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Miniature Microstrip Antenna with and without a Superstrate at THz Frequency

Anurag Anupam
Department of Electronics and Communication Engineering
Jabalpur Engineering College, Jabalpur, India
anuraganup@gmail.com

Sunil Kumar Singh
Department of Electronics and Communication Engineering
Jabalpur Engineering College, Jabalpur, India
sspjec2007@gmail.com

ABSTRACT

This paper presents comparative study of a rectangular Microstrip patch antenna at Terahertz (THz) frequency ranging from 0.6 to 1 THz with and without superstrate. The results reported here were obtained using Ansoft HFSS 11.0 which uses full wave finite element method for simulation. In this study the miniature antenna was simulated first and then we load it with a superstrate and varied the height of the superstrate to optimize the antenna performance. Here in this paper we have selected 4 antenna configurations to compare. First antenna is a simple rectangular patch, second antenna is having a superstrate of height 50 microns, Third antenna is with a superstrate of 75 micron height and the fourth antenna is with a superstrate of 100 micron. Best performance of antenna i.e., -10dB bandwidth of around 19% was achieved at central frequency of 0.5 THz and 75 micron superstrate height.

Keywords

Patch antenna, Rectangular patch, superstrate, THz electromagnetic spectrum, Microstrip line.

1. INTRODUCTION

An explosive growth of the wireless radio communication systems is currently observed in the microwave band. In the short range communications or contactless identification systems, antennas are key components, which must be small, low profile, and with minimal processing costs. The Microstrip patch antennas are of great interest for aforementioned applications due to their compact structure. The flexibility afforded by microstrip antenna technology has led to a wide variety of design and techniques. The main limitations of the microstrip antennas are low efficiency and narrow impedance bandwidth[1]. The bandwidth & gain of the microstrip antenna can be increased using various techniques such as loading patch with slots or by using EBG structures or through superstrate[2]. Here we have studied the effect of superstrate of different heights. In order to enhance the bandwidth of MSA, the numbers of techniques have been proposed.

The available literatures, reveal that the environmental effects (such as snow, raindrops, etc.) deteriorate the performance of antenna; particularly resonance frequency/bandwidth wherever they are used for long duration. This is the reason, superstrate (cover) dielectric layers are often used to protect microstrip antenna from external hazards, or naturally formed (e.g. ice layers) during flight or severe weather conditions. Whether a cover layer is naturally formed or imposed by design, it may affect adversely the antenna performance characteristics, such as gain, directivity, radiation and efficiency[3]. In this paper, a theoretical investigation of the effect of dielectric superstrate on return loss and bandwidth of rectangular microstrip patch antenna is presented. This paper is organized as follows. In section 2 we have presented the design of antenna with four configurations. That is with no superstrate and with superstrate of height 50, 75 and 100 micron. Section 3 have discussed simulated results and in section 4 we have concluded our work.

2. SIMULATION MODELS OF PROPOSED ANTENNA CONFIGURATIONS

The proposed Microstrip patch antenna consists of a rectangular patch and varying height of superstrate of high dielectric permittivity. We have considered four antenna configurations with the same basic design consideration. Each antenna is having same shape and dimensions. The dimension of ground plane and substrate is 1000µm ×1000µm with substrate having thickness of 200µm. The substrate material is RT/Duriod 6006 (ε_r =6.15 & tan δ= 0.0019)[4]. Dimension of rectangular patch is 600µm ×400µm. In all three configurations. Height of

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superstrate has been denoted by h_1,h_2 ,h_3,h_4 and that of substrate is denoted by `H` . To optimize our antenna we have considered the parameter "h/H" i.e. Antenna height factor (AHF) . During our course of study we have varied the Antenna height factor (AHF) starting from the value 0 up to 0.5 and considered four conditions at which we got better results. we have used a common feeding technique that is Microstrip line feed. Dimension of the feed line is 40µm × 300µm.In table 1 all dimensions are summarized.

Table 1.

	Length	Width	Height
Patch	600µm	400 µm	
Substrate	1000 µm	1000 µm	H=200 µm
Superstrate	1000 µm	1000 µm	h_1= 0 µm
	1000 µm	1000 µm	h_2=50 µm
	1000 µm	1000 µm	h_3 = 75 µm
	1000 µm	1000 µm	h_4 = 100 µm

In aforesaid four configurations we have introduced and varied the height of the superstrate and observe the positive change in the performance of the antenna. We have varied the height of superstrate extensively and selected four conditions in which we noticed some improvement in antenna performance. Further we have discussed each configuration one Starting from Zero height superstrate to 100 µm superstrate and equate their results to conclude with the best one. During our discussion we have seen the effect of superstrate on the antenna return loss and percentage bandwidth.

2.1 WITHOUT SUPERSTRATE

Here the first configuration is presented with zero height of superstrate that means without superstrate. Here we have resonant frequency of 0.7 THz and our proposed antenna responds with 10 dB bandwidth of around 8.2% and with return loss of -13dB. In this configuration Antenna height factor i.e.

$$AHF = h/H = 0$$

Dimensions of Superstrate, substrate and patch are discussed in table 1 above. Layout of configuration 1 is shown in figure1.

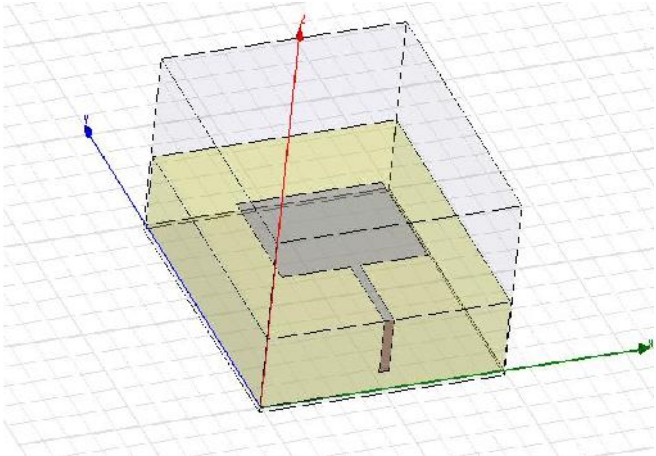

Figure 1

and its rectangular plot is shown in figure 2.which shows its bandwidth ,return loss and 10 db bandwidth.

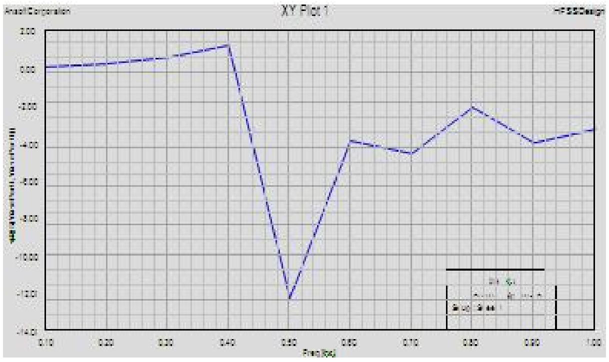

Figure 2

2.2 WITH SUPERSTRATE OF 50 µm HEIGHT

In 2nd configuration we have introduced a superstrate just over the patch with height of 50µm and with surface area same as substrate This configuration leads us to a better result with respect to return loss with all the conditions keeping same we found -10 dB percent bandwidth of around 8 % and return loss of -14.8 dB . Here we see improvement in return loss of antenna with introduction of superstrate of 50 µm. In this configuration Antenna height factor i.e.

$$AHF = h/H = 0.25$$

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HFSS layout of this Antenna configuration is shown in figure3 and rectangular plot is shown in figure 4.

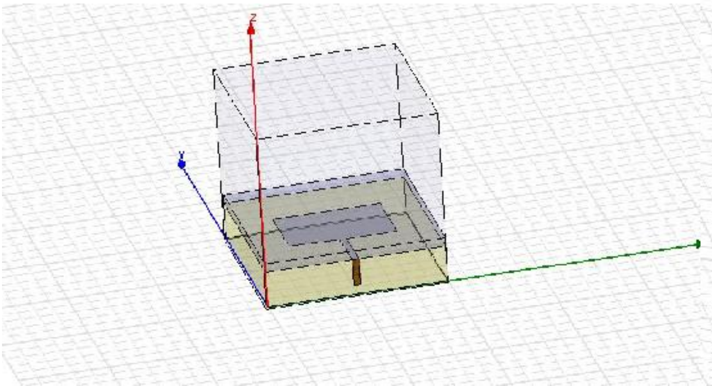

Figure 3

Rectangular plot is shown further

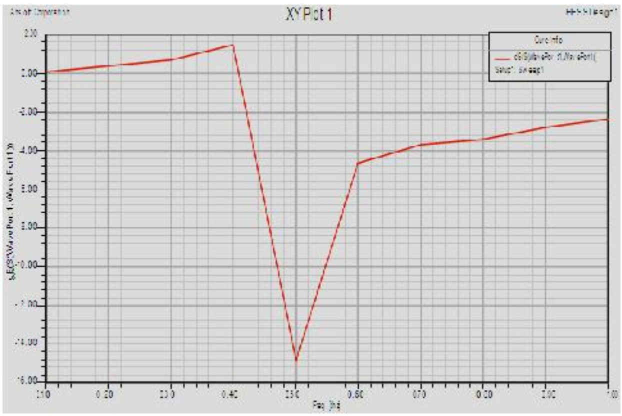

Figure 4

2.3 WITH SUPERSTRATE OF 75 µm HEIGHT

In this configuration we have increased the superstrate height over the patch up to 75µm and of dimension same as substrate dimension. This configuration leads us to a better result with all the conditions keeping same we found -10 dB percent bandwidth of around 19% and return loss of -23.5 dB . Here we see improvement in performance of antenna with introduction of superstrate of 75 µm. In this configuration Antenna height factor i.e.

AHF = h/H = 0..375

HFSS layout of this Antenna configuration is shown in figure 5 and rectangular plot is shown in figure 6.

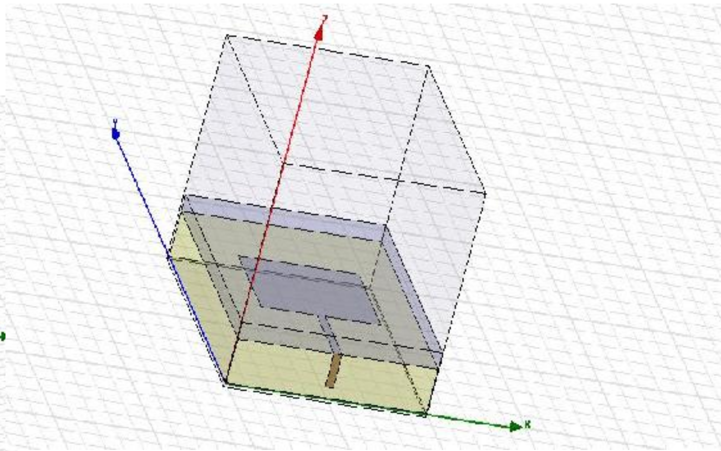

Figure 5

Rectangular plot of this antenna will inform us about return loss and bandwidth.

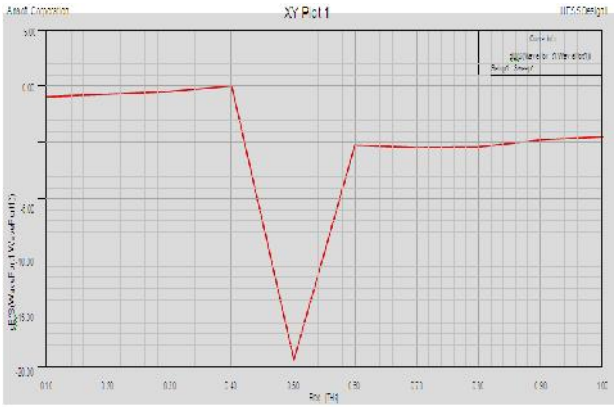

Figure 6

2.4 WITH SUPERSTRATE OF 100 µm HEIGHT

In 4th configuration we varied the height of superstrate and considered the superstrate height of 100 µm this configuration however have performance better than the first and is having values as follows.10dB percent bandwidth is around 12% and its return loss is -13dB.In this configuration Antenna height factor i.e.

AHF = h/H = 0.5

Further in figure 7 HFSS layout of 3rd configuration is shown and its rectangular plot is shown in figure 8.

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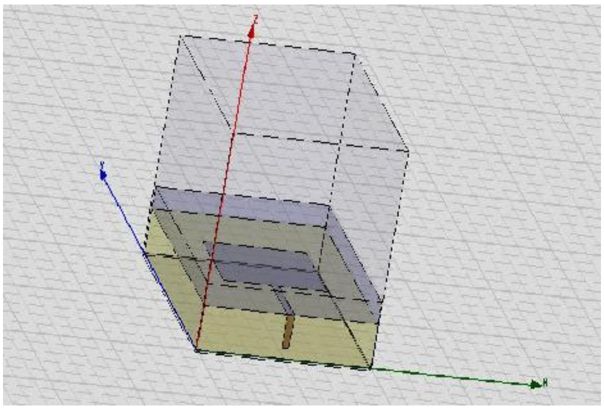

Figure 7

Rectangular plot of Antenna configuration 3 is as follows

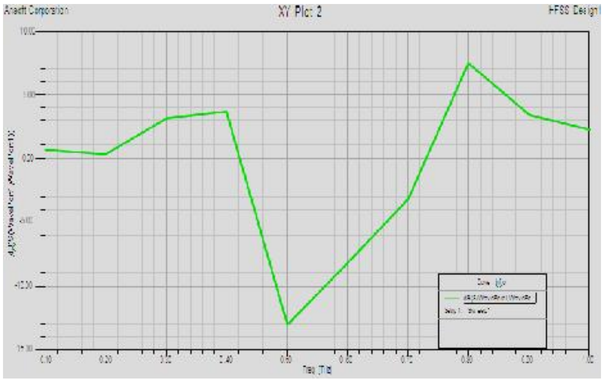

Figure 8

3. RESULTS AND DISCUSSION

Above we have seen and discussed four antenna configurations relative to substrate height. Rectangular plots are showing their performance and we notice considerable improvement in their performance. We have calculated our results using following basic formulae.

Antenna Height Factor (AHF) = h/H ………………. (iii)

Antenna configuration 1 ($h_1/H = 0$) has -10 dB percent bandwidth of around 8.2% and with return loss of -13dB.
Antenna configuration 2 ($h_1/H = 0.25$) has -10 dB percent bandwidth of around 8 % and return loss of -14.8 dB.
Antenna configuration 3 ($h_1/H = 0.375$) has -10dB percent bandwidth of around 19% and its return loss is -23.5dB. Antenna configuration 4 ($h_1/H = 0.375$) has -10dB percent bandwidth of around 12% and its return loss is -13dB.

To get a clearer view of the results we have created a superimposed rectangular plot which is self explanatory itself. Plot is shown in figure 9.

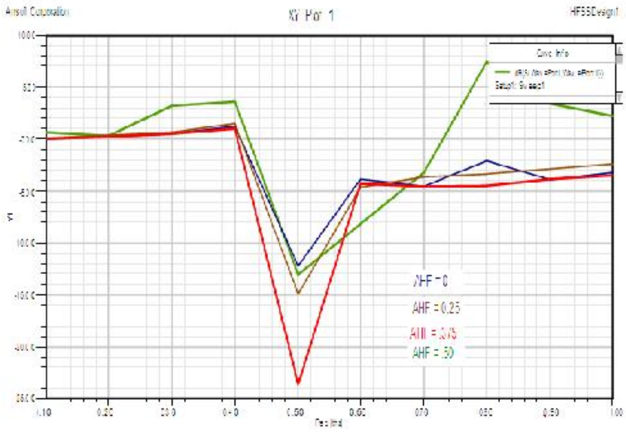

Figure 9

4. CONCLUSION

In the above discussion we have discussed about miniature antenna of Thz frequency range and considered the effect of superstrate on the performance of antenna as we know superstrate minimizes adverse effects of environment on the patch and add-ons in its performance. Out of all configurations of varying height of superstrate we pointed out four configurations with AHF value 0, 0.25, 0.375, and 0.5 i.e., with no superstrate, 50µm high superstrate, 75µm superstrate and 100µm high superstrate and concluded that antenna with 75µm high superstrate and having AHF value 0.375 gives the best result. This antenna is best suited for high data rate system and short distance wireless communication system.

5. REFERENCES

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