

# On Basic Frequency and Harmony Parameters with Different Frequencies of Mongolian Traditional Musical Instruments

**Bat-Enkh Oyunbileg<sup>1</sup>, Baatarkhuu Tsagaan<sup>1</sup>, Chuluuntsetseg Jamyaan<sup>2</sup>, Tuyatsetseg Badarch<sup>3</sup>, Battugs Oyunbileg<sup>2</sup>**

<sup>1</sup>Department of Information Technology, School of Information and Telecommunication, MUST, Ulaanbaatar, Mongolia

<sup>2</sup>Mongolian University of Art and Culture, Ulaanbaatar, Mongolia

<sup>3</sup>Mongolian National University, Department of Information Technology, Ulaanbaatar, Mongolia

## Email address:

o\_bat\_enkh@yahoo.com (Bat-Enkh O.), baatarkhuuc@yahoo.com (Baatarkhuu T.), ba.tuyatsetseg@mnu.edu.mn (Tuyatsetseg B.)

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**Abstract:** An instrument is a device that measures and/or regulates physical quantity/process variables as flow, temperature, level, or pressure. Instruments include many varied contrivance that can be as simple as valves and transmitters, and as complex as analyzers. We are determining Mongolian basic five instruments' electrical parameters, such as frequency and Hertz.

**Keywords:** Basic harmony, electrical parameters, Hertz and Db, harmonic series

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## 1. Introduction

Sound is air in motion – pushed, pulled, blown, plucked, talked, or sung into motion. Music is sound's highest achievement, a wonderfully varied mixture of patterned vibrations sent into the air by all kinds of instruments, from a cricket's hind legs to a massive pipe organ. Most people first visualize the frequency range from 20 Hz to 20,000 Hz.

Pitched musical instruments are often based on an approximate harmonic oscillator such as a string or a column of air, which oscillates at numerous frequencies simultaneously. At these resonant frequencies, waves travel in both directions along the string or air column, reinforcing and canceling each other to form standing waves. Interaction with the surrounding air causes audible sound waves, which travel away from the instrument.

The harmonic series is an arithmetic series ( $1 \times f$ ,  $2 \times f$ ,  $3 \times f$ ,  $4 \times f$ ,  $5 \times f$ , ...). In terms of frequency (measured in cycles per second, or Hertz (Hz) where  $f$  is the fundamental frequency), the difference between consecutive harmonic is therefore constant and equal to the fundamental. But because our ears respond to sound nonlinearly, we perceive higher harmonics as “closer together” than lower ones. On the other

hand, the octave series is a geometric progression ( $2 \times f$ ,  $4 \times f$ ,  $8 \times f$ ,  $16 \times f$ , ...), and we hear these distances as “the same” in the sense of musical interval. In terms of what we hear, each octave in the harmonic series is divided into increasingly “smaller” and more numerous intervals [2, 3].

The second harmonic (or first overtone), twice the frequency of the fundamental, sounds an octave higher; the third harmonic, three times the frequency of the fundamental, sounds a perfect fifth above the second. The fourth harmonic vibrates at four times the frequency of the fundamental and sounds a perfect fourth above the third (two octaves above the fundamental). Double the harmonic number means double the frequency (which sounds an octave higher).

## 2. Physical Characteristics of Mongolian Traditional Musical Instrument

There are Mongolian traditional basic five instruments, such as morin khuur, shudarga, khuuchir, limbe and yochin. The traditional musical instruments of Mongolia are most close to their life and customs and have constantly been used in their life. The Mongolian life and thought are peculiar and the folk music is distinctive in its melodious feature and

harmonious expression of the truth of the life.

**Limbe:** It is a wind instrument. The instrument is frequently used in accompaniment, occasionally also as a solo instrument. The sound reflects what is heard in the nature or the sounds of the natural and social environment.

**Morin Khuur:** (string instrument – horse-head-violin).

The Morin khuur is a typical Mongolian two-stringed instrument. The body and the neck are carved from wood. The end of the neck has the form of a horse-head and the sound is similar to that of a violin or a cello. The strings are made of dried deer or mountain sheep sinews.

Although, these traditional musical instruments are different in their mode, sound, structure and form they are compatible and correlated [6–8].

First, most of the above-mentioned musical instruments are stringed and bowed instruments, but only the limbe is a wind instrument and it plays a connecting role in softening and harmony of the sounds of the instruments.

Second, for their timbres they all are based on the five basic types of the pentatonic timbre of the folk music. For example, it is noted that the notes C, D, F, G and B, a popular pentatonic scale are similar to the composition of the pitches of the instruments including the shudarga, morinkhuur, and khuuchir. According to it the sound of each musical instrument has its peculiar timbre. The sounds of different musical instruments are proper high and low and they are different, depending on their timbre. The sound of a musical instrument is the physical phenomenon and feeling. The difference of the timbres depends on the proper vibrations of the waves of their double sounds. In other words, if the vibration of generating of sound is slow and wide in scope its continuation is slow. The vibration is an exact concept and first of all it is a combination of the vibrations of many parts of one body.

For example, according to the strings they vibrate only in its length and the vibration on the parts 2, 3, 4, 5, and 6 produces their own sound. Therefore, when the string fully vibrates its main tone is specially heard and it produces overtone. In other words, it is a sound refraction and one sound is the refraction of many micro sounds.

When a sound system in the bourdon system possesses a huge sound space in the stringed instrument, using the inner resource of a note it uses ultrahigh and infra low frequency. It is explained that although the sounds which are heard below the basic sound that can define the ascending overtone coincidence or the pitch, high sounds, accompanying sounds or double pitches sound above the basic sound, they belong to the ultrahigh sounds of the music [1–5, 7, 8].

According to the acoustics there are the additional sounds or resonance sounds except the basic sounds. The sounds of a musical instrument consist of the basic frequency and harmonies with different frequencies. For example the note G (Sol) of the lower octave of the shudarga unites many harmonies except the basic harmony (Table 1).

It in fact produces the harmony or timbre. The method to find the structure of the harmony of the sounds is disintegration of the frequency.

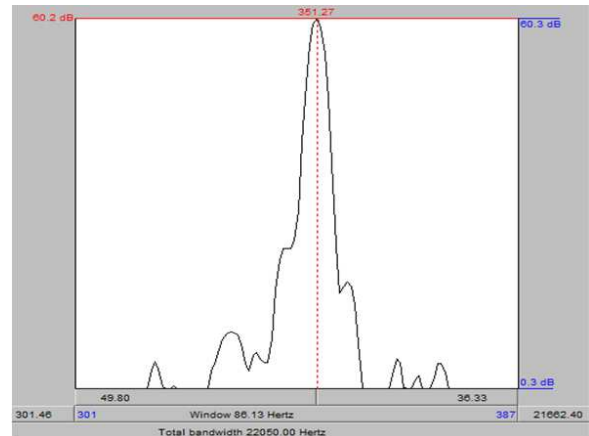
**Table 1.** G (Sol) Note of Lower Octave.

Harmonic Series	Hertz	Db
1	387.7	31.9
2	578.8	40.6
3	775.3	46.3
Basic	966.4	47.4
4	1161	42.6
5	1363	40.4
6	1552	37.4
7	1748	36.9
8	1939	31.6
9	2134	34.7
10	2327	34.5

### 3. Parameters of “morin khuur” Instrument

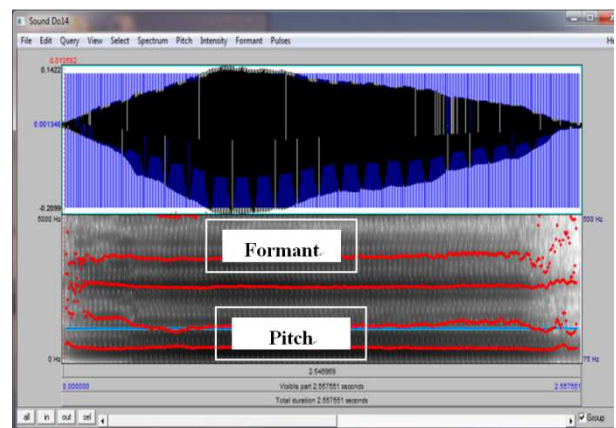
First, we defined some electrical parameters of Mongolian traditional instrument “Morin khuur.”

“Fig. 1” shows waveform and spectrogram of instrument “Morin khuur,” which illustrate Fa note of lower octave.



**Figure 1.** Electrical signals of Fa note of lower octave.

“Fig. 2” shows spectrum slice of instrument “Morin khuur”, which illustrates Fa note of lower octave. In this case, total duration is equal to 2.5 seconds and total bandwidth is equal to 22050 Hertz [3,10].



**Figure 2.** Electrical signals of “Morin khuur” instrument.

Fa note of lower octave for “Morin khuur” instrument include many harmonics. Its harmonic series, its Hertz and Db are presented in following Table 2. In this research we determined all electrical parameters of instrument “Morin khuur.” In following table (Table 3), there are basic, F1, F2, F3 and F4 harmonic series, its hertz and Db.

**Table 2.** Fa Note of Lower Octave.

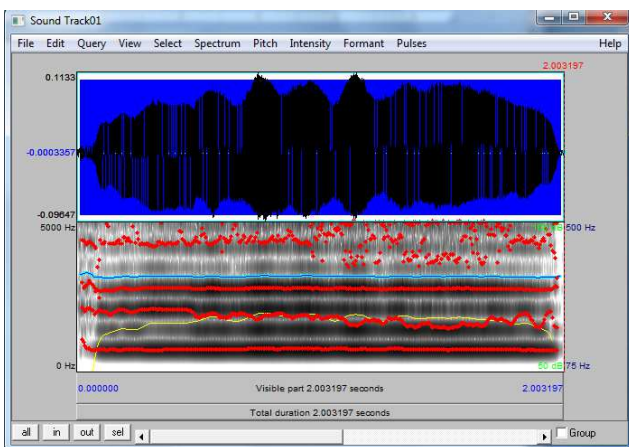
Harmonic Series	Hertz	Db
1	175.6	56.6
2	351.2	60.2
3	526.7	52.1
4	702.3	49.3
5	878	46.1
6	1053	40.6
7	1229	37.1
8	1404	36.5
9	1580	29.4

**Table 3.** Electrical Signal of “Morin khuur” Instrument.

	Basic	F1	F2	F3	F4
Do Hz	173.98	348	523.4	697.9	872.3
C Db	91.5	66	75.1	72.7	56
Re Hz	231.2	464.28	698.7	931.8	1164.8
D Db	84.5	83.7	78.9	54.4	62.4
Mi Hz	174.7	349.6	523.6	697.5	872.6
E Db	91.5	71.2	76.2	75.1	58.1
Fa Hz	697.5	1046	1396	1744	2094
F Db	84	61.8	54.9	51.8	68.6
So Hz	522.5	1045	1570	2090	2615
G Db	80	57.9	49.3	66.4	64.5
La Hz	3491	4187	4886	5585	6284
A Db	74.1	57.6	49.5	55.6	53.1
Si Hz	2637	3516	4397	5279	6154
B Db	77.7	74.8	67.7	64.9	59.9

## 4. Parameters of “Limbe” Instrument

We also defined basic frequency and harmony parameters of Mongolian traditional instrument “Limbe”. For example, we determined that basic parameters of Do note for



**Figure 3.** Electrical signals of Do note of lower octave.

“Limbe” are 63.0 Db, 689.7 Hertz.

“Fig. 3” and “Fig. 4” show waveform, spectrogram and spectrum slice of instrument “Limbe”, which illustrate do note of lower octave.

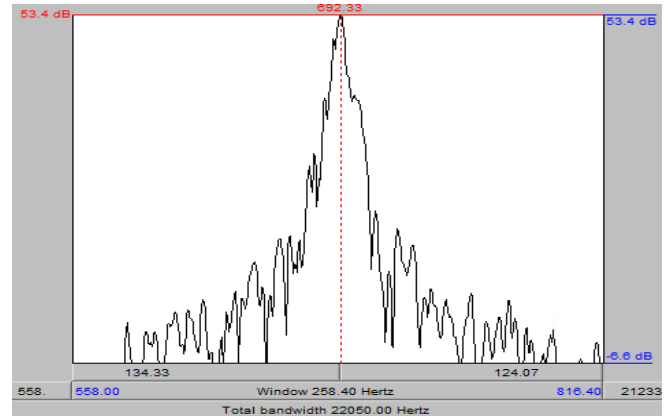
Also results of W (Bandwidth) and Harmonics (F1, F2, F3, F4) are presented in following Table 4 [3,10].

In this research we determined basic electrical parameters of instrument “Limbe”.

**Table 4.** Parameters of Do note for “Limbe” Instrument.

F1 (Hz)	W	F2 (Hz)	W	F3 (Hz)	W	F4 (Hz)	W
716.3	92.6	1770.2	312.3	2741.9	106.1	4228.3	1133

In following Table 5, there are basic, F1, F2, F3 and F4 harmonic series, its hertz and Db.



**Figure 4.** Electrical signals of “Limbe” instrument .

We used Praat 4 version. Praat is a software that is used to acoustic analysis. In other words, Praat is a free scientific computers software package for the analysis of speech in phonetics.

**Table 5.** Electrical Signal of “Limbe” Instrument.

	Basic	F1	F2	F3	F4
Do Hz	691	1381	2074	2765	3453
C Db	84.2	67.3	64.5	54	40.9
Re Hz	459	920.79	1383	1849	2304
D Db	78.9	66	62.9	45.1	51.4
Mi Hz	458.6	921	1385	1850	2308
E Db	77.4	60.6	60.6	48.8	51.4
Fa Hz	923	1861	2788	3718	4645
F Db	80.8	55.6	65.1	37.5	54.8
So Hz	1390	2074	2770	4165	5560
G Db	83.2	36.2	50.7	56.6	49.8
La Hz	1860	2798	3736	5612	7467
A Db	72.6	36.8	58	62.9	42.1
Si Hz	2366	2783	3014	4745	7079
B Db	82.7	28.9	29.1	41.3	40.6

## 5. Conclusion

Using Praat 4 software, we define basic frequency and harmony parameters of Mongolian traditional instrument. Mongolian basic five instruments that were enriched to become orchestra are kept until our century. Further we need

to research a consistency between other countries and Mongolian traditional instruments.

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