Sensory Robotics - ultrasound

Distance measurement on US-basis

Goals:

- distance measurement with ultrasound time-of-flight;
- investigation of the resonance-frequency of the US transmitter;
- getting familiar with active RC band-pass filters.

Short description of the exercise:

Software environment: -
Tools to use during this lab:

- 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.

During the measurement you have to fulfill 3 main tasks:

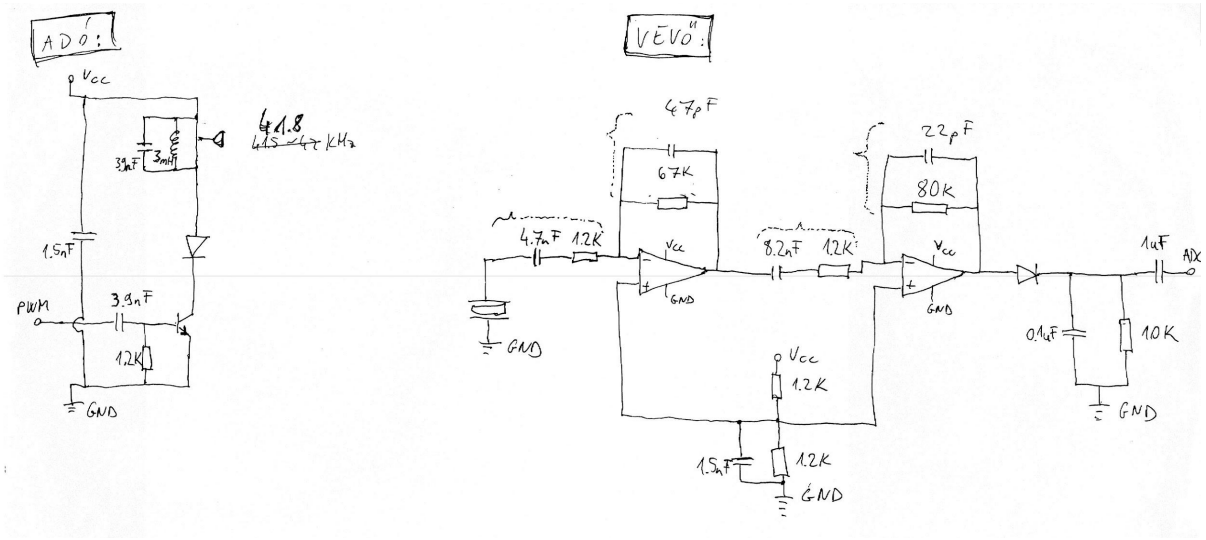
1. Please become familiar with active RC band-pass filters: how can we compute the corner frequency cut-off points, how can we compute the gain. Please overview the layout of the circuit (communicate with the lab instructor if necessary). Please calculate the parameters of the filters in the receiver circuit.
2. Please connect the function generator to the input of the US-transmitter, connect the oscilloscope to the lower point of the transmitter, and analyze the behavior of that oscillator in the function of the frequency.
3. Please connect the demoboard to the input of the US-transmitter, connect the oscilloscope to the end-terminal of the receiver (where you can measure the filtered-demodulated signal); then use the whole system to distance measurement.

Manuals to prepare yourself before the lab:
`oscilloscope_TektronixTDS2024.pdf`: page numbers according to the pdf-file: 31-49 (printed: 9-27)
`function_generator_HamegHM8030_6.pdf`: page numbers according to the pdf-file: 5-6 (printed: 18-19)

How does the active band-pass filter work (you can find this in the receiver as well):
http://www.electronics-tutorials.ws/filter/filter_1.html , filter_2, filter_3, …, filter_7
(What we will use: inverting band-pass filter, among the active band-pass filters; but please read the other circuits as well.)

Description of the circuit:

The following circuit can be found on the breadboard:
(left side: transmitter;
right side: receiver):



Every ultrasound transmitter / receiver has a main-frequency. Our devices are operating near the 40 KHz value.
The transmitter on the left hand side of the figure:

- on the upper right side: the LC-oscillator stabilizes the resonance frequency of the transmitter head,
- the bipolar transistor supplies the periodical, higher energy excitation to the oscillator; the base of the transistor is controlled by either the function generator, or the preprogrammed demoboard,
- other circuit elements: detachment of the supply rails, setting the base bias to the transistor, etc.

The receiver on the right hand side of the figure:

- two-stage active band-pass filter, then a demodulator part (to detach the envelope from the 40 KHz carrier signal).

Theoretical assumptions when computing circuits containing operational amplifiers:

- there is no in-coming current on the +/- input pins of the OpAmps, only voltage levels are present,
- if we have a closed-loop circuit (the output is connected to one of the input terminals), then the OpAmp will do its best to hold its two input terminals on equipotential levels (as far as its supply power makes it possible, of course).

Description of the measurement:

1. Please calculate the cut-off frequencies and gains of the filters on the receiver side; try to match the parts of the schematic drawing and the real circuit.
2. Analysis of the transmitter with different excitations:

a. please set up module B of the supply power to 5V; set up the function generator to 40 KHz, with squared shape, then switch off both of the instruments;
b. please connect the 5V terminals of the supply power to the power rails of the prepared breadboard circuit; connect the signal output of the function generator to the input of the transmitter; make equipotential the grounds;
c. please connect one probe of the oscilloscope to the output of the function generator, the other probe to the lower point of the oscillator in the transmitter, and both of the ground terminals of the probes to the ground itself;
d. please switch on the oscilloscope, the supply power and the function generator:
    i. please set up the scope to see the signals of the probes with the same amplitude-range,
    ii. please search for the ideal excitation frequency with the function generator, and also try two fairly non-ideal values as well (from the range 35-45 KHz), these values should be written in your report (optionally documented with photos as well),
    iii. please switch off the function generator, the supply power and the scope as well.

3. Distance measurement:
    a. please detach the function generator from the system, and connect the demoboard:
        i. connect +5V and GND (“metal rings” at the corner of the panel) to the appropriate terminals of the power supply,
        ii. output RC0 (long, white cable) will emitt the controlling signal to the transmitter, connect it to the input of the transmitter;
        iii. one probe of the scope should be connected to RC0, the other one to the output of the receiver circuit (grounds should be equipotential again);
    b. swithch on the supply power and the oscilloscope, then please observe
        i. the control signal from RC0, with differnt time-resolution (what you should see: 5 square signal bumps with 40 KHz, then 300 msec. silence);
        ii. then the return time / time-difference of the first returning signal packet (wave-envelope) (you will see also a received bump exactly when you transmit the signal, but this is only crosstalk/noise);
    c. measure distance: hold a sheet of paper as a perpendicular surface to the US heads with different distances (eg. 20cm, 0.5m), check the distance with a tape-measure; with the help of the scope’s display: calculate the distance on the basis of the horizontal axis (the speed of sound can be assumed as 340 m/s) - try to document these measurements with photos if possible;
    d. measure the distance of the ceiling.

What and when to upload:

What:

- your report (with photos if possible).

Please include in the report the calculated parameters of the filters; the observed phenomena during the measurement; the description of the results; and in general: what you have learnt from the filters, from the actual circuit, etc.

Deadline: indicated in moodle.

Thank you.
Miklós