PIANO TECHNICIANS
Journal
OFFICIAL PUBLICATION OF THE PIANO TECHNICIANS GUILD
March 2025 Vol. 68 No. 3

Bass Tuning, Part 3: Single Bass Strings

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Parts 1 and 2 of this series discussed the theory of coincident partials and shared the Stretch Interval Set (SIS), including information about how it is used to tune to a variety of levels of accuracy and precision and how it can correct drifted notes, especially in the "killer" (fifth) octave. This third part in our series will discuss the curious case of the lowest bass strings, the single strings or monochords. The following procedure for tuning the single bass strings can be used to tune the lowest bichords as well, if the beat rates are particularly hard to hear. (I just mute one string and treat it as a single bass string.)

Problems with the Low Bass

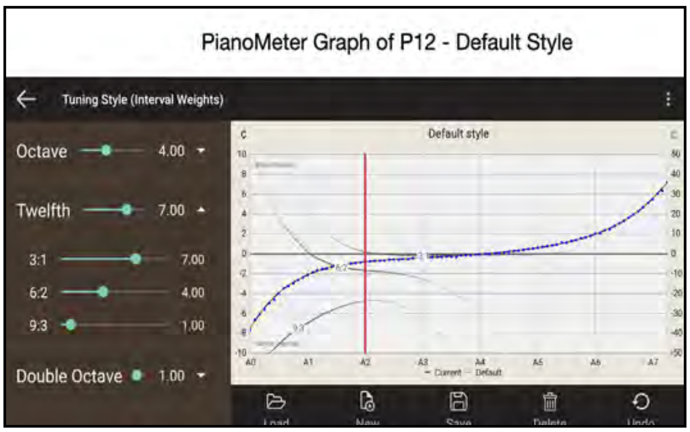

Figure 1: Screenshot from the PianoMeter app, showing a P12 at A2.

The SIS is used down to the lowest bichord; however, when trying to tune a pure 3:1 P12 or pure 6:1 P19, we may notice something: These intervals often do not sound clean at all. Upon careful listening, we may be able to discern that there is wild beating at the second coincident partial (CP) — the 6:2 for the P12, or the 12:2 for the P19. Using graphs from PianoMeter, we can see that that is exactly what we would expect to hear (Figure 1). Notice the vertical red line. This indicates the P12 at A2 (A2-E4). The default style has tuned the 3:1 as pure, but the 6:2 is narrow by 2.0 cents. The 9:3 is narrow by 4.8 cents. A quick calculation of the 6:2 and 9:3 beat speeds at 2.0 and 4.8 cents gives us the following:

Interval	A2-E4
CP	6:2
Note	E5
Freq. 1 ~	1320
Freq. 2	1318.5
Cents	2.0
BPS	-1.5
CP	9:3
Note	B5
Freq. 1 ~	987.8
Freq. 2	985.8
Cents	4.8
BPS	-2.7

Poor inharmonicity in the bass due to the strings being thicker and the fact that these high second coincident partials are now clearly audible creates this situation where the P12 and P19 cannot be tuned cleanly. What are we to do? If we retune the P12 or P19 so that the second coincident partial is pure, that beating will be transferred to the lower and more easily heard coincident partial. The intervals with a beating second coincident partial may sound bad, but those with a beating first partial sound worse!

When I teach, I talk about large-scale octaves, where the 4:2 and 6:3 are so far apart that the wide 4:2/narrow 6:3 sounds horrible, with clearly beating 4:2 and 6:3 coincident partials. I teach to tune those as pure 4:2 octaves. The result is that the 6:3 is now beating wildly, but a strange thing happens. The 4:2 is solid and we like it, and the 6:3 seems to take on the quality of so many other intervals in the piano: fast beating. Fast beating is the piano sound, so it is acceptable to our ear.

It is the same with these low P12s and P19s. They are considered large-scale intervals and are tuned with the second coincident partial beating wildly. If we were to try to slow the beating down, it would just make the interval sound worse. There is an argument that these P12s and P19s may be medium or small scale if the second coincident partials are beating slowly and, therefore, may sound better if we tweak the interval size, but these situations are rare and not part of this discussion.

How We Tune Single Bass Strings

The very low single strings have their own problems. If you've ever tried to bandpass-filter the fundamental of a low single bass string, you'll find something interesting. There is almost no volume; it is almost impossible to hear anything. So how is it possible that we hear anything at all?

Something called Difference Tone Theory states, "When two different frequencies are sounded, a third frequency equal to the difference of the first two is heard." A common example of this is playing 440 Hz and 441 Hz; a beat of 1 Hz can be heard. One theory about why we hear the fundamental has to do with how neighboring pairs of partials interact. The difference between any two neighboring partials is the fundamental, so a single bass string, with all its audible partials, will have many neighboring pairs that combine to enhance the fundamental. For example: A 100 Hz ideal string will produce partials at 100-200-300-400-500-600-etc. One can easily see that the difference between neighboring partials is 100 Hz: the fundamental.

How Can We Use This to Tune Bass Octaves?

Tuning bass octaves can be confusing. It's a fact that no matter what size you tune a bass octave, there will be beating somewhere. So, what can we do? Virgil Smith, who was a great and respected aural piano tuner for many years before he passed away, coined the phrase "the natural beat," and while many people have different ideas about what he meant by it, I have taken it to mean how to tune bass octaves.

The procedure involves tuning the low single bass string octave and listening to perceived beating at the fundamental of the low note. "At the fundamental?" you ask. "How can there be beating at the fundamental of the low note? There is only one frequency!" You are right, but when we tune in to that frequency, two things happen:

1. There may be an octave size that "seems" to be quieter, certainly in the low area of the spectrum of the octave.
2. Not only can there be wildly beating higher partials like the 10:5, for example, but if we try to tune any of those beating partials pure, the octave suffers. There appears to be a rumbling produced at the fundamental of the low note: the natural beat.

What's the theory behind this? We can only postulate. Using difference tone theory, it is possible to imagine the following situation with the low ideal octave of 100 Hz and 200 Hz. The frequencies produced by each note can be shown like this (frequencies produced by Note 2 in bold):

Note 1: 100-200-300-400-500-600-700-800-etc.
Note 2: 200-400-600-800-1000-etc.

By inspecting these different frequencies, it is possible to see pairs of partials that add up to the fundamental of the low note, 100 Hz. For example:

200–100
300–**200**
400–300
500–**400**
Etc…

I am not sure if this is what is really going on; it is too difficult to measure these very low partials. What I do know is that when listening to the fundamental of the low octave note and trying to tune the octave so there is stillness at this frequency, there may be higher partials beating wildly. And if the octave is retuned to make these higher partials pure, the octave sounds worse. This is the basic logic behind tuning the natural beat pure in the lowest octaves in the piano, usually from around A0-A1 to A1-A2, up until the lower octave note is a bichord. Then we also check what the low note sounds like with the P12, P19, and P22 above, being aware that the second coincident partials of the P12 and P19 may be beating wildly but will be ignored.

Conclusion

I have had great success teaching students the procedures described above for tuning the bass. The low notes of the piano generally do not slot into one particular interval very well, so if anything, having a method that seems to work gives the student a clear procedure to follow and, therefore, reduces confusion.

Here is a basic review of what was covered in the three parts of this article series:

- Tuning the high bass can be done in different ways that produce different levels of accuracy and precision.

- For more accuracy and precision, we use the intervals from the SIS; the more intervals we use, the more notes we can correct, and the more accurate and precise our tunings will be.

- We tune P12s as 3:1 and P19s as 6:1 and ignore the 6:2 and 12:2, or any other higher beating coincident partials, especially if they are beating fast.

For the low single bass strings, trying to tune the natural beat (that's the fundamental of the low octave note) pure seems to give the best result.

The low bass is not easy to tune. The intervals do not slot well in this section like they do in the higher registers of the piano. Having a specific procedure that produces results that are acceptable and consistent can reduce frustration and confusion and speed up tuning time. ■

Mark Cerisano, RPT*, is devoted to improving aural piano tuning techniques. He has used his background in mechanical engineering to test the reliability of assumptions routinely made by piano tuners. He has used his training in education to develop explanations of concepts that simplify understanding of aural piano tuning. Cerisano is the author of several books and* Journal *articles. He can be contacted through his website, IPTS.online.*

UPCOMING EVENTS

March 2025

2025 South Central Regional Conference (SCRC)
Starts: Mar 5, 2025 08:00 (CT) Ends: Mar 8, 2025 17:00 (CT)
Where: Hilton Hotel
113 South University Parks Dr.
Waco, TX 76701

Washington State Hands-on Seminar
Starts: Mar 27, 2025 08:00 (PT) Ends: Mar 29, 2025 17:00 (PT)
Where: Central Washington University
400 E University Way
Ellensburg, WA 98926

Hands-On Training for Piano Technicians
Starts: Mar 28, 2025 08:00 (ET) Ends: Mar 30, 2025 17:00 (ET)
Where: Courtyard by Marriott New Haven Orange/Milford
136 Marsh Hill Rd.
Orange, CT 06427

July 2025

2025 Annual PTG Convention & Technical Institute
Starts: Jul 16, 2025 08:00 (CT) Ends: Jul 19, 2025 17:30 (CT)
Where: Iowa Events Center and Hilton Des Moines Downtown
730 3rd St.
Des Moines, IA 50309

September 2025

Ken Eschete and Dale Erwin Saturday Technical
When: Sep 6, 2025 from 08:00 to 17:00 (CT)
Where: Northwestern University
633 Clark St.
Evanston, IL 60208