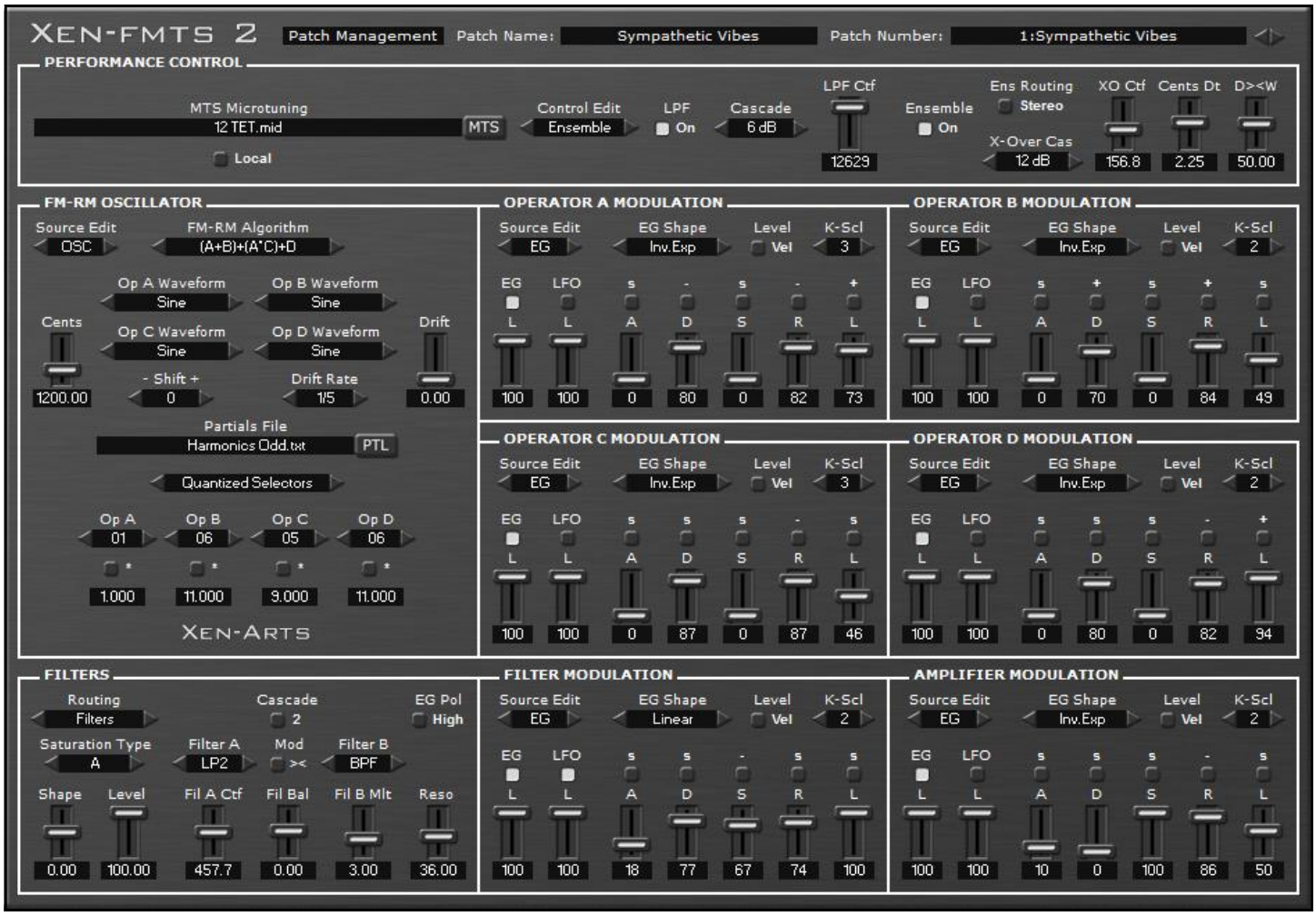
Xen-Arts

Presents

Xenharmonic FMTS 2



An FM Synthesis VSTi for the Creation of Microtonal and Xenharmonic Music

Welcome and thank you for your interest in our Xenharmonic FMTS 2 VSTi.

It has long been my feeling that one of the best ways to learn about the vast expressive potential of making music with alternative intonation systems is to have instruments available that include dedicated features for this kind of sonic exploration, where musicians and composers can gain firsthand experience of these intonations by actually playing them with their MIDI controllers.

This VSTi was the first in a series of Xen-Arts computer synthesis tools designed specifically for the study of musical instrument intonation and for the creation of xenharmonic and microtonal music. This instrument is inspired by the work of John Chowning (the inventor of FM Synthesis) and William Sethares (author of the book Tuning, Timbre, Spectrum, Scale), and has been created with a specialized set of features for the creation of xenharmonic and microtonal music.

Xenharmonic FMTS 2 is capable of producing a wide range of harmonic, quasi-harmonic and inharmonic timbres. It is possible to use the instrument for synthesizing basic waveforms, as well as rich timbral effects that one might associate with ensembles of instruments playing in unison. At the former extreme, the sounds produced may display a strong sense of timbral fusion with little sonic motion, while at the latter, it is possible to design ones that feature acoustic beating and chorusing effects within the timbre itself. While there is a bank of patches provided that covers a nice range of the possibilities, creative exploration with custom sound-design is strongly encouraged. The included default presets can be viewed as starting points for creating custom timbres for particular compositional requirements.

One of the central themes of this VSTi is the feature that enables musicians and composers to easily quantize the operator ratios of the FM-RM Oscillator to values that are coincident with the intonation system being used for musical composition. Being able to quantize the operator ratios in this way can be used to produce microtuning related side-bands in the signal of the synthesizer, thereby creating an audible correlation between the intonation and timbre of the instrument.

Algorithm 1, A+B+C+D, sums all four of the operators of the FM-RM Oscillator directly to the output and can be used to experiment with simple 4-partial additive synthesis using sine waveforms. Increasingly complex timbres may also be created by using the other available algorithms (and waveforms), in which the operators are variously able to be summed together, frequency-modulate and or ring-modulate each other.

The intonation system of the VSTi may be changed by loading MTS (MIDI Tuning Standard) files, and the FM-RM Oscillator operators may be configured with text files. Included with the instrument are a basic set of MTS microtunings for equal-temperaments 5-31, Bohlen-Pierce, Wendy Carlos Alpha, Beta and Gamma, as well as a selection of octave-based sections of the harmonic and subharmonic series that can be used for the study of just-intonation. A small library of partials files in the Windows TXT format are also provided for configuring the FM-RM oscillator frequency ratios to values that are coincident with the microtunings.

This update of Xen-FMTS to version 2 is a complete redesign and refinement of the original, and offers many new and exciting possibilities for xenharmonic and microtonal timbre creation. Xen-Arts hopes that you will enjoy making music with this instrument, and that it will inspire the deeper exploration of composing with alternative intonation systems and computer based sound-design.

Best Wishes,

Jacky Ligon
Xen-Arts
February 2014
xen-arts.com

About Xenharmonic FMTS 2

The word **xenharmonic** in the name of this VSTi is a term coined by the late American composer, theorist and instrument builder, **Ivor Darreg**, to indicate music which is created with intonation systems that sounds distinctly different from the Western 12 Tone Equal Temperament. This type of musical practice encompasses both the use of so called microtonal intervals and tunings, having scale steps that are recognizably smaller than a 12-tet semitone, as well as macrotonal tunings, having scale steps larger than those found in 12-tet. **FMTS** is a concatenation of **FM** (Frequency Modulation Synthesis) and **MTS** (MIDI Tuning Standard).

FM (Frequency Modulation Synthesis) and Ring Modulation

FM Synthesis was discovered by **John M. Chowning** in 1967 and was later licensed to **Yamaha** who used it in the classic **DX7** synthesizer. In the most simple sense, complex timbres can be created by a **Carrier** oscillator, or **Operator**, which is frequency modulated by another **Modulator** oscillator, thereby producing **sideband frequencies** above and below the carrier frequency. The original DX7 used 6 sine-wave operators, while the Xenharmonic FMTS VSTi uses 4 operators with eleven different waveforms being available for each operator.

Ring Modulation is a signal processing technique in which two signals are multiplied and the resulting waveform contains both the sum and difference frequencies of the two source signals. The Xenharmonic FMTS 2 VSTi uses a special type of **Ring Modulation Synthesis** in which oscillator signals are multiplied and the source oscillator signals are mixed with the ring modulated sum and difference frequencies. The typical Ring-Mod function is replaced with ((X*Level_X) * (Y*Level_Y)) + (Y*Level_Y). This allows Wave_Y to sound alone and add in the Ring sound with Level_X.

MTS (MIDI Tuning Standard)

The MIDI Tuning Standard is a specification for microtuning MIDI instruments agreed upon by the MIDI Manufacturers Association and was developed by microtonal composers Robert Rich and Carter Scholz. The standard includes both Bulk Dump and Single Note microtuning with a resolution of 0.0061 cent, which essentially divides the octave into 196,608 equal parts.

The Xenharmonic FMTS 2 VSTi can load internally, and receive externally, both Bulk Dump and Single Note MTS MIDI data.

Chris Kerry

This VSTi would not be possible without the DSP and programming skills of **Chris Kerry**, who has developed a line of **CK Module Packs** for the **SynthEdit** development environment. Xen-Arts wishes to here warmly thank Chris for his contribution to this project.

Xenharmonic FMTS 2 is a 4 Operator FM Synthesis VSTi with a specialized set of features for computer musicians interested in exploring the vast expressive possibilities of making music with alternative intonation systems. It is a 32-bit plugin instrument for Windows.

Microtuning Features
- Internally loads and externally receives both MTS (MIDI Tuning Standard) Bulk Dump and Single Note Microtuning Files
- Operator ratios can easily be set to values that are coincident with the microtuning being used, thereby producing intonation related sidebands in the timbre of the instrument
- Microtonal pitch-bend ranges may be configured in cents, harmonics and superparticular ratios
- Arbitrary microtonal pitch shifting makes it possible to easily pitch transpose the oscillators in both octave and non-octave increments

FM-RM Oscillator
- 4 Operator FM Synthesis with Ring-Modulation
- 57 Operator Algorithms
- 11 different Operator Waveforms
- Analog Pitch Drift Emulator
- Transposition by cents offsets
- Partials text files may be used to quantize the frequency ratios of the operators to user specified values
- Velocity-to-Harmonics Modulation enables oscillators to dynamically sound harmonics of the fundamental pitch

Modulators
- Seven dedicated hybrid modulators for Operators A, B, C, D, Filters, Amplifier and Pitch
- Each modulator includes an ADSR style envelope generator, and an LFO which can be switched to run at audio-rate
- Each ADSR Envelope Generator features Per-Stage Keyboard Tracking
- LFOs can either be synchronized to the host DAW tempo or set in Hertz. They include 24 Waveforms, a Slewer and can be switched to run at audio-rate

Filter Section
- Pre-Filter Saturation Stage with 20 Saturation Types
- Two Independent Filters with Six Filter Types: LP4, LP2, HPF, BPF, BRF, APF
- One and Two Stage Filter Cascade

Effects
- Chorus
- Lowpass Filter Cascade (Warm Filter) with 6 dB to 48 dB per-octave filters
- Stereo Ensemble

Performance Control
- Full controller MIDI Pitch Microtuning with MTS (MIDI Tuning Standard)
- MTS Support for both Single Note and Bulk Dump
- Loads MTS Microtuning Format Files Internally and Receives MTS Externally
- Local (Per-Patch) and Global Microtuning (Static Microtuning for All Patches)
- Microtunings can be loaded from any directory on hard drives or storage devices connected to the PC
- 12 Note Polyphonic
- Monophonic Legato Mode
- Monophonic Portamento
- Microtonal Pitch Bend
- Vibrato
- Effects include Chorus, Lowpass Filter Cascade (Warm Filter) with 6 dB to 48 dB per-octave filters and Stereo Ensemble

System Requirements

OS: For Windows XP Pro or higher.

Host DAW: The VSTi was rigorously tested in Reaper, Cubase, Ableton Live and FL Studio, and is known to work without problems in these hosts.

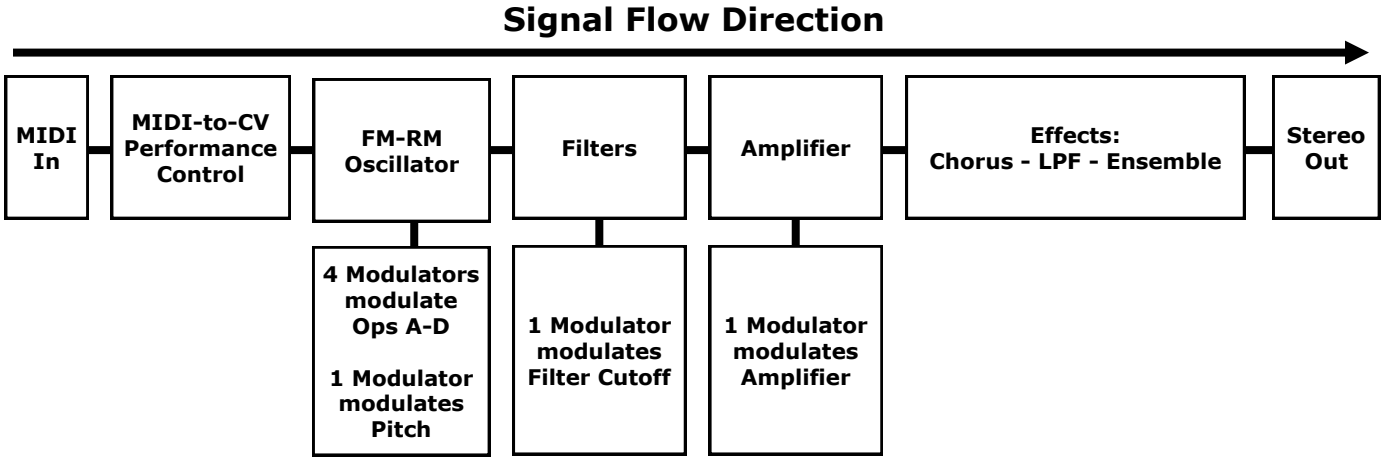
MTS Microtuning Creation: Install and use Scala to create your own custom microtunings for this instrument.

MIDI Controller: Requires the use of an external MIDI Controller such as a USB Halberstadt keyboard (standard 12-tone keyboard), a Generalized Keyboard such as the Axis-64 from C-Thru Music, the Opal Chameleon available from The Shape Of Music, the Starr Labs Microzone U-648 or U-990.

Installation

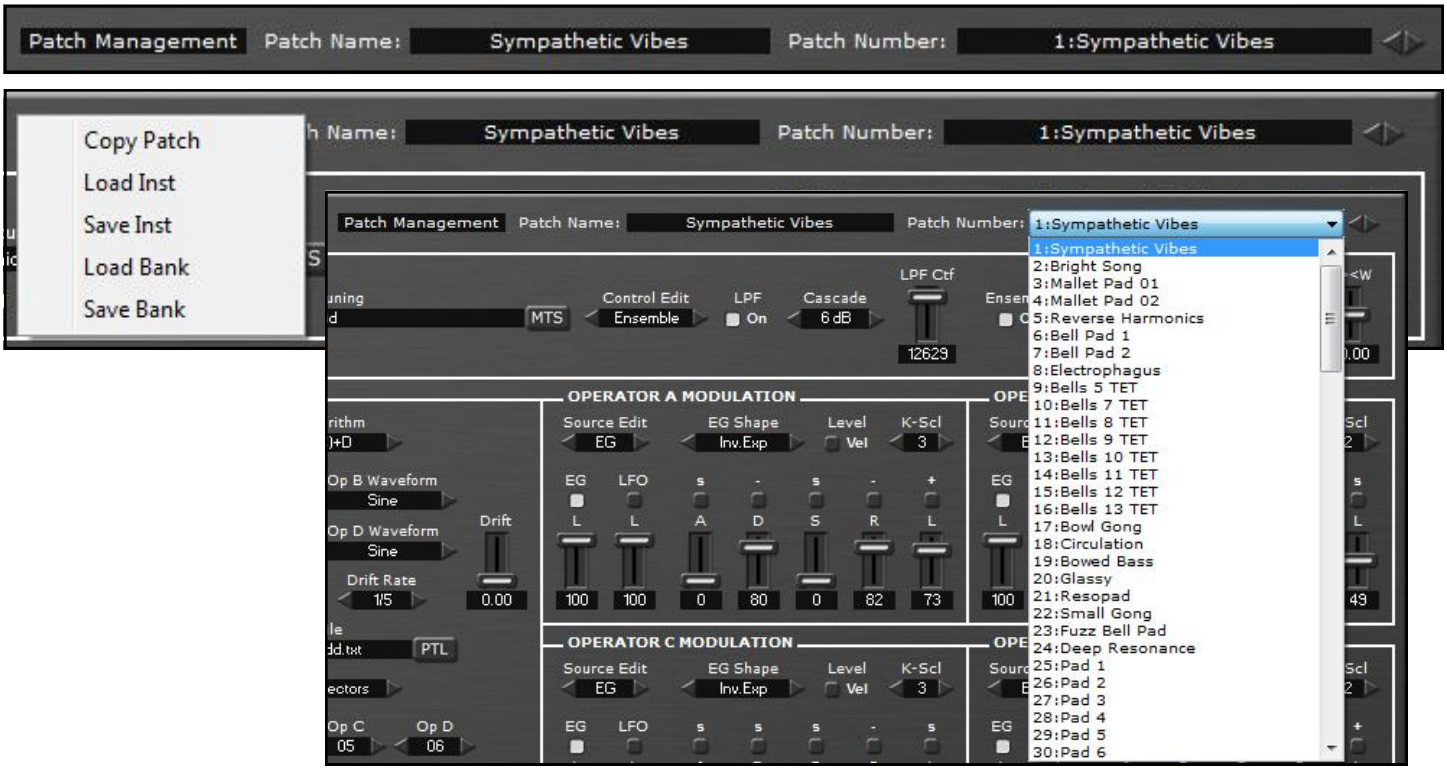
Extract the entire contents of the ZIP archive to your VST directory. This will place the VST DLL and all of the dependent files for the plugin in the required place and will ensure the correct operation of all the synthesis features. Win 7+ users should install the plugin in My Documents or some directory other than Program Files due to User Account Ccontrol, or otherwise choose to "**Run As Administrator**" when running their DAW for the first time, which will help to ensure the proper functioning of this plugin.

XENHARMONIC FMTS 2 - SIGNAL FLOW CHART



It is helpful in understanding the operation of the Xenharmonic FMTS 2 VSTi by visualizing the way the various sections of the instrument are connected and interact with each other.

Internally there are five main sections: Performance Control (MIDI-to-CV), FM-RM Oscillator, Filters, Amplifier and Effects.



The Patch Management features

Use the Patch Management features at the top of the VSTi to create, load and store your instrument patches and banks.

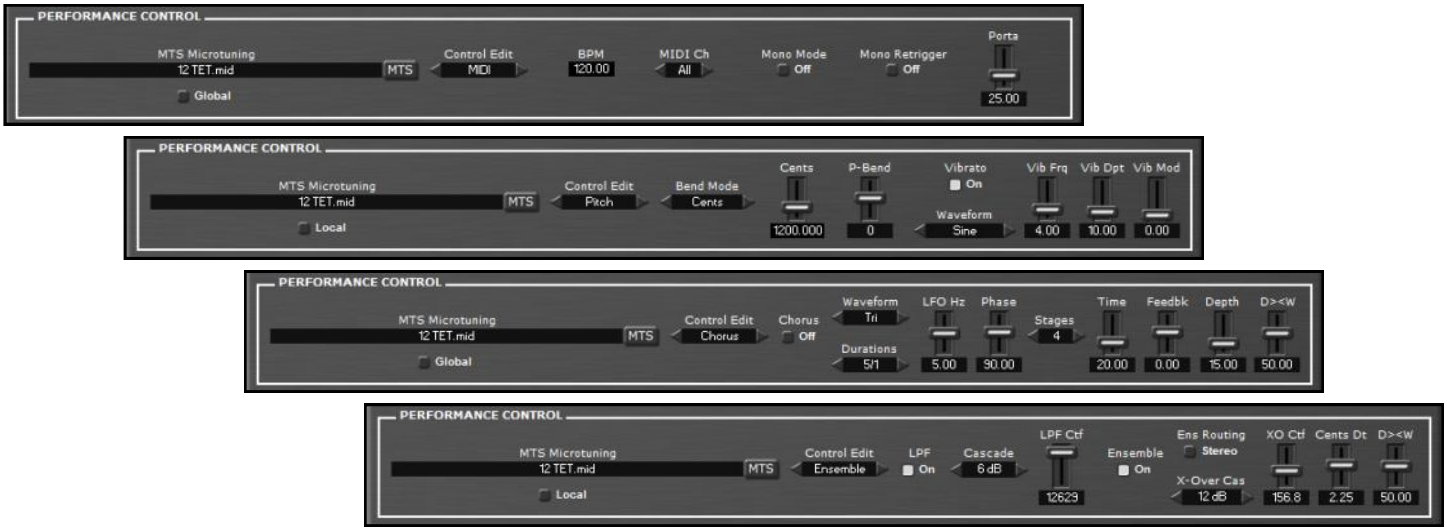
Click the **Patch Management** button to access patch **Copy**, **Load** and **Save** options:

- Copy patches to a single location or to a range of patches with the **Copy Patch** menu option.
- Load an FXP single instrument patch file with the **Load Inst** menu option.
- Save an FXP single instrument patch file with the **Save Inst** menu option.
- Load an FXB bank file that can contain up to 128 patches with the **Load Bank** menu option.
- Save an FXB bank file that can contain up to 128 patches with the **Save Bank** menu option.

Type a new name for the current patch into the **Patch Name** field when designing custom timbres.

Select from the available 128 patches stored in the current bank by clicking the **Patch Number** drop-down menu, or alternatively use the left and right arrow buttons found to the right of the menu to step through the available patches in a bank.

Any changes made to the currently selected patch are automatically saved with that patch number.



The Global and Local Microtuning file loaders, as well as the four Performance Control pages for MIDI, Pitch, Chorus and Ensemble.

Use the **Performance Control** (MIDI-to-CV) section to make basic performance settings for the control of the VSTi. Switch between the four **Performance Control** pages: **MIDI**, **Pitch**, **Chorus** and **Ensemble** using the **Control Edit** selector. The **Chorus** and **Ensemble** effects in this section are placed at the final output stage of the VSTi and are able to make the component parts of the FM timbre blend and cohere in a pleasant way.

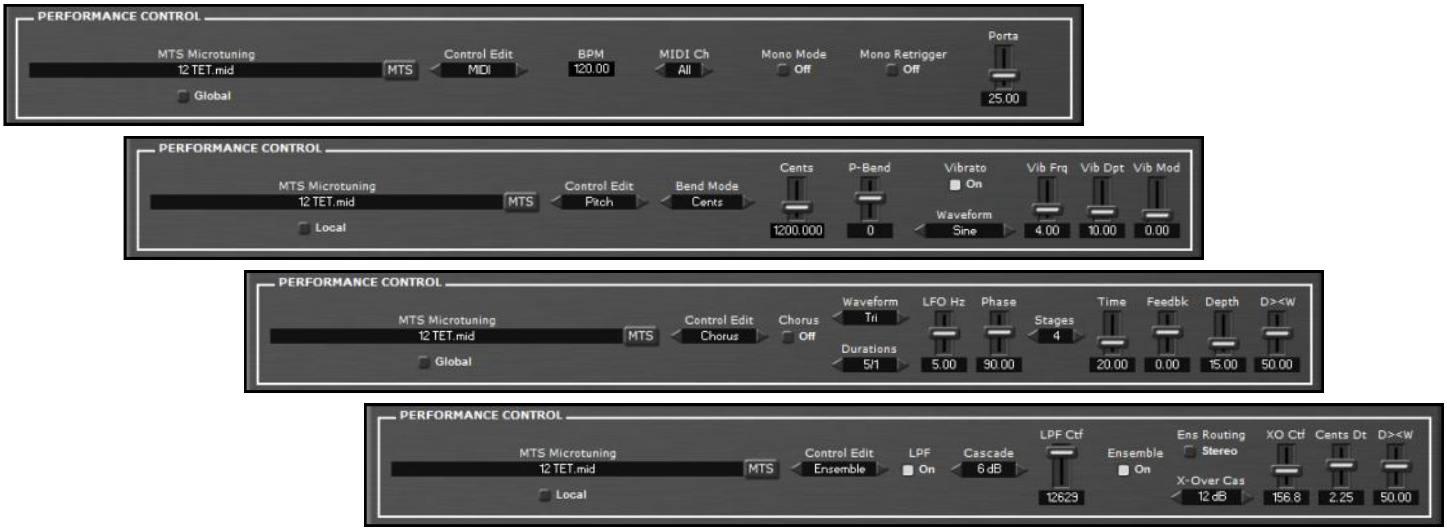
The Xenharmonic FMTS 2 VSTi enables loading both a **Global MTS Microtuning** as well as a **Local MTS Microtuning**. The Global MTS Microtuning will stay loaded even on patch changes and can be used to play in a constant tuning while previewing the patches in a bank. The Local MTS Microtuning, however, is saved at the patch level and is restored whenever a patch with an associated microtuning is opened. Choose to play the current patch with either the loaded Global or Local MTS Microtuning by using the button beneath the **MTS Microtuning** file loader.

MIDI: View the host tempo in the **BPM** display. Select the desired **MIDI Channel** with the **MIDI Ch** selector. Activate or deactivate **Monophonic Mode** with the **Mono Mode** selector. While in **Mono Mode** the synthesizer will only be capable of playing one note at a time, which is useful for bass and single note melodic lines and leads. Activate or deactivate **Mono Retrigger** using the selector. Enabling **Mono Retrigger** while the synthesizer is in **Mono Mode** causes **Envelope Generators** to be retriggered with each note-on. Leave this in the Off position to play smooth mono-legato passages. Set the Portamento Time using the **Portamento** slider. **Note: Portamento is only available when Mono Mode is active.**

Pitch: Choose from the three pitch bend modes using the **Bend Mode** selector: **Harmonic** (harmonic series), **Super** (superparticular ratios) and user configurable **Cents**. **Harmonic Bend Mode**: Using the Ratios selector, set the Pitch Bend range with the available Harmonic Series intervals. Range is from 2/1 to 8/1. **Super Bend Mode**: Using the Ratios selector, set the Pitch Bend range with the available Superparticular intervals. Range is from 2/1 to 32/31. **Cents Bend Mode**: Set the pitch bend range in cents using the Cents slider. Range is 4800 cents max. The **Bend** knob is, by default, mapped to the pitch-bend controller.

Activate or deactivate **Vibrato** using the selector. Choose from the available **vibrato waveforms** using the **Vibrato Wave** dropdown list. Set the **vibrato rate** in Hertz using the **Vib Frq** slider. Set the **depth of vibrato** using the **Vib Dpt** slider. **Vibrato** is by default mapped to the **MIDI Modulation** controller. Movements of the **Mod-Wheel** on an attached MIDI controller will move the **Vib Mod** slider. It is possible to map this parameter to other MIDI Continuous Controllers if needed.

The default selection of MTS microtunings saved with the VSTi have the 1/1 of the tuning on MIDI Note C 60 with a Reference Pitch of 261.626 Hertz at note C 60.



The Global and Local Microtuning file loaders, as well as the four Performance Control pages for MIDI, Pitch, Chorus and Ensemble.

Chorus: Chorus is an effect that is created with multiple LFO modulated delay lines (called here Stages) with short time delays, where each of the LFO waveforms can be set to modulate with a different phase. These modulated delay line Stages (independent voices in the Chorus) are mixed with the dry input signal, which creates the characteristic ensemble effect that we typically associate with chorus.

A related effect is called Flanging. The difference between Flanging and Chorus is a matter of the delay times of the modulated delay lines:

- Flanging delay times are typically within an approximate boundary of 0-20 ms. Flanging also incorporates higher level Feedback settings to get that characteristic notched sweeping sound.

- Chorus delay times are typically within an approximate boundary of 20-60 ms. Chorus will usually have lower, or no, Feedback settings.

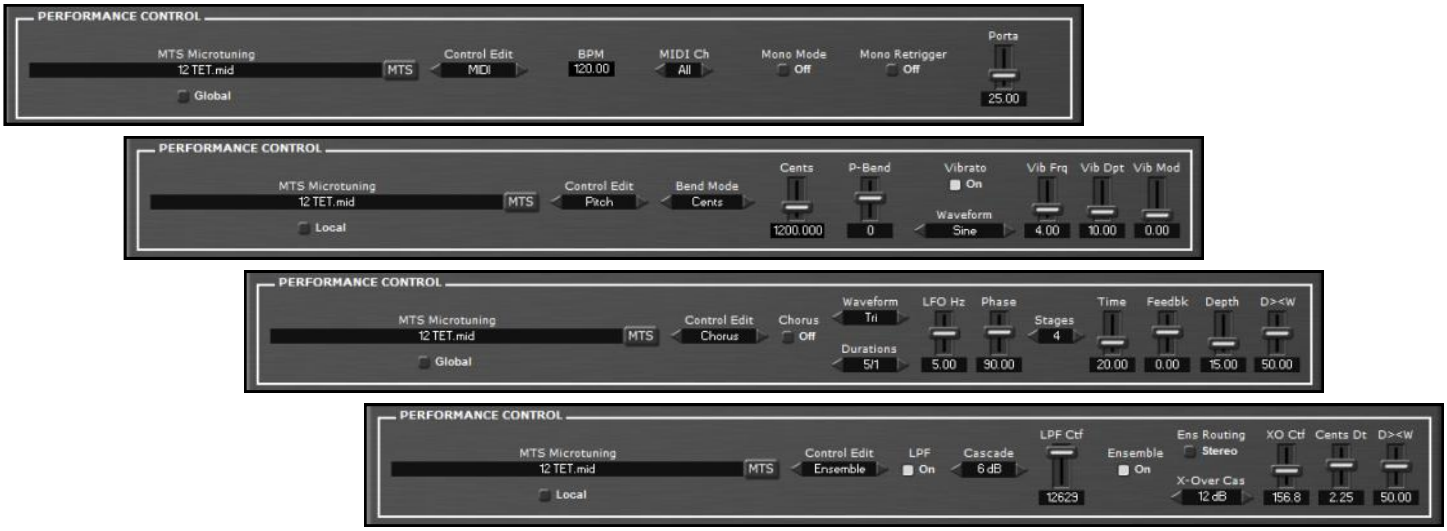
The Chorus effect in this VSTi is extremely versatile and can operate within a range of 0-100 ms, making it possible to create myriad fine gradations of Flanging and Chorus sounds.

Activate or deactivate the **Chorus** Effect using the **Chorus On-Off** button. Select the waveform for the LFO using the **Waveform** selector. Options are **Sine**, **Tri**, **Peak**, **Dip**, **Hump** and **Noise**, each of which imparts a unique modulation character.

Select the musical duration period for the selected LFO waveform using the **Durations** selector. The first option available in the list of choices if **Hertz**, and when this is selected, the rate of the LFO is set manually using the **LFO Freq** slider within a range of .**001-10 Hz**. When any of the other musical duration options are selected, the LFO operates in a mode in which it is synced to the host DAW tempo.

Use the **Phase** slider to change the phase relationships of the four internal LFOs that are used to modulate each **Stage** of the selected effect. Changing these phase relationships creates a corresponding change to the sonic character of the modulation, as well as the overall timbre of the oscillator signal.

Use the **Stages** selector to specify the number of available stages that will be modulated by the LFO. Chorus has from 1 to 4 Stages. Set the delay time in milliseconds using the **Time** slider. The **Time** range is from 0 to 100 ms. Set the feedback level using the **Feedbk** slider. The feedback range is from **–100 to 100** and the extremes of high and low feedback settings will produce a sound that is more characteristic of **Flanging**, while lower, or no, feedback settings are typical of **Chorus**. Set the depth at which the LFO will modulate the selected effect using the **Depth** slider. This is an important setting for creating a useful blend and fusion between the dry oscillator signal and the wet processed one. Balance the levels between the dry oscillator signal and the processed effect signal using the **D><W** slider. At a setting of 50 there is an equal mix of dry signal with the effect, at 0 all Dry, at 100 all Effect. This is also a critical setting for creating a musically useful blend between the dry and effects signals.



The Global and Local Microtuning file loaders, as well as the four Performance Control pages for MIDI, Pitch, Chorus and Ensemble.

Ensemble: Activate or deactivate the Lowpass Filter ('warm' filter) using the **LPF** selector. Set the slope of the filter using the **Cascade** selector. Range is from 6 dB to 48 dB per-octave. Using the 6 dB setting, the roll off of upper frequency content in the synthesizer signal is more subtle, while the opposite extreme 48 dB setting gives one the ability to sharply roll off upper frequencies of the timbre, which can be useful for controlling extremely bright sounding timbres or aliasing resulting from Ring and Audio-Rate Modulation of the Operators, Filters, Amplifier and Pitch. Set the cutoff frequency of the **LPF** effect using the **LPF Ctf** left and right arrows.

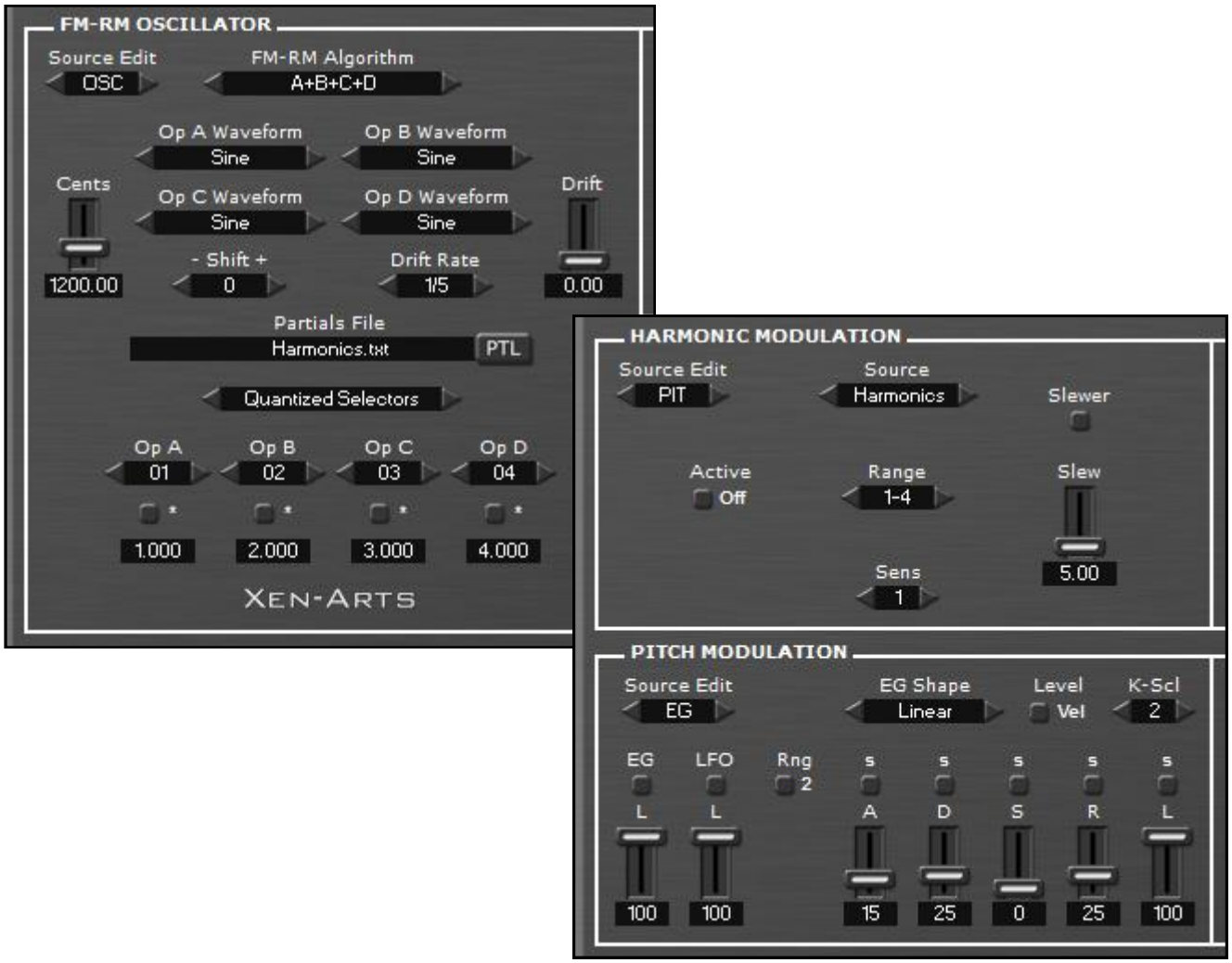
Activate or deactivate the Ensemble effect using the **Ensemble** selector. This is a four-voice ensemble detuning effect that can be used to make waveforms more rich sounding by playing copies of the sound at different closely spaced intervals. Choose to place the four voices of the **Ensemble** effect in either a stereo arrangement, or otherwise collapse all of them to mono using the **Ens Routing** options.

The **Ensemble** effect has a **crossover filter** that passes frequencies in the synthesizer signal above the filter cutoff which are then processed by the four-voice stereo (or mono) Ensemble effect, while frequencies beneath the cutoff frequency are not processed and are in heard mono. Set the filter response of the crossover filter using the **X-Over Cas** (Crossover Filter Cascade) selectors. The options are:

6 dB - 6 dB per octave Low-Pass and High Pass filters.
12 db - 12 dB per octave Low-Pass and High Pass filters.
18 dB - 18 dB per octave Low-Pass and High Pass filters.
Bypass - In the Bypass mode, the crossover filter is disabled and the full frequency range of the synthesizer signal is processed by the Ensemble effect.

Set the **cutoff crossover frequency** in Hz of the **X-Over Filter** using the **XO Ctf** slider. This can radically transform and shape the sound of the synthesizer in quite musically useful ways. Set the depth of detuning of the **Ensemble** effect using the **Cents Dt** slider. The maximum range is -/+ 55 cents. Set the **dry-to-wet balance** of the **Ensemble** effect using the **D><W** slider. Values below 50 have less of the effect, while greater than 50 makes the effect more pronounced. It is often a good idea to allow some of the dry signal to pass through by keeping the slider in the middle range, as the dry synth sound is also a fifth 'voice' in the effect.

Special Note: Xen-Arts cares about protecting musician's audio gear and has added to the Ensemble section of this VSTi a steep low-cut filter. This hidden filter attenuates extremely low frequencies that are typically beneath the reproducible range of most consumer monitors and headphones.

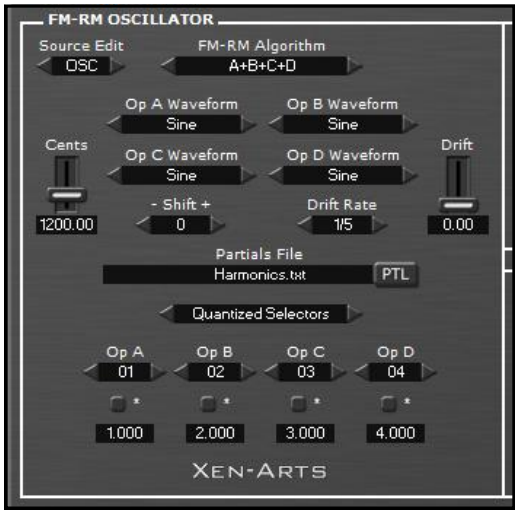


The two Source Edit pages of the FM-RM Oscillator section: OSC (Oscillator) and PIT (Pitch).

The **FM-RM Oscillator** section of the Xenharmonic FMTS 2 VSTi has two pages accessible by using the **Source Edit** selector: **OSC** (Oscillator) and **PIT** (Pitch).

Source Edit: OSC
Access editing functions related to control of the FM-RM Oscillator: **Algorithms**, **Waveforms**, **Pitch Transposition**, **Pitch Drift** and **Partials**.

Source Edit: PIT
Access editing functions related to pitch modulation of the FM-RM Oscillator: **Harmonic Modulation** and **Pitch Modulation**.



The FM-RM Oscillator functions

The **FM-RM Oscillator** section is the heart of the VSTi and is capable of producing a wide range of complex timbres for microtonal and xenharmonic music creation. The oscillator itself is a hybrid including both FM and Ring Modulation synthesis capabilities. Partials files may be loaded here to configure the operator ratios to values that are coincident with the MTS microtuning one has loaded in the Performance Control (MIDI-to-CV) section (which can generate tuning related FM sidebands), thereby creating an audible correlation between the timbre of the instrument and the intonation system being used for musical composition.

The FM-RM Oscillator is made up of 4 Operators - which are in fact 4 separate oscillators in one - and these operators are variously able to: sum to the output, frequency modulate, and or ring modulate each other according to the selected algorithm.

Arbitrary pitch transpositions of the oscillator may be set by using the **Cents** slider (which permits typing and pasting values into its field) and using the - **Shift +** selector. The range of transposition is -/+ 16 times the value specified in the Transpose Cents field. This unique feature enables microtonal musicians and composers to transpose the pitch of the instrument to any interval required. This can be very useful where the period (or repeat-ratio) of the microtuning may be something other than the typical 2/1 of 1200 cents, such as in a scenario where one is composing with non-octave tunings and might need to transpose the instrument to a non-octave period. A good example would be the **Bohlen–Pierce** temperament, which is a division of the 3rd harmonic into 13 equal steps. To transpose the VSTi by the period of the Bohlen–Pierce temperament, type or paste **1901.955** into the Cents field. The Bohlen–Pierce temperament MTS Microtuning File, Operator Ratio File and a selection of BP patches are included with Xen-FMTS for musicians to explore this fascinating non-octave microtuning.

Choose from the available **57 FM Algorithms** using the **FM-RM Algorithm** selector.

Each Operator can be set to one of eleven different waveforms, which can be selected using the **Op Waveform** dropdown lists. The **Operator Waveform** options are: Sine, Saw, Ramp, Soft Ramp, Peak Ramp, Square, Triangle, Peak, Octava, Cluster1 and Cluster2.

It is possible to use the Sine waveforms for standard FM synthesis tasks, while choosing the other harmonic waveforms will generate more complex composite spectra.

Drift Rate: Controls Rate of Analogue Drift. Simulates the small voltage variances of analogue synths causing pitch drifting over time. **Drift** slider: Controls the depth of the Analogue Drift.

All of the **Algorithms** are displayed in a mathematical equation style. Functions within brackets are performed first, as is usual, and from left to right in other cases.

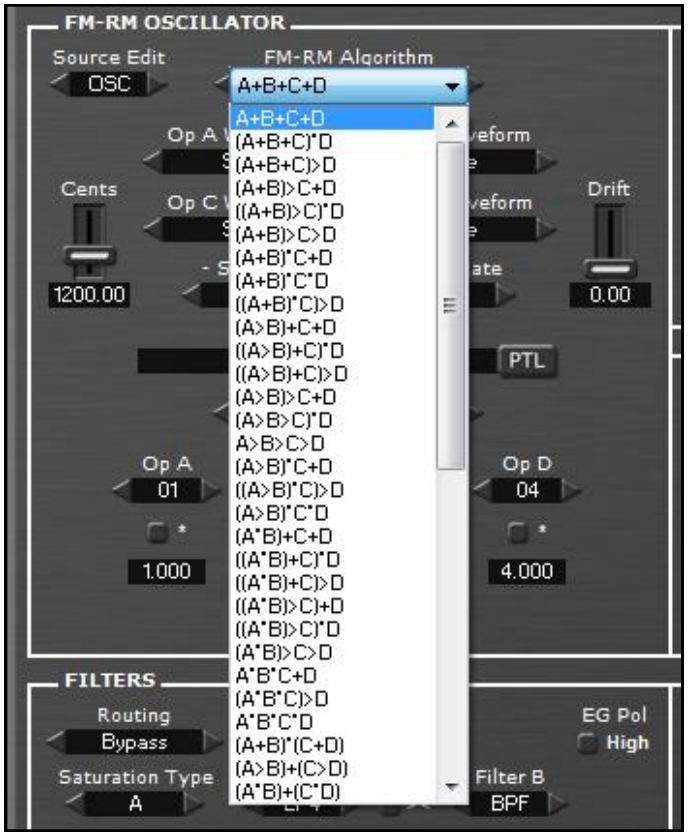
' ***** ' Indicates the **Ring-Mod** function, i.e., (A*B) Wave_A Ring-modulates Wave_B

' **>** ' Indicates the **FM** function, i.e., (A>B) Wave_A FM-modulates Wave_B

Where "A>B>C" = Wave_A FM-modulates Wave_B, the resulting Wave then FM-modulates Wave_C

The Algorithm List:

01	A+B+C+D	34	(A>B)+(A>C)+D
02	(A+B+C)*D	35	(A>B)+(A>C)+(A>D)
03	(A+B+C)>D	36	(A>B)+(A*C)+D
04	(A+B)>C+D	37	(A>B)+(A*C)+(A>D)
05	((A+B)>C)*D	38	(A>B)+(A*C)+(A*D)
06	(A+B)>C>D	39	(A*B)+(A*C)+D
07	(A+B)*C+D	40	(A*B)+(A*C)+(A*D)
08	(A+B)*C*D	41	(A+B)+(A>C)+D
09	((A+B)*C)>D	42	(A+B)+(A*C)+D
10	(A>B)+C+D	43	(A+B)+(A>C)+(A>D)
11	((A>B)+C)*D	44	(A+B)+(A*C)+(A*D)
12	((A>B)+C)>D	45	(A+B)+(A>C)+(A*D)
13	(A>B)>C+D	46	((A+B)>C)+((A+B)+D)
14	(A>B>C)*D	47	((A+B)>C)+((A+B)>D)
15	A>B>C>D	48	((A+B)>C)+((A+B)*D)
16	(A>B)*C+D	49	((A+B)*C)+((A+B)*D)
17	((A>B)*C)>D	50	((A>B)>C)+((A>B)+D)
18	(A>B)*C*D	51	((A>B)>C)+((A>B)>D)
19	(A*B)+C+D	52	((A>B)>C)+((A>B)*D)
20	((A*B)+C)*D	53	((A>B)*C)+((A>B)*D)
21	((A*B)+C)>D	54	((A*B)>C)+((A*B)+D)
22	((A*B)>C)+D	55	((A*B)>C)+((A*B)>D)
23	((A*B)>C)*D	56	((A*B)>C)+((A*B)*D)
24	(A*B)>C>D	57	((A*B)*C)+((A*B)*D)
25	A*B*C+D		
26	(A*B*C)>D		
27	A*B*C*D		
28	(A+B)*(C+D)		
29	(A>B)+(C>D)		
30	(A*B)+(C*D)		
31	(A*B)+(C>D)		
32	(A>B)*(C>D)		
33	(A*B)*(C>D)		

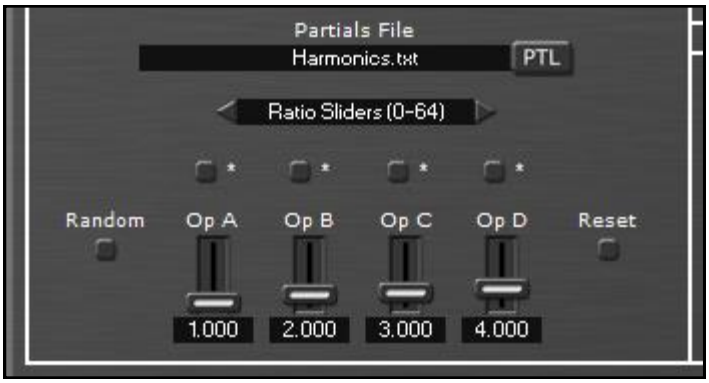


The versatile FM-RM Oscillator includes 57 different algorithms

The Xenharmonic FMTS 2 VSTi offers users four different methods for specifying the frequency ratios of the **Operators** in the FM-RM Oscillator: **Ratio Sliders (0-64)**, **Random Index Sliders**, **Iso-Index** and **Quantized Selectors**. The user may switch between these four options using the selector beneath the **Partials File** field.

All of the settings made with each of these options are saved at the patch level, and provide an easy way to create up to four timbre variations in a patch.

When using the **Random Index Sliders**, **Iso-Index** and **Quantized Selectors**, the frequency ratios for the Operators are set by loading a **Partials File**, which is an index of 32 ratio values contained in a text (TXT) file. With these selection modes, the operator frequency ratios are quantized to the index values contained in the loaded TXT file. Click the **PTL** button to load a **Partials File**. A selection of partials files are included with the VSTi, but users may freely create their own using **Windows Notepad**. Type or paste your own ratio values into Notepad, where each of 32 lines contains a single frequency ratio value. **Set the TXT file properties to 'Read Only' in order to preserve their contents and formatting, and save them into the plugin content directory of Xen-FMTS 2.**



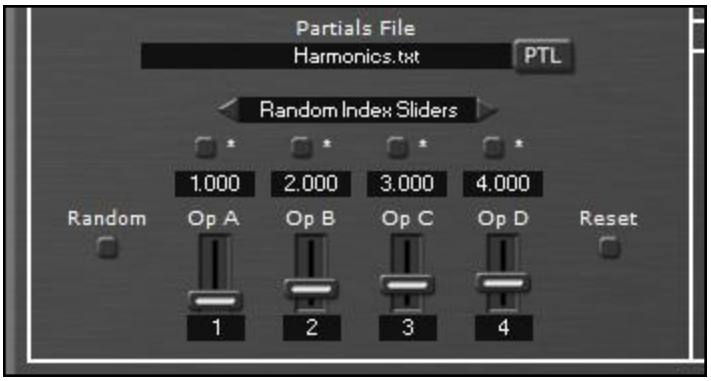
Source Edit: OSC | Ratio Sliders (0-64)

With the **Ratio Sliders (0-64)** option selected, the row of sliders labeled **Op A, B, C, D** may be used to specify any arbitrary frequency ratio values for the Operators within the range of 0 to 64. Values for each slider may also be directly typed or pasted into the fields beneath the controller.

Additionally the sliders may be randomized by pressing the **Random** button, or reset to their default settings: 1, 2, 3, 4 by pressing the **Reset** button.

Selectors directly above each slider enable the user to either **Multiply *** or **Divide /** the pitch of the operator by the specified frequency ratio.

IMPORTANT: This method of specifying the operator ratios does not utilize the FM-RM Oscillator Partials Files.

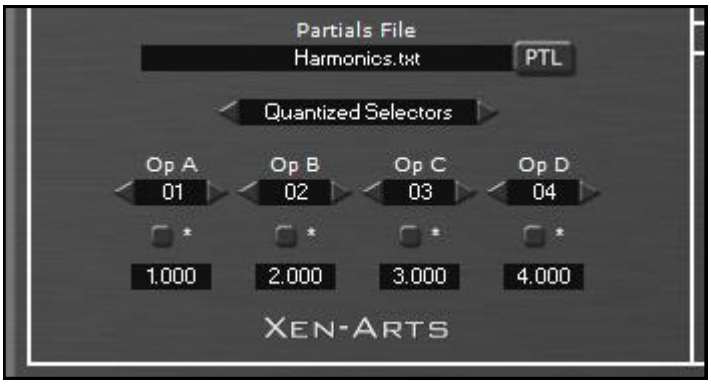


Source Edit: OSC | Random Index Sliders

Using the **Random Index Sliders** option, the operator frequency ratio values are quantized to the loaded **Partials File** and may be randomized by pressing the **Random** button, or reset to their default settings: 1, 2, 3, 4 by pressing the **Reset** button.

Values underneath the sliders indicate the selected **Index** value, while the readouts above the sliders display the frequency ratio values for the selected index of the currently loaded **Partials File**.

Selectors above each slider enable the user to either **Multiply *** or **Divide /** the pitch of the operator by the specified frequency ratio.



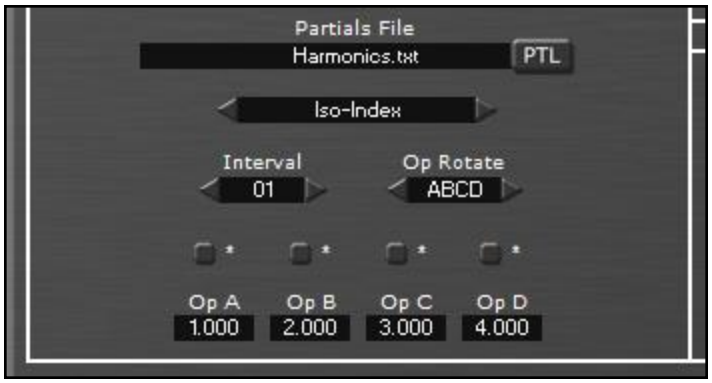
Source Edit: OSC | Quantized Selectors

With the **Quantized Selectors** option, each of Operators A-D may be set to any of the available 32 index values in the currently loaded FM-RM Oscillator Partials File, which gives the user maximum flexibility for quantizing the frequency ratio values for particular algorithms.

Use the **Op A**, **Op B**, **Op C**, **Op D** selectors to make Index selections. Frequency Ratio values for the Index selections are displayed in the readouts below.

Selectors above each frequency ratio readout enable the user to either **Multiply *** or **Divide /** the pitch of the operator by the specified frequency ratio.

A common application for creating timbres with the FM-RM Operator Partials Files is to load a file that has frequency ratio values made for the particular MTS Microtuning one has loaded in the FM-RM Oscillator section, which creates a correlation between the tuning and the timbre. For instance, load the Partials File, 07 TET Partials.txt, when using the MTS microtuning, 07 TET.mid.



Source Edit: OSC | Iso-Index

With the **Iso-Index** option, users can specify an equal value between each of the four Indexes using the **Interval** selector to place gaps between each index value.

For instance, when one has loaded the **Partials File**, **Harmonics.txt**, and with the **Interval** value set to 1, the output Operator frequency ratios are set to 1, 2, 3, 4, as displayed by the readouts beneath the selector. With the Interval value set to 2, the output operator frequency ratio values are set to 1, 3, 5, 7, and with it set to 3, they are 1, 4, 7, 10, and so on.

The range of the **Iso-Index** is from 1 to 30. Once the size of the **Interval** selector exceeds the index range, values are wrapped downward. Astonishing variations in the timbre can be created as the index values wrap, creating interesting new relationships between the operators. This is an extremely powerful feature for microtonal and xenharmonic music sound-design.

A significant enhancement to **Xen-FMTS 2** over the previous versions is the addition of the **Op Rotate** feature for the **Iso-Index**, which enables the user to reroute the frequency ratio values of the Iso-Index to other operators.

For example, with the Harmonic Series.txt Partials File loaded, and Interval set to 1:

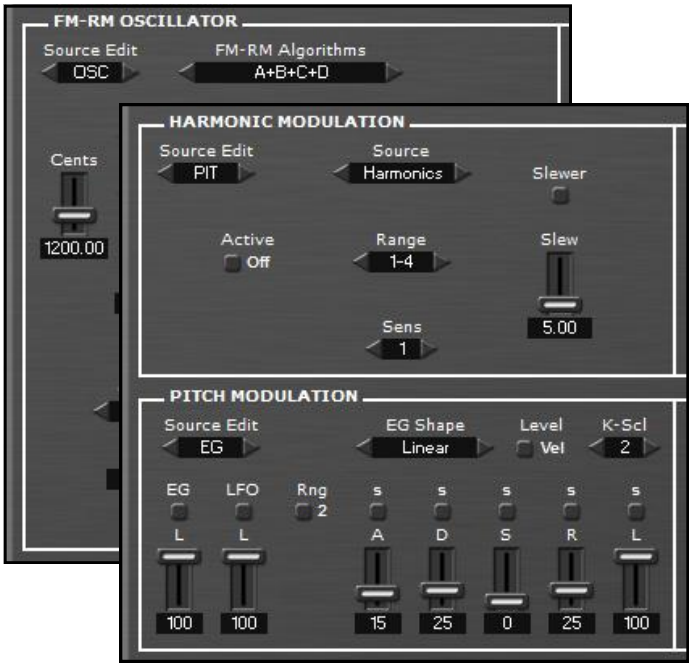
Op Rotate: ABCD routes **Op A** = 1, **Op B** = 2, **Op C** = 3, **Op D** = 4

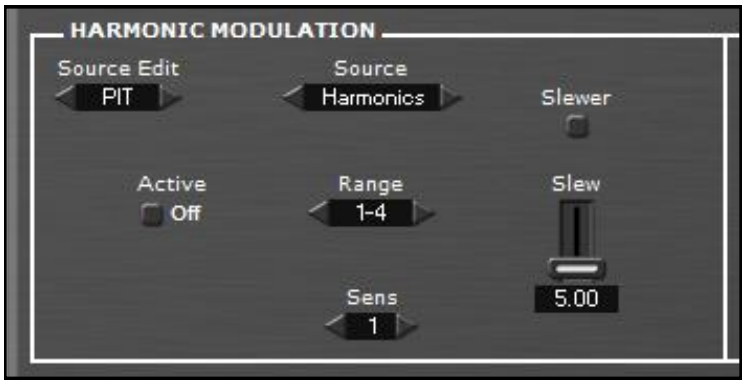
Op Rotate: BCDA routes **Op A** = 2, **Op B** = 3, **Op C** = 4, **Op D** = 1

Op Rotate: CDAB routes **Op A** = 3, **Op B** = 4, **Op C** = 1, **Op D** = 2

Op Rotate: DABC routes **Op A** = 4, **Op B** = 1, **Op C** = 2, **Op D** = 3

Selectors above each frequency ratio readout enable the user to either **Multiply *** or **Divide /** the pitch of the operator by the specified frequency ratio.





Harmonic Modulation enables MIDI Velocity controlled modulation of the fundamental pitch of the oscillator by harmonics, or alternatively, index values of the loaded partials files

Source Edit: PIT | Harmonic Modulation

This VSTi has a unique feature found only in **Xen-Arts** instruments: **Velocity-to-Harmonics Modulation**, which enables musicians to dynamically break out harmonics of the fundamental pitch in a manner similar to acoustic instruments such as winds and strings, where force from MIDI Velocity directly controls the harmonic level. The **Harmonic Modulation** functions are found on the **PIT Source Edit** page of the **FM-RM Oscillator** section.

Activate or deactivate Velocity-to-Harmonics Modulation using the **Active** button. Set the harmonic range using the **Range** selector. Options are harmonics **1-2**, **1-4**, **1-8** and **1-16**.

Specify whether MIDI Velocity will modulate the fundamental pitch of the oscillator according to a **Harmonic Series** or the loaded **Partials** file using the **Source** selector.

Set the sensitivity response of MIDI Velocity for harmonic modulation using the **Sens** selector. Options are **1**, **2** and **3**. A lower setting sets the sensitivity such that lighter force is required to break out higher harmonics, while higher settings require stronger force on the MIDI controller.

Activate or deactivate the Slewer with the **Slew** button. Use the Slew slider to specify the slew rate in milliseconds. This can be used for creating short pitch glides that smooth the transitions of the harmonic modulation. Range is from **0** to **250 ms**.

Shown in the red areas above are the seven Xen-FMTS 2 modulators: one each for Operators A-D, Filters, Amplifier and Pitch

The Xen-FMTS 2 VSTi features seven dedicated hybrid modulators for Operators A, B, C, D, Filters, Amplifier and Pitch.

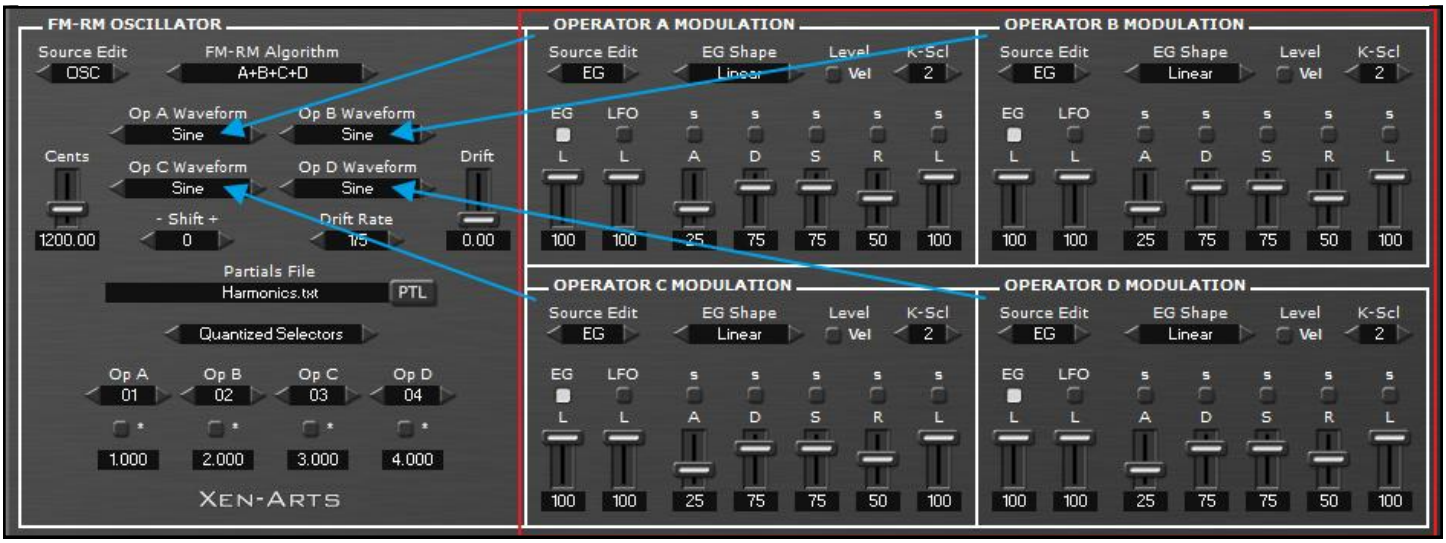
Each modulator includes an ADSR style envelope generator, and an LFO which can be switched to run at audio-rate.

Each ADSR Envelope Generator features Per-Stage Keyboard Tracking.

LFOs can either be synchronized to the host DAW tempo or set in Hertz. They include 24 Waveforms, a Slewer and can be switched to run at audio-rate.

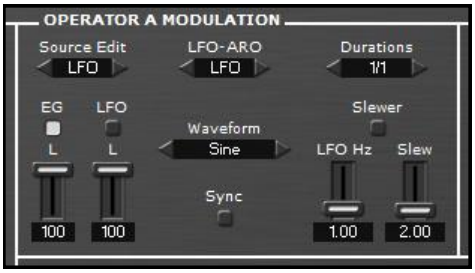
On pages that will follow this brief overview, the functions of the Modulators will be explained in detail.

All of the seven modulators share common features. Let's consider those dedicated to modulating the amplitude of the Operator waveforms, which is a core feature of the synthesis engine.

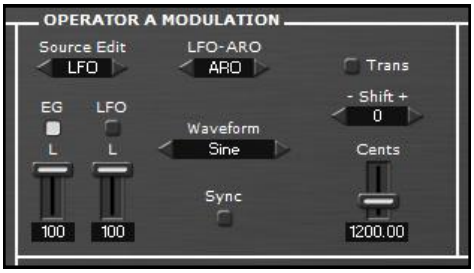


The modulators for Operators A-D are used for modulating the amplitude of the selected waveform

The Envelope Generator page



The LFO page



The LFO page switched to ARO

Each modulator has two primary pages: the **EG** (Envelope Generator) and **LFO** (Low Frequency Oscillator) The **LFO** has an **ARO** sub-page for switching the LFO to run at **Audio-Rate**.

Switch between the **EG** and **LFO** pages using the **Source Edit** selector.

The mixer for the EG and LFO modulation sources

Directly below the **Source Edit** selector is a simple mixer for the **EG** and **LFO** which is always visible. The mixer includes activator switches for the enabling or disabling the **EG** and **LFO**, and sliders, labeled **L**, for mixing their relative levels.

Please note that when both the EG and LFO are active, the EG modulates the level of the LFO.

The Envelope Generator page

The modulator **EG** page includes an **ADSR** style **Envelope Generator** with keyboard tracking features.

A = Attack, D = Decay, S = Sustain, R = Release and L = Level

Set the **ADSR** timings for the **EG** using the provided sliders, or otherwise type timing values into the fields beneath them. Range is 0-100 max.

Above each **ADSR** slider there is a three position selector for configuring the behavior of linear keyboard tracking for each stage of the envelope generator. In the '**s'** position, keyboard tracking is disabled and the stage is controlled entirely by the slider alone. When set to '**+'**, playing lower on the MIDI controller will shorten the time of the envelope stage, while playing higher will lengthen it. Conversely, when the selector is set to '**-'**, playing lower on the MIDI controller will lengthen the time of the envelope stage, while playing higher will shorten it.

Use the **K-Scl** selector to scale the linear keyboard tracking. This operates in direct relation to, and in interaction with, the settings made to the keyboard tracking selector for each of the envelope stages, and enables the user to find the best balance and tracking behavior for the ADSR across the MIDI range.

Specify the shape of the **EG** control signal using the **EG Shape** selectors. **Linear** is the EG standard mode, while the other shapes radically change the timing and rate of the EG control signal, which can be useful for synthesizing plucked-string-like timbres and percussive sounds.

Use the **Level** mode selector to switch between the two level modes, which also determines the behavior of the **Level** slider:

Vel - In this mode the **Level** slider sets the depth of **MIDI Velocity** amplitude modulation, enabling dynamic performance volume control. Softer play on the MIDI controller will sound quieter, while greater force of play will be louder.

Lvl - In this mode the overall volume of the synthesizer is set with the **L** slider and the EG does not respond to MIDI Velocity.

The LFO page

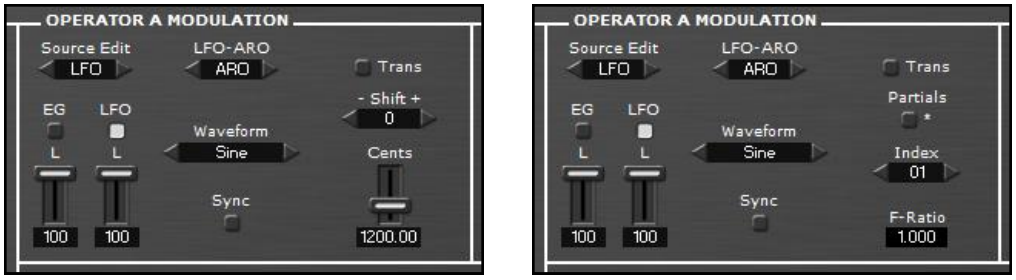
Switch to the **LFO** edit page using the Source Edit selector. Switch between the **LFO** and **ARO** functions using the **LFO-ARO** selector.

Choose the waveform for LFO-ARO modulation using the **Waveform** selector.

Choose whether or not to sync the **LFO** waveform to each **MIDI Note-On** using the **Sync** activator button. Leave this off for pad-type sounds for a continuously evolving modulation effect, and on for timbres that use the LFO as a kind of periodic envelope generator, where one needs the LFO waveform to consistently start at the beginning of the wave cycle.

Use the **Durations** selector to choose from either **Hertz** (the first choice in the list), which enables using the **LFO Hz** slider to specify the frequency of the LFO, or otherwise host synchronized standard musical durations ranging from 128/1 to 1/128.

Activate or deactivate the slewer using the **Slewer** activator button. When activated, specify the slew rate in milliseconds using the **Slew** slider. Range is 0 to 250 ms. The Slewer enables smoothing the transitions of certain waveforms.



The LFO page with the LFO switched to run at audio-rate (ARO)

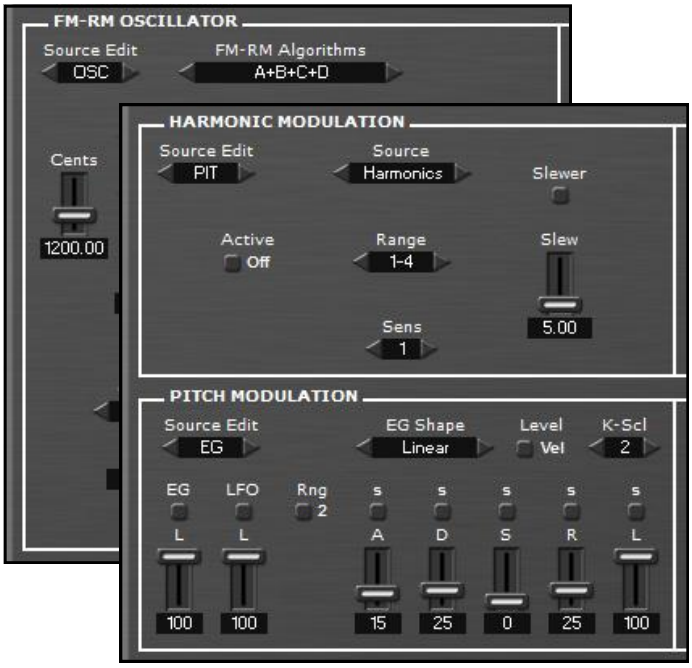
Switch to the **LFO** edit page using the Source Edit selector. Switch between the **LFO** and **ARO** (Audio Rate Oscillator) functions using the **LFO-ARO** selector. With the LFO running at audio-rate, the pitch is controlled by the **MIDI-to-CV** and the loaded **MTS Microtuning** file; transforming the LFO into a pitch-accurate microtonal-controlled oscillator, which is in turn capable of introducing microtuning related sideband spectra into the composite synthesizer signal.

Choose the waveform for LFO-ARO modulation using the **Waveform** selector. Select whether or not to sync the **LFO** waveform to each **MIDI Note-On** using the **Sync** activator button. Leave this off for a free-running **ARO**, and on where one needs the LFO waveform to consistently start at the beginning of the wave cycle.

Use the **Trans** selector to switch between the two different **ARO** transposition modes: **Cents** and **Partials**. In the **Cents** mode, the transposition interval is specified in cents using the **Cents** slider. Cents transposition offsets are made using the **- Shift +** selector. Range is from –16 to 16.

In the **Partials** transposition mode, transposition offsets are quantized to the loaded **Partials File**. Use the **Index** selector to set the degree of transposition.

Choose to Multiply ***** or Divide **/** the fundamental pitch of the ARO by the selected frequency ratio using the **Partials */** button.



The Pitch Modulation section of the FM-RM Oscillator

Source Edit: PIT | Harmonic and Pitch Modulation

The **PIT** page of the **FM-RM Oscillator** features a **Pitch Modulation** section, which is a dedicated hybrid modulator that includes an ADSR style Envelope Generator, and an LFO that can be switched to run at audio rate.

The Pitch Modulation section has two primary pages: the **EG** (Envelope Generator) and **LFO** (Low Frequency Oscillator) The **LFO** has an **ARO** sub-page for switching the LFO to run at **Audio-Rate**.

Switch between the **EG** and **LFO** pages using the **Source Edit** selector.

The mixer for the EG and LFO modulation sources

The Rng button can be used to limit the Range of Pitch Modulation

Directly below the **Source Edit** selector is a simple mixer for the **EG** and **LFO** which is always visible. The mixer includes activator switches for the enabling or disabling the **EG** and **LFO**, and sliders, labeled **L**, for mixing their relative levels.

Please note that when both the EG and LFO are active, the EG modulates the level of the LFO.

To the right of the modulation mixer is the **Rng** button, which can be used to constrain the range of pitch modulation from 1 to 4 octaves.

The Pitch Envelope Generator

The **Pitch EG** page includes an **ADSR** style **Envelope Generator** with keyboard tracking features.

A = Attack, D = Decay, S = Sustain, R = Release and L = Level

Set the **ADSR** timings for the **EG** using the provided sliders, or otherwise type timing values into the fields beneath them. Range is 0-100 max.

Above each **ADSR** slider there is a three position selector for configuring the behavior of linear keyboard tracking for each stage of the envelope generator. In the '**s'** position, keyboard tracking is disabled and the stage is controlled entirely by the slider alone. When set to '**+'**, playing lower on the MIDI controller will shorten the time of the envelope stage, while playing higher will lengthen it. Conversely, when the selector is set to '**-'**, playing lower on the MIDI controller will lengthen the time of the envelope stage, while playing higher will shorten it.

Use the **K-Scl** selector to scale the linear keyboard tracking. This operates in direct relation to, and in interaction with, the settings made to the keyboard tracking selector for each of the envelope stages, and enables the user to find the best balance and tracking behavior for the ADSR across the MIDI range.

Specify the shape of the **EG** control signal using the **EG Shape** selectors. **Linear** is the EG standard mode, while the other shapes radically change the timing and rate of the EG control signal, which can be useful for synthesizing plucked-string-like timbres and percussive sounds.

Use the **Level** mode selector to switch between the two level modes, which also determines the behavior of the **Level** slider:

Vel - In this mode the **Level** slider sets the depth of **MIDI Velocity** modulation, enabling dynamic performance control.

Lvl - In this mode the overall level is set with the **L** slider and the EG does not respond to MIDI Velocity.

The LFO page

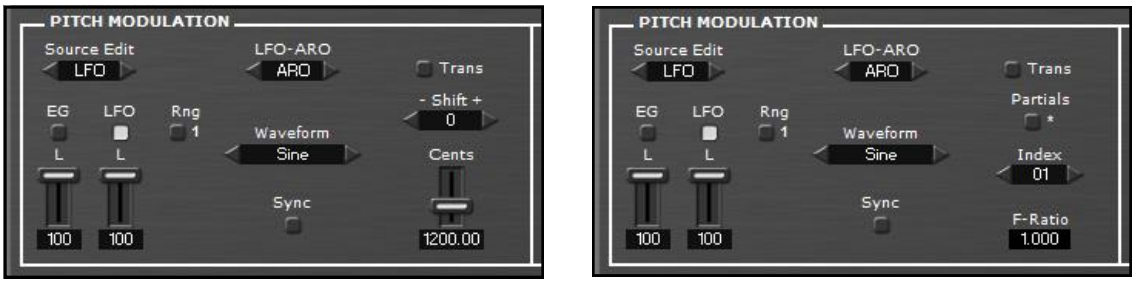
Switch to the **LFO** edit page using the Source Edit selector. Switch between the **LFO** and **ARO** functions using the **LFO-ARO** selector.

Choose the waveform for LFO-ARO modulation using the **Waveform** selector.

Choose whether or not to sync the **LFO** waveform to each **MIDI Note-On** using the **Sync** activator button. Leave this off for pad type sounds for a continuously evolving modulation effect, and on for timbres that use the LFO as a kind of periodic envelope generator, where one needs the LFO waveform to consistently start at the beginning of the wave cycle.

Use the **Durations** selector to choose from either **Hertz** (the first choice in the list), which enables using the **LFO Hz** slider to specify the frequency of the LFO, or otherwise host synchronized standard musical durations ranging from 128/1 to 1/128.

Activate or deactivate the slewer using the **Slewer** activator button. When activated, specify the slew rate in milliseconds using the **Slew** slider. Range is 0 to 250 ms. The Slewer enables smoothing the transitions of certain waveforms.



The LFO page with the LFO switched to run at audio-rate (ARO)

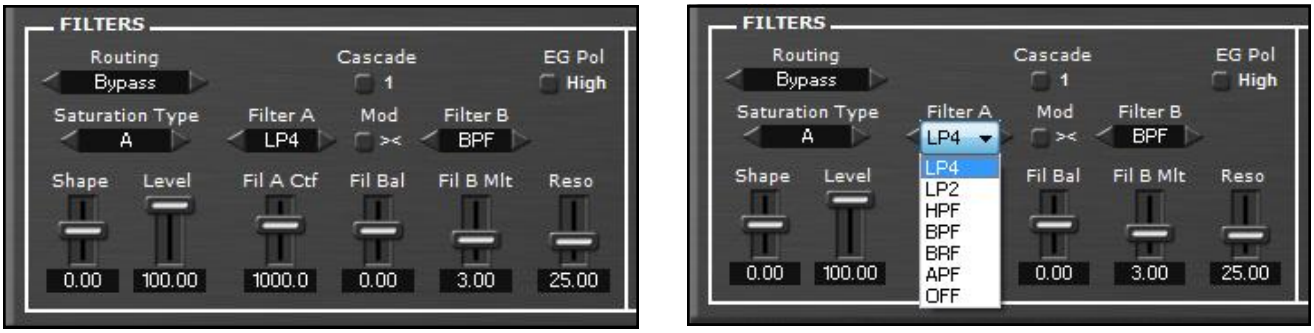
Switch to the **LFO** edit page using the Source Edit selector. Switch between the **LFO** and **ARO** (Audio Rate Oscillator) functions using the **LFO-ARO** selector. With the LFO running at audio-rate, the pitch is controlled by the **MIDI-to-CV** and the loaded **MTS Microtuning** file; transforming the LFO into a pitch-accurate microtonal-controlled oscillator, which is in turn capable of introducing microtuning related sideband spectra into the composite synthesizer signal.

Choose the waveform for LFO-ARO modulation using the **Waveform** selector. Select whether or not to sync the **LFO** waveform to each **MIDI Note-On** using the **Sync** activator button. Leave this off for a free-running **ARO**, and on where one needs the LFO waveform to consistently start at the beginning of the wave cycle.

Use the **Trans** selector to switch between the two different **ARO** transposition modes: **Cents** and **Partials**. In the **Cents** mode, the transposition interval is specified in cents using the **Cents** slider. Cents transposition offsets are made using the **- Shift +** selector. Range is from –16 to 16.

In the **Partials** transposition mode, transposition offsets are quantized to the loaded **Partials File**. Use the **Index** selector to set the degree of transposition.

Choose to Multiply ***** or Divide **/** the fundamental pitch of the ARO by the selected frequency ratio using the ***/** button.



The Filters section features a saturation stage followed by two parallel filters with six filter types.

This section features a pre-filter saturation stage followed by two parallel filters.

Configure the way the FM-RM Oscillator signals are processed by the filter section using the **Routing** selectors. The options are:

Bypass – In this mode the source signals bypass the saturation and filters entirely.

Saturation – The source signals are passed through the saturation stage only and the filters are bypassed.

Sat + Filters – The source signals are passed through both the Saturation stage and Filters.

Filters – The source signals are passed through the filters only and the saturation stage is bypassed.

Using the **Saturation Type** selectors, select from the available 20 different saturation types, each of which imparts a unique quality of saturation, from subtle wave-shaping to extreme distortions.

Use the **Shape** slider to change the wave-shaping and tone quality of the saturation.

Control the relative wet and dry balance between the unprocessed source signals and the saturation effect using the **Level** slider. Lower settings let more of the unprocessed signal pass through, while when set to 100%, the source signals are fully processed by the saturation stage.

Use the **Cascade** selector to switch between (1) a single filter for filters A and B, and (2) two filters in series for each filter.

There are two parallel filters with six different filter types. Select from the filter types using the **Filter A** and **Filter B** selectors. When the **Cascade** selector is set to **1**, the available filter responses are as follows:

LP4 – 4-Pole, 24 dB per octave, Low-Pass filter with a saturation stage and aggressive resonance, which sounds similar to a Moog style filter.

LP2 – 2-Pole, 12 dB per octave, Low-Pass Filter.

HPF – 2-Pole, 12 dB per octave, High-Pass Filter.

BPF – 1-Pole, 6 dB per octave, Band-Pass Filter.

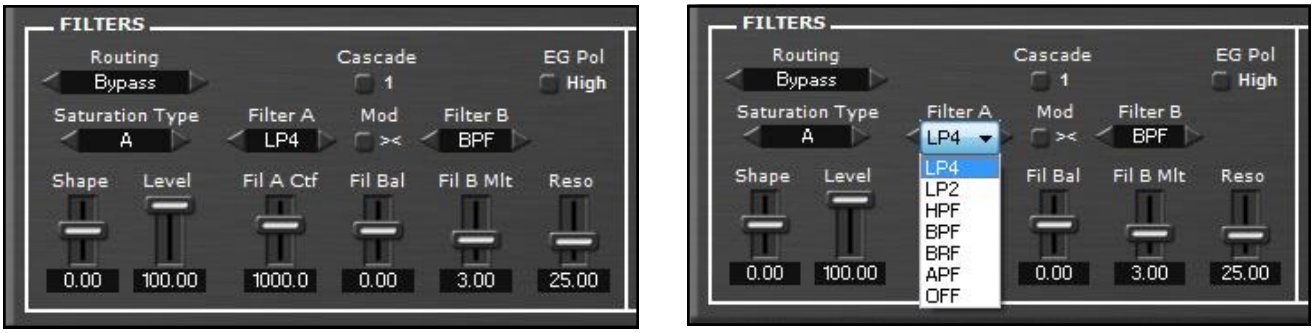
BRF - 1-Pole, 6 dB per octave, Band-Reject Filter.

APF - 2-Pole, 12 dB per octave, All-Pass Filter.

OFF – Disable the filter.

When the **Cascade** selector is set to **2**, then the filter responses for filters A and B are doubled.

Set of the cutoff frequency for Filter A using the **Fil A Ctf** silder. The range is 30 Hz to 8 kHz.



The Filters section features a saturation stage followed by two parallel filters with six filter types.

Use the **Fil Bal** slider to set the relative balance between Filter A and Filter B. Negative values balance towards Filter A, while positive ones toward Filter B. This enables creating unique and complex composite filter sounds. A setting of 0 creates an equal balance between the filters.

The cutoff frequency of Filter B is specified as a multiple of the Filter A cutoff frequency using the **Fil B Mlt** slider. Range is from 1 to 8 times the setting for the Filter A cutoff frequency. For instance, if the cutoff frequency of Filter A is set to 100 Hz, and the Fil B Mlt slider is set to a value of 3, then the cutoff frequency of Filter B is 300 Hz.

Set the resonance of Filters A and B using the **Reso** slider. Be aware that high resonance settings, especially with the Cascade selection of 2, can produce exceedingly loud audio signals. It is advised to take precautions to protect both hearing and audio gear in the event that one chooses to generate loud audio signals in this manner.

The modulation signals that are used for modulating the cutoff frequencies of Filter A and Filter B may be set to either **Unipolar** or **Bipolar** modulation. Use the **Mod** switch to change between these two modes:

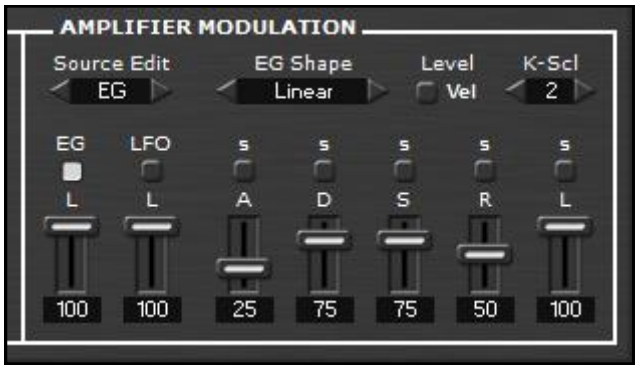
<u>Uniploar Modulation Mode</u> = **>>**
The unipolar modulation mode causes the modulation signals to modulate the cutoff frequencies of Filter A and Filter B in the same direction.

<u>Biploar Modulation Mode</u> = **><**
The bipolar modulation mode causes the modulation signals to modulate the cutoff frequencies of Filter A and Filter B in an opposite direction. This modulation mode for the filters is capable of creating many unique filtered synthesizer sounds.

The Filters Modulation section is dedicated to modulating the Cutoff Frequency of the Filters and features an ADSR style envelope generator, and an LFO which can be switched to run at audio rate.

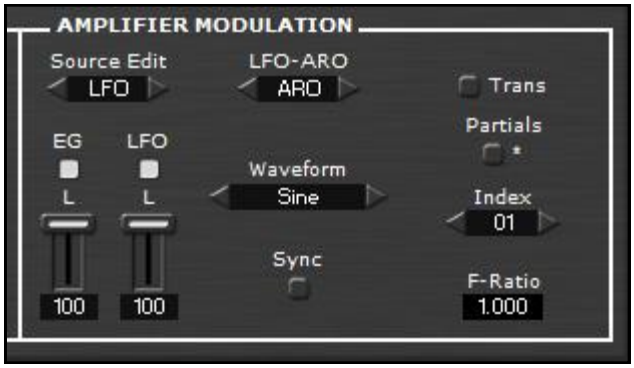
The **Filter Modulation** section features are identical to the other modulators, however, in this context, they are dedicated to modulating the **Cutoff Frequency** of the filters.

Especially useful in this context is the ability to **Audio Rate** modulate the **Cutoff Frequency** of the **Filters** with the LFO switched to **ARO**, which can be utilized to introduce **sidebands** into the composite synthesizer signal.



The Envelope Generator page

The LFO page



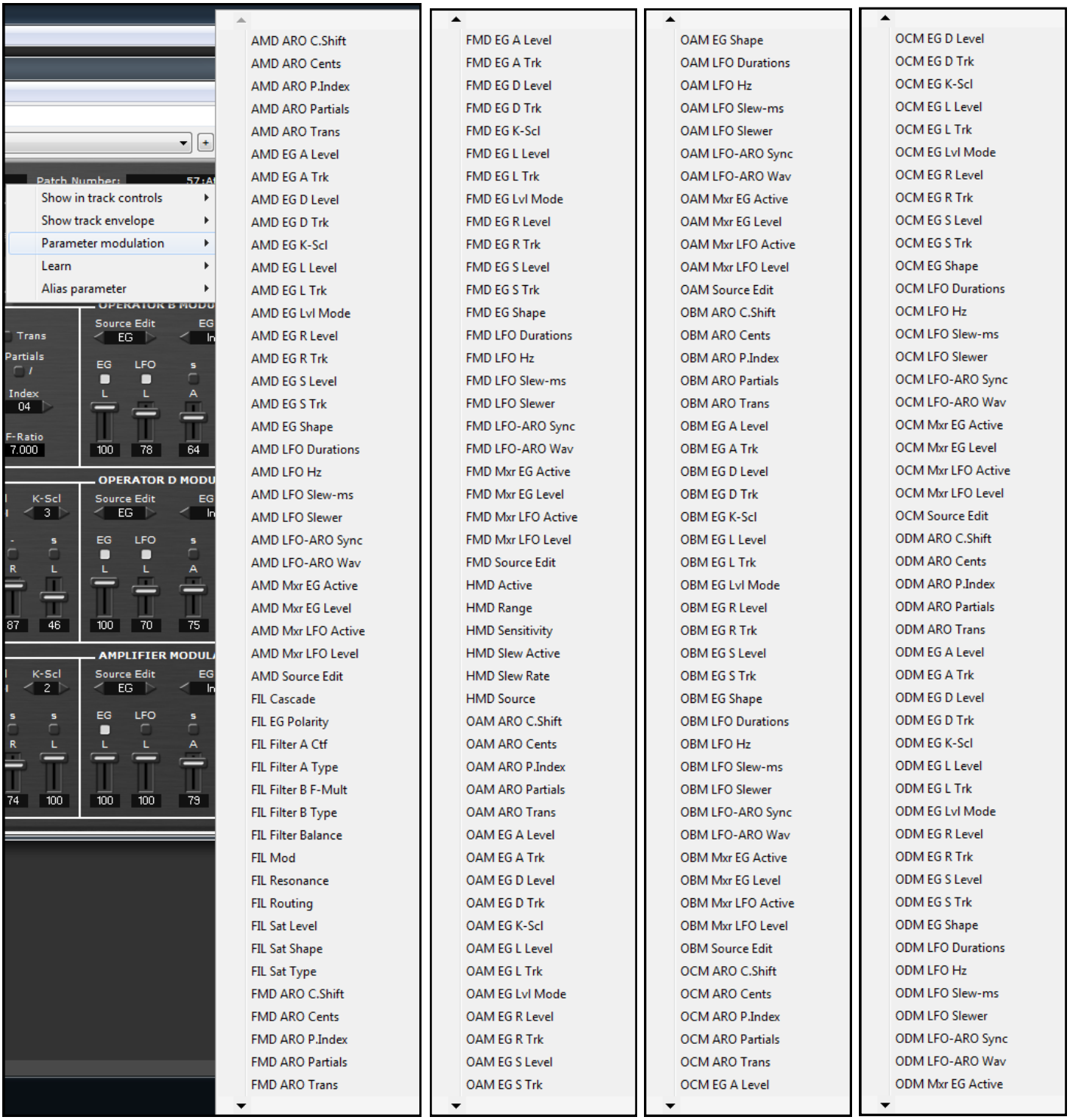
The LFO page with the LFO switched to run at audio-rate (ARO)

The Amplifier Modulation section is dedicated to modulating the VCA of the instrument and features an ADSR-style envelope generator, and an LFO which can be switched to run at audio rate.

The **Amplifier** (VCA: Voltage Controlled Amplifier) section is the final stage of the synthesizer signal before it is passed to the effects in the Performance Control section.

The **Amplifier Modulation** section features are also identical to the other modulators, but in this context, they are dedicated to modulating the amplitude of the **VCA**.

Especially useful in this context is the ability to **Audio Rate** modulate the amplitude of the **VCA** with the LFO switched to **ARO**, which can be utilized to introduce **sidebands** into the composite synthesizer signal.



The Parameter Modulation list in the REAPER DAW showing some of the available automation targets.

This VSTi exposes **321 MIDI Automation Targets** to the host DAW and practically every function of the synth can be track automated. Consult your DAW manual for instructions on how to automate these parameters.

The following pages contain a reference list of all these automation targets, including brief explanations and the corresponding page numbers in this manual for more detailed information about each synthesis function.

Automation Label	Synth Section	Automation Function	Manual Pages
AMD ARO C.Shift	Amplifier Modulation | ARO | Cents Transposition	Set the Cents Transposition offset interval using the "-Shift +" selector. Range is from -16 to 16 times the value set with the Cents Slider.	18-27
AMD ARO Cents	Amplifier Modulation | ARO | Cents Transposition	Set the Cents Transposition value using the Cents Slider.	18-27
AMD ARO P.Index	Amplifier Modulation | ARO | Partials Transposition	Choose an ARO Partials Transposition Index value and its associated frequency ratio using the Index Selector.	18-27
AMD ARO Partials	Amplifier Modulation | ARO | Partials Transposition	Set the ARO Partials Transposition to Multiply or Divide by the currently selected Index and its associated frequency ratio value.	18-27
AMD ARO Trans	Amplifier Modulation | ARO | Common Setting	Switch between the Cents and Partials Transposition Modes using the Trans Toggle Button.	18-27
AMD EG A Level	Amplifier Modulation | Envelope Generator	The Attack Slider.	18-27
AMD EG A Trk	Amplifier Modulation | Envelope Generator	Set the keyboard tracking behavior of the Attack stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-27
AMD EG D Level	Amplifier Modulation | Envelope Generator	The Decay Slider.	18-27
AMD EG D Trk	Amplifier Modulation | Envelope Generator	Set the keyboard tracking behavior of the Decay stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-27
AMD EG K-Scl	Amplifier Modulation | Envelope Generator	Set the EG Scale for Keyboard Tracking.	18-27
AMD EG L Level	Amplifier Modulation | Envelope Generator	The Level Slider.	18-27
AMD EG L Trk	Amplifier Modulation | Envelope Generator	Set the keyboard tracking behavior of the Level stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-27
AMD EG Lvl Mode	Amplifier Modulation | Envelope Generator	Set the EG Level type: Velocity or Level.	18-27
AMD EG R Level	Amplifier Modulation | Envelope Generator	The Release Slider.	18-27
AMD EG R Trk	Amplifier Modulation | Envelope Generator	Set the keyboard tracking behavior of the Release stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-27
AMD EG S Level	Amplifier Modulation | Envelope Generator	The Sustain Slider.	18-27
AMD EG S Trk	Amplifier Modulation | Envelope Generator	Set the keyboard tracking behavior of the Sustain stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-27
AMD EG Shape	Amplifier Modulation | Envelope Generator	Set the EG Shape.	18-27
AMD LFO Durations	Amplifier Modulation | LFO	Choose from the available rhythmic duration values for the LFO using the Durations selector. Options range from 128/1 to 1/128 notes, or Hertz Slider.	18-27
AMD LFO Hz	Amplifier Modulation | LFO	When the 'Hertz' option is selected with the Durations selector, this LFO Hz Slider sets the frequency of the LFO in Hz.	18-27
AMD LFO Slewer	Amplifier Modulation | LFO	Activate or Deactivate the LFO Slewer using the Slewer Switch.	18-27
AMD LFO Slew-ms	Amplifier Modulation | LFO	With the Slewer switch activated, the Slew Slider sets the Slew Rate in milliseconds.	18-27
AMD LFO-ARO	Amplifier Modulation | LFO-ARO | Common Settings	Switch between the LFO and ARO pages using the LFO-ARO selector.	18-27
AMD LFO-ARO Sync	Amplifier Modulation | LFO-ARO | Common Settings	Activate or Deactivate LFO-ARO Sync.	18-27
AMD LFO-ARO Wav	Amplifier Modulation | LFO-ARO | Common Settings	Choose from the available waveforms for the LFO or ARO using the Waveform selector.	18-27
AMD Mxr EG Active	Amplifier Modulation | Envelope Generator	Activate or Deactivate the EG.	18-27
AMD Mxr EG Level	Amplifier Modulation | Envelope Generator	The Modulation Mixer EG Level Slider.	18-27
AMD Mxr LFO Active	Amplifier Modulation | Envelope Generator	Activate or Deactivate the LFO.	18-27
AMD Mxr LFO Level	Amplifier Modulation | Envelope Generator	The Modulation Mixer LFO Level Slider.	18-27
AMD Source Edit	Amplifier Modulation	Select the Source Edit panel for editing.	18-27
FIL Cascade	Filters	Set the Filter Cascade.	25-26
FIL EG Polarity	Filters	Set the Polarity of the Filter Envelope Generator.	25-26
FIL Filter A Ctf	Filters	Set the Cutoff Frequency of Filter A.	25-26
FIL Filter A Type	Filters	Set the filter type for Filter A.	25-26
FIL Filter B F-Mult	Filters	Set the Cutoff Frequency of Filter B as a multiple of the Cutoff Frequency of Filter A.	25-26
FIL Filter B Type	Filters	Set the filter type for Filter B.	25-26
FIL Filter Balance	Filters	Set the Balance between Filters A and B.	25-26
FIL Mod	Filters	Switch the Filter Modulation relationship of Filters A and B between Unipolar and Bipolar.	25-26
FIL Resonance	Filters	Set the Resonance level for the filters.	25-26
FIL Routing	Filters	Select Filter Routing options.	25-26
FIL Sat Level	Filters	Set the Saturation Level.	25-26
FIL Sat Shape	Filters	Set the Saturation Shape.	25-26
FIL Sat Type	Filters	Select Saturation options.	25-26
FMD ARO C.Shift	Filter Modulation | ARO | Cents Transposition	Set the Cents Transposition offset interval using the "-Shift +" selector. Range is from -16 to 16 times the value set with the Cents Slider.	18-26
FMD ARO Cents	Filter Modulation | ARO | Cents Transposition	Set the Cents Transposition value using the Cents Slider.	18-26
FMD ARO P.Index	Filter Modulation | ARO | Partials Transposition	Choose an ARO Partials Transposition Index value and its associated frequency ratio using the Index Selector.	18-26

Automation Label	Synth Section	Automation Function	Manual Pages
FMD ARO Partials	Filter Modulation | ARO | Partials Transposition	Set the ARO Partials Transposition to Multiply or Divide by the currently selected Index and its associated frequency ratio value.	18-26
FMD ARO Trans	Filter Modulation | ARO | Common Setting	Switch between the Cents and Partials Transposition Modes using the Trans Toggle Button.	18-26
FMD EG A Level	Filter Modulation | Envelope Generator	The Attack Slider.	18-26
FMD EG A Trk	Filter Modulation | Envelope Generator	Set the keyboard tracking behavior of the Attack stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-26
FMD EG D Level	Filter Modulation | Envelope Generator	The Decay Slider.	18-26
FMD EG D Trk	Filter Modulation | Envelope Generator	Set the keyboard tracking behavior of the Decay stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-26
FMD EG K-Scl	Filter Modulation | Envelope Generator	Set the EG Scale for Keyboard Tracking.	18-26
FMD EG L Level	Filter Modulation | Envelope Generator	The Level Slider.	18-26
FMD EG L Trk	Filter Modulation | Envelope Generator	Set the keyboard tracking behavior of the Level stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-26
FMD EG Lvl Mode	Filter Modulation | Envelope Generator	Set the EG Level type: Velocity or Level.	18-26
FMD EG R Level	Filter Modulation | Envelope Generator	The Release Slider.	18-26
FMD EG R Trk	Filter Modulation | Envelope Generator	Set the keyboard tracking behavior of the Release stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-26
FMD EG S Level	Filter Modulation | Envelope Generator	The Sustain Slider.	18-26
FMD EG S Trk	Filter Modulation | Envelope Generator	Set the keyboard tracking behavior of the Sustain stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-26
FMD EG Shape	Filter Modulation | Envelope Generator	Set the EG Shape.	18-26
FMD LFO Durations	Filter Modulation | LFO	Choose from the available rhythmic duration values for the LFO using the Durations selector. Options range from 128/1 to 1/128 notes, or Hertz Slider.	18-26
FMD LFO Hz	Filter Modulation | LFO	When the 'Hertz' option is selected with the Durations selector, this LFO Hz Slider sets the frequency of the LFO in Hz.	18-26
FMD LFO Slewer	Filter Modulation | LFO	Activate or Deactivate the LFO Slewer using the Slewer Switch.	18-26
FMD LFO Slew-ms	Filter Modulation | LFO	With the Slewer switch activated, the Slew Slider sets the Slew Rate in milliseconds.	18-26
FMD LFO-ARO	Filter Modulation | LFO-ARO | Common Settings	Switch between the LFO and ARO pages using the LFO-ARO selector.	18-26
FMD LFO-ARO Sync	Filter Modulation | LFO-ARO | Common Settings	Activate or Deactivate LFO-ARO Sync.	18-26
FMD LFO-ARO Wav	Filter Modulation | LFO-ARO | Common Settings	Choose from the available waveforms for the LFO or ARO using the Waveform selector.	18-26
FMD Mxr EG Active	Filter Modulation | Envelope Generator	Activate or Deactivate the EG.	18-26
FMD Mxr EG Level	Filter Modulation | Envelope Generator	The Modulation Mixer EG Level Slider.	18-26
FMD Mxr LFO Active	Filter Modulation | Envelope Generator	Activate or Deactivate the LFO.	18-26
FMD Mxr LFO Level	Filter Modulation | Envelope Generator	The Modulation Mixer LFO Level Slider.	18-26
FMD Source Edit	Filter Modulation	Select the Source Edit panel for editing.	18-26
HMD Active	Harmonics Modulation	Activate or Deactivate Harmonics Modulation.	17
HMD Range	Harmonics Modulation	Set the Range of Harmonics Modulation: 1-2, 1-4, 1-8, 1-16.	17
HMD Sensitivity	Harmonics Modulation	Set the HMD Sensitivity of Harmonics Modulation: 1, 2, 3	17
HMD Slew Active	Harmonics Modulation	Activate or Deactivate the Harmonics Modulation Slewer.	17
HMD Slew Rate	Harmonics Modulation	Set the Slew Rate Slider in milliseconds.	17
HMD Source	Harmonics Modulation	Switch between the two Harmonic Modulation Sources: Harmonics and Partials.	17
OAM ARO C.Shift	Operator A Modulation | ARO | Cents Transposition	Set the Cents Transposition offset interval using the "-Shift +" selector. Range is from -16 to 16 times the value set with the Cents Slider.	18-21
OAM ARO Cents	Operator A Modulation | ARO | Cents Transposition	Set the Cents Transposition value using the Cents Slider.	18-21
OAM ARO P.Index	Operator A Modulation | ARO | Partials Transposition	Choose an ARO Partials Transposition Index value and its associated frequency ratio using the Index Selector.	18-21
OAM ARO Partials	Operator A Modulation | ARO | Partials Transposition	Set the ARO Partials Transposition to Multiply or Divide by the currently selected Index and its associated frequency ratio value.	18-21
OAM ARO Trans	Operator A Modulation | ARO | Common Setting	Switch between the Cents and Partials Transposition Modes using the Trans Toggle Button.	18-21
OAM EG A Level	Operator A Modulation | Envelope Generator	The Attack Slider.	18-21
OAM EG A Trk	Operator A Modulation | Envelope Generator	Set the keyboard tracking behavior of the Attack stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OAM EG D Level	Operator A Modulation | Envelope Generator	The Decay Slider.	18-21
OAM EG D Trk	Operator A Modulation | Envelope Generator	Set the keyboard tracking behavior of the Decay stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21

Automation Label	Synth Section	Automation Function	Manual Pages
OAM EG K-Scl	Operator A Modulation | Envelope Generator	Set the EG Scale for Keyboard Tracking.	18-21
OAM EG L Level	Operator A Modulation | Envelope Generator	The Level Slider.	18-21
OAM EG L Trk	Operator A Modulation | Envelope Generator	Set the keyboard tracking behavior of the Level stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OAM EG Lvl Mode	Operator A Modulation | Envelope Generator	Set the EG Level type: Velocity or Level.	18-21
OAM EG R Level	Operator A Modulation | Envelope Generator	The Release Slider.	18-21
OAM EG R Trk	Operator A Modulation | Envelope Generator	Set the keyboard tracking behavior of the Release stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OAM EG S Level	Operator A Modulation | Envelope Generator	The Sustain Slider.	18-21
OAM EG S Trk	Operator A Modulation | Envelope Generator	Set the keyboard tracking behavior of the Sustain stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OAM EG Shape	Operator A Modulation | Envelope Generator	Set the EG Shape.	18-21
OAM LFO Durations	Operator A Modulation | LFO	Choose from the available rhythmic duration values for the LFO using the Durations selector. Options range from 128/1 to 1/128 notes, or Hertz Slider.	18-21
OAM LFO Hz	Operator A Modulation | LFO	When the 'Hertz' option is selected with the Durations selector, this LFO Hz Slider sets the frequency of the LFO in Hz.	18-21
OAM LFO Slewer	Operator A Modulation | LFO	Activate or Deactivate the LFO Slewer using the Slewer Switch.	18-21
OAM LFO Slew-ms	Operator A Modulation | LFO	With the Slewer switch activated, the Slew Slider sets the Slew Rate in milliseconds.	18-21
OAM LFO-ARO	Operator A Modulation | LFO-ARO | Common Settings	Switch between the LFO and ARO pages using the LFO-ARO selector.	18-21
OAM LFO-ARO Sync	Operator A Modulation | LFO-ARO | Common Settings	Activate or Deactivate LFO-ARO Sync.	18-21
OAM LFO-ARO Wav	Operator A Modulation | LFO-ARO | Common Settings	Choose from the available waveforms for the LFO or ARO using the Waveform selector.	18-21
OAM Mxr EG Active	Operator A Modulation | Envelope Generator	Activate or Deactivate the EG.	18-21
OAM Mxr EG Level	Operator A Modulation | Envelope Generator	The Modulation Mixer EG Level Slider.	18-21
OAM Mxr LFO Active	Operator A Modulation | Envelope Generator	Activate or Deactivate the LFO.	18-21
OAM Mxr LFO Level	Operator A Modulation | Envelope Generator	The Modulation Mixer LFO Level Slider.	18-21
OAM Source Edit	Operator A Modulation	Select the Source Edit panel for editing.	18-21
OBM ARO C.Shift	Operator B Modulation | ARO | Cents Transposition	Set the Cents Transposition offset interval using the "-Shift +" selector. Range is from -16 to 16 times the value set with the Cents Slider.	18-21
OBM ARO Cents	Operator B Modulation | ARO | Cents Transposition	Set the Cents Transposition value using the Cents Slider.	18-21
OBM ARO P.Index	Operator B Modulation | ARO | Partials Transposition	Choose an ARO Partials Transposition Index value and its associated frequency ratio using the Index Selector.	18-21
OBM ARO Partials	Operator B Modulation | ARO | Partials Transposition	Set the ARO Partials Transposition to Multiply or Divide by the currently selected Index and its associated frequency ratio value.	18-21
OBM ARO Trans	Operator B Modulation | ARO | Common Setting	Switch between the Cents and Partials Transposition Modes using the Trans Toggle Button.	18-21
OBM EG A Level	Operator B Modulation | Envelope Generator	The Attack Slider.	18-21
OBM EG A Trk	Operator B Modulation | Envelope Generator	Set the keyboard tracking behavior of the Attack stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OBM EG D Level	Operator B Modulation | Envelope Generator	The Decay Slider.	18-21
OBM EG D Trk	Operator B Modulation | Envelope Generator	Set the keyboard tracking behavior of the Decay stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OBM EG K-Scl	Operator B Modulation | Envelope Generator	Set the EG Scale for Keyboard Tracking.	18-21
OBM EG L Level	Operator B Modulation | Envelope Generator	The Level Slider.	18-21
OBM EG L Trk	Operator B Modulation | Envelope Generator	Set the keyboard tracking behavior of the Level stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OBM EG Lvl Mode	Operator B Modulation | Envelope Generator	Set the EG Level type: Velocity or Level.	18-21
OBM EG R Level	Operator B Modulation | Envelope Generator	The Release Slider.	18-21
OBM EG R Trk	Operator B Modulation | Envelope Generator	Set the keyboard tracking behavior of the Release stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OBM EG S Level	Operator B Modulation | Envelope Generator	The Sustain Slider.	18-21
OBM EG S Trk	Operator B Modulation | Envelope Generator	Set the keyboard tracking behavior of the Sustain stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OBM EG Shape	Operator B Modulation | Envelope Generator	Set the EG Shape.	18-21
OBM LFO Durations	Operator B Modulation | LFO	Choose from the available rhythmic duration values for the LFO using the Durations selector. Options range from 128/1 to 1/128 notes, or Hertz Slider.	18-21
OBM LFO Hz	Operator B Modulation | LFO	When the 'Hertz' option is selected with the Durations selector, this LFO Hz Slider sets the frequency of the LFO in Hz.	18-21
OBM LFO Slewer	Operator B Modulation | LFO	Activate or Deactivate the LFO Slewer using the Slewer Switch.	18-21

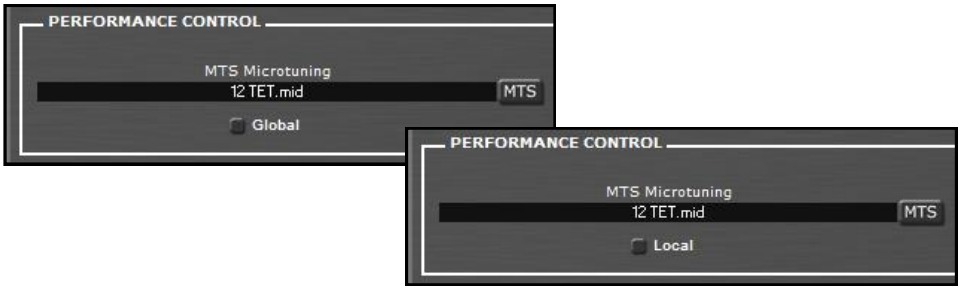
Automation Label	Synth Section	Automation Function	Manual Pages
OBM LFO Slew-ms	Operator B Modulation | LFO	With the Slewer switch activated, the Slew Slider sets the Slew Rate in milliseconds.	18-21
OBM LFO-ARO	Operator B Modulation | LFO-ARO | Common Settings	Switch between the LFO and ARO pages using the LFO-ARO selector.	18-21
OBM LFO-ARO Sync	Operator B Modulation | LFO-ARO | Common Settings	Activate or Deactivate LFO-ARO Sync.	18-21
OBM LFO-ARO Wav	Operator B Modulation | LFO-ARO | Common Settings	Choose from the available waveforms for the LFO or ARO using the Waveform selector.	18-21
OBM Mxr EG Active	Operator B Modulation | Envelope Generator	Activate or Deactivate the EG.	18-21
OBM Mxr EG Level	Operator B Modulation | Envelope Generator	The Modulation Mixer EG Level Slider.	18-21
OBM Mxr LFO Active	Operator B Modulation | Envelope Generator	Activate or Deactivate the LFO.	18-21
OBM Mxr LFO Level	Operator B Modulation | Envelope Generator	The Modulation Mixer LFO Level Slider.	18-21
OBM Source Edit	Operator B Modulation	Select the Source Edit panel for editing.	18-21
OCM ARO C.Shift	Operator C Modulation | ARO | Cents Transposition	Set the Cents Transposition offset interval using the "-Shift +" selector. Range is from -16 to 16 times the value set with the Cents Slider.	18-21
OCM ARO Cents	Operator C Modulation | ARO | Cents Transposition	Set the Cents Transposition value using the Cents Slider.	18-21
OCM ARO P.Index	Operator C Modulation | ARO | Partials Transposition	Choose an ARO Partials Transposition Index value and its associated frequency ratio using the Index Selector.	18-21
OCM ARO Partials	Operator C Modulation | ARO | Partials Transposition	Set the ARO Partials Transposition to Multiply or Divide by the currently selected Index and its associated frequency ratio value.	18-21
OCM ARO Trans	Operator C Modulation | ARO | Common Setting	Switch between the Cents and Partials Transposition Modes using the Trans Toggle Button.	18-21
OCM EG A Level	Operator C Modulation | Envelope Generator	The Attack Slider.	18-21
OCM EG A Trk	Operator C Modulation | Envelope Generator	Set the keyboard tracking behavior of the Attack stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OCM EG D Level	Operator C Modulation | Envelope Generator	The Decay Slider.	18-21
OCM EG D Trk	Operator C Modulation | Envelope Generator	Set the keyboard tracking behavior of the Decay stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OCM EG K-Scl	Operator C Modulation | Envelope Generator	Set the EG Scale for Keyboard Tracking.	18-21
OCM EG L Level	Operator C Modulation | Envelope Generator	The Level Slider.	18-21
OCM EG L Trk	Operator C Modulation | Envelope Generator	Set the keyboard tracking behavior of the Level stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OCM EG Lvl Mode	Operator C Modulation | Envelope Generator	Set the EG Level type: Velocity or Level.	18-21
OCM EG R Level	Operator C Modulation | Envelope Generator	The Release Slider.	18-21
OCM EG R Trk	Operator C Modulation | Envelope Generator	Set the keyboard tracking behavior of the Release stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OCM EG S Level	Operator C Modulation | Envelope Generator	The Sustain Slider.	18-21
OCM EG S Trk	Operator C Modulation | Envelope Generator	Set the keyboard tracking behavior of the Sustain stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
OCM EG Shape	Operator C Modulation | Envelope Generator	Set the EG Shape.	18-21
OCM LFO Durations	Operator C Modulation | LFO	Choose from the available rhythmic duration values for the LFO using the Durations selector. Options range from 128/1 to 1/128 notes, or Hertz Slider.	18-21
OCM LFO Hz	Operator C Modulation | LFO	When the 'Hertz' option is selected with the Durations selector, this LFO Hz Slider sets the frequency of the LFO in Hz.	18-21
OCM LFO Slewer	Operator C Modulation | LFO	Activate or Deactivate the LFO Slewer using the Slewer Switch.	18-21
OCM LFO Slew-ms	Operator C Modulation | LFO	With the Slewer switch activated, the Slew Slider sets the Slew Rate in milliseconds.	18-21
OCM LFO-ARO	Operator C Modulation | LFO-ARO | Common Settings	Switch between the LFO and ARO pages using the LFO-ARO selector.	18-21
OCM LFO-ARO Sync	Operator C Modulation | LFO-ARO | Common Settings	Activate or Deactivate LFO-ARO Sync.	18-21
OCM LFO-ARO Wav	Operator C Modulation | LFO-ARO | Common Settings	Choose from the available waveforms for the LFO or ARO using the Waveform selector.	18-21
OCM Mxr EG Active	Operator C Modulation | Envelope Generator	Activate or Deactivate the EG.	18-21
OCM Mxr EG Level	Operator C Modulation | Envelope Generator	The Modulation Mixer EG Level Slider.	18-21
OCM Mxr LFO Active	Operator C Modulation | Envelope Generator	Activate or Deactivate the LFO.	18-21
OCM Mxr LFO Level	Operator C Modulation | Envelope Generator	The Modulation Mixer LFO Level Slider.	18-21
OCM Source Edit	Operator C Modulation	Select the Source Edit panel for editing.	18-21
ODM ARO C.Shift	Operator D Modulation | ARO | Cents Transposition	Set the Cents Transposition offset interval using the "-Shift +" selector. Range is from -16 to 16 times the value set with the Cents Slider.	18-21
ODM ARO Cents	Operator D Modulation | ARO | Cents Transposition	Set the Cents Transposition value using the Cents Slider.	18-21
ODM ARO P.Index	Operator D Modulation | ARO | Partials Transposition	Choose an ARO Partials Transposition Index value and its associated frequency ratio using the Index Selector.	18-21
ODM ARO Partials	Operator D Modulation | ARO | Partials Transposition	Set the ARO Partials Transposition to Multiply or Divide by the currently selected Index and its associated frequency ratio value.	18-21

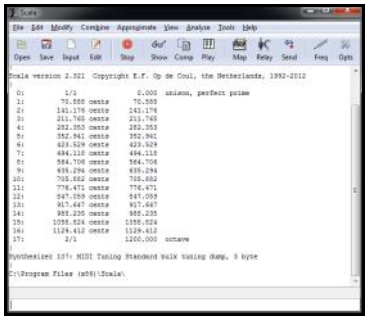
Automation Label	Synth Section	Automation Function	Manual Pages
ODM ARO Trans	Operator D Modulation | ARO | Common Setting	Switch between the Cents and Partials Transposition Modes using the Trans Toggle Button.	18-21
ODM EG A Level	Operator D Modulation | Envelope Generator	The Attack Slider.	18-21
ODM EG A Trk	Operator D Modulation | Envelope Generator	Set the keyboard tracking behavior of the Attack stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
ODM EG D Level	Operator D Modulation | Envelope Generator	The Decay Slider.	18-21
ODM EG D Trk	Operator D Modulation | Envelope Generator	Set the keyboard tracking behavior of the Decay stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
ODM EG K-Scl	Operator D Modulation | Envelope Generator	Set the EG Scale for Keyboard Tracking.	18-21
ODM EG L Level	Operator D Modulation | Envelope Generator	The Level Slider.	18-21
ODM EG L Trk	Operator D Modulation | Envelope Generator	Set the keyboard tracking behavior of the Level stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
ODM EG Lvl Mode	Operator D Modulation | Envelope Generator	Set the EG Level type: Velocity or Level.	18-21
ODM EG R Level	Operator D Modulation | Envelope Generator	The Release Slider.	18-21
ODM EG R Trk	Operator D Modulation | Envelope Generator	Set the keyboard tracking behavior of the Release stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
ODM EG S Level	Operator D Modulation | Envelope Generator	The Sustain Slider.	18-21
ODM EG S Trk	Operator D Modulation | Envelope Generator	Set the keyboard tracking behavior of the Sustain stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	18-21
ODM EG Shape	Operator D Modulation | Envelope Generator	Set the EG Shape.	18-21
ODM LFO Durations	Operator D Modulation | LFO	Choose from the available rhythmic duration values for the LFO using the Durations selector. Options range from 128/1 to 1/128 notes, or Hertz Slider.	18-21
ODM LFO Hz	Operator D Modulation | LFO	When the 'Hertz' option is selected with the Durations selector, this LFO Hz Slider sets the frequency of the LFO in Hz.	18-21
ODM LFO Slewer	Operator D Modulation | LFO	Activate or Deactivate the LFO Slewer using the Slewer Switch.	18-21
ODM LFO Slew-ms	Operator D Modulation | LFO	With the Slewer switch activated, the Slew Slider sets the Slew Rate in milliseconds.	18-21
ODM LFO-ARO	Operator D Modulation | LFO-ARO | Common Settings	Switch between the LFO and ARO pages using the LFO-ARO selector.	18-21
ODM LFO-ARO Sync	Operator D Modulation | LFO-ARO | Common Settings	Activate or Deactivate LFO-ARO Sync.	18-21
ODM LFO-ARO Wav	Operator D Modulation | LFO-ARO | Common Settings	Choose from the available waveforms for the LFO or ARO using the Waveform selector.	18-21
ODM Mxr EG Active	Operator D Modulation | Envelope Generator	Activate or Deactivate the EG.	18-21
ODM Mxr EG Level	Operator D Modulation | Envelope Generator	The Modulation Mixer EG Level Slider.	18-21
ODM Mxr LFO Active	Operator D Modulation | Envelope Generator	Activate or Deactivate the LFO.	18-21
ODM Mxr LFO Level	Operator D Modulation | Envelope Generator	The Modulation Mixer LFO Level Slider.	18-21
ODM Source Edit	Operator D Modulation	Select the Source Edit panel for editing.	18-21
OSC Drift Level	FM-RM Oscillator | Oscillator Settings	Set the Level of Drift using the Pitch Drift Level Slider.	11-12
OSC Drift Rate	FM-RM Oscillator | Oscillator Settings	Set the Rate of Drift using the Pitch Drift Rate Selector.	11-12
OSC FM-RM Algos	FM-RM Oscillator | Oscillator Settings	Switch between the 57 available FM-RM Algorithms.	11-12
OSC Op A Wave	FM-RM Oscillator | Oscillator Settings	Choose from the available 11 Operator Waveforms.	11-12
OSC Op B Wave	FM-RM Oscillator | Oscillator Settings	Choose from the available 11 Operator Waveforms.	11-12
OSC Op C Wave	FM-RM Oscillator | Oscillator Settings	Choose from the available 11 Operator Waveforms.	11-12
OSC Op D Wave	FM-RM Oscillator | Oscillator Settings	Choose from the available 11 Operator Waveforms.	11-12
OSC Source Edit	FM-RM Oscillator | Oscillator Settings	Switch between the Oscillator and Pitch Source Edit Panels using the Source Edit Selector.	11-12
OSC Trans Cents	FM-RM Oscillator | Oscillator Settings	Set the Transposition Degree is Cents using the Cents Slider.	11-12
OSC Trans Shift	FM-RM Oscillator | Oscillator Settings	Set the Transposition Degree Offset. Range is -16 to 16.	11-12
PAR III A*/	FM-RM Oscillator | Partials Settings | Iso-Index	Operator A Isointerval Index Multiply or Divide switch.	14-16
PAR III B*/	FM-RM Oscillator | Partials Settings | Iso-Index	Operator B Isointerval Index Multiply or Divide switch.	14-16
PAR III C*/	FM-RM Oscillator | Partials Settings | Iso-Index	Operator C Isointerval Index Multiply or Divide switch.	14-16
PAR III D*/	FM-RM Oscillator | Partials Settings | Iso-Index	Operator D Isointerval Index Multiply or Divide switch.	14-16
PAR III Interval	FM-RM Oscillator | Partials Settings | Iso-Index	Set the interval value for the Isointerval Index using the Interval Selector. Range: 1-30.	14-16
PAR III Rotate	FM-RM Oscillator | Partials Settings | Iso-Index	Reroute the partials values in each index to other Operators using the Op Rotate selector options.	14-16
PAR ILF A*/	FM-RM Oscillator | Partials Settings | Isointerval LFO	Operator A Isointerval LFO Multiply or Divide switch.	14-16

Automation Label	Synth Section	Automation Function	Manual Pages
PAR ILF B*/	FM-RM Oscillator | Partials Settings | Isointerval LFO	Operator B Isointerval LFO Multiply or Divide switch.	14-16
PAR ILF C*/	FM-RM Oscillator | Partials Settings | Isointerval LFO	Operator C Isointerval LFO Multiply or Divide switch.	14-16
PAR ILF D*/	FM-RM Oscillator | Partials Settings | Isointerval LFO	Operator D Isointerval LFO Multiply or Divide switch.	14-16
PAR ILF Depth	FM-RM Oscillator | Partials Settings | Isointerval LFO	Set the modulation depth of the Isointerval LFO using the Depth Slider.	14-16
PAR ILF Durations	FM-RM Oscillator | Partials Settings | Isointerval LFO	Choose from the available rhythmic duration values for the Isointerval LFO using the Durations selector. Options range from 128/1 to 1/128 notes, or Hertz Slider.	14-16
PAR ILF Hz	FM-RM Oscillator | Partials Settings | Isointerval LFO	When the 'Hertz' option is selected with the Durations selector, this LFO Hz Slider sets the frequency of the Isointerval LFO in Hz.	14-16
PAR ILF Rotate	FM-RM Oscillator | Partials Settings | Isointerval LFO	Reroute the partials values in each index to other Operators using the Op Rotate selector options.	14-16
PAR ILF Slew ms	FM-RM Oscillator | Partials Settings | Isointerval LFO	With the Slewer switch activated, the Slew Slider sets the Slew Rate of the Isointerval LFO in milliseconds.	14-16
PAR ILF Slewer	FM-RM Oscillator | Partials Settings | Isointerval LFO	Enable or disable the Isointerval LFO Slewer using the Slew button.	14-16
PAR ILF Sync	FM-RM Oscillator | Partials Settings | Isointerval LFO	Enable or disable Isointerval LFO Sync using the Sync button.	14-16
PAR ILF Wave	FM-RM Oscillator | Partials Settings | Isointerval LFO	Choose from the available LFO waveforms for modulating the Isointerval LFO using the Waveform Selector.	14-16
PAR QS A*/	FM-RM Oscillator | Partials Settings | Quantized Selectors	Operator A Quantized Selectors Multiply or Divide switch.	14-16
PAR QS B*/	FM-RM Oscillator | Partials Settings | Quantized Selectors	Operator B Quantized Selectors Multiply or Divide switch.	14-16
PAR QS C*/	FM-RM Oscillator | Partials Settings | Quantized Selectors	Operator C Quantized Selectors Multiply or Divide switch.	14-16
PAR QS D*/	FM-RM Oscillator | Partials Settings | Quantized Selectors	Operator D Quantized Selectors Multiply or Divide switch.	14-16
PAR QS Op A	FM-RM Oscillator | Partials Settings | Quantized Selectors	Operator A Quantized Selector.	14-16
PAR QS Op B	FM-RM Oscillator | Partials Settings | Quantized Selectors	Operator B Quantized Selector.	14-16
PAR QS Op C	FM-RM Oscillator | Partials Settings | Quantized Selectors	Operator C Quantized Selector.	14-16
PAR QS Op D	FM-RM Oscillator | Partials Settings | Quantized Selectors	Operator D Quantized Selector.	14-16
PAR RIS A*/	FM-RM Oscillator | Partials Settings | Random Index Sliders	Operator A Random Index Slider Multiply or Divide switch.	14-16
PAR RIS B*/	FM-RM Oscillator | Partials Settings | Random Index Sliders	Operator B Random Index Slider Multiply or Divide switch.	14-16
PAR RIS C*/	FM-RM Oscillator | Partials Settings | Random Index Sliders	Operator C Random Index Slider Multiply or Divide switch.	14-16
PAR RIS D*/	FM-RM Oscillator | Partials Settings | Random Index Sliders	Operator D Random Index Slider Multiply or Divide switch.	14-16
PAR RIS Op A Slider	FM-RM Oscillator | Partials Settings | Random Index Sliders	Operator A Random Index Slider.	14-16
PAR RIS Op B Slider	FM-RM Oscillator | Partials Settings | Random Index Sliders	Operator B Random Index Slider.	14-16
PAR RIS Op C Slider	FM-RM Oscillator | Partials Settings | Random Index Sliders	Operator C Random Index Slider.	14-16
PAR RIS Op D Slider	FM-RM Oscillator | Partials Settings | Random Index Sliders	Operator D Random Index Slider.	14-16
PAR RIS Random	FM-RM Oscillator | Partials Settings | Random Index Sliders	Randomize all Random Index Sliders.	14-16
PAR RIS Reset	FM-RM Oscillator | Partials Settings | Random Index Sliders	Reset all Random Index Sliders.	14-16
PAR RS A*/	FM-RM Oscillator | Partials Settings | Ratio Sliders (0-64)	Operator A Ratio Slider (0-64) Multiply or Divide switch.	14-16
PAR RS B*/	FM-RM Oscillator | Partials Settings | Ratio Sliders (0-64)	Operator B Ratio Slider (0-64) Multiply or Divide switch.	14-16
PAR RS C*/	FM-RM Oscillator | Partials Settings | Ratio Sliders (0-64)	Operator C Ratio Slider (0-64) Multiply or Divide switch.	14-16
PAR RS D*/	FM-RM Oscillator | Partials Settings | Ratio Sliders (0-64)	Operator D Ratio Slider (0-64) Multiply or Divide switch.	14-16
PAR RS Op A Slider	FM-RM Oscillator | Partials Settings | Ratio Sliders (0-64)	Operator A Ratio Slider.	14-16
PAR RS Op B Slider	FM-RM Oscillator | Partials Settings | Ratio Sliders (0-64)	Operator B Ratio Slider.	14-16
PAR RS Op C Slider	FM-RM Oscillator | Partials Settings | Ratio Sliders (0-64)	Operator C Ratio Slider.	14-16
PAR RS Op D Slider	FM-RM Oscillator | Partials Settings | Ratio Sliders (0-64)	Operator D Ratio Slider.	14-16
PAR RS Random	FM-RM Oscillator | Partials Settings | Ratio Sliders (0-64)	Randomize all Ratio Sliders (0-64).	14-16
PAR RS Reset	FM-RM Oscillator | Partials Settings | Ratio Sliders (0-64)	Reset all Ratio Sliders (0-64).	14-16
PAR Selector	FM-RM Oscillator | Partials Settings | Global	Choose from the five partial selection features: Ratio Sliders (0-64), Random Index Sliders, Quantized Selectors, Isointerval Index, Isointerval LFO.	14-16
PC CHO Active	Performance Control | Chorus	Activate or Deactivate the Chorus effect.	8-10

Automation Label	Synth Section	Automation Function	Manual Pages
PC CHO Depth	Performance Control | Chorus	Set the Chorus Depth.	8-10
PC CHO Dry-Wet	Performance Control | Chorus	Set the Chorus Dry to Wet level.	8-10
PC CHO Durations	Performance Control | Chorus	Choose from the available rhythmic duration values for the LFO using the Durations selector. Options range from 128/1 to 1/128 notes, or Hertz Slider.	8-10
PC CHO Feedback	Performance Control | Chorus	Set the Chorus Feedback level.	8-10
PC CHO LFOHz	Performance Control | Chorus	With the Durations selector set to Hertz, use the LFO Hz slider to set the Chorus modulation rate frequency.	8-10
PC CHO Phase	Performance Control | Chorus	Set the LFO phase for Chorus modulation using the Phase slider.	8-10
PC CHO Stages	Performance Control | Chorus	Choose from 1-4 Chorus stages.	8-10
PC CHO Time	Performance Control | Chorus	Set the Chorus Modulation Time.	8-10
PC CHO Waveform	Performance Control | Chorus	Choose from the available Waveforms for Chorus Modulation using the Waveform selector.	8-10
PC Control Edit	Performance Control | Global	Switch between the four Performance Control Edit panels: MIDI, Pitch, Chorus, Ensemble.	8-10
PC ENS Active	Performance Control | Ensemble | LPF	Activate or Deactivate the Ensemble effect.	8-10
PC ENS CentsDt	Performance Control | Ensemble | LPF	Set the detuning amount for the Ensemble effect using the Cents Dt slider.	8-10
PC ENS Dry-Wet	Performance Control | Ensemble | LPF	Set the Ensemble Dry to Wet level.	8-10
PC ENS LPF Active	Performance Control | Ensemble | LPF	Activate or Deactivate the Lowpass Filter that precedes the Ensemble effect.	8-10
PC ENS LPF Cascade	Performance Control | Ensemble | LPF	Set the LPF Cascade. Range is from 6 dB to 48 dB per-octave lowpass filters.	8-10
PC ENS LPF Cutoff	Performance Control | Ensemble | LPF	Set the LPF Cutoff frequency using the LPF Ctf slider.	8-10
PC ENS Routing	Performance Control | Ensemble | LPF	Set the Ensemble Routing to either Stereo or Mono.	8-10
PC ENS XO Ctf	Performance Control | Ensemble | LPF	Set the X-Over Filter Cutoff frequency using the XO Ctf slider.	8-10
PC ENS X-OverCas	Performance Control | Ensemble | LPF	Set the X-Over Filter Cascade. Range is from 6 dB to 24 dB per-octave filters.	8-10
PC Microtune G-L	Performance Control | Microtuning	Switch between Global and Local Microtuning.	8-10
PC MID Mono	Performance Control | MIDI	Activate or Deactivate Monophonic Mode.	8-10
PC MID MonoRetrig	Performance Control | MIDI	Activate or Deactivate Monophonic Retrigger Mode. When active, envelope generators are retriggered with each new MIDI Note On.	8-10
PC MID Porta	Performance Control | MIDI	Set the monophonic Portamento Time.	8-10
PC P-Bender	Performance Control | Pitch | Pitch Bend	Pitch Bend slider. Mapped by default to MIDI Pitch Wheel.	8-10
PC PIT Bend Mode	Performance Control | Pitch | Pitch Bend	Switch between the three Bend Modes: Harmonic, Superparticular and Cents.	8-10
PC PIT CentsSlider	Performance Control | Pitch | Pitch Bend	Set the Pitch Bend range in Cents using the Cents Slider.	8-10
PC PIT HarmRatios	Performance Control | Pitch | Pitch Bend	Choose from the available Harmonic Ratios for Pitch Bend.	8-10
PC PIT SuperRatios	Performance Control | Pitch | Pitch Bend	Choose from the available Superparticular Ratios for Pitch Bend.	8-10
PC PIT VibAct	Performance Control | Pitch | Vibrato	Activate or Deactivate Vibrato.	8-10
PC PIT VibDpt	Performance Control | Pitch | Vibrato	Set the Vibrato Depth.	8-10
PC PIT VibFrq	Performance Control | Pitch | Vibrato	Set the Vibrato Frequency.	8-10
PC PIT VibMod	Performance Control | Pitch | Vibrato	Set the Vibrato Modulation amount. Mapped by default to MIDI Modulation Wheel.	8-10
PC PIT VibWave	Performance Control | Pitch | Vibrato	Choose from the available Vibrato Waveforms using the Waveform selector.	8-10
PMD ARO C.Shift	Pitch Modulation | ARO | Cents Transposition	Set the Cents Transposition offset interval using the "-Shift +" selector. Range is from -16 to 16 times the value set with the Cents Slider.	22-24
PMD ARO Cents	Pitch Modulation | ARO | Cents Transposition	Set the Cents Transposition value using the Cents Slider.	22-24
PMD ARO P.Index	Pitch Modulation | ARO | Partials Transposition	Choose an ARO Partials Transposition Index value and its associated frequency ratio using the Index Selector.	22-24
PMD ARO Partials	Pitch Modulation | ARO | Partials Transposition	Set the ARO Partials Transposition to Multiply or Divide by the currently selected Index and its associated frequency ratio value.	22-24
PMD ARO Trans	Pitch Modulation | ARO | Common Setting	Switch between the Cents and Partials Transposition Modes using the Trans Toggle Button.	22-24
PMD EG A Level	Pitch Modulation | Envelope Generator	The Attack Slider.	22-24
PMD EG A Trk	Pitch Modulation | Envelope Generator	Set the keyboard tracking behavior of the Attack stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	22-24
PMD EG D Level	Pitch Modulation | Envelope Generator	The Decay Slider.	22-24
PMD EG D Trk	Pitch Modulation | Envelope Generator	Set the keyboard tracking behavior of the Decay stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	22-24
PMD EG L Level	Pitch Modulation | Envelope Generator	The Level Slider.	22-24

Automation Label	Synth Section	Automation Function	Manual Pages
PMD EG L Trk	Pitch Modulation | Envelope Generator	Set the keyboard tracking behavior of the Level stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	22-24
PMD EG Lvl Mode	Pitch Modulation | Envelope Generator	Set the EG Level type: Velocity or Level.	22-24
PMD EG R Level	Pitch Modulation | Envelope Generator	The Release Slider.	22-24
PMD EG R Trk	Pitch Modulation | Envelope Generator	Set the keyboard tracking behavior of the Release stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	22-24
PMD EG S Level	Pitch Modulation | Envelope Generator	The Sustain Slider.	22-24
PMD EG S Trk	Pitch Modulation | Envelope Generator	Set the keyboard tracking behavior of the Sustain stage. S = Slider, + = Positive Tracking, - = Negative Tracking.	22-24
PMD EG Scale	Pitch Modulation | Envelope Generator	Set the EG Scale for Keyboard Tracking.	22-24
PMD EG Shape	Pitch Modulation | Envelope Generator	Set the EG Shape.	22-24
PMD LFO Durations	Pitch Modulation | LFO	Choose from the available rhythmic duration values for the LFO using the Durations selector. Options range from 128/1 to 1/128 notes, or Hertz Slider.	22-24
PMD LFO Hz	Pitch Modulation | LFO	When the 'Hertz' option is selected with the Durations selector, this LFO Hz Slider sets the frequency of the LFO in Hz.	22-24
PMD LFO Slewer	Pitch Modulation | LFO	Activate or Deactivate the LFO Slewer using the Slewer Switch.	22-24
PMD LFO Slew-ms	Pitch Modulation | LFO	With the Slewer switch activated, the Slew Slider sets the Slew Rate in milliseconds.	22-24
PMD LFO-ARO	Pitch Modulation | LFO-ARO | Common Settings	Switch between the LFO and ARO pages using the LFO-ARO selector.	22-24
PMD LFO-ARO Sync	Pitch Modulation | LFO-ARO | Common Settings	Activate or Deactivate LFO-ARO Sync.	22-24
PMD LFO-ARO Wav	Pitch Modulation | LFO-ARO | Common Settings	Choose from the available waveforms for the LFO or ARO using the Waveform selector.	22-24
PMD Mxr EG Active	Pitch Modulation | Envelope Generator	Activate or Deactivate the EG.	22-24
PMD Mxr EG Level	Pitch Modulation | Envelope Generator	The Modulation Mixer EG Level Slider.	22-24
PMD Mxr LFO Active	Pitch Modulation | Envelope Generator	Activate or Deactivate the LFO.	22-24
PMD Mxr LFO Level	Pitch Modulation | Envelope Generator	The Modulation Mixer LFO Level Slider.	22-24
PMD Range	Pitch Modulation | Global	Set the maximum Pitch Modulation Range in octaves.	22-24
PMD Source Edit	Pitch Modulation	Select the Source Edit panel for editing.	22-24





Create MTS microtuning files for this VSTi with the popular Scala microtuning software application developed by Manuel Op de Coul.

MTS is the **MIDI Tuning Standard**, which is a kind of MIDI System Exclusive (SYSEX) that is able to do full keyboard microtunings in the same way that the popular TUN format can, although there are distinct advantages over these kinds of fixed tuning-table formats, such as the ability to retune ensembles of MTS-enabled VSTi from a single track in a DAW by transmitting the MTS to a number of VSTi instrument tracks simultaneously.

MTS files can be created in **Scala** in the same way that TUN files are, with the variation of setting the synth type to a different number (107).

MTS is really just a MIDI file, with a file extension of MID, and this kind of file is basically 'played' into, or transmitted, to the synth. In the Xenharmonic FMTS VSTi, the transmission of the MTS file can be done internally using the MTS file open dialogs, or it can receive MTS externally by playing it from a track in your DAW and routing the MIDI to the VSTi track.

To create MTS files in Scala:

1. Open Scala.

2. Using the menus File/New/Scale or Ctrl+N, open the Input Current Scale dialog to create a new scale. Paste or type your tuning values into the Pitches field and click OK. Obviously, there are a number of ways to create tunings, such as opening SCL files from the Scala archive, or using the other File/New options.

3. To see your scale, type Show then press Enter, or press the Show button on the toolbar, or even press F6 on your keyboard.

4. To set Scala to create the MTS (Synthesizer 107: MIDI Tuning Standard bulk tuning dump, 3 byte), type 'set synth 107' into the command line at the bottom of the program and press Enter. Alternatively, click the Opts button on the toolbar to display the User Options dialog. Click the Synth button on the left to switch the dialog to the Synth options. Under Synthesizer Tuning Options, choose Tuning Model: "107: MIDI Tuning Standard bulk tuning dump."

5. On the File menu choose Export Synth Tuning, or press Shift+Ctrl+T, to open the export dialog (Curiously, this dialog is titled Select MIDI File To Save).

6. Use the Places navigation pane on the left to navigate to a directory where you wish to save your MTS file. Type a file name at the bottom with the file extension MID, such as '5-tet.mid'. Press OK.

Now you have saved an MTS file that can be opened by this VSTi.

Scala: http://www.huygens-fokker.org/scala/

Please note that the microtunings included with this VSTi have the 1/1 mapped to C60 @ 262 Hz.

This and the following pages contain reference information regarding the Partials (TXT) files and MTS Microtuning files included with this VSTi.

For musicians and composers who may be new to the sounds of xenharmonic and microtonal intervals, the Xenharmonic FMTS VSTi will provide a nice introduction and overview of some of the expressive possibilities of making music with alternative intonation systems.

With this instrument alone, you can explore the sound of equal temperaments 5 through 31. Also it will provide a great introduction to just intonation microtuning and includes octave-based segments of the harmonic and subharmonic series as tunings that can be directly played from your MIDI controller. The popular Bohlen-Pierce temperament, as well as Wendy Carlos Alpha, Beta and Gamma are also included as an introduction to the amazing sounds of non-octave microtunings.

Partials TXT Files	Description
05 TET Partials.txt	Partials for 5 Tone Equal Temperament
07 TET Partials.txt	Partials for 7 Tone Equal Temperament
08 TET Partials.txt	Partials for 8 Tone Equal Temperament
09 TET Partials.txt	Partials for 9 Tone Equal Temperament
10 TET Partials.txt	Partials for 10 Tone Equal Temperament
11 TET Partials.txt	Partials for 11 Tone Equal Temperament
12 TET Partials.txt	Partials for 12 Tone Equal Temperament
13 TET Partials.txt	Partials for 13 Tone Equal Temperament
14 TET Partials.txt	Partials for 14 Tone Equal Temperament
15 TET Partials.txt	Partials for 15 Tone Equal Temperament
16 TET Partials.txt	Partials for 16 Tone Equal Temperament
17 TET Partials.txt	Partials for 17 Tone Equal Temperament
18 TET Partials.txt	Partials for 18 Tone Equal Temperament
19 TET Partials.txt	Partials for 19 Tone Equal Temperament
20 TET Partials.txt	Partials for 20 Tone Equal Temperament
21 TET Partials.txt	Partials for 21 Tone Equal Temperament
22 TET Partials.txt	Partials for 22 Tone Equal Temperament
23 TET Partials.txt	Partials for 23 Tone Equal Temperament
24 TET Partials.txt	Partials for 24 Tone Equal Temperament
25 TET Partials.txt	Partials for 25 Tone Equal Temperament
26 TET Partials.txt	Partials for 26 Tone Equal Temperament
27 TET Partials.txt	Partials for 27 Tone Equal Temperament
28 TET Partials.txt	Partials for 28 Tone Equal Temperament
29 TET Partials.txt	Partials for 29 Tone Equal Temperament
30 TET Partials.txt	Partials for 30 Tone Equal Temperament
31 TET Partials.txt	Partials for 31 Tone Equal Temperament
Antiharmonics.txt	Musical Antimatter: Square root boundaries lying between degrees of the harmonic series
Bohlen-Pierce Partials.txt	Partials for Bohlen-Pierce tuning
Cluster Partials (1200 TET).txt	Fine Tuning: 1 cent increments
Cluster Partials (2400 TET).txt	Fine Tuning: 0.5 cent increments
Cluster Partials (300 TET).txt	Fine Tuning: 4 cents increments
Cluster Partials (4800 TET).txt	Fine Tuning: .25 cent increments
Cluster Partials (600 TET).txt	Fine Tuning: 2 cents increments
Fibonacci Series	1, 2, 3, 5, 8, 13...
Harmonics Even.txt	Even harmonics
Harmonics Odd.txt	Odd harmonics
Harmonics.txt	Everyone's historical favorite: The Harmonic Series
Isoharmonic 1.txt	Harmonic Difference (1)
Isoharmonic 2.txt	Harmonic Difference (2)
Isoharmonic 3.txt	Harmonic Difference (3)
Isoharmonic 4.txt	Harmonic Difference (4)
Isoharmonic 5.txt	Harmonic Difference (5)
Isoharmonic 6.txt	Harmonic Difference (6)
Primes	Prime Number Harmonics (1 is included to provide a fundamental pitch where needed.)
Random Partials 01.txt	Random Partials
Random Partials 02.txt	Random Partials
Random Partials 03.txt	Random Partials
Random Partials 04.txt	Random Partials
Random Partials 05.txt	Random Partials
Random Partials 06.txt	Random Partials
Random Partials 07.txt	Random Partials
Random Partials 08.txt	Random Partials
Random Partials 09.txt	Random Partials
Random Partials 10.txt	Random Partials
Wendy Carlos Alpha Partials.txt	Wendy Carlos Alpha Partials.txt
Wendy Carlos Beta Partials.txt	Wendy Carlos Beta Partials.txt
Wendy Carlos Gamma Partials.txt	Wendy Carlos Gamma Partials.txt

MTS Microtuning Files	Description
05 TET.mid	5 Tone Equal Temperament
07 TET.mid	7 Tone Equal Temperament
08 TET.mid	8 Tone Equal Temperament
09 TET.mid	9 Tone Equal Temperament
10 TET.mid	10 Tone Equal Temperament
11 TET.mid	11 Tone Equal Temperament
12 TET.mid	12 Tone Equal Temperament
13 TET.mid	13 Tone Equal Temperament
14 TET.mid	14 Tone Equal Temperament
15 TET.mid	15 Tone Equal Temperament
16 TET.mid	16 Tone Equal Temperament
17 TET.mid	17 Tone Equal Temperament
18 TET.mid	18 Tone Equal Temperament
19 TET.mid	19 Tone Equal Temperament
20 TET.mid	20 Tone Equal Temperament
21 TET.mid	21 Tone Equal Temperament
22 TET.mid	22 Tone Equal Temperament
23 TET.mid	23 Tone Equal Temperament
24 TET.mid	24 Tone Equal Temperament
25 TET.mid	25 Tone Equal Temperament
26 TET.mid	26 Tone Equal Temperament
27 TET.mid	27 Tone Equal Temperament
28 TET.mid	28 Tone Equal Temperament
29 TET.mid	29 Tone Equal Temperament
30 TET.mid	30 Tone Equal Temperament
31 TET.mid	31 Tone Equal Temperament
Bohlen-Pierce.mid	13 Tone Division of 3/1
Harmonics 05-10.mid	Harmonics 5-10
Harmonics 06-12.mid	Harmonics 6-12
Harmonics 07-14.mid	Harmonics 7-14
Harmonics 08-16.mid	Harmonics 8-16
Harmonics 09-18.mid	Harmonics 9-18
Harmonics 10-20.mid	Harmonics 10-20
Harmonics 11-22.mid	Harmonics 11-22
Harmonics 12-24.mid	Harmonics 12-24
Harmonics 13-26.mid	Harmonics 13-26
Harmonics 14-28.mid	Harmonics 14-28
Harmonics 15-30.mid	Harmonics 15-30
Harmonics 16-32.mid	Harmonics 16-32
Subharmonics 10-05.mid	Subharmonics 10-5
Subharmonics 12-06.mid	Subharmonics 12-6
Subharmonics 14-07.mid	Subharmonics 14-7
Subharmonics 16-08.mid	Subharmonics 16-8
Subharmonics 18-09.mid	Subharmonics 18-9
Subharmonics 20-10.mid	Subharmonics 20-10
Subharmonics 22-11.mid	Subharmonics 22-11
Subharmonics 24-12.mid	Subharmonics 24-12
Subharmonics 26-13.mid	Subharmonics 26-13
Subharmonics 28-14.mid	Subharmonics 28-14
Subharmonics 30-15.mid	Subharmonics 30-15
Subharmonics 32-16.mid	Subharmonics 32-16
Wendy Carlos - Alpha.mid	78 Cents Equal Temperament
Wendy Carlos - Beta.mid	63.8 Cents Equal Temperament
Wendy Carlos - Gamma.mid	35.1 Cents Equal Temperament

The microtunings included with this VSTi have the 1/1 mapped to C60 @ 262 Hz.

7 TET Cents:	0.00	171.43	342.86	514.29	685.71	857.14	1028.57	1200.00
Partial Index	0	1	2	3	4	5	6	7
1	1.00	1.10	1.22	1.35	1.49	1.64	1.81	2.00
2	2.00	2.21	2.44	2.69	2.97	3.28	3.62	4.00
3	2.97	3.28	3.62	4.00	4.42	4.88	5.38	5.94
4	4.00	4.42	4.88	5.38	5.94	6.56	7.25	8.00
5	4.88	5.38	5.94	6.56	7.25	8.00	8.83	9.75
6	5.94	6.56	7.25	8.00	8.83	9.75	10.77	11.89
7	7.25	8.00	8.83	9.75	10.77	11.89	13.13	14.49
8	8.00	8.83	9.75	10.77	11.89	13.13	14.49	16.00
9	8.83	9.75	10.77	11.89	13.13	14.49	16.00	17.67
10	9.75	10.77	11.89	13.13	14.49	16.00	17.67	19.50
11	10.77	11.89	13.13	14.49	16.00	17.67	19.50	21.53
12	11.89	13.13	14.49	16.00	17.67	19.50	21.53	23.78
13	13.13	14.49	16.00	17.67	19.50	21.53	23.78	26.25
14	14.49	16.00	17.67	19.50	21.53	23.78	26.25	28.98
15	16.00	17.67	19.50	21.53	23.78	26.25	28.98	32.00
16	17.67	19.50	21.53	23.78	26.25	28.98	32.00	35.33
17	19.50	21.53	23.78	26.25	28.98	32.00	35.33	39.01
18	21.53	23.78	26.25	28.98	32.00	35.33	39.01	43.07
19	23.78	26.25	28.98	32.00	35.33	39.01	43.07	47.55
20	26.25	28.98	32.00	35.33	39.01	43.07	47.55	52.50
21	28.98	32.00	35.33	39.01	43.07	47.55	52.50	57.97
22	32.00	35.33	39.01	43.07	47.55	52.50	57.97	64.00
23	35.33	39.01	43.07	47.55	52.50	57.97	64.00	70.66
24	39.01	43.07	47.55	52.50	57.97	64.00	70.66	78.02
25	43.07	47.55	52.50	57.97	64.00	70.66	78.02	86.14
26	47.55	52.50	57.97	64.00	70.66	78.02	86.14	
27	52.50	57.97	64.00	70.66	78.02	86.14		
28	57.97	64.00	70.66	78.02	86.14			
29	64.00	70.66	78.02	86.14				
30	70.66	78.02	86.14					
31	78.02	86.14						
32	86.14							

The above table is an example visualization of coincident frequency ratios (partials) for 7 tone equal temperament.

1. The ratios shown in column 0 are the values that are found in the default **Operator Ratios File**, **07 TET Partials.txt**, which are a list of frequency ratios representing 32 harmonics that have been adjusted to match 7 TET. Column 0 may be thought of as the 1/1 of the tuning with its associated partial structure.

2. At the top of the table, running horizontally, the cents values for 7 TET are listed, and Row 1 shows the decimal values for this tuning. This is the same as the MTS microtuning file, **07 TET.mid**.

3. Each of the following columns 1 through 7 represent intervals and their partials sounded with the 1/1 in column 0.

4. The fields shown in yellow depict the partials that are directly coincident with the intervals of 7 tone equal temperament.

Loading an **FM-RM Oscillator Ratios File** with its corresponding **MTS Microtuning** file into the Xenharmonic FMTS VSTi, such as **07 TET Partials.txt** and **07 TET.mid**, creates and audible correlation between the timbre of the instrument and the tuning itself.

Using the FM-RM Oscillator Ratio File features to configure the ratios of the FM Operators to match a given microtuning enables musicians and composers to create complex timbres with tuning related sidebands.

Harmonic Model ET Spectra

Index Number	5 TET	7 TET	8 TET	9 TET	10 TET	11 TET	12 TET	13 TET	14 TET	15 TET	16 TET	17 TET	18 TET	19 TET	Harmonic Series
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1
2	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2
3	3.031	2.972	3.084	2.939	3.031	2.919	2.997	3.064	2.972	3.031	2.954	3.007	3.055	2.988	3
4	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4
5	5.278	4.876	5.187	5.040	4.925	5.147	5.040	4.951	5.124	5.040	4.967	4.905	5.040	4.979	5
6	6.063	5.944	6.169	5.879	6.063	5.838	5.993	6.128	5.944	6.063	5.907	6.014	6.110	5.975	6
7	6.964	7.246	6.727	6.858	6.964	7.053	7.127	6.817	6.896	6.964	7.025	7.079	7.127	6.914	7
8	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8
9	9.190	8.833	8.724	9.332	9.190	9.075	8.980	8.900	8.833	9.190	9.110	9.041	8.980	8.925	9
10	10.556	9.752	10.375	10.079	9.849	10.293	10.079	9.902	10.247	10.079	9.935	9.809	10.079	9.958	10
11	12.126	10.767	11.314	10.886	11.314	10.963	11.314	11.016	10.767	11.055	10.834	11.085	10.886	11.109	11
12	13.929	11.888	12.338	11.758	12.126	11.676	11.986	12.256	11.888	12.126	11.815	12.027	12.219	11.950	12
13	16.000	13.125	13.454	12.699	12.996	13.244	12.699	12.927	13.125	13.300	12.884	13.049	13.198	12.855	13
14	18.379	14.492	14.672	13.716	13.929	14.105	14.254	13.635	13.792	13.929	14.050	14.158	14.254	13.828	14
15	21.112	16.000	16.000	14.814	14.929	15.023	15.102	15.169	15.227	15.277	15.322	14.747	14.814	14.874	15
16	24.251	17.665	17.448	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16
17	27.858	19.504	19.027	17.281	17.148	17.041	16.951	16.876	16.812	16.757	16.708	16.666	17.281	17.211	17
18	32.000	21.534	20.749	18.664	18.379	18.149	17.959	17.801	17.665	18.379	18.221	18.082	17.959	17.851	18
19	36.758	23.776	22.627	20.159	19.698	19.329	19.027	18.775	18.562	19.248	19.027	18.834	18.664	19.202	19
20	42.224	26.251	24.675	21.773	21.112	20.587	20.159	19.804	20.494	20.159	19.870	19.618	20.159	19.915	20
21	48.503	28.983	26.909	23.516	22.627	21.926	21.357	20.888	21.534	21.112	20.749	21.285	20.950	20.655	21
22	55.715	32.000	29.344	25.398	24.251	23.352	22.627	22.032	22.627	22.111	21.668	22.171	21.773	22.218	22
23	64.000	35.331	32.000	27.432	25.992	24.871	23.973	23.239	23.776	23.156	22.627	23.093	22.627	23.044	23
24	73.517	39.008	34.896	29.628	27.858	26.488	25.398	24.511	24.983	24.251	23.629	24.055	24.439	23.900	24
25	84.449	43.069	38.055	32.000	29.857	28.211	26.909	25.854	26.251	25.398	24.675	25.056	25.398	24.788	25
26	97.006	47.552	41.499	34.562	32.000	30.046	28.509	27.270	27.583	26.600	25.768	26.098	26.396	25.709	26
27	111.430	52.501	45.255	37.329	34.297	32.000	30.204	28.763	28.983	27.858	26.909	27.184	27.432	26.664	27
28	128.000	57.966	49.351	40.317	36.758	34.081	32.000	30.338	30.454	29.175	28.100	28.316	28.509	27.655	28
29	147.033	64.000	53.817	43.545	39.397	36.298	33.903	32.000	32.000	30.555	29.344	29.494	29.628	28.683	29
30	168.897	70.662	58.688	47.032	42.224	38.659	35.919	33.753	33.624	32.000	30.643	30.721	30.791	29.748	30
31	194.012	78.017	64.000	50.797	45.255	41.173	38.055	35.601	35.331	33.513	32.000	32.000	32.000	30.854	31
32	222.861	86.138	69.792	54.864	48.503	43.851	40.317	37.551	37.124	35.098	33.417	33.332	33.256	32.000	32

The above table shows the coincident partials for equal temperaments 5 through 19 used in the partials TXT files. These values represent the most closely matching ratios to a harmonic series model.

It is interesting to note that at 19 tone equal temperament there is a fairly good representation of the harmonic series up to partial 32, where there is at least one harmonic identity lying within the square root boundaries between each of the first 32 members of the harmonic series. This is one of the primary reasons that 19 TET intervals sound good when played with harmonic series timbres.

This and the following pages provide detailed information about the just intonation microtunings included with this VSTi. These tunings, derived as octave-based sections from the harmonic and subharmonic series, represent some of the fundamental intervals of melody and harmony in music made with harmonic series timbres. Historically speaking, harmonic and subharmonic series intervals have made up an important part of the foundations of music going back to ancient Greek tetrachord theory, Renaissance and Maqam music.

As an introduction to just intonation, it is suggested to play through all of these just tunings using some of the included harmonic timbres in an effort to understand the unique sonic character each can impart to the music. Listen carefully for the wonderful acoustic blending effects that occur with this special category of microtuning.

Just Intonation: Harmonic and Subharmonic Octave Segments 1-32

	Harmonic Numerary Nexus in Denominator Otonal: Major Tonality							Subharmonic Numerary Nexus in Numerator Utonal: Minor Tonality						
Degree	Harmonics: Numerator	Numerary Nexus: Denominator	Ratio Steps	Steps Cents	Ratio Degrees	Degrees Cents	Degree	Numerary Nexus: Numerator	Subharmonics: Denominator	Ratio Steps	Steps Cents	Ratio Degrees	Degrees Cents
0	1	1			1/1	0.000	1	2	1			2/1	1200.000
1	2	1	2/1	1200.000	2/1	1200.000	0	2	2	2/1	1200.000	1/1	0.000
0	2	2			1/1	0.000	2	4	2			2/1	1200.000
1	3	2	3/2	701.955	3/2	701.955	1	4	3	3/2	701.955	4/3	498.045
2	4	2	4/3	498.045	2/1	1200.000	0	4	4	4/3	498.045	1/1	0.000
0	3	3			1/1	0.000	3	6	3			2/1	1200.000
1	4	3	4/3	498.045	4/3	498.045	2	6	4	4/3	498.045	3/2	701.955
2	5	3	5/4	386.314	5/3	884.359	1	6	5	5/4	386.314	6/5	315.641
3	6	3	6/5	315.641	2/1	1200.000	0	6	6	6/5	315.641	1/1	0.000
0	4	4			1/1	0.000	4	8	4			2/1	1200.000
1	5	4	5/4	386.314	5/4	386.314	3	8	5	5/4	386.314	8/5	813.686
2	6	4	6/5	315.641	3/2	701.955	2	8	6	6/5	315.641	4/3	498.045
3	7	4	7/6	266.871	7/4	968.826	1	8	7	7/6	266.871	8/7	231.174
4	8	4	8/7	231.174	2/1	1200.000	0	8	8	8/7	231.174	1/1	0.000
0	5	5			1/1	0.000	5	10	5			2/1	1200.000
1	6	5	6/5	315.641	6/5	315.641	4	10	6	6/5	315.641	5/3	884.359
2	7	5	7/6	266.871	7/5	582.512	3	10	7	7/6	266.871	10/7	617.488
3	8	5	8/7	231.174	8/5	813.686	2	10	8	8/7	231.174	5/4	386.314
4	9	5	9/8	203.910	9/5	1017.596	1	10	9	9/8	203.910	10/9	182.404
5	10	5	10/9	182.404	2/1	1200.000	0	10	10	10/9	182.404	1/1	0.000
0	6	6			1/1	0.000	6	12	6			2/1	1200.000
1	7	6	7/6	266.871	7/6	266.871	5	12	7	7/6	266.871	12/7	933.129
2	8	6	8/7	231.174	4/3	498.045	4	12	8	8/7	231.174	3/2	701.955
3	9	6	9/8	203.910	3/2	701.955	3	12	9	9/8	203.910	4/3	498.045
4	10	6	10/9	182.404	5/3	884.359	2	12	10	10/9	182.404	6/5	315.641
5	11	6	11/10	165.004	11/6	1049.363	1	12	11	11/10	165.004	12/11	150.637
6	12	6	12/11	150.637	2/1	1200.000	0	12	12	12/11	150.637	1/1	0.000
0	7	7			1/1	0.000	7	14	7			2/1	1200.000
1	8	7	8/7	231.174	8/7	231.174	6	14	8	8/7	231.174	7/4	968.826
2	9	7	9/8	203.910	9/7	435.084	5	14	9	9/8	203.910	14/9	764.916
3	10	7	10/9	182.404	10/7	617.488	4	14	10	10/9	182.404	7/5	582.512
4	11	7	11/10	165.004	11/7	782.492	3	14	11	11/10	165.004	14/11	417.508
5	12	7	12/11	150.637	12/7	933.129	2	14	12	12/11	150.637	7/6	266.871
6	13	7	13/12	138.573	13/7	1071.702	1	14	13	13/12	138.573	14/13	128.298
7	14	7	14/13	128.298	2/1	1200.000	0	14	14	14/13	128.298	1/1	0.000

Just Intonation: Harmonic and Subharmonic Octave Segments 1-32

	Harmonic Numerary Nexus in Denominator Otonal: Major Tonality						Subharmonic Numerary Nexus in Numerator Utonal: Minor Tonality						
Degree	Harmonics: Numerator	Numerary Nexus: Denominator	Ratio Steps	Steps Cents	Ratio Degrees	Degrees Cents	Degree	Numerary Nexus: Numerator	Subharmonics: Denominator	Ratio Steps	Steps Cents	Ratio Degrees	Degrees Cents
0	8	8			1/1	0.000	8	16	8			2/1	1200.000
1	9	8	9/8	203.910	9/8	203.910	7	16	9	9/8	203.910	16/9	996.090
2	10	8	10/9	182.404	5/4	386.314	6	16	10	10/9	182.404	8/5	813.686
3	11	8	11/10	165.004	11/8	551.318	5	16	11	11/10	165.004	16/11	648.682
4	12	8	12/11	150.637	3/2	701.955	4	16	12	12/11	150.637	4/3	498.045
5	13	8	13/12	138.573	13/8	840.528	3	16	13	13/12	138.573	16/13	359.472
6	14	8	14/13	128.298	7/4	968.826	2	16	14	14/13	128.298	8/7	231.174
7	15	8	15/14	119.443	15/8	1088.269	1	16	15	15/14	119.443	16/15	111.731
8	16	8	16/15	111.731	2/1	1200.000	0	16	16	16/15	111.731	1/1	0.000
0	9	9			1/1	0.000	9	18	9			2/1	1200.000
1	10	9	10/9	182.404	10/9	182.404	8	18	10	10/9	182.404	9/5	1017.596
2	11	9	11/10	165.004	11/9	347.408	7	18	11	11/10	165.004	18/11	852.592
3	12	9	12/11	150.637	4/3	498.045	6	18	12	12/11	150.637	3/2	701.955
4	13	9	13/12	138.573	13/9	636.618	5	18	13	13/12	138.573	18/13	563.382
5	14	9	14/13	128.298	14/9	764.916	4	18	14	14/13	128.298	9/7	435.084
6	15	9	15/14	119.443	5/3	884.359	3	18	15	15/14	119.443	6/5	315.641
7	16	9	16/15	111.731	16/9	996.090	2	18	16	16/15	111.731	9/8	203.910
8	17	9	17/16	104.955	17/9	1101.045	1	18	17	17/16	104.955	18/17	98.955
9	18	9	18/17	98.955	2/1	1200.000	0	18	18	18/17	98.955	1/1	0.000
0	10	10			1/1	0.000	10	20	10			2/1	1200.000
1	11	10	11/10	165.004	11/10	165.004	9	20	11	11/10	165.004	20/11	1034.996
2	12	10	12/11	150.637	6/5	315.641	8	20	12	12/11	150.637	5/3	884.359
3	13	10	13/12	138.573	13/10	454.214	7	20	13	13/12	138.573	20/13	745.786
4	14	10	14/13	128.298	7/5	582.512	6	20	14	14/13	128.298	10/7	617.488
5	15	10	15/14	119.443	3/2	701.955	5	20	15	15/14	119.443	4/3	498.045
6	16	10	16/15	111.731	8/5	813.686	4	20	16	16/15	111.731	5/4	386.314
7	17	10	17/16	104.955	17/10	918.642	3	20	17	17/16	104.955	20/17	281.358
8	18	10	18/17	98.955	9/5	1017.596	2	20	18	18/17	98.955	10/9	182.404
9	19	10	19/18	93.603	19/10	1111.199	1	20	19	19/18	93.603	20/19	88.801
10	20	10	20/19	88.801	2/1	1200.000	0	20	20	20/19	88.801	1/1	0.000
0	11	11			1/1	0.000	11	22	11			2/1	1200.000
1	12	11	12/11	150.637	12/11	150.637	10	22	12	12/11	150.637	11/6	1049.363
2	13	11	13/12	138.573	13/11	289.210	9	22	13	13/12	138.573	22/13	910.790
3	14	11	14/13	128.298	14/11	417.508	8	22	14	14/13	128.298	11/7	782.492
4	15	11	15/14	119.443	15/11	536.951	7	22	15	15/14	119.443	22/15	663.049
5	16	11	16/15	111.731	16/11	648.682	6	22	16	16/15	111.731	11/8	551.318
6	17	11	17/16	104.955	17/11	753.637	5	22	17	17/16	104.955	22/17	446.363
7	18	11	18/17	98.955	18/11	852.592	4	22	18	18/17	98.955	11/9	347.408
8	19	11	19/18	93.603	19/11	946.195	3	22	19	19/18	93.603	22/19	253.805
9	20	11	20/19	88.801	20/11	1034.996	2	22	20	20/19	88.801	11/10	165.004
10	21	11	21/20	84.467	21/11	1119.463	1	22	21	21/20	84.467	22/21	80.537
11	22	11	22/21	80.537	2/1	1200.000	0	22	22	22/21	80.537	1/1	0.000

Just Intonation: Harmonic and Subharmonic Octave Segments 1-32

Harmonic Numerary Nexus in Denominator Otonal: Major Tonality							Subharmonic Numerary Nexus in Numerator Utonal: Minor Tonality							
Degree	Harmonics: Numerator	Numerary Nexus: Denominator	Ratio Steps	Steps Cents	Ratio Degrees	Degrees Cents	Degree	Numerary Nexus: Numerator	Subharmonics: Denominator	Ratio Steps	Steps Cents	Ratio Degrees	Degrees Cents
0	12	12			1/1	0.000	12	24	12			2/1	1200.000
1	13	12	13/12	138.573	13/12	138.573	11	24	13	13/12	138.573	24/13	1061.427
2	14	12	14/13	128.298	7/6	266.871	10	24	14	14/13	128.298	12/7	933.129
3	15	12	15/14	119.443	5/4	386.314	9	24	15	15/14	119.443	8/5	813.686
4	16	12	16/15	111.731	4/3	498.045	8	24	16	16/15	111.731	3/2	701.955
5	17	12	17/16	104.955	17/12	603.000	7	24	17	17/16	104.955	24/17	597.000
6	18	12	18/17	98.955	3/2	701.955	6	24	18	18/17	98.955	4/3	498.045
7	19	12	19/18	93.603	19/12	795.558	5	24	19	19/18	93.603	24/19	404.442
8	20	12	20/19	88.801	5/3	884.359	4	24	20	20/19	88.801	6/5	315.641
9	21	12	21/20	84.467	7/4	968.826	3	24	21	21/20	84.467	8/7	231.174
10	22	12	22/21	80.537	11/6	1049.363	2	24	22	22/21	80.537	12/11	150.637
11	23	12	23/22	76.956	23/12	1126.319	1	24	23	23/22	76.956	24/23	73.681
12	24	12	24/23	73.681	2/1	1200.000	0	24	24	24/23	73.681	1/1	0.000
0	13	13			1/1	0.000	13	26	13			2/1	1200.000
1	14	13	14/13	128.298	14/13	128.298	12	26	14	14/13	128.298	13/7	1071.702
2	15	13	15/14	119.443	15/13	247.741	11	26	15	15/14	119.443	26/15	952.259
3	16	13	16/15	111.731	16/13	359.472	10	26	16	16/15	111.731	13/8	840.528
4	17	13	17/16	104.955	17/13	464.428	9	26	17	17/16	104.955	26/17	735.572
5	18	13	18/17	98.955	18/13	563.382	8	26	18	18/17	98.955	13/9	636.618
6	19	13	19/18	93.603	19/13	656.985	7	26	19	19/18	93.603	26/19	543.015
7	20	13	20/19	88.801	20/13	745.786	6	26	20	20/19	88.801	13/10	454.214
8	21	13	21/20	84.467	21/13	830.253	5	26	21	21/20	84.467	26/21	369.747
9	22	13	22/21	80.537	22/13	910.790	4	26	22	22/21	80.537	13/11	289.210
10	23	13	23/22	76.956	23/13	987.747	3	26	23	23/22	76.956	26/23	212.253
11	24	13	24/23	73.681	24/13	1061.427	2	26	24	24/23	73.681	13/12	138.573
12	25	13	25/24	70.672	25/13	1132.100	1	26	25	25/24	70.672	26/25	67.900
13	26	13	26/25	67.900	2/1	1200.000	0	26	26	26/25	67.900	1/1	0.000
0	14	14			1/1	0.000	14	28	14			2/1	1200.000
1	15	14	15/14	119.443	15/14	119.443	13	28	15	15/14	119.443	28/15	1080.557
2	16	14	16/15	111.731	8/7	231.174	12	28	16	16/15	111.731	7/4	968.826
3	17	14	17/16	104.955	17/14	336.130	11	28	17	17/16	104.955	28/17	863.870
4	18	14	18/17	98.955	9/7	435.084	10	28	18	18/17	98.955	14/9	764.916
5	19	14	19/18	93.603	19/14	528.687	9	28	19	19/18	93.603	28/19	671.313
6	20	14	20/19	88.801	10/7	617.488	8	28	20	20/19	88.801	7/5	582.512
7	21	14	21/20	84.467	3/2	701.955	7	28	21	21/20	84.467	4/3	498.045
8	22	14	22/21	80.537	11/7	782.492	6	28	22	22/21	80.537	14/11	417.508
9	23	14	23/22	76.956	23/14	859.448	5	28	23	23/22	76.956	28/23	340.552
10	24	14	24/23	73.681	12/7	933.129	4	28	24	24/23	73.681	7/6	266.871
11	25	14	25/24	70.672	25/14	1003.802	3	28	25	25/24	70.672	28/25	196.198
12	26	14	26/25	67.900	13/7	1071.702	2	28	26	26/25	67.900	14/13	128.298
13	27	14	27/26	65.337	27/14	1137.039	1	28	27	27/26	65.337	28/27	62.961
14	28	14	28/27	62.961	2/1	1200.000	0	28	28	28/27	62.961	1/1	0.000

Just Intonation: Harmonic and Subharmonic Octave Segments 1-32

	Harmonic Numerary Nexus in Denominator Otonal: Major Tonality						Subharmonic Numerary Nexus in Numerator Utonal: Minor Tonality						
Degree	Harmonics: Numerator	Numerary Nexus: Denominator	Ratio Steps	Steps Cents	Ratio Degrees	Degrees Cents	Degree	Numerary Nexus: Numerator	Subharmonics: Denominator	Ratio Steps	Steps Cents	Ratio Degrees	Degrees Cents
0	15	15			1/1	0.000	15	30	15			2/1	1200.000
1	16	15	16/15	111.731	16/15	111.731	14	30	16	16/15	111.731	15/8	1088.269
2	17	15	17/16	104.955	17/15	216.687	13	30	17	17/16	104.955	30/17	983.313
3	18	15	18/17	98.955	6/5	315.641	12	30	18	18/17	98.955	5/3	884.359
4	19	15	19/18	93.603	19/15	409.244	11	30	19	19/18	93.603	30/19	790.756
5	20	15	20/19	88.801	4/3	498.045	10	30	20	20/19	88.801	3/2	701.955
6	21	15	21/20	84.467	7/5	582.512	9	30	21	21/20	84.467	10/7	617.488
7	22	15	22/21	80.537	22/15	663.049	8	30	22	22/21	80.537	15/11	536.951
8	23	15	23/22	76.956	23/15	740.006	7	30	23	23/22	76.956	30/23	459.994
9	24	15	24/23	73.681	8/5	813.686	6	30	24	24/23	73.681	5/4	386.314
10	25	15	25/24	70.672	5/3	884.359	5	30	25	25/24	70.672	6/5	315.641
11	26	15	26/25	67.900	26/15	952.259	4	30	26	26/25	67.900	15/13	247.741
12	27	15	27/26	65.337	9/5	1017.596	3	30	27	27/26	65.337	10/9	182.404
13	28	15	28/27	62.961	28/15	1080.557	2	30	28	28/27	62.961	15/14	119.443
14	29	15	29/28	60.751	29/15	1141.308	1	30	29	29/28	60.751	30/29	58.692
15	30	15	30/29	58.692	2/1	1200.000	0	30	30	30/29	58.692	1/1	0.000
0	16	16			1/1	0.000	16	32	16			2/1	1200.000
1	17	16	17/16	104.955	17/16	104.955	15	32	17	17/16	104.955	32/17	1095.045
2	18	16	18/17	98.955	9/8	203.910	14	32	18	18/17	98.955	16/9	996.090
3	19	16	19/18	93.603	19/16	297.513	13	32	19	19/18	93.603	32/19	902.487
4	20	16	20/19	88.801	5/4	386.314	12	32	20	20/19	88.801	8/5	813.686
5	21	16	21/20	84.467	21/16	470.781	11	32	21	21/20	84.467	32/21	729.219
6	22	16	22/21	80.537	11/8	551.318	10	32	22	22/21	80.537	16/11	648.682
7	23	16	23/22	76.956	23/16	628.274	9	32	23	23/22	76.956	32/23	571.726
8	24	16	24/23	73.681	3/2	701.955	8	32	24	24/23	73.681	4/3	498.045
9	25	16	25/24	70.672	25/16	772.627	7	32	25	25/24	70.672	32/25	427.373
10	26	16	26/25	67.900	13/8	840.528	6	32	26	26/25	67.900	16/13	359.472
11	27	16	27/26	65.337	27/16	905.865	5	32	27	27/26	65.337	32/27	294.135
12	28	16	28/27	62.961	7/4	968.826	4	32	28	28/27	62.961	8/7	231.174
13	29	16	29/28	60.751	29/16	1029.577	3	32	29	29/28	60.751	32/29	170.423
14	30	16	30/29	58.692	15/8	1088.269	2	32	30	30/29	58.692	16/15	111.731
15	31	16	31/30	56.767	31/16	1145.036	1	32	31	31/30	56.767	32/31	54.964
16	32	16	32/31	54.964	2/1	1200.000	0	32	32	32/31	54.964	1/1	0.000

End User License Agreement

This instrument is offered as freeware as a way to inspire musicians and composers experiment with computer music, sound synthesis and alternative musical instrument intonations (aka microtonal and xenharmonic music).

The instrument can be used in any kind of musical production, commercial or otherwise, completely free of charge.

Selling this VSTi is not permitted.

It is not permitted to distribute this VSTi in any way without prior permission.

Xen-Arts assumes no responsibility for any kind from damages resulting from the use of this software.

The **Xenharmonic FMTS 2 VSTi** is truly a collaborative effort involving many creative musicians, composers and programmers from around the world:

Concept, construction, GUI, patch sound-design and this user manual by **Jacky Ligon ● Xen-Arts ● xen-arts.com**

This instrument was created in the **SynthEdit** environment from developer **Jeff McClintock**. The highest possible level of gratitude goes out to Jeff for implementing **MTS (MIDI Tuning Standard)** in SynthEdit; the ultimate microtonal tuning format.

Jeff McClintock ● SynthEdit ● synthedit.com

This instrument features modules developed by **Chris Kerry**, including his amazing **CK 4-Operator FM-2 Add-Ring Oscillator**, as well as modules by **David Haupt**.

Chris Kerry ● CK Modules & VST ● chriskerry.f9.co.uk/CK_Modules.html

Dave Haupt ● Dave Haupt's SynthEdit Pages ● dehaupt.com/SynthEdit/

Design consultant, microtonal software developer: **X. J. Scott ● Microtonal Software ● microtonalsoftware.com**

Beta-testers included computer musicians, composers, performers, modular synthesists, sound-designers and label owners:

Sean Archibald ● Sevish ● seanarchibald.co.uk

Warren Burt ● Warren Burt | Journal ● warrenburt.com

Tony Dubshot ● Dubbhism ● dubbhism.com

Brian Ginsburg

Nedim Zengovski ● Basari Studios ● basaristudios.com

The **MTS** microtunings included with this synthesizer were created using the **Scala** application developed by **Manuel Op de Coul**. Many thanks goes out to Manuel for his decades long support of microtonal musicians and composers and for offering his application as freeware.

Manuel Op de Coul ● Scala ● huygens-fokker.org/scala

Enormous inspiration for this instrument was derived from the work of **John Chowning** and **William Sethares**.

John Chowning ● ccrma.stanford.edu/people/john-chowning

William Sethares ● Relating Tuning and Timbre ● sethares.engr.wisc.edu/consemi.html

Harmonics consultants: **Kraig Grady** and **John Chalmers**

Thanks goes out also to the many helpful members of the **SynthEdit** Users group for helping to make this instrument a reality.

This VSTi is a gift to musicians and composers who are interested in exploring the exciting possibilities of alternative intonation systems in their music.

Recommended Reading
The use of alternative intonation systems, FM synthesis, and the practice of correlating timbre and microtuning, are vast, technically complex and scientific topics. While the Xenharmonic FMTS 2 VSTi wraps a lot of this complexity into the form of an instrument that can be used for relatively easy experimentation with these concepts, invariably some users will wish to more deeply explore the technical details of this fascinating category of musical practice. For that purpose, the following list of suggested readings are offered:

Synth Secrets, Part 12: An Introduction To Frequency Modulation
http://www.soundonsound.com/sos/apr00/articles/synthsecrets.htm

Synth Secrets, Part 13: More On Frequency Modulation
http://www.soundonsound.com/sos/may00/articles/synth.htm

Relating Tuning and Timbre | William Sethares
http://sethares.engr.wisc.edu/consemi.html

Tuning, Timbre, Spectrum, Scale | William Sethares
http://sethares.engr.wisc.edu/prelude.html
http://sethares.engr.wisc.edu/ttss.html
http://www.amazon.com/Tuning-Timbre-Spectrum-William-Sethares/dp/1852337974

Musical Mathematics | On the art and science of acoustic instruments | Cris Forster
http://www.chrysalis-foundation.org/musical_mathematics.htm

Microtunings
It was not the design goal for this VSTi to feature a comprehensive selection of microtunings and only a very basic set are included as factory defaults. The included microtunings should essentially be regarded as starting points for further investigation. The creation, discovery and exploration of custom microtunings is left to the discretion of musicians. Microtonal and xenharmonic music - and musical instrument intonation in general - is a vast topic, and a field in which one should anticipate working with lots of different intonations and spending a significant number of years to understand and master the use of alternative intonation systems in one's music.

Microtonal Pitch Bends
One of the powerful features of this synthesizer is the ability for musicians and composers to precisely specify the pitch-bend range in cents. While there are many possible applications for this functionality, one use for this is to is to configure a pitch bend range that lies directly between a single step of an equal temperament.

For example, in the case of 8 tone equal temperament, we know that the tuning is made up of equal step sizes of 150 cents. To set a pitch bend range at 1/2 of this step size, we can type in 75 cents into the pitch bend cents field, and with the Bend Selector in the Cents mode, when we bend the pitch wheel of the MIDI controller we are able to precisely play pitches that lie between the steps of 8-TET, which, are in fact, notes found in the next highest multiple of this temperament: 16-TET. So in effect we are able to move the pitch wheel to precisely play notes from a higher multiple of a given equal-temperament, and with this same kind of logic, we can examine any microtuning to determine what would be other musically useful settings for expressive microtonal pitch-bends that are contextual to a given intonational setting.

The Xen-FMTS 2 VSTi features one of the most comprehensive pitch-bend systems found in virtual instruments, which enables users to configure the pitch-bend range in terms of Cents, Harmonics and Superparticular intervals.

Microtonal Oscillator Transposition
In addition to the microtonal pitch bend functions, this VSTi also features the ability to precisely configure transposition offsets of the oscillators in cents, and alternatively, in the case of the Audio Rate Oscillators (ARO) found in all of the Modulators, according to degrees of the loaded Partials Files.

While most synthesizers and samplers force musicians to use octaves, semitone steps of 12 tone equal temperament and cents, this VSTi enables musicians to easily make oscillator transposition settings that fit with any intonational context required by the music at hand. This is especially useful for musical composition scenarios in which the intonation system does not repeat at an exact interval of 2/1 @ 1200 cents. There are many beautiful microtunings of this nature, such as Bohlen-Pierce and the wonderful Wendy Carlos, Alpha, Beta and Gamma; all of which are included as default microtunings in this instrument.

MIDI Velocity Modulation of Harmonics
Musicians and composers who are familiar with playing acoustic instruments such as winds and strings will appreciate the expressive ability to sound harmonics of the fundamental pitch by over-blowing or plucking at harmonic nodes. This VSTi has a unique feature that enables direct pitch modulation of the oscillators by degrees of the harmonic series or the loaded partials file using MIDI Velocity, where, when activated, increased force on the controller can be used to break out higher harmonics, which are in effect, integer multiples of the fundamental frequency of the sounding waveform. As previously explained in the FM-RM Oscillator section of this manual, the range options are from 1-2, 1-4, 1-8 and 1-16 harmonics. The interaction between the sensitivity setting and the range of harmonics can be easily configured by musicians to fit with the requirements of a particular musical or performance scenario.

Per-Stage ADSR Keyboard Tracking
Another of the innovative synthesis features offered in this VSTi, are the Per-Stage ADSR Keyboard Tracking functions, where each stage of the ADSR may be independently modulated by keyboard-tracking. These are the three position switches that appear over the ADSR Envelope Generator sliders in the Oscillator, Pitch, Filter and Amplifier Modulation sections.

These switches, when used in conjunction with the Key Scale feature, enable setting up sophisticated, keyboard-position dependent modulation effects, where each note across the range can potentially have it's own unique envelope character.

When, for instance, they are applied to the Pitch Envelope Generator in the Oscillator section, the character and timing of the pitch modulations can be configured to change as one plays across the MIDI range, where they might get shorter as one plays higher, and longer when lower.

Also one might apply these keyboard tracking functions to pad type sounds and make the attack fade in more slowly when playing higher on the controller, while faster in the lower range. The applications are fairly infinite, and this unique feature makes this instrument stand out as an incredibly expressive tool for microtonal music sound-design.

Bass and Distortion Timbres
Xen-FMTS 2 inherits a number of features from the Xen-Arts Ivor VSTi, which was originally conceived as a bass and distortion synthesizer capable of creating deep basses and heavy distorted guitar-like timbres. The key features that are involved in creating these kinds of distortion patches with this VSTi, are the Pitch Modulation section, as well as the Saturation stage found in the Filters section. Emulation of guitar-like sounds relies heavily on being able to synthesize the plucked attack and the Pitch Envelope Generator - with its many control Shapes - makes this possible. The Analog Pitch Drift feature also contributes to this kind of sound by emulating the random micro-fluctuations of pitch observable in many analog, acoustic and electro-acoustic musical instruments.

Polyrhythmic LFO
Using the Low Frequency Oscillators found in the Modulators, makes it possible to create myriad kinds of polyrhythmic transformations to the timbre of the instrument. Setting each LFO to different durations is capable of creating incredibly complex and sonically alluring rhythmic timbral effects that can be synced to the musician's host DAW.

Alternative Intonation Preferences and Practice
With even a cursory examination of the pitch informed sound worlds of alternative intonation, one will immediately observe that there are as many kinds of microtunings - and musical practices with them - as stars in the night sky. Consensus about intonation is rare in this field of rich diversity - where universals that apply uniformly to all musical and cultural contexts around the world are virtually nonexistent - and practicing musicians approach the topic from seemingly infinite possible angles; some from the perspectives of ethnomusicology, others from the intonational topographies of their own historical and cultural backgrounds, while yet others from a contemporary theoretically informed world view. Finally, there are those who find resonance in the more subjective practice of just letting their ear be the guide for microtuning their musical instruments.

Some categories of musical practice required by alternative intonation musicians and composers may involve mapping densely microchromatic tunings to their instruments in order to have immediate access to all of the available pitches in their chosen systems. The requirements of others may operate at almost the opposite extreme, where microtunings with less pitches are a desired facet of their practice. There is also the important practice category of dynamic adaptive intonation, such as embodied in fine a capella choral groups, as well as some of the most cutting edge software tools. Timbre, timing, space and style also work to inform intonational choice and practice, and it could be stated with a great degree of accuracy, that among the most fundamentally important musical interactions are those between the intonation and musical instrument timbres. All of these approaches are perfectly valid and especially those that are motivated by actual practice and musical expression.

Finding the intervals, microtunings and timbres one prefers for their music and style is a highly subjective and personal process that may take time to develop and refine, but discovery through the vehicle of practice - i.e. - listening, composing, playing musical instruments and singing - has always been, and will remain among the most highly recommended approaches to this field of artistic endeavor.

These are among the ways that the underlying theoretical concepts of alternative musical instrument intonation systems are permitted to live through practicing musicians, composers and cultures; thereby taking on a final tangible and aesthetic form through the medium of musical sound, and which can then in turn be appreciated by listeners around the world. Therein lies the completion of the musical creative cycle.