Bluetooth Enabled Stethoscope

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ABSTRACT

In noisy environments or for individuals with specific conditions, accurately capturing heart sounds can be challenging. This issue is further compounded by the inconvenience of physicians frequently removing earpieces. Additionally, the close face-to-face proximity required for auscultation (within 30-40 cm) increases the risk of cross-infection between patient and physician. Innovations such as wireless stethoscopes, digital transmission, and tele- auscultation can address these issues by enabling listening and reducing the need for close contact. The heart's acoustic signals are captured, converted into electrical impulses via a microphone with a built-in preamplifier (MAX4466), amplified using a power amplifier (LM386), and transmitted in real-time to a receiving device where the signal is further amplified (PAM8403) and output to headphones, speakers. Its user-friendly interface and portability make it ideal for personal health monitoring and clinical diagnosis.

Keywords: wireless stethoscopes, acoustic signals

INTRODUCTION

In the field of medical diagnostics, the phonocardiogram (PCG) is a crucial tool for recording and analyzing heart sounds, aiding in the assessment of cardiovascular health. This non- invasive method captures acoustic signals produced by the heart using a microphone placed on the chest. By examining these recorded sounds, healthcare professionals can gain essential insights into the cardiac cycle and detect conditions such as murmurs, valve abnormalities, and other cardiovascular disorders [1]. Unlike electrocardiography (ECG), which measures the electrical activity of the heart, PCG focuses on the mechanical sounds generated by cardiac movements. When properly analyzed, these sound patterns provide unique information about the physiological behavior of the heart, aiding in the early detection of numerous heart conditions. The advancement of stethoscope technology has played a significant role in diagnosing disorders such as abnormal heart rhythms, coronary artery disease, heart attacks, and angina. The stethoscope, a fundamental device in clinical practice, enables physicians to auscultate heart sounds, which serve as critical indicators of cardiovascular function. During auscultation, the chest piece is placed against the patient's body, while the earpieces allow the physician to listen to heart sounds [2]. However, traditional stethoscope models present two notable challenges in clinical settings. First, the frequent removal and reinsertion of the earpieces can be inconvenient for healthcare providers. Second, the necessity for close face- to-face interaction during auscultation can be problematic,

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particularly in situations requiring infection control [3]. These challenges became even more pronounced during the COVID-19 pandemic, where minimizing direct physical contact between medical personnel and patients was crucial in reducing cross-infection risks. As a solution to these concerns, we have designed and developed a Bluetooth-Enabled Stethoscope, which enables remote auscultation. This innovative device allows healthcare professionals to monitor and analyze heart sounds from a distance, significantly improving both safety and convenience in clinical practice[4, 5]. By eliminating the need for direct physical proximity, this system enhances the overall efficiency of cardiac assessments, ensuring that medical professionals can perform auscultations effectively while maintaining patient and provider safety. This technological advancement represents a significant step forward in the field of telemedicine and remote diagnostics, offering an effective solution for modern healthcare challenges.

OBJECTIVES

The objective of the system is to amplify the heart sounds picked up by the stethoscope's microphone. It incorporates transmitter and receiver modules that enable wireless transmission of the heart sounds, allowing real-time monitoring with improved sound quality. This non-invasive heart sound detection system accurately captures and transmits heart sounds from a distance, enabling the listener to hear them clearly through headphones.

MATERIALS AND METHODS

The block diagram given the fig 1, represents the functional components of a Bluetooth-enabled stethoscope, designed to capture, amplify, transmit, and receive heart sounds wirelessly. This system eliminates the need for direct physical proximity between the patient and the healthcare provider, enhancing convenience and safety in clinical practice. The process begins with a microphone, which acts as a sensor to detect heart sounds when placed on the patient's chest. These sounds, which are often weak, require amplification before further processing. The pre- amplifier increases the signal strength while maintaining clarity and minimizing noise interference. To ensure the signal is within an appropriate voltage range, a potential divider is used. This component regulates voltage levels before the signal is passed to the next stage. The conditioned signal is then sent to a power amplifier (LM386), which further enhances the audio quality, making it suitable for transmission without distortion. For wireless communication, the Bluetooth module transmitter encodes and transmits the amplified heart sounds over a Bluetooth connection. A battery provides power to the system, while a voltage regulator (AMS1117) ensures that the supplied voltage remains stable, particularly for the Bluetooth module, which requires consistent power for efficient data transmission.

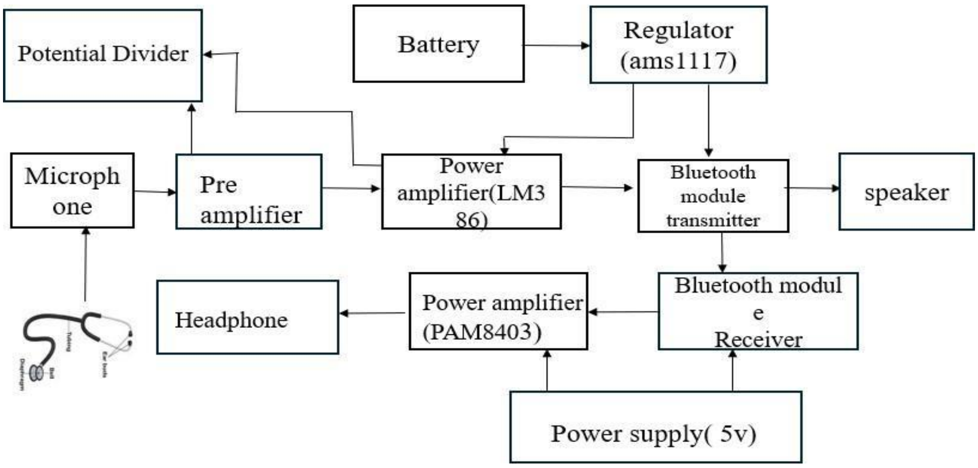

Fig 1: Block diagram of the system

On the receiving side, the Bluetooth module receiver captures the transmitted heart sound signals and forwards them to a power amplifier (PAM8403). This amplifier further boosts the received signal, ensuring that the audio remains clear and strong for accurate auscultation. The final output is delivered through either headphones or a speaker, allowing the healthcare professional to listen to the heart sounds remotely. The entire receiving unit is powered by a 5V power supply, ensuring stable operation. This Bluetooth-enabled stethoscope offers several advantages over traditional models. It enables remote auscultation, making it highly useful in telemedicine and emergency care. Additionally, it helps reduce the risk of cross- infection, which is especially critical in scenarios like the COVID-19 pandemic, where minimizing physical contact is essential. In conclusion, this system provides a wireless, efficient, and safer alternative to conventional stethoscopes. By integrating wireless technology, it enhances diagnostic capabilities, improves patient monitoring, and ensures a more hygienic approach to heart sound analysis.

HOUSING TUBE AND DIAPHRAM

It is a round and circular end of the chest piece is the diaphram. Its large size allows to listen to a wider area of the patient's body. It can detect sounds with higher frequencies in large areas of the patient. Nowadays, diaphragms are designed to eliminate the chill when it is placed directly against the patient's skin. A crucial part of the stethoscope is the chest piece, with its round, flat end called the diaphragm. This large surface area is ideal for examining a broader region of the patient's body. It excels at picking up high- frequency sounds across these larger areas. Modern diaphragms are designed to be comfortable against the skin, eliminating the unpleasant chill that older models could cause. Connected to the chest piece is the stethoscope tubing, a flexible pipe typically made of rubber or PVC. This seemingly simple part plays a vital role in transmitting the sounds captured by the diaphragm and bell to the headset with minimal distortion. The quality of this transmission can even be influenced by the type of tubing used in the stethoscope' s construction. Interestingly, stethoscope tubing can come in two designs. Single tube or dual lumen. The innovative dual-lumen design splits the tube halfway down, allowing for the transmission of differentiated sounds to each earpiece.

PRE-AMPLIFIER

A preamplifier is an essential component in many electronic devices, serving to amplify weak signals before they are further processed by a main amplifier. Circuit diagram of the preamplifier is given the given fig 2 Using a BC547 transistor, which is a commonly used NPN bipolar junction transistor (BJT), we can construct a simple and effective preamplifier circuit. Input Stage is where the weak signal is applied. Biasing Network is sets the correct operating point of the transistor. Coupling capacitors block DC components while allowing AC signals to pass and load Resistor is develops the output voltage signal.

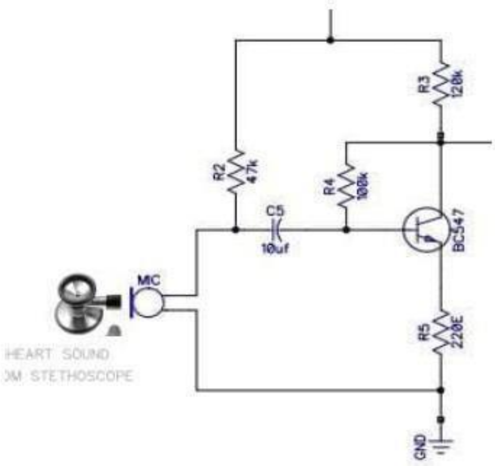

Fig 2: Preamplifier

POWER AMPLIFIER

Two power amplifiers are used to amplify the signal. The first power amplifier(LM386)is in the transmitter side and other amplifier .The primary use of a bluetooth-enabled stethoscope is to facilitate wireless transmission of heart and lung sounds for real-time monitoring, remote diagnosis, and digital analysis. Power Amplifier(PAM8403) is a popular and widely used Class- D stereo audio amplifier chip. It has dual channels, meaning it can drive stereo speakers. PAM8403 is known for its compact size, high efficiency, and low power consumption making it ideal for portable and battery-operated applications such as portable speakers, bluetooth speakers and headphone amplifiers. Digital interface compatibility and low distortion and noise is one of its main features.

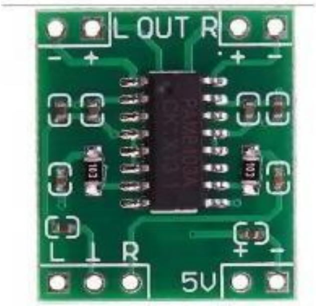

Fig 3:PAM 8403.

Power amplifier (LM386) is an integrated circuit containing a low-voltage audio power amplifier. It is suitable for battery-powered devices such as radios, guitar amplifiers, and electronics projects. The IC consists of an 8-pin dual inline package (DIP-8) and can output 0.25 to 1 watt of power, depending on the model, using a 9-volt power supply. Fig 3 and fig 4 give the PCB layout of PAM 8403 and circuit diagram of LM386.

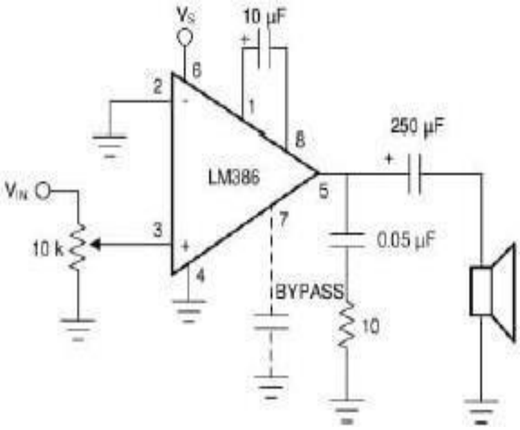

Fig 4:LM386

MICROPHONE

An electret microphone is a microphone whose diaphragm forms a capacitor that incorporates an electret. The electret's permanent electric dipole provides a constant charge Q on the capacitor. Sound waves move the diaphragm, changing the capacitance C, which produces a corresponding voltage change across the capacitor of V =Q/C. The electret's constant charge eliminates the need for the polarizing power supply required for non-electret condenser microphones, though a preamplifier is typically incorporated to boost the audio voltage signal.

REGULATOR

The AMS117 is a workhorse in the world of voltage regulation. Fig 5 provide the layout of AMS117 regulator. This tiny chip ensures electronic components receive the precise voltage they need by converting an unregulated input to a steady output. Available in fixed voltages from 1.5V to 12V, it offers flexibility for various circuits. Here we use regulator of 5V. Built-in overload protection and thermal shutdown safeguard the AMS117 from damage, while its simple design with minimal external components makes it easy to use for both beginners and experienced electronics enthusiasts. overall, the AMS117 is a reliable and user-friendly solution for maintaining stable voltage in electronic projects.

BLUETOOTH MODULE

Fig 5:AMS117 Regulator

The Pagaria BT 3.5 Bluetooth module is a versatile device designed to function as both a transmitter and a receiver, supporting bluetooth 5.0 for enhanced range and lower latency. It features a 3.5mm audio jack, making it compatible with a wide range of audio devices such as speakers, older audio systems, and wired headphones. This module excels in streaming high- quality audio wirelessly, allowing users to connect non-bluetooth devices to bluetooth headphones or speakers seamlessly. Its dual functionality, combined with a compact design and easy setup, makes it an excellent choice for upgrading traditional audio setups to modern wireless standards.

OPERATIONAL FRAMEWORK

The entire system consist of hardware and two parts. The transmitter part and the receiver part. The hardware setup includes assembling components such as two power amplifiers (PAM8403 and LM386), regulator(AMS117), bluetooth module with transmitter and receiver, battery, speaker. An 8-volt battery powers this system, so the battery is connected to regulator(AMS117),which can be connected to the three components, that is microphone with a preamplifier, a power amplifier, and a bluetooth module transmitter, but not directly to the module. The 8-volt battery might not perfectly match the specific voltage requirements of each component. The AMS117 takes that unregulated input voltage and converts it to a fixed voltage level (e.g., 3.3V or 5V) that’s appropriate for the circuit. The heart sounds from the stethoscope are captured and amplified by the microphone with a preamplifier before being sent to the power amplifier, which has a potentiometer for volume adjustment. Then the analog signal is then given to the power amplifier(LM386), it is used to boost the weak electrical signal from a source like microphone. The amplified signal is then transmitted to bluetooth module transmitter, which can send the signal to either a speaker or a bluetooth module receiver. Once transmitted, the signal is processed by a low voltage audio power amplifier and then sent to the headphones. This setup ensures that the battery powers the critical components without directly connecting to the speaker. The

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microphone with a preamplifier initially amplifies the heart sounds, followed by further amplification and volume control by the power amplifier. The final amplified signal is wirelessly transmitted, ensuring flexibility and high-quality audio output through either a speaker or headphones, effectively combining convenience and performance in monitoring heart sounds. This comprehensive design allows the system to efficiently capture, amplify, and transmit heart sounds, making it suitable for various listening devices while maintaining clear audio quality and ease of use.

DESIGN ARCHITECTURE

The design begins with the transmitter side. Fig 6 provides hardware connection of the transmitter part. The heart sounds from the stethoscope are captured and amplified by the microphone with a preamplifier before being sent to the power amplifier, which has a potentiometer for volume adjustment. Here, preamplifier consists of capacitor, the capacitor C1 acts as a coupling capacitor. It uses the coupling capacitor as a filter to block the DC component of the input signal; we also call it a DC-blocking capacitor. It prevents the headphones or speakers from getting damaged by the flow of DC. Transistor act either as a switch or an amplifier. So here this BC547 NPN transistor acts as an amplifier. After the micro microphone preamplifier strengthens the faint heart sounds, the signal is likely fed into the LM386. This component takes that pre-amplified signal and boosts it to a much higher level. The LM386 can directly drive speakers without needing additional filters, making it a good choice for this application. The small size of the LM386 is likely beneficial for the portability of this heart sound monitoring system. The amplified signal is then transmitted to the bluetooth module transmitter, which can send the signal to either a speaker or a bluetooth module receiver.

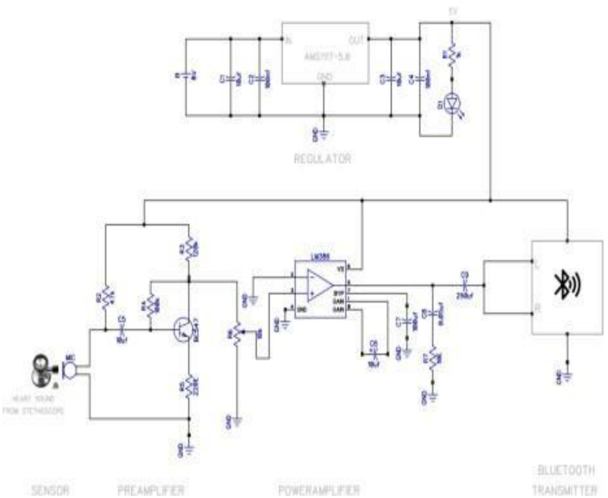
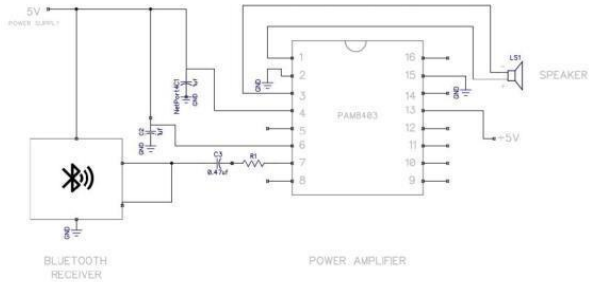


Fig 6: Hardware connection of the transmitter part

Once transmitted, the signal is processed by a Class-D stereo amplifier and then sent to the headphones. Fig 7 provides the hardware connection of the transmitter part. We also use a regulator, the regulator to ensure that the battery powers the critical components without directly connecting to the speaker. Here we use the regulator named AMS117,in the context of a heart sound amplifier system using a

PAM8403, the AMS117 voltage regulator would be used to provide a stable and consistent voltage supply to the various electronic components. The 8-volt battery might not perfectly match the specific voltage requirements of each component. The AMS117 takes that unregulated input voltage and converts it to a fixed voltage level (e.g., 3.3V or 5V) that's appropriate for the circuit. The microphone with a preamplifier initially amplifies the heart sounds, followed by further amplification and volume control by the power amplifier. The final amplified signal is wirelessly transmitted, ensuring flexibility and high-quality audio output through either a speaker or headphones, effectively combining convenience and performance in monitoring heart sounds. This comprehensive design allows the system to efficiently capture, amplify, and transmit heart sounds, making it suitable for various listening



devices while maintaining clear audio quality.

Fig 7: Hardware connection of the transmitter part

RESULT AND DISCUSSION

The system ensures clear and enhanced heart sound transmission for remote monitoring and diagnosis of cardiac conditions. The fig 8 provides the circuit image for the transmitter side The transmission and reception process in the Bluetooth enabled stethoscope involves capturing heart acoustic signals using a microphone with a preamplifier, which converts the sounds into electrical impulses.

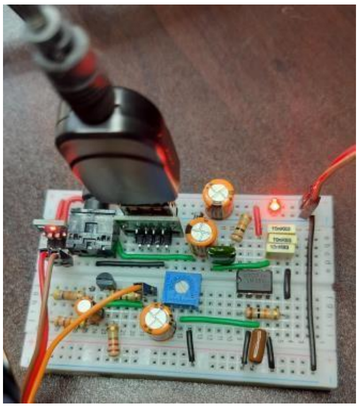


Fig 8 : Transmitter side

These signals are amplified using an LM386 power amplifier and transmitted wirelessly via a Bluetooth module to receiving device. Fig 9 provide the circuit diagram for the receiver side. Upon reception, the signals are further amplified using a PAM8403 power amplifier to ensure clarity and volume enhancement. The final output is delivered through devices such as headphones, speakers, smartphones, or computers, enabling real-time monitoring and analysis. This seamless transmission and reception

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system ensures accurate and clear audio quality for cardiac diagnostics.

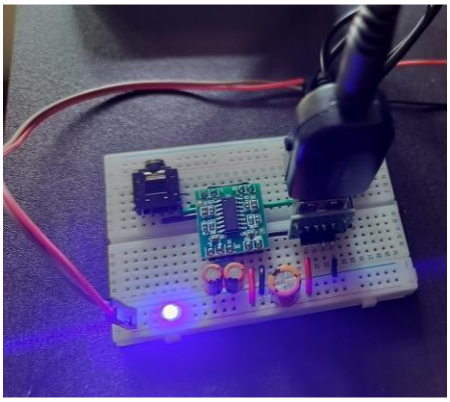

Fig 9: Receiver side

The table. 1 below presents the results of the system tested on four adults, highlighting the frequency variations in heart sounds. The normal range of heart sounds, as heard through a stethoscope, is between 20 Hz and 1000 Hz. The sound was recorded, and its frequency was analyzed using audacity, a free and open-source audio editing software. The results indicate that the frequency range of heart sounds varies from person to person, and the system effectively captures these heart sounds. Fig 10 provides the image of the final product.

Table 1: Heart Sound Frequency Analysis

SI No	Age category	No peoples	Frequency
1	10 to 20	2	45 Hz
2	20 to 35	3	46 Hz
3	48 to 65	3	58 Hz, 80 Hz

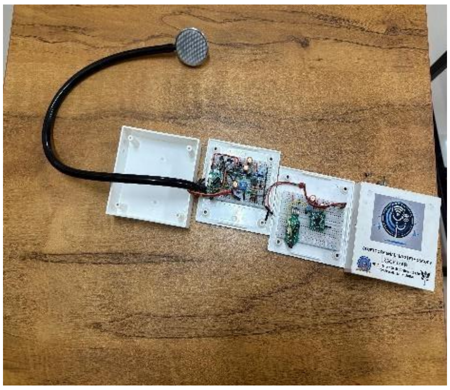

Fig 10: Final Product

CONCLUSION

In conclusion, this system effectively demonstrates the feasibility of employing bluetooth technology for remote heart sound detection via a stethoscope prototype. The prototype captures heart sounds with a microphone, processes them to extract crucial information, and transmits the data wirelessly using bluetooth modules this project effectively demonstrates the feasibility of employing bluetooth technology for remote heart sound detection via a stethoscope prototype. The prototype captures heart sounds with a microphone, processes them to extract crucial information, and transmits the data wirelessly using bluetooth modules. This paves the way for a more accessible and potentially continuous monitoring approach compared to traditional stethoscopes. Additionally, the reliability of Bluetooth transmission over distance and the reduction of latency (data delay) require refinement for real-time monitoring applications. Finally, ensuring compliance with medical device regulations is paramount for safe and trustworthy deployment in healthcare settings. By addressing these aspects, this technology, leveraging the combination of stethoscope-like sound acquisition, bluetooth modules for transmission, and advanced processing algorithms, holds immense promise for revolutionizing heart health monitoring. It can empower patients with greater autonomy in managing their cardiovascular health, facilitate telemedicine consultations for improved access to care, and potentially integrate with wearable devices for personalized wellness tracking.

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