การสังเคราะห์เสียงเพื่อเซตฟังก์ชันจูนนิ่งระบบเสียงสำหรับเครื่องดนตรีไฟฟ้าสากลร่วมสมัยตามแนวระบบเสียงดนตรีไทย

SYNTHESIZING SOUND FOR SETTING FUNCTION TUNING (USED IN ELECTRONIC INSTRUMENTS FOLLOW THAI TRADITIONAL MUSICAL SCALE)

*Thassana Asoksiri**

ABSTRACT

This thesis is about researching and developing. Studying the structure of 7 equidistant tone musical system use by Thai traditional musical bands and how to setup tuning functions in electronic musical instruments. Using electric musical instruments in a Thai traditional musical band for performance is the objective. The results of this study are as follows:

1. The format of Thai 7 equidistant tone musical system that is divided by equal 7 intervals in an octave. It uses 5 tones to create the Thai musical scale. It can modulate to another scale in the Thai 7 equidistant tone musical system when being performed.

2. Setup the frequency of the notes by using the Micro tuning function in electronic instruments, such as keyboards or synthesizers, to tune the frequency of notes when performing with Thai traditional instruments.

Master Degree, College of Music, Mahidol University
**Correspondent author: tazzuya@aol.com*

Keywords : THE 7 EQUIDISTANT TONE MUSICAL SCALE SYSTEM, TUNING INSTRUMENTS INTO THE THAI MUSICAL SCALE, FORMAT OF MUSICAL SCALE USED IN THAI MUSIC

บทคัดย่อ

วิทยานิพนธ์เรื่องการสังเคราะห์เสียงเพื่อเซตฟังก์ชันจูนนิ่งระบบเสียงสำหรับเครื่องดนตรีไฟฟ้าสากลร่วมสมัยตามแนวระบบเสียงดนตรีไทยเป็นการวิจัยเชิงการทดลองและพัฒนา โดยมีวัตถุประสงค์เพื่อศึกษารูปแบบและแนวทางของระบบเสียงดนตรีไทยแบบ 7 เสียงแบ่งเท่าและการเซ็ทฟังชันจูนนิงในเครื่องดนตรีไฟฟ้าสากล เพื่อให้สามารถนำเครื่องดนตรีไฟฟ้าสากลมาบรรเลงร่วมกับวงดนตรีไทยได้อย่างลงตัว ผลการวิจัยมีข้อค้นพบดังนี้

1. รูปแบบของระบบเสียงดนตรีไทยแบบ 7 เสียงแบ่งเท่ามีโครงสร้างระยะห่างของโน้ตเท่ากันทุกเสียงใน 1 ช่วงเสียง (Octave) โดยมีโน้ตทั้งหมด 7 เสียง เมื่อใช้บรรเลงจะมีการใช้โน้ตหลัก 5 เสียง และมีการเปลี่ยนกลุ่มของโน้ตหลักได้ในขณะบรรเลง

2. การเซ็ทฟังชันจูนนิงในเครื่องดนตรีไฟฟ้าสากลเพื่อที่จะนำมาบรรเลงกับวงดนตรีไทยประเภทคีย์บอร์ด(Keyboard) หรือ ซินธิไซเซอร์(Synthesizer) พบว่า จะต้องใช้ฟังชันที่เรียกว่า Micro Tuning (การปรับเสียงแบบละเอียด) จึงจะสามารถปรับความถี่เสียงให้ตรงกับระบบเสียงแบบ 7 เสียงแบ่งเท่าที่ใช้บรรเลงในวงดนตรีไทยได้

คำสำคัญ : ระบบบันไดเสียงดนตรีไทยแบบ 7 เสียงแบ่งเท่า การจูนระดับเสียงของเครื่องดนตรีเข้ากับระบบบันไดเสียงไทย รูปแบบระบบบันไดเสียงที่ใช้ในดนตรีไทย

Introduction

Statement of the objective of study

Thai classical music is one of the cultural heritages of Thailand!

The objective of research has become to synthesize the frequencies of pitches used in classical music for tuning function used in electric instruments, such as synthesizer and Thai classical instruments. Unfortunately, at present, the frequency of each note that appears in the musical scale system can not be identified because there is no standard of frequency for each pitch. Because there is no reference to tune electric instruments to musical scale, tuning Thai instruments for Thai classical bands has a variety of frequencies in difference locations. Nowadays, Thai musicians try to tune the pitch of their instruments to the Western musical scale system when they perform with western instruments, that changes the unique sound of Thai classical instrument characteristics. However because of this, the objective of research has become to synthesize the frequencies for tuning function use in electric instruments according to the musical scale system.

Significance of research

I have discovered in my research, the Thai musical scale system is different from Western music! If there were methods to develop tuning electric instruments for modern Thai contemporary bands the following musical scale system. Electric instruments, such as keyboards or synthesizers, must be tuned into the musical scale in order to be played in harmony with classical instruments for the contemporary bands. From the observations I have found, the significance of classical music can be identified by two characteristics; the structure of songs and the musical scale system.

Classical songs can be categorized according to the band who performs it. Classical bands have been categorized according to which events they performed and which instruments are used, such as Mahori or Piphat. Songs performed by Mahori were used to help the King sleep and Piphat songs are performed for ceremonies.

Another characteristic that can be identified is the musical scale system. If electric instruments were tuned the musical scale when play with traditional instruments, it would keep the characteristics of the music and develop them into a modern style with the uniqueness of classical music in the future. The results of research can be references to tune other electric instruments or musical software. It is an exciting opportunity to create a new style of classical music in the future.

Objective of the research

1. To study the this musical system that has been used in culture from past to present in Piphat.

2. To synthesize function of the tuning system used in electronic musical instruments into the traditional musical scale system.

Hypothesis

1. The appearance of structure and format of Thai musical scale system.

2. How to setup tuning function in electric instruments following the Thai musical scale system for performing with Thai instruments on Thai classic song.

Scope and delimitation of research

1. The musical scale system used in this research will be followed by the musical scale system that is used in the traditional band called Piphat.

2. Development of the tuning system used by musical software to setup the tuning function and generate the sound of electronic instruments for research.

Methods of Research

Method of this research consists of four parts. Firstly, study of the musical scale used in classical music from documents. Secondly, I have studied in private classes of Thai instruments performing with professors of classical music at College of music, Mahidol University. Thirdly, I have recorded sound samples of classical instruments to use as example to adjust frequencies of pitches into the musical scale system by computer programs following the results of studies from documents. Finally, I my researching, I have studied function tuning that was used in electronic instruments, such as synthesizer, including software and hardware.

Study to format and structure of the Thai musical scale system for documents

I have studied context and structure of the 7 equidistant tones of the Thai musical scale system that is used by Thai Piphat musicians, from the past to present. While studying documents and research, from many languages including musical notations, related to the 7 equidistant tones of the musical scale, in order to study the structure and format of the musical scale system. I used “cent theory” to compare and represent intervals or pitches that appear in the musical scale. The formula of cent is as follows

$$Cent = \frac{1200.log^{\frac{I_1}{I_2}}}{log\ 2}$$

Study to perform Thai musical instruments with professors in Thai music

Interview data has been collected from studies in private music classes with professors of classical music or musicians that had been accepted by people who work in genre.

My research was conducted with the following music professors: Prof. Dach Koneam (Ranad Eak-musical instrument) from Nakhon Sawan Rajabhat University. Mr.Saharat Chancheleum (treble fiddle) at Mahidol University. Mr. Paitoon Choeicharoen (Gong Wong Yai). Mr. Samrit Saravade (Percussion class) at Mahidol University. I also collected interview data of musical theories from Prof. Narongchai Pidokrajt, Mahidol University and Western music structure scale system from Assist. Prof. Dr. Anak Charanyanada also at Mahidol University. After classes, all data was used to correct and support information that was taken from documents.

Adjustment of pitches of Thai instruments sound samples into frequencies of musical scale by computer program follow results of study of musical scale structure

I recorded the sound of the following instruments: Ranad Eak, Ranad Tum Lek and Gong Wong Yai as example sounds to adjust into musical scale. The sound samples of instruments were used to tune the frequency that resulted from the study of the musical scale system.

Study function tuning used in electronic instrument

In studying tuning function used in software and hardware synthesizers to adjust pitches into the 7 equidistant musical scale system.

Data management and analysis

Document data and interview data

Data analysis follow first order of hypothesis, The principle used to analyze the context of 7 equidistant tone musical system of the musical scale system, is an analysis of opinion from an interview with evidence for the musical scale system. Data form documents and interview of the musical scale system was categorized into a database. This database was then used to reference information for tuning the pitch into the musical scale system.

Sound samples of Thai instrument

The steps of the process as follows

1. Tune the pitch of instruments sound data into the reference frequency for synthesize following the musical scale structure

2. Set the frequency of pitch in electric instrument into the 7 equidistant tone musical system by using the tuning function

3. Program song by midi on DAW and run sampler plugin for Thai instruments and softsynth together for the experiment.

Results

The context of Thai musical scale system

According to many documents, the concept of the musical scale is known for dividing the octave into 7 tones. These tones are different from the Western musical scale system when they are compared. The oldest

recorded evidence was in 1885 by English musicologists, from documents of The Study of the Musical Scale System by Mr.Alfred James Hipkens and Mr.Alexander J. Ellis from a Thai band who performed at the London Inventions Exhibition in 1885. It was recorded on the document called “On the Musical Scales of Various Nations” (Chareoensook, S., 1997, p7). The oldest Thai document to mention the musical scale was published in a book called ‘Wachirayanwisaek’ in 1890 (Chareoensook, S., 1997, p23). Also, another book called ‘Siamese Music’ mentioned the equal 7 tones of the musical scale is a different scale from Western music. A photo shows the ratio of intervals when compared with Western music (Figure 1). In 1950, The Fine Arts Department of Thailand published a musical notation of evening prelude, which has one section mentioning the equal 7 tones of the musical scale system (Figure 2). In 1976, Mr.David Morton recorded the results of his research for his Doctorates Degree for the University of California in a book called, ‘The Traditional Music of Thailand’, Diagram (Figure 3) compares the structure of cents of adjacent pitches between the two scales. From the information above, including information collected from these music private classes. The musical scale system has been equally divided into 7 pitches in an octave. It has intervals of 171.42 cents adjacent of each pitch (Figure 4). The research has arranged the results of the study to compare the intervals in cent between the 7 equidistant tone musical scale and the equal temperament scale system into the table. The decimal has been rounded up; if the value is equal to or more than 0.5. On the other hand, if the value is less than 0.5, it has been rounded down for tuning electric instruments (table 1).

Structure and format of the Thai musical scale system

Structure of 7 equidistant tone musical scale system has equal 171.42 cents intervals (Figure 5). Notes used in the musical scale system include 7 pitches in an octave (Figure 6). The musical scale that uses 5 notes, consisting of C, D, E, G, and A, is similar to the pentatonic scale that is found in Western music (Figure 7). In addition to the 5 notes that are mainly used in the musical scale for performing classical songs, the other 2 notes have been used for different accents with in the songs or, it can be used to modulate to another scale when performing. The Thai word used for the musical scale is "Thang"(Figure 8-14).

Searching for frequency of pitch in Thai musical scale system

To calculate the frequency used in the initial frequency by changing cent value, use software from website www.sengpielaudio.com/calculator-centsration.htm (Figure 15). According to the study of documents on the musical scale system used in Pinphat, the frequency of each note that appears in the musical scale system, can not be identified because there is no standard of frequency for each pitch. There are a variety of frequencies found in different locations in Thailand. This research used the reference frequency pitch from the equal temperament scale system that is displayed on the piano keys (Figure 16). From the study of these musical notations, the accidentals, sharp (#) or flat (♭), were not found (Figure 17-18). I have considered pitch without accidentals only to experiment a method of calculating a frequency. Also, I have taken the initial tone form equal temperament for calculation by using C note, with a frequency of 261.63 Hz and uses the cent value form the study of the musical structure. The results of the calculation of the musical scale system is show in table (table 2).

Tuning sound samples into 7 equidistant tone musical scale system

In my fieldwork, I have recorded the sound of the following instruments: Ranad Tum Lek, Ranad Ek and Gong Wong Yai (Figure 19) into digital recording software called Protools LE8 (Figure 20), to make these sound samples. There was no standard frequency of pitch in this scale system. All pitches of these sound samples have been tuned into the equal temperament scale system. The frequency of the sound samples was adjusted into the equal temperament scale system as a reference for the sound samples by the Autotune software (Figure 21-22). After that, all pitches have been adjusted again into the 7 equidistant tone musical scale system by a plug-in called Pitch Shift, from Protools following results of this study, (see Figure 23-24). I had also used a sampler plug-in in Logic pro9, called EXS24. Mapping all sound samples into a keyboard of EXS24 pitch by pitch. After mapping the sound samples, use the plug-in with MIDI note that has been programed from Tub Nang Cinderella (Roongruang, P., 2001, p.1). The instruments used on MIDI note were Ranad Ek, Kong Wong Yai, Ranad Tum Lek and Ching. The result is as follow https://youtu.be/p9jEnxNw4VI

Tuning function used in Electric instruments software and Hardware

From this study of tuning functions used in Softsynth or Synthesizer hardware. In general, the Synthesizer Software or Hardware does not have an adjustable frequency or cent value of the pitch. It can only adjust the value of filters or the value of the effect parameters. The waveform can be changed when adjusting with an audio effect or filter. However; it does not effect the frequency of pitch. The frequency of pitch is generated following the equal temperament scale system. This is why, when a synthesizer or keyboard is played in contemporary band's the sound does not go well with these Thai instruments. When using a synthesizer software or hardware to

perform with (Roongruang, P., 2001, p.1). Thai instruments, it must be set the tuning function in the Synthesizer software or hardware, because the musical scale system has a different cent value or frequency of these notes. This is called the "micro tuning function" (Figure 25-26). Using softsynth called FM8 (Figure 27), that was tuned to the 7 equidistant tone musical scale, to play these music with a Thai sampler. The result as follow https://youtu.be/esX0siOxun4

Discussion

The results of the study of the 7 equidistant tone musical scale system are it has 7 pitches, these are C, D, E, F, G, A and B. They have been arranged into 7 scales, consisting of the following "Thang Piang-aw-lang, Thang Nai, Thang Klang, Thang Piang-aw-bon, Thang Nok, Thang Klang-hap and Thang Chawa". All scales include 5 of the 7 pitches in the musical scale system (Figure 7). The fourth and seventh note degrees have been used in other functions. They were used to modulate into another scale when performing some of the national characteristics. In a Thai band, consideration of which musical scale to use depends on which Thai duct flute, or Khlui is used.

After adjusting the frequency into electric instruments by computer software and playback over MIDI tracks of a song to musical professors at College of music, Mahidol University. The result of using the micro tuning function in electric instruments to perform classical music, the audience experienced a smooth sound. However, if micro tuning function was not used, they experienced and out of tune scale from the instruments. The results of the study can be used to tune these instruments, as well as to preserve the specific characteristic of the classical scale system.

After playback over MIDI tracks of a song, I have played scale in order pitch by pitch to the musical professors. Some of them heard a different interval from the regular musical scale. This is because from the study of the method of tuning used in the band using a Piphat in the past, they tuned the pitch by using woodwind instruments, such as Khlui, to tune the pitch for the other instruments in the band. The tuning of these instruments was done by ear. The reason Khlui is used to tune the pitch of the other instruments is because, it is difficult to tune the pitch of Khlui. Considering the use of an instrument as reference to tune another, it is difficult to adjust the pitch. The Thai woodwind instruments have an un-adjustable pitch, that is why they are used to tune other instruments. "The Pi-nai" is the woodwind instrument that it used to tune other instruments in Piphat. In the Phrabat Somdat Phra Pinklao Chaoyuhua (Rama 4) era, new instruments, called Ranad Ek Lek and Ranad Tum Lek, were built to use in Piphat (The sound frequency of the notes used in the musical scale, 1999, p.7) Both of them were difficult to adjust the pitch because of the process of building those instruments. It was difficult to build these woodwinds and bar sticks made from iron. As a result, the woodwinds were no longer used for tuning of the Piphat. Ranad Ek Lek and Ranad Tum Lek are used as a reference for tuning instruments in Piphat instead. Nowadays, it has mobile application to tune these instruments called Thai tuner by Mahidol University's Creative Economy Center (Mahidol University, Creative Economy Center, 2017). The structure of cent used in application close to the result of this research as follow 171.42 cents.

To use other electric instruments such as electric guitar or bass, all frets on fretboard must be removed and setup into the equal temperament system. This would be difficult to use with the musical scale system. However, using fretless instruments to perform with a classical band will work well while performing.

After that, when I discovered the frequency of the musical scale system by changing an initial frequency into other pitches in the equal temperament scale system, consisting of D, E, F, G, A and B. Using the same method of calculation to formulate the frequency of the pitch, the results are as follows (table 3). The findings varied when changing the initial frequency to that of the 7 equidistant tone musical scale. but it does not change a structure when used.

Recommendation

Recommendations from the research

1. The initial frequency to calculate the musical scale system should be the C note, as in the equal temperament system because musicians use C note as a reference pitch for tuning.

2. Consideration of using initial frequency to tune electric instrument depend on the instrument being used (i.e: duct flute).

General recommendations

1. The results of the study of the cent value can be used as a reference for the 7 equidistant tone musical scale system.

2. The results of the study of the structure and method of the 7 equidistant tone musical scale can be a reference for studying the Thai musical scale system.

3. The method of tuning musical instruments used in this research can be a reference for tuning electric instruments into the Thai musical scale system.

4. Sound can be generated by a synthesizer, or musical software, to imitate Thai musical instruments, if the sound samples can not be found or recorded.

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Mahidol University's Creative Economy Center (2017). *Thai tuner.* Retrieved May 23, 2017, from https://www.facebook.com/CreativeEconomy Center/?ref=py_c

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Table 1 Comparison of cent

Note	Equal Temperament scale system (Cent)	Thai musical scale system (Cent)	Deviation	Deviation rounding
C	0	0	-	-
D	200	171.4	-28.6	-29
E	400	342.8	-57.2	-57
F	500	514.2	+14.2	+14
G	700	685.7	-14.3	-14
A	900	857.1	-42.9	-43
B	1,100	1028.5	-71.5	-72
C	1,200	1,200	-	-

Table 2 The frequency of the equal temperament and Thai 7 equidistant tone musical scale comparison chart

Equal Temperament scale		Note	Thai 7 equidistant tone musical scale	
Frequency (Hz)	Cent		Frequency (Hz)	Cent
261.63	0	C	261.63	0
293.66	200	D	288.86	171.42
329.63	400	E	318.92	342.84
349.23	500	F	352.12	514.26
392	700	G	388.77	685.68
440	900	A	429.23	857.10
493.89	1,100	B	473.91	1,028.52
523.26	1,200	C	523.26	1,200

Table 3 The results of calculation of different initial frequencies

Note	Frequency (Hz)						
	C	D	E	G	G	A	B
1	261.63	293.66	329.63	349.23	392	440	493.88
2	288.86	324.22	363.93	385.57	432.80	485.79	545.28
3	318.92	357.97	401.81	425.71	477.84	536.36	602.04
4	352.12	395.23	443.64	470.02	461.42	592.18	664.70
5	388.77	436.36	489.81	518.94	582.49	653.82	733.88
6	429.23	481.78	540.80	572.95	643.12	721.87	810.27
7	473.91	531.93	597.08	632.59	710.06	797.01	894.61
8	523.26	587.32	659.26	698.46	784	880	987.76

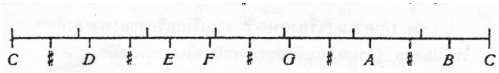

Figure 1 Picture from *Siamese Music*

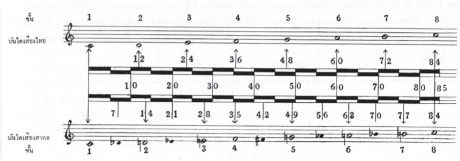

Figure 2 Picture form The Fine Arts Department

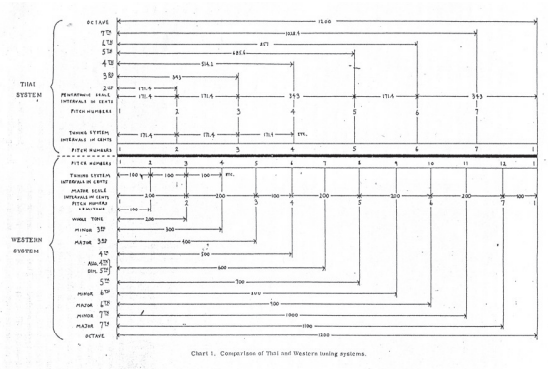

Figure 3 Diagram from The Traditional music of Thailand

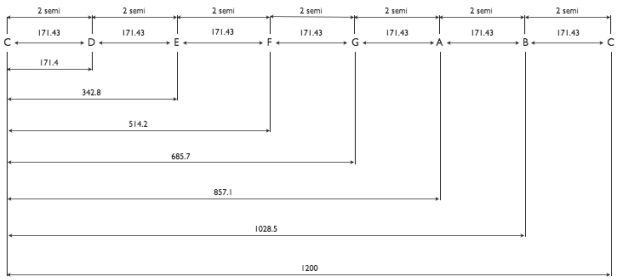

Figure 4 Structure of Thai musical scale system

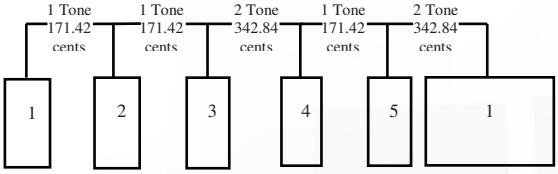

Figure 5 Structure of Thai musical scale

C	D	E	F	G	A	B
1	2	3	4	5	6	7

Figure 6 Notes used Thai musical scale system

C	D	E	G	A
1	2	3	5	6

Figure 7 Notes used in Thai musical scale

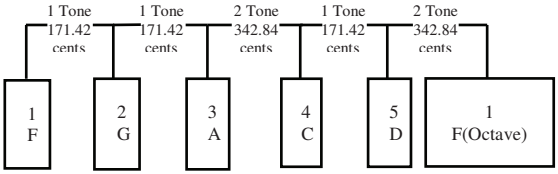

Figure 8 Thang Piang-aw-lang

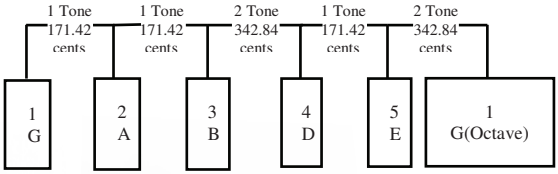

Figure 9 Thang Nai

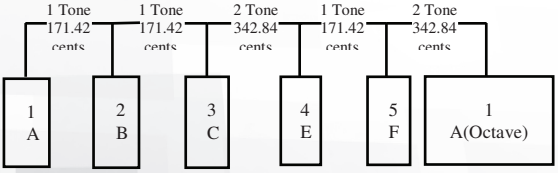

Figure 10 Thang Klang

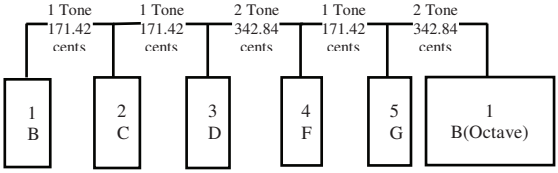

Figure 11 Thang Piang-aw-bon

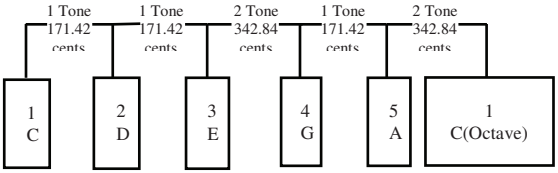

Figure 12 Thang Nok

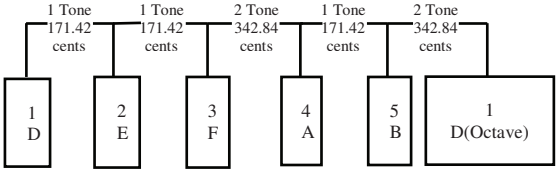

Figure 13 Thang Klang-hap

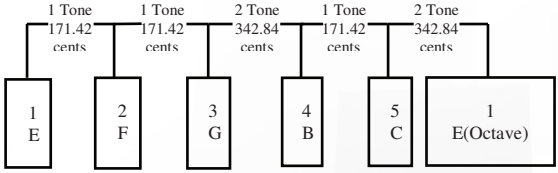

Figure 14 Thang Chawa

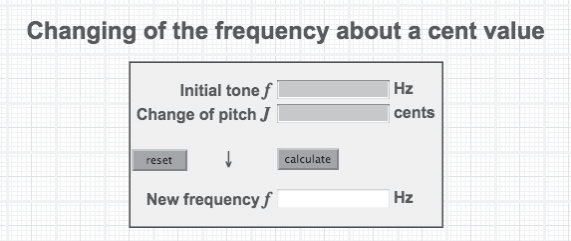

Figure 15 Calculator software
from www.sengpielaudio.com

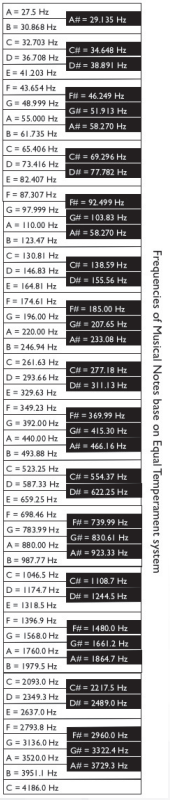

Figure 16 Frequencies of equal temperament scale

- - - ซ	- - - ซ	- ซ - ด	- - - ด	- ท ด ร	- ด - ท	- ด - ร	- ฟ - ด
- ฟ - ร	- ด - ท	- ด - ร	- ฟ - ด	- ร ฟ ซ	- ท - ด	- ร - ด	- ท - ซ
- - - ซ	- - - ซ	- ร - ซ	- ท - ด	- ซ ฟ ร	- ด - ท	- ด - ร	- ฟ - ด
- ฟ - ร	- ด - ท	- ด - ร	- ฟ - ด	- ร - ฟ	- ซ - ท	- - ร ด	ท ด - ร

Figure 17 Thai musical notation

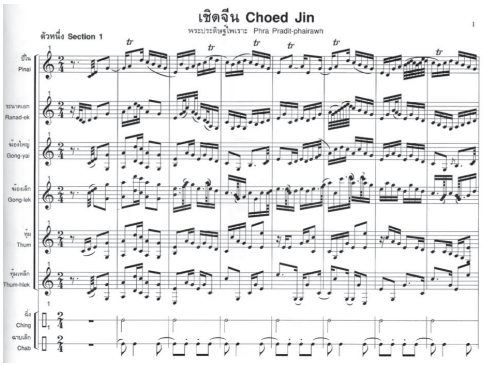

Figure 18 Thai classical song notation from Collect works of the Thai Classic Repertoire Volume 4

Figure 19 Recording of Thai classical instruments

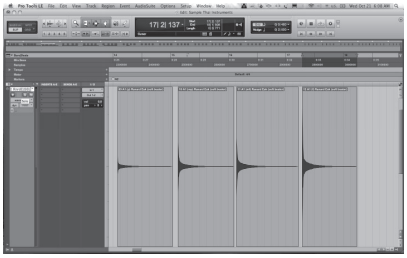

Figure 20 Waveform of Thai classical instruments

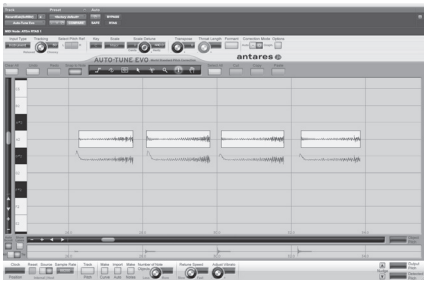

Figure 21 Adjust pitches of Thai classical Samples to equal temperament scale system

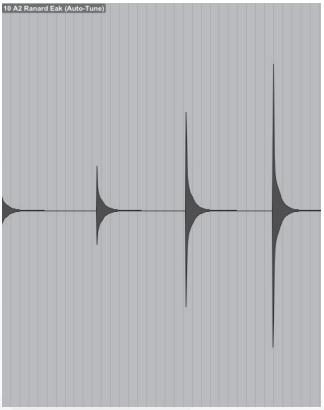

Figure 22 Waveform of Thai classical instruments after pitch adjustment of equal temperament scale system from Autotune software

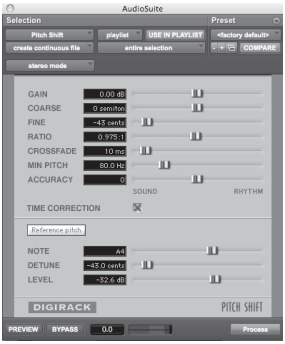

Figure 23 Adjust pitches of Thai classical instruments into Thai 7 equidistant tone musical system

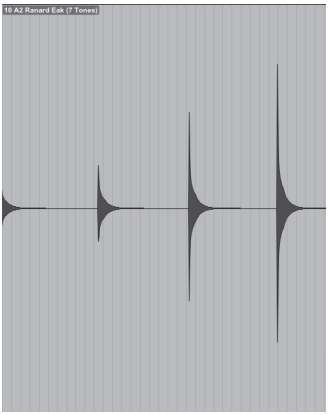

Figure 24 Waveform of Thai classical instruments after pitch adjustment into 7 equidistant scale system from Pitch shift software

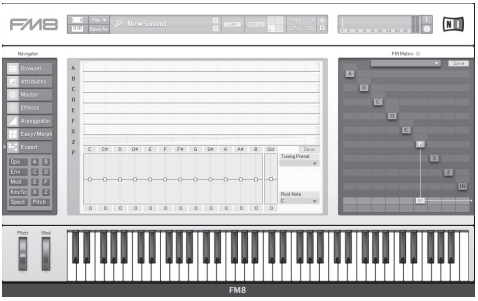

Figure 25 Micro tuning function used in Softsynth (FM8)

Figure 26 Micro tuning function used in Hardware

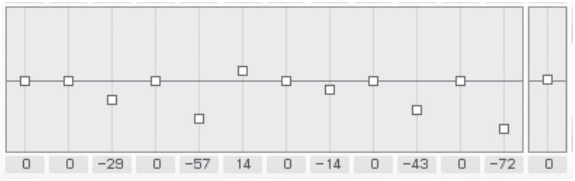

Figure 27 Micro tuning function in FM8 Softsynth