# Measurement methodology to characterize acoustic parameters of Thai fiddle (Sx ȃwng).

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***Abstract*** **The acoustic parameters and sound characteristics of an acoustic instrument are essential for a general use into the musical field. With the information, the musical instrument maker can use for developing in the design so that the quality of the musical instrument will be improved. The study in this area also provides knowledge for virtual acoustic parameters and recording techniques. This research aims to develop an effective and economic measuring methodology to characterize the acoustic parameters such as sound directivity of Thai string instruments (Sx ȃwng) in a real acoustic environment.**

***Keywords— Acoustic parameters, Sound directivity, Thai string instruments, Sx ȃwng,***

## I. INTRODUCTION

This paper present the measurement methodology which is the point out acoustic parameters process of Thai fiddle (Sx ȃwng) resonator. the Benefit of the directivity study of a musical instrument, to know the characteristic of the musical instrument. to be able to chose the right position for recording the musical instrument sound, to be able to indicate acoustic parameters of of music instrument. so that musical instrument maker can improve the quality of the musical instrument.

## II. BACKGROUND OF STUDY

In western music , The physics of musical instruments has been studying for centuries. There are several research study on direction of symphony orchestra Instruments.[x] The well known publication covering the subject of this paper has been written over 40 years ago by J.Meyer [4] who discussed the sound and directivity of the symphony orchestra instruments. Another publication that also the subject related to this paper written by Jukka Pätynen and Tapio Lokki in 2010. [7] Those research was woking only on the wastern music couture. But in area of Thai music instrument, expecailly the fiddle, there only similar research by Professor Udom Arunrath in1992.

In this paper is focus on the measurement methodology that can identify acoustic parameters of resonator of Thai fiddle (Sx ȃwng). The Sx ȃwng is a Thai fiddle, with two string that made of silk, with a handle of 72 cm long. The bow is approximately 68 cm long. It uses 120 to 150 ponytails. The resonator of the Sx ȃwng was originally used to make bamboo. The diameter of the resonator is about 7 cm wide and about 13 cm long. However, it can also make of rosewood or ivory.

Text

The resonator of the Sx ȃwng sound by the vibration of leather sheet of a python that is stretch on one side of resonator. [2]

Figure 1 Thai fiddle (Sx ȃwng)

Thai musical instrument design normally, it was made in the family from generation to generation.The creation of Thai musical instruments is made in a conservative manner. The design knowledge pass only family member. There have not been any rational explanation of the modification. Until recently, there is a design for extension of the Sx ȃwng handle's length and expand the size of resonator. Because of the modification of Sx ȃwng, to made musician can play the Sx ȃwng in chromatic scale easier, nevertheless the methodology of classify the sound quality is given by the words of the instrument maker or the musician. So that, the researchers have begun to interested in the study of Sx ȃwng acoustic parameters, which can be apply to classify the sound quality of the instruments objectively. the study will provide rational knowledge of how the musical instrument works,

## III. METHDOLOGY

From the literature review, there are two different methodologies to characterize acoustic parameters. First, the subjective methodology, that have a professional musician perform the passage of musical pieces and use microphone arrays record the sound simultaneously. For the objective methodology that is also commonly used as well, using a tone generator send out a test signal to drive the musical

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instrument via a transducer. then use an omnidirectional microphone record the sound for the musical instrument. The musical instrument must be place on the turntable and turned one degree at a time for record the sound form 360 degree angles. Both methods were conducted in the anechoic chamber. [3] [5] [6] 8] [10]

For this experiment is design measurement system base on the subjective method because the intention of researcher is to design a simple and economic system for musical instrument maker be able to effort and use. This will benefit the Thai society so that the Sx ȃwng will be improve and possibly be able to set the quality standard of Thai musical instrument.

### *A. Set up the system*

The first part of the system include the personal computer with a digital audio workstation software that send the digital audio signal to generate the test signal, which is a sine wave with specific frequency according to native playing range. [10]

For the reference of the signal amplitue level, it was set at – 12dB in order to prevent the damage of the leather sheet . Then the signal was amplify and send to the output transduser that drive the leather sheet to sound.

Table 1 Native playing range of Sx ȃwng.

| Number | Frequency (Hz.) | Note name |
|---|---|---|
| 1 | 377.8 | Sol (G) |
| 2 | 417.2 | La (A) |
| 3 | 460.6 | Si (B) |
| 4 | 508.8 | Do (C) |
| 5 | 561.5 | Re (D) |
| 6 | 619.9 | Mi (E) |
| 7 | 684.4 | Fa (F) |
| 8 | 755.7 | Sol (G) |
| 9 | 834.4 | La (A) |

[a] The Sound Frequency of Notes Used in the Thai Musical Scale. [1] [9]

The scound part is the input transducer that is a real time analizer microphone. The calibration of the omnidirectional microphones was carefully done with the microphone calibrater to match the reference signal level. However, there is minor concern about reflection of the sound from the floor that possible effect the acoustic property ( see in the Figure 1.) So that, Along the recording process, the turntable was put on a sheet of tick carpet and covered by the heavy blanket to prevent the room response.

The measurement was conducted in the sound control environment that has a noise criteria value as NC 40. So the there is not noise can effect the measurement because of a very high signal to noise ratio.

### *B. Recording techneque*

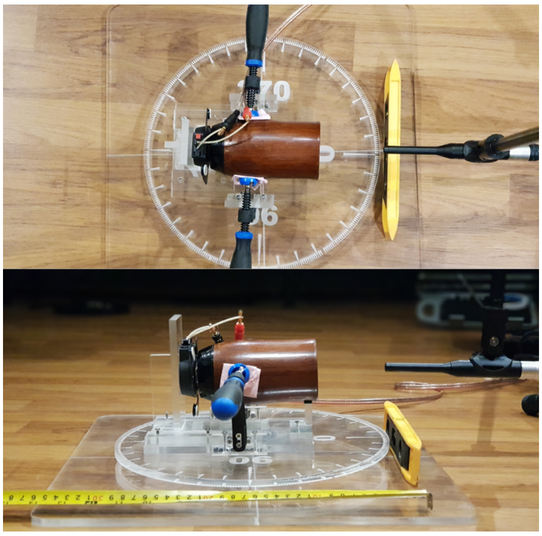
The meansued object that is the rasonator box of Sx ȃwng was fermly secured on the acrylic made turntable . On the surface of the turntable top was laser engraved the degree unit from 0 degree to 360 degree.

The measurement is made every 45 degree begin from the on axis position witch was set as the hollowed end or the resonator. In each recording position, the test signal that is sine wave of each note will be play ten time. For example, at zero-degree position, there was sine wave at 377.8 Hz (G) play 10 time each time play 10 seconds follow by with 3 seconds silen gap in between. then the next pich play 10 time till the ninght note. Then the turntable was manually 45-degree turned and repeat those step with the next note, until all sample was collected.

In term of microphone position, it was set at 15 cm far-from the center of the turntable. This is the closest position, due to the turntable size and clams position. If the position were closer than this, it would be very difficult to identify the deference of each angle. The sample of test signal was record in the same digital audio workstation with the digital audio resolution at 24 bit 48 kHz. The researcher also records the pitch of the resonator by using a stick strike a leather sheet of a python. The audio sample show the audio analizer that the pich of the resonator is ≈ 800 Hz

In addition, there are the resonators that use in this experiment. Those was made by difference musical instrument maker. However, the physical dimensions are almost the same. As the result, the measurement methodology will process with the resonators, if it able to point out the different or the similarity of the acoustic parameters such as sound directivity.

Figure 2 the setup of measurement system



## IV. Result

Analysis on the resonator provided results showing a uniform directivity in every native pitch. The data was processed. With the spreadsheet and calculated to average the data. the arithmetic mean in Table 2 - 4.

Table 2 Record data from Resonator A.

| (Hz.) | 0* | 45* | 90* | 135* | 180* | 225* | 270* | 315 |
|---|---|---|---|---|---|---|---|---|
| 377.8 | - 13dB | - 16dB | - 20dB | - 22dB | - 21dB | - 23dB | - 21dB | - 19dB |
| 417.2 | - 6dB | - 10dB | - 15dB | - 22dB | - 13dB | - 23dB | - 16dB | - 12dB |

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|---|---|---|---|---|---|---|---|---|
| 460.6 | - 9dB | - 14dB | - 15dB | - 20dB | - 13dB | - 20dB | - 16dB | - 13dB |
| 508.8 | - 13dB | - 15dB | - 19dB | - 22dB | - 13dB | - 20dB | - 16dB | - 14dB |
| 561.5 | - 15dB | - 18dB | - 19dB | - 22dB | - 13dB | - 21dB | - 19dB | - 17dB |
| 619.9 | - 13dB | - 17dB | - 20dB | - 21dB | - 13dB | - 22dB | - 19dB | - 17dB |
| 684.4 | - 11dB | - 15dB | - 19dB | - 22dB | - 13dB | - 22dB | - 18dB | - 15dB |
| 755.7 | - 8dB | - 11dB | - 13dB | - 18dB | - 13dB | - 17dB | - 14dB | - 13dB |
| 834.4 | - 1dB | - 4dB | - 10dB | - 13dB | - 13dB | - 16dB | - 11dB | - 6dB |

[b] in dB Full Scale.

Table 3 Record data from Resonator B.

| (Hz.) | 0* | 45* | 90* | 135* | 180* | 225* | 270* | 315 |
|---|---|---|---|---|---|---|---|---|
| 377.8 | - 14dB | - 17dB | - 20dB | - 20dB | - 19dB | - 21dB | - 20dB | - 19dB |
| 417.2 | - 17dB | - 22dB | - 22dB | - 23dB | - 20dB | - 24dB | - 20dB | - 23dB |
| 460.6 | - 17dB | - 19dB | - 22dB | - 23dB | - 23dB | - 20dB | - 16dB | - 13dB |
| 508.8 | - 16dB | - 20dB | - 22dB | - 24dB | - 25dB | - 21dB | - 20dB | - 20dB |
| 561.5 | - 16dB | - 18dB | - 21dB | - 24dB | - 24dB | - 21dB | - 20dB | - 19dB |
| 619.9 | - 15dB | - 17dB | - 20dB | - 24dB | - 23dB | - 24dB | - 20dB | - 18dB |
| 684.4 | - 13dB | - 15dB | - 19dB | - 21dB | - 23dB | - 22dB | - 18dB | - 18dB |
| 755.7 | - 8dB | - 11dB | - 12dB | - 16dB | - 16dB | - 17dB | - 14dB | - 13dB |
| 834.4 | - 8dB | - 8dB | - 12dB | - 14dB | - 16dB | - 19dB | - 13dB | - 8dB |

[b] in dB Full Scale.

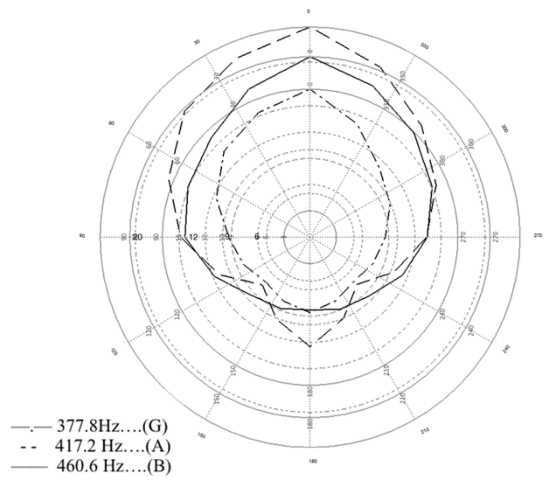
Table 4 Record data from Resonator C.

| (Hz.) | 0* | 45* | 90* | 135* | 180* | 225* | 270* | 315 |
|---|---|---|---|---|---|---|---|---|
| 377.8 | - 7dB | - 14dB | - 15dB | - 15dB | - 13dB | - 14dB | - 14dB | - 18dB |
| 417.2 | - 5dB | - 10dB | - 12dB | - 13dB | - 13dB | - 19dB | - 15dB | - 11dB |
| 460.6 | - 7dB | - 13dB | - 15dB | - 18dB | - 20dB | - 20dB | - 16dB | - 12dB |
| 508.8 | - 13dB | - 13dB | - 16dB | - 19dB | - 19dB | - 21dB | - 14dB | - 14dB |
| 561.5 | - 14dB | - 16dB | - 17dB | - 19dB | - 19dB | - 20dB | - 16dB | - 15dB |
| 619.9 | - 11dB | - 15dB | - 16dB | - 19dB | - 18dB | - 21dB | - 17dB | - 14dB |
| 684.4 | - 10dB | - 15dB | - 17dB | - 20dB | - 18dB | - 20dB | - 17dB | - 13dB |
| 755.7 | - 9 dB | - 11dB | - 12dB | - 16dB | - 15dB | - 17dB | - 14dB | - 11dB |
| 834.4 | - 3 dB | - 6dB | - 19dB | - 10dB | - 10dB | - 16dB | - 10dB | - 6dB |

[b] in dB Full Scale.

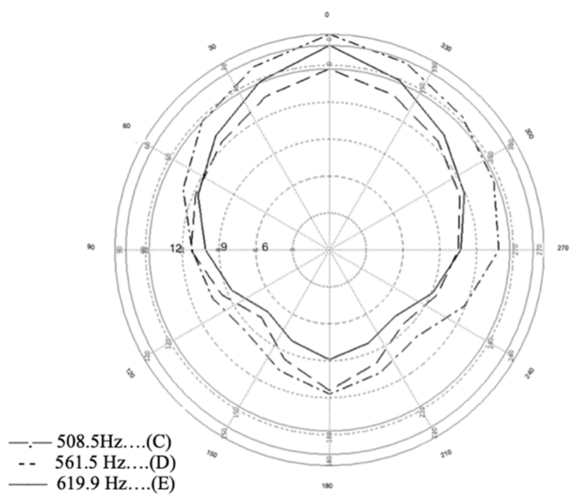
As exsample, the reseachers ploting the graph by an open source sofware mane Seilab. The direction of the rasonator A. shown in the Figure 2-4. In the Figure 2 shown the direction of the first three notes withch are 377.8 Hz (Sol /G) , 417.2 Hz ( La/ A), 460.6 Hz (Si /B). The directional of resonator of Thai is a super cardio shape. Even though the polarrity is the same pattern, the amplitue of each note is a bit deferent. This is possibly occur for any acoustic instrument which is normal phinorminon.

Figure 2 Graph show the direction of note G, A and B



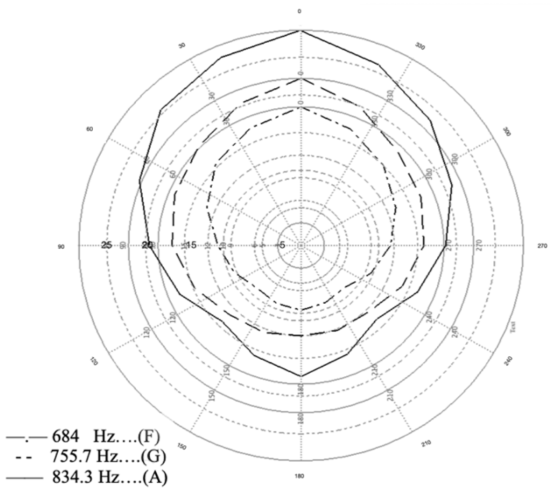

In the Figure 3 shown the direction of another three notes witch are 508.8Hz (Do/ C), 561.5Hz (Re /D), 619.9Hz (Mi / E). The polar pattern is super cardio which is the same as the first three note. This is possibly said the direction of resonator is uniform and a preferred shape, because the resonator can produce the same value both amplitude and the direction in every note. This is predictable and constant directivity.

Figure 3 graph show the direction of note C, D and E




In the Figure 4 shown the direction of another three notes that are witch are 684.4 Hz (Fa /F), 755.7 Hz (Sol /G), 834.4 Hz (La /A). This graph shows obviously the difference of amplitude of 684.4 Hz (Fa /F) and 834.4 Hz (La /A). This is unusual phenomenon because acoustically the higher of the frequency the lower of amplitude.

Figure 4 graph show the direction of note F, G and A




## V. Discussion

This experiment show the measurement methodology is practical. It can be use in the factorial situation as a quality assurance system. However, there is an upgrade the system as an option that will be some cost added, having a portable anechoic chamber that has cut off frequency at 300 Hz The anechoic chamber will reduce the noise and other effect from acoustical interferes.

In term of the measurement of the direction of the Thai fiddle (Sx̂ dwng) sound, include the study microphone recording technique, there should be measure by using the professional musician plays the instrument in an anechoic chamber and record data with microphone arrays. Because the method can identify the directivity of the Sx̂ dwng in the real performing situation precisely which the musician can uses various playing technique that acutely perform on stage.

The last measurement methodology that is possibly do, is to build and an automatic bowing machine to replace the output transducer or exciter. This method can generate the test sound equivalently for each time that the sample is collected. Moreover, this method can reduce the number of the measurement microphones because it will record sample one point at a time, compare to the second method that uses microphone array, but still have to do in the anechoic chamber. [8]

## VI. Conclusion

In conclusion, it was conformed that the measurement methodology is satisfactory work. It can characterize the polar pattern of The Sx̂ dwng resonator. It describes character of the musical instrument sound according to plan. It can point out in three aspects that include amplitude, frequency and directivity. additionally, the data from the measurement methodology can be apply for microphone technique. Particularly, in the area of Thai musical acoustic that have not been study yet. This possibly said that the measurement methodology has opened gate of the study in Thai musical acoustic.

In the next step, the system will be improved by adding portable and use in the real situation as a quality assurance tool for the musical instrument factory.

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