

LAYOUT DESIGN AND SIMULATION OF COMPLEMENTARY METAL –
OXIDE – SEMICONDUCTOR (CMOS) OPERATION AMPLIFIER

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To my beloved parents, sisters, and friends, who have encouraged me throughout my journey of education. A warm thanks to all.

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ABSTRACT

Today's atmosphere and demands continue to drive operating voltages down, especially for widely used components such as the operational amplifier. Some of the motivations driving the market are integration, battery operated components, and biomedical instrumentation. The increased packaging densities in integrated circuits require reduction in feature size that, in turn, reduces breakdown voltages thereby limiting the power supply. In order to ascertain low voltage and smaller in size operational amplifier, CMOS operational amplifier is preferred. In this project, the design and simulation of low power, moderate gain, and fast settling time CMOS operational amplifier consisting of two stages is implemented. The design was implemented using SILVACO EDA tool. Gateway tool will be used to draw the schematic for this design, while Expert tool will be used for design the layout.

ABSTRAK

Dewasa ini permintaan dan keperluan bagi komponen-komponen elektronik yang beroperasi dalam voltan rendah semakin meningkat terutamanya bagi komponen yang banyak digunakan seperti penguat operasi. Beberapa motivasi yang menggalakkan pasaran ialah integrasi, komponen yang menggunakan bateri dan peralatan bio-perubatan. Peringkat kepadatan bungkusan bagi litar bersepadu memerlukan komponen yang bersaiz tetapi dapat menghadkan sumber kuasa. Alternatif yang paling berkesan dalam memenuhi keperluan ini adalah dengan beralih kepada CMOS (*Complementary Metal-Oxide-Semiconductor*) yang menawarkan komponen dengan keperluan kuasa yang rendah dan kecil dari segi saiz. Dalam projek ini, rekabentuk dan simulasi penguat operasi CMOS yang mempunyai ciri-ciri kuasa yang rendah dan gandaan yang sederhana serta terdiri daripada dua peringkat telah diimplikasikan. Rekabentuk ini dilaksanakan menggunakan dalam perisian SILVACO EDA. Pekakasan yang digunakan bagi lakaran skematik adalah *Gateway*, manakala untuk melakar *layout* menggunakan perisian *Expert*.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	PROJECT TITLE	i
	DECLARATION	iii
	SUPERVISOR DECLARATION	iv
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRACT	vii
	ABSTRAK	viii
	TABLE OF CONTENTS	xi
	LIST OF FIGURES	xvi
	LIST OF TABLES	xvii
	LIST OF SYMBOLS AND ABBREVIATIONS	xviii
	LIST OF APPENDIX	xix
I	INTRODUCTION	
		1
	1.1 Historical Background	2
	1.2 Problem Statement	3
	1.3 Objectives	3
	1.4 Scope	4
	1.5 Project Outline	
II	LITERATURE REVIEW	

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
2.1	MOSFET (Metal-Oxide-Semiconductor Field Effect Transistor)	5
2.2	Modes of operation	7
2.2.1	Cut-Off or Sub-Threshold Mode	7
2.2.2	Triode or Linear Region	7
2.2.3	Saturation	8
2.2.4	CMOS (Complementary-Metal-Oxide Semiconductor)	9
2.3	CMOS Operational Amplifier	10
2.4	Ideal Op Amp	11
2.5	Modes and Parameters	12
2.5.1	Open - Loop Gain	12
2.5.2	Input Common Mode Range	13
2.5.3	Output Voltage Swing	13
2.5.4	Unity Gain Frequency	14
2.5.5	Slew Rate	15
2.6	Two-Stage Operational Amplifier Design	15
2.6.1	Current Mirror	17
2.6.2	Differential Amplifier	18
2.6.3	Two Stage Operational Amplifier Architecture Relationships	18
2.7	Compensation	20
2.8	Layout Design Rules	22
2.9	Transistor Layout	23

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	2.9.1 Relief the Stress	24
	2.9.2 Protect the Gate	25
	2.9.3 Improve Yield	27
	2.9.4 Bulk Connection	27
III	METHODOLOGY	
3.1	Methodology	28
3.2	Methodology Flowchart	30
3.3	Schematic Process Flow	32
3.4	Layout Process Flow	33
3.5	Design Schematic	35
3.6	Design Objective	36
3.7	Design	37
	3.7.1 DC Gain	37
	3.7.2 Common-Mode Input Range	38
	3.7.3 Output Swing	38
	3.7.4 Power Dissipation	39
	3.7.5 Unity Gain Frequency	39
3.8	Design Steps	39
3.9	Circuit Design	44

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
IV	RESULTS AND DISCUSSIONS	
4.1	The layout of CMOS operational amplifier	46
4.1.1	The Basic CMOS Operation Amplifier Layout	47
4.1.2	The Compact of CMOS Operation Amplifier Layout	54
4.2	Design Rules Check (DRC)	59
4.3	Layout versus Schematic (LVS)	60
4.4	Discussions	61
V	CONCLUSION AND SUGGESTION	
6.1	Conclusion	63
6.2	Suggestions	64
6.3	Commercialization Potential	64
	REFERENCE	65
	APPENDIX A	67

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	APPENDIX B	68
	APPENDIX C	70
	APPENDIX D	72
	APPENDIX E	74
	APPENDIX F	76

LIST OF FIGURES

NO.	TITLE	PAGE
2.1	MOSFET Structure	5
2.2	Comparison of Enhancement-Mode and Depletion-Mode MOSFET Symbol	6
2.3	Cross Section of MOSFET Operating in Linear Region	7
2.4	Cross Section of MOSFET in Saturation Region	8
2.5	CMOS Symbol for NMOS and PMOS	9
2.6	Block Diagram of a General Two-Stage CMOS Op-Amp	10
2.7	Symbol of an Op-Amp	11
2.8	Configuration for the Measurement of the Open Loop- Gain	13
2.9	The Configuration for Measurement of CMR	13
2.10	The Configuration for Measurement of Output Voltage Swing	14
2.11	Unity Gain Frequency	14
2.12	Slew Rate	15
2.13	Two Stage Operational Amplifier	16
2.14	Current Mirror	17
2.15	Differential Amplifier	18
2.16	Single-Loop Negative Feedback System	20
2.17	Compensation Capacitor	21
2.18	Folded to Compact Transistor	23
2.19	Bird-Peak	24

LIST OF FIGURES

NO.	TITLE	PAGE
2.20	Mechanical Stress from STI on Diffusion	24
2.21	Dummy Transistor	25
2.22	Measures to Protect the Gate	26
3.1	Project Flowchart	30
3.2	Process Flow of the Schematic Phase	32
3.3	Process Flow for Layout Process	33
3.4	The Schematic Design for the CMOS Operational Amplifier	35
3.5	The Complete Schematic Design for the CMOS Operational Amplifier.	44
4.1	Schematic Design of CMOS Operation Amplifier	47
4.2	Pdiff Cells for (a) M8 and (b) M5	48
4.3	Pdiff Cells for (a) M1 and (b) M2	49
4.4	Pdiff Cell for M7	50
4.5	Ndiff Cell for M6	51
4.6	Ndiff Cells for (a) M3 and(b) M4	52
4.7	Complete Basic Layout of CMOS Operational Amplifier	53
4.8	M6 Four Fingers Transistor	55
4.9	M3 and M4 Three Fingers Transistor	55
4.10	M5 and M8 Three Fingers Transistor	56
4.11	M1 and M2 with Four Fingers Transistor	57

LIST OF FIGURES

NO.	TITLE	PAGE
4.12	M7 Four Finger Transistor	57
4.13	Complete Compact Layout of CMOS Operational Amplifier	58
4.14	Simulation from DRC	59
4.15	Simulation from LVS	60

LIST OF TABLES

NO.	TITLE	PAGE
1.0	Design Rules	22
2.0	Transistor values summary	44

LIST OF SYMBOLS, ABBREVIATIONS OR NOMENCLATURE

K	-	Transconductance parameter (in saturation)
Γ	-	Bulk threshold parameter
V_T	-	Threshold voltage
λ	-	Channel length modulation parameter.
G_m	-	Transconductance
F_u	-	Unity gain frequency
VDSAT	-	Saturation voltage
VGS	-	Gate to source voltage.
GBW	-	Gain bandwidth
W	-	Width
L	-	Length
DRC	-	Design rule check.
LVS 1	-	Layout versus schematic.
S/D	-	Source/Drain

LIST OF APPENDICES

NO.	TITLE	PAGE
A	Schematic Netlist of CMOS Operation Amplifier	67
B	DRC Script For Folded and Multi-Finger Transistor	68
C	LPE Summary File for Multi-Finger Transistors	70
D	Hierarchical Spice File for Multi-Finger Transistors	72
E	LPE Summary File for Folded Transistor	74
F	Hierarchical Spice File for Folded Transistor	76

CHAPTER I

INTRODUCTION

This project uses software SILVATO EDA tools for design and simulate for layout. The background of the study is thoroughly elaborated. This chapter also outlined on the objective and scope of the research.

1.1 Historical Background

The Metal–Oxide–Semiconductor Field-Effect Transistor (MOSFET) is a voltage controlled device used to amplify electronic signals or acted as a switch. The MOSFET includes a channel of n-type or p-type semiconductor material and is accordingly called an NMOSFET or a PMOSFET (also commonly NMOS or PMOS). It is one of the most common transistors used in both analog and mixed-signal circuits for advanced integrated circuit (IC) design. MOSFET has the advantages which the switching time is about 10 times faster than a bipolar transistor, very much smaller switching current, and less affected by temperature when compared to bipolar 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.

The operational amplifier often referred to informally as an op amp, is a circuit that provides extremely high-gain amplification of the difference in voltage between two inputs. One input is known as the inverting input and the other is known as the non-inverting input. There is only a single output. The input impedance of the inverting and non-inverting inputs is extremely high. The output impedance of the op amp is very low.

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.

1.2 Problem Statement

There are two problems. First, while the voltage gain is high, it is not predictable. Second, in order for the circuit to function properly, the transistors used in differential amplifiers must be matched exactly. The first problem can be corrected by using negative feedback to control the gain. CMOS is use because they made from the same block of silicon and it easier to match.

1.3 Objectives

The objectives of this project can be summarized as below:

- (i) To understand the use of SILVACO EDA tool.
- (ii) To design layout of Complementary Metal Oxide Semiconductor operational amplifier.
- (iii) To validate the layout and schematic of the amplifier

1.4 Scope

This project is based on analog electronic devices and advanced integrated circuit design fundamentals. It involves 2 basic concepts, design and verification using SILVACO EDA tool software.

- (i) Gateway supports flat or hierarchical designs of any technology. Gateway readily accepts legacy designs from other schematic editors (PSPICE, OrCAD, Composer, etc) through EDIF 200 standard. Gateway can be used by large design teams through global preferences and handles multiple designs and technologies with specific workspaces [1].
- (ii) Expert is a high performance hierarchical IC layout editor with full editing features, large capacity and fast layout viewing. Expert provides high level of design assistance with Netlist Driven Layout and parameterized cells (Pcells) [1].

1.5 Project Outline

This project is organized into five chapters as follows:

Chapter 1 clarifies the background of the study for this project. This chapter also outlined on the objective and scope of the research.

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.

Chapter 3 presents the methodology for the two stages CMOS operational amplifier design. The transistor sizes then calculated according to schematic.

Chapter 4 present results and discussion of CMOS operational amplifier generated using SILVACO EDA tool. The discussion is about the finding and observation from layout design performance.

Chapter 5 outlines the conclusion and suggestion for this work. 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.

CHAPTER II

LITERATURE REVIEW

In this chapter, the basic theories of MOSFET transistors and the characteristics of an ideal operational amplifier will be reviewed. The important relationships of two stages CMOS operational amplifier is reviewed.

2.1 MOSFET (Metal – Oxide - Semiconductor Field Effect Transistor)

The metal – oxide - semiconductor field effect transistor (MOSFET, MOS-FET, or MOS FET), is by far the most common field effect transistor in both digital and analog circuits. Figure 2.1 shows the structure of MOSFET.

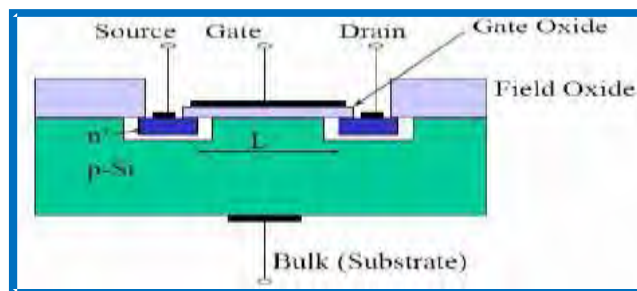


Figure 2.1: MOSFET Structure