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Frequency and Time domain Analysis of Dual-Band Biomed Antenna

Kavitha. V. P [1], Afra Fathima. K[2], Aishwarya. K[3], Chandrasekhar Manasa[4], Kavyadevi.R[5]
[1, 2, 3, 4, 5] Department of Electronics and Communication Engineering Velammal Engineering College (Aff. to Anna University) Chennai. India

Abstract: *In this paper we propose to design an efficient implantable antenna system with the most user friendly antenna design tool, Computer Simulation technology (CST) Studio. This is a comparative study of three different types of microwave antennas (patch, helical and loop) based on their return loss(S11) parameter along with the study of direction of line feed , which in turn will help in bringing out the most efficient implantable antenna that can be used in the UHF (GHz) zone. The external and implantable antennas are then fabricated in accordance to the efficiency analysis in the time and frequency domain. The two requirements that drive the design of this implanted antenna system are : They need to remain powered over a long duration and have the capacity to communicate with an external system with sufficient bandwidth. The design of these antennas is capable of communication with implants inside the human body as well. With the limitation in the technological facilities available, only a model of the implantable antenna system can be designed but can be refined in the future for commercial use.*

Keywords*: Antenna, Spiral, Helical, Microstrip patch, UHF system, Frequency domain, Time domain, return loss, Communication*

I. INTRODUCTION

The medical technology is currently developed to be at a high performance level and the role of biomedical applications in engineering is more than the past. Today glucose monitoring, insulin pumps, deep brain simulations and endoscopy are a few examples of the medical applications that can take advantage of remote monitoring system and body implantable unit. Body implantable devices are widely researched for humans, in the applications such as monitoring blood pressure and temperature, tracking dependent people or lost pets, wirelessly transferring diagnostic information from an electronic device implanted in the human body for human care and safety, such as a pacemaker, to an external RF receiver. Antennas can be implanted into human bodies or can just be mounted over the torso (skin-fat-muscle) to form a bio-communication system between medical devices and exterior instruments for short range biotelemetry applications.

The implantable antenna becomes an important part of the wireless communication between implantable device and external transceiver, where it can improve the performance of wireless communication link without increase of transmit power. High performance implantable antenna of a small size is needed for this application[1].

For real time monitoring applications, the dual band implantable antenna is proposed to be operated in the frequency of 402–405 MHz (MICS band) and for transmission of data , 2.4-2.48 GHz (industrial scientific and medical band: ISM band)[3]

It is well-known that the optimal choice of operating frequency for transferring power in an implanted device is a function of the size of the implanted system as well as the electromagnetic properties of the tissue in which it is embedded. For recording and stimulation , with implants in the ≈ 1 cm^3 volume class, transferring wireless power in the HF spectrum (e.g. 13.56 MHz) represents a good compromise between antenna size and efficiency.[1] To support data rates in 10sec to hundreds of Mbps, a communication link in the UHF spectrum (GHz) is a common choice, due to the very limited bandwidth available in the HF spectrum. The antenna system is intended for dual band systems where power is supplied to the implant via inductive coupling in the HF band, while data is transferred via UHF near-field coupling.

We thereby propose a comparative study of three different types of microwave antennas (patch, helical and spiral) based on their return loss (S11) parameter. This in turn will help us in proving which antenna is more efficient in the UHF zone. Measuring the frequency response of a communication channel (antenna) and anticipating of the shape of the bits (in time) through the channel will be affected can help in understanding the viability of the antenna. The external and implantable antenna can then be fabricated in accordance to the efficiency analysis in the time and frequency domain.

II. RETURN LOSS (S11)

S_{11} is a measure of how much power is reflected back at the antenna port due to mismatch from the transmission line. When connected to a network analyzer, S_{11} measures the amount of energy returning to the analyzer – not what's delivered to the antenna. The amount of energy that returns to the analyzer is directly affected by how well the antenna is matched to the transmission line. A small S_{11}indicates a significant amount of energy has been delivered to the antenna. S_{11} values are measured in dB and are negative.

III.MICROSTRIP PATCH ANTENNA

The microstrip patch antenna consists of a metallic patch on a grounded substrate. The metallic patch can take many different configurations; however the rectangular and circular patches are the most popular because of ease of analysis and fabrication, and their attractive radiation characteristics.

Microstrip antennas are low profile, conformable to planar and non-planar surfaces, simple and inexpensive to fabricate and mechanically robust when mounted on rigid surfaces. When the particular patch shape and mode are selected they are very versatile in terms of resonant frequency, polarization, pattern and impedance. The patch elements radiate primarily linearly polarized waves if conventional feeds are used with no modification.

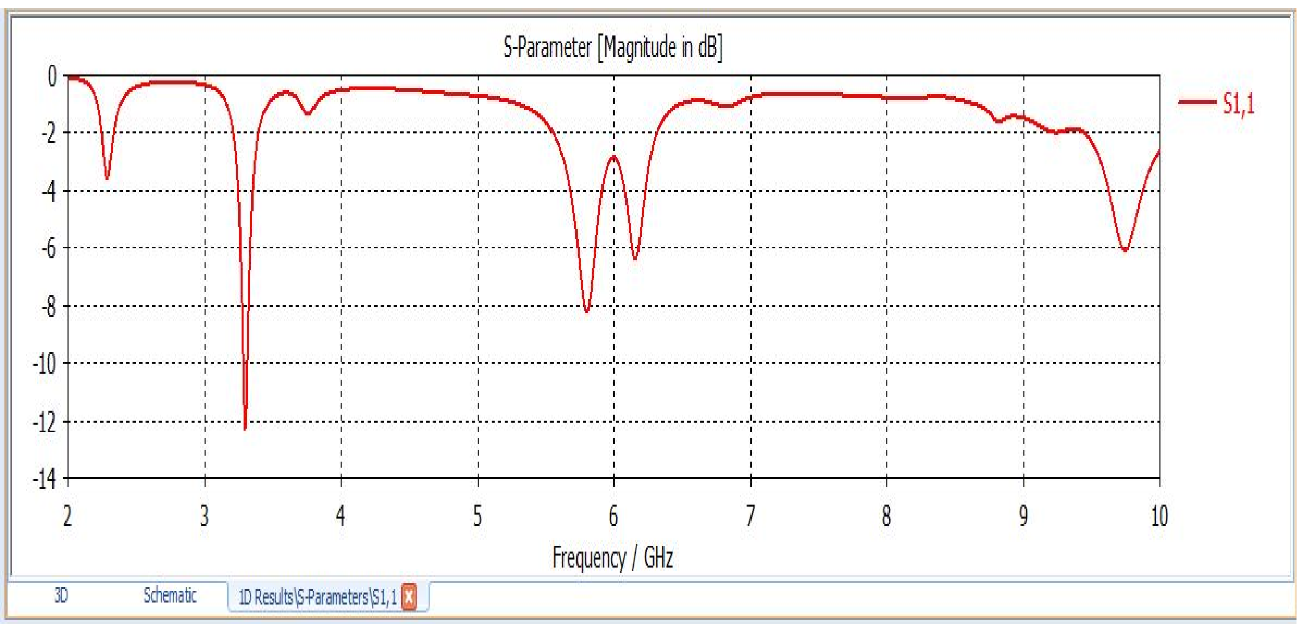
IV.SIMULATION

Microstrip patch antenna is designed in frequency domain within the range of 2GHz to 10GHz .As already specified, this antenna consists of ground plane , dielectric and line feed.

The template settings of the ground plane for both time and frequency domain analysis is as follows – length is 60mm width is 60mm, thickness is 0.03 mm, material is copper. Dielectric has a length of 60mm , width of 60mm, thickness of 1.56mm and the material is FR-4 lossy . Line field is of thickness 0.03mm and width is 1mm. Patch is of length 29.8mm ,width is 38.4mm and the material used for patch is copper. The excitation is given at the end of line feed and the entire process is simulated and the return loss is observed.

A. Frequency domain analysis : S-parameter - Return loss (S11)

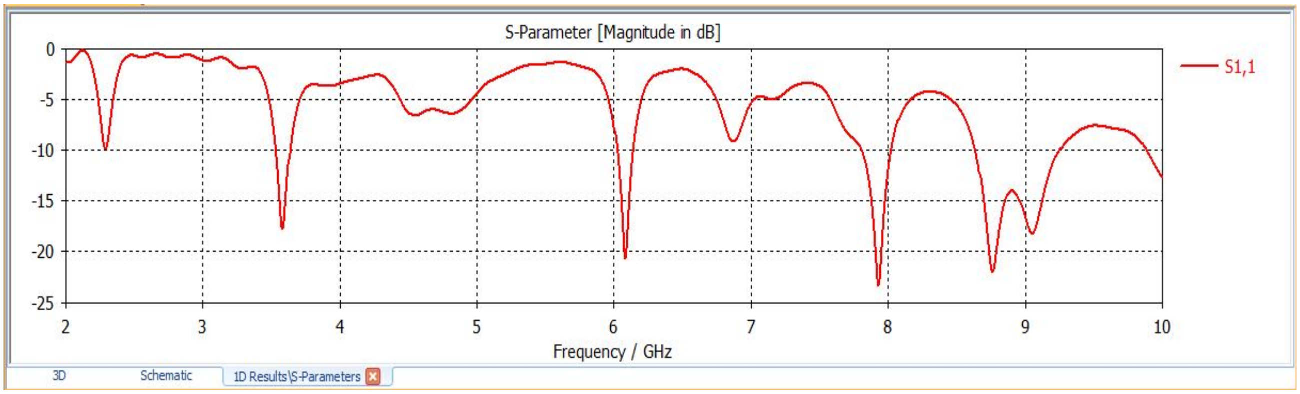
In the Frequency domain analysis of microstrip patch antenna , the return loss ripples within the frequency range of 2GHz to 10GHz was found to be as follows:



The dip near the ISM band (2.4GHz) is nearly -4dB while the next sudden dip occurs at around 3.4GHz with -12dB

B. Time domain analysis : S-parameter - Return loss (S11)

In the Time domain analysis of microstrip patch antenna , the return loss ripples within the frequency range of 2GHz to 10GHz was found to be as follows:



The modulation dips are found to be more frequent in the time domain starting with -10dB at the ISM band till nearly -25dB at 6.1GHz

V. SPIRAL ANTENNA

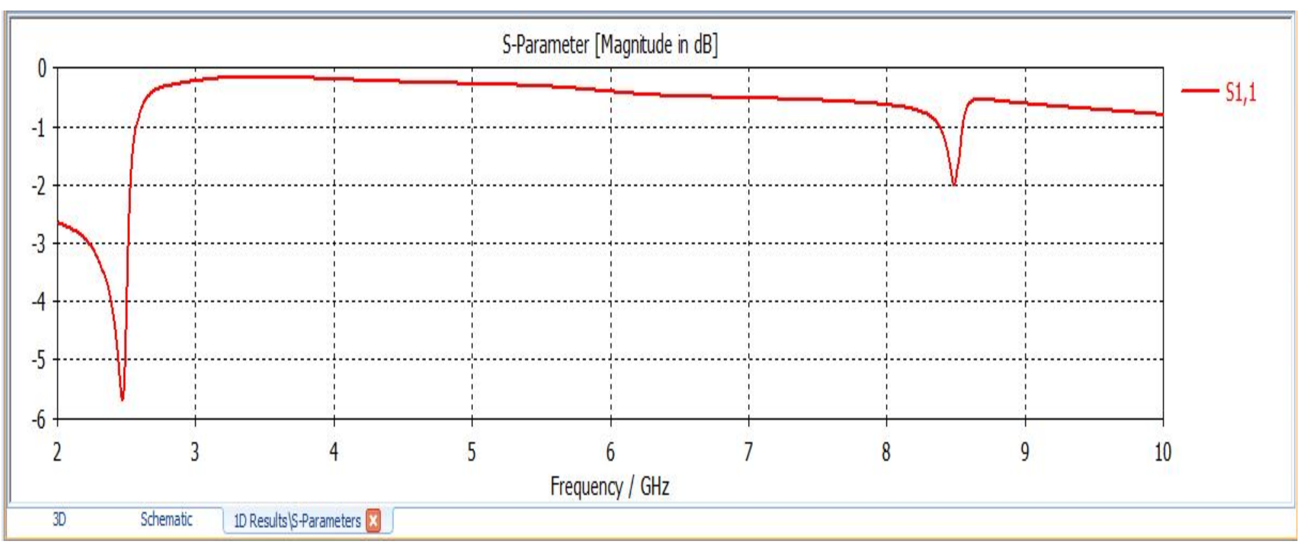
Spiral antennas belong to the class of frequency independent antennas which operate over a wide range of frequencies. Polarization, radiation pattern and impedance of such antennas remain unchanged over large bandwidth. Such antennas are inherently circularly polarized with low gain. Array of spiral antennas can be used to increase the gain. Spiral antennas are reduced size antennas with its windings making it an extremely small structure. Lossy cavities are usually placed at the back to eliminate back lobes because a unidirectional pattern is usually preferred in such antennas. Spiral antennas are classified into different types; Archimedean spiral, square spiral and star spiral etc. Archimedean spiral is the most popular configuration.

VI. SIMULATION

Spiral antenna is designed in time domain with frequency within the range of 2GHz to 10GHz .The thickness of the spiral is 0.095mm , number of turns is 4 , width is 1.3mm , gap is 1.2mm . The base material is made of pure copper separated from the spiral ring by a dielectric, which is made of FR-4 material. The spiral ring is made of copper to which the feed is given . the entire template is then simulated and the inferences are observed.

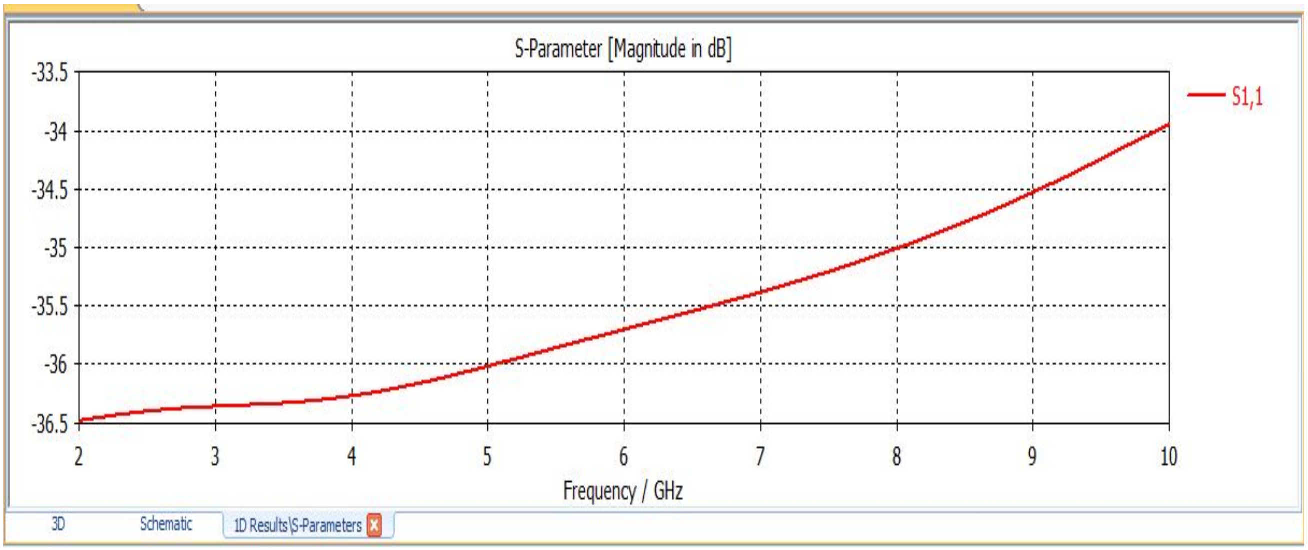
A. Frequency domain analysis : : S-parameter - Return loss (S11)

In the Frequency domain analysis of spiral antenna , the return loss within the frequency range of 2GHz to 10GHz was found to be as follows:



B. Time domain analysis : : S-parameter - Return loss (S11)

In the Time domain analysis of spiral antenna , the return loss within the frequency range of 2GHz to 10GHz was found to be as follows:



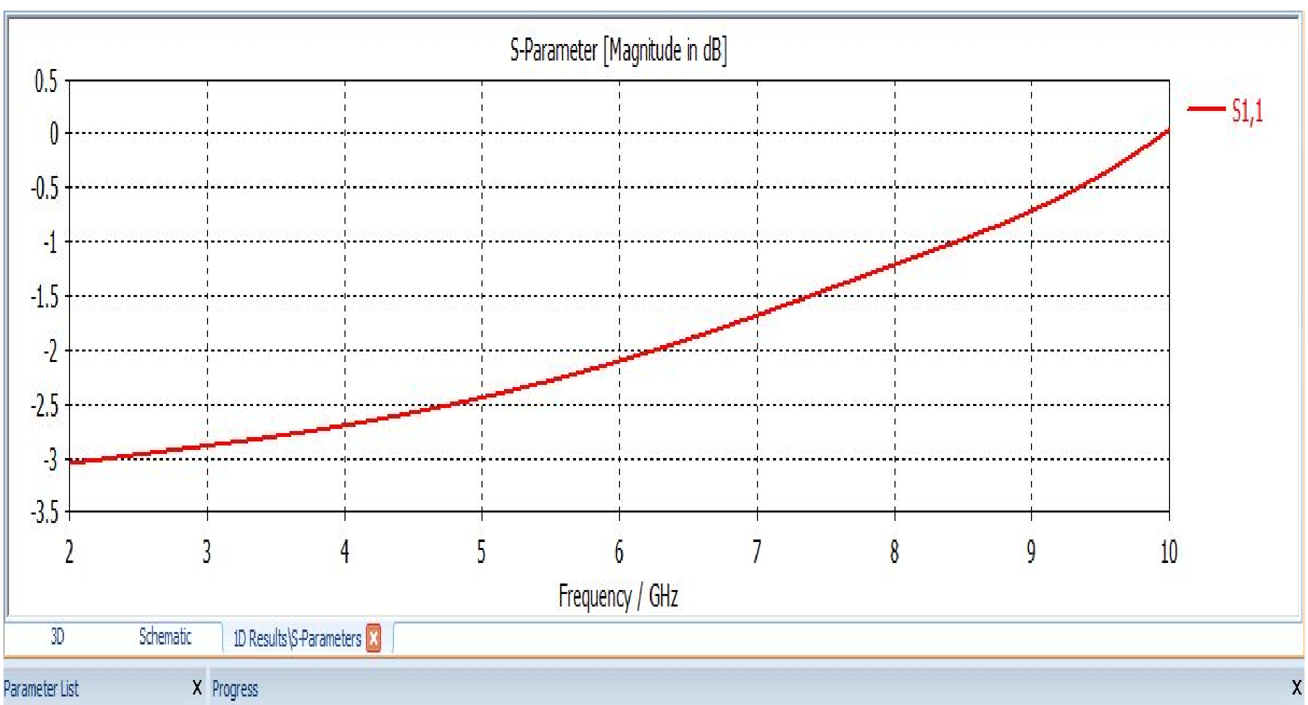
VII. HELICAL ANTENNA

Helical antennas can operate in one of two principal modes: normal mode or axial mode. In the normal mode of operation the field radiated by the antenna is maximum in a plane normal to the helix axis and minimum along its axis. To achieve normal mode operation, the dimensions of the helix are usually small compared to the wavelength.

These simple and practical antennas were primarily designed to replace very large antennas. Their reduced size is therefore most suitable to mobile and portable communication systems.

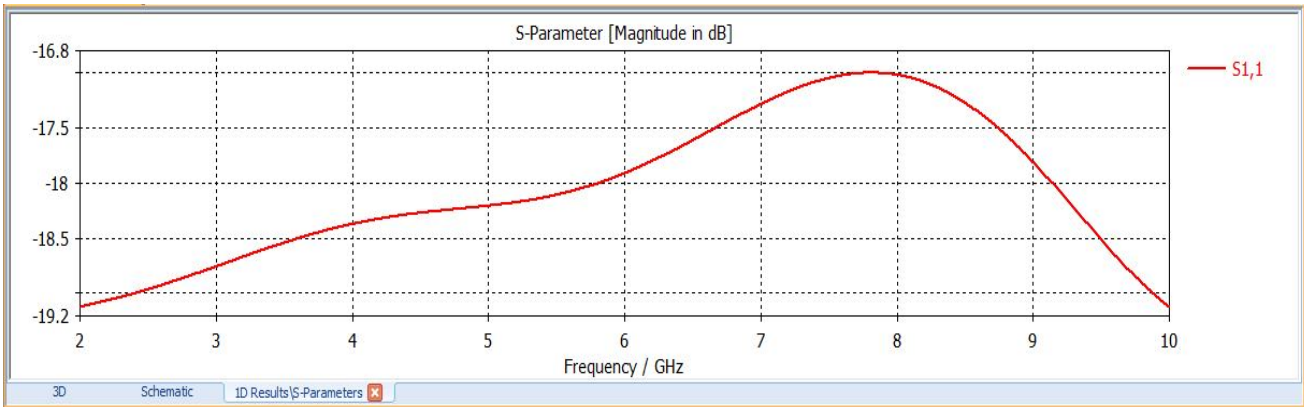
A. Frequency domain analysis: : S-parameter - Return loss (S11)

In the Frequency domain analysis of helical antenna , the return loss within the frequency range of 2GHz to 10GHz was found to be as follows:



C. Time domain analysis : S-parameter - Return loss (S11)

In the Time domain analysis of helical antenna , the return loss within the frequency range of 2GHz to 10GHz was found to be as follows:



V. CONCLUSION

On an overall basis , this paper was framed to show a comparative study of three different types of antennas (Microstrip patch , Helical and Spiral) based on their return losses especially in the ISM band (2.4GHz) and also for the wider range from 2GHz to 10GHz using the CST Software Studio.

An antenna to be used in the biomed implantable application should have a high return loss for a good line match .The larger the impedence difference the number of modulation dips increase within the desired frequency range. This desired type of the return loss requirement was analysed and was found to be satisfied in the spiral antenna analysis. This study was conducted based on observing the radiation pattern obtained and the drop in the s-parameter levels.

On further study , the directivity and s- parameter analysis in both the time and frequency domain can be considered to frame an indepth research analysis about the communication flow of the antenna in detail.

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