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Design of circular spiral antenna for mobile satellite communication

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***Abstract*- This paper presents the simulation, design, and fabrication of a circular spiral antenna for mobile - satellite communication with wide bandwidth. The centre frequency is 1.78 GHz with the bandwidth is 60 MHz radiation pattern of this antenna shows bidirectional pattern with voltage standing wave ratio of less than two, return loss of less than -10 dB, the line impedance of 50 Ω . All the design and simulation of this Antenna is carried by using a commercial cst simulator. The antenna is fabricated on Fr-4 substrate with 4.3 dielectric constant and 1.6 mm of thickness. Transient solver is used to measure all the parameters of this Antenna. It is observed that the simulated and measured values of the parameters of the antenna were quite close with each other.**

***Keywords*- Circular spiral antenna, cst simulator, microstrip**.

I. INTRODUCTION

The history of contemporary wireless communications system has increased rapidly together with the need for antennas which provide a wireless land mobile or terrestrial-satellite network .With time and requirements, these devices become smaller in size and also to be smaller and lightweight which results microstrip antenna .The advantage of microstrip antenna makes them popular in many application requiring a low profile antenna and it's promising to be a good candidate for the future technology due the flexibility of the structure as it is easy to fabricate have low cost and can be easily into the communication equipments.

The spiral antennas offer (due their relatively simple geometry) additional attractive features like light weight, easy fabrication as well as integration with microwave and millimetre-wave circuit. Their wide-band characteristics accompanied with their low profile as well as their low cost make these antennas prime candidates for use in mobile satellite communication compare to other antennas. The spiral is one geometrical configuration whose surface can be described by angles. Due to the circular polarization characteristic and frequency independent is very usefull. Frequency independent antennas are antenna whose radiation pattern, impedance and polarization remain virtually unchanged over a large bandwidth .Their electrical dimensions however scale with frequency. Ideally the electrical size of such antennas would remain constant over the entire electromagnetic spectrum .A broad band antenna could find wide application in many systems. The circular spiral antenna is selected for this work due the bidirectional radiation characteristic and the frequency independent characteristics at a relatively very small size for mobile satellite communication. Furthermore, this antenna can avoid the use of different antenna for different services [1] since an excessive number of access points in one area can prevent the access due the interference with other access points. The prototype is fabricated on FR-4 substrate with dielectric 4.3 and 1.6 mm of thickness [2].

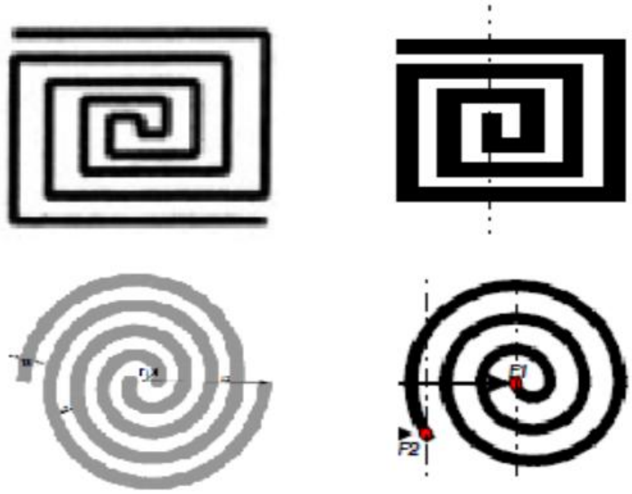

Fig.1 Variety of spiral antenna for broadband application.

II. METHODOLOGY

The design and simulation of this circular spiral antenna is carried out using a cst simulator with the dimension as in Table 1 and the substrate properties as indicated by Table 2 respectively.

Number of turns	3
Width w (mm)	2
Inner radius (IR)(mm)	3
Space s (mm)	1
Height h (mm)	0.508

TABLE 1. ANTENNA DIMENSION

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properties	Fr-4
Dielectric constant	4.3
Mue	1
EI. and T	0.098
Thickness(mm)	1.6
Metal thickness(mm)	0.038
Resistivity	1

TABLE 2.PROPERTIES OF SUBSTRATE

A. Design Procedure

The geometry of the slot was generated by dn = 2(n-1) d1, (n=2,3,...,10) where 2d1 (= ab) a denotes the length of the first turn of the single arm circular spiral slot respectively. It was assumed that the slot width, W was very narrow compared with the wavelength, λ_0 at the resonance frequency f_0.

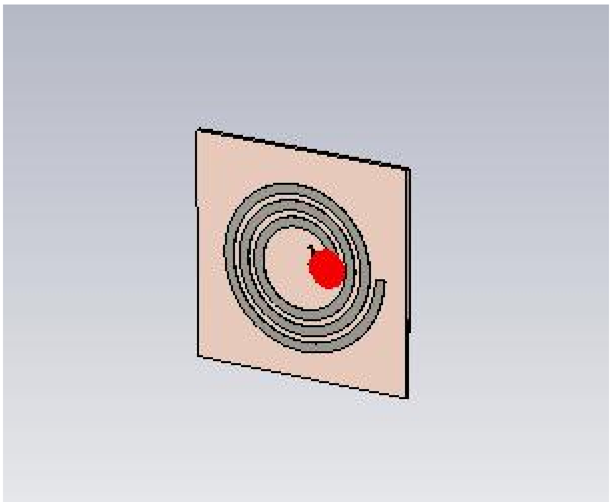

Fig.2 Circular spiral antenna

B. Feeder network

There are many methods that can be adopted to feed the antenna and can be classified into two categories; contacting and non-contacting. The four most popular approaches are the microstrip line, coaxial probe, aperture coupling .The inner conductor of the probe extends through the dielectric at a point whereby the impedance matched the input impedance and then soldered to the radiating patch, while the outer conductor is connected to the ground plane. The input impedance Zo of the antenna is also affected by the inner and outer radius of the coaxial feed, the distance between the lines s, the dielectric constant and also the thickness t_{su} of the substrate. The disadvantage of this feeding technique will result in an increase in probe length that makes the input impedance more inductive leading to the matching problem

C. CST Simulation

Simulation of circular spiral antenna inclusive of the coaxial feed was carried out. The inner radius(IR), W of the circular spiral antenna is varied to obtain the optimum performance as to meet the specification .The dimensions of the antenna was kept constant at 70 mm x 70mm. The best width, W for this antenna to perform as a mobile satellite communication is 0.508 mm. Figure [3] shows the simulated circular spiral antenna while Figure [4] back view, Figure [5] return loss and Figure [6] illustrated the simulation results for the various parameters of the antenna fig [5] return loss, S11, voltage standing wave ratio, VSWR, line impedance, *Zo*, and radiation pattern respectively.

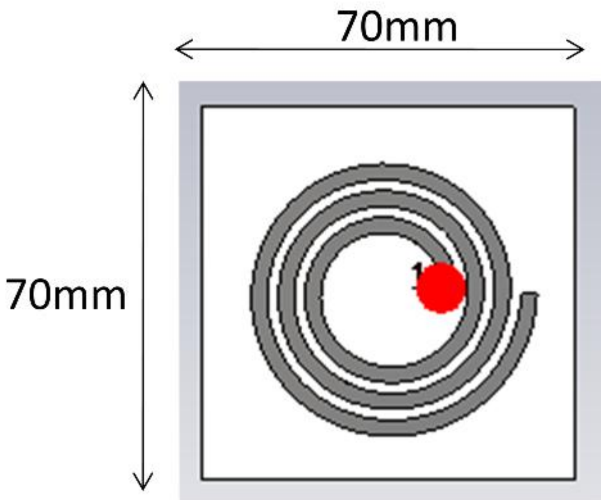

Fig.3 Simulated antenna

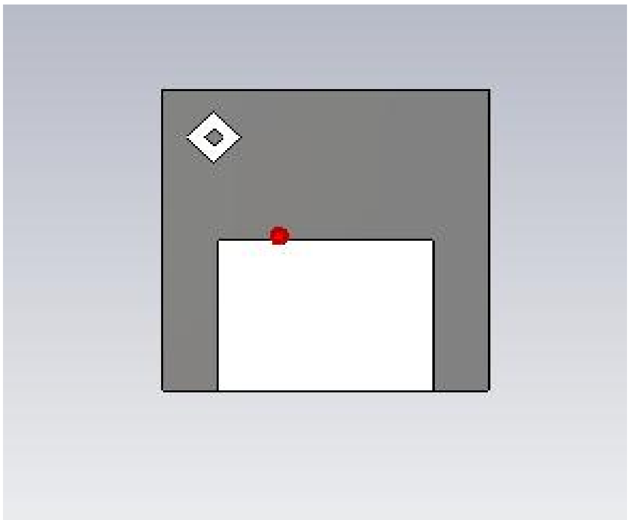

Fig. 4 Back view of antenna

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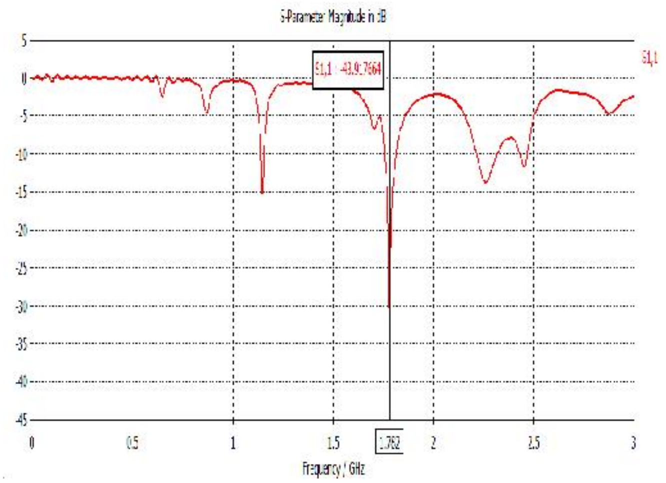

Fig.5 Return loss at 1.78GHz

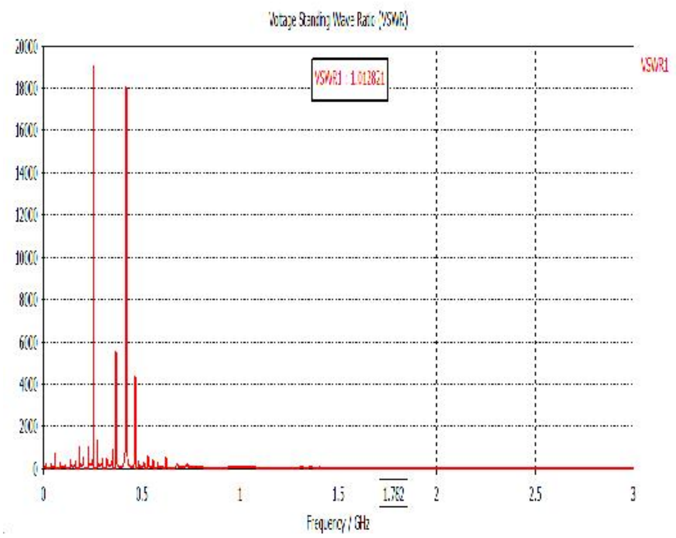

Fig.6 VSWR at 1.78GHz

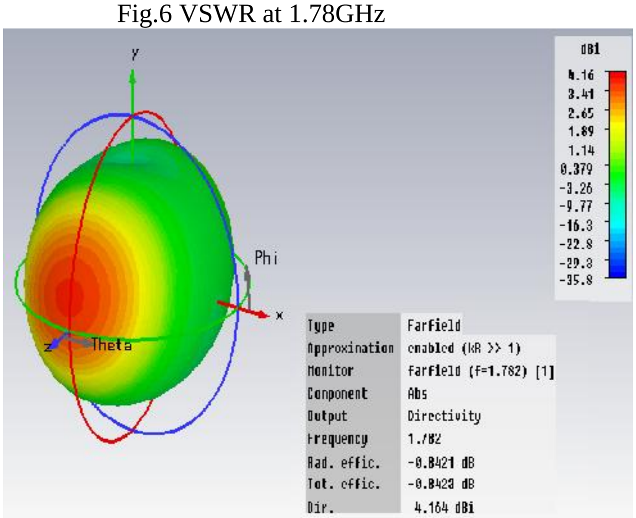

Fig.7 3D Radiation pattern at 1.9 GHz

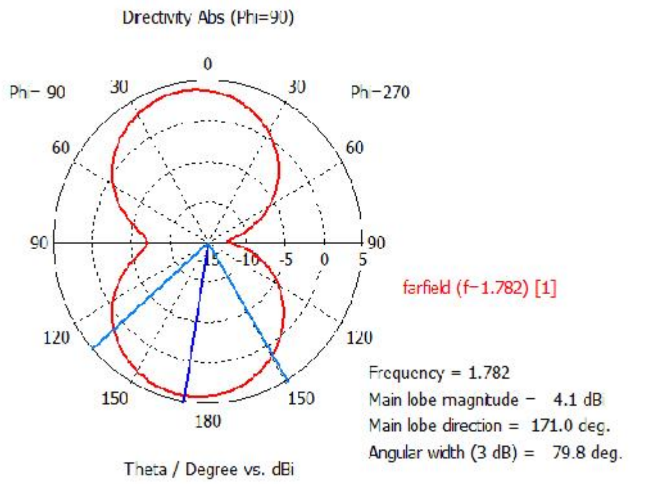

Fig.8 3D radiation pattern in polar form

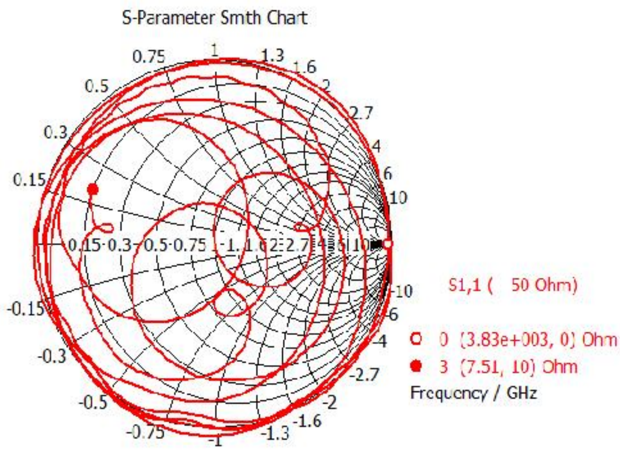

Fig.9 Line Impedance

In geometry of antenna ,two types of cut in the ground ,first is the rectangular cut dimension of (24mmx24mm) second cut in antenna is cylindrical is the dimension of inner radios 2mm and the outer radios is 6mm with centre (24,24) to fulfils the required values of parameters to act as a mobile satellite antenna.

III. RESULTS AND DISCUSSIONS

The fabrication of the antenna has been achieved on Fr-4 lossy substrate with $\varepsilon_r = 4.3$ and $h = 1.6$ mm. The prototype of the antenna is shown in Figure [2] with the dimensions of $W = S = 3$ mm and inner radius= 4 mm. Measurements of the return loss, voltage standing wave ratio and impedance *were* carried out by using a transient solver. Standard calibration procedure is used prior to the measurement. Analysis of the measured and simulated values for *S11*, VSWR, and radiation pattern were carried out, and as illustrated by Figures [5], [6], [7] and [8] ,[9] respectively.

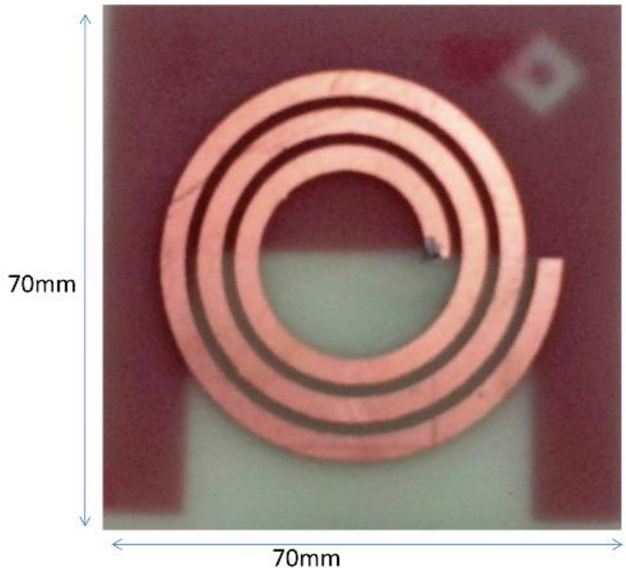

Fig.10 Front view of hardware

Fig.11 Back view of hardware

Parameter	Simulation	Measured
Frequency	1.78	1.77
Return loss	-43.6dB	-37.2dB
VSWR	1.012	1.010
Radiation pattern	Bidirectional	Bidirectional
Bandwidth	59MHz	60MHz

TABLE 3. COMPARISON BETWEEN MEASURED AND SIMULATED VALUES

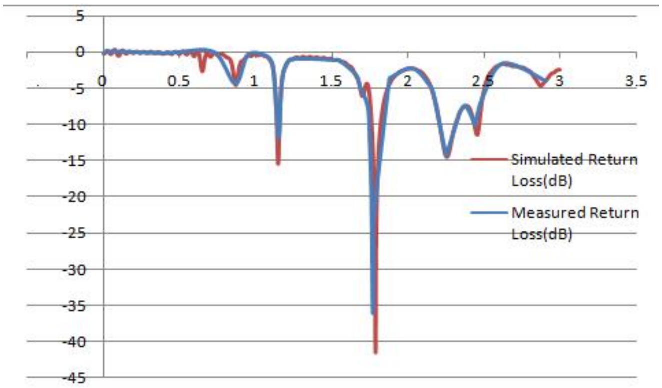

Fig.12 Simulated and Measured values of S_{11}

The value of the return loss (S_{11}) is -43.6 dB at 1.78 GHz in the simulation and -37.2 dB in the measuring result .This value very good since it was lower than -10 db. It shows the simulated value of VSWR is 1.012 and the measured value for VSWR is 1.010 while VSWR for the ideal antenna is unity it shows close agreement between measured and simulated VSWR. The low value of VSWR indicated that the antenna has low value of reflected power for F_c1.78 GHz. There are slight discrepancies between the simulated and measured values of the parameter of the circular spiral antenna .The measured value of VSWR is1.010 for F_c 1.77 GHz. The bandwidth for 1.9 GHz is 60MHz.The use of coaxial feeding techniques caused the input impedance to be inductive and vary slightly in values from the simulated value. However, the values were quite close with each other. The radiation pattern of the antenna was bi-directional as depicted by Fig. [8] Which obeyed the requirement to act as a space to earth antenna .The discrepancies might be due to the parasitic losses and the value of FR4 dielectric constant that was used during fabrication process. The FR4 dielectric constant may vary from 4.3 to 4.9. The discrepancy of dimension during fabrication also contributed factors that caused the errors were the effects of connectors, soldering patch and air gap that introduced to the error .The measured value of Zo is 50Ω which is slightly differs from simulated value. Specialty of this antenna is voltage standing wave ratio is very close to1.

IV.CONCLUSION

The unique feature of this antenna is its simplicity to get performance .This paper presents a geometric configuration for the circular spiral antenna for mobile satellite communication which provides a mean to higher directive gain and maximum radiation efficiency without using special techniques this antenna is special for voltage standing wave ratio because it is equal to 1.The response are considered to be acceptable as the measured results are quite similar to simulated circuit.

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