Simulation of Microstrip Patch Antenna for Cranial Implant

M.Najira Banu

Department of Electronics and Communication Engineering

IFET College of Engineering,

(An Autonomous Institution),

Villupuram, TamilNadu, 605108.

ernajirahanif@gmail.com

K.Jayabarathy

Department of Electronics and Communication Engineering

IFET College of Engineering

(An Autonomous Institution),

Villupuram, TamilNadu, 605108.

indhujaya55@gmail.com

ABSTRACT:

The Ultimate objective of this paper is to simulate an antenna for medical applications. The Antenna is made to Resonate at a particular frequency or specific application. Microstrip patch antenna Brings true awareness to the powerful devices they connect and simplify the lives. Its modest size and simple construction make it highly appealing. Microstrip Patch Antenna is made to resonate at 5.8 GHz for a cranial implant. CST Microwave Studio, a commercially available simulation program, was used to create the simulation of the Microstrip Patch Antenna. Slots are created at the patch such that it resonates at a particular frequency. Various return loss value is obtained at several frequencies. The return loss and gain obtained from the antenna is up to -34.4dB and 3.60214 respectively.

Keywords: Rectangular Microstrip Patch Antenna, Cranial Implant, Return Loss, VSWR, Bandwidth, Gain, Directivity.

I. INTRODUCTION

Microstrip Patch antennas are increasing popularity and becoming highly appealing in current and future wireless communication systems. It is especially intended to transmit and/or receive electromagnetic radiation for very brief periods of time. It is well understood that Microstrip Patch Antenna design continues to be a crucial element in to measure distance with high degree of accuracy. In order to provide improved efficiency and gain, Microstrip Patch Antenna is used [9]. The power density ranges from 1/10,000 to 1/100,000. So the impact on human health is negligible. Microstrip patch antenna provides better medical applications without the demand for manual labour or physicians to track sportsmen and health issue patient's body conditions. Most connected devices rely on what and when to anticipate needs. Microstrip patch antenna provides a third eye that can see in every direction. The implanted antenna communicates with the external source via uplink and downlink. The uplink connects the implant antenna to the external device while the external device communicates with the implant antenna via downlink. [7]. A Micro strip or Patch Antenna is a metal patch installed at ground level with a dielectric substance in between. Because they can be printed directly onto a circuit board, Microstrip or patch antennas are becoming more popular. They can be fixed on flat surfaces because of their low profile shape, which is generally square or rectangular. The proposed antenna must operate at the frequency of 5.8 GHz. If the resonating frequency and dielectric constant of the material used in substrate is known, it is easy to calculate the width and length of the patch antenna using the below formulae .

$$width = \frac{c}{2f_0\sqrt{\frac{\varepsilon_R+1}{2}}}; \quad \varepsilon_{eff} = \frac{\varepsilon_R+1}{2} + \frac{\varepsilon_R-1}{2}\left[\frac{1}{\sqrt{1+12(\frac{h}{w})}}\right]$$

$$Length = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} - 0.824h\left(\frac{(\varepsilon_{eff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{w}{h}+0.8\right)}\right)$$

Formula to Calculate Width and Length

To confirm the utility of the current proposed design, results in terms of VSWR, Return Loss, and Bandwidth Efficiency will be shown.

II. DESIGN FLOW:

The design flow for the entire project is:

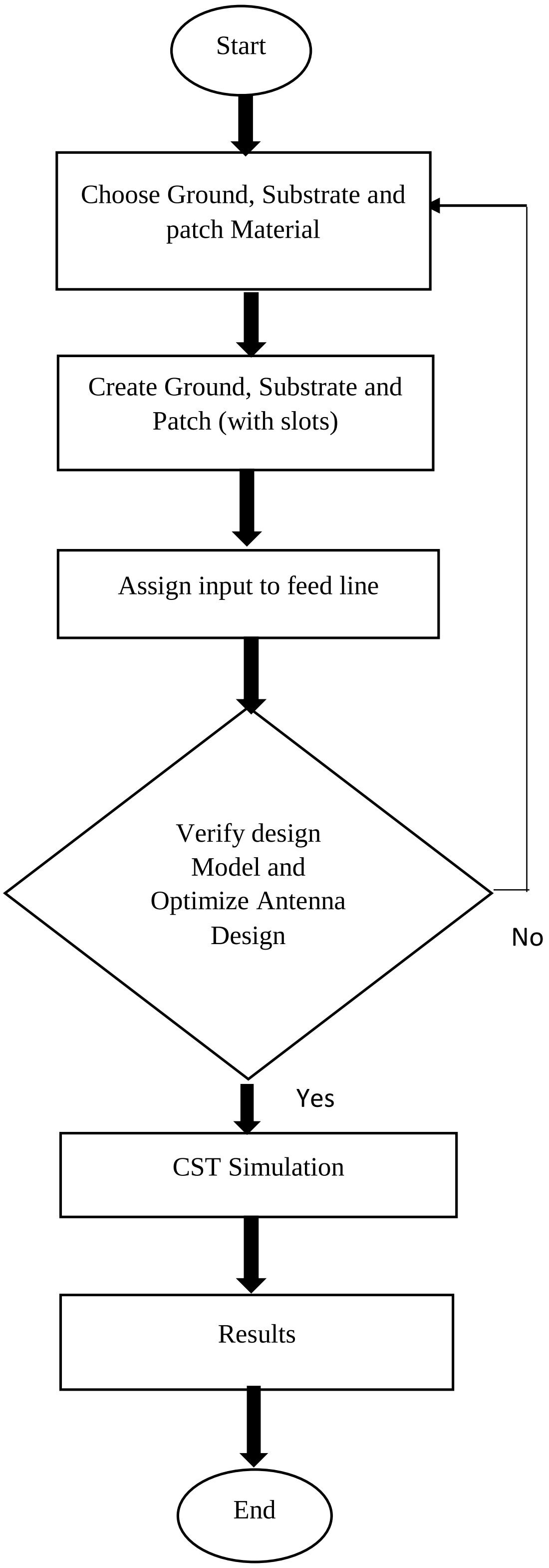

Fig 2.1 Design flowchart

III. MICROSTRIP PATCH ANTENNA FOR CRANIAL IMPLANT:

Microstrip patch antenna is very popular due to its light weight conformability and low cost. Over the last two decades, wireless communication has increased at an exponential rate. It is capable of communicating over long distances [3]. A Microstrip Patch antenna is made up of a radiating patch on one side and a ground plane on the other side of a dielectric substrate. The patch is usually composed of conductive metals like copper or gold and may be manufactured into any form. On the dielectric substrate, the radiating patch and feed lines are normally photo etched. The fringing fields between the patch edge and the ground plane those are what cause Microstrip patch antennas to emit. The designed antenna is made from FR-4, a low-cost and widely accessible dielectric material with a permeability of 4.4.

IV. ANTENNA DESIGN:

The antenna designed for cranial implant is rectangular in shape with the slots at the patch. Ground is created with the dimension of 44 x 41 and substrate is created with the same dimension above the ground. Out of the three layers, ground and patch uses copper as a material with the thickness of 0.035mm. The material used for the substrate is FR-4 which has a thickness of 1.6mm and dielectric constant of 4.3 [1]. A slot is created at the centre with the same thickness (0.035) and that is subtracted from the patch such that its performance is been enhanced [2]. By creating the slots and patch, the antenna structure is optimized to resonate at particular frequency.

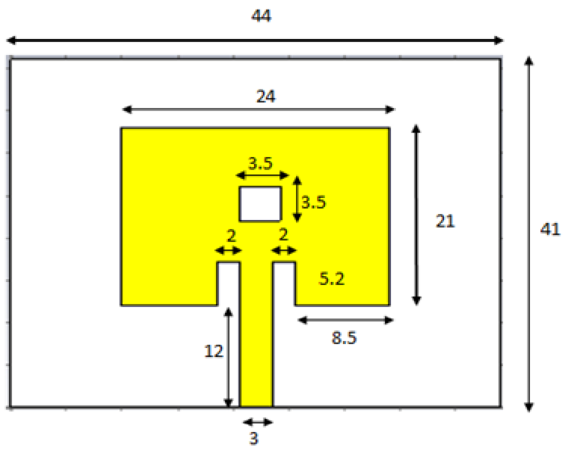

Fig 4.1 Proposed antenna structure with dimensions

The thermal expansion capabilities of copper and the circuit board base material FR4 are advantages. Because of its inexpensive cost and mechanical qualities, FR4 is still the preferred substrate for many applications [3]. The usage of FR-4 material as a substrate has a high strength to weight ratio, light weight and moisture resistant.

V. DESIGN REQUIREMENTS:

The dimensions of the proposed antenna are critical in achieving the desired outcomes. The following table shows the design requirements for a rectangular micro strip patch antenna[5].

Notation	***Value(mm)***	***Description***
Wp	24	Width of the patch
Wg	44	Width of the ground
Wf	3	Width of the feed
Wc	2	Width of the cut
Lp	21	Length of the patch
Lg	41	Length of the ground
Lf	12	Length of the Feed
Lc	5.2	Length of the cut
ht	0.035	Thickness of ground and patch
hs	1.6	Thickness of Substrate

TABLE 1 Antenna design parameters with dimensions

VI. FINAL DESIGN

The finalized antenna structure obtained using this design process is depicted in below figure using the CST software.

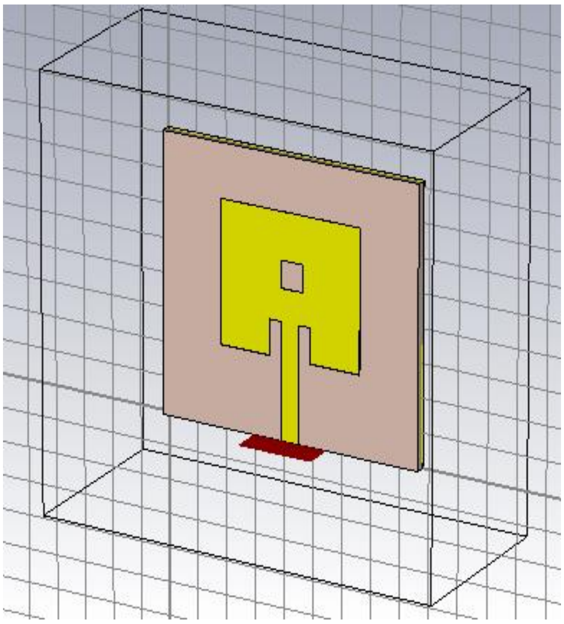

Fig 6.1 Front View of Antenna structure

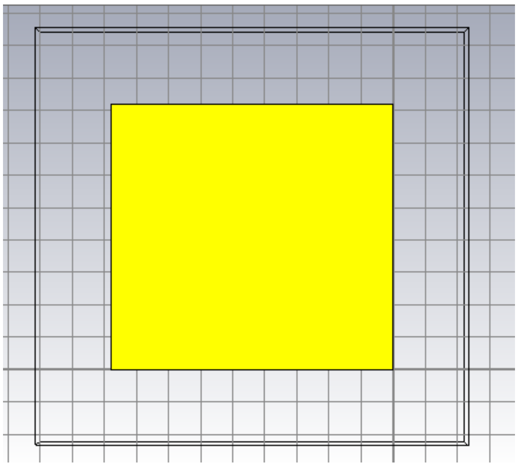

Fig 6.2 Back View of Antenna Structure

VII. SIMULATION OUTPUT

The antenna is analysed with the parameters like Return loss, VSWR, Bandwidth and Gain along with radiation pattern [8] [10]. The bandwidth obtained in this design is 290MHz.

1. RETURN LOSS:

Return loss is a measurement of how modest the "return" or reflection/echo is, or it is the measurement of the reflected wave or signal power moving or returning from an antenna to a transmitter. The average return loss must be less than-10dB. The obtained return loss is-34dB.

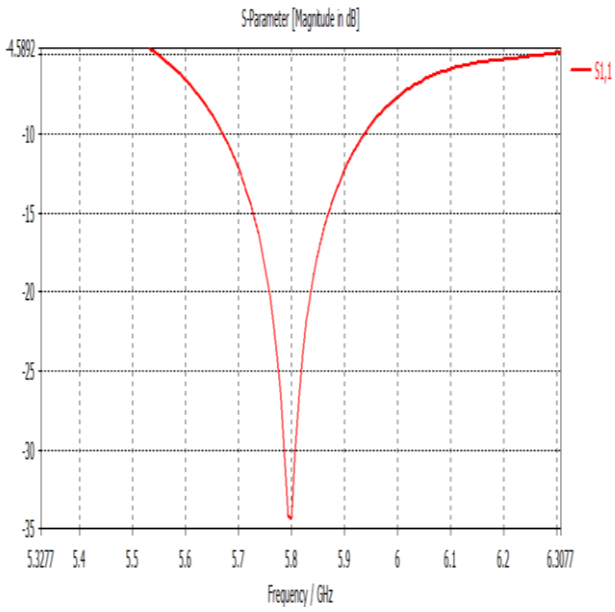

Fig 7.1 Return loss

2. VSWR

It officially stands for Voltage Standing Wave Ratio. This dimensionless ratio (no measurement units) is the same parameter as return loss, just expressed in a different scale. VSWR is somewhat old fashioned, and was often measured by the transmitter itself while transmitting into an antenna. The ideal VSWR value must be less than 2. The obtained VSWR value is 1.041215.

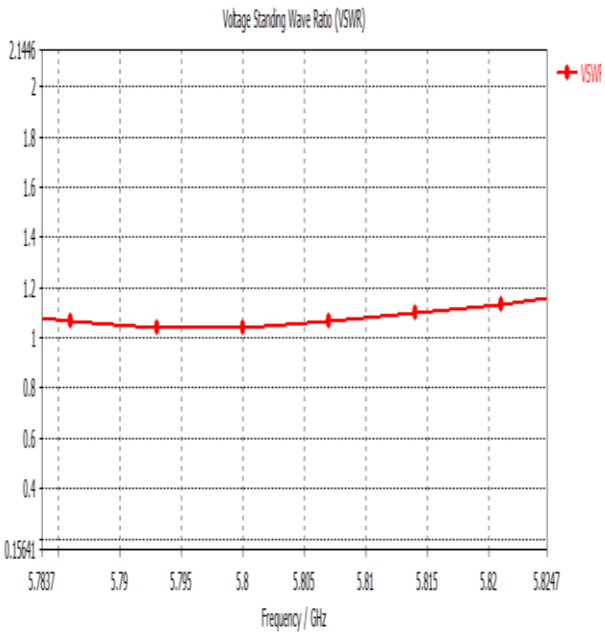

Fig 7.2 VSWR

3. RADIATION PATTERN

The radiation pattern is described as a mathematical function or graphical depiction of the antenna's far field radiation qualities as a function of the electromagnetic (EM) wave's direction of departure.

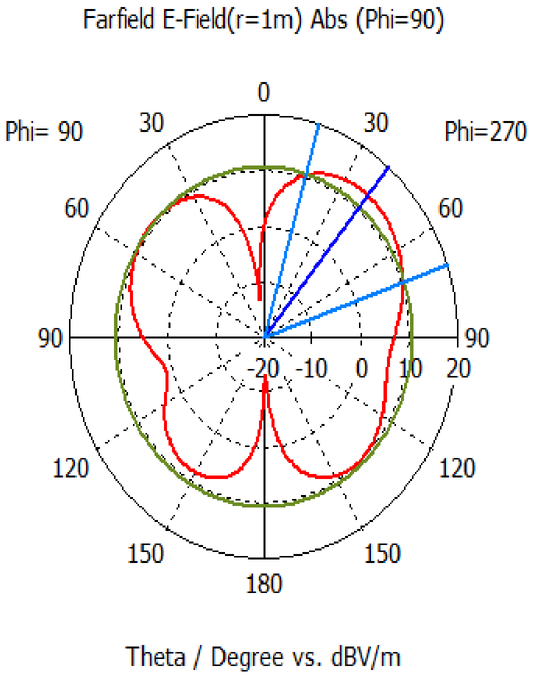

Fig 7.3 Radiation pattern for E-Field

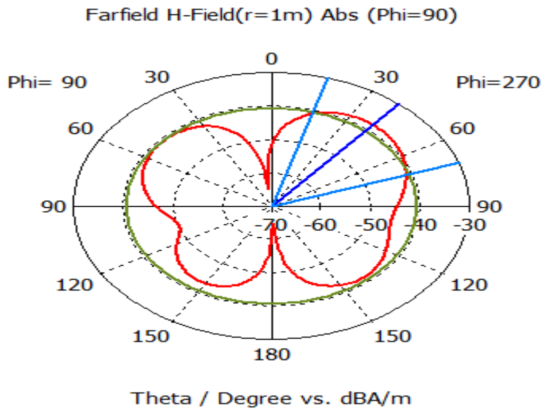

Fig 7.4 Radiation pattern for H-Field

4. GAIN

The gain obtained for the design of Microstrip patch antenna for cranial implant is 3.602 db.

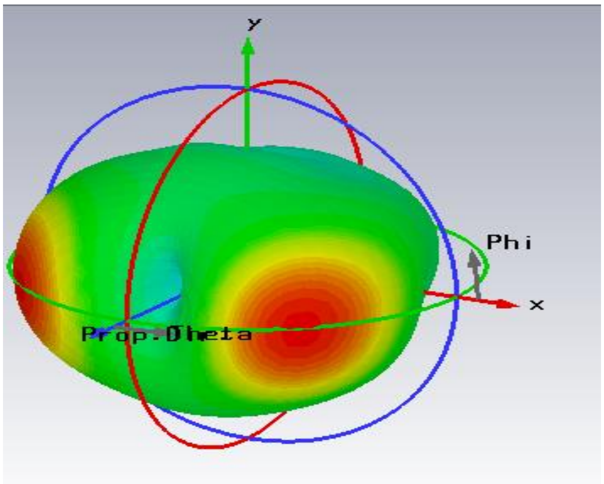

Fig 7.5 Gain

5. DIRECTIVITY

The directivity obtained is 5.279dB for the cranial implant using Microstrip patch antenna.

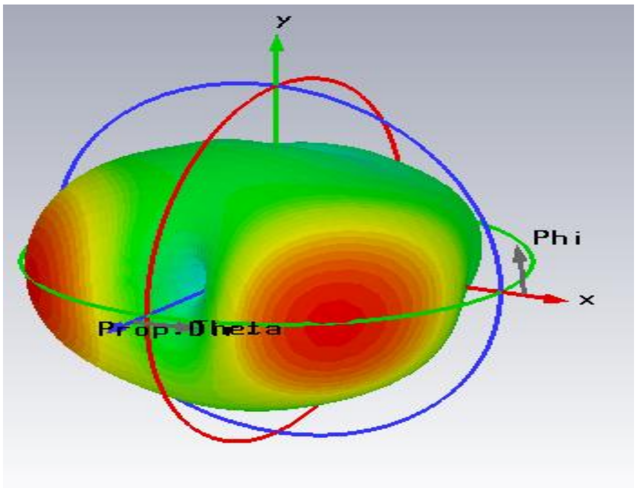

Fig 7.6 Directivity

VIII. CONCLUSION:

Cranioplasty is a surgical treatment that repairs a bone defect or deformity in the skull, which can be accomplished with the use of cranial implants. The majority of such anomalies are repaired to restore the structure and function of the lost cranial bone. The designed Antenna produces better VSWR value, return loss and efficient Bandwidth. It can be easily integrated with microwave integrated circuits. Thus it is best suitable for the cranial implant in medical application**.**

IX. REFERENCES:

[1] Jayabharathy.K, Shanmuganantham.T “A Cat Face Shaped Textile Wearable UWB Antenna for Smart Garment,” IEEE, International Conference on Intelligent Computing, Instrumentation and Control Technologies, July 2019.

[2] Shaobo Chen; Hongwei Howard Liu “UWB slot antenna on shielding can for high accuracy positioning application” IEEE, 2020 Global Congress on Electrical Engineering (GC-ElecEng), December 2020.

[3] Anubhav Kumar; Divya Saxena “Compact UWB Microstrip Antenna for THz Communication Application” IEEE, 2020 9th International Conference System Modelling and Advancement in Research Trends (SMART), February 2021.

[4] Priyanka Das; Mouli Ghosh “A Novel Design of Microstrip Monopole Antenna for UWB Applications” IEEE, 2020 4th International Conference on Electronics, Materials Engineering & Nano-Technology (IEMENTech), November 2020.

[5] Prince Kumar; Girish Chandra Ghivela; Joydeep Sengupta “Optimized N-Sided Polygon Shaped Microstrip Patch Antenna for UWB Application” IEEE, International Conference on Computing, Communication and Networking Technologies (ICCCNT) , December 2019.

[6] Mengyu Wang; Jun Xiao; Tongyu Ding “A Microstrip Antenna for UWB Applications” IEEE, Cross Strait Radio Science and Wireless Technology Conference (CSRSWTC), December 2021.

[7] F A. Lalitha Bhavani Konkyana; B. Alapati Sudhakar “A Review on Microstrip Antennas with Defected Ground Structure Techniques for Ultra-Wideband Applications” IEEE, International Conference on Communication and Signal Processing (ICCSP), April 2019.

[8] N. Sheshaprasad; S. B. Bhanu Prashanth “A Study of UWB Microstrip Antenna Parameters for Wireless Applications” IEEE, International Conference on Data Science and Communication (IconDSC), August 2019.

[9] Sonmati Verma; Rajiv Kumar Singh; Neelam Srivastava “Design of Stacked Patch Microstrip Antenna for UWB Applications” IEEE, IEEE 7th Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON), March 2021.

[10] Md. Ali Akbar; Swarup Chakraborty; “Performance Analysis of a Microstrip Patch Antenna for Biomedical Applications” IEEE, International Conference on Electrical, Computer and Communication Engineering (ECCE), April 2019.

[11] E.Annalakshmi, and Prabakaran.D, “A Patch Array Antenna for 5G Mobile Phone Applications”, Asian Journal of Applied Science and Technology, Vol. 1. No. 3, Pp. 48-51, 2017.

[12] R., Senthil Kumaran, D. Prabakaran, S. Mohammed Nizar, and K. Suresh Kumar. "Software-Defined Network (SDN) Architecture and Security Considerations for 5G Communications." Design Methodologies and Tools for 5G Network Development and Application, Pp.28-43. 2021.

[13] E.Aravindraj, G.Nagarajan and R.Senthil Kumaran, "Design and Analysis of Recursive Square Fractal Antenna for WLAN Applications, "2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE), IEEE Explore, Vellore Institute of Technology, Vellore, India, 2020, pp. 1-5.

[14] Hire, M. R., & Ahire, “AReview on Microstrip patch antenna Design and its applications”, Available at SSRN 4043696, 2022.

[15] S. Jagatheeshwari,M. Arulaalan and K. Mahendran, S.Subbulakshmi, “Design of Gamma Shaped Patch Antenna for UWB Applications”, Journal of Xidian University, 2020. (ISBN No: 1001 – 2400)