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OPTIMIZATION OF GAIN OF MICROSTRIP PATCH ANTENNA

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ABSTRACT

An antenna plays a primary role in transmission and reception of electromagnetic waves. There are different types of antennas such as Wire Antennas, Aperture Antennas; Micros tip Antennas, Array Antennas, Reflector Antennas and Lens Antennas. The physical size of electronics systems is reduced due to advancements in integrated circuits. With reduction in size of electronics systems, there is also an increasing demand of small and low cost antennas. A Microstrip antenna in this area plays a significant role as it is becoming increasingly useful because they can be printed directly into a circuit board. They are becoming very widespread within the mobile phone market.

In this project, the dimension of a rectangular micro strip patch antenna of a given frequency (5.88 G Hz) is established with the help of mathematical analysis and is designed and simulated with the help of IE3D software. This patch antenna is also optimized at that frequency with the help of IE3D software and also being simulated. In this analysis a comprising study is developed for both the cases.

KEYWORDS: Microstrip Patch antenna, Gain Optimization, EM Optimization, Single element Patch antenna, Rectangular Patch antenna.

1. INTRODUCTION

In high performance spacecraft, aircraft and satellite applications where weight, size, ease of installation, cost, and performance highly required and low-profile antennas would be required. Presently there are many other applications like mobile radio and wireless communications that have similar specifications. To meet these requirements, micro strip patch antennas can be used [1].These antennas are low profile, conform able to non-planar surfaces and planar surfaces, simple and affordable to design using modern printed-circuit technology, mechanically shouldered when mounted on rigid surfaces, compatible with MMIC designs, and when the particular patch shape and mode are selected, they are very various in terms of resonant frequency, radiation pattern. There has been an ever growing demand, in both the military as well as the commercial sectors, for antenna design that features the following highly desirable evaluate: i) Tiny Size ii) Low profile iii) Conformal iv) Broadband or multiband.

2. OVERVIEW OF EM OPTIMIZATION TECHNIQUE

Assume we want to optimize this antenna to a perfect match at 1.88 GHz. We would like to study what we can do for it. EM optimization is one of the most important features of IE3D. It can help designers to achieve their goal with much less effort. Some goal may even be impossible by manual tuning.

For the antenna we are discussing, we can adjust the length L to change the resonant frequency. We can adjust the inset depth D to tune the matching. Also, both variables are not independent or changing L may change the matching and changing D may change the resonance. If they are independent, we can optimize one dimension at a time and it may make an optimization much easier.

Our goals are: Re[S(1,1)] = 0 and Im[S(1,1)] = 0 at 1.88 GHz.

We show two groups of vertices in Figure 1: Vertex Group 1 includes vertices 7, 8, 9 and 10. Vertex Group 2 includes vertices 3, 4, 11 and 12.

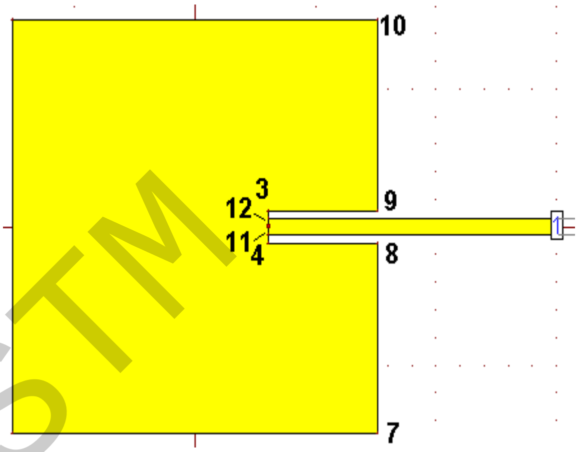

Figure 1: The patch and its vertices to be defined as optimization variables.

To change the patch length L, we can change the X-coordinate of Vertex Group 1. To change the inset depth D, we can change the X-coordinate of Vertex Group 2. Can we define the X-offset values of the two groups as optimization variables? Certainly, we can do it. However, it is not the best.

The reason is related to the bounds of the optimization variables. We know the difference in the X-coordinate between Vertex Group 1 and Vertex Group 2 is D = 452 mils. If we define the X-offset of Group 1 as the first variable V1, and the

X-offset of Group 2 as the second variable V2, we need to make sure the high bound of V2 can not be too big and the low bound of V1 can not be too small. Otherwise, we may cause the vertex 3 to go to the right hand side of vertex 8. For this particular structure, such a situation may not create an invalid geometry. However, there is quite a chance we may create invalid geometry when the bounds of optimization variables are not defined properly. As you will see later, we are defining the variables and their bounds one by one. We may not know the bounds or ranges of previous variables when we are defining a specific variable. For this particular structure, we would like to define the X-offset of the two groups as V1. Then, we define the extra X-offset of Group 2 as the V2. In this way, when we define the high bound of V2, we just need to make sure V3 will not go to the right hand side of V8 visually.

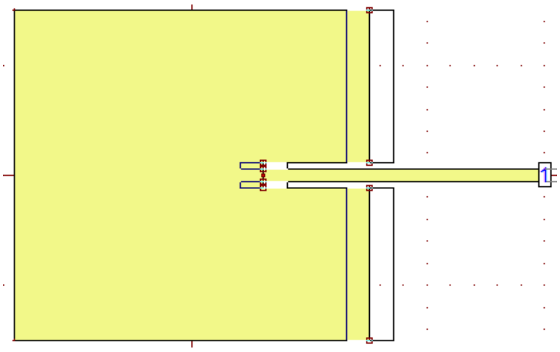

Figure 2: the trends and bounds of the No.1 variable

RESULTS

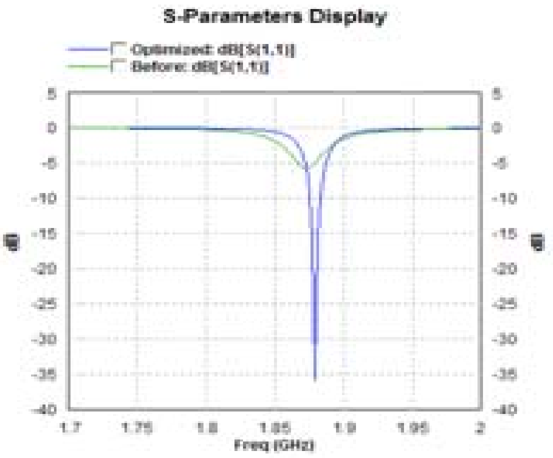

Figure 3: Comparison in S-parameters between original and optimized structures.

According to Figure 3, S11 Parameter for the design before the Optimization, VSWR cannot be measure because of the line of dB inclined above the desired parameter i.e. -10dB. So the designed antenna cannot be resonated in the desired frequency range.

While, S11 Parameter for the design after the optimization, VSWR is likely to -35.5 dB and optimized antenna will resonate on the 1.87 GHz frequency.

3. THE BASIC GEOMETRY OF SINGLE ELEMENT PATCH ANTENNA

The resonant frequency selected for our design is 5.88 GHz. The dielectric constant εr =2.2 and height of the dielectric substance h=0.795. The substance with high dielectric constant has been selected since it reduces the dimension of the patch. The width (W) of the Microstrip patch by using the essential parameters for the design is 20.167, debth (D) is 2.56 mm and length (L) is 16.778 mm.

3.1 UNOPTIMIZED RECTANGULAR PATCH ANTENNA

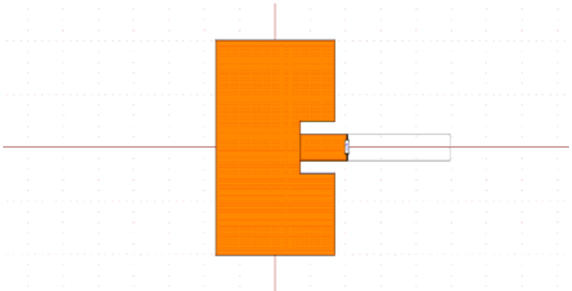

Figure 4: Single element un-optimized patch

3.2 SIMULATION RESULTS OF UN-OPTIMIZED PATCH ANTENNA

The software used to model and simulate the Microstrip patch is Zeland Inc's IE3D electromagnetic simulator. It has been widely used in the design of patch antenna. It can be used to calculate and plot the S- parameter, current distribution as well as the radiation pattern of any geometrical shaped Microstrip patch antenna.

3.3 RETURN LOSS OF THE UN-OPTIMIZED PATCH ANTENNA

The return loss (RL) and radiation characteristics are the vital study of patch antenna design.

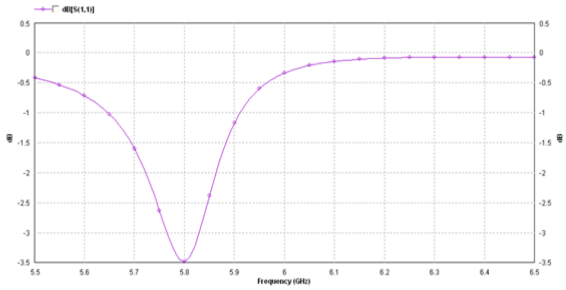

Figure 5: Return loss vs frequency graph

3.4 3D RADIATION PATTERN OF UNOPTIMIZED PATCH ANTENNA

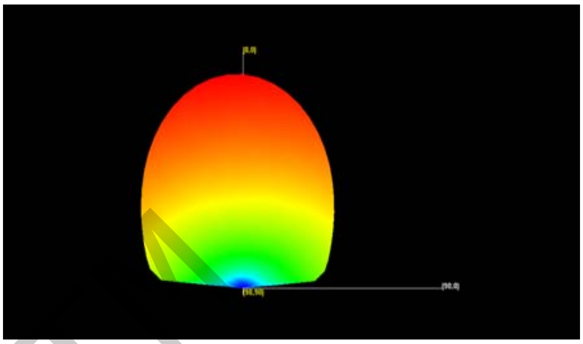

Figure 5: 3D radiation pattern of un-optimized single patch

3.5 2D RADIATION PATTERN OF UN-OPTIMIZED PATCH ANTENNA

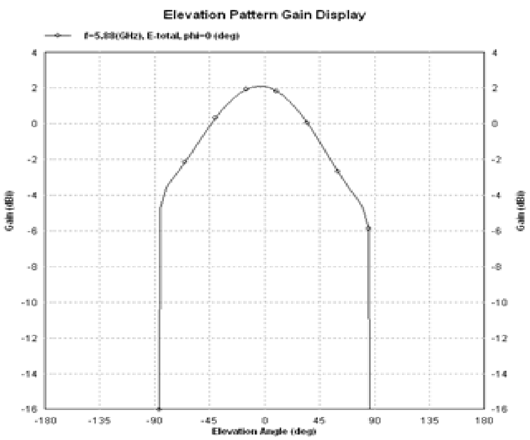

Figure 6: Gain Vs elevation angle graph

4. THE BASIC GEOMETRY OF OPTIMIZED PATCH ANTENNA

To meet the designed operating frequency of 5.88 GHz. The optimization method have been used to get the actual width, debth and length of the patch and the modified L of 16.884 mm, D of 2.45 and W of 20.i67 mm has been taken.

OPTIMIZED PATCH

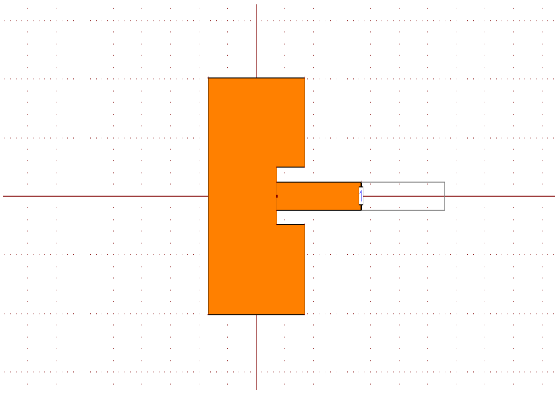

Figure 7: single element optimized patch

4.1 SIMULATION RESULTS OF OPTIMIZED PATCH ANTENNA

The software used to model and simulate the Microstrip patch is Zeland Inc's IE3D electromagnetic simulator. It has been widely used in the design of patch antenna. It has been also used to optimize (geometrical tuning). It can be used to calculate and plot the S-parameter, current distribution as well as the radiation pattern of any geometrical shaped Microstrip patch antenna.

4.2 RETURN LOSS OF THE OPTIMIZED PATCH ANTENNA

The return loss (RL) and radiation characteristics are the vital study of patch antenna design.

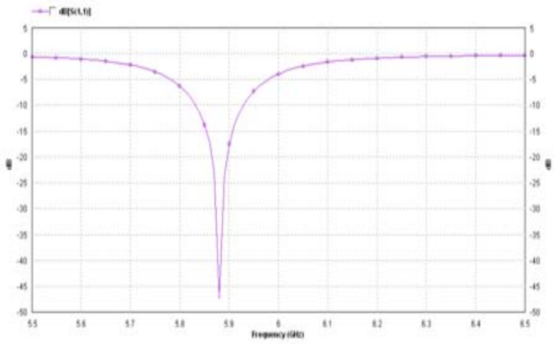

Figure 8: return loss Vs frequency graph

4.3 3D RADIATION PATTERN OF OPTIMIZED PATCH ANTENNA

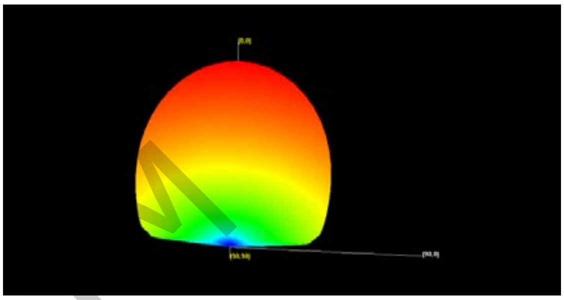

Figure 9: 3D radiation pattern of optimized single patch

4.4 2D RADIATION PATTERN OF OPTIMIZED PATCH ANTENNA

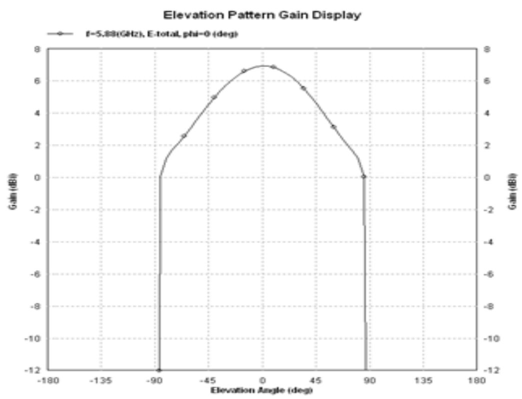

Figure 10: Gain Vs elevation angle graph

5. COMPARISON OF RESULTS BETWEEN UN-OPTIMIZED & OPTIMIZED SINGLE PATCH ANTENNA

5.1 CHANGE IN DIMENSION OF THE PATCH ANTENNA

For the antenna we can adjust the length L to change the resonant frequency and debth D to tune the matching. So by the help of IE3D software, we optimize the patch to get more accurate result and also a slight change in dimension occurs due to this automatic tuning.

Patch dimension	Un-optimized patch	Optimized patch
Length(L)	16.778 mm	16.884 mm
Width(W)	20.167 mm	20.167 mm
Debth(D)	2.56 mm	2.45 mm

5.2 CHANGE IN FREQUENCY OF THE PATCH ANTENNA

By the un-optimized patch we do not get the desired frequency 5.88 GHz but by optimization process we get the exact frequency 5.88 GHz

Frequency	Unoptimized patch	Optimized patch
Minimum S-parameter occur at frequency	5.8 GHz	5.883 Hz

5.3 MINIMUM S-PARAMETER OR RETURN LOSS AT 5.88 GHZ

By the optimization process a perfect match is obtained between 50 ohm transmission line and the patch, so minimum return loss is observed for optimized patch.

S-Parameter	Unoptimized patch	Optimized patch
Minimum return loss	-3.5db	-48 db

5.4 COMPARISON OF GAIN AT FREQUENCY 5.88 GHZ

Due to perfect matching & perfect dimension at desired frequency, a better gain is obtained in optimization process

Gain	Un-optimized patch	Optimized patch
Gain at frequency 5.88 GHz	2 db	6.96 db

6. DISCUSSION

Now a days Microstrip patch antenna is widely used in communication system. The investigations on un-optimized & optimized single patch Microstip antenna at frequency 5.88 GHz are reported. The optimized patch antenna shows good return loss & good radiation efficiency over un-optimized patch. The minimum return loss for the single element un-optimized patch is-3.5 dBi and that of optimized patch is -48dBi. Also the peak gain for the single element un-optimized patch is 2 dBi and that of optimized patch is 6.96 dBi.

7. CONCLUSION

A single element un-optimized patch antenna and a single element optimized patch antenna have been demonstrated. The most significant issue is the requirement of optimization on single element patch antenna. Actually optimization required to maintain good system performance and reduce the loss .Both the antennas has been simulated by IE3D software which is based upon method of moment. The agreement of the results and formation of radiation lobe has been obtained.

8. FUTURE SCOPE

The future scope of this research paper is very prosperous. The paper clears the pathway for experimenting Microstrip antennas. We want to work further by taking optimized power divider to get better return loss result and by which we can increase the gain above 12 dbi. The gain can be increase by taking 4 by 4 models or 8 by 8 models. We also want to work in the field of phased array antenna as well as linear array antenna by introducing phase difference by changing the path length of 50 ohms line.

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