CHAPTER 1

INTRODUCTION

1.1 Historical Background

Recent advances in Very Large Scale Integration (VLSI) technologies have made possible the realization of complete systems on a single chip. Since complete systems often include analog devices as well as digital devices, there has been a reemergence of interest in Metal-Oxide Semiconductor (MOS) analog circuits. Examples of these types of integrated circuits include: Digital-to-Analog Converters, Analog-to-Digital Converters, Voltage-Controlled Oscillators, Analog Input/Output Pads, and amplifiers. All these devices can be based on a simple element in MOS design, the MOSFET transistor.

Complementary Metal-Oxide-Semiconductor (CMOS) technology is circuit implementation using both pMOS and nMOS transistors on the same silicon chip. CMOS designs typically offer high gain and speed at low power consumption. In addition, CMOS scales well to smaller devices without drastic changes in performance.

One of the most common analog circuit elements is the operational amplifier. Operational amplifier are amplifiers (controlled sources) that have sufficiently high forward gain so that when negative feedback is applied, the closed-loop transfer function is practically independent of the gain of op amp. This principle has been exploited to develop many useful analog circuits and systems. It will compare two inputs (**V+** an **V-**) and amplify their difference. This device is commonly used to amplify small signals, to add or

subtract voltages, and in active filtering. It must have high gain, low current, high input output impedance and should function over a variety of frequencies.

The primary requirement of an op amp is to have an open loop gain that is sufficiently large to implement the negative feedback concept. Most of the amplifiers do not have a large enough gain. Consequently, CMOS op amps use two or more stages of gain. One of the most popular op amp is a two stage op amp. The first is because it is simple yet robust implementation of an op amp and second it can be used as the starting point for the development of other types of op amp.

Compensation concept is very important in two stage op amp. The goal of compensation is to maintain stability when negative feedback is applied around the op amp. An understanding of compensation, along with previous concepts, provides the necessary design relationships to formulate a design approach for the two stage op amp.

In designing a CMOS op amp, the designer starts with building blocks whose performance can be analyzed to a first-order approximation by hand or calculator methods of analysis. The advantage of this step is the insight it provides to the designer as the design of the circuit develops. However, at some point the designer must turn to a better means of simulation. For the CMOS op amp this is generally a computer analysis program such as Mentor Graphics. The design can be optimized and many other questions such as tolerances, stability, and noise can be examined.

1.2 Project overview

The flow chart as shown in figure 1.1 details the overview of the project. It is consists of four stages. At first stage, the design of the CMOS operational amplifier is studied based on theories of advanced analog circuit design. Then the calculation of transistors width over length ration and its bias currents is calculated.

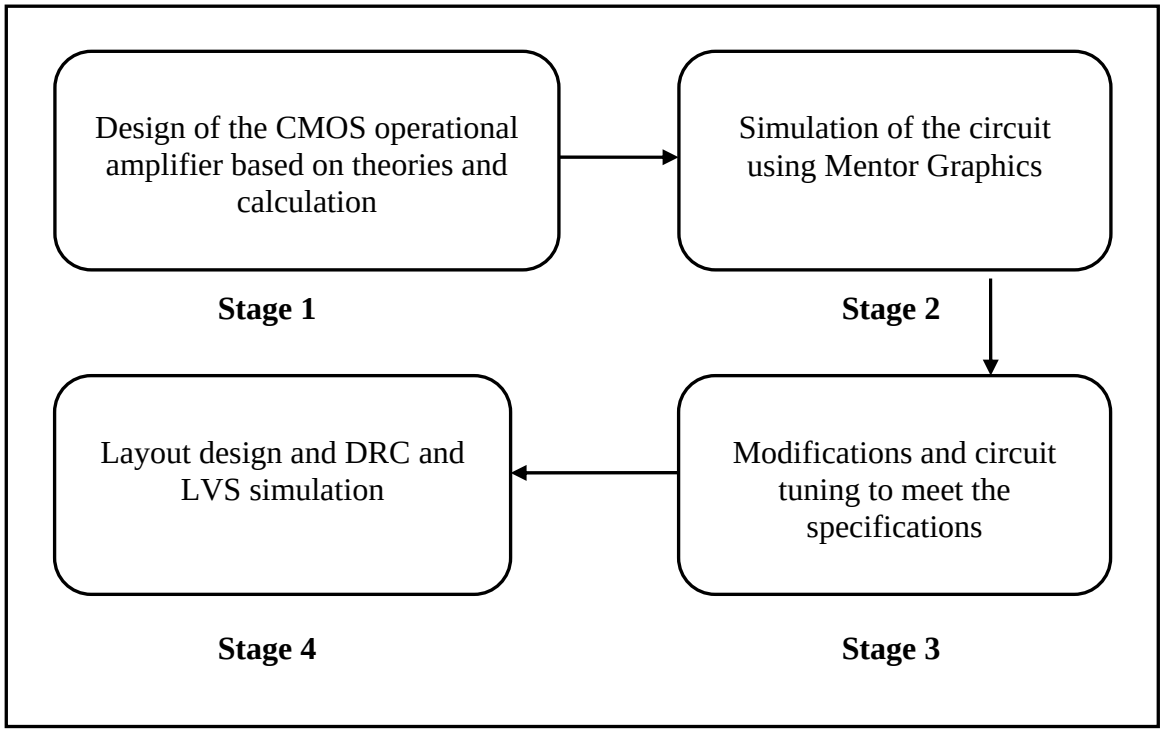

Figure 1.1: The project overview

In the next stage, the two stage CMOS operational amplifier circuit is developed and simulated. The simulation results compared with the calculated results in theories. Multiple simulations are performed in order to get accurate results. In the following stage, the circuit is modified and tuned to meet the operational amplifier specifications. Some redesign needed in this stage. At the final stage, the complete CMOS operational amplifier circuit's layout is drawn and simulated. Details explanation and design of the CMOS operational amplifier were discussed in chapter 3.

1.3 The Aim and Objectives

The aim of the project is to design and simulate two stage CMOS operational amplifier circuit employing Mentor Graphics tool. The basic operation of CMOS operational amplifier need to be understood clearly and two stage design topology need to be implemented and verified by simulation. The main objectives of the task undertaken were:

- To design the Complementary Metal Oxide Semiconductor operational amplifier.
- To determine the width over length ratio (W/L) and bias currents of the transistors.
- To simulate and investigate the design to verify the operation.
- To design the layout of the amplifier and perform DRC and LVS simulation.

1.4 Scope of study

This project is based on analog electronic devices and advanced integrated circuit design fundamentals. It involves 3 basic concepts, design, simulation and verification using Mentor Graphics software.

1.5 Project outline

This project is organized into five chapters as follows.

Chapter 2 discusses the literature survey on the theories of an ideal operational amplifier and its performance characteristics. This chapter also details the two stages operational amplifier design technique consist of differential gain stage and common source gain stage. The existing method to generate an operational amplifier with stable performance through compensation is also discussed.

Chapter 3 presents the methodology for the two stages CMOS operational amplifier design. The design objectives and the compensation network were determined from theories of advanced analog circuit design. The transistor sizes and its bias currents then calculated according to design objectives. Once a satisfactory architecture has been obtained, the circuit entered the simulation stage.

Chapter 4 discussed the simulation and experimental results of CMOS operational amplifier generated using test bench circuit. The discussion of transistor bias summary and its design performance is done and concluded.

Chapter 5 outlines the conclusion and future works. Conclusion for the overall project findings especially on the CMOS operational amplifier circuit is done and the suggestion for the future works is also stated.