MUSHROOM SHAPED MONOPOLE ANTENNA WHICH HAS TUNING ON GROUND PLANE WITH SLOT ETCHING TECHNIQUE IS TWO LAYERS OF STAIR FOR APPLYING ULTRA WIDEBAND (UWB) TECHNOLOGY

Watcharaphon Naktong [1] Apinya Innok[1] Supatinee kornsing [1] and Amnoiy Ruengwaree[2]
[1]Department of Telecommunication Engineering, Faculty of Engineering and Architecture, Rajamangala University of Technology Isan (RMUTI), NakhonRatchasima, Thailand
[2] Department of Electronics and Telecommunication Engineering, Faculty of Engineering, Rajamangala University of Technology Thanyaburi (RMUTT), Pathumthani, 12110, Thailand E-mail: apinya_in@hotmail.com

ABSTRACT

This research presents the mushroom shaped monopole antenna with slot etching technique is two layers of stair on both side of the ground plane which have distance between a layer about $\lambda/32$.This technique is designed to increase impedance bandwidth applying UWB as IEEE 802.15.3a which has frequency at 3.1-10.6 GHz. In this research is used the CST Microwave studio to find other parameters of the antenna on FR4 print circuit board. From the result found that both the 1st and 2nd of antenna have impedance bandwidth at 89.4% (3.09-12 GHz) , the gain average at 3.95 dBi, the group delay has distance 10-30 cm and the insertion loss at $\pm$ 1.5 ns.

INTRODUCTION

Ultra wideband technology (UWB) is a form of transmission that occupies a very wide bandwidth. Typically this will be many Gigahertzes, and it is this aspect that enables it to carry data rates of Gigabits per second. The fact that UWB transmissions have such a wide bandwidth means that they will cross the boundaries of many of the currently licensed carrier based transmissions. As such one of the fears is that UWB transmission may cause interference. However the very high bandwidth used also allows the power spectral density to be very low, and the power limits on UWB are being strictly limited by the regulatory bodies. In many instances they are lower than the spurious emissions from electronic apparatus that has been certified. In view of this it is anticipated that they will cause no noticeable interference to other carrier based licensed users. Ultra-Wideband (UWB) provides an interesting new technology for short-range ultra-high speed communications in the frequency band 3.1 GHz to 10.6 GHz (G. Y. Chen, et al., 2005), A.A. Kishk, et al., 2012 and M. Zolfaghari, et al., 2013). It supports a bit rate greater than 100 Mbps within a 10-meter radius for wireless personal area communications. The advantages of UWB include low-power transmission, robustness for multi-path fading and low power dissipation. The low power transmission of the UWB is the key characteristic that might allow it to coexist with other wireless networking standards such as 802.11 LAN, 802.16 MAN and WAN. There are a wide number of applications that UWB technology can be used for the range from data and voice communications through to radar and tagging. With the growing number of way in which wireless technology can be used, the list is likely to grow. Although much of the hype about UWB has been associated with commercial applications, the technology is equally suited to military applications. One of the advantages is that with the pulses being spread over a wide spectrum they can be difficult to detect. This makes them ideal for covert communications. According to mention, this research just interest to develop an antenna for extensive UWB range by antenna design must Omni directional for reduced complexity of tuning on ground plane, simple design and save cost to create. Structure of the antenna has been selected anode and cathode of CPW-Fed planar monopole on the same side to tune being easy, reduce losses, radiation pattern of an antenna is more symmetric and no need drill holes when must to connect with the ground which this technique is technology of Coplanar Waveguide (CPW) (Jan J**.** Y**.**, et al., 2006, W. Naktong, et al, 2010, S. Kumar, et al., 2013, S. Kumar, et al, 1982 and T. Suwan, et al, 2014). The antenna is designed by using CST program to simulate parameters being the best suitable with this antenna.

DESIGN AND SIMULATION

Structure design of antenna used the slot etching technique on ground plane (W. Naktong, et al, 2010, S. Kumar, et al., 2013, S. Kumar, et al, 1982 and T. Suwan, et al, 2014) work together with the mushroom shaped antenna by starting from rectangular shaped monopole antenna which was prototype antenna. All tuning had 3 parts to reduce complicatedness including:

First, slot etching 1st layer both side of the ground plane which had length (L_2) 3 levels are 1 mm, 2 mm and 3 mm and had been constant width (W_2) at 11.2 mm. From tuning 3 levels were found that L_2 = 3 mm and W_2 =11.2 mm were appropriate value by relative wavelength (λ_g) had 2 ranges, 0.01 λ_g to 0.05 λ_g and 0.1 λ_g to 0.2 λ_g . From experiment had been refection coefficient but was not yet lower than line -10 dB ($S_{11} \le -10$ dB) which frequency between 1.24 GHz – 11.45 GHz (160.10%) by observed from A point as follow figure 1 which be not able to build real structure thus must tuning in the 2nd part.

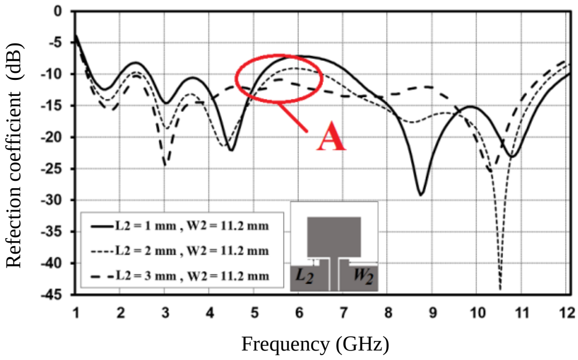


Fig.1 Refection coefficient when was tuned L_2 and W_2

Second, slot etching 2nd layer both side of the ground plane which had length (L_3) 3 levels are 1 mm, 2 mm and 3 mm and had been constant width (W_3) at 5 mm. From tuning 3 levels were found that L_3 = 2 mm and W_3 =5 mm were appropriate value by relative wavelength (λ_g) had 2 ranges, 0.01 λ_g to 0.05 λ_g and 0.06 λ_g to 0.08 λ_g . From this experiment had been Refection coefficient (S_{11}) better than A point by observed from B point as follow figure 2.

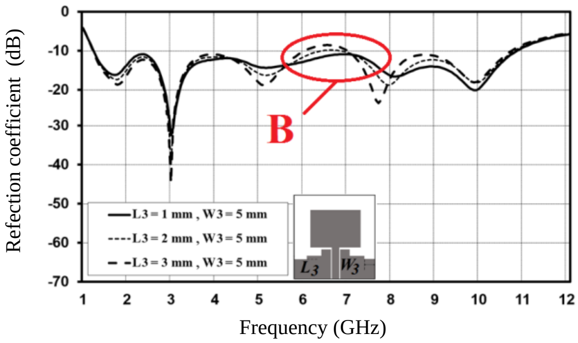


Fig.2 Refection coefficient when was tuned L_3 and W_3

Finally, slot etching technique on ground plane was brought to use with mushroom antenna. This antenna structure was designed on FR4 print circuit board which had dielectric (ε_r) at 4.3, loss tangent dielectric constant at 0.015, thickness at 0.764 mm, thickness of the copper plate at 0.017 mm and size of PCB was 35x40 mm^2. The antenna had been designed top side by mushroom shape which radius (r) was $a/2$ (a was diameter) as equation (1) and (2) (S. Kumar, et al, 1982 and T. Suwan, et al, 2014).

$$a = \frac{F}{\left\{1+\frac{2h}{\pi\varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{1/2}} \tag{1}$$

and

$$F = \frac{8.791\times10^9}{f_r\sqrt{\varepsilon_r}} \tag{2}$$

On the part of step was compared with the relative wavelength (λ_g) as follow equation (3) (S. Kumar, et al, 1982 and T. Suwan, et al, 2014).

$$\lambda_g = \frac{c}{f\sqrt{\varepsilon_{eff}}} \tag{3}$$

From equation analysis of antenna structure in conjunction with simulation on CST program was able to tune until the desired structure as figure 3 and the parameters had been shown as table 1

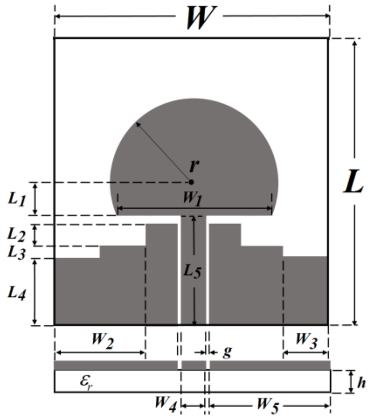


Fig.3 Antenna structure

Table 1 Variable size of antenna design

Width (mm)		Length (mm)	
W	34	*L*	40
W_1	19	L_1	4
W_2	11.2	L_2	3
W_3	5	L_3	2
W_4	3	L_4	8
W_5	15.2	L_5	14
g	0.3	*h*	0.764

This antenna had been tuned radius (r) at 10 mm, 11 mm and 12 mm by length (L_1) at 4 mm to compare with relative wavelength during 0.06 λ_g to 0.08 λ_g . This experiment had been return loss as show in figure 4 by had frequency range at 2.76 GHz – 1.67 GHz (117.88%) which was following IEEE 802.15.3a (3.1 GHz -10.6 GHz)

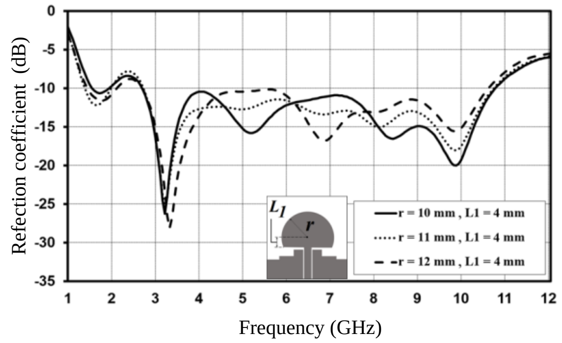
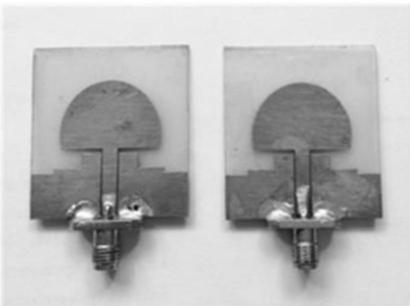


Fig.4 Refection coefficient when was tuned L_3 and W_3

ACTUAL CREATION AND MEASUREMENT

From the simulation of the mushroom antenna was brought actual creation as shown in figure 5(a) and was tested by Network Analyzer E5071C version as followed figure 5(b). This research was measured the Refection coefficient $\left(S_{11}\right)$, VSWR, gain, pattern radiation and group delay which was shown in figure 6-13



(a) Mushroom shaped monopole antenna

(b) Network analyzer

Fig.5 Microstrip antennas and Network analyzer

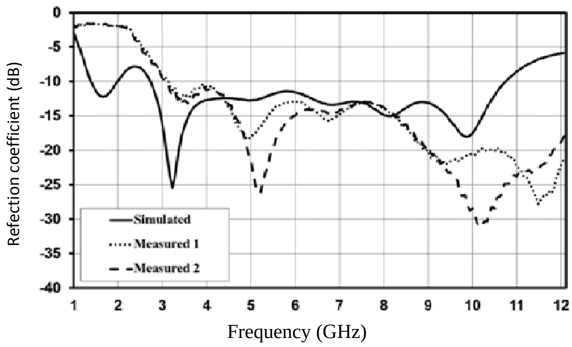


Fig.6 Measurement and simulation of S_{11}

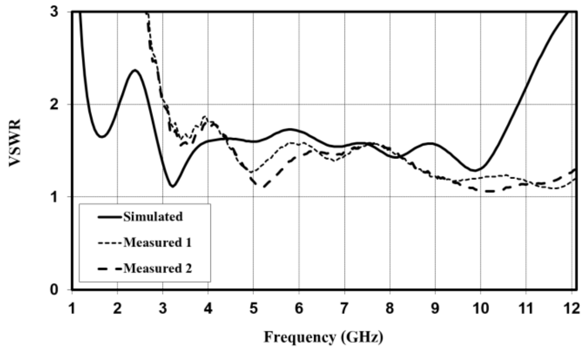


Fig.7 Measurement and simulation of VSWR

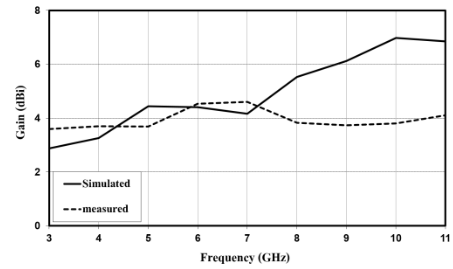
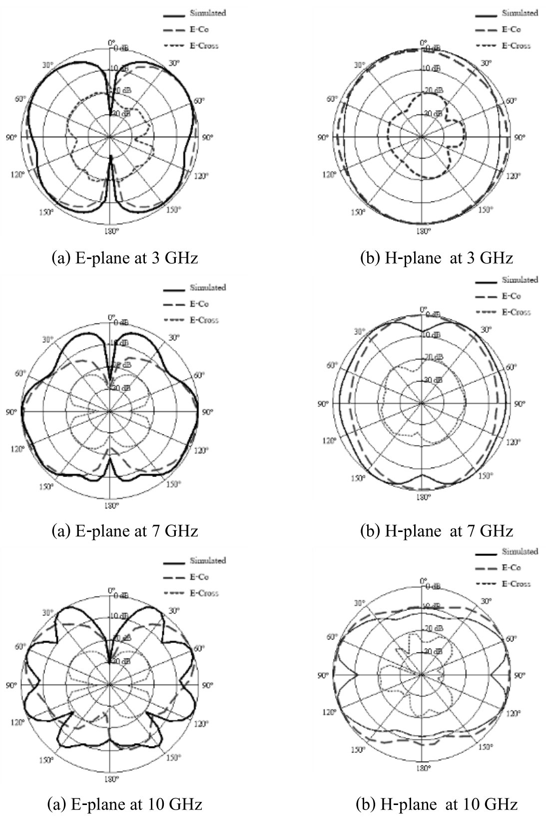


Fig.8 Measurement and simulation of gain



(a) E-plane at 3 GHz (b) H-plane at 3 GHz

(a) E-plane at 7 GHz (b) H-plane at 7 GHz

(a) E-plane at 10 GHz (b) H-plane at 10 GHz

Fig.9 Compared result of radiation pattern

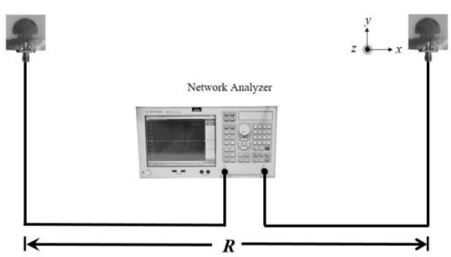


Fig.10 Preparations to measure group delay at 30 cm

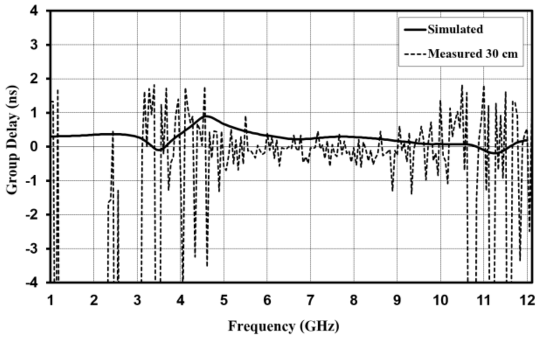


Fig.11 Compared result between measurement and simulation of group delay at 30 cm

CONCLUSION

In this research, the proposed antenna is designed to apply for ultra-wideband (UWB) by using slot etching technique at ground plane. The slot etching is two layers of stair together with tuning mushroom shaped monopole antenna. The research has investigated covering bandwidth of 89.4% (3.09 - 12 GHz) with VSWR as 1.3:1. The average gain is 3.95 dBi with nearly stable omni-directional radiation properties over the entire frequency band of interest. The measurement of group delay at the distance of 30 cm is $\pm$ 1.5 ns.

ACKNOWLEDGMENT

The authors gratefully acknowledge simulation CST software support for this research project from the Department of Electronics and Telecommunication Engineering, Faculty of Engineering, Rajamangala University of Technology Thanyaburi (RMUTT), Pathumthani, Thailand. Moreover, thank you the department of Telecommunications Engineering, Faculty of Engineering and Architecture, Rajamangala University of Technology Isan for supporting the equipment and research funding.

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Watcharaphon Naktong
Received the B.Eng. (2003), and M.Eng. (2011) degrees in electronics and telecommunication engineering from Rajamangala Universityof Technology Thanyaburi. He is Lecturer Rajamangala University of Technology Isan. Interested research includes antenna design.

Apinya Innok
Received the B.E. (2009), M.E. (2011), and D.E. (2013) degrees in the telecommunication engineering from Suranaree University of Technology. She is a Lecturer, Rajamangala University of Technology Isan. Interested research includes wireless communications and antenna applications.

Supatinee Kornsing
Received the B.Eng. (2006), and M.Eng. (2012) degrees in electronics and telecommunication engineering from Rajamangala Universityof Technology Thanyaburi. She is Lecturer Rajamangala University of Technology Isan. Interested research includes antenna design.

Amnoiy Ruengwaree
Received the Dr. Ing (Electrical Engineering) (2008) degrees from Kassel University, Germany. He is a Lecturer, Department of Electronics and Telecommunication Engineering, Faculty of Engineering, Rajamangala University of Technology Thanyaburi (RMUTT), Pathumthani, Thailand. Interested research includes Ultra Wideband Radar System, Ultra Fast Electrical Pulse Generator, and Antenna Design.