Polytone AMS

Welcome to Polytone AMS! Polytone AMS is an Additive Microtonal Synthesizer that is capable of generating limitless tones by adding harmonics together via ‘drawbar’ sliders. Polytone AMS can divide the octave into any arbitrary ratios, including equal tempered scales of any degree, just intonation, and even Harry Partch’s 43-note just scale. There is a global ADSR envelope, and each individual drawbar harmonic also has its own ADSR so you can customize how the harmonics of your tone develop and fade out. You can also choose from four standard waveforms (sine, triangle, saw, square) as well as an individual sample file of your choosing, either globally or on a per-drawbar basis. It is easy to map physical MIDI controllers to parameters in Polytone AMS. Presets, temperaments, drawbar ratios, and MIDI maps can all be easily saved and recalled. Below you will find detailed information on how this synthesizer works!

App Version: 0.1.0
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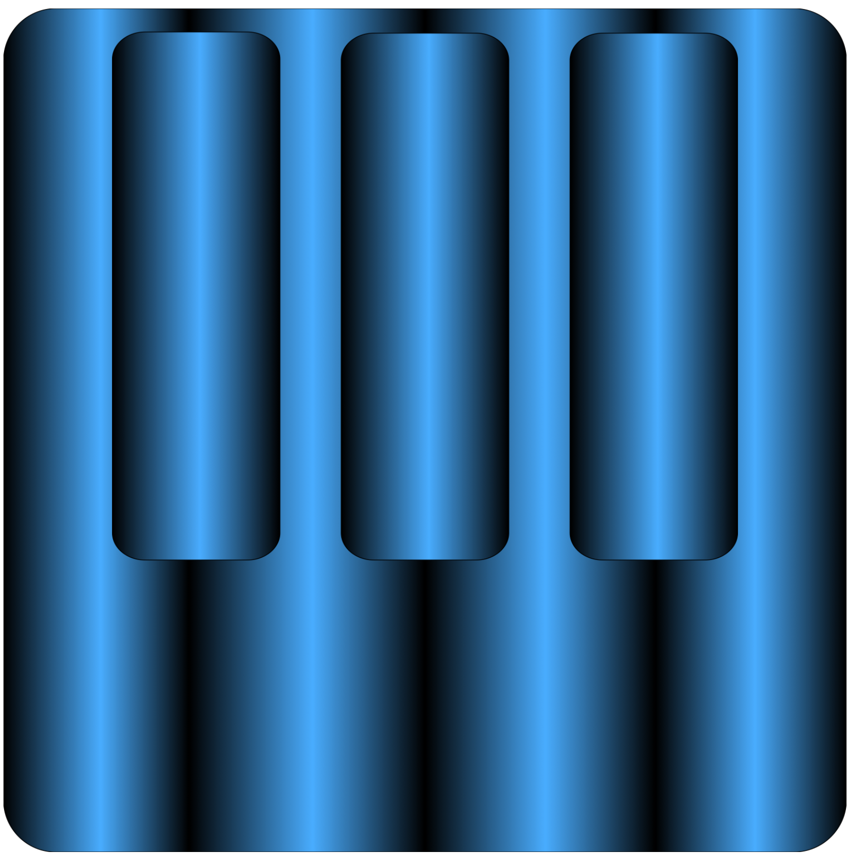

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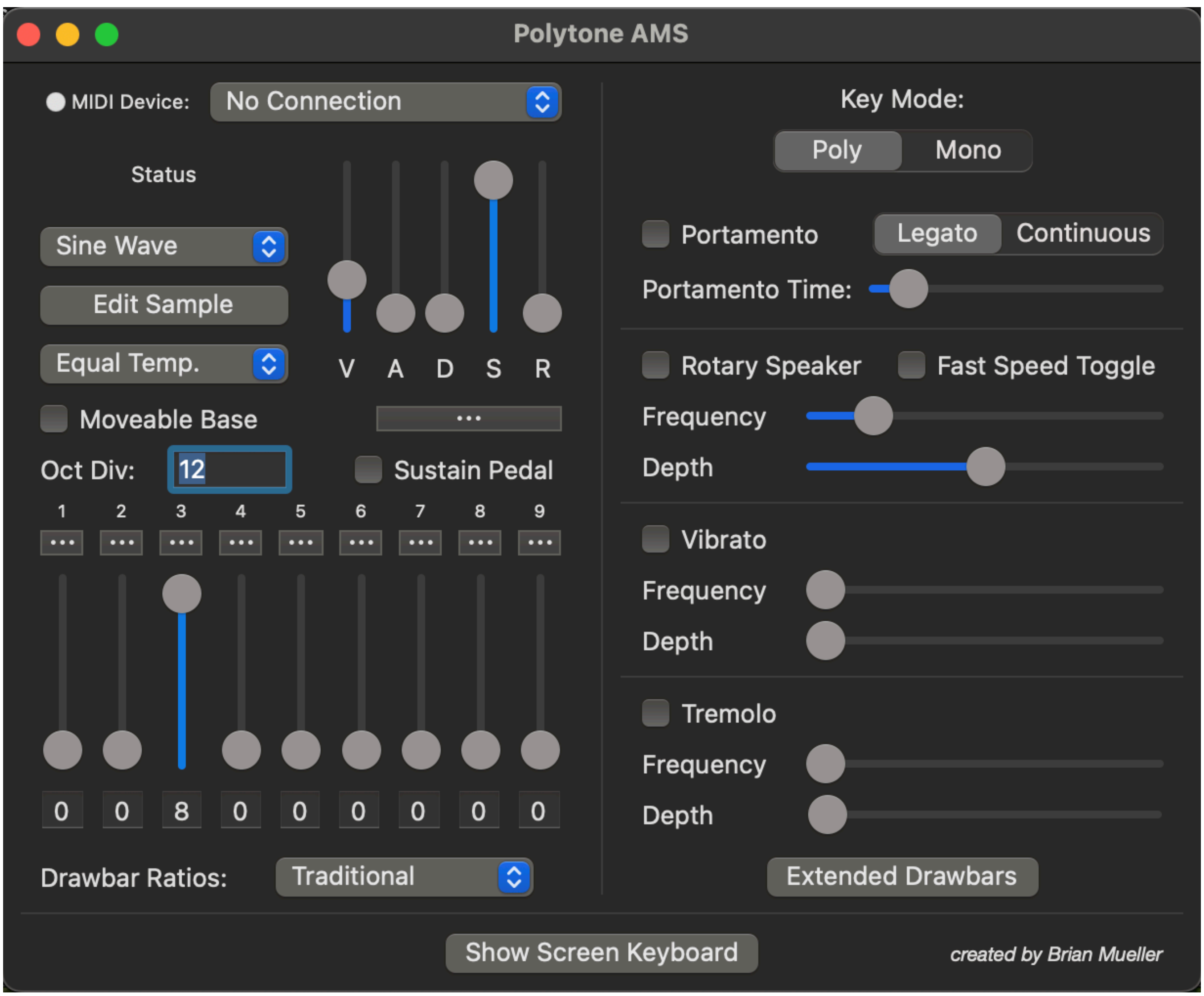
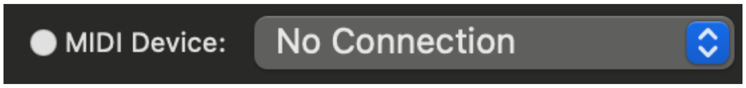


Part 1 - Basic Operation

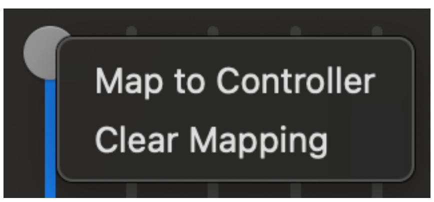
Connecting Your MIDI Device



Polytone AMS will recognize any MIDI device you have connected. The first time you run the app, you will see “No Connection” listed by the MIDI Device reading. Click on the popup menu to see a list of currently connected devices. The app will always attempt to connect to your most recently used device so under normal circumstances you won’t have to manually select a device every time you run the app. The white LED light next to the “MIDI Device” text shows the connection status: white means everything is normal. Red indicates there was a problem connecting to your device. Green means that a connection was established and a default MIDI map was loaded. MIDI maps will be covered later.

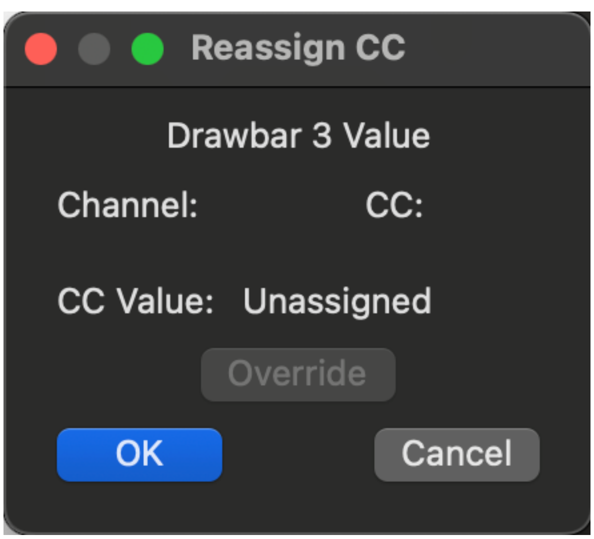
Mapping Physical Controls to Parameters

It is very easy to map a physical control on your MIDI device to any on-screen parameter within Polytone AMS. Every control (slider, check box, segmented selection control) is mappable. Simply right click (secondary click) on the control, and you will see a context menu.



If a parameter has already been mapped to a control, you will see two options: “Map to Controller” and “Clear Mapping.” If the controller is not yet assigned, you will only see the “Map to Controller” option.

Clicking the “Map to Controller” item will open the “Reassign CC” window.

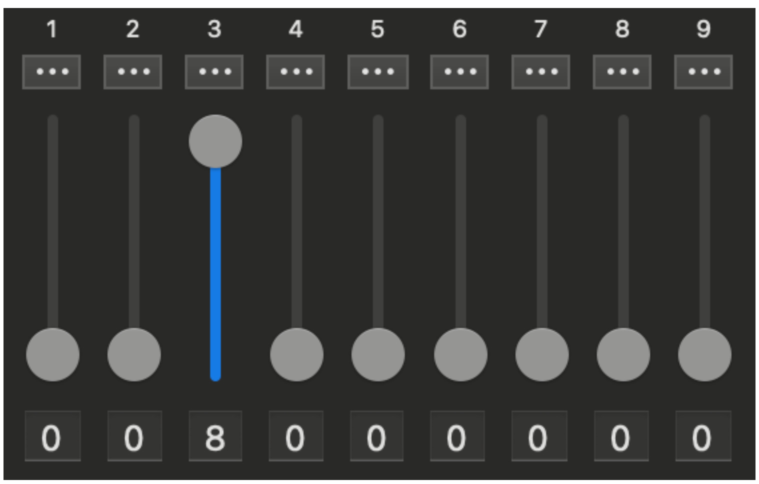


When this window is open, any change you make to a controller on your MIDI device will be picked up and displayed here. If that particular control is already assigned to another parameter, the CC value will read “UNAVAILABLE” and the Override button will be come enabled. If you wish to break the connection between that control and its parameter, click Override. Otherwise, simply move another control on your device until you find a control that is available. Once you do, click Ok to save the assignment. Once this is complete, you will be able to use that control to adjust the parameter in Polytone AMS.

Note: Refer to the documentation for your particular device to learn how to assign MIDI control numbers to the physical controls on the device itself.

When you have assigned a number of controls to parameters, you can save this information as a “Control Map.” Click the “Control Maps” menu and from there you can save and load control map files. Another option in the menu is “Save Default Control Map.” If you plan on using a MIDI device often, you should consider saving a default control map. The control map is saved and associated with your current MIDI controller, and each time you connect (or auto-connect) to this device, Polytone AMS looks for a control map associated with it. If the map file is found, it is loaded, and the LED light next to the MIDI Device selector will be green, indicating a successful loading of a default map file. You can always overwrite / update a default map file simply by clicking “Save Default Control Map” again.

Basic Operation: The Drawbars



If you have a MIDI keyboard or other MIDI device connected, you will be able to play tones from Polytone AMS. Notice that by default, the third drawbar is turned to its maximum value (as pictured above). The drawbars are initially set up with ‘traditional’ ratios which are similar to Hammond drawbars. These ratios correspond to the following relationships. Note names are relative to C4 (middle C):

Drawbar 1: Sub-Octave (16’; sounds one octave lower than the fundamental - C3)
Drawbar 2: Fifth (5-1/3’; sounds one fifth above the fundamental - G4)
Drawbar 3: Unison (8’; sounds the fundamental - C4)
Drawbar 4: Octave (4’; sounds one octave above the fundamental - C5)
Drawbar 5: Twelfth (2-2/3’; sounds and octave and a fifth above the fundamental - G5)
Drawbar 6: Super-Octave (2’; sounds two octaves above the fundamental - C6)
Drawbar 7: Seventeenth (1-3/5’; sounds two octaves and a major third above the fundamental - E6)
Drawbar 8: Nineteenth (1-1/3’; sounds two octaves and a fifth above the fundamental - G6)
Drawbar 9: Super-Super Octave (1’; sounds three octaves above the fundamental - C7)

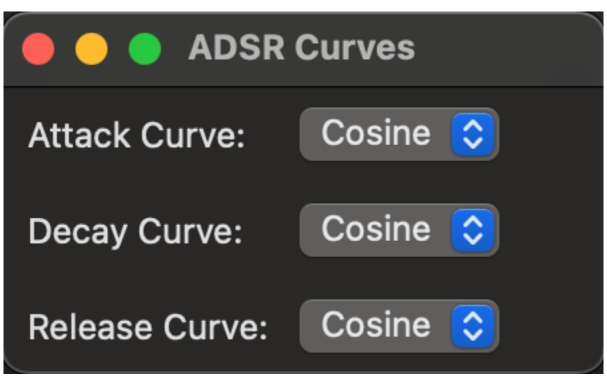
To add harmonics to your tone, simply adjust the sliders to your liking. There are 9 drawbars on the main screen, and there are an additional 9 drawbars (making 18 total) available from the “Extended Drawbars” screen which will be covered later. The number listed underneath each drawbar is a quick reference to the volume on a scale from 0 - 8 (similar to the markings on the drawbars of classic drawbar organs). The actual level of each drawbar is continuous (it is not segmented into 8 discrete levels) but these numbers are provided as a simple reference when attempting to re-create actual drawbar settings. Drawbar settings are saved as part of AMS Preset files.

Adjusting the Master Volume and the ADSR Envelope

The master volume slider on the left, along with the global ADSR envelope determines the overall Volume of the synth, as well as the Attack time, Decay time, Sustain level, and Release time for all 9 (or 18, in extended mode) drawbars. When you make a change to these sliders, all drawbars are affected. Attack determines how long it takes for the sound to fade in to the maximum level (as set by the V slider); Decay determines how long it takes for that maximum level to fade to the Sustain level; Sustain determines the volume of the sustained sound; and Release determines how long it takes for the sound to fade to silence after releasing the key.

ADSR Curves

Clicking the “Triple Dot” button below the ADSR sliders will open the ADSR Curves Window:



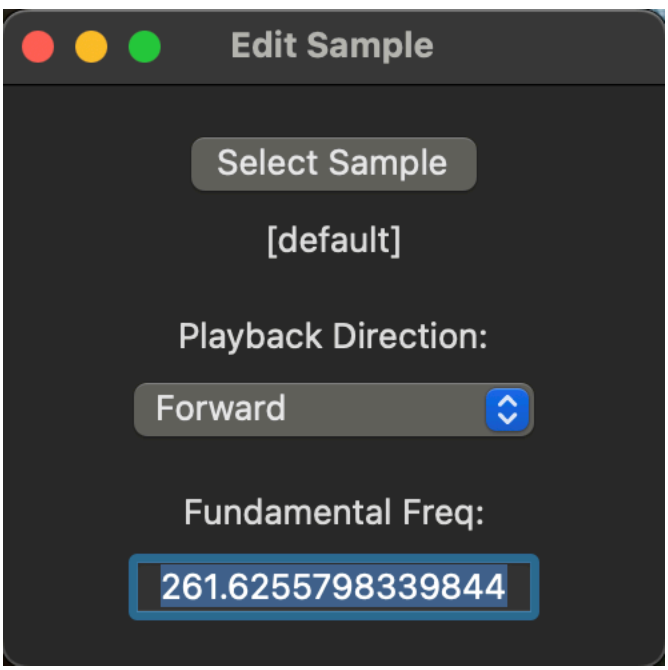
From here, you can choose what type of curve the various stages of the envelope should follow. The default is the Cosine curve, but other options include Linear, Square, and Cube. The curve selection has a subtle but noticeable effect on how the volume of the sound is shaped during transitions between envelope phases. Note that this is a global setting - individual drawbars do not have their own curve settings.

Adjusting the Global Waveform

You can select from four waveform types, as well as a sample, through the menu to the left of the Global ADSR controls. By default, each drawbar generates a simple sine wave, and combing sine waves through drawbar settings gives you access to many tones. You can also choose to you more complex waves as your starting point: Triangle adds color to the sine wave; Sawtooth is a very aggressive waveform with many higher harmonics; Square adds harmonics but is a smoother sound than the Sawtooth; and you can also choose to use a sample. Polytone AMS includes one simple sample of a piano note playing Middle C - this is the default sound you will hear when you initially select Sample.

Editing Sample Properties

If you would like to use your own sound file in place of the default piano sample, simply click “Edit Sample” which will open the Edit Sample window as seen here:

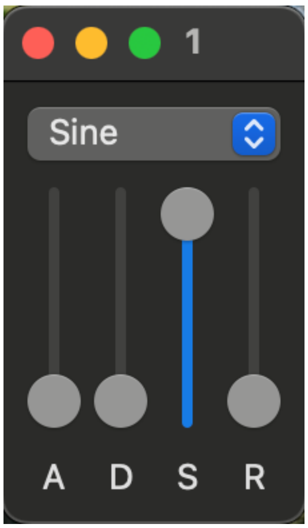


Click the “Select Sample” button to locate a sound file on your computer. Playback Direction determines how the sample is played when you press a key - the options include Forward, Backward, Forward-Backward, Backward-Forward, and Loop. The Fundamental Freq field should match the fundamental frequency of your sample. The frequency can be entered as a raw value (as seen above) but can also be entered as a MIDI note (so if your sample is a Middle C, you can enter the text “C4” into the Fundamental Freq field, and Polytone AMS will convert this into a frequency for you).

The URL of the sample you have chosen, as well as the playback direction and fundamental, will be saved as part of a Polytone AMS preset.

Adjusting the Properties of Individual Harmonics

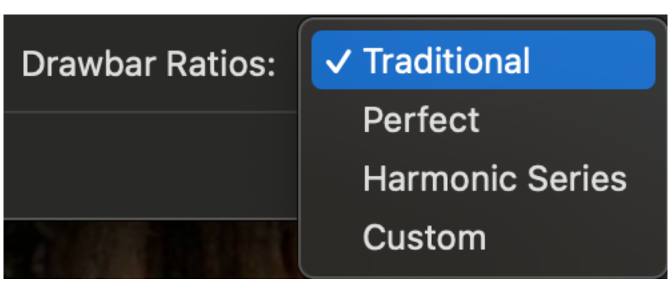
If you click the “Dot” button above any individual drawbar, you will be able to edit the waveform and ADSR settings for that harmonic individually:



When you make changes to the individual drawbar settings, they override the global settings, so it is possible to choose a different waveform or envelope shape on a per-drawbar basis. Note that if you make a change to the global waveform or ADSR settings, those changes will then override any custom drawbar settings you have established, so when crafting a sound, set the global parameters first, and then customize the individual harmonics after that. The window title bar indicates which drawbar is being edited. You can open multiple drawbar property windows as once as you would like.

Note that there is only one global sample - at this time it is not possible to assign individual sample files to individual drawbars.

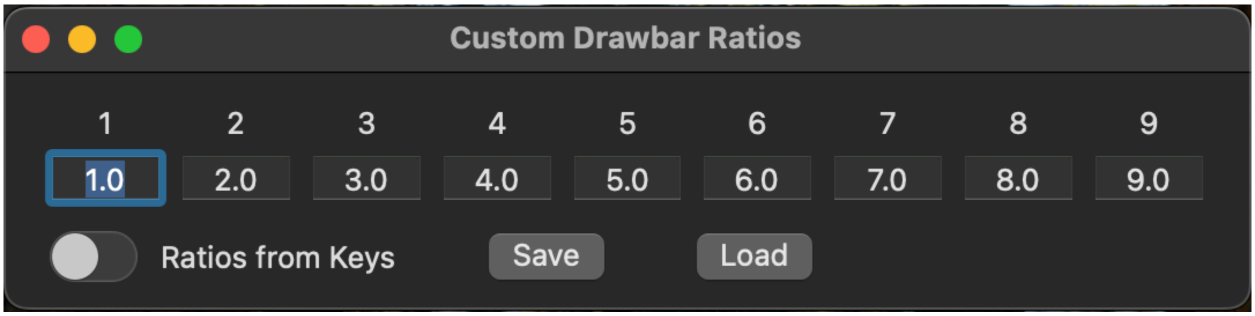
Changing the Drawbar Ratios



By default, the drawbars are set to ‘Traditional’ which means they are an equal-tempered version of standard Hammond-like harmonics. If you select Perfect, the drawbars still correspond to Hammond harmonics, but the intervals are tuned to perfect (just) ratios: true 3/2 perfect fifths, and a pure 5/4 major third. The Harmonic Series selection causes the first drawbar to correspond to the fundamental, and each subsequent drawbar then generates the next natural (whole number) harmonic, so the drawbar number and the ratio of the frequency match (1st drawbar = 1st harmonic, 2nd drawbar = an octave up, 3rd drawbar = 3 times the fundamental, etc). In this case, you have instant access to up to 9 natural harmonics.

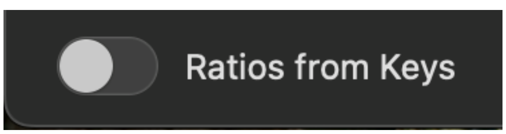
Customizing the Drawbar Ratios

If you click on “Custom” in the Drawbar Ratios menu, you will be taken to the Custom Drawbar Ratios screen:



By default, the “Custom” ratios are the same as the “Harmonic Series” setting described above. However, the ratios of each drawbar can be customized. You can enter any number into these fields, and you can also enter Ratios - so, for a perfect fifth above the fundamental, you could enter either the number 1.5, or the ratio “3/2” - both will have the same result. This opens up many creative possibilities for crafting tones through additive synthesis.

Getting Drawbar Ratios from the Keyboard

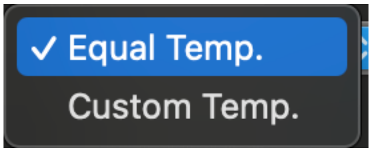


When you click the “Ratios from Keys” switch, the ratios of the drawbars are determined by what notes you press on your MIDI keyboard. Once you enable this function, the frequency of the very next note you press becomes the fundamental (1/1) and the ratio of each subsequent note becomes the ratio of the next drawbar. In this way, you can tune your drawbars to a particular chord, or to other creative ratios. The ratios are determined not just by the MIDI note you play, but by what frequency that note happens to generate within Polytone AMS, so if you have enabled a custom temperament, your custom frequencies will be used to determine each drawbar ratio. If you click “Ratios from Keys” again, or if you simply press a total of 9 keys, the “Ratios from Keys” function will disable and you can then begin experimenting with your new drawbar ratios.

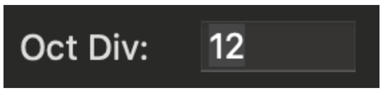
For more information about ratios, and entering them into Polytone AMS, see “Thinking about Ratios,” “Harmonic Identities,” and “Entering Ratios” below.

You can independently save and load drawbar ratio settings by tapping the “Save” and “Load” buttons.

Part 2 - Changing the Temperament



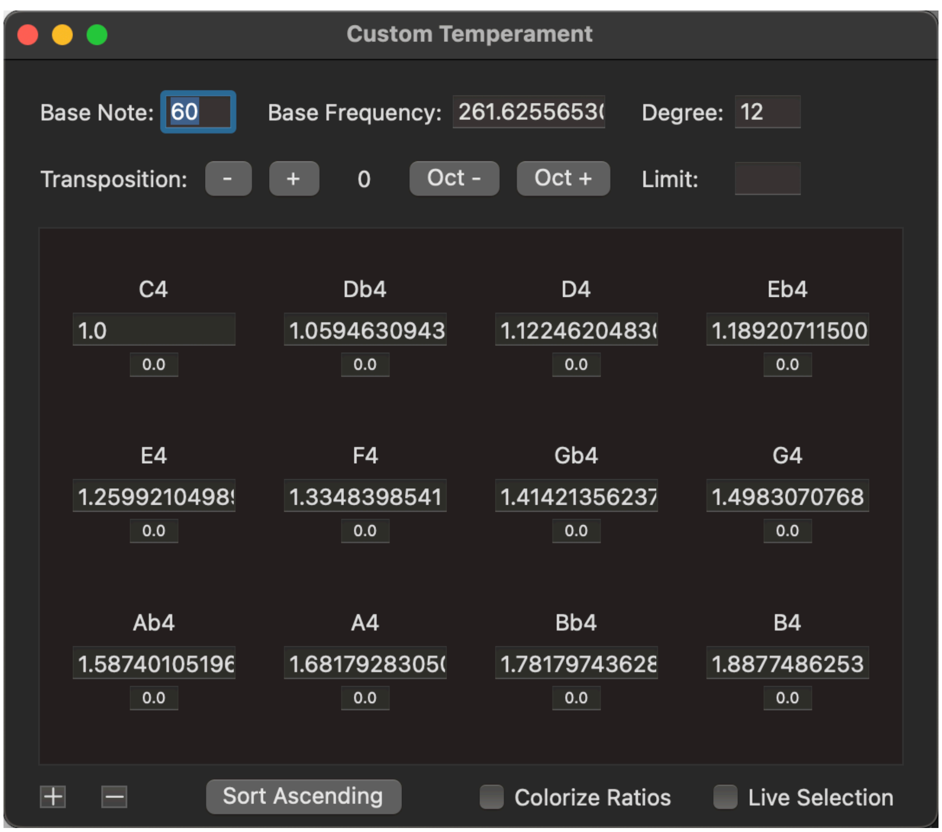
By default, Polytone AMS is tuned to an equal tempered scale that divides the octave evenly into 12 steps (the typical equal-tempered scale). You can evenly divide the octave into any number of segments simply by entering a new number in the “Oct Div” field:



To generate perfect quarter tones, for instance, simply enter “24” into this field, and the octave will be divided into 24 equal segments. You can try other interesting values as well: 96 will divide each individual half step into 6 steps; 5 and 7 give you evenly-spaced pentatonic and heptatonic scales. This is a very quick and fun way to throw normal tonality out the window! When you select an octave division on the main screen in this way, Middle C remains constant and the rest of the scale is built around this pitch. If you would like to build an equal tempered scale (or any other scale) around a different root note, you’ll need to use the Custom Temperament editor by clicking “Custom Temp.” in the popup menu.

If you click “Custom Temp,” Polytone AMS will switch to Custom Temperament mode, and the temperament window will open if it is not already.

Custom Temperaments



The Temperament Editor is a powerful tool for exploring, experimenting with, and creating custom tuning schemes for Polytone AMS. Individual scale steps can be created, deleted, and re-arranged easily. Ratios can be entered as decimal numbers, or as actual ratios (as in 3/2, 5/4, etc). You can create and organize the steps of any equal tempered scale, generate the degrees of a scale of “limits,” and fine tune (or de-tune) any scale step by cents. When values are entered as ratios, they can be colorized according to Harry Partch’s color scheme utilized on his Chromelodeon. With Live Selection enabled, the most recently pressed note will be selected automatically.

The settings at the top of the screen include:

Base Note: this is the MIDI key that corresponds to the Base Frequency.

Base Frequency: the frequency from which ratios are derived.

Degree: the number of steps in the scale. If you enter a number here, an equal tempered scale will automatically be generated (this has the same effect as typing a number into the Octave Division field on the main screen). The value in this field will be updated as you create and delete steps in the editor.

Transposition: this transposes the scale by scale step (note that this does not necessarily correspond with a half step).

Oct +/-: this transposes the keyboard by one octave, which may or may not correspond with 12 keyboard steps.

Limit: this generates a justly tuned scale constructed only of ratios that can be formed with whole numbers up to and including the “limit” value. In other words, if you enter a limit of 3, the possible ratios will be:

1/1, 1/2, 1/3, 2/1, 2/2, 2/3, 3/1, 3/2, 3/3

Some of the above ratios are simply octave duplicates of themselves. Others are lower than the fundamental - and in this case, they will be raised a number of octaves so that all values fall between the fundamental (1/1) and the next octave up (2/1). So for a 3-limit scale, the following applies:

a) 1/1 is the fundamental - it will **remain**.

b) 1/2 is simply 1/1 one octave lower, so will be <u>removed</u>.

c) 1/3 is an octave + a perfect fifth BELOW the fundamental - so it will be normalized in order to fall between 1/1 and 2/1, by raising it two octaves - resulting in a ratio of 4/3. This is not yet accounted for, and so will **remain**.

d) 2/1 is an octave above 1/1, and so it will be <u>removed</u>.

e) 2/2 is the same as 1/1, and so it will be <u>removed</u>.

f) 2/3 is a perfect fifth below the fundamental. Normalizing this will result in a ratio of 4/3, which is already present in the scale, so it will be <u>removed</u>.

g) 3/1 is an octave and a fifth above the fundamental. Dropping this down an octave will result in a ratio of 3/2, which is not yet accounted for, so it will **remain**.

h) 3/2 is a perfect fifth above the fundamental, and is already accounted for, so it will be <u>removed</u>.

i) 3/3 is the same as 1/1, so it will be <u>removed</u>.

Therefore, in a limit of 3, there are only three completely unique ratios:
1/1 - The fundamental
4/3 - A perfect fourth above the fundamental
3/2 - A perfect fifth above the fundamental.

With a base frequency of Middle C (C4), you would end up with three notes in the scale: C, F, and G.

This same process is repeated with any limit you enter.

Editing Scale Steps

Each scale step is represented in the editor by a box with a note indicator and two editable fields:

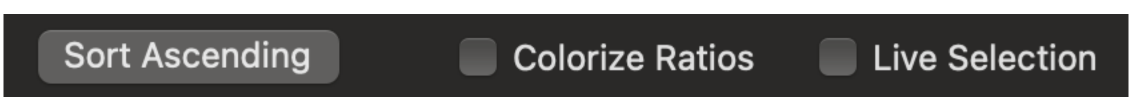
Each scale step reading includes a note name which shows which MIDI key corresponds to that step, relative to the assigned Base Note. Below this is the ratio field, which shows the ratio of this scale step relative to the Base Frequency. The small field beneath this is the fine-tuning field, where you can specify positive or negative pitch offsets measured in cents (1/100th of a semitone). When a scale step is selected, it is outlined with a white border as shown in the image above. Scale steps can be dragged within the editor to re-arrange as you wish, so you do not have to create / edit them in any particular order when crafting a scale.

Adding and Removing Steps

To add steps to your custom scale, click the plus button. If you have no step currently selected, the new step will be inserted at the beginning of the scale. If you do have a step selected, the new step will be inserted immediacy after the selected step.

Clicking the minus button will delete the currently selected step. You can also delete a selected step simply by pressing *delete* on your keyboard.

Other Temperament Editor Options



The other options at the bottom of the window are as follows:

Sort Ascending - this will sort your scale from the smallest to largest ratio values. This is useful if you have entered a number of ratios in an arbitrary order and would like to sort them from lowest to highest. Note that your scale does not have to be ordered low to high: you are free to create scales that move up and down in any order you wish.

Colorize Ratios - With this setting enabled, the numerator and denominator of ratios will be displayed in various colors depending on their relationship to the fundamental. This is completely based on Harry Partch's color coding that was used on his Chromelodeon. The fundamental, and its octave doublings, are red. (So, 1, 2, 4, 8…. Any power of 2.). The third harmonic (corresponding to a perfect fifth) is orange. Refer to the section "Harmonic Identities" for more information on this color coding scheme and how it relates to the musical scale.

Live Selection - when this is enabled, each time you play a note in Polytone AMS, the scale degree that was triggered will be selected.

Part 3 - Intervals and Ratios

Polytone AMS provides a great environment to experiment with frequency ratios. I was particularly inspired to explore this area after learning about Harry Partch's Chromelodeon, and reading his book, Genesis of a Music. Below are some thoughts to help get you in the right mindset to explore this way of thinking about intervals:

Understanding Equally Tempered Scales

Each perceived interval (octave, minor second, perfect fifth, etc) is represented as a ratio. If you want to raise a particular frequency one octave, you double the frequency. So, the octave can be represented as the ratio 2/1, or 2.0. If you multiply again by 2, the frequency will be raised yet another octave. So, if you want to raise an A of 440Hz one octave, multiply by two: 440 x 2 = 880. For two octaves, multiply by two again: 880 x 2 = 1,760. Or, to express in another way, raising A 440 two octaves means multiplying by two *twice*: 440 x 2 x 2 = 1,760. To put it more succinctly:

440 * 2^2 = 1760.

Now, how do we find the half step ratio for a typical 12-note equal tempered scale? Multiplying our A 440 by this ratio *once* would raise the pitch to a Bb. Multiplying this Bb by the *same* ratio would bring us to a B natural. Multiplying 440 by this number twelve times would bring us to 880, one octave higher.

So, 440 * x^{12} = 880. Divide each side by 440 and we discover that we are really solving this equation:

$$x^{12} = 2$$

In other words, x = $\sqrt[12]{2}$. This turns out to be an irrational number, approximately equal to 1.05946309. This information will explain the ratios you see when you first open the temperament editor: each scale step is represented as the next power of this number.

With this in mind, it is simple to calculate the ratio of a step in an equally tempered scale of any degree (by degree, I mean the number of steps in the scale). To divide the octave into 5 equal parts, take the fifth root of two:

$$x = \sqrt[5]{2}$$

To divide an octave into equal quarter tones (a 24 note scale):

$$x = \sqrt[24]{2}$$

So to summarize:

The ratio of a single scale step in an equally divided octave = $\sqrt[steps]{2}$.

This implies that if you wanted to equally divide some other interval, instead of an octave, you would simply take the *steps* root of that interval. To divide a perfect fifth (a ratio of 1.5) into 9 equal parts the formula would be:

$$x = \sqrt[9]{1.5}$$

Pure Intervals

We have established that intervals are simply ratios, and equal divisions of ratios generally produce irrational numbers. The benefit of equal division is that music can be transposed exactly - no matter where you are in the scale, moving up or down by a number of steps will produce the exact same intervals. This is what we are used to in typical Western instrumental music. Another approach to tuning is called just intonation, and is based on the idea of using simple, whole-number ratios, rather than irrational numbers, to build a scale. This is derived from the natural harmonic series, in which tones and intervals are all related to the harmonic series of a fundamental. The harmonic series can be generated by multiplying a fundamental frequency by whole numbers. If our fundamental is A440, the harmonic series of this pitch to the 9th harmonic would be:

Harmonic	Frequency (Hz)	Note Name	Distance from Fundamental
1	440	A4	Unison
2	880	A5	+ one octave
3	1320	E5 (+2 cents)	+ one octave and a fifth
4	1760	A6	+ two octaves
5	2200	C#7 (-14 cents)	+ two octaves and a major third
6	2640	E7 (+2 cents)	+ two octaves and a fifth
7	3080	G7 (-31 cents)	+ two octaves and a minor seventh
8	3520	A8	+ three octaves
9	3960	B8 (+4 cents)	+ three octaves and a major second
10	4400	C#8 (-14 cents)	+ three octaves and a major third
11	4840	D#8 (-49 cents)	+ three octaves and a flat tritone

It is important to note that every tone in this series, with the exception of the octave doublings of A, is “out of tune” compared to the equal tempered scale, as denoted by cent offsets marked next to the note name. If we continue adding more harmonics to the above table, the resulting intervals will become smaller and smaller, and more and more ‘out of tune’ compared to equal temperament. However, these justly tuned (“pure”) intervals actually sound more stable to our ears when heard in harmony. For example, the third harmonic produces an octave and a fifth above the fundamental - a ratio of 3/1. We can *normalize* this ratio, bringing it between 1/1 and 2/1, by dividing the ratio itself by 2:

$\frac{\frac{3}{1}}{2}$ = 3/2

This is the ratio for a true ascending perfect fifth. Compare this value (exactly 1.5) to the equal tempered version:

$(\sqrt[12]{2})^7$ = 1.49830708

In this case, the values are very close, but not exact.

A pure major third is represented as the fifth harmonic, a ratio of 5/1. Dividing this by two, we end up with 5/2, which is still greater than an octave. Divide by two again, and we have the normalized form of this ratio: 5/4. 5/4 = 1.25. The equal tempered counterpart would be:

$(\sqrt[12]{2})^4$ = 1.25992105

Thus, an equal tempered major triad and a “pure” major triad sound quite a bit different. You will notice that a pure triad has no “beating” in the sound, whereas an equal tempered triad does in fact have “beating,” and when compared side by side, the equal tempered triad will actually sound out of tune with itself.

To hear the difference, simply enable Custom Temperament, change the value of the E in the Temperament Editor to 5/4, and change the value of the G to 3/2, and then play a C major triad on your keyboard. While still holding the keys down, switch to an equal tempered scale from the main screen, and the frequencies will be altered mid-stream, so you can compare the two side by side easily.

Thinking about Ratios

Scale steps are measured as ratios relative to the fundamental (Base Frequency). As explored above, whole number multiples of a fundamental generate the harmonic series, or overtone series. When the ratios are inverted, an undertone series is generated, which creates an exact mirror image of the overtone series:

<- Undertones Overtones ->

Ab0	C1	F1	C2	C4	C5	G5	C6	E6
1/5	1/4	1/3	1/2	1/1	2/1	3/1	4/1	5/1

Notes from the undertone and overtone series can be combined to create a scale. In order to do this, the ratios must be *normalized* - which involves scaling them to fit within one octave (so the values all fall between 1/1 and 2/1). Overtone ratios that are outside this range can be normalized by dividing them by powers of 2, and undertone ratios outside this range can be normalized by multiplying them by powers of 2. For instance, the second overtone is 3/1, which is an octave and a fifth above the fundamental. Dividing this by 2 results in a ratio of 3/2, which falls within the normalized range and produces a perfect fifth above the fundamental. Likewise, the second undertone has a ratio of 1/3, which can be normalized by multiplying it by 4 (2 x 2), resulting in a ratio of 4/3, which again falls within the normalized range and produces a perfect fourth above the fundamental.

When looking at more complex ratios that involve higher harmonics, understanding the harmonic identity of the numbers becomes useful.

Harmonic Identities

Harry Partch refers to each unique ratio (excluding octave doublings) as an *identity*. When an identity is found in the numerator of a ratio (what he terms the over-number), he refers to this is an odentity. When an identity is found in the denominator of a ratio (what he terms the under-number) he refers to this as a udentity. He color coded each identity and marked the color schemes on the keys of his Chromelodeon. If you would like the ratios in the Temperament Editor to be colorized, simply enable “Colorize Ratios” by clicking the check box at the bottom of the window.

The following table outlines the color coding scheme modeled after Partch’s system, as used in Polytone AMS:

Identity (harmonic)	Color	Closest Tempered Scale Degree
1 (also including 2, 4, 8, 16…)	Red	Root
3 (also including 6, 12, 24…)	Orange	Fifth
5 (also including 10, 20, 40…)	Yellow	Third
7 (also including 14, 28, 56…)	Green	Flat Seventh
9 (also including 18, 36, 72…)	Blue	Second
11 (also including 22, 44, 88…)	Magenta	Sharp 11th

As you experiment with ratios, you can begin to acquire an intuition about the tonalities implied by the ratio values, especially as you compare udentities and odentities. Any ratio with a udentity of 1 (which includes 2, 4, 8, 16, etc) can be understood as an overtone of the fundamental. 3/2, for instance, has a denominator of 2, which is a 1 udentity. Therefore, given the 3 odentity, it is easy to see that this ratio represents a perfect fifth above the fundamental. Likewise, any ratio with an odentity of 1 will be an undertone of the fundamental. 16/11 has a 1 odentity (16 represents the fundamental doubled 4 times). The 11th harmonic is a very flat tritone, so since it is the udentity, it will generate a very *sharp* tritone above the fundamental (if the fundamental was a C, this ratio would produce a Gb a quarter-tone sharp compared to the equal tempered pitch).

Just intonation can accommodate many varieties of the same interval - the tritone ratio above (16/11) could be inverted and normalized to 11/8 and would produce the flattened version of the same note. So, 16/11 and 11/8 each represent approximately a “Gb” or “F#” - the first is a quarter-tone sharp, and the second a quarter-tone flat, compared to an equal tempered tritone.

For more complex ratios, the same principles apply, but the overtones and undertones are measured against pitches other than the fundamental. For instance, the ratio 7/6, which is in the normalized range, represents a 7th harmonic (which is approximately a flat seventh) above the 5th undertone (which is an octave plus perfect fifth below the fundamental). (Or, you can think of it as the 5th undertone below the 7th harmonic.) If our fundamental is a C, then this ratio represents a flat seventh above an F, or a perfect fifth below a Bb, so 7/6 is will generate an ‘out of tune’ minor third above the fundamental.

Entering Ratios

Ratios can be entered into the Custom Temperament editor, as well as the Custom Drawbar Ratios editor, simply by typing the numerator, followed by a forward slash, and then the denominator, as in “3/2” or “11/8.”

You can also enter decimal numbers as part of your ratios. For instance, you could drop a perfect fifth down one octave with this expression: “1.5/2.” This could also be achieved by simply dividing again: 3/2/2.

Normalizing Ratios: If you immediately follow a ratio with an exclamation mark, that ratio will be automatically ‘normalized’ - so, for instance, if you enter “1/7!” this will be translated into 8/7 automatically.

Simple Mathematical Expressions: It is possible to enter simple mathematical expressions as part of your ratios. The operators allowed are the multiplication sign (*) and the exponent sign (^). This is helpful if you have a ratio entered and would like to double it, or multiply it by itself. 3/2 * 2 will bring the 3/2 ratio up one octave. 3/2 * 3 will raise the 3/2 an octave and a fifth (producing the 3rd harmonic above the 3/2 frequency). 16/15 is a justly tuned half step - to produce an entire chromatic scale of this interval, you could enter the following into the Temperament (or Custom Drawbar Ratios) editor:

1 16/15 16/15 ^ 2 16/15 ^ 3 16/15 ^ 4 etc…

You can also use this functionality to combine ratios. If you would like to produce a note one just half step above a perfect fifth, you could use this expression:

3/2 * 16/15

Note that whitespace (blanks) are ignored when the ratio expression is interpreted. Operator precedence is as follows:

Operator	Meaning	Precedence	Explanation
!	Normalization	Highest	Ratios are normalized before any other operation
/	Division	High	Divisions are calculated first.
^	Exponent	Medium	Exponents are calculated after divisions, but before multiplications.
*	Multiplication	Low	Multiplications are calculated last.

So, a complex ratio expression such as 3/2 * 5/4 ^ 3 would be equivalent to the following:

(3/2) * ((5/4) ^ 3)

Which would be equivalent to a perfect fifth above the fundamental, being raised by a minor sixth (5/4 is a major third, and it is being taken to the 3rd power). Please note, at the moment, parentheses are not valid in ratio expressions.

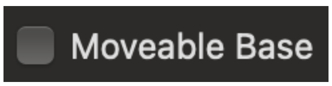
These operators are intended to simplify some common mathematical operations when experimenting with ratios in Polytone AMS. For more complicated scenarios, you may need to do your math ‘by hand’ before entering values into the editors.

Part 4 - Additional Controls and Effects

Sustain Pedal

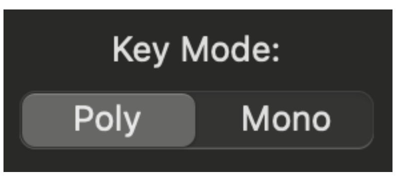
Clicking this checkbox has the same effect as pressing a sustain pedal on your keyboard - every note you press will sustain until the checkbox is unchecked (until the pedal is released). Initially, this parameter is not associated with any MIDI controller, so in order for this control to respond to pedal presses, you'll need to map your pedal controller to this parameter by right (secondary) clicking the check box, and then pressing the pedal, as described in "Mapping Physical Controls to Parameters" above.

Moveable Base



When this is selected, each time you press a new note, the Base Note and Base Frequency of your Custom Temperament become adjusted to the equally-tempered note and frequency you would normally expect from the key you pressed. As long as you keep this key held down, that new base note and base frequency will remain, allowing you to, for instance, tune a pure triad in the temperament editor, and easily transpose that pure triad onto any note of a normal equally-tempered scale - the first note you press will always become the new base, and other notes you press in tandem will reflect your custom temperament.

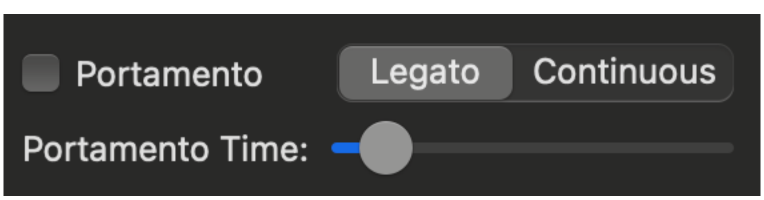
Key Mode



Polytone AMS can be operated in polyphonic mode, or monophonic mode. In polyphonic mode, Polytone AMS can generate up to 32 simultaneous voices. When in monophonic mode, only one note at a time can be generated. Each new note causes any currently playing note to be released, following the release envelope established with the ADSR envelope settings.

Key mode can be particularly useful when used in conjunction with the Portamento setting described below.

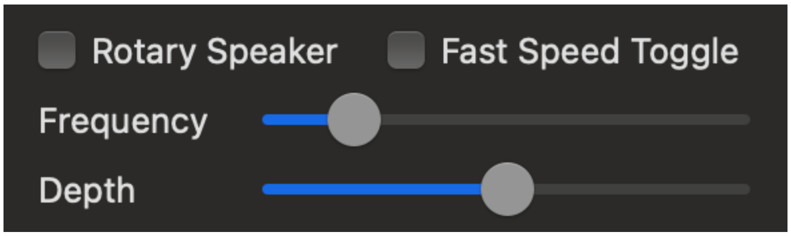
Portamento



When portamento is enabled, the frequency of each note slides smoothly from the previous frequency, creating a glissando effect. The Portamento Time slider determines how quickly the pitch changes.

The Legato / Continuous selector determines how the portamento effect responds to key presses. In legato mode, the pitch only glides from one note to the next when the notes are played in a legato (connected) fashion. When keypresses are disconnected from one another, there is no glissando effect. In Continuous mode, the pitch glides even when keypresses are separated.

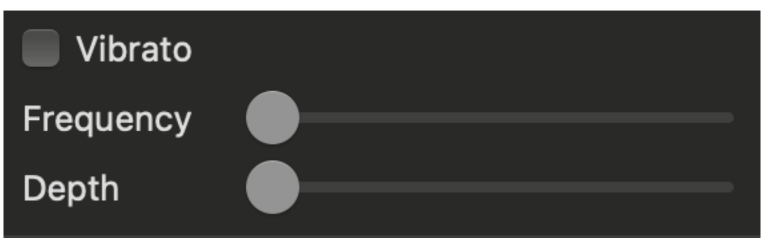
Rotary Speaker Effect



When Rotary Effect is enabled, the panning of the sound oscillates from left to right, simulating the effect of a rotating speaker. The Frequency slider determines how quickly the sound pans back and forth, and Depth determines how dramatic the panning effect is. If the depth is set to 0, there is no effect, and if the depth is set to maximum, the sound will move from 100% on the left, to 100% on the right.

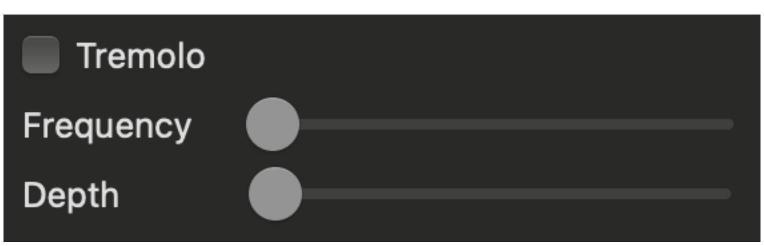
The Fast Speed Toggle switch will cause the frequency to toggle between a pre-determined “fast” speed (when checked) and a pre-determined “slow” speed (when unchecked), simulating the fast and slow settings on rotary speakers.

Vibrato



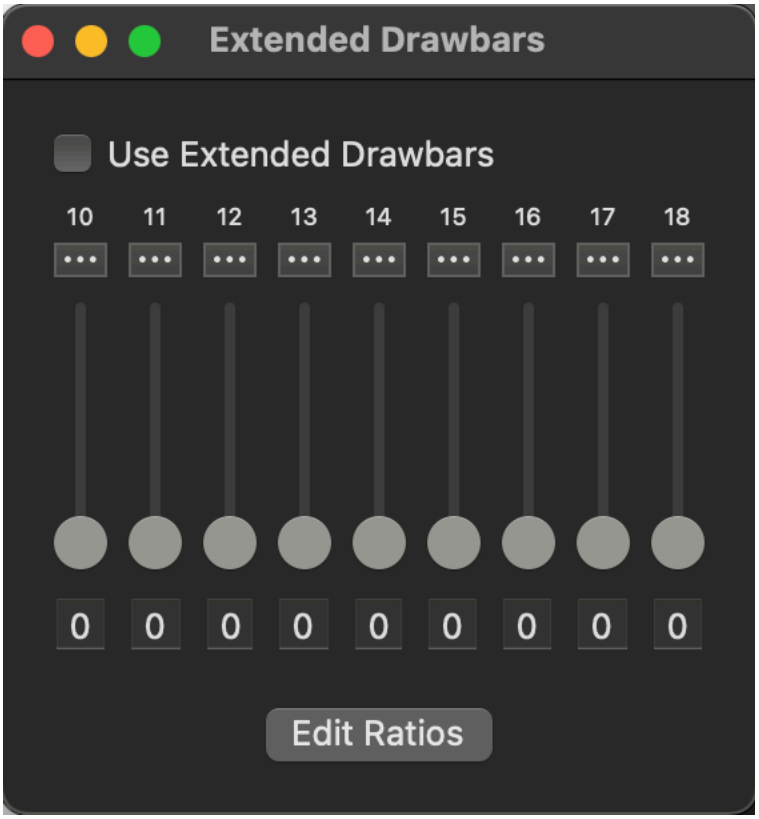
The Vibrato setting causes the pitch of Polytone AMS to oscillate up and down. The Frequency setting determines how quickly the pitch oscillates, and the Depth setting determines how far the pitch bends.

Tremolo



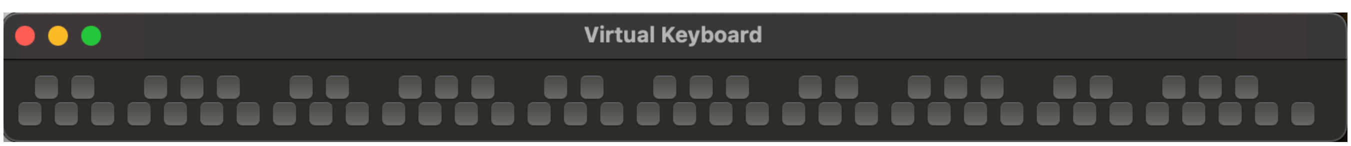
The Tremolo setting causes the volume of Polytone AMS to oscillate up and down. The Frequency settings determines how quickly the volume oscillates, and the Depth setting determines how dramatic the volume change will be. If Depth is set to the minimum, no effect will be applied, and at maximum level, the volume oscillates between full volume and silence.

Extended Drawbars



If you click the Extended Drawbars button on the bottom right side of the main window, the Extended Drawbars window appears. From here, you can enable the extra set of drawbars by clicking the “Use Extended Drawbars” checkbox. When enabled, these extra drawbars give you access to 9 additional harmonics that can be tuned to custom ratios. By default, the extra drawbars correspond to the 10th through 18th natural harmonics, but clicking the Edit Ratios button will open the custom drawbar ratios window for the extended drawbars. The ratios can be edited in the same manner as described above in “Customizing the Drawbar Ratios.”

The Onscreen Keyboard



The onscreen keyboard can be opened by clicking the “Show Screen Keyboard” button at the bottom of the main screen. When this is open, you can click any checkbox to essentially press and hold that key. The key will be released when you uncheck the checkbox. When this keyboard window has the main application focus, you can also tap the keys on your computer keyboard to activate the octave between Middle C (C4) and C5, in this layout:

  W E   T Y U
A S D F G H J K

Note that key computer keyboard will only generate notes when the onscreen keyboard has focus.