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DESIGN OF POWER AMPLIFIER AT 5.2 GHz FOR RADIO OVER FIBER TECHNOLOGY

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

Signature : ……………………………….

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(*Keywords:Power Amplifier, Radio Access Point, Radio over Fiber)*

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.

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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.

CHAPTER II

RADIO OVER FIBER TECHNOLOGY

Chapter two is about literature review regarding to the application of this project. It contains method to do research, theory used to solve problems in this project and so on.

2.1 Introduction

RoF technology is a technology by which microwave (electrical) signals are distributed by means of optical components and techniques. RoF technology was first developed in early 1980s in United States for military applications [5]. It was used to distance the radar emitters (dish) far from the control electronics and personnel, because of the development of radar-seeking missiles (anti radiation missiles). Since then the international research community has spent much time investigating the limitations of RoF and trying to develop new, higher performance RoF technologies. Many laboratory demonstrations and field trials have been performed, but currently RoF still remains a niche application within the broad remit of optical fiber technology.

Generally, one natural way to increase capacity of wireless communication systems is to deploy smaller cells (micro and picocell). This is generally difficult to achieve at low frequency microwave carriers, but by reducing the radiated power at the antenna, the cell size may be reduced somewhat. Picocells are also easier to form inside buildings, where the high losses induced by the building walls help to limit the cell size. In contrast, the high propagation losses, which radio waves experience at millimeter wave frequencies, together with the line-of-site requirements, help to form small cells. Another way to increase the capacity of wireless communication systems is to increase the carrier frequencies, to avoid the congested Industrial, Scientific and Medical (ISM) band frequencies. Higher carrier frequencies offer greater modulation bandwidth, but may lead to increased costs of radio front ends in the base stations and the mobile unit.

Smaller cell sizes lead to improved spectral efficiency through increased frequency reuse. But, at the same time, smaller cell sizes mean that large numbers of RAP are needed in order to achieve the wide coverage required of ubiquitous communication systems. Furthermore, extensive feeder networks are needed to service the large number of RAP. Therefore, unless the cost of the RAP and the feeder network are significantly low, the system wide installation and maintenance costs of such systems would be rendered prohibitively high. This is where RoF technology comes in.

2.2 Radio over Fiber System

RoF technology entails the use of optical fiber links to distribute RF signals from a CS to RAP. In narrowband communication systems and WLAN, RF signal processing functions such as frequency up-conversion, carrier modulation, and multiplexing, are performed at the RAP, and immediately fed into the antenna. RoF makes it possible to centralize the RF signal processing functions in one shared location (headend), and then to use optical fiber, which offers low signal loss (0.3 dB/km for 1550 nm, and 0.5 dB/km for 1310 nm wavelengths) to distribute the RF signals to the base station (BS) or RAP, as shown in Figure 2.1.

RAPs are simplified significantly, as they only need to perform optoelectronic conversion and amplification functions. The centralization of RF signal processing functions enables equipment sharing, dynamic allocation of resources, and simplified system operation and maintenance. These benefits can translate into major system installation and operational savings, especially in wide coverage broadband wireless communication systems, where a high density of RAP is necessary.

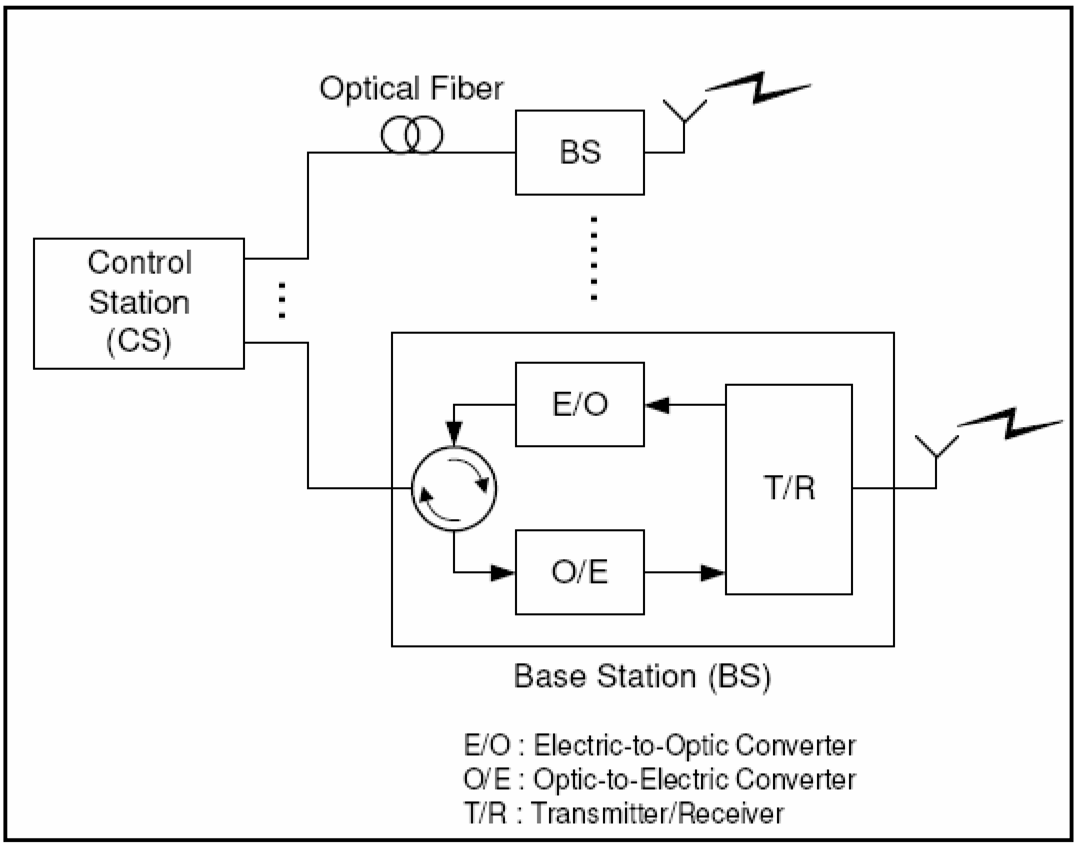

Figure 2.1: General radio over fiber system [5]

2.2.1 RoF Optical Link

In this section, a brief overview of how to generate and transport radio signal over an optical fiber in RoF networks is given. Essentially, three different methods exist for the transmission of microwave or mm-wave signals over optical links with intensity modulation: direct intensity modulation (IMDD), external modulation, and remote heterodyning (RHD) [5].

All RoF systems have a same basic configuration: a two way interface contains the analog laser transmitter and photodiode receiver, which connect to the base station transmitter and receiver to a pairs of optical fibers link. At the other end of the fibers is a remote unit (RAP) that uses a similar photodiode receiver and analog laser transmitter to convert the optical signals to and from antenna suitable for radiating the signals. At the optical transmitter, the RF or intermediate frequency (IF) signal can be imposed on the optical carrier by using direct or external modulation of the laser light.

In an ideal case, the output signal from the optical link will be a copy of the input signal. However, there are some limitations because of nonlinearity and frequency response limits in the laser and modulation device as well as dispersion in the fiber. The transmission of analogue signals outputs certain requirements on the linearity and dynamic range of the optical link. These demands are different from and more exacting than requirements on digital systems.

2.2.1.1 Direct Laser Modulation

Direct laser modulation is relatively straightforward as shown in Figure 2.2. In principle the electrical IF or RF signal is superimposed on the biasing current of the laser module. The laser transforms an electrical signal into a coherent light signal. Beyond the threshold current, the light power increases approximately linear with the input current which shown in Figure 2.3. By biasing the laser to the middle of the linear region, the