Design an Ultra-Wide Band Antenna for Microwave Imaging Systems

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***Abstract*— Microwave imaging technology has attracted many interests nowadays. This imaging system has been used in a variety of applications such as: non-destructive testing and evaluation, through-the-wall imaging, concealed weapon detection at security check points, structural health monitoring and medical imaging. Microwave imaging techniques have in recent decades experienced strong growth as a research topic in biomedical diagnostics. The basic idea of using microwave imaging system is to transmit electromagnetic waves from a transmitting antenna to the target material and receive the scattered waves at a receiving antenna. Thus, antenna choice plays an important role for the system. There is a need for compact sized, low cost and high efficiency antennas which can radiate ultra-wideband signal to transmit short pulses. Especially, 'large bandwidth' is vital to attain good time domain characteristics which is important for microwave imaging systems. In this study; we selected the circular patch antenna with a slot, due to their ease of fabrication, properties, small size and other advantages of microstrip technology. The schematic of the proposed antenna is presented and the dimensions are summarized in the paper. Ansoft HFSS software is used to design the proposed structure and optimize the radiation pattern and return loss. Simulation results such as directivity and return loss are given and discussed in the result part.**

***Keywords*— Microstrip Antenna, Utra-Wide Band Antenna, Return Loss, Microwave Imaging**

I. INTRODUCTION

Microwave imaging techniques have shown excellent capabilities in various fields such as civil engineering, nondestructive testing, industrial applications, and have in recent decades experienced strong growth as a research topic in biomedical diagnostics. Many research groups throughout the world work on prototype systems for producing images of human tissues in different biomedical applications, particularly breast tumor detection [1]. The basic idea of using microwave imaging system is to transmit electromagnetic waves from a transmitting antenna to the target material and receive the scattered waves at a receiving antenna. Thus, antenna choice plays an important role.

Microwave imaging systems require certain preprocessing steps, which accept only a single polarization of the incident field as input. Also, the designed antenna must have higher gain levels together with a higher front-to-back ratio level. Furthermore, there is a need for compact sized, low cost and high efficiency antennas. Consequently, microwave imaging systems require wide-band, linearly polarized, high gain and compact antennas as their scattered field sensors [2].

For microwave imaging, researchers are interested in the 1-11 GHz frequency range because it appears to balance the conflicting demands of better spatial resolution (higher frequencies) and better penetration depth (lower frequencies) [3].

In this study; the microstrip antenna which has circular shaped patch with slot is selected due to their ease of fabrication, properties, small size and other advantages of microstrip technology. Ansoft HFSS software is used to design the proposed structure and optimize the radiation pattern and return loss.

The paper is organized as follows. In Section II, the schematic of the proposed antenna is presented and the dimensions are summarized. In Section III, simulation results are demonstrated and discussed.

II. ANTENNA DESIGN

Ultra-wideband (UWB) technology has its frequency defined in the range of 3.1 GHz to 10.6 GHz by the Federal Communication Commission (FCC) for UWB radio applications [4]. This technology has become very popular in recent years and has found widespread applications in communications landmine detection and biomedical applications. Another important application is the UWB technology in early breast cancer detection by using microwave imaging system. For this system, there is a need for compact sized, low cost and high efficiency antennas which can radiate ultra-wideband signal to transmit short pulses. Large bandwidth is vital to attain good time domain characteristics which is important for microwave imaging systems [5]. Recent research is on UWB antenna is planar technology as they are more practical in term of manufacturing and integration with the entire system.

There are several compact UWB antennas are proposed in planar technology but they exhibit omini directional radiation property. However, in microwave imaging system, antenna's HPBW is one of the main parameters determining the resolution; finer details can be resolved by using a narrower beam.

In this study, first omini directional planar UWB antenna is designed, then we try to improve it to directional planar UWB. The proposed antenna is a modification of the antennas given in [6], which didn't use slot on patch.

Microstrip antennas produced with printed circuit technology includes a thin layer of low loss nonconductive material with a radiating conductive layer on one side and conductive ground layer that completely covers the non-conductive. Microstrip antennas are basically fed by the micro strip or a coaxial line. Along with technological advances, researchers have focused on different feeding structures and developed three different feeding techniques [7,8,9]. In this study a microstrip line feeding technique that is easy to design and produce is presented.

The purpose of our study is to propose an antenna which has the impedance bandwidth between 5 and 10.5 GHz for use in near field near surface imaging applications. According to this span, center frequency will be 7.5 GHz and wavelength (λ) is equal to 40 mm. For the optimum results, radius of the circular disk should be λ/4 =10 mm [10]. Also we added a slot to circular patch which has 4 mm radius and return loss graphic has been improved by using this slot. To achieve directivity in designed circular monopole antenna, generally L– shaped reflector is used. In our study, ground parameters were changed manually to obtain better results. Due to this modification, front-to-back ratio is higher than the antenna which presented in [11].

Figure 1 shows the layout view of designed circular disc monopole antenna. Dimension of ground plane is shown in figure. Width and length of microstrip line feed is 3mm and 17.2 mm respectively to match with 50Ω impedance line. Center point of slot is same with center of circular patch and diameter of circular disc is 20 mm.

As nonconductor material "FR4_epoxy" was selected for the constructed antenna, dielectric constant (εr) was taken as 4.4 and dielectric height (h) was 1.6 mm.

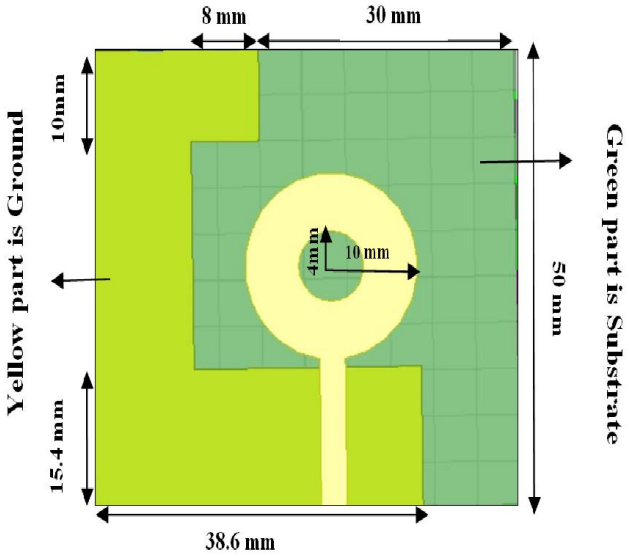


Fig. 1 Design parameters of proposed antenna

III. ANTENNA SIMULATION

For simulation findings, high frequency structure simulator (HFSS) [12] based on full-wave finite elements method and widely used in the analysis of electromagnetic structures was utilized. Presentation of the proposed ultra-wide band antenna with HFSS is given in Figure 2.

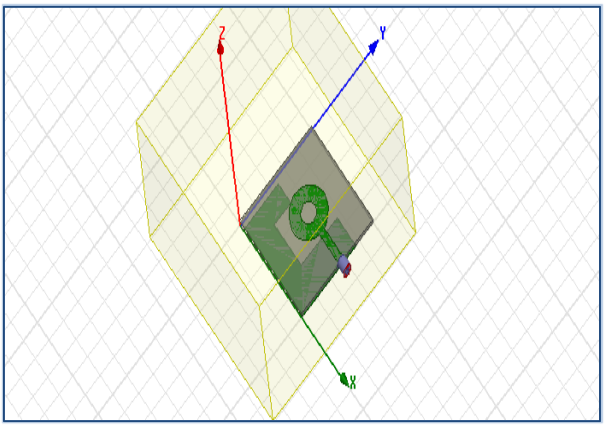


Fig. 2 Proposed antenna with HFSS

When simulation results are analyzed based on 10 dB return loss criterion, it was observed that the impedance bandwidth is between 5 and 10.5 GHz. At maximum operating frequency of the proposed antenna Return Loss value was obtained as -33.98 dB. RL characteristic (S11) of the antenna is presented in Figure 3.

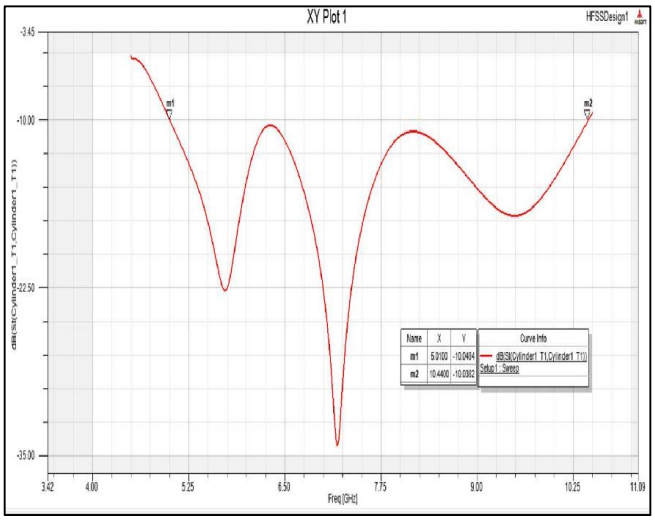


Fig. 3 RL characteristic (S11) of the proposed antenna

One of the important parameters that demonstrate the antenna performance for microwave imaging is the directivity. Radiation pattern of the antenna at 7 GHz is given in Figure 4. According to pattern, front-to-back ratio is calculated 14 dB which is the good value for directivity feature. Unfortunately, it seems that there are unwanted side loop which cause to fall quality of antenna. We will try to improve this negativity and hope to obtain better radiation pattern before the operation of printing antenna on board.

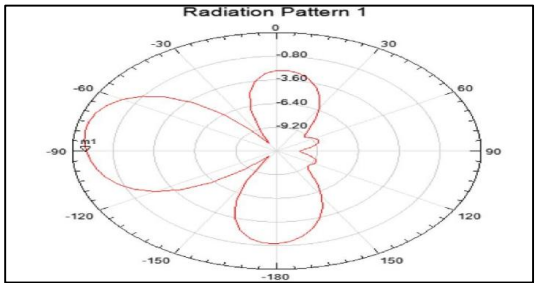


Fig. 4 Radiation pattern of proposed antenna at 7 Ghz

IV. CONCLUSIONS

Size, directivity and a good reflection coefficient are the most important characteristics of the antenna design requirements for use in near field near surface measurement applications such as the microwave breast cancer imaging system. In this study, compact and small size of the antenna is presented. Simulation results confirm that reflection coefficient is under -10dB throughout 5-10.5 GHz. The properties of compact and UWB antennas have been ensured. Radiation pattern shows that, front-to-back ratio is 14 dB which is the good value for directivity feature. Unfortunately, it seems that there are unwanted side loop. This problem can be resolved by making some modification on ground plane.

From simulation we can conclude that circular monopole antenna is favorable for microwave imaging systems.

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