PHOTONIC ANTENNA FOR WIRELESS LOCAL AREA NETWORK BACKHAUL APPLICATION

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Appreciation and specially dedicated to

my beloved family members, lecturers and course mates

who always encourage, and inspire me to throughout my Masters degree program

at UTM

ABSTRACT

The surge demand for broadband services and high speed internet connection has pushed the development and deployment of wireless local area network (WLAN) applications such as providing coverage to in-campus or inter-building. WLAN application is definitely a cheaper option compare to fiber optic and yet provides good coverage as a last mile or backhaul network connection. However, due to the complexity and expensive setup of electronic equipment and switches, it potentially will hinder the customers from using this technology. The present of photonic antenna which integrates antenna into optoelectronic device provide an economically viable solution as the device is small, light weight and easy to install at customer sites without any issue. Basically, photonic antenna is capable to work as bridging for Radio Access Units and wireless connection to customer sites. This project will explore different antenna design, particularly on microstrip antenna which provides directive and good gain to transmit radio frequency wirelessly for distance up to average of 10km in a Radio over Fiber (RoF) system. Four patches and 4x2 array patches Microstrip antennas are designed to meet high gain and directive for point to point application. From the result of simulation, 4x2 array Microstrip antenna is capable to achieve ~9.63dB gain with low side lobes and good power efficiency to extend the wireless distance in RoF system.

ABSTRAK

Gelombang permintaan untuk perkhidmatan broadband dan sambungan internet kelajuan tinggi telah mendorong pengembangan dan penyebaran rangkaian kawasan tempatan wayarles (WLAN) aplikasi seperti menyediakan perlindungan dalam kampus atau antar-gedung. Aplikasi WLAN jelas merupakan pilihan yang lebih murah berbanding dengan serat optik dan WLAN memberi liputan yang baik sebagai sambungan rangkaian terakhir. Namun begitu, peralatan elektronik dan switch yang mahal dan rumit berpotensi untukn menghalang pelanggan daripada menggunakan teknologi ini. Antena fotonik yang terintegrasi ke dalam peranti optoelektronik memberikan pilihan dan harga berpatutan sebagai peranti kecil, ringan dan mudah untuk dipasang di halaman pelanggan tanpa sebarang masalah. Pada dasarnya, antena fotonik berkemampuan bekerja sebagai "bridging" untuk Radio Akses Unit (RAU) dan sambungan wayarles ke halaman pelanggan. Projek ini akan mengeksplorasi antenna fotonik yang berbeza, terutama mengenai antenna microjalur yang boleh member satu arah tuju gelombang baik untuk mentransmisikan frekuensi radio tanpa kabel untuk jarak sampai dengan rata-rata 10km di radio atas gentian(RoF) sistem. Empat patch dan patch antena array 4x2 Mikrostrip direka untuk memenuhi keuntungan yang tinggi dan direktif untuk titik ke aplikasi titik. Dari hasil simulasi, array 4x2 patch antena Mikrostrip mampu untuk mencapai ~ 9.63dB keuntungan dengan sisi lobus rendah dan kecekapan kuasa yang baik untuk melanjutkan jarak wayarles dalam sistem RoF.

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LIST OF SYMBOLS

W	-	Width
L	-	Length
h	-	Patch thickness
$\|\Gamma\|$	-	Reflection coefficient
V	-	Voltage
Z_L	-	Load impedance
Z_0	-	Characteristic impedance
η	-	Efficiency
P	-	Power
c	-	Speed of light 3 $x10^{-8}$ m/s

CHAPTER 1

INTRODUCTION

1.1 Introduction

The explosive growth and demand for broadband service has driven internet technology to deliver fast internet connection with real-time video streaming and multimedia data. Wireless communication is playing an important role to provide high speed broadband service to many areas especially in the urban cities and rural areas in the modern world of internet. Basically, fiber optic is used to connect all the underlying network due to fiber has low transmission loss over long distances, immunity of electromagnetic interference and faster data transmission speed. Radio over Fiber (RoF) system is becoming common nowadays and essential for last mile solution and large capacity. Figure 1.1 describes the IEEE standards use for wireless technologies particularly WLAN application which falls under IEEE 802.11 standard.

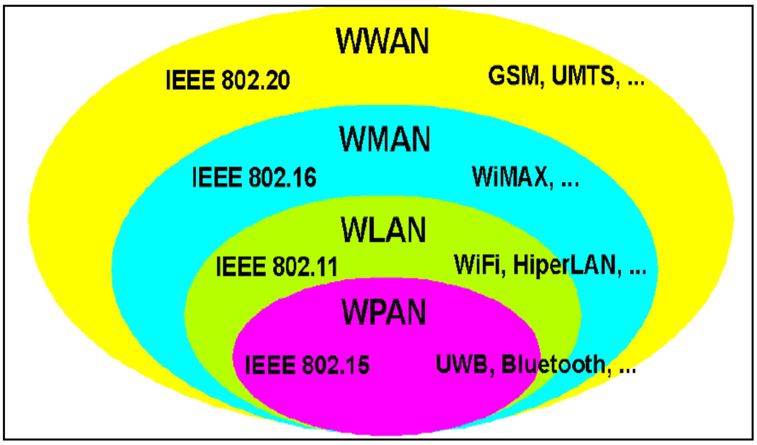

Figure 1.1: IEEE standards for wireless technologies

However, extending fiber optic to backhaul, outdoor and rural/campus area is challenging due to high cost. Hence, backhaul network and connection usually is extended using WLAN signal. For WLAN signal, IEEE 802.11 is used for local area networking technology which designated to provide in-building or campus broadband coverage. In wireless backhaul network, an expensive optical switch is required to convert the optical signal to electrical signal and configure with WLAN protocol to form RF wireless signal [1]. Then the RF signal is radiated using antenna. The optical fiber as works a transport module for transporting radio signals from a central location to remote located antenna sites. This will allows flexible way for interfacing with multiple antennas remotely as simple antenna is located nearer to customer location. Basically, WLAN standard is consists of IEEE 802.11b, IEEE 802.11a and HIPERLAN/2 as shown in Table 1.1.

Table 1.1: A comparison of different IEEE standards for WLAN applications [2]

Standard Parameter	IEEE 802.11b	IEEE 802.11a	HIPERLAN/2
Operating Frequency Bands	2.4 – 2.4835 GHz 2.471 – 2.497 GHz	5.150 – 5.350 GHz 5.725 – 5.825 GHz	5.150 – 5.350 GHz 5.470 – 5.725 GHz
Data Rate vs. Range (for omni directional antennas)	11 Mbps (60 m) 2 Mbps (100 m)	24 Mbps (30 m) 6 Mbps (60m) (Max: 54 Mbps)	Same
Modulation vs. Data Rate	DBPSK (1 Mbps) DQPSK (2 Mbps) CCK* (5.5, 11 Mbps)	BPSK (6, 9 Mbps) QPSK (12, 18 Mbps) 16-QAM (24, 36 Mbps) 64-QAM (54 Mbps)	Same
Occupied Bandwidth	26 MHz (per logical channel	16.6 MHz (per carrier)	Same
Allocated Bandwidth	83.5 MHz (26 MHz – Japan)	300MHz (100 MHz – Japan)	455 MHz

*CCK = Complementary Code Keying

To reduce the cost of expensive optical switch, it is possible to use photonic antenna and integrated with optoelectronics and use to transmit RF wireless signal with direct feed in from optical fiber directly. Basically, photonic antenna consists of PIN diode, band pass filter and antenna. The working range for optical frequency is around 1300 – 1550nm. Photonic antenna is simple, light weight and can be used as bridging for point to point or multipoint. In bridging application, antenna design is critical to ensure narrow beam width and high gain obtained. Thus, this will extend the wireless distance capability, typically >10km is considered average distance coverage.

In this project, we will further explore on how to design an antenna that capable to extended backhaul network wireless distance by providing point to point application.

1.2 Objective

The objective of this project is to design and simulate a photonic antenna for WLAN backhaul application at 5.8GHz in a Radio over Fiber (RoF) system. The study and investigation will be conducted to analyze the performance of photonic antenna in RoF system as well using OptiSystem simulation software.

1.3 Scopes

To achieve the objective of the project, below are the following project scopes will be cover:

i) Design and simulation of several photonic antenna array designs at 5.8GHz for WLAN backhaul application using CST software.

ii) Antenna design will be evaluated on the performance in RoF system by performing simulation and analysis using OptiSystem software.

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