Design a Planar Antenna of Integrated Microwave Imaging Radar for Detecting Earlier Breast Cancer

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Abstract— *In this paper, a compact design and construction of micro strip feed planar antenna comprising both coupling and decoupling structure is presented. Each antenna element working under wider frequency range of about 2-16 GHz. To achieve a better imaging radar tool a dedicated radar transceiver is proposed. Segmentation is applied to the decoupled image from transceiver. After, a novel hybrid artifact removal algorithm for microwave breast imaging applications is presented, which combines the best attributes of two existing algorithms to effectively remove the early-stage artifact while preserving the tumor dynamic range of bandwidth is proposed. . The main concern of this project is to diagnose the benign tissue at the earliest as most cancer cells are completely curable at the earlier stage. The tool is best suited for diagnosis of earliest breast cancer causing tumor cells having resolution of about 3 mm.*

Keywords— Breast cancer, Planar Antenna, Artifact removal, microwave imaging, ultra wideband radar, Micro strip feed skin effect.

I. INTRODUCTION

The dramatic development of wireless communication leads to the development of microwave imaging technique to image human body has been taking place now. As reported in [1], breast cancer is one of the most incident tumours among the female population. Since 95% of the cures are possible if they are identified in the benign stage and it could be treated as well and prevented from being the tissue to be malignant. These Microwave integrated devices has its wider applications in the biomedical field.

A novel hybrid artifact removal algorithm for microwave breast imaging applications is presented. The novelty of this study is threefold. First, the authors propose a hybrid artifact removal algorithm that combines the best attributes of the Entropy-based Time Windowing algorithm[1] and Wiener Filter algorithm[2] to effectively remove the early-stage artefact while preserving the tumor response. Second, the algorithm is evaluated using an anatomically and dielectrically accurate 3-D finite-difference time-domain (FDTD) model (compared to the 2-D homogeneous FDTD model originally used[1]). Third, the hybrid algorithm presented here shows a very clear improvement compared to the original algorithm across a range of appropriate metrics.

II. PLANAR ANTENNAS

Planar antennas are the newest generation of antennas boasting such attractive features such as low profile, low weight, low cost and ease of integration into arrays. These features make them ideal components of moderncommunication systems, particularly in biomedical field. Here in this paper the planar antennas are used for the designing a novel Microwave imaging radar tool which has its valuable usage as a diagnostic tool in the detection of tumour cells at an earlier stage. In this planar antenna layout the strip is designed and feed is through a microstrip line with 50 ohms microstrip line.

III. UWD PATCH ANTENNA

A. *Theory*

The proposed module comprises two antenna element which are considered to be the monopole structure. Each antenna element working under a wide bandwidth and has an operating frequency range of about 2 to 9 GHz . Antenna top layer layout depicts the transmitting and receiving radiating patches. The radiation pattern combines both the rectangular and circular patches. The semicircular tapering part gives a better impedance matching all over the bandwidth. The feeding line is chosen to be centre feed. The centre microstrip feed line to these radiating patch provides equal current distribution and provides a good power patch.

Impedance matching should be equal to 50 ohms, that certainly provides better input and output transmission and reception. Top layer of the antenna structure depicts the coupling structure where the monopoles are placed facing at the same face. To achieve a compact design the monopoles are placed very close to each other which causes mutual coupling between the antenna. These mutual coupling introduces losses and there is a need to avoid these mutual coupling. To avoid this unavoidable mutual coupling a T shaped decoupler is being added to the back of the laminate, which reduces the losses introduced.

B. Antenna Design

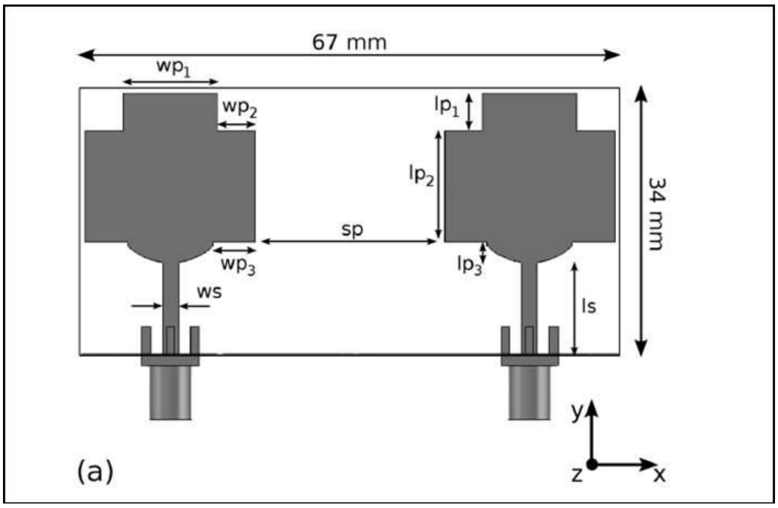
Factors determining the antenna compact design includes insertion and isolation factors. For perfect input and output matching to get occur insertion should be high, thereby the insertion loss should be low as possible. Isolation between these monopoles should be high and isolation loss should be as low as possible. The upper part isolation control is adapted by the parameters say ***wd2*** and ***ld2***. Isolation control is adapted by the parameters say ***wd1*** and ***ld1*** which controls the isolation between the two radiating patches, at the lower part with an operating frequency band of about 2 to 9 GHz.
) reads as "equation 3"). Ensure that any miscellaneous numbering system you use in your paper cannot be confused with a reference [4] or an equation (3) designation.

Table 1:Design considerations

Frequency	*3.3 GHz to 8.5 GHz*
Substrate	*1.524*
Loss Tangent	*0.0027*
Feed line (Top	*Length = 9.9mm*
	Width = 1.7mm
Substrate	*3.55*
Ground Plane	*Length = 67 mm*
	Width = 34 mm

C. Antenna Geometry

The Planar antenna geometry is illustrated in the figure 1. The antenna layouts includes the (a) Top layer layout for the coupling structure and (b) Bottom layer layout for decoupling structure with partial ground plane and overall dimensions given. The layout is schematized using software MATLAB . The parameters that are needed to calculate includes S parameters, reflection coefficients and VWSR. The designing of monopole planar antennas in advanced design systems software includes Laying out the radiating planar patches. Microstrip line feeding through various feeding techniques and here centre fed is given to ensure that the entire radiation patch is getting equal power distribution. Schematic of the line feed being created and all attached to the radiating element and consequently the ports are been checked for coupling, which energises transmission and reception. Upon estimating mesh frequencies S parameter simulation frequencies are being set up to get the radiation pattern. The top layer and bottom layer are simulated individually to get the radiation pattern. The parameter analyzed includes polarisation and radiation pattern measurements in magnetic plane is made.



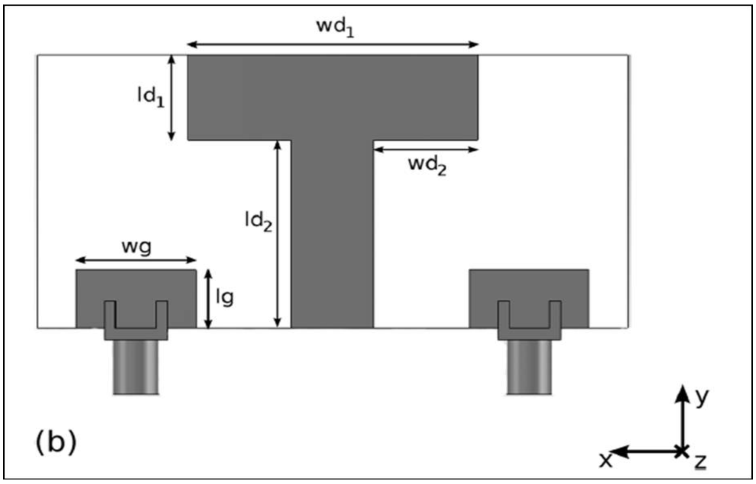


Fig A: Layout of antenna structures (a) Top layer layout with transmitting and receiving radiating patches (b) Bottom layers with decoupling structures an partial ground plane. Dimensions *wp1*=10mm *wp2*=4mm, *wp3*=4mm, *lp1*=4mm, *lp2*=12mm, *lp3*=2.1mm, *ws*=1.7mm, *ls*=9.9mm, *sp*=20mm, *wg*=11.5 mm, *lg*=6.25mm, *wd1*=28 mm, *wd2*=10 mm,*ld1*= 9mm, *ld2*=20mm.

D. Artifact-Dominant Window Selection For Adaptive Artifact Filtering

The proposed novel artifact removal algorithm combines the best attributes of the Entropy-based Time Window algorithm and the Wiener Filter algorithm. The first step of the proposed artifact removal algorithm is to automatically select the artifact-dominated portion of backscattered signals based on entropy values. In order to better select the artifact window, the proposed algorithm improves upon the original Entropy-based Time Window artifact removal algorithm proposed. While their algorithm is effective in removing the artifact, it often fails to correctly estimate the exact portion of the signal containing the artifact. It also tends to remove part of tumor response when early-time artifact and tumor responses overlap in time.

Therefore, an improved algorithm was developed by the authors that more accurately estimates the artifact-dominated portion of the signal. The Entropy-based Time Window algorithm is based on the assumption that the artifacts in the received signals are similar across all channels, unlike the case for the tumor response in real breast imaging scenarios (the tumor response is delayed and attenuated differently due to variations in the tissue structures at each channel). A larger value of entropy is obtained from similar artifacts in the early portion of the radar signal, and conversely, the tumor reflections result in a much lower entropy value.

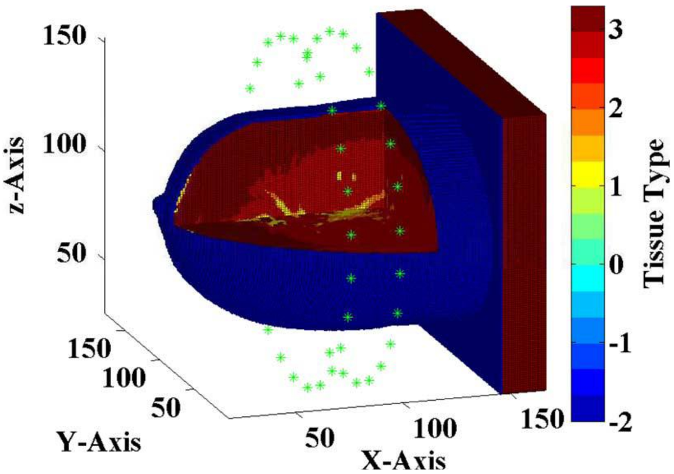


Fig. 1. Three-dimensional FDTD breast model and antenna configuration.

IV. SIMULATIONS AND PERFORMANCE METRICS

An accurate 3-D FDTD model must incorporate the appropriate geometrical properties of the breast, the heterogeneity, and spatial distribution of the different constituent tissues within the breast. The models considered in this study are based on the UWCEM MRI breast cancer repository . The antenna elements are immersed in a coupling medium matching the dielectric properties of adipose tissue.. The entire simulation space is 150mm, 150mm ,150 mm . Each location within the breast is described in terms of (x mm, y mm, z mm). For completeness, three breast models have been considered in this study: a homogeneous breast model composed of adipose breast tissues only; a heterogeneous model with heterogeneous adipose tissues; and finally a full heterogeneous model with both heterogeneous adipose and fibro glandular tissues. An 8-mm tumor is placed at different locations within each breast model: a tumor located close to the skin at position (65 mm, 65 mm, 35 mm); at position (88 mm65 mm, 45mm); and at (88 mm, 65mm, 100 mm). A 200-ps differentiated Gaussian pulse is transmitted and recorded at each of the 50 antennas. The input pulse has a center frequency of 6.0 GHz and a 3-dB bandwidth of 5 GHz. FDTD simulations are conducted at a sampling rate of 576 GHz. Prior to any signal processing, all FDTD signals are down-sampled from 576 to 57.6 GHz.

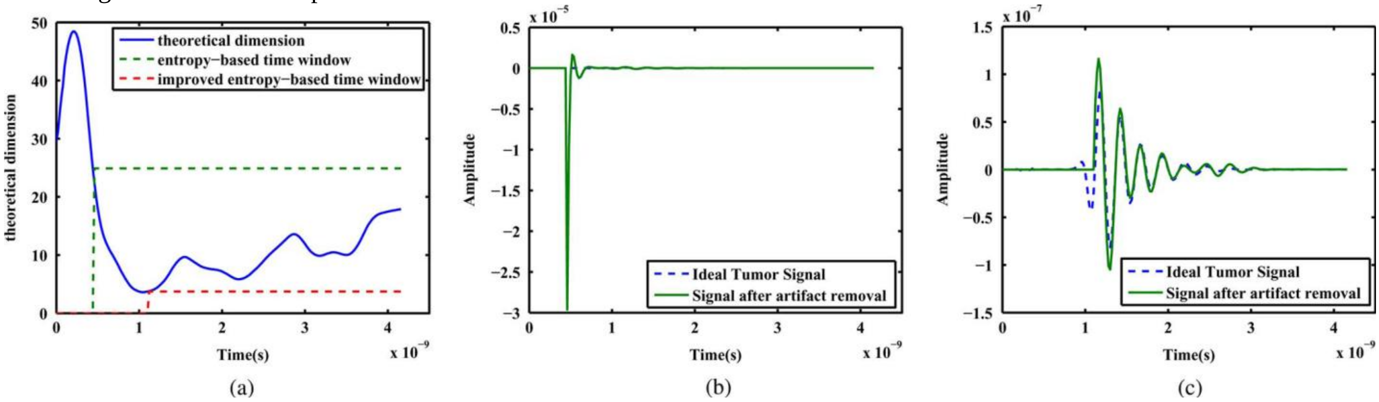


Fig. 2. (a) Theoretical dimension and time window functions. (b), (c) Time-domain signals obtained after multiplying time window functions and corresponding ideal tumor signals. (a) Original time window. (b) Original time window. (c) Improved time window.

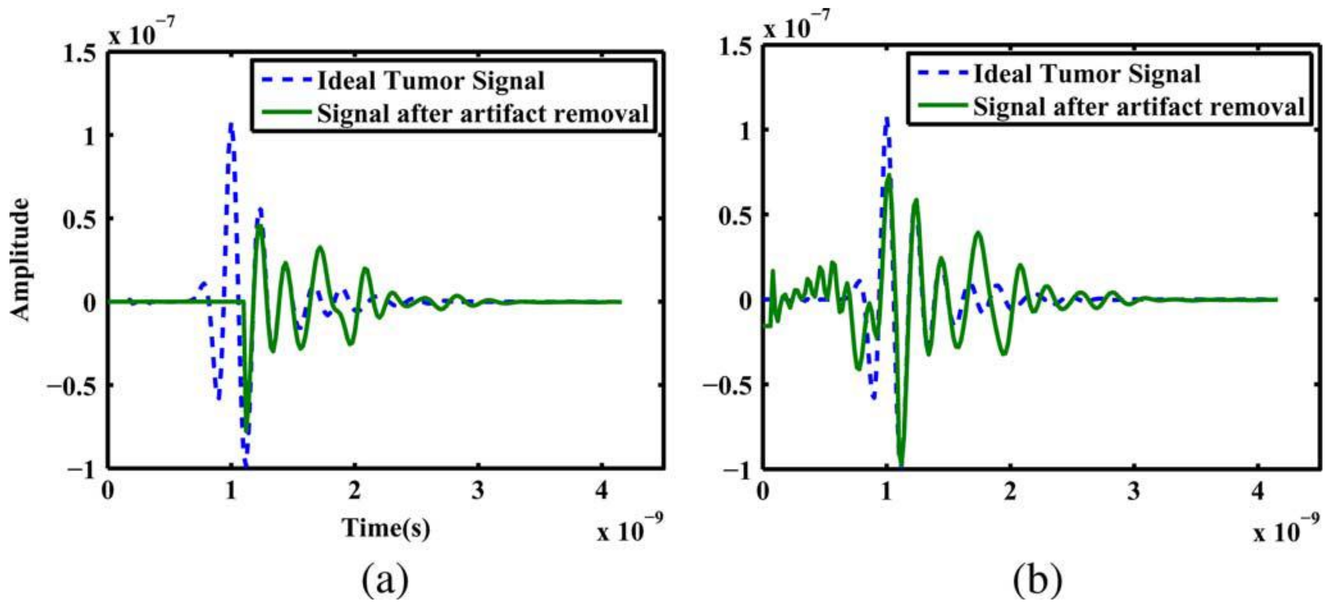


Fig. 3. Time-domain signals after artifact removal. (a) Multiplication with improve time window. (b) Wiener Filter over improved time window.

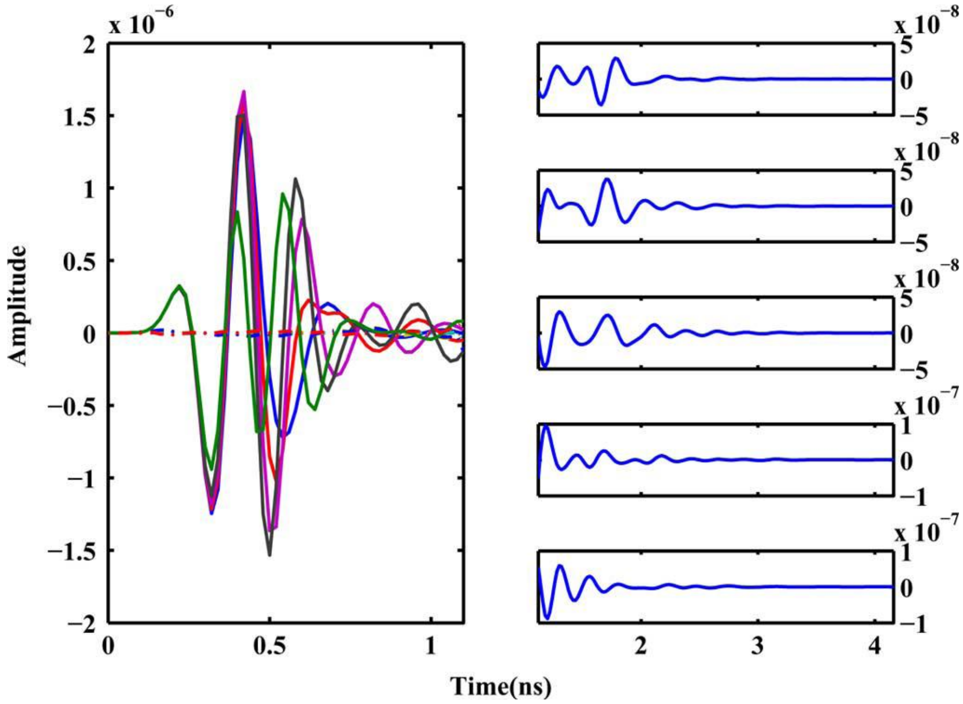


Fig. 4. Time-domain signals before (solid lines) and after (dotted lines) artifact removal using proposed hybrid algorithm at five different channels: *(left)* early time response (artifact) and *(right)* late-time response (tumor signal) (note different amplitude ranges between early and late-time signals).

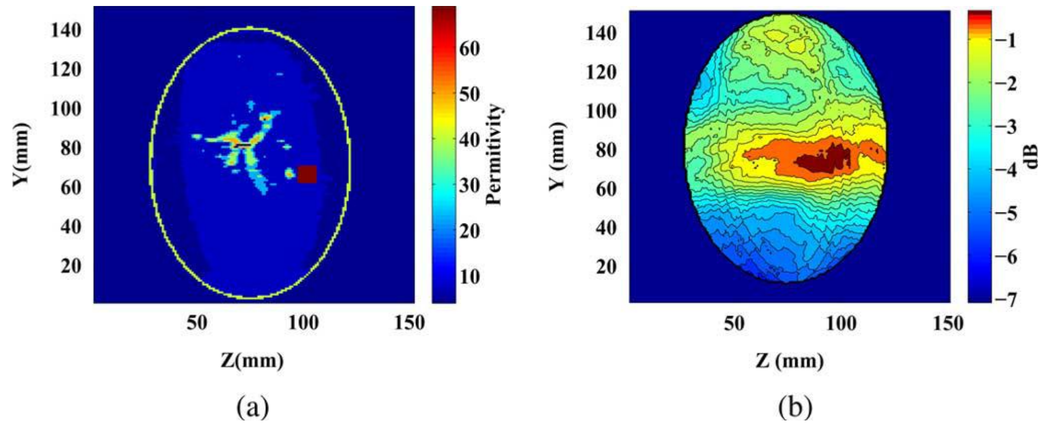


Fig. 5. Coronal view of FDTD breast model showing (a) permittivity of breast tissues computed at 6.0 GHz and (b) corresponding beam formed image obtained after artifact removal using hybrid algorithm.

V. CONCLUSION

In this letter, a hybrid artifact removal algorithm for microwave breast imaging applications is presented, which combines the best attributes of two existing algorithms to effectively remove the early-stage artifact while preserving the tumor response. A time window is designed based on the entropy values, which represents the artifact-dominant part of the signal, and the artifact is removed by applying the Wiener Filter algorithm over the estimated artifact window.

After artifact removal, beam formed images are obtained using a simple delay-and-sum beam former. Results indicate that the proposed algorithm provides for an improved artifact window selection and uses a Wiener Filter to remove the artifact while preserving the tumor response across all channels. The algorithm is compared to the Entropy-based Time Window algorithm, and results indicate that the proposed algorithm performs better in terms of signal and image quality metrics, from simple homogeneous scenarios to more realistic dielectrically heterogeneous scenarios.

Future work will focus on extending the proposed algorithm for artifact removal to the more challenging scenario of multistatic radar signals.

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