THAI TRADITIONAL MUSIC TUNING SYNTHESIZING FOR FUNCTION TUNING SETTING USED IN CONTEMPORARY ELECTRONIC MUSICAL INSTRUMENTS

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THAI TRADITIONAL MUSIC TUNING SYNTHESIZING FOR FUNCTION TUNING SETTING USED IN CONTEMPORARY ELECTRONIC MUSICAL INSTRUMENTS

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ABSTRACT

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

1. The format of Thai equal 7 tone 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 equal 7 tone system when being performed.

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

KEY WORDS: THE THAI MUSICAL SCALE SYSTEM/ TUNING INSTRUMENTS INTO THE THAI MUSICAL SCALE SYSTEM/ MICRO TUNING/ FORMAT OF THE THAI MUSICAL SCALE SYSTEM/ THAI CONTEMPORARY MUSIC

239 pages

การสังเคราะห์การเซ็ทฟังชันจูนนิงระบบเสียงสำหรับเครื่องดนตรีไฟฟ้าสากลร่วมสมัยตามแนวระบบเสียงดนตรีไทย

THAI TRADITIONAL MUSIC TUNING SYNTHESIZING FOR FUNCTION TUNING SETTING USED IN CONTEMPORARY ELECTRONIC MUSICAL INSTRUMENTS

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บทคัดย่อ

วิทยานิพนธ์ฉบับนี้เป็นการวิจัยเชิงการทดลองและพัฒนา 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 จึงจะสามารถปรับความถี่เสียงให้ตรงกับระบบเสียงแบบ 7 เสียงแบ่งเท่าที่ใช้บรรเลงในวงดนตรีไทยได้

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CHAPTER I
INTRODUCTION

1.1 Significance and statement of the objective of study

Thai classical music is one of the cultural heritages of Thailand. It has developed form and function of songs and bands from each era and knowledge has been passed on to the next generation for many years. It can be categorized from the periods of the history of Thailand. The oldest evidence of Thai music was found during the King Ram Khamhaeng era. During this period, knowledge of Thai classical music was passed on orally in a group or family without transcription. The musical transcription was not found until later on, during the Rattanakosin era. At present, ancient melodies can be found even though they were not transcribed.

Nowadays, Thai classical music has developed into many musical styles. It has been categorized into contemporary music. Thai contemporary music has been adapted for the modern life style of Thai people. Thai contemporary bands combine a variety of musical instruments, such as the synthesizer or electric guitar, with traditional Thai instruments. They have been greatly influenced by Western music. The resulting groups are called Thai contemporary bands.

Since Western music, such as rock music or pop music, was introduced to Thai people, it has become popular and has influenced the style of Thai music. Thai composers or musicians try to combine Western instruments with Thai traditional instruments in Thai contemporary bands. Electric musical instruments such as the electric guitar, synthesizer or acoustic instruments such as the piano, violin or drum kit have become famous instruments in Thailand too. This has developed the format of songs and bands in Thailand.

From observation and study of researcher, the significance of Thai classical music can be identified by two characteristics; the musical scale system and the characteristics of the songs.

Thai classical songs can be categorized according to the band which performs it. Thai classical bands have been categorized according to which events they perform at 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.

At present, songs performed by Thai contemporary bands can come from the original classic songs and are then rearranged into new versions or newly composed. From observation of researcher, most of the songs that have been composed in the last ten years have a structure that references western music.

Another characteristic that can be identified is the Thai musical scale system. Researcher has found that the Thai musical scale system is different from Western music. Unfortunately, at present, the frequency of each note that appears in the Thai musical scale system can not be identified because there is no standard of frequency for each pitch. There are a variety of frequencies in different locations in Thailand. Tuning of instruments in modern Thai contemporary bands has been influenced by the Western musical scale system. Thai musicians try to tune the pitch of their instruments to the Western musical scale system when they perform with western instruments. However; tuning Western instruments to the Thai musical scale has not been noted. Characters of Thai classical music are one of the cultural heritages of Thailand. Unfortunately, significant characters of Thai classical music have disappeared because of above reason.

If there were methods to develop Thai classical music for modern Thai contemporary bands that follow Thai musical theories, such as song structure or Thai musical scale system, it would be beneficial for Thai music. It would keep the characteristics of Thai traditional music and develop them into a modern style with the unique characteristic of Thai classical music. This is the reason of significance and

statement of the objective of this thesis. Synthesizing the Thai classical music tuning for function tuning setting used in contemporary electronic musical instruments has become the objective of research.

1.2 Objective of the research

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

1.2.2 To synthesize function of tuning setting used in electronic musical instruments into the Thai musical scale system.

1.3 Hypothesis

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

1.3.2 How to setup tuning function in electric instruments following the Thai musical scale system for performing with Thai instruments on Thai songs.

1.4 Benefit of research

1.4.1 The results of research can be a standard of tuning pitch for Thai instruments and electronic instruments for Thai contemporary music.

1.4.2 To have a standard method to tune the pitch in Thai contemporary bands.

1.5 Scope and delimitation of research

1.5.1 The musical scale system used in this research will be followed by the musical scale system that is used in Thai traditional bands called Piphat.

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

1.6 Preliminary agreement

1.6.1 The sound of Thai traditional instruments recorded by Thai instruments used in Piphat.

1.6.2 Identify the pitch of notes by letters C, D, E, F, G, A and B followed by Fied do solfege.

1.7 Definition of terms

Equal temperament scale system	refers to	Musical temperament that is a system of tuning, in which an octave is separated to 12 tones. Every pair of adjacent pitches was divided into equal ratio or intervals.
Equal 7 tone scale system	refers to	Musical temperament is a system of tuning, in which an octave was separated to 7 tones. Every pair of adjacent pitches was divided into equal ratio or intervals.
Tuning	refers to	The process of adjusting the pitch or tone of musical instruments to the reference pitch or frequency.
Contemporary Music	refers to	A musical style. The concept of following modern ideas or fashion.
Cent	refers to	A unit of measurement of intervals of adjacent pitch.

Sampler	refers to	A Machine or software that is able to record, store and playback sound.
MIDI	refers to	The initials of the Musical Instrument Digital Interface, a protocol that is used by electronic instruments to communicate with other instruments.
Synthesizer	refers to	An electric musical instrument that can generate sound by electric signals in a verity of methods.
DAW	refers to	Initials of the Digital Audio Workstation, a musical sequencing program that can be used for many functions, such as composing, recording, editing and mixing.
Keyboard controller	refers to	The piano style interface used to control the software program by sending MIDI commands over a USB or MIDI cable.
Audio Plug-ins	refers to	A software component that is used to add a specific feature in DAWs.
Audio Interface	refers to	An interface for a computer that is used to convert analog signal to digital signal and digital to analog or generate sound. It is also called a sound card.
Audio frequency	refers to	The period of vibration, it produces sound via frequency of vibration from the sound source.
Sampling	refers to	The method of converting analog signals into digital signal format.

VSTi	refers to	The initials of Virtual Studio Technology instruments. It is a virtual musical instrument run on DAW.
Octave	refers to	Interval between pitches, it is double or half of the frequency of the initial pitch.

CHAPTER II

LITERATURE REVIEW

2.1 Theory and Concept

This research has followed the concepts and theories of Thai classical music. It uses modern musical technology to develop the Thai musical scale system.

2.1.1 Structure of The Equal temperament scale system

The Equal temperament scale system is used in Western musical culture. It divided the octave into 12 pitches; C, C#, D, D#, E, F, F#, G, G#, A, A#, B. It has equal intervals of adjacent pitch, with has 100 cents to each note, all equal to each other. Alternatively, it can be called 1 semitone or half step.

The structure of cent, as it appears in the equal temperament scale system, that is displayed in the picture below to identify the distance between pitches.

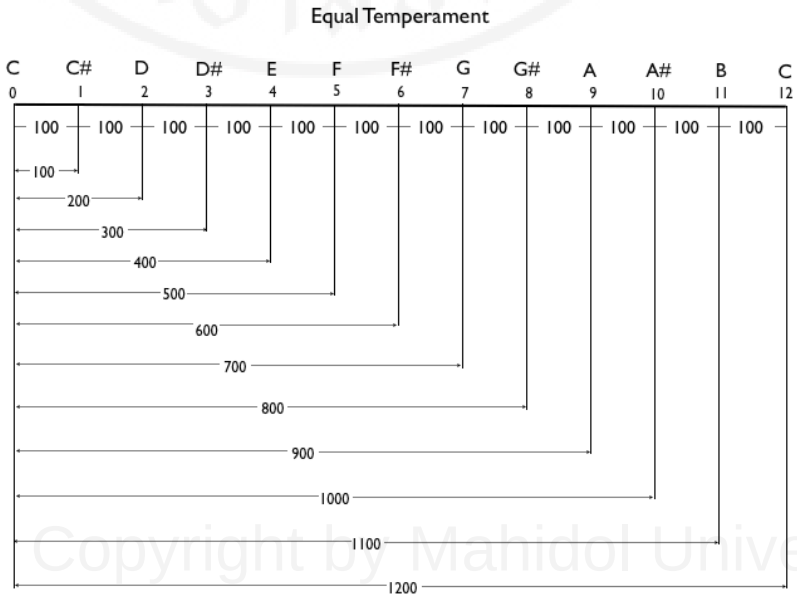


Figure 2.1 Structure of equal temperament

Example of the structural scale system, that uses pitches in the equal temperament system, to create other musical scales that have been used in tonal music of Western musical theory is as follows.

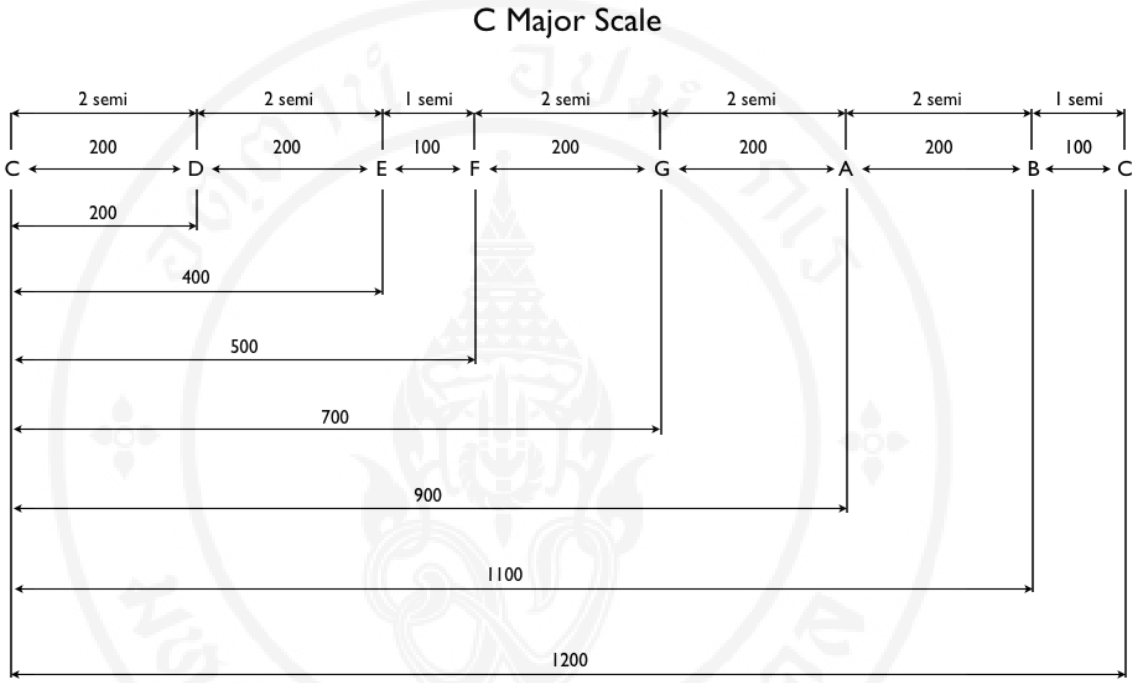


Figure 2.2 Structure of Major scale

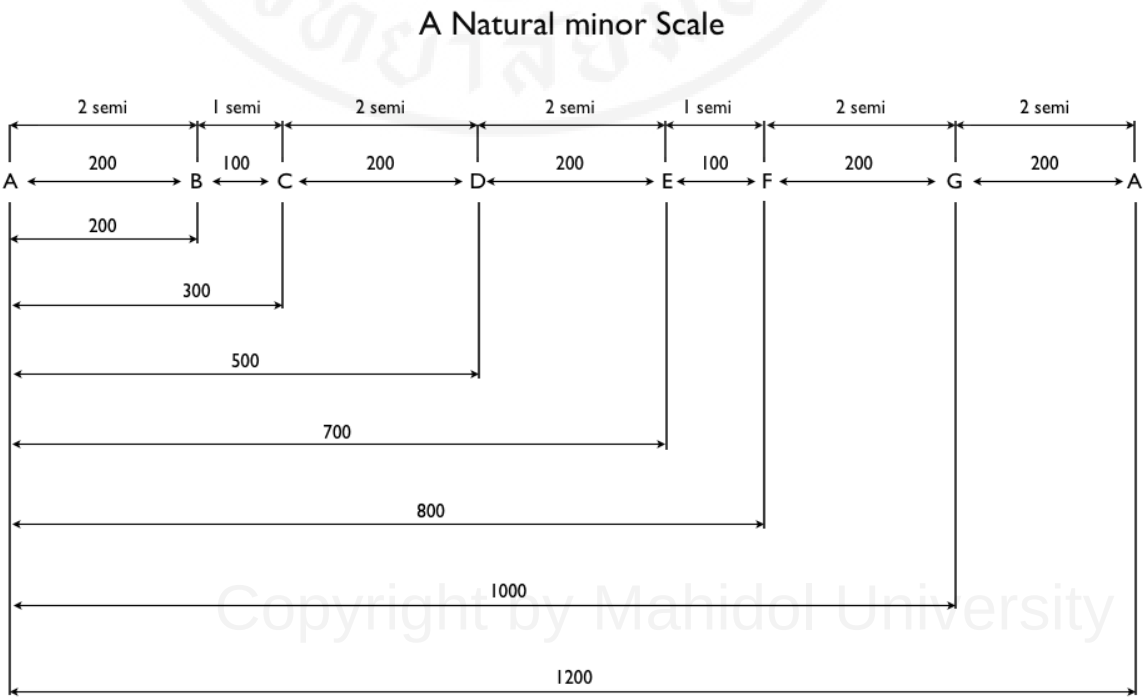


Figure 2.3 Structure of natural minor scale

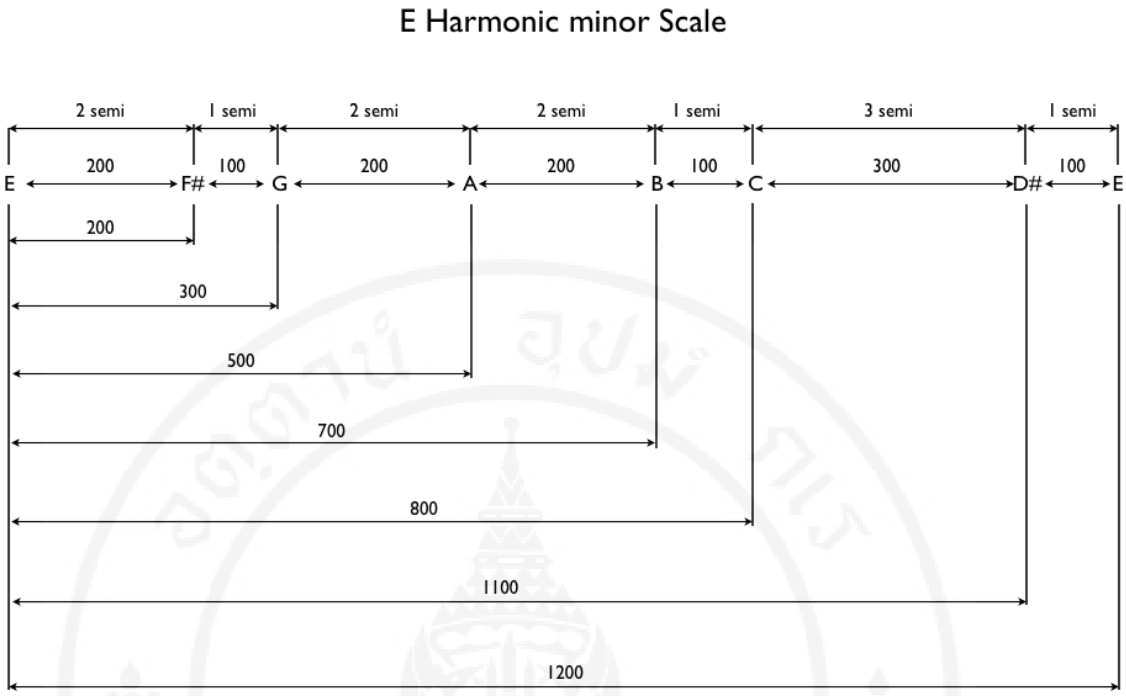


Figure 2.4 Structure of harmonic minor scale

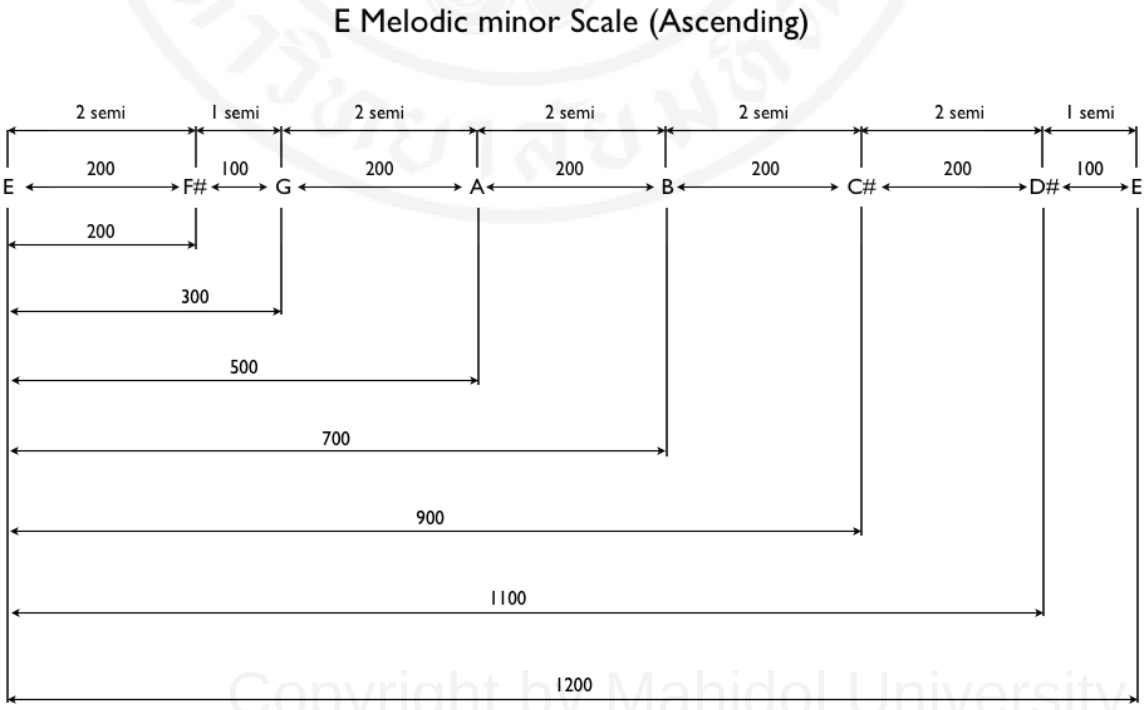


Figure 2.5 Structure of melodic minor scale

2.1.2 Cent theory

Cent theory was invented by Mr.Alexander J. Ellis. It can be used for comparing and representing intervals or pitches that appear in different musical scales around the world. In mathematics, it is called logarithm. The formula of cent is as follows.

$$\text{Cent} = \frac{K.\log 2^{(L1/L2)}}{\log 2}$$

K = 1200 (Constant number of intervals in an octave, based on the equal temperament scale system.)

2.1.3 Theory of the concept of the Thai equal 7 tone musical system

The concept of the Thai musical scale, that is known for dividing the octave into 7 tones, has been around since 1884. The oldest evidence comes from documents of the study of the Thai musical scale system by Mr.Alfred James Hipkins and Mr.Alexander J. Ellis. The King of Thailand sent a Thai classical band to perform at the London Inventions Exhibition in 1885. Mr.Sugree Charoensook (1997.p7) said,“a study of the Thai musical scale system, from a Thai classical band that included nineteen musicians, who performed in London, England in 1885. At this time, the sound of Thai instruments was recorded at Albert hall or another place.” It was recorded on the document called “On the Musical Scales of Various Nations.” It was established in the Journal of the Society of Arts on March 27, 1885. This book has become a reference for a book called ‘On the Sensations of Tone’, that was written by Mr.Hermann Helmholtz. It was published in 1954, by Dover Publications (1954.p556). The book is quoted “The King of Siam sent over his Court Band, with their instruments, to the London Inventions Exhibition 1885, and the Siamese minister obligingly allowed Mr. Hipkins and myself to determine the musical scale. Prince Prisdang told us that the intention was to divide the octaves into 7 equal intervals, each of which would then have 171.43 cents.”

According to the quote above, this is oldest evidence that mentioned the structure of the equal 7 tones of Thai musical scale system. Results of study were not the same as the concept of the Thai musical scale system that mentioned the equal intervals of adjacent pitch as 171.43 cents. At the same time, intervals of the pitch on each instrument were not equal when compared to the other instruments. Instruments have determined the musical scale that was recorded on a document as follows.

1. Ranad Ek (The bars made from wood slabs)

The results of the study are displayed in cent as follows.

1st Octave : 0, 208, 326, 537, 698, 883, 1048, 1208

2nd Octave : 0, 200, 359, 537, 711, 883, 1057, 1222

3rd Octave : 0, 193, 347, 549, 698

2. Ranad Thong Leng (The bars made from brass slabs)

The results of the study are displayed in cent as follows.

0, 200, 340, 537, 699, 881, 1043, 1207

3. Ranad Lek (The bars made from metal slabs)

The results of the study are displayed in cent as follows.

1st Octave : 0, 327, 519, 679, 856, 1075, 1202

2nd Octave : 0, 150, 299, 447, 614, 743, 960, 1179

3rd Octave : 0, 90, 222, 430, 609

4. Chakhe

The results of study are displayed on cent as follows.

0, 198, 362, 528, 720, 890, 1080, 1250

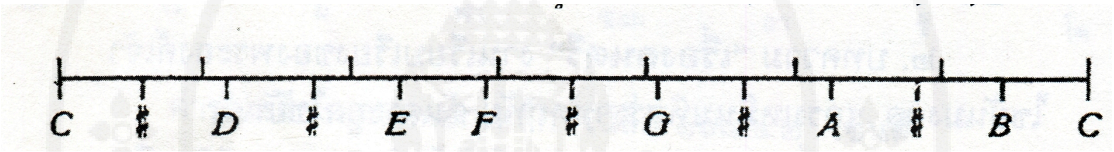
From the results of the study of Thai instruments, it was reported that some instruments are out of tune, because the tuning lumps had fallen from the bar.

The oldest Thai document to mention the Thai musical scale was found while researching in 2016, in an article called ‘The Story of Music’ edited by Prince Mahisara Rajaharudaya. It was published in a book called ‘Wachirayanwisaek’ in 1890. A significant quote from the book is “Pitches of Thai instruments can be divided into only 7 tones. The pitch of the eight note degree is similar to the first note in octave and the ninth note degree is similar to the second note degree, it was always

a parallel interval like this till the end" (Sugree Charoensook 1997.p 23)

In 1932, Mr. Paul J. Seelig, published a book called 'Siamese Music'. It included 150 pieces of Thai music. He mentioned the equal 7 tones of the Thai musical scale as follows.

"It was a problem when trying to do transcriptions of Thai music, because Thai musical scale has a different structure of the musical scale from Western music. Character of the Thai musical scale is diatonic scale. Ratio of interval is 1:7 by 1:12 when compared with Western music." (Seelig, P. J. 1932.p1)



Paul J. Seelig

Figure 2.6 Picture from *Siamese Music*

In 1938, a quote from a document of Thai musical narration, written by Mr. Montree Tramod as follows

"The principle of science of playing Thai musical instruments, included only 7 pitches in order. The sequence of pitch in 7 tones all have equal intervals of adjacent pitch until the eight pitch, which was similar pitch to first pitch. As the principle of Western music includes 7 tones as Thai music but interval of each pitch was not equal. Also it can divide an octave into equal 12 pitches" (p. 15)

In 1950, the Fine arts Department of Thailand published a musical notation of evening prelude. They were a consigned publishing company called J. Thibouville-Lamy & Co. in England. It was in form of notation score, that included description in Thai and English, by Phra Chenduriyang. It has one section that mentions the equal 7 tones of the Thai musical scale system as follows

"The Thai Musical scale is equally divided within its octave into seven degrees of seven full tones equidistant as regards the different pitches. Had it any

semitones, it would have fourteen but such is not the case.” This is merely mentioned here for the purpose of comparison with the Western Chromatic Scale of twelve semitones to the octave.

The Western Chromatic Scale is, by the equal temperament scale system, divided within its octave into twelve semitones. A comparison between the two scales will prove the difference by examining the following diagram” (p. 20).

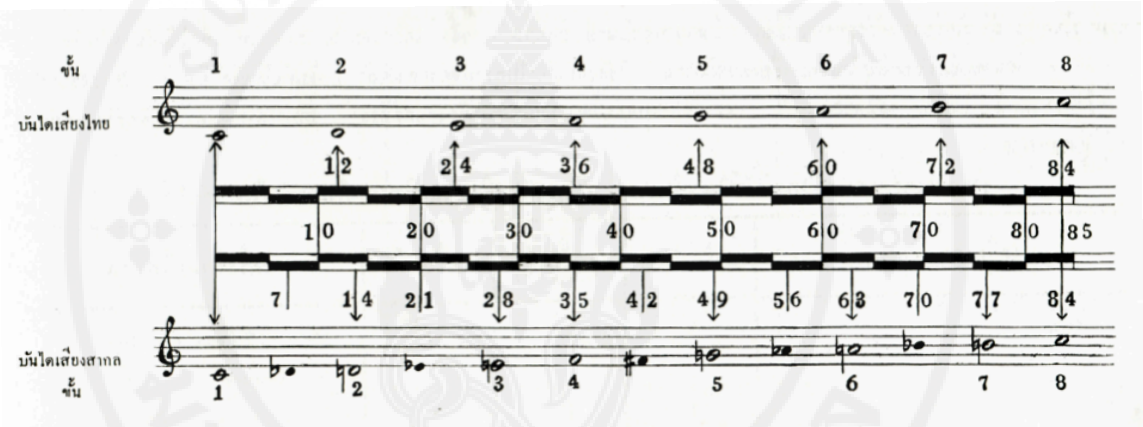


Figure 2.7 Picture form The Fine Arts Department

In 1968, from the book ‘Thai Culture New Series No.15’, on the subject matter of Thai Music that was edited by Phra Chenduriyang, it mentioned the equal 7 tones Thai musical scale as follows

“As already stated, the Thai diatonic scale is composed of seven full tones when in an octave. These are evenly distributed in equidistant steps and there are no semitones between any of these full tone-steps” (Bangkok Thailand: The Fine Arts Department.p 9)

In 1971, The King Bhumibol Adulyadej permitted The Fine Arts Department of Thailand to publish the ‘Thai Classical Music Book No.1.’ It has one paragraph that mentions the Thai musical scale as follows

"The Thai musical scale is equally divided within its octave into seven degrees of seven full tones equidistant as regards to the different pitches. Had it any semitones, it would have fourteen, but such is not the case. This is merely mentioned here for the purpose of comparison with the Western Chromatic Scale of twelve semitones to the octave."

In 1974, from the book that was distributed at the funeral of Mr.Tevaphasit Pattayakoson, on the subject of the project of Thai musical research, it was edited by Pisud Satapornpurisuk. On pages 124-125 it mentioned the Thai musical scale system as follows

"From the Thai musical theory of the Thai musical scale system, an octave is equally divided into 7 pitches" (Chulalongkorn, 1999, p.68)

In 1976, Mr. David Morton came to Thailand to study Thai music for his research for his doctor's degree from the University of California. He recorded the results of his research in a book called 'The Traditional Music of Thailand.' This book is famous overseas for people who want to study Thai classical music in English.

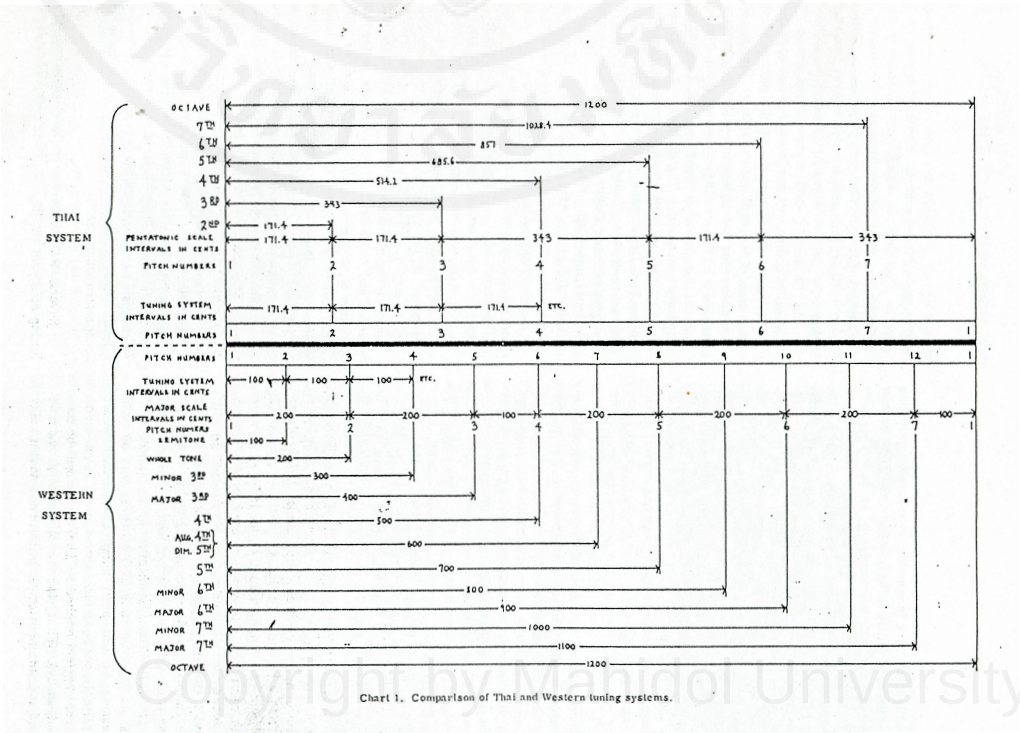


Chart 1. Comparison of Thai and Western tuning systems.

Figure 2.8 Diagram from The Traditional music of Thailand

From the diagram, the comparison of the Western musical scale and the Thai musical scale by Mr. David Morton (Morton, D 1976) shows a structure of cents of adjacent pitches between the two scales.

From the information above, the conclusion was to equally divide the Thai musical scale system into 7 pitches in an octave.

2.1.4 Digital recording system

Nowadays, the recording system has changed, from analog to digital format, and from recording on tape machine, to recording on hard disk. Benefits of working with a digital recording system include powerful editing, playback and mixing sound data without loss of quality. When sound has been recorded to digital format, it gives the opportunity to synthesize sound data for creating a new sound with a computer or laptop, it is called sound design.

Equipments used in digital recording systems that record the sound source to digital format as follows

2.1.4.1 Microphones

The principle of the microphone is to convert a signal from acoustic to electric. Microphones can be categorized as condenser microphones, dynamic microphones and ribbon microphones. Using different microphones to record one sound source has a different effect on the sound quality. To achieve the highest sound quality while recording, consider which microphone to use, depending on the character of the sound source, frequency response and polar pattern of the microphone. This is because each microphone has a different frequency response and polar pattern.

2.1.4.2 Audio Interface

Audio Interface or sound card is an important piece of electronic equipment for the digital recording system. It is used to record sound into the computer for playback or editing. It includes internal and external audio interfaces depending on the application of the user. Audio Interface works to convert an electric signal or analog signal received from the microphone or other sound source, into the

hard disk in the computer. Alternatively, it can be used to convert a digital signal to analog or electric signal for playback on speakers or headphones.

2.1.5 Sampler

A sampler is an electric musical instrument that it used to record sound into a machine to play back again or to reload sound from a hard disk. It can not generate sound by itself like a synthesizer. Some sampler machines are controlled by an external keyboard or midi commands. Some benefits of the sampler are, it is convenient to record, store and playback sound. It gives an opportunity to play the sound of many musical instruments on a keyboard controller or pad, such as a drum kit or woodwind instruments. It is useful for people who can not play many musical instruments or can not afford other musical instruments for performing or recording. Samplers are available in hardware and software versions.

Picture from www.soundonsound.com

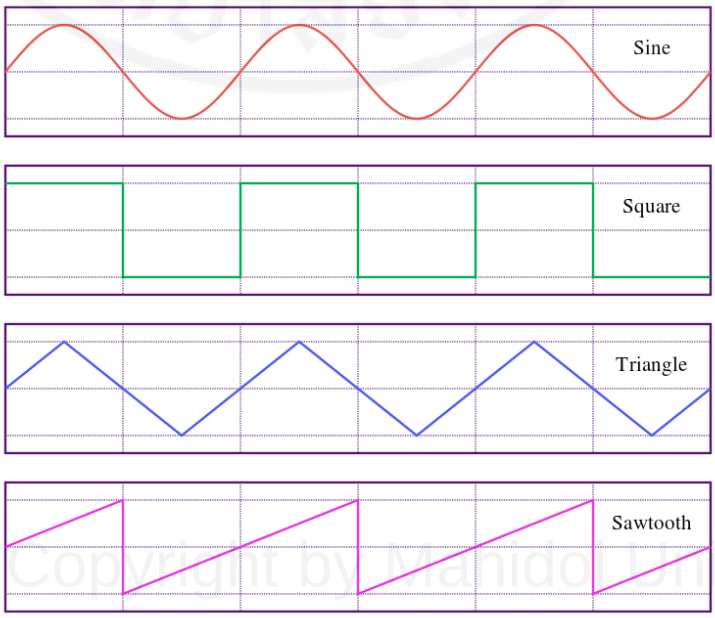
Figure 2.9 AKAI sampler machine Hardware

Picture from www.vintagesynth.com

Figure 2.10 Sampler plugin in Reason 4

2.1.6 Synthesizer

The synthesizer is an electronic musical instrument that can generate sound from an electronic signal from an oscillator. The oscillator can generate a variety of waveforms, such as sine wave and sawtooth waveform. It can imitate the sound of other existing instruments or sounds, or generate new sounds by combining waveforms that are generated from the oscillator, to a variety of filter effects.



Picture form http://10rem.net/blog/2011

Figure 2.11 Waveform generated from oscillator

The synthesizers that do not include keyboards are called sound modules. They can be controlled by an external midi controller or other instruments such as the guitar synthesizer. Nowadays, synthesizers include software and hardware.

Picture from www.3quarksdaily.com
Figure 2.12 Hardware synthesizer

Picture from http://fr.audiofanzine.com
Figure 2.13 Software synthesizer

CHAPTER III
METHODS OF RESEARCH

Method of this research began from the study of Thai musical theories and the history of Thailand in each period. Research includes interviews with Thai musicians and professors of Thai classical music. Researcher has recorded the sound of Thai instruments that are used in Piphat. Afterwards, all data was synthesised by computer program as follows.

3.1 Study to context of the Thai musical scale system

Following the hypothesis, Researcher has studied the context of the equal 7 tones of the Thai musical scale system that is used by Thai Piphat musicians, from the past to present. Researcher has studied documents and research, from many languages, related to the equal 7 tones of the Thai musical scale system. As well as interviews with professors of Thai classical music or Thai musicians that had been accepted by people who work in Thai classical music.

3.2 Study for how to set tuning function used in electric instruments

This research used musical software to study how to set the tuning function in electric instruments, such as synthesizers. The instrument software is called Softsynth. The study was to the limits of the tuning functions that were used to set the frequency of pitch that is used in Softsynth.

3.3 Collection of Data

Data from documents of the Thai musical scale system and Thai musical theories have been collected from a variety of resources as follows

3.3.1 Documents data

Following the first order of hypothesis, Researcher has methods of collecting data of Thai musical scale system from different resources as follows
Data from documents of the Thai musical scale system and Thai musical theories have been collected from a variety of resources as follows

- Jiew Bangsue Music library, Mahidol University
- H.R.H. Princess Mahachakri Sirindhorn Music library, Mahido University
- Musical websites as follows, Library Music Source, IPA Source, Music Online Reference Package, Naxos Music Library, Oxford Bibliographies online, Oxford Music Online, RILM Abstracts of Music Literature

Data has been collected from research including ‘The Sound Frequency of the Notes Used in the Thai Musical Scale’ by Churalongkorn University, ‘Sound and Musical Scale of Thai Classical Music’ by Mr.Sugree Charoensook, ‘Sound Adjustment of Thai Classical Music’ by Mr. Somchai Rutsamee and ‘Research of the Traditional Music of Thailand’ by Mr.David Morton.

Books that have mentioned the Thai musical scale system include, ‘On the Sensations of Tone’ by Hermann Helmholtz, ‘Analysis of Thai Classical Music’ by Mr.Manop Wisudtipad, ‘Thai Score’ published by The fine arts department of Thailand, ‘Siamese Music’ by Mr.Paul J. Seelig and ‘Thai music’ by Phra Chenduriyang.

3.3.2 Interview data

Interview data has been collected from professors and musicians who are experts in Thai music as follows

- Assoc. Prof. Narongchai Pidokrajt, Mahidol University.

- Assist. Prof. Dr.Anak Charanyananda, Mahidol University.
- Prof. Dach Koneam, Nakhon Sawan Rajabhat University.
- Mr.saharat Chancheleum, Mahidol University.
- Mr.Paitoon Choeicharoen

* Quantity of reviewers depended on the situation of fieldwork*

3.3.3 Sound of Thai musical instruments

Study of the structural musical scale system used by Thai musical instruments by recording sounds in fieldwork included Ranad Ek, Ranad Tum and Kong Wong Yai. Instruments have been recorded into a digital recording system by Protools software. After that, it was analyzed by computer software and tune pitches into the Thai musical scale system following results from study of the Thai musical structure. Next, sound map with sampler software to programing synthesizer software. Thai musical instruments were recorded at College of music, Mahidol University Thailand. Instruments for recording were selected according to the condition of each.

3.3.4 Method of Thai instruments recording

All Thai instruments have been recorded into a digital recording system by Protools software pitch by pitch. Each pitch has been recorded in four different levels, from soft to loud. Using three or four microphones to record each instrument, pitches of the Thai musical instruments have been recorded as follows

- Ranad Ek consists of 22 pitches.
- Kong Wong Yai consists of 16 pitches.
- Ranad Tum Lek consists of 17 pitches.

All Thai instruments have been recorded by Mr.Songpone Ledgobgul, who is a musician and instructor in the Thai music department at College of music, Mahidol University Thailand.

3.3.5 Photo Data

All photos have been taken by camera phone to show recording

equipment, Thai instruments, steps of recording Thai musical instruments, and Thai musicians.

3.4 Data management

All data has been collected from a variety of methods including documents, interviews, and sound of Thai instruments. The data management methods used are as follows

3.3.1 Document data

Documented data was categorized into a database. It was then used to reference information for tuning the pitch into the Thai musical scale system.

3.3.2 Interview data

Interview data was used to correct and support an information that was taken from documents.

3.3.3 Sound data of Thai instrument

The sound samples of Thai instruments were used to tune the frequency that resulted from the study of the Thai musical scale system. After that, it was used for mapping with a sampler plugin to be a reference to set tuning function in Softsynth.

3.5 Data analysis

The method to analyze data that has been collected from a variety of resources, is as follows

3.5.1 Data analysis follow first order of hypothesis

The principle used to analyze the context of equal 7 tone of the Thai musical scale system, is an analysis of opinion from an interview with evidence from the Thai musical scale system.

3.5.2 Data analysis following second order of hypothesis

Using information from a study of the Thai musical scale system to synthesize a standard frequency of pitches in equal 7 tones of the Thai musical scale system in electric instruments and set function tuning in electronic instruments to the Thai musical scale system. The steps of the process are as follows

3.3.2.1 Synthesize frequency of pitches of the Thai musical scale by computer software following the Thai musical scale structure.

3.3.2.2 Tune the pitch of Thai instruments sound data into the reference frequency from synthesize following the Thai musical scale structure.

3.3.2.3 Set the frequency of pitch in electric instruments into the Thai musical scale system by using the tuning function.

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

3.6 Research presentation

Researcher presented all data that has been studied following the hypothesis as follows.

- Chapter 4 Study of the structure and format of the Thai musical scale system.

- Chapter 5 Synthesize function of the tuning setting used in electronic musical instruments.

3.7 Research regulation

This research has a regulation that is used for reference of the frequency of C note from the equal temperament scale system, it is 261.63Hz. The value of cent is equal to 171.42 cents of pitch in the scale.

CHAPTER IV
STUDY OF STRUCTURE AND FORMAT OF THE THAI MUSICAL SCALE SYSTEM

4.1 Structure of the Thai musical scale

According to information that was found in documents on the Thai musical scale system, an octave contains 7 pitches that have equal intervals for each pitch. The eight pitch is similar to the first pitch but has double the frequency. The method that was used in the past to tune the frequency of pitch in an octave of Thai musical scale system is as follows. First, using the initial pitch to tune the next pitch to the octave (The sound frequency of the notes used in the Thai musical scale (1999). p. 8.)

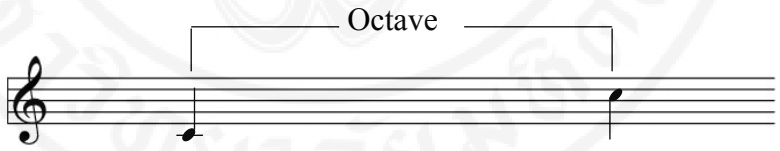


Figure 4.1 Octave interval

From the picture, intervals of notes are an octave. After that, find the next pitch by tuning the pitch into perfect fifth interval from the first note. This pitch is the fifth pitch in the scale. It is a perfect fifth interval from the first note and a perfect fourth from the octave of the first note. This is G note, the fifth note degree in the scale.

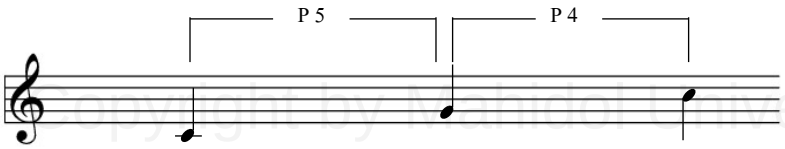


Figure 4.2 Perfect 5th and Perfect 4th intervals

Next, is E note, the third note degree in the scale. It has Major third interval between C note and G note.

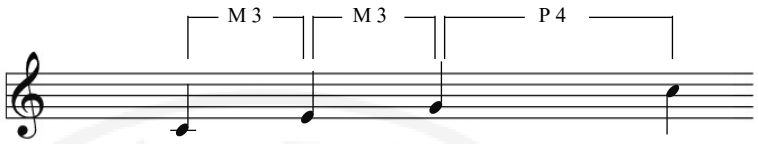


Figure 4.3 Major 3rd and Perfect 4th intervals

The next notes are D and F, thy are the second and fourth note degrees on the scale. They are found in the middle, D is between C and E notes and F is between E and G notes. Both of them have Major Second interval.

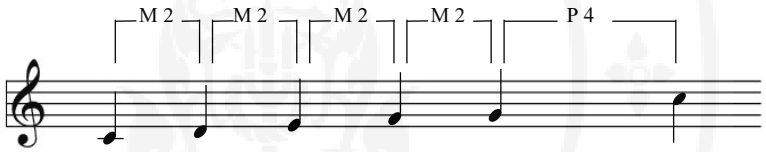


Figure 4.4 Major 2nd and Perfect 4th intervals

Last, are notes A and B, the sixth and seventh note degrees in the scale. Both of them have Major Second intervals.

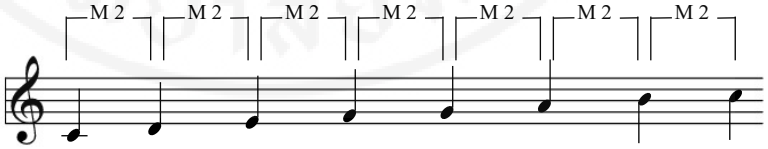


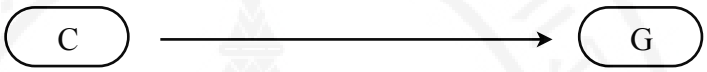
Figure 4.5 Major 2nd intervals

From the method above, it is concluded that the equal 7 tone scale consists of C, D, E, F, G, A and B notes. Each note has equal intervals that are Major second interval or 2 semitones. This method was used to tune Thai instruments in the Thai musical scale in the past.

It was recorded, in a study by Chulalongkorn University, that the creation of sound of the 7 tone system came from Thai classical music. They experimented to create sound by using many kinds of Thai duct flute, called Khlui. The way to experiment is to play one note with different forces of air. The result of the study is as follows.

Playing one note with different forces of air can produce four different pitches, including initial note, Perfect eight (Octave), Perfect fifth and Major third, in that order. Next, the process was repeated again, but the initial pitch was changed to the perfect fifth that was created by the first note. Continue the process until all 7 notes used by Thai classical bands are found. The process is as follows.

Starting on C note, create a new pitch that has perfect fifth interval from C note, G note is the fifth note scale degree.



Second, Change the initial pitch to G note. It will produce D note. It is the fifth interval of G note, it is the second note scale degree.

Third, change the initial pitch to D note. It will produce A note. It is the fifth interval of D note, the sixth note scale degree.

When the steps of the process are continued, it will produce all notes used in Thai classical music.

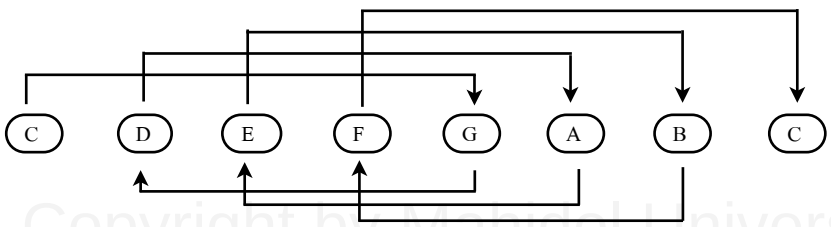


Figure 4.6 Picture of step of pitch produced in Thai classical music

4.2 Method of tuning used in Piphat

From the study of the method of tuning used in 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 other 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 instrument, it is difficult to adjust the pitch of the instrument. The Thai woodwind instruments have an unadjustable 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 Thai musical scale (1999). p7). Both of them were difficult to adjust the pitch because of the process of building those instruments. It was difficult to build Thai woodwinds and bar sticks made from iron. As a result, Thai woodwinds were no longer used to tune instruments in Piphat. Ranad Ek Lek and Ranad Tum Lek are used as a reference for tuning instruments in Piphat instead.

4.3 Thai musical notation

Thai music did not have notation in the past. They transmitted orally from teacher to student. They had to identify the pitch by imitating the sound of instruments such as Ting, Nong or Noin. The study from fieldwork found that different places in Thailand used different words to imitate the sound of instruments.

Nowadays, the identity of pitches in Thai classical music has been influenced by Western music. The Thai letter that it used to identify the pitches has been translated from the English letter and consists of C (ด), D (ร), E (ม), F (ฟ), G (ซ), A (ล) and B (ท) in equal the 7 tones of the Thai musical scale system. There is no evidence of using accidentals, such as sharp (♯) or flat (♭), in Thai musical notation.

The example of Thai musical notation is as follows.

- - - 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 4.7 Thai musical notation

In the period of Prince Damrong Rajanubhab, the prince took the position of prime minister of The Royal Society of Siam, which started to record Thai classical notation in the way Western music notation is done. It was the first time musical staff was used for Thai musical notation in Thailand. It started in the throne room in the Varadis Palace on February 19, 1930 (Tham Kwan (1994). p6). The supervisor was H.S.H. Pattanayu Diskul and Phra Chenduriyang was the director. Thai musical teachers gave example songs to Western musicians to make the musical notation in a Western musical notation style.

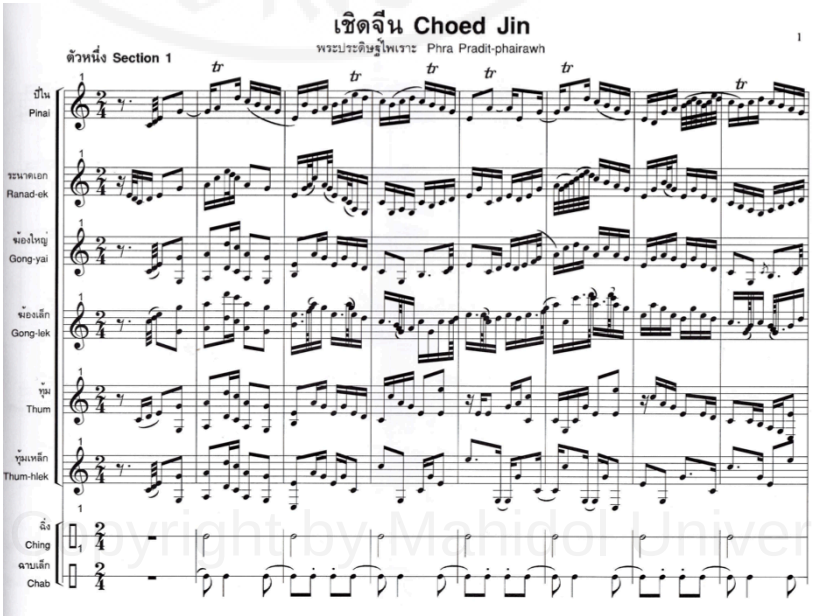


Figure 4.8 Thai classical song notation

4.4 Format of the Thai musical scale system

From the study of the structure of the Thai musical scale system, the Thai musical scale system equally divided an octave into seven tones, so that all pitches have equal intervals. When the study continued to look for a standard of frequency of each pitch used in the Thai musical scale, none could be identified. From the information on the frequency of Thai music, researched by H.M. the King and undertaken by the Faculty of Engineering of Chulalongkorn University (The sound frequency of the notes use in the Thai musical scale(1999).p 29), the result of the study of frequency of the pitch on Ranad Tum Lek, shows that in different places the frequency of the pitch on Ranad Tum Lek, was different from other places when compared.

The researcher has attempted to identify a frequency of pitch in the Thai musical scale system that it used by the Piphat method as follows

4.5 Finding a frequency of pitch by Cent

The method of finding a frequency of pitch used Cent to identify the structure of the Thai musical scale system first. After that, use the results of Cent to find the frequency of pitch in the Thai musical scale system. First, the researcher has attempted to identify the structure of equal temperament by Cent as follows.

4.5.1 Structure of Cent of Equal Temperament

Equal temperament is an octave divided into 12 pitches. The octave intervals is equal to 1200 Cents. Use a mathematic equation of Cent to calculate each interval adjacent of pitch in the equal temperament scale system. A mathematic equation by Alexander J. Ellis is as follows

$$\text{Cent} = \frac{1200 \times \text{Log2}^{(L1/L2)}}{\text{Log2}}$$

Factors from the equation are as follows

K = 1200 (Interval of the octave that is fixed for equal temperament scale system)

L1/L2 = $2^{(1/12)}$ = Ratio of frequency or length of equal temperament scale system.

Ratio of frequency or length of equal temperament scale system is as follows.

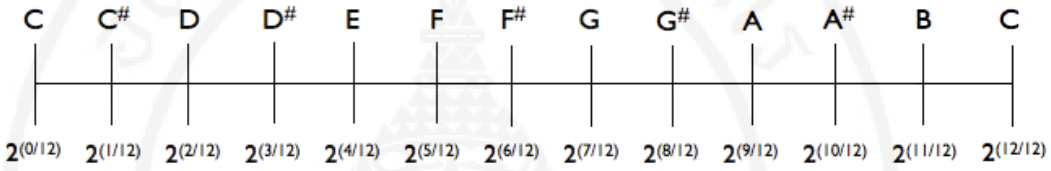


Figure 4.9 Ratio of frequency of equal temperament scale system

The researcher has represented all factors in the equation for the study of structure of cent in the equal temperament scale system. The result is as follows.

Cent of C and C♮

- $\text{Cent} = \dfrac{1200 \times \text{Log}2^{(1/12)}}{\text{Log}2}$

- $\text{Cent} = \dfrac{1200 \times \frac{1}{12}\ \text{Log}2}{\text{Log}2}$

- Cent = 100

The result proves the cent interval of C and C♮ is 100 Cents

The researcher continued to calculate the cent intervals of each pitch in the equal temperament scale system. The result of study is as follows

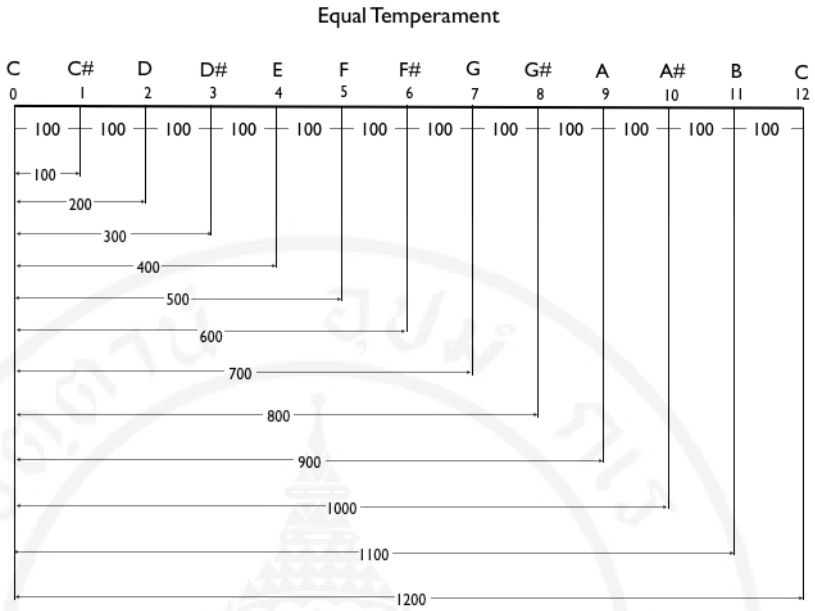


Figure 4.10 Structure of Cent in Equal temperament scale system

4.5.2 Structure of Cent of Thai musical scale system.

From the method that was used to find the structure of Cent in the equal temperament scale system, the researcher has followed this method to find the structure of cent of the Thai musical scale system as follows.

$$\text{Cent} = \frac{1200 \times \text{Log2}^{(1/7)}}{\text{Log2}}$$

K = 1200 (Interval of Octave that is referenced by the equal temperament scale system)

$L1/L2 = 2^{(1/7)}$ = Ratio of frequency or length of the Thai musical scale system.

Ratio of frequency or length of the Thai musical scale system is as follows.

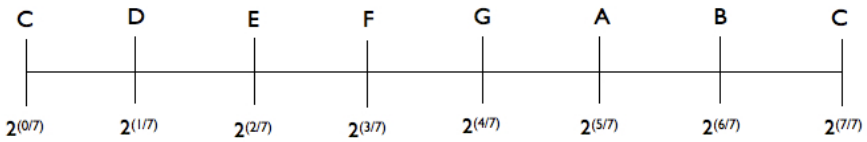


Figure 4.11 Picture of ratio of Thai musical scale system

Cent of C and D

- $\text{Cent} = \frac{1200 \times \text{Log}2^{(1/7)}}{\text{Log}2}$

- $\text{Cent} = \frac{1200 \times \frac{1}{7}\text{Log}2}{\text{Log}2}$

- Cent = 171.428

Cent of C and E

- $\text{Cent} = \frac{1200 \times \text{Log}2^{(2/7)}}{\text{Log}2}$

- $\text{Cent} = \frac{1200 \times \frac{2}{7}\text{Log}2}{\text{Log}2}$

- Cent = 342.857

Cent of C and F

- $\text{Cent} = \frac{1200 \times \text{Log}2^{(3/7)}}{\text{Log}2}$

- $\text{Cent} = \frac{1200 \times \frac{3}{7}\text{Log2}}{\text{Log2}}$

- $\text{Cent} = 514.285$

Cent of C and G

- $\text{Cent} = \frac{1200 \times \text{Log2}^{(4/7)}}{\text{Log2}}$

- $\text{Cent} = \frac{1200 \times \frac{4}{7}\text{Log2}}{\text{Log2}}$

- $\text{Cent} = 685.714$

Cent of C and A

- $\text{Cent} = \frac{1200 \times \text{Log2}^{(5/7)}}{\text{Log2}}$

- $\text{Cent} = \frac{1200 \times \frac{5}{7}\text{Log2}}{\text{Log2}}$

- $\text{Cent} = 857.142$

Cent of C and B

- $\text{Cent} = \frac{1200 \times \text{Log2}^{(6/7)}}{\text{Log2}}$

- $\text{Cent} = \frac{1200 \times \frac{6}{7} \text{Log2}}{\text{Log2}}$

- Cent = 1028.571

All the results of cent have been arranged in order and displayed as a picture to show the structure of the Thai musical scale system on cent as follows.

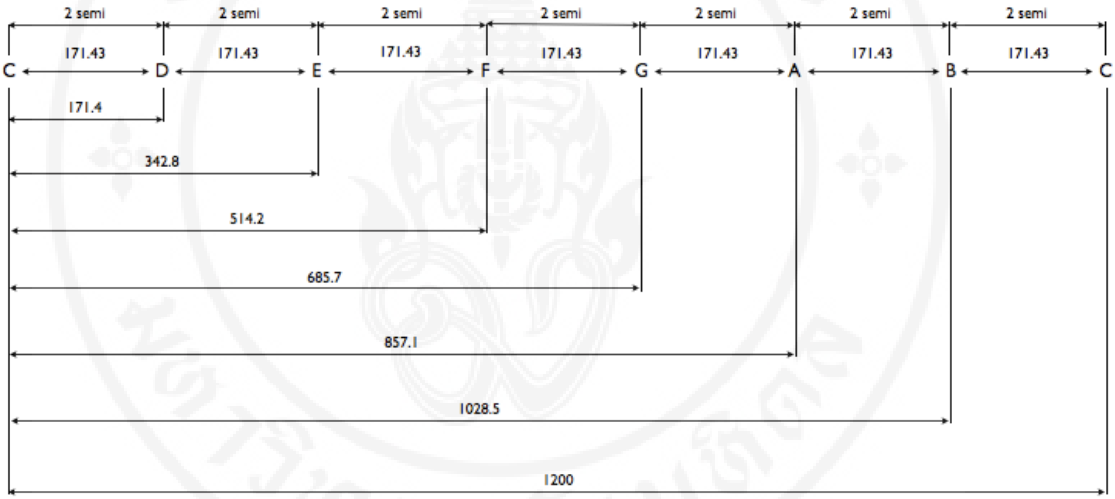


Figure 4.12 Structure of Thai musical scale system

It has the same result as the structure of Thai musical scale system when compared with the picture from a document by Mr.David Morton as follows.

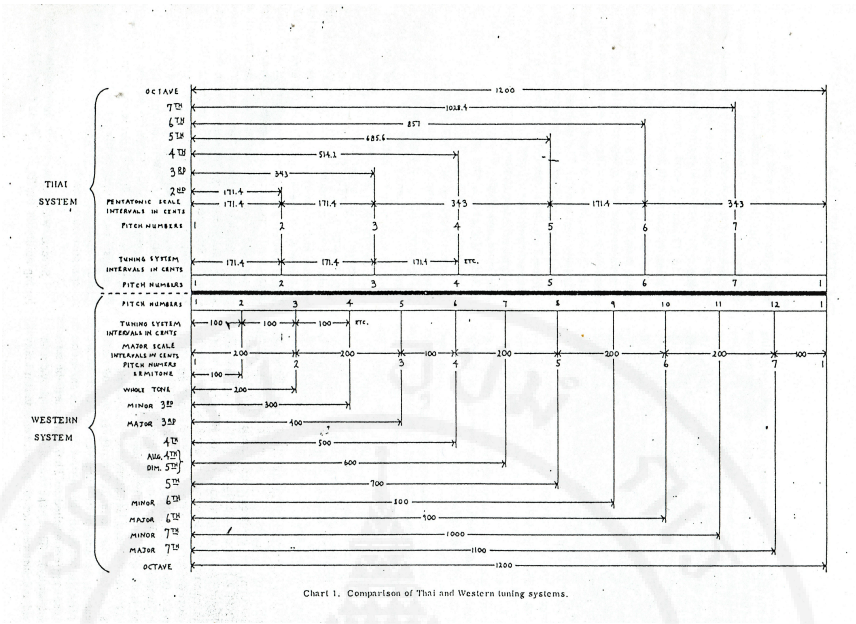


Figure 4.13 Picture from The Traditional music of Thailand book

In conclusion, the Thai musical scale system has been equally divided into 7 tones in an octave. The interval of each pitch is 171.42 Cents. The researcher has arranged the results of the study to compare the intervals in cent between the Thai musical scale system and the equal temperament scale system into the table as follows.

Table 4.1 Comparison of Cent

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

The deviation is on a decimal point that is difficult to use for tuning electric instruments. The researcher has rounded the decimal of deviation as follows; if the value is equal to or more than 0.5, it has been rounded up. On other hand, if the value is less than 0.5, it has been rounded down. The results of rounding the decimal are displayed on the table as follows.

Table 4.2 The rounding of the deviation

Note	Old deviation	New deviation
C	-	-
D	-28.6	-29
E	-57.2	-57
F	+14.2	+14
G	-14.3	-14
A	-42.9	-43
B	-71.5	-72
C	-	-

4.6 Method of searching for frequency of pitch in musical scale system

This research used the reference frequency pitch from the equal temperament scale system. The researcher has studied the frequency of pitch that was used in the equal temperament scale system, and the frequency of pitch of equal temperament is displayed on the piano keys as follows

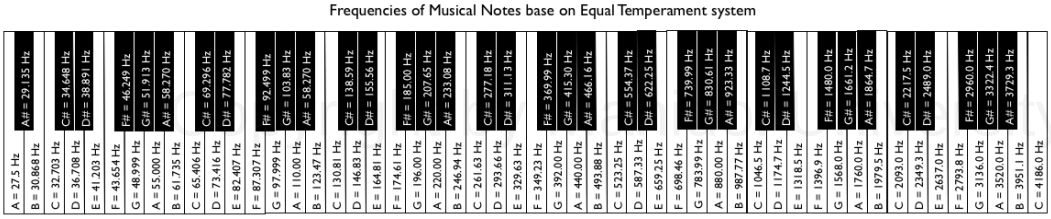


Figure 4.14 The Frequency of pitch on piano

From the study of Thai musical notation, the accidentals, sharp(♮) or flat (♭), were not found. The researcher has considered pitch without accidentals only to experiment a method of calculating a frequency.

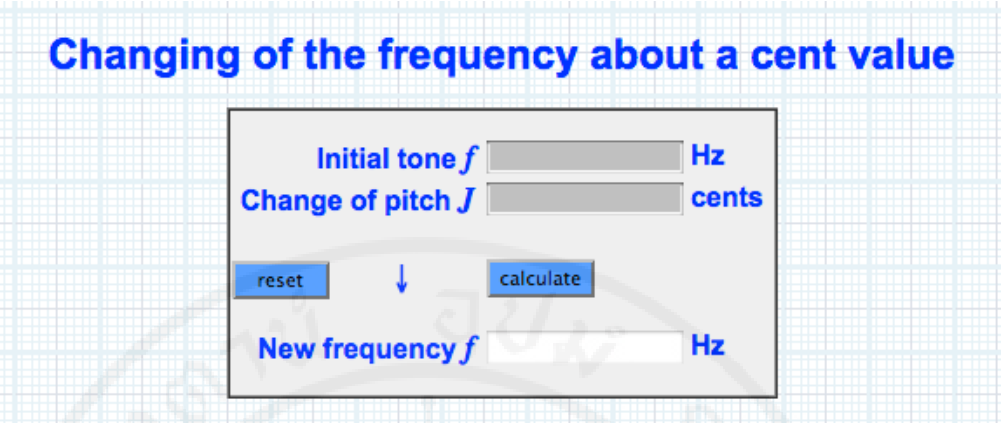
4.6.1 Calculation of frequency of pitch in the equal temperament scale system

Researcher has used the pitch C, D, E, F, G, A and B in an octave. These notes are used in the equal temperament scale system for calculation. Frequencies of those pitches are displayed on the table as follows.

Table 4.3 The frequencies and Cents of the equal temperament scale system

Note	Frequency (Hz)	Cent
C	261.63	0
D	293.66	200
E	329.63	400
F	349.23	500
G	392	700
A	440	900
B	493.88	1,100

To calculate the frequency used in the initial frequency by changing cent value, use software from website http://www.sengpielaudio.com/calculator-centsratio.htm. For testing software, Researcher has first calculated to find the frequency of pitch in the equal temperament scale system. The result of the calculation of frequency in the equal temperament as follows.



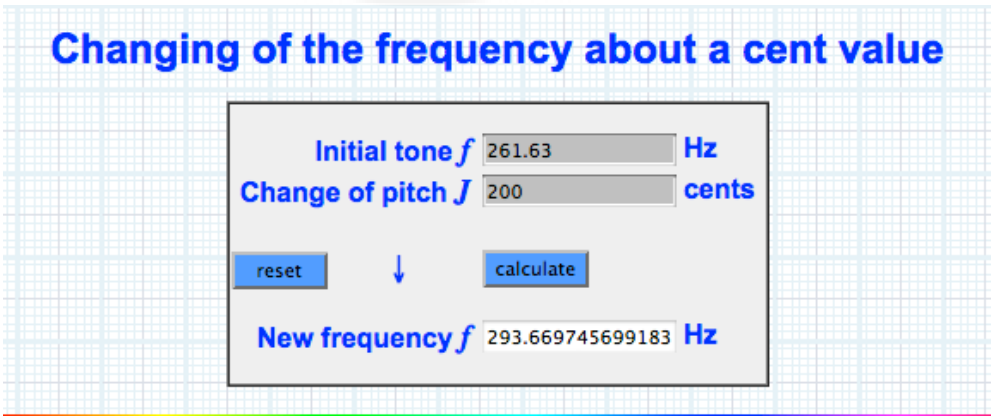
(Picture from www.sengpielaudio.com)

Figure 4.15 Changing of the frequency by cent value software

The initial tone of C note that is used in the equal temperament scale system has a frequency of pitch that is 261.63Hz. Change of pitch parameter has changed by cent value following the result of study of structure in the equal temperament scale system.

Frequency of D note

Following the structure of equal temperament, D has cent value of 200 cents or 2 semitones. Enter a representation of cent value to calculate the results as follows.



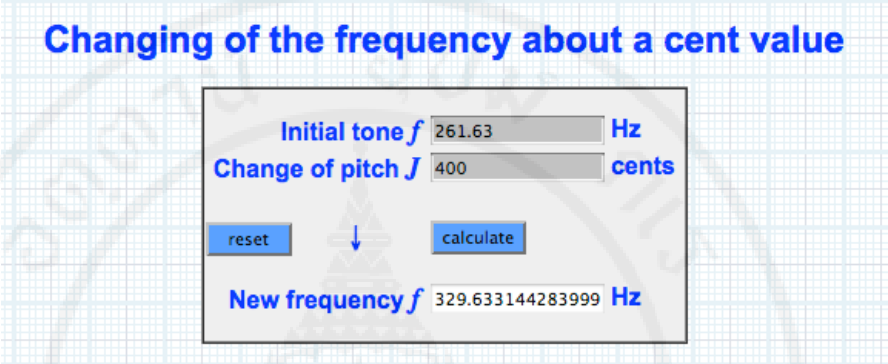
(Picture from www.sengpielaudio.com)

Figure 4.16 Frequency of D note by cent value of equal temperament

The result of the calculation, D note has a frequency of pitch that is 293.66Hz.

Frequency of E note

Following the structure of equal temperament, E has cent value of 400 cents or 4 semitones. Enter a representation of cent value to calculate the results as follows.



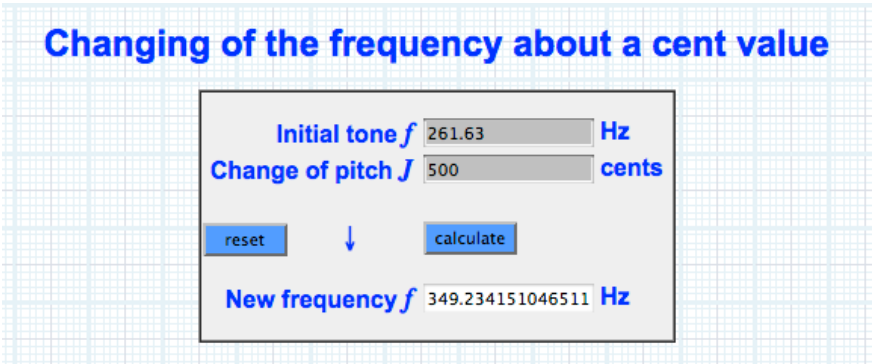
(Picture from www.sengpielaudio.com)

Figure 4.17 Frequency of E note by cent value of equal temperament

The result of the calculation, E note has a frequency of pitch that is 293.66Hz.

Frequency of F note

Following the structure of equal temperament, F has cent value of 500 cents or 5 semitones. Enter a representation of cent value to calculate the results as follows.



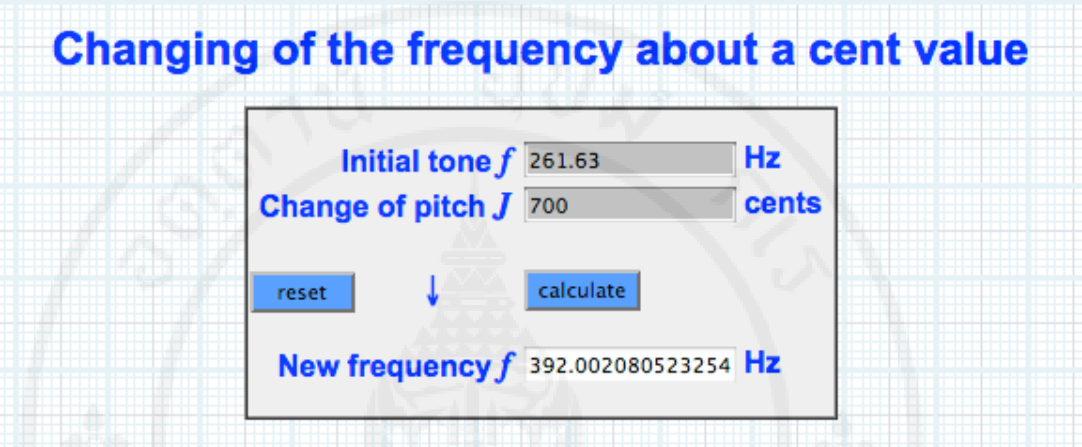
(Picture from www.sengpielaudio.com)

Figure 4.17 Frequency of F note by cent value of equal temperament

The result of the calculation, F note has a frequency of pitch that is 349.23Hz.

Frequency of G note

Following the structure of equal temperament, G has cent value of 700 cents or 7 semitones. Enter a representation of cent value to calculate the results as follows.



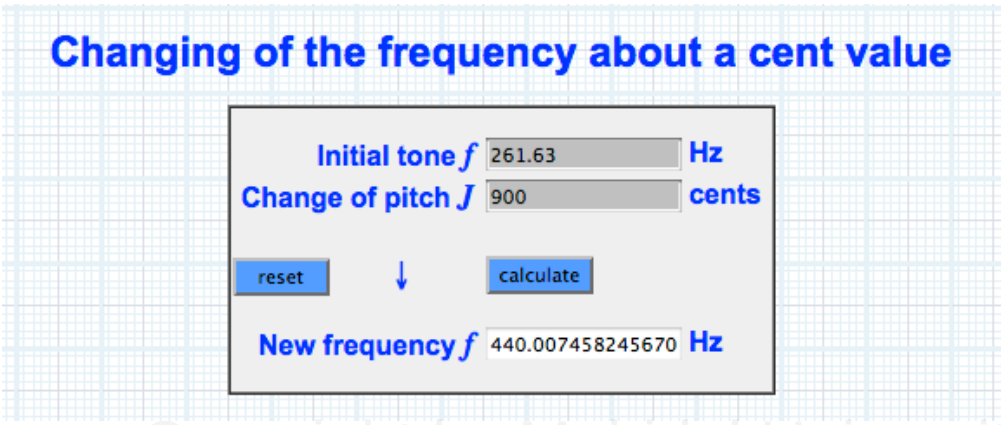
(Picture from www.sengpielaudio.com)

Figure 4.18 Frequency of G note by cent value of equal temperament

The result of the calculation, G note has a frequency of pitch that is 392Hz.

Frequency of A note

Following the structure of equal temperament, A has cent value of 900 cents or 9 semitones. Enter a representation of cent value to calculate the results as follows.



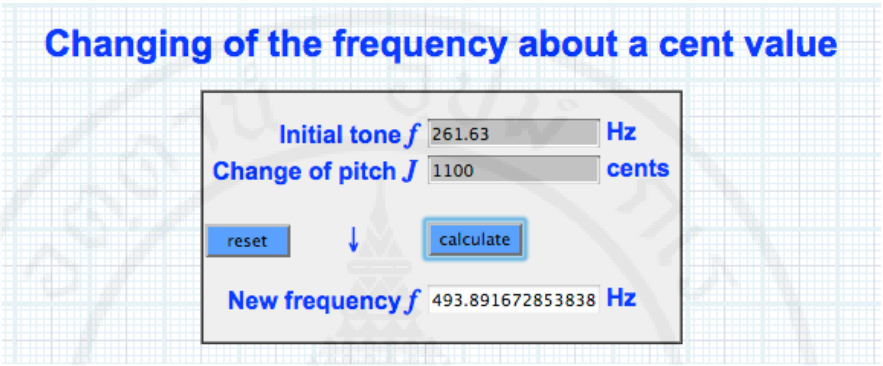
(Picture from www.sengpielaudio.com)

Figure 4.19 Frequency of A note by cent value of equal temperament

The result of the calculation, A note has a frequency of pitch that is 440Hz.

Frequency of B note

Following the structure of equal temperament, B has cent value of 1,100 cents or 11 semitones. Enter a representation of cent value to calculate the results as follows.



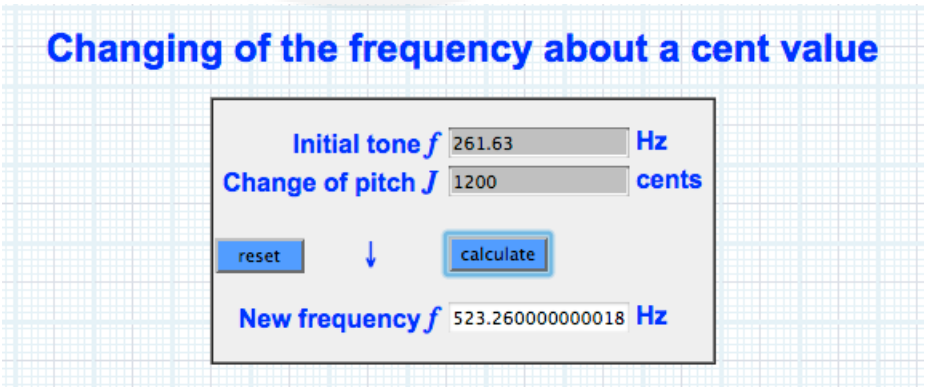
(Picture from www.sengpielaudio.com)

Figure 4.20 Frequency of B note by cent value of equal temperament

The result of the calculation, B note has a frequency of pitch that is 493.89Hz.

Frequency of C note (octave)

Following the structure of equal temperament, C (octave) has cent value of 1,200 cents or 12 semitones. Enter a represent of cent value to calculate the results as follows.



(Picture from www.sengpielaudio.com)

Figure 4.21 Frequency of C note by cent value of equal temperament

The result of the calculation, B note has a frequency of pitch that is 523.26Hz.

The results are then displayed, for all frequencies that were taken from the calculations of the frequency of pitch in equal temperament, for comparison. The results are as follows.

Table 4.4 Frequencies from the calculations and equal temperament comparison

Note	Equal temperament (Hz)	Frequency from calculation (Hz)
C	261.63	261.63
D	293.66	293.67
E	329.62	329.63
F	349.23	349.23
G	392.00	392
A	440.00	440
B	493.88	493.89
C	532.25	532.26

According to the table, when considering a frequency of calculation and frequency of equal temperament, the results of the comparison were similar to each other. The frequency of the calculation differed from the frequency of the equal temperament by only 0.01 Hz. Therefore; method has been proven to find the frequency of pitch in Thai musical scale system.

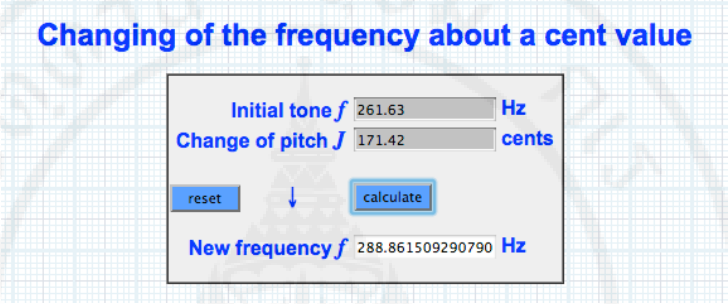
4.6.2 Calculation of frequency of pitch in the Thai musical scale system

According to the study of documents on the Thai musical scale system used in Piphat, there is no standard frequency of pitch. There are various pitches of frequency in different places around Thailand. Also researcher has taken the initial tone from 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 Thai musical structure.

The results of the calculation of frequency of the Thai musical scale system is as follows.

Frequency of D note

Following the structure of the Thai musical scale, D has cent value of 171.42 cents. Enter a representation of cent value to calculate the results as follows.



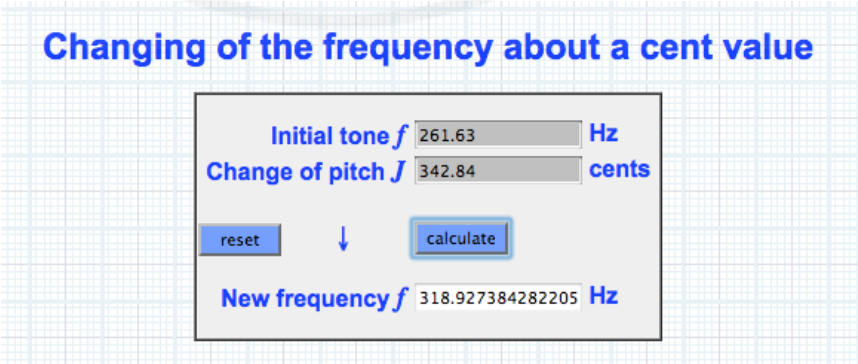
(Picture from www.sengpielaudio.com)

Figure 4.22 Frequency of D note by cent value of Thai musical scale

The result of the calculation, D note has a frequency of pitch that is 288.86Hz.

Frequency of E note

Following the structure of the Thai musical scale, E has cent value of 342.84 cents. Enter a representation of cent value to calculate the results as follows.



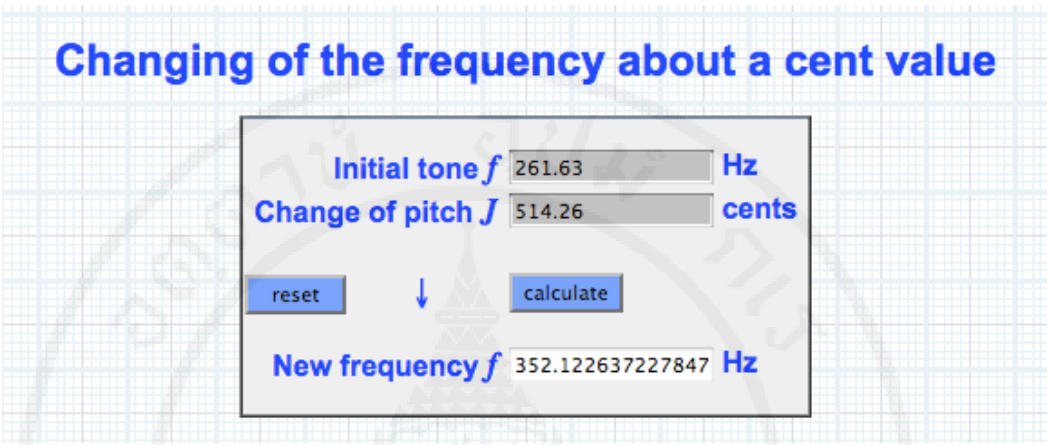
(Picture from www.sengpielaudio.com)

Figure 4.23 Frequency of E note by cent value of Thai musical scale

The result of the calculation, E note has a frequency of pitch that is 318.92Hz.

Frequency of F note

Following the structure of the Thai musical scale, F has cent value of 514.26 cents. Enter a representation of cent value to calculate the results as follows.



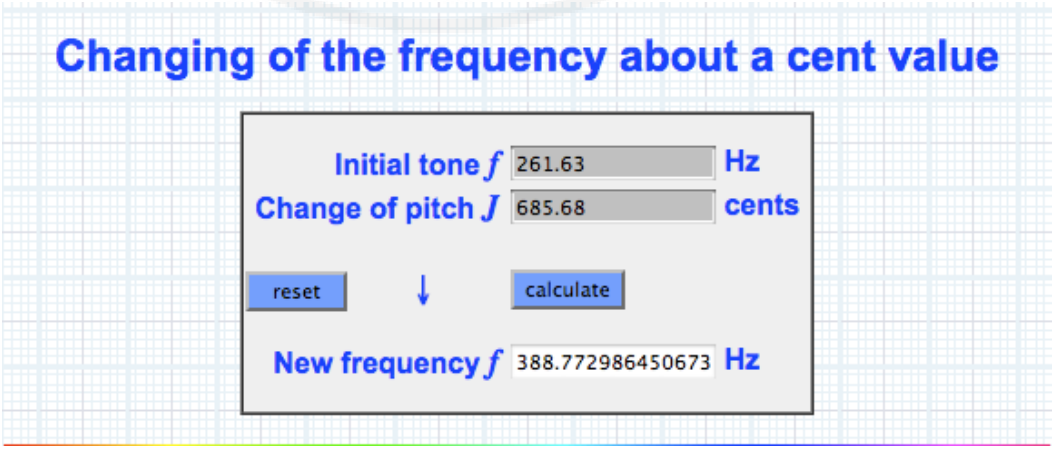
(Picture from www.sengpielaudio.com)

Figure 4.24 Frequency of F note by cent value of Thai musical scale

The result of the calculation, F note has a frequency of pitch that is 352.12Hz.

Frequency of G note

Following the structure of the Thai musical scale, G has cent value of 685.68 cents. Enter a representation of cent value to calculate the results as follows.



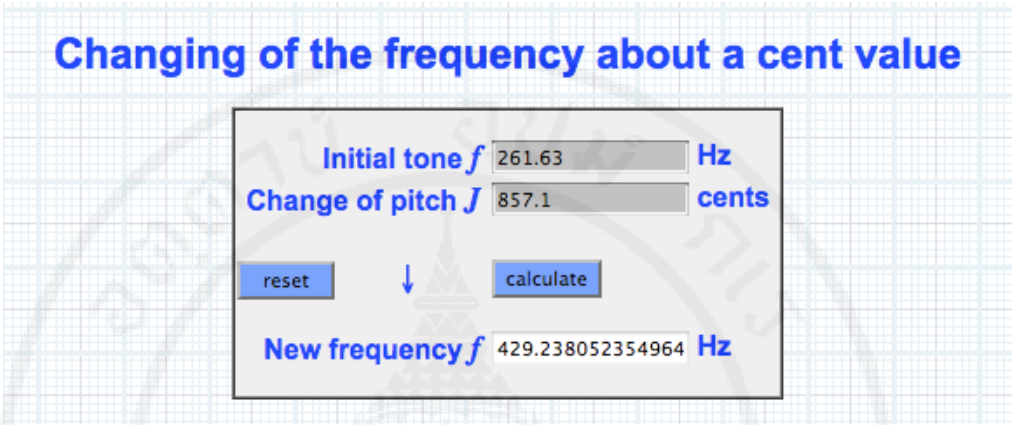
(Picture from www.sengpielaudio.com)

Figure 4.25 Frequency of G note by cent value of Thai musical scale

The result of the calculation, G note has a frequency of pitch that is 388.77Hz.

Frequency of A note

Following the structure of the Thai musical scale, A has cent value of 685.68 cents. Enter a representation of cent value to calculate the results as follows.



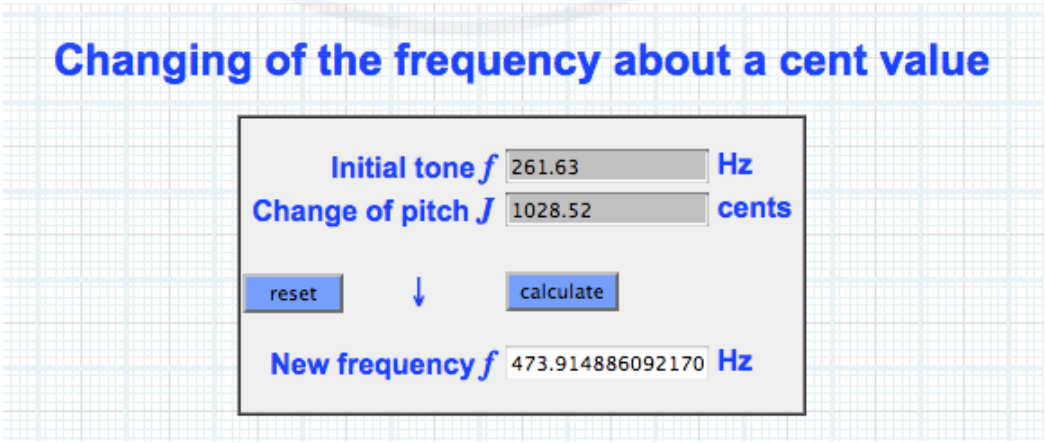
(Picture from www.sengpielaudio.com)

Figure 4.26 Frequency of A note by cent value of Thai musical scale

The result of the calculation, A note has a frequency of pitch that is 429.23Hz.

Frequency of B note

Following the structure of the Thai musical scale, B has cent value of 685.68 cents. Enter a representation of cent value to calculate the results as follows.



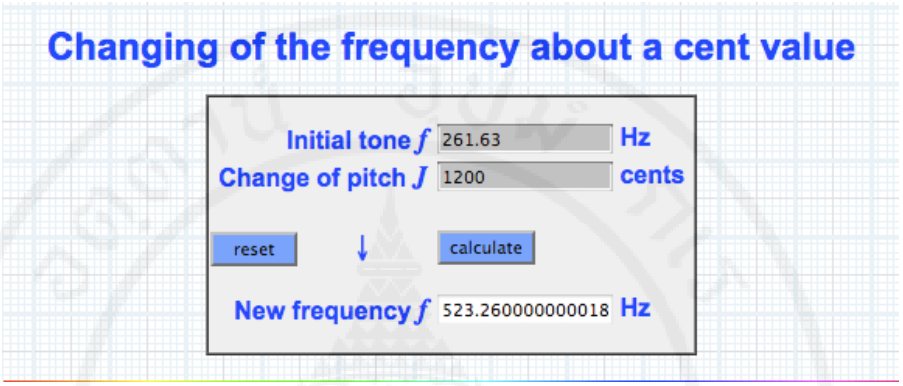
(Picture from www.sengpielaudio.com)

Figure 4.27 Frequency of B note by cent value of Thai musical scale

The result of the calculation, B note has frequency of pitch that is 473.91Hz.

Frequency of C note (octave)

Following the structure of the Thai musical scale, C (octave) has cent value of 1,200 cents. Enter a representation of cent value to calculate the results as follows.



(Picture from www.sengpielaudio.com)

Figure 4.28 Frequency of C note by cent value of Thai musical scale

The result of the calculation, C (octave) has a frequency of pitch that is 523.26Hz. In other words, the octave has a double frequency.

The results of the frequencies of the Thai musical scale system are displayed on the following table.

Table 4.5 The frequencies of the Thai musical scale system

Note	Frequency (Hz)
C	261.63
D	288.86
E	318.92
F	352.12
G	388.77
A	429.23
B	473.91
C	523.26

Comparison of cent and frequency between the Thai musical scale system and Equal temperament is displayed on the following table.

Table 4.6 The Frequency of the equal temperament and Thai musical scale comparison chart

Equal Temperament	Note	Thai musical scale
Frequency (Hz)		Frequency (Hz)
261.63	C	261.63
293.66	D	288.86
329.63	E	318.92
349.23	F	352.12
392	G	388.77
440	A	429.23
493.89	B	473.91
523.26	C	523.26

Table 4.7 Cent value of the equal temperament and Thai musical scale comparison chart

Equal Temperament	Note	Thai musical scale
Cent		Cent
0	C	0
200	D	171.42
300	E	342.84
500	F	514.26
700	G	685.68
900	A	857.10

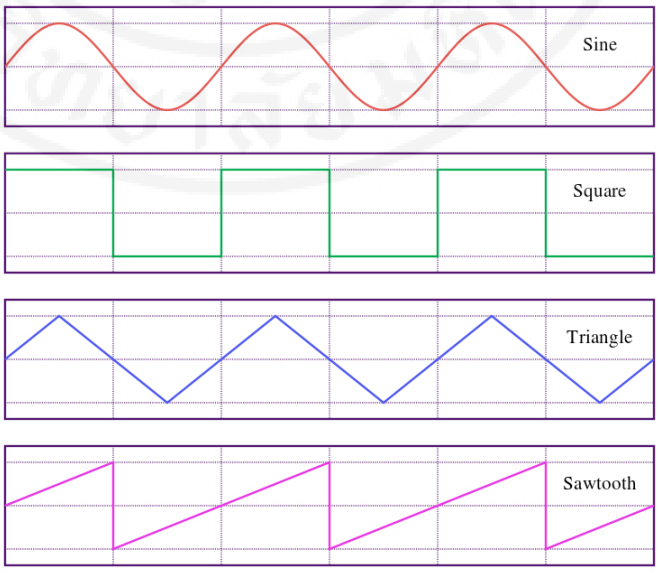
Equal Temperament	Note	Thai musical scale
Cent		Cent
1,100	B	1028.52
1200	C	1200

CHAPTER V
SYNTHESIZING TUNING FUNCTION IN ELECTRONIC INSTRUMENTS

Researcher used the results of the study in the previous chapter to synthesize tuning function in electronic instruments. The method is as follows.

5.1 Synthesizing tuning function in Synthesizer Software

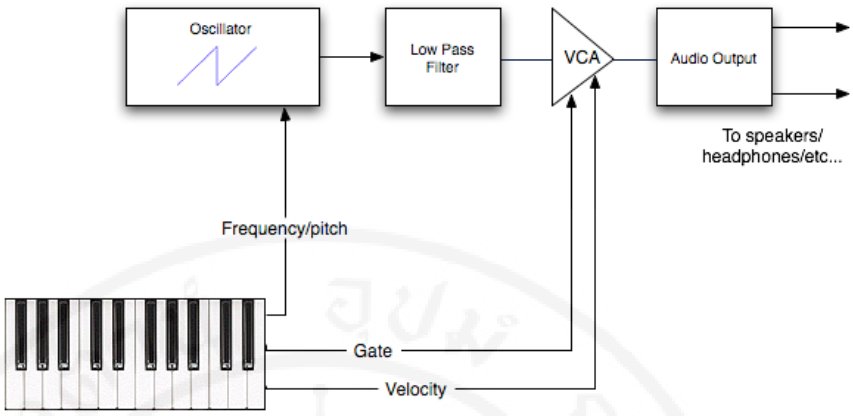
Synthesizer Software, or Soft synth, is a plug-ins that is used with DAW. It generates sound by an Oscillator. An Oscillator can generate sound from various waveforms such as sine wave, sawtooth wave or triangle wave. After that, the signal is sent to filters to adjust the audio effects before going to output.



(Picture from http://10rem.net/blog/2011)

Figure 5.1 Basic of waveform

The diagram of the signal flow is displayed for the structure of the sound generator as follows.



(Picture from http://beausievers.com)

Figure 5.2 The diagram of the signal flow

From the study of tuning function used in Softsynth or Synthesizer hardware, in general, 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 Parameter. 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 that follows.

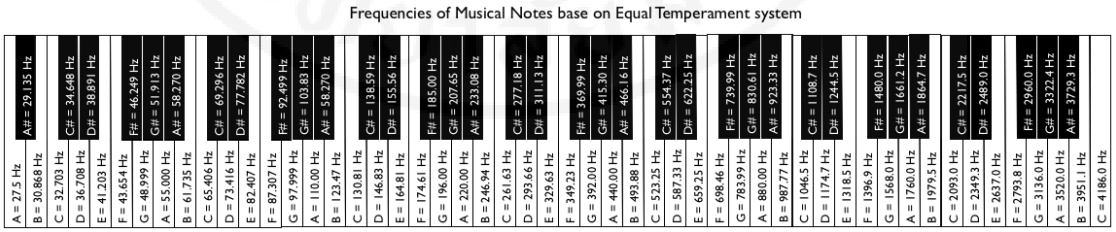


Figure 5.3 Frequencies of Equal temperament scale system

This is why, when a synthesizer or keyboard is played in Thai contemporary bands the sound does not go well with Thai instruments. When using a synthesizer software or hardware to perform with Thai instruments, it must be set the tuning function in the Synthesizer software or hardware, because the Thai musical scale system has a different cent value or frequency of notes. This is called the micro tuning function.

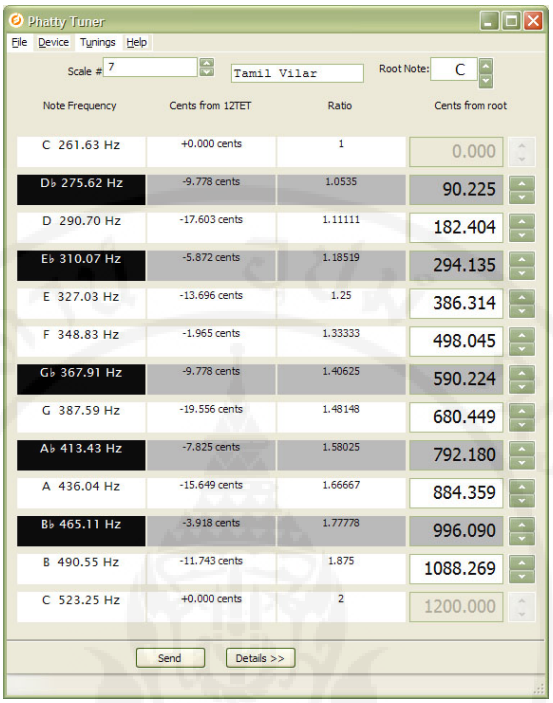
5.1.1 Micro tuning Function

The micro tuning function is designed to tune a different frequency of each note into other musical scale systems. This gives the opportunity to use a keyboard or synthesizer to perform with other instruments that do not use the equal temperament scale system. A preset or template can be saved depending on the software or hardware. Functions can be adjusted by cent value or frequency.

(Picture from http://www.moogmusic.com)

Figure 5.4 Synthesizer Hardware

In this picture is the synthesizer hardware from Moog called Slim Phatty. This is the one of the synthesizers that has the micro tuning function. It connects to PC, Mac computer or laptop, in order to adjust the function and save it into preset. It can adjust any pitch by cent value or frequency.



(Picture from www.gearslutz.com)

Figure 5.5 Phatty Tuner software for PC

5.1.2 Absynth 5 softsynth

(Picture from http://www.native-instruments.com)

Figure 5.6 Abysnth 5 softsynth

The Absynth was developed by Native Instruments. The latest version of Absynth is Absynth 5. The program includes 3 Oscillators; A, B and C. The signal is generated by oscillators, is first sent to a filter module and then to a modulator module before going to master section.

5.1.2.1 Oscillator Module

Figure 5.7 Oscillator Module in Absynth 5

All oscillators can generate different waveforms at the same time. Each parameter can adjust values independent from each other. It can produce many sounds by combining sounds generated from 3 oscillators. The researcher studied the function used in the oscillator module as follows.

5.1.2.2 Waveform

Figure 5.8 Waveform in Absynth 5

Waveforms are categorized into 2 characters; Simple Waves and Morph Waves. Simple waveforms are a standard waveform, such as Sine, Triangle, Saw or Square. Morph waveforms are new waveforms that are formed by combining 2 waveforms into a new waveform.

Figure 5.9 List of waveform in Absynth 5

5.1.2.3 Frequency menu and frequency control

This function is used to set the frequency that is generated by oscillators as follows.

Trans

Figure 5.10 Trans function in Absynth 5

This function is used to adjust a frequency by step of semitone. For example, setting to 1.0 will lead to a transposition of 1 tone or 2 semitones compared with the pitch of the note played.

Ratio

Figure 5.11 Ratio function in Absynth 5

This function is used to adjust a frequency by frequency ratio. For example, along with the harmonic sequence: 2 corresponds with a transposition of 12 halftones, 3 with a transposition of 19 halftones, etc (Absynth5 reference manual, (n.d.), p.47).

Hz

Figure 5.12 Hz function in Absynth 5

This function is used to fix a pitch in Hertz. It is useful for frequency and ring modulation. In this mode, the oscillator ignores the pitch of the note played (Absynth5 reference manual,(n.d.), p.47).

Note

Figure 5.13 Note function in Absynth 5

The fixed pitch corresponds to a selected MIDI note. This mode is similar to the frequency mode Hz, but is more appropriate when you want to use the oscillator on a note-bound frequency, (Absynth5 reference manual,(n.d.), p. 47).

From the study of the oscillator function in Absynth 5, the oscillator is flexible, so that the frequency is adjustable. It is useful to adjust the frequency of Absynth 5 to the frequency of the Thai musical scale system. The researcher has used Hz function to tune the frequency of Absynth 5 into the frequency of the Thai musical scale system following the results of the study from the previous chapter.

5.1.3 FM8 Softsynth

Figure 5.14 FM8 Softsynth

FM8 softsynth was developed by Native Instrument. It is based on the synthesizer hardware by Yamaha, called DX7. It is an FM synthesizer (Frequency Modulation). It was famous in 80s, and has been used by many musicians, especially in pop music.

(Picture from http://medias.audiofanzine.com)

Figure 5.15 Yamaha synthesizer Model DX7

FM8 has a micro tuning function that comes with many different presets of scale structure. It can adjust frequency of pitch by cent value

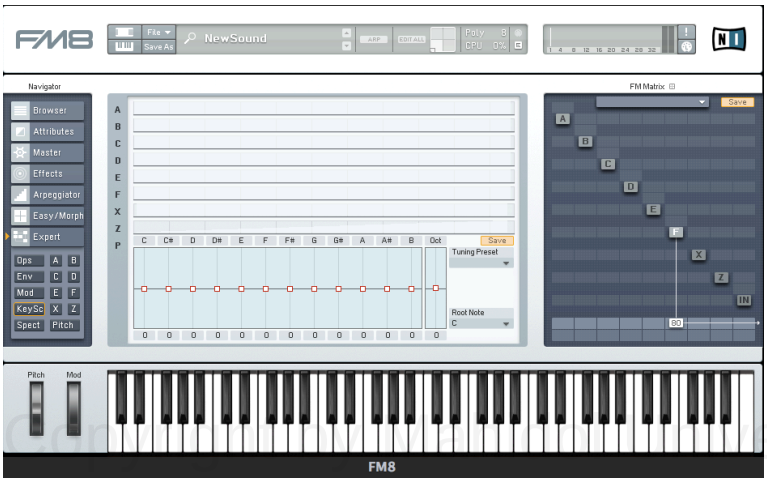


Figure 5.16 Micro tuning Function in FM8

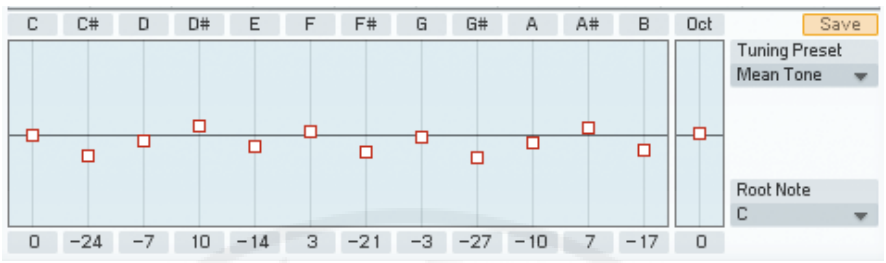


Figure 5.17 Mean Tone Scale in FM8

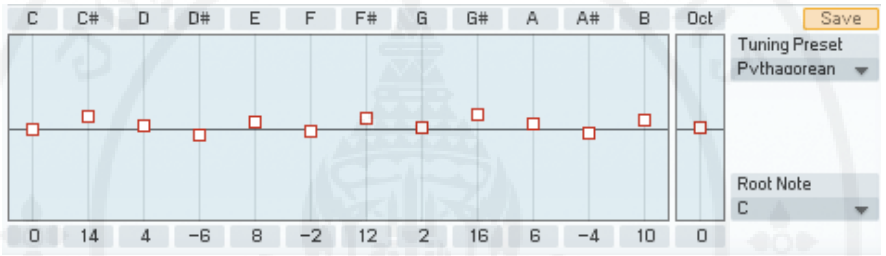


Figure 5.18 Pythagorean Scale in FM8

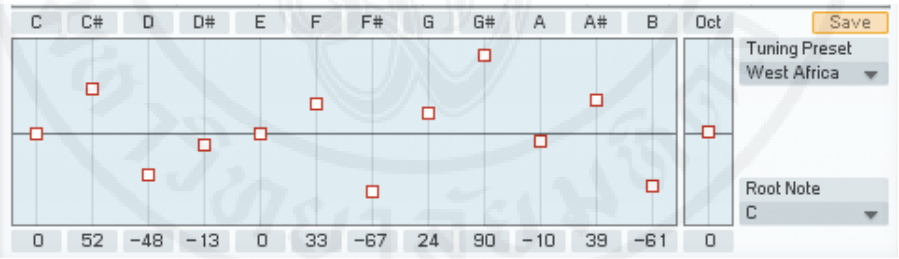


Figure 5.19 West Africa Scale in FM8

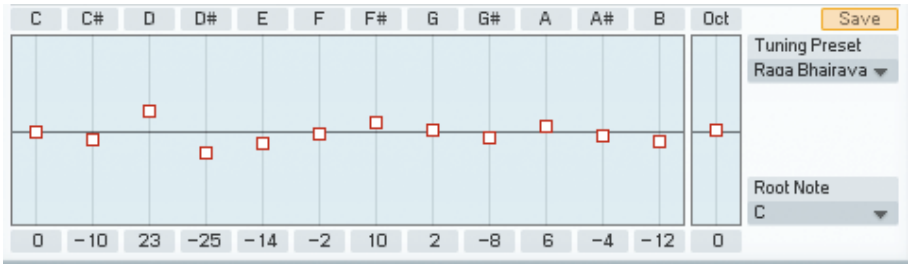


Figure 5.20 Raga Bhairava in FM8

The researcher used the value of cent, from the results of the study of Thai musical scale system, to fill in the parameters as follows.

C = 0 Cent

D = - 29 Cents

E = - 57 Cents

F = +14 Cents

G = - 14 Cents

A = - 43 Cents

B = - 72 Cents

The result of the parameter, in micro tuning function in FM8, is as follows.

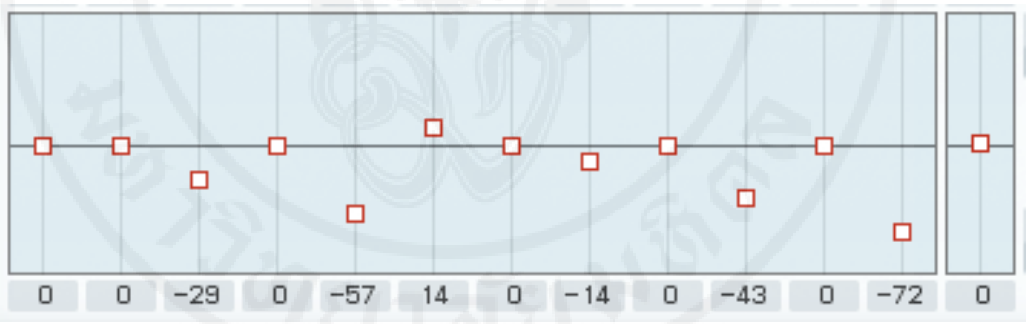


Figure 5.21 Structure of Thai musical scale by cent

Next, researcher used FM8, that was tuned to the Thai musical scale system, to play Thai music with a Thai sampler.

5.2 Method of collecting sound samples of Thai instruments

In fieldwork, the researcher has recorded the sound of Thai instruments Ranad Tum Lek, Ranad Ek and Kong Wong Yai. They were recorded pitch by pitch, into digital recording software called Protools LE8, to make Thai sound samples. Each pitch has been recorded in 4 dynamics; soft (*p*), moderately soft (*mp*), moderately loud (*mf*) and loud (*f*).

Figure 5.22 Protools LE8 Software

5.2.1 Sound samples of Ranad Tum Lek

The researcher has recorded the sound of Ranad Tum Lek, in College of music, Mahidol University. The method of selecting an instrument is to choose one according to its condition. The microphones that were used for the recording of Ranad Tum Lek, were model No.C414 by AKG, for recording sound the from bar sticks and U89 by Neumann, for recording sound from overhead.

Figure 5.23 Overhead microphone U89 by Neumann

Figure 5.24 Recording sampling of Ranad Tum Lek

D note

Figure 5.25 D note of Ranad Tum Lek waveform

E note

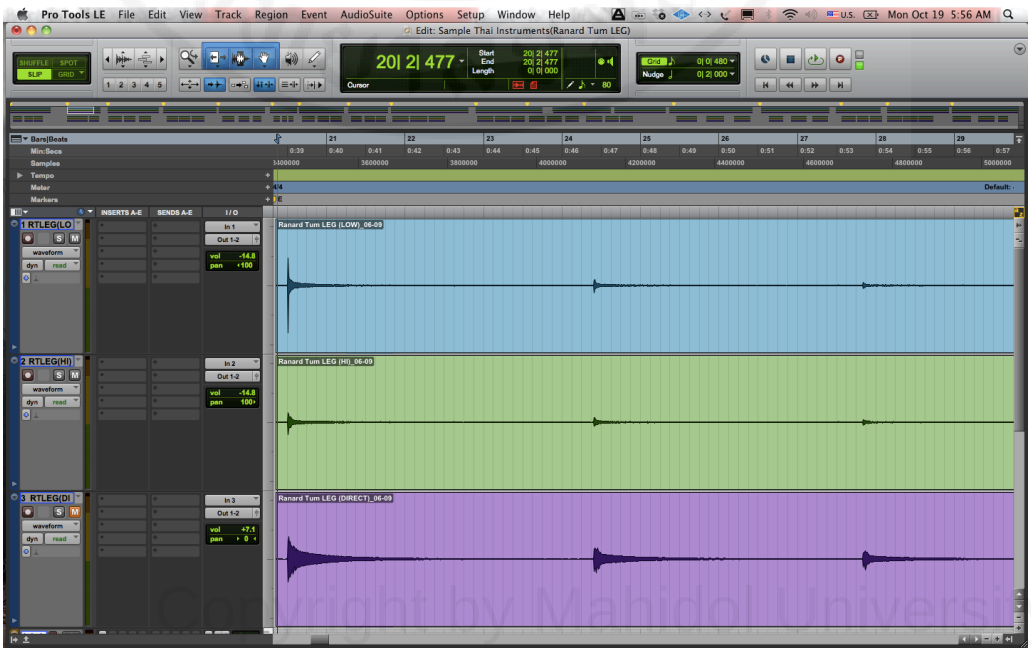


Figure 5.26 E note of Ranad Tum Lek waveform

F note

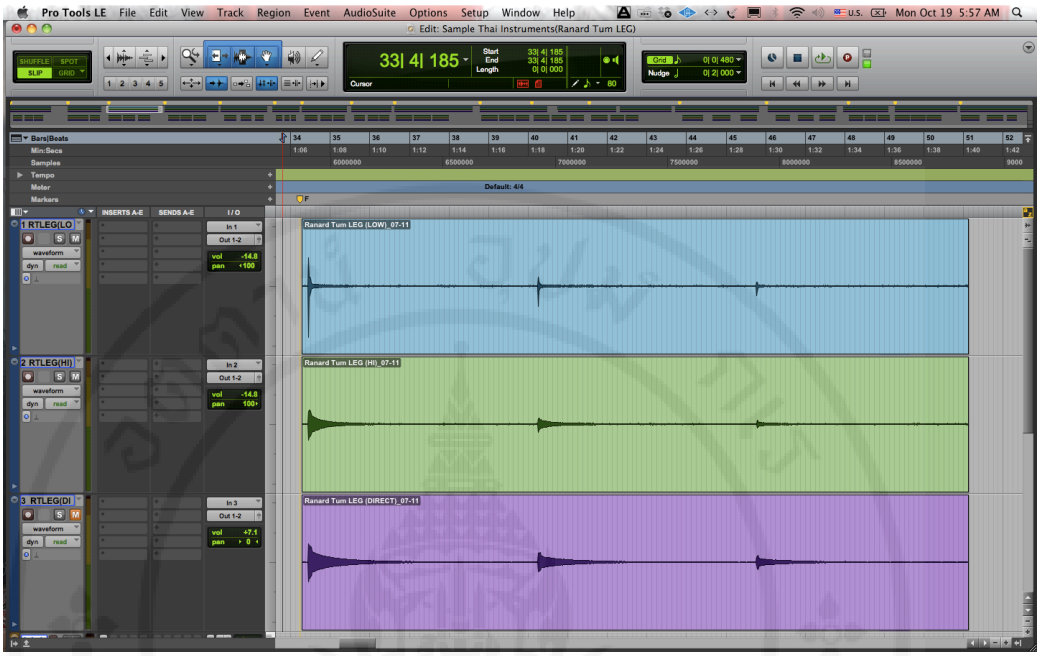


Figure 5.27 F note of Ranad Tum Lek waveform

G note

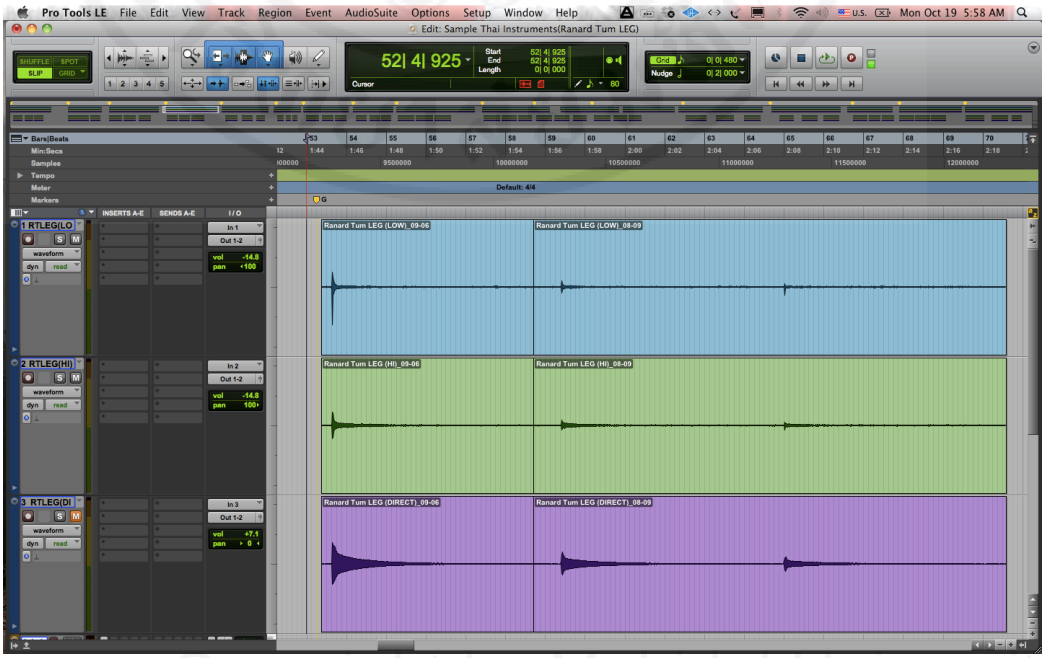


Figure 5.28 G note of Ranad Tum Lek waveform

A note

Figure 5.29 A note of Ranad Tum Lek waveform

B note

Figure 5.30 B note of Ranad Tum Lek waveform

C2 Note

Figure 5.31 C2 note of Ranad Tum Lek waveform

D2 note

Figure 5.32 D2 note of Ranad Tum Lek waveform

E2 note

Figure 5.33 E2 note of Ranad Tum Lek waveform

F2 note

Figure 5.34 F2 note of Ranad Tum Lek waveform

G2 note

Figure 5.35 G2 note of Ranad Tum Lek waveform

A2 note

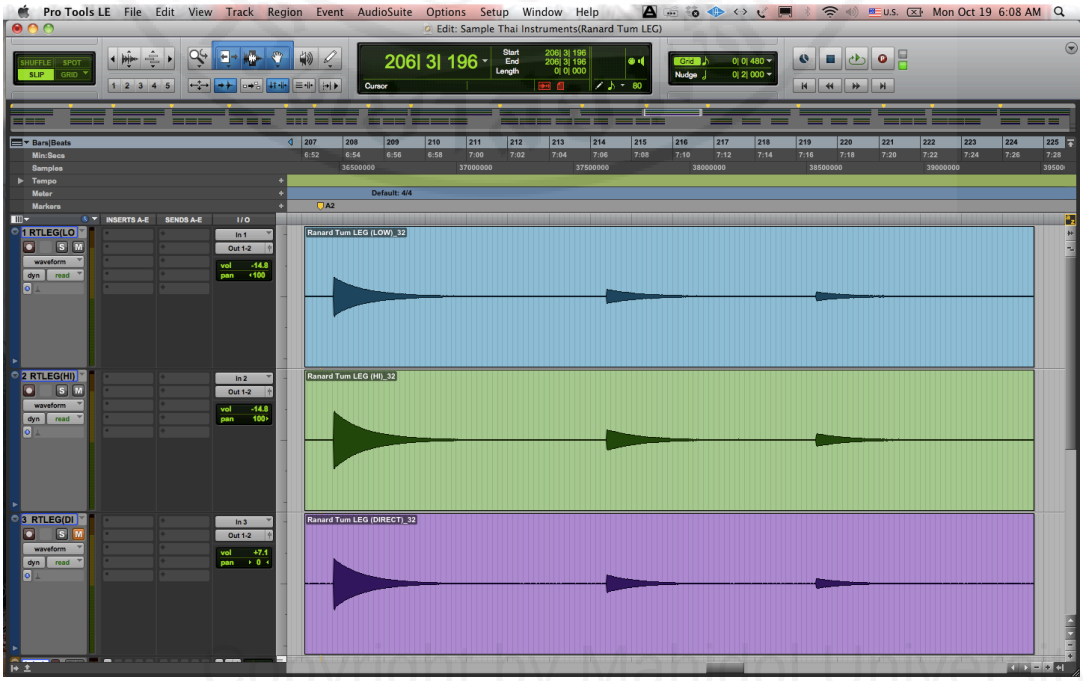


Figure 5.36 A2 note of Ranad Tum Lek waveform

B2 note

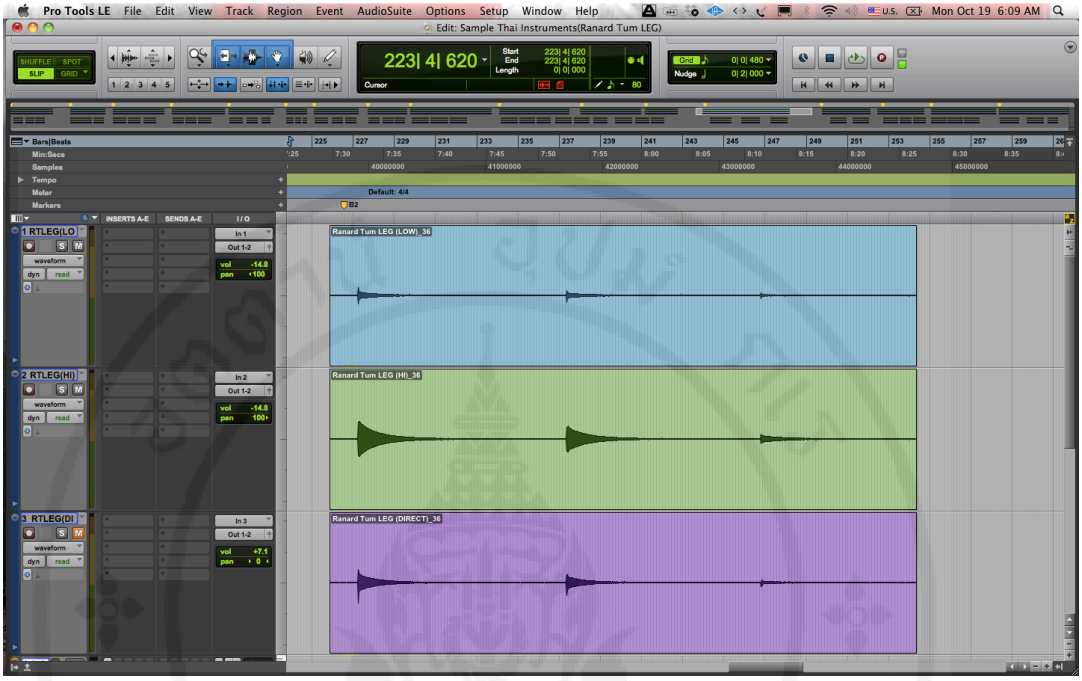


Figure 5.37 B2 note of Ranad Tum Lek waveform

C3 note

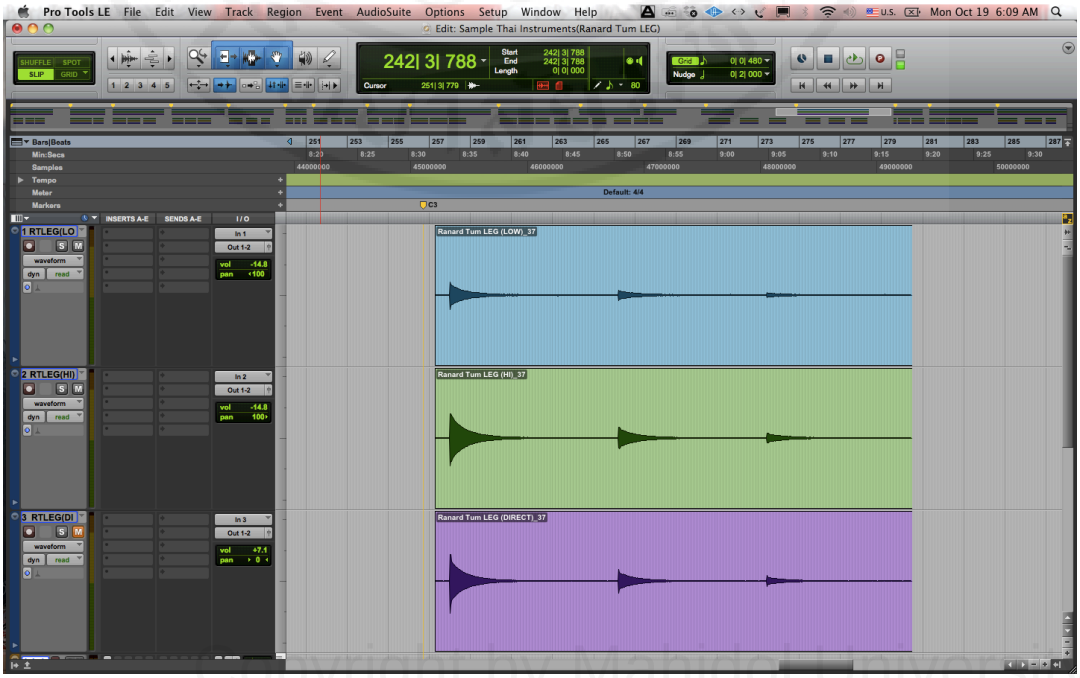


Figure 5.38 C3 note of Ranad Tum Lek waveform

D3 note

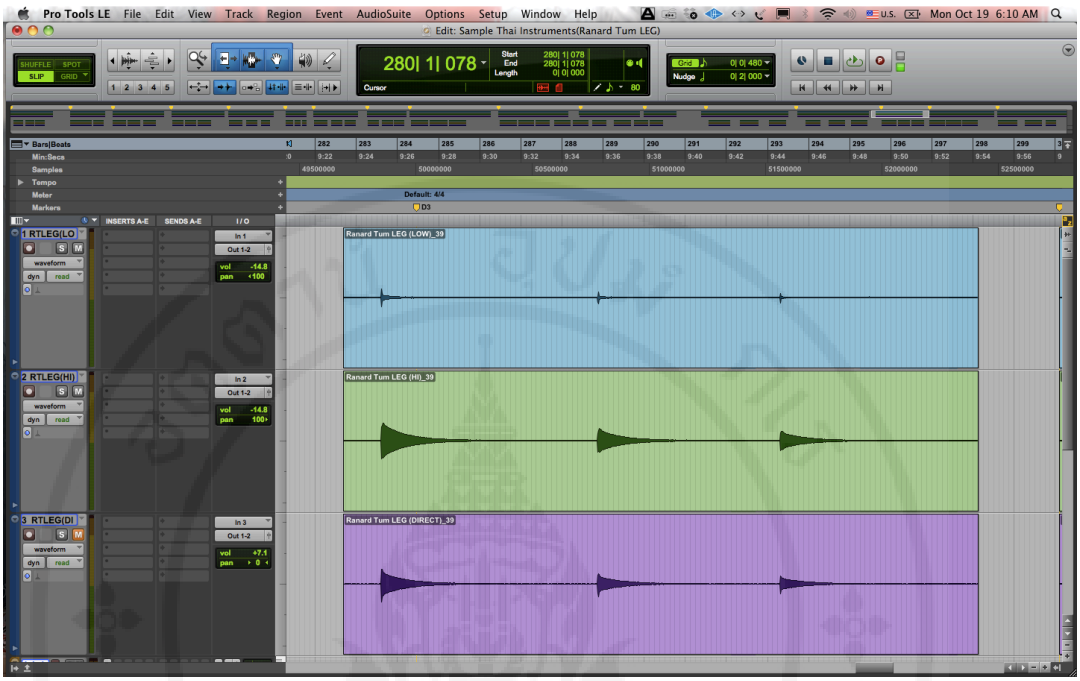


Figure 5.39 D3 note of Ranad Tum Lek waveform

E3 note

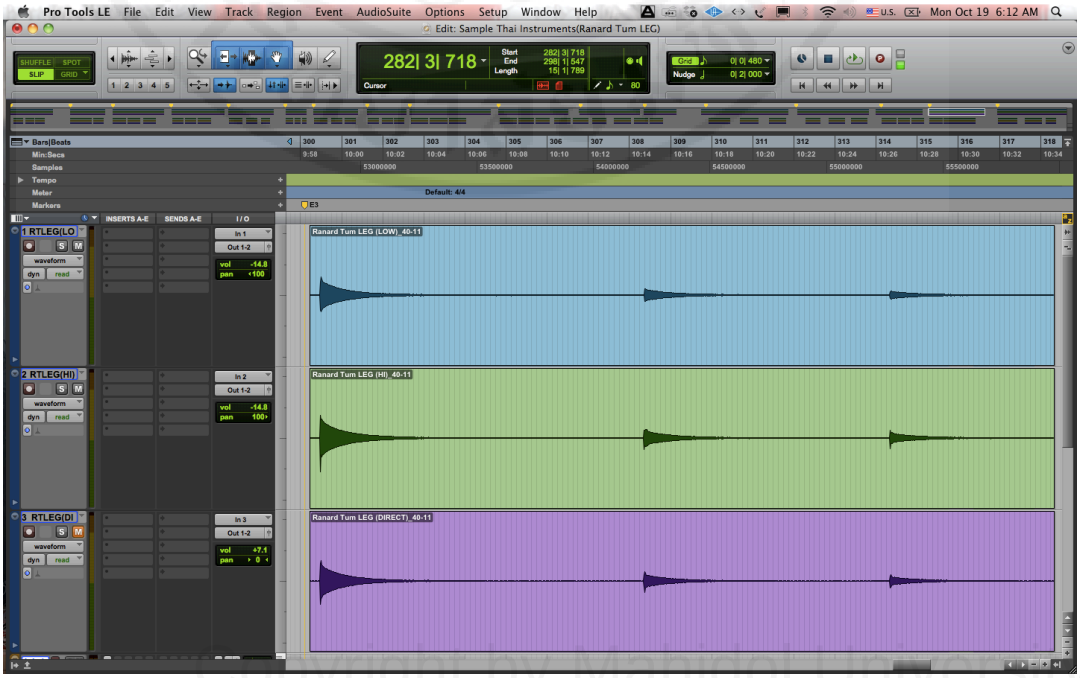


Figure 5.40 E3 note of Ranad Tum Lek waveform

F3 note

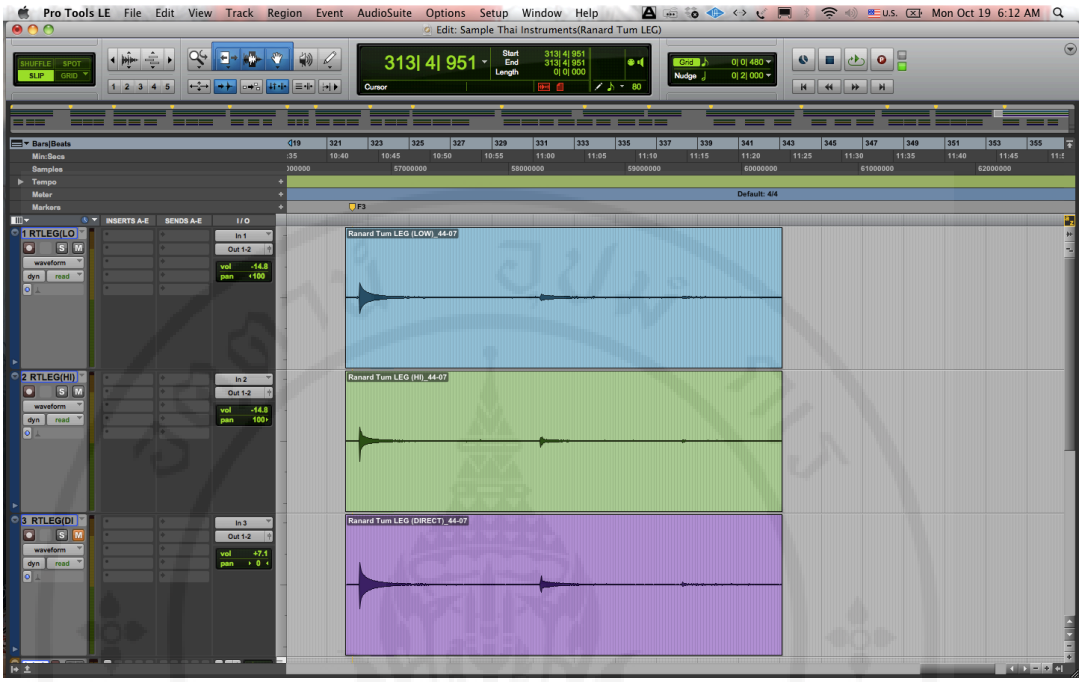


Figure 5.41 F3 note of Ranad Tum Lek waveform

All pitches of Ranad Tum Lek were recorded. In all, they are 17 pitches that were recorded in 3 dynamics; soft(*p*), moderately loud(*mf*) and lond(*f*).

5.2.2 Sound samples of Kong Wong Yai

The researcher has recorded the sound of Kong Wong Yai, in College of music, Mahidol University. The method of selecting an instrument is to choose one according to its condition. The microphones that were used to record the samples of Kong Wong Yai were model No.C414 by AKG, to record sound from the gongs and overhead.

Figure 5.42 C414 by AKG

Figure 5.43 Recording samples of Kong Wong Yai

Kong Wong Yai was recorded in 4 dynamics; soft(p*),* moderately soft(*mp*), moderately loud(*mf*) and loud(*f*).

D note

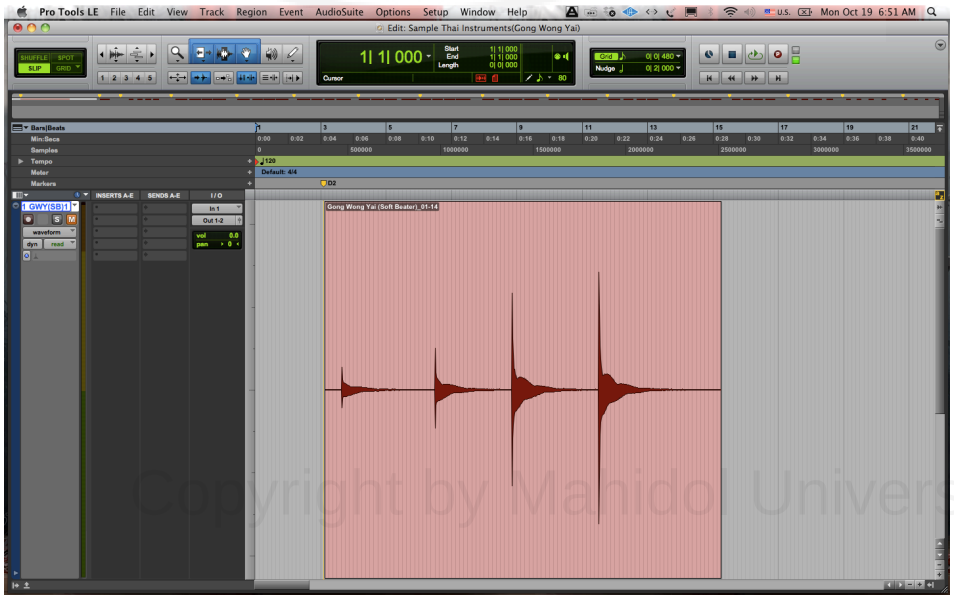


Figure 5.44 D note of Kong Wong Yai waveform

E note

Figure 5.45 E note of Kong Wong Yai waveform

F note

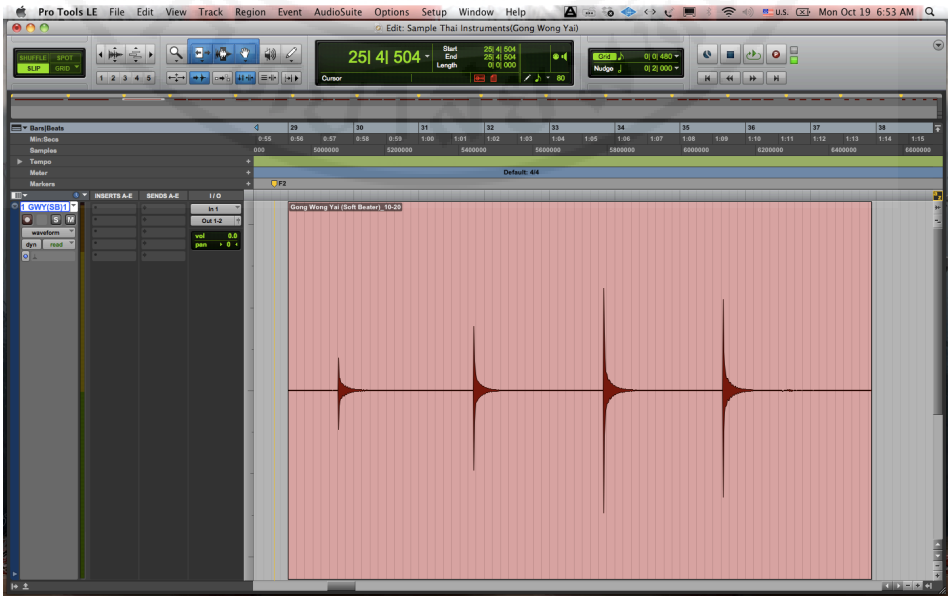


Figure 5.46 F note of Kong Wong Yai waveform

G note

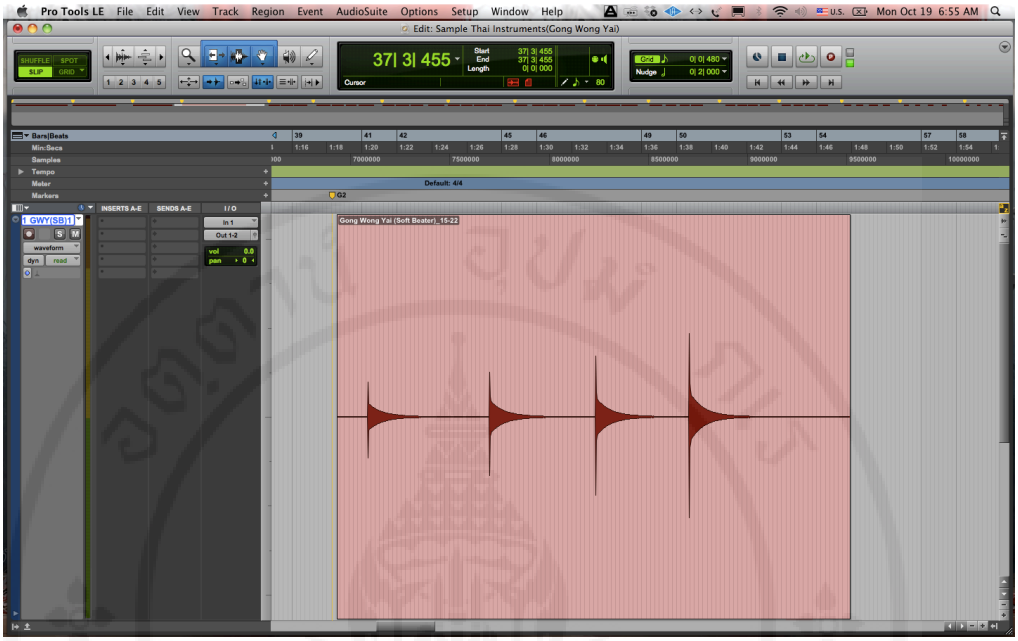


Figure 5.47 G note of Kong Wong Yai waveform

A note

Figure 5.48 A note of Kong Wong Yai waveform

B note

Figure 5.49 B note of Kong Wong Yai waveform

C2 note

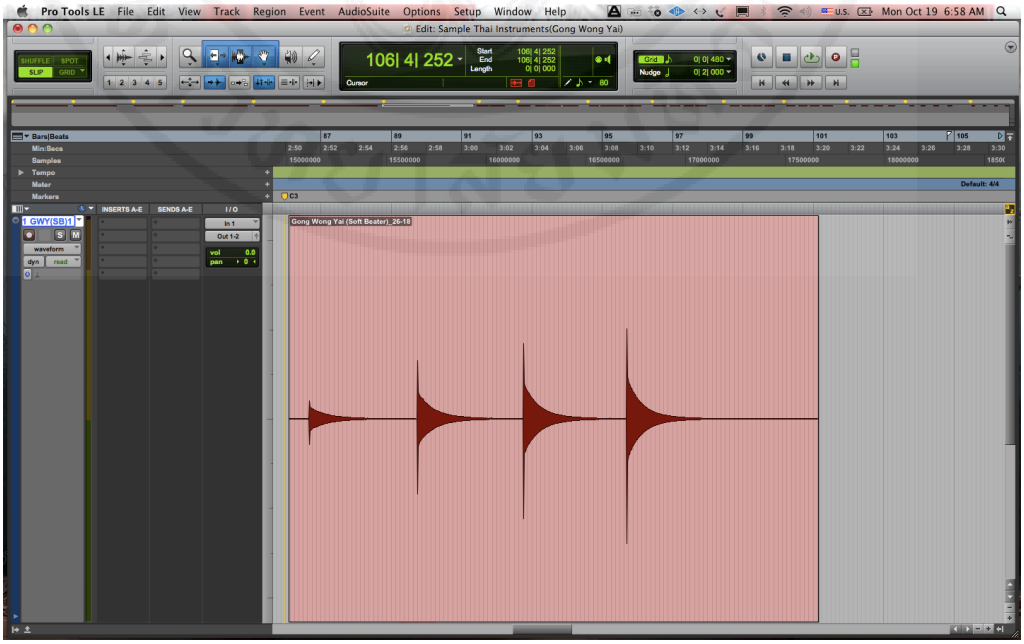


Figure 5.50 C2 note of Kong Wong Yai waveform

D2 note

Figure 5.51 D2 note of Kong Wong Yai waveform

E2 note

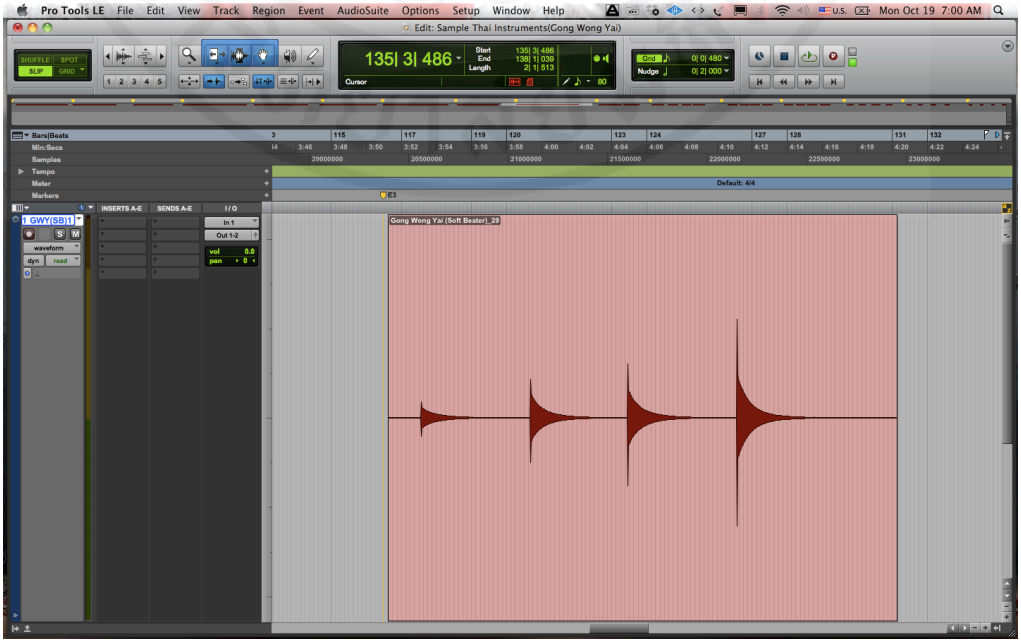


Figure 5.52 E2 note of Kong Wong Yai waveform

F2 Note

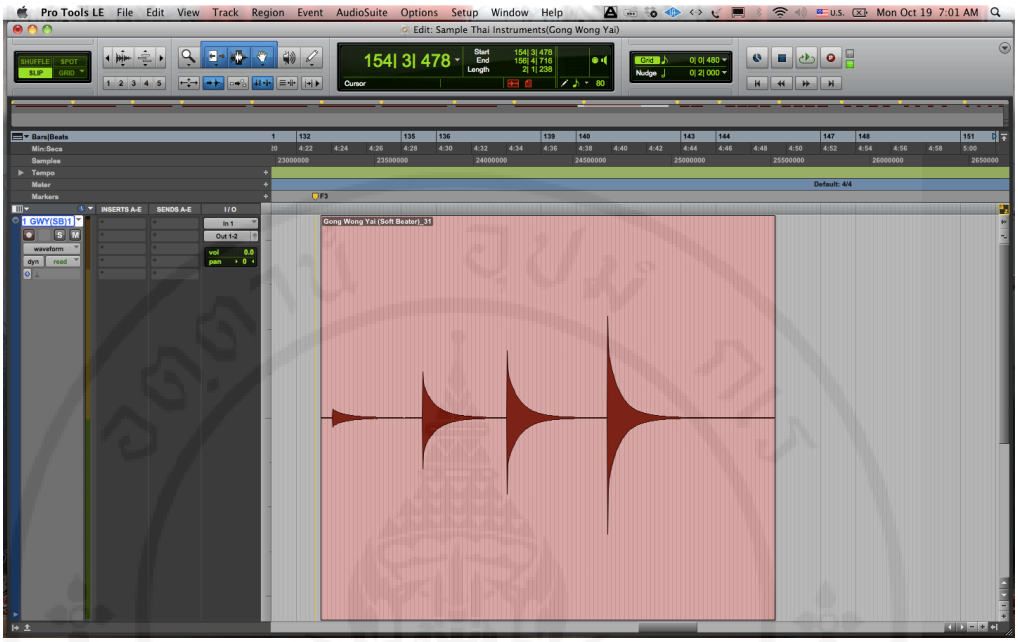


Figure 5.53 F2 note of Kong Wong Yai waveform

G2 Note

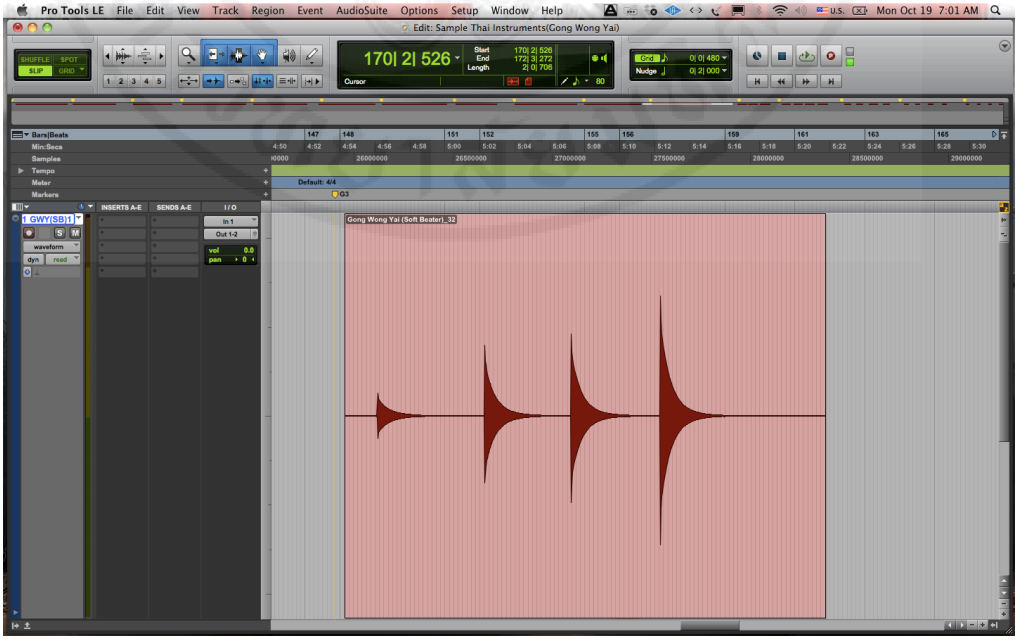


Figure 5.54 G2 note of Kong Wong Yai waveform

A2 note

Figure 5.55 A2 note of Kong Wong Yai waveform

B2 note

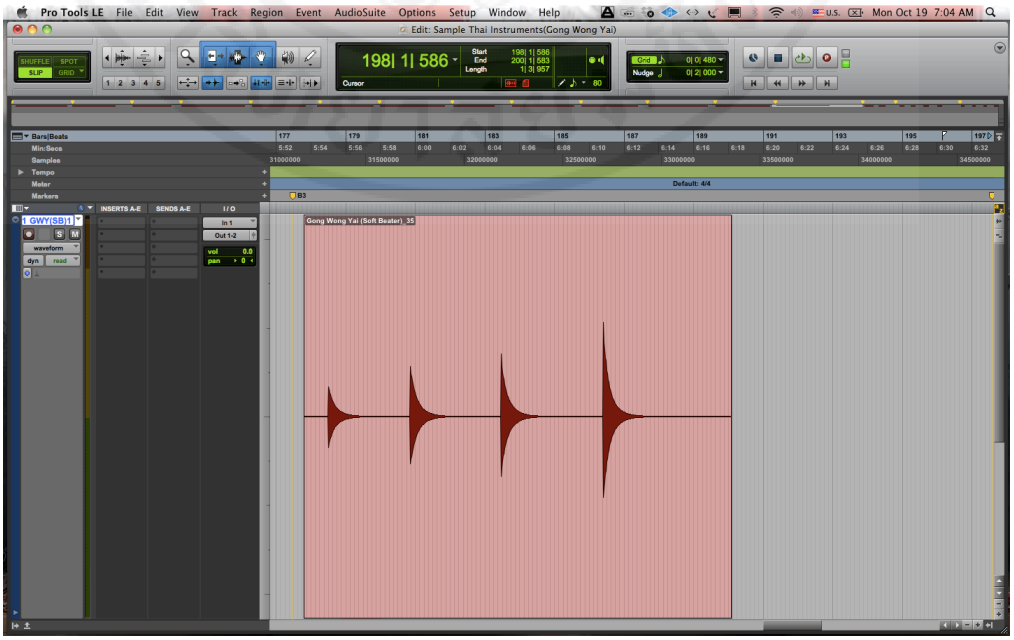


Figure 5.56 B2 note of Kong Wong Yai waveform

C3 note

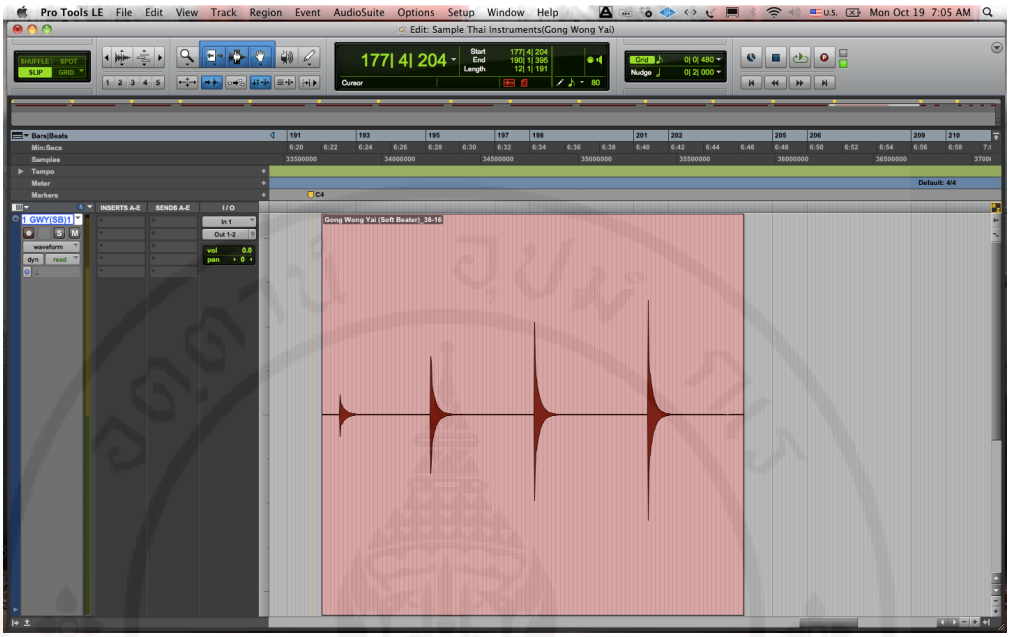


Figure 5.57 C3 note of Kong Wong Yai waveform

D3 note

Figure 5.58 D3 note of Kong Wong Yai waveform

E3 note

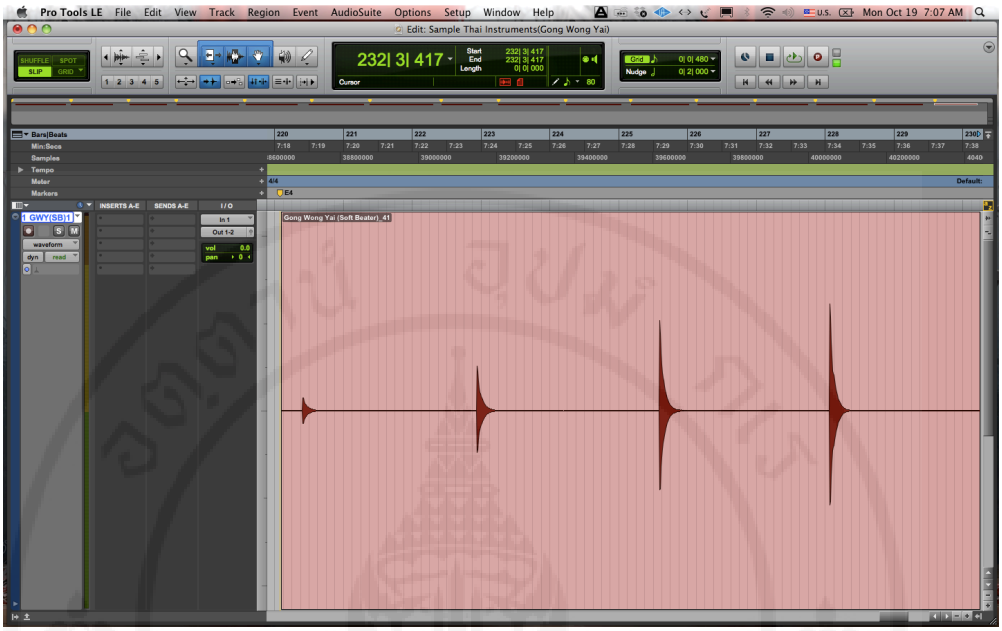


Figure 5.59 E3 note of Kong Wong Yai waveform

In all, 17 pitches were recorded from Kong Wong Yai.

5.2.3 Sound samples of Ranad Ek

The researcher has recorded the sound of Ranad Ek in College of music, Mahidol University. The method of selecting an instrument is to choose one according to its condition. The microphones that were used to record Ranad Ek were model No.MD421 by Sennheiser, for recording the sound from bar sticks and U89 by Neumann, for recording sound from overhead.

Figure 5.60 Recording samples of Ranad Ek

Figure 5.61 Recording samples of Ranad Ek

F note

Figure 5.62 F note of Ranad Ek waveform

G note

Figure 5.63 G note of Ranad Ek waveform

A note

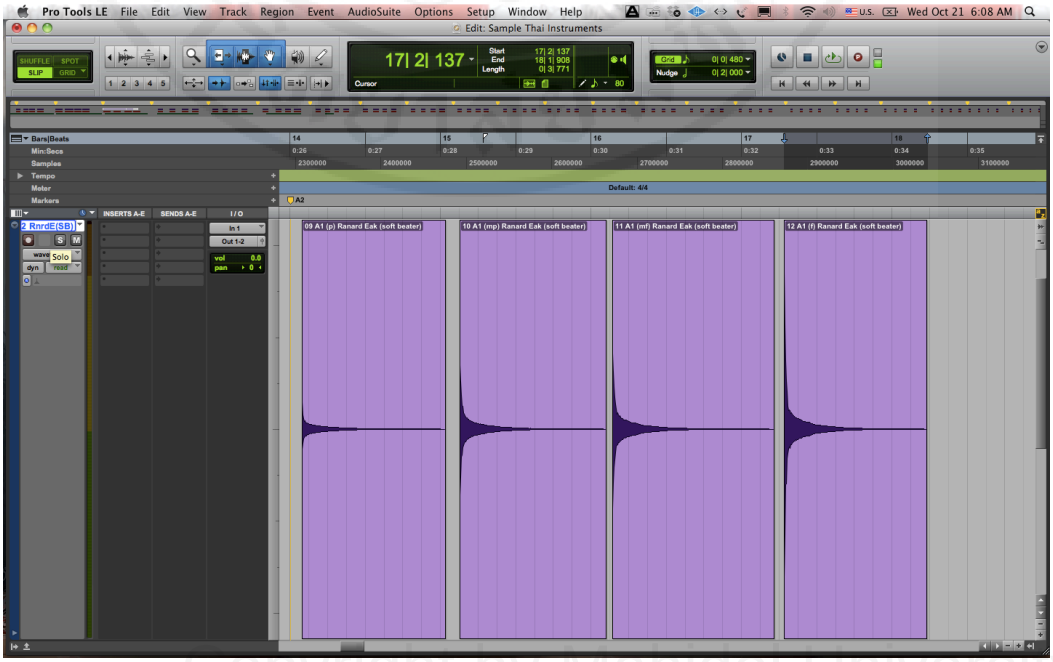


Figure 5.64 A note of Ranad Ek waveform

B note

Figure 5.65 B note of Ranad Ek waveform

C2 note

Figure 5.66 C2 note of Ranad Ek waveform

D2 note

Figure 5.67 D2 note of Ranad Ek waveform

E2 note

Figure 5.68 E2 note of Ranad Ek waveform

F2 note

Figure 5.69 F2 note of Ranad Ek waveform

G2 note

Figure 5.70 G2 note of Ranad Ek waveform

A2 note

Figure 5.71 A2 note of Ranad Ek waveform

B2 note

Figure 5.72 B2 note of Ranad Ek waveform

C3 note

Figure 5.73 C3 note of Ranad Ek waveform

D3 note

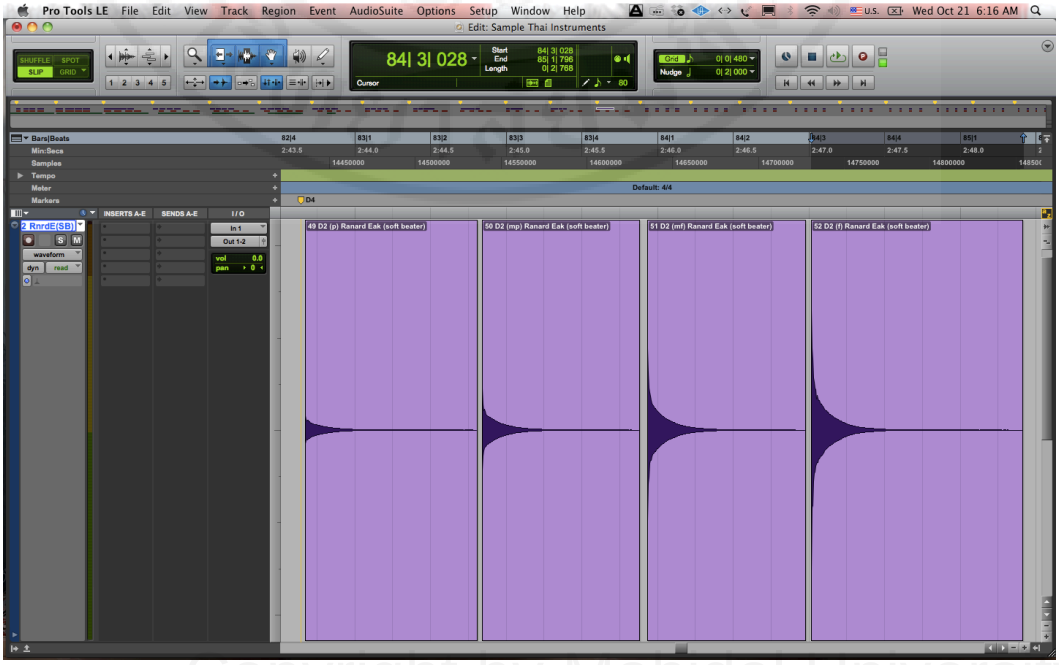


Figure 5.74 D3 note of Ranad Ek waveform

E3 note

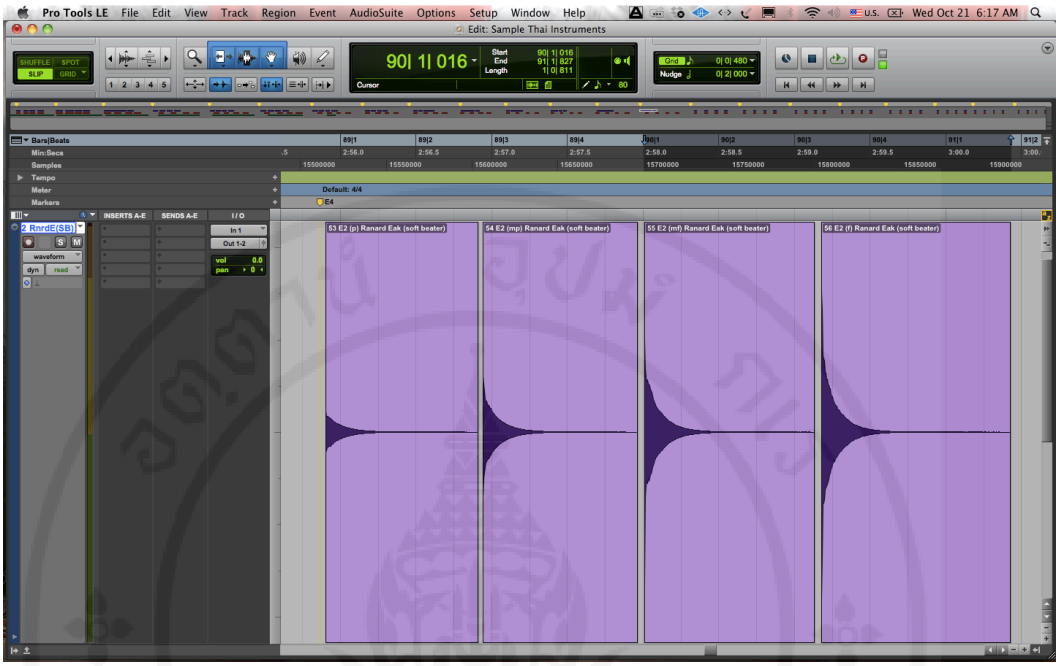


Figure 5.75 E3 note of Ranad Ek waveform

F3 note

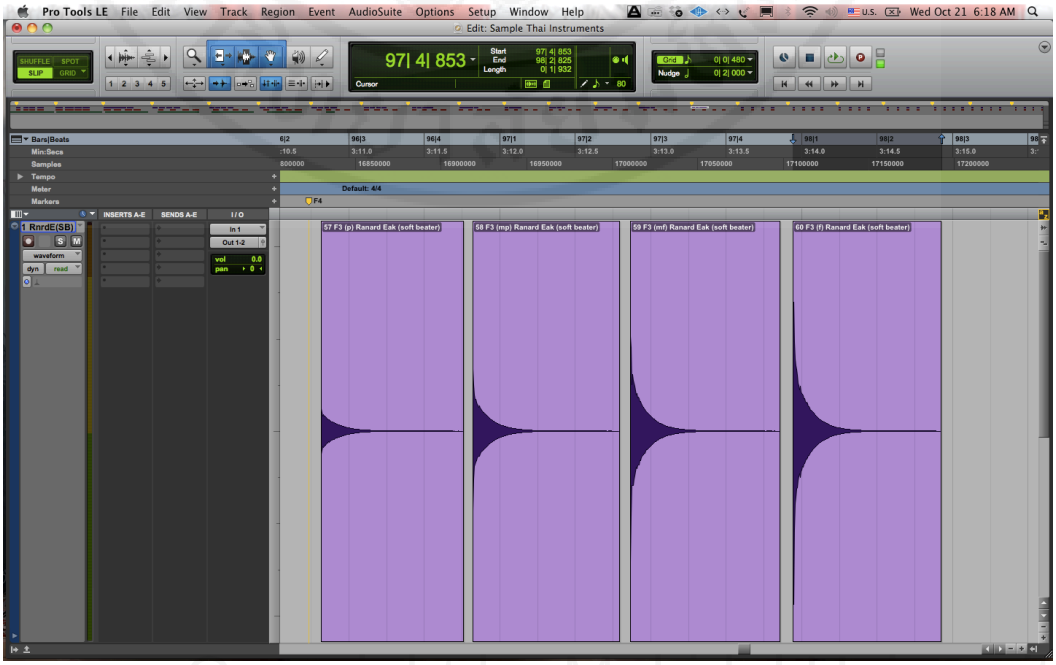


Figure 5.76 F3 note of Ranad Ek waveform

G3 note

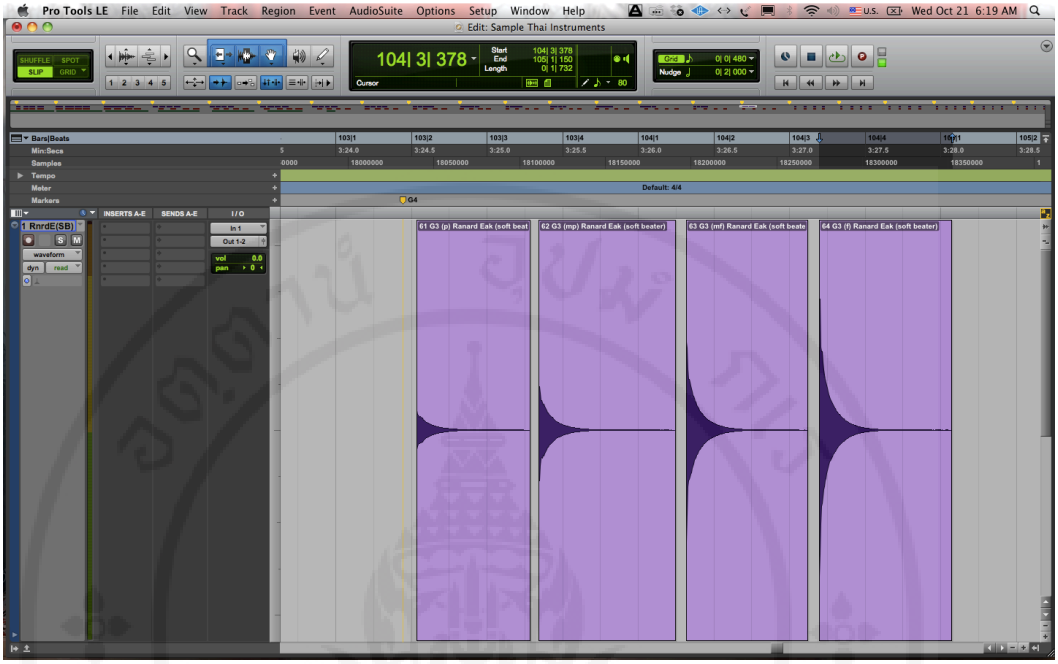


Figure 5.77 G3 note of Ranad Ek waveform

A3 note

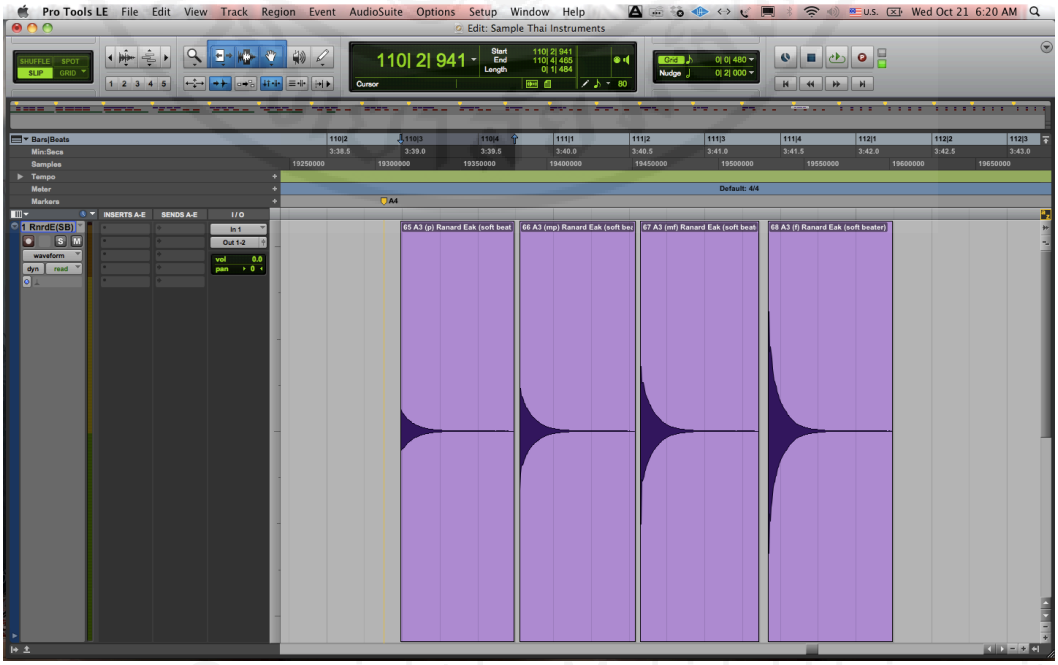


Figure 5.78 A3 note of Ranad Ek waveform

B3 note

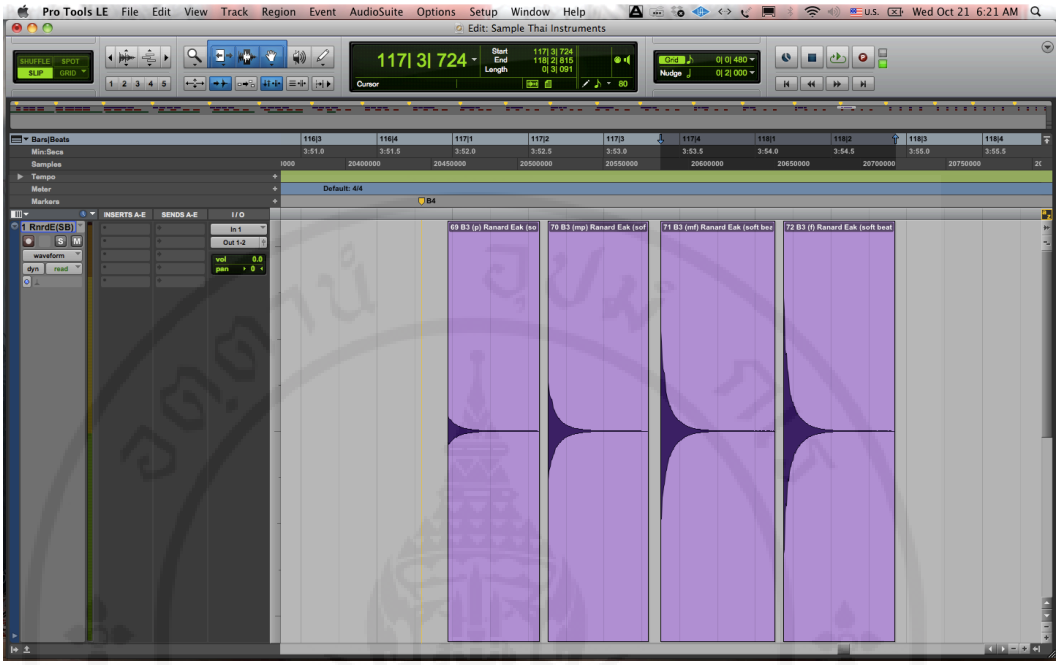


Figure 5.79 B3 note of Ranad Ek waveform

C4 note

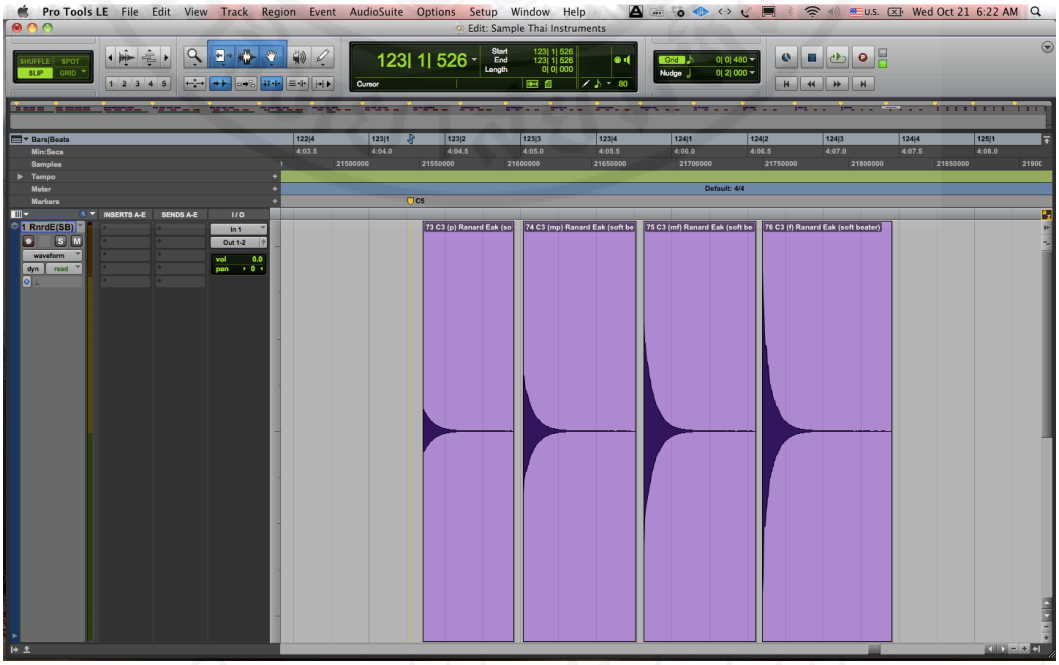


Figure 5.80 C4 note of Ranad Ek waveform

D4 note

Figure 5.81 D4 note of Ranad Ek waveform

E4 note

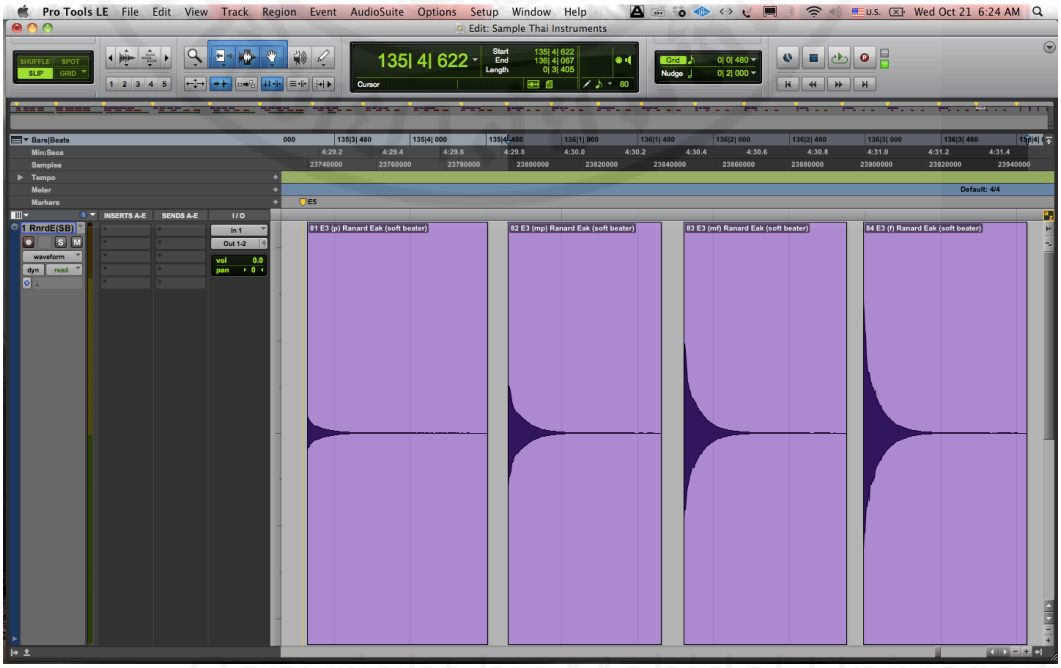


Figure 5.82 E4 note of Ranad Ek waveform

F4 note

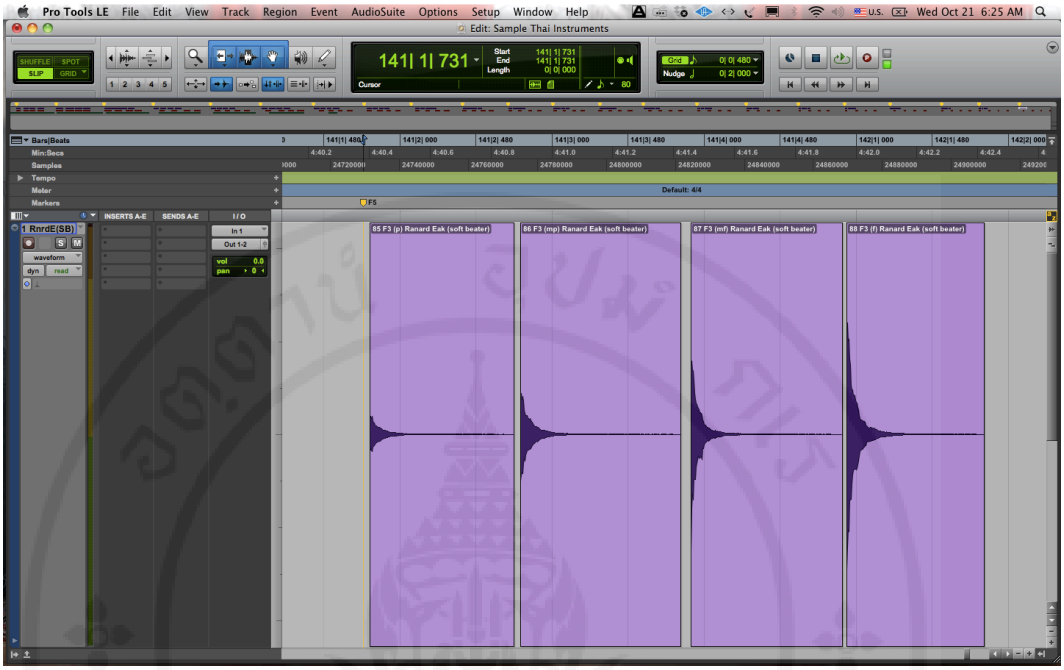


Figure 5.83 F4 note of Ranad Ek waveform

In all, 22 pitches were recorded from Ranad Ek.

The results of recording Thai instruments sound samples as follows.

- Ranad Tum Lek has D - F3 notes, totaling 17 pitches.
- Ranad Ek has F - F4 notes, totaling 22 pitches.
- Kong Wong Yai has D - E3 notes, totaling 16 pitches

After that, a computer program was used to adjust the frequency of all pitches into the frequency of the Thai musical scale system by cent value. The adjusted frequency method has the following process.

- Adjust all pitches of Thai instruments sound samples into equal temperaments to use as a reference frequency.

- After the sound sample is tuned into the equal temperament scale system, it will have an adjusted frequency the same as in the results of the study of the Thai musical scale system.

5.3 Adjustment of all pitches of Thai instruments sound samples into the equal temperament scale system to use as a reference frequency

Because there was no standard frequency of pitch in the Thai musical scale system, all pitches of the Thai instruments sound samples have been tuned into the equal temperament scale system. The frequency of the sound samples has been adjusted into the equal temperament scale system as a reference for the Thai sound samples. The method to adjust the Thai sound samples into the equal temperament is as follows.

5.3.1 Adjustment of a frequency of Thai sound samples into the Equal Temperament by VST Plug-in

The researcher has used VST Plug-ins (Virtual Studio Technology) to adjust frequency of the Thai sound samples into the equal temperament system. There are many kinds of VST plug-ins on the market nowadays, some of them can imitate the effect processor hardware that has been used in recording studios.

API 2500 Compressor Plug-in

Figure 5.84 Effect Processor Plug-in

(Picture from http://www.sweetwater.com)

Figure 5.85 API 2500 Compressor Hardware

This research used a Plug-in called Auto-Tune Evo, by Antares to adjust the Thai sound samples. The process of adjustment is as follows.

Auto-Tune Plug-in

Figure 5.86 Auto-Tune Plug-in

Auto-Tune Plug-in can be used to tune the frequency of instruments by selecting ‘instrument’ for the input type.

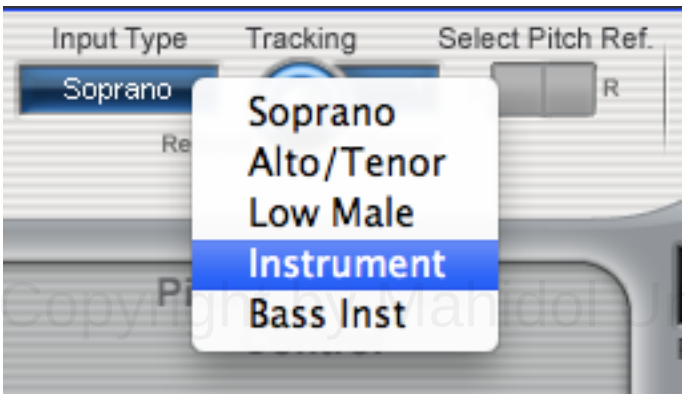


Figure 5.87 Input type in Auto-Tune Plug-in

From the study of the Auto-Tune Evo manual, there are 2 modes of tuning methods; Automatic mode and Graphic mode. In Automatic mode, the pitch is tuned by selecting the musical scale, such as A major, B minor etc. The Graphical mode, has more flexible and accurate tuning than the Automatic mode.

Figure 5.88 Automatic Mode

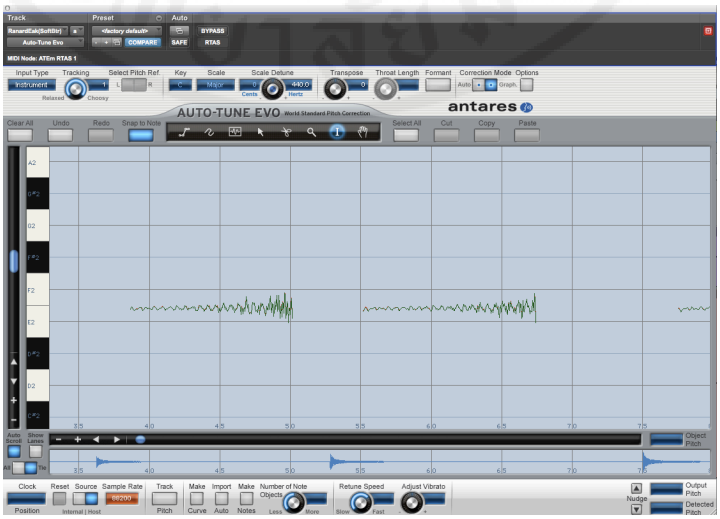


Figure 5.89 Graphic Mode

The researcher has used Graphic Mode to adjust the frequency of the Thai sound samples into the equal temperament scale system.

5.3.2 Adjustment of Ranad Ek sound samples

From the sound samples of Ranad Ek there are 22 pitches, from F-F4.

F note

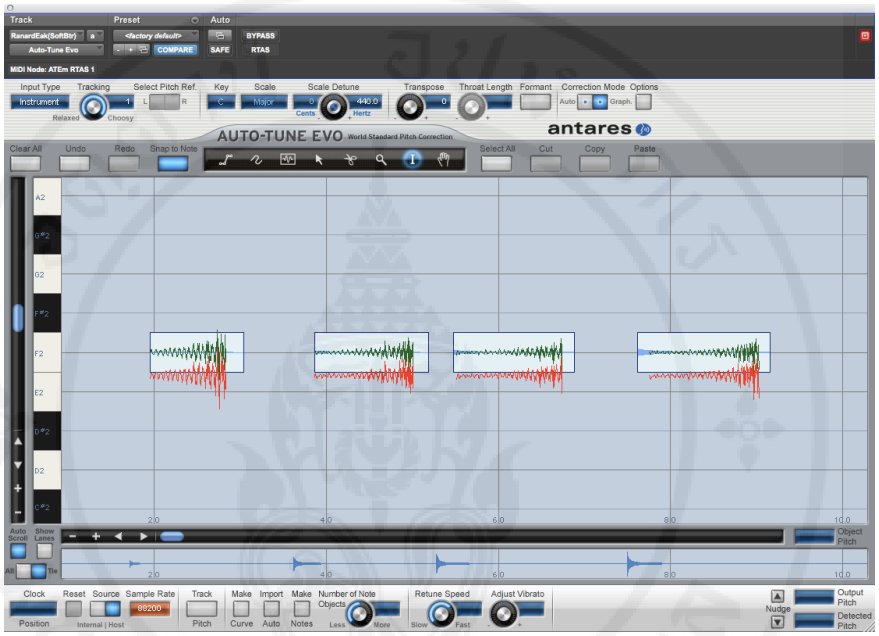


Figure 5.90 F note adjustment of Ranad Ek by Auto-Tune Plug-in

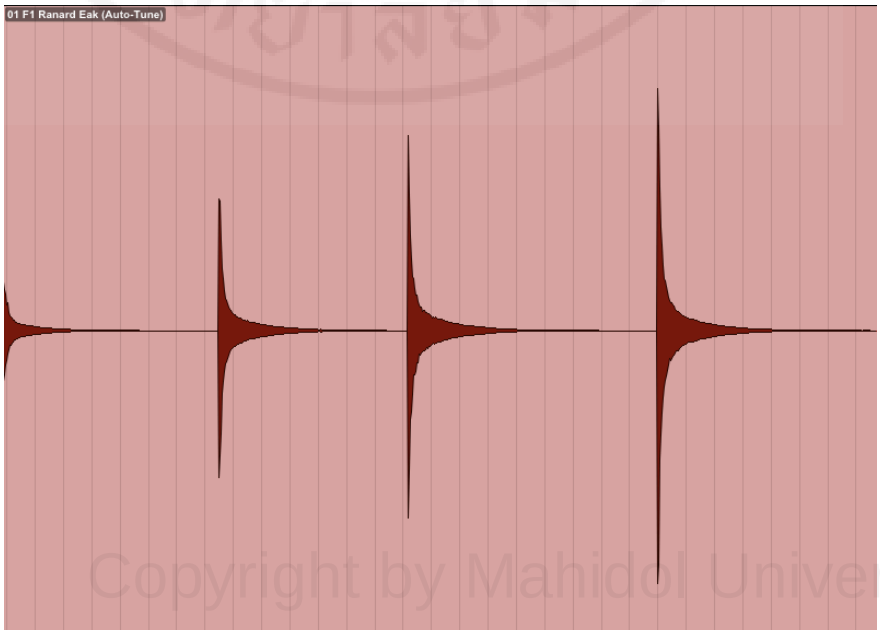


Figure 5.91 F note after adjustment of Ranad Ek waveform

G note

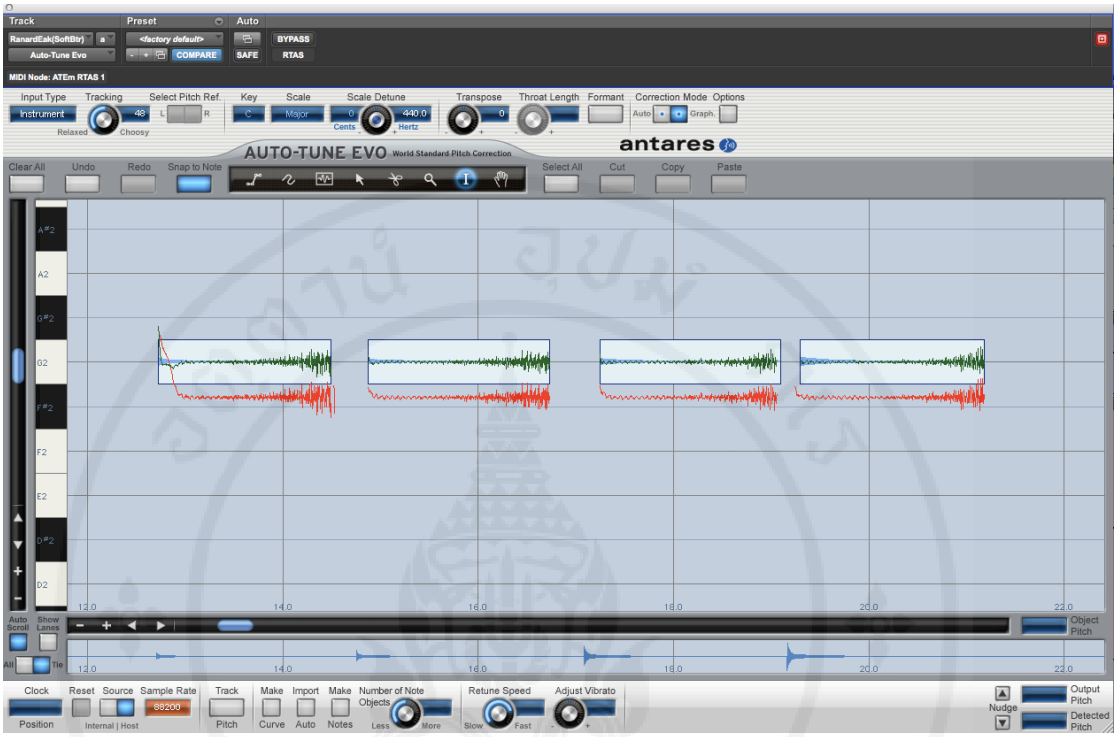


Figure 5.92 G note adjustment of Ranad Ek by Auto-Tune Plug-in

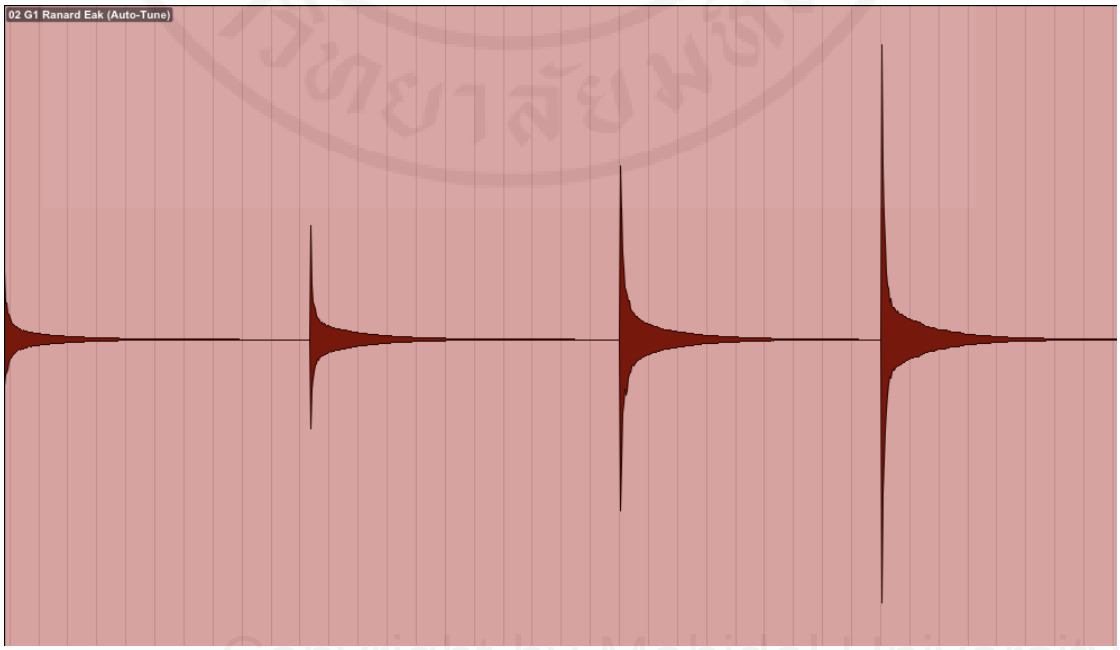


Figure 5.93 G note after adjustment of Ranad Ek waveform

A note

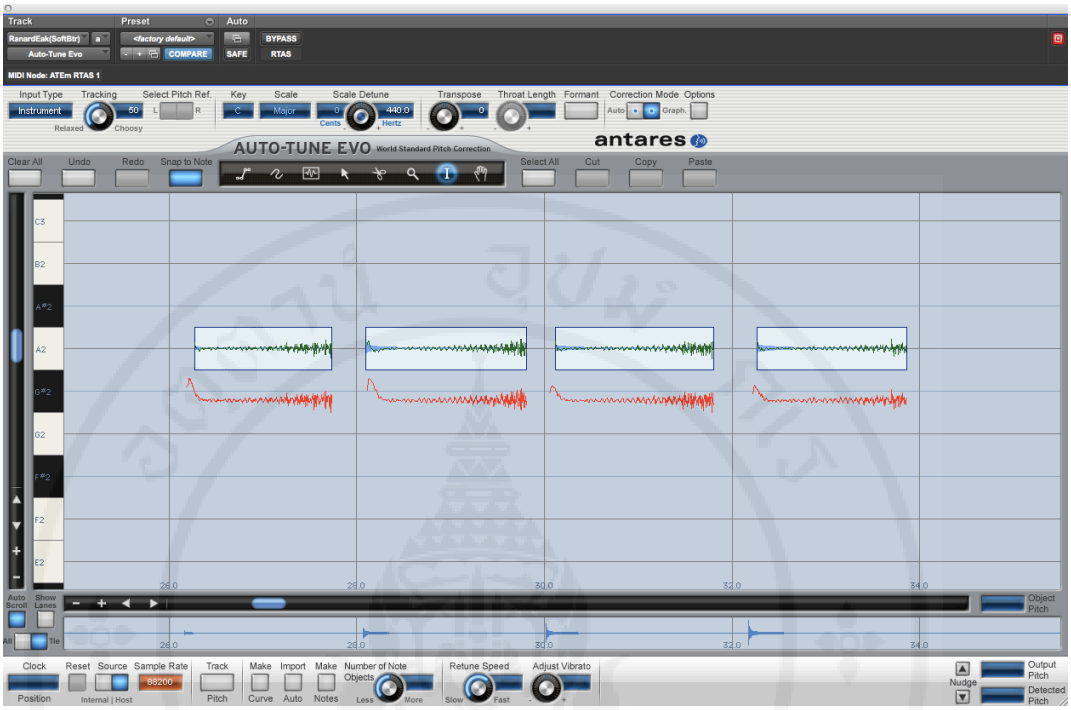


Figure 5.94 A note adjustment of Ranad Ek by Auto-Tune Plug-in

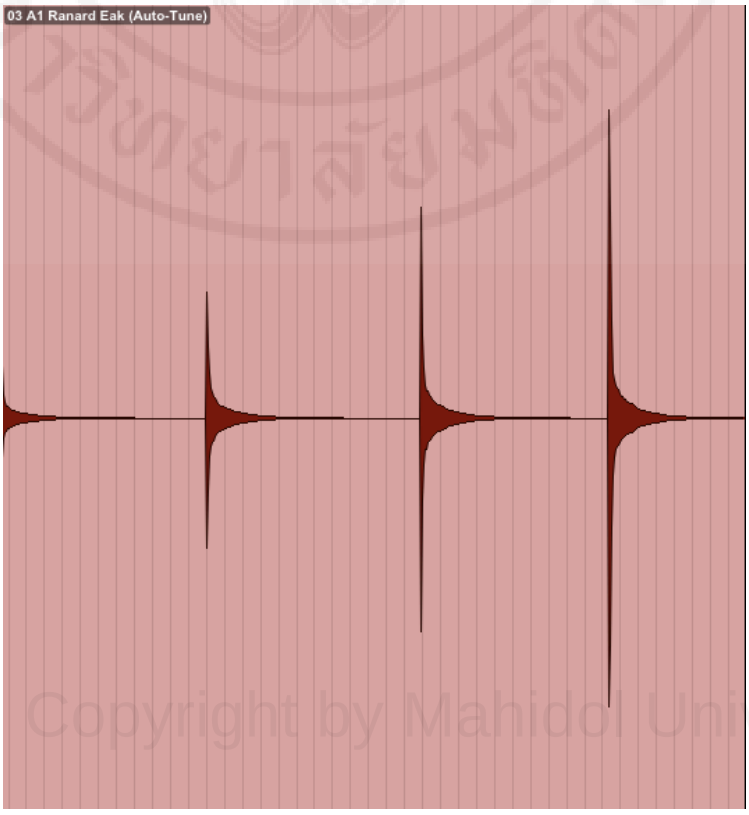


Figure 5.95 A note after adjustment of Ranad Ek waveform

B note

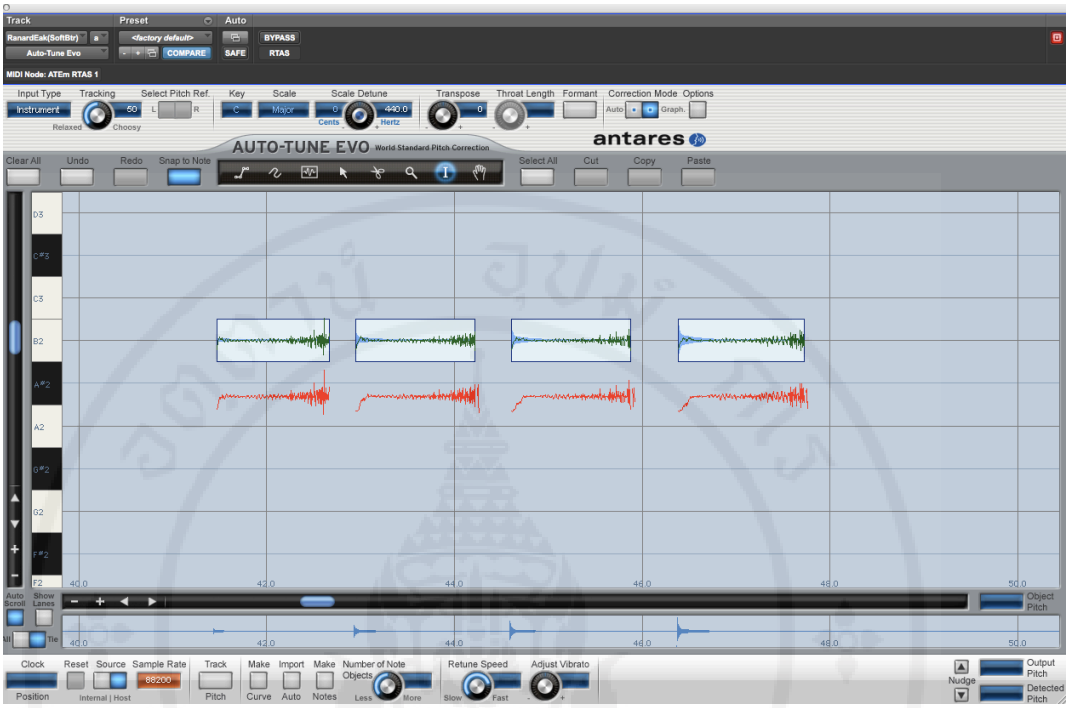


Figure 5.96 B note adjustment of Ranad Ek by Auto-Tune Plug-in

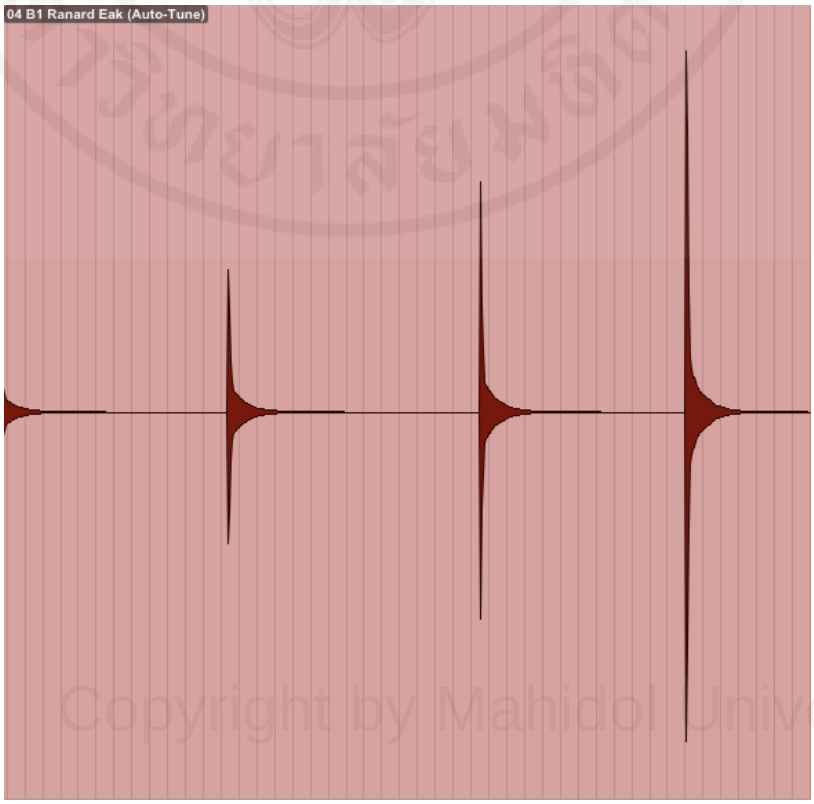


Figure 5.97 B note after adjustment of Ranad Ek waveform

C2 note

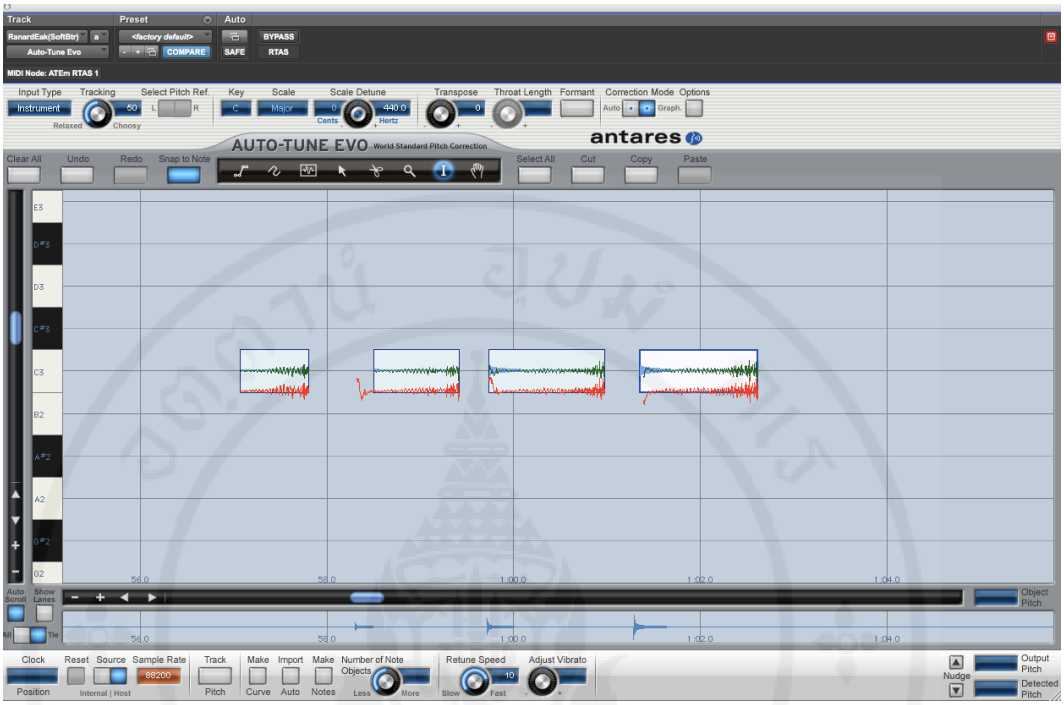


Figure 5.98 C2 note adjustment of Ranad Ek by Auto-Tune Plug-in

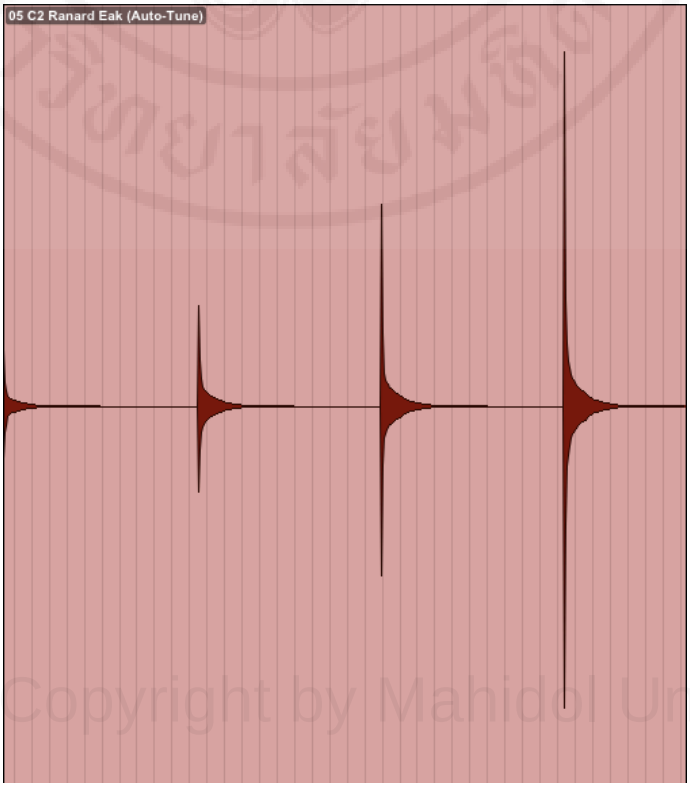


Figure 5.99 C2 note after adjustment of Ranad Ek waveform

D2 note

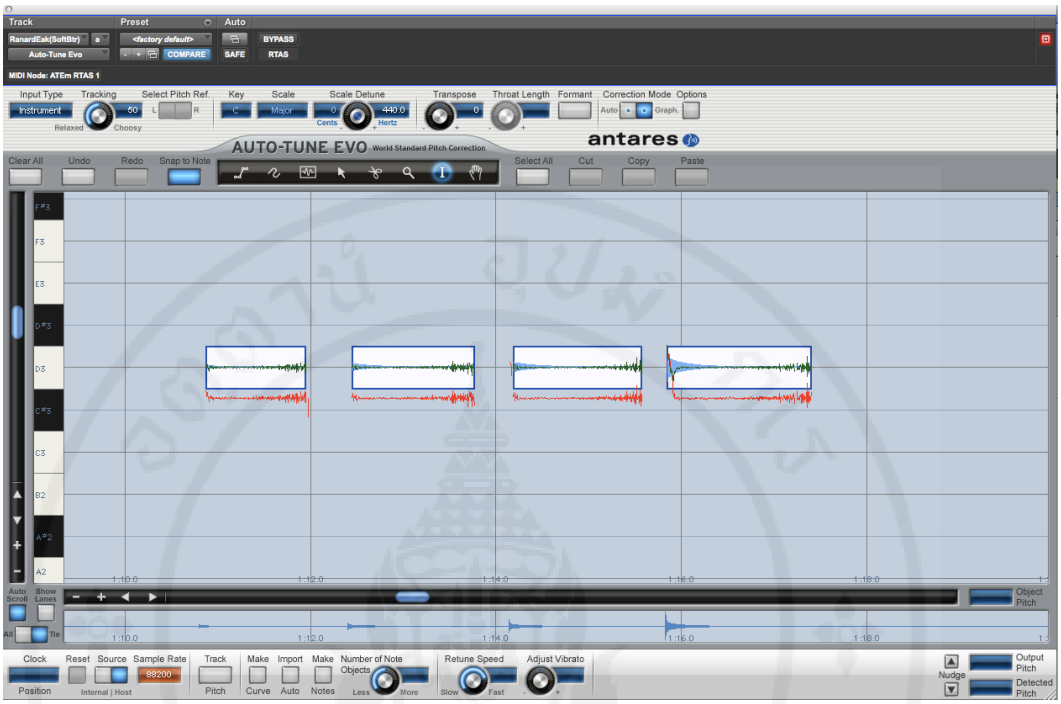


Figure 5.100 D2 note adjustment of Ranad Ek by Auto-Tune Plug-in

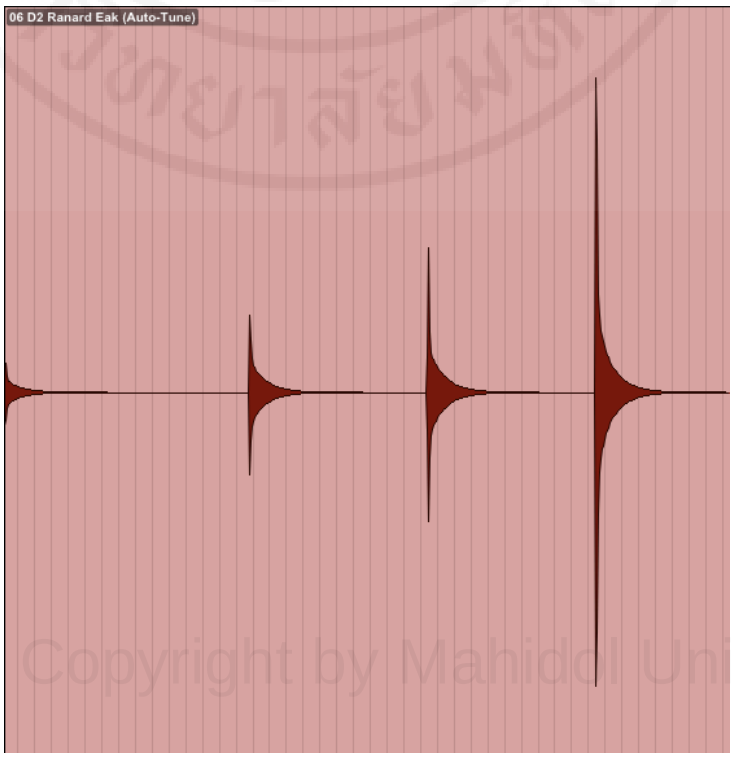


Figure 5.101 D2 note after adjustment of Ranad Ek waveform

E2 note

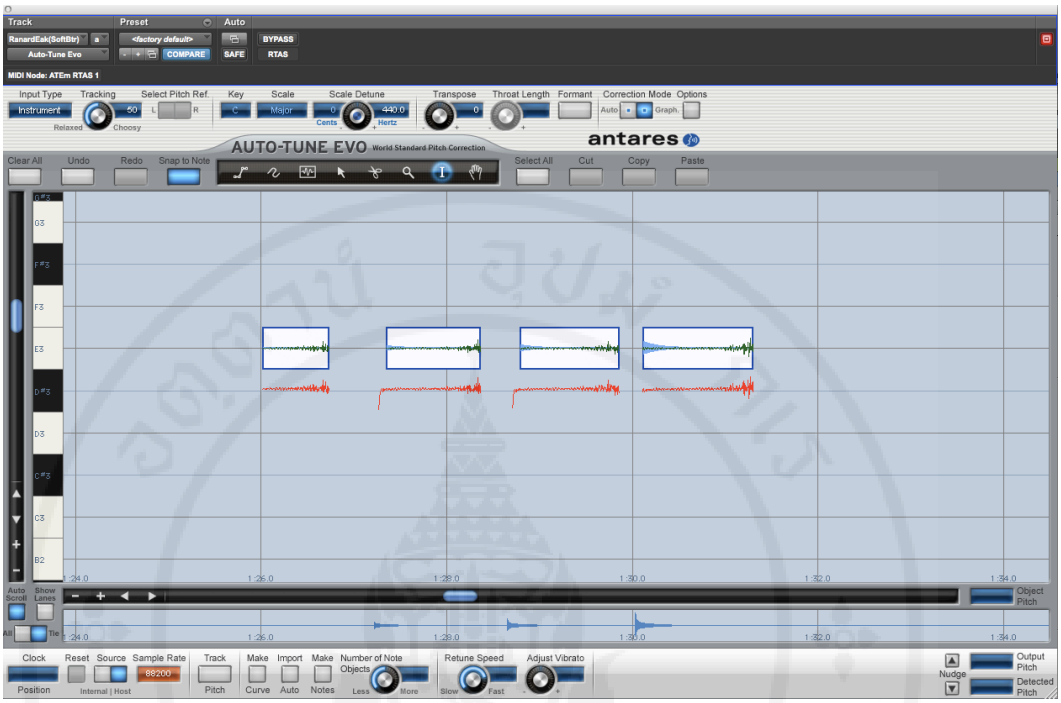


Figure 5.102 E2 note adjustment of Ranad Ek by Auto-Tune Plug-in

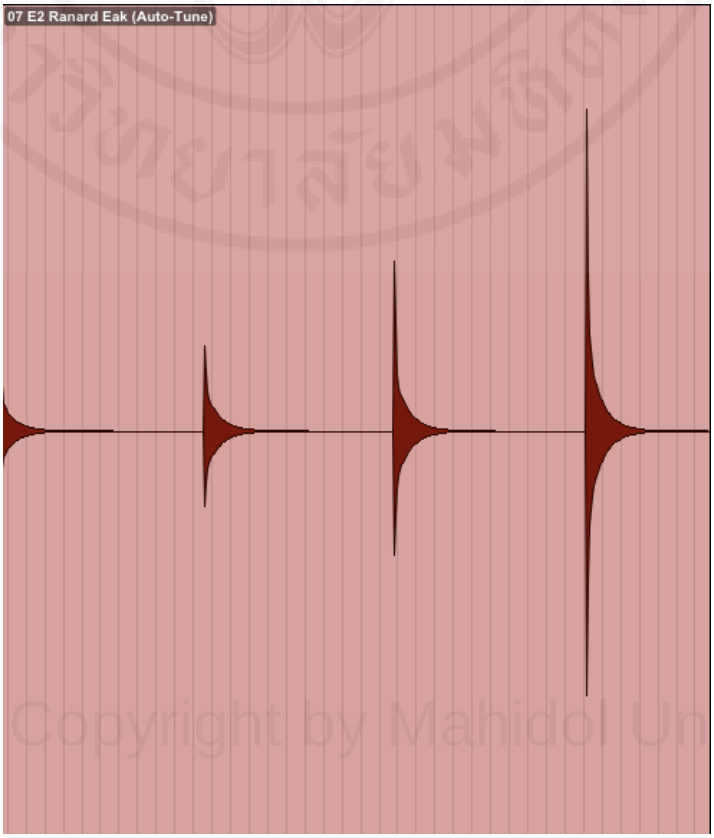


Figure 5.103 E2 note after adjustment of Ranad Ek waveform

F2 note

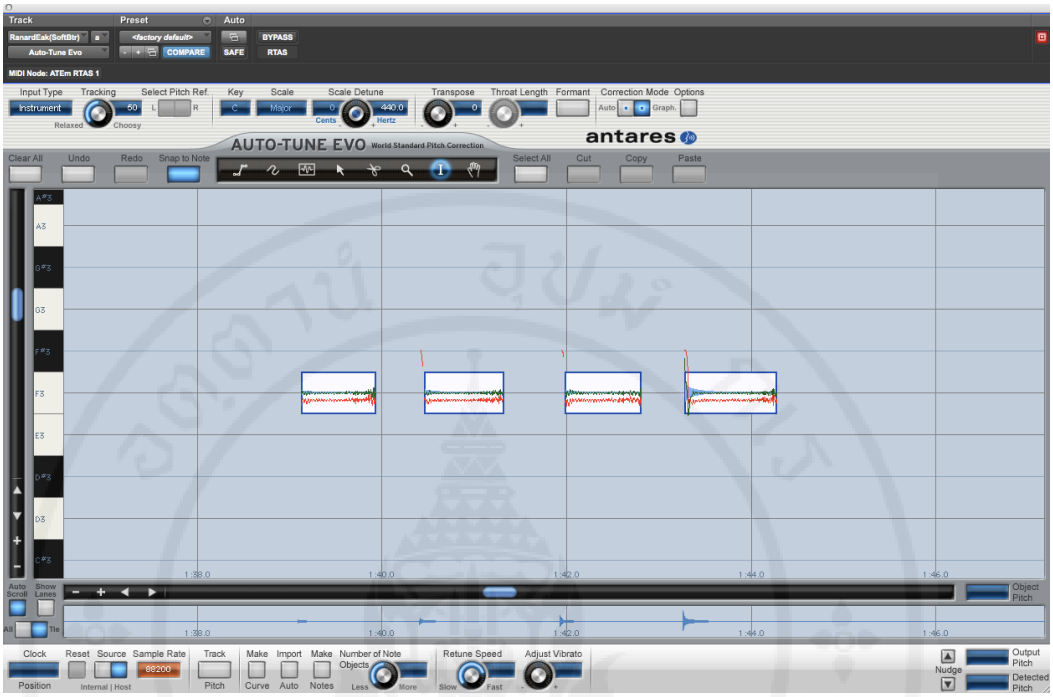


Figure 5.104 F2 note adjustment of Ranad Ek by Auto-Tune Plug-in

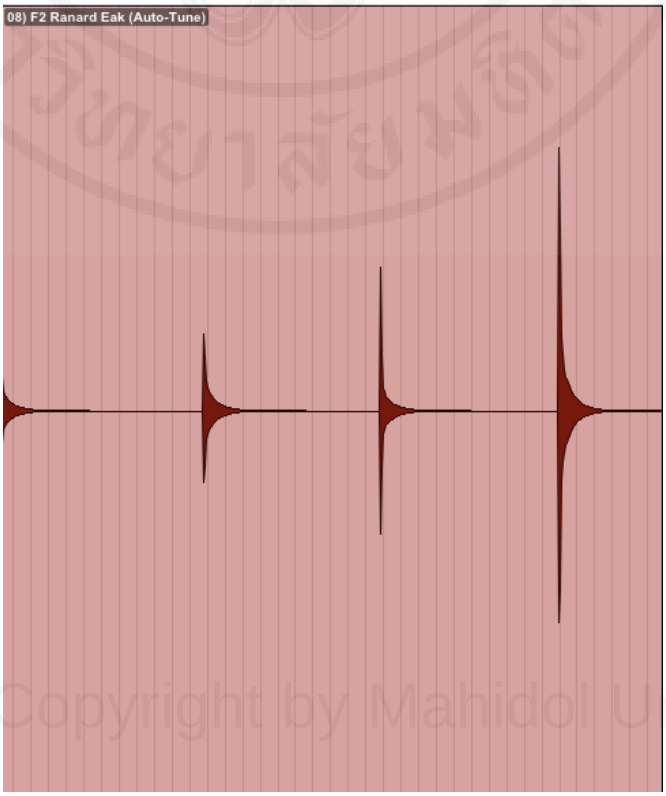


Figure 5.105 F2 note after adjustment of Ranad Ek waveform

G2 note

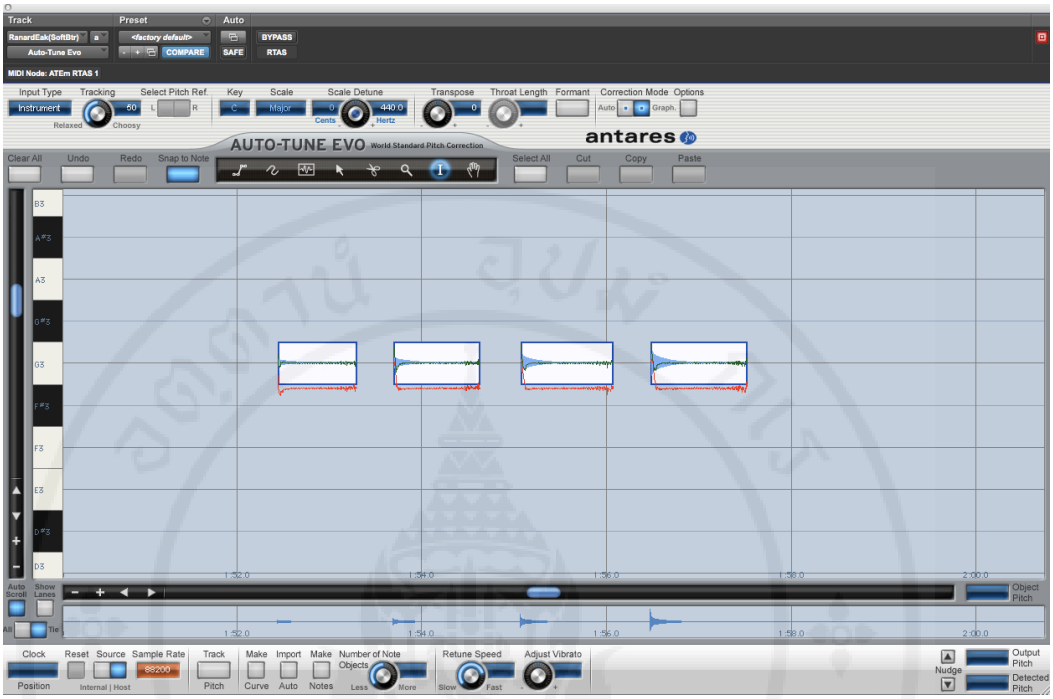


Figure 5.106 G2 note adjustment of Ranad Ek by Auto-Tune Plug-in

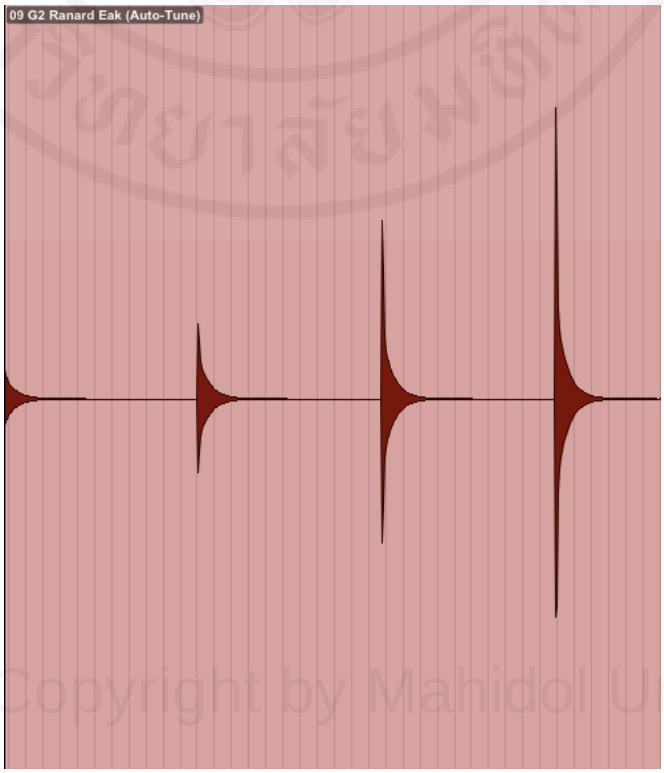


Figure 5.107 G2 note after adjustment of Ranad Ek waveform

A2 note

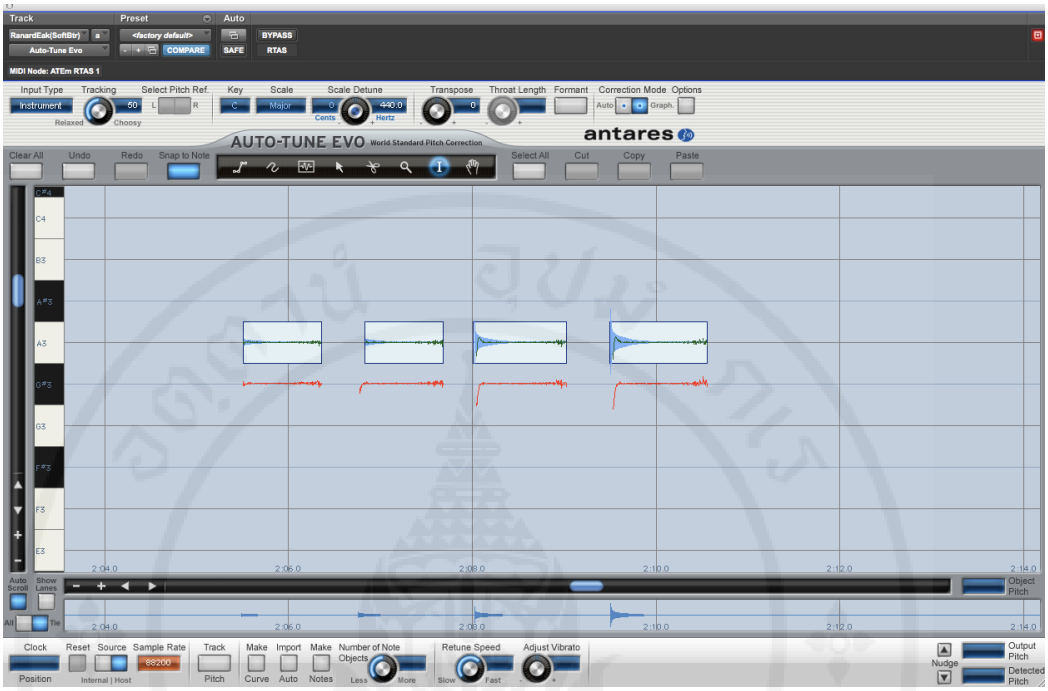


Figure 5.108 A2 note adjustment of Ranad Ek by Auto-Tune Plug-in

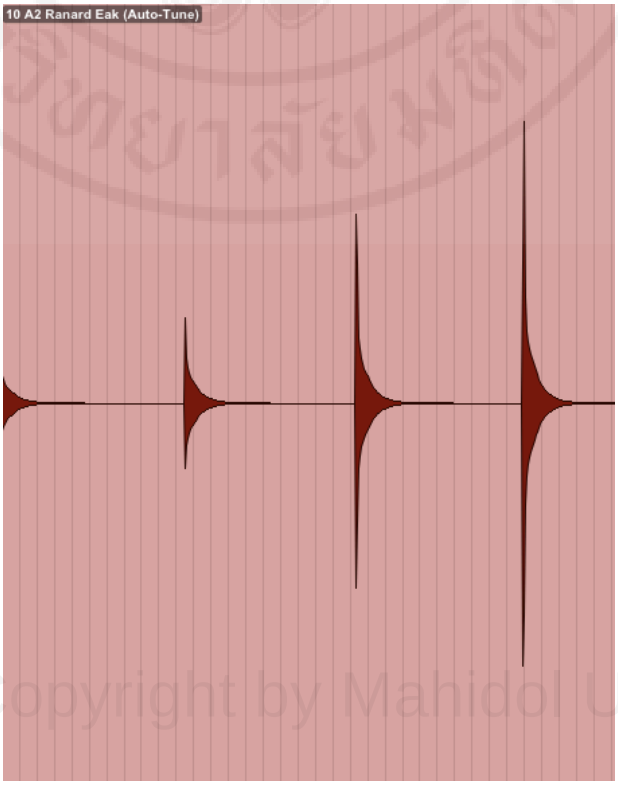


Figure 5.109 A2 note after adjustment of Ranad Ek waveform

B2 note

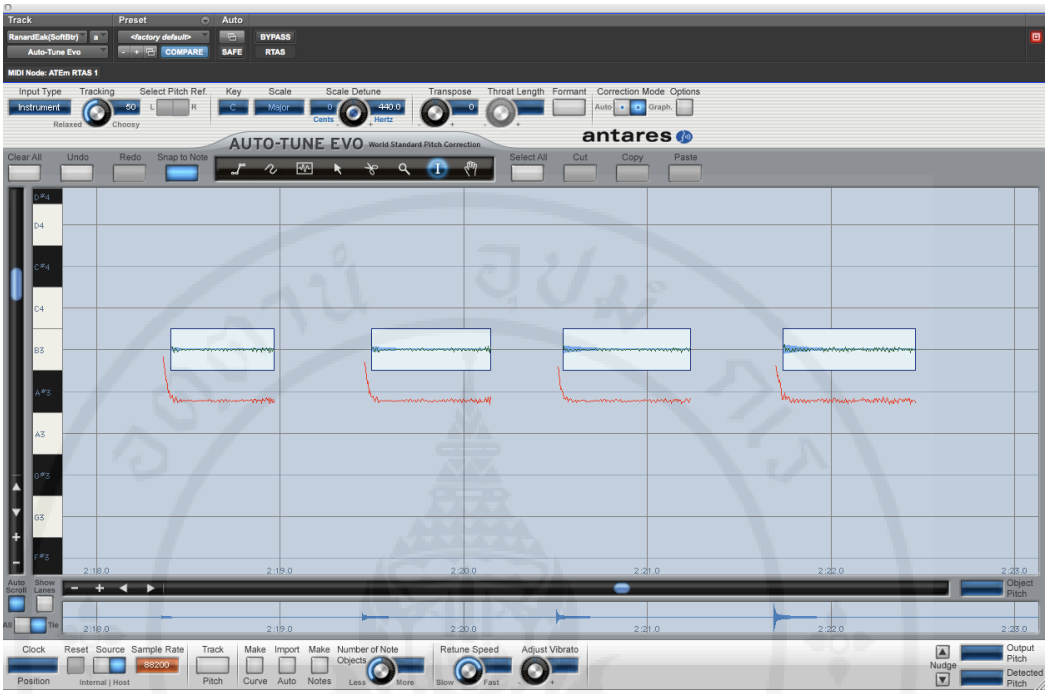


Figure 5.110 B2 note adjustment of Ranad Ek by Auto-Tune Plug-in

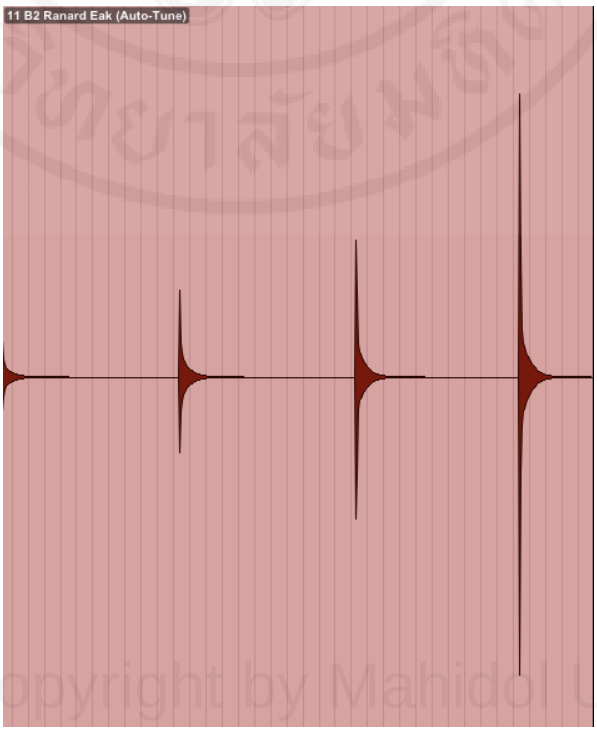


Figure 5.111 B2 note after adjustment of Ranad Ek waveform

C3 note

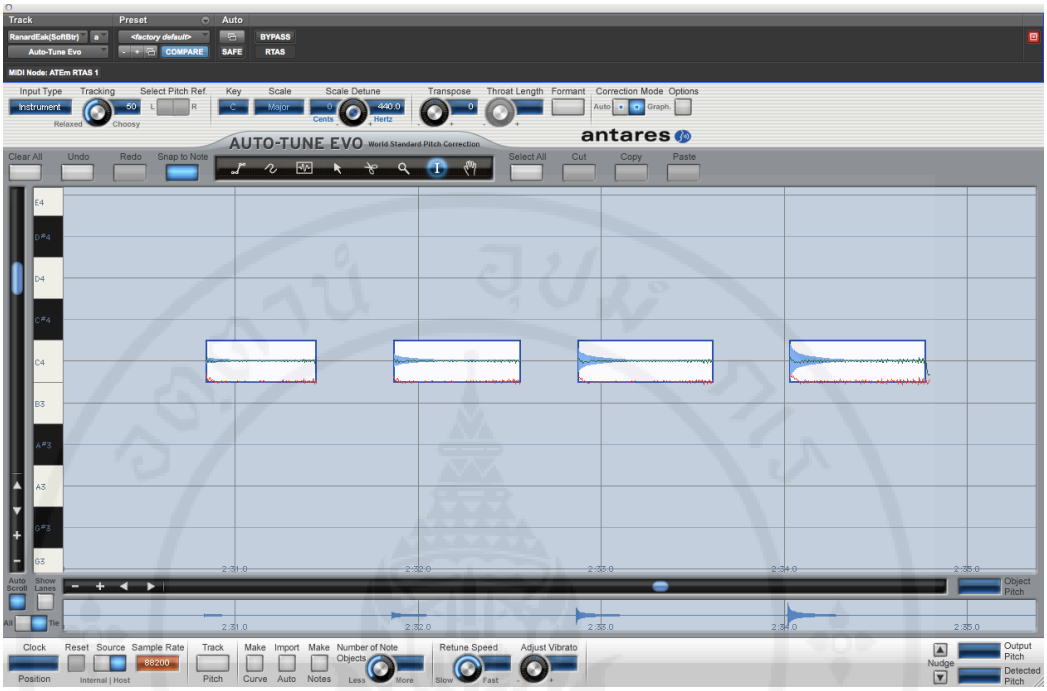


Figure 5.112 C3note adjustment of Ranad Ek by Auto-Tune Plug-in

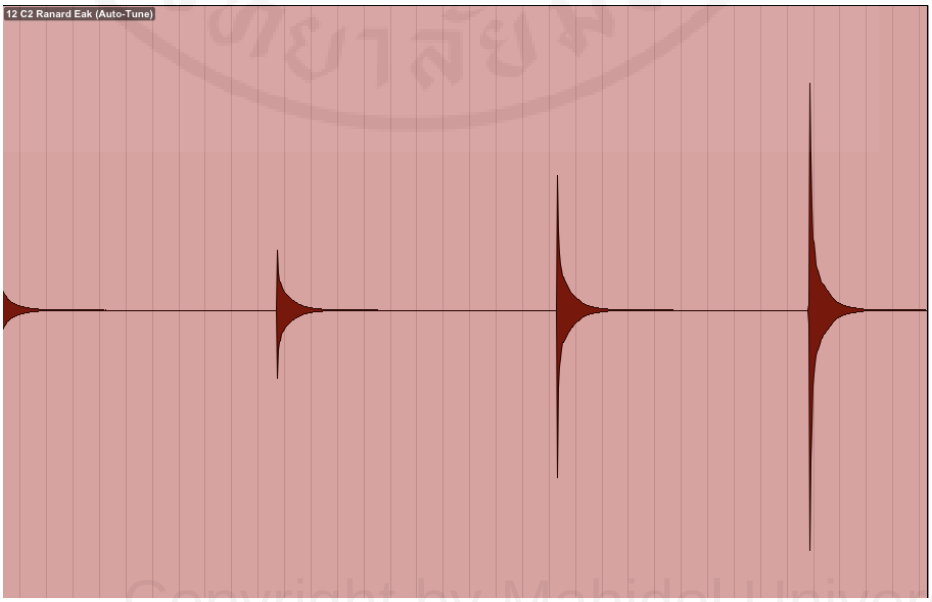


Figure 5.113 C3 note after adjustment of Ranad Ek waveform

D3 note

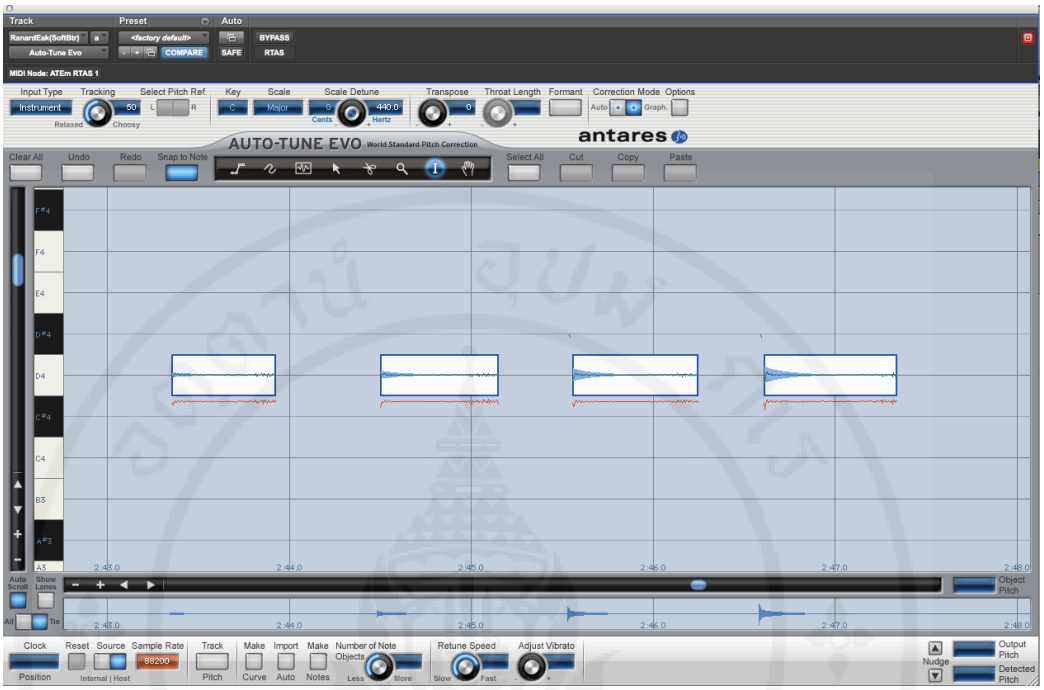


Figure 5.114 D3 note adjustment of Ranad Ek by Auto-Tune Plug-in

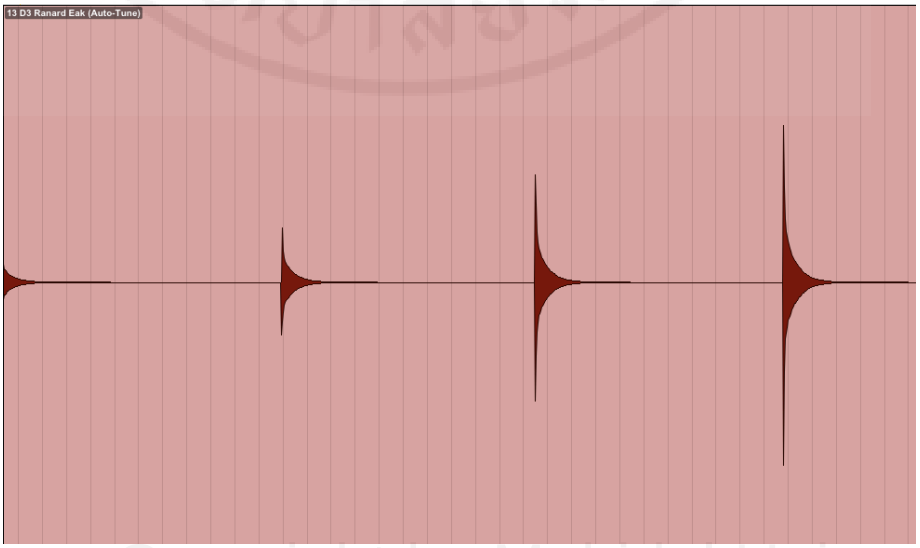


Figure 5.115 D3 note after adjustment of Ranad Ek waveform

E3 note

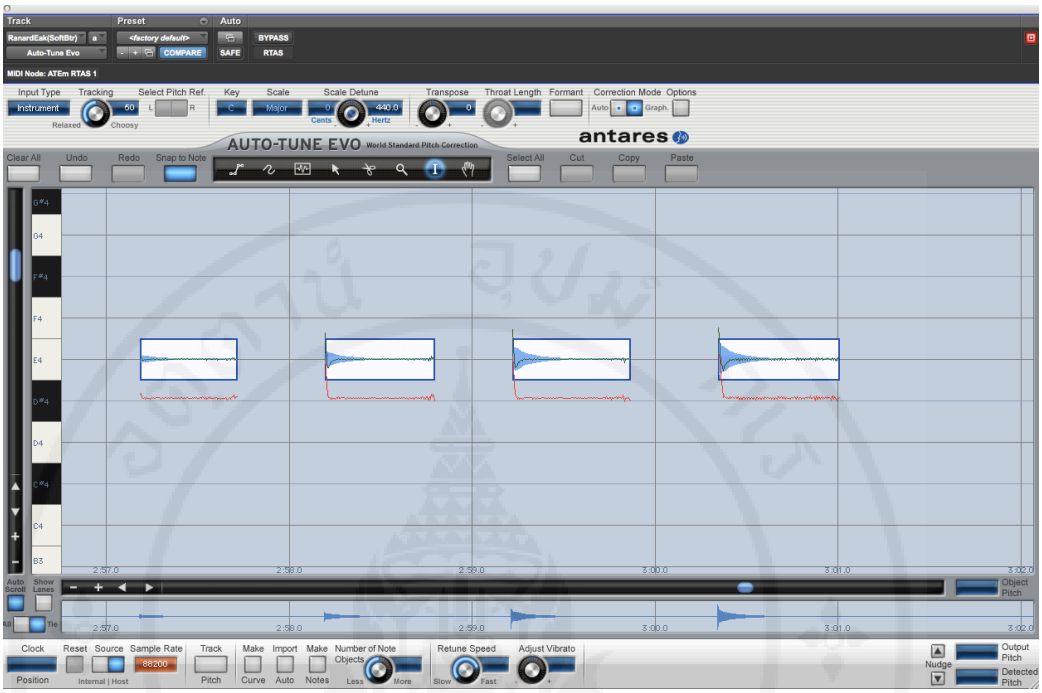


Figure 5.116 D3 note adjustment of Ranad Ek by Auto-Tune Plug-in

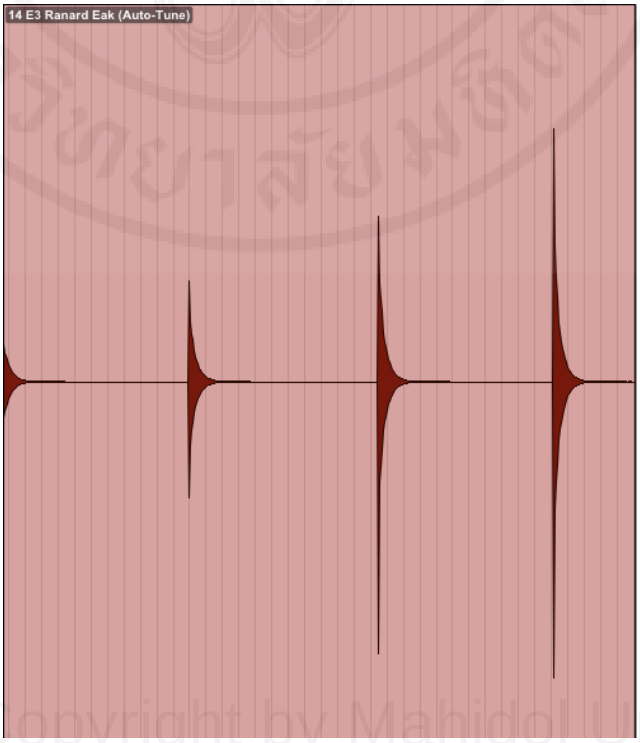


Figure 5.117 E3 note after adjustment of Ranad Ek waveform

F3 note

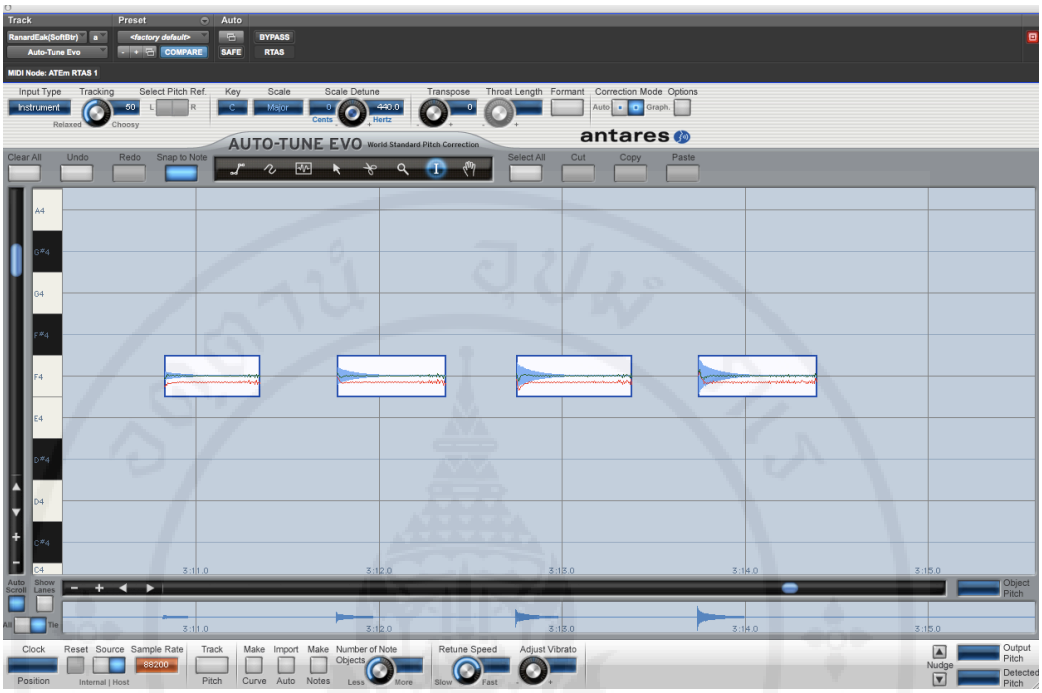


Figure 5.118 F3 note adjustment of Ranad Ek by Auto-Tune Plug-in

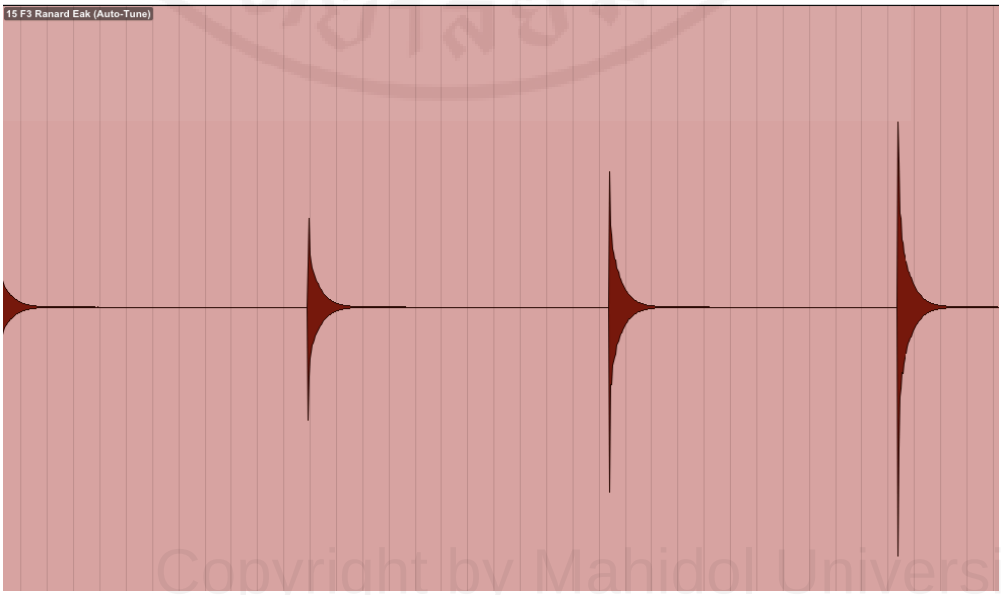


Figure 5.119 F3 note after adjustment of Ranad Ek waveform

G3 note

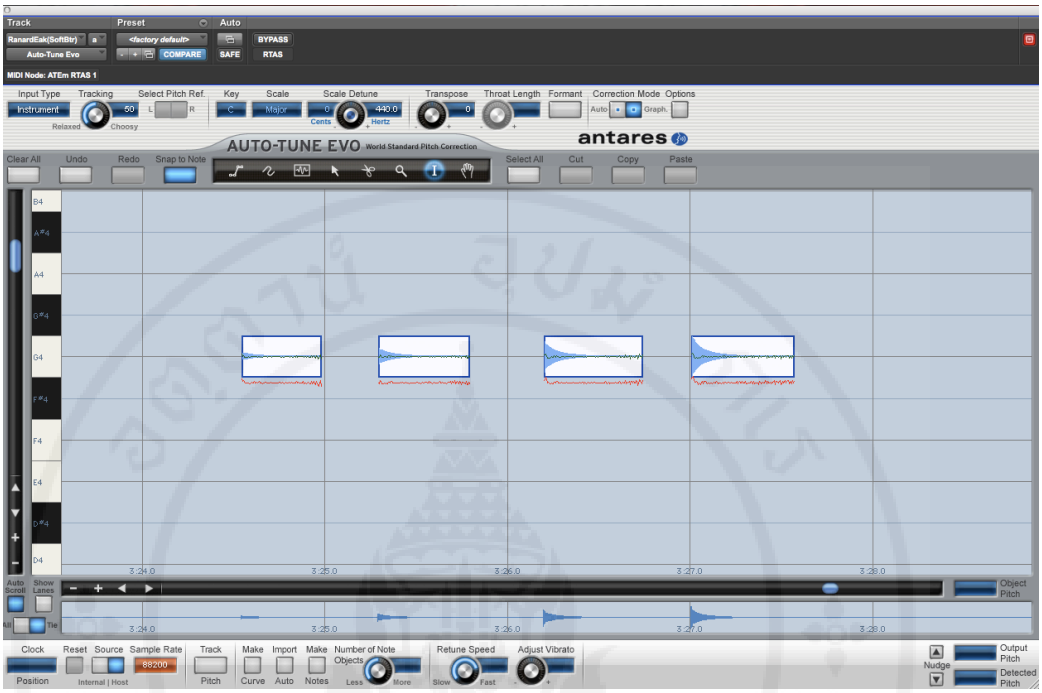


Figure 5.120 G3 note adjustment of Ranad Ek by Auto-Tune Plug-in

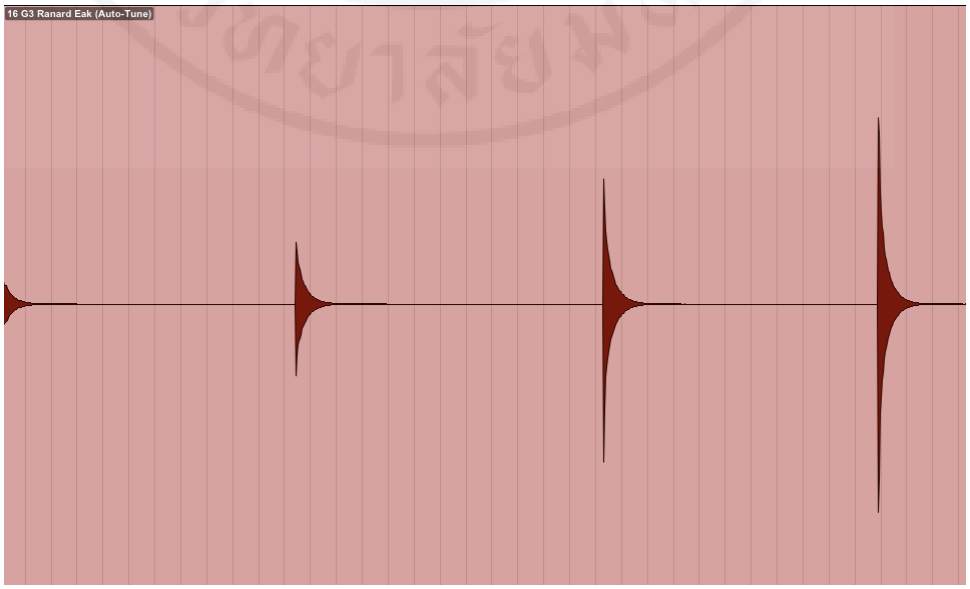


Figure 5.121 G3 note after adjustment of Ranad Ek waveform

A3 note

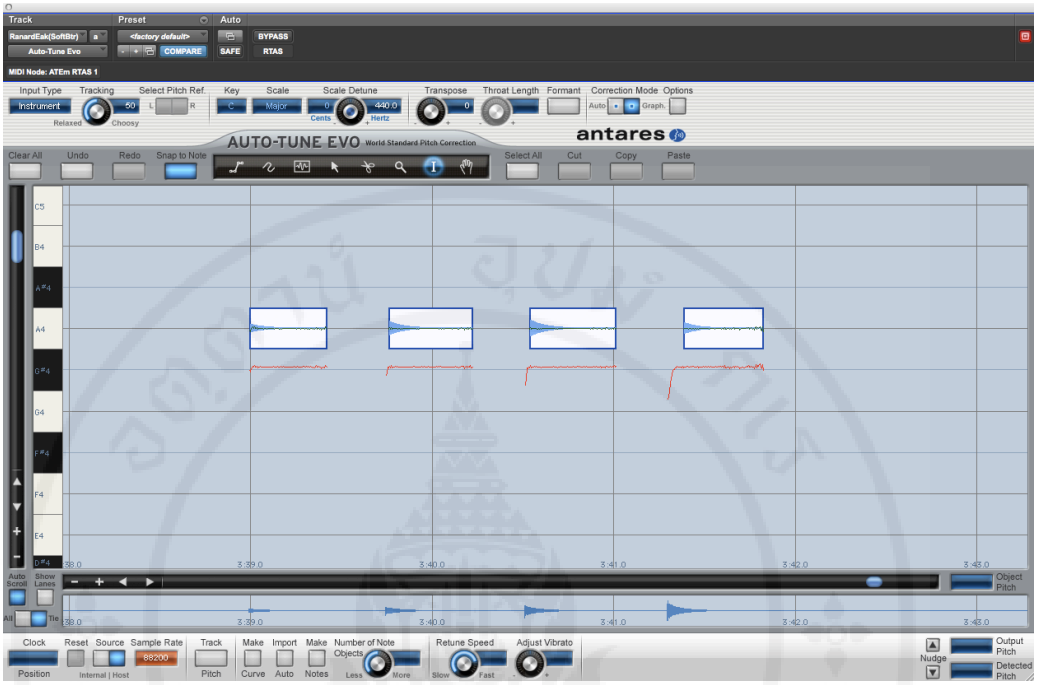


Figure 5.122 A3 note adjustment of Ranad Ek by Auto-Tune Plug-in

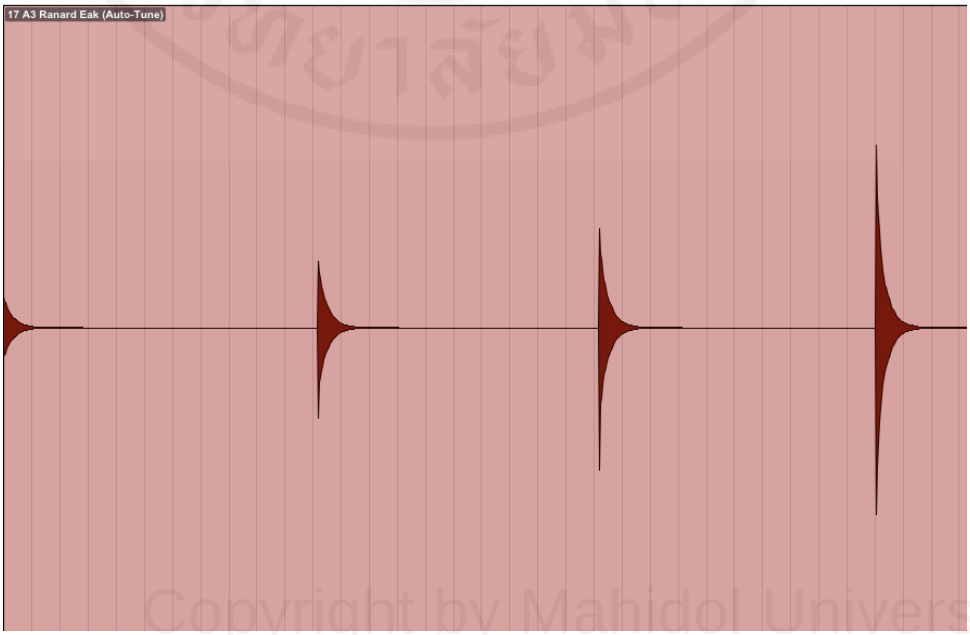


Figure 5.123 A3 note after adjustment of Ranad Ek waveform

B3 note

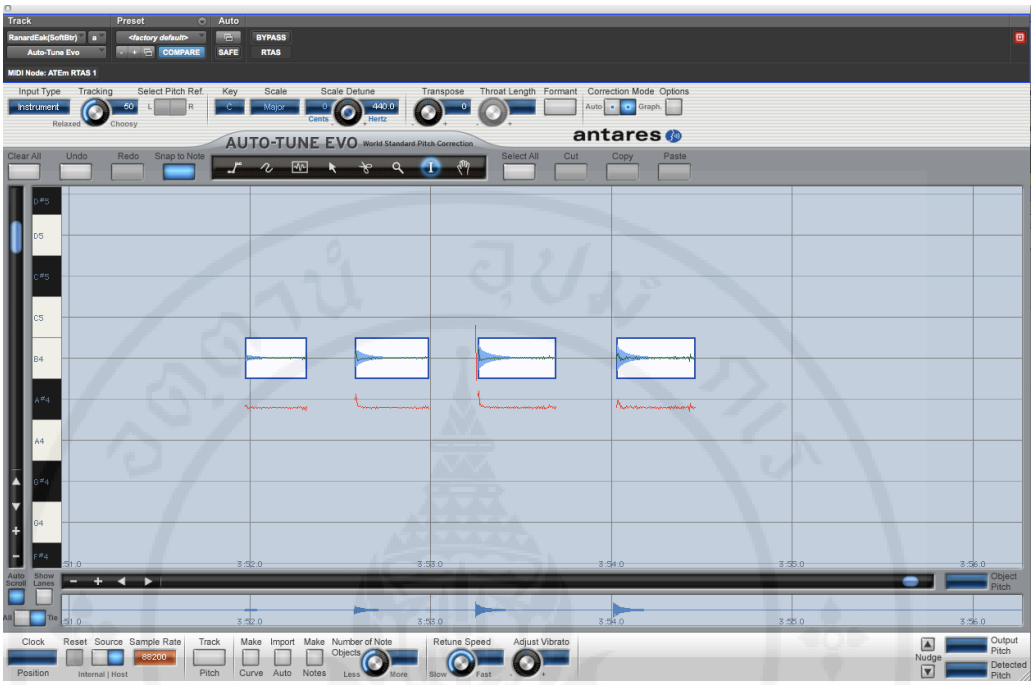


Figure 5.124 B3 note adjustment of Ranad Ek by Auto-Tune Plug-in

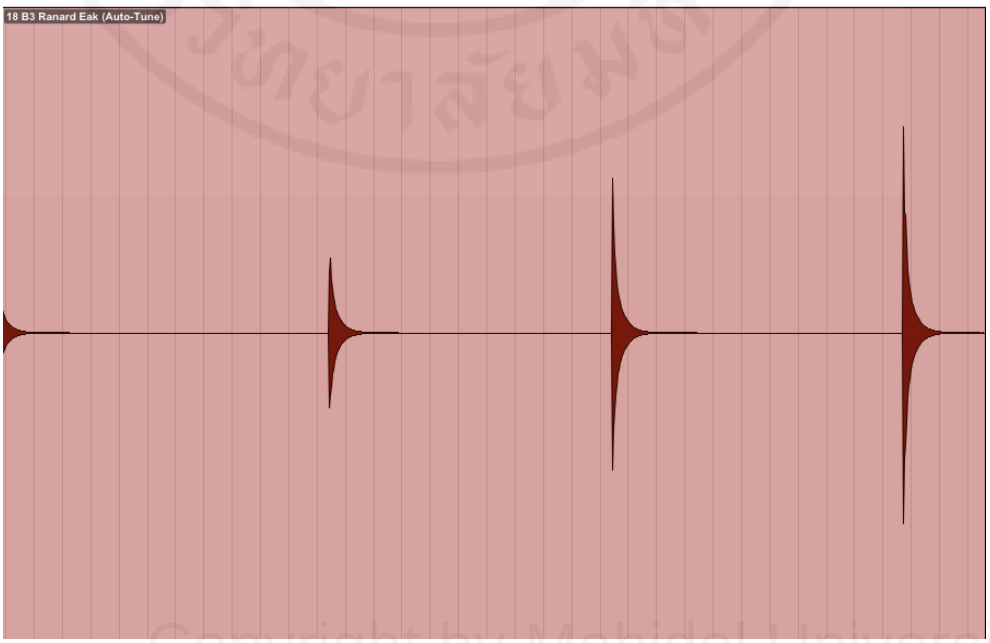


Figure 5.125 B3 note after adjustment of Ranad Ek waveform

C4 note

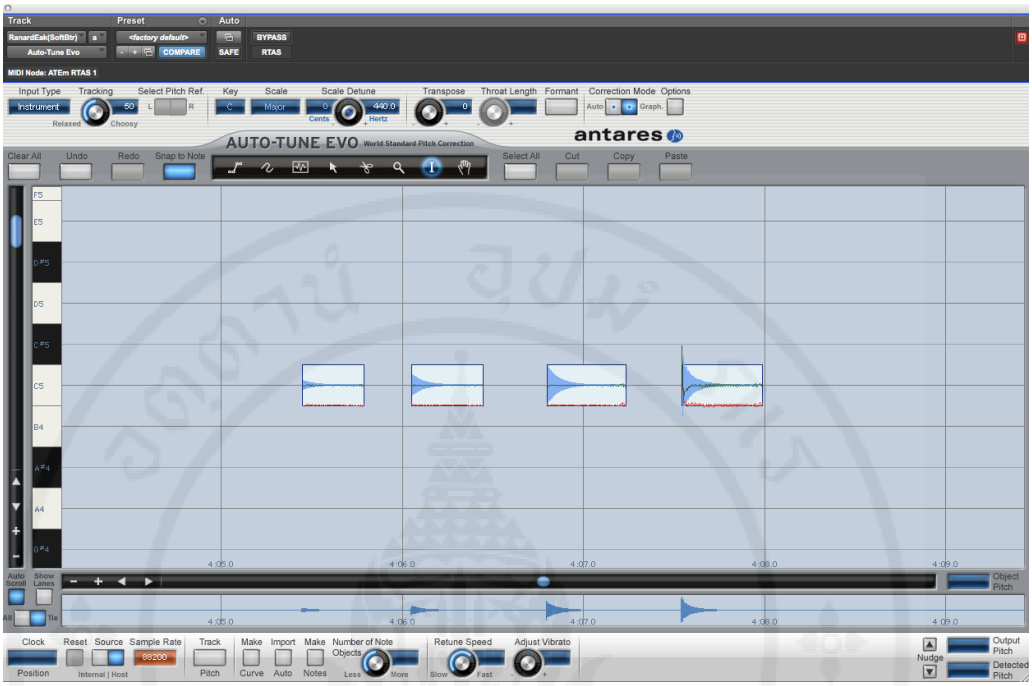


Figure 5.126 C4 note adjustment of Ranad Ek by Auto-Tune Plug-in

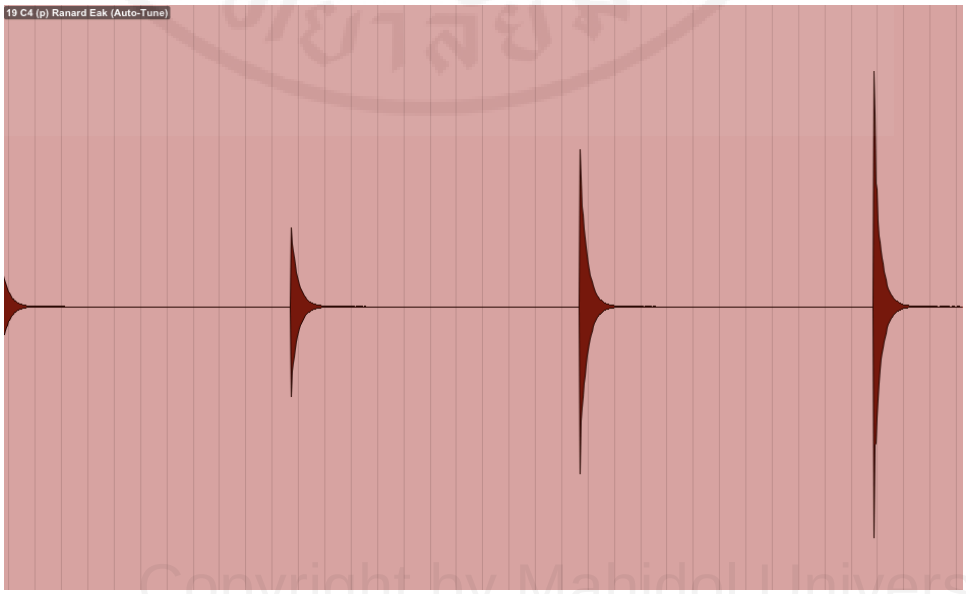


Figure 5.127 C4 note after adjustment of Ranad Ek waveform

D4 note

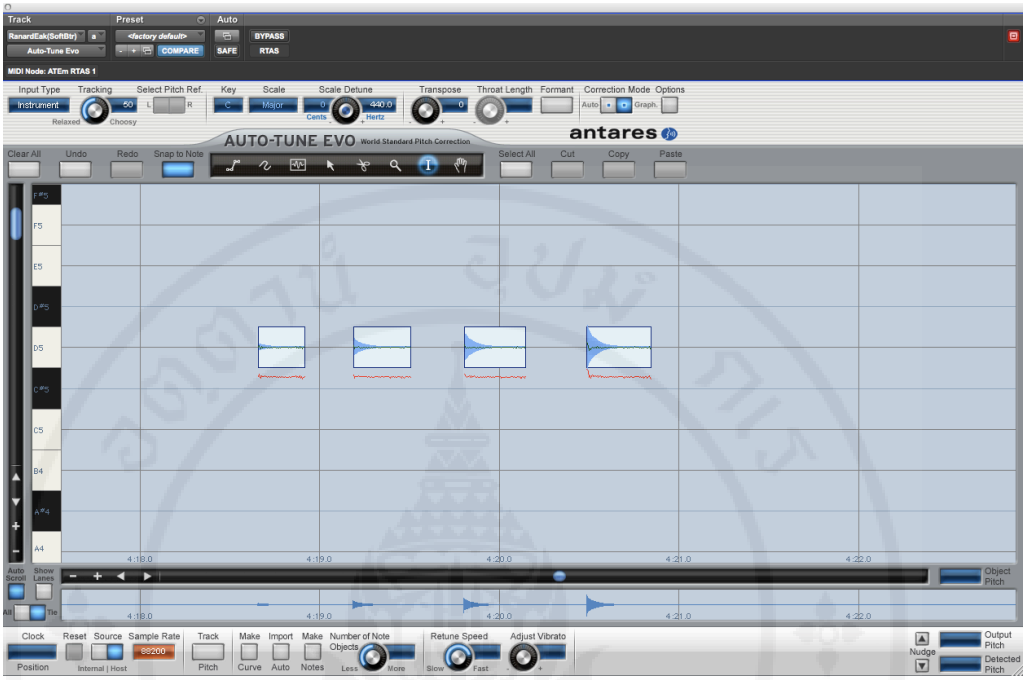


Figure 5.128 D4 note adjustment of Ranad Ek by Auto-Tune Plug-in

Figure 5.129 D4 note after adjustment of Ranad Ek waveform

E4 note

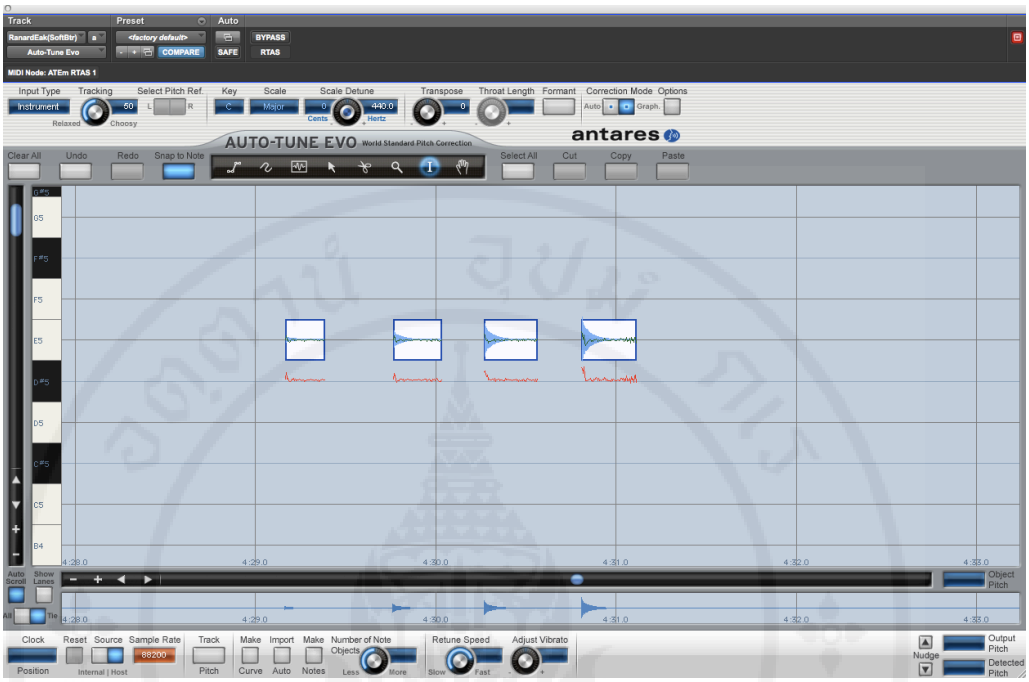


Figure 5.130 E4 note adjustment of Ranad Ek by Auto-Tune Plug-in

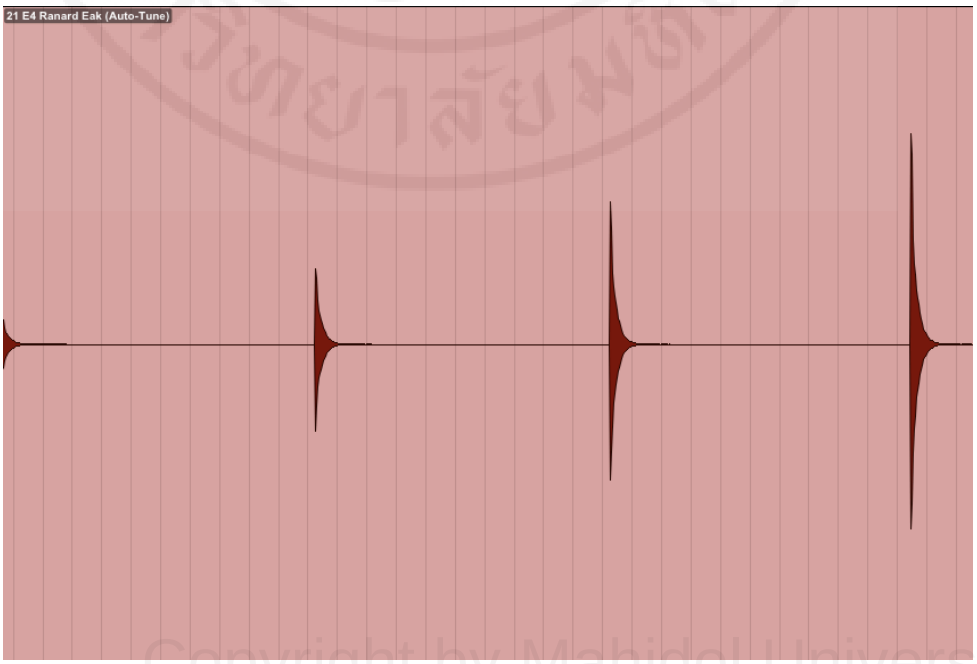


Figure 5.131 E4 note after adjustment of Ranad Ek waveform

F4 note

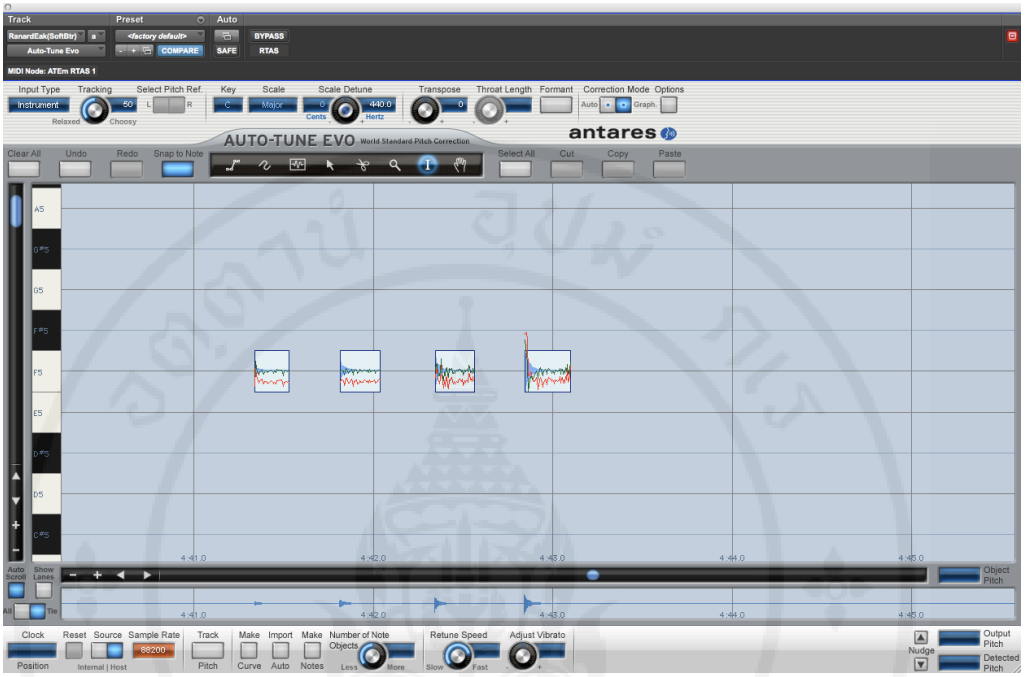


Figure 5.132 F4 note adjustment of Ranad Ek by Auto-Tune Plug-in

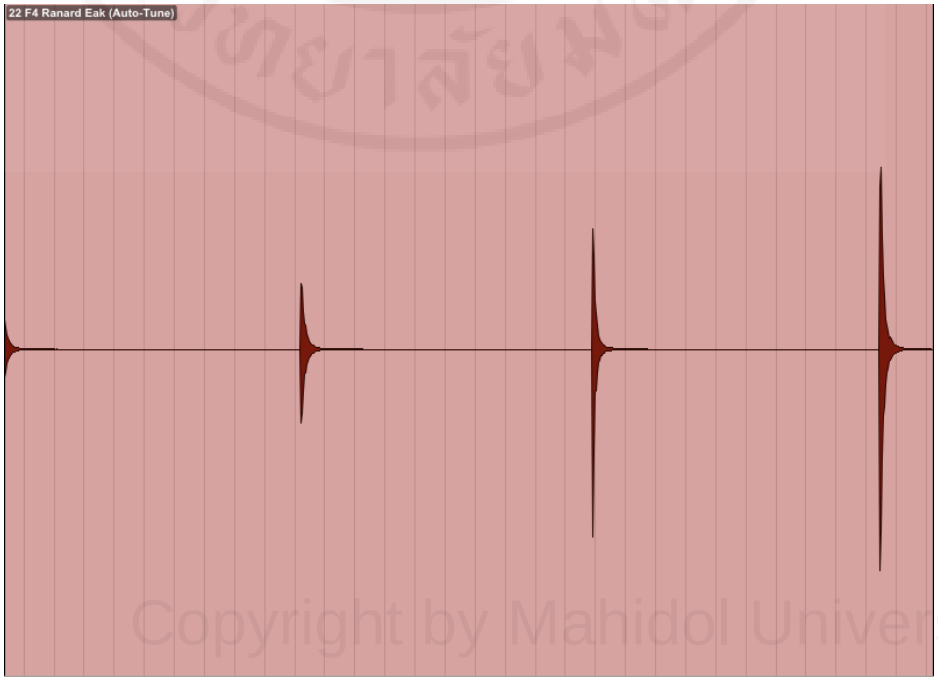


Figure 5.133 F4 note after adjustment of Ranad Ek waveform

5.3.3 Adjustment of Ranad Tum Lek sound samples

Form the sound samples of Ranad Tum Lek there are 17 pitches, from D-F3.

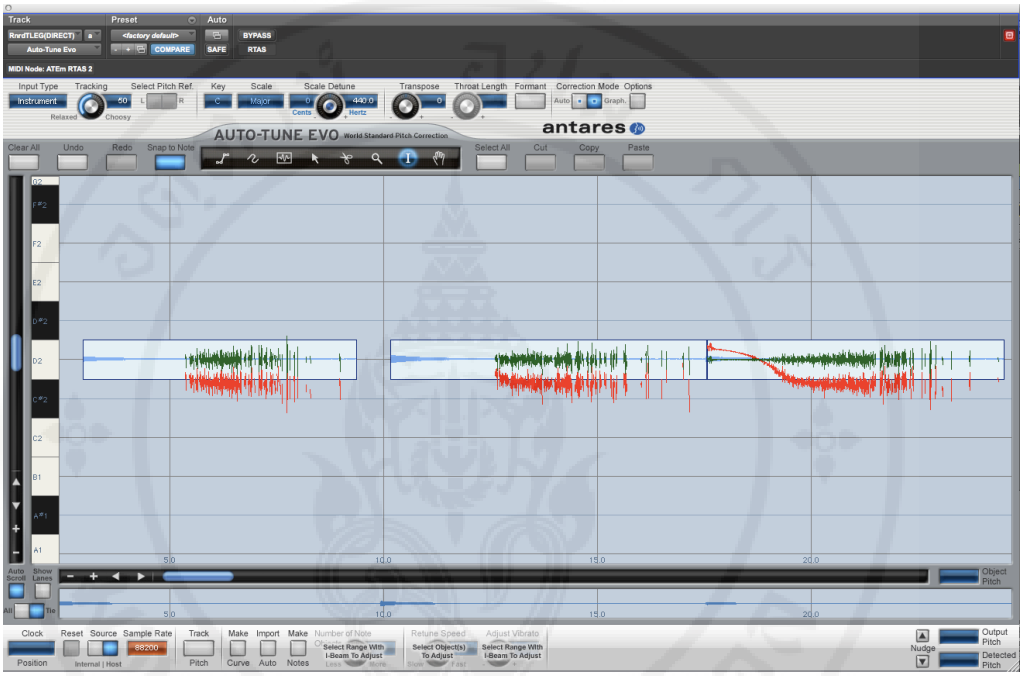


Figure 5.134 D note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

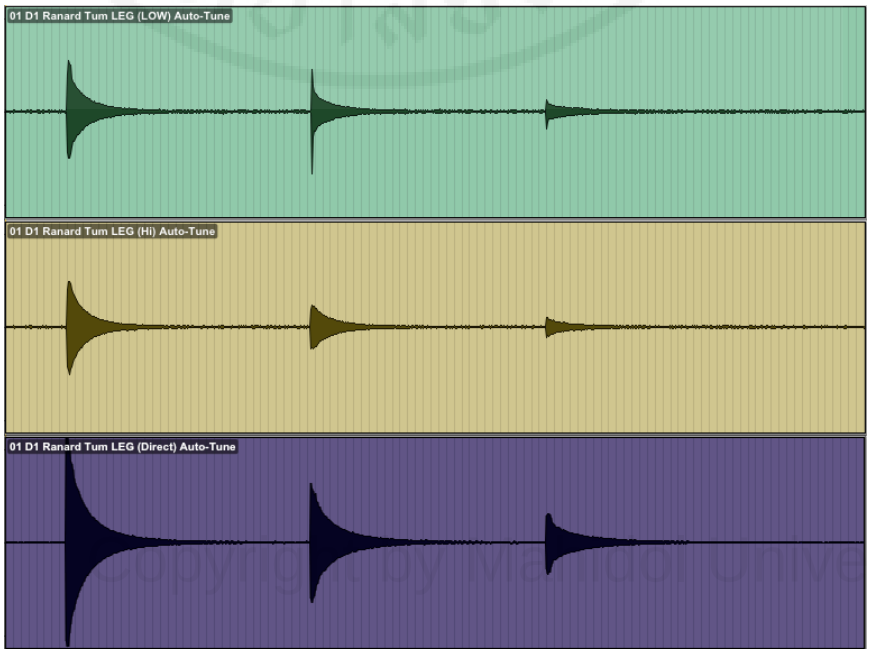


Figure 5.135 D note after adjustment of Ranad Tum Lek waveform

E note

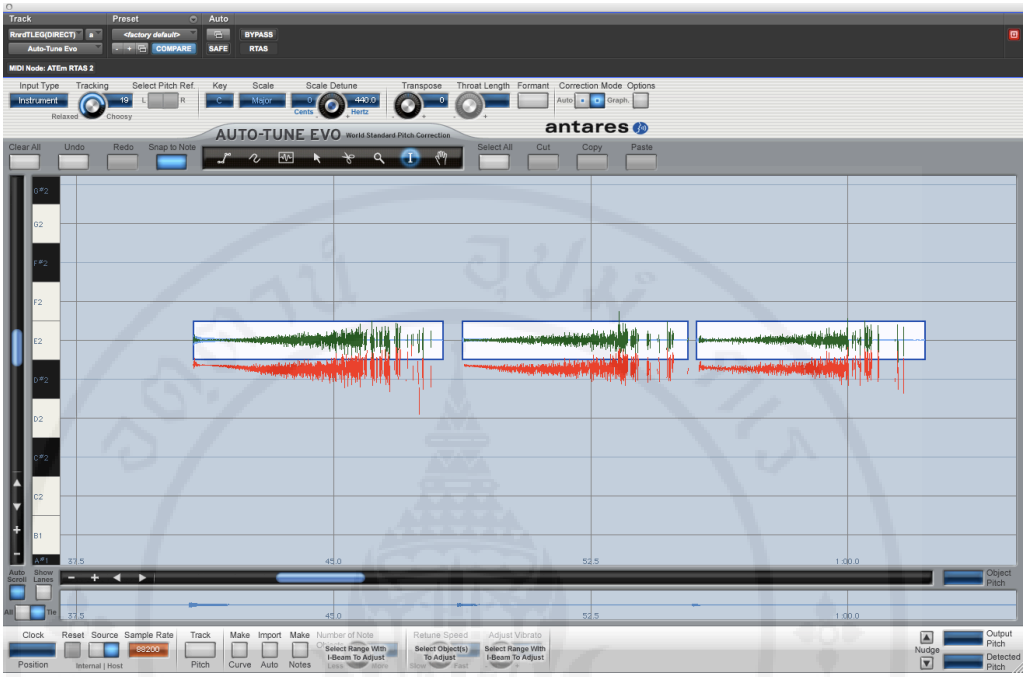


Figure 5.136 E note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

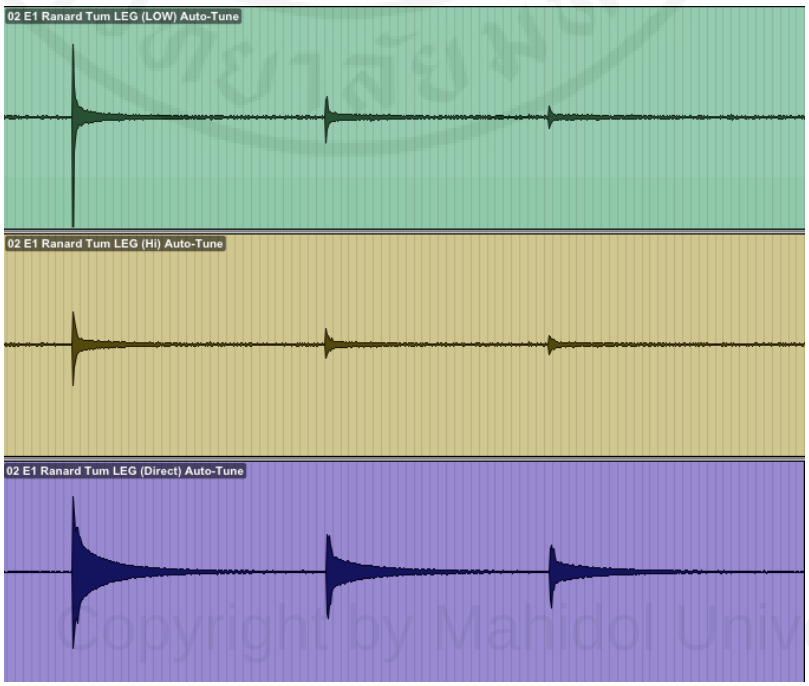


Figure 5.137 E note after adjustment of Ranad Tum Lek waveform

F note

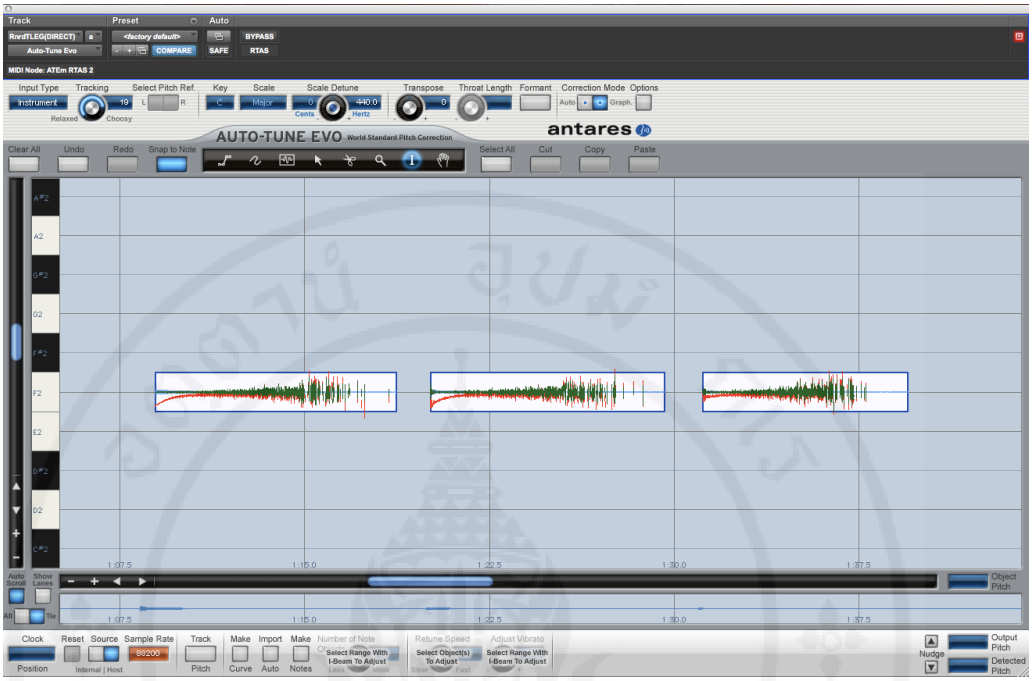


Figure 5.138 F note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

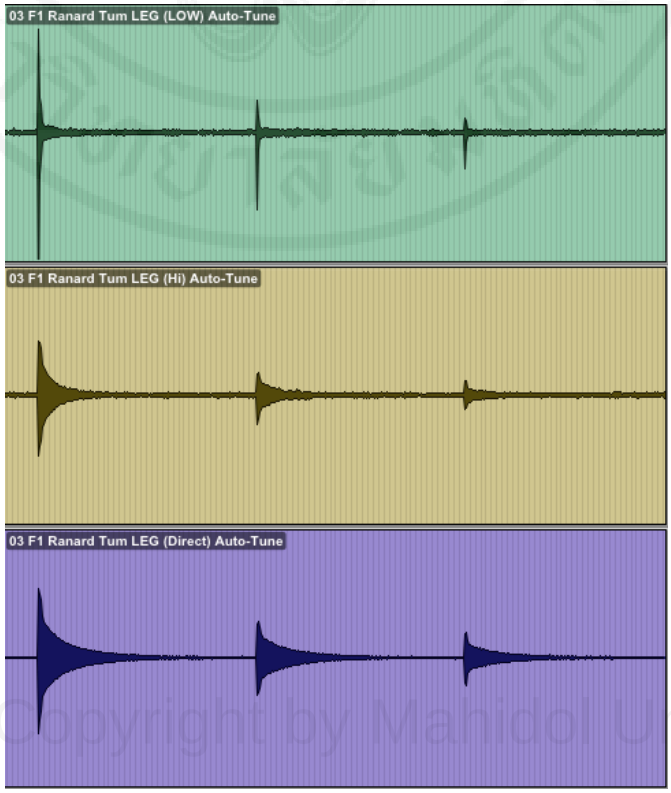


Figure 5.139 F note after adjustment of Ranad Tum Lek waveform

G note

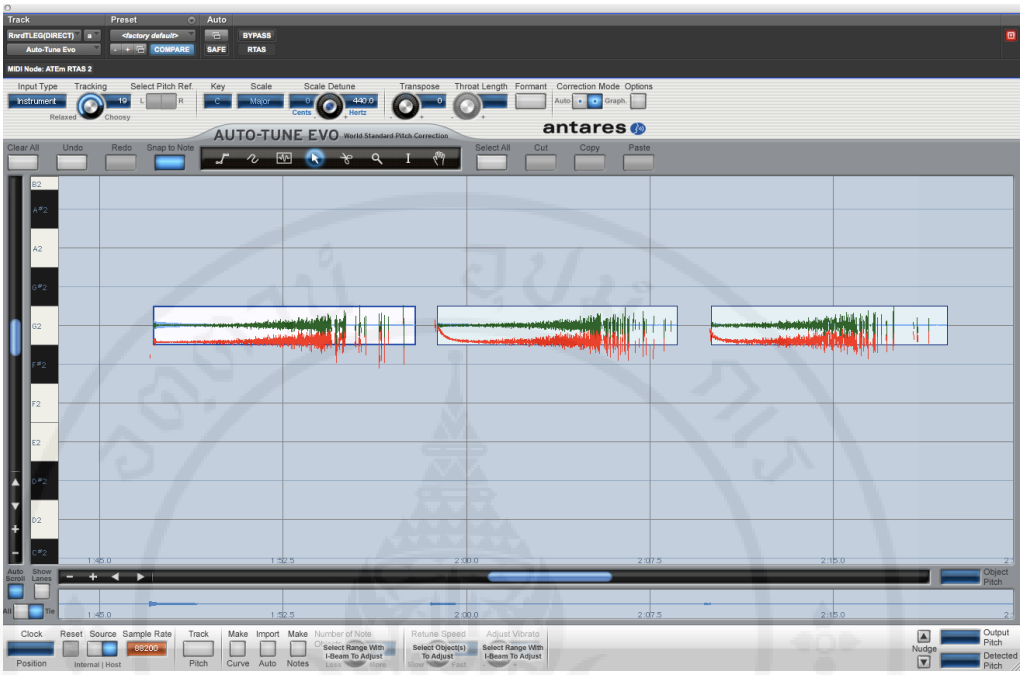


Figure 5.140 G note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

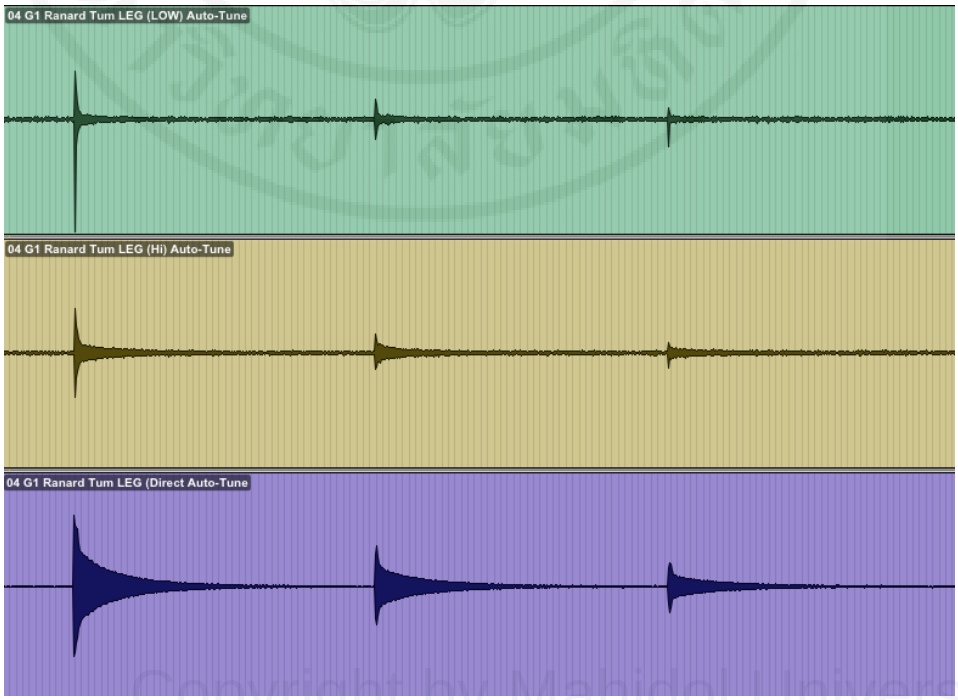


Figure 5.141 G note after adjustment of Ranad Tum Lek waveform

A note

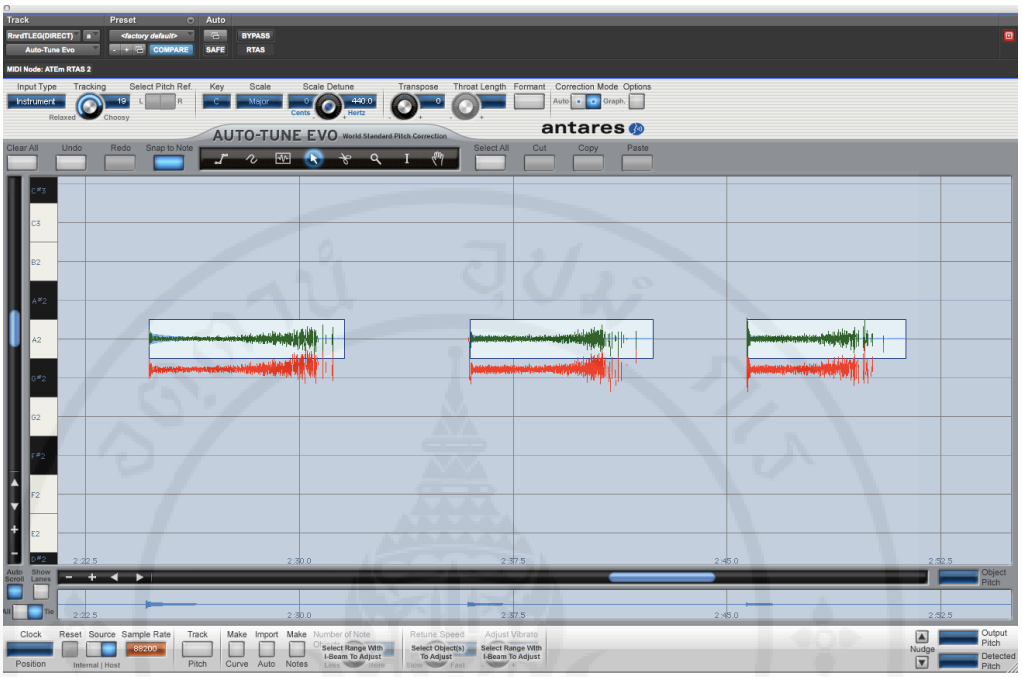


Figure 5.142 A note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

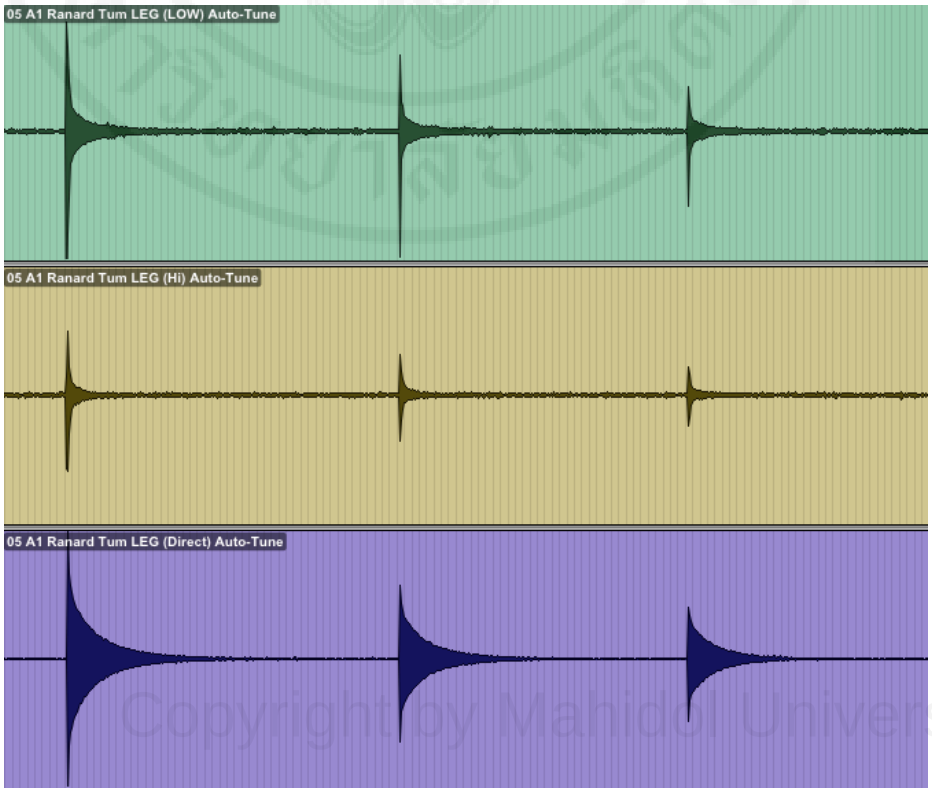


Figure 5.143 A note after adjustment of Ranad Tum Lek waveform

B note

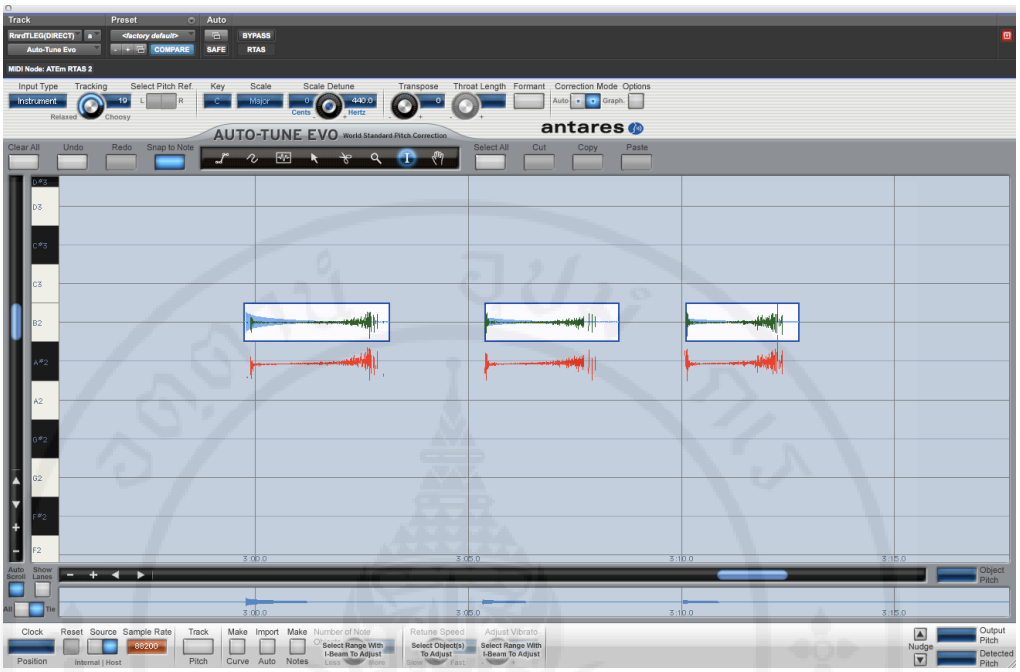


Figure 5.144 B note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

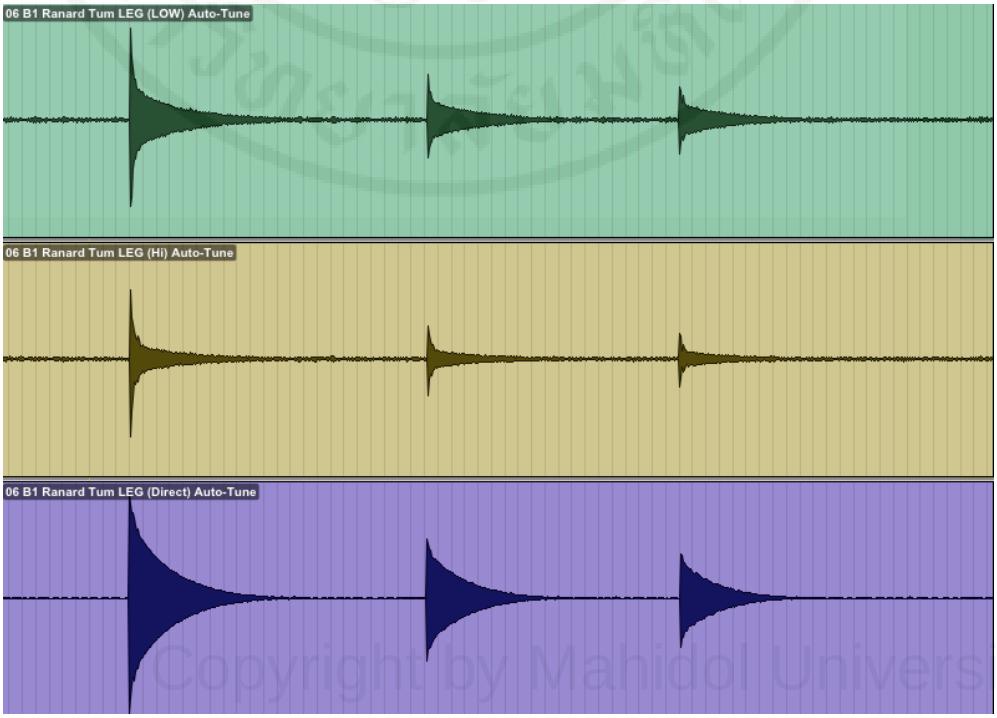


Figure 5.145 B note after adjustment of Ranad Tum Lek waveform

C2 note

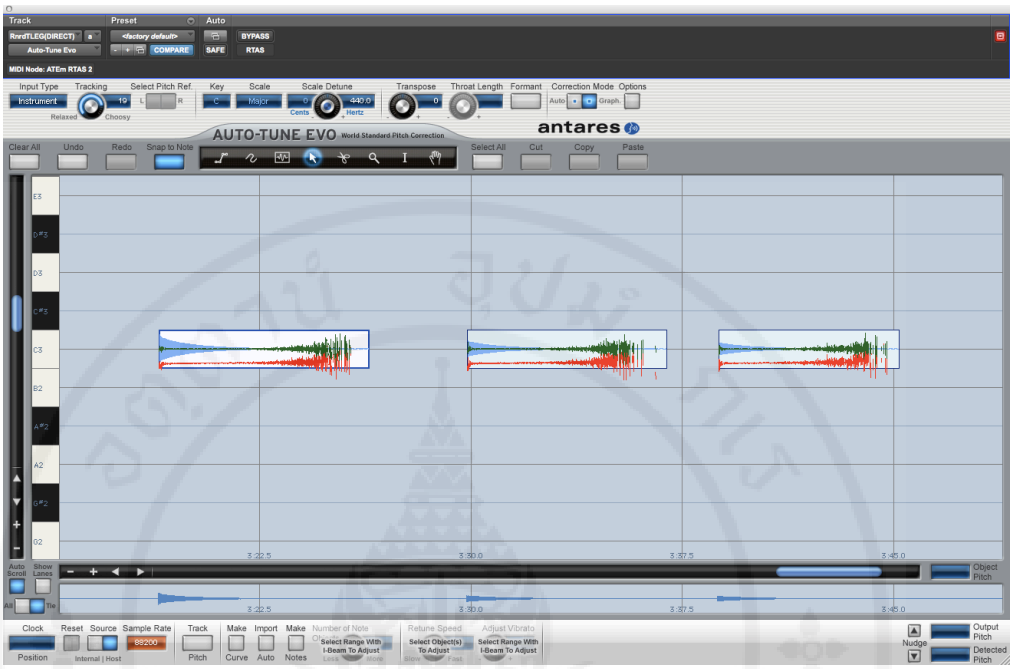


Figure 5.146 C2 note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

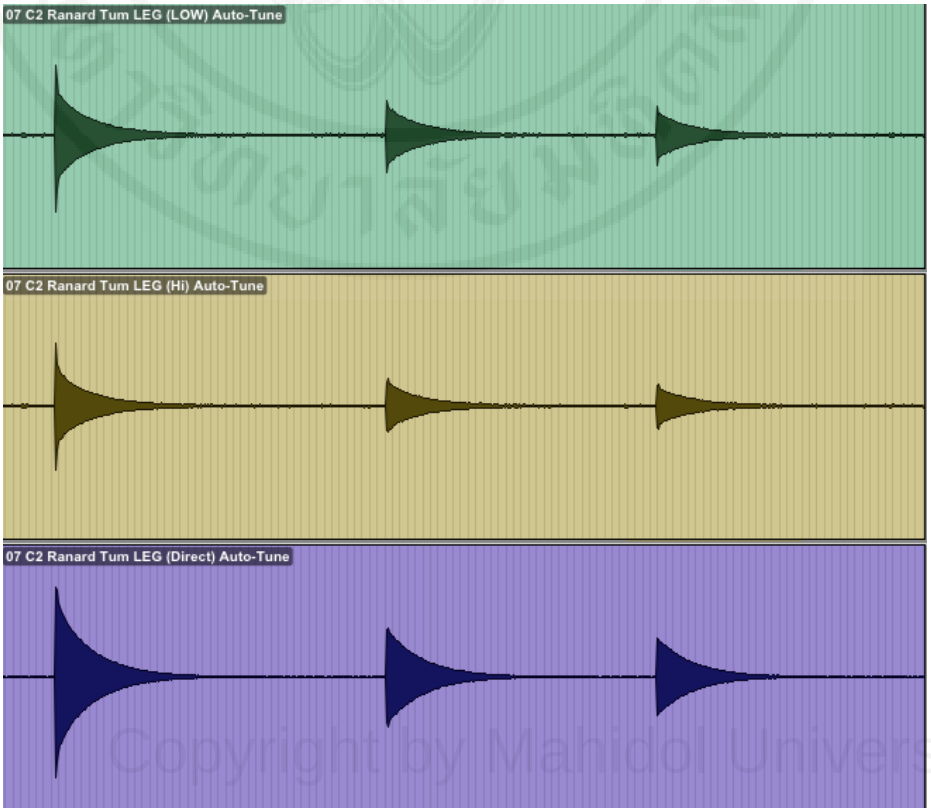


Figure 5.147 C2 note after adjustment of Ranad Tum Lek waveform

D2 note

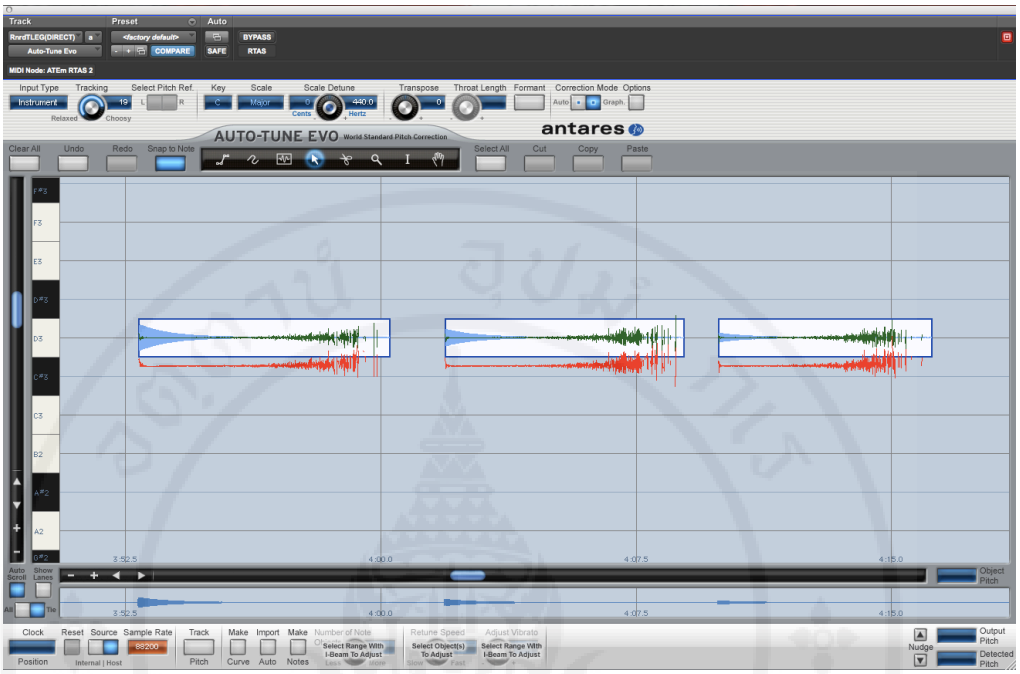


Figure 5.148 D2 note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

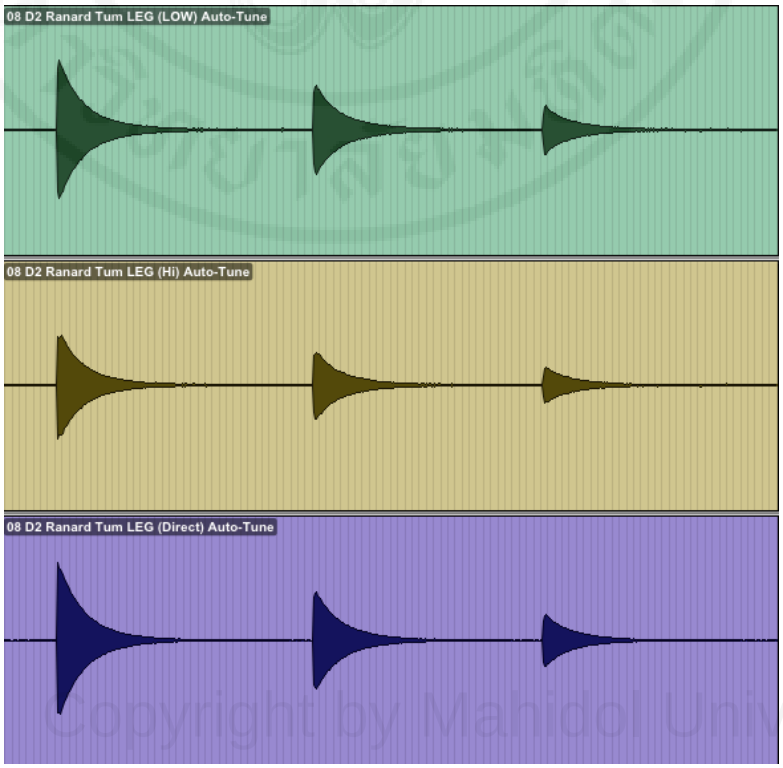


Figure 5.149 D2 note after adjustment of Ranad Tum Lek waveform

E2 note

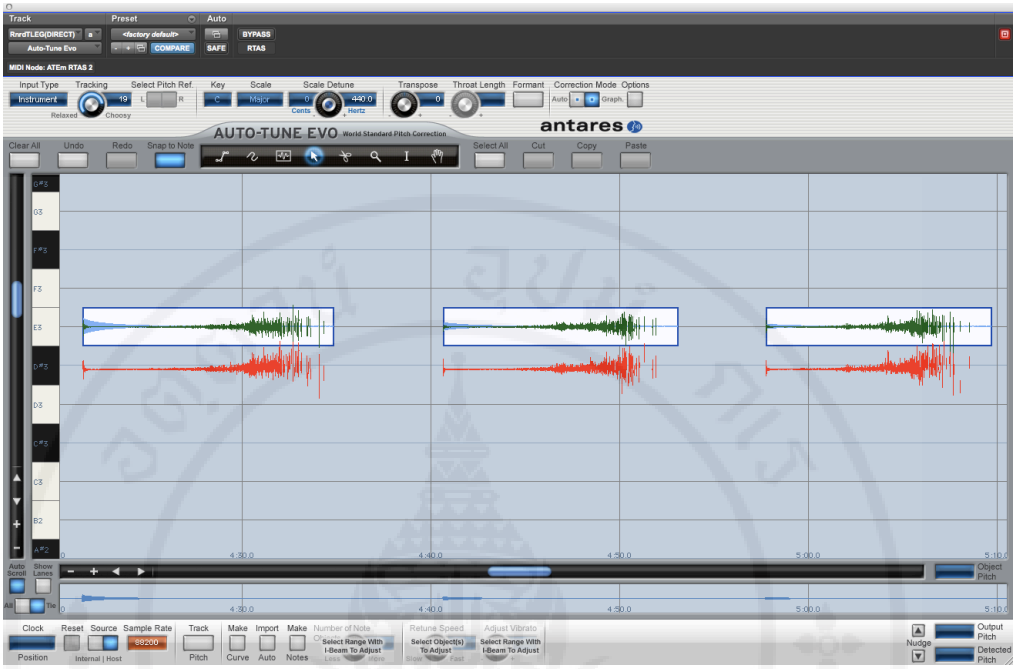


Figure 5.150 E2 note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

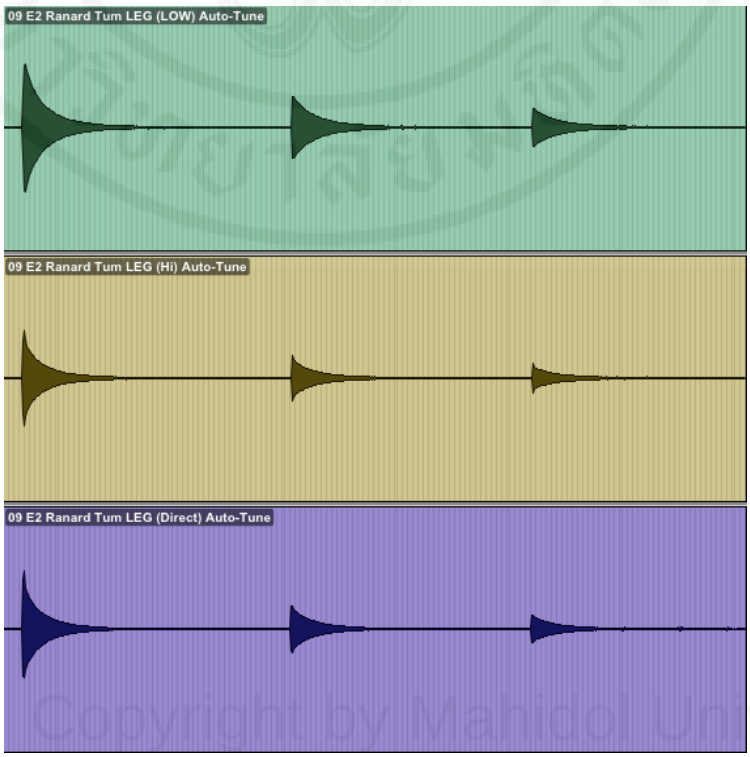


Figure 5.151 E2 note after adjustment of Ranad Tum Lek waveform

F2 note

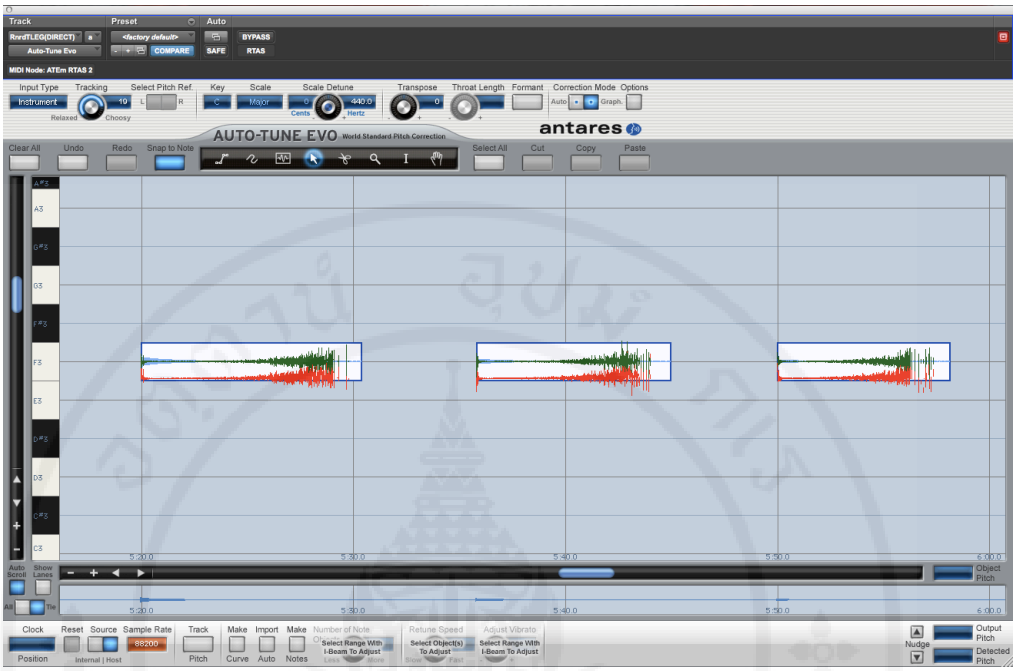


Figure 5.152 F2 note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

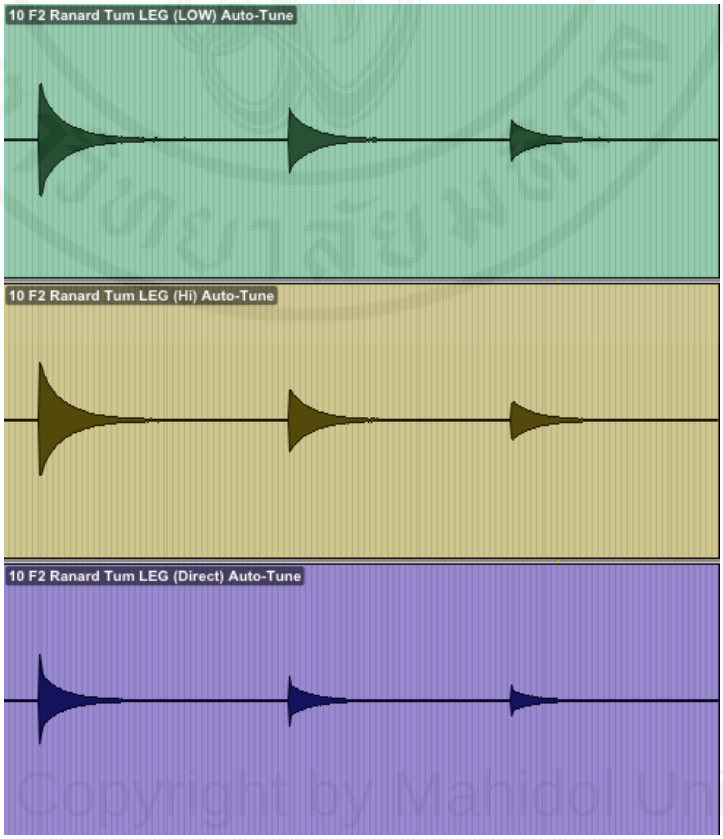


Figure 5.153 F2 note after adjustment of Ranad Tum Lek waveform

G2 note

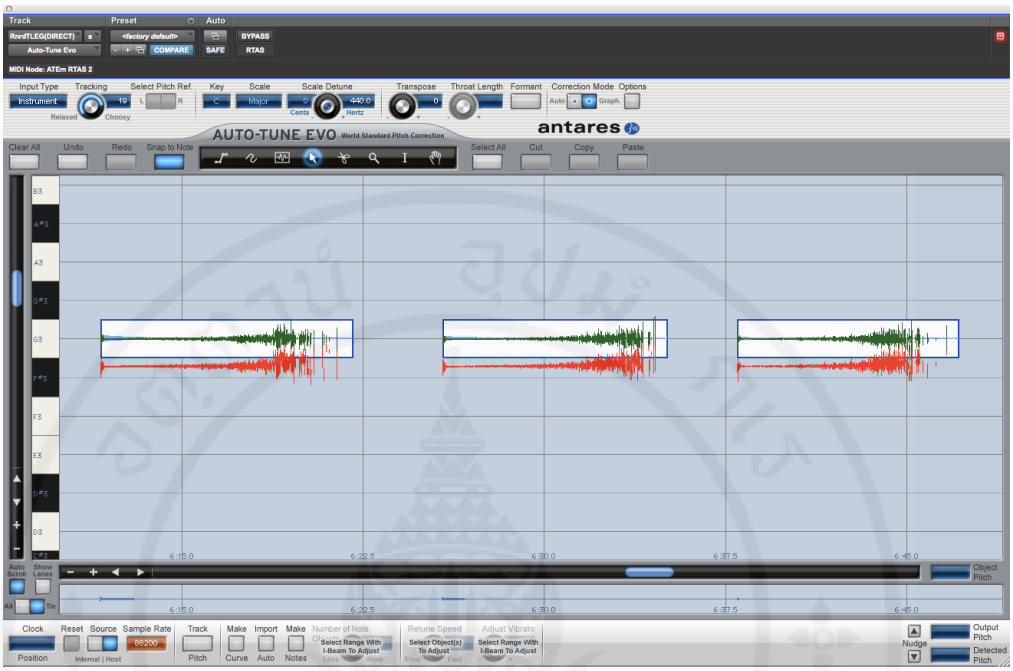


Figure 5.154 G2 note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

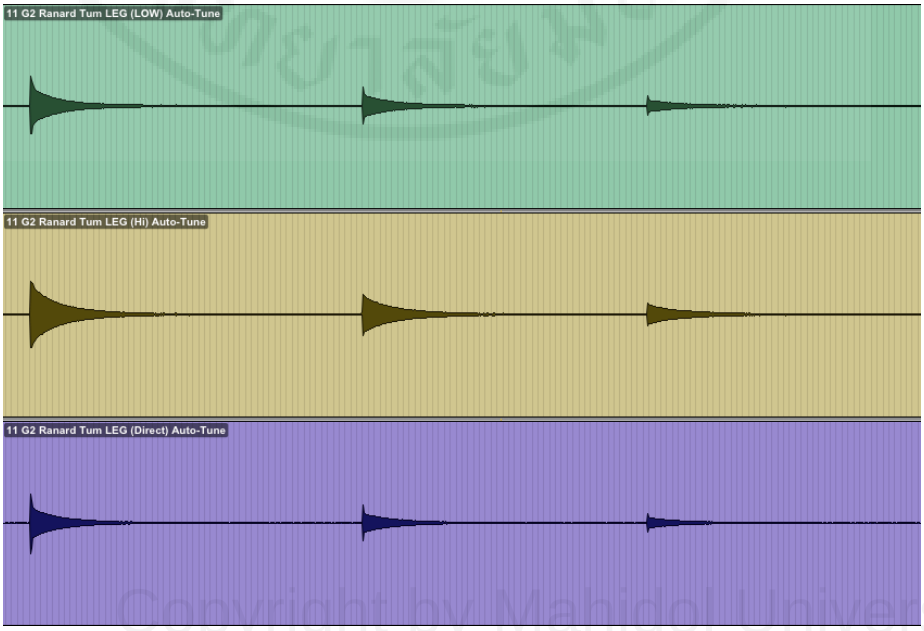


Figure 5.155 G2 note after adjustment of Ranad Tum Lek waveform

A2 note

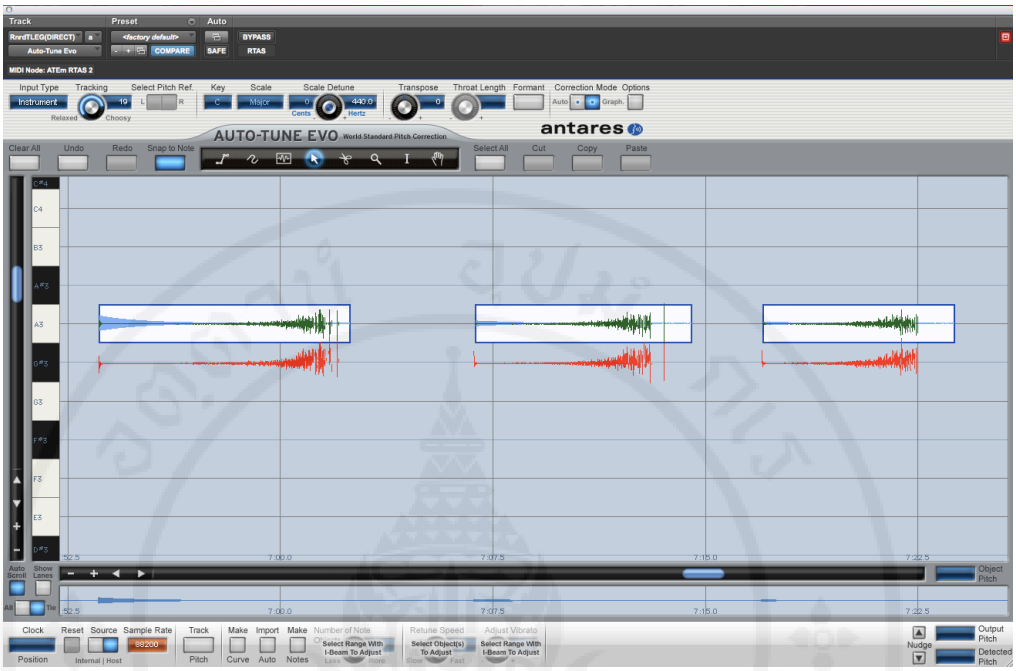


Figure 5.156 A2 note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

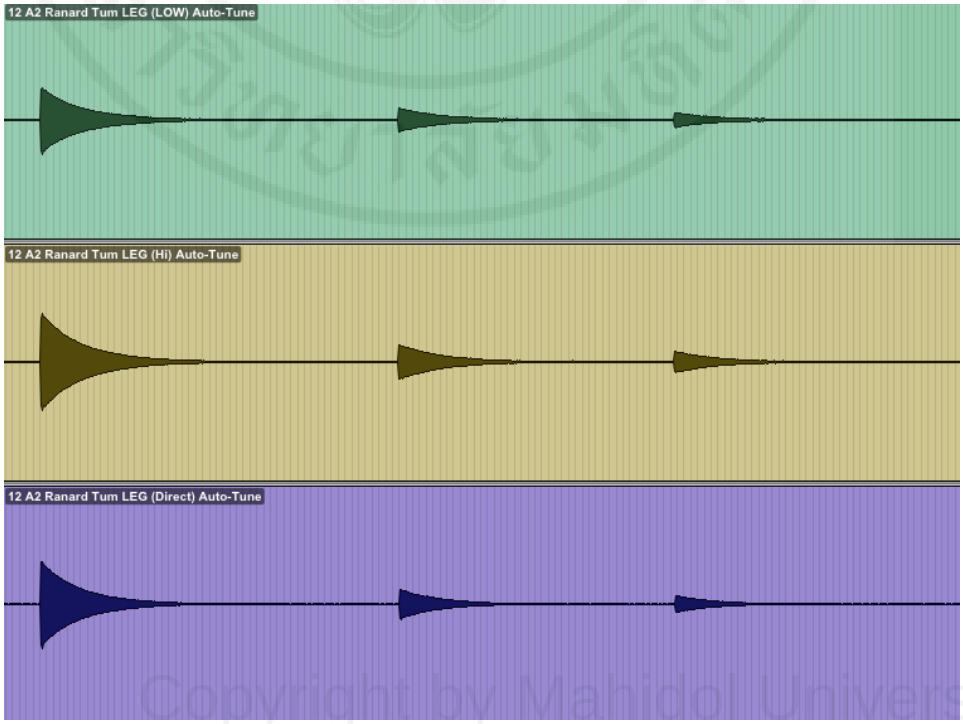


Figure 5.157 A2 note after adjustment of Ranad Tum Lek waveform

B2 note

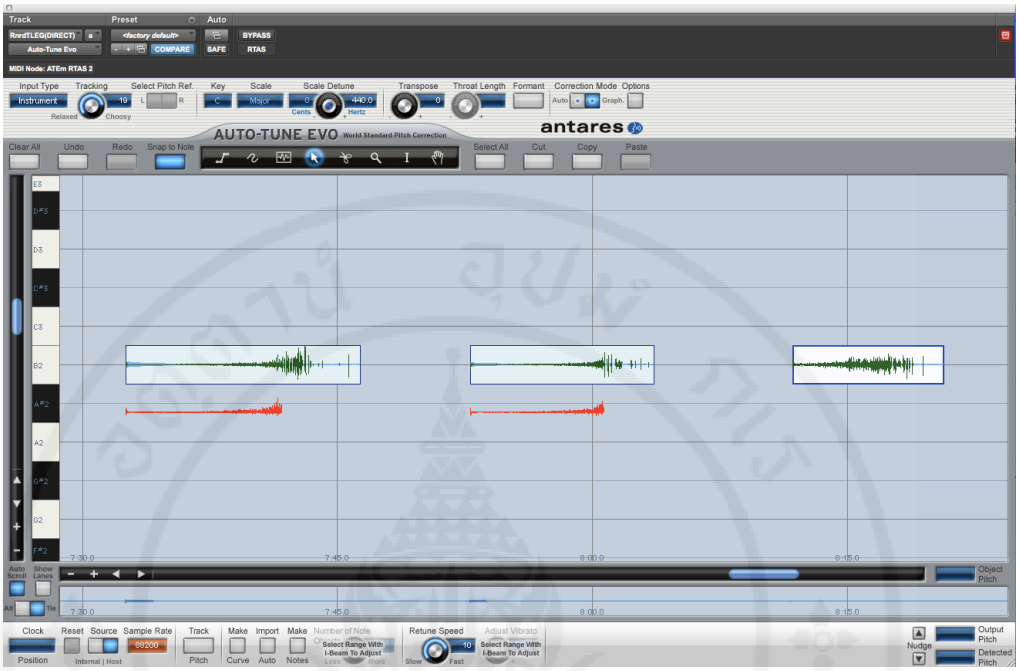


Figure 5.158 B2 note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

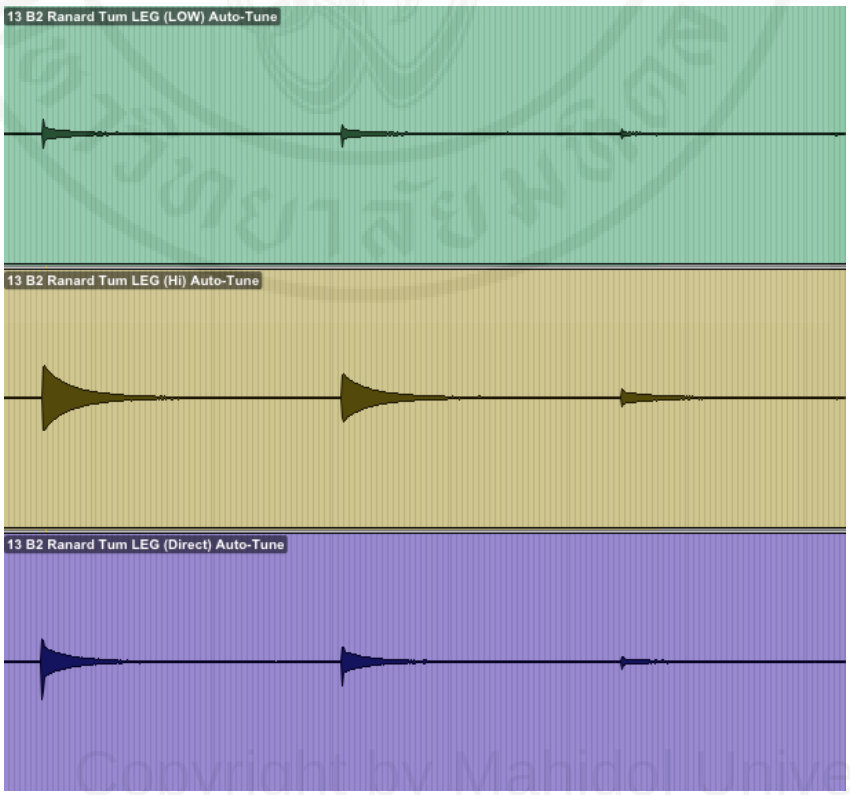


Figure 5.159 B2 note after adjustment of Ranad Tum Lek waveform

C3 note

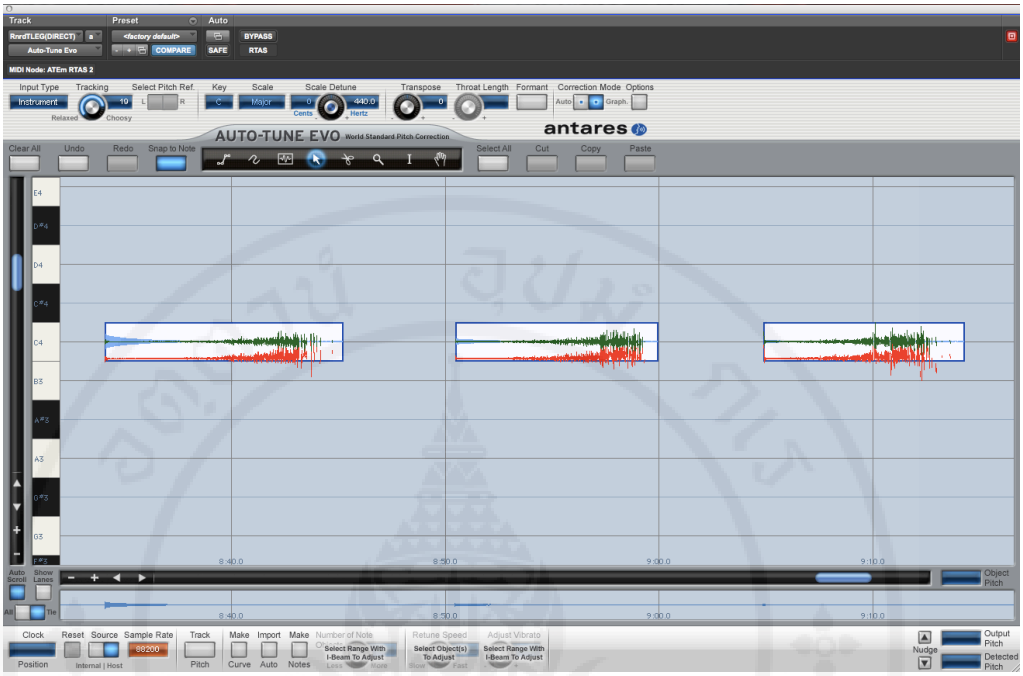


Figure 5.160 C3 note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

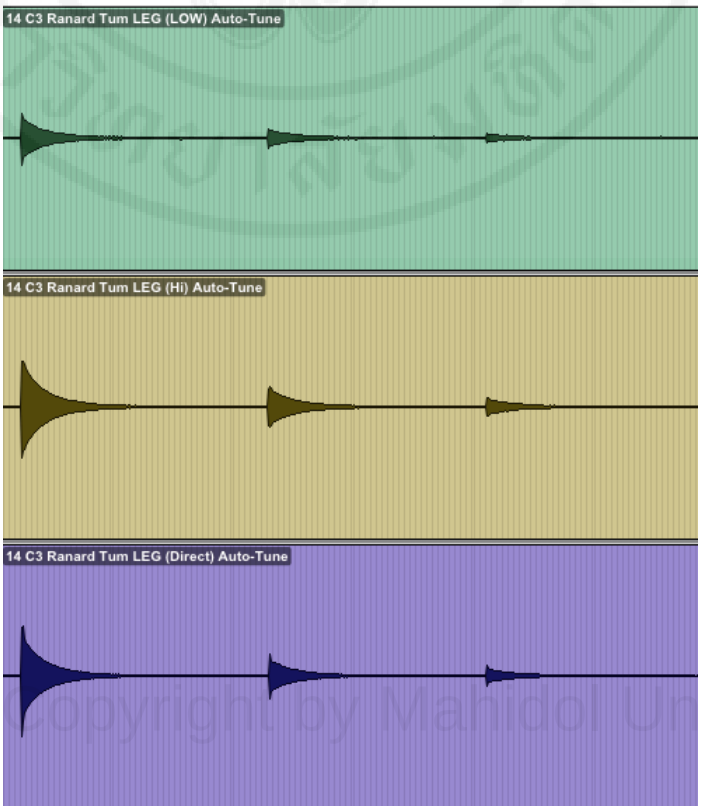


Figure 5.161 C3 note after adjustment of Ranad Tum Lek waveform

D3 note

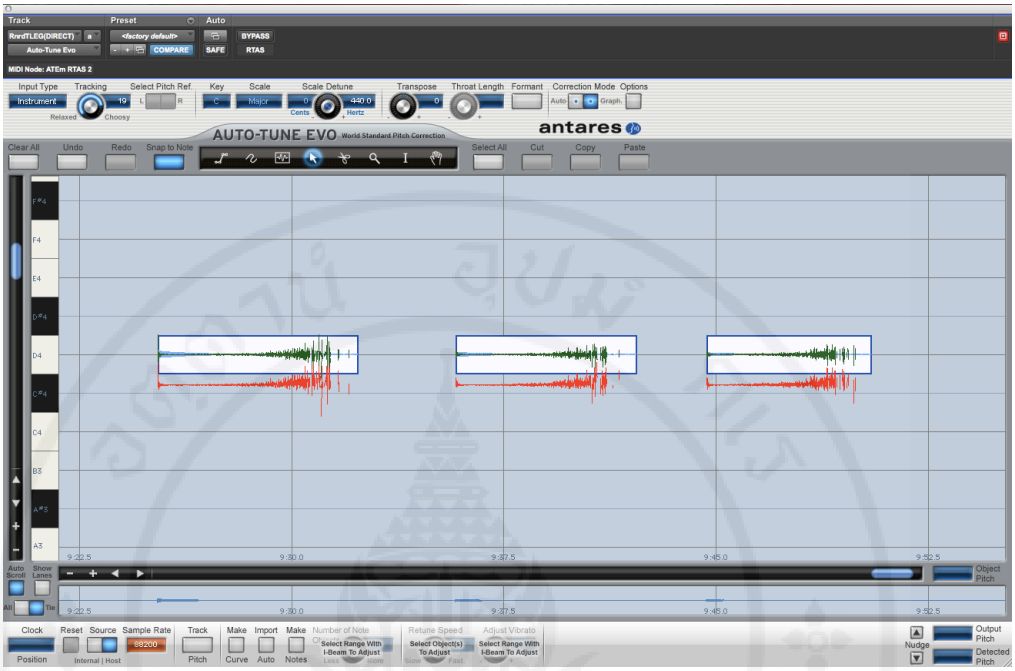


Figure 5.162 D3 note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

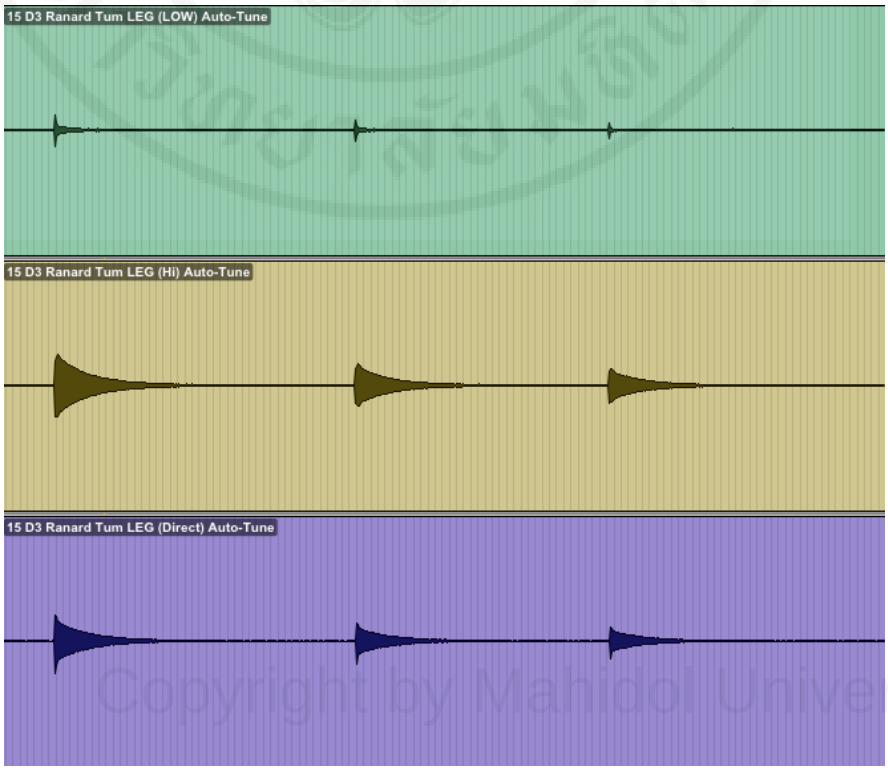


Figure 5.163 D3 note after adjustment of Ranad Tum Lek waveform

E3 note

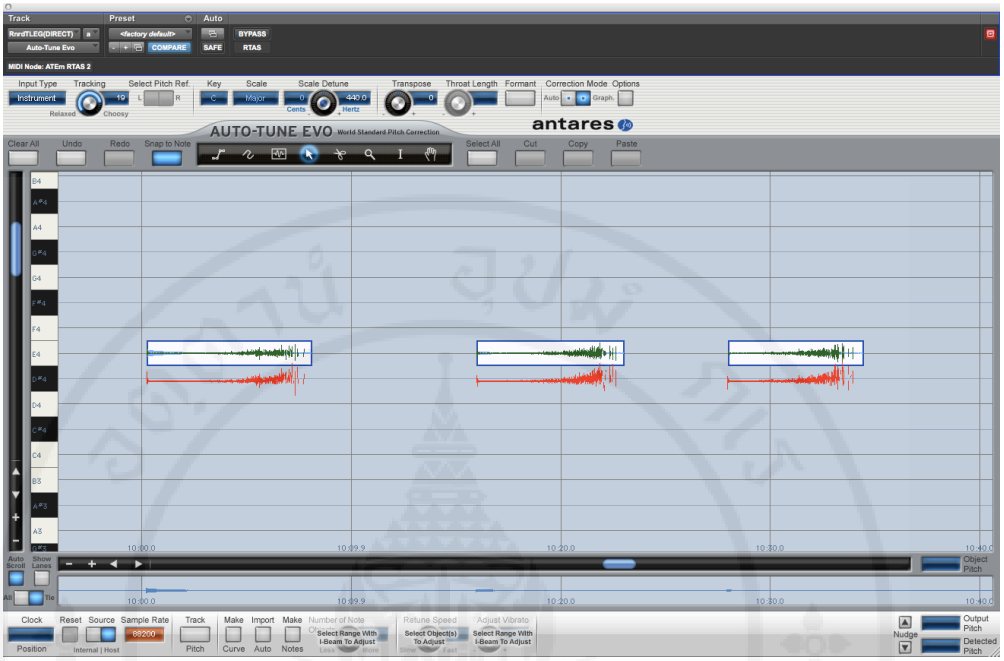


Figure 5.164 E3 note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

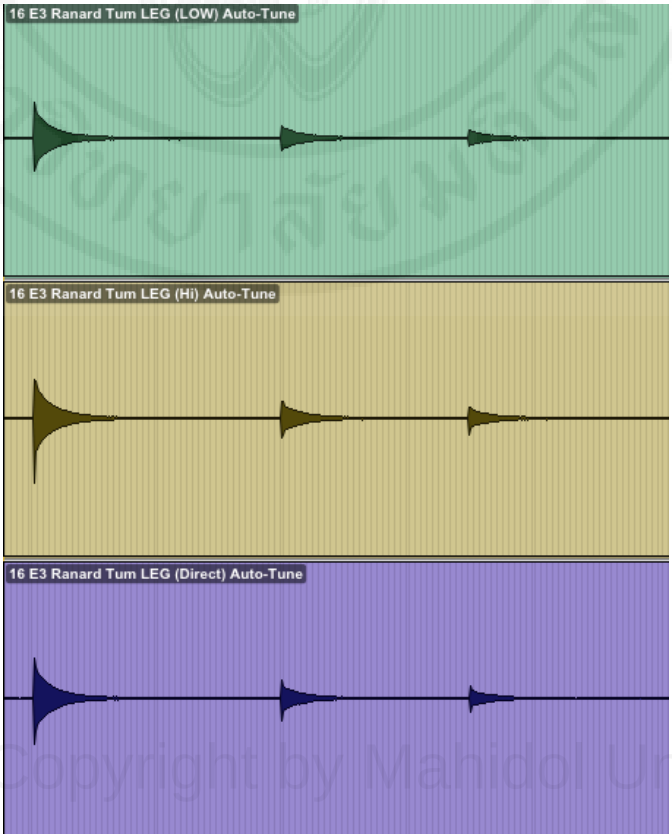


Figure 5.165 E3 note after adjustment of Ranad Tum Lek waveform

F3 note

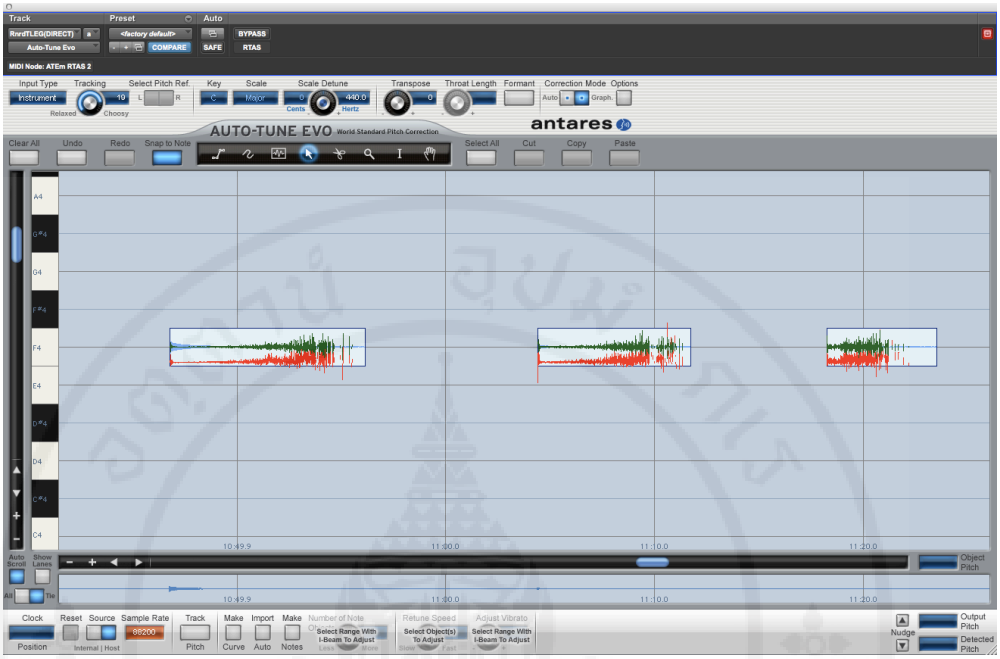


Figure 5.166 F3 note adjustment of Ranad Tum Lek by Auto-Tune Plug-in

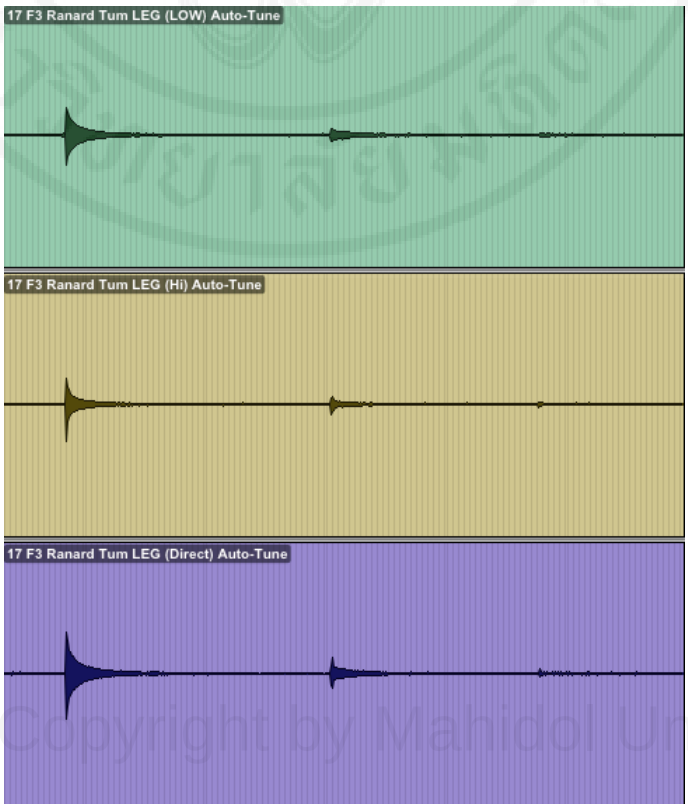


Figure 5.167 F3 note after adjustment of Ranad Tum Lek waveform

5.3.4 Adjustment of Kong Wong Yai sound samples

From the sound samples of Kong Wong Yai there are 16 pitches, from D-E3.

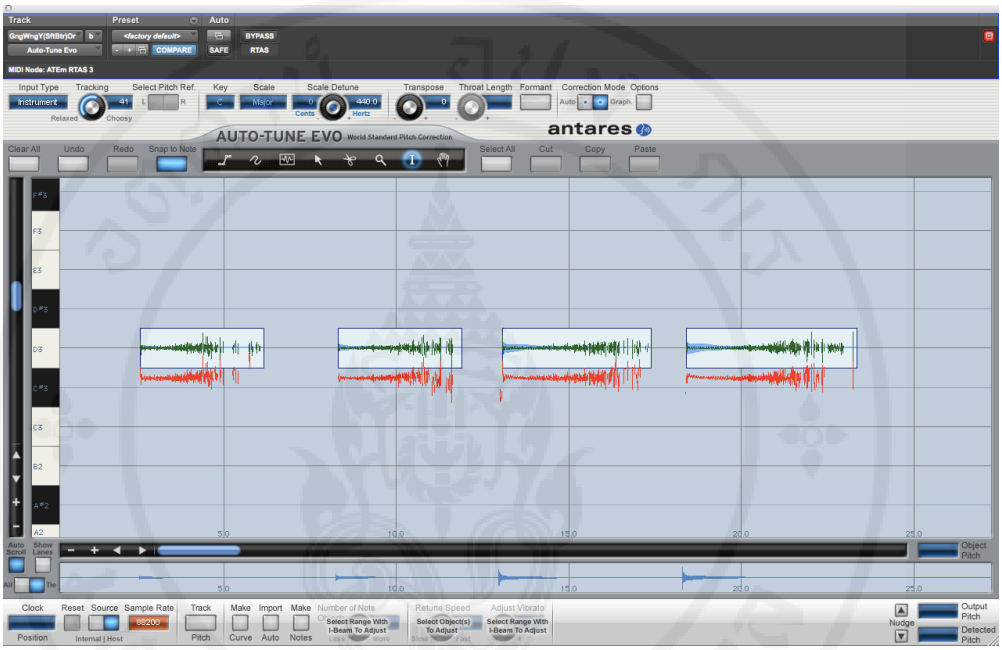


Figure 5.168 D note adjustment of Kong Wong Yai by Auto-Tune Plug-in

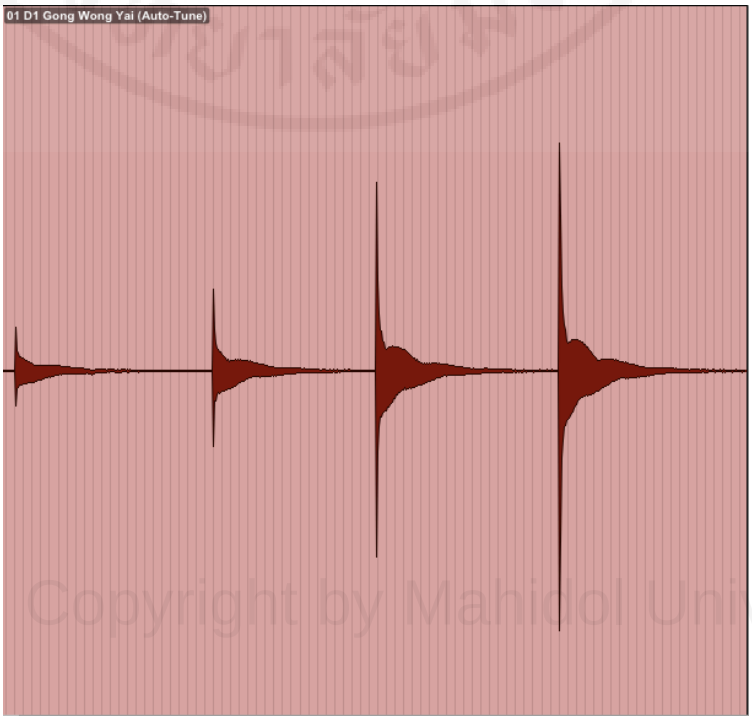


Figure 5.169 D note after adjustment of Kong Wong Yai waveform

E note

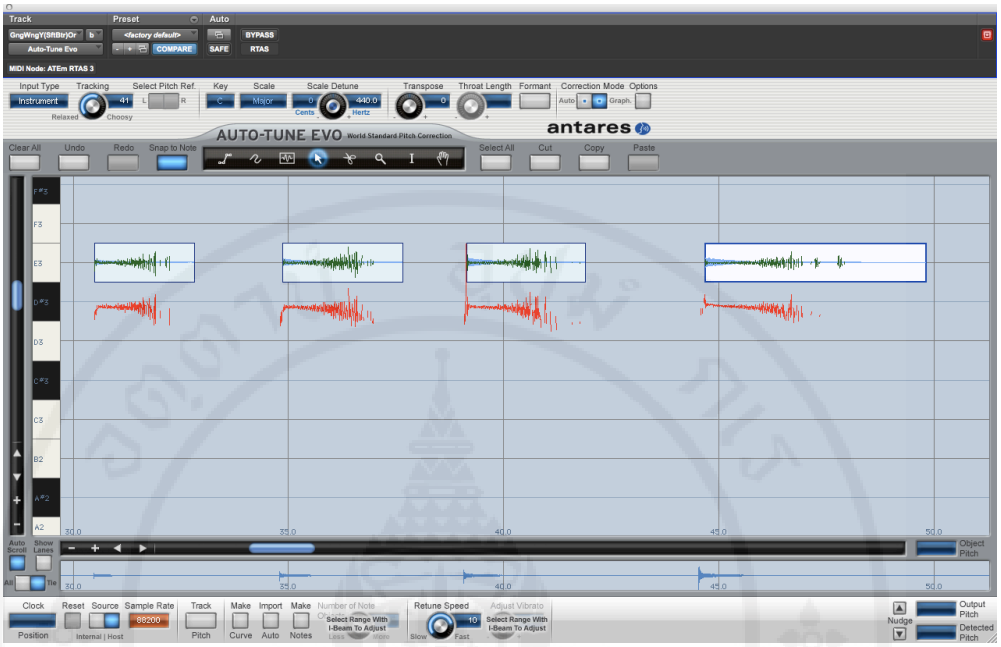


Figure 5.170 E note adjustment of Kong Wong Yai by Auto-Tune Plug-in

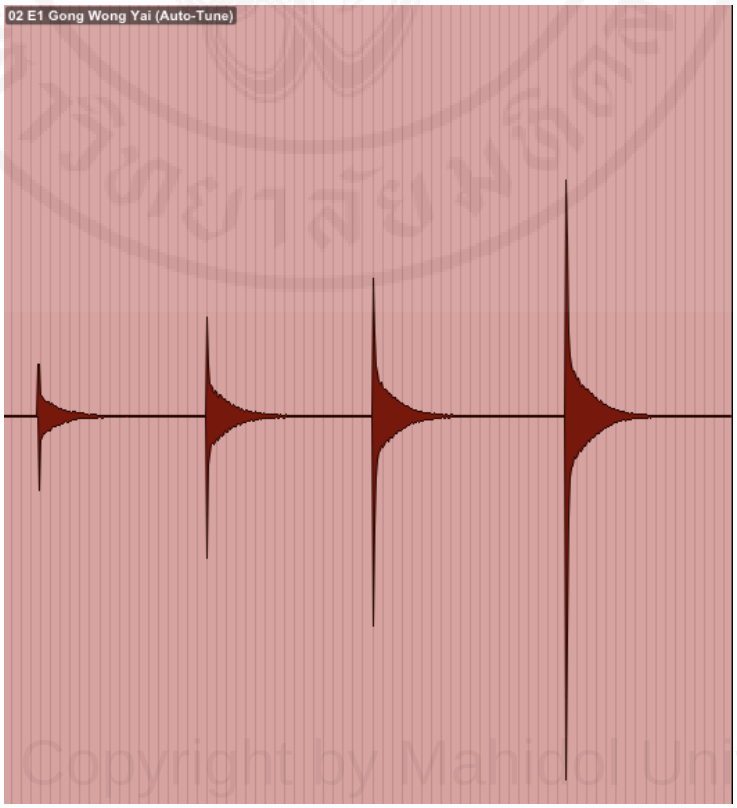


Figure 5.171 E note after adjustment of Kong Wong Yai waveform

F note

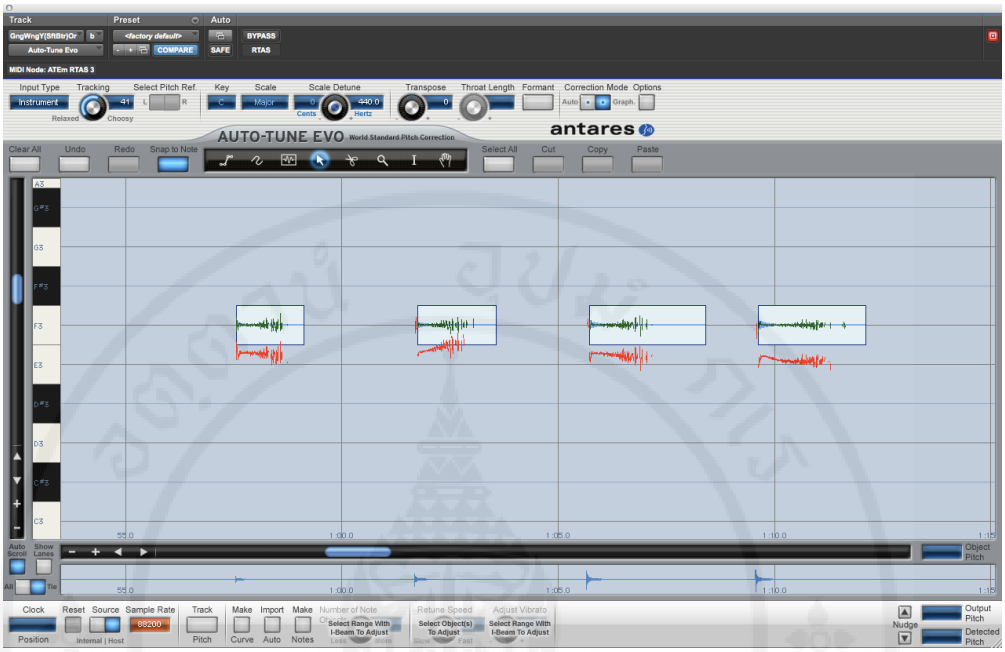


Figure 5.172 F note adjustment of Kong Wong Yai by Auto-Tune Plug-in

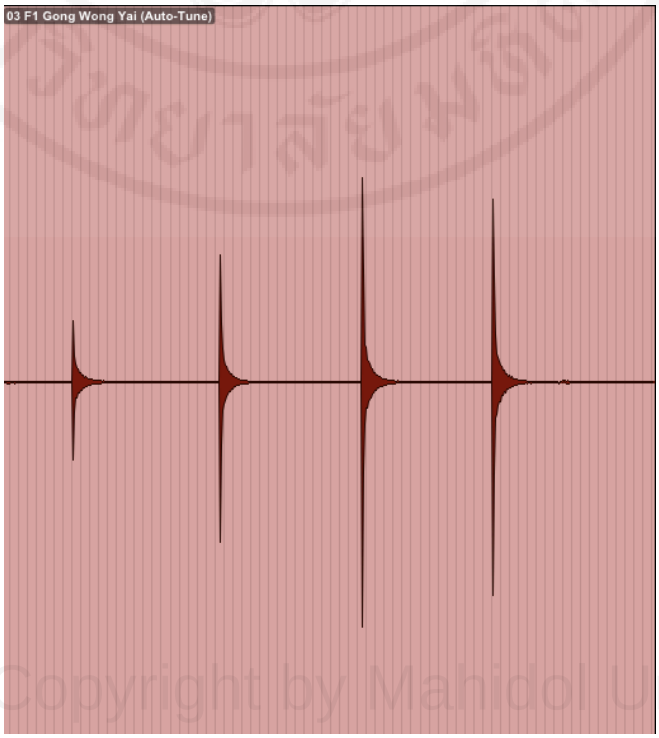


Figure 5.173 F note after adjustment of Kong Wong Yai waveform

G note

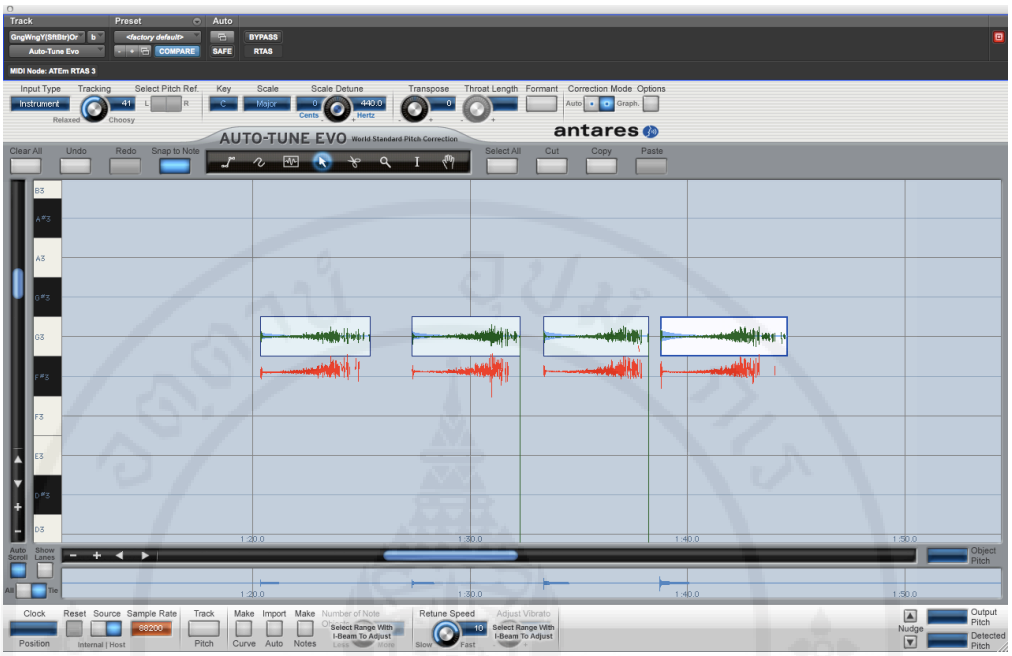


Figure 5.174 G note adjustment of Kong Wong Yai by Auto-Tune Plug-in

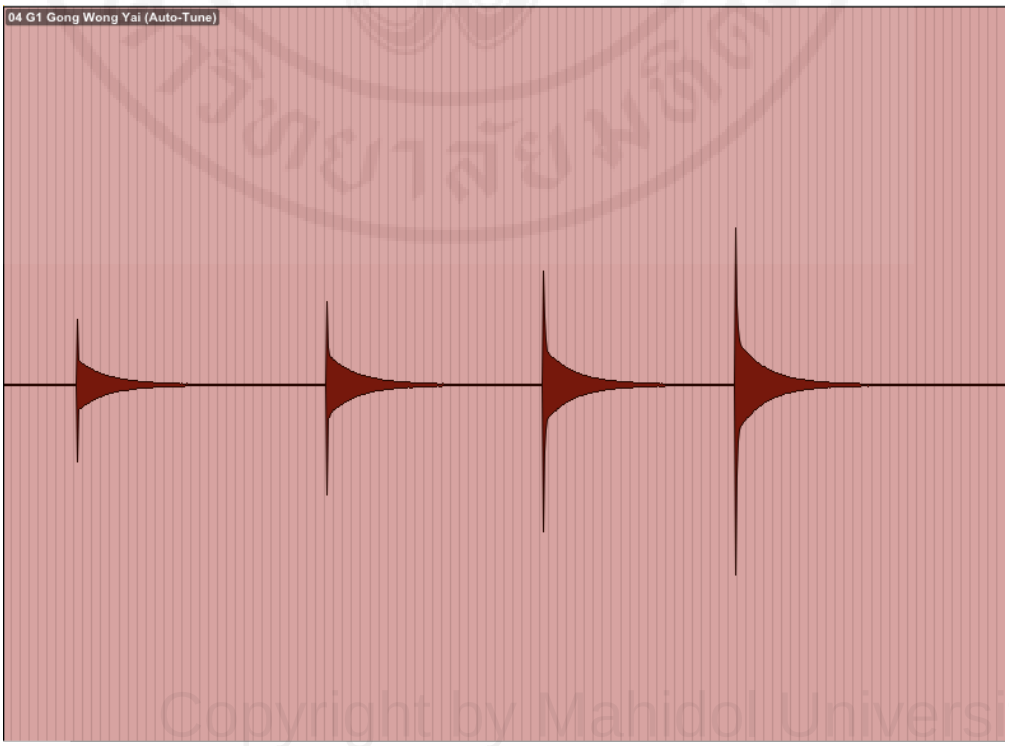


Figure 5.175 G note after adjustment of Kong Wong Yai waveform

A note

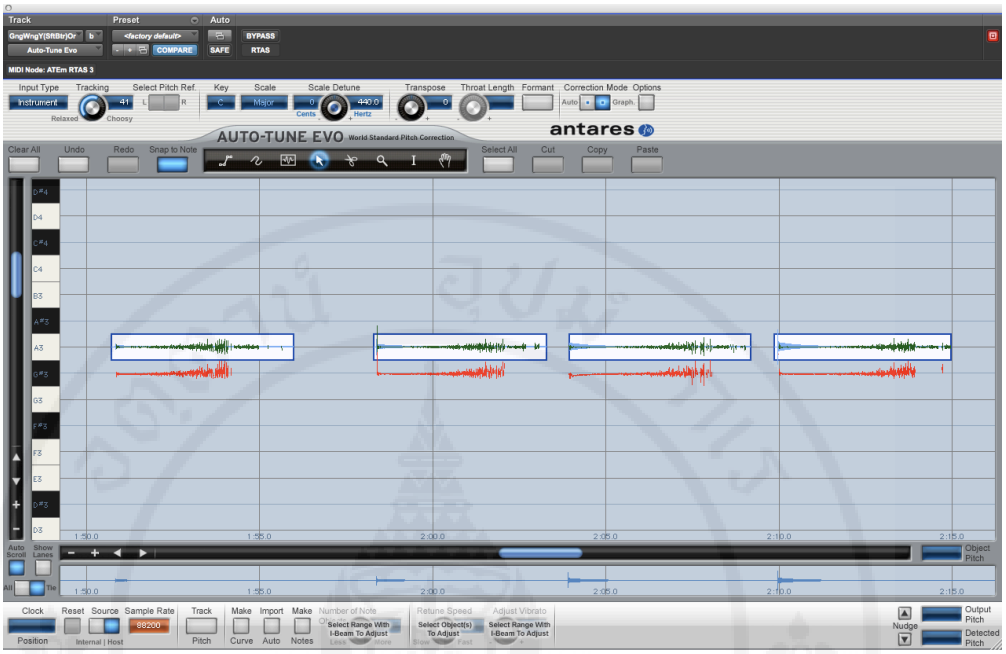


Figure 5.176 A note adjustment of Kong Wong Yai by Auto-Tune Plug-in

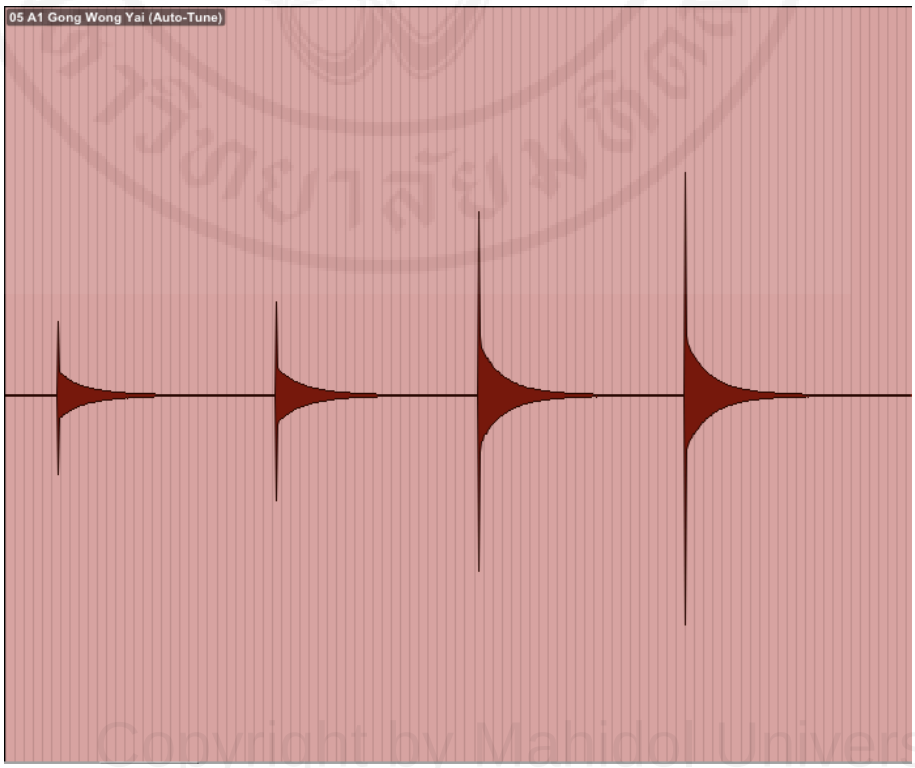


Figure 5.177 A note after adjustment of Kong Wong Yai waveform

B note

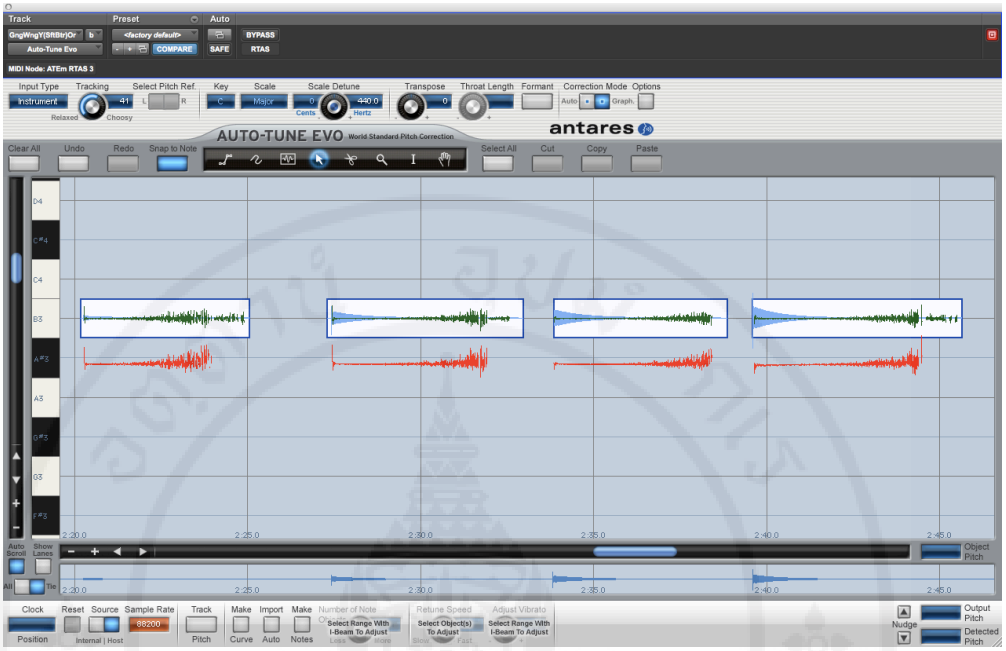


Figure 5.178 B note adjustment of Kong Wong Yai by Auto-Tune Plug-in

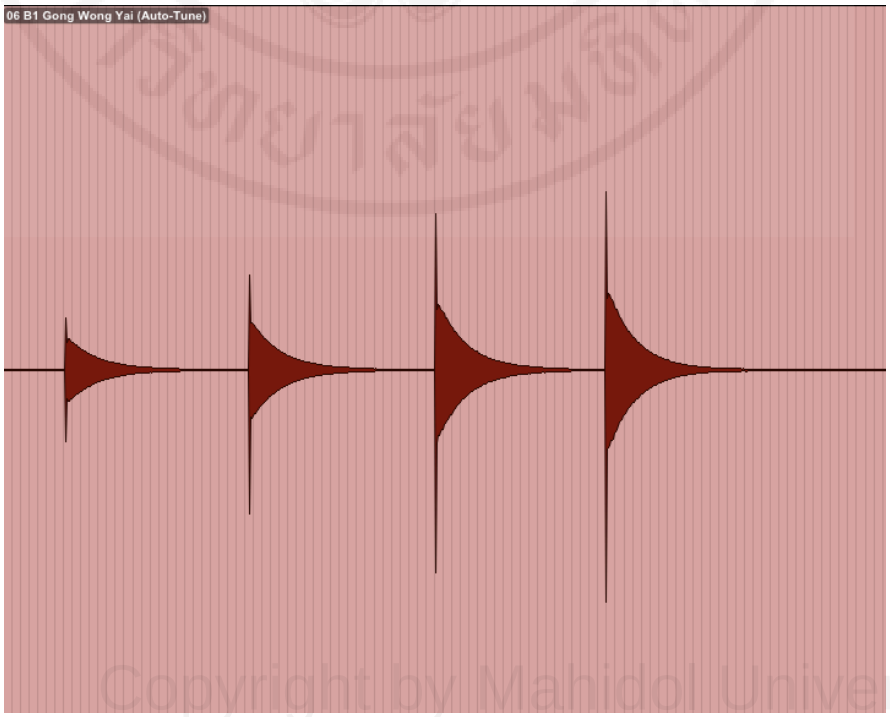


Figure 5.179 B note after adjustment of Kong Wong Yai waveform

C2 note

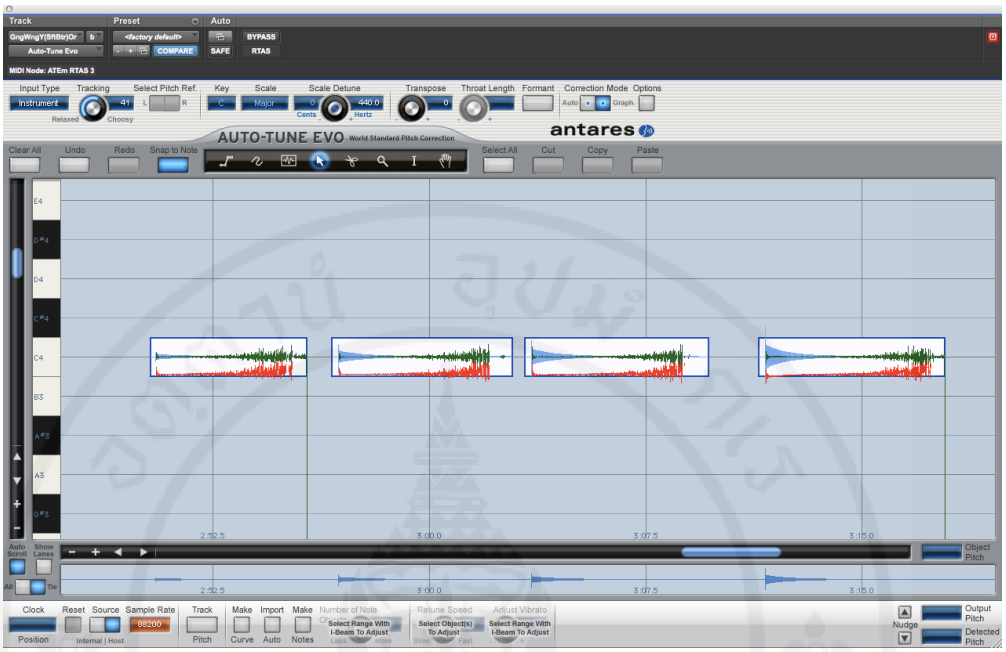


Figure 5.180 C2 note adjustment of Kong Wong Yai by Auto-Tune Plug-in

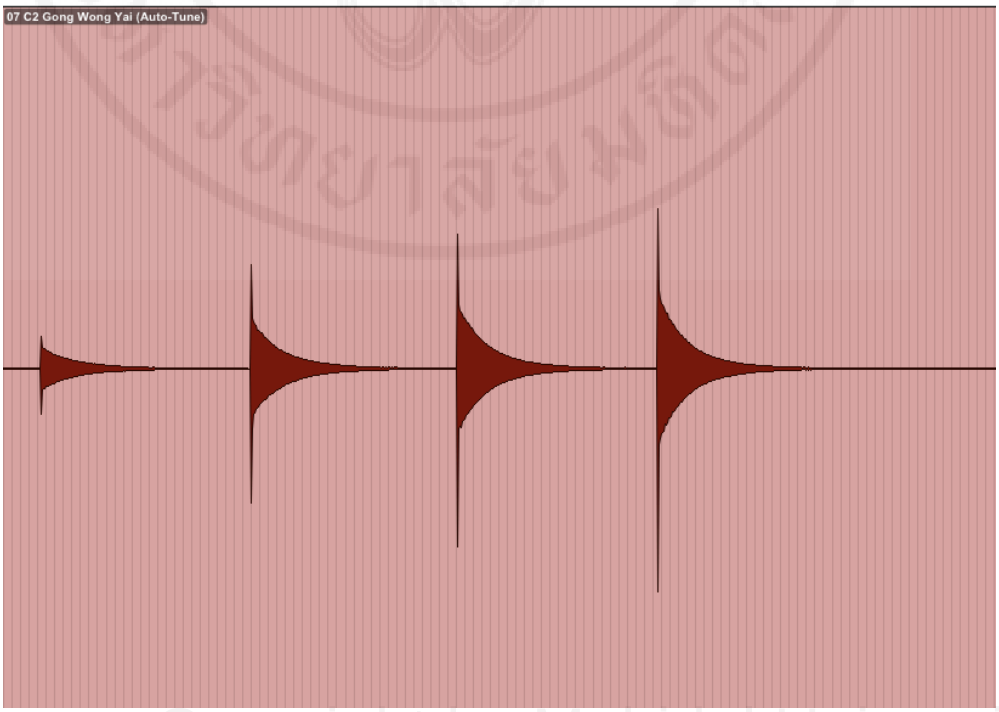


Figure 5.181 C2 note after adjustment of Kong Wong Yai waveform

D2 note

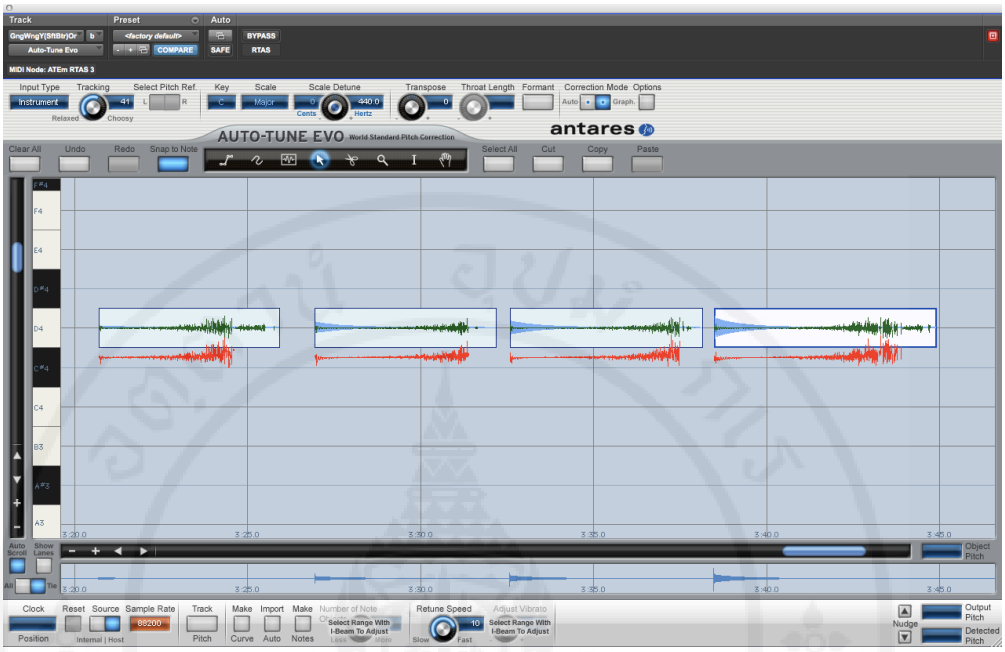


Figure 5.182 D2 note adjustment of Kong Wong Yai by Auto-Tune Plug-in

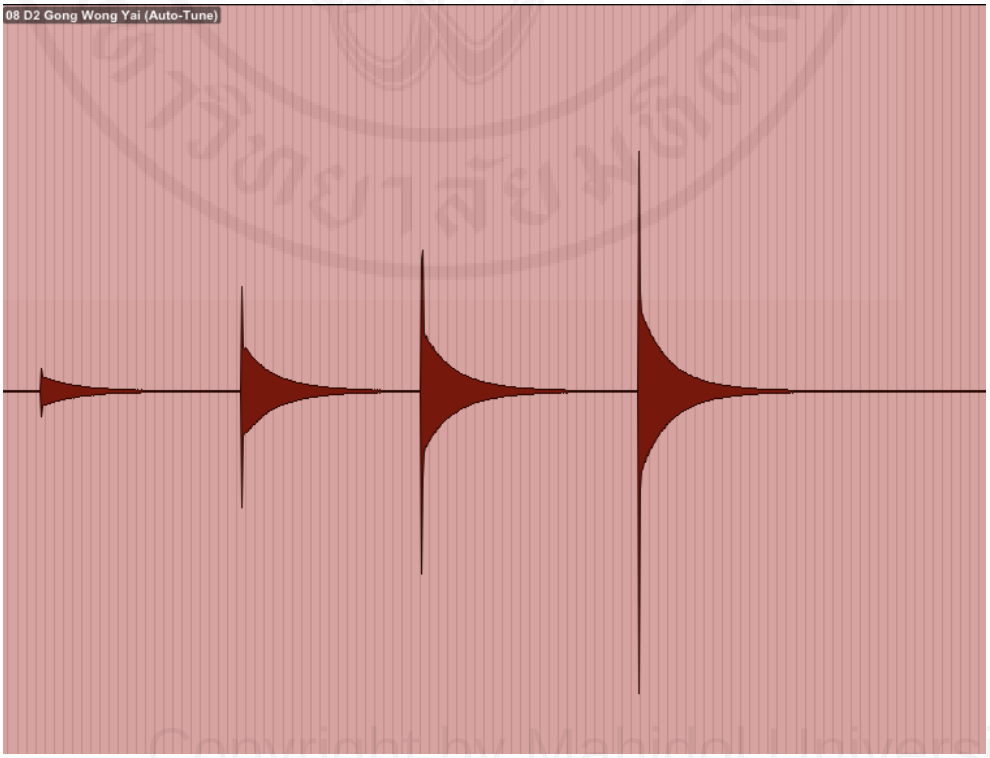


Figure 5.183 D2 note after adjustment of Kong Wong Yai waveform

E2 note

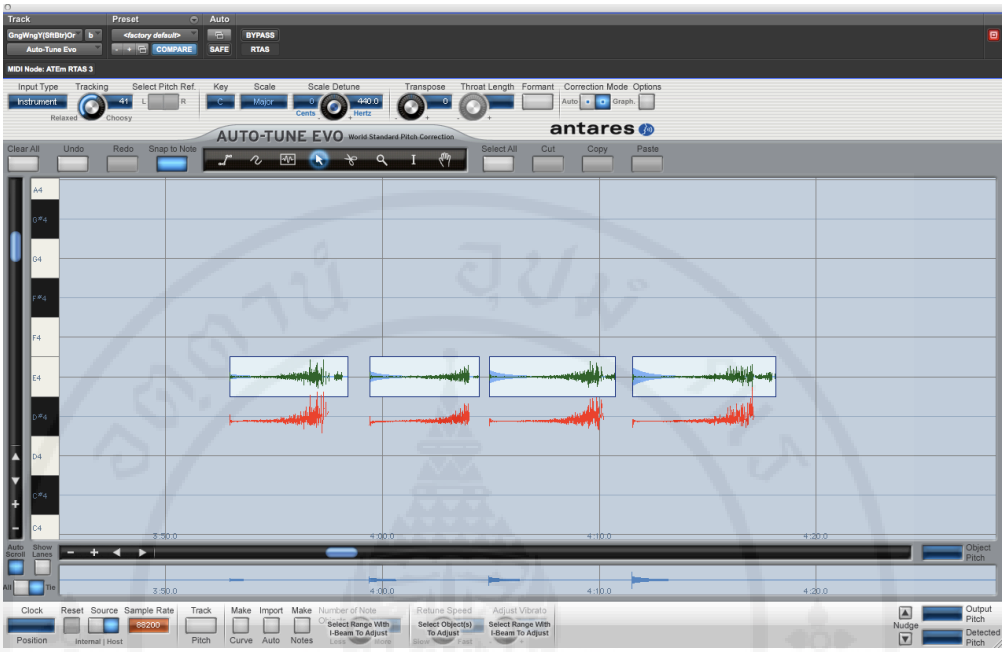


Figure 5.184 E2 note adjustment of Kong Wong Yai by Auto-Tune Plug-in

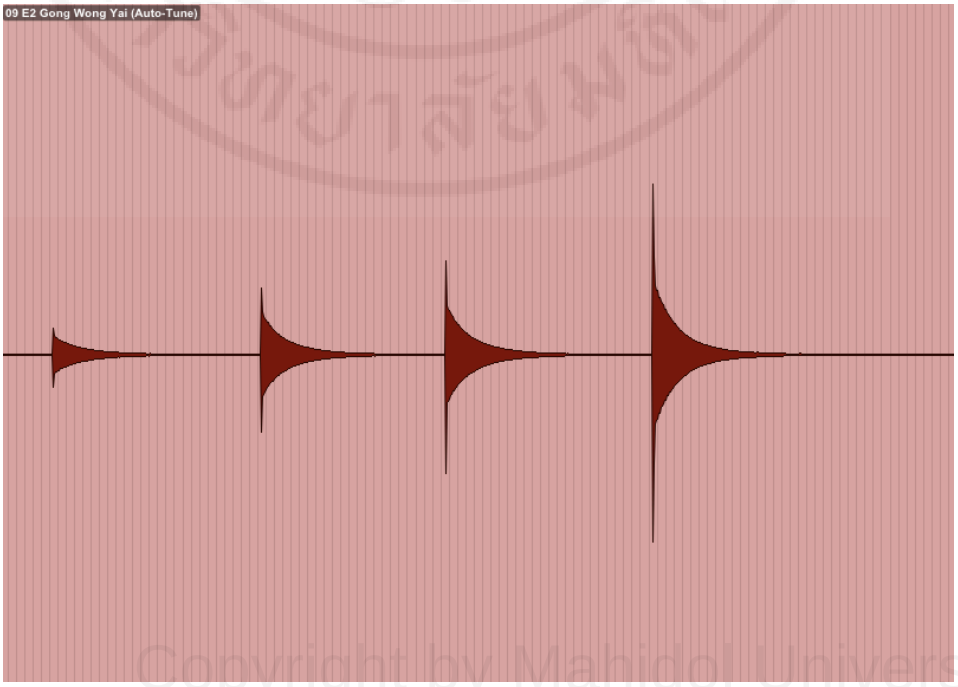


Figure 5.185 E2 note after adjustment of Kong Wong Yai waveform

F2 note

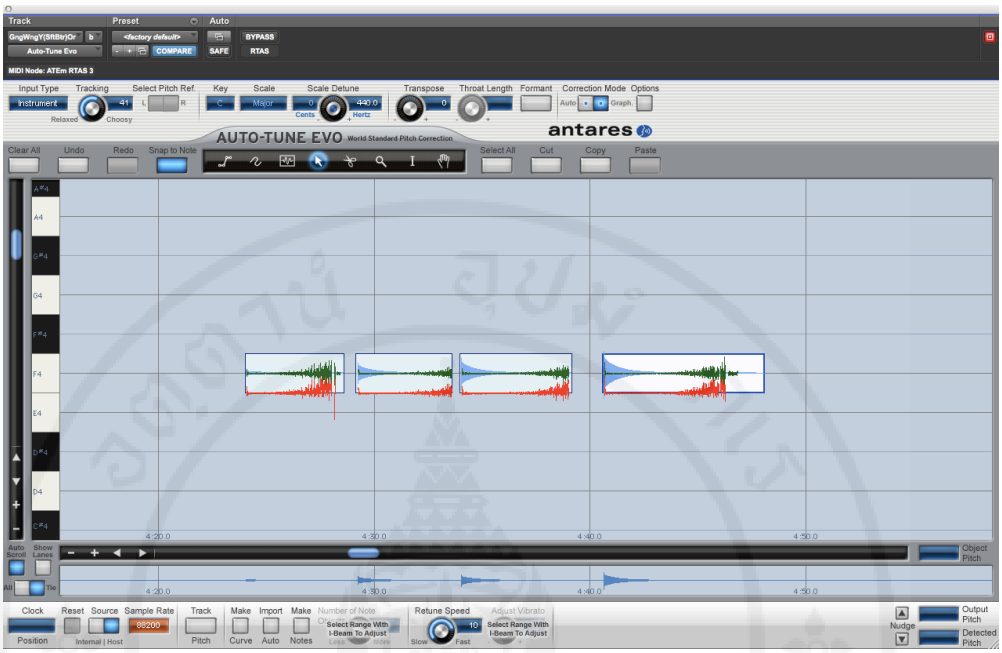


Figure 5.186 F2 note adjustment of Kong Wong Yai by Auto-Tune Plug-in

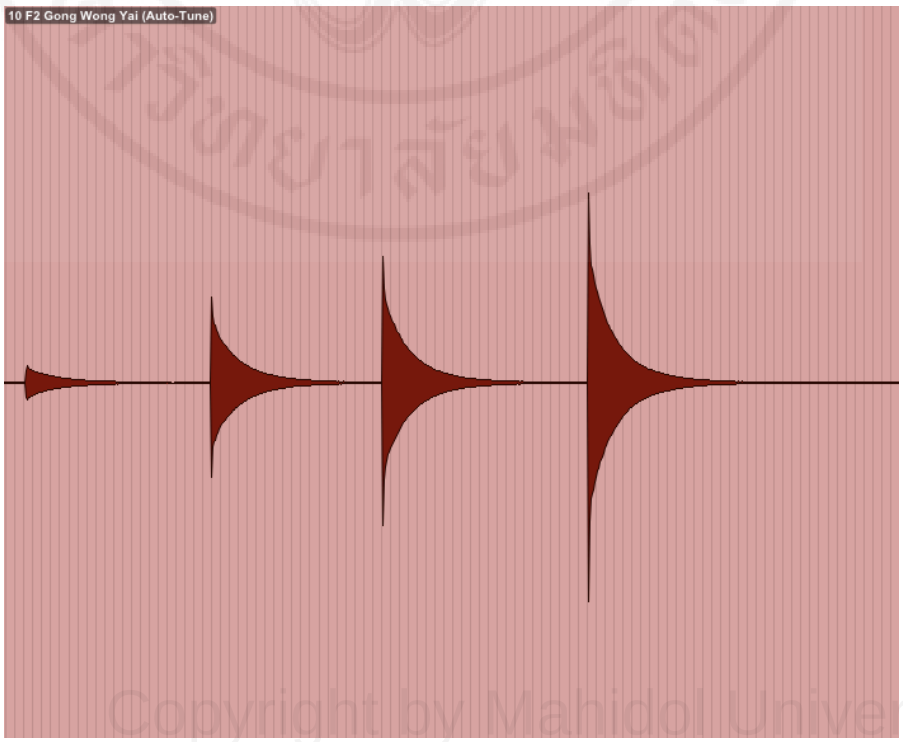


Figure 5.187 F2 note after adjustment of Kong Wong Yai waveform

G2 note

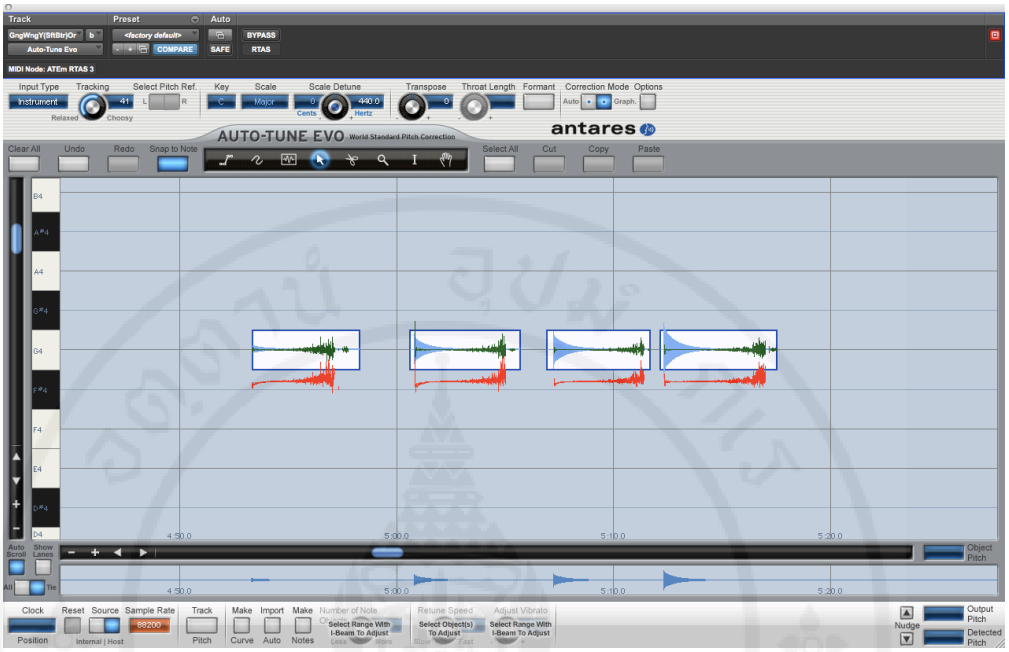


Figure 5.188 G2 note adjustment of Kong Wong Yai by Auto-Tune Plug-in

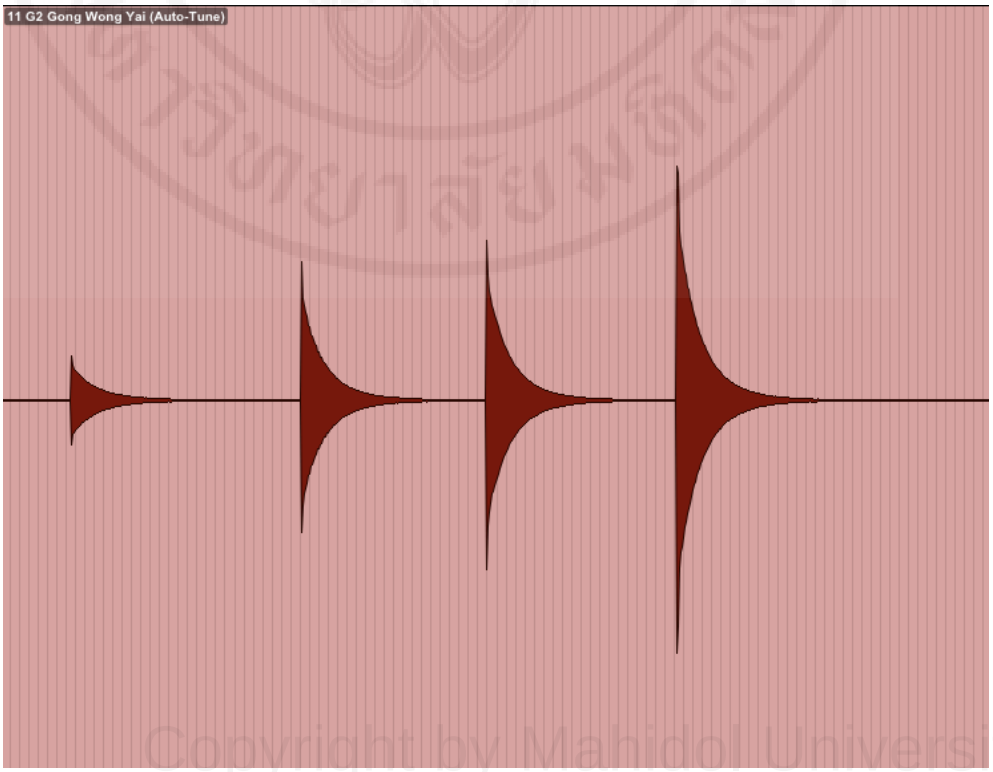


Figure 5.189 G2 note after adjustment of Kong Wong Yai waveform

A2 note

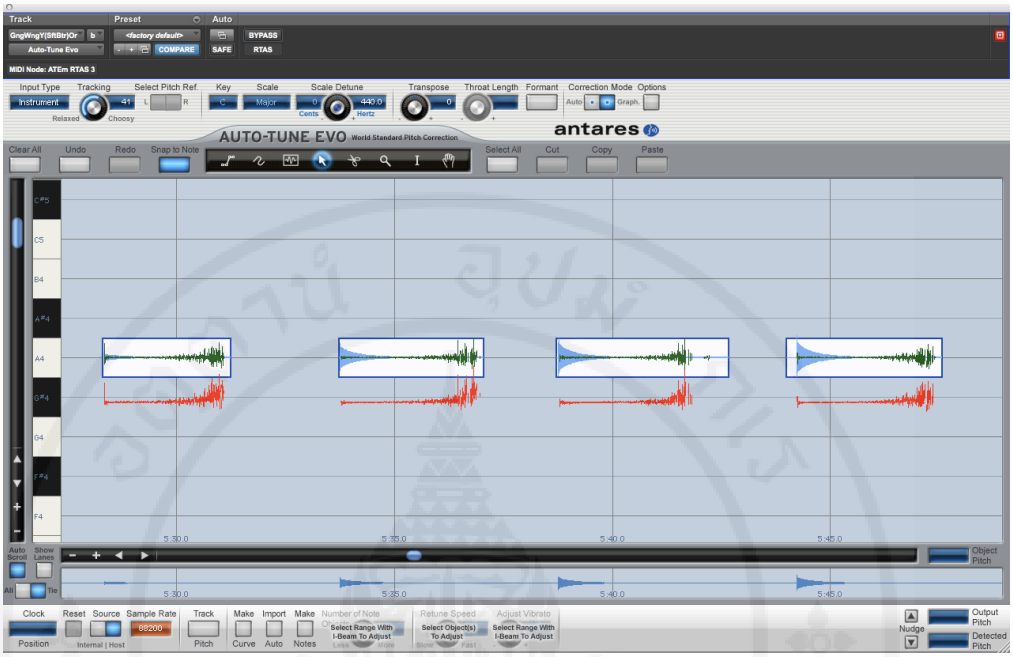


Figure 5.190 A2 note adjustment of Kong Wong Yai by Auto-Tune Plug-in

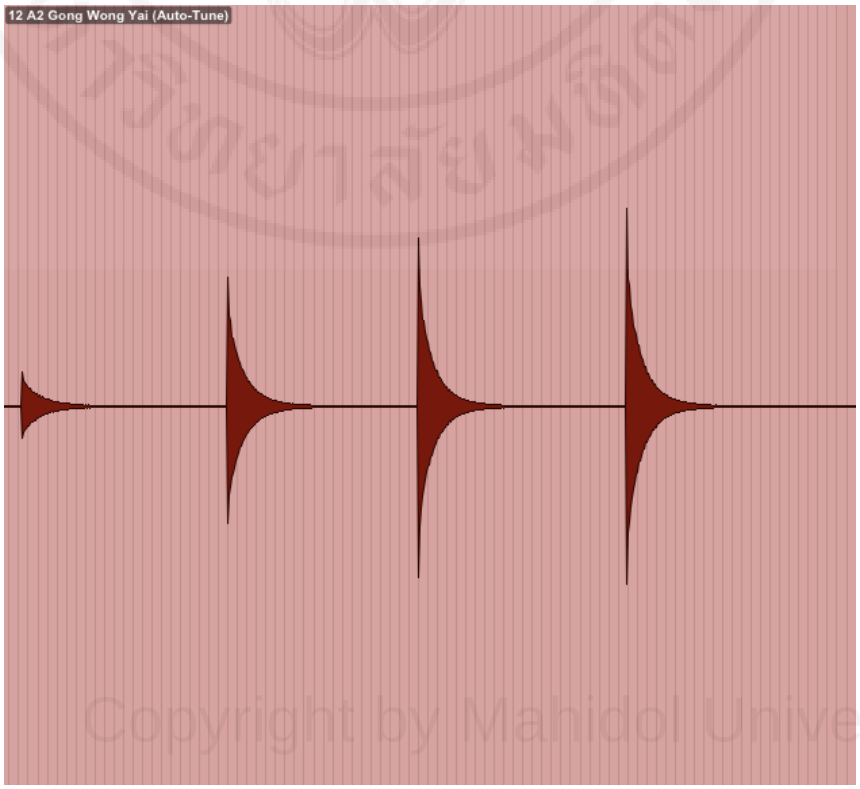


Figure 5.191 A2 note after adjustment of Kong Wong Yai waveform

B2 note

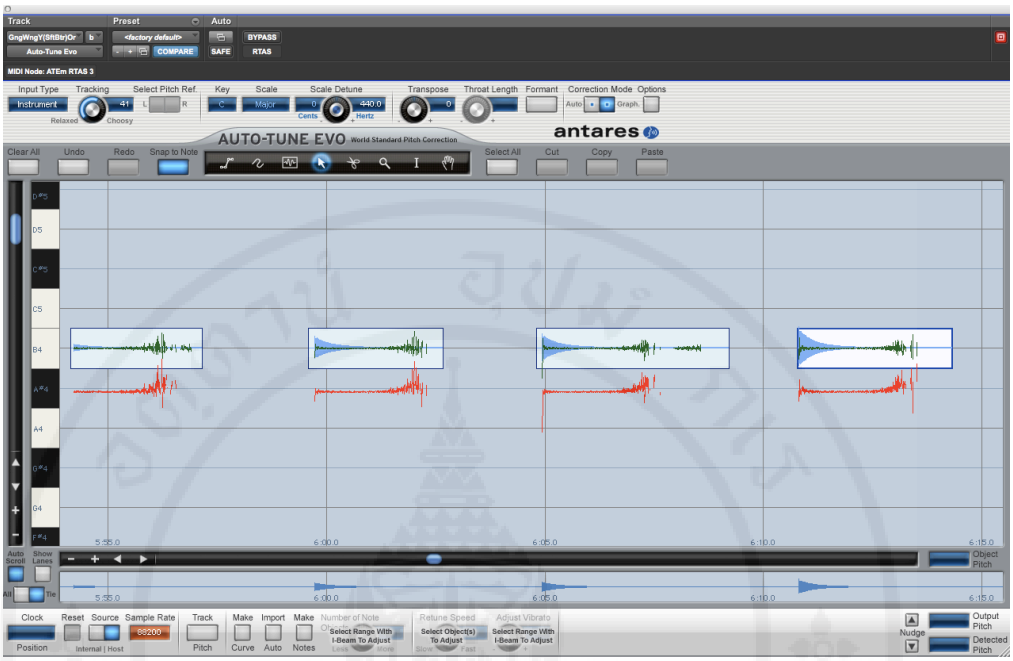


Figure 5.192 B2 note adjustment of Kong Wong Yai by Auto-Tune Plug-in

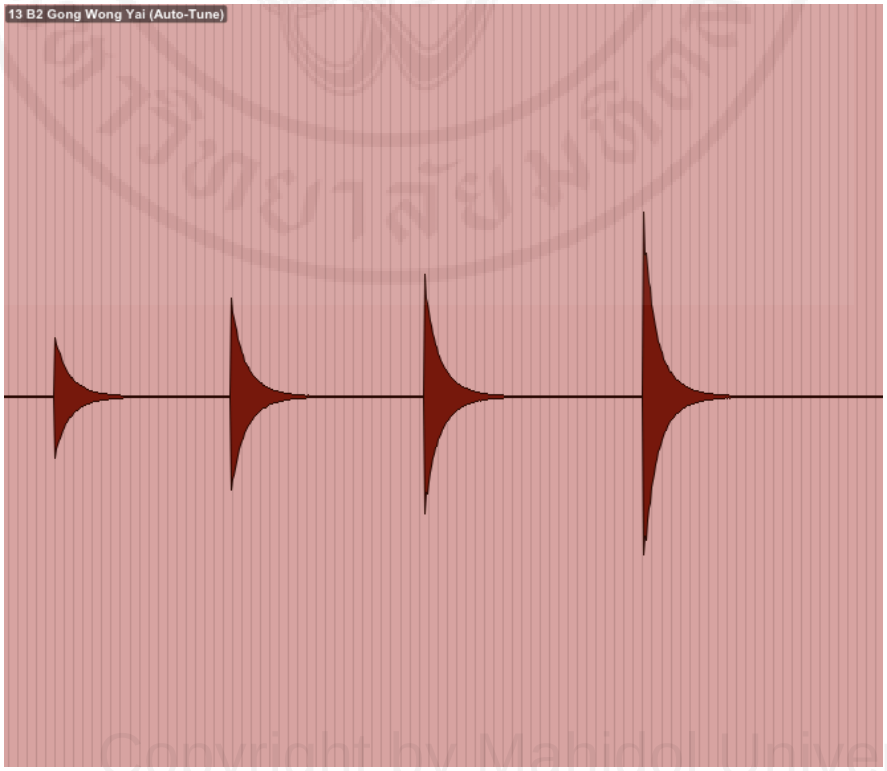


Figure 5.193 B2 note after adjustment of Kong Wong Yai waveform

C3 note

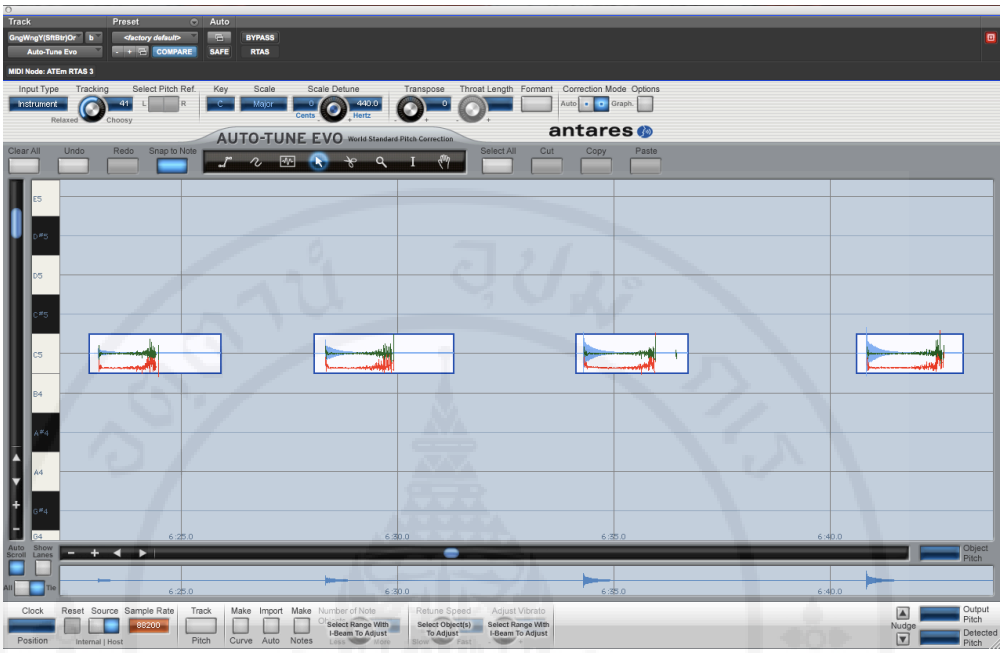


Figure 5.194 C3 note adjustment of Kong Wong Yai by Auto-Tune Plug-in

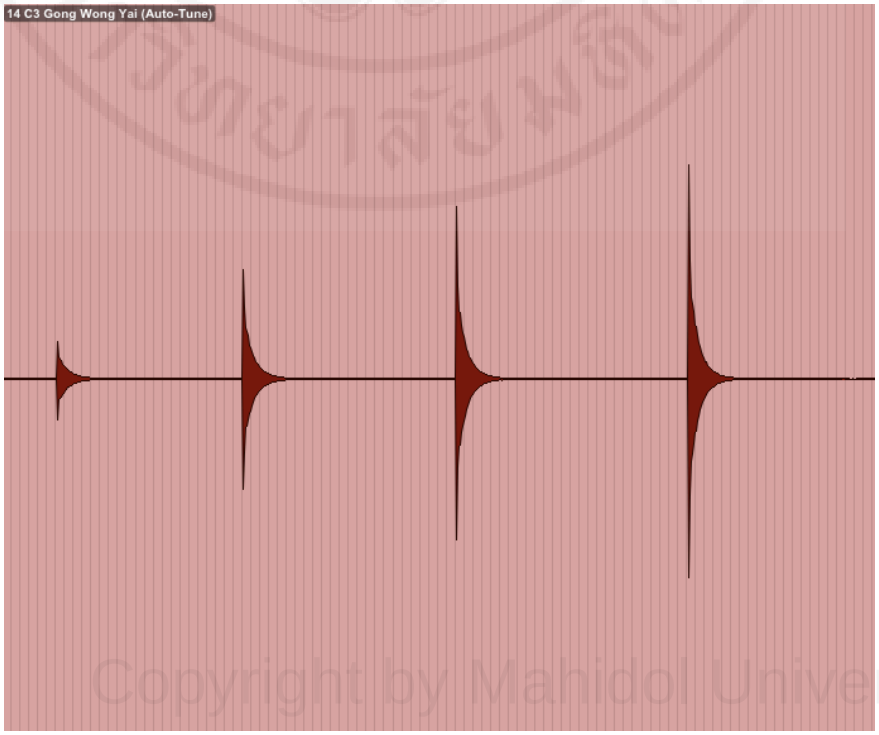


Figure 5.195 C3 note after adjustment of Kong Wong Yai waveform

D3 note

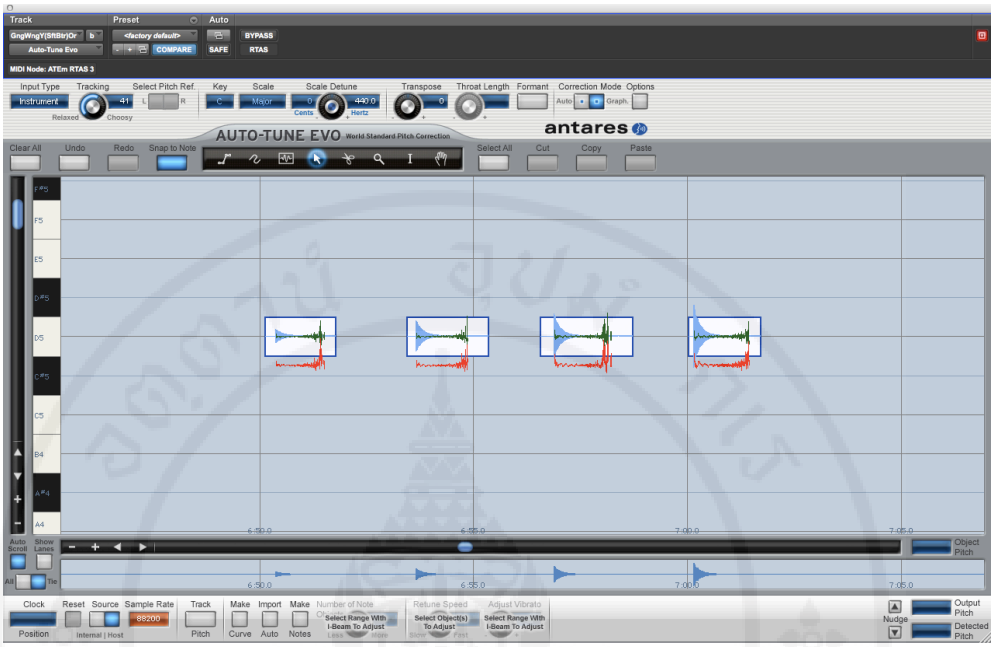


Figure 5.196 D3 note adjustment of Kong Wong Yai by Auto-Tune Plug-in

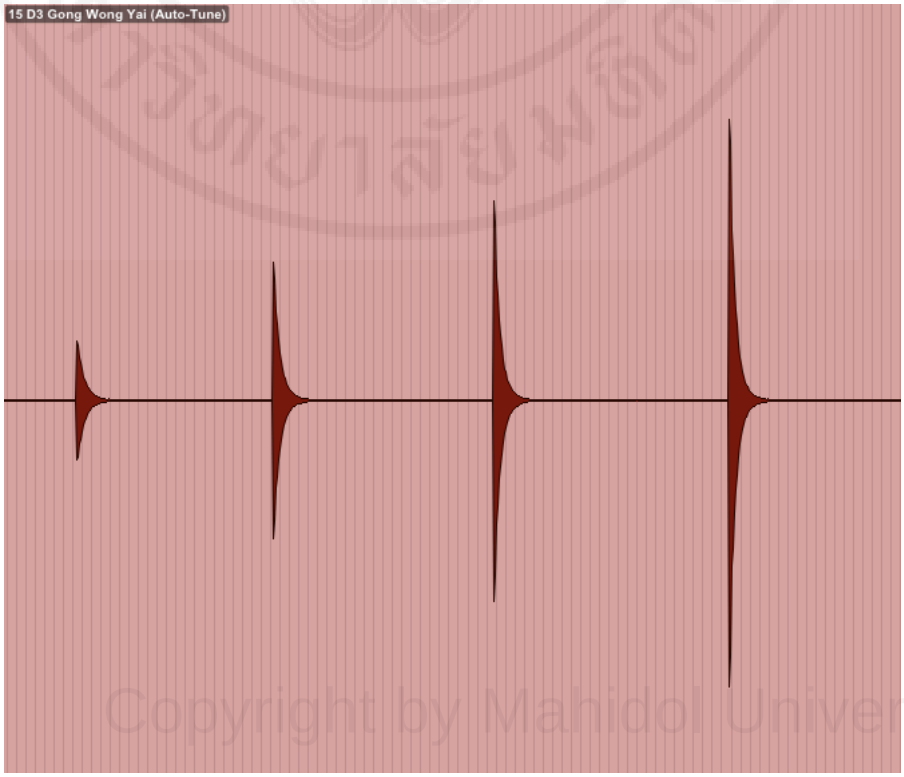


Figure 5.197 D3 note after adjustment of Kong Wong Yai waveform

E3 note

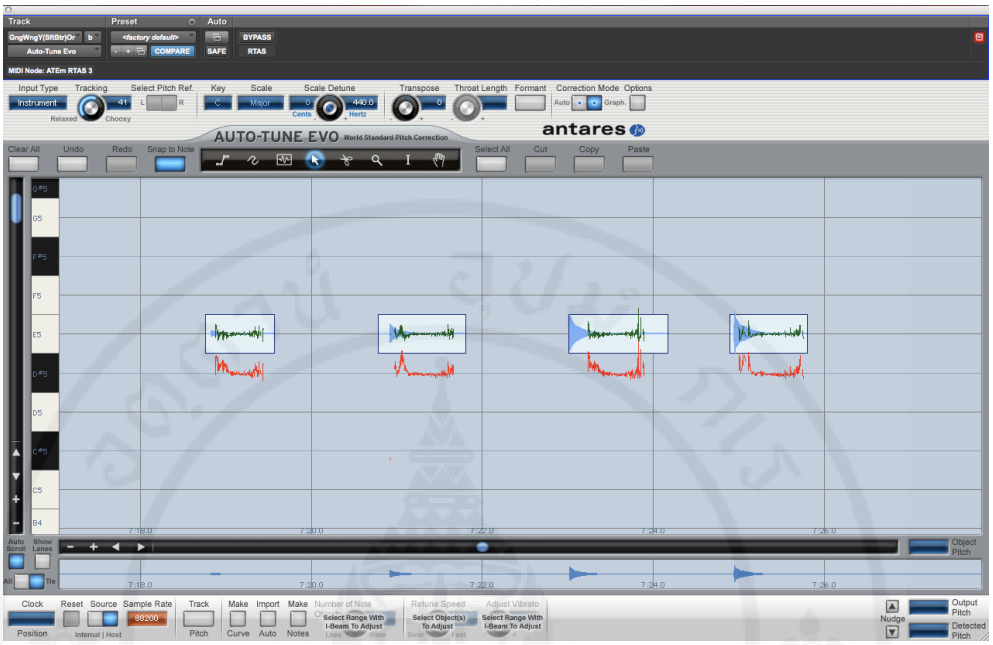


Figure 5.198 E3 note adjustment of Kong Wong Yai by Auto-Tune Plug-in

Figure 5.199 E3 note after adjustment of Kong Wong Yai waveform

5.4 Adjustment of all pitches of Thai sound samples into the Thai musical scale system

All the pitches have been adjusted to that of the Thai sound samples in to the equal temperament scale system. Next, all pitches have been adjusted again into the Thai musical scale system by a plug-in called Pitch Shift, from Protools.

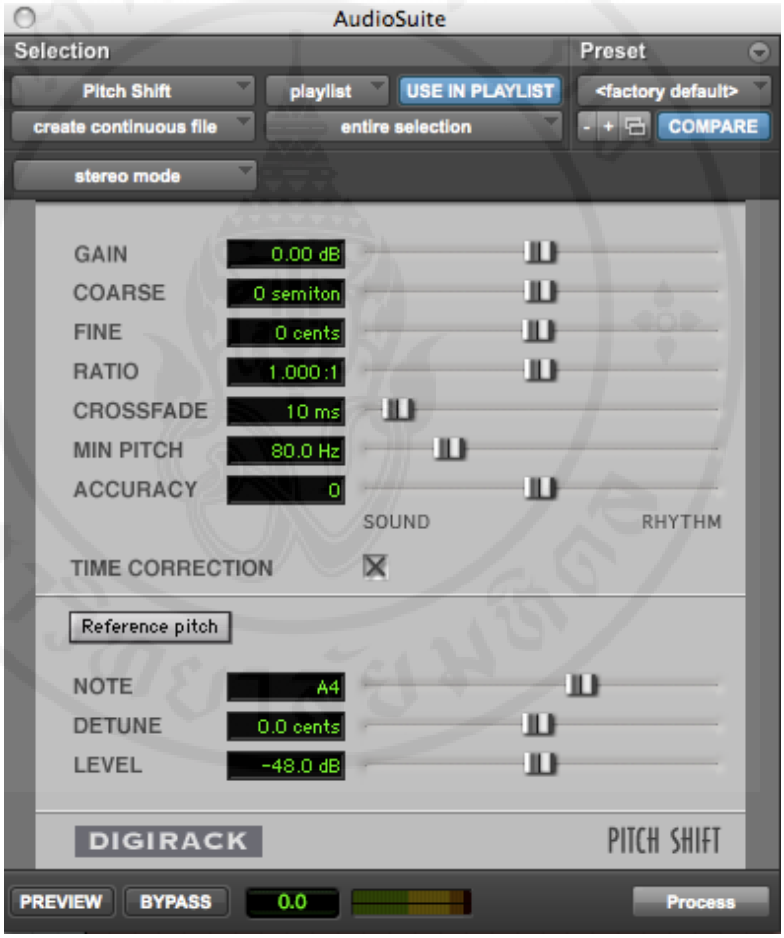


Figure 5.200 Pitch Shift Plug-in

This plug-in can adjust the pitch of cent value up or down. Using the fine parameter for adjustment, it is able to adjust 50 cents up or down. To adjust more then 50 cents, it can be used with the coarse parameter. It can be adjusted by semitone. For example, to raise the frequency of G up more than 60 cents, change the coarse parameter to 1 semitone and the fine parameter to -40 cents. G note will have a 60 cents higher frequency than G note in the equal temperament scale system.

5.4.1 Adjustment of Thai sound samples of Kong Wong Yai into the Thai musical scale system

D note

The cent value of D note has a value of minus 29 cents of D note of the equal temperament scale system. The reference pitch has been adjusted to D4 note and the detune parameter set to minus 29 cents.

Figure 5.201 D note adjustment of Kong Wong Yai by Pitch Shift Plug-in

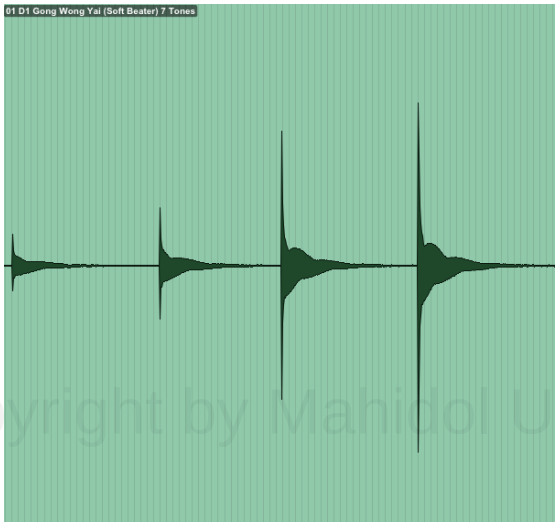


Figure 5.202 D note after adjustment of Kong Wong Yai waveform

E note

Cent value of E note has a value of minus 57 cents from E note of the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 43 cents. For a reference sound, change the reference pitch to D♯4 and adjust the detune parameter to 43 cents.

Figure 5.203 E note adjustment of Kong Wong Yai by Pitch Shift Plug-in

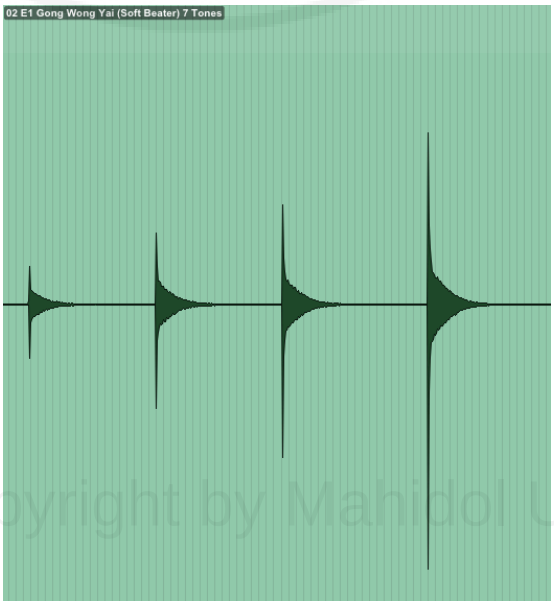


Figure 5.204 E note after adjustment of Kong Wong Yai waveform

F note

The cent value of F note is 14 cents more than that of F note from the equal temperament scale system. The reference pitch has been adjusted to F4 note and the detune parameter set to 14 cents.

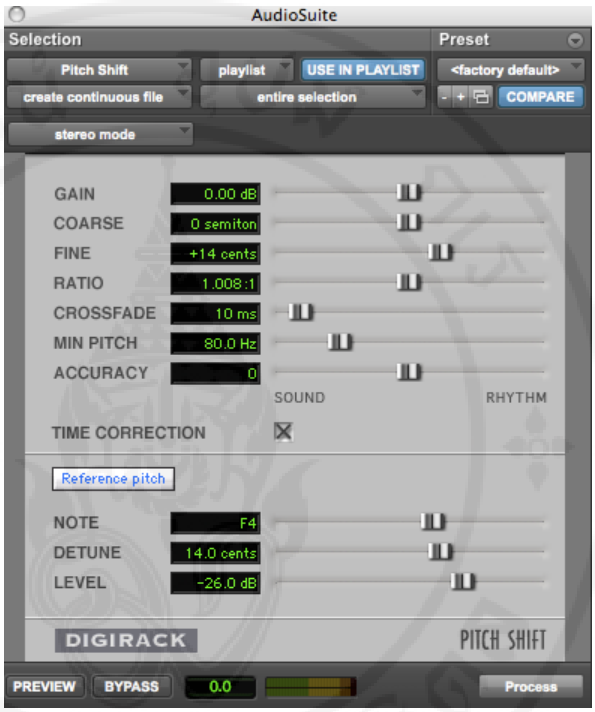


Figure 5.205 F note adjustment of Kong Wong Yai by Pitch Shift Plug-in

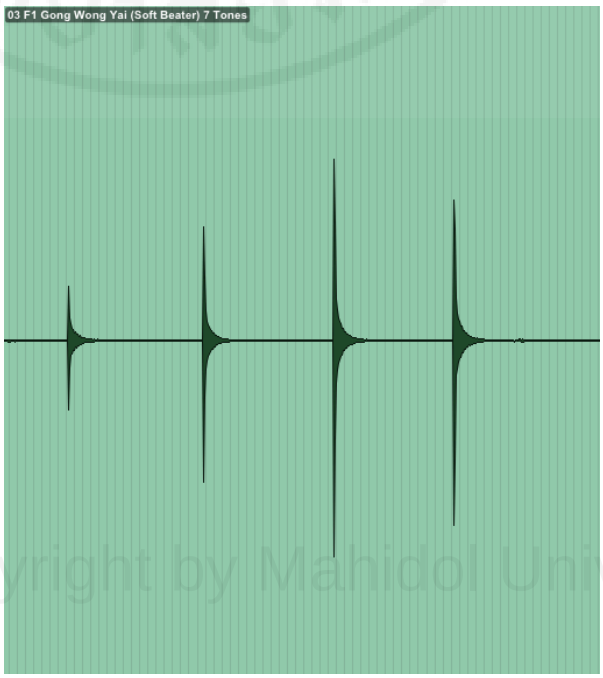


Figure 5.206 F note after adjustment of Kong Wong Yai waveform

G note

The cent value of G note is minus 14 cents of G note from the equal temperament scale system. The reference pitch has been adjusted to G4 note and the detune parameter set as minus 14 cents.

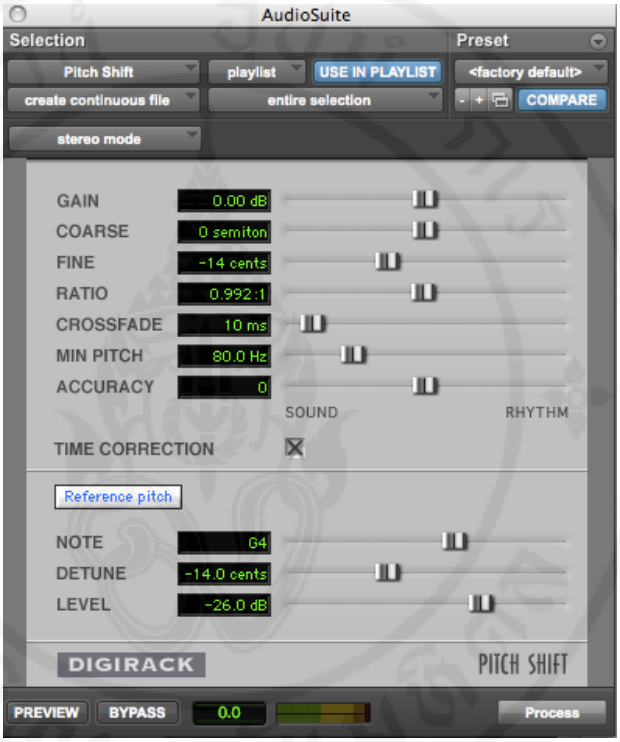


Figure 5.207 G note adjustment of Kong Wong Yai by Pitch Shift Plug-in

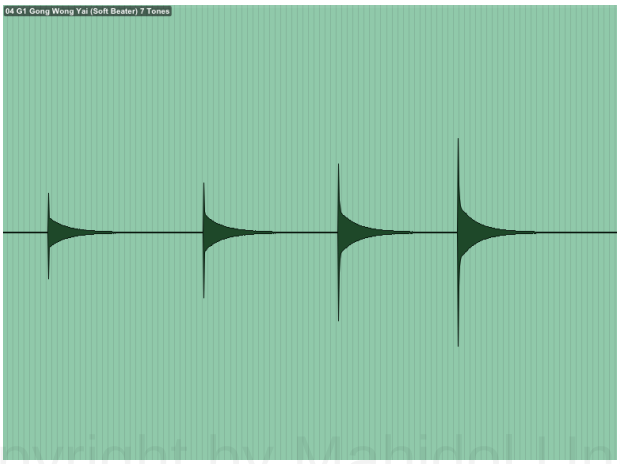


Figure 5.208 G note after adjustment of Kong Wong Yai waveform

A note

The cent value of A note is minus 43 cents of A note from the equal temperament scale system. The reference pitch has been adjusted to A4 note and the detune parameter set as minus 43 cents.

Figure 5.209 A note adjustment of Kong Wong Yai by Pitch Shift Plug-in

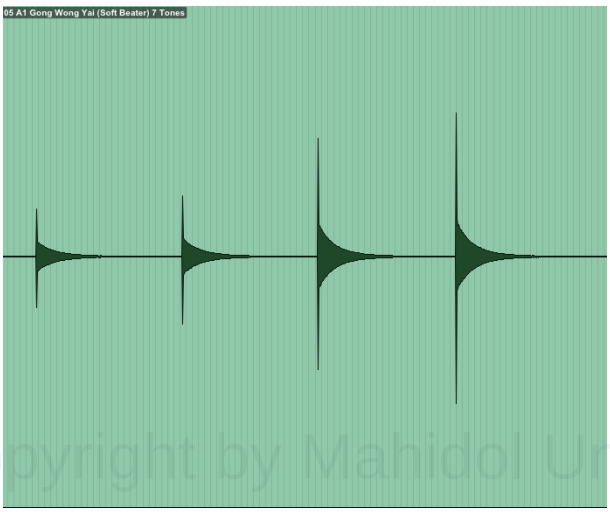


Figure 5.210 A note after adjustment of Kong Wong Yai waveform

B note

Cent value of B note is minus 72 from the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 28 cents. For reference sound, change the reference pitch to A♯4 and adjust the detune parameter to 28 cents.

Figure 5.211 B note adjustment of Kong Wong Yai by Pitch Shift Plug-in

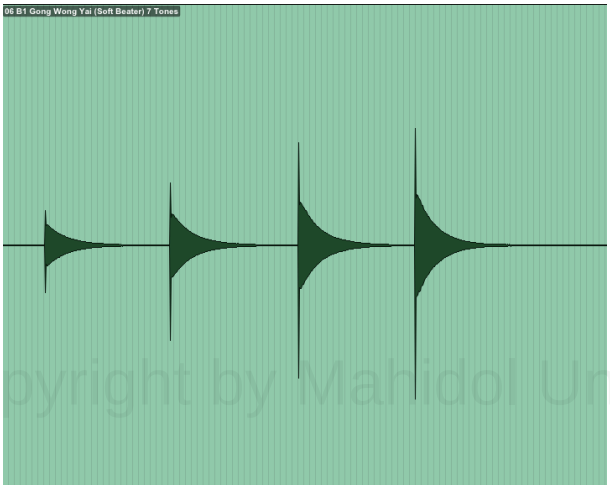


Figure 5.212 B note after adjustment of Kong Wong Yai waveform

C2 note

This research used C note from the equal temperament scale system to be the initial frequency to calculate the Thai musical scale system. The C note in the Thai musical scale system has the same frequency as the C note in the equal temperament scale system.

D2 note

The cent value of D note is minus 29 cents of D note from the equal temperament scale system. The reference pitch has been adjusted to D5 note and the detune parameter set as minus 43 cents.

Figure 5.213 D2 note adjustment of Kong Wong Yai by Pitch Shift Plug-in

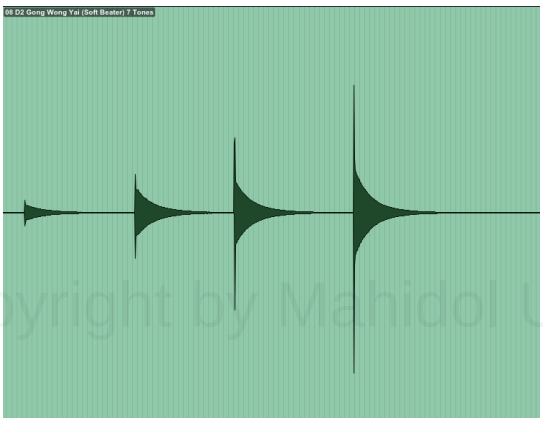


Figure 5.214 D2 note after adjustment of Kong Wong Yai waveform

E2 note

Cent value of E note has a value of minus 57 cents from E note of the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 43 cents. For a reference sound, change the reference pitch to D♯5 and adjust the detune parameter to 43 cents.

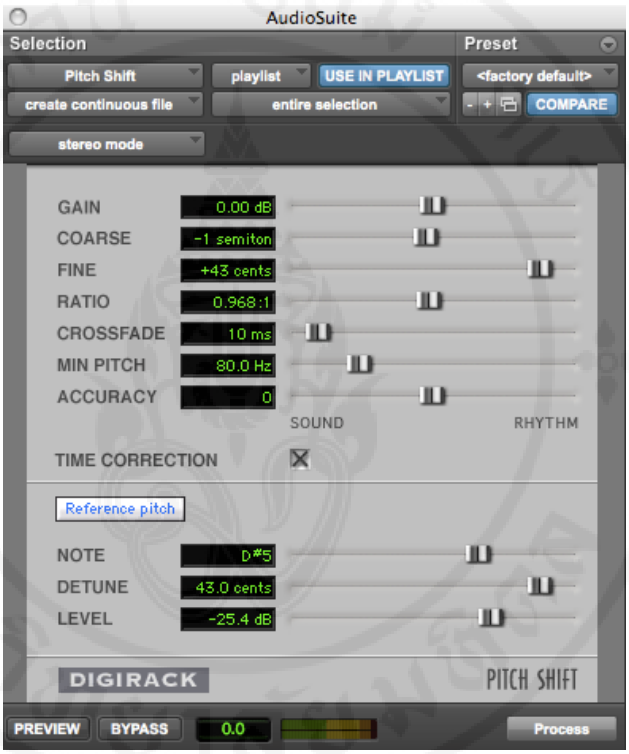


Figure 5.215 E2 note adjustment of Kong Wong Yai by Pitch Shift Plug-in

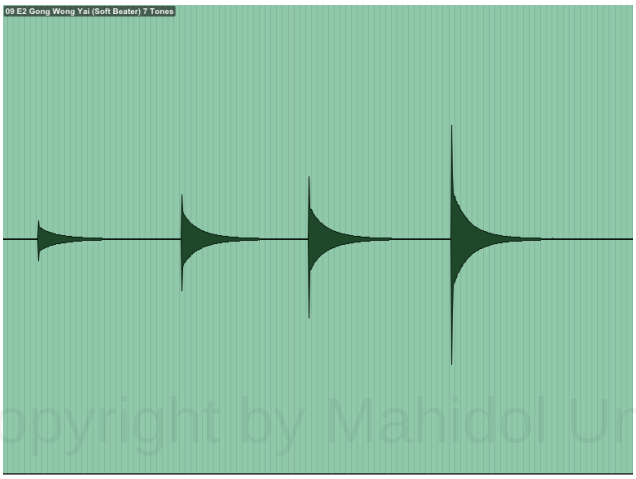


Figure 5.216 E2 note after adjustment of Kong Wong Yai waveform

F2 note

The cent value of F note is 14 cents more than that of F note from the equal temperament scale system. The reference pitch has been adjusted to F5 note and the detune parameter set to 14 cents.

Figure 5.217 F2 note adjustment of Kong Wong Yai by Pitch Shift Plug-in

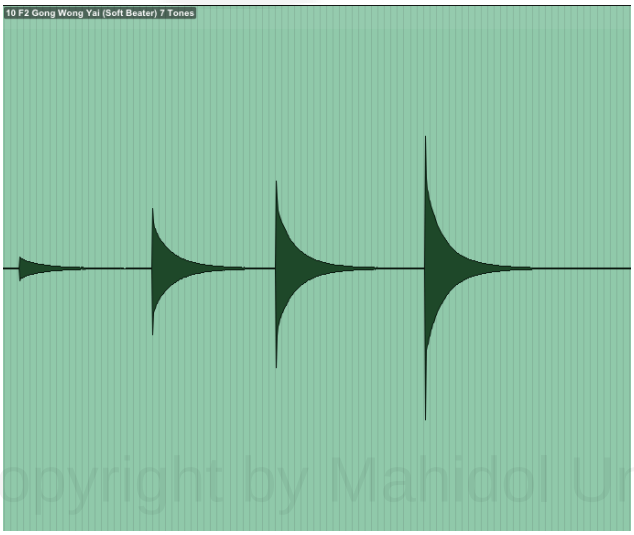


Figure 5.218 F2 note after adjustment of Kong Wong Yai waveform

G2 note

The cent value of G note is minus 14 cents of G note from the equal temperament scale system. The reference pitch has been adjusted to G5 note and the detune parameter set as minus 14 cents.

Figure 5.219 G2 note adjustment of Kong Wong Yai by Pitch Shift Plug-in

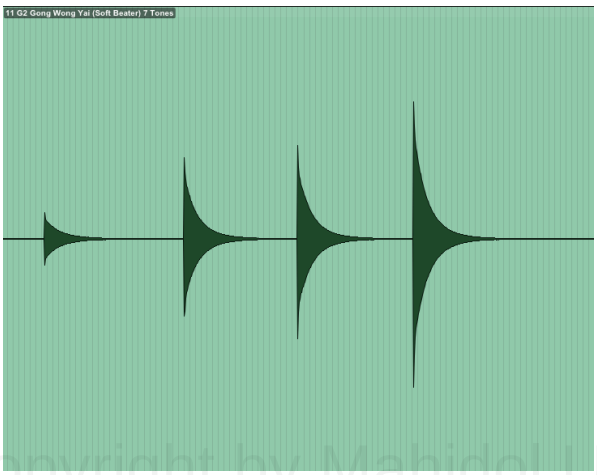


Figure 5.220 G2 note after adjustment of Kong Wong Yai waveform

A2 note

The cent value of A note is minus 43 cents of A note from the equal temperament scale system. The reference pitch has been adjusted to A5 note and the detune parameter set as minus 43 cents.

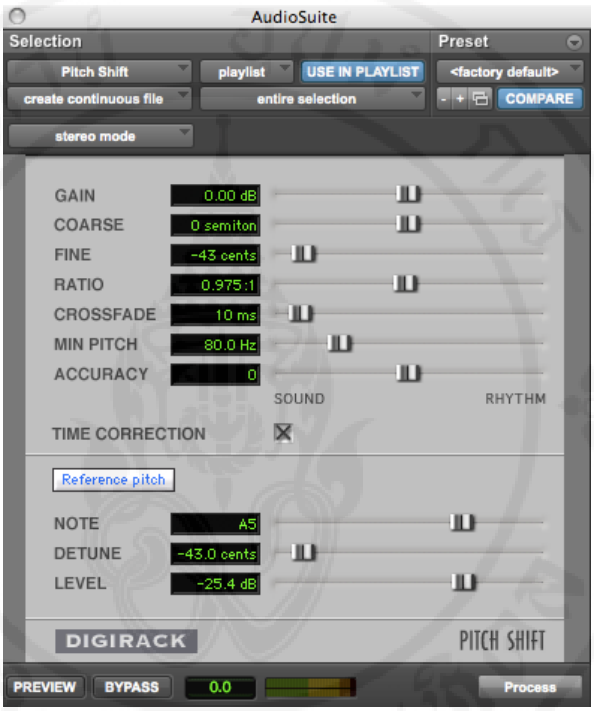


Figure 5.221 A2 note adjustment of Kong Wong Yai by Pitch Shift Plug-in

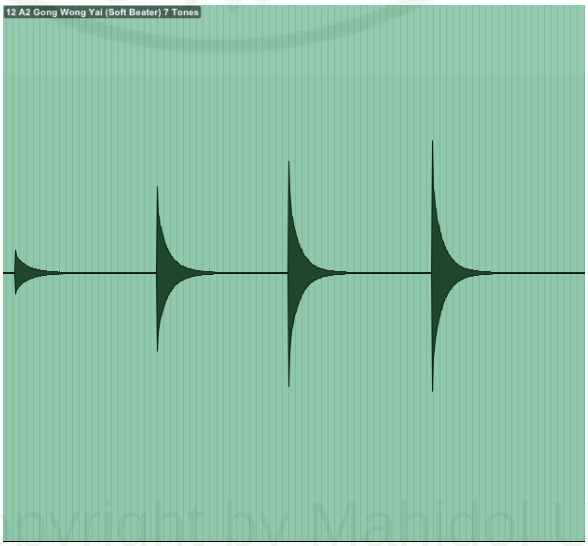


Figure 5.222 A2 note after adjustment of Kong Wong Yai waveform

B2 note

Cent value of B note is minus 72 from the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 28 cents. For reference sound, changing the reference pitch to A♯5 and adjust the detune parameter to 28 cents.

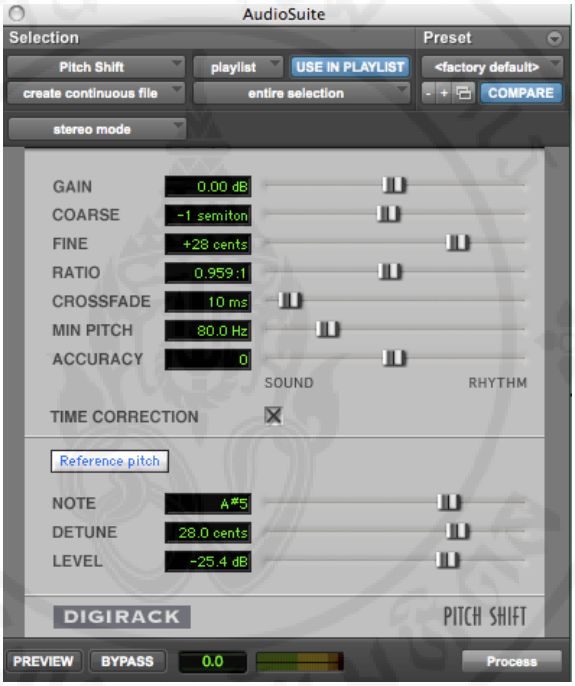


Figure 5.223 B2 note adjustment of Kong Wong Yai by Pitch Shift Plug-in

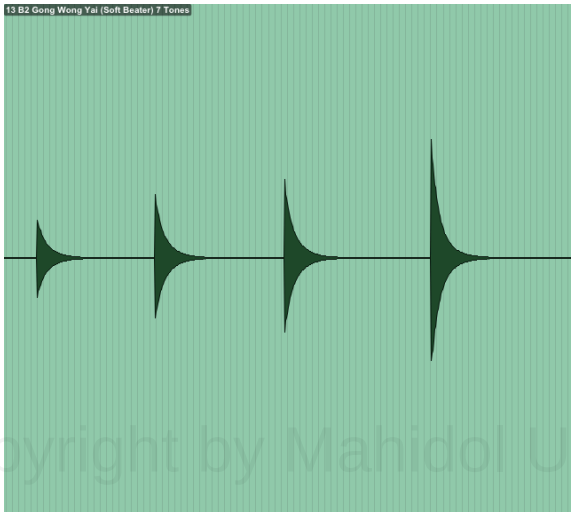


Figure 5.224 B2 note after adjustment of Kong Wong Yai waveform

C3 note

This research used C note from the equal temperament scale system to be the initial frequency to calculate the Thai musical scale system. The C note in the Thai musical scale system has the same frequency as the C note in the equal temperament scale system.

D3 note

The cent value of D note is minus 29 cents of A note from the equal temperament scale system. The reference pitch has been adjusted to D6 note and the detune parameter set as minus 43 cents.

Figure 5.225 D3 note adjustment of Kong Wong Yai by Pitch Shift Plug-in

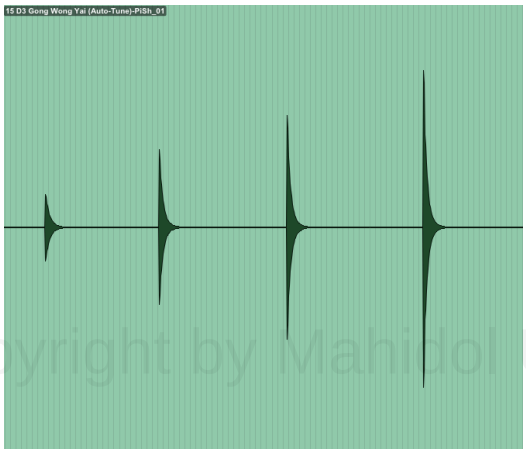


Figure 5.226 D3 note after adjustment of Kong Wong Yai waveform

E3 note

Cent value of E note has a value of minus 57 cents from E note of the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 43 cents. For a reference sound, change the reference pitch to D♯6 and adjust the detune parameter to 43 cents.

Figure 5.227 E3 note adjustment of Kong Wong Yai by Pitch Shift Plug-in

Figure 5.228 E3 note after adjustment of Kong Wong Yai waveform

The 16 pitches of the Kong Wong Yai sound samples have been adjusted to the Thai musical scale.

5.4.2 Adjustment of Thai sound samples of Ranad Tum Lek into the Thai musical scale system

D note

The cent value of D note has a value of minus 29 cents of D note of the equal temperament scale system. The reference pitch has been adjusted to D4 note and the detune parameter set to minus 29 cents.

Figure 5.229 D note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

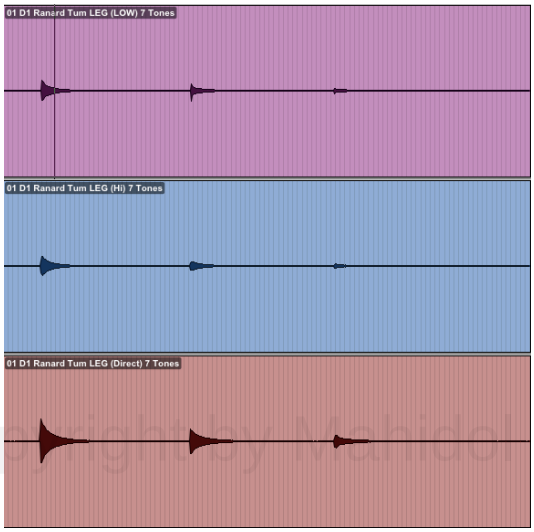


Figure 5.230 D note after adjustment of Ranad Tum Lek waveform

E note

Cent value of E note has a value of minus 57 cents from E note of the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 43 cents. For a reference sound, change the reference pitch to D♯4 and adjust the detune parameter to 43 cents

Figure 5.231 E note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

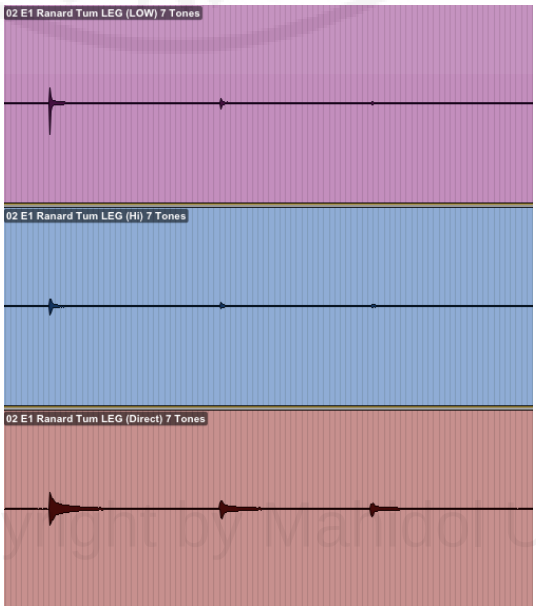


Figure 5.232 E note after adjustment of Ranad Tum Lek waveform

F note

The cent value of F note is 14 cents more than that of F note from the equal temperament scale system. The reference pitch has been adjusted to F4 note and the detune parameter set to 14 cents.

Figure 5.233 F note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

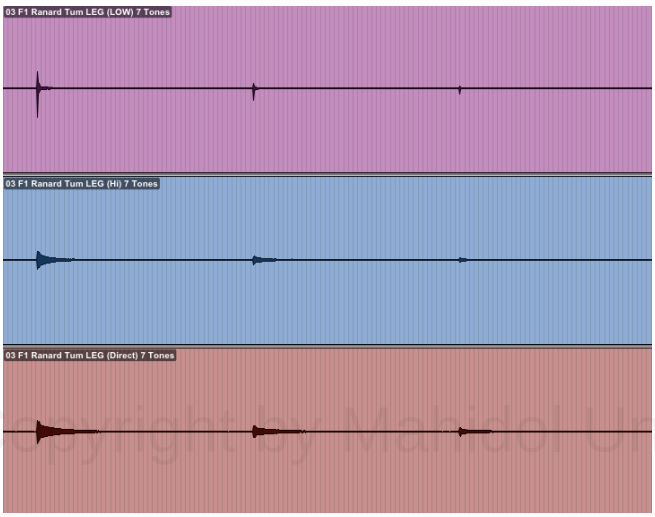


Figure 5.234 F note after adjustment of Ranad Tum Lek waveform

G note

The cent value of G note is minus 14 cents of G note from the equal temperament scale system. The reference pitch has been adjusted to G4 note and the detune parameter set as minus 14 cents.

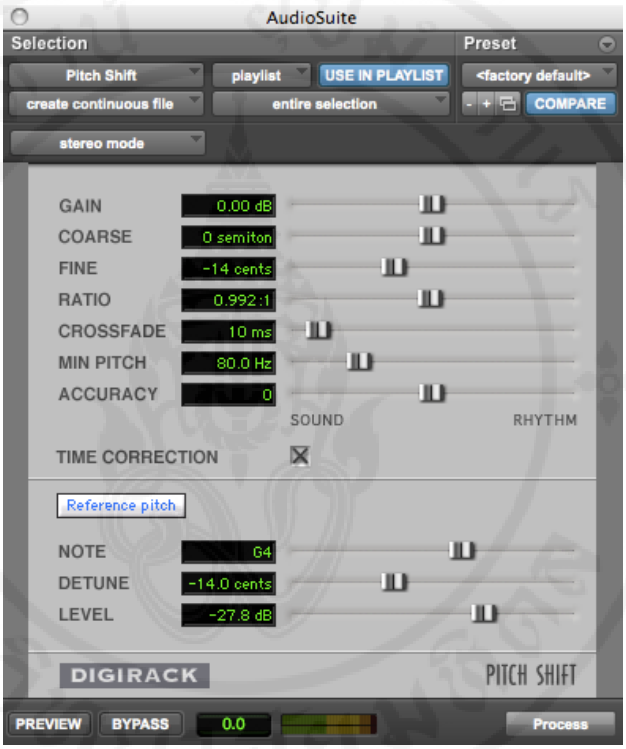


Figure 5.235 G note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

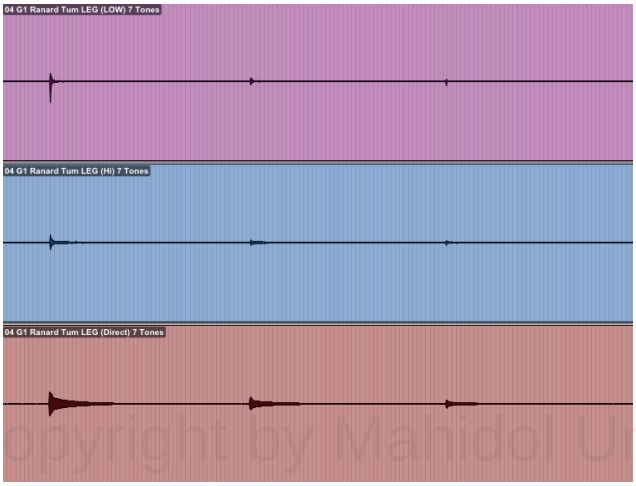


Figure 5.236 G note after adjustment of Ranad Tum Lek waveform

A note

The cent value of A note is minus 43 cents of A note from the equal temperament scale system. The reference pitch has been adjusted to A4 note and the detune parameter set as minus 43 cents.

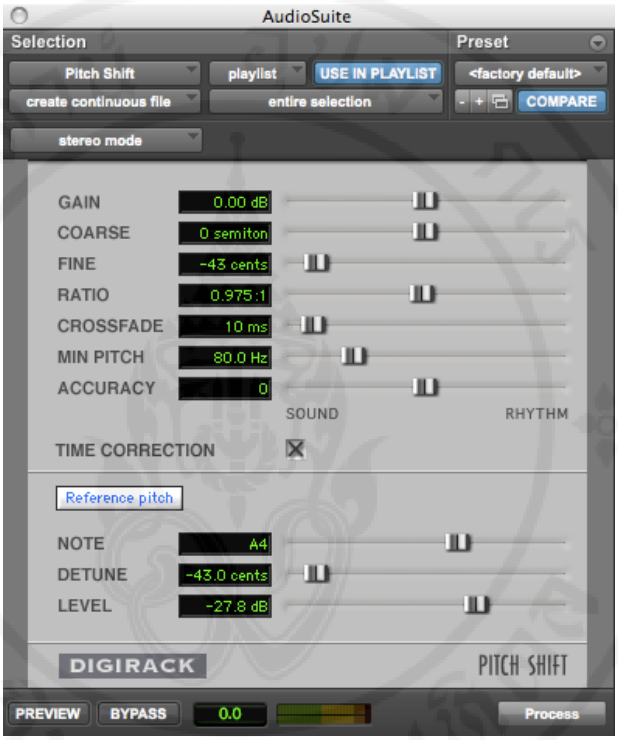


Figure 5.237 A note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

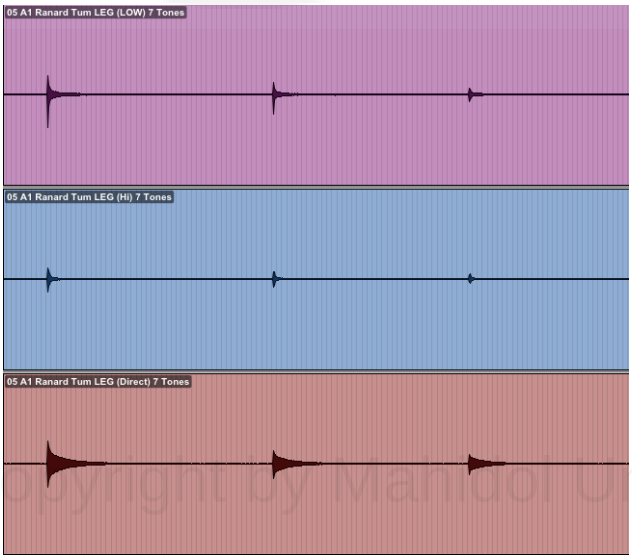


Figure 5.238 A note after adjustment of Ranad Tum Lek waveform

B note

Cent value of B note is minus 72 from the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 28 cents. For a reference sound, changing the reference pitch to A♯4 and adjust the detune parameter to 28 cents.

Figure 5.239 B note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

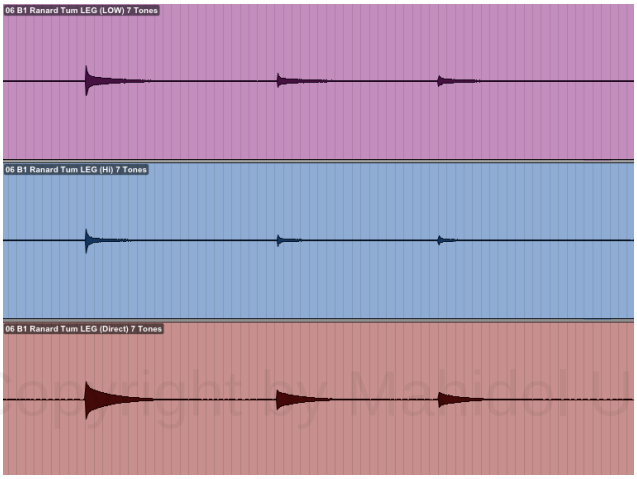


Figure 5.240 B note after adjustment of Ranad Tum Lek waveform

C2 note

This research used C note from the equal temperament scale system to be the initial frequency to calculate the Thai musical scale system. The C note in the Thai musical scale system has the same frequency as the C note in the equal temperament scale system.

D2 note

The cent value of D note is minus 29 cents of D note from the equal temperament scale system. The reference pitch has been adjusted to D5 note and the detune parameter set as minus 43 cents.

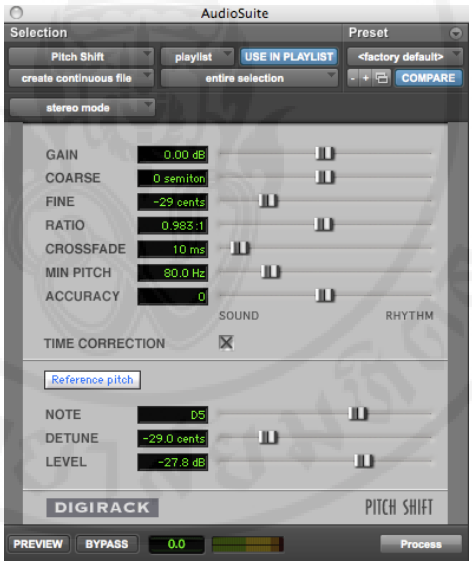


Figure 5.241 D2 note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

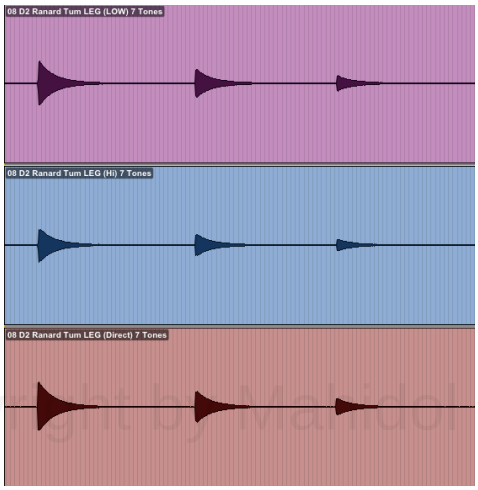


Figure 5.242 D2 note after adjustment of Ranad Tum Lek waveform

E2 note

Cent value of E note has a value of minus 57 cents from E note of the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 43 cents. For a reference sound, change the reference pitch to D♯5 and adjust the detune parameter to 43 cents.

Figure 5.243 E2 note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

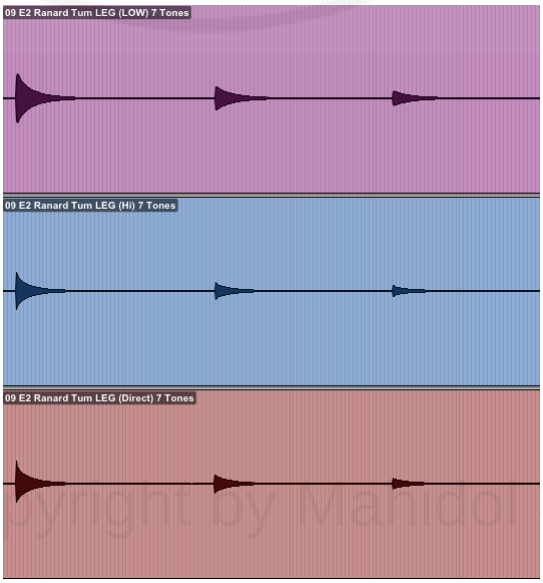


Figure 5.244 E2 note after adjustment of Ranad Tum Lek waveform

F2 note

The cent value of F note is 14 cents more than that of F note from the equal temperament scale system. The reference pitch has been adjusted to F5 note and the detune parameter set to 14 cents.

Figure 5.245 F2 note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

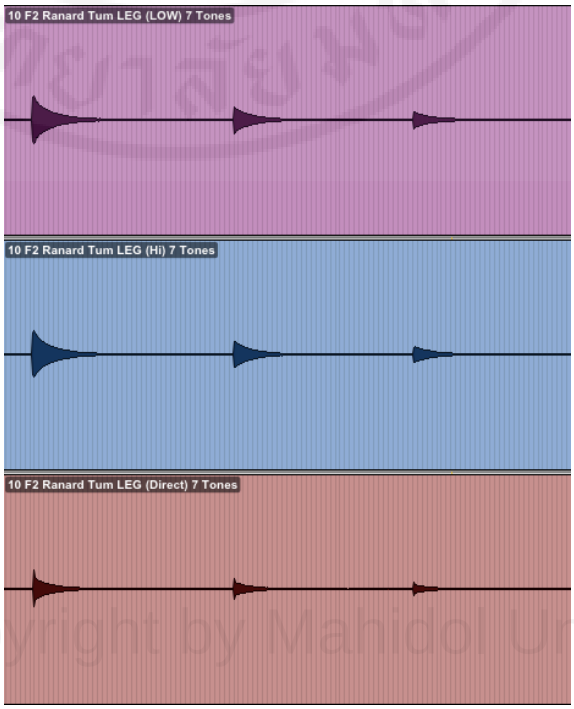


Figure 5.246 F2 note after adjustment of Ranad Tum Lek waveform

G2 note

The cent value of G note is minus 14 cents of G note from the equal temperament scale system. The reference pitch has been adjusted to G5 note and the detune parameter set as minus 14 cents.

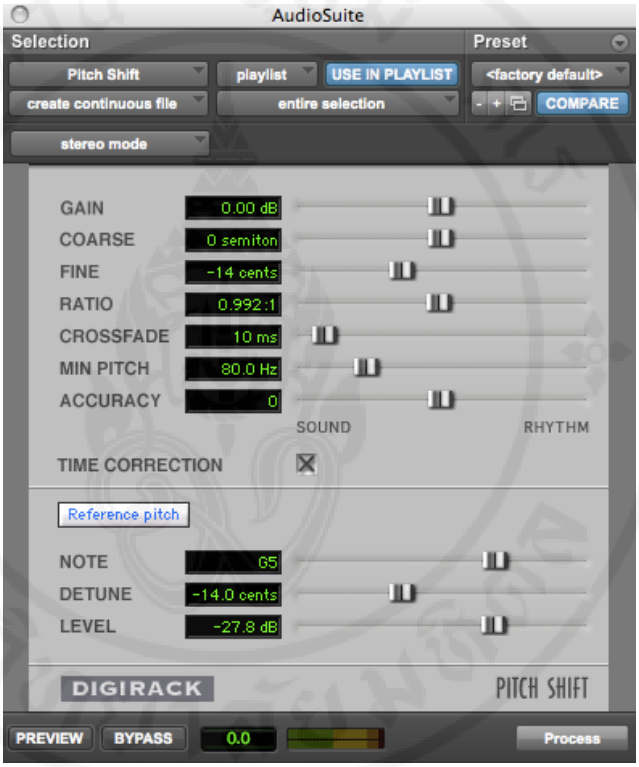


Figure 5.247 G2 note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

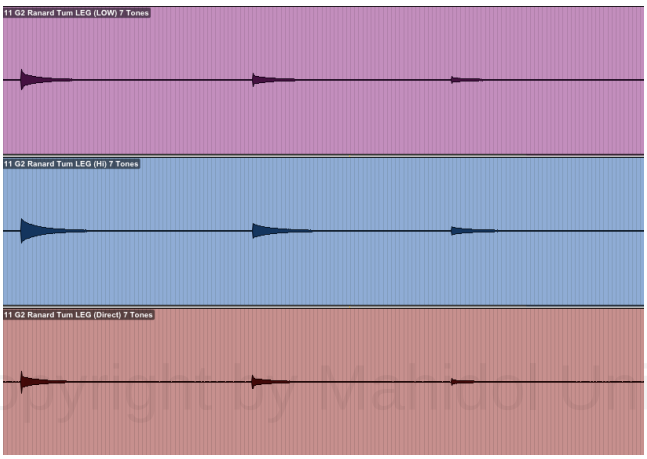


Figure 5.248 G2 note after adjustment of Ranad Tum Lek waveform

A2 note

The cent value of A note is minus 43 cents of A note from the equal temperament scale system. The reference pitch has been adjusted to A5 note and the detune parameter set as minus 43 cents.

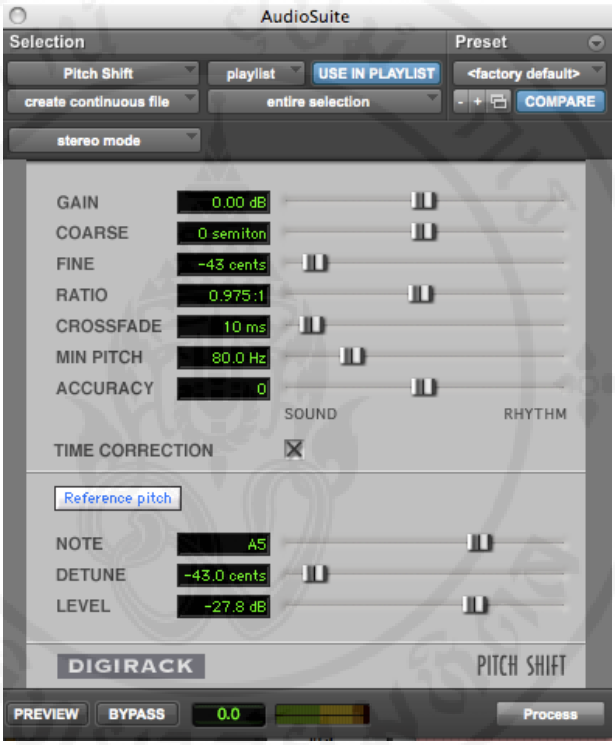


Figure 5.249 A2 note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

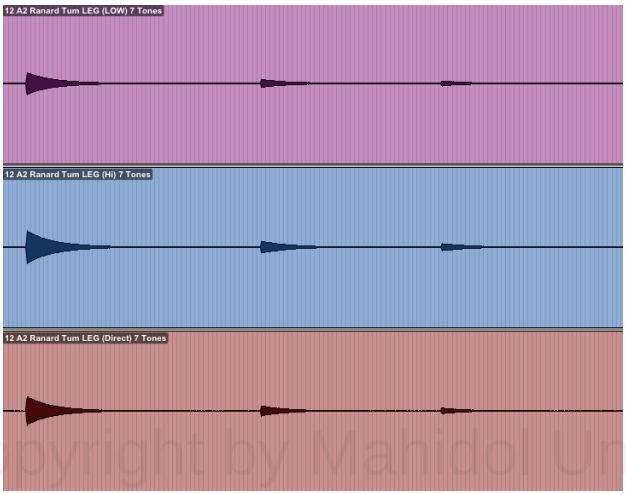


Figure 5.250 A2 note after adjustment of Ranad Tum Lek waveform

B2 note

Cent value of B note is minus 72 from B note in the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 28 cents. For reference sound, change the reference pitch to A♯5 and adjust the detune parameter to 28 cents.

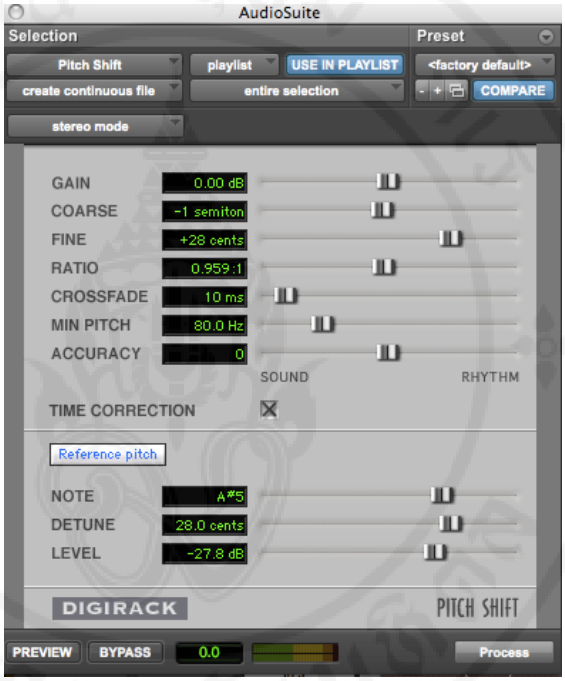


Figure 5.251 B2 note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

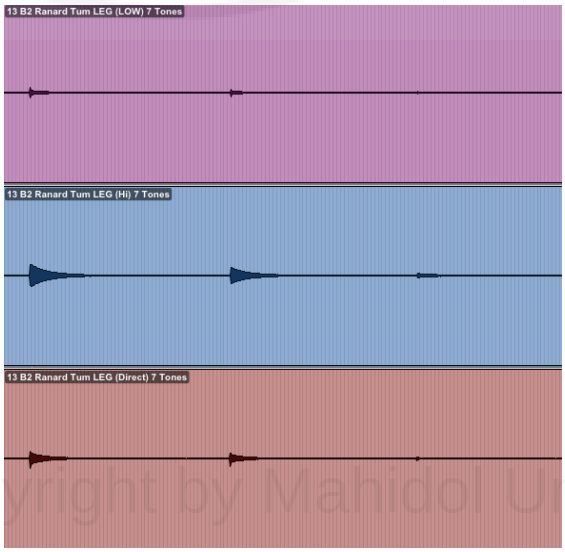


Figure 5.252 B2 note after adjustment of Ranad Tum Lek waveform

C3 note

This research used C note from the equal temperament scale system to be the initial frequency to calculate the Thai musical scale system. The C note in the Thai musical scale system has the same frequency as the C note in the equal temperament scale system.

D3 note

The cent value of D note is minus 29 cents of D note from the equal temperament scale system. The reference pitch has been adjusted to D6 note and the detune parameter set as minus 43 cents.

Figure 5.253 D3 note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

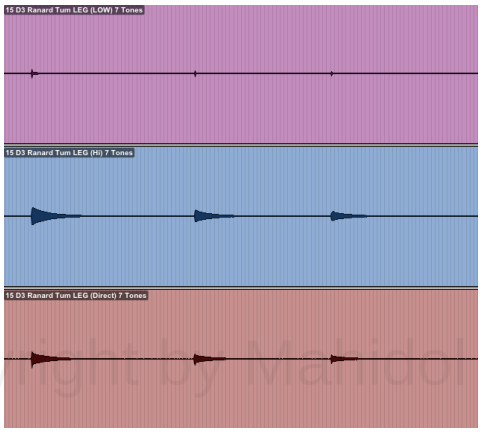


Figure 5.254 D3 note after adjustment of Ranad Tum Lek waveform

E3 note

Cent value of E note has a value of minus 57 cents from E note of the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 43 cents. For a reference sound, change the reference pitch to D♯6 and adjust the detune parameter to 43 cents.

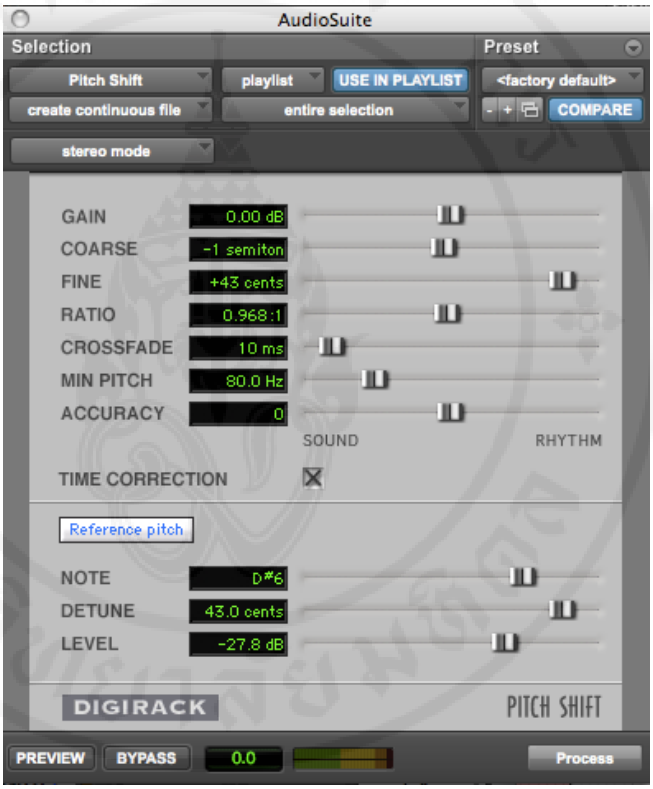


Figure 5.255 E3 note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

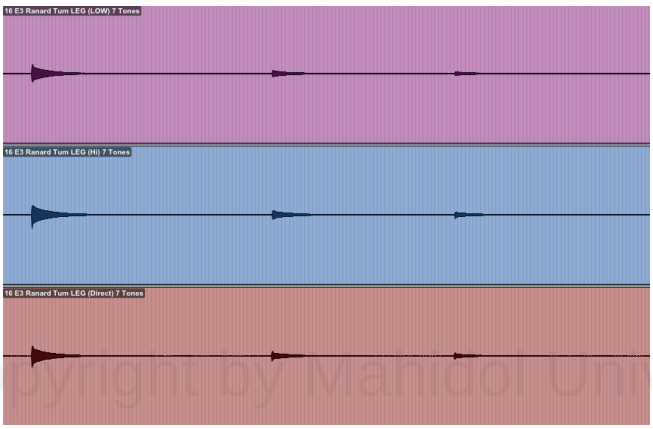


Figure 5.256 E3 note after adjustment of Ranad Tum Lek waveform

F3 note

The cent value of F note is 14 cents more than that of F note from the equal temperament scale system. The reference pitch has been adjusted to F6 note and the detune parameter set to 14 cents.

Figure 5.257 F3 note adjustment of Ranad Tum Lek by Pitch Shift Plug-in

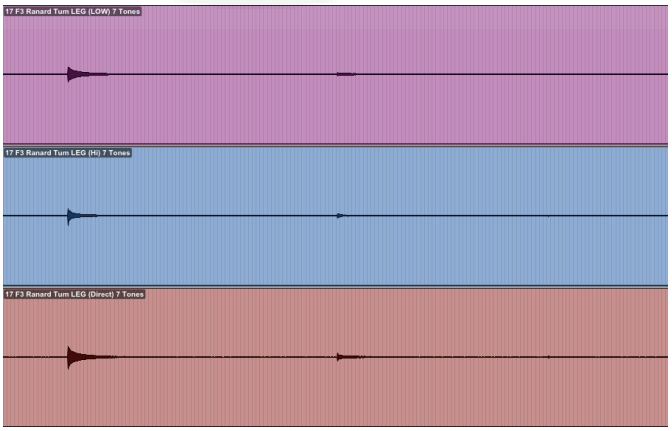


Figure 5.258 F3 note after adjustment of Ranad Tum Lek waveform

The 17 pitches of the Kong Wong Yai sound samples have been adjusted to the Thai musical scale.

5.4.3 Adjustment of Thai sound samples of Ranad Ek into the Thai musical scale system

F note

The cent value of F note is 14 cents more than that of F note from the equal temperament scale system. The reference pitch has been adjusted to F3 note and the detune parameter set to 14 cents.

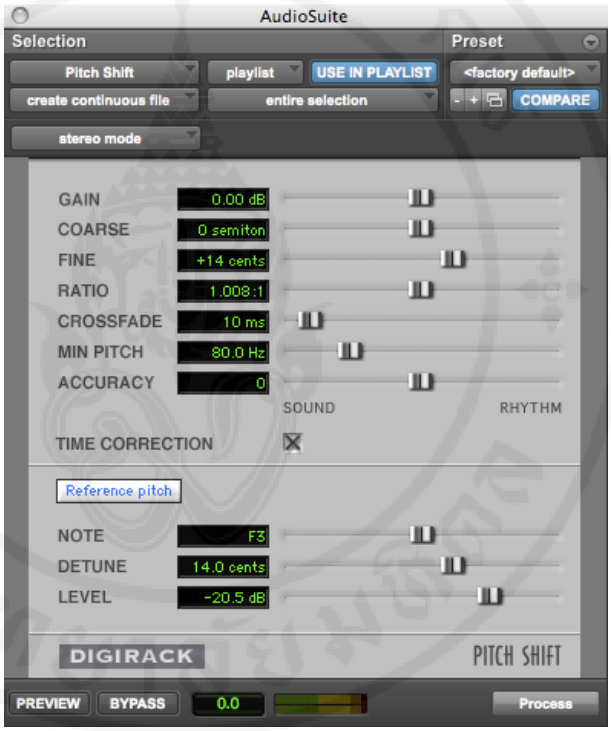


Figure 5.259 F note adjustment of Ranad Ek by Pitch Shift Plug-in

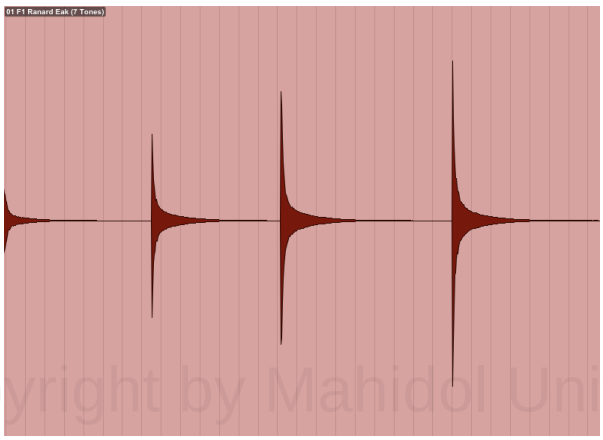


Figure 5.260 F note after adjustment of Ranad Ek waveform

G note

The cent value of G note is minus 14 cents of G note from the equal temperament scale system. The reference pitch has been adjusted to G3 note and the detune parameter set as minus 14 cents.

Figure 5.261 G note adjustment of Ranad Ek by Pitch Shift Plug-in

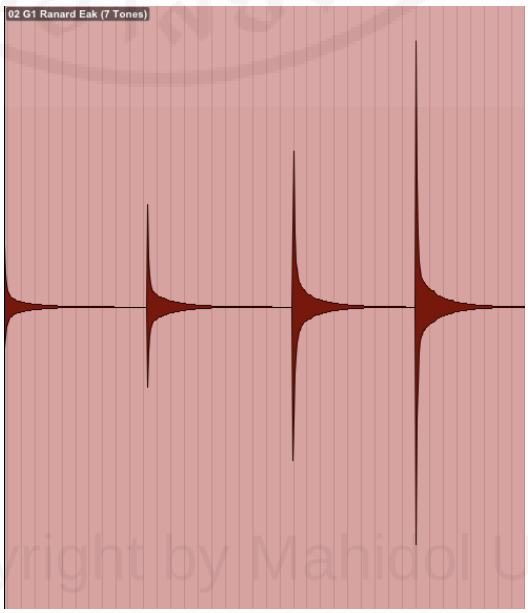


Figure 5.262 G note after adjustment of Ranad Ek waveform

A note

The cent value of A note is minus 43 cents of A note from the equal temperament scale system. The reference pitch has been adjusted to A3 note and the detune parameter set as minus 43 cents.

Figure 5.263 A note adjustment of Ranad Ek by Pitch Shift Plug-in

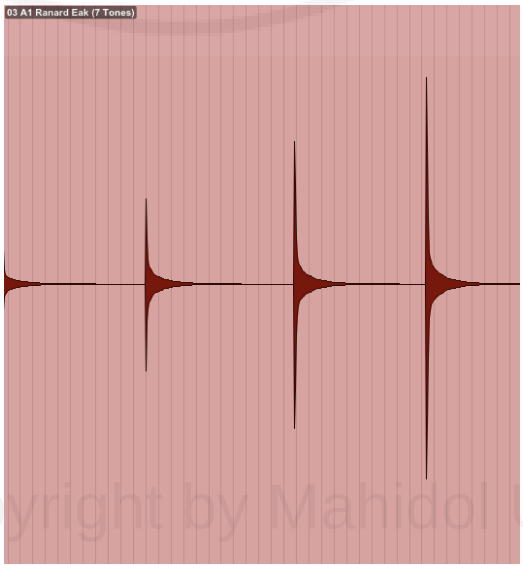


Figure 5.264 A note after adjustment of Ranad Ek waveform

B note

Cent value of B note is minus 72 from B note in the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 28 cents. For reference sound, change the reference pitch to A♯3 and adjust the detune parameter to 28 cents.

Figure 5.265 B note adjustment of Ranad Ek by Pitch Shift Plug-in

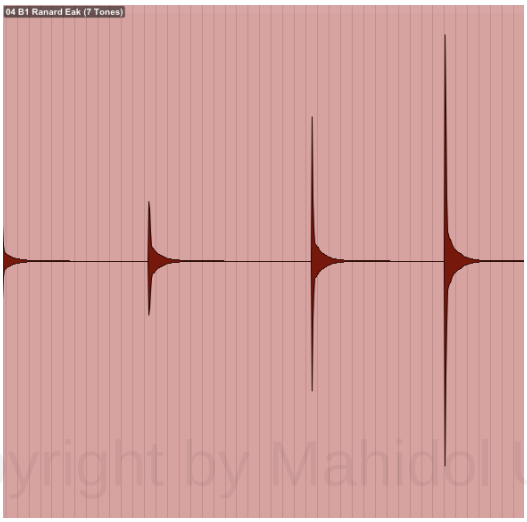


Figure 5.266 B note after adjustment of Ranad Ek waveform

C2 note

This research used C note from the equal temperament scale system to be the initial frequency to calculate the Thai musical scale system. The C note in the Thai musical scale system has the same frequency as the C note in the equal temperament scale system.

D2 note

The cent value of D note is minus 29 cents of D note from the equal temperament scale system. The reference pitch has been adjusted to D4 note and the detune parameter set as minus 43 cents.

Figure 5.267 D2 note adjustment of Ranad Ek by Pitch Shift Plug-in

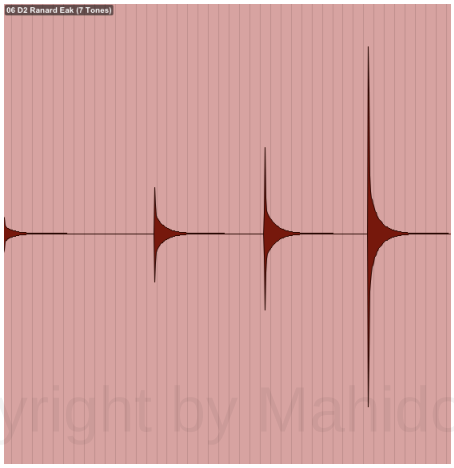


Figure 5.268 D2 note after adjustment of Ranad Ek waveform

E2 note

Cent value of E note has a value of minus 57 cents from E note of the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 43 cents. For a reference sound, change the reference pitch to D♯4 and adjust the detune parameter to 43 cents.

Figure 5.269 E2 note adjustment of Ranad Ek by Pitch Shift Plug-in

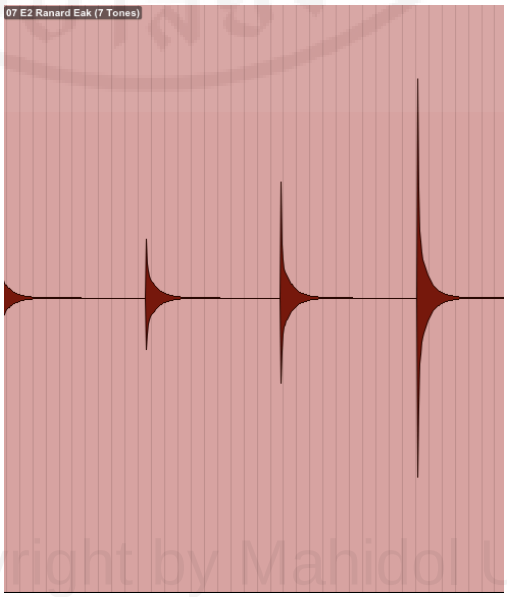


Figure 5.270 E2 note after adjustment of Ranad Ek waveform

F2 note

The cent value of F note is 14 cents more than that of F note from the equal temperament scale system. The reference pitch has been adjusted to F4 note and the detune parameter set to 14 cents.

Figure 5.271 F2 note adjustment of Ranad Ek by Pitch Shift Plug-in

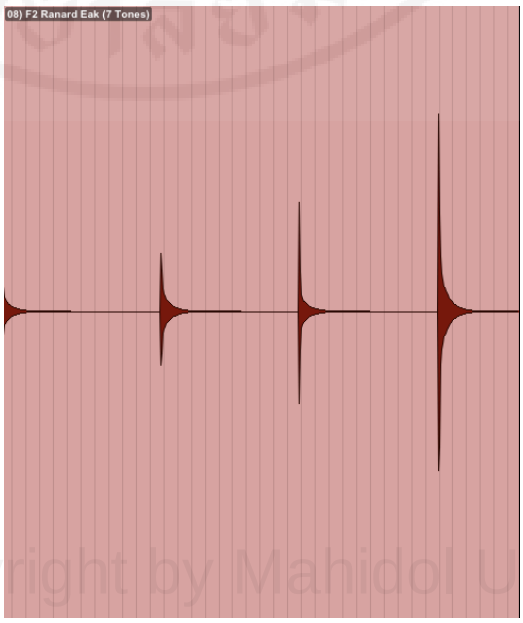


Figure 5.272 F2 note after adjustment of Ranad Ek waveform

G2 note

The cent value of G note is minus 14 cents of G note from the equal temperament scale system. The reference pitch has been adjusted to G4 note and the detune parameter set as minus 14 cents.

Figure 5.273 G2 note adjustment of Ranad Ek by Pitch Shift Plug-in

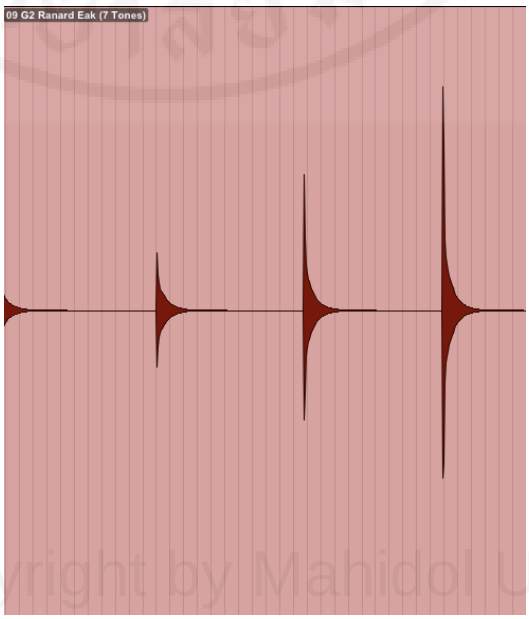


Figure 5.274 G2 note after adjustment of Ranad Ek waveform

A2 note

The cent value of A note is minus 43 cents of A note from the equal temperament scale system. The reference pitch has been adjusted to A4 note and the detune parameter set as minus 43 cents.

Figure 5.275 A2 note adjustment of Ranad Ek by Pitch Shift Plug-in

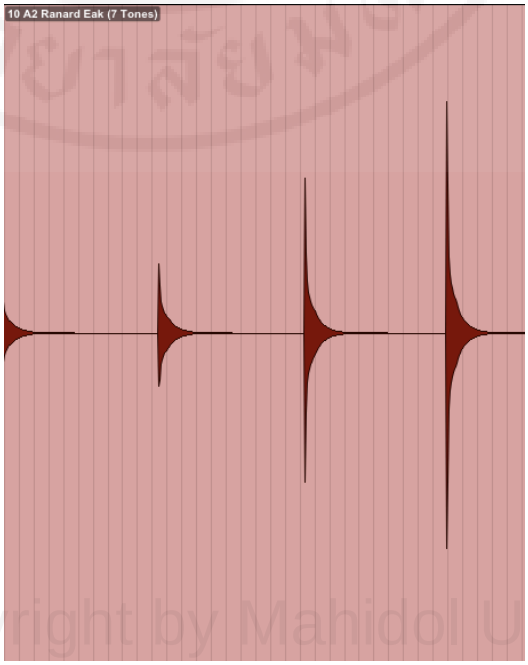


Figure 5.276 A2 note after adjustment of Ranad Ek waveform

B2 note

Cent value of B note is minus 72 from B note in the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 28 cents. For reference sound, change the reference pitch to A♯4 and adjust the detune parameter to 28 cents.

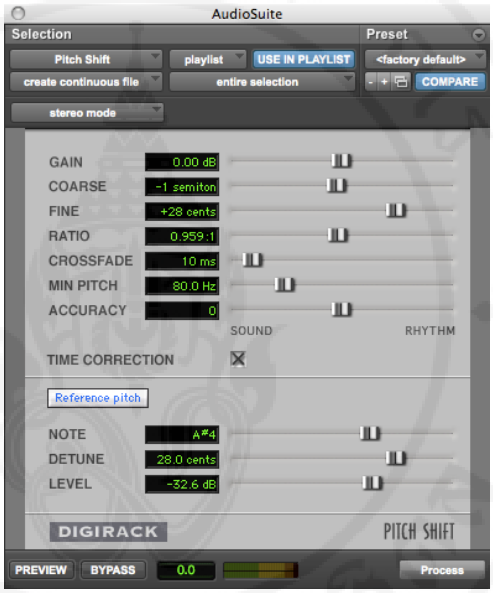


Figure 5.277 B2 note adjustment of Ranad Ek by Pitch Shift Plug-in

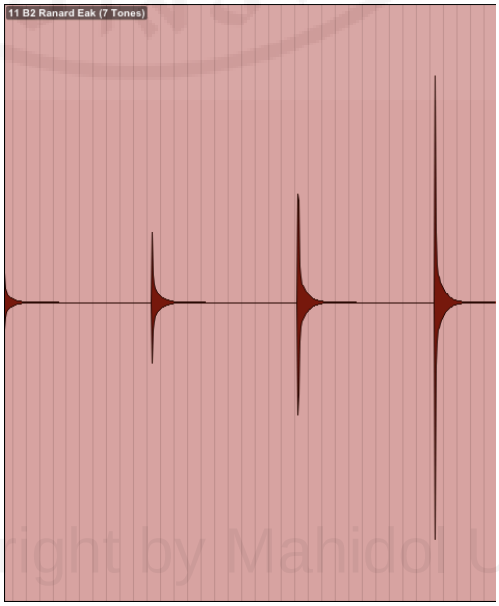


Figure 5.278 B2 note after adjustment of Ranad Ek waveform

C3 note

This research used C note from the equal temperament scale system to be the initial frequency to calculate the Thai musical scale system. The C note in the Thai musical scale system has the same frequency as the C note in the equal temperament scale system.

D3 note

The cent value of D note has minus 29 cents of D note from the equal temperament scale system. The reference pitch has been adjusted to D5 note and the detune parameter set as minus 43 cents.

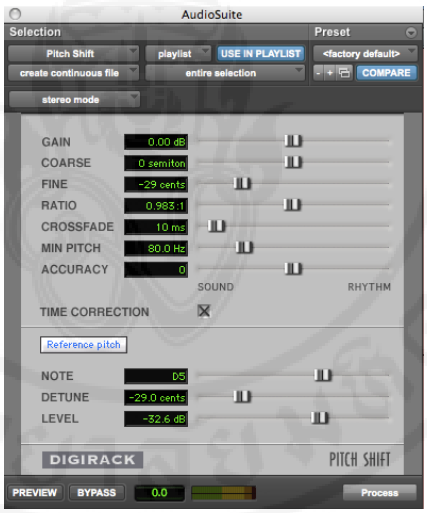


Figure 5.279 D3 note adjustment of Ranad Ek by Pitch Shift Plug-in

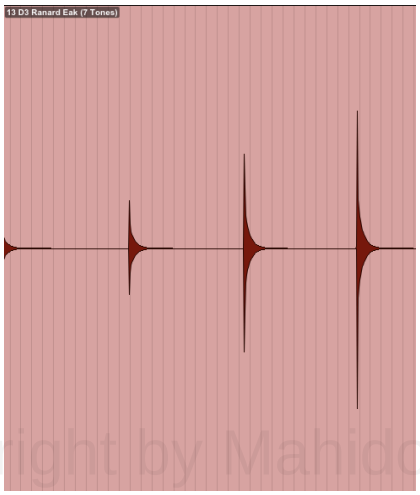


Figure 5.280 D3 note after adjustment of Ranad Ek waveform

E3 note

Cent value of E note has a value of minus 57 cents from E note of the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 43 cents. For a reference sound, change the reference pitch to D♯5 and adjust the detune parameter to 43 cents.

Figure 5.281 E3 note adjustment of Ranad Ek by Pitch Shift Plug-in

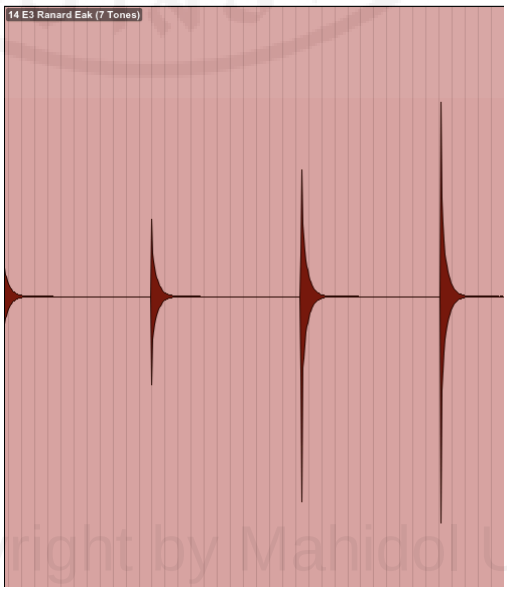


Figure 5.282 E3 note after adjustment of Ranad Ek waveform

F3 note

The cent value of F note is 14 cents more than that of F note from the equal temperament scale system. The reference pitch has been adjusted to F5 note and the detune parameter set to 14 cents.

Figure 5.283 F3 note adjustment of Ranad Ek by Pitch Shift Plug-in

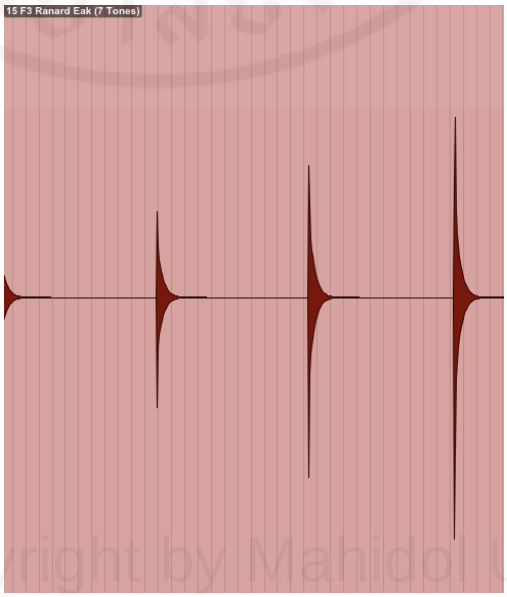


Figure 5.284 F3 note after adjustment of Ranad Ek waveform

G3 note

The cent value of G note is minus 14 cents of G note from the equal temperament scale system. The reference pitch has been adjusted to G5 note and the detune parameter set as minus 14 cents.

Figure 5.285 G3 note adjustment of Ranad Ek by Pitch Shift Plug-in

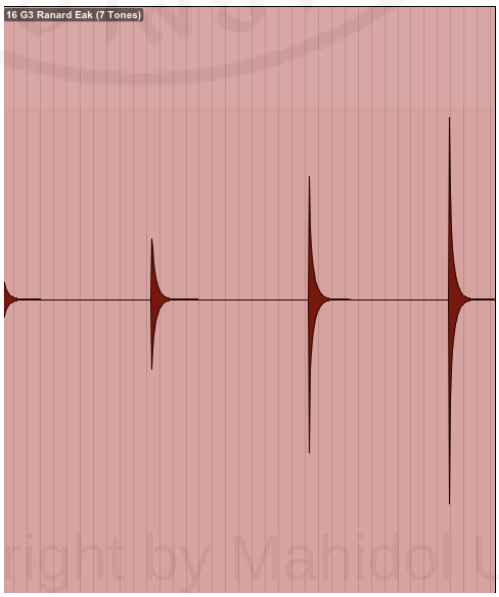


Figure 5.286 G3 note after adjustment of Ranad Ek waveform

A3 note

The cent value of A note is minus 43 cents of A note from the equal temperament scale system. The fine parameter has been adjusted as minus 43 cents.

Figure 5.287 A3 note adjustment of Ranad Ek by Pitch Shift Plug-in

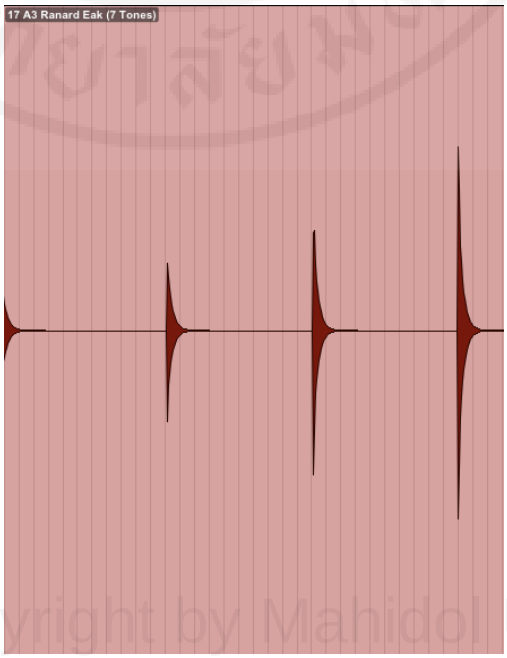


Figure 5.288 A3 note after adjustment of Ranad Ek waveform

B3 note

Cent value of B note is minus 72 from the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 28 cents.

Figure 5.289 B3 note adjustment of Ranad Ek by Pitch Shift Plug-in

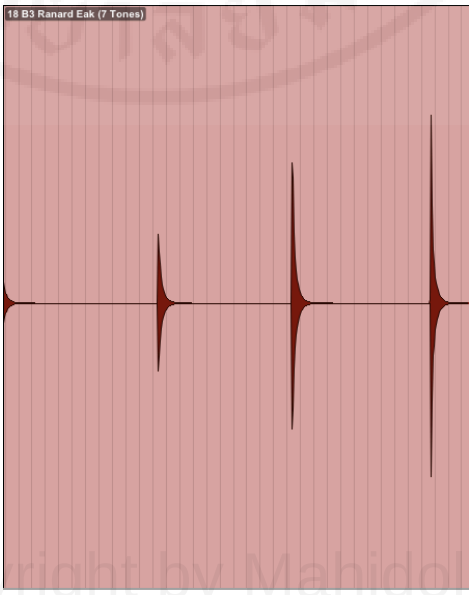


Figure 5.290 B3 note after adjustment of Ranad Ek waveform

C4 note

This research used C note from the equal temperament scale system to be the initial frequency to calculate the Thai musical scale system. The C note in the Thai musical scale system has the same frequency as the C note in the equal temperament scale system.

D4 note

The cent value of D note is minus 29 cents of D note from the equal temperament scale system. The fine parameter has been adjusted to minus 29 cents.

Figure 5.291 D4 note adjustment of Ranad Ek by Pitch Shift Plug-in

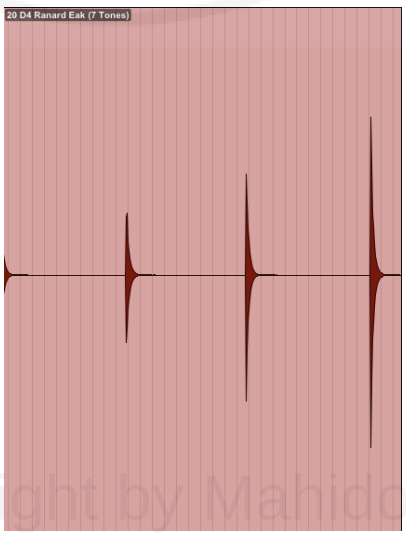


Figure 5.292 D4 note after adjustment of Ranad Ek waveform

E4 note

Cent value of E note has a value of minus 57 cents from E note of the equal temperament scale system. It can be adjusted by changing the coarse parameter to minus 1 semitone and changing the fine parameter to 43 cents. For a reference sound, change the reference pitch to D♯5 and adjust the detune parameter to 43 cents.

Figure 5.293 E4 note adjustment of Ranad Ek by Pitch Shift Plug-in

Figure 5.294 E4 note after adjustment of Ranad Ek waveform

F4 note

The cent value of F note is 14 cents more than that of F note from the equal temperament scale system. The reference pitch has been adjusted to F5 note and the detune parameter set to 14 cents.

Figure 5.295 F4 note adjustment of Ranad Ek by Pitch Shift Plug-in

Figure 5.295 F4 note after adjustment of Ranad Ek waveform

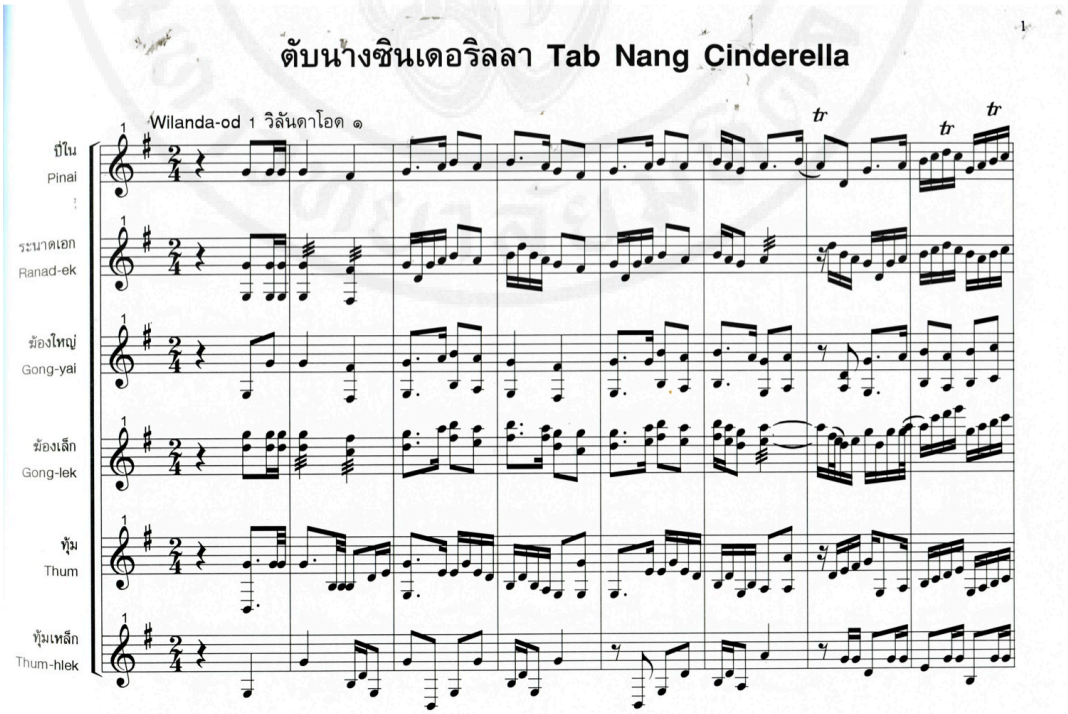
The 22 pitches of the Ranad Ek sound samples have been adjusted to the Thai musical scale.

5.5 Using Thai sound samples with Thai classical music

After adjusting the pitches of Thai sound samples into the Thai musical scale system, the researcher programed MIDI note of a Thai classical song into Logic pro 9 to be an example for using Thai sound samples and electric instruments to be played together.

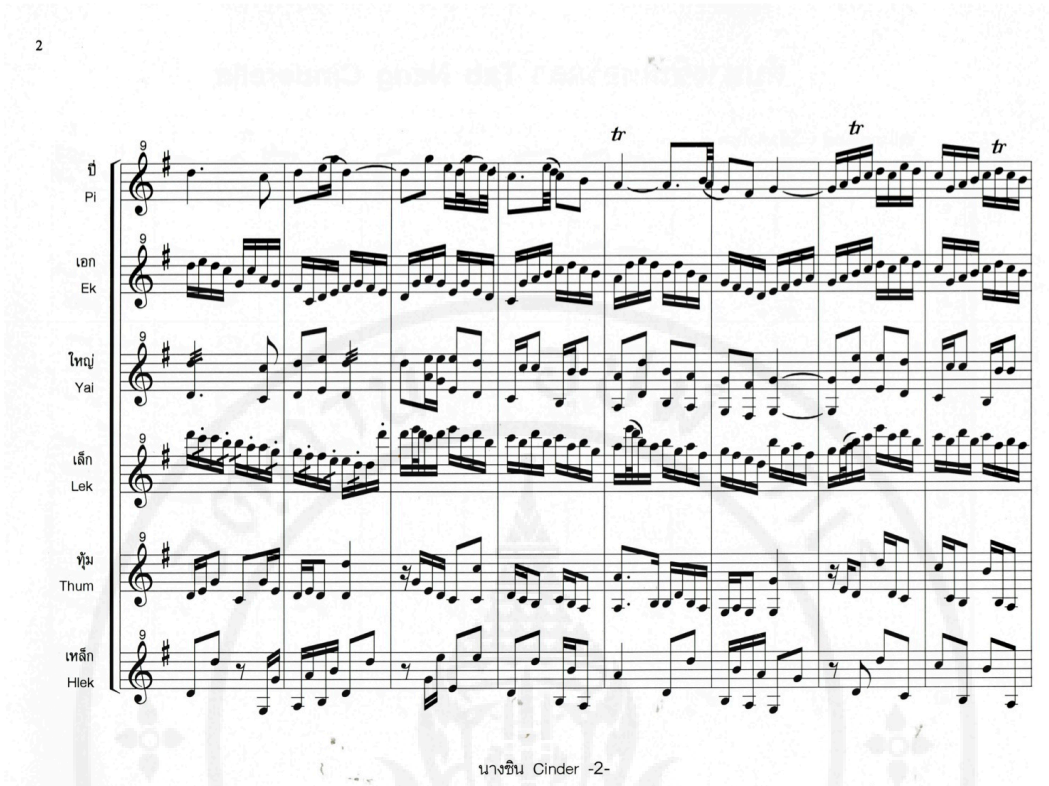
5.5.1 The Thai classical song

The song used to program MIDI note is called Tab Nang Cinderella. It is a score that included all the notations of all the instruments in Piphat. The score was taken from the Thai music manuscript collection, as transcribed by the Thai music manuscript committee, between 1930 and 1932 and 1936 to 1942, microfilmed by David Morton in 1957. It was published by Panya Roongruang and his companies. The score is as follows.



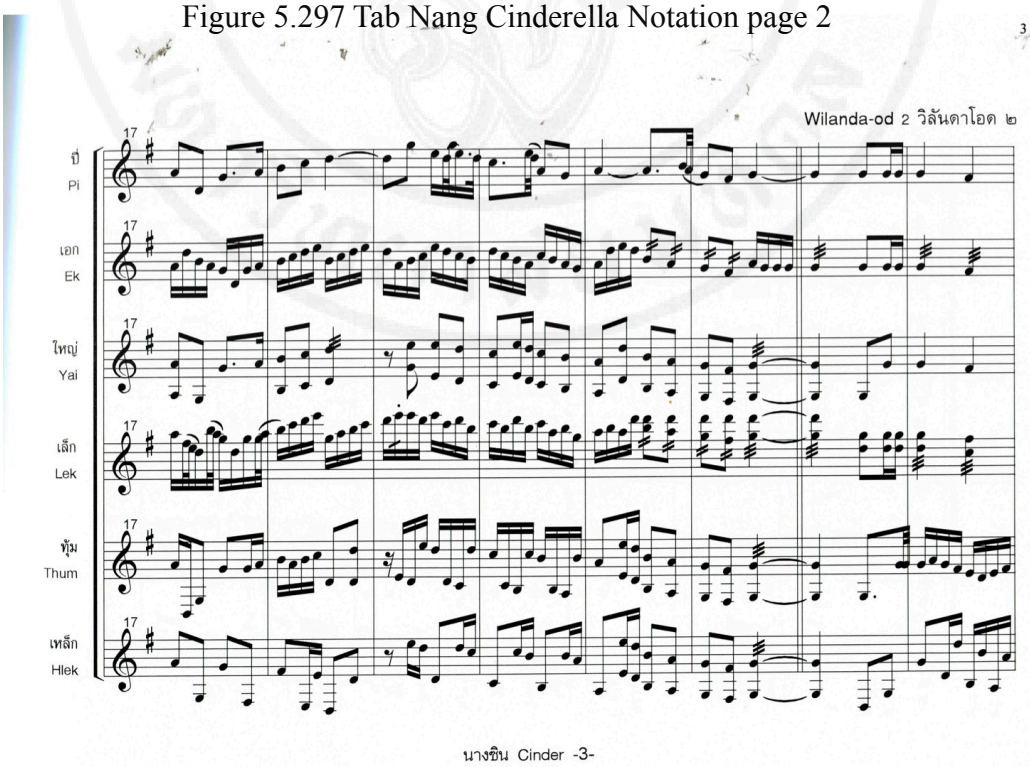
(Collected works of the Thai classical repertoire volume 6)

Figure 5.296 Tab Nang Cinderella Notation page 1



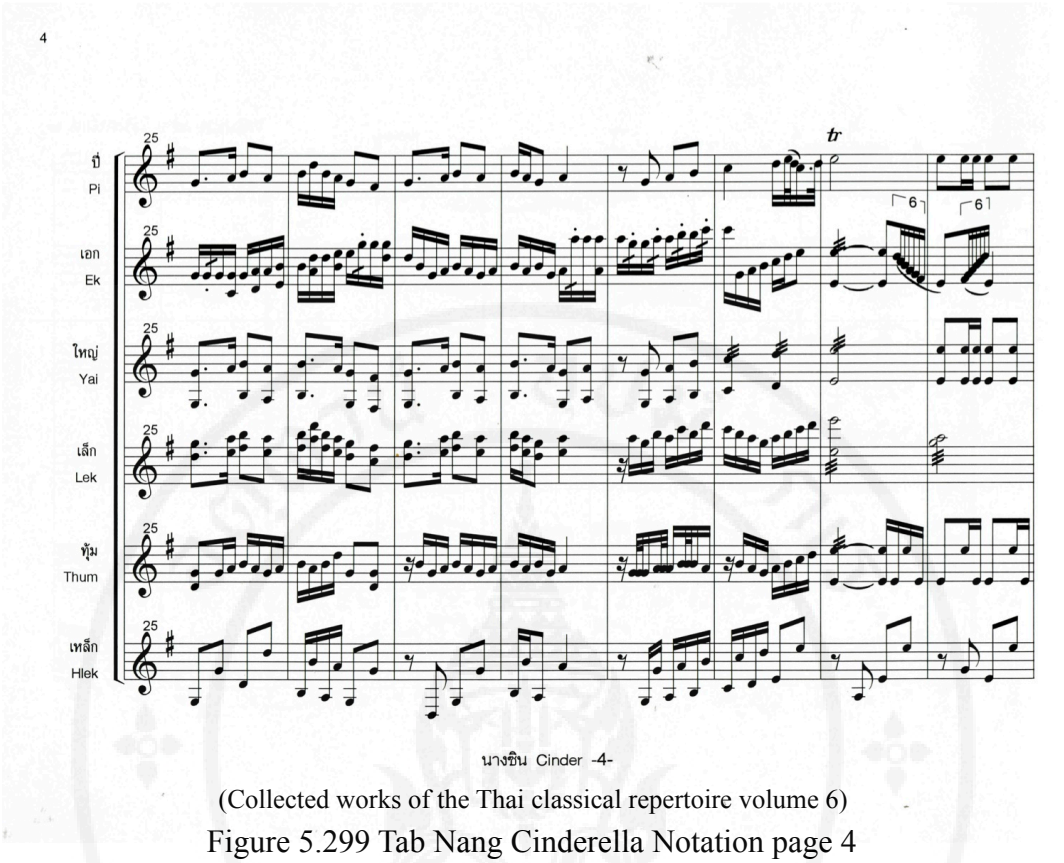
(Collected works of the Thai classical repertoire volume 6)

Figure 5.297 Tab Nang Cinderella Notation page 2



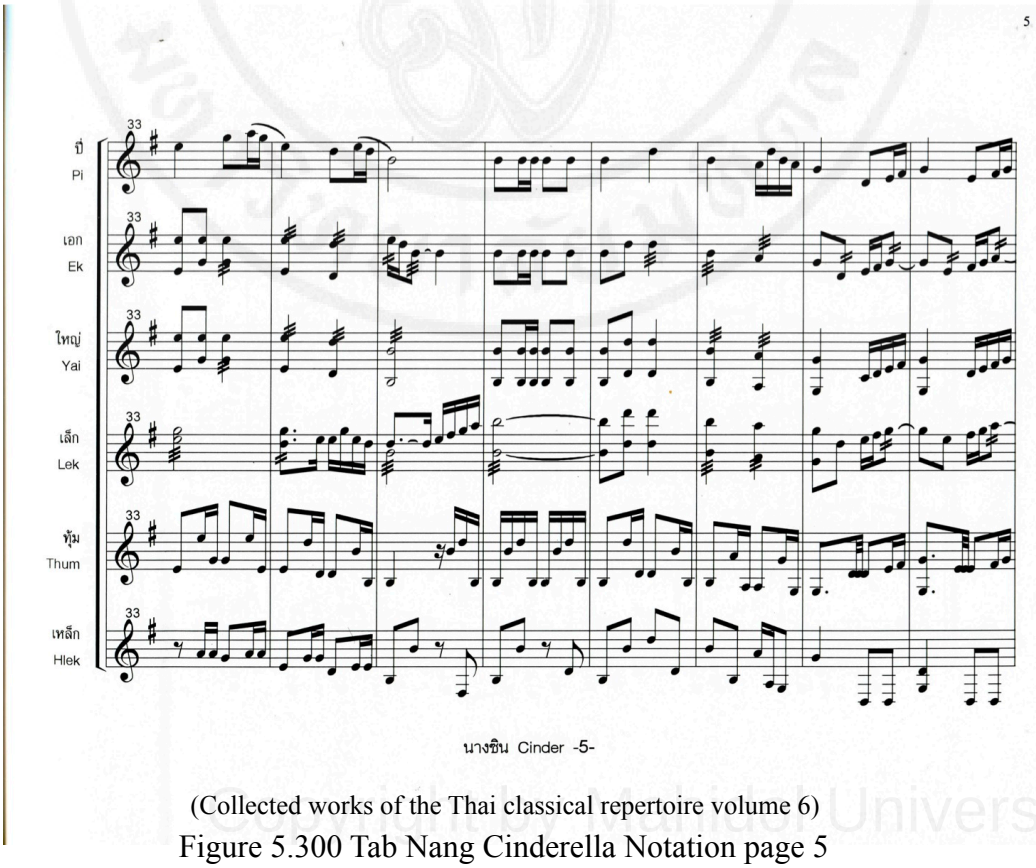
(Collected works of the Thai classical repertoire volume 6)

Figure 5.298 Tab Nang Cinderella Notation page 3



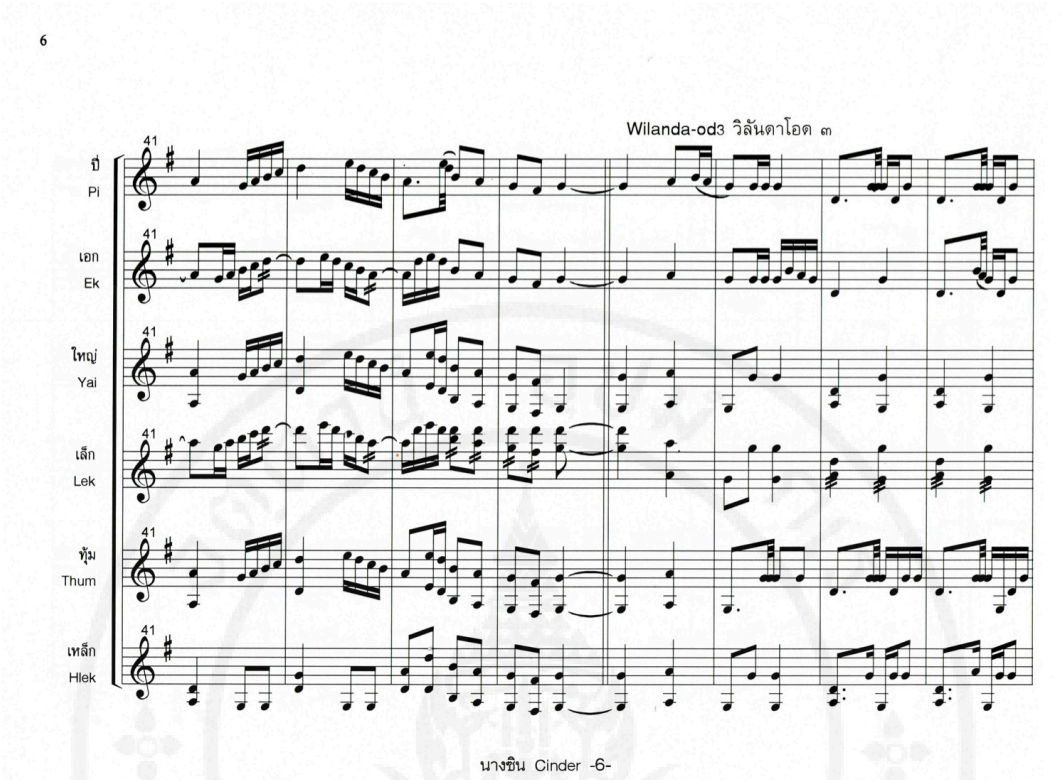
(Collected works of the Thai classical repertoire volume 6)

Figure 5.299 Tab Nang Cinderella Notation page 4



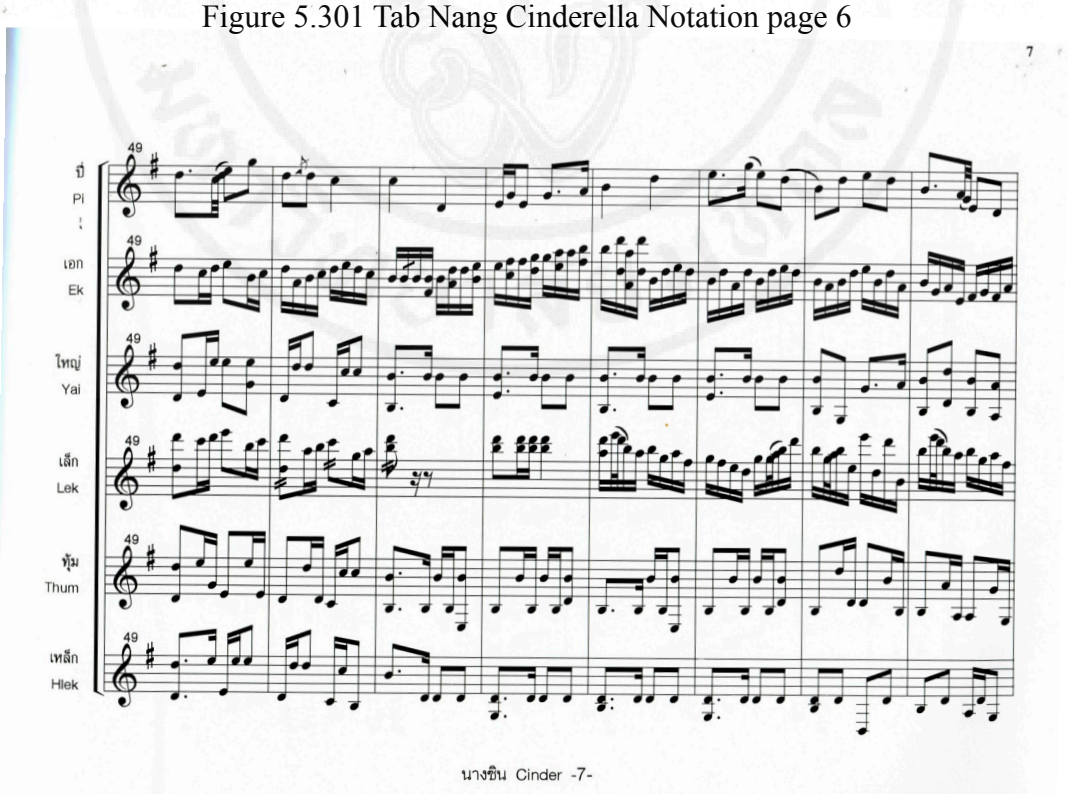
(Collected works of the Thai classical repertoire volume 6)

Figure 5.300 Tab Nang Cinderella Notation page 5



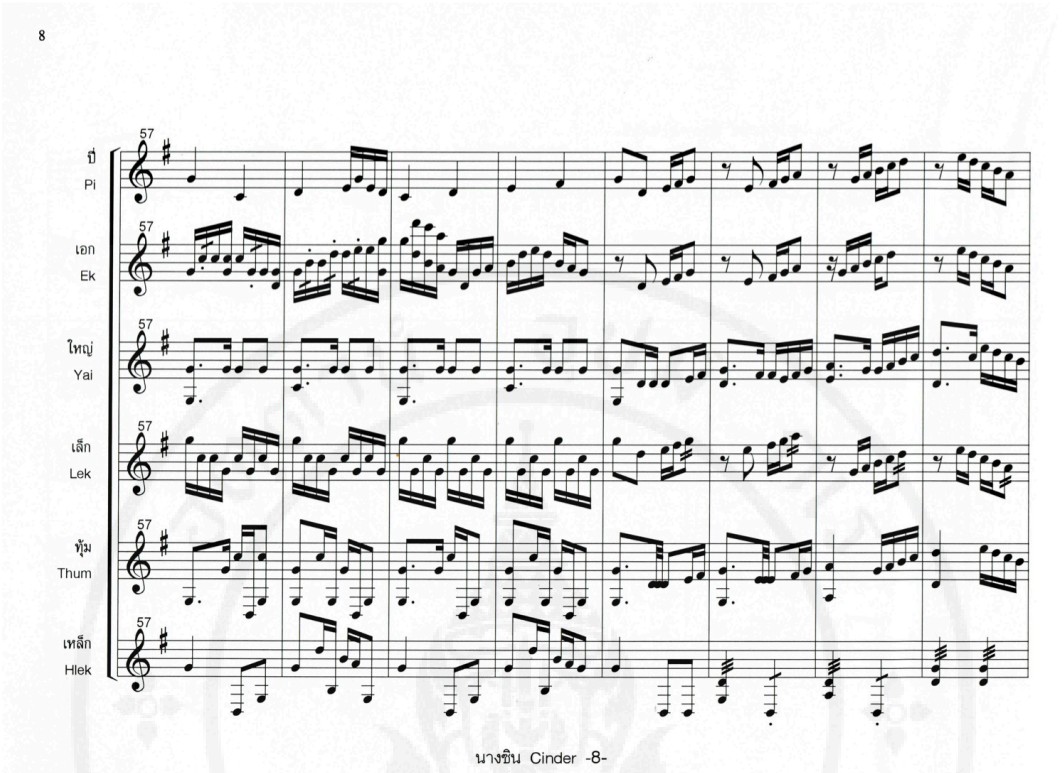
(Collected works of the Thai classical repertoire volume 6)

Figure 5.301 Tab Nang Cinderella Notation page 6



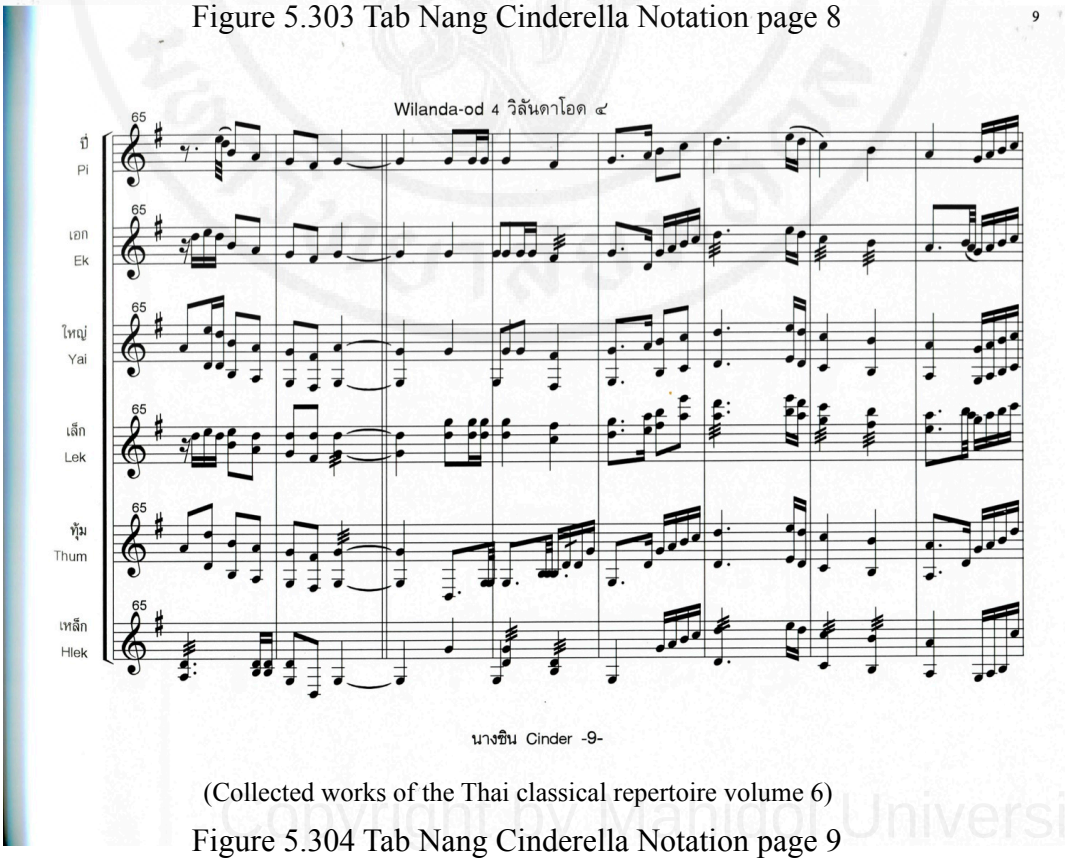
(Collected works of the Thai classical repertoire volume 6)

Figure 5.302 Tab Nang Cinderella Notation page 7



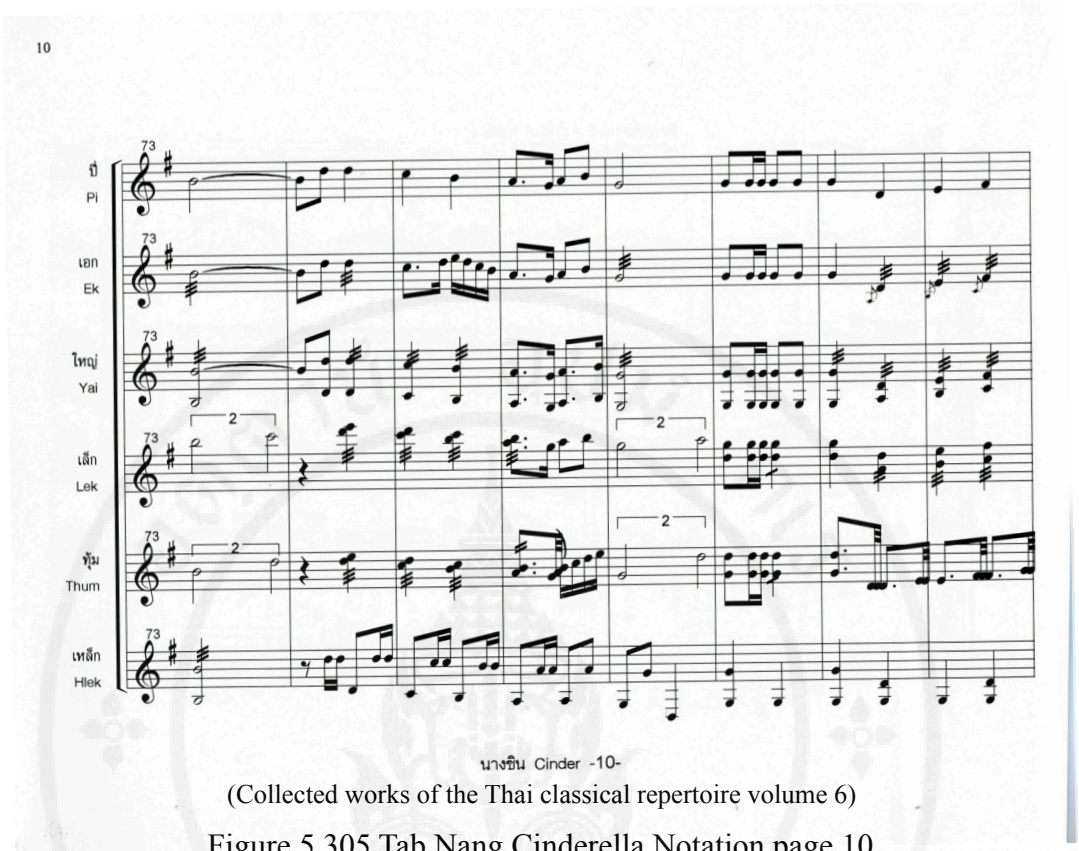
(Collected works of the Thai classical repertoire volume 6)

Figure 5.303 Tab Nang Cinderella Notation page 8



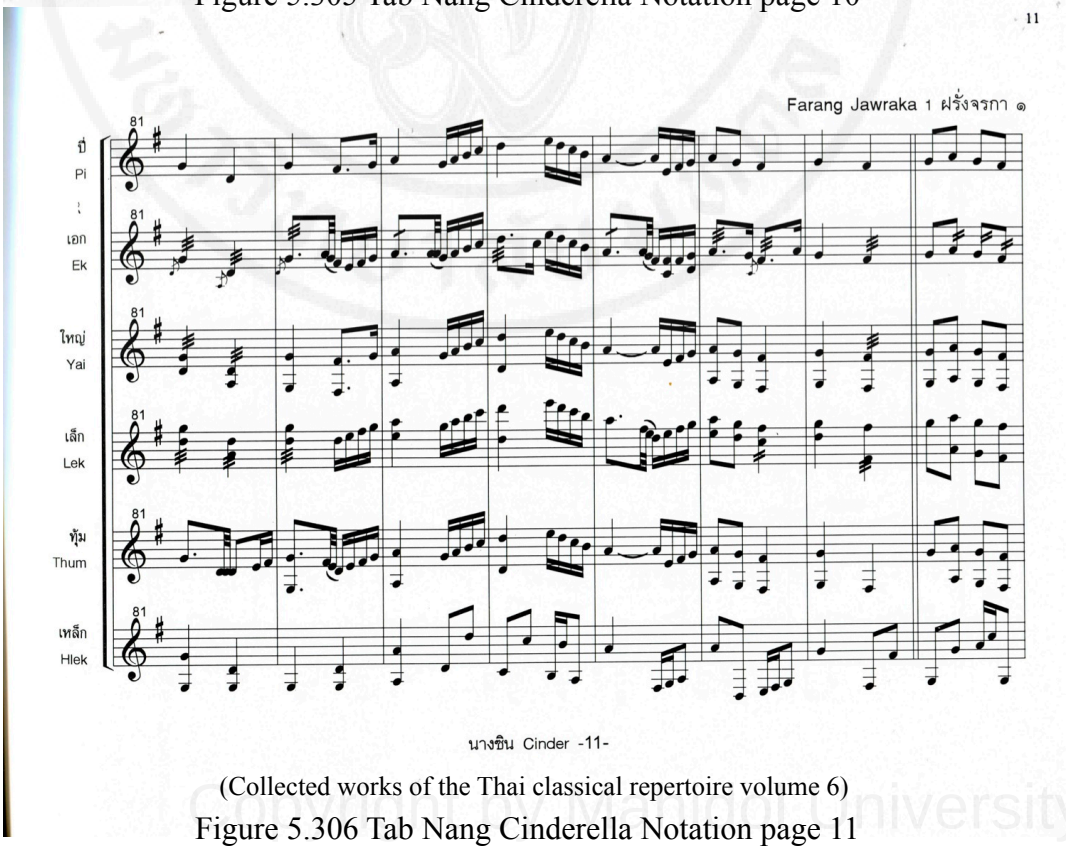
(Collected works of the Thai classical repertoire volume 6)

Figure 5.304 Tab Nang Cinderella Notation page 9



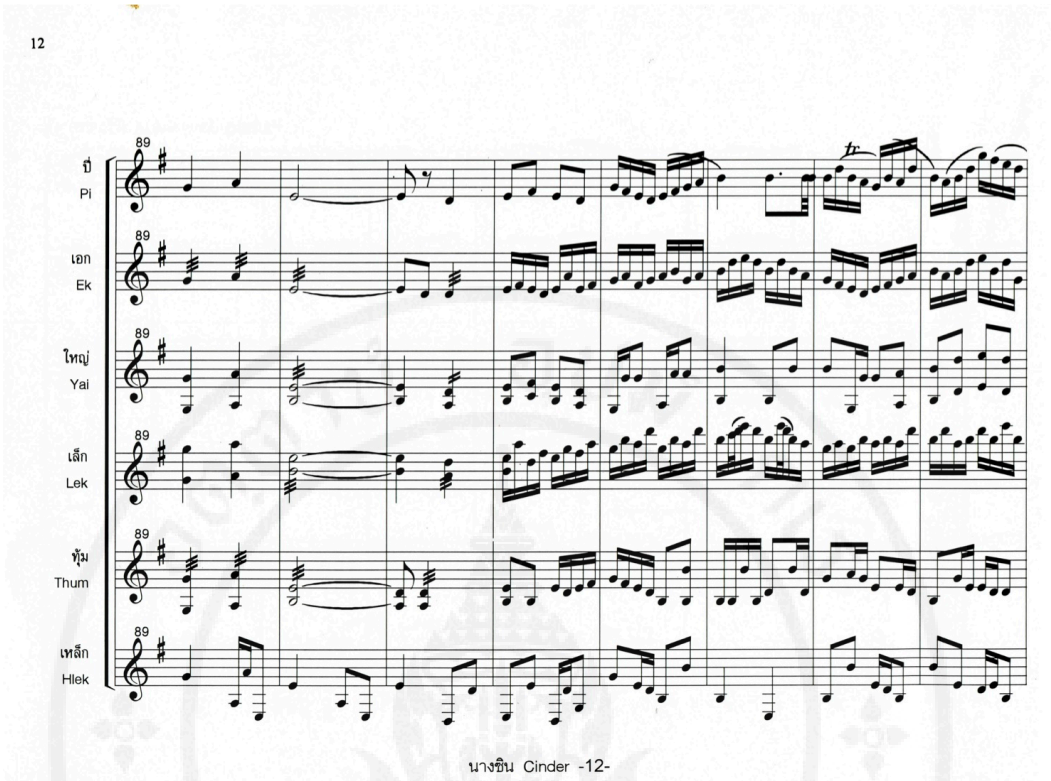
(Collected works of the Thai classical repertoire volume 6)

Figure 5.305 Tab Nang Cinderella Notation page 10



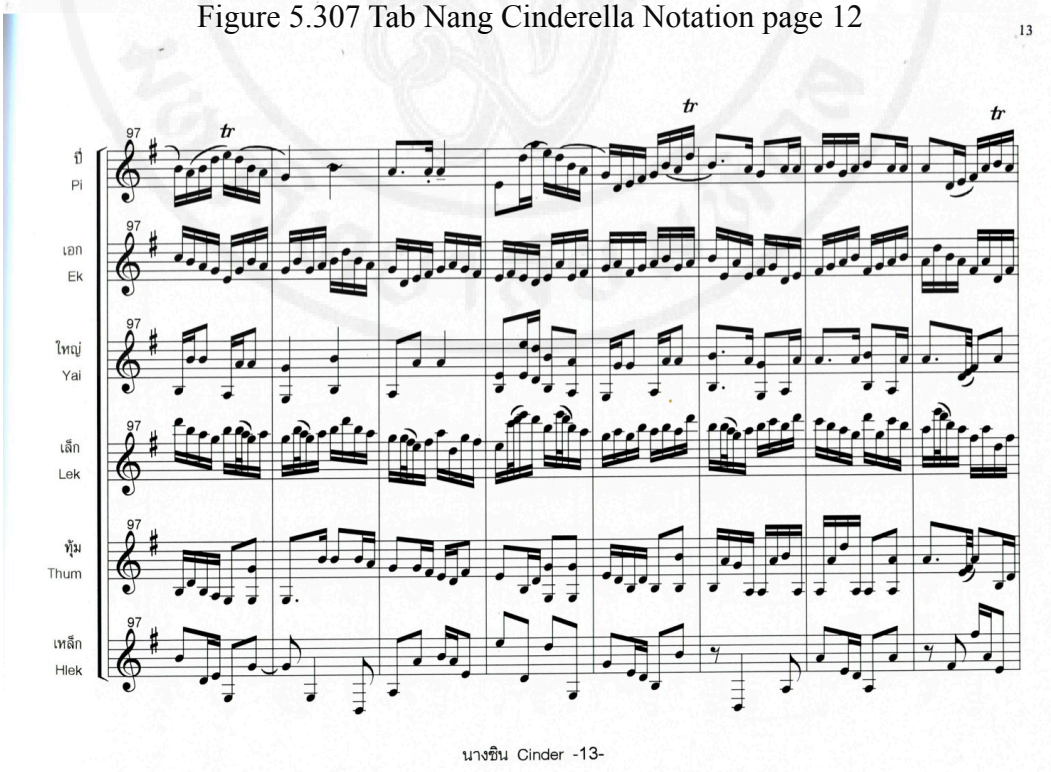
(Collected works of the Thai classical repertoire volume 6)

Figure 5.306 Tab Nang Cinderella Notation page 11



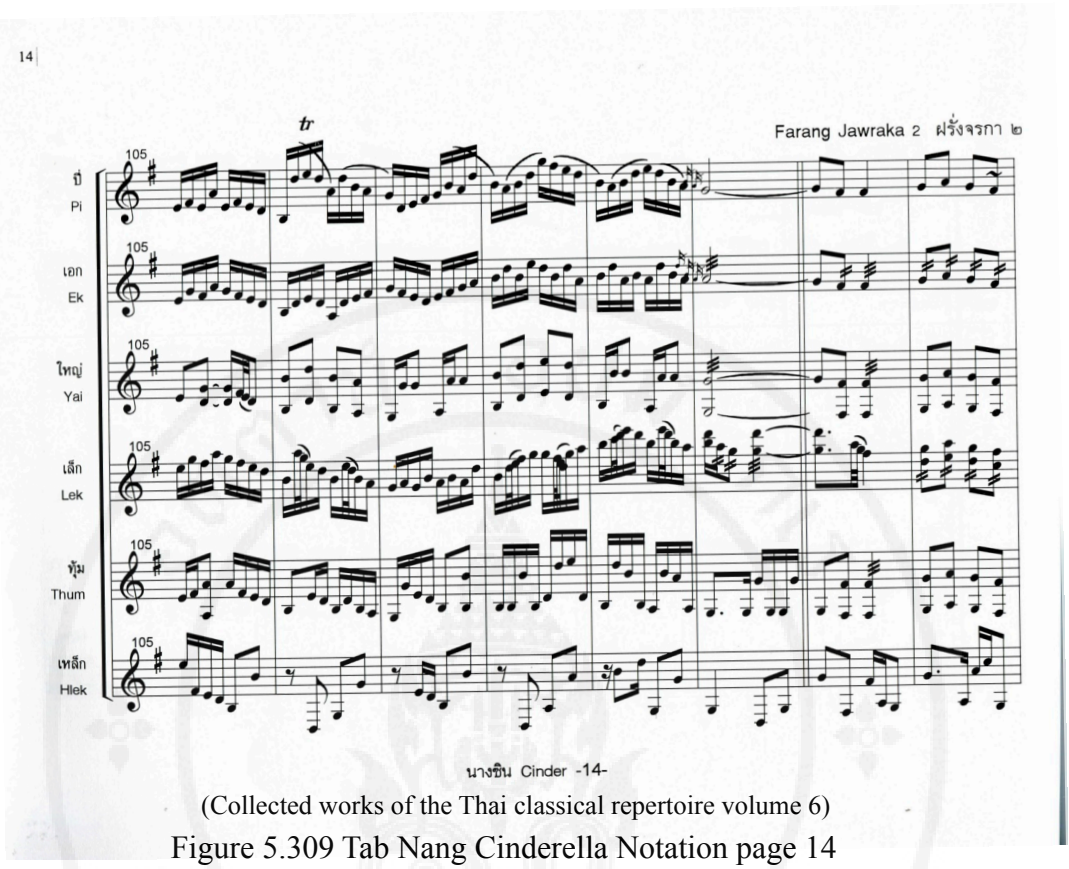
(Collected works of the Thai classical repertoire volume 6)

Figure 5.307 Tab Nang Cinderella Notation page 12



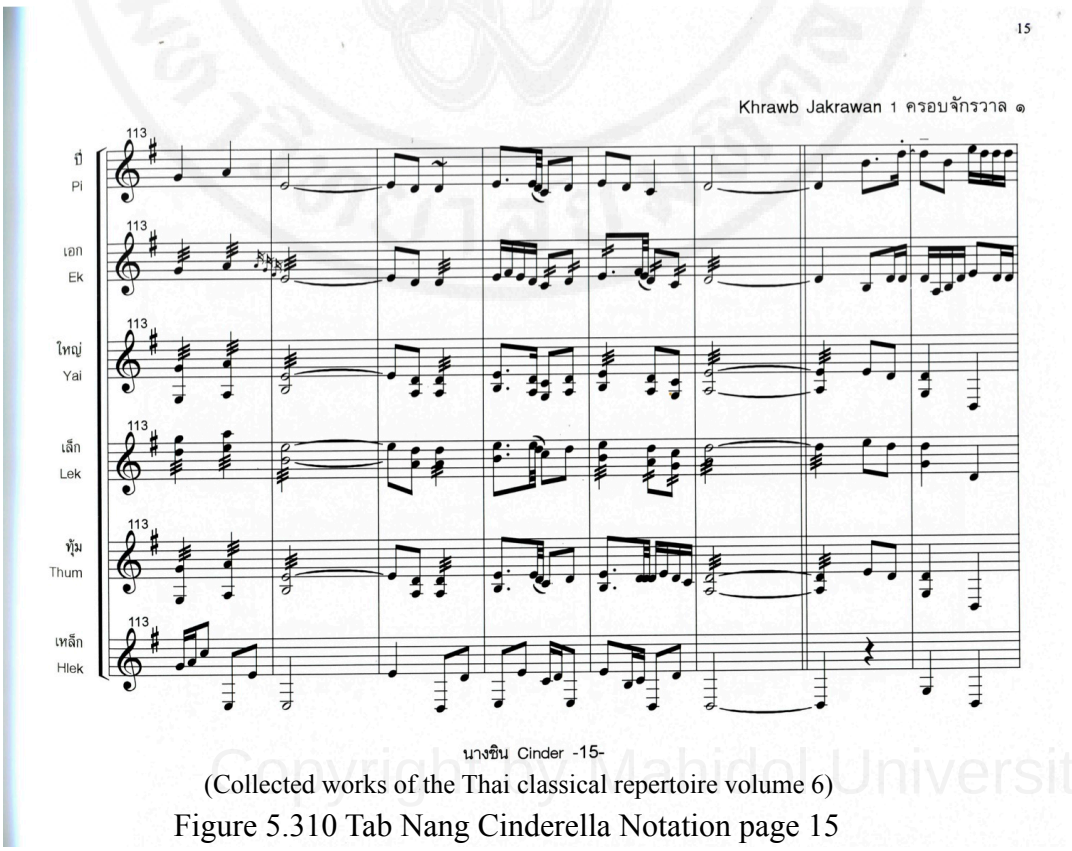
(Collected works of the Thai classical repertoire volume 6)

Figure 5.308 Tab Nang Cinderella Notation page 13



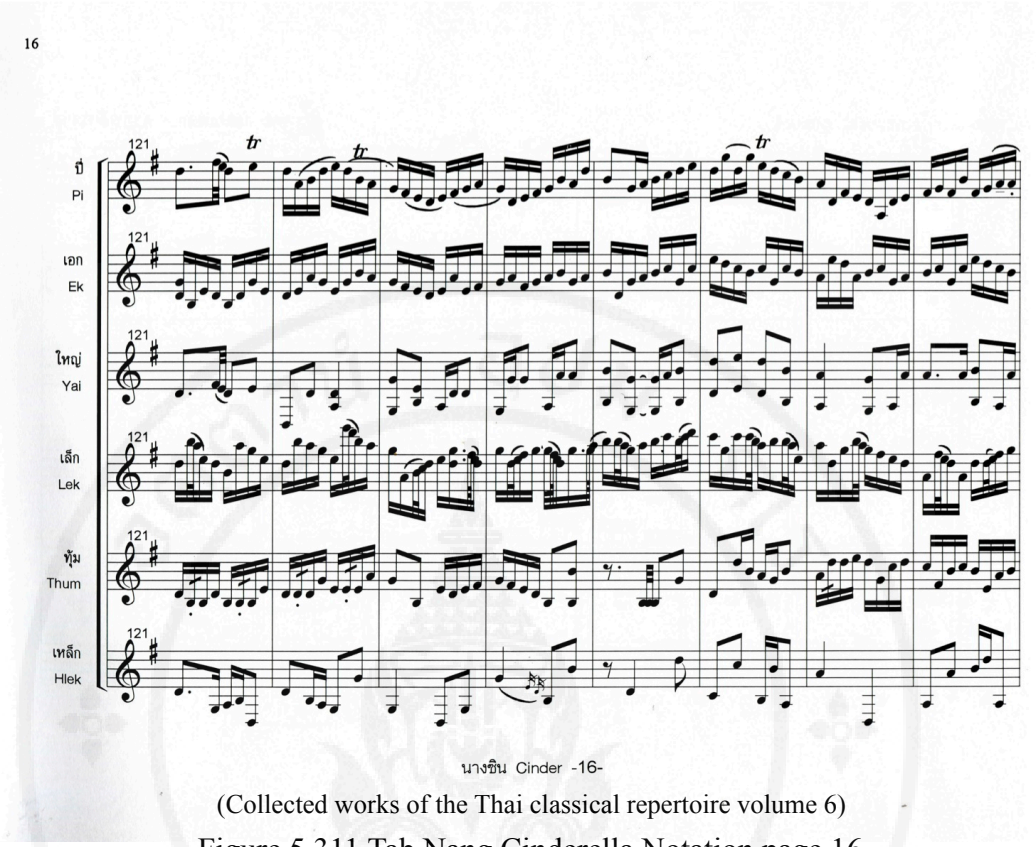
(Collected works of the Thai classical repertoire volume 6)

Figure 5.309 Tab Nang Cinderella Notation page 14



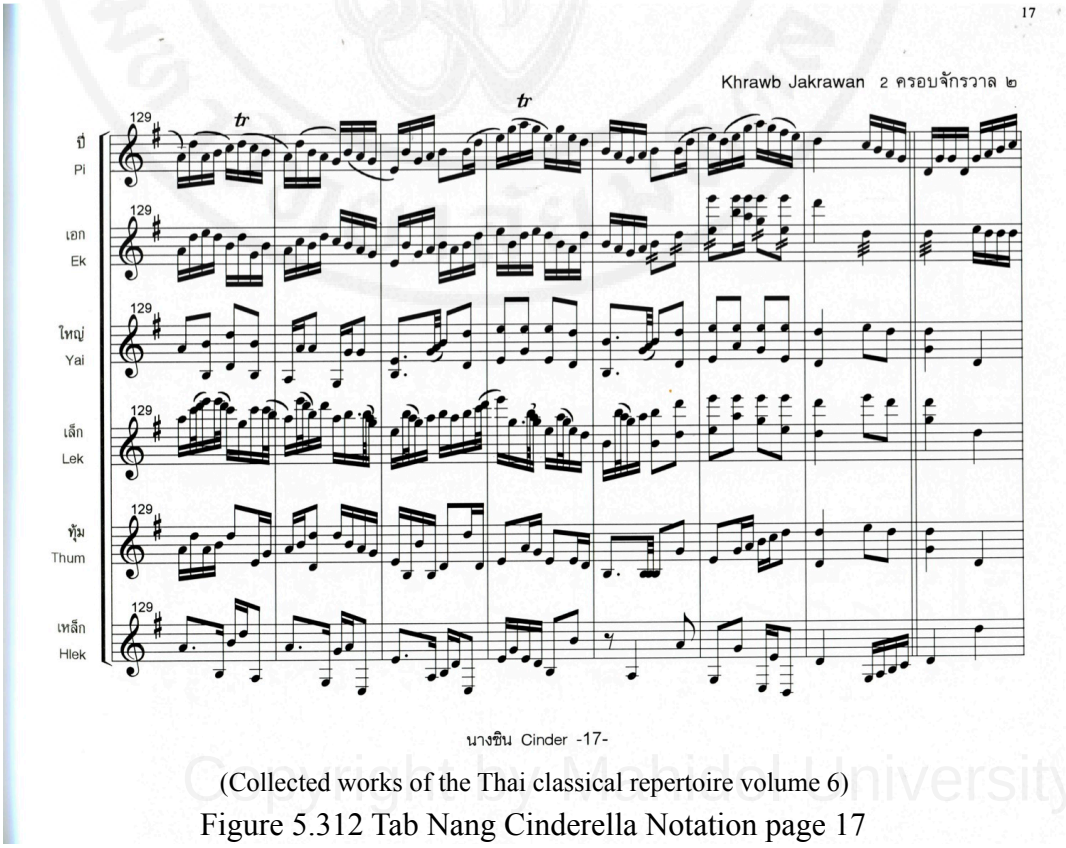
(Collected works of the Thai classical repertoire volume 6)

Figure 5.310 Tab Nang Cinderella Notation page 15



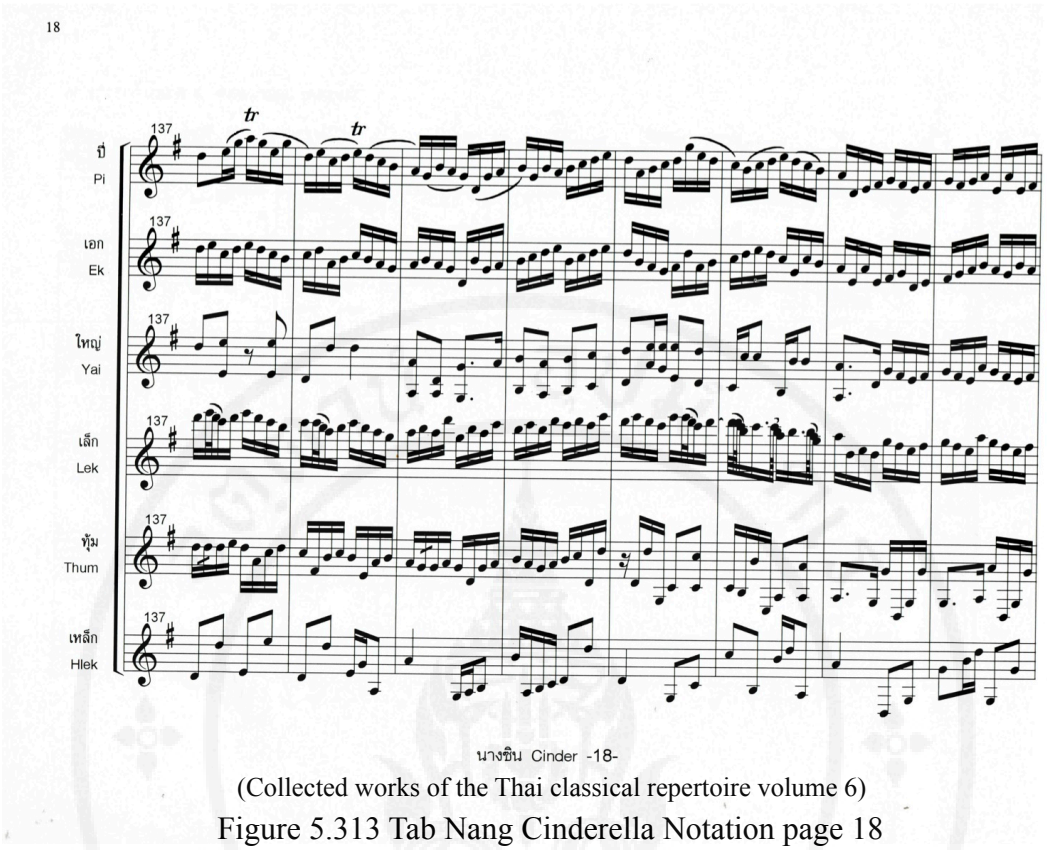
(Collected works of the Thai classical repertoire volume 6)

Figure 5.311 Tab Nang Cinderella Notation page 16



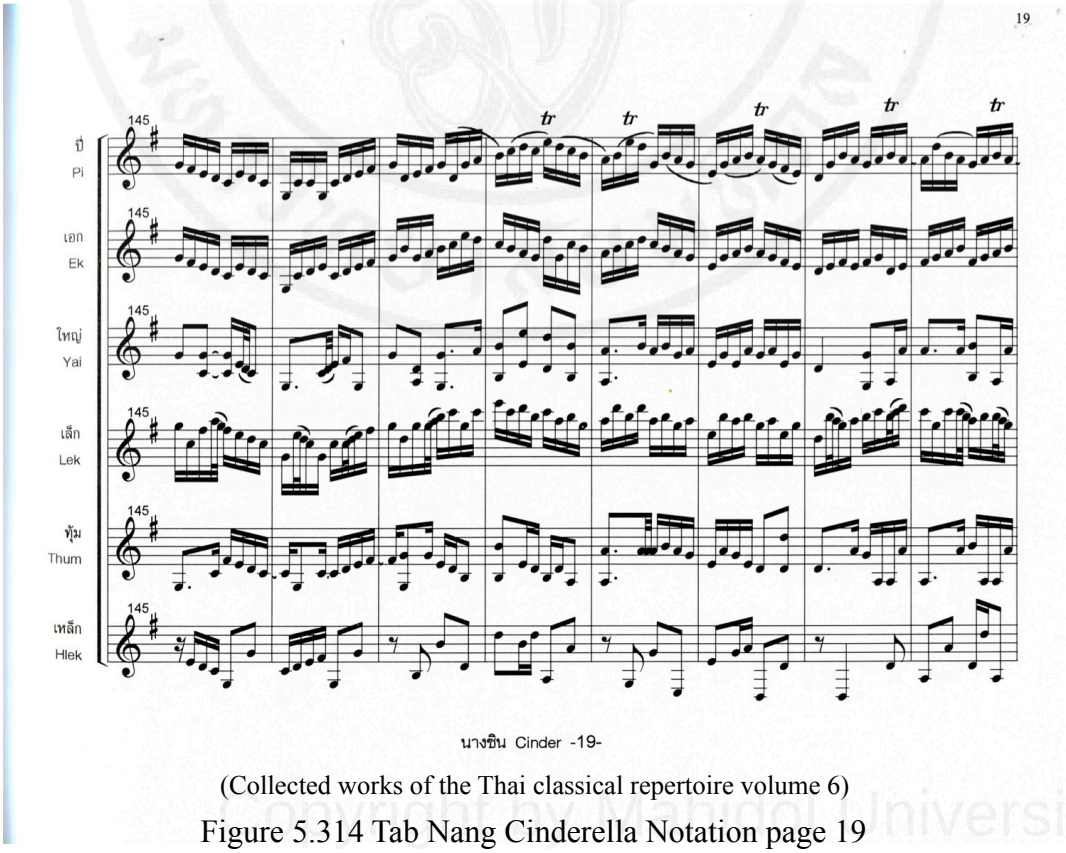
(Collected works of the Thai classical repertoire volume 6)

Figure 5.312 Tab Nang Cinderella Notation page 17



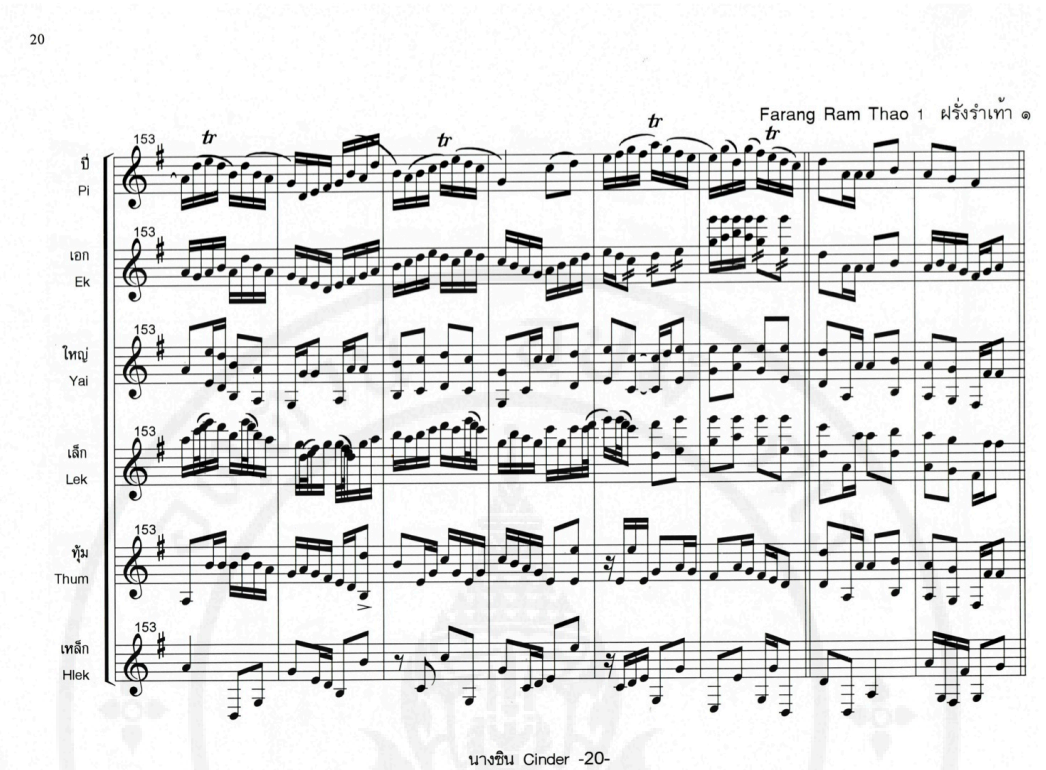
(Collected works of the Thai classical repertoire volume 6)

Figure 5.313 Tab Nang Cinderella Notation page 18



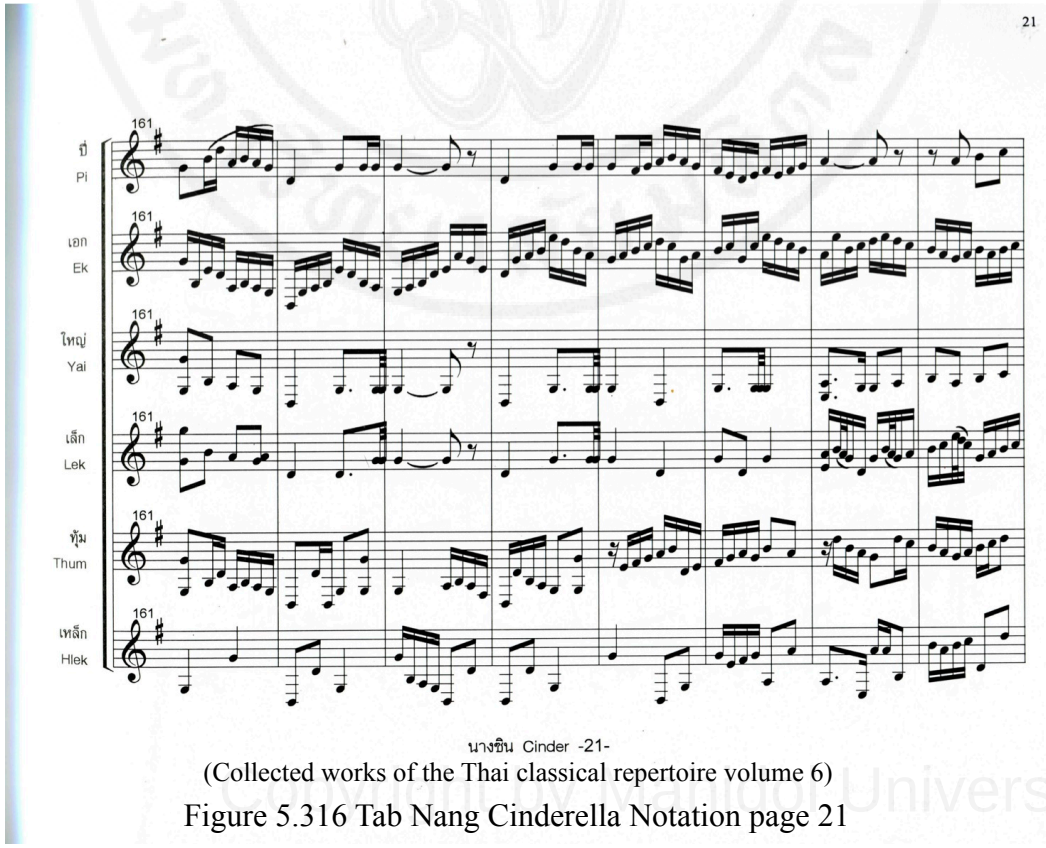
(Collected works of the Thai classical repertoire volume 6)

Figure 5.314 Tab Nang Cinderella Notation page 19



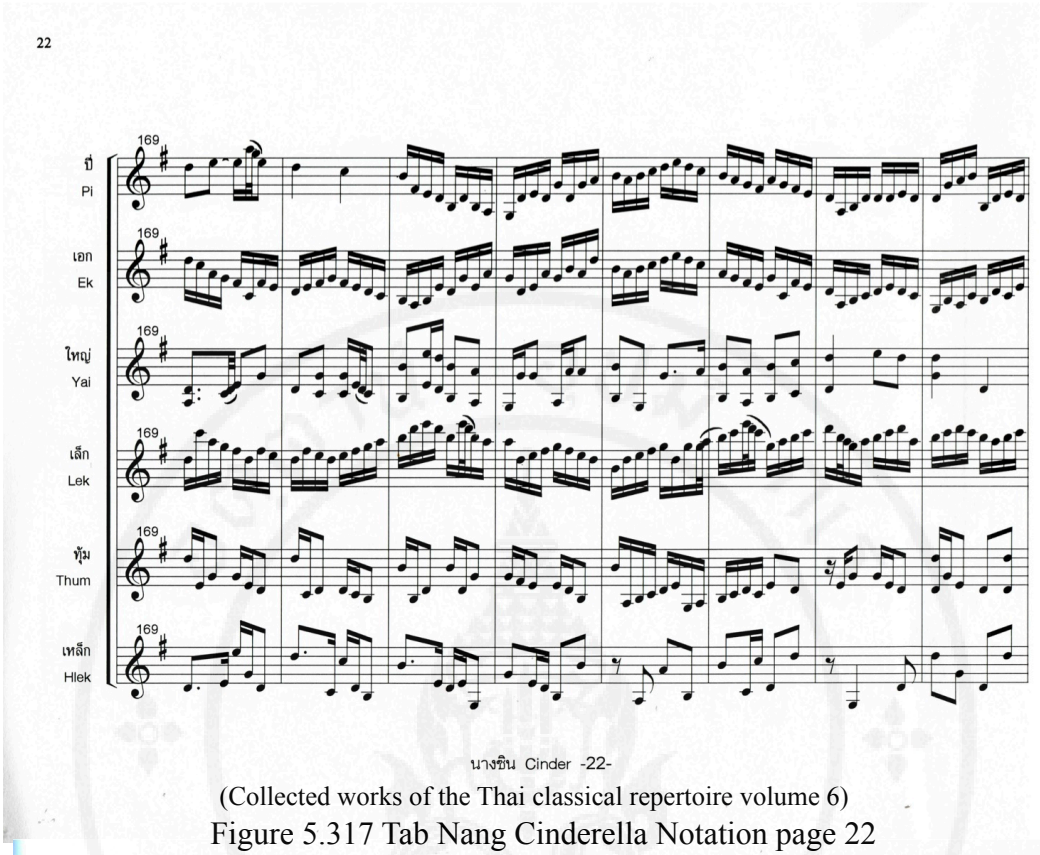
(Collected works of the Thai classical repertoire volume 6)

Figure 5.315 Tab Nang Cinderella Notation page 20



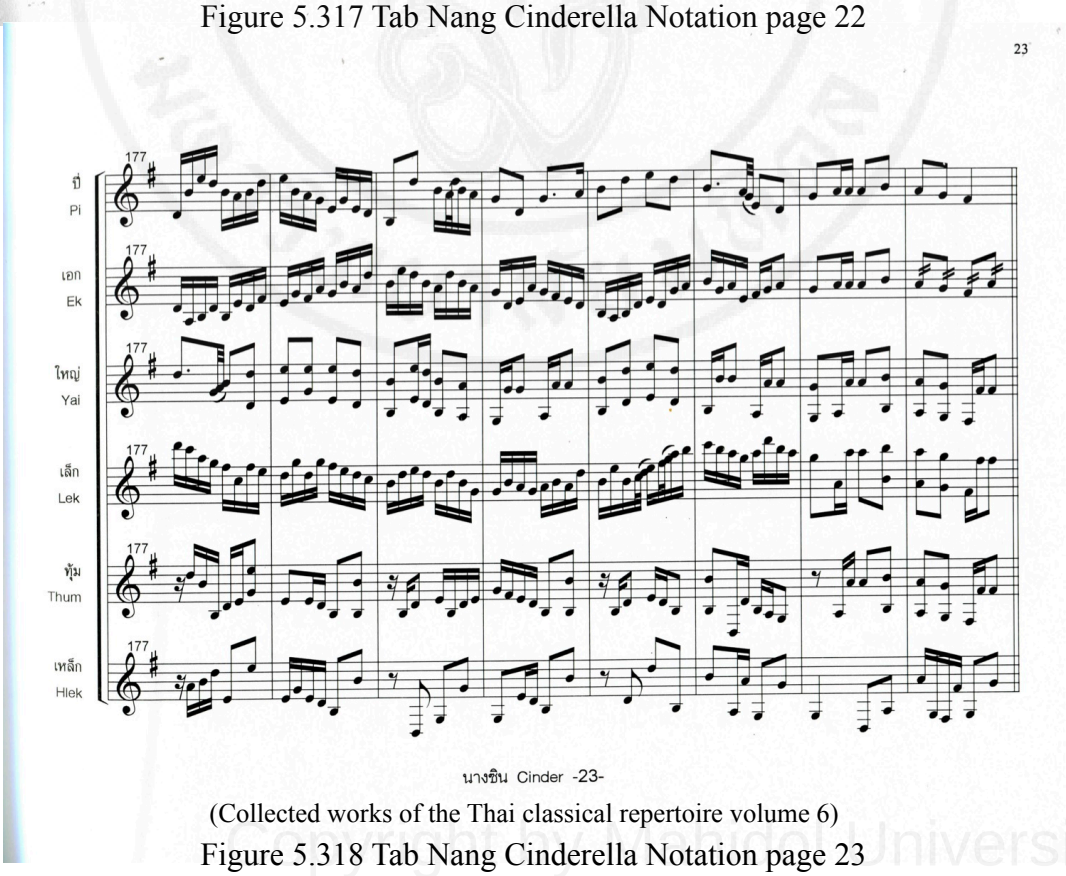
(Collected works of the Thai classical repertoire volume 6)

Figure 5.316 Tab Nang Cinderella Notation page 21



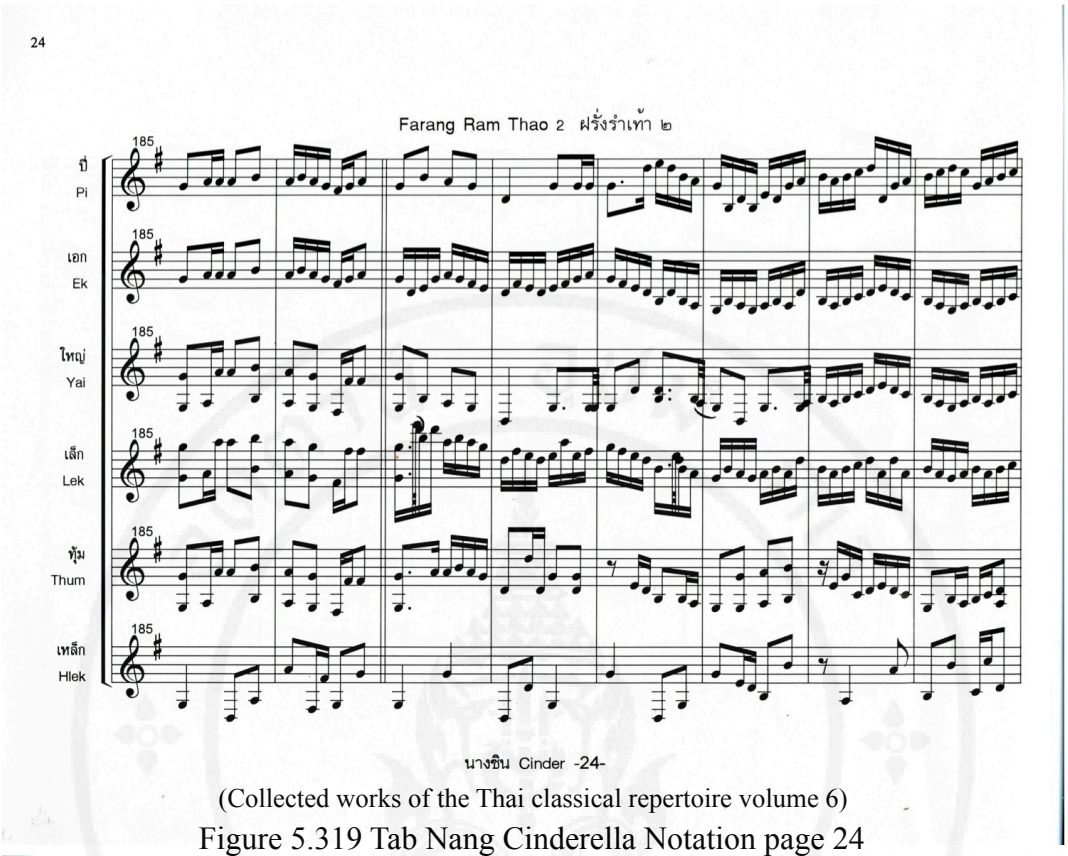
(Collected works of the Thai classical repertoire volume 6)

Figure 5.317 Tab Nang Cinderella Notation page 22



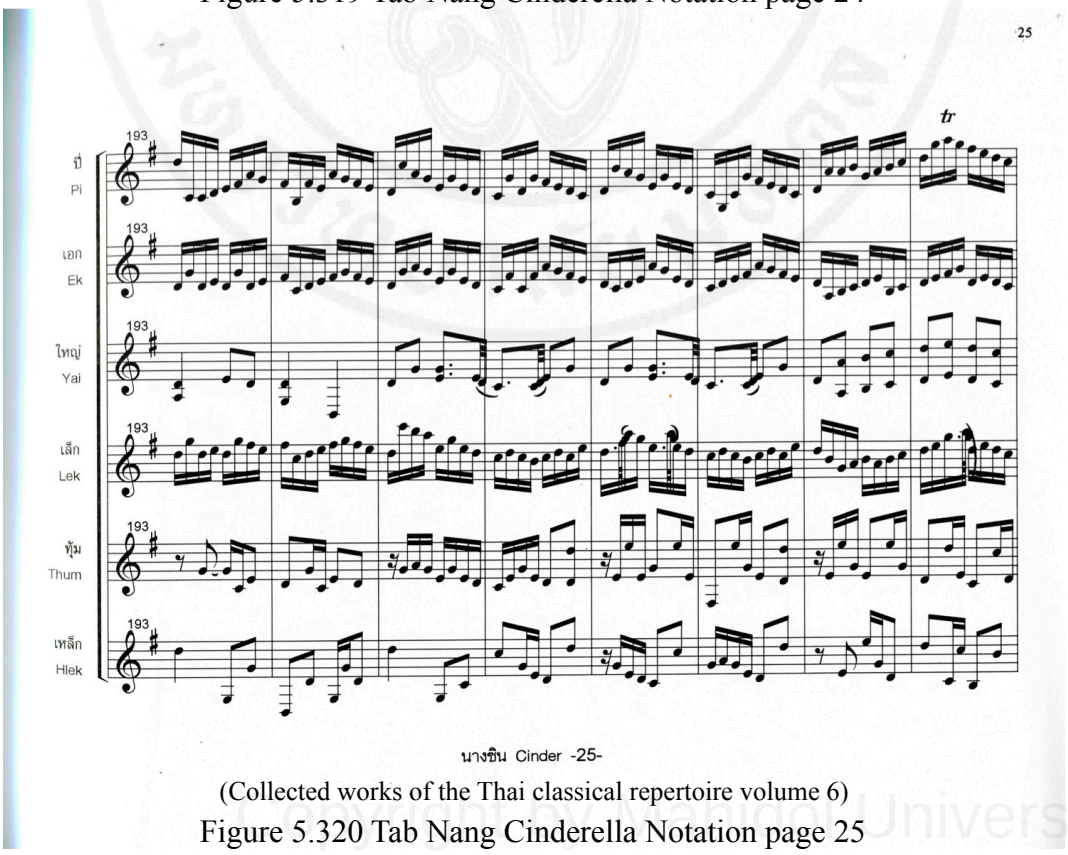
(Collected works of the Thai classical repertoire volume 6)

Figure 5.318 Tab Nang Cinderella Notation page 23



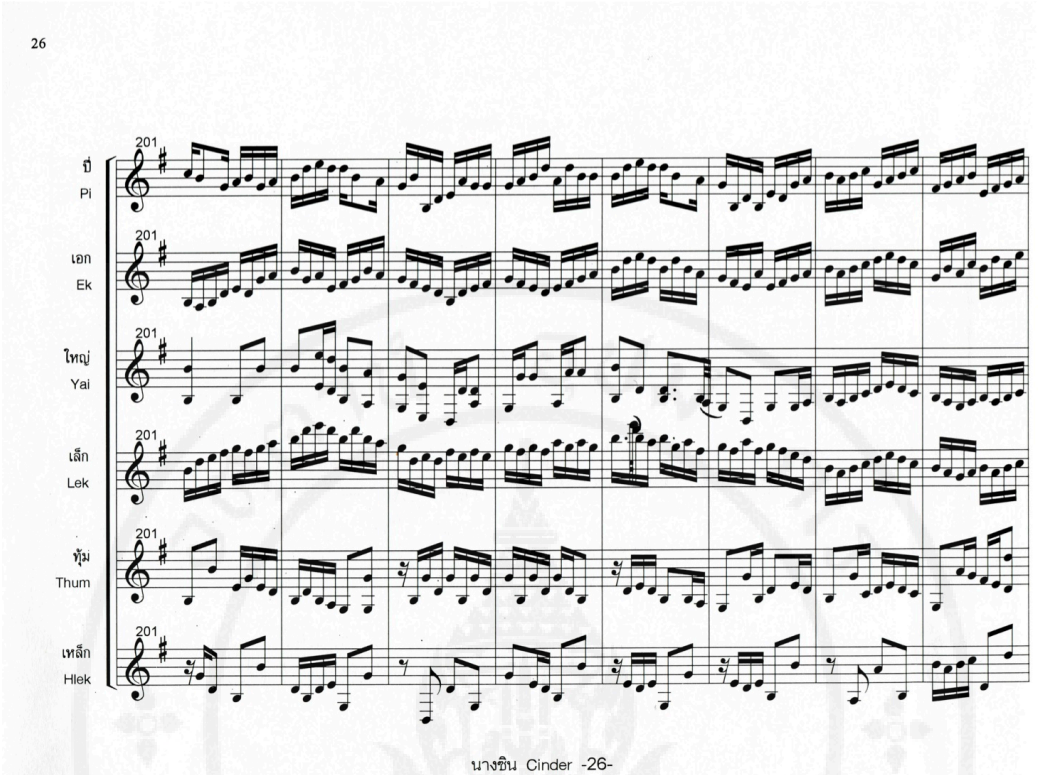
(Collected works of the Thai classical repertoire volume 6)

Figure 5.319 Tab Nang Cinderella Notation page 24



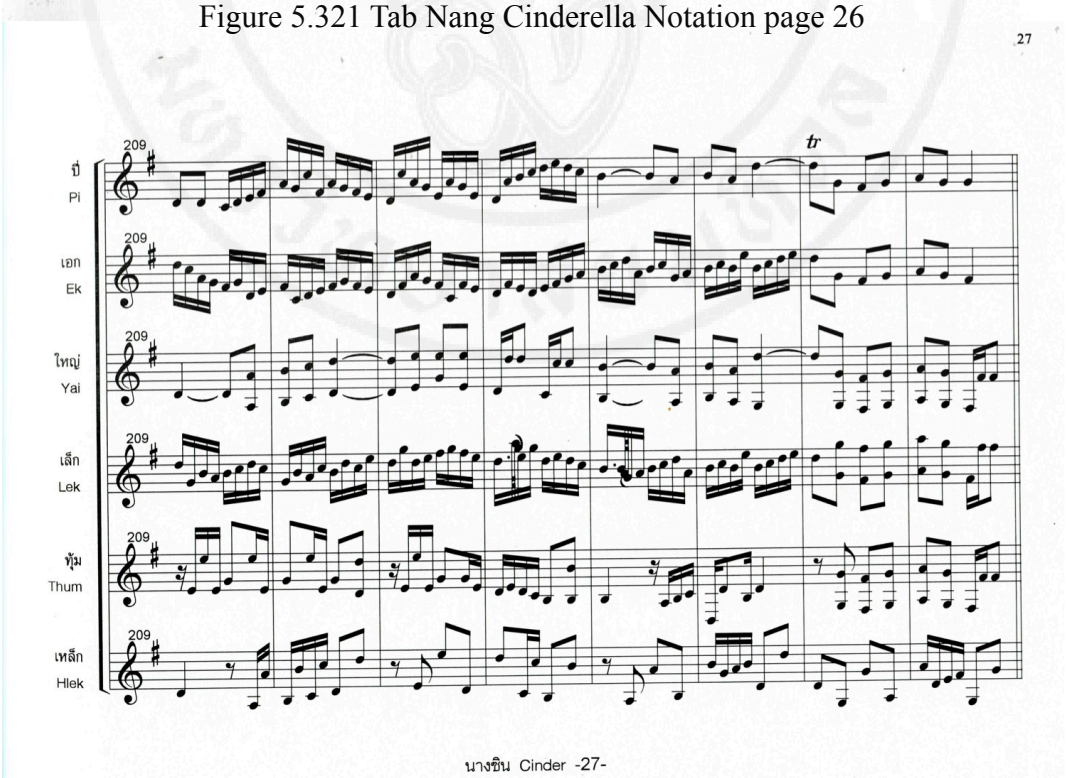
(Collected works of the Thai classical repertoire volume 6)

Figure 5.320 Tab Nang Cinderella Notation page 25



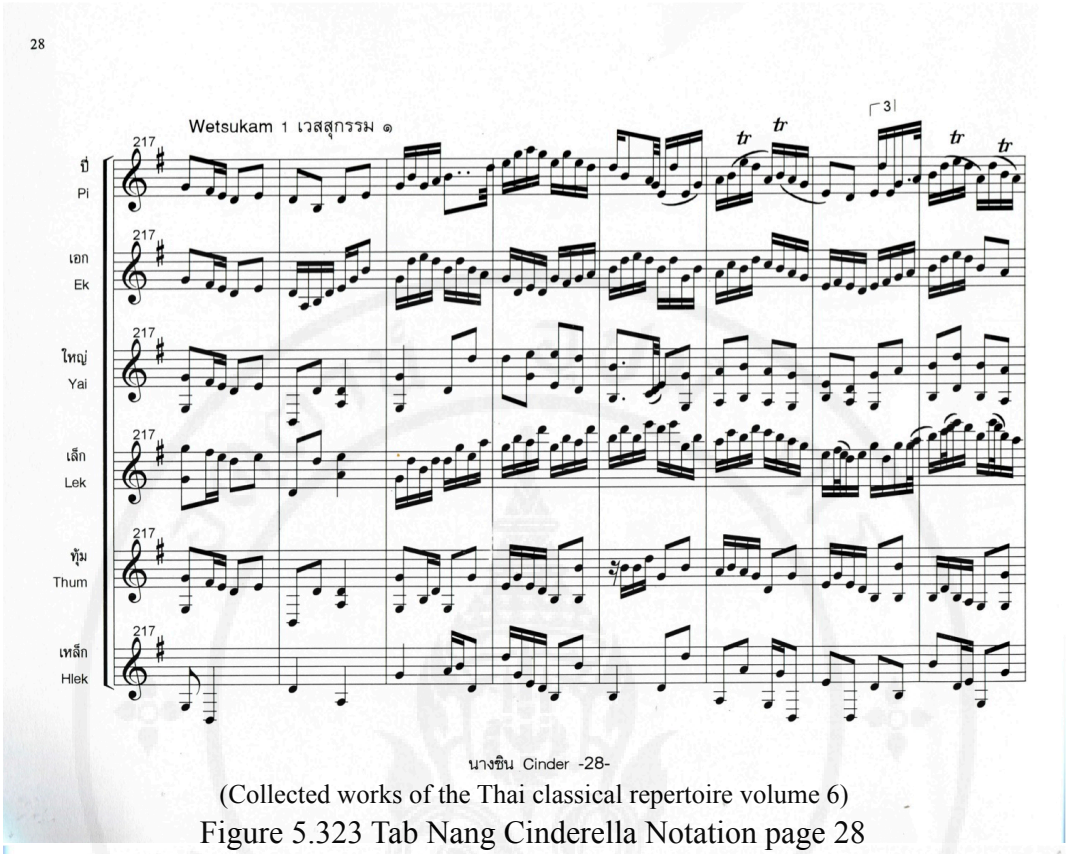
(Collected works of the Thai classical repertoire volume 6)

Figure 5.321 Tab Nang Cinderella Notation page 26



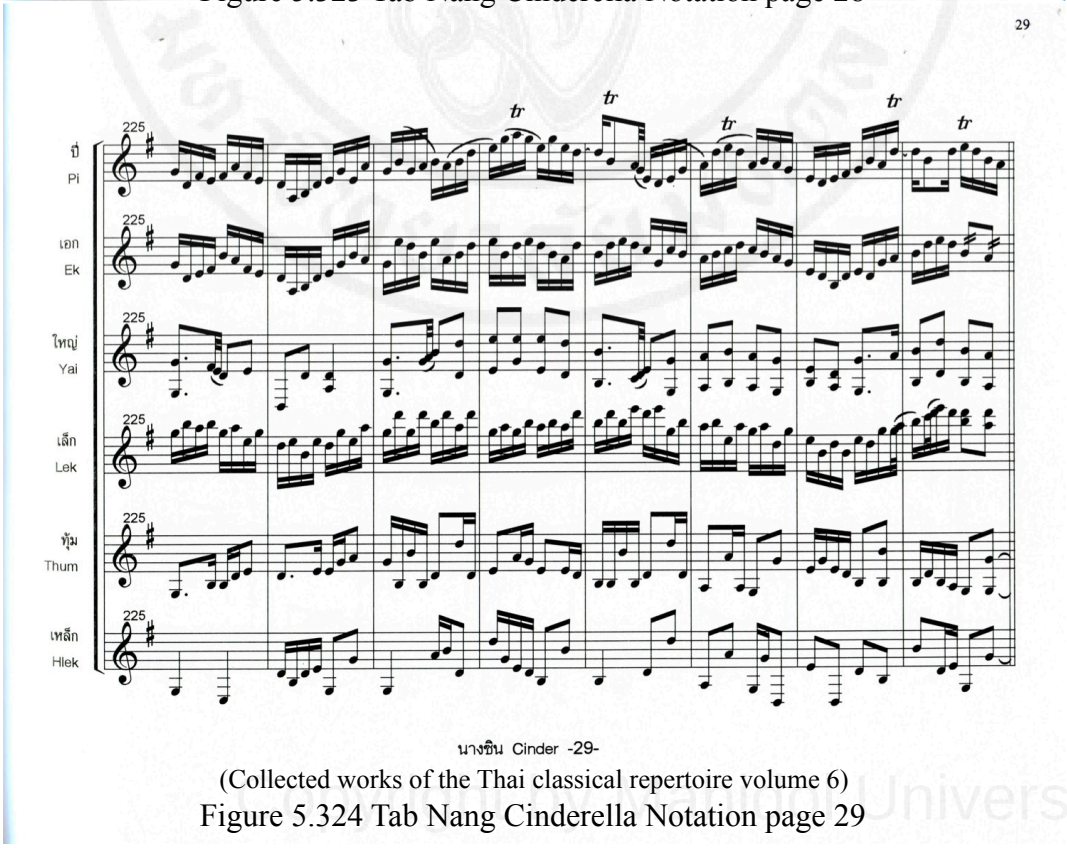
(Collected works of the Thai classical repertoire volume 6)

Figure 5.322 Tab Nang Cinderella Notation page 27



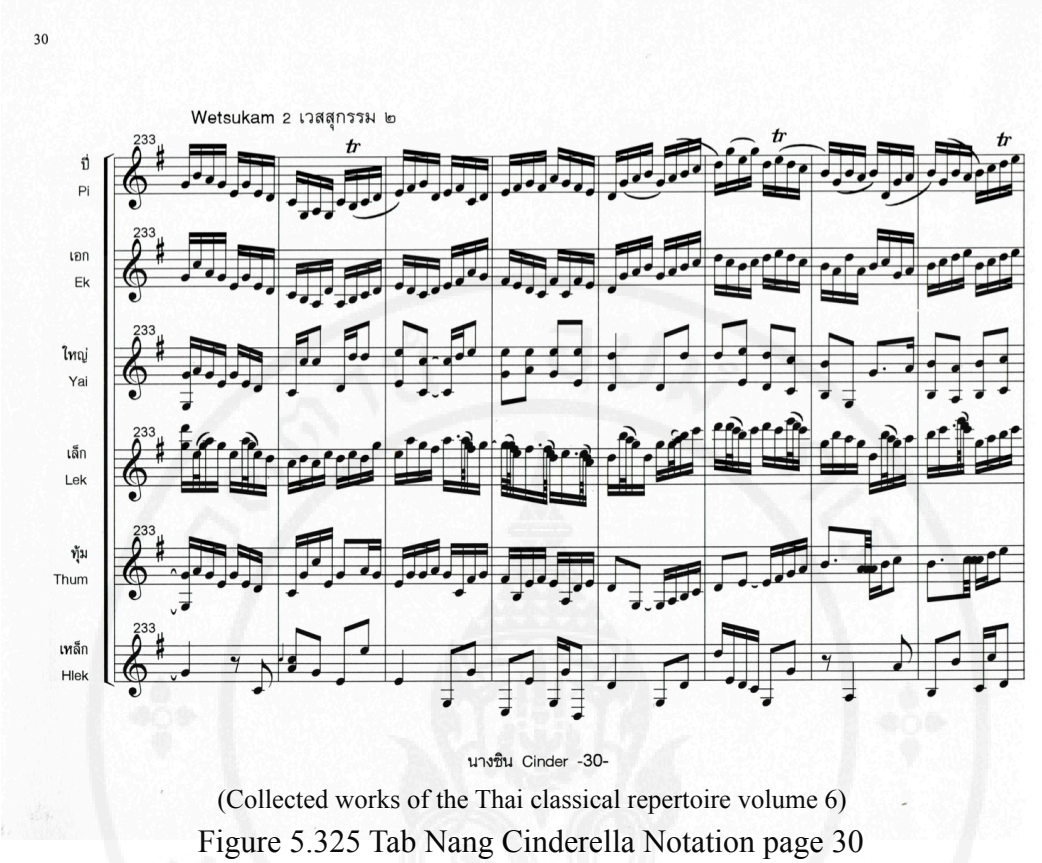
(Collected works of the Thai classical repertoire volume 6)

Figure 5.323 Tab Nang Cinderella Notation page 28



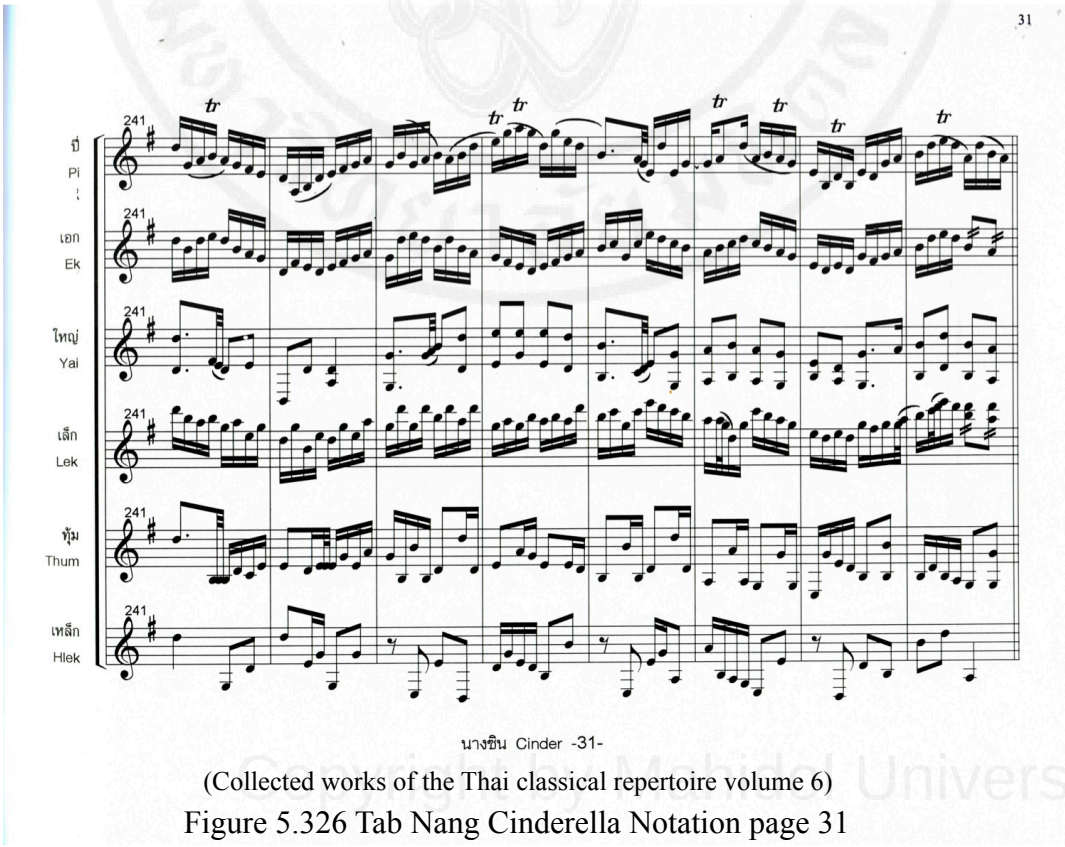
(Collected works of the Thai classical repertoire volume 6)

Figure 5.324 Tab Nang Cinderella Notation page 29



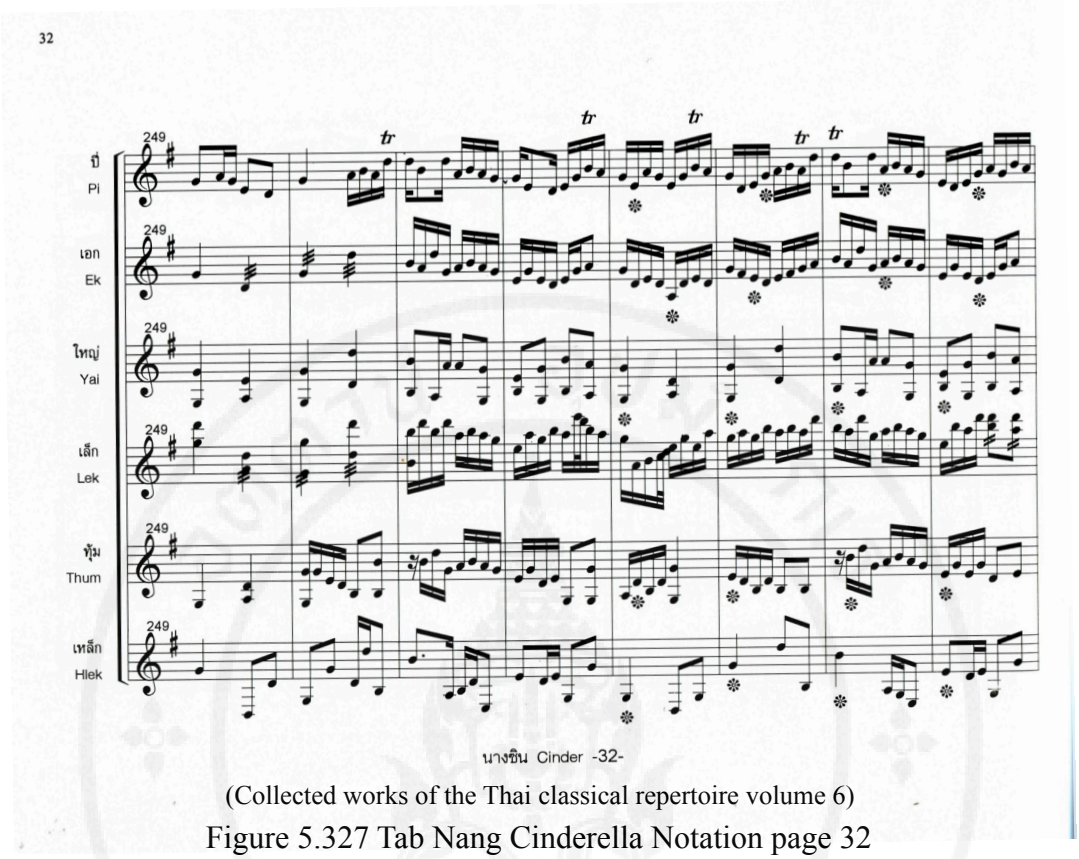
(Collected works of the Thai classical repertoire volume 6)

Figure 5.325 Tab Nang Cinderella Notation page 30



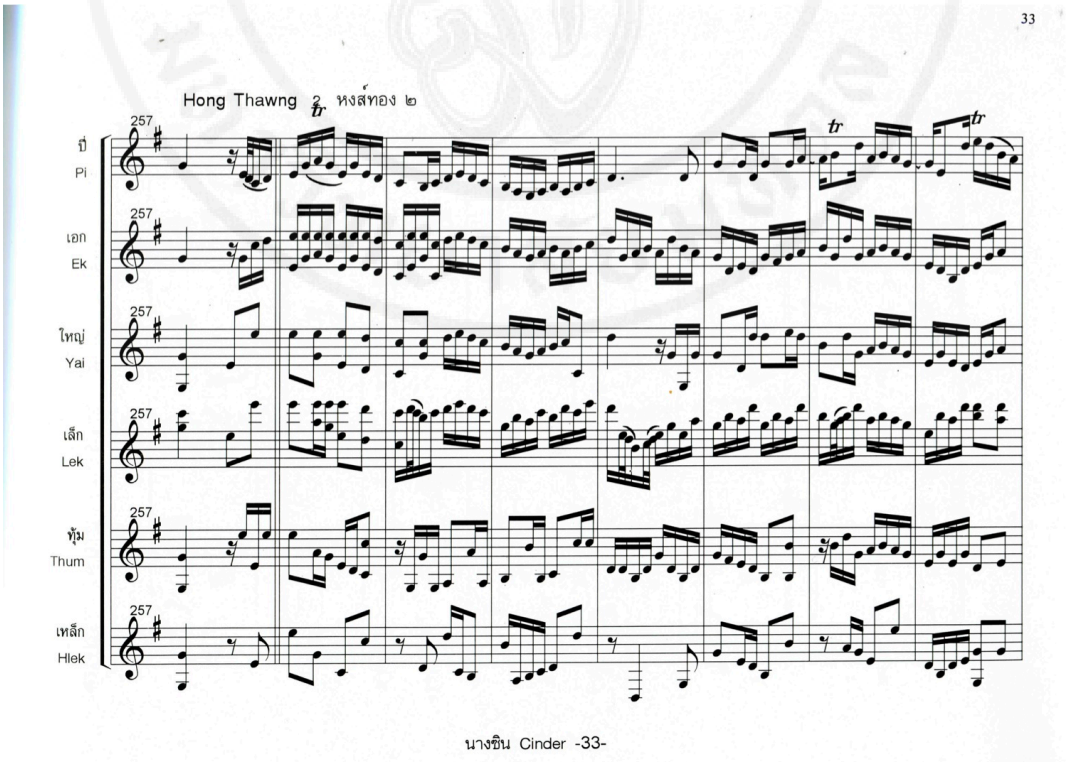
(Collected works of the Thai classical repertoire volume 6)

Figure 5.326 Tab Nang Cinderella Notation page 31



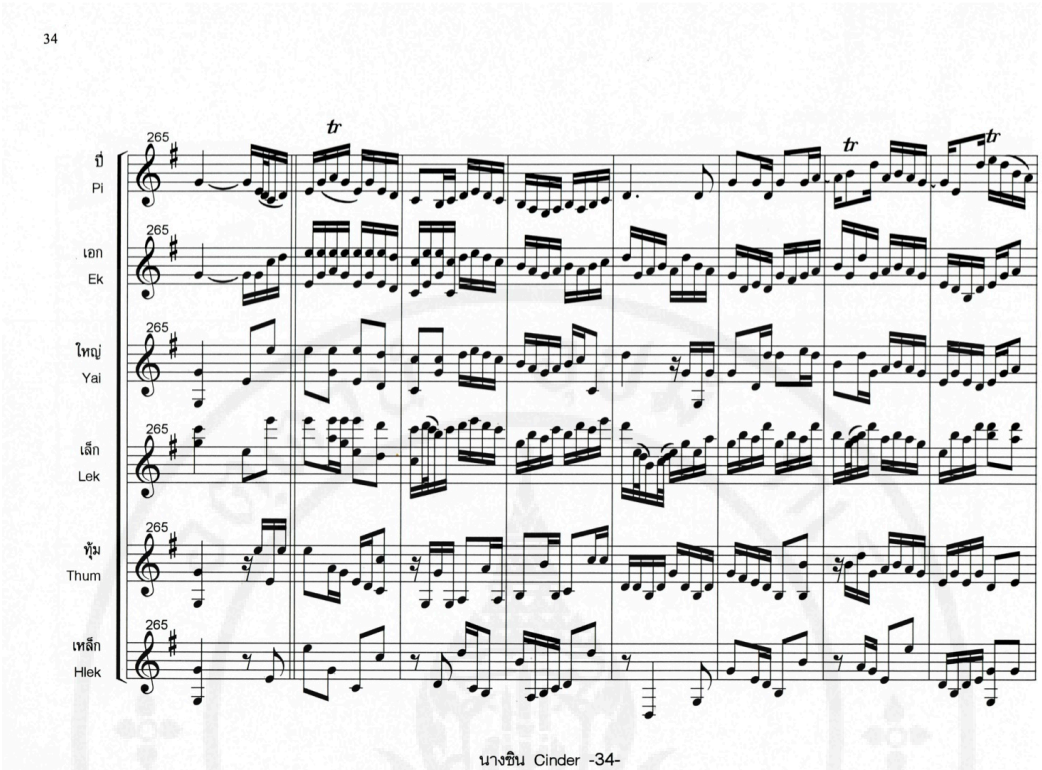
(Collected works of the Thai classical repertoire volume 6)

Figure 5.327 Tab Nang Cinderella Notation page 32



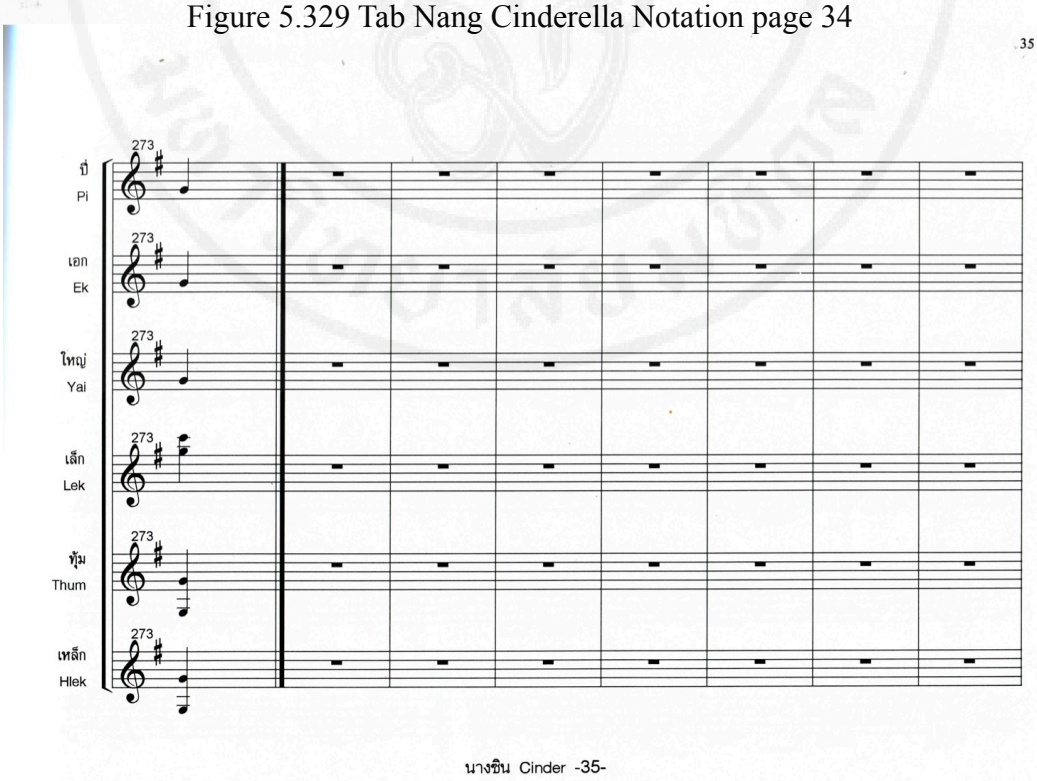
(Collected works of the Thai classical repertoire volume 6)

Figure 5.328 Tab Nang Cinderella Notation page 33



(Collected works of the Thai classical repertoire volume 6)

Figure 5.329 Tab Nang Cinderella Notation page 34



(Collected works of the Thai classical repertoire volume 6)

Figure 5.330 Tab Nang Cinderella Notation page 35

5.5.2 Using Sampler Plug-in

The researcher used a sampler plug-in in Logic pro 9, called EXS24.

Figure 5.331 EXS24 Sampling Plug-in

Mapping all Thai sound samples into a keyboard of EXS24 pitch by pitch and save sound preset into plug-in.

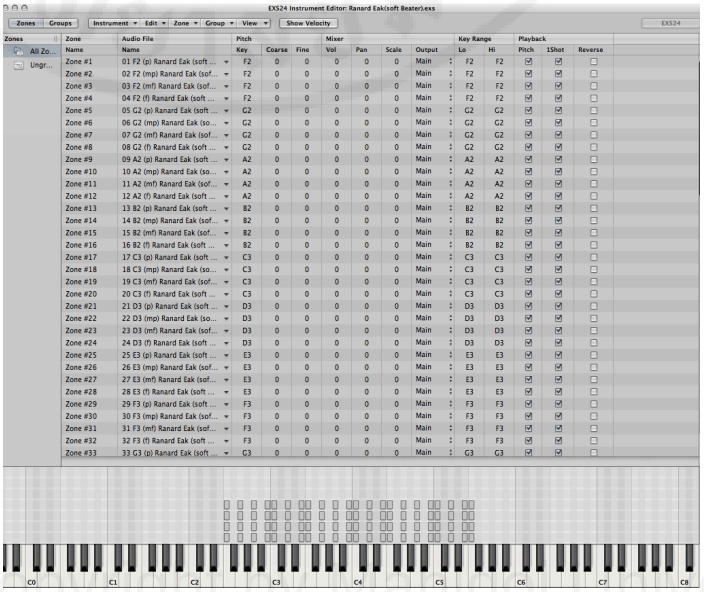


Figure 5.332 Thai sound samples Mapping

After mapping the sound samples, use the plug-in with MIDI note that has been programed from Tub Nang Cinderella. The Thai instruments used on MIDI note were Ranad Ek, Kong Wong Yai, Ranad Tum Lek and Ching.

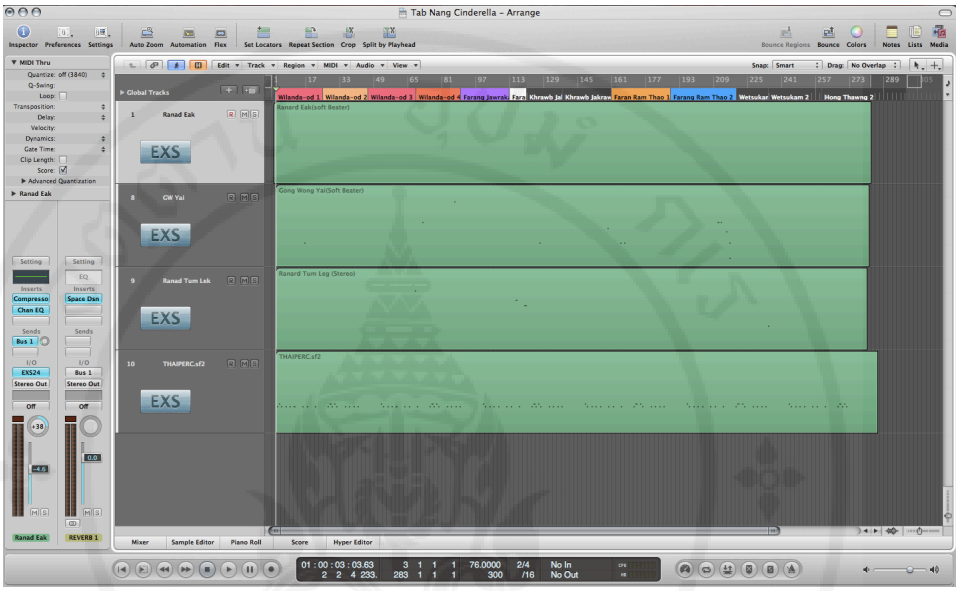


Figure 5.333 MIDI Tracks of instruments of Thai sampling sound

After that, add more electric instruments by using softsynth as an example for preforming with electric instruments.

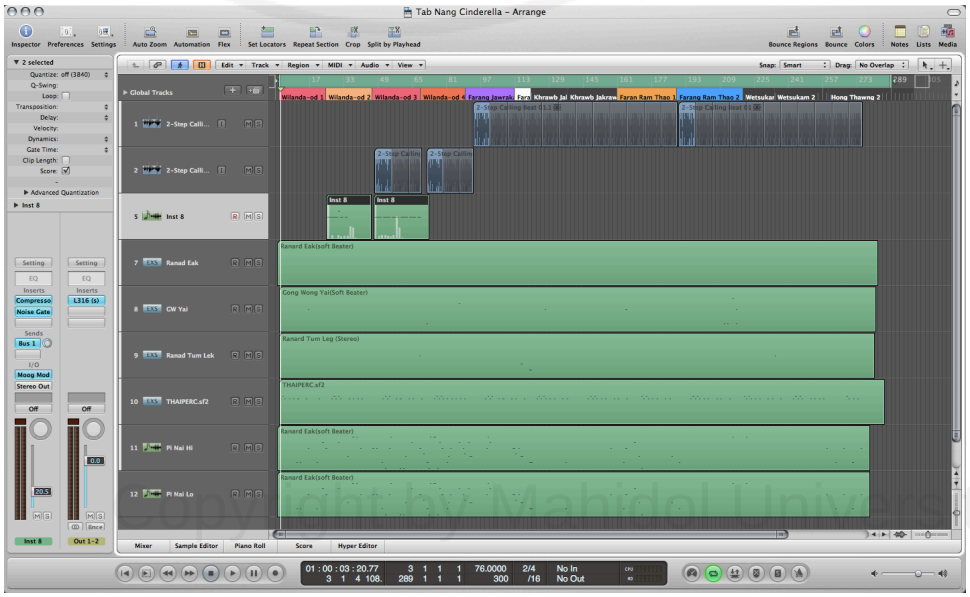


Figure 5.334 Adding more tracks of electric instruments

CHAPTER VI
RESULTS, CONCLUSION AND RECOMMENDATION

6.1 Results of study

The results of studying the Thai musical scale system and function setting used in electronic instruments is presented as follows

6.1.1 Structure of the Thai musical scale system

The Thai musical scale system has been equally divided into 7 pitches in an octave. It has intervals of 171.42 cents adjacent of each pitch. The table displays a comparison for all frequencies of pitches used in the Thai musical scale system and the equal temperament scale system, using the initial frequency as 261.63Hz, or C note in the equal temperament scale system, to calculate all frequencies.

Table 6.1 Equal temperament scale and Equal 7 tones scale comparison chart

Equal Temperament Scale		Note	Equal 7 Tones Scale	
Frequency (Hz)	Cents		Frequency (Hz)	Cents
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

Equal Temperament Scale		Note	Equal 7 Tones Scale	
Frequency (Hz)	Cents		Frequency (Hz)	Cents
523.26	1,200	C	523.26	1,200

From the information in this table, the frequencies of the other octaves can be found. The frequencies of the notes in the other octaves will always be halved or doubled in frequency. To calculate the next octave, double the frequency of the next consecutive note if of a higher pitch, or half the frequency if of a lower pitch. The results of the frequency of Thai notes are displayed on the piano keys as follows.

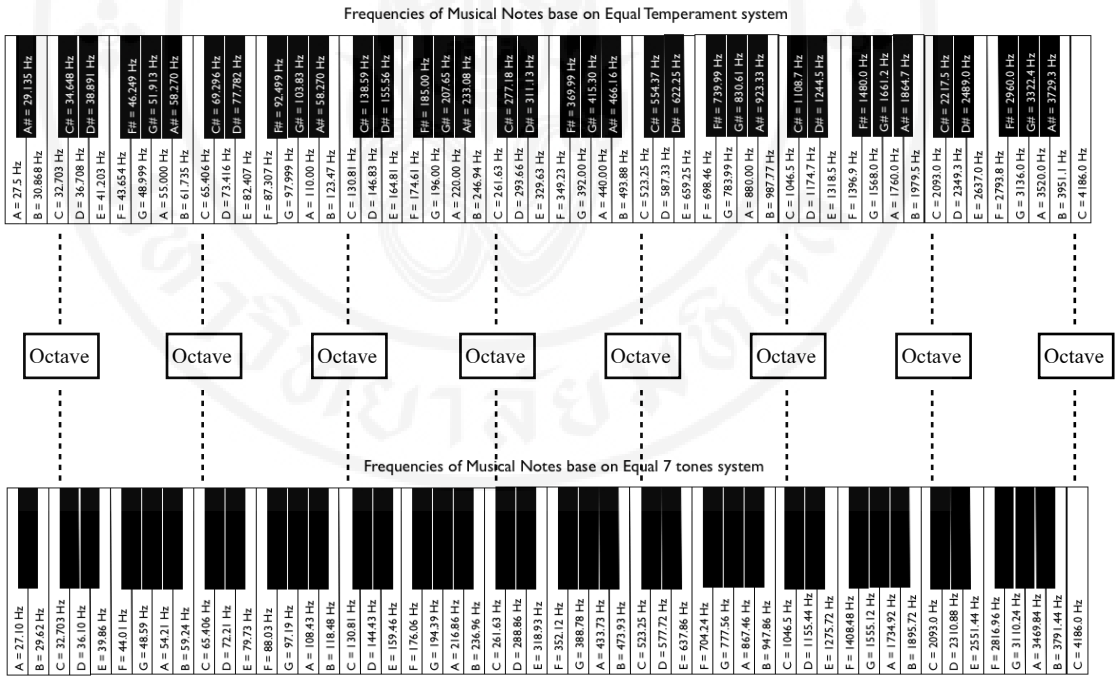


Figure 6.1 Comparison of Thai musical scale system frequency and Equal temperament

6.1.2 Format of the Thai musical scale system

Notes used in the Thai musical scale system include 7 pitches in an octave. The Thai 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.

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

Figure 6.2 Notes used Thai musical scale system

6.1.2 Format of the Thai musical scale system

Notes used in the Thai musical scale system include 7 pitches in an octave. The Thai 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.

C	D	E	G	A
1	2	3	5	6

Figure 6.3 Notes used in Thai musical scale

In addition to the 5 notes that are mainly used in the Thai musical scale for performing Thai classical songs, the other 2 notes have been used for different accents in different songs or it can be used to modulate to another scale when performing. The Thai word used for the musical scale is “Thang”. It consists of 7 musical scales, ordered as follows.

1.Thang Piang-aw-lang

2. Thang Nai

3. Thang Klang

4.Thang Piang-aw-bon

5. Thang nok

6. Thang Klang hap

7. Thang Chawa

Comparison of the graphics of the 7 Thai musical scales is displayed on Kong Wong Yai and piano to show all positions of all notes in each Thai musical scale

as follows.

6.1.2.1 Thang Piang-aw-lang

The first note is on the third gong. It is called Thang Piang-aw-lang, because it was played with a Thai duct flute, called Piang-aw.

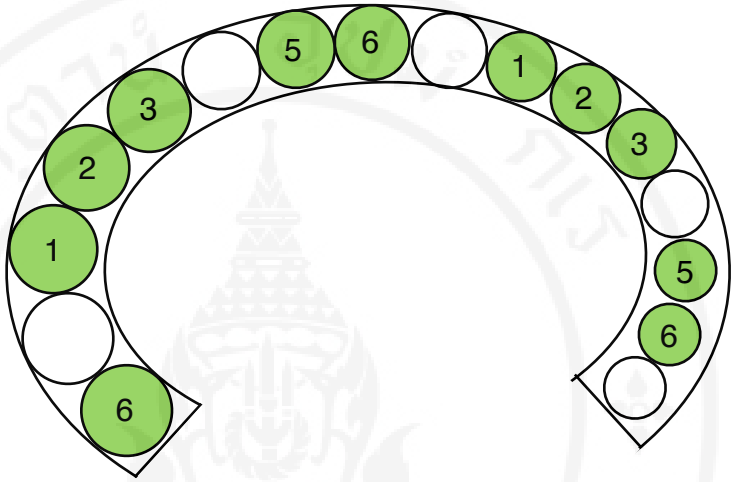


Figure 6.4 Thang Piang-aw-lang on Kong Wong Yai

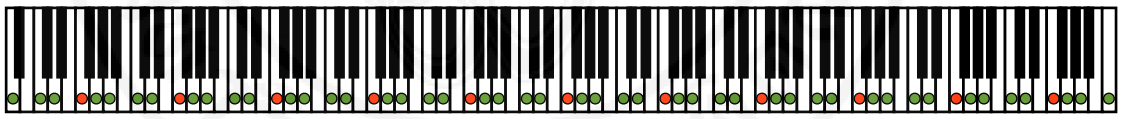


Figure 6.5 Thang Piang-aw-lang on Piano

6.1.2.2 Thang Nai

The first note is on the fourth gong. It is called Thang Nai, because it was played with a Thai reed Oboe, called Pi Nai.

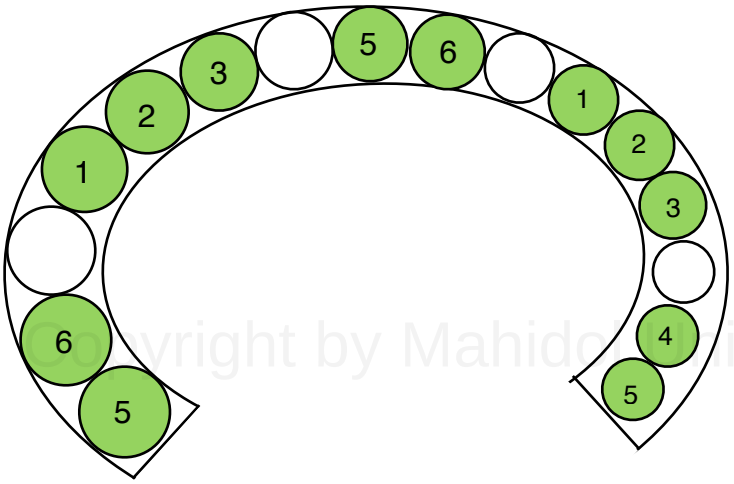


Figure 6.6 Thang Nai on Kong Wong Yai

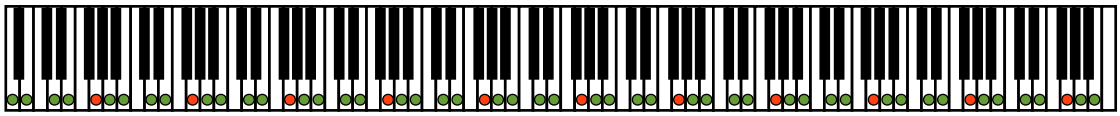


Figure 6.7 Thang Nai on Piano

6.1.2.3 Thang Klang

The first note is on the fifth gong. It is called Thang Klang, because it was played with Thai reed Oboe, called Pi Klang.

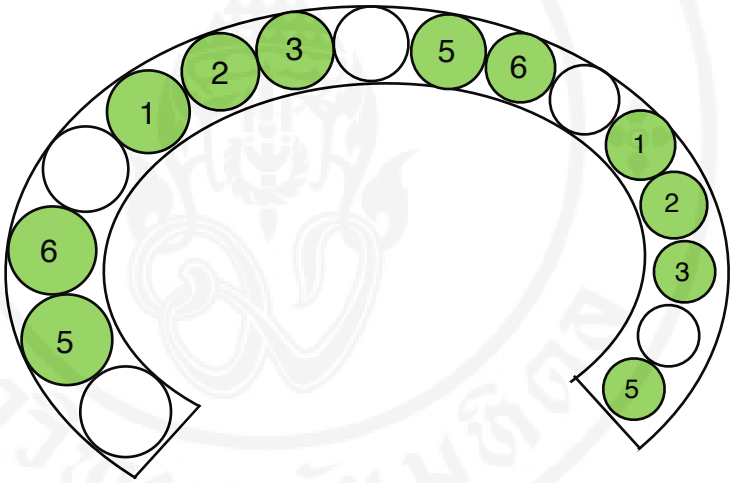


Figure 6.8 Thang Klang on Kong Wong Yai

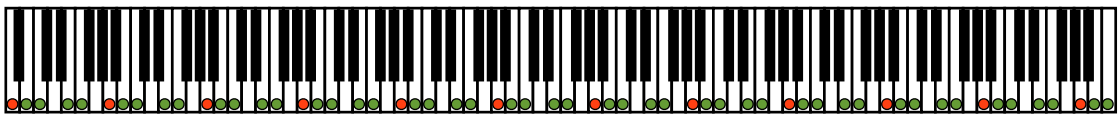


Figure 6.9 Thang Klang on Piano

6.1.2.4 Thang Piang-aw-bon

The first note is on the sixth gong. It is called Thang Piang-aw-bon, because it was played with a Thai duct flute, called Piang-aw.

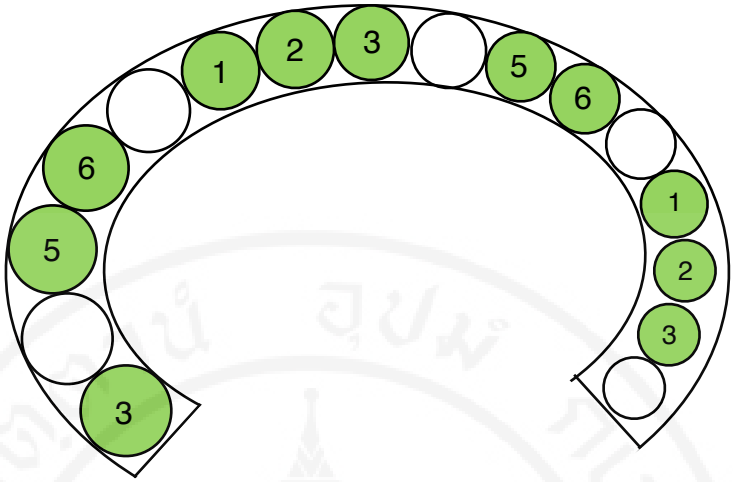


Figure 6.10 Thang Piang-aw-bon on Kong Wong Yai

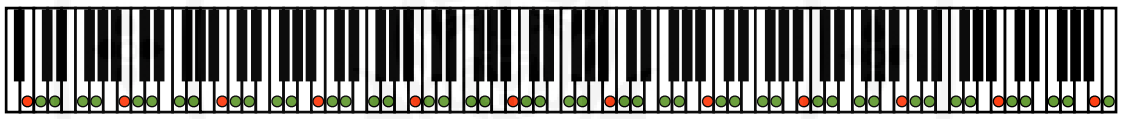


Figure 6.11 Thang Piang-aw-bon on Piano

6.1.2.5 Thang Nok

The first note is on the seventh gong. It is called Thang Nok, because it was played with a Thai reed Oboe, called Pi Nok.

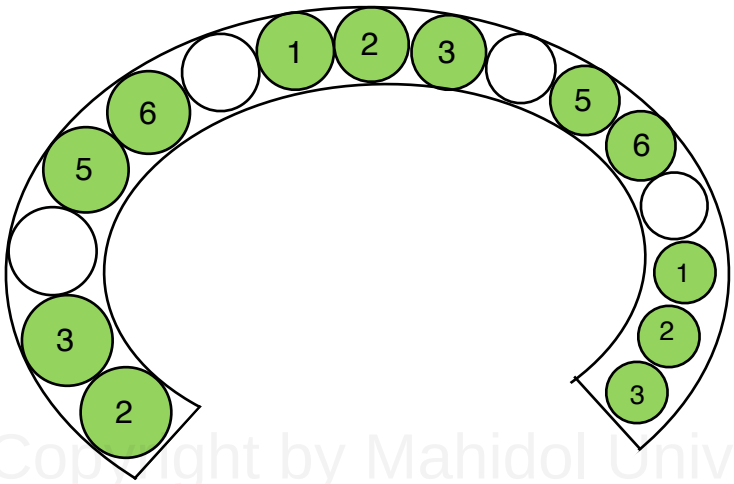


Figure 6.12 Thang Nok on Kong Wong Yai

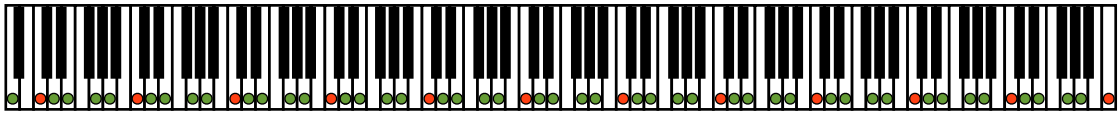


Figure 6.13 Thang Nok on Piano

6.1.2.6 Thang Klang hap

The first note is on the eighth gong. It is called Thang Klang hap, because it was played with a Thai reed Oboe, called Pi Klang.

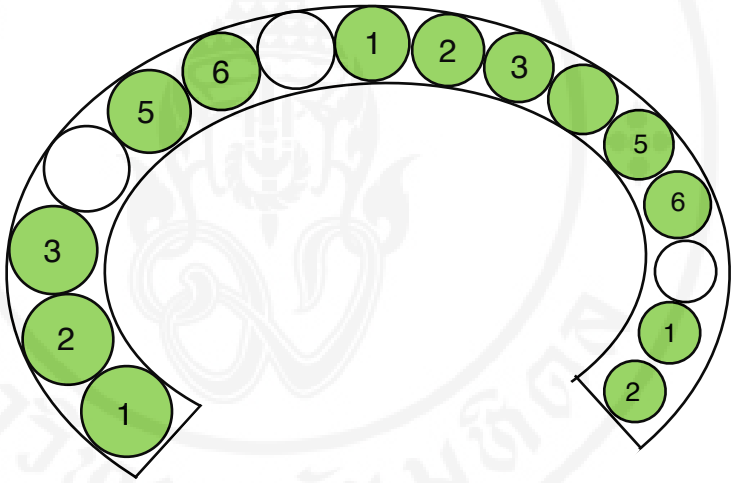


Figure 6.14 Thang Klang hap on Kong Wong Yai

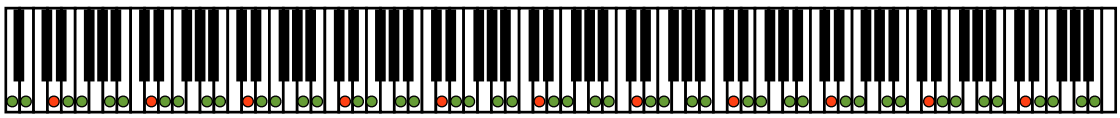


Figure 6.15 Thang Klang hap on Piano

6.1.2.7 Thang Chawa

The first note is on the ninth gong. It is called Thang Chawa, because it was played with a Thai reed Oboe called, Pi Chawa.

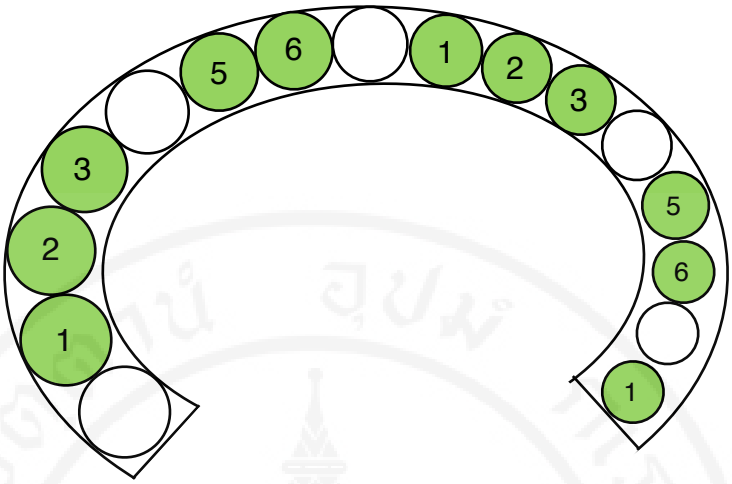


Figure 6.16 Thang Chawa on Kong Wong Yai

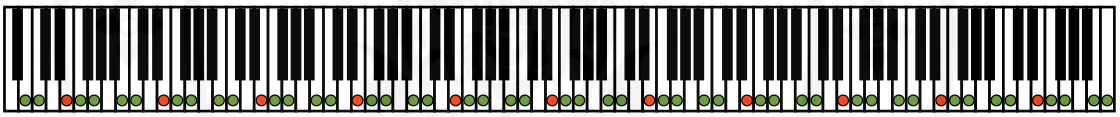


Figure 6.17 Thang Chawa on Piano

From the results of the study of the Thai musical scale, all Thai musical scale has the same structure, it consists of 1, 2, 3, 5 and 6 notes degree in the Thai musical scale system. It is similar to the movable Do Solfege method.

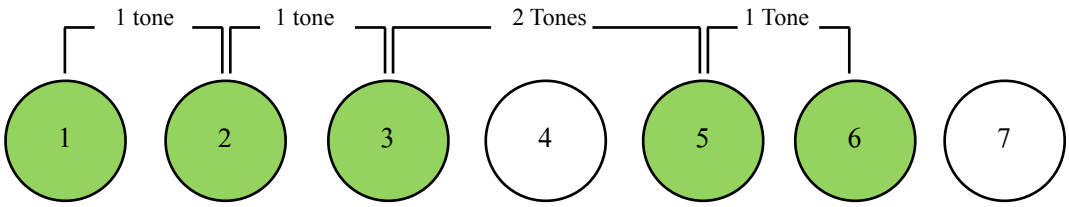


Figure 6.18 Structure of Thai musical scale

6.1.3 Setting tuning function of electric instruments into the Thai musical scale system

To set the frequency of pitches in electric instruments, such as the synthesizer or keyboard, into the Thai musical scale, a micro tuning function is used to adjust the frequency of pitch. For this reason, a frequency used by electric instruments has been set into equal temperament from a factory. If using electric instruments tuned in the Thai musical scale when performing with a Thai classical band, the sound will not be in tune. The micro tuning function can not be found on all electric instruments or software. Frequency of pitch can be adjusted by cent or by frequency.

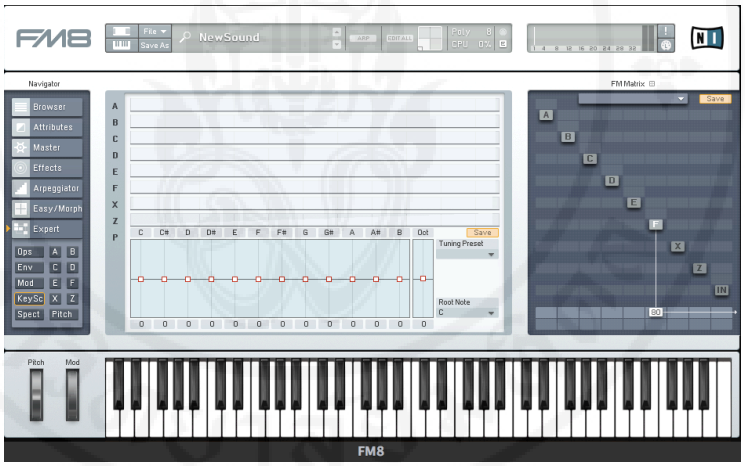


Figure 6.19 Micro tuning function in FM8 Plug-in

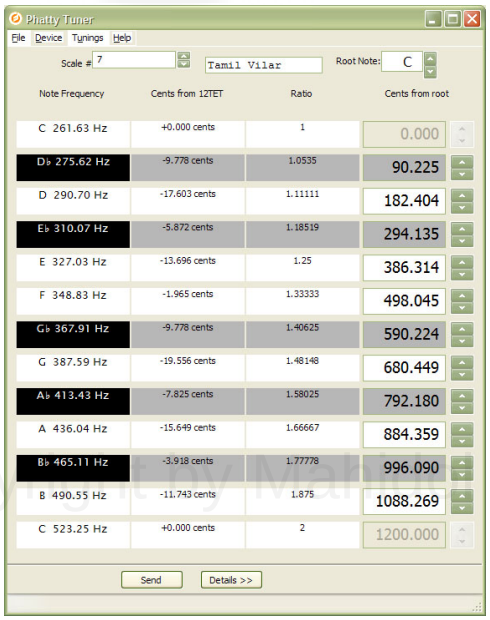


Figure 6.20 Micro tuning function by Moog in Phatty model

The result of using the micro tuning function in electric instruments with Thai instruments for performing Thai classical music, the audience felt a smooth sound but if micro tuning function was not used, then they felt a strange sound from the instruments. The results of the study can be used to tune Thai instruments and electric instruments, as well as to preserve the specific characteristic of the Thai classical scale system.

To use other electric instruments such as electric guitar or bass, all frets on fretboard must be taken off. Because the frets have been setup into the equal temperament system, it will be hard to use with the Thai musical scale system. Using fretless instruments to perform with a Thai classical band will work well when playing Thai classical music.

Figure 6.21 Fretless electric guitar

6.2 Discussion

After the structure of format of the Thai musical scale system and tuning function in electric instruments have been studied, the results have been discussed as follows

6.2.1 The frequency of the Thai musical scale system

The results of the frequency of Thai musical scale system have been calculated by using the initial frequency from C note in the equal temperament scale system (C = 261.63 Hz). The frequency of the Thai musical scale system is displayed in the table as follows.

Table 6.2 Cent and frequencies of Equal 7 tones scale

Note	Equal 7 Tones Scale	
	Frequency (Hz)	Cent
C	261.63	0
D	288.86	171.42
E	318.92	342.84
F	352.12	514.26
G	388.77	685.68
A	429.23	857.10
B	473.91	1028.52

According to the study, electric instruments work well with Thai instruments when adjusting the frequency into electric instruments by computer software and playback over MIDI tracks of a Thai song in Logic pro 9. This will preserve the characteristic of the Thai classical musical scale system.

After that, the researcher also calculated the frequency of the Thai 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 calculate the frequency of pitch, the results are as follows.

Table 6.3 Using D note frequency to be initial frequency of calculation

Initial frequency D = 293.66 Hz		
Note	Frequency (Hz)	Cent
1	293.66	0
2	324.22	171.42
3	357.97	342.84
4	395.23	514.26

5	436.36	685.68
6	481.78	857.10
7	531.93	1028.52
8	587.32	1200

Table 6.4 Using E note frequency to be initial frequency of calculation

Initial frequency E = 329.63 Hz		
Note	**Frequency (Hz)**	**Cents**
1	329.63	0
2	363.93	171.42
3	401.81	342.84
4	443.64	514.26
5	489.81	685.68
6	540.80	857.10
7	597.08	1,028.52
8	659.26	1,200

Table 6.5 Using F note frequency to be initial frequency of calculation

Initial frequency F = 349.23 Hz		
Note	**Frequency (Hz)**	**Cent**
1	349.23	0
2	385.57	171.42
3	425.71	342.84
4	470.02	514.26

5	518.94	685.68
6	572.95	857.10
7	632.59	1,028.52
8	698.46	1,200

Table 6.6 Using G note frequency to be initial frequency of calculation

Initial frequency G = 392 Hz		
Note	**Frequency (Hz)**	**Cents**
1	392	0
2	432.80	171.42
3	477.84	342.84
4	461.42	514.26
5	582.49	685.68
6	643.12	857.10
7	710.06	1,028.52
8	784	1,200

Table 6.7 Using A note frequency to be initial frequency of calculation

Initial frequency A = 440 Hz		
Note	**Frequency (Hz)**	**Cents**
1	440	0
2	485.79	171.42
3	536.36	342.84
4	592.18	514.26
5	653.82	685.68

6	721.87	857.10
7	797.01	1,028.52
8	880	1,200

Table 6.8 Using B note frequency to be initial frequency of calculation

Initial frequency B = 493.88 Hz		
Note	**Frequency (Hz)**	**Cents**
1	493.88	0
2	545.28	171.42
3	602.04	342.84
4	664.70	514.26
5	733.88	685.68
6	810.27	857.10
7	894.61	1,028.52
8	987.76	1,200

The results of calculation have been displayed in one table as follows

Table 6.9 The results of calculation of different initial frequencies

Note	**Frequency (Hz)**						
	C	**D**	**E**	**F**	**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

The results varied when changing the initial frequency to calculate the frequency of the Thai musical scale system.

6.2.2 Structure of the Thai equal 7 tone musical scale system

The results of the study of The Thai 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 Thang Piang-aw-lang, Thang Nai, Thang Klang, Thang Piang-aw-bon, Thang Nok, Thang Klang-hap and Thang Chawa. The structure of the Thai musical scales are as follows.

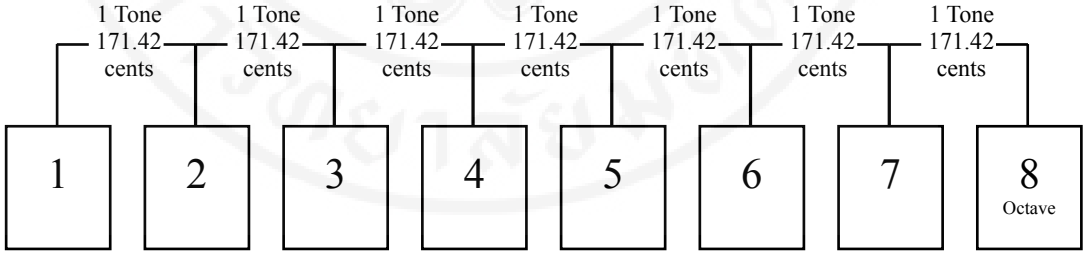


Figure 6.22 Structure of Thai musical scale system

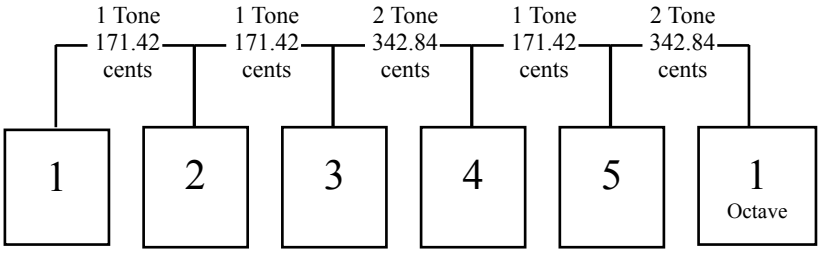


Figure 6.23 Structure of Thai musical scale

When considering notes that have been used in the 7 different Thai musical scales, they all have the same structure of intervals as follows

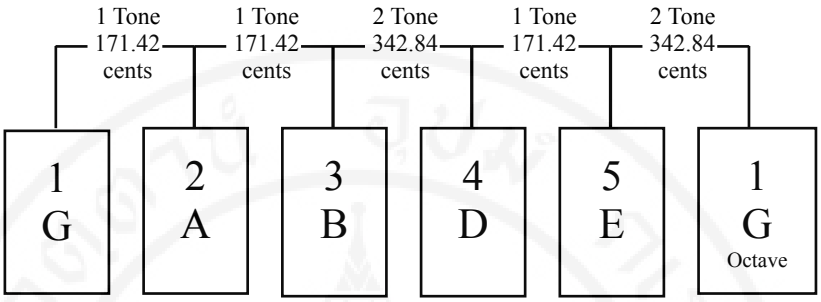


Figure 6.24 Thang Piang-aw-lang

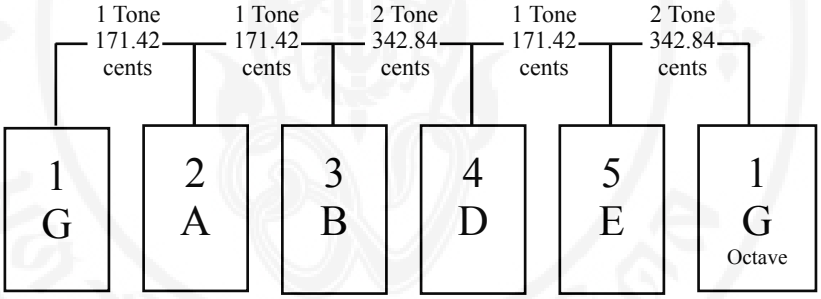


Figure 6.25 Thang Nai

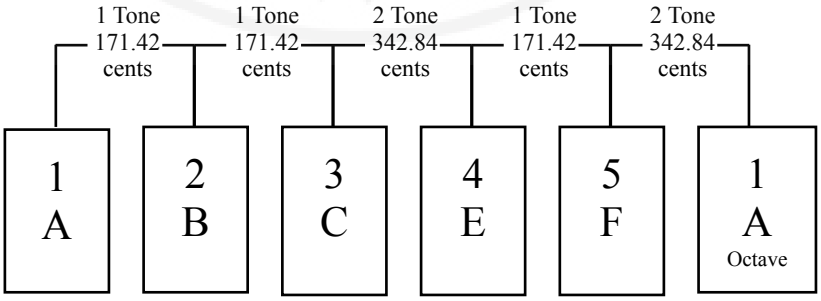


Figure 6.26 Thang Klang

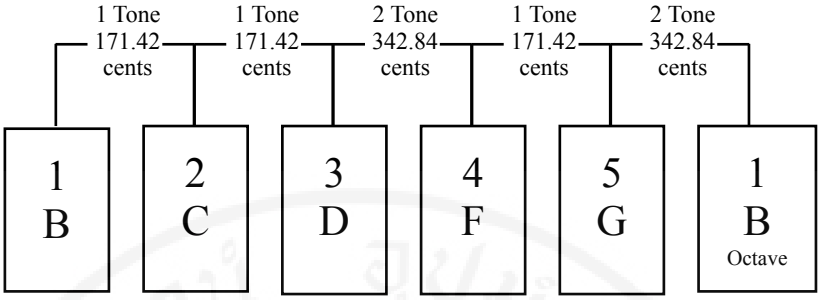


Figure 6.27 Thang Piang-aw-bon

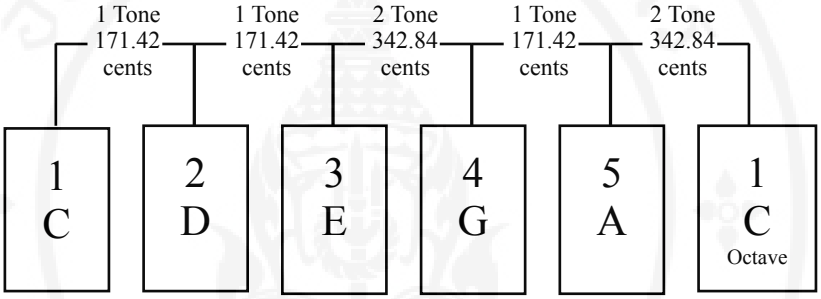


Figure 6.28 Thang Nok

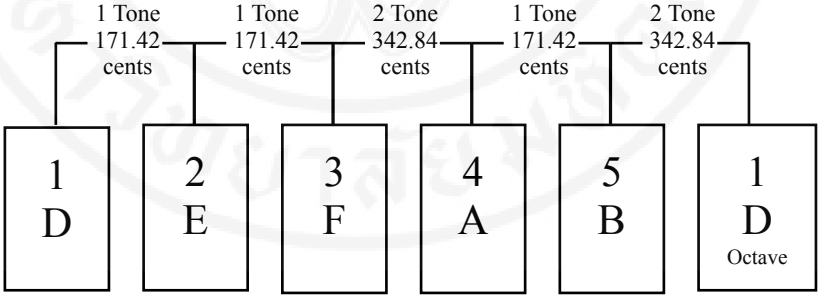


Figure 6.29 Thang Klang-hap

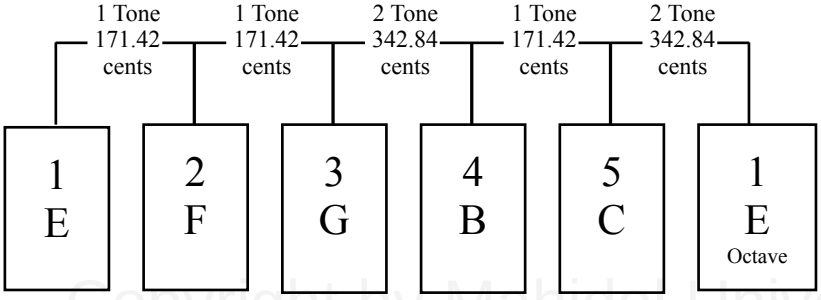


Figure 6.30 Thang Chawa

From the pictures of the structure of the Thai musical scale, consider the intervals of Thai musical scale. All scales have the same structure as follows.

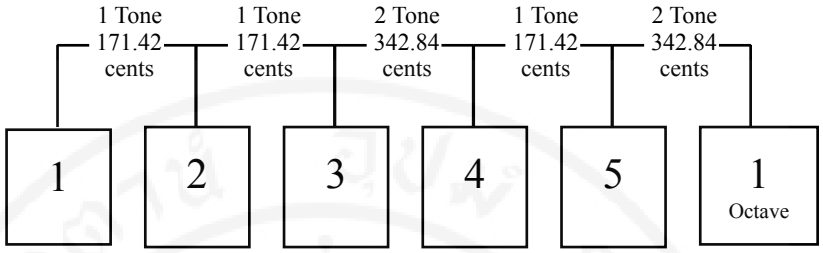


Figure 6.31 Structure of Thai musical scale

All scales include 5 of the 7 pitches in the Thai musical scale system. The sequence of pitches is as follows.

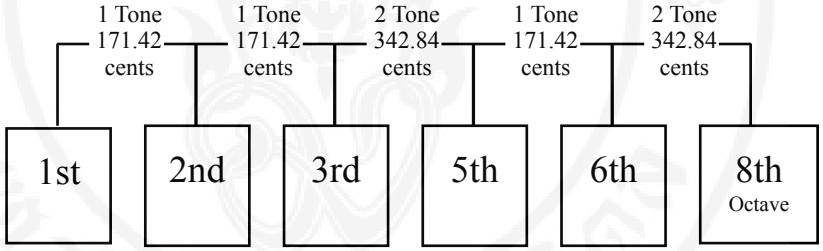


Figure 6.32 A sequence of Pitches in scale

The fourth and seventh note degrees have been used in other functions. They were used to modulate into another scale when performing a song or using for implied to some national characteristic. In a Thai band, consideration of which Thai musical scale to use depends on which Thai duct flute, or Khlui, is used.

6.3 Recommendation

6.3.1 Recommendations from the research

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

6.3.2 General recommendations

1.) The results of the study of the cent value can be used as a reference frequency for the Thai musical scale system.

2.) The results of the study of the structure and method of the Thai 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 Thai sound samples can not be found or recorded.

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