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DECEL week – tutorial 2: Ultrasound imaging with Redpitaya

1) Aim: Record and reconstitute an ultrasound image (what can I find in the water tank?)

In this first part, we propose to sequentially record ultrasonic pulse/echo signals in water for several angles of the probe driven by the servo motor.

2) Arduino sequence and acquisition with python

In order to drive easily the servomotor an Arduino board is used. This board will emit the TRIG signal for the Pulser board and run the servo motors in order to do an angular scanning.
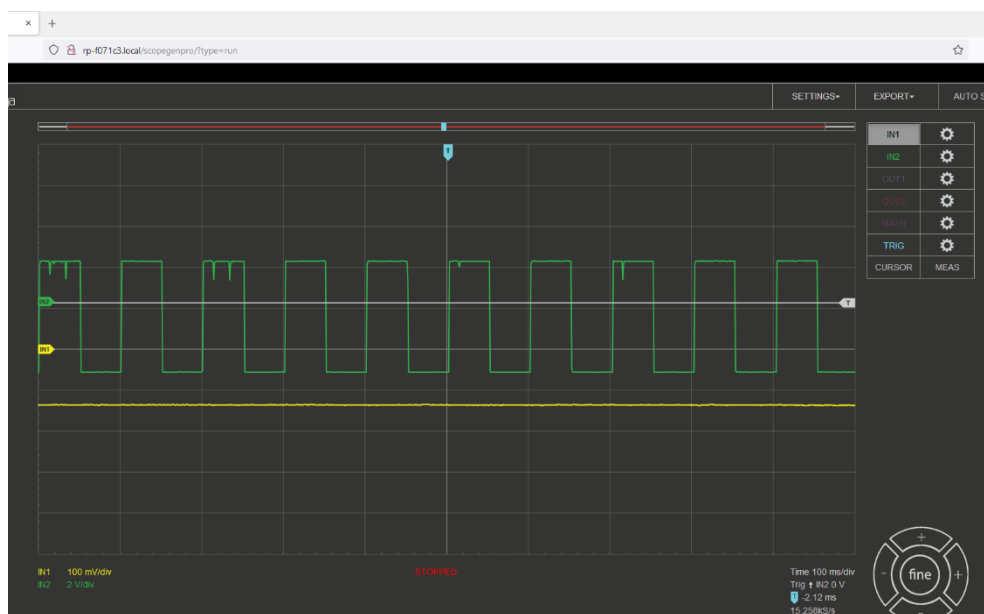
The one step of a basic algorithm could be the following one:

```
…

SERVOMOTOR: go to angle X

TRIG: pass from 0 to 1

WAIT 1 ms

TRIG: pass from 1 to 0

…
```

(then X=X+1, Note that X should go on a small angular range only, example: 45° to 135°)

During the waiting time, the Redpitaya performs the signal acquisition. In addition, the trig signal can be connected to IN2 of the Redpitaya to trigger the acquisition and to be able to count it.
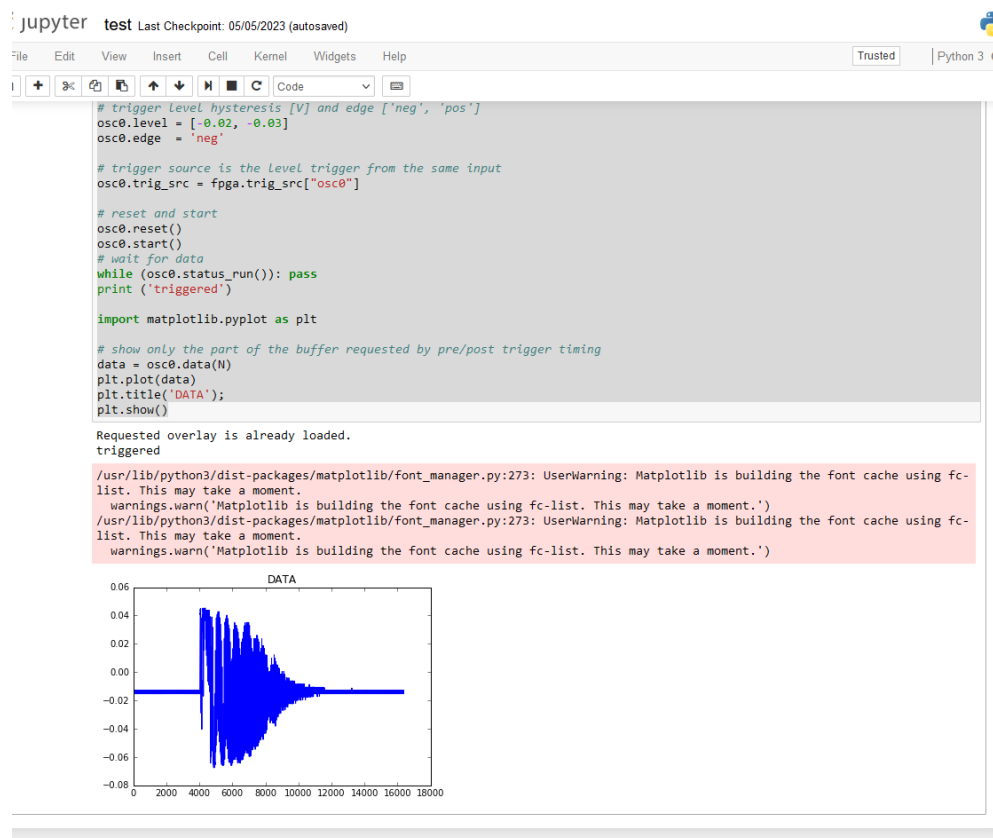
▪ First, implement the algorithm on the Arduino board. The servomotor should move and a periodic signal should be observed using a scope on the programmed output pin of the microcontroller (note that a proper implementation should include an interrupt for this periodic signal generation).):

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- Second, connect the TRIG signal generated with Arduino to the pulser board TRIG IN, go to the scope app, you should see the ultrasonic pulses while the servo sweeps the probe. What can you observe about the echo intensity in relation to the probe angle?
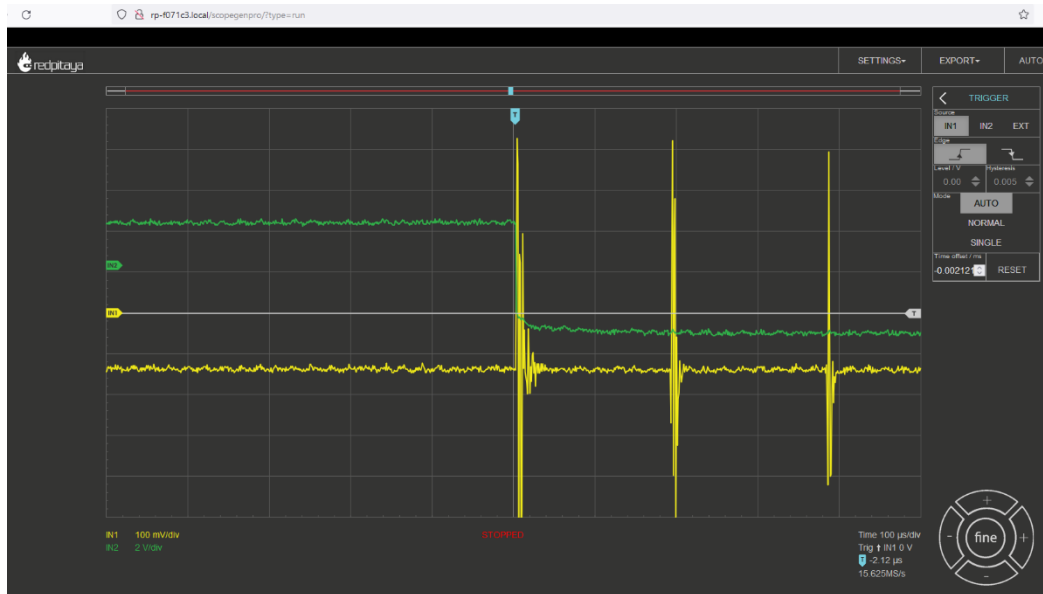
- Third, open the Jupyter app and launch the example code entitled Oscilloscope level trigger (osc_trigger_level.ipynb). Adjust the trig level and polarity (cf. figure bellow). You should be able the get your first signal acquisition.

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3) How to get an image?

For each angle of the sweep, an acquisition is done (the RF line). This acquisition must be setup to record the pulses and at least the first echo. Then each RF line can be treated in order to have the time of the main impulsion and of each echoes (as illustrated in the following figure).
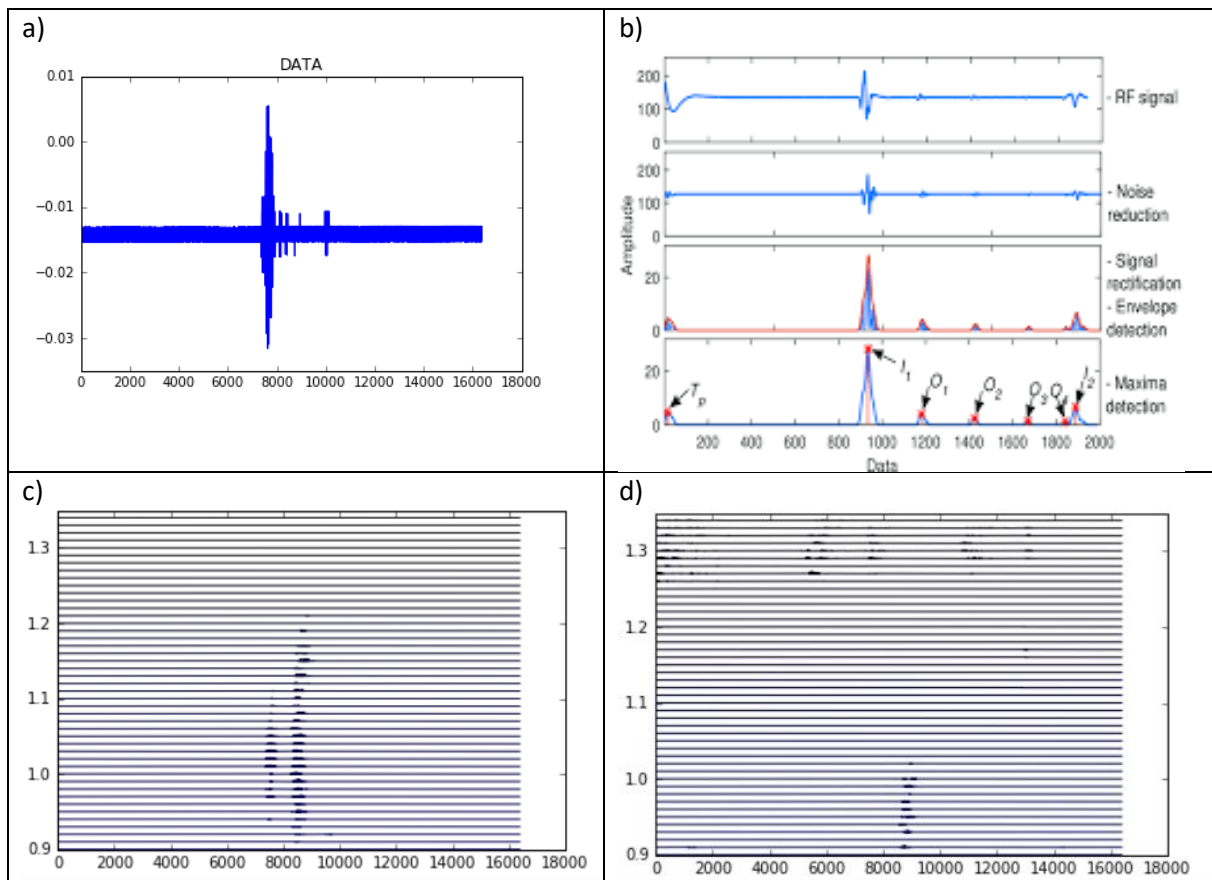

Figure 1

By cumulating several RF lines in the same plot, you should be able to get your first B-scan!

4) How to go faster?

The implemented imaging solution works on the software level, especially on the interpreted (and not compiled) software level, which slows down the imaging sequence. What kind of signal processing could be implemented in the FPGA of the Redpitaya to optimize this sequence?

5) How to get more resolution?

What kind of sequence repetition and signal processing could be implemented in order to get more resolution on the ultrasound image?