

Study on breast cancerous organ's depth and coverage parameters via Debye and monostatic radar techniques with UWB-microstrip patch antennas.

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Abstract

A 5 GHz class of Microstrip Patch Antenna (MPA) designed, simulated, fabricated and measured has been presented in this research paper. Furthermore, comparative study on existing Debye test bed and Monostatic radar techniques have been implemented for depth and coverage of cancerous organ parameters respectively via 2×2 array pattern of Ψ_U shaped UWB-MPAs. The proposed MPA offers enhanced design parameters and lesser complexity than existing 3GHz MPAs. For an example, the proposed UWB-MPAs prototype provides operating frequency of 4.53 GHz (15.99% of Fractional Bandwidth (FBW)) and complexity of $18.64 \times 23.92 \times 1 \text{ mm}^3$. Hence, these MPAs have to analyse the vector dimensional and depth of cancerous organ has been presented in paper.

Keywords: Breast cancer diagnosis system, Debye test bed, Monostatic radar technique, Fractional bandwidth and UWB-MPAs.

Accepted on November 12, 2016

Introduction

Breast cancer is a major challenge and health issue of the present society. The death rate has doubly risen in the past 30 years. The various diagnosis systems are authorized and followed to reduce the death rate. The Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET) are the existing diagnosis trials. The X-ray mammography (XRM) is an efficient diagnostic tool but it has some limitations in the screening detection methods. They are, the heavy chemical dose applied on the human breast to affect ionization effects within the body and the harmful radiation effects during the clinical tests. Both of the above results provide in the injurious health issues. Normally, these radiology diagnostic trials do not offer the tissue's sample based analysed report. These drawbacks of MRI, XRM and other existing techniques are recovered using the Microwave Imaging (MI) methods in [1]. The proposed test beds are able to conduct below 10 GHz range of microwave signals which requires the Specific Absorption Ratio (SAR) value of 4 W/Kg limitations. The microwave transmission of medical diagnosis has thermal and radiation effects. The thermal effect is used in therapy treatment which removes the cancerous organ. As the result of diagnosis, test beds provide the ionization and injurious effects. The radiation effect offers the non-ionization; cost effective, harmless effects and more number of clinical trials are possible to under the screening test. The Microwave Imaging (MI) methods provide the UWB based a radar approach which classifies the tumor resolution stages using scattered mapping algorithms. Consequently, efficient MPAs designs are required

for breast cancer detection in UWB-MI diagnosis methods. The proposed UWB-MI diagnosis system and the drawbacks of prior diagnosis systems are discussed in the [1-3].

Materials and Methods

The compact size of 2×2 array pattern of MPAs with 5 GHz UWB band of operation and Industrial Scientific and Medicine (ISM) band of applications are presented in this section. The conductive patch strips propose to design a 2×2 array of four radiating elements. The proposed MPAs are design and simulated and fabricated procedures are followed in [3]. Furthermore, their complexity is lesser than existing design. Analyze of depth and coverage of parameters is justified in cancerous organ by existing test bed of [3]. The 5 GHz resonance class of 2×2 array patterns of MPAs and equivalent dielectric breast model are justified for depth of cancerous organ using different dielectric strengths of coupling materials. It has shown in Figure 1, the early time peak response of 25.75 dB has been obtained at 4.475 GHz. These scattered drops have clearly described the opposite values of dielectric strengths in the scattered responses. As the scattered drops of the higher dielectric strength offer above the 85 dB of scattered drops. These kinds of values are not reordered in the Agilent (N99917A) Microwave Analyzer with VNA. The healthy tissue module consisting of MPAs logically connects to wristband which is measured using Agilent (N99917A) Microwave Analyzer with VNA [3]. The return losses of 41.78 dB (S_{ii}), 47.45 dB (S_{jj}) has been obtained at 2.414 GHz and 2.301 GHz. While, coupling losses ($S_{ji}=S_{ij}$) of 47.781 dB;

61.778 dB measured at 3.454 GHz to 3.812 GHz in the 2×2 array of a Ψ_U shaped MPAs based healthy tissue module respectively. Figure 1 show the subtracted scattered responses of the proposed MPAs respectively. The tumor information of 2.1 GHz to 4.834 GHz and early time responses are found at

2.53 GHz. These scattered responses are followed by previous test bed and derived from Equation [3]. The depth of the tumor of 2×2 array patterns of Ψ_U shaped MPAs based on Debye test model are compared with the MPAs based on Debye test model listed in the Table 1.

Table 1. Comparison of the depth of the tumor in the 2×2 Array of a Ψ_U shaped MPAs and the existing MPAs based on Debye test beds [4-7].

Proposed mpas based debye test beds	Resolution stages/tumor size	Depth of major stage frequency f_{major} (GHz)	Depth of early stage frequency f_{early} (GHz)	Travelling time δ_t (ns)	Analysed in proposed test beds Parameters			Fear et al. analysed in existing Debye test beds parameters			Physical Distance between the tumor with MPAs (cm)
					Dielectric strength of tumor	Velocity of propagation (mm/s)	Depth of tumor by numerical analysis (mm)	Dielectric strength of tumor	Velocity of propagation (mm/s)	Depth of tumor by numerical analysis (mm)	
	Early-I 1 cm	3.3	5.89	0.36	48.5	4.3×10^{10}	30.96	9	10^{11}	72	129.8
	Minor-II 2 cm	2.55	5.49	0.34	48.5	4.3×10^{10}	29.24	9	10^{11}	68	127.4
	Growing-III 2.5 cm	2.56	5.45	0.34	48.5	4.3×10^{10}	29.24	9	10^{11}	68	109.2
	Major-IV 3 cm	3.65	5.49	0.53	48.5	4.3×10^{10}	45.58	9	10^{11}	106	110.4
Proposed MPAs analysed in the existing test beds	Kiruthika et al. 5 mm Tumor Size	3.3	5.89	0.36	21.3	6.5×10^{10}	46.8	9	10^{11}	72	129.8
	10 mm Tumor Size	2.55	5.49	0.34	21.3	6.5×10^{10}	44.2	9	10^{11}	68	127.4
	15 mm Tumor Size	3.65	5.45	0.53	21.3	6.5×10^{10}	68.9	9	10^{11}	106	110.4
Salvador Et al..	1 cm Tumor Size	2.55	5.49	0.34	20 to 40	5.3×10^{10}	36.04	9	10^{11}	68	129.4
	2 cm Tumor Size	3.65	5.49	0.53	60 to 80	3.1×10^{10}	32.86	9	10^{11}	106	109.2

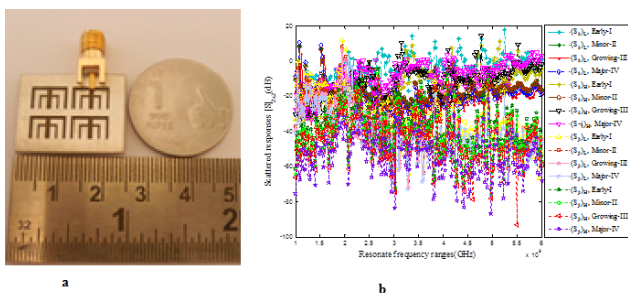


Figure 1. (a) Fabricated MPAs prototypes, (b) Scattered Responses of 2×2 Array of a Ψ_U Shaped MPAs Test Beds.

It can be described that the perfectly matched tumor depth with a physical distance from phantom breast model has reliable accuracy with the Debye breast tumor model. The 2×2 array of Ψ_U shaped MPAs based Debye test beds are made up of two way duplex transmissions which is used for detection of dielectric equivalent of tumor materials placed in dielectric equivalent of the breast phantom model. Based on Debye test bed setup results are followed and determined in the two way monostatic radar modelling of Equations [3] are used to find out the detection of tumor resolution stages along the cancerous organ which are examined in Table 2.

Table 2. Analysis of the Maximum Target Detection of 2×2 Array of a Ψ_U shaped mpas based debye test beds.

Coupling mediums	Tumor resolution stages	Target factor	gain	Space path loss αG_0 dB	Received power at target P_r dB	Maximum coverage R_{Max} dB	target	Maximum sensitivity MOS	Total G_r dB	gain
Lower Dielectric Strength	Early-I 1 cm	129.89	164.43	297.57	41.49	-45.5	175.39			
	Minor-II 2 cm	140.77	169.52	306.67	83.13	-49.5	190.27			
	Growing-III 2.5 cm	147.356	172.34	308.29	80.79	-76.86	224.2			
	Major-IV 3 cm	153.186	175.33	313.94	79.38	-78.3	231.48			
Higher Dielectric Strength	Early-I 1cm	129.67	164.2	297.52	86.54	43.48	172.7			
	Minor-II 2 cm	141.97	170.73	305.3	82.49	76.28	218.25			
	Growing-III 2.5 cm	147.53	172.51	308.57	80.83	77.3	224.8			
	Major-IV 3 cm	153.186	175.33	314.05	79.79	64.94	218.13			

Conclusion

The proposed MPAs have been concluded that the 1×2 array of Ψ_U shaped MPA is FBW of 31.7 % greater than 3 GHz class of UWB-MPAs [3]. Therefore, Sakthisudhan et al. [3] prototypes are not clearly defined as UWB types of MPAs prototypes. However, Ψ_U shaped MPA provides enhanced FBW, UWB of bandwidth than other UWB-MPAs. A 2×2 array of Ψ_U shaped MPAs offer the resonance of 5.26 GHz, wide band of 4.5 GHz to 5.5 GHz and FBW of 19.60. These 2×2 array of MPAs and equivalent dielectric breast model are validated using higher and lower dielectric strength of coupling medium which are obtained from the different tumor resolution stages. Therefore, the results are experimentally analysed in the selection of different tumor dielectric equivalent material. For experimental purpose, these test bed results are compared with healthy tissue modules. Hence, the cancer resolution stages are described by scattered mapping algorithms. These proposed MPAs based Debye test beds have been numerically analyzed using two way monostatic radar approach. This method provides the maximum sensitivity, maximum target of coverage and other related parameters. Hence, the 2×2 array of Ψ_U shaped MPA is a more efficient antenna design than other MPAs for UWB-MI system and it suitable for breast cancer diagnosis system [3,8-11].

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