LAB07 – DIFFERENTIAL OUTPUT OP AMP DESIGN

Overview:

The objective of this laboratory is to design a differential-in, differential-out op amp that will meet a given set of specifications.

The steps in the laboratory are:

- Specifications
- Approach
- Simulation/Test Benches
- Tips and Tricks

Dr. Phillip Allen
Prof. Emeritus, ECE, Georgia Tech

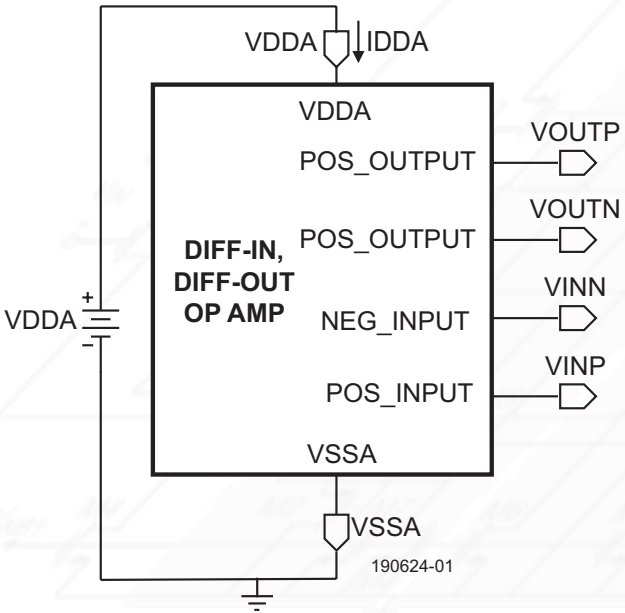
Version 190624

Lab07 - Specifications

Specifications

Technology - xFab XH035B

Block diagram:



Parameter	Symbol	Min	Typ	Max	Units
Power Supply Voltage	VDDA	3	3.3	3.6	V
Ground	VSSA	0	0	0	V
Bulk Bias Voltage	VBBA	0	0	0	V
Junction Temperature	TJ		27		°C

Note: You are only responsible for the circuits within the box labelled **DIFF-IN, DIFF-OUT OP AMP**

Lab07 - Specifications

Specifications – Continued

(VDDA = 3.3V, TJ = 27°C, C_L = 10pF unless otherwise specified below)

Parameter	Symbol	Condition	Min	Typ	Max	Units
Bias Current for total circuit	IDDA	VDDA = 3.3V, VICM=1.65V			300	µA
Low frequency open loop gain	AVD	VDDA = 3.3V, VICM=1.65V	60			dB
Gain-bandwidth	GB	VDDA =3.3V, VICM=1.65V, CL=10pF	5			MHz
Phase Margin	PM	VDDA = 3.3V	60			Deg
Slew Rate (CL=10pF)	SR	VINP=1.65V, VIN(p-p)=0.5V at VICM	2			V/µs

Test Bench 1

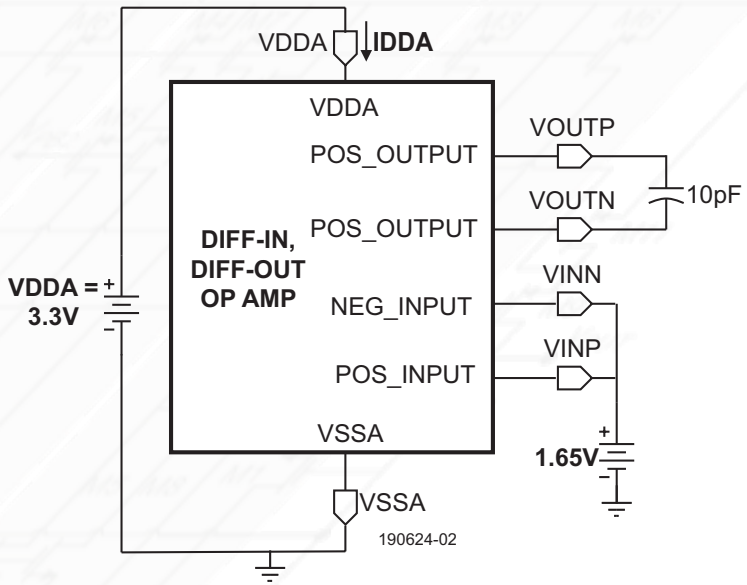
IDDA - DC OP

This Test Bench does the following:

1.) Determines IDDA for nominal model, tm

Note that you do not have to stabilize the amplifier because the output common mode stabilization circuit should hold the output common mode at the desired voltage.

It is the only configuration of the op amp that can be run open loop in simulation or experimental operation

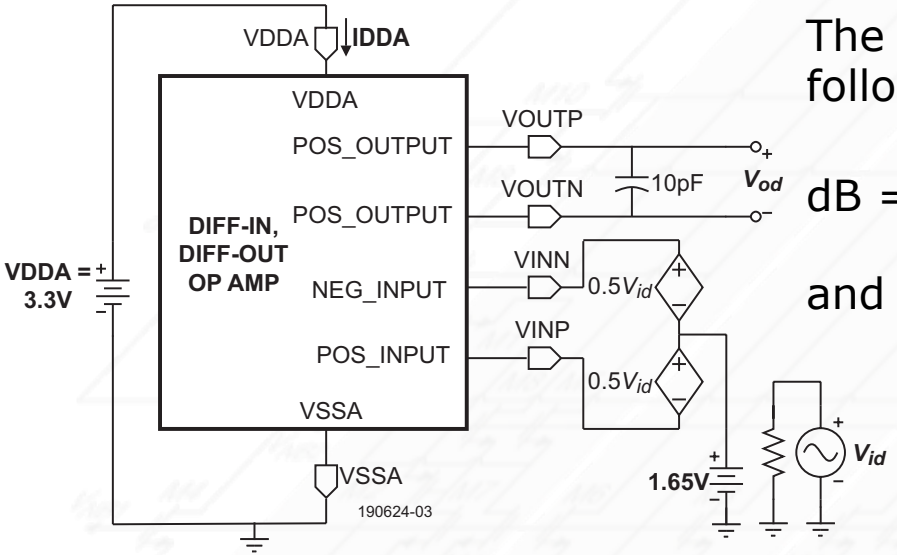


Test Bench 2

AVD, GB, and PM – AC

This Test Bench does the following:

1.) Measures the open loop gain when VDDA = 3.3V, VINP=1.65V.



The frequency response is found using the following relationships:

$$dB = 20log\sqrt{(ReV_{01} - ReV_{02})^2 - (ImV_{01} - ImV_{02})^2}$$

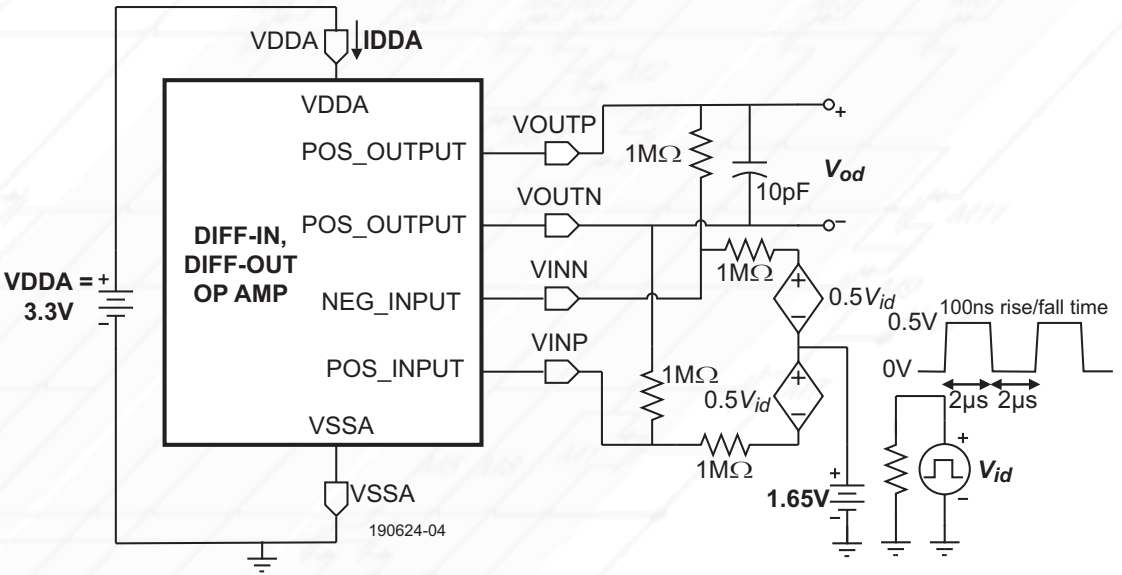
and $$Phase = tan^{-1}\left(\frac{ImV_{01} - ImV_{02}}{ReV_{01} - ReV_{02}}\right)$$

Test Bench 3

SLEW RATE - TRAN

This Test Bench does the following:

1.) Measures the slew rate of the op amp when VDDA = 3.3V. A differential input pulse of 0.5V p-p, with rise and fall time of 0.1µs, pulse width of 2µs, and period of 4µs is applied.



Note that you cannot put the differential-in, differential-out op amp in the unity gain configuration because the input is directly coupled to the output.

Electrical Design

Steps

1. Choose one of the appropriate design procedures
2. Hand design using the design procedure
3. Use the test benches to determine the performance of your design keeping your design constant from test bench to test bench
4. After you have used the test benches provided to simulate your circuit, a specification sheet will be generated to indicate how well your circuit meets the specifications.
5. If you did not meet specifications, you are encouraged to modify your circuit in an attempt to meet specifications

Tips and Tricks

Helpful Ideas for Lab07

1. If your output common voltage stabilization circuit is working, you should not have to worry about dc operation when the loop is open.
2. The differential-in, differential-out op amp cannot be put in the unity gain mode.
3. When simulating, measuring the differential output voltage can be challenging. Most simulators only find the frequency response of a node and not the difference between nodes. You can approximate the magnitude by multiplying the frequency response of one output node by two.
4. If you assume the $Re[V_{o1}] = -Re[V_{o2}]$ and $Im[V_{o1}] = -Im[V_{o2}]$, then the differential phase shift can be approximated by the phase shift of V_{o1} or V_{o2} shifted up or down appropriately.

Summary – Lab07

Differential Output Op Amp Design

- Understand the lab specifications
- Selection of an appropriate design procedure and topology
- Develop the design using the design procedure
- Use test benches to simulate and determine performance
- Modify as necessary