REPORT

On

Heartbeat Monitoring and Health Analysis Using Digital Stethoscope

Submitted by

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Abstract

The digital stethoscope represents a significant advancement in medical diagnostic tools, enhancing traditional auscultation with digital technology. Unlike conventional stethoscopes, digital stethoscopes convert acoustic sounds into electronic signals, allowing for amplification, recording, and real-time visual display of heart, lung, and other body sounds. These devices are equipped with Bluetooth or USB connectivity for data sharing and integration with electronic health records (EHR), improving the efficiency of clinical workflows. Digital stethoscopes find applications across various healthcare settings, including telemedicine, primary care, cardiology, pulmonology, and medical training. In telehealth, they enable remote auscultation, allowing doctors to assess patients in distant locations accurately. Their ability to store and replay auscultation sounds enhances clinical evaluation and supports second opinions or further analysis. The advantages of digital stethoscopes are numerous. They offer superior sound clarity and noise reduction, making it easier to detect faint or abnormal heart and lung sounds. Their recording feature aids in documentation and education, while visual waveform displays provide an additional diagnostic dimension. Furthermore, digital stethoscopes can be paired with artificial intelligence (AI) tools to assist in the early detection of diseases like heart murmurs or respiratory disorders. Overall, digital stethoscopes are transforming patient care through improved diagnostics, accessibility, and data-driven insights.

WORKING OF STETHOSCOPE

A stethoscope works by collecting and amplifying internal body sounds, such as heartbeats and lung movements. When the chest piece (diaphragm or bell) is placed on the body, it captures sound vibrations. The diaphragm picks up higher-frequency sounds, while the bell captures lower-frequency sounds. These vibrations travel up the hollow rubber tubes to the earpieces, preserving the sound's original quality. The stethoscope's tubing isolates external noise, ensuring clear transmission. Inside the earpieces, the sound waves are directed into the listener's ears, allowing medical professionals to diagnose conditions based on subtle differences in sound patterns and rhythms. Doctors diagnose heart rhythm by listening to the timing, intensity, and regularity of heart sounds through a stethoscope. They detect abnormalities like irregular beats, murmurs, or extra sounds, which can indicate conditions such as arrhythmias, valve disorders, or heart failure. Careful listening helps identify deviations from a normal heartbeat pattern.

BLOCK DIAGRAM

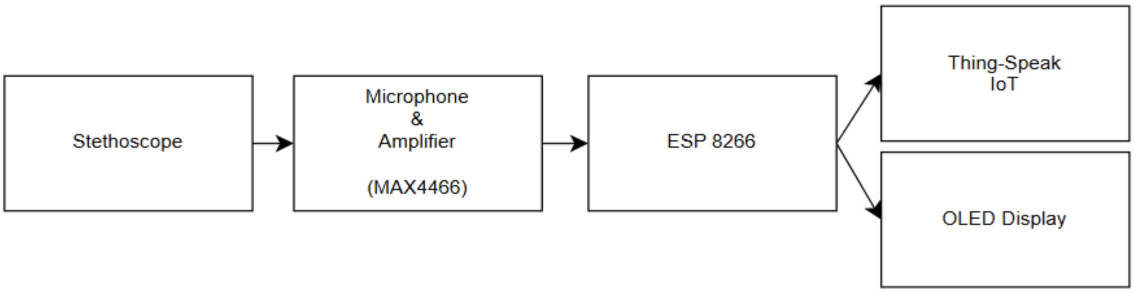


Figure 1: Diagram of Digital Stethoscope

The digital stethoscope system converts body sounds into digital data for visualization and analysis. The working is as follows:

- **Stethoscope**:
  The traditional stethoscope diaphragm captures internal body sounds like heartbeats or lung sounds. Instead of passing them directly to human ears, these sound vibrations are sent to the next stage.

- **Microphone & Amplifier (MAX4466)**:
  A sensitive microphone picks up the captured sounds. Since biological sounds are very low in amplitude, the MAX4466 amplifier boosts the signal strength without significant noise, ensuring a clear audio signal for processing.

- **ESP8266**:
  The ESP8266 microcontroller digitizes the analog sound signals using its ADC (Analog-to-Digital Converter). It can process the data, extract useful information (such as heart rate), and prepare it for display. Additionally, the ESP8266's Wi-Fi capability can be used for transmitting data to remote servers if needed.

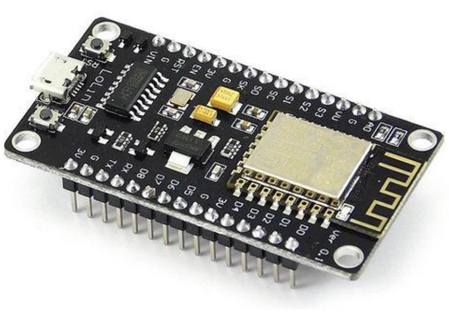
- **OLED Display**:
  The processed data (like sound waveforms or measured heartbeats per minute) is displayed in real-time on an OLED screen. This provides users with immediate visual feedback, making diagnosis easier and more accurate.

- **Thing-Speak IoT Platform**:
  Simultaneously, the ESP8266 uploads the collected and processed data to the Thing-Speak cloud platform over Wi-Fi. This allows remote monitoring, real-time data logging, and analysis. Doctors can access patient data from anywhere, enabling telemedicine and historical tracking for better diagnostics.

A digital stethoscope with IoT not only amplifies and records body sounds but also transmits data wirelessly to cloud platforms or medical devices for remote monitoring and analysis. In contrast, a regular stethoscope relies solely on direct sound transmission to the user's ears without any recording, processing, or remote connectivity.

HARDWARE/SOFTWARE DESCRIPTIONS

The **MAX4466** is a low-noise, high-gain microphone amplifier designed for audio applications requiring precise signal amplification. It integrates an electret microphone preamp with a built-in operational amplifier, optimized for low power and high performance. The module features a single-supply operation from 2.4V to 5.5V and includes a gain control via an onboard potentiometer, adjustable up to 125× (42dB). Its low input-referred noise (30nV/√Hz) and wide bandwidth (up to 20kHz) make it ideal for capturing clear audio signals. The MAX4466 is commonly used in voice recognition systems, digital stethoscopes, and sound detection projects for its compact design and reliability.



The **ESP8266** is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability, developed by Espressif Systems. It operates at 3.3V and features a 32-bit RISC CPU running at 80–160 MHz, with built-in RAM and flash memory. The chip supports IEEE 802.11 b/g/n standards and offers GPIO, SPI, I²C, UART, and PWM interfaces, making it highly versatile for IoT applications. Its integrated Wi-Fi module allows seamless wireless connectivity, enabling remote control and data transmission. Commonly used in home automation, wireless sensor networks, and smart devices, the ESP8266 offers a compact, energy-efficient solution for developing connected electronics.

The **0.96-inch OLED display** is a compact, low-power screen based on organic light-emitting diode technology. It typically offers a 128x64 pixel resolution and communicates via I²C or SPI interface. Known for its high contrast, wide viewing angles, and fast response time, it's ideal for embedded systems, IoT devices, and portable electronics requiring clear visual feedback.

The Arduino IDE is a popular platform for programming microcontrollers like the ESP8266, a Wi-Fi-enabled chip ideal for IoT projects. By installing the ESP8266 board package through the Board Manager, users gain access to specific libraries such as ESP8266WiFi.h, which simplify tasks like connecting to Wi-Fi networks, setting up web servers, and sending HTTP requests. The IDE offers a user-friendly environment to write, compile, and upload code, making ESP8266 development accessible even for beginners.

Thing-Speak is an IoT analytics platform that allows devices like the ESP8266 to send, store, and retrieve data using the internet. It supports real-time data visualization and analysis through channels. The ESP8266 connects to Thing-Speak using its Wi-Fi capabilities and sends sensor data via HTTP POST requests. By using libraries like ESP8266WiFi.h and Thing-Speak.h, developers can easily upload and monitor data, making it ideal for remote sensing, home automation, and IoT research projects.

WORKING MODEL

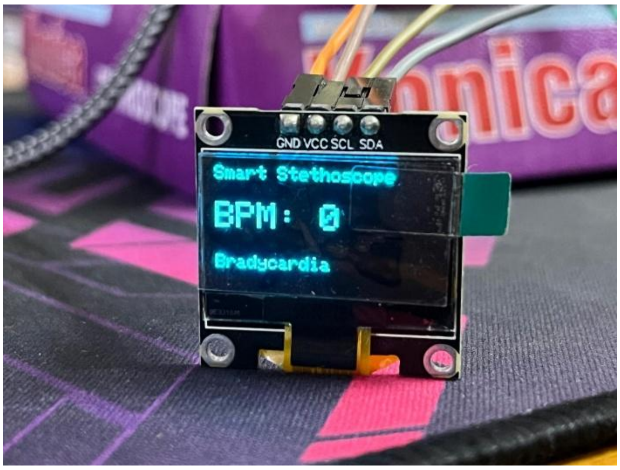


Figure 2: Low Heart beat

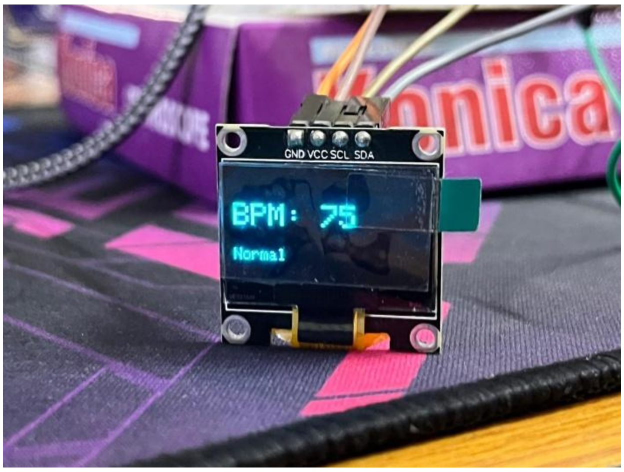


Figure 3: Normal Heart beat

Figure 4: Connecting to IoT platform

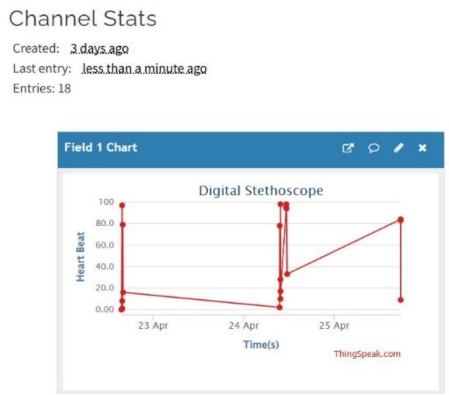


Figure 5: IoT monitoring

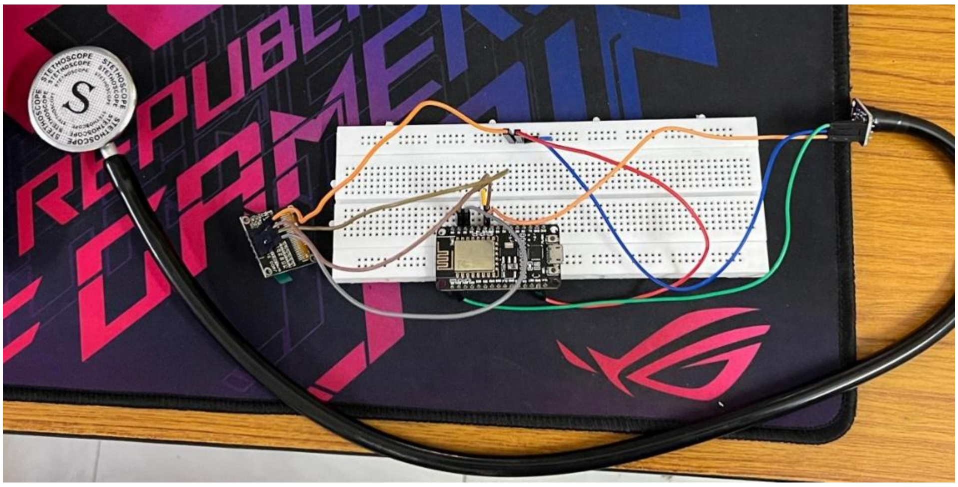


Figure 6: Experimental Set-Up

RESULT AND ANALYSIS

The digital stethoscope successfully captured and processed physiological sounds such as heartbeats and lung sound with enhanced clarity. By using a MAX4466 microphone amplifier connected to an ESP8266 microcontroller, the system transmitted real-time audio data wirelessly to a connected device for visualization and analysis.

The recorded data was analysed using waveform visualization, enabling identification of heart sounds like S1 and S2, as well as abnormal patterns such as murmurs or irregular rhythms. Compared to traditional stethoscopes, the digital system provided amplified, noise-reduced signals and the ability to store, playback, and share recordings for further diagnostics.

Key Observations:

- The amplified output offered improved detection of low-intensity heart sounds.
- The ESP8266 allowed wireless transmission, making it suitable for telemedicine applications.
- The system-maintained accuracy even in moderately noisy environments due to built-in noise filtering.
- Data logging helped in comparing recordings over time, supporting longitudinal patient monitoring.

Overall, the digital stethoscope enhanced diagnostic capabilities, especially in remote or mobile healthcare scenarios, by combining traditional auscultation with modern data analysis tools.

CONCLUSION

The digital stethoscope offers a modern and efficient alternative to traditional auscultation tools by combining sound amplification, noise reduction, and digital signal processing. It enables accurate detection of heart and lung sounds, supports audio recording, and allows real-time waveform visualization. With wireless data transmission using modules like the ESP8266, it is ideal for telemedicine and remote diagnostics. The system enhances diagnostic precision, supports medical training, and provides a reliable platform for long-term patient monitoring. Its portability, cost-effectiveness, and ability to integrate with AI tools make the digital stethoscope a valuable innovation in both clinical and remote healthcare environments.