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Timbre Spectrum of Gamelan Instruments from Four Malay Gamelan Ensembles

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ABSTRACT

Gamelan in general is categorized as a group of gongs. This traditional Malay gamelan ensemble is in a slendro scale i.e. five notes per octave. The rhythms, pitch, duration and loudness classify the various groups of gongs such as bonang, kenong, gender, peking and gambang. The cast bronze peking, kenong and bonang were chosen from a range of Malay gamelan ensemble from Universiti Malaysia Sarawak (UNIMAS), Universiti Putra Malaysia (UPM), Universiti Kebangsaan Malaysia (UKM) and Universiti Teknologi Mara (UiTM). The sounds were recorded by PicoScope Oscilloscope. The PicoScope software displays waveform and spectrum in time and frequency domain respectively. The peking lowest and highest frequencies from UiTM were 293 Hz and 1867 Hz, from UPM were 644 Hz and 1369 Hz, from UKM were 1064 Hz and 2131 Hz and from UNIMAS were 1072 Hz and 2105 Hz respectively. The kenong lowest and highest frequencies from UiTM were 259 Hz and 463 Hz, from UPM were 294 Hz and 543 Hz, from UKM were 300 Hz and 540 Hz and from UNIMAS were 293 Hz and 519 Hz respectively. The fundamental frequencies of bonang from UPM were higher than that of UKM, UiTM and UNIMAS. The harmonics were not successive but interrupted by another frequency. The harmonics of each bonang was similar except for gamelan from UKM.

Keywords: Bonang, fundamental frequencies, kenong, overtone, peking

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INTRODUCTION

The Malay gamelan normally consists of seven main instruments i.e. gambang, bonang, saron demung, kenong, small gong and big gong and 2 instruments from saron group namely saron barung and saron panerus (Sumarsam, 2003). The gamelan is a collection of bronze gongs, gong-chimes, metallophones, drums, flute, bowed and plucked string instruments. Each gamelan is different from the other where iron sometimes is replaced with bronze. Gambang is also one of the main instruments in a gamelan ensemble which consists of pieces of hard wood placed on wooden box which function as a sound resonator. This piece of wood is hit with a set of covered wood mallet and produces certain pitch. Gendang is another traditional instrument that is very significant in the traditional Malay music ensemble like gamelan. The surface is made from goat or cow leather and its tension is made by rattan. The resonator is made from hard wood such as *merbau*. Recently, gamelan music is also played in the West (Suprapto et al., 1993, Sumarsam, 2002, Sumarsam, 2003, Spiller, 2004). The melody of a single instrument is not separable from the whole ensemble. The instruments are tuned to either five-tone slendro or seven-tone pelog. The Malay gamelan instruments have their own pitch characteristics compared to the Javanese gamelan. Hence, the intensity and frequency of the instruments are different between each other. The peking (also known as Saron Panerus) bar shape has rounded top side while the kenong has the shape of an inverted bowl (Sethares, 2005). Figure 1 and 2 show a typical set of peking bar and a typical kenong kettle respectively. The frequency of Gamelan Swastigitha and Gamelan Kyai Kaduk Manis has been measured using oscilloscope (Sudarjana et al., 1993) whereas the frequency of gong has been measured using sonogram by Kuswanto, 2012 as stated by Pramudya et al. (2018).

The lowest and the highest frequencies of Pelog Peking are 1176.1±1.1 Hz and 2101.0±0.0 Hz, respectively, whereas the lowest and the highest frequencies of Slendro Peking are 928.1±2.2 Hz and 2118.1±1.1 Hz, respectively (Pramudya et al., 2018). Table 1 shows the frequencies of each peking and their comparison to the other measurements.

Table 1
The frequencies of each Peking and their comparison to the other measurements (*Pramudya et al., 2018)*

Tone of pelog	Frequency	Gamelan ITB	Tone of slendro	frequency	Gamelan ITB
1	1176	1208	6	928.1	928
2	1272	1300	1	1075	1073
3	1409	1391	2	1234	1246
4	1643	1639	3	1423	1418
5	1765	1757	5	1636	1639
6	1862	1854	6	1870	1854
7	2101	2050	1	2118	2167

Figure 1. A typical peking

Figure 2. A typical kenong

Saron is a metallophone consisting of six or seven bronze bars that form one octave (either slendro or pelog tuning). The saron families consist of saron demung, saron barung, and saron panerus. Saron barung provides the medium octave while saron panerus gives the highest octave as it has thicker and narrower bars than saron demung. Saron panerus forms the core melody. Saron demung has the largest bars and produces the lowest pitch. Saron barung is one octave higher than the saron demung where the higher pitch is produced by the smaller bar. The bars are 35.5cm long and 9 cm wide. The mallet is struck at an angle to produce a full sound. The note is dampened half a beat before it is struck again for repeated notes (Tenzer, 2006). Every saron is distinguished from the size and the different sound. These saron groups consist of 6 arranged blades of bronze and they are hit using mallet. Saron demung's size is bigger compared to saron barung and saron panerus. Saron panerus has the smallest size. The 6 bronze blades in saron are arranged according to the scale tones 1, 2, 3, 5, 6 and 1'.

Kenong is also made of bronze and it functions as a colotomic instrument in gamelan music. Colotomy describes the rhythmic and metric patterns of gamelan music. It acts to mark off nested time intervals or dividing rhythmic time into such nested cycles. Kenong has fixed pitch based on the western tempered scale. It consists of 5 medium-size gongs which are arranged according to the scale tones of 1, 2, 3, 5, 6 (the sound 1' replaced by 1). Gong is the main complement in gamelan music composition. There are 2 types of gong that are different in sizes and they are called the big gong and the small gong. Bonang is a musical instrument from idiophone category which has the shape of a kettle (small gong) and having sound characteristic based on low humming principle. Bonang starts the opening of the music which later followed by another gamelan instrument. Bonang is also made from bronze and it is the main melodic instrument in a gamelan ensemble. The lowest and highest frequencies of the first row of Pelog Bonang Barung are 609.6 $\pm$ 0.1265 Hz and 1050 $\pm$ 0.09487 Hz, respectively. For the second row, the lowest and highest frequencies are 300.1 Hz and 512.8 Hz, respectively (Pramudya et al., 2018). Table 2 shows the frequencies of each kettle on the second row (lower pitch) of Pelog Bonang Barung and their comparison to the other measurements.

Table 2
The frequencies of each kettle on the second row (lower pitch) of Pelog Bonang Barung and their comparison to the other measurements (Pramudya et al., 2018)

Tone	Frequency	Swastigitha	Kyai kaduk Manis
1	300.1	300	310
2	322.3	324	336
3	345.8	353	362
4	411.0	415	424
5	459.5	444	445
6	476.1	472	482
7	512.8	525	538

Figure 3 shows a set of 10 bonang ensembles (the upper row is called bonang penerus, the lower row is called bonang barung).

Figure 3. A set of 10 bonang ensemble (the upper row is the bonang penerus, the lower row is the bonang barung)

Studies on Javanese gamelan were done by experts from the West and East. The tones measurement has been pioneered by Ellis and Hipkins (1884) scientifically. Sudarjana et al. (1993) investigated the vibration frequency of gamelan instrument tone system. Sudarjana et al. (1993) measured the tone of Javanese gamelan and Schneider (2001) studied the sound, pitch and scale of idiophones such as gamelan instrument. In this work, we measure the fundamental and overtone frequency which is also called the timbre. Fourier transformation determines fundamentals, harmonics and sub harmonics. Different intensity and harmonics or sub harmonics (overtones) distinguish each instrument characteristics.

The relationship between time and frequency has been well-established which include the study of the sound that coincides with the Fourier analysis. Fourier analysis yields the frequency content to understand the sound. In the Fourier analysis, the signal in real voltage-time axis is converted to dB-frequency axis. In PicoScope only dB-frequency is displayed for the whole spectra. In Melda analyser, the dB is displayed with a frequency at one specific time. While PicoScope displays only changes of frequency in the whole spectra, Melda analyser displays several frequencies at one particular time. Melda analyser displays changes of several frequencies at different time. It also shows how the fundamental frequency changes with time and overtone frequency become dominant after certain period of time.

The purpose of this work is to study the tone in a peking/kenong/bonang. These spectra are used to identify the pitch of the sound produced by the signal. These spectra display several peaks which are obviously dominant and can be classified as the fundamental and overtones peaks. These peaks coincide with the notes intended for the sound produced from the instruments signal. The individual peak represents the pitch/notes of the instruments. The first highest dominant fundamental frequency determined the pitch of the instrument. The addition of the frequency with the overtones creates the sound and the quality of this sound is determined from the harmonic/non-harmonic frequencies.

The musical scales such as the well-tempered scale are based on a logarithmic scale for frequencies, but spectrograms display frequencies on a uniform scale (Johnston, 1989). Since the human ear is not capable of distinguishing the individual harmonics of a complex tone, the identification of the partials may be nearly impossible in listening to tones in a musical context (Plomp, 1976). Thus, experimental evidence using the spectra is utmost important for analysing the frequency. The pitch is sometimes guessed by Mother Nature using the tuner's ear. In a field trip to Jogjakarta, the tuner used a pianica to listen the pitch and tune the instrument using his hearing solely. Experimental evidence using the spectra produces a series of frequencies which can be analysed consisting of the dominant fundamental frequency and all the possible overtones frequencies. The scheme of peking slendro and kenong slendro note arrangement is shown in Figure 4.-

PEKING SLENDRO	C6 (1046.5)	D6 (1174.7)	E6 (1318.5)	G6 (1568.9)	A6 (1760.0)	C7 (2093.0)
KENONG SLENDRO	D4 (293.67)	E4 (329.63)	G4 (392.00)	A4 (440.0)	C5 (523.25)	- -

Figure 4. The tuning schemes of peking slendro and kenong slendro with the note arrangement

In this work we study the colour of sound of Malay gamelan peking/kenong/bonang from Universiti Malaysia Sarawak (UNIMAS), Universiti Putra Malaysia (UPM), Universiti Kebangsaan Malaysia (UKM) and Universiti Teknologi Mara (UiTM). The colour of sound indicates a collection of frequency starting from the fundamental and all the possible overtone- sometimes defined as the timbre. Sound from a generated pure sinusoidal wave produces only one frequency and does not produce any colour of sound. We investigate the sound frequency using PicoScope.

MATERIAL AND METHODS

The peking, kenong and bonang are part of the gamelan ensemble from UKM, UPM, UiTM and UNIMAS. The frequency was measured at the studio hall of UKM, UPM, UiTM and UNIMAS. The acoustic spectra of the measured sets of just-tuned cast bronze peking, kenong and bonang which were made in Indonesia were captured using PicoScope oscilloscopes to investigate the fundamental and the overtone frequencies. Excitation was done by beating by an expert player. The microphone was held above the top surface along the axis of symmetry at a distance of about 20 cm (Figure 5). The PicoScope computer software (Pico Technology, 3000 series, Eaton Socon, UK) was used to view and analyse the time signals from PicoScope oscilloscopes (Pico Technology, 3000 series, Eaton Socon, UK) and data loggers for real time signal acquisition. PicoScope software enables analysis using Fast Fourier transform (FFT), a spectrum analyser, voltage-based triggers, and the ability to save/load waveforms to a disk. Figure 5 shows the schematic diagram of the experimental setup. The peking/kenong/bonang was placed to where the sound could be captured with minimum interference. The amplifier (Behringer Powerplay Pro XL, Behringer, China) ensured the sound capture was loud enough to be detected by the signal converter.

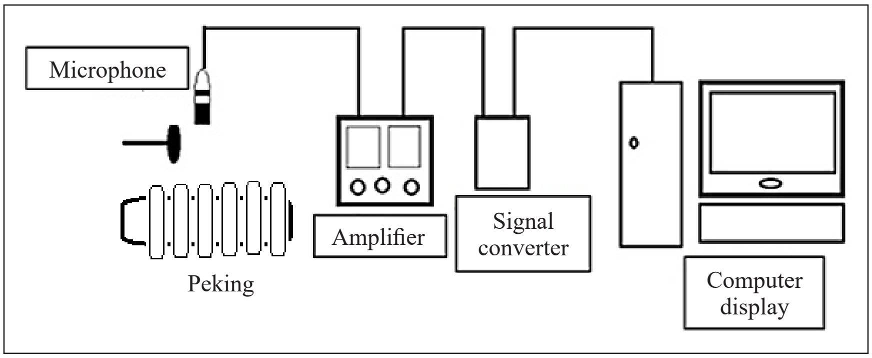

Figure 5. Schematic diagram of the experimental setups

In this study, the audio signal derived from the striking by an expert player was recorded. The audio signal was recorded in mono, at 24-bit resolution and 48 kHz sampling rate. The audio signal was recorded with the aid of a digital audio interface in a wave format. To ensure the recorded audio signal was at the optimum level, audio signal calibration of the recording system was carried out. A test tone of 1 kHz sine wave was used in calibrating the recording system. Here the 'unity' calibration level was at +4dBu or -10dBV and was read by the recording device at '0 VU'. In this regard, the EBU recommended the digital equivalent of 0VU is that the test tone generated to the recording device of the experimentation was recorded at -18 dBFS (Digital) or +4dBu (Analog) which is equivalent to 0VU. In this thorough procedure of calibration, no devices were unknowingly boosting or attenuating its amplitude in the signal chain at the time of the recording was carried out. The recording apparatus was the Steinberg UR22 mkII audio interface, Audio-Technica AT4050 microphone, XLR cable (balance), with microphone position on axis (<20 cm) and microphone setting with low cut (flat) 0dB.

RESULTS AND DISCUSSION

The PicoScope measured the intensity and time of the signal. The Fast Fourier Transform (FFT) analysed the fundamental and overtone frequency for each tone. The typical FFT spectra of peking and kenong from UNIMAS are shown in Figure 6 and 7 respectively.

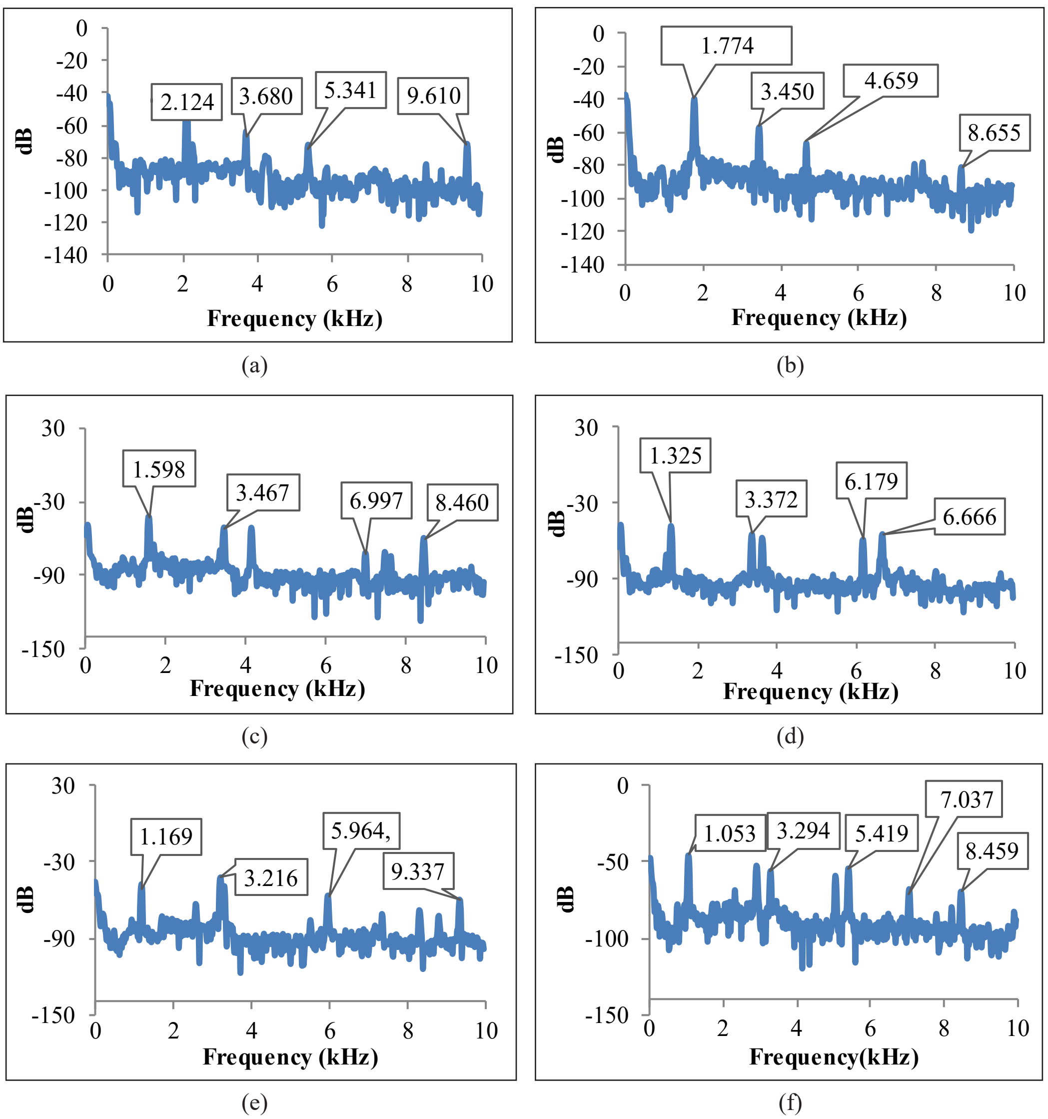

Figure 6. Spectra of peking (a) 1 (C6), (b) 2 (D6), (c) 3 (E6), (d) 5(G6), (e) 6(A6) and (f) 1' (C7) from UNIMAS

Table 3 shows the ratio of overtone to fundamental (f_o) frequency for each peking from UNIMAS, UKM, UiTM and UPM. Table 4 shows the ratio of overtone to fundamental (f_o) frequency for each kenong from UNIMAS, UKM, UiTM and UPM. $1^{st}/f_o$, $2^{nd}/f_o$ and $3^{rd}/f_o$ indicate the ratio of the first, second and third overtone frequency to the fundamental frequency. The bold numbers in the table indicate the exact harmonic of the overtone frequencies.

The results of kenong from this work are compared to gamelan Swastigitha and Kyai Kaduk Manis (Sudarjana et al., 1993). Table 5 shows the fundamental frequency of kenong from UNIMAS, UKM, UPM, UiTM and gamelan Swastigitha and Kyai Kaduk Manis.

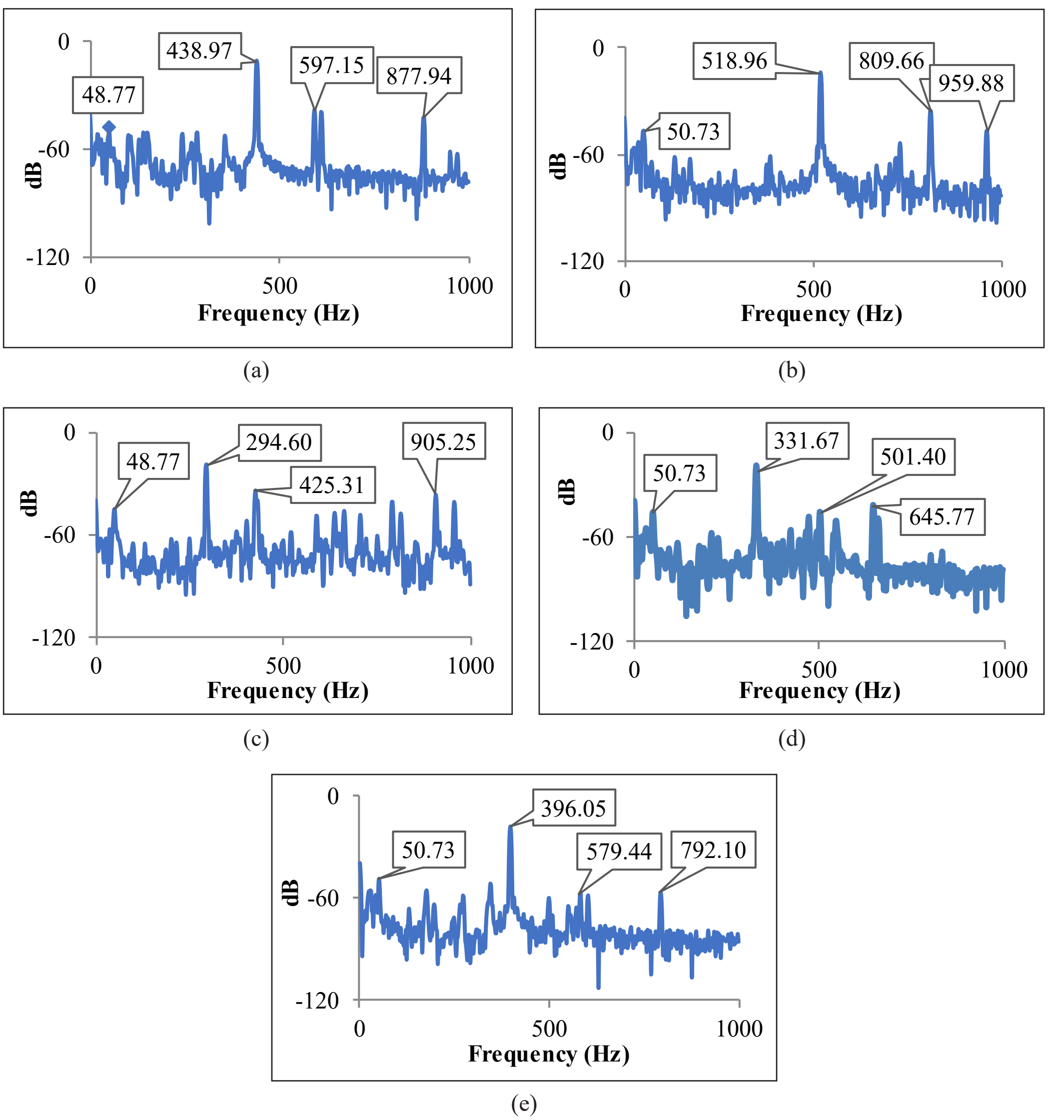

Figure 7. Spectra of Kenong (a) A, (b) C, (c) D, (d) E and (e) G from UNIMAS

Table 3
Ratio of overtone to fundamental (f_o) for each peking from UNIMAS, UKM, UiTM and UPM

	UNIMAS			UKM			UiTM			UPM		
Overtone/ f_o	$1^{st}/f_o$	$2^{nd}/f_o$	$3^{rd}/f_o$	$1^{st}/f_o$	$2^{nd}/f_o$	$3^{rd}/f_o$	$1^{st}/f_o$	$2^{nd}/f_o$	$3^{rd}/f_o$	$1^{st}/f_o$	$2^{nd}/f_o$	$3^{rd}/f_o$
Peking 1’	1.76	2.54	4.57	1.69	-	3.84	1.73	2.45	4.17	1.50	-	-
Peking 6	1.93	2.64	4.87	1.81	-	3.89	**2.00**	2.48	4.49	1.61	-	-
Peking 5	2.19	2.63	5.36	**2.05**	2.49	-	2.46	4.36	6.87	1.77	2.38	-
Peking 3	2.54	4.65	-	2.54	4.41	-	1.44	1.55	-	1.86	-	-
Peking 2	2.70	**5.02**	**7.00**	2.54	-	-	1.27	2.48	3.26	**2.02**	2.81	**3.06**
Peking 1	2.72	**5.05**	**7.91**	**2.91**	4.39	**7.09**	1.59	**4.01**	**10**	1.88	2.45	2.77

Table 4
Ratio of overtone to fundamental (f_o) for each bonang from UNIMAS, UKM, UiTM and UPM

	UNIMAS		UKM		UiTM		UPM	
	$1^{st}/f_o$	$2^{nd}/f_o$	$1^{st}/f_o$	$2^{nd}/f_o$	$1^{st}/f_o$	$2^{nd}/f_o$	$1^{st}/f_o$	$2^{nd}/f_o$
Kenong C	1.56	1.85	1.37	**1.99**	1.39	**2.00**	1.30	**2.00**
Kenong A	1.33	**1.99**	1.41	**2.00**	1.61	**3.00**	1.48	**2.00**
Kenong G	1.46	**1.99**	1.56	**3.06**	1.72	**3.00**	1.51	**2.00**
Kenong E	1.51	**1.95**	1.64	3.13	1.76	3.54	1.50	**2.00**
Kenong D	1.44	**2.00**	1.71	3.76	1.72	4.38	1.50	4.65

The results show that the frequencies from Malay gamelan were different compared to Javanese gamelan. Table 5 shows that the slendro kenong from UNIMAS is very close to the frequency obtained from the equal temperament scale.

Table 5
The fundamental frequency of kenong from UNIMAS, UKM, UPM, UiTM and gamelan Swastigitha and Kyai Kaduk Manis (Sudarjana et al., 1993)

Equal temperament (Hz)	UNIMAS	UKM	UPM	UiTM	Swastigitha	KyaiKaduk manis
B3(246)	-	-	-	-	-	242
C4(261.6)	-	-	-	259	-	-
D4(293.67)	293	300	294	292	-	-
E4(320.63)	332	344	330	-	-	320
F4(349)	-	-	-	349	357	-
F#4(369)	-	-	368	-	-	369
G4(392)	396	403	-	391	-	-
G#4(415)	-	-	-	-	412	421
A4(440)	441	453	436	-	-	-
A#4(466)	-	-	-	463	472	478
C5(523.25)	519	540	543	-	-	-
C#5(554)	-	-	-	-	-	557
D#5(622)	-	-	-	-	623	-

Figure 8 and 9 display typical frequency spectrum for bonang barung and bonang penerus sets from UNIMAS respectively. Table 6 presents the fundamental and overtone frequency (in hertz) for each bonang from UKM, UPM, UiTM and UNIMAS respectively.

The harmonics were not successive but interrupted by another frequency. In the spectra, there existed a series of frequencies starting form the highest dominant pitch followed by the overtone pitch. In an ideal case all the overtones are harmonic or in-harmonic which decay accordingly. But in some cases, there exist an interrupted pitch which is not in the harmonic or in-harmonic series. This interrupted frequency is due to the uncertain vibration of the uneven structure of the musical material. The harmonics of each bonang was similar except for gamelan UKM. This phenomenon is different from the assumption which states that percussion instruments have harmonic overtones. Percussion instruments consist of pitch and non-pitch instruments. The pitch instruments normally have harmonic overtones. Although gongs are pitch percussion, this phenomenon is different with the assumption which states that percussion instruments have harmonic overtones instruments because gongs are percussion instruments which do not have harmonic overtones. This is due to the nature of manufacturing using beating and hammering process. The different overtone frequency indicates their timbre is different for each bonang. The number of harmonics of all bonang for all Malay gamelan set were very inconsistent as shown in bold in Table 6. From Table 6, gamelan UKM has 3 harmonics i.e. penerus 1, penerus 2, penerus 3 and barung 2 showed 2nd harmonic while penerus 3 showed 3rd harmonics. From Gamelan UPM has 2 harmonics i.e. barung 5 showed 3rd harmonic while penerus 6 showed 2nd harmonic. Gamelan UiTM has 1 harmonic i.e. penerus 5 and penerus 6 showed 2nd harmonic. Gamelan UNIMAS has 2 harmonics i.e. barung 1, penerus 5 and penerus 6 showed 2nd harmonic while penerus 1 showed 3rd harmonic. The timbre differences between the bonang may be due to differences in both material and manufacture. Nevertheless, the fundamental

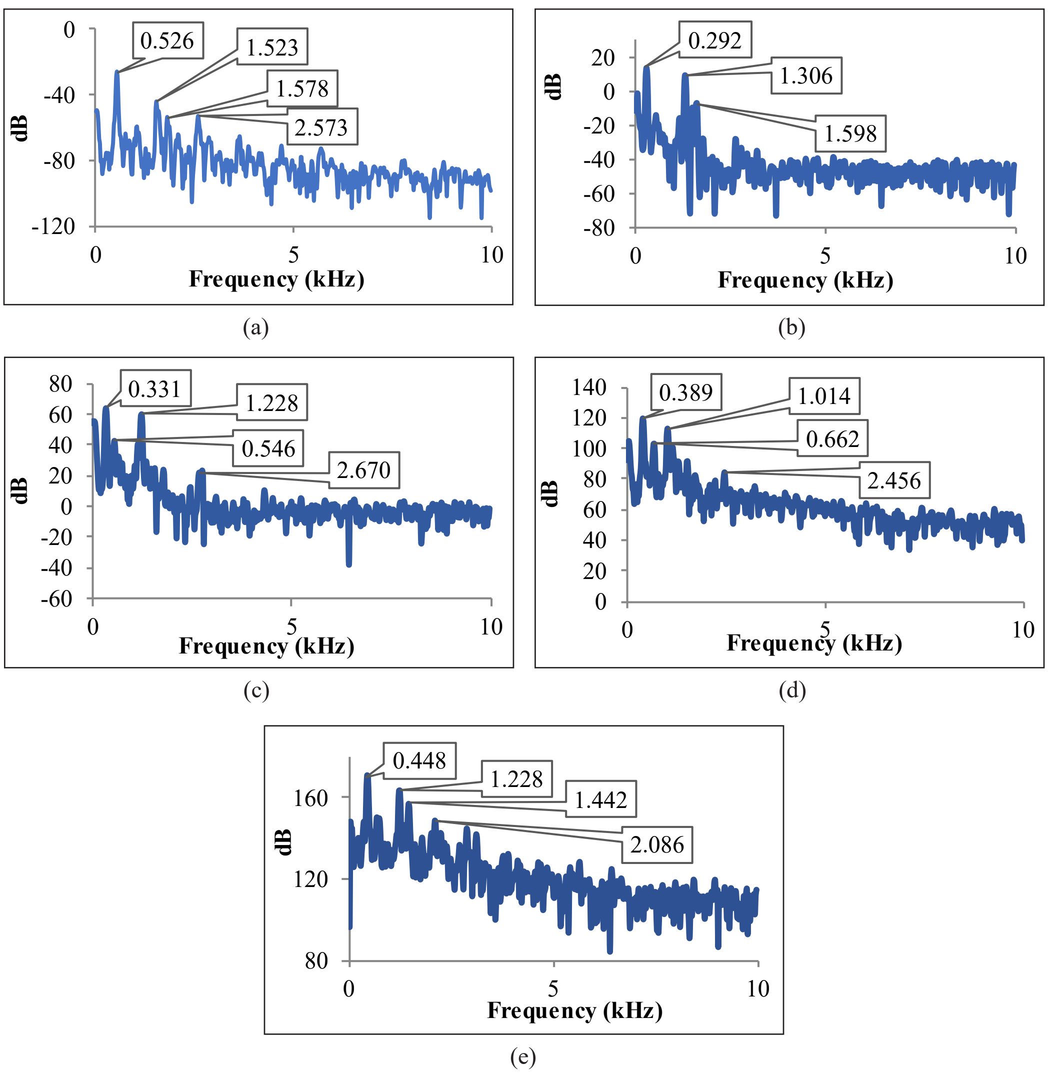

Figure 8. Frequency spectrum for bonang barung set (a) 1, (b) 2, (c) 3, (d) 5, (e) 6 from UNIMAS showing the fundamental, first, second and third overtone frequency

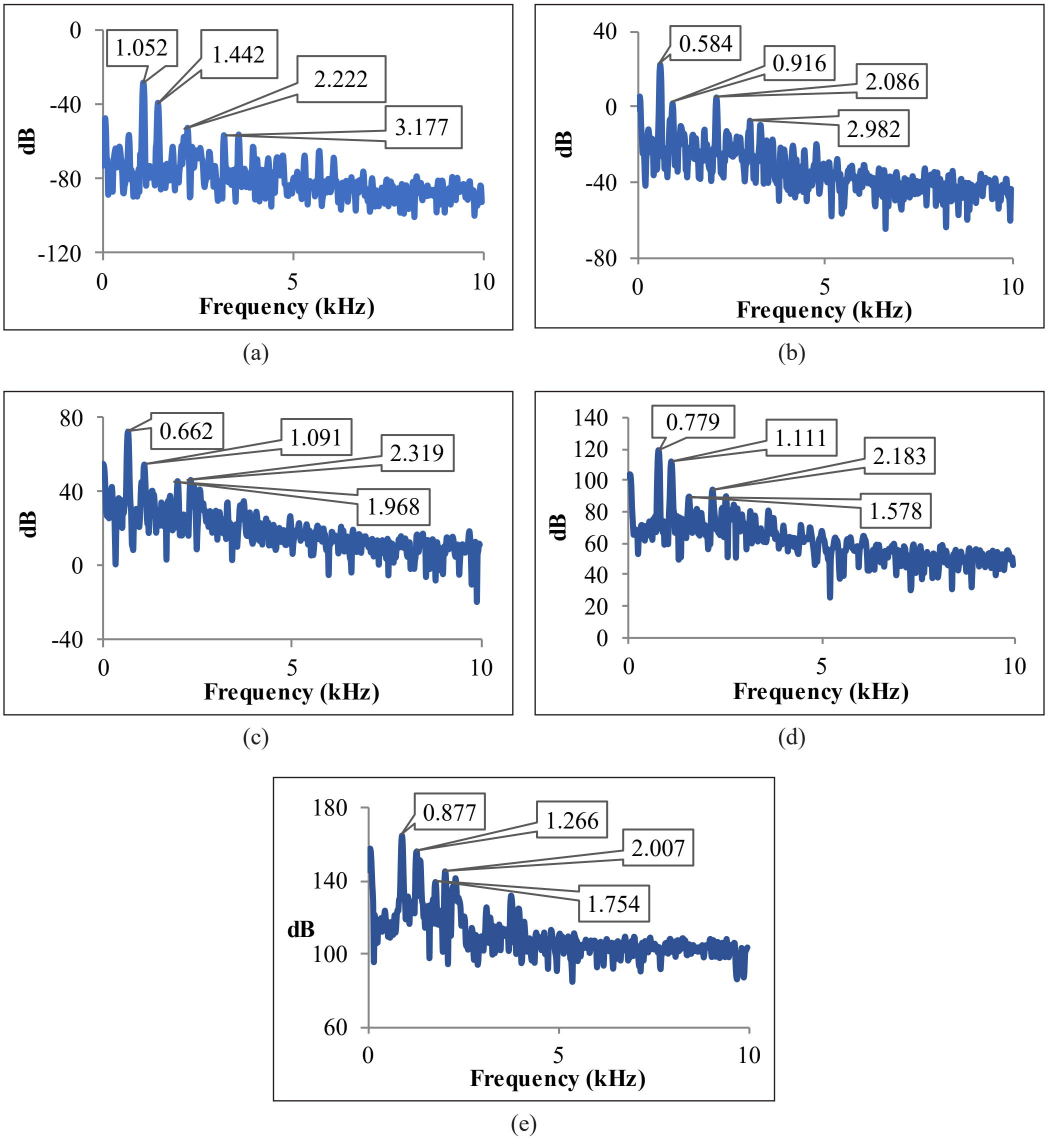

Figure 9. Frequency spectrum for bonang penerus set (a) 1, (b) 2, (c), 3 (d) 5, (e) 6 from UNIMAS showing the fundamental, first, second and third overtone frequency

pitch tends to be similar except for gamelan UPM. This result will be more meaningful if comparisons are made with more Malay gamelan sets.

Comparison between the results in Table 6 showed a variation in the fundamental and the overtones frequencies of the bonang set from UKM, UPM, UiTM and UNIMAS respectively. These differences are plotted in Figure 10 and 11 for the individual bonang penerus and bonang barung 1, 2, 3, 5 and 6 respectively from different universities. Bonang penerus 1 showed consistency in their fundamental and 1st overtone frequencies (Figure

Table 6
Fundamental and overtone frequency (in kHz) for each bonang

	UKM			UPM			UiTM			UNIMAS		
	f_1/f_o	f_2/f_o	f_3/f_o	f_1/f_o	f_2/f_o	f_3/f_o	f_1/f_o	f_2/f_o	f_3/f_o	f_1/f_o	f_2/f_o	f_3/f_o
Penerus1	1.32	**2.03**	-	1.30			1.45	2.13	-	1.37	2.11	**3.01**
Barung 1	1.52	2.28	2.78	1.25	1.68		1.58	2.45	2.79	2.88	**3.00**	4.89
Penerus 2	1.49	**2.00**	3.31	1.43			1.64	3.79	-	1.56	3.57	5.10
Barung 2	3.77	**3.98**	-	1.26			4.29	9.21	-	4.47	5.13	
Penerus 3	1.43	**2.00**	**3.04**	1.41			1.61	3.59	-	1.66	3.06	3.57
Barung 3	1.65	3.61	7.49	1.43			3.48	4.41	5.35	1.19	3.88	8.58
Penerus5	1.47	-	-	1.46			1.62	**2.98**	3.54	1.43	**2.00**	2.77
Barung 5	1.66	2.86	-	1.26	1.35	**2.03**	1.73	3.10	3.39	1.70	2.60	6.26
Penerus 6	1.41	2.00	2.21	1.45	**3.15**		1.56	**2.00**	2.74	1.42	**2.00**	2.29
Barung 6	2.77	-	-	1.27	1.36	1.79	1.65	3.24	3.59	2.81	3.36	4.86

Notes. The bold numbers in the table indicate the exact harmonic of the overtone frequencies.

10a). Bonang penerus 1 from UPM did not display 2nd overtone frequency and only bonang penerus 1 from UNIMAS displayed 3rd overtone frequency. Bonang barung 1 also showed consistency in their fundamental and 1st overtone frequencies, except from UNIMAS (Figure 11a). Bonang barung 1 from UNIMAS displayed all higher overtone frequency. All bonang barung 1 (except from UPM) displayed 3rd overtone frequency.

Bonang penerus 2 also showed consistency in their fundamental and 1st overtone frequencies except from UPM (Figure 10b). Although bonang penerus 2 from UPM displayed higher frequencies in both fundamental and 1st overtone, both 2nd and 3rd overtone disappear. Bonang penerus 2 from UiTM also did not display 3rd overtone frequency. Bonang penerus 2 from UNIMAS displayed highest 3rd overtone frequency. Although bonang barung 2 from UPM displayed the highest fundamental frequency, the 1st overtone for bonang barung 2 from UPM displayed the lowest frequency (Figure 11b). Like bonang penerus 2, bonang barung 2 from UPM also did not display the 2nd overtone. All bonang barung 2 did not display the 3rd overtone.

Bonang penerus 3 from UPM were displaying both highest frequencies in the fundamental and 1st overtone but both frequencies are missing in the 2nd and 3rd overtone (Figure 10c). Only bonang penerus 3 from UKM and UNIMAS displayed 3rd overtone. Bonang barung 3 from UPM still showed the highest fundamental frequency with the 1st overtone almost similar to UiTM (Figure 11c). Once again like bonang penerus 3, the 2nd and 3rd overtone for bonang barung 3 from UPM were missing.

Bonang penerus 5 displayed consistent fundamental and 1st overtone frequency from all universities (Figure 10d). It was found that only bonang penerus 5 from UiTM and UNIMAS displayed 2nd and 3rd overtone frequencies. Bonang barung 5 like bonang penerus 3 from UPM were displaying both highest frequencies in the fundamental and 1st overtone

(Figure 11d). Unlike bonang penerus 3 from UPM, (where both frequencies are missing in the 2nd and 3rd overtone) bonang barung 5 from UPM displayed both 2nd and 3rd overtone. Bonang barung 5 from UKM did not display 3rd overtone.

Although in the above discussion bonang barung 5, like bonang penerus 3 from UPM were displaying both highest frequencies in the fundamental and 1st overtone , bonang penerus 6 from UPM displayed the lowest frequencies in the fundamental, 1st overtone, 2nd

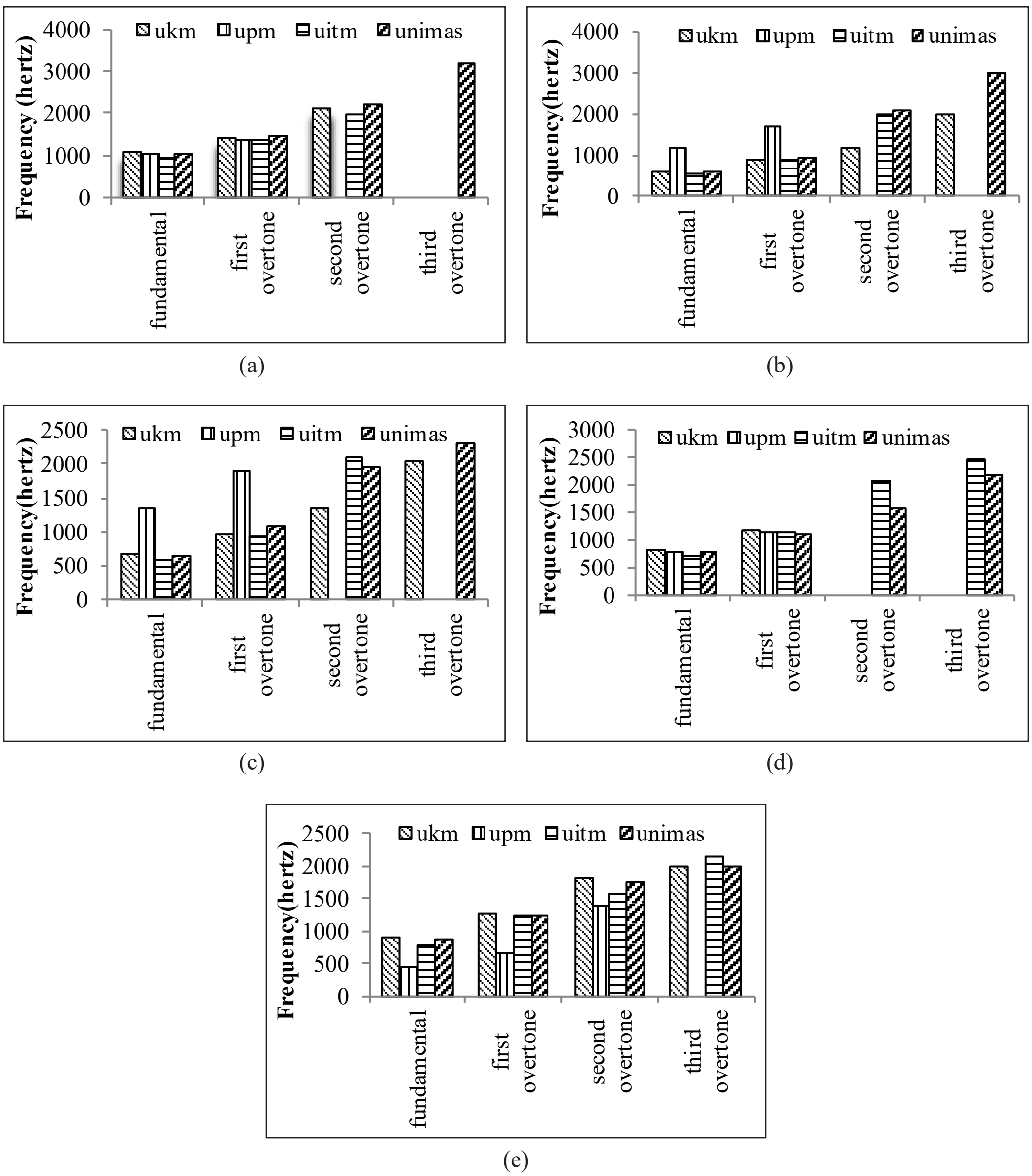

Figure 10. Fundamental and overtones frequencies of bonang penerus (a) 1, (b) 2, (c) 3, (d) 5, (e) 6 from UKM, UPM, UiTM and UNIMAS

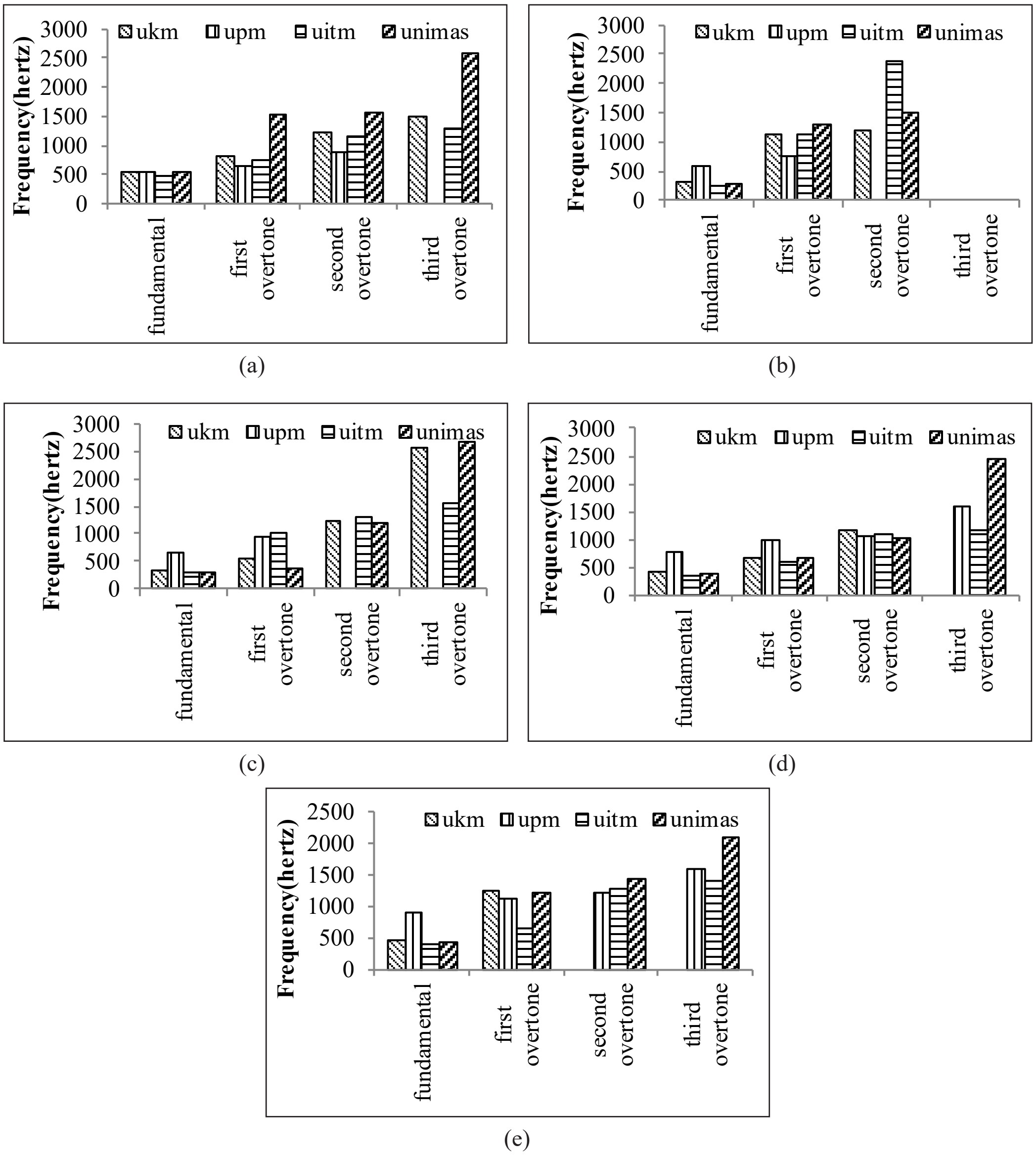

Figure 11. Fundamental and overtones frequencies of bonang barung (a) 1, (b) 2, (c) 3, (d) 5 and (e) 6 from UKM, UPM, UiTM and UNIMAS

overtone and totally missing in the 3rd overtone (Figure 10e). Although bonang penerus 6 from UPM showed the lowest fundamental frequency, surprisingly bonang barung 6 from UPM showed the highest fundamental frequency (Figure 11e). Only bonang barung 6 from UiTM showed inconsistent 1st overtone frequency and bonang barung 6 from UKM showed missing 3rd overtone frequency.

The fundamental pitch of bonang from UPM was higher compared to other bonang from UKM, UiTM and UNIMAS as indicated in Figure 12 and 13 below. The trend in the fundamental frequency of bonang from Malay gamelan UKM, UiTM and UNIMAS was almost similar. It can be concluded that UPM Malay gamelan sets are from different materials. Both bonang penerus and bonang barung from UPM had higher fundamental frequencies than other Malay gamelan sets except for bonang penerus 5 and bonang penerus 6 which showed lower frequencies.

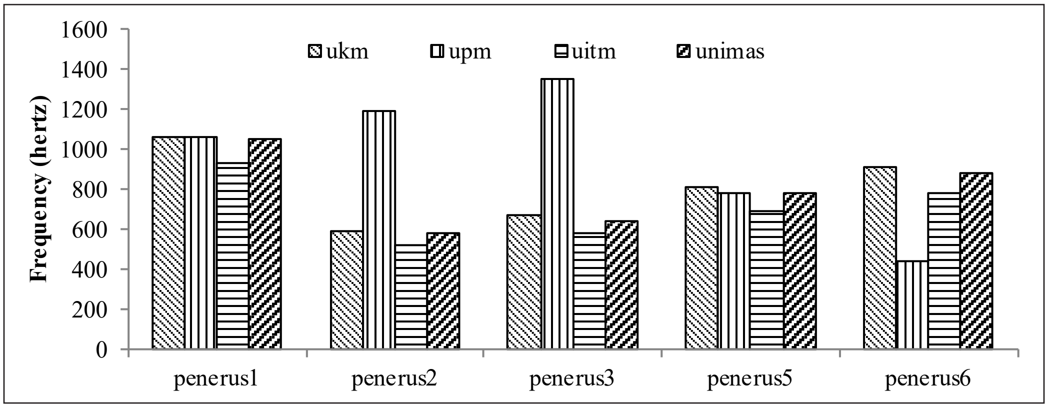

Figure 12. Fundamental frequency of bonang penerus UKM, UPM, UiTM and UNIMAS

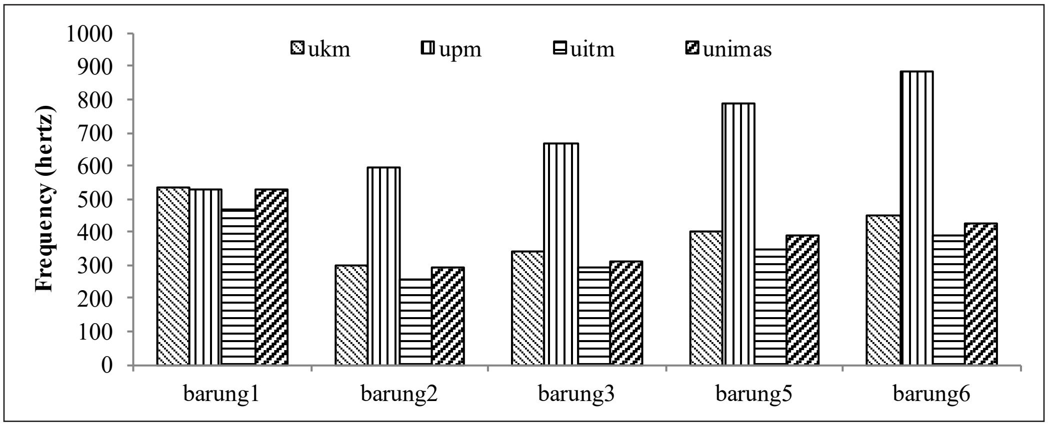

Figure 13. Fundamental frequency of bonang barung UKM, UPM, UiTM and UNIMAS

CONCLUSION

In this paper we have examined slendro peking and slendro kenong from four Malay gamelan ensemble. PicoScope reading produces spectral peaks within entire signals and provides the fundamental and several overtones frequencies in the entire signal. The peaks from peking are non-harmonic spectra since they are non-integral multiples of the fundamental except for peking 5 from UKM, peking 2 from UPM and peking 6 from UiTM (shown in bold). The two tone quality of the kenong sets namely the kenong of gamelan Swastigitha and Kyai Kaduk Manis are compared with kenong D, E, G, A and C from this study which are well tuned to D4, E4, G4, A4 and C5 based on the C major scale. The kenong of gamelan Swastigitha used their tuning set to F4, G#4, A#4 and D#5 with 3 sharp. Whereas the kenong of gamelan Kyai Kaduk Manis are tuned to B3, E4, F#4, G#4, A#4 and C#5 in the A major scale (with 3 sharps i.e. F#, C# and G#). This study confirms that one gamelan is inevitably different in intonation, tone, and feels from another gamelan. In this research, this tuning was read with PicoScope analysis and it proved that the transmission of the tuner onto the tuning of the gamelan set can be shown on the aspect of intonation, tone, and feels. From this work, the fundamental frequencies of bonang penerus and bonang barung of gamelan UPM are higher than that of UKM, UiTM and UNIMAS, the harmonics are not successive, but interrupted by another frequency. The number of harmonics of each bonang of UKM, UPM, UiTM and UNIMAS are different where only gamelan UKM has three harmonics frequencies and the fundamental frequencies tend to be similar except for gamelan UPM.

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