DESIGN AND CHARACTERIZATION OF ACOUSTIC COMPARISON COUPLER AS A PORTABLE CALIBRATION MEDIA AND MECHANICAL SOUND SOURCE FOR CALIBRATION OF ACOUSTIC MEASUREMENT INSTRUMENTS

RANCANG BANGUN DAN KARAKTERISASI ACOUSTIC COMPARISON COUPLER SEBAGAI MEDIA KALIBRASI PORTABEL DAN SUMBER SUARA MEKANIK UNTUK KALIBRRASI ALAT UKUR BESARAN AKUSTIK

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ABSTRACT

Design and characterization for an acoustic comparison coupler has been carried out at Deputy of National Measurement Standard-BSN by Research Group for Acoustics and Vibration. The aim of this work is to contrive a design and characterize this prototype that has an ability to be used either as the portable of calibration medium or as the sound source for calibration of the acoustic instruments. This prototype is consists of two main sections that made from aluminum material. The first section is a body part that is assembled some components such as a super low noise connector, a glass wool, and a loudspeaker. Meanwhile for a head part as the second section, it is formed a concave space inside, and a coupler hole of microphones. In addition, some stages of testing of this prototype are also reported in this paper, consists of measurement of insulation level, frequency response, maximum of sound pressure level (SPL), long term stability, and total harmonic distortion (THD), respectively. From the first stage, the difference of SPL between the two rooms and its background noise is not significant where it shown that the deviation of SPL values are 15.0 dB and 0.9 dB, respectively. Subsequently, the SPL maximum and long-term stability test is obtained at range of SPL of 118.0 dB – 124.0 dB, and 0.1 dB – 0.5 dB respectively at the frequency of 63 Hz – 8000 Hz in one third octave band. Moreover, the total harmonic distortion that measured in the final stage is still in a tolerance limit, where it has a value as 1.88 % for the aforementioned frequencies.

Keywords: acoustic comparison coupler, portable calibration medium, mechanical sound source, acoustic instruments, calibration

ABSTRAK

Rancang bangun dan karakterisasi sebuah acoustic comparison coupler telah dilakukan di Deputi Standar Nasional Satuan Ukuran, Badan Standardisasi Nasional, oleh Kelompok Penelitian Akustik dan Vibrasi. Tujuan dari penelitian ini, yaitu merancang sebuah desain dan mengarakterisasi prototipe yang memiliki kegunaan baik sebagai media kalibrasi portabel dan atau sumber bunyi mekanik untuk kalibrasi alat ukur besaran akustik. Sebuah acoustic comparison coupler terdiri dari dua bagian utama yang terbuat dari bahan aluminium. Bagian pertama, yaitu bagian badan yang di dalamnya dipasang beberapa komponen, seperti super low noise connector, glasswool, dan sebuah loudspeaker. Adapun bagian kepala yang di dalamnya dibentuk sebuah ruang cekung, dan terdapat lubang koneksi mikrofon. Sebagai tambahan, beberapa tahapan pengujian pada prototipe ini juga didiskusikan pada karya tulis ini, diantaranya pengukuran untuk level insulasi, frekuensi respon, tingkat tekanan bunyi maksimum, kestabilan jangka panjang, dan distorsi harmonik total. Dari hasil uji tahap pertama, perbedaan tingkat tekanan bunyi (SPL) antara prototipe di ruangan pengukuran (ruang anti gema dan ruang gema) dengan tingkat tekanan bunyi latar tidak signifikan dimana perbedaan nilai SPL yang diperoleh yaitu masing-masing sebesar 15,0 dB and 0,9 dB. Selanjutnya, pengukuran SPL maksimum dan stabilitas jangka panjang dipeoleh pada rentang SPL masing-masing, yaitu 118,0 dB – 124,0 dB, dan 0,1 dB – 0,5 dB pada frekuensi 63 Hz – 8000 Hz. Selain itu, distorsi harmonik total yang diukur pada pengukuran tahap akhir yaitu masih berada pada limit toleransi, di mana nilai yang diperoleh adalah 1,88%.

Kata Kunci: *acoustic comparison coupler, media kalibrasi portabel, sumber bunyi mekanik, alat ukur akustik, kalibrasi*

1. INTRODUCTION

Number of the acoustic instruments application such as sound level meter, noise dosimeter, and incubator analyzer system, which have an important role to control and monitor the non-auditory and auditory effects of noise pollution (Kuznetsov, Kuz, Lyakhov, Pereselkov,

& Prosovetskiy, 2019), have been recorded to increase significantly, including in Indonesia that shown a rapid growing in the infrastructure sectors for the last decades (Series, 2018).

Consequently, it will affect to the number of the calibration demand that applied by the industrial companies, and some institutions such as the government companies, the medical foundations, and academic institute, where it has been indicated that the value of these orders incline to increase of its number. In contrast of this circumstance, availability of the calibration facilities to these handheld tools is limited in Indonesia. Moreover, the calibration supporting equipment such as the multifunction calibrator as the working standard of acoustic calibration, and the full anechoic chamber as the calibration medium are having a high level of complexity to be implemented, and of course, realization of building of this system is scarce.

Furthermore, this situation is a defiance to the National Standardization Agency of Indonesia (BSN) as the National Metrology Institute (NMI) through the Research Group of Acoustics and Vibration to perform a research to produce a prototype that has a capability to support the traceability needs to the secondary calibration laboratories, industries, and other institutions. Moreover, it is also applied to minimize the complication of the aforecited issues with devising a system that has a function as a sound calibrator as well as a calibration medium, wherein its implementation is more convenient than the aforementioned facilities.

In addition, there is a similar prototype that is mentioned as a low frequency coupler that provide as basic idea of this research, and mostly has been made by East Asia Countries, and it is shown in Figure 1.

This frequency coupler is a sound source that designed for frequency response measurement of acoustic devices such as sound level meter and microphone. It has an effective frequency response of 31.5 Hz – 500 Hz, and appropriate to be applied for acoustic measurement in low to middle of frequencies. It is manufactured by aluminum-magnesium alloy, and suitable for 1-inch, ½ inch, and ¼ inch of microphones (BSWA, 2018).

Figure 1. The low frequency coupler (BSWA, 2018)

Therefore, the purpose of this research is to contrive a design of an acoustic comparison coupler system as the prototype that has the ability to be used either as the portable of calibration medium or as the sound calibrator for the calibration of acoustic instruments where it is applicable for a pressure type of microphones, sound level meter, and noise dosimeter with the frequency range of 63 Hz – 8000 Hz. Moreover, some stages of testing for this prototype also are reported in this paper.

Even though other NMI is prefer to utilize a free field facilities or multifunction acoustic calibrator as a standard calibration equipment for calibration of acoustic measurement instruments, this prototype is considered to be an optional choice for the secondary calibration laboratory particularly.

2. MECHANICAL DESIGN

Basically, the design of the acoustic comparison coupler is based on the acoustic calibrator design that has a small form, handheld, and generally consist of a signal controller, control unit, and other supporting devices, where its functional block diagram is shown in Figure 2 (Podg, 2014). The signal controller is used to stabilize the acoustic signal that generated in the chamber. It works in the feedback loop together with the acoustic chamber, the reference microphone (RM) and the loudspeaker (LS) when digital signal processing is performed. Meanwhile, the control unit has a role to manage the work of the whole calibrator, such as measure the temperature and the atmospheric pressure, calculate the correction to the generated signal, and write it to the signal controller. Additionally, it is connected to the memory where the parameters of the calibrator can be stored, and controls the user interface (UI) and the communication interface (CI), which is used to presetting of the calibrator (Podg, 2014).

In addition, there is a difference between the two devices significantly. In contrast of the calibrator as discussed above that has the built-in equipment system (Calibra-, 1988), the signal controller is not a part of the design of this prototype. Nevertheless, an external generator is an optional to be used as the supporting device. Moreover, the application of this generator is reasonable because it has a wide range of frequencies and levels that is capable to be applicated to the calibration system (Frederiksen, 2013) (Hak & Wenmaekers, 2010).

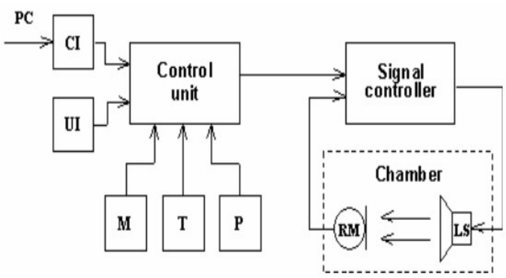

Figure 2. Block diagram of the acoustic calibrator (Podg, 2014)

In principle, the prototype that is designed in this research comprises the two main sections. The first is the body part, meanwhile the other is the head part. The both of these sections are made from an aluminium that its density is 2700 kg/m3 , and have the form of a solid cylinder. Moreover, the aluminium preference is based on its characteristic physically and chemically, where its mass is light but solid, stainless, and easy to be formed (Balysheva, 2016). Furthermore, the schematic diagram of these sections are shown in Figure 3.

From figure 3, the left side section has a dimension that consists of an outer and inner diameter that has the values are 0.18 m and 0.16 m respectively, an outer and inner height with their values are about 0.9 m and 1 m successively, and a pair of connector holes that has the value is about 1.3 cm for the outer diameter, while for the inner side is about 0.5 cm. Hereinafter, the right side section has the size of its outer diameter as well as the previous section, while its inner diameter size is about 0.164 m. Thereto, a microphone hole also is created that the outer diameter is about 0.26 cm, and is inserted an seal o-ring inside this hole.

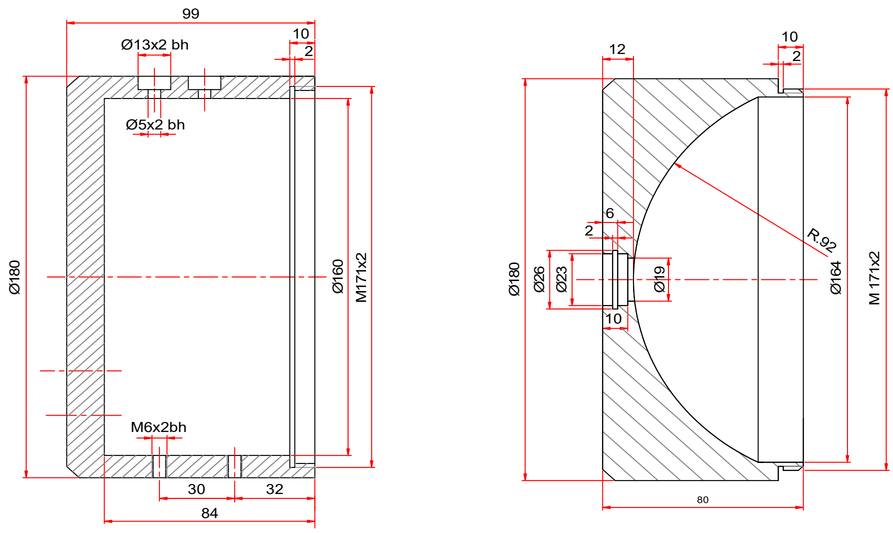

Figure 3. Dimensional schematic of the body (left) and head sections (right) of the acoustic comparison coupler.

In addition, inside these sections is installed some components that support their whole function that is shown in Figure 4. From this figure, the former section is consists of a super low noise connectors (1), a glasswool with density is 100 kg/m^3 (2), and a loudspeaker (3). The connector has the function is to reduce an unwanted noise and harmonic distortion that generated by the generator directly (Huiying, Xiangyang, & Haitao, 2016). It is assembled to a pair of holes that sealed by an o-ring. Meanwhile, assembling of the glasswool has a purpose to minimize the effect of a sound reflection, and a sound that propagate through the holes, and convert it into a heat (Freitas, Pereira, & Mattioli, 2016). The last component of this section is a loadspeaker that has a diameter of 0.16 m, and integrated with a tweeter with its diameter is 0.05 m. Hereinafter, the objective of its installation to this speaker is to provide a balance between the low and high sound pressure levels at the mid-high of audio frequencies (Ryu & Seonghyun, 2019).

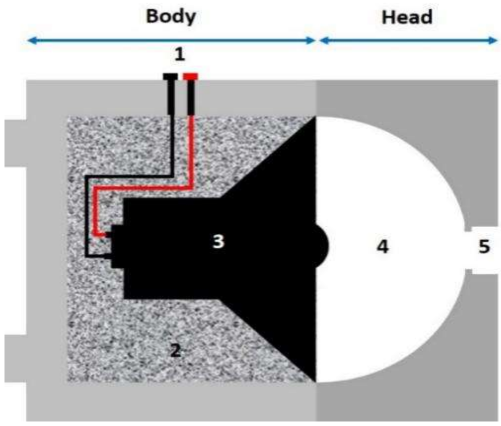

Figure 4. Diagram schematic of acoustic comparison coupler components.

Additionaly, this device has the specifications as follows: a low impedance that its value is 4 ohm, the effective of frequency range is 63 – 10 kHz, and has a capability to generate the maximum sound pressure level is 120 dB at the distance of 1 m from it. Moreover, from this performance and the specification information, it is appropriate to be used for acoustical instruments calibration.

Meanwhile, the later section of the system consists of a concave space that has the form of half round inside (4), and a coupler hole of microphones (5). The purpose of creating this space is to increase homogeneity of the sound distribution in this area, and to maintain the environmental conditions such as the area temperature, the relative humidity, and the ambient pressure in order to conform to the requirements that their value range are 20 ˚C – 26 ˚C, 25 %RH – 70 %RH, and 85 kPa – 105 kPa respectively (Bistafa, 2014), (Narang & Bell, n.d.). Whilst, the coupler slot has the diameter is 0.03 m and its depth is 0.01 m. Moreover, the distance of this hole and the loudspeaker can be calculated using the equation (1) (Hak & Wenmaekers, 2010):

$$S = \frac{1}{2}\, d \qquad (1)$$

Where, d is the diameter of loudspeaker, while S is the distance between the coupler and the membrane of speaker, where in this research is found that its value is 0.08 m.

Furthermore, some coupler adaptors also is made from a black foam material where the intention of its design is to adjust the microphone diameter from one inch to other sizes. The adaptors are consists of an one inch to half inch (1-2), an one inch to one third inch (1-3), and an one inch to one quarter inch (1-4). The first adaptor is used for calibration of the acoustical instruments that has the diameter microphone of a half inch, and, commonly, it is found in the sound level meters. Meanwhile, other acoustic devices such as a general noise exposure meter that also is known as the noise dosimeter is calibrated using the second adaptor. Furthermore, the last adaptor is a rare to be applied in the acoustics calibration and measurement regularly. However, some research institutions and aerospace industrials are necessary to measure the acoustical parameter for their necessity using the ¼ inch of microphone at the very high frequencies, such as the wind tunnel testing. Moreover, the design schematic of these adaptors is shown in Figure 5.

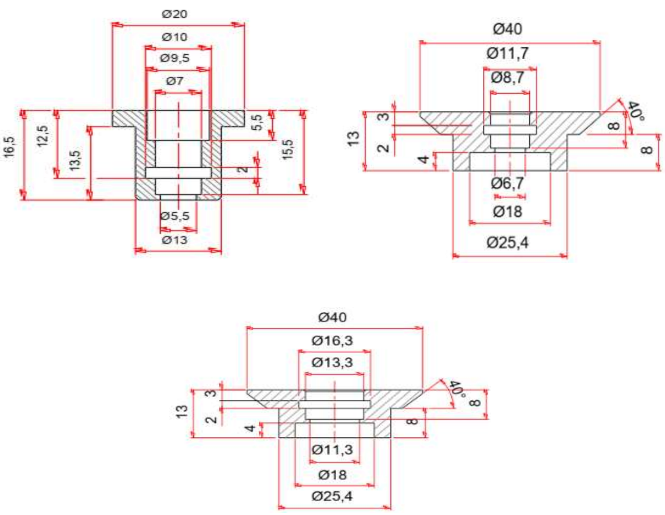

Figure 5. The coupler adaptors: one inch to one quarter inch (left), one inch to one third inch (right), and one inch to a half inch (center).

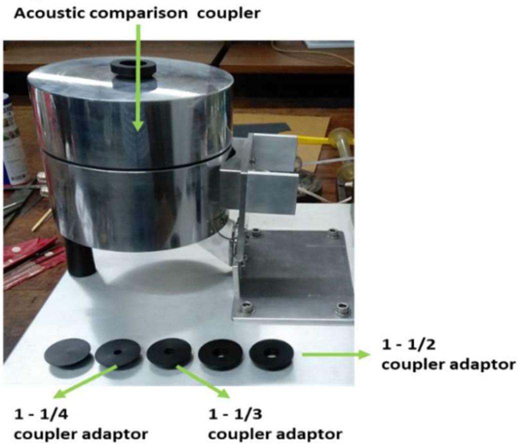

Figure 6. The acoustic comparison coupler as a prototype along with its adaptors.

Therefore, the final design of this prototype as a result of this work is shown in Figure 6 along with its adaptors.

3. METHODOLOGY OF TEST

In this work, the serial tests of the prototype also is carried out in the Laboratory of Acoustics and Vibration, SNSU-BSN, where it comprises of five stages that include measurement of insulation level, frequency responses, maximum of sound pressure level (SPL), long term stability, and total harmonic distortion, respectively. Thereto, the stages of this experiment will be discussed singly.

3.1. Measurement of insulation level

This test is performed using the direct method inside the anechoic chamber and a room that has a background noise around 45 dB separately (Pollard, Tran, Letowski, & Resources, 2013). After that, the result is compared between the two rooms. Farther, the purpose of this test is to observe and analyze the sound pressure level around prototype (detect the sound leakage) when the sound is generated. The equipments used in this measurement therewith the specifications are as follow:

Table 1. The device/equipment used in the measurement of insulation level

Device/Equipment	General Specification
Signal generator (sine generator)	Fluke 282 Arbitrary Waveform Generator: Frequency range 0.1 mHz – 16 MHz, resolution 7 digits, frequency accuracy 10 ppm/year, output level 25 mV to 10 V p-p into 50 Ω, Resolution 4 digits
Power amplifier	Brüel & Kjær type 2716: Maximum voltage gain 30 dB, frequency response 20 Hz - 20 kHz, and output impedance 0.03 Ω
Full anechoic chamber	Dimension 10 m x 10 m x 10 m, rock wool absorber, 0.1 dB deviation due to characterization and positioning of unit under test at 1 meter in front of a sound source.
Integrating sound level meter (sound level meter)	Brüel & Kjær type 2250: Dynamic range of SPL 20 dB – 140 dB, Frequency range 31.5 – 16 kHz, Self generated noise is below 15 dB.

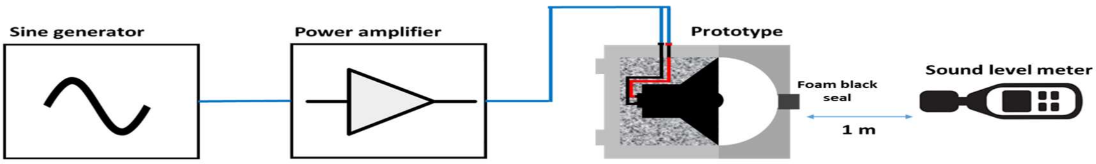

Figure 7. Block diagram of insulation level measurement

Experiment

The system measurement of this test is shown in Figure 7 using the aforementioned equipment.

From figure 7, the foam black-seal was inserted to the prototype. After that, it was placed at the center of the full anechoic chamber. Subsequently, it was connected to the generator and the amplifier outside the chamber. Afterwards, a sound level meter was installed in the distance of 1 m from this prototype. Thereafter, with adjusting the generator at the frequency of 1000 Hz, a signal was generated, and the result of measurement was recorded in the sound meter. The same step also applied in a reverberant room and also other positions of the sound level meter around the prototype with the same distance.

3.2. Measurement of Frequency Response

The method that used in this second stage is the coupler method where the transducer is putted off to the hole of the acoustic comparison coupler directly (Plinge, Jacob, Haeb-umbach, & Fink, 2016). Moreover, this test is carried out in order to observe and monitor the effective range of frequency at the sound pressure level of 94 dB as the reference value of acoustic measurement that equal to 1 Pa. The specifications of equipments that used in this test are as follow:

Table 2. The device/equipment used in the measurement of frequency response

Device/Equipment	General Specification
Signal generator (sine generator)	Fluke 282 Arbitrary Waveform Generator: Frequency range 0.1 mHz – 16 MHz, resolution 7 digits, frequency accuracy 10 ppm/year, output level 25 mV to 10 V p-p into 50 Ω, Resolution 4 digits
Power amplifier	Brüel & Kjær type 2716: Maximum voltage gain 30 dB, frequency response 20 Hz - 20 kHz, and output impedance 0.03 Ω
Pressure working standard microphone WS2	Brüel & Kjær type 4191 Secondary standard of acoustic measurement.
Sound analyzer	Brüel & Kjær type 3650-C: PC with LAN interface, PULSE software, and IDAe-based data acquisition front-end hardware.

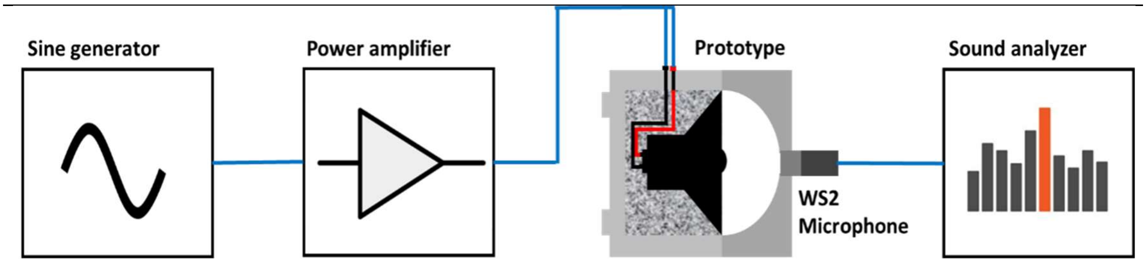

Figure 8. Block diagram of frequency response level measurement.

Experiment

The system measurement of the frequency response measurement is From this figure, the signal was generated by the sine generator at the frequency of 20 Hz and amplified by the power amplifier. After that, the signal was altered by the loudspeaker as the SPL that was detected by the calibrated microphone, and recorded by the analyzer. Subsequently, with increasing the frequency of 10 Hz through the generator, the SPL was recorded by the analyzer. the same step also applied until the frequency of 10 kHz.

3.3. Measurement of Maximum of Sound Pressure Level

The same method also is performed in this test with the prior stage. Furthermore, it is applied to obtain its capability to generate the maximum SPL at the one octave band of the frequencies that started from 63 Hz to 8000 Hz when shown in Figure 8 using the aforecited equipment.used in a coupler field. The same equipment and apparatus setup also performed in these test with the foregoing stage.

Experiment

From this figure, the signal from the generator was produced at the aforementioned frequencies. After that, the SPL that generated by the loudspeaker was received by the microphone, and recorded by the analyzer.

3.4. Measurement of Long Term Stability

In this test, the same method also is used with the prior stages, where it is applied to determine a deviation of the SPL at the same frequencies range when this system is operated for the period time of 30 minutes (IEC 61672-3, 2013). Whilst, the same equipment and step also applied with the previous tests.

In addition, this system is operated for the period time of 2 hours beyond the aforecited frequencies. After that, the SPL is recorded by the analyzer within interval 10 minutes.

3.5. Measurement of Total Harmonic Distortion (THD)

There are some methods to measure THD of a sound source, such as electrical test and acoustical methods (Jaisiva, Neelan, & Ilansezhian, 2016). The former can be applied using time selective response technique without a loudspeaker, while the later can be performed with it. In this work, the second method was chosen to measure THD with narrow band analysis, because the loudspeaker as a part of the acoustic comparison coupler systems (Dwisetyo et al., 2019). In this method, the loudspeaker and the microphones installed inside the coupler. The equipments used in measurement of THD are as follow:

Table 3. The device/equipment used in the measurement of THD

Device/Equipment	General Specification
Signal generator	Fluke 282 Arbitrary Waveform Generator:
(sine generator)	Frequency range 0.1 mHz – 16 MHz, resolution 7 digits, frequency accuracy 10 ppm/year, output level 25 mV to 10 V p-p into 50 Ω, Resolution 4 digits
Power amplifier	Brüel & Kjær type 2716:
	Maximum voltage gain 30 dB, frequency response 20 Hz - 20 kHz, and output impedance 0.03 Ω
Laboratory standard microphone LS2	Brüel & Kjær type 4180:
	Primary standard of acoustic measurement
Band pass filter	Brüel & Kjær type 1621
Sound analyzer	Brüel & Kjær type 3650-C:
	PC with LAN interface, PULSE software, and IDAe-based data acquisition front-end hardware.
Acoustic calibrator	Brüel & Kjær type 4231:
	Nominal sound pressure level 94 dB, frequency 1000 Hz

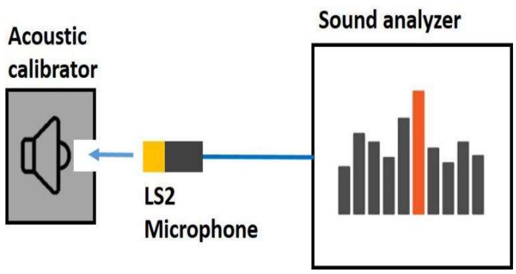

Figure 9. Determination of SPL of 94 dB.

Experiment

In this work, an experiment was set up using the aforementioned equipment and the first step is shown in Figure 9.

A standard microphone LS2 was connected to the sound analyzer. Next, the microphone was putted off to a coupler of the acoustic calibrator. By selecting frequency of 1000 Hz and sound pressure levels at 94 dB of the calibrator, the signal is generated, and is detected by the microphone thereafter, and read by the sound analyzer in voltage parameter. Further, it is taken as a reference voltage to measure the THD for fundamental frequency of 1000 Hz.

Secondly, the standard microphone was installed at hole of the acoustic comparison coupler. Then, by connecting it with the signal generator and the amplifier, they are arranged as that shown in Figure 10.

Thirdly, frequency of 1000 Hz was selected by configuring the signal generator menu. After that, by adjusting the output level, the sound analyzer was arranged so to make the display indicated the same value as the reference voltage for sound pressure level of 94 dB.

Subsequently, the measuring amplifier is connected to the bandpass filter. In order to avoid bypass signal, it is necessary to be configured this filter device by selecting filter bandwidth is 3% and specified frequency range is 200 Hz – 20 kHz.

Finally, by controlling frequency tunning of the filter, and then selecting window (flat-top) of the analyzer, the harmonic distortion can be measured and recorded directly through this analyzer and displayed in the personal computer.

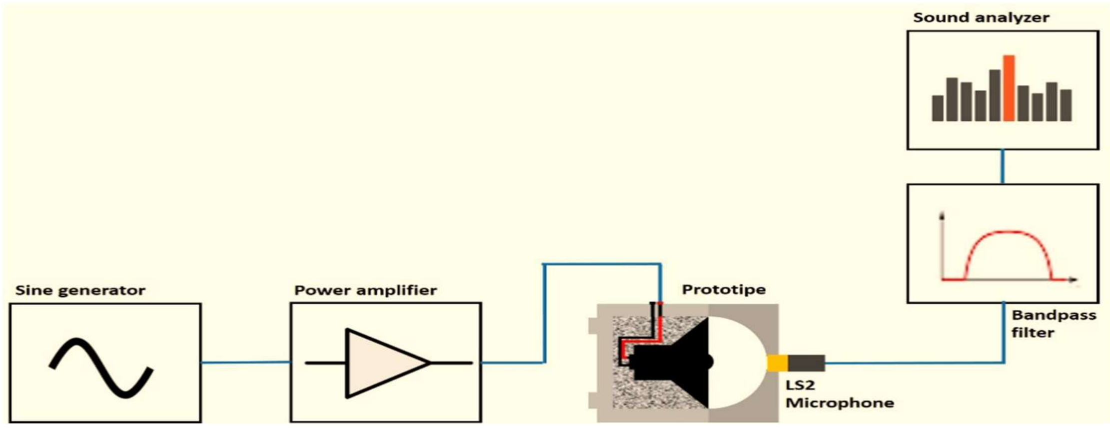

Figure 10. The diagram of THD measurement.

4. RESULT AND DISCUSSION

The results of the insulation level measurement inside the two rooms are shown in Table 4.

Table 4. Measurement results of the insulation level measurement of prototype

Positions of SLM	SPL (dB) Full Anechoic Chamber	SPL (dB) Reverberant Room
1	33.7	45.3
2	33.2	44.9
3	33.4	45.2

From Table 4, it is shown that the recorded SPL inside the full anechoic chamber for the position 1 is 33.7 dB. After that, its value tends to decrease to the minimum SPL that its value about 33.2 dB in the second position, and go up slightly to 33.4 dB in the last position. A deviation of SPL is found at the value of 0.5 dB due to difference positions. In addition, this SPL values increase of 15.0 dB to the background noise value that have been measured before conducting this measurement stage, where it has value as about 18.7 dB.

Meanwhile for the other room, it is found that the background noise that measured before measurement is about 44.5 dB. After that, the SPL has a maximum value in the first position where the determined value is about 45.3 dB. Afterwards, the same trend of SPL values is found in this step where it goes down to 44.9 dB for the next position, and reach to 45.2 dB in the last position. Thereafter, in this step also is found that the deviation between this SPL values and the background noise is very smooth, that it is about 0.9 dB.

From this stage, it is discovered that the difference between of the SPL values within the two rooms and its background is slight, where their values are 15.0 dB and 0.9 dB respectively. Hence, according to this result, this prototype is receiveable to be used in an independent rooms for the calibration of acoustical instruments.

For the second stage of this experiment related to the frequency response measurement, it is shown in Figure 11.

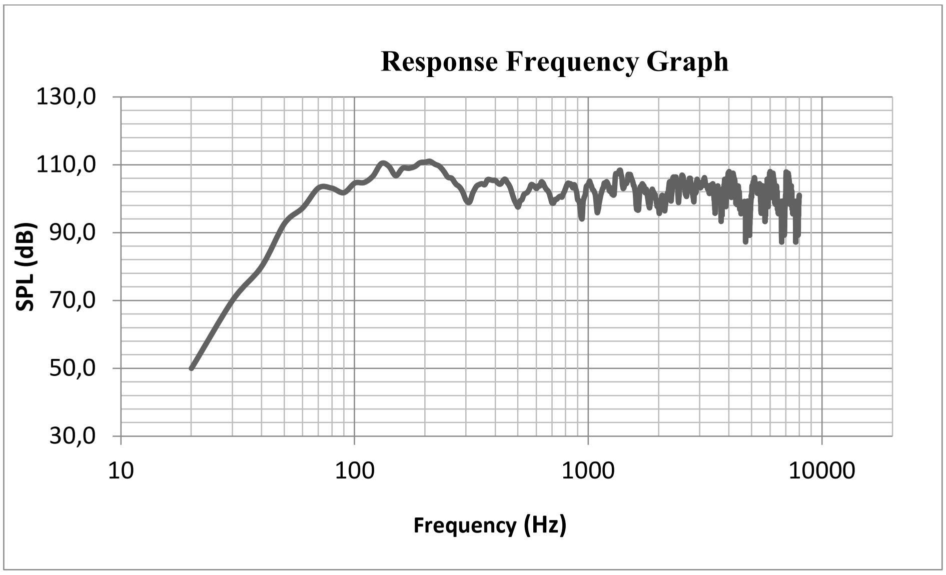

Figure 11. The result of frequency response measurement.

From figure 9, the SPL value has a tendency to increase linearly that is initiated from frequency of 20 Hz to 50 Hz where the obtained values are 50.2 dB and 92.6 dB, respectively. After that, it tends to go up and down instead of flat ather this frequency. Therefore, it is shown that it fluctuates beyond these frequencies, where the maximum SPL is found as 111.0 dB at the frequency of 210 Hz. Further, its value decrease to 87.4 dB at the frequency of 4710 Hz, and then raise up and down fluctuatingly from the frequency of 4720 Hz to 8000 Hz. Thereafter, it leans to decreasing slightly to the frequency of 10000 Hz. Moreover, factor of geometry inside the prototype is possible to contribute the alteration of this SPL at the range of 60 Hz to 8000 Hz. Eventhough the installation of absorber is capable to minimize the sound reflection effect, probability of interference between the sounds inside this prototype is feasible.

Meanwhile, the measurement of maximum SPL of the prototype as the third stage of this work is shown in Table 5. From Table 5, it is indicated that the SPL at the frequency of 2000 Hz has the biggest value among these frequencies that it is about 123.6 dB. Meanwhile, the minimum value is found at the frequency of 63 Hz that its value is 118.2 dB. In addition, according to this results, the prototype is feasible to be applied for calibration of noise dosimeter that is necessary using the high SPL among these frequencies, where the sound pressure level required is more than 94 dB.

Table 5. Measurement results of maximum SPL

Frequency (Hz)	Maximum SPL (dB)
63	118.2
125	122.4
250	122.1
500	123.4
1000	122.8
2000	123.6
4000	122.4
8000	119.7

Furthermore, the result of the long term stability measurement for the aforecited frequencies and sound pressure levels are shown in Table 6.

Table 6. Long term stability measurement

Frequency	Deviation at SPL of 94 dB	Deviation at SPL of 114 dB
(Hz)	(dB)	(dB)
63	0.2	0.3
125	0.2	0.3
250	0.2	0.2
500	0.1	0.1
1000	0.2	0.2
2000	0.1	0.1
4000	0.2	0.3
8000	0.3	0.5

From this results, the highest deviation is found at the frequency of 8000 Hz for the both of sound pressure levels that the values are 0.3 dB and 0.5dB, respectively. The SPL deviation at the frequency of 8000 Hz for SPL of 114 dB is exceed to the tolerance limit required by standard that its maximum value is 0.3 dB (IEC 61672-1, 2013), whereas at the frequency of 500 Hz and 2000 Hz, the minimum values are obtained among these frequencies that the value is 0.1 dB. Moreover, at the frequency of 1000 Hz and the two aforementioned frequencies, the deviation of their SPL have the same value for the two sound pressure levels, where it contrasts to the other frequencies that their deviation values have a tendency to increase as 0.1 dB. In addition, from this results, it is considered to be used as the uncertainty budget for the calibration of acoustical instruments using this prototype.

According to the system used (generator and amplifier), a noise effect measurement has been conducted in the previous work at the high SPL at the frequency of 8000 Hz, where it is recorded as 25.9 dB, compare to other audio frequencies in one-third octave band that the values tend to below 10 dB. However, it can be used for calibration considerably in consequence of having a big value of the uncertainty measurement at this SPL and frequency, where the maximum uncertainty that can be achieved is 0.7 dB.

The result of total harmonic distortion measurement at the fundamental frequency of 1000 Hz as the last stages of this work are shown in Figure 12.

At this frequency, it is shown that the SPL values increase from the 1st harmonic that the corresponding SPL is 57.8 dB to the maximum value at the 2nd harmonic that its SPL is 67.1 dB. From this frequency, the SPL values has a tendency to decrease until the 5th harmonic that has SPL value is 51.4 dB. After that, the SPL values go up and go down beyond this frequency. From these SPL values, the THD can later be determined, where it is obtained that this prototype has the THD is about 1.88 %. The THD values that are determined from this experiment are in tolerance limit, where its magnitudes are not more than limit of acceptance test that its maximum permissible value is 4% that required by IEC 60942 (IEC 60942, 2017). In order to get a comparation result, in addition, it is recommended to be compared and validated using the calibrated THD meter where the values can be measured through this instrument directly, where this comparison will be discussed later.

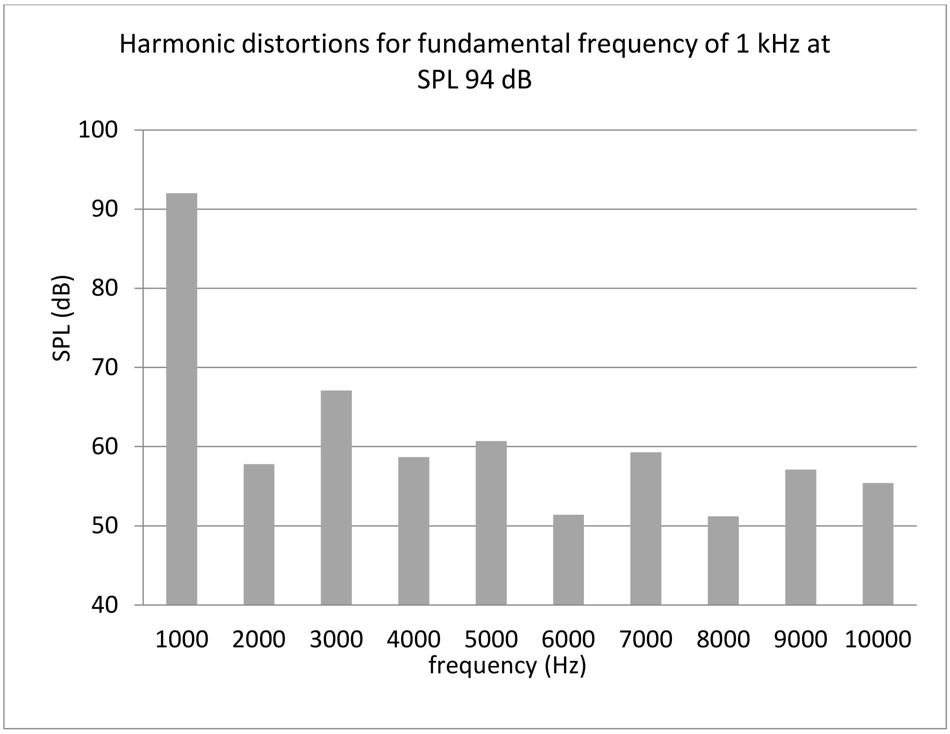

Figure 12. The result of frequency response measurement.

5. CONCLUSION

In this work, design for the acoustic comparison coupler has been carried out at Deputy of National Measurement Standard-BSN by Research Group for Acoustics and Vibration, Center for Research and Human Resource Development BSN. Furthermore, the supporting tests for this prototype also is applied with the objective is to identify its performance.

From the test results, it has a kind performance according to all experiment stages relatively. From the first stage, the difference of sound pressure level (SPL) between the two rooms and its background noise is not significant where it shown that the deviation of SPL values are 15.0 dB and 0.9 dB, respectively. Subsequently, the SPL maximum and long term stability test for the corresponding frequencies is obtained at range of SPL of 118.0 dB – 124.0 dB, and 0.1 dB – 0.5 dB, respectively. Moreover, the total harmonic distortion that measured in the final stage is still in a tolerance limit, where it has a value as 1.88 %. However, the SPL deviation of the long term stability test at the frequency of 8000 Hz for SPL of 114 dB is exceed to the expected value. Therefore, it is still acceptable in in consequence of having a big value of the uncertainty measurement at this SPL and frequency, where the maximum uncertainty that can be achieved is 0.7 dB.

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