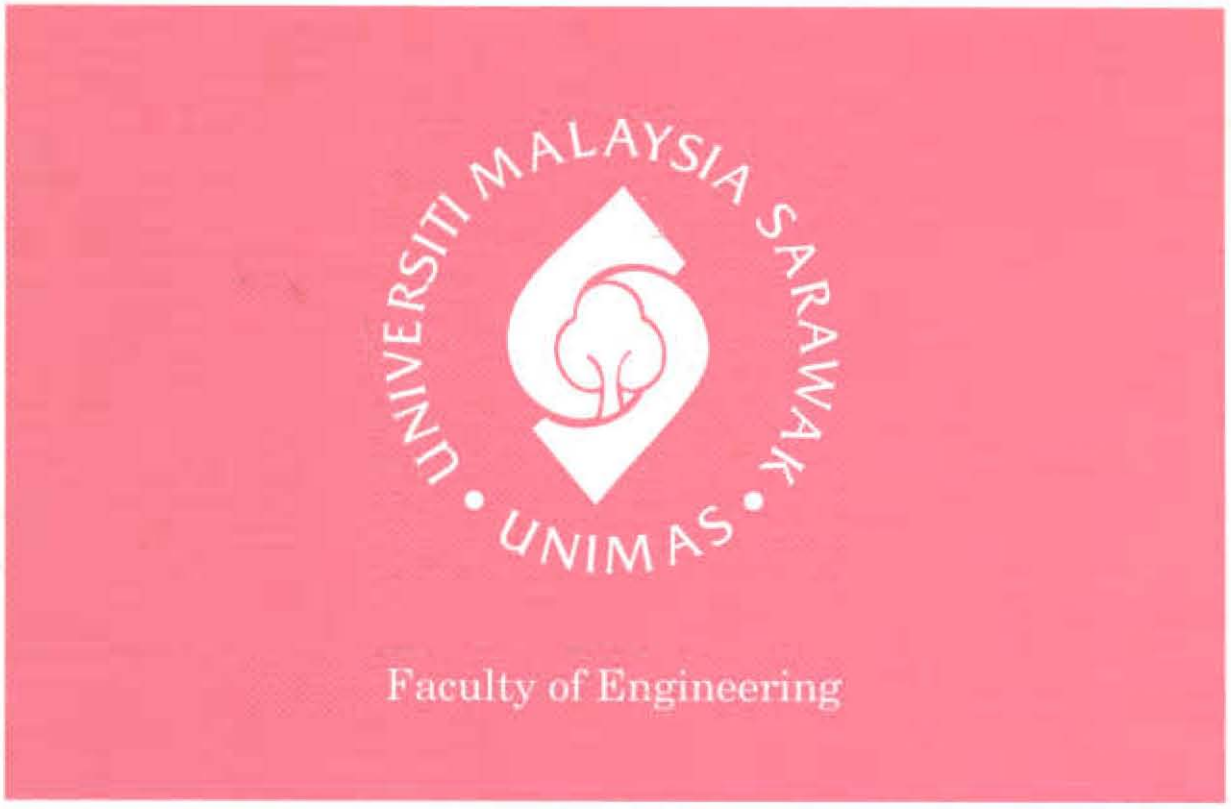


DESIGN OF CMOS POWER AMPLIER

Khoo Kian Hua

Bachelor of Engineering with Honours
(Electronics and Telecommunication Engineering)
2011

UNIVERSITI MALAYSIA SARAWAK

BORANG PENGESAHAN STATUS TESIS

Judul: **DESIGN OF CMOS POWER AMPLIFIER**

SESI PENGAJIAN: 2010/2011

Saya **KHOO KIAN HUA**

mengaku membenarkan tesis * ini disimpan di pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Sarawak.
2. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Membuat pendigitan untuk membangunkan Pangkalan Data Kandungan Tempatan.
4. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
5. ** Sila tandakan (✓) di kotak yang berkenaan

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

Disahkan oleh

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat tetap: 2, Jalan Melur 6,
Taman Melur,
31000 Batu Gajah,
Perak.

Tarikh 13/6/2011

En. Ng Liang Yew
Nama Penyelia

Tarikh 13 June 2011

CATATAN

* Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah, Sarjana dan Sarjana Muda.

** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.

APPROVAL SHEET

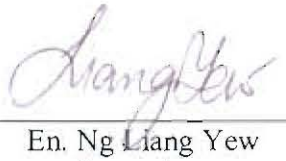
Final Year Project below:

Title : Design of CMOS Power Amplifier

Author : Khoo Kian Hua

Matric No. : 18716

Hereby read and approved by:



En. Ng Liang Yew
Supervisor

13 June 2011
Date

DESIGN OF CMOS POWER AMPLIFIER

KHOO KIAN HUA

This thesis is submitted to

Faculty of Engineering, Universiti Malaysia Sarawak

in partial fulfillment of the requirements

for the degree of Bachelor of Engineering with Honours

(Electronic and Telecommunication Engineering)

2010/2011

To my beloved parents, family members and friends.

ACKNOWLEDGEMENT

I would like to express my sincere thanks to every individual that has offered their help and guidance to me during the entirety of the project.

I am keen to show my utmost gratitude and appreciation to my supervisor, Mr Ng Liang Yew for his excellence patient, invaluable advice and continue support for this Final Year Project. Without his encouragement and guidance, I would not have completed this project.

I am also thankful to my colleagues in the Universiti Malaysia Sarawak for their support, advice and assistance.

Last but not least, my heartfelt thanks to my family members for their encouragement and support during the process of completing this project.

ABSTRAK

Penguat kuasa merupakan penghantar terima wayarles komponen yang penting dalam sistem komunikasi. Penguat kuasa menggunakan frekuensi radio untuk penghantaran data antara infrastruktur wayarless bergerak. Teknologi CMOS digunakan dalam penguat kuasa untuk mereka sistem integrasi pada chip. Ini disebabkan CMOS meningkatkan operasi kelajuan melalui pengkecilan saiz. Sebagai komponen yang mengguna kuasa yang tinggi di hahagian depan frekuensi radio, mereka penguat kuasa yang mempunyai prestasi yang tinggi merupakan salah satu cabaran dalam penghantar terima wayarles. Penguat kuasa prestasi boleh ditentukan dari segi kelinearan isyarat, kuasa keluaran dan gandaan kuasa. Penguat kuasa kelas AB telah dicadangkan untuk meningkatkan prestasi penguat kuasa. Alat simulasi yang digunakan dalam projek ini ialah LTspice IV. Penguat kuasa beroperasi dalam frekuensi 3 GHz dengan kuasa masukan 8 dBm dan voltan bekalan 3 volt. Projek ini adalah untuk mereka cipta sebuah penguat kuasa RF CMOS bagi komunikasi bergerak.

ABSTRACT

Power amplifier (PA) is an important component of wireless transceiver in communications system. PA uses radio frequency for transmission between mobile wireless infrastructures. Complementary Metal Oxide Semiconductor (CMOS) technology is being used for design of system integration on chip in PA. This is due to its improved operation speed through downsizing. Being the most power hungry component of radio frequency (RF) front end, designing a high performance power amplifier is one of the most challenging parts in the wireless transceiver. The performance of power amplifier can be determined in terms of signal linearity, output power, and power gain. A proposed PA is a single-ended class AB cascode CMOS power amplifier. The simulation tool used in this project is LTspice IV. The power amplifier is operated at 3 GHz with an input power of 8 dBm and a supply voltage of 3 volt. This project is to design a RF CMOS power amplifier for mobile communications.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

1G	-	First Generation
2G	-	Second Generation
3G	-	Third Generation
4G	-	Fourth Generation
AC	-	Alternating Current
ADS	-	Advanced Design System
AMPS	-	Advanced Mobile Phone Service
ASIC	-	Application Specific Integrated Circuit
CDMA	-	Code Division Multiple Access
CDMA2000	-	Code Division Multiple Access 2000 Evolution Data
1xEV DO		Optimized
CMOS	-	Complementary Metal Oxide Semiconductor
DAMPS	-	Digital Advanced Mobile Phone System
DAT	-	Distributed Active Transformer
DC	-	Direct Current
EDA	-	Electronic Design Automation
EDGE	-	Enhanced Data Rates for Global Evolution
FDMA	-	Frequency Division Multiple Access
GPRS	-	General Packet Radio Services
GPS	-	Global Positioning System
GSM	-	Global System for Mobile

HSCSD	-	High Speed Circuit Switched Data
HSDPA	-	High Speed Downlink Packet Access
HSUPA	-	High Speed Uplink Packet Access
IC	-	Integrated Circuit
iDEN	-	Integrated Digital Enhanced Network
IEEE	-	Institute of Electrical and Electronics Engineers
IMT-2000	-	International Mobile Telecommunications-2000
IMTS	-	Improved Mobile Telephone Service
ITU	-	International Telecommunication Union
LTE Advanced	-	Long Term Evolution Advanced
MIM	-	Metal-Insulator-Metal
MOSFET	-	Metal Oxide Semiconductor Field Effect Transistor
NMT	-	Nordic Mobile Telephone
PA	-	Power Amplifier
PAE	-	Power Added Efficiency
PDC	-	Personal Digital Cellular
RF	-	Radio Frequency
SOC	-	System On Chip
SONNET	-	3d Planar High-Frequency Electromagnetic Software
TACS	-	Total Access Communication System
UMTS	-	Universal Mobile Telecommunications System
WCDMA	-	Wideband Code Division Multiple Access
WiMAX	-	Worldwide Interoperability for Microwave Access
WLAN	-	Wireless Local Area Network

CHAPTER 1

INTRODUCTION

1.1 CMOS Technology

Complementary Metal Oxide Semiconductor (CMOS) is formed by using a pairs of p-type and n-type Metal Oxide Semiconductor Field Effect Transistor (MOSFET) transistors for logic function and only one of the transistors is switched on at anytime [1]. The most common CMOS logic function is inverter as shown in Figure 1.1. The phrase "metal-oxide-semiconductor" is referred to the fabrication process where metal oxide is used to build CMOS chips as shown in Figure 1.2 [2]. Nowadays, the gate electrodes are mostly made from polysilicon instead of metal. However, the name CMOS nevertheless continues to be used in the future.

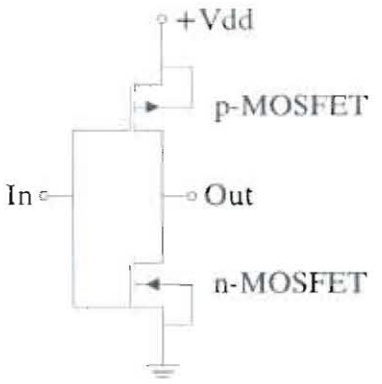


Figure 1.1 Basic CMOS inverter

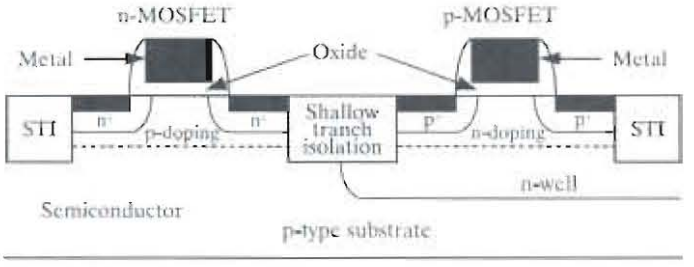


Figure 1.2 Cross section of CMOS inverter

CMOS has been a dominant technology over the years due to high speed performance and low power operation [3]. The decrease in all physical technology has indicated that the integration density and the circuit speed are significantly increased from generation to generation. This concept is known as concept of scaling. During the past, micrometre technology is used in manufacturing process. Year by year, nanometre technology has been slowly implemented into integrated circuit (IC) as shown in Table 1. In addition, CMOS is chose as the substitution of other technology due to the low power dissipation in CMOS circuit. Consequently, the low power dissipation provides low power delay and this allows very high integration densities [4]. Furthermore, high noise margin makes CMOS circuit resistant to variation of supply voltage, temperature and process. This is advantage for handling high complexity of future IC and fast realization of Application Specific Integrated Circuit (ASIC).

As a result, CMOS technology is implemented in many applications such as Third Generation (3G) mobile communication, Global Positioning System (GPS), Wireless Local Area Network (WLAN) and Bluetooth. In mobile communication system, CMOS is made as the technology of choice for its low voltage and low power operation of IC.

Table 1.1 CMOS manufacturing process [5]

Year	1999	2000	2002	2006	2008	2010	2011	2013	2015
Production technology	180nm	130nm	90nm	65nm	45nm	32nm	22nm	16nm	11nm

1.2 Communication System

Communication is a process that involves a sender who encodes and sends the message to the receiver where the receiver decodes the message and reply to the sender through a communication channel. A communication system is a system that consists of three basic components which are transmitter, communication channel, and receiver. In general, a communication system can be represented by the functional block diagram as shown in Figure 1.3.

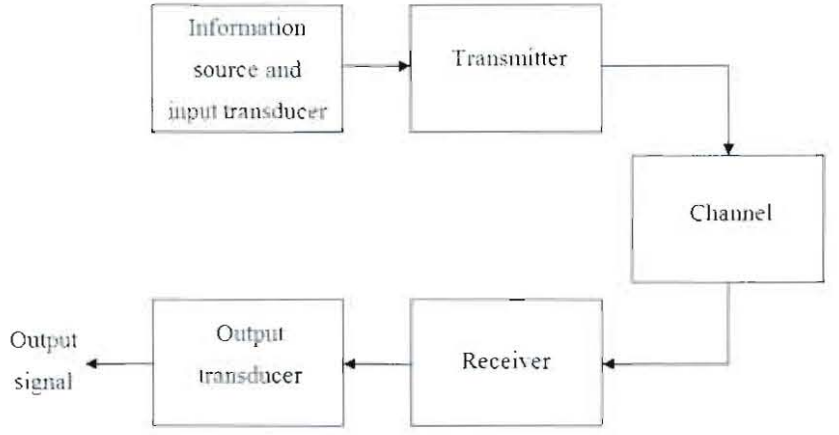


Figure 1.3 Functional block diagram of a communication system [6]

Communication system has been developed into a few types such as optical communication system, microwave communication system, satellite communication system and mobile communication system. Due to high speed requirement of multimedia access, mobile communication system continuously developed in recent years.

1.2.1 Mobile Communication System

The first mobile system was developed in the 1940s. However, these cell phones were constrained by limited mobility and poor limited service. In the 1960s, another new system called Improved Mobile Telephone Service (IMTS) has replaced the old system due to improvement on direct dialling and higher bandwidth [7]. Then, the first analogue mobile system is developed based on the IMTS in the late 1960s which is known as first generation (1G). At the end of 1980s, the second generation (2G) were introduced [8]. This continues to third generation (3G) which was launched in Japan in 2000. The fourth generation (4G) is currently under development. The technology is expected to launch by the year 2011 [8].

- **First Generation (1G)**

  Cell signals were based on analogue system transmission which is certainly voice. The technique used for transmission was based on Frequency Division Multiple Access (FDMA). The quality of 1G is low and it had low data rates. The most common standard is Nordic Mobile Telephone (NMT), Total

Access Communication System (TACS), and Advanced Mobile Phone Service (AMPS) [8].

- **Second Generation (2G)**

Unlike the 1G mobile communication system, the 2G mobile communication systems use digital radio transmission. Therefore, the new system allows transfer of both voice and digital data. The new system has better quality and higher capacity at lower cost to consumers. The four main standards for 2G systems are Global System for Mobile (GSM), Digital Advanced Mobile Phone System (DAMPS), Code Division Multiple Access (CDMA) and Personal Digital Cellular (PDC) [9].

- **Second Generation Transitional (2.5G, 2.75G)**

The 2G transitional systems are the advanced upgrade for the 2G system. The three common technologies of this system are High Speed Circuit Switched Data (HSCSD), General Packet Radio Services (GPRS) and Enhanced Data Rates for Global Evolution (EDGE) [9].

- **Third Generation (3G)**

International Mobile Telecommunications-2000 (IMT-2000) is also known as 3G mobile communication system which was born at International Telecommunication Union (ITU) [10]. The 3G mobile communication system provides faster communication services than 2G system. It allows

simultaneous transfer of voice and high speed digital data. The main standards of 3G mobile communication systems are Universal Mobile Telecommunications System (UMTS), Code Division Multiple Access 2000 Evolution Data Optimized (CDMA2000 1xEV DO), and Wideband Code Division Multiple Access (WCDMA) [9].

- **Third Generation Transitional (3.5G, 3.75G, 3.9G)**

The 3G transitional systems are the continuation and upgrade of 3G technology. It offers higher data rates and larger bandwidth than 3G technology. The two standards of 3G transitional systems are High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA) [10].

- **Fourth Generation (4G)**

The concept of International Mobile Telecommunications- Advanced (IMT-Advanced) from the ITU has lead to the development of 4G mobile communication system. The 4G system offers higher data transmission rates with high mobility than 3G systems. The two technologies of 4G system are Long Term Evolution Advanced (LTE Advanced) and IEEE 802.16m [9].

Table 1.2 Mobile Telephony Technologies and Standards[9]

Generation	Standard	Frequency band	Throughput
1G	NMT, C-Nets, AMPS, TACS	Allow voice calls and sending text messages	600-1200 bps
2G	GSM, CDMA, DAMPS, PDC, iDEN	Allows transfer of voice or low-volume digital data.	9.6 kbps
2G transitional (2.5G, 2.75G)	GPRS, EDGE, HSCSD, CDMA2000 1xRTT	Allows simultaneous transfer of voice and moderate digital data.	56 or 180 kbps
3G	UMTS, WCDMA-FDD, CDMA2000 1xEV DO	Allows simultaneous transfer of voice and high-speed digital data.	384 kbps, 1.8 or 3.6 Mbps
3G transitional (3.5G, 3.75G, 3.9G)	HSDPA, HSUPA	Allows simultaneous transfer of voice and very high-speed digital data.	7.2 Mbps-10 Mbps
4G	LTE advanced, WiMAX	Allows simultaneous transfer of voice and ultra high-speed digital data.	Up to 100Mbps