Design of Ultra-Wideband MIMO Antenna for Breast Tumor Detection

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Abstract. The breast tumor is rarely detected early; early detection helps to quickly and effectively treat. A number of methods are used to detect breast tumors, with mammography being the most popular breast screening method. Mammography is the X-ray tumor in the breast that has some limitation and is quite painful. Microwave imagery provides an enticing mammography alteration by detecting breast tumor using micro strip transmitter at microwave frequency. A fractal shaped UWB MIMO circular ring transmitter has a total size of 60 to 100 mm² and has a range of frequencies from 3.1 until 12.0 GHZ. The transmitter is designed using (CST) Studio Suite 3D EM simulation and analysis software.

1. Introduction
The most common cancer in the breast is prevalent cancer types and leading cause of female death. Where a high percentage of cases are observed in time. A lot of women worldwide are suffering from this disorder and have many unreturned problems due to not early diagnosis. Mammogram, which utilizes the variations an important tool for diagnosis” Is the spread of the natural and cancerous cells to X-rays. This technique however has substantial limitations [1]. Mammography by X-Ray Is the most commonly used strategy to request for the screening of tumors. The system, however, struggled with several limits. The radiation is ionized for electromagnetic waves high-power microwave and frequency greater than 1015 Hz and produce electrons Atom-bound mutate and become malignant [13]. The use of microwave imagery, potentially cost efficient at the same time, provides increased protection and accessibility, is a recent alternative approach [2] [3]. For a decade, heavily inspired researchers develop different, creative medicines applicable stuff for a mechanism for real-time and reliable detection of desires. Health identification and monitoring system at UWB functioning under the unlicensed frequency from 3.1 GHz to 10.6 GHz as per U.S.A standards [14].The techniques of microwave-imagery are focused on a dielectric reference essence of cancerous and healthy tumor membrane [4].The electrical properties of relevant tissues, such as conductance, magnetic permeability or dielectric metrics, are used to differentiate pathologically for both natural breast tissues and cancerous tumor organs through these gradient allocation maps [5] the tumor is detected using these methods by evaluating the scattered signals obtained from the transmitter. There are many approaches in the literature. Nonetheless, ultra-wideband signal approaches have newly received a significant amount of attention [6] [7]. The MIMO technique [8] is still essential for
this approach. In [9] a changed array transmits a wideband signal as well as gets it. Briefly discussed in [10] are the ultra-wide-band MIMO concepts used in the identification of tumors. Therefore, a circular transmitter shaped in Fractal is constructed in this paper. It can offer ultra-wideband characteristics of 3.1GHz–12.0GHz. This ultra-wide band function is obtained by connecting a fractal ring to the circular transmitter. “Such transmitter has two elements are used for MIMO implementations. Hundreds of checks is finished to get rid of that women's main killer. So the work in this paper, research was carried out investigation of some antenna models and they optimized to be able to get the best design of antenna with the best value per parameter. This antenna's bandwidth was 2–4 GHz which is limit for detection of breast tumors jafari et al. investigated two-element arrays, including co- and cross-polarized, for tumor detection [14]. Results showed operational bandwidths of 3.1–10 GHz and identification of a tumor close to the chest wall. The Vivaldi antenna, It is designed for strapline feed [16], Looks like a good fit for that program. There is wide bandwidth in the Vivaldi antenna, good pattern of directional radiation and with a narrowly profile. The aim is to use these antenna and electro-magnetic wave transmission and to receive the waves reflected considering the gap between, health tissues and ailing tissue, we're creating a picture to find the tumors. The used antenna is rectangular miniature satisfy elements of the UWB in terms of wide bandwidth and Loss Return S11 [15]. CST STUDIO SUITE was used to design the structure of antenna in this paper with a low-cost patch antenna with high insulation, low cross-polarization rates and stable radiation patterns that can work between 3.1-12.0 GHz. Design of antenna is explain in section 2 in this paper. Report and analysis was provided in section 3. It is concluded in section 4.

2. The antenna methodology

2.1 The design of antenna

Because of their ultra-wideband features, the large slot transmitters have gained more popularity. These are very common for applications with wide band and small volume. Figure 1 shows the structure proposed for the UWB MIMO transmitter. First, a circular monopoly with diameter A will be inserted into the monopoly to develop the transmitter a slot. The fed row with both the 50-Ω width line and the circular bug radius is B with a three-halfway circular range. Printed with relative permittivity of 2.2 and a spacing of 1.6 mm, this transmitter is printed on a FR-4 substratum. The transmitter has the same setup and sizes for all the three identical elements. The grounds appear in the bottom layer with length Lg and width Wg. In the bottom ground are the circular slots with radius B. And the circular spaces contain fractal rings of radius C, D, E, and F. Transmitter has two layers, one upside down and the other down. The MIMO transmitter has a signature wideband range of 3.1 to 12.0 GHz. And this article can therefore be perceived as analogous to a circular slot that is already being researched for a monopoly disc transmitter [11] [12]. Figure 2 shows the loss of the transmitter return with ring patch. The transmitter suggested must include different parameters and factors in MIMO's design systems. In the MIMO transmitter setup, mutual connections between the transmitter elements are a major factor in achieving high transmitter efficiency. In this document, we present a setting for MIMO transmitter components, in which two transmitter elements are situated opposite. The transmitters must be far apart for low mutual connection. The two components of the transmitter have opposite polarization, which can be the quarreling of the two transmitters. Figure 3 demonstrates the virtual 3D radiation trends for the two components of the transmitter. Orthogonal polarizations of the two components of the transmitter may occur. The pattern of 3D Radiation Power showed very good Radiation, in a specific direction. The ECC is calculable from S-parameters as shown below.
2.2 Breast phantom design

The phantoms are designed and developed by using CST. A model of the hemispheric breast of the sizes given in Table 1 have been using in all the simulations. The size of the tumor radius is from 0.2 cm or more to around 1.5 cm shown in figure 1(c). A circular fractal ring antenna use UWB for transmitter and received. Simulation, structure of UWB Is positioned directly or at a short distance from breast phantom surface.

\[
\rho_e = \left| \frac{S_{11}^* S_{12} + S_{21}^* S_{22}}{\left( \sqrt{1 - |S_{11}|^2} - |S_{21}|^2 \right) \left( \sqrt{1 - |S_{22}|^2} - |S_{12}|^2 \right) } \right|^2.
\]

**Figure 1.** The structure Geometry suggested. (a) View on front (b) View on back (c) CST model for phantom breast.
Table 1. Structure specifications.

| Parameters and description | Size       |
|----------------------------|------------|
| Width of substrate (WS)    | 100 mm     |
| Length of substrate (LS)   | 60 mm      |
| Thickness of substrate (H) | 1.59 mm    |
| Width of ground (Wg)       | 100 mm     |
| Length of ground (Lg)      | 25 mm      |
| Thickness of ground (YP)   | 0.035 mm   |
| Width of feed line (Wi)    | 20 mm      |
| Length of feed line (Li)   | 4 mm       |
| Radius of circular (A)     | 30 mm      |
| Radius of ring (A)         | 12 mm      |
| Radius of ring (C)         | 8 mm       |
| Radius of ring (E)         | 6 mm       |
| Thickness of patch (YP)    | 0.035 mm   |
| Width of (Wr)              | 15 mm      |
| Length of (Wr)             | 10 mm      |
| Breast diameter            | 12 cm      |
| Breast height              | 6 cm       |
| Skin thickness             | 0.2 cm     |
| Chest thickness            | 2 cm       |

Figure 2. Return loss of ring patched slot transmitter.
Figure 3. The two t structure components have 3D radiation patterns.

2.3. Mutual coupling
System MIMO antenna is creating appropriate isolation by placing the antennas appropriately at the corners of a substratum “FR-4”. It's about creating an extra coupling direction, so the ground plane is moving does not enter Port 2 from port 1. The mutual coupling between the two ports is below −35 dB. Mutual coupling describes energy absorbed by the receiver of one antenna while another nearby antenna transmits. That is, mutual coupling is typically unwanted, because a nearby antenna absorbs energy which should be radiated away.

3. Results and discussion
To verify the research the simulation is performed. The proposed structure will be simulated in CST with breast phantom. Figure 1 shows the proposed UWB MIMO transmitter being manufactured. Table 1 lists the detailed measurements. Figure 4, 5 demonstrates well understood simulated loss of return. The measured return loss bandwidths of-10 dB range from 3.1GHz to 12.0GHz, which covers an ultra-wideband. Figure 6 transmitter 1 and transmitter 2 respectively, in the E-plane and H-plane radiation peaks at 3 GHz, 7.5 GHz and 12 GHz. Transmitter 1 has bidirectional signals that are vertically polarized and transmitter 2 emits horizontally polarized radiation. The proposed transmitter is therefore more suitable for the ultra-wideband MIMO application for breast tumor detection. The two similar types of produced transmitter were mounted at a distance of 30 cm, respectively, in free space, face to face as well as side by side. The S21 can be seen decreasing as the distance between the transmitters increases. With the exception of some non-linearity, the undistorted reception of the transmitted signal is assured by almost °. The UWB frequency but at 7.5 GHz is slightly higher due to the more meandered current path created by the fractal pattern. The type of transmitter proposed is assessed as is the overall performance of the transmitter. Parametric analysis is conducted to determine the most optimal dimensional values for various transmitter parameters. This analysis is done iteratively by adjusting one parameter while staying constant with other parameters as shown in Table 1. The transmitter is typical FR4-based substratum. One can clearly see that the correct filtering property can be obtained by changing the transmitter 1 this modification can achieve triple stitched band, the triple band was successfully S11>-10 in all rejection bands while still maintaining good impedance matching at other UWB band frequencies. Identification of tumor Process using the breast cancer detection system built was checked numerically by drawing up the reflected power (S11 value) of each position of the antenna. In reality, the unit of antenna were gently moved and stay a distance constant to cover the whole surface of your breast. Impedance of antenal function bandwith is split to triple Calculation band loss of return below -10 dB through 3.1 to 12.0 GHz. One needs to remember though breast cancer detector is being developed later on the commonest dielectric locally available material is in the form of FR4 Epoxy Substratum. The dielectric substratum is
commonly used in the material for the printed circuit board. Simulation was performed by changing the distance \( h \) between the surface of the breast phantom and the tumors \( h \) up to the maximum breast size limit, using three combinations of the tumor size (10 mm, 20 mm and 30 mm) to determine and analyze the best resonant frequency observed return loss values. The places where the structure with the tumor axis \( S_{11} \) of simulations on structure was differentiated with and without, in same band 3.1-12.0 GHz as shown in figure 7.

![Figure 4. Simulated S11.](image)

![Figure 5. Simulated S22.](image)
Figure 6. Polarization pattern stimulation in E-plan H-plane (X-Y) at (a) 3 GHz (b) 7.5 GHz (c) 12GHz.

Figure 7. S11 (Tumor-free and with)
4. Conclusion.
This article describes a MIMO circular n fractal ring UWB. A couple of L-shaped slots is trimmed from those in the ground floor to suppress the interference of the WLAN band. The impedance frequency varies from 3.1 GHz to 12.0 GHz, except for the notch band at 7.5 GHz, indicating ultra-wideband impedance matching. So as to improve bandwidth several rings was carried in the antenna structure. The pattern of radiation is omnidirectional. The proposed transmitter will provide better performance in the detection of breast tumors. This design approach provides a solution for compact wideband transmitter with strong transmitter properties. The structural miniaturization makes it a good alternative for its applications in UWB. With "FR-4" as a material of substrate. In the design of the MIMO transmitters high mutual coupling is observed with low gain. In the patches a "rings" slot is inserted to circumvent this problem. Coaxial feeding technique is employed to reduce surface wave radiation. A pair of similar transmitter gets the transfer function in both face-to-face and side-by-side to analyze the time database efficiency of the proposed transmitter. The overall transmitter length is hundred mm X Sixty mm. When tissue in the breast is directly exposed to the signal of electromagnetics, energy created by heat. Therefore, care needs to be taken at the time of application of process of imagery. A method for microwave imaging was applied for the recognition the breast model has the presence and location of tumors.

5. Future work
Our future work consists of:
- Printed the structure of antenna design.
- Implementation these techniques with real breast model.
- Compare the implantation result with the stimulation result.

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