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A Slot Loaded Rectangular Microstrip Patch Antenna for Breast Cancer Detection

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Abstract - *The design of slot loaded rectangular microstrip patch antenna for breast cancer detection is discussed in this paper. The proposed antenna is implemented by using cost effective RT-Rogers 5880(lossy) substrate, which comprises of horizontal narrow slots on the radiating element and a ground plane. A breast phantom is developed with & without tumor and the antenna is simulated upon breast phantom with & without tumor separately and the field variations are observed. The reduced E-field value of 25167 V/m and H-field value of 129 A/m in the presence of tumor shows the efficient performance of the proposed antenna in detecting breast tumors.*

Key Words: **Microstrip patch antenna, Slots.**

1. INTRODUCTION

Breast cancer is one of the most common types of cancer in the world. The key factor in treatment is to reliably diagnose the cancer in the early stages. Statistics reveal that around 13.2 million deaths of cancer are expected in 2030 [1]. Moreover, currently used clinical diagnostic methods, such as X-rays, ultra-sound, magnetic resonance imaging (MRI) scan and computed tomography (CT) scan are limited by cost and reliability issues. These drawbacks have motivated researchers to develop a more effective, low-cost diagnostic method and involving lower ionization for cancer detection. Microwave tomography [2-5] and radar based microwave imaging techniques have been investigated in cancer detection [6]. In microwave tomography, the electric field distribution is reconstructed by solving the inverse non-linear function problem. Using radar based microwave imaging techniques, UWB pulses are transmitted from antenna array that surrounds the human head which is an expensive technique. In microwave imaging hidden objects can be detected using electromagnetic waves in microwave region (300 MHz - 300 GHz). Here, detection is based on the variations in electrical properties of the tumorous cells from the surrounding healthy tissues. Microwave imaging system has advantages such as low cost, being non- invasive and easy to use, with high image resolution and its thus good potential for early cancer detection. [7-9]. Recent technologies, particularly the use of ultra wideband (UWB) systems allow resolution enhancement in the detection. In paper [10] circular patch microstrip ultra-wideband antenna was designed with improved bandwidth for breast cancer detection. In paper [11] detection of breast tumor was based on field variations of the antenna when simulated upon breast phantom with tumor and without tumor. In paper [12] detection of tumor was based on E-field and H-field variations when the microstrip patch antenna was simulated upon breast phantom with and without tumor. In this proposed work, first the slot loaded rectangular microstrip patch antenna is designed and simulated over computer simulation technology(CST) microwave studio which is based on finite integration technique. Next the breast phantom is designed with appropriate dimensions using computer simulation technology. Then the proposed antenna is simulated upon breast phantom with and without tumor separately and it is found that the E-field & H-field values are reduced and current density value is also increased in the presence of tumor which shows the efficiency in detecting breast cancer. The steps involved in proposed method is shown in Fig -1.

2. PROPOSED METHOD

2.1 Design consideration of RMPA

The Microstrip patch antenna has a substrate made of Rogers RT 5880 which has a dielectric constant of 2.2 and thermal conductivity value 0.2 (W/K/m). The length of the substrate is 60 mm and the width of the substrate is 80 mm and the thickness of the substrate is 1.6 mm from the ground plane. The back side of the substrate contains the ground plane. The ground plane is made up of copper which is a lossy metal. The length of the ground plane is 60 mm and the width of the ground plane is 80 mm and it is of zero thickness. The other side of the substrate contains the patch that is made up of copper (annealed) which is a lossy metal. The length of the patch is 54.5 mm and the width of the patch is 80mm and the thickness of the patch is 1 mm. The patch is loaded with five horizontal slots. This proposed antenna is fed with microstrip line feed. The width of the feed line is 2 mm and the dimensions of the proposed antenna are shown in Table 1.

2.2 Breast phantom design

A breast phantom is designed by considering cone as a breast which is covered by the breast skin and sphere as a tumor which is inside the breast. The permittivity of the breast skin is 39 F/m and its conductivity is 1.1 S/m. The permittivity of the tumor is 54.2 F/m and its conductivity is 2.62 S/m. Breast glandular tissue from CST material library is chosen for breast. Tumorous cells used to have different dielectric properties and high conductivity than that of healthy tissues. The radius of the breast skin is 10 mm and the radius of the breast glandular tissue is 9 mm and the radius of the breast tumor is 2 mm.

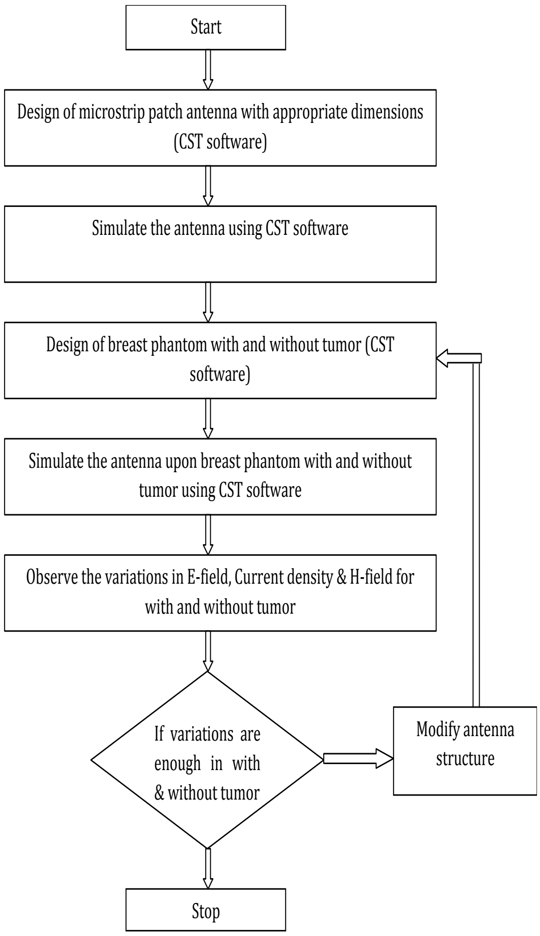

Fig -1: Steps involved in proposed work

Table -1: Antenna Design Specifications

S.No	Antenna Specifications	Dimensions
1	Length of patch	54.5 mm
2	Length of ground & substrate	60 mm
3	Width of patch substrate & ground	80 mm
4	Dielectric substrate	2.2
5	Height of substrate	1.6 mm
6	Feed to patch	Microstrip line feed
7	Width of feed	2 mm
8	Length of feed	5.5 mm
9	Length of slot	1 mm
10	Width of slot	50 mm

3. SPECIFICATIONS OF SLOTS

The proposed antenna has five equal horizontal slots with length and width of dimensions 1 mm and 50 mm respectively. Microstrip line feed is used for feeding the proposed antenna and the structure of the proposed antenna is shown in Fig -2.

The return loss can be calculated using the formula,

RL= 10 log (Pout/Pin)

Current density can be calculated by,

J=I/A

Electric field can be calculated by,

E= V/r

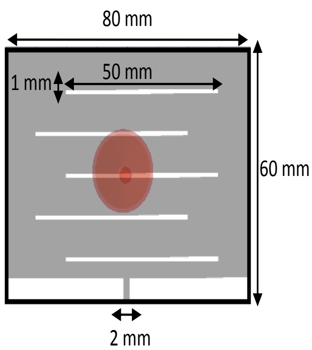

Fig -2: Structure of Proposed Antenna

4. RESULTS AND DISCUSSION

The performance of the proposed antenna is found by simulating the antenna with Computer Simulation Technology (CST) Microwave studio which is based on finite integration technique. The proposed antenna is kept at a distance of 1.4 mm from the breast phantom and simulated over CST for breast tumor detection.

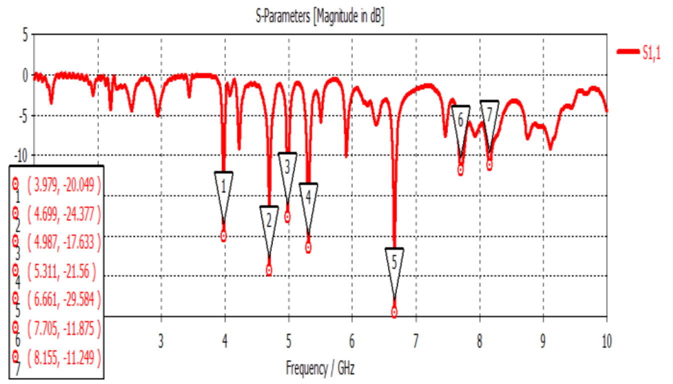

Fig -3: Simulated return loss (S11) curve versus frequency of proposed antenna

Fig -3 shows the return loss (S11) curve of the proposed antenna obtained by CST simulator. The proposed antenna has many resonant frequencies and here for breast cancer detection 3.979 GHz alone is considered.

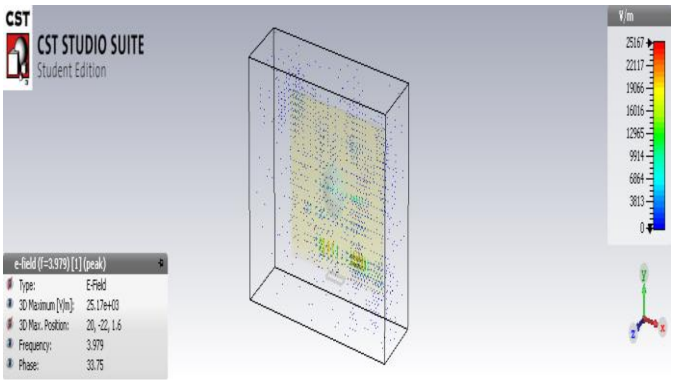

Fig -4: E-field at 3.979 GHz-without tumor

Fig-4 shows the E-field value of 25167 V/m at 3.979 GHz in the absence of tumor.

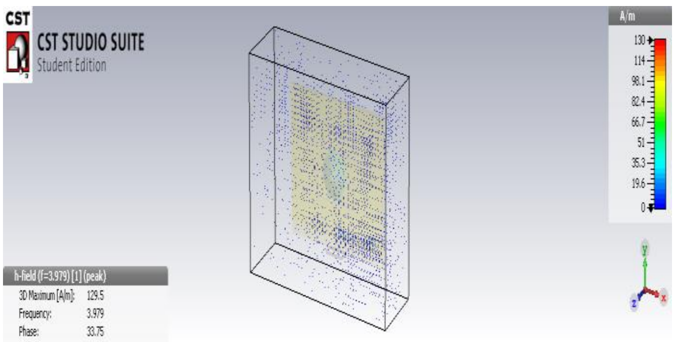

Fig -5: H-field at 3.979 GHz-without tumor

Fig-5 shows the H-field value of 130 A/m at 3.979 GHz in the absence of tumor.

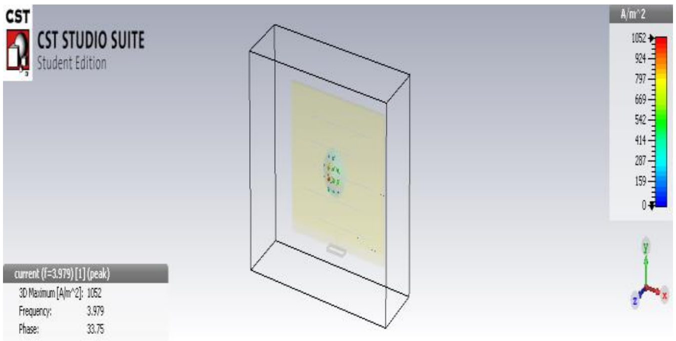

Fig -6: Current density at 3.979 GHz-without tumor

From Fig-6, it was observed that the antenna has a current density of 1052 A/m^2 at 3.979 GHz in the absence of tumor.

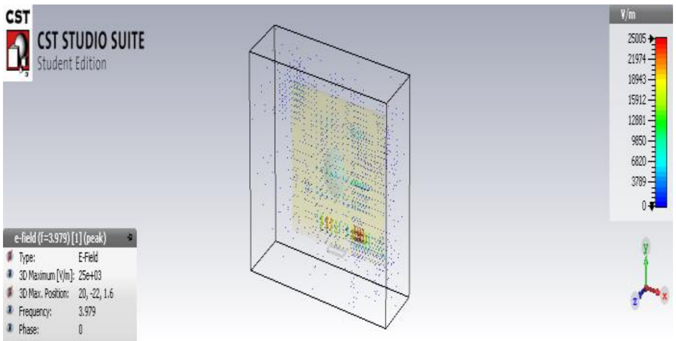

Fig -7: E-field at 3.979 GHz-with tumor

Fig -7 shows the E-field value of 25005 V/m at 3.979 GHz in the presence of tumor. It shows that the E-field value has been reduced than that of the breast without tumor.

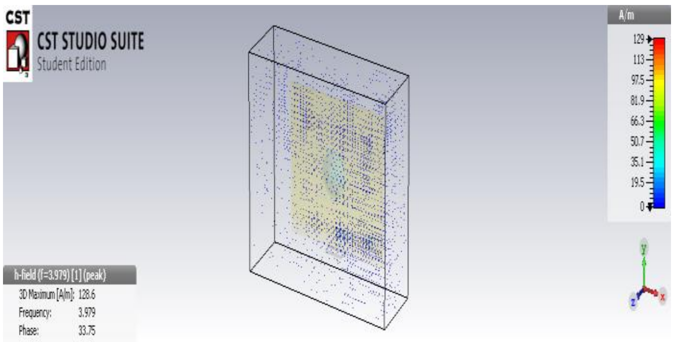

Fig -8: H-field at 3.979 GHz-with tumor

Fig-8 shows the H-field value of 129 A/m at 3.979 GHz in the presence of tumor. This shows that the H-field value is reduced than that of the breast without having tumor.

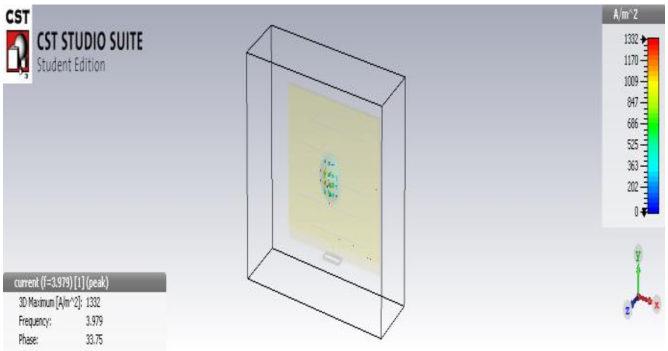

Fig -9: Current density at 3.979 GHz-with tumor

From Fig-9, it was observed that the antenna has a current density of 1332 A/m² at 3.979 GHz in the presence of tumor which is much greater than the breast without tumor.

5. CONCLUSION

A slot loaded rectangular microstrip patch antenna was successfully designed and optimized over CST simulator for breast cancer detection. Based on the field variations in the presence and absence of tumor over the breast after simulating it with antenna shows the efficient performance of the proposed antenna with reduced E-field and H-field value.

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