

GD Logbook

by Gabriel Dunning

Submission date: 13-Dec-2024 09:51AM (UTC+0000)

Submission ID: 245947195

File name: 58765_Gabriel_Dunning_GD_Logbook_631850_1010561962.docx (7.47M)

Word count: 1963

Character count: 9869

Workshop Skills Logbook

Gabriel Dunning

Student Number: 2412488

L4 - Workshop Skills

ACDA4022

Electrical & Electronic Engineering Degree
Apprenticeship

Introduction:

The purpose of this report is to document and record the design, simulation, building and testing process of a simple non-inverting op-amp circuit with an optimal gain of 3 under ideal operating conditions, the gain of the circuit is calculated using the standard gain formula $A = \frac{V_{out}}{V_{in}}$. The schematic for which is seen in Figure 1 below.

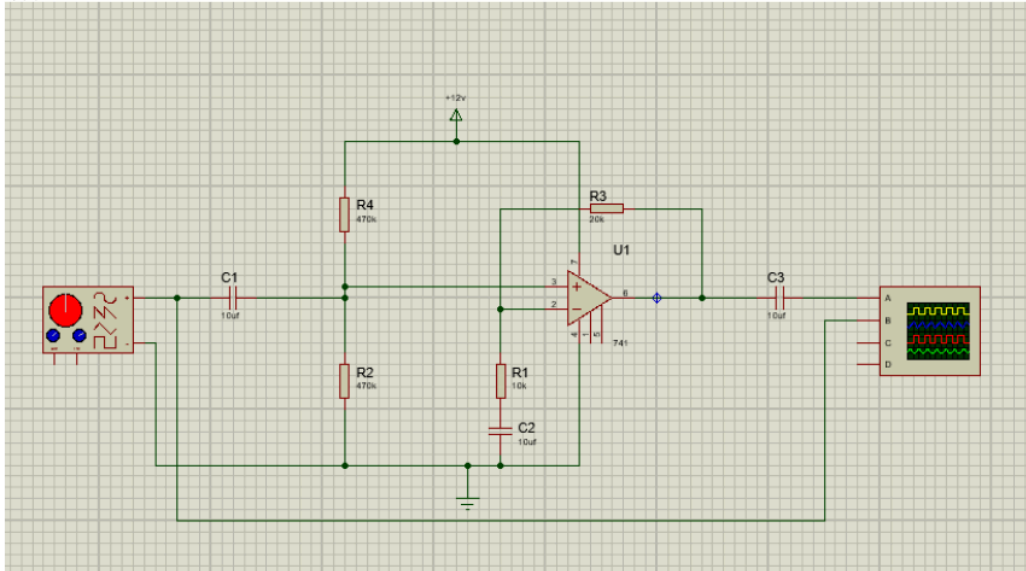


Figure 1: schematic of the non-inverting amplifier circuit, drawn in Proteus.

Circuit Simulation:

After the schematic of the circuit (Figure 1) was drawn up, It was then simulated in Proteus which produced a table of values seen below (Figure 2). As seen below in Figure 2, a set of frequencies ranging from 1Hz to 500 KHz was tested on a logarithmic scale, with the input voltage being a constant 2V. The output voltage was then measured and, following that, the gain was calculated for each frequency which was then used to create the plot in figure 2.

Table 1: A table showing the results of the simulation testing in Proteus. The gain calculated in the gain column as well as in the graph is calculated by the formula $Gain(dB) = 20\log_{10}(\frac{V_{out}}{V_{in}})$.

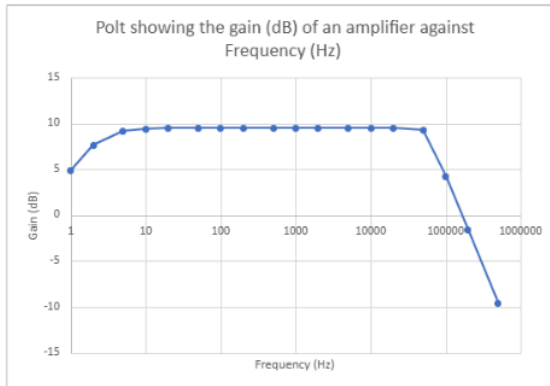


Figure 2: A graph showing the results of the simulation testing in Proteus.

Freq	Vin	Vout	Gain (dB)
1	2	3.54	4.959465327
2	2	4.84	7.67630732
5	2	5.76	9.187849755
10	2	5.92	9.425834221
20	2	5.98	9.513423766
50	2	6	9.542425094
100	2	6	9.542425094
200	2	6	9.542425094
500	2	6	9.542425094
1000	2	6	9.542425094
2000	2	6	9.542425094
5000	2	6	9.542425094
10000	2	6	9.542425094
20000	2	6	9.542425094
50000	2	5.82	9.27785978
100000	2	3.26	4.243752088
200000	2	1.68	-1.514414279
500000	2	0.666	-9.55111533

The chip being simulated in Proteus is the LM741, which is also the chip that is used in the final constructed circuit, meaning that the response gained from the simulation will be almost identical to the response gained from the real circuit. As the graph shows a consistent gain value of 9.542 dB from 50 Hz to 20 KHz, which is good since this will be the normal operating range of the Amplifier, whilst the graph also shows that from 1 Hz to 20 Hz the gain is slowly increasing from 4.959 dB to 9.513 dB. The graph also shows that from 50 KHz onwards, the gain drops off quite rapidly and at 500 KHz it even begins to attenuate the input voltage rather than amplify it. However this isn't an issue as 500 KHz is well beyond the usual frequency that the amplifier will be used at.

Circuit and PCB Design:

After the circuit had been simulated in Proteus, the design was translated onto a schematic in Easy-PC where the design was later converted into a PCB design, fully fitted with appropriate tracks and grounding planes. After the PCB design was created, an appropriate file was generated and sent off to an external company for manufacture.

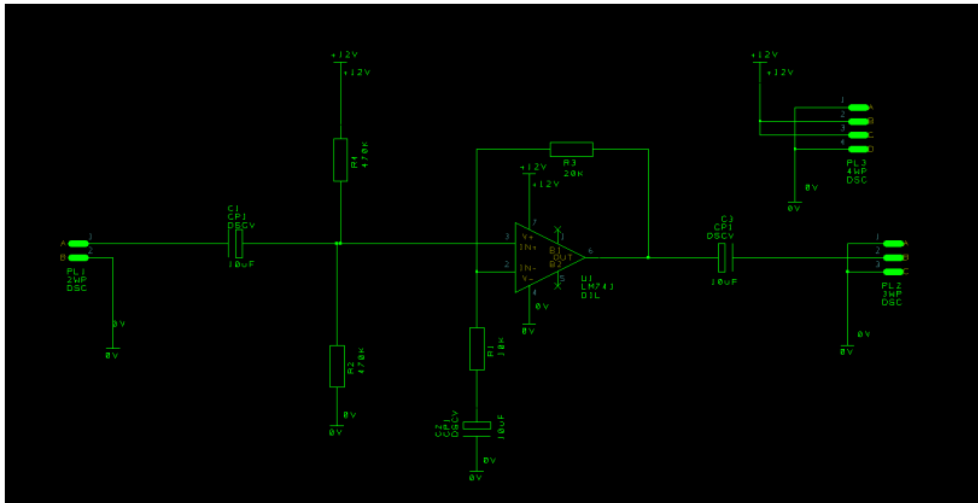


Figure 3: A screenshot showing the circuit design recreated in the Easy-pc software to enable easier creation of a PCB schematic.

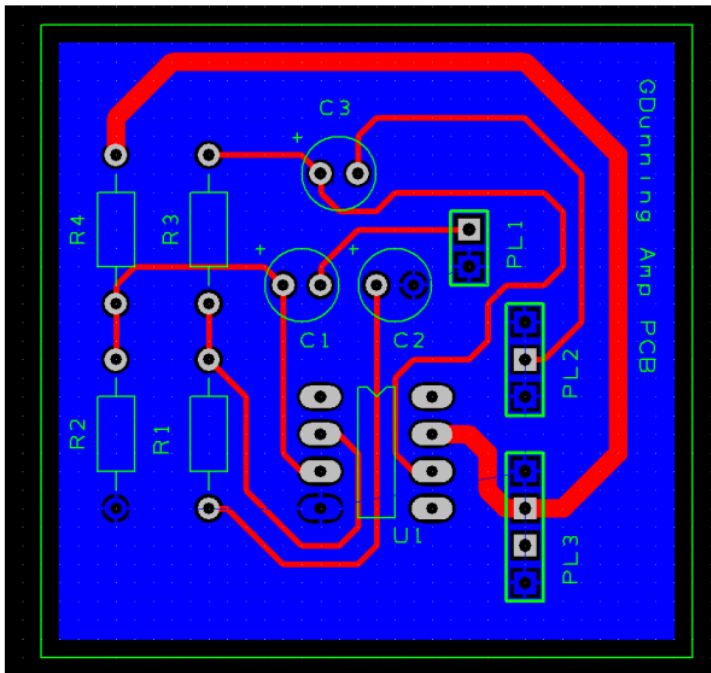


Figure 4: The PCB design of the aforementioned Easy-pc schematic of the amplifier circuit. The blue traces represent copper grounding whereas the Red connections represent "live" tracks.

After the design was sent off for manufacture I began to create a prototype of the final circuit on a breadboard so that I could run the same Frequency/Gain tests as I did in the simulation and then compare the results to each other to see if they match.

I began this process by planning out how I was going to construct my bread board by using a pin sheet, this sheet enabled me to visualise the physical layout on the breadboard a lot easier as well as allowing me to more effectively plan things like how I was going to set up my Ground and Power rails, as well as where I was going to position my Input and output pins so that they were easily accessible during testing.

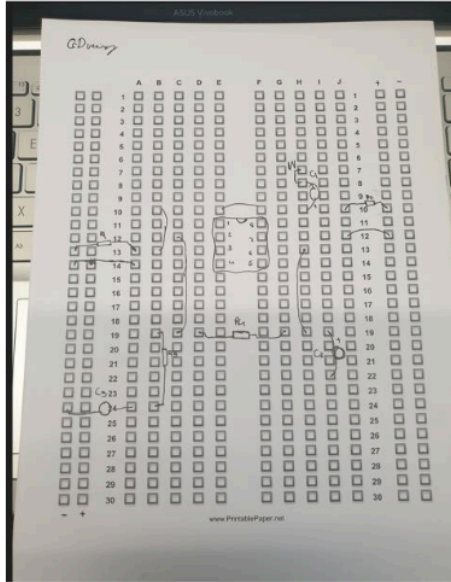


Figure 5: An image of the pin sheet used to plan the layout of the breadboard, with the inclusion of both grounding and power tracks

After the pin sheet was used to plan the breadboard, I then set about gathering the appropriate components and constructing a prototype of the circuit on the breadboard. Whilst constructing this prototype I endeavoured to keep any connecting wires between components as short as possible and to keep them flat against the board when possible too, this was mainly done for the sake of neatness and best practice however in more extreme circumstances, unnecessarily long connecting wires can sometimes become antennae accidentally and introduce unintended noise into the circuit.

In addition to keeping connections as short as possible, I also deviated slightly from my pin sheet plan, as, in practice I positioned my components closer together than I initially intended. This was due to one again, wanting to keep my connections as short as possible, whilst also being due to not wanting to take up too much room on the breadboard which was quite a bit smaller than the A4 sized pin planning sheet.

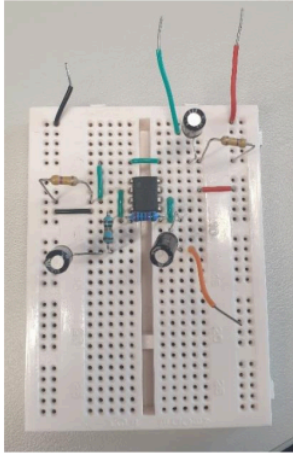


Figure 6: The constructed prototype of the amplifier circuit on breadboard.

After constructing the bread board, I set up a series of test equipment in order to test the frequency response of the amplifier circuit in the same manner with which I simulated the circuit previously. The equipment I set up in order to do this included; a benchtop power supply, a signal generator, oscilloscope probes and an oscilloscope.

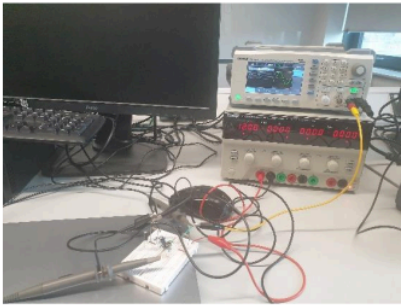


Figure 7: Image depicting the test equipment and setup that was used to test the breadboard, image features a signal generator and power supply

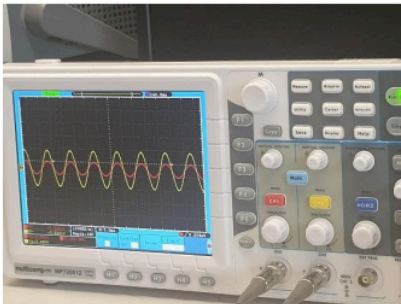


Figure 8: Images depicting the test equipment and setup that was used during breadboard testing. Image features Oscilloscope and a live reading from the breadboard.

When performing testing, the two oscilloscope probes were connected to the input and output pins of the circuit, this was in order to record the amplitude of the input waveform as well as the waveform produced after amplification and then use the both of them in the

previously mentioned formula $Gain(dB) = 20\log_{10}(\frac{V_{out}}{V_{in}})$ in order to calculate the actual measured gain and then compare to the simulated results mentioned previously. The parameters used for testing were an input waveform with an amplitude of 2Vpp with a frequency ranging from 1 Hz to 500 KHz, The breadboard was powered by 12V supplied by the benchtop power supply. The results gained from this testing were then used to create the table and plot shown in Figure 8.

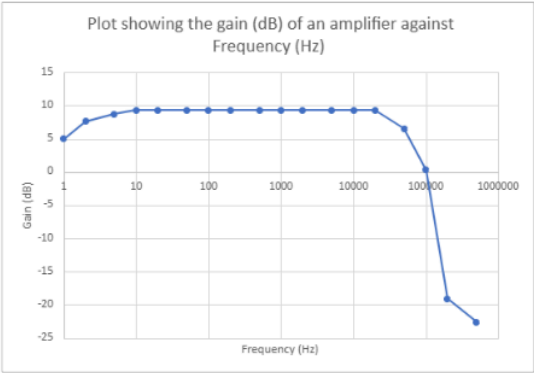


Figure 9: A table of results and graph, depicting the frequency response of the amplifier circuit

Freq	Vin	Vout	Gain (dB)
1	1.44	2.56	4.997549464
2	1.84	4.4	7.57269707
5	2.08	5.68	8.725700015
10	2.08	6.04	9.259472073
20	2.08	6.08	9.316804886
50	2.08	6.08	9.316804886
100	2.08	6.08	9.316804886
200	2.08	6.08	9.316804886
500	2.08	6.08	9.316804886
1000	2.08	6.08	9.316804886
2000	2.08	6.08	9.316804886
5000	2.08	6.08	9.316804886
10000	2.08	6.08	9.316804886
20000	2.08	6.08	9.316804886
50000	2.08	4.4	6.50778683
100000	2.16	2.24	0.315885344
200000	2.16	0.24	-19.08485019
500000	2.16	0.16	-22.60667537

Table 2: A table of results depicting the frequency/gain measurements of the amplifier circuit

70.7% of Vout	4.299V	Lower Bound	1.939HZ
		Upper Bound	53KH
GBP	159000		

Table 3: a set of calculations for the frequency bandwidth of the circuit as well as the Gain Bandwidth Product (GBP) using the formula $GBP = \text{Bandwidth} * \text{Gain}$

The results above are very similar to the simulated results depicted earlier in the logbook but with some differences such as a much steeper drop off in gain than the simulation. These differences can be explained by a variety of factors, these include things such as the simulation software not taking factors like component tolerances into account as well as the input voltage from the benchtop power supply not being 2 Vpp exactly and instead being slightly different like 2.08V or 2.16V.

Final Circuit Build:

After the breadboard was built and tested, the PCB's had been created and delivered from the external company, this meant that the final iteration of the amplifier could be constructed, this was done by simply transposing the components from the breadboard prototype onto the corresponding component footprint on the PCB.

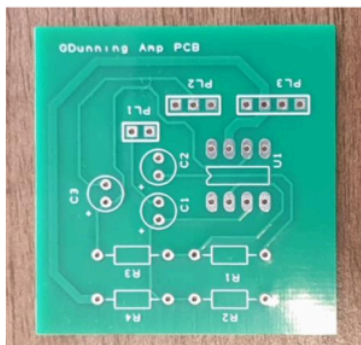


Figure 10: An image showing the final manufactured version of the PCB

This process of constructing the finalised PCB of the circuit was done via soldering, which involved the use of a variety of equipment such as, a soldering iron, fume extractor, solder (unleaded), tip cleaner and a croc clip stand. The clip stand was used to keep the board steady and stable whilst the soldering operations were taking place, in addition, the fume extractor was used to prevent the inhalation of potentially harmful solder fumes and finally the tip cleaner was used to maintain a clean soldering iron tip, which enabled more effective heat transfer between the iron and the contacts on the board. Initially it was difficult to solder effectively on the board, due to the available soldering iron being slightly too large for the scale of soldering being done, making it cumbersome. However after a while, the soldering technique was adjusted by changing the angle of application of the soldering iron in order to reduce the total surface area that was making contact the pads on the board, and the job became much easier. The methodology used when soldering the components to the board was to firstly solder the chip as it is the key component in the circuit and had the most pins on it, afterwards, groups of components were soldered onto the board as they were grouped together, as such, the pin headers were then next to be soldered, then capacitors and lastly,

the resistors. Great care was taken to ensure that the correct resistors were soldered in the correct places, the consequences of failing to do so would be significant as this would likely result in the gain of the amplifier being changed, rendering all previous testing and simulation calculations incorrect.

After the components were transposed and properly soldered onto the board, the same tests that were performed on the breadboard prototype were performed on the completed board. This included the standard frequency/gain tests that had been performed on previous iterations as well as calculating the upper and lower bounds of the circuit and calculating the total bandwidth and gain bandwidth product of the circuit.

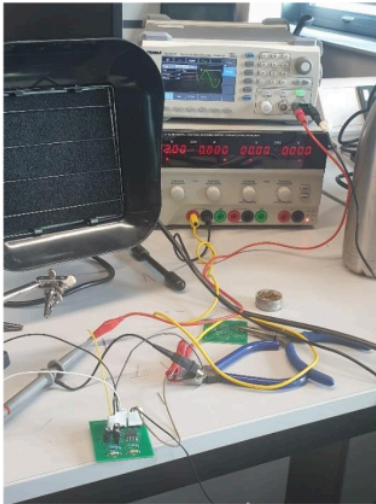


Figure 11: An image displaying the test setup for the finished PCB, the image also includes the waveform generator and benchtop power supply being used.

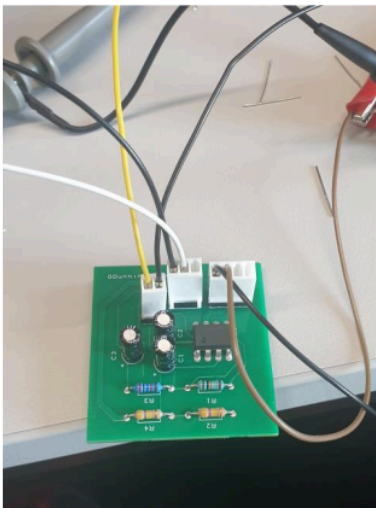


Figure 12: An image showing the final PCB with all the components soldered to it.

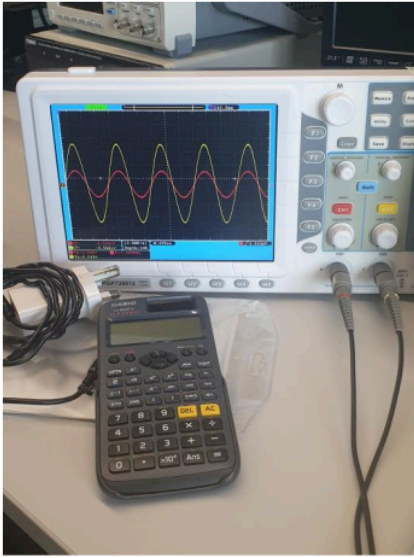


Figure 13: An image showing the Oscilloscope used for testing, displaying a live output from the PCB

When the testing was taking place the equipment used was the same that had been used for the breadboard testing previously (Power supply, Oscilloscope, Sig generator etc.) The results gathered from the testing can be seen below.

Freq	Vin	Vout	Gain (dB)
1	1.44	2.56	4.997549464
2	1.84	4.4	7.57269707
5	2.04	5.72	8.955317227
10	2.08	6.04	9.259472073
20	2.08	6.08	9.316804886
50	2.08	6.08	9.316804886
100	2.08	6.08	9.316804886
200	2.08	6.08	9.316804886
500	2.08	6.08	9.316804886
1000	2.08	6.08	9.316804886
2000	2.08	6.08	9.316804886
5000	2.08	6.08	9.316804886
10000	2.08	6.08	9.316804886
20000	2.08	6.08	9.316804886
50000	2.08	4.56	6.818030154
100000	2.08	2.32	0.948492999
200000	2.08	1.2	-4.777641778
500000	2.08	0.52	-12.04119983

Table 4: A table showing the final set of measured results from the PCB circuit

70.7% Vout		Lower Bound	1.915Hz
4.3V		Upper bound	52.700KHz
GBP	158100		

Table 5: A table showing the Gain Bandwidth Product calculations for the final set of measurements

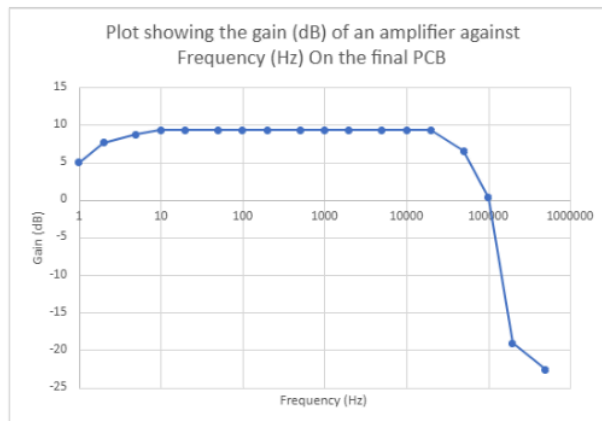


Figure 14: A Graph showing the Gain Frequency measurements of the completed PCB circuit.

As the testing shows, the recorded results from the testing show that the measured results for the final circuit are very similar to the results for the breadboard testing the only exception being measurements towards the higher frequency end of the spectrum, however this shouldn't be a cause for concern as it's out of the main operational bandwidth of the amplifier, this can be seen in the gain/bandwidth product table above.

Appendix:

LM741 Datasheet:

https://www.ti.com/lit/ds/symlink/lm741.pdf?ts=1729057566079&ref_url=https%253A%252F%252Fwww.google.com%252F

GD Logbook

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

79/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7



Comment 1

your table is separate and has its own caption

PAGE 8



Comment 2

You should always solder components on in height order - shortest first. This makes it much easier to fit the components. For this board, that means the order should have been: resistors, amplifier chip, pin headers, capacitors.

PAGE 9

PAGE 10

PAGE 11

GRADING FORM: SMU GENERIC_SMOSEY

GABRIEL DUNNING**78.50****ENGAGEMENT WITH LITERATURE***including reading, referencing, academic conventions and academic honesty*

There are no marks available for this section

0**KNOWLEDGE & UNDERSTANDING***Knowledge of the basic underlying concepts and principles of a subject.*

Excellent knowledge and understanding shown.

30**COGNITIVE & INTELLECTUAL***Evaluate underlying concepts and principles of a subject and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements.*

There are no marks available for this section

0

PRACTICAL APPLICATION SKILLS

Different approaches to solving problems in particular contexts.



Soldering 75% - Most joints have either too much solder or not enough.

Layout 60% - Components are spread too far apart, pin headers should be nearer the edge of the board. Some tracks could have been a lot shorter if better component positioning was adopted.

Populating 100% - All components fitted neatly to board.

Functioning 100% - PCB functions correctly
 $(75+60+100+100)/10=33.5\%$

33.5

TRANSFERABLE SKILLS

Communicate the results of their study/work accurately and reliably, and with structured and coherent arguments; the qualities needed for employment requiring the exercise of some personal responsibility within a structured and managed environment.



Can communicate professionally and, confidently in a suitable format.

Work is coherent, very fluent and is presented professionally.

15