Biomedical Application of Microstrip Patch Antenna

Maneesha Nalam, Nishu Rani, Anand Mohan

Abstract— Micro strip antennas are finding a growing medical application in imaging, diagnosis, and treatment. In this paper an optimized E-shaped patch antenna is presented. This paper presents a flexible micro strip antenna that can be placed in contact with the human skin. Microwave breast imaging (MBI) uses low power and longer wavelength signals to obtain information about breast tissues, and promises a safer and more accurate modality for regular breast scanning. In this paper, a method is shown to reduce the effect of signal reflection from the breast skin by placing the antenna in-contact with the breast skin. The skin can be considered a layer of the antenna substrate. This reduces the signal scattering from the skin and more transmitted signal is irradiated on the tumor, thus, increasing the tumour detection sensitivity. Design and simulation in Ansoft High Frequency Simulation Software (HFSS) is presented.

Index Terms—wireless communications, patch antenna, tumour, imaging Cancer, Patch Antenna, High Frequency Simulation Software.

I. INTRODUCTION

In 2009, more than 192 thousand new cases of breast cancer were expected in the United States and more than 40 thousand women were estimated to lose their lives. Antennas have long been used in many medical applications including, microwave imaging, medical implants, hyperthermia treatments, and wireless wellness monitoring. Reducing the size and complexity of the antennas used in these applications has been the primary objective of recent antenna research. In 2007, 1.3 million new cases of breast cancer and 465 thousand deaths were estimated worldwide.

Microwave imaging of biological compositions have developed an enormous amount of attention because of its ability to access the breast for imaging.MBI infrastructure consists of several deficiencies that conclude ex-vivo circumstances, electromagnetic (EM) signals coupled with giga-hertz signal frequencies. An understanding of the breast tissue and skin diplomacy is documented to help one better understand how current methods detect as well as acknowledge between healthy and malignant tissue. The design and simulation of microwave breast imaging using 2.54 GHz signal has been presented. HFSS has been used for the modeling and simulation. While, the experimental implementation of the concept is still in progress, the simulation results presented shows that the direct placement of the antenna on the breast skin can significantly increases the sensitivity of the MBI systems.

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The microwave breast imaging technique utilizes the signal scattering by an object when the object is illuminated by an electromagnetic signal. The signal scattering by an object depends on various factors, including the environment, signal strength, and the material properties of the object. For a given signal source and the environment, the scattered signal depends on the electrical properties of the object, especially dielectric and conductivity. This principal is utilized to detect the tumour in the breast using microwave signals. The breast tumours have very distinct electrical properties (higher dielectric permittivity and higher conductivity), which allows them to detect by analysing the scattered signals. As shown in Figure 1, the amount of signal scattered by a breast tumour is higher than that of normal breast tissues, which can be received by a separate antenna or the property change of the transmitting antenna due to the scattered signals, can be analysed and utilized for the tumour detection.

II. WIRELESS PANS (PERSONAL ANTENNA NETWORK) IN MEDICAL APPLICATIONS

The aim is the creation of a patient-cantered RF hub that can receive vital signs from patients, concentrate them and send them to a base station in a relatively short range via a wireless personal area network. WPANs can be used for connecting to a higher level network and the Internet (uplink) and even for wireless communication among the ECG sensors themselves (intrapersonal communication).

The criteria that are mostly considered for the selection of the most appropriate and efficient protocol in this area are:

- Data rate
- Range
- Low battery power requirement
- Safety and reliability
- Security
- Data Latency

One very widely spreading application in Biomedical Science is **Non-Invasive Method Investigation for Blood Pressure Measurements**. The old traditional way of checking Blood Pressure is called Cuff method and this new method is done with Arterial tonometer which is a biomedical application of Antenna.

Cuff

- Accurate
- Non-continuous monitoring
- Discomfort from pressure
- Arterial Tonometer
- Applies constant pressure on artery at the wrist
- Constant pressure creates discomfort

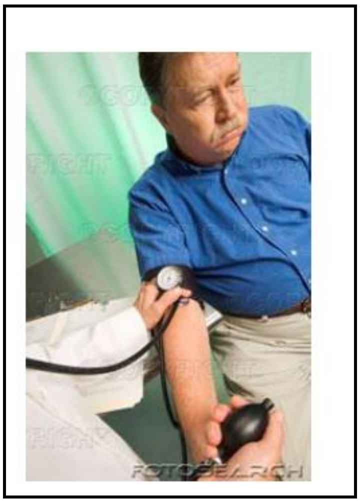

Fig.1 Earlier Method used to check Blood Pressure

Fig.2 Arterial Tonometer investigation for Blood pressure

III. PHYSICAL PARAMETERS OF THE ANTENNA

The antenna parameters of this antenna can be calculated by the transmission line method, as exemplified below.

Width of the Patch

The width of the antenna can be determined by

$$W = \frac{C}{2f_0\sqrt{\frac{\epsilon_r + 1}{2}}}$$

Length of the Patch

The effective constant can be obtained by :

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left(1 + 12\frac{h}{W}\right)$$

Where ϵ_{reff}= Effective dielectric constant

ϵ_r= Dielectric constant of substrate

h = Height of dielectric substrate

W = Width of the patch

The dimensions of the patch along its length have now been extended on each end by a distance ΔL, which is given empirically by

$$\Delta L = 0.412\,h\frac{1}{\epsilon_{eff} - 0.258}(\epsilon_{eff} + -0.3)\,.\frac{1}{\frac{W}{h} + 0.8}\left(\frac{W}{h} + 0.264\right)$$

The actual length L of the patch is given as

$$L_{eff} = L + 2\Delta L$$

Feed Location Design

The position of the coaxial cable can be obtained by using:

$$G = \frac{W}{120\,\lambda 0}(1 - (k_0 H)^2/24)$$

$$Y_0 = \frac{L}{\pi}(cos)^{-1}[\sqrt{100G}]$$

Where k_0 = propagation constant

IV. DESIGN METHODOLOGY

Table 1

Parameters Used	Value
Frequency	1.89 & 2.4GHz
Input impedance	50Ω
Di electric coefficient	39
Conductivity	1.1S/m
Height (substrate)	16mm
Patch length	40mm
Patch width	10mm

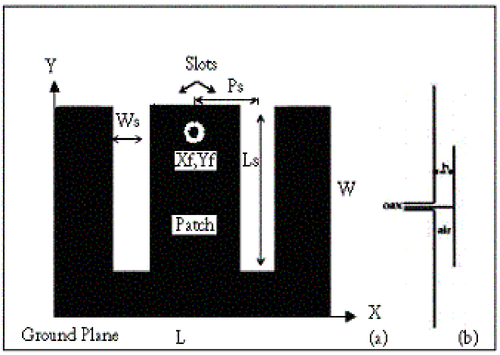

Fig. 3 Schematic diagram of Antenna Skin Substrate

V. DESIGN OF ANTENNA IN HFSS

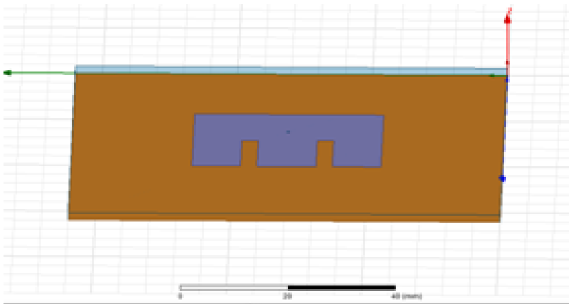

Fig. 4: Antenna in HFSS Design

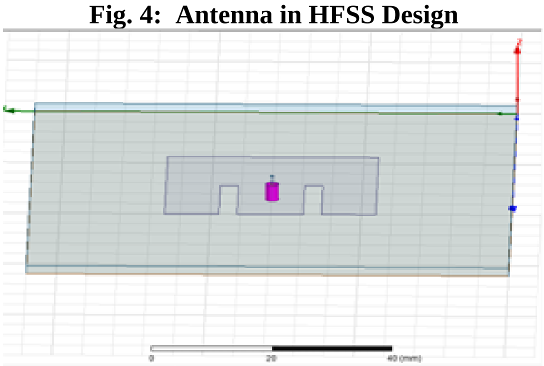

Fig. 5: Antenna in HFSS Design with probe feed

VI. RESULTS

Using the substrate parameters, an initial rectangular patch antenna was designed and simulated without any skin layer. The simulated |*S*11| parameter in dB (20 log10 |*S*11|), will be called as |*S*11| hereafter) and the radiation pattern of a flexible micro strip antenna. After tuning the antenna for 1.9 and 2.45 GHz, the antenna was fabricated. The optimised antenna model was used to simulate with the breast models developed in HFSS.

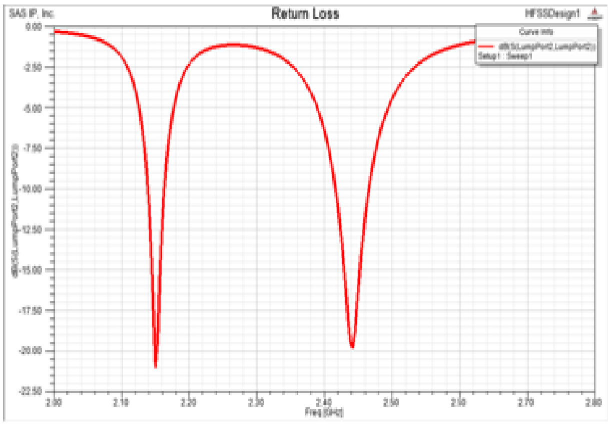

Fig. 6: Experimental |*S*11| of the Antenna

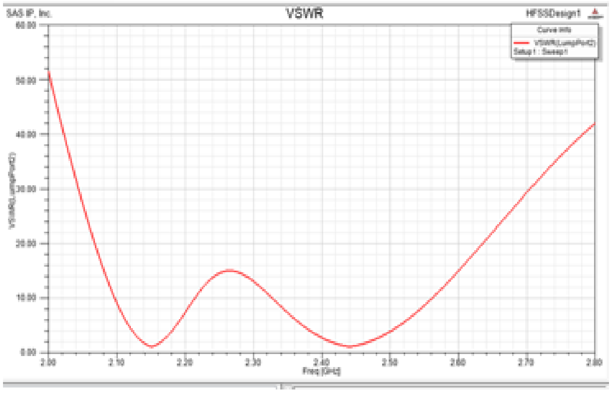

Fig. 7: VSWR of the Antenna

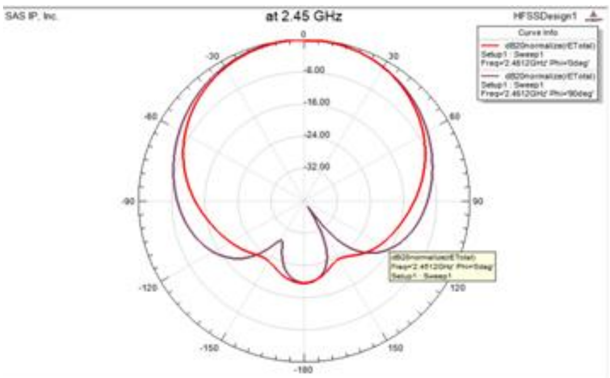

Fig. 8: Radiation pattern of the Antenna

VII. CONCLUSION

A flexible micro strip antenna developed for skin contact application has been presented. The presented planer flexible antenna can be used in wide varieties of medical applications, including, in developing wearable medical devices. In this paper, the prospect of an antenna that can be placed on the breast skin has been presented and a simple antenna design for the case has been discussed.

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