

Charles H Workshop skills logbook

by Charles H

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WORKSHOP SKILLS LOGBOOK

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Module:

L4 – Workshop skills for electronics

ACDA 4022

Embedded Electronics Apprenticeship

Introduction:

This logbook is a record of the process of testing and creating a non-inverting amplifier with a gain of 3. The amplifier was made both breadboard and then moved over to PCB, from a pre-set design.

Design stage:

The first stage was to design the circuit in Proteus. This would allow it to be run as a simulation, and test that it functioned as intended. It would also mean measurements could be taken and assess the results and changes could also easily be made.

After running the simulation, data was taken to measure the gain of the amplifier across varying frequencies. At the time it was noticed that there was only an amplification of two, as the 20K feedback resistor had been set at 10k. The original data table is in the appendices.

The resistor was then corrected to 20K to get the 3-gain amplifier needed. The simulation was then re-run with the new value.

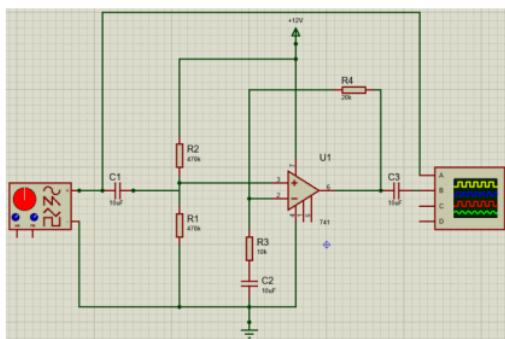


Figure 1 – Design of the circuit in Proteus.

TABLE I

BROAD SIMULATION RESULTS FROM PROTEUS

Frequency (Hz)	V in	V out	V Gain (dB)	Amplification
0.1	0.530	0.445	-1.5183172	0.839623
0.2	0.850	0.850	0	1
0.5	0.955	1.24	2.2683663	1.298429
1	0.985	1.77	5.0907407	1.796954
2	0.995	2.42	7.7198457	2.432161
5	1	2.88	9.1878498	2.88
10	1	2.96	9.4258342	2.96
20	1	2.99	9.5134238	2.99
50	1	3	9.5424251	3
100	1	3	9.5424251	3

200	1	3	9.5424251	3
500	1	3	9.5424251	3
1,000	1	3	9.5424251	3
2,000	1	3	9.5424251	3
5,000	1	3	9.5424251	3
10,000	1	3	9.5424251	3
20,000	1	3	9.5424251	3
50,000	1	2.89	9.2179569	2.89
100,000	1	1.64	4.296877	1.64
200,000	1	0.785	-2.1026069	0.785
500,000	1	0.350	-9.1186391	0.35
1,000,000	1	0.1875	-14.539975	0.1875
2,000,000	1	0.05	-26.0206	0.05
5,000,000	Simulation Failed			

The simulation used a sine wave with varying frequency with an amplitude of 1V.

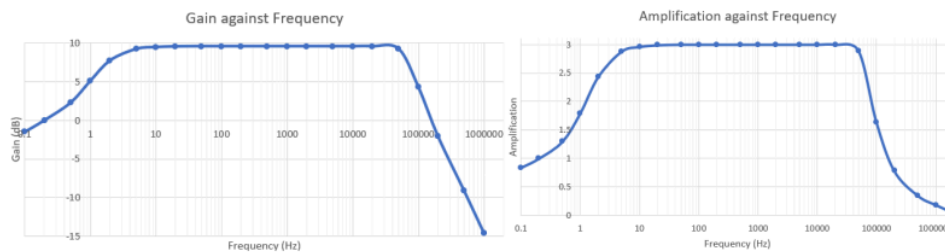


Figure 2 – Graph showing the gain (dB) against the range of frequencies.

Figure 3 – Graph showing output amplification against the range of frequencies.

During the simulations it was noted that the output wave began to deform at 50Khz and was triangular at 100Khz. From 500Khz upwards the output was extremely poor.

Gain-bandwidth product:

The gain frequency product is a characteristic of an amplifier which is a relation between the gain that the amplifier outputs and the frequency that the amplifier works with that gain up to. The gain bandwidth will never change. If the gain of the amplifier is modified by changing the resistors, then the bandwidth that it will output that new target gain will change to keep the gain bandwidth the same. The bandwidth is calculated by finding where the gain of the amplifier has dropped by 3dB from the gain. The gain product bandwidth is calculated by Bandwidth * gain.

TABLE II

GAIN-BANDWIDTH PRODUCT MEASUREMENTS FROM PROTEUS SIMULATION

Freq (HZ)	V in	V Out	Gain (dB)	Freq (KHZ)	V in	V Out	Gain (dB)
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2.1	1.02	2.34	7.21231		60	1.02	2.82	8.83298
2.05	1.02	2.16	6.51707		70	1.02	2.62	8.19402
2	1.02	2.12	6.35471		80	1.02	2.34	7.21231
1.9	1.02	2.06	6.10534		90	1.02	2.12	6.35471
1.7	1.02	1.92	5.49402		100	0.9975	1.64	4.31862
1.5	1.06	1.74	4.30487		120	1	1.37	2.73441
1	0.985	1.77	5.0907407		115	0.9975	1.42	3.06751
0.9	0.985	1.69	4.6890095		116	0.9975	1.41	3.00612
0.5	0.955	1.24	2.2683663		117	0.9975	1.40	2.9443

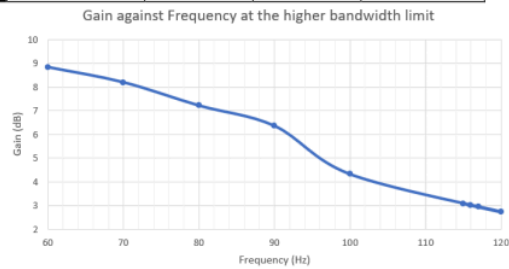
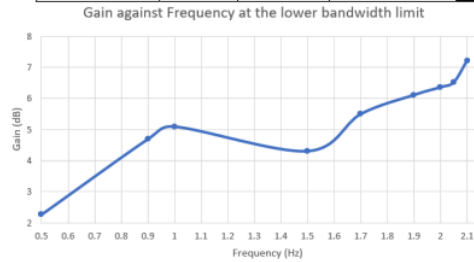


Figure 4 – Graph showing the gain against the frequency at the lower bandwidth limit in proteus simulation.

Figure 5 – Graph showing the gain against the frequency at the higher bandwidth limit in proteus simulation.

Since the lower bandwidth is only a couple of hertz, it becomes negligible when taken away from the higher limit. The gain-product bandwidth of the proteus design is $90,000\text{Hz} \times 9.54\text{ dB} = 858,600\text{Hz}$, rounding to $860,000\text{Hz}$ at 2.S.F.

PCB Design:

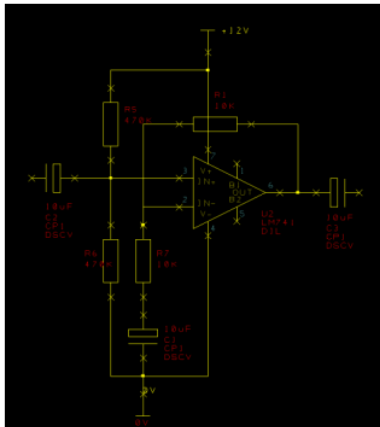


Figure 6 - Circuit design in easy-PC.

TABLE III
COMPONENTS USED:

Components	Used Label	Ideal Label
2x 470K Ω resistors.	R5 + R6	R1 + R2
1x 10K Ω resistor.	R7	R3
1x 20k Ω resistor.	R1	R4
3x 10uF capacitors	C1, C2, C3	C1, C2, C3
1x OP-Amp UA417CP	U2	U1

The labels aren't consecutive as during the design process in easy-PC, components were added and then deleted, which retained the numbering already used. It wasn't realised at the time, and the design had already been sent for creation once it was.

The first stage of design for the PCB was creating the circuit diagram within Easy-PC, copying it over from proteus. It was made as a duplication of the design in proteus with each component in a similar place, so if an issue was noticed later its much easier to compare.

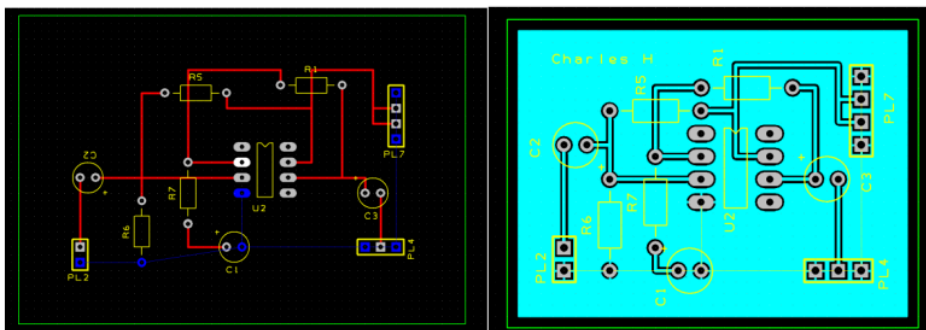


Figure 7 (left) - First PCB design.

Figure 8 (right) - Final PCB Design.

The next stage was creating the PCB design. I started with laying the components required out on a large board and ensuring that the traces were connecting the components properly. Space was not a concern as it could be shrunk down. The traces were made short while using components to bridge over other traces, instead of taking a long winding route round. One of the main concerns was diagnosing any issues on the board if it was too small. To avoid the components getting in the way, the traces were moved onto the back of the board. It also means that it would be easier to follow traces on the back rather than trying to look under components, and so the board could be made even smaller. It wasn't made as small as it could, as it's the first board the creator made and it was thought that making it too small would become challenging to solder together.

Instead of making traces for ground/0V, the back of the board had a ground plane. A small gap was left between the edge of the ground plane and the edge of the board.

Breadboard Design:

The amplifier was then created on a breadboard. Ideally this would be done before the PCB creation, however it was done after due to lead times on the PCB creation. Making the circuit on a breadboard meant the simulation data could be compared to the physical circuit and any differences found.

The circuit design was converted onto a paper printout of a breadboard first to ensure all components could fit on the board and laid out easily. This also makes it easier to put together and check the components are in the right place. The breadboard design was started with the largest component in the centre of the breadboard, the comparator, and worked outwards from the first pin in a counterclockwise direction to avoid skipping any pins. Each component was then checked to make sure its own individual connections were correct, and if correct the board should have no issues. The breadboard was then put together in the same style.

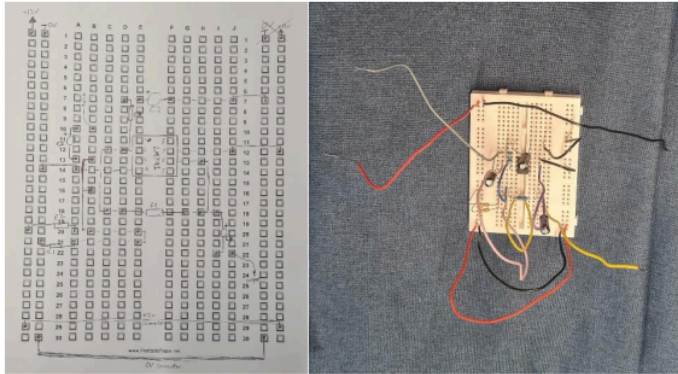


Figure 9 – Breadboard design on paper.

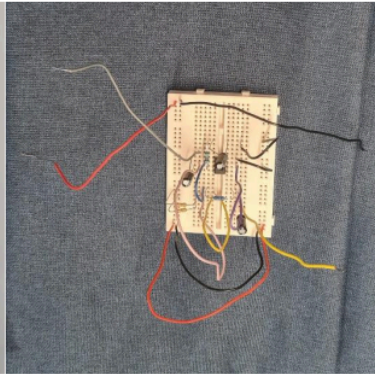


Figure 10 – Photo of the breadboard after creation.

Breadboard Testing:

The breadboard circuit was then tested using the same method as the proteus test. At first it didn't have any output wave, as the first 470K resistor was going into the wrong row, and the yellow wire connecting the two 470K resistors wasn't in properly either. The results from testing one the issues were fixed are shown below.

The oscilloscope used for measuring both input and output was a MP720012 by Multicomp. The power supply was a 72-13300 and the wave generator was a 72-14111 by Tenma. The same equipment was used for testing the PCB later.



Figure 11 (left) – signal generator.

Figure 12 (middle) – power supply.

Figure 13 (right) – Oscilloscope.

TABLE IV

BROAD RESULTS FROM BREADBOARD

FREQUENCY (HZ)	V IN	V OUT	V GAIN (DB)	V AMPLIFICATION
0.05	2.08	1.12	-5.376906246	0.538461538

0.1	2.08	1.60	-2.278867046	0.769230769
0.2	2.08	2.08	0	1
0.5	2.08	2.88	2.826583056	1.384615385
1	2.08	3.76	5.142490199	1.807692308
2	2.08	5.04	7.68734403	2.423076923
5	2.08	5.84	8.966990243	2.807692308
10	2.08	6.00	9.201758308	2.884615385
20	2.08	6.00	9.201758308	2.884615385
50	2.08	6.00	9.201758308	2.884615385
100	2.08	6.08	9.316804886	2.923076923
200	2.08	6.08	9.316804886	2.923076923
500	2.08	6.08	9.316804886	2.923076923
1,000	2.08	6.08	9.316804886	2.923076923
2,000	2.08	6.08	9.316804886	2.923076923
5,000	2.08	6.08	9.316804886	2.923076923
10,000	2.08	6.16	9.430347544	2.961538462
20,000	2.08	6.08	9.316804886	2.923076923
50,000	2.08	4.08	5.851936563	1.961538462
100,000	2.08	2.08	0	1
200,000	2.08	1.04	-6.020599913	0.5
500,000	2.08	0.480	-12.73644195	0.230769231
1,000,000	2.08	0.320	-16.25826713	0.153846154
2,000,000	2.08	0.160	-22.27886705	0.076923077
5,000,000	1.92	0.160	-21.58362492	0.083333333
10,000,000	1.52	0.080	-25.57507202	0.052631579

During the testing of the breadboard, it was noted that the input wave was inconsistent below 2Hz and very poor at 0.5Hz. Going up from 10KHz it had the same issues as the proteus simulation.

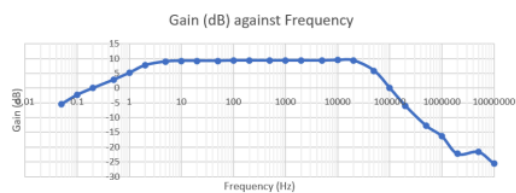


Figure 14 – Graph showing the gain against the range of frequencies on the breadboard.

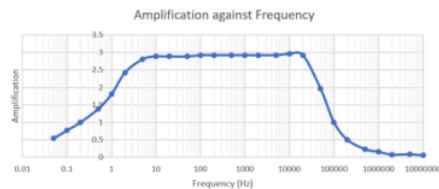


Figure 15 – Graph showing the output amplification against the range of frequencies on breadboard.

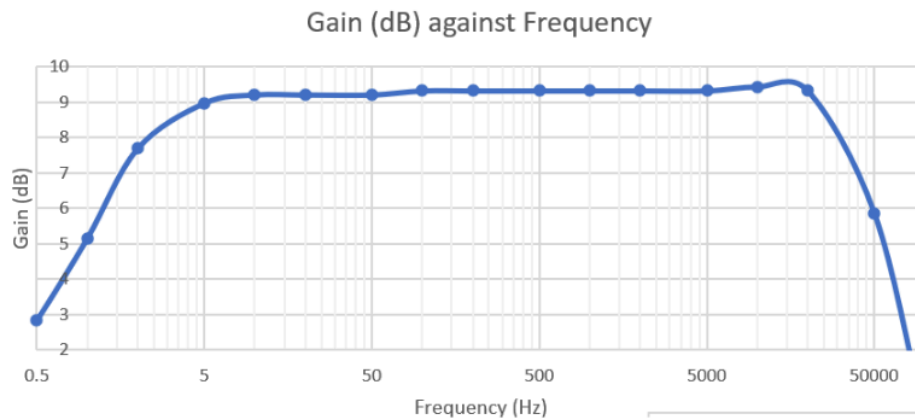


Figure 16 – Graph showing the frequency between 0.5Hz and 100KHz where the gain is greater than 0dB.

A gain-product can't be calculated directly as the data wasn't collected at the time, however, can be interpolated from the data above. Compared to the simulation data, the performance drops off much earlier on the breadboard. The higher limit of the bandwidth is roughly 45KHz in figure 13. This is much lower than the expected value from the simulation, which suggests that either the simulation data is incorrect, or the breadboard has another undiagnosed problem which is more likely as the output wave showed the same deformation behaviour as the simulation. The gain-product bandwidth of the breadboard is $45,000 \times 9.3 = 418,500$ which is 420,000 at 2.S.F.

Soldering onto PCB:

The process used for soldering the components to the PCB was first straightening the component leads when they come out of the breadboard. For resistors, one side was bent over and poked through the via. The resistor was then picked up using the pliers where the second leg covered the hole and then bent there and put back in. For other components with legs coming from beneath, then were put straight in place. For components with long legs, one side was bent beneath the board to hold it in place. The other side was cut short and then soldered before doing the second leg/ For the components without long legs, they were held in place with a clamp to get one pin connected. If it wasn't in properly, the solder joint was heated to then reposition the component. The clamp could then be removed from the component to complete the rest of the joints.

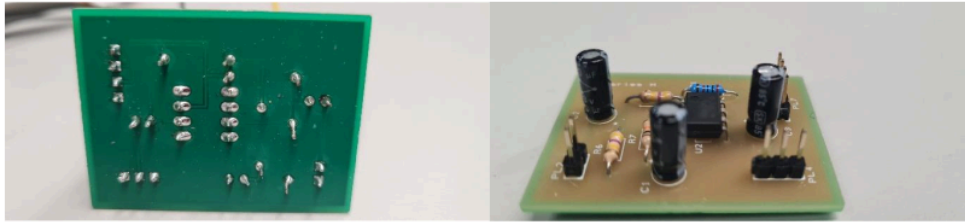


Figure 17 (left) - Back of PCB after soldering.

Figure 18 (right) – top of PCB after soldering.

Testing PCB:

At first the PCB didn't work, and the output showed the same curve as a capacitor charging. The capacitors were then checked to make sure they were orientated correctly to the silk screen which they were. The silkscreen was then checked to the proteus design, and the issue was that the C2 capacitors silk screen was the wrong way round. Once fixed the circuit worked. The gain throughout the range was not recorded once the PCB was built because it got forgotten about, however it did perform similar to the simulation. The gain-bandwidth product was calculated, and the testing results are shown below.

TABLE V
GAIN-PRODUCT TESTING FROM PCB

Freq (HZ)	V in	V Out	Gain (dB)		Freq (HZ)	V in	V Out	Gain (dB)
2.2	1.04	2.24	6.66429		90	1.04	2.32	6.96909
2.1	1.04	2.2	6.50779		95	1.08	2.2	6.17998
2	1.04	2.16	6.34841		100	1.08	2.12	5.85824
1.5	1.04	1.76	4.56959		110	1.08	1.92	4.99755
1.4	1.04	1.68	4.16552		130	1.08	1.64	3.6284
1.1	1.04	1.36	2.33011		140	1.08	1.52	2.9684
1.3	1.04	1.52	3.29621		138	1.08	1.56	3.19402
1.2	1.04	1.44	2.82658					
1.25	1.04	1.52	3.29621					

The gain was originally calculated using 3dB at the target and provided in the appendices.

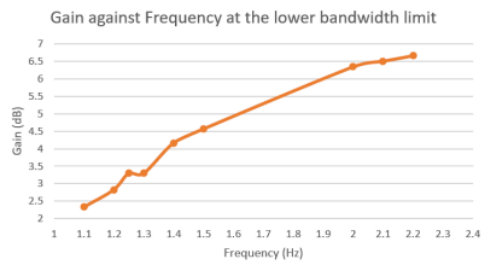


Figure 19 – Graph showing the gain against frequency at the lower bandwidth limit on the final PCB.

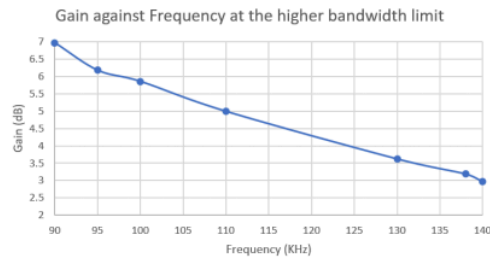


Figure 20 – graph showing the gain against frequency at the higher bandwidth limit on the final PCB.

The lower bandwidth limit can once again be ignored as it becomes negligible. The higher bandwidth limit is roughly 93KHz from figure 15. That maxes the gain bandwidth product be $(93,000 \times 9.31) = 865,830$ or 870,000 at 2.S.F.

Because of the inaccuracy with taking the bandwidth, 90KHz and 95KHz were used to give a high and low limit which are 837,900 which becomes 840,000 and 884,450 which becomes 880,000 both to 2.S.F.

The simulated value was 870,000Hz at 2.S.F which is exactly the same as the results from the PCB, showing that there must have had another issue with the breadboard not identified at the time.

Charles H Workshop skills logbook

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

77 /100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11



Comment 1

Your GBP should be calculated using the gain as a ratio, not in dB

GRADING FORM: SMU GENERIC_SMOSEY

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.



Knowledge is extensive. Exhibits understanding of the breadth and depth of established views.

26**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 70% - Very good but some joints have too much solder on them. Some component leads could have been trimmed shorter.

Layout 70% - Not too bad although the components could have been closer together. I was expecting to see a double sided PCB.

Populating 100% - All components fitted flush to PCB with no gaps beneath.

Functioning 70% - PCB does not function correctly
- C1 is reverse polarity so the signal is clipped.

$(70+70+100+70)/10=36\%$

36

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