SURGE XT

FREE & OPEN SOURCE
HYBRID SYNTHESIZER

Surge XT User Manual

Ver 1.0.0 - January 23, 2022

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Getting Started

Thank you for using **Surge XT!**

Surge XT is a virtual synthesizer originally released as "Surge" into open source by creator Claes Johanson in September 2018. Since then, it is maintained by a group of volunteers.

This first section is intended to give you a brief overview of some concepts that are specific to this synthesizer and an introduction on how to navigate, manipulate, and use Surge XT to its full potential.

For detailed information regarding the synthesis engine and other advanced technical specifications and options of this synthesizer, there is a second section dedicated to Technical Reference.

Finally, for more tips and tricks, tutorials, and to download additional content, you can also take a look at Surge's wiki.

Installing or building Surge XT

Surge XT's installer is available at https://surge-synthesizer.github.io.

Windows

On the Windows platform, Surge XT is delivered as both a 32 or 64-bit VST3 plug-in instrument.

The filename for the VST3 is Surge XT.vst3.

System Requirements:

- Windows 7 or newer
- A reasonably fast CPU (Pentium 4/Athlon 64 or above)
- At least 4GB of RAM
- VST-compatible host application

In addition, to use the 64-bit version on Windows you need the following:

- A CPU supporting the x64 (AMD64/EM64T) instruction set
- A **64-bit** version of Windows
- An application capable of hosting 64-bit VST plug-ins

The VST3 version of the plug-in should be automatically installed in the default VST3 plug-in location and should be found by your host application. However, the Windows version also comes with a **portable mode**:

- Portable Mode allows you to store assets in the same directory as your Surge XT.vst3.
- If Surge XT.vst3 is installed in a folder and in that same folder there is a directory called SurgeXTData, Surge XT will use that for factory data rather than %PROGRAMDATA%\Surge XT.
- If in that same folder there is a directory called SurgeUserData, Surge XT will use that for user data rather than %DOCUMENTS%\Surge.
- Either none, one, or both of those folders can be there. Surge XT will fall back to the defaults if they are not present. You can always see your data paths in the About screen.

macOS

On Mac, Surge XT is delivered as a 64-bit Plug-in Instrument for both the Audio Unit (AU) and VST Plug-in interfaces (VST3).

System Requirements:

- Mac OS X 10.11 or newer
- A 64-bit Intel CPU
- At least 4GB of RAM
- 64-bit AU or VST-compatible host application

To install, run the packaged installer. You will be given the option of automatically installing the AU Surge XT.component and the VST3 Surge XT.vst3 to their correct locations. The factory presets and wavetables will also be automatically installed.

Running the packaged installer will install Surge for all of the users of your Mac.

Linux

On Linux, Surge is available as a 64-bit VST3 in the form of a **deb** and **RPM** package.

The system requirements can be hard to determine, as there are a lot of distributions out there and other factors. However, the following information might be good to know:

- The installation package on **Surge XT's website** is in the form of a Debian package
- The distribution package is built on Ubuntu 18.04
- The packages required are listed in the source and in the deb file

Note: Some actions in Surge XT are done by doing Alt + Drag or scroll wheel. On certain Linux distributions, those shortcuts and gestures may cause conflicts between Surge and the desktop environment. We decided we couldn't give up alt-drag for all platforms because one window manager in one distribution used it by default. Therefore, it's often possible to disable that global gesture in desktop environments, and would be the easiest way to solve that possible issue.

Building from source

If you would like to build Surge XT from source, see the instructions on our Github repository.

Installing Surge XT alongside Surge 1.9 and earlier

Although Surge XT represents an evolution of Surge, Surge XT is an entirely new plugin. This means that you can effortlessly install it alongside Surge 1.9 or earlier, and you will need to keep Surge 1.9 installed in order to open existing projects containing older versions of Surge.

Locations

Windows

The preset library and wavetables are at C:ProgramData\Surge XT. The user presets are at C:\Users\your username\My Documents\Surge XT.user default settings for the first time

macOS

The preset library and wavetables are at /Library/Application Support/Surge XT. The user presets are at ~/Documents/Surge XT.

Linux

The plugin itself, preset library and wavetables are at /usr/share/surge-xt with a standard install. The user presets are at ~/Documents/Surge XT, this directory will be created once you store a patch or preset or change the .

Note: These locations can be changed in Surge's menu (see Data Folders).

If you put user content in the factory folder or otherwise change it, future installers will erase it. Surge XT's installers never touch anything in the user area.

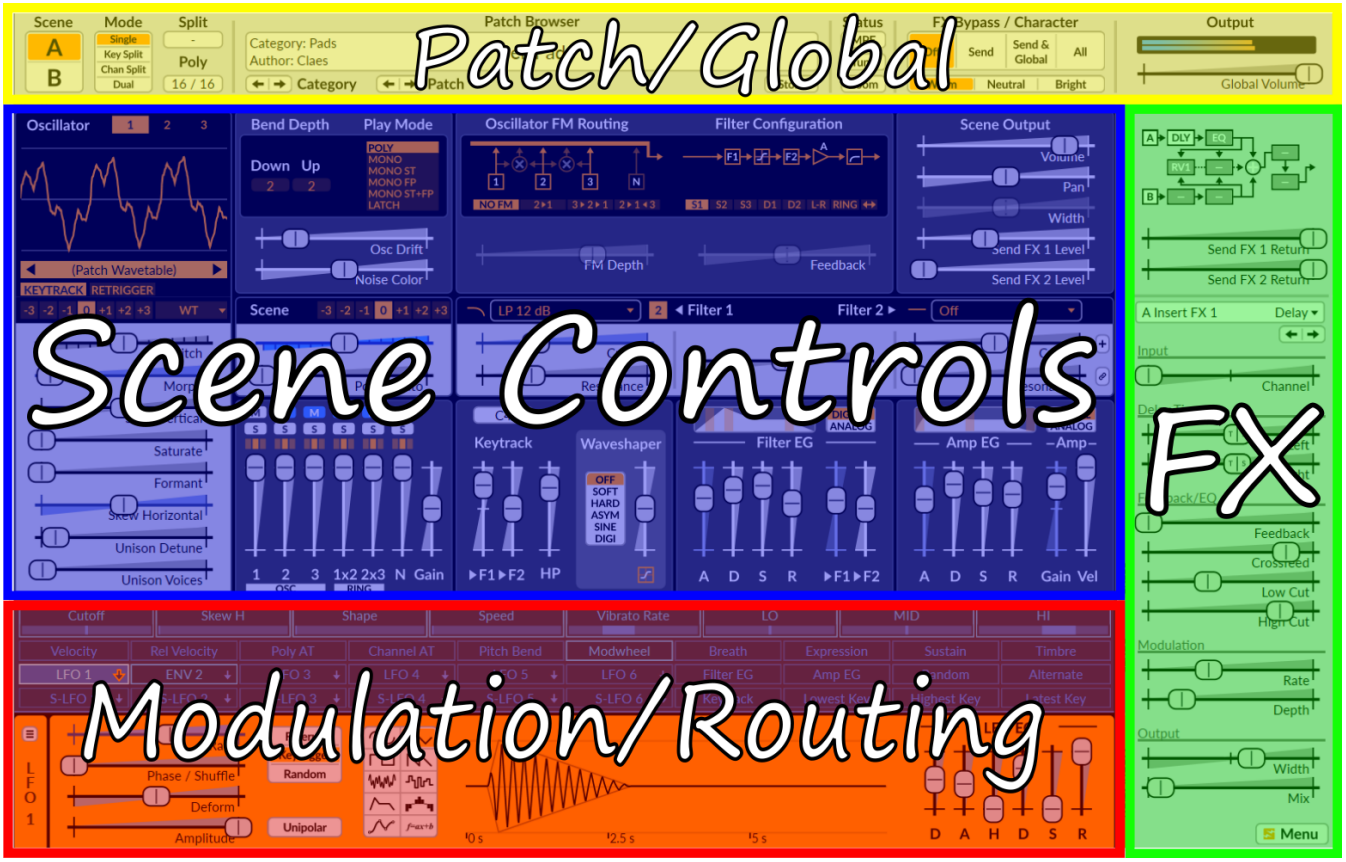
So, if you want to install a custom skin, set of patches, or otherwise add things to Surge, put them in your user data folder instead of here, or risk losing them when you upgrade.

Introduction to the User Interface

The user-interface of Surge XT is divided into four main sections:

- Patch/Global
- Scene controls
- Modulation/Routing
- FX

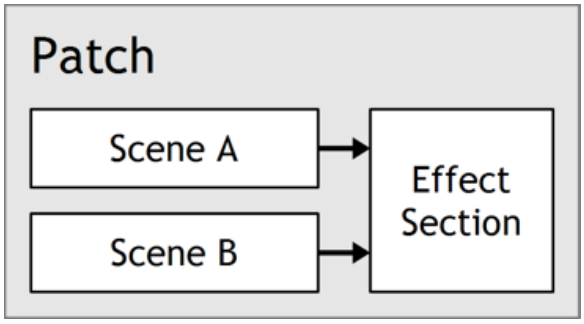
Keeping this structure in mind will make it easier to understand the layout.



The four sections of the user-interface that Surge is divided into.

The “Scene” Concept

Every patch in Surge XT contains two scenes (A & B) and an effect-section. Both scenes and all effect settings are stored in every patch. A scene is similar to a traditional synthesizer patch as it stores all the information used to synthesize a voice. Since there are two scenes in each patch, it’s possible to have layered or split sounds stored within a single patch. (see Scene Select and Scene Mode).



Audio Outputs

When loaded into a DAW, each instance of Surge XT has 3 audio outputs:

- Stereo Out
- Scene A Out
- Scene B Out

In some hosts, like FL Studio for instance, Surge XT will disable the individual scene outputs due to a conflict with the DAW’s audio routing architecture. To enable those additional outputs in such cases, see this option in the Surge XT menu.

Sliders and controls

The most common user-interface control in Surge XT is the slider. They come in both horizontal and vertical orientations but their functionality is otherwise identical.

Sliders are always dragged, there is no jump if you click on the slider tray instead of the slider head, it enters dragging mode nonetheless.

Slider interactions:

- **Left-click drag** - Drag slider
- **Shift + Left-click drag** - Drag slider (fine)
- **Ctrl/Cmd + Left-click drag** - Drag slider (quantized steps)
- **Alt + Left-click drag** - Drag slider in elastic mode (snaps back to initial position upon release)
- **Scroll Wheel** - Move Slider
- **Shift + Scroll Wheel** - Move slider (fine)
- **Double left-click** - Reset parameter to default value
- **Right-click** - Context menu
- **Hover** - See the slider's current value without clicking on it

Other than sliders, some of Surge XT's parameters are also displayed as number and value fields, buttons and button rows.

Parameter context menu

Any parameter's context menu can be brought up with a right-click. This menu has numerous useful functions:

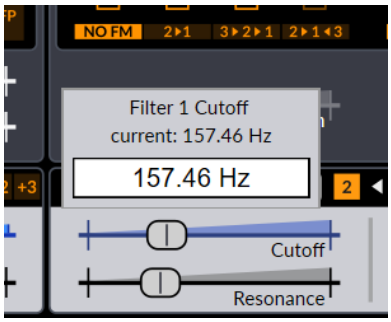
Name and contextualized help

Clicking on this first option will open this user manual to the correct section explaining the parameter in question.

Edit Value

This option allows you to type in the desired value of a parameter. Once the value popup appears, its text will already be highlighted, and you can start typing the value right away. When you are done, simply press Enter to confirm the change. To cancel and close this popup, simply press the Escape key or move any other parameter.

Note that for any value type-in windows in Surge XT, there is no need to type in the unit of the entered value.



For discrete parameters (Unison Voices, or a button row for instance), instead of a type-in field, all the possible values will be displayed right in the menu so they can be accessed directly.

Extend Range

Some parameters can have their range extended. The option **Extend range** will appear in the context menu if they do. **Pitch**, for instance, is one of those parameters.

Tempo Sync

Some parameters can be synchronized to the host tempo. The option **Tempo sync** will appear in the context menu if they do.

Once tempo-synced, when using the Surge XT Classic skin, the slider will show a "TS" symbol on their handles to indicate that state, like so:

This indication can vary depending on the skin used.

Enabled

Some parameters can be enabled or disabled. If a slider appears transparent or is missing its handle, in some cases, it can be because the parameter is disabled. To toggle it, simply click on that option.

Modulations

This section of the menu will appear if the right-clicked slider is being modulated by some modulation source(s) (if it has a blue tint). See Routing for more information.

- **Red X icon -** Clicking on this icon to the left of a modulation source will clear that modulation routing.
- **Speaker icon -** Clicking on this will allow you to mute (bypass) a modulation source in the list. Simply click that icon again to unmute that source.
- **Pencil icon -** This will bring up the modulation amount type-in window. Simply type-in the desired amount of modulation you want to apply to that parameter. See Edit Value for more information.

Add Modulation From

As its name suggests, this menu entry allows you to directly link a modulator to the right-clicked control. All the available modulation sources are sorted in different categories so you can find the desired one easier. Once a modulation source is chosen, a type-in window will appear, allowing you to enter the modulation amount you want to apply.

Assign parameter to...

This option allows to assign the right-clicked parameter to any MIDI CC.

MIDI Learn Parameter...

This is where you assign a MIDI controller to the desired slider. To abort MIDI learning on that parameter, simply right-click again and the option will now become **Abort Parameter MIDI Learn.**

Clear learned MIDI (...)

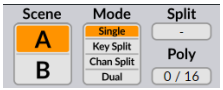
This option will be available if the selected parameter has already been MIDI learned. It allows you to clear that link (the existing link MIDI CC number will be shown in parentheses).

VST3 Options

Finally, the VST3 version of Surge XT supports VST3 context menu items. Depending on the host, there may be more or less options regarding automation, MIDI, or parameter values.

Patch/Global Section

Scene Select and Scene Mode



There are two setups of all controls within the Scene section of the user interface. The **Scene Select** buttons **[A|B]** determine which one is selected for editing. Right-clicking on these buttons brings up a context menu that allows you to copy/paste scene content.

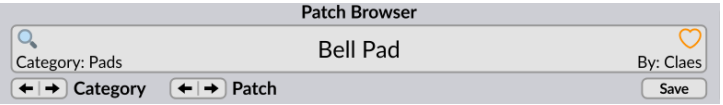
Depending on the **Scene Mode**, these two buttons could also be used to choose which scene will be *played*. Indeed, whether a scene will generate a voice when a key is pressed is determined by the **Scene Mode** setting:

- **Single** – Notes will be played only by the selected scene.
- **Key Split** – Notes below the split key will be played by scene A, notes above and including the split key will be played by scene B.
- **Channel Split** - Notes from MIDI channels below the split MIDI channel will be played by scene A, notes from MIDI channels above and including the split MIDI channel will be played by scene B.
- **Dual** – Both scenes will play all the notes.

In both **Key Split** and **Dual** mode, if MPE is disabled, the system also supports MIDI channel routing where Channel 2 plays only Scene A and channel 3 plays only Scene B. MIDI channel 1 and all other channels higher than 3 play the Split/Dual mode.

Poly shows the number of voices currently playing and allows you to set an upper limit to the number of voices allowed to play at the same time by dragging horizontally on the value. The voice-limiter will kill off excess voices gently to avoid audible artifacts, thus it's not uncommon for the voice count to exceed the limit.

Patch Browser



Navigating through presets

Cycling through sounds in Surge XT is easy: just press the arrow buttons until you find something you like. If you left-click the patch-name field (anywhere in the white area), a menu will list all available patches arranged into categories. A right-click will bring up a menu with just the patches of the current category.

These categories are also grouped into three sections depending on who created them:

- **Factory Patches -** Patches created in-house by the Surge XT authors.
- **3rd party patches -** Patches created by users and 3rd parties. Categorized by creators.
- **User Patches -** Your own patches will be stored here. How you categorize them is entirely up to you.

At the bottom, there is an option to download additional content.

You can also directly load patches (.fxp) by dragging and dropping them anywhere over the Surge XT interface.

There is also an option in the patch menu to set the current patch as the default one to be loaded when opening a new instance of Surge XT.

Finally, the patch menu allows you to rename or delete a patch. Those options will only appear if you have a non-factory patch loaded in the synth.

Finding Presets

To find presets by patch name, simply click on the magnifier glass icon to the left of the preset name area. You may see Surge XT first update the preset database before being able to type in your search query.

You can also search for presets by **author** or **category** by typing "AUTHOR=" or "CATEGORY=", followed by your search query.

The Save Dialog

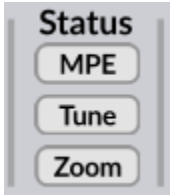
Clicking the **Save** button of the patch browser opens the save dialog. This is where you name your new patch and choose which category it should belong in. You can also create a new category manually here as well. The patches you save will end up in the user section at the bottom of the patch menu. The save dialog also provides text fields for the name of the patch creator and comments.

Note: You can display the comments of a particular patch by hovering over the patch name area with your mouse.

Favoriting patches

Adding a patch to your favorites list is as easy as pressing the heart icon to the right of the patch name area. Right-clicking on that same icon will allow you to access the favorite patches list.

Status Area



This area is meant to be a quick access to some of Surge XT's features that are also present in the Menu. (see Menu Button)

Right-clicking on one of these buttons will reveal more options which are also present in sub-menus under the Menu button as well.

For instance, the first time you press the **Tune** button if no custom tuning is loaded, it will open the same menu as if you would have right-clicked on that button. Once a custom tuning is loaded

however, left-clicking on it will turn the loaded tuning on or off. See Microtonal Tuning for more information.

Alternatively, **.scl** and **.kbm** files can also be dragged and dropped anywhere on the interface to import custom tuning. //FIXME

FX Bypass, Character and Global Volume

FX Bypass lets you quickly hear what a patch sounds like without the effect-units. (see FX Section)

- **Off** – Bypass is disabled, all effects are active.
- **Send** – The send effects are bypassed.
- **Send + Global** - The send and global effects are bypassed.
- **All** – All effects are bypassed.

Character controls the amount of high-frequency content present in most of Surge XT's oscillator algorithms. Available choices are Warm, Neutral and Bright.

Global Volume controls the last gain stage before the output. The VU meter above it shows the output level and will become red if it goes above 0 dBFS. You can choose to hard clip the global output either at **+18 dBFS** (default) or **0 dBFS**.

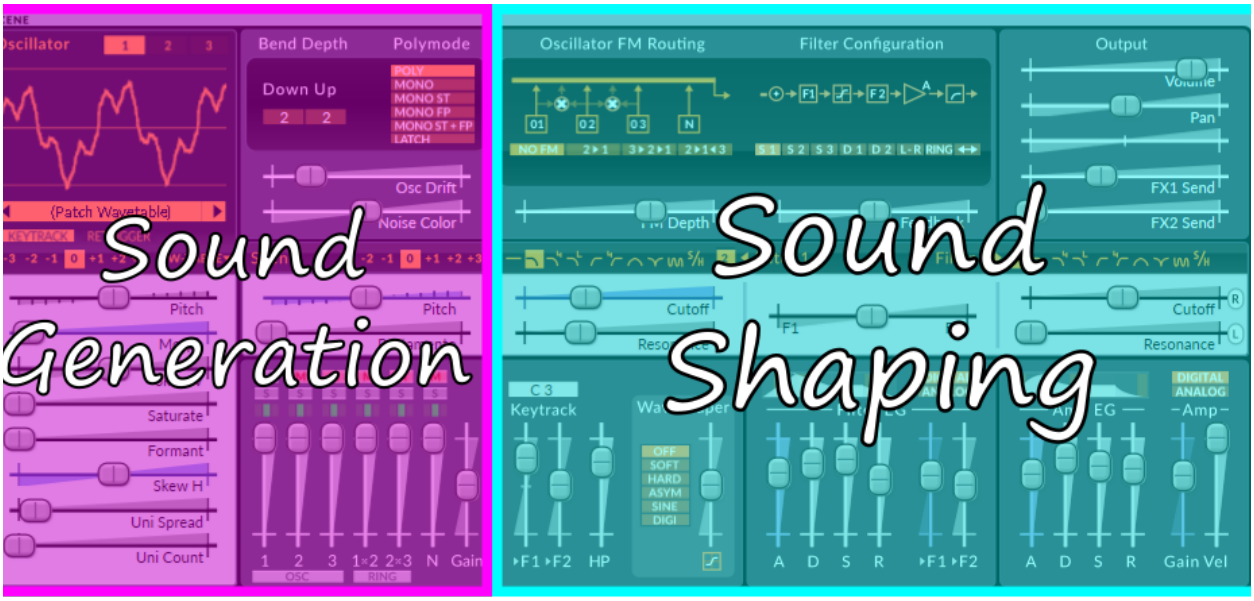
The state of these two settings are **not** stored with patches. They are however stored by the host application in your project files.

Scene Controls Section

The UI of the scene section can also be further divided into two parts:

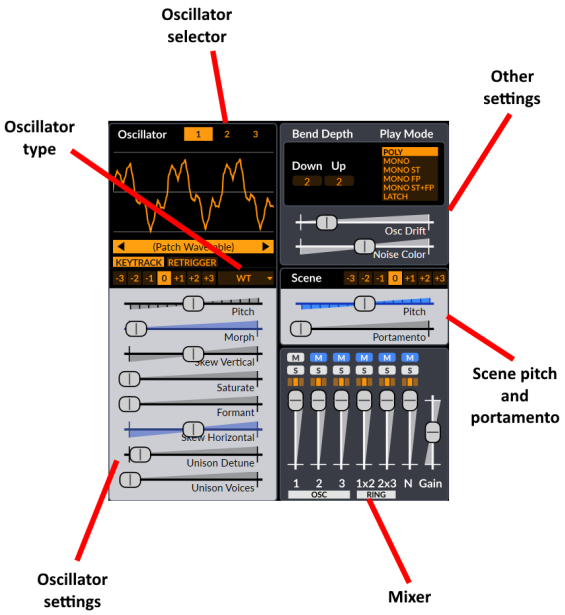
- Sound generation
- Sound shaping

The sound is generated and mixed in the sound generation section. After that, it goes through the sound shaping section.



Sound Generation

This is where the sound is born. The oscillators generate waveforms according to the notes played. They are then summed up in the mixer.



Oscillators

1/2/3-buttons – Chooses the active oscillator for editing. You can right-click on one of them and a context menu with the name, Copy and Copy (with modulation) options will show up.

Display – Shows the active waveform. When the Wavetable or Window oscillator is used, it will also work as wavetable selector by clicking on the orange bar or on the arrows to cycle through them.

Type – Oscillator type. Chooses which algorithm is used for the oscillator. Available options are:

- Classic
- Modern
- Wavetable
- Window
- Sine
- FM2
- FM3
- String
- Twist
- Alias
- S&H Noise
- Audio Input

See Oscillator algorithms in the Technical Reference section for more information.

Pitch & Octave – Controls the pitch for this particular oscillator. Its context menu can be used to extend its range, or to set the pitch to **Absolute** mode, which makes the pitch shift in absolute frequency as opposed to relative to the note that is being played.

Keytrack – When disabled, the oscillator will play the same pitch regardless of the key pressed. This button can be right-clicked to toggle its state across all oscillators in the scene.

Retrigger – If active, the oscillator and all its unison voices will always start immediately at the same phase position. This is useful for snappy sounds where you want the attack to sound exactly the same each note. This button can be right-clicked to set its state across all oscillators in the scene.

Other - The rest of the sliders from the oscillator editor are specific to each oscillator type. See Oscillator algorithms in the Technical Reference section for more information.

Mixer

Mixer Channels

Excluding the **Pre-filter Gain** (slider on the right), the Mixer has 6 channels (sources) from left to right:

- Oscillators 1, 2, 3
- Ring Modulation of 1x2, 2x3 – The source of these two channels is digital ring modulation from the oscillators. This type of RM is a bit different from the traditional carrier-modulator style ring modulation. Digital ring modulation is simply the result of multiplying the output of oscillators 1 and 2, or 2 and 3.
- Noise Oscillator

Channel Parameters

Each channel has the following controls:

- M – Mute. You can of course have multiple channels muted at the same time, but you can also keep only the channel you mute muted by holding down Ctrl / Cmd and clicking on the desired mute switch.
- S – Solo (only play channels that have solo active). You can have multiple channels in solo at the same time, or only one at a time by holding down Ctrl / Cmd and clicking on the desired solo switch.
- Triple Orange Box (Filter routing) – Chooses which filter the channel is routed to. The left position routes the channel output to filter 1, the right position routes it to filter 2, while the middle position, which is selected by default, routes it to both. However, this setting will only route the channel output to filter 1 if a serial filter block configuration is used, since the audio will then go through the second one in the filter block anyways. If any other configuration than serial is used, the audio will then be routed to both filters, as expected.
- Slider – Gain control for each input.

Other sound generation parameters

Pitch & Octave – Controls the pitch for the entire scene. Affects the filter key-tracking and the keytrack modulation source as well. The range of the slider can be extended using the context menu.

Portamento – Portamento is when a new note will slide in pitch from the pitch of the last played note. This setting determines how long the slide will be. A setting of 0 disables Portamento. This parameter can be tempo-synced.

Portamento has some interesting options accessible in its context menu:

- **Constant rate -** If this option is enabled, the time to cover one octave is defined by the Portamento slider value. From there on, gliding between 2 octaves for instance will take twice as long, and so on. By default, this option is disabled, so the glide rate is proportional to the distance between the two keys, making it so that it always takes the same time to glide between any two keys.
- **Glissando -** If this option is enabled, the pitch slide will be quantized to the scale degrees.
- **Retrigger at scale degrees -** If this option is enabled, the FEG and AEG (see Envelope Generators) will be triggered each time the portamento slide crosses a scale degree.
- **Curve options -** You can choose between a Logarithmic, Linear or Exponential portamento curve. By default, the portamento slide follows a linear curve.

Osc Drift – Applies a small amount of instability to the pitch of all oscillators, making them subtly detuned. Although the parameter is shared, the randomness of the instability effect is independent for all oscillators and all the unison voices of each oscillator. By right-clicking on this control, you can choose to also randomize the pitch at the very start of the note by enabling the **Randomize initial drift phase** option.

Noise Color – Affects the frequency spectrum of the noise generator. The middle position results in white noise. Moving the slider to the left emphasizes low frequencies while moving it to the right emphasizes high frequencies.

Bend Depth – Pitch Bend Depth Up/Down. Controls the range of the pitch bend wheel, in semitones.

This control can be extended with the dedicated option in its context menu. It enables type-ins of fractions and cents for configuring microtonal pitch-bends of arbitrary size within the range of 24 semitones.

Play Mode – Chooses how multiple notes are handled. Poly will allow multiple notes to be played simultaneously, while Mono will only let the last note play. Latch will continuously play the last played note (mono).

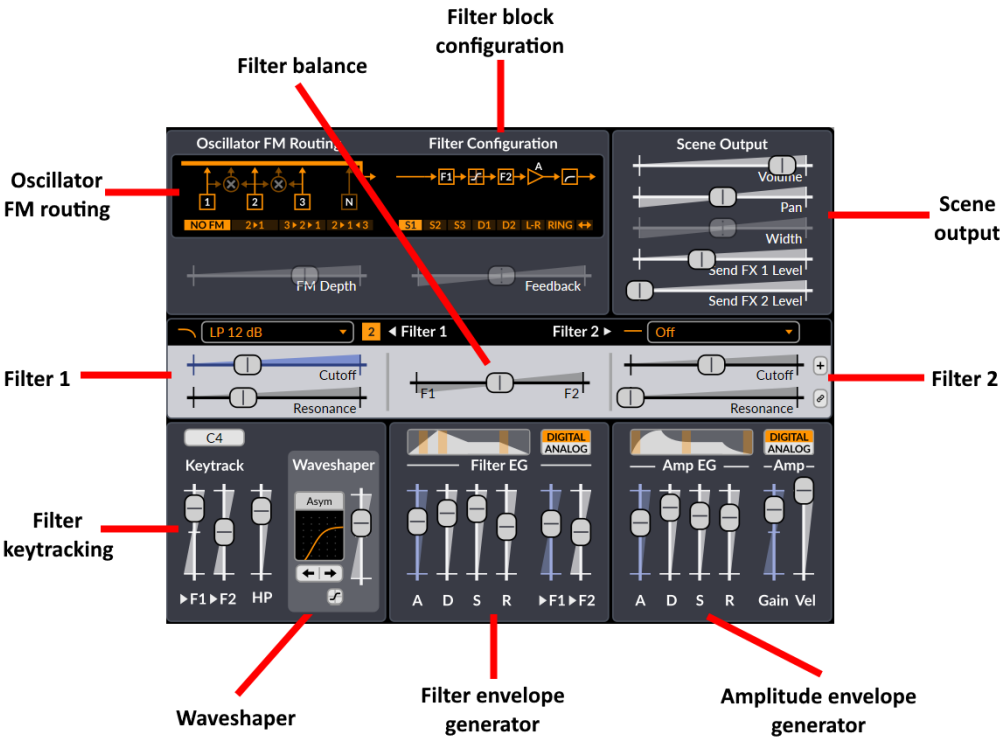
Mono has two possible modifiers:

- **Single Trigger EG (ST)** means that the two envelope generators are not restarted when sliding between two notes (two notes that overlap in time)
- **Fingered Portamento (FP)** means that portamento is only applied when sliding between notes and not when there is time between the played notes.

When **Play Mode** is set to one of the Mono modes, the context menu of that button list will display additional options related to mono note priority:

- **Last note priority -** Will play the latest note when multiple notes are played together
- **High note priority -** Will play the highest note when multiple notes are played together
- **Low note priority -** Will play the lowest note when multiple notes are played together
- **Legacy note priority -** When multiple notes are played together, it will play the latest note once hit and play the highest remaining note once released.
- Sustain pedal in mono mode
    - **Sustain pedal holds all notes (no note off retrigger) -** If sustain is engaged and multiple notes are hit then held one after the other, Surge XT will stay on the latest note when releasing that note instead of switching to the previous note.
    - **Sustain pedal allows note off retrigger -** If sustain is engaged and multiple notes are hit then held one after the other, Surge XT will switch to the previous note when the latest note is released.

Sound shaping



Filter controls

Filter Block Configuration – Chooses how the filters, waveshaper and the gain stage are connected together. Note that only the Stereo and Wide configurations will output a stereo signal.

Feedback – Controls the amount (and polarity) of output that's fed back into the input of the filter block. It has no effect when using the Serial 1 filter block configuration (which because of this has a lower CPU load).

***Note*:** Be careful with your monitoring volume when using feedback. It's easy to make really loud high-pitched noises by mistake if you're not familiar with how the synth reacts to feedback.

Don't let this scare you though. There's a lot to be gained from proper and creative use of feedback. Changing the character of filters, making filters interact together, making basic physical models, making sounds that are just about to break apart. It is these things that make Surge XT truly special.

Filter Balance – Controls how the two filters are mixed. The behavior depends on the filter block configuration.

Type – Selects the type of the filter. There are numerous types available. You can disable the filter in question here by unchecking the **Enabled** option below the different filter type categories.

Subtype – Selects variations of each filter type. The difference can vary from subtle to radical depending on how the filter is used. See Filter algorithms in the Technical Reference section for information regarding subtypes of each filter type. It is displayed as a number next to the filter type (when available).

Cutoff – Controls the cutoff frequency of the filter. When tweaked, while its tooltip will show frequency in Hz, it will also show its approximate MIDI note value, very useful when using the filter for melodic and tuning purposes. You can also right-click on this control and choose the option **Reset cutoff to keytrack root** which makes it very easy to tune filters when using filter keytracking. Finally, the **Apply SCL/KBM tuning to filter cutoff** option can be accessed when the **Apply tuning after modulation** option is enabled in the Tuning menu. See this section in the technical reference for more information.

Resonance – Controls the amount of resonance of the filter.

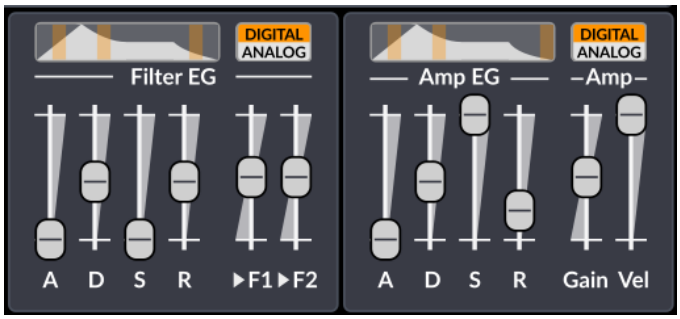
Filter 2 Offset Button – (small "+" button to the right of the filter parameters) – When active, the cutoff frequency will be set relative to filter 1. This includes any modulations (including the hardwired FEG depth & keytracking). Filter 2's cutoff frequency slider **becomes an offset** setting relative to filter 1's cutoff frequency.

Resonance Link Button – (small button, filter 2 only) – Makes the slider follow filter 1's resonance slider setting.

Keytrack > F1/F2 – Controls how much the pitch of a note affects the cutoff frequency of the filter. A setting of 100% means the filter frequency will follow the pitch harmonically.

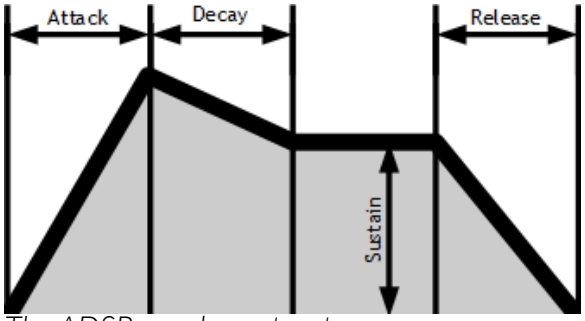
Envelope Generators

There are two envelope generators connected to the filter block.



On the left is the Filter Envelope Generator (Filter EG). It is hardwired to the two filters, whose depth is set by the **>F1** and **>F2** sliders.

On the right is the Amplitude Envelope Generator (Amp EG). This one is hardwired to the gain stage of the filter block.



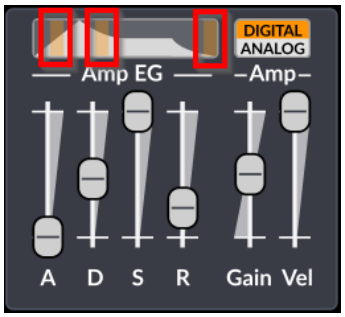
The ADSR envelope structure

The envelope generators are of the 4-stage ADSR type. This is the most common form of EG used in synthesizers and it is named after its four stages **Attack**, **Decay**, **Sustain** and **Release**. If you're new to synthesizer programming the illustration should give you a good idea how they work. The thing you need to remember is that after going through the attack & decay stages the envelope will stick in the sustain stage until the key is released.

Attack, **Decay** and **Release** are time-based parameters and can be tempo-synced by right-clicking on one of those sliders. You will also find an option to tempo-sync those three controls at once for each envelope generator.

Above the envelope stage controls is a graphic representation of the ADSR structure.

If the envelope mode is set to **Digital**, there will be small adjustable orange fields on the graphic. Dragging them horizontally allows you to choose the curvature of the different stages of the envelope.



If the envelope mode is set to **Analog**, the curvature of the different stages will automatically be set to a shape that tries to emulate analog behavior.

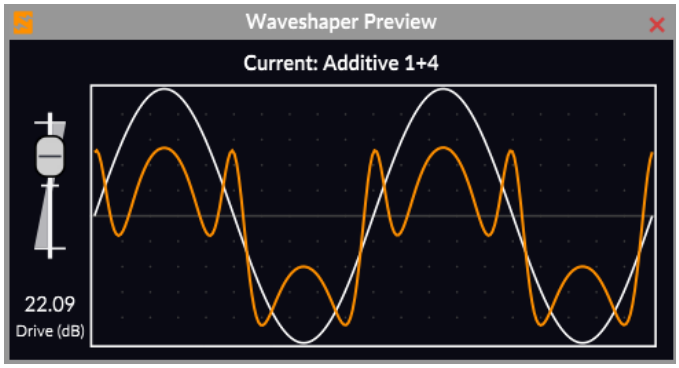
Waveshaper

The waveshaper module now features 43 waveforms and is an integral part of Surge's audio path.

Waveshaper selector - Menu allowing you to change the type of the non-linear wave-shaping. Alternatively, you can also use the arrow buttons, left-click and drag, or scroll with the mouse wheel over the waveshaper display to cycle through the different shapes.

Waveshaper drive – The vertical slider to the right of the waveshaper display. Sets the drive amount of the waveshaper. This control can be extended.

Waveshaper Analysis window - This panel can be opened by clicking on the small icon at the bottom of the waveshaper module. It allows you to visually preview the output of the waveshaper at different input levels, which can be controlled with the **Drive** vertical preview slider.



Other sound shaping parameters

Keytrack root note – Sets the root key of the filter keytracking and the keytrack modulation source. At the root key, the keytrack modulation source will have the value zero. Above/below it it will have positive/negative modulation depending on the distance to the root key in octaves. This parameter does not affect the oscillator pitch.

Keytrack amount sliders - Sets the amount of filter keytracking applied to each filter.

HP – Controls the scene high-pass filter (scene parameter). This parameter can be disabled, which will remove it from the audio path.

FM configuration – Chooses how oscillator FM (frequency modulation) is routed.

FM depth – Sets the depth of the oscillator FM.

Amp Vel. - Controls how the Amp Gain scales with velocity. This is neutral at the maximum position. Other settings provide attenuation at lower velocities, thus this setting will never increase the Amp Gain parameter by velocity.

Amp Gain – Controls the gain element inside the filter block.

Scene output

The output stage is located after the filter block in the audio-path. As it's outside the filter block-structure changing the gain here doesn't have any affect on the timbre of the voice (unlike the previous gain-control which may affect how the feedback and wave-shaping acts), but it can still change the timbre of the effect section if non-linear effects (like distortion) are used.

Volume – Scene volume control. You can choose to hard clip the scene output at **+18 dBFS** (default), **0 dBFS** , or to **disable hard clipping** by right-clicking this control and choosing the desired option.

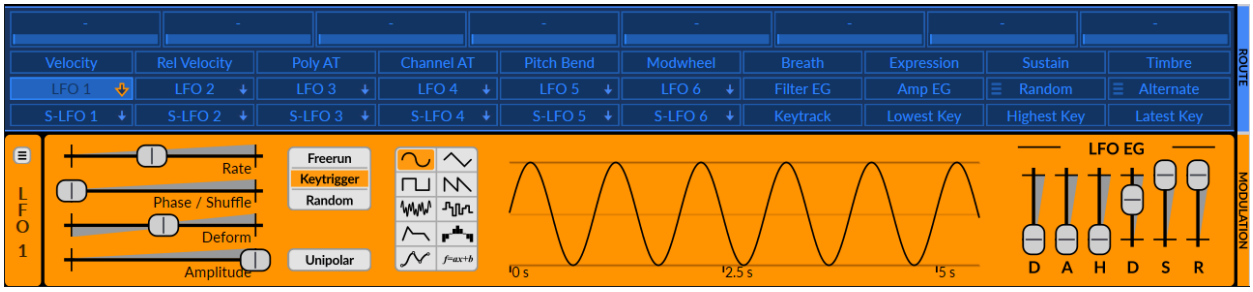
Pan – Pan/balance control

Width – The amount of stereo spread (only present for the Stereo and Wide filter block configurations)

Send FX 1/2 or 3/4 Level – Send levels to send slot 1 to 4 (scene parameters). To display send 3/4 levels, simply select one of those send FX units in the unit selector (see Effect Unit Selector).

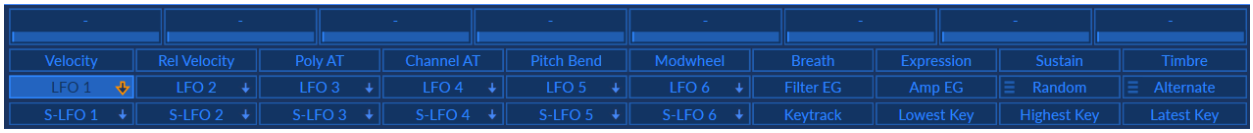
Modulation/Routing Section

The modulation section is different from the sound generation and shaping sections as no audio data is passed through it. Instead it allows you to control the parameters in the other sections from various sources.



Routing

Modulation routing in Surge XT is a bit different compared to most synthesizers, but it's actually very intuitive and extremely powerful, thanks to the routing bar.

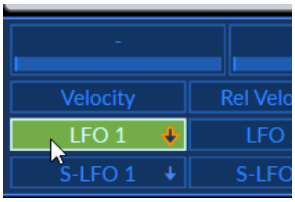


How to apply modulation to parameters

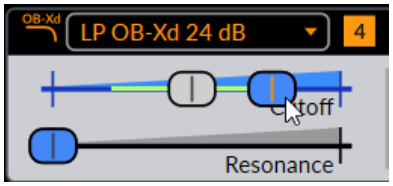
Here's how it works:

1. Select the modulation source you want to use.

2. Engage routing mode with a second click on the source. It will become bright green, and sliders that can be modulated will display a blue modulation depth slider on top of their normal sliders.



3. Drag the desired modulation slider (blue slider) to the position you want the parameter to be at when fully modulated (at the top peak of a Sine LFO, or after the attack stage of an envelope for example). The modulation's full range will then be shown with the corresponding green bar on the slider.



4. Disengage routing mode by clicking again on the modulation source.

Alternatively, routing mode can also be engaged or disengaged by pressing the middle mouse buttons anywhere over the interface, or by pressing **TAB** on the keyboard if this option is enabled (see Workflow section in the menu).

You can also directly access the numerical modulation amount dialog (explained here) by dragging the desired modulation source over a modulatable parameter.

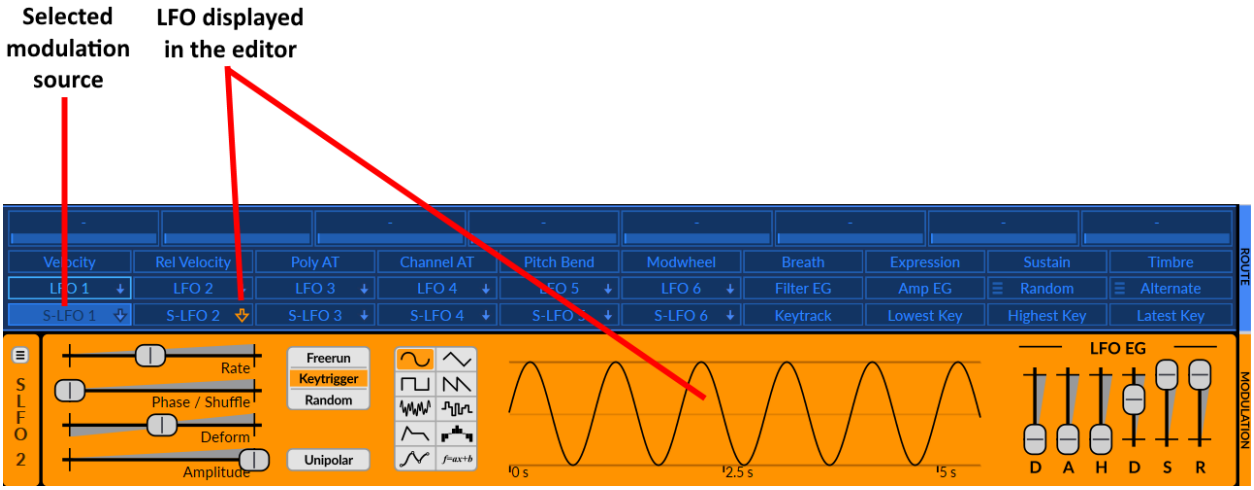
Note that modulation range is always **relative** to the base value represented by the gray slider, meaning that moving its position will then shift the whole modulation range up or down. This also means that if a modulation slider's value is smaller than the base value, the modulation polarity will be inverted.

Also, when applying modulation to certain time-based parameters (such as Portamento, envelope attack, etc.) that are set to 0.00 seconds, in some cases, the modulation won't trigger properly due to the way it works internally. To fix this, simply increase the parameter in question by a very small amount, just so it doesn't have a value of 0.

Modulating LFO parameters with another modulator

When clicking on one of the LFO buttons in the routing bar, both the LFO source selection and the LFO editor will be selected. However, the two actions can be separated, as you can choose which button is selected as the modulation routing source, and at the same time edit parameters from **a different LFO** than the source.

To do that, select the source normally, and then click on the mini-button on another LFO (the small orange arrow):

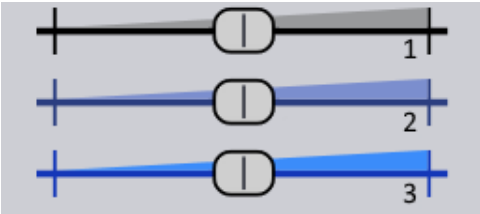


This effectively lets you **modulate the parameters of one LFO with any other mod source(s)**. However, as an example, note that logistically, an S-LFO can modulate parameters of an LFO, but an LFO **cannot** modulate parameters of an S-LFO (see Voice modulators vs. Scene modulators).

Remember that you can also see which LFO is currently being displayed in the editor by looking at what's written vertically to the left of the editor.

Modulated sliders

Once a slider is routed to a modulation source, the shade of blue on its tray indicates whether the parameter is modulated and by which source.



1. Parameter is not modulated (gray)
2. Parameter is modulated (gray-blue)
3. Parameter is modulated by the currently selected modulation source (bright-blue)

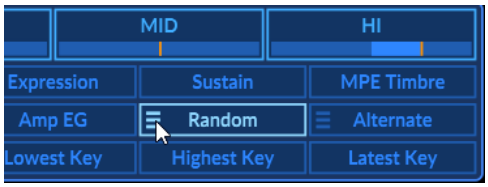
Moreover, if you hover your mouse pointer over any modulated slider, the source(s) it's being modulated from will be highlighted in the routing bar. This makes it easier to see what modulation source(s) are linked to a parameter.

Modulation source selectors

Once routed to any parameter, the modulation source selectors change their appearance depending if they are selected, and if they are routed in the current patch or not. (scene dependent)

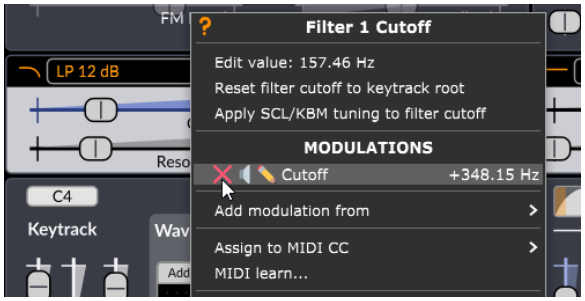
1. Unused modulation source
2. Used modulation source
3. Unused selected modulation source
4. Used selected modulation source

Some modulation source selectors in the routing bar have a hamburger menu. This serves as an indicator that different types of that modulation source are available. You can access them directly by clicking on that hamburger menu, by right-clicking and going into the **Switch to...** submenu, or simply by scrolling with the mouse wheel over the modulation source selector in question.



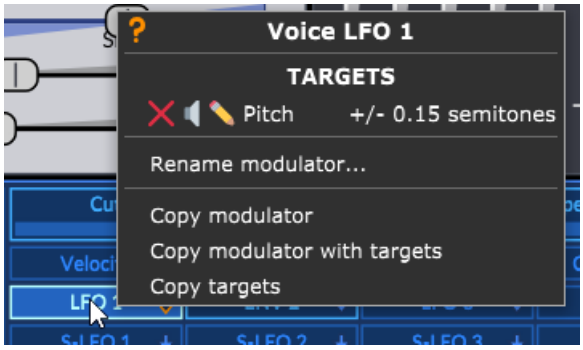
Clearing modulation

After right-clicking on a modulated slider, you will see an option to easily clear the modulation and un-link it from its source.



Alternatively, you can also reset its modulation slider (blue slider) to 0 by double-clicking on it when routing mode is engaged, or entering 0 in the type-in editor (see Edit Value).

Furthermore, by right-clicking on any modulation source, there will be options to clear a particular linked parameter, but also all of them at once.



Modulation list

Surge XT has a detailed modulation list that can be displayed by clicking on the vertical rectangular button at the left of the routing bar:

This panel will display the modulation routings and their amounts from both scenes in the current patch. Different display options are available to the left of its interface:

Sort by - Allows you to choose whether the list of modulations is grouped according to the source they are coming from or to the target they are routed to.

Filter By... - This option allows you to only display certain modulation routings by hiding those that aren't included in the desired source or target in this list.

Add Modulation - These two menus allow you to directly add a new modulation routing directly from the modulation list panel. Simply select a modulation source and a modulation target to link a modulator to a parameter.

Value Display - Allows you to choose between 4 different display options regarding the modulation values displayed in the sliders section, ranging from **None** to **Values**, **Depths** and **Ranges**.

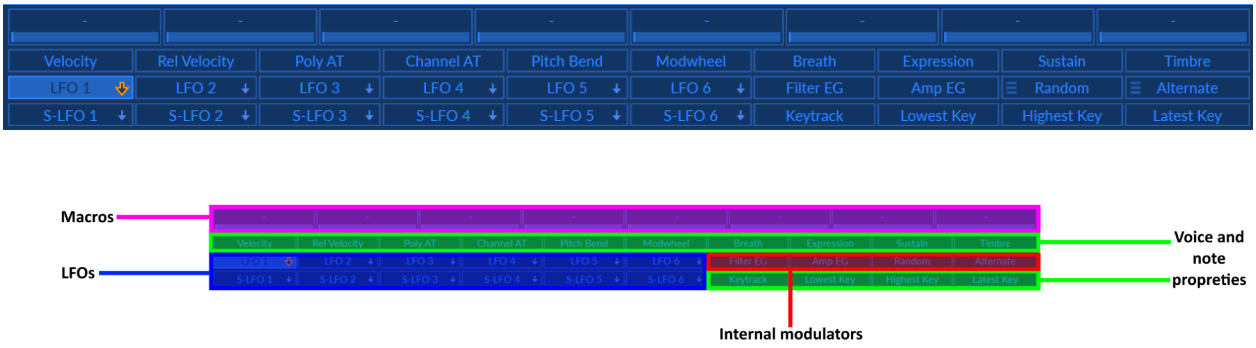
Finally, in the sliders section, you can both adjust the different modulation amounts, but also directly **mute** or **remove** a modulation routing entirely.

Modulators

Surge XT has four main types of modulation sources :

- LFOs
- Internal modulators
- Voice and note properties
- Macros

All of these modulation sources are located in the routing bar (see Routing) :



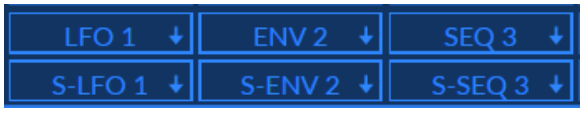
The four types of modulation sources, separated in categories.

Voice modulators vs. Scene modulators

Some modulation sources operate at the voice level, while others operate at the scene level. Although they might seem similar, there is an important factor that distinguishes them.

One one hand, a voice modulator has separate modulation paths for each voice, meaning it can control voice-level parameters (like filter cutoff) but cannot control scene level parameters (like FX levels or scene pitch).

On the other hand, a scene modulator has one identical modulation path for the whole scene, so it can control both scene level parameters **and** voice level parameters.



On top, three voice LFOs. On the bottom, three Scene LFOs, "S-" meaning Scene.

To demonstrate this distinction, let's say an sine wave LFO is modulating the cutoff of a filter. Now, if 3 notes are being hit with a small delay between each of them, the phase of the LFO will be delayed between the notes accordingly.

You will indeed clearly hear the cutoff of the filter moving independently for each note, which gives the impression that there are three LFOs and three filters (which there actually is!). The same principle applies for envelopes.

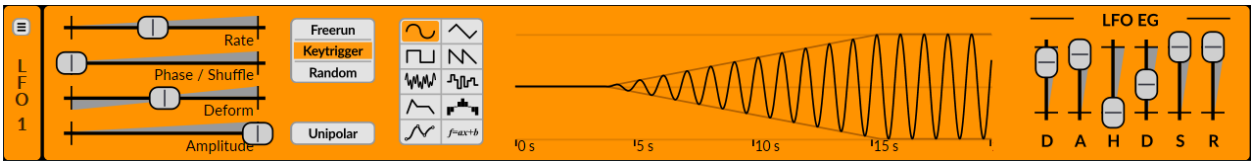
However, unlike the first demonstration, this time, if an S-LFO is modulating a certain parameter, hitting more notes will not "add" an LFO for each voice, which gives the impression that there is a single LFO modulating the cutoff frequency of the filter instead of many.

See Modulation routing in-depth in the Technical Reference section for more information.

LFOs

Compared to some other synthesizers, Surge XT does not have dedicated **LFO**, **Envelope**, **Step sequencer** or **MSEG** modulation sources. Instead, those are integrated within every LFO. This effectively enables the flexibility of having up to 12 LFOs, envelopes, step sequencers or MSEGs, and everything in between simply by changing their shape.

Surge XT's LFOs are very flexible and come with a built in DAHDSR-envelope which can either work as a dedicated envelope generator or shape the amplitude of other modulation types over time.



Surge XT has a total of 12 LFOs:

- 6 Voice LFO sources (labeled LFO 1-6 for instance)
- 6 Scene LFO sources (labeled S-LFO 1-6 for instance)

See Voice modulators vs. Scene modulators for an explanation about the difference LFOs and S-LFOs.

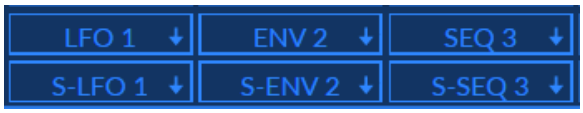
Shapes

LFO shapes (from left to right, top to bottom):

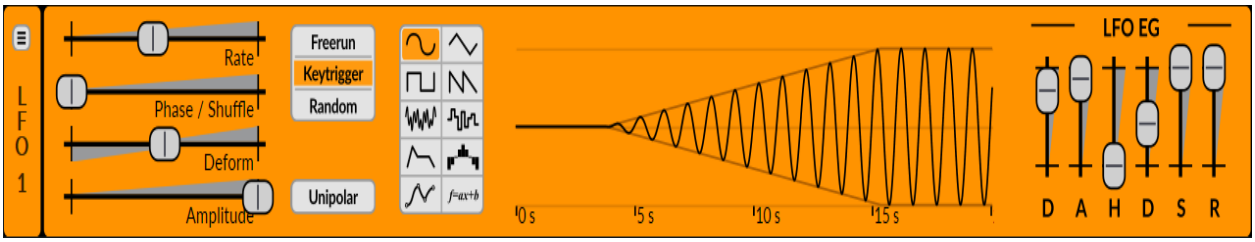
Sine	Sine wave LFO	Vertical bend
Triangle	Triangle wave LFO	Vertical bend
Square	Pulse wave LFO	Pulse width
Sawtooth	Sawtooth wave LFO	Vertical bend
Noise	Smooth noise LFO	Correlation
S&H	Sample & Hold (stepped noise) LFO	Correlation
Envelope	Envelope generator - sets the LFO to a constant output of 1, which can then be shaped by the LFO EG (see LFO Envelope Generator)	Envelope shape
Step Seq	16 step step-sequencer (see Step Sequencer).	Smoothness/ Spikyness
MSEG	Fully editable MSEG (Multi-Segment Envelope Generator) with a large number of curve types and various editing options (see Multi-Segment Envelope Generator)	Depends on segment type and configuration
Formula	Script (LUA) enabled formula modulator	Depends on the coded modulation

*On the left, the different shapes and their explanation. On the right, the way that the **Deform** parameter affects the waveform.*

Depending on the selected shape for a particular LFO, its name in the routing bar will change. When using the first 6 waveforms, it will be called **LFO**. However, when using the envelope shape, **ENV** will be displayed, **SEQ** will be displayed when the step-sequencer is used, and for the MSEG, **MSEG** will be displayed. Scene LFOs have their equivalent labels as well:



Parameters



Rate – Controls the modulation rate. When the type is set to Step Seq, one step equals the whole cycle. This slider can be tempo-synced and disabled from its context menu. Deactivating the rate effectively freezes the LFO to a certain constant value depending on the Phase/Shuffle parameter. This can be useful for manually scrubbing in a waveform cycle of an LFO for instance, and can also be used in the same way in the sequencer. This feature can also be used to make the modulation source act as a **randomizer** in tandem with the "Random" trigger mode. A simpler Random modulation source can however also be used for that purpose. Furthermore, modulation can even be applied to the Phase/Shuffle parameter with another modulation source which opens up a lot of possibilities, such as effectively using the frozen LFO as a mod mapper.

Note: In the LFO editor, when right-clicking parameters that can be tempo-synced, there will also be an option to Tempo sync all the LFO parameters at once.

Phase/Shuffle - Controls the starting phase of the modulation waveform. As with any parameter, it can be modulated. However, in this case, its modulated value will not change after the modulation is triggered (for instance, it's not possible to shift an LFO's phase while a note is pressed). Only starting phase is taken into account. This control can also be extended, allowing for bipolar shuffle, useful for adding swing in the step sequencer.

Amplitude – Controls the amplitude of the modulation. This is the parameter you should use if you want to control the depth of an LFO with a controller (like controlling vibrato depth with the modulation wheel, for instance). This control can also be extended form its context menu, which allows you to reach a negative amplitude range (-100 to 100% instead of 0 to 100%).

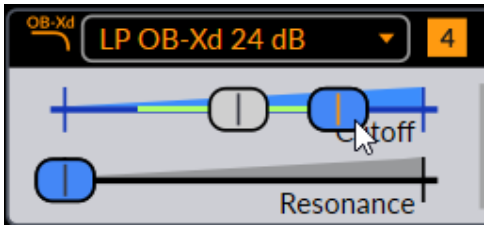
Deform – Deform the modulation shape in various ways. The effect varies depending on the selected shape. Different deform types are available for the **Sine**, **Triangle**, **Sawtooth**, **S&H** and **Envelope** shapes, and can be accessed by right-clicking on the Deform slider.

Trigger mode – Chooses how the LFO is triggered when a new note is played:

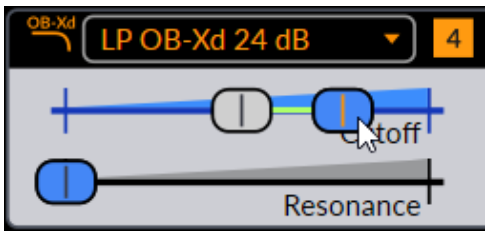
- **Freerun** – The LFO's starting phase is synchronized with the host's song position to make it continuously running in the background. The modulation will be triggered at its starting phase when playback position is either at the beginning position and the song starts playing, or when playback position goes back at the beginning of a loop for instance. Freerun behaves the same on voice LFOs or scene LFOs.
- **Keytrigger** – The LFO's starting phase is triggered when a new note is pressed. If the synth is set to "Poly", each new voice gets its own LFO triggered with it when using a voice LFO. However, when using an scene LFO, the first voice sets the LFO's position, then the other ones will follow it.
- **Random** – The LFO's starting phase is set to a random point in its cycle. If the synth is set to "Poly", each new voice gets its own LFO triggered with it when using an voice LFO. However, when using an scene LFO, the first voice sets the LFO's position, then the other ones will follow it.

Unipolar - If active, the modulation will be in the [0 .. 1] range (unipolar). If not, it will be in the [-1 .. 1] range (bipolar).

The modulation range on a parameter is represented by a green bar when routing mode is engaged (see Routing).



Modulation on a control from a bipolar source



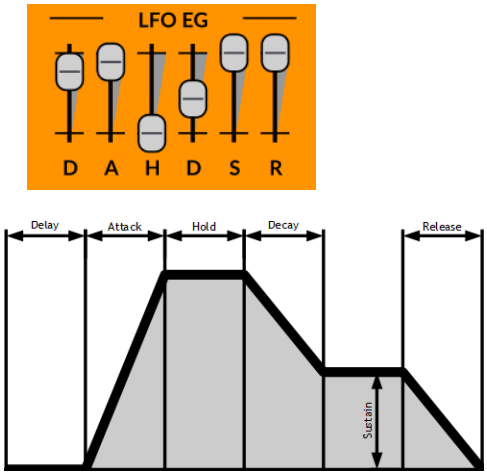
Modulation on a control from a unipolar source

LFO Envelope Generator

The Envelope Generators are of the 6-stage DAHDSR type that are multiplied with the waveform generator, no matter what the selected LFO shape is. This means that if the LFO shape is set to Envelope, the output will simply be 100%, and can then be shaped by the LFO EG.

Also, note that when using the Envelope shape, the envelope will always trigger on key trigger, no matter what the trigger mode is set to.

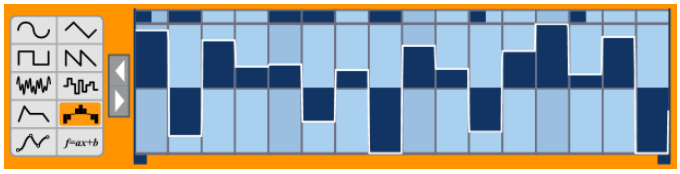
The LFO envelope generator can be completely disabled by right-clicking on one of its controls and unchecking the **Enabled** option.



6-stage DAHDSR envelope

Step Sequencer

The **Step Seq** shape houses a step sequencing editor where the LFO display would be. It allows you to draw the output waveform with up to 16 steps.



Step Sequencer editor

The two blue markers define loop-points in which the sequence will repeat once it gets into the loop. The left mouse button is used for drawing while the right one can be used to clear the values to zero.

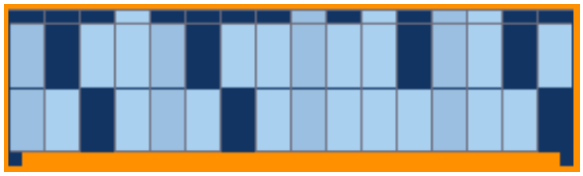
To quickly reset a step to 0, either double-click on a step, or hold down Ctrl/Cmd and click or drag with the mouse over the desired step(s).

Right-clicking and dragging over steps allows you to draw a straight line over the desired steps, thus creating a perfectly linear staircase pattern.

Holding down **Shift** while drawing will quantize the values to the scale degrees (1/12th in case of standard tuning, or possibly other for custom tuning) spanning the range of **one octave.** Furthermore, holding down **Shift + Alt** makes two times more values available, hence useful when modulating pitch by **two octaves** instead.

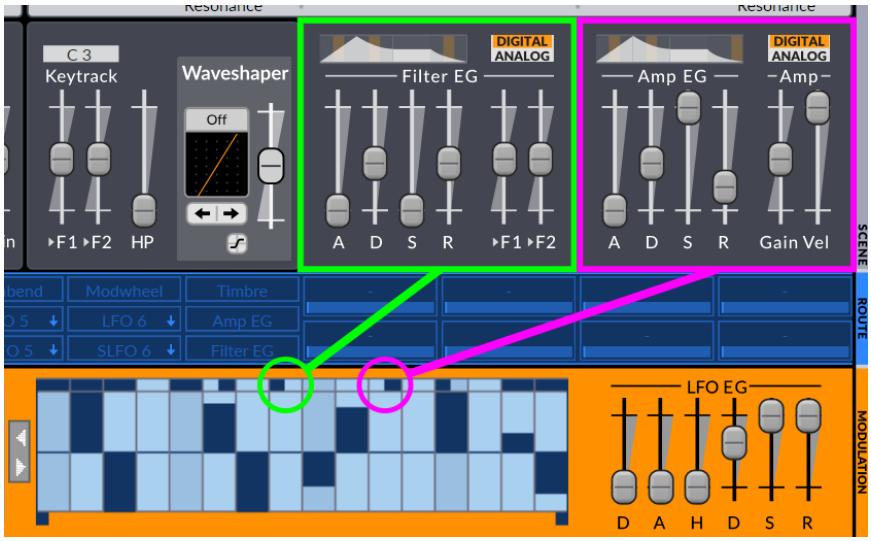
For more information on microtonal pitch modulation using the step sequencer, you can read this article on Surge's wiki.

The step sequencers inside **voice LFOs** have an extra lane at the top of the step editor allowing to re-trigger the two regular voice envelopes (The Amplitude and Filter Envelope Generators) when the small rectangle is filled at that particular step.

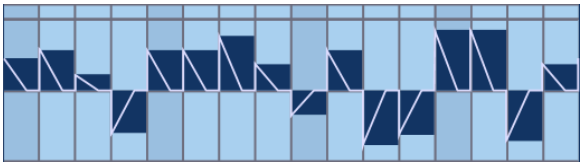
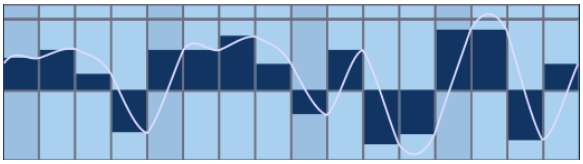


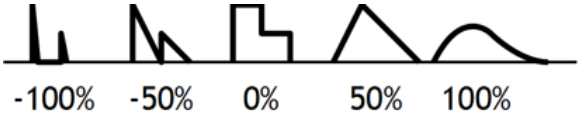
Step Seq of LFO 1 containing the re-trigger pane

However, shift-clicking or right-clicking those rectangles allows the specified step in the sequencer to **only trigger one of the two envelopes**. When the step is half-filled on the left, only the filter envelope will be triggered. When filled on the right, only the amplitude envelope will be triggered.



The **Deform** parameter gives the Step Seq waveform a lot of flexibility. A value of 0% will output the steps just as they look on the editor. Negative values will give an increasingly spiky waveform while positive values will make the output smoother.

Negative deform	
Positive deform	

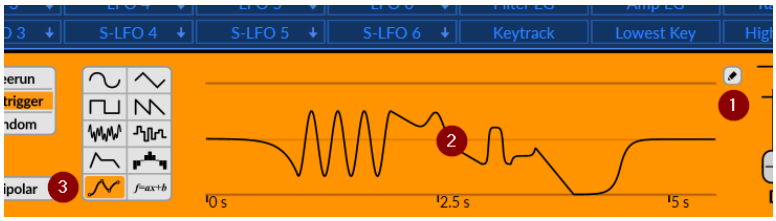


Effect of the deform parameter on the step Seq waveform

Multi-Segment Envelope Generator (MSEG)

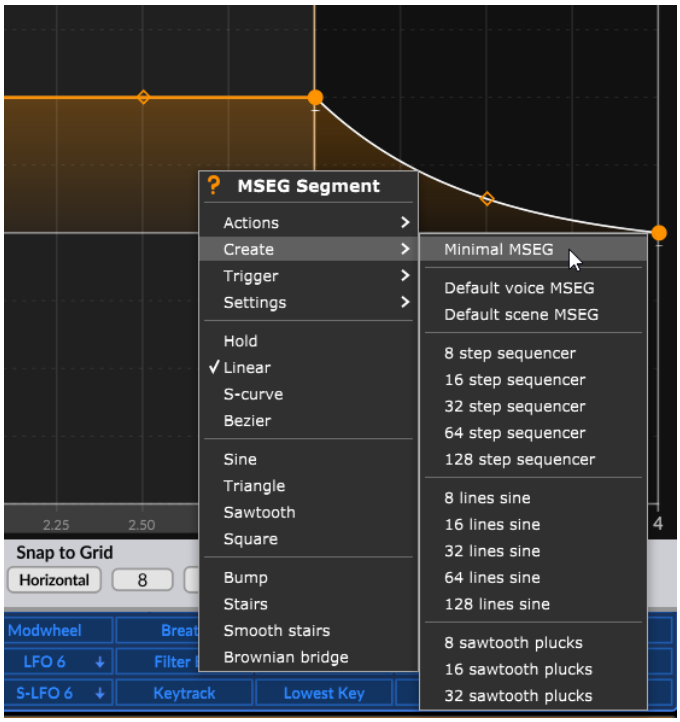
Surge XT's Multi-Segment Envelope Generator (MSEG) is powerful and fully editable with a large number of curve types and various editing options. It can be used to create more complicated LFO waveforms or envelopes compared to the previously mentioned modulation shapes. With the combination of various settings in the editing window and the usual parameters from the LFO editor, you can practically create any modulation shape you could think of.

To open this MSEG editing window, you can either click on the little pencil button next to the wave display (1), click on the wave display itself (2), or double-click on the MSEG icon in the modulation type selector (3):



Default MSEG state

Once opened, you will see a shape working as an envelope if you're using a voice LFO, or a triangle wave working as an LFO if you're using a scene LFO. In any case, you can either build upon these shapes if they suit your needs, or you can reset them to a simple straight line by right-clicking anywhere in the edit window, then choosing **Create -> Minimal MSEG**. More information on those menu entries can be found below.



Zooming and panning

In the MSEG editor, you can pan the view left or right by either left-clicking or middle-clicking, then drag on the background left or right.

You can also zoom in and out by either scrolling with the mouse wheel or left-clicking then dragging your mouse up or down. Alternatively, you can again middle-click and drag if you prefer.

Moving nodes

To move a node, simply left-click and drag it. To do the same with multiple nodes at the same time, you can Shift+left-click and drag, which makes a selection.

Adding and removing nodes

In Surge XT's MSEG, a segment is comprised of its starting node (point) and the segment itself. A "segment's end node" is actually the next segment's starting node. To add a new node, simply double-click where you want it to be added. To remove a node and its following segment, simply double-click on the node you want to remove. Note that you can only remove nodes if there are more than two nodes remaining in the shape.

Control points

In addition, you will also often find a **control point** in the middle of a segment. This one can be dragged vertically (and also sometimes horizontally) to alter the segment's curvature or other properties depending on the line type. To reset a control point to its default position, simply double-click on it.

MSEG editing and behavior options

At the bottom of the editor are a couple of options to configure editing modes and general behavior of the MSEG:

- **Movement Mode -** Sets the behavior when moving nodes.
    - **Single -** When dragging a node horizontally, moves a single node without affecting the others.
    - **Shift -** When dragging a node horizontally, shifts around the nodes following the node being moved, keeping the length of the segment belonging to that node constant.
    - **Draw -** Locks horizontal dragging of nodes, allowing you to draw over existing nodes to set their value in a simple sweeping motion.

- **Edit Mode -** Configures the MSEG editor to work in Envelope or LFO mode.
    - **Envelope -** Displays draggable loop points and region (effectively representing the Sustain stage in an envelope).
    - **LFO -** Hides the draggable loop points and region, links the value of the start and end nodes to complete the waveform cycle, always keep loop mode enabled (even if set to off).

- Loop Mode
  - **Off -** Don't loop when in Envelope mode, turn off draggable loop points.
  - **On -** Loop forever in the loop region (between the loop points). Subsequent segments, if any, will never be reached.
  - **Gate -** Loop until the note is released, then immediately transition to the segments following the loop region.

- Snap To Grid
  - **Horizontal -** Enables horizontal snapping to the grid. The number field to the right corresponds to the horizontal grid resolution. You can also temporarily enable horizontal snapping by holding down the Ctrl/Cmd key while dragging.
  - **Vertical -** Enables vertical snapping to the grid. The number field to the right corresponds to the vertical grid resolution. You can also temporarily enable vertical snapping by holding down the Alt key while dragging.

Segment options

Each segment has options in a context menu which can be accessed with a right-click in the area of that segment. Some of them are only applied to the right-clicked segment, while others are applied to the whole shape:

- Actions
  - **Split -** Splits the segment into two by adding a new node in its center
  - **Delete -** Remove the segment and its starting node
  - **Double duration -** Doubles the total duration of the whole shape
  - **Half duration -** Halfs the total duration of the whole shape
  - **Flip vertically -** Flips the whole shape vertically
  - **Flip horizontally -** Flips the whole shape horizontally
  - **Quantize notes to snap division -** Quantizes the nodes in the whole shape to the nearest horizontal grid position. Available in Envelope edit mode only.
  - **Quantize notes to whole units -** Quantizes the nodes in the whole shape horizontally to the nearest whole time units. Available in Envelope edit mode only.
  - **Distribute nodes evenly -** Distributes the existing nodes from the whole shape evenly in the horizontal axis between the first and last node.

- Create
  - **Minimal MSEG -** Loads a straight line going from 1 to 0 in value, a great starting point to build upon.
  - **Default voice MSEG -** Loads the default voice MSEG preset (envelope shape).
  - **Default scene MSEG -** Loads the default scene MSEG preset (triangle wave LFO shape).
  - **8 to 128 step sequencer -** Replaces the existing shape by an 8 to 128-step sequencer shape.
  - **8 to 128 sawtooth plucks -** Replaces the existing shape by an 8 to 128 sawtooth plucks shape.
  - **8 to 128 lines sine -** Replaces the existing shape by a sine wave made out of 8 to 128 segments.

- Trigger
  - **Fiter EG -** Triggers the hardwired filter envelope generator at that point.
  - **Amp EG -** Triggers the hardwired amplifier envelope generator at that point.
  - **Nothing -** Disables the triggering of both the filter and amplifier envelope generators at that point.
  - **All -** Enables the triggering of both the filter and amplifier envelope generators at that point.

- Settings
  - **Link start and end nodes -** Links the value of the start and end nodes (useful for seamless looping for example).
  - **Deform applied to segment -** Sets if the selected segment is affected by the Deform parameter found in the LFO editor or not (see deform parameter).
  - **Invert deform value -** Inverts the deform polarity applied to the selected segment.

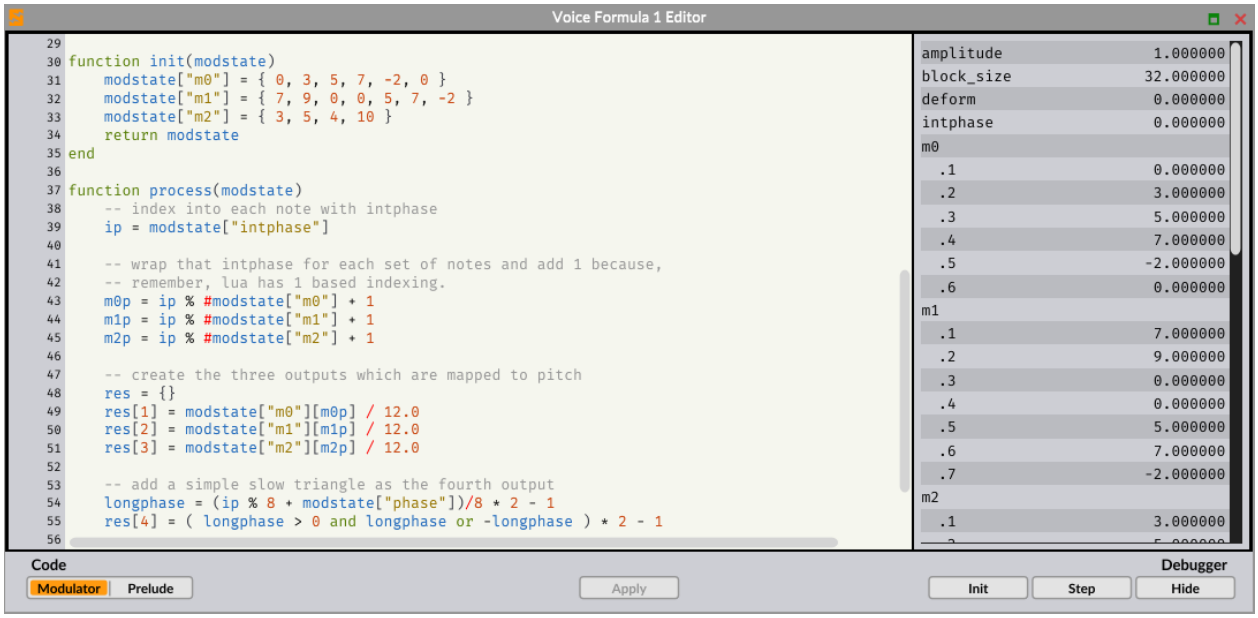
- **Segment types -** List of line types from which a segment can be. The control point, if present, will have a different effect depending on the type used.
  - **Hold -** Holds the value of the previous node up to the segment's end node. No control point available.
  - **Linear -** Single line. The control point controls the curvature of the segment.
  - **Bezier -** Single line. The control point can freely bend the segment.

- **S-curve -** Curved line. The control point determines how abrupt the S-shape is and its direction.
- **Bump -** Single line. The control point can be moved up or down to create a "bump" in the segment.
- **Sine, sawtooth, triangle, square -** Sine, sawtooth, triangle or square waves. The control point determines how many wave cycles there are between the segment's beginning and end node.
- **Stairs, smooth stairs -** Stair or smooth stairs line types. The control point determines how many steps there are between the segment's beginning and end node.
- **Brownian bridge -** Random between the beginning and end node every time it's being triggered. Moving the control point down adjusts the number of steps while quantizing them up to 24 equidistant steps (useful for random scales, for instance). Moving the control point up also adjusts the number of steps, but this time without any quantization. The horizontal value of the control point adjusts correlation.

Formula

The Formula modulator shape is a fully-fledged and LUA-enabled scriptable modulation source. Although this shape may not be as straight forward to use and to understand as the others listed above, in its complexity hides true modulation power, which technically-geared users will truly appreciate.

Surge XT comes with a series of tutorials for the formula modulator available in the patch browser, each of them explaining different aspects and ideas you can re-create in the formula editor:



These tutorials are definitely worth consulting, but here are some basic principles that may help you get started with the formula modulator.

Every formula modulator instance must contain at least a **process** function. This is where the modulator output will be set or calculated.

Different **variables** can be accessed (and some modified), allowing you to create the desired modulation behavior:

- **rate -** Value of the modulator's Rate parameter.
- **startphase -** Value of the modulator's Phase slider.
- **amplitude -** Value of the modulator's Amplitude parameter.
- **deform -** Value of the modulator's Deform parameter.
- **output -** Output value of the formula modulator itself (ranges from -1 to 1).
- **phase -** Continuous value representing the realtime phase position of the modulator output.
- **intphase -** Integer value set to the number of cycles that have been executed.
- **released -** Is set to true when the modulator is in the release state.
- **songpos -** Host song position
- **tempo -** Host tempo
- **samplerate -** Host sample rate
- **block_size -** Buffer size used by Surge

You can access or modify those values by using the following syntax:

modstate["variable-name"]

To see a list of values corresponding to those variables, you can open the integrated Debugger by clicking on the **Show** button at the right of the interface. This debugger also allows you to initialize the modulator by clicking on **Init**, and to step through the code using the **Step** button.

Since Formula is an indexed modulator, you can have up to 8 different outputs on a single formula modulator instance. This can be done by assigning the output to an array of values instead of a single value. An example of this can be seen in the tutorial *Both Time And Space* (#10).

After entering code or modifying existing code, press the **Apply** button for changes to take effect. You will see the output display update with the new shape.

Finally, you can switch to the **Prelude** view of the code by clicking on the corresponding button. The Surge prelude is loaded in each surge session and provides a set of built in utilities we've found handy in writing modulators.

LFO presets

To the left of the **Rate** parameter, a small menu icon can be found. Clicking on it will reveal options to save the selected LFO state, open previously saved states, and finally rescan presets to update the list. Presets will be categorized by modulation shape.

Copy/Paste options

Finally, after setting up an LFO, its settings with or without its targets can be copied and pasted to another LFO. To do this, simply right-click on the source LFO in the routing bar and use the desired **Copy** option, depending on what you want to replicate on the new modulation source. Then, use the **Paste** option to paste it.

Renaming

LFOs and S-LFOs can be renamed to be more representative of their role and to help the user keep track of what each modulation source is doing in a patch. To do this, simply right-click on the LFO or SLFO in question, select **Rename Modulator...** and enter the desired name.

For more information on LFO algorithms, see LFOs in the Technical Reference section.

Internal modulators

Filter EG modulation source

The Filter Envelope Generator modulation source, which is labeled "Filter EG", is simply a modulation source corresponding to the output of the Filter EG, which as its name suggests is already hardwired to the filter modules. Other parameters can also be modulated by the Filter EG by various amounts, simply by routing them to this source.

Amp EG modulation source

The Amp EG modulation source, which is labeled "Amp EG", is simply a modulation source corresponding to the output of the Amp EG, which as its name suggests is already hardwired to the output amp module. Other parameters can also be modulated by the Amp EG by various amounts, simply by routing them to this source.

Random modulation source

This modulation source operates at voice level. It will generate a single random value inside the modulation range for each voice every time a voice is played.

By default, this modulation source is bipolar and its value distribution is uniform. However, you can switch to a unipolar and normalled versions of it by right-clicking on it and selecting **Switch to...**, and then choosing the desired type from the list. All of those can be used at the same time, so they can be considered independent modulation sources.

Note that multiple parameters routed to that modulation source will all receive the same value (in percentage). To send different randomized values to different parameters, multiple LFOs can be configured in a way to do this and with greater control. See the explanation of the Rate parameter.

Alternate modulation source

This modulation operates at the voice level. It will generate alternating values between the two modulation range's extremums.

By default, this modulation source is bipolar. However, you can switch to a unipolar version of it by right-clicking on it and selecting **Switch to -> Alternate Unipolar**. The two can also be used at the same time, so they can be considered two independent modulation sources.

Voice and note properties

Like other synthesizers, Surge XT receives MIDI data to determine what note(s) to play. However, it can also use **MIDI CC** data to modulate any routable parameter.

There are 14 of those voice and note properties in the routing bar:

Velocity	Per note velocity amount	Voice modulator	Unipolar
Release Velocity	Per note release velocity amount	Voice modulator	Unipolar
Polyphonic Aftertouch (labeled Poly AT)	Per note polyphonic aftertouch	Voice modulator	Unipolar
Channel Aftetouch (labeled Channel AT)	Monophonic aftertouch if MPE is disabled	Scene modulator, Voice modulator in MPE mode	Unipolar
Pitch Bend	Pitch bend wheel value	Scene modulator	Bipolar
Modwheel	Modulation wheel value	Scene modulator	Unipolar
Breath	Breath controller signal	Scene modulator	Unipolar
Expression	Often used in pedals and for crescendos or decrescendos	Scene modulator	Unipolar
Sustain	Sustain signal, often from a pedal	Scene modulator	Unipolar
Timbre	Primarily used for MPE controllers	Voice modulator	Bipolar
Keytrack	Per note keytrack value	Voice modulator	Bipolar
Lowest Key	Keytrack value corresponding to the lowest note played	Scene modulator	Bipolar
Highest Key	Keytrack value corresponding to the highest note played	Scene modulator	Bipolar
Latest Key	Keytrack value corresponding to the latest note played	Scene modulator	Bipolar

Note that only scene-level modulation sources can be routed to FX sends and parameters. For instance, you can use **Latest Key** instead of **Keytrack** to modulate FX parameters, as Keytrack is a voice-level modulation. See Voice modulators vs. Scene modulators for more details.

Macros

There are 8 macros, and by default, they are blank.

What separates these assignable controllers from the rest is that with a right-click, they can be assigned to a MIDI controller or any MIDI CC signal, and their value can be edited on-screen with the blue digital slider below their names.

By default, the macros are assigned to midi CC 41-48, which is often mapped by default to knobs or slider banks for a lot of midi controllers.

See Continuous Controller information (CC) in the Technical Reference section for more information.

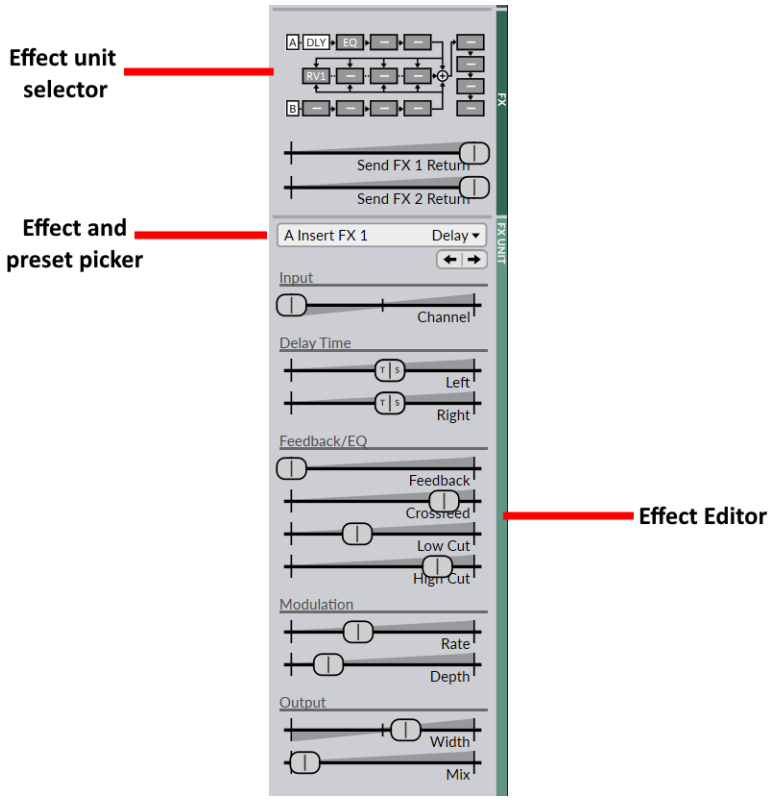
The right-click context menu also allows you to rename the controller. There is also the typical routing and clearing options, (see Routing) and you can choose if their modulation is bipolar (both positive and negative with 0 in the middle) or unipolar (just positive).

Macros can also be dragged and dropped over other macros to make them switch place. To do so, simply left-click + drag over the desired macro slot location.

Finally, note that macros are considered **global modulators**, meaning they are shared between and act on both scenes A and B. This is useful in case you would want to quickly control certain parameters from both scenes in a single place.

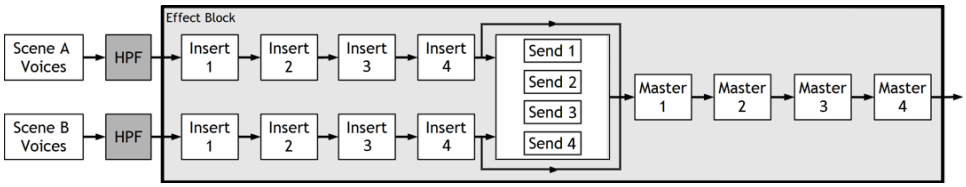
FX Section

The FX Section controls the 8 effect units of the effect block stored in every patch.



Effect Unit Selector

The effect unit selector can be found towards the top of the FX section. It also represents the signal path of the effects block. Here it is in more detail:



The effect block

A **left-click** on a particular unit in the effect unit selector brings that unit in the editor. A **right-click** on a unit disables/enables it. This state is stored within patches, unlike the global FX bypass setting.

Moreover, you can drag-and-drop units over other units to make them switch places. Holding down **Ctrl/Cmd** and dragging allows you to duplicate (copy) units on other units instead, and holding **Shift** allows to simply replace (overwrite) the target unit with the source one.

Finally, you can right-click on either the **A** or **B** icons in the diagram to bring up output hard clipping options, which are the same as explained earlier in the Scene Output and Global Volume sections.

Effect and preset picker

Effects can be added or removed from the **Effect and preset picker** (just below the FX return sliders). You can also cycle through effects and presets using the same arrow buttons as those found in the global Patch Browser.

You can also save your own effect presets which will be stored globally with the synth. Finally, at the bottom of this menu, there are **Copy** and **Paste** options, which allows you to copy an effect and its parameters and paste it on another unit. You can also use drag-and-drop gestures to accomplish this (see Effect Unit Selector).

Effect Editor

This is where every effect parameter can be edited. Like with the oscillator editor, the parameter of each slider will change depending on the loaded effect.

Here's a list of the available effects:

- EQ
- Exciter
- Graphic EQ
- Resonator
- CHOW
- Distortion
- Waveshaper
- Neuron
- Tape
- Combulator
- Frequency Shifter
- Nimbus
- Ring Modulator

- Treemonster
- Vocoder
- Chorus
- Ensemble
- Flanger
- Phaser
- Rotary Speaker
- Delay
- Reverb 1
- Reverb 2
- Spring Reverb
- Airwindows (56 effects collection from Airwindows)
- Conditioner

See Effect algorithms in the Technical Reference section for more information about each effect.

Note: remember that **FX parameters are scene controls**. This means that only scene-level modulation sources can modulate them.

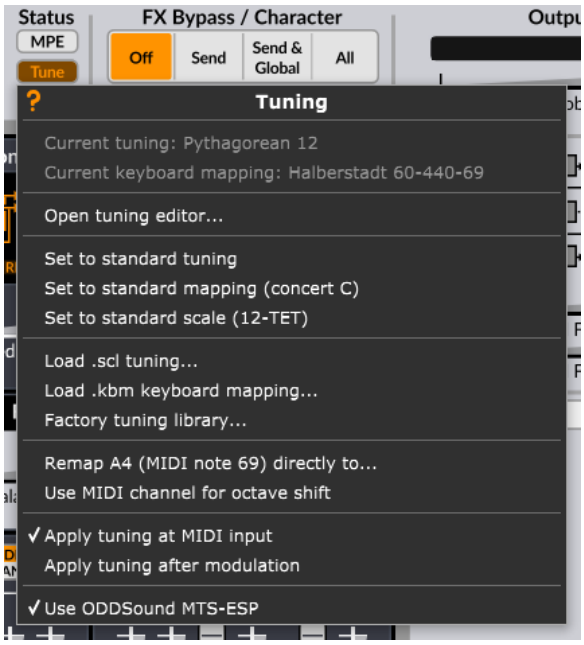
Microtuning

Surge is becoming well known for its extensive microtuning options, and Surge XT features full keyboard microtuning support using the complete **Scala SCL** and **KBM** format, as well as integration with **ODDSound MTS-ESP**.

When utilizing either of these microtuning modes, the musical intonation related features of Surge XT contextually switch accordingly for the **Tune** and **Filter Cutoff** menus.

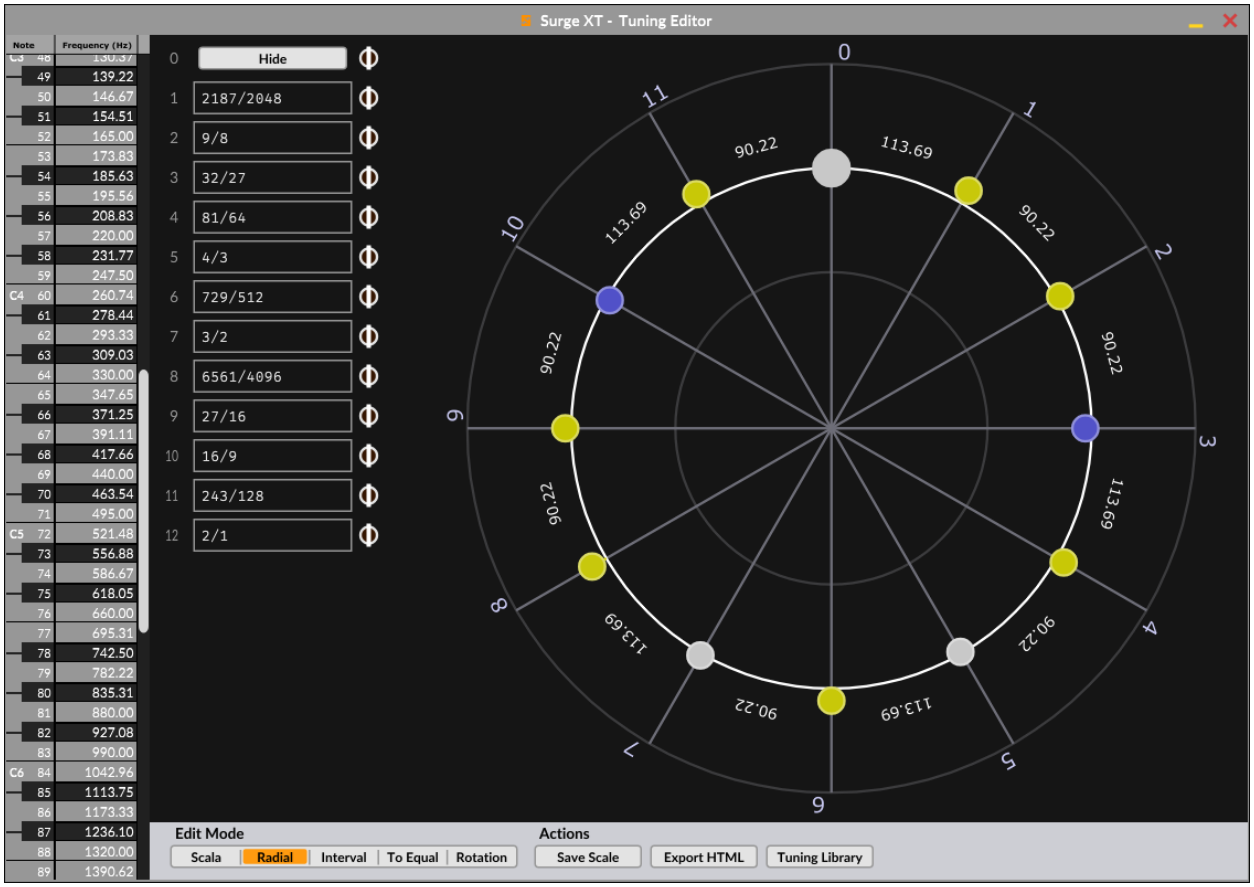
Scala SCL-KBM mode

When using the default Scala SCL-KBM microtuning mode, users can right-click on the **Tune** button to view the contextual **Tuning** menu options as follows:



- **Current tuning -** Scala SCL (scale) tuning tables may be loaded into Surge XT using drag-and-drop onto its UI, from the Factory Tuning Library, or the integrated Tuning Editor. Once an SCL file has been loaded, the filename of the tuning will appear here, otherwise, with no SCL file loaded, this option will not be visible in the Tuning menu.
- **Current keyboard mapping -** Scala KBM (keyboard mapping) files may also be loaded into Surge XT using drag-and-drop onto its UI, from the Factory Tuning Library, or the integrated Tuning Editor. Once a KBM has been loaded, the filename of the keyboard mapping will appear here, otherwise, with no KBM file loaded, this option will not be visible in the Tuning menu.
- **Open tuning editor... -** Clicking this option will open the integrated Surge XT Tuning Editor with features for loading, modifying, analysis and export of Scala SCL-KBM tuning tables that enable working with a broad range of historical and contemporary musical intonation systems.

For more detailed information about microtuning and on the microtuning editor featured in Surge XT, see Tuning Editor.



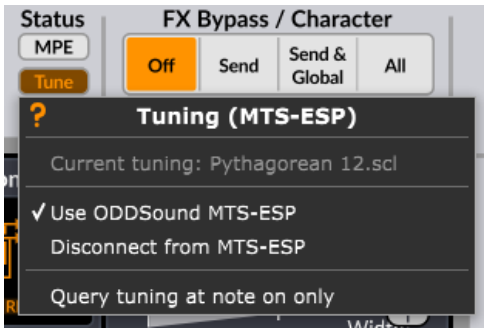
Radial page of the tuning editor

The following three Tuning menu options are available when Scala SCL and KBM files have been loaded into Surge XT, permitting resetting the instrument to standard intonation settings. When no SCL or KBM are loaded, these options are grayed out:

- **Set to standard tuning… -** Resets the currently loaded SCL tuning table to 12 tone equal temperament, keeping the currently loaded KBM.
- **Set to standard mapping (concert C) -** Resets the currently loaded KBM, such that the 1/1 of the loaded SCL is mapped to middle C.60 at 261.626 Hz
- **Set to standard scale (12-TET) -** Resets the currently loaded SCL tuning table to 12 tone equal temperament and the KBM such that the 1/1 of the intonation is mapped to middle C.60 at 261.626 Hz.
- **Load .scl scale… -** Allows the user to load SCL tuning table files from their computer.
- **Load .kbm keyboard mapping… -** Allows the user to load SCL tuning table files from their computer.

Note: Scala SCL and KBM files can also be imported via the Status Area, or via drag-and-drop anywhere on Surge's interface.

- **Factory Tuning Library -** Clicking this option will open the file browser containing the included Surge XT factory SCL-KBM content.
- **Remap A4 (MIDI note 69) directly to... -** Enables the user to type in custom Hz values for MIDI Note A.69.
- **Use MIDI channel for octave shift -** Enables users of generalized array keyboard controllers (such as the Lumatone) to map large tuning gamuts and equal-temperaments contiguously across all 16 MIDI Channels.
- **Apply runing at MIDI input -** When this option is checked (which it is by default), modulation is tuned to the loaded scale, and pitch bends are in key space.
- **Apply runing after modulation -** When checked, tuning is only applied at the keyboard, and modulation is in 12-TET space. Since this fundamentally changes how a patch would play in tuned mode, this option is stored at the patch level.
- **Use ODDSound MTS-ESP -** Activates ODDSound MTS-ESP. With this option checked and an instance of MTS-ESP Master (or MTS-ESP Mini) is loaded into the DAW project, settings made in the MTS-ESP Master plugin then control the intonation of Surge XT.



The Surge XT Tuning menu in MTS-ESP microtuning mode.

ODDSound MTS-ESP mode

As mentioned above, with the Tuning menu option checked for Use ODDSound MTS-ESP, and an instance of MTS-ESP Master (or MTS-ESP Mini) is inserted into the DAW project, the menu contextually changes, showing the following options:

- **Tuning (MTS-ESP) -** Indicates that an instance of MTS-ESP Master (or MTS-ESP Mini) is inserted into the DAW project and is controlling the intonation of instrument.
- **Current tuning -** Displays the name of the currently active tuning in MTS-ESP.

- **Use ODDSound MTS-ESP -** When this option is checked, Surge XT is configured to operate with MTS-ESP.
- **Disconnect from MTS-ESP -** Provides a way to disable MTS-ESP in Surge XT, even when an instance of MTS-ESP Master (or MTS-ESP Mini) are inserted into the DAW project, whereupon the Tuning menu will contextually switch to the Scala SCL-KBM mode.
- **Query tuning at note on only -** Query tuning at note on only Either snap the tuning at note on and hold it consistent through the note voice, or otherwise query the tuning as the note progresses. So if for example, you play a D and adjust the tuning of the second note in your scale with this on, you will hear the pitch change, while with it off you won't.

Consult the documentation for ODDSound MTS-ESP Suite or MTS-ESP Mini for more detailed information about their operation.

Menu Button

You can find this menu in the bottom-right corner of Surge XT's interface. Clicking it reveals various configuration options.

Note: Some of these options are also present at the top of the user interface for easier access (see Status Area).

This menu can also be opened by right-clicking anywhere on the user interface where there are no controls.

Zoom

The **Zoom** option can be extremely useful on certain monitors and configurations.

In its sub-menu there are various options to change the scale of the whole user-interface to a certain size. Keep in mind that it will not let you change it to any size, as there is an upper limit depending on your screen resolution.

When a new instance of Surge is loaded, its zoom will be set to default size. To change this value, go back in this sub-menu and select the option "Set [zoom %] as default", or "Set default zoom to …" then enter the desired value.

Skins

This is where the UI skin can be chosen. Surge XT comes with two factory skins: Classic and Dark.

Classic:

Dark:

This menu also contains option to display the skin inspector or the skin development guide. Both will open in your default browser.

From there, you can also reload the current skin, rescan skins, open the current skin folder location, open the skin inspector and open the skin development guide.

If you would like to get on board with the skin engine and developing skins, see the documentation on developing Surge XT skins.

Value displays

- **High Precision Value Readouts -** Allows value popups that appear when tweaking parameters to show more digits after the decimal point (6 digits). This can be useful in some more advanced and precise scenarios.
- **Modulation value readout shows bounds -** Allows the value popup that appears when applying modulation and adjusting its amount to a parameter to show more values, such as the relative range in the negative direction, and both absolute minimum and maximum values underneath.
- **Show value readout on mouse hover -** Allows you to enable or disable the gesture of hovering over a slider to display its value.
- **Show ghosted LFO waveform reference -** Allows you to enable or disable the LFO waveform at full amplitude displayed with a dotted line in the LFO display area.
- **Middle C -** Allows you to change the reference octave used in popup displays of some frequency-related parameters, such as filter cutoff for instance. You can change Middle C to be either C3, C4 or C5.

Data Folders

In this sub-menu, there are a couple of options regarding user data and patches.

- **Open User Data Folder -** This opens the location where custom patches saved by the user will be stored.
- **Open Factory Data Folder -** This opens the location where factory patches, wavetables and other configuration files are stored.
- **Set Custom User Data Folder -** This allows you to change where user patches will be saved.
- **Rescan All Data Folders -** This option can be useful after importing patches created by someone else, after transferring user patches to another computer, or after downloading patches from the internet.

Mouse Behavior

This sub-menu contains options allowing you to change the sensitivity of the mouse when moving sliders. While *Legacy* is used by default, the other 3 options range from *Slow* (more granular) to *Exact* (as fast as the mouse pointer). Also, there is an option to keep showing the mouse pointer on the screen when dragging on a control.

Touchscreen mode automatically sets the mouse options to give the user the best experience when using Surge on a touch screen.

Patch Defaults

This is where you can configure what appears by default in the **Author** and **Comment** fields when saving a patch. You can also set the currently loaded patch as the default patch, append the original author name to modified patches or not, and configure tuning and tuning mapping when loading patches.

Workflow

- **Activate individual scene outputs -** Enable or disable the individual audio scene outputs. In most DAWs, this option will be enabled by default, but for compatibility reasons, some other DAWs (such as FL Studio for instance) will have that option disabled by default, and will need to be enabled then configured in the plugin wrapper to use this feature.
- **Load MSEG snap state from patch -** Tells Surge XT if it should load the MSEG snap parameters from the saved patch or keep the existing settings.
- **Remember tab positions per scene -** Remember tab positions (for example, currently selected oscillator or LFO currently shown in the LFO editor) separately for each scene or unified in the whole synth.
- **Previous/next patch constrained to current category -** Turn this option off to allow the previous/next patch arrow buttons in the patch browser area to automatically switch categories after hitting the end of one, for instance.
- **Tab key arms modulators -** Older versions of Surge had the Tab keyboard shortcut to arm modulation mode. This behavior can be restored by enabling this option.
- **Use keyboard shortcuts -** Enables of disables the keyboard shortcuts. See Keyboard Shortcuts for the full list of keyboard shortcuts available in Surge XT.
- **Show virtual keyboard -** Toggle this option to show or hide the virtual on-screen keyboard at the bottom of the user interface.

MPE Options

MPE stands for **MIDI Polyphonic Expression**. It can be enabled or disabled in its sub-menu. The current and default pitch bend range can be changed here as well. Finally, you can also configure the MPE pitch bend smoothing amount.

Tuning Options

These options are also present in the Tuning menu at the top of the interface. See Microtuning for detailed explanations on the tuning implementation within Surge XT.

MIDI Settings

This sub-menu contains options for MIDI mappings.

Controller smoothing

This sub-menu contains options to set the amount of desired MIDI controller smoothing.

Sustain pedal in mono mode

- **Sustain pedal holds all notes (no note off retrigger) -** If sustain is engaged and multiple notes are hit then held one after the other, Surge XT will stay on the latest note when releasing it instead of switching to the previous note.
- **Sustain pedal allows note off retrigger -** If sustain is engaged and multiple notes are hit then held one after the other, Surge XT will switch to the previous note when the latest note is released.

Save MIDI Mapping As...

This allows you to save the current MIDI mapping. The newly created profile will appear in this menu under the two top options.

Show Current MIDI Mapping...

This opens up an HTML file listing the currently loaded MIDI mapping.

Clear current MIDI mapping

As its name suggests, this option clears the existing MIDI mapping in Surge XT and resets it back to default.

Online Options

The following items are for reaching the developers and user feedback information, reading the code on GitHub, downloading additional content, opening Surge's website, and finally opening this user manual.

About Surge XT

Finally, there is an option to open the **About** pane containing various version, configuration and license information.

Developer Menu

When right-clicking on the Menu button, some more options for development and testing purposes appear in various sub-menus.

Accessibility

The surge XT user interface can be completely navigated from the keyboard. Pressing Tab will allow you to move through all controls in the user interface, while pressing the up and down arrow keys will let you adjust them. Just like holding shift or CTRL/Command while moving a slider with the mouse lets you make smaller or more precise adjustments, holding these modifiers while pressing the arrow keys will have a similar effect. Pressing Home, End or Delete will let you set a control to its maximum, minimum and default value respectively. Finally, pressing Shift+F10 or the Applications key on any control will open its right-click menu.

With the exception of tab, the other keys mentioned here need to be turned on before they can be used. If you press one of these keys with the shortcuts turned off, you will be asked whether you want to turn them on. Alternatively, they can be turned on by checking the "Use keyboard shortcuts" option in the Workflow Menu. A number of additional shortcuts are available which allow you to quickly open specific dialogues, change patches or save your work and more. Refer to the Keyboard Shortcuts section of this manual for a full list.

In addition to full keyboard support, Surge XT is compatible with screen reader software on both Mac and Windows. This means that as you navigate through the interface, the screen reader will give you full speech and braille feedback on the control that's focused and what its value is. You can also navigate the interface using your screen reader's review commands.

For additional help on using Surge with specific Screen Readers, refer to this page.

Keyboard Shortcuts

Here is a list of all of Surge XT's keyboard shortcuts:

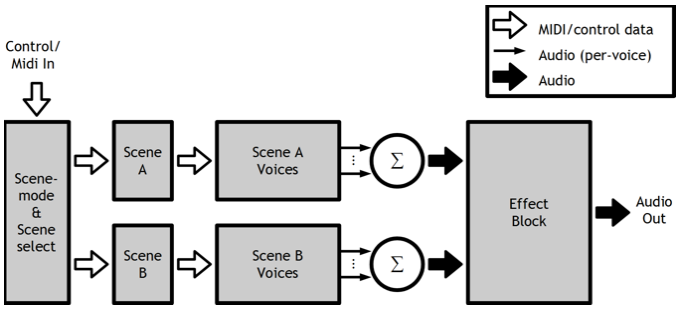
- **Num +/Num -** zooms in/out by 10%, Shift+Num +/Num - zooms in/out by 25%, Shift+Num / resets zoom to default.
- **Up/Down** modifies focused slider value, Home/End modifies the slider value to minimum/maximum.
- **Shift + Left/Right** changes to previous or next patch category, Control/Command+Left/Right loads the previous or next patch.
- **Ctrl/Cmd + S** opens the Save Patch dialog.
- **Ctrl/Cmd + F** starts patch search typeahead.
- **Alt + F** to toggle setting the patch as favorite.
- **Alt + E** to toggle the appropriate LFO editor overlay (MSEG or Formula).
- **Alt + T** to toggle the new Tuning Editor overlay.
- **Alt + M** to toggle the new Modulation List overlay.
- **Alt + D** to toggle the debug console.
- **Alt + K** to toggle the new Virtual Keyboard.
- **Alt/Option + 1/2/3** to toggle between the oscillators.
- **Alt + S** to toggle between the scenes.
- **F1** to open the manual.
- **F5** to refresh the currently loaded skin.
- **F12** to show the About screen.

You can enable the use of these shortcuts in the Surge XT menu.

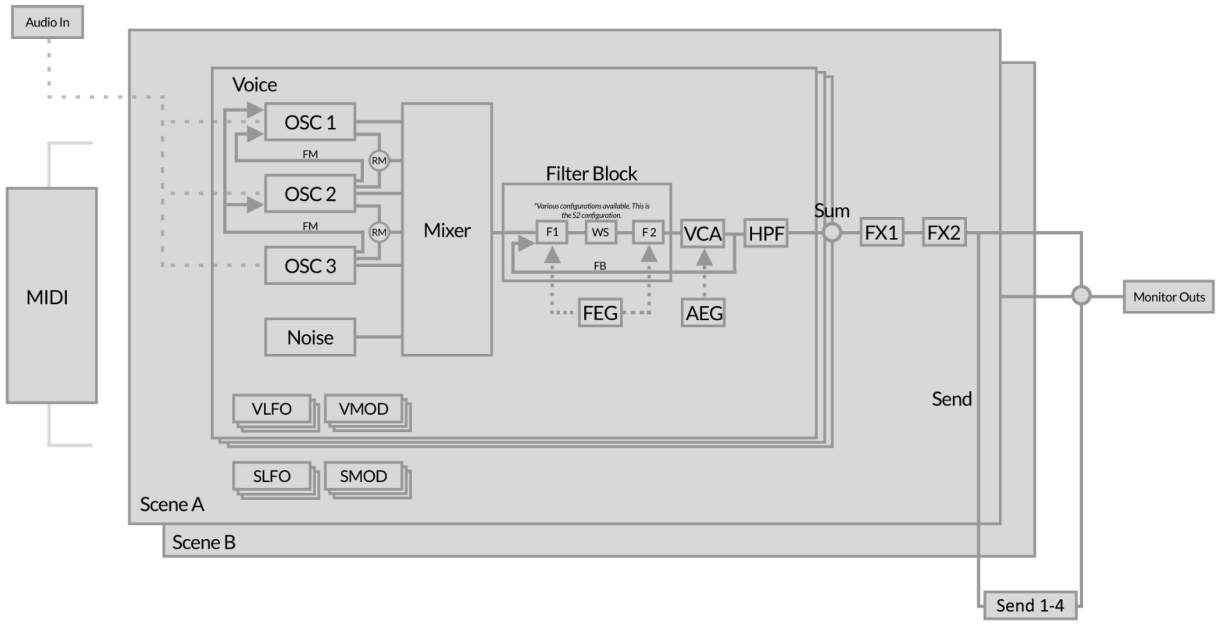
Technical Reference

Surge XT Hierarchy

Overview

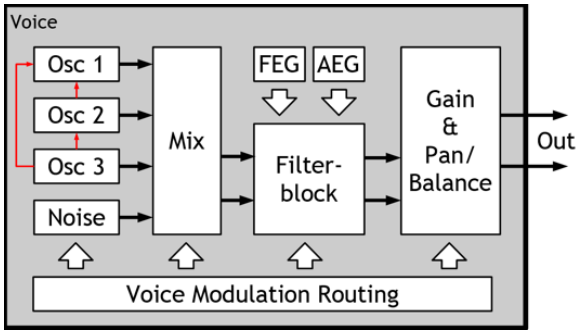


Block diagram of the synthesizer engine.



Ilustration shows an overview of the synthesizer engine of Surge XT.

Voices

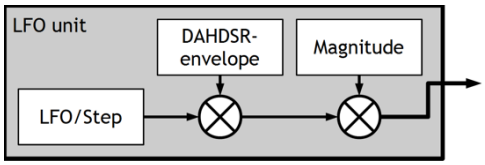


Block diagram of a synthesizer voice

Illustration shows most audio and control-paths of a single voice. Not all processing elements of the voice are shown in the diagram.

LFOs

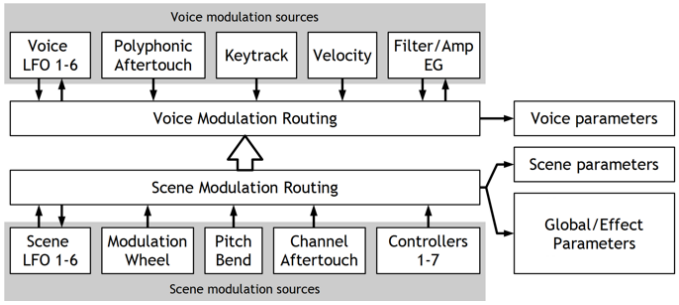
Each voice has 6 configurable LFOs and each scene has an additional 6 configurable LFOs, making each voice effectively capable of receiving modulation from a total of 12 LFOs.



LFO block diagram

Modulation routing in-depth

How the modulation routing works internally isn't something you normally have to think about when using Surge XT. Just activate the modulation mode with the desired source and see which of the sliders that become blue. Nonetheless, it is useful to know which limitations are present and why.



Modulation routing behind the scenes

The thing to remember is that voice modulation sources can't modulate scene parameters, global/effect parameters or parameters from scene LFOs, since these are two distinctly different modulation paths. Other than that it should be pretty straightforward.

Oscillator algorithms

Surge XT provides 8 different oscillator algorithms, each capable of generating sound in different ways with a different set of controls. They're not just different waveforms.

Classic

The classic oscillator algorithm consists of a main oscillator that can generate a pulse wave, a sawtooth wave, a dual-saw wave or anything in between.

A sub-oscillator provides a pulse-wave one octave below the main oscillator. Changing the pulse-width of the sub-oscillator does affect the main oscillator as well, as they will both change levels at the same time except that the main oscillator does it twice as often.

The classic algorithm is also capable of oscillator self-sync. Note that the sub-oscillator will be used as the base-pitch for the sync.

The algorithm provides unison at the oscillator-level with up to 16 instances. Unlike the wavetable-oscillator the cost of unison in terms of CPU usage for the classic oscillator is quite modest. The unison oscillator-instances are affected by the scene-level Osc-Drift parameter independently.

Shape	Waveform shape. -100% = pulse, 0% = saw, 100% = dual saw	-100 .. 100 %
Width 1	Duty cycle (pulse) or relative phase (dual saw)	0 .. 100 %
Width 2	Squeezes or expands the waveform in a different way. If positive, the two latter halves of two consecutive single cycles get squeezed closer together	0 .. 100 %
Sub Mix	Sub-oscillator mix, 0% = only main, 100% = only sub	0 .. 100 %
Sync	Oscillator hard sync	0 .. 60 semitones
Unison Detune	Detuning of unison oscillators. Can be extended Can be switched between relative (default) and absolute	0 .. 100 cents 0 .. 1200 cents 0 .. 16 Hz 0 .. 192 Hz
Unison Voices	Number of oscillators used for unison (1 = disabled)	1 .. 16

Modern

The Modern oscillator algorithm is a multi-waveform oscillator which creates clean, low aliasing versions of pulse, triangle, saw and sine waveforms with unison and sub-oscillator capabilities. It is based on the differentiated polynomial waveform algorithm, from this paper.

Three parameters labeled **Sawtooth**, **Pulse** and **Triangle** control relative mixes of those waveforms, while the **Width** parameter controls pulse width for the Pulse wave. **Sync** offsets the pitch of the oscillator against the pitch of the internal reference oscillator while resetting the phase of the main oscillator to the phase of the reference oscillator, to achieve typical hard sync effects. Unison controls work like in other Surge XT oscillators.

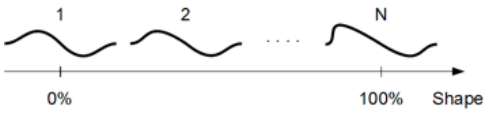
Sawtooth	Amplitude of the Sawtooth waveform	-100 .. 100 %
Pulse	Amplitude of the Pulse waveform	-100 .. 100 %
Triangle/Sine/ Square	Amplitude of the third waveform, can be right-clicked (for more information, see below this parameter list)	-100 .. 100 %
Width	Duty cycle of the Pulse waveform	0 .. 100 %
Sync	Oscillator hard sync	0 .. 60 semitones
Unison Detune	Detuning of unison oscillators Can be extended Can be switched between relative (default) and absolute	0 .. 100 cents 0 .. 1200 cents 0 .. 16 Hz 0 .. 192 Hz
Unison Voices	Number of oscillators used for unison (1 = unison disabled)	1 .. 16

Third Waveform Parameter

The third waveform parameter (labeled “Triangle” by default) is special in that it has several waveform options to choose from. If you right-click it, you can see that it can generate a triangle wave, a sine wave, or a square wave. This control can also become a sub-oscillator, playing at half the frequency of the other two waveforms. Importantly, in sub-oscillator mode, the third waveform does **not** participate in unison, which is in contrast to the Sub Mix parameter in Classic oscillator. Finally, there is also an option for the sub-oscillator to bypass hard syncing against the internal reference oscillator.

Wavetable

A wavetable in Surge XT consists of up to 4096 single-cycle waveforms. Using the **Morph** parameter it is possible to sweep across the waveforms in the wavetable.



The individual waves are equidistant in the table. When the shape setting is between two individual waves, they will be mixed to ensure smooth travel. You can’t edit the wavetable contents directly within Surge XT, but it is possible to generate custom wavetables with external software.

Surge XT can also import wavetables containing a **clm** block to indicate loop size (as used by Serum), a **cue** block (as used by various products including Native Instruments) and a **smpl** block. Wavetable files without loop information are loaded as one-shots.

This effectively lets you import various wavetables from other products such as **Serum**. All those 3rd party wavetables that have been tested in Surge XT have been reported to work flawlessly.

To import custom wavetables, use the wavetable selection bar at the bottom of the oscillator display. This is where you can also download additional wavetable content.

Alternatively, you can simply drag-and-drop any compatible wavetable file anywhere over the Surge interface to load it.

You can even create your own wavetables for Surge using wt-tool or WaveEdit.

Once a wavetable is loaded, you can also export it using the wavetable selection bar.

Then, by modulating the **Morph** parameter, it is possible to create motion, dynamic response to playing and sonic variation. If you want to select an exact frame, drag the slider while holding down Ctrl/Cmd, which allows you to snap to exact values in the table, useful for switching between distinct shapes, for example.

What real-life property, if any, the **Morph** parameter is supposed to mirror depend on each wavetable. Common cases are:

- **Analyzed from sounds that evolve over time**. The behavior can be recreated by letting shape increase over time by modulation. It's the most common among the analyzed wavetables.
- **Analyzed from static sounds over different pitches** to capture the formant shift of a sound. The behavior can be recreated by modulating shape by the keytrack modsource.
- **A parameter of a mathematical equation**.

In the end it's just a set of data and Surge XT doesn't care how it was generated, all that matters is how it sounds.

The wave-table oscillator has some interesting sonic characteristics. It outputs the waveform in a stair-stepped fashion, making no attempts to 'smooth the steps' in the process, but does so in a manner that is completely band-limited. This makes it similar in sound to 1980s era wave-table synths and samplers which didn't use resampling but had dedicated D/A-converters for each voice instead and changed the pitch by varying the sample rate of the individual D/As.

The fact that the steps aren't smoothed causes an artifact known as harmonic aliasing. This is not to be confused with inharmonic aliasing which sounds somewhat similar to an AM-radio being tuned and is generally nasty. Instead, this artifact will cause the harmonics of the waveform to repeat themselves and fill up the entire audible spectra even at low pitches, just like a square-wave would, preventing the waveform from sounding dull. As this artifact is completely harmonic it is also musically pleasing. Nonetheless, it may sound a bit out of place on very smooth waveforms but the effect can be filtered out by a lowpass-filter in the filter block if desired. Some of the wave-tables, such as the regular triangle wave, are large enough for this artifact to never appear in the normally used range for this specific reason.

The important thing is that just like most other oscillators in Surge XT, it doesn't output any inharmonic aliasing whatsoever or any audible levels of interpolation-noise, two artifacts which has played a big part in giving digital synthesizers a bad name.

For more information, you can read this article on Surge's wiki.

For developers and advanced users:

There is a reference for the .wt file-format used by the wavetables. It is located at: `surgedata/wavetables/wt fileformat.txt`

Morph	Interpolates between wavetable frames. 0% = first frame, 100% = last frame	0 .. 100 %
Skew Vertical	Vertical skew of the waveform	-100 .. 100 %
Saturate	Soft saturation of the waveform	0 .. 100 %
Formant	Compresses the waveform in time but keeps the cycle-time intact	0 .. 60 semitones
Skew Horizontal	Horizontal skew of the waveform	-100 .. 100 %
Unison Detune	Detuning of unison oscillators Can be extended. Can be switched between relative (default) and absolute	0 .. 100 cents 0 .. 1200 cents 0 .. 16 Hz 0 .. 192 Hz
Unison Voices	Number of oscillators used for unison. 1 = disabled	1 .. 16

Window

The window oscillator is another shot at wavetable synthesis that is quite different from the previous wavetable algorithm.

The wave, which can be any waveform included with Surge XT, is multiplied by a second waveform, the window, which can be one of 9 waveform types that are specifically made for the window oscillator. The formant parameter controls the pitch of the wave independently of the window, but as the wave is always restarted with the window the pitch will remain the same. Instead, the timbre of the sound will change dramatically, much depending on which window is selected.

Unlike the wavetable algorithm, the window oscillator uses a more traditional resampling approach which doesn't result in harmonic aliasing.

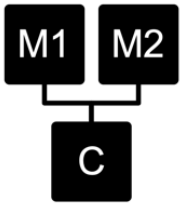
Morph	Selects a frame from the wavetable, without interpolation. 0% = first frame, 100% = last frame. Can be set to continuous	0 .. 100 %
Formant	Adjusts pitch of the wavetable frame, independently from the pitch of the window	-60 .. 60 semitones
Window	Chooses the waveform used for the amplitude window	Triangle, Cosine, Blend 1, Blend 2, Blend 3, Sawtooth, Sine, Square, Rectangle
Low Cut	Cutoff frequency of built-in highpass filter Must be activated in context menu	13.75 .. 25087.71 Hz
High Cut	Cutoff frequency of built-in lowpass filter. Must be activated in context menu	13.75 .. 25087.71 Hz
Unison Detune	Detuning of unison oscillators. Can be extended. Can be switched between relative (default) and absolute	0 .. 100 cents 0 .. 1200 cents 0 .. 16 Hz 0 .. 192 Hz
Unison Voices	Number of oscillators used for unison. 1 = disabled	1 .. 16

Sine

Quite unsurprisingly, this oscillator generates a sine waveform. However, there's a number of other interesting things this oscillator can do!

Shape	Various variants of sine wave achieved through quadrant masking, shifting and frequency doubling	1 .. 28
Feedback	FM feedback amount. Can be extended	-100 .. 100 % -400 .. 400 %
FM Behavior	Chooses whether FM behaves like Surge 1.6.1.1 and earlier, or consistent with FM2/3 oscillators	Legacy (before v1.6.2), Consistent with FM2/3
Low Cut	Cutoff frequency of built-in highpass filter. Must be activated in context menu	13.75 .. 25087.71 Hz
High Cut	Cutoff frequency of built-in lowpass filter. Must be activated in context menu.	13.75 .. 25087.71 Hz
Unison Detune	Detuning of unison oscillators. Can be extended Can be switched between relative (default) and absolute	0 .. 100 cents 0 .. 1200 cents 0 .. 16 Hz 0 .. 192 Hz
Unison Voices	Number of oscillators used for unison, 1 = disabled.	1 .. 16

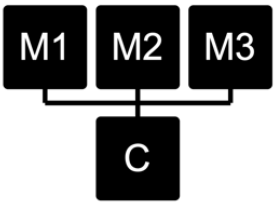
FM2



FM2 provides a miniature FM-synthesizer voice in an oscillator that is specifically tailored towards making nice and musical FM sounds. A single sine carrier is modulated by two sine modulators, whose ratios to the carrier are always integer thus the resulting waveform is always cyclic. However, **M1/2 Offset** lets you offset the modulators slightly in an absolute fashion, creating an evolving and pleasing detune effect.

M1 Amount	Modulation amount of the first modulator	0 .. 100 %
M1 Ratio	Ratio of the first modulator to the carrier	1 .. 32
M2 Amount	Modulation amount of the second modulator	0 .. 100 %
M2 Ratio	Ratio of the second modulator to the carrier	1 .. 32
M1/2 Offset	Absolute detuning of the modulators Can be extended	-10 .. 10 Hz -1000 .. 1000 Hz
M1/2 Phase	Changes the initial phase of the modulators to give different variations of the waveform	0 .. 100 %
Feedback	Modulation amount of the carrier to itself Extended mode (default) can be disabled	-400 .. 400 % -100 .. 100 %

FM3



As a contrast to FM2, FM3 is the algorithm of choice for scraping paint off walls. The modulators have a larger range, the ratios can be non-integer and there's a third modulator which has its rate set as an absolute frequency.

M1 Amount	Modulation amount of the first modulator	0 .. 100 %
M1 Ratio	Ratio of the first modulator to the carrier, can either be extended or absolute	0.0 .. 32.00 1/32.0 .. 32.0 ~ 8 Hz .. 24 kHz
M2 Amount	Modulation amount of the second modulator	0 .. 100 %
M2 Ratio	Ratio of the second modulator to the carrier, can either be extended or absolute	0.0 .. 32.00 1/32.0 .. 32.0 ~ 8 Hz .. 24 kHz
M3 Amount	Modulation amount of the third modulator	0 .. 100 %
M3 Frequency	Frequency of the third modulator	~ 14 Hz .. 25 kHz
Feedback	Modulation amount of the carrier to itself Extended mode (default) can be disabled	-400 .. 400 % -100 .. 100 %

String

The String oscillator uses a physical modeling technique where excitation sources are sent into a tuned delay line with feedback, with various filters inline (based on the original Karplus-Strong algorithm). The oscillator runs two strings at all times which can be detuned from each other and individually damped.

To make the model create sound, you need to excite it. We have two classes of excitation modes, **Burst** and **Constant**. In Burst mode, the delay line is loaded with a pattern before a note is played, and then no further signal is added to the oscillator. Think of this as emulating a plucked string. In Constant mode, the delay line is also pre-loaded, but the signal continues to be applied for as long as you hold the key. Think of this as emulating a bowed string. In almost all cases, Continuous excitation modes would be used along with modulation of **Exciter Level** parameter, in order to emulate bow pressure, and so on.

Exciter modes provide various waveforms - noise, pink noise, ramp, etc. - which you can use to excite the strings, leading to different timbres. Surge XT's audio input can also be used as an exciter signal!

Exciter	Determines mode and waveform used to excite the string.	Burst, Constant
Exciter Level	Determines how strongly the string gets excited	-100 .. 100 %
String 1 Decay	Sets the decay time of the first string (amount of delay line feedback)	-100 .. 100 %
String 2 Decay	Sets the decay time of the second string (amount of delay line feedback)	-100 .. 100 %
String 2 Detune	Adjusts tuning of the second string. Can be extended Can be switched between relative (default) and absolute	-100 .. 100 cents -1200 .. 1200 cents -16 .. 16 Hz -192 .. 192 H
String Balance	Adjusts mix between the two strings	-100 .. 100%
Stiffness	Applies lowpass (left) and highpass (right) filters in the feedback loop, which emulates various levels of stiffness of the string. Results in inharmonic timbres at the extremes	-100 .. 100%

Twist

This oscillator imports a rather famous Eurorack macro oscillator into Surge XT, based on Émilie Gillet's device. You can read the manual for the hardware module on which this oscillator is based here.

This implementation presents all 16 oscillator modes and the controls are dynamically renamed appropriately for every model. Core differences between the hardware module and Surge XT's implementation are:

1. By default, the LPG in the module is disabled, but by activating the LPG level and decay sliders with (right-click, then Activate), the LPG will be triggered per voice for each received MIDI note.

2. By default, you can mix between the main and the auxiliary oscillator outputs with the Mix parameter. You can also right-click the Mix parameter and enable Pan main and auxiliary signals option, in which case -100% value is Main to left/Aux to right, +100% is Main to right/Aux to left, and 0% is an even mix of both signals sent to both left and right. Do note that for this to be audible, you have to be in one of stereo filter configuration modes.

Twist can be more CPU demanding than most other Surge XT oscillator algorithms. Judiciously using maximum polyphony setting and being careful with Amp EG release times can go a long way in minimizing the CPU usage, thus making robust patches.

Alias

The Alias oscillator purposefully ignores a few decades of research into making digital signals with low or no aliasing, and does all the things you shouldn't do, so it purposefully sounds digital, gross, broken, terrible, yet awesome all at once.

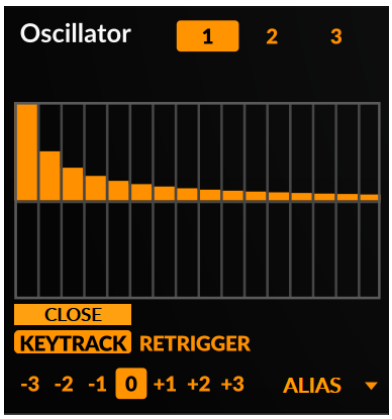
Shape	Sets the oscillator waveform	See explanation below
Wrap	Mangles the waveform by amplifying it, then making it wrap around from the other side instead of hard clipping	-100 .. 100 %
Mask	Sets a 8-bit bitmask applied to the waveform	-100 .. 100 %
Threshold	Adjusts the turning point (ramp), duty cycle (pulse) or wavetable readout offset (others) of the waveform	-100 .. 100 %
Bitcrush	Sets the amount of bitcrushing applied to the waveform	1.00 .. 8.00 bits
Unison Detune	Detuning of unison oscillators. Can be extended. Can be switched between relative (default) and absolute	0 .. 100 cents 0 .. 1200 cents 0 .. 16 Hz 0 .. 192 Hz
Unison Voices	Number of oscillators used for unison, 1 = disabled	1 .. 16

Shape

Shape parameter (comes in the form of a menu) is very important and is worth explaining in more detail, as it allows you to choose the source used for the Alias algorithm.

In addition to the more regular shapes (such as Sine, Ramp, Pulse and Noise), Surge XT's audio input can be also used.

Going further, there is Additive, which allows you to create a custom waveform by adjusting amplitudes of up to 16 harmonics, accessible by clicking on the Edit button that appears in this mode:



This editor works in a similar way to the step sequencer editor, however there are some additional options available when right-clicking:

- **Shapes -** Partial level presets which roughly represent different wave shapes, including a random option.
- **Absolute -** Sets the level of all the partials in the positive range.
- **Invert -** Flips the partial levels vertically.
- **Reverse -** Flips the partial levels horizontally.

Additionally, you can also use **Quadrant Shaping** waveforms as a source, which are also found in the Sine oscillator.

Finally, we have various **Memory from...** options:

- **This Alias Instance -** Generates a waveform based on reading memory associated with the currently selected instance of Alias.
- **Oscillator Data -** Generates a waveform based on reading memory associated with general oscillator data.
- **Step Sequencer Data -** Generates a waveform based on reading memory associated with step sequencer data.

- **Scene Data -** Generates a waveform based on reading memory associated with general scene data.
- **DAW Chunk Data -** Generates a waveform based on reading memory that serves as additional DAW chunk data (various non-automatable parameters and settings).

Note: When using **Memory From...** as a source, there is no guarantee that the resulting waveform will be consistent, as memory data can vary depending on a number of things: the DAW used, the particular Surge XT instance, rebooting your machine, and so on. Thus, it's good practice to bounce the audio output from Surge XT when using this mode. You know what they say; "If you like it, you should... put a mic on it."

S&H Noise

S&H is an abbreviation for 'Sample and Hold'. The S&H Noise oscillator algorithm works like a pulse oscillator, but instead of always switching between +1 and -1, the levels used are determined stochastically.

The correlation parameter determines how new levels are calculated. A setting of 0% will have no memory and each new level will effectively be a random number (white noise). A lower setting will favor new values that are closer to the previous level and will provide noise with a darker spectra. Higher values will favor values as far away from the previous one as possible, with 100% resulting in a harmonic pulse wave.

Correlation	Noise correlation. 0% = white noise, 100% = pulse wave	-100 .. 100 %
Width	Duty cycle of the oscillator	0 .. 100 %
Low Cut	Cutoff frequency of built-in highpass filter. Must be activated in context menu	13.75 .. 25087.71 Hz
High Cut	Cutoff frequency of built-in lowpass filter. Must be activated in context menu	13.75 .. 25087.71 Hz
Sync	Oscillator hard sync	0 .. 60 semitones
Unison Detune	Detuning of unison oscillators. Can be extended. Can be switched between relative (default) and absolute	0 .. 100 cents 0 .. 1200 cents 0 .. 16 Hz 0 .. 192 Hz
Unison Voices	Number of oscillators used for unison. 1 = disabled	1 .. 16

Audio Input

Audio Input lets you route external audio into the voice architecture of Surge XT. It also allows you to route the audio output from Scene A into Scene B.

Audio In L/R Channel	Chooses which external input is used. -100% = left, 0% = both (stereo), 100% = right.	-100 .. 100 %
Audio In Gain	External input gain in dB	48 .. +48 dB
Scene A L/R Channel[1]	Chooses which input from Scene A is used. -100% = left, 0% = both (stereo), 100% = right	-100 .. 100%
Scene A Gain[1]	Scene A input gain in dB	48 .. +48 dB
Audio In<>Scene A Mix[1]	Blend control between the external audio-in signal and the output of Scene A	-100 .. +100%
Low Cut	Cutoff frequency of built-in highpass filter. Must be activated in context menu	13.75 .. 25087.71 Hz
High Cut	Cutoff frequency of built-in lowpass filter. Must be activated in context menu	13.75 .. 25087.71 Hz

[1] Only available in Scene B

Note: When using the Audio Input oscillator type in Scene B to get audio from Scene A, you will likely want to **set Play Mode to Latch**. That way, Scene B will always be triggered.

For more information and possible applications, you can read this article on Surge's wiki.

Filter algorithms

There are multiple filter algorithms available for each of the 2 filter units in the filter block. Each of the algorithms have different subtypes, which alter their sound.

Some of the filter-(sub)types have some non-linear elements in them to allow them to self-oscillate in a stable and predictable manner. This means they will sound different depending on how hard they're driven, which can be conveniently controlled with the Pre-Filter Gain setting found in the mixer. For example, if the resonance peaks of a filter is too loud, increase the Pre-Filter Gain to make the rest of the signal more dominant (and if needed decrease the gain at the output stage of the voice to compensate).

Filters in Surge XT are divided into the following categories:

- Lowpass filters
- Highpass filters
- Bandpass filters
- Notch filters
- Effect filters

Filter Models

12 dB - 2-Pole filter. Available in Lowpass, Highpass, Bandpass and Notch types.

24 dB - 4-Pole filter. Available in Lowpass, Highpass, Bandpass and Notch types.

Sub-types for both **12 dB** and **24 dB**:

1. **Clean -** clean with a strong resonance, capable of self-oscillation. Handles transient behavior extremely well.
2. **Driven -** chesty, somewhat distorted sound with a more held-back resonance. Capable of self-oscillation.
3. **Smooth -** the smoothest subtype, capable of lower resonance than the others, which is suitable when you do not want the sound of the filter to be noticed but only to roll-off a part of the spectrum.

Legacy Ladder - 4-Pole ladder filter. This is Surge's original and older ladder filter. It has stable self-oscillation and requires less CPU processing than the newer Vintage Ladder filter. Available in **Lowpass** type.

Sub-types:

1. **6 dB -** Output taken from 1st stage (1-pole).
2. **12 dB -** Output taken from 2nd stage (2-pole).
3. **18 dB -** Output taken from 3rd stage (3-pole).
4. **24 dB -** Output taken from 4th stage (4-pole).

Vintage Ladder - 4-Pole ladder filter. This is a more recent, accurate and often better-sounding ladder filter. It also has stable self-oscillation, but requires more CPU processing than the older Legacy Ladder filter. Available in Lowpass type.

Sub-types:

1. **Type 1 -** Imitates a Moog resonant filter by Runge-Kutta numerical integration of a differential equation approximately describing the dynamics of the circuit.
2. **Type 1 Compensated -** Gain-compensated version of Type 1.
3. **Type 2 -** Moog Ladder filter that builds upon the work done by Smith and Stilson from Antti Huovilainen's paper.
4. **Type 2 Compensated -** Gain compensated version of Type 2.

Thanks to @ddiakopoulos for maintaining this very useful repository of research and code which heavily informed the models we implemented.

K35 - 12 dB/Octave filters from the Odin 2 synthesizer, and inspired by the Korg MS-20 filter topology. Increasing resonance will make them sound dirtier and more aggressive. Available in **Lowpass** and **Highpass** types.

Sub-types:

1. No Saturation
2. Mild Saturation
3. Moderate Saturation
4. Heavy Saturation
5. Extreme Saturation

Thanks to @TheWaveWarden for allowing us to implement Odin 2's K35 filters inside Surge XT. You can download Odin 2 here, or read the code here.

Diode Ladder - 4-pole diode ladder filter from the Odin 2 synthesizer with individually tapped pole outputs. This filter attempts to model the sound of a ladder filter that uses diodes instead of transistors. This filter does not self-oscillate without feedback. Available in Lowpass type.

Sub-types:

1. **6 dB -** Output taken from 1st stage (1-pole).
2. **12 dB -** Output taken from 2nd stage (2-pole).
3. **18 dB -** Output taken from 3rd stage (3-pole).
4. **24 dB -** Output taken from 4th stage (4-pole).

Thanks to @TheWaveWarden for allowing us to implement Odin 2's Diode Ladder filters inside Surge XT. You can download Odin 2 here, or read the code here.

OB-Xd 12dB - 12dB filters from the OB-Xd synthesizer by discoDSP, and from the work of Vadim Filatov, which is based on the filters found in the Oberheim OB-Xa. Available in **Lowpass**, **Highpass**, **Bandpass** and **Notch** types.

Sub-types:

1. **Standard -** Standard filter response.
2. **Pushed -** Adds boosted non-linearities that drives the filter into more self-oscillation at high resonance values.

Thanks to discoDSP for allowing us to implement OB-Xd's filters inside Surge XT. You can get OB-Xd here, or read the source here.

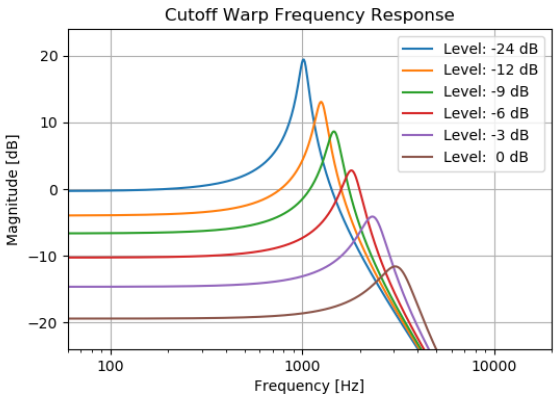
OB-Xd 24dB - 24dB filters found in the OB-Xd synthesizer by discoDSP, and from the work of Vadim Filatov, which is based on the filters found in the Oberheim OB-Xa. Available in **Lowpass** type.

Sub-types:

1. **6 dB -** Output taken from 1st stage (1-pole).
2. **12 dB -** Output taken from 2nd stage (2-pole).
3. **18 dB -** Output taken from 3rd stage (3-pole).
4. **24 dB -** Output taken from 4th stage (4-pole).

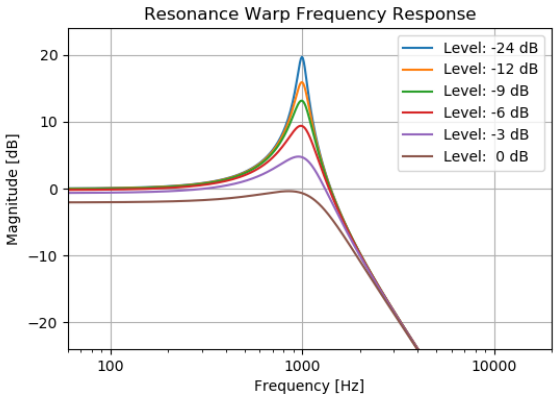
Thanks to discoDSP for allowing us to implement OB-Xd's filters inside Surge XT. You can get OB-Xd here, or read the source here.

Cutoff Warp - 12dB/Octave filters created using a nonlinear biquad filter structure. The nonlinearities in the Cutoff Warp filter cause the cutoff frequency to sweep to higher frequencies as the signal level increases (see below). Available in **Lowpass**, **Highpass**, **Bandpass**, **Notch** and **Allpass (Effect)** types.



For more information on the Cutoff Warp filter, you can see this blog post by Jatin Chowdhury, or this 2020 DAFx paper, specifically section 4.

Resonance Warp - 12dB/Octave filters created using a nonlinear biquad filter structure. The nonlinearities in the Resonance Warp filter cause the resonance of the filter to decrease as the signal level increases (see below). Available in **Lowpass**, **Highpass**, **Bandpass**, **Notch** and **Allpass (Effect)** types.



For more information on the Cutoff Warp filter, you can see this blog post by Jatin Chowdhury, or this 2020 DAFx paper, specifically section 3.

Sub-types for **Cutoff Warp** and **Resonance Warp**:

1. **1 Stage tanh -** Output taken from 1st stage (2-pole), using tanh nonlinearities.
2. **2 Stages tanh -** Output taken from 2nd stage (4-pole), using tanh nonlinearities.
3. **3 Stages tanh -** Output taken from 3rd stage (6-pole), using tanh nonlinearities.
4. **4 Stages tanh -** Output taken from 4th stage (8-pole), using tanh nonlinearities.
5. **1 Stage Soft Clip -** Output taken from 1st stage (2-pole), using soft-clipping nonlinearities.
6. **2 Stages Soft Clip -** Output taken from 2nd stage (4-pole), using soft-clipping nonlinearities.
7. **3 Stages Soft Clip -** Output taken from 3rd stage (6-pole), using soft-clipping nonlinearities.
8. **4 Stages Soft Clip -** Output taken from 4th stage (8-pole), using soft-clipping nonlinearities.
9. **1 Stage OJD -** Output taken from 1st stage (2-pole), using OJD nonlinearities.
10. **2 Stages OJD -** Output taken from 2nd stage (4-pole), using OJD nonlinearities.

11. **3 Stages OJD -** Output taken from 3rd stage (6-pole), using OJD nonlinearities.
12. **4 Stages OJD -** Output taken from 4th stage (8-pole), using OJD nonlinearities.

Tri-Pole - 3-pole filter based on the Threeler filter designed by Ian Fritz, which contains 3 filter stages and a resonance stage all in a global feedback loop.

1. **Low -> Low -> Low, First -** Output taken from the 1st filter stage.
   Filter stages are: LPF, LPF, LPF.
2. **Low -> High -> Low, First -** Output taken from the 1st filter stage.
   Filter stages are: LPF, HPF, LPF.
3. **High -> Low -> High, First -** Output taken from the 1st filter stage.
   Filter stages are: HPF, LPF, HPF.
4. **High -> High -> High, First -** Output taken from the 1st filter stage.
   Filter stages are: HPF, HPF, HPF.
5. **Low -> Low -> Low, Second -** Output taken from the 2nd filter stage.
   Filter stages are: LPF, LPF, LPF.
6. **Low -> High -> Low, Second -** Output taken from the 2nd filter stage.
   Filter stages are: LPF, HPF, LPF.
7. **High -> Low -> High, Second -** Output taken from the 2nd filter stage.
   Filter stages are: HPF, LPF, HPF.
8. **High -> High -> High, Second -** Output taken from the 2nd filter stage.
   Filter stages are: HPF, HPF, HPF.
9. **Low -> Low -> Low, Third -** Output taken from the 3rd filter stage.
   Filter stages are: LPF, LPF, LPF.
10. **Low -> High -> Low, Third -** Output taken from the 3rd filter stage.
    Filter stages are: LPF, HPF, LPF.
11. **High -> Low -> High, Third -** Output taken from the 3rd filter stage.
    Filter stages are: HPF, LPF, HPF.
12. **High -> High -> High, Third -** Output taken from the 3rd filter stage.
    Filter stages are: HPF, HPF, HPF.

For more information on the development of the Tri-Pole filter, please see this Python notebook which outlines the development of the signal processing building blocks behind the filter.

Allpass - As its name suggests, this filter passes all frequencies equally in gain. However, it is useful to alter the phase relationship in the spectrum. Unless feedback is involved, its effect can mostly be heard when the Cutoff frequency is in movement. Thus, modulation can be used to get interesting results. Allpass can be found under the **Effec**t category.

Comb+ and Comb- Comb filter, which is different compared to the previous filter types since it doesn't filter any part of the spectrum, but instead plays back the original signal with a delay. The former type has positive feedback and the latter has negative feedback.

Sub-types:

1. 50% Wet
2. 100% Wet

When the sub-type is set to 2 and resonance is 0%, the comb filter will work purely as a delay unit (with sub-sample precision). This can be used together with the other filter unit along with filter block feedback to provide interesting options. The "Winds/Clarinet" and " Plucks/Simple Waveguide" presets showcase how this ability can be used for simple physical modeling. They only use the oscillator section to ignite the sound, the rest is in the filter block.

Moreover, the negative comb filter produces the sound an octave lower than the positive comb filter.

Comb + and Comb - can be found in the **Effect** category.

Sample & Hold - The Sample & Hold module will sample the audio at the rate set by the cutoff frequency. Resonance will emphasize oscillations around the cutoff frequency, not unlike the resonance peak of a lowpass filter.

Sample & Hold can be found in the **Effect** category.

Effect algorithms

Surge XT has 8 effect units which each can run one of the 10 provided algorithms.

EQ

The EQ unit provides 3-bands of fully parametric equalizing. This high-quality algorithm has a much better response at high frequencies than digital equalizers usually have.

Band 1/2/3 Gain	Band gain, can be disabled	-48 .. +48 dB
Band 1/2/3 Freq	Band frequency	14Hz .. 25kHz
Band 1/2/3 Bandwidth	Band bandwidth	0 .. 5 octaves
Output gain	Gain control	-48 .. +48 dB
Mix	Blend control between the dry and the wet signal	0 .. 100 %

Exciter

Exciter is a harmonic exciter based on the famous Aphex Aural Exciter unit. For more information, see this blog post by Jatin Chowdhury.

Drive	Controls the amount of generated harmonics	0 .. 100 %
Tone	Controls the tone balance of the generated harmonics	0 .. 100 %
Attack	Controls the attack time of the generated harmonics	5 .. 20 ms
Release	Controls the release time of the generated harmonics	50 .. 200 ms
Mix	Controls the mix of wet and dry signals	0 .. 100 %

Graphic EQ

Graphic EQ is, as its name suggests, a graphic equalizer. It is comprised of 11 level-adjustable and deactivatable (from the right-click menu) bands, which makes this equalizer better than the normal EQ at sculpting relatively complex response curves. Apart from the fact that there is also an output gain control at the bottom of the interface, there is not much else to add.

Resonator

The Resonator provides carefully tuned lowpass, bandpass, bandpass + notch or highpass filters, each with individual output gain and resonance. By default, the filters cannot be driven into self-oscillation, but if you right-click any of the three **Resonance** parameters and enable **Modulation extends into self-oscillation**, modulation sources can drive the filters to a self-oscillating point. Similarly, the three resonator bands are tuned to match the ranges of a very famous resonator circuit, but they can be extended to allow a wider range.

Frequency 1/2/3	Frequency of the filter for the the first, second or third band Can be extended	60 .. 300 Hz 60 .. 7500 Hz
Resonance 1/2/3	Amount of resonance for the first, second or third band. Modulation can be allowed to push the filter into self-oscillation from the right-click menu	0 .. 100 %
Gain 1/2/3	First, second or third band gain	-inf .. 0 dB
Mode	Sets the filter type used in the resonator effect	Lowpass, Bandpass, Bandpass+Notch, Highpass
Mix	Controls the mix of wet and dry signals	0 .. 100 %

CHOW

Chow is a half-wave rectifier distortion effect with controls similar to those found in a compressor. The original effect was implemented as an open source audio plugin by Jatin Chowdhury.

Threshold	Controls the threshold at which rectification starts.	-96dB .. 0dB
Ratio	Controls the amount of rectification	1:1 .. 1:20
Flip	Flips the output signal to be positive or negative	On/Off
Mix	Controls the mix of wet and dry signals	0 .. 100 %

Distortion

Distortion algorithm. Provides plenty of EQ options as well as a feedback loop to alter the tonality of the clipping stage.

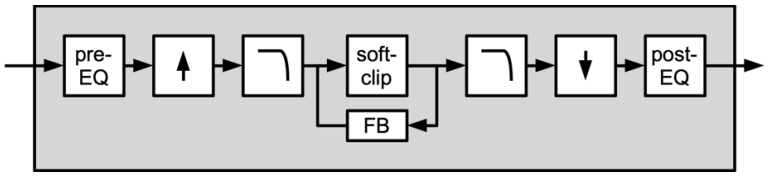
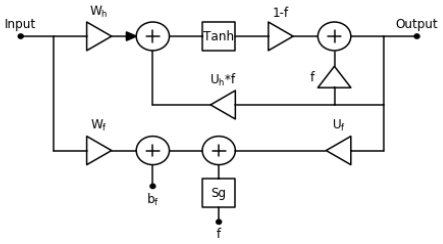


Illustration 21: Distortion algorithm block diagram

Pre-EQ Gain/ Freq/BW	Parametric EQ band parameters prior to the clipping stage, Gain can be extended	
Pre-EQ High cut	High cut element prior to the clipping stage	14Hz .. 25kHz
Model	Waveshaper used for distortion	Soft, Hard, Asymmetric, Sine, Digital
Drive	Drive of the clipping stage Can be extended	-24 .. +24 dB -120 .. 120 dB
Feedback	Feedback loop around the clipping stage	-100 .. 100 %
Post-EQ Gain/ Freq/BW	Parametric EQ band parameters after the clipping stage Gain can be extended.	
Post-EQ High cut	High cut element prior to the clipping stage	14Hz .. 25kHz
Output gain	Output gain	-24 .. +24 dB

Neuron

Neuron is an effect based on a Gated Recurrent Unit (GRU), a commonly used building block in recurrent neural networks.



For more information on the development of the Neuron effect, you can read this blog post by Jatin Chowdhury.

Drive	The Wh coefficient of the GRU; controls the input gain of the main signal path	0 .. 100 %
Squash	The Wf coefficient; controls the input gain of the sidechain signal path	0 .. 100 %
Stab	The Uf coefficient; controls the feedback gain of the sidechain signal path	0 .. 100 %
Asymmetry	The Uh coefficient; controls the feedback gain of the main signal path	0 .. 100 %
Bias	The bf coefficient; controls the bias amount of the sidechain signal path	0 .. 100 %
Comb Freq	Controls the length of the feedback delay, creating an internal comb filter	14Hz .. 25kHz
Comb Separation	Controls the separation between the comb frequencies in the left and right channels	-96 .. 96 semitones
LFO Waveform/ Rate/Depth	Controls for the modulation of the comb frequency.	

Tape

Tape effect is a port of the Chow Tape Model tape emulation effect, a real-time physical model of a reel-to-reel analog tape machine. The model contains parameters for controlling the amount of tape distortion and degradation, as well as physical characteristics of the tape machine, like the play head width, or tape thickness.

The original plugin can be found on GitHub, and signal processing details are outlined in this 2019 DAFx paper.

Drive	Controls the gain of the tape distortion	0 .. 100 %
Saturation	Controls the amount of tape saturation	0 .. 100 %
Bias	Controls the amount of tape bias	0 .. 100 %
Tone	Controls the tone balance of the tape distortion	-100 .. 100 %
Speed	Controls the tape speed	1 .. 50 ips
Gap	Controls the width of the playhead gap	0.1 .. 20 microns
Spacing	Controls the spacing between the tape and the playhead	0.1 .. 50 microns
Thickness	Controls the tape thickness	1 .. 50 microns
Depth	Controls the tone balance of the tape distortion	0 .. 100 %
Amount	Controls the tone balance of the tape distortion	0 .. 100 %
Variance	Controls the tone balance of the tape distortion	0 .. 100 %
Mix	Controls the mix of wet and dry signals	0 .. 100 %

Waveshaper

The full waveshaper module present in the sound shaping section of the synth (see Waveshaper) is also available as an effect unit which, like other effects, can be loaded anywhere in the FX signal path. It also hosts additional controls for further adjustments of the resulting distorted output.

Low Cut (pre)	Low cut filter prior to the waveshaping stage. disabled by default, but can be activated	13.75 Hz .. 25kHz
High cut (pre)	High cut filter prior to the waveshaping stage. disabled by default, but can be activated	13.75 Hz .. 25kHz
Shape	Shape used for waveshaping	Full list of wave shapes also present in the waveshaper
Bias	Alters the symmetry of the shaping curve	-100 .. 100 %
Drive	Drive of the waveshaping stage. Can be extended	-24 .. +24 dB -120 .. 120 dB
Low Cut (post)	Low cut filter after the waveshaping stage. Can be activated	13.75 Hz .. 25kHz
High cut (post)	High cut filter after the waveshaping stage. Can be activated	13.75 Hz .. 25kHz
Gain	Output gain	-24 .. +24 dB
Mix	Controls the mix of wet and dry signals	0 .. 100 %

Combulator

Combulator effect is somewhat similar to the Resonator in that it is also made of three filter bands. However, it uses comb filters instead. These three filters are tuned to a center pitch and two offsets, each with its own gain control, and combs 2 and 3 with individual pan. A common use case is to use a monophonic (scene-level) modulation source like **Highest Key** to modulate the center pitch. The circuit also implements an envelope follower on the input signal, and mixes additional noise in based on the followed envelope and the **Extra Noise** parameter.

Extra Noise	Controls the level of extra noise added to the comb filters	0 .. 100 %
Center	Master center pitch control, offsets the three comb filters simultaneously	0.5 .. 25087.71 Hz %
Offset 1/2	Controls the offset independently for two of the comb filters	-60 .. 60 semitones
Feedback	Controls the feedback amount applied to the comb filters	-100 .. 100 %
Tone	Applies lowpass (left) or highpass (right) filtering	-100 .. 100 %
Comb 1/2/3	Output gain for each of the comb filters	-inf .. 0 dB
Pan 2/3	Independent output panning controls for two of the comb filters	-inf .. 0 dB
Mix	Controls the mix of wet and dry signals	0 .. 100 %

Frequency Shifter

Frequency shifter effect. Provides a delay unit and a feedback loop to give consecutively shifted repeating delays.

Left	Amount of frequency shift (in Hertz) for the left channel Can be extended	-10 .. 10 Hz -1 .. 1 kHz
Right	Amount of frequency shift (relative to the left channel) for the right channel	-100 .. 100 %
Time	Delay time for the frequency-shifted signal. Can be tempo-synced	0 .. 32 s 1/512 .. 16 whole notes
Feedback	Feedback around the frequency shifter and delay-unit	-inf .. 0 dB
Mix	Blend control between the dry and the wet signal	0 .. 100 %

Nimbus

The Nimbus effect imports the granular texture effect from Émilie Gillet's eurorack project. You can read the manual for the hardware device on which this effect is based here.

The labels and ranges in the effect adjust based on the mode to allow you to use this effect appropriately in Surge XT.

Ring Modulator

Flexible ring modulation algorithm.

Shape	Shape used by the carrier oscillator	1 .. 24
Frequency	Frequency of the carrier oscillator	8.18 .. 12543.86 Hz
Unison Detune	Detuning of the carrier unison voices. Can be extended Can be switched between relative (default) and absolute	0 .. 100 cents 0 .. 1200 cents 0 .. 16 Hz 0 .. 192 Hz
Unison Voices	Number of unison voices used by the carrier oscillator. 1 = disabled	1 .. 16
Forward Bias	Controls the approximate model of the diode[1]	0 .. 100 %
Linear Region	Controls the approximate model of the diode[1]	0 .. 100 %
Low Cut	Low cut element before the output stage	13.75 .. 25087.71 Hz
High Cut	High cut element before the output stage	13.75 .. 25087.71 Hz
Mix	Blend control between the dry and the wet signal	0 .. 100 %

[1] For more information on the diode model used by the ring modulator, you can read this paper.

Treemonster

Treemonster is a specialized effect ported from Shortcircuit 2, a proper Vember Audio classic! Treemonster runs a naive pitch detection algorithm on the input signal, runs a sine oscillator at the detected pitch, then ring modulates the input signal with the resulting tuned sine oscillator. It can get pretty crazy, especially if you apply pitch shifts to the generated oscillator. Like the emulated analog ring modulation in Surge XT, this effect can very rapidly become very inharmonic.

Threshold	Level above which the input signal will have its pitch detected	-96 .. 0 dB
Speed	Transition speed between two detected pitches	0 .. 100 %
Low Cut	Cutoff frequency of the highpass filter applied to the input signal before pitch detection. Can be disabled	13.75 .. 25087.71Hz
High Cut	Cutoff frequency of the lowpass filter applied to the input signal before pitch detection. Can be disabled	13.75 .. 25087.71Hz
Pitch	Pitch offset of the carrier oscillator	0 .. 100 %
Ring Modulation	Mix between the clean sine carrier oscillator (left) and the ring modulated signal (right)	0 .. 100 %
Width	Stereo width. 0% = mono, 100% = stereo, -100% = reverse stereo	-100 .. 100 %
Mix	Blend control between the dry and the wet signal	-100 .. +100%

Vocoder

The audio input of Surge XT is used to modulate the carrier signal at the input stage of this 20-band vocoder algorithm.

Gain	Gain control of the modulator	-48 .. +48 dB
Gate	Bands below this level will be silenced	-96 .. 0 dB
Env Follow	Rate of the envelope followers	0 .. 100 %
Q	Controls the steepness of the filters	-100 .. 100 %
Bands	The number of vocoder bands	4 .. 20
Min Frequency	Frequency of the lowest vocoder band applied to the carrier. Bands will be spread evenly in pitch between it and the high band	55 .. 3520 Hz
Max Frequency	Frequency of the highest vocoder band applied to the carrier. Bands will be spread evenly in pitch between it and the low band	440 .. 14080 Hz
Input	Chooses the input source configuration	Mono Sum, Left Only, Right Only, Stereo
Range	Squeezes or expands the range of the modulator bands	-100 .. 100 %
Center	The modulator bands default to the carrier bands, but this re-centers the modulator while keeping the same low/high distance	-100 .. 100 %

Chorus

4-stage chorus algorithm.

Rate	Rate of the modulation Can be tempo-synced	0.008 .. 512 Hz 64 .. 1/1024 note
Depth	Depth of the modulation	0 .. 100 %
Time	Delay time used as center	0 .. 0.125 s
Feedback	Amount fed from the output back into the input.	-inf .. 0 dB
Low/High-cut	EQ controls of the chorused signal	14Hz .. 25kHz
Width	Gain scaling of the Side component of the wet signal	-24 .. 24 dB
Mix	Blend control between the dry and the wet signal	0 .. 100 %

Ensemble

Ensemble chorus effect based on BBD (bucket-brigade device) delay lines (with optional clean digital delay lines, too).

Implementation of the BBD chip is based on a 2018 DAFx paper by Martin Holters and Julian Parker.

Filter	The frequency of the anti-aliasing filter used by the BBD	14Hz .. 25kHz
Modulation Freq 1/2	Controls the modulation frequency of the chorus	0.01 .. 20 Hz
Modulation Depth 1/2	Controls the modulation depth of the chorus	0 .. 100 %
Delay Type	Controls the type of delay line used for the chorusing effect	128 .. 4096 BBD Stages, Digital
Clock Rate	Controls the clock rate used by the BBD delays	1.5kHz .. 100kHz
Saturation	Controls a BBD-style saturation on the chorusing delays	0 .. 100 %
Feedback	Controls feedback around the chorusing delays, creating a flanging effect	0 .. 100 %

Flanger

Versatile Flanging algorithm.

Waveform	Waveform of the modulation	Sine, Triangle, Sawtooth, Sample & Hold
Rate	Rate of the modulation, Can be tempo-synced	0.008 .. 512 Hz 64 .. 1/1024 note
Depth	Depth of the modulation	0 .. 100%
Count	Number of comb filters used for the flanging algorithm	1.00 .. 4.00
Base Pitch	Cutoff frequency/pitch of the first comb filter	0 .. 127 semitones
Spacing	Cutoff frequency offset for the other comb filters	0 .. 12 semitones
Feedback	Increases the flanging resonance	0 .. 100 %
LF Damping	Damping for low frequencies	0 .. 100%
Mode	Mode used for the flanging algorithm	Dry Signal + Combs, Combs Only, Dry Signal + Arpeggiated Combs, Arpeggiated Combs Only
Width	Gain scaling of the Side component of the wet signal	-24 .. +24 dB
Mix	Blend control between the dry and the wet signal	-100 .. +100%

Phaser

Flexible phaser with adjustable number of stages.

Waveform	Shape of the modulation	Sine, Triangle, Sawtooth, Noise, Sample & Hold, Square
Rate	Rate of modulation LFO Can be tempo-synced. Can be disabled[1]	0.008 .. 512 Hz 64 .. 1/1024 note
Depth	Depth of the phaser modulation LFO	0 .. 100 %
Stereo	LFO Phase relation between stereo channels 0% = 0 degrees, 100% = 180 degrees	0 .. 100 %
Count	Number of stages	2 .. 16
Spread	Distance between the stages	0 .. 100%
Center	Base frequency for the stages	-100 .. 100 %
Sharpness	Q setting for the stages	-100 .. 100 %
Feedback	Feedback of the phaser	-100 .. 100 %
Width	Gain scaling of the Side component of the wet signal	-24 .. +24 dB
Mix	Blend control between the dry and the wet signal	0 .. 100 %

[1] Once disabled, the Rate parameter acts like a phase parameter, which can be scrubbed through and modulated to achieve manual phasing and combing effects.

Rotary Speaker

Rotary speaker simulator algorithm.

Horn rate	Rate of HF horn rotation, the LF horn is a lower multiple of this rate, Can be tempo-synced	0.008 .. 512 Hz 64 .. 1/1024 note
Rotor Rate	Rotor rate (as a factor of Horn rate)	0 .. 200 %
Model	Waveshaper used for distortion	Soft, Hard, Asymetric, Sine, Digital
Drive	Distortion amount	0 .. 100 %
Doppler	The amount of Doppler shift (vibrato)	0 .. 100 %
Tremolo	The amount of amplitude modulation	0 .. 100 %
Width	Gain scaling of the Side component of the wet signal	-24 .. +24 dB
Mix	Blend control between the dry and the wet signal	-100 .. +100%

Delay

The delay algorithm in Surge XT is very versatile and can work well both as an echo/delay and chorus.

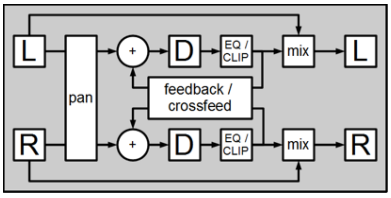


Illustration 20: Delay algorithm block diagram

There is an LFO connected to the delay lines (not shown in diagram) which can provide stereo-widening/detuning of the delay line.

Channel	Routes the two channels to the delay-units by panning. The gain of the input-channels remain unaffected, it's only their stereo location that changes. (a sound only heard in the left channel will still be heard when pan is set to 100% here, but only in the right channel.)	-100 .. 100 %
Delay time Left	Delay time for the left channel. Can be tempo-synced	0 .. 32 s 1/512 .. 16 whole notes
Delay time Right	Delay time for the right channel. Can be tempo-synced Can be linked to left channel	0 .. 32 s 1/512 .. 16 whole notes
Feedback	Amount fed from the channel to its own input.	-inf .. 0 dB
Crossfeed	Amount fed from the channel to the input of the opposing channel	-inf .. 0 dB
Low/High-cut	EQ controls of the delayed signal	14Hz .. 25kHz
Modulation rate	Rate of the modulation LFO (triangle)	0.008 .. 512 Hz 64 .. 1/1024 note
Modulation depth	Indirect control of the modulation LFO depth. The effect adjust the depth to match the detuning in cents set here	0 .. 200 cents
Width	Gain scaling of the Side component of the wet signal	-24 .. 24 dB
Mix	Blend control between the dry and the wet signal	0 .. 100 %

Reverb 1

The Reverb 1 algorithm is a classic and older sounding digital reverb.

Pre-Delay	Amount of delay applied to the signal before it is fed to the reverberation unit. Can be tempo-synced	0 .. 32 s 1/512 .. 16 whole notes
Room Shape	Selects between 4 room shapes that has different sounds. (changing this parameter will interrupt the signal)	0 .. 3
Size	Changes the apparent size of the simulated room. (changing this parameter will interrupt the signal)	0 .. 100 %
Decay Time	The time it takes for the reverberation to ring out. (-60 dB)	0 .. 64 s
HF Damping	Amount of HF damping applied to the signal inside the reverberator	0 .. 100 %
Low Cut, Peak Freq/Gain, High Cut	Post-reverb equalizer controls	
Width	Gain scaling of the Side component of the wet signal	-24 .. 24 dB
Mix	Blend control between the dry and the wet signal	0 .. 100 %

Reverb 2

The Reverb 2 algorithm is a second version of Surge's original Reverb effect and has a different algorithm and controls. Reverb 2 is more natural and contains less digital artifacts. For most use cases, Reverb 2 sounds better than Reverb 1.

Pre-Delay	Amount of delay applied to the signal before it is fed to the reverberation unit. Can be tempo-synced	0 .. 2 s 1/512 .. whole notes
Room Size	Changes the apparent size of the simulated room	-100 .. 100 %
Decay time	The time it takes for the reverberation to ring out. (-60 dB)	0 .. 64 s
Diffusion	Changes the complexity of the room, thus adjusting diffusion amount	0 .. 100 %
Buildup	Controls how long the reverb takes to come to its peak and how "smeared" in time the effect is	0 .. 100 %
Modulation	Amount of pitch modulation applied to the input for a more lush sound	0 .. 100 %
LF/HF Damping	The amount of absorption/redution for Low or High frequencies	0 .. 100 %
Width	Gain scaling of the Side component of the wet signal	-24 .. 24 dB
Mix	Blend control between the dry and the wet signal.	0 .. 100 %

Spring Reverb

The Spring Reverb algorithm is an emulation of old spring reverb effects. It is based loosely on the algorithm outlined by Parker (EURASIP 2011).

Size	Size of the springs being used to create the reverb	0 .. 100 %
Decay	Decay time of the reverb	0.5 .. 4.5 s
Reflections	Amount of early reflections propagated through the springs	0 .. 100 %
Damping	Amount of high-frequency damping in the springs	0 .. 100 %
Spin	Amount of frequency smearing happening in the springs	0 .. 100 %
Chaos	Amount of random modulation used to excite the springs	0 .. 100 %
Knock	Emulates the sound of a person knocking against the spring reverb unit	Off/On
Mix	Blend control between the dry and the wet signal	0 .. 100 %

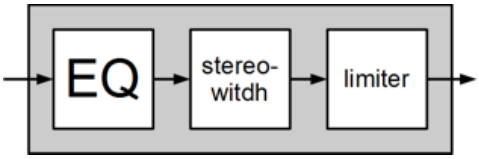
Airwindows

Airwindows effect is an integration of 53 diverse effects by Chris Johnson. Thanks to Airwindows for providing high quality open source effects!

You can read more about those effects here, and read the code here.

Conditioner

The conditioner is a simple EQ, stereo image control and a limiter built into one unit. The limiter applies make-up gain automatically.



Bass	LF boost/cut.	-12 .. +12 dB
Treble	HF boost/cut	-12 .. +12 dB
Width	Stereo width. 0% = mono, 100% = stereo, -100% = reverse stereo	-100 .. 100 %
Side Low Cut	Low cut filter for the Side content. Must be enabled to be used.	13.75 .. 25087.71 Hz
Balance	Stereo balance (left-right).	-100 .. 100 %
Threshold	Limiter threshold level	-48 .. 0 dB
Attack	Limiter attack rate	-100 .. 100 %
Release	Limiter release rate	-100 .. 100 %
Output	Limiter output attenuation	-48 .. 0 dB

Mid-Side Tool

The Mid-Side tool is a set of controls useful for transforming a stereo signal to mid-side and vice-versa, with additional separate filtering for the mid and side signal.

(Mid) Low Cut	Low cut filter for Mid content. Must be enabled to be used	13.75 .. 25087.71 Hz
(Mid) Gain	Gain of the Mid peak band. Must be enabled (with Frequency) to be used	-24 .. 24 dB
(Mid) Frequency	Frequency of the Mid peak band. Must be enabled (with Gain) to be used	-24 .. 24 dB
(Mid) High Cut	Low cut filter for Mid content. Must be enabled to be used	13.75 .. 25087.71 Hz
(Side) Low Cut	Low cut filter for Side content. Must be enabled to be used	13.75 .. 25087.71 Hz
(Side) Gain	Gain of the Side peak band. Must be enabled (with Frequency) to be used	-24 .. 24 dB
(Side) Frequency	Frequency of the Side peak band. Must be enabled (with Gain) to be used	-24 .. 24 dB
(Side) High Cut	Low cut filter for Side content. Must be enabled to be used	13.75 .. 25087.71 Hz
Mid Gain	Ouput level of Mid content	-48 .. 12 dB
Side Gain	Ouput level of Side content	-48 .. 12 dB
Balance	Stereo balance (left-right)	-100 (Left) .. 100 % (Right)

Tuning Editor

The integrated Surge XT Tuning Editor has a built-in collection of microtuning utilities for loading, modifying, analysis and export of Scala SCL-KBM tuning tables that enable working with a broad range of historical and contemporary musical intonation systems. It is also worth mentioning here that Surge XT supports the use and creation of non-monotonic intonation systems that may not necessarily be sorted in a linear order.

To open the Tuning Editor, right-click on the Tune button and from the Tuning menu, choose **Open tuning editor...,** where the following features are available:

Keyboard Mapping - On the far left of the Tuning editor UI, there is a keyboard diagram showing the current tuning and how its frequencies are mapped directly to **MIDI Note Numbers** across the musical range.

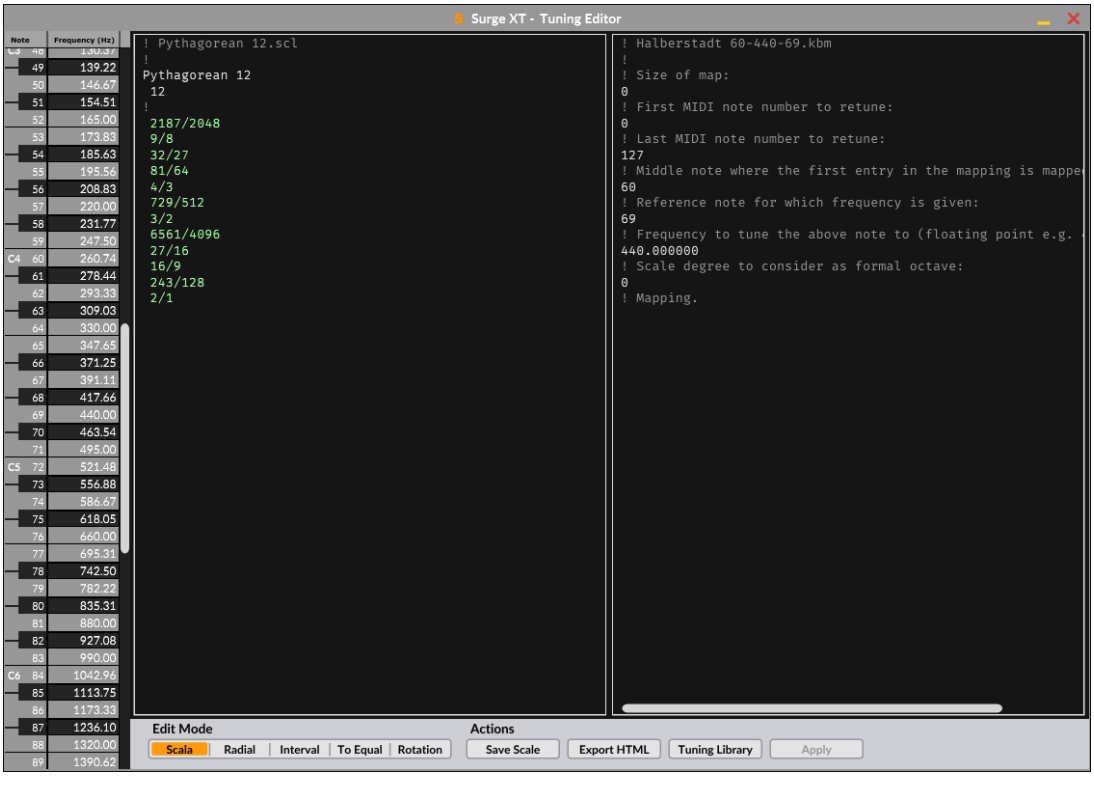
Notice that when playing notes from a MIDI controller, that the keys will light up showing the notes that are being played as well the fundamental pitches that Surge XT is sounding with each MIDI Note On.

Edit Modes

Along the bottom left of the Tuning Editor are five buttons that switch between the different editing and analysis functions:

Scala

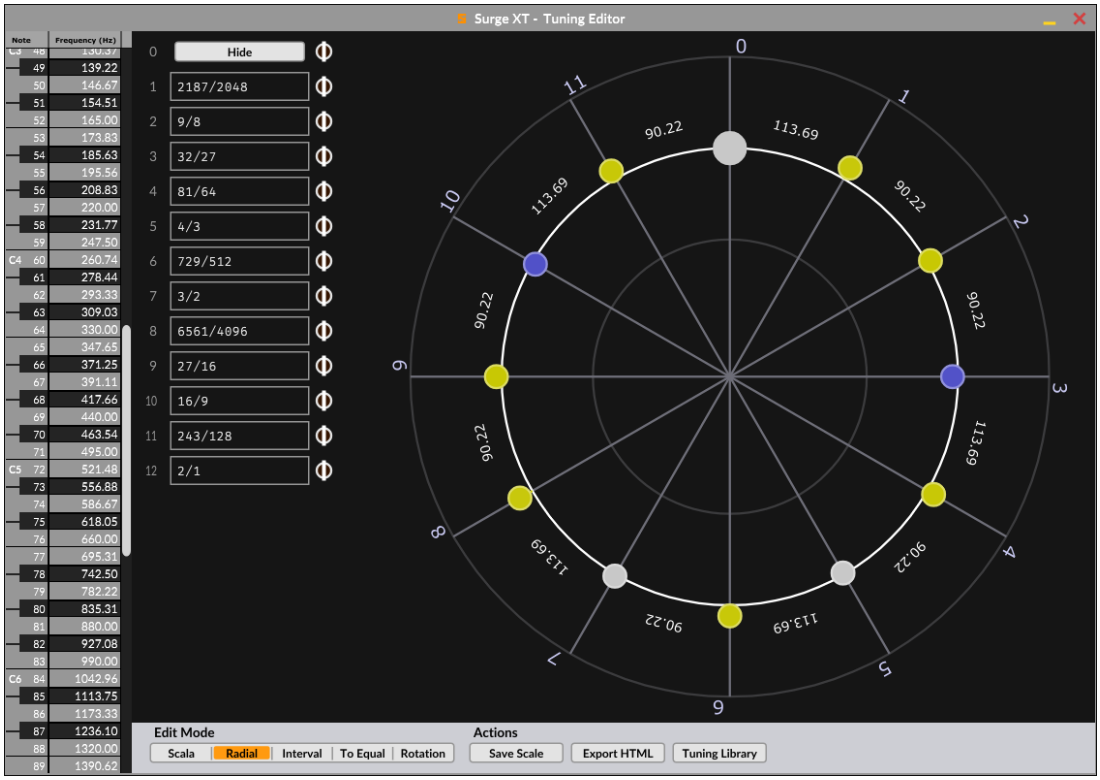
Click Scala button, where the values for the currently loaded Scala SCL and KBM file can be viewed and or edited. In the left pane is the Scala SCL, with the KBM on the right. Notice here too that input from an attached MIDI controller will highlight the scale degrees being played from the keyboard.



It's possible to directly edit SCL and KBM values in either pane, then using the Save Scale feature, export the results to any directory on the user's computer. Editing SCL and KBM is a slightly advanced topic, so it is advised to only make changes to tunings here, when one understands how these features work for creating custom tuning tables that can be read by Surge XT, or any other virtual-instruments that use the Scala SCL-KBM format.

Radial

Click the **Radial** button to access features for creating new scales, or otherwise modifying existing ones, with its features for tuning by ear using either the Scale Tones on the left, or the Tone Wheel on the right.



The **Scale Tones** features show the ratios or cents for each degree of the current tuning. The dials to the right of each scale degree can be used to retune each pitch of the scale by ear and the dial on the top right can be used to uniformly compress or stretch the current tuning.

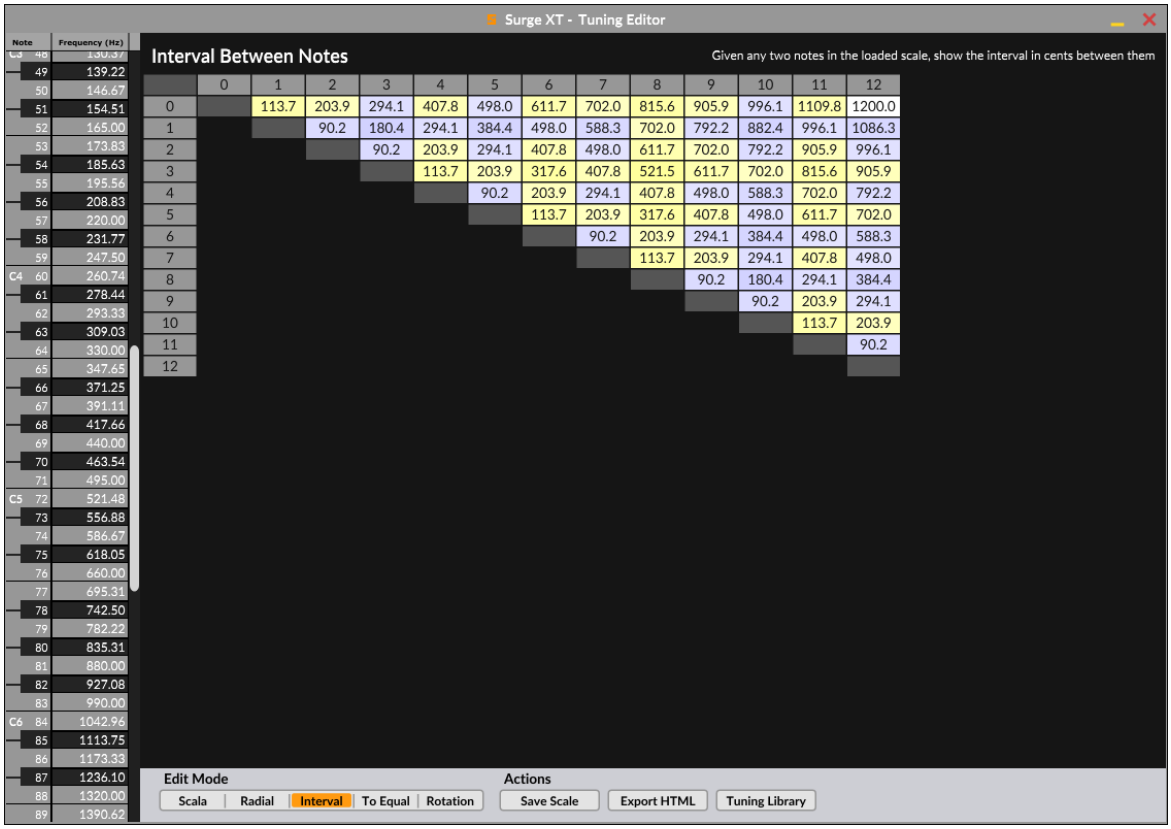
Holding **Shift** on the typing keyboard while moving the tuning dials counterclockwise or clockwise allows fine adjustments while retuning the scale by ear. Use the Hide button to hide the scale degrees when tuning by ear, then click Show to see the results of the tuning exercise.

It is also possible to type new values for each of the scale degrees in either ratios or cents.

Any changes made to the Scale Tones dials are immediately reflected on the Radial Tone Wheel to the right, and it's also possible to click on the circular nodes of the Tone Wheel and retune each by ear as well.

Interval

Provides a way to view the intervals of the current scale, given any two notes in the loaded scale and show the interval in cents between them.

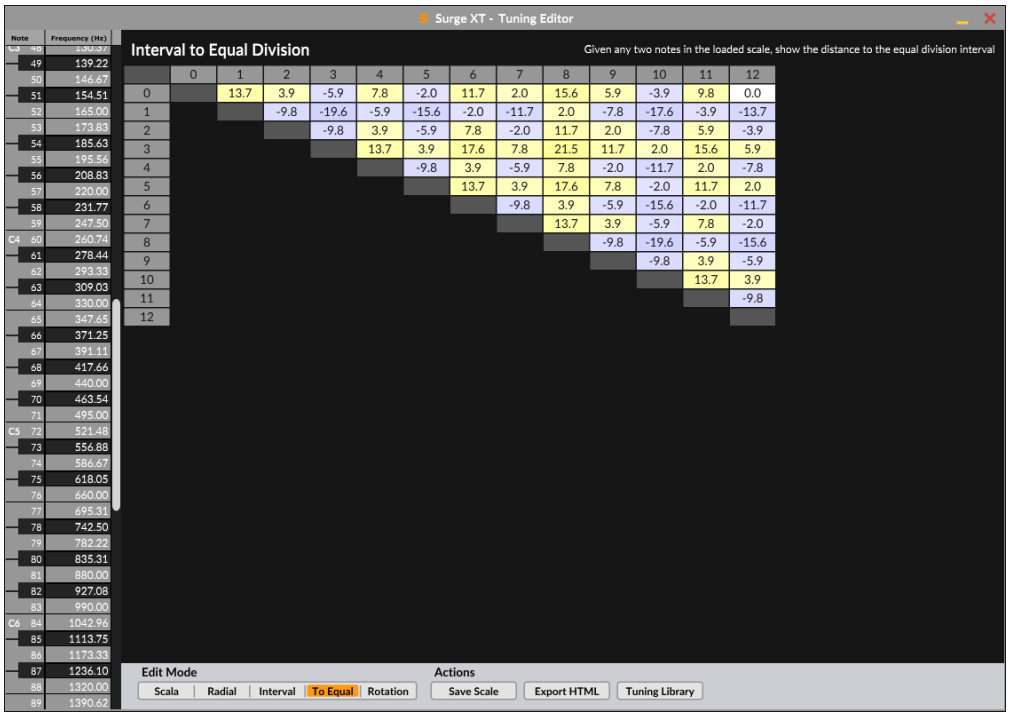


It's also possible to hold keys on an attached MIDI controller, then click and drag on any of the columns to retune each degree by ear in real-time.

Notice here too that input from a MIDI controller also highlights the scale degrees being played in the matrix.

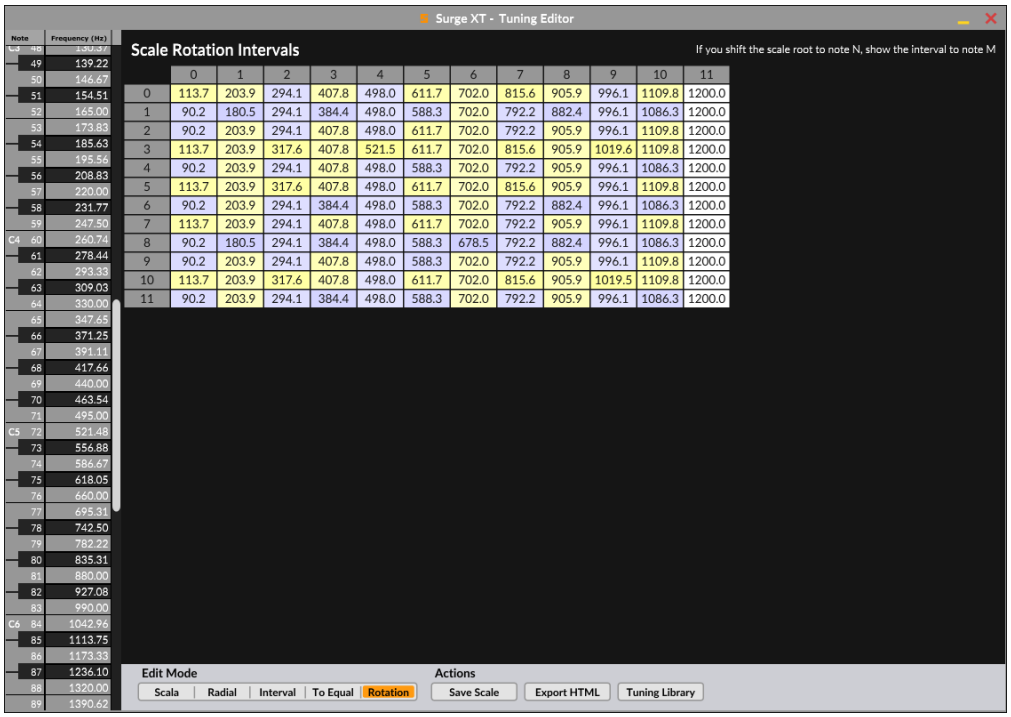
To Equal

Given any two notes in the loaded scale, show the distance to the equal division interval.



Rotation

Shows the current tuning in an interval matrix for modal rotation analysis, where each row reveals the intervals available from each starting point of the scale.



Actions

The Surge SXT Tuning Editor has a set of Actions with the following features:

Save Scale

Click this button to export the current scale in the Scala SCL format to any location on the user's computer, where they can later be loaded back into Surge XT, or other virtual-instruments that use the Scala format.

Export HTML

Opens the current scale in an HTML page, where users can view complete information about the intonation, including the Scala SCL scale degrees, the frequency mapping to MIDI Notes across the range, the KBM in use, as well as an interval matrix that shows the current tuning under both modal and interval rotation. More information can be found below.

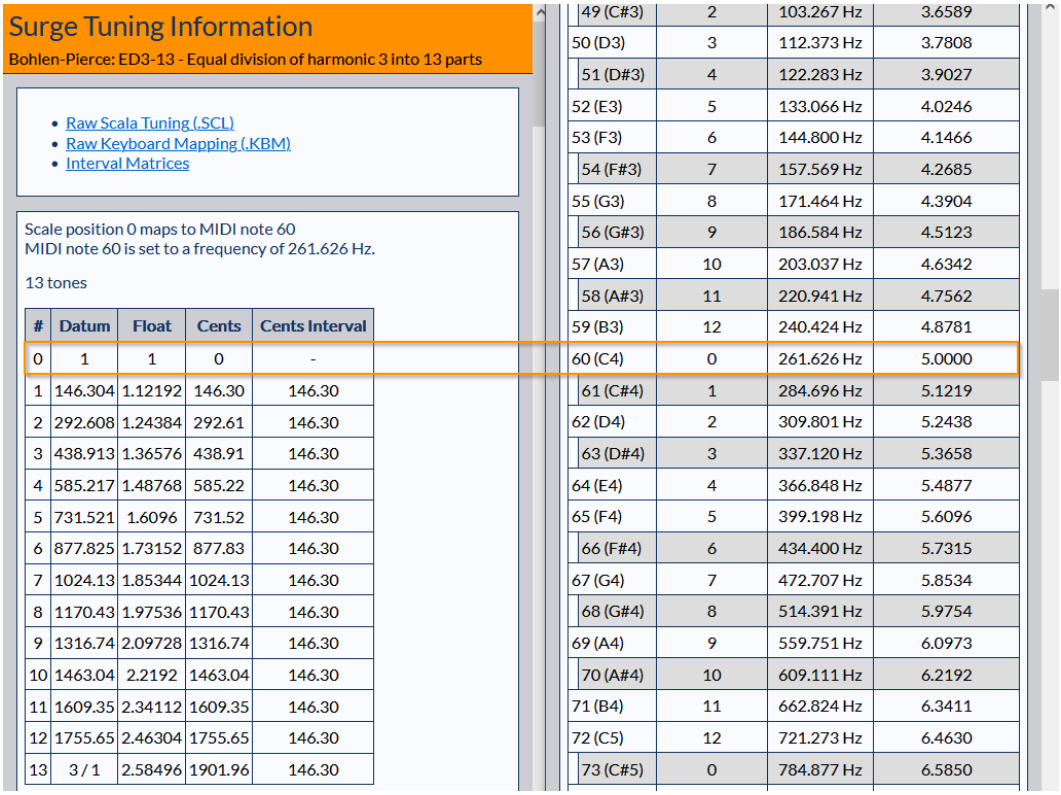
Tuning Library

Clicking the Tuning Library button will open the directory containing the Surge XT factory SCL and KBM content, making it easy to drag-and-drop SCL and KBM files onto the UI.

Export HTML

Clicking the Export HTML button from within the Surge XT Tuning Editor opens the current tuning in an HTML page enabling viewing information about the loaded Scala SCL and KBM files, and how the pitches are mapped to MIDI Notes on the keyboard controller.

The exported HTML page then shows the tuning description contained in the SCL file, the degrees of the scale, and the mapping of pitches to MIDI Notes. Below we can see that the Bohlen-Pierce tuning is mapped with its 1/1 starting note on C.60 at 261.626 Hz.



Surge Tuning Information

Bohlen-Pierce: ED3-13 - Equal division of harmonic 3 into 13 parts

- Raw Scala Tuning (.SCL)
- Raw Keyboard Mapping (.KBM)
- Interval Matrices

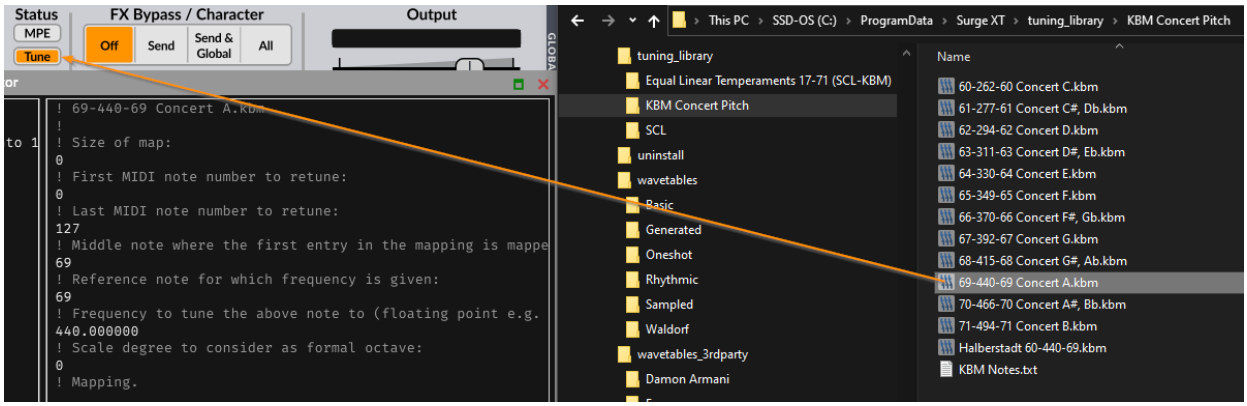
Scale position 0 maps to MIDI note 60
MIDI note 60 is set to a frequency of 261.626 Hz.

13 tones

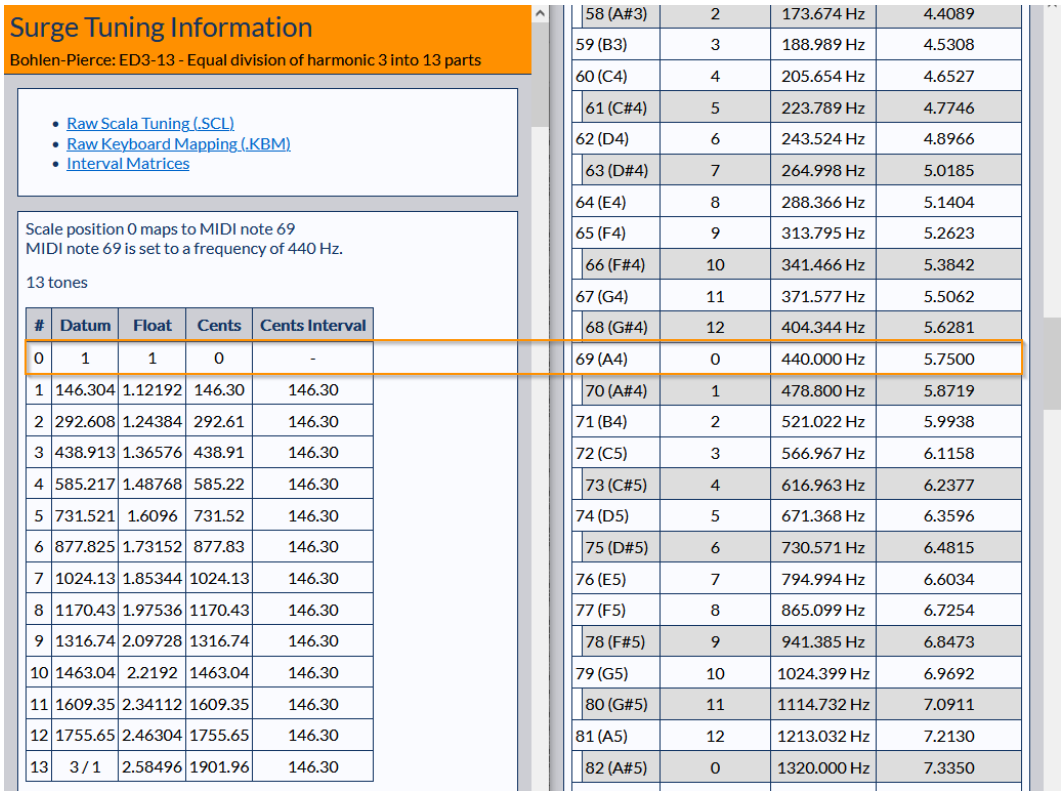
#	Datum	Float	Cents	Cents Interval
0	1	1	0	-
1	146.304	1.12192	146.30	146.30
2	292.608	1.24384	292.61	146.30
3	438.913	1.36576	438.91	146.30
4	585.217	1.48768	585.22	146.30
5	731.521	1.6096	731.52	146.30
6	877.825	1.73152	877.83	146.30
7	1024.13	1.85344	1024.13	146.30
8	1170.43	1.97536	1170.43	146.30
9	1316.74	2.09728	1316.74	146.30
10	1463.04	2.2192	1463.04	146.30
11	1609.35	2.34112	1609.35	146.30
12	1755.65	2.46304	1755.65	146.30
13	3 / 1	2.58496	1901.96	146.30

49 (C#3)	2	103.267 Hz	3.6589
50 (D3)	3	112.373 Hz	3.7808
51 (D#3)	4	122.283 Hz	3.9027
52 (E3)	5	133.066 Hz	4.0246
53 (F3)	6	144.800 Hz	4.1466
54 (F#3)	7	157.569 Hz	4.2685
55 (G3)	8	171.464 Hz	4.3904
56 (G#3)	9	186.584 Hz	4.5123
57 (A3)	10	203.037 Hz	4.6342
58 (A#3)	11	220.941 Hz	4.7562
59 (B3)	12	240.424 Hz	4.8781
60 (C4)	0	261.626 Hz	5.0000
61 (C#4)	1	284.696 Hz	5.1219
62 (D4)	2	309.801 Hz	5.2438
63 (D#4)	3	337.120 Hz	5.3658
64 (E4)	4	366.848 Hz	5.4877
65 (F4)	5	399.198 Hz	5.6096
66 (F#4)	6	434.400 Hz	5.7315
67 (G4)	7	472.707 Hz	5.8534
68 (G#4)	8	514.391 Hz	5.9754
69 (A4)	9	559.751 Hz	6.0973
70 (A#4)	10	609.111 Hz	6.2192
71 (B4)	11	662.824 Hz	6.3411
72 (C5)	12	721.273 Hz	6.4630
73 (C#5)	0	784.877 Hz	6.5850

To change the 1/1 mapping to another MIDI Note, drag-and-drop a different KBM file onto the Surge XT interface, then click the Export HTML button again to see how it changed the mapping.



Below we can see that the 1/1 for Bohlen-Pierce is now mapped to MIDI Note A.69 at 440 Hz:



Surge Tuning Information

Bohlen-Pierce: ED3-13 - Equal division of harmonic 3 into 13 parts

- Raw Scala Tuning (.SCL)
- Raw Keyboard Mapping (.KBM)
- Interval Matrices

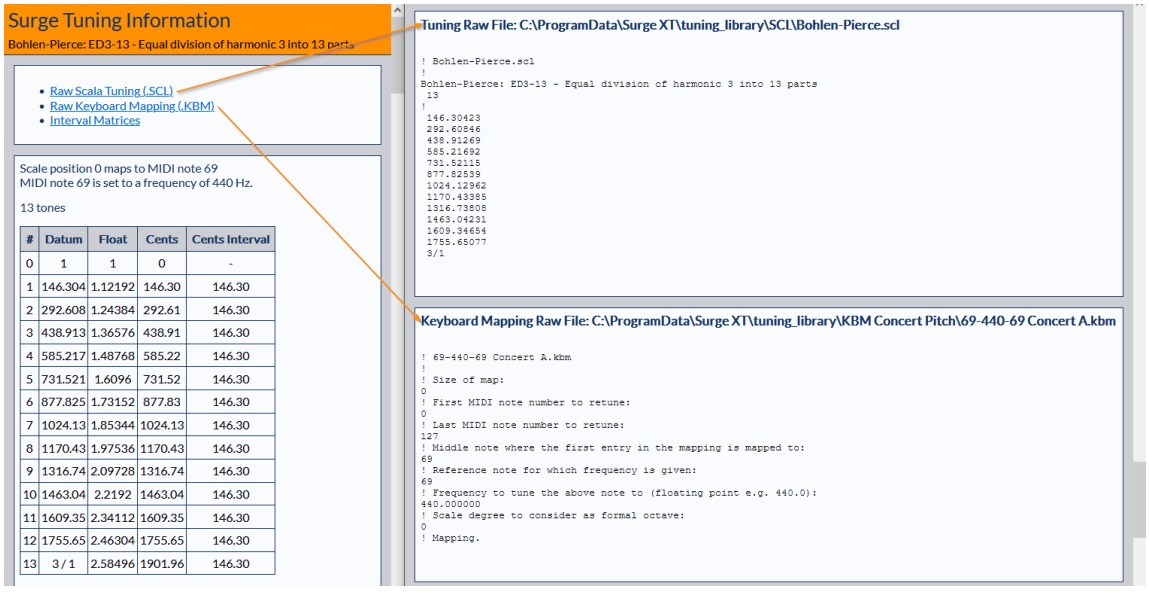
Scale position 0 maps to MIDI note 69
MIDI note 69 is set to a frequency of 440 Hz.

13 tones

#	Datum	Float	Cents	Cents Interval
0	1	1	0	-
1	146.304	1.12192	146.30	146.30
2	292.608	1.24384	292.61	146.30
3	438.913	1.36576	438.91	146.30
4	585.217	1.48768	585.22	146.30
5	731.521	1.6096	731.52	146.30
6	877.825	1.73152	877.83	146.30
7	1024.13	1.85344	1024.13	146.30
8	1170.43	1.97536	1170.43	146.30
9	1316.74	2.09728	1316.74	146.30
10	1463.04	2.2192	1463.04	146.30
11	1609.35	2.34112	1609.35	146.30
12	1755.65	2.46304	1755.65	146.30
13	3/1	2.58496	1901.96	146.30

58 (A#3)	2	173.674 Hz	4.4089
59 (B3)	3	188.989 Hz	4.5308
60 (C4)	4	205.654 Hz	4.6527
61 (C#4)	5	223.789 Hz	4.7746
62 (D4)	6	243.524 Hz	4.8966
63 (D#4)	7	264.998 Hz	5.0185
64 (E4)	8	288.366 Hz	5.1404
65 (F4)	9	313.795 Hz	5.2623
66 (F#4)	10	341.466 Hz	5.3842
67 (G4)	11	371.577 Hz	5.5062
68 (G#4)	12	404.344 Hz	5.6281
69 (A4)	0	440.000 Hz	5.7500
70 (A#4)	1	478.800 Hz	5.8719
71 (B4)	2	521.022 Hz	5.9938
72 (C5)	3	566.967 Hz	6.1158
73 (C#5)	4	616.963 Hz	6.2377
74 (D5)	5	671.368 Hz	6.3596
75 (D#5)	6	730.571 Hz	6.4815
76 (E5)	7	794.994 Hz	6.6034
77 (F5)	8	865.099 Hz	6.7254
78 (F#5)	9	941.385 Hz	6.8473
79 (G5)	10	1024.399 Hz	6.9692
80 (G#5)	11	1114.732 Hz	7.0911
81 (A5)	12	1213.032 Hz	7.2130
82 (A#5)	0	1320.000 Hz	7.3350

Click the Raw Scala Tuning (SCL) or Raw Keyboard Mapping (KBM) links to view the mapping data for the currently loaded SCL and KBM files.



Surge Tuning Information

Bohlen-Pierce: ED3-13 - Equal division of harmonic 3 into 13 parts

- Raw Scala Tuning (.SCL)
- Raw Keyboard Mapping (.KBM)
- Interval Matrices

Scale position 0 maps to MIDI note 69
MIDI note 69 is set to a frequency of 440 Hz.

13 tones

#	Datum	Float	Cents	Cents Interval
0	1	1	0	-
1	146.304	1.12192	146.30	146.30
2	292.608	1.24384	292.61	146.30
3	438.913	1.36576	438.91	146.30
4	585.217	1.48768	585.22	146.30
5	731.521	1.6096	731.52	146.30
6	877.825	1.73152	877.83	146.30
7	1024.13	1.85344	1024.13	146.30
8	1170.43	1.97536	1170.43	146.30
9	1316.74	2.09728	1316.74	146.30
10	1463.04	2.2192	1463.04	146.30
11	1609.35	2.34112	1609.35	146.30
12	1755.65	2.46304	1755.65	146.30
13	3/1	2.58496	1901.96	146.30

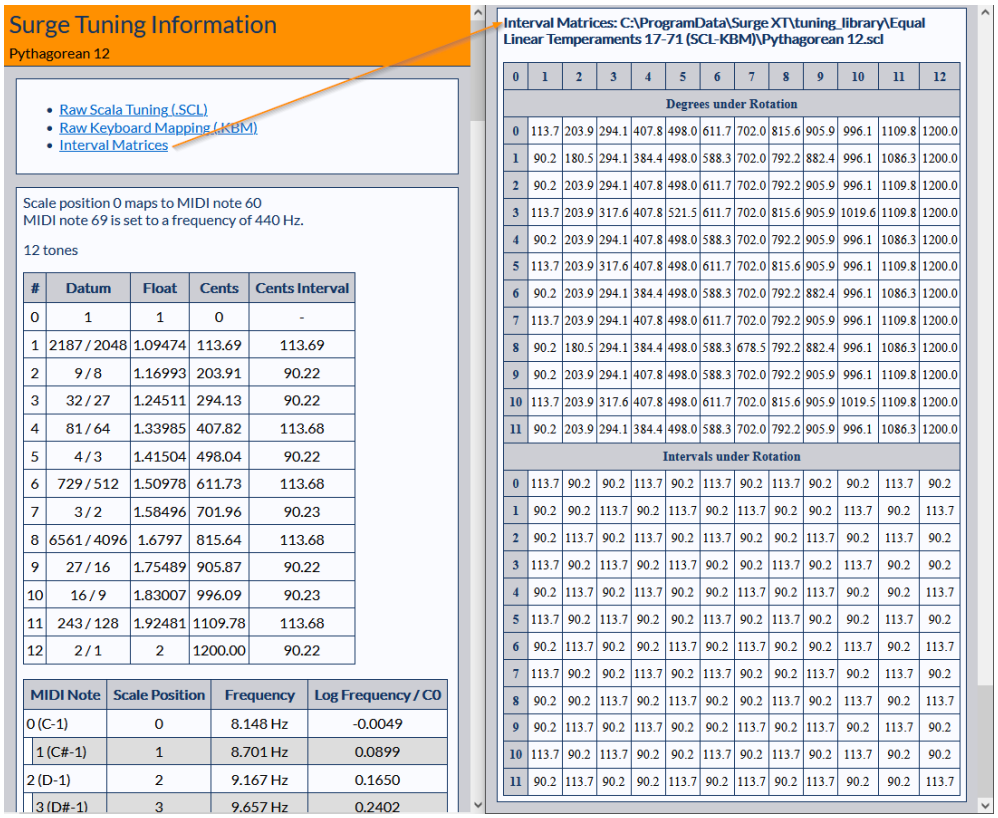
Tuning Raw File: C:\ProgramData\Surge XT\tuning_library\SCL\Bohlen-Pierce.scl

```
! Bohlen-Pierce.scl
!
Bohlen-Pierce: ED3-13 - Equal division of harmonic 3 into 13 parts
 13
!
 146.30423
 292.60846
 438.91269
 585.21692
 731.52115
 877.82539
 1024.12962
 1170.43385
 1316.73808
 1463.04231
 1609.34654
 1755.65077
 3/1
```

Keyboard Mapping Raw File: C:\ProgramData\Surge XT\tuning_library\KBM Concert Pitch\69-440-69 Concert A.kbm

```
! 69-440-69 Concert A.kbm
!
! Size of map:
0
! First MIDI note number to retune:
0
! Last MIDI note number to retune:
127
! Middle note where the first entry in the mapping is mapped to:
69
! Reference note for which frequency is given:
69
! Frequency to tune the above note to (floating point e.g. 440.0):
440.000000
! Scale degree to consider as formal octave:
0
! Mapping.
```

Click the Interval Matrices link to view a modal rotation of the current tuning by scale degrees and interval steps.



Surge Tuning Information

Pythagorean 12

- Raw Scala Tuning (.SCL)
- Raw Keyboard Mapping (.KBM)
- Interval Matrices

Scale position 0 maps to MIDI note 60
MIDI note 69 is set to a frequency of 440 Hz.

12 tones

#	Datum	Float	Cents	Cents Interval
0	1	1	0	-
1	2187 / 2048	1.09474	113.69	113.69
2	9 / 8	1.16993	203.91	90.22
3	32 / 27	1.24511	294.13	90.22
4	81 / 64	1.33985	407.82	113.68
5	4 / 3	1.41504	498.04	90.22
6	729 / 512	1.50978	611.73	113.68
7	3 / 2	1.58496	701.96	90.23
8	6561 / 4096	1.6797	815.64	113.68
9	27 / 16	1.75489	905.87	90.22
10	16 / 9	1.83007	996.09	90.23
11	243 / 128	1.92481	1109.78	113.68
12	2 / 1	2	1200.00	90.22

MIDI Note	Scale Position	Frequency	Log Frequency / C0
0 (C-1)	0	8.148 Hz	-0.0049
1 (C#-1)	1	8.701 Hz	0.0899
2 (D-1)	2	9.167 Hz	0.1650
3 (D#-1)	3	9.657 Hz	0.2402

Interval Matrices: C:\ProgramData\Surge XT\tuning_library\Equal Linear Temperaments 17-71 (SCL-KBM)\Pythagorean 12.scl

	0	1	2	3	4	5	6	7	8	9	10	11	12
Degrees under Rotation													
0	113.7	203.9	294.1	407.8	498.0	611.7	702.0	815.6	905.9	996.1	1109.8	1200.0	
1	90.2	180.5	294.1	384.4	498.0	588.3	702.0	792.2	882.4	996.1	1086.3	1200.0	
2	90.2	203.9	294.1	407.8	498.0	611.7	702.0	792.2	905.9	996.1	1109.8	1200.0	
3	113.7	203.9	317.6	407.8	521.5	611.7	702.0	815.6	905.9	1019.6	1109.8	1200.0	
4	90.2	203.9	294.1	407.8	498.0	588.3	702.0	792.2	905.9	996.1	1086.3	1200.0	
5	113.7	203.9	317.6	407.8	498.0	611.7	702.0	815.6	905.9	996.1	1109.8	1200.0	
6	90.2	203.9	294.1	384.4	498.0	588.3	702.0	792.2	882.4	996.1	1086.3	1200.0	
7	113.7	203.9	294.1	407.8	498.0	611.7	702.0	792.2	905.9	996.1	1109.8	1200.0	
8	90.2	180.5	294.1	384.4	498.0	588.3	678.5	792.2	882.4	996.1	1086.3	1200.0	
9	90.2	203.9	294.1	407.8	498.0	588.3	702.0	792.2	905.9	996.1	1109.8	1200.0	
10	113.7	203.9	317.6	407.8	498.0	611.7	702.0	815.6	905.9	1019.5	1109.8	1200.0	
11	90.2	203.9	294.1	384.4	498.0	588.3	702.0	792.2	905.9	996.1	1086.3	1200.0	
Intervals under Rotation													
0	113.7	90.2	90.2	113.7	90.2	113.7	90.2	113.7	90.2	90.2	113.7	90.2	
1	90.2	90.2	113.7	90.2	113.7	90.2	113.7	90.2	90.2	113.7	90.2	113.7	
2	90.2	113.7	90.2	113.7	90.2	113.7	90.2	90.2	113.7	90.2	113.7	90.2	
3	113.7	90.2	113.7	90.2	113.7	90.2	90.2	113.7	90.2	113.7	90.2	90.2	
4	90.2	113.7	90.2	113.7	90.2	90.2	113.7	90.2	113.7	90.2	90.2	113.7	
5	113.7	90.2	113.7	90.2	90.2	113.7	90.2	113.7	90.2	90.2	113.7	90.2	
6	90.2	113.7	90.2	90.2	113.7	90.2	113.7	90.2	90.2	113.7	90.2	113.7	
7	113.7	90.2	90.2	113.7	90.2	113.7	90.2	90.2	113.7	90.2	113.7	90.2	
8	90.2	90.2	113.7	90.2	113.7	90.2	90.2	113.7	90.2	113.7	90.2	113.7	
9	90.2	113.7	90.2	113.7	90.2	90.2	113.7	90.2	113.7	90.2	113.7	90.2	
10	113.7	90.2	113.7	90.2	90.2	113.7	90.2	113.7	90.2	113.7	90.2	90.2	
11	90.2	113.7	90.2	90.2	113.7	90.2	113.7	90.2	113.7	90.2	90.2	113.7	

Continuous Controller information (CC)

The eight macros towards the right of the routing bar have automatically assigned CC's.

The list is as follows:

Control 1 = CC 41

Control 2 = CC 42

Control 3 = CC 43

Control 4 = CC 44

Control 5 = CC 45

Control 6 = CC 46

Control 7 = CC 47

Control 8 = CC 48

Questions?

Feel free to visit the Surge Synth Team Discord here if you have questions about Surge XT, want to help in developing it further or if you come across any bugs or other issues.