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Trapezoidal Patch CPW Fed Array Antenna in Wearable Devices for Medical Application

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ABSTRACT

To monitoring the enlargement of lateral ventricle and brain atrophy by using a wearable non-invasive antenna .the most common form of neurode generation disease is Alzheimer's disease and leading cause of dementia today. The progressive shrinkage of the brain volume and weight is the effect of Alzheimer's disease. Currently, MRI and CT scanners can detect and show images of the brain during different stages of Alzheimer's disease. However, its limited accessibility, high costs, and static structure make it inconvenient for some to use. This paper presents a wearable device comprising of flexible microwave antennas, with an operating frequency range of 300 MHz to 3 GHz that detects the progression of brain atrophy and lateral ventricle enlargement in patients with Alzheimer's at the earliest stage possible. In this work, the software used to analyse and design the proposed antenna is CST studio suite. The operating principle of the antennas are simulated in near field using CST and the device is experimentally validated using lamb brain samples and samples representing cerebral spinal fluid (CST). The measured reflection coefficients (s11) were found to correlate with changes in brain volume and changes in volume successfully, thus giving an indication of the progression of Alzheimer's disease in a patient.

Keywords- Electromagnetic, Vector Network Analyser (VNA), Flame Retardant (FR-4), Wearable RF Device, Microwave RF Coaxial Switch, Vivaldi antenna, Cerebral Spinal Fluid (CSF).

I. INTRODUCTION

Neuro degenerative diseases result from a progressive loss of structure or function of neurons, including the death of neurons. Dementia is a disorder of the brain affecting memory and language skills in elderly people. Alzheimer’s disease is the most common type of dementia and about 5 - 6% of people in the age group of 65 – 70 years in India suffer from this problem. Worldwide around 50 million people have dementia and there are nearly 10 million new cases every year

.Symptoms includes: substantial memory loss, problems with language, disorientation, loss in concentration [1],

[2] Mood swings, behavioural issues, and eventually leading to loss of bodily functions and death [3]. The life expectancy of those diagnosed with Alzheimer's disease is between 3 to 9 years. One of the distinguishing features of Alzheimer's disease is the progressive shrinkage of the brain due to atrophy [4]. It has been found that the brain volume can reduce by more than 22% of the normal brain in Alzheimer's patients and that the brain's weight after Alzheimer's disease frequently falls under 1 kg as compared to the normal adult brain weight of 1.2 to 1.4kg[5]. Detection and imaging of neurodegenerative diseases, such as Alzheimer's disease, has been the focus of research studies in the past decade. In previous studies, computed tomography (CT) and magnetic resonance imaging (MRI) were used to diagnostically rule out other causes of dementia. Structural MRI is a recently developed tool that can be used to assess atrophy and changes in tissue characteristics. An advantage of MRI is its availability and has been recommended extensively in the diagnosis of dementia [6] in European and U.S. Practices. However, this comes at a high cost, which makes it difficult for some patients to pay for, and may not be readily available in certain countries. In addition, patients with a severe case of Alzheimer's disease may not tolerate MRI procedures, or CT scans.

In the last few years' application have been developed that utilized microwave technology to detect and image diseases in the brain such as stroke and brain tumour. An initial approach was discussed about to design a Vivaldi antenna [7] in operating at a frequency range of 1 GHz to 4 GHz [8] was simulated. Then improve the reflection coefficient to alternate the antenna structure will developed in two dimensional array model in CST & HFSS antenna compare at the same frequency range. This antenna was able detect the occurrence of stroke in the head region. However, the study utilized a switching system using microwave [9] coaxial switches in order to connect the elements of the array. A textile-based antenna was discussed above for proposed use in microwave head imaging. This antenna operated in the range of 1.2 GHz to 6 GHz. Although the antenna provided good SAR values and S11 results which are in line with the specifications need for a safe head imaging system [10], the size of the antenna was too big to create a proper array. In a novel wearable antenna array system was designed for head imaging. The wearable head imaging system utilizes 8 flexible directional UWB monopole antennas. To ensure flexibility, the antennas were created using a very thin flexible Flame Retardant (FR4) substrate with a thickness of mm. The antenna operates data frequency range between 0.3 MHz to GHz that would allow sufficient penetration and resolution. The flexible nature of the Antenna and implementation in clothing fabrics makes the device wearable and portable to the user. This paper presents a novel application of a low- non-invasive wearable device to monitor the progression of brain atrophy and lateral ventricle enlargement in patients with Alzheimer's disease.

II. WEARABLE TWOD IMENSIONAL ARRAY ANTENNA

A. Antenna Design

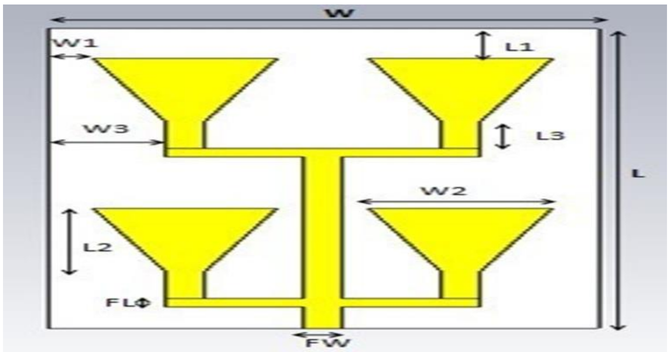
In this work, the software used to analyse and design the proposed antenna is CST STUDIO SUITE. Instead of directly stepping into the final design, first, we discussed on however each final Vivaldi antenna design and then its functionality. An FR4 material having thickness 2.4 mm is a substrate for all the design shown in this paper. The antennas were designed in order to be conformable and directional. In order to utilize a radar-based approach for microwave imaging, the designed antennas should exhibit ultra-wideband (UWB) performance. For this application, a planar monopole antenna is one of the best candidates due to its low-profile configuration as compared to a 2D array antenna in CST & HFSS antenna, which has a high- profile structure along the direction of propagation, thus making it unsuitable for wearable applications. At low frequency levels, the antennas can achieve more penetration but less resolution.

Tablei. Dinemsions Of The 2d Array Antenna

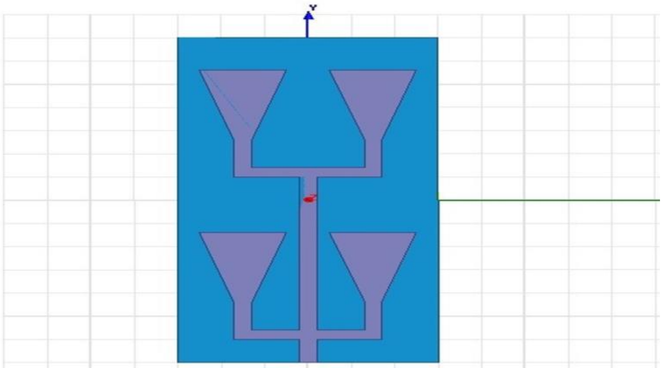
Parameter	Value	Parameter	Value
L	70	W	30
L1	7	W1	2.5
L2	15	W2	10
L3	6	W3	6.5
FL	2	FW	2
LT1	20	WG	7
LT2	44	G	0.5

At high frequencies, on the other hand, the antennas can achieve less penetration but higher resolution. By using UWB antennas, the aim is to achieve good penetration and resolution for the antennas, so that they can be utilized eventually for radar-based imaging. The detailed dimensions are listed in the Table 1.

Fig. 1 (a) shows the schematic diagram of two dimensional array antennas in CST .and 1 (b) shows the 2 dimension Vivaldi antenna in HFSS. The feeding line is made of a co-planar waveguide (CPW) structure where its characteristic impedance is 50 ohms, while a trapezoidal patch was selected as the radiating element in order to provide a smooth transition of the input current from the feeding line to the radiating elements, ensuring good impedance matching across the intended frequency.



(a)



(b)

Fig.1. (a) Schematic diagram of two dimensional array antennas, (b) Schematic diagram of Vivaldi antenna in HFSS model.

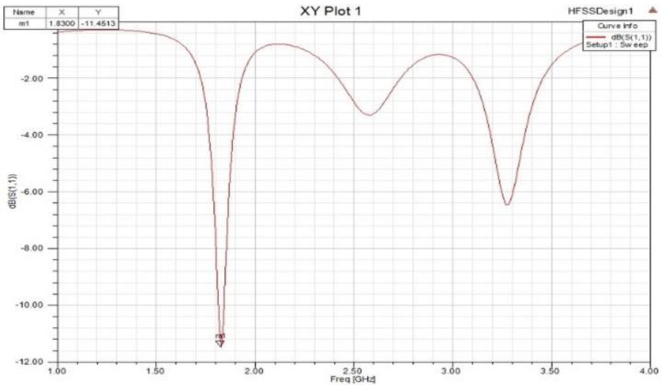
B. Simulation Methods

In order to simulate the brain atrophy and lateral ventricle enlargement were performed in near field using CST Microwave Suite. A realistic human head model was used that contained several tissues, such as: skin, skull, blood, white matter, and gray matter. The dielectric constant of the substrate used is 2.4. To ensure good penetration into the head, a working frequency between 0.3 MHz to 3 GHz was utilized in the design of this antenna. These antennas were placed on each side of the human head model next to the skin and near field measurements were obtained in the simulations. In this wearable flexible antenna will be placed in the top and the side of human head. Characteristics of brain atrophy were simulated by uniformly reducing the size of the inner objects white matter and gray matter replacing the gap with cerebrospinal fluid, and keeping the size of the other objects (i.e. skull, skin, and blood) constant.

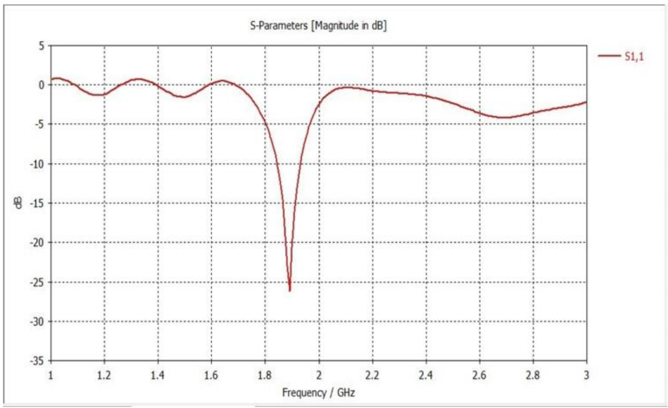
III. MEASUREDRESILTS

A. Simulation Results

Fig.5.Shows the S-parameter of the wearable 2 dimensional array antenna in HFSS & CST.



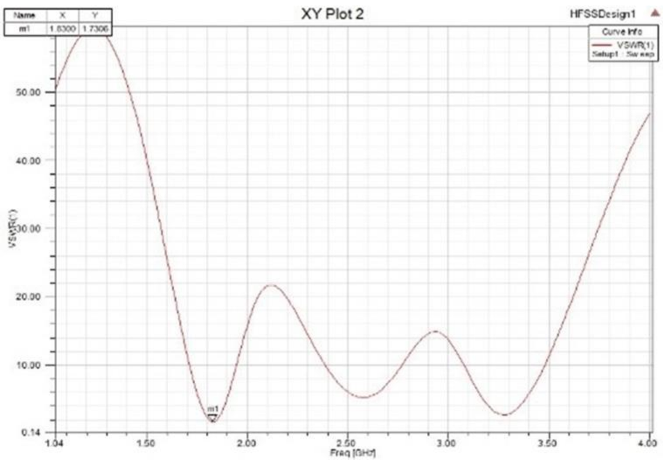
(a)



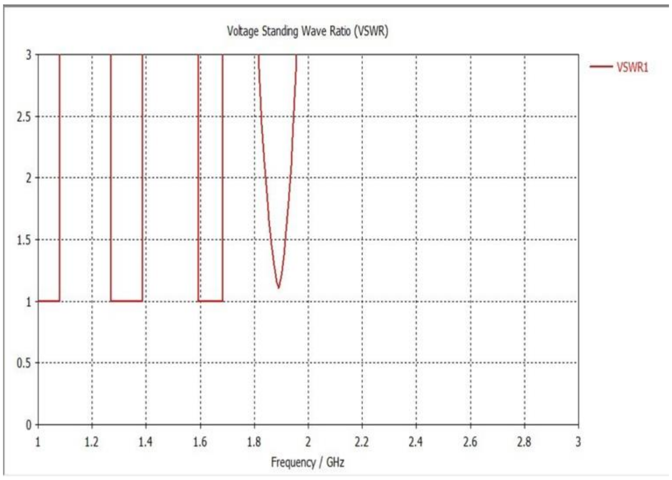
(b)

Fig. 2. Simulation plot showing the reflection coefficient between the 2D array antennas in CST&HFSS.

Fig. 3. Shows the Voltage Standing Wave Ratio of the wearable 2D array antenna in CST & HFSS compare in this simulation VSWR is nearer to 1 in both of the results.

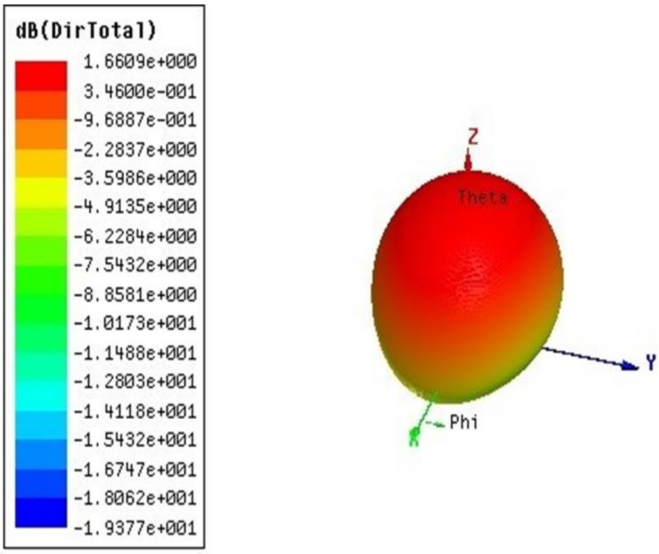


(a)

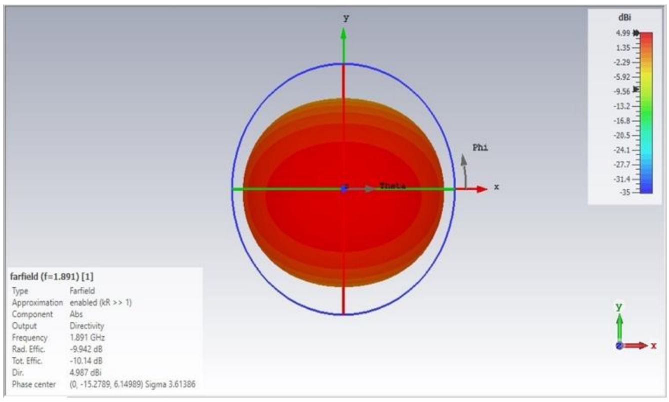


(b)

Fig. 3. Simulation plot showing the Voltage standing wave ratio between the 2D array antenna and the Vivaldi antenna.



(a)



(b)

Fig. 4. Simulation plot showing the fare field of the 2D array antenna in CST & HFSS.

Fig.4. Shows the fare field of a 2D array antenna and the Vivaldi antenna will be compared in the figure. Fare field of the antenna will be measured in 3D view.

IV. RESULT DISCUSSION

A wearable non-invasive RF device will be designed in the structure of Vivaldi antenna and the reconstruct into the 2 dimensional array antenna designed. After the simulation varies output parameters can be measured using CST simulation tool. In this heading will discuss about varies parameter output of the 2D array antenna in CST & HFSS antenna. TABLE II will compare the different parameter result at the resonant frequency of a 2D array antenna in CST & HFSS.

The simulated output will collect different parameters in a 2D array antenna in CST &HFSS to compare in the above table. Simulation will be performed then get both the Electric field and the Magnetic field of the antenna. From the comparison table to analyze the changes in the reconstructive structure of antenna. Both of the antennas are simulated in the 0.3 MHz to 3 GHz frequency range. This antenna will place in the human head model to measure the reflection coefficient.

TABLE II. COMPARISON OF PARAMETER FOR ANTENNA.IN DIFFERENT SIMULATION TOOL

Parameter	**Two Dimensional Array Antenna In CST**	**Two Dimensional Array Antenna in HFSS**
Resonant frequency (GHz)	1.891	1.83
Operating Frequency range(GHz)	1.8434 -1.9343	1.8000 -1.8600
Return loss (dB)	-26.118	-11.4513
Band width (MHz)	90.90	60
VSWR	1.1076	1.7304
Main lobe magnitude (dBi)	4.99	4.78
Side lobe level (dB)	8.9	8.65
Wavelength (mm)	158.536	168.992
Max Electric field (v/m)	36124.2	15653.7
Max Magnetic field (A/m)	160.53	56.6327
Power flow at resonant frequency (W)	0.4773	0.3585
Radiating Efficiency (dB)	-9.942	-12.73
Directivity (dBi)	4.987	4.175

V. CONCLUSION

Simulations and experiments were performed to verify the design of a two dimensional array antenna and the Vivaldi antenna of wearable non-invasive RF device capable of monitoring the progression of brain atrophy and lateral ventricle enlargement in the brain as a result of Alzheimer's disease. The device contained UWB antennas that operated between 0.8 and 3 GHz. The non-invasive monitoring approach and wearable design makes it a novel tool for medical diagnostic devices. Results from simulations and experiments show that the antennas in the device are capable of detecting different levels of brain atrophy and lateral ventricle enlargement in the reflection thus providing a promising tool for monitoring patients with Alzheimer's disease. This study is the foundation for future work to be performed in developing early-stage Alzheimer's disease detection approaches.

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