HIGH LINEARITY POWER AMPLIFIER FOR WCDMA APPLICATION

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For Mom, RAHMAH BT USOP

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ABSTRACT

This report is investigated the analysis, design and implementation of high linearity power amplifiers for WCDMA application. The basic study background about high linearity power amplifier and specification of WCDMA application have been analyze before the design process start. The basic procedure in designing high linearity power amplifier require DC biasing, stability checking, input and output matching and maximum output power consumption. In high linearity power amplifier design, maximize the linearity and also the efficiency is one of the challenging task. In order to solve that, topology of power amplifier has been made to compare the result of the power amplifier. The design topology are Single Stage Amplifier, Balanced Amplifier and Feedback Amplifier. The best performanced from this three design is from Balanced Amplifier which gives higher return loss and output power which are -20.236 dB and 24.571 dB. Meanwhile the Feedback Amplifier gives higher gain which is 27.452 dBm. The simulation work is done by using Advanced Digital Software (ADS) and will be compared with the actual circuit. The optimization function of the software can help in getting accurate result.

ABSTRAK

Laporan ini dihasilkan bertujuan untuk menganalisis dan menghasilkan penguat kuasa yang tinggi kelinearanya untuk kegunaan WCDMA. Kajian meneyeluruh mengenai kelinearan yang tinggi dan spesifikasi yang di perlukan untuk kegunaan WCDMA perlu dilakukan sebulam proses reka bentuk dihasilkan. Prosedur asas bagi menghasilkan litar ini adalah analisis DC pincangan, pemeriksaan kestabilan transistor, reka bentuk rangkaian padanan dan hasil maksima penguat kuasa. Salah satu cabaran dalam menghasilkan litar ini adalah untuk memaksimakan kelinearan dan kecekapan penguatkuasa. Bagi menyelesaikan msalah ini, topologi kuasa penguat telah dibuat untuk membandingkan hasil daripada penguat kuasa. Reka bentuk topologi adalah Peringkat Single Amplifier, Amplifier Seimbang dan Maklum Balas Amplifier. Keputusan yang terbaik daripada tiga reka bentuk ini adalah dari Amplifier Seimbang yang memberi kerugian pulang yang tinggi dan kuasa keluaran yang -20,236 dB dan 24,571 dB. Sementara itu Amplifier Maklum balas memberikan keuntungan yang lebih tinggi iaitu 27,452 dBm. Kerja simulasi akan dihasilkan di dalam *Advanced Digital Software (ADS)* dan akan dibandingkan dengan litar sebenar. Fungsi pengoptiman perisian boleh membantu dalam mendapatkan hasil yang tepat. Fabrikasi litar akan dilakukan dengan papan cetak mikrostrip FR4 dan akan diuji untuk mengesahkan prestasi penguat reka bentuk.

Table of contents

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

ADS	**ADVANCED DESIGNED SYSTEM**
ACPR	**ADJACENT CHANNEL POWER RATIO**
E-PHEMT	**ENHANCEMENT MODE PSEUDOMORPHIC HEMT**
HEMT	**HIGH ELECTRON MOBILITY TRANSISTOR**
FET	**FIELD-EFFECT TRANSISTOR**
DC	**DIRECT CURRENT**
FDD	**FREQUENCY DIVISION DUPLEX**
GSM	**GLOBAL SYSTEM FOR MOBILE**
IMD3	**THIRD ORDER INTERMODULATION DISTORTION**
IP3	**THIRD ORDER INTERCEPT POINT**
PA	**POWER AMPLIFIER**
PAE	**POWER AMPLIFIER EFFICIENCY**
PHS	**PERSONAL HANDPHONE SYSTEM**
P1dB	**1DB COMPRESSION POINT**
QPSK	**QUARTER PHASE SHIFT KEYING**
RF	**RADIO FREQUENCY**
TDD	**TIME DIVISION DUPLEX**
WCDMA	**WIDE-BAND CODE DIVISION MULTIPLE ACESS**
WLAN	**WIRELESS LOCAL AREA NETWORK**

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Project Background

Mobile communication has become quite common in today's world with the increasing needs of effectively utilized bandwidth, and efficient and compact device technologies. The growth of wireless technologies is expressly fast. The information can easily communicate by the mobile communication system such as GSM, PHS, and third generation Wide-Band Code Multiple Access (W-CDMA). The wireless networking systems such as wireless local area network (WLAN), Bluetooth also are developed. High speed and high data rate are always required to provide better communication qualities and services in these wireless systems.

Power amplifiers (PAs) are typically blocks of RF front end circuits, which take more care to get efficient RF PA for saving the power consumption. However, Pas has most efficient when operating at compressed region as a nonlinear amplifier [1].

These nonlinear power amplifier can only amplify RF signal with introduce insignificant distortion. The traditional way to design linear power amplifier is back off the output power of PA to reduce distortion until an acceptable regime.[2] The PA implemented in such systems to achieve the linear capability is being important issues, which usually adjusts the operating region to obtain a satisfactory linearity over the transmitter's dynamic range. Recently, some approaches are proposed to

design the high efficiency amplifier with the non-linear mode combined with a complex linearity improvement technique such as Doherty amplifier, DC-DC converter amplifier

1.2 Objective Of Project

The objectives of this project is to study the characteristic and specification of high linearity power amplifier for wireless communication which is for WCDMA application. Besides, design a high linearity power amplifier that can be used for WCDMA application and simulate by using Agilent Advanced Digital Software (ADS).

1.3 Problem Statement

High efficiency and good linearity are among the important characteristics of a base station that power amplifier used in plurality of the communication applications. Both the characteristics have always been contradictory to demand for creative power amplifier design techniques. Maintaining the high efficiency which over a wide range of the power amplifier operation is an added requirement in these applications making power amplifier design a challenging task.

1.4 Scope of project

Scope of this project can be divided into three parts which are:

a) Literature review
   - The study of RF fundamental and characteristic of the high linearity power amplifier especially on the gain, return loss, stability which must be taken into consideration in designing this project.

b) Design and simulation
   - The amplifier is designed and simulated at 2.1GHz using ADS and optimization will be performed to get the best result.

c) Test analysis and measurement

- The performance of the designed amplifier will be tested and compared with the simulation result.

1.5 Thesis Outline

This thesis is a document that delivers the ideas generated and the concepts applied in this project. In chapter one contains the introduction of high linearity power amplifier for WCDMA application. The introduction consists of project background, objectives, problems statement, scope and thesis outline.

Meanwhile, chapter two is the project literature review. In order to execute this project, literature review must be done to comprehend the whole system and to decide the best inputs, outputs and used devices. Data obtained from the journal, books, magazines and internet.

Chapter three describes the methodology of the project flow and its functional block diagram. It also discusses the method used for the project, such the software applied.

Chapter four consist of actual result and analysis of this project. It included all the main components together with the functionality and description applied in this project.

Lastly, chapter five is the project conclusion and recommendation. This chapter contains the achievement of the whole project and gave the recommendation for the future development of this project.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

In order to execute this project, literature review must be done to comprehend the whole system and to decide the best inputs, outputs and used devices. From literature review, there will be an analysis regarding the method are used for complete this project. Literature review also will help to gain more information about the high linearity power amplifier for WCDMA application.

2.2 History of WCDMA

Wideband Code Division Multiple Access (W-CDMA) has become a standard of the most widely adopted 3G air interfaces. The specification was finalized at 1999. The specifications have been standardized by 3GPP. W-CDMA includes TDD (time division duplex) mode, and FDD (frequency division duplex) mode. As depicted in Fig1 [3]. The frequency band of W-CDMA/FDD locates at 1920-1980MHz for transmit and 2110-2170MHz for receive paired uplink and downlink, channel spacing of 5 MHz and raster of 200 KHz. An Operator needs 3-4 channels to build a high speed and high capacity network. The frequency band of W-CDMA/TDD locates at 1900-1920MHz and 2010-2025MHz Unpaired, channel spacing of 5MHz and raster of 200 kHz. Transmit and receive are not separated in

frequency. At modulation technique, QPSK has been introduced for W-CDMA system which higher data rate and global roaming around the multi-standard communication sets, to achieve linear 3 capabilities is being important issues of mobile handset. The system will provide a high data services up to 3.84Mbps.

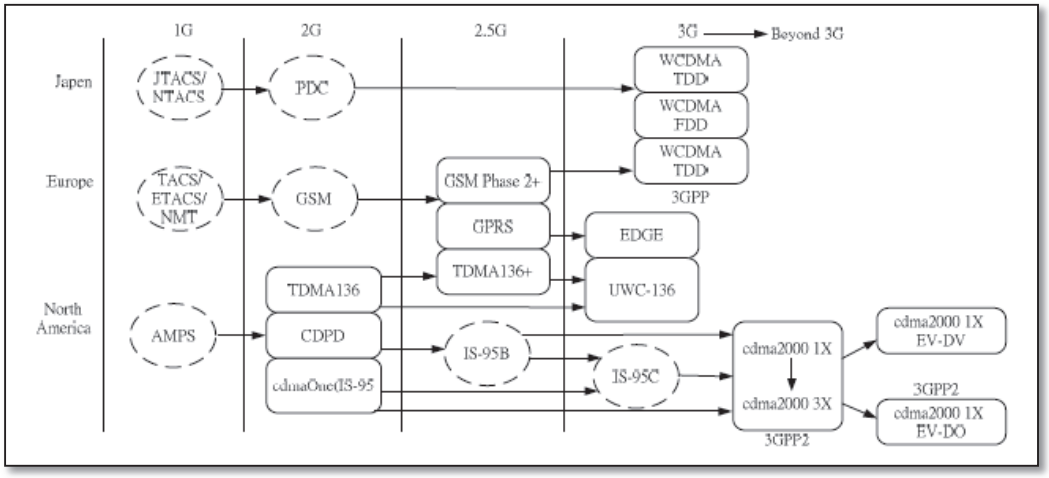

Figure 1 :Evolution of wireless network system

2.3 Characteristics of Power Amplifier

2.3.1 Linearity

The RF power amplifiers are inherently non-linear and are the primary for harmonic distortion products in a transmit chain. The typical reason of non-linear effects in power amplifiers is due to the compression behavior of the transistor operated at high input level. The non-linearity of a power amplifier can be attributed to gain compression and harmonic distortions that result in imperfect reproduction of the amplified signal. Some of the widely used figures to quantify the linearity are given as following:

- 1dB compression point (P1dB)
- Third order intermodulation distortion (IMD3)
- Third order intercept point (IP3)
- Efficiency (PAE)
- Adjacent channel power ratio (ACPR)

2.3.2 1dB compression point (P1dB)

The characteristic of non-linear response explains in a power amplifier when the output is driven to a point close to saturation as the input level increase. At the time, the amplifier gain downfalls or compresses. The output 1dB compression point (P1dB) can be expressed as the output level at which the gain compresses by 1dB from its linear region. Fig.2 shows the relationship between the input and output power of a typical power amplifier. Where Pin,max at the 1dB compression point is related to 6 corresponding output power Psat, where Pin,max is the linear power without distortion, Psat is the saturated power with distortion, and P1dB is the gain at the compression point.

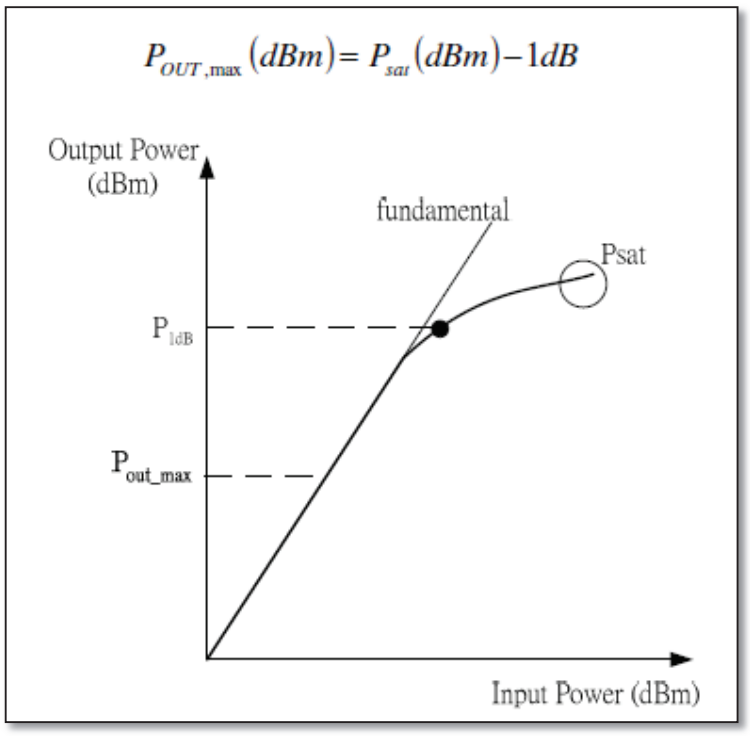

Figure 2: 1dB compression point

2.3.3 Third order intermodulation distortion (IMD3)

Third order intermodulation distortion is a phenomenon of generation of undesirable mixing products. The third order intermodulation distortion products (IMD3) have the significant effect on the signal, since they are nearby the fundamental signal. The unwanted spectral components such as the harmonics can be filtered out. Since the filtering is not imperfect, IMD3 are very close to the fundamental signal. Fig.3. shows the frequency domain representation of the IMD3 due to the input two tone signals.

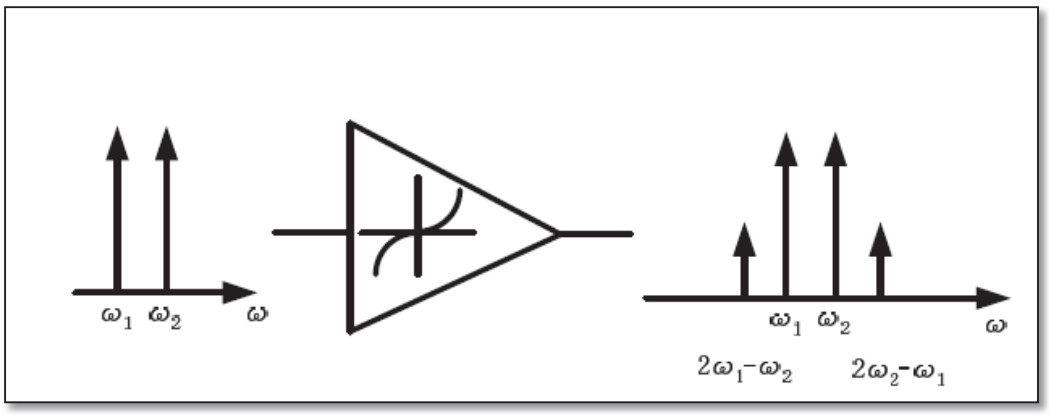

Figure 3 : IMD3 in a nonlinear system

2.3.4 Third Order Intercept Point (IP3)

The other important parameter to describe linearity is the intercept point. It is defined linear extension of the particular distortion component intersects the linear extension of the output line. Fig.4 illustrates the third order intercept point (IP3) in a plot of input power versus the output power. This parameter explains in the analysis of device performance, because the higher IP3 means the higher linearity and the lower distortion. The horizontal coordinate of this point is called the input IP3 (IIP3), and the vertical coordinate is called the output IP3 (OIP3).

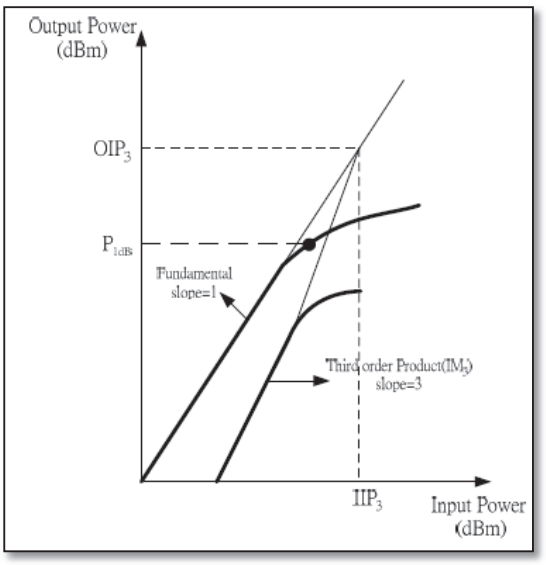

Figure 4 : Third Order Intercept Point

2.3.5 Efficiency

Efficiency in power amplifiers is expressed as the part of the dc power that is converted to RF power, and there are three definitions of efficiency that are commonly used. Collector efficiency is the ratio of the RF output power to the dc input power.

$$\eta = \frac{P_{OUT}}{P_{DC}} \tag{2.1}$$

Power-added efficiency (PAE) describes the power of the input signal into account and can be expressed by

$$PAE = \frac{P_{OUT}-P_{IN}}{P_{DC}} = \frac{P_{IN}\times(G-1)}{P_{DC}} \tag{2.2}$$

PAE is generally used for analyzing PA performance when the gain is high. Finally, the average power efficiency is a measure of the ratio of the total energy transmitted to the total energy drawn usable for all kinds of performance evaluations.