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EE 313 LAB06

Lab Exercise 6 BJT Audio Amplifier

In this lab we were tasked with designing and implementing an Audio Amplifier by following the circuits given in our textbook page 445. 3 stages are given in the textbook however we do not need the first stage in this design. We will only need Gain and Output stage.

The Gain stage is given as a common-emitter amplifier(e) and the output stage is a common-collector amplifier.

By using the values given in the book and with some minor adjustments I have designed this circuit in the LTspice software:

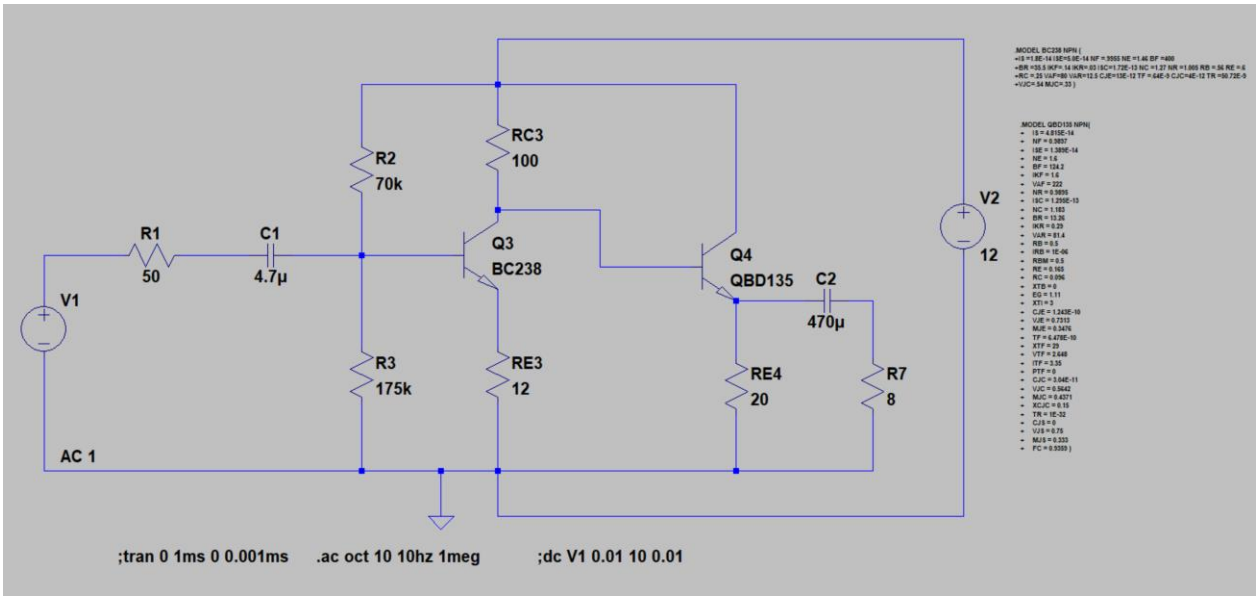

Figure 1 (LTspice implementation with official transistor models)

In this implementation I have found the real values of the respective transistors and add them as SPICE models in ".model" format in order to get closer results to the real life implementation.

Simulation Results

At 1Khz we see these waveforms:

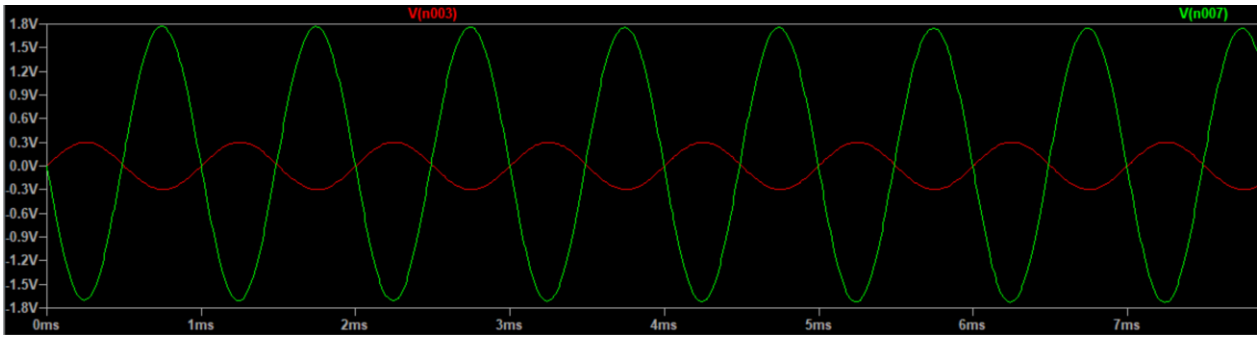

Figure 2 (V (n003) is input at 1Khz and V(n007) is output)

We can see the Gain in the pass band is around 6 times which corresponds to around 15 dB of gain.

The input is in here 0.3V and there is no distortion. The distortion starts around 0.4V in this configuration.

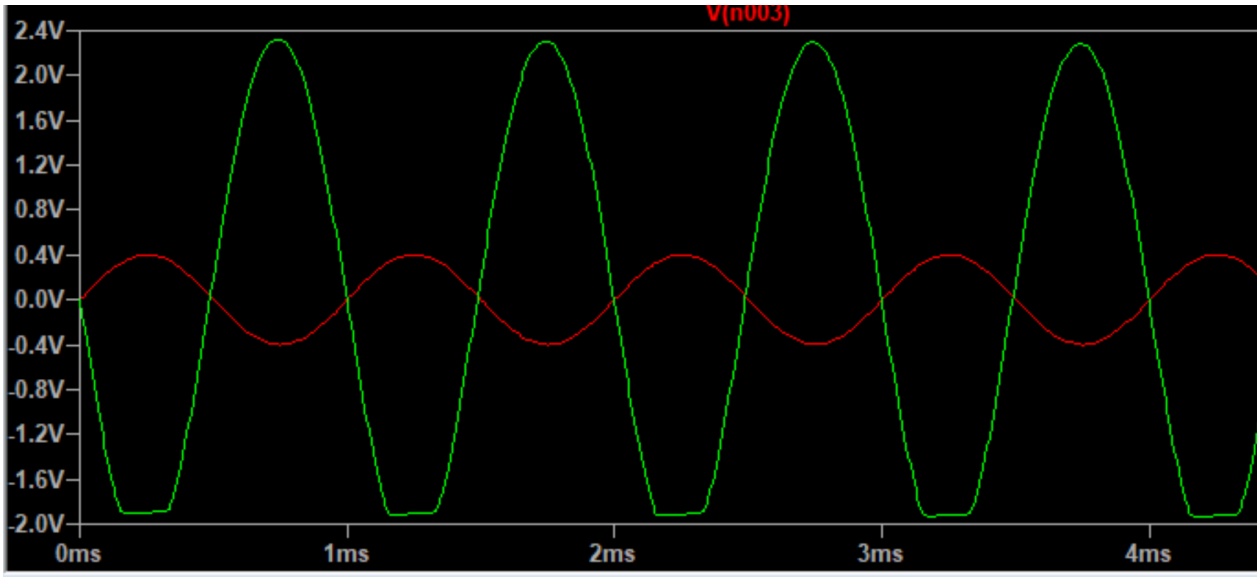

Figure 3 (Distortion can be seen after 0.4 Volts)

Lastly I have run my simulation to see frequency range of this amplifier:

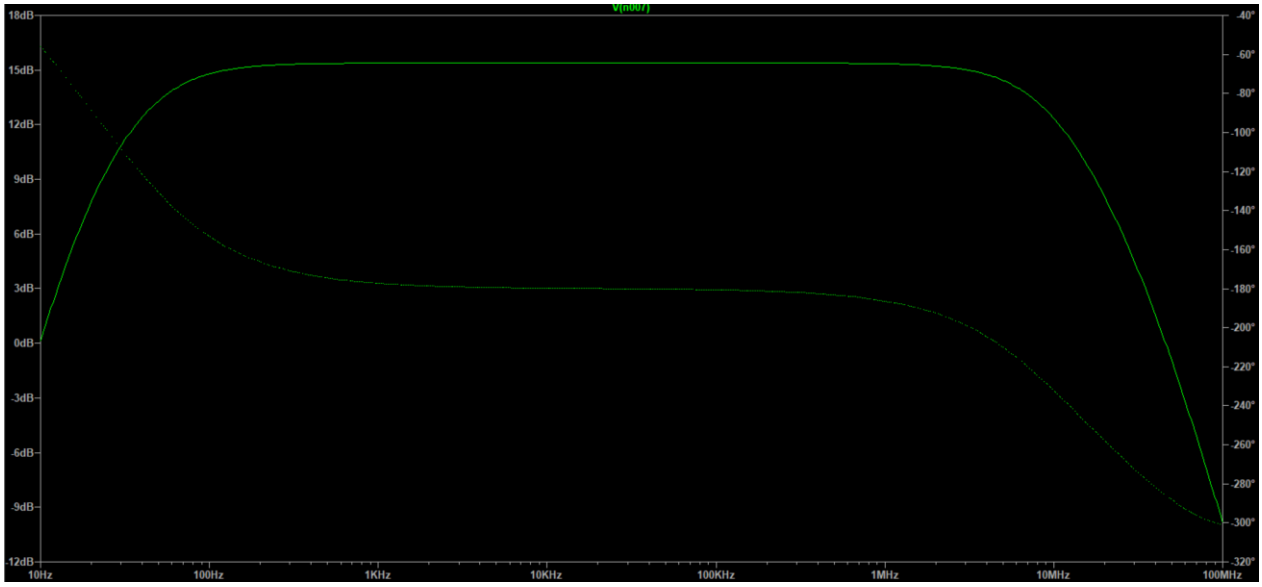

Figure 4 (Frequency Range)

As we can see in the pass band the gain is around 15dB which is consistent with previous simulation result as expected. In addition, we can see that the gain drops in the very high and the very low frequency range. Also there is a noticeable phase difference as well.

Lab Implementation

I have implemented my circuit in the lab exactly as the LTspice model. (The 20Ω resistor started to burn little bit after some time but I have get my readings before that)

This is my circuit:

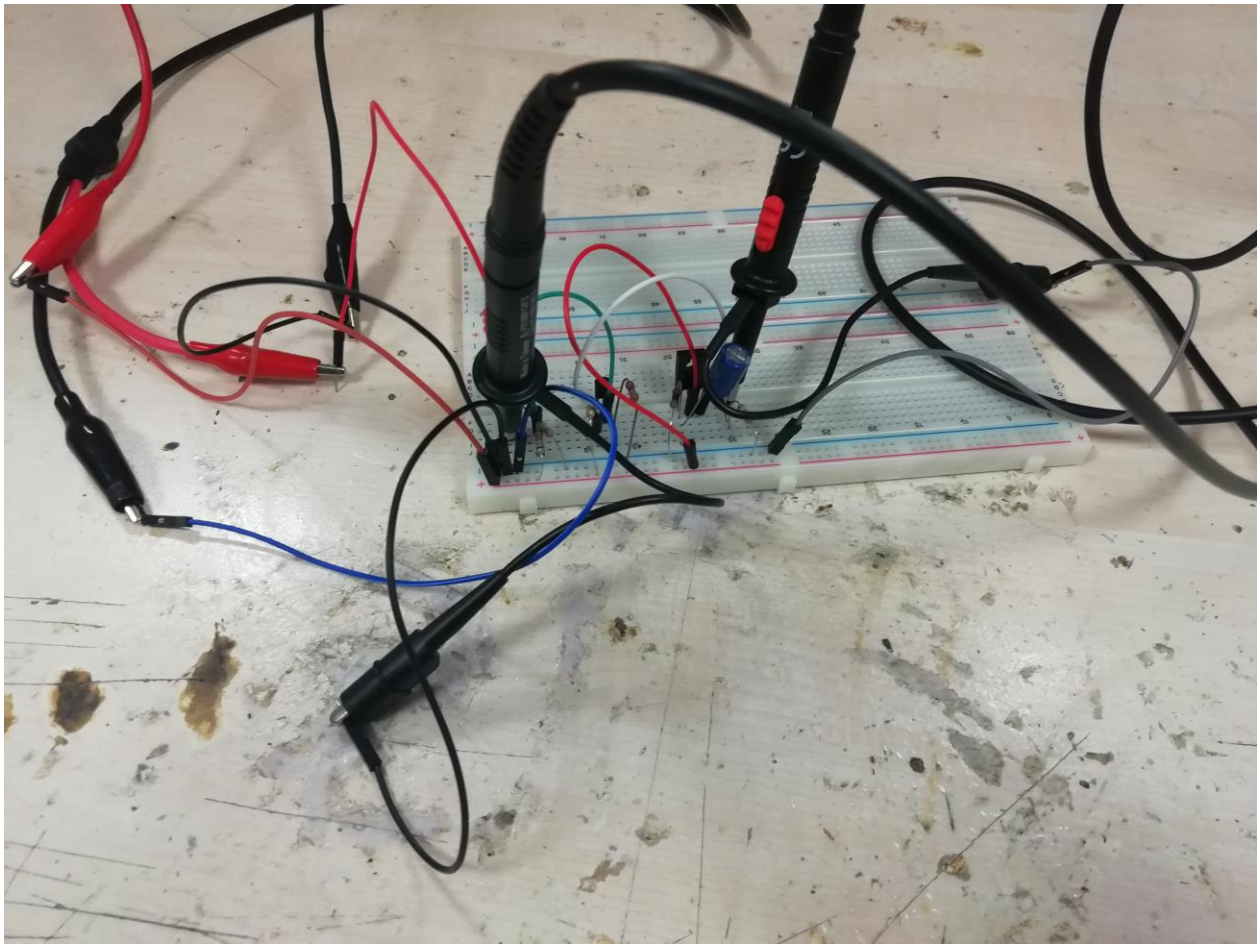

Figure 5 (Lab implementation)

At 1 Khz I have observed this waveforms:

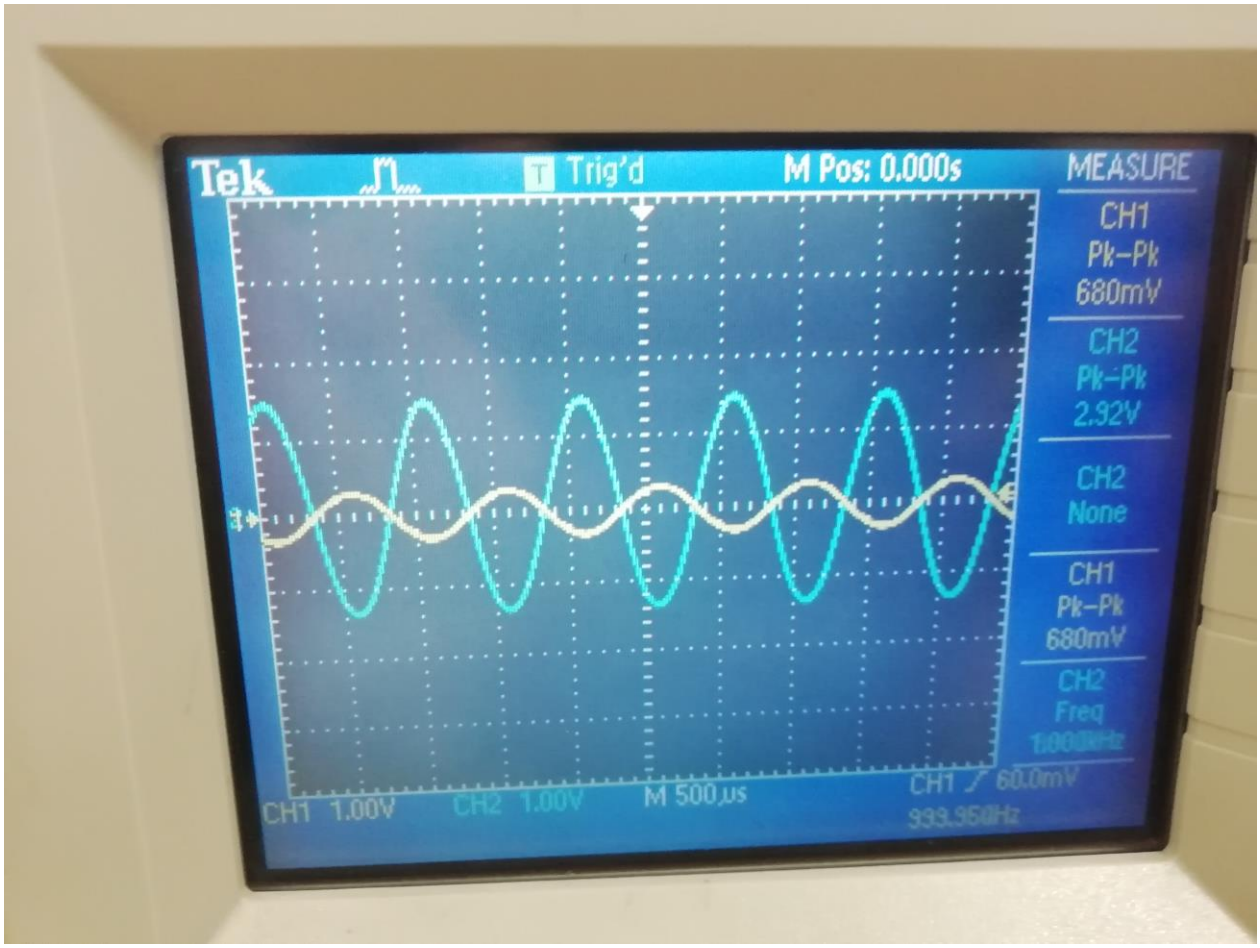

Figure 6 (Yellow is input, Blue is output Gain is around 5)

The resulting waveforms are very similar to the simulation results. However the gain appears to be decreased to 13dB from 15 dB. This minor decrease expected in real life implantation since I could not find exact resistor components.

I have also checked 20Hz and 20kHz as instructed.

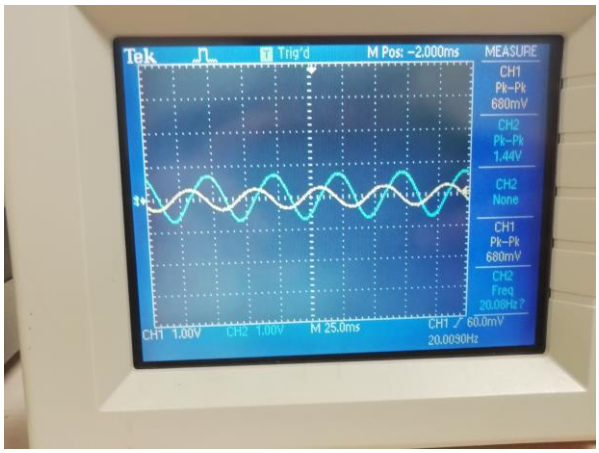

Figure 7 (20 Hz)

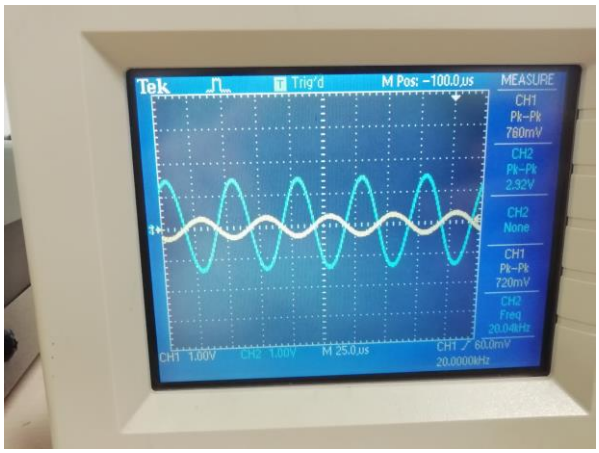

Figure 8 (20Khz)

We can see that the 20Khz is easily inside the pass band. For 20Hz signal the gain decreased slightly because it is very low low frequency. In simulation we have observed that less than 100Hz signal started to yield less and less gain and more phase shift. This also appears to be the case in the real life implementation.

At 100Hz:

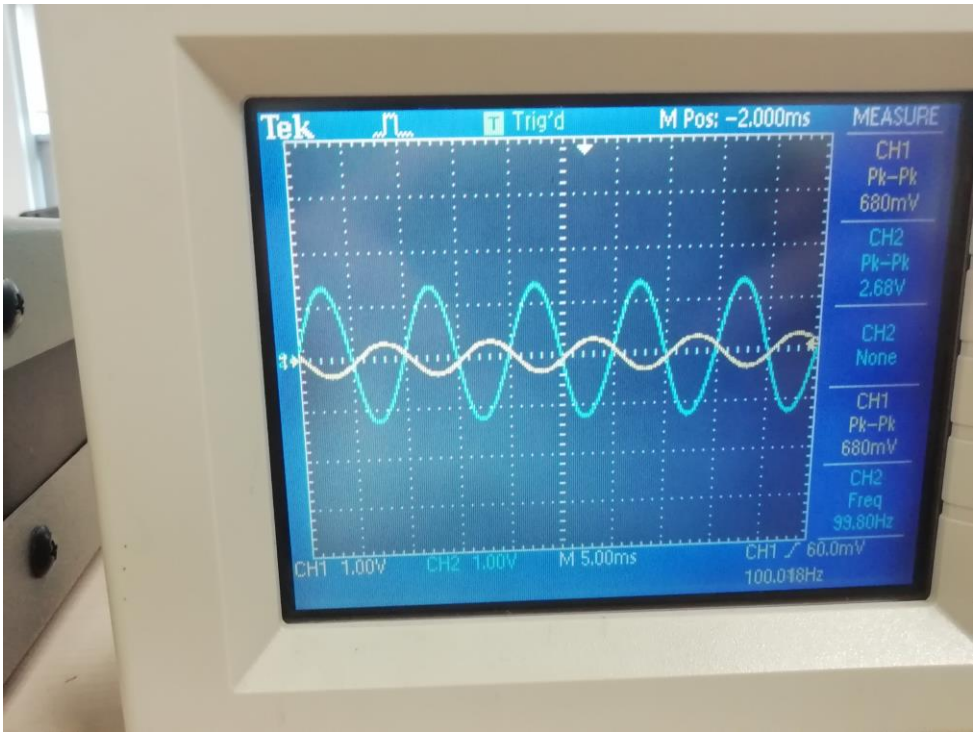

Figure 9 (100Hz)

At 100Hz the gain is around 12 dB which is very close to the expected value.

In all of these plots the input was 0.3Vpeak-to-peak. It started to distort after 0.4Volts as we expected from the simulation results. Also the transistor were okay at kHz RANGE BUT IN MHz range the results became very unstable the transistor did not work very well under 20Hz and above the 10MHz limit.

Conclusion

In this lab we have constructed a BJF audio amplifier by using the generalized design given in our text book. There were three stages in original design but we have assumed that our audio source was low impedance thanks to that we were able to skip the input buffer stage. The gain stage gave us around 15 dB(6 times) gain in simulation and 13dB gain in the lab implementation. The output stage was common collector BJT circuit which acts as a buffer between output of gain stage and the output voltage. Output stage gain should be close to 1. Gain was around 0.985 in our case which is reasonably close. With all the stages we were able get an audio amplifier circuit that gives us the 5 times the input signal at the output.

The simulation results were pretty close to the real life implementation of the circuit. The gain is dropped little bit but not an unreasonable amount. Also as we saw in simulations the pass band is between 100Hz and 10MHz outside of this range the gain starts to decrease from desired 15dB value. Naturally the parasitic and coupling capacitors cannot be ignored in these extreme frequencies. They will start to effect the results in very high and low frequencies.

Overall we have become familiar with a basic BJF audio amplifier and learned to design and implement such systems in software and real life environment.