Pass Laboratories

Xono Owner's Manual

Rev. 2.0 - 03/12/2002

Introduction:

The Xono is a high performance phono preamplifier for use with moving magnet and moving coil cartridges. It features extremely low noise and distortion, very high adjustable gain, very high output swing, variable cartridge loading, and balanced output.

The Xono uses three stages of circuitry. An ultra-low noise non-inverting pre-preamplifier circuit is used to boost the low output of moving coil (MC) cartridges by a selectable 16, 20, 26 or 30 dB without equalization. This drives the primary non-inverting gain stage, which also amplifies the high output of moving magnet (MM) cartridges, and provides RIAA equalization. Gain for moving magnet cartridges is a fixed 40dB and may not be adjusted. Output of the primary gain stage is also applied to an inverting unity gain stage to provide the negative polarity for the balanced output.

The main gain stage uses low noise matched JFETs for the input circuit and power MOSFETs elsewhere in the gain path. Voltage gain devices are operated cascode mode, and the single-ended circuitry is biased by constant current sources.

The main gain stage uses a combination of active and passive equalization to achieve the RIAA characteristic. The active equalization works in the mid-band of the audio range and the passive equalization determines the characteristic and the highest and lowest frequencies. This stage has a fixed gain value of 40 dB at 1 KHz single-ended and 46 dB balanced.

The pre-preamplifier circuit uses four matched ultra-low noise JFETs operated in parallel to provide an input random noise floor less than 500 picovolts (-186 dBV). The cascoded output of these JFETs drives another JFET to deliver a selectable 16, 20, 26 or 30 dB of un-equalized non-inverting gain. There is no feedback employed.

Cartridge loading of the Xono is very fexible. Moving Magnet cartridges can be loaded with capacitance from 0 to 650 pF in increments of about 100 pF. There is provision for two load positions for any additional value that the user may choose to insert. Moving Coil cartridge loading ranges from 5 to 1000 ohms to 47 Kohms using eight switches with binary weighting and providing 256 different values. The moving magnet loading default is 47K ohms.

The balanced and unbalanced output connections of the preamplifier have an output impedance of 300 ohms, which will drive a 1000 pF cable load flat to about 1 megahertz.

The Xono has a very accurate RIAA equalization characteristic, varying plus or minus 1/10 of a decibel from 20 to 20 KHz. This accuracy does not vary with gain or loading.

The preamplifier has extremely low noise. The Moving Magnet noise floor at more than -100 dB below a 10 millivolt input, which gives it an unweighted total noise of -90 dB. The Moving Coil noise floor is better than -90 dB referenced to 1 millivolt input, giving a -81 dB unweighted audio band noise figure.

The Xono is adjustable to very high gain, 76 dB @ 1 KHz, which makes it capable of delivering .5 V line level output for cartridges with 80 microvolts output. This appears to be the best figure in the audio industry.

The preamplifier has very low distortion and very high output. Maximum harmonic distortion is less than .05% (1 KHz) at outputs of 20 volts RMS. or less. This figure holds for MM operation and highest gain MC.

The power supply for the Xono is contained in a separate chassis and consists of an oversized, shielded toroidal power transformer delivering an unregulated 85 volts peak to peak DC through separate rectifiers and capacitors for each channel which is then passively RC filtered before being sent to the main Xono chassis. A custom manufactured shielded cable carries the DC power from the supply to the main Xono chassis. The main chassis of the Xono has separate stages of active regulation for each channel followed by passive filtering and then feeding the constant current sources which bias the various gain stages. There is a total of 120, 000 mfd of filter capacitance and five stages of filtering and regulation.

The Xono is based on the design pioneered in the Aleph Ono. The basic Ono design has not changed but been extended and refined. The separate power supply combined with the additional filtering and dual mono power supply design contribute to the lower noise floor and sonic improvements. The main circuit board layout has been completely revised to reduce noise, shorten the signal path and reduce the length of connecting wires. Sonically critical parts have been optimized and upgraded through continued extensive listening tests.

The Xono like the ono design was based on listening and not measurements. Considering this, it is perhaps remarkable that the final product displays such spectacular objective qualities. However, we view the specifications as a secondary source of pride in this product.

The measurements only hint at the listening experience with the Xono. The sound is lush and smooth, with a wide sound stage, fine detail and spectacular layering, and a nice firm bottom. The preamplifier will allow you to renew your acquaintance with your vinyl collection and appreciate the essential character of the finest analog recordings.

Wayne Colburn

Vice President, Design

Setup

The Xono consists of two chassis; powersupply and preamplifier, linked by a power umbilical.

The preamplifier has two sets of input connections, and two sets of output connections, and power conection through a DB-25, D-Sub connector.

The powersupply chassis has an AC line power connection, fuseholder and two Sub-D connectors. The amplifier's voltage and current rating are indicated on the rear. It will be either 240 volts, 220 volts 120 volts, or 100 volts. A 0.5 amp 3AG slow blow fuse is provided with 100-120 volt units, and a 0.25 amp slow blow fuse is provided with 220-240 volt units. The frequency rating of the power supply is 50 to 60 Hz. The preamplifier typically draws 20 watts during operation. The powersupply has twin DB-25 connectors that povide power and control functions to the preamplifier. **This cable must be installed before the unit is powered up.**

The shielded DB-25 cable may be installed into either outlet, but we suggest the outemost (right side, viewed from the rear) as it was optimised specifically for the Xono. These cables are designed to be a snug fit, but must never be forced.

We have provided a standard AC power cord which fits into the IEC line receptacle at the rear of the powersupply. The preamplifier is equipped for operation with an earth ground provided by the AC outlet. Do not defeat this ground. The chassis and circuit ground of the preamplifier is connected to earth through a power thermistor, which gives a ground connection but helps avoid ground loops.

The preamplifier has two sets of input connections on the rear, which are pairs of RCA connectors with right and left channels indicated. If your signal source is a low output moving coil cartridge, you will use the moving coil input. If your signal source is a high output moving magnet cartridge, you will use the moving magnet input. A ground post is provided for grounding the turntable.

The two sets of output connections on the rear are a pair of RCA connectors with right and left channels indicated. These connections provide a single ended output of the preamplifier. A pair of XLR connectors provides a balanced output connection. On these connectors, pin 1 is grounded, pin 2 is the positive signal output, and pin 3 is the negative signal output.

The output signal of the balanced connector is twice the level of the unbalanced circuitry, by the virtue of having the same amplitude signal plus its inverse.

The output impedance of the single ended output connection is 300 ohms. The output impedance of the balanced output connection is 300/300 ohms. This value is low enough to drive ten thousand picoFarads (10000 pF) of cable capacitance flat to 100 KHz.

Selection of input, adjustments for gain and cartridge loading are accomplished via switches on the interior of the Xono.

To change these settings, it is necessary to take the top off the preamp using a 5/32 hex wrench, which we supply.

It is very important that you always disconnect the AC line power before opening the preamp.

If you do not feel capable of safely adjusting the settings internally, please contact your dealer or the factory.

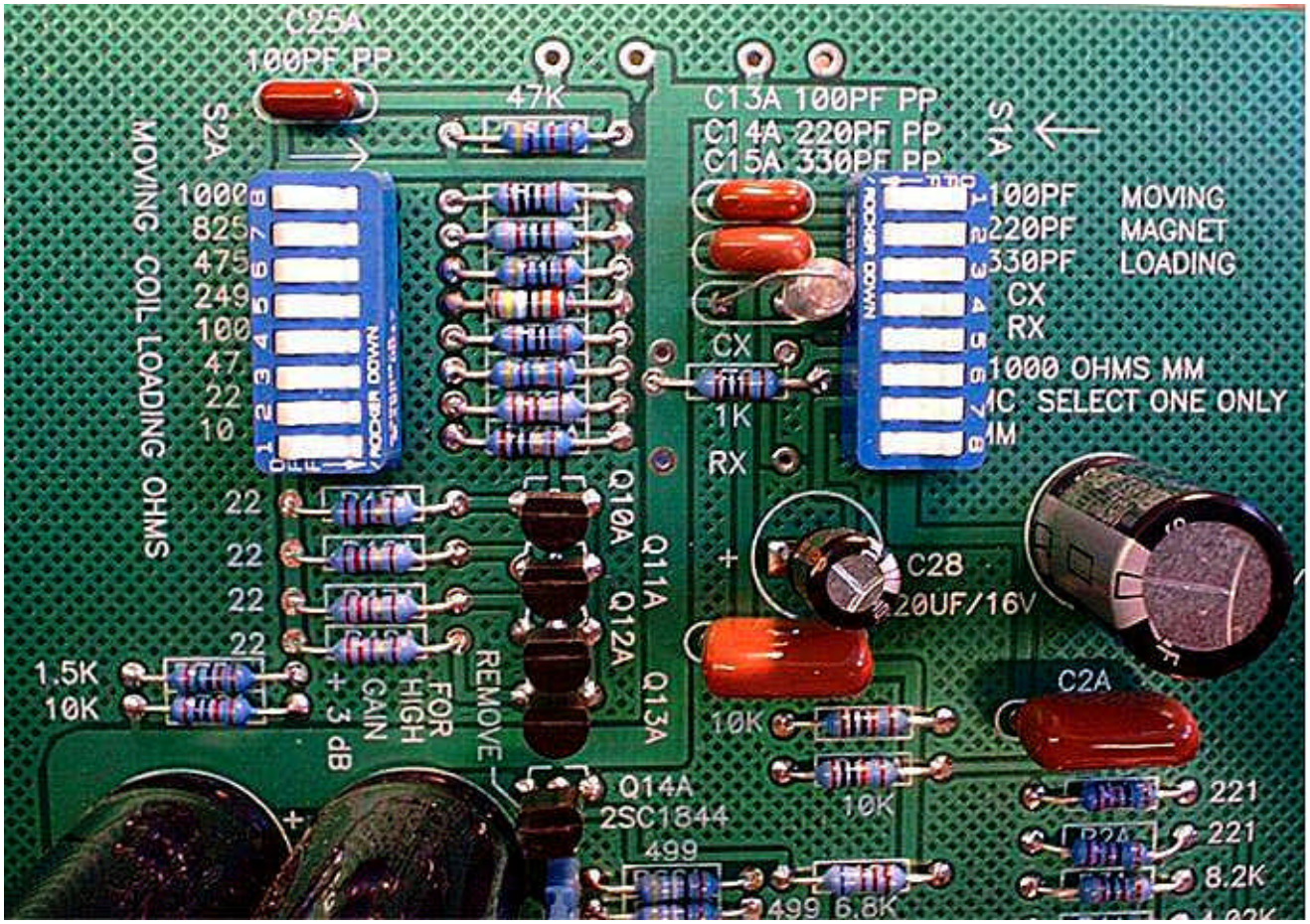
On the main board you will see a set of DIP switches which are used to alter the input connections.

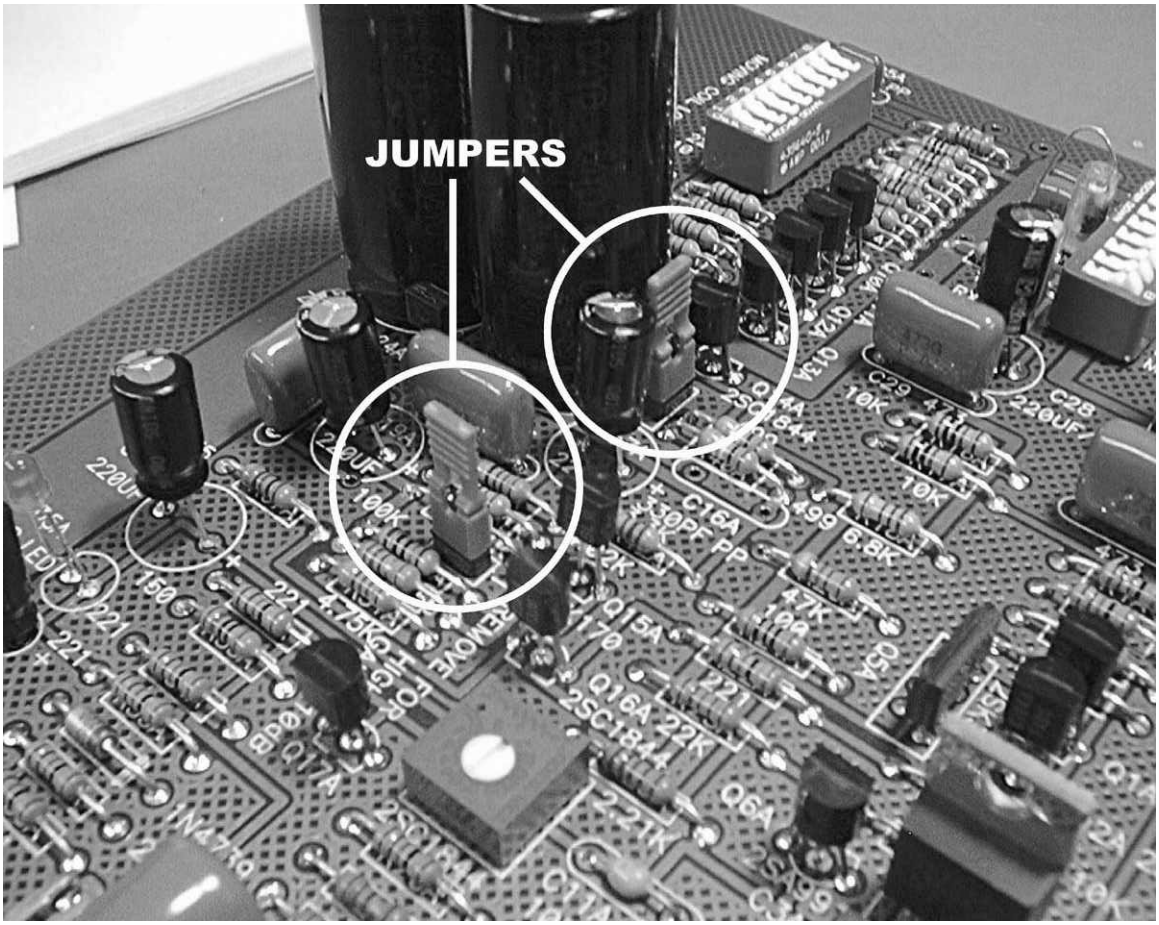
Two switches, S1 and S1A, are used to select moving coil and moving magnet inputs. Positions 7 and 8 are labeled MC and MM. Select one only by depressing the switch toward the silk screened label, which is the ON position of the switch.

On these same switches, positions 1 through 3 are used to select the capacitive loading of the moving magnet cartridge input. You may select 100 pF, 220 pF, and 330 pF, or any combination of these values, which are additive, for a maximum of 650 pF, or no capacitance by simply leaving the switches in the off position. Two additional blank positions 4/CX and 5/RX are available for you to solder your own loading values onto the main board. Position 6 allows 1000 ohm loading of the moving magnet stage for use with some cartridges.

Switches S2 and S2A are used to adjust the resistive loading of the inputs for low output moving coil cartridges. Switch positions 1 through 8 will load the input from 10 ohms up to 1000 ohms in roughly binary steps. The switches and resistors are in parallel, so placing more than one switch in the "on" position loads the cartridge with the two resistor values in parallel. Placing all resistors "on" will give approximately 5 ohms loading.

The preamplifier is shipped with the moving coil stage enabled, with the higher gain setting (69 dB single ended, 75 dB balanced) and a 100 ohm input load. To obtain 4 dB lower gain, locate the jumper connectors for each channel next to the two large capacitors. Please study the annotated photograph before you attempt this. As an added reference, they are midway between the two loading switches, but several inches nearer the front. With the jumpers in place, the


C25A
100PF PP
47K
C13A 100PF PP
C14A 220PF PP
C15A 330PF PP
S1A
S2A
MOVING COIL LOADING OHMS
1000
825
475
249
100
47
22
10
100PF
220PF
330PF
CX
RX
MOVING
MAGNET
LOADING
1000 OHMS MM
SELECT ONE ONLY
1M
CX
1K
RX
Q10A
Q11A
Q12A
Q13A
C28
220UF/16V
22
22
22
22
1.5K
10K
FOR HIGH GAIN
+3 dB
REMOVE
10K
C2A
Q14A
2SC1844
499
10K
221
221
8.2K
499
6.8K


JUMPERS

moving coil gain is the lower value. There is a second set of jumpers on the board for additional gain adjustment of the MC stage. These are to the right of the first set of jumpers. Installing these decreases the gain 10dB. Either or both sets can be used together for -4, -10, or -14dB from max. The board is marked on the silk screen. For clarification please see the enclosed photograph, which will indicate the location of the jumpers. Only one channel is shown the other however is identical in layout.

I will try to give you a sense of how one might go about optimizing the performance of a particular cartridge.

Please understand, the loading of a moving coil cartridge is a very inexact science, specific recommendations should be taken (and offered) very lightly. I encourage you to think separately from the cartridge manufacture and choose your loading resistive values accordingly. The cartridge manufacture may have anticipated a transformer being used for the initial stage of gain, the Xono with its active elements is a very different proposition. As an added complexity some tonearms use special high resistance wiring which must be accounted for in this loading.

An improperly loaded cartridge will suffer every sonic anomaly ranging from lack of definition and bass to a very strident and screechy high end. Cartridge loading is a compromise between what works best for the cartridge and what sounds best for the listener. Specifically we are looking for that compromise loading which sounds best across the whole audio spectrum.

I suggest that you start with the following:

Always turn the volume on your preamp to a minimal setting and your power amps off before making any adjustments to the Xono. Changes made to the Xono can send loud pulses through the signal chain and cause damage to your speakers.

Once the volume is reduced and the power amps turned off, remove the top cover of the ono and set the loading to 100 ohms. Replace the cover and give the Ono two or three minutes to settle electronically, and turn the power amps back on. Listen to the system for a period of time (10 minutes to an hour) using various musical selections.

Now, turn the volume down and the power amps off again. Remove the cover and set the loading switches to the next lowest resistive position. Replace the cover and once again give the unit a few minutes to stabilize, then listen again to the same musical selection. If the selections sound better with the new loading you can be assured that the loading change was in the right (lower in this example) direction.

If the change resulted in a more pleasant presentation of the musical selections, once again turn down the volume and the amps off. Select the next lowest loading and listen to the same selection again. If the sonics improve repeat the selection to the next lowest value. Once you find the value where the sound deteriorates, move back to the last value that sounded excellent. Once this is done, you have reached the correct loading.

If going below 100 ohms did not improve the sound, then obviously the correct change would have been to go to the highest level above 100 ohms and repeat the listening. I am sure you get the idea, it's not complicated but it can be time consuming.

Again, I would like to stress that you are listening for a musical balance in the selections that you play. Some loading selections will offer better bass, but poor high end resolution. Some will offer better high end and definition. You are seeking the one that has the best top to bottom balance in conjunction with correct spatial information.

Please note that the Xono operates best with the top cover on and screwed down. This helps keep the unit thermally stable and the noise down.

Likewise the moving magnet settings are very much a set to taste situation. When analyzing capacitive loading you must assume that the cables from cartridge headshell to preamp input have some level of capacitance. Some cables may have but little, others a significant amount; those with significant amounts will require that you reduce your chosen settings in the Xono accordingly.

When you are done adjusting the input gain and loading, replace and tighten the cover before reconnecting the AC line power.

Product Philosophy and Design

For a long time there has been faith in the technical community that eventually some objective analysis would reconcile critical listener's subjective experience with laboratory measurement. Perhaps this will occur, but in the meantime, audiophiles largely reject bench specifications as an indicator of audio quality. This is appropriate. Appreciation of audio is a completely subjective human experience. We should not more let numbers define audio quality than we would let chemical analysis be the arbiter of fine wines. Measurements can provide a measure of insight, but are no substitute for human judgment.

As in art, classic audio components are the results of

individual efforts and reflect a coherent underlying philosophy. They make a subjective and an objective statement of quality which is meant to be appreciated. It is essential that the circuitry of an audio component reflects a philosophy which addresses the subjective nature of its performance first and foremost.

Lacking an ability to completely characterize performance in an objective manner, we should take a step back from the resulting waveform and take into account the process by which it has been achieved. The history of what has been done to the music is important and must be considered a part of the result. Everything that has been done to the signal is embedded in it, however subtly.

Experience correlating what sounds good to knowledge of component design yields some general guidelines as to what will sound good and what will not:

1) Simplicity and a minimum number of components is a key element, and is well reflected in the quality of tube designs. The fewer pieces in series with the signal path, the better. This is often true even if adding just one more gain stage will improve the measured specs.

2) The characteristic of gain devices and their specific use is important. Individual variations in performance between like devices is important, as are differences in topological usage. All signal bearing devices contribute to the degradation, but there are some different characteristics that are worth attention. Low order nonlinearities are largely additive in quality, bringing false warmth and coloration, while abrupt high order nonlinearities add harshness.

3) Maximum intrinsic linearity is desired. This is the performance of the gain stages before feedback is applied. Experience suggests that feedback is a subtractive process; it removes information from the signal. In many older designs, poor intrinsic linearity has been corrected out by large application of feedback, resulting in loss of warmth, space, and detail.

A very important consideration in attempting to create an amplifier with a natural characteristic is the selection of the gain devices. A single ended Class A topology is appropriate, and we want a characteristic where the positive amplitude is very, very slightly greater than the negative. For a current gain device, that would mean gain that smoothly increases with current, and for a tube or field effect device a transconductance that smoothly increases with current.

Triodes, JFETs, and Mosfets share a useful characteristic: their transconductance tends to increase with current. Bipolar power devices have a slight gain increase until they hit about an amp or so, and then they decline at higher currents. In general the use of bipolar in a single ended Class A circuit is a poor fit.

Another performance advantage shared by Tubes and Fets is the high performance they deliver in simple Class A circuits. Bipolar designs on the market have between four and seven gain stages associated with the signal path, but with tubes and Mosfets good objective specifications are achievable with as few as one gain device in the signal path.

Regardless of the type of gain device, in systems where the utmost in natural reproduction is the goal, simple single ended Class A circuits are the topologies of choice.

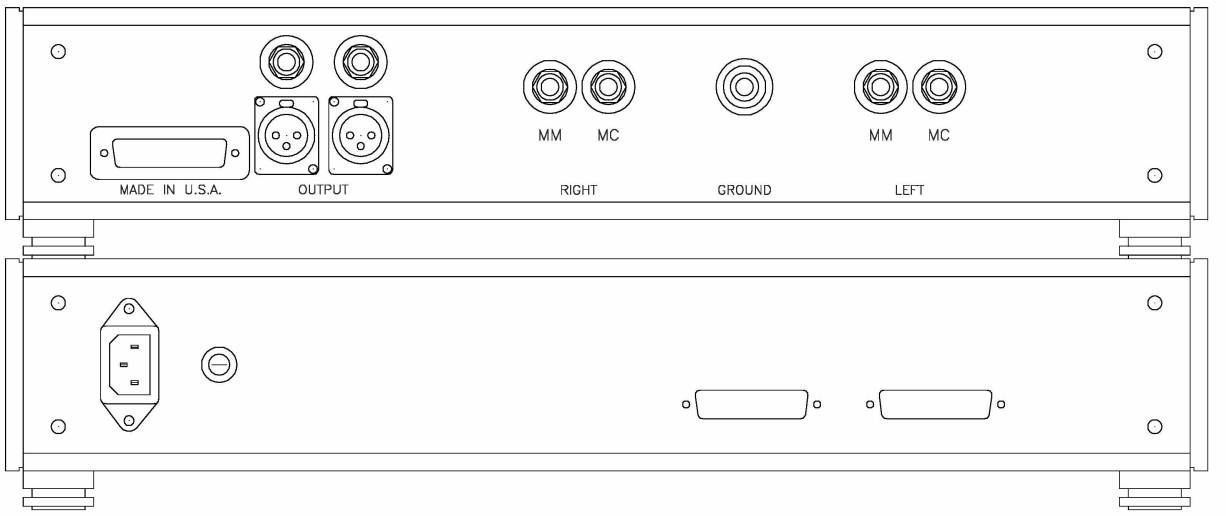
The gain devices in the Xono were all selected for top performance in each part of the circuits. A quad of ultra low noise matched JFETS form the input stage, followed by power Mosfets for output devices.

Resistors are all precision RN55D or better. Film capacitors are used for all values below 10 uF, and bypassed low impedance/high bandwidth electrolytics are used for greater values.

The external power supply for the Xono consists of an oversized, shielded, toroidal power transformer delivering an unregulated 85 volts peak to peak DC through separate rectifiers and capacitors for each channel which is then passively RC filtered before being sent to the main Xono chassis. A custom manufactured shielded cable carries the DC power from the supply to the main Xono chassis. The main chassis of the Xono has separate stages of active regulation for each channel followed by passive filtering and then feeding the constant current sources which bias the various gain stages. There is a total of 120,000 mfd of filter capacitance and five stages of filtering and regulation. The power supply noise reaching the circuit is on the order of a microvolt, and is differentially rejected at the output in a balanced system. There are a total of 22 high performance power electrolytics with an aggregate capacitance in excess of 120,000 mfd used to accomplished energy storage and passive filtering of the power supply.

The chassis of the Xono is made entirely of machined aluminum. The top cover is made from aluminum. The face plate too is milled from thick aluminum stock.

The Xono was designed by Wayne Colburn.



Warranty

The Xono is warranted by Pass Laboratories to meet performance specifications for 3 years from date of manufacture. During that time, Pass Laboratories will provide free labor and parts at the manufacturing site. The warranty does not include damage due to misuse or abuse or modified products and also does not include consequential damage.

XONO Specifications

Gain	40 dB @ 1 KHz (MM) fixed output 71 dB @ 1 KHz (MC) max, single ended 76 dB @ 1 KHz (MC)max, balanced
RIAA response	plus/minus .1 dB 20-20 KHz
Distortion	< .05 % THD @ 20 volts bal @ 1KHz
Maximum Output	20 volts rms.
Output Impedance	300/300 ohms
Input Impedance	47 K or 1K / 0-650 pF (MM) 5 ohm - 47 Kohm moving coil
Unweighted Noise	-90 dB ref. 10 mV input moving magnet -81 dB ref. 1 mV input moving coil
Power consumption	20 watts
Dimensions main chassis	17 " W x 11.5 " D x 3.5 " H
Weight	46 lbs.

PASS

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	switch	switch	switch	switch	switch	switch	switch	switch	
	pos 1	pos 2	pos 3	pos 4	pos 5	pos 6	pos 7	pos 8	
	10 ohm	22 ohm	47 ohm	100 ohm	249 ohm	475 ohm	825 ohm	1K ohm	
Cartridge									Cartridge
Loading									Loading
Ohm's									Ohm's
5.4	ON	ON	ON	ON	ON	ON	ON	ON	5.4
5.43	ON	ON	ON	ON	ON	ON	ON	OFF	5.43
5.44	ON	ON	ON	ON	ON	ON	OFF	ON	5.44
5.47	ON	ON	ON	ON	ON	OFF	ON	ON	5.47
5.47	ON	ON	ON	ON	ON	ON	OFF	OFF	5.47
5.5	ON	ON	ON	ON	ON	OFF	ON	OFF	5.5
5.5	ON	ON	ON	ON	ON	OFF	OFF	ON	5.5
5.52	ON	ON	ON	ON	OFF	ON	ON	ON	5.52
5.53	ON	ON	ON	ON	ON	OFF	OFF	OFF	5.53
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5.56	ON	ON	ON	ON	OFF	ON	OFF	ON	5.56
5.59	ON	ON	ON	ON	OFF	OFF	ON	ON	5.59
5.59	ON	ON	ON	ON	OFF	ON	OFF	OFF	5.59
5.62	ON	ON	ON	ON	OFF	OFF	ON	OFF	5.62
5.63	ON	ON	ON	ON	OFF	OFF	OFF	ON	5.63
5.66	ON	ON	ON	ON	OFF	OFF	OFF	OFF	5.66
5.71	ON	ON	ON	OFF	ON	ON	ON	ON	5.71
5.74	ON	ON	ON	OFF	ON	ON	ON	OFF	5.74
5.75	ON	ON	ON	OFF	ON	ON	OFF	ON	5.75
5.78	ON	ON	ON	OFF	ON	OFF	ON	ON	5.78
5.79	ON	ON	ON	OFF	ON	ON	OFF	OFF	5.79
5.82	ON	ON	ON	OFF	ON	OFF	ON	OFF	5.82
5.82	ON	ON	ON	OFF	ON	OFF	OFF	ON	5.82
5.85	ON	ON	ON	OFF	OFF	ON	ON	ON	5.85
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5.95	ON	ON	ON	OFF	OFF	OFF	ON	OFF	5.95
5.96	ON	ON	ON	OFF	OFF	OFF	OFF	ON	5.96
6	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	6
6.11	ON	ON	OFF	ON	ON	ON	ON	ON	6.11
6.14	ON	ON	OFF	ON	ON	ON	ON	OFF	6.14
6.15	ON	ON	OFF	ON	ON	ON	OFF	ON	6.15
6.18	ON	ON	OFF	ON	ON	OFF	ON	ON	6.18
6.19	ON	ON	OFF	ON	ON	ON	OFF	OFF	6.19
6.22	ON	ON	OFF	ON	ON	OFF	ON	OFF	6.22
6.34	ON	ON	OFF	ON	OFF	OFF	ON	ON	6.34
6.35	ON	ON	OFF	ON	OFF	ON	OFF	OFF	6.35
6.38	ON	ON	OFF	ON	OFF	OFF	ON	OFF	6.38
6.39	ON	ON	OFF	ON	OFF	OFF	OFF	ON	6.39
6.43	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	6.43
6.5	ON	ON	OFF	OFF	ON	ON	ON	ON	6.5

	switch	switch	switch	switch	switch	switch	switch	switch	
	pos 1	pos 2	pos 3	pos 4	pos 5	pos 6	pos 7	pos 8	
	10 ohm	22 ohm	47 ohm	100 ohm	249 ohm	475 ohm	825 ohm	1K ohm	
Cartridge									Cartridge
Loading									Loading
Ohm's									Ohm's
6.55	ON	ON	OFF	OFF	ON	ON	ON	OFF	6.55
6.55	ON	ON	OFF	OFF	ON	ON	OFF	ON	6.55
6.59	ON	ON	OFF	OFF	ON	OFF	ON	ON	6.59
6.6	ON	ON	OFF	OFF	ON	ON	OFF	OFF	6.6
6.64	ON	ON	OFF	OFF	ON	OFF	ON	OFF	6.64
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6.68	ON	ON	OFF	OFF	OFF	ON	ON	ON	6.68
6.69	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	6.69
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6.73	ON	ON	OFF	OFF	OFF	ON	OFF	ON	6.73
6.77	ON	ON	OFF	OFF	OFF	OFF	ON	ON	6.77
6.78	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	6.78
6.82	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	6.82
6.83	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	6.83
6.88	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	6.88
7.16	ON	OFF	ON	ON	ON	ON	ON	ON	7.16
7.21	ON	OFF	ON	ON	ON	ON	ON	OFF	7.21
7.23	ON	OFF	ON	ON	ON	ON	OFF	ON	7.23
7.27	ON	OFF	ON	ON	ON	OFF	ON	ON	7.27
7.28	ON	OFF	ON	ON	ON	ON	OFF	OFF	7.28
7.33	ON	OFF	ON	ON	ON	OFF	ON	OFF	7.33
7.34	ON	OFF	ON	ON	ON	OFF	OFF	ON	7.34
7.37	ON	OFF	ON	ON	OFF	ON	ON	ON	7.37
7.39	ON	OFF	ON	ON	ON	OFF	OFF	OFF	7.39
7.43	ON	OFF	ON	ON	OFF	ON	ON	OFF	7.43
7.44	ON	OFF	ON	ON	OFF	ON	OFF	ON	7.44
7.49	ON	OFF	ON	ON	OFF	OFF	ON	ON	7.49
7.5	ON	OFF	ON	ON	OFF	ON	OFF	OFF	7.5
7.55	ON	OFF	ON	ON	OFF	OFF	ON	OFF	7.55
7.56	ON	OFF	ON	ON	OFF	OFF	OFF	ON	7.56
7.62	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	7.62
7.92	ON	OFF	ON	OFF	ON	OFF	OFF	ON	7.92
7.96	ON	OFF	ON	OFF	OFF	ON	ON	ON	7.96
7.98	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	7.98
8.03	ON	OFF	ON	OFF	OFF	ON	ON	OFF	8.03
8.04	ON	OFF	ON	OFF	OFF	ON	OFF	ON	8.04
8.1	ON	OFF	ON	OFF	OFF	OFF	ON	ON	8.1
8.1	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	8.1
8.16	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	8.16
8.18	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	8.18
8.25	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	8.25
8.45	ON	OFF	OFF	ON	ON	ON	ON	ON	8.45
8.52	ON	OFF	OFF	ON	ON	ON	ON	OFF	8.52
8.54	ON	OFF	OFF	ON	ON	ON	OFF	ON	8.54

	switch	switch	switch	switch	switch	switch	switch	switch	
	pos 1	pos 2	pos 3	pos 4	pos 5	pos 6	pos 7	pos 8	
	10 ohm	22 ohm	47 ohm	100 ohm	249 ohm	475 ohm	825 ohm	1K ohm	
Cartridge									Cartridge
Loading									Loading
Ohm's									Ohm's
8.6	ON	OFF	OFF	ON	ON	OFF	ON	ON	8.6
8.61	ON	OFF	OFF	ON	ON	ON	OFF	OFF	8.61
8.68	ON	OFF	OFF	ON	ON	OFF	ON	OFF	8.68
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8.75	ON	OFF	OFF	ON	OFF	ON	ON	ON	8.75
8.77	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	8.77
8.82	ON	OFF	OFF	ON	OFF	ON	ON	OFF	8.82
8.84	ON	OFF	OFF	ON	OFF	ON	OFF	ON	8.84
8.91	ON	OFF	OFF	ON	OFF	OFF	ON	ON	8.91
8.92	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	8.92
8.99	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	8.99
9.01	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	9.01
9.09	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	9.09
9.23	ON	OFF	OFF	OFF	ON	ON	ON	ON	9.23
9.32	ON	OFF	OFF	OFF	ON	ON	ON	OFF	9.32
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9.41	ON	OFF	OFF	OFF	ON	OFF	ON	ON	9.41
9.42	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	9.42
9.5	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	9.5
9.52	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	9.52
9.59	ON	OFF	OFF	OFF	OFF	ON	ON	ON	9.59
9.61	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	9.61
9.68	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	9.68
9.7	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	9.7
11.76	OFF	ON	ON	ON	ON	ON	ON	ON	11.76
11.9	OFF	ON	ON	ON	ON	ON	ON	OFF	11.9
11.93	OFF	ON	ON	ON	ON	ON	OFF	ON	11.93
12.05	OFF	ON	ON	ON	ON	OFF	ON	ON	12.05
12.07	OFF	ON	ON	ON	ON	ON	OFF	OFF	12.07
12.2	OFF	ON	ON	ON	ON	OFF	ON	OFF	12.2
12.23	OFF	ON	ON	ON	ON	OFF	OFF	ON	12.23
12.34	OFF	ON	ON	ON	OFF	ON	ON	ON	12.34
12.38	OFF	ON	ON	ON	ON	OFF	OFF	OFF	12.38
12.49	OFF	ON	ON	ON	OFF	ON	ON	OFF	12.49
12.53	OFF	ON	ON	ON	OFF	ON	OFF	ON	12.53
12.67	OFF	ON	ON	ON	OFF	OFF	ON	ON	12.67
12.68	OFF	ON	ON	ON	OFF	ON	OFF	OFF	12.68
12.83	OFF	ON	ON	ON	OFF	OFF	ON	OFF	12.83
12.86	OFF	ON	ON	ON	OFF	OFF	OFF	ON	12.86
13.03	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	13.03
13.32	OFF	ON	ON	OFF	ON	ON	ON	ON	13.32
13.5	OFF	ON	ON	OFF	ON	ON	ON	OFF	13.5
13.54	OFF	ON	ON	OFF	ON	ON	OFF	ON	13.54
13.71	OFF	ON	ON	OFF	ON	OFF	ON	ON	13.71

	switch	switch	switch	switch	switch	switch	switch	switch	
	pos 1	pos 2	pos 3	pos 4	pos 5	pos 6	pos 7	pos 8	
	10 ohm	22 ohm	47 ohm	100 ohm	249 ohm	475 ohm	825 ohm	1K ohm	
Cartridge									Cartridge
Loading									Loading
Ohm's									Ohm's
13.73	OFF	ON	ON	OFF	ON	ON	OFF	OFF	13.73
13.9	OFF	ON	ON	OFF	ON	OFF	ON	OFF	13.9
13.94	OFF	ON	ON	OFF	ON	OFF	OFF	ON	13.94
14.07	OFF	ON	ON	OFF	OFF	ON	ON	ON	14.07
14.13	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	14.13
14.28	OFF	ON	ON	OFF	OFF	ON	ON	OFF	14.28
14.32	OFF	ON	ON	OFF	OFF	ON	OFF	ON	14.32
14.5	OFF	ON	ON	OFF	OFF	OFF	ON	ON	14.5
14.53	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	14.53
14.72	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	14.72
14.76	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	14.76
14.99	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	14.99
15.68	OFF	ON	OFF	ON	ON	ON	ON	ON	15.68
15.93	OFF	ON	OFF	ON	ON	ON	ON	OFF	15.93
15.98	OFF	ON	OFF	ON	ON	ON	OFF	ON	15.98
16.21	OFF	ON	OFF	ON	ON	OFF	ON	ON	16.21
16.24	OFF	ON	OFF	ON	ON	ON	OFF	OFF	16.24
17.08	OFF	ON	OFF	ON	OFF	ON	OFF	ON	17.08
17.34	OFF	ON	OFF	ON	OFF	OFF	ON	ON	17.34
17.37	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	17.37
17.65	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	17.65
17.71	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	17.71
18.03	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	18.03
18.59	OFF	ON	OFF	OFF	ON	ON	ON	ON	18.59
18.94	OFF	ON	OFF	OFF	ON	ON	ON	OFF	18.94
19.02	OFF	ON	OFF	OFF	ON	ON	OFF	ON	19.02
19.35	OFF	ON	OFF	OFF	ON	OFF	ON	ON	19.35
19.39	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	19.39
19.73	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	19.73
19.81	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	19.81
20.09	OFF	ON	OFF	OFF	OFF	ON	ON	ON	20.09
20.21	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	20.21
20.5	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	20.5
20.59	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	20.59
20.98	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	20.98
21.03	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	21.03
21.43	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	21.43
21.53	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	21.53
22	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	22
25.25	OFF	OFF	ON	ON	ON	ON	ON	ON	25.25
25.9	OFF	OFF	ON	ON	ON	ON	ON	OFF	25.9
26.04	OFF	OFF	ON	ON	ON	ON	OFF	ON	26.04
26.66	OFF	OFF	ON	ON	ON	OFF	ON	ON	26.66
26.74	OFF	OFF	ON	ON	ON	ON	OFF	OFF	26.74

	switch	switch	switch	switch	switch	switch	switch	switch	
	pos 1	pos 2	pos 3	pos 4	pos 5	pos 6	pos 7	pos 8	
	10 ohm	22 ohm	47 ohm	100 ohm	249 ohm	475 ohm	825 ohm	1K ohm	
Cartridge									Cartridge
Loading									Loading
Ohm's									Ohm's
27.39	OFF	OFF	ON	ON	ON	OFF	ON	OFF	27.39
27.55	OFF	OFF	ON	ON	ON	OFF	OFF	ON	27.55
28.09	OFF	OFF	ON	ON	OFF	ON	ON	ON	28.09
28.33	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	28.33
28.91	OFF	OFF	ON	ON	OFF	ON	ON	OFF	28.91
29.09	OFF	OFF	ON	ON	OFF	ON	OFF	ON	29.09
29.86	OFF	OFF	ON	ON	OFF	OFF	ON	ON	29.86
29.96	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	29.96
30.78	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	30.78
30.98	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	30.98
36.5	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	36.5
37.73	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	37.73
38.03	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	38.03
39.07	OFF	OFF	ON	OFF	OFF	ON	ON	ON	39.07
39.54	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	39.54
40.66	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	40.66
41.01	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	41.01
42.57	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	42.57
42.77	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	42.77
44.47	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	44.47
44.89	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	44.89
47	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	47
54.55	OFF	OFF	OFF	ON	ON	ON	ON	ON	54.55
57.69	OFF	OFF	OFF	ON	ON	ON	ON	OFF	57.69
58.41	OFF	OFF	OFF	ON	ON	ON	OFF	ON	58.41
61.62	OFF	OFF	OFF	ON	ON	OFF	ON	ON	61.62
62.03	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	62.03
65.67	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	65.67
66.6	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	66.6
69.85	OFF	OFF	OFF	ON	OFF	ON	ON	ON	69.85
71.35	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	71.35
75.09	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	75.09
76.31	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	76.31
81.89	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	81.89
82.61	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	82.61
89.19	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	89.19
90.91	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	90.91
100	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	100
120	OFF	OFF	OFF	OFF	ON	ON	ON	ON	120
136.36	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	136.36
140.42	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	140.42
160.56	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	160.56
163.36	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	163.36
191.27	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	191.27

	switch	switch	switch	switch	switch	switch	switch	switch	
	pos 1	pos 2	pos 3	pos 4	pos 5	pos 6	pos 7	pos 8	
	10 ohm	22 ohm	47 ohm	100 ohm	249 ohm	475 ohm	825 ohm	1K ohm	
Cartridge									Cartridge
Loading									Loading
Ohm's									Ohm's
199.36	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	199.36
231.62	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	231.62
249	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	249
301.44	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	301.44
322.03	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	322.03
452.06	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	452.06
475	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	475
825	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	825
1000	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	1000
47000	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	47000