ELE 504 Lab Report 2

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Introduction

Op-Amps used in real life applications are never fully ideal, which is why the slight imperfections that they come with should be taken into consideration when dealing with the design of a circuit that consists of Op-Amps. The ideal Op-Amp does not exist and this means that Op-Amps consist of non-infinite voltage gains, input offset voltages, and input bias currents that can affect the output of the circuit. This lab will take a look at the imperfections of Op-Amps and how we can minimize their impacts through design modifications.

Objective

The objective of this lab is to use several LM741 Operational Amplifiers and different types of circuits to understand D.C. imperfections and use this knowledge to mitigate the effects when designing amplifiers. Another objective of this lab is to understand the frequency response and Slew-Rate behaviour with an A.C. signal and how different Operational Amplifiers exhibit different behaviours to choose the most appropriate type in amplifier design.

Circuit Screenshots

<u>Part 1</u>

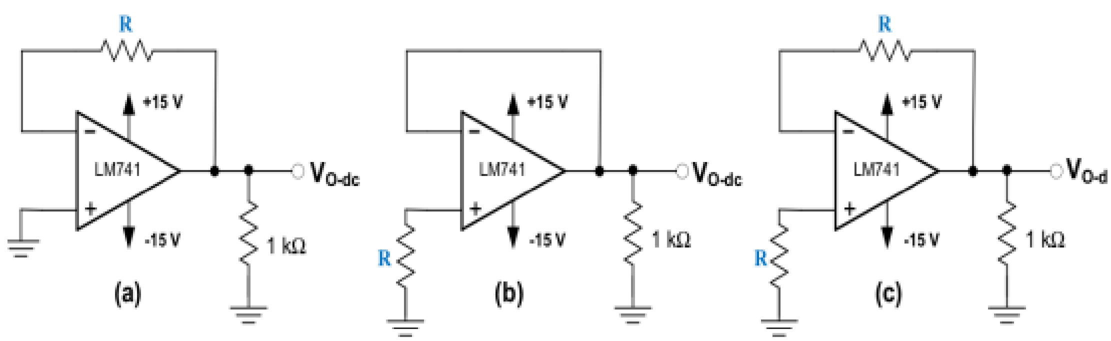

Figure 1

<u>Part 2, 3 and 4</u>

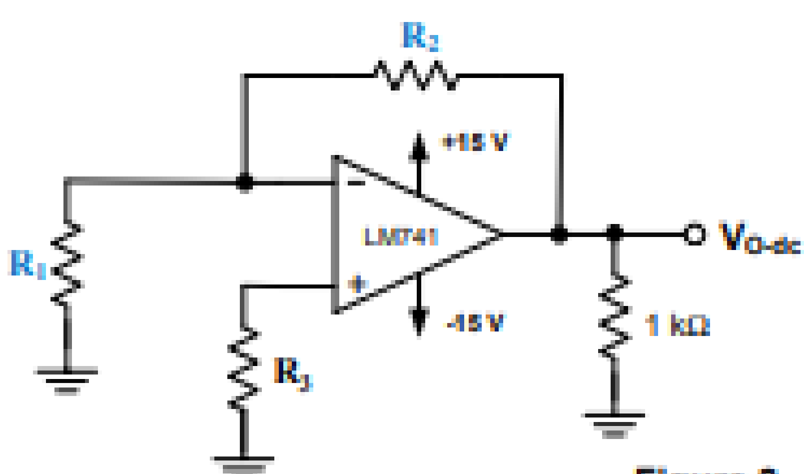

Figure 2

Part 5

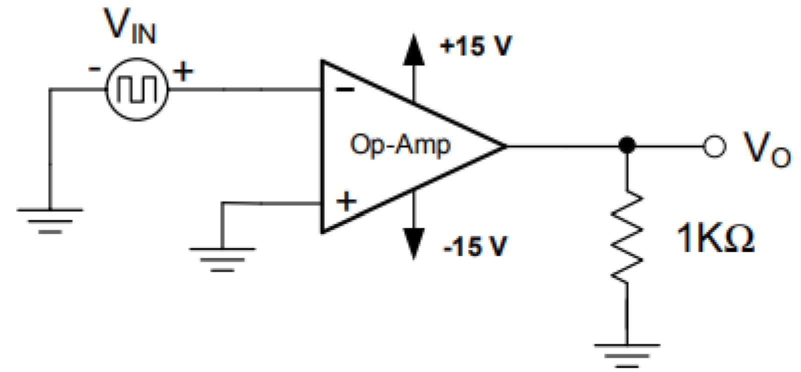

Figure 3

Results and Tables

Table 1 for Part a

LM741-1	$V_{O\text{-dc}}$	I_B^-	I_B^+	$(I_B^- - I_B^+)$
Fig. 1(a)	48.55mV	48.55nA		
Fig. 1(b)	-46.49mV		46.49nA	
Fig. 1(c)	1.25 mV			1.25 nA

LM741-2	$V_{O\text{-dc}}$	I_B^-	I_B^+	$(I_B^- - I_B^+)$
Fig. 1(a)	49.72mV	49.72nA		
Fig. 1(b)	-47.55mV		47.55nA	
Fig. 1(c)	1.7 mV			1.7nA

LM741-3	$V_{O\text{-dc}}$	I_B^-	I_B^+	$(I_B^- - I_B^+)$
Fig. 1(a)	48.1 mV	48.1nA		
Fig. 1(b)	-47.7mV		47.7nA	
Fig. 1(c)	0.25mV			0.25 nA

LM741-4	$V_{O\text{-dc}}$	I_B^-	I_B^+	$(I_B^- - I_B^+)$
Fig. 1(a)	47.2 mV	47.2nA		
Fig. 1(b)	-45.1 mV		45.1nA	
Fig. 1(c)	0.89mV			0.89nA

Table 2 for Part a

	Bias Current $I_B = (I_B^+ + I_B^-)/2$	**Offset Current** $I_{os} = \|\|I_B^- - I_B^+\|\|$
Derived from Simulation results =>	80nA	20nA
LM741CN Specification datasheet =>	80nA	20nA
Derived from *average* values of above 4 measurements =>	47.55 nA	1.02 nA

Table 3 for Part b

LM741	$V_{O\text{-}dc}$ (measured)	Vi_{os} (as derived from $V_{O\text{-}dc}$)	Vi_{os} (from Simulation)	Vi_{os} (from Datasheet)
1	1.38 mV	0.43125 mV	31 mV	15 mV
2	1.88 mV	0.5875 mV		
3	0.4 mV	0.125 mV		
4	1.22 mV	0.381 mV		
Average Vi_{os} =>		0.381 mV		

Table 4 for Part c

LM741CN		$V_{O\text{-}dc}$ (measured)	$V_{O\text{-}dc}$ (from Simulations)	$V_{O\text{-}dc}$ (from Pre-Lab Analysis)
Figure 2	**$R_3 = 0$**	50.85 mV	103.309 mV	73.2 mV
Figure 2	**$R_3 = R_2//R_1$**	1.84 mV	45.446 mV	64.7 mV

Table 5 for Part d

LM741CN	$R_1 = 1k\Omega$, $R_2 = 1M\Omega$, and $R_3 = 1k\Omega$ ($\approx R_2//R_1$)	$V_{O\text{-}dc}$ (measured)	$V_{O\text{-}dc}$ (from simulation)
Figure 2	With no modification to the circuit as in above **(1)**	1.32V	1.039V
Figure 2	With modification to the circuit as in above **(2)**	0.55V	1.039V

Table 6 for Part e

Op-Amp type	**Slew Rate (SR)** V/µSec (measured)	**Slew Rate (SR)** V/µSec (from simulations)	**Slew Rate (SR)** V/µSec (from datasheet)
LM741CN in Figure 3	0.67	0.255	0.5
LM318N in Figure 3	34.17	7.58	70

Figure 1 for Part e

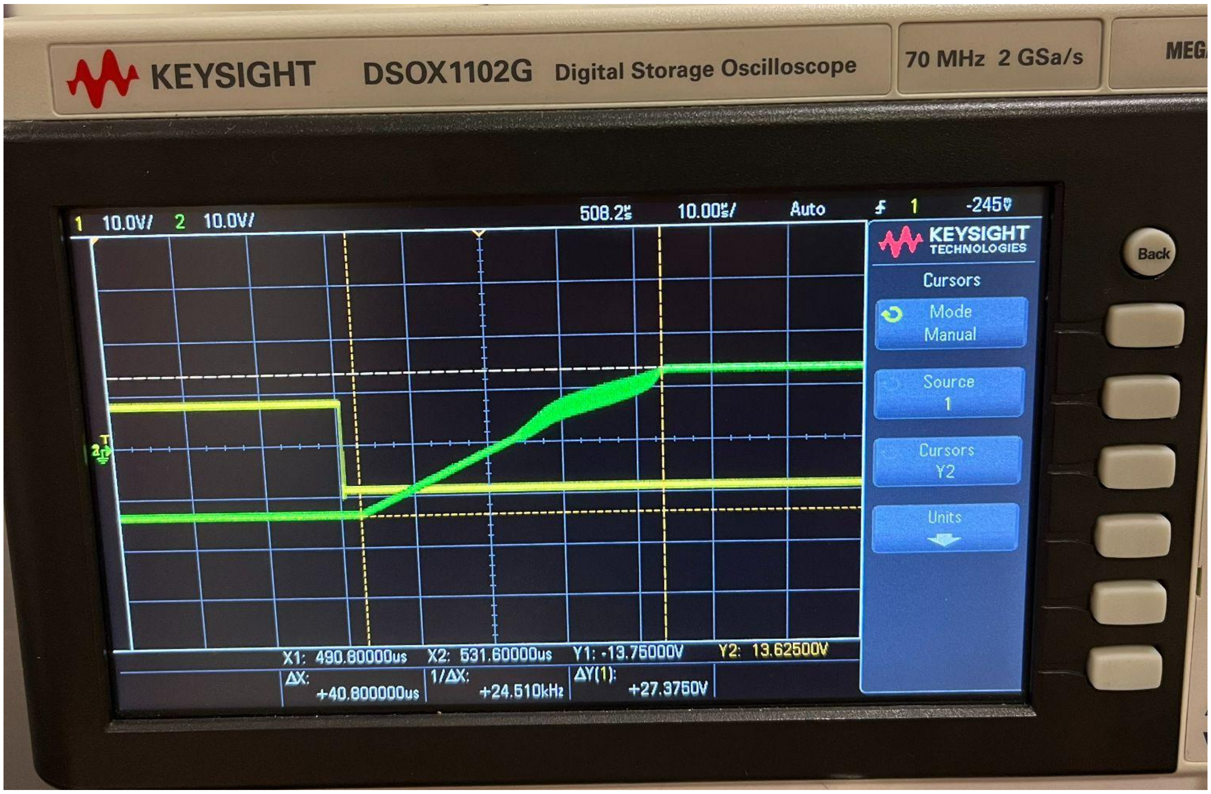

Figure 2 for Part e

Conclusion

After completing the experiment, several conclusions can be drawn from the results. In Figure 1a and 1b, the input bias currents and the input offset voltage were observed to have a noticeable effect of around 45 mV on the DC output voltage of the amplifier. Then, the offset was observed to decrease to around 1 mV when the resistor values in Figure 1c were implemented. In the circuit in Figure 2, the design decision of making R3 = R2||R1 was observed to greatly reduce the effects of the input bias currents and input offset voltage when compared to having R3 set to 0, which can be seen in Table 4. Also, the addition of a capacitor in series with R1 also resulted in a large decrease in the offset at the output and this can be seen in Table 5. Lastly, the slew rate measured with the circuit in Figure 3 was larger when the LM318N Op-Amp was used compared to the LM741CN Op-Amp which showed how the LM318N is better at responding to large rates of changes in the input voltage. Overall, the input offset voltage and input bias currents were observed to have an effect on the output voltage, however certain design decisions were able to greatly reduce that effect.