Instrumentation Lab - Analysing Op-Amps

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1 Introduction to Operational Amplifiers

The op-amp is a complete integrated amplifier gain block. It is a DC-coupled differential amplifier with single-ended output and extraordinarily high gain, often designed as a "gain engine", due to the presence of negative feedback, and is generally known for its input symmetry and zero current input. In simpler words, op-amps are basic circuit components to amplify the difference in voltage between two inputs. The plus (+) and minus (-) terminals in the operational amplifiers are called non-inverting and inverting inputs respectively. Let us now take a look at the symbol representing an op-amp.

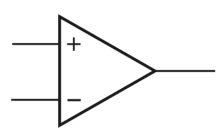

Figure 1: An image of the symbol of an Op-Amp

2 Analysing the working and the structure of Operational Amplifiers

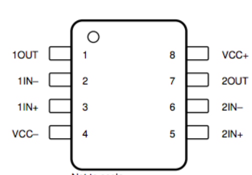

Figure 2: TL082x 8-Pin top view of an operational amplifier

3 Circuit Design

The main goal of this project was to build and test an Inverting Amplifier Circuit. Like its name suggests, the Inverting Amplifier circuit inverts a signal that it is provided. This circuit consists of an input resistor, a feedback resistor, and an Op-Amp. Circuits usually have two types of control systems, open and closed loop. An open loop system is called a non-feedback system because it processes input without feedback. While a closed loop system uses feedback to process the input, and that is accomplished by the feedback resistor. The feedback resistor takes some of the output voltage and feeds it back to the input, controlling the output voltage making sure that it is within the desired range. This is how the resistors can be used to set a desired amount of gain and adjusting these values can adjust the amount of gain. Gain is defined as the ratio of the feedback resistance and the input resistance. For our circuit that gain would be negative because it is an inverting amplifier. Using a 10 kilo ohm input resistor and a 100 kilo ohm feedback resistor, we set the desired gain to be 10 ohms. The following circuit diagram illustrates our initial design.

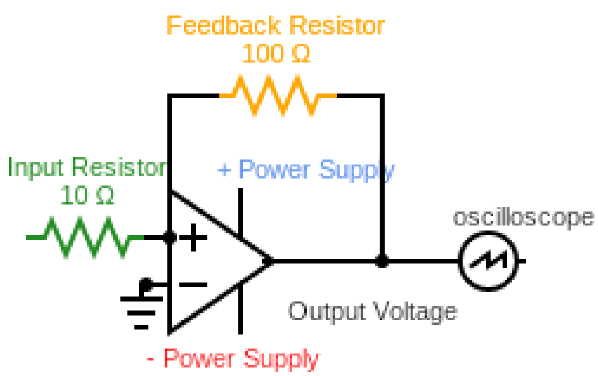

Figure 3: Circuit Diagram of inverting Amplifier circuit

4 Building The Circuit

Before we began building the circuit, we sketched out a plan on how we would build the circuit. The feedback resistor would need to connect the inverting input, and the the output(pins 1 and 2). The input resistor would connect to the input, and the input power supply. Since we designed an inverting amplifier circuit, the non-inverting input will be grounded(pin 3). Next, we need to provide the amplifier with a power source. Pins 8 and 4 would be connected to the positive and negative power supplies respectively.

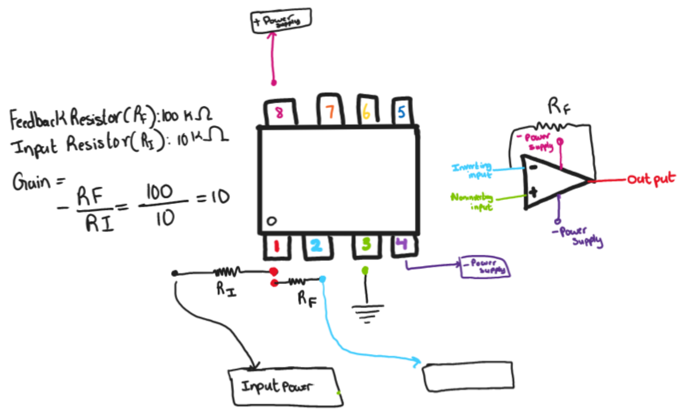

Figure 4: A sketch of the operational Amplifier

We used a solder-able circuit board to build our circuit. A socket holder was soldered onto the circuit board, and the Op Amp was placed in it. The two resistors were, and wires that would be connected to the power supply, function generator, and oscilloscope were soldered onto the board. Having just learned soldering a couple weeks prior to building our circuit, one of the mistakes we made was soldering on the wrong side of the circuit board, which did not have the metal circles to make a good solder connection. We observed that our solder joints were not strong, and that is when we realized our mistake. After correcting our mistake we made sure that the solder joints were secure there were no interfering connections, using a multi meter. A sketch of our predicted setup and a picture of our actual setup:

5 Collecting Data

From our experiment, we aimed to create a frequency response plot of the Op-Amp. A frequency response graphically represents how a device responds to different frequencies. Frequency response graphs provide useful insight about the device in question, and is utilized to make decisions when designing systems using that device. To create our frequency response graph, we varied our frequencies from a range of 100 kHZ to 10,000 kHZ, increasing the frequency by a 100 kHZ, and measured the input and output voltage for each frequency. A function generator was used to a create a square-wave function and provide variable frequencies. At each frequency, the input and output voltage was measured, which was used to calculate the gain.The gain was then converted to decibels and plotted over the frequency, to create our frequency response.

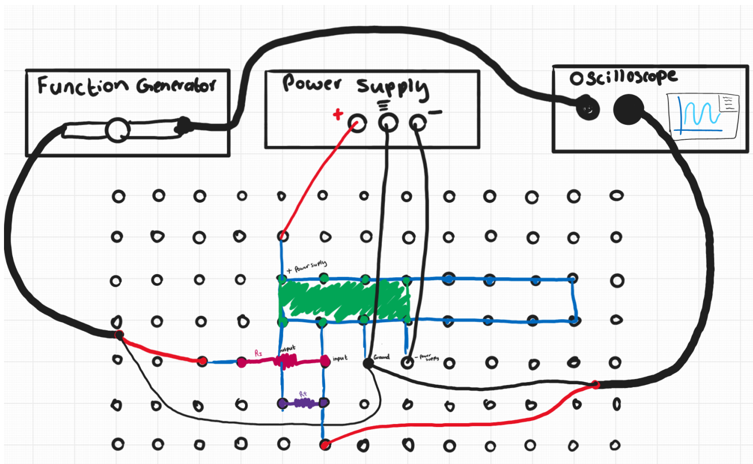

Figure 5: A sketch of our Inverting Amplifier Circuit

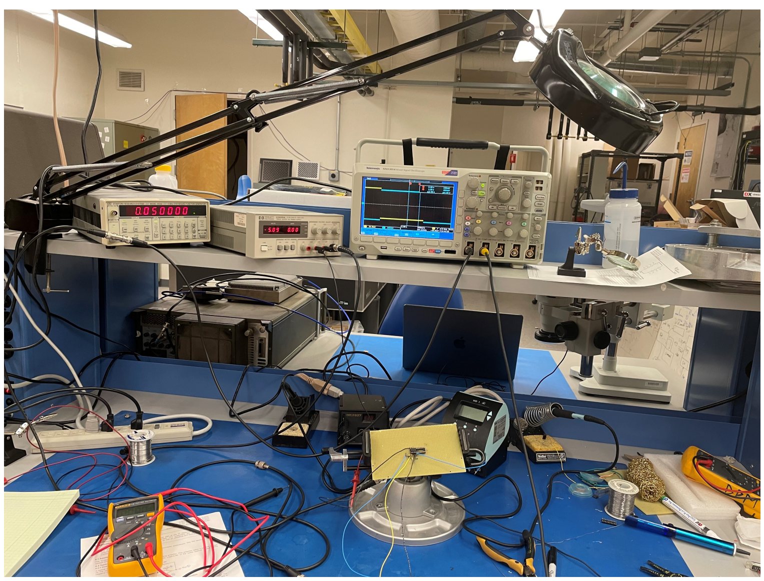

Figure 6: An image of our lab setup

Vout (voltage)	Vin(Volts)	Frequency(kHZ)	Gain	Change in Gain
1.01	0.1	100	10.1	1.288118812
0.89	0.101	300	8.811881188	1.089108911
0.78	0.101	400	7.722772277	1.089108911
0.67	0.101	500	6.633663366	1.188118812
0.55	0.101	700	5.445544554	1.287128713
0.42	0.101	900	4.158415842	0.495049505
0.37	0.101	1000	3.663366337	1.363366337
0.23	0.1	1500	2.3	0.6
0.17	0.1	2000	1.7	0.1
0.16	0.1	3000	1.6	0.975
0.06	0.096	4000	0.625	-0.1118421053
0.07	0.095	5000	0.7368421053	-0.01584606678
0.07	0.093	6000	0.752688172	-0.05812263877
0.06	0.074	7000	0.8108108108	0.01081081081
0.06	0.075	8000	0.8	0
0.06	0.075	9000	0.8	0
0.06	0.075	10,000	0.8	0
0.06	0.075	8000	0.8	0
0.06	0.075	9000	0.8	0
0.06	0.075	10,000	0.8	0.8

6 Frequency response experiment

The 3dB point in a frequency response indicates the point where the output amplitude is reduced to half the maximum value. On a graph, this point is usually found where the amplitude of the device steeply drops until which it is predicted to maintain a flat shape visualizing its maximum output. In summary, the 3dB point indicates the range over which the device performs effectively.

7 Analysing Gain (dB) vs Frequency(kHz) graph

The closed loop shows a gain of 10 or 20 dB. The response remains flat until it approaches the open loop gain. Once there's less than 10dB of feedback (when the open loop gain falls below 30dB), the closed-loop response falls.

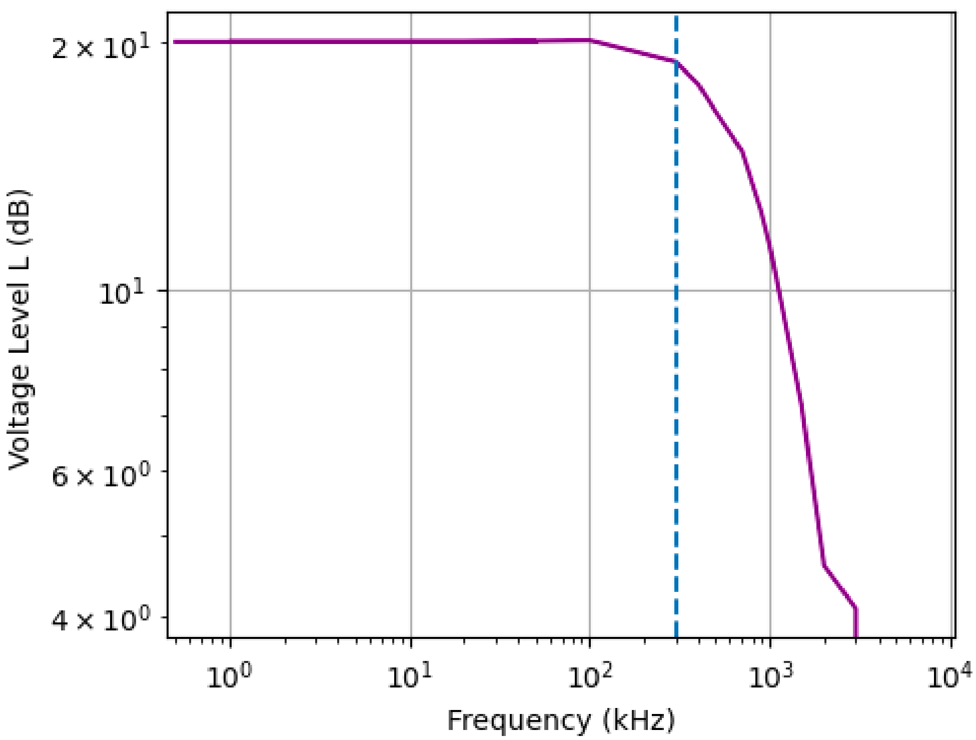

Figure 7: Gain vs Frequency