The Characteristic of L-shape and Triangular Slot Antenna

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Abstract: To describe the performance of an antenna, some parameters are necessary. Some of the parameters are interrelate and not all of them must be specified for complete description of antenna performance. The parameters in characteristics of printed antenna for this analysis are radiation pattern, input impedance, VSWR, S parameter and electromagnetic field. In this paper we will consider two shaped of slot antennas one is triangular slot antenna and other is L – shape slot antenna for compare the radiation pattern, return loss, and VSWR. Two slot antennas are designed to have a resonant frequency at 10 GHz. The microstrip line is designed to be 50 ohms in order to match the measurement system, it has the substrate of the thickness = 1.52 mm and dielectric constant (ε_r) 2.17. The problem space in the FDTD analysis are 60x123x100 cells for L-shape slot antenna and 50x171x120 cells for triangular slot antenna with the cell dimensions Δx = 0.152 mm., $\Delta y = \Delta z$ = 0.15 mm.

Keywords: microstrip , antenna, L-shape slot, triangular slot

1. INTRODUCTION

Recently, mobile communication is used in various frequency and the number of frequency bands increases. Although the various antennas have been proposed and analyzed, it is important to analyze an antenna with is used in various frequency bands. Printed antenna is one type of antennas and is widely used in satellite mobile communications [1]. The slot antenna is a type of antenna with have many configurations and geometry shapes. Therefore, we will investigate two shape of slot antennas fed by microstrip line on the ground plane. To simulating this antenna by using finite difference time domain (FDTD). The finite difference time domain methods solve electromagnetic problems through simulation of wave interaction and propagation in the time domain, the need to solve large-scale linear simultaneous equations and related problems such as convergence, stability and spurious response is avoided. The most distinguished advantages of these time domain techniques are their great flexibility and versatility in applying to virtually all types of electromagnetic problem, from simple one dimensional to the most complicated three-dimensional structures with arbitrary material properties.

2. ANTENNA CONFIGURATION

The configuration of L-shape slot antenna and triangular slot antenna is shown in Fig 1 and Fig 2. The slot antenna on the ground plane is fed by a microstrip line. The microstrip line is designed to be 50 ohms in order to match the measurement system, it has the substrate of the thickness h = 1.52 mm and the dielectric constant ε_r = 2.17 . L-shape slot antenna look like the triangular slot antenna because of side length. In this research, we start to set two perpendicular side of L-shape slot in the same length. The adjusting for match impedance at desire resonance frequency of two shape slot antennas can be done by adjusting the length of microstrip line. In this case, only L-shape slot can slightly adjust the side for more match impedance.

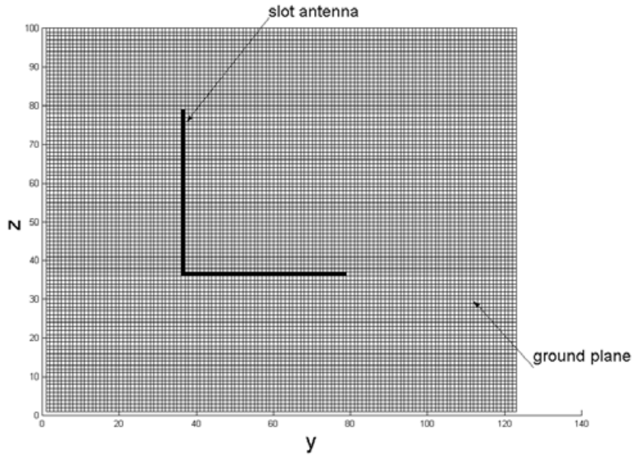

Fig. 1 L-shape slot antenna structure.

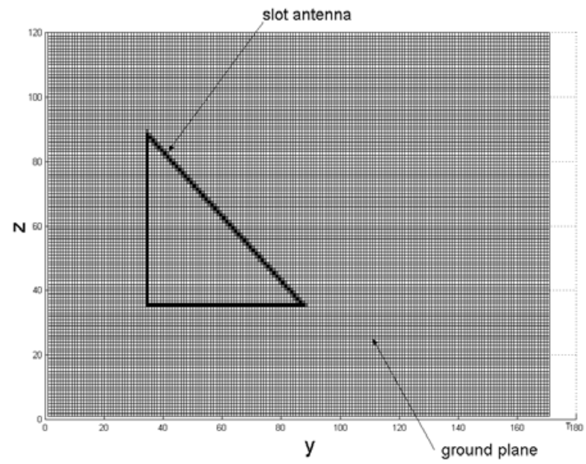

Fig. 2 Triangular slot antenna structure

The characteristics of L-shaped and triangular slot antenna has been presented [2], [3].

3. FDTD METHOD

The algorithm of FDTD electromagnetic field analysis was introduced by Kane Yee. FDTD technique can be treats in transient conditions such as pulse in the time domain, and computational electromagnetic modeling which can predict and analysis of the electromagnetic responses of complex problems [4]. The analytical space of L-shape slot antenna consists of 60x123x100 cells and 50x171x120 cells for Triangular slot antenna with the cell dimension Δx=0.152 mm, $\Delta y=\Delta z$=0.15 mm. The time step satisfies the following courant condition.

$$\Delta t \leq \frac{1}{c}\sqrt{\frac{1}{(\Delta x)^2}+\frac{1}{(\Delta y)^2}+\frac{1}{(\Delta z)^2}} \quad (1)$$

The equations of electromagnetic field in FDTD method is analyzed in the boundary condition that calculate by central difference expressions base on Maxwell's equations and can easily derive Yee's famous "leap-frog" algorithm for updating the six electromagnetic field components with respect to a certain type of source excitation [5]. For source excitation of the antenna is input voltage V(t) base on Gaussian pulse and express as

$$V(t) = e^{-\left(\frac{t-t_0}{T}\right)^2} \quad (2)$$

Where t_o is the center of the pulse (75 ps), T is the pulses width at its 1/e characteristic decay point (25 ps).

4. SIMULATION RESULT

This section will consideration and compare between L-shape slot antenna and triangular slot antenna on the same substrate.

4.1 Return loss

The return loss or reflected loss set as S_{11} parameter is given as equation (3). Where $\Im$ shows a Fourier Transform and L is the length between observing point and a reference point.

$$S_{11} = \frac{\Im[V_{ref}(t)]}{\Im[V_{inc}(t)]}e^{2\gamma L} \quad (3)$$

$$\gamma = \alpha + j\beta \quad (4)$$

The propagation constant γ can be defined by equation (4). Where γ and β are attenuation and phase constant, respectively. The return loss of L-shape and Triangular are shown in Fig. 3 and Fig.4. The results of good matching can be obtained at resonance frequency of L-shape slot antenna 10.04 GHz and triangular slot antenna 10.01GHz are -40.17dB and -47.49 dB, respectively.

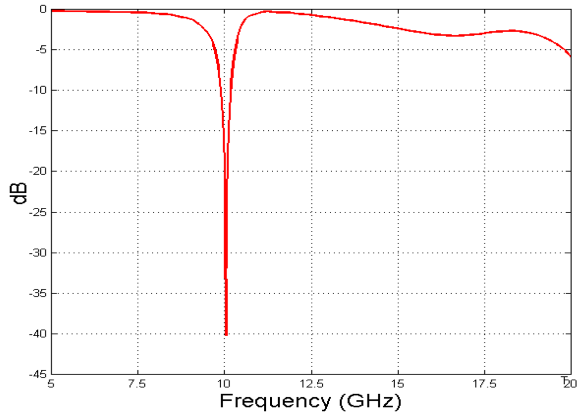

Fig. 3 Return loss of L-shape slot antenna

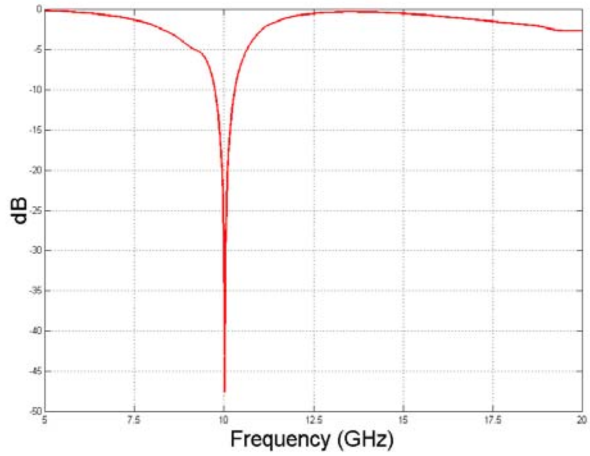

Fig. 4 Return loss of Triangular shape slot antenna

4.2 Characteristics of input impedance

The input impedance is the complex number and can be find out as follow.

$$Z_{in} = \left[\frac{(1+S_{11})}{(1-S_{11})}\right]Z_o \quad (5)$$

By adjusting technique, real part and imaginary part of Z_{in} are nearly 50 ohms and 0 ohm, respectively. The characteristics of input impedance of L-shaped slot antenna and Triangular slot antenna are as follow

L-shape slot :

Z_{in}(real)=50.04 Ω
Z_{in}(imag)=0.97Ω

Triangular slot :

Z_{in}(real)=49.91 Ω
Z_{in}(imag)=0.41Ω

4.3 Current Density

Fig. 5 shown current density of L-shaped slot antenna. It have high density at two ends of L-shaped and low density at right-angle of L-shaped. For Triangular slot antenna current density as shown in Fig. 6.

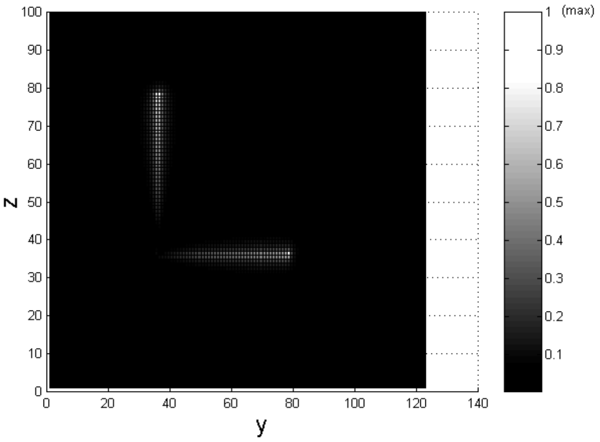

Fig. 5 Current density of L-shape slot antenna

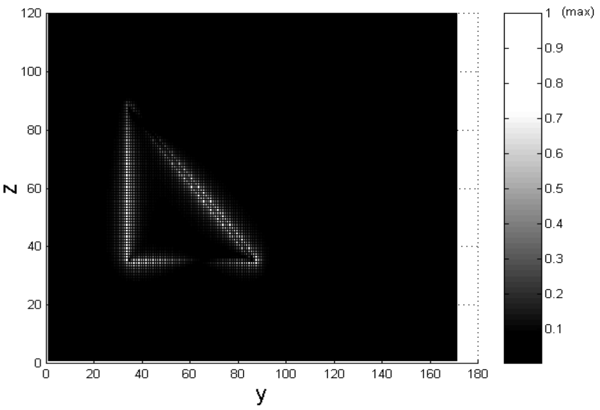

Fig. 6 Current density of triangular shape slot antenna

4.4 VSWR

VSWR is a characteristic for show the performance of antenna which relate to reflected wave as show in Fig. 7. The VSWR, denoted by ρ, can define by the ratio between the maximum voltage V_{max} and the minimum voltage V_{min} as follows:

$$\rho = \frac{V_{\max}}{V_{\min}} = \frac{1+|\Gamma|}{1-|\Gamma|} \quad (6)$$

Where Γ is the reflection coefficient

In a properly designed system for impedance matching the VSWR of L-shaped slot antenna is about 1.019 at resonance frequency 10.04 GHz and VSWR of triangular slot antenna is about 1.008 at resonance frequency 10.01 GHz. For a VSWR less than 2.0 the bandwidth of L-shaped slot antenna is 320 MHz and the bandwidth of Triangular slot antenna is 600 MHz .

4.5 Far Field Patern

By using FDTD method, it is possible to transform the near field to far field by discrete Fourier Transform to

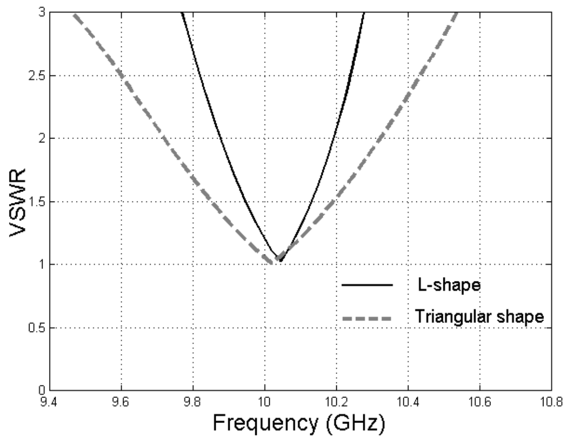

Fig. 7 VSWR of L-shaped slot antenna and Triangular slot antenna

carry out for the equivalent electric and magnetic current densities during the FDTD iteration. Fig.8 to Fig.11 presents the normalized radiation patterns for L-shaped slot antenna and triangular slot antenna in the xy and xz plane.

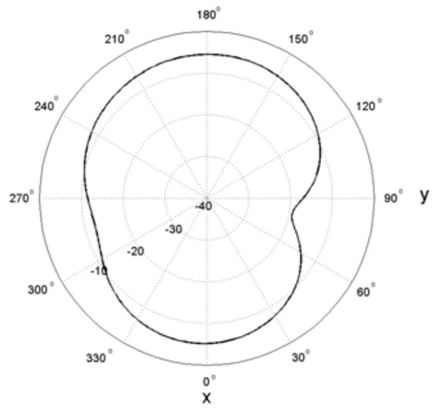

Fig. 8 Far field pattern on the xy plane of L-shape slot antenna

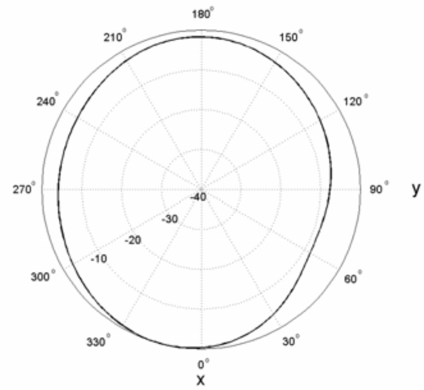

Fig. 9 Far field pattern on the xy plane of triangular shape slot antenna

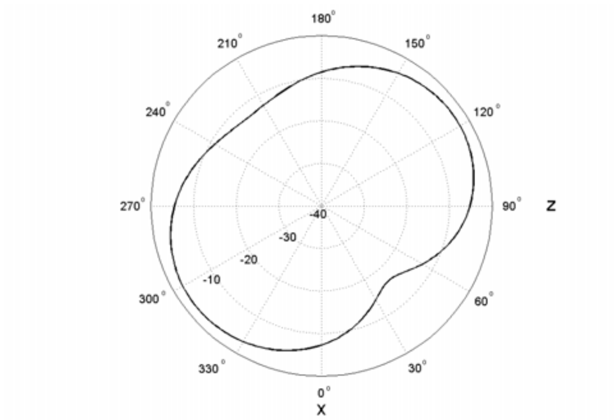

Fig. 10 Far field pattern on the xz plane of L-shape slot antenna

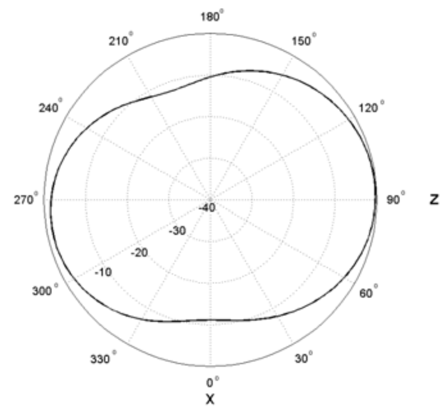

Fig. 11 Far field pattern on the xz plane of triangular shape slot antenna

5. CONCLUSION

The comparison between L-shape antenna and triangular shape slot antenna has been proposed. The triangular slot antenna has more efficiency than the L-shape slot antenna at the same design frequency (10GHz), same thickness and same dielectric substrate. The S_{11} parameter of the triangular shape was down more than the L-shape antenna and from Fig 7. the bandwidth of the triangular shape was wider than the L-shape. Whereas the radiation patterns of two antennas are likeness. Disadvantage of the triangular antenna are it's difficult to adjust the matching impedance and the antenna size is little larger than the L-shaped antenna.

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