Software and Embedded Systems 2: Circuit report

Audio Amplifier Circuit

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1 Introduction

This report focuses on building and testing a microphone circuit. We first started by looking at building an audio amplifier circuit. This circuit was made using a current source of 3μ which can be assumed to represent a voice signal. The circuit was then made and tested on LTspice. When tested and operational the circuit was recreated on a breadboard. The breadboard was then tested before running code on it. When running the code the microphone recorded for 6 seconds and the data was recorded on a computer. The data was then plotted on Mathlab and from this, it was possible to turn the data into an audio file and play it back on the computer.

2 Circuit design

2.1 Initial circuit design

During the week 3 lab, the task was to design an audio amplifier circuit that would result in an output of at least 1V peak-to-peak output and test it on LTspice initially the circuit had different component values. The circuit submitted on week 5 is shown in the appendix.

2.2 Final circuit design

The circuit worked fine until week 9 where the circuit was tested. Due to some issues that I did not control, I had to change the component values, and the final circuit design was obtained. This final circuit was also designed to look more like it should be on a breadboard making it easier to build. The final circuit is also shown in the appendix.

After looking at the data sheet it can be seen that the optimal value for R0 is 2.2kΩ and 1μF for C_0. In this case, the capacitor operates as a high-pass filter. To prevent altering the function of the circuit this is required to prevent the DC current from the microphone. It was then possible to start choosing values for the rest of the resistors and capacitors. In the brief, the cut-out frequency was advised as 3.3kHz (for C1).

$$Gain = \frac{R_2}{R_0 + R_1}$$

To create an LPF with a gain of 100 the equation above is used to determine values for R_1 and R_2. For simplicity let's make the value of $R_1 = R_0$. Using this the value of R_2 can be calculated to be 440kΩ. The closest resistor found in the lab is 470kΩ and this will give us a gain value of 107. Using the cut-off frequency of 3.3kHz and the equation below.

$$f_0 = \frac{1}{2\pi R_2 C_1}$$

Which we can rearrange to get C_1.

$$C_1 = \frac{1}{2\pi R_2 f_0}$$

$$C_1 = \frac{1}{2\pi \cdot 470 \cdot 10^3 \cdot 3 \cdot 10^3} = 112.9pF$$

Rounding this calculation up to the nearest E12 value gives us 100pF and a cut-off frequency of roughly 3386.3Hz.

As the Nucleo board is used to power the circuit only 0 and 3.3V are available. Therefore the output has to be centered around 1.65V to make the halfway point of the signal to get the full range.

$$V_{\text{out}} = V_2 \cdot \left(\frac{R_4}{R_3 + R_4}\right) \cdot \left(\frac{R_1 + R_2}{R_1}\right)$$

In our circuit for the DC analysis, we are assuming that $R_1 \approx \infty$ we can ignore the second part of the equation as it acts as an open circuit.

As V_2 is equal to 3.3V and I have chosen the values for R_3 and R_4 to be 10kΩ this yields V_{out} to be 1.65V.

In addition to the main circuit, there are 3 other smaller circuits that were made. Firstly, two capacitors are connected in parallel to reduce the noise coming from digital circuits on the STM32Nucleo board. Secondly, we connect an LED to test and be able to see if the 3.3v is connected. Finally, the third circuit is made to test the output of the analog-to-digital converter.

3 Circuit testing

After building the circuit on a breadboard it was tested. The first test was made using the circuit with the LED. The LED being on showed that the voltage was applied successfully in the circuit. In order to test the DC voltages across the circuit the microphone was removed and the voltage was measured. The DC voltage measured at the inverting and non-inverting input was calculated to be around 1.65V and then measured at 1.6V. The same was measured at the output, but as time went on the voltage started decreasing. This could be due to the parasitic capacitance in the circuit.

After conducting those tests the microphone was placed back in its place. The code copied directly from the slides was then added to the STM project and was then debugged and run. Furthermore asked one of my peers to sing his favorite music within 30 centimeters of the microphone. Following the code being run, putty started outputting numbers on the screen (mentioned in the brief as 24 000 lines for one block of 3 seconds). I waited until the ADC values finished outputting. This took longer than the 6-second recording as there were a lot of values to output on the terminal. The data was then collected in a single text file and was then processed in MATLAB. The plot shows how some frequencies were amplified and not others due to the bandpass filter. As the wav file was created I heard the sound that we previously sang to the microphone and the quality exceeded what I thought this small microphone was capable of.

4 Final conclusion

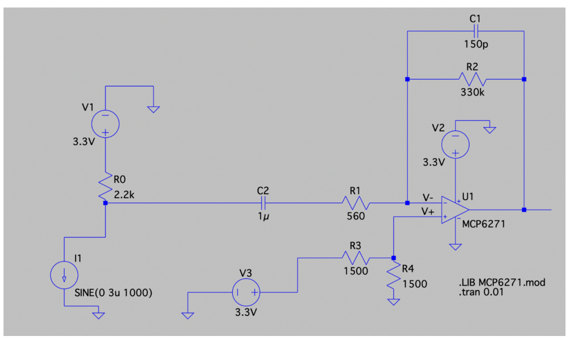
- The gain was similar enough to the one calculated previously that error where said to be ignored.
- Due to the high gain, certain louder samples encountered clipping because the output voltage surpassed the supply range and exceeded the values readable by the ADC.

Appendix

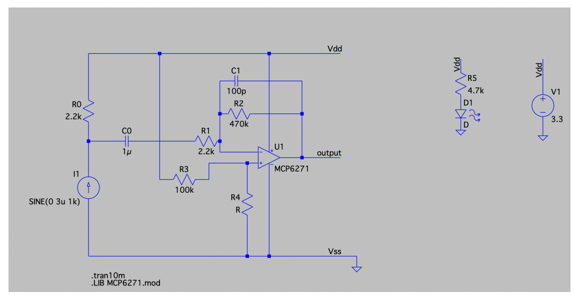
References

- The slides with the basic to build a circuit on LTspice use the slides from week 3 "Amplifier part 1"
- The basic STM32 configuration uses slides from week 5 "Embedded Systems Overview"
- The slides to set up the breadboard and the test circuits came from week 7 "STM32 Nucleo Slides"
- Learning how to use putty was also taken from week 7 under "Putty Instruction"

LT Spice Circuit Diagram



(a) Initial circuit made in week 3



(b) Final circuit design

Figure 1: Comparison of initial and final circuits

Result LTspice circuit

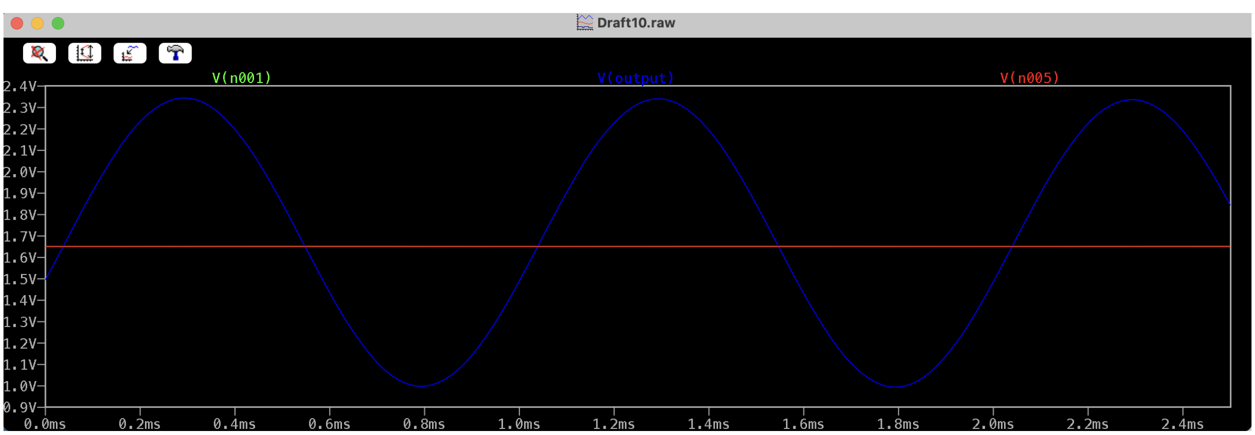


Figure 2: Result graph

Breadboard Picture

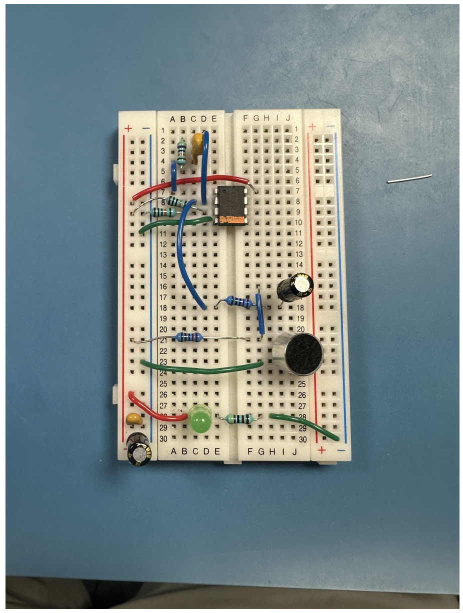
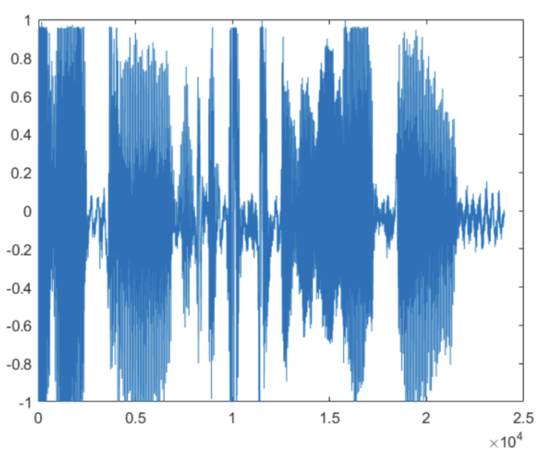
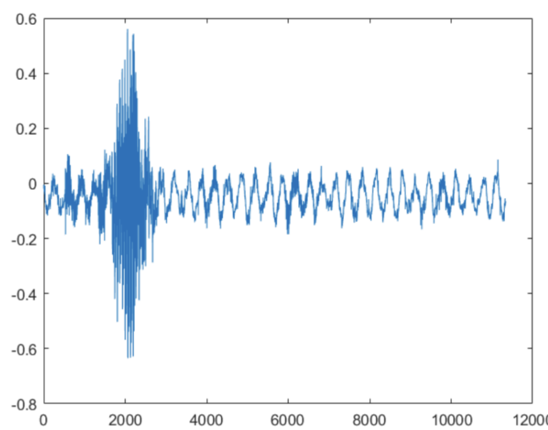


Figure 3: Breadboard picutre

Result signal



(a) signal 1



(b) Signal 2

Figure 4: Breadboard and result signals