RESEARCH ARTICLE

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Simulation of T shape MSPA for UWB Application

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Abstract

Using the CADFEKO tool, a T-shaped Microstrip patch antenna (MSPA) with an epoxy substrate was designed and simulated to achieve the best possible result. MSPA is frequently utilized because of its numerous benefits, including its light weight, low volume, and low manufacturing cost. The antenna's bandwidth, gain, return loss, VSWR, and radiation pattern were assessed. Maximum impedance is attained at 6.85 GHz, antenna gain is 8dB, directivity is 4.5, and return loss is -10.80dB at 5.725 GHz and 12.48dB at 10.6 GHz for the T-shape rectangular Microstrip patch antenna for ultra-wideband applications. 50Ω is used to power the T-shaped Microstrip antenna. The simulated results of the proposed antenna are good radiation patterns. The return loss is less than -10 dB and VSWR is less than 2 throughout the UWB band. At 3.1 to 10.6 GHz resonant frequencies, the S11are -10.80dB,-12.48dB, and antenna efficiency is 100 % due to all losses being zero.

Keywords: CADFEKO, Gain, Directivity, Impedance, Microstrip antenna, Return loss, T-Shaped, Ultra-wideband (UWB), VSWR.

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Introduction

"Deschamps" was the first to invent the Microstrip Antenna (MSA). The idea brings from printed circuit technology not only for the circuit active and passive components and transmission lines but also for the radiating elements of an electronic system. The MSAs are one of the most common forms of printed antennas, and they play an important role in wireless communication systems.

The antennas are broadly classified as wire-, printed-, reflector-, lens-, aperture-, and array-antenna. The MSA is very simple in fabrication using a conventional microstrip fabrication technique. The Figure 1 shows the radiating patch on one side of a dielectric substrate (FR4) and the others is a ground plane (Cu).

A thick dielectric substrate with a low dielectric constant (<6) is desirable for enhanced antenna performance. We needed more efficiency, larger bandwidth, and better radiation. As a result of this arrangement, the antenna is larger. A substrate with a higher dielectric constant (<12), which results in lesser efficiency and narrower bandwidth, is required to construct a compacted microstrip patch antenna. As a result, a compromise between antenna size and antenna performance must be found.

The electromagnetic energy source is guided to the patch by excitation, which generates negative charges at the feed point and positive charges on the other side of the patch. The difference in charges causes electric fields in the antenna, responsible for the patch antenna's radiations. In the field of wireless communication, Satellite communication, for example, necessitates circularly polarised radiation patterns, which can be produced using either a square or circular patch microstrip antenna. Circularly polarised microstrip antennae are employed in global positioning satellite (GPS) systems. Because of their location, they are quite small and pricey. The suggested antenna has a T form and is suited for ultra-wideband frequencies. The proposed antenna is created with a microstrip feed, and CADFEKO is used to simulate it. Figure 2 depicts a standard patch antenna.

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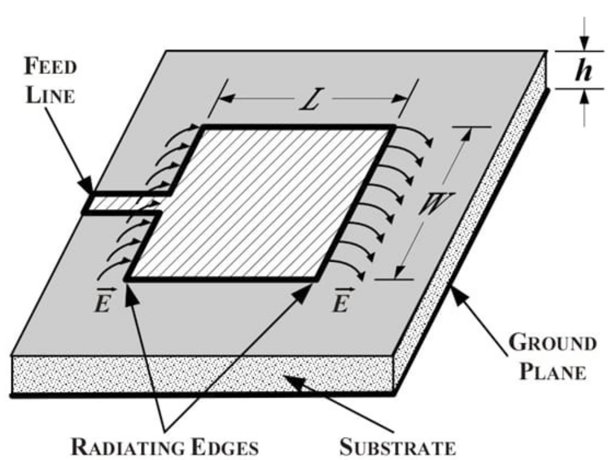

Figure1: Structure of Rectangular Microstrip Patch Antenna

Literature Survey

Table I represents the literature survey of existing works. Each paper having its drawback with less return loss, and more space occupancy with feed. To avoid this, we are going to design an antenna using Microstrip feed

Design Methodology

The Calculation of MSPA

Step 1: The Width (W) is calculated as follows:

$$W = \frac{c}{2\,fo\sqrt{(\text{€}r+1)/2}} \quad (1)$$

Step 2: The Effective Dielectric Constant is calculated. This is estimated based on the patch antenna's height, dielectric, and calculated width.

$$\text{€eff} = \frac{\text{€}r+1}{2} + \frac{\text{€}r-1}{2}\left[1+12\frac{h}{w}\right]^{-1/2} \quad (2)$$

Step 3: Calculation of the Effective length

$$Leff = \frac{c}{2fo\sqrt{\text{€eff}}} \quad (3)$$

Step 4: The length extension ΔL is calculated.

$$\Delta L = 0.412h\,\frac{(\text{€eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\text{€eff}-0.258)\left(\frac{W}{h}+0.8\right)} \quad (4)$$

Step 5: Calculation of the patch's real length

$$L = L_{\text{eff}} - 2\Delta L \quad (5)$$

Where

f_0 is the Resonance Frequency
W is the Width of the Patch
L is the Length of the Patch
h is the thickness
ε_r is the dielectric substrate's relative permittivity.
C= 3 x 10^8 meters/second is the speed of light.

The TABLE II represents substrate parameters, electrical parameters and physical parameters. The substrate parameters are a) di-electric constant b) di-electric height c) frequency. The electrical parameters are Zo, Electric Length. The physical Parameters are width. The table consists of fabrication details of T shape antenna

Figure 2A represents the geometry of proposed MSPA by using microstrip feed-in CADFEKO. The Figure 2b represents T type antenna with Mesh.

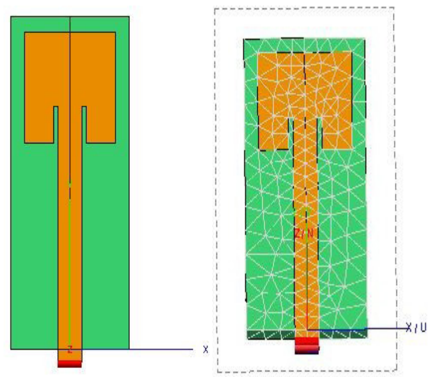

Figure 2: (a) Geometry of proposed micro strip patch antenna (b) T Antenna with Mesh

Table I: Shows the literature survey

S.No	*Author*	*Substrate*	*Advantages*
I	Rashmi Gyawali.et al [10]	€r =4.4, h=1.6mm diminished size of 30mm×25mm	Omni directional high gain, low return loss, all through the WLAN band
II	Satya Kumar. V.et al [11]	€r =4.4, h=1.6mm microstrip feed line	S11 < - 10dB stableunidirectional radiation models
III	J. Jasika Fa.et al [23]	€r =46.6 Ϭ=0.064	for a biomedical skin which has its (εr) =46.6 & (σ) =0.64.
IV	Mohamed Tarbouch.et.al [24]	CPWfed T-shaped printed	S= - 10 db. Satisfactory radiation
V	John Colaco.et al [30]	€r =2.2	Return loss -33.4 VSWR < 2, high percentage increase of 10 dB

TABLE II: Illustration of the plan system

Different Parameters of Antenna			
S.NO	*PARAMETER*	*PARTICULARS*	*RANGE*
I	SUBSTRATE PARAMETERS	a) DI-ELECTRIC CONSTANT	3.4
		b) DI-ELECTRIC HEIGHT	1.6mm
		C)FREQUENCY	Resonant frequency (Fr) is 5.8 GHz, Minimum Frequency (Fmin) is 3.1 GHz, Maximum Frequency (Fmax) is 10.6 GHz
II	ELECTRICAL PARAMETERS	a) Zo	50
		b) ELECTRIC LENGTH	10mm
III	PHYSICAL PARAMETERS	WIDTH (W)	3.69 mm

Antenna Parameters

Directivity

Directivity is an important antenna characteristic. It measures the 'directionality' of an antenna's radiation pattern. An antenna that radiates equally in all directions has zero directionality, and its directivity is one (or 0 dB).

It is the ratio of maximum power density P(θ,φ)max to its average value over a range as observed in the far-field of an antenna. The directivity D is most important parameters of an antenna.

$D = P(\theta,\varphi)_{max} / P(\theta,\varphi)_{av}$. Directivity from Pattern (6)

$D = 4\pi / \Omega_A$. Directivity from beam area (Ω_A). (7)

Axial Ratio or Pivotal Proportion

The Pivotal Proportion or Axial Ratio of a receiving wire is characterized as the proportion between the major and minor hub of a circularly captivated radio wire design. If a radio wire has amazing roundabout polarization, this proportion would be 1 (0 dB). Thusly, it is consistently bigger than 1 (>0 dB) in an oval.

Gain

By adding energy converted from the power source to the signal, the antenna gain is used to measure a two-port circuit that extends the facility or amplitude of a signal from the input to the output port. The logarithmic decibel (dB) units are frequently used to express it ("dB gain").

Radiation Pattern

When it comes to antennas, the

- a. Field pattern is a representation of the amplitude of an electric or magnetic field as a function of annular space (in linear scale).
- b. Power pattern depicts a visualization of the magnitude square of the magnetic or electric field as a function of space (in linear scale).
- C.Power pattern (in dB) that describes the magnitude of the magnetic field as a function of annular space

Resonant Frequencies

The frequency should be recorded at the greatest point gain in decibels. The antenna looks to be purely resistive at its highest position; the resistance is a combination of the loss resistance and the radiation resistance

Return Loss

The percentage of a signal's power reflected by a transmission line or optical fiber gap is known as the Return Loss. This gap could be caused by a mismatch between the line's characteristic impedance and the end or load attached to it. In dB, P_{in} (incident Power) to P_{ref} (reference Power)

Voltage Standing Wave Ratio

It is the ratio to measure how professionally radio-frequency power is transmitted from one power source to another, through a transmission line, into output, i.e., load. If 100%energy is transmitted means that system is the ideal one.

Axial Ratio (AR)

It is the major and minor axis ratio of a circularly polarized antenna pattern. If an antenna has a faultless circular polarization, this ratio would be 1 (0 dB). When the antenna has an elliptical polarization means AR ratio has greater than 1 (>0 dB).

This ratio tells us the nonconformity of an antenna from the ideal case of circular polarization over a specified pointed range.

Simulation Results

Return loss

The percentage of a signal's power reflected by a transmission line or optical fiber gap is known as the Return Loss. This gap could be caused by a mismatch between the line's characteristic impedance and the end or load attached to it. In dB, P_{in} (incident Power) to P_{ref} (reference Power). The Figure 3 represents Return loss of T patch Antenna S11=-19dB for the frequency of 5.685 GHz

Figure (4a) shows a far-field (Phi=0 deg) with frequencies ranging from 3.1 GHz to 10.6 GHz. Figure (4b) shows the absolute increase in the far-field (Theta=90 deg) for various frequencies ranging from 3.1 to 10.6 GHz. Figure (4c) shows far field complete addition (Phi=9 deg) at several frequencies ranging from 3.1 to 10.6 GHz. Figure 5 shows the smith graph. The Smith outline, imagined by Phillip H. Smith (1905–1987) and autonomously by Mizuhashi Tosaku, is a graphical adding machine or nomogram intended for electrical and hardware engineers to spend significant time in radio frequency (RF) designing to help with taking care of issues with transmission lines and coordinating with circuits. Let Z = R + jx be the impedance at some area Z=967.953-J147.173 for F =4.1GHz

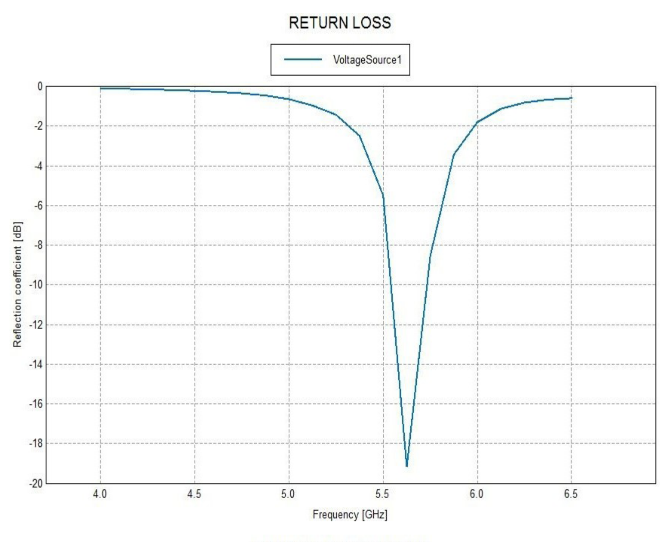

Figure 3: Return loss of T patch Antenna S11=-19dB

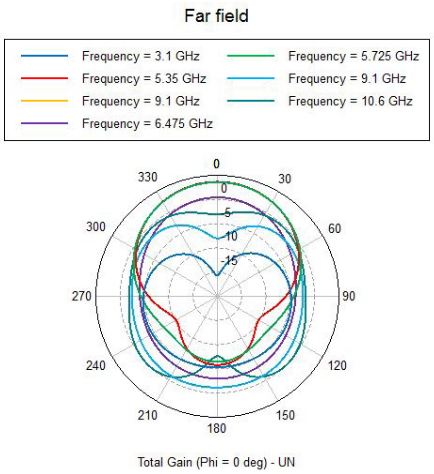

Figure 4(a): Far field Phi=0 degree

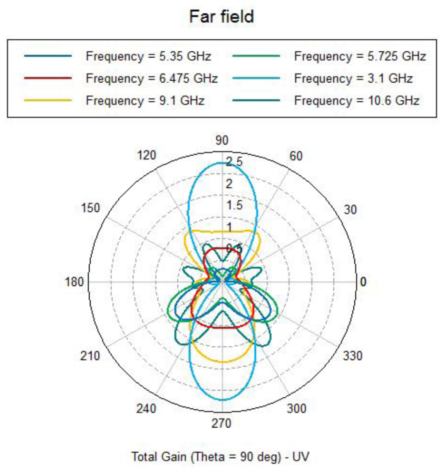

Figure 4(b): Theta=90 degree

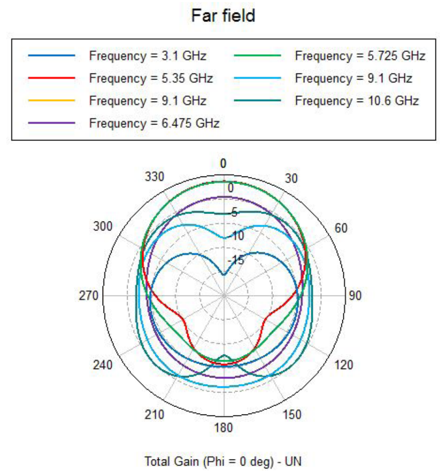

Figure 4(c): Phi= 90 degree

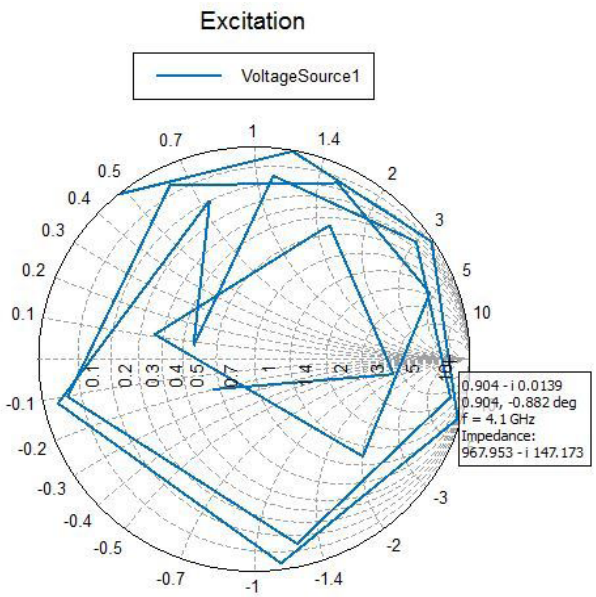

Figure 5: Smith Chart

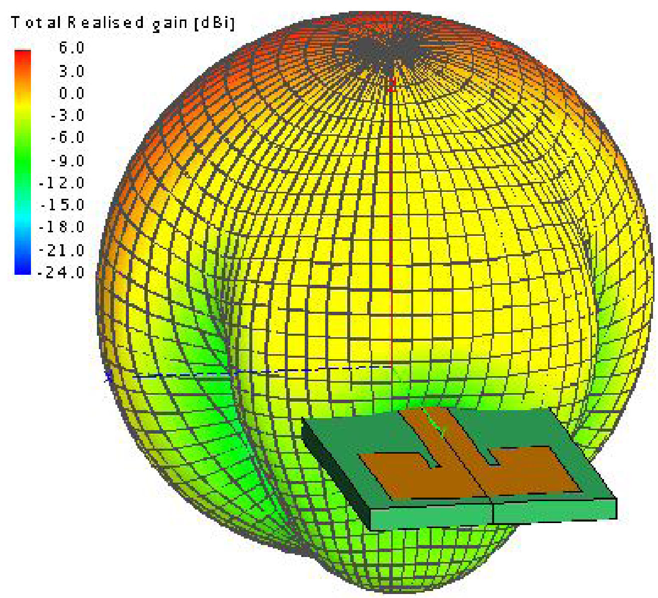

Figure 7: Plot of 3D radiation pattern of Total Realized Gain with different frequencies

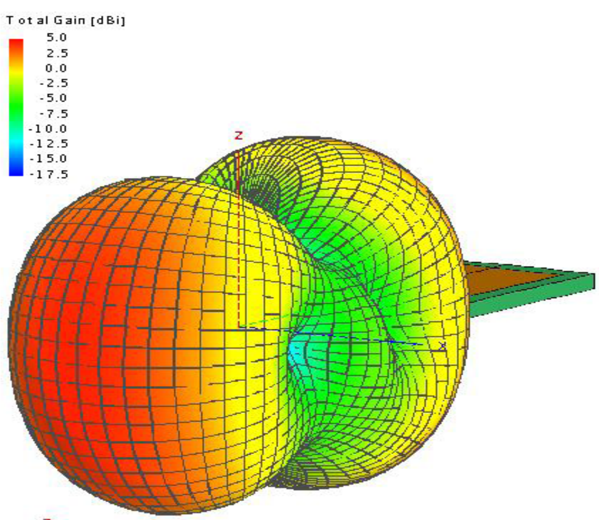

Figure 6: Plot of 3D radiation pattern of Total Gain

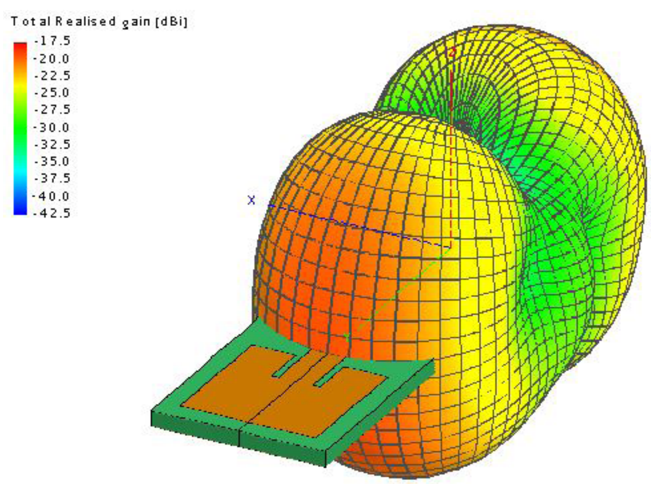

Figure 8: Plot of 3D radiation pattern of Total Realized Gain with different frequencies

The Figure 6 represents the Radiation pattern of total gain for the frequency of 6.5 GHz is 5 dB and for the frequency 5.875 GHz is 7.5dB. The Figure 7 represents the 3D radiation pattern of Total Realized Gain with different frequencies and for the frequency of 5.685 GHz The total realized gain is 6dB The Figure 8 represents the 3D radiation pattern of Total Realized Gain with different frequencies for the frequency of 5.87GHz is -17.5dB Figures 9 to 11 Axial Ratio is under 0 dB for the frequencies 3.1GHz,5.875 GHz,10.6GHz. The Figure 12,13 addresses Handedness with left and appropriate for the recurrence of 5.875 GHz,10.6GHz

The Table III represents the parameters of antenna with different frequencies

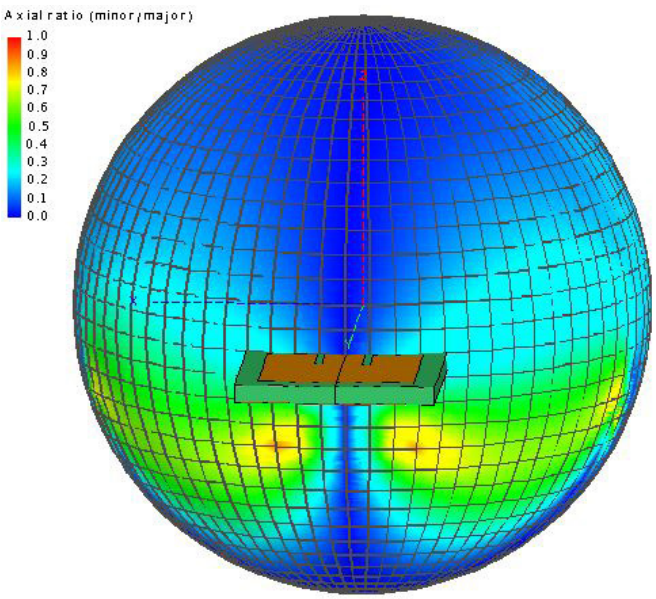

Figure 9: Axial Ratio less than 0dB for the frequency of 3.1GHz

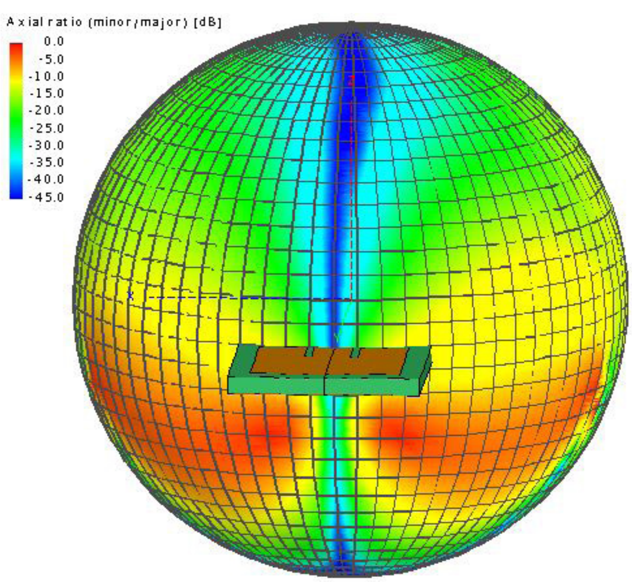

Figure 10: Axial Ratio less than 0dB for the frequency of 5.875 GHz

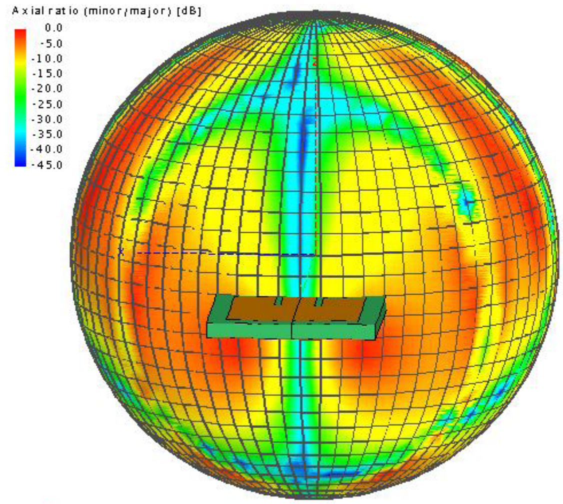

Figure 11: Axial Ratio less than 0dB for the frequency of 10.6GHz

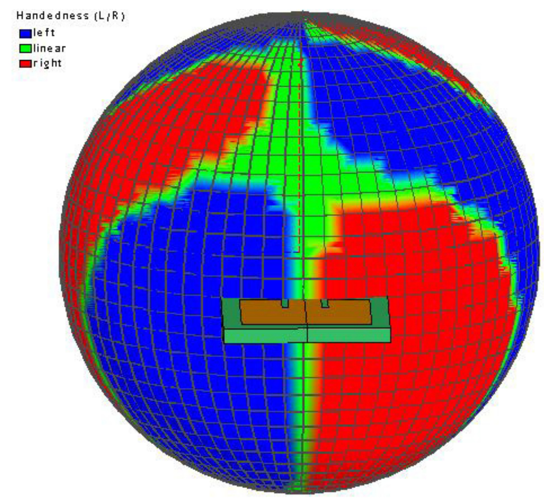

Figure 12: Handedness with left and right for the frequency of 5.875 GHz

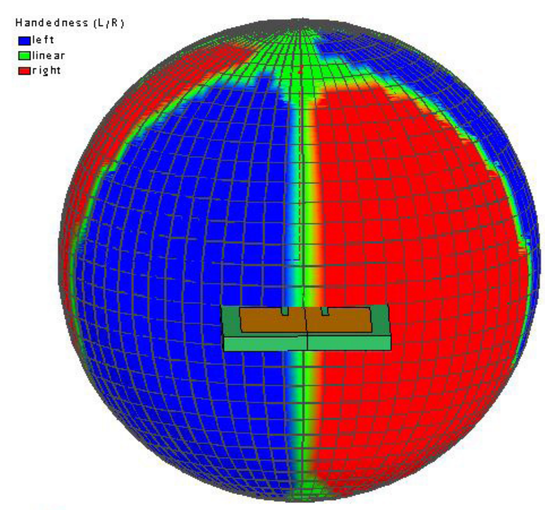

Figure 13: Handedness with left and right for the frequency of 10.6GHz

Table III: Change of frequencies and parameters values

SNo	*Freq (GHz)*	*Gain dB*	*Total Relaised Gain dB*	*Total E-field Magnitude*	*Total Directivity*	*Axial ratio [minor/major] dB*
1	3.1	5	17.5	112.5mV	3.1	0
2	5.35	7.5	2.5	990mV	4.5	0
3	5.725	8	6	2.25V	4.5	0
4	6.475	8	0	320mV	4.5	0
5	9.1	6	3	675mV	3	0
6	10.6	5	5	1.50V	2.7	0

Conclusion

This paper proposes a new type of antenna that is inexpensive, simple, and tiny in size. The antenna described above is suitable for both the UWB frequency spectrum (ranging from 3.1 to 10.6 GHz) and the other two frequency bands (Fmin=3.1 GHz and Fmax=10.6 GHz, respectively). According to the simulation results, all electromagnetic parameters are in the required and good circumstances. For both UWB ranges, the simulated return loss is less than -10 dB, and the VSWR is less than 2. As a result, the suggested antenna is suitable for use in a UWB system and can also be used in dual-band applications. This project's study aims to create a T-shaped rectangular Microstrip patch antenna for use in ultra-wideband applications. The rectangular patch antenna has been built with a 50 ohm Micro strip feed. At 6.85 GHz, the antenna gain is 8 dB, the directivity is 4.5, the return loss is -10.80dB at 5.725 GHz and -12.48dB at 10.6 GHz the antenna efficiency is 100% due to zero losses.

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