Distance measurement with US time-of-flight
Lab Report

Csomai Borbála, ZZMDFE
Kastal Csilla Noémi, CQN7S6

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The measurement

The measurement consisted of two parts. In the first part the appropriate frequency was measured. In the second part the distance between the demo board and a sheet of paper was measured.

Used equipment

- already prepared circuit on a breadboard
- oscilloscope (Tektronix TDS 2024)
- function generator (to measure the resonance frequency of the US transmitter, HAMEG HM 8030-6)
- PIC picdem 2 plus demoboard, with an already programmed microcontroller (necessary to generate impulses to the real measurement)
- power supply

The already built circuit consisted of two part: the transmitter and the receiver part. The transmitter part has a bipolar transistor, it's basis is controlled through a capacitor. The resonant circuit contains an inductor, a capacitor and parallel with it the ultrasound transmitter is connected. The receiver part has two operational amplifiers and supplementary resistors and capacitors.

The function generators output terminal is connected to the transmitter's input terminal. The generator generates a signal with roughly 40 kHz. The excitation frequency coming from the function generator is measured with the red probe. The oscillator's yellow probe is connected to one terminal of the transmitter. This way the inner behavior of the oscillator circuit can be measured. As the excitation frequency is increases the transmitter circuit's sinusoidal wave becomes more and more beautiful. The ideal frequency to excite the transmitter is approximately 41.86 kHz. The circuit can emit the highest energy at this frequency. If the frequency is higher or lower than this value, than the sinusoid wave gets distorted.

The function generator is replaced with a demoboard, an already programmed microcontroller. This generated around five bumps with approximately 40 kHz, after there is a 300 ms silence. This silence is important in case of distance measurement, because in case of constant excitation we won't be able to tell when we started emitting the first pulse. The specific output terminal of the microcontroller is connected to the input of the transmitter. Parallel with the five bumps on oscilloscope there is a signal from the receiver part. If we zoom out we can see the distance between the starting of the first pulse and beginning of the first beginning signal in time distance. As the paper is moved further away, the returning pulse train is getting further away from the starting pulse. Thus the distance can be calculated from the receiver signals by using the speed of sound ($\sim 340 \frac{m}{s}$). The calculated distance value has to be divided by two, because the measured distance is from the board to the paper and then back to the board.

Our task was to calculate the lower and higher frequency values on the basis of the neighbouring resistors and capacitances. We had to calculate the parameters both of the active band pass filters and the cutting frequencies both in the lower and higher end of the band pass filters. We also had to calculate the amplification ration on the basis of the resistors.

Results

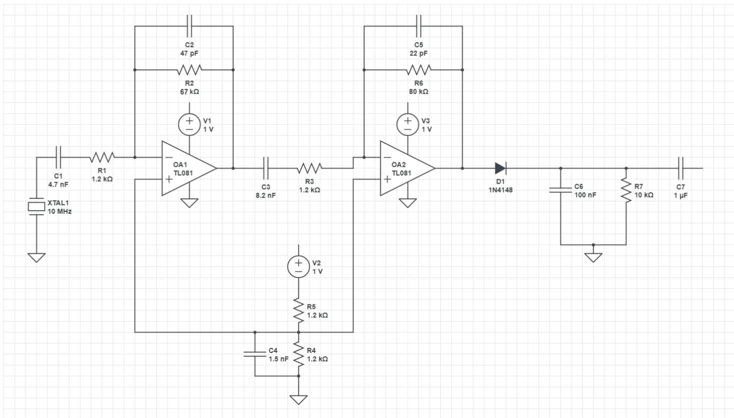

Figure 1: The receiver circuit

The formulas we used to calculate the cutoff frequencies:
$f_L = \frac{1}{2\pi R_1 C_1}$
$f_H = \frac{1}{2\pi R_2 C_2}$
$A = -\frac{R_2}{R_1}$

The results for the first stage:
$R_1 = 1.2\ k\Omega$
$R_2 = 67\ k\Omega$
$C_1 = 4.7\ nF$
$C_2 = 47\ pF$
$f_L = 28.218\ kHz$
$f_H = 50.541\ kHz$
$A = -55.83$

The results for the second stage:
$R_1 = 1.2\ k\Omega$
$R_2 = 80\ k\Omega$
$C_1 = 8.2\ nF$
$C_2 = 22\ pF$
$f_L = 16.174\ kHz$
$f_H = 90.428\ kHz$
$A = -66.667$