HIGH EFFICIENCY POWER AMPLIFIER DESIGN FOR LONG TERM EVOLUTION (LTE)

SITI SAHARAH BINTI ZAHARI

This Report Is Submitted In Partial Fulfillment of Requirements for the Bachelor Degree of Electronic Engineering (Telecommunication Electronic)

FACULTY OF ELECTRONIC ENGINEERING AND COMPUTER ENGINEERING

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2013

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : High Efficiency Power Amplifier Design for Long Term Evolution (LTE)

Sesi Pengajian : 2012 / 2013

Saya   SITI SAHARAH BINTI ZAHARI 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)

Alamat Tetap:
470, Blok 21 Felda Keratong 03,
26900 Bandar Tun Abdul Razak,
Pahang

Tarikh: ....   Tarikh: ....

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

Signature   : …………………………………

Author's name   : SITI SAHARAH BINTI ZAHARI

Date   : 11 JUNE 2013

"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 (Electronic Telecommunication) With Honors."

Signature   : …………………………………………

Supervisor's name : Engr. NOOR BADARIAH BINTI ASAN

Date   : 11 JUNE 2013

For my parents Zahari Mohamad and Mariation Majid this is for you. For my supervisor and co-supervisor Noor Badariah Asan and Mohamad Harris Misran, thanks for helping to finished this project. For my entire supporter, I love you all.

ACKNOWLEDGEMENT

Alhamdullillah. Bless from Allah, I already finished this report to complete Final Year Project for Bachelor in Electronic Engineering of Telecommunication. In this acknowledgement, I want to thanks to my parent, Zahari Mohamad and Mariation Majid that always supported me and always advised me when I'm doing wrong. I also want to thanks to my supervisor Noor Badariah Asan and my co-supervisor Mohamad Harrris Misran that always helping me on my project and give some opinion about my project until it successful. For my friend that always supported and helping me to finish this project, thanks to you.

ABSTRAK

Penguat kuasa *(PA)* biasanya pengguna utama kuasa arus terus (DC) dalam kebanyakan peranti wayarles tangan, jadi kecekapan penguat adalah satu pertimbangan yang amat penting. Untuk menyelesaikan masalah ini, kita perlu untuk mereka bentuk kecekapan tinggi *PA* untuk evolusi jangka panjang (LTE) yang mengurangkan gangguan apabila menghantar isyarat. Dalam komunikasi, pada dasarnya mereka menggunakan penguat kuasa Kelas A & AB. Ini adalah kerana ia mempunyai nilai gandaan yang lebih tinggi dengan mengurangkan kandungan spektrum tetapi kecekapannya kurang dari 70%. Jangkaan kecekapan untuk penguat kuasa bagi projek ini adalah lebih daripada 70%. Proses modulasi kuasa mesti cekap kerana hanya kuasa dihantar (kadang-kadang hanya sebahagian daripadanya) akan ditafsirkan oleh penerima. Penguat kuasa yang cekap adalah penting dalam teknologi terkini.dan akan diperlukan pada masa akan datang juga. Objektif utama projek ini adalah untuk merekabentuk dan membangunkan kecekapan tinggi kuasa penguat untuk LTE. Dalam usaha untuk mencapai matlamat ini, beberapa kaedah telah dicadangkan. Pada mulanya, kajian literatur termasuk pemahaman mengenai parameter penguat kuasa dan struktur akan menjadi kajian. Kemudian, kita akan merekabentuk dan menganalisis penguat kuasa. Pada akhir projek ini, saya akan belajar tentang reka bentuk penguat kuasa dan teknik. Parameter yang akan digunakan dalam projek ini adalah kehilangan yang dikembalikan. Kami menggunakan teknik pengukuran gelombang mikro untuk mengira ukuran untuk reka bentuk ini. Dalam projek ini, saya sudah selesai reka bentuk penguat kuasa untuk LTE.

ABSTRACT

The power amplifier (PA) is usually the primary consumer of DC power in most hand-held wireless devices, so amplifier efficiency is a very important consideration. To solve this problem, we need to design high-efficiency PA for LTE (Long Term Evolution) that reduce noise when transmit the signal. In communication, basically they use Class A & AB power amplifier. It is because it has higher gain with reduced spectral content but its efficiency below than 70%. The expected efficiency power amplifier for this project is more than 70%. The power-modulation process must be efficient, since only the delivered power (sometimes only part of it) is to be interpreted by the receiver. Efficient power amplifiers are necessary in state-of-the-art technology and are going to be necessary in the future as well. The main objective for this project is to design and develop high-efficiency power amplifier for LTE. In order to achieve the objective, several methodologies have been proposed. In the beginning, literature review including understanding of power amplifier parameters and structure will be studies. Later on, we will design and analyze the power amplifier. At the end of the project, I will learn about power amplifier design and technique. Parameter that will use in this project is return loss. We use Microwave measurement technique to calculate the measurement for this design. In this project, I already finished design power amplifier for LTE.

TABLE OF CONTENTS

II   LITERATURE REVIEW

III   METHODOLOGY

IV   RESULT AND DISCUSSION

LIST OF FIGURE

LIST OF TABLE

LIST OF ABBREVIATION

ADS - Advanced Design System

BJT - Bipolar Junction Transistor

CDMA -Code Division Multiple Access

DC - Direct Current

EDGE - Enhanced Data rates for GSM Evolution

EM - Electromagnetic

FEM - Finite Element Method

GPRS - General Packet Radio Service

GSM - Global System for Mobile

HSPA - High Speeds Packet Access

IBIS AMI - Input output Buffer Information Specification-Algorithmic Modeling Interface

JFET - Junction Field – Effect Transistor

LNA - Low Noise Amplifier

LPF - Low Pass Filter

LTE - Long Term Evolution

MBMS - Multimedia Broadcast Multicast Service

PA - Power Amplifier

PACAD - Power Amplifier Design

PAE - Power Added Efficiency

PCB - Printed Circuit Board

PIC - Peripheral Interface Controller

PLC - Programmable Logic Controller

PLL - Phase Locked Loop

RFC - Request for Comments

RF System - Radio Frequency System

SAE - System Architecture Evolution

TD-SCDMA - Time Division – Synchronous Code Division Multiple Access

UMTS - Universal Mobile Telecommunication System

VSWR - Voltage Standing Wave Ratio

WiMAX - Worldwide interoperability for Microwave Access

WLAN - Wireless Local Area Network

CHAPTER I

INTRODUCTION

The power-modulation process must be efficient, since only the delivered power (sometimes only part of it) is to be interpreted by the receiver. Despite the current miniaturization and power saving trends in electronic devices, human-scale powers must be handled in order to interact with the real-world environment. Therefore, efficient power amplifiers are necessary in state-of-the-art technology and are going to be necessary in the future as well.

The power amplifier is usually the primary consumer of DC power in most hand-held wireless devices, so amplifier efficiency is a very important consideration. To solve this problem, we need design high-efficiency power amplifier for LTE that can be reduce noise when transmit the signal. Class A & AB designs are more to mobile unit

because higher gain with reduced spectral content but the efficiency only below than 70%. The expected efficiency power amplifier for this project is more than 70%.

A better measure of amplifier efficiency is called ***power added efficiency***, defined as:

$$\eta_{PAE} = PAE = \frac{P_{out} - P_{in}}{P_{DC}} = \left(1 - \frac{1}{G}\right)\frac{P_{out}}{P_{DC}} \dots\dots\dots\dots\dots\dots\dots (1.1)$$

For this project we need to design and also develop high efficiency power amplifier design for Long Term Evolution (LTE). To design power amplifier, we choose to use Advanced Design System (ADS) software compare to Power Amplifier Design (PACAD) software. To develop power amplifier, we have to fabricate design from ADS software. ADS software also can print the circuit to the PCB board to fabricate.

1.1   Problem Statement

The power-modulation process must be efficient, since only the delivered power (sometimes only part of it) is to be interpreted by the receiver. Despite the current miniaturization and power saving trends in electronic devices, human-scale powers must be handled in order to interact with the real-world environment. Therefore, efficient power amplifiers are necessary in state-of-the-art technology and are going to be necessary in the future as well. In communication, basically they use Class A & AB power amplifier. Currently high-efficiency power amplifier for LTE is below than 70%.

1.2   Objective

The main objective for this project is to design and develop high-efficiency power amplifier design for LTE. The other objective is learned how to use ADS software to design power amplifier.

1.3   Scope

For this project, we use ADS2008 (Advanced Design System) software to design high-efficiency power amplifier for LTE. This project also use hardware based on design from ADS. Hardware that use are Power Amplifier. For measure power amplifier, we use Microwave measurement technique. In this project, parameter that use is return loss.

In order to achieve the objective, several methodologies have been proposed. In the beginning, literature review including understanding of power amplifier parameters and structure will be studies. Later on, we will design and analyze the power amplifier. At the end of the project, I will learn about power amplifier design and technique. We also will gain programming skills. Parameter that will use in this project is return loss. We use Microwave measurement technique to calculate the measurement for this design.

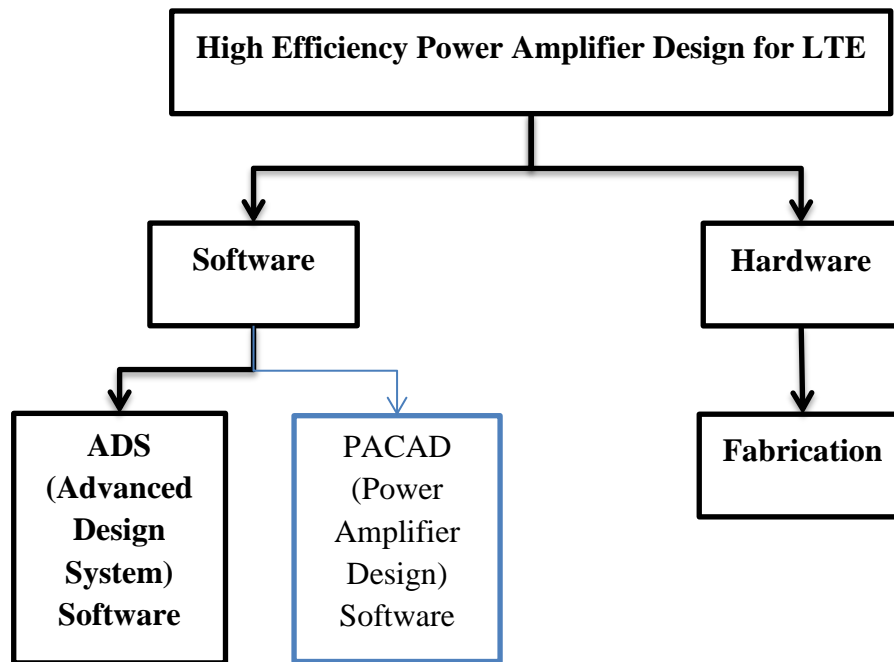Chart on the next page show summary of scope in this project.

```
┌─────────────────────────────────────────────────────┐
│     High Efficiency Power Amplifier Design for LTE    │
└─────────────────────────────────────────────────────┘
```

```
┌──────────────┐                        ┌──────────────┐
│   Software   │                        │   Hardware   │
└──────────────┘                        └──────────────┘
```

```
┌──────────────┐  ┌──────────────┐      ┌──────────────┐
│     ADS      │  │    PACAD     │      │  Fabrication │
│  (Advanced   │  │   (Power     │      │              │
│    Design    │  │  Amplifier   │      │              │
│   System)    │  │   Design)    │      │              │
│   Software   │  │   Software   │      │              │
└──────────────┘  └──────────────┘      └──────────────┘
```

Figure 1.1: Scope work of Project

1.3.1   SOFTWARE (ADS Software)

In this project, we use software and hardware to accomplish this project. For this project, we have two softwares that we can use to design power amplifier. But in this project, we choose ADS software compare to Power Amplifier Design (PACAD) software. The introduction and advantage of ADS software will be discuss further in the subtopic of this topic. We will go deep to what exactly this software.

Why we use software to design power amplifier? This is because we can't estimate the possibility of design in success by using calculation. By using software, we can simulate the design circuit with the other possibility easier. For example we can to test design on the difference frequencies without do so much calculations.

1.3.1.1 What is Advanced Design System (ADS)

Agilent Technologies Inc. made ADS software in the industry's leading RF, microwave & high speed digital electronic automatic software for wireless communication & networking, aerospace & defense, and signal integrity application. ADS software is software that has high speed digital design and simulation tools that provides solution for multi-gigabit/s chip-to-chip links.

Why communications use ADS software? It is because in nowadays communication we used high speed digital signal and the frequency is higher. So, ADS can design on the high speed digital signal. Agilent always upgrade ADS software to meet the needed of increasing complexity and integration. Most of ADS looked like same as the other version but some importance been made to support the breakthrough technology in new ADS.

The new ADS have their new capabilities such as easier to simulate and multi-chip design. User no longer restricted to a single project folder. They can easy to create multi-technology design and designs containing IP from multiple engineers. User can create design tat use components from multiple process and designs will use the technology defined in the library. Duplicate of the component names are supported as long as the parts are in different libraries.

The other capabilities are easily select models for simulation. User can easily simulate without activating and deactivating and this concept known as dynamic model selection that means user can simulate same designs with different models.

The next capabilities are more efficient electromagnetic (EM) setup. This new ADS has redesigned EM user interface for both momentum and FEM which provides a ore streamlined use model for creating substrates (MSub), defining port(Port) and generating EM models. EM setup are easier to configure and can be reused.

1.3.1.2 How to use ADS?

If this is first time on using ADS software, firstly we need to create some workplace for save our design. To create workplace, just click on button W with symbol plus like this figure. Workplace not only can create one folder. We also can create other workplace with the difference name. To create workplace, make sure that name not contain any symbol.

This button is to open the workplace that we already create. We can choose which one workplace that we want to open. It will display window that we need to search the directory of the workplace. Display window shown as picture below.
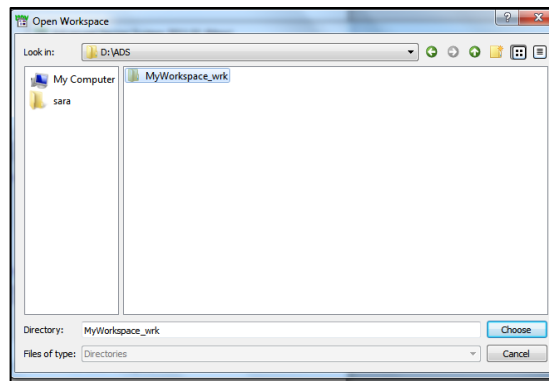

After opened the workplace, it will show the all design that we already save before this. Display below showed the opened workplace that already has the previous design.
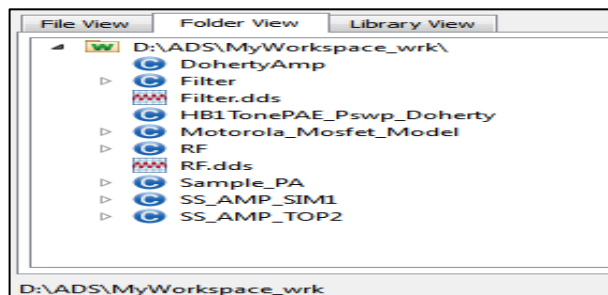
To start design circuit, we need to know the use of the button at the header of

ADS software. For this button , it's for design new schematic of the design circuit. We can name or rename the schematic based on the circuit design. Picture below show the specification schematic that we want to the circuit.
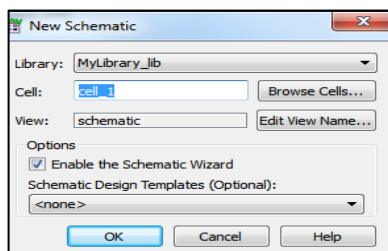

This button is to create new layout to the circuit. In the cell can have schematic, layout and symbols. Picture below show the option on create new layout.
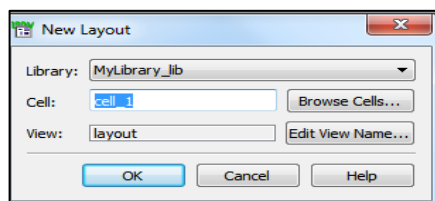
This button is for add new symbol to the circuit or cell. Figure below shown option on creating new symbol for circuit design.
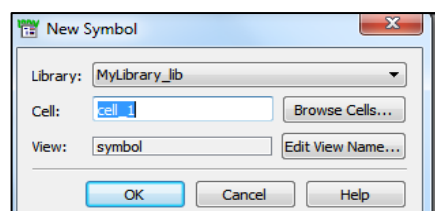
Button use when want to display the simulation. This button use to display data window. In this window we can get the data not only the digital value input output, we can also display the input and output value via smith-chart and graph. It also has the other method to display the result of this design. It easier to student compares the value

between calculation and measurement simulation. Figure below show the data display window.
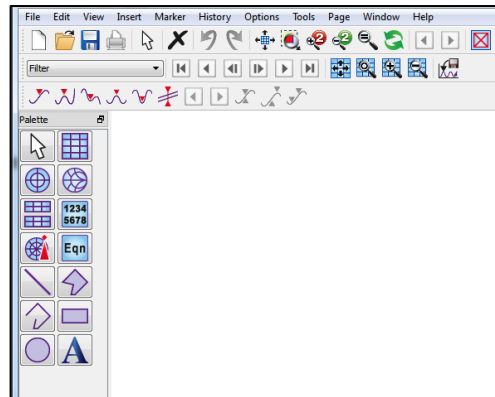

Figure 1.2 shows the example of circuit for designing 3dB branch line coupler. In this circuit, we use micro-strip line component. We can see the component name MLIN, MTEE and etc. Based on the name of the component, we can know the designing use which type of applications. At the end of the component, we need to put port. This port is the importance part because result will measure from this port. In all port should have termination (TERM) with the ground. In coupler, we measure by using s-parameter. So we need to put s-parameter to measure from the circuit. Msub is use to set the specification of the design. In S-parameter, we also put the frequency that we want to measure.
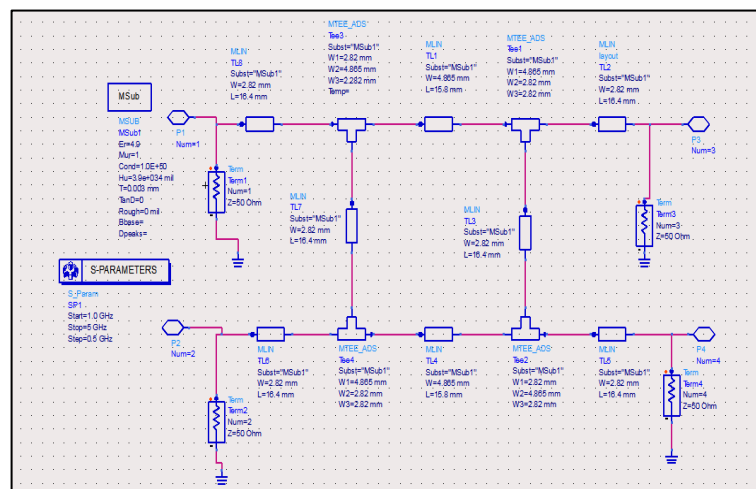


Figure 1.2: 3dB Branch Line Coupler

Sometime we have problem when want to find this components. So, from the designing, we should know that what application we use to design circuit. We also can search the component by typing on the search component. It shows in figure below.

In scrolling the application on ADS, we can see the component. It's specific to source, simulation and etc. If we want to use GSM technology, it also can be find at the component. The display of component searching can be show in figure below.
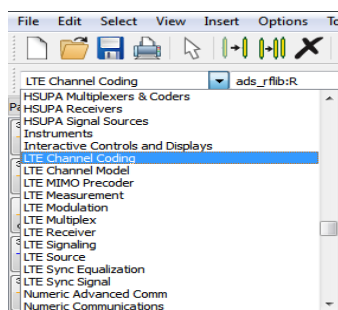
The first bar on other software, it usually the basic item like file, edit, select, view, insert, option, tools and helps. For ADS, it have additional item like layout, simulate, window, DynamicLink and DesignGuide. What use of this item? For layout and window item, it uses to add another layout and window to the design. In simulate item, it's about how to simulate the design and the simple simulation of the other design.
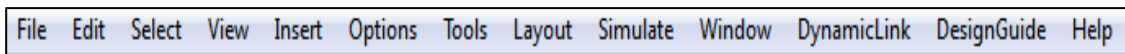
We can refer simulate to compare between example and our design if there something wrong when design can't simulate. For item DesignGuide, its guide users how to design circuit. In this option, it uploads the example of the designing on the other application.

For example, it already uploads the design of amplifier of class A to class D. if we want to design amplifier, we can refer only with the example circuit. It's not only for amplifier. The other applications like mixer and WiMAX also already upload to the DesignGuide. It make user easier to use this software.