LAYOUT DESIGN OF FOLDED CASCODE OPERATIONAL AMPLIFIER (OP-AMP)

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A thesis submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Engineering electronic (Computer)

Faculty of Electronic Engineering and Computer Engineering
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BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : LAYOUT DESIGN OF FOLDED FOLDED CASCADE OPERATIONAL AMPLIFIER (OP-AMP)

Sesi Pengajian : 2010/2011

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I declare that this thesis entitled "Layout Design Of Folded Cascade Operational Amplifier (Op-Amp)" is the result of my own research except as cited in thereferences. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Specially dedicated to

my beloved mother and father and my family

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ABSTRACT

Complementary metal–oxide–semiconductor (CMOS) is a technology for constructing integrated circuit. CMOS technology is used in microprocessors, microcontrollers, static RAM, and other digital logic circuits. CMOS technology is also used for several analog circuits such as image sensors, data converters, and highly integrated transceivers for many types of communication. Metal-oxide- semiconductor -field -effect -transistor is a device used for amplifying or switching electronic signals. In MOSFETs, a voltage on the oxide-insulated gate electrode can induce a conducting channel between the other two contacts called source and drain. The popularity of a folded cascade mostly comes from the flexible input common mode level and the availability of shorting the input and output together even though it consumes higher power and requires more complicated design. Regarding to project applications, the noise coming from the input signals will affect both signal paths. The noise that affects both input paths are identical and will be rejected by this differential characteristic. In this project,will SILVACO EDA tool will be used to design the layout and schematic of folded cascade operational amplifier (Op-Amp). Both of them must be equivalent in the validation step before proceed to fabrication process.

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ABSTRAK

Complementary metal–oxide–semiconductor (CMOS) adalah teknologi untuk membina litar bersepadu. Teknologi CMOS digunakan dalam mikropemproses, microcontroller, RAM statik dan litar logik digital. Teknologi CMOS digunakan untuk beberapa litar analog seperti sensor imej, penterjemahan data, dan integrasi *transceiver* tinggi untuk pelbagai jenis komunikasi. *Metal – Oxide –semiconductor-field- effect –transistor* merupakan peranti yang digunakan untuk menguatkan atau pensuisan isyarat elektronik. Di dalam MOSFET, voltan pada elektrod get berpenebat oksida boleh menyebabkan saluran terbentuk antara kedua-dua penyambung yang di kenali sebagai punca dan saliran. Sebahagian besar Popularitі "folded cascade" berasal dari tingkat mod masukan bersama yang fleksibel dan ketersediaan penyambungan masukan dan keluaran bersama-sama walaupun ia mengambil kuasa yang lebih tinggi dan memerlukan rekabentuk yang lebih rumit. Merujuk kepada aplikasi projek ini, hingar yang berpunca daripada isyarat masukan akan memberi kesan kepada kedua-dua laluan isyarat. Hingar yang memberi kesan kepada kedua-dua laluan masukan tersebut akan dikenalpasti dan dibuang oleh perincian perbezaan. Dalam projek ini perisian SILVACO EDA akan digunkan untuk merekabentuk *layout* dan skematik untuk *folded cascade operational amplifier*. Kedua-duanya perlu setara semasa langkah penyetaraan sebelum ia boleh difabrikasi.

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LIST OF ABBREVIATIONS

FC	-	Folded Cascode
MOSFET	-	metal –Oxide semiconductor field–effect transistor
NMOS	-	n channel MOSFET
PMOS	-	p channel MOSFET
EDA	-	electronic design automation
CMOS	-	Complementary metal –oxide-semiconductor
Op- Amp	-	operational amplifier
CMVR	-	common mode voltage range
CMR	-	common mode range
S EDA	-	SILVACO EDA

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CHAPTER I

INTRODUCTION

1.0 Background

This project more focus to design the schematic and layout of folded cascade operational amplifier (op - amp). Then simulation of the layout design was examined and compare with the simulation obtain in schematic level design. For this project used the metal – oxide semiconductor field – effect transistor (MOSFET) is used. The fundamental knowledge of MOSFET will be explain to give basic knowledge about MOSFET. MOSFET is a device used for amplifying or switching electronic signals. In MOSFETs, a voltage on the oxide-insulated gate electrode can induce a conducting channel between the two other contacts called source and drain. The channel can be of n-type or p-type and is accordingly called an nMOSFET or a pMOSFET (also commonly NMOS or PMOS) [1].

The op - amps can achieve higher speed and wider swing with special designs, like a folded-cascade op-amp and a current mirror op-amp. They usually called Operational transconductance Amplifier because of the importance of their transconductance value. Instead of using a Miller compensation capacitor as in two-stage op - amp design, OTAs use the load capacitor to achieve compensation. The basic idea of the folded-cascade op-amp is to apply cascade op - amp transistors to the input differential pair but using transistors opposite on type from these used in the input stage. The arrangement of opposite-type transistors allows the output of this

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single gain – stage amplifier to be taken at the same bias-voltage levels as the input signals [1].

The folded cascade op-amp can cascade an output stage to get extremely high gain with lower output resistance. The folded cascade op - amp is useful for moderately low supply voltages, at the cost of some extra current, but has limited performance in sub 1 V applications, as well as a limited Vcm (in). The gain of a folded cascade op amp is normally lower than that of a corresponding conventional cascade op amp due to the lower impedance of the devices in parallel. A folded cascade op amp has a pole at the folding connection which is lower compared to that node pole of the conventional cascade op - amp. This is due to the larger parasitic capacitance of extra and possibly wider devices in the folded structure. t the output voltage swing of a folded cascade op amp is only in significantly higher than that of a conventional cascade topology. The popularity of a folded cascade mostly comes from the flexible input common mode level and the availability of shorting the input and output together even though it consumes higher power and requires more complicated design. Regarding our project applications, the noise coming from the input signals will affect both signal paths. The noise that affects both input paths is identical, and will be rejected by this differential characteristic. In other words, the noise will have no effects on the differential signals since both sides of the signals see the same noise. The design, simulation, and testing were performed on the Computer Aided Design Software, SILVACO EDA tools [2].

1.2 Problem Statement

Many method or software that will be used to integrated circuit design. The software that can be use in this project is Cadence Virtuoso, SILVACO EDA tool and so on. In other word, when design the integrated circuit (IC), actually it will be a problem to the signal. The problem that will occur in the signal is a noise. When signal have a noise or distortion, the result of the signal is in not goods condition. Therefore, it needs some solution to avoid or reduce the noise.

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1.3 Objective

Upon completion of this thesis, using the silvaco eda tool software, we should able to:-

(i) To understand the use of SILVACO EDA tools.
(ii) To be familiar with Silvaco Gateway,Expert, and Smart Spice Layout Processor
(iii) To analyze CMOS transistor characteristics
(iv) To design the schematic and layout of folded cascade operational amplifier.
(v) To validate the layout with schematic of folded cascade operational amplifier.

1.4 Scope

In this project,will used the SILVACO EDA tool software. The electronic design automation (EDA) is a category of software tools for designing electronic systems such as printed circuit boards and integrated circuits. The tools work together in a design flow that chip designers use to design and analyze entire semiconductor chips. The SILVACO EDA tool divides three paths, Smart Spice, expert and gateway.

1.5 Project Outline

1.5.1 Chapter I

For this thesis in chapter I we discuss about introduction of project. We include of background project, problem stamen of project, objective from this project and scope of project.

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1.5.2 Chapter II

Conduct the literature review studies about fabrication and characteristic of MOSFET and overview CMOS in final year project seminar 1. Continue the literature studies at final year project II, about characteristic of Operational Amplifier (op - amp) and basic of folded cascade characteristic and operation.

1.5.3 Chapter III

Discuss the methodology of project. Draw the flow chart to make work a more systematic. And this chapter also explains how to use a gateway and expert in SILVACO EDA tools to draw schematic and build the layout folded cascade op - amp.

1.5.4 Chapter IV

For this chapter, entry the result of layout and schematic and discuss about the result.

1.5.5 Chapter V

Write the conclusion of project and make a recommendation of project in future work.

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CHAPTER II

LITERATURE REVIEW

2.0 Transistors

The most popular technology for realizing microcircuits makes use of Metal Oxide Semiconductor Field Effect Transistor (MOSFET). CMOS circuits use two complementary types of transistors, n-channel and p-channel. N-channel devices conduct with a positive gate voltage while p-channel devices conduct with a negative gate voltage. More over, electrons are used to conduct current in n-channel transistors, while holes are used in p-channel transistors. The symbols of PMOS and NMOS in SILVACO EDA are represented as below.

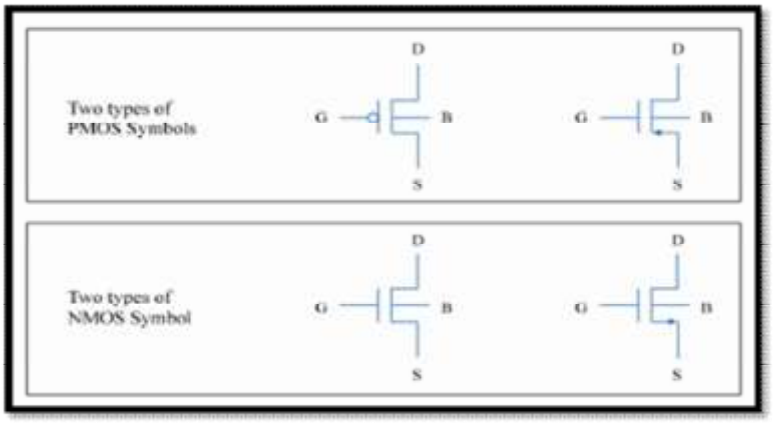

Figure 2.1: The symbols of PMOS and NMOS [3]

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The bulks of the PMOS and the NMOS are usually connected to power and ground respectively. If the bulk terminal is omitted from the schematic symbol, the connections can be assumed to be what is shown in the following diagram [3].

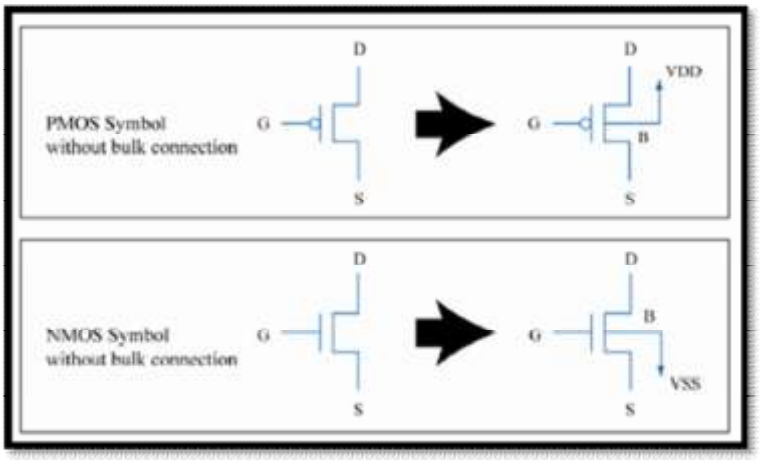

Figure 2.2: Bulk of PMOS and NMOS [3]

2.2 Types Terminal of Mosfet

2.2.1 4 - Terminal of MOSFET

MOSFET are 4 - terminal devices with a gate that controls the conduction of the drain to source channel. The body (or substrate) of the typical n-channel enhancement mosfet is a p-type material with the drain and source formed from N-type materials. The oxide layer insulates the metal gate connection from the other layers. There are holes in the oxide layer left for the metallic contacts of the drain and source [4].

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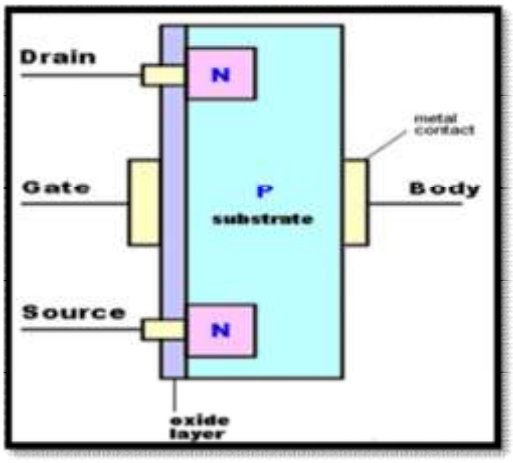

Figure 2.3:The Basic Of MOSFET Schematic [4]

A 4 – terminal N - P junctions act as diodes, and because the layers of the mosfet have p-type and n-type materials in close contact, diodes are formed from the body to the drain or source, as shown in the drawing here of the 4 - terminal mosfet. If you were to leave the body connection floating, there could be no voltage flow through the two PN body diodes because they are reverse connected to each other.

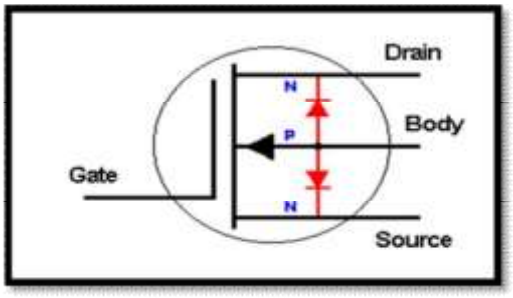

Figure 2.4: The 4 Terminal N - P Junctions [4]

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2.2.2 3 - Terminal of MOSFET.

However, in the 3 - terminal mosfets that are commonly used in guitar effects pedals, the body and source are connected internally and this shorts out the PN junction of the lower diode and removes it from the circuit. The top body diode can now conduct from drain to source because of the internal connection and therefore has to be taken into consideration during circuit design. This means that every 3 - terminal mosfet has a body diode due the construction of the device. It is not added as a separate component inside the mosfet.

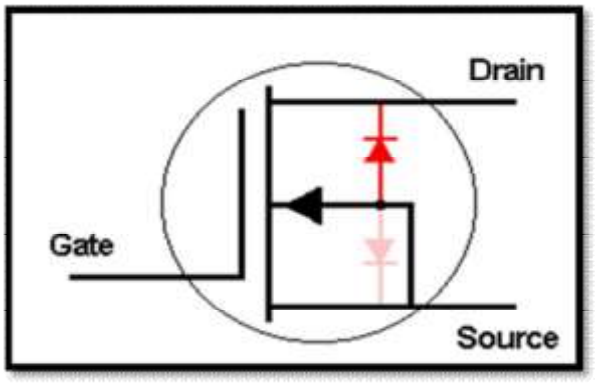

Figure 2.5: The 3-Terminal MOSFET [4]

2.2.3 The Operation of Mosfet

The operation of MOSFET can be devide two operation of MOSFET N channel and MOSFET P channel. Both are describing as a below:

(i) Basic MOSFET N Channel Operation.

- The gate electrode is placed on top of a very thin insulating layer.
- There are a pair of small n-type regions just under the drain & source electron

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