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Analysis of triangular microstrip patch antenna for different substrate materials

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Abstract
Microstrip patch antenna has gained prominence because of the versatile features and expanding areas of wireless application. In this paper, a compact triangular patch configuration is designed to operate in 2.5GHz frequency range. The antenna is designed and analyzed using FEM basedHigh frequency Structure Simulator (HFSS) software. The analysis of the antenna and the simulation is performed with twodifferent substrates of Taconic TLC and Roger RT 5880 Duroidof different thickness to find the optimal performance. Based on the outcome of the analysis, an optimal antenna configuration is proposed with maximum gain.

Keywords—*microstrip, HFSS, Gain, Radiation pattern, patch*

1. INTRODUCTION

In high performance aircraft, spacecraft, satellite and missile applications, where size, weight, cost, performance, ease of installation and aerodynamic profile are constraints, low profile antennas may be required.These antennas are low profile, conformable to planar and non planar surfaces, simple and inexpensive to manufacture using modern printed circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs, and when the particular patch shape and mode are selected they are very versatile in terms of resonant frequency, polarization, pattern and impedance[1].

Microstrip antennas are often referred to as patch antennas. The radiating elements and the feed lines are photoetched on the dielectric substrate. The radiating patch may be square, rectangular, circular, elliptical, and triangular or any other configuration.The microstrip antennas are used in a wide range of applications from communication systems to satellite and biomedical applications. In this paper, a triangular configuration is considered .This is due to theirsmall size compared with other shapes like the rectangular and circular patch antennas [2].Compared to other patch geometries, the triangular microstripis physically smaller having radiation properties similar to the rectangular patch but has a lower radiation loss [3].The triangular microstrip antennas is a suitable choice for radiating elements because of the relatively wider bandwidth compared to other resonant conventional microstrip [4]. Methods to feed microstrip antenna are microstrip line, coaxial probe, aperture coupling and proximity coupling [5], [6].

2. ANTENNA DESIGN

The triangular patch antenna is designed by considering the height of the substrate as 70mm and width of the substrate as 50 mm.The substrate is made of Taconic TLC of dielectric constant 3.2.The triangular patch antenna is fed by a microstrip line feed of width 1 mm and height 31.25 mm.Micro strip line feed is used for this design of triangular patch antenna. The designed triangular patch antenna is shown in fig1.

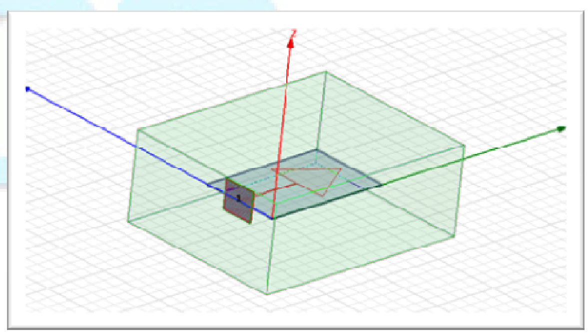

Fig.1.Triangular microstrip antenna

3. EFFECT OF SUBSTRATE THICKNESS

The substrate thickness of the antenna is varied for two thickness of 1.6 mm and 2.4 mm of Taconic TLC and Roger RT 5880 Duroid to analyse the performance parameters such as return loss, VSWR and gain. The simulation is performed using FEM based HFSS software. The results obtained are as shown in Table-1.

Substrate Material	Thickness (mm)	Relative Permittivity	Resonant Frequency	Return Loss	Gain
Taconic TLC	1.6	3.2	2.5 GHz	-12.8 dB	6.1 dB
Taconic TLC	2.4	3.2	2.5 GHz	-10.8 dB	6.6 dB
Roger RT 5880 Duroid	1.6	2.2	2.8 GHz	-10.8 dB	5.28 dB
Roger RT 5880 Duroid	2.4	2.2	2.8 GHz	-10 dB	6.17 dB

Table-1: Effect of Substrate thickness on performance parameters of triangular microstrip antenna

4. SIMULATED RESULTS

The triangular microstrip patch antenna is designed and simulated using HFSS and the results for return lossand radiation pattern are plotted for two substrate materials Taconic TLC and Roger RT 5880 Duroid of thickness 1.6mm and 2.4 mm.

4.1 RETURN LOSS

Return loss is defined as the ratio of reflected power to incident power. The plot of return loss versus frequency for Taconic TLC and Roger RT 5880 Duroid is as shown below.

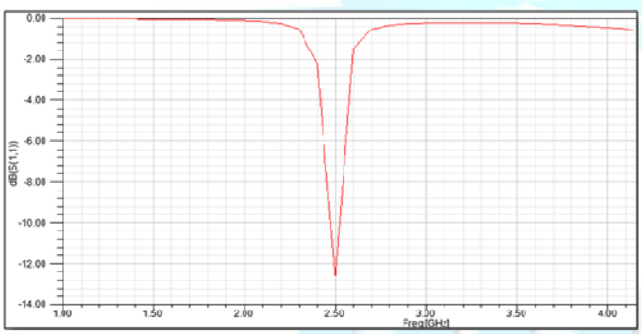

Fig.2.Plot Return loss for triangular microstrip patch antenna with Taconic TLC substrate of thickness1.6mm

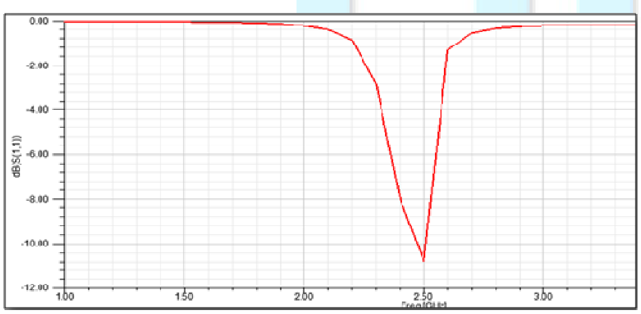

Fig.3.Plot Return loss for triangular microstrip patch antenna with Taconic TLC substrate of thickness 2.4mm

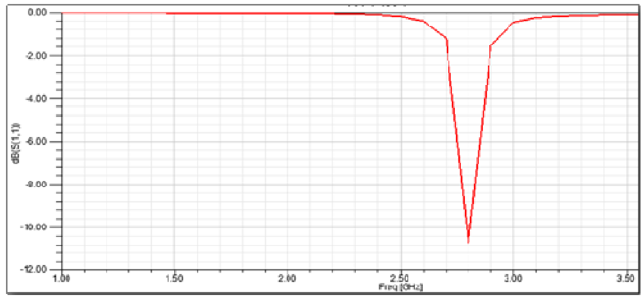

Fig.4.Plot Return loss for triangular microstrip patch antenna with Roger RT 5880 Duroid substrate of thickness 1.6mm

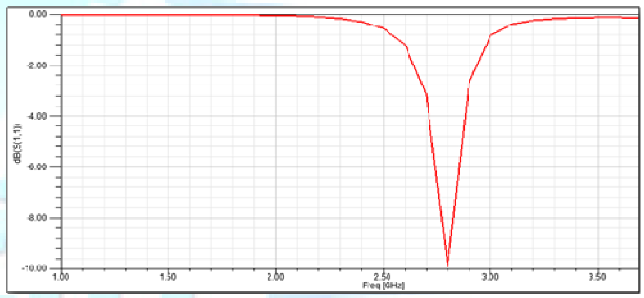

Fig.5.Plot Return loss for triangular microstrip patch antenna with Roger RT 5880 Duroid substrate of thickness 2.4mm

4.2RADIATION PATTERN

The radiation pattern is a graphical representation of the spatial distribution of the radiation from the antenna as a function of angle. The 3D polar plot of the designed triangular microstrip patch antenna for Taconic TLC and Roger RT 5880 Duroid is as shown below.

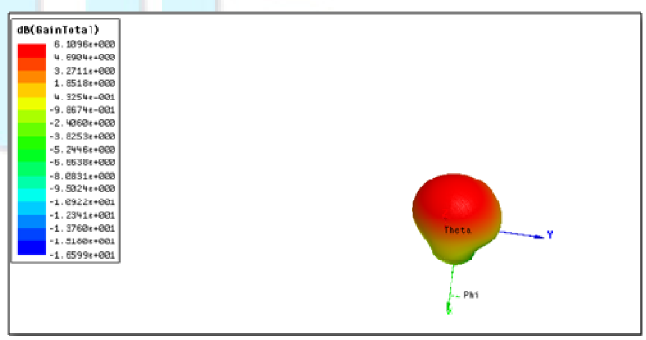

Fig.6.Three dimensional radiation pattern of triangular microstrippatchantennawith Taconic TLC substrate of thickness1.6mm

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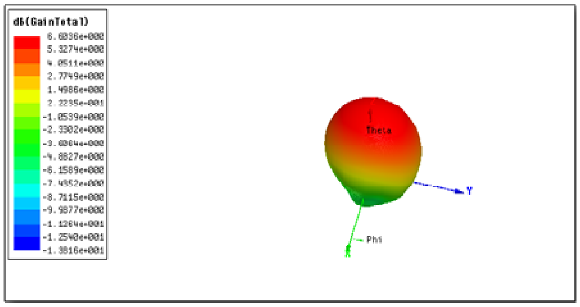

Fig.7.Three dimensional radiation pattern of triangular microstrip patch antenna with Taconic TLC substrate of thickness 2.4mm

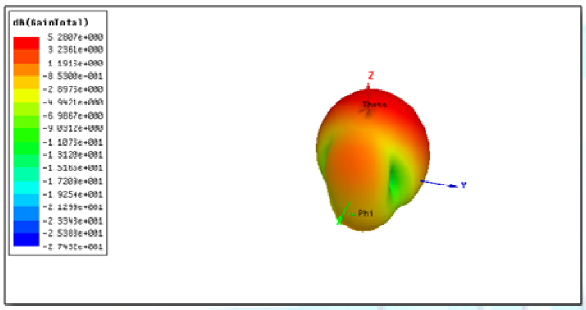

Fig.8.Three dimensional radiation pattern of triangular microstrip patch antenna with Roger RT 5880 Duroid substrate of thickness 1.6mm

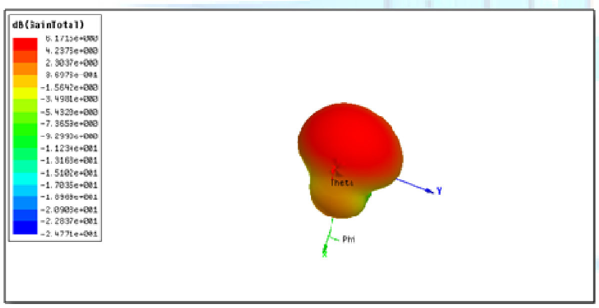

Fig.9.Three dimensional radiation pattern of triangular microstrip patch antenna with Roger RT 5880 Duroid substrate of thickness 2.4mm

4.3 RADIATION EFFICIENCY

The radiation efficiency of an antenna is defined as the ratio of total power radiated by an antenna to the net power accepted by the antenna.The radiation efficiency for Taconic TLC and Roger RT 5880 duroid with thickness 1.6 mm and 2.4 mm were 78.96%, 88.21%, 77.47% and 87%.

4.4 DIRECTIVITY

The directivity of an antenna is the maximum value of it's directive gain. The directivity is found to be 7.12 dB, 7.14dB, 6.38 dB and 6.69 dB for Taconic TLC and Roger RT 5880 duroid with thickness 1.6 mm and 2.4 mm.

5. RESULTS AND DISCUSSION

5.1 RETURN LOSS

For a practical antenna, the return loss should be less than -10 dB. The simulated results shows that the return loss for Taconic TLC and Roger RT 5880 Duroid substrate with thickness 1.6mm and 2.4mm were -12.8 dB, -10.8 dB, -10.8 dB and -10 dB respectively.

5.2 VOLTAGE STANDING WAVE RATIO (VSWR)

For the antenna to radiate, VSWR should be less than 2. The simulated results shows that the VSWR obtained for Taconic TLC and Roger RT 5880 Duroid substrate with thickness 1.6mm and 2.4mm were less than 2.

5.3 GAIN

From the 3D polar plot, the gain obtained for Taconic TLC and Roger RT 5880 Duroid substrate with thickness 1.6mm and 2.4mm were 6.1 dB, 6.6 dB, 5.28 dB and 6.17 dB. From the simulated results, the maximum gain is found to be 6.6 dB for Taconic TLC substrate with thickness 2.4mm.

5.4 BAND WIDTH

The band width percentage for Taconic TLC and Roger RT 5880 Duroid substrate with thickness 1.6mm and 2.4mm were 19.6, 24, 14.28 and 21.4. From the simulated results, the maximum band width is found to be 24% for Taconic TLC substrate with thickness 2.4mm.

5.5 RADIATION EFFICIENCY

The simulated results shows that the radiation efficiency for Taconic TLC is found to be better compared to the other three efficiencies with 88.21%.

5.6 DIRECTIVITY

The directivity of triangular microstrip antenna with Taconic TLC substrate of thickness 2.4 mm is 7.14 dB which is quite large.

6. CONCLUSION

A triangular microstrip patch antenna is designed for two different substrate materials with various thickness and simulated using FEM based HFSS software. The simulation is performed by varying the thickness of the substrate to analyse the performance. The band width is found to be increasing with the increase in substrate thickness. From the analysis, it is concluded that triangular microstrip patch antenna with Taconic TLC substrate of thickness 2.4mm has the maximum gain of 6.6 dB and Band width of 24%.

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