Design of Planar Archimedean Spiral Antenna for Wi-Max Using Different Materials

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***Abstract* – The purpose of this paper is to study and analysis of planar Archimedean spiral antenna using different substrate materials. The designed antenna is for Wi-Max application and the optimum output is taken at 3.65 GHz frequency. The simulation results are done in HFSS v13 software and the dielectric materials used are FR4, Rogers RT/ duroid 5880 (tm), Teflon (tm).**

***Keywords* - HFSS, Spiral Antenna, Wi-Max**

I.INTRODUCTION

There are many research areas but wireless technology is one of the main areas of research for the communication systems and a study of communication systems understanding of the operation and fabrication of antennas is necessary. Antenna is the structure associated with the region of transition between a guided wave and a "free space" wave, or vice versa [1]. The spiral antenna is a wideband antenna with low profile and circular polarization. The frequency band of a spiral antenna depends on the physical dimension of the antenna. The planar Archimedean spiral antenna is the class of frequency independent antenna [2]. Frequency independent antennas are design to minimize finite lengths and maximize angular dependence. The design and simulations are carried out in HFSS v13 software. In this paper the planar Archimedean spiral antenna is designed for the Wi-Max application and also the comparative analysis of designed antenna with different materials.

II.ANTENNA DESIGN, GEOMETRY & CONFIGURATION

The Archimedean spiral increases uniformly with the angle.

$$r = a\phi + b \qquad (2.1)$$

Where, r- distance from the origin, b-initial point and a-growth rate. The growing spiral arm separate the currents. A spiral radiates RHC (right hand side circular) polarization and LHC (left hand side circular) Polarization.

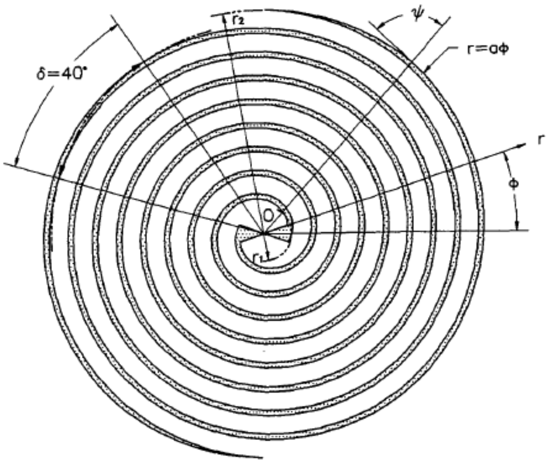


Fig.2.1 Archimedean spiral antenna [3]

Here arm of an Archimedean spiral is linearly proportional to the angle ϕ and the relationship is

$$r = r_0\phi + r_1 \ \& \ r = r_0(\phi - \pi) + r_1 \qquad (2.2)$$

Where r_1 is the inner radius of spiral and r_0 is the proportionality constant and getting from,

$$r_0 = \frac{s+w}{\pi} \qquad (2.3)$$

Where s is the spacing between each turn and w is the width of each arm. The width of the arm can be found by the following equation

$$s = \frac{r_2 - r_1}{2N} - w \quad (2.4)$$

Where, r_2 is the outer radius of spiral and N is the number of turns. For the self-complementary antenna spacing or width can be written as,

$$s = w = \frac{r_2 - r_1}{2N} \quad (2.5)$$

For probe feeding, the relation between strip widths to radius of wire can be found by,

$$a = \frac{w}{4} \quad (2.6)$$

Where, a is wire radius and w is width of each spiral arm.

The important parameter is setting the value of inner radiusr_1, for the frequency independent behavior of spiral antenna inner radius is equal to the strip width or spacing between turns so we get

$$r_1 = \frac{r_2}{4N+1} \quad (2.7)$$

The below is the HFSS design of the Planar Archimedean Spiral Antenna.

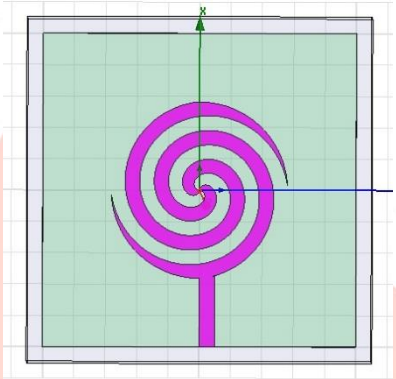


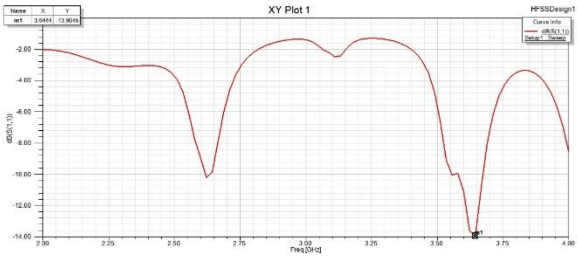
Fig.2.2 Planar Archimedean Spiral antenna (1.5 turn) HFSS design.

PARAMETERS	VALUES
Frequency	Wi-Max band(3.65 GHz)
Substrate material	FR4-epoxy
Substrate dielectric constant	4.4
Substrate height	1.6 mm
No of turns	1.5
Inner radius	0.0001 mm
No of arms	2
Offset angle	90^0

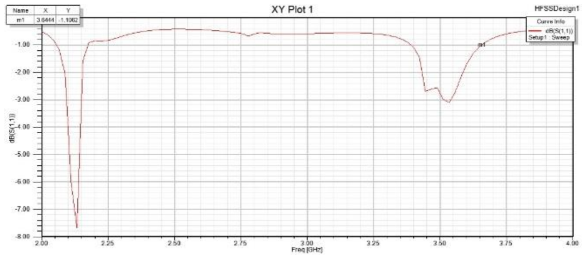
Table.2.1. Design Specifications

Here feeding is given by lumped port. Width of the feed is 5mm and the length of the feed line is 22mm. The substrate materials are FR4-epoxy, RT Duroid and Teflon with dielectric constant 4.4, 2.2 and 2.1 respectively. The spiral is made of copper. Air box size is 110x110x50 mm.

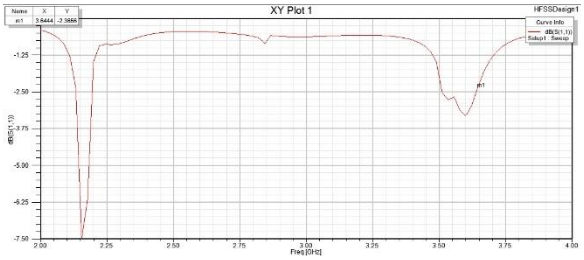
III.RESULTS



(a)

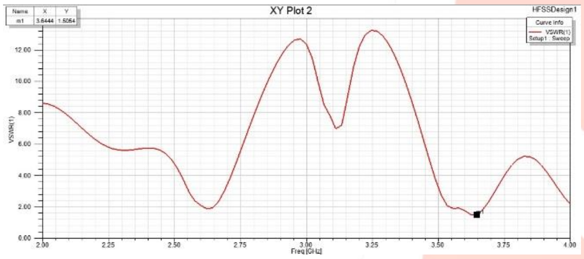


(b)

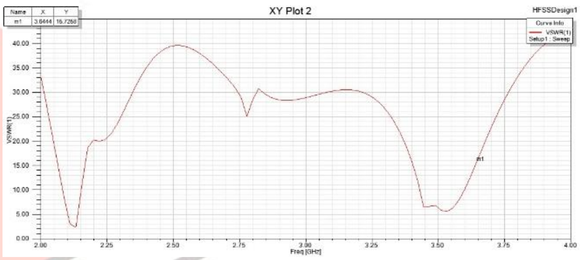


(c)

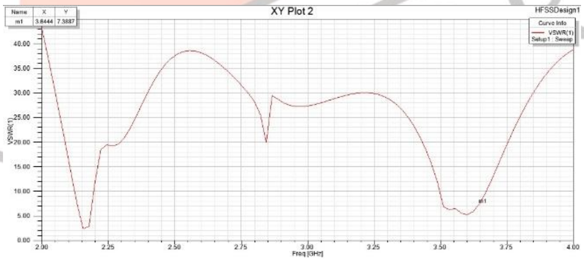
Fig.3.1 Return loss of Planar Archimedean Spiral Antenna (a) Using FR4 (b) Using RT Duroid (c) Using Teflon



(a)

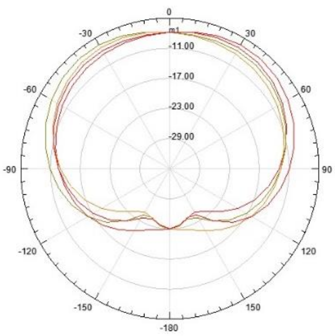


(b)

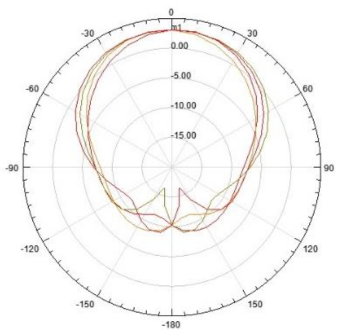


(c)

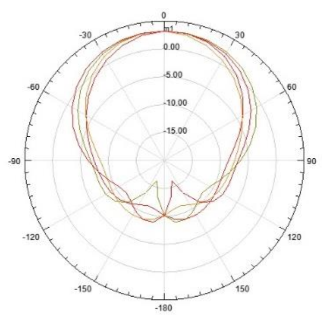
Fig.3.2 VSWR of Planar Archimedean Spiral Antenna (a) Using FR4 (b) Using RT Duroid (c) Using Teflon



(a)

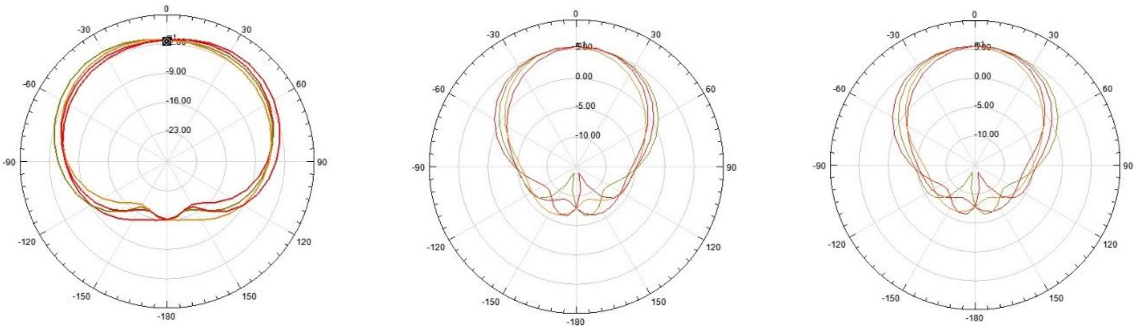


(b)



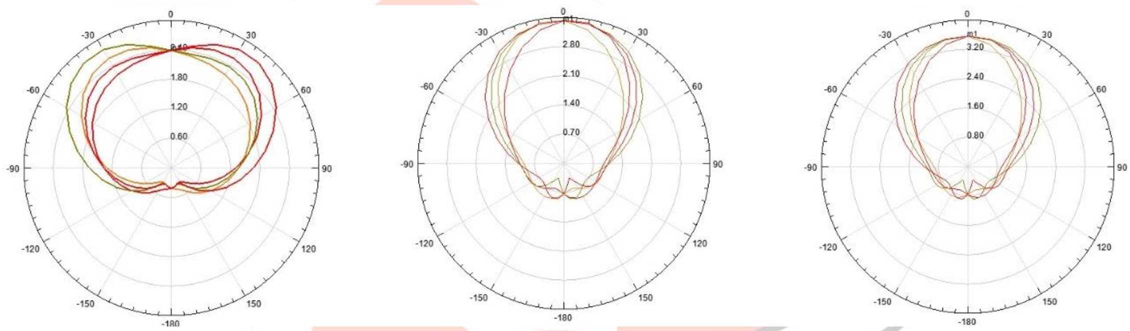
(c)

Fig.3.3 Gain of Planar Archimedean Spiral Antenna (a) Using FR4 (b) Using RT Duroid (c) Using Teflon



(a) (b) (c)

Fig.3.4 Gain radiation pattern of Planar Archimedean Spiral Antenna (a) Using FR4 (b) Using RT Duroid (c) Using Teflon



(a) (b) (c)

Fig.3.5 Directivity radiation pattern of Planar Archimedean Spiral antenna (a) Using FR4 (b) Using RT Duroid (c) Using Teflon

IV.CONCLUSION

The above figure shows the results of the Planar Archimedean Spiral Antenna. The comparative analysis using different materials is shown in below Table (2).

PARAMETERS	**MATERIALS**		
	FR4	**RT Duroid**	**Teflon**
Return Loss	-13.9045	-1.1062	-2.3656
VSWR	1.5054	15.7258	7.3887
Gain	-7.8096	3.0608	3.1823
Directivity	-0.9280	5.4352	5.5833
Radiation Efficiency	2.3864	3.4208	3.5535

Table 4.1 Result Analysis

Thus, in this paper we designed a Planar Archimedean Spiral antenna using different materials. The study of comparative results shows that using FR4 material we get the better return loss than other materials but the gain and directivity improved by using RT Duroid & Teflon materials.

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