

Abu Dhabi University

EEN 360 - Electronic Devices and Circuits II

Lab Report 2 Differential Amplifier

Author: Muhammad Obaidullah 1030313 Bilal Arshad 1011929

Supervisor: Dr. Riad Kanan

Section 1

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Abstract

The purpose of this lab is to understand the operation of the MOSFET Differential Amplifier and to understand how to construct and simulate electronic components using MULTISIM from National Instruments.

1 Introduction

The MOSFET is used world wide very extensively for both digital and analogue signal processing and circuits. It is the key pillar of modern electronics. Among the many useful uses, one of the main usage of a MOSFET transistor is the development and manufacturing of MOSFET Differential Amplifier. MOSFET transistor are mainly used instead of other BJT transistors because the input resistance is literally close to infinity the reason behind it being that the gate pin is not connected by a conductor to the other pins of the transistor. The duty of the operational amplifier is to take the error of the two inputs (difference) and amplify the resulting signal.[1]

In this lab we will be first making a new component which is a NMOS Transistor and then a PMOS Transistor which has basic properties like a normal MOSFET.

In the general topology of a differential amplifier, two active devices are connected to a positive voltage supply through a passive series elements such as a resistor or current mirror circuit. The lower terminals of the active device are joined together and are connected to a current source for forcing the bias on the transistors to work in active mode.[2]



Figure 1: This is the basic topology for differential amplifier [2]

The current mirror is usually used in combination with the differential amplifier to affect the bias so that the transistors operate in active mode. The referencing current is produced outside the chip usually and then this current is mirrored all over the chip for biasing circuit purposes. The basic current biasing can be understood by the just imagining that if a castle has a gate and a army(current) is passing through. Then while the army is passing, the gate keeper cannot close the gate of the castle. Such is the case in a transistor, when a current is flowing, it forces it way through the transistor from drain to source.

2 Experiment Set-up

We connect the circuit as shown in the figure:-



Figure 2: This is how we set p the circuit

3 List of Equipment used

- A PC Workstation.
- National Instrument's Multisim.
- Text Editor.



Figure 3: These are the things that are needed for the experiment to be performed[1]

4 Procedure

4.1 Constructing a component in Multisim

The MOSFET differential amplifier we will build today requires a special MOSFET component which we our self have to define and is CD4007 which is SMOS array that allows the use of matched transistor pairs.

To add a new component in Multisim, we do the following steps:-

• Go to Component Wizard in the tools menu.

🚮 Desig	📾 Design4 - Multisim - [Design4]										
🚰 Eile	Edit	⊻iew	Place	MCU	<u>S</u> imulate	Tr <u>a</u> nsfer	Tools	<u>R</u> eports	Options	<u>W</u> indow	Help
0 🖻	Ē	9	Q,	X Ba	B 19 (· 🗐 🛛 لا	(* <u>5</u> Co	omponent \	<u>N</u> izard		· 🔳 🏝 🗹
+ ~~~	· +}+	⊀ ⊅>	75 9		🏡 🗐 🖻	🗄 MISC 🚛	Da	atabase			▶]] ▼
	0.			. 1		2 : :	Gi	rcuit Wizar IICE Notlict	ds Viewer		

• Now just name the component as shown in the figure below

Component Wizard - Step 1 of 7	
Enter component information	
Component name:	Function:
NMOS-CD4007	<u>~</u>
Author name:	~
Ahmed Sweleh	<
O Simulation and layout (model and footprint)
 Simulation only (model) 	
OLayout only (footprint)	
\bigcirc Simulation and PLD export (model and VHE	DL export)
Component type:	
Analog 🛛 🗸	
Nex	t > Cancel Help

• Single section components should be selected and the number of pins should be 4.

Component Wizard -	Step 2 of 7			×
Enter footprint information				
Footprint manufacturer:			Select a footpri	nt
Footprint type:]	
• Single section compo	onent	🔿 Multi-sectio	n component	
Number of pins:	4			
	r Back		Capcel Helr	

• Now that we have got that out of the way, we have to enter the information of the symbol and the information is available from Engineer and we have to copy the code from the text file into the DB.

Compone	nt Wizard - Step 3 of 7	\mathbf{X}
Enter symb	ol information	
	$\begin{array}{c} \begin{array}{c} \begin{array}{c} \\ \end{array}{} \\ \end{array}{} \\ \end{array}{} \\ \end{array}{} \begin{array}{c} 1 \\ 2 \\ \end{array}{} \\ \\ \\ \end{array}{} \\ \end{array}{} \\ \end{array}{} \\ \\ \end{array}{} \\ \\ \\ \end{array}{} \\ \\ \end{array}{} \\ \end{array}{} \\ \\ \\ \end{array}{} \\ \\ \\ \end{array}{} \\ \\ \\ \end{array}{} \\ \end{array}{} \\ \\ \\ \\ \end{array}{} \\ \\ \\ \\ \end{array}{} \\ \\ \\ \\ \\ \\ \end{array}{} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Symbol set ANSI DIN
	< Back Ne:	t > Cancel Help

• Now we have to select the component icon from the window of the component wizard.

🚟 Select a Symbol							
Database:	Component:	Symbol (ANSI)					
Master Database 🛛 🐱	MOS_4TEN_VIRTUAL						
Group:	BJT_NPN_4T_VIRTUAL	Ť	Close				
⊀ Transistors 🛛 🗸	BJT_NPN_VIRTUAL		Search				
Family:	BJT_PNP_4T_VIRTUAL	ļ	Detail report				
All Select all familie:	BJT_PNP_VIRTUAL		View model				
	GaAsFET_N_VIRTUAL		Help				
S BJT NPN							
K BJT_PNP	JFET_P_VIRTUAL	Function:					
K BJT ARRAY	MOS_3TDN_VIRTUAL	VIRCUAI Enhancement Mode NMOSPET					
Z DARLINGTON N	MOS_3TDP_VIRTUAL						
Z DARLINGTON P	MOS_3TEN_VIRTUAL						
K IGBT	MOS_3TEP_VIRTUAL						
IN MOS STON	MOS_4TDN_VIRTUAL	Model manufacturer/ID:					
IE MOS STEN		III / IDEAL_HTEN					
1월 MOS_STEN	MOS_TTEN_VIRTUAL						
]				
		Pootprint manuracturer/type:					
→L JFET_P ==							
JEP POWER_MOS_N							
POWER_MOS_P		Hunavlinka					
I R POWER_MOS_C ⊻		пуреннік:					
Components: 16	Searching:						

• Now we can select the pins and set the property.

Component Wiza	ard - Step 4 of 7						
Set pin parameters Pin table:		Add hidden pin	Delete hidden pin				
Symbol pins	Section	Туре	ERC status				
S	A	BIDIRECTIONAL	INCLUDE				
D	A	BIDIRECTIONAL	INCLUDE				
G	A	BIDIRECTIONAL	INCLUDE				
SUB	A	BIDIRECTIONAL	INCLUDE				
	·						
< Back Next > Cancel Help							

• Now we can paste the code.

Component V	Wizard - Step 5 of 7	7		×
Select simulatio	n model			elect from DB
				Copy to
Model name:	NCD4007			Load from file
Model data:				Model maker
.model N(+ Level=: + Tox=12(+ Rd=0 + Cgdo=0	CD4007 NMOS 1 Gamma= 0 00n Phi=.6 Cbd=2.0p .1p Is=16.64p	Xj=0 Rs=0 Cbs=2.0p N=1	Kp=111u Pb=.8	Vto=2.(Cgso=0.
<				>
	< Back	Next >	Cancel	Help

• Now we can set the pins.

Component Wizard - Step 6 of 7								
Set mapping information between symbol and simulation model (The symbol must contain at least as many pins as the model has connection points.)								
Pin mapping table:	Symbol pins	Model nodes						
	S	3						
	D	1						
	G	2						
	SUB	4						
			_					
The order for the model nodes is:1)Drain, 2)Gate, 3)Source, 4)Substrate								
	< Back Next	> Cancel Help	<u></u>					

• This is the last step and here we select the database in which the component should be stored.

🚟 Component Wizard - Step 7 of 7		
Family tree:	Database:	User Database
🛆 🚊 🞒 User Database	Group:	Transistors
Sources	Family:	NMOS
Auto- Basic		Family
		Def
📃 🕂 Transistors		Del
Def NMO54007		ANSI O DIN
Def PMOS		
Def NMOS		Add family
Analog		
🗸		
< Back	Finish	Cancel Help

• Now we can see the new component in the database.

🚟 Select a Component		
Database:	Component:	Symbol (ANSI)
User Database 🛛 👻	NMOS-CD4007	- Close
Group:	CD4007NMOS	
⊀ Transistors 🛛 👻	NMOS-CD4007	
Family:		Detail report
All Select all families		View model
Det NMOS		Help
Del PMOS		Function
Det NMOS4007		
		Model manufacturer/ID:
		Generic / NCD4007
		Footprint manufacturer/type:
		Hyperlink:
Components: 2	Searching:	

4.2 Measurement of DC operating point

N ow we have to measure the DC operating point. It is the point at which the amplifier starts to operate in active mode. With zero differential input, the bias current should be shared equally by U3 and U4. Resistors R2 and R3 are chosen to achieve a DC bias level of 3.3V at each output. The circuit below is built using the component.



4.3 Differential Small Signal Gain

I N this step we have to apply small sin wave at the input and measure the small signal gain from input to output in the circuit shown. Measure the single ended gain and the differential gain of the circuit.



Figure 4: This should be the output.

5 Results and Discussions

At the end of the lab we got the following results:-



Figure 5: When we input the triangular wave and perform the math operation on the two received signals from channel A and channel B, the resulting wave is much more amplified triangular wave. Here the output is taken from both of the transistors separately.



Figure 6: This is the output of each of the transistors when a triangular wave is input to the differential amplifier.



Figure 7: Here we are using probes to measure the voltages across the transistors separately and both of the gates of the transistor are grounded so that the input signal is zero. SO when the input signal is zero, the each amplifier produces about 6.316 Volts.

6 Conclusion

- The differential amplifier reduces noise by cancellation technique and extracts the useful information for amplification purposes. this is the reason that mostly it is used as the first stage amplifier.
- The differential gain is actually the amplification done on the the difference of the input given to the first transistor and second transistor.
- Single ended gain is the gain calculated from output over the input of the single transistor.
- Differential gain stage is usually followed single stage amplifier to amplify and stabilize the overall output signal and to increase further the gain of the total amplifier.
- The current mirror is usually used in combination with the differential amplifier to affect the bias so that the transistors operate in active mode. The referencing current is produced outside the chip usually and then this current is mirrored all over the chip for biasing circuit purposes. The basic current biasing can be understood by the just imagining that if a castle has a gate and a army(current) is passing through. Then while the army is passing, the gate keeper cannot close the gate of the castle.
- The lower terminals of the active device are joined together and are connected to a current source for forcing the bias on the transistors to work in active mode.
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Part and Member	Weight Grade	Muhammad Obaidullah	Bilal Arshad
Abstract	10%	50%	50%
Introduction	15%	50%	50%
Procedure Part 1	15%	50%	50%
Procedure Part 2	15%	50%	50%
Results Part 1	15%	50%	50%
Results Part 2	15%	50%	50%
Conclusion	15%	50%	50%
Total	100%	50%	50%

7 Team Dynamics

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