A Compact UWB Antenna Design for Breast Cancer Detection

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Abstract— Near field imaging using microwave in medical applications has gain much attention recently as various researchers show its high ability and accuracy in illuminating object compares to well known screening tools. This paper documents the development of new compact ultra wide bandwidth antenna designed primarily for microwave imaging application such as breast cancer detection. A parametric study is carried out using two well known softwares packages to achieve optimum antenna performances. The performance of the Prototype antenna is tested and analyzed experimentally and exhibit reasonable agreement with the simulations.

1. INTRODUCTION

Breast cancer is the most common non-skin related malignancy and the second leading cause of cancer death among women in the world [1]. Every year thousand of women die from the disease. Early detection will be look upon as the best hope for reducing the serious toll of this disease until research uncovers a way to prevent breast cancer or to cure all women. The early detection of cancer by screening reduces mortality from cancer.

Fifty years ago there was no establish method for detection of breast cancer at an early stage but advance in technology and legal mandates have thoroughly changed the situation. The use of X-ray imaging for detection of breast was first suggested, Mammography was not an acceptable technology until the 1960s. Over the past decade the investment in breast cancer research including early detection has increased significantly. New or improved technologies are rapidly emerging and providing hope of early detection.

The X-ray mammography is proved to be the most effective tool and play an important role in the early breast cancer detection. Despite showing high percentage of successful detection compare to other screening tools, X-ray mammography also has its limitations. The uncomfortable breast compression associated with this diagnose method prevents patients to undergo early stage examination and both false positive and negative rate have been reported which subsequently introduces to alternative screening. Another issue that raises the concern by using X-ray mammography is the radiation level from ionizing X-ray.

All these imperfection factors have motivated and encouraged to search for the better solution. One of the alternatives under investigation is microwave imaging. The applications of microwave technology were increasing in the field of biomedical engineering for diagnostic purposes. Based on the variations of the dielectric properties this technique promises non destructive evaluation of the biological tissue, which creates the images related to the electrical properties of the breast tissue. This will identify that the tissue with malignant tumor has higher water content than the normal breast tissue, hence they have higher dielectric properties than the normal tissue which have low water content, therefore strong scattering take place when the microwave hit the tissue with malignant tumor. Several applications of microwave imaging in the medical field were recorded and implemented for breast cancer detection [2].

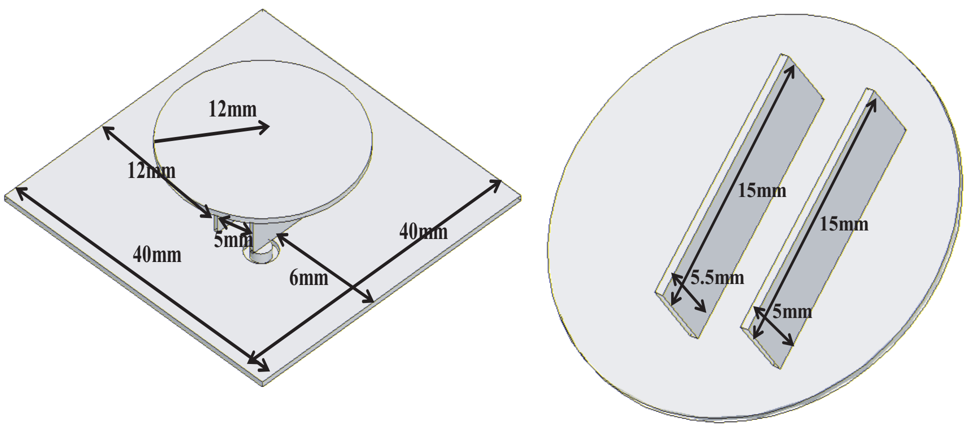
Antenna is the key element of the microwave imaging system that radiates and receives signals to or from nearby scatterer objects. The application is similar to the GPR but operating at high frequencies. Various wideband (WB) and ultra wideband (UWB) antennas have been proposed for microwave imaging. Most of the antennas present in the literature show omni-directional radiation pattern with low gain [3–5]. These type of antenna are suitable for short range indoor and outdoor communication. However, for a microwave imaging system that is used to operate and detect the breast tumor might preferable to have a directive antenna with high gain [2, 6–8]. This paper presents a planar metal plat antenna in terms of circular disc mounted on the two vertical rectangular plates. The antenna is designed using Ansoft High Frequency Structure Software (HFSS). The results of two softwares including the measured one show good agreement.

The layout of the paper is as follow. Section 2 presents the geometry, the antenna model and the parametric study of various antenna dimensions; Section 3 discusses the simulated and the experimental results performed and Section 4 is summarized the final conclusions of this study.

2. ANTENNA DESIGN AND FABRICATION

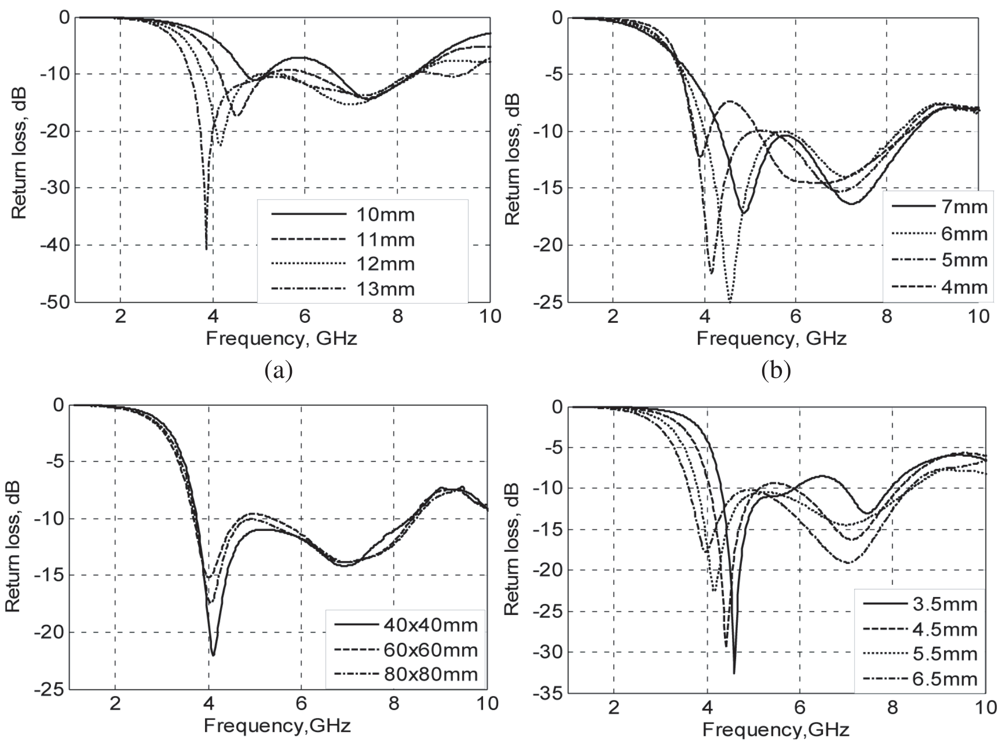
Figure 1 shows the geometry of the antenna. The antenna is placed on the ground plane of dimension $L = W = 40$ mm and thickness 0.5 mm. The antenna is fed by vertical plate of maximum height 5 mm and width of 15 mm, in which it is connected to the feeding probe through the slot of 4 mm diameter in the ground plane. The antenna is modelled and optimised using high frequency structure simulator (HFSS).

The parametric simulation is carried out with HFSS in which the numerical analysis is based on the Finite Element Method (FEM). The parametric study helps to optimise the antenna performance before the antenna is manufactured and tested experimentally. Different antenna parameters are considered for optimisation the operated bandwidth subject to suitable radiated power gain. Some of these parameters are the total size of the ground, feed length, diameter of the circular disc



(a) Top View (b) Bottom view

Figure 1: Geometry of proposed antenna.



(a) (b) (c) (d)

Figure 2: Parametric study. (a) Radius of the circular disc, (b) Gap between the vertical plates, (c) Ground size, (d) Height of the antenna from ground.

and gap between the vertical plates. To check the influence of these parameters on the impedance bandwidth, one parameter is varied and the remaining parameters remain fixed. Simulation result shows that the affect of changing these dimensions of antenna have appreciable change in the resonant frequency and return loss as shown in Figure 2.

3. RESULTS AND DISCUSSION

The antenna is also modelled using CST software package for comparison. Figure 3 shows the simulated return loss computed from HFSS and CST softwares, the result show good agreement. The gain of the antenna was found slightly more than 8 dBi at central frequency 6 GHz as shown in Figure 4. In addition, a directional radiation pattern was detected as preferred for imaging application as shown in Figure 5. A prototype of the antenna is fabricated from a copper sheet of thickness 0.5 mm for the practical realization. The HP 8510C network analyser was used for measurements. The experimental result shows reasonable agreement with the simulated one as illustrated in Figure 6. The slight differences in the return loss curves can be attributed to the fabrication inaccuracies.

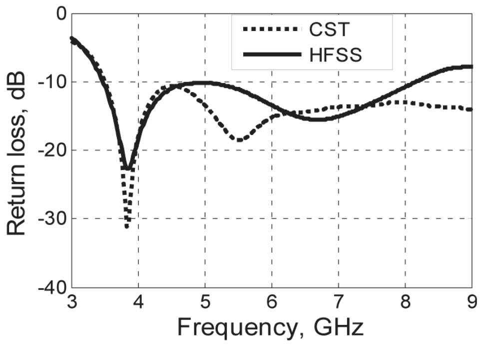


Figure 3: Simulated return loss.

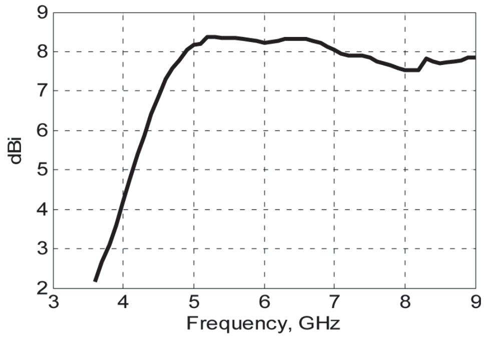


Figure 4: Gain of the antenna.

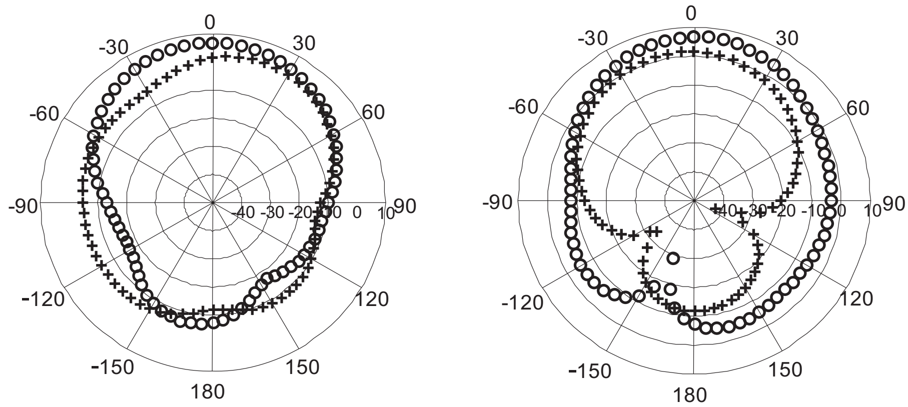


Figure 5: Radiation patterns for the proposed antenna at 6 GHz in dBi at z-x plane (left) and z-y plane (right) ('+++' E_θ and 'o o o' E_φ).

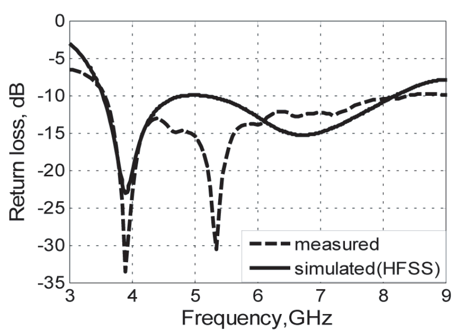


Figure 6: Input return loss of the proposed antenna.

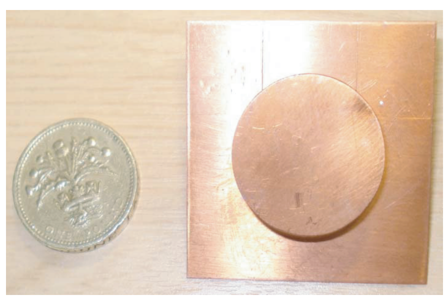


Figure 7: Photograph of the prototype antenna.

4. CONCLUSION

In this paper a new compact UWB antenna design has been presented. The affect of the various antenna parameters on the bandwidth and the resonance characteristic were discussed. The operating bandwidth of the antenna at a minimum workable return loss of 10 dB achieved was 3.5 GHz to 8 GHz. The measurement results show a good agreement with the simulated one. The antenna exhibited good directional radiation pattern with acceptable gain of 8 dBi over most of the UWB considered as preferred for imaging application.

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