KLIK: Kajian Ilmiah Informatika dan Komputer
ISSN 2723-3898 (Media Online)
Vol 4, No 1, Agustus 2023, Hal 243-251
DOI 10.30865/klik.v4i1.1014
https://djournals.com/klik

Design of Cardionics Stethoscopes and Bluetooth Wireless to Analyze Lung Sounds Using LabView Software

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Abstract−The lungs are organs in humans that run the respiratory system (breathing) and function as an exchange of oxygen and carbon dioxide. To detect lung sounds, a stethoscope is needed as a tool to listen to sounds in the lungs. This technique is commonly called auscultation. This article aims to modify the Cardionics digital stethoscope medical device by adding Bluetooth Wireless so that it can be recorded in a software program called LabView. The sound produced from the Cardionics stethoscope is connected to a Bluetooth transmitter type, and the signal will be received by a Bluetooth receiver type that has been connected to MyRio. MyRio will then be connected to LabView software to display a graph of the Lung sound signal. This research will make it easier for doctors to analyze the patient's lung sounds.

Keywords: Lung sounds; Stethoscope Cardionics; Bluetooth Wireless; LabView; Auscultation

1. INTRODUCTION

The lungs are one of the organs that play an important role in running the respiratory system in humans. This is to meet the needs of oxygen in the body. When air reaches the lungs, there will be an exchange between oxygen from outside the body and carbon dioxide from the blood. If the lungs experience disorders or abnormalities that will have a negative impact on the performance of the respiratory system, this process will also be disrupted, and if not treated immediately and seriously, it can cause death for the sufferer [1].

The lungs function as one of the organs of respiration that are interconnected with circulatory circulation. The main function of the lungs is as a temporary shelter and for the exchange of oxygen and carbon dioxide. This organ works every day, so if there is even the slightest damage to any part, it will affect the functional body and be fatal to the body [2]. Lung disease can be caused by several factors, such as genetic factors, diet, air pollution, smoking too often, and bacterial or viral infections. As for some diseases in the lungs, such as asthma, lung cancer, lung infections, and chronic obstructive pulmonary disease (COPD) [3].

One way to prevent lung disease is to recognize the symptoms that often occur in the lungs. By looking at the symptoms that occur in the lungs. A tool that is often used is a stethoscope. By using a stethoscope, a lung specialist can determine the condition of the lungs, which will contain aspects such as the type of disease, the name of the disease, the way of transmission, and the way of development of lung disease against other diseases [4].

A stethoscope is a tool commonly used in the field of Health to detect a person's condition. Stethoscopes are commonly used to listen to sounds that exist in a person's body, such as breathing sounds in humans lungs. This technique is called auscultation. From the results of this auscultation, the doctor will determine the condition of a patient. The auscultation technique using a stethoscope has many limitations and disadvantages. This technique is a subjective process where the results depend on the hearing ability and experience of a person [5].

On the other hand, technology is increasingly developing towards wireless technology, and with this rapid advancement comes an increasing number of functions on electronic devices. With so many activities, most people choose to learn independently and not focus on one place or time. That is, one can learn anywhere and anytime. A learning application becomes a person's strategy to utilize technology to increase knowledge that can be done anywhere and anytime [6].

While wireless communication, or wireless, is a communication system whose transmission medium is non-physical (without wires), There are several types of wireless communication, one of which is via Bluetooth wireless, which is now widely used by many people [7]. To reduce the risk of limitations of this auscultation technique, a device was created that can convert the sound signals produced by the lungs into a graphical display in LabView software. So that it can make it easier to recognize sound patterns that can be produced by the lungs and to make it easier to monitor the sound of one's lungs with a wireless network so as to make it easier to monitor a condition with a distance far enough so that it can minimize time.

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The device designed using a stethoscope as an initial detection of lung sounds has been modified by adding a Bluetooth transmitter. The sound signal will then be captured by a Bluetooth receiver that has been connected to MyRio. MyRio will then be connected to LabView software, and the signal will display a graph on a Personal Computer (PC). So that it can help in analyzing the patient's lung sound and become a more effective and efficient examination. In this case, the doctor does not need to analyze in the examination room; he can simply look at the visualization displayed by LabView software on a Personal Computer (PC).

Respiratory sound is part of the sound of breathing into the lungs and has two processes, namely inspiration and expiration. Breathing sounds include sounds in the mouth and trachea, while sounds around the chest are called lung sounds. The sound in the lungs of a human being is caused by air turbulence when air enters the respiratory tract. Differences in airways in the respiratory system will cause turbulence so that air flows from a wide channel to a narrower channel and vice versa [8].

Lung sounds are divided into three categories: normal lung sounds, abnormal lung sounds, and additional sounds. There are 12 auscultation sites in the anterior chest and 14 locations posteriorly. Breathing sounds can be divided into several categories, as shown in Table 1. Figure 1 shows the auscultation position often performed by pulmonologists.

Table 1. Types of Lung Sounds

Normal	Abnormal	Adventious
tracheal	absent/decreased	crackles
bronchial	harsh vesicular	wheeze
bronchovesicular		rhonchi
vesicular		stidor
		pleural rub

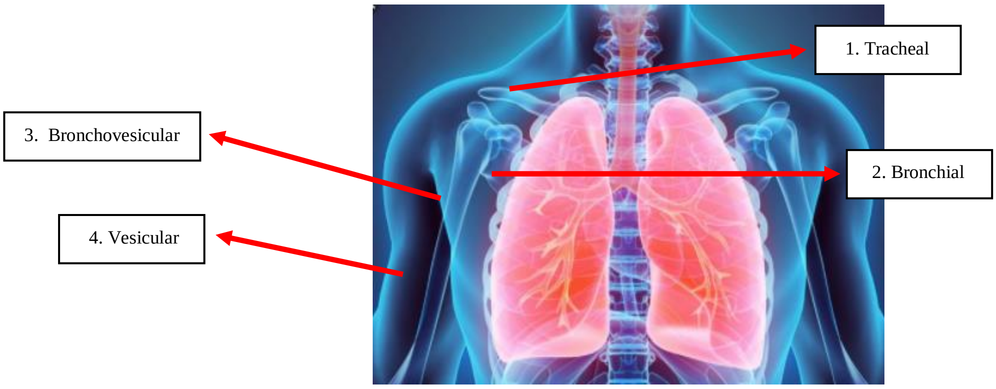

Figure 1. Normal lung sound categories based on auscultation position

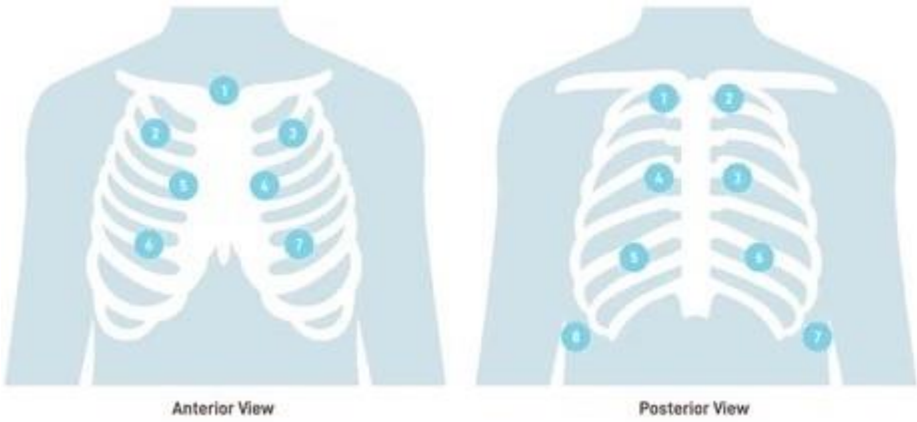

Figure 2. Anterior and posterior abnormal lung sound categories

Several lung sound detection designs have been carried out by researchers. Like Dodik Kurniawan's research [8], which has the title "Design a Lung Sound Detection Device to Analyze Android-Based Lung Abnormalities," to make an Android-based lung sound detection tool. The design of the device uses a stethoscope as an initial detection of lung sounds that is amplified with a series of pre-amplifiers for signal reinforcement from the stethoscope, which is connected to a series of low-pass filters that cut the signal at a cutoff frequency of 1000 Hz and pass the signal below 1000 Hz, a high-pass filter that cuts the signal in the frequency area above 20 Hz, and a Notch Filter with a cutoff of 50 Hz to reduce noise and smooth the appearance of the signal. The output of this circuit will be read by Arduino as input, and then the reading data will be communicated serially using Bluetooth HC-05, which is then visualized in Android.

In his research, Endang Budiasih [9], entitled "Development of Electronic Stethoscopes and Auscultation Analysis Software," made a tool consisting of a hardware part in the form of an electronic stethoscope and a software part for auscultation analysis. Electronic stethoscopes function to acquire lung sound data, while software functions to record, store, display, and analyze lung sounds.

In Syah Alam's research [10] entitled "Design a Heart Rate Monitoring System Using Bluetooth and LabView-based Electrocardiographs," This study proposes to design a prototype of a human heart rate monitoring device based on Arduino and LabView, which is communicated using Bluetooth so that it can be accessed effectively using wireless. The design uses electrode sensors connected to the initial amplifier, band pass filter, end amplifier, clamper circuit, and Arduino Uno connected to the HC-05 serial Bluetooth module, which can be monitored by LabView software using a Personal Computer (PC).

Table 2. State Of The Art

Authors	Research Title	Deficiency	Reference
Dodik Kurniawan	Design a Lung Sound Detection Device to Analyze Android-Based Lung Disorders	The display of voice signals on Android is not very clear because the Arduino microcontroller is not so fast at reading circuit data.	[8]
Endang Budiasih	Development of Electronic Stethoscopes and Auscultation Analysis Software	Acoustic stethoscopes that are less sensitive and less high gain cause poor recording results	[9]
Syah Alam	Design a Heart Rate Monitoring System Using Bluetooth and LabView-Based Electrocardiogave	Heart rate calculation is not good where the 60-second heart rate change is sometimes less stable.	[10]

In today's era where digital technology seamlessly weaves itself into almost all aspects of our lives, Health fields like cardiology and stethoscopes are no exception. This electronic medical device serves to help solve voice problems and amplify the sound heard on the chest or other body parts. The electronic sound is then converted into an electrical wave, which will later produce a clearer sound when it reaches the ear. It provides superior sound quality with up to 120x amplification, which is very useful for detecting subtle and hard-to-hear sounds. Its selection feature allows users to switch between heart and lung sounds, minimize ambient noise, and focus on the required frequency [11].

Figure 3. Stethoscope Cardionics

Bluetooth wireless can be used in two modes: transmitter mode and receiver mode. When Bluetooth transmitter mode is on, the device can send a signal. While the receiver is in Bluetooth mode, it will receive the signal to be converted into graphics in LabView software.

Figure 4. Bluetooth Wireless

MyRio is hardware made by National Instruments indevelopment of applications utilizing onboard FPGAs and microprocessorsBy manipulating the functions of a system withuses three I/O connectors and has wireless capabilities as well.using ARM Cortex A9 x2 cores, 28 nm process, Neo SIMD, VFPv3 VectorFloatNI. On the NI MyRio board, there are several peripherals that can be used.such as wifi, LED, Accelerometer, push button, USB, analog input and output, and digitalinput and output. MyRio uses LabView as an IDE.

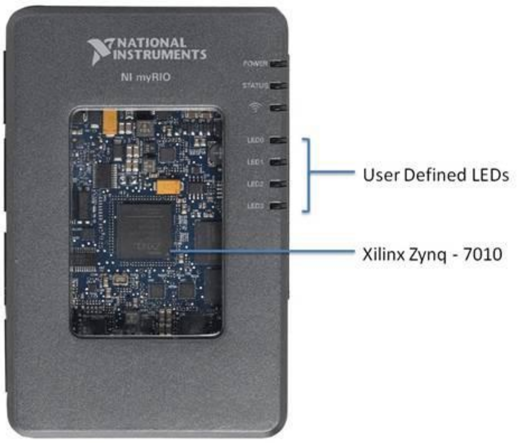

Figure 5. MyRio

Once connected to MyRio, it is then connected to LabView software. LabView, which stands for Laboratory Virtual Instrumentation Engineering Workbench, is software for data processing and visualization in the fields of data acquisition, instrumentation control, and industrial automation. LabView is a graphical program that uses icons instead of text to create applications. The LabView program is often referred to as a virtual instrument (VI) because some of the displays and operations in the LabView program resemble an instrument such as an oscilloscope and multimeter [12].

Figure 6. LabView Logo

2. RESEARCH METHODOLOGY

2.1 Research Methods

The method used in this study is the auscultation method, where the Cardionics stethoscope is used as the initial detection to listen to lung sounds in patients, and signals will be sent via Bluetooth Wireless connected to MyRio connected to LabView software. Then the sound signal will be displayed in the LabView software. The following block diagram as a whole can be seen in Figure 7.

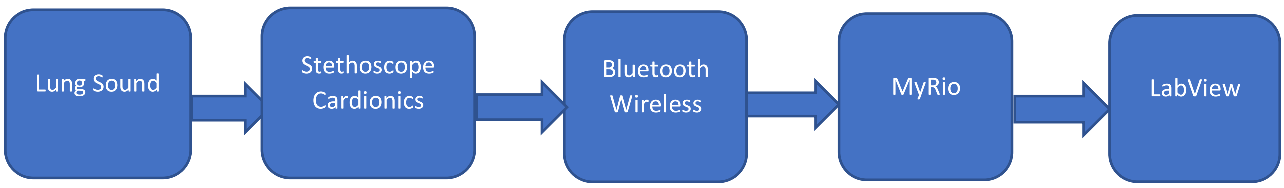

Figure 7. Lung Sound Detection Design Diagram Block

The block diagram Figure 7 describes the overall flow of the tool to be designed. To find out the stages of the system passed in this study, a flowchart is needed, which can be seen in Figure 8 below.

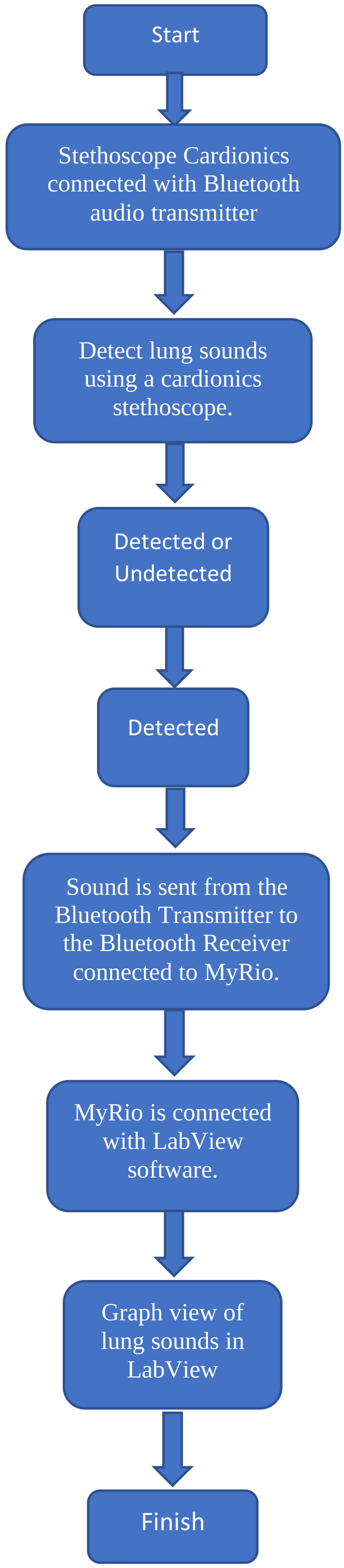

Figure 8. Lung Sound Detection Design Flowchart

2.2 Schematic Research Series

The schematic of the lung sound detection circuit can be seen in Figure 9. To perform auscultation, it requires a Cardionics stethoscope to detect lung sounds. A stethoscope that has been connected to a Bluetooth Transmitter will send a signal to the Bluetooth receiver that has been connected to MyRio. Then MyRio will be connected to a laptop that uses LabView software. The LabView software will display a graph of the lung sounds.

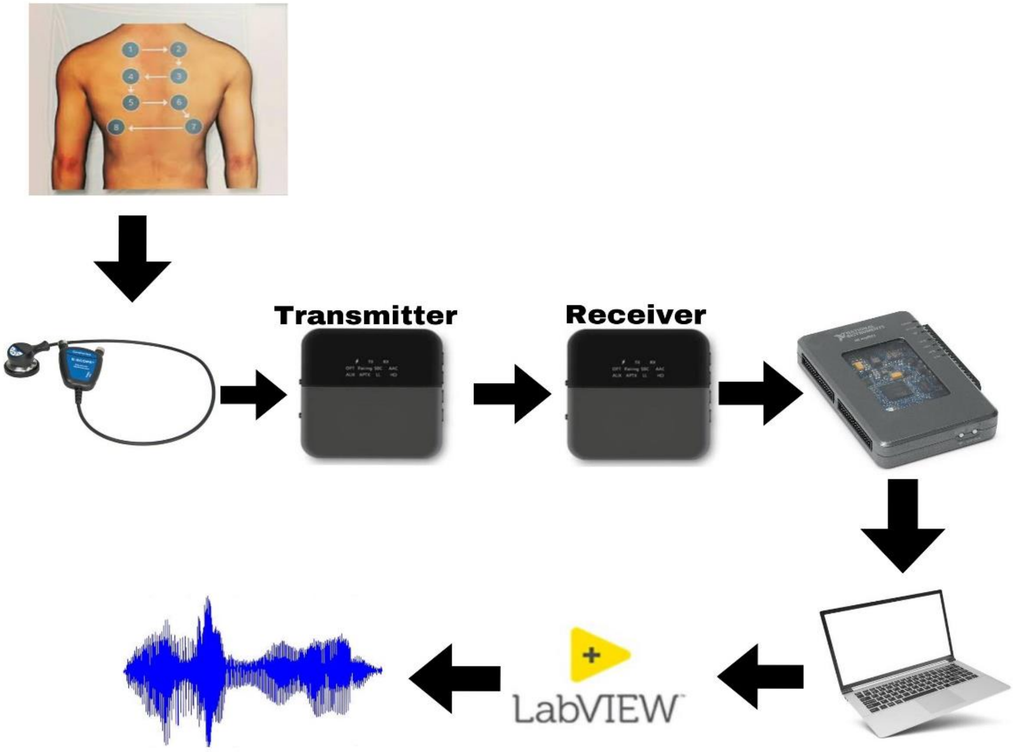

Figure 9. Schematic of Lung Sound Detection Network

3. RESULTS AND DISCUSSION

In this chapter, the author explains the test results and discusses the system. This is done to find out the working system of hardware and software and whether the tool that has been made runs and functions as expected. The process of analyzing lung sounds is based on the duration of time and patterns of the inspiration process and expiratory process to analyze the normal sound of the lungs, while for adventitious sounds it will be easier to analyze in the form of spectrograms and scalograms because it is to find or take the characteristics of the lung sound signals.

3.1 Steps to Retrieval Data Through Software

a. Make sure the tool to be used is in good condition and can be used by re-checking the equipment and making sure the cables connected to the tool are correct.
b. Connect the Cardionics stethoscope to the Bluetooth audio Transmitter using the aux TS to TRS cable.
c. Then connect the Bluetooth Transmitter and receiver that are already connected to MyRio.
d. When MyRio and LabView software are connected, it will output a signal graph as shown in figure 10.

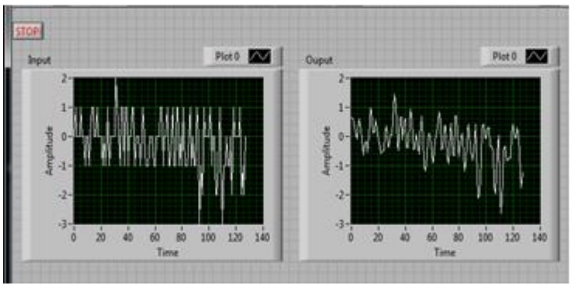

Figure 10. LabView Software Graphic Display

e. Next, place the pre-modified stethoscope at the auscultation site on the anterior or posterior chest to detect lung sounds.

3.2 Steps to Capture Data in Real Time

The steps for data collection carried out directly on the person to be examined (the patient) are as follows:
a. Prepare all lung sound detection equipment that has been designed for testing.
b. Before testing, recheck the equipment that has been designed to be tested directly on the person to be examined.

c. Place the stethoscope on the tracheal, bronchial, bronchovesicular, and vesicular parts of the person to be examined.
d. Do a direct examination on someone in a sturdy sitting position and make sure the position of the stethoscope is right on the part to be examined.
e. After completion of the inspection, disconnect all cable connections and turn off all equipment connected to the power supply.
f. Finally, neatly rearrange all cables and equipment.

3.3 Presentation of Normal Lung Sound Data

Each type of normal lung sound has different characteristics. Normal lung sounds themselves are divided into four parts depending on the location when performing the auscultation process. The analysis of normal lung sounds is done by comparing the type of normal lung sound to intensity, pitch, location, and the ratio of inspiration and expiration.In this normal lung sound analysis, the author focuses on comparing normal tracheal, bronchial, bronchovesicular, and vesicular lung sounds.

3.3.1 Normal Tracheal Lung Sound

In figure 11 below, it can be seen that for normal tracheal lung sounds, this is very clear compared to other normal lung sounds. The sound part of the tracheal lungs is found in the tracheal area (base of the neck). The duration of the tracheal sound expiration process is longer than the inspiration process (1). This tracheal lung sound is very loud and has a high pitch (2). Then, in the process of inspiration and expiration, this tracheal sound sounds equally strong (3).

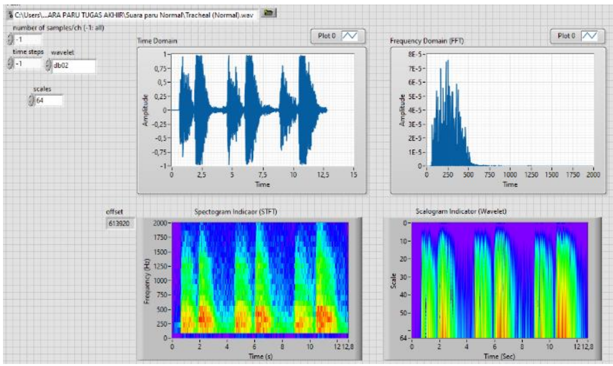

Figure 11. Front Panel Sound Normal Tracheal Lung

3.3.2 Normal Bronchial Lung Sound

In figure 12 below, it can be seen that normal bronchial lung sounds are sounds found in the branching bronchus in the right and left lungs, or can be said to be in the middle between the right and left lungs. For the sound of the lungs, this part sounds quite loud and high-pitched. This type of bronchial lung sound has the same powerful process as the processes of inspiration and expiration.

The long duration of expiratory sound tends to be almost as long as the sound of inspiration (1), so that the frequency range in the respiratory process looks more even (2). However, for the process of inspiration and expiration in bronchial sounds, there is a time lag to carry out the process of inspiration and expiration (3).

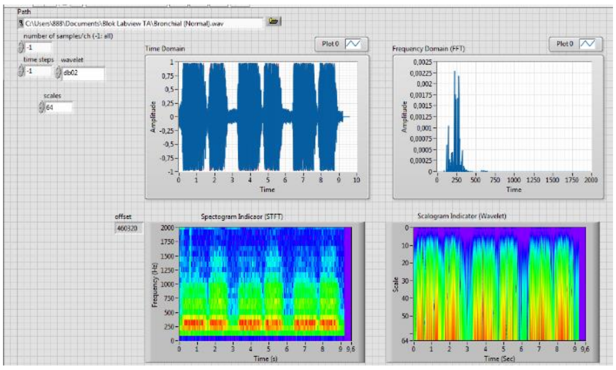

Figure 12. Front Panel Sound Normal Bronchial Lungs

3.3.3 Suara Paru-paru Normal Bronchovesicular

As can be seen in figure 13 below, normal bronchovesicular lung sounds are located in the bronchius area, which is located in the middle of the right or left lung. This bronchoveicular voice has moderate intensity and pitch. At a long duration, the processes of inspiration and expiration are almost the same, so that the processes of inspiration and expiration look the same length (1). For bronchovesicular lung sounds, it has a pitch that is as strong as the inspiration and expiration processes, so that the frequency range between the inspiration and expiratory processes looks more even (2). The characteristic of bronchovesicular sound is that there is almost no pause (time) during the process of breathing inspiration and expiration (3). This bronchovesicular voice is almost similar to the bronchial voice, but the difference lies in the pause (time) to carry out the process of inspiration and expiration.

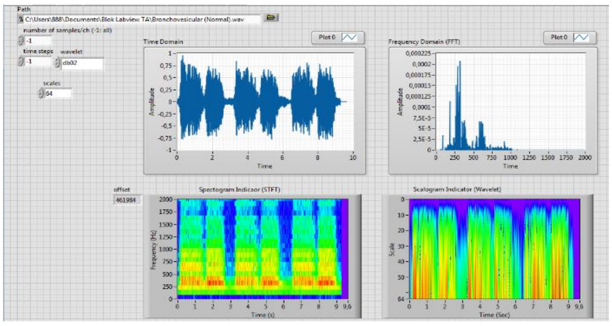

Figure 13. Front Panel Sound Normal Bronchovesicular Lung

3.3.4 Normal Vesicular Lung Sounds

As can be seen in figure 4.12 below, normal vesicular lung sounds are normal lung sounds that are heard in the side chest area and near the abdomen. This vesicular voice sounded soft and low-pitched. The long duration of sound in the process of inspiration sounds longer than the sound during the expiration process. The duration of the inspiration process looks longer than the expiration process (1); from the graph in figure 4.11 above, it can be seen that the inspiration process is stronger than the expiration processes (2) and (3).

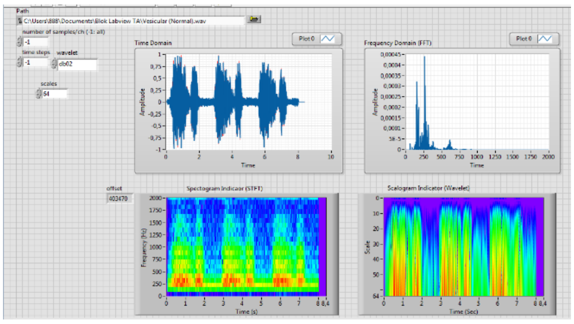

Figure 14. Front Panel Sound Normal Vesicular Lung

3.4 Presentation of Lung Sound Data Directly to Patients

The results of the data obtained in testing this tool were carried out using the auscultation process; in this case, the author made direct observations of several patients. The following is the result of lung sound recordings obtained from patients:

3.4.1 Testing on males aged 22 years

The results of lung sound data were taken from a patient named Ahmad Gani, a male with an age of 22 years. The following is the result of the patient's lung sound display visualized using LabView software, as seen in Figure 15 below.

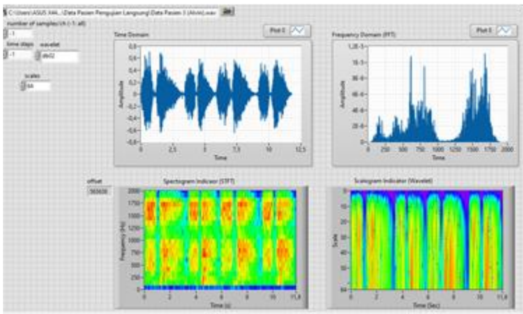

Figure 15. Results of Lung Sound at the age of 22 years

From the results of the examination directly to this patient. When the expiration process is long. Then for the frequency in the process of inspiration and expiration seen at 1750 Hz, From the results of the graphic display above, it can be seen and analyzed that lung sounds in these patients can be classified as normal Tracheal lung sounds.

3.4.2 Testing on males aged 11 years

The results of this lung sound data were taken from a patient named Pandu, a male with an age of 11 years. The following is the result of the patient's lung sound visualized using LabView software, as seen in Figure 16 below.

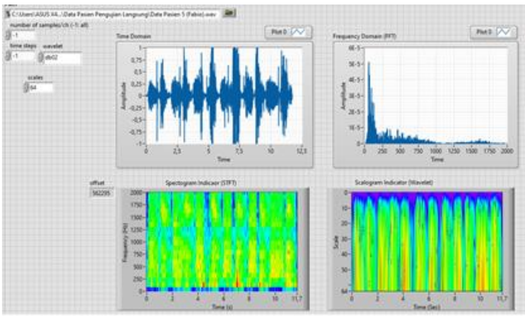

Figure 16. Lung Sound Results age 11 Years

From the results of Figure 16 above, this male patient with an age of 11 years has normal lung sounds. By looking at the results of inspiration and expiratory patterns where the pitch is quite loud and high-pitched. Then, for the duration of inspiration and expiration, it's almost the same length; it's just that the inspiration process has a frequency of 250 Hz and expiration has a frequency of 500 Hz. And between inspiration and expiration, there is a time lag. This lung sound can be classified with normal bronchial lung sounds.

4. CONCLUSION

From the research that has been done, the author is interested in conducting lung sound detection research using a Cardionics stethoscope, so that the sound signal that has been captured by the Cardionics stethoscope that has been connected to the Bluetooth transmitter will be received by a Bluetooth receiver that has been connected to the LabView software, making it easier to analyze the lung sound of a patient by displaying the sound graph in the LabView software. Lung sound data collection is carried out by the auscultation technique, where the data obtained has a normal lung sound pattern that is categorized into normal tracheal and bronchial lung sounds.

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