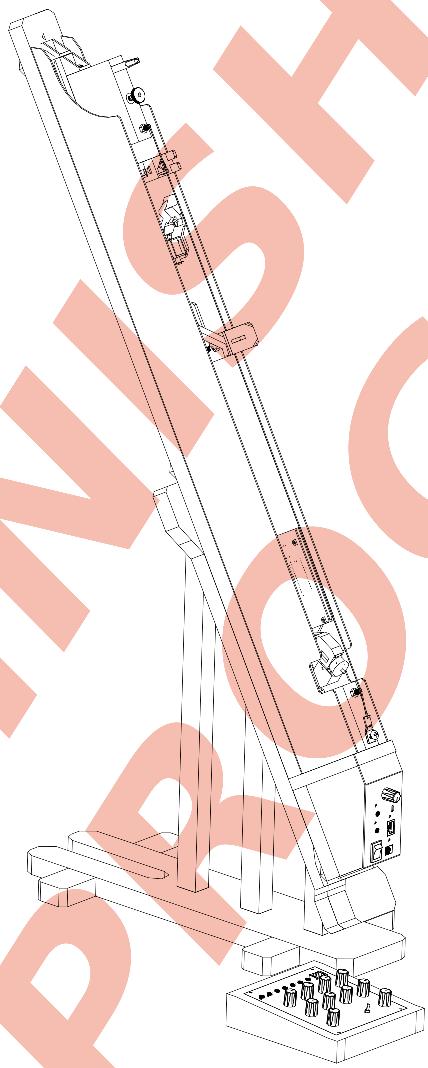
THE EKDAHL

FAR



KNAS

Manual

Table of contents

Introduction

The Ekdahl FAR is a string based electro-acoustic instrument whose main mode of generating sound is by utilizing a *bowing wheel* and by very precisely controlling the speed of the wheel emphasizing natural overtones in a string. The bowing wheel is situated on a controllable pivot in order to affect both volume and harmonic content, to further extend the capabilities of the instrument it also has a *hammer*, a variable *mute* and a electromagnetic pickup. While the audio path on The Ekdahl FAR is entirely analog-acoustic, the internals of the instrument is a highly sophisticated network of sensors, motors and a built-in computer running a complex firmware allowing for precision control and interfacing via USB-MIDI, MIDI, CV and USB-Serial.

Like all Knas instruments, the Ekdahl FAR - while a new and somewhat experimental concept - can be used for any regular musical composition and expression, but also allows for deep explorations of naturally occuring overtones within the realms of digital precision control and repeatability. The instrument is designed to perform excellently whether being in an improvisational setting, or being sequenced. All aspects of The Ekdahl FAR can be mapped to respond to any avaliable control mechanisms (USB, MIDI, CV etc.) and emphasis has been put on configurability and modification both from a software and a hardware perspective.

Getting started

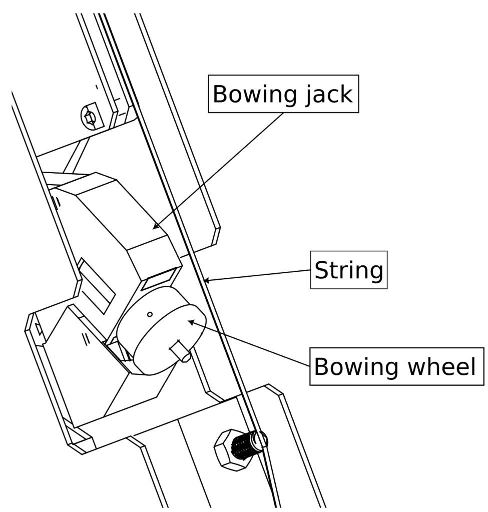
To get started with the Ekdahl FAR there are a number of key concepts and other bits of information that you need to know, the instrument works on a principle quite unlike anything else thus to get the most out of it i implore you to take a few minutes and read this document.

The Ekdahl FAR should come calibrated to a standard set of parameters but even so, due to its acoustic nature, minor periodic maintenance is requied. Most notably the instrument will have to be regularly fine tuned in order for the bowing of specific overtones to function, an out of tune instrument will not resonate.

The main ways of creating sound is by

•using the *bowing wheel* to precisely bow the string with a given speed, the speed of the *bowing wheel* determines which - if any - naturally occurring overtone(s) in the string is being emphasized. The *pressure* with which the *bowing wheel* is pressed against the string will affect both loudness and harmonic content.

•using the hammer to strike the string with a given force, the amount of force will affect both loudness and harmonic content



These modes can either be used separately or together.

There is also a mute that can be set to either being completely disengage from the string, freely do partial muting to supress or exaggerate certain overtones, or to do full muting of the string.

The overtone(s) to be emphasized are selected by the *harmonic number*s where harmonic 0 is the fundamental frequency of the string and all overtones are being calculated from this fundamental using the selected *harmonic table*. The default *harmonic table* is using just intonation in a 12-tone scale, thus harmonic 12 will be one octave above the fundamental, harmonic -12 will be on octave below etc. The effective range, resonance and sound of harmonics avaliable depends on the string tuning and the physical maximum and minimum speed of the bowing motor.

Terminology

•*Bowing wheel* - the wheel attached to the bowing motor which is actually rubbing against the string

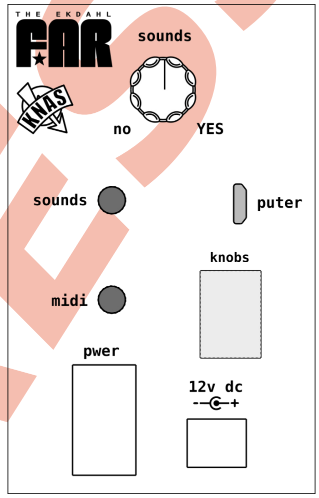
• *Bowing jack* - the assembly that holds the bowing motor and bowing wheel, this can be tilted up and down applying different *pressure* on the string

• *Pressure* - the positioning of the *bowing jack*. While the bowing wheel is touching the string this essentially sets the amount of force with which the *bowing wheel* is pressed against the string.

• *Bow pressure position* - sets one of the pre-defined *bowing jack* pressure positions where the *rest* position is where the *bowing wheel* is not touching the string at all, and *engage* is where it's starting to barely touch the string.

• *Harmonic table* - A list of ratios used to emphasize overtones in the string, each ratio corresponds to a MIDI or CV note in an octave. The default *harmonic table* contains 12 ratios per octave and the ratios are derived from just intonation.

• *Harmonic / Harmonic number* - a single ratio and octave in the current *harmonic table*. The ratio is used to calculate the bowing frequency from the fundamental, this frequency will emphasize a certain overtone. e.g. a *harmonic number* 17 in a 12-note scale refers to the 5th ratio on the second octave from the fundamental.

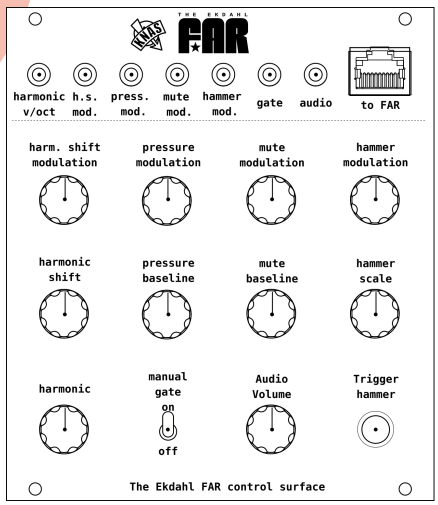


•*Harmonic shift / fine tune* - freely shifts the frequency of the bowing wheel from the *harmonic number* set. This command is dependent on the *harmonic shift range* which can be edited with the *configuration utility*.

• *Control method* - the method of control used. This can be CV, USB-MIDI, MIDI or USB-Serial as of the writing of this document.

• *Command* - the Ekdah FAR is entirely controlled by internal *commands*, these decide what the instrument is doing and changes internal parameters. When a MIDI event occurs or a new CV / knob value is read, the *commands* associated with it will be sent to the instrument. This can be things like "engage hammer" or "set the fundamental frequency" etc. Some of the avaliable *commands* are mainly used for calibrating and setting up the instrument and are usually saved into the instruments memory, these will be executed whenever the instrument is turned on. All *commands* can be manually invoked via USB-Serial.

The Front Panel



The front panel has all the basic connections required to interface with the Ekdahl FAR.

• The *sounds* jack is the main audio output and the volume is set with the *sounds* knob, due to the fact that different strings will have a different output levels, the gain offered will make the sound distort if turned up too high at times. Care should be taken to find a good balance in between noise floor and the possibility of the sound distorting.

• The *MIDI* jack is a TRS 3.5mm Type A jack as adopted by the MIDI standard.

• The *puter* jack is the USB connection and works in device mode, when connected to a USB host it presents itself as a USB-MIDI device and a USB-Serial device.

• The *knobs* jack currently only connects to the *Control Box*, this is however configured as a versatile port that may interface with other - future - control surfaces and interfaces.

• The *12v dc* jack is the main power for the Ekdahl FAR, it currently requires a center-positive 12V DC supply at 2.5 amps.

The Control Box

The Control Box is designed to be used as a master controller for The Ekdahl FAR in conjunction with CV, MIDI, USB, as a free improvisation controller - or all at once. Please note that the information supplied only applies to the *default configuration* the instrument is originally supplied with.

Since the internal workings of the instrument is by necessity digital, the knobs and jacks on the *Control Box* reports any changes via internal *commands* to the instrument. The very same *commands* are sometimes sent by different *control methods* thus one can freely combine various analog and digital controllers for optimal versatility. It can however also be a source of confusion when the same *command* is sent from several different sources at the same time.

The sum of the *harmonic v/oct* jack and *harmonic* knob determines which *harmonic number* to emphasize and sets the bow frequency accordingly[1]), the sum is quantized so that 1V / octave applies in the standard fashion of however many harmonics is in an octave by the selected *harmonic table* (12 tones by default). By default, when using a MIDI or USB-MIDI as well, this value is overridden by any *Note On* MIDI message.

The *h.s. mod*. jack, *harm. shift modulation* knob and *harmonic shift* knobs shifts the *bowing wheel* frequency from the current *harmonic number* by an amount derived in conjunction with the *harmonic shift range*. [2]) This jack can be used as a unquantized version of the *harmoni v/oct* jack. By default, the *MIDI pitchbend* message sends the same *commands*.

The *press. mod*. jack, *pressure modulation* knob and *pressure baseline* knob modifies the pressure of the bowing jack.[3]) by default, the *MIDI Continuous Controller #1 (Modulation wheel)* message sends the same *commands*.

The *mute mod* jack, *mute modulation* knob and *mute baseline* knob sets the position of the mute. [4])

The *hammer mod.* jack and *hammer modulation* knob engages the hammer with a variable force that is dependent on the voltage of the trigger signal[5]). The *hammer scale* knob affects the scale of **all** incoming hammer hits regardless of their *control method*.

Please note that MIDI note G5 does not necessarily mean the 5th octave on whatever controller you are using, MIDI allows for a ~10 octave span and the 5th MIDI octave is normally considered the "middle" octave of the keybed of whatever controller you are using. For a 4 octave keyboard, the 3rd physical octave from the bottom will usualy be the 5th MIDI octave.

The *gate jack* and *manual gate on/off* switch will when active raise the *bowing jack* and start the bowing motor[6]), the switch is ignored when a cable is plugged into the *engage jack*. Any MIDI *Note On* or *Note Off* message will send the same *command* and override the switch and/or jack.

The *audio* jack on the control box is a supplementary audio output mainly intended for use with modular CV/Gate systems, but it can be used a regular audio jack too. In this case however the *audio volume* knob will most likely need to be turned down quite a bit for the receiving equipment not to distort.

Basic MIDI Setup (USB or Hardware)

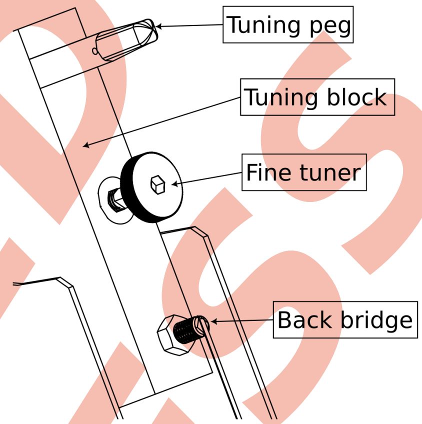
As of this writing, the MIDI implementation does not differ in between MIDI messages that are sent over hardware MIDI or USB-MIDI.

In order to use MIDI to control the Ekdahl FAR you need to have all the MIDI parameters and configurations setup correctly. By default the instrument will respond to all midi channels (omni), any keyboard / sequencer sending *Note On* / *Note Off* MIDI messages (standard) can be used to control the overtone being emphasized. The tuning of the instrument is decided by the stored *fundamental frequency* and *base note*, where *fundamental frequency* is the tuning of the string and *base note* is which MIDI key that is mapped to the fundamental (*harmonic number* 0). All other keys will be playing harmonics that are calculated up and down from the *base note* using the selected *harmonic table*. The default setting for the fundamental frequency is a G at 99 Hertz and the base note is set to MIDI key G5 (G on octave 5).

When a key is depressed on a midi keyboard and received by the Ekdahl Far, it will (by default) start the motor, set the bow frequency to the corresponding *harmonic number* and raise the *bowing jack* to the *engage* position. The *engage* position is the lowest point for the bowing jack where the *bowing wheel* is barely, or not quite, touching the string. In order to make a fuller / louder sound the *bowing jack* will have to be raised further by either sending the *pressure baseline* or the *pressure modifier commands*. By default, the MIDI *modulation wheel* controller (CC #1) is mapped to the *pressure baseline command* and MIDI *channel aftertouch* is

[1]) issues a *BowControlHarmonic* command
[2])Issues a *BowControlHarmonicShift5* command
[3]) Issues a *BowPressureBaseline* command
[4]) Issues a *MuteSetPosition* command
[5]) Issues a *SolenoidEngage* command
[6]) Issues a *BowMotorRun* and *BowPressureEngage* command

mapped to the *pressure modifier command*. If your controller has neither a modulation wheel nor aftertouch you will have to map a knob, slider or similar to send the *pressure modifier* or *pressure baseline commands* using the *configuration software*.



When a key is depressed that is outside the range of what the instrument can play (higher or lower frequency than the bowing motor is physically able to produce or control reliably) the instrument will do one of the following things; a) set it to the closest possible frequency b) attempt the frequency and fail, this will result in the bowing motor either stopping or going into oscillation c) refuse to do anything

Getting tuned up

Getting the tuning right is fundamental to get the string to sound the way you want at the various overtones, an out of tune instrument will sound dull, create a "beating" sound or not resonate at all. Since the instrument relies on the tuning information stored in it, this means that if the tuning of the actual string deviate by as little as a tenth of a Hertz the bowing motor speed given will not correspond to the resonant points on the string.

A couple of things should be realized before we get started; this being an acoustic instrument we're talking about physical strings fastened to physical objects and all of these things will shift due to things like temperature, humidity etc. To make matters worse, a string heats up a lot during initial playing and will thus expand. My recommendation when preparing to use the instrument is to turn it on ~10 minutes before "serious" use, play the instrument as intended for a while and tune the instrument. After 10 minutes or so, adjust the tuning again as required - it should now be good for a while.

The first order of business is getting the tuning within +/- 50 cents of the desired note by adjusting the *tuning peg* using a piano tuning hammer. The tuning could be monitored by ear, using an audio reference or with the help of the automatic tuner in the *configuration software*. Make sure to NOT try and force the tuning peg down too low, around 6mm / 1/4" of the threads on the tuning peg should be visible at the lowest point. Trying to turn the peg further into the tuning block than this could end up cracking the block, rendering the instrument unplayable.

Tuning using the control box

Once the string has gotten close enough we need to use the bowing wheel to get it perfect. Start by turning the *harm. shift modulation* knob to zero, putting the *harmonic shift* knob in the middle position and the *harmonic* knob at the zero position - this will set the motor to emphasize the fundamental. Make sure all the other knobs are turned all the way to zero and flip the *gate* switch to *on* - this will start the motor. Slowly turn up the *pressure baseline* knob until the *bowing wheel* rubs against the string with a steady speed, since the string isn't yet properly tuned it may not resonate. Be careful to not add too much pressure, the bowing speed being uneven is often a good indicator that the motor isn't able to keep up and may be overloaded due to the *bowing wheel* being pressed too hard into the string.

Use the *fine tuner* on the Ekdahl FAR (located right below the *tuning peg*) to get the instrument to start resonating, depending on the string it may be difficult to turn the knob by hand in which case you can use a hex key. It should be abundantly clear when the tuning is right as the instrument will go from making a fairly quite "scraping" sound to much louder full resonance.

The string will resonate at the fundamental even if the string tuning is off by a few cents so the next step is to make sure that the 12th *harmonic number* (one octave up) is also resonating by turning the *harmonic* knob up and verifying the string tuning. Watch out for any beating, adjust if necessary. The final tuning is usually done by checking that the 7th *harmonic number* also sounds correct.

One can keep going and check the more "difficult" *harmonic numbers* in order to tune the string even better, but whether these overtones are present or not depends on your string choice, string dampening, *bowing wheel* etc. There is a definite possibility of trying to approach certain "impossible" overtones and thus detuning the entire instrument to the point of having to start over. As a rule of thumb, the closer the *harmonic number* is to the fundamental or its octaves, the more difficult it is to make that overtone resonate - the 1st, 2nd, and 11th *harmonic numbers* are rarely present or they are too close to the fundamental meaning that the fundamental will "swell in" and take over.

Tuning using MIDI

When using MIDI to tune and play the instrument, if the control box is connected its parameters may override any MIDI messages sent. Hence before continuing, all controls should be zeroed except the *harmonic shift* knob which should be set to its middle position.

First thing that needs to be done is to locate the key which corresponds to the fundamental tuning of the string and add enough pressure that the *bowing wheel* is firmly rubbing against the string. Refer to the "MIDI Setup" if you have difficulties with this. The next steps are the same as in the previous paragraph.

Tuning on the fly

Sometimes retuning can be quite cumbersome, in for example a live setting you may not be able to just stop everything you're doing to retune the string. One can temporarily "correct" small deviations by adding a small *harmonic shift* by for instance using the control box or a mapped MIDI controller. Please realize that this means that the string is still out of tune and you actually just made the electronics do it wrong too to compensate so it may sound funny with other instruments and some harmonic numbers ratios may get whacky - sometimes funny and whacky is good tho.

Hard and soft limits, the range of possibilities and need for calibration

Before getting into the weeds of how to change strings and bowing wheels, you should know about the concept of hard and soft limits. Within automated machining, a hard limit is simply a point beyond which a machine will not function - an example of a hard limit in the Ekdahl FAR is for instance the maximum speed of the *bowing wheel*; at a certain point the motor simply cannot go any faster. A soft limit is a point before the hard limit where the machine in question **technically** could go further, but beyond which it may not be reliable, could potentially run into trouble due to external circumstances, or simply won't provide any benefits. An example of a soft limit in the Ekdahl FAR is the *maximum pressure* of the *bowing jack*; at some point the *bowing wheel* can be pressed so hard into the string that the motor simply won't have the power to keep up, this could result in the motor not emphasizing the correct overtones, the string distorting - or worst case, the motor overheating and being destroyed[7] - a soft limit is placed before this point so that you won't run into these problems. All soft limits can be set by the user, but care has to be taken with limits that are there to protect the Ekdahl FAR. Other limits that are simply there to enhance the usability of the instrument can sometimes be tweaked to allow for "unmusical" behavior, which sometimes creates the most interesting sounds. The Ekdahl FAR offers ways of automatically calibrating some of these features, certain other features will have to be manually set. Currently there are hard and soft limits for the *pressure position*, *mute position* and the *hammer force*.

Pressure limits

The bow pressure has three preset positions associated with it; *bow pressure position rest*, *bow pressure position engage* and the *bow pressure position max*. The *bow pressure position rest* is the lower soft limit and *bow pressure position max* is the upper soft limit. All of these presets can be changed by the user and saved into the instrument.

The *bow pressure position rest* is where the *bowing wheel* is completely disconnected from the string, thus starting the *bowing motor* in this position will not cause any contact-vibrations in the string (though the string could still start to resonate due to air turbulence created by the *bowing wheel*). The Ekdahl FAR will normally stay at the *rest* position when no key is pressed. Having the *rest* position correctly set is cruical in getting the most rapid action from the Ekdahl FAR, a rest position that is too far from the string will cause a noticable latency from keypress to wheel contact when playing, a position that is too close may still touch the string when the *bowing*

[7] In theory this should not happen due to over-power protection in The Ekdahl FAR but why take the chance

motor is winding down, creating an audible sound.

The *bow pressure position engage* is the point where the *bowing wheel* first makes contact with the string, this position is basically where the *bowing wheel* will normally go at a keypress when all pressure modifications (aftertouch, *pressure* knob etc.) are set to zero. This position may or may not produce any audible sound as it should barely touch the string at this point.

Bow pressure position max represents the maximum soft limit, any added pressure modifications at this point will be ignored as further pressure could make the *bowing motor* be unable to keep its speed or make it go over its power limit (which will cause the motor to immediately shut down).

The pressures hard limits can be set by loosening the two screws holding the *pressure motor* and sliding the carriage back and forth. This adjustement should rarely have to be performed as it should be pre-set, but if you change the height of the bridges, change into a string of a different thickness or a differently sized *bowing wheel* you may have to. The position of the carriage should be set so that when the *bowing jack* is at its lowest mechanical point, the *bowing wheel* is roughly 1mm away from the string. The easiest way to set the *bowing jack* to its lowest mechanical point is to use the *configuration software* and click the "Reset pressure rest and go to rest position"-button in the "Basic bow parameters". This will set the *bow pressure rest position* to zero and tell the *bowing jack* to go to the *pressure rest position*. If the shield is taken off of the Ekdahl FAR you can instead, while the unit is off, rotate the *corkscrew* that controls the position of the *bowing jack* to its minium position.

Mute limits

The mute also has three preset positions associated with it; *mute rest position* (lower soft limit), *mute full mute position* (upper soft limit) and *mute half mute position*. By reading the previous paragraph the *mute rest position* and *mute full mute position* should hopefully be quite obvious, the *mute half mute position* is an auxilary position that can be set to do things like supressing the fundamental, do a pinch harmonic or anything else your heart desires.

Just like with the pressure, the mute has two screws for adjusting the *mute motor*, however the mute also has an *uppper mute* that should first be set to rest roughly 1mm above the string. Reset the mute position mechanically or use the *configuration software* and press the "Reset rest position and go to rest position"-button in "Hammer parameters". Slide the *mute motor carriage* to where the *lower mute* rests about 1mm below the string.

Hammer force limits

The hammer force limits are a little different than the previous limits discussed, furthermore the commands associated with the hammer are prefixed by the word *solenoid* as this is the device that actually causes the hammer action. The *solenoid min force* and *solenoid max force* parameters here are simply a convenience that makes it easier to control the instrument. A solenoid force of zero always means "no hammer action", *solenoid min force* is the **lowest amount of force necessary for the hammer to hit the string** and *solenoid max force* is the maximum force usable. The reason to set the minimum force is because without it, if mapped to for instance velocity of a keyboard, there will be a lot of "dead" values on the lower end where the hammer isn't reaching the string or even triggering the solenoid at all. The maximum amount is used because there can be an upper range where the increase of power to the solenoid simply doesn't audibly change the hammer hit, meaning the upper range would all sound the same. Another use of the upper range can be to limit the force due to the fact that certain strings, mostly thinner ones, will distort or just sound bad when hit too hard.

Automatic calibration

The *bowing motor speed*, *bowing pressure* and *mute* all offer automatic calibration. As machines are not infallable and programmers certainly are not (meaning me as of this writing), the automatic calibrations may sometimes not do a great job and may have to be run two or more times in order to properly assess what's going on. Furthermore **you have to do the calibrations in the proper order or it will not work**.

The first calibration that should be done is the *bowing motor speed calibration* this measures the minimum and maximum speed of the motor. This is done at assembly and should in theory only have to be done again if you change the *bow motor voltage* or for some reason replace the motor. If you are using a *bowing wheel* that puts an abnormal strain on the *bowing motor* you may also have to do this.

The second calibration is the *bow pressure calibration* and this should be done any time you change the string, *bowing wheel* or change the physical position of the *pressure motor*. This calibration tries to gage the min and max pressure that should be used and will set the rest position to a preset value below the min position. This calibration uses the min and max position of the motor for its testing.

The third cailbration is the *mute calibration*, this needs to be performed when the position of the *mute motor* has changed, a string with a different thickness has been put on the instrument, or the bridge heights have changed. The mute calibration works by playing the fundamental of the instrument and digitally analyzing the sound of the pickup while moving the mute into different positions. Therefore the instrument must have gone through the *pressure calibration* and it should be reasonably in tune, if this is not the case you will most likely get garbage values.

Changing the string

To change the string of the Ekdahl FAR you need to first loosen the old string by turning the *tuning peg* counter-clockwise using a tuning hammer. When all the windings of the string against the *tuning peg* have been unwound, unscrew the *string retainer screw* and remove the string. Take note of the amount of turns that the string has on the peg and try to replicate this when putting the new string on. If the old string has a *string holding lug*, remove it and keep it for future use.

When preparing to put on the new string you need to take note of the end type of the string. Certain types of strings, like cello, piano and viola have a loop end and the *string retainer screw* can simply be put through the loop to hold the string. Other types like guitar and bass strings have a ball-end and needs to use a *string holding lug* in order to be held in place. For ease of replacement, the *string holding lug* is simply whats known as a ring terminal, these can be bought pretty much anywhere and come in different sizes, a differently thick string may need a smaller or larger ring terminal depending.

Screw down the *string retainer screw* down to where the *string holding lug* is close to the tail stock but not squashed against it, when the string is resting against the bridge the angle of the string should be roughly 45 degrees vs the tail stock. If you are experiencing rattling or other unpleasanties in the sound, this may be a caused by improper fastening of the string.

Changing the bowing wheel

Chasad