YAMAHA

Exploring the Preset Microtunings

DX7 II-FD/D

DIGITAL PROGRAMMABLE ALGORITHM SYNTHESIZER

SUPPLEMENTAL BOOKLET

Welcome

This booklet is the first in a series which will introduce you to the concepts and musical uses of microtuning. It consists of four sections which describe the preset tunings found in the DX7 II.

Section 1 is an introduction which presents the definitions of some basic terms used throughout this and subsequent booklets.

Section 2 provides a guide to exploring the presets which describes the process by which the preset tunings are selected and examined.

Section 3 presents information on using the presets, and includes several musical application suggestions for which the presets can be used.

Section 4 presents a brief description of each preset microtuning and the tuning data for each.

For continuing information concerning the DX7 II FD/D, consult AfterTouch, the official publication of the Yamaha Users Group. Many advanced functions will be discussed in its pages in the coming months. There will also be information concerning the availability of other materials concerning more advanced applications. To receive a free copy of AfterTouch every month, send your request to AfterTouch, P.O. Box 7938, Northridge, CA 91323-7938. On your letter or postcard, be sure to indicate that you are the owner of a DX7 II FD/D.

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1 Introduction

There are many hallmarks in the evolution of contemporary music and the use of electronic synthesis. One obvious example is the introduction of the Yamaha DX7 Digital Synthesizer. Bringing fully digital technology to the creative musician, this single instrument has changed the sound of modern music forever.

The DX7 II Digital Synthesizers bring many new innovations and creative possibilities to the field of contemporary music. One of the most significant new features found on these instruments is their ability to produce an infinite variety of scales. Once again, this single technological development represents a major evolutionary step for all musicians.

Scales & Tuning Systems

The story of scales and their use throughout the history of music is a long and fascinating one. It begins at the dawn of recorded time and continues to stimulate discussion and debate to this day. As scales and tuning systems have been developed, many notable examples have survived as hallmarks of musical evolution. While not in general use today, these scales provide a glimpse into the past. They also portend an exciting future in which alternate tunings will play an increasingly important musical role.

Microtuning is a process whereby the pitch of individual musical notes is adjusted in very small (microtonal) increments. By so doing, many different scales and tuning systems can be realized. The implementation of this process in the DX7 II is the subject of this and subsequent supplemental booklets in the microtuning series.

The DX7 II contains eleven preset microtunings in its permanent memory. They include some of the most important historical tunings developed over the past 2500 years. These presets provide an introduction to the sounds of alternate tunings not often heard in today's musical milieu.

This booklet will acquaint you with the preset scales found in the DX7 II. You'll learn how to explore these presets and use them in your own music making. In order to fully benefit from the information presented here, you should be familiar with the basic operation of the DX7 II and the information found in its owner's manual. This booklet also assumes that you have a basic understanding of musical concepts such as notes, intervals, and the major and minor diatonic scales.

While this booklet does not contain any mathematics or technical terminology, there are a few terms with which you should be familiar. These terms are introduced below.

Equal Temperament

Equal temperament is the tuning system used by virtually all keyboard musicians for the last 150 years. Its foundation lies in the division of the octave into twelve equal intervals called semitones. These semitones correspond to what we call half steps or minor seconds. As these semitones are equally spaced within the octave, any interval will sound identical in quality no matter which two notes are used to form it. For example, the perfect fifth formed with C and G will sound identical in quality to the one formed by B and F#. As you will soon see, this is not true for any other tuning system.

The word "temperament" literally means modification or adjustment. In the case of equal temperament, each of the intervals in the twelve tone scale are modified, or tempered, away from being perfectly in tune, or pure. Ironically, pure intervals permit musical performances only in certain keys on conventional keyboard instruments. The reasons for this phenomenon will be covered in subsequent booklets. For the moment, suffice it to say that equal temperament became the standard tuning in part because it allows composers to write increasingly complex diatonic music in any key whatsoever with equal ease.

The tunings in the DX7 II are created by adjusting the notes away from equal temperament. Since equal temperament is itself a modification of pure intervals, this process could be considered an "unmodification" of the slightly out-of-tune, or impure, intervals found in equal temperament. Since it has been the standard tuning for as long as anyone can personally remember, equal temperament is a convenient reference from which to build other tunings and temperaments.

Cents

As equal temperament was becoming the standard tuning system, musical theorists devised a means by which intervals could easily be compared. The octave was divided into 1200 increments called cents. Since there are twelve equally spaced semitones per octave, each semitone encompasses exactly 100 cents. This unit of musical measurement will be used throughout this and subsequent booklets.

Tuning Units

The DX7 II divides the octave into 1024 fine tuning units (abbreviated TU). Recalling that there are 1200 cents per octave (or 100 cents per equal tempered semitone), this means that each TU represents approximately 1.17 cents (1200/1024 = 1.17).

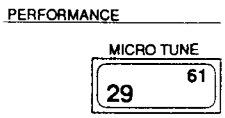
Using the fine tune control, each note on the DX7 II can be adjusted by as much as +/- 42 TU. This means that an equal tempered semitone is roughly equal to 85 TU. To put it precisely, 85 TU = 99.61 cents. The fact that TU do not correspond exactly with cents means that some of the equal tempered semitones must be assigned 86 TU in order to maintain perfect octaves.

2 Exploring the Presets

It is important to become familiar with the parameter settings and characteristic sound of each preset tuning. This section describes how to display the presets and their settings in the DX7 II LCD display. As you examine each one, be sure to play on the keyboard as suggested in the manual in order to hear the differences between them.

While the preset tunings can be applied to any patch in the DX7 II, it is suggested that you begin your intonational explorations using the Grand Harpsichord patch (ROM Cartridge Bank 1 #18). The sound produced by this patch is well suited for hearing the subtle differences between the preset tunings.

Control Mode



To hear the various preset tunings, you must first enter the Microtuning Control Mode. This is accomplished in the following manner.

1. Press the Performance button.
2. Press the Edit button.
3. Press the microtune button (#29) to access the microtuning LCD display. Depending on what you have done before entering this mode, you may need to press the microtune button a number of times until the words "Micro tuning" appear in the LCD display.

There are several parameters in this display which are described below.

Table Select

The Microtuning presets consist of tables which specify the tunings of each note in the DX7 II. These tables, and the presets they specify, are selected in the following manner.

1. Position the cursor at the Table select parameter using the cursor keys.
2. Select a preset tuning using the +1/-1 keys or the data entry slider.

One way to start becoming familiar with the different tunings is to play various intervals in each of the presets. For example, playing fifths (such as C-G followed by B-F# or Ab-Eb) in the Pure Major tuning illustrates the difference between various fifths in this tuning. Listen to other intervals such as fourths, thirds, and sixths as well. Triads can also be quite illuminating.

If you are a keyboard player with suitable technique, try playing some Bach, Scarlatti, or other baroque keyboard pieces in the Werkmeister, Kirnberger, or Valloti & Young tunings. The music you hear by doing so will be much closer to the sound Bach intended than anything performed today on equal tempered instruments. To step even further back in time, play some keyboard pieces by Renaissance or Medieval composers such as Frescobaldi or Sweelinck using the Mean Tone or Pythagorean tunings.

Key

Most early tunings and temperaments were designed to be used only in certain keys. This was due to the fact that some intervals in these temperaments were quite out of tune. The temperaments were designed in such a way that the offending intervals were not used in the keys for which the temperaments were intended.

The key parameter appears in the control mode display when the Pure Major, Pure Minor, Mean Tone, and Pythagorean temperaments are selected. This parameter provides a significant advantage over acoustic keyboard instruments by allowing these tunings to be played in any key with equal ease.

To hear the effect of the key parameter, select a tuning for which the parameter appears, position the cursor, and use the +1/-1 keys to change the key setting. Play an interval such as C-G for each new key. You will hear the interval change as different keys are specified. This is particularly noticeable using the interval C-G in the keys of C and then E.

In addition to playing the same interval with different key settings, play an interval fundamental to each key. For example, select the key of C and play the interval C-G followed by Ab-Eb. Change the key to Ab and play the interval Ab-Eb again. This illustrates the fact that the DX7 II allows you to play with these tunings instantly in any key. Acoustic keyboard instruments using these tunings must be retuned to play in a different key. This precludes the performance of a piece written in several disparate keys on a single instrument.

Try the experiments described above while playing triads as well. This will illustrate the differences between the key-oriented tunings even more graphically.

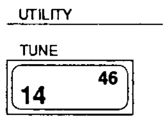
Microtune On/Off

You can specify whether or not the two voices of the DX7 II will conform to the selected tuning in the following manner.

1. Position the cursor at the A or B parameter.
2. Use the +1/-1 keys or the data entry slider to specify a value of OFF or ON.

If the parameter value is OFF, the specified voice will not conform to the selected tuning. It will play in equal temperament (the default tuning). In a dual patch such as Grand Harpsichord, turning one of the two voices OFF while the other one is ON produces some interesting detuning effects. In general, however, both voices should be ON in dual or split mode to use the microtuning feature of the instrument. In the Grand Harpsichord patch, both voices are ON as programmed.

Edit Mode



This mode displays the tuning data for any intonation. It also provides you with the ability to create your own tunings. This will be covered in a subsequent booklet. The tuning data is displayed in the following manner:

1. Follow the procedure for entering the Microtuning Control Mode outlined earlier in this section of the manual.
2. Select the tuning you wish to examine.
3. Press the Tune button (#14). Depending on what you have done before entering this mode, you may need to press the Tune button a number of times until the words "Micro tuning" appear in the LCD display.
4. The selected note (and consequently, the key on the keyboard) is displayed in the >>>>> <<<<< section of the display. The notes immediately above and below the selected note are displayed to the right and left respectively.
5. There are two ways to select a note for examination:
   a. Use the Internal and Cartridge buttons as left and right cursor controls to select adjacent notes.
   b. Hold the key corresponding to the desired note and press either the Internal or Cartridge key. The note you held will be displayed in the >>>>> <<<<< section of the display.

Note:

> *You can switch directly between the Microtuning Table Select display and the Editing display by pressing the appropriate button (#29 and #14). This is very useful for selecting different presets and displaying their tuning data.*

In this mode, you can see how the different preset tunings differ from equal temperament by looking at the deviation from the equal tempered pitch values. This deviation is indicated by a number preceded by "+" or "-" signs. This number represents the tuning units described previously.

There are two parameters in the Edit mode display. These parameters allow you to create your own tunings. For now, here is a description of these parameters. The procedures for using them to change the presets will be presented in a subsequent booklet.

Course Tuning

The course tuning parameter allows you to assign any note in the equal tempered chromatic scale to the selected key on the keyboard. You could go so far as to assign all the keys on the DX7 II to the same note!

In more common applications, the course tuning parameter provides the ability to create scales of varying numbers of notes. For example, a scale with nineteen notes per octave could be created. Two of the preset tunings illustrate this concept as well. They are the 1/4 tone and 1/8 tone scales. Examine the tuning data for these scales and play the keyboard. You will hear some very interesting sounds indeed.

Fine Tuning

The fine tuning parameter provides highly accurate control over the frequency of each note. The +1/-1 keys add or subtract one tuning unit from the number representing the note being edited. As you'll recall, this tuning unit represents an increment of 1.17 cents.

Examine the tuning data for any of the presets numbered from 2 to 8. Each note on the keyboard retains its original note value from the equal tempered chromatic scale, indicating that the course tuning parameter has not been edited in these tunings. However, the fine tuning parameter has been edited for almost every note. The degree to which each note has been adjusted away from equal temperament is indicated with a "+" or "-" followed by a number of tuning units.

You will undoubtedly notice that the A has not been adjusted away from its equal tempered value in any of these tunings. This was done in order to preserve the master tuning of the instrument which is based on A3 = 440 cycles per second. This is the pitch standard used throughout the world today. It can be changed using the Master Tune parameter which is described in the DX7 II fd/d Owner's Manual.

3

Using the Presets

The concepts of microtuning provide a fascinating intellectual pursuit. However, the most important (and often the most overlooked) aspect of microtuning is found in its musical application. This and subsequent booklets will present a variety of ideas concerning the use of alternate tunings in your music making. These ideas are only a starting point from which you can begin to explore the vast world of microtonality.

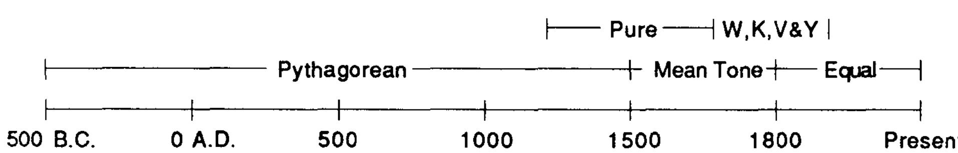
Patches

The Grand Harpsichord patch provides a very good sound with which to become familiar with the preset tunings in the DX7 II. Of course, other patches may be used as well. Certain types of sounds work better than others when used with different tunings.

In general, sounds with clearly defined pitch are best suited to be used with alternate tunings. Brass, string, keyboard, and voice sounds work very well. Bell and gong sounds also work well with different tunings, particularly those of Indonesia. These scales will be covered in subsequent booklets. Sounds with indistinct pitch such as sound effects may not impart the power of alternate tunings.

Performance

Many of the presets are historical tunings used by Bach, his contemporaries, and his predecessors. The approximate periods during which these tunings were in popular use are shown in the time line below.



Clearly, the performance of music written in any of these periods would be well served by using the appropriate tuning(s).

Contemporary music can also be profoundly affected by using alternative scales. Extended chords such as sevenths and ninths exhibit whole new qualities in some of the presets. Try playing a jazz or pop tune with the Werkmeister, Kirnberger, or Vallotti & Young preset. The Pythagorean, Mean Tone, Pure Major, and Pure Minor presets also produce some very interesting effects. However, modulations into various keys will sound quite different than you might expect.

Charles Ives, a twentieth century composer of note, wrote several duets intended for performance on two pianos tuned a quarter step apart. The 1/4 Shifted Equal preset tunes the entire keyboard up by a quarter step and is therefore ideally suited for the performance of these and other such pieces using two DX7 II synthesizers. Other contemporary composers have written pieces in quarter tone and eighth tone scales for which the 1/4 Tone and 1/8 Tone presets would be exceedingly appropriate.

Sequencing

The preset tunings can be used with a sequencer to achieve effects not otherwise practical or possible. You can engage in many microtonal explorations with a single DX7 II and a sequencer.

Step Loading

If you are not technically proficient at the keyboard, you can still hear the effects of alternate scales with the impact of a full performance. By step loading a piece into a sequencer and playing it back with the DX7 II, you can hear music as it has not been heard in 200 years or more. Try step loading a keyboard piece such as those suggested in Section 2 using the Grand Harpsichord patch.

With a single DX7 II and sequencer, you will be capable of hearing up to two different voices simultaneously. For example, you could sequence a keyboard part and a bass part. To reproduce the sound of a larger ensemble, you will need one or more additional microtonal instruments such as the DX7 II or TX81Z. The other alternative is to use a multi-track tape recorder as described below.

Multi-Track Recording

The sound of a large ensemble can be achieved using a single DX7 II, a sequencer, and a multi-track tape recorder. Different parts can be recorded into the sequencer one at a time. Then each part can be recorded onto the tape with a different patch. You could even assign a different tuning to each part as it is recorded onto tape. For example, each part of an Ives duet for two pianos tuned a quarter step apart could be played into a sequencer. As each part is then recorded onto the tape, the Equal Temperament preset would be used for one of the parts and the 1/4 Shifted Equal preset would be used for the other part.

This process requires the application of multi-track synchronization. There are several methods by which this technique can be applied which depend on the type of sequencer you are using. If you are unfamiliar with synchronization techniques, the Bibliography contains several references which present this information.

4 Preset Tuning Data

This section presents a list of the preset tunings found in the DX7 II with a short description of each one. The accompanying tables reveal the tuning data for each preset over the octave C3-C4. The corresponding notes in the other octaves are modified by the same amount as those in this octave and are therefore not listed.

The tables contain the information found in the Edit mode LCD display including the note name, course and fine tune values, and the number of tuning units used to represent each note. In addition, the deviation of each note from equal temperament in cents is indicated in the column labeled "Δ ET." The size of the interval between consecutive notes is also indicated in tuning units (TU) and cents.

Equal Temperament

Equal Temperament, of course, is the compromise reached by musicians nearly 200 years ago to facilitate modulations into increasingly dissimilar keys. Each semitone forms an interval which corresponds to 100 cents. This means that all the various intervals will sound identical no matter which two notes are used to form them, allowing music to be played in any key with equal ease. It also has the disadvantage that none of these intervals are perfectly in tune.

Here is the table of DX7 II tuning values for the Equal Temperament preset. Notice that the first out of every three semitones is 86 TU while the other semitones are 85 TU. This is due to the fact that 1 TU = 1.17 cents. If all of the semitones were 85 or 86 TU, the octave would not be in tune.

EQUAL TEMPERAMENT

Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 3 <<<	C 3	+0	(5034)	+0.00		
					86	100.78
>>> C#3 <<<	C# 3	+0	(5120)	+0.00		
					85	99.61
>>> D 3 <<<	D 3	+0	(5205)	+0.00		
					85	99.61
>>> D#3 <<<	D# 3	+0	(5290)	+0.00		
					86	100.78
>>> E 3 <<<	E 3	+0	(5376)	+0.00		
					85	99.61
>>> F 3 <<<	F 3	+0	(5461)	+0.00		
					85	99.61
>>> F#3 <<<	F# 3	+0	(5546)	+0.00		
					86	100.78
>>> G 3 <<<	G 3	+0	(5632)	+0.00		
					85	99.61
>>> G#3 <<<	G# 3	+0	(5717)	+0.00		
					85	99.61
>>> A 3 <<<	A 3	+0	(5802)	+0.00		
					86	100.78
>>> A#3 <<<	A# 3	+0	(5888)	+0.00		
					85	99.61
>>> B 3 <<<	B 3	+0	(5973)	+0.00		
					85	99.61
>>> C 4 <<<	C 4	+0	(6058)	+0.00		

Pure (Major)

The Pure major preset is one example of what is called Just Intonation. It is designed so that most of the intervals in a particular scale (most importantly the major third and perfect fifth) are pure. Of course, some of the other intervals must be detuned in order to maintain perfect octaves. By specifying a key, the pure major tuning can be applied to any major key without having to retune the instrument. This is one of the advantages of exploring tunings with electronic instruments.

Here is the table of DX7 II tuning values for the Pure Major preset in the key of C major.

PURE MAJOR (Key of C)

Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 3 <<<	C 3	+14	(5048)	+16.41		
					60	70.31
>>> C#3 <<<	C# 3	-12	(5108)	-14.06		
					114	133.59
>>> D 3 <<<	D 3	+17	(5222)	+19.92		
					95	111.33
>>> D#3 <<<	D# 3	+27	(5317)	+31.64		
					60	70.31
>>> E 3 <<<	E 3	+1	(5377)	+1.17		
					96	112.50
>>> F 3 <<<	F 3	+12	(5473)	+14.06		
					60	70.31
>>> F#3 <<<	F# 3	-13	(5533)	-15.23		
					114	133.59
>>> G 3 <<<	G 3	+15	(5647)	+17.58		
					60	70.31
>>> G#3 <<<	G# 3	-10	(5707)	-11.72		
					95	111.33
>>> A 3 <<<	A 3	+0	(5802)	+0.00		
					114	133.59
>>> A#3 <<<	A# 3	+28	(5916)	+32.81		
					60	70.31
>>> B 3 <<<	B 3	+3	(5976)	+3.52		
					96	112.50
>>> C 4 <<<	C 4	+14	(6072)	+16.41		

Pure (Minor)

The pure minor preset is another example of Just Intonation. It is designed in the same manner as the pure major scale except for the fact that it is tuned to retain most of the pure intervals in the minor scale. As with the pure major tuning, some of the other intervals must be detuned in order to maintain perfect octaves. This tuning can also be applied to any minor key.

Here is the table of DX7 II tuning values for the pure minor preset in the key of A minor.

PURE MINOR (Key of A mi)

Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 3 <<<	C 3	+14	(5048)	+16.41		
					60	70.31
>>> C#3 <<<	C# 3	-12	(5108)	-14.06		
					95	111.33
>>> D 3 <<<	D 3	-2	(5203)	-2.34		
					114	133.59
>>> D#3 <<<	D# 3	+27	(5317)	+31.64		
					60	70.31
>>> E 3 <<<	E 3	+1	(5377)	+1.17		
					96	112.50
>>> F 3 <<<	F 3	+12	(5473)	+14.06		
					60	70.31
>>> F#3 <<<	F# 3	-13	(5533)	-15.23		
					114	133.59
>>> G 3 <<<	G 3	+15	(5647)	+17.58		
					60	70.31
>>> G#3 <<<	G# 3	-10	(5707)	-11.72		
					95	111.33
>>> A 3 <<<	A 3	+0	(5802)	+0.00		
					114	133.59
>>> A#3 <<<	A# 3	+28	(5916)	+32.81		
					60	70.31
>>> B 3 <<<	B 3	+3	(5976)	+3.52		
					96	112.50
>>> C 4 <<<	C 4	+14	(6072)	+16.41		

Mean Tone

Mean tone temperament arose out of some of the first attempts to adjust the pure and Pythagorean tunings so that music in a wider variety of keys could be played.

In this temperament, the interval between the root and the fifth is tuned slightly flat. This causes the interval between the root and the second degree of the scale to be exactly halfway between a pure major second and a pure minor second. This average, or mean, whole tone is the source of this temperament's name.

Since the Mean Tone temperament is based on a specific key note, the key parameter is active. Here is the tuning data for the Mean Tone scale in the key of C.

MEAN TONE (Key of C)

Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 3 <<<	C 3	+9	(5043)	+10.55		
					65	76.17
>>> C#3 <<<	C# 3	-12	(5108)	-14.06		
					100	117.19
>>> D 3 <<<	D 3	+3	(5208)	+3.52		
					100	117.19
>>> D#3 <<<	D# 3	+18	(5308)	+21.09		
					65	76.17
>>> E 3 <<<	E 3	-3	(5373)	-3.52		
					100	117.19
>>> F 3 <<<	F 3	+12	(5473)	+14.06		
					64	75.00
>>> F#3 <<<	F# 3	-9	(5537)	-10.55		
					100	117.19
>>> G 3 <<<	G 3	+5	(5637)	+5.86		
					65	76.17
>>> G#3 <<<	G# 3	-15	(5702)	-17.58		
					100	117.19
>>> A 3 <<<	A 3	+0	(5802)	+0.00		
					100	117.19
>>> A#3 <<<	A# 3	+14	(5902)	+16.41		
					65	76.17
>>> B 3 <<<	B 3	-6	(5967)	-7.03		
					100	117.19
>>> C 4 <<<	C 4	+9	(6067)	+10.55		

Pythagorean

The Pythagorean scale is derived by tuning by pure perfect fifths upward from specific note. This leads to some pure intervals and some very impure intervals. It turns out that the octave is quite sharp in this tuning. In order to maintain pure octaves, one of the fifths must be tuned flat to compensate for this anomaly. The fifth chosen to be mistuned is called the "wolf" because early musicians described its sound as the "howling of wolves." In the key of C, the wolf is found in the fifth between Ab and Eb because these notes are not usually encountered in early music written in this key. The key parameter in this preset indicates the note from which the scale was derived.

Here is the table of DX7 II tuning values for the Pythagorean preset in the key of C.

PYTHAGOREAN (Key of C)

Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 3 <<<	C 3	-5	(5029)	-5.86		
					96	112.50
>>> C#3 <<<	C# 3	+5	(5125)	+5.86		
					78	91.41
>>> D 3 <<<	D 3	-2	(5203)	-2.34		
					77	90.23
>>> D#3 <<<	D# 3	-10	(5280)	-11.72		
					97	113.67
>>> E 3 <<<	E 3	+1	(5377)	+1.17		
					77	90.23
>>> F 3 <<<	F 3	-7	(5454)	-8.20		
					97	113.67
>>> F#3 <<<	F# 3	+5	(5551)	+5.86		
					77	90.23
>>> G 3 <<<	G 3	-4	(5628)	-4.69		
					97	113.67
>>> G#3 <<<	G# 3	+8	(5725)	+9.38		
					77	90.23
>>> A 3 <<<	A 3	+0	(5802)	+0.00		
					77	90.23
>>> A#3 <<<	A# 3	-9	(5879)	-10.55		
					97	113.67
>>> B 3 <<<	B 3	+3	(5976)	+3.52		
					77	90.23
>>> C 4 <<<	C 4	-5	(6053)	-5.86		

Werckmeister

Andreas Werckmeister was a musical theorist of Bach's day who was concerned with adjusting the tuning of keyboard instruments so that they could be played in any key. It was under this impetus that Bach wrote the famous "Well Tempered Clavier." Contrary to popular belief, this set of pieces written in each of the major and minor keys was not intended for performance in equal temperament. Performed in a temperament such as Werckmeister's, each key exhibits a unique character which Bach himself described in his writings.

This is only one of many temperaments devised by Werckmeister. Here is the tuning data for the DX7 II.

WERCKMEISTER

Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 3 <<<	C 3	+10	(5044)	+11.72		
					76	89.06
>>> C#3 <<<	C# 3	+0	(5120)	+0.00		
					88	103.13
>>> D 3 <<<	D 3	+3	(5208)	+3.52		
					87	101.95
>>> D#3 <<<	D# 3	+5	(5295)	+5.86		
					82	96.09
>>> E 3 <<<	E 3	+1	(5377)	+1.17		
					92	107.81
>>> F 3 <<<	F 3	+8	(5469)	+9.38		
					77	90.23
>>> F#3 <<<	F# 3	+0	(5546)	+0.00		
					92	107.81
>>> G 3 <<<	G 3	+6	(5638)	+7.03		
					82	96.09
>>> G#3 <<<	G# 3	+3	(5720)	+3.52		
					82	96.09
>>> A 3 <<<	A 3	+0	(5802)	+0.00		
					92	107.81
>>> A#3 <<<	A# 3	+6	(5894)	+7.03		
					82	96.09
>>> B 3 <<<	B 3	+3	(5976)	+3.52		
					92	107.81
>>> C 4 <<<	C 4	+10	(6068)	+11.72		

Kirnberger

Johann Philipp Kirnberger wrote a treatise entitled "The Art of Pure Strings In Music" in 1774. He was also concerned with tempering the scale to allow performances in any key. Here is the tuning data for one of Kirnberger's many temperaments.

KIRNBERGER

Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 3 <<<	C 3	+9	(5043)	+10.55		
					77	90.23
>>> C#3 <<<	C# 3	+0	(5120)	+0.00		
					88	103.13
>>> D 3 <<<	D 3	+3	(5208)	+3.52		
					86	100.78
>>> D#3 <<<	D# 3	+4	(5294)	+4.69		
					79	92.58
>>> E 3 <<<	E 3	-3	(5373)	-3.52		
					95	111.33
>>> F 3 <<<	F 3	+7	(5468)	+8.20		
					79	92.58
>>> F#3 <<<	F# 3	+1	(5547)	+1.17		
					90	105.47
>>> G 3 <<<	G 3	+5	(5637)	+5.86		
					82	96.09
>>> G#3 <<<	G# 3	+2	(5719)	+2.34		
					83	97.27
>>> A 3 <<<	A 3	+0	(5802)	+0.00		
					91	106.64
>>> A#3 <<<	A# 3	+5	(5893)	+5.86		
					79	92.58
>>> B 3 <<<	B 3	-1	(5972)	-1.17		
					95	111.33
>>> C 4 <<<	C 4	+9	(6067)	+10.55		

Vallotti & Young

Francescantonio Vallotti and Thomas Young, both living in the mid-1700s, devised an adjustment to the Pythagorean tuning in which the first six fifths are lowered by the same slight amount. This temperament, derived from a key-based tuning, is capable of performance in any key. Here is the tuning data for the DX7 II.

VALLOTTI & YOUNG

Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 3 <<<	C 3	+5	(5039)	+5.86		
					81	94.92
>>> C#3 <<<	C# 3	+0	(5120)	+0.00		
					87	101.95
>>> D 3 <<<	D 3	+2	(5207)	+2.34		
					87	101.95
>>> D#3 <<<	D# 3	+4	(5294)	+4.69		
					80	93.75
>>> E 3 <<<	E 3	-2	(5374)	-2.34		
					94	110.16
>>> F 3 <<<	F 3	+7	(5468)	+8.20		
					76	89.06
>>> F#3 <<<	F# 3	-2	(5544)	-2.34		
					91	106.64
>>> G 3 <<<	G 3	+3	(5635)	+3.52		
					84	98.44
>>> G#3 <<<	G# 3	+2	(5719)	+2.34		
					83	97.27
>>> A 3 <<<	A 3	+0	(5802)	+0.00		
					91	106.64
>>> A#3 <<<	A# 3	+5	(5893)	+5.86		
					76	89.06
>>> B 3 <<<	B 3	-4	(5969)	-4.69		
					94	110.16
>>> C 4 <<<	C 4	+5	(6063)	+5.86		

1/4 Shifted Equal

This preset shifts the entire equal tempered scale up by 42 TU. This corresponds to 49.14 cents which is just under a quarter step. In this tuning, some of the keys on the DX7 II keyboard have been assigned different note values. As in the equal tempered scale, this is because the tuning units do not correspond exactly with cents. Here is the tuning data for the 1/4 shifted equal scale.

1/4 SHIFTED EQUAL

Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 3 <<<	C# 3	-43	(5077)	-50.39		
					85	99.61
>>> C#3 <<<	C# 3	+42	(5162)	+49.22		
					86	100.78
>>> D 3 <<<	D# 3	-42	(5248)	-49.22		
					85	99.61
>>> D#3 <<<	E 3	-43	(5333)	-50.39		
					85	99.61
>>> E 3 <<<	E 3	+42	(5418)	+49.22		
					86	100.78
>>> F 3 <<<	F# 3	-42	(5504)	-49.22		
					85	99.61
>>> F#3 <<<	G 3	-43	(5589)	-50.39		
					85	99.61
>>> G 3 <<<	G 3	+42	(5674)	+49.22		
					86	100.78
>>> G#3 <<<	A 3	-42	(5760)	-49.22		
					85	99.61
>>> A 3 <<<	A# 3	-43	(5845)	-50.39		
					85	99.61
>>> A#3 <<<	A# 3	+42	(5930)	+49.22		
					86	100.78
>>> B 3 <<<	C 4	-42	(6016)	-49.22		
					85	99.61
>>> C 4 <<<	C# 4	-43	(6101)	-50.39		

1/4 Tone

The 1/4 tone preset demonstrates a scale with more than twelve notes per octave. This scale contains twenty-four equally spaced notes per octave. Each pair of consecutive notes forms an interval of roughly 50 cents, or one half of an equal tempered semitone. Remember that the tuning units do not correspond exactly with cents. This is corrected by tuning every two quarter tones to 50.13 cents followed by one quarter tone tuned to 49.14 cents. Since this tuning is based on equal temperament, none of the intervals found in the preset are pure.

As there are twenty-four notes per octave, it requires two octaves worth of keys to play one octave in pitch. The following tuning data therefore spans two octaves.

1/4 TONE

Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 2 <<<	C 3	+0	(5034)	+0.00		
					43	50.39
>>> C#2 <<<	C# 3	-43	(5077)	-50.39		
					43	50.39
>>> D 2 <<<	C# 3	+0	(5120)	+0.00		
					42	49.22
>>> D#2 <<<	C# 3	+42	(5162)	+49.22		
					43	50.39
>>> E 2 <<<	D 3	+0	(5205)	+0.00		
					43	50.39
>>> F 2 <<<	D# 3	-42	(5248)	-49.22		
					42	49.22
>>> F#2 <<<	D# 3	+0	(5290)	+0.00		
					43	50.39
>>> G 2 <<<	E 3	-43	(5333)	-50.39		
					43	50.39
>>> G#2 <<<	E 3	+0	(5376)	+0.00		
					42	49.22
>>> A 2 <<<	E 3	+42	(5418)	+49.22		
					43	50.39
>>> A#2 <<<	F 3	+0	(5461)	+0.00		
					43	50.39
>>> B 2 <<<	F# 3	-42	(5504)	-49.22		
					42	49.22
>>> C 3 <<<	F# 3	+0	(5546)	+0.00		

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Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 3 <<<	F# 3	+0	(5546)	+0.00		
					43	50.39
>>> C#3 <<<	G 3	-43	(5589)	-50.39		
					43	50.39
>>> D 3 <<<	G 3	+0	(5632)	+0.00		
					42	49.22
>>> D#3 <<<	G 3	+42	(5674)	+49.22		
					43	50.39
>>> E 3 <<<	G# 3	+0	(5717)	+0.00		
					43	50.39
>>> F 3 <<<	A 3	-42	(5760)	-49.22		
					42	49.22
>>> F#3 <<<	A 3	+0	(5802)	+0.00		
					43	50.39
>>> G 3 <<<	A# 3	-43	(5845)	-50.39		
					43	50.39
>>> G#3 <<<	A# 3	+0	(5888)	+0.00		
					42	49.22
>>> A 3 <<<	A# 3	+42	(5930)	+49.22		
					43	50.39
>>> A#3 <<<	B 3	+0	(5973)	+0.00		
					43	50.39
>>> B 3 <<<	C 4	-42	(6016)	-49.22		
					42	49.22
>>> C 4 <<<	C 4	+0	(6058)	+0.00		

1/8 Tone

This preset forms a scale with forty-eight notes per octave. Each pair of consecutive notes forms an interval of approximately 25 cents, or one quarter of an equal tempered semitone. The discrepancy between tuning units and cents is corrected by tuning every two eighth tones to 24.57 cents followed by one quarter tone tuned to 25.74 cents. As in the 1/4 tone scale, none of the intervals are pure due to the fact that this tuning is based on equal temperament.

Since there are forty-eight notes per octave, it requires four octaves worth of keys to play one octave in pitch. The following tuning data therefore spans four octaves.

1/8 TONE

Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 2 <<<	C 3	+0	(5034)	+0.00		
					22	25.78
>>> C#2 <<<	C 3	+22	(5056)	+25.78		
					21	24.61
>>> D 2 <<<	C# 3	-43	(5077)	-50.39		
					21	24.61
>>> D#2 <<<	C# 3	-22	(5098)	-25.78		
					22	25.78
>>> E 2 <<<	C# 3	+0	(5120)	+0.00		
					21	24.61
>>> F 2 <<<	C# 3	+21	(5141)	+24.61		
					21	24.61
>>> F#2 <<<	C# 3	+42	(5162)	+49.22		
					22	25.78
>>> G 2 <<<	D 3	-21	(5184)	-24.61		
					21	24.61
>>> G#2 <<<	D 3	+0	(5205)	+0.00		
					21	24.61
>>> A 2 <<<	D 3	+21	(5226)	+24.61		
					22	25.78
>>> A#2 <<<	D# 3	-42	(5248)	-49.22		
					21	24.61
>>> B 2 <<<	D# 3	-21	(5269)	-24.61		
					21	24.61
>>> C 3 <<<	D# 3	+0	(5290)	+0.00		

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Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 3 <<<	D# 3	+0	(5290)	+0.00		
					22	25.78
>>> C#3 <<<	D# 3	+22	(5312)	+25.78		
					21	24.61
>>> D 3 <<<	E 3	-43	(5333)	-50.39		
					21	24.61
>>> D#3 <<<	E 3	-22	(5354)	-25.78		
					22	25.78
>>> E 3 <<<	E 3	+0	(5376)	+0.00		
					21	24.61
>>> F 3 <<<	E 3	+21	(5397)	+24.61		
					21	24.61
>>> F#3 <<<	E 3	+42	(5418)	+49.22		
					22	25.78
>>> G 3 <<<	F 3	-21	(5440)	-24.61		
					21	24.61
>>> G#3 <<<	F 3	+0	(5461)	+0.00		
					21	24.61
>>> A 3 <<<	F 3	+21	(5482)	+24.61		
					22	25.78
>>> A#3 <<<	F# 3	-42	(5504)	-49.22		
					21	24.61
>>> B 3 <<<	F# 3	-21	(5525)	-24.61		
					21	24.61
>>> C 4 <<<	F# 3	+0	(5546)	+0.00		

– continued –

Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 4 <<<	F# 3	+0	(5546)	+0.00		
					22	25.78
>>> C#4 <<<	F# 3	+22	(5568)	+25.78		
					21	24.61
>>> D 4 <<<	G 3	-43	(5589)	-50.39		
					21	24.61
>>> D#4 <<<	G 3	-22	(5610)	-25.78		
					22	25.78
>>> E 4 <<<	G 3	+0	(5632)	+0.00		
					21	24.61
>>> F 4 <<<	G 3	+21	(5653)	+24.61		
					21	24.61
>>> F#4 <<<	G 3	+42	(5674)	+49.22		
					22	25.78
>>> G 4 <<<	G# 3	-21	(5696)	-24.61		
					21	24.61
>>> G#4 <<<	G# 3	+0	(5717)	+0.00		
					21	24.61
>>> A 4 <<<	G# 3	+21	(5738)	+24.61		
					22	25.78
>>> A#4 <<<	A 3	-42	(5760)	-49.22		
					21	24.61
>>> B 4 <<<	A 3	-21	(5781)	-24.61		
					21	24.61
>>> C 5 <<<	A 3	+0	(5802)	+0.00		

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Note Name	Coarse Tune	Fine Tune	Tuning Units	Δ ET Cents	Interval Size TU	Interval Size Cents
>>> C 5 <<<	A 3	+0	(5802)	+0.00		
					22	25.78
>>> C#5 <<<	A 3	+22	(5824)	+25.78		
					21	24.61
>>> D 5 <<<	A# 3	-43	(5845)	-50.39		
					21	24.61
>>> D#5 <<<	A# 3	-22	(5866)	-25.78		
					22	25.78
>>> E 5 <<<	A# 3	+0	(5888)	+0.00		
					21	24.61
>>> F 5 <<<	A# 3	+21	(5909)	+24.61		
					21	24.61
>>> F#5 <<<	A# 3	+42	(5930)	+49.22		
					22	25.78
>>> G 5 <<<	B 3	-21	(5952)	-24.61		
					21	24.61
>>> G#5 <<<	B 3	+0	(5973)	+0.00		
					21	24.61
>>> A 5 <<<	B 3	+21	(5994)	+24.61		
					22	25.78
>>> A#5 <<<	C 4	-42	(6016)	-49.22		
					21	24.61
>>> B 5 <<<	C 4	-21	(6037)	-24.61		
					21	24.61
>>> C 6 <<<	C 4	+0	(6058)	+0.00		