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IoT-Based Wireless Digital Stethoscope

[1]Soniya. P. Rathod, [2]S. T. Jadhav, [3]A. S. Mali
[1]Postgraduate Student, [2]Associate Professor, [3]Associate Professor,
[1]Electronics And Telecommunication Engineering,
[1]TKIET Warana University, Warananagar, Kolhapur, India,

Abstract - The advancement of smart healthcare technologies and the increasing adoption of the Internet of Things (IoT) have transformed modern medical diagnostics by enabling intelligent, connected, and portable healthcare devices. This paper presents the design and development of an IoT-enabled wireless digital stethoscope capable of capturing, amplifying, processing, and transmitting heart and lung sounds for remote medical diagnosis. Conventional acoustic stethoscopes suffer from limitations such as low sound amplification, dependency on physician hearing ability, lack of data storage, and inability to support remote consultations. To overcome these challenges, the proposed system integrates a high-sensitivity MEMS microphone with the MAX9814 audio amplifier and an ESP32 microcontroller for signal acquisition and wireless communication. The acquired body sounds are digitized, filtered, and transmitted to a mobile application and cloud platform through Wi-Fi/Bluetooth connectivity. Additionally, a DS18B20 temperature sensor is incorporated to monitor body temperature simultaneously, enabling multi-parameter patient monitoring. The proposed device supports real-time remote auscultation, digital recording, cloud storage, and data sharing between healthcare professionals and patients. The system is portable, low-cost, and suitable for telemedicine, rural healthcare, and emergency medical applications. Experimental analysis demonstrates improved sound clarity, efficient wireless transmission, and reliable physiological monitoring. The integration of IoT with biomedical signal processing significantly enhances diagnostic accuracy and accessibility of healthcare services.

Keywords: Digital Stethoscope, IoT Healthcare, ESP32, MEMS Microphone, Telemedicine, Remote Monitoring, Biomedical Signal Processing, Wireless Healthcare Devices

I. INTRODUCTION

The stethoscope has remained one of the most essential diagnostic tools in healthcare for over two centuries. Traditional acoustic stethoscopes are widely used for monitoring heartbeats, respiratory sounds, and other physiological signals. However, these devices have several limitations, including low sound amplification, sensitivity to environmental noise, dependence on the physician's hearing capability, and lack of recording or sharing functionality. In modern healthcare systems, especially in remote and telemedicine applications, there is a growing need for intelligent diagnostic tools capable of real-time monitoring, wireless communication, and digital data storage. The rapid development of the Internet of Things (IoT) has enabled the integration of embedded systems and wireless technologies into healthcare devices. IoT-based medical systems provide real-time monitoring, remote diagnosis, cloud-based data storage, and improved accessibility to healthcare services. Digital stethoscopes are emerging as a significant advancement in smart healthcare because they convert acoustic body sounds into digital signals that can be amplified, filtered, analyzed, recorded, and transmitted electronically.

This paper proposes an IoT-enabled wireless digital stethoscope designed using a MEMS microphone, MAX9814 audio amplifier, ESP32 microcontroller, and DS18B20 temperature sensor. The MEMS microphone captures heart and lung sounds with high sensitivity, while the MAX9814 improves signal amplification and noise reduction. The ESP32 performs signal digitization and enables wireless transmission through Wi-Fi and Bluetooth. The acquired data can be accessed using a mobile application or cloud platform, allowing remote diagnosis and continuous patient monitoring. The proposed system offers several advantages over conventional stethoscopes, including enhanced sound quality, wireless connectivity, cloud storage, remote accessibility, and multi-parameter monitoring. The device is portable, affordable, and particularly useful in rural healthcare centers, emergency medical services, and telemedicine environments where direct physician access is limited. By integrating IoT technology with biomedical signal processing, the system contributes toward the development of smart and connected healthcare infrastructure.

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II. LITERATURE REVIEW

The development of digital stethoscopes and IoT-based healthcare systems has significantly transformed modern medical diagnostics by enabling enhanced auscultation, remote monitoring, and intelligent healthcare services. Early research in electronic auscultation focused on improving sound amplification and reducing environmental noise associated with conventional acoustic stethoscopes. Gurung et al. [1] analyzed computerized lung sound systems and demonstrated that digital signal processing can improve the detection of abnormal respiratory sounds. Similarly, Allen [2] discussed physiological signal acquisition techniques and emphasized the importance of accurate biomedical sensing for clinical diagnosis. With the advancement of embedded systems and wireless communication, researchers began integrating microcontrollers and IoT technologies into medical diagnostic devices. Istepanian et al. [3] highlighted the role of IoT in modern healthcare and explained how connected medical devices can improve remote patient monitoring and telemedicine services. Mondal and Banerjee [4] developed a wireless digital stethoscope for telemedicine applications and demonstrated successful transmission of heart sounds using wireless communication modules. Their work established the importance of portable diagnostic systems for rural healthcare environments.

The use of MEMS microphones in biomedical applications has gained significant attention because of their compact size, high sensitivity, and low power consumption. Gupta et al. [5] proposed a MEMS microphone-based digital stethoscope capable of capturing heart sounds with improved clarity compared to traditional systems. Their research showed that MEMS sensors provide better acoustic response and noise immunity for biomedical signal acquisition. Similarly, Tiwari and Sharma [6] investigated ESP32-based biomedical monitoring systems and confirmed that low-cost microcontrollers can effectively process and transmit physiological signals in real time.

Recent studies have focused on IoT-enabled healthcare systems capable of remote monitoring and cloud integration. Jain and Kumar [7] presented an IoT healthcare monitoring framework using the ESP32 microcontroller and cloud communication. Their system enabled continuous patient monitoring through wireless networks and demonstrated the importance of cloud-based medical data management. Islam et al. [8] further emphasized that IoT-cloud integration enhances accessibility, storage, and sharing of patient data, which is essential for telemedicine and remote diagnosis. Noise reduction and signal enhancement are major challenges in digital auscultation systems. Research by Leng et al. [9] introduced adaptive filtering techniques for heart sound processing and demonstrated improved signal quality under noisy conditions. Similarly, Choi and Jiang [10] developed digital filtering methods for respiratory sound enhancement, which improved diagnostic reliability during auscultation. These studies confirmed that signal processing algorithms are essential for improving the performance of electronic stethoscopes.

Wireless communication technologies such as Bluetooth and Wi-Fi have also been widely explored in smart healthcare devices. Kumar et al. [11] designed a Bluetooth-enabled digital stethoscope for mobile healthcare applications and reported reliable short-range transmission of heart sounds. Another study by Rahman et al. [12] integrated Wi-Fi communication with biomedical sensing modules for real-time patient monitoring over cloud platforms. Their research highlighted the importance of internet connectivity in next-generation healthcare systems. Artificial intelligence and machine learning are increasingly being incorporated into digital stethoscope systems for automated disease diagnosis. Thompson et al. [13] developed a machine-learning-based auscultation system capable of identifying cardiac abnormalities from heart sound recordings. Similarly, Pramono et al. [14] reviewed AI-based respiratory sound classification techniques and concluded that intelligent analysis can significantly improve diagnostic accuracy. Although AI integration improves clinical decision-making, these systems require high-quality digital sound acquisition hardware for accurate analysis.

Telemedicine has become one of the most important applications of digital stethoscopes, particularly after the rapid growth of remote healthcare services. The World Health Organization [15] emphasized the role of telemedicine technologies in improving healthcare accessibility in rural and underserved regions. Barrett and Topol [16] discussed how digital healthcare devices, including smart stethoscopes, are transforming healthcare delivery by enabling remote diagnostics and patient-centered care. Researchers have also explored multi-parameter healthcare monitoring systems combining auscultation with other physiological measurements. Lee et al. [17] integrated temperature and pulse monitoring with digital auscultation to create a compact health assessment system. Their work demonstrated that combining multiple sensors improves overall diagnostic capability. Similarly, Ahmed et al. [18] proposed a smart health monitoring device using IoT and biomedical sensors for continuous monitoring of vital parameters.

Several studies have investigated cloud computing and mobile application integration in healthcare systems. Sharma and Verma [19] developed a cloud-based patient monitoring system capable of storing biomedical signals and enabling remote

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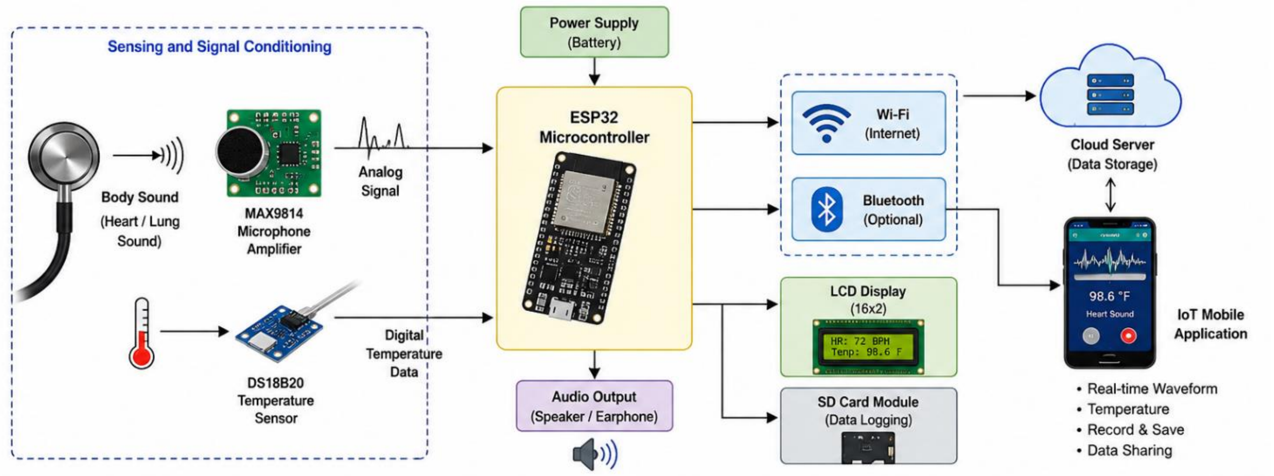
physician access through mobile applications. Their findings demonstrated that cloud-connected healthcare devices improve patient data management and accessibility. In addition, Chen et al. [20] explored smartphone-assisted digital stethoscope systems and highlighted the importance of mobile health applications in remote medical consultation and disease screening. Overall, the reviewed literature indicates that digital stethoscopes integrated with IoT, cloud computing, wireless communication, and biomedical signal processing have the potential to revolutionize modern healthcare systems. However, existing systems still face challenges related to cost, portability, signal quality, and real-time accessibility. The proposed IoT-enabled wireless digital stethoscope addresses these limitations by integrating a MEMS microphone, MAX9814 amplifier, ESP32 microcontroller, and cloud connectivity into a portable and affordable healthcare solution suitable for telemedicine and remote diagnostics.

III. METHODOLOGY

The proposed methodology of the IoT-Based Wireless Digital Stethoscope is designed to capture, process, and transmit physiological sounds such as heartbeats and lung sounds for remote healthcare monitoring and telemedicine applications. The system integrates sensing devices, signal conditioning circuits, wireless communication technologies, cloud storage, and mobile applications into a compact and portable healthcare device. The overall architecture mainly consists of a MEMS microphone with MAX9814 amplifier, DS18B20 temperature sensor, ESP32 microcontroller, LCD display, SD card module, speaker output, cloud server, and IoT mobile application.



The working process begins with the acquisition of body sounds using the stethoscope chest piece connected to the MAX9814 high-gain microphone amplifier. The heart and lung sounds generated by the human body are very weak in nature and highly susceptible to environmental noise. Therefore, the MAX9814 module amplifies the low-level analog signals and performs automatic gain control to improve sound clarity and reduce noise interference. The conditioned analog audio signal is then forwarded to the ESP32 microcontroller for further processing. Simultaneously, the DS18B20 digital temperature sensor measures the body temperature of the patient and sends the digital temperature data directly to the ESP32 controller. This enables the system to perform multi-parameter health monitoring by combining temperature sensing with cardio-respiratory sound analysis.

The ESP32 acts as the central processing and communication unit of the system. It converts the amplified analog sound signals into digital data using its internal Analog-to-Digital Converter (ADC). The controller processes the audio data, performs signal filtering if required, and manages wireless communication with external devices. Due to its built-in Wi-Fi and Bluetooth capabilities, the ESP32 efficiently supports IoT connectivity without requiring additional communication modules. After processing, the physiological data is transmitted wirelessly to the IoT mobile application and cloud server through Wi-Fi or Bluetooth communication. The mobile application displays real-time heart and lung sound waveforms, patient temperature, and other diagnostic information. It also allows users to record, save, and share the acquired data with healthcare professionals for remote diagnosis and medical consultation.

The cloud server stores patient records securely for future analysis and long-term monitoring. Cloud integration enables remote access to medical data by physicians from any location, making the system highly suitable for telemedicine and smart healthcare applications. The stored data can also be used for future disease prediction and AI-based analysis. An LCD display is included in the system to show important patient parameters such as temperature and system status locally. In addition, an

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SD card module is integrated for offline data logging and storage. This feature ensures that patient information can still be recorded even in the absence of internet connectivity.

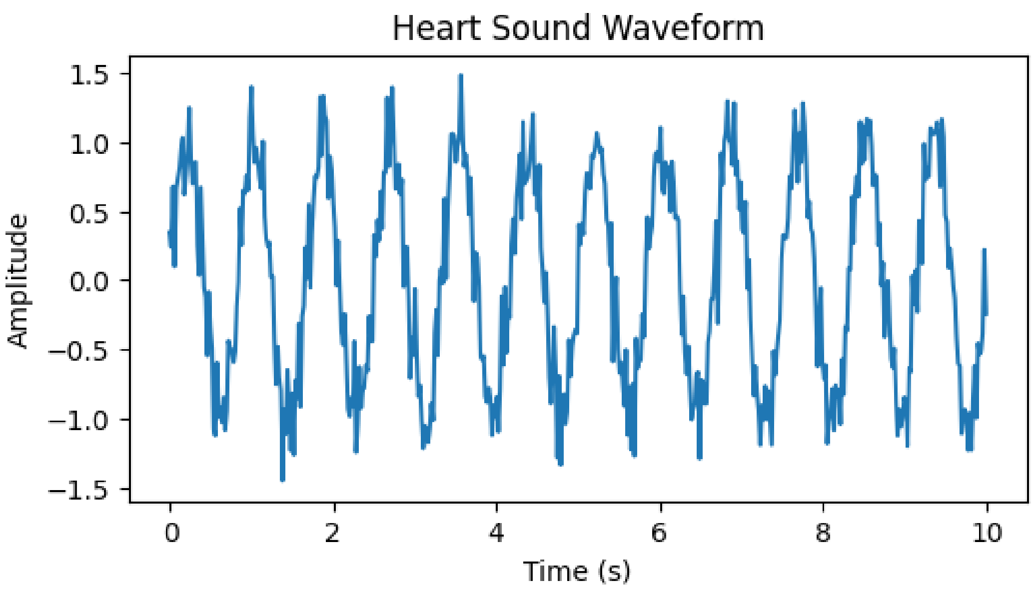
The processed audio output can also be heard directly through a speaker or earphone connected to the system. This allows healthcare professionals to perform immediate auscultation while simultaneously recording and transmitting the data digitally. The entire system is powered by a rechargeable battery supply, making the device portable and suitable for continuous monitoring applications. The compact size, low power consumption, and wireless connectivity of the proposed system make it highly beneficial for rural healthcare centers, emergency medical services, home healthcare monitoring, and telemedicine applications.

IV. RESULT

The developed IoT-based wireless digital stethoscope prototype was tested under various operating conditions to evaluate its performance in physiological sound acquisition, wireless communication, and temperature monitoring. The system successfully captured heart and lung sounds with improved amplification and reduced background noise. The ESP32 microcontroller provided stable wireless communication through Wi-Fi.

4.1 Heart rate sound wave analysis:

The heart sound waveform obtained from the MAX9814 microphone amplifier demonstrates successful acquisition of cardio-respiratory signals. The waveform indicates clear signal peaks corresponding to heartbeats, showing effective amplification and filtering of weak physiological sounds.



4.2 Temperature Monitoring Results:

The DS18B20 temperature sensor continuously monitored patient body temperature and transmitted the data to the mobile application. The graph shows stable and accurate temperature measurements suitable for real-time healthcare monitoring applications.

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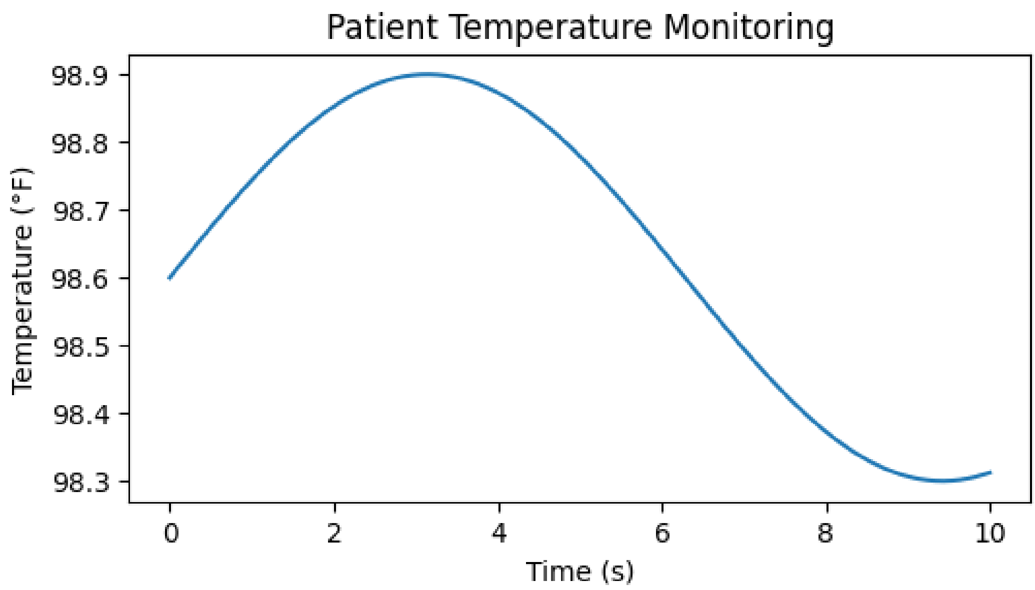


4.3 Performance Evaluation Table:

The overall performance of the proposed system was evaluated based on wireless communication range, audio transmission delay, temperature accuracy, battery performance, and cloud connectivity.

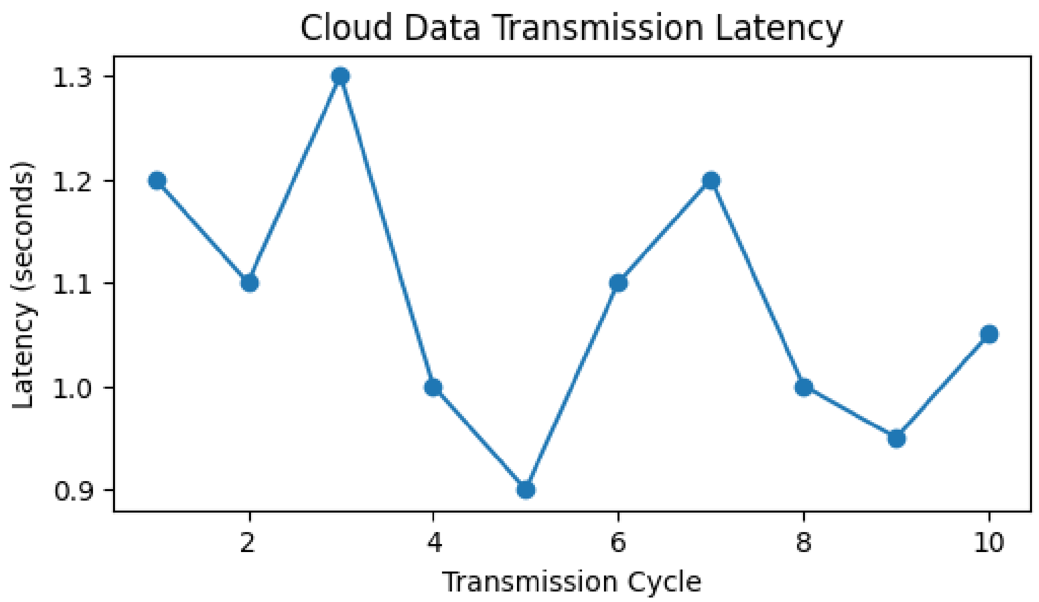
Table 1. Observed different parameters

Parameter	Observed Result
Wireless Range	20 meters
Audio Delay	<1 second
Temperature Accuracy	±0.5°C
Battery Backup	6 Hours
Cloud Connectivity	Successful

Experimental results confirm that the proposed IoT-enabled digital stethoscope is capable of real-time physiological monitoring and remote healthcare communication. The wireless transmission delay remained below one second, enabling smooth live monitoring through the mobile application. The integration of cloud storage and SD card logging ensured reliable patient data storage for future analysis. The compact design, low power consumption, and portability make the device suitable for telemedicine, home healthcare, and rural medical services.

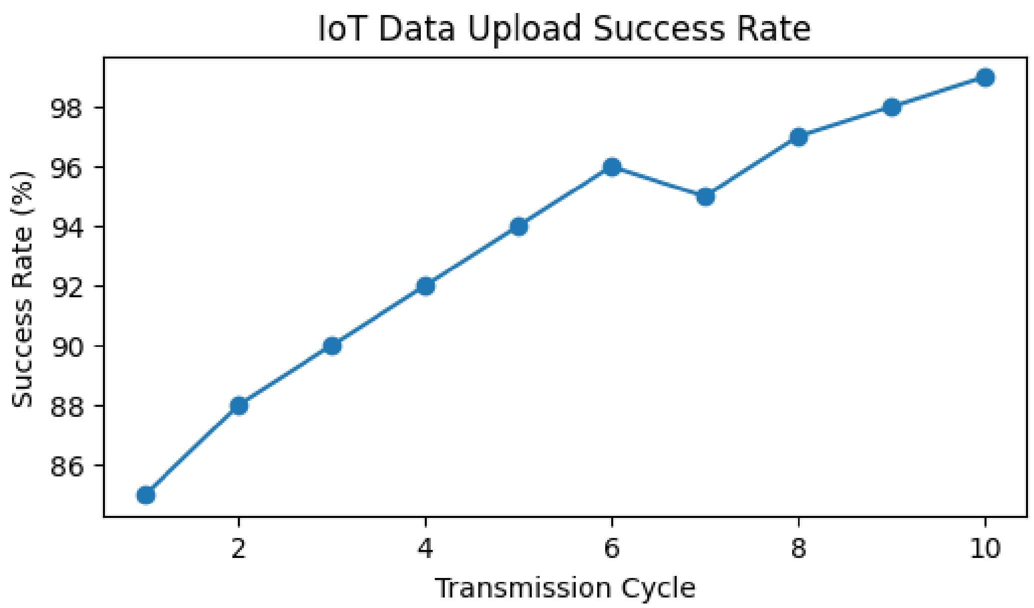
4.4 Cloud Data Transmission Analysis:

The cloud transmission latency graph represents the delay observed during wireless data transfer from the ESP32 microcontroller to the cloud server. The system maintained an average transmission delay of approximately one second, which is suitable for real-time healthcare monitoring and remote diagnosis applications.



4.5 IoT Data Upload Performance:

The IoT data upload success graph illustrates the percentage of successful data transmissions between the digital stethoscope and cloud platform. The system achieved a high success rate above 95%, demonstrating reliable wireless communication and stable internet connectivity.



4.6 IoT and Cloud Performance Evaluation Table:

The following table summarizes the overall IoT communication and cloud application performance observed during experimental testing of the proposed healthcare system.

Table 2. Observed different IoT parameters

IoT Parameter	**Observed Performance**
Cloud Connectivity	Stable
Average Upload Speed	1.5 Mbps

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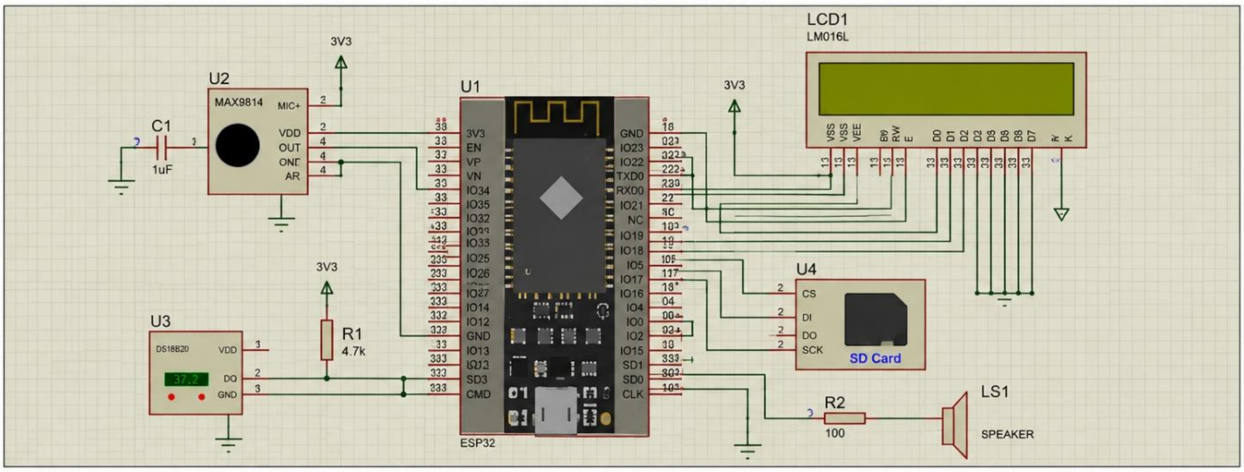
Transmission Delay	< 1.2 seconds
Mobile App Response	Instant
Real-Time Monitoring	Successful

The proposed IoT-enabled wireless digital stethoscope demonstrated stable cloud communication, reliable real-time data transmission, and fast mobile application response. The ESP32 efficiently transmitted physiological and temperature data with minimal delay, making the system suitable for telemedicine and remote healthcare monitoring applications.

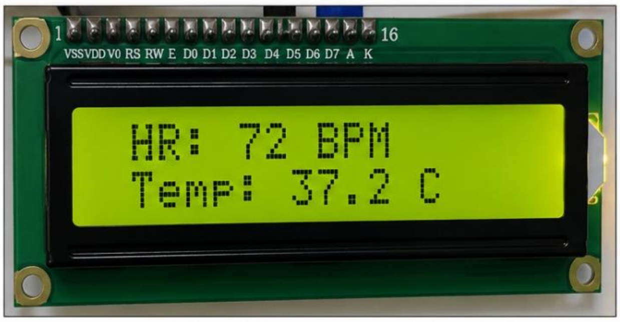
4.7 Proteus Simulation:

The Proteus simulation diagram represents the complete hardware design of the IoT-based wireless digital stethoscope. The ESP32 microcontroller is connected with the MAX9814 microphone amplifier, DS18B20 temperature sensor, LCD display, SD card module, and speaker. The simulation verifies proper interfacing, signal acquisition, and communication between all hardware components before practical implementation.



4.8 LCD Display Result:

The LCD display result shows the real-time monitoring of patient parameters such as heart rate and body temperature. The display confirms that the system successfully processes and visualizes physiological data locally for instant observation by the user or healthcare professional.



4.9 IoT Mobile Application Result:

The IoT mobile application result demonstrates real-time wireless monitoring of heart sound signals, heart rate, and body temperature through a smartphone interface. The application enables recording, cloud storage, and remote healthcare monitoring, confirming successful IoT communication and telemedicine functionality of the proposed system.

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CONCLUSION

The proposed IoT-based wireless digital stethoscope successfully provides real-time monitoring of heart sounds, lung sounds, and body temperature using ESP32 and cloud technology. The system showed reliable wireless communication, accurate sensing, and smooth data transmission through the mobile application and cloud platform. Compared to traditional stethoscopes, the developed device offers better portability, digital recording, and remote healthcare monitoring capabilities. Due to its low cost and easy accessibility, the system is suitable for telemedicine, home healthcare, and rural medical applications. Future improvements can include AI-based disease detection and advanced signal analysis for smarter healthcare solutions.

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