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Audio Bio Harmonic with WT5001 Smartchip using Solar Cell

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Abstract: The design of audio bio harmonic (ABH) with smart-chip WT5001 using solar cell technology in the form of ABH instrumentation with an electricity resource derived from solar energy has been successfully created and tested, which includes (i) testing the peak frequency of sound and sound output, and (ii) emptying and charging tests to determine the effectiveness of the use of the solar cell as the power provider. The ABH system consists of (i) a sound generator device composed of WT5001 sound modules, amplifiers, and horn speakers, and (ii) structured power supply devices for solar cell modules, charge controllers, and batteries for storing power. The test results of the peak frequency for the insect (*garengpung*) sound files and the output sound of the ABH device indicate a deviation of the peak frequency of 13.46 Hz to 140.81 Hz. The 15 hours emptying test results in on mode with battery charging for 7 hours shows that the use of 10Wp solar cell is effective to provide electrical power in ABH tool operation.

Keywords: ABH; peak frequency; solar cell module; WT5001.

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I. PRELIMINARY

Sound is a longitudinal wave due to objects that vibrate. Sound propagates through a medium, such as air. Physically, the propagation of vibrations produced by the sound source raises the phenomenon of density and stretch due to differences in molecular density and air pressure which has an energy proportional to the square of the frequency of vibration produced [1]. This phenomenon is used to influence the growth and development of plants by exposing sound to plants in addition to the provision of nutrient fertilizer known as sonic bloom technology [2, 3]. Audible sound exposure in plants of a certain duration can affect the pattern of the opening of plant stomata [4, 5] so that plants can optimally absorb leaf nutrients. In addition, sound exposure has been known to affect the physiological and biochemical properties of plants [6], morphological characteristics, and plant productivity levels [7–9].

The idea of sound waves that can affect the growth and productivity of plants is one of the reasons underlying ABH research by utilizing the original sounds of insects, e.g. *garengpung*. Field testing of increased crop productivity with sound exposure for 2 to 3 hours per day by Kadarisman (2011), showed positive results including increased growth rates of potato plants (*Solanum tuberosum* L.), increased productivity in soybean plants (*Glycine max*), increased production red onion (*Allium cepa*), and improved quality of plant morphology [10]. *Garengpung* (*Dundubiamanifera*) sound exposure

on local pea plants (*Vicia faba* Linn) in the Dieng area by Widyawati (2011) resulted in an increase in plant productivity. Sound exposure of gecko grasshoppers (*Orthoptera*) to peanut plants (*Arachis hypogaea*) in Gunungkidul resulted in the growth rate increase of red ginger (*Zingiber Officinale*) [11]. From the results of the field test, ABH sound-producing instruments were developed using the WT5001 sound chip to play sound recordings with a peak frequency of 3000 Hz to 5000 Hz [12]. ABH's weaknesses are power devices, sound player generators, and speakers that are still separate systems. Overcoming the aforementioned weakness will produce an ABH that is designed to be portable and practical to be applied to agricultural lands [13]. Furthermore, in this study, the ABH instrumentation uses the WT5001 sound chip and portable system developed by applying solar cell technology as a power provider intended to produce ABH instruments that are practical and energy-efficient.

A solar cell is the smallest part of a solar technology device that utilizes photovoltaic effects by converting solar energy (photons) to electricity [14, 15]. The use of solar cell technology in ABH allows the supply of electrical power that can be directly used by the tool when exposed to the sun. This modification is expected to replace the role of household electricity used to supply electrical power or recharge the battery for the application of ABH devices on agricultural lands. This study specifically aims to produce the ABH using a smart-chip WT5001, which contains the peak frequency sound recording files and uses solar cells as a provider of power.

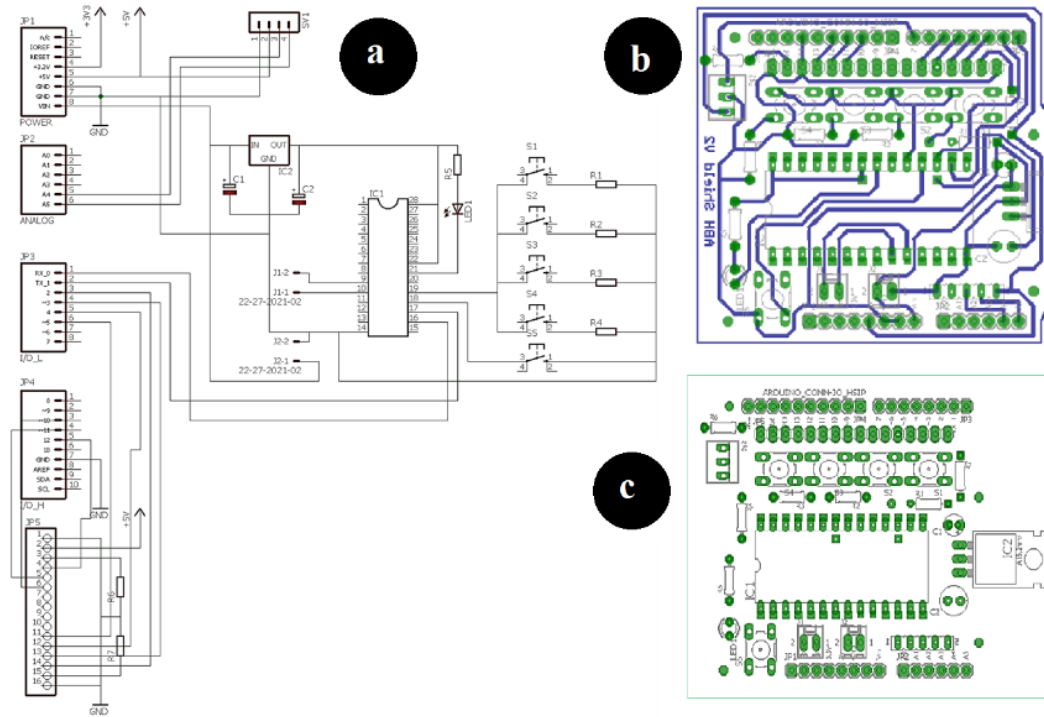


FIG. 1: (a). Sound generation circuit scheme, (b). PCB circuit path, (c). Component layout.

II. METHODS

Construction design preparation

The design preparation includes: i) preparing the sound source, ii) making the layout and PCB sound instrument electronic circuits, and iii) making the microcontroller programming. The sound source used in the ABH device is designed in the form of *garengpung* sound recording consisting of 7 files in mp3 format with variations in peak frequencies of 2000, 3000, 3500, 4000, 4500, 5000, and 6000 Hz. The sound file is stored in the Sdcard, which will be paired in the WT5001 sound module [6]. Instrumentation schemes of sound-producing devices are shown in Fig. 1(a). The figure shows that the WT-5001 sound module is connected to a microcontroller programmed through JP1 (power), JP2 (analog input), JP3 and JP4 (digital output) and also JP5 (LCD pin) sockets. This scheme also adds infrared remote sensors connected via SV1. A set of S1-S5 buttons is installed internally on the tool to provide the manual setting, reset, and selection of sounds without the remote. The circuit scheme is then printed in the PCB as shown in Fig. 1(b) with the component layout shown in Fig. 1(c). The microcontroller program used is the Arduino Uno IDE.

Design and manufacture of tools

The design and manufacture of the tools begin with modular system characterization on sound-producing devices, namely sound modules, amplifiers, horn speakers, and on charging devices, namely solar panels, MPPT (power tracker) and batteries. Furthermore, the device is designed in such a way as to carry out the ABH work function, i.e.: the sound module reads the sound files stored in the Sdcard then the output signal from the sound module is amplified with an amplifier according to the horn's power capability. This study uses PAM8610 amplifiers (10-watt stereo audio) for 12 watt Nara speaker horns. The charging device uses a 10Wp monocrystalline solar panel which has an optimum operating voltage of 17.2 volts and an optimum operating current of 0.58 amperes with power storage in the form of a 12-volt VRLA battery 7.2 amperes.

Frequency testing

Testing the peak frequencies of the *garengpung* sound mp3 files and the output sound of the ABH device are carried out to determine the frequency deviation generated by the ABH device. Testing the peak frequencies in the mp3 files is done by playing the *garengpung* sound file using the Spectraplus application to display and analyze the spectrum of the *garengpung* sound. This test is done for all sound files that are used in the

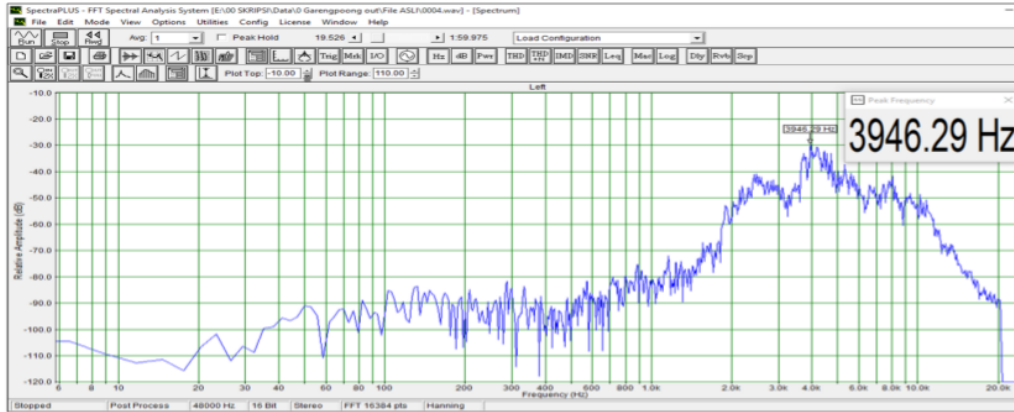


FIG. 2: Sound spectrum at a peak frequency of 3946.29 Hz with Spectraplus application.

ABH device. Fig. 2 shows one example of the display on the Spectraplus application for the peak frequency data from the sound sample of 3946.29 Hz. Furthermore, testing the output sound of the ABH device is done by recording the sound produced by the device through the horn speaker using the same application at a distance of 50 cm, 100 cm, and 150 cm, where one sound file produces three data peak frequency results.

Testing the level of effectiveness

Effectiveness testing aims to determine the effectiveness of using 10 Wp solar cells as a component of the power supply based on the ABH power requirement analysis. This is conducted by discharge and charging tests on the battery. In this test, the main parameters monitored are the decrease in sound intensity, voltage, electric current, power, and energy used by the ABH device.

III. RESULTS AND DISCUSSION

The results of [5] study are ABH instrumentations with dimensions of ± 40 cm in length, ± 30 cm in width, and ± 50 cm in height. This ABH device is portable with electrical power storage in the form of a 12V dry battery and 12W speaker attached to the device making it practical to move (portable). The result of the ABH design using solar cells is shown in Fig. 3.

The parts of the device based on Fig. 3 include: 1) a switch for turning ON or OFF; 2) infrared sensor (IR receiver) that functions as a signal received from the remote control; 3) LCD front 16x 2 as information display of time and date; 4) the front (screen) of the digital multimeter display to display the value of the voltage, current, power, and energy of the ABH device; 5) monocrystalline 10 Wp solar cell modules as energy converters from sunlight to produce DC electricity; 6) horn speaker as a sound output component to expose the sound of the *garengpung*; 7) the box containing electronic circuits and modules that must be installed internally to protect from

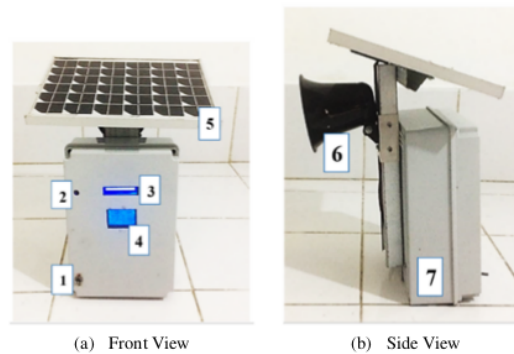


FIG. 3: Instrumentation of the ABH device with solar cells.

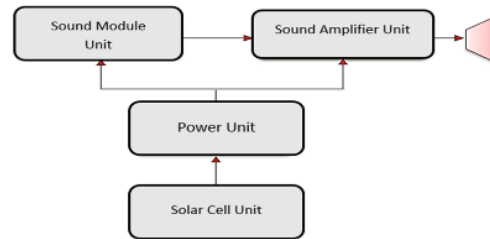


FIG. 4: ABH device diagram block.

weather changes and other factors of the environment that can affect the workings of the device. In general, the ABH workflow with the solar cells is shown in Fig. 4.

The working principle of the ABH can be observed in Fig. 5. Solar cells function as converters of solar energy into DC electrical energy and stored in dry batteries like an electrical power source of the device. The charging process occurs when there is sufficient sunlight intensity to produce a charge-

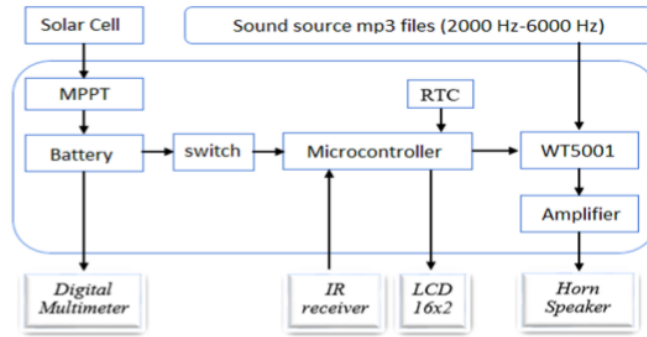


FIG. 5: Chart of the working principle of the ABH tool using solar cells.

ing voltage. The MPPT component is needed to harmonize the need for charging batteries with the voltage generated by the solar panels. The voltage on the battery can be monitored through a digital multimeter screen.

In the operation of the device or when the switch is ON, the microcontroller is active and supplies the sound instrument electronic circuit, the active RTC, and the LCD display information on time and date. The microcontroller will then instruct the WT5001 sound module to play a sound file with a certain frequency according to the remote command received by the IR receiver. The *garengpung* sound source consists of 7 sound files in mp3 format, stored in the SDcard, which is attached to the WT5001 sound module. The audio output from the sound module (9 and 10 pins) is connected to the PAM8610 amplifier so that the power gain becomes 10 watts. The output of the amplifier is connected to the horn speaker to produce a floating sound up to 100 dB.

The operation of the ABH device starts by shifting the switch to the ON state (in Fig. 3 shown by number 1). The device can be operated when the LCD is on. Screening of a self-contained sound file with a certain frequency can be done by pressing the remote control button, where one button represents one frequency. The sound intensity (volume) produced by the device can be adjusted as well. The tool can be turned OFF by shifting the switch position to OFF or can be operated in standby mode on the remote control.

The peak frequency testing is done to determine the peak frequency value of the harmonic sounds. The sound samples tested are the mp3 sound source and output sound recordings produced by the ABH device. The peak test results are obtained in Table I. The peak frequency values can be determined through the sound spectrum analysis, which is tested with the Spectraplus application.

The peak frequency test shows that the measured 2000, 3000, 3500, 4000, 4500, 5000, and 6000 Hz sound source files are 1982.42, 2972.66, 3483.00, 3946.29, 4438.48, 5036.13, 5988.28 Hz for the original spectrum of the files, respectively, and around 2042.96, 3060.41, 3469.54, 4067.98, 4297.67, 4998.39, and 6103.76 Hz for the sound outputs of the ABH device, respectively. The difference in peak values of the out-

TABLE I: Peak frequency test results.

No	Audio Frequency (Hz)	Audio 50 cm	Frequency 100 cm	Output 150 cm	Frequency Output (Hz) Average $\pm \Delta f$ (Hz)
1	1982.42	2088.72	2034.89	2005.28	2042.96 \pm 42
2	2972.66	3001.19	3095.40	3084.63	73060.41 \pm 52
3	3483.00	3483.00	3456.08	3469.54	3469.54 \pm 13
4	3946.29	4072.47	4007.87	4123.61	4067.98 \pm 58
5	4438.48	4355.09	4263.57	4274.34	4297.67 \pm 50
6	5036.13	5001.09	4998.39	4995.70	4998.39 \pm 3
7	5988.28	6099.28	6107.35	6104.66	6103.76 \pm 4

put of the sound record with the peak values possessed by the original files used as the sound source in the ABH device might be due to technical errors in the sound output of the device connected with the horned character in spreading sound. At certain angles, this produces different sound characters and measurements on the sound recording fragments that are very difficult to do at the same time. Hence, the results obtained are in the form of average measurements.

Power test

Discharging the device is performed by operating the ABH to produce a sound at a particular frequency, e.g.: 2000 Hz, in a certain period of time at the maximum volume. For every 10 minutes, the battery voltage and electric current on the multimeter display are observed and recorded in order to obtain the decline of the voltage Graph, which may be observed in Figure 8. Based on the figure the voltage reduction is observed for 15 hours starting from a voltage of 12.5 V (full charge) until the minimum battery voltage is around 6.0 V with a decrease character that is not linear. In the first 12 hours the voltage drop is relatively small (ramps graph) with a measured electrical current of around 3 A to 3.5 A and the resulting sound, intensity ranges from 90 dB to 100 dB. The graph is steep when it reaches a battery voltage value of less than 10 V to a voltage of 6.0 V and the device is unable to produce sound. It may be observed that the current also decreases and the sound

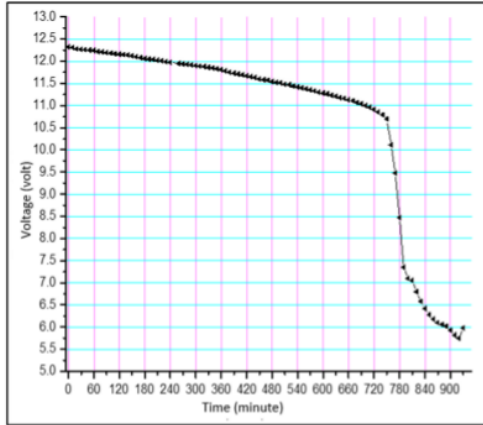


FIG. 6: Power test voltage graph.

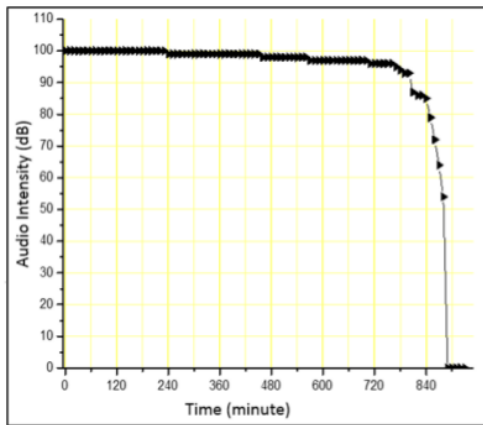


FIG. 7: Graph of decreasing sound intensity of the ABH device.

intensity produced by the device is unstable until it reaches 0 dB (no sound). Sound intensity measurement (Fig. 7) is carried out at a distance of 2 meters from the output component of the ABH using a sound level meter.

Data on the decrease in voltage, electrical current, power consumption, and energy in the ABH discharging test for every 1 hour can be presented as Table II. It can be seen that the average power consumption for 15 hours is 1.12 W.

Charging test

Charging ABH using solar cells is done by placing the device in a place that is exposed to sunlight with sufficient intensity. In this ABH charging system, the regulator charger controller in the MPPT module is arranged in such a way as to avoid power storage from the effect of overcharging. In the testing, MPPT is supplied using a power supply and then the input

TABLE II: ABH power discharge test data results.

Time (hour)	Voltage Drop (V)	Electric Current Average (A)	Power (W)	Energy Deviation (Wh)
1	0.08	3.23	0.26	18
2	0.08	3.48	0.28	14
3	0.1	3.44	0.34	12
4	0.08	3.39	0.27	13
5	0.08	3.24	0.26	12
6	0.09	3.25	0.29	14
7	0.14	3.4	0.48	13
8	0.13	3.42	0.44	14
9	0.12	3.5	0.42	16
10	0.14	3.4	0.48	18
11	0.15	3.4	0.51	19
12	0.22	3.39	0.75	23
13	2.44	3.44	8.39	33
14	2.05	1.66	3.40	11
15	0.44	0.62	0.27	6
Average	0.42	3.08	1.12	15.73

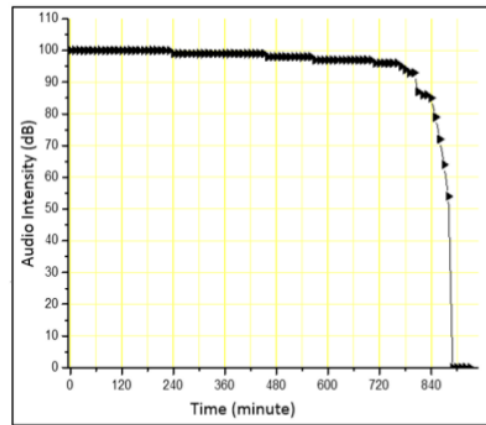


FIG. 8: Character voltage charger-controller.

voltage value is measured.

Fig. 8 shows the relationship between input and output voltages in the MPPT module characterization with the regulator setting of a 13-volt voltage limit. Based on the results of the characterization it can be seen that the MPPT module output voltage used in ABH has a value that tends to be stable around 13 V to 13.5 V even though the input voltage is increased to 22 V, while the output voltage is zero when the input voltage is less than 13 V. From the results of this characterization it can be interpreted that when MPPT is installed in the ABH device with input voltage coming from a solar cell module, the battery charging process will take place when the output voltage of the solar cell is greater than 13 V. Furthermore, in the solar cell module, the amount of voltage produced is influenced by the high and low intensity of sunlight. This can be observed by measuring the output voltage of the solar cell

TABLE III: Solar cell voltage test results.

Time	Light intensity (lux)	Solar cell Voltage (V)	Condition
08:30	48000	18.59	Sunny
09:30	14600	11.11	Cloudy
10:30	46000	13.90	Sunny
11:30	58000	15.01	Sunny
12:30	45500	15.00	Sunny

TABLE IV: Charging the battery with solar cells.

No	Time	Battery voltage (V)	Light intensity (lux)
1	07:00	6.86	28700
2	08:00	8.63	29000
3	09:00	10.79	41500
4	10:00	11.00	4800
5	11:00	11.85	45200
6	12:00	12.30	30800
7	13:00	12.45	31700
8	14:00	12.50	32900

module under exposure to sunlight. The results of measuring the sunlight intensity and the voltage produced by the solar cells are presented in Table III.

From Table III, information on the value of sunlight intensity at various time points and weather conditions is qualitatively obtained from 08.30 to 12.30 AM in the morning. The measurement data in Table III is then used as a reference for charging the battery using the solar cell module. Based on the results of the characterization of the charge controller and the solar cell module, adjustments to the power storage specifications in the form of a VRLA 12 V battery charging test and the filling data are presented in Table IV.

The charging test is carried out when the battery voltage to supply the minimum operating device is around 6.8 V until a maximum voltage of 12.50 V is adjusted to the battery specifications and the power requirements for the operation of the ABH device. The time needed to charge a 12 V battery using a 10Wp solar cell is around 7 hours with a light intensity of 28700-45200 lux which is randomly distributed from 07.00 AM to 02.00 PM. Cloudy weather conditions when charging

cause low sunlight intensity and result in the voltage generated by solar cells to be less than optimum. Charging that is carried out in sunny weather needs less than 7 hours.

Effectiveness of the Use of solar cells

The level of effectiveness of using 10 Wp solar cell module in providing electrical power for the ABH device can be determined based on the results obtained from the power consumption test and battery charging test, namely, the battery can be used for 13 hours effectively with only 7 hours of charging time. If the average use of tools is 2-4 hours a day, the tool can be used for 3-6 days without charging. In addition, if the daily intensity of sunlight is always sufficient to charge the battery then the device can operate without relying on the source of electrical energy from the house at all, which is more energy-efficient. Another advantage of this design is that if the device is operated under exposure to sunlight, the power for the operation does not use the stored power but directly from the solar cell voltage so that the battery has no reduced power. Thus the ABH device designed in this study can be used to expose sound according to the needs of plants, for example by adjusting the frequency level, setting the duration of exposure time, adjusting the intensity of sound to the distance and level needed by plants. The device is also tested in maximum conditions, with the output sound having a stable intensity, supported by programs that allow it to be constantly updated according to the needs of the device such as an alarm, as well as other components for additional applications.

IV. CONCLUSIONS

The ABH with solar cell technology has been designed and tested. The device is composed of a file player system, a hollow sound horn, an electric charging system with a solar energy source, and a choice of sound source files with frequencies of 2000, 3000, 3500, 4000, 4500, 5000, and 6000 Hz. The results of the peak frequency test of the *garengpung* sound file and the output sound produced by the tool show a deviation of the peak frequencies around 13 Hz to 141 Hz. The 15 hours emptying test results are in the ON mode. The charging test for 7 hours shows that the use of a 10Wp solar cell module is effective enough to provide electrical power to the ABH device at 12 volts.

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