DESIGN OF POWER AMPLIFIER FOR RADIO OVER FIBER TECHNOLOGY (ROF)

ARISITA DUWI SAPIT

This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) With Honours.

Faculty of Electronic and Computer Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APRIL 2010

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : DESIGN OF POWER AMPLIFIER FOR RADIO OVER FIBER TECHNOLOGY (ROF)

Sesi Pengajian :

0	9	/	1	0

Saya ARISITA DUWI SAPIT
mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐	**SULIT***	*(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD****	**(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	**TIDAK TERHAD**	

Disahkan oleh:

_____ (TANDATANGAN PENULIS)

_____ (COP DAN TANDATANGAN PENYELIA)

Tarikh: 30 APRIL 2010

Tarikh: 30 APRIL 2010

"I hereby declare that this report is the result of my own work except for quotes as cited in the references.''

Signature : .....

Author : ARISITA DUWI AK SAPIT

Date : 30TH APRIL 2010

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) With Honours.''

Signature : ……..

Supervisor's Name: MR.AZAHARI BIN SALLEH

Date : 30TH APRIL 2010

To my beloved mother and father

ACKNOWLEDGEMENT

First and foremost, I would like to extend my appreciation to all those who contributed time, concern and efforts to lend a helping allowing me to gain invaluable knowledge. On the top of that, I would like to express my appreciation to my supervisor, Mr Azahari Bin Salleh for all his encourages, guidance, advice and motivation throughout this whole project. Without his continue support and interest, this project would not have been same as presented here.

I would like to thank my beloved family for their encouragement and never ending support. Their support and lovely companionship is another important source of strength for me. Without their devoted love and sacrifices, none of this would have been possible. However, the experiences that I have gained would not been made possible without the guidance of my deepest appreciation goes to all my lovely friends and seniors.

Lastly, I would like to acknowledgement every individual who give me a helping hand in order to achieve this accomplishment. It would not have been possible to complete a report of this magnitude without the support from them.

ABSTRACT

Based on wireless network radio over fiber (RoF) technology has been proposed as a promising cost effective solution to meet ever increasing user bandwidth and wireless demands. In this network, a central station (CS) is connected to numerous functionally simple radio access point (RAP) via an optical fiber. The only components required at the passive RAP are electro absorption modulator (EAM) and antenna where EAM is used as a remote transceiver. There are practical limitations on the power that can produce by the passive RAP which can affect the dynamic range. In order to improve the dynamic range of passive picocell (RAP), the power amplifier is placed between the EAM and the antenna. The aim of this project is to design power amplifier for radio over fiber technology with short range application (picocell) which operating at 5.2 GHz, with power amplifier gain above 10 dB and required to achieve transmit power below 30 dBm. Picocells use power lower than 1 Watt (30 dBm). The transistor used for power amplifier design is Agilent ATF-55143 because it met all of the requirements for the target specifications. Microwave Office Software is used in power amplifier design simulation. In the simulation, the analyses of scattering parameters are concerned which presents the gain, power output and efficiency of power amplifier. From the simulation results; gain is 12.17 dB, power output is 25.07 dBm and efficiency is 23.01%. At the end of design, the power amplifier is purposed as a RF front end of RAP for RoF technology.

ABSTRAK

Berdasarkan kepada rangkaian tanpa wayar teknologi radio atas gentian (RoF) telah dicadangkan yang menjanjikan penyelesaian berkesan kepada kos untuk memenuhi pertambahan jalur lebar pengguna dan permintaan terhadap tanpa wayar. Dalam rangkaian ini, pusat stesen (CS) disambungkan kepada titik akses radio (RAP) yang berfungsi ringkas dengan melalui gentian optik. Komponen yang diperlukan di RAP pasif hanyalah pemodulat penyerapan elektro (EAM) dan antena di mana EAM digunakan sebagai penghantar terima jauh. Batasan praktikal terhadap kuasa dihasilkan di RAP pasif boleh menjejaskan julat dinamik. Penguat kuasa telah diletakkan antara EAM dan antena bagi memperbaiki julat dinamik di piko sel pasif (RAP). Matlamat projek ini ialah untuk merekabentuk penguat kuasa di RAP dengan julat dinamik di piko sel pasif beroperasi pada jalur 5.2 GHz, dengan gandaan melebihi 10 dB dan kuasa penghantaran kurang dari 30 dBm. Piko sel menggunakan kuasa kurang dari 1 Watt (30 dBm). Pengaruh voltan yang digunakan untuk merekabentuk penguat kuasa adalah Agilent ATF-55143 sebab memenuhi semua ciri-ciri matlamat projek ini. Perisian Microwave Office telah digunakan untuk simulasi terhadap merekabentuk penguat kuasa. Dalam simulasi, analisis melibatkan parameter serakan yang menunjukkan gandaan, kuasa penghantaran dan kecekapan bagi penguat kuasa. Dari keputusan simulasi; gandaan adalah 12.17 dB, kuasa penghantaran adalah 25.07 dBm dan kecekapan adalah 23.01%. Di akhir rekabentuk, penguat kuasa telah dicadangkan sebagai bahagian depan RF di RAP untuk teknologi RoF.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Symbol	Definition
ADS	Advanced Design System
BPF	Bandpass Filter
BRS	Broadband Radio Service
BS	Base Station
CS	Central Station
DECT	Digital Enhanced Cordless Telecommunication
DFB	Distributed Feedback
DR	Dynamic Range
EAM	Electroabsorption Modulator
EMI	Electromagnetic Interference
FCC	Federal Communications Commission
FET	Field Effect Transistor
FP	Fabry Perot
GSM	Group Special Mobile
IF	Intermediate Frequency
IL	Insertion Loss
IMD	Intermodulation Distortion
IMDD	Intensity Modulation Direct Detection
ISM	Industrial, Scientific and Medical
LED	Light Emitting Diode
LNA	Low Noise Amplifier
MAG	Maximum Available Gain

MBS	Mobile Broadband System
MU	Mobile Unit
MVDS	Multipoint Video Distribution Services
MWO	Microwave Office
NF	Noise Figure
OFDM	Optical Time Division Multiplexing
OTDM	Orthogonal Frequency Division Multiplexing
PA	Power Amplifier
PAE	Power Added Efficiency
PD	Photo Detector
POF	Polymer Optical Fiber
QAM	Quadrature Amplitude Modulation
RAP	Radio Access Point
RF	Radio Frequency
RHD	Remote Heterodyning Detection
RIN	Relative Intensity Noise
RoF	Radio over Fiber
SFDR	Spurious Free Dynamic Range
SMF	Single Mode Fiber
SOA	Safe Operating Area
TEM	Transverse Electric Magnetic
UMTS	Universal Mobile Telecommunications System
VSWR	Voltage Standing Wave Ratio
WLAN	Wireless Local Area Network

LIST OF SYMBOLS

C	Capacitor
dB	Decibel
f	Frequency
g	Element Values
G	Giga
h	Height
Hz	Hertz
I	Current
K	Rollet's Stability Factor
km	Kilometer
L	Inductance
M	Meter
mA	Miliampere
mm	Milimeter
mW	Miliwatt
nm	Nanometer
π	Pi
P	Power
R	Resistance
S	Scattering
T	Tera
V	Voltage
w	Angular Frequency

Y	Admittance
Z	Impedance
Γ	Reflection Coefficient
δ	Fractional Bandwidth
εr	Relative Dielectric Constant
η	Efficiency
λ	Wavelength
Ω	Ohm

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Chapter one is focusing on the project background, problem statements, project objectives, scope of work and thesis outline.

1.1 Project Background

The main purpose of this project is to design power amplifier for radio over fiber (RoF) technology which operating at 5.2 GHz. The applications target range of this project is from mobile cellular networks, wireless local area network (WLAN) at millimeter (mm) wave bands and broadband wireless access network to road vehicle communication.

RoF is refers to a technology whereby light is modulated by a radio signal and transmitted over an optical fiber link to facilitate wireless access [1]. The focus is on transmitter design of radio access point (RAP) for downlink transmission (RAP to central station). This process involves design method, simulation and analyses of power amplifier for RoF.

Wireless Communication is becoming an integral part of today's society. The proliferation of mobile and other wireless devices coupled with increased demand for broadband services are putting pressure on wireless systems to increase capacity. To achieve this, wireless systems must have increased feeder network capacity, operate at higher carrier frequencies, and cope with increased user population densities. However, raising the carrier frequency and thus reducing the radio cell size leads to costly radio systems while the high installation and maintenance costs associated with high-bandwidth silica fiber render it economically impractical for in-home and office environments [2].

Radio-over-fiber (RoF) technology has emerged as a cost effective approach for reducing radio system costs because it simplifies the remote antenna sites and enhances the sharing of expensive radio equipment located at appropriately sited (e.g. centrally located) Switching Centers (SC) or otherwise known as Central Sites/Stations (CS). On the other hand, Graded Index Polymer Optical Fiber (GIPOF) is promising higher capacity than copper cables, and lower installation and maintenance costs than conventional silica fiber [3].

1.2 Problem Statement

Electro-absorption modulator (EAM) is used in an optical radio system. A radio signal to be transmitted is first used to modulate a central semiconductor laser, which is connected via the downlink optical fiber to the EAM transceiver in the remote antenna unit. The uplink fiber is used as a return path to the optical receiver in the central location.

EAM have two optical radio options that are passive optical radio access point and active optical radio access point [4]. In passive optical radio access point there are practical limitations on the amount of RF power that can be produced by the radio

access point. Active optical radio access point is use electrical power for EAM biasing and signal amplification.

The operating range limitation of passive optical radio access point can be overcome by using electronic amplification within the antenna unit. Simply by placing a power amplifier between the EAM and the antenna it is possible to improve on the operating range of a passive pico-cell. With the sufficient amplification from the power amplifier it would be possible for an EAM active access point to achieve the same output power as conventional electronic systems.

1.3 Project Objective

The objective of the project is to design power amplifier for radio over fiber technology which operating at 5.2 GHz, with power amplifier gain of > 10 dB and required to achieve transmit power of < 30 dBm.

1.4 Scope of Work

In order to achieve the objective of this project, there are following scopes will be covered:

a) To study the concept of the RoF technology.
b) It focuses to design and simulate the power amplifier which is operating in downlink transmission of RAP.
c) All of parts of design are operating at 5.2 GHz band.
d) Microwave Office software is used to perform the simulation.
e) Scattering parameters of power amplifier stability, biasing, input and output matching network, optimization and intermodulation distortion are analyzed.

1.5 Thesis Outline

This thesis is a document that delivers the ideas generated and the concept applied. In chapter one briefly introduces the overall of the project. The introduction consists of background, objective, problem statement, scopes and thesis outline.

Meanwhile, chapter two contains the literature review of the RoF system and chapter three contains the literature review of the PA. It discusses the researches done upon the related project and data obtained through journals, books, magazines, and internet.

Chapter four describes the methodology of the project which includes the project flow and its functional block diagram. It also discusses the methods used for the project such as software applied and the reasons behind it.

Chapter five included all the main components together with the functionality and descriptions applied in this project. It consists of result and discussion of the project, finding and analysis throughout the research and project development.

Lastly, chapter six is the project conclusion. This chapter rounds up the attained achievement of the whole project and gave the recommendations for the future development of this project.