

EE313 Analog Electronic Laboratory

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FMCW Based Distance Measuring System

1st Halil TEMURTAS 2094522 halil.temurtas@metu.edu.tr
 2nd Erdem TUNA 2167419 erdem.tuna@metu.edu.tr

Abstract—Design of a Frequency Modulated Continuous Wave (FMCW) Based Distance Measuring System Aim: In this project, you are going to design a distance measurement system as depicted in Figure 1.

Index Terms—component, formatting, style, styling, insert

I. INTRODUCTION

Design of a Frequency Modulated Continuous Wave (FMCW) Based Distance Measuring System Aim: In this project, you are going to design a distance measurement system as depicted in Figure 1.

II. TRANSMITTER

A. VCO

B. Power Amplifier

C. Speaker

III. RECEIVER

A. Microphone & Microphone Driver

To receive the sound signal coming from the speaker and turn it into an electrical signal, some kind of speaker should be used. For this purpose, an electret microphone will be used.

To drive the electret microphone, a driver circuit will be designed. The design should include feeding for the transistor inside the microphone and amplify the output signal since the output signal would be too small to be used. But before going amplifying the signal, we shall remove possible dc offsets and noises by a passive high pass filter. The designed driver can be seen at Figure 1.

With simple node analysis in the frequency domain, the cutoff frequency of the passive high pass filter can be found as

$$f_c = \frac{1}{2\pi R_{42} C_{10}} \quad (1)$$

If we take $R_{42} = 10k\Omega$ and $C_{10} = 0.1\mu F$, cutoff frequency f_c can be found as

$$f_c = \frac{1}{2\pi 10k\Omega 0.1\mu F} \approx 159Hz \quad (2)$$

This frequency is pretty good for blocking dc offset and noise.

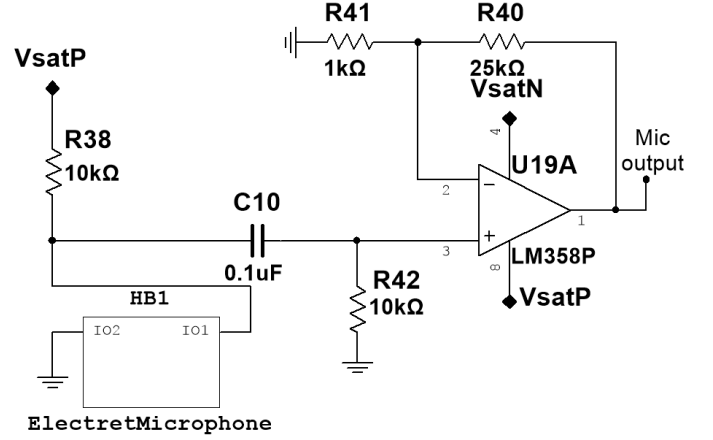


Figure 1: Driver Circuit for Electret Microphone

B. Mixer

Mixer is the device that accepts two input signals and gives an output signal that consists of two distinct signals with different frequencies. While, one of these signals has a frequency that is equal to the difference between the frequencies of first signal and second signal, other signal has a frequency that is summation of the frequencies of first and second signal. In other words, if we assume input signal 1 has a frequency f_1 and input signal 2 has a frequency f_2 . The output would look like

$$O/P \text{ Signal} = A(f_1 + f_2) + B(|f_1 - f_2|)$$

where A and B are the signals having frequencies

$$f_A = f_1 + f_2 \text{ \& } f_B = |f_1 - f_2|$$

respectively.

We know that the distance between source and receiver causes a time delay proportional to the distance for the received signal in comparison to the transmitted signal. Thanks to the triangular wave used at the very beginning of the project, the distance between the source and receiver is also proportional to the frequency difference between the original source signal and the received signal by the receiver. This can be understood from the basic principle of VCO. Assume that the first signal left the VCO and entered the mixer at Time 0 and has a frequency f_1 proportional to the magnitude of the triangular wave at Time 0.

Similarly second signal entered the Mixer at Time 1 and has a frequency f_2 proportional to the magnitude of triangular wave at Time 1. Therefore, the time shift " $Time\ 1 - Time\ 0$ " is proportional to the " $|f_2 - f_1|$ ". Thus, if we can find the frequency difference between this signal, we can easily find the desired distance since the distance can be found by

$$d = (Time\ 1 - Time\ 0) * v_s = K * |f_1 - f_2|$$

where K is a constant and v_s is the speed of sound.

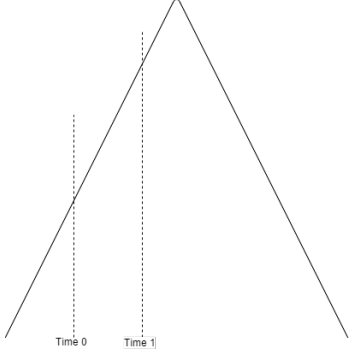


Figure 2: One Period of Triangular Wave

For that purpose, a mixer circuit is what we need and a basic mixer circuit we are planning to use can be seen at Figure 3.

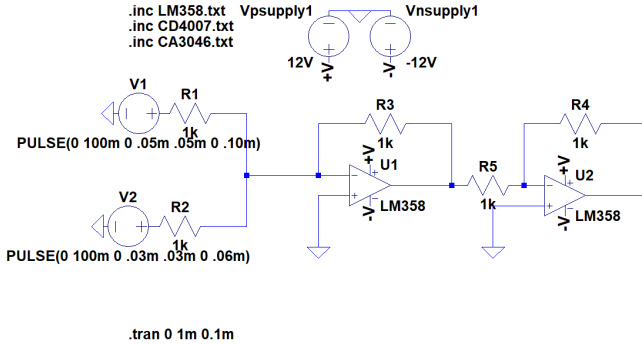


Figure 3: A Multiplier Circuit

C. Low Pass Filter

Unfortunately, the output signal of mixer does not only carry the frequency difference info but also frequency summation info. Since we are interested with the difference between the frequencies only, a low pass filter should be used to extract the wanted signal.

Low Pass Filters are the type of filters that passes and amplifies the signals having the frequencies lower that the desired frequencies also known as the cut-off frequencies of the filter. Other signals having higher frequencies would be eliminated at the output of the low pass filter.

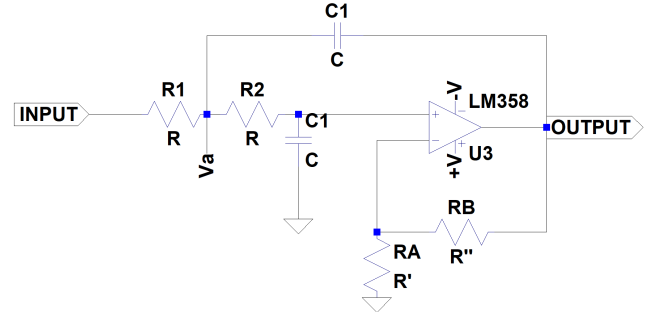


Figure 4: A Second Order Low-Pass Filter