; S11: -20.9171 dB – Resonant Peak

Simulation result of 10 x 30 mm patch:

- Freq: 5.5276 GHz; S11: -17.1487 dB – Resonant Peak
- Freq: 7.1690 GHz; S11: -06.9580 dB – Dip
- Freq: 9.3268 GHz; S11: -19.2582 dB – Resonant Peak

Simulation result of 10 x 40 mm patch:

- Freq: 4.2551 GHz; S11: -05.5089 dB – Dip
- Freq: 7.1045 GHz; S11: -04.1451 dB – Dip
- Freq: 8.2202 GHz; S11: -09.2352 dB – Dip
- Freq: 8.4629 GHz; S11: -26.2666 dB – Resonant Peak

Simulation result of 10 x 50 mm patch:

- Freq: 3.4528 GHz; S11: -02.9941 dB – Dip
- Freq: 6.6803 GHz; S11: -17.1321 dB – Resonant Peak
- Freq: 7.0123 GHz; S11: -04.3638 dB – Dip
- Freq: 8.0082 GHz; S11: -11.6859 dB – Resonant Peak
- Freq: 9.9907 GHz; S11: -13.3507 dB – Resonant Peak

Simulation result of 10 x 60 mm patch:

- Freq: 2.9180 GHz; S11: -01.9317 dB – Dip
- Freq: 5.6198 GHz; S11: -10.5338 dB – Resonant Peak
- Freq: 7.0123 GHz; S11: -02.8889 dB – Dip
- Freq: 7.7131 GHz; S11: -07.0749 dB – Dip
- Freq: 8.3032 GHz; S11: -14.7301 dB – Resonant Peak
- Freq: 9.2254 GHz; S11: -28.8576 dB – Resonant Peak

Simulation result of 10 x 70 mm patch:

- Freq: 2.2079; S11: -01.1221 – Dip
- Freq: 4.2827; S11: -04.3279 – Dip
- Freq: 6.3207; S11: -17.4540 – Resonant Peak
- Freq: 6.9661; S11: -02.9146 – Dip
- Freq: 7.3903; S11: -05.0589 – Dip
- Freq: 8.3586; S11: -22.8527 – Resonant Peak
- Freq: 9.6772; S11: -22.4015 – Resonant Peak

Simulation result of 10 x 80 mm patch:

- Freq: 2.2079; S11: -01.1220 – Dip
- Freq: 4.2827; S11: -04.3275 – Dip
- Freq: 6.3207; S11: -17.4527 – Resonant Peak
- Freq: 7.3903; S11: -05.0587 – Dip
- Freq: 8.3586; S11: -22.8762 – Resonant Peak
- Freq: 9.6772; S11: -22.4205 – Resonant Peak

Simulation result of 10 x 90 mm patch:

- Freq: 1.9590; S11: -00.9197 – Dip
- Freq: 3.8217; S11: -03.1475 – Dip
- Freq: 5.6475; S11: -16.2659 – Resonant Peak
- Freq: 7.2336; S11: -03.4879 – Dip
- Freq: 7.4733; S11: -18.8093 – Resonant Peak
- Freq: 8.0358; S11: -07.4001 – Dip
- Freq: 9.2438; S11: -22.5915 – Resonant Peak

Simulation result of 10 x 100 mm patch:

- Freq: 1.7838; S11: -00.8129 – Dip
- Freq: 3.4528; S11: -02.6165 – Dip
- Freq: 5.1127; S11: -11.6211 – Resonant Peak
- Freq: 6.7541; S11: -11.7924 – Resonant Peak
- Freq: 7.2151; S11: -04.2486 – Dip
- Freq: 7.8514; S11: -05.6010 – Dip
- Freq: 8.3770; S11: -11.8501 – Resonant Peak
- Freq: 8.7920; S11: -13.6565 – Resonant Peak
- Freq: 9.9815; S11: -14.6177 – Resonant Peak

5. Conclusion

It has been observed from the above study that the number of Resonant Peaks as well as Dips increases in regular proportion with the increase in patch width, which is the point of focus. A proper knowledge of Peaks and Dips are extremely important while designing a multiband patch antenna. We have to opt for chosing an optimum patch width to fulfill our desired requirements since patch width is an obvious issue for mini radiating systems.

6. References

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