WIRELESS COMMUNICATION DESIGN

(RF CMOS Low Noise Amplifier)

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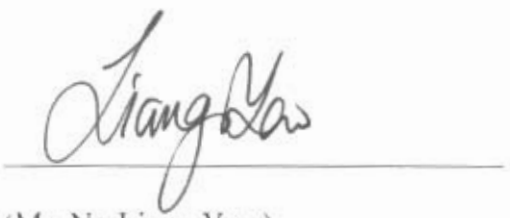

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WIRELESS COMMUNICATION DESIGN

(RF CMOS LOW NOISE AMPLIFIER)

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Thesis Submitted to the Faculty of Engineering,
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As a partial fulfilment of the Degree of
Bachelor of Engineering with Honours
(Electronics and Telecommunication Engineering)
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Special Dedicated To My Beloved Family

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ABSTRACT

In today's world, most of the wireless communication systems are based on high frequency. Usually, these systems have to duel with noisy circuits and able to detect small signal. Among multi-stages of wireless communication system, LNA are normally used in the front end of the system to amplify the incoming signal. In the mean while, LNA also used to overcome the noise form subsequent stage. It is desirable to implement RF receiver together with base band digital circuits to lower the total system cost.

Today, most of the wireless communication circuitry is built with the combination of analog, digital and RF circuit in the small form of single chip. To increase the performance, Complementary metal-oxide-semiconductor (CMOS) technology is used due to it is a low cost technology and several others advantages.

In this thesis, a low noise amplifier (LNA) has been implemented and designed using CMOS process. A cascade three stage LNA with a wide-band RF performance is presented. The objective is to meet the common goals of LNA.

ABSTRAK

Pada zaman kini. kebanyakan sistem komunikasi tanpa dawai adalah berasaskan frekuensi yang tinggi. Biasanya, sistem-sistem ini terpaksa berdepan dengan litar yang mempunyai jindar yang agak tinggi, sementara itu, ia mempunyai keupayaan untuk menerima isyarat yang kecil. Di antara pelbagai bahagian dalam sistem komunikasi tanpa dawai, pembesar jindar rendah (low noise amplifier, LNA) adalah biasa digunakan di bahagian depan system untuk membesarkan isyarat yang diterima. Pada masa yang sama, LNA juga digunakan untuk mengatasi jindar dari pelbagai bahagian dalam sistem. Ia adalah keinginan untuk menggabungkan penerima frekuensi radio and litar digital bersama untuk menurunkan perbelanjaan sistem keseluruhannya.

Kini, kebanyakan litar komunikasi tanpa dawai adalah dibina dengan pergabungan di antara litar analog, litar digital and litar frekuensi radio dalam satu cip yang kecil. Untuk meningkatkan kebolehan litar, teknologi CMOS digunakkan sebab ia adalah teknologi yang murah and beberapa kebaikan yang lain.

Dalam tesis ini, LNA telah dilaksana and direka dengan menggunakan teknologi CMOS. Gabungan tiga bahagian LNA yang mempunyai kebolehan band lebar frekuensi lebar telah dibinakan. Objectifnya adalah memcapai pencapaian yang umum.

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CHAPTER 1

INTRODUCTION

1.1 Introduction to Communication

Figure 1.1 Simplified block diagram of communication system

The term communication is referring to the process of sending and receiving the information through a medium between two points. Which means one end is sending information through a medium, which is capable to transmit information from one end to another end, then the information can reach, and receive by the other end. The information can be analog signal or digital data.

Ideally, the information data that being sent and being received have to be the same, without any error, noise or interference. But in the real world, noise and

interference will happened. To maintain the quality of the information at the receiving end, systems and components are designed to reduce the noise and interference that occurred.

Communication system is the system that transmits information through a medium to the destination. The medium can be wire or wireless such as coaxial cable, fiber optic cable, free space or microwave. Communication system can divide into wire communication system and wireless communication system.

In today's world, the main uses of communications are in:

a. Exploration

   People design communication system to do some exploration job. Example: like exploration at outer space. People built satellite and space ship to get information from outer space.

b. Industry

   The industries need communication system like GPS to locate certain area correctly.

c. Medicine

   In the medical field, doctors can interchange their knowledge through communication system.

d. Military and police

   The military need communication system to communicate with head quarter and locate enemies' bases correctly. The police departments also need communication system to identify criminals from different states and different countries.

e. Entertainment and news

Everyday people use the Internet to look for entertainment and news that happened all around the world.

f. Home automation:

Remote metering/control:

- Electricity
- Gas
- Water

Alarm/security:

- Fire
- Intruder
- Social alarm

Power control:

- Power outlets
- Light switches
- Heating/ air-conditioning

Comfort functions:

- Window control
- Garage door openers
- Building keyless entry

White goods:

- Refrigerator
- Microwave-oven
- Washing machine

1.2 Introduction to Wireless Communication System

Figure 1.2 Simplified block diagram of wireless communication system

Wireless is a term used to describe telecommunications in which electromagnetic waves carry the signal over part or the entire communication path. Wireless communication system is the system that transmits information through free space to certain destination.

Common examples of wireless equipment in use today are shown below:

Wireless Equipments	Functionality
Cellular phones and pagers	• Provide connectivity for portable and mobile applications, both personal and business
Global Positioning System (GPS)	• Allows drivers of cars and trucks, captains of boats and ships, and pilots of aircraft to ascertain their location anywhere on earth
Cordless computer peripherals	• Cordless mouse, keyboards and printers are wirelessly linked to a computer via wireless

Cordless telephone sets	• These are limited-range devices, not to be confused with cell phones
Home-entertainment-system control boxes	• The VCR control and the TV channel control are the most common examples; some hi-fi sound systems and FM broadcast receivers also use this technology
Remote garage-door openers	• One of the oldest wireless devices in common use by consumers; usually operates at radio frequencies
Two-way radios	• This includes Amateur and Citizens Radio Service, as well as business, marine, and military communications
Baby monitors	• These devices are simplified radio transmitter/receiver units with limited range
Satellite television	• Allows viewers in almost any location to select from hundreds of channels
Wireless LANs or local area networks	• Provide flexibility and reliability for business computer users

Table 1.1 Functionality of several wireless equipments

1.3 Thesis Background

Wireless communication services industry is growing rapidly for the past few years. Mobile cellular and home cordless telephones become part of our daily lives. Wireless short distance communication and Wireless LAN also become popular as well. Most of the wireless communication systems are operated at high frequency bands, in GHz. Usually, these systems are using circuits which are quite noisy, and to be able to detect small signal. The circuit consists several ICs and components, which is power hungry. But the demands of the wireless communication industry required low power, low cost and small form factor or small size single chip devices.

LNA are normally used in the front end of the wireless communication system. It is important part in the transceiver of the wireless communication system. LNA is used to amplify the incoming signal enough to overcome the noise form subsequent stage, especially when the received signal was travel million of miles before reach the destination. It is desirable to implement RF receiver together with base band digital circuits to lower the total system cost.

Standard	Frequency (GHz)
GSM	0.9/1.8/1.9
PDC	0.8/1.4
IMT-2000	1.9/2.1
Bluetooth	2.4
IEEE 802.11b	2.4
IEEE 802.11a	5.2
HiperLAN	5.15-5.35 5.47-5.725

Table 1.2 Some Communication Standards [1]

1.3.1 Revolution of Cellular Network

First Generation (1G) is analogue network. 1G networks is said to be analog network because the speech signal are not digitized. However, the control and supervision of the 1G network are digital. Analogue systems include AMPS, TACS and NMT. 1G network still in use today, but they are being phased out by the 2G system.

Second Generation (2G) is digital system. 2G networks are fully digitized, although they remain basically telephone network. 2G started at the year 1996, and used to support low-speed data. 2G digital systems include GSM, CDMA, TDMA, PDC and PHS.

2.5 Generation (2.5G) is consists of a mix of analogue and digital systems. 2.5G is said as a bridge to 3G systems.

Third Generation (3G) is a term coined by the global cellular community to indicate the next generation of mobile service capabilities, like higher capacity and enhanced network functionalities, which allow advanced services and applications including multimedia. 3G systems include IMT-2000, Bluetooth, HiperLAN and some other bands indicated in IEEE 802.11a and 802.11b standards.

Fourth Generation (4G) is expected to be launch in the year 2010. 4G is a development of core basic technology. [2]

1.3.2 Popularity of Mobiles Cellular

In the past few years, mobiles cellular become more and more popular. Now, not only businessmen carry mobile cellular phone, even though primary school students carry one of their own. Why mobiles cellular become more popular in this past few year? The reasons are:

- The price of handset, services and network become cheaper because of growing market sizes and much more competition.
- The weight of handset become lighter, only few hundred grams and easy to carry to everywhere.
- The coverage is widespread
- The mobile network is easy to access with pre-paid cards
- Much more features and services
- As a fashion accessories which become more attractive in small screen, brightly coloured casing, and several ring tone

1.3.3 The Challenges of Cellular Design

The continuous increasing demand for affordable mobile communication has introduced numerous challenges in design of cellular and cordless telephones. Mobiles communication system must compete on the basis of

- Low cost
- Low power consumption
- Small size

- Lighter weight
- More features

All these requirements are met through innovations of networking and communications, transceiver architectures, circuit design and device technology. Among all these innovations, we will focus on the development of a single-chip transceiver capable of adapting to the various communication standards in a low cost CMOS technology. In a single-chip transceiver, there are several building blocks each play important job and correlated to each other. The first stage designation in the receiving path is LNA.

A typical design may take months for a designer with years of experience. But rapid evolution of wireless standards and fierce market competition demand minimal design effort and time to market with no compromise of product quality. Traditional labor-intensive manual design methodologies cannot meet the challenge. Design methodology and superior computer-aided design tools are need to reduce design cycle time and increase productivity.

1.4 Project Overview

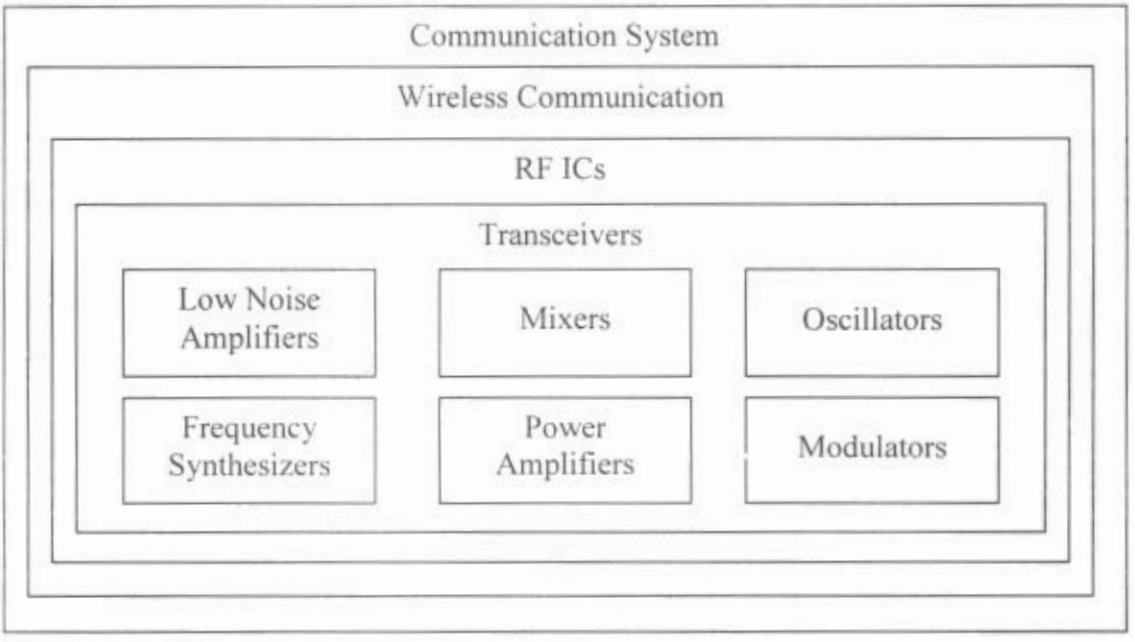

Figure 1.3 Project Overview

1.5 The Objective of the Project

The objectives of the project are:

1. Developing new design
2. Better understanding of
    - Low noise/voltage amplifier towards WLAN
    - RF circuit design and achievable performance
    - Characterization & modeling of RF performance of standard VLSI technologies.
    - Develop simulator software, canon's tool is used to simulate and verify the design.

CHAPTER 2

Literature Review

2.1 Communication

The process of communications can be simple as sending, receiving and processing of information by electronic devices and components.

The history of the communications system started with wire telegraphy in the 18^{th} century. Then it follows by development of telephony some decades later and radio communication systems at the beginning of 20^{th} century. Radio communication, made possible by the invention of the triode tube, was greatly improved by the work done during World War II. It subsequently became even more widely used and refined through the invention and use of the transistor, integrated circuits and other semiconductor devices. More recently, the use of satellites and fiber optics has made communications even more widespread, with an increasing emphasis on computer and other data communications.