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SARON DEMUNG'S TIMBRE AND SONOGRAM OF GAMELANS *GUNTURMADU* FROM *KERATON NGAYOGYAKARTA*

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ABSTRAK

Penelitian ini bertujuan untuk mempelajari spectrum warna bunyi (*timbre*) dan sonogram dari Saron Demung Gamelan Gunturmadu dari Keraton Ngayogyakarta. Suara setiap wilahan direkam dengan bantuan pengolah suara yang ada pada komputer. Akurasi frekuensi yang dapat diperoleh dengan pengolah ini adalah 1 Hz. Frekuensi dasar dari saron demung gamelan Gunturmadu untuk setiap wilahan #1 sampai dengan #7 masing-masing adalah 197, 207, 221, 261, 285, 304, 326 Hz. Lokasi frekuensi harmonik tidak berturutan akan tetapi disisipi dengan frekuensi tak harmonis. Jumlah frekuensi harmonis dan tak harmonis yang membentuk warna bunyi untuk setiap wilahan berbeda. Ketebalan garis frekuensi dasar pada sonogram bertahan lebih lama dibandingkan dengan frekuensi lain pada suatu wilahan.

ABSTRACT

The aim of this research is to study the timbre spectrums of *Saron Demung* instruments of gamelans *Gunturmadu* of *Keraton Ngayogyakarta*. This gamelan, as a set of traditional Javanese ensemble, are a pelog scale, seven scale in one octave. Sound of *Saron Demung* instruments are recorded by sound software. This software can display waveform in time domain and spectrum in frequency domain. The fundamental frequency is shown directly by software. Other peak frequencies can be traced by shifting the cursor on top of it. The accuracy of frequency that can be produced is 1 Hz. Fundamentals frequencies of *Saron Demung* keys #1 to #7 of gamelan *Gunturmadu* are 197, 207, 221, 261, 285, 304, 326 Hz respectively. The location of the harmonic frequencies are not always consecutive, but sometimes punctuated by another frequency. The numbers of harmonics and inharmonic frequencies of each keys are different. The thick lines of the fundamental frequency in sonogram exist in longer time than the other.

Keywords: gamelan; *saron demung; gunturmadu*

INTRODUCTION

Musical instruments have been of interest to scientists from the time of Pythagoras, 2500 years ago, and since then many famous physicists, among them Helmholtz, Rayleigh and Raman, have devoted at least some of their attention to them (Fletcher,1999). Every musical instrument produces a unique sound wave with distinguished characteristics. Human's hearing perception could detect the differences between two or more musical sound waves. The unique characteristics of sound wave can be determined by frequency, sound pressure level, time duration of sound wave's propagation, and time envelope (Sethares, 2005).

Good starting point for discussing Indonesian gamelan music is Gamelan Sekaten (*Gunturmadu* and *Nagawilaga*) for several reasons. Because of its great *age*, we can imagine that its musical style is reminiscent of pre-Islamic gamelan music. Its musical structure provides some insight into how gamelan music might mimic the organization of the cosmos. Many of the musical principles that govern Sekaten music are apparent in more modern gamelan styles.(Spiller, 2004). Gamelan Sekaten is associated with a festival called Garebeg Maulud or Sekaten, which honors the anniver-

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sary of the birth of the prophet Muhammad. Sekaten takes place during Muslim "holy week," which is the 6th to the 12th of the third Javanese month Maulud (equivalent to the Islamic month Rabi'ul Awal). Gunturmadu is one of two the (Sumarsam, 1980).

The Javanese gamelan has been studied by experts from both Western and culture of the East. British physiologist AJ Ellis in 1884 was pioneer on scientific investigation with measurement of Javanese gamelan tones. have Dutch musicologist Jaap Kunst in 1933 (Wasisto,1969) has conducted investigations on the gamelan tone system intensively by measuring the frequency of vibration instrument. The main tool used at the time was the thoroughness monochord rely on the ability of hearing (ears) a person. Then in 1969, Wasisto *et al*. also studied the gamelan used the instrument more modern than the previous, Cathode Ray Oscilloscope. However, Jaap Kunst and Wasisto *et al*. limited to measuring the fundamental frequencies, i.e. frequencies that have the highest amplitude, but cannot display the timbre in the study of music theory (Sethares, 2005). Guangming (2006) used the result of Wasisto to construct a theory of *slendro*.

Timbre is one of the factors that enables us to distinguish the G played on the violin from an equally loud G played on a piano or a trumpet or any other instrument. Two instruments that are producing the same *steady* musical note are producing periodic patterns having the same frequency. It is this frequency that determines the *pitch* of the note. However, the two sets of relative amplitudes of the Fourier components are different. This difference is one of the important factors that distinguish the timbres of musical instruments (Gunther, 2012). Timbre analysis utilizing Fourier transformation, a transformation that changes the waveform in time domain to the form of spectrum is in frequency domain. Fourier spectra do an excellent job of identifying the frequency content of individual notes, it is as easy here to assign fundamentals and overtones (Howard, 2009). The Fourier spectrum tells us the most important information pertinent to the timbre of the sound wave. We can use an electronic device called a Fourier analyzer, or spectrum analyzer, to determine the harmonic content of any arbitrary musical tone or other waveform (Berg, 2005). This technique has been used to study the Javanese music as *angklung* (Ridzuwary, 2009), and gamelan music (Merthayasa, 2008; Suprapto, 2011; Heru, 2011).

Saron is a generic term for a keyed instrument with six or seven keys that covers one octave of either the *slendro* or *pelog* tuning system. The saron family of instruments are *Saron Demung, Saron Ricik,* and *Saron Peking.* They are metallophones with six or seven bronze keys placed on a wooden frame which serves as a resonator. The r*icik*, which has thick keys provides the medium octave of the *Saron* group. The *Saron Demung*, which has thick keys (narrower than the *ricik*'s keys) provides the high octave of the saron group. The *Saron Peking*, which has thick keys narrower than the *Saron Demung*, provides the highest octave of the *saron* group.

The sound of *Saron Demung*'s keys of gamelan *Gunturmadu* are analyzed in this research. Analyzing the *Saron Demung* is important to recognize the main characteristics that make up the unique sound of the *Saron Demung*. This research will examine the timbre of each *Saron Demung's* keys and determine the main characteristics. This research will also compare the fundamental frequency resulted from different methods.

METHOD

Data are collected in *Karaton Kasultanan* Ngayogyakarta (Yogyakarta Sultanate Palace), Indonesia. The musician blends are palace courtiers assigned as the gamelans. The appointment was recommended by *Panghageng Kawedanan Hageng Punakawan Kridhamardawa* in *Karaton Ngayogyakarta, GBPH Yudhaningrat*.

Microphones to capture sound are placed near each instrument. These microphones are connected to a portable computer that already contains sound processing software. The resulting sound is recorded and stored. Preliminary analysis is carried out after each recording to determine the consistency of the resulting spectrum. Further analysis is conducted in the laboratory.

Audio processing software displays the waveform of the signal intensity in the form of graphic as a function of time. To obtain a frequency spectrum of intensity as a performed function, the spectrum analyzer menu is turned on. This menu works based on Fast Fourier transform (FFT). The frequency range is displayed in the audio, which is 20 -20 000 Hz. By turning on the statistics menu, the signal being analyzed can be displayed directly from the fundamental frequency. The next peak fre-

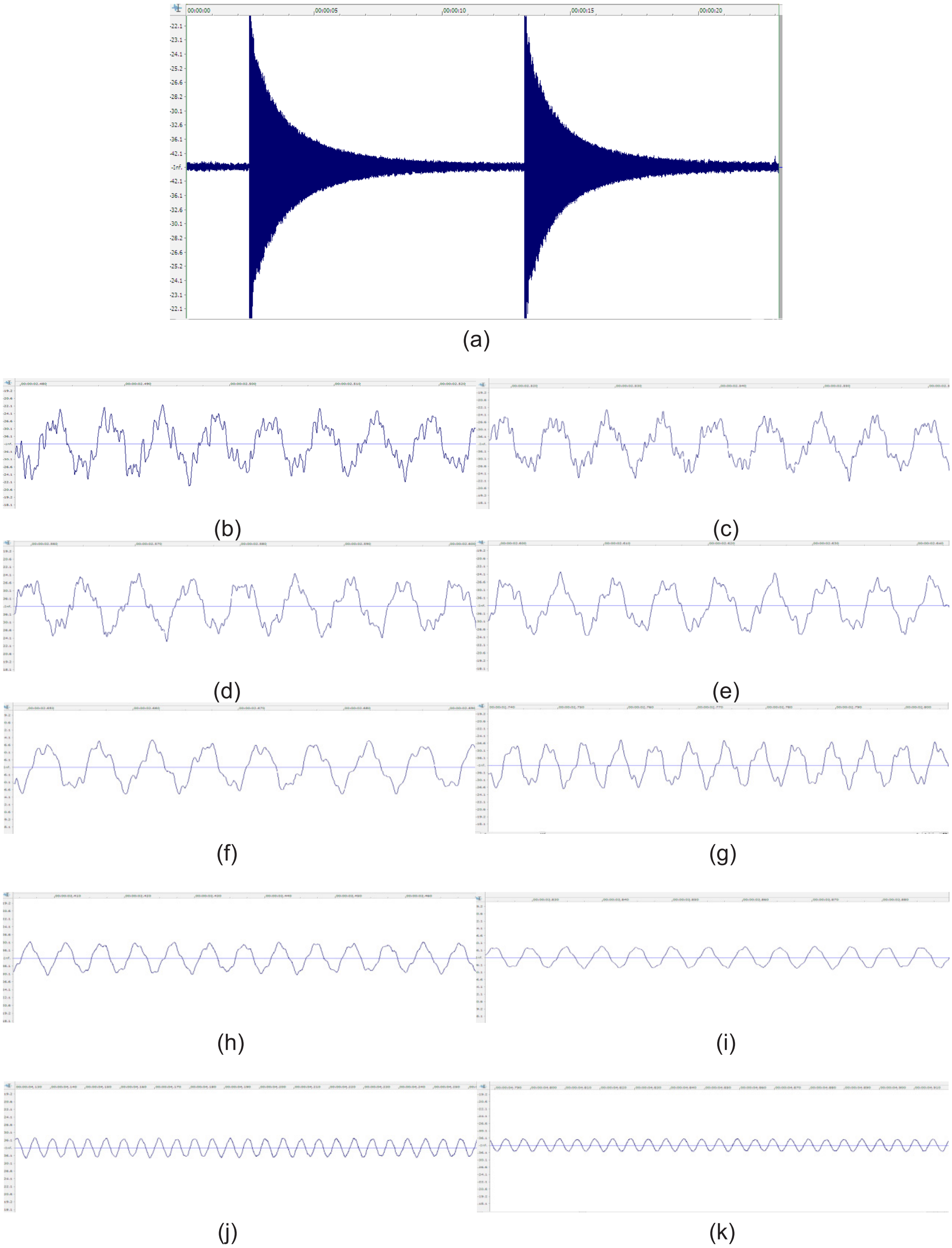
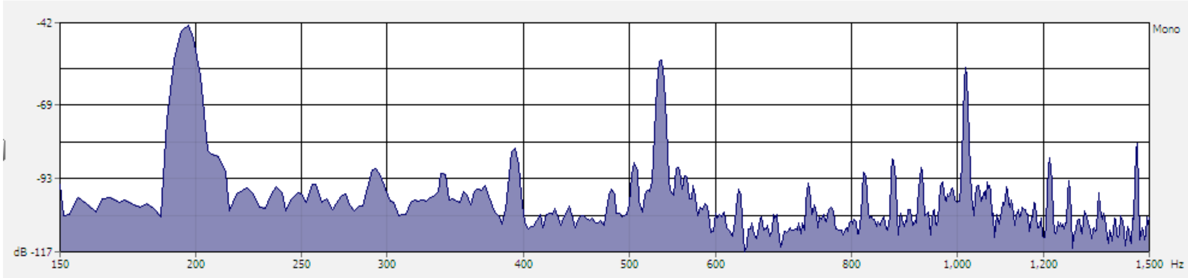


Figure 1. Evolution of waveform *Saron Demung* key #1

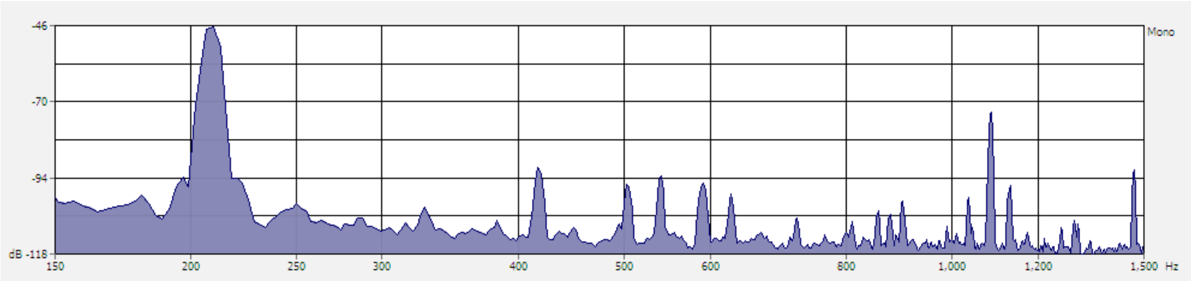
quencies can be determined by shifting the cursor on the top of it. The accuracy that can be generated frequency is 1 Hz.

RESULTS AND DISCUSSION

Figure 1(a) shows the waveform of key #1 of *saron demung* of *Gunturmadu*. The peak intensities start at 00:00:025 second and finish at 00:00:105 second. Waveform is sliced to determine the evolution of its constituent waves, as shown in Figure 1 (b) to 1(k). The first waveform element in Figure 1 (a) shows the inharmonic wave, indicate that it was constituted by


-42
-69
-93
dB -117
150
200
250
300
400
500
600
800
1,000
1,200
1,500 Hz
Mono

#1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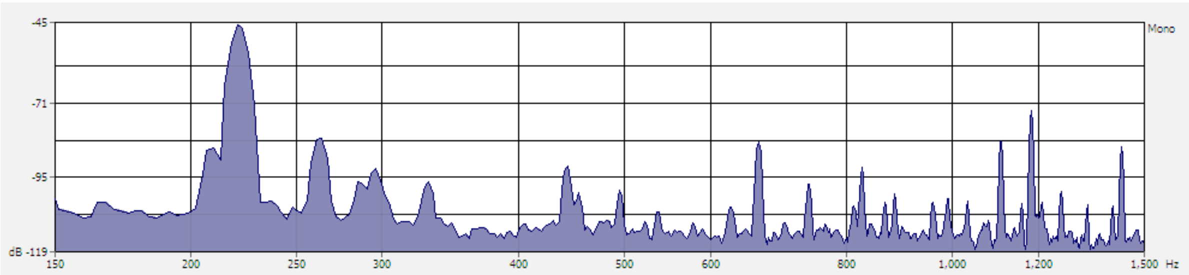
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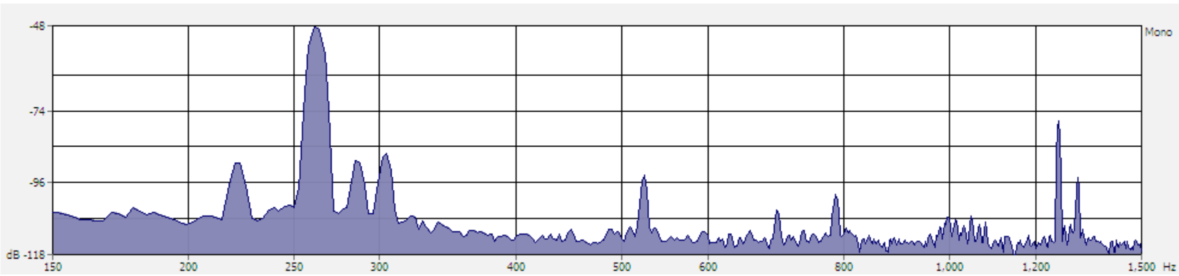
#3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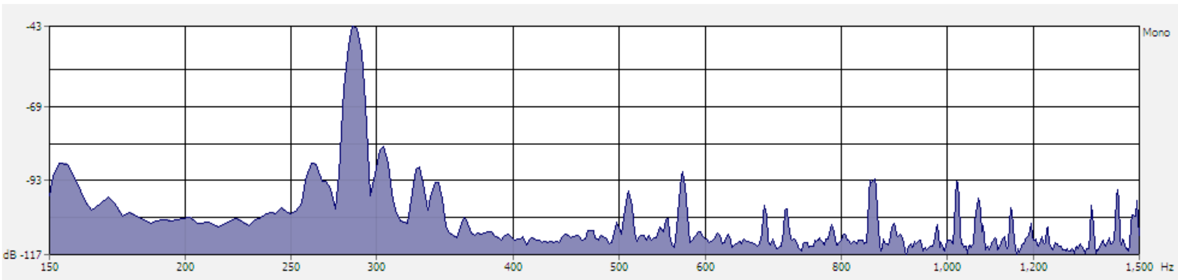
#4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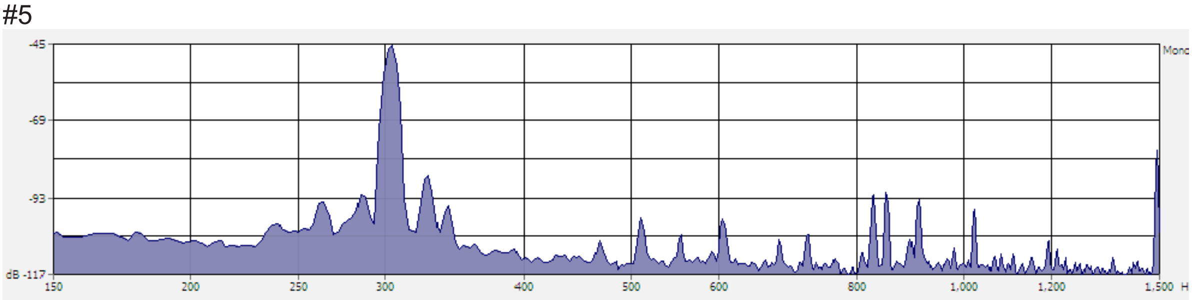
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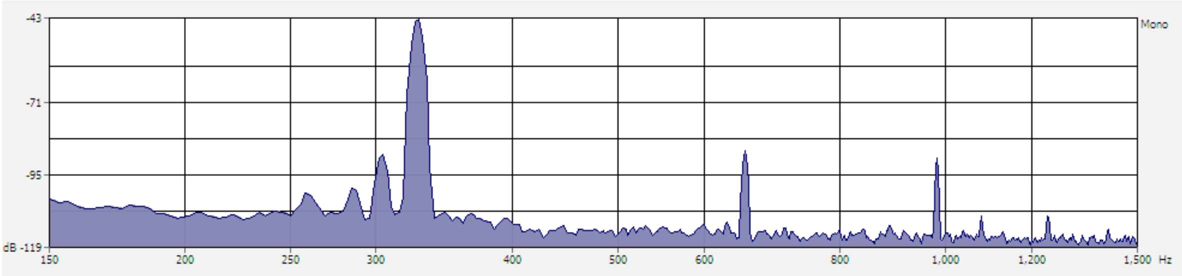


#7

Figure 2. The spectrum for each key saron demung. Each key shows the spectrum for the fundamental frequency and the frequency of non-harmonic.

many wave with different frequencies. The waveform changes slowly and finally becomes a harmonic wave. This shows that several constituents waves weakened, leaving the main wave with particular frequency. Similar result of an *angklung*. (Ridzuwary, 2009).The frequency spectrum of an *angklung* that each primary rattle has a single fundamental frequency. Harmonics of that frequency are either very weak or nonexistent. Some inharmonic peaks are observed to be present in the spectrum.

The frequency of the constituents' waves can be seen in Figure 2. Figure 2 is a Fourier transformation- the intensity as a function of frequency- from Figure 1 which is a function of time for each keys (*wilahan*). Frequency which has the highest intensity is the fundamental frequency. This frequency is in the region is quite wide compared to other frequency regions. Fundamental frequency and the frequency adherents formed the distinctive timbre of each musical instrument. It seen from the Figure 2 #1 to #7 that the fundamental frequency is different for each key. Table 1 shows the fundamental frequency obtained from #1 to #7. The results of this study compared with the results of Wasisto (1969) which showed a similarity. The difference is that in this study may indicate the timbre that is generated for each key. Table 2 shows the frequencies that make up the timbre produced by each key. These frequency values are normalized to the fundamental frequency. Figures in bold indicate multiples of the fundamental frequency, which means frequency harmonics. Harmonic frequency is inserted with inharmonic frequency, which is characterized by not integer numbers. The number of harmonic frequencies for each key is different. Likewise, non-harmonic frequency.

Table 1. Comparison fundamental frequencies (in Hz) of *Gunturmadu* of this study and in Wasisto (1996)

Keys number	This study	Wasisto (1996)
#1	197	198
#2	207	207
#3	221	220
#4	261	267
#5	285	288
#6	304	304
#7	326	328

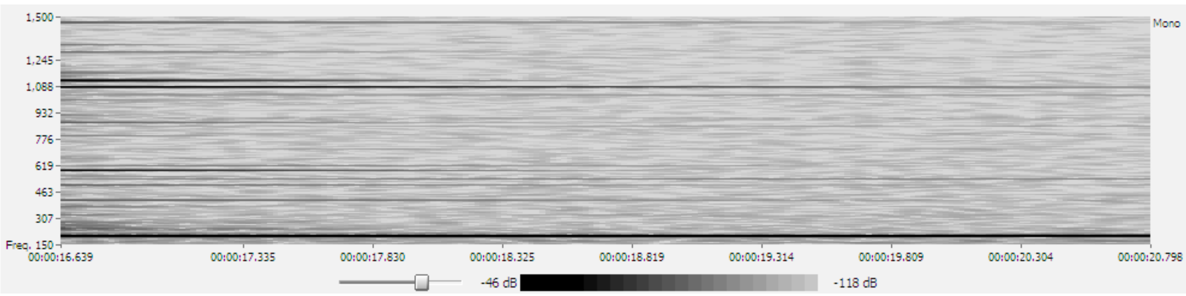
Evolution of frequency versus time is described by the sonogram shown in Figure 3. The thickness of the lines on the sonogram shows the intensity of that frequency. The thick lines which are at the bottom is at the fundamental frequency. These lines exist in a period of time longer than the other. The existence of a line indicates the frequency that gives color to the sound. The line of frequency rather than the fundamental frequency gradually decreased in intensity which eventually disappeared.

CONCLUSION

Fundamentals frequencies of *Saron Demung* keys #1 to #7 of gamelan *Gunturmadu* are 197, 207, 221, 261, 285, 304, 326 Hz respectively. The location of the harmonic frequencies are not always consecutive, but sometimes punctuated by another frequency. The numbers of harmonics and inharmonic frequencies of each keys are different. The thick lines of the fundamental frequency in sonogram exist in longer time than the other.

Table 2. The timbre of each instrument of *Saron Demung* on gamelan *Gunturmadu*. Frequency peaks are normalized to the fundamental frequency of each instruments.

Peak order	Keys number						
	#1	#2	#3	#4	#5	#6	#7
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1.71	2.01	1.19	1.10	1.06	1.08	2.00
3	1.98	2.43	1.33	1.16	1.15	1.12	3.01
4	2.72	2.61	1.49	2.01	1.20	1.67	3.32
5	4.22	2.85	2.01	2.66	1.79	1.82	3.81
6	5.17	3.03	2.06	2.81	2.01	1.99	4.82
7	6.17	3.48	2.25	3.02	2.39	2.24	
8	7.43	4.12	2.43	3.82	2.50	2.38	
9		4.25	2.84	4.02	2.99	2.72	
10		4.34	3.00	4.82	3.59	2.80	
11		5.00	3.34	5.02	3.75	2.99	
12		5.24	3.74	5.81	4.02	3.36	
13		5.45	3.93		4.76	4.91	
14		6.25	4.00		5.02		
15		7.10	4.22				
16			4.67				
17			5.02				
18			5.24				
19			5.34				
20			5.70				
21			6.02				
Number of harmonics	2	5	6	5	5	3	3



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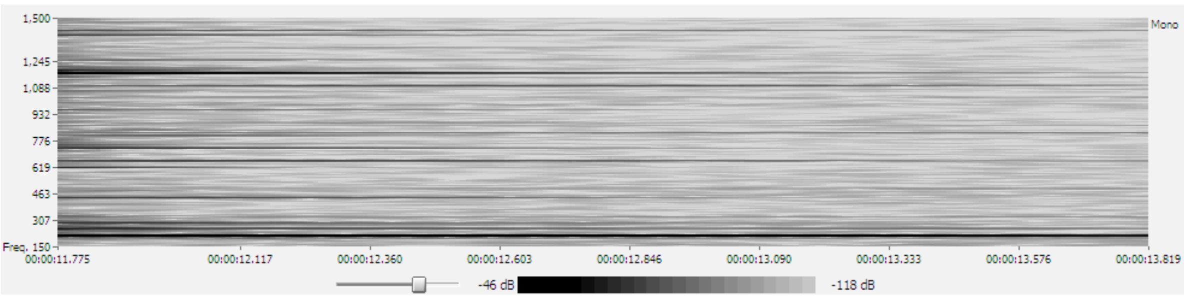

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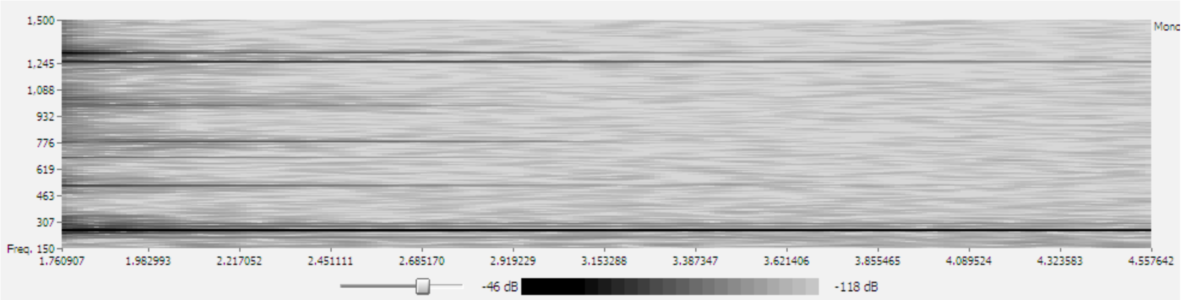

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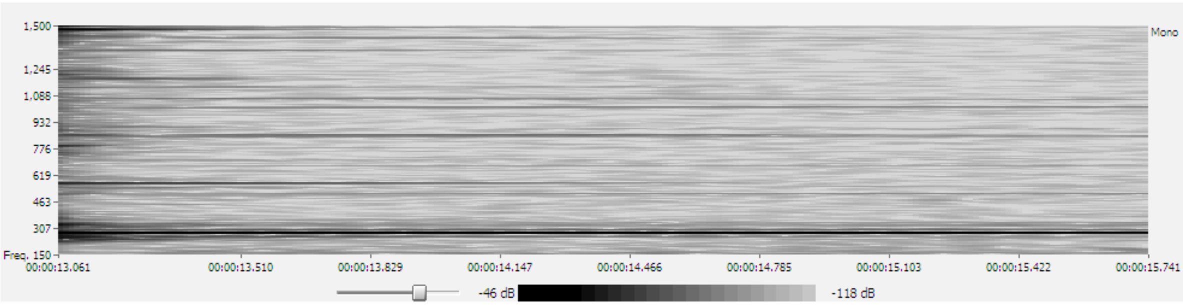

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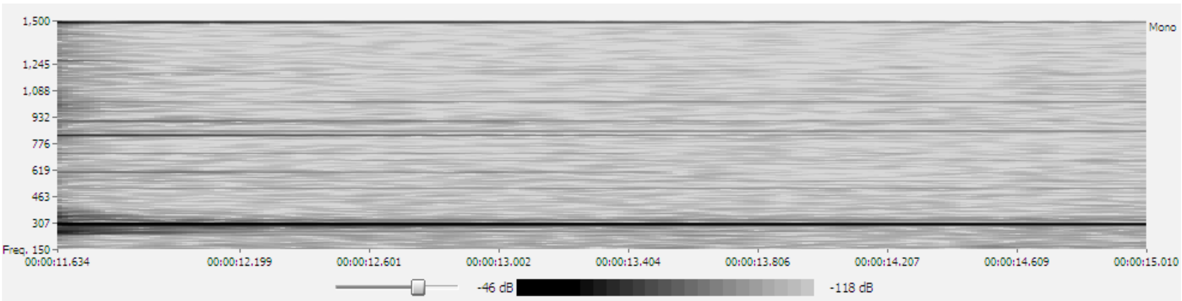

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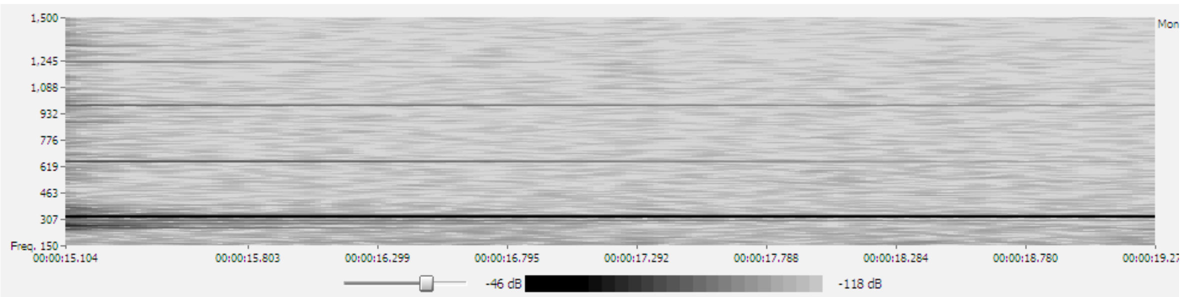

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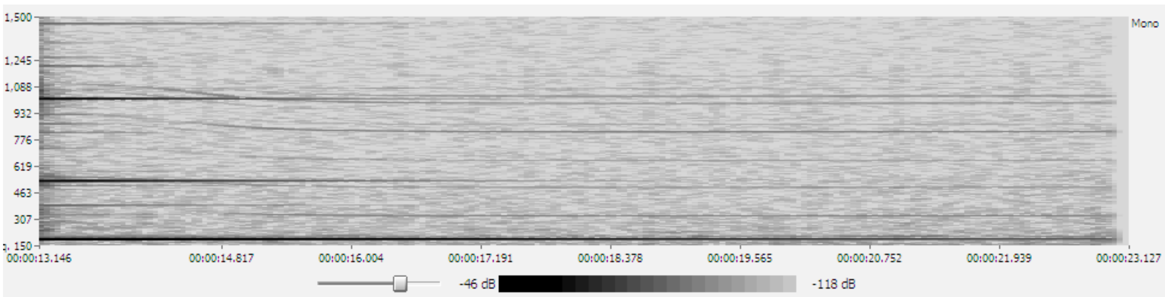

#7

Figure 3. The sonogram -evolution of frequency versus time- of *Saron Demung* key #1 to #7.

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