Ultrasound Imaging System for Educational Purposes

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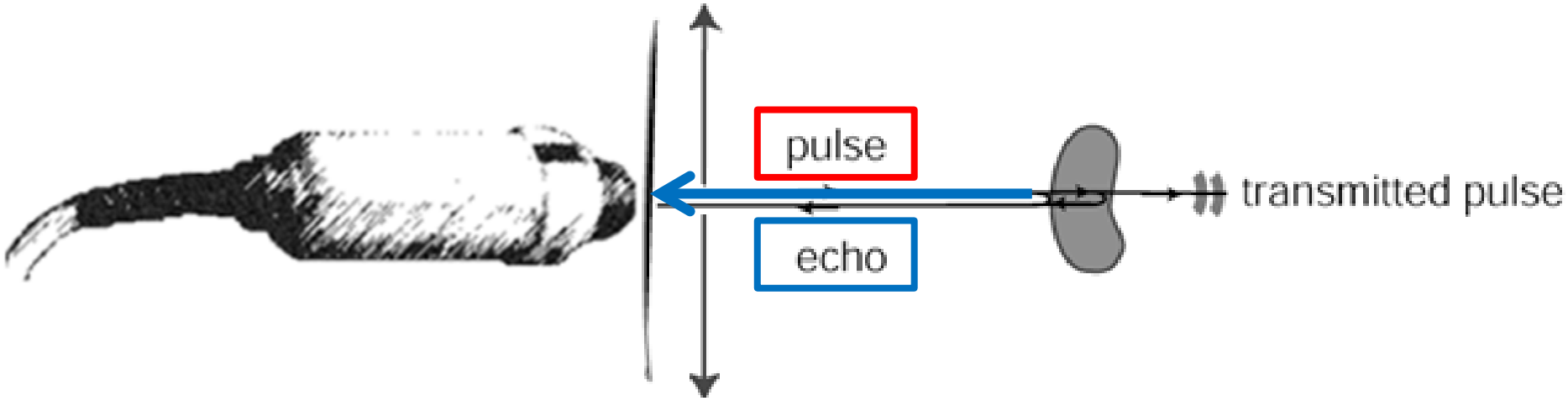
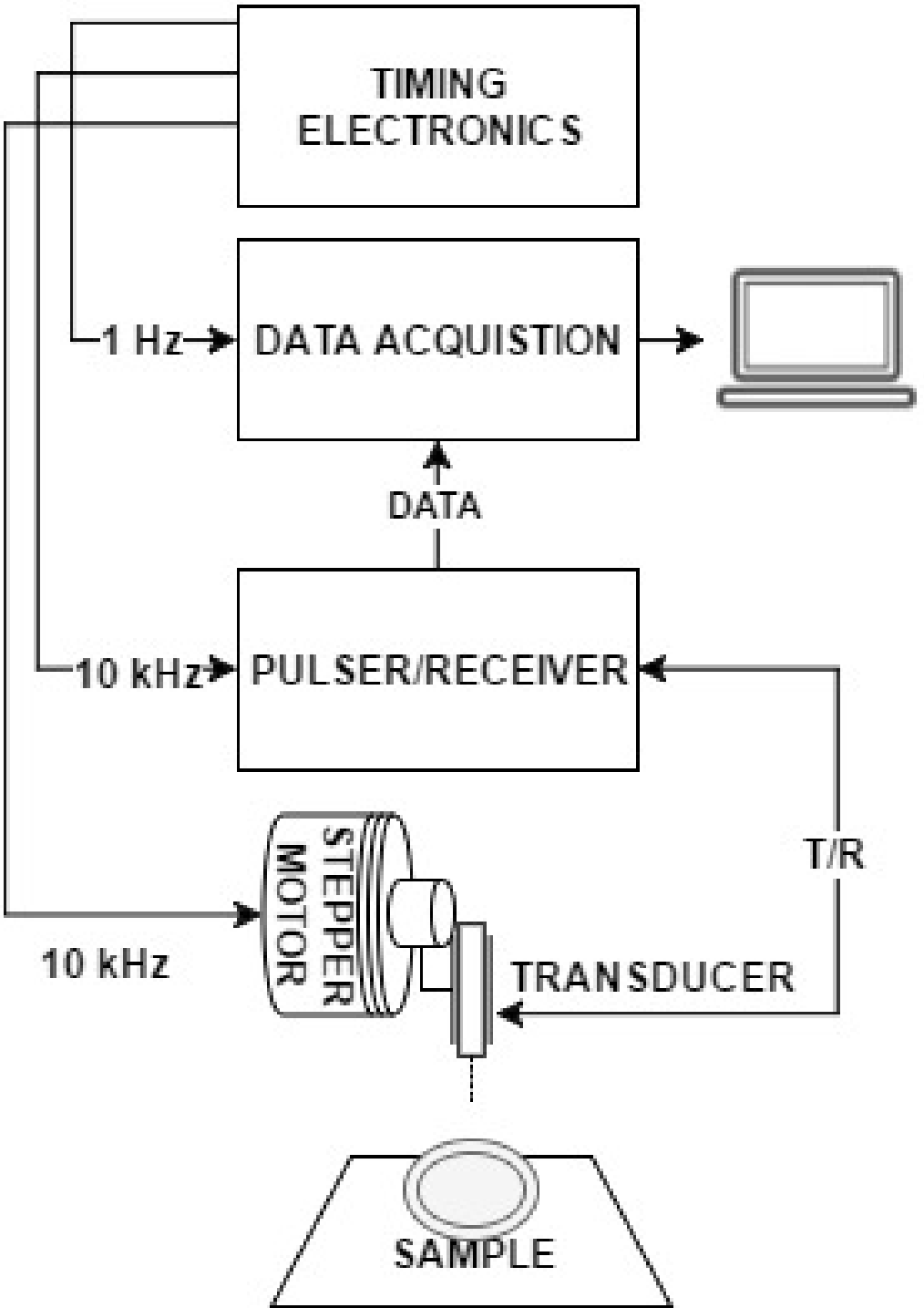
Principles of Ultrasound Imaging

- Echo-ranging technique
- Transducer emits a short ultrasonic pulse into the object
- Same transducer records the echoes that come back
- Transducer is scanned across the object



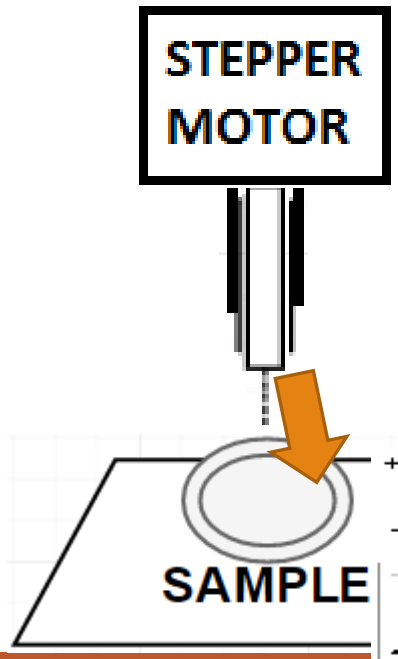
Motivation

- The constructed Ultrasound Imaging System will serve as an Educational tool.
  - Better Understanding for Ultrasound.
  - Better Understanding for Electronics involved.
- TIMING ELECTRONICS: Triggers Data Acquisition, PULSER/RECEIVER and controls Stepper-motor.
- Improved System
  - Accuracy
  - Flexibility
  - Modularity



Specifications

400 A-Lines



➢ **Generate Signals**

1 Hz pulses: 1 FPS; 10 kHz pulses: Acquiring Data stream pulsing 400 A-Lines.

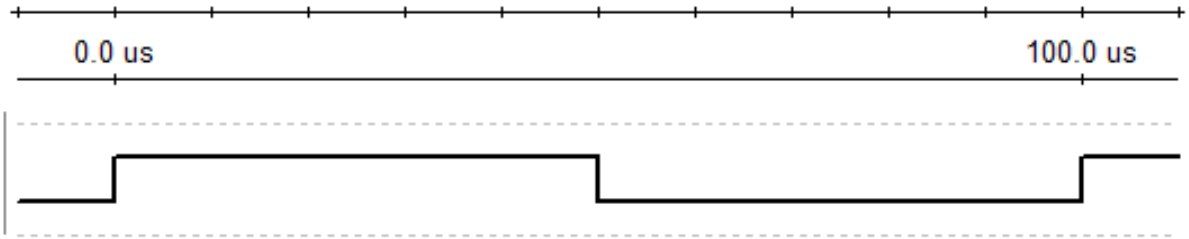
➢ **Accuracy Requirement**

Worst-case error after 1000 pulses is 1 us

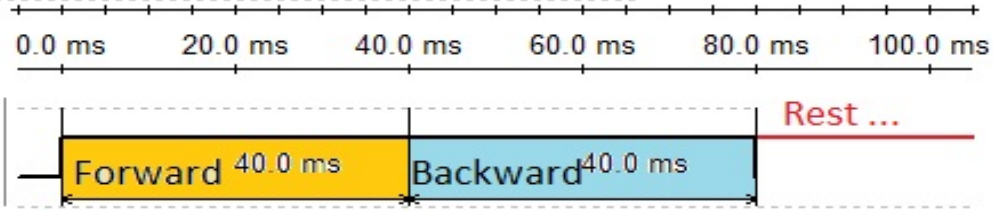
Shift in the ultrasound image of less than 1 mm

➢ **Data acquisition and processing environment**

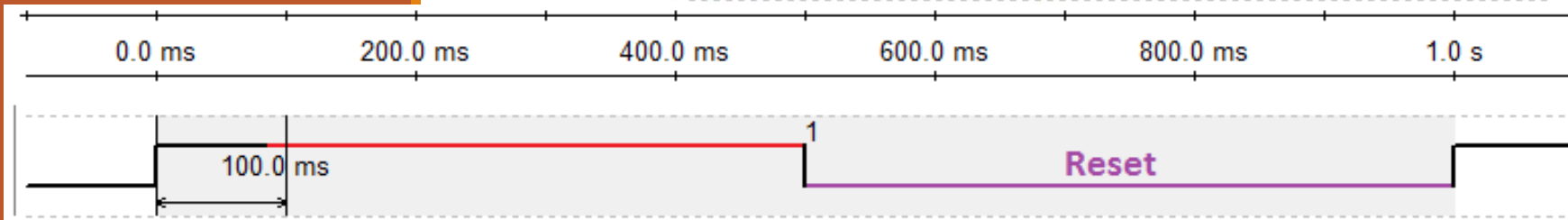
➢ **Drive Stepper motor**



10kHz



1Hz



Design and Testing FPGA vs Microcontroller

MICROCONTROLLER

Familiarity with programing Language.

Clock Speed: 22.118MHz.

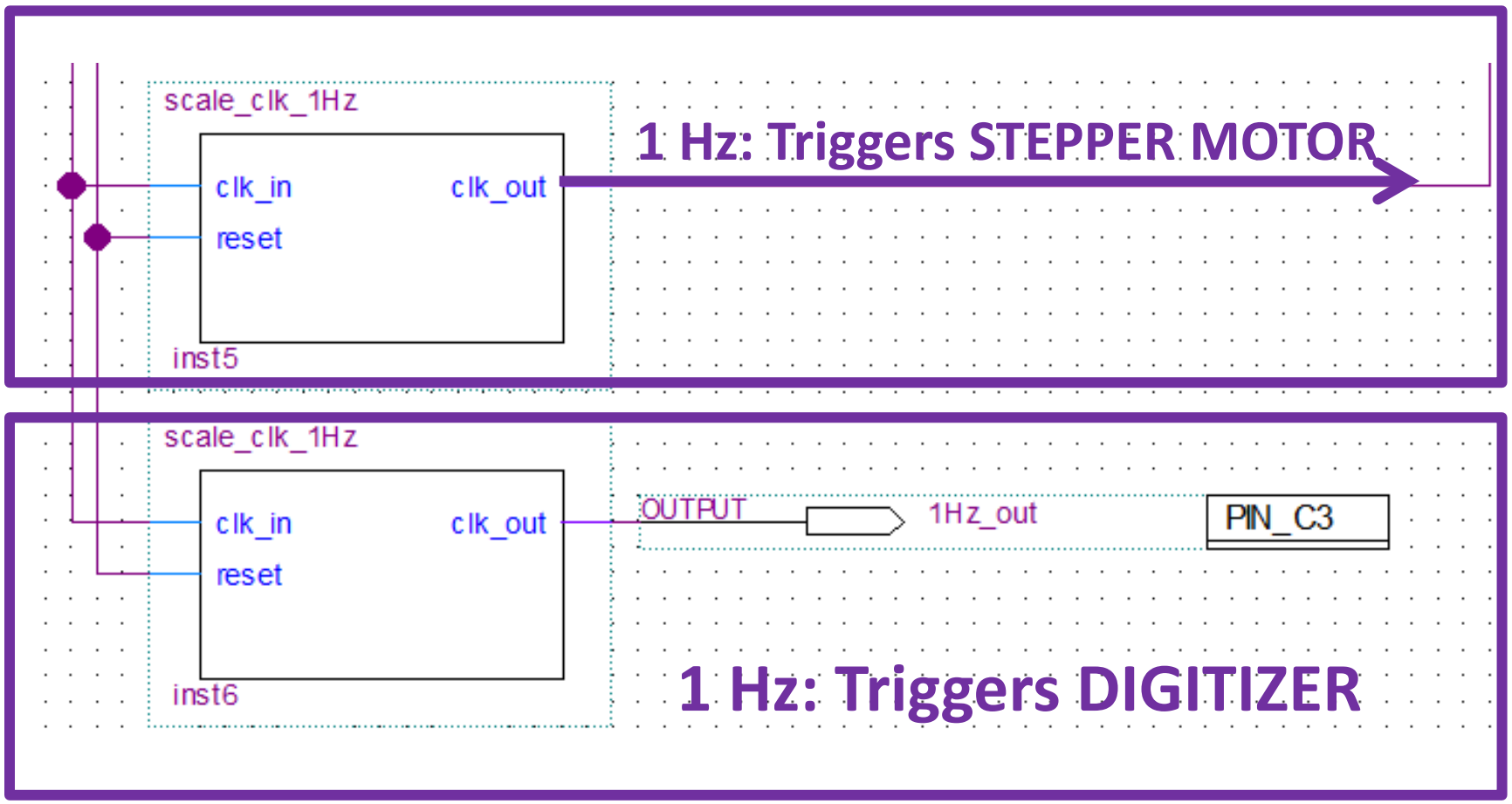
FPGA (ALTERA DE BOARDS)

Hardware: Parallel execution

Clock Speed: 50MHz.

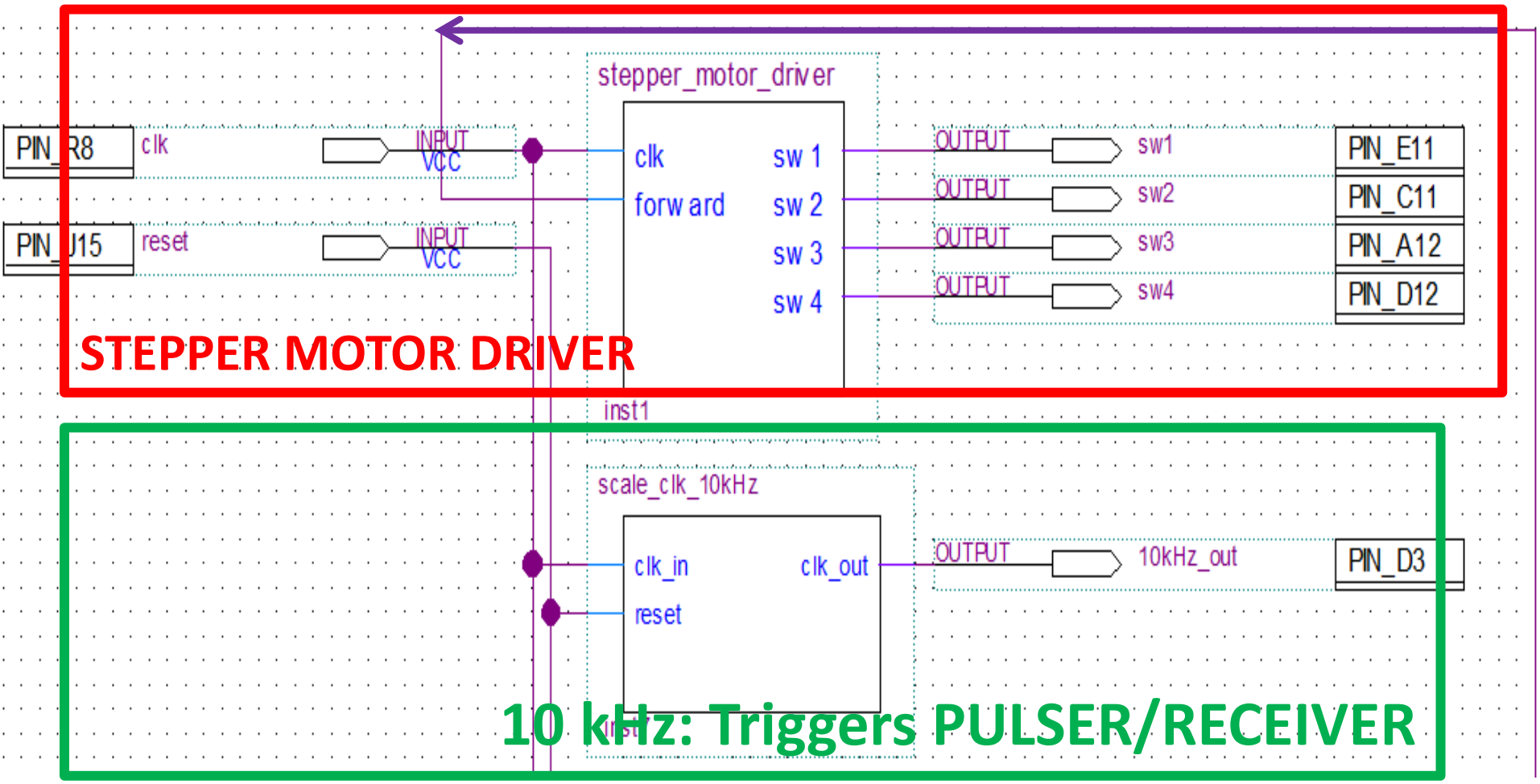
Interfaces include

1. External GPIO headers
2. On-board memory devices
3. General user peripheral with LEDs, Switches and push-buttons.



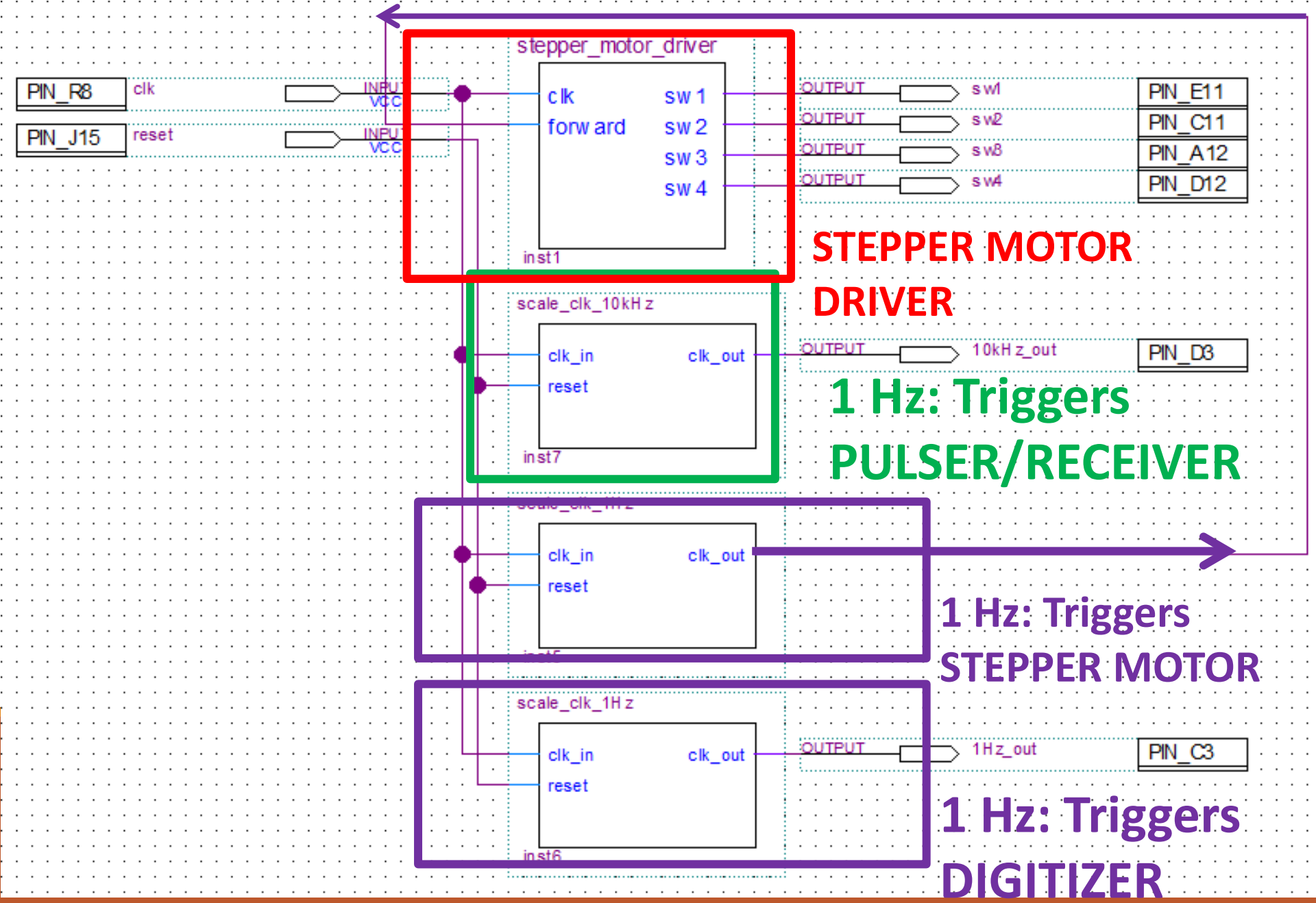
1 Hz Schematic

Clock Divider: 50MHz System Clock in, 1 Hz out.

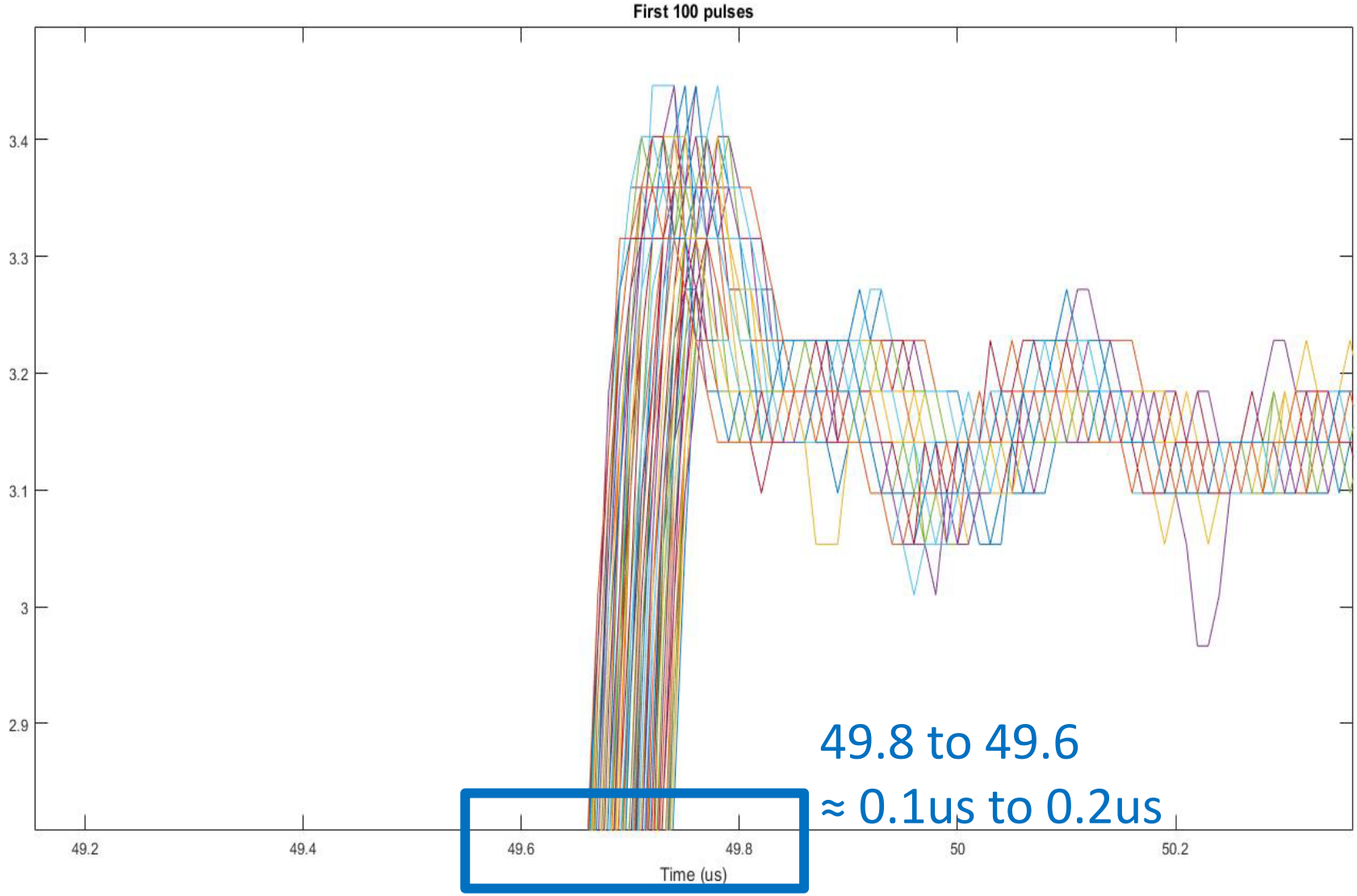


10 kHz and Stepper-Motor Driver Schematics

-- 10 kHz Clock Divider: 50MHz System Clock in, 10 kHz out.
-- Stepper Motor Driver



Ultrasound System Schematic



Generated Pulses Accuracy

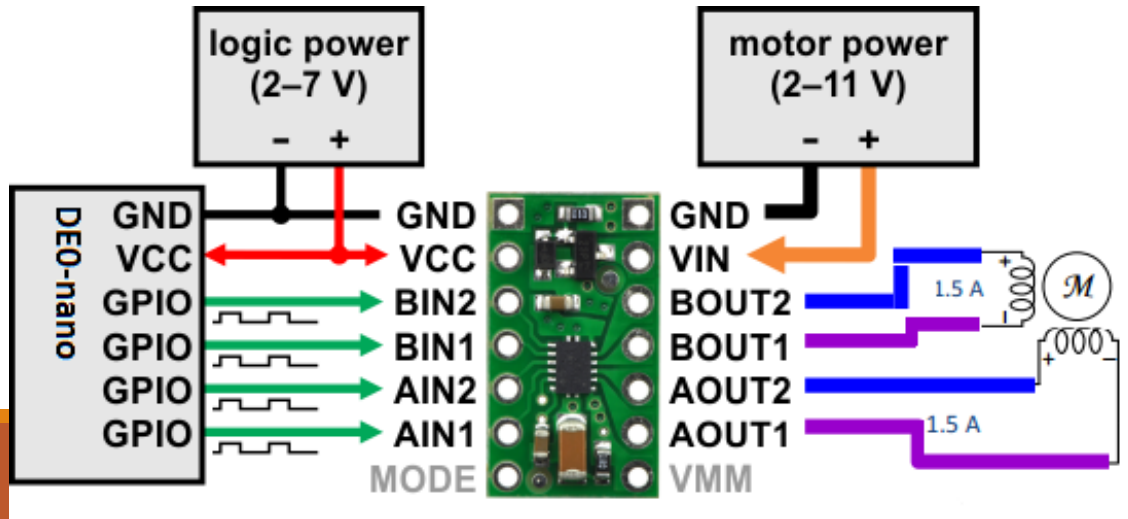
Stepper Motor

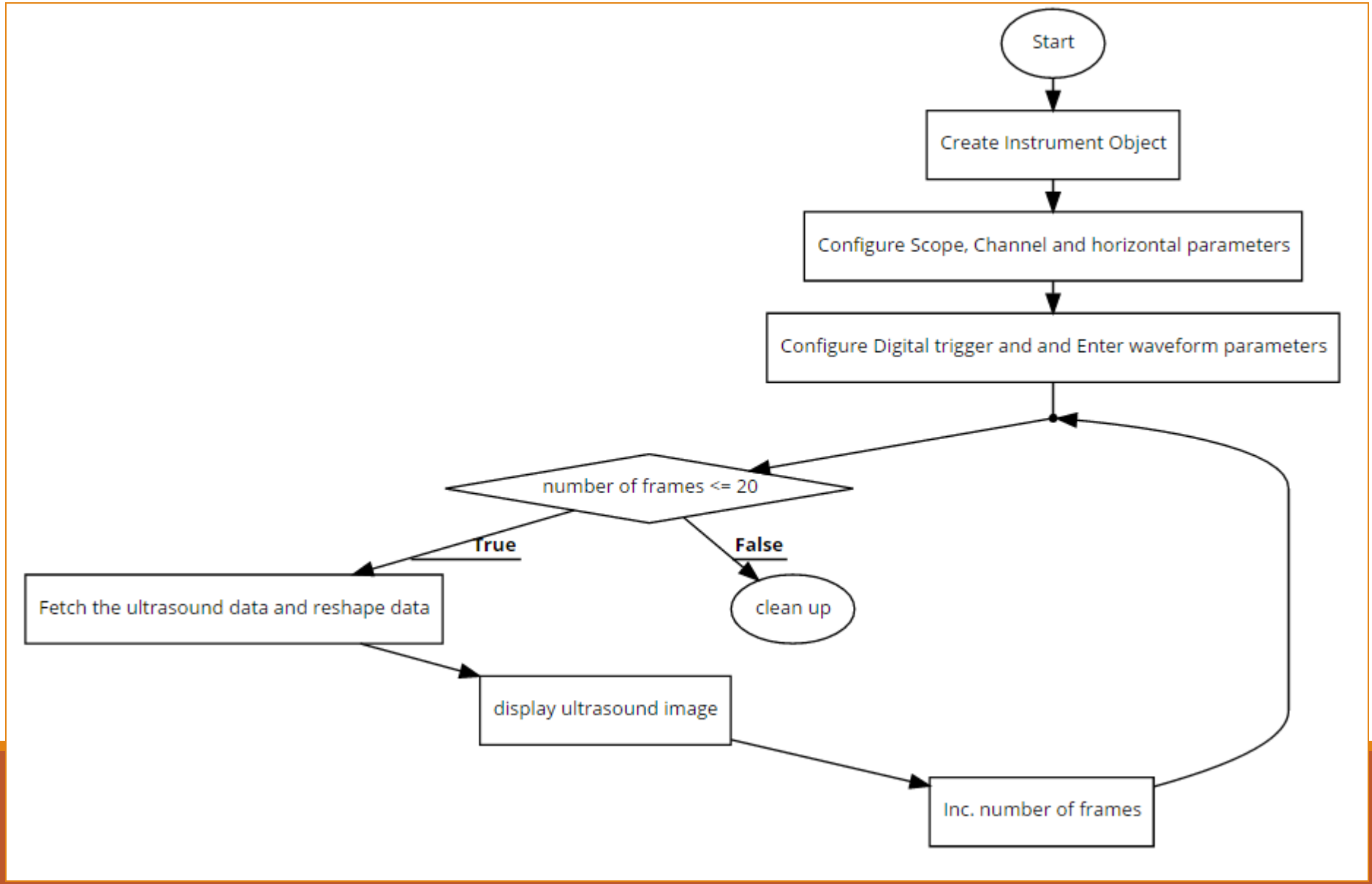
Why?

1. Better accuracy
2. Reduced effects of resonance

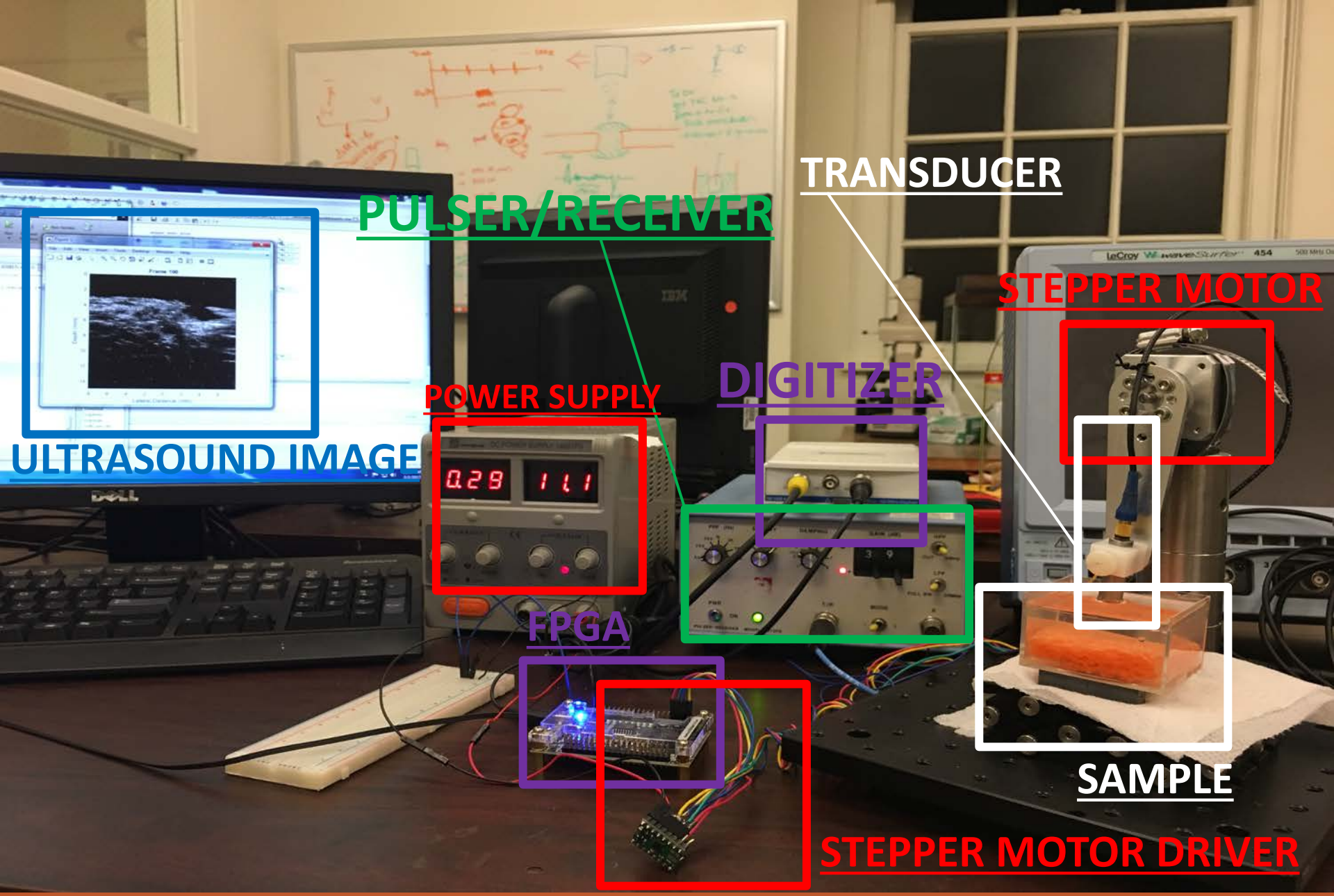
Requirement

Drive a 200 step per revolution motor via micro-stepping (1/64)





Data Processing (MATLAB) Flowchart



Ultrasound Imaging System Setup

Conclusion

REQUIREMENT	ACHIEVED?
➢A good demonstration techniques for mediating learning	➢YES!
➢Improved Accuracy	➢Signals were generated accurately (with in limit)
➢Higher Flexibility	➢Smaller Size; System employs user peripheral with LEDs, Switches and push-buttons.
➢Modularity	➢Adaptable Blocks and Reusable code
➢Trigger Data Acquisition, Pulser/Receiver and control a Stepper-motor	➢FPGA was used
➢Process Data and Acquire images	➢MATLAB, Ultrasound Images

Future Work

- Implement different Modes for triggering and acquiring data
  - MUXs and switches.
- User input taken through FPGA only.
- Data processing using a different environment
  - Implement a User Interface
- Improve stepper motor driver
  - Support other micro stepping modes

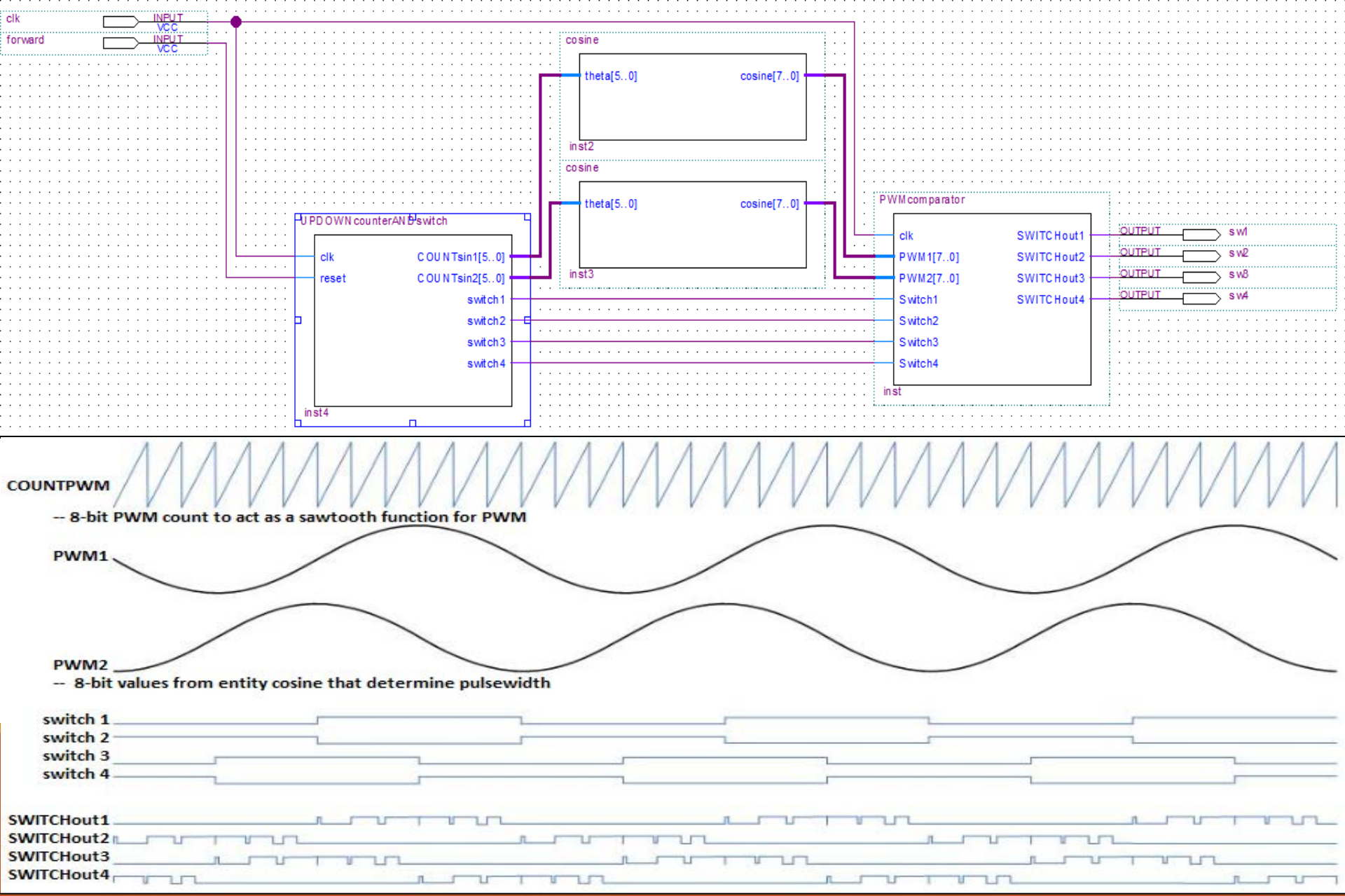
Questions?

Appendix

Parts

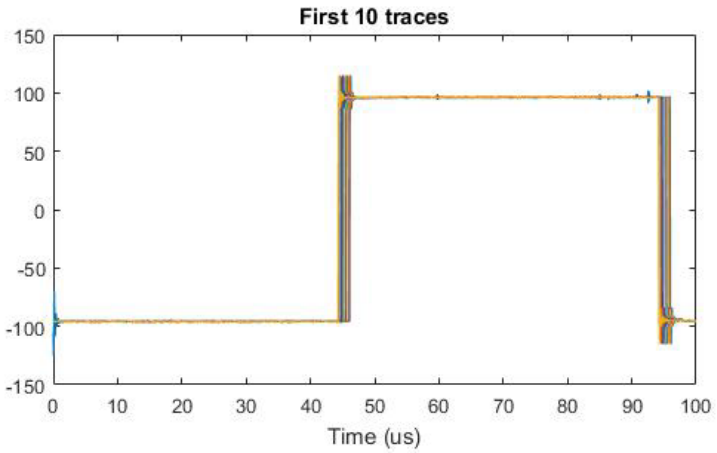
DE0-nano Development and Education Board http://www.terasic.com.tw/cgi-bin/page/archive.pl?Language=English&No=364	$120
Stepper Motor Driver https://www.pololu.com/product/2135/pictures	$5
Stepper Motor with Cable https://www.sparkfun.com/products/9238	$14.91
Total	**$110**

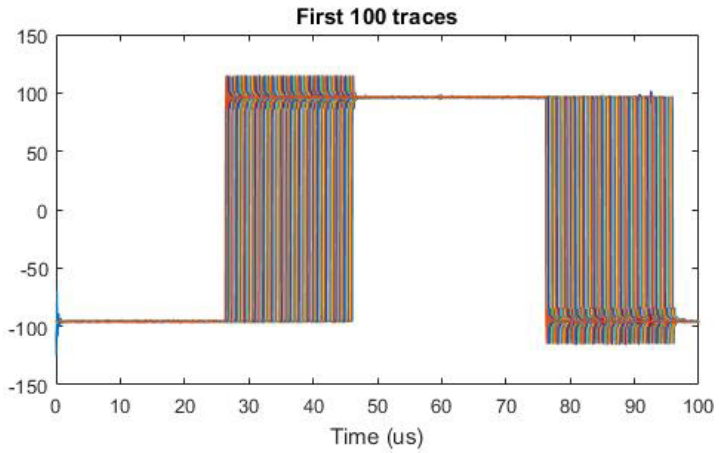
The project requires some additional components. These components will be covered by the faculty advisor overseeing this project, and/or the Electrical Engineering Department. The Altera DE2 Development, Olympus 1073PR Pulser-Receiver, NI USB-1133 acquisition board, c8011 microcontroller and a computer.



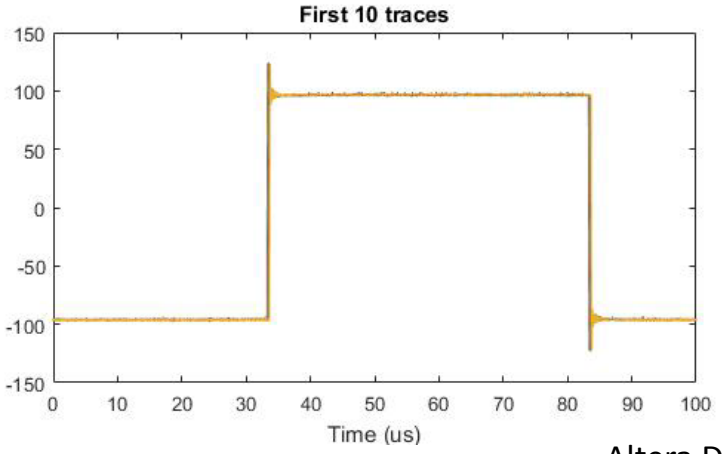
Component schematic and a timing diagram of a PWM uni-polar stepping motor controller.

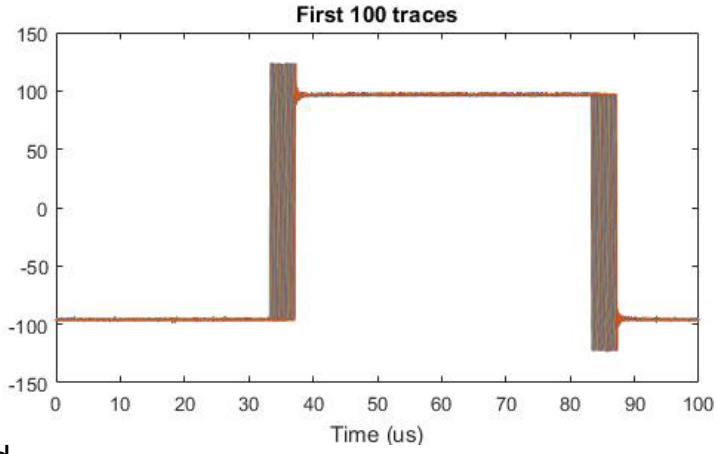
Preliminary Data



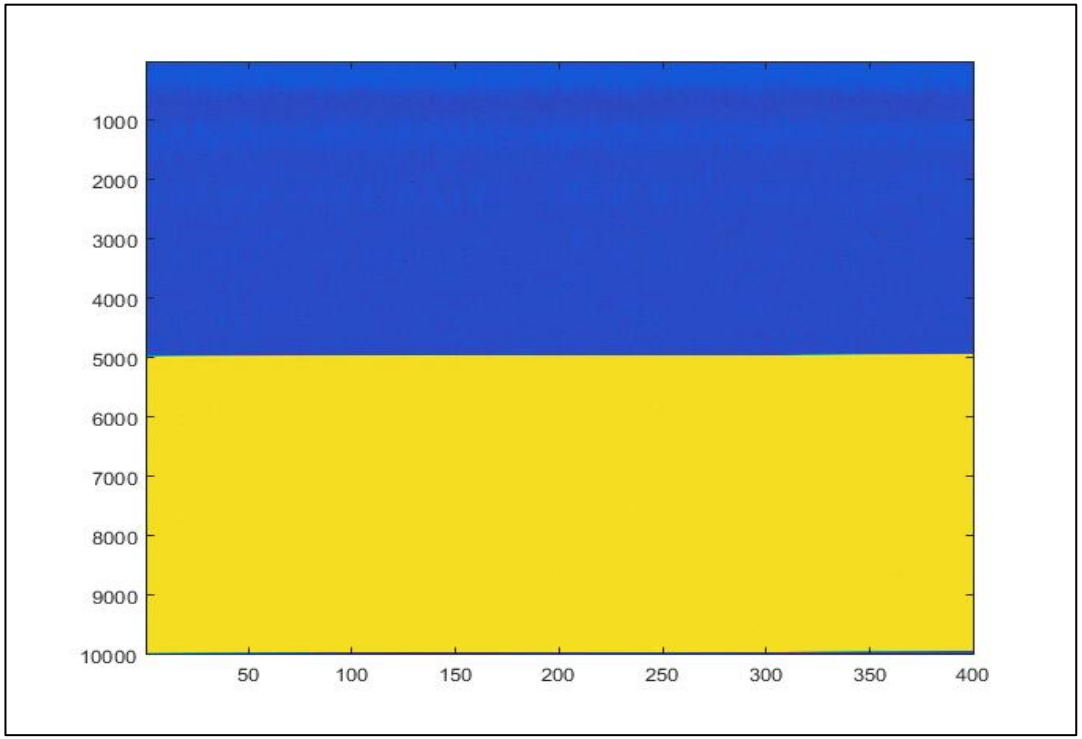


8011 Microcontroller, $\Delta T = 0.16\mu s$





Altera DE2 Board



1. Create Instrument Object
2. Configure the scope
   - Configure the vertical range for channels: Range, Offset, Coupling and Probe Attenuation.
   - Configure Channel
   - Configure the horizontal parameters: SamplingRate, numSamples ...
   - Setup the digital trigger and configure it.
3. Enter waveform parameters
4. Fetch the ultrasound data and reshape into 2D matrix
5. select portion of ch0_data
6. display ultrasound image