Student 1 : Furkan Ersüllü2374916
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Assistant : Mehmet Çetinkaya

Date :8/12/2019
Group : Monday Afternoon

EE213 Pre-Report

Introduction

In this project, our goal is to design a sound level detector circuit that contains pulse width modulation circuit to adjust the duty cycle of signals with respect to environmental sound level and displays those different duty cycle by a LED. Our circuit design generally consists of 3 units. The first unit, the input unit, consists of a microphone circuit that converts environmental sounds to our input voltage. The decision unit, which is the second unit, consists of a circuit which produces PWM signals according to the 4 different sound levels requested from us by evaluating the received input. The output unit, which is the last unit, consists of a LED circuit that flashes according to the PWM signals produced and shows us the sound level.

Overall Circuit Block Diagram & Explanations

Input Unit

a) Electret Microphone Circuit

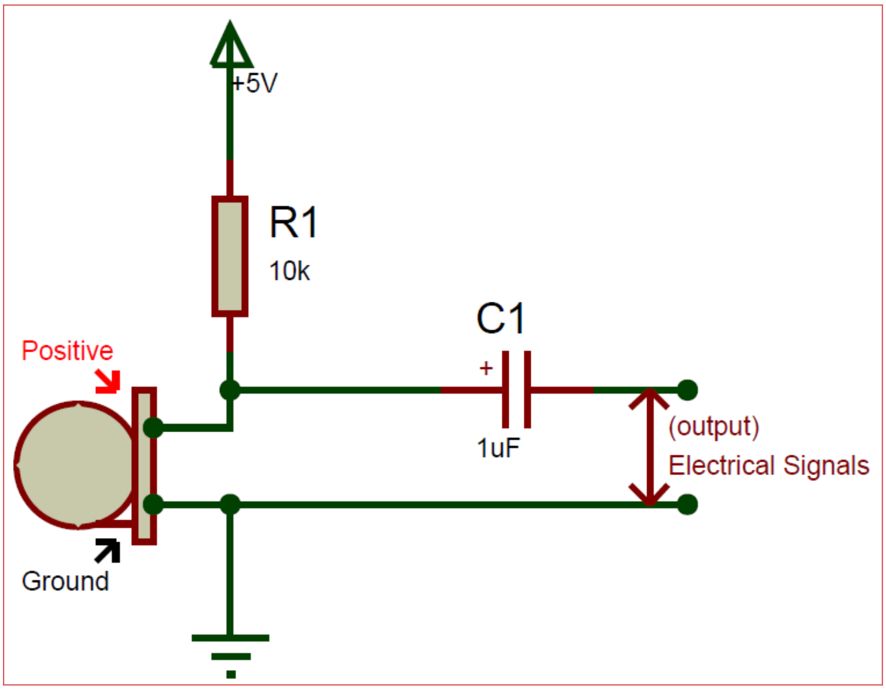

Figure 1: Microphone Circuit

Since we can only use analog components, we decided to use an electret microphone to detect environmental sounds as our input. An electret microphone is a type of electrostatic capacitor-based microphone, which eliminates the need for a polarizing power supply by using a permanently charged material. Since microphone is not included in the LTspice program which we used for the simulation, we replaced the microphone circuit with an AC voltage source when creating the overall circuit block diagram.

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Decision Unit

a) Non-inverting Amplifier

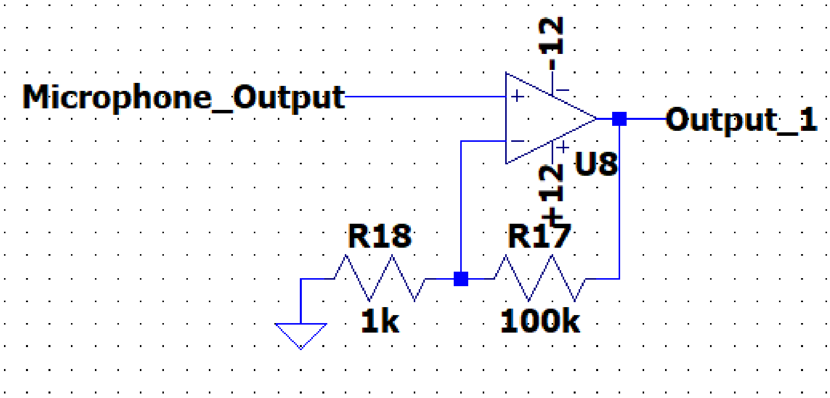

Figure 2: Non-inverting Amplifier Circuit

Since the voltage obtained from the microphone is not sufficient to observe, we used a non-inverting amplifier to increase the voltage. In order to make a comparison with 6 volts in the comparator circuit which is the other part of our circuit, and according to our research and observations, we have increased the maximum voltage value to about 7 volts by increasing the voltage by 100 times (actually 101 times) since the maximum voltage obtained from the microphone is approximately 0.07 volts.

b) Full-Wave Rectifier

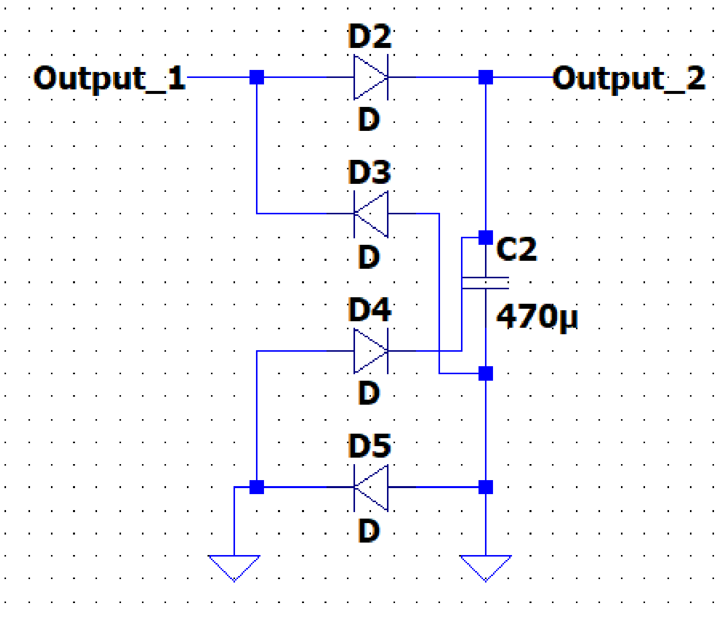

Figure 3: Full Wave Rectifier Circuit

In order to make a comparison with a DC source in the comparator circuit, we converted the voltage value in Output_1 to DC by connecting it to the full wave rectifier.

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c) Comparators and Summing Amplifier

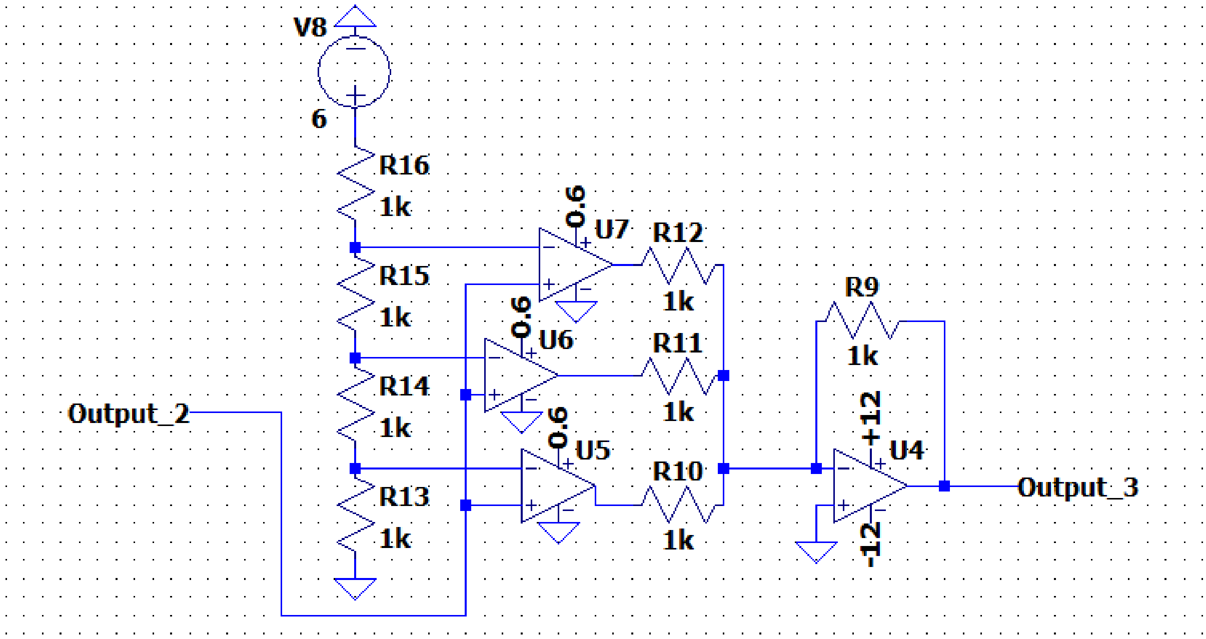

Figure 4: Comparator and Summing Amplifier Circuits

Since the PWM signal is requested according to 4 different sound levels, before the PWM signal is generated, we have compared our DC voltage value of Output_2 with 3 different voltage values. Then, we sum the outputs of the comparators using summing amplifier to obtain 4 different voltage levels (with 0 level).

Since the voltage values of the non-inverting input part of the comparator system used to generate PWM signals vary between 0 and -2.4V, we tried to set our Output_3 value between 0 and -2.4V. Output_3 must be -1.8V for the PWM duty cycle to be 75% at high level, -1.2V for 50% at mid-level, and -0.6V for 25% at low level.

For each level increase, in order to increase our Output_3 voltage by 0.6V we connected a 0.6V source to the positive voltage source of each comparator.

-1.8V at the highest level (because the output of the summing amplifier is negative), -1.2V at the medium level, -0.6V at the low level, and 0V at the lowest is observed.

d) Triangular Waveform Generator

This subcircuit is a negative resistive converter to produce a triangular wave for pwm and a buffer with a summing amplifier. As we know from experiment 6 part 3, a triangular wave can be obtained by connecting a capacitor to a negative resistive converter. Voltage across the capacitor is a triangular waveform, and it can be used to produce a pwm signal. The buffer was used to keep the triangular waveform unaffected from the rest of the circuit. Since our DC voltages from the comparator system are all negative voltages, we want to make the triangular waveform in negative voltages. For this purpose, since summing amplifier has a negative output, we summed the triangular waveform with 6V DC voltage. Also, we scaled the resulting voltage with 1/5 by having R_{in} as 5k and R_f as 1k ohms for convenience.

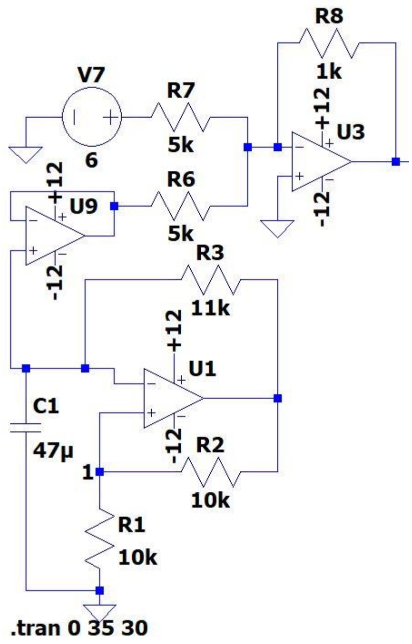

Figure 5: Triangular waveform generator

e) PWM Generator

This subcircuit is a simple comparator. Triangular waveform and DC voltage from part c was compared using a comparator. Resulting voltage is a pwm signal with the required duty cycles.

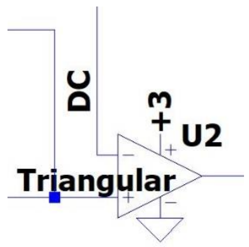

Figure 6: Comparator as a pwm generator

Display Unit

By connecting a LED and a resistor to the output of the comparator in part e of decision unit, all the required specimens for the project are satisfied. LED blinks same as the duty cycle of the resulting pwm.

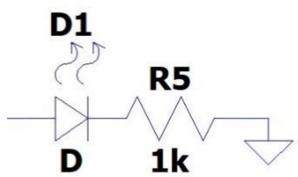

Figure 7: A LED and a Resistor as the Display Unit

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Basic Formulations

$V_{in} - V_{out}$ relation of the summing amplifier : $V_{out} = (-R_f/R_{in})V_{in}$

$V_{in} - V_{out}$ relation of the comparator : $V_{out}=V_{s-}$ if $V_->V_+$, $V_{out}=V_{s+}$ if $V_+>V_-$

$V_{in} - V_{out}$ relation of the non-inverting amplifier : $V_{out}= (1+R_f/R_{in})V_{in}$

$V_{in} - V_{out}$ relation of the buffer : $V_{out}=V_{in}$

Frequency of triangular waveform : f=1/(2.R3.C.ln(3))

Simulation Results

Simulation Results (When Microphone_output is 0.01V)

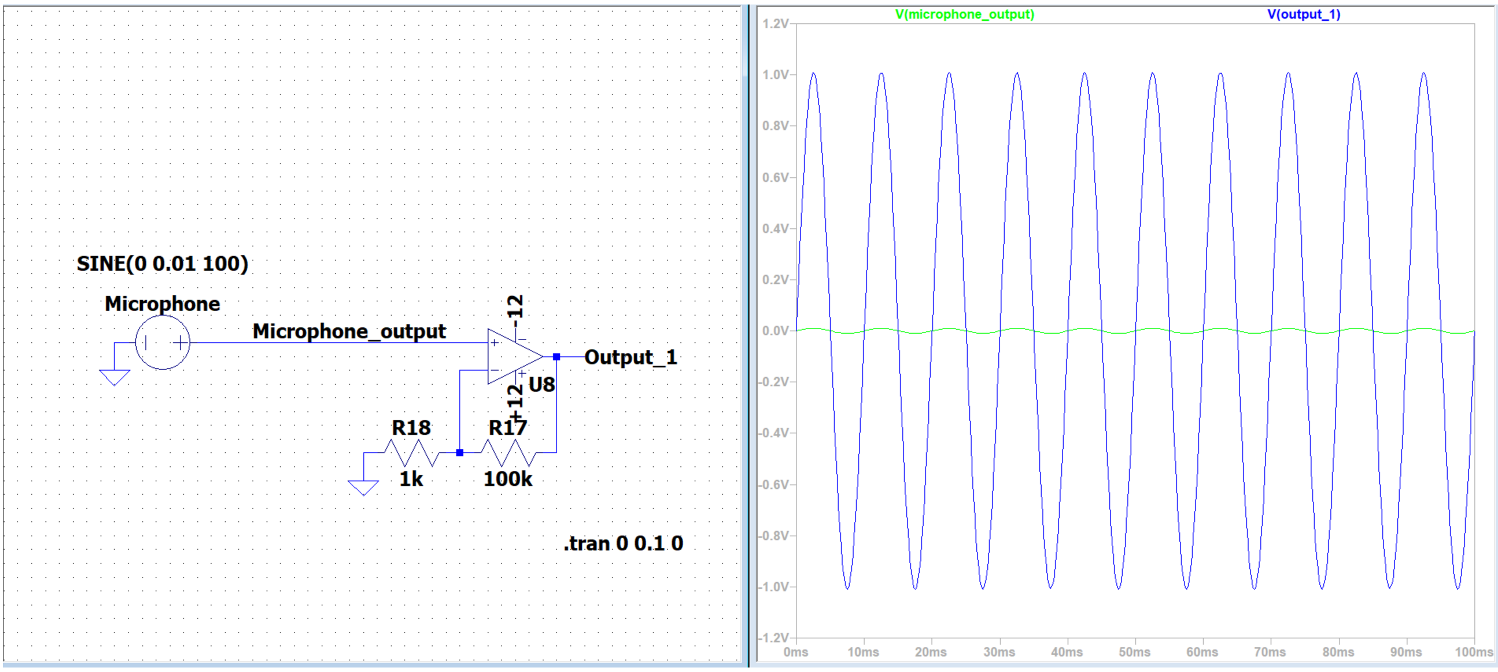

Figure 8.1: Output wave of microphone

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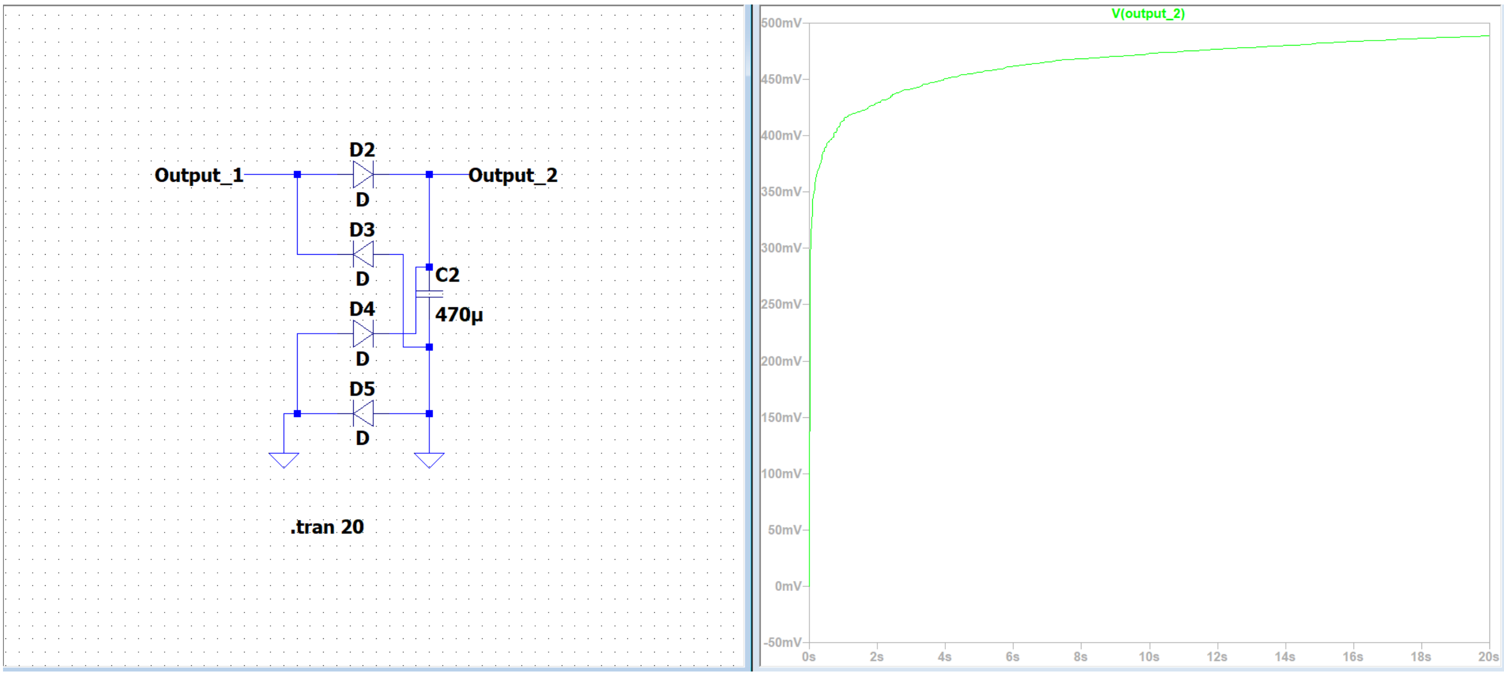

Figure 8.2: Full wave rectifier and the resulting DC voltage

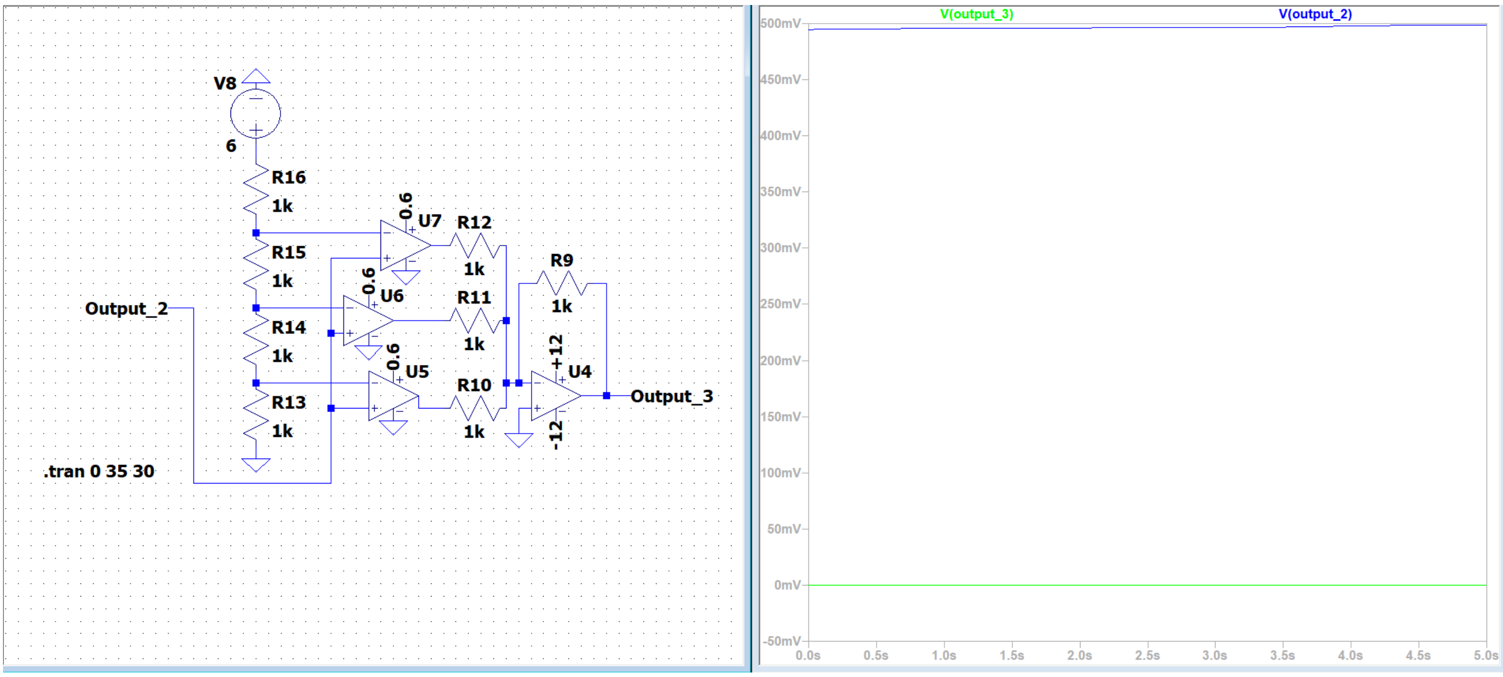

Figure 8.3: Comparator decision subcircuit and resulting DC output

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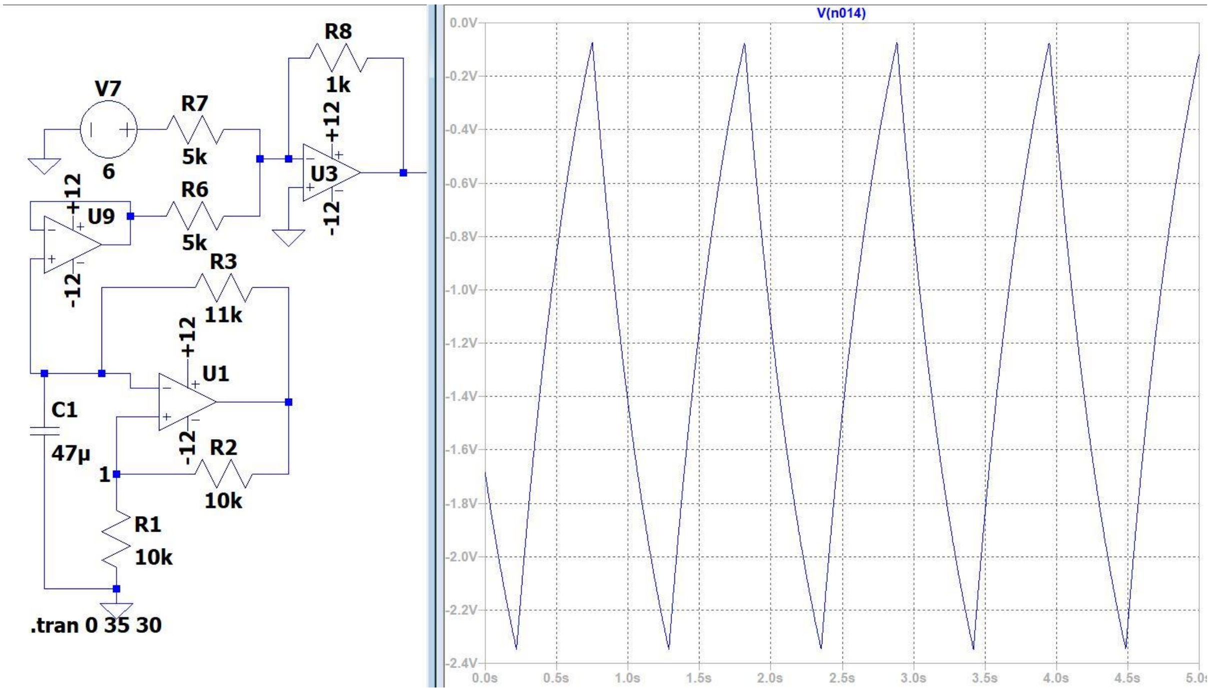

Figure 8.4: Triangular waveform generator and triangular waveform

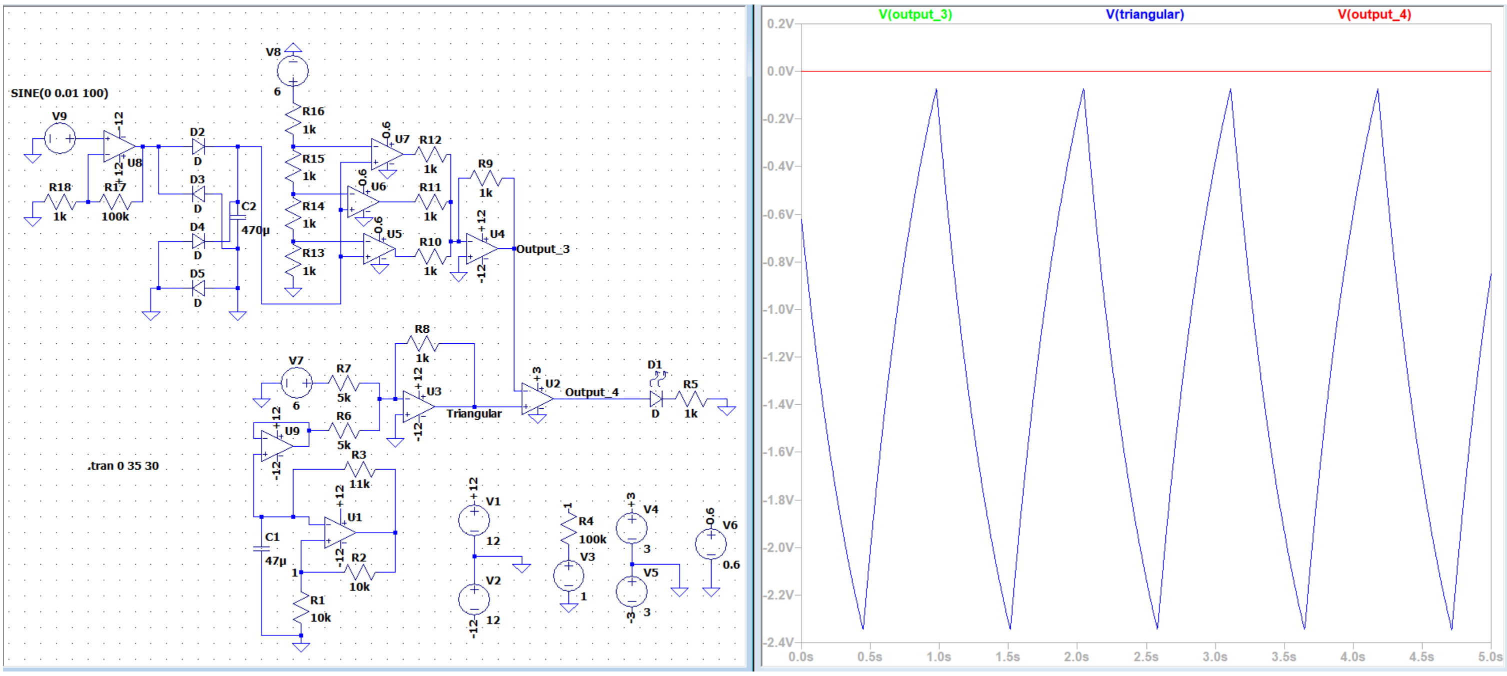

Figure 8.5: Whole circuit and resulting waveforms

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Simulation Results (When Microphone_output is 0.02V)

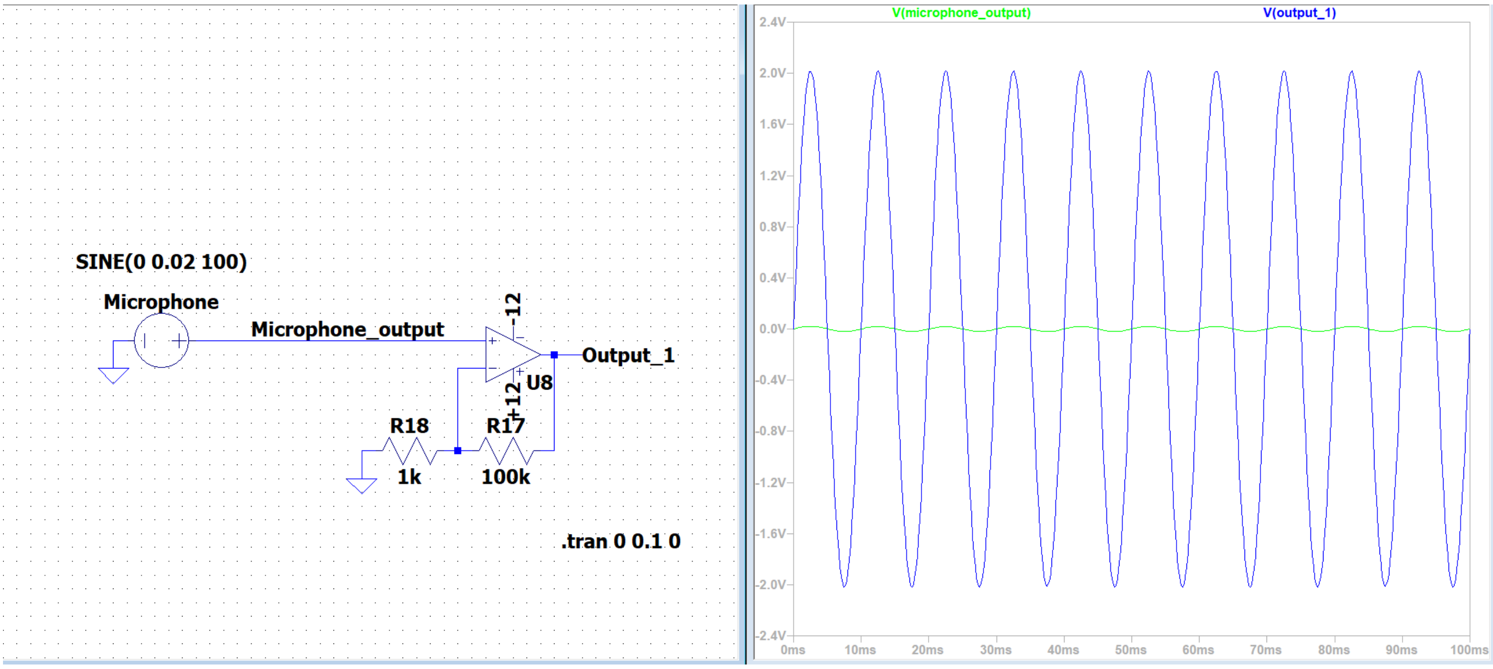

Figure 9.1: Output wave of microphone

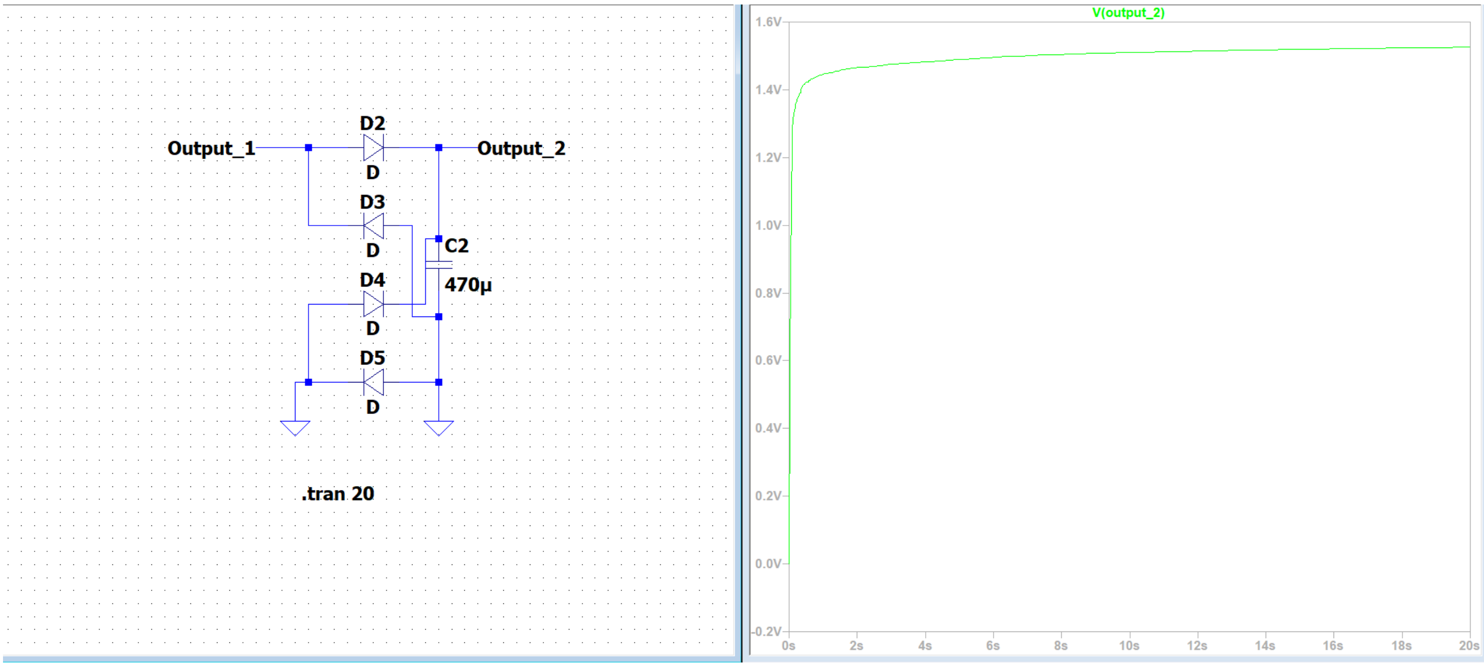

Figure 9.2: Full wave rectifier and the resulting DC voltage

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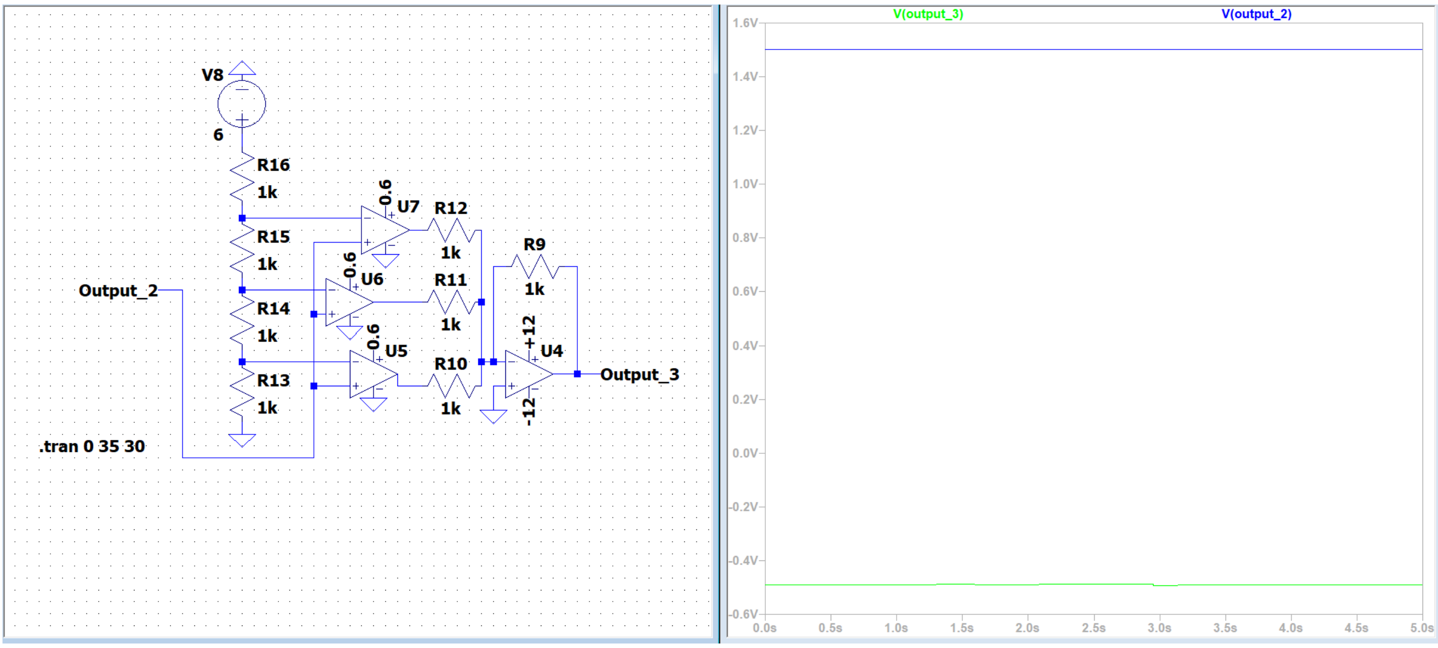

Figure 9.3: Comparator decision subcircuit and resulting DC output

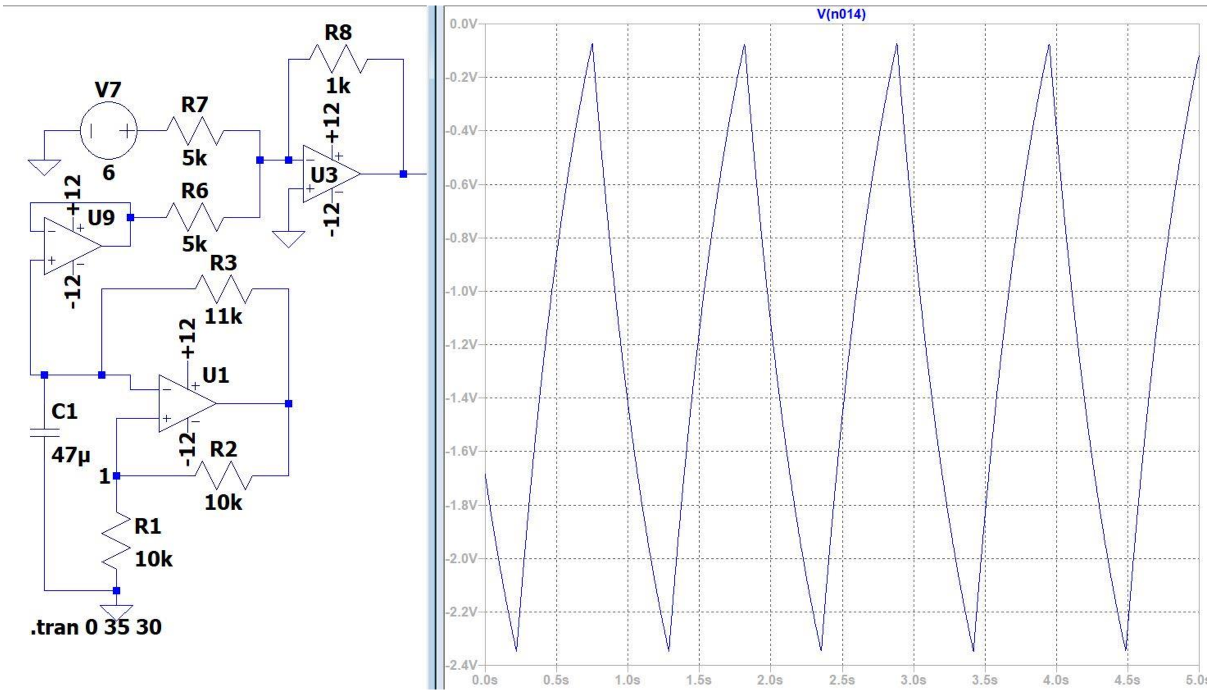

Figure 9.4: Triangular waveform generator and triangular waveform

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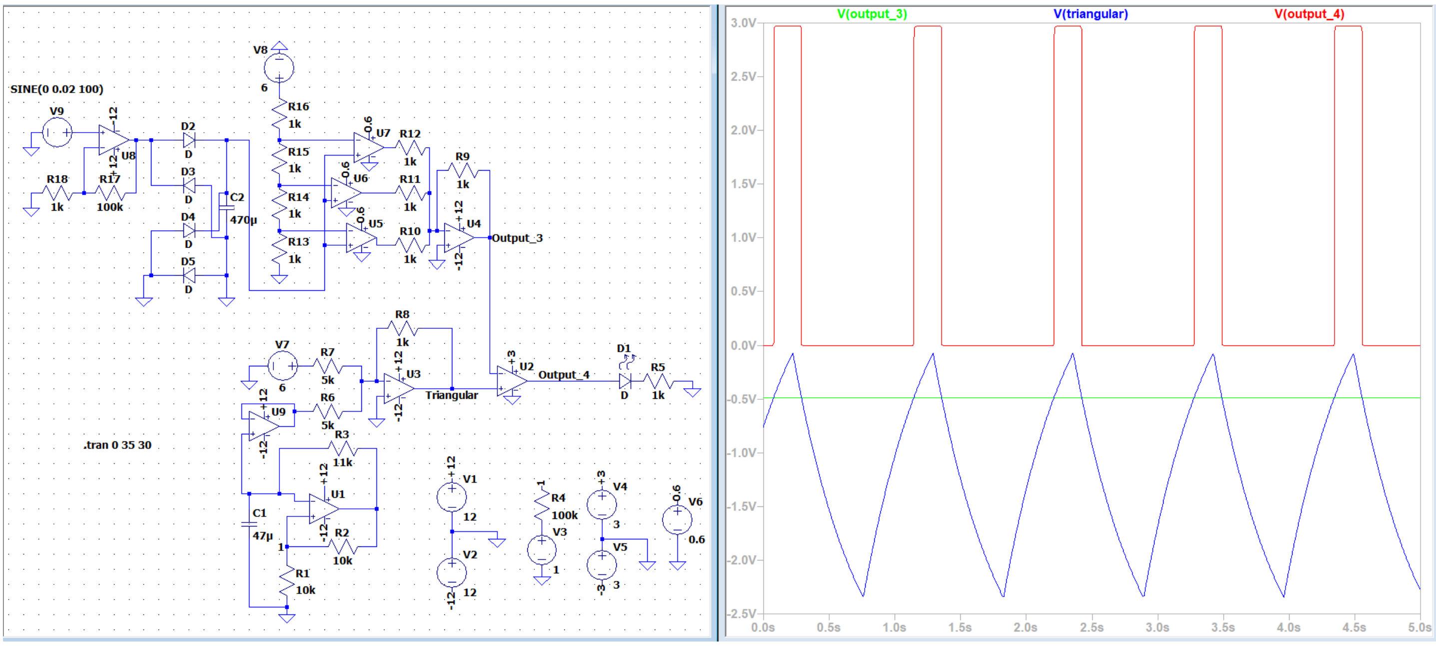

Figure 9.5: Whole circuit and resulting waveforms

Simulation Results (When Microphone_output is 0.04V)

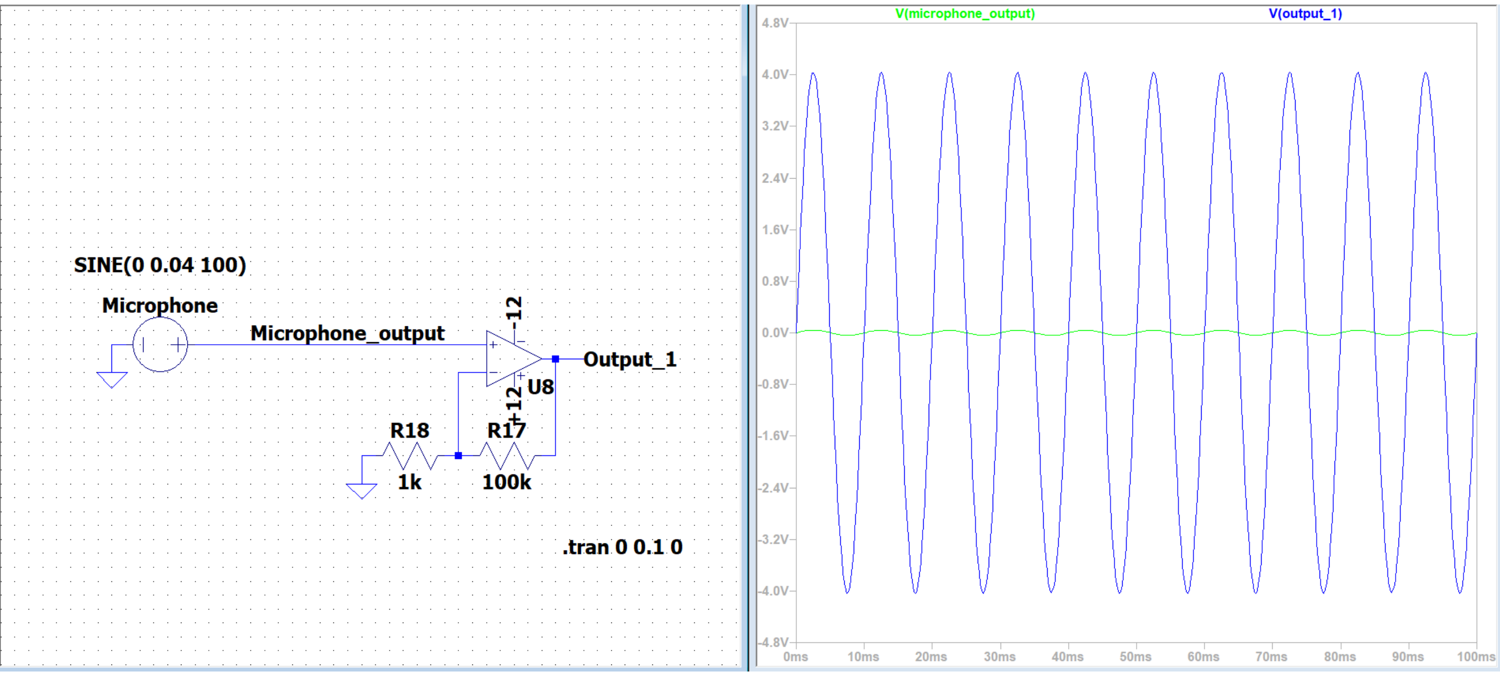

Figure 10.1: Output wave of microphone

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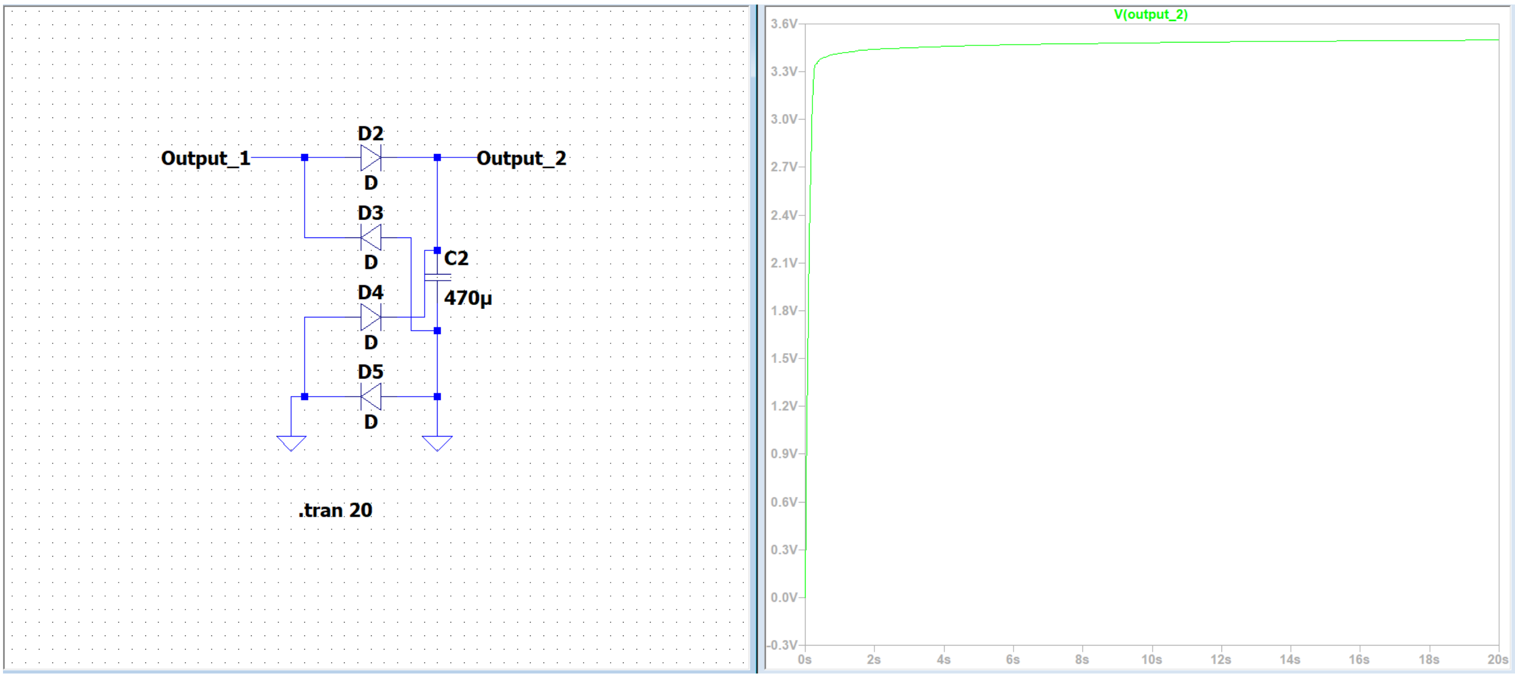

Figure 10.2: Full wave rectifier and the resulting DC voltage

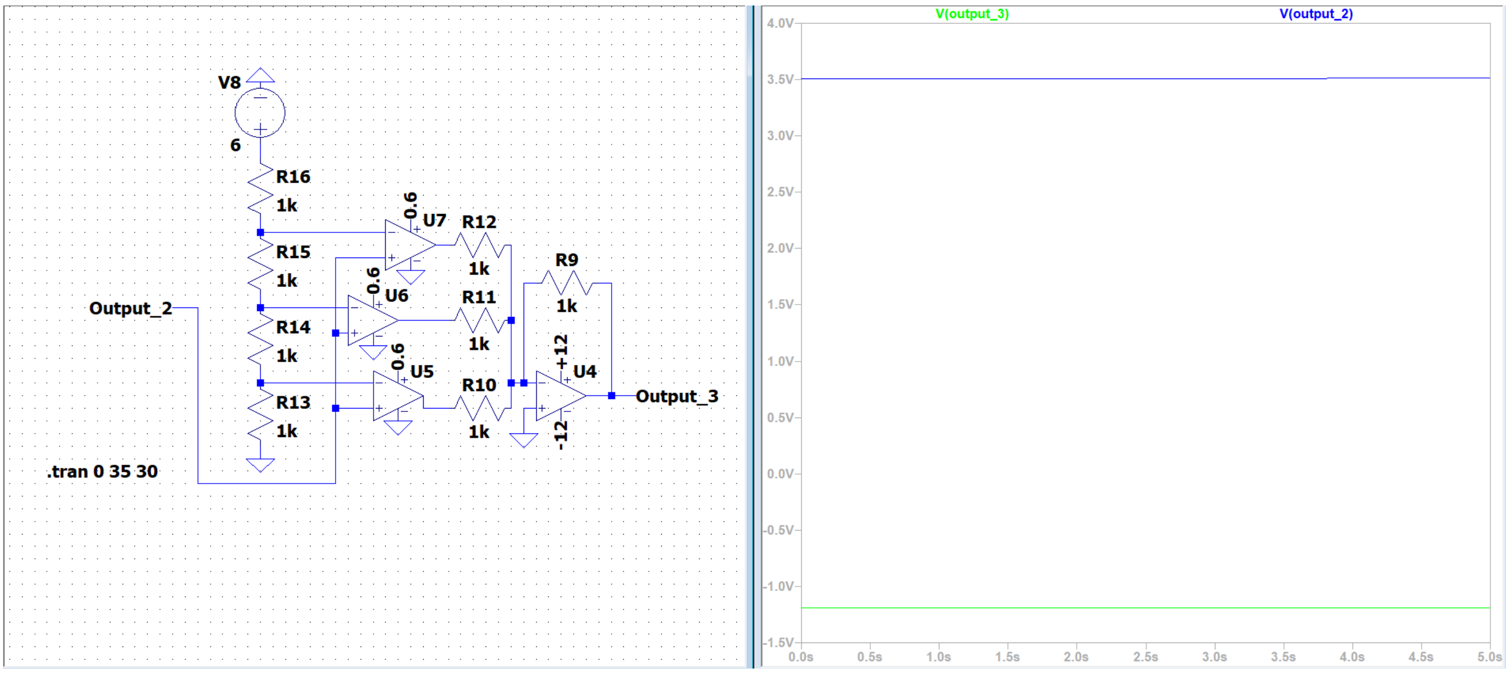

Figure 10.3: Comparator decision subcircuit and resulting DC output

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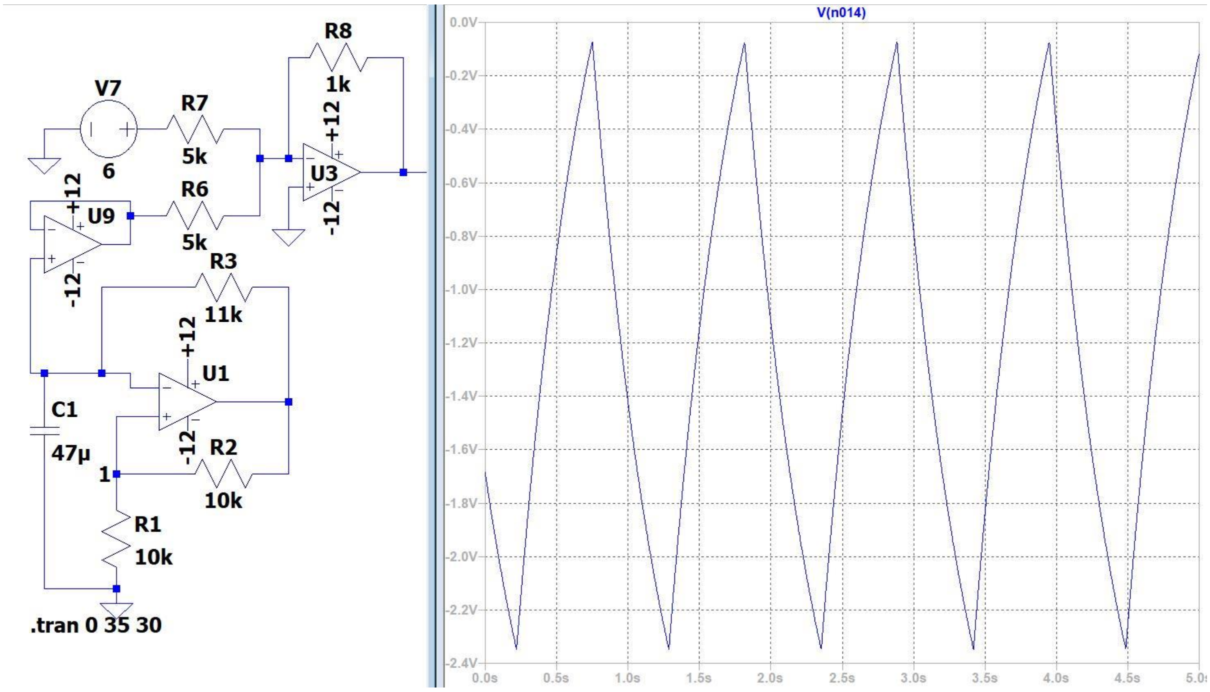

Figure 10.4: Triangular waveform generator and triangular waveform

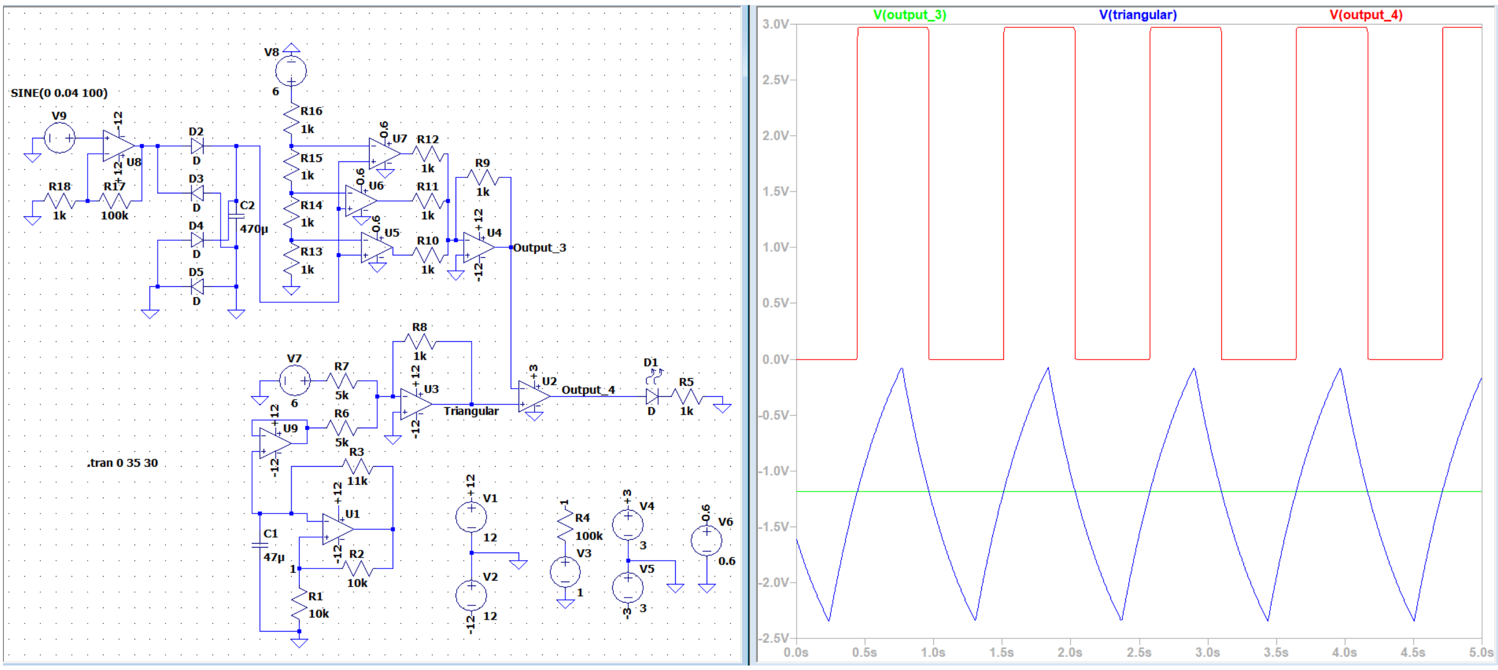

Figure 10.5: Whole circuit and resulting waveforms

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Simulation Results (When Microphone_output is 0.05V)

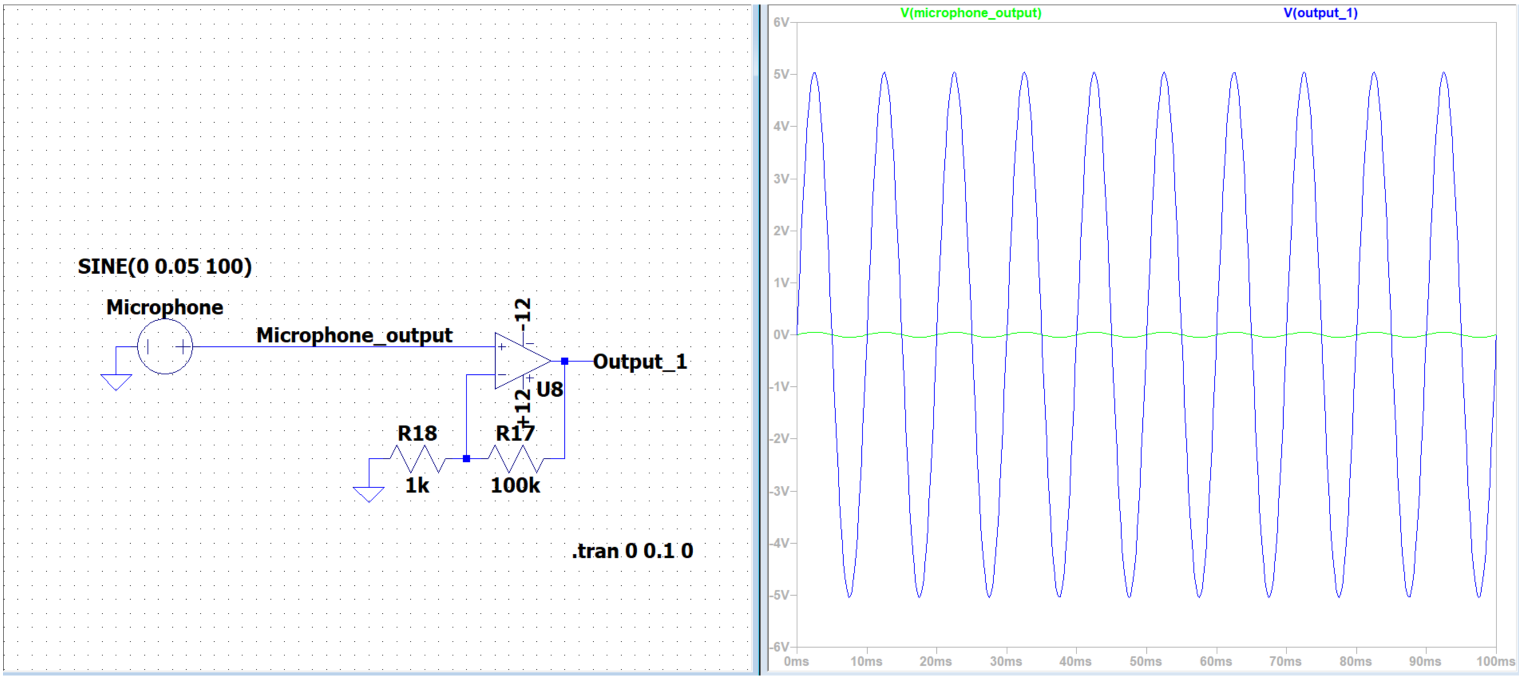

Figure 11.1: Output wave of microphone

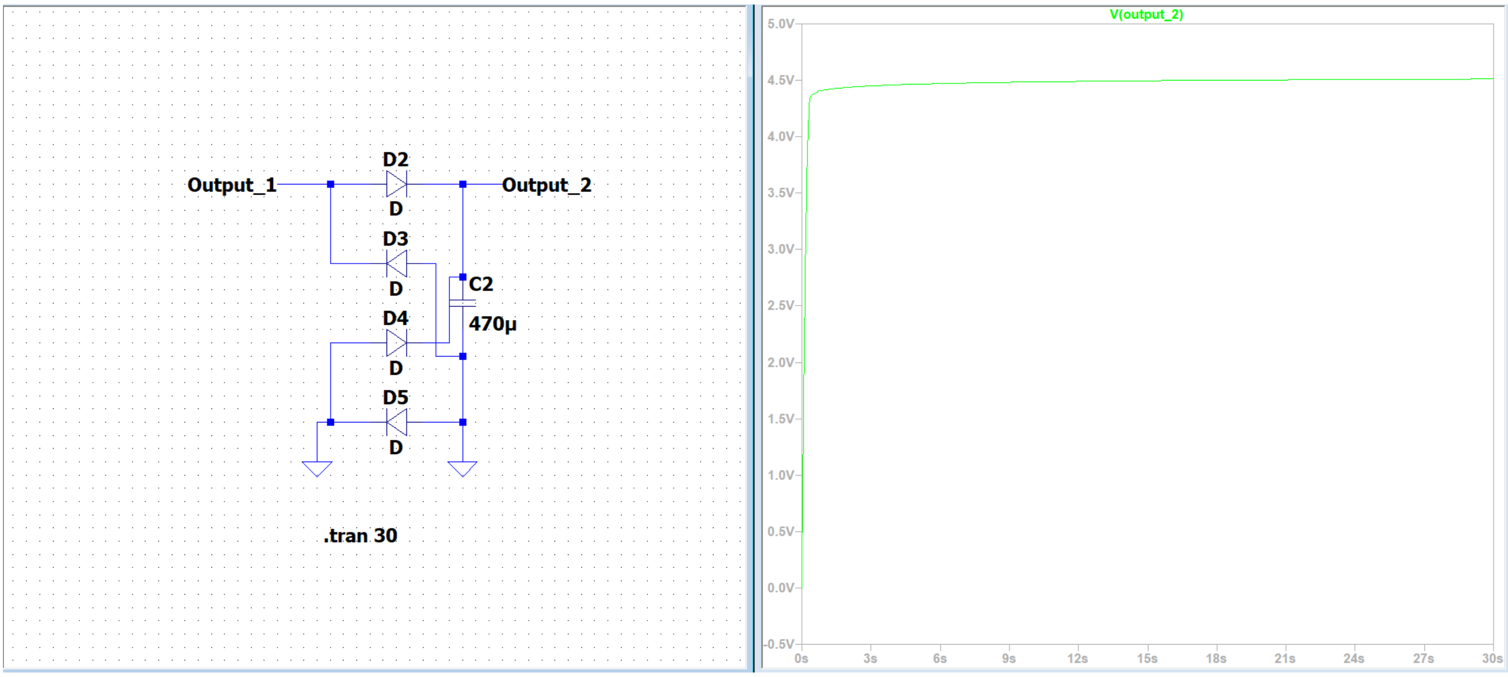

Figure 11.2: Full wave rectifier and the resulting DC voltage

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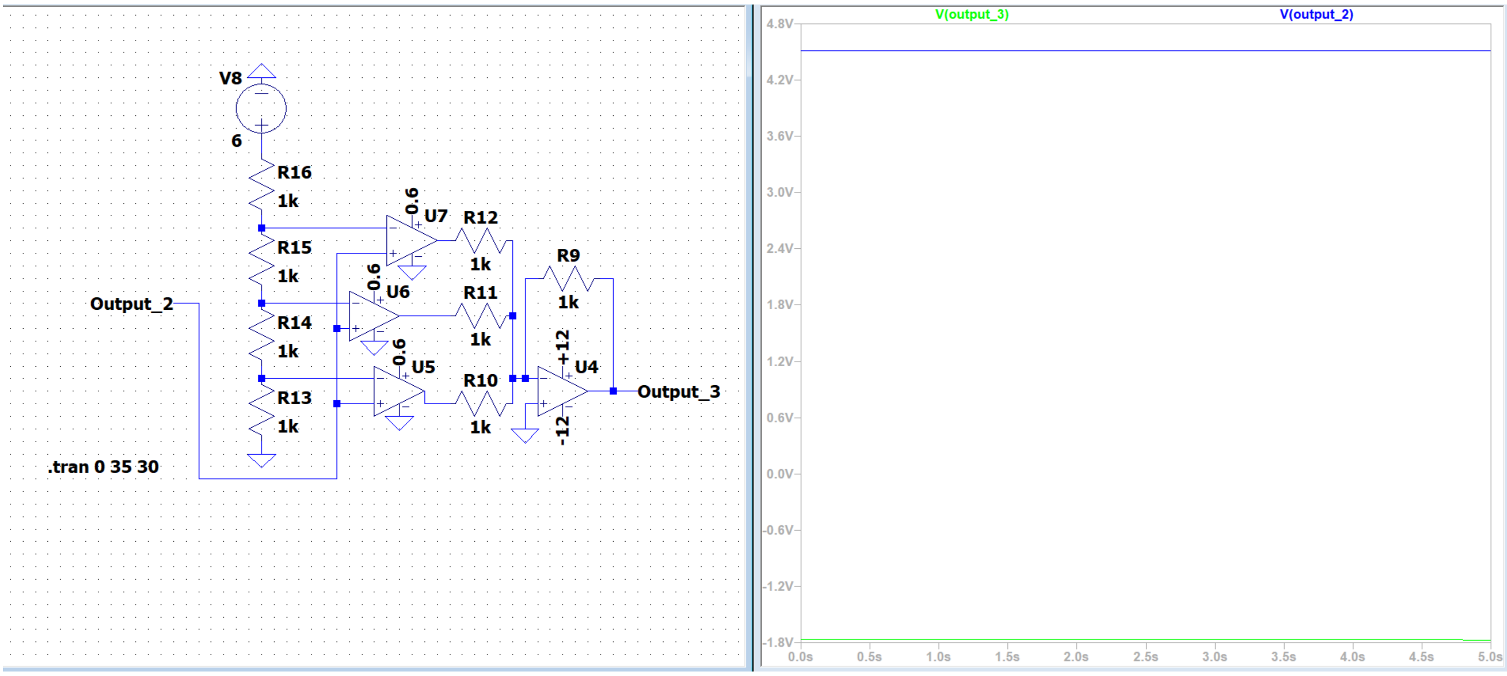

Figure 11.3: Comparator decision subcircuit and resulting DC output

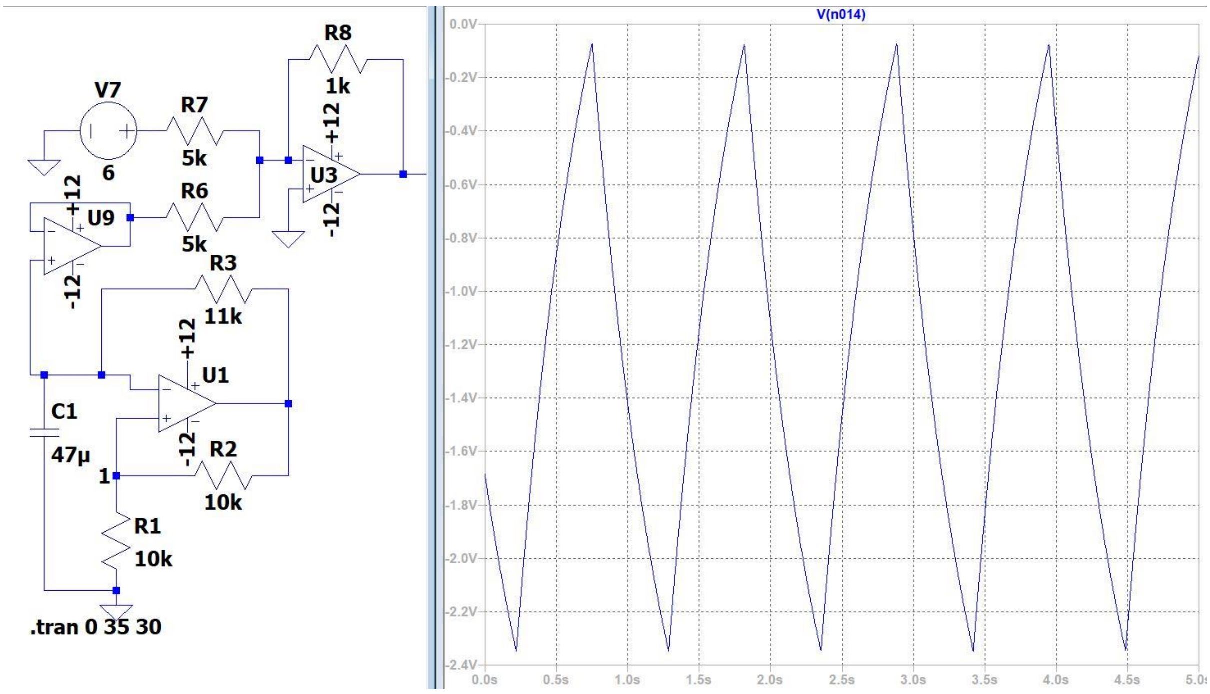

Figure 11.4: Triangular waveform generator and triangular waveform

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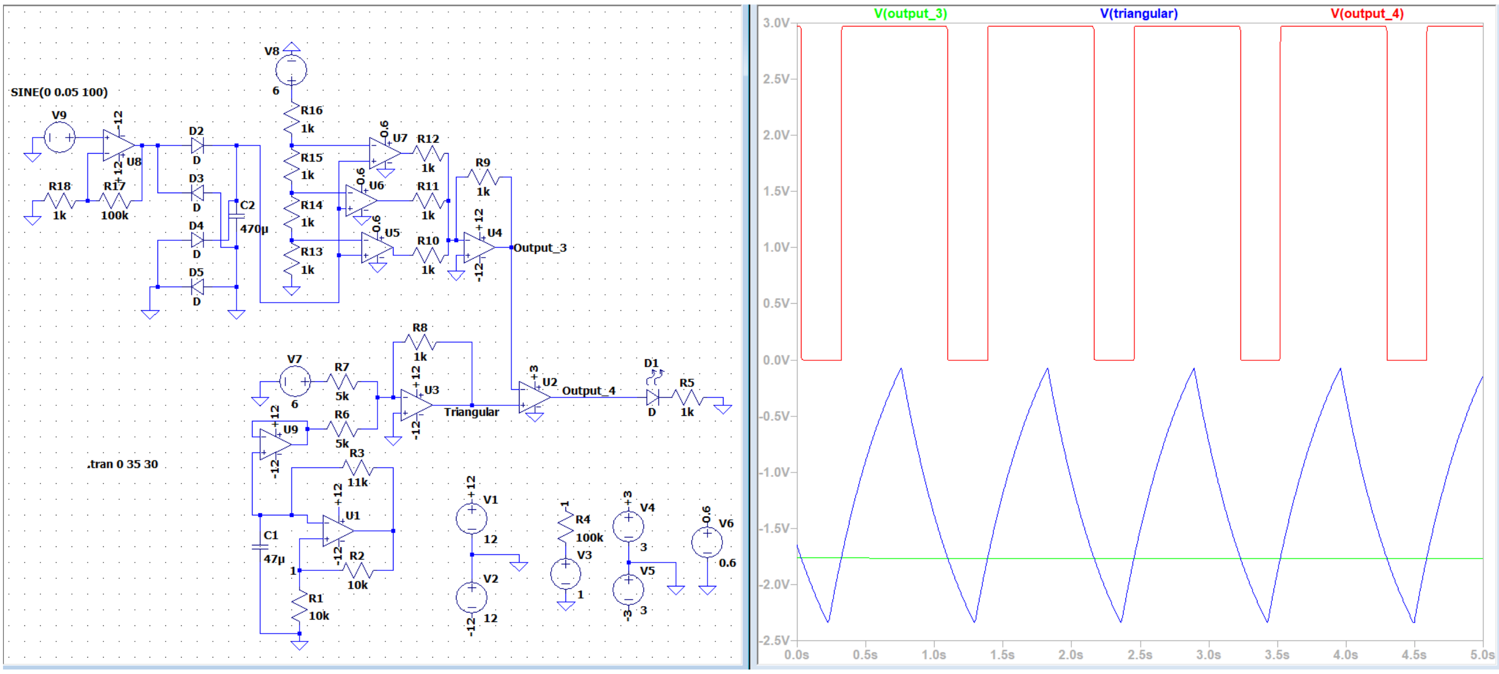

Figure 11.5: Whole circuit and resulting waveforms

Conclusion

To conclude, in this project, we learned how pwm works and produced. Pwm is a signal with two different DC voltages, one being low and the other being high voltage. The thing that makes pwm special is that on-off times of a pwm cycle is changeable. Percentage of on cycle with respect to period of pwm is called duty cycle of pwm. Our LED emits light on 4 different duty cycles with 1 second period. For representing no sound, or very low sound levels, our pwm has %0 duty cycle which means our LED is off all the time. For representing low-medium sound levels, our pwm has %25 duty cycle which means our LED is on only 0.25 seconds. For representing medium-high sound levels, our pwm has %50 duty cycle which means our LED is on only 0.50 seconds. And lastly, for representing high sound levels, our pwm has %75 duty cycle which means our LED is on only 0.75 seconds. These duty cycles are acquired by comparing different DC voltages with a triangular waveform which has a period of 1 seconds. Percentage of DC voltage with respect to peak voltages of the triangular waveform determines the duty cycle of pwm. Thus, input from the microphone was enhanced and rectified. Additionally, voltage values in 2nd block was set accordingly. A triangular waveform was formed in 3rd block with a negative resistive converter with a capacitor. Then, this waveform was summed with 6V DC supply and scaled with 1/5 for convenience. After then, outputs of 2nd and 3rd blocks were compared by a comparator opamp to get a pwm. Lastly, a LED was used to observe this pwm which also indicates the sound levels.

Appendix I

Total time spent on/during

- Pre-Design Report : 6 hours
- Pre-Report : 20 hours (average time during the design and report writing)

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