Height measurement - ultrasonic

For the measurement of the height of the tennis ball is used an ultrasonic sensor. This document is the operation and use of the sensor discussed .

This sensor is located on the PCB of the ping pong tower. For information you also have here

- **The complete circuit diagram of the PCB (https://canvas.vub.be/courses/20138/files/540026/download?wrap=1)** **(https://canvas.vub.be/courses/20138/files/540026/download?download_frd=1)**
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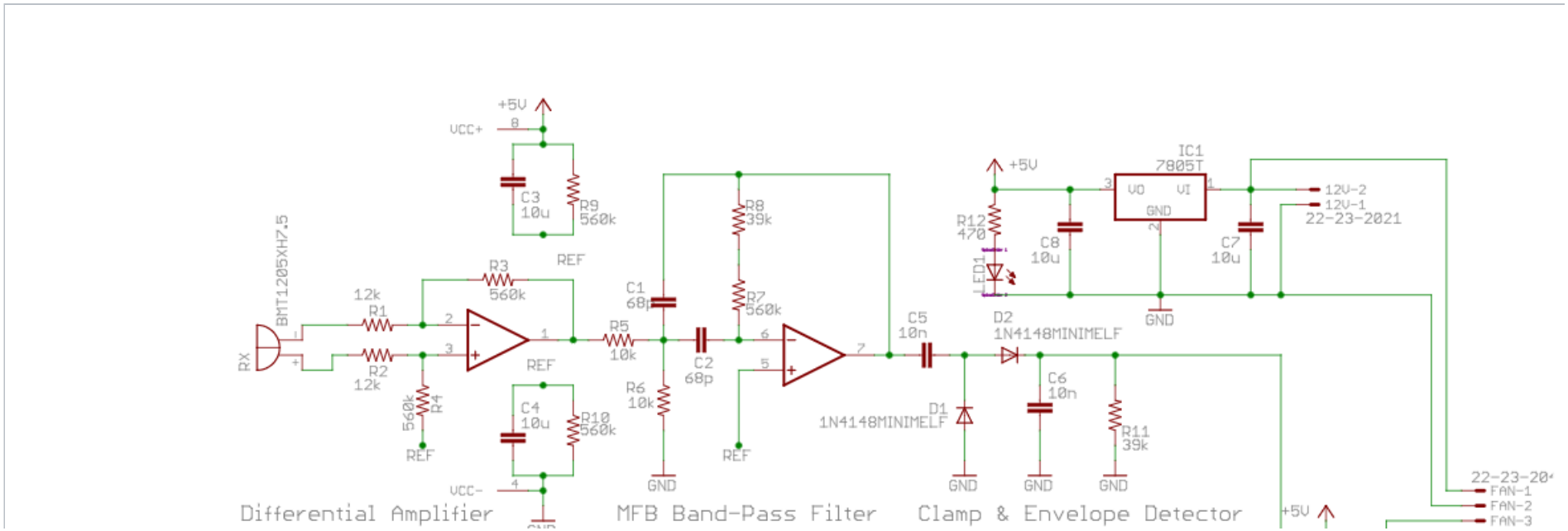

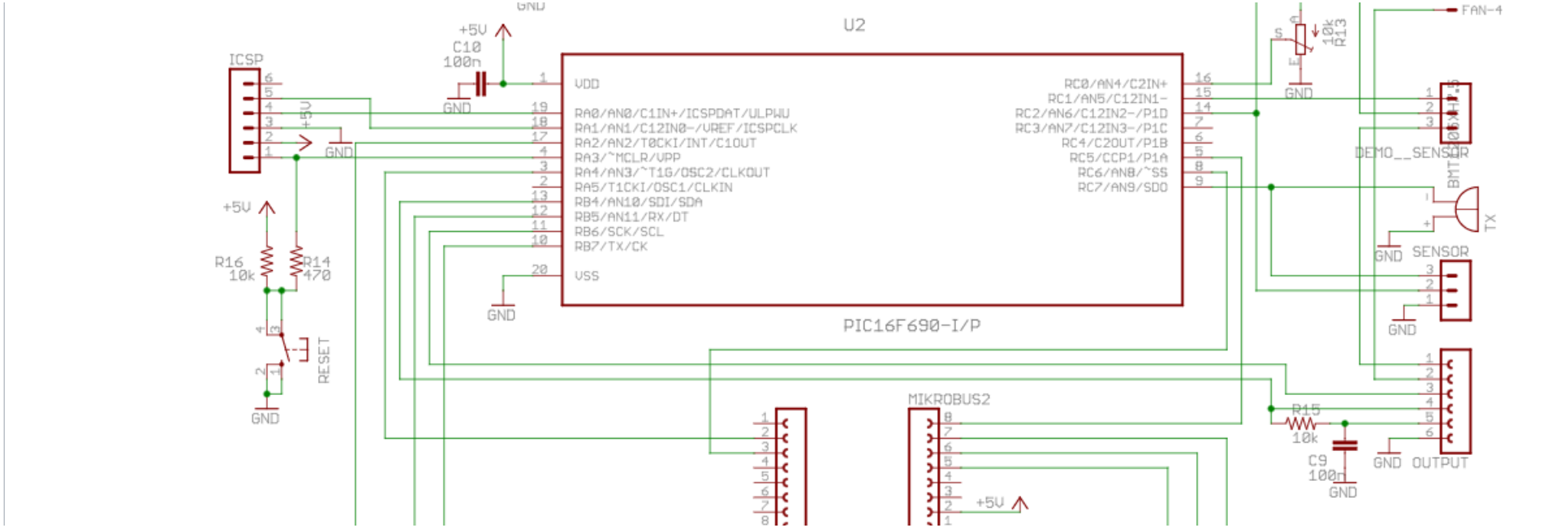

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- **The layout of the PCB (https://canvas.vub.be/courses/20138/files/540132/download?wrap=1)** **(https://canvas.vub.be/courses/20138/files/540132/download?download_frd=1)**

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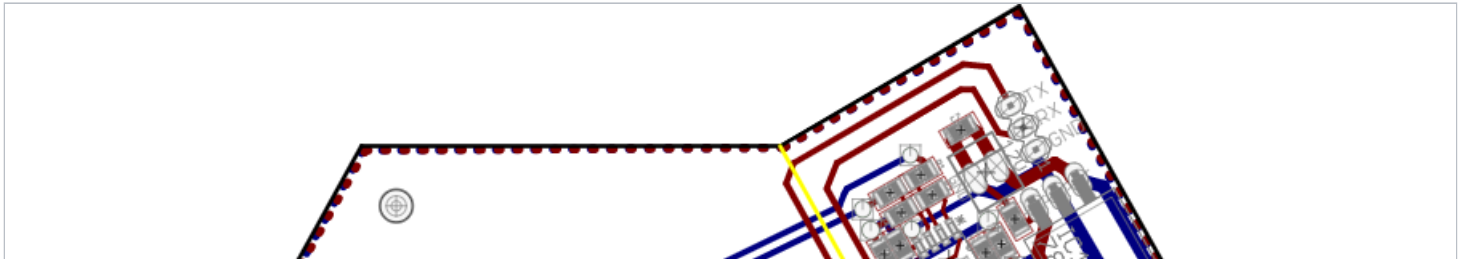
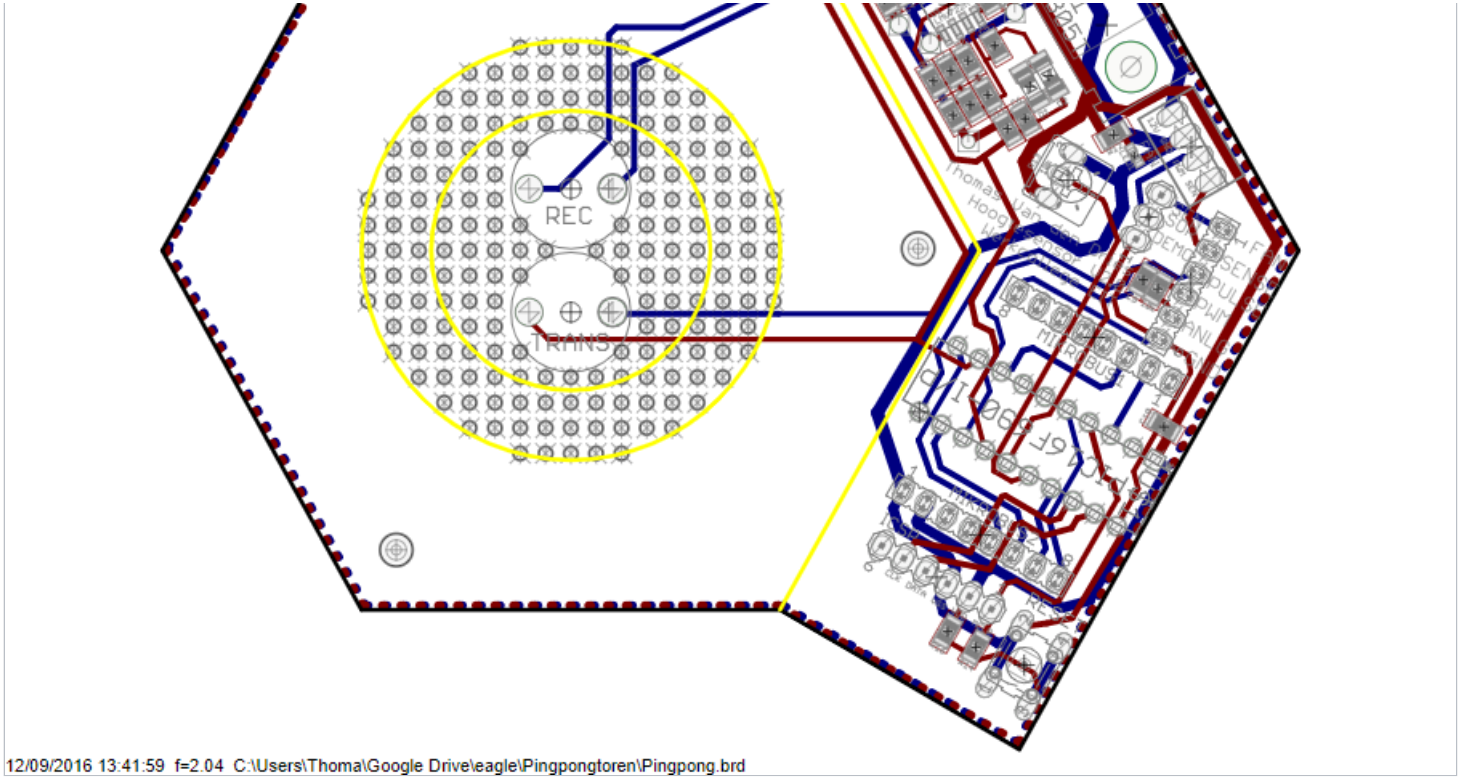
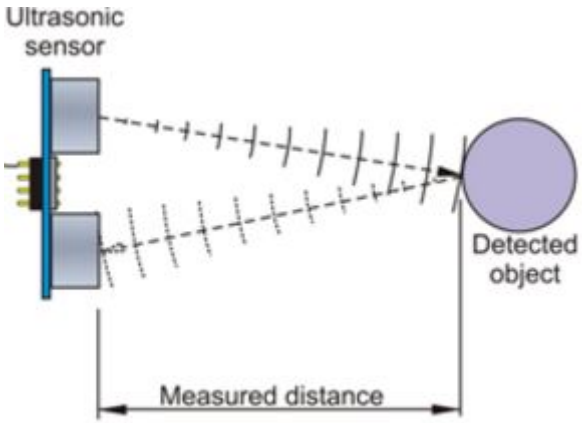




the operation

The operation of the height sensor is based on the use of ultrasonic transmitter and receiver. The transmitter sends pulses of 40 kHz, whereupon the receiver, the reflections of this survey .
The further an object deleted is, the longer it will take before the received reflection is .
The transmitted pulses can be measured with an oscilloscope on the TX pin, the received pulses on the RX pin.



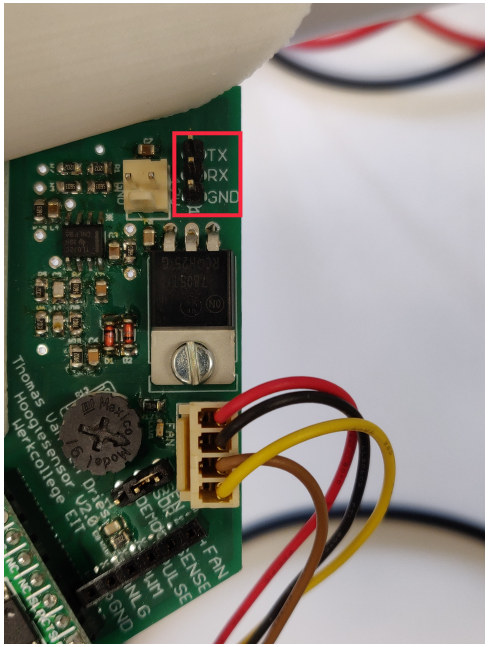


Figure 1: The working principle of an ultrasonic measurement

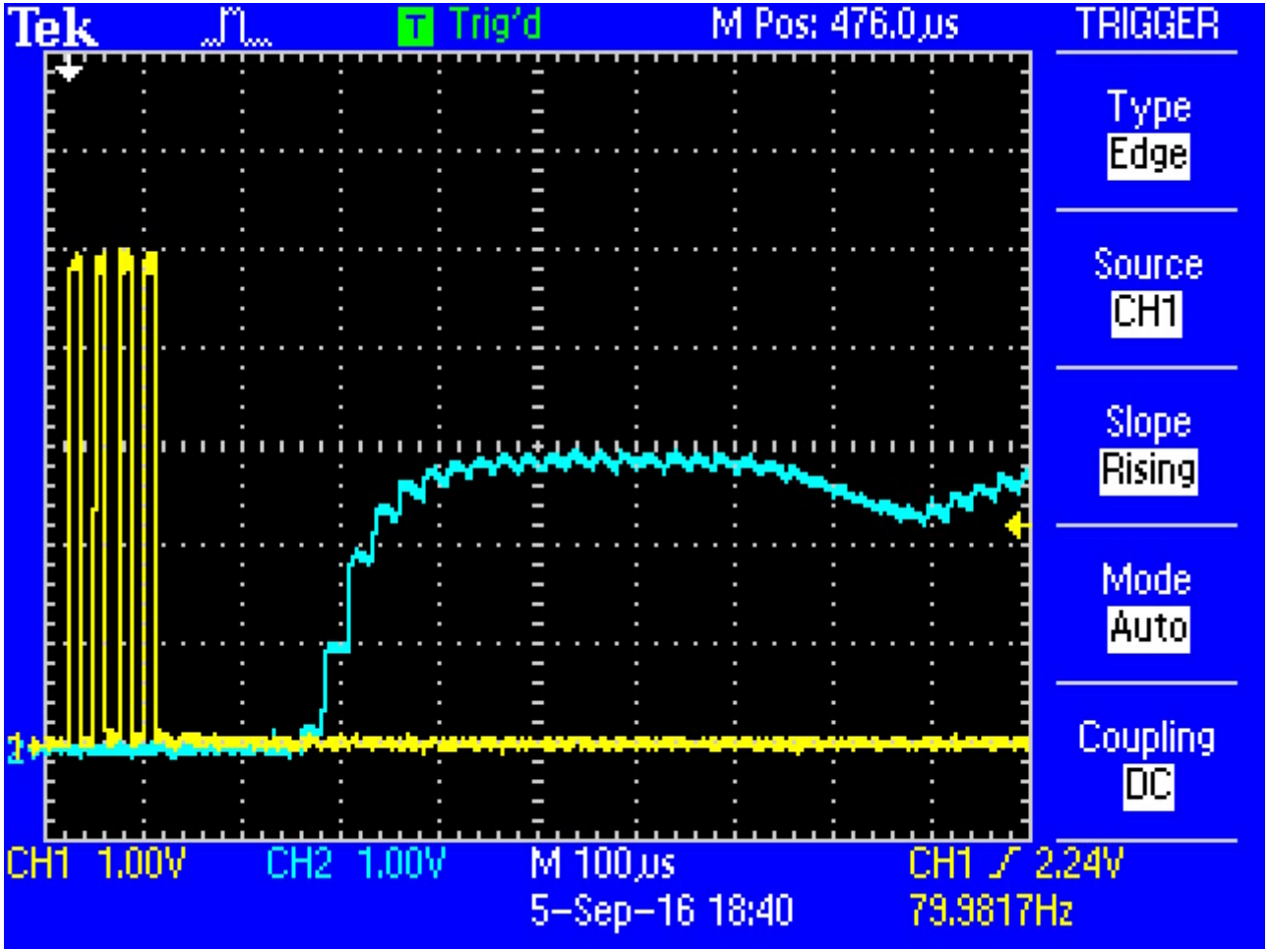


Figure 2: The transmitted signal (yellow) and the received signal (blue)

You will see that there are always reflections on the RX signal, which are independent of the height of the ball.
These reflections come from the Plexiglas tube itself, and are filtered out by the sensor after calibration.

The calibration

To calibrate the system , the fan must be connected to the ping pong tower and then the reset button must be pressed for a few seconds .
The ball will be blown upwards and the reflections of the tube will be measured. Then it will float a little lower; this indicates that the calibration

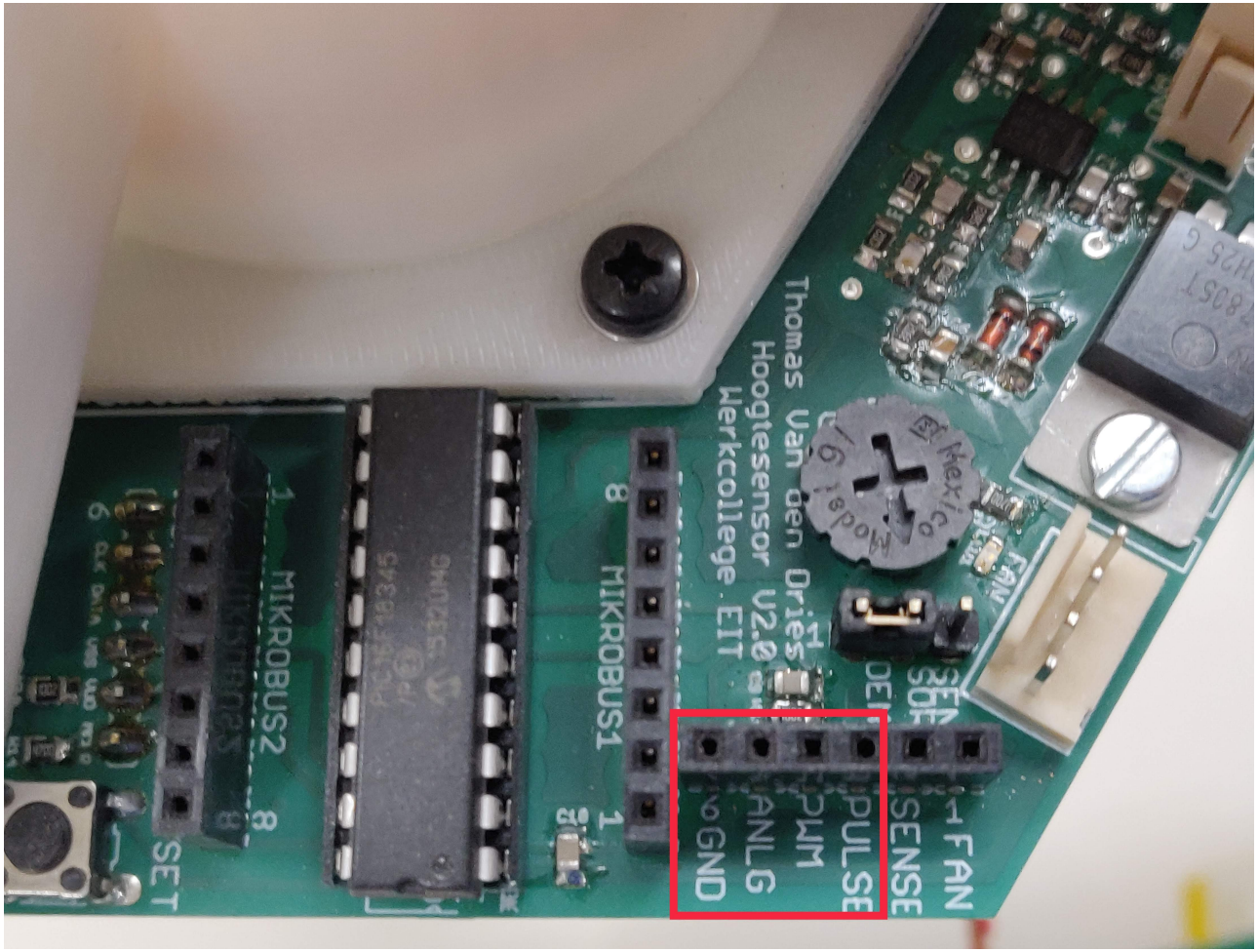
was successful.

!!! DO THIS EVERY TIME AFTER STARTING UP THE ALTITUDE SENSOR !!!
The height sensor forgets its calibration when power down, so always do this when you apply the power!

You can read the details behind this calibration in the document **Altitude measurement - calibration (https://canvas.vub.be/courses/20138/pages/hoogtemeting-calibratie)**

Height sensor outputs

The height sensor returns the height in four ways, so there are several options for processing the data. These outputs can be found on the PCB of the tower (don't forget to connect the ground as well). Make sure the red switch is on SENSOR when using the height sensor!

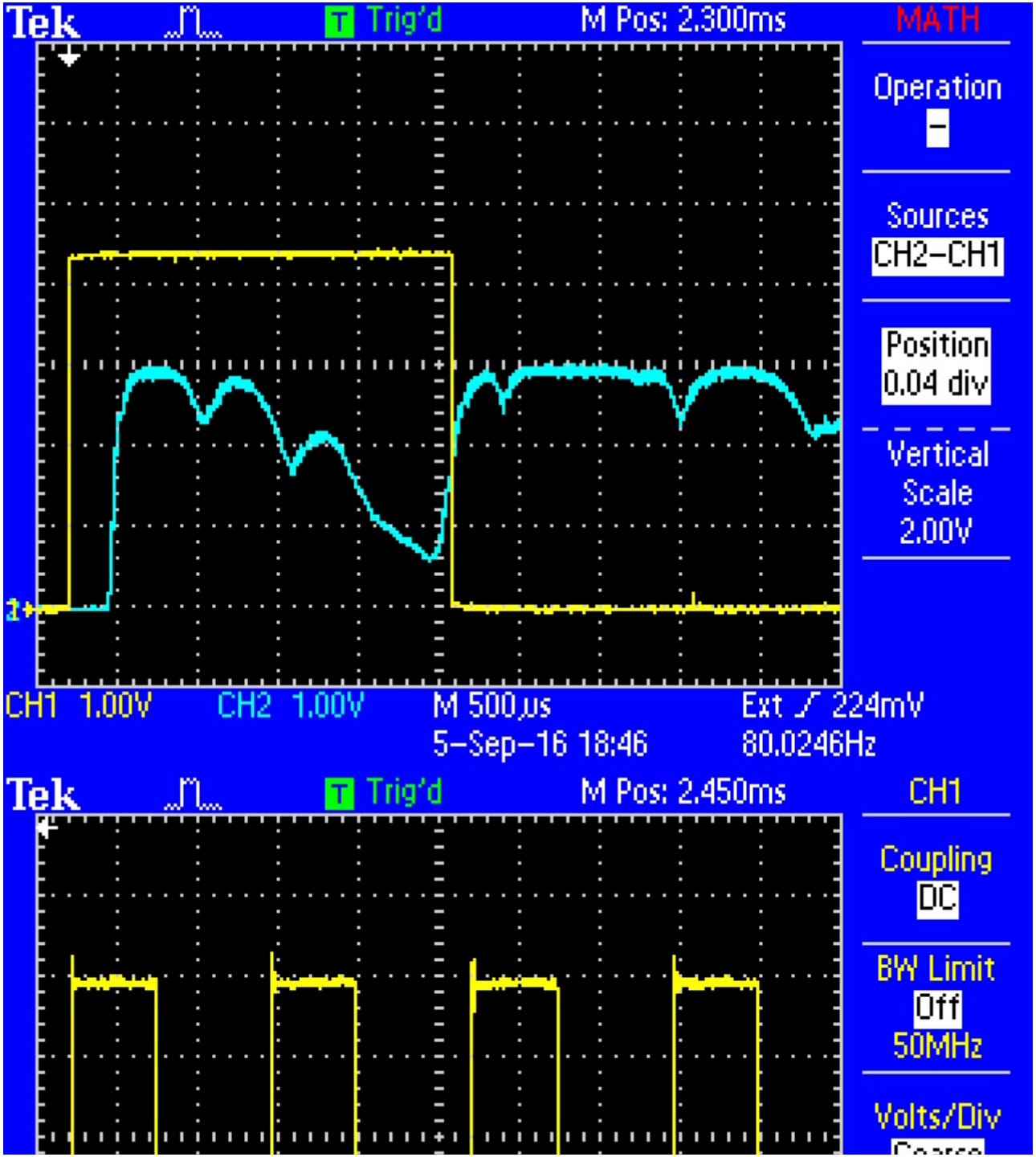


1. Time pulse (PULSE) The yellow pulse on the figures above is the primary output of the system. The length thereof is proportional to the height . This time is then converted into other signals . (Yellow graph in Figure 3 left)

2. Square wave (PWM) Another output is a PWM that has a duty cycle proportional to height . A duty cycle of 100% corresponds to the ball at the top of the tube. (Yellow graph in Figure 3 right)

3. Analog Voltage (ANLG) The PWM is also filtered to generate an analog voltage. A voltage of 5 V corresponds to the ball at the top of the tube. (Blue graph in Figure 3 right)

4. **Digital (UART)** An extra UART to USB module can be clicked on the board to read the height in java. A height of 255 here corresponds to the ball at its highest position.


Tek
Trig'd
M Pos: 2.300ms
MATH
Operation
−
Sources
CH2−CH1
Position
0.04 div
Vertical
Scale
2.00V
CH1 1.00V
CH2 1.00V
M 500µs
Ext ⁄ 224mV
5−Sep−16 18:46
80.0246Hz
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Coupling
DC
BW Limit
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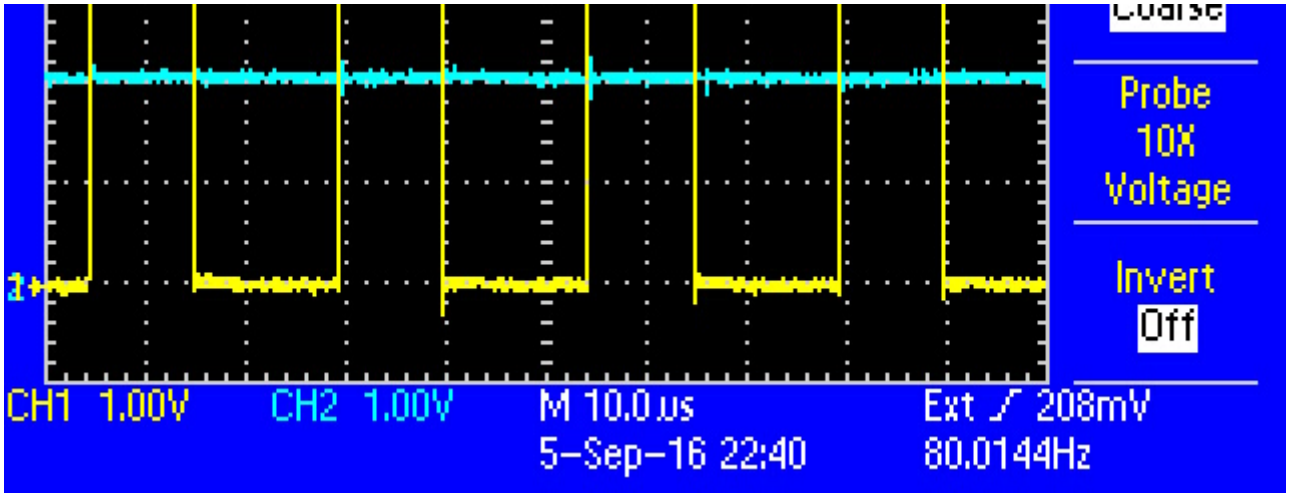

Figure 3: (left) PULSE output (yellow) (right) PWM output (blue) and corresponding analog voltage (yellow)

Conclusion

You now know how the height measurement works. You also have 4 signals that are proportional to the height of the ball, they are the output of our system.
We can use this to build a control system together with the input (speed of the fan).