DEVELOPMENT OF QUAD-RIDGED HORN ANTENNA FOR UWB COMMUNICATIONS

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Supervisor's Name : DR. MOHDAZLISHAH BIN OTHMAN

Date : 29th DECEMBER 2014

Special dedicate to my family, supervisor, and all my fellow friends to help me to accomplish my report.

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ABSTRACT

An Ultra-Wideband Quad-Ridged Horn Antenna in ultra-wideband communication system is described in which offer unique advantages its own structure characters. Federal Communications Commission (FCC) regulate that the frequency for the UWB technique is from 3.1GHz to 10.6GHz. UWB pulse is generated in a very short time period (sub-nano second). So, it has spectrum below the allowed noise level. This feature makes it possible to be used for high-speed over short distances. Besides, UWB has many other applications such as high resolution penetrating radar, hidden object detection system, EMC experiments, free-space time-domain (FTD) measurement systems and feed for reflectors. By simulation and optimization, the 3.1GHz to 10.6GHz Quad-Ridged Horn Antenna can realize high gain and dual polarization operations, and the operating bandwidth is enough for practical operation. The Quad-Ridged Horn Antenna excited by two orthogonal laid coaxial-lines working at the operation frequency band from 3.1GHz to 10.6GHz is built and simulated with the application of CST Microwave Studio® Software. This project researches some radiate character such as the gain, return loss and etc. Research shows that Quad-Ridged Horn Antenna can get to high gain and dual polarization. Also, it has the similar with the simple horn antenna. These characteristics will make the antenna a widely application in ultra-wideband communication system.

ABSTRAK

Quad Antena Ultra-Jalur Lebar berpunca dalam sistem komunikasi ultra-jalur lebar menawarkan kelebihan yang unik aksara struktur yang tersendiri. Suruhanjaya Komunikasi Persekutuan (FCC) mengawal selia bahawa kekerapan untuk teknik UWB adalah dari 3.1GHz untuk 10.6GHz. Nadi UWB dihasilkan dalam tempoh masa yang singkat (sub-nano yang kedua). Oleh itu, ia mempunyai spektrum di bawah paras bunyi yang dibenarkan. Ciri ini membolehkan untuk digunakan untuk kelajuan tinggi pada jarak yang pendek. Selain itu, UWB mempunyai banyak aplikasi lain seperti resolusi tinggi radar, sistem pengesanan objek tersembunyi, eksperimen EMC, ruang bebas masa-domain (FTD) sistem pengukuran dan memberi makan untuk reflektor. Oleh itu, simulasi dan pengoptimuman, 3.1GHz hingga 10.6GHz quad-berpunca pedalaman tanduk antena boleh menyedari keuntungan yang tinggi dan operasi dua polarisasi, dan lebar jalur operasi yang cukup untuk operasi praktikal. Quad Antena berpunca dari dua ortogon dibentangkan sepaksi-garis bekerja di jalur frekuensi operasi dari 3.1GHz untuk 10.6GHz dibina dan simulasi dengan penggunaan perisian CST Microwave Studio®. Projek ini menyelidik beberapa watak memancarkan seperti keuntungan, kerugian pulangan dan lain-lain Kajian menunjukkan bahawa quad-berpunca pedalaman tanduk antena boleh mendapatkan keuntungan yang tinggi dan dua polarisasi. Juga, ia mempunyai yang sama dengan antena tanduk mudah. Ciri-ciri ini akan membuat antena permohonan secara meluas dalam sistem komunikasi ultra-jalur lebar.

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BW	-	Bandwidth
c	-	Speed of light
D	-	Directivity
εr	-	Dielectric constant
fr	-	Resonant frequency
G	-	Gain
L_{eff}	-	Effective length
RL	-	Return loss
$tan\delta$	-	Tangential loss
$VSWR$	-	Return loss
Γ	-	Reflection coefficient
A_{eff}	-	Aperture of horn antenna
P_R	-	Power radiated
P_T	-	Power transmitted
G_T	-	Gain of transmitter
G_R	-	Gain of receiver
P_{CL1}	-	Cable loss of cable 1
P_{CL2}	-	Cable loss of cable 2

λ	-	Waveguide length
d	-	Distance
HPBW	-	Half-Power Beam Width
e_o	-	Total efficiency
e_r	-	Reflections efficiency
e_c	-	Conduction efficiency
e_d	-	Dielectric efficiency

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CHAPTER I

INTRODUCTION

1.1 Introduction

In the era of advanced technology, Ultra Wide Band (UWB) communications system provides a very different approach to wireless technologies compare to conventional narrow band systems. This brings huge research interests in it. Because of this, UWB has many potential applications to be researched. One of the assuring applications areas using UWB is in medicine.

Some unique features of UWB are in medicine. Some unique features of UWB make it very suitable for medical areas. Ultra-wideband (UWB) radio is an emerging technology with some unique attractive features, which are combined with researches in other fields such as wireless communications, radar, and medical engineering fields. UWB can be applied to any band segmentations, such as single, dual and multi-bands.

Usually, the UWB system covers the frequency of 3.1-10.6GHz. Formally, before 2001, UWB's application is limited mainly in military areas. However, since 2002, Federal Communications Commission (FCC) has gradually allowed the commercial usage of these bandwidths, which makes it possible that all common people could use the benefit of UWB features[4]. The FCC regulates that the frequency for the UWB band is from 3.1GHz to 10.6GHz in America. It is known the UWB pulse is generated in a very short time period (sub-nanosecond). So, it has spectrum below the allowed noise level. This feature makes it possible to get Gigabit per second (Gbps) speed by using 10GHz spectrum. So, UWB is suitable to be used for high-speed over short distances. UWB is often deemed as a possible alternative of remote sensing and imaging.

Compared with X-ray imaging, UWB radar probes use non-ionizing electromagnetic waves, which proved to be harmless to human body. Moreover, the UWB radar has very low average power level and is very power efficient[5]. This is suitable to be a potentially cost effective way of human body imaging, especially in real time imaging.

By 1999, many works have begun for UWB medical applications in cardiology, obstetrics, breath pathways and arteries. Besides, UWB has many other applications such as high-resolution penetrating radar, hidden object detection system, EMC experiments, free-space time domain (FTD) measurements systems and feed for reflectors[3].

UWB technology has many benefits due to its ultra-wideband nature, which include the following:

i. High data rate

UWB technology is likely to provide high data rates in short and medium range (such as 20m, 50m) wireless communications.

ii. Less path loss and better immunity to multipath propagation

As UWB spans over a very wide frequency range (from very low to very high), it has relatively low material penetration losses. On the other hand, UWB channels exhibit extremely frequency selective fading, and each received signal contains a large number of resolvable multipath components. The fine-time resolution of UWB signals facilitates the receiver to coherently combine multipath signal components with path length differentials down to about 30 cm. The carrier-less nature of UWB signals results in less fading, even when pulses overlap. This reduces fade margin in link budgets.

iii. Availability of low-cost transceivers

The transceiver structure may be very simple due to the absence of the carrier. The techniques for generating UWB signals have existed for more than three decades. Recent advances in silicon process and switching speeds make commercial low-cost UWB systems possible.

iv. Low transmit power and low interference

For a short-range operation, the average transmit power of pulses of duration on the order of one nanosecond with a low duty cycle is very low. With an ultra-wideband spectrum bandwidth, the power spectral density of UWB signals is extremely low. This gives rise to the potential that UWB systems can coexist with narrowband radio systems operating in the same spectrum without causing undue interference. Also, UWB operates with emission levels commensurate with common digital devices such as laptop computers, palm Pilots, and pocket calculators. It may further utilize the frequency spectrum used by existing services.

1.2 Problem Statements

Generally, the using of ultra-wideband communication technologies continues to increase. These systems can use in many fields such as measurement, equipment, electromagnetic compatibility test, electronic warfare, and else.

Research and development of new communication technologies for the ultra-wideband communication systems in particular have been progressed to achieve the high performances such as high gain, wide band and dual polarization character.

Recently, the main type of ultra-wideband has Biconical Antenna, Log Periodical Antenna, Helical Antenna and Ridged Horn Antenna and for the need of high gain and stable phase center in some systems.

Thus, the Ridged Horn Antenna has obvious advantage which is widely device for transmission and reception of the electromagnetic waves. It has very wide frequency band, relative small capacity, stable phase center and high bore efficiency.

However, to accommodate the application requirement of the systems mentioned above, a very attractive option for all these applications is the Ridged Horn Antenna. Simple horn antenna is one kind of typical high gain and antenna with already very integrated theory. In order to realize ultra-wideband character, the simple horn antenna need further to improve.

1.3 Significance of Study

The significance of this project is this project can penetrate and produce the design of Quad Ridged Horn Antenna from the calculation process. From the design and simulation process, all the simulation and measurement result can be analyzed.

The finding of the study is can know how the ultra-wideband communication systems in particular have been progressed to achieve the high performances such as high gain, wide band and dual polarization character. Therefore, from the simulated with the application of CST Microwave Studio® Software, the quad-Ridged Horn Antenna excited by two orthogonal laid coaxial-lines working at the operation frequency band from 3.1GHz to 10.6GHz.

Lastly, from the simulation process the Quad-Ridged Horn Antenna can get to high gain and dual polarization. These characteristics will make the antenna a widely application in ultra-wideband communication system.

1.4 Objectives of Study

The main goal of this project is to study the development Quad-Ridged Horn Antenna for UWB communication. This project goal is supported by the following objectives:

1. To calculate and design of Ultra-Wideband Quad-Ridged Horn Antenna.
2. To achieve the high performances such as high gain, wide band and dual polarization operations by simulation and optimization of Quad-Ridged Horn Antenna.
3. To analyses and make an observations on the ultra-wideband communication systems in particular have been progressed to achieve the high performances such as high gain, wide band and dual polarization character.

1.5 Scope of Study

The scope for this project is to design and to simulate of Ultra-Wideband Quad-Ridged Horn Antenna. In this project in order to simulate and optimize, the 3.1GHz to 10.6GHz Quad-Ridged Horn Antenna can realize high gain and dual polarization operations and the operating bandwidth is enough for practical operation.

Research and development of new communication technologies for the ultra-wideband communication systems in particular have been progressed to achieve the high performances such as high gain, wide band and dual polarization character. Recently, the main type of ultra-wideband has log Periodical Antenna, Helical Antenna and Ridged Horn Antenna and for the need of high gain and stable phase center in some systems.

The ridged horn antenna has obvious advantage which is widely device for transmission and reception of the electromagnetic waves. It has very wide frequency band, relative small capacity, stable phase center and high bore efficiency.

To accommodate the application requirement of the systems mentioned above, a very attractive option for all these applications is the ridged horn antenna. In order to realize ultra-wideband character, the simple horn antenna need further improve is determined by the cut-off wavelength radio of fundamental mode and higher harmonic mode.

By coaxial-line feeding, the driving-point is located at the center of the ridged waveguide, and therefore it can restrain the transmission of higher harmonic mode. So, the bandwidth can be more expanded and realize the ultra-wideband character. Two input ports are located separately at the vertical plane and horizontal plane and adjusted the position and the distance properly, so that can provide dual polarization character.

The key design of quad-ridged horn antenna mainly includes quad-ridged waveguide, horn and converter of the coaxial-line and the ridged waveguide. The horn antenna has two input ports to realize vertical polarization and horizontal polarization ability at the meantime. The ridged horn antenna is in good radiated characteristic and can use in many practical application. The structure of the quad-Ridged Horn Antenna model is built and optimized by CST Microwave Software.

1.6 Methodology

The methodology of the project started with literature review by doing research on journals related to Pyramidal Horn Antenna, basic Horn Antenna, Double-Ridged Horn Antenna and Quad-Ridged Horn Antenna.

The antenna is then designed to become UWB (Ultra-Wideband) which has the frequency range from 3.1GHz to 10.6GHz. The designed antenna is running simulation for the parameters of return loss, bandwidth, realized gain, maximum value of directivity and total efficiency using CST Microwave Studio Suite 2011. Parametric study is done to get the optimized and desired design.