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EE-313 ANALOG ELECTRONICS LABORATORY
2019-2020 FALL TERM PROJECT PROPOSAL REPORT
A LANE ADJUSTER CIRCUIT FOR SMART CAR APPLICATIONS

INTRODUCTION

In this project, we are going to design a circuit which allows the autonomous cars to adjust their lanes in different cases in order to obey the traffic rules, which are leaving the lanes for the ambulances and police cars. We will achieve this by using sirens with different frequencies to distinguish the car type and different amplitudes to determine on which lane they are. Ambulances have the highest priority, then police cars have the second-highest priority, and regular cars have the lowest priority. Therefore, our car should be able to determine the lane on which it should be traveling, according to the priorities of the cars coming behind.

DESIGN OVERVIEW

We will first create three different sinusoidal waves with different frequencies and amplitudes to distinguish the car types and on which lane they are moving. Then, we will use a power amplifier circuit in order to provide sufficient power to the output load to drive the speaker. After that, we will use a speaker to convert the signals into the sound waves. By doing so, we will be able to transmit the signals even if there is a distance between the circuits. Next, the sound wave, which is created by the speaker, will be collected by the microphone. Also, we will use a preamplifier circuit to drive the microphone because it will create a signal which will be very small in magnitude. After the preamplifier circuit, we will use three different active bandpass filter circuits to separate the three signals which have different frequencies. Then, we will use full-wave rectifier circuits to transform sinusoidal AC signals to DC outputs for each signal with different frequencies. Therefore, we will be able to use comparator circuits with LEDs to determine on which lane the cars are present. Finally, we will use logic circuits in order to decide on which lane our car should be traveling by looking at the DC inputs that are being received.

DESCRIPTION OF THE SUB-BLOCKS

We will use three different sub-blocks in this project, which are the audio signal generator, siren detector, and lane decider.

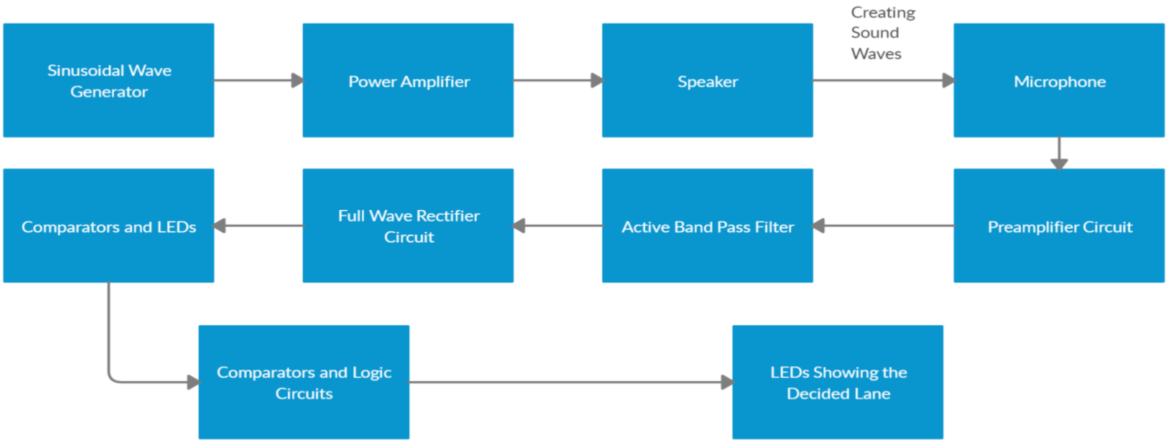

Figure 1. The general overview of the project

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1) Audio Signal Generator Block

In this block, we will first create three different sinusoidal waves using Wien Bridge Oscillator. With this circuit, we will be able to create sinusoidal waves in different frequencies and amplitudes by changing the resistance and capacitance values. It is one of the most commonly used circuits for audio applications. This is due to the fact that it can be implemented easily and has a quite large frequency range. Also, it has low distortion. However, in order to minimize the oscillations in the output amplitude, we should use an automatic gain control circuit, incandescent bulb, or diodes. In this case, we used diodes as can be seen in Figure 2. We can calculate the frequency of the created sinusoidal wave with the formula $f=1/(2*\pi *R*C)$ when all R values are the same and all C values are the same. By changing the resistances, we can adjust the amplitude of the sine waves. Therefore, we can determine if the sine wave corresponds to the left lane or right lane by checking if it is larger than the threshold voltage or lower than the threshold voltage. After creating the sine waves, we will combine the generated sinusoidal waves before the power amplifier circuit.

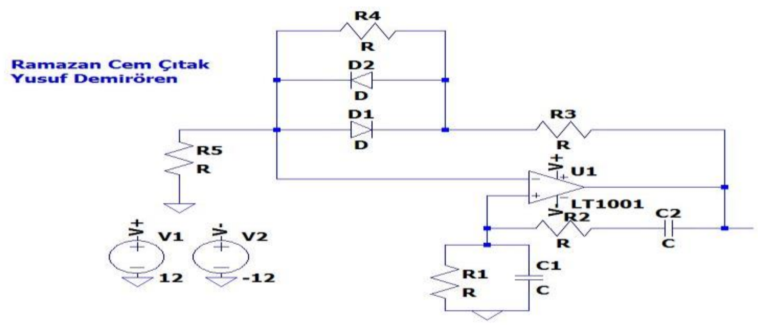

Figure 2. The circuit schematic of the sinusoidal wave generator circuit

After that, we will use a power amplifier in order to provide sufficient power to the speaker. Since the speaker has a quite small resistance value, we need an amplifier to dissipate enough power on the speaker. We will use a class AB power amplifier since its efficiency is higher, and also it has low crossover distortion. For this purpose, we can use the circuit given in Figure 3.

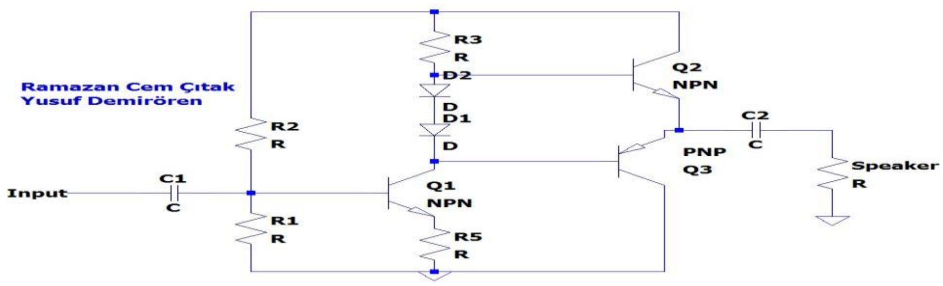

Figure 3. The circuit schematic of the power amplifier

2) Siren Detector Block

In this block, we will first collect the signals that were created in the first block by using a microphone with a preamplifier circuit. We need a preamplifier circuit to drive the microphone in order to have signals with reasonable amplitudes. The circuit schematic of the preamplifier circuit can be seen in Figure 4.

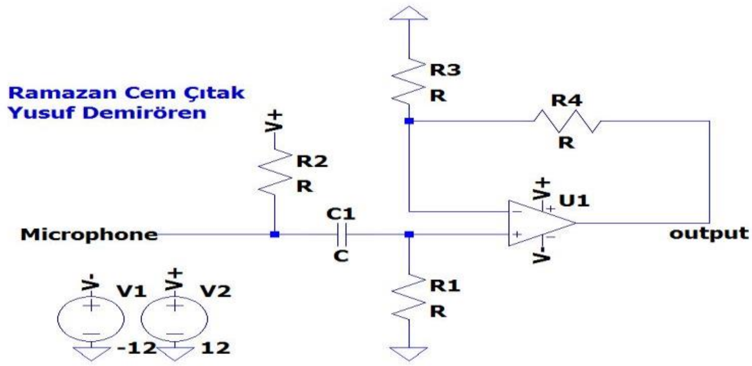

Figure 4. The circuit schematic of the microphone preamplifier circuit

After that, we should separate the signals using active bandpass filters. In order to do that, we need three different bandpass filters. Low-frequency cut-off can be determined by $f_L=1/(2*\pi*R1*C1)$, and the high-frequency cut-off can be determined by $f_H=1/(2*\pi*R4*C2)$. Also, the gain of the amplifier is (R3+R2)/R2 V/V. By manipulating the resistance and capacitance values, we can change the high-frequency cut-off and the low-frequency cut-off of the filter. An example of the active bandpass filter can be seen in Figure 5.

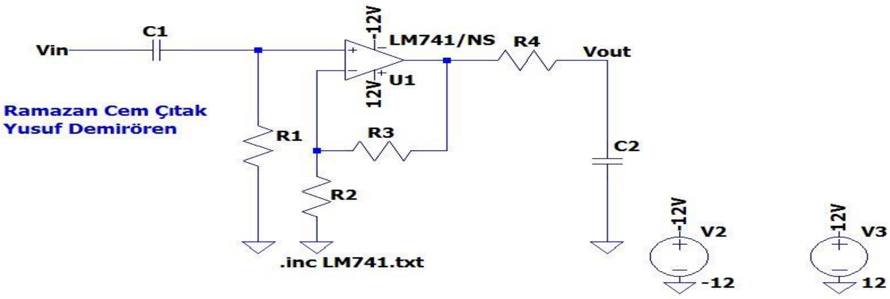

Figure 5. The circuit schematic of the active bandpass filter

Then, we will use full-wave rectifier circuits to transform the AC inputs to DC outputs. After this, we will use two comparators consecutively in which we will compare the amplitudes of the DC signals to 0 Volt and threshold voltage. In the first stage, we will determine if the car is on the way and in the second stage, we will determine on which lane the car is present. If the DC signal has non-zero amplitude but is smaller than the threshold voltage, one of the LEDs will be on, and if the DC signal is larger than the threshold voltage, both of the LEDs will be on. This means if the car is on the right lane, one of the LEDs will be on, and if it is on the left lane, both of the LEDs will be on. Also, if the car is not present, both of the LEDs will be off.

3) Lane Decider Block

In this block, we will use the outputs of the siren detector block, which are DC voltages, as the inputs. Since the car changes its lane only due to the presence of a police car or an ambulance, we only need two inputs, corresponding to the police car and the ambulance. We can first determine if a police car or an ambulance is present on the road and, after that, we will determine on which lane they are moving, provided they are present on the road. We can achieve this by using comparator circuits to compare their amplitudes to zero voltage and the reference voltage. After that, by using logic circuits, we can decide on which lane our car should be going.