A Slotted Elliptical patch antenna with a shorting pin for C-band Applications

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Abstract - *In this paper, a novel design of an elliptical patch antenna is presented for ultra wideband wireless communication applications. Designed Microstrip patch antenna consists of an elliptical patch which is found to resonate at frequencies 4.4897 GHz and 6.6938 GHz, with return loss -12.37 dB and -20.21 dB respectively with satisfactory radiation properties. The results are simulated by using a software called High Frequency Structure Simulator (HFSS 13.0). The proposed antenna is a compact design of 30mm × 30 mm² area on the FR4-epoxy substrate with dielectric constant of 4.4 and thickness of 1.8 mm. The designed antenna structure with o.91 dBi and 5.77 dBi gain is planar, simple and compact hence it can be easily embedded in wireless communication systems and integrated with microwave circuitry for low manufacturing cost, this design is mainly suitable for C-band applications.*

Key Words: Elliptical Patch, C-Band, Microstrip Patch Antenna, shorting pin, slot, HFSS

1.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, helical, 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 impedence 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]. Microstrip patch antenna with elliptical shape also called as EMSA are the ones considered for antenna design of this paper as their geometry has greater potential for a variety of low-profile antenna applications. Elliptical shapes are advantageous as they provide larger flexibility and they have largest bandwidth in the range of GHz [11], [12]. It is also found that elliptical shaped patch antennas may give better return loss, directivity, gain and radiation pattern when we are ready to compromise with the size of antenna [10]. But there is also a need for miniaturization of antenna so as to conveniently integrate within the compact communication equipment and devices. This need has opened large interest for developing compact antennas and their miniaturization techniques [13], [14]. 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 [15], [16]. In this paper elliptical microstrip patch antenna using slot on the radiating patch.

2.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 elliptical shape is considered with major axis as 14mm and ratio as 0.4mm and a slot is made at the center of the elliptical patch. The feed point is taken at position (-7,3,0) . 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.

Table -1: Antenna parameters

Antenna design Parameters	Values
Substrate material	FR4
Substrate thickness 'H'	1.8mm
Length of Substrate 'L'	30mm

Width of Substrate 'w'	30mm
Dielectric constant	4.4
Dielectric loss tangent	0.02
Elliptical Patch major axis	14mm
Elliptical Patch ratio	0.4mm
Radius of the Coaxial Probe	0.5mm
Position of the coaxial Probe	(-7,3,0)
Material of the Shorting Pin	copper
Radius of the shorting pin	0.5mm
Position of the Shorting Pin	(7,1.5,0)
Dimensions of slot (x-axis X y-axis)	2mm X 2 mm

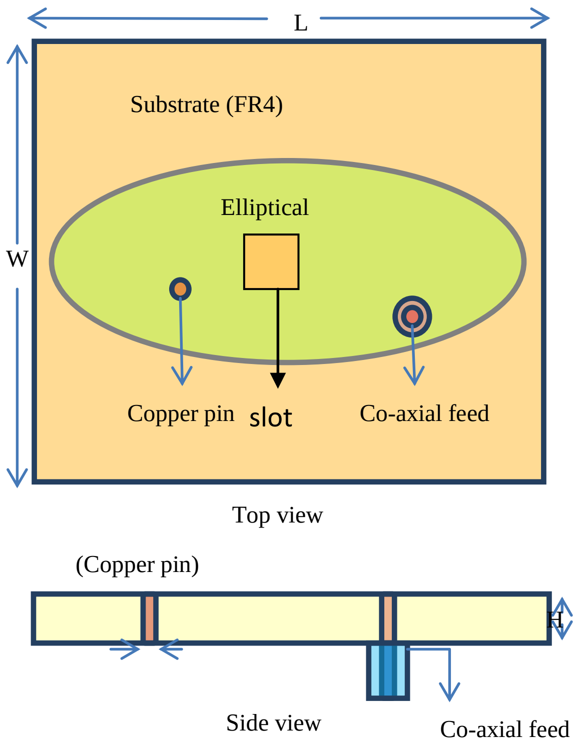

Fig -1: top view and side view of the proposed antenna

3. RESULTS AND DISCUSSION

3.1 Return Loss (S11)

The proposed antenna shows better return loss characteristics that is -12.3653 dB and -20.4519 dB at resonant frequencies 4.4897 GHz and 6.6938 GHz respectively. Increasing negative value of return loss implies good impedance matching w.r.t the reference impedance of 50ohms. Return loss can be further improved by using different feeding techniques.

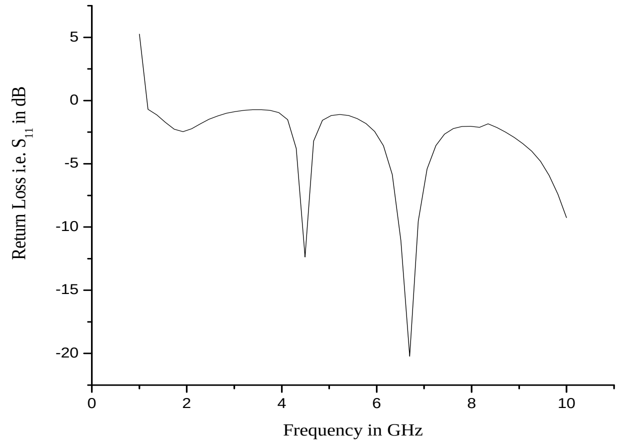

Fig -2: Graph showing Return loss Vs frequency

3.2 VSWR

The VSWR graph of proposed antenna shows the VSWR value is 4.2702 at frequency 4.4897 GHz and 1.7009 at frequency 6.6938 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.

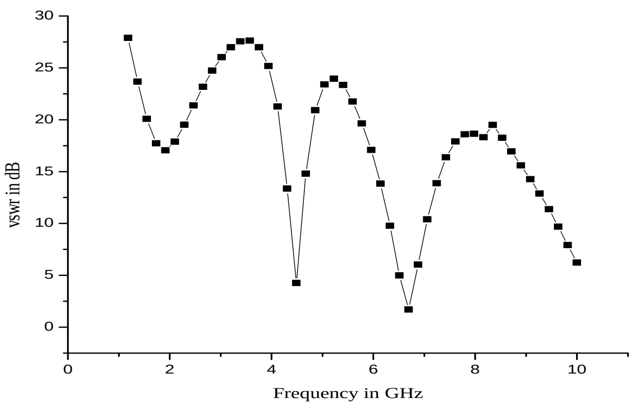

Fig -3: Graph showing VSWR Vs frequency

3.3 Gain

Antenna gain tells how much of the power is radiated in a given direction. The designed antenna has a good gain of 5.7715 dBi at a resonant frequency of 6.6938 GHz, which means the antenna is more efficient at this frequency, while a low gain of 0.9114 dBi at a resonant frequency of 4.4897 GHz as is understood by the black line graph, which means the antenna is lesser efficient at this frequency.

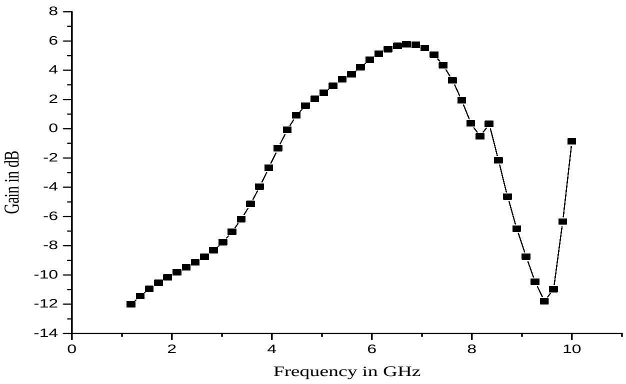

Fig -4: Graph showing Gain Vs frequency

3.4 Directivity

It is the ability of an antenna to focus energy in a particular direction when transmitting, or to receive energy better from a particular direction when receiving. The directivity plot given below shows the maximum amount of radiation intensity that is equal to 6.5903 dB is achieved at a resonant frequency 6.6938 GHz, while a directivity value of 3.2775 dB is obtained at resonant frequency of 4.4897 GHz.

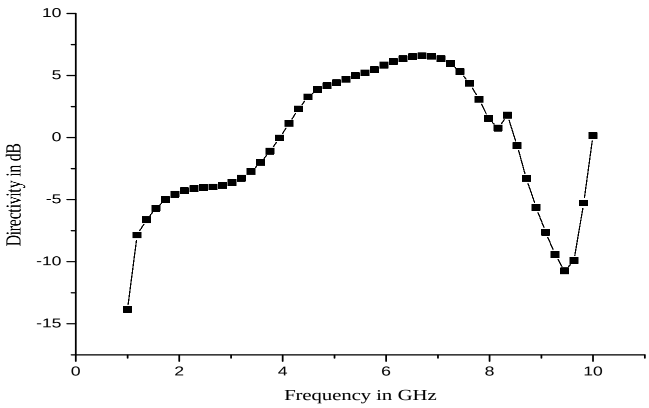

Fig -5: Graph showing Directivity Vs frequency

3.5 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 frequencies 4.4897GHz and 6.6938GHZ, the radiation pattern is nearly omnidirectional in the azimuthal and elevation plane.

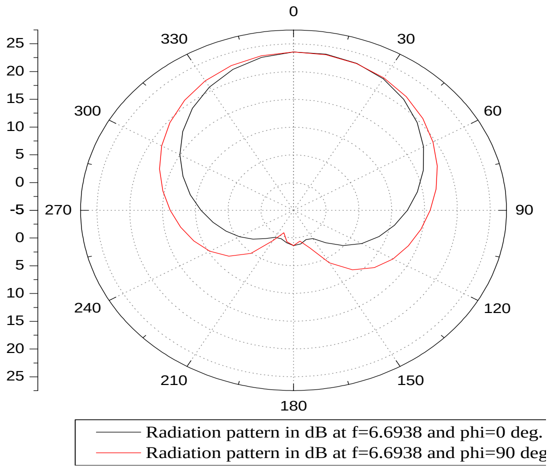

Fig -6: Radiation pattern at frequency 6.6936 GHz

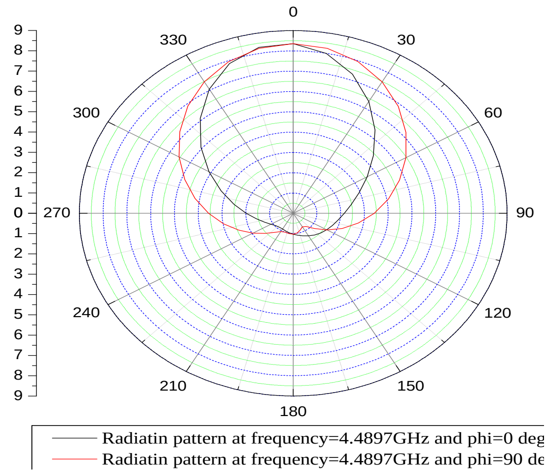

Fig -7: Radiation pattern at frequency 4.4897 GHz

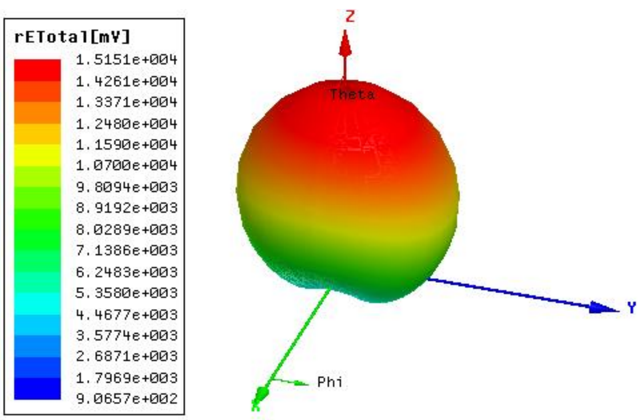

Fig -8: Polar plot

Table -2: Performance analysis data table

Freq. (GHz)	Return loss (dB)	VSWR (dB)	Gain (dBi)	Directivity (dB)
4.4897	-12.3653	4.2702	0.9114	3.2775
6.6938	-20.2143	1.7009	5.7715	6.5903

4. CONCLUSIONS

The proposed compact elliptical microstrip patch antenna design shows that by using elliptical patch with a slot and a shorting pin antenna is able to resonate at frequencies 4.4897GHz and 6.6938 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 appropriate for C applications. The obtained radiation characteristics are appropriate. Gain, return loss, and directivity parameters have also been discussed in this work. Different feeding techniques can also be used for increasing the efficiency of antenna.

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