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Slotted Pentagonal Shaped Patch Antenna with A Shorting Pin for C-Band Application

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***Abstract*— In this paper, a novel design of a Pentagonal shaped patch antenna is presented for ultra wideband wireless communication applications. Designed microstrip patch antenna consists of a pentagonal patch which is found to resonant at frequency 4.8571 GHz, with return loss -19.65 dB having satisfactory radiation properties. The proposed antenna is a compact design of 30mm × 20mm area on the FR4-epoxy substrate with dielectric constant of 4.4 and thickness of 1.8 mm. The designed antenna structure with 3.45 dB gain is planar, simple and compact hence it can be easily embedded for wireless communication systems and integrated with microwave circuitry for low manufacturing cost.**

***Keywords*—Pentagonal Patch, Microstrip Patch Antenna, shorting pin, slot.**

I. INTRODUCTION

With the rapid development and advancement of the wireless communication systems, antennas have become an essential part of any wireless communication [1]. Out of many types of miniature antennas, microstrip patch antennas have drawn the maximum attention of researchers over past few decades [2],[3],[4],[5] because they provide significant advantages like low profile, low weight, low manufacturing cost, polarization diversity, ease of fabrication etc [1].

A microstrip antenna can simply be defined as a sandwich of two parallel conducting layers separated by a dielectric substrate. The upper conductor is a metallic patch and the lower conductor is a ground plane [6, 7]. The efficiency of a microstrip antenna depends upon patch size, shape, substrate thickness, dielectric constant of substrate, feed point type and its location, etc. The patch of microstrip antenna can be of shapes like circular, elliptical, triangular, pentagonal, rectangular, etc. [8]. Since microstrip antenna has a drawback of narrow bandwidth, for this many solutions have been suggested including the use of different shapes of the patch, which covers multiple mode surface current waves, which causes resonance at multiband frequencies and finally widen the impedance bandwidth across UWB range. [6], [7].

The UWB operates over an ultra wide bandwidth with satisfactory radiation properties over the entire frequency range, a good impulse response with minimal distortion and low power utilization [9].

The pentagonal shaped radiating patch antenna design is not explored by many researchers. In [10, 11], authors have used pentagonal shape for the radiating patch and ground plane in the design of coplanar antennas. Pentagonal geometry is one of the various shapes for microstrip antennas capable of circular polarization and linear polarization [13, 18]. For this paper, pentagonal shaped patch antenna is considered using thick substrate for enhancing bandwidth of antenna with a simple configuration and the characteristics of the pentagonal patch antenna are analyzed.

There is a need for optimization of this type antenna so as to conveniently integrate within the compact communication equipment and devices. This has opened large interest for developing the compact antennas and their miniaturization techniques [14, 15]. There has been many techniques proposed and applied to microstrip patch antenna such as using dielectric substrate of high permittivity, slot on the radiating patch, defected ground structure at the ground plane or a combination of them [16,17]. In this paper, the pentagonal patch antenna is miniaturized using slotting technique on the radiating patch.

II. PROPOSED ANTENNA DESIGN

Substrate FR4-epoxy of dielectric constant 4.4 has been taken for this design. The antenna has been designed and simulated using Ansoft HFSS. The radiating patch of pentagonal shape is considered with radius 10mm and a slot is made at the center of the pentagonal patch. The feeding point is taken at coordinate as (-5, 0, 0). A shorting pin of material copper is also used in this design of height 1.8mm and radius 0.5mm. Various parameters considered are indicated in the table below.

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TABLE I.
ANTENNA PARAMETERS

Antenna design Parameters	*Values*
Substrate material	FR4
Substrate thickness 'H'	1.8mm
Length of Substrate 'L'	30mm
Width of Substrate 'w'	20mm
Dielectric constant	4.4
Dielectric loss tangent	0.02
Pentagonal Patch radius	10mm
Radius of the Coaxial Probe	0.5mm
Position of the coaxial Probe	(-5,0,0)
Material of the Shorting Pin	copper
Radius of the shorting pin	0.5mm
Position of the Shorting Pin	(-3,0,0)
Dimensions of slot (x-axis X y-axis)	2mm X 2 mm

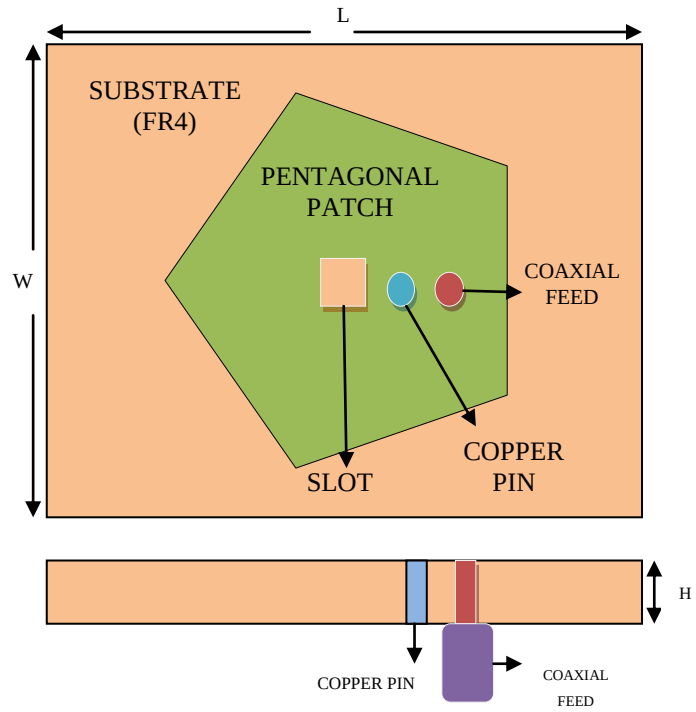

Figure1- Top view and Side view of the proposed antenna

III. Results And Discussions

A. *Return Loss*

The proposed antenna shows a better return loss characteristic that is -19.6505 dB at resonant frequency 4.8571 GHz. Increasing negative values of return loss implies good impedance matching with respect to the reference impedance of 50ohms. Return loss can be further improved by using different feeding techniques.

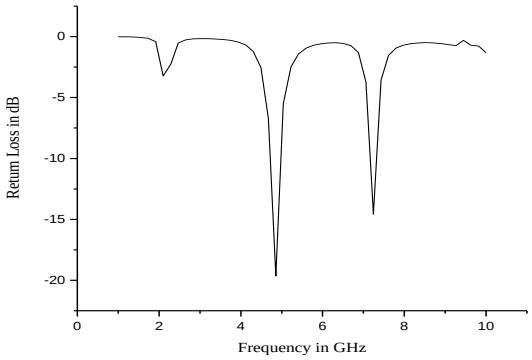

Figure 2- Return loss Vs Frequency

B. *VSWR*

The VSWR graph of proposed antenna shows the VSWR value is 1.8151 at frequency 4.8571 GHz. VSWR values imply the impedance matching between the source and the feed is good, which is an essential requirement for the proper working of the antenna.

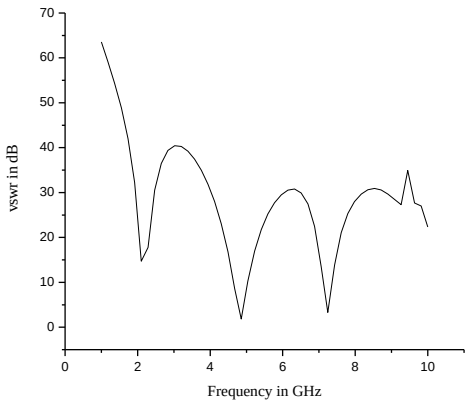

Figure 3- VSWR Vs Frequency

C. *Gain*

Antenna gain tells how much of the power is radiated in a given direction. The designed antenna has a good gain of 3.4529 dB at a resonant frequency of 4.8571 GHz, which means the antenna is more efficient at this frequency.

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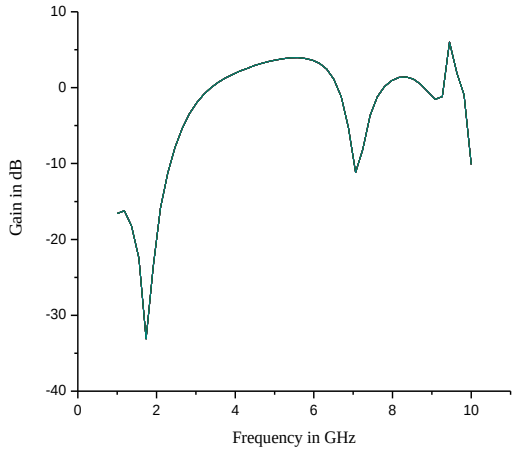

Figure 4- Gain Vs Frequency

D. Directivity

The directivity plot given below shows the maximum amount of radiation intensity that is equal to 5.3160 dB is achieved at a resonant frequency of 4.8571 GHz. Directivity is nothing but the ability of antenna to radiate energy in a particular direction whether it is transmitting, or to be receiving the energy from a particular direction.

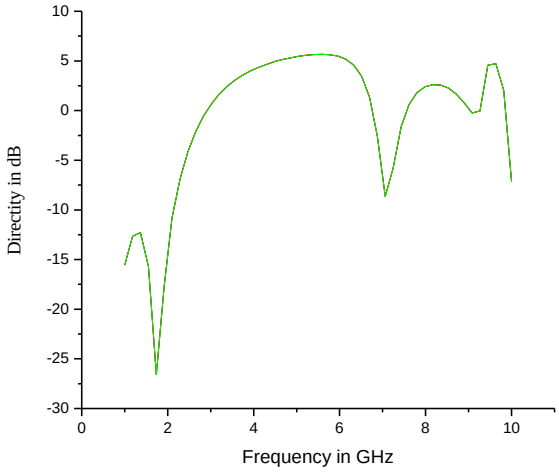

Figure 5- Directivity Vs frequency

E. Radiation Pattern

The 2D radiation patterns for the elevation and azimuthal plane respectively of the proposed antenna is given in figures below. Radiation pattern is the graphical representation of the radiation properties of the antenna as a function of space. Radiation pattern describes how the energy is radiated out into the space by the antenna or how it is received.

For the resonant frequency 4.8571 GHz, the radiation pattern is nearly omnidirectional in the azimuthal and elevation plane.

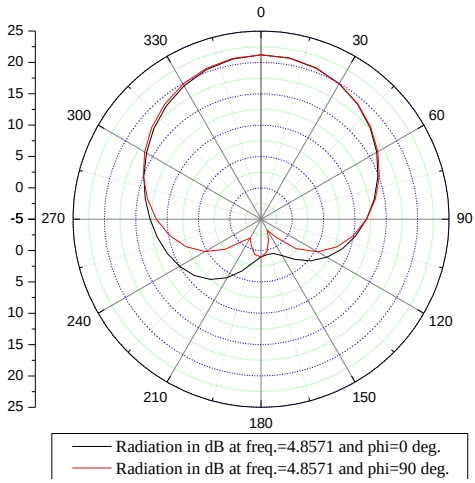

Figure 6- Radiation pattern at Frequency 4.8571 GHz

IV. Conclusion

The proposed compact pentagonal microstrip patch antenna design shows that by using pentagonal shaped patch with a slot and a shorting pin, antenna is able to resonate at frequency 4.8571 GHz. It is realized that with the introduction of the slot, the effective patch size is marginally reduced but the performance of antenna is significantly improved. The designed antenna is suitable for C-band applications. The obtained antenna characteristics are appropriate. The each characteristic such as Gain, return loss, and directivity have been discussed in this paper

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