x / y
Tunings and Temperaments

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X / Y Tunings and Temperaments

In the good old days of rock and roll before the advent of electronic tuners we tuned our guitars by ear. If we played a song with lots of G chords we invariably by ear tuned the B on the second string slightly lower. For the C and D chords, the C and D notes on the second string would now no longer be perfect, but we chalked it up to a slight chorusing as the slightly better major third or B of the G chord made that chord sound a huge amount better. If we did the same thing on the first string, dropping the E slightly, the C and D chords as well would sound a whole lot better. Nobody knew what they were doing mathematically or theoretically. We only knew or the ear knew that tuning the guitar was different for every different set of chords. Heaven help when we went to play another song in a new key like E. Things right away would sound out of tune, but with a few twists of the tuning keys a new compromise was quickly reached and things sounded good once again!

Now with electronic tuners the standard of being in tune is when the meter lights up green or red in the middle of the display. No consideration for the idiosyncrasies or flaws of the guitar, no chance for the ear to tweak the tuning to make the chords sound better for the main key of the song. Sure if one is playing all night in many different keys then probably the compromise of everything being tuned as best as possible in twelve note equal temperament might seem advisable. In the studio however, when only one song is being recorded at a time, slightly tweaking the tuning of the guitar to the style and chords of the song will make the guitar part sound a huge amount better and in tune.

We don't need any theoretical knowledge or understanding here. There are no charts how to tweak the tuning of this set of chords compared to that set of chords. Ignorance is bliss if we just follow our ears, but we don't anymore. We just slap on the electronic tuner and think we are done. Maybe with regular open chords we shouldn't tweak too much as in the end we can make one chord sound absolutely great while all the other chords will be slightly off. Still if the song only has one chord why shouldn't we make that chord sound perfect? A tuner will tune the strings so all the chords can be played, but tuning-wise each chord will be on the edge of tolerability. The ear on the other hand can tune a single chord to absolute perfection to the detriment of every other chord. This aspect of fine tuning and tweaking is not an art, it is just what we used to do in the past. It made the music sound the best as we lost ourselves emotionally in the resonance of the sound.

The above is how we would approach tuning a guitar to play full major and minor open chords. Tweaking could be very subtle to make the chords sound as best as possible to our ears. The same cannot be said about electric guitar with lots of distortion. There is no subtle tweaking here, there is only one way, which is dictated by the power and volume of the sound and the clip of the distortion. Any interval not perfectly in tune would have a very pronounced wobble or beating to it and we would simply tune the interval and know it was perfect when the beating disappeared. Regular tuned open guitar chords with distortion sound like absolute garbage. Tuning an electric guitar with distortion then is without any tweaking whatsoever and only dependent upon the clip of the distortion. We play our power chords and they are called power chords for a reason. When the three notes of a power chord sound together the sound is powerful and vibrates internally with a life all its own. That is the sound of rock and roll. We can never achieve this incredible richness on a keyboard instrument tuned in equal temperament. It is one reason I always seek electronic keyboard instruments that allow themselves to be retuned.

Let's look at a few ways of tuning an electric guitar with distortion. Four charts are laid out to see exactly what is happening tuning and interval wise. One of the most common ways of tuning a distortion guitar is with harmonics. The fifth fret harmonic of one string is compared to the seventh fret harmonic of the next string and so on. The second and first strings are then tuned by the seventh fret harmonics of the sixth and fifth strings (Guitar Tuning 1). I have always known that this method is no good if one wants the open chords to be usable. Open chords

using this method sound absolutely horrible. This method though is the main tuning method when using three string power chords built on the sixth and fifth strings. I always assumed that the bottom four strings tuned with harmonics were pretty much in Just Intonation. The truth or reality is quite different! We have forgotten that we will be playing the chords on tempered frets. Sure the open strings are in Just Intonation tuning to one another but we have a big surprise when we calculate out the actual pitches of the frets. We find that not even the octaves of the power chords built on the sixth and fifth string are true! The octaves are flat by almost 4 cents which is a lot. Octaves are never tempered. The fifths of the power chords are also flat by the same amount.

How is it possible to tolerate such mis-tuning in what is one of the most standard distortion tunings? I think there are two answers here. The first is that distortion or clipping has the ability to pull into tune slightly out of tune intervals. The second answer is that just in the physical act of playing and even in depressing the power chords the two upper strings of the power chords are pulled ever so slightly sharp and into tune. Basically there is a leeway when the hand is pulling the strings as it is traversing across the neck. There is also a warmth to these power chords that we lose when everything is tuned perfectly with a tuner.

There is a variation on the above tuning that is not well known or understood and so not well utilized (Guitar Tuning 2). Sometimes when playing the power chord built on the fifth string, the flat of the half barred third finger on the fourth and third string (or the way I play it with the fourth finger) can as well include the second string. With distortion this second string quickly muddies the clip of the power chord. If we lower the second string slightly though the second string comes perfectly in tune and the four string power chord built on the fifth string now sounds great. As well all the harmonics played together on the fourth, third and second string sound incredible. We can actually see how much we have lowered the second string when we play it together with the first string and hear how out of tune these two strings are now! We have lowered the second string around a fifth of a semitone. We can however so quickly and easily tune back and forth between the two tunings using harmonics or open strings that we could utilize both tunings even within the same song.

If we wanted to have perfect octaves in our power chords then we would tune according the third tuning chart (Guitar Tuning 3). Not only are the octaves perfect now but so is the fifth of the power chord built on the fifth string. The entire six string bar chord built upon the A chord is now completely just and perfectly in tune. The sixth string power chord still has the fifth that is about 4 cents flat. It is not possible to get both power chords absolutely perfect with perfect fifths and octaves. The third tuning chart is given with the lowered second string which could very easily be raised to be in tune with the first string instead.

The final tuning chart is a good way to tune a guitar by ear when a tuner isn't readily handy (Guitar Tuning 4). It gives identical results to tuning the open strings with a tuner. Here both power chords have perfect octaves with fifths now tuned less than 2 cents flat from just. This is as close as we can get to perfect power chords but there is no leeway if the strings are slightly pulled and stretched and it is not exactly a given that the power chords here sound better than the first three tunings. However, playing power chords (with a lesser amount of distortion), while letting the top two strings ring clear, sounds best when the guitar is tuned straight forwardly with a tuner.

Every guitarist knows (with the first three distortion tunings) that when the distortion is turned off and simple open chords are attempted they sound awful or even worse than awful! Of course nobody understands why this is so and so it is just easier to turn the distortion back on! If one has a double neck guitar one neck can be tuned for distortion chords using one of the first three distortion tunings and the other neck for open chords simply with a tuner or the remaining tuning.

The above is an example of what I call “X / Y Tunings and Temperaments” where within one instrument or system we have two different types of tuning and/or temperament. The frets on a guitar are in 12 tone Equal Temperament and we can’t change that unless we refret the instrument. We can however change the tuning relationship of the strings. In the above example we strive to tune the strings in Just Intonation for maximum in-tuneness especially with power chords using distortion. The frets organize then the scale steps of the system while the tuning of the strings organizes the tuning relationship of the notes within a chord! Hence we have two different tuning/temperament systems simultaneously!

In the Equal Meantone Temperaments chapter I mentioned I tune the strings of my 5 string cello with a tuner to 12 note Equal Temperament. What would compel me to do such a thing! Firstly if I tune all the fifths just, then the relationship of the lowest string C to the highest string E is the very sharp Pythagorean third or ditone whose ratio is 81/64. 81/64 at 407.82 cents is 7.82 cents sharper than 12Et and a whole Syntonic Comma (21.51 cents) sharper than a just 5/4 major third at 386.31 cents. By tuning the fifths of my cello slightly flat I am bringing down the overly large major third between the top and bottom strings. The fifth being only 1.9550 cents flat from just, nowhere loses its quality and is barely discernibly different from a just 3/2 perfect fifth. As well the strings correspond perfectly to a piano tuned to 12Et. Sometimes when watching a performance of a Baroque oratorio or passion we see the string players tuning each string separately to the chamber organ. What is happening here? Here the string players are tuning to a continuo instrument that is tuned in a Well Temperament or even a Meantone Temperament. Here the fifths of the string instruments could be up to 4 or 5 cents flattened from just which is twice as much as what I squash my fifths by!

With the 5 string cello whose strings are tuned to 12Et, we are using an “X/Y Tunings and Temperaments” system opposite to that of the guitar laid out above. Here the tuning of the strings are in an equal temperament while of course the playing of the individual notes on the strings is done by ear which of course gravitates always to playing in a floating Just Intonation.

To give one more example, Partch’s Tonality Diamond could also be said to fall under the designation of “X/Y Tunings and Temperaments”, except here the X and Y axis are both tunings. On each note of Partch’s Otonal (4:5:6:7:9:11) and Utonal (1/4 : 1/5 : 1/6 : 1/7 : 1/9 : 1/11) hexachords Partch further constructs the same hexachords. Specifically, on the Otonal hexachord he constructs descending Utonal hexachords and on the Utonal hexachord he constructs ascending Otonal hexachords. These interlocking Otonal and Utonal hexachords together form the Tonality Diamond. The reader is referred to the “Partch 43 Tone Scale” chapter.

The simple focus of this chapter is to demonstrate how it is possible to combine simultaneously two different tuning and/or temperaments each serving a different function. In one sense only the exposition is new. Guitarists have been doing this already for a very long time! For guitar, the frets organize everything into equal divisions of the octave. The specific tuning of the strings aligns everything in Just or almost Just Intonation. This concept of course can be applied to all stringed instruments, especially instruments in open chordal tunings like the banjo. Besides string instruments like the guitar etc, how I tune my 5 string cello and Partch’s Tonality Diamond I am at a loss to think of other different examples of “X/Y Tunings and Temperaments”. Maybe the high Tierce and Quint stops of an organ can apply if they are truly just to the fundamental. “X/Y Tunings and Temperaments” then are something that can be taken into consideration when developing and tuning instruments of the future! There is great efficiency in having only twelve notes to the octave to deal with while at the same time having the ability to build purer tuned chords on top of each of these notes!

X / Y Tunings and Temperaments

Guitar Tuning 1

Strings 6-5 | Fifth fret harmonic = seventh fret harmonic
Strings 5-4 | (lower string) (higher string)
Strings 4-3 |
Strings 6-2 | Seventh fret harmonic = open second string (or twelfth fret octave harmonic)
Strings 5-1 | Seventh fret harmonic = open first string (or twelfth fret octave harmonic)

	VI - E	V - A	IV - D	III - G	II - B	I - E
0	**1/1**	**4/3**	**16/9**	**32/27**	**3/2**	**1/1**
Cents	0	498.04	996.09	294.13	701.96	0
+/-12ET	0	-1.96	-3.91	-5.87	1.96	0
	F	**Bb**	**Eb**	**Ab/G#**	**C**	**F**
I	**1/1 * 2^(1/12)**	**4/3 * 2^(1/12)**	**16/9 * 2^(1/12)**	**32/27 * 2^(1/12)**	**3/2 * 2^(1/12)**	**1/1 * 2^(1/12)**
Cents	100	598.04	1096.09	394.13	801.96	100
+/-12ET	0	-1.96	-3.91	-5.87	1.96	0
	F#	**B**	**E**	**A**	**C#**	**F#**
II	**1/1 * 2^(2/12)**	**4/3 * 2^(2/12)**	**16/9 * 2^(2/12)**	**32/27 * 2^(2/12)**	**3/2 * 2^(2/12)**	**1/1 * 2^(2/12)**
Cents	200	698.04	1196.09	494.13	901.96	200
+/-12ET	0	-1.96	-3.91	-5.87	1.96	0
	G	**C**	**F**	**Bb**	**D**	**G**
III	**1/1 * 2^(3/12)**	**4/3 * 2^(3/12)**	**16/9 * 2^(3/12)**	**32/27 * 2^(3/12)**	**3/2 * 2^(3/12)**	**1/1 * 2^(3/12)**
Cents	300	798.04	96.09	594.13	1001.96	300
+/-12ET	0	-1.96	-3.91	-5.87	1.96	0
	G#	**C#**	**F#**	**B**	**D#**	**G#**
IV	**1/1 * 2^(4/12)**	**4/3 * 2^(4/12)**	**16/9 * 2^(4/12)**	**32/27 * 2^(4/12)**	**3/2 * 2^(4/12)**	**1/1 * 2^(4/12)**
Cents	400	898.04	196.09	694.13	1101.96	400
+/-12ET	0	-1.96	-3.91	-5.87	1.96	0
	A	**D**	**G**	**C**	**E**	**A**
V	**1/1 * 2^(5/12)**	**4/3 * 2^(5/12)**	**16/9 * 2^(5/12)**	**32/27 * 2^(5/12)**	**3/2 * 2^(5/12)**	**1/1 * 2^(5/12)**
Cents	500	998.04	296.09	794.13	1.96	500
+/-12ET	0	-1.96	-3.91	-5.87	1.96	0
	Bb	**Eb/D#**	**Ab/G#**	**Db/C#**	**F**	**Bb**
VI	**1/1 * 2^(6/12)**	**4/3 * 2^(6/12)**	**16/9 * 2^(6/12)**	**32/27 * 2^(6/12)**	**3/2 * 2^(6/12)**	**1/1 * 2^(6/12)**
Cents	600	1098.04	396.09	894.13	101.96	600
+/-12ET	0	-1.96	-3.91	-5.87	1.96	0
	B	**E**	**A**	**D**	**F#**	**B**
VII	**1/1 * 2^(7/12)**	**4/3 * 2^(7/12)**	**16/9 * 2^(7/12)**	**32/27 * 2^(7/12)**	**3/2 * 2^(7/12)**	**1/1 * 2^(7/12)**
Cents	700	1198.04	496.09	994.13	201.96	700
+/-12ET	0	-1.96	-3.91	-5.87	1.96	0

Guitar Tuning 2

Strings 6-5 | Fifth fret harmonic = seventh fret harmonic
Strings 5-4 | (lower string) (higher string)
Strings 4-3 |
Strings 4-2 | Ninth fret harmonic = seventh fret harmonic
Strings 5-1 | Seventh fret harmonic = open first string (or twelfth fret octave harmonic)

	VI - E	V - A	IV - D	III - G	II - B	I - E
0	**1/1**	**4/3**	**16/9**	**32/27**	**40/27**	**1/1**
Cents	0	498.04	996.09	294.13	680.45	0
+/-12ET	0	-1.96	-3.91	-5.87	-19.55	0
	F	**Bb**	**Eb**	**Ab/G#**	**C**	**F**
I	**1/1 * 2^(1/12)**	**4/3 * 2^(1/12)**	**16/9 * 2^(1/12)**	**32/27 * 2^(1/12)**	**40/27 * 2^(1/12)**	**1/1 * 2^(1/12)**
Cents	100	598.04	1096.09	394.13	780.45	100
+/-12ET	0	-1.96	-3.91	-5.87	-19.55	0
	F#	**B**	**E**	**A**	**C#**	**F#**
II	**1/1 * 2^(2/12)**	**4/3 * 2^(2/12)**	**16/9 * 2^(2/12)**	**32/27 * 2^(2/12)**	**40/27 * 2^(2/12)**	**1/1 * 2^(2/12)**
Cents	200	698.04	1196.09	494.13	880.45	200
+/-12ET	0	-1.96	-3.91	-5.87	-19.55	0
	G	**C**	**F**	**Bb**	**D**	**G**
III	**1/1 * 2^(3/12)**	**4/3 * 2^(3/12)**	**16/9 * 2^(3/12)**	**32/27 * 2^(3/12)**	**40/27 * 2^(3/12)**	**1/1 * 2^(3/12)**
Cents	300	798.04	96.09	594.13	980.45	300
+/-12ET	0	-1.96	-3.91	-5.87	-19.55	0
	G#	**C#**	**F#**	**B**	**D#**	**G#**
IV	**1/1 * 2^(4/12)**	**4/3 * 2^(4/12)**	**16/9 * 2^(4/12)**	**32/27 * 2^(4/12)**	**40/27 * 2^(4/12)**	**1/1 * 2^(4/12)**
Cents	400	898.04	196.09	694.13	1080.45	400
+/-12ET	0	-1.96	-3.91	-5.87	-19.55	0
	A	**D**	**G**	**C**	**E**	**A**
V	**1/1 * 2^(5/12)**	**4/3 * 2^(5/12)**	**16/9 * 2^(5/12)**	**32/27 * 2^(5/12)**	**40/27 * 2^(5/12)**	**1/1 * 2^(5/12)**
Cents	500	998.04	296.09	794.13	1180.45	500
+/-12ET	0	-1.96	-3.91	-5.87	-19.55	0
	Bb	**Eb/D#**	**Ab/G#**	**Db/C#**	**F**	**Bb**
VI	**1/1 * 2^(6/12)**	**4/3 * 2^(6/12)**	**16/9 * 2^(6/12)**	**32/27 * 2^(6/12)**	**40/27 * 2^(6/12)**	**1/1 * 2^(6/12)**
Cents	600	1098.04	396.09	894.13	80.45	600
+/-12ET	0	-1.96	-3.91	-5.87	-19.55	0
	B	**E**	**A**	**D**	**F#**	**B**
VII	**1/1 * 2^(7/12)**	**4/3 * 2^(7/12)**	**16/9 * 2^(7/12)**	**32/27 * 2^(7/12)**	**40/27 * 2^(7/12)**	**1/1 * 2^(7/12)**
Cents	700	1198.04	496.09	994.13	180.45	700
+/-12ET	0	-1.96	-3.91	-5.87	-19.55	0

Strings 6-5 Fifth fret harmonic = seventh fret harmonic
Strings 6-4 Twelfth fret harmonic = second fret
Strings 4-3 Fifth fret harmonic = seventh fret harmonic
Strings 4-2 Ninth fret harmonic = seventh fret harmonic
Strings 5-1 Seventh fret harmonic = open first string (or twelfth fret octave harmonic)

Guitar Tuning 3

	VI - E	V - A	IV - D	III - G	II - B	I - E
0	**1/1**	**4/3**	**1/1 * 2^(10/12)**	**4/3 * 2^(10/12)**	**5/3 * 2^(10/12)**	**1/1**
Cents	0	498.04	1000	298.04	684.36	0
+/-12ET	0	-1.96	0	-1.96	-15.64	0
	F	**Bb**	**Eb**	**Ab/G#**	**C**	**F**
I	**1/1 * 2^(1/12)**	**4/3 * 2^(1/12)**	**1/1 * 2^(11/12)**	**4/3 * 2^(11/12)**	**5/3 * 2^(11/12)**	**1/1 * 2^(1/12)**
Cents	100	598.04	1100	398.04	784.36	100
+/-12ET	0	-1.96	0	-1.96	-15.64	0
	F#	**B**	**E**	**A**	**C#**	**F#**
II	**1/1 * 2^(2/12)**	**4/3 * 2^(2/12)**	**1/1**	**4/3**	**5/3**	**1/1 * 2^(2/12)**
Cents	200	698.04	0	498.04	884.36	200
+/-12ET	0	-1.96	0	-1.96	-15.64	0
	G	**C**	**F**	**Bb**	**D**	**G**
III	**1/1 * 2^(3/12)**	**4/3 * 2^(3/12)**	**1/1 * 2^(1/12)**	**4/3 * 2^(1/12)**	**5/3 * 2^(1/12)**	**1/1 * 2^(3/12)**
Cents	300	798.04	100	598.04	984.36	300
+/-12ET	0	-1.96	0	-1.96	-15.64	0
	G#	**Db/C#**	**F#**	**B**	**D#**	**G#**
IV	**1/1 * 2^(4/12)**	**4/3 * 2^(4/12)**	**1/1 * 2^(2/12)**	**4/3 * 2^(2/12)**	**5/3 * 2^(2/12)**	**1/1 * 2^(4/12)**
Cents	400	898.04	200	698.04	1084.36	400
+/-12ET	0	-1.96	0	-1.96	-15.64	0
	A	**D**	**G**	**C**	**E**	**A**
V	**1/1 * 2^(5/12)**	**4/3 * 2^(5/12)**	**1/1 * 2^(3/12)**	**4/3 * 2^(3/12)**	**5/3 * 2^(3/12)**	**1/1 * 2^(5/12)**
Cents	500	998.04	300	798.04	1184.36	500
+/-12ET	0	-1.96	0	-1.96	-15.64	0
	Bb	**Eb/D#**	**Ab/G#**	**Db/C#**	**F**	**Bb**
VI	**1/1 * 2^(6/12)**	**4/3 * 2^(6/12)**	**1/1 * 2^(4/12)**	**4/3 * 2^(4/12)**	**5/3 * 2^(4/12)**	**1/1 * 2^(6/12)**
Cents	600	1098.04	400	898.04	84.36	600
+/-12ET	0	-1.96	0	-1.96	-15.64	0
	B	**E**	**A**	**D**	**F#**	**B**
VII	**1/1 * 2^(7/12)**	**4/3 * 2^(7/12)**	**1/1 * 2^(5/12)**	**4/3 * 2^(5/12)**	**5/3 * 2^(5/12)**	**1/1 * 2^(7/12)**
Cents	700	1198.04	500	998.04	184.36	700
+/-12ET	0	-1.96	0	-1.96	-15.64	0

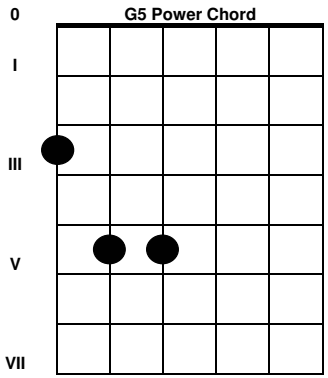
Strings 6-5 Twelfth fret harmonic = seventh fret (not seventh fret harmonic!)
Strings 5-4 (lower string) (higher string)
Strings 4-3
Strings 3-2 Fourth fret = open second string (or twelfth fret octave harmonic)
Strings 2-1 Fifth fret = open first string (or twelfth fret octave harmonic)

Guitar Tuning 4

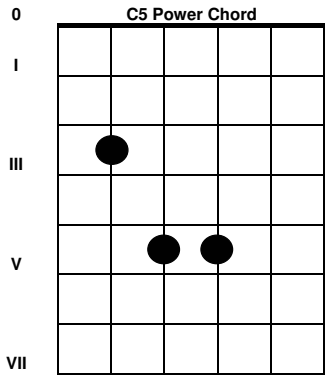
	VI - E	V - A	IV - D	III - G	II - B	I - E
0	**1/1**	**1/1 * 2^(5/12)**	**1/1 * 2^(10/12)**	**1/1 * 2^(3/12)**	**1/1 * 2^(7/12)**	**1/1**
Cents	0	500	1000	300	700	0
+/-12ET	0	0	0	0	0	0
	F	**Bb**	**Eb**	**Ab/G#**	**C**	**F**
I	**1/1 * 2^(1/12)**	**1/1 * 2^(6/12)**	**1/1 * 2^(11/12)**	**1/1 * 2^(4/12)**	**1/1 * 2^(8/12)**	**1/1 * 2^(1/12)**
Cents	100	600	1100	400	800	100
+/-12ET	0	0	0	0	0	0
	F#	**B**	**E**	**A**	**C#**	**F#**
II	**1/1 * 2^(2/12)**	**1/1 * 2^(7/12)**	**1/1**	**1/1 * 2^(5/12)**	**1/1 * 2^(9/12)**	**1/1 * 2^(2/12)**
Cents	200	700	0	500	900	200
+/-12ET	0	0	0	0	0	0
	G	**C**	**F**	**Bb**	**D**	**G**
III	**1/1 * 2^(3/12)**	**1/1 * 2^(8/12)**	**1/1 * 2^(1/12)**	**1/1 * 2^(6/12)**	**1/1 * 2^(10/12)**	**1/1 * 2^(3/12)**
Cents	300	800	100	600	1000	300
+/-12ET	0	0	0	0	0	0
	G#	**C#**	**F#**	**B**	**D#**	**G#**
IV	**1/1 * 2^(4/12)**	**1/1 * 2^(9/12)**	**1/1 * 2^(2/12)**	**1/1 * 2^(7/12)**	**1/1 * 2^(11/12)**	**1/1 * 2^(4/12)**
Cents	400	900	200	700	1100	400
+/-12ET	0	0	0	0	0	0
	A	**D**	**G**	**C**	**E**	**A**
V	**1/1 * 2^(5/12)**	**1/1 * 2^(10/12)**	**1/1 * 2^(3/12)**	**1/1 * 2^(8/12)**	**1/1**	**1/1 * 2^(5/12)**
Cents	500	1000	300	800	0	500
+/-12ET	0	0	0	0	0	0
	Bb	**Eb/D#**	**Ab/G#**	**Db/C#**	**F**	**Bb**
VI	**1/1 * 2^(6/12)**	**1/1 * 2^(11/12)**	**1/1 * 2^(4/12)**	**1/1 * 2^(9/12)**	**1/1 * 2^(1/12)**	**1/1 * 2^(6/12)**
Cents	600	1100	400	900	100	600
+/-12ET	0	0	0	0	0	0
	B	**E**	**A**	**D**	**F#**	**B**
VII	**1/1 * 2^(7/12)**	**1/1**	**1/1 * 2^(5/12)**	**1/1 * 2^(10/12)**	**1/1 * 2^(2/12)**	**1/1 * 2^(7/12)**
Cents	700	0	500	1000	200	700
+/-12ET	0	0	0	0	0	0

X / Y Tunings and Temperaments

3 String Power Chords built on the Sixth String



3 String Power Chords built on the Fifth String



4 String Power Chords built on the Fifth String