Research and Innovation Conference 2016

Development of a ‘bone stethoscope’:
A system for aiding early detection of osteoporosis

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Development of a ‘bone stethoscope’

A system for aiding early detection of osteoporosis

Osteoporosis leads to nearly 9 million fractures annually worldwide, and over 300,000 hospital patients in the UK each year.

Currently used techniques for diagnosis:

- Dual X-ray Absorptiometry (DXA)
- Quantitative Computed Tomography (QCT)
- Quantitative Ultrasound (QUS)

These techniques are very expensive and access to them is very limited within a clinical environment.

Early detection of osteoporosis can allow interventions reducing the likelihood of occurrence and could significantly reduce the overall long term treatment costs by reducing hospital admissions.

Project Outline

The aim of this project is to design and develop a prototype ‘Bone Stethoscope’ system to assist clinical practitioners in detecting osteoporosis, improving early detection rates.

Our core aims:

- Design and develop a low cost data acquisition interface and software analysis package.
- Test and validate the system in the laboratory.
- Bid for external funding to develop the product to commercial stage.
- Produce publications in world class journals and present at national and international conferences.
- Develop intellectual property which could lead to future revenue streams.

Measurement System

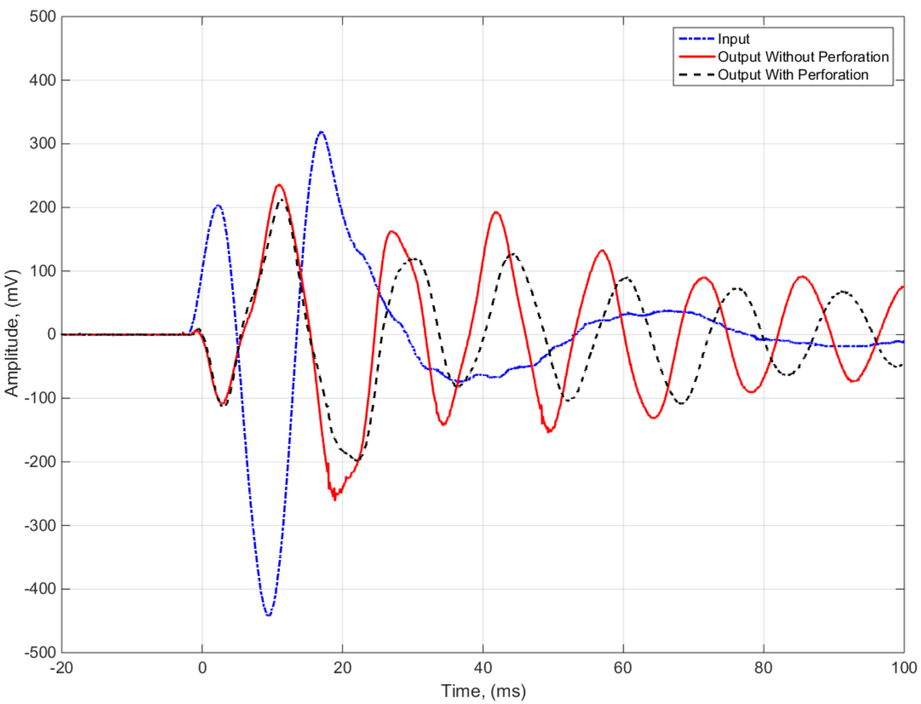
As bone is affected by osteoporosis the internal structure of it changes, which causes signals that pass through it to react differently than in healthy bone.

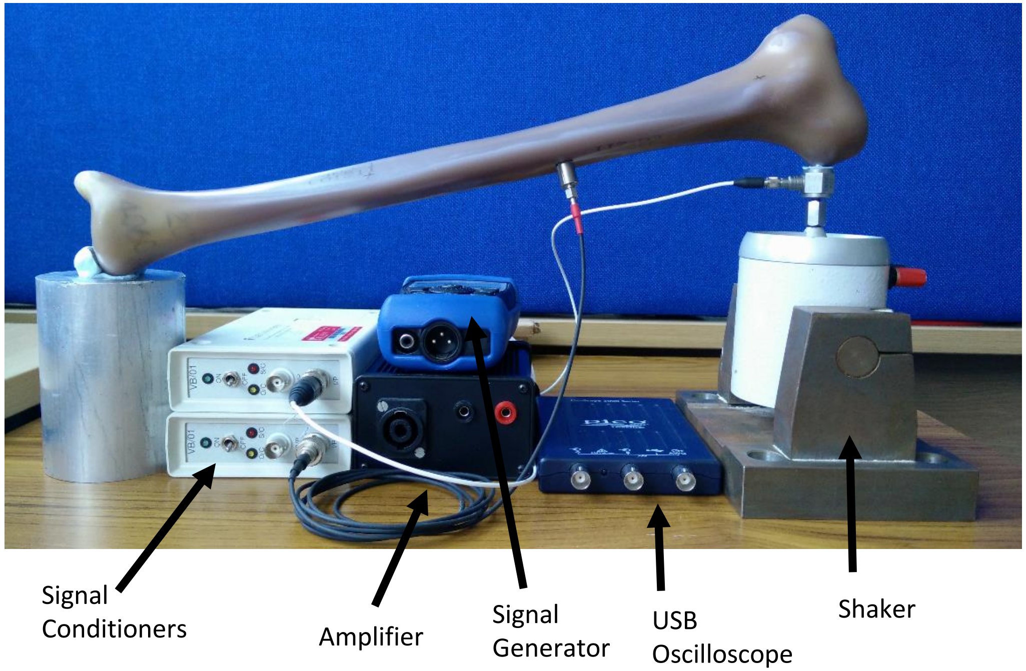
We are aiming to detect the early signs of osteoporosis by analysing a transmitted signal and comparing it to known healthy bone.

A number of different hardware and software configurations have been investigated in order to identify the most suitable for use on humans:

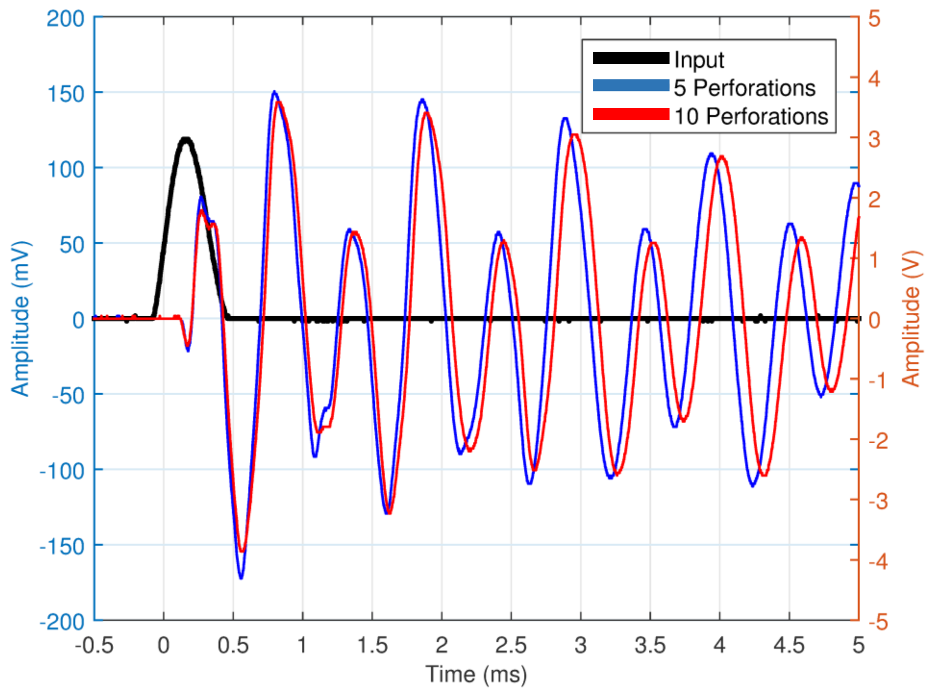
- Rigid connection, using a shaker as an excitation force.
  - Tested on wood and artificial composite bone.
- Impact excitation via impact hammer.
  - Tested on human tibia *in vivo* and wood.


LDS
VB/01
VB/01


Input
Output Without Perforation
Output With Perforation
Amplitude, (mV)
Time, (ms)
500
400
300
200
100
0
-100
-200
-300
-400
-500
-20
0
20
40
60
80
100

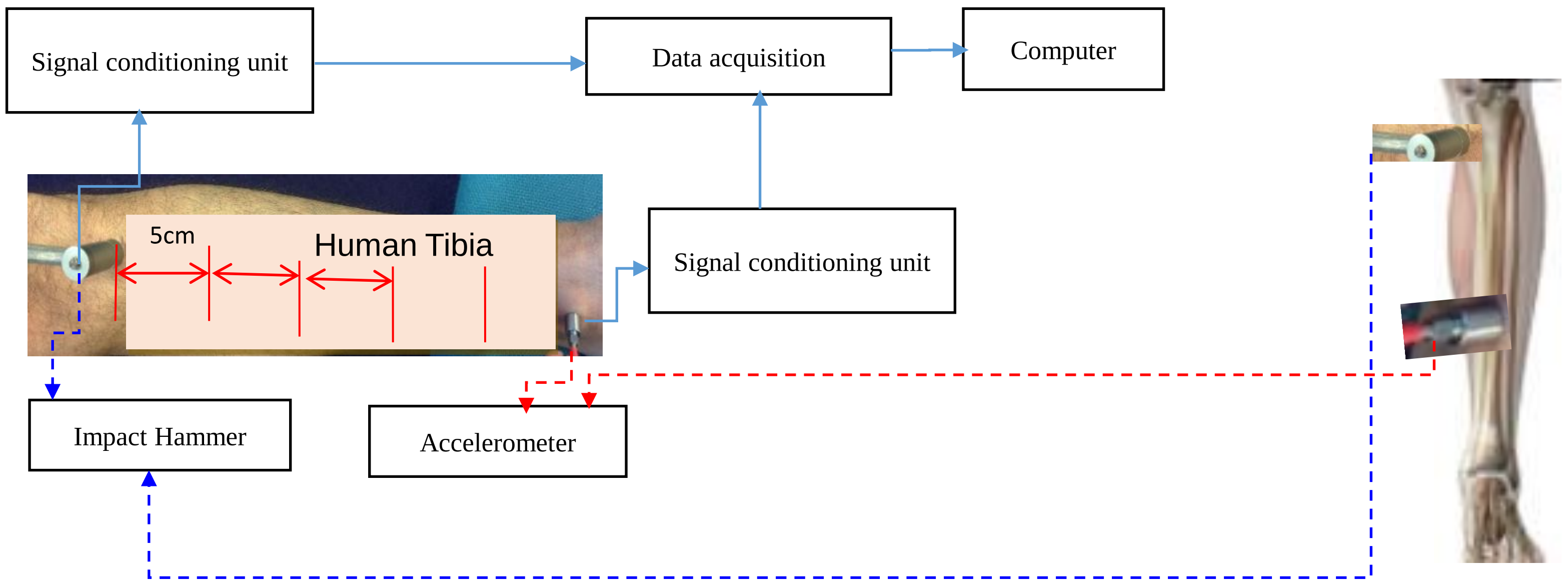


Signal Conditioners
Amplifier
Signal Generator
USB Oscilloscope
Shaker



Input
5 Perforations
10 Perforations
Amplitude (mV)
Amplitude (V)
Time (ms)
200
150
100
50
0
-50
-100
-150
-200
5
4
3
2
1
0
-1
-2
-3
-4
-5
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

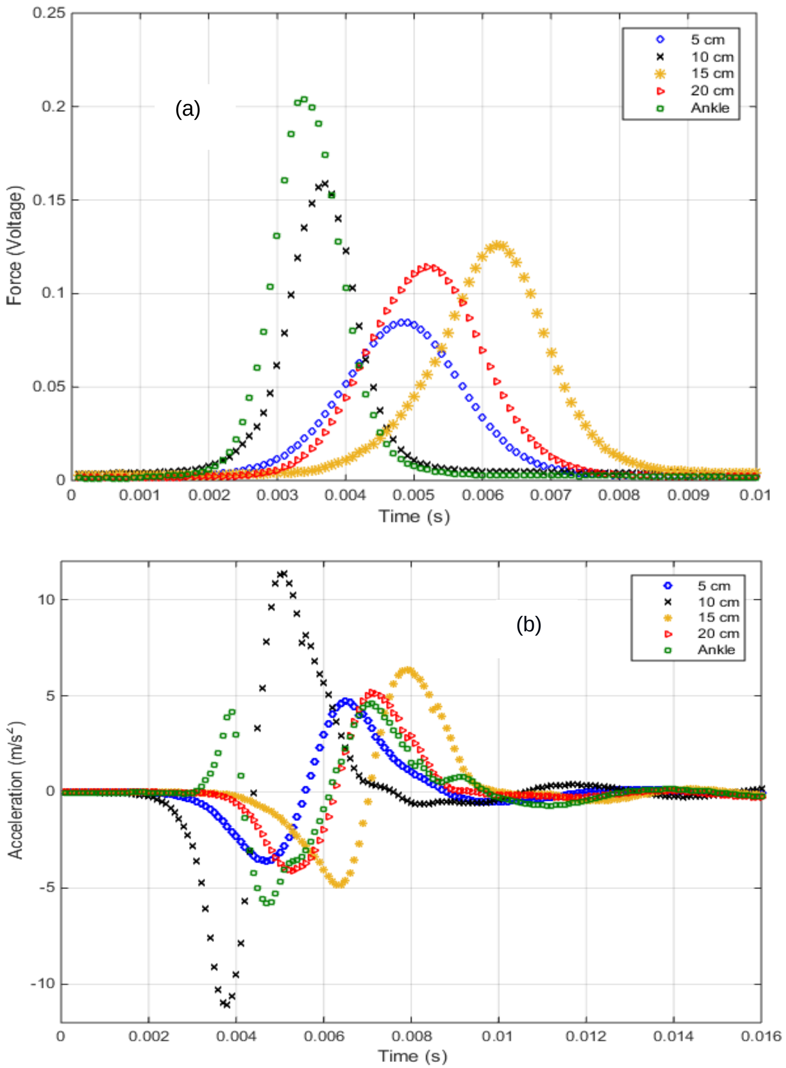
Measurement set-up for human tibia



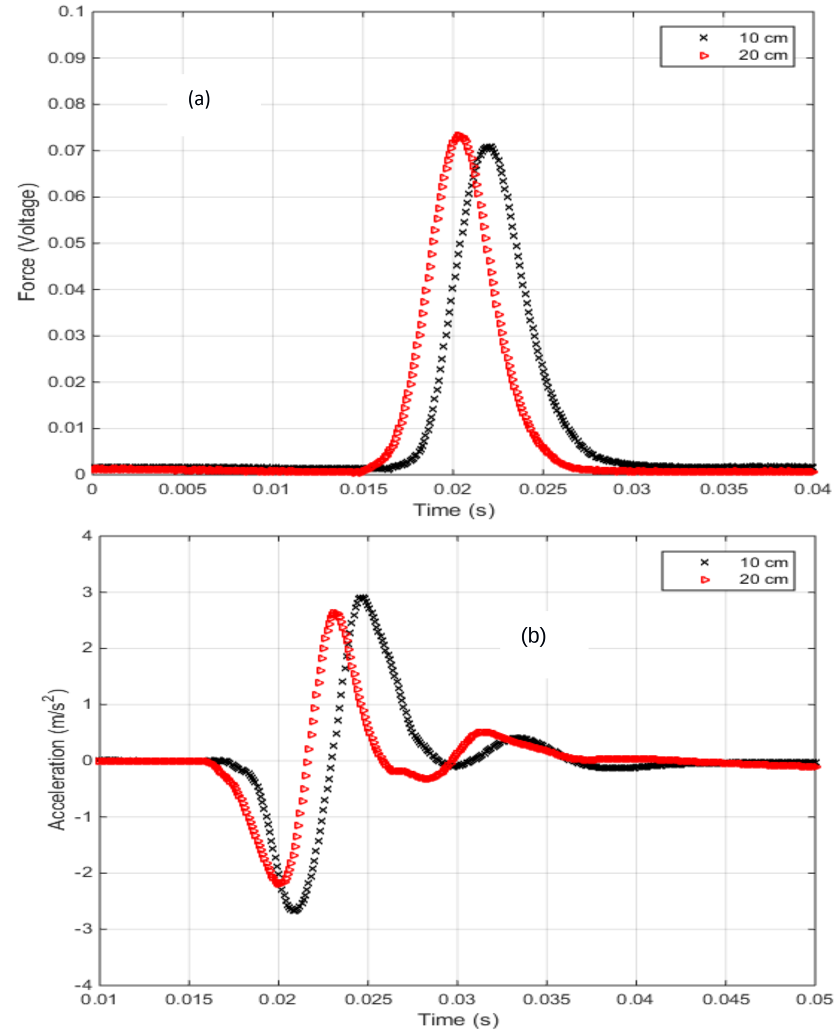
Measurement set-up for human bone:

- An impact hammer is used to generate structural borne acoustic waves. The response is detected by using an accelerometer.
- Impact hammer and accelerometer are connected to signal conditioning units, which feed data acquisition, which is connected to a computer for analysis.

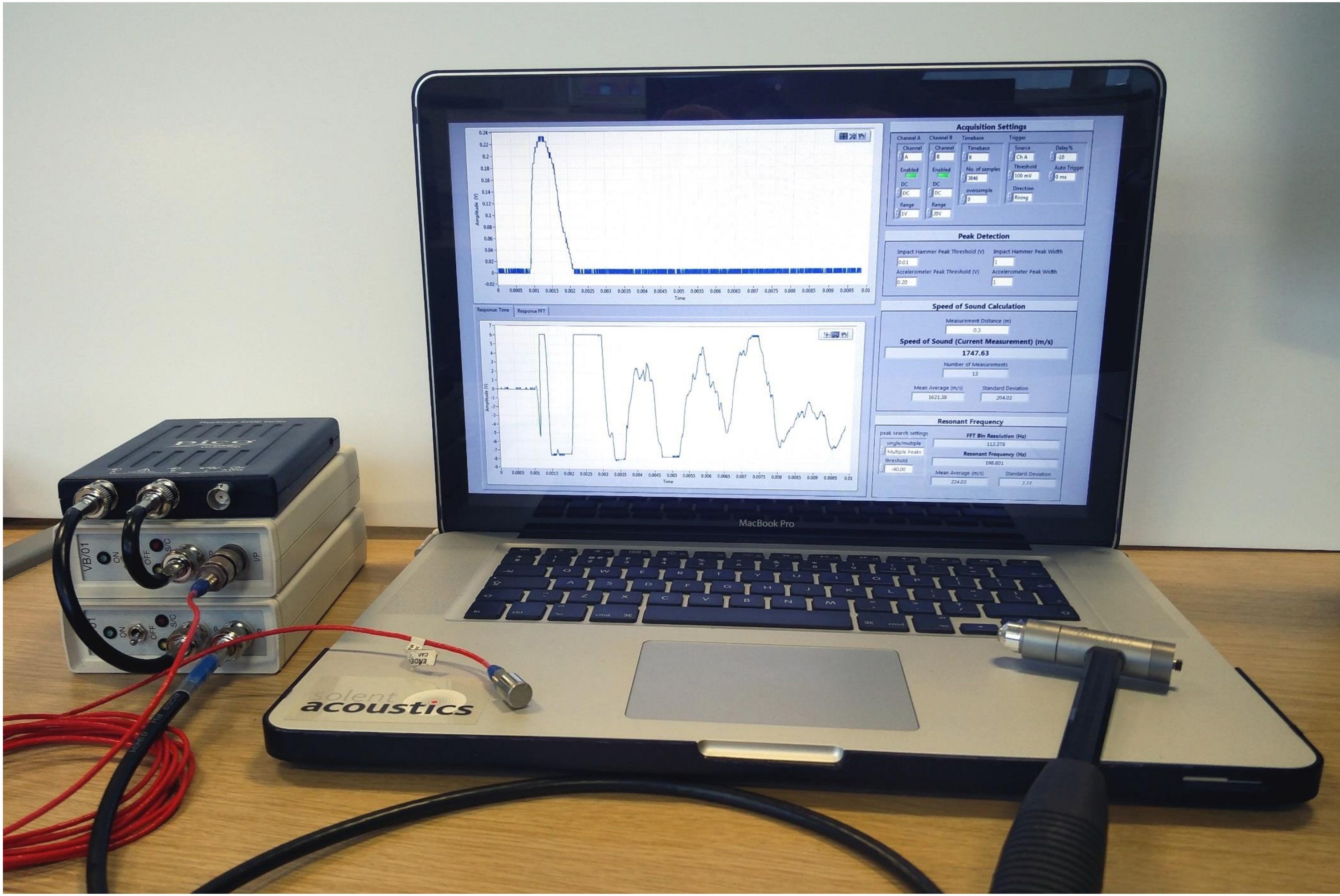
Tibia Transmission Results



a-) Input force applied to male tibia under knee cap by impact hammer b-) its responses detected at different locations along tibia.



a-) Input force applied to female tibia under knee cap by impact hammer b-) its responses detected at different locations along tibia.


Acquisition Settings
Channel A
Channel B
Timebase
Trigger
Channel
A
B
Enabled
DC
Range
1V
20V
Timebase
8
No. of samples
3846
oversample
0
Source
Ch A
Threshold
100 mV
Direction
Rising
Delay%
-10
Auto Trigger
0 ms
Peak Detection
Impact Hammer Peak Threshold (V)
0.01
Impact Hammer Peak Width
1
Accelerometer Peak Threshold (V)
0.20
Accelerometer Peak Width
1
Speed of Sound Calculation
Measurement Distance (m)
0.3
Speed of Sound (Current Measurement) (m/s)
1747.63
Number of Measurements
13
Mean Average (m/s)
1621.38
Standard Deviation
204.02
Resonant Frequency
peak search settings
single/multiple
Multiple Peaks
threshold
-40.00
FFT Bin Resolution (Hz)
112.378
Resonant Frequency (Hz)
198.601
Mean Average (m/s)
224.03
Standard Deviation
7.77
Amplitude (V)
Time
Response: Time
Response FFT
MacBook Pro
VB/01
ON
OFF
S/C
I/P
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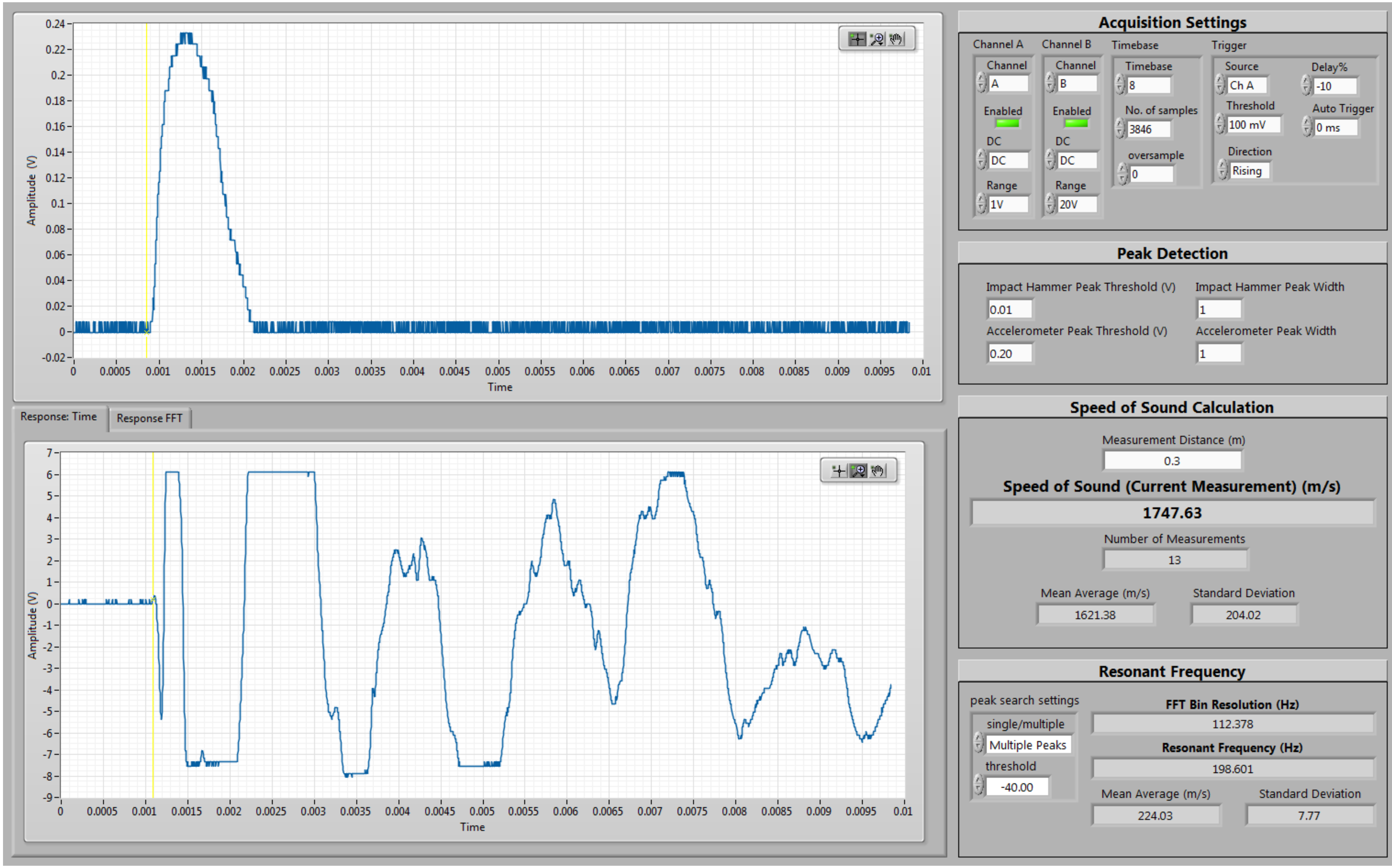
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Time
Response: Time
Response FFT
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Channel B
Timebase
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DC
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Channel
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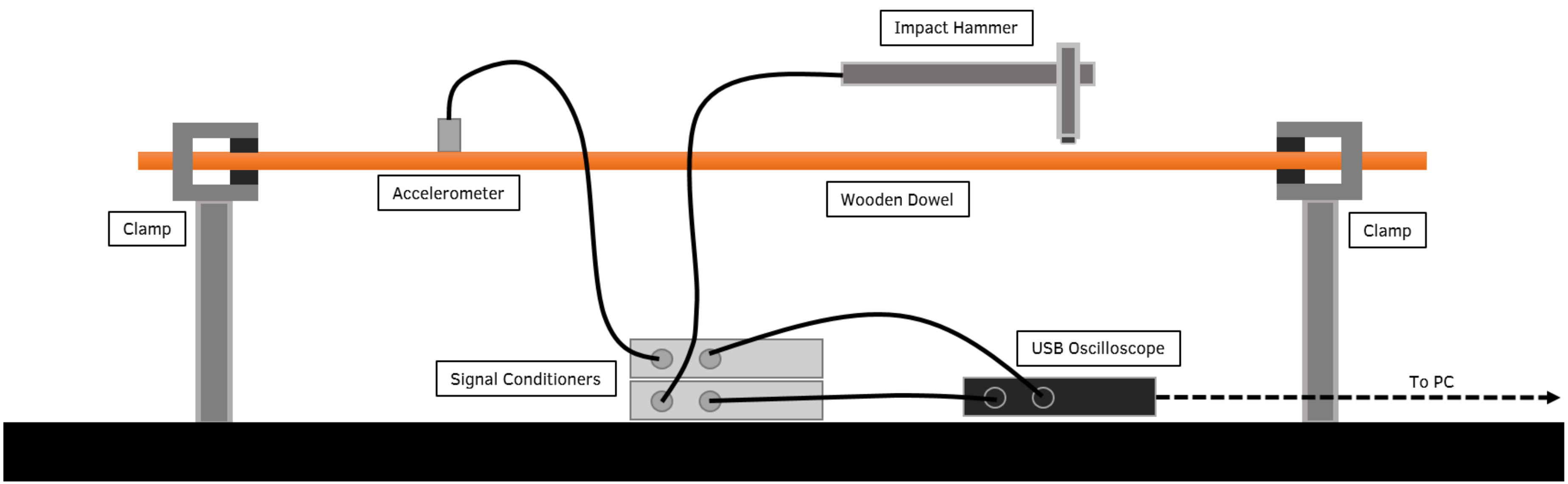
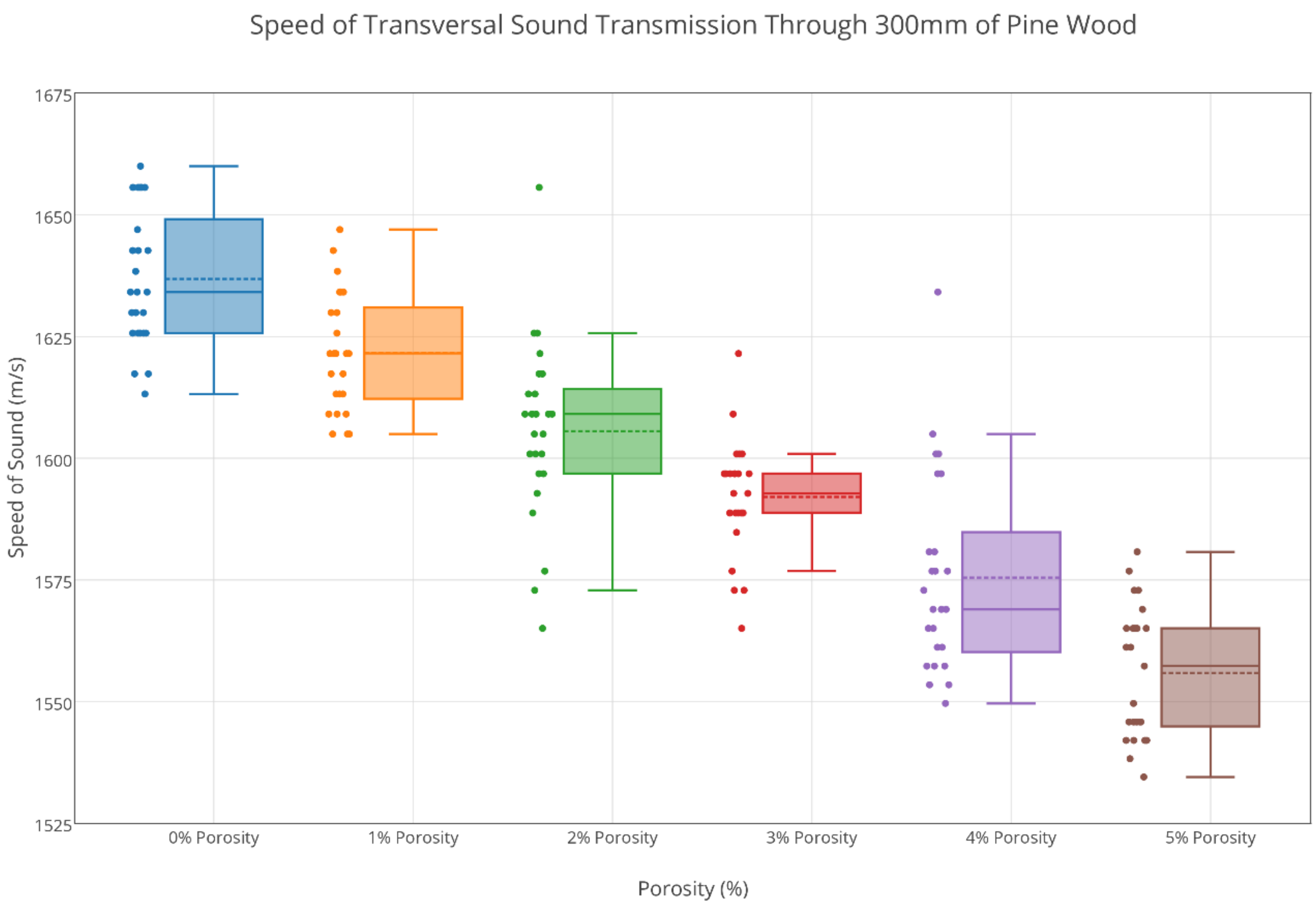
Example Measurement

- 25 impacts were made at the same location, with the same distance between transducers.
- The porosity of the wood was increased in 1% increments, from 0% to 5%.
- Results were compared to investigate changes to the transmitted signal caused by changes in porosity.

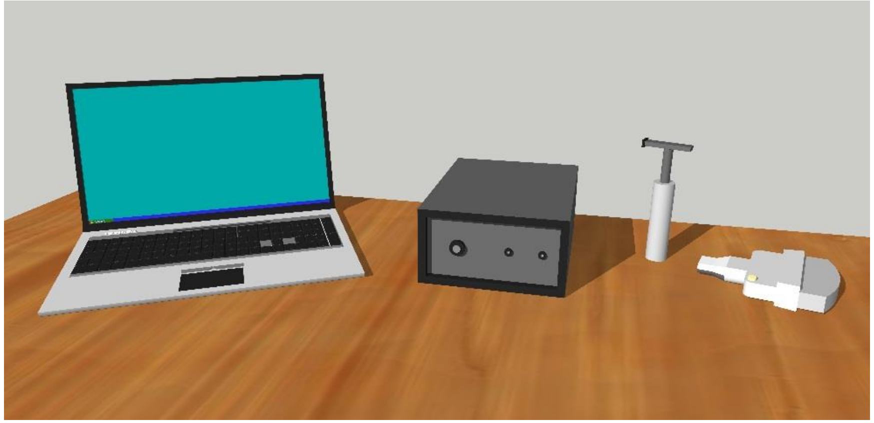




Average change to the speed of transmission: -16.2m/s

Further Development

- The system will need to be tested on other materials, such as metals and plastics, with a range of different densities, porosities, and thicknesses.
- Further testing is required to evaluate the effects of soft tissue (skin), as well as variable cortical (outer hard layer) bone thickness.
- We would then like to refine the system into a smaller package, as shown below.
- The concept is for the device to have a simple interface, in order to be useable by health professionals without extensive training, allowing for use in a variety of hospital departments and GP surgeries.



Acknowledgements

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InterManager