GOA UNIVERSITY

TALIGAO PLATEAU, GOA, 403206

2021-2022

CONSTRUCTION OF SMART ELECTRONIC STETHOSCOPE BASED ON EMBEDED SYSTEM APPLICATION

Submitted in partial fulfilment of the requirements for Masters degree in school of physical and applied sciences department of electronics Goa University is the bonafide work of

Narayan V. Sawant (20p0430041)

Unmesh L. Naik (20p0360011)

Gouresh D. Shelko (20p0360007)

DECLERATION

We the students of the "Goa University" School of Physical and Applied Sciences, Department of Electronics here by solemnly declare that this project under the tittle "CONSTRUCTION OF SMART ELECTRONIC STETHOSCOPE BASED ON EMBEDED SYSTEM APPLICATION" is a record work that has been composed by us, and this has not been submitted anywhere else for the Award of any diploma or degree to the best of our knowledge.

Unmesh Naik Narayan Sawant Gouresh Shelko

ABSTRACT

Heart sound stethoscope is a preliminary stage to access diseases in this project we have design an electronic stethoscope based on Embedded system which will overcome the flaws of acoustic stethoscope, with the functions like gain adjustment, filtering of the signal, auto calculation of heart beat. This aims to achieve minimum human error while analyzing heartbeat.

This is achieved with the help of op amp LM-741 as a pre-amplifier and LM-386 as a power amplifier having variable gain adjustment. The heartbeat calculation is attained with the help of microcontroller 'Arduino-Uno' where in R-peak detection method is used to calculate heartbeat. Heart signal is transmitted through wireless transmission using HC-05 Bluetooth module.

This model will provide graphical as well as numeric data of heart sound for the analysis. We have tested different heart signals for the same model.

The design implementation and observation are presented in this report.

ACKNOWLEDGEMENT

We take the opportunity to whole-heartedly thank all those who are instrumental in helping us in progress to our goal, both directly and in directly.

We would like to extend our dignified **Vice Dean Prof. R.S Gad** and the **Head of the Department of Electronic, Prof. J.S Parab.**

We sincerely express our gratitude to **Assistant Prof. Marlon Sequeira**, **Assistant Prof. Narayan Vetrekar, Assistant Prof. Aniketh Gaonkar.**

For mentoring us as far as project is concern, for channelling our efforts, supervising and for providing vital input which helped us immensely and is pillar of support that we have banked in the time of difficulties.

We are grateful to our lab assistant **Mr. Vishant Malik** for extending lab access and equipment's time to time.

Our thanks to all the **teaching and non-teaching staff** of **Department of Electronic, Goa University** for their help and support.

We also need to thank our **parents, family members and all well-wishers** along with the **Almighty** without whom this work would not have taken shape.

Thank You All.

TABLE OF CONTENT

CHAPTER 1

1.1 Motivation:

Heart diseases are a measure cause of ill health throughout the world in India, annually the mortality attributed to heart diseases exceeds 30%.

In India Cardiovascular diseases (CVD). Have been estimated to affect between 15-30% of the adult population. Cardiovascular diseases such as coronary artery diseases and high blood pressure are common diseases in increasing incidence. The diagnosis of this common chest disease is facilitated by heart auscultation using a stethoscope.

A conventional method of auscultation with an acoustic stethoscope provides useful information to the physician to diagnose heart disorders. However, it is a subjective method that depends on the auditory perception among physicians, experience, and the ability to differentiate sound patterns to overcome this limitation, a quantitative techniques for objective assessment of heart sound have been developed over the past three decades. The computerized method for recording and analysing of heart sounds has overcome many limitations of simple auscultation.

Integrating electronics with medical science has given birth to the field of biomedical instruments this has served boon for diagnosing and treating diseases. The problem faced by the doctors at present time and the difficulties of their Acoustic stethoscope while using, sparked our interest and led us to try to find a solution to their difficulties and to minimize as much as possible because the stethoscope is a significant tool for diagnoses at the preliminary stage for any particular disease.

1.2 History of Stethoscope

Early stethoscopes: The stethoscope was invented in France in 1816 by René Laennec at the Necker-Enfants Indeed, his invention was almost indistinguishable in structure and performance from the trumpet, which was commonly called a "microphone In 1852 George's device was the identical because the common device, a historical style of hearing aid indeed, his invention was almost indistinguishable in structure and performance from the trumpet, which was commonly called a "microphone In 1852 George Cammann perfected the planning of the instrument for commercial production. By 1873. There are descriptions of a differential stethoscope that might attach with slightly different locations to make a tiny low stereo effect, though this did not become an everyday tool in clinical practice. Fig 1.1

Fig 1.1

Rappaport and Sprague designed a replacement stethoscope within the 1940s, which became the standard by which other stethoscopes' are measured, consisting two sides, one of which is utilized for the system and thus the alternative is employed for the cardiovascular system.

1.3 Types of stethoscopes:-

1) Acoustic:

Acoustic stethoscopes are familiar to the general public, and be sure of ten transmission of sound from the chest piece, via air-filled hollow tubes, to the listener's ears. The chest piece usually consists of two sides, which can be placed against the patient for sensing sound a diaphragm (plastic disc) or belt (hot low cup). If the diaphragm is placed on the patient, body sound vibrates the diaphragm, causing acoustic pressure waves which travel up the tubing to the listener’s ears. If the bell is placed on the patient, the vibrations of the skin directly produce acoustic pressure waves travelling up to the listener's ears. He bell transmits low frequency sounds, where as the diaphragm transmits higher frequency sounds. This 2-sided stethoscope was invented by Rappaport and Sprague within the first element of the 20th century. One problem with acoustic stethoscopes was that the sound level is extremely low. This problem was surmounted in 1999 with the invention of the stratified continuous (inner) lumen, and also the kinetic acoustic mechanism in 2002. Acoustic stethoscopes are the most commonly used. Acoustic stethoscope with the bell upwards.

Fig1.2

Fig1.2

2) Electronic:-

The rapid technological advancements in the field of cardiovascular medicine over the years has led to the decreased utility of conventional stethoscope. Attempts to enhance the flaw in previous versions of stethoscope have led to new enthusiasm within the art of clinical cardiology again. In this, we try to briefly describe how an electronic stethoscope operates, its difference from a conventional stethoscope, and what its potential utility is in modern clinical cardiology with the available evidences to this point.

An electronic stethoscope (or stethophone) overcomes the low sound levels by electronically amplifying body sounds. However, amplification of stethoscope the contact artifacts, and component cut-offs (frequency response thresholds of electronic stethoscope microphones, pre-amps, amps, and speakers) mitt electronically amplified stethoscope’s overall utility by amplifying mid-range sounds, while simultaneously attenuating high and low-frequency range sounds Currently,a variety of companies offers electronic stethoscopes. Electronic stethoscopes require the conversion of acoustic sound waves to electrical signals which can then be amplified and processed for optimal listening Unlike acoustic stethoscopes, which are all supported the identical physics, transducers in electronic stethoscopes vary widely`, the only and least effective method of sound detection is achieved by placing a microphone within the chest piece This method suffer from ambient noise interference and has fallen out of favour Another method, uutilized in Welch-Alyn’s Meditron stethoscope, comprises placement of a piezoelectric crystal at the head of a metal shaft, the underside to the shaft making contact with a diaphragm. Think labs' Rhythm 32 inventor Clive Smith uses an Electromagnetic Diaphragm with a conductive miner surface to create a capacitive sensor. This diaphragm responds to sound waves identically to a standard acoustic stethoscope, with changes in an electric field replacing changes in atmospheric pressure. This preserves the sound of an acoustic stethoscope with the benefits of amplification.

Because the sounds are transmitted electronically, an electronic stethoscope can be a wireless device, are often a recording device, and might provide noise reduction, signal enhancement, and both visual and audio output. All of these features are helpful for purposes of telemedicine (remote diagnosis and teaching. fig 1.3

Fig1.3

Data acquisition

Heart sound is converted into digital analog by both using microphone and the piezoelectric sensor to a mass and transducer the sound energy into electricity. This is then amplified and processed by passing through a band pass filter to scale back the unwanted noise corrupting the sound signal.

Pre-processing model

A second round of diagnosing is finished with a digital filter, to extract the signal of interest from the waveband. Some advanced artefact removal techniques are incorporated here. The guts sounds obtained within the process are normalized to a selected scale and are segmented into cycles. This helps us in detecting the heart sound components clearly.

Signal processing module

The data obtained as an electrical signal are further represented in parametric form and are classified. This helps in decision-making. As an example, the sound data obtained from electronic stethoscope are often transferred via Bluetooth to laptop and analysed by special software.

There are various electronic stethoscopes available. The two most common ones used are the Littman 3M model and therefore the Think labs One Digital. There are other models which don’t seem to be used as popularly because the former two. These are Welch Allyn Elite electronic stethoscope, Card Ionics E-scope II, Eco Scope, and VI Scope. A number of these models, as an example, the Welch Allyn Elite electronic stethoscope, aren’t no longer available.

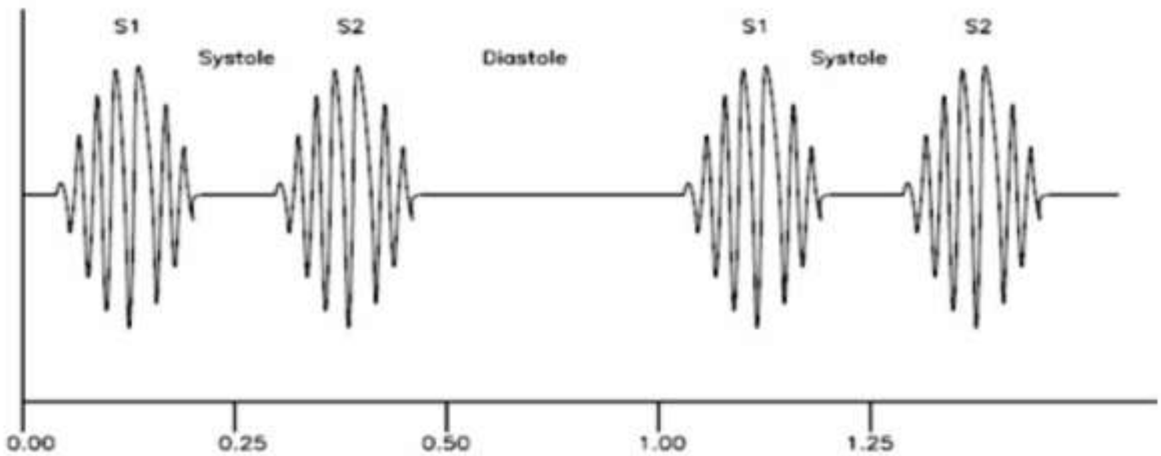
1.4 DETAILS OF FREQUENCY OF HEART

Heart Auscultation:- Auscultation refers to listening for sounds from within the body so as to know the condition of the heart. Physician perform auscultation with the help of a stethoscope, an instrument design to amplify and attenuate frequencies of interest

A normal heart will produce two heart sounds, S1 and S2. S1 symbolizes the start of systole. The sound is made when the mitral and tricuspid valves close after blood has returned from the body and lungs. S1 is consist of energy in the 30Hz - 45 Hz range.

S2 symbolizes the top of systole and the beginning of diastole. The sound is formed when the aortic and pulmonic valves close as blood exits the heart to the body and lungs, which lie with maximum energy in the 50 Hz-70 Hz range with higher pitch.

Heart sounds and murmurs are of relatively low intensity and are band limited to about 100–1000 HZ. Speech signal is perceptible to the human hearing. Therefore, auscultation with an acoustic stethoscope is a kind of difficult. fig 1.4



HEART SOUNDS

Fig1.4

HEART SOUND

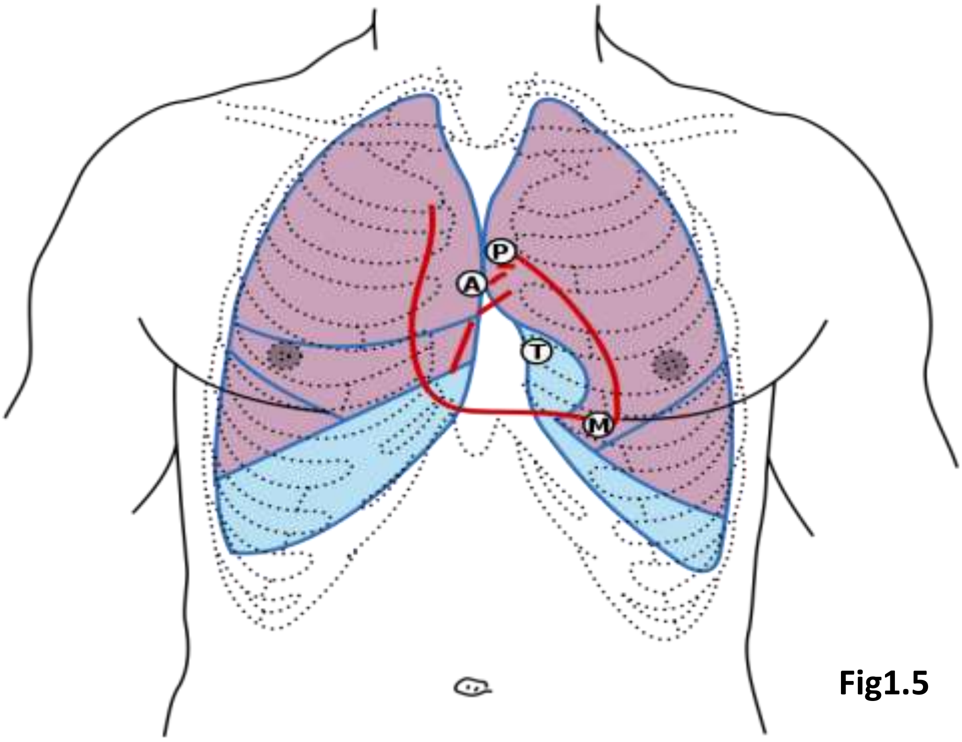


Fig1.5

Heart sounds are the noises generated by the beating heart and the resultant flow of blood through it. Specifically, the sounds reflect the turbulence created when the heart valves snap shut. In cardiac auscultation, an examiner may use a stethoscope to listen for these unique and distinct sounds that provide important auditory data regarding the condition of the heart.

In healthy adults, there are two normal heart sounds, often described as a lub and a dub that occur in sequence with each heartbeat. These are the **first heart sound** (S_1) and **second heart sound** (S_2), produced by the closing of the atrioventricular valves and semilunar valves, respectively.In Addition to these normal sounds, a variety of other sounds could also be present including heart murmurs, adventitious sounds, and gallop rhythms S_3 and S_4.

Heart murmurs are generated by the turbulent flow of blood and a murmur to be heard as turbulent flow must require a pressure difference of a minimum of 30 mm of Hg between the chambers therefore the pressure dominant chamber will outflow the blood to the non-dominant chamber in a diseased conditions which leads to Left-to-right shunt or Right-to-left shunt based on the pressure dominance. Turbulence may occur inside or outside the heart; if it occurs outside the heart then the turbulence is called bruit or a vascular murmur. Murmurs is also physiological (benign) or pathological (abnormal). Abnormal murmurs are often caused by stenosis restricting the opening of a heart valve, resulting in turbulence as blood flows through it. Abnormal murmurs may additionally occur with valvular insufficiency (regurgitation), which allows backflow of blood when the incompetent valve closes with only partial effectiveness. Different murmurs are audible in several parts of the cardiac cycle, depending on the reason for the murmur.

First heart sound

The **first heart sound**, or **S_1**, forms the "lub" of "lub-dub" and consists of components M_1 (mitral valve closure) and T_1 (tricuspid valve closure). Normally M_1 precedes T_1 slightly. It is caused by the closure of the atrioventricular valves, i.e. tricuspid and mitral (bicuspid), at the start of ventricular contraction, or systole. When the ventricles begin to contract, so do the papillary muscles in each ventricle. The papillary muscles are attached to the cusps or leaflets of the tricuspid and mitral valves via chordae tendineae (heartstrings). When the papillary muscles contract, the chordae tendineae become tense and thereby prevent the backflow of blood into the lower pressure environment of the atria. The chordae tendineae act a bit like the strings on a parachute, and permit the leaflets of the valve to balloon up into the atria slightly, but not so much as to Evert the cusp edges and permitted backflow of blood. It's the pressure created from ventricular contraction that closes the valve, not the papillary muscles themselves. The contraction of the ventricle begins just before AV valves closing and before the opening of the semilunar valves. The sudden tensing of the chordae tendineae and also the squeezing of the ventricles against closed semilunar valves, send blood rushing back toward the atria, and therefore the parachute-like valves catch the rush of blood in their leaflets causing the valve to snap shut. The S1 sound results from reverberation within the blood related to the sudden block of flow reversal by the valves. The delay of T1 even more than normally causes the split S1 which is heard in a right bundle branch block.

Second heart sound

The **second heart sound**, or **S_2**, forms the "dub" of "lub-dub" and is consists of components A_2 (aortic valve closure) and P_2 (pulmonary valve closure). Normally A_2 precedes P_2 especially during inspiration where a split of S_2 can be heard. It's is caused by the closure of the semilunar valves (the aortic valve and pulmonary valve) at the end of ventricular systole and also the beginning of ventricular diastole. As the left ventricle empties, its pressure falls below the pressure in the aorta. Aortic blood flow quickly reverses back toward the left ventricle, catching the pocket-like cusps of the aortic valve, and is stopped by aortic valve closure. Similarly, because the pressure in the right ventricle falls below the pressure in the pulmonary artery, the pulmonary valve closes. The S2 sound is caused by reverberation within the blood due to the abrupt reversal of flow. Because the drop in intrathoracic pressure increases the time required for pulmonary pressure to reach that of the right ventricular pressure, S2 splitting, also known as physiological split, happens most commonly during inhalation. A widely split S2 can be linked to a number of various cardiovascular problems, and the split can be large and fluctuating or wide and stable. Right bundle branch block, pulmonary stenosis, pulmonary hypertension, and ventricular septal defects all have a wide and varied split. In an atrial septal defect, S2 splits wide and permanently. In pulmonary hypertension and pulmonary embolism, pulmonary S2 (P2) is amplified (loud P2). In the aortic arch, S2 gets softer

Third heart sound

The third heart sound or **S_3** is rarely heard and is additionally called a protodiastolic gallop, ventricular gallop, or informally the "**Kentucky**" gallop as an onomatopoeic reference to the rhythm and stress of S1 followed by S2 and S3 together (S1=Ken; S2=tuck; S3=y).

"lub-dub-ta" or "slosh-ing-in" If new, indicates heart failure or volume overload.

It occurs at the start of diastole after S2 and is lower in pitch than S1 or S2 because it isn't of valvular origin. The third heart sound is benign in youth, some trained athletes, and sometimes in pregnancy but if it re-emerges later in life it should signal cardiac problems, like a failing left ventricle as in dilated congestive heart failure (CHF). S3 is believed to be caused by the oscillation of blood back and forth between the walls of the ventricles initiated by blood rushing in from the atria. The reason the third heart sound doesn't occur until the center third of diastole is may that within the first part of diastole, the ventricles aren't filled sufficiently to make enough tension for reverberation.

It may even be a results of tensing of the chordae tendineae during rapid filling and expansion of the ventricle. In other words, an S3 heart sound indicates an increased volume of blood within the ventricle. An S3 heart sound is best heard with the bell-side of the stethoscope (used for lower frequency sounds). A left-sided S3 is best heard within the left lateral decubitus position and at the apex of the heart, which is often located within the 5th left intercostal space at the midclavicular line. A right-sided S3 is best heard at the lower left sternal border. The way to distinguish between left and right-sided S3 is to watch whether it increases in intensity with inhalation or exhalation. A right-sided S3 will increase on inhalation, while a left-sided S3 will increase on exhalation.

S3 can be a normal finding in young patients but is generally pathologic over the age of 40. The most common cause of pathologic S3 is congestive heart failure.

Fourth heart sound

The fourth heart sound, or $\mathbf{S_4}$ when audible in an adult is termed a presystolic gallop or atrial gallop. This gallop is produced by the sound of blood being forced into a stiff or hypertrophic ventricle.

"ta-lub-dub" or "a-stiff-wall"

It is a indication of a pathologic state, usually a failing or hypertrophic left ventricle, as in systemic hypertension, severe valvular aortic stenosis, and hypertrophic cardiomyopathy. The sound occurs just after atrial contraction at the end of diastole and immediately before S1, producing a rhythm sometimes observed because the "**Tennessee**" gallop where S4 represents the "Ten-" syllable. It's is best heard at the cardiac apex with the patient within the left lateral decubitus position and holding his breath. The combined presence of S3 and S4 is a quadruple gallop, also called as the "Hello-Goodbye" gallop. At rapid heart rates, S3 and S4 may merge to produce a summation gallop, sometimes referred to as S7.

Atrial contraction must be present for production of an S4. It's absent in atrial fibrillation and in other rhythms within which atrial contraction doesn't precede ventricular contraction.

1.5 HEART MURMURS

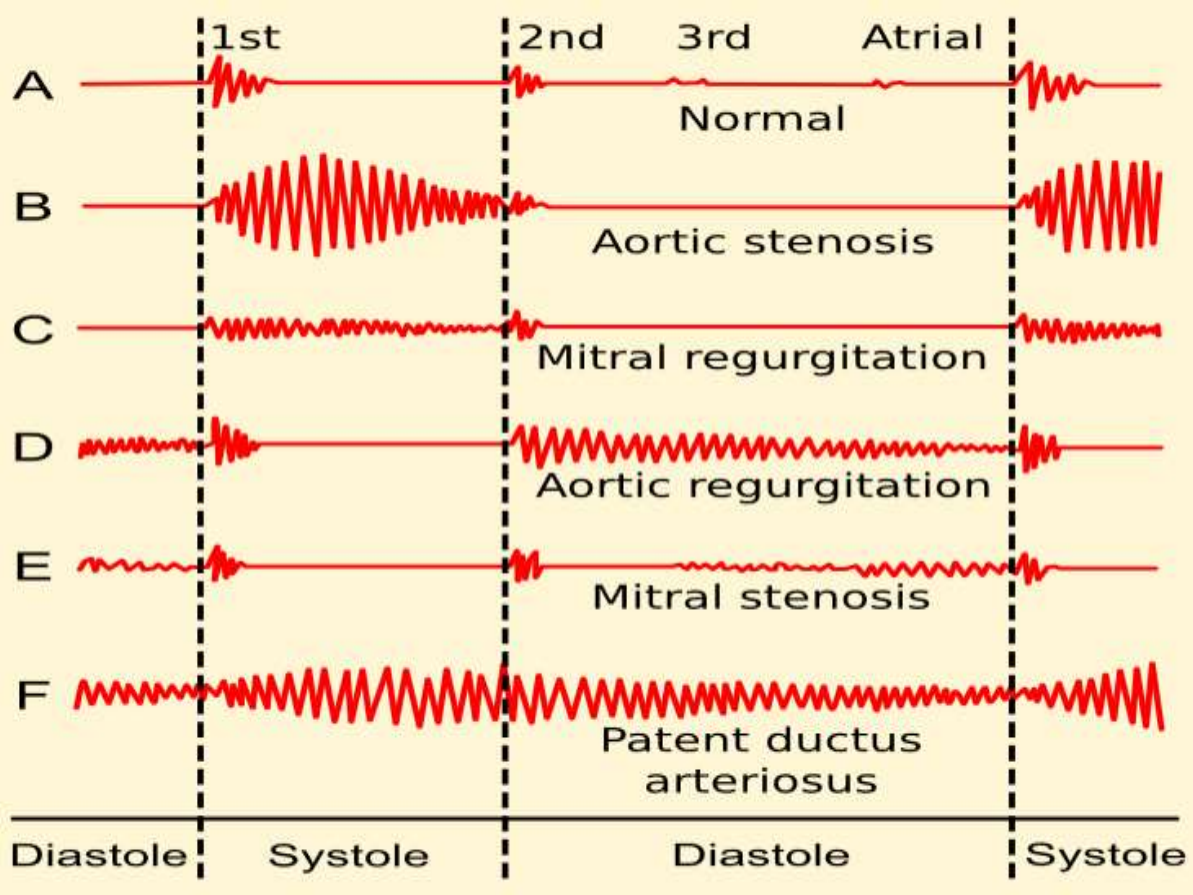


Fig1.6

Heart murmurs are unique heart sounds produced when blood flows across a heart valve or blood vessel. This happens when turbulent blood flow creates a sound loud enough to listen to with a stethoscope. Turbulent blood flow isn't smooth. The sound differs from normal heart sounds by their characteristics. As an example, heart murmurs may have a distinct pitch, duration, and timing. The most important way health care providers examine the heart on physical exam is heart auscultation. A murmur is a sign found during the cardiovascular exam. Murmurs are of various types and are important in the detection of cardiac and valvular pathologies (i.e. can be a sign of heart diseases or defects).

There are two types of murmurs. A functional murmur or "physiologic murmur" could be a murmur that's primarily due to physiologic conditions outside the heart. Other types of murmurs are due to structural defects in the heart itself. Functional murmurs are benign (an "innocent murmur").

Most of the time murmurs are normal variants. These types of murmurs are present at various ages. This is due to changes in the body with age. For example, chest size, blood pressure, pliability, or rigidity of structures. Normal variants are present without a cardiovascular problem.

Murmurs may aadditionally be the result of various problems. For example, narrowing or leaking of valves, or the presence of abnormal passages through which blood flows in or near the heart. Murmurs caused by a disease process are pathologic murmurs. Pathologic murmurs may have an evaluation by a cardiologist.

Heart murmurs are frequently categorized by timing. These include systolic heart murmurs, diastolic heart murmurs, or continuous murmurs. These differ within the part of the heartbeat they create sound, during systole, or diastole. Yet, continuous murmurs create sound throughout both parts of the heartbeat. Continuous murmurs are not placed into the categories of diastolic or systolic murmurs.

Classification

Murmurs have seven main characteristics. These include timing, shape, location, radiation, intensity, pitch, and quality.

- Timing refers to whether is a systolic, diastolic, or continuous murmur. Shape refers to the intensity over time. Murmurs can be crescendo, decrescendo or crescendo-decrescendo. Crescendo murmurs increase in intensity over time. Decrescendo murmurs decrease in intensity over time. Crescendo-decrescendo murmurs have both shapes over time. These have a progressive increase in intensity, peak, and progressive decrease in intensity. Crescendo–decrescendo murmurs resemble a diamond or kite shape.

- Location refers to where the heart murmur is usually heard best. There are four places on the anterior chest wall to listen for heart murmurs. Each location roughly corresponds to a specific part of the heart. Health care providers listen to these areas with a stethoscope.

Region	**Location**	**Heart Valve Association**
Aortic	2nd right intercostal space	Aortic valve
Pulmonic	2nd left intercostal spaces	Pulmonic valve
Tricuspid	4th left intercostal space	Tricuspid valve

Mitral	5th left mid-clavicular intercostal space	Mitral valve

- Position for auscultation: The patient is most frequently lying on their back (supine) with the head of the bed at a slight upward angle. The head of the bed is typically at a 30-degree upward angle.
- Usually the health care provider is standing to the right of the person they're examining. Below are positional changes that one may use:
- Left lateral decubitus (lying on the left side). This can decrease the distance from the wall of the chest to the apex of the heart. This may help to examine the point of maximal impulse. Also, this can help to listen to extra heart sounds (S3 or S4). With the patient sitting upright.
- With the patient seated, leaning forward, and holding the breath after exhalation. This may decrease the distance of the chest wall to the left ventricular outflow tract. Doing so will help find the presence of an aortic regurgitation murmur.
- Radiation refers to where the sound of the murmur travels. The rule of thumb is that the sound radiates within the direction of the blood flow.
- Intensity refers to the loudness of the murmur with grades according to the Levine scale, from 1 to 6.

Levine scale	**Murmur Description**
1	Only audible on listening carefully for some time
2	Faint but immediately audible on placing the stethoscope on the chest
3	Loud, readily audible but with no palpable thrill.
4	loud with a palpable thrill
5	loud with a palpable thrill. So loud that it is audible with only the rim of the stethoscope touching the chest.
6	loud with a palpable thrill. Audible with the stethoscope not touching the chest but lifted just off it.

- Pitch may be low, medium or high. This depends on whether auscultation is best with the bell or diaphragm of a stethoscope.
- Quality refers to unusual characteristics of a murmur. For example, blowing, harsh, rumbling or musical.

Interventions that change murmur sounds

- Inhalation results in a rise in intrathoracic negative pressure. This increases the capacity of pulmonary circulation, thereby prolonging ejection time. This can affect the closure of the pulmonary valve. This finding is additionally called Carvallo's maneuver. This maneuver in studies had a sensitivity of 100% and a specificity of 80% to 88% in detecting murmurs originating within the right heart. Positive Carvallo's sign describes the rise in intensity of a tricuspid regurgitation murmur heard inspirationally.

- Abrupt standing
- Squatting, by increasing afterload and increasing preload. Squatting leads to an increase in systemic vascular resistance. A rise in systemic vascular resistance leads to rising in afterload. With HOCM, an increase in afterload will hold the obstruction in a more open configuration. This may decrease the loudness of the murmur with HOCM.
- Handgrip maneuver, by increasing afterload. Like squatting, this can decrease the loudness of the HOCM murmur.
- Valsalva maneuver. Valsalva maneuver has utility in detecting hypertrophic obstructive cardiomyopathy (HOCM). According to one study, it has a sensitivity of 65% and specificity of 96% in HOCM. Valsalva maneuver, as well as standing, decreases venous return to the heart. As a result, this decreases left ventricular filling. With HOCM, the outflow obstruction increases with a decrease in preload. This will increase the loudness of the murmur with HOCM.

- Post ectopic potentiation
- Inhaled amyl nitrite. This is a vasodilator that diminishes systolic murmurs in left-to-right shunts in ventricular septal defects. It also reveals right-to-left shunts within the setting of pulmonic stenosis and a ventricular septal defect.
- Methoxamine
- Positioning of the patient. within the lateral decubitus position or lying on the left side. This will make murmurs in the mitral valve area more pronounced.

Anatomic sources

Systolic

Aortic valve stenosis is a crescendo/decrescendo systolic murmur. It's best heard at the right upper sternal border (aortic area). It sometimes radiates to the carotid arteries. In mild aortic stenosis, the crescendo decrescendo is early peaking. Whereas in severe aortic stenosis, the crescendo is late-peaking. In severe cases, obliteration of the S2 heart sound may occur.

Stenosis of Bicuspid aortic valve is like the aortic valve stenosis heart murmur. But, one may hear a systolic ejection click after S1 in calcified bicuspid aortic valves. Symptoms tend to present between 40 and 70 years old.

Mitral regurgitation is a holosystolic (pansystolic) murmur. One can best hear it at the apex location and it may radiate to the axilla or precordium. When associated with mitral valve prolapse, one may hear a systolic click. During this scenario, valsalva maneuver will decrease left ventricular preload. This will move the murmur onset closer to S1. Isometric handgrip will increase left ventricular afterload. This will increase the murmur intensity. In acute severe mitral regurgitation, one might not hear a holosystolic (pansystolic) murmur.

Pulmonary valve stenosis is a crescendo-decrescendo systolic murmur. One can hear it best at the left upper sternal border. It's associated with a systolic ejection click that increases with inspiration. This finding results from an increased venous return to the right side of the heart. Pulmonary stenosis sometimes radiates to the left clavicle.

Tricuspid valve regurgitation is a holosystolic (pansystolic) murmur. It presents at the left lower sternal border with radiation to the left upper sternal border. One even may see prominent v and c waves with the JVP (jugular venous pressure). The murmur will increase inspirationally.

Hypertrophic obstructive cardiomyopathy (or hypertrophic sub aortic stenosis) is a systolic crescendo decrescendo murmur. One can best hear it at the left lower sternal border. Valsalva maneuver will increase the intensity of the murmur. Going from squatting to standing will increase the intensity of the murmur.

Atrial septal defect will present with a systolic crescendo-decrescendo murmur. It's best heard at the left upper sternal border. This is often the result of an increased volume going through the pulmonary valve. It has association with a fixed, split S2 and a right ventricular heave.

Ventricular septal defect (VSD) will present as a holosystolic (pan systolic) murmur. One can hear it at the left lower sternal border. It has association with a palpable thrill, and increases with isometric handgrip. A right to left shunt (Eisenmenger syndrome) may develop with uncorrected VSDs. This is due to worsening pulmonary hypertension. Pulmonary hypertension will increase the murmur intensity and may present with cyanosis.

Flow murmur presents at the right upper sternal border. It may present in certain conditions, such as anaemia, hyperthyroidism, fever, and pregnancy.

Diastolic

Aortic valve regurgitation will present as a diastolic decrescendo murmur. One can hear it at the left lower sternal border. One might additionally hear it at the right lower sternal border (when associated with a dilated aorta). Other possible exam findings are bounding carotid and peripheral pulses. These are called Corrigan's pulse or Watson's water hammer pulse. Another possible finding is a widened pulse pressure.

Mitral stenosis presents as a diastolic low-pitched decrescendo murmur. It is best heard at the cardiac apex within the left lateral decubitus position. Mitral stenosis may have an opening snap. Increasing severity will shorten the time between S2 (A2) and therefore the opening snap. For instance, in severe MS the opening snap will occur earlier after A2.

Tricuspid valve stenosis presents as a diastolic decrescendo murmur. One can hear it at the left lower sternal border. One might even see signs of right heart failure on exam.

Pulmonary valve regurgitation presents as a diastolic decrescendo murmur. One may hear it at the left lower sternal border. A palpable S2 within the second left intercostal space correlates with pulmonary hypertension due to mitral stenosis.

The cooing dove murmur is a cardiac murmur with a musical quality (high pitched). Associated with aortic valve regurgitation (or mitral regurgitation before rupture of chordae). It's a diastolic murmur heard over the mid-precordium.

Continuous and Combined Systolic/Diastolic

Patent ductus arteriosus may present as a continuous murmur radiating to the back. Severe coarctation of the aorta can present with a continuous murmur. One may hear the systolic component at the left infraclavicular region and therefore the back. This can be because of the stenosis. One may hear the diastolic component over the chest wall. This is due to blood flow through collateral vessels.

Acute severe aortic regurgitation may present with a three phase murmur. First, a midsystolic murmur followed by S2. Following this is often a parasternal early diastolic and mid-diastolic murmur (Austin Flint murmur). The exact cause of an Austin Flint murmur is unknown. Hypothesis is that the mechanism of murmur is from the severe aortic regurgitation. In severe aortic regurgitation the jet vibrates the anterior mitral valve leaflet. This causes collision with the mitral inflow during diastole. As such, the mitral valve orifice narrows. This leads to increased mitral inflow velocity. This results in the jet impinging on the myocardial wall.

Ruptured aortic sinus (sinus of Valsalva) may present as a continuous murmur. This is often uncommon reason for continuous murmur One may hear it at the aortic area and along the left sternal border.

Types and disease associations

Continuous machinery murmur, at the left upper sternal border
Classic for a patent ductus arteriosus (PDA). Signs of infants related to serious cases of PDA are poor feeding, failure to thrive and respiratory distress. Other examination findings may include widened pulse pressures and bounding pulses.

Systolic murmur loudest below the left scapula
Classic for a coarctation of the aorta. Coarctation of the aorta is narrowing of the aorta. This might occur in Turner's Syndrome, (gonadal dysgenesis). Turner's syndrome is an Xlinked disorder with absence of one X-chromosome. Other exam findings of coarctation of the aorta include radio-femoral delay. This can be when the femoral pulse is later than the radial pulse. The pulses within the lower extremity may be weaker than those of the upper extremity. Another exam finding is of varying blood pressure in the upper and lower extremities. This presents as higher blood pressure in the arms and lower blood pressure in the legs.

Harsh holosystolic (pansystolic) murmur at the left lower sternal border
Classic for a ventricular septal defect (VSD). This could cause to the development of the delayed-onset cyanotic heart disease known as Eisenmenger syndrome. Eisenmenger syndrome is a reversal of the left-to-right heart shunt.

This is the result of hypertrophy of the right ventricle over time. This causes a right-to-left heart shunt. The VSD allows deoxygenated blood to flow from the right to left side of the heart. This blood bypasses the lungs. The lack of oxygenation in the pulmonary circulation results in cyanosis.

Widely split fixed S_2 and systolic ejection murmur at the left upper sternal border

Classic for a patent foramen ovale (PFO) or atrial septal defect (ASD). A PFO is lack of closure of the foramen ovale. At first, this produces a left-to-right heart shunt. This does not produce cyanosis, but causes pulmonary hypertension. Longstanding uncorrected atrial septal defects can also result in Eisenmenger syndrome. Eisenmenger syndrome can result in cyanosis.

1.6 Details on Arduino-Uno:

Arduino is a prototype platform (open-source) based on an easy-to-use hardware and software. It consists of a circuit board, which can be programed (referred to as a microcontroller) and a ready-made software called Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board.

The key features are −

- Arduino boards are able to read analog or digital input signals from different sensors and turn it into an output like activating a motor, turning LED on/off, connect with the cloud and plenty of other actions.
- You can control your board functions by sending a collection of instructions to the microcontroller on the board via Arduino IDE (referred to as uploading software).
- Unlike most previous programmable circuit boards, Arduino doesn't need an additional piece of hardware (called a programmer) so as to load a new code onto the board. You can simply use a USB cable.
- Additionally, the Arduino IDE uses a simplified version of C++, making it easier to be told to program.
- Finally, Arduino provides a standard form factor that breaks the functions of the micro-controller into a more accessible package.

Board Types

Various styles of Arduino boards are available depending on different microcontrollers used. However, all Arduino boards have one thing in common: they're programed through the Arduino IDE.

The differences are based on the number of inputs and outputs (the number of sensors, LEDs, and buttons you can use on a single board), speed, operating voltage, form factor etc. Some boards are designed to be embedded and have no programming interface (hardware), which you would need to buy separately. Some can run directly from a 3.7V battery, others need a minimum of 5V.

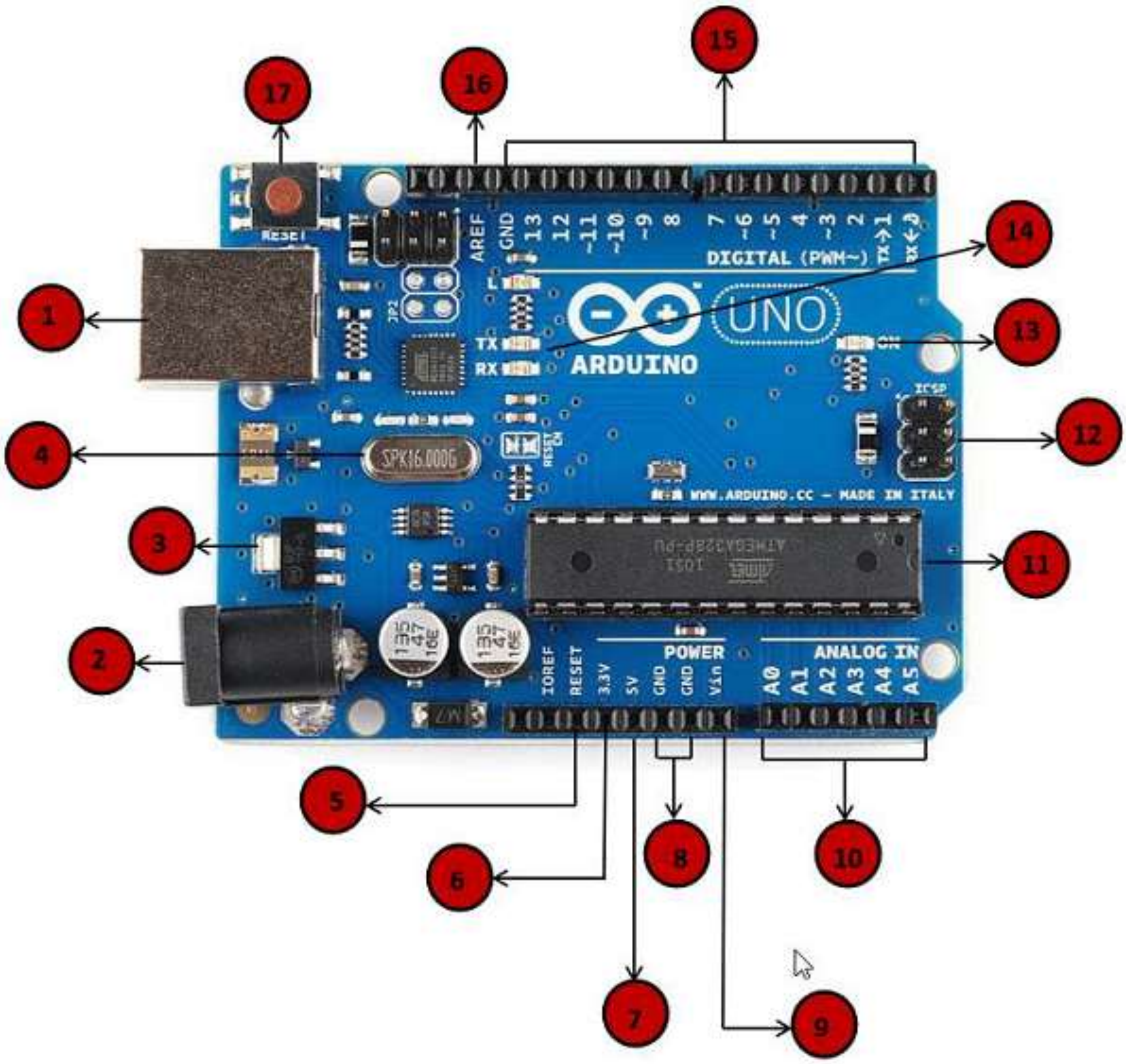


Fig1.7

Power USB Denoted as 1pin

Arduino board can be powered by using the USB cable from your computer. All you would do is connect the USB cable to the USB connection (1).

Power (Barrel Jack) 2pin

Arduino boards can be powered directly from the AC mains power supply by connecting it to the Barrel Jack (2).

Voltage Regulator 3pin

The function of the voltage regulator is to control the voltage given to the Arduino board and stabilize the DC voltages used by the processor and other elements.

Crystal Oscillator 4pin

The crystal oscillator helps Arduino in dealing with time issues. How does Arduino calculate time? The answer is, by using the crystal oscillator. The number printed on top of the Arduino crystal is 16.000H9H. It tells us that the frequency is 16,000,000 Hertz or 16 MHz.

Arduino Reset 5,17pins

You can reset your Arduino board, i.e., start your program from the beginning. You'll be able to reset the UNO board in two ways. First, by using the reset button (17) on the board. Second, you'll connect an external reset button to the Arduino pin labelled RESET (5).

Pins (3.3, 5, GND, Vin) 6,7,8,9pins

- 3.3V (6) − Supply 3.3 output volt
- 5V (7) − Supply 5 output volt
- Most of the components used with Arduino board works fine with 3.3 volt and 5 vol your circuit.
- Vin (9) − This pin also can be used to power the Arduino board from an external power source, like AC mains power supply.

GND (8)(Ground) − There are several GND pins on the Arduino, any of which could be used to ground Analog pins 10pin

The Arduino UNO board has six analog input pins A0 through A5. These pins can read the signal from an analog sensor just like the humidity sensor or temperature sensor and convert it into a digital value that can be read by the microprocessor.

Main microcontroller 11pin

Each Arduino board has its own microcontroller (11). You can assume it as the brain of your board. The main IC (integrated circuit) on the Arduino is slightly different from board to board. The microcontrollers are usually of the ATMEL Company. You want know what IC your board has before loading up a new program from the Arduino IDE. This information is available on the top of the IC. For more details about the IC construction and functions, you can refer to the data sheet.

ICSP pin 12 pin

Mostly, ICSP (12) is an AVR, a small programming header for the Arduino consisting of MOSI, MISO, SCK, RESET, VCC, and GND. It's often named to as an SPI (Serial Peripheral Interface), which could be considered as an "expansion" of the output. Actually, you're slaving the output device to the master of the SPI bus.

Power LED indicator pin 13

This LED should light after you plug your Arduino into a power source to indicate that your board is powered up correctly. If this light doesn't turn on, then there is something wrong with the connection.

TX and RX LEDs pin 14

On your board, you will find two labels: TX (transmit) and RX (receive). They appear in two places on the Arduino UNO board. First, at the digital pins 0 and 1, to indicate the pins responsible for serial communication. Second, the TX and RX led (13). The TX led flashes with different speed while sending the serial data. The speed of flashing depends on the baud rate used by the board. RX flashes during the receiving process.

Digital I/O pin15

The Arduino UNO board has 14 digital I/O pins (15) (of which 6 provide PWM (Pulse Width Modulation) output. These pins are configured to work as input digital pins to read logic values (0 or 1) or as digital output pins to drive different modules like LEDs, relays, etc. The pins labelled “~” can be used to generate PWM.

AREF pin16

AREF stands for Analog Reference. It’s sometimes, used to set an external reference voltage (between 0 and 5 Volts) because the upper limit for the analog input pins.

1.7 OBJECTIVE

- To design and construct a electronic stethoscope capable of having features like
- Audio output of heart rate.
- Digital display of heart BPM.
- Interface for heart rate diagnosis.
- Long distance transmission of output through proper channel for further diagnosing.

CHAPTER 2

The objective of listening the vibrations in the heart is to impart to the human observer as much of information as possible in a form that is quickly assimilated and interpreted. Once these vibrations transduced to electrical signal, the signal may be processed by several techniques before being presented to the observer audiotiourily or visually. These report discuss the several techniques that have been proposed till date for automatic analysis of heart sounds. These studied aimed at detecting abnormal conditions of the heart in individuals presenting with adventitious heart sound such as blowing, whooshing or rasping. Some of these prior studies and the techniques used there in are mentioned in detail below

- The study by Batyrkhanomarov et, al. [1] develop a real time electronic stethoscope for heart diseases detection. A computerized phonocardiogram, a non-invasive acoustic system for detecting heart abnormalities, that receives heart sound from patient, classifies them using machine learning techniques, and diagnoses the patient in real time whether the patient has pathology in heart or not. The full functional stethoscope system includes three sub system as portable digital electronic stethoscope, decision making system that that applied machine learning to classify heart sounds, and sub system for visualizing and displaying results in an understandable form. The stethoscope can detect abnormal heartbeat in 15s. Accuracy of the stethoscope has hit 93% in normal heart detection, and 93.25% in abnormal heartbeat detection.

- Electronic stethoscope using Arduino [2] by Prof .N.S Mundane et, al. This device takes associate inputs signals from the sensors, It can also manage a crystal reflector, speaker and wireless communication ZigBee. Condenser microphone housed in a plastic coupling device designed in solid works and printed on a 3D printer. The signal is then sent through a DC interference condenser followed by n non-inverting voltage follower, a second-order low pass filter, and finally an active gain stage providing a gain of 10. Project uses Arduino Nano and Arduino Mega as a microcontroller to receive data and then transfer it through ZigBee pro series 1 for wireless communications.

- Designing of electronic stethoscope based on ZigBee [3] by Ms. Kadam Patil D.D and Mr. Shastri R.K.An embedded digital stethoscope is designed and simulated by using an embedded processor. Preamplifier is amplifying signal for gain 20. Designed filter is giving proper output until cutoff frequency and showing attenuation above that frequency. Frequency selection can be possible by selecting by selecting capacitor value with the help of switch. Gain of power amplifier can be controlled by changing value potentiometer connected at input due to which volume control is possible. Signal pre-processing circuit consist of three parts: primary amplifier circuit, filter circuit and second amplification circuit. Circuitry is designed by using operational amplifier. Here Opam LM741 is used for designing of pre amplifier, which is having gain of 20. Output of preamplifier is fed to an active low pass filter with cutoff of 100Hz and 1000Hz. Filter is having gain of 1.6. The output signal from filter is processed by power amplifier to supply necessary power to drive the headphones for further amplification.

- Electronic method for detection of heart valve defects was done by Aparajita et, al. [4] have presented technique to detect heart valve defect by Fast Fourier transform and recorded heart sound from 350 subjects but it didn’t give clear distinction about the status of heart condition. They have also recorder heart sound using phonograph for subjects in noise free environment. In this technique frequency components with the maximum magnitude (Hz) was observed to be of varying values across some heart sound hence normal heart sound could not be categorized in generic way. To overcome this problem they have use Shannon energy method which has clearly classified the condition of heart S1 (lub)and S2(dub)frequency component ,if they lie between 30-100 Hz the heart is normal and it is above 100hz than heart function is abnormal.Recorded Heart sound reflects the heart valve functioning. By using Shannon energy algorithm the S1 and S2 are detected very accurately. This presented automatic detection and identifying algorithm will eliminate the noise interferences i.e. heart murmurs and background noises, and effectively detects the primary heart sound (i.e. First heart sound and Second heart sound).

- Smart vest for continuous heart monitoring with stethoscope and Electrocardiography [5] by Katherine Tian. It is heart monitoring device, called as smart vest. vest consists of embedded digital stethoscope and 12 lead electrocardiography(ECG) for continuous heart monitoring. The smart vest can detect high quality signals with a good signal to noise ratio. Ultra low electronics, including sensor signal processing, analog to digital converter, and a microcontroller to reduce smart vest's power consumption. The stethoscope sensors are located at typical locations to detect the sound from the four heart valves. The analog signals from the stethoscope and 12 lead ECG sensors are connected to the ADC inputs The ADC input is read by an ultra-low power micro controllers. ultra-low power microcontrollers with artificial intelligence. Whole system is running on two rechargeable batteries.

- Design of Electronic stethoscope and Heart Rate Monitor for Remote Area Application [6] by V.R. PRASAD The design of Electronic stethoscope with the help of ATMEL -328 microcontroller Arduino Uno processor. Signal captured from human organ using stethoscope is given to the audio amplifier for signal amplification, LCD and keypad is also interface for the user interaction with stethoscope. The amplifier LM358, which amplifies the signal taken from human organ with analog sensor, applied to the Arduino board for processing of signal. Keypad 20x4 is connected to the Arduino board for user command, LCD display is also embedded with Arduino board for viewing heart beats, simple programming is used for communicating Arduino board with other interface equipment's.

- Design and Development of a Digital Stethoscope for Cardiac Murmur [7] by Kuldeep Singh and Preeti Abrol .The proposed system consists of the subsequent hardware components: 1) ATmega16 microcontroller 2) Microphone Bias and Amplifier Circuit 3) LCD 4) Serial EEPROM 5) MATLAB interface. . The objective is to develop a way which makes a clear distinction between normal heart sounds and heart murmurs. The data can be analyzed by using analytic tool like MATLAB .The ATmega16 is 8-bit microcontroller based on the AVR enhanced RISC architecture. It's a low-power CMOS device. By executing powerful instructions in a single machine cycle, the ATmega16 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed. It can work maximum frequency of 16MHz.The aim of this circuit is to properly bias the microphone and amplify the sensor output to detect voltage swings caused by sounds. A function generator is connected to the input of the circuit and frequencies are manually swept to test and verify the circuit's frequency response. A 16x2 LCD is interfaced with microcontroller to show the heart beats per minute (HBM).The analog output, which is obtained from stethoscope, is split into two parts: Pre-amplifier stage and Filtering stage. One amongst our major objectives is to reduce the noise from the analog input For this various filtering methodology are being used. The output obtained after filtering the noise from the pre-amplifier stage and the results are obtained at CRO. After counting the number of pulses by microcontroller for 1 minute the result is displayed on LCD.

- WIRELESS ELECTRONIC STETHOSCOPE USING ZIGBEE Ms. Ashlesha Khond, Ms. Priyanka Das, Ms. Rani Kumari[8]. The electronic stethoscope is based on embedded processor. The data can be transmitted through wireless transmission using ZigBee module. A microphone is used to pick up the sound of the heart beat.System design consists of two parts that is transmitter and receiver. The transmitter system consists of the subsequent hardware components: 1)Front end circuitry-sensor, preamplifier, filter and power amplifier with variable gain 2)

Microcontroller 3) ZigBee module. The hardware design of receiver consists of following parts: Zigbee module, microcontroller, DAC, Power amplifier.]. Microphones and accelerometers are the common choice of sensor for sound recording. Microphone is perfect for the application. The output of the microphone is fed to signal pre-processing module. Signal pre-processing circuit consists of three parts, which are primary amplification circuit, filter circuit and second amplification circuit . The role of signal pre-processing circuit is to adjust the signal from sensor with a series of amplification and filtering so that it meets the follow-up A/D sampling demands and therefore signal-noise ratio is improved. The output of signal Pre-processing Circuit is converted into digital form by ADC. Inbuilt successive approximation 12 bit ADC of microcontroller is used ZigBee module captures the signal within the air and transmits to microcontroller. We have to play this signal on speaker phone. But received signal is in digital form hence we have to first convert it into analog. Hence signal from microcontroller is given to 12 bit digital to analog converter.. With the help of PC connectivity, system can even store data and replay for further analysis and consultation. It will help to enhance the accuracy of the cardiovascular diseases diagnosis.

- A NOVAL DIGITAL STETHOSCOPE IN HEALTHCARE APPLICATION FOR TRIBAL AND ILLITERATE COMMUNITY by Dr. R. Sagayaraj and S. Karthikeyana[9]. Digital stethoscope, which is based on Embedded C programming, to meet the requirement of current major clinical application of the heart sound auscultation. It is folded with the following attractions such as the heart sound signal can be amplified and played in a speaker in real-time, avoids manual heartbeat counting and can be communicated to the smartphone. The gain of the amplification can be modified to satisfy the user‘s requirement. Also, the prevailing condition of the patient heartbeat can be sent to the physician and later as per the advice of the doctor it paves a way to undertake preliminary treatment. The LED screen on the portable device displays the heartbeat status as normal/abnormal level, which aids the tribes or illiterate community to safeguard the valuable human life. A novel digital design based Stethoscope replaces the conventional stethoscope. This device consists of a digital display with a disc-shaped resonator connected to earpieces, which shows the rate of heart beat per minute within 6 seconds the device will count the sound deflection and calculate the heart beat per minute by an output of disc-shaped resonator. Also, we can hear the heartbeat sound by headphones. The power will retrieve from the battery, located in the device. A divider interface card is connected for a smartphone app and to record the frequency rate from the headphone connectivity

- ALGORITHM DEVELOPMENT SIMULATOR FOR HUMAN HEART BEAT RATE by M. Olagunju, and A. E. Adeniyi[10]. Heart rate can simply be described as the speed of the heartbeat measured by the number of contractions of the heart per minute (bpm). For this definition to be meaningful, an algorithm must be design to determine the human heart beat rate. Algorithm design can simply be describe as a way of using mathematical expression in solving problems. Template method pattern and decorator pattern are the most common techniques used in algorithm design other include dynamic programming and divide-and-conquer.
  The essence of Algorithm design is to put the design into a meaningful scaling so that we can have a reasonable result. Divide and conquer algorithm was used in this study because is used to break down a complex problem into simpler form for efficient solution. It is used in sorting, multiplying large numbers, finding the closest pairs of points. The selected algorithm is to be applied into heartbeat functioning system since we know that heartbeat is working in a systematic format. For healthy people, the Target Heart Rate or Training Heart Rate (THR) is a desired range of heart rate reached during aerobic exercise which enables one's heart and lungs to receive the most benefit from a workout. This

theoretical range varies based mostly on age; however, a person's physical condition, sex, and previous training also are used in the calculation. There are two ways to calculate one's THR. In each of these methods, there is an element called "intensity" which is expressed as a percentage. The THR can be calculated as a range of 65–85% intensity. However, it is crucial to derive an accurate HRmax to ensure these calculations are meaningful. Algorithm to calculate accurate maximum heart beat rate in human, you have to: Determine the heart rate rest Determine the heart rate reserve Determine the heart rate maximum The Heart Rate Rest can be determined by using your pulse with your stopwatch in ten second.

CHAPTER 3

3.1 Proposed method:

The main objective of our system is to detect human heart sound for detecting heart arrhythmia using pre-amplifier and microprocessor. This is the technique to detect different heart sounds cause due to heart diseases such as Aortic stenosis, Mitral regurgitation, Aortic regurgitation, Mitral stenosis, Patent ductus arteriosus, etc.

In this project work we are constructing a digital stethoscope to analyse heart sounds. This analyses will provide a non-invasive and objective assessment of heart function especially aged people, young children’s and disable people. This can be achieved by using pre-amplifier and microprocessor. In this method heart sound sample is taken from patient using digital stethoscope and is given to Arduino-uno. Which identifies and detects R-Peak of heart sound and gives heart beats per minute (BPM).

3.2 BLOCK DIAGRAM OF PROPOSED SYSTEM

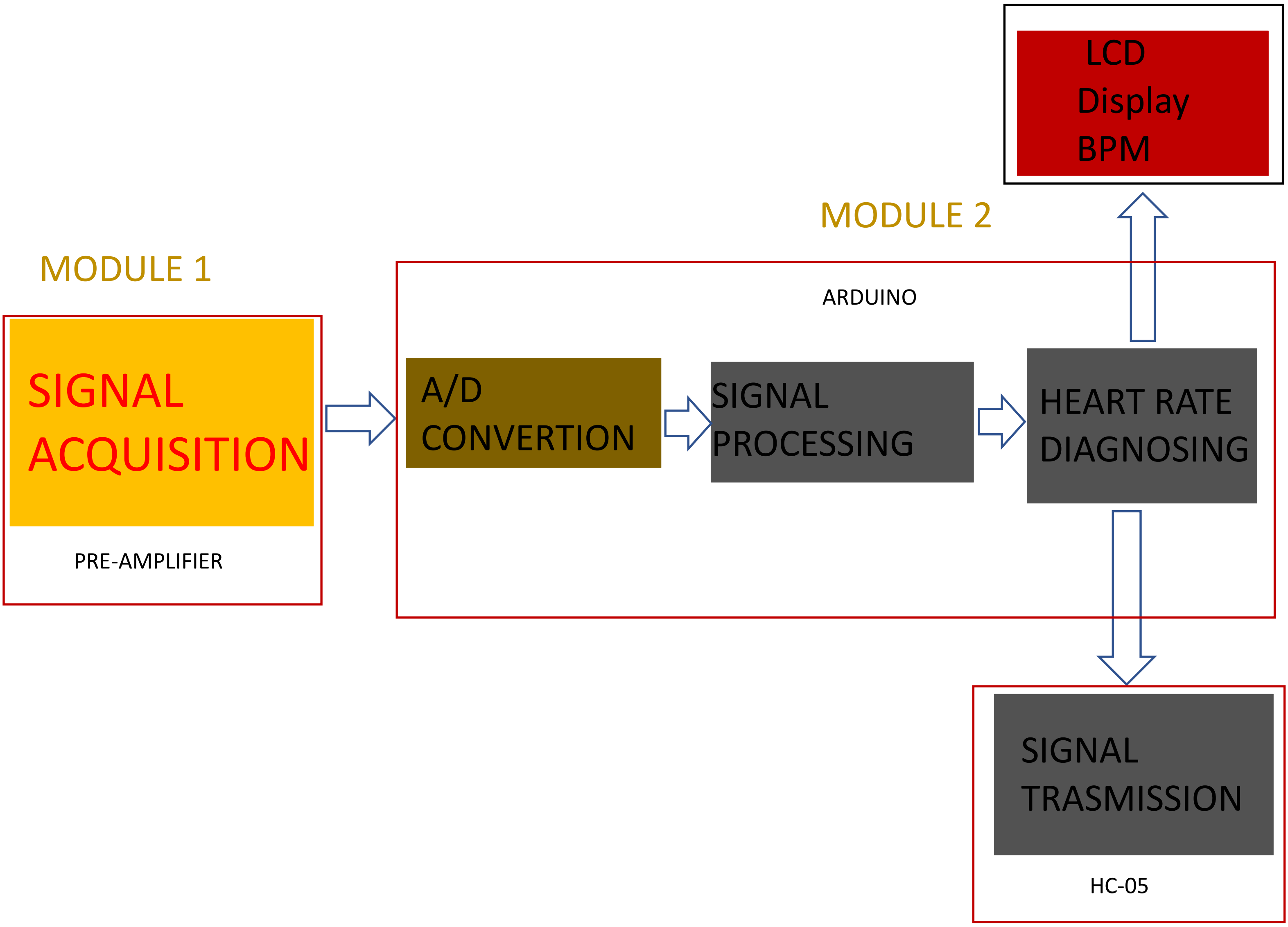


Fig 3.1 block diagram of proposed method

3.3 Methodology:

1) Heart sound is acquired from transducer.
2) Acquired heart signal is pass through noise reduction.
3) Then signal is pre-amplified using LM-741 IC.
4) Amplified signal is pass through active low pass filter.
5) This signal is amplified using LM-386.
6) Now we have audio output of our signal.
7) Then this analog signal is given to Arduino-UNO for A/D conversion and processing for heart beat detection.
8) The signal then can be transmitted over a long distance for further analysis if require.
9) End.

3.4 Flow Chart

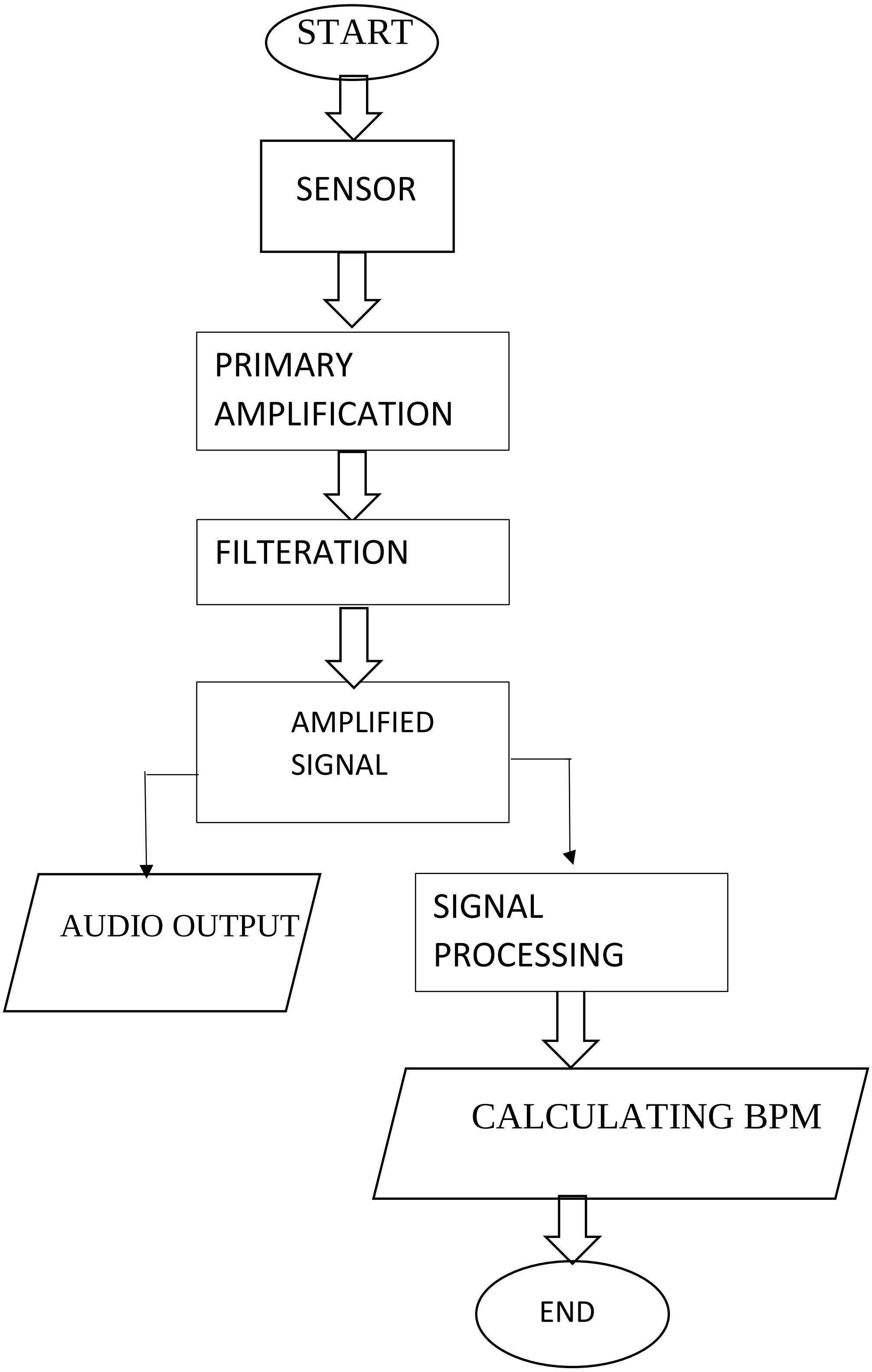


Fig 3.2 system flowchart

3.5 System Layout

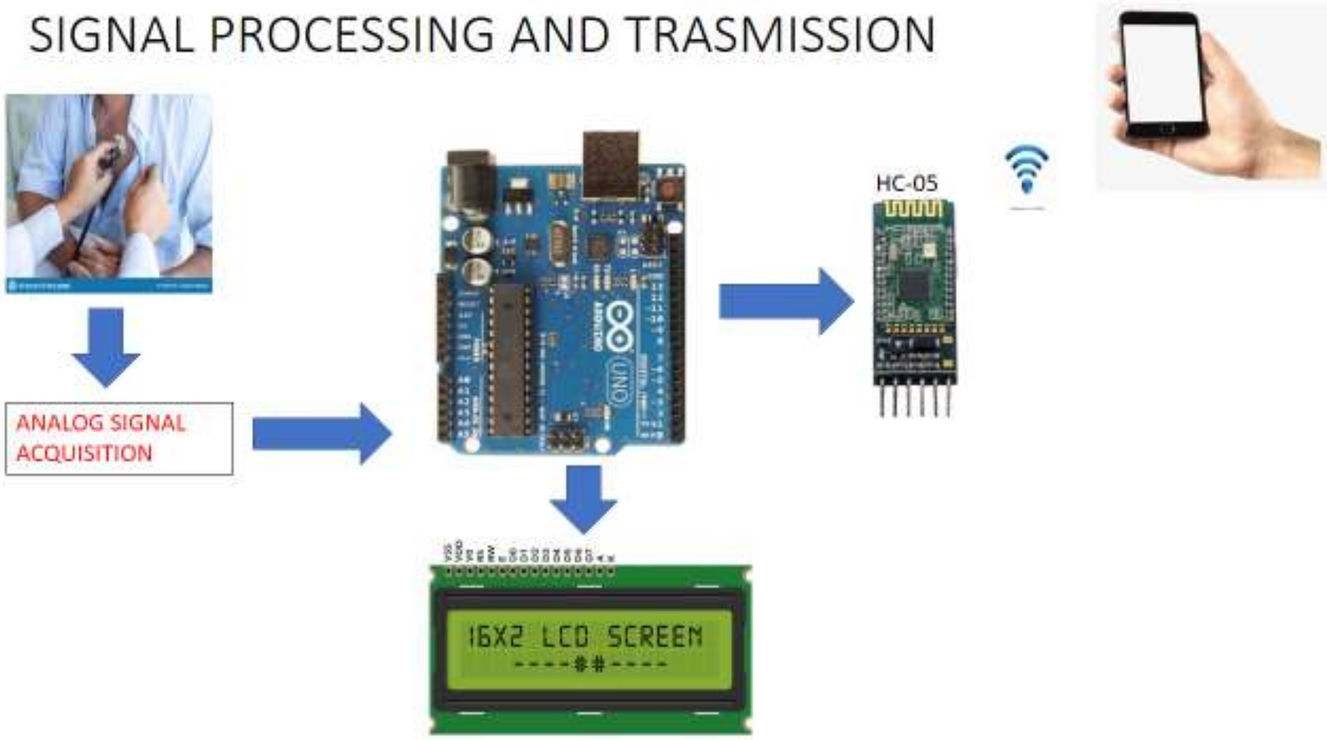


Fig 3.3

Signal Acquisition Flow

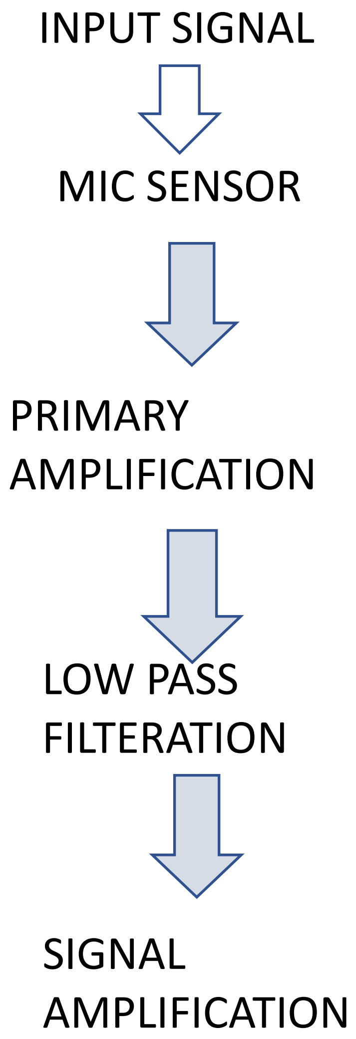


Fig 3.4

List of Component used in construction of Electronic Stethoscope.

NAME	**QUANTITY**	**VALUE OF COMPONENT**
R_{1}, R_{9}	2	10K 1/4 W RESISTOR
R_2	1	1K1/4W RESISTOR
R_3	1	2.2K 1/4W RESISTOR
R_4	3	47K 1/4W RESISTOR
R_5,R_6,R_7	3	33K 1/4W RESISTOR
R_8	1	56K 1/4W RESISTOR
RV_1	1	2.2K to 10K Audio Taper Pot
C_1,C_9, C_{10}	3	470uF 16V Electrolytic Capacitor
C_5,C_3	2	4.7nF Ceramic Capacitor
C_2	1	4.7uF 16V Electrolytic Capacitor
C_6,C_4	2	47nF 100k Polystyrene Capacitors
C_7	1	1000uF 16V Electrolytic Capacitor
C_8	1	0.05uF Ceramic Capacitor
U_1, U_2	2	741 Op-Amp
U_3	1	LM386 Audio Power Amp
J_1, J_2	1	1/8" Stereo Headphone Jack
MIC	1	Two Wire Electric Microphone
Batt1,Batt2	2	9V Alkaline Battery
SW/PUSH SW	2,1	DPST Switch/Push Switch
PRNT PCB	2	6.3 cm X 10.8cm Printed PCB
MISC	1	Stethoscope head, knob for R_{11} etc…

IC's Used In Signal Acquisition

1) LM386 Low Voltage Audio Power Amplifier

General Description:

The LM386 is power amplifier designed for use in low voltage consumer applications. The gain is internally set to 20 to keep external part count low, but addition of external resistor and capacitor between pins 1 and 8 will increase the gain to any value from 20 to 200. The inputs are ground referenced while the output automatically biases to one-half the supply voltage.

The quiescent power drain is just 24 mill watts when operating from a 6 Volt supply, making the LM386 ideal for battery operation.

Equivalent Schematic and Connection Diagrams:

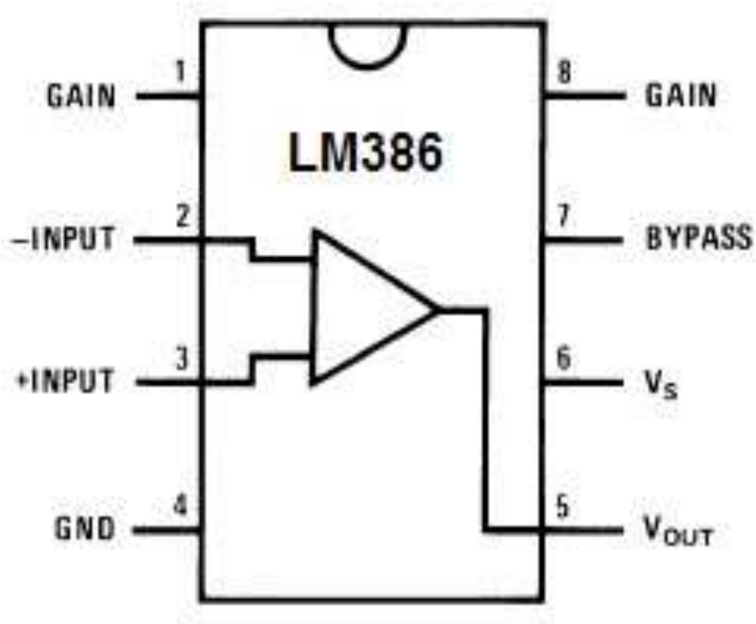


Fig 3.5

Application Hints

1) Gain Control:

To make the LM386 a more versatile amplifier, two pins (1 and 8) are provided for gain control. With pins 1and 8 open,

The 1.35kW resistor sets the gain at 20 (26 dB). If a capacitor is put from pin 1 to 8, bypassing the 1.35kW resistor, the gain will go up to 200 (45dB). If a resistor is placed in series with the capacitor, the gain can be set to any value from 20 to 200. Gain control can also be done by capacitive coupling a resistor (or FET) from pin 1 to ground Additional external components can be placed in parallel with the internal feedback resistors to tailor the gain and frequency response for individual applications. As an example, we can compensate poor speaker bass response by frequency shaping the feedback path.

This is done with a series RC from pin1 to 5 (paralleling the internal 15 kW resistor). For 6 dB effective bass boost: R=10 kW if pin 8 is open. If pins 1 and 8 are bypassed then R as low as 2 kW can be used. This restriction is because the amplifier is only compensated for closed-loop gains greater than 9.

Input biasing:

The schematic shows that both inputs are biased to ground with a 50 kW resistor. The base current of the input transistors is about 250 nA, so the inputs are at about 12.5 V when left open. If the DC source resistance driving the LM386 is higher than 250 kW it will contribute very little additional offset (about 2.5 mV at the input, 50 mV at the output). If the DC source resistance is between these values we can

Eliminate excess offset by putting a resistor from the unused input to ground, equal in value to the dc source resistance. Infact all offset problems are eliminated if the input capacitively coupled. When using the LM386 with higher gains (bypass the 1.35kW resistor between pins 1 and 8) it is necessary to bypass the unused input, preventing degradation of gain and possible instabilities. This is done with a 0.1 pF capacitor or a short to ground depending on the dc source resistance on the driven input.

Typical applications:

Fig 3.6

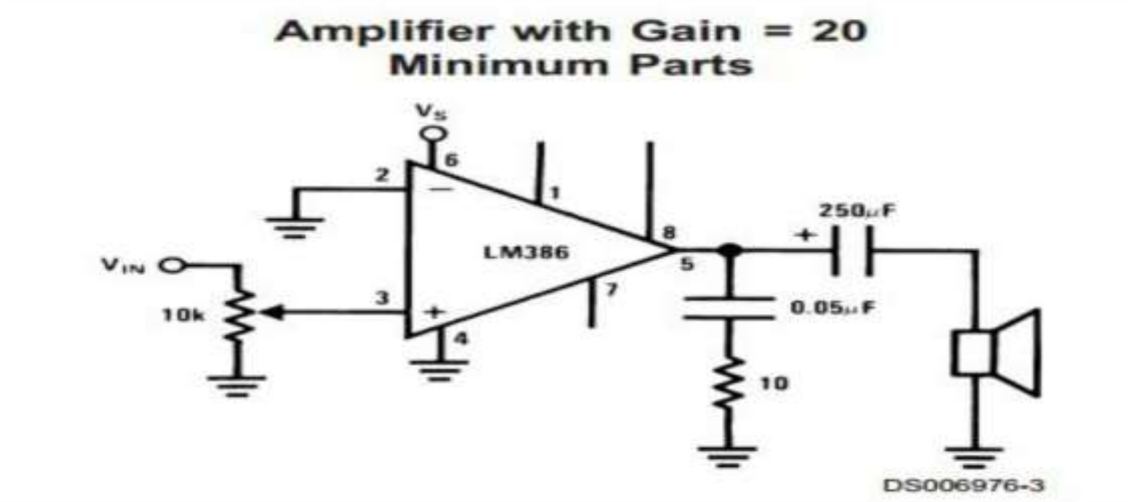
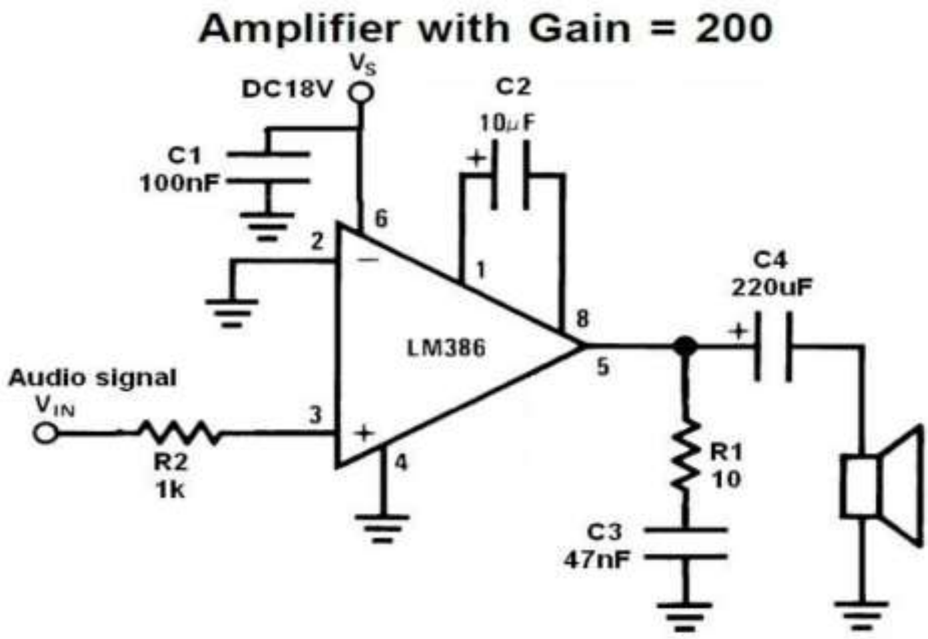


Fig 3.7



2) LM741 Operational Amplifier

General Description:

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439 and 748 in most applications. The amplifiers offer many features which make their application nearly fool proof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations. The LM741C is identical to the LM741/LM741A except that the LM741C has their performance guaranteed over a 0 degree Celsius to70 degree Celsius temperature range, instead of -55 degree Celsius to +125 degree Celsius.

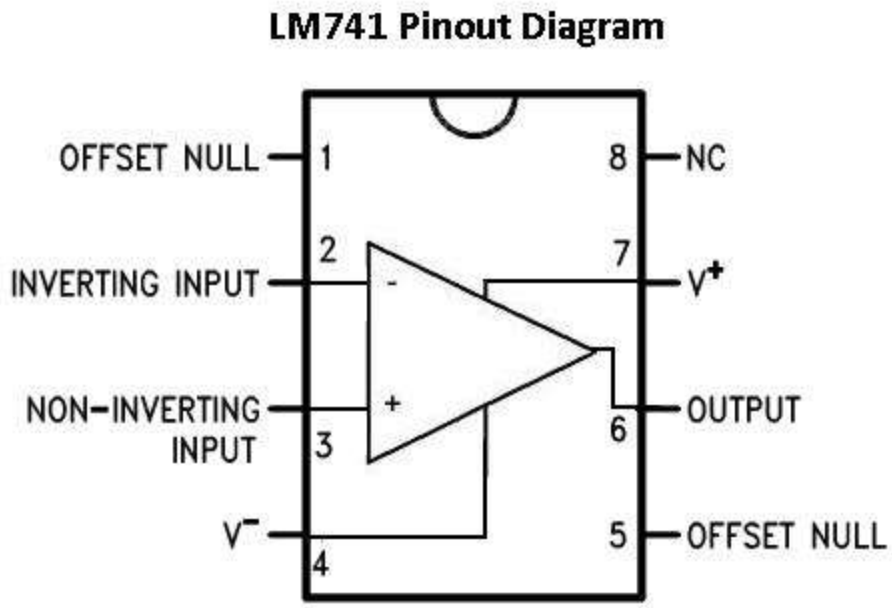


Fig3.8

Features:

- ❖ Wide common-mode (up to +Vcc) and differential voltage range
- ❖ Low noise en=15 nV/$\sqrt{Hz}$(typ)
- ❖ Output short-circuit protection
- ❖ High input impedance JFET input stage
- ❖ Low harmonic distraction: 0.001% (typical)
- ❖ Internal frequency compensation
- ❖ High slew rate: 16V/us(typ)

3.6 Front End Circuitry:

It is a signal acquisition and pre-processing system. First part is a sensor. There are multiple types of sensor that can be used in the chest piece of an electronic stethoscope to convert body sounds into electronic signal. Microphone and accelerometer are common choice of sensor for sound recording. Microphone is the perfect for the application. The output of the microphone is fed to the signal pre-processing module.

Signal Pre-Processing Circuit consist of three parts, which are primary amplification circuit, filter circuit and second amplification circuit. The role of signal pre-processing circuit is to adjust the signal from sensor with the series of amplification and filtering so that it meets the follow-up A/D sampling demands and the signal noise ratio is improved. This circuitry is designed by using operational amplifier. The preamplifier is created to increase the low signal from the condenser microphone to line-level for further amplification. Here op-amp LM741 is used for designing of preamplifier. It is having gain of 20 which is calculated by feedback resistor value. The output of the preamplifier is fed to an active low pass filter with cut-off of 100 Hz and 1000 Hz so that Heart sounds and respiration sounds are passed and background sounds are reduced. Frequency is selected by selecting capacitor value. Filter is having gain of 1.6. The output signal from the filter is processed by power amplifier to supply the necessary power to drive the headphones for further amplification. The LM386 circuit is an audio amplifier designed for use in low voltage consumer applications which provides both voltage and current gain for signals. Hence power amplifier with variable gain is designed with the help of op-amp LM386. Gain can vary by varying input given to amplifier through pot.

Fig 4.7 shows signal pre-processing circuit.

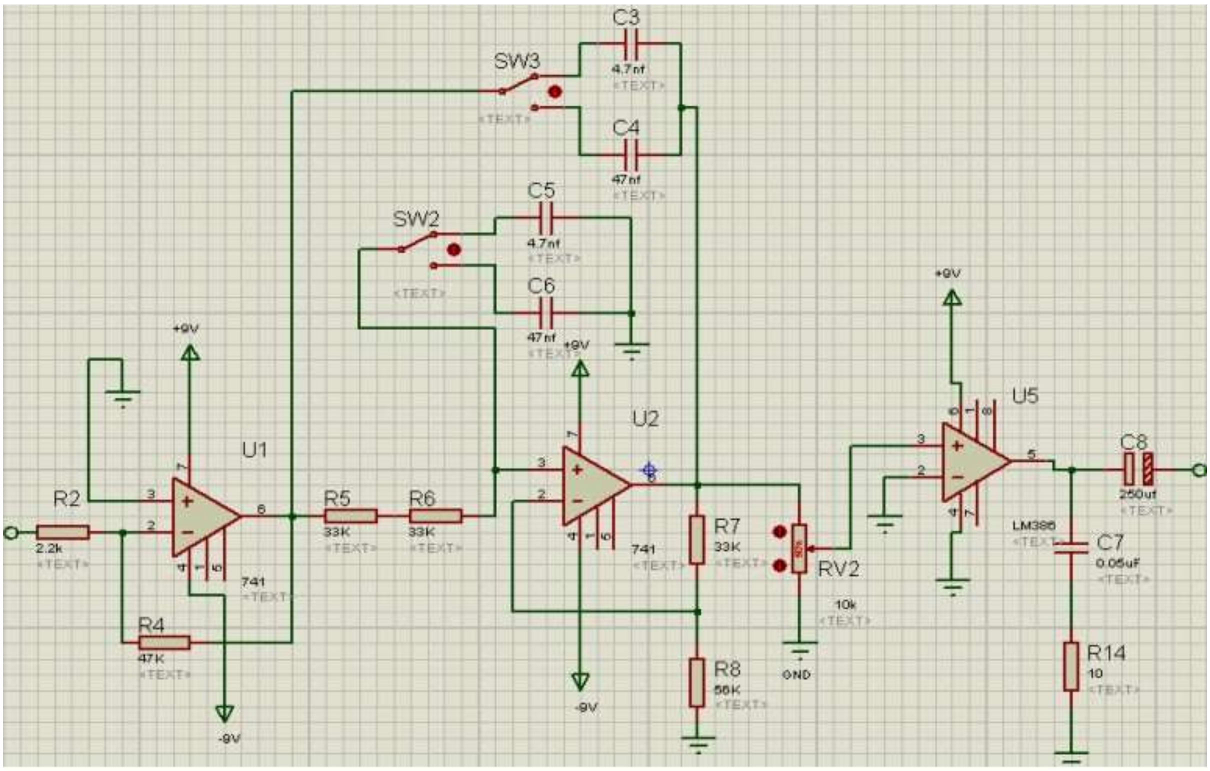


Fig 3.9

3.7 SENSORS DETAILS:

Selection of proper sensor for acquiring heart signal is very important. Here are the some of the sensors that we have come across. The details are as follows:

CONDENSOR MIC WITH SHIELDED CABLE:

Fig 3.10

Specification

- Low noise
- Low power consumption
- Suitable for a wide variety of Electronic products
- Multi-channel
- Frequency Range: 50 – 20KHz
- Microphone sensitivity 56 – 58DB

PIEZOELECTRIC SENSOR

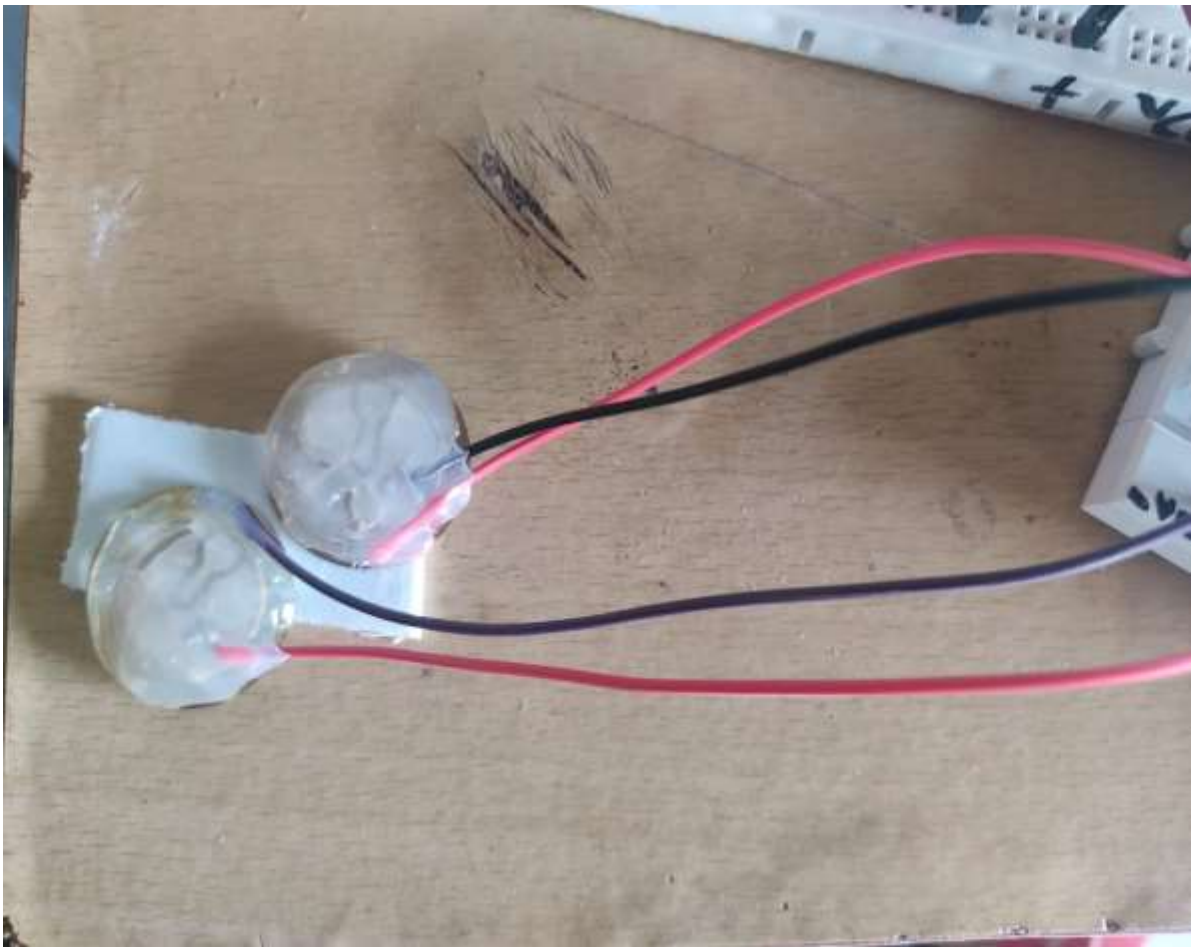


Fig 3.11

Specification

- Impedance:≤500Ω;
- Voltage:≤30Vp-p;
- Operating temperature:-20°C~+60°C
- Storage temperature:-30°C~+70°C
- Low Soldering temperature
- Strain sensitivity: 5V/µƐ
- Material: Quartz (mostly used)

CONTACT MICROPHONE

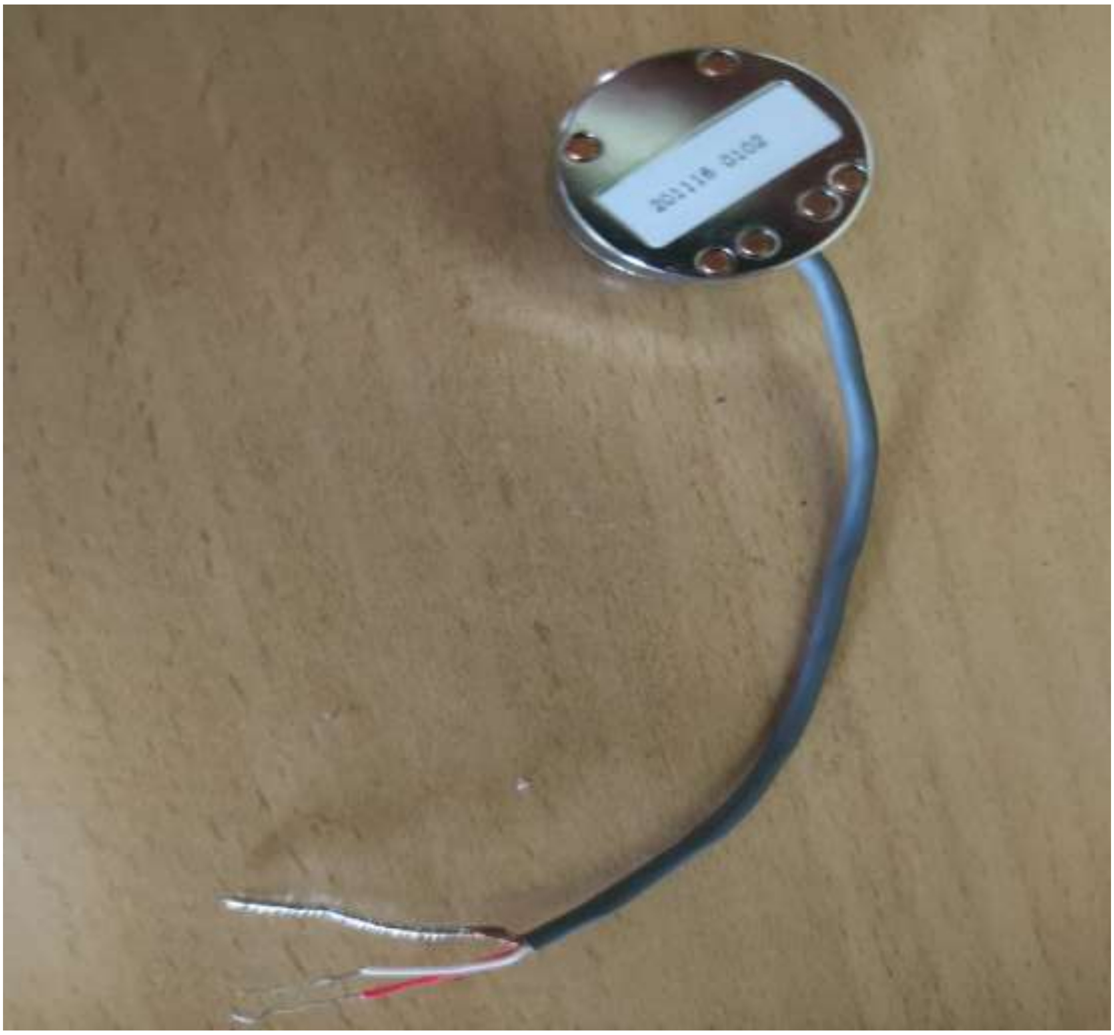


Fig 3.12

Specification

- High Sensitivity
- Robust
- Low Noise
- Piezo Film Technology
- Shielded Cable

The CM-01B Contact Microphone uses sensitive but robust PVDF piezo film combined with a low-noise electronic preamplifier to provide a unique sound or vibration pick-up with buffered output. The design minimizes external acoustic noise while offering extremely high sensitivity to vibration applied to the central rubber pad. The CM-01B is ideal for detecting body sounds.

FEATURES

- Broad Bandwidth
- High Sensitivity
- Excellent Impact Resistance
- Lightweight
- Low Cost

APPLICATIONS

- Electronic Stethoscope
- Bone-conducted Sound Pickup
- General Purpose Contact Microphone
- Vibration/Impact Sensing

Performance Specification

CHARACTERISTICS	Min	Type	Max	Units
Sensitivity		40		V/mm
Lower Limiting Frequency (-3 dB)		8		Hz
Upper Limiting Frequency (+3 dB)		2.2		kHz
Resonance Frequency		5		kHz
Spring Constant		20		N/m
Electronic Noise		1		mV pk-pk
Supply Voltage	4	5	30	V-DC
Supply Current		0.1		mA
Operating Temperature	+5		+60	°C
Storage Temperature	-20		+85	°C

SELECTION OF BEST STETHOSCOPE CHEST PIECE

Different size of diaphragm are selected as shown below.

Fig 3.13

It is found that the stethoscope with wide area of diaphragm has greater sensitivity as compare to that of smaller area of diaphragm.

In order to get good signal from diaphragm to microphone a special arrangement were made so to have good signal pick up.

Fig 3.14

3.8 PCB DESIGN

Our signal is very sensitive even a small fluctuation can hamper the original signal so it is very necessary to have a compact and less resistive circuit design. We opt for single layer printed circuit board which were design using proteus software.

PCB Preview

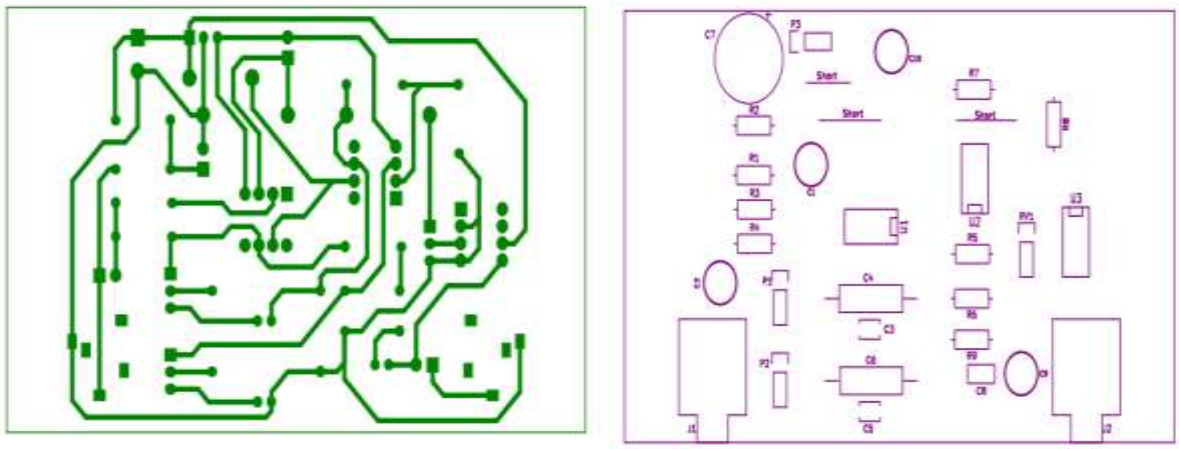


Fig 3.15

Printed Circuit Board

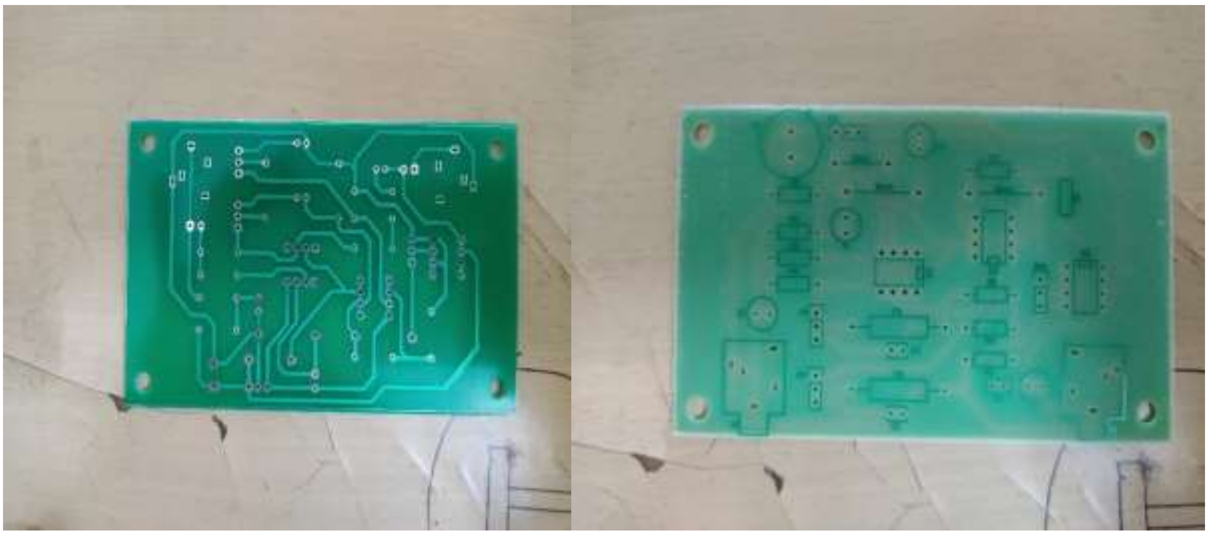


Fig 3.16

3.9 Signal Processing On Arduino-Uno

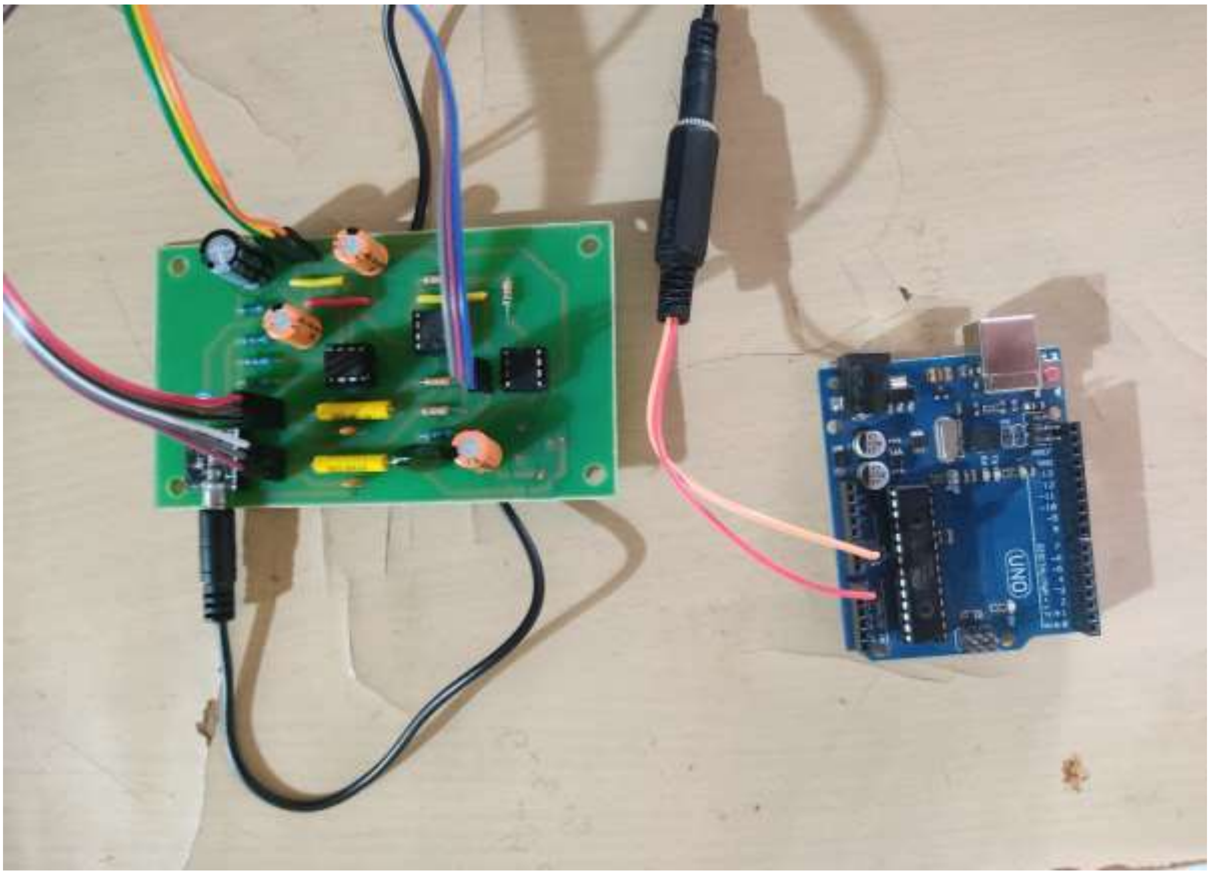


Fig 3.17

Fig Output of pre-amplifier is fed to Arduino-Uno.

The output of acquired signal is converted into digital form by ADC. Inbuilt successive approximation 10-bit ADC of microcontroller is used here Arduino-Uno microcontroller is used some features are as follows:

- Microcontroller ATmega328
- Operating Voltage 5V
- Analog Input Pins 6pins
- Flash Memory 32KB
- 2KB SRAM
- ADC Resolution 10bit

Microcontroller And HC-05 Bluetooth Module

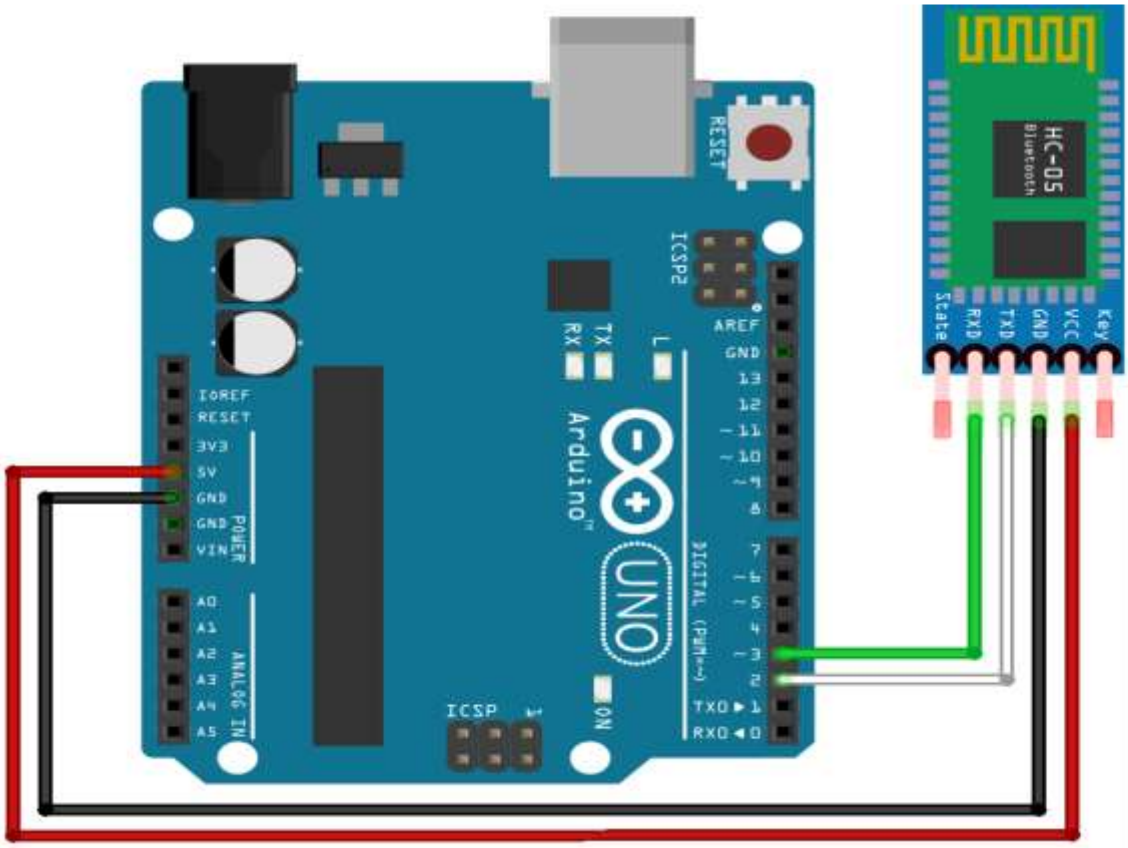


Fig3.18

For a wireless transmission of the signal HC-05 Bluetooth module is preferred. HC-05 is low powered, high performance surface mount module. Some of the features of HC-05 are as follows:

- HC05 follows "Bluetooth V2.0+EDR" protocol (EDR stands for Enhanced Data Rate).
- It's operating frequency is 2.4 GHz ISM Band.
- HC05 uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology.
- This module follows the IEEE (Institute of Electrical and Electronics Engineers) 802.15.1 standard protocol.
- It's operating voltage is 5V.
- It sends and receives data by UART, which is also used for setting the baud rate.
- it has -80dBm sensitivity.
- This module has the ability to work as a master/slave mode.
- This module can be easily connected with laptop or mobile phone via Bluetooth.

Microcontroller And LCD Display

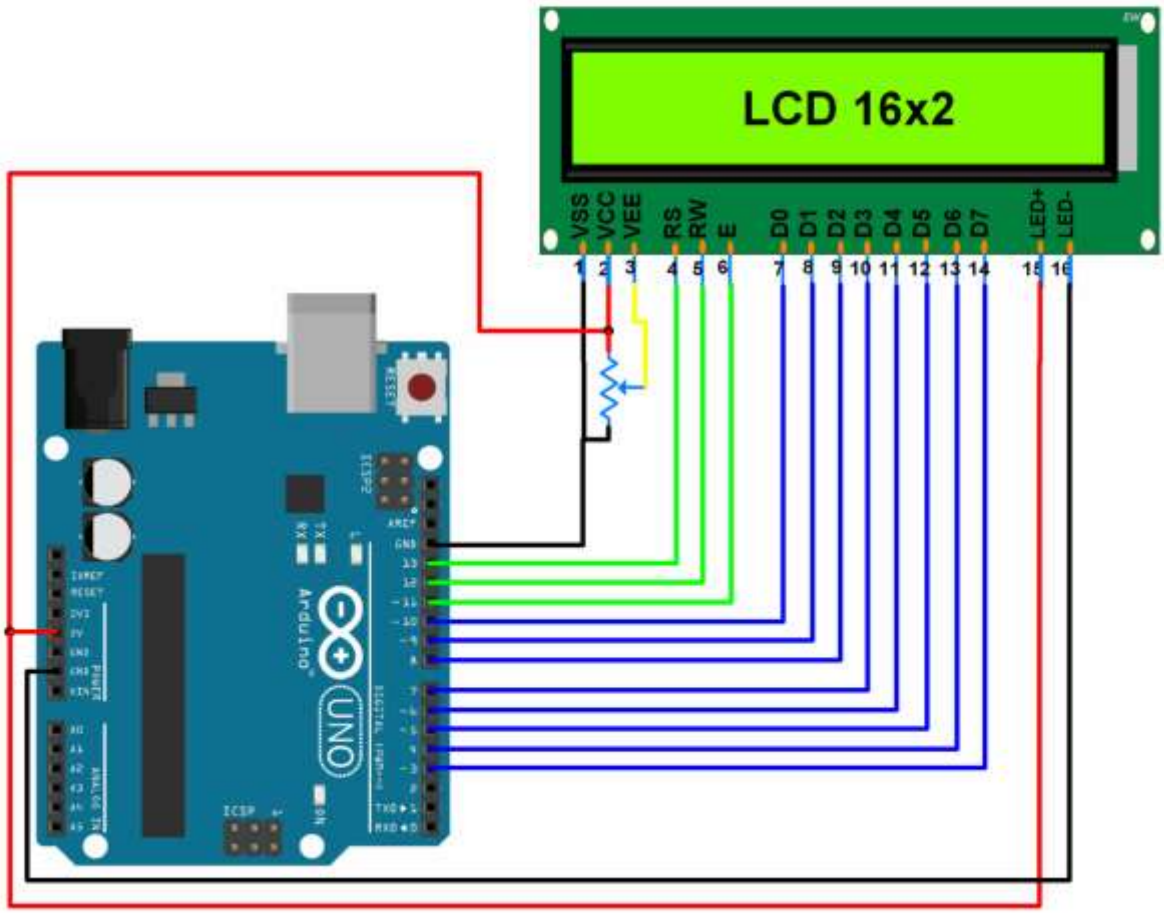


Fig 3.19

The numeric representation of signal is possible with the help of LCD display. The LCD have parallel interface, meaning that the microcontroller has to manipulate several interface pins at once to control the display. The interface consist of the following pins

- A **register select (RS) pin** that controls where in the LCD's memory you're writing data to. You can select either the data register, which holds what goes on the screen, or an instruction register, which is where the LCD's controller looks for instructions on what to do next.

- A **Read/Write (R/W) pin** that selects reading mode or writing mode
- An **Enable pin** that enables writing to the registers
- 8 **data pins (D0 -D7)**. The states of these pins (high or low) are the bits that you're writing to a register when you write, or the values you're reading when you read.

Hardware Required

- Arduino Board
- LCD Screen (compatible with Hitachi HD44780 driver)
- pin headers to solder to the LCD display pins
- 10k ohm potentiometer
- 220 ohm resistor
- hook-up wire

3.10 Preparation Of Panel

The require dimensions for panel making is selected then Acrylic plate is cut according to the requirement and necessary holes were drill. The various switches were fixed in the proper position. The whole circuitry placed inside the cabinet with the help of screw.

Fig 3.20

CHAPTER 4

4.1 To detect heart arrhythmia we have design a algorithm flow which will enable us to do so.

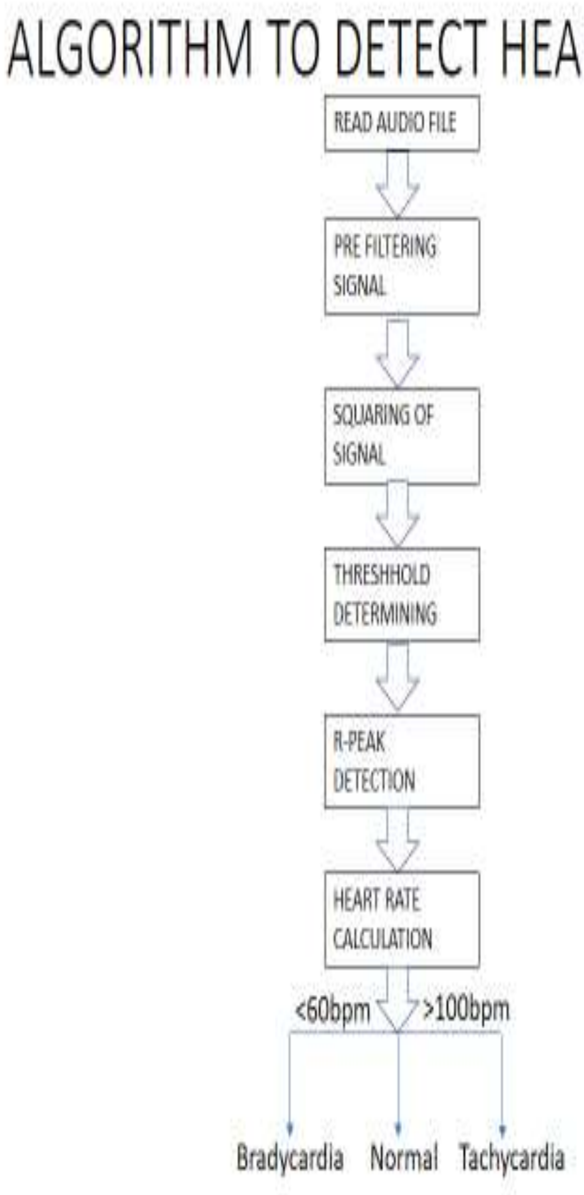


Fig 4.1

4.2 Description of the algorithm as per block.

- Read Audio File:
  The audio file was taken from signal acquisition module then it is fed to analog port of microcontroller that measures the value of analog signals. The ADC convert a analog voltage into a digital value. The function use in order to obtained the value of analog signal is analog read (pin).

- Pre Filtering of Signal:
  A digital high pass filter is used to filter out electronic noise and ripple in the signal. So to get read noise free intelligent signal.

- Squaring of The Signal:
  Squaring is necessary to remove left over low noise. It also gives more weight to larger differences.

- Threshold Determination:
  Threshold is set so that there is no interference of any low level peaks. Here we have set threshold at 50% of its amplitude.

- R-Peak Detection/Calculation:
  R-Peak detection is one of the method that widely used to diagnose heart rhythm irregularities and estimate heart-rate variability (HRV).
  The criteria for selecting the peak of every overshoot is based on : 1) at least one peak is selected; 2) two or more peaks implies the presence of split first or second heart sound hence first peak is selected to get the onset of each and every sound. In order to eliminate additional peak, a time interval between every neighbouring peaks are calculated.

  - Decision Making
  Once the BPM calculated it is pass through a criteria where in if signal lies between 60-100 BPM then it is said to be normal. If signal lies above 100 BPM then it is said to be tachycardia. If signal lies below 60 BPM then it is said to be bradycardia.

5.1 Test Results From The Sensors.

We have tested different sensors and results are obtained as follows.

- **Condenser Microphone**

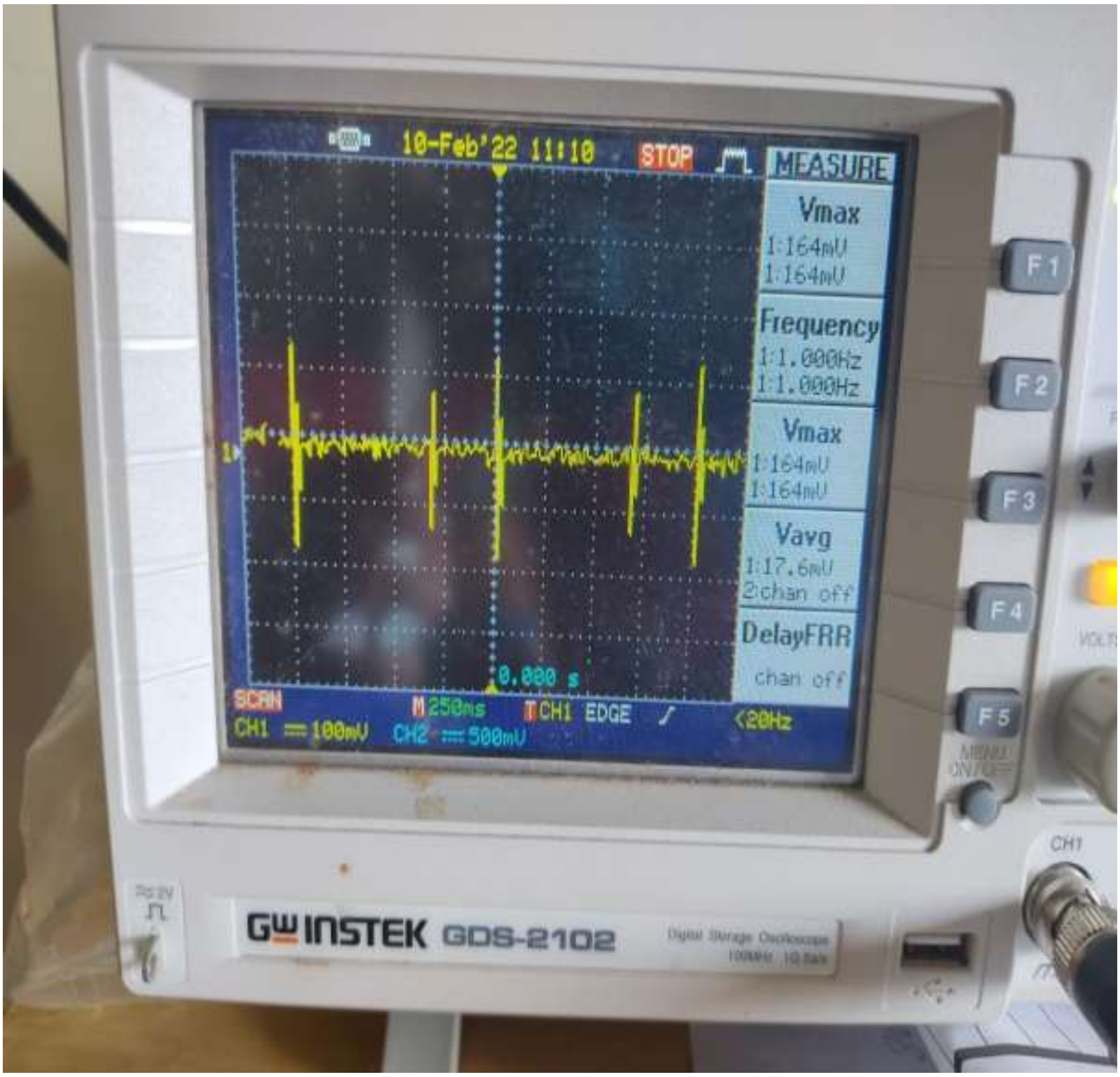


Fig 5.1(a) Output for Condenser Microphone

➢ The output for Condenser microphone is observe as shown above.

- **Piezoelectric Sensor**

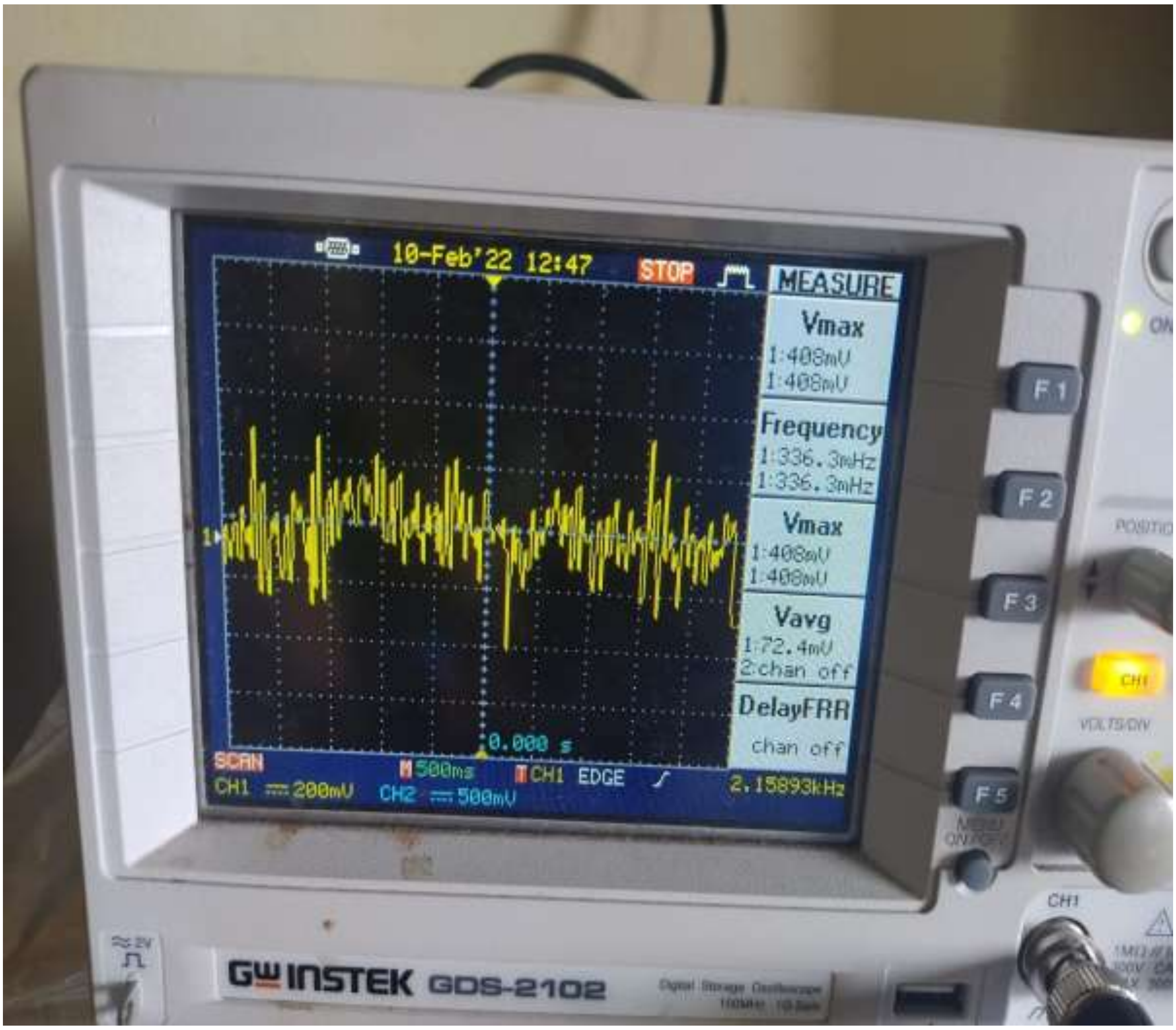


Fig 5.1(b) Output For Piezoelectric Sensor

- The output for piezoelectric sensor is noted.

5.2 Pre-amplifier circuit testing at pre-amplifier stage, Filter stage, Amplifier stage as shown in fig 5.2(a), 5.2(b), 5.2(c) respectively. Using wave file as a input.

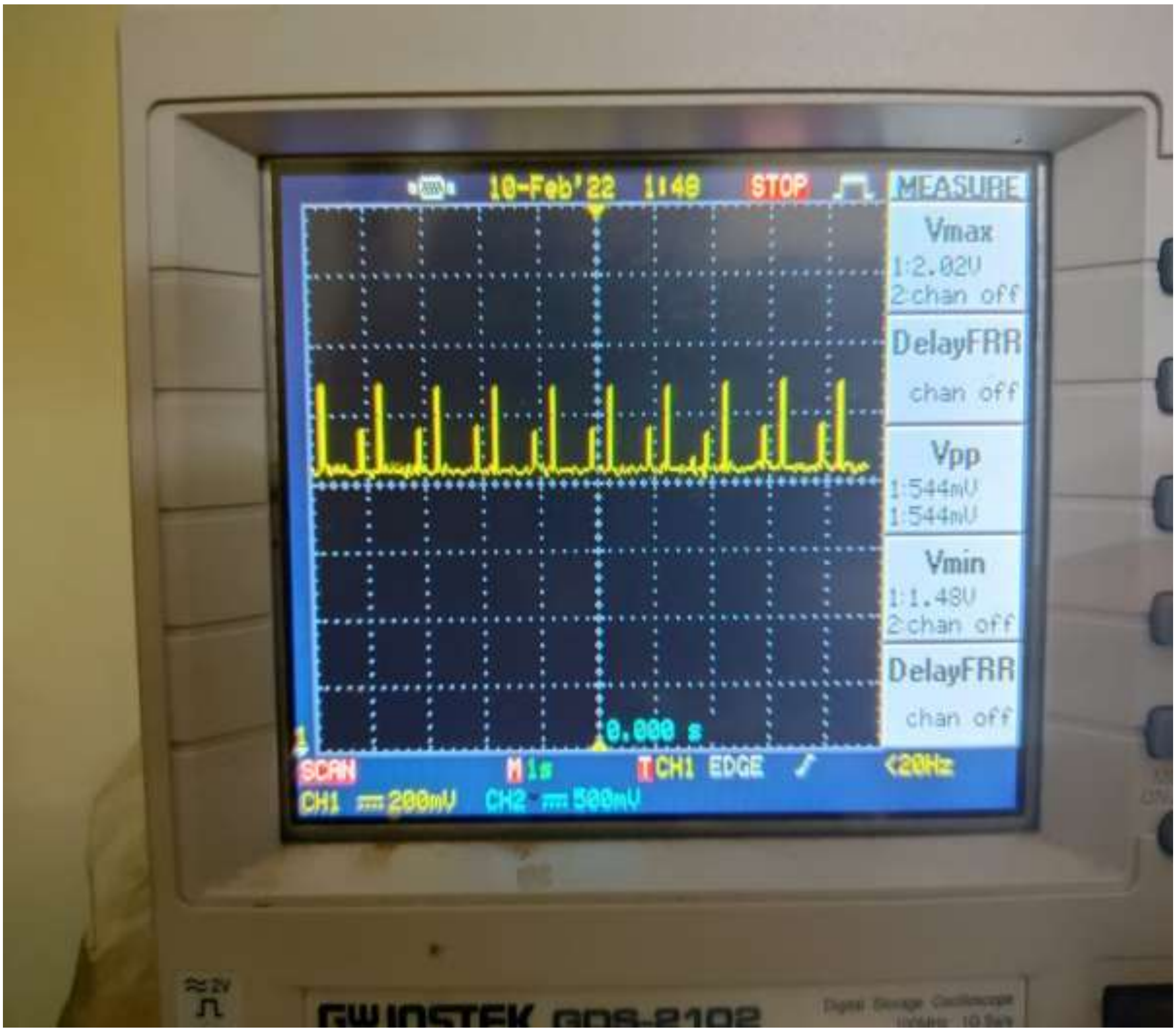


Fig 5.2 Heart Sound as Input

- Heart signal from wave file is directly given as a input to the CRO to observe the pattern.

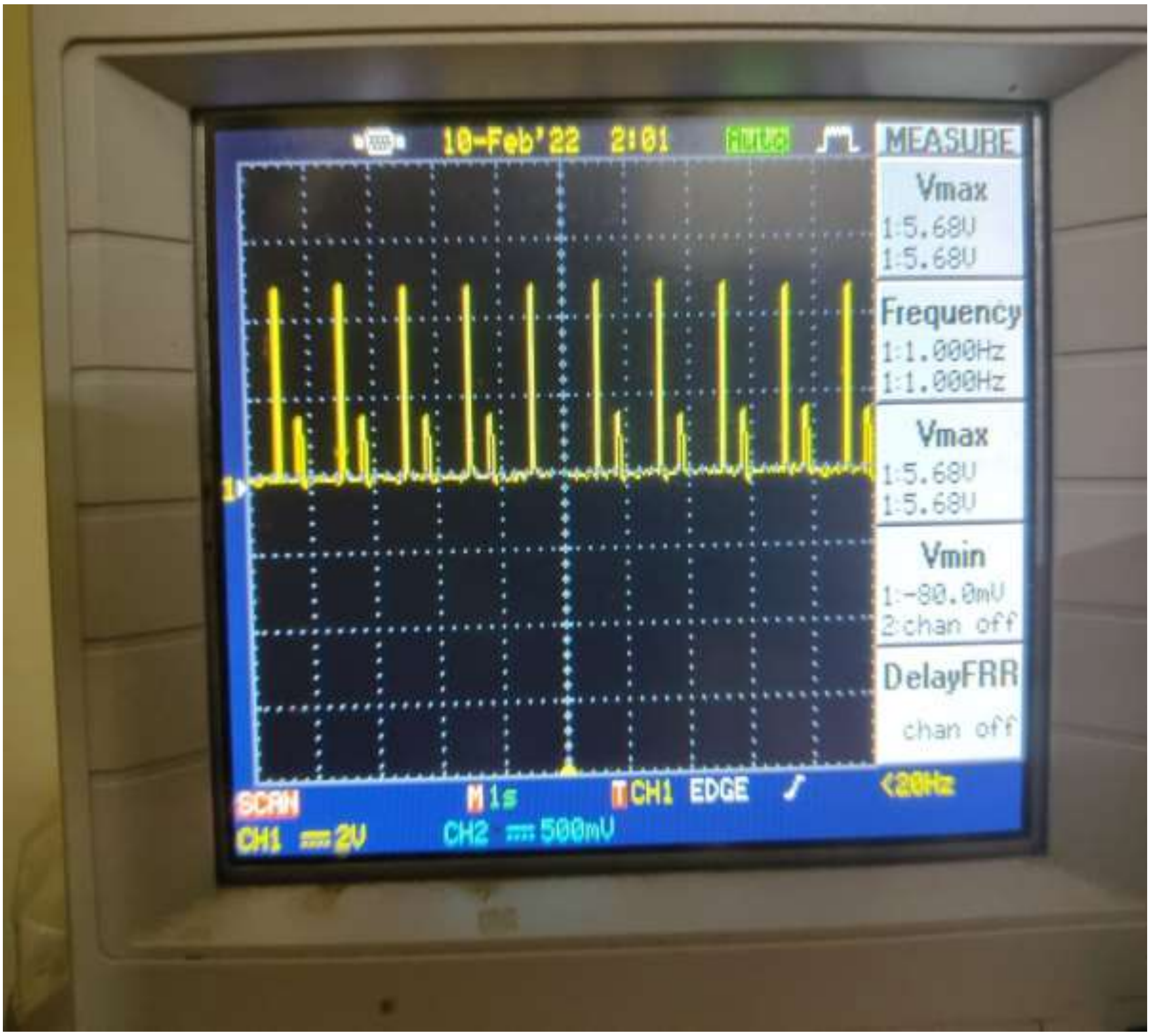


Fig 5.2(a) Waveform at Pre-amplifier Stage

- The output at pre-amplifier is observe.

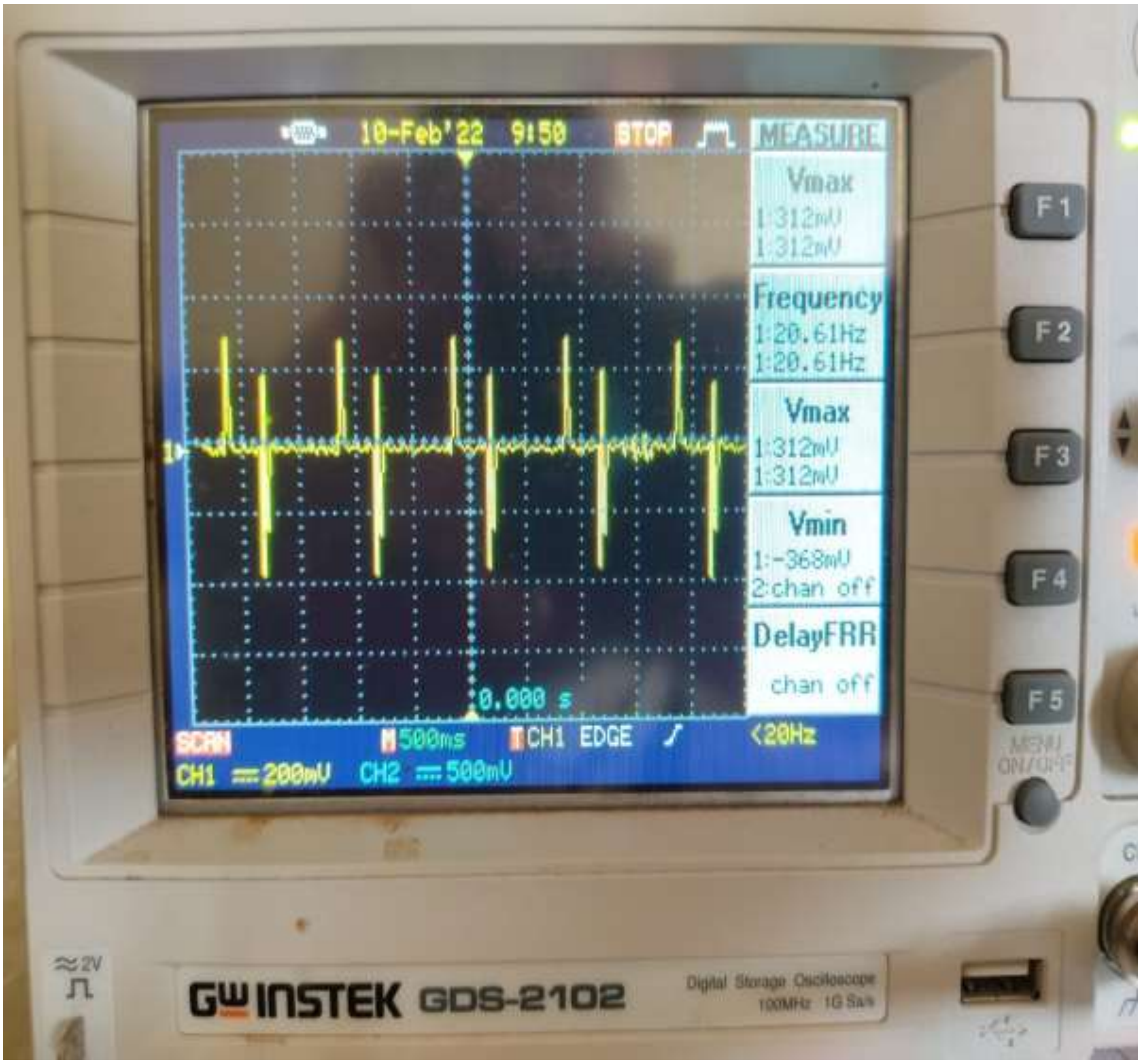


Fig 5.2(b) Waveforms at Filter Stage

- The output at filter stage of pre-amp is observed as shown above.

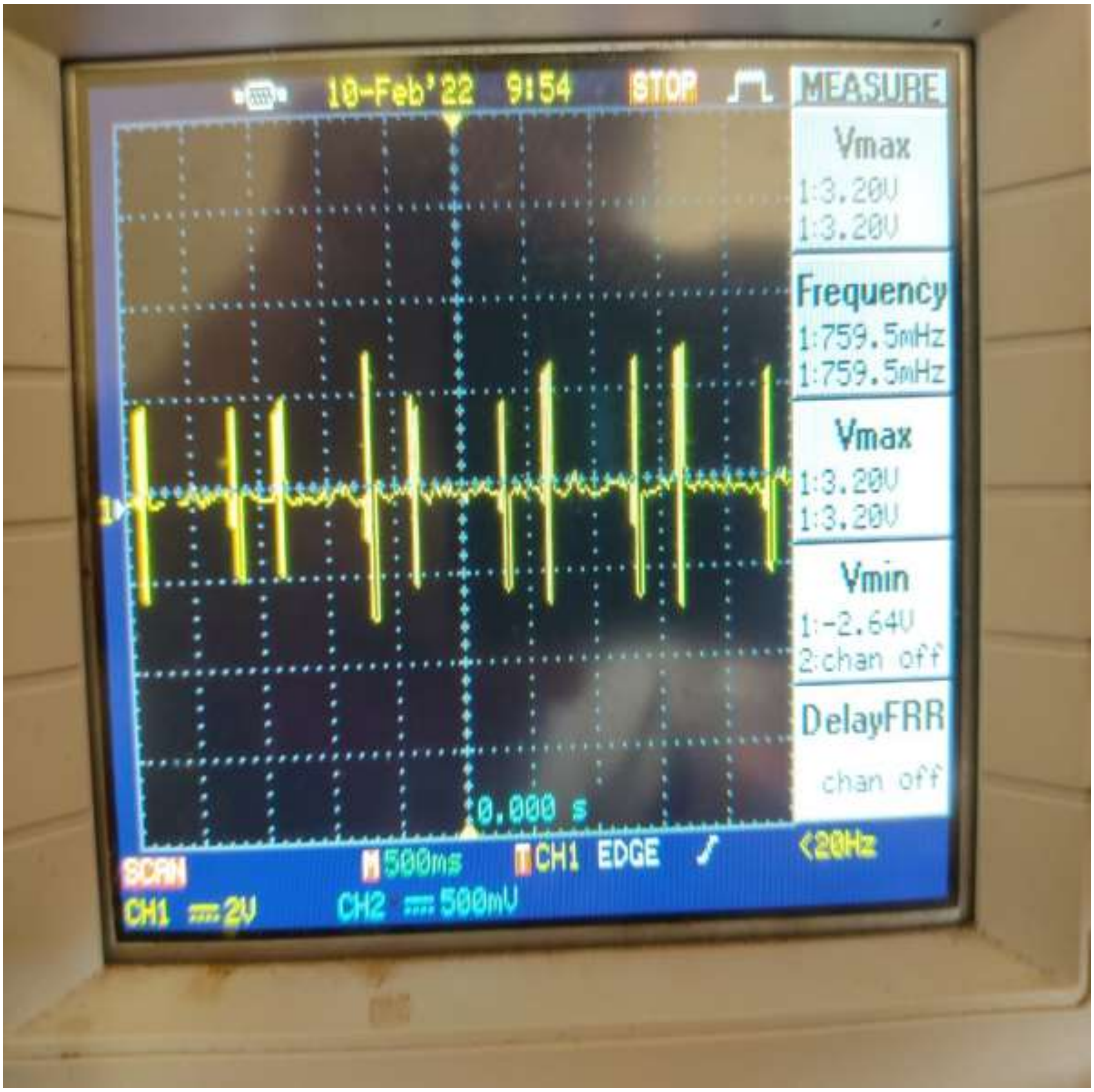
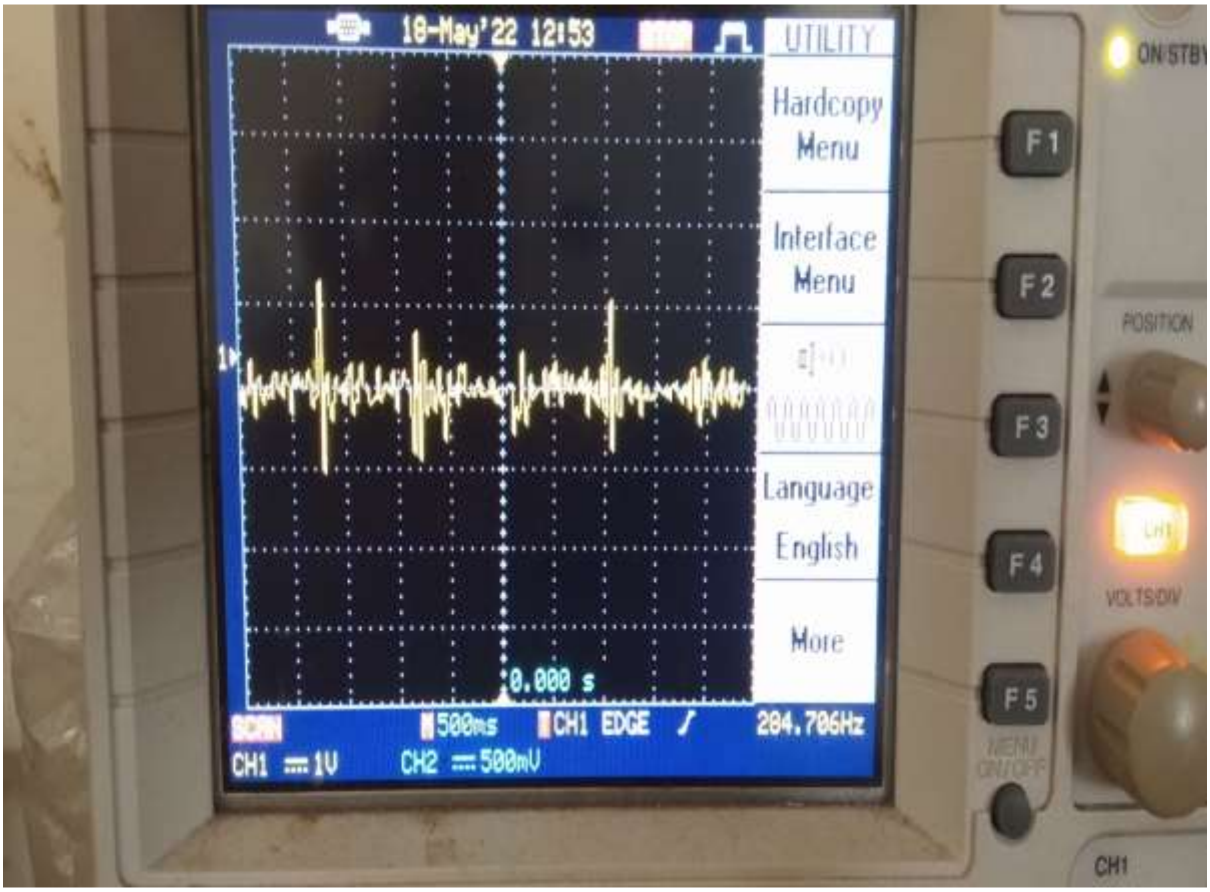


Fig 5.2(c) Waveform at Power Amplifier

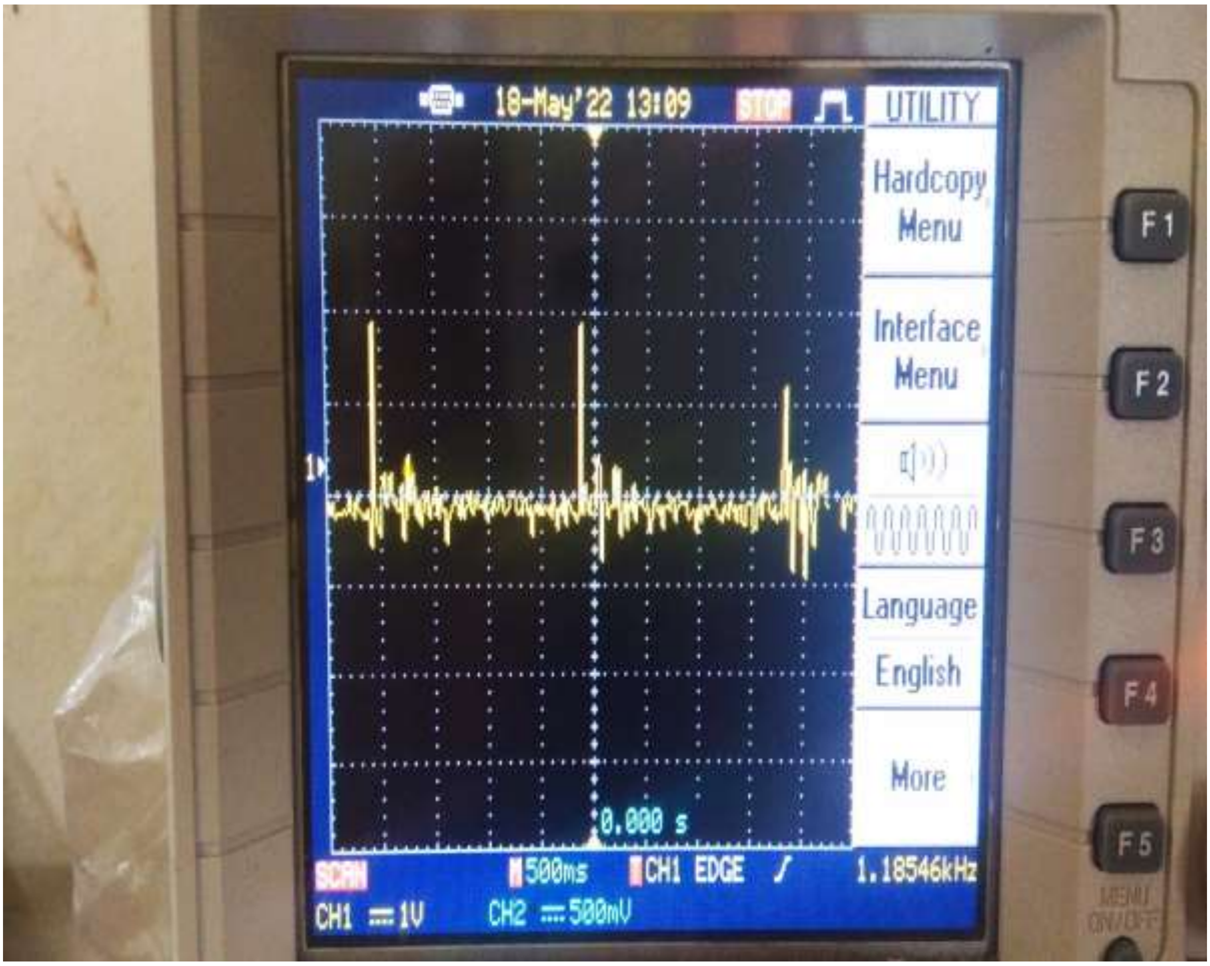
- The output at power amplifier stage is observe.

5.3 REPRESENTATION OF HEART SIGNAL IN PRE PROCESSING SYSTEM

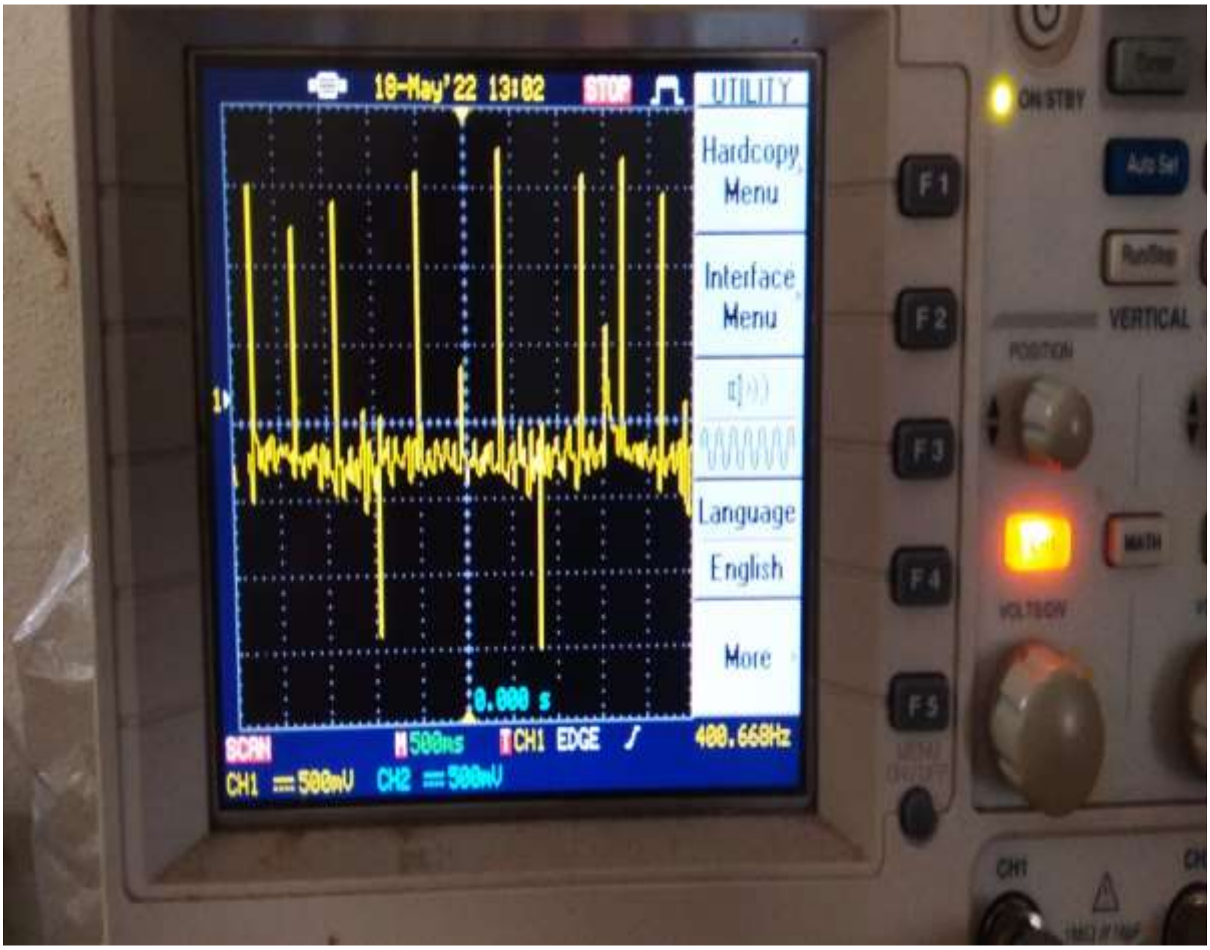
Examination of circuit is done for three major different types of heart sounds like normal heart sound (60–100 bpm), bradycardia heart sound (<60 bpm), tachycardia heart sound (>100 bpm). Which are shown in fig 5.3(a), 5.3(b), and 5.3(c) respectively.



5.3(a) Normal Heart Rate at 73bpm



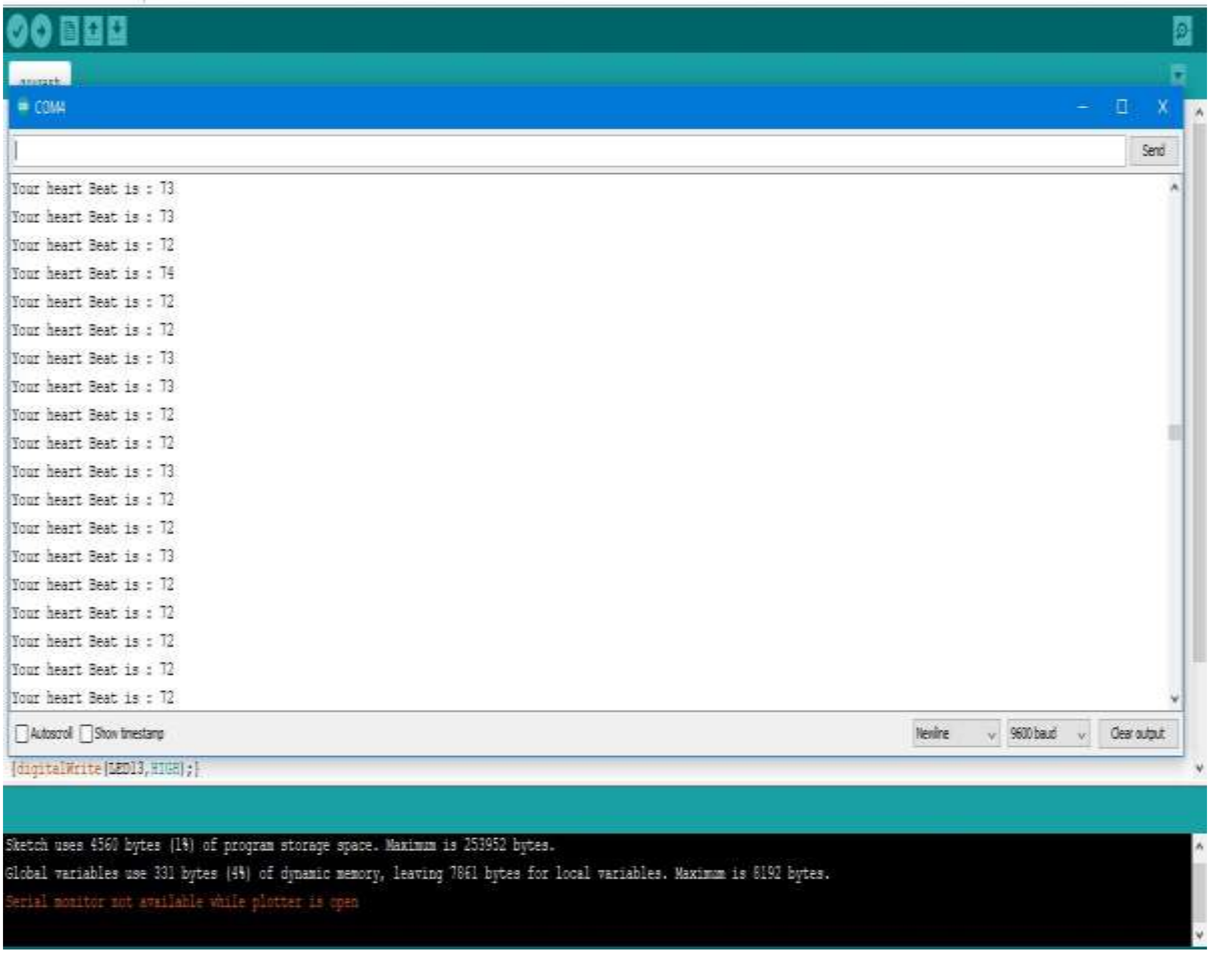
5.3(b) Bradycardia Heart Rate at 40bpm



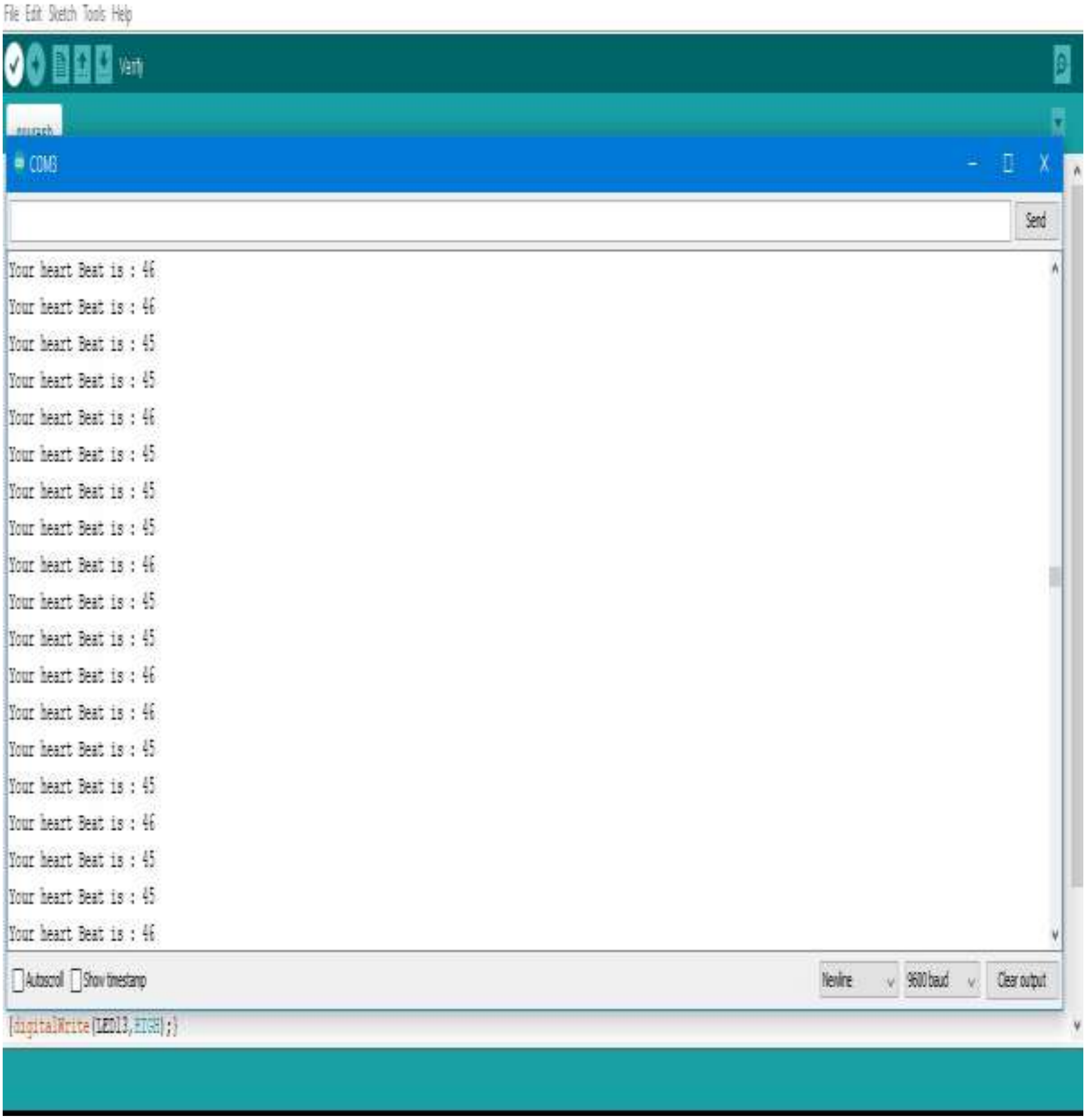
5.3(b) Tachycardia Heart Rate at 114bpm

5.4 DISPLAY OF HEART BEAT USING ARDUINO-UNO

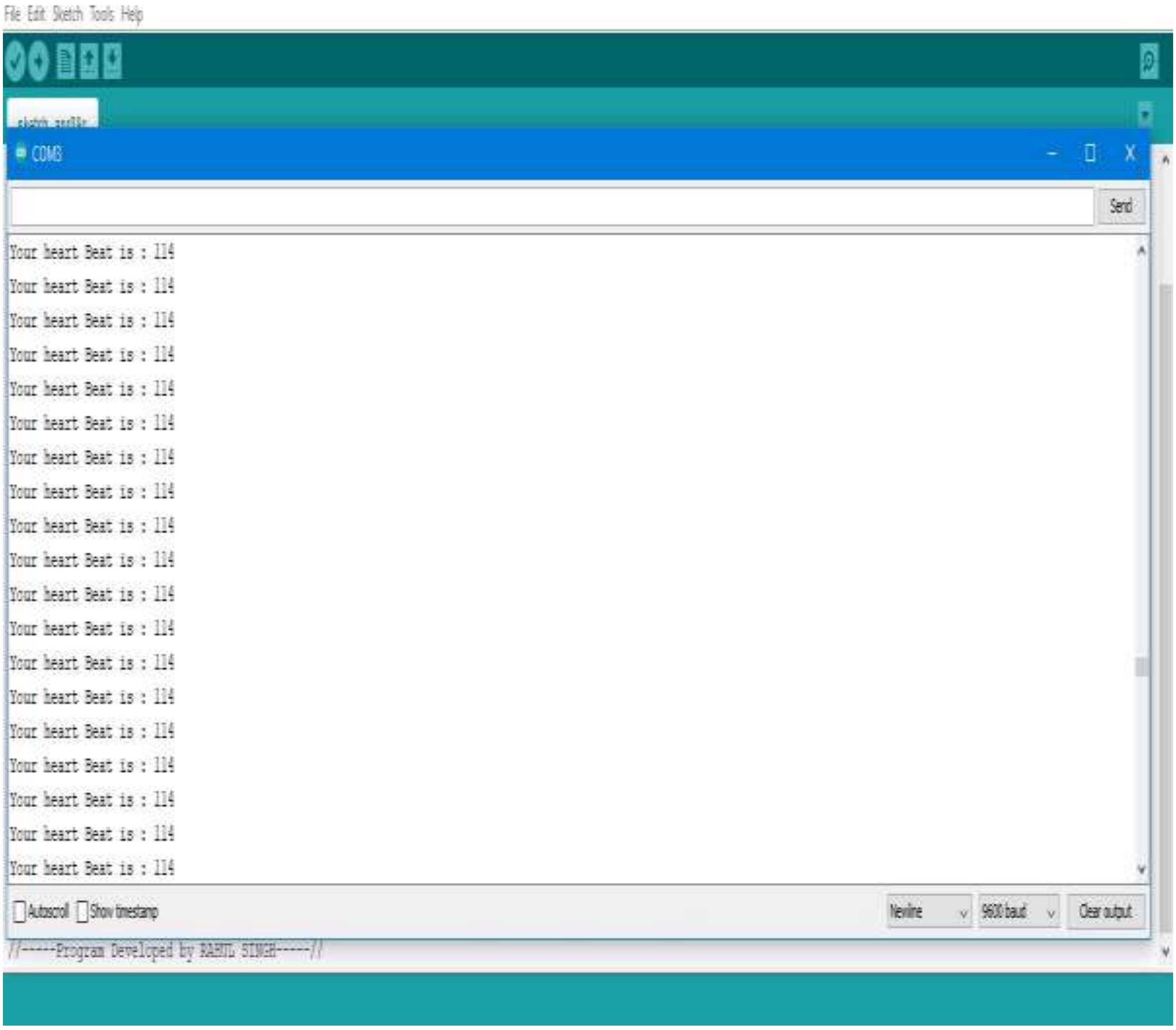
Heart signal is taken from pre-amplifier circuit and represented in Microcontroller, results were taken for 3 major different Heart Sound like normal heart sound (60–100 bpm), bradycardia heart sound (<60 bpm), tachycardia heart sound (>100 bpm). Which is shown in fig 5.4(a), 5.4(b), and 5.4(c) respectively.



5.4(a) Normal Heart Rate at 72bpm



5.4(b) Bradycardia Heart Rate at 40bpm



5.4(b) Tachycardia Heart Rate at 114bpm

CHAPTER 6

6.1 Goals and Contribution

In this chapter, we review the goals and contributions of our project work on design of stethoscope and heart arrhythmia, make suggestion for future work, end the report including remarks. The goal of our work was to build tools that could be used to understand better the characteristic of heart arrhythmia from normal heart sound. To abnormal sound or pathological sounds. This led us to build digital Stethoscope.

6.2 FINDINGS OF TEST RESULTS

1. **Sensor Testing**

- It is observe that condenser microphone is comparatively more sensitive then piezo sensor for signal acquisition.

2. **Pre-Amp Testing**

- It is notice that pre-amplifier is amplifying signal for gain 20.
- The design filter is working fine until the cut off frequency and showing attenuation. The frequency selection is possible by selecting capacitors value with the help of switch.
- Power amplifier gain can be control by varying potentiometer due to which volume is controlled.

3. **Representation of Heart Sounds**

- Three major classification of heart sounds are test, Normal, tachycardia, bradycardia heart sounds for design pre-amp circuit.

6.3 Features

It is possible to acquire low pitch heart and lung sounds with clear audibility so any noisy area also properly auscultated. Noise reduction taken place by filters, which enhance the accuracy. There is a gain control provision for power amplifier and frequency selection facility for filter selection. The heart sound can be also be store on pc and access through internet so to consult with physician.

6.4 Future Work

1) The algorithm in our tool kit needs to be redefine and tested on live patient data in order to gauge their true accuracy rates.
2) Based on heart sound, one can calculate respiratory airflow and hence the heart compliance which is of important in crucial cares to put the patients on the ventilators.

6.5 Concluding Remarks

Heart diseases affect millions of people in the worldwide. An effective, convenient, minimally invasive, and less expensive alternative to diagnosing, screening for, and monitoring pulmonary diseases would be of great benefits to those afflicted with this disease. In addition, automated heart sounds analyser could be the solution.

It is clear that digital processing techniques and modern communications may be applied to study heart sounds as an aid to clinical diagnoses. Compare with the ubiquitous acoustic stethoscope, a computer equipped with sound acquisition equipment offers subjunctive, quantitative results in graphical form, long term storage, instant communication's and many other advantages. Disadvantages such as increased cost, requires batteries, possibility of catching faint static while listening to patient heart.

Hence after all we can say that electronics plays a vital role in progress of biomedical instrument's and hence fourth leads to immense progress medical world.

References:

[1] The study by Batyrkhanomarov et, al. [1] develop a real time electronic stethoscope for heart diseases detection.

[2] Electronic stethoscope using Arduino [2] by Prof .N.S Mundane

[3] Designing of electronic stethoscope based on ZigBee [3] by Ms. Kadam Patil D.D and Mr. Shastri R.K.

[4] Electronic method for detection of heart valve defects was done[4] by Aparajita

[5] Smart vest for continuous heart monitoring with stethoscope and Electrocardiography [5] by Katherine Tian.

[6] Design of Electronic stethoscope and Heart Rate Monitor for Remote Area Application [6] by V.R. PRASAD

[7] Design and Development of a Digital Stethoscope for Cardiac Murmur [7]Kuldeep Singh and Preeti Abrol .

[8] WIRELESS ELECTRONIC STETHOSCOPE USING ZIGBEE [8] Ms. Ashlesha Khond, Ms. Priyanka Das, Ms. Rani Kumari

[9] A NOVEL DIGITAL STETHOSCOPE IN HEALTHCARE APPLICATIONS FOR TRIBAL AND ILLITERATE COMMUNITY by [9] Dr. R. Sagayaraj and S. Karthikeyan

[10] DESIGN AND DEVELOPMENT OF WIRELESS STETHOSCOPE WITH DATA LOGGING FUNCTIONS SITI NUR HIDAYAH BINTI AB. MALEK.

[11] python; audio; detecting silence in audio signal - Signal Processing Stack Exchange

[12] Heart Sounds & Murmurs | S1, S2, S3, S4 | Systolic & Diastolic Murmurs (rermedapps.com)

[13] find heartrate of the signal using py - Bing.

Sites:

I. www.wikipedia.com

II. www.technologyedition.blogspot.com

III. www.howstuffworks.com

IV. www.circuitlab.com

V. Analysing a Discrete Heart Rate Signal Using Python – Part 1 – paulvangent.com

VI. python; audio; detecting silence in audio signal - Signal Processing Stack Exchange
VII. Heart Sounds & Murmurs | S1, S2, S3, S4 | Systolic & Diastolic Murmurs (rermedapps.com)
VIII. find heartrate of the signal using py - Bing

Books :

"Electronic Devices and Circuit Theory" by Robert L. Boylestad, Louis Nashelsky.

IX. "A text book of medical instruments" by S.Ananthi
X. "Biomedical instrumentation and measurements" by Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer.
XI. "Elements of Electronic Instrumentation and measurements" by Curtis D. Johnson.

Program for Signal Processing:

```
//void setup(){
//  Serial.begin(9600);
//  }
//
//void loop(){
//  int value=analogRead(A0);
//  value=map(value,-100,100,-125,125);
//  if(value>0){
//  Serial.println(value);}
//  }
//

//high pass filter
int sensorPin = 0;    //pin number to use the ADC
int sensorValue = 0;  //initialization of sensor variable, equivalent to EMA Y
float EMA_a = 0.3;    //initialization of EMA alpha
int EMA_S = 0;        //initialization of EMA S
int highpass = 0;
int squaring;
int detsq[600];
int i;
void setup(){
  Serial.begin(115200);              //setup of Serial module, 115200 bits/second
  EMA_S = analogRead(A0);     //set EMA S for t=1
  i=0;
```

```
}
int pulse;
int upflag=0;
int last=0;
float t,p;
int first=0;
void loop(){
  sensorValue = analogRead(A0);              //read the sensor value using ADC
  EMA_S = (EMA_a*sensorValue) + ((1-EMA_a)*EMA_S);  //run the EMA
  highpass = sensorValue - EMA_S;
  Serial.println(highpass);
 //calculate the high-pass signal

//     Serial.print("sensorValue:"); Serial.print(sensorValue);Serial.print("     ");
//     Serial.print("EMA_S:"); Serial.print(EMA_S);Serial.print("     ");
//     Serial.print("highpass:"); Serial.print(highpass);Serial.print("     ");
     squaring=highpass*highpass;
//      Serial.print("squaring:"); Serial.print(squaring);


//  Serial.println(squaring);


 int desqt=squaring;
```

```
//for(int i=0;i<squaring;i++){
  p=0;
   if(desqt >196){
//       Serial.print("    geater than 81:");Serial.print(squaring);


//Serial.print(desqt);
       first=last;
       last=desqt;
//       Serial.print("    first :");Serial.print(first);Serial.print("    last
:");Serial.print(last);


    if( upflag==0){


     if(last>0){


    t = first - last ;
      p = 1000/t*60;
//      Serial.print("    p :");Serial.print(p);
      }
//      last=1;
    }
    upflag=100;
   }


    else{
      if(upflag>0){
         upflag = upflag - 1;
       }
```

```
    }




  pulse=p;
//  Serial.print(" pulse :");Serial.print(pulse);
//  Serial.println("");

//
//  }




  delay(20);                         //20ms delay
}
```

Code For LCD Display:

```
#include <LiquidCrystal.h>

// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

void setup() {
  // set up the LCD's number of columns and rows:
  lcd.begin(16, 2);
  // Print a message to the LCD.
  lcd.print("circuitschools.");
}

void loop() {
  // set the cursor to column 0, line 1
  // (note: line 1 is the second row, since counting begins with 0):
  lcd.setCursor(0, 1);
  // print the number of seconds since reset:
  lcd.print(millis() / 1000);
}
```