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3.5GHz OF ICE CREAM CONE WITH BOW TIE ANTENNA FOR MICROWAVE IMAGING APPLICATION

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ABSTRACT

The objectives of this paper are to design, simulate, fabricate and examine Ice Cream Cone with Bow Tie Antenna for microwave imaging application. This antenna is designed for frequency 3.5GHz and simulated using CST Microwave Studio Simulation. The antenna was fabricated on FR4 substrate with relative permittivity of dielectric constant (Ɛr), 4.6. The result of return loss, bandwidth, gain, directivity and radiation pattern are discussed in this paper. To achieve the best antenna performance, the return loss must below than -10dB and gain at 3dB. Ice Cream Cone with Bow Tie antenna is one of the design for microwave imaging application in the span of breast cancer imaging.

Keywords: ice cream cone with bow tie, microwave imaging application, return loss, gain.

INTRODUCTION

An increasing number of research groups are pursuing microwave imaging for biomedical applications, especially breast-cancer detection. The use of microwave imaging for breast-cancer detection is based on the contrast in electromagnetic parameters between the healthy and the cancerous tissue which has been reported by several authors. Both nonlinear inverse scattering (also known as microwave tomography) and UWB radar techniques have been proposed for microwave imaging of the breast.

Small antennas have been extensively investigated and described in various medical applications for some times. Note that small ultra wideband (UWB) antennas are additionally commanded for medical applications recently. One of the medical applications that need the UWB antennas is the microwave imaging of breast cancer. This imaging modality sends lower power short microwave pulses (tens picoseconds to nanoseconds) into the body and detects the differentiated scattering due to the dielectric contrast between malignant and health tissues.

The best selection of antenna is compact and cheap because it is a low cost material, light weight and also easy to fabricate. These characteristics are needed for microwave imaging applications such as wireless communications, indoor positioning and medical imaging. In addition, the antenna needs to have good radiation characteristics, i.e. consistent outlines over the entire operating bandwidth and good time-domain characteristics - negligible pulse distortion. Therefore, it yet stays as an engineering challenge to design suitable antenna for this application. The biggest challenge to fit these antennas in UWB setup is to widen their impedance bandwidth as maintaining the radiation efficiency.

Ice Cream Cone with Bow Tie printed monopole antenna is proposed in this paper because this antenna shows the reasonable return loss and wide bandwidth. The simulation for proposed antenna is carried out using CST Microwave Studio 2011. Several studies about the effects of varying the parameter study of the antenna have been done and discussed in this paper.

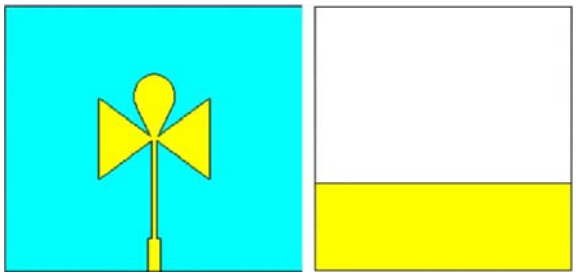

Figure-1. Schematic diagram of Ice Cream Cone with Bow Tie antenna (a) front view, (b) back view.

ANTENNA DESIGN

The proposed antenna is designed on a FR-4 substrate with dielectric constant of 4.6 and a thickness of 1.6 mm. The thickness of the copper is 0.035 mm. To encounter the demands of a decreased antenna size, a greater dielectric substrate is necessary. By employing a substrate with high dielectric constants, it will provide a small antenna size. Therefore, an antenna called as Ice Cream Cone with Bow Tie antenna has been designed.

The geometrical configuration as illustrated in Figure of the proposed small ice cream cone with bow tie antenna are Ws=111mm, Ls=94mm, Lf1=11.5mm, Lf2=21.5mm, Lr=2mm, Wr=15mm. The ground plane is cut on the bottom side of the board that has dimensions L1 and L2. Therefore, the antenna ice cream cone with bow tie is fabricated on FR4 substrate with dimensions of 111mm x 94mm.

In this paper, the Ice Cream Cone with Bow Tie antenna design is using high dielectric constants such as FR4 with relative permittivity of Ɛr,= 4.6 and thickness of 1.6 mm to get a smaller antenna size. An analysis and a comparison between the simulation and measurement

results are conducted to investigate the effect of parameter for length by rectangular on antenna performance. Thus, the dimensions of the patch of antenna is using the formula of:-

Effective radius of patch:

Actual/physical radius of patch:

Width of patch:

Length of patch:

Effective of dielectric constant:

Length of side of patch:

The calculation value is used in the CST Microwave Studio Simulation Software. The parameter design adjusted by the parametric method is used to achieve the requirement that operates at 3.5 GHz. Figure-1 shows the geometry of the Ice Cream Cone with Bow Tie antenna. The antenna is fabricated on a thin FR4 substrate of thickness 1.6 mm with relative permittivity of Ɛr, 4.6. Referring to Figures-1.1 it shows that antenna has a dimension board of 111 mm x 94 mm. This patch is directly matched connected to the SMA connected.

Figure-1.1. The geometry of the Ice Cream Cone with Bow Tie antenna.

This Ice Cream Cone with Bow Tie antenna is a printed monopole structure resembles a scoop of ice cream on a wafer cone and bow tie shape which is equaliteral triangle shape. The main reason of selecting the microstrip antenna because it has lot of advantages such as ease of fabrication, planar structure, UWB working characteristic, and additionally bidirectional radiation patterns. Table I displays the dimension of the modified Ice Cream Cone with Bow Tie antenna.

Table-1. Dimension of the ice cream cone with bow tie patch antenna.

Part	Symbol	Dimension (mm)
Substrate width	W_s	111.00
Substrate length	L_s	94.00
Feed width	W_f	2.20
Feed length	L_f	21.50
Ground width	W_g	111.00
Ground length	L_g	11.50

A small size of single antenna is selected. The selected antenna is a combination of two patches; a triangle, and semi-circular patches. The triangular patch will produce a higher cross-polarization due to its unsymmetrical geometry. Meanwhile, the semi- circular patches will expense of the bandwidth and gain.

In order to optimize the antenna, a parameter study was carried out. By analysis of parameter studies, the antenna will be achieving the optimum value of return loss, bandwidth and gain.

RESULT AND DISCUSSIONS

The parameters that are considered in this work are resonant frequency, return loss, bandwidth, gain and directivity of the antenna.

Figure-2 represents the return loss, S11 in dB at frequency 3.5GHz of Ice Cream Cone with Bow Tie antenna. From the simulation, the antenna achieves the target with a broad bandwidth as the resonance as in Figure-3. The design is simulated by using the CST Microwave Studio Simulation. The results show that the antenna operates at 3.5 GHz. The best Return Loss, S11 for this antenna is obtained at -19.65dB for simulation and -14.4dB for measurement.

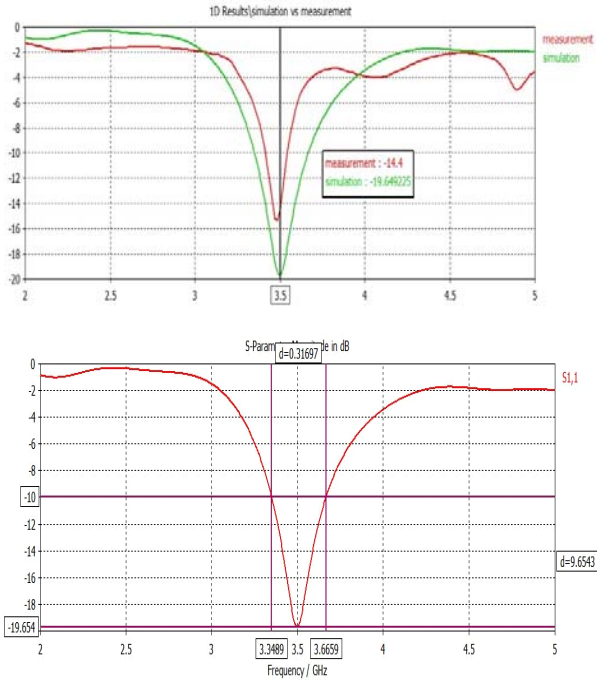

Figure-2. Return loss, S11 of Ice Cream Cone with Bow Tie antenna at frequency 3.5GHz for measurement and simulation.

Figure-3. Bandwidth at frequency 3.5GHz

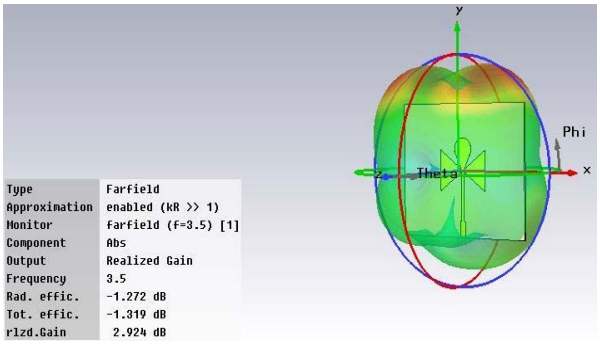

Figure-4. The transparent gain with the antenna.

The ice cream cone with bow tie antenna achieved gain at 2.924dB that is nearer to 3dB so that it can receives ambient RF signal more efficiently. Figure-4 displays the realized gain of the antenna in 3D far field view.

Besides that, the directivity of the antenna is 4.243 dBi. Figure-5 shows the directivity of the antenna. It has been observed that the directivity is almost same as the antenna gained across the band of operation.

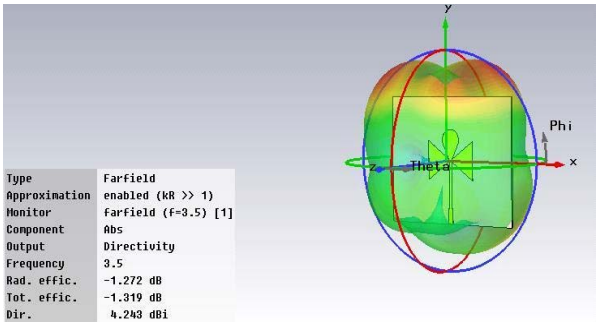

Figure-5. The directivity of the antenna.

The radiation pattern analyses are shown in Figure-6 and Figure-7. Figure-6 shows the simulated 1800 planar (phi) while Figure-7 shows the conical (theta) cut radiation patterns at 3.5 GHz for the antenna. From the radiation pattern, it is clearly shows that the proposed antenna is omnidirectional in azimuth plane and has maximum between 180o-270o. The efficiency of the antenna is the product of the reflection and radiation efficiency.

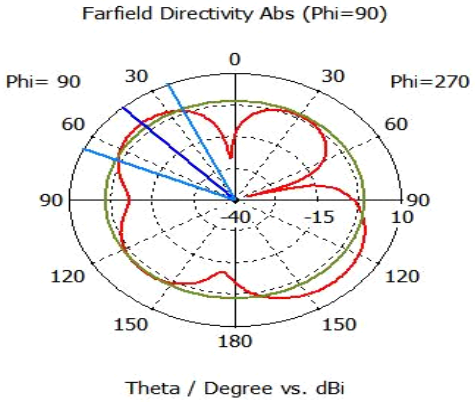

Figure-6. Simulated E-Field Radiation Pattern.

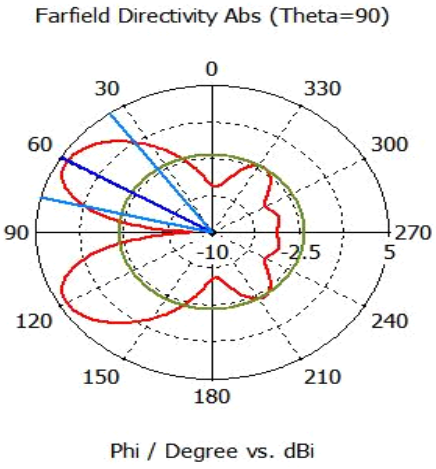

Figure-7. Simulated H-Field Radiation Pattern.

While for the surface current, it is important in designing the antenna because it can determine the antenna is functioning and operates at the desired frequency which is 3.5GHz. Figure-8 shows the surface current of the antenna.

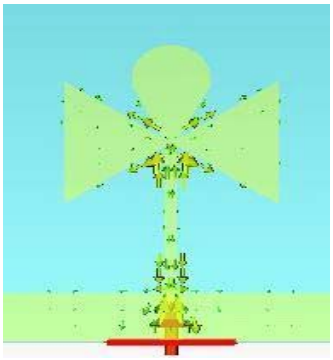

Figure-8. Surface current of antenna.

Figure-9 shows the S-parameter simulations of the Ice Cream Cone with Bow Tie antenna at different length, Ws by substrate is simulated by using the CST Microwave Studio Simulation.

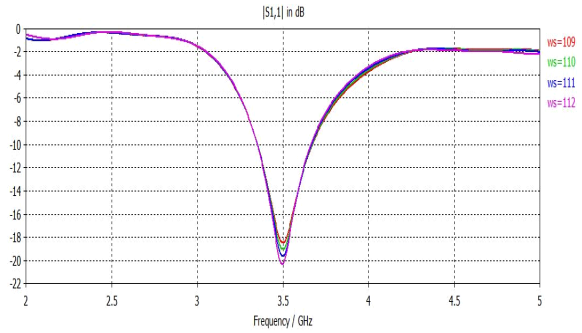

Figure-9. S-parameter (S11) simulations of the Ice Cream Cone with Bow Tie antenna for different length, Wsby substrate.

The most effective response for the antenna is at Ws=111 mm. The most challenging task in designing the antenna is to sufficiently match to the frequency that needs to achieve and return loss below than -10dB. The parameter design adjusted by the parametric method is used to accomplish the frequency requirement that operates between 3.5GHz. The design is simulated by using the CST Microwave Studio Simulation.

CONCLUSIONS

From the simulation, a new small antenna called the Ice Cream Cone with Bow Tie has been designed and simulated. This paper presents an antenna with board dimensions 111.00mm x 94.00mm and was printed on a FR4 substrate with thickness 1.6 mm² and relative permittivity of Ɛr, 4.6. The parametric study by varying the dimension of each antenna effects the parameters of antenna. The Ice Cream Cone with Bow Tie antenna can be used in medical imaging applications. The antenna achieves the frequency target in applying for microwave imaging application**.**

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