Design and Simulation of Microstrip Patch Antenna Array for Brain tumor detection

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*ABSTRACT— **Brain tumor is unknowingly progresses desease. Brain Imaging working in microwave frequency range in medical field is one of the important diagnosing mechanisms for Brain tumor detection. In this study, single element,double elements and four elements patch antenna array are designed, optimized and simulated for brain tumor detection which operates at 5.8 GHz band. 5.8 GHz is used for Industrial, Scientific and Medical (ISM) band. A four-layered tumorous human head phantom model is also made by inserting a tumor model inside head. The dimensions and electrical properties of tumor model are chosen randomly that reflect the actual ones. To get the imaging results, proposed antenna is simulated with tumorous head phantom model by CST software .The proposed antenna arrays are high gain, low side effects , low-cost, low weight base station Antenna. The characteristic analyses such as return loss, radiation pattern ,bandwidth, of the prototype antenna array have been investigated . In this investigation, return loss of -21.633 dB and antenna gain of 7.195607 dBi have been achieved for four elements microstrip patch array. Ansoft HFSS 13 is used for designing simulation.***

Index terms—*Microstrip patch antenna, Antenna Array, Electromagnetic simulator, Brain tumor detection, Human head phantom, CST Studio Suite 2017.*

I. INTRODUCTION

In recent years, microstrip patch antenna [1-9] is one of the interesting research topic. Microstrip patch antenna arrays are widely accepted for Wireless communication because it is lightweight and easy of fabrication. The basic idea of patch antenna is to lay a very thin copper strip with perfect size on top of a substrate and bottom side too as a ground plane. At present the wireless communication system has experienced a significant growth from first generation (1G) analog voice signal to forth coming fourth generation (4G) mobile technology. The 4G communication system is necessary to provide Wireless Fidelity (Wi-Fi) communication network and high quality audio and video services. Microstrip patch antenna is also used for Microwave imaging[10] is one of the active wave-based non-invasive imaging method. Microwave imaging technology is used for tumor, detection, tissue assessment [11-16] because it offers an almost safe, low cost, low profile , rapid, non-invasive, planar configuration and highly accurate system solution which involves nonionizing radiation . Brain is the central organ of human nervous system. Brain tumor is actually the growth of abnormal cells in our brain. A brain imaging system is working in microwave frequency range to detect brain tumor. Two important parts of the brain imaging system[17] are modeling of human head phantom[18] and efficient microstrip patch antenna. This article describes the design, analysis and simulation of single element and multi elements patch antenna array for brain tumor detection which operates at 5.8 GHz band. 5.8 GHz is used for Industrial, Scientific and Medical (ISM) band. The antenna is designed, optimized and analyzed by Ansoft HFSS 13 electromagnetic simulator.

A four-layered tumorous human head phantom model is also made by inserting a tumor model inside head. The dimensions and electrical properties of tumor model is chosen randomly that reflect the actual ones. To get the imaging results, proposed antenna is simulated with tumorous head phantom model by CST software[19].

II. ANTENNA DESIGN

The Microstrip patch antenna has a substrate made of FR4_epoxy which has a relative permittivity 4.4 and relative permeability value 1. The length of the substrate is 63.7366 mm and width of the substrate is 33.8142 mm and thickness of the substrate is 1.58 mm from the ground plane for single element patch. The back side of the substrate, contains the ground plane. The ground plane is made by copper which is a lossy metal. The length of the ground plane is 63.7366 mm and the width of the ground plane is 33.8142 mm for single element patch. The other side of the substrate contains the patch that is made up of copper which is a lossy metal. The length of the patch is 15.73 mm and width of the patch is 11.75mm. The Centre to Centre patch element distance is 0.435λ . The proposed antenna is fed by coaxial probe feed. Coupling of power through a probe is the basic mechanism for the transfer of microwave power. The radius of the probe inner conductor of this coaxial line feeding is 0.25mm which is used to transfer power from a stripline to a microstrip antenna patch through a slot in the common ground plane. The radius of the probe outer conductor of this coaxial line feeding is 0. 5mm.

Initially the geometries of a single element, double elements, four elements microstrip patch antenna arrays with characteristic parameter like radius, length, width are shown in Figure 1-3.

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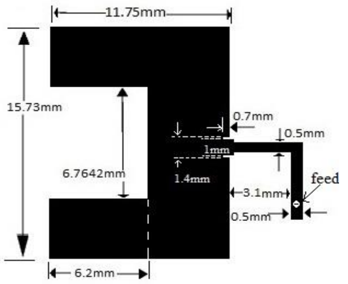

Fig 1 : Geometry of a single element microstrip patch antenna

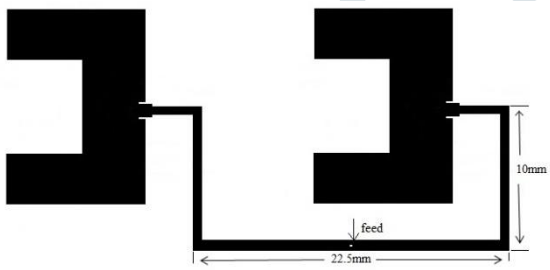

Fig 2 : Geometry of a double elements microstrip patch antenna array

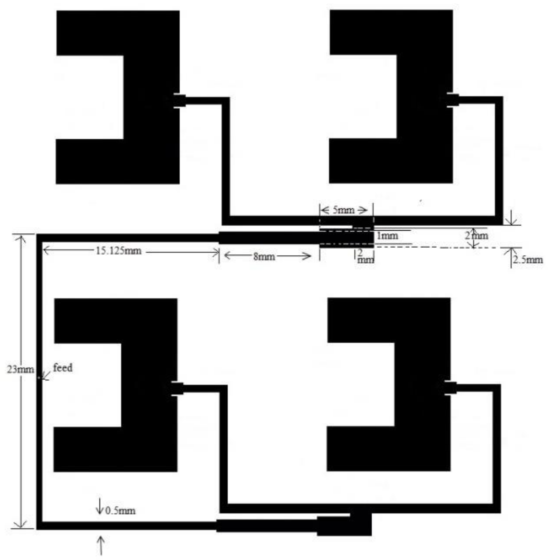

Fig 3 : Geometry of a four elements microstrip patch antenna array

III. SIMULATION RESULTS AND DISCUSSION

The characteristic analyses such as return loss , radiation pattern ,bandwidth and radiation pattern of the prototype antenna array have been investigated . In this investigation, return loss of -11.1102 dB and antenna gain of 3.596770 dBi have been achieved for single element microstrip patch array, return loss of -10.869 dB and antenna gain of 5.449551 dBi have been achieved for double elements microstrip patch array, return loss of -21.633 dB and antenna gain of 7.195607 dBi have been achieved for four elements microstrip patch array. Following Figs 4-10 show the return loss and radiation pattern of the proposed antenna at 5.8 GHz.

Return Loss (RL)

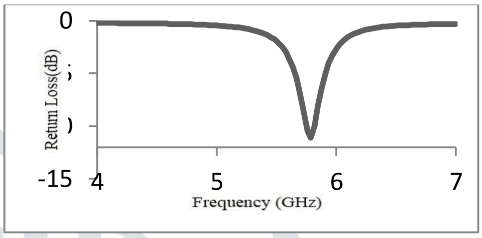

Fig 4 : RL for single element microstrip patch antenna

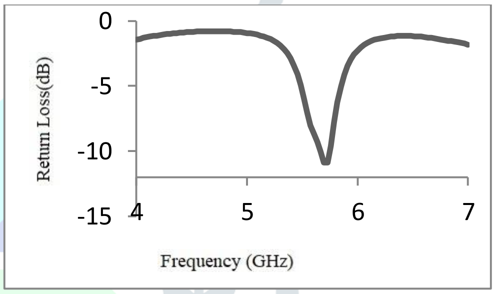

Fig 5 : RL for double elements microstrip patch array

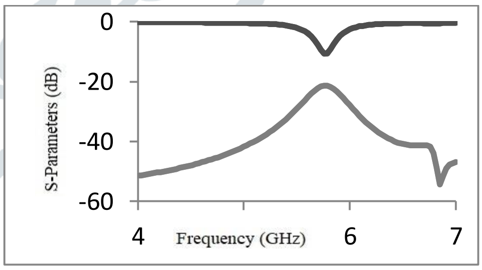

Fig 6 : mutual coupling for double elements microstrip patch antenna

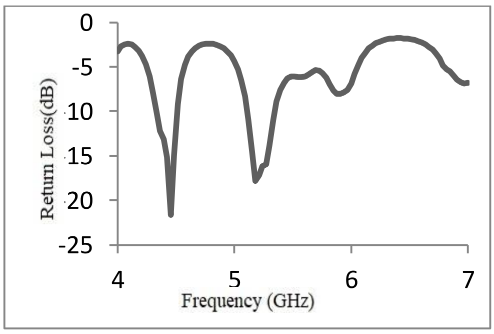

Fig 7 : RL for four elements microstrip patch array

Radiation Pattern

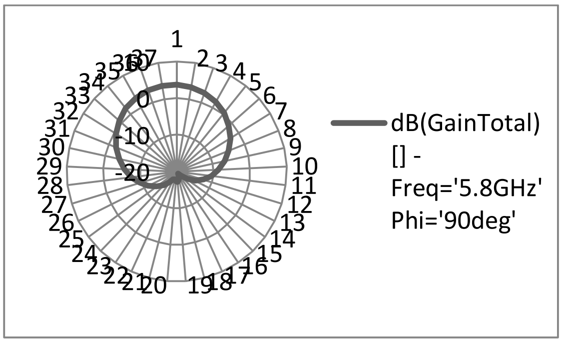

Fig 8 : Radiation Pattern for single element microstrip patch antenna

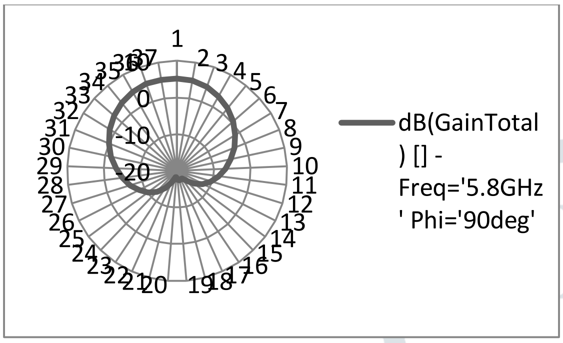

Fig 9 : Radiation Pattern for double elements microstrip patch array

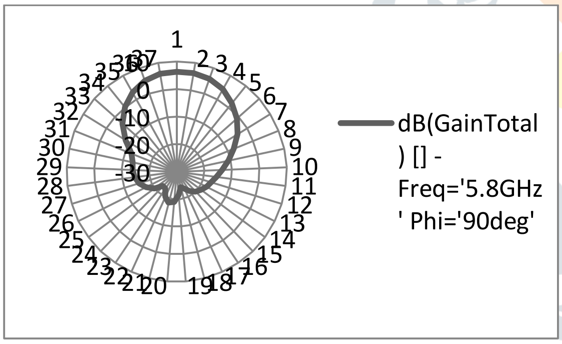

Fig 10 : Radiation Pattern for four elements microstrip patch array

IV. COMPARISON OF ANTENNA PERFORMANCE PARAMETER

Comparison of antenna performance parameter like Return Loss (RL), Radiation Pattern are given in Table 1-

Microstrip Patch Array	Return Loss	Radiation Pattern
single element	-11.1102 dB	3.596770 dBi
double elements	-10.869 dB	5.449551 dBi
four elements	-21.633 dB	7.195607 dBi

Table 1 : Comparison of antenna performance parameter

V. SYSTEM MODEL FOR MICROWAVE BRAIN TUMOR DETECTION

The normal four-layered tumorous human head phantom model is made by inserting a tumor model inside head, to detect tumor inside human head phantom by this new patch antenna array. The dimensions and electrical properties of tumor model are chosen randomly which reflect the actual one. To get the imaging result, proposed patch antenna array is simulated with tumorous head phantom model by CST software.

Radius of Brain, Bone, Fat, Skin four layers of head phantom and tumor are given in Table 2.

	Radius (mm)
Brain	81.4
Bone	87
Fat	91.5
Skin	91
Tumor	5

Table 2 : Human Head Phantom modelling parameter

Fig 11-12 show the imaging results of tumorous head phantom model with proposed patch antenna array which is simulated by CST software.

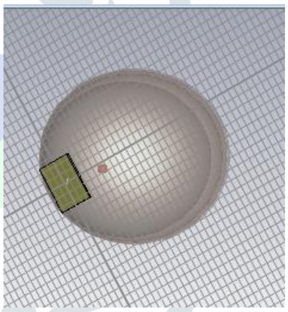

Fig 11 : Tumerous Human Head Phantom with antenna

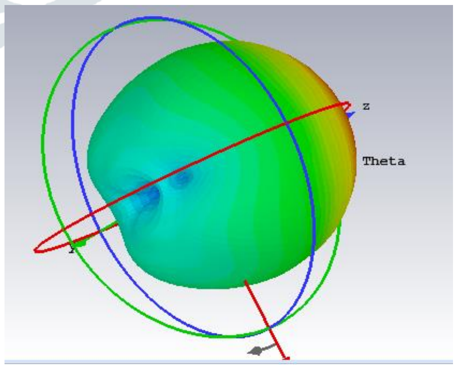

Fig 12 : Tumor detection in Human Head Phantom through antenna radiation

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CONCLUSION

In this paper, single element and multi elements patch antenna array are designed and simulated for brain tumor detection which operates at 5.8 GHz band. The proposed design can be used for other tumor detection. 5.8 GHz is very much available for wireless devices , so proposed antenna can be used for Wi-Fi devices . Proposed antenna array can be used for some other industrial, scientific and medical applications. The proposed microstrip antenna arrays have the merit of keeping important bandwidth and radiation performance at 5.8 GHz. Due to it performances, this antenna array design is suitable for tumor detection which can be investigated to construct a low size, cost and weight microwave thermography radiometer .

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