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RESPIRATORY SOUND ANALYSIS FOR THE DIAGNOSIS OF RESPIRATORY ABNORMALITIES

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ABSTRACT

Respiratory diseases are common and can be potentially deadly. The most commonly used diagnostic tool for diagnosing respiratory sound abnormalities are stethescope. This Auscultation gives useful information for diagnosing abnormalities and disorders in the respiratory system. By using a stethescope quantitative measurement and permanent record of the ralated data is difficult. Digital signal processing techniques is advance technique which overcomes the limitations of stethoscope auscultation.

In this paper, for signal recording the piezoelectric transducer interfaced with mircophone is used. Signal processing was done in MATLAB by using bandpass filter for noise reduction. Design technique of bandpass filter is proposed using Kaiser Window function. Fast forier transform is plotted to observe different frequency range of a signal. Power spectral density graph is calculated and plotted to obeserve the frequency at maximum peak value of the waveform. Our objective is to observe and calculate the frequency response of respiratory sounds for diagnosing respiratory abnormalities. Then to check the efficiency of proposed hardware the results obtained using the proposed hardware are calculated and compared to the prerecorded lung sounds that were obtained online. Classification was done as a Normal and Abnormal Respiratory sound.

Keywords— Piezoelectric Transducer, Band pass filter, Kaiser Window, Fast forier transform, Power Spectral Density.

I. INTRODUCTION

In the process of respiration specific organs and structures are involved in an organism. In human beings, respiration takes place in the lungs which is the main respiratory organ [1]. The air enters into the lungs and oxygen is supply to the body this process is known as inhalation, and the air is expels out of the lungs to force out carbon dioxide is known as exhalation; this process is collectively called “breathing”.

In respiration system air enters into the body thorough nose then passes through nasal cavity into the pharynx then through the epiglottis into the trachea. Air enters into the lungs through the bronchi which started at the bottom of trachea which splits into the right and left bronchi. The bronchi then split into even smaller sections that are spread out throughout the lungs called bronchioles. Bronchi branches and rebranches into lungs to form a thin walled air sacs called alveoli. The actual exchange of gas takes place in alveoli. In two adult lungs aound 300 million alveoli are present. Respiration system is the energy releasing and supplying process in all living organisms. Respiration helps the organism to produce energy which can be used for cell growth and cell repairs.

The diagnosis of the respiratory diseases is aided by pulmonary auscultation using a stethoscope. Stethescope was invented in France in 1816 by the French Physician, Rene Laennec. Doctors still used the commonest diagnostic tool stethescope for auscultation. The limitations of respiratory auscultation using stethoscope are, it depends on individuals own hearing, experience and ability to differentiate between the different respiratory sounds [2]. It is difficult for measurement and permanent data record of the diagnosed diseases by using this device. The computerized analysis methods for measurment and storing the respiratory sounds data may overcome some of limitations of auscultation using stethoscope.

In this Study [3], the Bandpass FIR filter is designed using various Window Function. In the designing of the bandpass filter as compared to other windows Kaiser Window gives best result. Therefore it is very common window for simple and fast Bandpass filter design. The kaiser window with bandpass filter design gives the minimum mainlobe width with high peak.

In this Study [4], IIR filters designed with Bilinear method is explained. From the results it has been concluded that Elliptic IIR filter is more efficient than the butterworth filter and chbyshev filter.

The paper is organized as follows: Section II describes Experimental procedures, Section III describes Block diagram of proposed model. Section IV describes the Respiratory sounds. Section V describes the Comparision and Results, Section VI describes Conclusion and finally References.

II.EXPERIMENTAL PROCEDURE

The experimental set up is shown in Fig.1. In proposed work we used the piezoelectric transducer interfaced with microphone for signal recording. The Respiratory sound signal get recorded by using microphone [6].

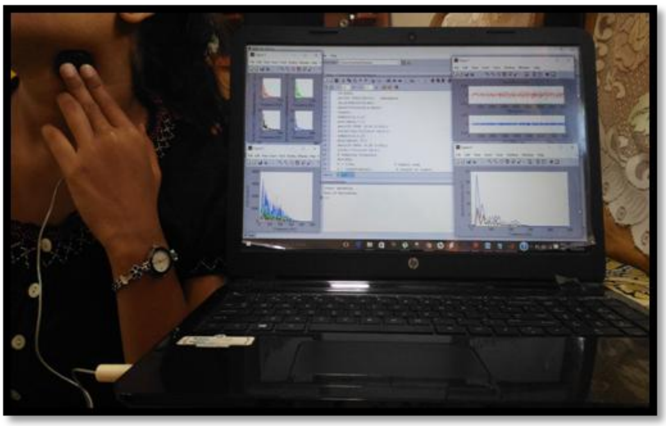

Fig. 1. respiratory sound analysis instrumentation diagram.

The transducer was placed on the throat region to peak up the respiratory signals. The respiratory sound signal was amplified and fed to computer through audio input. Signal processing was done in MATLAB. In MATLAB Fast Fourier Transform (FFT) was plotted to observe different frequency range of the signal and then Power spectrum density verses frequencies of filtered respiratory sound signal was plotted to observe the frequency at maximum peak value of the waveform.

III. BLOCK DIAGRAM OF PROPOSED METHOD

The block diagram of Respiratory Sound Analysis is shown in Fig. 2. It consists of Piezoelectric Transducer, Band pass filter, Windowing function, Fast Fourier Transform and Power Spectral Density.

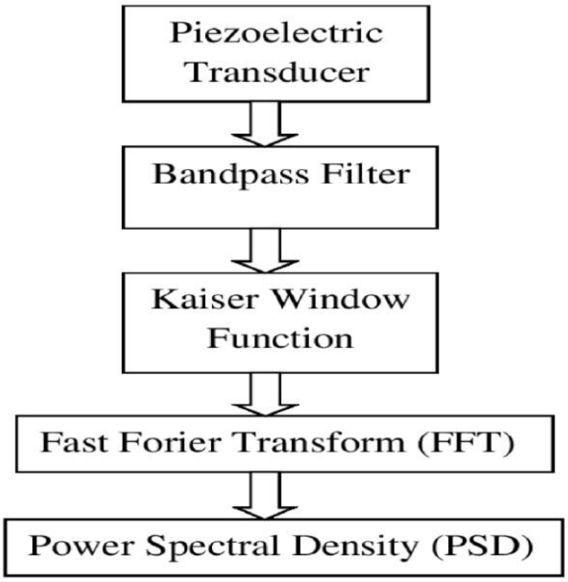

Fig. 2. block digram of respiratory sound analysis.

A. Piezoelectric Transducer

The proposed system includes a low cost hardware prototype used to detect and record the respiratory sound of a people. A piezoelectric transducer is bonded to a Microphone so as to capture the sound signals [7]. The microphone is the interface between the acoustic field and the measuring system. It responds to sound pressure and transforms sound signal into an electric signal which can be well explained by the measuring instrument. The piezoelectric sensor with microphone cable has a very high impedance level and a much higher output than other types. The piezoelectric sensor interfaced with microphone is as shown in fig.3.

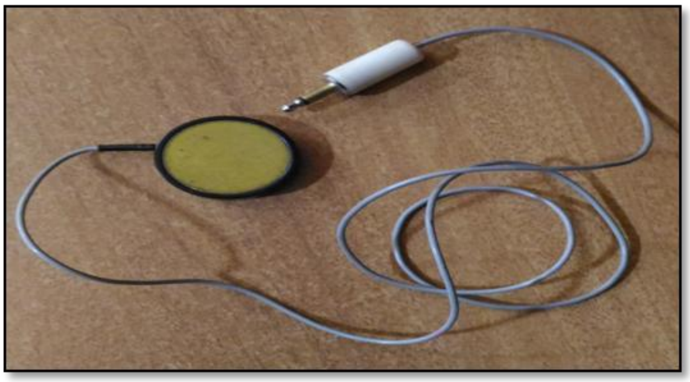

Fig. 3. piezoelectric transducer

B. Band Pass Filter

In this report the band-pass IIR filter is used for signal processing. Bandpass filter passes the signals within the specified frequency passband and reject the frequency other than the passband specification. Then the filtered signal can be further used for the signal feature extraction applications such as noise reduction, frequency boosting, digital audio equalizing and digital crossover among others [3]. As compared to other filters bandpass IIR filter gives the stable results and can play a major role in speech signal processing applications such as, speech filtering, speech enhancement, noise reduction and automatic speech recognition.

C. Window Function

In this report the design technique of bandpass filter is proposed using Kaiser Window function. There are many window techniques available for designing the Band Pass Filter [3]. These window functions are Hamming, Hanning, Blackman and Kaiser window. The Kaiser window is a kind of adjustable window function which provides independent control of the main lobe width and ripple ratio.

In this study we first choose "Bandpass filter" in Filter Type, choose "IIR Window" in option of Design Method then choose "Blackman, hamming, hanning and Kaiser" one by one in option of Window. As compared to other windows Kaiser Window gives best results with Bandpass filter design. It gives high peak value with minimum mainlobe width for respiratory sound. So we are using Kaiser Window function in our proposed method.

D. Fast Fourier Transform

In MATLAB Fast Fourier Transform (FFT) was plotted to observe different frequency range of the signal which is usefull for the classification of Respiratory sound [7].

E. Power Spectral Density

Power spectrum density is a plot of Power spectrum density verses filtered respiratory sound signal frequencies. In the Power density the maximum peak value of the waveform was found [7]. The corresponding frequency at maximum peak was calculated. Power spectrum density is the main part of this paper. By observing Power Spectral Density we can understand the respiratory abnormalities.

IV. RESPIRATORY SOUNDS

During respiration process sounds are generated these sounds are classify as normal respiratory sound and abnormal respiratory sound,

A. Normal Breath Sounds:

The pattern of normal breath sounds are created by the effect of body structures on air moving through airways. In addition to their location normal breathing sounds are categorized as follows,

1) Bronchial sound :

This sound is similar to the normal breathing heard over large airways. Bronchial breath sounds are tubular, hollow sounds consist of loud, high pitch, full inspiration and expiration phase with a short pause between them and inspiration phase usually being louder [1]. Bronchial sounds are mostly heard over the region of trachea and larynx.

2) Vesicular sound :

Vesicular breath sounds consist of a soft, quite, wispy inspiratory phase with short, almost silent expiratory phase [1]. They are heard over the periphery of the lung field heard over the thorax, lower pitched and softer than bronchial breathing.

3) Bronchovesicular sound :

Bronchovesicular sounds intermediate between bronchial and vesicular breath sounds. Bronchovesicular breath sounds includes full inspiratory phase with expiratory phase shortened and softer [1]. They are usually being audible over the hilar region.

B. Abnormal Breath Sounds:

These sounds are generated in certain pathological conditions of the airways or lungs. Identification of abnormal breath sound can assist for diagnosis of respiratory disorder [1].

1) Wheezing:

Wheezing is a continuous, coarse, whistling sound produced in the respiratory airways during breathing. It is heard most clearly when exhale, but in severe cases it can be heard when inhale. In patients with obstructive airways diseases such as asthma wheezing sound is produced [1].

2) Stridor:

Stridor is a loud wheeze which occurs due to partial obstruction in the upper respiratory airways (pharynx, larynx) and due to painful swelling of the upper respiratory tract includes upper part of the trachea. It usually occurs during inspiratory as well as expiratory phase. Stridor is mostly occurs in infants and babies because of their small supraglottic area. Other symptoms that occur include drooling, coughing and vomiting. Stridors are produced in patients with the diseases such as Epiglottitis and Croup [1].

3) *Crackles:*

Crackles are produced by opening of airway and secretion within airway. Crackles are discontinues clicking or explosive sound. Fine crackles and Coarse crackles are the types of Crackles sound. Respiratory sound frequency for the fine crackles is higher than coarce crakles sound. Fine crackles are brief, discontinuous, popping lung sounds that are high-pitched. Coarse crackles are of less amplitude and longer duration than fine crackles. The crackles are also observed in cardio respiratory disorders. Crackles are produced in patients with the diseases such as Pneumonia and Heart failure [1].

4) Rhonchi Sounds :

Rhonchi are continuous low pitched, rattling lung sounds that often resemble snoring. Obstruction or secretions in larger airways are frequent causes of rhonchi [1]. They can be heard in patients with chronic obstructive pulmonary disease (COPD), bronchiectasis, pneumonia, chronic bronchitis, or cystic fibrosis. Rhonchi usually clear after coughing.

5) Pleural Rub :

In pleural surface inflammation the two pleura rub together during respiration and produces sound called as pleural rub sound. Pleural Rub is produced in patients with the diseases such as Cough, Pulmonary Embolism and Pneumonia [1].

V. RESULTS AND CLASSIFICATION

For our analysis, respiratory sounds from 20 different normal and abnormal subjects and prerecorded data of respiratory sounds were considered. The PSD of these sounds were plotted and peak frequency was calculated. According to peak frequency classification of respiratory sound was done as a normal and abnoraml.

Table 1 shows the classification of different subjects with their maximum peak point frequency obtained using proposed hardware.

TABLE.I. Classification of Subjects with their Observed Peaks in PSD

Subject	Frequency (HZ)	Patient's State
Sub1	47	Normal
Sub2	39	Normal
Sub3	44	Normal
Sub4	72	Abnormal
Sub5	120	Abnormal
Sub6	85	Abnormal
Sub7	70	Abnormal
Sub8	128	Abnormal
Sub9	48	Normal
Sub10	44	Normal
Sub11	87	Abnormal
Sub12	45	Normal
Sub13	39	Normal
Sub14	105	Abnormal
Sub15	89	Abnormal
Sub16	51	Normal
Sub17	47	Normal
Sub18	37	Normal
Sub19	95	Abnormal
Sub20	49	Normal

Fig.4 shows the PSD (Power spectral density) of prerecorded Bronchial sound which is a normal repiratory sound. The peak value of PSD obtained for a pre-recorded normal Bronchial sound was 47 Hz.

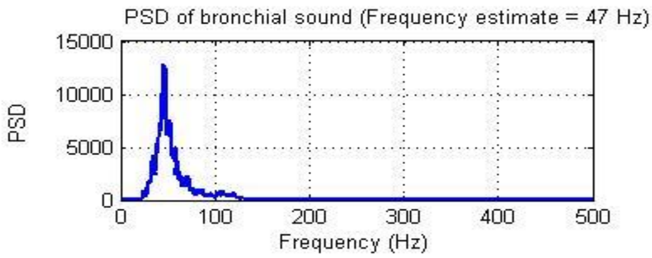

Fig. 4. PSD of prerecorded bronchial sound [8].

Fig.5 shows the PSD of prerecorded Vesicular sound which is a normal repiratory sound. The peak value of PSD obtained for a prerecorded normal Vesicular sound was 39 Hz.

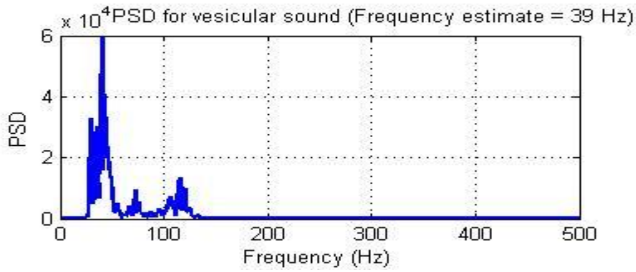

Fig. 5. PSD of prerecorded vesicular sound [8].

Fig.6 shows the PSD of prerecorded Bronchovesicular sound which is a normal repiratory sound. The peak value of PSD obtained for a pre-recorded normal Bronchovesicular sound was 44 Hz.

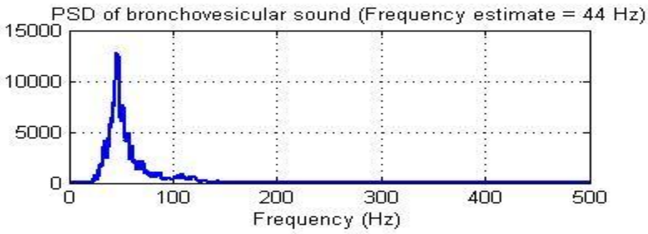

Fig. 6. PSD of prerecorded bronchovesicular sound [8]

Fig.7 shows the PSD of prerecorded Wheeze sound which is an abnormal repiratory sound. The peak value of PSD obtained for a prerecorded abnormal Wheeze sound was 85 Hz.

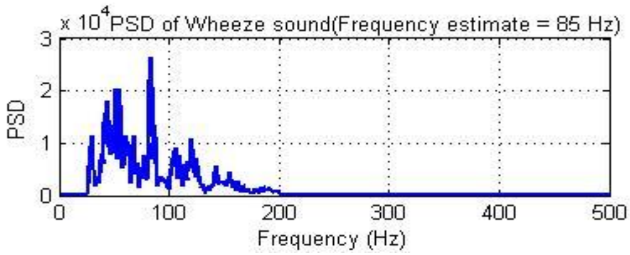

Fig. 7. PSD of prerecorded wheeze sound [8].

Fig.8 shows the PSD of prerecorded Crackles sound which is an abnormal repiratory sound. The peak value of PSD obtained for a prerecorded abnormal Crackles lung sound was 105 Hz.

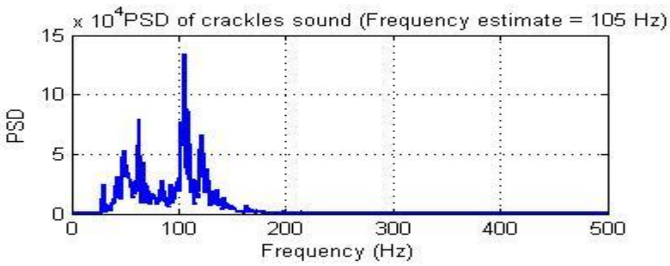

Fig. 8. PSD of prerecorded crackles sound [8].

Fig.9 shows the PSD of prerecorded Stridor sound which is an abnormal repiratory sound. The peak value of PSD obtained for a pre-recorded abnormal Stridor sound was 72 Hz.

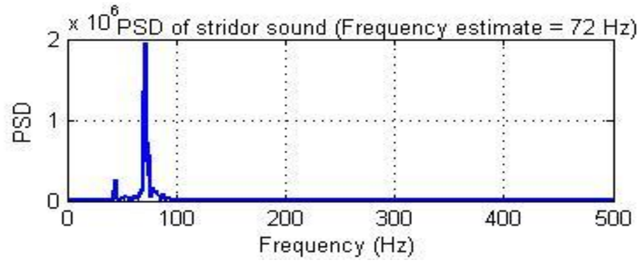

Fig. 9. PSD of prerecorded stridor sound [8].

Fig.10 shows the PSD of prerecorded Rhonki sound which is an abnormal repiratory sound. The peak value of PSD obtained for a prerecorded abnormal Rhonki sound was 120 Hz.

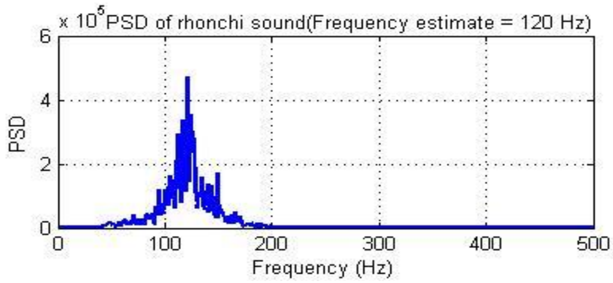

Fig. 10. PSD of prerecorded rhonchi sound [8].

Fig.11 shows the PSD obtained for the Normal subject using proposed hardware. The peak value of PSD for normal lung sound was obtained at 47 Hz. This is similar to the prerecorded Bronchial sound.

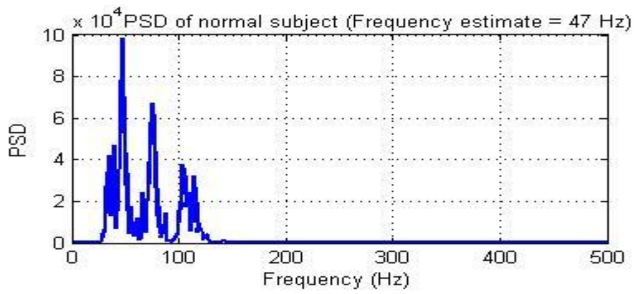

Fig. 11. PSD of normal subject 1 obtained using proposed hardware.

Fig.12 shows the PSD obtained for the Normal subject using proposed hardware. The peak value of PSD for normal lung sound was obtained at 39 Hz. This is similar to the prerecorded Vesicular sound.

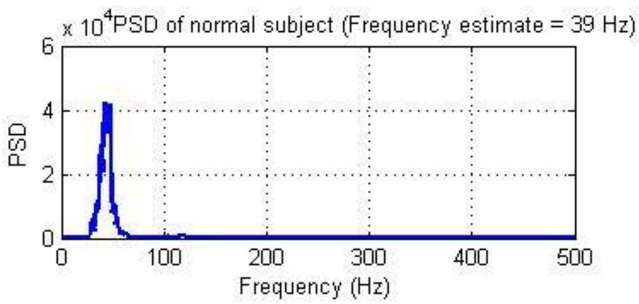

Fig. 12. PSD of normal subject 2 obtained using proposed hardware.

Fig.13 shows the PSD obtained for the Normal subject using proposed hardware. The peak value of PSD for normal lung sound was obtained at 44 Hz. This is similar to the prerecorded Bronchovesicular sound.

Fig.14 shows the PSD of Stridor sound which is a abnormal repiratory sound. The peak value of PSD obtained for a prerecorded abnormal lung sound was 72 Hz. This is similar to the prerecorded Stridor sound.

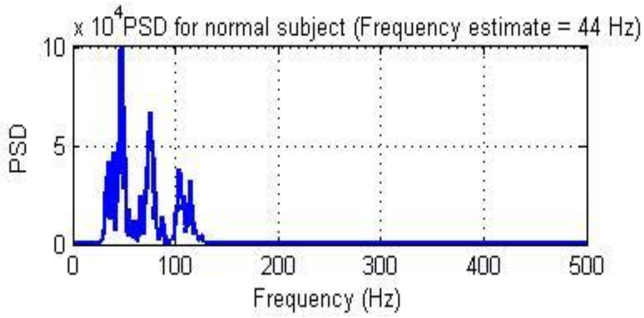

Fig. 13. PSD of normal subject 3 obtained using proposed hardware.

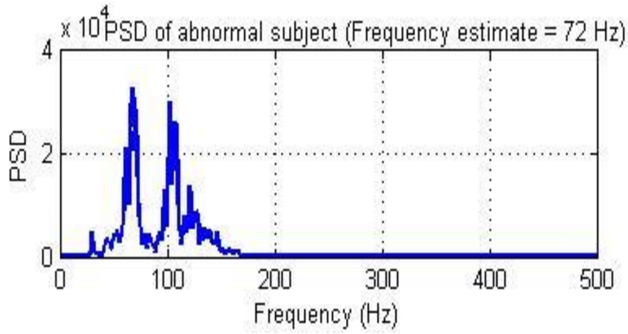

Fig. 14. PSD of abnormal subject 4 obtained using proposed hardware.

Fig.15 shows the PSD obtained for the Abnormal subject using proposed hardware. The peak value of PSD for Abnormal lung sound was obtained at 120 Hz. This is same for a prerecorded Rhonki sound.

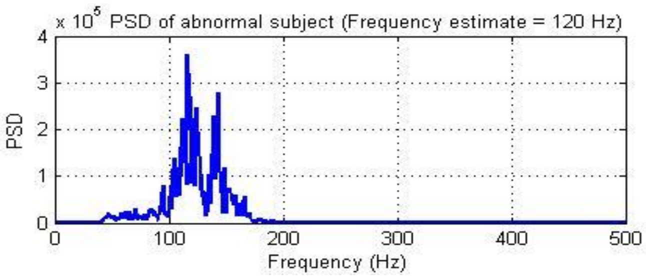

Fig. 15. PSD of abnormal subject 5 obtained using proposed hardware.

Similar analysis has been done for more respiratory sounds but only few results have been shown here. From the above results it can be seen that the results obtained for normal and abnormal subjects using proposed hardware has the same frequency range as that of the prerecorded online data.

The data obtained using proposed hardware was compared with the prerecorded respiratory sounds data. This clearly indicates the efficiency of the hardware developed.

The above classification is usefull for those subjects who were suffering from respiratory abnormalities. Our proposed hardware can provide the early detection of respiratory infection. So by recording the respiratory sounds using this hardware the person can undersand their respiratory status and if it is abnormal then further analysis can be done for the confirmation of particular diagnostic disease.

VI. CONCLUSION

From the results, it can be seen that the computerized analysis methods for measurment and storing the respiratory sounds data may overcome some of limitations of auscultation using stethoscope. Which facilitate the detection of respiratory sound changes and diagnosing of respiratory abnormalities. The results obtained using the proposed hardware are compared to the prerecorded lung sounds data that were obtained online. This clearly indicates the efficiency of the hardware developed. Classification of Respiratory sound was done as a Normal and Abnormal sound. By Recording the Respiratory sounds, we would know what type of Respiratory sound occurs such as: bronchial, crackles, wheezes, stridor, rhonchi etc.

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