SonoSOFT FAQ Printed Documentation

A Note to the reader (added to this document April 9, 2022):

This is a legacy Sonometrics document, and while it is called "FAQ.PDF" it is very much
out of date. But since some web-searches still point to this document (and it is sometimes downloaded) we will keep it on our site.

Almost none of the information contained in this document will be of any use in helping the reader understand any of the current hardware and software products offered by Sonometrics today, and we urge the reader to contact us (sales@sonometrics.com or sonometrics@gmail.com) to get some really good information and explanation as to how our products can help you achieve your scientific research goals.

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Frequently Asked Questions (FAQ)

Welcome

Welcome to Sonometrics FAQ and Help pages. Please select a topic listed below.

(Note: Use the Search Tool to help in finding the appropriate topics)

1) FAQ: Hardware and Technical Information (Crystal information, board information, analog and DAC specifics, principles of sonomicrometry.)

2) FAQ: Software

3) FAQ: Application

4) Help: Acquisition (SonoLAB, Data Convert)

5) Help: Analysis (SonoVIEW, CardioSOFT, SonoVOL)

6) Help: SonoXYZ

FAQ: Hardware and Technical Information

FAQ: Hardware and Technical Information

To further identify the question, please select from the following:

1) Board information (size, diagrams, installation procedures)

2) Crystal information (size and specifications, cleaning, number of uses, suggested crystals for applications)

3) Analog channels (voltage required, conversion to unit of measurement)

4) Principles of Sonomicrometry.

5) DAC Channels (output range, distance vs voltage, limitations if any)

6) TRX Box

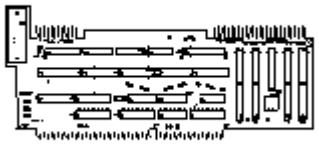
7) Computer

Board Specifications

Board Specifications

Sonometrics hardware previously consisted of three computer boards connected by 2 ribbon cables. The updated hardware consists of one computer board, a board socket and one to two ribbon cables (two with A/D option). For installation procedures for the three board system please go to Board Installation, for the single board system go to Single Board Installation.

1) Transceiver Controller board.



2) Transceiver Counter board

3) A/D Controller board.

Board Installation

1) Turn computer off and unplug the power cord.

2) Remove the cover by unscrewing three screws on back plate of computer.

3) With the cover removed, examine the number of available slots to ensure that at least three consecutive ISA slots exist. For systems that have 16 to 32 Transceiver Channels, you will need four consecutive ISA slots.

4) If three consecutive slots are not available, you will need to move the existing cards to free up the space. Be careful to reconnect any cables that you remove during this process. It is advisable that once the cards have been repositioned, start the computer to ensure nothing has gone wrong with regular system performance.

5) With the power off and the computer unplugged, position the Transceiver Counter Board in a vacant slot that is closest to the outer edge of the computer. For systems that are 16 to 32 Channels, there will be an "A" Transceiver Counter Board and a "B" Transceiver Counter Board. Position the "A" Board in the slot closest to the outer edge. The "B" Board sits in the next consecutive slot. When the card(s) is(are) properly placed, the back plate connector should make a tight fit with the back of the computer case.

6) Repeat procedure 5) for the A/D Controller Board into next adjacent slot.

7) Repeat procedure 5) for the Transmitter Controller Board in the slot adjacent to the A/D Controller Board. We recommend this order of card placement as it permits a gradual vertical slope for the black, card edge connectors.

8) Attach card edge connectors for intercard communication. There are two separate cardedge connectors to be placed, the first with 20 contacts, and a second with 50 contacts. Care should be taken when placing the card edge connector. If too much pressure is applied when pressing down on the cards, they may tilt out of their proper seating in the motherboard. (Note: the 20 pin connector connects the Counter Board and the Controller Board, the 50 pin connector connects all three boards).

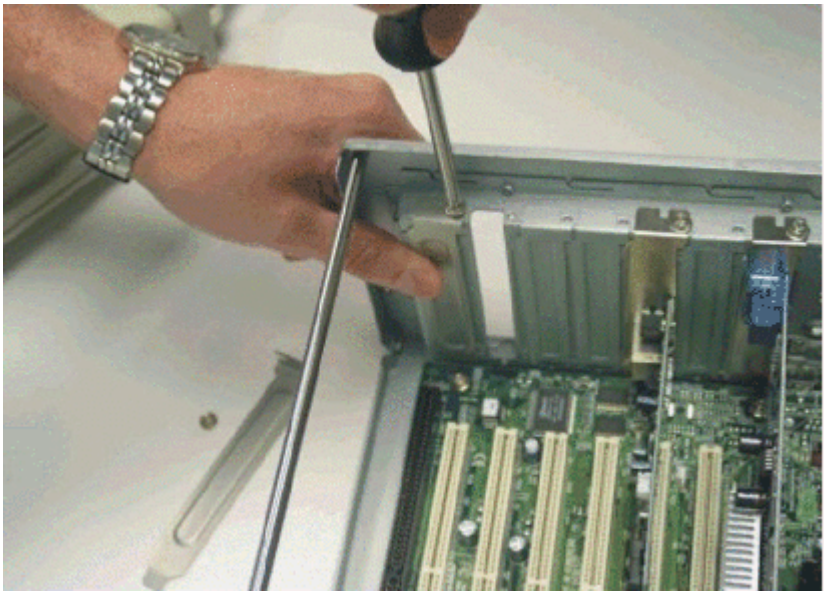
9) Power up the computer and verify normal system operation by starting SonoLAB and allowing a full system diagnostic to be performed at boot up. If any board failure messages are given, please reconfirm board order and contact with mother board and ribbon cables.

10) If your system operates properly, power down the computer and fasten down each of the Sonometrics' boards using the provided back plate screws.

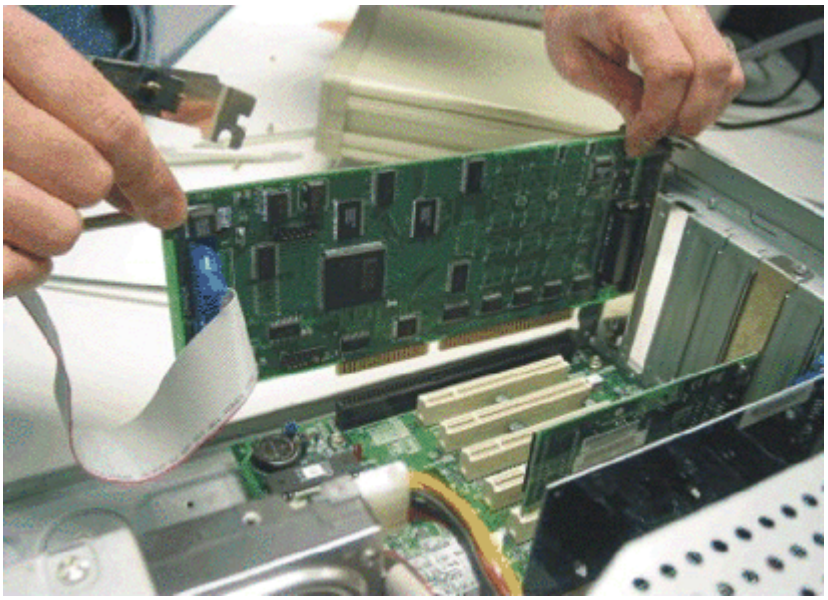
11) Finally, replace the computer cover and secure the fastening screws.

Single Board Installation

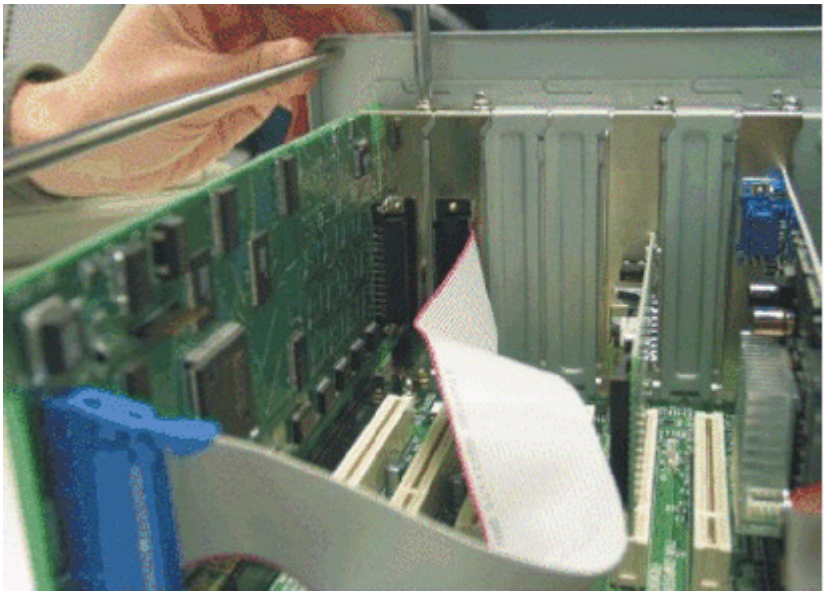
1. Disconnect the power cable to the computer, open the case and remove the 2 expansion slot cover plates.



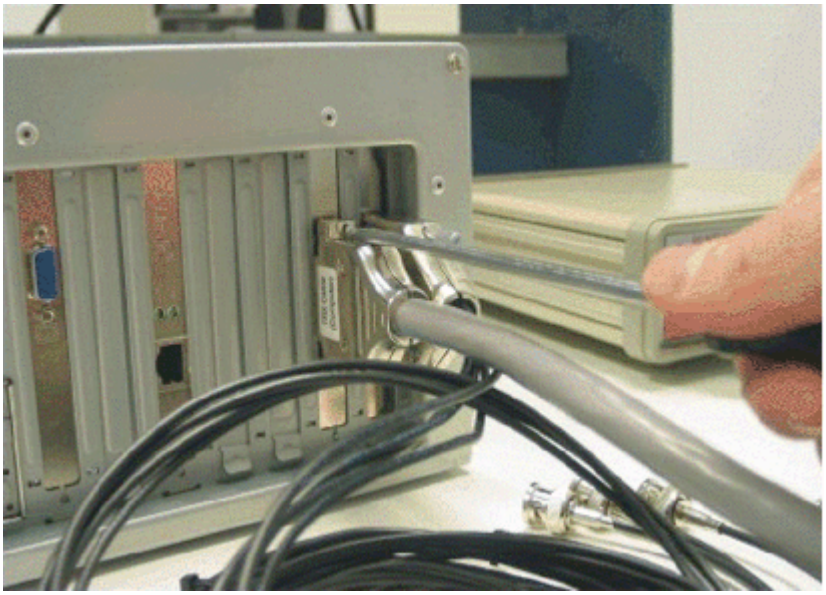
2. Align the Sonometrics board with the ISA motherboard socket and press the board into place.



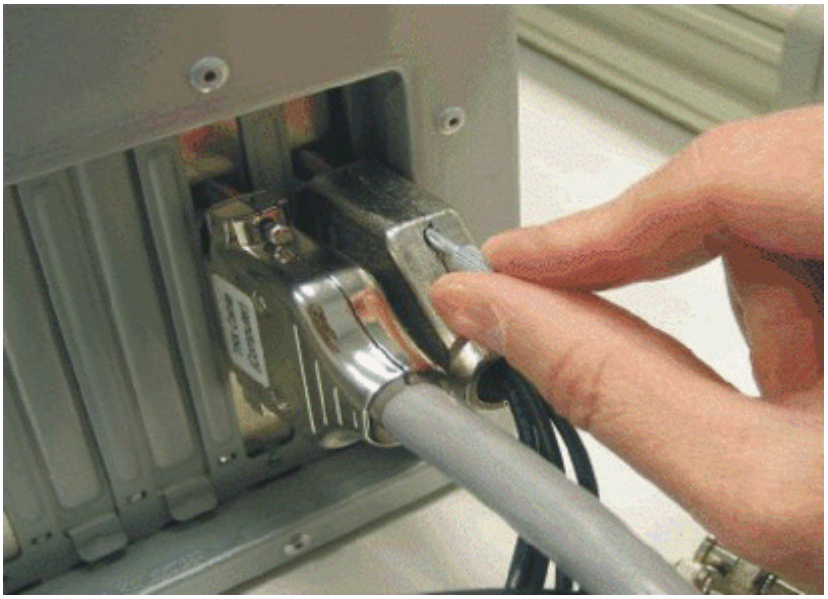
3. Fasten the card bracket and the TRX cable bracket to the computer case with screws.



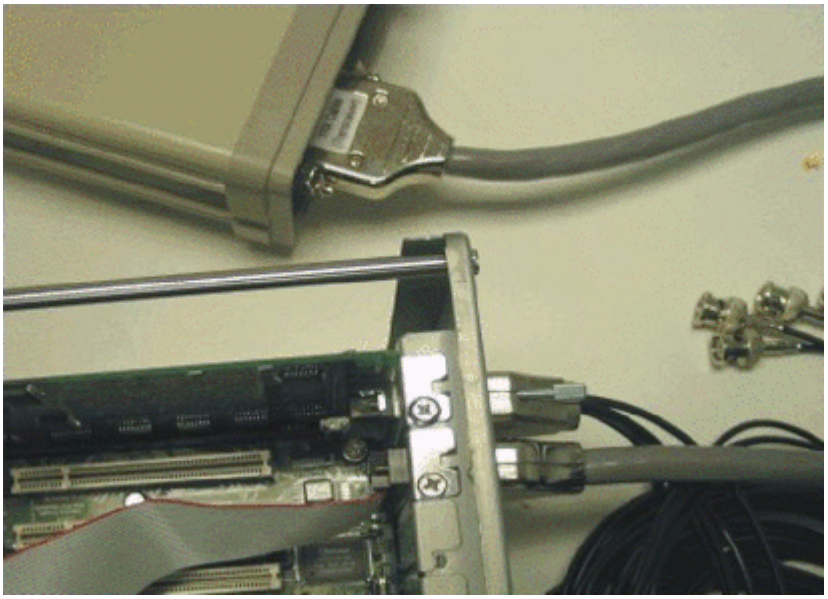
4. Plug the TRX and A/D cables into their respective sockets. Note that the A/D cable is plugged into the board socket and the TRX cable in the ribbon cable socket.



5. Secure the cables to the connector using either your fingers or a small screw driver, DO NOT OVER TIGHTEN!



6. Inspect the final assembly and put the cover back on the computer. Plug power, mouse, VGA and keyboard back into the computer. Turn on the computer and install the Sonometrics software.



Crystal Information

Crystal Information

Crystal features may control many aspects of an experiment. For quick tips, please select from the following:

1) Individual crystal specifications (size, weight, minimum and maximum distances).

2) Wire Specifications (diameter, weight, options).

3) Cleaning suggestions for crystals.

4) Crystal suggestions by application.

Cleaning Crystals

Sonometrics crystals are made for multiple acute experiments. For cleaning crystals we suggest the following guidelines of what to and not to use:

1) Do not autoclave or heat sterilize the crystals as they will melt. Gas Sterilization is suggested.

2) Do not clean with harsh or abrasive solutions. Solutions such as highly concentrated bleach will erode the epoxy from the crystal and cause premature failure. Use a mild soap where possible.

3) If crystals are fibrosed to the tissue, remove as much tissue as possible and allow crystals to soak. If too much tissue has collected around the crystal and wire they probably have been implanted chronically. Chronically implanted crystals are not suggested for reuse.

4) If Vet Bond Glue has been used to attach the crystal, a mild solvent may be used to soak the crystals. Crystals should not be left to soak for more than 1 hour.

Wire Specifications

	Copper Wire			*Stainless Steel Wire*	
	34 AWG	*38 AWG*	*42 AWG*	*36 AWG*	*38 AWG*
Mass (per foot)	*0.41 Grams*	*0.06 Grams*	*0.007 Grams*	*0.06 Grams*	*0.007*
Silastic tubing possible	*Yes*	*Yes*	*No*	*Yes*	*Yes*
Crystals for use with	*TAC* *2mm*	*TAC* *2mm* *1mm*	*2mm* *1mm* *0.75mm*	*TAC* *2mm*	*TAC* *2mm* *1mm*

Crystal Selections By Application

Crystal Selections By Application

Please select from the following:

1) Chronic Implantation.

2) Acute Implantation.

3) How to select appropriate size of crystal.

Crystal Sizing for Application

Various crystal sizes allow a large range of tissue sizes to be measurements. The distance to be measured should determine the size of crystal used. Attachment options may also be chosen to assist in implantation (larger crystals are recommended if possible). For distances measured for each size of crystals please go to Crystal Specifications or please see crystal pricing page for diagrams and advantages of attachment options.

Crystals for Chronic Implantation

Chronic implantation exposes the crystals to bodily fluids and stress more so than acute implantations. For this reason Sonometrics has developed Silastic Tubing to help shield the crystal wire. Silastic tubing is available on TAC, 2mm and now 1mm crystals with stainless steel wire.

If crystals will not be implanted for extended periods of time, i.e. only for 3 to 21 days, stainless steel wire alone may be used for the crystals. Stainless steel wire is both stronger than copper wire and has been shown withstand chronic implantation better.

Crystal wire length may be customized along with the type of connector and possible extension cables used.

For more information please contact our sales team at (519) 652-6464 or by email to Sales@sonometrics.com.

Acute Implantation.

Acute crystals have lasted from 5 to 100 experiments. For acute experiments copper wire is suggested due to the added flexibility of the wire and lower cost.

In these cases the wire length and connector type or extension cable may be customized. For further information, please contact our sales team at (519) 652-6464 or email to sales@sonometrics.com.

Crystal Specifications

Crystal Specifications

	TAC Crystals	2mm Crystals	1mm Crystals	0.75mm Crystals
Crystal Diameter	3mm	2.3mm	1.0mm	0.75mm
Measurement Range	0.5 - 10cm	0.5 - 10cm	0.2 - 3cm	0.2 - 2cm
Frequency of Ultrasound	1.2MhZ	1.2MhZ	1.6MhZ	1.6MhZ
Crystal Head Mass		0.0223 Grams	0.002 Grams	
Attachment Options-Crystal	B-Barbs Heat Shrink	B-Barbs A-Barbs Heat Shrink Suture Loops Suture Lines Combinations	B-Barbs Suture Line	B-Barbs Suture Line
Wire Types Possible	34 AWG Copper 36 AWG Stainless Steel 38 AWG Copper 38 AWG Stainless Steel 42 AWG Copper	34 AWG Copper 36 AWG Stainless Steel 38 AWG Copper 38 AWG Stainless Steel 42 AWG Copper	38AWG Copper 38AWG Stainless Steel 42 AWG Copper	42 AWG Copper

Wire Specifications

	Copper Wire			Stainless Steel Wire	
	34 AWG	38 AWG	42 AWG	36 AWG	38 AWG
Mass (per foot)	0.41 Grams	0.06 Grams	0.007 Grams	0.06 Grams	0.007
Silastic tubing possible	Yes	Yes	No	Yes	Yes
Crystals for use with	TAC 2mm	TAC 2mm 1mm	2mm 1mm 0.75mm	TAC 2mm	TAC 2mm 1mm

Analog Channels

Analog Channels

Please select from the following to better define your question:

1) Input range of Analog signals.

2) Conversion from volts to digital units.

3) Low Pressure Waves

For information on time delays and analog channels refer to:

What is the time delay between...

Analog Conversion from Digital Units to Volts

Until calibration, SonoLAB acquisition software reads incoming signals as a voltage and converts to a digital unit as follows:

1 Volt=205.8 Digital Units

1 Digital Unit=0.00488 Volts

These values may be considered irrelevant since SonoLAB will internally use these numbers to properly calibrate using the values entered by user.

Analog Input Voltage

Sonometrics Digital Sonomicrometer acquires analog signals from external devices to be saved with crystal information or independent of crystal distance readings. Analog signals should have an output voltage between –10 volts and +10 volts.

If the analog signal is not between these limits the signal should be amplified. For a full listing of amplifiers available from Sonometrics Corporation, please contact our sales department by (519) 474-6464 or email to sales@sonometrics.com.

Low Pressure Waves

Q: Why do my pressure waves seem to be very low?

A: Check to see if the values you are seeing are consistent with published results. If not, erroneous pressure values may be the result of one or more of the following:

- non-healthy animal
- problems with the pressure transducer such as

poor position of pressure transducer or damaged

transducer or transducer improperly operated

Principles of Sonomicrometry.

Principles of Sonomicrometry.

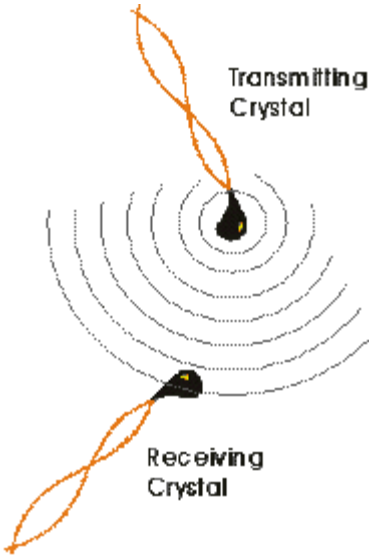
Please select from the following:

1) General Information

2) Triggering Points of the System

General Information

Sonomicrometry, as applied to biomedical research, is the measurement of distances within soft tissue by using sound energy. Small piezoelectric crystals



perform the task of transmitting and receiving short pulses of ultrasonic energy. These crystals are embedded, sutured, or otherwise fixed to the endpoints of the distances to be measured.

As illustrated, for a single distance measurement, one crystal is electrically energized causing an oscillatory shape change, which results in a burst of sound typically several hundred kHz or a few MHz in frequency. This process is not unlike a hammer hitting a bell. Depending on the shape of the crystal, this sound wave can travel in a narrow beam, or it can radiate in many directions. Eventually, this sound wave will impinge on a second crystal, causing it to produce a weak electrical current in response to the sound-pressure energy emitted by the first crystal.

It is the "time of flight" of the sound wave as it travels between the transmitting and receiving crystals that is actually measured in sonomicrometry. Since the speed of sound in soft tissue is well characterized, a simple calculation (Distance = Velocity x Time) yields the distance between the crystals.

If two, or more, crystals are used as receivers, then a simultaneous distance measurement between the transmitting crystal and all receiving crystals can be made. In addition, it is possible to alter the function of some or all of the crystals so that they are capable of both transmitting and receiving. These crystals are called transceivers. The advantage of having a group of crystals acting as transceivers is that all possible distance measurements between crystals can be obtained.

Typically, 2 to 32 crystals are implanted during an experiment. During operation, the computer rapidly switches these crystals between transmit and receive modes, thus allowing the user to obtain measurements between any of the implanted crystals. The delay between successive measurements is usually small enough to be considered insignificant when compared to biological motion.

Triggering Points of the System

Q: What if the system triggers on the second or third rising edge, not on the first?

A: Triggering on multiple rising edges is certainly one phenomenon associated with our system. Sometimes during operation, the triggering point of the system alternates between the first 2 (or 3 ?) cycles of the signal. These events are called "skips" or "level-shifts". There are two possible results, and they depend on the design of the sonomicrometer in question.

In traditional analog sonomicrometers, the results of individual transmit-receive cycles are output through simple analog techniques (i.e. varying the charge on an output capacitor). What these techniques do is to "smooth out" the transition point of these skips. A separate computer doing data acquisition on such signals further complicates the issue by acquiring the output at relatively low data rates (i.e. 200 to 400 Hz). The end result can often be that the skips are not detected by visually inspecting the data. It does not mean, however, that they are not there.

In our Digital Sonomicrometer, the results of each and every distance measurement is transferred directly to the ISA-AT bus of a conventional PC as a digital number that represents the ultrasound transit-time. If a skip occurs between 2 consecutive cycles, then it appears distinctly in our data-stream as a discrete "level-shift" of 1 full wavelength of the crystal frequency (typically 1.2 mm). This shift is so recognizable when viewing data that the operator can either make an adjustment to the crystal positions or our software will process the data afterwards and remove the level-shift from the data by subtracting a constant from the affected region. Level shifts therefore do not produce the kind of "invisible" errors on our system, that they do on conventional analog systems.

DAC Channels

DAC Channels

Sonometrics Sonomicrometer system allows the user to send crystals signals to another acquisition system. Please select from the commonly asked questions listed below.

1) Output range.

2) Voltage to distance equivalents.

3) Output Values

Output Range

The voltage range put out by the DAC option is between 0 and 5 volts.

Output Values

Q) When I enter a DAC output value, Sonolab responds by printing "Closest output value" which is sometimes very different than what I wanted. What's going on? Which value is actually being output?

A) In the DAC calibration menu, the user is asked for a desired value (in mm) that will appear on the DAC outputs. It should be noted that the sonomicrometer hardware in the computer is not capable of generating a DAC output that exactly matches the user-defined value. There are limitations in the generated values based partly on the hardware and partly on the version of Sonolab being used.

In older versions of Sonolab, the actual DAC output values were (roughly) multiples of 25 mm if the system in question had the standard sonomicrometer resolution (0.024 mm). For hi resolution systems (0.015) there was a better match between the desired and actual output, usually to within 1 mm. With newer versions of Sonolab and standard resolution systems, this situation improved and the DAC output value can more closely match any desired user value, usually to within 2 mm.

NOTE: The DAC output has a basic output limitation of 63 mm (hi-resolution system) or 97 mm (standard resolution), and for systems with older software this cannot be changed. On these systems any distance that exceeds those values would not be output correctly on the DAC channels. With newer versions of Sonolab a scaling factor has been added to extend the maximum output range of the DAC by factors of 2 and 4. However, if your measurements never exceed 63 or 97 mm then this situation would not affect you.

In any case, the user should note the "Closest output value" when calibrating the DAC outputs because that is the actual value being output by the DAC channel in question, regardless of what the desired user value is. The only exception to this rule is when the desired user value exceeds the maximum DAC output, in which case explaining exactly what the DAC output value represents is problematic.

DAC Voltage to Distance Equivalents

DAC Voltage to Distance Equivalents

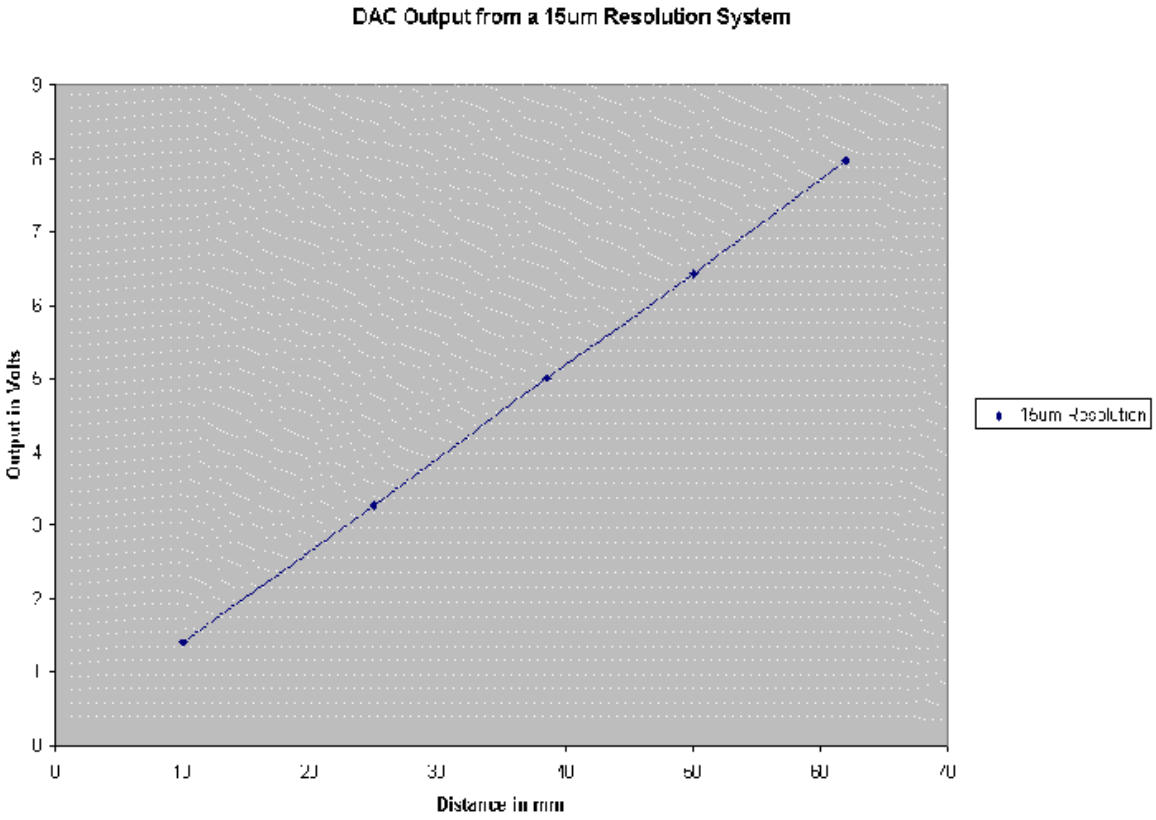
when used the DAC sends out a voltage reading equal to a distance measurement. The voltage sent is dependant on the resolution of the sonomicrometer system. Please select from the following.

1) 100MHz (15um) high resolution.

2) 64MHZ (24um) standard resolution.

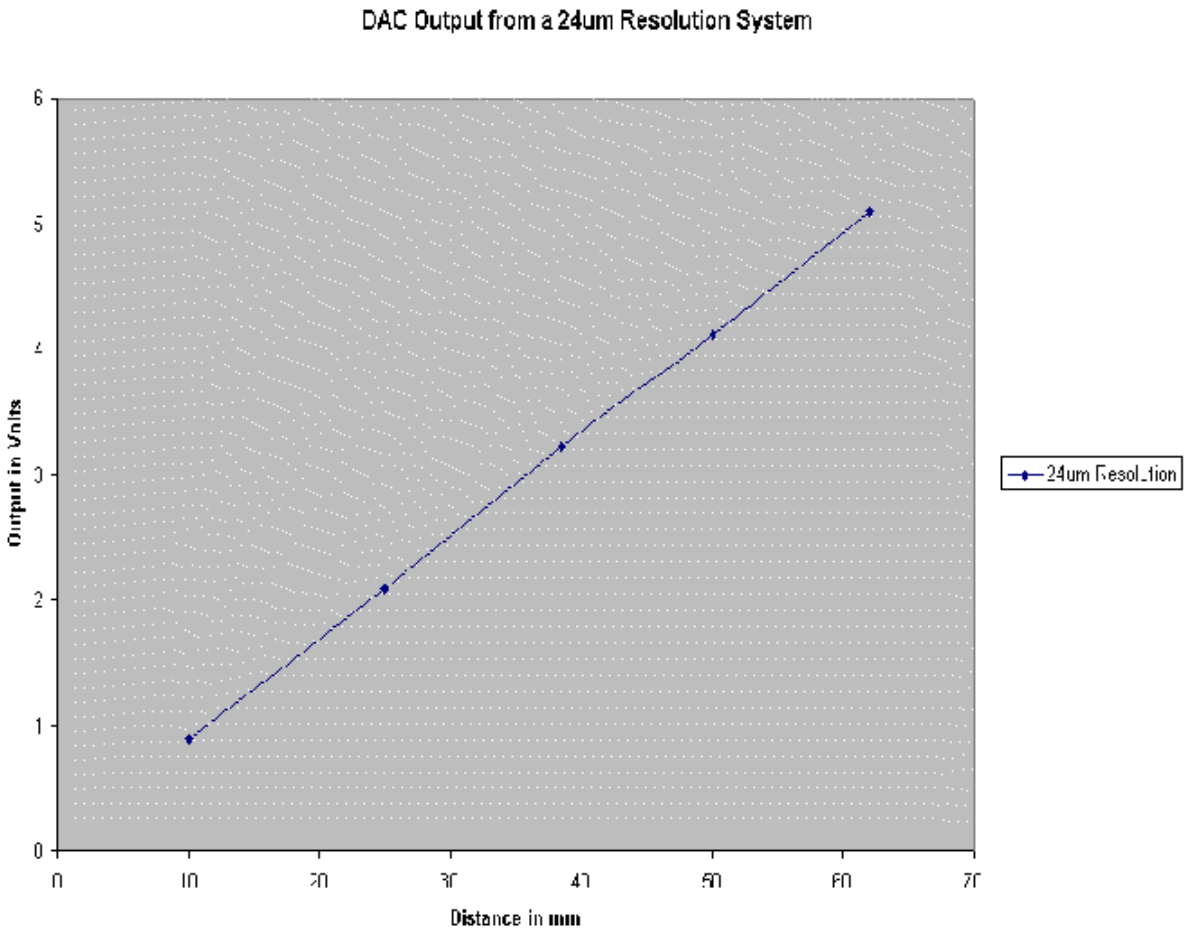
100MHz (15um) Resolution DAC Voltage

The following is a graphical representation of voltage vs distance output by the DAC.



64MHz (24um) Resolution DAC Voltage

The following is a graphical representation of voltage vs distance output by the DAC.



TRX Box

TRX Box

1) Sensitivity Control

2) What is the time delay between...

3) Adjusting Sampling Rates

4) Adjusting Transmitting Crystals

Sensitivity Control

Q: What do the knobs on the front of my TRX box do?

A: These knobs are your sensitivity knobs.

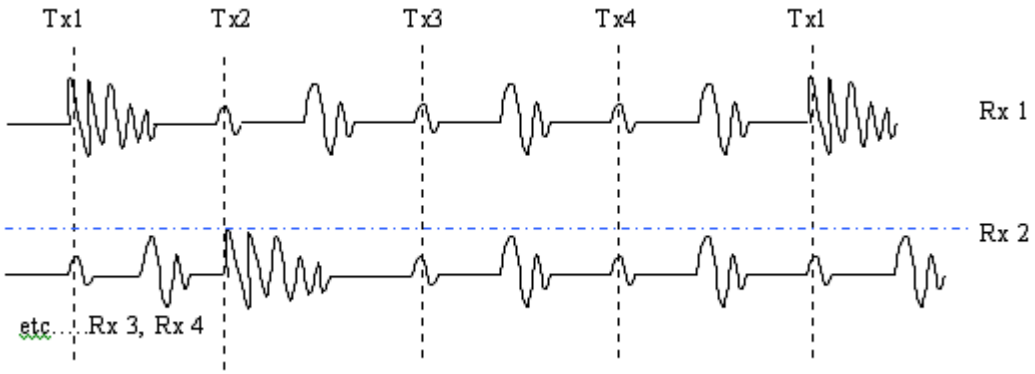
As shown on the figure below, Transmitters are at the top and Receivers are the side.

When Tx 1 pings (transmits), Rx 2 hears some noise due to cross talk - this is the noise that you have Rx2 not remember by using the inhibit delay. Next you want to set your sensitivity to hit the real wave of transmitter 1 that receiver 2 hears. This is a theoretical drawing, a real drawing would have more noise and your sensitivity would have to be decreased in order to get the real wave. Please refer to the manual for sensitivity adjustments.

Sensitivity setting

Decrease sensitivity - line moves up onto a higher rising point on the wave

Increasing sensitivity - line moves down to a lower rising point on the wave



What is the time delay between...

Q: What is the time delay between:

a) Sonomicrometer measurement Tx-A/Rx-B and Tx-C/Rx-D

b) A/D channel "A" and A/D channel "B"

c) Sonomicrometer measurement Tx-A/Rx-B and A/D channel C

A: The Sonometrics digital hardware generates timing signals that control the transmitting sequence of the sonomicrometer crystals as well as controlling data acquisition of the A/D channels. The user can control the crystals that are used for transmitting by turning the transmit function on or off for each crystal. The hardware then creates a transmit pattern that starts with the first transmitting crystal to the last crystal (as specified by the user). Note that all crystal between the first and last will transmit, regardless if the user has turned off some of the intermediate crystals. The entire transmit sequence from the start to end crystal is known as a *transmit cycle*.

The user has control of the overall data sampling rate of the system. The sampling period is the inverse of the sampling rate. For example, if the sampling rate is 200 Hz, then the sampling period is 0.005 seconds (5 milli-seconds). During the sampling period, all crystals from the start crystal to the end crystal will transmit one at a time. For example, if the user has turned on the transmit function for crystals 1, 2, 3 and 4, then the transmit pattern will be (in this order) 1, 2, 3 and 4. Since there are 4 transmitting crystals, and since the sampling period is 5 milli-seconds, then the time between transmissions will be 5 / 4 = 1.25 milli-seconds. So if time-zero represents the time when crystal 1 transmits, then crystal 2 transmits at time 1.25 ms, crystal 3 transmits at time 2.5 ms, crystal 4 transmits at time 3.75 ms. If the user turns off the transmit function of one or more of the intermediate crystals (such as 2 or 3 or both in this example) then the system would still cause them to transmit, but the distance data from them to any receiving crystal will not be saved or displayed.

Because each crystal transmits in sequence with a fixed time-delay between transmissions, there are small time differences between different measurements. For example, from the above example consider the time delay between the measurements from crystals 1-2 and crystals 3-4. Looking specifically at Tx-1/Rx-2 and Tx-4/Rx-3, the time delay would be 3.75 ms. because the time difference between crystal 1 transmitting and crystal 4 transmitting is 3.75 ms. However, we can look at the same measurements by looking at Tx-2/Rx-1 and Tx-3/Rx-4, and in this case the time difference is only 1.25 ms. In cases where the same transmitting crystal is used for two measurements (such as between Tx-1/Rx-2 and Tx-1/Rx-4) there is no delay between measurements.

These examples show that there are small time differences between sonomicrometer measurements made during a single sampling interval. These differences are small when compared to the time between samples (ie the sampling period). If the sampling rate is sufficiently high to catch the fine details in physiological wave-forms, then these smaller time delays between crystals become negligible.

A/D inputs, Sampling and Time Delays

The measurements of external analog signals via the A/D inputs are performed in exact synchrony with the crystal transmission pattern. As mentioned above, the user selects a transmit patters from which a start and end transmit crystal is determined, at which point all crystals between the start and end crystal transmit one at a time. All analog signals are sampled exactly at the same time (to within 10 nano-seconds). So there is no time differences between analog signal measurements, regardless if the system in question has 4 A/D channels or 16 A/D channels. The sampling of the a/d channels occurs exactly when the start crystal is given the signal to transmit. So, the a/d channels are sampled at the start of the transmit cycle, and they are not sampled again until the next sampling interval.

So there is no delay between the sampling of the a/d channels, but there is some delay between the a/d sampling and the crystal measurements. In the above example with 4 crystals and a sampling rate of 200 Hz, the sampling period was 5 ms and the time-delay between transmitting crystals was 1.25 ms. Since the a/d channels are sampled at the same time that crystal 1 transmits, there is no delay between the a/d measurements and the sono measurements between crystals Tx-1/Rx-2, Tx-1/Rx-3, and Tx-1/Rx-4. But there is a delay of 1.25 ms between the a/d channels and the sono measurements Tx-2/Rx-1, Tx-2/Rx-3, and Tx-2/Rx-4. Similarly, the delay increases to 2.5 ms for the sono measurements Tx-3/Rx-1, Tx-3/Rx-2, and Tx-3/Rx-4. The delay reaches a maximum of 3.75 for the measurements Tx-4/Rx-1, Tx-4/Rx-2, and Tx-4/Rx-3.

Adjusting Sampling Rates

Q: Why can't I adjust the sampling rate to even numbers like 250 Hz, 500 Hz, or 1000 Hz?

What sampling rate should I use?

My sono measurements become noisy at high sampling rates, but they look clean at low sampling

rates-why?

A: For cardiovascular / hemodynamic measurements, a good rule of thumb is to use sampling rates of 250 Hz for large animals (dogs, pigs, sheep, etc), 1000 Hz for rats, and 1500 Hz for mice.

A sonomicrometer measurement is made when one crystal is given the signal to transmit a short burst (ping) of ultrasound. A short time later a second crystal will receive this signal. The time is converted to a distance by knowing the speed of sound in the material the crystals are in. If several receiving crystals are in the material then they all will detect the transmit ping eventually. At some point later this particular transmit window will close and the next crystal in sequence will transmit it's ping. Normally at this time the echo remnants of the first ping will have dissipated to the point that they are no longer being detected by the receiving crystals. This is important as the receiving crystals can't distinguish between these echoes from the previous transmission and the direct reception of the ping from the current transmitting crystal.

Considering the example with 4 crystals (all transmitting and receiving) and a sampling rate or 200 Hz, there is a transmitter-to-transmitter spacing of 1.25 ms. 1.25 ms is 1250 microseconds. In water or tissue sound travels roughly at 1.5 mm per microsecond. So in 1250 microseconds sound can travel 1875 mm, which is almost 2 meters. This is quite a long distance, and in this time the ultrasound is likely to reflect off of many interfaces or boundaries, and with each reflection the energy of the signal is reduced. In a physiological setting (such as large-animal cardiac measurements) the ultrasound transmission can fade away in 200 to 300 microseconds. The worst way to arrange crystals is to put them in a glass or metal container of about 1 liter in size. The hard walls of those containers reflect much more ultrasound than they absorb, which means it takes a long time for a transmit ping to fade away. Many people make the mistake of using water in a glass beaker to test crystals, and this will almost always lead to sono signals that look very noisy. Instead of glass or metal, a plastic beaker should be used.

In physiological settings, it can be expected that it will take 150 to 250 microseconds for the transmit pings to fade. The smaller crystals (.7 and 1.1 mm) take less time to fade than the larger (2.2 mm) crystals. If 4 1.1 mm crystals are used, then 4 x 150 microseconds = 600 microseconds (.6 ms). So if the sample period is 0.6 ms then the sampling rate would be 1,667 Hz. This is the highest sampling rate you can expect to get by using 4 crystals and get no noise due to the reflections from transmit pings. However, it is not uncommon to get over 2000 Hz with some preparations. For the larger 2.2 mm crystals, using 250 microseconds as an example, if the number of crystals is increased, then the effective "safe" sampling rate will decrease. For example, the expected safe sampling rate for 8 crystals would be 1 / (8 x 250 u-sec) = 500 Hz, 12 crystals would be 333 Hz, 16 crystals would be 250 Hz, and 32 crystals would be 125 Hz.

There is no harm done by raising the sampling rates beyond the above values, other than having the sonomicrometer traces become noisy. If that happens, you can either live with the noise (and possibly filter it out later), you can reduce the sampling rate to the point where the noise disappears, or you can do a combination of reducing the Transmit-Pulse setting and / or reducing the receiver sensitivity of the crystals by turning the sensitivity control on the TRX box counter-clockwise. Reducing the Transmit Pulse setting has the effect of reducing the strength of the transmit ping.

A/D inputs, Sampling and Time Delays

The measurements of external analog signals via the A/D inputs are performed in exact synchrony with the crystal transmission pattern. As mentioned above, the user selects a transmit patters from which a start and end transmit crystal is determined, at which point all crystals between the start and end crystal transmit one at a time. All analog signals are sampled exactly at the same time (to within 10 nano-seconds). So there is no time differences between analog signal measurements, regardless if the system in question has 4 A/D channels or 16 A/D channels. The sampling of the a/d channels occurs exactly when the start crystal is given the signal to transmit. So, the a/d channels are sampled at the start of the transmit cycle, and they are not sampled again until the next sampling interval.

So there is no delay between the sampling of the a/d channels, but there is some delay between the a/d sampling and the crystal measurements. In the above example with 4 crystals and a sampling rate of 200 Hz, the sampling period was 5 ms and the time-delay between transmitting crystals was 1.25 ms. Since the a/d channels are sampled at the same time that crystal 1 transmits, there is no delay between the a/d measurements and the sono measurements between crystals Tx-1/Rx-2, Tx-1/Rx-3, and Tx-1/Rx-4. But there is a delay of 1.25 ms between the a/d channels and the sono measurements Tx-2/Rx-1, Tx-2/Rx-3, and Tx-2/Rx-4. Similarly, the delay increases to 2.5 ms for the sono measurements Tx-3/Rx-1, Tx-3/Rx-2, and Tx-3/Rx-4. The delay reaches a maximum of 3.75 for the measurements Tx-4/Rx-1, Tx-4/Rx-2, and Tx-4/Rx-3.

Adjusting Transmitting Crystals

Q: If a crystal is turned off as a transmitter, will the hardware still cause it to transmit?

A: The user can control the crystals that are used for transmitting by turning the transmit function on or off for each crystal. The hardware then creates a transmit pattern that starts with the first transmitting crystal to the last crystal (as specified by the user). Note that all crystal between the first and last will transmit, regardless if the user has turned off some of the intermediate crystals. The entire transmit sequence from the start to end crystal is known as a *transmit cycle*.

Computer

Computer

Please select from the following topics:

1) Monitor Settings

Monitor Settings

Q: What monitor display settings should I use?

A: The monitor setting for Sonometrics software **cannot** be set to 256 colors. If it is on this setting, the buttons will disappear or multiple buttons will be shown and while setting the 2D zone, all the trace data will go blank. Please change your colors setting under Display – Settings to True Color (16, 24 or 32 bit).

FAQ: Software

FAQ: Software

Please select from the following topics:

1) Optimizing Acquisition in SonoLAB

2) New Version of SonoLAB on Old Computer

3) SonoLAB- Velocity of Ultrasound

Optimizing Acquisition in SonoLAB

Q: How can I increase the acquisition speed (i.e. higher sampling rate) or decrease my file size in SonoLAB?

A: When a Sonometrics sono system is shipped with a computer, the SonoLAB software is pre-installed and configured to match the number of channels your system has. If you ordered a system with 8 TRX channels, then naturally you can activate and save data from all 8 channels in SonoLAB. That also means when SonoLAB is saving data, it saves data from ALL TRX channel combinations (in the raw data format) even if you turn some TRX channels off. For systems with many TRX channels (16, 24, 32) data is acquired from all channels, which requires additional file space and time. You can configure a new SonoLAB for less crystals if required, this will reduce file size and increase the maximum acquisition speed.

To perform this function, see section 5: Operating Other Software from SonoSOFT Platform from the SonoSOFT manual (found under Windows Start Menu then Program Files then SonoSOFT). In that section, you will create an alternate SonoLAB setup file using fewer TRX channels.

For example, you may have a 12 channel TRX system, but wish to use only 4 crystals for a given experiment. So you will create a 4-TRX configuration file. When SonoLAB runs with this file, it will only save the raw data from TRX crystals 1, 2, 3 and 4. It will not allow you to turn on any other TRX channels. In this condition, SonoLAB will save the equivalent of (4 x 4) = 16 TRX channels, instead of (12 x 12) = 144 TRX channels. This is a data reduction of a factor of 9. By reducing the amount of raw data saved, SonoLAB can save data reliably at much higher sampling rates. There is also a reduction in the number of raw data files saved, because there is more data saved in each individual raw segment file.

When selecting an alternate TRX configuration, keep to multiples of 4 channels. Use the following table as a guide:

TRX Channels	A/D channels
4	4
4	8
4	16
8	4
8	8
8	12
8	16
12	4
12	8
12	16
16	4
16	8
16	16

When ever you enter a combination of TRX and A/D channels, SonoLAB searches for its equivalent driver file. If that driver file does not exist, you will get an error message. A driver file exists for the combinations in the above table, as well as others that are not listed in that table. If you get this error, please try inputting the configuration again, if you still get this error contact support@sonometrics.com

New Version of SonoLAB on Old Computer

Q: SonoVIEW Version 3.1.0 and up need Windows 98 to run, but my acquisition computer does not have enough memory to upgrade from Win95 to Win98. Can I still use the new version of SonoLAB (Version 3.1.3 and up) with real time dP/dt and volume to acquire my data?

A: Yes, please follow the details below.

1) On your Win 95 OS computer rename SonoLAB.exe – oldSonoLAB.exe.

2) Install the latest version of SonoSOFT (SonoVIEW or CardioSOFT) onto a Win98 OS computer that you plan to do your analysis with.

3) Find SonoLAB.exe and transfer this latest version to your Win95 OS computer and place SonoLAB.exe in the same directory as the oldSonoLAB.exe (as created in first instruction).

REMEMBER: Before transferring acquired data from the Win95 computer to the analysis computer (Win98), **CONVERT** all data into ##B format.

SonoLAB- Velocity of Ultrasound

Q: In SonoLAB set-up, what should I set my velocity of ultrasound at?

A:

Note that the total range (below) is from 1450 to 1580, a difference of 80 m/s. The default in SonoLAB is 1540 m/s.

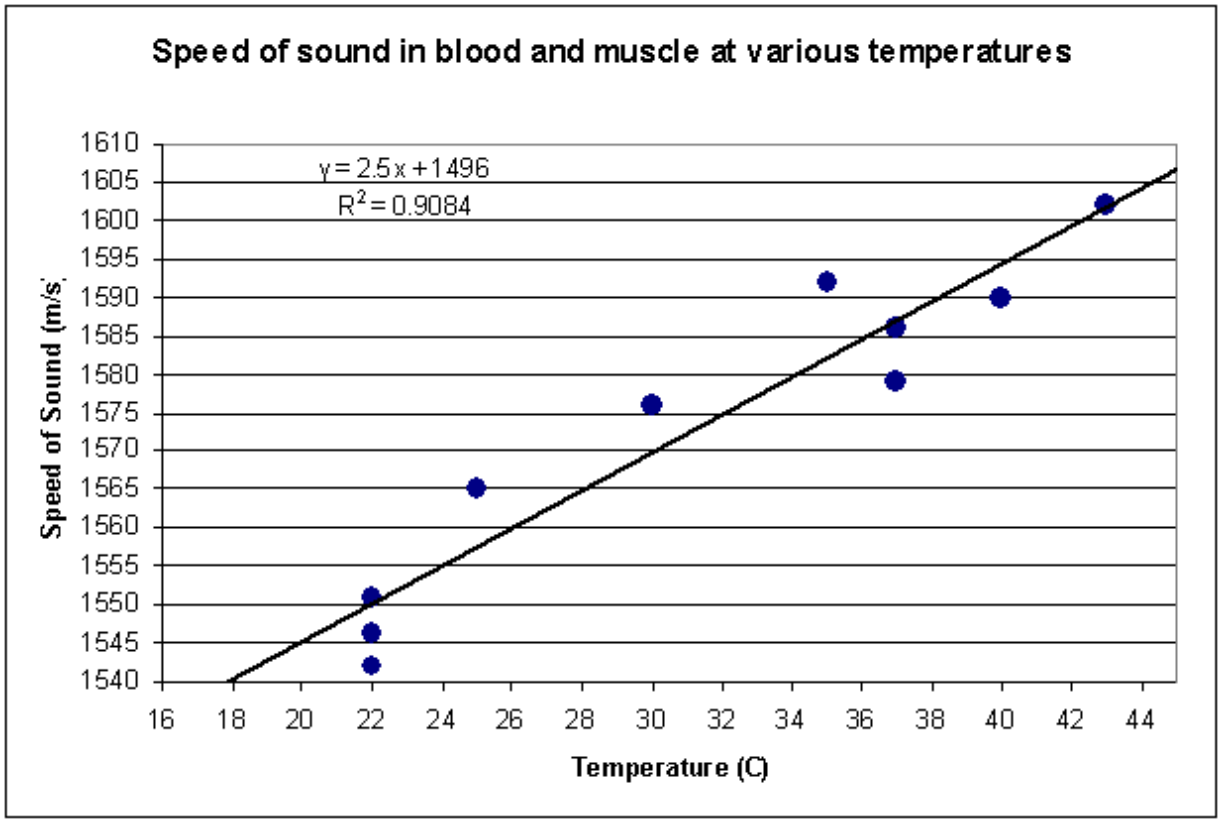
Velocity of sound in some Biological Materials

Material	Velocity of Sound (m/s)
Fat	1450
Water	1480
Average Human Soft Tissue	1540
Brain	1540
Liver	1550
Kidney	1560
Blood	1570
Muscle	1580
Lens of eye	1620

We have produced a graph comparing the speed of ultrasound versus temperature for blood and heart muscle taken from Goss SA *et al.* (1980, 1978). Our graph agrees well with Nasoni RL (1981) blood and cardiac muscle results.

For cardiac and muscle studies, we suggest using **1590 m/s for 37°C**

- for every °C below 37°C , subtract 2.5m/s
- for every °C above 37°C, add 2.5m/s



Goss SA, Johnston RL, and Dunn F

Comprehensive compilation of empirical ultrasonic properties of mammalian tissues. J. Acoust. Soc. AM. 64:423, 1978.

Goss SA, Johnston RL, and Dunn F

Comprehensive compilation of empirical ultrasonic properties of mammalian tissues. II, J. Acoust. Soc. AM. 68:93, 1980.

Nasoni RL

Temperature corrected speed of sound for use in soft tissue imaging. Med.Phys. 8:4, 1981.

FAQ: Application

FAQ: Application

Please select from the following topics:

1) Improving Occlusion Studies
2) Synchronizing with Transonic Flow Probes
3) Using Other Ultrasound Devices
4) Conducting an Experiment (3-D Coordinate Calculation)

Improving Occlusion Studies

Q: How can I improve my occlusion study results?

A: Please try the following suggestions:

- A good occlusion is shown by approximately 50% drop in peak LVP values
- you should ideally see this decrease over 12 or more LVP, LV_V cycles
- do not move the heart when occluding the VC, this will alter
the crystal data therefore the LV_V
- Please refer to other researchers occlusion techniques through
papers

Synchronizing with Transonic Flow Probes

Q: I want to use a Transonic flow probe to measure flow and use crystals. Do I need to synchronize the flow meter with the sonomicrometer? How does this synchronization work?

A: In situations where flow will be measured with a Transonic flow probe, it is sometimes necessary to synchronize the flow meter with the sonomicrometer so that they don't interfere with each other. There are situations where synchronization is not required. For example, where the frequency of the flow probe is higher than 4 MHz then synchronization is not required because frequencies above 4 MHz are not detected well by the sonomicrometer signals. Transonic does publish the frequencies of all their probes, but if you don't know the frequency of a given probe, a rule of thumb is that the frequency goes higher as the probe gets smaller. Probes used to measure coronary artery flow in large animals are typically 4 MHz or higher, and hence don't interfere with the sono measurements. However, larger probes used to measure pulmonary or aortic flow in large animals typically are less then 4 MHz (sometimes less than 1 MHz) and these probes will interfere with sonomicrometer signals. Once exception is when the probes are separated by a good distance from the site where the crystals are attached.

If you will be using large flow probes or probes with operating frequencies less than 4 MHz, it is advisable to have the synchronization module on-hand and ready to use but to try first running the flow meter unsynchronized and then assess the degree of interference. By switching the power on and off on the flow meter you should see tell-tale signs of interference in the sonomicrometer signals (the interference will look like "rain" in the sono traces). If you see no noise then you can proceed with data acquisition.

If you do see noise from the flow probe, then connect the synchronization module and set the flow meter sync switch to "Slave". The sync module functions by sending the flow meter a signal that is time-interleaved with the crystal transmit signals. There is evidence that the "quality" of the flow signal is affected by a synchronization signal that is too slow. This can be remedied by increasing the sampling rate of the sonomicrometer, or turning on some extra (un-used) crystals as transmitters.

Using Other Ultrasound Devices

Q: I want to use other ultrasound devices (like doppler flow cuffs or echo imaging consoles). Will there be interference with the sonomicrometer crystals?

A: There are several ultrasound devices used for invasive hemodynamic measurements such as doppler flow cuffs and "single-crystal" wall-thickness transducers. These transducers send out high-frequency ultrasound which is reflected from blood cells or tissue boundaries and the reflected signal is analyzed for frequency shifts that are caused by flow or motion. The frequencies used by these transducers are usually 10 MHz or higher, which means they are not detected at all by the sonomicrometer crystals (and vice-versa) so no synchronization or special precautions are needed.

It is a different situation for echo imaging systems. The imaging probes used by these systems are typically in the range of 1 to 3 MHz, and these signals can be picked up by the sonomicrometer crystals. The interference caused by these probes usually looks like "rain" under the sonomicrometer trace. To a lesser extent, it may be possible to see speckles of noise on the echo image that is coming from the crystals. There is really no way to synchronize a clinical echo imaging scanner with the sonomicrometer because the scanners are usually not equipped with any means to connect an external synchronization signal. The remedy in this case is to simply not collect sonomicrometer data when echo imaging is being performed. Echo images are usually not collected on a continuous basis, but instead are collected intermittently, and this gives the opportunity to collect sonomicrometer data either immediately before or after a series of echo images have been acquired.

Conducting an Experiment (3-D Coordinate Calculation)

How to conduct an experiment using many crystals with 3-D coordinate calculation in mind:

When a preparation is instrumented with many crystals with the goal of performing 3-D calculations on the data, there are some general procedures to follow that will improve the quality of the data that is collected. Something to try right before crystal implantation is to test each crystal one at a time against a reference crystal plugged into channel 1. Use a 500 ml plastic beaker of water (not glass or metal). With a normally functioning pair of crystals it should be possible to manipulate their position randomly, up to the limits of the walls of the beaker, and have their distance signal track cleanly and smoothly.

Phase 1: Crystal implantation / attachment

As the crystals are attached to the preparation, the Sonolab trace-display screen should be arranged to show the traces as they are added. For example, if 16 crystals are to be used, then all 16 RX channels should be turned on, and initially they should be paired to TX channel 1 while viewing the traces. After the first two crystals (1 and 2) are attached, the quality of Tx-1/Rx-2 should be noted by viewing the screen and looking for a smooth trace. A fragmented trace is indicative of intermittent contact between one of the crystals and the preparation. A trace with sporadic single-point noise indicates that the preparation is picking up noise which is being conducted into the crystals by way of fluid seepage into a cut or nick in the wires, or directly into the crystal head (typical if the crystal has many hours of previous usage). Refer to other Sonometrics documentation that describes various non-ideal signal patterns and how to correct them.

Helpful hint: During the crystal attachment phase, it is helpful to reduce the sampling rate, especially if you are using more than 16 crystals. At any given sampling rate, as more crystals are added to the transmitting sequence, the time between transmissions must decrease in order to keep the sampling rate constant. When the transmit - to - transmit time becomes too short, echoes from the previous transmission can interfere with the current measurement. This interference can make the distance signals look choppy or broken up, which is similar to bad contact between the crystal and the preparation. For 16 or fewer crystals, a good sampling rate to start with would by 150 Hz. For 20 crystals use 120 Hz, for 24 crystals use 100 Hz, and for 32 crystals use 75 Hz for the initial sampling rate. When all the crystals are attached and the signals are acceptable, increase the sampling rate one step at a time until you've reached your desired sampling rate (or until the signals become noisy / fragmented, in which case you should back off the sampling rate).

As subsequent crystals are added to the preparation (#3, #4, #5, etc) a new signal trace will appear on the Sonolab screen, showing the distance between that crystal and crystal #1. This is where you can make slight adjustments to the sensitivity control for the crystal that was just added to obtain a smooth distance trace. If the traces appear good at some times but not so good at other times (such as when the preparation is manipulated by hand), that is ok - it is not necessary to re-adjust the sensitivity controls to compensate. It is only when the handling the preparation is finished that you should go over the sensitivity controls and make final adjustments.

Always have extra crystals on hand. It may have been some time since you last used the crystals, so you don't always know if some have gone bad (become noisy). If you plug in a crystal and it's noisy when in contact with the preparation, no matter where you set the sensitivity setting, immediately unplug that crystal and set it aside (it's probably bad). Don't hesitate to try one or two crystals in a particular location to see if you can get a better signal.

It may be the case that no matter what you do, the signal between a particular crystal and crystal #1 always looks bad. If re-positioning that crystal or adjusting it's sensitivity setting doesn't solve the problem, you might want to check other distance traces between it and other transmitting crystals. You can do this now by manually changing which transmitting crystal you pair it with for display, or you can wait until all crystals are attached.

Phase 2: Over-all Signal Verification.

Once all crystals are attached and the preparation is situated in the position where experiments are ready to be conducted, a quick scan can be made of all sono distance traces. Do this by pressing the F1 or F2 keys. This will

increment or decrement the transmitting crystal that is paired with all other crystals simultaneously. So you can quickly go from seeing all distances between crystal 1 to all other crystals to crystal 2 to all other crystals, and so on. If you have 16 crystals in total, then by pressing the F1 key 16 times you will see all 240 combinations of traces.

If during this scan you notice that some traces on a given channel are consistently bad, then this is where you would adjust the sensitivity control for that channel. One thing not to do is to adjust the sensitivity control of a given channel so low that it can pick up one or two hard-to-get traces while at the same time you "flat-line" most of the other traces. In other words there can be an "optimal" setting where you maximize the number of traces that come in smooth and unbroken.

An important item to remember is that it is not necessary for all traces to be smooth and noise-free. For 3-Dimensional reconstruction, quite a few of the traces (20% to 40%) can be bad and yet over-all a 3-D mathematical reconstruction can be performed using only the good traces. The minimum requirement is that there are at least 3 good distances between each crystal and 3 other crystals.

Phase 3: Data Acquisition

This is the phase where you perform the experiment, typically starting with a base-line data collection. As the experiment progresses, scan through the signals by pressing F1 or F2 (as explained above) and look for any changes to the quality of the signals that might be caused by a crystal coming loose from the preparation. Some signals between crystals can change if hard objects are introduced into the preparation, or if the physical configuration of the preparation changes markedly during the experiment.

Other tips:

If there are large groups of signals that can't be adjusted to come in smoothly, it would be a good idea to view the actual ultrasound signals on an oscilloscope. For this you need a TRX box that has the external "AMP" connections on the back of the box. This allows for a direct view of the ultrasound signals between individual pairs of crystals (a transmitting and receiving pair). Refer to other Sonometrics documents for descriptions of the wave-forms you can expect to see on the scope, what they mean, and how to correct them.

3-D Measurements and the Sample Space

There are times when crystals are applied to a heterogeneous volume space where the shape or size of one component within the volume is to be compared with either the boundaries of the volume or to another component within the volume. The volume is said to be heterogeneous if there are sufficient density differences within the volume. In physiological systems, this can arise when the volume space is composed of soft tissues, cartilage, bone, pockets of air, and / or lung tissue. Given a spatially-distributed set of crystals within the volume space, the transit-path of ultrasound between the various combinations of crystal pairs will experience attenuation and multi-path distortion to differing degrees. Several things can be done to optimize sono measurements, such as:

a) Prevent the occurrence of air gaps in the direct path between any two crystals. Air pockets may form transiently or periodically as a result of physiological motion. A constant air gap can prevent the distance measurement from occurring at all, or it may introduce errors in the measurement as the path-length around the gap is reported instead of the straight-line distance.

b) Prevent the crystals from being in direct contact with dense objects. A crystal that is in contact with bone or some other relatively dense object (dense when compared to soft tissue) can have it's ultrasound radiation pattern change drastically. Also, a dense object (such as a tendon or ligament) that runs in parallel with the sound beam between crystals can cause multi-path interference by conducting a portion of the signal at a faster velocity that the soft tissue around it. A special case of this occurs when the wires from adjacent crystals run close to, or come into contact with, other crystals heads. A rule of thumb is that the closest thing to the head of any crystal should be the head of another crystal - not the wire leads from another crystal. In any case a separation of 2 to 3 cm between a wire and a crystal head is sufficient. The use of an oscilloscope is especially helpful in determining if multi-path distortion is occurring.

c) Slide the introducers back from the crystal! The plastic introducers that allow the crystals to be pushed into tissue should be withdrawn all the way out of the preparation when their job is done.

d) Orient the crystals so that they face each other (or so they face the center of the sample volume) and their leads face away from the other crystals. The side where the wires exit the crystal is least able to transmit and receive signals so it should face away from other crystals.

e) High sampling rates will lead to choppy or broken signals, and this is more likely as the number of crystals increases. Use these numbers as a guide for the maximum sampling rate that can be achieved before interference starts to occur: 125 Hz for 32 crystals, 250 Hz for 16 crystals, and 500 Hz for 8 crystals.

f) Ground the sample volume. Large preparations can act like antennas, receiving 50 or 60 Hz power-line signals that may in turn be picked up by the crystals, leading to single-point data drop-outs at best and totally obscuring a sono signal at worst. If the preparation is on a metal table, connect a ground lead between the table and the ground connection on the back of the TRX box. If there is some metal object in contact with some portion of the preparation (such as a chest spreader) then use that as a ground. Note: If defibrillation is necessary then disconnect the ground lead from the animal just to be safe.

g) In situations where the noise seems to be intermittent, check for causes such as heating elements, motors or cauterizers near the preparation. Turn them off if possible. High current devices can induce noise in the crystal wires, and if they are on all the time then so to will the noise be present all the time. Cauterizers used in adjacent surgery rooms have been known to induce noise in crystal signals.

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