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SMART UWB ANTENNA FOR EARLY BREAST CANCER DETECTION

Nirmine Hammouch and Hassan Ammor
Smart Communications Research Team, Engineering for Smart and Sustainable Systems Research Center, EMI, Mohammed V University in Rabat, Morocco
E-Mail: hammouchnirmine1@gmail.com

ABSTRACT
Early diagnosis is the most important key to detect breast cancer and ensure a fast and effective treatment in order to reduce women mortality. This paper proposes a new UWB antenna design for biomedical applications, especially for breast cancer detection. Some new techniques are applied to the antenna in order to achieve a broad bandwidth, high gain and to improve some understanding of the antenna characteristics. The UWB antenna is printed on the FR-4 substrate with thickness of 1.58 mm and relative permittivity εr=4.3, operating in the range of 2.96 - 10.68 GHz. Parametric studies of the proposed antenna are provided. All numerical simulations are performed using two different electromagnetic solvers.

Keywords: UWB antenna, biomedical applications, breast cancer.

1. INTRODUCTION
Worldwide, Breast cancer is the most frequent type of cancer in women. Each year, a million new cases of breast cancer are recorded, which makes of this cancer more diagnosed in the world, It is considered the leading causes of death in females. Early detection is the most important key to combat it and assure efficient treatment for cancer patients [1, 2, 3].

X-Ray Mammography is the most commonly used diagnostic technique for earlier breast cancer diagnosis, this method frequently generates a wide range of limitations and undesired sides such as painful scans, ionizing radiation, false positive and false negative results, and high cost [4, 5].

Microwave imaging is proposed as an imaging modality for tumor detection of breast cancer. This microwave method has the potential advantages including low cost, more safety and high accuracy. It consists of transmitting microwave signals through the breast tissue and recording the received signals scattered from different locations [6, 7, 8]. Therefore, this technique is known by utilizing Ultra Wide Band (UWB) antennas with a frequency of 3.1 GHz to 10.6 GHz according to the Federal Communications Commissions (FCC) standard [9, 10]. An UWB antenna must be small size and inexpensive without degrading the performance to improve the detection of tumor inside the breast.

In this paper, a compact planar UWB antenna is successfully designed, simulated and verified, which makes of this antenna a good competitor for UWB systems, especially for tumors detection. All numerical simulations are performed using two different EM solvers respectively based on Finite Integration Technique (FIT) and Finite Element Method (FEM).

2. ANTENNA DESIGN
The configuration of antenna used for this study is shown in Figure-1. The radiating element has dimensions of WxL, and ground plane dimensions are WsxLs. This antenna is printed on the FR-4 substrate with thickness of t=1.58 mm, relative permittivity εr=4.3 and loss tangent of δ=0.02. The final dimensions of the antenna structure are listed in Table-1.

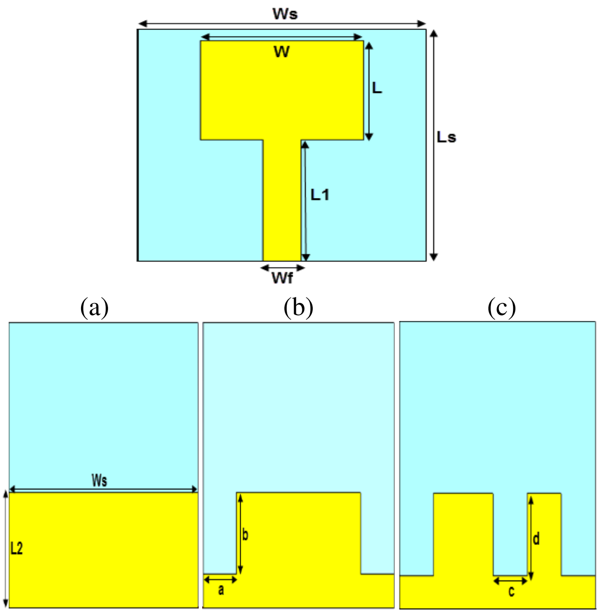

Figure-1. Geometry of the proposed antenna. (a), (b), (c), Design evolution of the final ground plane.

Table-1. Optimized dimensions in mm.

Parameters	Value (mm)	Parameters	Value (mm)
Ws	23	L2	8.5
Ls	21	t	1.58
W	13	a	4
L	9	b	6.5
Wf	3	c	4
L1	11	d	6

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3. SIMULATION RESULTS AND DISCUSSION

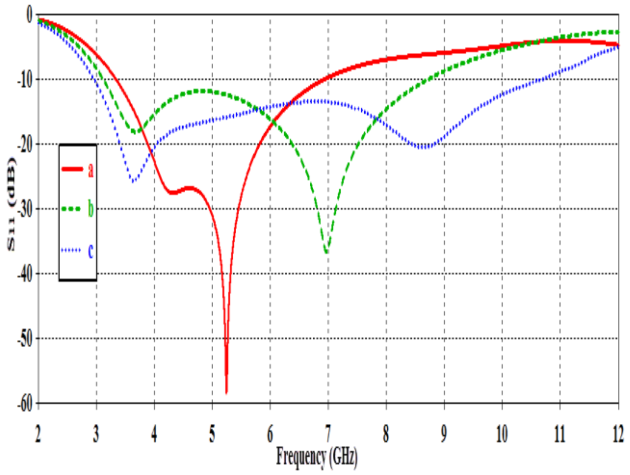
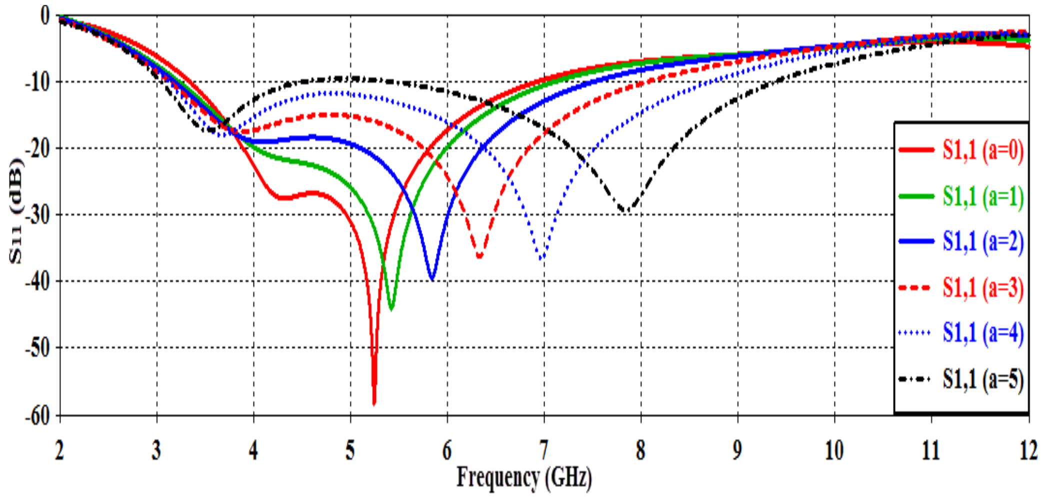


Figure-2. Simulated reflection coefficient of the antenna for different structures.

Figure-2 shows the progress in the reflection coefficient achieved through step-by-step ground changes. Each step gives us the opportunities to improve the bandwidth of the proposed antenna.

Table-2. The bandwidths of the proposed antenna for different structures.

structures	Resonant frequency (GHz)	Return loss (dB)	Bandwidth (GHz) (< -10dB)
a	5.24	-58.37	3.33-6.94
b	3.68 6.97	-18.08 -36.58	3.12-8.73
c	3.65 8.64	-25.60 -20.45	2.96-10.68



Figuire-3. The Simulated reflection coefficient for the proposed antenna for different values of a.

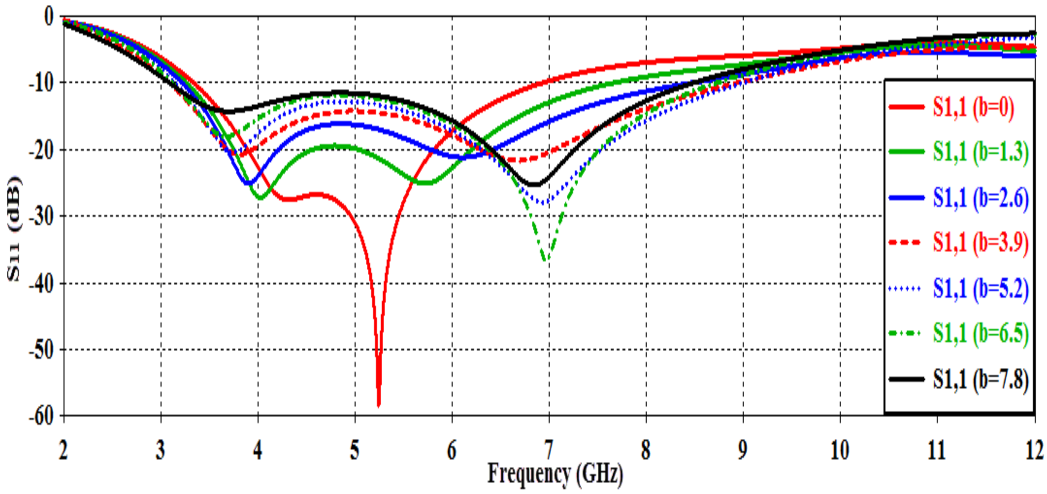


Figure-4. The Simulated reflection coefficient for the proposed antenna for different values of b.

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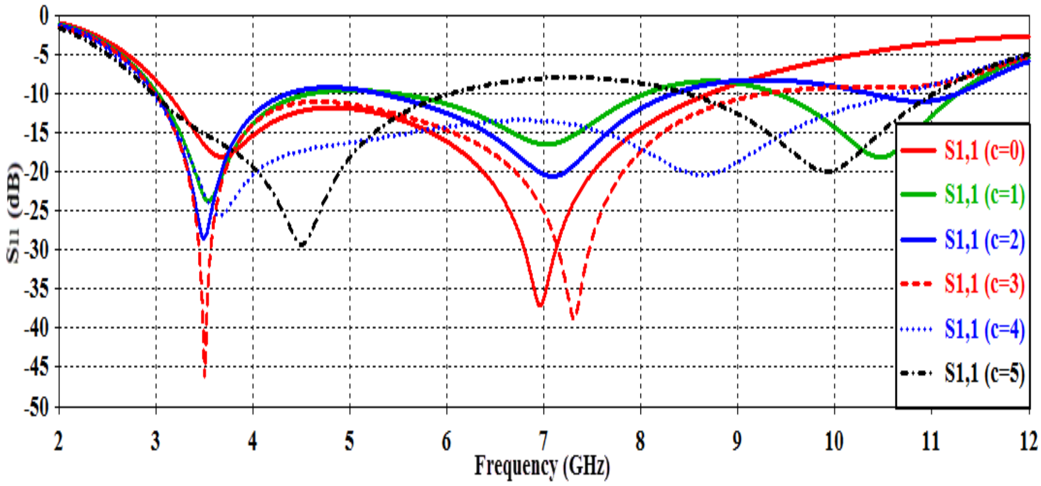

Figure-5. The Simulated reflection coefficient for the proposed antenna for different values of c.

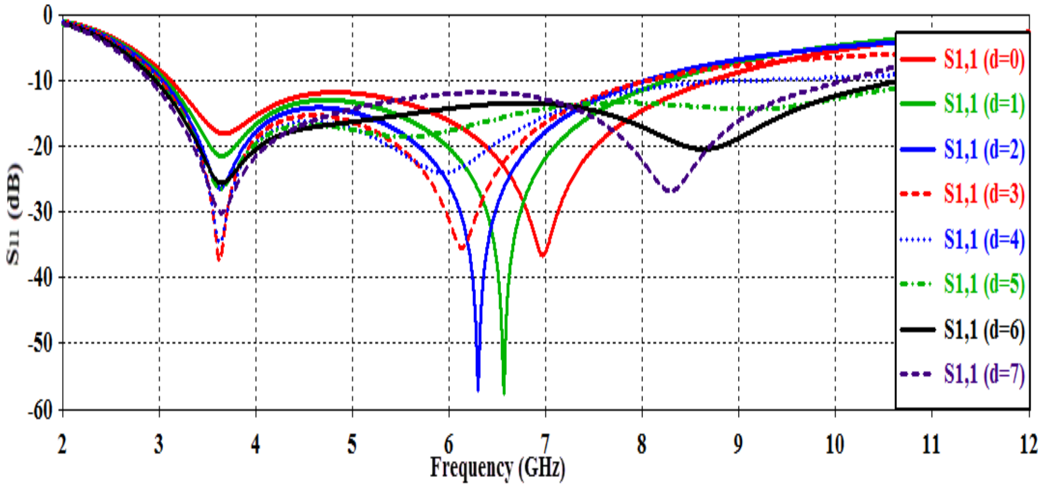

Figure-6. The Simulated reflection coefficient for the proposed antenna for different values of d.

The aim of this parametric study is to improve some understanding of the antenna characteristics. For that reason, we investigated the effects of all parameters (a, b, c, d) on the performance of the antenna. The procedure followed for this study is to change only one parameter and observe its effects on the proposed antenna characteristics.

Table-3. The bandwidths of the proposed antenna for different electromagnetic solvers.

Solver methods	**Resonant frequency** (GHz)	**Return loss** (dB)	**Bandwidth** (GHz) **(< -10dB)**
FIT	3.65 8.64	-25.605 -20.457	2.96-10.68
FEM	8.385	-28.782	2.41-10.62

From all this obtained results Figures 3, 4, 5, 6 we remark that a very good performance can be achieved by optimizing all parameters of the antenna. The proposed antenna has a good performance with respect to bandwidth ranging from 2.96 to 10.68 GHz.

To validate the previous results, another simulation is performed using Finite Element Method (FEM). Figure-7 shows the comparison between the S parameter measured with two different electromagnetic solvers.

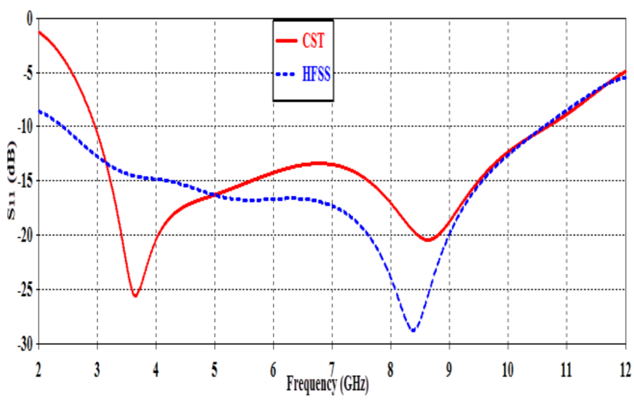

Figure-7. Simulated reflection coefficient of UWB antenna.

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A good agreement is observed between the two simulations even if we remark some differences due to the fact that they are based on two different solving algorithms and meshing techniques.

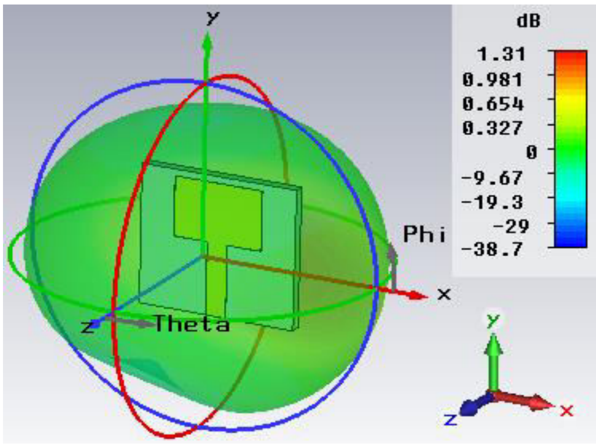


Figure-8. Radiation pattern 3D of the basic antenna at 3.65 GHz.

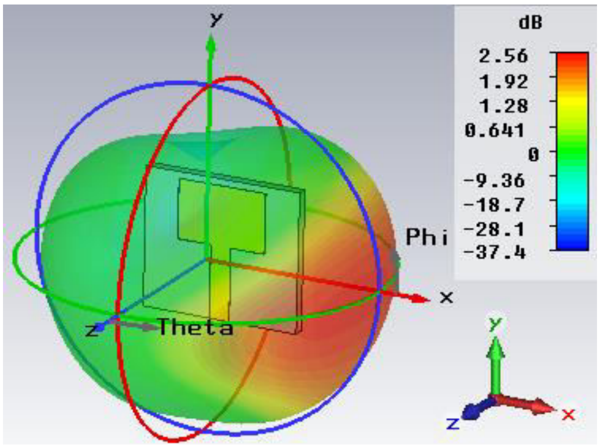
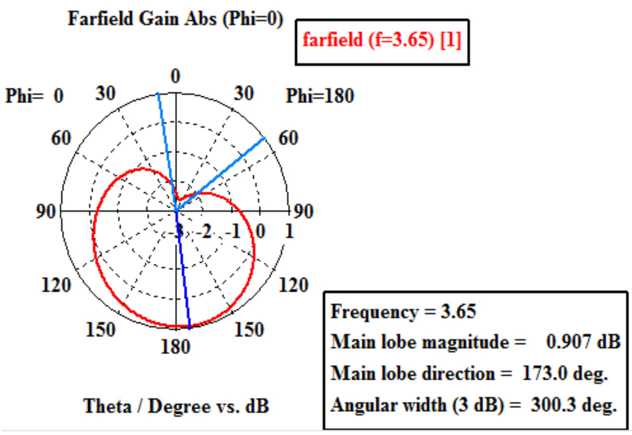


Figure-9. Radiation pattern 3D of the basic antenna at 8.64 GHz.



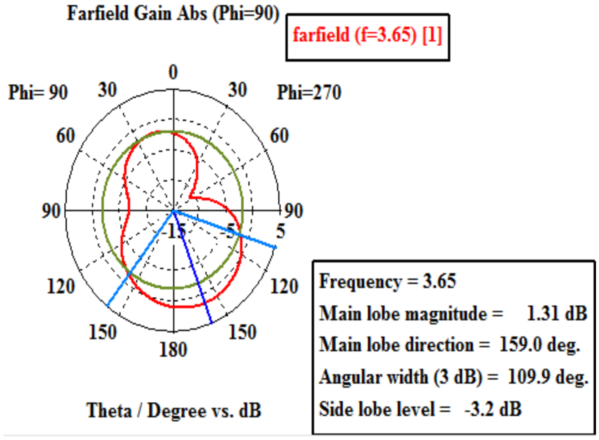


Figure-10. Radiation pattern 2D of the basic antenna at 3.65 GHz.

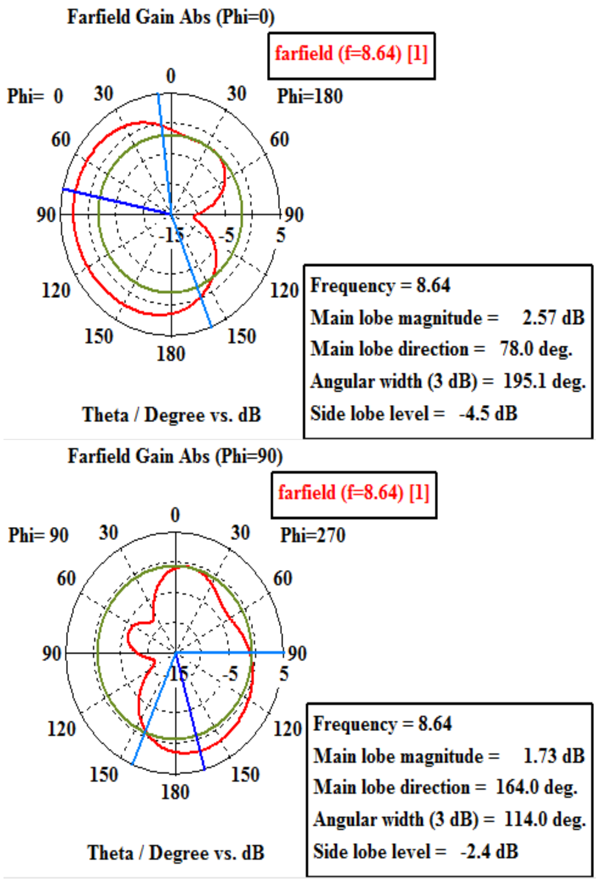


Figure-11. Radiation pattern 2D of the basic antenna at 8.64 GHz.

The proposed patch antenna for UWB applications has nearly omnidirectional radiation characteristic. Good radiation patterns characteristics are obtained for all resonance frequencies.

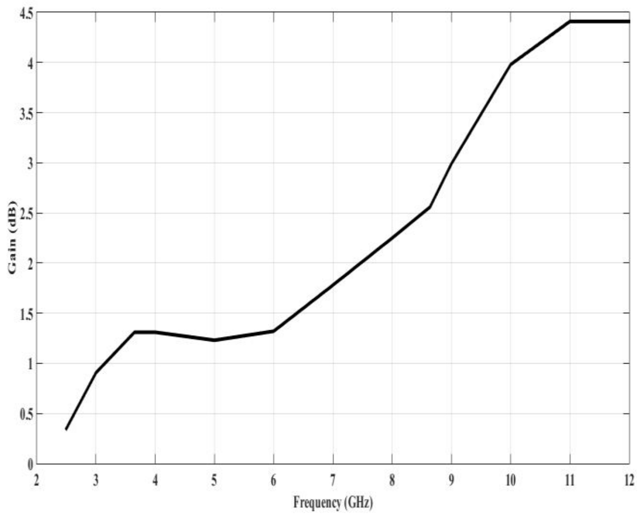


Figure-12. Gain of the proposed antenna.

The gain has certain stability over the whole range of operating frequency, and has a maximum value of 4.41 dB at 11 GHz. The proposed antenna has a good gain performance.

Table-4. Comparison of previous designs with the proposed antenna.

Antenna	**Substrat** (Ɛr)	**Antenna area** (mm)	**Bandwidth** (GHz) **(< -10dB)**
[11]	4.3	73.4x41.9	5-10
[12]	not reported	45x40	6-10
[13]	3.38	42x19	3-8
This work	4.3	21x23	2.96-10.68

Table-4 presents a comparison between the performance of some previous UWB antennas and the proposed antenna. The proposed antenna has advantages compact in size, easy in fabrication, wider impedance bandwidth, simple design and good performances are achieved.

4. CONCLUSIONS

In this paper, a new compact UWB patch antenna for biomedical applications has been presented and discussed. The effects of the different antenna parameters on the bandwidth characteristics were discussed. The simulated results show that the antenna has a reflection coefficient of -10dB from 3.1 GHz to 10.6 GHz (according to FCC). The proposed antenna has the advantages of simple structure, small size, easy fabrication, wider impedance bandwidth, which make this antenna to be an attractive candidate for medical imaging system to detect breast cancer.

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