**Lab 2 Operational Amplifiers**

**Keegan** **Smith**

**Bench** #19

**Electronics** 1 Lab

**EECE.3110**

**Date submitte**d 02/07/2022

**Due date** 02/07/2022

1. **SUMMARY**

This document reports my findings as well as construction and operation of four types of op-amp circuits using one Op-amp. The constructed circuits include the buffer, inverting op-amp, summing Op-amp and the comparator. An Op-amp buffer allows for a signal to not be affected by a load that a load may have. The inverting Op-amp inverts and amplifies a signal. Summing Op-amps are used to take multiple input currents and combines them into a singular output. Finally, the comparator will output +5V if the positive input is higher than the negative input, he output will be -5V if the negative input is higher than the output and have an output of 0V if both inputs are the same value.

1. **EQUIPMENT**

**Table 1. Equipment**

|  |  |  |
| --- | --- | --- |
| **Equipment Type** | **Details** | |
| * Oscilloscope | *Make:* | InfiniiVision |
| *Model:* | DSO-X2004A |
| *Serial Number:* | MY52161432 |
| * Digital Multimeter | *Make:* | Keithley |
| *Model:* | 2110 5½ |
| *Serial Number:* | 8004026 |
| * DC Power Supply | *Make:* | GWInstek |
| *Model:* | GPD-3303D |
| *Serial Number:* | EM840514 |
| * Breadboard * Bench “Shoebox” with connector cables, adapters, clips etc. | N/A | |

**Table 2. Components**

|  |  |  |
| --- | --- | --- |
| **Component Type** | **Quantity** | **Details** |
| Decade resistance box | 1 | N/A |
| TI microchip | 1 | LF353 Operational Amplifier |
| Resistor | 1 | 1k Ω |
| Resistor | 1 | 2k Ω |
| Resistor | 3 | 10k Ω |
| Resistor | 4 | 20k Ω |
| Potentiometer | 3 | 10k Ω |
| Diligent PowerBRICK | 1 | Output +/-9V or +/-12V |

1. **INTRODUCTION**

Digital circuits function in two states, a high and low voltage, or on and off. However, analog circuits do not. This type of circuit operates on continuous, or linear, signals consisting of extremely high or extremely low voltages and everything in between. The Operational Amplifier is one such type of circuit. The output of an Op-amp is dependent on its input, and that ratio can be changed based on two resistors, RIN and ROUT. An Op-amp has two inputs, V- (inverting input) and V+ (non-inverting input), as well as an output VO. Some, such as the comparator, have more than two inputs, but those are used for gain control. During this laboratory we are going to build four types of Op-amp circuits and measure the output to compare them to their ideal, or calculated values.

The Buffer, Figure a. The buffer is an op-amp circuit where VO is shorted to the inverting input and the signal coming in goes into the non-inverting input. The interesting part about the buffer is that it as a gain of 1, meaning the input is equal to the output. The point of this is because an op-amp has an extremely high impedance seen by the output. So, this removes the signal from loading another circuit or the rest of the circuit it’s in.

The Inverting Amplifier, Figure b. The inverting amplifier does what it sounds like, it inverts and amplifies a signal. Unlike the buffer, as seen in Figure b, there is a resistor on the input (RIN) and a resistor on the feedback (RF) loop from VO. VO can be adjusted using these two resistors with the following equation.

(1)

The Summing Amplifier, Figure c. The summing op-amp takes an input current I­IN and adds them together. The circuit is like that of the inverting amplifier, but the summing op-amp does not have an input resistance. Instead, each supply going into the inverting input has its own resistor, hence why we look at current to calculate VO. The equations for this are as follows.

IRF = ∑ VRN / RN (2)

VO = IRF \* RF (3)

The Comparator, Figure d. The comparator compares two input voltages and will either have a output of +5V, -5V or 0V. The relationship is when the non-inverting input is greater than the inverting input, the output is +5V. However, when the inverting input is greater than the non-inverting input, the output is -5V. When both inputs are equal, the output is 0V.

1. **CIRCUIT DESCRIPTION**

Figure a.

A picture containing text, antenna

Description automatically generated

Figure b.

Diagram, schematic

Description automatically generated

Figure c.

Diagram, schematic

Description automatically generated

Diagram, schematic

Description automatically generatedFigure d.

1. **MEASUREMENTS**

**Table 1. Buffer Voltage Measurement vs. Calculations**

|  |  |  |
| --- | --- | --- |
| **V­IN** | **VOUT** | |
| Units, Volts (V) | Calculated | Measured |
| +2.0 | +2.0 | +1.984 |
| -2.0 | -2.0 | -1.988 |
| +5 | +5 | +4.959 |
| +7.0 | +7.0 | +5.622 |

**Table 2. Buffer with Decade Box**

|  |  |
| --- | --- |
| **R Value of Decade Box** (Ω) | **Voltage Measurement** (V) |
| 1 | 0.02821 |
| 10 | 0.21918 |
| 100 | 2.1215 |
| 1000 | 4.964 |
| 10000 | ~5 |
| 100000 | 5.008 |
| 1000000 | 4.989 |

**Table 3. Inverting Op-Amp Measurements vs. Calculations with Rf = 10KΩ, RIN = 2KΩ**

|  |  |  |
| --- | --- | --- |
| **Rf = 10KΩ, RIN = 2KΩ** | | |
| **VIN** | **VOUT** | |
| (volts) | Calculated | Measured |
| +0.2 | -1 | -0.973 |
| -0.3 | +1.5 | +1.433 |
| 0 | 0 | -.011 |
| +0.32 | -1.6 | -1.552 |

**Table 4. Inverting Op-Amp Measurements vs. Calculations with Rf = 24KΩ, RIN = 10KΩ**

|  |  |  |
| --- | --- | --- |
| **Rf = 24KΩ, RIN = 10KΩ** | | |
| **VIN** | **VOUT** | |
| (volts) | Calculated | Measured |
| +0.3 | -0.72 | -0.729 |
| -0.25 | +0.6 | +0.596 |
| -0.2 | +0.48 | +0.4754 |
| +0.4 | -0.96 | -0.970 |

**Table 5. Summing Op-Amp**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Input Voltages** | | | **VOUT** | |
| **V1** | **V2** | **V3** | **Calculated** | **Measured** |
| +1 | +1 | +1 | -3 | -2.976 |
| -1 | -1 | +1 | +1 | +0.976 |
| -1 | -1 | +2 | 0 | -0.0187 |
| +3 | -3 | -3 | +3 | +2.954 |
| -2 | +1 | -2 | +3 | 2.956 |

1. **DISCUSSION**
2. **CONCLUSION**
3. **QUESTIONS**
4. **REFERENCES**
5. <https://en.wikipedia.org/wiki/Buffer_amplifier#:~:text=A%20buffer%20amplifier%20(sometimes%20simply,load%20may%20be%20produced%20with.>
6. Circuit pictures for figures a, b, c and d were taken from the laboratory procedure.