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Miniaturized Microstrip Patch Antenna for Biomedical Applications

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Abstract:
Miniaturized slotted patch antenna for biomedical applications like stroke imaging, tumor detection in breast cancer to characterize malignant, benign, and normal breast tissues is proposed in this paper. The antenna geometries are being developed on FR4 substrate with $10\times10\times0.5mm^3$ dimensions of compact and simple structure. The simulated and measured results of the proposed antenna show, that the antenna can be used for the biomedical applications. The proposed antenna obtained good results with high gain and low return loss with omnidirectional radiation pattern due to which the antenna allows the good reception of signals, with the advantage of non-ionizing radiation. This antenna can also be used for therapeutic applications based on local heating: prostate hyperplasia, heart and other tissue ablation, angioplasty which come under Ultra-wideband microwave radar techniques. The design is verified using HFSS tool for simulation and measurements are taken from VNA after fabrication.

Keywords: *Biomedical applications, microstrip patch antenna, miniaturization, stroke imaging and tumor detection, super high frequencies.*

I. INTRODUCTION

In the present world of advanced communications, antennas play prominent role in various fields like 5G wireless communication, biomedical applications [1, 2] etc. The microwave frequencies and imaging [3, 4] techniques provide the ease of building portable compact tools for medical diagnostics at low cost. The microwave imaging techniques distinguish healthy and unhealthy tissues using electrical properties. It is evident from different studies that the permittivity of the tumors can be 10-20% greater compared to the surrounding healthy tissues. Through microwave imaging it is able to visualize the internal structure of the object using electromagnetic fields at ultra-high frequency and super high frequencies.

The substrate which is the intermediate of radiating patch and ground plane, which are placed on either side of the substrate, plays prominent role in fabrication. Researchers are suggesting the use of photonic band gap as substrate in order to improve the efficiency, but at the same time it reduces the surface wave propagation on the radiating patch. In this paper FR4 material with dielectric constant of 4.4 and loss tangent of 0.02 with 50Ω microstrip line feeding is employed due to ease of availability.

II. ANTENNA DESIGN

Fig 1 shows the proposed microstrip patch antenna [5, 6, 7], it is a flexible compact antenna. The main purpose of the antenna is the usage for on-body biomedical applications. In order to fulfill the above criteria proper dimensions are being chosen. In the place of radiating patch, ground [8, 9, 10] and feedline conducting copper is being used. The dimensions of the antenna are tabulated in Table 1. The designed antenna is simulated in HFSS Software and after getting the simulated results, the antenna is fabricated, tested, and results are obtained using Anritsu Vector Network Analyzer. The fabricated antenna is as shown in Fig 2.

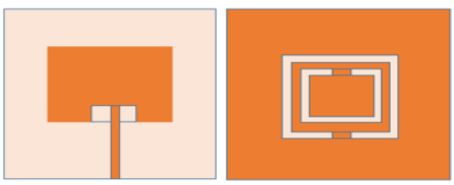

Fig. 1: Antenna Structure a) Top View b) Bottom View.

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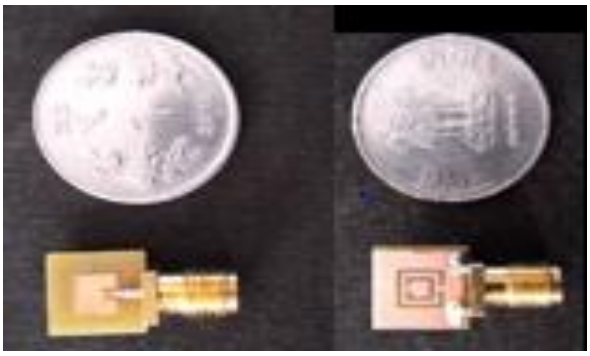

Fig. 2: Fabricated Antenna.

Table 1 Antenna Size Parameters.

Parameter	Value
Dielectric constant	4.4
Substrate size	10mm×10mm
Length of patch	4.9mm
Width of patch	4.26mm
Height of substrate	0.5mm
Ground Slot width	0.5mm
Length of Inset	1.62mm
Width of Inset	1.55mm
Length of Feed	4.42mm
Width of Feed	0.2mm

III. SIMULATED RESULTS

Microstrip patch antenna with ground defects has center frequency of 9.8GHz with 300MHz impedance bandwidth and good omnidirectional radiation performance. Fig. 3 shows the S_{11} Vs frequency plot and Fig. 4 shows the 2D radiation pattern of the designed antenna. Gain is 9.14dB at 9.8GHz as shown in Fig. 5 with VSWR of 1.1 as shown in Fig. 6 with S_{11} of -25.7dB.

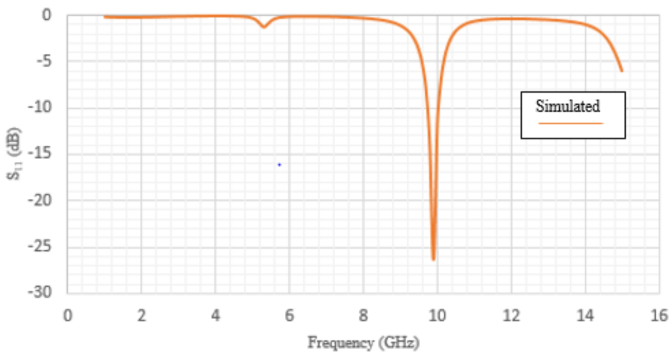

Fig. 3: Simulated S_{11} vs Frequency Plot of the Proposed Antenna.

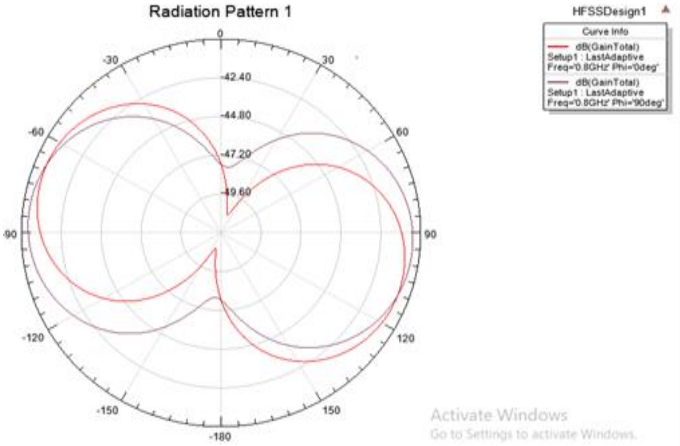

Fig. 4: 2D Radiation Pattern of the Proposed Antenna.

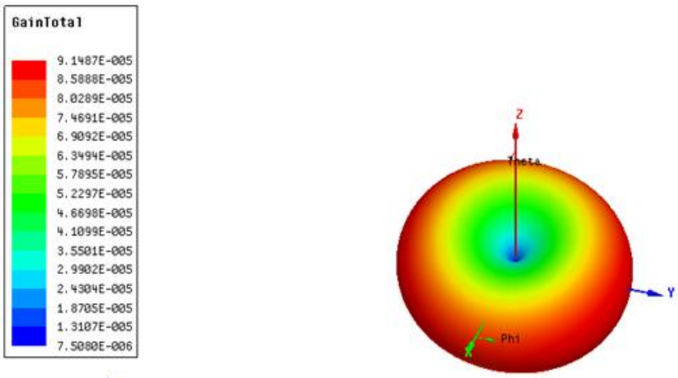

Fig. 5: Gain Plot of the Proposed Antenna.

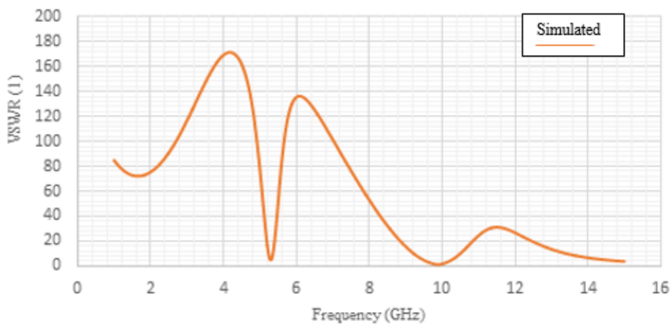

Fig. 6: Simulated VSWR Vs Frequency Plot of the Proposed Antenna.

IV. MEASURED RESULTS

The comparison plot of simulated and measured results are as shown in Fig. 7. Both the results agree with each other to a maximum extent. Measured results of S_{11} is -26.75dB at 10.5GHz as shown in Fig. 8 with 1.1 VSWR at 10.5GHz frequency as shown in Fig. 9.

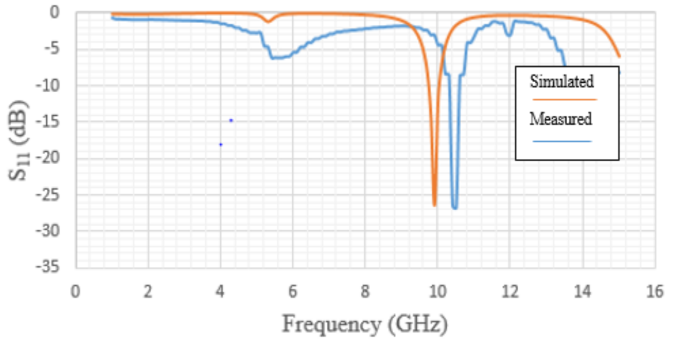

Fig. 7: Comparison Plot of Simulated and Measured S_{11}Vs Frequency Results.

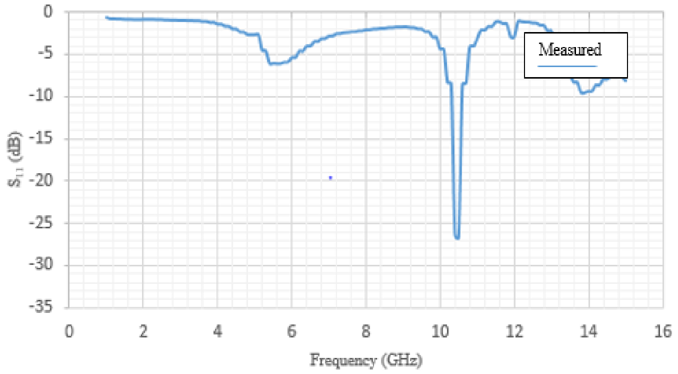

Fig. 8: Measured S_{11} Vs Frequency Plot of the Proposed Antenna.

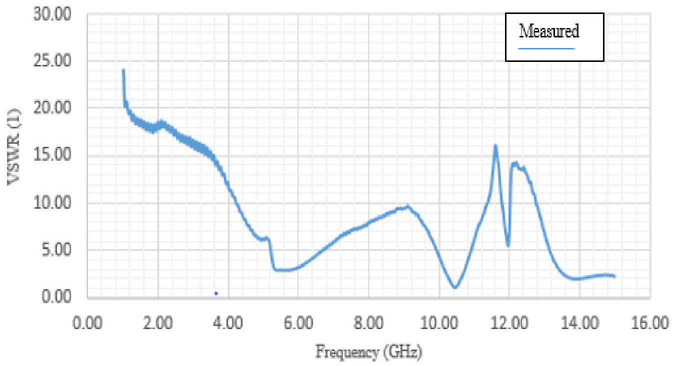

Fig. 9: Measured VSWR Vs Frequency Plot of the Proposed Antenna.

IV. CONCLUSION AND FUTURE SCOPE

It can be concluded that the proposed antenna can be used for biomedical applications like stroke imaging and tumor detection, the miniaturized size gives the ease of scope for the antenna to be placed anywhere on the body.The simulated and measured results are evaluated and compared for Reflection Coefficient and VSWR. The gain and omnidirectional radiation pattern of the antenna allows good reception of signals. The future work includes the proposed antenna is to be tested under different conditions of human phantom models. Antenna array can also be used for beam steering applications with the unit cell for the biomedical applications.

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