April 20, 2022

- Range 100 KHz – 1 MHz } Driving freq. on waveform generator
- Waveform parameters saved : APRIL-20

Frequency	File Name
100 KHz	apr20-1.csv
300 KHz	apr20_2.csv
500 KHz	apr 20_3.csv
800 KHz	apr 20-4.csv
1 MHz	apr20_5.csv

Waveform Generator → Oscilloscope

Transducers

153 → s

103 → p

Pump (Large) V1548

PU1 → 970416

PU2 → 1110595

Transducer Labels

p-transducers; clamp, no honey

S	Serial #
1	953364
2	953363

P	
1	1189382
2	1185582
3	1189385
4	1189383
5	1189384
6	1185581

No Honey - Clamp

~~[illegible]~~

: changed osciliscope because USB port not working

Transducers: P # 5 + 6 (6 trans, 5 recieve)

Frequency:	100 kHz	300 kHz	500 kHz	800 kHz	1
File Name:	apr20_6.csv	" " _7.csv	" " _8.csv	" " _9.csv	" " _1(

P # 1+2 (1 trans, 2 recieve)

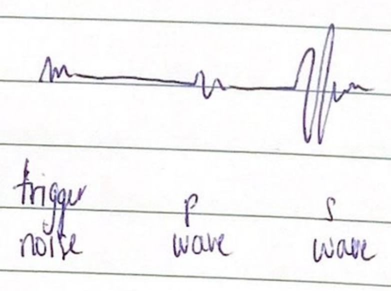
Freq.	100 kHz	300 kHz	500 kz	800 kHz	1 MHz
File Name	" " _11				

* Acquire → Aquisition Mode : Averaging

* if I can't see a signal, turn dial right above ① to lower the voltage range (zoom into mV scale)

* Take note of honey (temp, how old, etc)

* Take picture of set-up
Check wave speed in a known material to confirm set-up



S-transducer signal. p transducers won't have S-wave.

Apr. 27, 2022

Save Waveform parameter file : STATE_2.sta

Waveform → Oscilloscope (100 kHz) : apr27_0

	Driving Frequency				
Transducers	100 KHz	300 kHz	500 kHz	800 kHz	1 MHz
P 1 + 2	apr27_1	apr27_2	apr27_3	apr27_4	apr27_5
P 3 + 4	apr27_6	apr27_7	apr27_8	apr27_9	apr27_10
P 5 + 6	apr27_11	apr27_12	apr27_13	apr27_14	apr27_15
S 1 + 2	apr27_16	apr27_17	apr27_18	apr27_19	apr27_20

↳ File names for oscilloscope data from transducers clamped together, no sample, no couplant.

	Driving Frequency				
Transducers	100 kHz	300 kHz	500 kHz	800 kHz	1 MHz
P 1 + 2	apr27_21	apr27_22	apr27_23	apr27_24	apr27_25
P 3 + 4	apr27_26	apr27_27	apr27_28	apr27_29	apr27_30
P 5 + 6	apr27_31	apr27_32	apr27_33	apr27_34	apr27_35
S 1 + 2	apr27_36	apr27_37	apr27_38	apr27_39	apr27_40

↳ File names for oscilloscope data from transducers clamped together <u>with honey</u>, no sample.

<u>Note:</u> Even # transducers were transmitting (2, 4, 6) and odd # transducers were receiving (1, 3, 5).

Honey was heated in microwave (12 sec) then used 1hr* later

Sandstone (#NS6) clamped w/ transducers + honey:

	Driving Frequency				
Transducers	100 KHz	300 kHz	500 kHz	800 KHz	1 MHz
S 1+2	apr27_41	apr27_42	apr27_43	apr27_44	apr27_45
P 1+2	apr27_46	apr27_47	apr27_48	apr27_49	apr27_50
P 3+4	apr27_51	apr27_52	apr27_53	apr27_54	apr27_55
P 5+6	apr27_56	apr27_57	apr27_58	apr27_59	apr27_60

Aluminium (A2) clamped w/ transducers + honey:

Tranducers	100 KHz	300 kHz	500 kHz	800 kHz	1 MHz
S 1+2	apr27_61	apr27_62			
P 1+2					
P 3+4					
P 5+6					

Oscilloscope stopped recognizing USB after apr27_49. I turned it off + back on, then re-entered USB. ✓
↳ again at _57

Aluminium results for s-transducer was unexpected (pictures in DM to Alison in Slack) so we shut it down to try again tomorrow.

np.fft.fft

May 16, 2022

Save Wave Generator parameters: STATE_3.sta

Wave Generator → Oscilloscope (Control) Redo

Freq.	100 kHz	300 kHz	500 kHz	800 kHz	1 MHz
File	may16_1.csv	may16_2	may16_3	may16_4	may16_5

* Figure out gen. → oscilloscope unit conversion
↳ probe ratio, and/or resistor
channel #, probe, 10:1 } what is this?

Parameters (Mar 3, 2023)

- Generator → Sync Src CH1, Sync ON, Source 1mm
  → Trig Out, Source CH1, Trig out ↑

Scope → Zoom in as much as possible so dt is small
→ Connect to Trig Out on back
→ Averaging

June 2, 2022

How to adjust probe amplitude on oscilloscope:
→ $\boxed{1}$ → Probe → Turn "Push to select" knob until it reads "1.00 : 1"

Wave Generator parameters: STATE_4.sta
Gen. to Oscill. (w/ 1:1 adjustment) @ 1 MHz: jun2_0.csv
Transducers (P12) @ 1 MHz
↳ clamped, no honey: jun2_1.csv
Transducers (P12) @ 1 MHz
↳ clamped with honey: jun2_2.csv

Note: Burst off, # cycles = 4

P12 used for remainder of day: (1 transmitting, 2 recieving)

Freq.	Aluminum (A2)	Sandstone (NS6)	Styrofoam
100 kHz	jun2_3.csv	jun2_8.csv	
300 kHz	jun2_4.csv	jun2_9.csv	
500 kHz	jun2_5.csv	jun2_10.csv	
800 kHz	jun2_6.csv	jun2_11.csv	
1 MHz	jun2_7.csv	jun2_12.csv	

• See pictures for sample orientation

Freq	Delrin (white)	Acrylic Glue + Vacuum (clear)	Bedding (stone)
100 KHz	jun2_13.csv	jun2_18.csv	jun2_23.csv
300 KHz	jun2_14.csv	jun2_19.csv	jun2_24.csv
500 KHz	jun2_15.csv	jun2_20.csv	jun2_25.csv
800 KHz	jun2_16.csv	jun2_21.csv	jun2_26.csv
1 MHz	jun2_17.csv	jun2_22.csv	jun2_27.csv

How to change # of cycles:

- Burst (ON), # cycles, turn dial of #
- Trigger → Immediate, Trig Out → select ↑ or ↓

For continuous: Burst Off, N cycle, Infinite, Trig Immed.

Sample Dimensions (See photo for orientation)

	Sample	Length (mm)	Width (mm)	Height (mm)
	Aluminum (A2)	74.89	152.32	51.38
	Delrin	90.07	159.50	18.96
A	Sandstone (NS6)	101.29	100.82	52.43
B	Sandstone (Bedding)	51.11	104.22	25.28
	Acrylic	71.20	73.55	24.54

June 10, 2022

# of cycles and longer time (higher sampling rate in frequency)

Aluminium

# cycles	100 kHz	300 kHz	500 kHz	800 kHz
1	jun10_1	jun10_2	jun10_3	jun10_4
4	jun10_6	jun10_7	jun10_8	jun10_9
contin.	jun10_11	jun10_12	jun10_13	jun10_14

	1 MHz
1	jun10_5
4	jun10_10
contin.	jun10_15

generator parameter file: STATE_5.sta

- Sampling time: 10 μs
- Transducers 1 + 2 (P-wave)
  → 1 trans, 2 receive
- Honey

June 17, 2022

Comparing # of cycles (cont. from Jun. 10)

→ sampling time: 10 μs STATE_7.sta (24)

Generator parameter file: STATE_6.sta (17)

Material	# Cycles	100 kHz	300 kHz	500 kHz	800 kHz	1 MHz
Sandstone (NS6)	1	jun17_1	jun17_2	jun17_3	jun17_4	jun17_5
	4	jun17_6	jun17_7	jun17_8	jun17_9	jun17_10
	cont.	jun24_21	jun24_22	jun24_23	jun24_24	jun24_25
Sandstone (Bedding)	1	jun24_26	jun24_27	jun24_28	jun24_29	jun24_30
	4	jun24_31	jun24_32	jun24_33	jun24_34	jun24_35
	cont.	jun24_36	jun24_37	jun24_38	jun24_39	jun24_40
Delrin	1	jun24_	jun24_	jun24_	jun24_	jun24_
	4	jun24_	jun24_	jun24_	jun24_	jun24_
	cont.	jun24_	jun24_	jun24_	jun24_	jun24_
Acrylic	1					
	4					
	cont.					

~~was~~ Noticed changing voltage scale knob was changing the amplitude reading.

Check:

	Knob setting	File
1 MHZ	2 mV	jun17_10.csv
	5 mV	jun17_11.csv
	1 mV	jun17_12.csv

↳ Sandstone (NS6), 4 cycles, 10 μs

Transducer Only - Honey, No Sample (P12)

# cycles	100 kHz	300 kHz	500 kHz	800 kHz	1 MHz
1	jun24_1	jun24_2	jun24_3	jun24_4	jun24_5
4	jun24_6	jun24_7	jun24_8	jun24_9	jun24_10
Cont.	jun24_11	jun24_12	jun24_13	jun24_14	jun24_15

(P35) 3 trans., 5 rec.

Cont.	jun24_16	jun24_17	jun24_18	jun24_19	jun24_20

Note: check that channel 1 probe is set to 1:1 instead of 10:1

$\left.\begin{array}{l}10\,\mu s,\ 100\,mV\end{array}\right\}$ scale

Page11 : Sandstone (NS6) cont. : 5 mV scale
Sandstone (Bedding). 1,4,Cont.: 10 mV scale

↳ Data was cut off, need to redo.

Gen. to Oscilloscope June 27, 2022

# cycles	100 kHz	300 kHz	500 kHz	800 kHz	1 MHz
1	jun27_	jun27_	jun27_1		
4			jun27_2		
cont			jun27_3		

Parameter Gen. file: STATE_8.sta

Scale: 2 μs, 5 V

500 KHz with longer time: 10 μs

1	jun27_4.csv
4	jun27_5.csv
Cont	jun27_6.csv

June 30, 2022

Experiment: How amplitude changes with vertical scale adjustments.
Parameters: 1 MHz, P12 together, no sample, 1:1 setting, 1 μs scale.

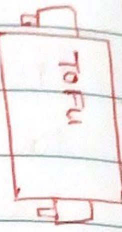
Scale	(Pk – Pk) Amplitude	(Pk – Pk) Osc. ↔ Gen Amplitude
5 V	690 mV	10 V
2 V	690 mV	10.02 V
1 V	701 mV	9.94 V
500 mV	707 mV	> 5.11 V
200 mV	704 mV	> 2.04 V
100 mV	702.3 mV	> 1.02 V
50 mV	> 510.6 mV	> 510.6 mV
20 mV	> 204.2 mV	> 204.2 mV
10 mV	> 102.1 mV	> 102.1 mV
5 mV	> 51.06 mV	> 51.06 mV
2 mV	> 40.84 mV	> 40.84 mV
1 mV	> 40.84 mV	> 40.84 mV

Experiment: Amplitude changes with frequency
Scale: [illegible], P12 together, 200 mV scale

Freq.	Pk-Pk Amplitude (P12)	Pk-Pk (P21)
100 kHz	124 mV	131 mV
200 kHz	202 mV	203 mV
300 kHz	322 mV	310 mV
400 kHz	493 mV	481 mV
500 kHz	589 mV	574 mV
600 kHz	650 mV	634 mV
700 kHz	709 mV	685 mV
800 kHz	751 mV	725 mV
900 kHz	766 mV	732 mV
1 MHz	711 mV	678 mV
1.1 MHz	621 mV	602 mV
1.2 MHz	501 mV	490 mV
1.3 MHz	368 mV	364 mV
1.4 MHz	253 mV	250 mV
1.5 MHz	169 mV	169 mV
1.6 MHz	107 mV	111 mV
1.7 MHz	70 mV	71 mV
1.8 MHz	43.6 mV	44 mV
1.9 MHz	24 mV	25 mV
2 MHz	10.3 mV	12 mV

* No freq. shift, all readings were same as driving freq. (on scope)

July 13, 2022



Tofu

- Sunrise, Extra Firm, refridgerated
- In plastic, + honey

Continuous cycles + 4 cycles

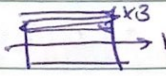
#	100 kHz	300 kHz	500 kHz	800 kHz	1000 kHz
Cont.	jul13_1.csv	jul13_2.csv	jul13_3.csv	jul13_4.csv	jul13_5.csv
4	jul13_6.csv	jul13_7.csv	jul13_8.csv	jul13_9.csv	jul13_10.csv

10 μs set – cont.

~~10~~ 10 μs set for 4 cycles ~~60~~ ~~280~~ μs

↳ Delay set to ~~60~~ μs to bring wave to left side of screen (direct signal and not include reflection)

Note: Reflection signal occurs at a time 3x greater than the direct signal



- Could not store state for generator would not recognize usb. Stored on generator as STATE_jul13kj.sta

FFT spacing Experiment July ~~21~~ 18, 2022

↳ see how changing time scale affects the freq. sampling in FFT space. 1 MHz waves, continuous, gen → scope, no sample, no trans.

Scale	File Name
200 ns	jul18_1.csv
500 ns	jul18_2.csv
1 μs	jul18_3.csv
2 μs	jul18_4.csv
5 μs	jul18_5.csv
10 μs	jul18_6.csv
20 μs	jul18_7.csv
50 μs	jul18_8.csv

Repeatability Experiment   Nov. 10, 2022

Sandstone 1 : ~~NS6~~ labelled "Bedding"

Freq.	Rep. 1	Rep. 2	Rep 3
150 kHz	nov10_0.csv	nov10_6.csv	nov10_12.csv
375 kHz	nov10_1.csv	nov10_7.csv	nov10_13.csv
525 kHz	nov10_2.csv	nov10_8.csv	nov10_14.csv
790 kHz	nov10_3.csv	nov10_9.csv	nov10_15.csv
930 kHz	nov10_4.csv	nov10_10.csv	nov10_16.csv
1050 kHz	nov10_5.csv	~~nov10_11.csv~~	nov10_17.csv

- 4 cycles
- "odd" frequencies (ones I haven't tried yet)
- Generator parameter file: STATE_NOV10KJ.sta (on generator, USB not recognized)
- P12 (2 trans, 1 rec.)
- Averaging: 4096
- Probe 1, 1:1 ratio
- 10 V_{pp}
- Honey was warmed before I arrived

* Set-up was disassembled and reassembled for each replicate. Honey was re-warmed to approx. same viscosity (8-10 sec microwave)

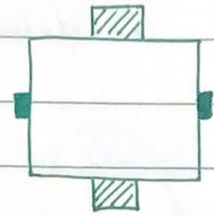
- "Bedding" was chosen because it had the largest amplitude in prev experiments

Data from scope:

Freq. (kHz)	Rep 1. (kHz, mV)	Rep 2. (kHz, mV)	Rep 3. (kHz, mV)
150	164 ; 91.6	163.8 ; 85.4	164.8 ; 86.4
375	368.2 ; 320.1	367.5 ; 313.9	367.8 ; 309.3
525	527 ; 578.9	527 ; 570.1	530 ; 544.0
790	790 ; 837	790 ; 813	790 ; 773
930	929 ; 831	930 ; 804	928 ; 762
1050	1046 ; 718	1044 ; 687.2	1042 ; 643

Pump/Probe Experiments (Jacob's Set-up)

Nov. 24, 22'



▨ = Pump
↳ S-wave
↳ 4 cycles
↳ low freq.

■ = Probe
↳ p-wave
↳ 1 cycle
↳ high freq.

- Pump is perturbing the probe.
- We change the difference in time between the pump + probe (delay) so the probe "interacts" or "lines up" with different parts of the pumb.

What we measure:

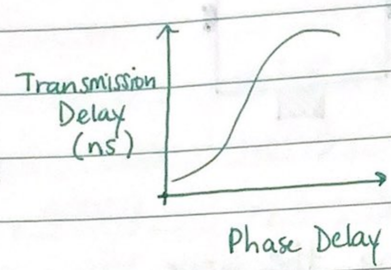
1) Probe only (S_1)
   ↳ measure 10 cycles to improve FFT
2) Pump only (S_2) → recorded at probe receiver
3) Pump + probe together (S_3)
4) Pump only (S_4) → recorded at pump receiver

Calculations:

1) Perturbed probe (S_5) : $S_5 = S_3 - S_2$
2) Cross-correlation between perturbed probe + probe alone:
$$(S_5 * S_1)\tau = \int_0^\infty S_1(t) S_4(t+\tau)\, dt$$
3) Compare pump from both receivers : S_2 + S_4

4) Once all data is collected (from all delay times), create a delay curve:

ex:



Phase Delay: set on the generator. Delay time between when we sent the pump + probe.

Transmission Delay: calculated. Travel time of "Probe only" ~~minus~~ vs. travel time of perturbed probe. From cross-correlation.

Jacob's Data:

pp0 → pump + probe signal at delay 0

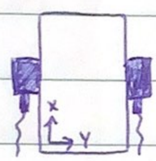
pr0 → probe only at delay 0

pu0 → pump only at delay 0

Repeating Jacob's Experiments Dec 13, 2022

Part 1: Probe Only

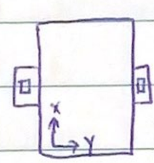
① Sample: Cement w/ Copper wire network (5mm)
Transducers: S-wave (1,2)
Orientation:



Amplitude: 5 Vpp
Cycles: 4
Gen. Parameters: STATE_11.sta

Frequency (KHz)	File (.csv)
100	dec13_0
200	dec13_1
300	dec13_2
400	dec13_3
500	dec13_4
600	dec13_5
700	dec13_6

② Sample: Cement w/ Copper wire network (5mm)
Transducers: S-wave (1,2)
Amplitude: 5 Vpp
Cycles: 4
Orientation:

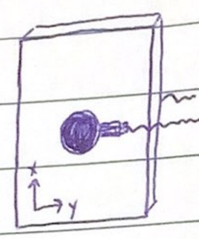


* Transducer cables are facing ceilling (out of page)

Frequency (KHz)	File (.csv)
100	dec13_7
200	dec13_8
300	dec13_9
400	dec13_10
500	dec13_11
600	dec13_12
700	dec13_13

(all dec 13)

③ Sample: Cement w/ copper wire network (5 mm)
Transducers: S-wave (1,2)
Amplitude: 5 Vpp
Gen. parameters: STATE_12.sta
Cycles: Cont.
Orientation:



Freq. (kHz)	File (.csv)
100	dec16_0
200	dec16_1
300	dec16_2
400	dec16_3
500	dec16_4
600	dec16_5
700	dec16_6

④ Sample: Cement w/ Cu wire net. (5 mm)
Trans: S-wave (1,2)
Amp: 5 Vpp
Cycles: Cont.
Orientation:

Freq. (kHz)	File (.csv)
100	dec16_7
200	dec16_8
300	dec16_9
400	dec16_10
500	dec16_11
600	dec16_12
700	dec16_13

Note: transducers were actually opposite of picture above (facing downward, cord upward)

Laser Set-up - Transducer Testing — Dec 16, 2022

Materials:

- Laser vibrometer
- oscilloscope
- wave generator
- 3 cables
- transducer
- reflective tape
- clamp

Set-up:

1) Connect laser (blue box) vibrometer to oscilloscope with cable from 'velocity' output to 'CH1' input.
2) Connect wave generator to oscilloscope with cable from 'Sync' to 'Ext trig in'.
3) connect generator to transducer from 'CH1' with cable. Stick reflective tape to tranducer face.
4) Turn laser vibrometer on. Switch on back. Let it warm up for a few mins.
5) Clamp tranducer onto something (marble box) on lab table. Adjust the laser position using the stepping motor controls: White buttons are x-axis (Jog 1); Blue buttons are y-axis (Jog 2).
6) Turn laser light on by pressing 'Laser' button on vibrometer.

Note: Turn off laser when leaving room. Unplug + switch off devices when shutting down lab.

Notes:

- oscilloscope reads/displays voltage. To convert the signal back to velocity, multiple the voltage data (y column) by the velocity displayed on the vibrometer [2 mm/s/V for example.]
- The laser shows its at its 'sweet spot' (when the distance between the laser + the reflective surface) in the bar lights on the laser. More bars means better signal.

* - laser works best when generator is set below 300 kHz:
  - above 300 kHz we still see a signal but its misleading (edge effect)
  - no edge effect w/ Continuous signal
  - The stop/start portion of a sine wave includes all frequencies.

 so when we go above 300 kHz w/ a # of cycles, the scope shows a signal but its due to the lower frequencies that create the stop/start part, not the true freq. we set on the generator.

Single Tranducer Control Experiment w/ Laser

Dec. 29/22

- vibrometer: 2 mm/s/V, HP off, LP off, velocity
- Continuous cycles

Transducer	Frequency In	File Name	Scope Reading (KHz)
S1	100	dec29_1	~100 (99.7-100.3)
	200	dec29_2	200
	300	dec29_3	Low signal
S2	100	dec29-17	100
	200	dec29-18	200
	300	dec29_19	low signal
P1	100	dec29_20	100
	200	dec29_21	200
	300	dec29_22	low signal
P2	100	dec29_23	100
	200	dec29_24	200
	300	dec29_25	low signal

- STATE_13.sta, 10 Vpp, 500 mV/, 20 µs/, delay 0 s

S1 (1 cycle)	100	dec29_4	67.7
	200	dec29_5	188-190
	300	dec29_6	189
S1 (4 cycles)	100	dec29_7	28-22
	200	dec29_8	192
	300	dec29_9	No edge

Show Edge Effect

S1 transducer - 10 cycles

Freq. (KHz)	File Name	Scope Reading
100	dec29_10	10.495 kHz
200	dec29_11	67.08 kHz
300	dec29_12	no edges
400	dec29_13	no edges
500	dec29_14	no edges
600	dec29_15	no edges
700	dec29_16	no edges

Note: all data collected on dec29 was lost/ not saved to usb.

* Moving forward, ensure "Save" is selected rather than "Recall", and file format is "CSV", not "Setup".

What determines FFT resolution? Jan 13, 2023

In plotting generator to scope data, I found that FFT peak width was increasing with input frequency. But, this is not a result of frequency, but rather, it's related to the total time and/or # cycles per time ratio, or # cycles. The following data should illuminate what determines df.

Gen. File: STATE_14.sta (on usb)

1) Holding time window fixed + ~~changing~~ frequency fixed, changing # cycles: (100 kHz, 10 μs / box, 10 boxes)

# cycles	1	2	3	4
File Name	jan13_1.csv	jan13_2.csv	jan13_3.csv	jan13_4.csv

Note: "Length" setting was changed from 2000 to 7680.

2) Holding time window + cycle # fixed, changing frequency: (5 μs/box, 4 cycles)

Freq (kHz)	100	200	300	400	
File Name	jan13_5.csv	jan13_6	jan13_7	jan13_8	

3) Holding frequency + cycles fixed, changing time window display only: (100 kHz, 4 cycles)

Time Window	5 μs	10 μs	20 μs	50 μs
File Name	jan13_9.csv	jan13_10.csv	jan13_11.csv	jan13_12

4) Hold everything (# cycles, freq, time window) fixed and only change # of data points :

# Points	1000	2000	5000	7680
File Name	jan13_13.csv	jan13_14	jan13_15	jan13_16.csv

Note: How to ~~change~~ change length of data file (# points in .csv) :

1. "Save/Recall" button under "File".
2. "Save" button (first to left under screen)
3. "Settings" button (4th from left under screen)
4. "Length" button, turn "Push to select" Knob.

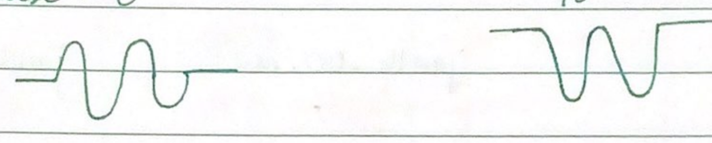
Note: Generator #1 and Scope #2 were used for the above experiments.
The following single-transducer experiments used Generator #1 and Scope #1.

(Jan 16) Note: Freq data used 10 μs/ on scope,
10 Vpp, phase 0°, 4096 avgs
All 1), 2), 3) used 7680 pts in saved file.
Burst period : 2 ms
Trigger Knob on Scope (top right displayed screen): 0.0 V
~~Generator Parameters: STATE_15.sta~~

What determines FFT resolution? (cont.) Jan 16, 2023

Note: Data collected on Jan 13, 2023 was accidentally set to "Start Phase: 90°". This setting seems to have thrown off FFT results. Ex:

start phase: 0° 90°



Below data are collected with same parameters as Jan 13, besides "start phase" setting, which was set to 0° moving forward.

How to adjust phase: "Burst" → "Start Phase"

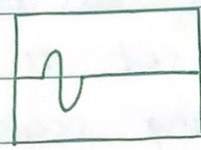
Check: jan16_0.csv
- Make sure "phase" is fixed
- Make sure files are saving
- check FFT, is it better with 0° phase?

↳ 1 MHz, 10 Vpp, 0 V offset, 0° start phase, 6 cycles, 2 μs/, delay 2.3 μs, 50.0 V/

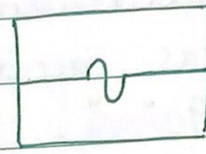
1)	# cycles	1	3	6	9
	File Name	jan16_1.csv	jan16_2.csv	jan16_3.csv	jan16_4
2)	Frequency (KHz)	100	300	600	900
	File Name	jan16_5.csv	jan16_6.csv	jan16_7.csv	jan16_8
3)	Time window (μs/)	5	10	20	50
	File Name	jan16_9 csv	jan16_10.csv	jan16_11.csv	jan16_12
4)	# points	100	500	2000	7680
	File Name	jan16_13.csv	jan16_14 csv	jan16_15.csv	jan16_16.csv

Check if "Delay" on scope affects FFT

ie.

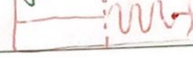


Delay 0

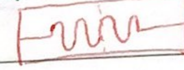


centered

jan16_00.csv



jan16_000.csv



delay 20 μs

↳ 100 kHz, 4 cycles, 10 μs/

<u>Result</u>: changing the delay on the scope did not change the FFT, in the case of a near ideal sine wave where the whole wave is visible and surrounding signal is zero.

Gen # 2, Scope # 2

Re-Do Laser Experiments

Jan 17, 2023

Data collected on Dec. 29 was not stored on USB and files are lost. So, the data below is to replace it.

Transducer	Freq. In (kHz)	Scope Reading (kHz)	File Name (.csv)
P2	50	49.5	jan17_1
	100	99.7	jan17_2
	200	197	jan17_3
	300	152 / No Edges	jan17_4
P1	100	99.5	jan17_5
	200	199	jan17_6
	300	33 / No Edges	jan17_7
S2	50	49.9	jan17_8
	100	96.6	jan17_9
	200	203 / No Edges	jan17_10
S1	100	99.7	jan17_11
	200	198	jan17_12
PU1	50	49	jan17_13
	100	103.8	jan17_14
	~~150~~ 200	196	jan17_15
PU2	50	49	jan17_16
	100	101	jan17_17
	~~150~~ 200	199	jan17_18

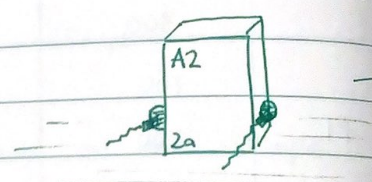
Parameters: 10 cycles, 10 V_{pp}, 0° phase shift, 16384 avgs on scope

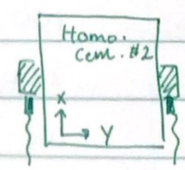
Gen # 1, Scope # 1

Gen. parameter File: STATE_JAN17.sta

(Saved on Gen)

S1	50	51.7	jan17_19.csv





laying on back

(top view)

S-Wave Trans...

1)

Freq	100 kHz...
File	

· Two transduce...

·

2)

Freq	100 kHz
File	jan18_0-...

· Sample: Alu...

3)

Freq	800 kH...
File	jan18_4.c...

· Sample: H...

· 4 cycles, ...

· 5 μs windo...

* May need ...

S-Wave Transducer Testing

Jan 18, 2023

1)

Freq	100 kHz	200 kHz	300 kHz	400 kHz	
File					

- Two transducers together with couplant
-

2)

Freq	100 kHz	200 kHz	300 kHz	400 kHz	
File	jan18_0.csv	jan18_1 csv	jan18_2.csv	jan18_3.csv	

- Sample: Aluminum (A2), no couplant, 4 cycles, start phase 0

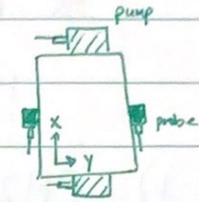
3)

Freq	800 kHz	700 kHz	600 kHz	500 kHz	400 . . . .
File	jan18_4.csv	jan18_5	jan18_6.csv	jan18_7	signal decayed below 500

- Sample: Homogeneous Cement # 2 (Jacob's sample)
- 4 cycles, 10 Vpp, 10 mv/, 30.8 μs delay
- 5 μs window, both p & S wave saved, 7680 pts

* May need amp. for lower freq?

Prep. For Pump/Probe Experiment Jan 25, 2023



Sample: Homogeneous Cement #2
Pump : PU2 transmitting, PU1 receiving
Probe : S2 transmitting, S1 receiving

Before Code:

Pump : 70 kHz, 3 V_{pp} (150 V_{pp} after amp), 4 cycles
Probe : 800 kHz, 10 V_{pp}, (1 cycle, 12 cycles)

Pump:

1) Recorded on Pump receiver : jan25_0.csv
2) Recorded on Probe receiver: jan25_1.csv

Probe:

(12 cycles) 1) Recorded on probe rec. (No Filter) : jan25_2.csv
2) Recorded on probe rec. (Filtered) : jan25_3.csv

(1 cycle) 3) Recorded on probe rec (with Filter) : jan25_4.csv
↳ S-wave & P-wave included
4) Recorded on probe rec. (with Filter) : jan25_5.csv
↳ P-wave only (delay ≏ 156 μs)

Note: measure velocities (or check Jacob's) to check if these arrival times are expected

Note: filter was set to 600 [see images on phone of setup)

* Retake measurments from prev. page.

1) CH2 was selected on gen. as sync source. This changed the travel times.

2) Probe needs to be amplified

Jan 27, 2023

Sample: Homogeneous Cement #2

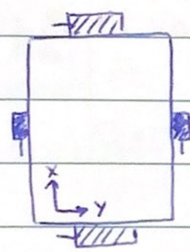
Pump: PU2 trans, PU1 rec.

70 kHz, 3 Vpp (150 Vpp after amp), 4 cycles

Probe: S2 trans, S1 rec

800 kHz, 10 Vpp, Filter 600

* CH1 (probe) setting for 'Sync Src' set to CH1 *



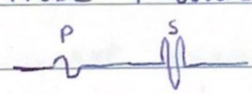
$y \approx 117$ mm

$x \approx 183$ mm

Velocities: Probe

Note: velocities measured on scope #2 prior to measurments

1) Probe P-wave: Delay = 41.3 μs



$V_p = \frac{117 \times 10^{-3} m}{41.3 \times 10^{-6} s} = 2833$ m/s

$\lambda_p = \frac{2833 m/s}{800\,000 Hz} = 0.0035 m = 3.5$ mm

2) Probe S-wave: Delay = 63.8 μs

$V_s = \frac{117 \times 10^{-3} m}{63.8 \times 10^{-6} s} = 1834$ m/s

$\lambda_s = \frac{1834 m/s}{800\,000 Hz} = 0.0023 m = 2.3$ mm

Pump: Delay = Delay = 100 μs

↳ measured with CH2 Sync Source as CH2

$V_{Pu} = \frac{183 \times 10^{-3} m}{100 \times 10^{-6} s} = 1830$ m/s

$\lambda_{Pu} = \frac{1830 m/s}{70\,000 Hz} = 0.026 m \approx 26$ mm

Length of Pump signal: 77.2 μs

Pump

1) recorded on Pump receiver : jan27_0.csv
2) recorded on probe receiver : jan27_1.csv

Probe

12 cycles:

1) recorded on probe rec. : jan27_2.csv
(No Filter)
2) recorded on probe rec. : jan27_3.csv
(with Filter)

1 cycle: (with filter)

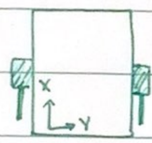
3) S + P-wave include : jan27_4.csv
(recorded on probe)
4) P-wave only (zoomed in) : jan27_5.csv

Note: USB port on scope #2 not working today.
I switched to scope #1 and AUGC2017 USB

Feb 8: Observation changing the # of cycles caused a loud (audible) vibration, increasing in volume as # cycles increased (~ +4 cycles at 800 kHz)
I didn't check other frequencies

Cement w/ Cu wires (5 mm) - Probe Freq. Feb 8, 2023

Repeat some of the experiments from Dec 13th. This time, take note of how/which part of the wave is being saved. Probe was amplified. Honey room temperature.



Parameters: S-wave transducers (S1 → S2)
1 cycle, 10 Vpp (x50 amp)
P-part of S-wave (Delay = 31.6 μs)

Frequency (kHz)	100	200	300	400	500	600	700	800	900	1000
File (.csv)	feb8_9	feb8_10	feb8_11	feb8_8	feb8_7	feb8_6	feb8_5	feb8_0	feb8_3	feb8_4

feb8_1 → set to 900 kHz (but noticed trigger blinking)
feb8_2 → set to 1 MHz (trigger blinking)

* Trigger was blinking after pressing "Parameters" on generator, each time trying to change freq.
* Probe (p-part) clearly not changing as I adjust driving frequency. 500 - 1000
* 100 - 300 wave is audible + signal looks much different

Note: 400-1000 were collected 'zoomed' in on same region. Did not adjust scope settings over this range.
Repeat entire experiment and auto scale each time to find p-wave part fresh each time.

100 } → entire region between delay 0 + S-wave
200
300

p-wave not very visible (I can't find it)

600 kHz : feb8_12.csv

↳ Started from autoscale
+ found P-wave part myself

900 kHz : feb8_13.csv

STATE_FEB on gen # 2

- used gen # 2, scope # 2

Note: Experiment was repeated on Feb 9^{th} to verify results (page 49)

Control: Generator to Scope   Feb 1, 2023

# cycles	Frequency (kHz)	File (.csv)
4	100	feb1 - 6
	200	feb1 _ 7
	400	feb1 _ 8
	600	feb1 _ 9
	800	feb1 - 10
	1000	feb1 - 11
Cont.	100	feb1 _0
	200	feb1 _ 1
	400	feb1 - 2
	600	feb1 - 3
	800	feb1 _ 4
	1000	feb1 - 5

Honey is couplant on next page. →

Control: Two Transducers

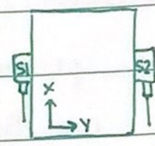
Transducers	Cycles	Freq. (kHz)	File (
S1 → S2	4	100	feb1_12
		200	feb1_13
		400	feb1_14
		600	feb1_15
		800	feb1_16
		1000	feb1_17
S1 → S2	Cont.	100	feb1_18
		200	feb1_19
		400	feb1_20
		600	feb1_21
		800	feb1_22
		1000	feb1_23
PU1 → PU2	4	100	feb1_24
		200	feb1_25
		50	feb1_26
		75	feb1_27
		150	feb1_28
PU1 → PU2	Cont.	100	feb1_31
		200	feb1_33
		50	feb1_29
		75	feb1_30
		150	feb1_32

Future Experiments: Feb 3, 2023

- Run PUMP/probe experiment with S1 and S2 switch. See if trans. order changes non-linear measurement
- Run PUMP/probe using a P-wave pump. See if probe trans. type changes non-linear measurement
- Run PUMP/probe experiment with 4 cycle probe + then cont. probe. See if this changes non-linear measurement.
- Run Pump/Probe experiment with S-wave transducers. See if monitoring P-wave or S-wave part of probe is better for non-linear measurements
- Try different couplants (Olympus says more viscous means better signal). Compare warm vs. solid/room temp honey, vaseline, KY jelly, etc.
- Measure delays induced by the transducers to verify 0.2 + 0.3 correction Alison mentions in protocol.
- Added Feb 9: Check amp with 1 cycle, S transducer on aluminum + compare to FFT w/o amp.
- Try S1 and S1 no sample again to confirm they work well.

See page 43
(Feb 8 experiments)

Cement w/ 5mm Cu (Trial 2)



- Amplified Probe, Probe is S1 → S2
- Room temp. honey
- 1 cycle, 10 Vpp (x50), phase 0°, Burst 2ms
- Gen #2, Scope #2

Set-up was dissembled from Feb 8 and reassembled For trial #2. Autoscale after each freq. change.

Frequency	Whole Wave	P-part	S-part
1 MHz	Feb9_1.csv	Feb9_2.csv	Feb9_3.csv
900 kHz	Feb9_4.csv	Feb9_5.csv	Feb9_6.csv
800 kHz	feb9_7.csv	feb9_8.csv	feb9_9.csv
700 kHz	feb9_10.csv	feb9_11.csv	feb9_12.csv
600 kHz	feb9_13.csv	feb9_14.csv	feb9_15.csv
500 kHz	feb9_16.csv	feb9_17.csv	feb9_18.csv
400 kHz	feb9_19.csv	Feb9_20.csv	feb9_21.csv
300 kHz	feb9_22.csv	feb9_23.csv	feb9_24.csv
200 kHz	Feb9_25.csv	feb9_26.csv	feb9_27.csv
100 kHz	feb9_28.csv	feb9_35.csv	feb9_34.csv

Before the above data was collected, I performed a visual check than Gen → Scope + S1 → S2 (no sample) signal changed as I changed driving frequency.

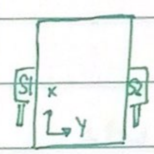
- I changed the frequency on the scope, pressed the Trigger, Autoscaled, Time Ref to left, Aquire → Averaging, 4096 Avgs
- Audible resonance began at 400 kHz (I started from 1 MHz) and went down to 100 kHz). 400 kHz is also when a lot of noise was visible, especially around trigger (See photo on phone 9:50 am Feb 9). Both of which persisted moving toward 100 kHz. Noise was loudest at 100 kHz!

Saving 100 kHz file in "zoomed" in segments to get good resolution of whole P-wave: (bc not sure where it is)

Delays	0-18 μs	18-36 μs	36 μs-42	42-49	49-56
	feb9_29	feb9_30	feb9_31	feb9_32	feb9_33

Homogeneous Cement (#2)

≈ 40 μs to P-wave
≈ 62 μs to S-wave



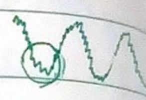
- Amplified probe, Probe S1 → S2, room temp honey
- 1 cycle, 10 Vpp (x50), phase 0°, burst 2 ms
- Gen #2, Scope #2

kHz	P-part	S-part		kHz	P-part	S-part
100	~~feb9_~~	~~feb9_69~~		700	feb9_57	feb9_58
200	feb9_67	feb9_68		800	feb9_55	feb9_56
300	feb9_66	feb9_65		900	feb9_53	feb9_54
400	feb9_63	feb9_64		1000	feb9_51	feb9_52
500	feb9_61	feb9_62				
600	feb9_59	feb9_60				

Couldn't collect at 100 kHz, USB port on scope stopped working.

Cement w/ 5mm Cu: Continuous Cycles

Freq	100	200	300	400	500
File	feb9_36	feb9_37	feb9_38	feb9_39	feb9_40
Freq	600	700	800	900	1000
File	feb9_41	feb9_43	feb9_45	feb9_47	feb9_49

At 600 kHz, the continuous wave was "wiggly" 

feb9_42.csv is zoomed in on one of the wiggles ie.

Could this be P-wave?

Note: Zoomed in on wiggles within larger wave:

kHz	600	700	800	900	1000
File	Feb9_42	Feb9_44	feb9_46	feb9_48	feb9_50

* Continuous wave did not cause audible resonance sound (like 1 cycle did).

Note: this 'wiggle' was noticed at 600 kHz as being noticable, but upon going back it is also very slightly visible at lower frequencies.
It occurs at different points on the wave as I change freq. but maybe at same location in time?

* All same parameters as top of pg. 48

Testing Amplifier

Feb 16, 2023

I discovered this week that my experiments which included the amp were giving 'freq. conversion' results.

① S-wave transducers, No amp., No sample, 1 cycle

	200 kHz	400 kHz	600 kHz	800 kHz	1 MHz
S1 → S2 :	feb16_1	feb16_2	feb16_3	feb16_4	feb16_5
S2 → S1 :	feb16_6	feb16_7	feb16_8	feb16_9	feb16_10

- 5 V input, Gen #2, Scope #2, honey room temp.

(switched to scope #2 before starting, USB not working on gen 1)

(~~Black USB on front port of scope 2 worked, not other USBs~~)

Both scopes are not recognizing / allowing USB.

Scope 3 used (Tektronix). Note: files save as TEK0001.csv
so, # after feb16_ is actually # after TEK00....

② S-wave transducers, No amp, No sample, 4 cycles (S2 → S1)

Freq.	200	400	600	800	1 MHz
TEK00	11	12	13	14	15

③ S-wave trans " ", Continuous

Freq.	200 kHz	400	600	800	1 MHz
TEK00	16	17	18	19	20

Repeat experiments ① → ③ with amplifier #

Amp: x 50

Set Generator to 0.1 V so (0.1 V)(50) = 5 V

↳ 0.1 V = 100 mV , S2 → S1

This way we can compare our results to prev. experiments to see if amp really is x 50.

# cycles	200 kHz	400 kHz	600 kHz	800 kHz	1 MHz
1	35	34	33	32	31
4	26	27	28	29	30
Cont.	25	24	23	22	21

* Note: file names are 'TEK00' + #.csv in table above.

P-wave part of S-wave Probe — Feb 19, 2023

Next, I'm looking to find out if the P-wave part of an S-wave probe does not change as I change the input frequency (ie. Is it simply a characteristic side effect of the tranducers shearring?)

- Homogeneous Cement #2:
- S-wave probe (S2 → S1), 5V amplified (x50), p-part:
- P-Part

# Cycles	600 kHz	800 kHz	1 MHz	1.2 MHz
1	36	37	38	39
4	40	41	42	43

- S-part:

	600 kHz	800 kHz	1 MHz	1.2 MHz
1	50	52	54	56
4	57	59	61	63

'TEK00' + '# above' + '.csv' file name, saved on black USB

P-part:	700 kHz	900 kHz	1.1 MHz
4 cycle	44	45	46
1	47	48	49

S-part:	700 kHz	900 kHz	1.1 MHz
4 cycle	58	60	62
1 cycle	51	53	55

I repeated the experiment from the previous page using Sandstone (NS6) across the Y direction same parameters as prev. page.

P-wave part:

# cycles	700 kHz ~~#cycles~~	600 kHz	800 kHz	900 kHz	1 MHz
1	70	69	71	72	73
4	65	64	66	67	68

S-wave part:

# cycles	600	700	800	900	1 MHz
1	74	75	76	77	78
4	79	80	81	82	83

"TEK00' + # in table + '.csv'

P-Wave Probe

Feb 21, 2023

My recent results are suggesting that perhaps the S-wave transducers produce a characteristic 'start pulse' signal. If only one cycle is generated, this characteristic region is the entire pulse, making frequency changing not possible at 1 cycle. Today, I'm testing the viability of P-wave transducers as a probe.

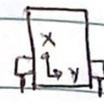
① Transducers only:

- P1 → P2, 0.1 V (x 50 amp) ⇝ gen set at 100 mVpp

Freq (kHz)	1 cycle	4 cycles
100	TEK0084.csv	TEK0094.csv
200	TEK0085.csv	TEK0095.csv
300	TEK0086.csv	TEK0096.csv
400	TEK0087.csv	TEK0097.csv
500	TEK0088.csv	TEK0098.csv
600	TEK0089.csv	TEK0101.csv
700	TEK0090.csv	TEK0102.csv
800	TEK0091.csv	TEK0103.csv
900	TEK0092.csv	TEK0104.csv
1000	TEK0093.csv	TEK0105.csv

② Homogeneous Cement

- P1 → P2, (5V x 50 amp)
- Across y direction



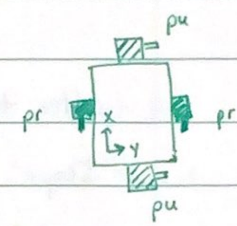
Freq (kHz)	1 cycle	4 cycles
100	TEK0106.csv	TEK0116.csv
200	TEK0107.csv	TEK0117.csv
300	TEK0108.csv	TEK0118.csv
400	TEK0109.csv	TEK0119.csv
500	TEK0110.csv	TEK0120.csv
600	TEK0111.csv	TEK0121.csv
700	TEK0112.csv	TEK0122.csv
800	TEK0113.csv	TEK0123.csv
900	TEK0114.csv	TEK0124.csv
1000	TEK0115.csv	TEK0125.csv

Pump/probe Experiments March 3rd, 2023

To do:

① Homogeneous Cement
② Cement w/ 5mm Cu

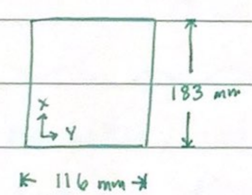
} · P-wave probe × 5 each
 · S-wave probe × 5 each



↳ orientation 1:
(as defined on pg. 20 Jacob's thesis)

Measure Delays:

① Homogeneous Cement



a) Probe (P-wave, P1 → P2), 800 kHz
· Arrival: 40.22 μs
· Shift: 40.~~40~~ μs

b) Pump (S-wave, S1 → S2), 50 kHz
Arrival: 95 μs

STATE: STATE_nonlin_KN.sta } load this standard state for all future runs

* Alison found keyosacquire

Python: Edit → Find + Replace → In a single cell replace all " " with " ".

Mar. 7^{th}, 2023

Aside: USB issues & files not saving on scope

1) I formatted a new USB to FAT32
2) I "Secure Erase(d)" scope # 1
(as per advice on Keysight website
edadocs.software.keysight.com)

After this, the USB was ~~reco~~ recognized by the scope. But remote saving of .csv still not working, only manual.

I noticed saveWave is asking for 5000 pts. So, I adjusted (manually) the # of pts on the scope to 5000 (under Save → length). This worked!

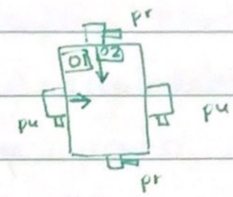
Run 1 : → Delays 0 to 200
→ ~~HoCe~~ 'HoCe' + 'pr' + # .csv
→ Saved on Desktop, katie, Run1_200 delays in HomogCement folder.

Repeat on Crab Orchard Sandstone (from Somaya's paper

May 7th, 2023

Crab Orchard Sandstone - Nonlinear Run 1

- "CrOr" prefix
- STATE_nonlin_KN.sta



- pump arrival time: 40.2 μs
- probe arrival time: 51.4 μs (45 μs to center it)
- pump length/duration: 167 μs - 40.2 μs = 127 μs

To center probe: 45 μs delay
2 μs/box
10 mV/box

Run 2 - "ACrOr" prefix

↳ no filter, no amplifier (by accident)
↳ Run by Alison on May 8th to test new additions to code (trying to minimize # of corrupted files)
↳ only 64/130 delays saved, but no corrupted data.

Run 3 - "BCrOr" prefix

↳ amplified probe + pump (Samaya's fixed sample)

* Important note :

Delay / arrival time changes significantly on the scope depending on scope settings (time scale ~~voltage~~)

ex. Crab Orchard
probe (@ 50 mV/) : 51.1 μs
probe (@

Single Trans. Test w/ Laser Apr. 10, 2023

I wanted to conclude that coupling transducer w/ material is causing a "coupling signature" which makes it difficult to measure proper frequency of single cycle wave. I need to confirm that this "signature" is not present before coupling (ie. when transducer is alone, producing signal.) 10 Vpp

S1 transducer:

~~4~~ 5 cycles	50 kHz	apr1023_0
	100 kHz	apr1023_1
	150 kHz	apr1023_2
1 cycle	50 kHz	apr1023_3
	100 kHz	apr1023_4
	150 kHz	apr1023_7
	200 kHz	apr1023_8

Note: Oscilloscope failed to save files when Horizontal axis was "zoomed in" more than 10 μs/div. May be a coincidence, but it saved to usb when zoomed back out again.

Saved on blue MUN usb + moved to lap PC.