THREE BODY MANUAL

Technical Information

Voltage Levels

The Three Body is designed for compatibility with Eurorack voltage standards. Inputs are scaled to certain ranges to optimize ADC precision. Inputs and outputs are voltage and current protected and should not but damaged by any level within the Eurorack ecosystem (-12V to +12v, or 24v peak to peak).

All inputs and outputs are DC coupled.

SIGNAL TYPE	LEVEL	Notes
Volts per octave CV input	-8V to +8V	Best tracking between -5V and +5V
Phase or frequency CV input	-8V to +8V	Will clip bipolar signals above 16 volts peak to peak or unipolar inputs above 8V
Index CV input	0 to 10V	Unipolar inputs for envelopes, will clip below 0V and above 10V
Sync input	0.7V threshold	Comparator input stage triggers around 0.7V
Output	-5 to 5V	All outputs are bipolar 10V peak to peak (or slightly higher, up to 12V peak to peak)

Sample Rates and Bit Depth

All inputs are sampled at 12bit 96kHz but volts per octave and indexes are over sampled to achieve 14 bit precision at the expense of a lower effective sample rate closer to a few kilohertz.

The internal sample rate of the Three Body audio path is 12.5MHz to achieve low aliasing and high quality modulation effects.

The outputs are implemented with delta sigma modulation on the FPGA itself and are approximately 16 bit quality with 96kHz sample rate.

Current Draw

+12V: 95mA

-12V: 50mA

Inrush current on +12V: approx 200mA

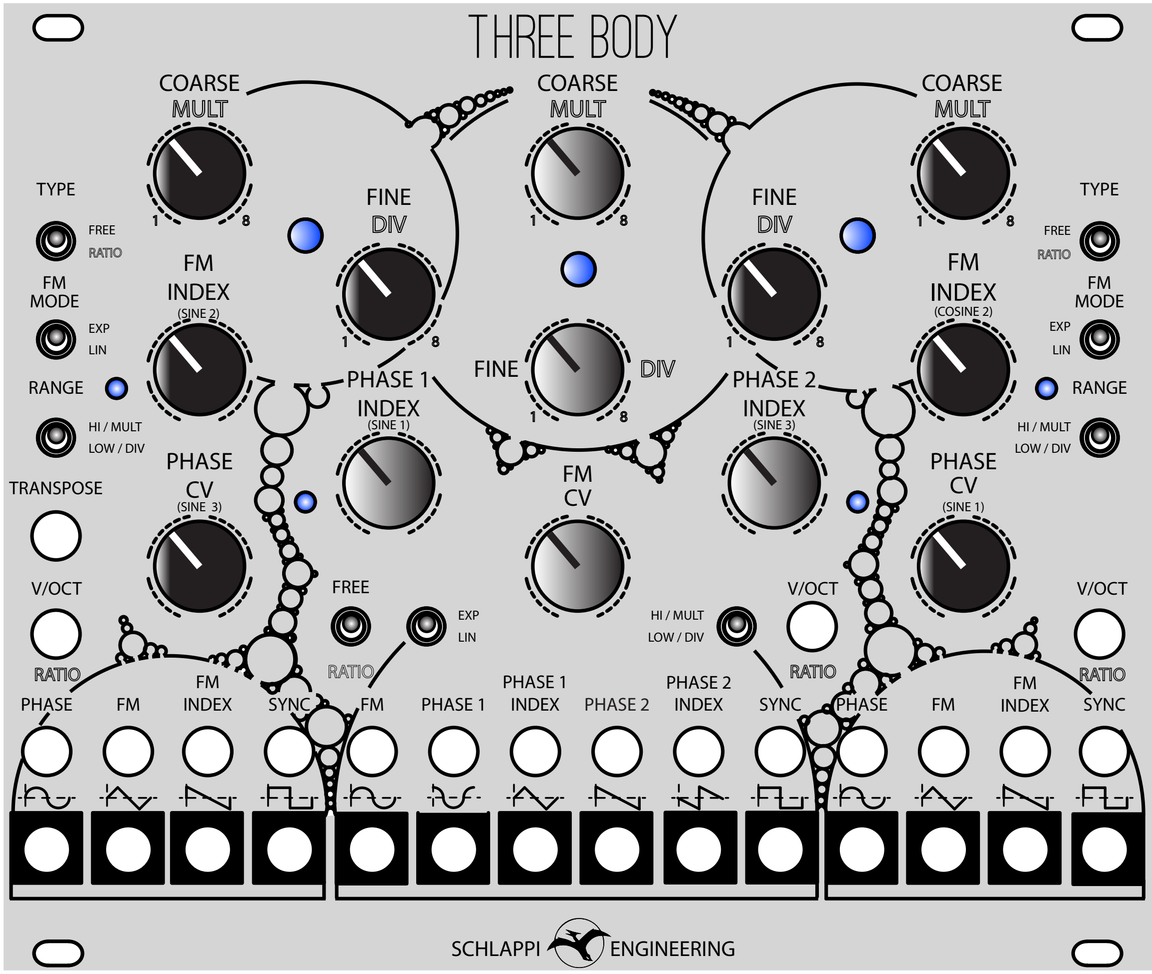
The Three Body has been designed for low power usage, however it will draw a bit more current on startup than during operation as indicated by the inrush current listed above.

Module Description and Features

Introduction

The Three Body is a phase and frequency modulation toolkit, designed to bring digital techniques to an analog interface.

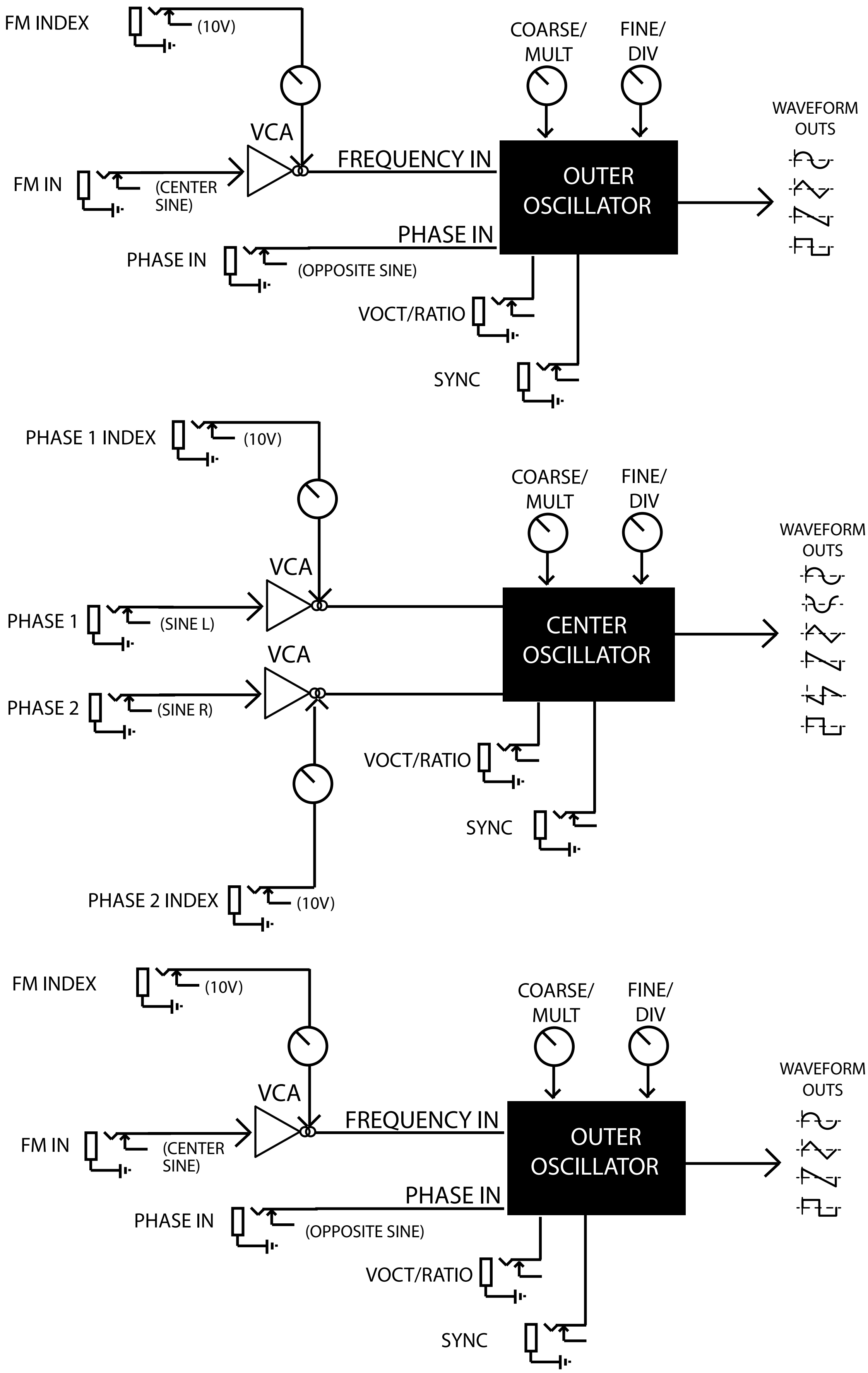
It consists of three oscillators which can be used independently but which have normalized connections to facilitate exploration and improvisation.

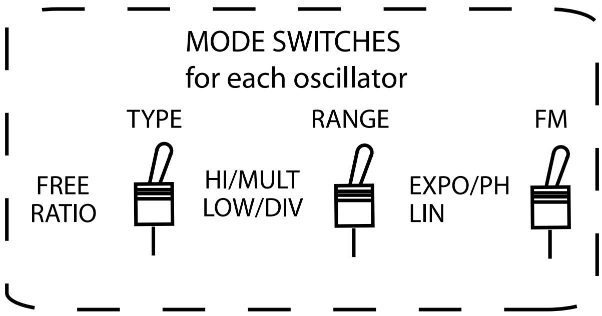


The separate oscillators can be identified by differing knobs colors and the boundaries shown in the panel design.

Each oscillator has three switches to define it’s state (or mode) as well as a collection of inputs and outputs (identified by the boxes around the jack).

Block Diagram



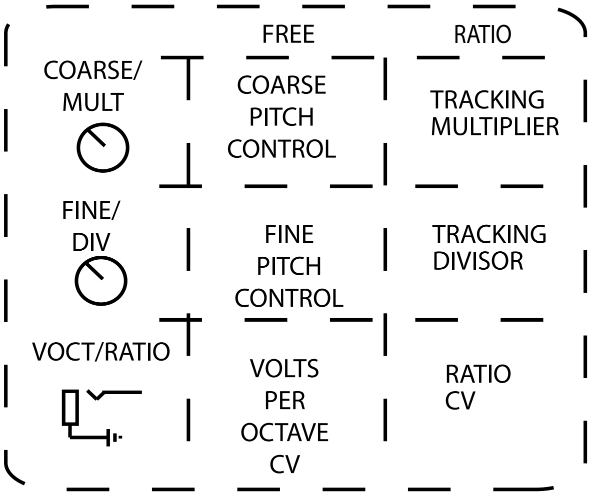


States

At the heart of the three body is a digital logic state machine with 8 states (per oscillator) defined by three switches (per oscillator). This determines whether the oscillator is free, operating much like an analog oscillator, or tracking in a ratio mode as is necessary for Chowning style digital FM. It also determines the behavior of the VOCT/RATIO CV, frequency modulation, and sync inputs.

FREE/ RATIO	EXPO/ LIN	LOW/HIGH/ DIV/MULT	DESCRIPTION
FREE	EXPO	LOW	LFO with exponential frequency modulation
FREE	EXPO	HIGH	VCO with exponential frequency modulation
FREE	LIN	LOW	LFO with linear frequency modulation
FREE	LIN	HIGH	VCO with linear frequency modulation
RATIO	PHASE	DIV	Tracking oscillator with phase modulation and CV over division
RATIO	PHASE	MULT	Tracking oscillator with phase modulation and CV over multiplication
RATIO	LIN	DIV	Tracking oscillator with linear frequency modulation and CV over division
RATIO	LIN	MULT	Tracking oscillator with linear frequency modulation and CV over multiplication

Each oscillator also has a phase modulation input which is not state dependent and a SYNC input. In FREE mode the SYNC input will act as a classic hard sync and in RATIO mode the oscillator will track whatever signal is at the SYNC input.



Controls

Controls affected by the FREE/RATIO state, works the same for each oscilllator.

CONTROL	FREE	RATIO
COARSE/MULT	Coarse pitch control	Tracking multiplier
FINE/DIV	Fine pitch control	Tracking divider

Modulation controls are the same for the outer oscillators, but the inner oscillator has an extra phase input and index control (VCAs) on phase modulation instead of frequency

CONTROL	DESCRIPTION	Oscillator
PHASE CV	Attenuator over phase input	outer
PHASE INDEX 1	Attenutor for CV control over amount of phase input 1	inner
PHASE INDEX 2	Attenutor for CV control over amount of phase input 2	inner
FM CV	Attenuator for amount of FM input	inner
FM INDEX	Attenuator for CV control over amount of phase input	outer

Inputs

Inputs affected by the FREE/RATIO state, works the same for each oscillator

INPUT	FREE	RATIO	notes
TRANSPOSE	Global Volts per octave input, adds to all oscillators pitch	Has no effect	Affects all oscillators in free mode, including those in LFO mode
VOCT/RATIO	Volts per octave input	CV adding to multiplier or divider	Bipolar, can be used at audio rate
SYNC	Hard sync	Tracking input	threshold at 1V, tracks on rising edge

Modulation inputs are the same for the outer oscillators, but the inner oscillator has an extra phase input and index control (VCAs) on phase modulation instead of frequency

INPUT	RATIO	
PHASE	Phase input, breaks internal normalization	
PHASE INDEX	CV control over amount of phase, breaks normalization to 10V	Outer osc
FM	Frequency modulation input, expo or lin, breaks internal normalization	
FM INDEX	CV control over amount of phase, breaks normalization to 10V	Inner osc

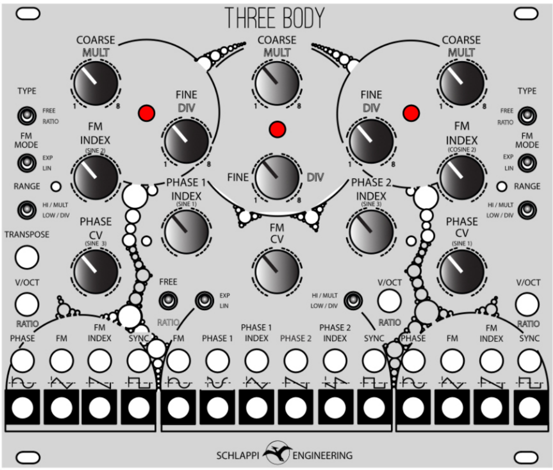
Outputs

All outputs are bipolar, approximately 10V peak to peak (may be a bit higher), and affected by the phase or frequency modulation of the related oscillator.

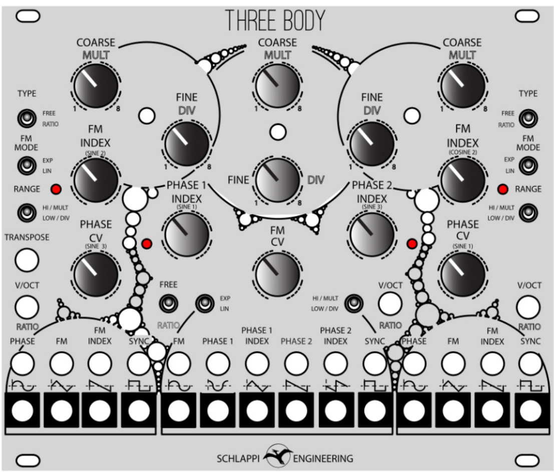
LABEL	NAME	DESCRIPTION
	SINE	Sine wave output, modulation subtracting from the phase
	COSINE	Cosine output, 90 degrees offset ahead of sine output with modulation adding to the phase. center oscillator only
	TRIANGLE	Triangle wave output, modulation adding to the phase
	SAW	Saw wave output, modulation subtracting from the phase
	COSAW	Saw wave 90 degrees offset ahead of saw output with modulation adding to the phase. center oscillator only
	SQUARE	Square wave output, modulation subtracting from the phase

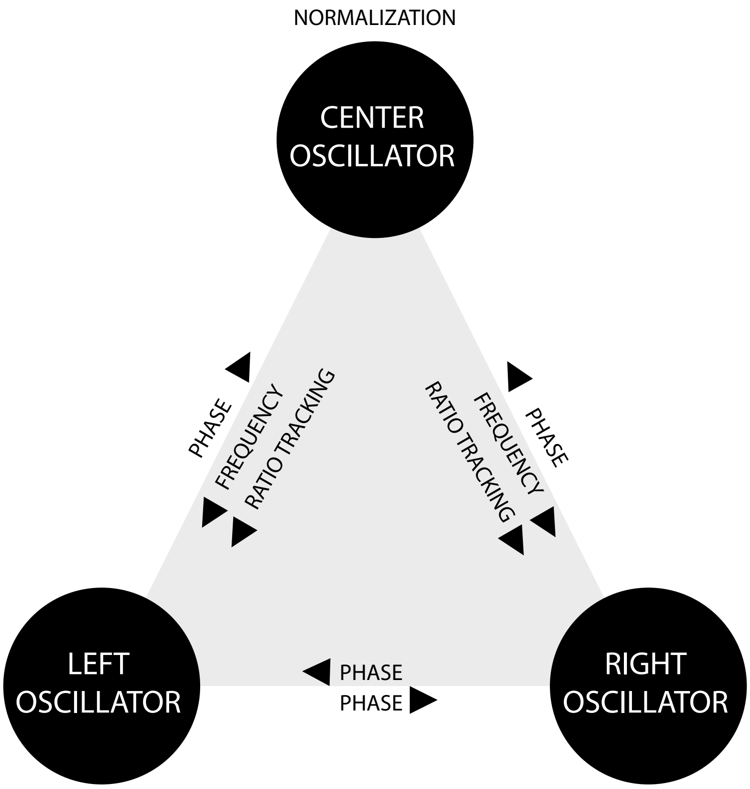
Indicators

The three large LEDs across the top are all tied to the respective sine wave output of that oscillator. When this oscillator is below audio rates it will show blue when positive and red when negative and when at or above audio rates it will show as some variation of purple.



The four small LEDs across the middle are all tied to the output of the index VCA next to it. This way you will see both the intensity and the rate of the modulation.





Modulation Normalization

While the three oscillators can be used totally independently, there are some normalization in place to aid easy exploration as a stereo fm oscillator, drone bank, or even a standalone noise box.

The inner oscillator PHASE inputs are normalized to received modulation from the outer oscillators sine outputs.

The outer oscillators FM inputs are normalized to the inner oscillators sine (for the left side) and cosine (for the right side).

The outer oscillators PHASE inputs are normalized to the opposite outer oscillators sine wave output (so the left sine goes to the right phase in, and the right sine out goes to the left phase input).

Ratio Normalization

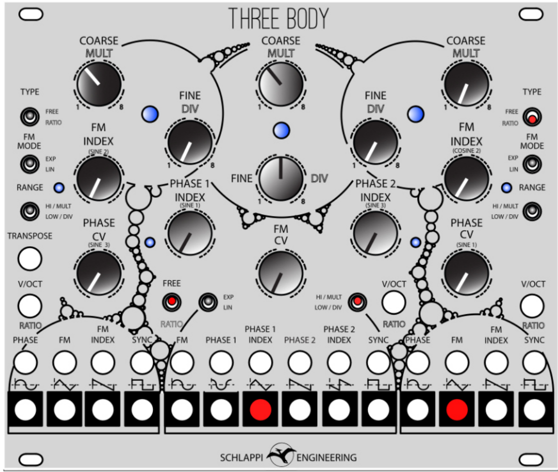
The two outer oscillators are set to track the inner oscillator if set to RATIO mode with no cable plugged into their respective SYNC jacks.

Patches to start exploring with:

Unmodulated Ratios

Start with all modulation related controls fully counter clockwise. Listen to a sine or triangle output from the center oscillator as well as one from the right oscillator.

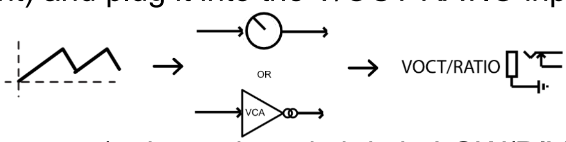
Set the center oscillator to “free” and “high” and the right oscillator to “ratio”.



If the division (the FINE DIV knob) of the right oscillator is set to one (fully counter clockwise) then turning the multiplication (COARSE MULT) will travel up and down the harmonic series.

If the division is set higher than one then changing the multiplication value will travel through a scale of sorts, moving in half octave intervals in the case of a division of 2, or third octave ratios in the case of a division of three.

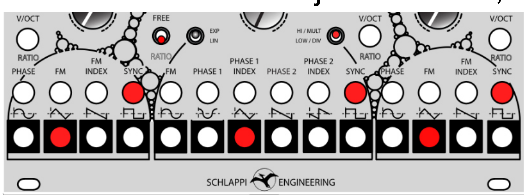
Next take a modulation signal like an envelope or LFO, attenuate it with an attenuator or VCA (this is important) and plug it into the V/OCT RATIO input of the right oscillator.



Depending whether the range/ratio mode switch is in LOW/DIV or HIGH/MULT this will add to either the multiplication or division value. If you attenuate the signal enough you can limit it to only one or two values which will create an arpeggiation effect if both the mult and div knobs are set fully counter clockwise.

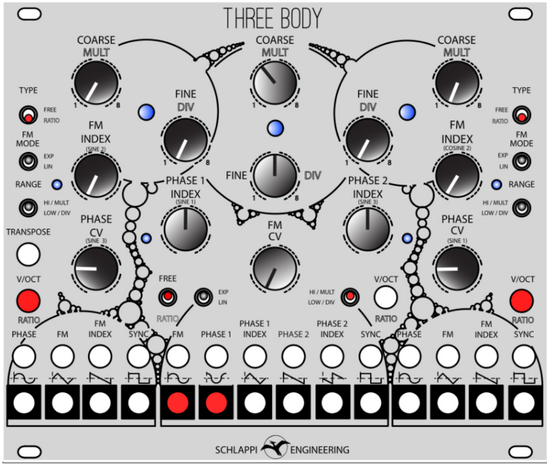
Try also setting the left oscillator to ratio mode and listening to all three oscillators while sending CV to the outer oscillators, depending on the modulation this can turn into a wall of arpeggios or slowly moving harmonic drones.

A variation is to set the center oscillator to ratio as well and plug an external oscillator into the SYNC jack. The center oscillator will then track the external oscillator at a ratio and the other two oscillators will still track the center oscillator (unless you mult the external signal and run it into those SYNC jacks as well, then they will track it instead).



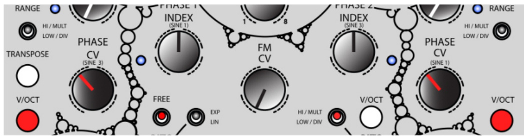
Phase modulation with ratios

Start with the ratio patch as above but listen to the sine and cosine outputs of the center oscillator instead. Bring up the PHASE INDEX 1 and PHASE INDEX 2 controls (making sure all other modulation controls are down.)



You should be able to hear the ratios or modulated arpeggios through the center oscillator but as phase modulated timbre changes instead of directly (listening to the outside oscillators).

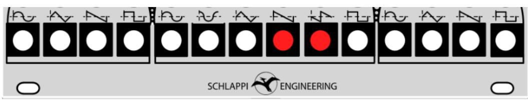
If you bring up the PHASE CV controls (carefully, less than halfway) of the outside oscillators then they will cross modulate each other resulting in high harmonic content, even if you are just listening to the center oscillator.



If you bring up the cross modulation too high it will disintegrate into noise, but just a little can really bring life to a patch.

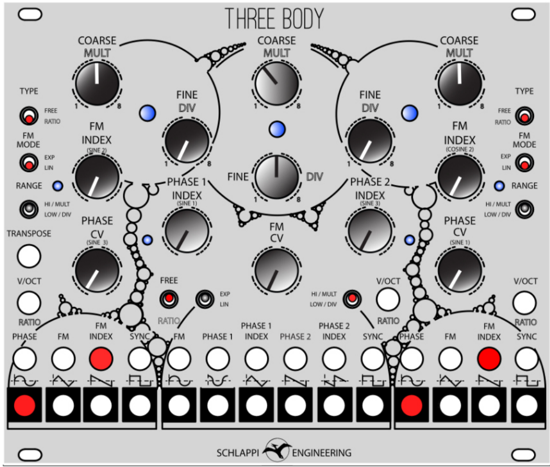
A nice variation is to set the left oscillator to free and low mode so it becomes an unsynced lfo (you may want to remove any modulation that may have been plugged into the V/OCT RATIO jack). If you are still listening to the sine cosine pair your patch should gain a large stereo element.

When you have done all this try also listening to the saw and cosaw outputs of the center oscillator, you will also get a large stereo field but with much more harmonic content.



Stereo Frequency modulation

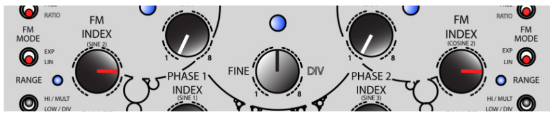
Put the outer oscillators into ratio and linear fm modes, put the divide controls fully counter clockwise and the multiply controls at noon or higher so they are at a significantly higher frequency than the center oscillator. You may want the center oscillator to be in a pretty low register so this isn't too painful.



Make sure all modulation controls are fully counter clockwise.

Take the outputs from the outer sine wave outputs, this will give us our nice clean sine wave fm.

Now (slowly) turn up the FM indexes of the outer oscillators, you should hear a gradual build up of harmonics.

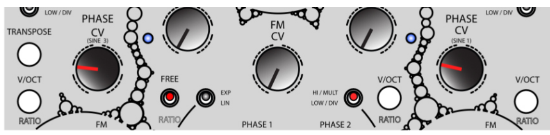


Next insert a modulator like an LFO or envelope into the FM index inputs.

With very slow modulation on the FM index you should have a deep and ever changing timbre.

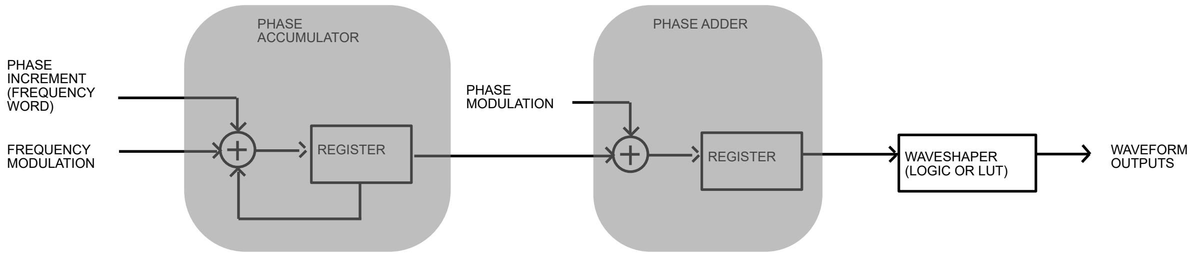
Next try changing the frequency of either the carriers (the outer oscillators) or the modulator (the inner oscillator). You may find that if the index is high enough the fundamental is effectively erased and it doesn't matter very much what frequency the carriers are as long as they are higher than the modulator, they act more as a filter for the modulation than independent oscillators.

If you want a little more spice on the sound add some cross phase modulation between the outer oscillators.

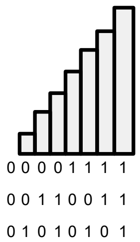


Theory and Usage

Phase Vs Frequency Modulation

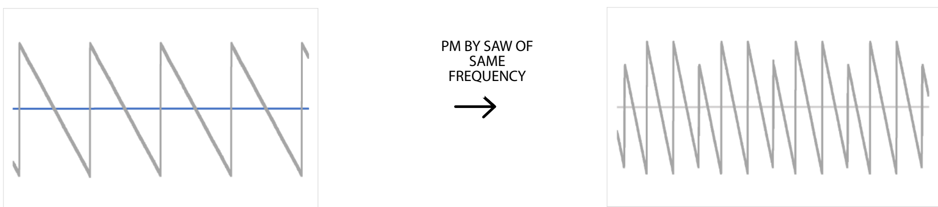


A traditional digital oscillator (direct digital synthesis or DDS) is accomplished with an accumulator. The accumulator can also be thought of as a counter, where each clock tick some amount is added to the counter along with the previous value of the counter. This can be visualized as a stepped sawtooth waveform.



Frequency modulation is accomplished by changing the amount that is added to the accumulator each clock tick, which results in a change in pitch. However the accumulator (a digital version of an integrator) acts as a filter on the modulating frequency. This means that the modulator should be a lower frequency than the carrier and also that DC offsets can affect pitch.

Phase modulation is accomplished by adding to the output of the accumulator (a triangle wave representing phase) before entering the waveshaper. By simply adding to the phase value you get an effect closely related to frequency modulation (a spreading of the power spectrum from the harmonic to various harmonic or inharmonic partials depending on whether the modulation or carrier are related by a simple ratio or not) but without pitch change with DC offsets or the filtering effect caused by the integration.



Another effect that phase modulation is closely related to is wavefolding, as the effect of rolling over the register (moving the phase past 0 or 180 degrees) is analogous to “folding” the waveform back over once a threshold is reached.

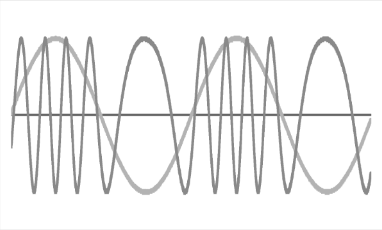
The guidelines I keep in mind when using frequency and phase modulation are:

- With frequency modulation: The modulating frequency must be below the carrier frequency (or it will be attenuated or disappear completely).

FM EQUATION (FROM WIKIPEDIA) SHOWING MODULATION INDEX DIVIDED BY MODULATION FREQUENCY

$$y(t) = A_c \cos\left(2\pi f_c t + \frac{f_\Delta}{f_m}\sin(2\pi f_m t)\right)$$

- With frequency modulation: Low frequency (below audio rate, including DC offsets) modulators will result in a change in pitch of the oscillator.



- With phase modulation the modulating frequency either needs to be in audio range or you need to mix multiple outputs with different phases to hear the modulation. Slow differences in phase are not audible without a reference.

Consider that phase modulation is just adding two waves before a waveshaper, if they are not audible beforehand they will not be audible afterwards (unless they are compared against a reference, like in a phaser implementation).

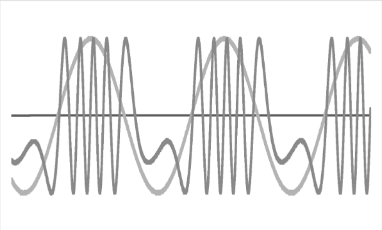
- With audio rate modulation (either frequency or phase) simple ratios are required to create harmonic sounds. This may or may not correspond to musical ratios (or scales).

SELECTED FREQUENCY RATIOS WITHIN A SCALE

1:1 UNISON
2:1 OCTAVE
3:2 PERFECT FIFTH
4:3 PERFECT FOURTH
5:3 MAJOR SIXTH
5:4 MAJOR THIRD
8:5 MINOR SIXTH
6:5 MINOR THIRD

Through-Zero Effects

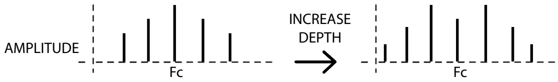
The phase and frequency modulation in the Three Body are both implemented with signed addition (or subtraction). This means the waveform can reverse direction if it changes signs (or goes through zero). For phase modulation this is part of the wavefolding action mentioned above. For frequency modulation this occurs when the modulation index is large relative to the carrier frequency and can be seen on the negative side of the modulating cycle.



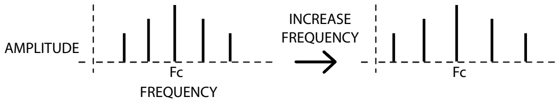
Modulation Depth

Modulation depth (or index) increases the number of partials or harmonics that are created and the relative spectral power of the partials to fundamental.

Holding the modulation depth steady and changing the modulation frequency keeps the same number of partials but changes their spacing (spread in the frequency domain).



Holding the modulation frequency steady and changing the depth keeps their spacing but increases their number.



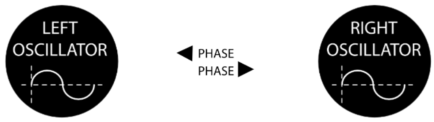
The modulation depths on the three body have been selected as a compromise between effect, musicality, and usefulness within a system where cross modulation is available.

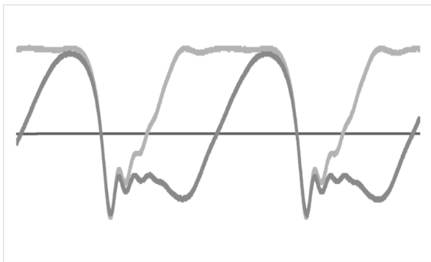
Internally the linear frequency modulation and phase modulation have been greatly amplified so that the linear FM is actually much stronger than the exponential FM. In using the linear through zero FM you have the option to go so deep that the fundamental is completely overwhelmed and some very satisfying sound design can be reached, however you may want to keep the index pretty low if you are looking for more traditional timbres.

The high amplification of the phase modulation also allows some non-traditional timbres quite similar to wavefolding. The downside to this is that noise from the ADC is amplified as well. To combat the high frequency noise I introduced some filtering on the external phase inputs of the outside oscillators (which have no internal routing). You can reduce this filtering (at the cost of additional noise) by using the “External filter select” header 16 H.

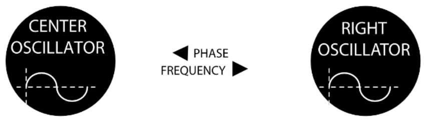
Cross Modulation

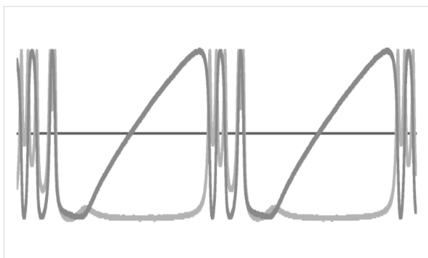
Cross modulation is when one oscillator modulates another which is also modulating it back. Cross modulating two or more oscillators will create a feedback loop and greatly increase the perceived amount of modulation.



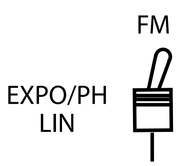


Cross modulating two oscillators with frequency modulation (either with frequency modulation both ways or phase one way and frequency the other) will cause pitch instabilities and rather unpredictable behavior. It may also cause one oscillator to lock on to another or to cease oscillating independently. It is recommended not to do this when you are attempting a melodic patch or looking for anything other than unpredictability and chaos.





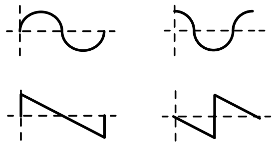
This is also one of the reasons that phase modulation was substituted for exponential frequency modulation in ratio mode, the other is that exponential modulation with ratios does not make a lot of sense (and was difficult to accomplish for various technical reasons related to the architecture of the system).



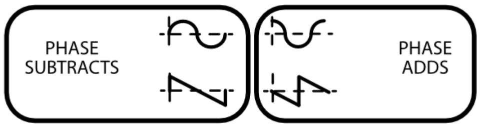
Cross modulating two oscillators with phase modulation will drastically increase the mount of high frequency content. With the default external filters this is tamed a bit, with the external filter header on this can quickly get into shrieking territory and with either filter pushing both other phase CVs up past noon will likely enter noise territory.

Phase Related Outputs and Stereo Usage

The Three Body has two pairs of phase related outputs on the center oscillator. Sine and Cosine, as well as Saw and Cosaw. No, “cosaw” is not a real term but it is shorter than saying “a second saw wave ninety degrees out of phase with the first” and perhaps more relatable than using quadrature terminology.



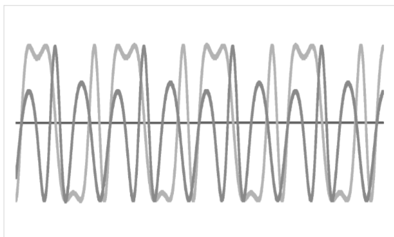
In the Three Body these two sets of outputs are implemented with separate phase adders, with the first phase adder having the phase modulation inputs adding to the oscillators phase counter and the second subtracting from it.



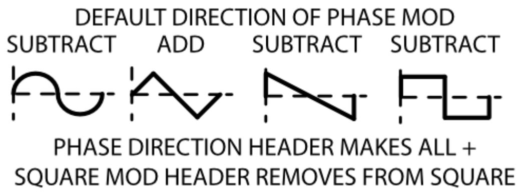
This has the effect of creating a wide stereo image with phase modulation, without being likely to cancel in mono. Thus the sine and cosine can be used as one stereo pair suitable for use as a voice where modulation is being used to add harmonics and a filter is probably unnecessary.

The saw and cosaw outputs will also act as a stereo pair in situations where you desire more base harmonics, something to for a filter to work with, or a different tonality.

This somewhat unusual phase modulation arrangement does technically break the phase relationship of the outputs. With modulation the sine and cosine outputs (or saw and cosaw) are no longer 90 degrees apart from each other and thus the labels are no longer accurate.

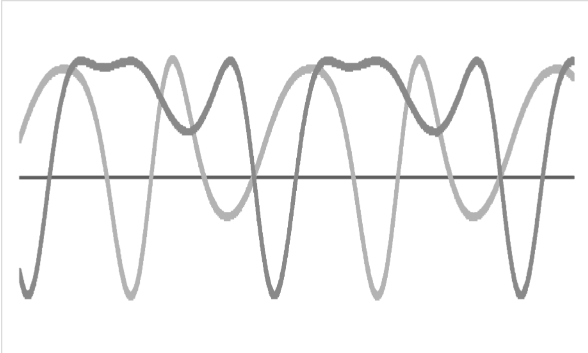


Another unusual implementation is that the triangle wave has phase modulation applied in the positive direction (like the cosine and cosaw), this means on the outside oscillators it moves in the opposite directions of the other waveforms. This provides another tool to create complex waveforms with external mixing and processing.

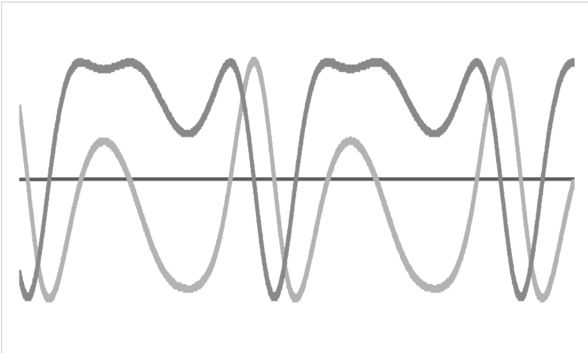


In case it is desirable to maintain the quadrature relationship with phase modulation applied, use header (8 D) “Phase direction”. This will cause all outputs to have phase modulation applied in the positive direction and thus maintain phase relationships under modulation.

OPPOSING PHASE DIRECTIONS

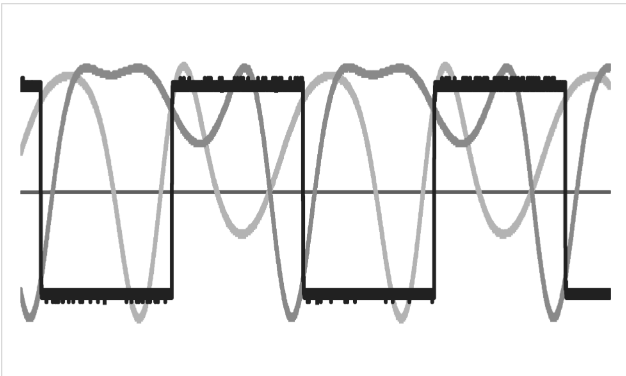


SAME PHASE DIRECTIONS



There is also a header (14 G) to remove phase modulation from all the square wave outputs. This is useful for synchronizing oscillators as well. It is also useful to have an output that can be filtered down to the fundamental and mixed with the others to create a thicker sound. For more information see the “Configuration Headers” section of this manual.

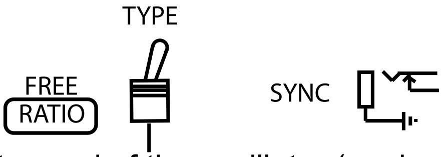
SQUARE MODULATION REMOVED WITH OPPOSING PHASE DIRECTIONS



Another method to create a stereo image is to use one output each from the outer oscillators in ratio mode where they are tracking the center oscillator. They will be locked to some frequency ratio but are still free running (not phase locked). This can provide the illusion of a single source but a wide stereo field and can be enhanced by using cross modulation between the two. The more modulation is used the more pitch differences are perceived as timbre changes instead.

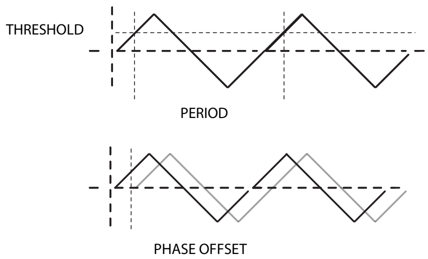
External Tracking

When in Ratio if you plug an external signal into the “SYNC” input the oscillator will track that signal at a ratio instead of an internal oscillation



It will track from the slowest speed of the oscillator (a minute or so) up to around 10kHz (a limit induced to make the tracking more accurate at slower speeds by eliminating fast temporary transitions).

By default the tracking is done by calculating the period (the length of a waveform) then translating that into a control signal for an oscillator (the “phase word’). This is accurate for frequency, but will not have the same phase as the external signal.



The tracking measurement is taken the rising edge of a comparator set around a volt and ends at the next rising edge, and is averaged over 8 measurements. This means pulse width is not important but it may take moment to exactly match a quickly changing signal.

The tracking only works for simple waveforms and monophonic signals. Anything with more than one zero crossing per cycle or multiple tones with confuse it. It also works better with a steady signal without any modulation.

There is also an option on the rear header (18 I) for Phase Locking Loop (PLL) tracking. This is useful for tracking a clock signal as a tempo locked LFO or clock divider. It is also useful in other situations where you want the phase to match (like oscillographics). The downside to PLL mode is a zipping type noise each time the signal it is tracking or the ratio it is tracking at changes, as the oscillator gradually slows down or speeds up to match the external signal.

This mode is less recommended for audio harmonization and FM purposes. If you do want to use for oscillographics or phase locked FM/PM you may also want to use the square wave output and square phase mod (14 G) headerto give it a steady source to lock on to.

Configuration Headers

On the rear of the module are configuration headers, default (recommended) position is always off. These are provided as a means of addresses some niche uses. Future additions are unlikely, as it requires an FPGA specific toolchain to update the module and the chip is quite full (so any additional functionality would have to come at expense of current functionality or heavy optimization).

Number	Letter	Name	Shunt Off (default)	Shunt On
20	J	Expander	Expander off	Expander on
18	I	PLL Mode	Period external tracking	PLL external tracking
16	H	External Filter Select	Low	High
14	G	Square phase mod	Phase modulation on square outputs	No phase modulation on square outputs
8	D	Phase Direction	Phase mod in opposite direction on sin/cos, saw/cosaw, tri/sin	Phase mod all in same direction

Expander: There may or may not be a future expander for the Three Body. I have tried various interesting ideas out but so far nothing has seemed truly necessary and thus earned a spot in my case. If an expander is released this header will enable it.

PLL Mode: Default period tracking only follows frequency, not phase. For most musical applications this is unimportant, but for oscillographics and LFO usages it may be useful to lock phase. In this case putting the shunt on will activate PLL mode for external tracking. The downsides to PLL mode include an audible lock on time which may be annoying if you are using control voltage over a ratio.

External filter select: choose the degree of filtering for three of the external CVs, OSC1 and OSC3 PHASE and OSC2 FM. This creates a different character to the OSC1 and OSC3 cross modulation and controls some of the high frequency noise amplified by the high phase modulation depth. The default mode is on LOW which filters down to around 3kHz, high opens the filter up to around 6kHz which sounds a little better but also allows more noise from the 12 bit ADC to come through.

Square Phase Mod: By default phase modulation applies equally to all oscillator outputs. Adding the header option allows you to remove phase modulation from the square wave output. This can be useful because heavy phase modulation is sonically interesting but spreads energy from the fundamental to other frequencies and often is lacking in bass. If the square wave output is run through a filter you can recover the fundamental and control the amount of harmonics to include, this can then be mixed back in with the other outputs for a fuller sound. It is also useful as a sync signal.

Phase Direction: Shunt off has phase modulation in opposite direction for sine and cosine, as well as saw and cosaw, for use in stereo patches. The triangle also moves in the same direction as the cosaw, this is useful on the outside oscillators to create more movement in your patches. Shunt on sets all outputs to move in the same direction and preserve the 90 degree phase relationship.

Default headers positions are all off

Calibration

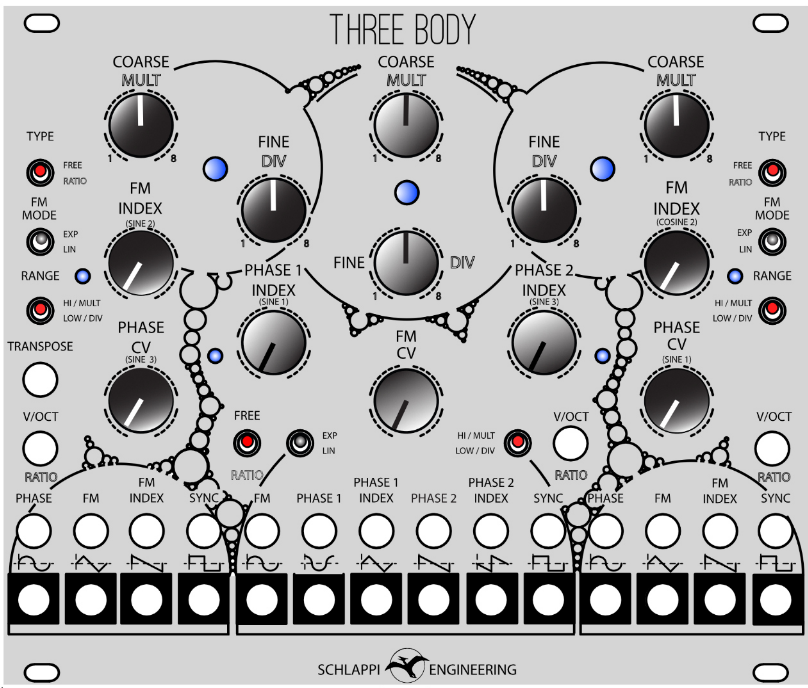
All Three Body units come calibrated by us. If for some reason the calibration needs to be redone (large temperature changes or to accommodate for the quirks of a particular midi to CV controller) the steps are included below.

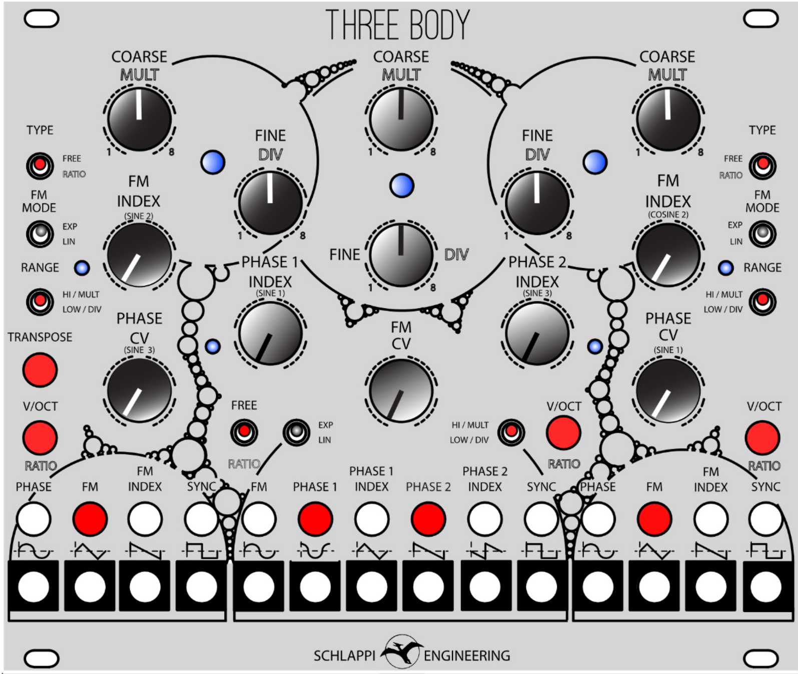
Please do not do this unless you are certain it is necessary as it will change both the volts per octave scaling and the zero offset for the modulation indexes (making sure the modulation can be turned off).

If you look at the small board on the rear of the module you will see two small buttons in the upper left hand corner marked "CALIBRATION BUTTONS"*, these are what you will use for this procedure.* ***You will need to be able to reach both the back and front of the module to perform the procedure.***

You will also need a calibrated 0V and 4V source that can be plugged into 3.5mm jacks on the front panel.

See below diagram for knob positions. The procedure will use these same knob positions the whole time and will involve inserting 0V into 8 jacks then hitting the LOW button after each one, then inserting 4V into 4 jacks and hitting the HIGH button after each one. Detailed procedure begins on next page.





All input controls should be fully counter clockwise (FM INDEX, PHASE CV, PHASE INDEX, FM CV)

Pitch controls should be at 12 o clock (COARSE/MULT, FINE/DIV)

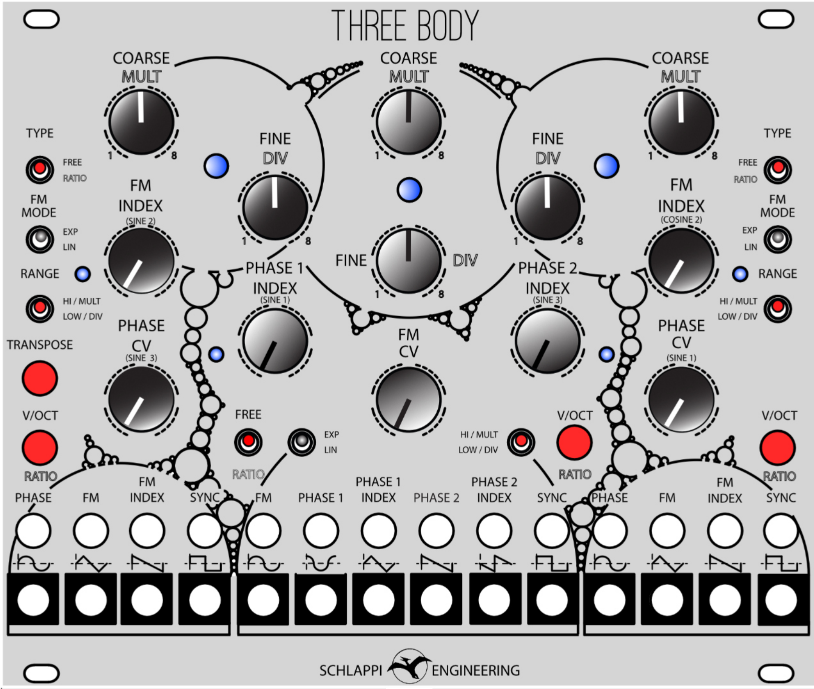
Start with setting the voltage source to 0V:

1. Plug the cable into "FM" on the left oscillator, hit "LOW" calibration button
2. Move the cable into "PHASE 1" on the center oscillator, hit "LOW" calibration button
3. Move the cable into "PHASE 2" on the center oscillator, hit "LOW" calibration button
4. Move the cable into "FM" on the right oscillator, hit "LOW" calibration button
5. Plug the cable into "TRANSPOSE", hit "LOW" calibration button
6. Move the cable into "VOCT" left, hit "LOW" calibration button
7. Move the cable into "VOCT" center, hit "LOW" calibration button
8. Move the cable into "VOCT" right, hit "LOW" calibration button

After each time you hit the LOW calibration button the LEDs (D4,D3,D2) will list the next oscillator in binary descending from the top.

000: FM left
001: PHASE 1 center
010: PHASE 2 center
011: FM right
100: TRANSPOSE
101: VOCT left
110: VOCT center
111: VOCT right

Continue procedure on next page



All input controls should be fully counter clockwise (FM INDEX, PHASE CV, PHASE INDEX, FM CV)

Pitch controls should be at 12 o clock (COARSE/MULT, FINE/DIV)

Change the voltage source to 4V:
1. Plug the cable into "TRANSPOSE", hit "HIGH" calibration button
2. Move the cable into "VOCT" left, hit "HIGH" calibration button
3. Move the cable into "VOCT" center, hit "HIGH" calibration button
4. Move the cable into "VOCT" right, hit "HIGH" calibration button

After each time you hit the HIGH calibration button the LEDs (D5,D4) will list the next oscillator in binary descending from the top.
00: TRANSPOSE
01: VOCT left
10: VOCT center
11: VOCT right

The LEDs are read from top to bottom.

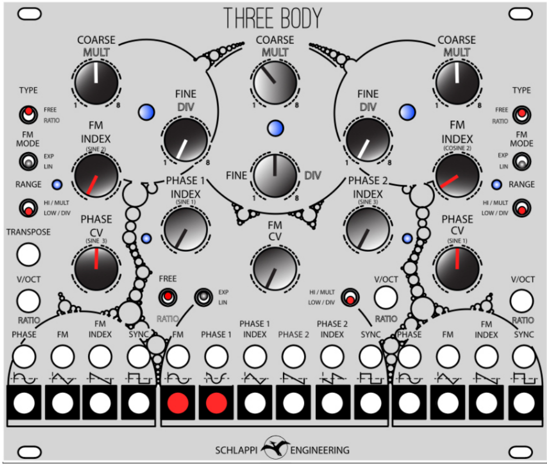
The calibration will update after the final “HIGH” calibration button press.

Verify the calibration:
1. Plug the cable into "TRANSPOSE",
2. Plug the sine wave output of the left oscillator into a high quality tuner
3. Tune the oscillator to C2
4. Step the power supply from 0 to 5V and verify that the oscillator remains in tune
5. Repeat for the left VOCT input (using left sine wave output again)
6. Repeat for center VOCT input (using center sine wave output)
7. Repeat for right VOCT input (using right sine wave output)

This ends the calibration procedure

More Recommended Patches

Rhythmic creaks:

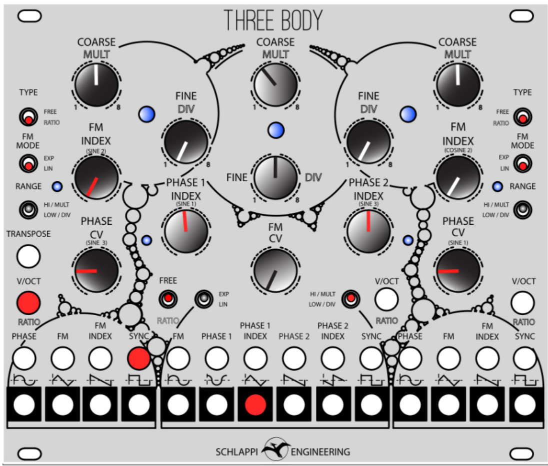


Set center oscillator to FREE, LOW

Outer oscillators to RATIO or FREE, LOW

Listen to the center oscillators sine outputs as a stereo voice, turn PHASE INDEX 1 and 2 all the way up, then start experimenting with turning up the PHASE CV and FM INDEX knobs in all modes

Dubstep bass:



Listen to center oscillator on FREE, HIGH

Set left oscillator to RATIO, HIGH/MULT

Insert sequence clock into left SYNC

Send modulation into the left RATIO (V/OCT) input to change the multiplier ratio of the oscillator to the clock rate

You may need cross modulation or to patch some FM to make the modulation audible.

Left as an exercise for the reader (or a future edition of this manual):

Clocked LFO

Drone bank (chords, free)

Noise box

Replicate some DX7 patches

Replicate the Moog Subharmonicon

Contact Info:

If you have any questions please contact Eric Schlappi at: eric@schlappiengineering.com