DESIGN AND SIMULATION OF SPIRAL ANTENNA FORBIOMEDICAL APPLICATION AT 2.7GHz

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***Abstract*— Spiral antennas have emerged in thermal therapy implant devices due to their compact size, low profile, and wide bandwidth. They are also easy to fabricate, which makes them cost-effective and scalable for mass production. The spiral antenna for thermal therapy implant devices operating at 2.7 GHz. The proposed antenna consists of a copper spiral with eight turns on a Fleece substrate. The substrate has a dielectric constant of 3.2 and a thickness of 3 mm. The overall dimensions of the antenna are 36mm x 28 mm. The simulation results show that the antenna has a resonant frequency of 2.7 GHz. The antenna has a peak gain of 3.5 dBi and a radiation efficiency of 90%. The radiation pattern of the antenna is directional, with a maximum gain in the direction perpendicular to the plane of the antenna. The directional radiation pattern of the antenna allows for targeted heating of the tissue surrounding the implant, while the small size of the antenna ensures that it can be easily integrated into the implant device.**

Keywords *— Flexible antenna, fleece substrate, Implant devices.*

1.INTRODUCTION

In recent days, spiral antennas have gained significant attention due to their potential applications in emerging technologies. A spiral antenna is a type of radio antenna that is characterized by its spiral-shaped design. The spiral antenna operates over a wide range of frequencies and is commonly used in applications where the antenna needs to be compact and have a wide bandwidth. Spiral patch antennas have been an effective choice for thermal therapy applications due to their efficient energy conversion and ability to generate localized heating. Thermal therapy involves heating targeted tissue to a specific temperature range to either destroy abnormal cells or enhance the effectiveness of other treatments. Implantable devices can be used to deliver thermal therapy directly to the targeted tissue using electromagnetic radiation. To effectively deliver thermal therapy, these devices require an antenna that can efficiently convert the electromagnetic radiation into heat energy. In this paper antenna has been designed using spiral shaped patch on fleece substrate material.

The fleece substrate material makes the antenna to be flexible one. spiral antenna is a recent advancement, which has a ground plane at back side. Spiral antennae have circular polarization with gain value near to 3.5 dB, and VSWR < 2 db. Compared to old spiral patch antenna it has many more benefits that include lighter in weight (due to its simple geometry or spiral shape), appreciable directivity, consistent gain and excellent performance in circular polarization. Absence of side lobes and presence of main lobe indicates minimum wastage of energy with all incoming wave propagating in forward direction.

2. Design Analysis

The Spiral patch antenna design is accomplished by following steps:

Step 1: Determine the operating frequency range.

The operating frequency range of the antenna is typically determined by the desired application. The wavelength at the centre frequency can be calculated using the formula[1]:

$$\lambda = c / f \quad [1]$$

where λ is the wavelength in meters, c is the speed of light in meters per second, and f is the centre frequency in Hertz.

Step 2: Calculation of effective dielectric constant (ε_eff).

The substrate material should be selected based on its dielectric constant and thickness. The dielectric constant affects the electrical properties of the antenna, while the thickness affects the mechanical stability. The effective dielectric constant can be calculated using the following formula [2]:

$$\varepsilon_{eff} = (\varepsilon_r + 1) / 2 + (\varepsilon_r - 1) / 2 * (1 + 12h / W)^{(-1/2)} \quad [2]$$

where ε_r is the relative dielectric constant of the substrate, h is the substrate thickness, and W is the width of the patch.

Step 3: Determine the dimensions of the patch.

The dimensions of the patch can be calculated using the following formulas [3] and [4]:

$$W = \lambda / 2 * \mathrm{sqrt}(\varepsilon_{eff}) / (1 + \varepsilon_{eff}) \quad [3]$$

$$L = \lambda / 2 * \mathrm{sqrt}(\varepsilon_{eff}) / (1 - \varepsilon_{eff}) \quad [4]$$

where W is the width of the patch, L is the length of the patch, and ε_{eff} is the effective dielectric constant of the substrate.

Step 4: Design the spiral structure.

The spiral structure is typically designed as a series of concentric circles or an Archimedean spiral. The number of turns and the spacing between the turns will affect the impedance and the bandwidth of the antenna. The dimensions of the spiral can be calculated using the following formulas [5] and [6]:

$$d = \lambda / 2 * \mathrm{sqrt}(\varepsilon\_eff) \qquad [5]$$

$$R = (2n + 1) * d / 4\pi \qquad [6]$$

where d is the spacing between the turns, R is the radius of the nth turn, n is the number of turns, and ε_eff is the effective dielectric constant of the substrate.

Step 5: Determine the feed location.

The feed location should be optimized to minimize reflection and maximize radiation efficiency. The optimal feed location can be calculated using simulation software or empirical methods.

Step 6: Choose the feed mechanism.

The feed mechanism can be a coaxial probe or a microstrip line. The feed point should be located at the centre of the spiral or at a distance of λ/4 from the centre to minimize reflection.

Step 7: Simulate the antenna design.

Once the antenna design is complete, it should be simulated using electromagnetic simulation software to verify the performance of the antenna. After the antenna design has been simulated, it should be fabricated and tested to verify its performance in the real world.

3. Fleece Antenna Design Consideration

For biomedical applications, the proposed antenna has been designed with rectangular shaped fleece substrate material. Implant devices is premeditated to get better the quality of life by enhancing functionalities. The design, manufacture, and performance of the spiral shaped patch antenna on a fleece substrate which shows the feasibility of the use of textile materials in the design of antennas working in the simulated frequency range especially for bio medical application.

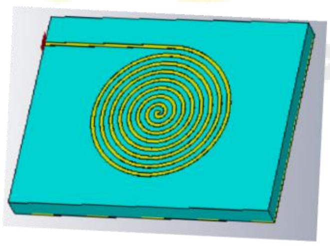

Figure 1. Design of spiral shaped patch antenna with fleece substrate material

The fleece substrate material having the permittivity of 1.3, dielectric constant of 3.2, tangent loss of 0.025mm and thickness of 3mm. The antenna is designed with number of turns in the radiating element to increase the gain and attain good bidirectional radiation characteristics. The design specifications of proposed antenna are listed in Table.1.

Table 1. Design specifications of the proposed antenna

S.NO	PARAMETERS	DIMENSIONS
1	No. of turns in Spiral	8
2	Width of each turn	0.25mm
3	Substrate Length	36mm
4	Substrate Width	28mm
5	Substrate Height	3mm
6	Feed Length	8.39mm
7	Feed Width	0.25mm
8	Fleece permittivity	1.3
9	Fleece dielectric constant	3.2
10	Fleece tangent loss	0.025

4. Simulated Results and Discussions

The simulation of spiral patch antenna done on CST (computer simulation technique) The geometry of spiral antenna consists of three basic parts that are spiral patch, ground plane and substrate. The substrate of antenna has been simulated on fleece having dielectric constant 'Ɛr' value of 3.2and thickness of 3mm. The antenna resonates at the frequency of 2.75GHz with low return loss which is estimated about -23 dB.

A. VSWR

Voltage standing wave ratio (VSWR) shows how effectively RF power is sent from source via transmission. link to sink or load. It gives ratio of the highest voltage and the lowest voltage value along the transmission medium. We have obtained a VSWR equal to 1.3.

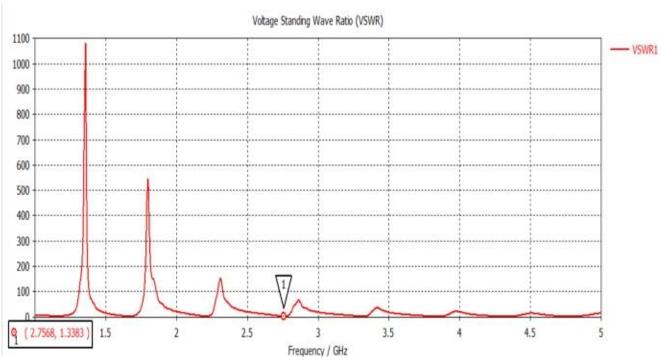

Figure 1. VSWR of the proposed antenna

B. S-Parameter

S11 parameter is also called ‘reflection coefficient’. The S parameter of antenna is equal to -18dB. For this antenna, return loss is minimum at operating frequency of 2.7 GHz.

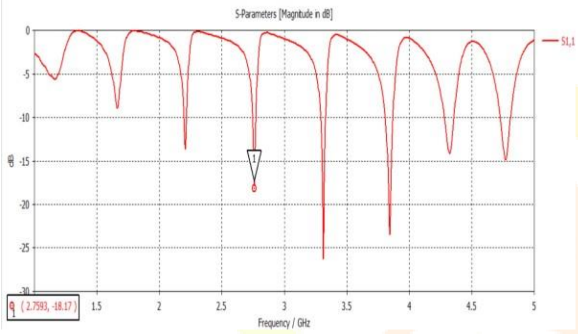

Figure 2. Frequency response of the spiral shaped patch antenna

C. Directive Gain

The gain obtained by the proposed antenna is 3.5 dB. Antenna gain relates the intensity of an antenna in each direction to the intensity that would be produced by a hypothetical ideal antenna that radiates equally in all directions and has no losses. The gain of an antenna is directly related to its directivity, and it is a measure that is also taken into account for the efficiency of the antenna.

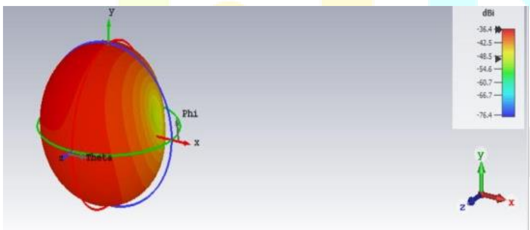

Figure 3. Gain of the spiral shaped patch antenna

5. CONCLUSION

This paper comprises the design of spiral shaped patch antenna with fleece substrate integrated into devices for biomedical applications. As the designed antenna is simple, cost effective and small in size, it facilitates integration into cloth for various applications. The antenna has been designed to operate at a frequency of around 2.75GHz used for implant devices and thermal therapy with the gain of 3.554 db.

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