Design and Manufacturing Audio Bioharmonic Technology with Manipulate Peak Frequencies for Crop Field

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Abstract: Applied physics can be involved and integrated with various fields of science. Sonic bloom technology by utilizing sound waves in fact can increase plant growth. This research is the development of the audio bioharmonic (ABH) device to create an efficient, practical, and easy-to-use for farmers. The design and manufacturing of an ABH device based on an Arduino UNO Atmega 328p with manipulated frequencies have been done. The original sound source of Garengpung (*Dundubia Manifera*) was manipulated around the range of 3000-5000 Hz and the frequency spectrum was calculated using Fast Fourier Transform (FFT) analysis. The results show that the peak frequencies obtained are 3241, 4167, and 4963 Hz as the sound sources of mp3 files. Furthermore, the ABH device was validated by comparing the results of the FFT analysis of the sound source of the mp3 files with the sound recording of the ABH device. As the result, the deviations of the peak frequency obtained are 259, 140, and 172 Hz. And the last, the sound pressure levels (SPL) of audio bioharmonic output at different frequencies are measured using a sound level meter in real-time for 30 minutes. All frequencies have stable SPL at 80-100 dB.

Keywords: Dundubia Manifera; Audio Bioharmonic; FFT Analisys; Matlab R2015a; Sound Pressure Levels; Arduino Uno.

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I. INTRODUCTION

The sound wave is a wave that causes molecular vibrations in its propagation medium. This shows the transfer of energy from the source to the end of the vibration. Sound waves are widely applied to increase positive stimulation in living things such as humans, plants, and others [1]. Sound wave technology can be applied to many different types of plants. Sound waves with frequency, sound pressure levels (SPLs), exposure periods, and distance from sound sources can affect plant growth. Sound waves with a certain value can significantly increase the activity of enzymes and endogenous hormones which are very good in crop fields [2]. Stimulating plants can be done by controlling the environment around plants such as temperature, light, wind, and even sound waves. Sound waves with a certain frequency and intensity can have a positive influence on plant biologicals such as seed germination, roots, plant height, callus growth, cells, transduction systems, enzymes, hormone activity, and plant genes [3].

Sonic bloom is a technology that applies sound waves at the frequency of 3500-5000 Hz. This technology combines high-frequency sound waves and organic nutrients to increase crop field productivity. This combination of sound waves and nutrients effectively opens the stomata widely at the frequency of 4000 Hz in soil moisture of 100%. Another impact that can increase the absorption of nitrogen, phosphorus, and potassium [4]. Various types of sound waves have been tested on plants such as animal sounds [5] and music (dangdut, jazz, rock, classical)[6]. The result can stimulate the opening of stomata wider than without treatment, thereby increasing the effectiveness of the absorption of fertilizer nutrients which are very useful for plant growth [7]. This study uses a sound source from garengpung (*Dundubia Manifera*) which has been used by many other researchers and can increase the productivity of the crop field [7–9]. Besides sound waves can stimulate crop field, the sound wave may also strengthen the immune system of plants from pests and virus diseases [2].

Audio Bioharmonic (ABH) is one of the media that can be used to apply sound waves that are more practical, efficient, and easy to use. This research is the development of an audio bioharmonic device for tomato fields. The device that used by farmers on tomato plants is larger, inefficient and impractical to use. Thus, the audio bioharmonic device designed in this study can be more practical, effective, and easy to use for farmers [10]. Many ABH devices have been created, one of them is using WT5001. ABH design with WT5001 smart chip provides quite good with a small deviation of the measurement results of mp3 files and ABH sound output [9]. Application of ABH Device significantly increases the growth of rubber [8]. The application of ABH device with solar energy can increase crop field productivity, such as cayenne, read onion, and maize that enhances to be 76.4%, 56.3%, and 67.8%, respectively [11].

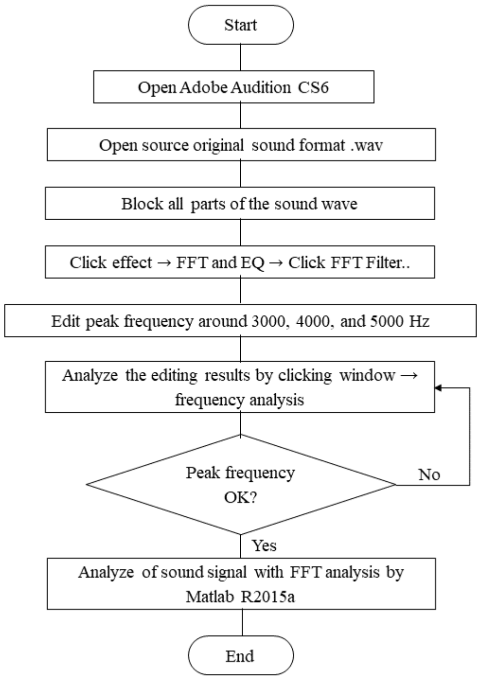

FIG. 1: Flowchart of the sound wave cutting process using Adobe Audition CS6 to get a peak frequency of 3000-5000 Hz.

II. METHOD

A. Manipulation of the Peak Frequency

Manipulation of the peak frequency of sound waves was done by two processes: 1) cutting sound waves from *Dundubia Manifera* voice recordings, and 2) manipulating the peak frequency of sound sources with Adobe Audition CS6 [5]. Manipulation of *Dundubia Manifera* sound sources with Adobe Audition CS6 aims to obtain high peaks frequency of 3000, 4000, and 5000 Hz as sound sources for stimulation of crop fields. These frequencies were chosen according to the reference that sonic bloom technology is in the frequency range of 3000 5000 Hz [4]. The flowchart of the sound wave cutting process using Adobe Audition CS6 to get a peak frequency of 3000-5000 Hz can be seen in Fig. 1.

B. Fast Fourier Transform (FFT) Analysis

Fast Fourier Transform (FFT) is performed to analyze the sound wave signal. FFT is a derivative of the Discrete Fourier Transform (DFT) equation. The following is the FFT calculation which can be written in sinusoidal form [12],

$$x(k) = \sum_{n=0}^{N-1} x(n) \sin\left(\frac{2\pi kn}{N}\right) + j \sum_{n=0}^{N-1} x(n) \cos\left(\frac{2\pi kn}{N}\right) \quad (1)$$

In which, $x(n)$ is coefficient of sine and cosine at 2πkn and $x(k)$ is the value of the k-th spectrum in the frequency domain.

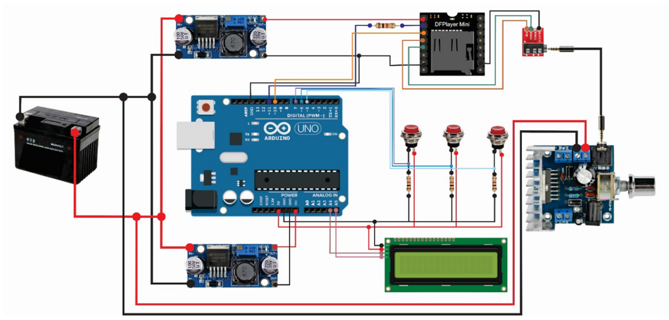

FIG. 2: Schematic of Audio Bioharmonic (ABH) device.

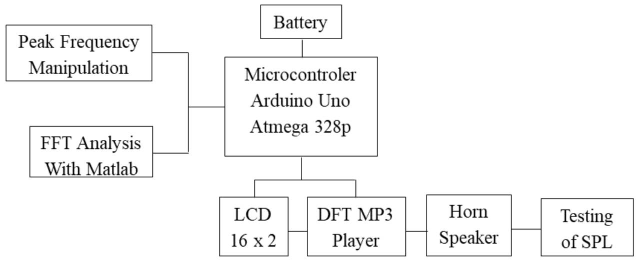

FIG. 3: Block diagram of the process of validating the ABH device.

k and n are the index of the frequency at the N-th frequency and the index of time, respectively.

C. Design of Audio Bioharmonic (ABH)

The audio bioharmonic (ABH) device is designed using electronic devices, namely the Arduino Uno Atmega 328p which functions as ABH controller, DFT MP3 Player, SD card, TRRS 3.5 mm audio jack, DC-DC Inverter, TDA 7297 amplifier, LCD 16 x 2, speaker horn narae 12 Watt, and 12 V battery. The electronic components are designed as the circuit schematic shown in Fig. 2.

Arduino Uno is a micro-controller device that can be programmed using a programming language to control all input/output electronic components. The output of the ABH device can produce sound pressure levels (SPLs) with higher pitches. This ABH device is also equipped with previous, next, and pause/start buttons which are displayed on the 16 x 2 LCD.

D. Testing the Sound Output of Audio Bioharmonic

Testing the sound output of the ABH device consists of two steps, namely 1) analyzing the sound frequency recorded from the ABH device output with FFT analysis, and 2) analyzing the sound pressure level (SPL) output of the ABH device. At first, sound frequency analysis was carried out to validate the output of the ABH device according to the original frequency using Matlab R2015a. After that, testing of SPL was carried

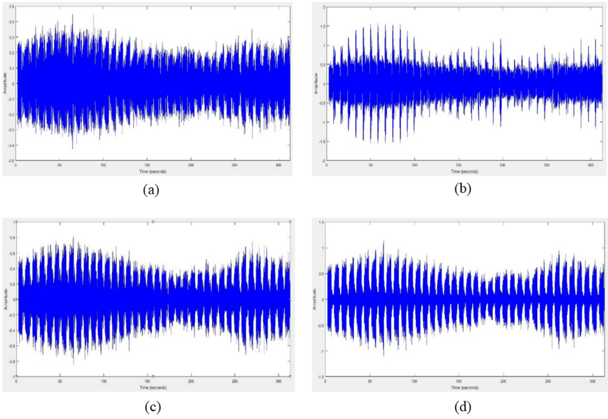

FIG. 4: Graph of the digital signal of amplitude (m) vs time (s) for a) original sound without editing, and at frequency of b) 3000 Hz, c) 4000 Hz, and d) 5000 Hz.

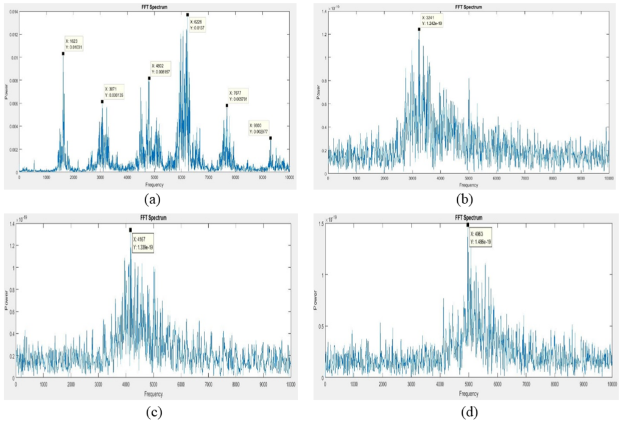

FIG. 5: Graph of FFT analysis of power vs frequency at a) original sound, b) 3000 Hz, c) 4000 Hz, and d) 5000 Hz.

out to measure the level of intensity produced by the ABH device that has been designed. This test uses an instrument of sound level meter which is performed in real-time to obtain the minimum and maximum intensity levels of sound output from the horn speaker for 30 minutes. The test is done in a laboratory that is far from noise to reduce the sensitivity of the sound level meter.

III. RESULTS AND DISCUSSION

This research is motivated to improve the ABH device that has been used previously on tomato fields which is more practical, efficient, and easy to use for farmers [10]. The ABH device that can be used in crop fields is a validated instrument. The design of the ABH device begins with preparing mp3 files that have been manipulated by its peak frequency. The sound waves used are sound waves derived from the pre-recorded *Dundubia Manifera* sound. The original sound of the D*Dundubia Manifera* sound does not yet have a specific peak frequency according to the sonic bloom theory in 3000-5000 Hz. The block diagram of the validation procedure of the ABH device can be seen in Fig. 3.

Adobe audition CS6 is software used for manipulating animal sounds in the frequency range 3000-5000 Hz [5]. This study uses Adobe Audition CS6 to obtain peak frequencies range of 3000-5000 Hz. Furthermore, sound signals are extracted to be converted into a time-domain digital signal using Matlab R2015a. The results can be seen in Fig. 4. Fig. 4 (a) is time-domain digital signal of the original sound without editing. Meanwhile, Figs. 4 (b), 4 (c), and 4 (d) are time-domain digital signals at 3000 Hz, 4000 Hz, and 5000 Hz, respectively. The manipulated sound signal changes the value of the wave amplitude with time. It can be seen that the amplitudes of the waves in Figs. 4 (b), 4 (c), and 4 (d) are smaller than the amplitudes of the original sound waves in Fig. 4 (a).

FFT analysis is used to transform time-domain digital signal of Fig. 4 into the frequency-domain signal of Fig. 5. This

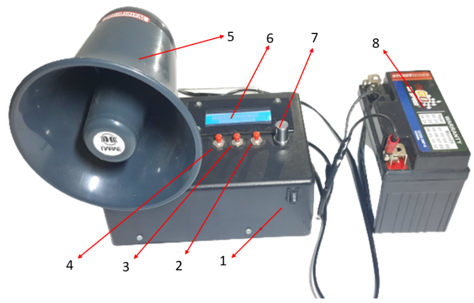

FIG. 6: The external design of the portable audio bioharmonic (ABH) device with dimensions of 180 x 115 x 60 mm.

approach is very useful for determining the parameters of the vibration system. Thus, the time-domain digital signal must be transformed into a frequency-domain signal to view the frequency spectrum [12]. FFT analysis was calculated with Matlab R2015a. Fig. 5 (a) shows the FFT analysis of the unmanipulated *Dundubia Manifera* sound. There are 6 peak frequencies, namely 1600, 3071, 4800, 6220, 7677, and 9300 Hz. Based on the results of the study by Hassanien (2014) that the frequency with a specific value can affect plant growth. This means that the peak frequency that appears in Fig. 5 (a) must be cut, which is in the range of 3000-5000 Hz. This is following the study of Kadarisman *et al* (2019), stimulators from animal sounds that have a peak frequency between 3000 Hz-5000 Hz are very useful for the agricultural field. Meanwhile, Figs. 5 (b), (c), and (d) are FFT analyses at manipulated frequencies of 3000, 4000, and 5000 Hz, respectively. The result shows that the peak frequency manipulated with Adobe Audition CS6 has a frequency of around 3241, 4167, and 4963 Hz. Measurements using FFT analysis provide a high level of accuracy [13]. This is also following the research of Xing *et al* (2020) that the accuracy of FFT analysis of acoustic signals is up to 95.6% [14]. The results of this FFT analysis explain that the results of manipulation of the peak frequency with Adobe Audition CS6 have been validated. Thus, validated mp3 files can be added to the ABH device.

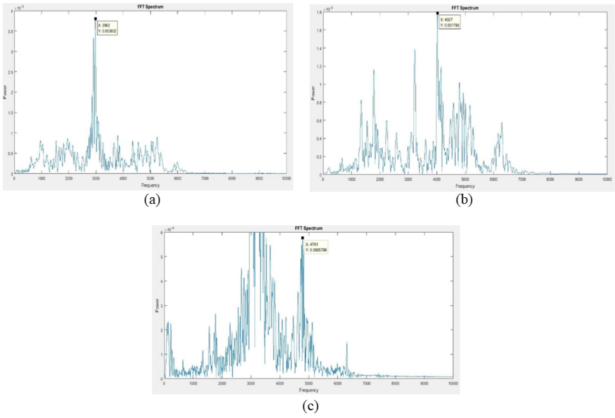

FIG. 7: Graph of FFT Analysis of power vs frequency output sound of ABH device at a)3000 Hz, b)4000 Hz, and c)5000 Hz.

TABLE I: The results of the comparison frequency between the original source of mp3 files and the output of horn speaker of ABH device.

Frequency of original source from mp3 files	Output frequency of horn speaker	Deviation
3241 Hz	2982 Hz	259 Hz
4167 Hz	4027 Hz	140 Hz
4963 Hz	4791 Hz	172 Hz

The design and manufacture of the ABH device have been completed. This portable ABH is assembled into a box that has dimensions of 180 x 115 x 60 mm. The ABH device is connected to the battery 12 Volt as a power source. Fig. 6 is an external view of the designed ABH device. Based on Fig. 6 from numbers 1-7 in a row, there are the ON/OFF button, the next button, the start/stop button, the previous button, the horn speaker, the 16 x 2 LCD, the tuning amplifier, and battery, respectively. The programmed Arduino Uno Atmega 328p gives commands to the MP3 DFT Player to run manipulated mp3 files (*Dundubia Manifera* sound). Horn speakers are used as outputs that emit sound from the ABH device. The tuning amplifier can be used to reduce/enlarge sound pressure levels (SPLs).

This ABH device was tested to obtain a frequency spectrum and sound pressure levels (SPLs). The test begins with recording the voice of *Dundubia Manifera* from the horn speaker's output using a voice recorder and changing the voice recording format to .wav. Furthermore, the digital signal from the recording is calculated using FFT analysis to obtain its frequency spectrum. The results obtained are 2982, 4027, and 4791 Hz as a horn speaker output, the results of which can be seen in Fig. 7. Table 1 shows very small deviations between source sound of mp3 files and output sound of ABH devices ranging from 259, 140, and 172 Hz. This deviation occurs because there are several factors such as the time-domain that is not the same at the time of measurement and the occurrence of errors in the speaker [9].

And the last, the test on the horn speaker narae 12 Watt output of the ABH device was performed with a sound level meter to determine the sound pressure levels (SPLs). The average SPL produced by frequencies range of 3241, 4167, and 4963 Hz is 82, 85, and 95 dB, respectively. This is consistent with the study conducted by Hassanien (2014) that the obtained SPL is in the range of 75-100 dB, which is very good for increasing plant productivity.

IV. SUMMARY

The design and manufacture of the ABH device have been completed. The original garengpung (*Dundubia Manifera*) sound must be manipulated for its peak frequency to be added to the ABH device. The ABH device can be used if it has been validated by comparing the results of the FFT analysis between the sound source of the mp3 files and the recorded sound from the speakers of the ABH device. As the result, the deviation between the two is very small and the ABH device can be used widely. It is hoped that this ABH device has the characteristics of being practical, efficient, and easy to use by farmers and can be useful for increasing crop fields.

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