Getting Started with Custom Equalizer
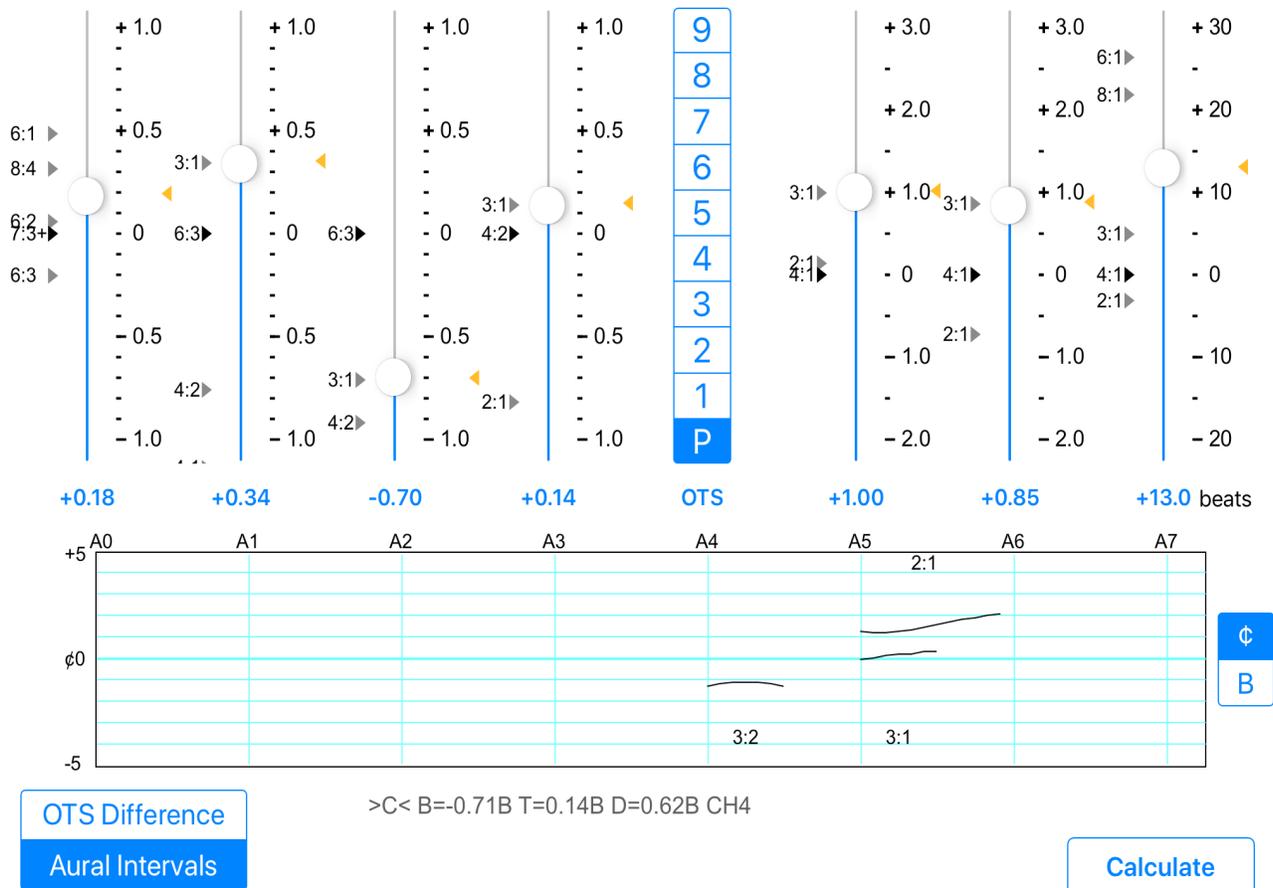
Custom Equalizer (CEQ) lets you micro-adjust the stretch of any octave of any Octave Tuning Style (OTS) and shows you graphs to let you "pre-listen" to your tunings.

CEQ is a very exciting and wonderful innovation. It's hard to imagine a better tool to create a "hybrid" tuning method which combines the best of visual and aural techniques.

But first, a word of caution:
CEQ is designed for experienced tuners and advanced RCT users. To use CEQ properly, you will need to listen carefully and have some understanding of inharmonicity, stretch, interval widths, and coincident partials. When you use CEQ, you're taking over from Chameleon's extensive system of internal safeguards and cross-checks. It's possible to create bad-sounding tunings with CEQ, so please use CEQ only if you're ready, willing, and able to assume responsibility for the results.

Custom EQ is available in CyberTuner running on iPad only - iPhones and iPod touches do not have the screen real estate to handle this tool.

To open CEQ, go to Chameleon and tap on the "Advanced" button. Then turn on the switch to enable Custom EQ. Tap the Done button to save your change. In Chameleon you will now see a "Custom EQ" button next to the Calculate button.

Intro to CEQ

CEQ's interface looks like a graphic equalizer for a high-end audio system. An audio graphic equalizer lets you adjust the relative volume of a limited frequency range, but CEQ lets you adjust stretch — in effect, the pitch —of a limited range of notes.

The first thing you'll notice are CEQ's seven sliders, each of which is located over an A note called the slider's control note. Each slider helps you set the stretch for its control note and surrounding notes. For example, the slider located over A5 controls the stretch of A5 and a half-octave on either side for a total of a one octave range. As is the case with most of Chameleon, CEQ's sliders are not "walled off" from each other; an adjustment in one area is automatically smoothly blended into adjacent areas.

The numbers alongside each slider are beats per second. On each slider is a triangle-shaped pointer that shows the setting for that slider. This pointer is what you drag a slider pointer to change a slider's setting. An indicator box under each slider shows the exact setting of its pointer.
To increase the stretch of an octave, drag its slider upwards; to decrease stretch, tap and drag it down.

Go ahead and try this. The number in the indicator boxes change in real time as you move a pointer. When you release the mouse, a new tuning is calculated using your new settings and a CEQ mini-graph is created.

CEQ graphs

There are two graphs in CEQ — OTS Difference and Aural Intervals. OTS Difference shows the difference between an OTS's standard settings and the "tweaks" you made when you moved the sliders.

The other graph is called Aural Intervals because it shows the width of octaves, double octaves, fifths, twelfths, etc. The Aural Intervals graph displays interval widths whether or not you've moved any sliders.

You can toggle between the two graphs — OTS Difference and Aural Intervals — by tapping on the button located near the bottom of the graph. Both graphs can be toggled between cents and beats by tapping on the Beats/Cents button on the right.
If beats are selected in the OTS Difference graph, each partial has a separate graph line, labeled at its right or left side.

In CEQ, beats and cents are calculated at the relevant partials, which may or may not the same partial at which the graph line is drawn.
When switching between beats and cents, remember that the proportion of beats to cents increases as notes ascend from bass to treble.
The horizontal scale of the graphs is the notes of the piano, marked with a vertical line at each A control note. The vertical scale is ± 5 cents or beats.

CEQ: Dynamic and Self-Adjusting

Before you go any further, there's a basic principle about CEQ you need to understand.
CEQ is dynamic. When you adjust a slider, CEQ automatically adjusts the pitches of outlying notes the same amount in order to retain beat rate relationships. For example, to increase the stretch of A4-A5, you might move the A5 slider up 0.5 beats, but you wouldn't want that to also decrease A5-A6 by

0.5 beats. That's why if you move A5 up 0.5 beats CEQ automatically raises A6 0.5 beats too. (In this example, A7 would be raised too.)

You can watch CEQ do this "self-adjusting." After raising A5's pointer, A5's beat rate increases but A6 and A7 beat rates stay the same. When talking about CEQ's graphs, you see an even clearer example of CEQ's dynamic self-adjusting.
By the way, there's no slider over A4 because A4 is the pitch of the entire tuning, which is better adjusted other places, like CE's pitch popup menu. It might help to think of A4 as the center point for all the sliders.

Learning how CEQ works
For the following example, instead of sampling a real piano, you'll use one of Chameleon's stored Demo pianos, the Yamaha C3 Demo piano. Select it by going to Chameleon and tapping the "Piano" button. Select the Yamaha C3 piano and press Done. This loads pre-sampled partial ladders from a Yamaha C3 into Chameleon. (Using Demo pianos is as great way to learn about CEQ.)

Open CEQ by tapping on Chameleon's Custom EQ button. The CEQ header will show the predicted beat speeds. If this is the first time you're opening CEQ, the OTS Difference graph will be selected and cents will be the display mode. If you've already changed it to another setting, change it back.
In the CEQ window are nine OTS buttons. Except for being vertical buttons, these are the same OTS choices as you see in Chameleon. If this is the first time you've opened CEQ, OTS P (Pure 12ths) will be selected. (CEQ's current settings are saved when CEQ is closed and restored the next time CEQ opens.)

Go ahead and tap on a few OTS buttons. When you change to another OTS, the pointers and beat rates change. Why? Higher numbered OTSs have more stretch and faster beat rates.
Drag some sliders around. After you move a slider, the graph shows the effect of these "tweaks." It's called the OTS Difference graph because it shows the difference between the standard OTS you selected and whatever changes you made when you moved a slider.
Tap the Cents/Beats button to toggle the graph to Beats. Toggle around for a while.
When you're done messing around, make sure you've selected the OTS Difference graph and set the graph to Cents not Beats.

Tap on OTS 4. All sliders will return to their standard settings for OTS 4. The A2 slider will be set to 0.24 bps and the A3 slider will be 0.32 beats, their normal beat rate for OTS 4. In CEQ's header box located below the graphic keyboard, these appear again as the T and B predicted beat rates. Alongside each slider are various ratios, such as 4:1, 2:1, 4:2, etc. These are the intervals used by RCT to calculate the pitch of each slider's control note.

Exception: if the 12th Tuning Partial is chosen in the low bass in CEQ, the 12:3 double octave ratio appears on the A0 slider for informational purposes only.

The A5, A6, and A7 sliders have the ratio 4:1 (a double octave) at 0.00. A5, A6, and A7 have 4:1 as their "zeroed" ratio. A3 has 4:2 as its zeroed ratio. A2 and A1 have 6:3 as their zeroed ratio. A0's zeroed ratio is not fixed; its zeroed ratio depends on the Tuning Partial you chose in Chameleon as the low bass partial. For example, if you chose low bass Tuning Partial 6, the zeroed ratio will be 6:3; for Tuning Partial 7, the zeroed ratio will be 7:3.5; for Tuning Partial 8 it'll be 8:4; if 10 then 10:5; if 12 then 12:6.

The beat rate of each slider's zeroed ratio is indicated by its pointer and is displayed in the indicator box. If there's more than one ratio on a slider, the zeroed ratio is bolded to help make it easy to see. The other slider ratios are called "non-zeroed" ratios and are not fixed to any one beat rate. Their locations are calculated by RCT and move around depending on the scale of the piano, the OTS selected, the settings of other sliders, and Limits (SOM and DMax).

You can figure the beat rate for a non-zeroed ratio by calculating the difference between the non- zeroed ratio and the pointer.

For instance, look at the A6 slider. It has 4:1 as its zeroed ratio, which means the pointer and indicator box of the A6 slider tell us the beat rate of the 4:1 double octave A4-A6, which is .25 bps. In our example, the non-zeroed 2:1 ratio is located approximately 1.75 bps below the zero point, which means the total distance from the 2:1 ratio to the pointer is 2.00 (1.75 + .25). The A5-A6 2:1 octave will beat approximately 2 bps for a Yamaha C3E using OTS 4.

Slider Specs
The four bass sliders (A0 to A3) have a scale of -1.0 to +1.0 and gradations of ±.02. The A5 and A6 sliders have a scale of -3.0 to +3.0 and gradations of ±.05. The A7 slider has a scale of -20 to +30 and gradations of .5. All measurements are beats per second.
A CEQ tuning is re-calculated automatically after any change to a slider, OTS selection, which means pointers or non-zeroed ratios will re-locate and the graph will be redrawn.
For those so inclined, this multi-partial dynamism will be endlessly fascinating and a powerful research tool.

Using CEQ
Let's customize a tuning for our Demo Yamaha C3E.
Reminder, If you are not sure what piano is being used in CEQ, please go to Chameleon and select the Yamaha C3 demo piano, then return to CEQ. The OTS Difference graph should be selected and its display mode should be cents.
Let's say you like the overall sound of OTS 4 for this piano, but would like to make a few changes:

1. You want the high treble a little sharper.
2. You'd like slightly less stretch in the tenor around A5.
3. You prefer slower 3rds around A2, so you're going to decrease the stretch at A2.
Choose OTS 4 by selecting the OTS 4 radio button. When you do, an OTS 4 tuning is instantly calculated, exactly as though you'd chosen OTS 4 in Chameleon and selected the Calculate button. (In fact,
if you wanted a tuning using non-customized OTS 4, you could select OK to exit CEQ then select Chameleon's Calculate button.)

Each slider's pointers are automatically set to the proper beat rate for OTS 4 and colored triangles appear next to each pointer. These triangles show the original location for each pointer. The triangle's color matches the color of the selected OTS radio button. (Low-numbered OTSs use "cooler" colors and high-numbered OTSs use "hotter" colors.)

Let's increase the stretch for the high treble. To do so, you'll raise A7's pointer from its present "stock" OTS 4 setting of 0.00 beats at its zeroed interval, a 4:1 double octave. Tap on the A7 pointer and drag it upwards until the indicator box reads +2.0.
This means the A7 4:1 double octave will now have 2.0 beats. High treble notes will now be a little bit wider than a pure double octave; in other words, slightly closer to an 8:1 triple octave.

When you release the mouse, a tuning with the new settings is calculated in the wink of a computer's eye. The change you just made to OTS 4 will be displayed on the OTS Difference graph. You increased the stretch at A7, which means the notes around A7 are now higher in pitch. The graph's curve rises from A6 to A7 showing that the increased stretch is smoothly distributed.

The OTS 4 beat rate for the A5 slider is +0.75 beats at the 4:1 double octave. Let's decrease it to +0.35 beats. Tap the A5 slider and drag downwards until the indicator box reads +0.35. As you move the slider, keep your eye on the graph and you'll see several interesting things happen.

1. The graph line will belly down at A5, verifying that the stretch is decreased at A5.
2. The graph line around A7 will move down but its shape will remain unchanged, illustrating that those notes have all been lowered the same number of cents so that beat rates for A6 and A7 will remain the same, as confirmed by their pointers and indicator boxes.
3. The pointer for A6 has moved slightly downward all by itself. Why? Look at the A6 slider. There are two ratios — 4:1, which is a double octave with A4 as its lower note, and 2:1, which is a single octave with A5 as its lower note. Both ratios are used to calculate the pitch of A6. (The 4:1 is weighted slightly more than the 2:1.) You just moved A5 down and A5 helps calculate A6. So CEQ moved A6 down too.
What if you change your mind about altering A5's stretch? Any pointer can be reset to its "stock" OTS setting by tapping on its colored triangle. Tap on A5's colored triangle and it will return to its original settings. The graph and other sliders will return to their "pre-A5 tweaked" positions.
For this example, you want slower 3rds near A2, so let's decrease A2's stretch. Move the A2 pointer from its present setting of +0.28 downwards till it's at +0.20. As expected, the graph at A2 moves up, showing us that A2 is now slightly higher in pitch.
If you were done tweaking a tuning in CEQ, you can create a tuning record by tapping on CEQ's Calculate button. But you're not done learning CEQ.

Aural Intervals graph
Tap on button in the lower left to choose "OTS Difference". The graph will toggle to the Aural Interval graph.
The Aural Intervals graph shows the width of 3:2 5ths, 3:1 12ths, 6:3 octaves, and 2:1 octaves. If you chose (or smart partials chooses) low bass partial 12 in Chameleon, the graph shows 12:6 octaves; if you (or smart partials) have chosen low bass partial 10, it shows 10:5 octaves.
You can view the Aural Interval graph as beats too.
Tap on different OTS buttons and watch the Aural Intervals graph change. Notice that this graph shows information even for non-tweaked OTSs, unlike the OTS Difference graph. Drag some sliders and watch the Aural Intervals change.
For notes above A4, graph points are set at the interval's upper note; for notes below A4, graph points are set at the lower note.
Aural Intervals displays data taken directly from the tuning chart. You can look at the tuning chart cells and do the subtraction in your head to figure the cents width of any available interval, or you can let Aural Intervals do the hard work for you.
For example, on a tuning chart for the Yamaha Demo piano using standard OTS 4 (no tweaks), D4 reads about 3.7¢ at partial 3 and A4 reads 1.9¢ at partial 2, meaning the D4-A4 3:2 5th is 1.8¢ narrow (3.7 minus 1.9 equals 1.8). If you look at the Aural Intervals graph in cents, the 3:2 graph line reads about -1.8¢ at A4.
The Aural Intervals graph can be very useful in customizing a tuning because you can see the actual width of important intervals and how they interact. For example, you might try raising the A5 slider to make the 3:2 5ths less narrow. At the same time, you'll be able to watch the affected 2:1 octaves get wider.

Beats or Cents?

Still using the Yamaha Demo piano, switch the Aural Intervals graph between cents and beats several times and notice that the 3:2 graph at A4 in beats is half of what it is in cents. That's because beats are calculated at the actual coincident partial, which is A5 for the D4-A4 3:2 5th. At A5 two cents equals about one beat.

Go back to OTS Difference graph and set to cents. Tap on OTS 4 to reset all sliders, and then drag A1 to +.70. That makes a big dip in the graph, and seems like it would affect the stretch in the bass a lot. Now toggle from cents to beats. The 6:3 octaves spread a little more than a half beat.

Tap A1's colored triangle to reset A1 and the graph should return to a straight line. Now lower A7's slider to -1.5, and watch the graph dive sharply down. Now switch back to cents. The graph line becomes less radical.

You've just demonstrated to yourself why cents is better than beats for displaying Spinner speed. Cents is more accurate in the bass and more controllable in the treble.

Adjusting Siders

You should still be using the Yamaha C3 Demo piano. Tap on OTS 4 to reset the sliders. It doesn't matter which graph or scale is displayed. In fact, feel free to toggle between graph modes and scales throughout the following examples.

Drag the A2 slider all the way to the top. A dialog box appears that says, "The A2 slider is outside the normal tuning range. A2 + A3 can't be greater than the A2-A4 Double Octave Max. RCT is telling us that our new A2 setting created a double octave that's wider than the Double Octave Maximum for OTS 4, which is 1.00. Tap on the OK button and watch what happens to the A2 pointer. CEQ will set the A2 slider to .68! Why .68? A3 is already set to .32, and .68 is as wide as A2 can get and still stay within the OTS 4 Double Octave Maximum of 1.00 (1.00 minus .32 equals .68). Also notice that the pointers for A0 and A1 have moved by themselves, for the same reason as the A6 slider moved independently when you altered the A5 slider — those ranges are calculated based on the slider you just moved, as indicated by the ratios (zeroed and non-zeroed) on the A0 and A1 sliders.

How should I use CEQ?

• Tune the piano and listen to it. If there are any areas you want to change, move the appropriate sliders, calculate another tuning record, then re-tune the piano.

This method is the easiest and most direct, and will probably be the most popular. With the piano at pitch and entirely strip muted, it takes very little time to tune one string per note, especially if you know you'll be making subsequent passes.

A truncated refinement: Especially on problem pianos, don't bother tuning all notes. Instead, tune only the tenor. Once you find on OTS that sounds good there, tune the outer octaves, using CEQ to tweak their stretch if desired

• Use CEQ to analyze and alter the stretch in certain areas to create interval widths that fulfill your mathematical wishes.

Some RCT users are especially interested in the width of 5ths in the mid-treble. Select Aural Intervals and look at the 3:2 graph line, which indicates the speed of the 5ths from D4-A4 to G#4-D#4. You might want these 5ths to be approximately the same size or, at best, get narrower very slightly. If the graph indicates that fifths at the top of this range are more than 3 cents narrow, the fifths are probably beating too fast and likely to sound bad. If they are too fast, you can decrease the beating of the fifths by raising the slider nearest the upper notes, which in this case is the slider at A5. (Lowering the slider near the lower note would work too, but that usually creates worse problems and is not recommended).

If this line of thought interests you, remember that as octaves ascend, beat speeds double for the same cents differential. This means a 2 cent narrow fifth in octave 4 will beat approximately 1 bps, but a 2 cent narrow fifth in octave 5 will beat twice as fast at 2 bps (theoretically!).

• Create a library of your own personal User Settings

After using CEQ for a while, you may find some CEQ settings that you like better than a "stock" OTS. You may also decide that a certain CEQ setting works especially well for a certain piano model.

For example, you may decide that a Steinway D concert piano sounds best with OTS 7, a little extra stretch at A5, tons of extra stretch at A7, and slightly less stretch at A2. But Steinways vary a lot even within the same model, so you don't want to use the same tuning record on a different model D. Instead, you'd save this as a User Setting named "Steinway D special sparkle" and apply it to your other Steinway D pianos.

• Using CEQ, an aural tuning can be closely matched. Then a similar CEQ tuning record can be calculated which will have much better note-to-note consistency.

• It's possible to use the Tuning Graph (not the OTS-CEQ difference graph in CEQ) to infer interval widths, especially the 3rd and 2nd partial lines for the interval of a 5th for notes D4 to G#5 (as described above). If these graph lines are nearly parallel, then the narrowness of the 5ths is relatively consistent. On the other hand, if the 2nd partial line is steeper than the 3rd partial line, the 5ths are getting narrower as they go up the scale, which may result in unacceptable beating.

Calculate button

When sampling is completed and Advanced users have made their Chameleon or CEQ choices, tap the Calculate button. A tuning record will be calculated based on the samples you took and the OTS and tuning partials selected. (If Chameleon is in Easy mode, the OTS and tuning partials are selected for you.) Chameleon will close and the tuning record's tuning chart will be displayed.

Hint

Before tapping the Calculate button, open the tuning file in which you want the new tuning record to be stored. This way, the new tuning record will automatically be placed into this tuning file when you create it by tapping the Calculate button.