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Performance Analysis of Microstrip Triangle Patch Antenna Using FR-4 Substrate

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Abstract: ***The microstrip patch antennas are used in various applications for the high performance in the wireless communication system. The simple method is designed and analysis of triangular shape microstrip antenna by varying FR-4 substrate with CST (Computer Simulation Technology) to obtain various results. We have taken the rectangular substrate FR-4 of dimension 7×7 mm. The antenna operates between 5 GHz to 25GHz range. The design of an antenna is described and simulated results for the main parameters like return loss, directivity, and radiation patterns are discussed. These antennas are useful for the applications like UMTS, ISM.***

Keywords: Microstrip patch antenna, Triangular, Equilateral triangle, FR-4 Substrate

1. Introduction

In the western canon, the significance of the Triangle date back to the Platonist's geometrical theories in which triangle is posited as the primary plane surface. The triangle was also significant to the Mayans, whose hieroglyph for the Sun- ray was triangle; in ancient India, [1] triangles was bought together nadir to apex from the "Bindu" or seed of manifestation. Triangle seems to everywhere. It has simple shape with three points and three lines[2]. In early civilizations the triangle has been the symbol of trilogy (or "triad") and has rich and complex history.

The triangle is a polygon with three edges and and three vertices. In geometry, the triangle is one of the basic shapes to construct.

1.1 Ultra Wide Band (UWB)

Ultra-wideband which is UWB, ultra-wide band and ultraband) is a radio technology pioneered by Robert A. Scholtz and others that can use a very low energy level for short-range, high-bandwidth communications over a large portion of the radio spectrum.UWB transmits in a manner that does not interfere with conventional narrowband and carrier wave transmission in the same frequency band. Ultra-wideband is a technology for transmitting information spread over a large bandwidth (>500 MHz).[1].

The main concept behind UWB radio systems is that they transmit pulses of very short duration, as opposed to traditional communication schemes, which send sinusoidal waves[3]. The role that UWB antennas play in all of this is that they have to be able to transmit these pulses as accurately and efficiently as possible.

1.2 Comparison Study of Triangular Microstrip Patch Antenna with Rectangular Microstrip Patch Antenna

a) Microstrip antenna: Microstrip antenna consists of a patch of very thin metallic strip. Microstrip antennas are used in very wide range applications with their advantageous features like low profile, light weight, easy fabrication and low cost. The disadvantages of microstrip antenna is low gain and narrow bandwidth.[1]

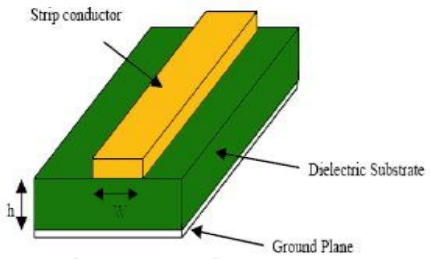

Figure 1.2(a): Microstrip line

In figure 1.2(a) the model represents the microstrip antenna by two slots of width W and height h, separated by the transmission line of length L[4]. themicrostrip is essentially a non homogeneous line of two dielectrics, typically the substrate and air.

1.3 Analysis of Rectangular Microstrip Patch Antenna:

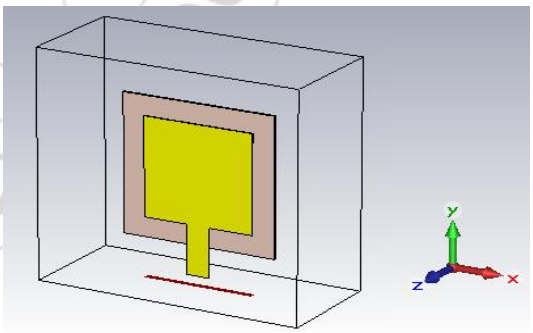

Figure 1.3(1): a schematic representation of rectangular patch antenna

Figure 2 provides the simple schematic view of rectangular patch antenna with length and width (L, W) of 7mm[5]. The length of the transmission line feed is 10mm and width is 5mm. the simulation is done in the frequency domain analysis with operating frequency 5 GHz to 25GHz.

S- parameter:

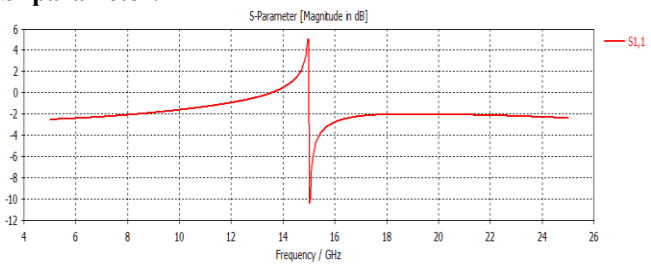

Figure 1.3(2): return loss

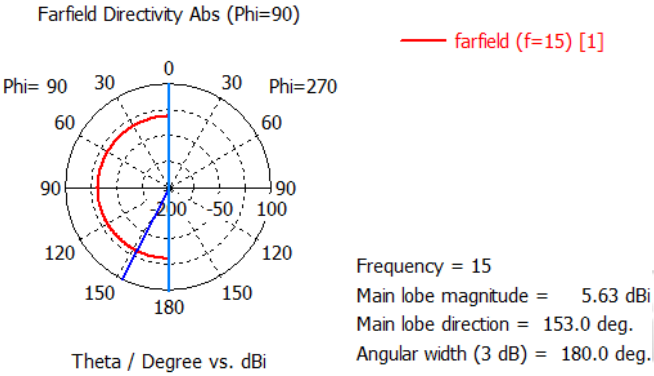

Figure 1.3(3): radiation pattern abs polar plot

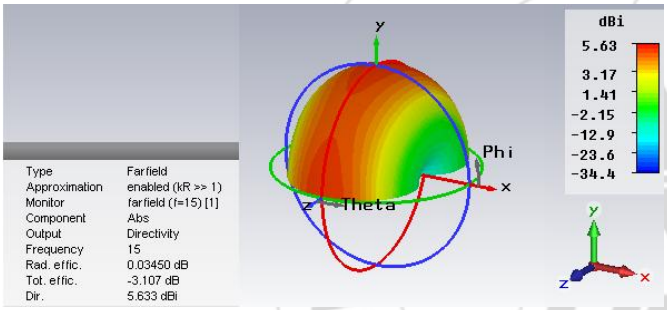

Figure 1.3(4): 3D radiation pattern of abs polar plot

Figure1.3(1) represents the return loss at frequency 15 GHz.Figure1.3(2)and 1.3(3) presents the radiation pattern with directivity 5.633dBi. and has total efficiency -3.107dB.

1.4 Analysis of Triangular Microstrip Patch Antenna

Triangle patches has been studied both theoretically and experimental[4]. They provide radiation characteristics similar to those of rectangular patches, with smaller sizes[5]. The antenna size can be further reduced by loading it with a short and/or slot. The simplest triangular shape considered to be equilateral triangle with grounded dielectric substrate[7]. Based in the model, the patch conductor normally consists of copper or silver material. The design presented in this paper is a equilateral triangle patch antenna.

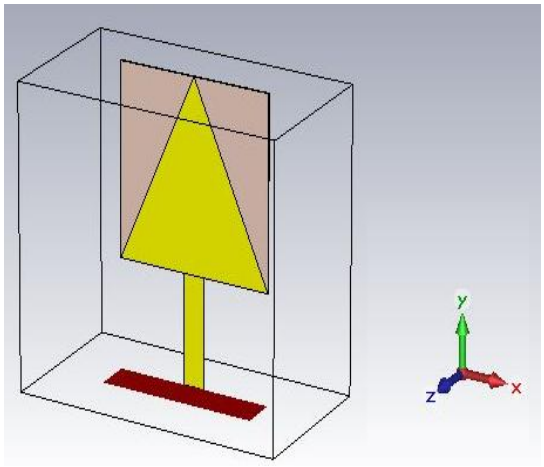

Figure 1.4(1): schematic representation of triangular patch antenna

Figure1.4(1) represents the schematic representation of triangular patch antenna with length and width of 7mm and The length of the transmission line feed is 15mm and width is 7mm[6]. The simulation is done in the frequency domain analysis with operating frequency 5 GHz to 25GHz.

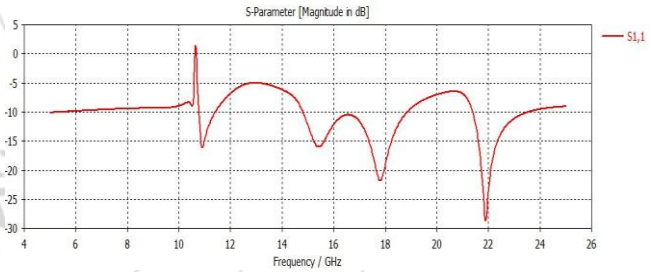

Figure 1.4(2): return loss

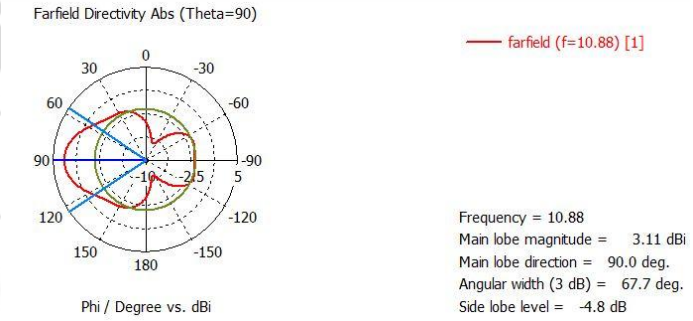

Figure 1.4(3): Radiation pattern abs polar plot

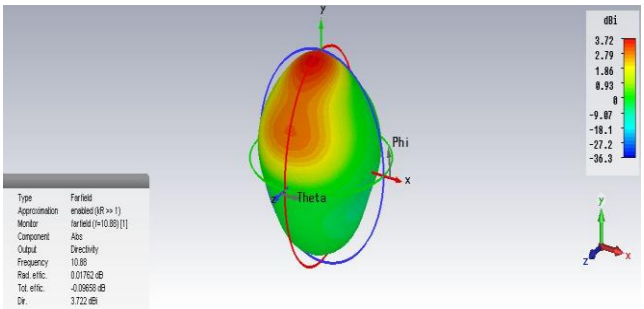

Figure 1.4(4): 3D radiation pattern

Figure 1.4(2) represents the return loss at four different frequencies i.e. (10.8, 15.4, 17.8, 21.8 GHz) which are used as ultra wide band for different applications. Figure 1.4(3) represents the absolute polar plot with frequency 10.88, it has angular width 67.7 degree.

Figure 1.4(4) shows the 3D radiation pattern of absolute plot which has directivity 3.77dBi. the total efficiency -0.09658dB.

Table 1: Comparative Analysis of Rectangular and Triangular Microstrip Patch Antenna

S.No	Antenna type	Return loss(In dB)	Angular width (In degree)	Directivity (In dB)	VSWR
1	Rectangular antenna	-10.2	180.0	5.633	15
2	Traingular antenna	-15.2	67.7	3.722	10.85

2. Antenna Design

The proposed antenna structure is shown in the figure 2.1. The antenna is simulated using the computer simulation technology (CST) software with FR-4 substrate and.designed in FDTD Simulation software in time domain analysis.The thickness of substrate is taken as 0.1mm. The height of patch is taken as 0mm.with copper material. The operating frequency of an antenna is operated from 5 GHz to 25 GHz.

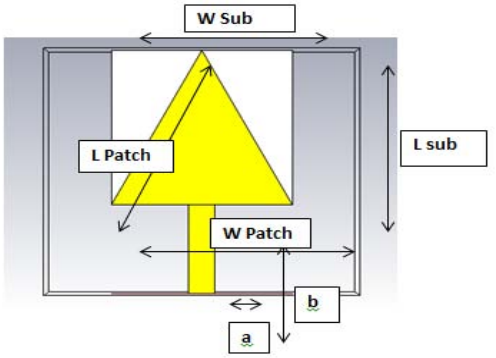

Figure 2.1: Design of Microstrip Triangular Patch Antenna

Table 2: Parameters Proposed for Antenna

Symbol	Size (mm)
L sub	7
W patch	7
L patch	7
a	1
b	15×7
r 1	1
r 2	1

3. Results

The resonant properties of proposed antenna have been predicted and optimized during using frequency domain analysis. Figure 3.1 shows the result of return loss of proposed microstrip triangular patch antenna. There are two resonant frequencies at 17.8 GHz and at 21.9 GHz. the s parameter shows two bands, whose values are -21.581 dB and -29.191dB.

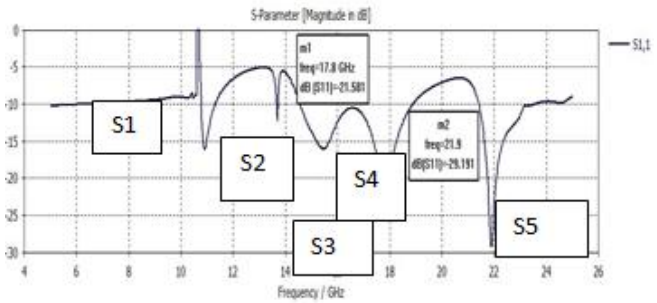

Figure 3.1(1): S Parameter (Return Loss)

Bandwidth: Bandwidth is the difference between the upper and lower frequencies in a continuous set of frequency and measured in hertz. Bandwidth can be described on the basis of axial ratio bandwidth, impedance or vswr bandwidth. The impedance bandwidth defines the range of frequencies over which the input impedance of antenna is perfectly matched to characteristic impedance of the feeding transmission line. Bandwidth can be define as:

$$BW = \frac{f_h - f_l}{f_c}$$

Where f_h and f_l are the lower and upper frequencies and f_c is the centre frequency.

Table 3: Comparative Analysis of Bandwidth at Different Frequencies

S.No.	S[11}	BW(KHz)	f_0	Q= f_0/BW
1	S1	0.078	10.907	139.833
2	S2	0.035	13.096	374.17
3	S3	0.369	15.45	41.869
4	S4	0.1875	17.805	94.96
5	S5	0.1275	21.897	177.303

Table 3 shows the comparative study of the bandwidth with 5 different frequencies which is used as a ultra wide frequency. The ultra wide band frequencies are used in many applications like communication like (wireless audio, data and video distribution and RF tagging), radar and precision geolocation.

VSWR: VSWR (the voltage standing wave ratio) is basically an alternative representation of Return Loss. VSWR is a reference to the actual voltages that are created within transmission line system when there are forward and reflected radio waves propagating simultaneously.

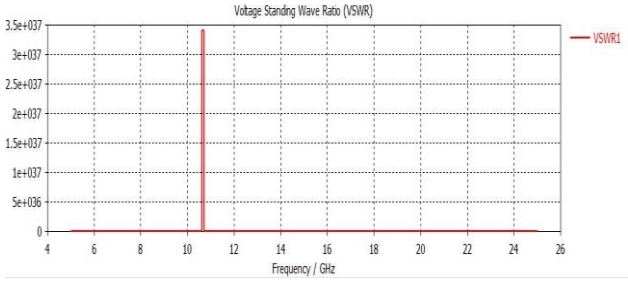

Figure 1.3(2): VSWR

Figure1.3(2) shows the VSWR curve which has frequency 10 GHz to 24 GHz simulated at frequency 10.72 GHz which shows the good impedance matching between the antenna and transmission line.

Farfield: Farfield calculation deals with the field behaviour which is far away from the corresponding source of the electromagnetic waves.

At frequency 17.8
Abs(polar):

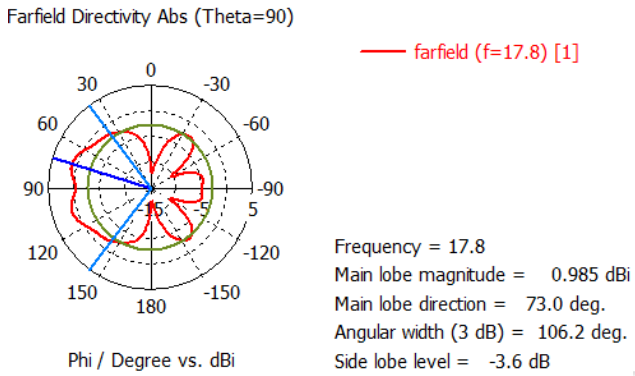

Figure 1.3(3): Farfield Absolute plot at frequency 17.8

Figure 1.3(3) shows the radiation pattern, theta(Θ) which has been set to 0 for all values phi(φ). The power is directed towards 90 degree with the main lobe magnitude of 0.985 dBi. 3 dB angular beam width is 106.2 degree. The power is radiated mostly in left hemisphere.

3D Plot:

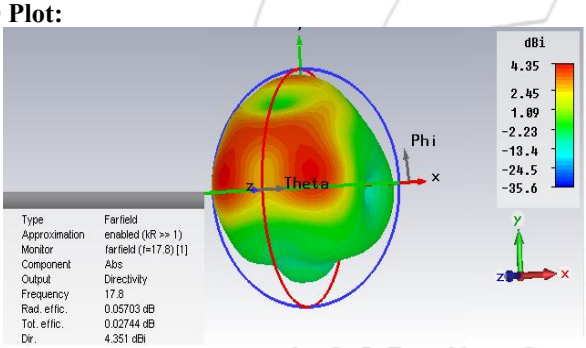

Figure 1.3(4): 3D Radiation pattern

Figure 1.3(4) shows the 3D radiation pattern which has directivity 4.351dBi over free space. The total efficiency of the antenna measured is 0.02744 dB.

At frequency 21.8

Abs (polar):

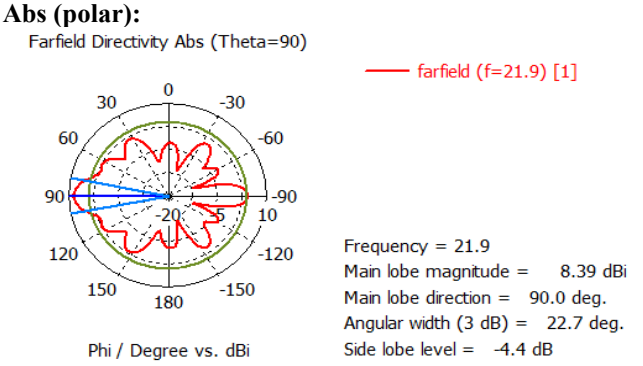

Figure 1.3(5): Farfield Absolute plot at frequency 21.8

Figure 1.3(5) shows the radiation pattern, theta(Θ) which has been set to 0 for all values phi(φ). The power is directed towards 90 and-90 degree with the main lobe magnitude of 90.0 dBi. 3 dB angular beam width is 22.7 degree. The power is radiated in both right and left hemisphere.

3D Plot:

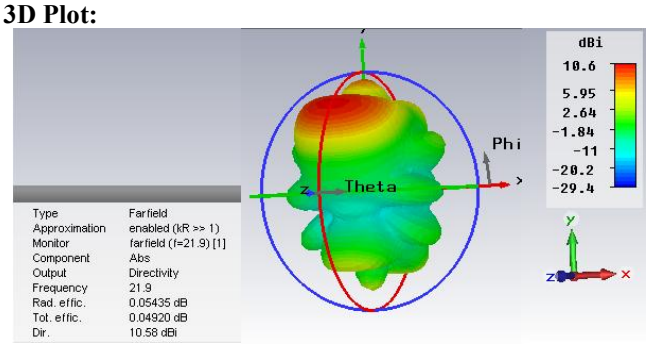

Figure 1.3(6): 3D Radiation Pattern

Figure1.3(6) shows the 3D radiation pattern which has directivity 10.58dBi over free space. The total efficiency of the antenna measured is 0.04920 dB.

4. Conclusion

A microstrip antenna is designed and compared with two types of antenna rectangular and triangular microstrip antenna with various parameters like return loss, directivity and bandwidth. The bandwidth of triangular antenna has five different frequencies which is used as ultra wide band antenna are used in various applications like radar communications which works on various bands. Some bands like X, Ku and Ka works on frequency like 8, 12, 18GHz which is almost equals to ultra wide frequency is working with simulated results in figure 1.2(2) and geolocation. A simple triangle antenna is presented. This technique is used with FR-4 Substrate along with triangular patch antenna to obtain the various results. Simplicity of design process, consistent radiation and other parameter make this antenna simple and very attractive for designing triangular microstrip patch.

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