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EE 313 Analog Electronics Laboratory

Fall 2017 - Term Project Proposal Report

1.Introduction

In this project we will design a distance measurement system based on FMCW concept. The system is built up with two different parts, i.e. transmitter and receiver. In the transmitter part, we generate a signal with changing frequency controlled by a triangular wave input and send it to the receiver using a speaker. In the receiver part, we obtain the signal by a microphone and a microphone driver circuit. Then, we multiply the incoming signal with the generated one by using a signal mixer circuit. The mixer generates two signals with different frequencies which are the summation and the difference of the generated and received signals. Finally, with the help of a low pass filter we isolate the signal with the difference frequency and measure the distance between the speaker and the microphone accordingly.

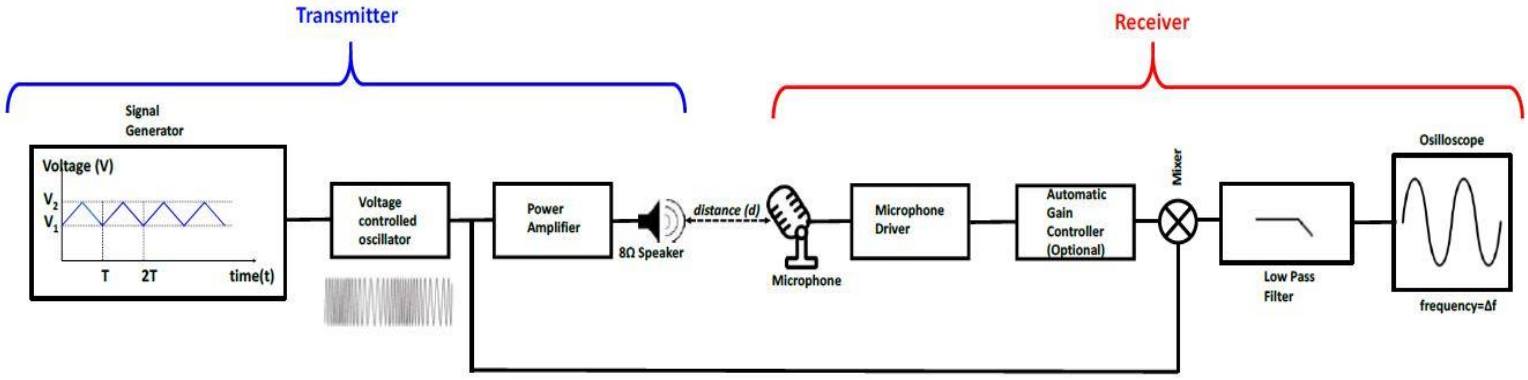

Figure 1: The overall diagram of the project

Equipment List

Transistors and power transistors, Resistors and power resistors

Op-amps, Capacitors, Diodes

Speaker, Microphone

2.Transmitter

2.1 Voltage Controlled Oscillator (VCO)

In this part, we construct an oscillator circuit that generates a square wave with changing frequency according to the input voltage. The frequency of the output voltage increases and decreases linearly according to the input amplitude since the input is a triangular wave with 10 Hz.

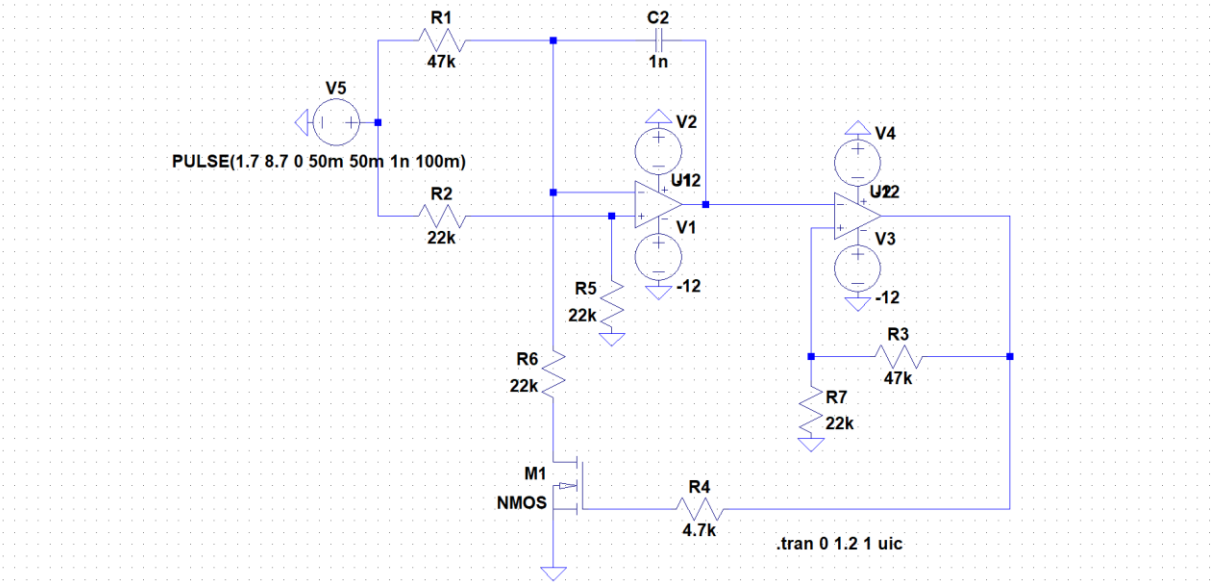

Figure 2: The circuit diagram of VCO

The output frequency varies from 1kHz to 5kHz when the input changes from 1.7 Volts to 8.7 Volts. We adjusted the frequency range by varying the capacitance value and the voltage divider at the second op-amp.

2.2 Power Amplifier

We will buffer the output signal of the VCO by using a power amplifier to load the 8 ohm speaker. Since we are required to generate 3 W of output power and the speaker has very low resistance, we should design an amplifier with high output resistance and low input resistance not to lose the signal. For this purpose, we need to use power transistors and power resistors since they will dissipate too much heat when a high current passes through them. Finally, we will load the output signal of this circuit to the speaker.

3. Receiver

3.1. Microphone Driver

The signal waveform obtained by the microphone is not suitable to compare with the generated signal as the amplitude of the output signal is very low. The microphone driver circuit transforms the microphone output into a meaningful signal so that we can process it in the mixer circuit.

3.2. Mixer

In this part, the mixer has the generated signal in VCO and received signal as inputs and multiply them. The output will be composed of two signals with different frequencies which are the summation and the difference of two input signals.

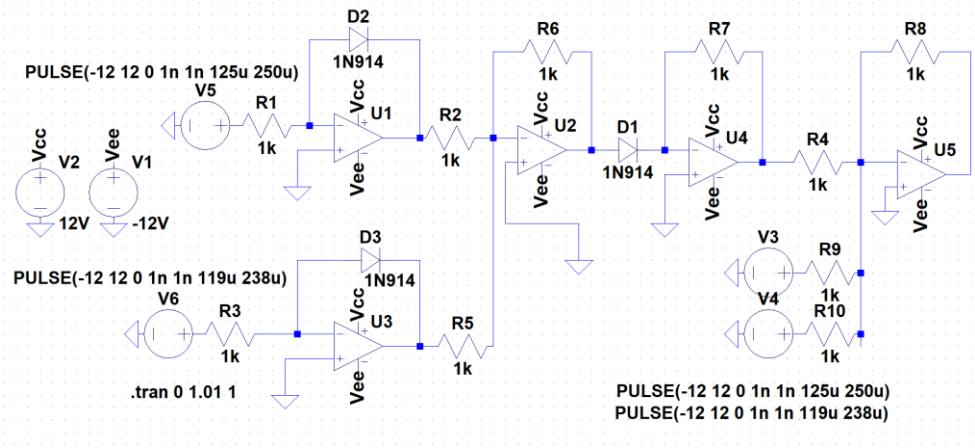

Figure 3: Signal multiplier circuit diagram

3.3. Low Pass Filter

In this part, we use a low pass filter to obtain the low frequency component of the mixer output. Then, the distance will be proportional to this frequency difference. Hence, the low frequency component will be observed on the oscilloscope.

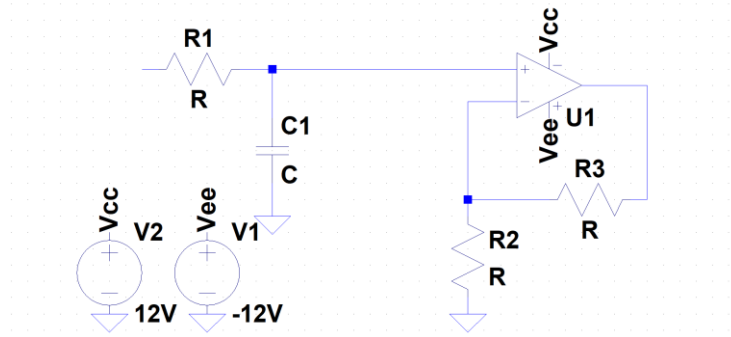

Figure 4: Active low-pass filter

We use the circuit in Figure 4 to filter the output of the mixer. We use an active filter since active filters are better at low frequencies and we need some gain to observe the signal on the oscilloscope. The gain and the cut-off frequency can be calculated as follows:

$$\text{Gain}=1+R3/R4 \quad (1)$$

$$\text{Cut-off frequency}=1/(2\pi R1C1) \quad (2)$$

4. Summary

In general, we are required to design an FMCW based distance measurement system using a speaker as the transmitter and a microphone as the receiver. We are required to generate a signal with changing frequency controlled by the 10 Hz triangular wave. Then, we buffer this signal by using power amplifiers and power resistors to load the speaker since we are required to produce 3W of power to generate high amplitude sound from the speaker and there will be too much power for normal components. We obtain that signal using a microphone and a microphone driver circuit. Then, we will multiply the generated signal and the received signal by using a mixer circuit and obtain a signal with a frequency which is the difference of the two signals using an active low pass filter. Finally, we will calculate the distance between the speaker and the microphone according to the frequency of the signal observed on the oscilloscope.