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Performance Analysis of Elliptical Patch Antenna for Super Wideband Applications

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ABSTRACT

This paper introduces a design and analysis of low profile planar elliptical antenna for super wideband applications. The proposed antenna consists of conducting elliptical patch with circular slot which yields almost the super wide impedance bandwidth of 20.93 GHz from 1.08-22.01GHz. Return Loss, VSWR, gain and radiation pattern are obtained for the proposed antenna through HFSS simulation. Simulated results shows the proposed antenna found to be a potential for super wide band applications.
Keywords: Elliptical, Semi-elliptical, SWB, HFSS.

I. INTRODUCTION

The rapid development and advancement in wireless broadband technologies requires light weight, low cost, and small size antennas. The ITU has designated for radio frequencies (RF) in the range between 3-30 GHz as Super wideband (SWB) utilised for various applications such as satellite communication by NASA microwave radio relay links, and numerous short range terrestrial data links, military and government institutions for weather monitoring, air, traffic control, vehicle speed detection and BSS(Broadcast satellite service)[like highly modernize aircraft, satellite spacecraft.[1] A Microstrip antenna in a simplest form, which is a sandwich of two parallel conducting layers separated by a single layer of dielectric substrate. The upper conductor is called as a metallic patch (usually Gold or copper), which is small fraction of wavelength. The efficiency performance of a microstrip antenna depends on patch size, shape, substrate thickness, dielectric constant of substrate, feed point type and its location, etc. A low dielectric constant is desirable for larger bandwidth, better efficiency and radiation, leading to a larger antenna size. The patch is of many shape like a circular, elliptical, triangular, helical, triangular etc. [1]One of the major disadvantages of microstrip patch antenna is narrow bandwidth. Numerous solutions have been introduced, in which usage of different shapes of the patch covers multiple mode surface current waves, which causes resonance at multiband frequencies and finally widen the impedance bandwidth across the UWB range. Out of many shapes like used in the microstrip antenna like rectangular, circular, square, helical, the elliptical shape chosen several advantages like providing larger flexibility in the design and it has the largest bandwidth in the range of GHz. It is observed that elliptical antenna gives better return loss, good directivity and radiation pattern when we are ready to compromise somewhat over the size of antenna.[1]

In this paper a novel Circular slotted elliptical patch antenna (CSEPA) is designed using High frequency Structure Simulator (HFSS).The paper is organized as follows; The design of elliptical patch antenna (EPA), Semi Elliptical patch antenna (SEPA) and CSEPA are discussed in Sec. II. The simulation result analysis of the above mentioned antenna are discussed in Sec.III. Performance analysis of the various parameters are discussed in Sec IV.

II. ANTENNA DESIGN

The designed printed elliptical monopole antenna EPA is shown in Fig.1, and the design parameters are calculated using the following steps:-[2]

a) Patch size (A & B)

The size of EPA can be calculated using the following equations (1-6)

$$f_L = \frac{7.2}{(L+r+P)\times k} \text{GHZ} \quad (1)$$

$$L = 2B \quad (2)$$

$$r = \frac{A}{4} \quad (3)$$

Where f_L is the lower edge frequency, P is the 50Ω feed line length, which has been estimated in this design to be equal to 0.3 mm, while $k = \sqrt{\varepsilon_{eff}}$ and the approximated value of is given by:-

$$\varepsilon_{eff} = \frac{\varepsilon_{r+1}}{2} \quad (4)$$

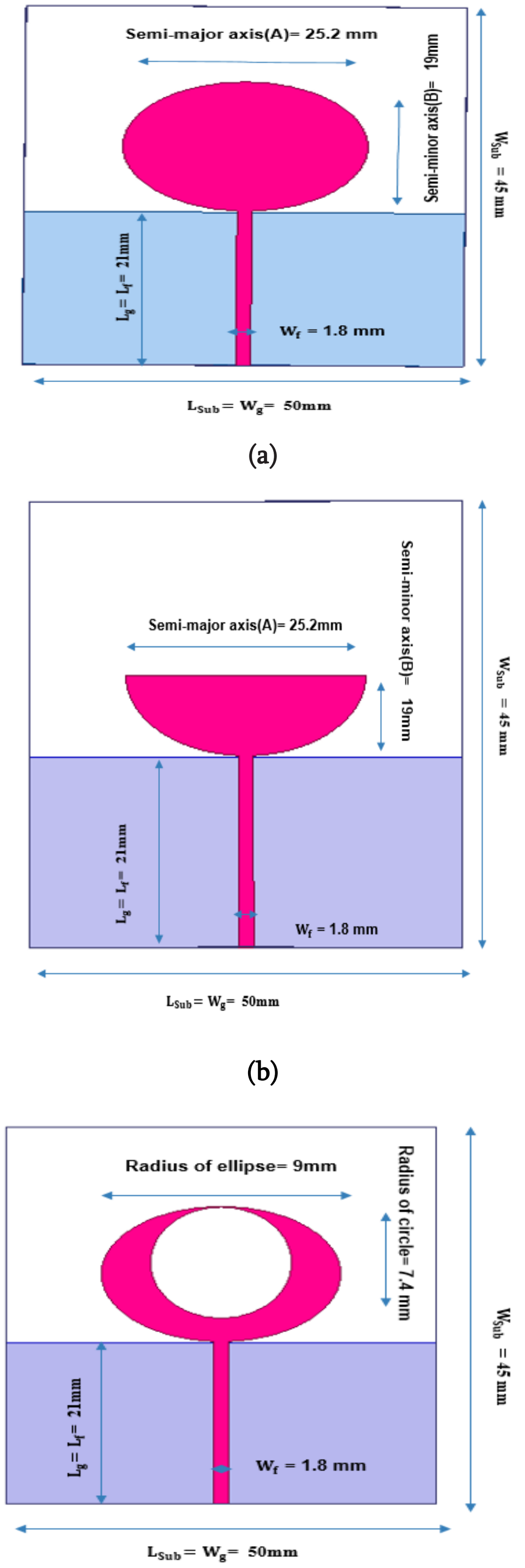
(b) Microstrip Line Width (Wstrl):

The line width can be calculated from the following equation:

$$Z_0 = \frac{87}{\sqrt{\varepsilon_{r+1}}} \ln\left(\frac{5.98h}{0.8W_{strl}+t}\right) \quad (5)$$

Where Z_0 the characteristic impedance of the line, h is the substrate thickness, t is the metallization thickness, W_{strl} is the microstrip feed line width and ε_r for FR4 substrate.

The top view of designed EPA, SEPA and CSEPA are shown in the Fig.1 with its appropriate dimensions.



(c)

Figure 1. Top View of the Antenna (a) EPA,(b)SEPA and (c) CSEPA

(c) Ground Plane Layer Length (L_G):-

The ground plane length has been found to be equal to $\frac{\lambda}{4}$ at the lower band-edge frequency 3.2 GHz as in the following calculations.

$$L_G = \frac{\lambda}{4} = \frac{c}{4\,k\,f_L} \qquad (6)$$

The top view of designed EPA, SEPA and CSEPA are shown in the above Fig.1.

III. SIMULATION RESULT ANALYSIS

(a) Return Loss

Figure 2.shows the plot for reflection coefficient versus frequency. The –10 dB return loss bandwidth of the antenna is considered as reference for calculation. As seen in the plot for that the return loss curve has resonance frequencies bandwidth range from 2.5-12.5 GHz for EPA, 3.31-19.35 GHz for SEPA and 1.08 to 22.01GHz .Hence, the proposed antenna satisfy for better performance in SWB range.

(a) Return Los

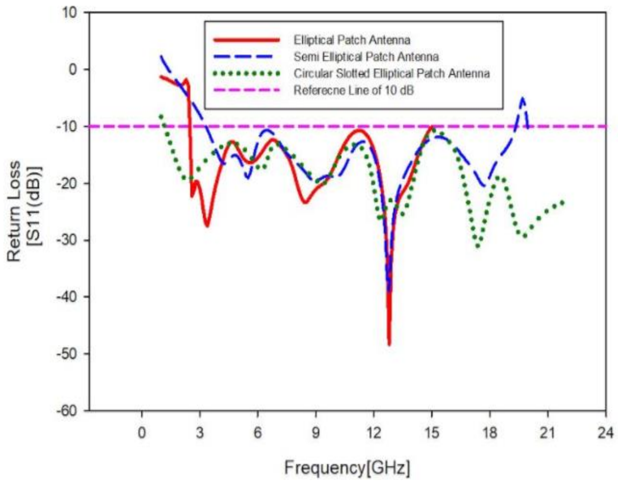


Figure 2. Return Loss Characteristcs

(b) VSWR

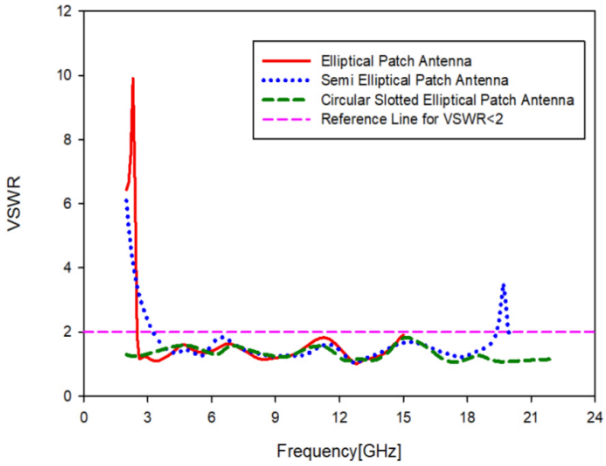
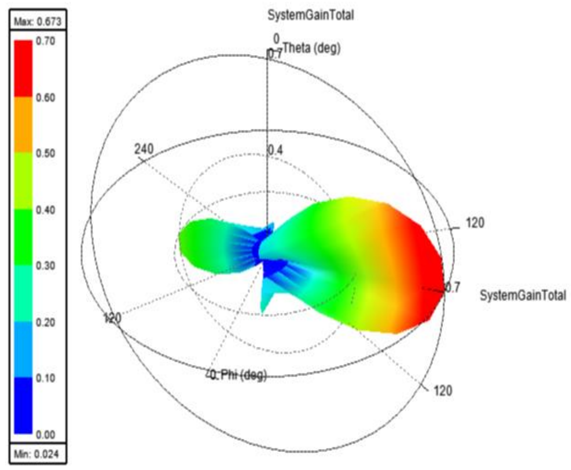


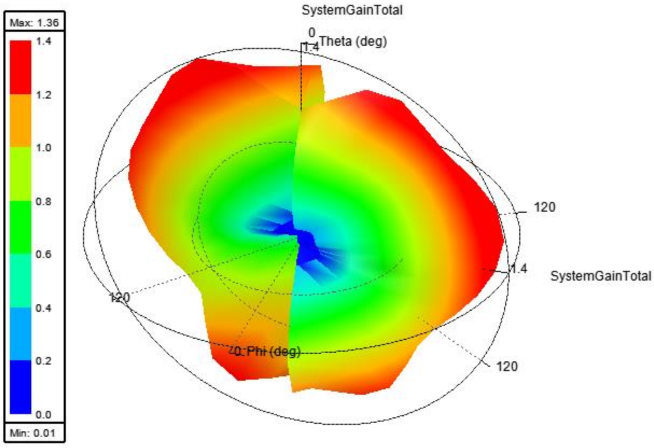
Figure 3. VSWR Characteristcs

Fig.3. shows the plot for VSWR against Frequency. The plot shows that the value of VSWR of the proposed antenna lies between 1 and 2 in its entire operating range which satisfies to consider the antenna for practical considerations.

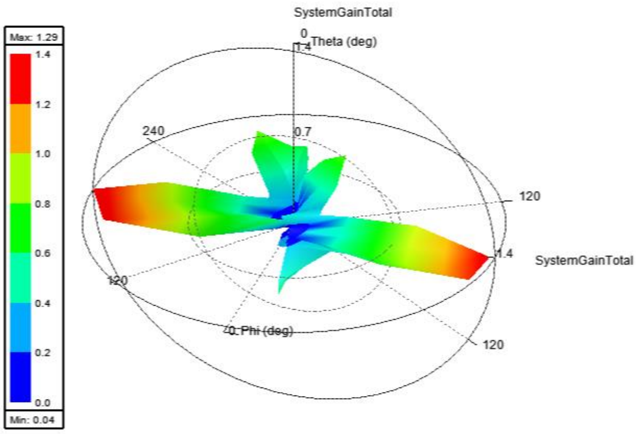
(c) Gain



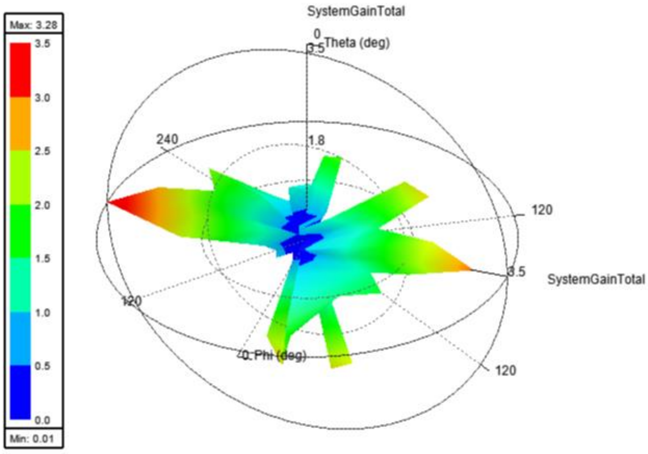
(a)



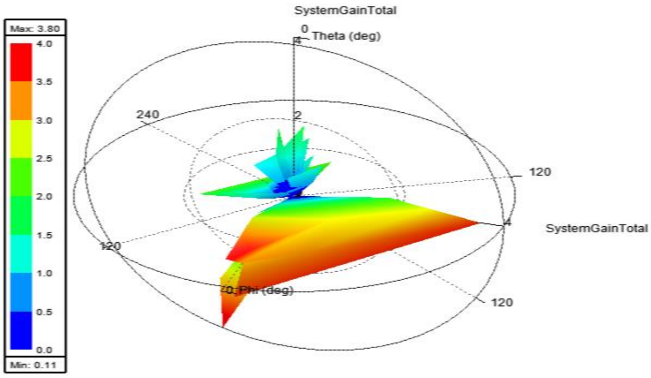
(b)



(c)



(d)



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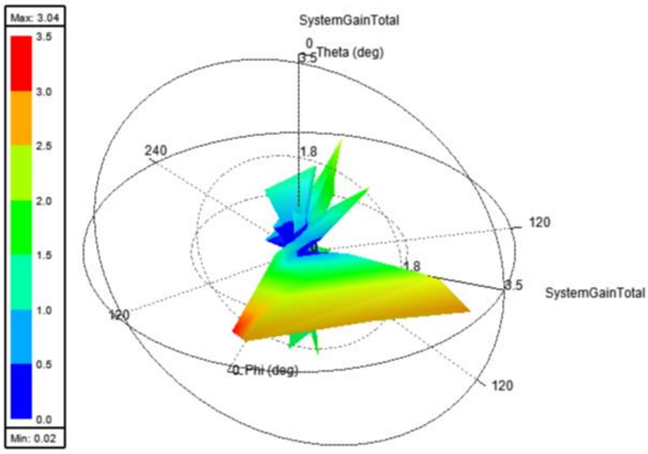

(f)

Figure 4. Gain Characteristcsof CSEPA at different resonance frequencies (a) at 2.4 GHZ (b) at 6.2 GHZ (c) at 9.3 GHZ (d) 12.4 GHZ (e) 17.7 GHZ (f)19.4 GHZ.

IV. PARAMETER COMPARISON

Parameters	EPA	SEPA	CSEPA
Bandwidth Range (GHZ)	2.5 – 15	3.31-19.35	1.08- 22.01
Bandwidth (GHz)	12.5	16.04	20.93

Resonant frequency (GHZ)	3.45,6.8 5.6,12.8	5.5,8.9 12.8,17.7	2.4,6.2 9.3,12.4, 17.4,19.7
Return Loss (dB)	-27.4, -16.36, -23.30 -48.30	-19.02,-19.49 -38.95,-20.40	-19.34,-17.67 -20.08,-26.61 -31.10,-29.40
VSWR	1.09,1.36, 1.15, 1.01	1.25,1.24 1.02, 1.2	1.24, 1.30,1.22 1.10,1.06 ,1.07
Gain (dB)	30.05, 0.75 0.86, 4.65	7.00,0.81 7.23 , 11.10	0.68,1.38,1.29 3.29, 3.80, 3.04

V. CONCLUSION

Elliptical microstrip patch antenna with circular slot is designed for SWB application. The antenna parameters like return loss, Gain and VSWR obtained for depicted model gives satisfactory performance and found to be potential aspirant for wide range of wireless applications.

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